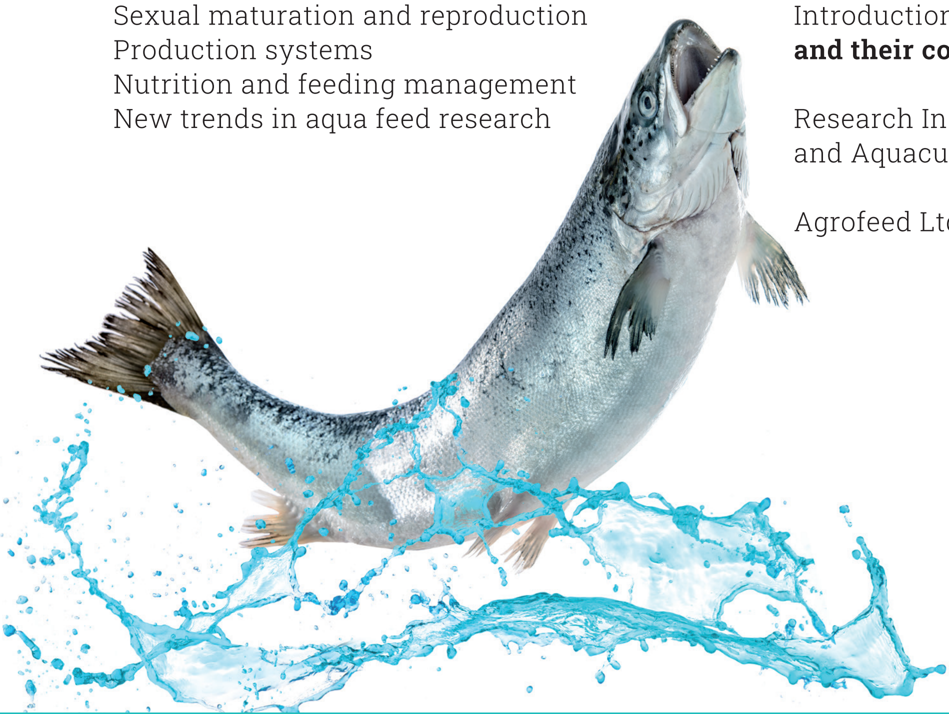
AGROFEED

Knowledge, which feeds

Agrofeed Ltd. &
MATE AKI (HAKI)

AQUACULTURE PUBLICATION

CONTENTS



INTRODUCTION

Aquaculture production has become a major global industry and an important source of income and food in many countries. Similar to livestock and poultry production, nutrition plays a key role in the aquaculture industry by influencing fish growth, health, product quality and waste generation.

The European Union's aquaculture production is 1.36 million tonnes. The EU needs to increase the own production because the 70% of fish comes from imports. The Rainbow Trout is the largest fish species (191.262 t) and Carp is the second most important freshwater fish produced in the EU. Hungary is the largest producer of African Catfish and the third largest carp producer in the EU.

Agrofeed Ltd. and **MATE AKI (HAKI)** has a professional relationship and cooperation in aquaculture. The most important common goal for both of us to find efficient premix and compound feed formulations which providing economically effective solutions for the players of international aquaculture business.

Development of nutritious, efficiently delivered and cost-ffective diets depends on knowing a species nutritional requirements and meeting those requirements with balanced diet formulations and appropriate feeding practices.

Of course, this type of publications having defined possibilities, so we have tried briefly to summarize the most important information related to world fishery and aquaculture production, the introduction of those fish species which have primary economy interest on Agrofeed export markets, like **Common Carp, Sturgeon species, Rainbow Trout and African Catfish.** We summarize all important information related to these species, like sexual maturity and reproduction, production systems, nutrition and feeding management.

The reader will understand the importance of nutrient requirements to the production of efficient, economical and sustainable feeds for use in aquaculture.

The type of culture system in which they are produced also aries considerably relative to production intensity.

The basic idea behind the joint professional work on this publication was to make it understandable, easy to read and above all, to help our partners future success and efficiency. Let it be a worthy basis of trust and professionalism for our further cooperation and mutual success in aquaculture as well.

Ákos Mezőlaki
Export Business Director

WORLD FISHERIES AND AQUACULTURE

(based to Fao The State Of World Fisheries And AquaculturE – 2016 publication)

Fisheries and aquaculture remain important sources of food, nutrition, income and livelihoods for hundreds of millions of people around the world. World per **capita fish supply** reached a new record **high of 20 kg in 2014**, thanks to vigorous growth in aquaculture, which now provides half of all fish for human consumption, and to a slight improvement in the state of certain fish stocks due to improved fisheries management. Moreover, fish continues to be one of the most-traded food commodities worldwide with more than half of fish exports by value originating in developing countries.

Faced with one of the world's greatest challenges – how to feed more than 9 billion people by 2050 in a context of climate change, economic and financial uncertainty, and growing competition for natural resources – the international community made unprecedented commitments in September 2015 when

UN Member States adopted the **2030 Agenda for Sustainable Development.** The 2030 Agenda also sets aims for the contribution and conduct of fisheries and aquaculture towards food security and nutrition in the use of natural resources so as to ensure sustainable development in economic, social and environmental terms.

Many millennia after terrestrial food production shifted from hunter-gatherer activities to agriculture, **aquatic food production has transitioned from being primarily based on capture of wild fish to culture of increasing numbers of farmed species.** A milestone was reached in 2014 when the aquaculture sector's contribution to the supply of fish for human consumption overtook that of wild-caught fish for the first time. Meeting the ever-growing demand for fish as food in conformity with the 2030 Agenda will be imperative, and also immensely challenging.

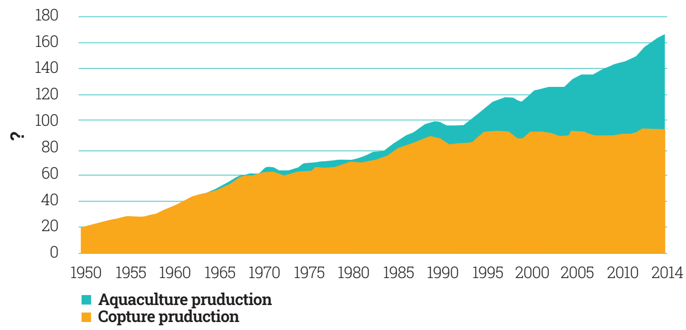
With capture fishery production relatively static since the late 1980s, aquaculture has been responsible for the impressive growth in the supply of fish for human consumption. Whereas aquaculture provided only 7 % of fish for human consumption in 1974, this share had increased to 26% in 1994 and 39% in 2004. **China** has played a major role in this growth as it **represents more than 60 % of world aquaculture production.**

However, the rest of the world (excluding China) has also benefited with its share of aquaculture in the overall supply of fish for human consumption more than doubling since 1995. **Growth in the global supply of fish** for human consumption has outpaced population growth in the past five decades, increasing at an average **annual rate of 3.2%** in the period 1961–2013, double that of population growth, resulting in increasing average per capita availability. World per capita apparent fish consumption increased from an average of 9.9 kg in the 1960s to 14.4 kg in the 1990s and 19.7 kg in 2013, with preliminary estimates for 2014 and 2015 pointing towards further growth beyond 20 kg. In **addition to the increase in production, other factors that have contributed to rising consumption include reductions in wastage, better utilization, improved distribution channels, and growing demand linked to population growth, rising incomes and urbanization.** International trade has also played an important role in providing **wider choices to consumers.**

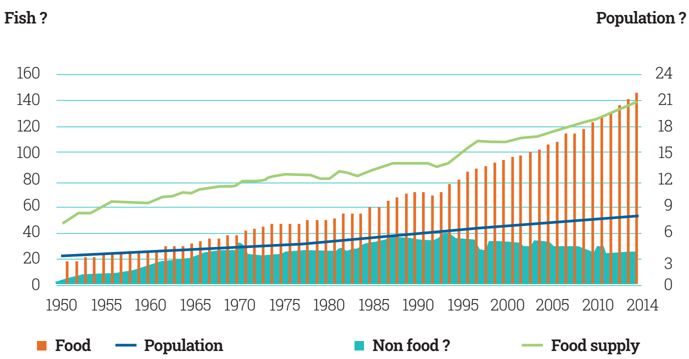
Although annual per capita consumption of fish has grown steadily in **developing regions** from 5.2 kg in 1961 to **18.8 kg in 2013,** and in low-income food-deficit countries (LIFDCs) (from 3.5 to 7.6 kg), it is still considerably lower than that in more developed regions, even though the gap is narrowing. In 2013, per capita apparent **fish consumption in developed countries was 26.8 kg.** A sizeable and growing share of fish consumed in developed countries consists of imports, owing to steady demand and static or declining domestic fishery production. In developing countries, where fish consumption tends to be based on locally available products, consumption is driven more by supply than demand. However, fueled by rising domestic income, consumers in emerging economies are experiencing a diversification of the types of available fish through an increase in fishery imports.

This significant growth in fish consumption has enhanced people's diets around the world through diversified and nutritious food. In 2013, **fish accounted for about 17 % of the global population's intake of animal protein and 6.7 % of all protein consumed.** Moreover, fish provided more than 3.1 billion people with almost 20 % of their average per capita intake of animal protein. In addition to being a **rich source of easily digested, high quality proteins containing all essential amino acids, fish provides essential fats** (e.g. long chain omega-3 fatty acids), **vitamins** (D, A and B) and **minerals** (including calcium, iodine, zinc, iron and selenium), particularly if eaten whole. Even small quantities of fish can have a **significant positive nutritional impact on plant-based diets**, and this is the case in many LIFDCs and least-developed countries. Fish is usually high in unsaturated fats and provides health benefits in protection against cardiovascular diseases. It also aids fetal and infant development of the brain and nervous system. With its valuable nutritional properties, it can also play a major role in correcting unbalanced diets and, through substitution, in countering obesity.

WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION



WORLD FISH UTILIZATION AND SUPPLY



Global total **capture fishery production in 2014 was 93.4 million tons, of which 81.5 million tons from marine waters** and 11.9 million tons from inland waters. For marine fisheries production, China remained the major producer followed by Indonesia, the United States of America and the Russian Federation. Catches of anchoveta in Peru fell to 2.3 million tons in 2014 – half that of the previous year and the lowest level since the strong El Niño in 1998 – but in 2015 they had already recovered to more than 3.6 million tons. For the first time since 1998, anchoveta was not the top-ranked species in terms of catch as it fell below Alaska pollock. Four **highly valuable groups** (tunas, lobsters, shrimps and cephalopods) registered **new record** catches in 2014. Total catches of **tuna and tuna like species were almost 7.7 million tons.** The Northwest Pacific remained the most productive area for capture fisheries, followed by the Western Central Pacific, the Northeast Atlantic and the Eastern Indian Ocean. With the exception of the Northeast Atlantic, these areas have shown increases in catches compared with the average for the decade 2003–2012. The **situation in the Mediterranean and Black Sea is alarming**, as catches have dropped by one-third since 2007, mainly attributable to reduced landings of small pelagics such as anchovy and sardine but with most species groups also affected.

World catches in inland waters were about 11.9 million tons in 2014, continuing a positive trend that has resulted in a 37 % increase in the last decade. **Sixteen countries have annual inland water catches exceeding 200 000 tons,** and together **they represent 80 % of the world total.**

Production of aquatic animals from **aquaculture in 2014 amounted to 73.8 million tons**, with an **estimated first-sale value of US$160.2 billion.** This total comprised 49.8 million tons of finfish (US$99.2 billion), 16.1 million tons of mollusks (US$19 billion), 6.9 million tons of crustaceans (US$36.2 billion) and 7.3 million tons of other aquatic animals including amphibians (US$3.7 billion).

China accounted for 45.5 million tons in 2014, or **more than 60 % of global fish production from aquaculture.** Other major producers were **India, Vietnam, Bangladesh and Egypt.** In addition, **27.3 million tons of aquatic plants** (US$5.6 billion) were cultured. Aquatic plant farming, overwhelmingly of seaweeds, has been growing rapidly and is now practiced in about 50 countries. Importantly in terms of food security and the environment, about half of the world's aquaculture production of animals and plants came from nonfeed species. These species include silver and bighead carps, filter-feeding animal species (e.g. bivalve mollusks) and seaweeds. However, growth in production has been faster for fed species than for nonfeed species.

An estimated **56.6 million people were engaged in the primary sector of capture fisheries and aquaculture** in 2014, of whom 36% were engaged full time, 23 %-part time, and the remainder were either occasional fishers or of unspecified status. Following a long upward trend, numbers have remained relatively stable since 2010, while the proportion of these workers engaged in aquaculture increased from 17% in 1990 to 33% in 2014.

In 2014, **84% of the global population engaged in the fisheries and aquaculture sector was in Asia,** followed by Africa (10%), and Latin America and the Caribbean (4%). Of the **18 million people engaged in fish farming, 94 % were in Asia.** Women accounted for 19 % of all people directly engaged in the primary sector in 2014, but when the secondary sector (e.g. processing, trading) is included women make up about half of the workforce.

The total number of **fishing vessels in the world in 2014 is estimated at about 4.6 million,** very close to the figure for 2012. The fleet in Asia was the largest, consisting of 3.5 million vessels and accounting for 75% of the global fleet, followed by Africa (15%), Latin America and the Caribbean (6%), North America and Europe (2-2%). Globally, 64% of reported fishing vessels were engine-powered in 2014, of which 80 % were in Asia, with the remaining regions all under 10 % each. In 2014, about 85 % of the world's motorized fishing vessels were less than 12 m in length overall (LOA), and these small vessels dominated in all regions. The estimated number of fishing vessels of 24 m and longer operating in marine waters in 2014 was about 64 000, the same as in 2012.

The state of the world's marine fish stocks has not improved overall, despite notable progress in some areas. Based on FAO's analysis of assessed commercial fish stocks, **the share of fish stocks within biologically sustainable levels decreased from 90% in 1974 to 68.6% in 2013.** The share of **world fish production utilized for direct human consumption** has increased significantly in recent decades, up from 67 % in the 1960s to 87 %, or more than **146 million** tons, in 2014. The remaining **21 million tons was destined for non-food products,** of which 76 % was reduced to fishmeal and fish oil in 2014, the rest being largely utilized for a variety of purposes including as raw material for direct feeding in aquaculture. Increasingly, the utilization of by-products is becoming an important industry, with a growing focus on their handling in a controlled, safe and hygienic way, thereby also reducing waste.

In 2014, **46%** (67 million tons) **of the fish for direct human consumption was in the form of live, fresh or chilled fish,** which in some markets are the most preferred and highly priced forms. The rest of the production for edible purposes was in different processed forms, with about 12 % (17 million tons) in dried, salted, smoked or other cured forms, 13 % (19 million tons) in prepared and preserved forms, and 30 % (about 44 million tons) in frozen form. Freezing is the main method of processing fish for human consumption, and it accounted for 55 % of total processed fish for human consumption and 26 % of total fish production in 2014.

Fishmeal and fish oil are still considered the most nutritious and digestible ingredients for farmed fish feeds. To offset their high prices, as feed demand increases, the amount of fishmeal and fish oil used in compound feeds for aquaculture has shown a clear **downward trend,** with their being more selectively used as strategic ingredients at l**ower concentrations and for specific stages of production, particularly hatchery, brood stock and finishing diets.**

International trade plays a major role in the fisheries and aquaculture sector as an employment creator, food supplier, income generator, and contributor to economic growth and development, as well as to food and nutrition security. Fish and fishery products represent one of the most-traded segments of the world food sector, with about **78% of seafood products estimated to be exposed to international trade competition.** For many countries and for numerous coastal and riverine regions, exports of fish and fishery products are essential to their economies, accounting for more than 40 % of the total value of traded commodities in some island countries, and **globally representing more than 9% of total agricultural exports** and 1 % of world merchandise trade, in value terms.

China is the main fish producer and largest exporter of fish and fishery products. It is also a major importer due to outsourcing of processing from other countries as well as growing domestic consumption of species not produced locally. However, in 2015, after years of sustained increases, its fishery trade experienced a slowdown with a reduction in its processing sector. **Norway, the second** major exporter, posted record export values in 2015. In 2014, **Vietnam became the third** major exporter, overtaking Thailand, which has experienced a substantial decline in exports since 2013, mainly linked to reduced shrimp production due to disease problems. In 2014 and 2015, the **European Union was by far the largest single market for fish imports,** followed by the United States of America and Japan.

Developing economies, whose exports represented just 37% of world trade in 1976, saw their share rise to 54% of total fishery export value and 60% of the quantity (live weight) by 2014. Fishery trade represents a significant source of foreign currency earnings for many developing countries, in addition to its important role in income generation, employment, food security and nutrition. In 2014, fishery exports from developing countries were valued at US$80 billion, and their fishery net export revenues (exports minus imports) reached US$42 billion, higher than other major agricultural commodities (such as meat, tobacco, rice and sugar) combined.

Governance of fisheries and aquaculture should be greatly influenced by the 2030 Agenda for Sustainable Development, the Sustainable Development Goals (SDGs), and the Paris Agreement of the Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change. The 17 SDGs and their 169 targets provide a framework to guide development actions of governments, international agencies, civil society and other institutions over the next 15 years with the ambitious aim of eradicating extreme poverty and hunger. Food security and nutrition, and sustainable management and use of natural resources, feature prominently in the SDGs and targets, applying to all countries, and integrating the three dimensions of sustainable development (economic, social and environmental). Moreover, the Paris Agreement recognizes that climate change is a fundamental threat to global food security, sustainable development and poverty eradication. Thus, governance needs to ensure that fisheries and aquaculture adapt to the impacts of climate change and improve the resilience of food production systems.

FAO's Blue Growth Initiative assists countries in developing and implementing the new global agenda, in relation to sustainable capture fisheries and aquaculture, livelihoods and food systems, and economic growth from aquatic ecosystem services. It promotes implementation of the Code of Conduct for Responsible Fisheries (the Code) and the ecosystem approach to fisheries and aquaculture (EAF/EAA). Reflecting the objectives of several SDGs, it especially targets the many vulnerable coastal and fisheries-dependent communities where ecosystems are already under stress from pollution, habitat degradation, overfishing and harmful practices.

There is a need to strengthen aquatic ecosystem governance to deal with the increasing use of water space and resources. It is necessary to coordinate various activities taking place in a given region, recognize their cumulative impacts, and harmonize sustainability goals and legal frameworks. This requires adding a layer of governance to deal with coordination across sectors and to ensure that common sustainability goals of environmental protection and ecosystem and biodiversity conservation are met while addressing social and economic development goals.

The **growth of responsible aquaculture** has been remarkable, with several countries now having procedures to conduct environmental assessments of aquaculture operations, to monitor operations and to minimize harmful effects of alien species introductions. Various seafood stakeholders wish to promote sustainable resource management and reward responsibly sourced seafood products with preferred market access. To this end, they have developed market-based measures commonly known as ecolabels. The number of voluntary certification schemes and their uptake by major import markets have increased dramatically since the first seafood ecolabel appeared in 1999. Such schemes can provide effective incentives for adherence to practices promoting sustainability.

Regional fishery bodies (RFBs) have a key role in the governance of shared fisheries. There are some 50 RFBs worldwide, most providing only advice to their members. However, regional fisheries management organizations (RFMOs), an important subset of RFBs, do have a mandate and the capacity for their members to adopt binding conservation and management measures based on best scientific evidence. The current state of many shared fishery resources has led to criticism of some RFBs, which, in turn, has led to debates on how to strengthen and reform them. Performance reviews of RFBs and revisions to their constitutive instruments have usually led to improved performance. However, RFBs can only be as effective as their member States allow, and RFBs' performance depends directly on their members' participation, engagement and political will.

Partnerships can be very effective in improving the sustainability of fisheries and aquaculture. Focusing on tuna and deep-sea fisheries, and with an emphasis on creating valuable partnerships and enhancing global and regional coordination on ABNJ issues, the Common Oceans ABNJ Program aims to promote efficient and sustainable management of fisheries resources and biodiversity conservation in ABNJ to achieve internationally agreed global targets. The innovative five-year ABNJ Program, which started in 2014, is funded by the Global Environment Facility (GEF) and coordinated by FAO in close collaboration with three other GEF implementing agencies and a variety of partners.

Another partnership initiative is the Global Aquaculture Advancement Partnership (GAAP) program established by FAO. Its aim is to bring partners together to channel their technical, institutional and financial resources effectively and efficiently in support of global, regional and national aquaculture initiatives. Specifically, GAAP seeks to promote and enhance strategic partnerships, and to use them to gather resources to develop and implement projects at the various levels.

FISH AND FISHERIES PRODUCTS

(FAO FOOD OUTLOOK - November, 2017)

GLOBAL FISH ECONOMY

According to the latest forecasts, global production of **fish and fisheries products** is expected to **expand by 2.3 percent in 2017,** a faster growth rate than last year. This acceleration is primarily accounted for by a recovery in **catches of anchoveta in South America following the end of El Niño** and by a further expansion of aquaculture production, which continues to rise at some **4–5% a year.** Although this growth is expected to slow gradually in the longer term, this year's OECD-FAO projections estimate that aquaculture will be the world's primary source of fish for all purposes within five years, while the proportion of fish utilized for human consumption supplied by aquaculture will also continue to rise.

Both **production and consumption growth will be increasingly driven by developing countries,** particularly those in Asia, a region whose already considerable importance as a producer and market will only continue to grow. In 2017, despite higher production, the demand stimulus resulting from improving economic conditions worldwide **has lifted prices for many important seafood commodities.** As a result, the total value of world exports is expected to rise by some 8 percent this year in US dollar terms, building on a similar increase in 2016. Higher prices for salmon, shrimp, tuna, cod, cephalopods and some small pelagic species have boosted export revenues for many large producers, particularly India, Norway and a number of Central and South American countries.

The **FAO Fish Price Index was 10 points higher in August,** the most recent available month, with all commodity groups higher than the same month in 2016. On the market side, the most important individual contributors to trade value growth are **China, the United States, the EU and Japan.** The economic revival of Brazil and the Russian Federation, two large emerging markets, will represent an additional boost to aggregate seafood demand if it continues into 2018 and beyond. OECD-FAO projections published in 2017 anticipate accelerating world GDP growth in 2017 and 2018 after years of sluggish economic performance in multiple world regions, which is a positive development for the seafood sector.

However, this growth is not evenly distributed geographically, as steady but slow economic expansion in the EU and Japan has been contrasted with more robust economic performance in the

Table 1. World fish market at a glance

	2015	2016 estim.	2017 f'casf	Change: 2017 over 2016
		million tonnes		%
WORLD BALANCE				
Production	169.2	170.1	174.0	2.3
Capture fisheries	92.6	90.1	90.4	0.3
Aquaculture	76.6	80.0	83.6	4.5
Trade value	%	6,4		
(exports USD billion)	133.2	142.4	153.5	7.8
Trade volume	МДж	5,2		
(live weight)	59.6	60.3	60.7	0.6
Total utilization	169.2	170.1	174.0	2.3
Food	148.8	150.6	153.3	1.8
Feed	15.1	14.3	15.6	8.7
Other uses	5.2	5.1	5.1	-0.8
SUPPLY AND DEMA	ИЭ	20000		
Per caput food consumption:	ИЭ	4000		
Food fish (kg/year)	20.2	20.2	20.3	0.7
From capture fisheries (kg/year)	9.8	9.5	9.2	-2.4
From aquaculture (kg/year)	10.4	10.7	11.1	3.3
FAO FISH PRICE INDEX (2002-2004=100)	2015	2016	2017	Change: Jan-Aug 2017 over Jan-Aug 2016 %
	142	146	152	5.9

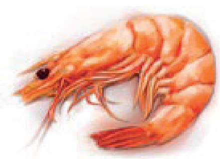
Source: Norwegian Seafood Council (NSC) Totals may not match due to rounding.

United States and rapid growth in developing regions, particularly Asia. **Seafood demand is highly sensitive to increases in income,** and thus it is these economic trends, combined with population growth rates, that will be the major determinants of future trade flows and consumption patterns. While Latin America and Africa are increasing their shares of the world market relative to the United States, the EU and Japan, it is the rapid transformation of large sections of the Asian population into urbanized, middle-class consumers that will be the most important single factor in shaping the global seafood market for some time to come.

International cooperation in **protecting the long-term health of marine environments remains a priority.** An agreement between WTO members that addresses the issue of overcapacity and overfishing resulting from such subsidy schemes is considered an essential component of Sustainable Development Goal (SDG) 14 Life Below Water, which concerns the wellbeing of the world's oceans. Another crucially important aspect of SDG 14 is climate change and how to mitigate its negative effects on fisheries and other marine-based resources, which was the topic of central focus at the VI edition of the CONXEMARFAO World Congress that was hosted in Vigo, Spain, on 2 October.

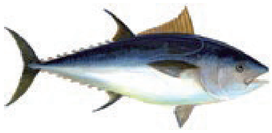
GLOBAL FISHERIES AND AQUACULTURE PRODUCTION

SHRIMP



Global farmed shrimp supplies were low during the first half of 2017, in balance with low to moderate demand in the traditional and emerging markets. Starting from July, however, the supply of farmed shrimp from Asia picked up. **China, the largest producer of shrimp,** saw lower production in 2017 compared with 2016 due to persistent disease issues, while in Indonesia, unfavorable weather has affected harvests. India, Vietnam and Thailand should see increased production, and in Argentina, a bumper catch of wild shrimp has been reported for 2017 with landings totaling 139 000 tones, 34.7 percent higher than last year. November to March is the low farming season in Asia, and overall availability of raw material will be limited until the new season in Asia begins in April 2018. The positive import trend in Japan is likely to continue through the year-end celebration into early 2018. Year-end is also one of the high consumption periods for shrimp in the United States, but the effects of the hurricanes, together with weaker overall demand, stagnant inventories and increased imports may mean lower prices in the coming months. In the EU, prices for Ecuadorian shrimp can be expected to fall if there is a weakening of interest from East Asian buyers.

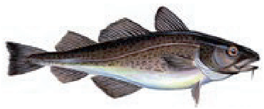
TUNA



Due to low inventories of raw material at canneries in Thailand and Ecuador, demand for **frozen skipjack** is likely to increase in the coming months. However, the catch outlook remains unclear until after the fish aggregating device (FAD) and "veda" fishing bans in the Pacific Ocean are lifted in October. As of September, the delivery price of frozen skipjack to Thailand had crossed USD 2 000 per tons, and if landings do not improve in the last quarter of 2017, particularly in the Pacific Ocean, **prices may increase further.** On the market side, imports of canned tuna in the US market are likely to improve during early 2018, as buyers take advantage of the annual import quota for canned tuna at the lower tariff rate.

In the EU, importers will continue to depend on and favors Ecuador and the Philippines due to their duty-free status to this market. Meanwhile, canned tuna producers in Thailand and Indonesia are focusing more on emerging markets as exports to the EU and United States are trending downwards, although the EU remains the economically logical choice for Ecuador for the time being. Overall, any further rise in raw material prices can be expected to have a negative impact on consumer demand for canned tuna worldwide.

GROUNDFISH



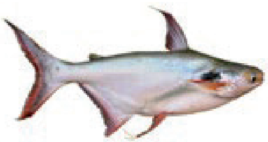
According to figures presented at the Groundfish Forum 2017, total global ground fish supplies, excluding Northern Blue Whiting, are **forecast to fall by some 3 percent** in 2018. The Barents Sea **cod quota is expected to be reduced,** with the International Council for the Exploration of the Sea (ICES) recommending a 20 percent cut in the 2018 quota. While such a cut may appear drastic, researchers are confident that the long-term outlook is very positive. The Joint Russian Federation-Norwegian Fisheries Commission, which will set the final quotas in November, is expected to take a cautionary approach, and **some price increases can be expected** as a consequence. In the **pollock market, demand is increasing** in Asia, North America and Europe, aided by the high prices for cod brought on by the supply shortage.

Overall, pollock prices are expected to edge upwards, as will cod prices, which most likely will continue their upward trend. Meanwhile, the market for surimi also appears to be picking up. It is expected that there will be a **general shortage of surimi this year,** as production is stagnant and demand is increasing, both in Japan and on the US market.

CEPHALOPODS

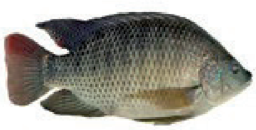
Demand for octopus and squid is growing stronger, but poorer landings mean limited supplies. Inventories are also low and observers expect **prices to continue increasing** over the coming months. With low catches in Morocco and Mauritania, the main market for octopus, Japan, will be looking for supplies from alternative sources such as China, Vietnam, Mexico and Southeast Asia. For squid, stocks off the coast of Argentina are reported to be in poor condition, contributing to upward pressure on prices, especially for Ilex squid. China, which also imports large quantities of squid from the Democratic People's Republic of Korea, is likely to see a sharp drop in shipments in the medium term as pressure mounts to isolate the Democratic People's Republic of Korea from international trade. Overall, cephalopod trade volumes are set to contract and prices will remain high.

PANGASIUS



During the first half of 2017, **global imports of frozen pangasius fell slightly,** mainly due to lower imports into the single largest market, the United States, while demand also continues to weaken in the EU. Imports into Latin America and Asia, however, comprised approximately 51 percent of the world's total over the same period, increasing from a 42 percent share the previous year. Overall, **prices remain relatively strong.** In **Vietnam, by far the largest pangasius producing country,** the Ministry of Agriculture and Rural Development is actively promoting the consumption of pangasius domestically as well as targeting expansion in international markets, particularly China.

TILAPIA



In total, during the first half of 2017, approximately 170 000 tons of tilapia (whole, fillets and breaded) entered the international market. While the US market grapples with weak demand, some recovery in the tilapia market is being observed in the EU market, although **prices remain weak.** In contrast, the markets in **Asia and Latin America continue to exhibit strong growth** as more production enters domestic markets, supplemented by imports from China. In order to offset the declining interest from US buyers, Chinese companies are also increasingly seeking opportunities for expansion in Africa, as well as taking advantage of the strong and growing demand for tilapia in the Chinese domestic market. Overall, considering the current demand situation in the major markets, imports are not expected to increase substantially in the near future nor should a significant price increase be expected despite firm demand in Asia, Latin America and Africa.

SEABASS AND SEABREAM

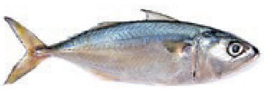
Total **farmed seabass and seabream production is expected to grow a further 5 to 7 percent in 2018,** and all industry participants will be mindful of the potential impact that this continued growth will have on price levels, which have already been negatively affected by supply growth. That said, it must be recognized that there are a number of positive developments in production, processing, logistics and marketing that will help to boost company margins through demand generation and cost savings. There have also been improvements in the economic outlook for a number of key markets, and a sustained increase in prices for some competing seafood items such as salmon.

Together, these developments represent an **improved long-term outlook for the sector,** but for 2018, it is still not clear that the positive effects will outweigh the downward pressure on prices resulting from continued supply growth.

SALMON

World **prices for farmed salmon remain high** but have fallen back somewhat due to higher harvest volumes in the second half of 2017. Further stability will depend both on the absence of a severe supply shock and on the ability of producing countries to keep pace with rapid demand expansion in an increasingly diversified range of markets. At present, consensus forward prices suggest downward pressure exerted by the expected increase of 7 to 8 percent in global production next year should be sufficient to keep the average 2018 price for fresh whole Atlantic salmon from Norway at around NOK 60 (USD 7.56) per kg. In the **wild salmon sector,** meanwhile, total catches are expected to come in above harvest but below the last equivalent year, 2015. On the market side, while consumer sensitivity to price hikes has dampened import growth in the more mature markets of the United States, the EU and Japan, the share of global salmon import volume and value claimed by urbanizing middle-class demographics in developing countries continues to increase. The flattening price trend, if it continues, together with product innovation focused on portion sizing and convenience, will be key in preventing consumers from making a long-term shift towards alternative protein sources, particularly in the larger, established markets.

SMALL PELAGICS



The supply outlook for small pelagics in 2018 is for **an increase in global landings,** mainly driven by higher landings of **Peruvian anchoveta,** although the ICES has recommended cuts in the North Atlantic mackerel and herring quotas. For the **2018 mackerel quota,** ICES has recommended a **35 percent** cut to 550 948 tones, and **for herring, the recommendation is for a 15 percent cut** to 546 472 tones. There has been speculation that, as a result of global warming, Atlantic mackerel stocks would move farther north in the Barents Sea. However, while some movement has been observed, the mackerel have not yet moved as far north as expected and the autumn mackerel season started with good catches, pushing prices lower. Total trade volumes of mackerel and herring are expected to go up, but there have been and will likely continue to be shifts

FISHMEAL AND FISH OIL

Global **supply of fishmeal is expected to be more stable** than in previous years in the first half of 2018, due to better climatic conditions and higher projected pelagic catches. **Prices are likely to follow an overall downward trend but with seasonal fluctuations.** A quota of 2.8 million tones for the first anchoveta fishing season in Peru, the highest since 2011, ended with a total catch of 2.37 million tons in 2017, representing 85 percent of the total allowable catch (TAC) and clearly giving buyers the advantage in price negotiations.

The outlook also looks positive for the second fishing season in Peru, set to begin in late 2017. However, the overall downward trend of Peruvian fishmeal price resulting from more plentiful supply will be softened in the longer term by continued demand growth, particularly from China.

CRAB

The Russian Federation Far East has seen increased quotas for 2017, and supplies are expected to **improve.** Russian Federation Illegal, Unreported and Unregulated (IUU) crab production appears to have been curbed and total Russian Federation Far East crab catches are expected to reach about 73 500 tones for the year. In the United States, the coming months should provide strong supplies from California and possible declining prices for Dungeness crab. However, **snow crab prices have been high and king crab prices even higher.** International trade in crab has declined a bit lately, but the Russian Federation is expecting to export more moving into 2018, especially to East Asia where demand is strong.

BIVALVES

Chilean mussel production seems to have recovered from the difficulties of last year, when red tides hit the main cultivation areas, but global production of mussels, as well as clams, is not growing fast enough to keep pace with the improving market environment. In France, the oyster season for 2018 is forecast to be good, as the mortality of juveniles this year is relatively low. In general, **supply competition in the EU can be expected from developing countries,** which are seeking to invest in good infrastructure and quality control in order to be able to export to the lucrative EU live bivalves market. At present, this market is only open to a small selection of countries. Overall, **demand for bivalve species is likely to stay strong in 2018 and supply will be tight, supporting high prices** for the major bivalve species with the exception of scallops and oysters.

LOBSTER

Lobster landings in the United States are forecast to be down by 20 percent in New England this year, and by as much as 30 percent in Maine. Some traders are now worried that a **shortage** may develop by early 2018, although there seems to be enough lobster meat on the market at the moment. Current high prices for lobster this season are to a large extent due to very good demand in China. Paradoxically, strong Chinese demand is the result of low prices and plentiful supply in 2012, which allowed North American exporters access to the Chinese market.

AGROFEED-HAKI AQUACULTURE SUMMARY

RAINBOW TROUT

Culture of Rainbow Trout (Oncorhynchus mykiss)

Introduction

Aquaculture plays an important role in the supply of fresh fish for human consumption. Fish **contains healthy proteins and essential omega-3 fatty acids,** both of which form part of a healthy and balanced diet. The rainbow trout (Oncorhynchus mykiss) is a **commonly raised fish species in aquaculture.** In **addition to the fish raised for consumption, millions of rainbow trout are raised for stocking** into ponds, lakes, streams, and rivers to provide additional sport fishing opportunities. Together, rainbow trout cultured directly for human consumption, and those cultured to enhance or provide sport fishing opportunities, account for a measurable proportion of global aquaculture production, with a total production exceeding **810,000 tons** in 2013 (FAO, 2015).

Rainbow trout is a hardy fish that is easy to spawn, fast growing, tolerant to a wide range of environments and handling, and the large fry can be easily weaned on to an artificial diet (usually feeding on zooplankton). Capable of occupying many different habitats, ranging from an anadromous life history (living in the ocean but spawning in gravel-bottomed, fast-flowing, well-oxygenated rivers and streams) to permanently inhabiting lakes. The anadromous strain is known for its rapid growth, achieving 7-10 kg within **3 years,** whereas the **freshwater strain can** only attain **4.5 kg** in the same time span. The species can withstand vast ranges of temperature variation (0-27 °C), but spawning and growth occurs in a narrower range, 9-14 °C. The **optimum water temperature** for rainbow trout culture is below 21 °C. As a result, temperature and food availability influence growth and maturation, causing **age at maturity** to vary; though it is **usually 3-4 years.**

Sexual maturation and reproduction

The sexual maturation of rainbow trout **depends on water temperature** in which fish live, feeding conditions, etc. Trout becomes sexually mature in fish farms sometimes even earlier than in nature if water temperature is higher and feeding is better than there. **Reproductive age for females within farm conditions is 4-6 years, 6-7 for males,** respectively. Females and males will produce eggs and milt (gametes) but they cannot spawn successfully under regular fish farm conditions unless all required favourable environmental conditions are simulated.

Though, reliable production of large quantities of fertile eggs and hatched larvae would be both difficult and expensive on this way. Therefore, there are other more efficient ways of artificial propagation of trout which result in the ovulation of eggs stripped and fertilized with milt from males (Hoitsy, 2012).

Females are able to produce up to 2 000 eggs/kg of body weight. Salmonid eggs are the largest among the eggs of bony fishes. The size of their dry eggs varies between 3.7 and 5.2 mm (32–100 mg) (Hoitsy, 2002). Most fish only spawn once, in spring (January-May), although selective breeding and photoperiod adjustment has developed hatchery strains that can mature earlier and spawn all year around. **Light conditions have a very important role in the reproductive behaviourand activity of trout.** Shortening days stimulate development of eggs and activate instincts of spawning migration. On large broodfish farms where the objective is a continuous, year-round propagation and eyed-egg production light conditions are also controlled in order to stimulate and synchronize ovulation in females.

Superior characteristic selection is also achieved by **cross breeding,** increasing growth rates, resistance to disease, and prolificacy, and improving meat quality and taste. Genetic manipulation of the embryo sex chromosomes producing sterile, triploid females, hence avoiding the 'hook-like' jaw that does not appeal to the customer, and ensuring that introduced/escaped individuals cannot breed.

Trout larvae are well developed at hatchery. In the wild, adult trout feed on aquatic and terrestrial insects, molluscs, crustaceans, fish eggs, minnows, and other small fishes, but the most important food is freshwater shrimp, containing the carotenoid pigments responsible for the orange-pink colour in the flesh. The **typical redness of the muscle is due to the presence of carotenoids** that the fish cannot synthesize in itself and must be obtained from its diet. The muscle colour of farmed trout is enhanced by adding two major carotenoids, namely **canthaxanthin and astaxanthin into its diet.** Astaxanthin is one of the major carotenoid pigments present in aquatic animals and has important biological functions, which include: prevention of the oxidation of unsaturated fatty acids; protection against the negative effects of ultraviolet light; action as pro-vitamin A; control of growth and reproductive behaviour; and enhancement of the immune system.

Production systems

Monoculture is the most common practice in rainbow trout culture, and intensive systems are considered necessary in most situations to make the operation economically attractive.

A potential site for commercial trout production must have a **year-round supply of high quality water** (without aeration - 1 l/min/kg of trout without aeration or 5 l/sec/tone of trout with aeration), that meets a number of criteria: DO2: near saturation, CO2: < 2ppm, temperature: 12-21 °C, pH: 6,5-8,5, alkalinity (as CaCO3): 10-400 mg/litre.

Ground water can be used where pumping is not required but aeration may be necessary in some cases. Supersaturated well water with dissolved nitrogen can cause gas bubbles to form in the blood of fish, preventing circulation, a condition known as gas-bubble disease. Alternatively, river water can be used but temperature and flow fluctuations alter production capacity. Where these criteria are met, trout are generally on-grown in raceways or ponds supplied with flowing water, but some are produced in cages and recirculating systems.

Nutrition and feeding management

The selection of the **proper feed** in combination **with appropriate feed management strategies are critical keys to obtaining efficient aquaculture production.** Matching the potential growth of the culture species with proper management of the feed

Name	Unit	Recommendations of the Hungarian Feed Codex (Codex Pabularis Hungaricus)			NRC 2011
	Age group	Fingerling	Grower	Finisher	Grower
Nutrient content					
Crude protein	%	53.0	45.0	42.0	
Digestible protein	%				38.0
Crude fat	%	8.0	8.0	8.0	
Crude fiber	%	max.3	max.4	max.4	
Crude ash	%	max.10	max.12	max.13	
Digestible energy	MJ/kg	15.0	13.5	12.0	17.6
Amino acids					
Arginine	%				1.5
Histidine	%				0.8
Isoleucine	%				1.1
Leucin	%				1.5
Lysine	%	2.6	2.2	1.5	2.4
Methionine	%	0.8	0.7	0.6	0.7
Methionine + cystine	%	1.4	1.2	1.1	1.1
Phenylalanine	%				0.9
Phenylalanine + Tyrosine	%				1.8
Threonine	%				1.1
Tryptophan	%				0.3
Valine	%				1.2
Taurine	%				NR
Macro minerals					
Calcium	%	0.6	0.6	0.6	NR
Magnesium	%				0.05
Total Phosphorus	%	1.3	1.1	0.9	
Available Phosphorus	%	1.1	0.9	0.8	0.07
Microminerals					
Copper	(mg/kg)				3
Iodine	(mg/kg)				1.1
Manganese	(mg/kg)				12
Selenium	(mg/kg)				0.15
Zinc	(mg/kg)				15
Fatty acids					
18:3n-3	%				0.7-1.0
18:2n-6	%				1
n-3 fatty acid	%	1.2	1.1	1.1	
n-6 fatty acid	%	1.2	1.1	1.1	
EPA	%	0.50	0.40	0.40	
DHA	%	0.40	0.30	0.30	
n-3 Lc PUFA					0.4-0.5

The nutrient requirement of different aged rainbow trout is presented in Table 1.

Nutrient content	Unit	DSM	BASF	Mézes	NRC 2011
Fat soluble vitamins					
Vitamin A	IU/kg	6000-10000	12 000	15 000	0.75 mg/kg
Vitamin D3	IU/kg	1800-2000	1 500	1 800	40 µg/kg
Vitamin E	mg/kg	150-300	100	100	50
Vitamin K3	mg/kg	3-6	4	10	R
Water soluble vitamins					
Vitamin B1	mg/kg	10-20	10	20	1
Vitamin B2	mg/kg	20-30	20	20	4
Vitamin B6	mg/kg	10-15	8	12	3
Vitamin B12	mg/kg	0.03-0.05	0.04	0.05	R
Niacin	mg/kg	150-200	140	120	10
Pantothenic acid	mg/kg	50-55	40	50	20
Folic acid	mg/kg	4-6	2	6	1
Biotin	mg/kg	0.8-1	1	1.2	0.15
Choline	mg/kg	600-1000	800	1 000	800
Vitamin C	mg/kg	600-800	200	300	20
Inositol	mg/kg	300-400	-	300	300

NR: not required; R: required in the diet, but not determined

ration and nutrient density of the feed to provide the proper daily delivery of nutrients is one of the most difficult task to effectively achieve.

The practical application of fish nutrition is to produce **feeds that support growth, heath, and welfare of farmed aquatic animals.** This objective is achieved by selecting appropriate feed ingredients, deciding how they should be combined to meet the nutritional requirements of farmed aquatic animals, and processing the combination or mixture of ingredients into a physical form suitable for practical use. Physical characteristics **of pellets, such as hardness and durability, water stability, and porosity, are determined by the blend of ingredients used during conditioning of the ingredient mixture and pelleting.** Feeds for rainbow trout have been modified over the years and **cooking-extrusion processing of feeds** now provide compact nutritious pelleted diets for all life stages. Pellets made in this way absorb high amounts of added fish oil and permit the production of high-energy feeds, with **over 16 percent fat.** Dietary **protein levels** in feeds have increased **from 35 to 45 percent** and **dietary fat levels** now exceed **22 percent in high energy feeds** (20-21 kJ).

Feeding methods vary for production systems. Hand feeding is suitable for small fish eating fine food. **Mechanical feeders, driven by electricity or solar power,** are frequently used to feed set amounts at set intervals depending on fish size, temperature and season. Demand **feeders can be used for fish greater than 12 cm.** Recommendation for feeding rate, feeding frequency and feed type and size for rainbow trout is shown in Table 2.

Life stage	Fish size (g)	Feed type	Feed size (mm)	Feeding rate (% body weight)	Feeding frequency (No./day)
Fat soluble vitamins					
Fry	0.3-1.0	crumble	0.3-0.7	5	10
Fingerling	1.0-25.0	pellet	0.7-2.0	3	4
Grower	25-1500	pellet	2.0-4.5	2	2
Broodstock	>1500	pellet	5	1.5	2

Table 2. Feeding table of rainbow trout (www.fao.org)

Nutrient content	Haltáp Kft. Szarvas, Hungary	COPPENS, Netherlands NRC 2011				
	Troutfingerling	Troutgrower	TroCoPre-Grower-18	TroCoPre-GrowerUltra	TroCo Grower Supreme-22	Repro
Dry matter	88.0%	88.0%				
Crude protein	48.0%	45.0%	45	48	44	48
Crude fat	7.5%	6.4%	18	22	22	15
Crude fibre	1.0%	1.8%	-	-	-	-
Lysine	3.3%	3.1%	-	-	-	-
Methionine	1.2%	1.2%	-	-	-	-
Methionine + cystine	1.7%	1.7%	-	-	-	-
Ca	1.7%	1.4%	-	-	--	
P	1.6%	1.3%	-	-	-	-
Na	0.5%	0.3%	-	-	-	-
Vitamin A	20000 IU	14000 IU	-	-	-	-
Vitamin D3	2000 IU	1400 IU	-	-	-	-
Vitamin E	100 mg/kg	70 mg/kg	-	-	-	
Feed size	0.5 – 1.2 mm	1.2 – 3.0 mm	2	2	3-6	8
Astaxanthin	µg/kg		-	-	-	40

Table 3. Composition of commercial trout feeds

Nutrient content	Haltáp Kft. Szarvas, Hungary	COPPENS, Netherlands NRC 2011				
	Troutfingerling	Troutgrower	TroCoPre-Grower-18	TroCoPre-GrowerUltra	TroCo Grower Supreme-22	Repro
Crude protein %	64	58	45	41	40-42	40-42
Crude fat %	12	9	15	24	30-32	30-32
Crude ash %	13	10.4	6.9	7	6-8	6.5-9.5
NFE %	2	14.5	23.8	20	12.5-15.5	11.5-14.5
Crude fiber %	1	2	3.3	2	0.7-1.9	0.8-1.8
P %	1.5	1.2	0.9	1	1	0.9
Gross energy (MJ)	20.4	20.1	21.2	22.9	24.1-27.1	24.1-27.1
Digestible energy (MJ)	19	18.2	17.6	20	22	22

New trends in aqua feed research

Commercial aquaculture feeds generally contain appreciable amounts of **fish meal and fish oil.** However, during recent years it has become evident that the increasing demands on these resources will outstrip supply unless level in feeds are reduced. As a consequence, a considerable amount of research in being devoted to identifying, developing, and evaluating **alternative ingredients.** Although progress has been made, there are currently insufficient substitutes to meet the demands of an expanding aquaculture industry, and this remains a very active area of research.

Feed formulations for rainbow trout use fish meal, **fish oil, grains and other ingredients,** but the amount of fish meal has been reduced to less than 50 percent in recent years by **using alternative protein sources such as soybean meal, cottonseed meal** etc. Present commercial fish feeds contain considerably **less than 13% of fishmeal and less than 8% fish oiland more plant-based raw materials and animal by-products.** These alternative ingredients make possible to produce high-performance fish feed that contains all the essential nutrients, such as omega-3 fatty acids. These high energy diets, are efficiently converted by the rainbow trout, often **close to 1:1 FCR.** Recently was investigated rainbow trout feeds with **100 % fishmeal**

Ingredient index (%)	Fish meal diet	Animal product diet	Plant product diet	Novel plant protein diet	Plant products with future potential
Menhaden fishmeal	22.0	-	-	-	-
Poultry by-product, pet food	6.00	27.00	-	-	-
Blood meal	4.00	5.00	-	-	-
Feather meal	-	5.00	-	-	-
Soybean meal 48% CP	15.00	15.00	15.00	-	-
Corn protein concentrate	15.00	9.00	23.00	22.00	12.00
Soy protein concentrate - Profine VF	-	-	23.00	-	-
High protein distillers dried grains	-	-	-	15.00	-
Soy protein concentrate - Hamlet protein	-	-	-	35.00	-
Soy full fat, Schillinger Gen.	-	-	-	-	30.00
Spirulina-Earthise	-	-	-	-	15.00
Barley protein concentrate	-	-	-	-	12.00
Wheat flour	16.36	17.65	11.99	1.71	5.42
Menhaden fish oil	15.99	14.88	18.12	17.33	18.04
Vitamin premix	1.00	1.00	1.00	1.00	1.00
Formulated nutrient content (%)					
CP dry	45.40	45.10	45.20	45.70	45.30
Lipid	20.00	20.00	20.00	20.00	20.00
DP dry	40.20	39.90	42.50	40.80	41.80
Digestible energy (cal g-1)	4919	4788	4991	4519	5194
Total phosphorus	1.19	0.98	1.03	1.05	1.17
Available-phosphorus	0.53	0.53	0.52	0.53	0.53

Table 4. Formulated diets of rainbow trout to determine the ability to remove fishmeal from feeds (Craft et al., 2016)

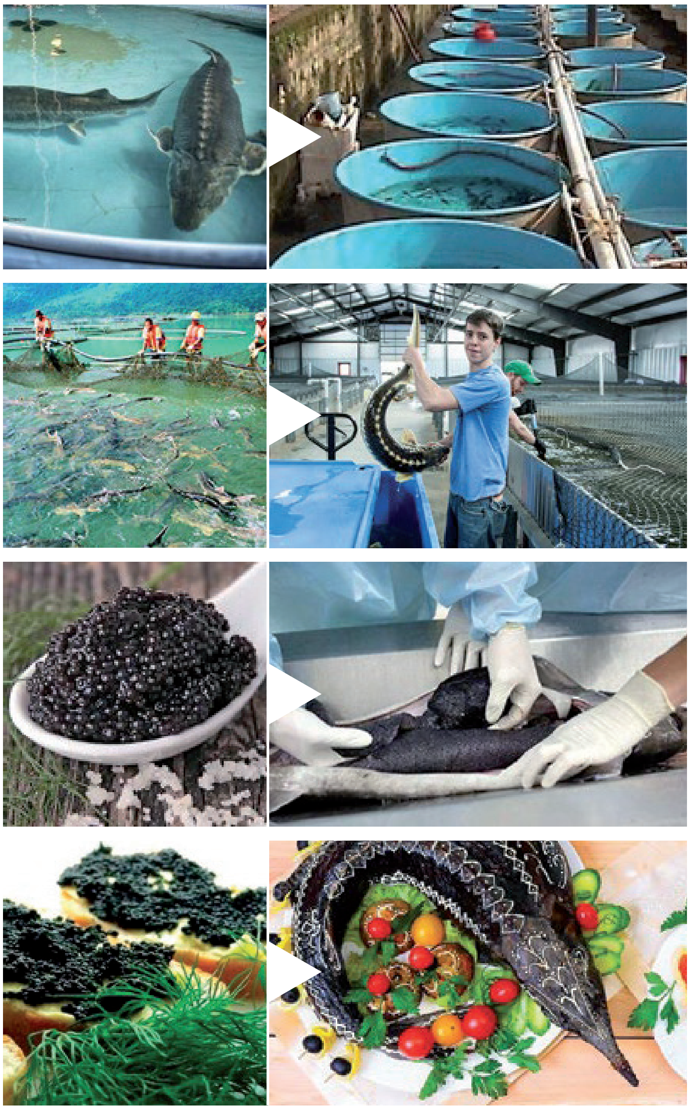
replacement by multiple plant protein sources. The experimental diets formulation has been showed at Table 4. (Craft et al., 2016). In this study, not surprisingly, the fishmeal-based (control) diet produced superior results in terms of specific growth rate, feed conversion rate and mean final wet weight. Nevertheless, the notable overlap among all feed groups in many of the examined growth metrics suggests that carefully-formulated feeds using animal and plant-based proteins can promote growth rates similar to those observed in fish consuming traditional, fishmeal-based diets. From consumer acceptance standpoint, fishmeal-free diets performed at similar levels. This suggests that **diet ingredient selection criteria could be more heavily influenced by ingredient prices and availability,** provided these ingredients are used in a nutritionally balanced feed.

Formulating a nutritionally balanced feed for aquaculture fish requires an in depth knowledge on the nutrient composition of the vast array of ingredients available. However, the **efficacy of the feeds** for farmed fish **relies also on a series of technical criteria** (e.g. pellet durability, starch gelatinization, expansion rate) which define the pellet water stability and its adequacy to the species feeding behaviour.

When changing aquaculture feeds from fish-derived ingredients to plant- or animal-based ingredients, **even slight changes on formulations can have profound effects on the physical properties of extruded feeds.** The complexity of the extrusion process, and limitations in basic knowledge on protein properties and protein/starch-interaction, make it a demanding task to obtain consistent product quality based on different types of raw materials. The "commonly used" incorporation levels and with a careful adjustment of extrusion conditions, the use of plant ingredients originates fish feeds with high physical quality and without detrimental effects on the environmental load of aqua feeds.

STURGEON SPECIES

Sturgeon production in
Recirculating Aquaculture Systems



Introduction

Diversification of cultured species, seafood product and technologies are ones of the main prerequisites for further sustainable growth of aquaculture sector. Since several years, the **sturgeon are recognized as one of the world's most promising commercial species, mainly prized for its roe** (branded as black caviar), but also for its meat and other product (skin, isinglass). The commercial sturgeon culture is continuously increasing, the delicate flesh and roe of sturgeons, and their wide ecological plasticity could make their **farming economically profitable.** Nowadays, the estimated farmed sturgeon production amounted above **120 000 t per year,** from this **about 30 % came from recirculating aquaculture systems** (RAS) which could meet the high and increasing demand for aquaculture products, but also fulfil the criteria of sustainable and environment-friendly production.

The most important **biological and ecological features of suitable sturgeon** species are: the possibility of being **fed exclusively with dry feeds, good growth and economically acceptable feed conversion ratio, good adaptability to different environmental** (e.g. high stocking density, temperature and general water quality) and **technological factors** (e.g. sampling, handling, transporting). Due to these expectations the most convenient and widely cultured in Europe species are the **Siberian** (Acipenser baerii) **and Russian sturgeons** (Acipenser gueldenstaedtii). Additionally, **sterlet** (Acipenser ruthenus) also could be a promising **candidate for freshwater intensive aquaculture** as it has several indisputable advantages comparing with other sturgeon species (relatively small size enabling easier handling with breeders, and faster growth to reach commercial weight and sexual maturity; under RAS conditions it can be propagated at age of 3-4 years with the inter-spawning period of 1 year.)

Sexual maturation and reproduction

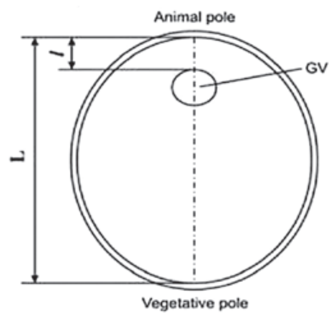
Nowadays reliable technologies are available to create a **system of artificial reproduction** on the base of broodstock reared in aquaculture conditions and on its repeated propagations. Sexual maturation of sturgeon broodstock is asynchronous; individuals of the same progeny become mature at different ages.

The **optimal water temperature** for broodstock rearing of most sturgeon species is between **18-22 °C,** but final **sexual maturation should be preceded by a short chilling period** (1-2 months at temperature well below 10 °C). Maturation processes are age, environment and temperature dependent; in RAS conditions the first batches of sterlet, Siberian and Russian sturgeons' males generally could reach sexual maturity at age of 2-3, 3-4 and 5-6 years, respectively. These ages for the females of the mentioned species could be expected at ages of 4-5, 5-6 and 6-7 years, respectively. In most cases males can be propagated every year; females can be used only by 2 years intervals. **Breeders should be fed with special feeds** containing generally 42-45 % of protein and 11-12 % of fat with **daily ration of 0.2-0.3 % of body weight.** In chilling period, the feeding could/should be excluded.

It has been shown that in the final stages of sexual maturation, low water temperature is needed for germinal vesicle migration; for fish kept in constant water temperature, induction of ovulation proved to be unsuccessful. Thus, it is important **to select spawners which are fully mature and ready for propagation.** Still today a **simple, quick, and fairly reliable method is widely used, which is based on determination of the germinal vesicle (nucleus).** With this method a few eggs are removed from the ovary through a 1-2 cm incision made on the abdominal wall of the fish. The eggs are boiled in water for 3-5 minutes, and then cut across their longitudinal axis. If the nucleus is immediately beneath the animal-pole, the response of the fish to hormone treatment will probably be positive. Lower values of polarization index (PI = A/B: proportion of distance of nucleus from animal pore to highest oocyte diameter) correspond to higher polarization of oocytes and, to a more advanced stage IV of gonad maturity and thus increased probability of successful propagation. It has been determined that the normal response of A. gueldenstaedtii follicles to pituitary injection is observed, if PI is below 0.07. The highest polarization of oocytes usually corresponds to values between 0.03-0.025.

Schematic representation of a cut through the oocyte taken from the gonad of IV stage of maturity. (GV - Germinal vesicle, or nucleus).

Layout view of dissected oocyste in sturgeon GV=germinal vesicle, L=diameter of oocyste



Measurement of the oocyste polarization index (PI) is calculated using the equation : PI= I/L

Where, I=distance from the germinal vesicle (outer edge) to animal pole and L=distance from the animal pole to the vegetal pole.

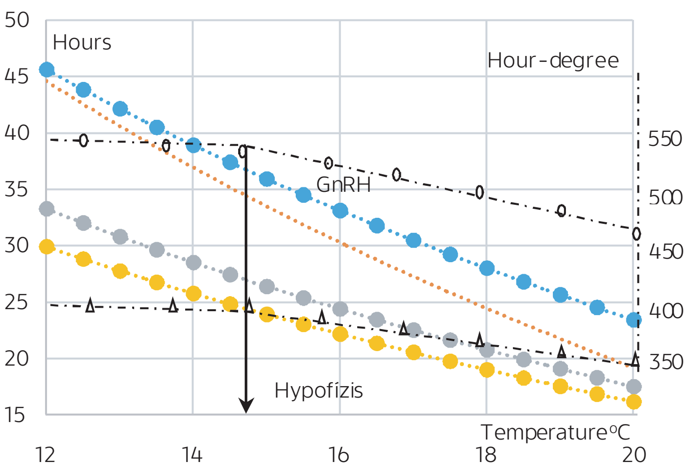
Nowadays the state-of-art maturation stage determination is based on the **ultra-sound diagnostic technique,** which also allows the early identification of sexes; selling of males optimizes the caviar-oriented production. This method can be used with high accuracy but **requires technical investment and high professional skill.**

In sturgeons reared in captive conditions the final sexual maturation rarely occurred. Thus, for **induction of ovulation and spermiation** some procedures should be required. At the beginning of sturgeon culture, attempts were made to control the environmental conditions to stimulate final maturation of the sexual products. This so-called ecological method was later replaced by the physiological method, with the release of sexual products induced by the gonadotropin hormone of the pituitary gland. In practice, the best results have been obtained by combining the two methods; the spawners were kept in tanks where the fish are first stimulated by a strong water current, and then injected with hormonal substances.

At the beginning of **artificial propagation of sturgeons for physiological stimulation** substances of natural origin (extract of pituitary glands collected from migrating fishes) were used (2.0-2.5 mg/kg body weight for females, and 1.0-1.5 mg/kg body weight for the males). However since decades it became clear that due to disadvantages of the use of sturgeon pituitary glands, or its extract (sturgeon pituitary is not always readily available; the exact quantity of gonadotropin hormone is unknown and it might contain some biologically-active components which can provoke undesirable immune reactions as well as vectors for different diseases) could be diminished, or even excluded by the **use of analogues of mammalian gonadotrop-releasing hormone** (mGnRH).These products are analogues of mammalian of mGnRH, among which des-Gly10 (D-Ala6)-LH-RH Ethylamide (LHRHa) is, now the most commonly used synthetic analogue. This hormone has been used successfully with several sturgeon species at different dosages for females; however, in most sturgeon species the doses are between 10-50 µg/kg body weights in a single injection. Dosages for males are decreased by about 50%. It was also proved, that other analogues of mGnRH (i.e azagly-nafarelin, or des-Gly10(D-Phe6)-LH-RH Ethylamide alone or in combination with dopamine antagonists) at a dose of 30-40 µg/kg could be used successfully to induce final oocyte maturation and spermiation. Both the synthetic hormone and pituitary gland extracts are injected into dorsal muscle of the fish in a physiological solution (0.65% NaCl).

When **pituitary gland is used ovulation start in 15-40 hours after the injection,** depending on species, water temperature and fish size/age. In the case of **mGnRH analogues, the time is further extended by about 5-6 hours.**

Time interval between hormonal stimulation and ovulation. Solid lines represent the expected ovulation of first females and the bold line that of majority of females.



The beginning of ovulation is indicated by the appearance of few eggs, either spontaneously or by a gentle pressure on the abdominal wall. Ovulation of the oocytes does not take place simultaneously; therefore, stripping is started 1-2 hours after the appearance of the first eggs. Stripping is delayed if the first eggs are not sticky, as this could indicate premature ovulation due to some abnormality.

As sturgeon females have a special oviduct, it is impossible to strip all the eggs from the fish. Thus, collection of ripe eggs could be done either by through an 8-10 cm incision made in the abdominal wall. Recently t**he method of minimally invasive surgeon technique is widely spreading,** which means that a small incision is made in the caudal section of the oviducts. If these surgical interventions are done carefully, the fish has a very good chance to survive. The relative amount of the collected eggs **could vary between 10 – 20 % of body weight** depending from species, their individual size and ages.

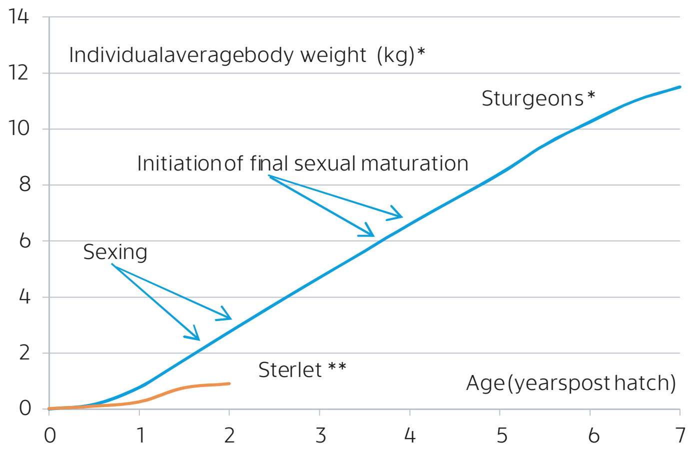
Male could be stripped easily by gentle pressure on the abdomen. **Sperm are highly mobile for 5-15 minutes in water.** Before fertilization the coelomic fluid - which hinders mobility of the spermiums -should be removed. In order to avoid polyspermy, the milt is diluted in water in a ratio of 1:200. **Milt from two or three males is used for the fertilization of eggs from each female.** Usually **10 ml milt is needed for the fertilization of 1 kg eggs.** Two or three minutes after mixing sperm and eggs together, a liquid suspensions (i.e. 10 % silt, or milk with 3.5-3.7 % lipid content diluted in 7 L of fresh water, or 1% talcum,or 50% household starch solutions) is added to eliminate stickiness of the eggs. The fertilized eggs are stirred gently in this solution for 40-50 minutes.

For incubation of sturgeon eggs different devices could be used as the so-called Yuschenko devices, as well as Zuger jars, or MacDonald devices. **Optimal temperature for incubation of eggs** of most sturgeon species is between 12-18 °C, and the oxygen concentration should be maintained above 80 % of saturation. Since the second day of incubation and then every day a prophylactic treatment against Saprolegnia infection should be performed. For this purpose, methylene blue or formalin or other antifungal bath solutions could be used. Died and proliferated eggs should be removed from the incubators. The initiation of **hatching depends on species and water temperature and varied from 3 days to 12 days and could last for 3-4 days even in the same batches of eggs. However the main issue is the prevention from fungal infection, which**

could be attained either by continous ozon, or ultraviolet treatments of hatchery water.

Production systems

For larvae rearing round tanks of 0.5–4.0 m^2 of bottom surface with central outflow are preferable. They provide a **permanent slow stream and fast cleaning possibilities.** Tanks are set indoors without straight sunshine, but in a light place. **When sturgeon juveniles reach body weight of 3.0-5.0 g fish could be transferred for larger rearing units,** in which the water depth is usually between 0.7 and 1.5 m and the **oxygen saturation** of outflow water desirably should be kept **about 70 %.**



Growth of sturgeons – as well as other fish species – strongly depend and correlate with different environmental and technological factors. In assumption of all available literature data and comprising that with our own results we did not find **any reliable differences between the growth of Siberian and Russian sturgeons.** However, it seemed clear that the **growth of sterlet is much slower,** but in spite of this fact we consider the latter species, as "emerging" one for RAS production.

Final **stocking density** in the growth-out period in RAS could reach, or exceed **100 kg/m³** of rearing volume. However, in such conditions **bacterial and viral diseases could create serious losses in sturgeon aquaculture.** The **application of different disinfecting methods and equipment** (e.g. UV irradiation, ozonisation) makes it possible to significantly decrease the risk of spreading different pathogenic agents within RAS systems. However, the most important tasks should be based on preventive actions, such as use of probiotics, **ensuring optimal conditions for the physiological status of fish, quarantine of the purchased stocking material, disinfection of devices and instruments, avoiding stress conditions,** etc.

Nutrition and feeding management

Hatchlings have a positive reaction to the light. First 2-3 days they actively move in water column up and down. Then they stay at the bottom congregating into swarms. The initiation of **exogenous feeding depends from the water temperature, and usually starts after 4 – 8 days after hatching.** When the larvae start vigorous swimming and schooling behaviour their feeding could be initiated either with small Crustaceans, or finely chopped Oligochateats. Daily feeding ration depends on several factors but usually it starts at 100 % of the body weight and decreases to 50 % in 5-10 days.

The success of further nursing largely depends on the method and efficiency of weaning. The duration of weaning is usually 3-4 days, when the quantity of natural food is gradually decreased and artificial feed increased. However, it was reported by several experimental studies that larvae of most sturgeon species could be grown successfully only with exclusive use of dry feeds since the beginning of **exogenous feeding,** but in such cases the **survival were generally lower compared to that with initially live food supply.**

Recommended* stocking density, daily feed intake and feed particle size for larvae of most cultured sturgeon larvae reared at about 20 °C temperature.

Weight (mg)	Density (thousands/m²)	Daily amount (% biomass/day)	Feed particle size (mm)
>50	10-12	20-23	0.2-0.4
50-100	6-8	18-22	0.4-0.6
100-1000	5-6	15-18	0.6-1.2
1000-3000	3-4	12-15	1.5-2.5

*All above data could be modified according to species, rearing temperature and feed quality

The **fish density and feed amount and particle size, as well as water supply should be changed according to fish weight. Very intensive feeding of fry could cause high lipid deposition in the liver,** while in sexually mature fish, fatty degeneration of gonads could develop.

Nutrient content	Haltáp Kft. Szarvas, Hungary		Aller-Aqua, Poland		Scretting, Norway	
	Sturgeon fingerling	Sturgeon grower	Metabolica	Aller Sturgeon Rep Ex	Advance Storioni 1St P	Advance Storioni XL
Dry matter	88.0%	88.0%				
Crude protein	48.0%	45.0%	52%	52%	50%	46%
Crude fat	7.5%	6.4%	15%	12%	16%	16%
Crude fiber	1.0%	1.8%	2%	1.6%	1.4%	1.5%
NFE			16%	17.9%		
Crude ash			7%	8.5%	8.3%	7.8%
Gross energy			21.3 MJ/kg	20.3 MJ/kg	25 MJ/kg	23 MJ/kg
Digestible energy (MJ)	19	18.2	17.6	20	22	22
Digestible energy			18.5 MJ/kg	17.8 MJ/kg		
Lysine	3.3%	3.1%				
Methionine	1.2%	1.2%				
Methionine + cystine	1.7%	1.7%				
Ca	1.7%	1.4%				
P	1.6%	1.3%	1.2%	1.4%	1.3%	1.2%
Na	0.5%	0.3%				
Vitamin A	20000 IU	14000 IU				
Vitamin D3	2000 IU	1400 IU				
Vitamin E	100 mg/kg	70 mg/kg				
Feed size	0.5 – 1.2 mm	1.2 – 3.0 mm	6 mm	6 mm	2.5 mm	9 mm

Composition of commercial sturgeon feeds

The juveniles, as well as the older age classes could be fed with diets containing 45-50% of protein, 8-11% of fat and 24-25% of digestible carbohydrates. Nowadays several commercial feeds are available for all age classes of sturgeons; most of them prepared by extrusion technology which can ensure higher digestibility and – consequently - lower environmental loads.

As it is generally well-known fish feed should be balanced on all vital substances and components; have vitamins and minerals, necessary for normal life activity. The last ones don't carry any energy but have a great influence for metabolism, healthy growth and evolution of all aged fish.

Based on the growth performance and feed conversion ratio the biological minimum of crude protein requirement of most sturgeon species could be generally estimated to be between 36-40 % of feed, however for economically feasible RAS rearing of juveniles, or older age classes of various sturgeon species minimum protein level of 40 and 45 % could be suggested, respectively. According to the results of our previous studies in the feeding of sturgeon feeds with low protein level can be used when the quantity of the diet ensures 1.6 - 1.7 % body weight/day protein.

Based on the above mentioned and taking into account the literature data as well as our own results the following general feeding recommendation could be given (outlying that it is only "recommendation", but not as "rule of thumb").

A general feeding program for sturgeons (should be taken into account with caution regarding species specific requirements and environmental conditions).

The **daily feed ration should be determined according to fish weight, temperature and feed quality**, taking into account the recommendation of fish feed manufacturers and also giving guides for particle size in accordance to fish size. For juveniles feed is provided either at short interval (2-3 hours), or continuously, grower (once or twice per day) feeding could be recom-

Average fish weight, g	Protein/fat				
	Market fish farming			Breed farming caviar market	
0.05-0.10	64/9				
0.1-0.5	56/11			64/12	
0.5-25.0	54/15			64/12	
5-35	50/20			56/18	
30-200	50/15	45/15	45/20	50/15	
200-500	47/14	45/15	45/20	47/14	
500-1000	47/14	45/15	45/20	49/12	
1000-2000	47/14	45/15	45/20	49/12	52/12
2000-4000	47/14			49/12	52/12

mended for older age classes. If feeding is done properly, fish are healthy and environmental conditions are kept in optimal ranges than **feed conversion rate could be kept well below 2 kg/kg** in case of fish reared for meat purposes, but it could be higher if goal is caviar production from large fish.

The still available sturgeon propagation and rearing technologies in RAS could strongly contribute not only to the diversification of fish production, but also to the reservation of genetic resources, **restoration of all 26 known sturgeon species endangered worldwide.**

Sterlet
(Acipenser ruthenus)

Russian sturgeon
(Acipenser gueldenstaedtii) Photo by Dr. István Lehoczky

Stellate sturgeon
(Acipenser stellatus)

CARP

Common Carp (Cyprinus carpio) production

Introduction

The Common Carp (Cyprinus carpio) has been **one of the oldest domesticated species of fish for human consumption due to its wide environmental tolerance, high adaptability, relatively fast growth and high fecundity, all these made the species ideal candidate for aquaculture production.**

The **global production** of the species reaches the **3.5 million tons annually.** The largest common carp production takes place in Asia however, mainly in Central and Eastern Europe beside the traditional common carp farming the application of semi-intensive and intensive production technologies are getting more applied in practice. It is due to the fact that the **intensification of production can reduce the average fixed costs** (such as water, energy, labor, etc.) considering one unit of product and even with the increasing feed cost the production can be more profitable when the yield reaches a certain intensity level if the water temperature high and the production period long enough for intensive production.

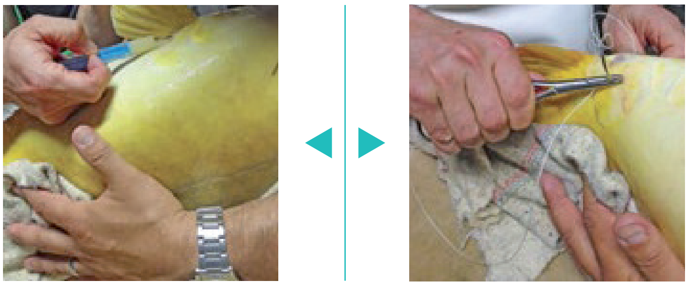
Sexual maturation and reproduction

The females sexually mature after 11 000 - 12 000 degree-days in the temperate and subtropical climatic zones; males mature 25-35% earlier. The natural spawning of European carp populations starts when water temperature reaches 17-18°C however, the **optimal temperature for spawning is 20-22°C.** Females release **100 to 230 g of eggs per 1 kg body weight.** Eggs are laid on submersed aquatic plants and after contact with water, they become adhesive and swell 3-4 times in volume. **Embryonic development takes 60-70 degree-days.** Hatched fry stick to substrate and live from yolk supplies. Three days after hatching the posterior part of the swim bladder develops, the larvae start to swim and consume external food of 150-180 µm size.

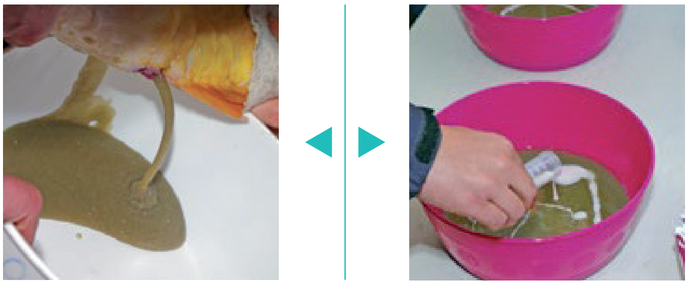
The majority of production of swimming-up larvae is based on artificial propagation in hatcheries. The earlier pre-selected broodfish are kept sex-separated in tanks with oxygen-saturated water at 20-22°C.

To induce and synchronize ovulation and spermiation hormonal treatment is used. The fish injected most commonly with pituitary extract or a mixture of GnRH/dopamine antagonist. Before injection, the broodfish should be tranquilized to avoid handling damages especially on females. The **hormonal injection is divided into two parts;** a pre-dose and a final dose in case of females. For pre-dose 8-10% of the full amount can be used and 12 hours later at the final dose the remaining 90-92% that triggers the ovulation. The pituitary dosage is 3.5-4.5 mg of pituitary extract per 1 kg body weight. The male fish are injected only once either at the time of pre-dose or final dose with 2 mg of pituitary extract per 1 kg body weight. The pituitary glands are pulverized in a mortar to fine powder form. This pituitary extract is diluted in 0.65% NaCl solution (3 mg extract in 2 ml of salt solution) and incepted by a medical syringe.

The **pituitary amount is calculated to the total bodyweight** of the selected broodstock for propagation and add +10% due to losses. The broodfish are injected either in their abdominal cavity (Picture 1.) or in the dorsal muscle. After the injection of final dose, the genital opening of the females is sewed (Picture 2.) to avoid spreading away the ovulated eggs. Thereafter the final injection the ovulation can be expected in 12-13 hours (240-260 degree-hours) if the water temperature is 21-22°C.



Picture 1-2. Hormonal injection into body cavity and the sewing the genital opening



Picture 3-4. Egg collection after ovulation and mixing gametes prior to fertilization

Twelve hours after the final injection the milt is collected from males and a smaller "indicator" male can be placed among the sewed females. **Those females are chosen for egg collection (stripping) that show the most active spawning behavior with the male.** Gametes are collected by the dry method (Picture 3.) for immediate fertilization but can be stored for few hours also. Milt from different males can be used for fertilization to ensure about the sperm quality and to secure the genetic diversity in the next generation.

The gametes are mixed (Picture 4.) in 100:1 portion of eggs and sperm respectively and small amount of hatchery water or Woynarovich solution (10 l water, 40 g NaCl and 30 g urea) used to activate the gametes. After gamete activation, the adhesiveness of eggs is eliminated either by the "Woynarovich method" using salt/urea and tannic acid bath, by treatment in milk, or enzymatic treatment. In the "Woynarovich method" salt and urea solution is used to eliminate the adhesiveness on the surface of the eggs. The **swelling process** starts after the fertilization and it takes 1-1.5 hours after fertilization while the size of eggs is swelling up to 3-5 times larger. During that time constant and gentle stirring is required and as the eggs are taking up water Woynarovich solution has to be added and exchange it in every 20 minutes. The sufficiently swollen up eggs finally treated with tannic acid solution (5-7 g tannic acid to 10 liter of water). One liter of tannic acid solution is poured onto 5-10 liter of swollen eggs and mixed for 15-20 seconds then rinsed thoroughly with clean hatchery water; this process can be repeated 2-3 times.

Incubation is carried out in hatchery jars. The water supply in the jars should be gentle in the first 24 hours then it should be strong enough to keep the all egg batch moving. At the second day of incubation (and the third day) a **prophylactic treatment** should be performed **against Saprolegnia infection.** For this purpose, methylene blue or formalin or other antifungal bath solutions could be used. One day before hatching white eggs will occur on the surface of the egg batch; these eggs should be removed by syphoning to avoid further fungal infection. When the hatching starts few hatched-out fries can be seen in the incubation jar, or drifted by the water, or hanging on the wall of jar. All the eggs must be syphoned to a basin with small quantity of water and kept for 10-12 minutes to accelerate the hatching. When majority of fry hatched out, the mixture of fry and eggshell should be poured into larval keeping devices.

Hatched fry are kept in large trays or conical tanks until stocking at the stage of swimming-up larvae into properly prepared nursery ponds. Approximately **300 000 to 800 000 newly hatched fry can be expected from a single female.**

Production systems

The farming cycle in Europe usually consists of the following steps. **Fry are nursed up to 0.5-1 g body weight** in shallow drainable ponds in monoculture upon zooplankton with supplementary feeding or in tanks on **zooplankton and starter feeds.**

The best solution is to use larva-keeping vessels for keeping hatched fry. The collar (filter surface) of the jar should have a filter mesh with max. 0.4 mm (preferable 0.35 mm) in order to avoid escaping fry. About **0.3 million** (max 0.5 million) **fry can be kept in one jar of 180 liter.** Since the fry cannot swim at beginning, they will sink to the conus of the jar, and will be drifted there by water. The current should not be too strong (5 l/min at the beginning, which can be increased up to 10 l/min during 2 days). **When the swim bladder occurs** (active feeding starts with external food), the **fry can be transferred to fish ponds** or keep feeding in the jars for two days with Artemia ssp. nauplii. The density of Artemia should be kept to 4-5 nauplii in 1 ml of water.

Production of advanced fry (nursing) is usually carried out in **monoculture in nursing ponds.** Ideal size of nursing ponds is between **0.3-1.0 ha, their depth is around 1 m.** The pond preparation, manipulation of plankton population, regular checking of health condition of fish, and the quick harvesting can be easily done in these small and shallow ponds. Fish can be protected effectively from frogs and birds in small ponds: these ponds can be fenced easily, and bird-nets can be fixed above the ponds. The harvesting of nursed fish is carried out in warm period, when the oxygen consumption of fish is high. In small ponds, emergency water supply can be arranged easily in order to avoid suffocation of in nets. Moreover, decreasing the number of predator insects before harvesting is easy in small water bodies. Preparation of equipment for quick transport to other ponds can be easily arranged if the ponds are not too big.

The **small water surface area and the shallow water helps to carry out optimal management of the ponds.** It makes easy

- Even distribution of manure before inundation,
- Quick filling the pond to required depth,
- Careful filtering inlet water,
- Easy manipulation of plankton population.

The number of **stocked fry** can be between **1-4 million/ha** (100-400 /m2). Low stocking density is necessary for getting **advanced fry with 0,5-0,7 g individual weight during a 30-day rearing period.** As the stocking density increases, smaller will be the individual weight of fry at the end of nursing. The nursing phase is a short period, not more than 1 month. The stocked Cyprinids are very small at stocking (5-6 mm), and they are small at harvesting (1.5-3.0 cm). However, the produced biomass of the advanced fry at harvesting can be as high as 400-800 kg/ha. The physical condition of the ponds must be suitable for ensuring the survival of fry and handling advanced fry.

The following works should be completed **before stocking:**

- Drying the pond bottom
- Cutting the vegetation
- Leveling the bottom
- Controlling the conditions of water in- and outlet structures for avoiding the penetration or escaping fish

Fingerling/yearling of up to 30-100 g bodyweight are produced in semi-intensive ponds upon manure/fertilizer-generated natural food and supplementary feeding.

The **optimal size of ponds** for production of Cyprinid fingerlings is **1-10 ha, and the depth should be between 1.0-2.0 m.** For filling and draining of these ponds is 3-8 days are necessary. The **water supplyshould be 50-60 l/sec for ponds under 5 ha, and 130-160 l/sec for larger ponds.** Facilities (pumps, canals and monks with large surface area) for quick inundation of fingerling production ponds is essential, otherwise dense population of aquatic plants will develop on pond bottom in the slowly increasing water.

Technical preparation of pond bottom is more or less the same than in case of nursing ponds. For avoiding diseases and getting healthy fingerlings, the **best is to keep the fingerling production ponds dry between harvesting of the last batch and stocking.** A shallow harrowing with disc tiller or shallow ploughing will cut the weeds. However, for this work the pond bottom must be fully dried. If the pond was not kept fully dry and aquatic vegetation developed, the weed can only be removed from ponds with hand-cutting. The aquatic weed can also be removed by chemical treatment. Roundup Bioactive (active ingredient is glyphosate, spraying dose 50-100 ml/m2) can be used for emerging aquatic weed as for example reed, bulrush and sedge. Diuron (active ingredient is 3-(3.4-Dichlorophenyl)-1.1-dimethylurea) in 0.1-0.5 g/m3 quantity is suitable for eradication of submerged aquatic weed. (These herbicides are not harmful for fish, and their use is allowed in EU.) **Application of manure and/or artificial fertilizers for supporting the**

development of natural food organisms should be done before inundation. Depending on the source of **manure, application of 2-3 t/ha** is suggested, preferable ploughed in the upper surface of the soil. If no ploughing is possible, the manure should be scattered on the pond bottom. If **no manure available, artificial fertilizers** can be distributed on the water surface in the quantity of **20 kg/ha N and 3 kg/ha P**(as active ingredients). It is important not to dilute the fertilizers during filling the pond, because it may support the development of aquatic vegetation.

In optimal case, when manure/fertilizer, cereals and pellet with 25 % protein content are also available, 1 500-1 700 kg/ha one summer old common carp can be produced with **70-80 g individual average weight, 35-40 000 nursed fry should be stocked for 1 ha pond area.** Without harming the production of common carp silver carp can also be stocked in these ponds. The period of fingerling production is shorter than the whole season in temperate climate, since it can only be started after nursing. Consequently, the **period when the temperature supports the quick growth is only 70-90-day long.**

Two-summer-old fish can be produced in intensive pond systems in monoculture on formulated complete feed with the planned final body weight of 1.5-2.0 kg in two years of production cycle.

The following types of systems can be applied in the **second year of intensive carp culture:**

- Cage system,
- Floating tank system,
- Irrigation reservoirs,
- Flow-through systems,
- Recirculation aquaculture systems (RAS).

Integrated systems can also be used e.g. extensive-intensive pond system or with animal husbandry and/or plant production are also used (e.g. carp-cum-duck in Central and Eastern Europe).

In intensive pond farming of **common carp smaller production ponds 1-10 hectares are preferable** due to the manageability point of view. The stocking density should be **1 000-1 200 large fingerling** (80-100 g) **per hectare in temperate climate.** In sub-tropical, tropical climate it can be higher due to the longer production period. If formulated complete value feed is applied automatic feeders should be established in several places of the culture pond and **the feeding ratio can be 2.5-3.0% of the total body weight** however, it highly depends on the water temperature and recommended to follow the feeding table provided by the feed manufacturer.

The growth of fish is mainly depending on the feeding technology applied and the environmental conditions however, the genetic potential of growth is not negligible at all. Therefore, **in intensive common carp production** it is highly recommended to use **fast growing breeds or hybrids** due to economical point of view.

Most of the world production is carried out using unselected strains. When they exist, breeding programs are mostly based on **crossbreeding** as it brings **quick improvement of growth performance** (heterosis effect) in F1 generation. It is widely used in Hungary, Israel, Czech Republic and other countries. **Crossbreeding of different common carp breeds improved survival rate of fry, disease and cold resistance.** However, improper use of hybrids for further breeding can be contaminated the purebred stocks.

In the **live gene bank of common carp** breeds genetic conservation and are continuous testing of new forms is carried out in MATE AKI (HAKI), Szarvas, **Hungary.**

Nutrition and feeding management

Pond farming of common carp is based on natural food with supplemental feeding of cereals. The optimal water temperature for high growth performance is between 23-30°C. The fish can survive cold winter and hot summer periods. Salinity up to about 5‰ is tolerated, optimal pH is 6.5-9.0; common carp can survive low oxygen concentration (0.3-0.5 mg/L) as well as supersaturation. Common carp is omnivorous; with the **majority of the consumption is benthic organisms, such as water insects, larvae of insects, worms, mollusks, and zooplankton.** Digging in the bottom in search for food items results turbid water in the production ponds. **Zooplankton consumption is dominant in fishponds where the stocking density is high.** Additionally, the carp consumes the stalks, leaves and seeds of aquatic and terrestrial plants, decayed aquatic plants, etc. Typical carp ponds in Europe are shallow, eutrophic with a muddy bottom and dense aquatic vegetation at the dikes.

Rotifers and other small organisms (Paramecium) are the main feed of fry in the first week after stocking. By the practice of fish farmers **feeding with small particle size** (0.1-0.3 mm) **meals is started one-two days after stocking.** However, fish consume only very small quantity of the meals in this period, and the soaked feed particles covered with bacteria are consumed mainly by the developing Cladocera population, and supports its blooming.

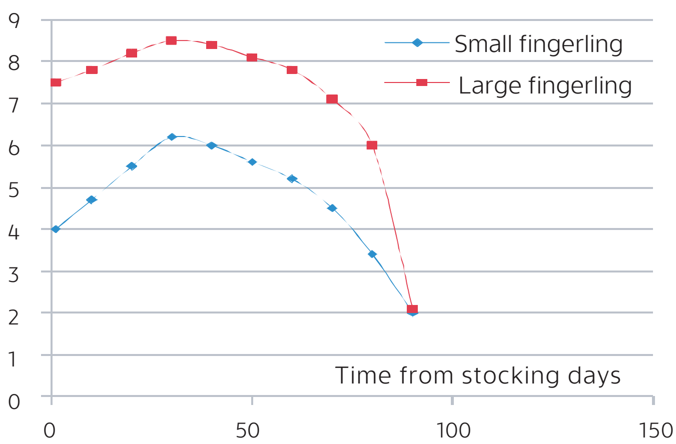
Feeding carp fry in ponds with formulated starter feed produced/sold by fish feed factories is **possible but expensive.** Composition of such feeds are presented in Table 1. Farm-made feed comprising mixture of soybean meal, wheat/barley meals, meat or fish meal is suitable for feeding developing fry. The daily ration is about **1 kg feed for 100 000 fry in the first week of rearing,** distributed at least 2, preferable **3 dose per day.** Quantity of **feed should be increased to 5 kg/100 000 surviving fish, till the end of nursing period.** Though application of locally mixed feed is appropriate for nursing, small size pellets (up till 1 mm) with high protein content (25-30%) also can be fed in the last third of nursing period, if it is affordable for the farm. However, **feeding fry entirely with pellet is not recommended.** If the plankton is not sufficient, the fry must be harvested.

Production of carp fries is also possible in RAS system when feeding is reached by artificial feeds. The protein requirement of carp fries is 45% (NRC 2011), but the fat and fatty acid level of the feeds has high importance. Recommendation for such feeds is to contain high fish meal and fish oil level. There are available feeds from different feed producer with different product quality.

Role of **natural food is extremely important in the fingerling production phase,** regardless if extensive rearing or intensive rearing of fish are carried out. For **maintaining the plankton population in productive status regular application of manure or fertilizers is suggested.** The optimal is to apply daily doses of manure in 70-100 kg/ha quantity. The manure should be scattered evenly on pond surface. If no time for daily application of manure, **weekly application** is suggested. The dose should be about **350-400 kg/ha.** When artificial fertilizers are used, also regular application of small doses is necessary. The best is to apply the f**ertilizers two times per week.** The dose is **5 kg/ha N and 1 kg/ha P in each occasion.** (This is equivalent to 15 kg/ha ammonium nitrate, or 24 kg/ha ammonium sulfate, or 11 kg/ha urea as N fertilizer, and 12 kg/ha superphosphate.)

Growth and the feed consumption is determined by the size (g) and quantity (fish/ha) of fish, by water temperature and the actual status of zooplankton in the pond. Consequently, it is not possible to give in advance the exact feed requirement. It can always be stated precisely with **daily checking of feed consumption.** However, it is possible to estimate and forecast the approximate feed consumption, which can be the basis of planning. The **approximate daily feed rations expressed in percentage of body weight of fish** are presented in Figure 1. The data refer on the temperature of 20 °C. If the temperature is higher, more feed should be given, as it is explained in Figure 1. The approximate quantity of daily feed when large fingerlings are produced with application only cereals and cereals and pellet together are shown in Figure 2.

Figure 1. Daily feed ration for small and for large fingerling kept on 20±1,5 C°. If the temperature is 25 C° the daily feed ration should be multiplied by 1.4. If the temperature is 28 C° these data should be multiplied by 1.6 for getting proper feed rations.

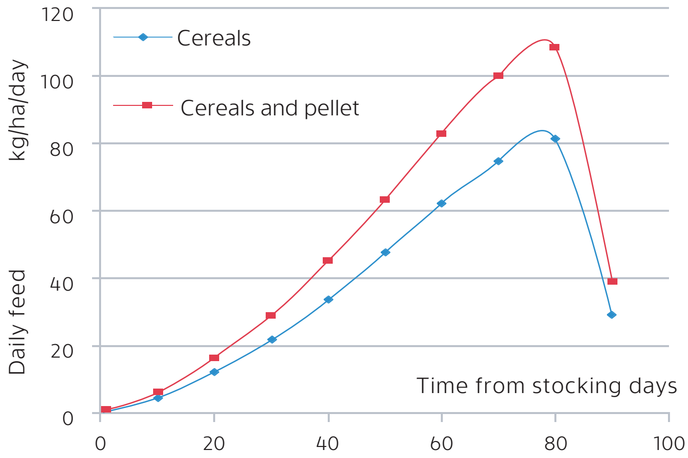


The **daily growth can be 2 to 4% of body weight** (bw) in optimal environmental and technological conditions. **Common carp can reach 0.6 to 1.0 kg bw or even higher within one season in subtropical/tropical polyculture.** Growth in temperate climate is slower; **the fish reach 1.5 kg bw after 2 or 3 rearing seasons** depending on the intensity level of the culture technology used.

Intensification of carp production in pond system is possible by application of **highly valuable extruded feeds**. The most important factor that limiting the fish production is the cost of the feed. In order to decrease the cost of feeds different feed ingredients are used. The **most common**

ingredients are: blood products, corn gluten, DDGS, feather meal, fish meal, poultry meal, rapeseed, rapeseed oil, linseed oil, soya, soya protein concentrate, sunflower protein conc., triticale, corn, wheat. High quality, but cheap dry feeds can enhance the intensification in aquaculture and improve profitability offering the possibility of cheaper production.

Figure 2. Approximate daily feed requirement of fish when the fingerling with planned large final weight (100 g) are fed with cereals and pellet



The sustainable aquaculture feeds are mainly based on **plant protein sources**, but inclusion of these types of ingredient makes a lot of challenges related to product quality and environmental impacts. **Locally available by-products from agriculture and feed processing** industry, such as the corn DDGS (Dried Distiller's Grain with Solubles) or **processed animal by-products** has minimal effects on the environment, and their application can make lower production costs. DDGS's high energy, mid-protein and digestible fiber - and accessible Phosphorous content enable the preparation of a fish feed with high nutritional value. DDGS has an advantage over other plant feed ingredients, namely its lack of antinutrient factors. There are new trends for application insect meals into fish feeds after was given permission last year by EC (2017/893/ EC).

Growing phases	Crude protein (%) (NRC, 2011)	Crude fat (%)	Crude ash (%)	Crude fibre (%)
Nursing (<20 g)	45	15	10.8	0.5
Growing I.	6-8	18-22	0.4-0.6	
(20-200 g)	38	9	7.8	4.2
Growing II. (200-600 g)	32	8	7.8	4.4
Growing III. (>600 g)	28	7	6.3	5.5

Table 1. Composition of feeds and recommended dietary protein level

Nutrient content	Unit	Starter	Grower	Finisher	Breeder	Carp adult NRC, 2011
Crude protein	%	39.0	36.0	30.0	32.0	
Digestible protein	%					32
Crude fat	%	8.0	7.0	7.0	7.0	
Crude fiber	%	max.2	max.4	max.5	max.5	
Crude ash	%	max.10	max.11	max.12	max.12	
Metabolized energy	MJ/kg	13.0	12.0	11.0	11.5	
Digestible energy	MJ/kg					13.4
Lysine	%	2.4	2.1	1.8	2.0	2.2
Methionine	%	1.2	1.0	0.9	0.9	0.7
Methionine + cystine	%	1.5	1.3	1.1	1.2	1.0
Ca	%	0.5	0.5	0.5	0.5	0.34
Total P	%	1.2	1.1	1.0	1.1	
Available P	%	0.9	0.8	0.7	0.8	0.7
n-3 fatty acid	%	1.1	1.0	1.0	1.1	0.5
n-6 fatty acid	%	1.1	1.0	1.0	1.1	1
EPA	%	0.35	0.30	0.30	0.35	
DHA	%	0.30	0.25	0.20	0.35	

Recommendations of the Hungarian Feed Codex (Codex Pabularis Hungaricus) and Nutrient Requirement of carp fish and shrimp (2011)

Added vitamins	Unit	DSM	BASF	Mézes	NRC 2011
Vitamin A	IU/kg	8000-12000	10 000	8 000	1.2-6 mg
Vitamin D3	IU/kg	1500-2000	1 250	1 500	-
Vitamin E	mg/kg	100-300	50	80	100
Vitamin K3	mg/kg	3-6	3	8	-
Vitamin B1	mg/kg	10-20	8	10	0.5
Vitamin B2	mg/kg	15-20	15	15	4-7
Vitamin B6	mg/kg	8-12	6	8	5-6
Vitamin B12	mg/kg	0.02-0.05	0.03	0.03	NR
Niacin	mg/kg	80-120	70	80	28
Pantothenic acid	mg/kg	40-45	30	50	30-50
Folic acid	mg/kg	3-4	1	4	NR
Biotin	mg/kg	0.5-1	0.5	1	1
Choline	mg/kg	600-1000	400	800	1500
Vitamin C	mg/kg	300-500	150	150	45
Inositol	mg/kg	100-200	-	150	440

Recommendations from Vitamin Suppliers (1 kg of carp compound feed)

Nutrient content	Starter	Grower	Finisher	Breeder
Dry matter	88.00%	88.00%	88.00%	88.00%
Crude protein	39.00%	24.00%	17.00%	26.50%
Crude fat	4.00%	2.60%	2.20%	3.00%
Crude fiber	2.60%	2.50%	2.50%	3.10%
Lysine	2.50%	1.40%	0.80%	1.50%
Methionine	0.66%	0.37%	0.30%	0.45%
Methionine + cystine	1.17%	0.74%	0.60%	0.80%
Ca	0.65%	0.29%		0.52%
P	0.90%	0.62%		0.64%
Na	0.16%	0.04%	0.42%	0.10%
Vitamin A	8000 IU	8000 IU	6000 IU	10000 IU
Vitamin D3	800 IU	800 IU	600 IU	1000 IU
Vitamin E	40 mg/kg	40 mg/kg	30 mg/kg	50 mg/kg
Feed size	0.5 - 1.2 mm	0.5 – 2.1 mm	2.1 – 3.0 mm	5 mm

Composition of commercial carp feeds (Haltáp Kft. Szarvas, Hungary)

Nutrient content	Fry	Fingerling	Starter	Grower	Finisher
Dry matter	90%	90%	90%	90%	90%
Crude protein	40%	38%	36%	36%	28%
Crude fat	5.8%	6.10%	6.10%	7.80%	8.10%
Crude fiber	1.2%	1.70%	1.70%	2.20%	3.20%
Lysine	1.42%	1.12%	1.12%	1.10%	1.02%
Methionine	0.63%	0.63%	0.63%	0.56%	0.52%
Ca	2.2%	1.86%	1.86%	2.20%	1.76%
P	1.4%	1.30%	1.30%	1.20%	1.12%
Na	0.34%	0.32%	0.32%	0.34%	0.19%
Vitamin A	9000 IU	9000 IU	9000 IU	9000 IU	9000 IU
Vitamin D3	1500 IU	1500 IU	1500 IU	1500 IU	1500 IU
Vitamin E	90 mg	90 mg	90 mg	90 mg	90 mg
Vitamin C	500 mg	500 mg	500 mg	500 mg	500 mg
Feed size	0.1 mm	0.3 mm	3.0 mm	4 - 6 mm	6 - 8 mm

Composition of commercial carp feeds (Nagyhegyesi Takarmány Kft, Hungary)

Nutrient content	Ffry Aller Performa Ex	Fry Aller Master	Fry Aller Classic	Grower Aller Primo	Grower Aller Classic
Crude protein	48%	35%	30%	37%	30%
Crude fat	21%	9%	7%	12%	7%
Crude fiber	1%	4.7%	5%	3.5%	5.5%
NFE	15%	36.3%	43.5%	32.5%	43.5%
Crude ash	7.7%	7%	6.5%	7%	6.3%
Gross energy	22.4 MJ/kg	18.8 MJ/kg	18.2 MJ/kg	19.6 MJ/kg	18.2 MJ/kg
Digestible energy	19.9 MJ/kg	14.9 MJ/kg	13 MJ/kg	16 MJ/kg	12.6 MJ/kg
Phosphorus	1.3%	1.1%	1%	1%	1%
Feed size	1.3-1.5 mm	2 mm	2 mm	3-6 mm	3-8 mm

Composition of commercial carp feeds (Aller Aqua, Poland)

AFRICAN CATFISH

Aquaculture production of African catfish

Introduction

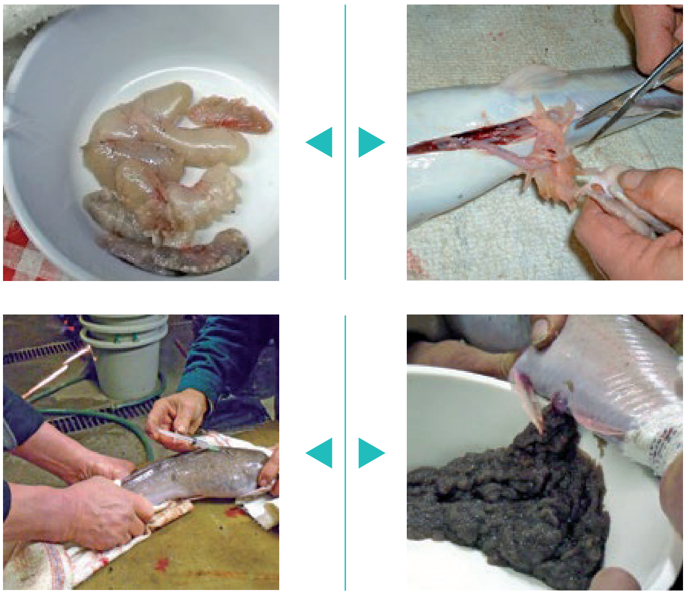
The biological features of North African catfish (Clarias gariepinus), as **high environmental tolerance, ability for living in waters with extremely low oxygen content, easily controllable breeding habit, wide food spectrum, adaptability to artificial** (tank) **environment,** make this catfish suitable for aquaculture production.

The species was introduced into the Netherlands for research purposes in 1977. It quickly became obvious that **mass production of African catfish was profitable in warm water systems located in temperate zone,** and the European market accepted well the filleted fish. Many **water recirculation systems** (RAS) were established for catfish production. Catfish fry were transferred to some European countries from Dutch research units, as Belgium, Germany, the Czech Republic, Poland and Hungary, and large-scale production of the species was started. About 5 000 tons of African catfish is produced in Europe annually. Large scale production of African catfish was started in Hungary, in 1990. **Flow through system were applied, supplied with geothermal water.** Partial water reuse systems and recirculation systems are used for catfish production recently. The annual production is around 3 500 tons of table fish.

The o**ptimal range of temperature for rearing African catfish is between 25-30 °C**. Under 20 °C the species is very sensitive to bacterial diseases. Though catfish is still able to survive at 10 °C in nature, in artificial systems mortality is inevitable under 16 °C. **Maximum tolerable temperature is 39-40 °C** for African catfish. African catfish is a freshwater species. Maximum salinity tolerated by the fish is 10 ppt. **African catfish can utilize oxygen not only from the ambient water but also from the air with the help of its accessory respiratory organ** (see picture). The organ **develops when fish are 15-20 days old and 2.5-3.0 cm long.**

Before reaching this size/age environmental requirements of catfish are similar to that of other species, for example Cyprinids. Later, as the organ becomes active, **fish will be able to tolerate extremely poor water conditions,** among others zero oxygen content or high ammonia, nitrite and hydrogen sulphide concentration. Although the species is able to survive in such environmental conditions, their development will be far behind optimal in extreme environment.

Sexual maturation and reproduction



Fish reared in closed systems in a permanently high temperature are able to attain maturity at the weight of **400-600 g, at the age of 6-9 months.** The belly of matured females ready for spawning is soft, relatively big and rounded. The genital opening is swollen, reddish and round-ended (Figure 2).

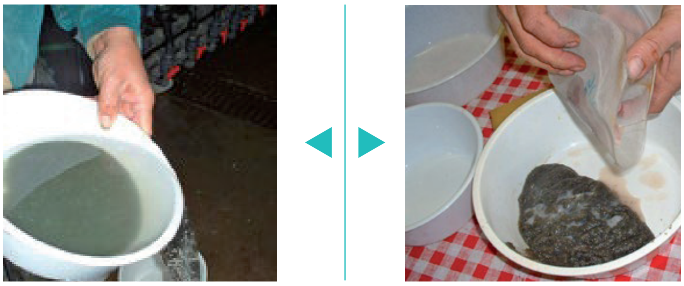


Figure 2: Mature female with swollen belly, the male fish and the testis

The weight of **ovaries in tanks with abundant feed supply can reach 25 percent of body weight** and may occupy 4/5 of the abdominal cavity. Male fish have long genital papilla.

Carp Pituitary Gland (CPG) is used most widely for hormone induced breeding procedure. It can be gained either from common carp or from Chinese carps. The CPG suspension is injected in the dorsal muscle of the fish in 4-5 mg/kg doses. The stripped eggs are only slightly sticky. Getting sperm with stripping is not possible. Male fish should be scarified, and the testis must be removed for getting sperm (Figure 3.).

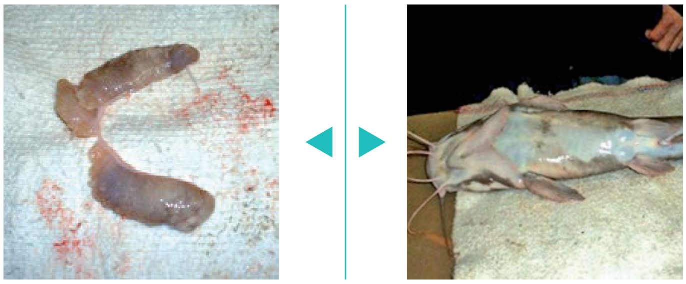


Figure 3: Process of artificial reproduction

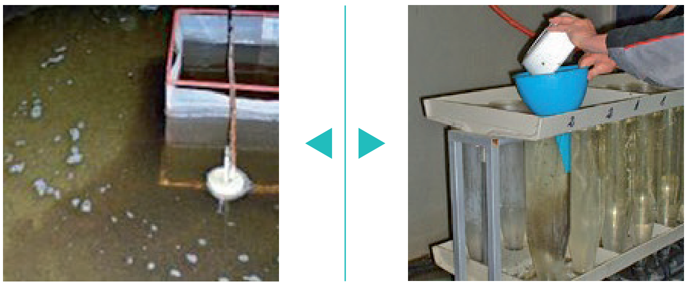
Spawning is cyclic in the nature. **Fish kept in stagnant temperature (25 °C) and fed about 0.5-0.7 % feed of their body weight can be bred around the whole year.** The diameter of ripe oocytes is around 1.0-1.2 mm. **Number of eggs in 1 kg is around 0,8-0,9 million.**

Production systems

There are **three phases of African catfish production** regardless whether it is carried out in a flow-through or a water recirculation system. The **first phase is fish seed production.** Weight of brood fish population represents about 0.2 percent of the quantity of total annual production. **From one female fish 20-40 000 fry (5-10 g fish) can be expected on average. Fingerlings of 100-150 g are reared in the second phase. Weight of the table fish is 1.1-1.6 kg. Time requirement of production (from breeding) is 30-50 weeks.** With reasonable management **from 300 kg** (Hungarian flow through systems) to 1 500 kg (Dutch RASs) **table fish can be harvested annually from each 1 m3 tank volumewith a feed conversion ratio of 0.9-1.4.**

Incubation and nursing

Zoug jars, or trays can be used for incubation. The **hatched out and the growing fry require good water quality up to development of accessory breathing organs. Fry must be fed for few days with live food (Artemia). After 7-8 days starter feed can be applied for rearing** (Figure 4.).



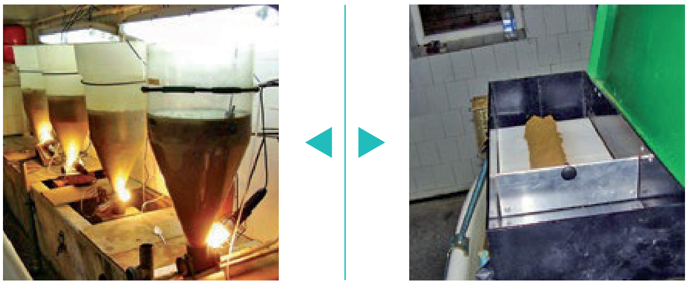


Figure 4: Incubation of eggs and larva rearing with Artemia and artificial feed

Fingerling production

The **nursed fry,** which have the accessory breathing organ, **can be reared in different form and size plastic or concrete tanks. Regular/frequent selection and removal of fish bigger than the average is inevitable,** otherwise the bigger (cannibalistic) individuals will kill and consume the smaller once (Figure 5.).

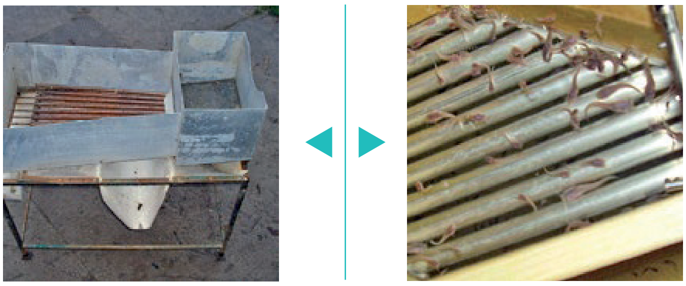


Figure 5: Tools for selection of fish

Rearing fish in flow-through systems

A most simple ways of African catfish production are the application of a **flow-through or some partial water reuse systems.** Production in flow-through systems does not require a sophisticated technical background. These rearing units are usually supplied by warm well water. This is a widely used method for African catfish production in Eastern Europe. Fish can be kept in lined ponds of different sizes or in rectangular or circular tanks made of concrete or plastic. **Water of 23-35 °C** is used to supply ponds or tanks (Figure 6).

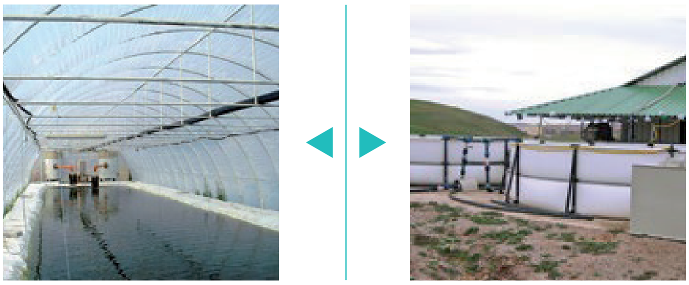


Figure 6: African catfish farms in Hungary operated as a flow-through and partial water reuse system

Water of artesian wells (groundwater coming from aquifers by pressure without pumping) or other hot groundwater wells can be used for rearing catfish. The expected yield of these system is 350-500 kg/m3/year.

Rearing fish in water recirculation systems

In the temperate zone significant part of African catfish is produced in water recirculation systems (RAS). **Lamella (tube) sedimentation units and ventilated trickling filters, or drum filters attached to moving bed bioreactors are used in these RASs. For production of 1 kg fish 0,15-0,2 m3 water is used in well managed RASs. The production capacity of the RAS systems can be as high as 1t/m3/year.**

Environmental aspects of African catfish production is important. After the production of 1 t of catfish 52 kg N, 9.8 kg P and 290 kg COD are released. **In many countries fish producers are obliged to pay a certain fee for environmental loading** (pollution). For decreasing of the quantity of discharged pollutants concentration and partial mineralization of organic materials and different forms of N and P is carried out in RASs, where **mechanical filters, sedimentation tanks, biological filters, denitrification tanks are used.** Mechanical filtration of effluents and wetlands are used for cleaning of discharged water from flow-through systems.

Nutrition and feeding management

African catfish is an omnivorous species. It has an extra wide food spectrum which includes zooplankton, aquatic and terrestrial insects, invertebrates, plant material and fish in the nature. It is **an opportunistic predator which means that the fish prefer to consume more easily accessible food items rather than hunting.** The species has a cannibalistic habit as well, which is stronger in groups of smaller size fish than in adult ones.

Nutrient content	Unit	African Catfishfingerling	African Catfish grower
Crude protein	%	48.0	45.0
Crude fat	%	7.0	5.0
Crude fiber	%	max.2.5	max.2.5
Crude ash	%	max.12	max.12
Met. energy	MJ/kg	11.5	11.0
Lysine	%	3.0	2.7
Methionine	%	1.9	1.8
Methionine + cystine	%	1.1	1.0
Ca	%	3.5	3.0
Total P	%	1.4	1.2
Available P	%	1.0	0.8
n-3 fatty acid	%	0.9	0.9
n-6 fatty acid	%	0.9	0.9
EPA	%	0.30	0.30
DHA	%	0.25	0.25

Recommendations of the Hungarian Feed Codex (Codex Pabularis Hungaricus)

Nutrient content	Haltáp Kft. Szarvas, Hungary		Scretting, Norway			Aller Aqua, Poland	
	African catfish fingerling	African catfish grower	Select C 1st P – 3 mm	Select C 2nd P – 4,3 mm	Select C 3rd P – 6,7 mm	Aller Futura Ex	Aller primo Float
Dry matter	88.0%	88.0%					
Crude protein	48.0%	45.0%	47%	45%	42%	64%	37%
Crude fat	7.5%	6.4%	12%	12%	12%	12.5%	12%
Crude fiber	1.0%	1.8%	3.5%	3.5%	4%	1%	2.8%
Crude ash			9%	8.5%	8%	13%	7%
NFE						2%	36.2
Gross energy						20.4 MJ/kg	20.1 MJ/kg
Digestible energy			14.6(MJ/kg)	14.1(MJ/kg)	14(MJ/kg)	19 MJ/kg	15.7 MJ/kg
Lysine	3.3%	3.1%					
Methionine	1.2%	1.2%					
Methionine + cystine	1.7%	1.7%					
Ca	1.7%	1.4%					
P	1.6%	1.3%	0.9%	0.9	0.8	1.5%	
Na	0.5%	0.3%					
Vitamin A	20000 IU	14000 IU					
Vitamin D3	2000 IU	1400 IU					
Vitamin E	100 mg/kg	70 mg/kg					
Feed size	0.5–1.2 mm	1.2–3 mm	3 mm	4.3 mm	6.7 mm	0.5-2 mm	3-6 mm
Feed size	0.5 – 1.2 mm	1.2 – 3.0 mm	6 mm	6 mm	2.5 mm	9 mm	

In tank-based systems pelleted or extruded (floating) feeds are applied for feeding catfish. Crude protein requirement of fish is high. It can be satisfied by adding artificial **feed with 54-66 % protein content for fry, 45-50 % in case of fingerling and 40-45 % for elder age groups. Fat content of the feed should be 10-18 %, 15-18 % and 10-13 % at the three age groups, respectively.**

Nauplius of Artemia salina are optimal starter food for African catfish larvae. **For 100 000 newly hatched fries about 200 g/day dry Artemia should be applied in the beginning. After about 5-7 days Artemia feeding, the daily ration should be complemented with crumbled feed of 55 percent protein content.** Optimal size of crumbles for 10-day-old fish is 0.3 mm. Daily doses of artificial feed must be distributed 4-5 times a day. For rearing about **80 000 nursed fry up to 0.8-1.0 g body weight about 10-15 kg feed of 0.3 mm, and 50 kg feed of 0.5-0.8 mm is necessary.**

Crumble feed of 0.8-1.5 mm size, preferable produced in specialized fish feed factories, should be fed **in the first phase of fingerling production period.** Feed utilization is much below 1.0 in this period. Feed applied for second phase of fingerling production should contain at least **44-45% digestible proteins** (48% raw one). Size of feed particles should be **1.5-3.0 mm. Both pelleted and extruded (floating) feed can be applied.**

The raw protein content of **grow-out feed** should be 44-45 percent with 42 percent digestibility. In water recirculation or flow through systems **high quality pelleted or extruded feed with high water stability** should be applied. The **feed conversion ratio is slightly above 1.0 in this period.**

Processing of African catfish

Catfish in its original form is not attractive for European consumers. **Mainly filleted or smoked fish can be marketed** here. The main processed products are the gutted fish (90-91 % of the body weight) fillet with fish (56 %) and the skinned fillet (49 %).

By-products of processing can also be utilized in factories equipped with specialized machines (e.g. meat separator). If all the necessary processing equipment is available, about 65 percent of the body can be utilized for human consumption. Dry and smoked sausages (salami) and tinned pastes with long expiry time can be prepared by using meat and a part of by-products (Figure 7).

INTRODUCTION OF HAKI AND AGROFEED, AND THEIR COOPERATION

MATE AKI (HAKI)

The MATE AKI (HAKI) (Szarvas, Hungary) is implementing a **multidisciplinary research work to provide scientific basis for the development of various fish culture technologies and for the proper use and protection of the aquatic environment.** The five major fields of research are: **development of aquaculture systems, applied aquatic ecology, fish biology, genetics and fisheries in natural waters.**

HAKI is an important participant of the freshwater aquaculture development in Hungary as well as the cooperation with numerous organizations in Central and Eastern Asia, Middle and South America, and Africa through the implementation of applied research work under bilateral agreements, National, and European research programs. Extension work, conferences, expert consultations and training programs are also organized and carried out by HAKI.

HAKI's main research philosophy is to link research results to practical application, thus research programmes are focusing on new challenges that aquaculture and fisheries have faced recently.

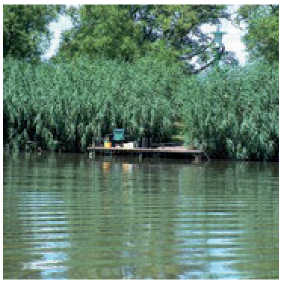
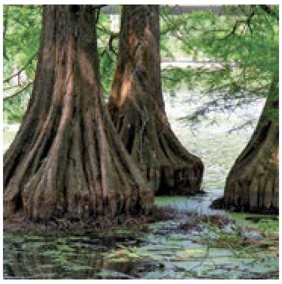
The scientific work is carried out in the frame of specific research topics such as: maintain the **live gene bank and the cryo-preserved sperm bank of common carp** (Cyprinus carpio L.) and the **sturgeon** (Acipenseridae) **gene bank.** The research-technology-development works focus on examination of biological, technical and technological factors in order to elaborate **complete production technologies** of several taxa as Cyprinidae, Percidae, Acipenseridae, Siluriformes.

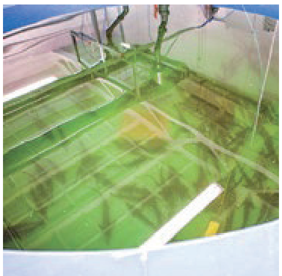
HAKI's wide range of activities is supported by a **unique complex of facilities** that comprises the following: **fish nutrition, genetics and genetics research laboratories; indoor experimental fish rearing system; experimental fishpond system;** Combined intensive-extensive experimental fish pond system; Extension and innovation centre; Library and conference hall.

Extension and training

- Consultancy, on-site consultancy and various forms of extension courses
- Elaboration of feasibility studies and innovation proposals
- Organisation of professional forums and demonstrations
- Dissemination of information through printed and electronic means
- Organisation of training programs for individuals and groups, both for Hungarian and foreign professionals
- Transfer of the newest research results to professionals

- Organisation of local and international professional forums, workshops and conferences
- **Research, development and innovation facilities**
- 8 hectares of experimental fish pond system
- 16 „pond in pond" intensive fish rearing unit
- 156 cubic meters (105 tanks) of experimental recirculating fish rearing system

AGROFEED LTD.

Agrofeed Ltd. is one of the most **significant European producer of high quality premix, concentrate and feed additive for a large spectrum of animal species,** with an **expanding market that includes over 40 countries** in Europe, Middle East and Northern Africa.

The focus of our strategy is on applying up-to-date knowledge, species specific expertise, and practical experience in everyday production, product development and professional service; **«we serve our customers».**

Agrofeed Ltd. was established in 2001 by Hungarian owners and started its sales activity since then to the Hungarian market and to Eastern Europe. The earlier contract manufacturing had changed into fully in-house production in our factory, built in **Szalkszentmárton** by 2005 in **Hungary**. We targeted the most advanced technology in premix, concentrate and pre-starter feed production, so we renewed and expanded our capacity in 2010 with new premix line and automation. In 2016 a **new premix and concentrate factory** was built in Jasnogorsk, **in Russia,** to serve the Russian and Eastern-European market, so now we have **two modern premix manufacturing facilities.**

Agrofeed's credo is **«knowledge, wich feeds»**; this perfectly describes our endeavors to provide **innovative and quality feed products at a reasonable price with high level of service support.** Agrofeed has been experiencing a very positive growth rate, and has become one of the biggest premix, concentrate and pre-starter feed producer in Central-Europe.

Agrofeed line of products for all animal species that include premixes, concentrates and other feed additives are solely produced from reliable raw material. Advanced knowledge and practical experience are the determining elements of our product development and production. Our factory in Szalkszentmárton manufactures **over 1 000 types of products each year. Agrofeed runs its business directly in Hungary, Russia and Ukraine, while in other export markets we cooperate with our distributors.**

Purchasing, production and distribution of products is controlled by **entrepreneur planning and production system** (Navision from Microsoft), and quality assurance systems, such as FAMI-QS (quality control system of European Union's premix manufacturing companies) and ISO 22000-2005.

Our quality control system includes HACCP and GMP+ systems as well.

The key of achieving profitability in concentrated large-scale animal production is to apply the most advanced, scientific and innovative, but practical techniques in livestock management and operations. Agrofeed Ltd. has recognized the need for the above-mentioned innovations and started its most modern, independent feed additive and raw material business. **Utilizing the experience, the expertise, research, field observations, and test results of our partners, professionals and contributors are capable to manufacture the best products in term of price and quality.**

The **Poultry and Aquaculture Business Division prepares individual proposals for premix and feed recipes considering a wide range of products for broiler-, layer- and turkey breeders and for turkey, broiler and commercial layer, waterfowl, rabbit and aquaculture. Consultancy** activity covers feed and premix optimization, feeding services, poultry production technology, operation and poultry-health advising. Feeding service requires flexibility and quick reflection and accepts the changing raw material market or prices. Our flexibility enhances our partners' profitable poultry production.

The **Ruminant Business Division** providing **feeding programs and products for dairy cattle, calves, sheep and goats** and professional service for our customers in Hungary and neighborhood countries. The Dairy Feeding Program of Agrofeed ensures high milk production during the hole lactation period.

We provide solution for beef cattle, sheep and goat feeding for our domestic and export market customers.

The **Monogastric Animal Division** is providing service for pig customers (it is significant and important business in Europe and many other countries), providing wide scale of products and service. The three specialized business divisions are responsible for optimization and formulation according nutritional and direct cost requirement of our customers and provide professional service on domestic and foreign markets.

The **Export Business Division** is responsible to sell all kind of products (panels, premixes, concentrates, pre-starter feeds and feed additives) on our export markets and providing background support and service for our customers in 40 countries.

Agrofeed strives to ensure the most efficient service background for our customers that contribute to their profitable in poultry-, monogastric animal or dairy production. To this end, not only ensuring the direct feed service such as premix and compound feed nutritional and direct cost optimization, but we participate in the raw materials and finished product testing and evaluation of the results, as well as feed manufacturing technical problems. Regular consulting and service on the farms are important elements of our success.

Agrofeed Ltd. believes that production success can be the link between the partners and our company, on a long-term basis.

AGROFEED

Centre

H-9022 Győr, Dunakapu tér 10.
Address: 9007 Győr, Pf.: 1007
Phone: +36 96/550-620
Fax: +36 96/550-621
E.mail: premix@agrofeed.hu

Site

H-6086 Szalkszentmárton, Vadas 7.
Phone: +36 76/539-016
Fax: +36 76/539-017

agrofeed.eu