



EUROFISH MAGAZINE



Hungary

FISH FARMERS ADAPT TO CHANGING WEATHER CONDITIONS

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**INVASIVE SPECIES
AND PREDATORS**
draws big audience

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revive **LATVIAN COASTAL
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MULTI-USE PLATFORMS
may be an answer to
conflicting uses of the
ocean



LJUBLJANA, SLOVENIA

SEP 28–OCT 1 2026

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Since 1976, EAS has been bringing people together for the sustainable development of European aquaculture. As we celebrate our 50th birthday, we look back on key moments and key persons that made EAS what it is today. And we also look forward - continuing to expand our student activities and network and propose benefits for members that are suited to their profile and needs. We will celebrate this milestone throughout the year on social media, and in person at Aquaculture Europe 2026 in Ljubljana, where we invite EAS members to join the celebrations.

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SELECTED ARTICLES

COLLABORATING FOR RESILIENT AND SUSTAINABLE FISH FARMING



HUNATiP, the Hungarian Aquaculture Technology and Innovation Platform, fosters collaboration between researchers, policymakers, and fish farmers to modernise pond aquaculture. It promotes innovation in productivity, sustainability, and climate resilience. Initiatives include nutrient management, recirculation aquaculture systems, ecosystem service valuation, and water retention strategies. HUNATiP also supports EU-funded decision-support tools, peer learning, and farmer exchanges. By linking science and practice, the platform strengthens Hungarian aquaculture's competitiveness while preserving traditions and ensuring adaptability to climate change.

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Off-flavours in aquaculture, particularly fish and seafood, cause major economic and reputational losses. These undesirable tastes and odours, often earthy or musty, mainly arise from geosmin and 2-methylisoborneol produced by cyanobacteria and actinomycetes in ponds and recirculating systems. Although not usually harmful to health, off-flavours reduce product acceptability. Current solutions include preventive methods like algicides, curative measures such as purging, and experimental alternatives like advanced oxidation processes or microbial degradation. Despite progress, completely eliminating off-flavours remains a complex challenge.

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Global food loss in fisheries and aquaculture, accounts for up to 35% of production lost before reaching consumers. Despite record-high production, inefficiencies in storage, transport, processing, and by-catch lead to major waste. Discards, often target species too small or damaged, further distort stock data. Post-harvest losses also stem from inadequate cold chains, poor infrastructure, and pest infestations. While Asia records the highest losses, even Europe loses a third of edible fish. Reducing waste requires investment, innovation, and coordinated strategies across the supply chain.

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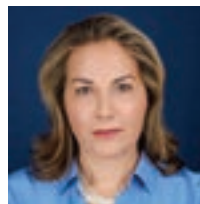
The third annual **Catch Welfare Platform** (CWP) conference is to be held from 19–21 November 2025 at Forteiland, IJmuiden. Founded in 2023, CWP unites 233 members from 25 countries to develop science-based solutions for wild-caught fish welfare. The event features keynote sessions, field visits, and two innovation competitions: the Catch Welfare Innovation Award and the Catch Welfare Idea Challenge. Topics include AI applications, flatfish stunning, and crustacean welfare. The last day of the event, Crustacean Day, will focus on crab and lobster handling, aiming to establish universal welfare standards.

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An international youth camp held in July in Jurmalciems, Latvia attracted 30 participants from Latvia and Germany. Supported by the Latvian Fish Fund, the camp explored Baltic fishing traditions, modern technologies, and sustainable futures for coastal communities. Activities included lectures, practical fishing, fish stock research, and cultural workshops. With Latvia's coastal fishing sector in decline, the camp emphasised innovation, tourism, and heritage preservation. Participants produced educational videos and sessions, aiming to inspire wider youth engagement in fisheries and promote knowledge exchange across Europe.

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Lara Barazi, the first female president of the Federation of European Aquaculture Producers (FEAP), stresses aquaculture's role in food security, climate resilience, and sustainability, while pushing for simplified licensing, stronger trade controls, and improved consumer trust through clearer labelling and communication. She also highlights inclusivity, youth engagement, and collaboration across diverse members as essential to ensuring aquaculture's growth, innovation, and strategic integration into EU policies.

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GERMANY



M3B GmbH/Oliver Saul

Germany's only trade fair dedicated to fish presents seafood companies from all stages of the value chain as well as associated companies from the fields of logistics, packaging, IT solutions and technology.

Fish international and Gastro Ivent return in 2026

In February 2026, Bremen will once again become the meeting point for the seafood and gastronomy sectors, as fish international and Gastro Ivent open their doors together in the exhibition halls of Messe Bremen. From Sunday to Tuesday, 22–24 February 2026, visitors can explore two complementary fairs under one roof, fostering new business contacts and knowledge exchange. Founded in 1988, fish international is Germany's only trade fair dedicated to fish and seafood. Under

new project management for the first time in 2026, the event will feature exhibitors from import, export, wholesale, processing, packaging, aquaculture, and technology. The forum will again provide a platform for discussing the future of the industry.

At the same time, Gastro Ivent will be held for the seventh time, serving as a central meeting place for professionals from catering, hotels, communal catering, and retail in north-west

Germany. The exhibition highlights the latest food and beverage trends, kitchen technologies, digital tools, and sustainable catering concepts. The programme also features three national coffee championships, tastings, and trend talks. Together, the two fairs create a key hub where seafood professionals and gastronomy experts can meet, network, and discover innovations. For more information, visit <https://fishinternational.de/en/>

DENMARK

Aquaculture firm to acquire 51% stake in Latvian company

Musholm, a Danish owned subsidiary of Japanese seafood group Okamura Foods will acquire a 51% stake in Latvia's company Riga Bay Aquaculture (RBA) following Musholm's aquaculture expansion strategy. RBA had won a competitive tender for the use of two sea areas in Riga Bay and is likely going to be issued a license for up to 10,000 tonnes of farmed fish.



Musholm, a subsidiary of Japan's Okamura Foods, is acquiring a site in Latvia in addition to existing ones in Denmark and Japan.

Latvia will become the company's third aquaculture base in addition to the preexisting sites in Denmark and Japan. The deal reflects the growing struggle of Musholm to navigate tightening Danish regulations on licenses and farming permissions. Okamura Foods has the goal of becoming one of the top 20 largest trout producers globally and looks to fully integrate their aquaculture company in Latvia with the new deal.

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DENMARK

Boasts a new fully circular trout farm

In the seaport town of Hirtshals, Denmark, a new trout farming operation is being pioneered by two Norwegian entrepreneurs, Samuel Muren and Håkon Volden, according to the fish-site.com. The project, called Onnest, is taking a multidisciplinary approach to trout farming that includes prioritising minimal waste, and transparency with the public. Their model of sustainability aims to integrate all parts of the production process into a closed, functioning loop. To achieve their goal of minimal waste, the farm will not rely on soy, a common ingredient in aquafeed, and instead will aim to produce feed from



Onnest, a trout-farming project in Hirtshals, seeks to minimise its environmental footprint by, among others, creating feed from algae grown on site.

algae that is grown on site. This move will lower the farm's carbon footprint and contribute to the circularity of the operation by maximising resource use and repurposing byproducts.

The operation plans to create products that not only benefit the environment but also improve human health. Onnest says that it wants to produce fish with a high omega-3 content through designing new feed and that its farming methods will minimise fish mortality. The company will also educate consumers on Onnest's sustainable farming methods.

SPAIN

Boosting fish consumption with promotional campaigns

In July Minister Luis Planas of the Spanish Ministry of Agriculture, Fisheries and Food presented seven newly signed cooperation agreements with industry organisations supported by a public investment of over €410,000. The aim is to boost the consumption of fish, seafood, and related products such as canned goods to try and reverse a worrying long-term trend: seafood consumption in Spain has fallen by nearly 30% over the past decade despite investments of over EUR11.5m in promotional initiatives by the ministry since 2019. In 2024, per capita consumption dropped by 3.7% year-on-year to just 22.3 kg. Most of this consumption—around 17.9 kg—is within households, and while prices have risen by 4% on average (above the general food price increase of 2.8%), the minister noted that seafood remains

available across a wide price spectrum. Campaigns will target young people and urban residents, with a focus on modern, ready-to-cook formats and messaging that highlights health benefits, sustainability, and the cultural heritage of Spanish fisheries. The organisations involved in the new promotional agreements include Fedepesca (the National Federation of Fish Retailers), the Spanish Federation of Fishermen's Guilds, Anfaco-Cecopesca (the National Association of Fish and Seafood Canning Producers), Anfabasa (the National Association of Cod and Salted Fish Producers), Interfish-España (the Inter-professional Fisheries Organisation), Conxemar (the Spanish Association of Fish Importers, Exporters and Processors), and the Association of Fisheries Producer Organisations.



Faced with a steady decline in seafood consumption, the Spanish Ministry of Agriculture, Fisheries and Food has forged strong alliances with key stakeholders in the fisheries and aquaculture sectors to reverse this trend.

HUNGARY

Lake Balaton remains on top of nation's catch rankings

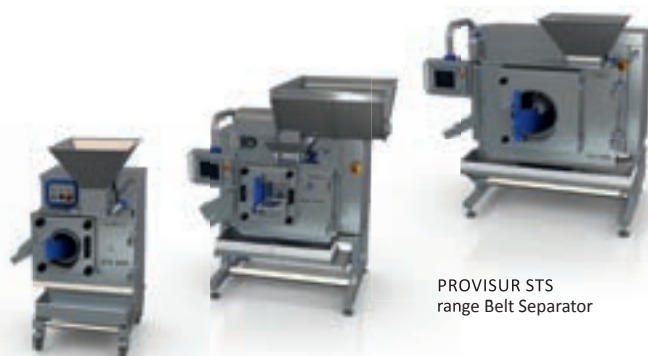


Anglers caught 633 tons of fish from Lake Balaton, followed by 180 tonnes and 160 tonnes of fish from the Danube and Tisza rivers, respectively.

Despite catch quantity dropping by 9.8% since 2023, Hungary's Lake Balaton still resides at the top of the nation's fish catch rankings, according to a report from the National Federation of Hungarian Anglers (MOHOSZ). Lake Balaton is a freshwater rift lake located in the nation's west. It is the largest lake in Central Europe and is the site of both tourism and inland fisheries. The decline in catch quantity is partially attributed to the recent drop in garda, a native fish species that once represented a large percentage of Hungary's seasonal yield. Now, species such as carp and bream head the list of caught biomass.

Although it is not common for fish restocking to be done in Europe, the process was carried out in 2023 by several Hungarian fishing organisations with the goal of restoring ecological balance, creating diversity, reintroducing native fish species, and partially compensating for the damage caused by cormorants. Extensive restocking in 2023 led to minimal restocking in 2024, which may have contributed to the decline in the recorded total catch.

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CROATIA

Tuna to enter the Chinese market

Croatian tuna, prized for its high quality, is now included in the list of 126 agricultural and food products from Central and Eastern European Countries (CEEC) that has been newly approved for import into China. The grant follows the fourth annual China-CEEC Exco and International Consumer Goods fair in Ningbo in east China. Croatia's new market access is part of China's broader effort to streamline European import procedures and broaden access to the market in general. Prior to this access, Japan had been the primary market for Croatian bluefish tuna. Other Eastern European products, such as Latvian canned fish, have already been approved for the Chinese market. Croatian tuna farmers capture juvenile tuna and fatten them over the course of a few months by feeding them small pelagic fish. The process ensures a high traceability and a high market value.



Croatian tuna farmers are expanding their markets in Asia. Sales to Japan will now be supplemented by exports to China.

ITALY

Mediterranean stocks in danger after illegal fishing of juvenile hake

Investigations from the Earth Journalism Network are uncovering the rapid decline of Mediterranean hake populations which are largely due to the illegal farming and selling of juvenile hake on the black market. These juvenile hake nicknamed “merluzzetti,” are illegal to sell, but seem to be extremely easy to purchase on fishing vessels close to docks on the western Italian coast. The shortest legal length for selling hake is 20 centimetres but the report states that in ports in Tuscany, Lazio, Campania, and Sicily, hake of just a few centimetres



Illegal fishing activity is what often leads to the harvesting of undersized hake. The most effective way to prevent these practices is by using larger mesh nets for fishing.

long were readily available to buy. Boxes of hake purchased from these docks have an average hake length of 7-15 centimetres. Oceana's fisheries manager for the Mediterranean sea, Giulia Guadagnoli, says that “hake is in a state of total biological collapse,” and that the species is unlikely to recover from such detrimental activity.

LITHUANIA

Working to protect Baltic seals against climate change

As climate change accelerates the decline of fish stocks and the melting of ice platforms, Lithuania has noticed that the Baltic seal population is suffering. Now, rescue efforts are being expanded at the Baltic Sea Animal Rehabilitation Centre located in Klaipeda. Seals that wash up on the Lithuanian shorelines are brought into the centre and returned to health. The centre has been seeing seals since the 1980s, but notes that recently, more and more seals are lining the coast. Arunas Grusasa a biologist at the centre, says that seals were taught how to feed themselves, and to get used to the sea again. The work of the centre is crucial, as the survival rate of seal pups was as



For many years, Lithuania has been committed to protecting their Baltic seal populations through conservation efforts and rehabilitation centres.

low as 5%. Once the scientists release the seals back into the wild, they equip them with GPS trackers to see where they migrate. The centre reports that they favour a route towards the Swedish Gotland Island where there are many fish. The centre has helped to rebuild the seal population, which fell to nearly 4,000 in the late 20th century. Now the Baltic seal population numbers up to 50,000 and is considered a menace by fishers and fish farmers in the Baltic.

SPAIN

Spain and Mauritania meet to discuss the responsible use of marine resources

Spain, a member of the European Union, and Mauritania, an African country, met in late July to consolidate and strengthen fishing cooperation between the two countries. The meeting reinforces the pair's collaboration as talks begin to renew the EU-Mauritania fisheries protocol ending in late 2026. This agreement impacts Spain, as Mauritania is a leading destination for Spanish fishing vessel exports. Over 30 Spanish fishing vessels operated in Mauritanian waters last year, capturing nearly 16,000 tons of fish. The agreement does not only allow Spain to

fish in Mauritania but also requires the Spanish fleets to employ local sailors. During the meeting, both ministers emphasised the importance of strengthening training programs and cooperations for these sailors. Spain agreed to launch a nautical training program called *Intermares* beginning in 2026. The meeting also concluded with a mutual agreement to better communicate closures in Mauritania's waters to EU fleets in order to prevent economic losses. As negotiations progress over the course of the next year, both countries aim to align their



WeAreAquaculture

Spain and Mauritania's leaders reinforced their partnership ahead of the impending expiration of the West African nation's agreement with the European Union.

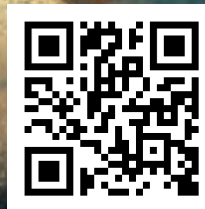
resource-sharing agreements and ensure fair representation and training within local fisheries.

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ALBANIA

Fishers in crisis as rising sea temperatures reduce yield

In the Adriatic Sea around one of the largest cities in Albania, it is feared that fish stocks have declined by 70%. Vlore and surrounding areas are being severely impacted by rising sea temperatures that threaten the survival of fish. Reshat Xhelilah, an official in Vlore, says that in 2025, the temperature of waters may exceed that of 2024, which was 30.5 degrees C. These rising temperatures can be attributed



Albania is battling rising sea temperatures and the influence of invasive species. They are developing new resilience strategies that include creating early warning technologies and better forecasting methods.

to climate change, which make it difficult for many marine organisms to reproduce and grow, particularly those adapted for cooler waters. Nexhip Hysolokaj of Tirana's Polis University says that at least a dozen invasive fish species are out-competing local species that are important to the marine food web. With populations of essential fish declining, parts of Albania's fishing industry are under threat.

NETHERLANDS

Seagrass EU conference gathers over 200 seaweed experts



At the site visit to Hortimare participants learned how the company offers innovative solutions and technical support to the industry.

Seagrass EU 2025, one of the leading conferences for the seaweed industry, successfully brought together more than 200 participants from 26 countries in Rotterdam from 17–19 June. This year's theme, "Seaweed 2.0: Today's Scaling for Tomorrow's Needs," underscored the industry's need to scale responsibly and collaboratively in response to growing global demand for sustainable seaweed. The event served as a platform to unite stakeholders across the seaweed value chain—including producers, policymakers, researchers, investors, and buyers—to foster synergies and build a resilient, scalable infrastructure for the future of the industry.

The event opened on 17 June with either a site visit to Hortimare where participants learned how the company approaches breeding and supports farming operations or to the Royal Netherlands Institute For Sea Research which hosted a scientific meeting in collaboration with the NWO-KIC projects *CircAqua*, *SeaSeeds*, and *From Sea to Society*. The main conference on 18–19 June featured five plenary sessions, two

panel discussions, and the Seaweed Elevator Pitches, a fast-paced format that allowed for broad project exposure and idea sharing. Nearly 50 speakers shared insights on applications, farming practices, and regulatory developments in the seaweed sector. The programme also featured sessions on professionalising the seaweed industry; collaboration as a tool for a successful seaweed industry; and a roadmap for the European seaweed industry, among others.

More than 15 exhibitors presented their latest technologies, equipment and services at the Seagrass trade show. Additionally, some 30 participants presented posters showcasing their latest research and projects. We're proud to support the community as it grows and connects, said Kuno Jacobs, managing director of DLG Benelux, the event organiser. He added that the next editions of the event would be Seagrass World 2026, 19–21 May 2026 in Bangkok, Thailand followed by Seagrass EU 2026, 16–18 June 2026 in Gothenburg, Sweden. For more information visit www.seagrass.eu or contact info@dlg-benelux.com.

Strengthening communities through food

Procuring, preparing, and consuming food play an important role in communities. These activities can contribute to solving economic, environmental, and social challenges in different layers of a society.



Participants at a conference on the role of food in community development learned how food can be used to promote regional identity while supporting economic and environmental goals.

On 20 August 2025, Eurofish International Organisation took part in A Seat at the Table, an international conference hosted at the Kitchen Collective in Copenhagen. Organised under the EU-supported initiative The Renaissance of Local Food, the event brought together people working across food, culture, and regional development to explore how culinary traditions can strengthen communities and support more sustainable futures.

What food means for a society

The programme featured five focused sessions that invited reflection on how food shapes society—from its role in reinforcing cultural identity to its capacity to support economic opportunities and ecological resilience. Speakers from across Europe, including Greenland, Åland, Denmark, Italy, and Turkey, offered regional perspectives grounded in lived practice and

research. The opening panel explored how traditional foodways contribute to identity and place-making. One of the highlights came from Inunnguaq Hegelund, who described the adaptive nature of Greenlandic food culture. In the Arctic, food is shaped not only by tradition but also by necessity. Drying, fermenting, and freezing are essential preservation methods, allowing communities to store and share food in a region where seasons are extreme and access to fresh imports limited.

Fishing and small-scale hunting continue to play a crucial role in food



The Renaissance of Local Food conference also featured local foods for participants to sample.

sovereignty and nutrition, particularly in coastal settlements. But the Arctic environment is changing. Rising temperatures are altering the range and abundance of fish species, which presents challenges for younger generations seeking to maintain traditional knowledge while adapting to ecological disruption.

Food as tourism, community, and governance

Other sessions focused on food's wider impact in society. The panel on food and community examined how shared meals can help reduce social isolation and foster a sense of belonging. Local initiatives in Denmark, including those led by Mia Maja Hansson and Lennart Lajboschitz, showed how communal dining experiences can be designed to welcome diverse groups—bringing neighbours, newcomers, and vulnerable individuals to the same table. The role of food in tourism and local economies was addressed in a separate session. From Åland, Viktor Eriksson shared examples of how regional food experiences—such as seafood tasting tours and fish-smoking workshops—support small producers while promoting regional identity. The discussion highlighted the potential of food not only to feed but to teach,

connect, and create value in rural and coastal areas. The fourth session turned to the policy dimension, with reflections on how municipalities and institutions can support alternative food networks. Speakers called for better integration of food policies into regional planning, particularly where it concerns public procurement, education, and support for small-scale producers.

Transforming food systems in response to pressures

The final session focused on the idea of transformation—how food systems must evolve in response to environmental, social, and economic challenges. Speakers advocated for a shift away from highly centralised, resource-intensive models and towards approaches that are more inclusive, decentralised, and circular.

Inclusive food systems prioritise access and participation. This means recognising the needs of different communities, including low-income households, minority food cultures, and remote producers. For example, some initiatives in Copenhagen have created community kitchens that offer affordable meals while employing local residents—blending food access with social entrepreneurship. Decentralised systems move

food production and decision-making closer to the communities they serve. A farm-to-school programme in Åland, for instance, connects small fisheries and vegetable growers with local schools, ensuring children receive fresh, local food while supporting micro-enterprises in the area. Circularity, meanwhile, refers to designing food systems that minimise waste and regenerate natural resources. This could mean composting food scraps to enrich local soil or using byproducts from fish processing in agricultural feed—practices that align ecological thinking with everyday routines.

Taken together, these ideas point towards food systems that are more resilient because they are more responsive, rooted in local knowledge, built around relationships, and designed to function within ecological limits.

Eurofish's role: listening and learning

Eurofish attended the event to engage with new perspectives and consider how fisheries and aquaculture fit into broader food system transitions. Eurofish's participation reflected a growing recognition that seafood is more than a commodity—it is a cultural and ecological resource that must be understood in context. In regions where fishing is still a way of life, the stories shared during A Seat at the Table underscore the importance of integrating seafood into local food strategies. Preserving marine food traditions, supporting artisanal fishers, and linking seafood to education, tourism, and health are all part of this wider transformation.

The conference concluded with a strong sense of shared purpose. As The Renaissance of Local Food continues, it offers not just a platform for discussion, but a laboratory for imagining food systems that nourish both people and places.

Ixai Salvo, Eurofish, ixai@eurofish.dk

Innovation awards and crustacean workshop at welfare conference

The Catch Welfare Platform has announced its third annual conference, a free, in-person event from 19 to 21 November 2025 at Forteiland in the Dutch port of IJmuiden, site of the world's largest lock.

Set against the backdrop of a working fishing port, the location is symbolic of the focus of this year's Catch Welfare Platform (CWP) conference: improving welfare for wild-caught fish in real-world settings. The three-day event will assemble global experts from science, the fishing industry, technology, and policy to exchange knowledge, debate standards, and showcase technical solutions. Delegates can expect keynote sessions, field visits, and two new competitive formats aimed at encouraging practical innovation.

CWP was founded in 2023 by Wageningen Research, the Institute of Marine Research Norway, Nofima, and Michelle Boonstra, who manages the platform. It brings together the seafood industry, research institutions, retailers, and other stakeholders to create pragmatic, science-based solutions that improve the welfare of the catch, including post-capture stunning and slaughter. Today it boasts 233 members from 25 countries across six continents. Speaking about the upcoming event, Michelle Boonstra said that the first conference in Bergen, Norway, in 2023 successfully brought together people from across marine science and the fishing industry. While last year's online format enabled global

participation, in-person meetings offer far greater scope for meaningful collaboration and direct engagement. They encourage stronger audience participation, she added, and we look forward to hearing well-reasoned contributions from all involved.

AI's role in fish welfare

The conference begins with a boat ride to Forteiland on 19 November. The day opens with the Innovation Award

ceremony, followed by pitches from the three finalists in the Advancing Catch Welfare Idea Competition. Sessions on Day 1 will cover gillnet fishing, cod welfare, flatfish stunning, ropeless gear, and updates on the innovative FloMo fishing system. The afternoon is themed "What can AI do for fish welfare?", and features demonstrations and a panel discussion with audience participation.

Day 2 kicks off with a presentation from Professor Wenbin Zhu of Zhejiang Ocean University about fish



The CWP conference hopes to encourage the practical implementation of scientific results in the field of capture fish and seafood welfare.

events

welfare research in Chinese fisheries. This will be followed by a dive into the world of criteria, indicators and welfare footprints. Attendees are also invited to join the CWP team on a field visit to a demersal fishing vessel which is experimenting with the first flatfish stunner. The field trip includes what promises to be an insightful visit to a local fishing company. A working lunch hosted by the EU-funded VeriFish project will explore how structured welfare and sustainability indicators could shape seafood communication. VeriFish is offering travel reimbursement for producers, retailers, and seafood associations attending the lunch and feedback session.

Industry workshop focused on crustaceans

Day 3, Crustacean Day, begins with a series of presentations that will provide

the latest scientific developments in the welfare of crab and lobster. Afternoon sessions will address practical handling and the development of new universal best-practice standards. The goal is to better connect science with industry needs. Crustacean Day is an invitation only event. Those working with crab and lobster are encouraged to attend and contribute to the workshop. Anyone who has not been invited can attend by sending an email to: michelle@catchwelfareplatform.com. CWP invites people to submit innovations or early-stage ideas that advance wild-caught fish welfare.

Entries for the Catch Welfare Innovation Award must demonstrate measurable impact over the past three years and will be judged on originality, welfare outcomes, and benefits to the fishing community. Winners will receive professional recognition, worldwide media coverage, a keynote speaking slot, and a handmade award trophy. The submission deadline is 26 September 2025 with results announced on 17 October 2025.

Catch welfare idea challenge

CWP is also seeking proposals for its catch welfare idea challenge, open to anybody with promising concepts that require support to develop. The top three entries will be pitched live at the conference. The winner, chosen by audience vote, will receive €4,000 in seed funding and will also have the opportunity to be introduced to potential funders. The deadline for idea submissions is 26 September 2025. The three chosen entries will be announced on 17 October 2025. Full details and application forms for the innovation award and idea challenge are available on the CWP website.

The conference contributes to the organisation's objectives of giving the fishing industry a voice in the conversation, sharing knowledge and creating practical, profitable solutions regarding fish and seafood welfare. More information and a link to register are available at catchwelfareplatform.com

LET'S TEAM UP

Eurofish partners with stakeholders in its member countries and beyond executing projects for the development of fisheries and aquaculture.

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Drawbacks and potential benefits of predators and invasive species

Predators and invasive species are a threat to fisheries and aquaculture across Europe, but also a potential resource. At a conference in Tallinn both aspects were explored in a series of presentations that covered the Baltic, Mediterranean, Black and North Seas as well as the earthen ponds used for the cultivation of freshwater species in many European countries.

Organised by Eurofish International Organisation in cooperation with the Estonian Ministry of Regional Affairs and Agriculture, the international conference *Predators and invasive species—a threat or a business opportunity* on 17 and 18 June 2025 in Tallinn brought together over 140 participants and 17 speakers from 20 countries. Among the attendees were delegations from ministries, researchers, industry experts, commercial and recreational fishers, as well as representatives from aquaculture and fisheries associations. The event was opened by Hendrik Johannes Terras, Minister of Regional Affairs and Agriculture of Estonia.

Human and environmental factors contribute to presence of invasive species

Following the minister's welcome, Marco Frederiksen, Director of Eurofish, expressed his gratitude to the

ministry for hosting the event and to the audience for their strong interest and participation. After opening remarks highlighting the current state

of Estonian fisheries and aquaculture, conference moderators Søren E. Schröder and Ixai Salvo, both from Eurofish, took over. In the first session



Participants at the conference jointly organised by Eurofish and the Estonian Ministry of Regional Affairs and Agriculture took back a wealth of information on the predators and invasive species that affect European seas and freshwater fish farms.

speakers focused on the overview of threats in different sea basins of Europe. Markus Vetemaa (Estonian Marine Institute, University of Tartu) introduced the audience to threats in the Baltic Sea and surrounding inland waters. He implicated heavy maritime traffic, brackish water environment, limited native biodiversity, and climate change in the presence of over 100 new species in the Baltic Sea since the 20th century. Mr Vetemaa emphasised that the cormorant is the most important invasive newcomer in Estonia from the fishery point of view.

The session continued with Matteo Leonardi and Andrea Fabris (Italian Fish Farmers Association) who both talked about invasive species in the Mediterranean Sea and surrounding inland waters. Spotted pufferfish (*Lagocephalus sceleratus*), scorpion fish (*Pterois miles*), dusky rabbitfish (*Siganus luridus*), striped rabbitfish (*Siganus argenteus*), blue spotted cornetfish (*Fistularia commersonii*) and blue crab (*Callinectes sapidus*) are just some of the new species in the sea basin. The audience also learned about benefits and risks in aquaculture production of alien species in the Mediterranean aquaculture. Pieter Boets (Provincial Centre for Environmental Research, Belgium) covered the most recent findings from the North Sea basin area, while Mehmet Aydin (Ordu University, Türkiye) closed the session with challenges and prospect in the Black Sea and adjacent inland waters.

Cormorants as food for human consumption

The second session addressed the commercial opportunities offered by predators and invasive species in salt-water areas and featured seven experts from Estonia, Greece, Denmark, Lithuania

and Norway. Annette Kägu and Rain Kuldjärv from the research organisation (TFTAK, Estonia) talked about potential developments on round goby fisheries for human consumption and pet food. Describing the potential of using cormorants to create tasty dishes Urpo Reinthal (*YliCool Catering*) inspired the audience with different recipes he is developing to support the consumption of cormorants and thereby decrease the burden on the Estonian aquaculture sector.

The draft EU plan to manage cormorant predation was examined by Niels Thorvald Jepsen (DTU Aqua, Denmark), while Papadaki Prinsus (IKE, Greece) showed some of the results from the EU HORIZON project VALIAS that aims to convert marine invasive species into sustainable aquafeed. The status of round goby and its market development in Lithuania was presented by Loreta Bražinskaitė (Ministry of Agriculture, Lithuania). Market dynamics, consumer acceptance, and business opportunities for selected products—including Pacific oysters, sea squirts, and clinging jellyfish—along with recommendations for stakeholders, were the key takeaways from the intervention on markets for products from invasive species by Christian Philip Unmack (Eurofish International Organisation). The first day's programme concluded with a presentation by Tina Thesslund (NOFIMA, Norway), on the evolution of the invasive king crab into a multi-million-dollar industry in Norway.

Markets for blue crab can be developed

The second day of the conference was opened by Preben Møller from Greenland (*Great Greenland A/S*), who showed the sustainable hunting, utilisation, and trade of ringed seals and

harp seals. Out of a total population of approximately 12 million, around 150,000 seals are hunted annually in Greenland. Sealskin has traditionally been used for housing, bedding, clothing, and other fashion items. Francesca Barazzetta (Eurofish International Organisation) shared her research findings on the utilisation of market opportunities for the American blue crab (*Callinectes sapidus*) and the blue swimming crab (*Portunus segnis*)—both invasive species in the Mediterranean Sea. Five case studies on blue crab use in markets in Italy, Spain, Turkey, Tunisia, and Greece supported her intervention. Mie Thorborg Pedersen (University of Southern Denmark) showed how jellyfish can contribute to diversifying sustainable food sources; however, limited supply and infrastructure remain key barriers in Europe, as harvesting and processing are not yet well developed.

The third and final session focused on business opportunities related to predators and invasive species in freshwater areas. Béla Halasi-Kovács (Federation of European Aquaculture Producers) discussed the implications of the draft EU Cormorant Management Plan from the perspective of aquaculture producers. Per Pettersson (Swedish Inland Fishermen's Federation) spoke about the utilisation of signal crayfish (*Pacifastacus leniusculus*), while Béla Urbányi (Institute of Agricultural Economics, Hungary) gave the final presentation on Chinese carps in Hungary.

The second day offered all participants the opportunity to gain first-hand experience during a field trip organised in cooperation with the Fisheries Information Centre of Estonia. At Hara Harbour, delegates had the chance to meet a local fisherman and learn how round goby and cormorants are being utilised in sustainable ways.

Toni Bartulin, Eurofish, toni@eurofish.dk



Fish feed, especially natural organisms in the pond bottom, is one of the important sources of off-flavours in bottom-feeding fish species.



The sediment contains countless microorganisms that release geosmin and 2-methylisoborneol. This is why the sludge should be regularly removed.

Economic losses and reputational damage due to off-flavours

Food is primarily for nourishment, but it can also be a source of pleasure when we perceive its smell and taste as pleasant. The disappointment is all the greater when our sensory perceptions do not meet our expectations. Off-flavours can also occur in fish and seafood, and they are more than just a minor annoyance—they cause enormous economic damage.

Corked wine, sour beer, or rancid-tasting coffee—flavour defects or off-flavours can occur in almost all foods and beverages, even though they may not be spoiled or unfit for consumption. It is not easy to distinguish between normal taste variability and a genuine off-flavour. The causes of off-flavours are diverse: incorrect processing temperatures, improper storage, early microbial spoilage, or oxidation caused by light or oxygen in the air. Often, it is enough for the levels of key flavour compounds to deviate from the norm or for certain components to be missing to noticeably alter the natural flavour profile. Foreign odours from the environment can also enter a food product and perceptibly change its original smell and taste. The range of sensory assessments extends from unpleasant to inedible, sometimes more finely distinguished into descriptions such as bitter, sour, rancid, rotten, unappetising, repulsive, spoiled, or disgusting.

Aside from severe microbial contamination, off-flavours are rarely harmful to health. The damage they cause to producers and retailers lies mainly in



The nose is a sensitive sensory organ that can detect lack of freshness and off-flavours through smell.

the rejection of off-flavour products and complaints from customers. In addition to financial losses, reputational damage can occur, as consumers often avoid such products for an extended period following negative experiences.

Multiple causes of off-flavours

In the fish and seafood sector, off-flavour is a truly global problem. It primarily affects aquaculture products from freshwater ponds and recirculating aquaculture systems (RAS), which often have a musty-earthy, mouldy, or damp smell and taste. These sensory defects can occasionally occur in marine fish species too, though far less frequently.

There are various possible causes of off-flavour in freshwater species. Many ponds, natural waters, and recirculation aquaculture systems (RAS)

are heavily loaded with micronutrients and organic substances, which lead to excessive growth of phytoplankton and microorganisms. These aquaculture systems provide ideal conditions for the proliferation of aquatic fungi, myxobacteria, and other proteobacteria. When certain filament-forming actinomycetes (bacteria) and cyanobacteria (blue-green algae) multiply excessively, their secondary metabolites accumulate in the water and produce a musty-earthy, muddy-rotten smell and taste.

The two substances most commonly associated with off-flavour in aquaculture are geosmin (GSM) and 2-methylisoborneol (MIB). In ponds and nutrient-rich lakes, both free-floating planktonic cyanobacteria and actinomycetes—particularly *Streptomyces* species that live in muddy sediments—contribute to the presence of GSM and MIB in the water. In RAS, odour-producing microorganisms mainly settle in the biofilter but also

develop in thin biofilms on tank walls and floors.

Identifying off-flavours does not require special expertise or sensory training, as the human nose is highly sensitive to musty smells reminiscent of a potato cellar. However, detailed sensory training can help with precise diagnosis and verbal description. Some companies that specialise in this field offer “flavour kits” to help users train with and recognise standard flavours. The sensory detection thresholds for GSM and MIB in fish flesh vary by species but are relatively low. GSM is detectable by the human nose at concentrations as low as 0.3 to 10 µg/kg, and MIB at 0.035 to 0.1 µg/kg.

Subjectively perceptible, but hard to quantify

To precisely identify and quantify off-flavour components call for instruments and analytical equipment typically available only in well-equipped laboratories. Accurate results require significant time, as complex extraction and concentration steps are necessary before analysis using gas chromatography-mass spectrometry (GC-MS). The difficulty is compounded by the fact that only a few laboratories specialise in GSM and MIB analysis and possess sufficient aquaculture expertise. Modern sensors and analytical instruments, such as “electronic noses” developed specifically for off-flavour detection, may offer a solution.

Although the main causes of off-flavour are largely understood, reliable prediction—let alone prevention—of its occurrence in farmed fish has not been achieved. Nevertheless, there have been repeated attempts with varying success, depending on the aquaculture system. Any measures to combat off-flavours must be environmentally

friendly, consumer-safe, efficient, and cost-effective. Since eutrophication is a major cause of off-flavour, efforts have been made to reduce nutrient accumulation in the water. One approach is to remove pond sediment to prevent the resuspension of nitrogen and phosphorus compounds and shifts in phytoplankton communities (e.g., from eukaryotes to cyanobacteria). However, even fish from such treated ponds often still exhibited an earthy-musty off-flavour, sometimes making them unsellable. The intensity of the off-flavour varied widely, but even small amounts of GSM and MIB were enough—depending on fat content, farming method, and diet—to significantly reduce the palatability of the fish. This is due to the uptake mechanisms of these substances,

which enter fish through the skin and gills directly from the water or via the gastrointestinal mucosa with food. Because GSM and MIB accumulate in the rearing water and sediments, it is nearly impossible to prevent fish—especially bottom-feeding species that consume natural food sources—from rapidly developing varying degrees of off-flavour and off-odour.

Ponds and RAS particularly affected

In aquaculture systems such as ponds and raceways, cyanobacteria are the most common producers of GSM and MIB, while in RAS, chemotrophic

bacteria—especially actinomycetes—are considered the main contributors. Studies have shown that in around 80 percent of water samples from commercial freshwater RAS, geosmin concentrations were higher than those of 2-methylisoborneol. This suggests that GSM plays a more significant role in causing off-flavours than MIB. A further complication is that fish absorb GSM more quickly, accumulate it more strongly, and eliminate it more slowly than MIB. As mentioned earlier, off-flavour in aquaculture products leads to considerable economic costs. Rough estimates suggest that flavour defects in *Ictalurus* products cause losses of 12 to 15 percent of the annual revenue of the U.S. catfish industry in the Mississippi-Missouri region.

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GSM and MIB are lipophilic substances that tend to accumulate in the fat tissue of fish species such as carp.

Additional, harder-to-quantify losses arise from reputational damage and declining market demand.

The growing pressure of the off-flavour problem is motivating researchers and industry professionals around the world to search more intensively for viable solutions. Three main strategies are being pursued: preventive, curative, and alternative methods. The preventive approach seeks to halt the microbial production of GSM and MIB in aquaculture systems—to address the problem at its root. Given the wide variety of microbiota capable of producing GSM and MIB, completely eliminating these organisms from the systems appears impossible. However, limited success has been achieved with the use of algicides to control or eliminate harmful cyanobacteria. Such substances must not harm fish or later pose a risk to consumers. Based on current experience, low-dose copper sulphate appears to be a promising and relatively economical solution in ponds. Co-stocking ponds with plankton-eating fish or mussels may also help mitigate algae problems. In isolated cases, colouring the pond water to reduce

light penetration and photosynthesis, thereby slowing algae growth, has been considered.

Purging often remains the only solution

The second approach, the curative strategy, is based on removing the GSM and MIB absorbed into the fish's body. As previously described, these substances enter the fish mainly through the gills, skin, and intestines, and accumulate primarily in body fat. Their uptake reflects a dynamic equilibrium that continues until approximately equal concentrations exist in the water and the fat of the fish. The absorption and bioaccumulation of geosmin and MIB are reversible. If fish with off-flavour are placed in pure water free from these compounds, the absorbed substances will diffuse back into the water depending on concentration gradients. However, the net efflux—or release—of GSM and MIB from fish tissue into the water occurs significantly more slowly than their uptake. Aquaculture producers

use this principle during purging or depuration to rid fish of off-flavours.

This cleaning process typically takes place at the end of the production cycle before delivery. During purging, fish are held without feeding in large volumes of clean, GSM- and MIB-free, ideally flowing freshwater to allow accumulated off-flavours to be eliminated from their bodies. The success of this process depends on multiple factors. Since off-flavours are released more slowly than they are absorbed, the effectiveness of purging depends heavily on the duration of exposure to clean water. If the “cleaning time” is too short, only partial removal of off-flavour occurs. Achieving satisfactory results requires experience. Moreover, the removal of off-flavours also depends on the fish species, fat content, intensity of the off-flavour, water temperature, swimming activity, feeding frequency prior to purging, and other variables. It is particularly difficult to estimate the time required for removing off-flavour from fatty tissues and organs. In the case of caviar production, sturgeon sometimes have to be purged for several months to produce truly off-flavour-free roe.



Fish from RAS often show pronounced off-flavours. Chemotrophic bacteria, especially actinomycetes, are the chief culprits.

All these factors make the curative effect of purging rather uncertain, partly ineffective, and costly. It requires large quantities of clean water, additional tanks and production areas, and pumps. As the fish are not fed during this time, they may lose weight, resulting in financial losses for producers. Additionally, animal welfare concerns have been raised, as long periods without feeding are seen by some as compromising fish welfare and the sustainability of the operation.

Alternative strategies are often still in early stages

For the reasons mentioned above, there is intensive research into methods to prevent GSM and MIB from forming or accumulating in fish. These efforts to optimise cleaning processes are grouped under the third strategy: “alternative methods.” This area is of particular interest to the RAS sector. As systems with high stocking densities that rely on water reuse and heavily populated biofilters, RAS are particularly susceptible to the development of GSM- and MIB-producing microorganisms. Although solid waste is continuously removed from recirculating water, many organic compounds that serve as substrates for off-flavour microbes still accumulate in the system. Studies of off-flavour have shown that actinomycetes, especially streptomycetes, are particularly common in the water treatment areas of RAS. Cleanliness and regular maintenance throughout the facility are therefore essential to prevent off-flavours.

In addition, researchers are seeking alternative methods to significantly reduce the need for cleaning. One such method is the chemical oxidation of GSM and MIB using ozone (O_3) or



Large purging facilities are often needed to remove off-flavours from pond fish before they are marketed. These facilities are also used for overwintering.

hydrogen peroxide (H_2O_2), ideally in combination. These treatments are already commonly and successfully used to remove off-flavours in drinking water production. In low doses, ozone is frequently used in RAS for disinfection, reducing turbidity, and clarifying water colour. However, effective control of GSM and MIB would require much higher doses, potentially in combination with intense UV irradiation, which could be harmful to fish if not used with activated carbon. As strong oxidising agents, ozone and hydrogen peroxide attack not only the off-flavour-producing organisms but all organic substances indiscriminately. Despite this, they are seen as promising because they break down easily and convert into harmless water and oxygen after use. To enhance their effectiveness and better control the processes, advanced oxidation processes (AOP) are used. These generate highly reactive hydroxyl radicals (OH) that destroy unwanted off-flavour substances and remove them efficiently from wastewater. In AOPs, oxidants such as ozone (O_3), hydrogen peroxide (H_2O_2), and peracetic acid (PAA) are combined to strengthen the treatment

against GSM and MIB. In commercial RAS trials, concentrations of off-flavour compounds in recirculating water were reduced by up to 77 percent for MIB and 93 percent for GSM.

A completely new idea, still in its infancy, is the selective degradation of geosmin and MIB by other microorganisms. Also, not ready for practical use are the so-called “low off-flavour RAS” systems with “off-flavour bioreactors.” These bioreactors currently operate based on an upflow sludge blanket principle. However, experts agree that much better results in off-flavour treatment would be achievable with moving bed biofilm reactors (MBBR). Work is already underway on this, but commercial readiness and practical implementation in RAS will take more time.

Another method—the “final” step, so to speak—for concealing the off-flavour of a fish from the consumer is through how the product is processed and preserved. Effective methods for masking off-flavour include intense seasoning, which makes off-flavours less noticeable, as well as heavy smoking, which can often partially cover up the unpleasant taste. *Manfred Klinkhardt*



From left, Béla Halasi-Kovács, Péter Lengyel, and László Váradi, office bearers of HUNATiP, the Hungarian Aquaculture Technology and Innovation Platform

Innovation in Hungarian pond aquaculture takes different forms

Hungarian aquaculture research institutions and pond fish farmers are collaborating to make the sector more productive and more resilient to the impacts of climate change. The partnership has resulted in innovations along the supply chain.

Innovation in Hungarian pond aquaculture finds its institutional heart in HUNATiP, the Hungarian Aquaculture Technology and Innovation Platform. Established as a mirror platform for the European Aquaculture Technology and Innovation Platform (EATiP), HUNATiP supports the coordination of national innovation programmes, facilitating research and

technology transfer among scientists, producers and innovators. As Dr László Váradi, president of HUNATiP, emphasises, innovation is vital if aquaculture is to remain sustainable and competitive in a rapidly changing world. HUNATiP's role in organising forums, workshops, and information exchange underscores this ambition. The innovation HUNATiP fosters addresses multiple

dimensions of pond aquaculture. First, productivity: encouraging better feeding strategies, genetic selection, and pond management techniques. Second, sustainability: improved water quality monitoring, environmentally friendly practices, and advanced nutrient and environmental management decision support tools. Third, resilience: helping farmers prepare for

droughts, temperature extremes, and regulatory shifts.

Connecting science, policy and practice

HUNATiP functions as a bridge between scientific understanding, policymaking, and farm practice. Dr Váradi underlines the difficulty that many pond fish farmers face in accessing innovation: knowledge often remains trapped in research institutions. HUNATiP aims to reverse that, by developing networks and workshops that bring together scientists, public bodies, and producers to share research findings, pilot practices, and exchange feedback. Despite the difficulties some farms have implemented innovative approaches to fish production developed, for example, at the Research Center for Fisheries and Aquaculture (HAKI) where the combined extensive-intensive systems of pond cultivation were studied. In these systems the extensive ponds are used as filters to remove nutrients generated in the intensive part of the production. Other farms cultivate sturgeons and process and market the caviar. The inter-branch organisation MA-HAL which represents the aquaculture value chain is a strategic partner. Dr Béla Halasi-Kovács, managing director of SCIAP Consulting and a founding member of HUNATiP, adds that MA-HAL has new leadership which is keen on bringing innovative ideas to its farming members. This has resulted in a joint initiative between HUNATiP, MA-HAL, and the Ministry of Agriculture to draft an innovation strategy for the sector.

Another breakthrough Dr Varadi points to is the collaboration between HUNATiP and the Managing Authority of the Hungarian operational programme of the European Maritime, Fisheries and Aquaculture Fund (EMFAF), whereby HUNATiP is involved in the development of the guidelines for

the evaluation of applications that seek support for innovation. At the same time Dr Varadi, Dr Halasi-Kovács, and other office bearers are promoting the idea of innovation as well as the opportunities offered by the EMFAF at meetings involving the sector. They advocate for the importance of creating not only new products, services, and ways of operating, but also new relationships and ways of thinking. One example is getting farmers to exchange information about good practices by going on field trips to visit farms within and outside Hungary. Another is rethinking the water management system in pond farms to retention the pond water in the rural landscape, or the use of data (rather than trial and error) to manage the production.

Knowledge exists but is not put into practice

Dr Varadi says that there are cases where field trials have delivered a proof of concept, but then this knowledge is not implemented. Some of our efforts should just go towards encouraging the farmers to use what is already known, he feels. Farmers also need to understand that area-based subsidies are unlikely to last forever and that greater innovation is the way forward if the sector is to thrive. Intensive aquaculture in recirculation systems, for example, already established with African catfish, would qualify as innovative if other high value species were produced like this. Support from the EMFAF should go towards discovering and deploying new times of aquaculture systems, says Dr Halasi-Kovács, so that we can increase Hungarian production. Increasing pond yields is theoretically possible but the market for larger volumes of pond-farmed fish is limited—more than half the production goes not for consumption but for restocking natural waters. Moreover, increasing yields would counteract the ecosystem services provided by ponds and is therefore

not desirable, Dr Varadi says. Hungarian fish consumption by capita is about 6.5 kg. However, less than a sixth of this (around 1 kg) comes from domestic production. Developing a market for new farmed species and introducing new systems to cultivate them in would qualify as innovative, Dr Halasi-Kovács feels.

Another area of innovation is data production and analysis. Data on ecosystem services need to be collected and processed to provide an accurate, science-based value of these services. Dr Varadi is in no doubt that both farmers and policymakers will find it useful to have credible data on the costs and benefits of ecosystem services. As climate change impacts become more intense, water management increases in importance. The Hungarian administration prioritises water retention as a way to adapt to periods of low precipitation or drought. Farmers play a critical role in water management as they know the ponds and the fish and the interplay between them. Encouraging farmers to consider themselves as custodians of the ponds rather than as pure producers would be an innovative approach, says Dr Varadi, that combines a focus on water management with fish production. The activity of cultivating fish contributes to keeping the pond in good health (not overrun with reeds, for example) as well as generating the revenue needed to cover the expense of maintaining them.

Innovation can be applied all along the value chain

Hungarian production from fish ponds has been stable unlike several other European countries where output has fallen. This was partly the result of innovations in monitoring, in nutrient management, water management, and other areas of pond production, says Dr Halasi-Kovács. Today, interest

in recirculation aquaculture systems (RAS) is increasing as they are well suited to three species groups—salmonids, sturgeons, and catfishes. Innovation in production must also be followed by innovation in processing, an area where much remains to be done, according to Dr Varadi. He attributes the lack of value-addition to the difficulties in processing fish from ponds which are five or six different species of different shapes and sizes with bones distributed in the flesh, and which are, moreover, harvested seasonally. Innovation can also be applied to distribution and sales. For example, a catfish farm has invested in mobile shops to sell its production. By positioning the shops at the same location and time week after week according to a fixed schedule, the farm has introduced catfish to remote areas enabling it to expand its customer base. The strategy could serve as a model to build interest in new species.

HUNATIP also promotes the adoption of decision support tools developed in EU funded projects, such as ClimeFish. MAHAL, which represents more than 90 per cent of Hungarian aquaculture

production, participated in ClimeFish by providing historical data and cocreating climate adaptation strategies in Hungarian case studies. Through HUNATIP's network, these tools are disseminated to producers, with onsite pilots and feedback loops to refine usability. The outcome is that farmers are not just aware of innovation—they are directly using it to guide management decisions.

Cultivating a future for pond aquaculture

Though innovation often sounds abstract, Dr Váradi and Dr Halasi-Kovács describe how workshops, publication of guides, and knowledge transfer events gradually build trust. Farmers who attend find that new technologies—such as remote sensors, adaptive feeding systems, or improved pond design—can yield savings, reduce environmental risk, and strengthen their business models. Rather than topdown directives, HUNATIP's approach uses peer learning and demonstration

plots to show what works. This is reflected in the platform's strategic partnerships. Alongside EATiP, HUNATIP works with FEAP, EAS, EUROFISH, FAO, CopaCogeca and other bodies to ensure innovation aligns with European objectives while remaining grounded in local realities. One of the greatest successes lies in these outward and inward connections—HUNATIP both elevates Hungarian innovation to a European stage and ensures European policy responds to the specific needs of pond aquaculture.

Behind the institutional role, both leaders foresee a future where Hungarian pond systems thrive through adaptability, data-driven management, and environmental integrity. Rather than supplanting tradition, innovation strengthens it—ensuring that centuries-old practices can endure in an era of climate uncertainty and changing markets. In enabling exchange between farmers, researchers, and policymakers, HUNATIP positions itself not simply as a platform, but as a linchpin in the future of sustainable aquaculture in Hungary.

Electronic surveillance of pond water parameters

With its electronics-filled buoys a Hungarian company is bringing the pond fish farming sector into the digital world.

Walise, short for Water and Life Services, is a Hungarian company founded to address the increasingly urgent challenges facing aquaculture in pond fish farms. Based in

Kaposvár, Walise has in just a few years established itself as an innovative provider of automated water quality profiling and intervention systems.

The company's origins lie in another business called Embedded Systems Hungary (ESH), which had been active for

many years designing specialised hardware solutions across a wide range of sectors, from medical devices to railway ticketing machines. As Tibor Koleszár, Walise's founder, explains, ESH functioned as a project company, solving one-off engineering problems for clients. But

when the economic climate worsened and customers could no longer invest in development, the team looked to their own ideas. One of these had been gathering dust for more than a decade: a concept for water monitoring buoys.

Mr Koleszár's personal interest in fishing and sailing meant that water had always held his attention, but he lacked the biological knowledge to know what to measure or why. The turning point came when he met a hydrobiologist specialising in fisheries ecology. He explained that climate change was creating acute problems in lakes and fish farms, from declining oxygen levels to harmful algal blooms. Mr Koleszár and his colleagues could build the technology; the hydrobiologist could define the ecological questions. Their partnership gave birth to the first automated Profiling Measurement Unit, or PMU, around 2015.

Building practical solutions for aquaculture

The PMU was a large, heavy device, weighing up to 240 kg. It was difficult and costly to deploy, requiring special equipment to lower it into the water. Realising that customers would need something more practical, the team redesigned it to be modular and transportable. Newer versions weigh from 2 to 85 kilograms and can be taken apart for easy transport in an ordinary vehicle. From these beginnings, Walise has developed a range of monitoring solutions. The PMU is still the flagship, capable of profiling water quality down to 20 metres, recording conditions at different depths to reveal stratification that can be invisible at the surface. A smaller version, the Shallow Measurement Unit or SMU, caters for shallower bodies of water, measuring just a couple of metres deep. There is also the Fixed Measurement Unit, or FMU, a compact, solar-powered station



Dr Levente Várkonyi, CSO; Mónika Cserjési, who is responsible for administration and marketing; and Tibor Koleszár, the founder and CEO of Walise.

that can be installed on a shoreline to monitor not only water but also soil and air parameters.

All devices feed into Walise's cloud-based platform. This system was originally conceived as an "early warning" tool for fish farms. Customers receive real-time notifications when parameters such as oxygen concentration or temperature cross critical thresholds. Over time, the platform has evolved into something more sophisticated. It now allows automated control of equipment such as aerators, pumps, and sluice gates. Farmers can set conditional rules so that, for example, if oxygen drops below a set point during a hot, still night, the system can activate aeration without human intervention.

Educating farmers and building trust

A major challenge Walise has had to confront is customer education. Many Hungarian fish farms historically relied only on handheld thermometers or dissolved oxygen meters, if at all. Farmers often believed that surface conditions

represented the whole pond. Walise's equipment revealed sharp differences in oxygen levels between layers, or striking variations between two ponds only metres apart, due to differences in sediment or algae. The data sometimes contradicted farmers' instincts, leading to scepticism. Typical calls to the company began with complaints that sensors must be faulty, only for handheld checks to confirm the readings. Once farmers became accustomed to the wealth of data and learned how to interpret it, many went on to purchase additional units.

This need for guidance has led Walise to work closely with universities, biologists, and associations such as the Hungarian Fishing Association (MOHOSZ). The company not only supplies equipment but also offers data interpretation, consultancy, and training. Real value lies in understanding what to do with data and Mr Koleszár expresses an ambition to develop educational resources so that knowledge can spread more widely. For Walise, raising awareness is as important as making sales. The company's clients so far are concentrated in Hungary, with a handful of installations in Serbia. Their model

has been to build personal relationships, visiting each site, studying the layout of ponds, and recommending a tailored configuration. In 2024, Walise began expanding abroad through Energofish, a Hungarian distributor with an established European network. The company presented at EFTTEX 2025, the European fishing tackle trade exhibition in Brussels, and has attracted interest from feed companies such as Aller Aqua, who see potential in monitoring to optimise feeding strategies.

Innovation for a changing climate

Walise's philosophy is encapsulated in its slogan: "Monitor, Adapt, Overcome." By monitoring, farmers gain a true picture of their waters. By adapting, they can make timely interventions. By overcoming, they prevent stock losses and maintain productivity even under stress. In an era when droughts, heatwaves, and extreme weather are becoming more frequent in Central Europe, such tools are moving from optional to essential.

The company continues to innovate. It is developing solar powered "airlifter" devices to circulate the water in stratified ponds without the need for external



The buoys are equipped with sensors that monitor a range of values including temperature, oxygen content of the water, phytoplankton levels, pH and other critical parameters (blue-green algae, ammonia, etc.).

power supplies. It is working on an autonomous boat, akin to a water drone, that can travel across large ponds to map conditions in real time. It is even testing systems to capture and analyse greenhouse gases emitted from water bodies. At the same time, the design of the buoys themselves has been refined to reduce maintenance: sensors retract out of the water when idle, so they need cleaning only once a month, saving labour. Cost remains a consideration, but Walise has positioned its products as affordable compared with large-scale marine monitoring systems designed for oceans. A full-featured PMU costs around €15,000, while the smaller SMU is about €6,500. For many farmers, this is a serious investment, but one that can be offset by avoiding catastrophic fish kills.

Climate change impacts make monitoring systems invaluable

The adoption of Walise's systems also speaks to broader environmental concerns. Hungary, like much of Europe, is facing declining water levels and rising temperatures. In some regions, ponds have run nearly dry in midsummer. In others, fertiliser runoff from adjacent fields has worsened water quality. By capturing data in such varied conditions, Walise is building not only a commercial product but also a scientific resource. Customers generally agree that their anonymised data may be used for research, helping to build a picture of climate impacts on inland waters.

Though the company is small, with only around eight employees, its network of partners and collaborators extends widely. Manufacturing of parts is handled in Kaposvár and nearby workshops, with assembly completed in-house. Software development, analytical work, and biological expertise are pooled from both employees and external specialists. This lean model allows Walise to remain agile while tackling complex problems and may enable its devices to become a fixture not only in Hungary but across Europe in the years to come.



Three of the company's models: from left, the CMU is for fixed depth measurements at 40 cm making it ideal for shallow lakes and rivers; the Shallow Measurement Unit (SMU) is used in water around 2 m deep; while the Profiling Measurement Unit (PMU) can be deployed in water up to 20 m deep.



From left, Alexandra Ferencz-Havel, Gabriella Kiss, Mónika Bojtárné Lukácsik, Ágnes Irma György

AKI collects and analyses aquaculture and fisheries data

The Aquaculture and Fisheries Analysis Department of the Hungarian Institute of Agricultural Economics (AKI) plays a central role in the collection, evaluation, and dissemination of fisheries and aquaculture data in Hungary.

The Aquaculture and Fisheries Analysis Department is both a professional research unit and a service provider to policymakers, stakeholders, and international organisations. By combining statistical rigour, economic analysis, and sectoral knowledge, the department has become the reference body for fisheries-related data and analysis in Hungary.

A department with national and international responsibilities

The Hungarian Institute of Agricultural Economics (AKI) itself has been a cornerstone of Hungarian agricultural

policy research for more than seventy years. Its mission is to provide the knowledge base that underpins food economy policy, including rural development, risk management, and market analysis. Within this framework, the Aquaculture and Fisheries Analysis Department is a relatively new but essential unit, created to bring together professional expertise in aquaculture and fisheries. Since 2024, the unit has been coordinated by Béla



Pond farms contribute to biodiversity, water retention, and flood control in addition to producing fish. Establishing the value of these ecosystem services is one of the tasks the Aquaculture and Fisheries Analysis Department is working on.

Urbányi, an agricultural engineer and the first fisheries specialist to become a member of the Hungarian Academy of Sciences. The department's mandate is both national and European. It supports Hungary in meeting its obligations under the European Union's Common Fisheries Policy (CFP) by managing the Data Collection Framework (DCF). At the same time, it provides independent analyses for Hungarian policymakers, fisheries producers, and consumer organisations. Its work bridges statistical reporting, sectoral evaluation, and long-term strategic planning.

The department is the national authority responsible for fisheries data collection under the DCF. The latest project, known as DCF3, runs from January 2024 to December 2029. It is funded entirely by a non-refundable grant of 1.39 billion forints (EUR 3.5m) under the MAHOP Plus operational programme. The project's aim is to ensure that Hungary collects, stores, and shares fisheries and aquaculture data in line with EU and national legislation. The framework covers environmental, economic, and social dimensions. Data are gathered on aquaculture production volumes, market prices,

processing, and trade. Collection extends across the entire value chain, from farm-gate prices to retail shelf prices, ensuring that trends in production costs, consumer preferences, and sectoral sustainability can be monitored. The department is also responsible for developing new methodologies, securing safe data storage, and ensuring that aggregated, non-confidential data are made publicly accessible.

Data from different sources deliver a comprehensive overview of the sector

The Institute maintains and develops several national data systems relevant to fisheries. These include:

- The Agricultural Statistical Information System (ASIR), which provides fish production and cross-sectoral agricultural data.
- The Market Price Information System (PÁIR), which tracks prices of fish products at farm, wholesale, and consumer levels.

Fish prices are collected from retail chains, markets, and specialised outlets in multiple Hungarian cities. Monthly monitoring distinguishes between live, gutted, and filleted fish. These data reveal both the seasonal role of species such as common carp—traditionally consumed at Easter and Christmas—and the growing popularity of imported salmon and other marine fish, particularly among younger consumers. The department also analyses apparent consumption, the calculation methodology used is aligned with that applied by EU member states, thereby ensuring compatibility and facilitating the comparability of data across member states. Around 80% of fish consumed in Hungary is imported, with salmon and processed marine species dominating. At the same time, Hungarian carp remains important both domestically and for export to neighbouring Romania.

Regular publications are an asset for policymakers

AKI has a strong publication record, with the department contributing annual and quarterly reports specific to fisheries. These include the annual harvest report, semi-annual reports on foreign trade, and a quarterly price report. In addition, the department produces a yearly comprehensive analysis of the Hungarian fisheries sector, covering production volumes, market processes, external trade, consumption trends, sectoral value and general financial situation. This synthesis provides the evidence base for both national policy and Hungary's input into EU fisheries discussions. Beyond official reports, the department contributes to Hungarian agriculture journals, sectoral newsletters, and Eurofish magazine. It provides country profiles, market analyses, and

news items to international platforms, ensuring that Hungarian aquaculture and fisheries are visible within the European professional community. While the department carries out the bulk of fisheries data collection, it also collaborates with external experts when needed. This may involve cooperation with Hungarian universities, although recent changes in university governance and disputes between the EU and Hungarian government have limited the ability to fund certain institutions. The department also works closely with professional associations such as MOHOSZ (Hungarian Angling Association) and MA-HAL (Hungarian Aquaculture and Fisheries Inter-branch Organisation) regarding fish price agreements and market developments.

Internationally, the department provides data to the European Commission, Eurofish, FEAP and FAO, ensuring comparability and transparency of Hungarian fisheries statistics. Its analyses were instrumental in convincing the Hungarian government to reduce value-added tax on fish products from 27% to 5%, a measure that improved sector transparency and reduced incentives for informal trade. Beyond statistical reporting, the department has begun to explore new research areas. One of the most promising is the economic valuation of ecosystem services linked to aquaculture. Pilot studies are underway to quantify the environmental benefits of pond systems, including biodiversity support and water management functions. Alexandra Ferencz-Havel, one of the department's younger staff members, is addressing this topic, which will provide new insights into the sustainability of Hungarian aquaculture. The department also evaluates the innovation potential of aquaculture production, the experiences of beneficiaries of operational programmes, and the profitability of both traditional pond systems and intensive recirculating (RAS) and flow-through aquaculture

systems. These analyses feed into the implementation of the National Aquaculture Strategy and provide guidance for investment priorities.

Team members specialise in different disciplines

The department is led by Béla Urbányi, supported by colleagues including Mónika Bojtárné Lukácsik, Ágnes Irma György, Zoltan Bokor, Alexandra Ferencz-Havel, Krisztián Szabó, Andrea Rózsa, Felföldi-Varga Viktória who bring expertise in economics, finance, statistics, communication, and ecology. The department works in close cooperation with Gabriella Kiss from the Agricultural Statistics Department of AKI, responsible for Hungarian fisheries statistical data collection. The team reflects AKI's broader tradition of interdisciplinary collaboration, with backgrounds ranging from agricultural engineering to nature conservation. While the core team is small, it coordinates a broad network of data providers, from fish farms to market monitors. It also interacts regularly with policymakers, ensuring that analyses are aligned with decision-making needs. The department faces several challenges. Fish consumption in Hungary remains low by European standards, and strongly seasonal. Younger consumers often prefer imported products over domestic carp, making market development for local pond aquaculture difficult. Price competition from cheap imports, such as occasional low-priced salmon, puts further pressure on Hungarian producers.

At the same time, opportunities exist. The pandemic years demonstrated that consumer demand for fish can rise when health consciousness increases. Ms. Bojtárné Lukácsik says that during the pandemic consumers,

the elderly in particular, turned to fish in a bid to live healthier. Home deliveries strengthened as hotels, restaurants and catering establishments closed down, but the data did not show a marked rise in fish prices—perhaps partly because Hungarian consumers are price conscious. The fish price monitoring provided the data that underpinned the decision to decrease VAT on fish, from 27% to 5%, says Ms Bojtárné Lukácsik. The VAT reduction has made the sector more transparent, and the growth of online retail and delivery services has created new channels for reaching consumers. By expanding data collection to cover processing and shelf prices, the department will provide a clearer picture of competitiveness and value creation along the fish supply chain. Looking ahead, the department aims to deepen its analysis of sustainability, integrate ecosystem service valuation into mainstream statistics, and strengthen public access to aggregated data through its online platform. These efforts will support both Hungarian aquaculture producers and the EU's broader objectives of sustainable food systems.

A vital task that benefits all stakeholders

In an industry marked by tradition, seasonal consumption, and strong international competition, the department provides the evidence base needed to understand developments in the sector and make forecasts about its direction. Whether through monitoring carp prices at Christmas, quantifying the environmental benefits of ponds, or negotiating data standards with Brussels, the department ensures that a reliable picture of the state of Hungarian aquaculture and fisheries is no more than a few mouse clicks away.

Tógazda Fish Farm – a sustainable aquaculture pioneer in Hungary

Pond fish farming in Hungary is changing character. From producing primarily for consumption, fish is now cultivated increasingly for restocking and the ecosystem services ponds provide are becoming ever more important as the intensity of climate change impacts grows.

Tógazda Halászati Zrt., led by Dr István Németh, is one of the largest and most innovative freshwater aquaculture enterprises in Hungary. Based in Somogyapáti and with ponds spread across seven counties, mostly in the region of Transdanubia in western Hungary, the company operates on 1,800 hectares of water surface. Since its establishment in the early 1990s, it has grown into the biggest private fisheries company in the western part of Hungary, with a workforce of around 70 full-time employees and a network of seasonal workers who join during harvest periods.

The scale of operations is significant: over 80 ponds are used to rear a wide variety of species, from common carp and Chinese carps to predatory fish such as pike-perch and catfish. Tógazda controls the full production cycle, from fry and fingerlings through to market fish. It sells to domestic and EU markets, supplies the angling sector,

and delivers directly to customers with its own fleet of trucks.

Balancing tradition and climate change

Hungarian pond aquaculture has traditionally relied on a three-year cycle. Fry are stocked in the first year when they grow into fingerlings, they grow to two-year fish in the second, and are harvested as market-size fish in the third. Historically, ponds were drained after harvest and refilled in spring with water from snowmelt. However, as Dr Németh explained, this method has become unsustainable. Winters now bring little snow, and springs often fail to provide enough water to refill ponds. Over the last ten years the number of dry periods has increased constantly. In fact, in the 100 ha pond in Somogyapáti, the water level is 1.5 m lower than normal due to drought. To adapt,



Dr István Németh, owner and manager of Tógazda Halászati Zrt., one of the biggest pond fish farms in Hungary.

Tógazda has changed its harvesting technology. Instead of draining ponds completely, they now harvest without releasing the millions of litres of water, which reduces water loss but adds cost and complexity. Summer harvesting requires an extra step to let fish empty their bellies of feed before they can be sold, whereas autumn harvesting—traditionally the main season—remains more efficient because fish are no longer feeding. Moreover, when draining the ponds the harvesting can be mechanised, while retaining the water calls for more manpower.

Climate change has also made fish farming riskier. Droughts and heatwaves have become more frequent, increasing pressure on stocks, particularly sensitive species such as pike-perch. The climate has changed faster than we were prepared for, Dr Németh says, adding that the company has had to rethink technology and management strategies to remain resilient.

Export markets are no longer what they were

Tógazda's annual income from fish farming is about €5 million. But maintaining this revenue has grown increasingly difficult. Prices fluctuate heavily depending on subsidy policies in neighbouring countries and the imbalance creates an uneven playing field, especially in export markets. Traditionally, Hungary exported to Romania, Serbia, Poland and Austria. But these markets are shrinking. Polish producers no longer need to import Hungarian carp. Bulgarian farms, using faster-growing intensive methods, are producing cheaper fish that undercut Hungarian exports. While Hungarian carp and pike-perch are recognised for higher quality, buyers in some markets prioritise lower prices. Cheaper fish from other countries is not the only threat—so is domestically produced meat. Pork, for example, is popular among consumers and is relatively cheap compared to fish. Although total production at Tógazda has remained stable, climate impacts force changes in the mix of produced species; less pike-perch, a high value species, for example, and more carps. This squeeze on profitability is compounded by rising labour costs. To hire and retain staff, Tógazda must pay wages comparable with other employers, among them international companies. Seasonal workers are essential for autumn harvests, but attracting reliable labour has become increasingly challenging.

To counter shrinking margins, Tógazda has embraced diversification. Beyond fish farming, it manages 12,000 hectares of hunting land across several counties, offering hunting and wildlife tourism. As part of this activity it runs the Tógazda Safari Hunting Lodge in Somogyapáti, a lakeside retreat featuring international trophy collections, traditional cuisine and wine tastings, as well as lodges in other counties. These ventures reflect a strategy of



Fish being harvested from a pond. Climate change compels water retention strategies, so the water is not drained from the pond making harvesting more labour intensive.

multifunctionality: combining aquaculture with hunting, tourism, bird-watching and gastronomy to stabilise income. This multifunctional approach mirrors broader trends in Hungarian aquaculture. With limited subsidies and environmental constraints, many pond farms rely on side activities to stay profitable. Angling, in particular, has become a crucial market. Hungary has about one million registered anglers—roughly 10 percent of the population—and Tógazda sells around 35 percent of its production into this sector. Angling organisations and producers now cooperate closely, even agreeing on indicative prices to stabilise the market.

Environmental stewardship

Tógazda is also known for its environmental commitments. Ponds are managed without antibiotics or artificial fertilisers, instead using organic methods and

Hungarian-produced feeds. Since March this year pond parameters (temperature, oxygen content, algae, etc.) have been continuously monitored by a sensor-filled buoy. Reed beds and aquatic plants are preserved, supporting biodiversity and providing shelter for waterbirds. Otters, a protected species, are accommodated by limiting disturbance during breeding seasons, while cormorants are controlled through non-lethal methods such as sound cannons. Dr Németh stresses the role of fishponds in water retention, biodiversity and climate mitigation. Covering some 27–30,000 hectares nationally, Hungarian fishponds not only produce food but also maintain wetlands, recharge groundwater, and support birdlife. He argues that subsidies should reflect these ecosystem services, especially given that monocultures such as maize fields receive more support despite offering far less biodiversity.

Despite its size and resilience, Tógazda faces the same uncertainties as the sector at large. Fish consumption in Hungary remains low—about

one kilogram of domestic fish per person annually—while imports of salmon, hake and even smoked carp from Argentina continue to rise. Supermarkets have helped normalise year-round fish consumption, but imported marine fish often outcompete local species on price and convenience. Another concern is generational renewal. Many Hungarian fish farms were founded in the early 1990s, and their owners are now approaching retirement age. The younger generation is often reluctant to continue in a sector with slim margins and high risks. Dr Németh sees solutions in professional management teams that include not only biologists but also

economists capable of innovating new business models.

A source of environmental and economic services

Nonetheless, he remains cautiously optimistic. Tógazda is investing in technology such as water quality monitoring systems, generators for electricity, and cranes which reduce the need for manpower. It has diversified revenue streams and maintained production volumes despite climate and market pressures.

And the management does not rule out a cyclical improvement in climate conditions in a few years potentially resulting in more precipitation. More generally, Dr Németh sees the biodiversity role of fishponds increasing in the future as well as their contribution to water retention. Ponds retain scarce water, recharge the water table, and modify the microclimate for the better. Apart from these ecosystem services, fish farms provide employment and contribute to attracting tourists often to remote areas thereby boosting local economies. But he is also realistic that pond fish farming with its approximately 2,400 employees will never carry the kind of political weight that agriculture or angling does.

Aquaculture research thrives at University of Debrecen

The University of Debrecen's faculty of agricultural and food sciences and environmental management includes the laboratory of fish biology and aquaculture that links classroom teaching to applied research in recirculating systems, aquaponics, hatchery practice, and extension work with anglers and pond managers.

The faculty sits on the Böszörményi út campus and delivers a broad slate of agricultural degrees in English, including agricultural engineering at BSc level and animal husbandry, crop production, and food-related MSc programmes. Aquaculture is taught not as a standalone undergraduate degree but as a specialisation in a structure that gives future fish farmers and

resource managers a grounding in biology, technology, and farm systems, before they choose a fisheries pathway. Run by two associate professors, Milán Fehér and Péter Bársony, the laboratory of fish biology and aquaculture describes itself as a modern teaching and research base serving regional freshwater needs and operating at national and international levels through research, training, and consultancy.

Close collaboration with fish farmers and anglers

In Debrecen's model, aquaculture is embedded in the five-year undivided agricultural engineering programme and related BSc and MSc pathways, rather than split off as a separate undergraduate degree. Students interested in



Prof. László Stündl, Dean of the Faculty of Agricultural and Food Sciences and Environmental Management

fisheries select a block of aquaculture and fisheries subjects; those who want deeper technical training later can return for a three-semester, postgraduate specialisation in aquaculture and fisheries. The approach reflects Hungary's labour market: demand for new pond and intensive-system managers fluctuates, and courses typically run when cohorts reach a viable size. Recognising Hungary's distinctive governance of inland waters—state ownership of aquatic resources and leased fishing rights—the faculty has also co-designed a master's-level programme for angling managers with sector partners. It targets those who run angling societies and manage reservoirs, lakes, and river stretches but lack a rounded mix of ecology, technology, finance, and legal knowledge. The first cohort graduated recently, and the faculty envisages repeat intakes to professionalise stewardship across an estate of roughly 150,000

hectares managed through more than 2,000 angling clubs. The faculty has also introduced an “animal health engineer” BSc intended to bolster farm-level health capacity across species, including fish. Graduates would not replace veterinarians but would extend veterinary guidance through prevention, monitoring, and day-to-day health management in farms and aquaculture units.

The laboratory houses recirculating aquaculture systems (RAS) at several scales—300 litres, 1,000 litres, and around 10 cubic metres—alongside two greenhouse halls dedicated to aquaponics and a containerised hatchery unit. The lab was established in 2015 and later upgraded through a major grant, with production and research areas clearly separated from filtration “hearts” built around drum filters, UV, and biofilters. The lab teaches students, runs experiments, and produces fry and fingerlings for farms under contract. Because space and water are limited, it focuses on early life stages rather than market fish. It also keeps costs down by manufacturing small batches of experimental pellets in-house—vital when commercial suppliers will not mill bespoke 10–20 kg lots.

On the aquaponics side, the team uses filtered RAS effluent to feed raft beds and ebb-and-flow troughs. Duckweed is cultivated as both a water-cleaning plant and a protein ingredient in feeds for the fish. Winter experiments often shift to watercress, which tolerates low temperatures and short days, keeping research moving through the off-season. Some of the herbs and vegetables produced in the aquaponics trials feed into the faculty's nearby food unit; basil for pesto is a favourite example.

Studies focus on fish feeds, health, and product quality

Much of the research focuses on feed formulation, digestion, and the fish microbiome. One strand replaces a portion of fishmeal with duckweed, tested at inclusion rates such as 7.5, 15, and 30 percent in isonitrogenous, isoenergetic diets dried at low temperatures to protect amino acids and vitamins. Another strand evaluates black soldier fly meal as a protein source for African catfish. At around 30 percent replacement, growth



Duckweed growing in an aquaponics system. Researchers are studying whether it could replace fishmeal in fish feed.



Dr Milán Fehér is responsible for the laboratory of fish biology and aquaculture where students and researchers are working on multiple experiments.



Dr Péter Bársony runs trials in cages placed in a lake that should benefit demand from anglers for valuable fish species such as European perch and common carp.

held steady against control diets; full fishmeal replacement is technically possible with amino-acid supplementation, but at present is uneconomic given input prices. Alongside growth, the team tracks fillet quality, fatty acids, off-flavour, and chitin effects, and it has studied microbial risks that insect substrates could introduce into closed systems. The lab targets two species for sale to farmers: common carp and African catfish. It carries out artificial propagation and rears fry and fingerlings to order,

typically selling African catfish at 3–5 g after about four weeks. Warm ground-water resources make catfish farming attractive, and Hungary has become a leading EU producer of African catfish by pairing thermal water with intensive systems. The lab prioritises spring and summer batches. Common carp work clusters in April–May; African catfish fills the warmer months. Across a production run, a single system can raise on the order of tens of thousands of African catfish juveniles per batch, with automatic feeders controlling ration frequency and incremental increases to match growth.

A short drive from campus, the faculty collaborates with the local angling association at a 60-hectare reservoir shaped like a pair of trousers where the depth in the two legs is 2–3 m versus 5–6 m in the deeper parts of the pond. The water comes via the Keleti irrigation channel from the Tisza. Here Dr Bársony operates floating cages as a semi-intensive nursery, rearing species that are hard to source in the right sizes for stocking, then releasing them directly to the water at the season's end. Trials have included European perch (*Perca fluviatilis*), tench (*Tinca tinca*), pike-perch (*Sander lucioperca*), and common carp, with feed delivered by automatic feeders and oxygen managed by pumping through the cages and adding aeration as needed. In one study, European perch was introduced at 50–60 g in May and reached around 150 g by October. The point is not only growth. By rearing fish in the very water into which they will be stocked, the programme improves acclimatisation to local temperature regimes, oxygen dynamics, and plankton communities, boosting post-release survival. The cages also serve as “recovery wards”: large, catch-and-release carp accumulate mouth injuries under intense angling pressure and can be held and rehabilitated before returning to the fishery, protecting the trophy fish that underpin the venue's appeal.

A unit that punches above its weight

The aquaculture unit is small by design but the training footprint is wide. Undergraduate, master's, and doctoral students use the facility for theses and internships that mix research with production tasks: induced spawning, sorting, diet formulation, system maintenance, and data collection. The lab hosts four to five PhD candidates at any time, and each year several BSc/MSc theses are completed on site. Because Hungary's aquaculture sector is intimate—“everybody knows everybody,” as Dr Fehér puts it—placement is often relational. Farmers call the lab when they need people; the lab vouches for students whose practical skills and attitude fit a role. Over the past decade, a steady stream of graduates has moved into intensive systems, hatcheries, and pond farms. For international students, the faculty's English-language degrees and Debrecen's campus infrastructure make the lab a convenient internship base within walking distance of dorms.

The University of Debrecen's aquaculture profile is not about scale. It is about fit: aligning teaching to the labour market; building research platforms that double as production units; designing RAS and aquaponics systems that are simple to run; and targeting research questions at the material problems of fish farming and fisheries management. This approach results in graduates who can run a hatchery experiment in the morning, adjust a biofilter in the afternoon, and brief an angling-club board in the evening. They can carry out feed trials that weigh protein prices and palatability alongside growth rates and fish welfare. And they contribute to securing the future of the Hungarian aquaculture sector at a time when interest in pond fish farming among young people in many European countries is dwindling.

MA-HAL represents all the stakeholders in Hungarian aquaculture

The Hungarian Aquaculture and Fisheries Inter-branch Organisation, known by its Hungarian acronym MA-HAL, is the umbrella body that links pond farmers, recirculation aquaculture producers, processors, traders, researchers, and educational institutions across the country.

Formed in 2017 through the merger of two legacy associations, MA-HAL represents the majority (>90%) of the national aquaculture output. The organisation has a strategic cooperation agreement with the Hungarian mirror platform of the European Aquaculture Technology and Innovation Platform (HUNATiP).

A range of functions in service of its members

MA-HAL is an interbranch organisation rather than a producer organisation. As an interbranch body, it convenes actors across the supply chain to promote best practice, gather and analyse market information, forecast production potential, support coordinated marketing, and explore export opportunities. It also contributes expert input into national rule-making, promotes fish consumption, strengthens origin and quality protection, backs vocational and higher-education training, and represents the sector in domestic committees and EU fora. Its functions include advocacy, coordination, knowledge transfer,

and the encouragement of innovation through national and EU projects. The board is chaired by president Nándor Puskás and the organisation comprises over a hundred entities, including major farms, processors, universities, research institutes, and angling organisations whose activities encompass traditional pond management to recirculating systems, product development, and market building.

Much of MA-HAL's day-to-day work is supporting a small but complex value chain. A portal on its website aggregates grant calls, legal updates, downloadable documentation, health guidance, training opportunities, and market price tools from the national research institute, making it a single point of reference for farm and factory managers. The publications section maintains current issues of *Halászati Lapok*, a trade journal, annual reports, health materials, and recipe booklets that translate sector messages for consumers. MA-HAL events mix public-facing promotion with professional networking, such as a National Fish-Cooking Competition, a Fishermen's Ball, and an Aquaculture Expo, alongside technical roundtables, fish-health training, and cross-border workshops.

The value of ecosystem services needs quantification

MA-HAL's significance is clearest when set against the profile of Hungarian aquaculture itself. The sector has two main pillars. Intensive aquaculture produces roughly 4,500 tonnes a year, an estimated 95 percent of which is African catfish, with smaller contributions from trout and sturgeon; this segment is increasingly vertically integrated from production through processing and retail. The larger pond-farming pillar covers about 27,000 hectares and yields some 18,000 tonnes of food fish centred on common carp, which accounts for roughly 82–85 percent of pond output. Pond systems are multifunctional assets. Beyond fish, they deliver ecological services, water management, and climate modulation. Holding water locally, slowing releases, and integrating pond outflows into wetlands or irrigation can buffer the country against increasingly volatile hydrology. At the same time, the biological engine of pond farming is plankton-based polyculture—an approach refined in Hungary over decades. Properly managed



Nándor Puskás (left), president of MA-HAL collaborates with Prof. István Szűcs, Director of the Institute of Economics, University of Debrecen, to establish the value of ecosystem services provided by pond farmers.

ponds generate the protein and micro-nutrients fish need from natural food webs, with limited supplemental grain and sparing use of artificial feeds. In the best managed farms, feed-to-gain ratios for grain additions can be kept to around 1.5 kg per kilogram of fish produced. This makes carp-based pond farming a low-trophic, resource-efficient model with biodiversity benefits that often exceed those of natural waters in terms of observed species richness around ponds.

Those non-productive functions are not free. Mr Puskás points out that current public support for pond multifunctionality has lagged comparable agricultural payments. Historical valuations set the worth of these ecosystem services at €204 per hectare in the 2000s under rural development funding, but current support levels are closer to

€100 per hectare while arable supports sit at roughly triple that. Together with István Szűcs, Director of the Institute of Economics at the University of Debrecen, MA-HAL is working on new calculations that recognise both ecological and climate services with a view to scientifically substantiating arguments for policy support at an appropriate level. Within pond production, herbivorous Chinese carps have lost share due to limited consumer demand at home, weak angling interest, and the disappearance of export markets that once absorbed significant volumes. This is despite the nutritional advantages of species such as silver carp, which contain polyunsaturated fatty acids. MA-HAL's response combines product development and promotion: align offerings with modern kitchens through ready-to-cook and ready-to-eat

formats, and keep promoting the healthfulness of freshwater fish.

Fostering balance between sometimes competing objectives

Policy debates around alien species illustrate the need for an interbranch voice. Grass carp is treated as an alien species under conservation law and cannot be stocked into natural waters, yet some managers argue for a more nuanced ecological assessment given its potential role in non-mechanical vegetation control. MA-HAL's forum helps keep that debate constructive, balancing conservation priorities with practical water-management needs. Climate volatility and wildlife interactions are also topics that MA-HAL is engaged in on behalf of its members. Pressure from fish-eating birds, notably cormorants, is considerable. Warmer weather allows them to hunt fish in winter as well, due to the lack of ice on the ponds. On the other hand, in warmer water the fish can be fed which accelerates growth. The sector is testing new winter-feeding regimes built around low-protein, high-energy diets with easily mobilised polyunsaturated fatty acids, alongside revised dosages and schedules. In parallel, digitalisation is moving beyond simple buoy-based monitoring toward early-warning systems that fuse in-pond data with weather forecasts to flag risk before catastrophic events occur. MA-HAL convenes the research partnerships behind these trials and helps disseminate outcomes across farms and processing plants.

Infrastructure modernisation is another priority. With precipitation patterns becoming less predictable, investments in controllable water infrastructure, water recirculation inside farm systems, and renewable energy

are advancing. The aim is resilience: keep water in the landscape, reduce energy exposure, and stabilise production for processors who need reliable raw material. MA-HAL emphasises that it is not a producer organisation in the EU sense. Many Hungarian farmers are reluctant to pool marketing, for reasons of history and trust. The interbranch model is therefore a pragmatic fit that still delivers coordination, advocacy, and shared services without requiring members to sell through a single commercial vehicle. The broad membership profile helps MA-HAL mediate between production, conservation, and recreation, especially where pond

operations intersect with biodiversity, water management, and public access. It also enables the organisation to push for the development of skills through vocational courses and continuing professional development.

Maintaining a dialogue between different interests

MA-HAL's value to Hungarian aquaculture and fish processing lies in its coverage and its range. It bundles

sector advocacy with technical coordination, quality assurance, training, events, and promotion. It moderates the debate between pond farmers and intensive catfish producers, factory managers and chefs, conservationists and water engineers. It represents the sector at home and abroad, and it offers practical tools that help farms and processors modernise in the face of climate stress and shifting markets. In a country where aquaculture's footprint is small but where ponds play outsized ecological and hydrological roles, MA-HAL plays a critical role thanks to the depth and breadth of its membership.

Angling in Hungary is highly organised

Angling is politically, economically, and environmentally significant in Hungary. Recreational fishers are organised into a multitiered structure of associations, topped by a national federation, which carry out a range of activities directly and indirectly related to fishing.

Hungary is a nation of anglers. More than a million people are registered to fish, making angling one of the country's largest mass-participation pastimes and a significant social institution. The national federation, MOHOSZ, describes itself as Hungary's largest networked civil organisation, and its activities in recreation, tourism, nature protection, and data collection gives it unusual weight in public life.

A national federation with several roles

MOHOSZ is not a simple membership body. Through a 2019 government agreement it became a public task-performing organisation, assuming responsibility for 38 state functions tied to fisheries management and angling. In practical terms, MOHOSZ coordinates access to, and stewardship of, an extensive estate of state-owned natural



**Dr István Dérer, Director General,
National Federation of Hungarian Anglers**

waters. According to Dr István Dérer, director general of MOHOSZ, the federation oversees 140,000 hectares across 1,310 water bodies, a scale that is unusual in Europe. This role sits alongside responsibilities including competitive sport, youth education, university-level training for fishery managers, and restocking programmes that favour native species. The organisational system beneath the centre is three-tier and countrywide. As of the end of 2023 it comprised 25 regional member federations, 1,186 local angling associations, and 17 special-status members, together forming a wide network for governance and service delivery on the ground.

Angling is economically relevant well beyond the value of fish. The federation's own analysis suggests that when a kilogram of fish is caught by an angler rather than bought, the total financial contribution to the economy—licences, tackle, bait, fuel, accommodation, etc.—can be roughly five times higher than the value of the fish. This is one reason MOHOSZ links angling policy to tourism, local services, and regional development. Public funding is part of the picture, but not the whole of it. Between 2014 and 2024 MOHOSZ received around HUF4.5 billion (EUR11.4 million) in budgetary support; over the same period, revenues from state angling permits surpassed HUF10.5 billion. The federation's hybrid model—state tasks, income from fishing licences, and members' contributions—underpins stocking, monitoring, digital systems, and sport events that in turn drive participation and spending.

Inputs to policymaking

The Hungarian stretch of the Danube is undammed, yet upstream impoundments and retention in neighbouring countries reduce water flow in the river. The policy response in Hungary emphasises retaining water in the landscape and MOHOSZ engages directly with

four ministries on these issues, feeding fisheries and angling interests into policy formation even though decisions rest with government. Water-scarcity compounds impacts of climate change such as drier seasons. Warmer conditions favour some predators such as European catfish, but other species face pressure from habitat alteration and winter conditions that, for instance, leave pike-perch more exposed to cormorant predation. These are not abstract trends; they show up in catch statistics, stocking choices, and the federation's list of supported species developed with scientists to strengthen biodiversity in natural waters.

MOHOSZ's stocking policy emphasises native species and ecosystem function. The federation is a major buyer of farmed fish for restocking—about a third of national aquaculture output, or roughly 6,500 tonnes per year—making it a critical market for pond farmers. The two parties, MOHOSZ and the farmers, hold discussions to maintain stability in fish prices and volumes. The ambition is to shift stocking gradually away from a carp-dominated profile, though angler preferences and the tradition of common carp consumption, keep demand high. Invasive aliens can be removed without limit, an approach that aligns angling practice with conservation objectives. Predator management is an area of practical cooperation. MOHOSZ supports non-lead-containing ammunition and controlled cormorant culling on fishponds and natural waters responding to estimates that recent cormorant consumption exceeded the total take by anglers on natural waters.

Digital transformation and compliance

One hallmark of MOHOSZ's modernisation is its digital infrastructure. The HORINFO system underpins licensing and data, while the HORGÁSZ mobile

app, launched in 2024, brings registration, the digital angling card, e-logbook functions, and online purchase of area tickets into a single interface. The app is integrated with horgaszjegy.hu, a MOHOSZ website to register anglers, so anglers log in with existing credentials rather than creating new accounts. Compliance is enforced by a large on-the-ground presence. Around 1,600 professional fish guards, supported by a similar number of volunteers, conduct licence checks, record infractions, and act as eyes and ears for water quality incidents. The federation equips many guards to take basic water measurements and to report rapidly to authorities when needed. Rules place personal responsibility on anglers for the cleanliness of their fishing spot, and local schemes—such as a paid rubbish bag service around Lake Tisza—contribute as well to the sanitation of fishing sites.

MOHOSZ runs school clubs and summer camps for thousands of children, framing angling as hands-on nature education that builds environmental literacy as well as skills. The federation also promotes fish consumption, arguing that wild or semi-wild fish from natural waters offer better meat quality than industrially farmed marine species. This nutrition message is now paired with a broader public campaign to raise domestic fish consumption, currently among the lowest in the EU, and to popularise the preparation of traditional and modern fish dishes.

Angling in Hungary is more than recreation. It is a mass civic activity that funds local environmental stewardship, teaches children about nature, shapes tourism choices, and supplies data that influence river and lake policy. The federation at its centre is part sports body, part nature service provider, part digital authority. Thanks to these different roles MOHOSZ serves Hungarian society in ways that angling federations in other countries can only dream of.

HAKI, a mainstay of the Hungarian aquaculture research establishment

Fish farming has an illustrious history in Hungary, where fish have long been grown in earthen ponds and more recently in tanks in various intensive systems. Supporting fish farmers are scientific research institutions of which MATE HAKI is one of the best-known.

The Research Center for Fisheries and Aquaculture (HAKI), part of the Hungarian University of Agriculture and Life Sciences (MATE), marks over 115 years of research, development and innovation in freshwater aquaculture and fisheries. Its mission is to lay a robust scientific foundation for sustainable fish production and management—from pond systems to natural waters—while delivering expertise both nationally and internationally.

Experimental infrastructure for most purposes

HAKI leverages a multi-departmental structure and a comprehensive gene bank to foster interdisciplinary exploration. A notable resource is its extensive experimental infrastructure, which includes 82 earthen ponds covering some 30 hectares, alongside

combined systems such as pond-in-a-pond and cage-in-a-pond arrangements. It is also home to the country's largest experimental recirculating aquaculture system (RAS) with a total volume of 160 m³, supporting intensive and precision aquaculture efforts. HAKI also hosts a gene bank for common carp and sturgeon species to conserve genetic diversity and facilitate breeding programmes. Beyond research, HAKI is involved in transferring knowledge and technology internationally. It plays a strategic advisory role in policy implementation, maintains the editorial office of *Halászat* (Hungary's longest-running fisheries journal), and hosts the annual National Scientific Conference on Aquaculture and Fisheries—held for over 40 years. The centre engages actively with FAO, FEAP, EUROFISH, EAS and other international organisations, while contributing to aquaculture development across Asia, Africa and Central America.

At the core of HAKI's expertise lies the department of fish biology, which spans both fundamental and applied



Zsuzsanna J. Sándor, head of the FISH Nutrition Research Group, Fisheries Research Centre, Hungarian University of Agriculture and Life Science

research into genetics, physiology, immunology, and nutrition. The fish nutrition research group focuses on identifying novel feed ingredients and creating innovative diets for



Cages in ponds are used for experiments in intensive-extensive aquaculture, where vegetation in the ponds neutralises the effluents from the intensively farmed fish in the cages.

freshwater species. It tests these diets across pond and intensive systems, and examines how the new diets affect fish health, meat quality and safety. Zsuzsanna J. Sándor, a senior research fellow and head of the fish nutrition research group explains how climate change influences common carp feeding strategies and indeed the feed itself. Warmer winters offer farmers the possibility to feed the carp in winter too thereby maintaining or even increasing the growth rate. However, the feed needs to be adapted to the cold rearing conditions, and Dr Sándor points to the need for further studies to establish the optimal protein energy ratios in carp feeds when water temperatures are six degrees and above.

DDGS can substitute plant ingredients in catfish, carp diets

Other experiments concerned the use of distillers' dried grains with solubles (DDGS), a by product of bioethanol production. This is a source of protein and energy and is commonly used in animal feeds. Dr Sándor's team discovered that it could substitute up to 30% of the corn or other plant ingredients with DDGS in feed for catfish. Carp gave more promising results as they are omnivorous and could handle even a 40% replacement of vegetal ingredients with DDGS. Dr Sándor is concerned, however, that hotter weather and lower precipitation

will negatively affect corn harvests in Hungary which could threaten the production of DDGS. Among the other trials Dr Sándor has been involved in, one tested the potential benefits of black soldier fly larvae oil as a component in hybrid African catfish and European catfish diets. Three diets were compared, where one with fish oil and rapeseed oil in a 1:1 mixture was the control; the second substituted 50% of the fish oil rapeseed oil mix with larvae oil; while the third replaced the fish oil rapeseed oil mix completely with larvae oil. The results for both species showed similar fish growth between dietary groups, but levels of omega-3 fatty acids in the body decreased and those of omega-6 fatty acids went up with the increase in larvae oil inclusion.



A recirculation aquaculture system allows HAKI researchers to conduct experiments with species cultivated intensively, such as African catfish.

Parallel with this a general tendency was observed in antioxidant capacity of liver, indicating that dietary use of black soldier fly oil could be associated with potential health benefits for fish. Taken together with other results, the study showed that black soldier fly larvae oil was a suitable alternative to fish and vegetable oils.

Another study looked at the impact on growth performance and reproductive success in common carp when feeding it on different diets, one without fishmeal or fish oil but with vegetable meal and linseed oil; another feed had moderate levels of fishmeal and fish oil, while the third was a traditional cereal-based diet composed primarily of winter wheat. The results showed that the traditional cereal-based diet was less efficient than either of the other two diets which had comparable outcomes. However, the use of linseed oil in the diet had a detrimental effect on gonadal development and the researchers advised against the use of a linseed-oil-supplemented plant-based diet for common carp being raised as broodstock.

Optimising fish farming technologies

Key research areas at the department of aquaculture technology include intensive culture methods for percid species, common carp, and sturgeons, broodstock management and artificial reproduction, juvenile rearing techniques for both fattening and restocking, species and technologies diversification in combined pond-RAS production systems, and modelling to optimise technology, inputs and climate adaptation strategies. Current ongoing research includes experiments to intensify common carp pond production. This species is traditionally grown rather extensively in ponds, and intensification would shorten the production cycle and reduce emerging wintering risks of bird predation and illness susceptibility in one summer-old juveniles. The department also aims to demonstrate to sturgeon farmers the effects of environmental enrichment

during larviculture for juvenile restocking in natural waters. Likewise, the department developed methods for triploidisation of pike-perch and its hybrids with Volga pike-perch, testing and documenting its feasibility for both farming and surrogate production purposes. Uroš Ljubobratović, the head of the department, has his main research background in the reproductive cycle management of domesticated pike-perch. His recent study demonstrated differences in gametogenesis dynamics in pike-perch populations originating from different latitudes when reared in common conditions. The department's most recent research focuses on the spawning behaviour of two nesting species, pike-perch and largemouth bass, defining and implementing behavioural ovulation indicators to improve fish welfare and commercial feasibility of artificial reproduction.

The department of hydrobiology centres its research on sustainable recreational fisheries. It develops sampling techniques tailored to these fisheries by combining conventional approaches with hydroacoustic and molecular methods. It assesses the ecological impacts of invasive species—such as bullheads, gobies, and the Amur sleeper—and designs potential eradication programmes. Additionally, it evaluates the effects of recreational fishing practices—like ground-baiting, increased fish biomass and catch-and-release—on nutrient dynamics in lentic habitats. In support of sustainable pond aquaculture, the department examines how effluent water influences zooplankton and macroinvertebrates in adjacent ecosystems, explores links between farming technologies and pond nutrient cycling, and assesses the ecosystem services offered by pond-based aquaculture.

With its research infrastructure, tradition for scientific investigation and, above all, its people, HAKI offers solutions to the constantly evolving challenges faced by the freshwater aquaculture industry.



Kristine Mame (Oskars Kalpaks Secondary School, Liepāja)

Latvian and German participants at an international youth camp dedicated to fisheries held in Jūrmalciems, Latvia in July this year.

Fisheries in focus at international Baltic Sea youth camp

Teenagers from Latvia and Germany visited a traditional fishing centre to learn how to preserve coastal fisheries customs while using new technologies to adapt them to the modern day.

In July this year, Jūrmalciems on Latvia's Baltic coast hosted an international youth summer camp, bringing together teenagers from Latvia and Germany to explore the past, present, and future of fisheries. Dedicated to coastal and inland fishing and supported by the Latvian Fish Fund, the camp marked its tenth edition in the past nine years. In total, 30 young people aged 14 to 18 took part—22 from Latvia and 8 from Germany.

From Soviet traditions to 21st-century challenges

Jūrmalciems is one of Latvia's traditional fishing centres, where coastal fishing practices established during Soviet times have been preserved. Youth camps were already organised here in the 1990s and early 2000s, and in recent years they have taken place along the Baltic Sea and Gulf of Riga coastlines,

involving young people from Latvia, Lithuania, and Germany.

The camp aimed to raise awareness among young people and teachers about the historic fishing traditions of Jūrmalciems, while also presenting modern solutions and showcasing how local customs can be enriched with new technologies. Participants explored the history of fishing, current challenges in the sector, and opportunities for future development. They also learned about the latest research on Baltic Sea

fish stocks. A central ambition was to inspire them to imagine new business opportunities linked to fisheries.

Tourism and innovation as lifelines for coastal communities

The number of coastal fishers in Latvia has plummeted—from 250 in 2004 to just 140 in 2025, according to the Ministry of Agriculture. With the average age of fishers rising, it is becoming increasingly difficult to introduce new technologies and modernise the sector. One solution is to combine fisheries with other industries, such as tourism. This not only helps preserve the identity and heritage of coastal communities—both tangible and intangible—but also creates new economic opportunities.

Jūrmalciems is more than just a modern fishing centre—its history is closely tied to the development of Latvian coastal fisheries. In 1937, the community landed 561 tonnes of cod, making it the second most productive fishing site in Latvia after Liepāja. That same year, President Kārlis Ulmanis visited Jūrmalciems, showing deep interest in the lives and needs of the fishers. He praised their achievements and suggested using seaweed as fertiliser to ensure good harvests in sandy coastal soils. The visit reinforced the idea that in Jūrmalciems, the coastal way of life could thrive with national support.

Today, Jūrmalciems' fishing traditions blend with innovation. Local fishers such as Oskars Kadeģis, Jānis and Dzintars Ziemelis, and Ivars Roga are working to preserve their heritage while adopting modern technologies and comforts. Knowledge gained abroad has helped them create a more attractive environment for younger colleagues. The Latvian Fishermen's Federation works closely with teachers from the Oskars Kalpaks Secondary School



Kristine Maime (Oskars Kalpaks Secondary School, Liepāja)

Located on the Latvian coast, Jūrmalciems, the site of the youth camp, has a long history of youth camps and an even longer one of fisheries.

in Liepāja and certified camp leaders to ensure that the younger generation is educated on Baltic Sea fisheries and ecological issues. For coastal fishers, compared to large trawler owners, it is especially important to preserve traditional knowledge and pass it on. This includes exploring e-technologies, short supply chains, logistics solutions, and in the future, the use of artificial intelligence.

Hands-on learning from experts and fishers

The camp featured experts from the Ministry of Agriculture's Fisheries Department, BIOR, the Nature Conservation Agency, the State Environmental Service, the University of Latvia, Riga Stradiņš University, Riga Technical University, the Latvian Fishermen's Federation, and the Latvian Environment, Geology and Meteorology Centre, as well as certified nature guides and coastal fishers. Guest speakers included well-known Latvian TV host and angling champion Normunds Grabovskis, biologist and journalist Māris Olte, and representatives of the Latvian Rural Advisory and Training Centre.

The programme included lectures on the competitiveness of Latvian fisheries and Baltic Sea fish stock research; exploration of the ecosystem-based approaches to fisheries; practical work such as seine hauling and fish fry counts; discussions on defending the rights of coastal communities; master-classes in fish smoking and making fishing gear; as well as excursions to learn from coastal community development.

Stories, skills and films—youth share their vision

Participants were tasked with creating a video and an educational session about the fishers of Jūrmalciems and their efforts to preserve and develop their traditional way of life. These were presented to teachers and pupils in Liepāja and Paderborn (Germany) and published on Facebook and the regional media outlet liepajniekiem.lv. The organisers hope the camp will inspire similar initiatives across Europe, encouraging cooperation, knowledge exchange, and greater engagement of young people in the fisheries sector.

*Ēvalds Urtāns,
Latvian Fishermen's Federation*

EU support helps save Latvia's coastal fisheries

Since 2022, Latvia's coastal fishers have had access to direct development support from the European Maritime, Fisheries and Aquaculture Fund (EMFAF)—the first time such targeted aid has been available. This has not only helped the sector survive but also significantly boosted revenues.

Coastal fishing in Latvia is relatively small-scale, providing local communities with jobs and fresh fish for the local market. Out of Latvia's average annual catch of 49,000 tonnes, only about 3,000 tonnes (just over 6%) are landed by coastal fishers. Officially, 140 coastal fishers are registered, but in reality no more than 50 depend on it for their livelihood. Over the past decade, their numbers have fallen by a third. The work is tough, income unstable, and fishing opportunities are limited by both weather and strict national regulations. For example, in the Gulf of Riga a full ban for 2.5 months each year restricts coastal fishing, while seals increasingly damage gear and catches. As a result, many fishers abandoned the trade and sought work abroad.

Lobbying pays off

Five years ago, the outlook began to change. The association *Mazjūras zvejnieki* (Small Sea Fishers) lobbied successfully for a special EMFAF programme, *Support for Coastal Fishers*. Initially funded with €2.3 million—later topped up with another €1 million—the scheme provided grants of up to €30,000 per

project, fully funded and paid in advance. Despite the modest size of the programme, it has revived many small-scale fishing enterprises and restored faith in the sector's future. Data from the Rural Support Service (RSS), which administers the scheme, show that revenues of 45 supported companies rose from €1.14 million to €2.06 million over four years.

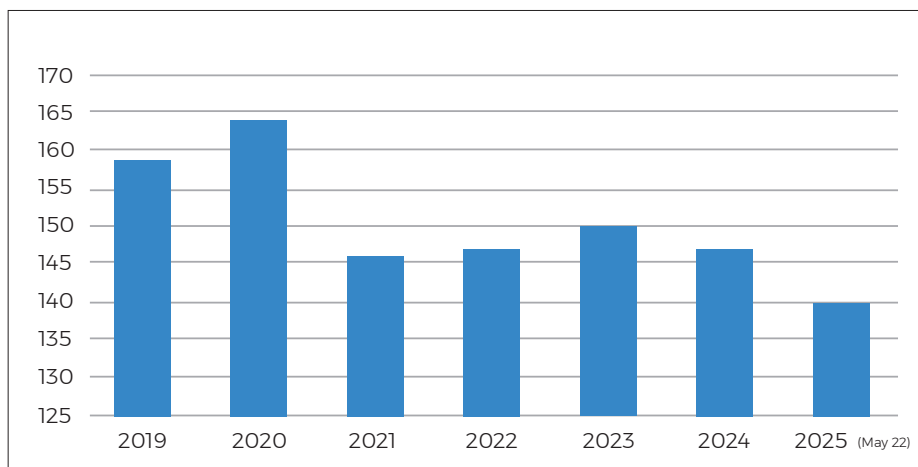
Rinalds Vācers, Director of the RSS Fisheries and State Aid Department, explains that previously, coastal fishers had almost no access to EU support, which undermined the sector's survival. Now, investments enable them to process the fish themselves—chilling, gutting, smoking, vacuum-packing—and sell at a higher value. At a time of declining fish stocks, he says, every fish matters. Support has also funded more selective, seal-safe fishing gear and improved working conditions. Equipment has been purchased to make handling nets easier, and vehicles for transporting fish and gear have been acquired, among other improvements. For the first time since EU accession, support has reached coastal fishers in a way that gives them and their families hope that fishing can still provide a living—and the belief that fishers are needed, Mr Vācers says.



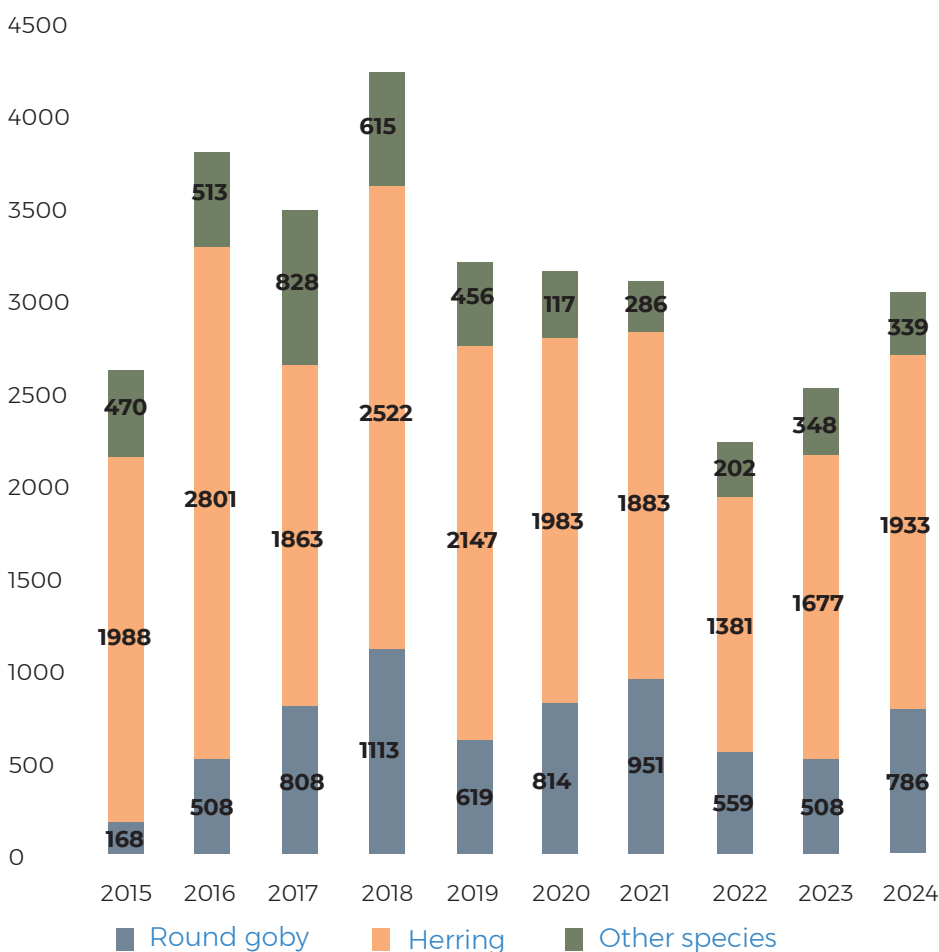
Andris Cīrulis, Chairman of the association "Mazjūras zvejnieki", stresses that coastal fishing in Latvia is environmentally friendly and carried out by only a few dozen fishers.

From wheelbarrows to quad bikes

Edgars Zviedris, a ninth-generation fisher from Saulkrasti, recalls how a few years ago he pushed his nets to the sea in a wheelbarrow never dreaming he would one day afford proper transport. Through three projects under the coastal support scheme, his enterprise *Silzviēdri* has bought a quad bike for hauling nets and catches, a trailer for selling fish, an ice machine, and storage containers. His income has doubled in three years, allowing him



Officially registered coastal commercial fishers in Latvia



Latvian coastal catches, tonnes

not only to support his family but also to modernise gear.

Across the Gulf of Riga, Ivars Cīrulis of *Ivars C* has also carried out three projects, purchasing a quad bike, a computer for catch reporting, a small processing unit, and a refrigerated van with EMFAF and LEADER support. The van allows him to transport fish from more distant fishing grounds near Ventspils back to his home and markets in Riga. “I could never have earned enough from fishing alone to buy all this equipment, which now makes my work easier and provides a more reliable income,” he says.

Ongoing challenges—and new threats

The association *Mazjūras zvejnieki* has been central to these successes. Its chairman, Andris Cīrulis, was awarded the national prize “*Lielais loms*” in recognition of his work. The group has launched the website www.piekrasteszivis.lv, awareness campaigns on fish consumption, and cooperates with research institutions on new selective, seal-proof fishing gear.

Yet looming EU control regulations, due in 2028, are raising alarm. Requirements such as species-level catch reporting at sea, electronic weighing and labelling, and GPS tracking of transport are seen as unrealistic for Latvia’s small-scale fishers, who typically work in 4–8 metre open boats with only basic equipment. The officials who wrote these rules clearly don’t realise our fishers go out in tiny boats on open seas, says Mr Cīrulis, “I’d gladly take them out to show what our work is really like.” For Latvia’s few dozen remaining coastal fishers, the hope is that recent EU support will not be undone by impractical regulations.

Iveta Tomšone
Head of Publications, Latvian Rural
Advisory and Training Centre

New EU rules, declining fish stocks, threaten Latvian fisheries

The Latvian fishing industry is calling for more resources to be invested in studying the causes behind changes to the Baltic Sea ecosystem.

Like their counterparts elsewhere in the Baltic, Latvian fishers face growing challenges from European Commission decisions. One key change came into force on 9 January 2024, when Regulation (EU) 2023/2842

amended the EU fisheries control framework. The rules, phased in until 2028, include stricter requirements for landing and weighing catches. From July 2024, the margin of tolerance in catch reporting was reduced to 10% per species, rather than 10% of the total

catch. This has hit the Baltic Sea fisheries hardest, particularly in the Gulf of Riga where, in addition to sprat and herring, fishers also target five other species. Many fear they face a choice between compliance and giving up fishing altogether.



Stricter EU rules governing landing and weighing are a source of concern in particular for fishers operating in the Gulf of Riga.

Length	Type of gear	Number of vessels			Total fleet catch in 2024 (%) of catch quota		
		31.12.2023	Active in 2024	31.12.2024	Cod	Sprat	Herring
VL1218	Trawler	9	9	9	0	3	27
VL2440	Trawler	33	27	28	0	97	73

Description and segmentation of the Baltic Sea (including the Gulf of Riga) offshore fleet in 2024

Seeking workable solutions

To mitigate these impacts, a working group was quickly formed, including representatives from the Ministry of Agriculture, the scientific institute BIOR, the State Environmental Service, and fishing organisations. Negotiations with the European Commission secured more flexible weighing procedures, based on five samples per landing, valid until the end of 2026. Looking ahead, one option is to obtain EU-recognised port status, which would allow to use the previous tolerance of 10% of the total catch. So far, only one certified landing site exists in Ventspils, while challenges concerning the separation of fish from ice prior to weighing remain.

In 2023–2025, Latvia reduced overcapacity by scrapping eight inactive vessels, and one vessel will be scrapped in 2026, from the VL2440 offshore trawler segment, in line with fleet balancing requirements.

But the future of the fleet depends on fish stock levels. According to ICES

data, stocks continue to fluctuate. Once considered stable, Gulf of Riga herring is now assessed to be in sharp decline for 2026.

Need for more research on environmental changes

Industry representatives stress that ecosystem changes—factors beyond their control—are having severe effects on Baltic fish stocks. Cod has been off limits for a decade, and other species now appear at risk. State institutions should allocate more resources to scientists so they can investigate the causes of these ecosystem changes that directly affect fish stocks in the Baltic Sea, they say. The industry is represented by two organisations, The National Fisheries Producers’ Organisation (Nacionālās zvejniecības ražotāju organizācija, NZRO), and the Latvian Fishermen’s Association (Latvijas Zivsaimnieku asociācija, LZA). The former is a

Europe-recognised producer organisation uniting Latvia’s 12 largest fishing companies which it represents at both national and EU levels, while the latter brings together all Latvian fishing companies operating in the Baltic Sea and the Gulf of Riga.

Latvian fishers were pioneers in certifying Baltic sprat and herring under the Marine Stewardship Council (MSC) standard. This allows them to use the blue MSC label and access premium export markets. Today, Latvia is the only country with an MSC certificate for herring in the Gulf of Riga. A new audit this autumn will extend certification for another five years, while MSC certification of Baltic sprat is expected by the end of 2026.

Investment and innovation

Latvia’s fishing companies continue to invest in new equipment and facilities under the EMFAF 2021–2027 Fisheries Development Programme, with €10 million already committed. Plans for 2025 include new repair facilities for vessels and fishing gear. However, the sector highlights a lack of EU support for renewing vessels themselves which stands in the way of creating a more sustainable fleet.

Viesturs Ulis, Chairman of The Board

The National Fisheries Producers’ Organisation (Nacionālās zvejniecības ražotāju organizācija, NZRO)



The future of the fleet depends on fish stock levels which continue to fluctuate.

How much of the fish eventually reaches the consumer?

While global fisheries landings have remained stable for decades, the volume of fish and seafood on the world market has been steadily increasing due to the rise in aquaculture production. In theory, it could be significantly higher, as valuable material is wasted and lost at every stage of the processing chain, from the point of origin to the plate. This indicates untapped potential that can still be harnessed.

According to the Food and Agriculture Organization (FAO), global fisheries and aquaculture production reached a record high of 223.2 million tonnes in 2022, worth a record USD 472 billion. However, these data also include algae and aquatic plants, which can distort the picture. Nevertheless, the production of aquatic animals alone reached a record level of 165 million tonnes in 2022. This means that since 1961, the available quantity has grown almost twice as fast as the world's population. In 1961, the global per capita availability of fish and seafood was just 9.1 kg per year, whereas by 2022, it had risen to an estimated 20.7 kg. This is in stark contrast to the predictions of empty seas and the imminent collapse of fish supply. Equally exaggerated are the claims regarding non-food uses, i.e. the proportion of seafood that is not used directly for human consumption. In 2022, it continued to decline, reaching only 20.8 million tonnes. Around 83% of this was used to produce fishmeal and fish oil. The fact



It is estimated that up to 35% of global fisheries and aquaculture production is lost during its journey from the source to the end consumer.

that fishmeal and fish oil volumes have remained almost the same is mainly due to the increased use of slaughterhouse waste and other by-products. They accounted for 34% of fishmeal production and 53% of fish oil production. The

main conclusion is positive: significant progress has been made in the trend towards the full utilisation of fish and seafood for human nutrition.

Accordingly, the outlook for fish supply in the coming years is optimistic.



'Food loss and waste' refers not only to inexpensive and less popular species, but also to popular and high quality fish.

According to FAO experts, it is expected to increase by 10% to 205 million tonnes by 2032. This will be mainly due to the expansion of aquaculture production to 111 million tonnes, but fisheries will also contribute 94 million tonnes. With this solid foundation, annual per capita consumption is expected to increase to 21.3 kg on average by 2032. And this will happen worldwide, on all continents. The only exception is Africa, particularly sub-Saharan Africa, where there are concerns about a potential decline in seafood consumption. According to the FAO, there are likely to be other significant shifts in the global seafood market. Rising incomes, urbanisation and changing dietary trends in many parts of the world are already having a significant impact on global trade flows. For example, the combined consumption of aquatic food products in Europe, Japan and the US fell from 47% to 18% of the total market between 1961 and 2021. Over the same period, the market shares of China, Indonesia and India rose from 17% to 51%. Since these countries are also major seafood producers, this is expected to have significant implications: while global exports of aquatic products accounted for 38% of total production in 2022, their share is projected to decrease to 34% by 2032.

Estimates instead of hard data

As impressive as these figures and the forecasts derived from them may be, much of it is unfortunately based on speculation. This is because the database lacks completeness, accuracy and thus reliability, a shortcoming that more or less limits the credibility of some FAO forecasts. For example, in 2022, around half of the 208 countries with aquaculture production did not report any data to FAO. The ratio of non-reporting producers to total producers was 27:52 in Africa, 25:48 in the Americas, 22:48 in Asia, 8:40 in Europe and 17:19 in Oceania. Due to a lack of reports, the FAO could only provide approximate estimates for the corresponding data in these cases. For aquatic animals alone, this amounted to 13.3 million tonnes, and for algae to 736,900 tonnes.

Although these statements refer only to aquaculture, it can hardly be assumed that the situation in fisheries could be fundamentally different. Especially since there is an even greater

risk that even the official reports contain some inaccuracies and errors. The sea is known to be wide and the night is dark, making control difficult. Small-scale, subsistence and recreational fishing cannot be fully and comprehensively monitored. There is also illegal, unreported and unregulated (IUU) fishing, the black catches of which can only be roughly estimated. Transshipments at sea are as difficult to monitor as landings in foreign ports, making it difficult to collect data on catches and trade statistics. Some countries do not even have vessel registers, which seriously undermines the quality of catch statistics. Missing, incomplete and poor quality data obscure the true situation and often result in erroneous assessments of the performance of fisheries and aquaculture.

Food loss is an untapped reserve

Despite these difficulties, the FAO is the only reliable source of global fisheries and aquaculture statistics. Its FishStat



Weight of discards in the North Sea and Baltic Sea from 2000 to 2019 (in 1,000 tonnes).

trade and markets

database is mainly based on annual data from national sources. Where national reports are missing or contain insufficient or contradictory data, FAO experts estimate the figures based on the best available sources using recognised methods. This does not rule out minor errors but does allow for basic conclusions and statements to be made. One of these, for example, is the depressing realisation that, in total, up to 35% of global fisheries and aquaculture production is lost annually on the way to and from the end consumer. Therefore, the target of a 10% increase in fish and seafood production by 2032 could potentially be achieved right now if we succeeded in eliminating the unnecessary waste of more than one-third of these valuable resources. The UN's Sustainable Development Goal SDG 12.3 therefore calls on the international community to halve post-harvest losses in production and supply chains by 2030. It is an understandable and reasonable demand, but it requires enormous effort to implement. This is because reductions do not depend on a single factor or a single change, such as the introduction of more efficient technologies. Minor errors and inefficiencies occur almost everywhere in value chains and contribute to these losses.

A complex approach is needed that not only holds politicians and



Material and value losses occur to varying degrees at all levels of the processing chain.

legislators accountable, but also requires the expansion of the required capacities and takes into account technological advances and socio-economic aspects. In order to develop appropriate strategies to reduce food loss and waste (FLW), a careful analysis of the baseline situation is needed first:

- Where and when does FLW occur?
- What are the reasons for this?
- How extensive is the waste and what are the economic consequences?
- Which stakeholders and interest groups are most affected?

Discard information is often speculative

Previous studies in this area have shown that the FLW rate can be reduced not only by minimising physical losses of fish in the processing chain, but also by making better use of fish by-products and their nutrients. Fish by-products can be used, for example, for fish silage or feed and fertiliser. They are rich in protein and often contain an abundance of essential amino acids. Some ingredients can be used as additives in the food industry, pharmaceuticals, cosmetic products, or in the manufacture of clothing and leather products. Even recycling as biodiesel is still more sensible than environmentally damaging dumping.

When it comes to the waste of resources, by-catch and discards in fisheries are the first things that come to mind for many. Every year, 90 million tonnes of fish are caught worldwide. However, as is well known, this is only a fraction of the actual catch, as most fisheries also have unwanted by-catch, sometimes referred to as secondary catch, in addition to the target species, no matter how selective the fishing gear is. A significant proportion



While the by-catch rate for many pelagic fish species fluctuates on average by only two per cent, in shrimp fishing it can reach almost 90% in extreme cases.



Separate collection of the individual components is often a prerequisite for the economic use of slaughterhouse waste and by-products.

of this has been and is being dumped back into the sea, thus being lost to alternative uses. Discards affect not only of by-catch species, but sometimes also target species, for example if they are too small, in poor condition or difficult to market. Sometimes there is simply not enough space on the fishing vessel to take the catch on board.

For a long time, by-catch and discards were largely overlooked in fisheries assessments. However, as environmental awareness has grown and concerns about overfishing and sustainability have gained increasing public attention, the issue has become a significant topic of focus. It has now been argued that this is a waste of resources, when attempts were made to quantify the biological, ecological, economic and cultural impacts of discards. If catch and landing volumes cannot be determined accurately, this is even more impossible for by-catches and discards. Based on the little data available at the time on the subject, Alverson et al. 1994 (FAO. No. 339) estimated that by-catches and discards from commercial fisheries range from 17.9 to 39.5 million tonnes per

year (average 27.0 million tonnes). The wide range of figures alone shows how uncertain the authors themselves were in their estimates. Nevertheless, an initial estimate was now available and understandably caused a stir. Around 40% of the world's catch is thrown back into the sea, dead or dying. The study proved useful to NGOs critical of the fishing industry, and they have since used it as an argument to accuse the industry of being wasteful and overly driven by profit. Especially since the economic losses,

which probably amounted to many billions of dollars, were compounded by ecological damage that could hardly be quantified.

Landing requirement is also controversial

Regardless of the polemics and populism, by-catch and discards are more than just a nuisance. They distort the stock assessment database and are a source of error in the calculation of fishing quotas. As a result, since the 1990s, by-catch recording has become a focus of research in fisheries biology, leading to somewhat more accurate estimates. Observers travel on fishing vessels and collect data. In addition, electronic technologies are employed to monitor fishing activities, and logbook data, along with voluntary information from fishers, is collected. This has significantly improved our understanding of the situation at sea, although there are still some areas where the data is still rather inaccurate and speculative. Based on data from 1992–2001, Kelleher (2005) estimates that an average of 7.3 million tonnes of fish are discarded worldwide. Discards vary considerably by region, species and fishing method.

Even this much more reliable figure is not accepted by everyone. Some

Continent	Production (wild-capture fisheries)	Processing (on land)	Retail	Food service (HoReCa)	Household consumption
Africa	3,18	3,93	1,71	1,44	0,15
Asia	14,04	15,66	4,42	0,56	2,32
Europe	6,33	17,51	3,47	0,85	3,64
North America	2,96	6,96	0,35	1,16	0,94
Oceania	0,60	1,23	0,04	0,04	0,04
South America	2,57	3,59	0,10	0,10	0,10

Percentage loss of edible aquatic food worldwide by continent and at key nodes in the value chain.



Unlike in rich industrialised countries, where fillets and loins are preferred, fish in other parts of the world is often prepared whole.

believe it to be relatively close to reality, while others doubt the figures and suspect that they are too low. However, it cannot be denied that discards have fallen in recent years due to more selective fishing gear, changes in regulations and better use of by-catch. The EU's fisheries policy also aims to end wasteful discarding practices and introduced a landing obligation in 2015, which has been in force since January 2019. Since then, the principle of 'you catch it, you keep it' has applied. All catches from stocks subject to a catch quota (TAC) must now be landed. However, the consequences of this requirement seem to have made some former critics change their views. In particular, ornithologists among conservationists are now warning that a ban on discarding fish at sea could also harm the marine environment, because other species now lack a food source. North Atlantic seabird populations are already declining, and the lack of food is tempting skuas to snatch puffin prey. The previously criticised 'waste of resources' is correct from an economic point of view, but for natural ecosystems, the discard is by no means 'waste'. The total energy is preserved as the discarded fish serve as food for other animals, such as seabirds and crabs. Some authors also point out that by-catch in nets is often made up of predators of the

target species. They follow their prey, so the simultaneous removal of prey and predators somehow balances out their relationship in the ecosystem.

Many options for solving the problem

The second largest source of losses in the value chain after discards is the processing of fish on board fishing vessels and on land. A considerable proportion of the catch is lost through gutting, de-heading, filleting, trimming and skinning. Whether it ends up as waste or is recycled in a meaningful way depends on several factors. Cultural and geographical differences also play an important role. The demand of regional markets and the dietary preferences of local consumers also influence the type and quantity of waste. In general, in countries with higher incomes, convenient and easy-to-eat products such as fillets or loins are preferred, which reduces the yield of fish parts consumed. By contrast, in countries with lower incomes, people tend to eat whole fish. It is less wasteful than consuming semi- or only partially processed products. Nevertheless, when all factors are taken into account, Asian countries still account for the highest post-harvest losses of aquatic food, at 37%. This is due not to consumption, but to losses during transport and storage. Europe is close behind, with almost a third. At the other end of the scale is Oceania, where, according to FAO data, less than 2% of the edible portion of fish and seafood is lost.

Food losses occur at almost every level of the processing chain. A 2021 report by the World Economic Forum estimates that we lose around 10–12 million tonnes of fish and seafood each year due to lack of refrigeration, improper storage or processing errors. Other sources put the loss of edible aquatic food as high as 23.8 million tonnes. These are only rough estimates, but they show the scale of the

problem. Basically, all areas of the chain are affected, albeit to varying degrees. This ranges from excessive transport times and incorrect storage without adequate cooling to pest infestation that renders fish products unusable in many parts of the world. It is estimated that sun-drying alone accounts for around 30% of the world's fish losses due to infestation by blowfly and beetle larvae. Not only is there a lack of know-how and suitable processing technology for handling and preservation on board and on land, but also quite often a lack of the general logistical conditions. In some areas, the power supply is unstable or even non-existent. Access to hygienic drinking water is not guaranteed everywhere, and the poor state of the road network complicates and delays the transport of perishable goods. Lack of cold storage makes it difficult to maintain a continuous cold chain, often requiring indirect methods to preserve the product. In retail, losses occur when a fish is not sold in time and exceeds its sell-by date.

These few examples show that good intentions and greater care on the part of those involved are not enough. Massive investments are needed to reduce food loss and waste. This is especially true for fish and seafood products, which are among the most widely traded foodstuffs worldwide, and which require appropriate logistical conditions. According to FAO forecasts, 181 million tonnes of aquatic food will be traded and consumed annually worldwide at the regional, national and international level by 2030. The more often a product is reloaded and temporarily stored en route from the producer to the end user, the higher the risk of damage or spoilage. Even in professional restaurant kitchens, fish and seafood are sometimes lost due to improper handling or human error in preparation. Despite taking great care, millions of ambitious amateur chefs in home kitchens also experience this. Reducing fish losses therefore remains an ongoing challenge for all of us.

Manfred Klinkhardt

Portugal has the prerequisites for a robust aquaculture sector

Portugal is a country that is traditionally associated with high capture seafood consumption, but the popularity of farmed fish and seafood is increasing. The combination of an extensive Atlantic coastline, favourable climatic conditions, and rich marine biodiversity provides strong foundations for growth of the aquaculture sector.

Shellfish farming has deep roots in Portugal and continues to thrive in the present day. The Algarve's Ria Formosa is a hub for clam farming, particularly for the grooved carpet shell clam, which remains a key product for both national and international markets and represented more than half the aquaculture production value in 2023. Mainly produced in small farms in intertidal zones and estuaries, typically less than 1 hectare in size, production volume reached 5,900 tons in 2023, valued at €115 million. This represented 26% and 53% of the total volume and value produced, respectively. Mussel farming, a traditional practice in coastal and transitional waters, is another area of strength. Portugal produced around 3,300 tonnes in 2023, and the sector has been boosted by certified organic production and a strong export orientation. Oysters, especially from the regions of Aveiro, Setúbal, and the Algarve, have similarly become increasingly sought-after, particularly in gourmet markets and among French buyers.

Fish farmed in both marine and freshwater

Regarding the production of marine fish, the most significant species cultivated is gilthead seabream, with production volumes reaching 4,100 tons in 2023, an increase of 22% since 2022. At the same time, Portugal is also a major producer of flatfish, where production of turbot and sole respectively reached 3,200 and 700 tons in 2023, generating a production volume of €46 million. The third major marine fish-species produced is European seabass. Production reached 1,700 tons in 2023, marking a 15% increase since 2022. Historically, freshwater species were the first to be farmed commercially, and they remain relevant to domestic supply despite representing only 0.5% of the total production value today. The most significant of these species is rainbow trout. It is farmed on a small scale, and production has fluctuated over the years due to drought. Production levels are down 67% since 2020.

Production techniques reflect a mix of traditional practices and innovative

technologies. Floating cages are commonly used for species such as seabream and seabass. Bottom culture methods are widely applied to shellfish farming, such as clams and oysters, and are valued for their environmental friendliness and reliance on natural processes. More advanced approaches include Recirculating Aquaculture Systems (RAS), which allow species like flatfish to be raised in controlled environments with minimal water use, and Integrated Multi-Trophic Aquaculture (IMTA), where fish, shellfish, and algae are cultivated together to promote resource efficiency and reduce negative ecological impacts.

Taken as a whole, the industry consists of 731 enterprises in 2022, 93% of which employed only five or fewer people. Overall employment reached 2,014 people, but in full-time equivalents only 1,511, reflecting the widespread use of seasonal and part-time work. Shellfish aquaculture was the largest employer, followed by marine aquaculture, with freshwater farming employing very few workers. In 2023 extensive production methods represented 58.5% of production, while semi-intensive methods



Aquaculture in Portugal includes finfish and shellfish farming. Pictured, bags containing oysters for which there is lively demand in France.

represented 10% and intensive methods represented 31.5%. In total, aquaculture production has increased by 19% between 2022 and 2023, with an increase of production value of around 40% from €154 million to €214 million. While Portugal only ranks 11th out of all EU countries in production volume, it has climbed to fifth place in terms of production value.

Environmental and market challenges hinder development

Despite its growing importance, Portuguese aquaculture faces a range of significant challenges. Environmental concerns remain at the forefront, where the expansion of aquaculture

risks increasing the pressure on marine and coastal ecosystems, particularly when farms compete for space with tourism, fishing, and conservation interests. Poorly managed expansion can result in spatial conflicts and environmental degradation, underscoring the need for strict site selection processes and sustainable operational models.

Market competition poses another major challenge. Portugal competes in a global seafood market dominated by large-scale producers, especially from countries with lower production costs. To remain competitive, Portuguese producers must continue to focus on quality, sustainability and innovation. They need to stand out by using certified production methods and strong branding that emphasizes both tradition and environmental responsibility. Domestic consumers, who have one of

the highest per capita consumptions of fish in the world, are increasingly conscious of food origin and sustainability. However, competing on price alone remains difficult in international markets. The Strategic Plan for Portuguese Aquaculture 2021-2030 aims to address the need for further sustainability efforts and a trusted certification process, as well as the internationalization of the Portuguese aquaculture industry. Among other efforts, the plan pursues initiatives that combat the pressures and new uncertainties for marine ecosystems introduced by climate change. Rising sea temperatures can affect fish growth rates and ocean acidification can threaten shellfish production. Altered salinity levels and the spread of new pathogens further threaten marine species and could undermine the resilience of aquaculture systems. These

environmental shifts could particularly threaten the yields and long-term viability of shellfish farmers, who produce the bulk of Portuguese aquaculture value. The sector will need to invest in adaptive strategies, such as selective breeding for climate-resilient species and new technologies to mitigate environmental variability. Spatial planning must also incorporate the changing oceanographic, physiochemical, geochemical and biological conditions of Portuguese coastal waters to select the best sites for different aquaculture operations.

Several factors favour aquaculture development

Despite the challenges presented, many of which are not unique to Portugal but rather occur globally in aquaculture, the outlook for Portuguese aquaculture is positive overall. Offshore aquaculture offers one of the most promising new areas for expansion, with projects such as a planned large-scale offshore fish farm in the Algarve region sparking excitement. Other new technologies, such as submerged cages and floating

platforms capable of withstanding harsh open-sea conditions, will be critical to realize this potential. Successful offshore expansion could help Portugal scale up production sustainably, while also reducing conflicts with coastal tourism and conservation areas. Technological innovation will present a key driver of future growth. Automated feeding systems, real-time water quality monitoring, and digital farm management platforms are transforming the efficiency and sustainability of aquaculture operations. Genetic research and selective breeding programs promise to improve growth rates and disease resistance, while advances in feed formulations, particularly those reducing reliance on fishmeal and animal-based ingredients, align production with sustainability goals. The adoption of these innovations will not only improve yields but also strengthen Portugal's reputation as a producer of high-quality, environmentally responsible seafood.

Sustainability will remain a defining feature of the industry's development. Consumer demand for certified, traceable products is growing, especially in European markets. Organic aquaculture and IMTA systems, which demonstrate clear environmental advantages, are examples that are well positioned to

meet these expectations. Certification schemes such as ASC and MSC also provide competitive advantages, particularly in export markets where regulatory and consumer scrutiny is high. By emphasizing sustainability, Portugal can leverage its natural resources responsibly while appealing to environmentally conscious consumers.

Close collaboration between industry and research establishment

Research and development are going to be vital in addressing the sector's long-term challenges. Universities and research institutions, often working in collaboration with industry, are already exploring innovative solutions to disease management, feed efficiency, optimal special planning and environmental sustainability. Expanding these collaborations will be essential in maintaining competitiveness and resilience. Market opportunities are also expanding, as global demand for seafood continues to rise and as Europe remains a key destination for Portuguese exports. Direct-to-consumer sales, including online distribution models, are reshaping the marketplace. These models allow smaller producers to access new customers while retaining a larger share of profits. High-end markets, particularly restaurants and gourmet retailers, are also showing strong interest in Portuguese aquaculture products, from seabream and seabass to oysters and mussels. Portugal can establish itself as a producer of premium, sustainable farmed seafood with the help of strategic branding, targeted marketing and the promotion of climate-conscious practices. In the process, it may even become a European leader in sustainable aquaculture.



Clams form an important component of Portuguese aquaculture production accounting for half its total value in 2023.

*Justus M. Dohmen, Eurofish,
justus@eurofish.dk*

Multi-use platforms: A blueprint for sustainable ocean development?

Multi-use platforms may support renewable energy production, food security, biodiversity, and climate resilience at a single site, thereby relieving some of the pressure on marine ecosystems and potentially offering a path to more sustainable ocean practices.

The ocean is becoming an overlooked battleground, where human interests compete for limited space and resources. Shipping lanes crisscross waters increasingly crowded with offshore wind farms, oil rigs, and aquaculture pens, while commercial fishing fleets chase often dwindling stocks. At the same time, climate change is jeopardising marine habitats, threatening biodiversity and

global food supplies. Marine Multi-Use Platforms (MUPs) may offer a solution to these sometimes conflicting activities and their impacts. MUPs bring together activities from different sectors in one place to make more efficient use not only of ocean space, but also of infrastructure, services, and personnel. MUPs represent a shift from traditional sector-specific development towards more integrated approaches, potentially creating synergies between energy

production, food provision, biodiversity enhancement, and more.

Wind, aquaculture and biodiversity at the same site

The European research project OLA-MUR explores the coexistence of offshore wind farms with low-trophic aquaculture (LTA), e.g. bivalve aquaculture, through multiple pilot cases such as WIN@Sea. This project analyses how offshore wind farms can share space with LTA, such as mussel and seaweed farming and national monitoring of the marine environment, while also investigating whether the wind farm foundations (i.e. scour protection) serve as artificial reefs.

MUPs can host a variety of industries, but one of the most common combinations pairs offshore wind energy production with LTA^[8]: the production of non-fed species such as seaweed and mussels. Such MUPs feature wind turbines with lines of mussel and seaweed growing between the turbines (Figure 1). Beneath the turbines, rocks placed around turbine foundations – known

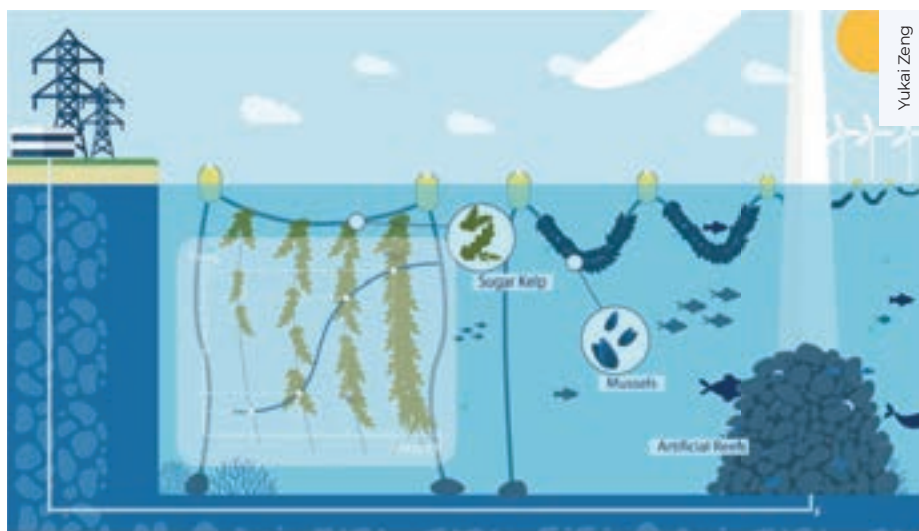


Figure 1: Multi-use platform combining renewable energy, sustainable aquaculture, and marine biodiversity initiatives.

as scour protection – prevent seabed erosion and serve as artificial reefs^[2], over time likely developing marine life and boosting local biodiversity. MUPs can act as symbiotic systems, where renewable energy, sustainable aquaculture, and biodiversity enhancement support one another. Offshore wind farms often create marine refuges by restricting fishing, allowing ecosystems to recover from commercial exploitation^[4]. Beyond potentially supporting marine life, MUPs like those studied by the WIN@sea project have the potential to drive economic growth and create jobs^[4]. Renewable energy and aquaculture are central to the EU Blue Growth strategy, which aims to improve resource efficiency, create jobs, and promote a sustainable ocean economy, all while improving biodiversity^[6].

Seaweed and mussel farming regenerating ecosystems

LTA may produce some of the most affordable and ecologically sustainable food products^[5], requiring no arable land, freshwater, or fertilisers. Moreover, it supports natural ecosystems and mitigates eutrophication. Mussels, sometimes termed the “intestines” of coastal ecosystems, naturally filter suspended particles, algae, bacteria, and even microplastics, while seaweed acts as a natural biofilter, absorbing excess nutrients such as nitrates and phosphates and thereby improving water quality. Seaweed can also serve as a carbon sink, capturing and storing atmospheric CO₂. Through photosynthesis, seaweeds assimilate carbon dioxide and release oxygen, increasing local oxygen concentrations and slightly raising pH, potentially helping to counteract local ocean acidification. Farmed seaweed can create underwater canopies resembling “forests,”

What is an artificial reef?

Artificial reefs come in many forms, from sunken ships to concrete blocks and boulders positioned on the seabed. From a biological perspective, an artificial reef can be any human-made construction or fixed structure on the seabed, offering biological reef functions (e.g. better shelter or food availability^[2]). In the case of MUPs, like the WIN@sea project, the scour protection around the individual turbine monopiles, typically rocks placed to prevent erosion, may also have such artificial reef functions^[7].

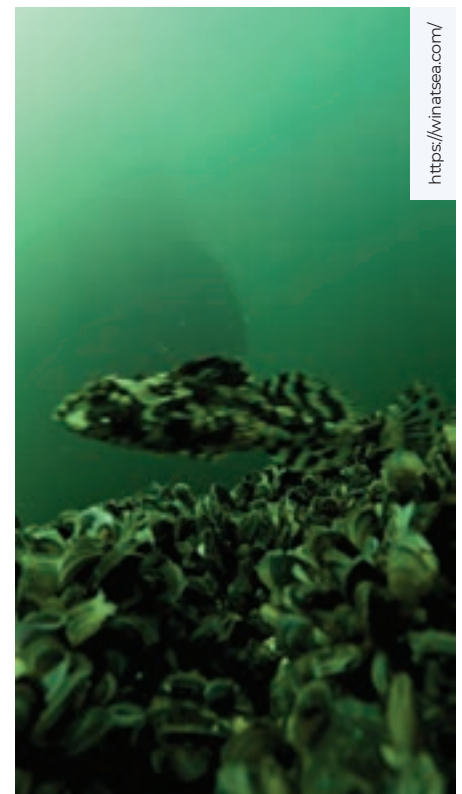
offering temporary shelter and nursery grounds for some marine species.

By cultivating species such as *Mytilus* sp. (blue mussels) and *Saccharina latissima* (sugar kelp) (Figure 2), the WIN@sea project demonstrates how aquaculture can deliver both environmental and nutritional benefits. Beyond their environmental role, both mussels and seaweed show promise as sustainable ingredients in animal feed, offering a lower-impact alternative to conventional protein sources. Through their ecological benefits and contribution to food security, the combination of mussel and seaweed farms may serve as a scalable and resilient component of MUPs for sustainable ocean development, benefiting people, the economy, and the planet. On a commercial scale, these “floating” farms may support the fight against climate change and ocean degradation.

When windmills become reefs

Driven by the EU’s climate and energy pledges, Europe’s offshore wind capacity is set to expand in the coming decades^[1]. Offshore wind farms are often built on a sandy seabed, which is vulnerable to erosion from currents, threatening the stability of the monopiles and offering limited shelter for animals^[7]. When scour protections are placed where natural hard substrates once existed, they may function

as reefs, restoring lost ecological functions and supporting life across the food web^[7]. These rocky surfaces provide substrate for sessile organisms



<https://winatsea.com/>

Scour protection around a wind turbine at the Win@Sea project. Small mussels and a fish can be seen. The photo was taken with an underwater camera placed on the seabed to study marine life on the reefs around the turbine foundations.



Figure 2: The cultivation of sugar kelp (left) and blue mussels (right) in the WIN@Sea project. Both species are grown on lines of rope that are suspended in the water.

that help filter water, absorb nutrients, and create shelter. Smaller species like fish and crabs settle there, potentially food for larger predators such as eider ducks, seals and porpoises. Over time, a food web may form, resembling the dynamics found on natural reefs.

Commercially important species like mackerel (*Scomber scombrus*) and Atlantic cod (*Gadus morhua*) are often found lingering near offshore structures, likely drawn by the new feeding grounds^[3]. This suggests that scour protection could play a role in supporting the recovery of various marine species. Projects like WIN@sea provide real-world insights by studying how existing offshore wind structures interact with the marine environment. In the Baltic Sea, the WIN@sea project aims to document the species communities that settle on the monopiles and the surrounding scour protection. The project will offer a better understanding of how wind farms can influence local biodiversity.

Understanding the risks and challenges

At a time when the world races to balance sustainability with economic and technological growth, MUPs could become a game-changer in marine contexts. But they face several hurdles. First, regulatory barriers can stall development. Combining activities such as offshore wind energy and aquaculture is often challenging, as each sector typically operates under its own regulatory and operational standards^[8]. For example, Danish marine spatial planning assigns separate zones for wind energy and shellfish farming, which can make combined licensing costly and difficult. In contrast, seaweed cultivation remains unassigned to specific zones, as the industry is still young and limited. Regulatory mismatches can make coordination difficult, delaying approvals and complicating potential MUP developments^[8].

MUPs may also introduce environmental disruptions. Wind farms can lead to habitat loss, collision risks for marine mammals and birds, and disruption of migratory routes. The installation of scour protections may attract new species to the area and thereby change local biodiversity. However, by covering soft sediments with rocks, scour protection may transform relatively homogenous seascapes, such as sandy seabed, into boulder reef-like habitats, a shift that favours certain species and could displace equally valuable communities adapted to sandy seabed. From a strict conservation perspective, this may not be desirable. Moreover, underwater noise pollution and electromagnetic fields emitted by power cables^[7] may pose additional threats to marine species.

Aquaculture brings its own set of challenges. Storms, harvesting, or maintenance can cause mussel shells and dead individuals to fall to the bottom, potentially altering seabed composition. Mussels also produce

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bio-deposits that might reduce oxygen levels locally. However, in offshore areas like Krieger's Flak, where the WIN@sea project is located, strong currents help disperse these, minimising the risk. Seaweed farms may release organic matter or attenuate light, yet with suitable management, these effects are limited. In Denmark, seaweed is not cultivated where natural seabed vegetation grows, and at the greater depths of offshore wind farms, light limitation is negligible, with little expected impact on the seabed. Another concern is the spread of invasive species. Structures like seaweed farms and wind turbines provide new surfaces for organisms to colonise, including non-native species that may compete with native species. These structures may act as "stepping stones," enabling species to extend their range more easily than they would in a pristine seascape, thereby potentially outcompeting native marine life.

If implemented with care and held to high standards, MUPs may become more than just an efficient use of space. They could offer a much-needed blueprint for working *with* nature, rather than against it, in shaping the ocean economy of the future. The potential is there. The challenge now lies in turning the vision into reality.

Authors

Yasmin Sassa Victor (s191311@student.dtu.dk) and Ana Liu Wu (s233315@student.dtu.dk), both DTU Aqua, are the joint primary authors of the article.

Annette Bruhn (anbr@bios.au.dk), Aarhus University; project leader WIN@Sea

Christian Riisager-Simonsen (chrii@aqua.dtu.dk), DTU Aqua

Tim Wilms (tim.wilms@vattenfall.com), Vattenfall

Lars Emil Juel Andersen (leman@aqua.dtu.dk), DTU Aqua

Jon C. Svendsen (jos@aqua.dtu.dk), DTU Aqua

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Finding opportunities among the challenges

The Federation of European Aquaculture Producers, FEAP, promotes the responsible development of the aquaculture sector, uniting European associations that represent fish farming. The mission of the organisation is to coordinate its national member associations' positions and provide accurate information to inform policy decisions.

Lara Barazi, the first female president of FEAP, has served as the organisation's vice president since 2018. In her new role, she headlines FEAP's engagement with member associations and EU institutions. Here she discusses FEAP's role in navigating new environmental pressures and regulation standards, focusing on the organisation's position on collaboration and unification across marine sectors.

In a rapidly evolving global landscape marked by environmental, economic, and geopolitical challenges, how is FEAP navigating these complex pressures?

The pressures facing aquaculture today are profound—from climate change and inflation to geopolitical instability and increasing regulatory demands. As FEAP, our job is to help producers navigate this uncertainty by being both a credible voice and a practical partner at the European level. First, on the environmental front, climate change is not a distant threat; it's already impacting water temperatures, fish health, extreme weather events, and even algal blooms. FEAP works closely with EU institutions, researchers, and industry to push for climate adaptation strategies that are tailored to aquaculture, while also supporting innovation in areas like selective breeding, health management, and more sustainable feed. On



Lara Barazi Geroulanou, president of the Federation of European Aquaculture Producers

the economic side, producers experience growing pressure from inflation, rising input costs, and in some cases unfair competition from third-country imports. FEAP actively advocates for a level playing field, calling for better enforcement of environmental and social standards in international trade, and for greater recognition of the high standards our producers already meet in Europe. Geopolitical tensions, including war and instability in neighbouring regions, have disrupted supply chains, energy prices, and logistics. These shocks have revealed how vulnerable food systems can be. That is why FEAP is pushing for European aquaculture to be recognised as a strategic sector, one that can strengthen food

security and reduce dependency on external sources of protein.

Among the many difficulties facing the sector, what priorities are you focusing on to ensure that European aquaculture remains resilient, competitive, and sustainable?

At FEAP, we're very clear on our priorities because the challenges are real, but so are the opportunities. To ensure that European aquaculture remains resilient, competitive, and sustainable, we're focusing on three strategic pillars: regulatory reform, climate adaptation, and fair market conditions. First, we are pushing hard

for a more efficient and enabling regulatory framework. Licensing in many countries is slow, complex, and unpredictable, it's a major bottleneck to innovation and growth. We work with the European Commission and national authorities to streamline procedures, reduce administrative burdens, and support digitalisation, while maintaining our high environmental and welfare standards. Second, we are prioritising climate change adaptation. European producers are already facing rising temperatures, extreme weather, and new disease pressures. FEAP advocates for investment in innovation, from selective breeding and improved health strategies to low-impact technologies and infrastructure upgrades, so that aquaculture can thrive under changing conditions. Third, we're focused on securing fair and competitive market conditions. European aquaculture operates under some of the highest standards in the world, and this must be recognised and defended. That means stronger controls on imported products, clearer labelling and traceability, and ensuring that sustainability is not just a burden for EU producers but a level playing field for all.

Aquaculture in the European Union has experienced little to no growth over the past 25 years. From your perspective, what are the core reasons behind this stagnation, and what structural or policy changes are most urgently needed to unlock the sector's full potential and reverse this trend?

This is one of the most critical questions we face as a sector, and unfortunately, it's not a new one. The first and most fundamental barrier is the complexity and rigidity of the regulatory environment. Aquaculture in Europe is subject to overlapping national and EU regulations, lengthy and uncertain licensing procedures, and often

contradictory policy goals. This creates risk and discourages investment. Second, there has been a lack of political ownership and strategic prioritisation. While aquaculture is recognised on paper as a key sector for food security and the Green Deal, that recognition has not consistently translated into concrete support or integrated policy. In some member states, aquaculture falls between ministries or lacks a clear development mandate. That needs to change, aquaculture must be treated as a strategic food-producing sector, not an afterthought. Third, negative narratives, often outdated or not based on facts, have influenced public opinion and, in turn, policy decisions. We need a more proactive, science-based communication strategy that explains the benefits of European aquaculture: its low carbon footprint, its contribution to coastal communities, and its role in sustainable food systems.

Climate change is rapidly altering the operating environment for fish farmers across Europe. What are the most urgent regulatory and infrastructural changes needed to enable aquaculture to remain resilient under these conditions?

On the regulatory side, the first step is to ensure that climate adaptation is fully integrated into national aquaculture strategies, marine spatial planning, and EU-level frameworks like the Strategic Guidelines for EU Aquaculture and the Nature Restoration Law. We need regulations that are flexible, science-based, and forward-looking, allowing producers to innovate, relocate, or modify operations in response to changing environmental conditions. For example, permitting procedures must allow for timely upgrades to infrastructure, adoption of new farming technologies, and movement of sites if climate conditions make existing areas unviable. Too often, rigid regulations and

slow authorisations become a barrier to adaptation, precisely when agility is needed most. On the infrastructural side, investment is critical. We urgently need targeted funding, particularly through instruments like the EMFAF, to support: Modernisation of farms to cope with temperature extremes and water quality fluctuations, selective breeding programs for climate-resilient species and strains, offshore and integrated production systems that can withstand more variable and energetic environments, and data collection and digital monitoring tools to better anticipate and manage climate risks.

As the first female president of FEAP, how has your experience shaped your perspective on gender and diversity in the industry? And what are your priorities for making aquaculture more inclusive?

It's an honour to serve as FEAP's first female president, and I see it not just as a personal milestone, but as a sign that the industry is evolving. Aquaculture has traditionally been male-dominated, particularly at senior leadership levels, but I believe that is starting to change, and it *must* change if we want the sector to be dynamic, innovative, and future-ready. I've seen first-hand how women contribute across the value chain, from hatcheries and farms to labs, marketing, and management, often with enormous dedication, resilience, and skill. At FEAP, we embed this thinking into all our work promoting visibility and leadership opportunities for women in aquaculture, not only through representation but also through mentorship, networks, and speaking platforms. We have organised a couple of one-week-long training sessions for young women aquaculture professionals in collaboration with the General Fisheries Commission for the Mediterranean and Black Sea (GFCM-FAO). We are also supporting

young professionals through engagement with universities, training programs, and industry-academia partnerships, ensuring they see aquaculture as a viable, forward-looking career path; championing inclusive hiring and skills development.

According to the recent Special Eurobarometer SP558 on EU consumer habits regarding fishery and aquaculture products, public awareness and trust in farmed fish remain uneven across Member States. What specific actions or communication campaigns is FEAP undertaking to improve public understanding?

The findings of Special Eurobarometer 558 confirm what many of us in the sector have known for some time: public perception remains one of the biggest barriers to the growth of sustainable aquaculture in Europe. While many consumers are open to farmed fish, awareness is uneven, and persistent myths, about quality, welfare, or environmental impact, continue to shape attitudes and consumption choices. At FEAP, we believe that building consumer trust is not just a communications issue, it's a strategic priority for the entire sector. FEAP is actively involved in shaping and supporting coordinated EU-wide messaging about aquaculture. We are working closely with the European Commission, particularly under the Common Market Organisation (CMO), to promote facts, not myths, and to highlight the nutritional, environmental, and economic benefits of farmed fish. We are also strong advocates for clearer, more informative labelling of aquaculture products across the EU. Consumers have a right to know where their fish comes from, how it was produced, and under what standards. By improving traceability and emphasising EU-origin products, we can reinforce

the message that European aquaculture is not only sustainable, it is also trustworthy. Additionally, we believe that when consumers understand the reality of farmed fish, the quality, care, and science behind it, trust will follow. FEAP is committed to making that happen.

As a pan-European organisation, how does FEAP ensure that the perspectives and needs of all its members are equally represented and reflected in its policy work and advocacy, and it does it work to foster cohesion across its members?

The diversity of European aquaculture is both a strength and a challenge. At FEAP, we represent producers from across the continent, from large-scale salmon operations in the North to small family-run carp ponds in Central Europe, and marine cage farms for bass and bream in the Mediterranean. Each country and production system comes with its own realities, priorities, and pressures, whether they relate to environmental conditions, regulatory frameworks, market access, or public perception. FEAP operates on the principle of consensus. Before taking public positions or engaging with EU institutions, FEAP consults its full membership to find common ground. This collaborative approach ensures that no single region, species, or interest dominates the narrative. Regular General Assemblies, technical meetings, and digital consultations allow members to voice concerns and propose priorities. These forums foster mutual understanding between regions that might otherwise be disconnected, for instance, between coldwater and warmwater producers or between large-scale and small-scale operators. Additionally, from environmental regulation to market disruptions or animal welfare standards, FEAP actively tracks how emerging

issues affect producers differently across the continent. This allows it to respond with informed and inclusive policy positions that acknowledge both common challenges and regional variation.

Looking toward the future, what are your key strategic priorities for FEAP over the next five years? And personally, what impact or legacy would you most like to leave from your tenure as president of the organisation?

Looking ahead, my key strategic priority for FEAP is to position aquaculture as a core pillar of Europe's sustainable food system. That means ensuring that our sector is not only heard, but truly integrated into major EU strategies, from climate adaptation and food security to rural development and ocean restoration. Over the next five years, FEAP will focus on securing structural reform that unlock growth particularly in licensing, championing climate adaptation and innovation, defending fair market conditions, driving generational renewal, and promoting cohesion and unit across our diverse membership. On a personal level, the legacy I hope to leave is twofold. First, I would like to be remembered for making FEAP more open, inclusive, innovative and future-facing, a platform that brings in new voices, champions diversity, and reflects the full energy of the sector. Second, I would like to be remembered for helping to transform FEAP into a more professional, transparent, and effective organisation, with strengthened governance, clearer structures, and more strategic engagement at the EU level. FEAP must continue evolving to meet the demands of a rapidly changing sector, and that means operating with the same level of professionalism and accountability we expect from ourselves as farmers.

diary dates



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<https://danfish.com>



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<https://www.conxemar.com/en/exhibition/>



13-17 October 2025
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wefta2025@mir.gdynia.pl
<https://wefta2025.com/>

29-31 October 2025
China Fisheries & Seafood Expo (SFSE)
Qingdao, China
info@seafarechina.com
<https://chineseafoodexpo.com/>

5-7 November 2025
Busan International Fisheries Expo
Busan, Republic of Korea
bisfe@bexco.co.kr
<https://bisfe.com/eng/>

10-13 November 2025
World Aquaculture India
Hyderabad, Telangana, India
mario@marevent.com
<https://was.org/Meeting/code/WAI2025>



19-20 November 2025
Catch Welfare Platform Conference *
Forteiland Ijmuiden, Netherlands
info@catchwelfareplatform.com
<https://catchwelfareplatform.com/third-conference/>



9-12 December 2025
AlgaEurope 2025 *
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info@dlg-benelux.com
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3-5 March 2026
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15-17 March 2026
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İzmir, Türkiye
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info@eurasiafairs.com

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DK-1553 Copenhagen V
Denmark

Tel.: +45 333 777 55, info@eurofish.dk
eurofish.dk

Managing editor Marco Frederiksen

Editorial offices Behnan Thomas (bt)
H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark

Tel.: +45 333 777 64
behnan@eurofish.dk

Dr. Manfred Klinkhardt (mk)
Redaktionsbüro Delbrück
Franz-Stock-Straße 23
D-33129 Delbrück
Germany

Tel.: +49 5250 933416
manfred.klinkhardt@web.de

Advertising Jan Byskou
FRONTMEDIA
Ny Banegårdsgade 55
8000 Aarhus C
Denmark

Tel.: +45 4822 4450
jan@frontmedia.dk

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