

Laser focus on Fish Health

Annual Report 2025



Stingray



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1.0

Stingray and the industry

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In 2025, warmer seas, sustained lice pressure, and stricter welfare expectations have accelerated the shift toward preventive, technology-driven fish health management. In response, Stingray has strengthened its organization, expanded its operations both in Norway and Iceland, and advanced continuous, non-invasive sea louse control as a foundation for improved welfare surveillance, documentation, and predictable aquaculture production.

Setting a new standard

62

New specialists at Stingray

The year 2025 has been shaped by regulatory reform, environmental volatility, operational challenges, and an intensified focus on fish welfare. In recognition of rising regulatory expectations and the environmental lessons of 2024, Stingray strengthened its organization with 62 new specialists and welcomed a new board of directors in July.

Across Norway and Iceland, producers faced tighter demands for documentation, increased biological pressures, and a growing awareness that sustainable growth must rest on data precision, prevention, welfare surveillance and non-invasive lice control. These developments reaffirm the importance of continuous optical delousing and the value of Stingray's

technology as a benchmark for data-driven decision-making.

Stingray has actively supported the Norwegian Food Safety Authority's renewed initiative to advance automation in aquaculture, particularly automatic lice counting, a process that will continue in 2026. In Iceland, Stingray has expanded its operational footprint and strengthened collaboration with local producers. Our work to reduce reliance on traditional delousing treatments together with our partners is of especially high importance in Iceland, where wellboat capacity is limited, thus access to delousing vessels is scarce, and handling carries greater biological risk due to colder waters and slower healing rates.

Our Fish Health Hub™ with laser-based sea lice control already monitors and protects 20–25% of farmed salmon in Norway, contributing to lower lice levels, fewer handling-based treatments, improved fish welfare, and reduced mortality at sea.

Around the clock, we live-stream data from about 15,000 cameras across more than 2,500 active nodes along the Norwegian coast, enabling rapid and continuous system improvement.

With Novo Holdings on board, Stingray can further accelerate development, supported by strong, visionary partners and co-owners as we look to the future.

JOHN ARNE BREIVIK
CEO, Stingray



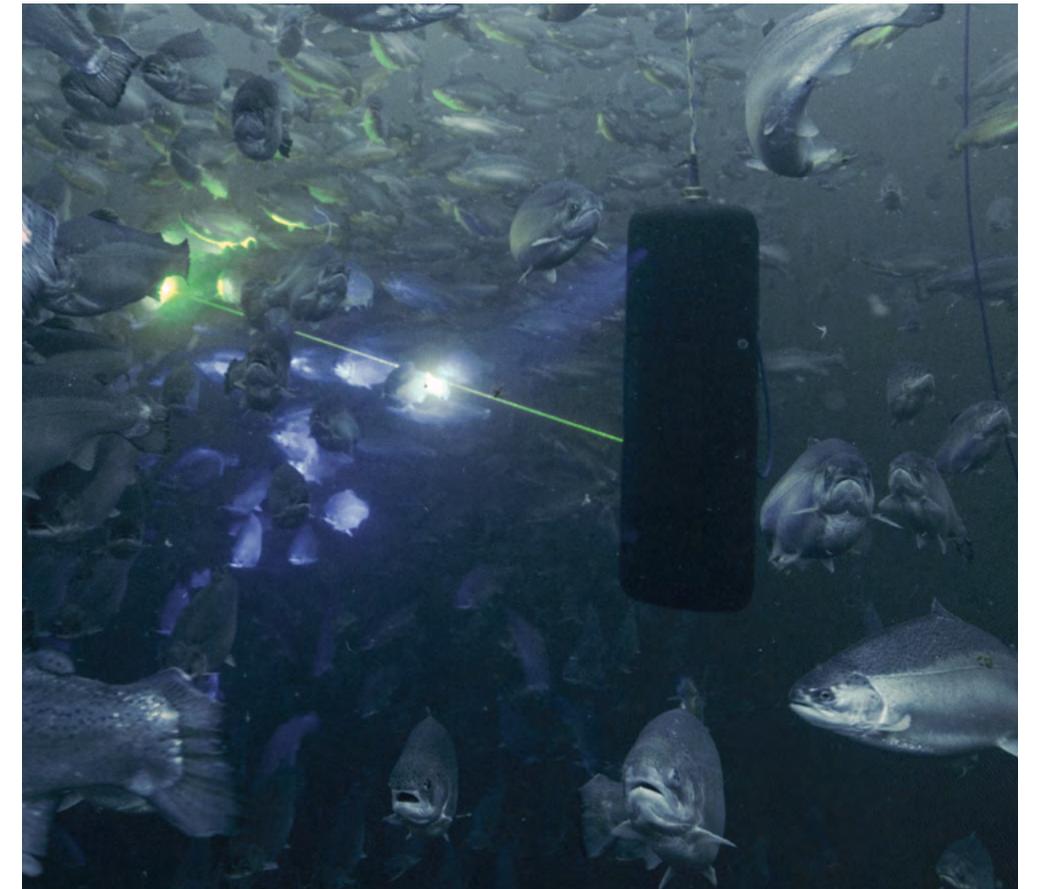
Fish health

70%

Drop in use of cleaner fish for the last 6 years

2025 has been marked by sustained and elevated lice pressure across the industry. Unusually high seawater temperatures recorded in the Northern regions of Norway in 2024 persisted into the winter and spring of 2025, resulting in higher lice levels in the summer season. Southwestern Norway experienced a pronounced marine heatwave during the summer and autumn months of 2025. Consequently, affected production areas (PAs) saw accelerated lice development, prolonged periods of elevated infestation pressure, and higher frequencies of reactive treatments.

Multiple outbreaks of infectious salmon anemia (ISA) were registered in 2025, with a clear concentration of cases in PA 9. Horizontal disease transmission is suspected for several of these outbreaks, highlighting the vulnerability of densely stocked production zones and the critical importance of strict biosecurity practices. The situation has also underscored the risks associated with increased traffic between sites, whether involving personnel, vessels, fish, or equipment, and emphasizes the need for stronger preventative barriers.



The use of cleaner fish in Norwegian aquaculture saw a sharp reduction in 2025, with the number of fish deployed dropping by nearly a quarter compared to 2024 and by close to 70% over the past six years. Stingray views this development positively, as high mortality and poor welfare of cleaner fish have long been among the most persistent welfare challenges in Norwegian salmon farming. In addition, to support farmers who continue to use lumpfish, Stingray released the Lumpfish Standard in May 2025, providing evidence-based guidance for ethical and effective use of biological lice control (see chapter Cleaner Fish for further explanation).

As biological pressure has intensified, the industry is undergoing a shift towards more preventive and technology-driven lice control strategies.

Increasingly, farmers are adopting systems that reduce the likelihood of lice entering the pen or enable constant, non-invasive control of the lice that do attach. Solutions such as Stingray's Fish Health Hub™,

semi-closed systems, and deep-water operations are becoming central tools of this transition.

All these methods are designed to minimize fish handling by reducing reliance on reactive treatments, which are closely associated with stress, injuries, secondary infections and subsequent elevated mortality.

This transition can be seen as the acknowledgement of the shared responsibility to reduce mortality and strengthen welfare across the fish farming sector, an expectation clearly reflected in the Animal Welfare White Paper adopted in April 2025. To meet these expectations, fish farmers require more systematic and broader insight into fish health. In response, Stingray is developing a comprehensive welfare scoring system (see chapter Stingray's Total Welfare Score) designed to detect emerging issues and support better-informed decisions. Moreover, automated welfare monitoring and lice counting reduce the need for weekly handling of large numbers of fish, supporting a more stable welfare baseline. These initiatives, alongside controlled delousing, aim to strengthen preventive health management and enable a more welfare-driven production model.

1.3

Iceland

56

Deployed nodes in Iceland in 2025

The establishment of Stingray in Iceland represents an important step in contributing to the continued development of a modern and sustainable aquaculture sector. Demand for technology that can strengthen production efficiency, fish welfare, and documentation is growing as the Icelandic industry expands. Authorities and the industry share the mutual goal of building national value through responsible

production, flexibility, and innovation. Here, the technology provided by Stingray plays a key role, supporting welfare and disease management. The opening of Stingray's new service center in March 2025, gives Icelandic producers improved operational support and faster response times, strengthening day-to-day operations and enabling a wider rollout of the Stingray system in Iceland.

The takeaway

By combining continuous lice control with detailed behavioral and welfare documentation, Stingray stands at the center of the industry's transformation. Both Iceland and Norway now benefit from a model where improved welfare, reduced stress, predictable production, and strong environmental performance align with the expectations of regulators, investors, and society alike.

This year's report provides a clear view of how Stingray's work creates real improvements in the daily lives of the fish under Stingray's care. The progress outlined in this report reflects not only technological development, but also the trust the customers place in Stingray and the responsibility shared for more than one hundred million animals in 2025.



DR. BENEDIKT FRENZL
Aqua Manager



HELENE BENTZEN
Veterinarian

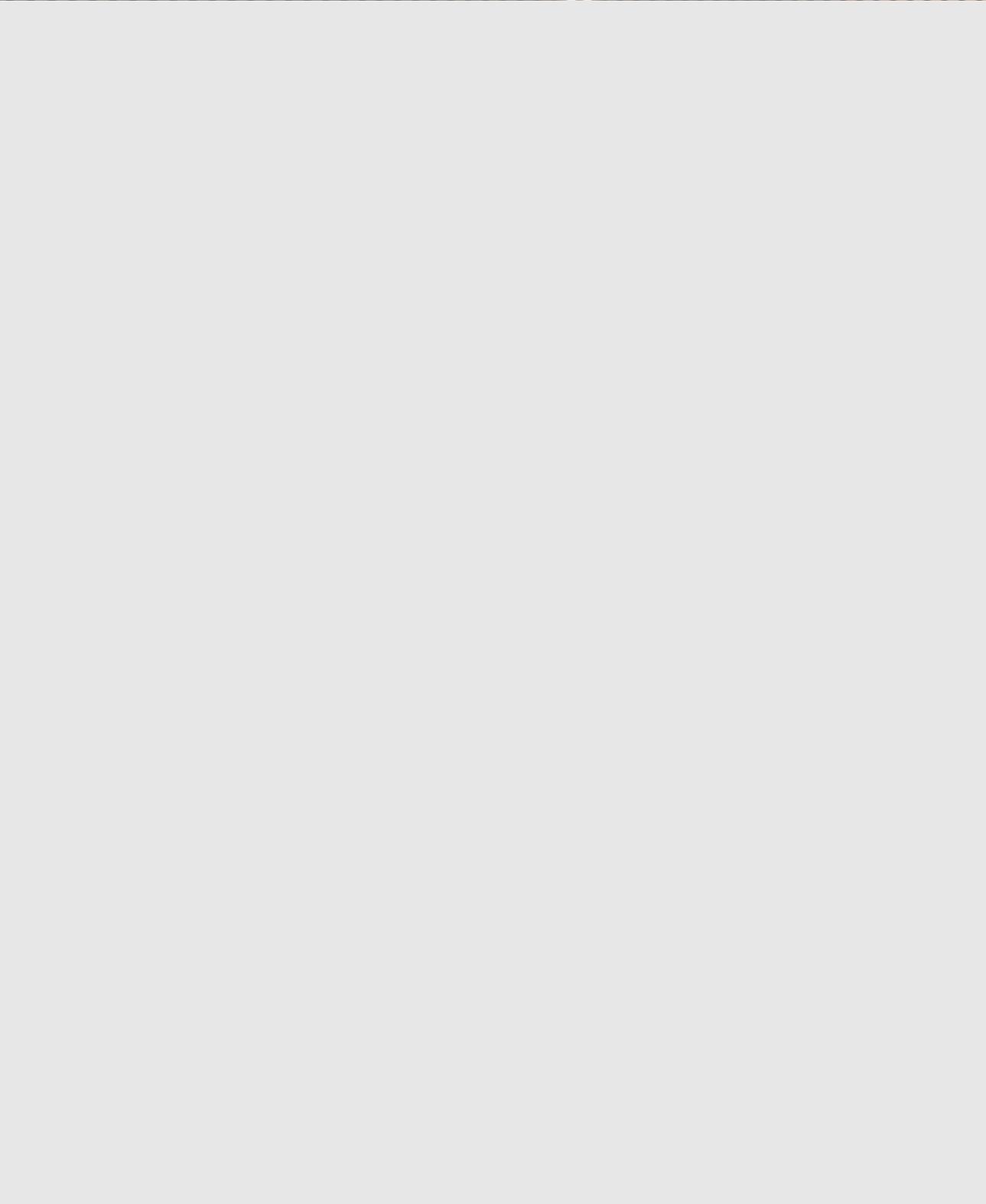




2.0

Key results

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Stingray Marine Solutions AS is a pioneer in sustainable, welfare-friendly technology for salmonid aquaculture. The company's patented sea louse control solution, Optical Delousing, offers customers a non-invasive, fish welfare-friendly, and technologically advanced approach to solving the sea louse problem. Modern camera and detection technology combined with advanced robotics, enables around-the-clock monitoring and fish surveillance. Highly skilled and specialized teams of employees, adhering to scientific, standardized, and certified processes, have established Stingray as the market leader in high-tech and artificial intelligence (AI) applications within salmonid aquaculture.

Performance snapshot

FIGURE 1.
Active Stingray sites

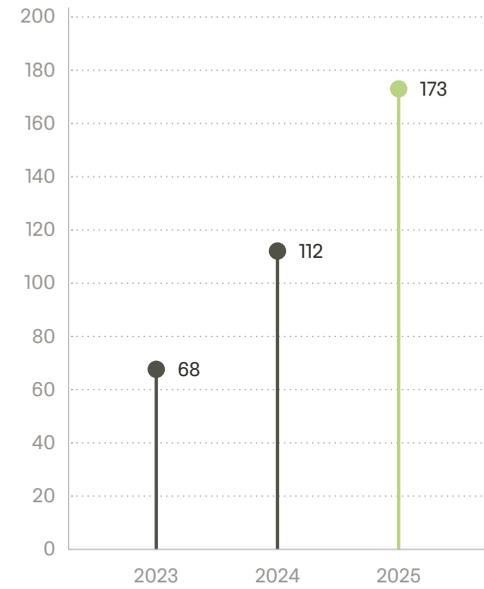
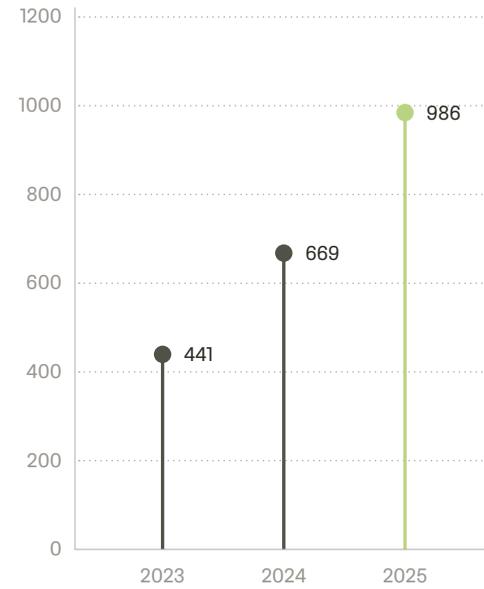


FIGURE 2.
Active pens



Sites using Stingray increased by nearly 60% from 2023 to 2025.

Pens with Stingray increased by nearly 600 from 2023 to 2025

FIGURE 3.
Average operational nodes per pen

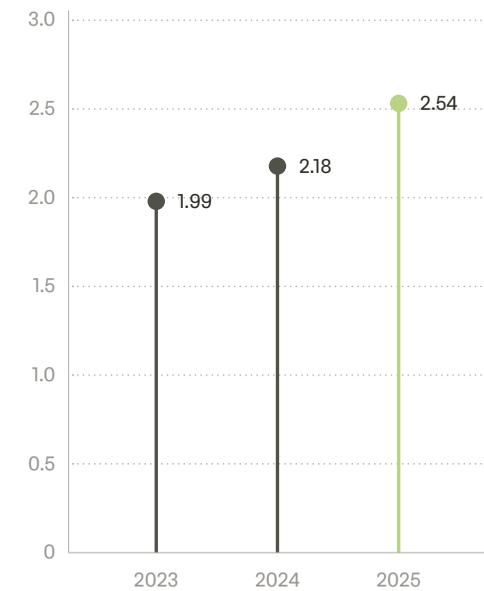
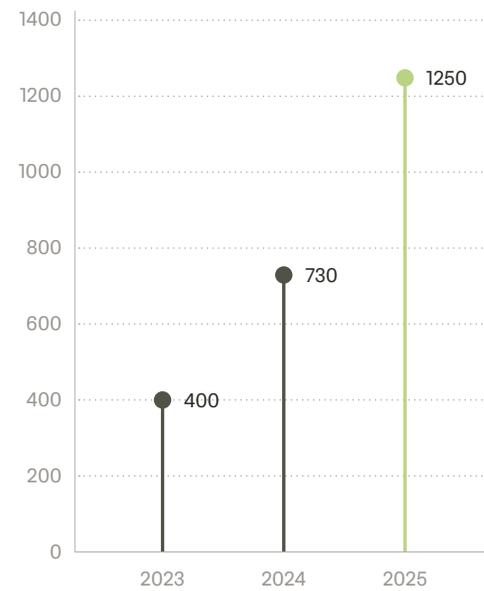


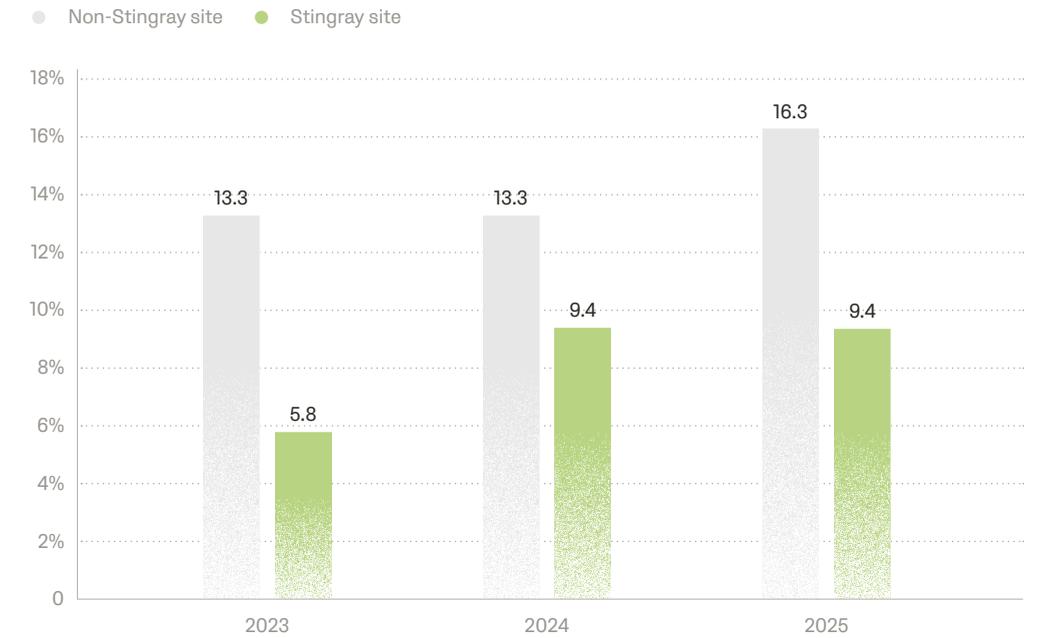
FIGURE 4.
Nodes produced



The average number of operational nodes per pen increased from ~2 to 2.5 between 2023 and 2025.

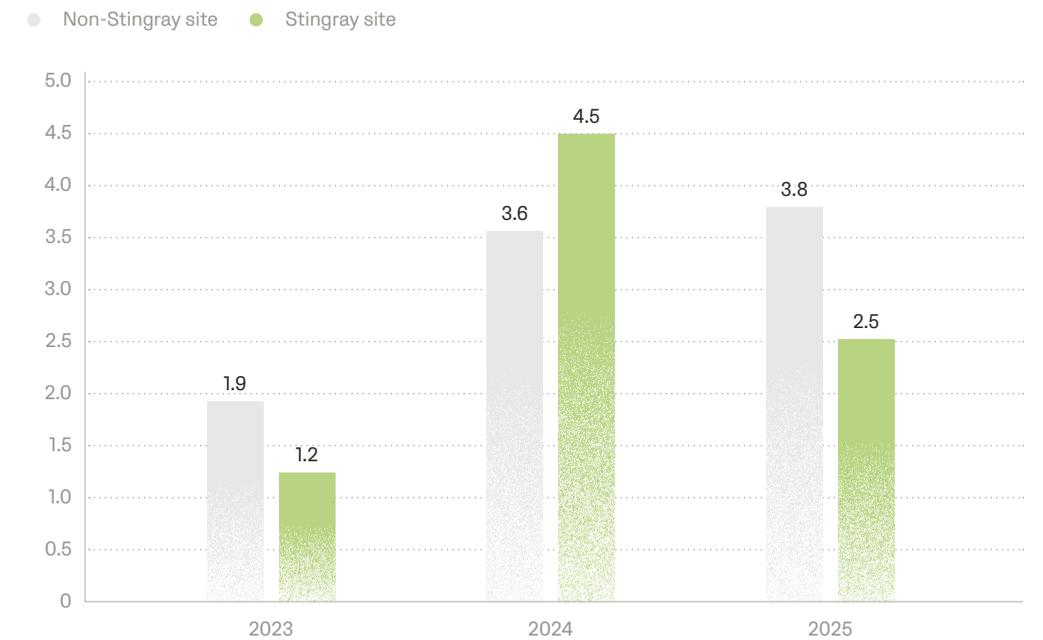
Annual node production increased steadily each year from 2023 to 2025.

FIGURE 5.
Treatment requirements



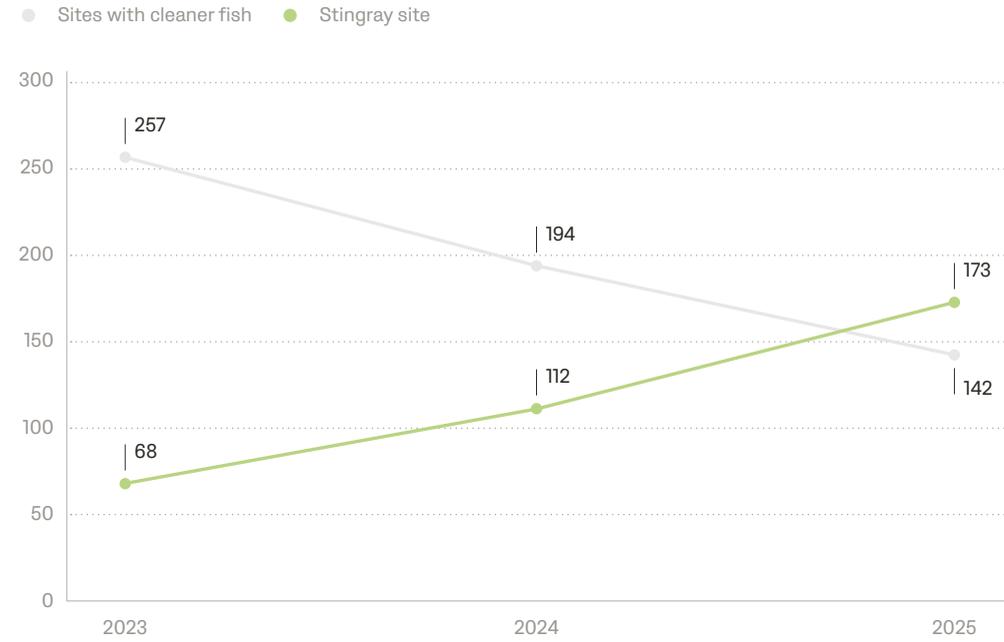
Stingray sites consistently showed a lower proportion of production weeks requiring treatment compared to non-Stingray sites from 2023 to 2025

FIGURE 6.
Weekly lice counts over limit



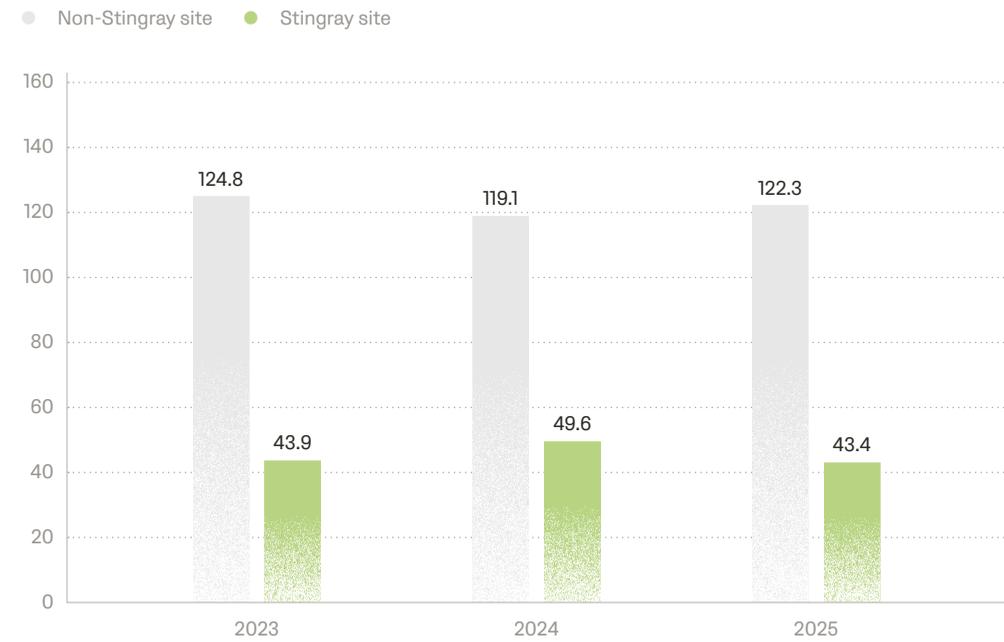
The share of weekly lice counts over the louse threshold differed between Stingray and non-Stingray sites from 2023 to 2025.

FIGURE 7.
Cleaner fish
vs. Stingray



A decline in cleaner fish use and a corresponding increase in Stingray laser node use are observed from 2023 to 2025, with Stingray surpassing cleaner fish in 2025.

FIGURE 8.
Stocked cleaner
fish per site
(in thousands)



The use of cleaner fish was substantially lower at Stingray sites compared to non-Stingray sites from 2023 to 2025.

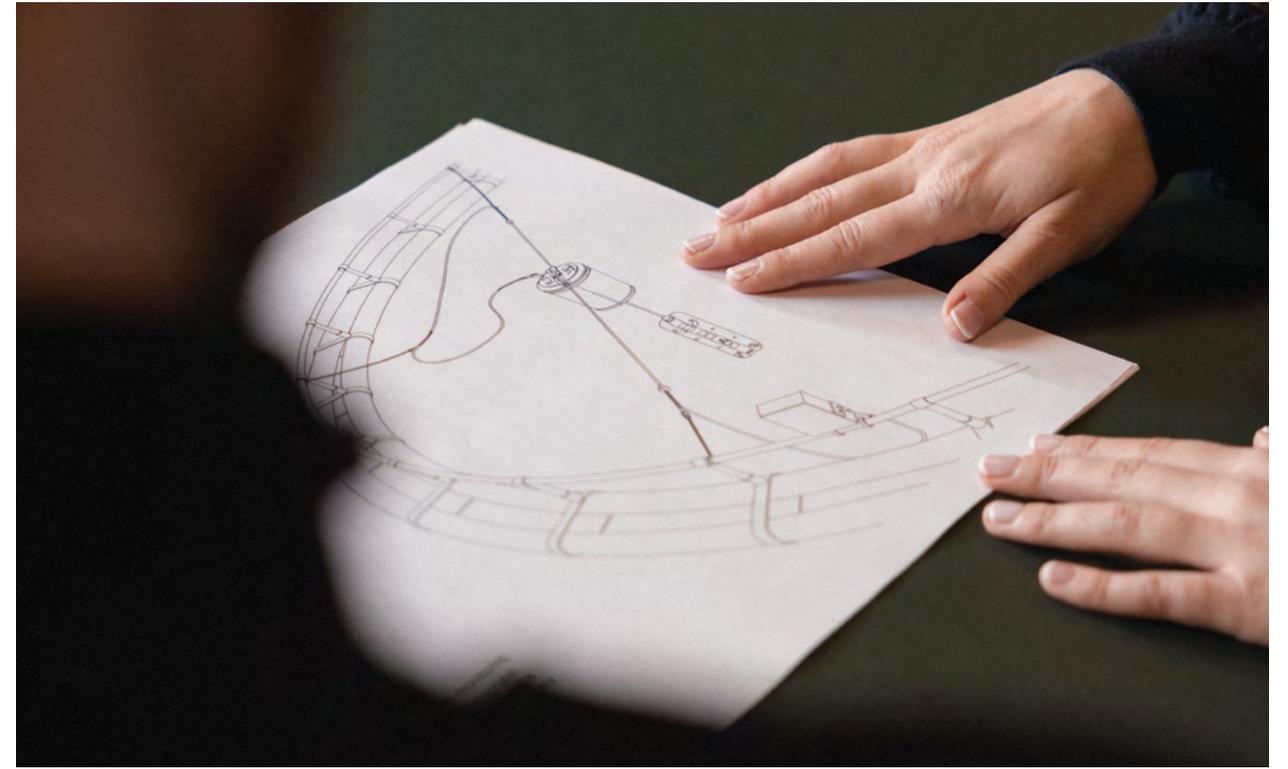
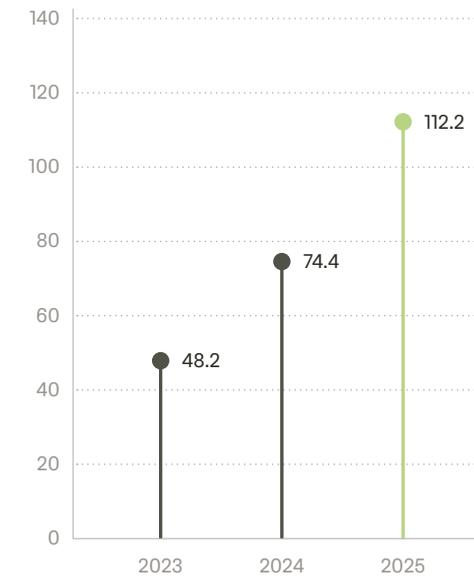


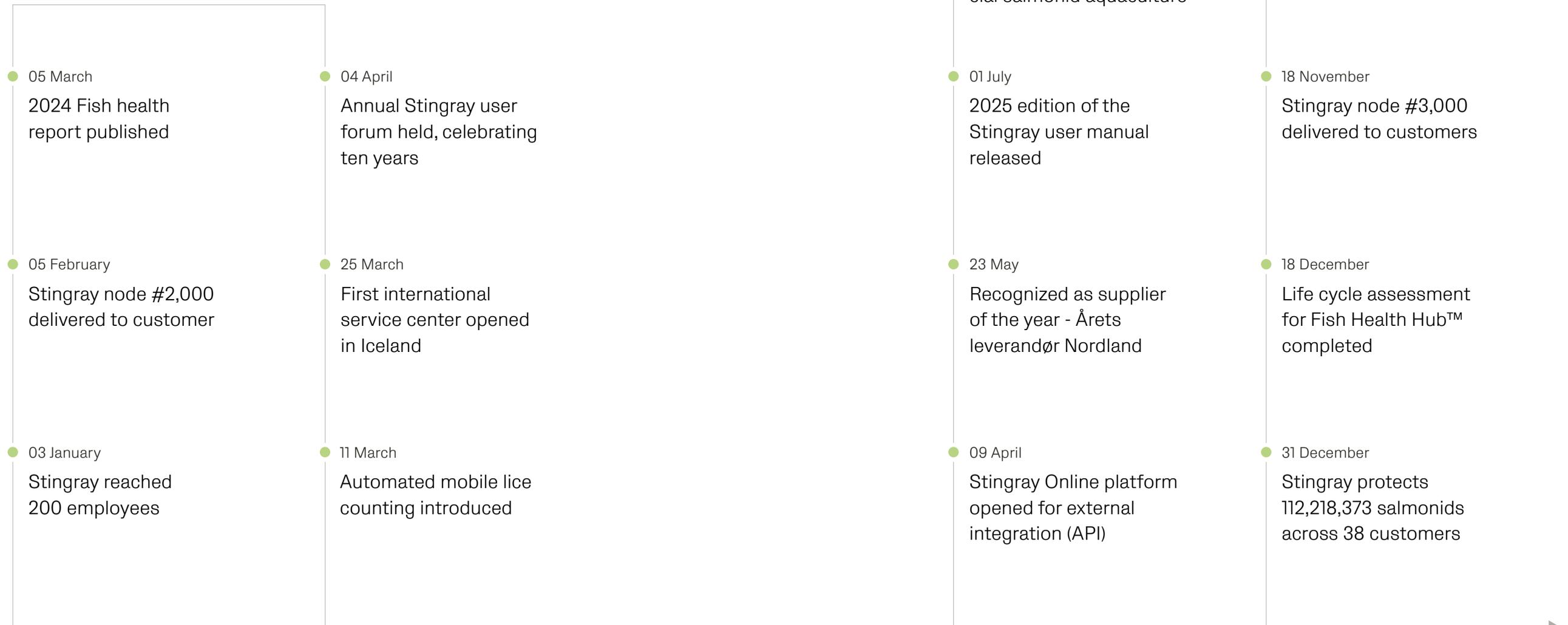
FIGURE 9.
Fish in laser pens
(in millions)



An increasing number of fish were protected by Stingray from 2023 to 2025.

Timeline

In 2025, Stingray strengthened its strategic position through scaled delivery, automation, digital integration, and expanded scientific and operational capacity. Organizational growth, international expansion, certification, updated standards, and sustainability commitments supported customer reach and long-term credibility. These developments underpin Stingray’s role in data-driven fish health management.

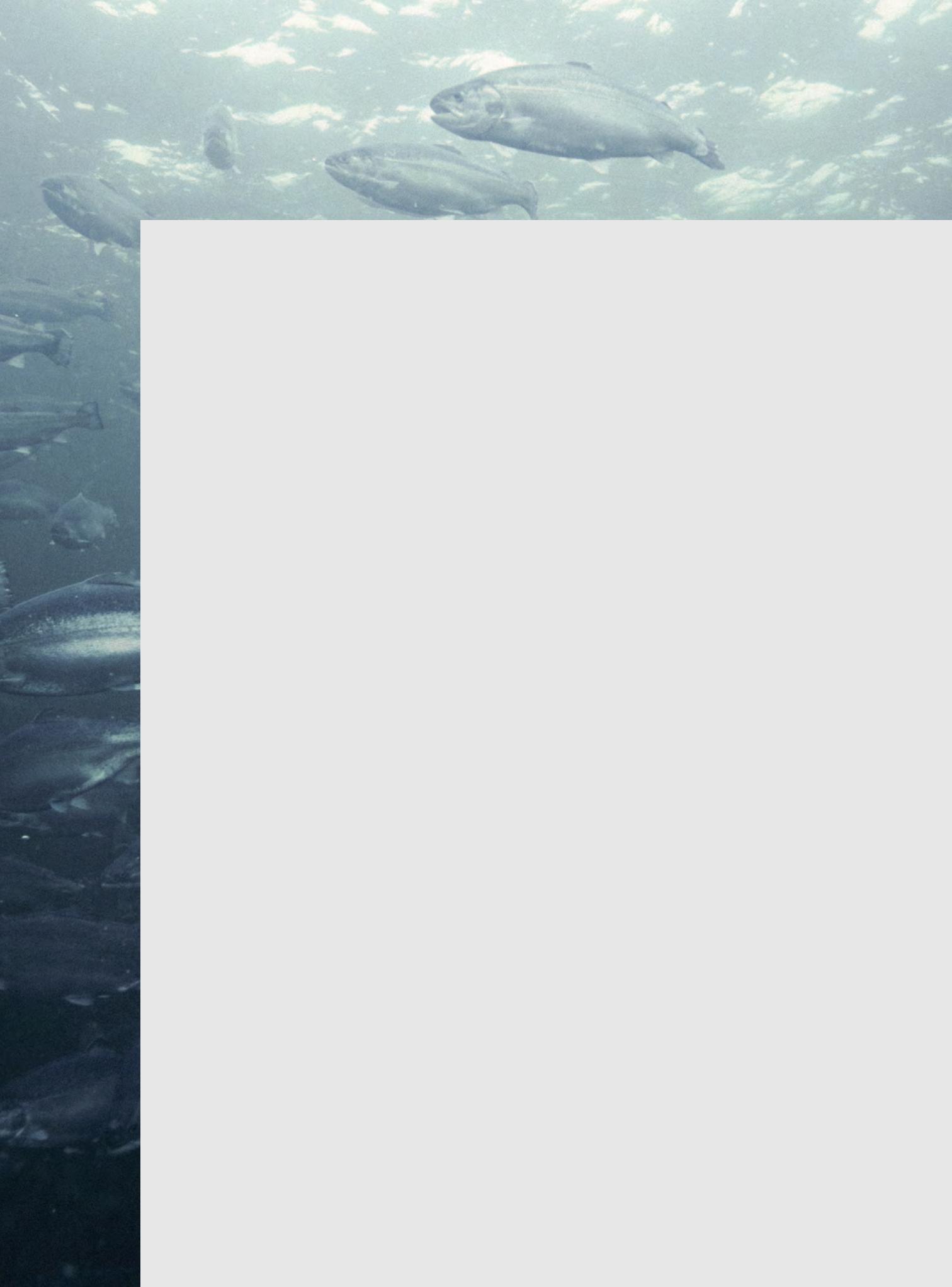




3.0

Sea lice and mitigation

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Optical delousing has progressed into a scientifically documented and widely adopted sea lice control method in Norwegian aquaculture. Large-scale data and 2025 results show that laser-based control consistently reduces the need for reactive treatments and supports low lice levels, even under higher temperatures and increased biological pressure.

Scientific documentation

While Stingray's operational results demonstrate the large-scale effect of optical delousing, understanding the underlying mechanisms and scientific basis has been a key research focus. When Stingray commercialized laser-based optical delousing against salmon lice (*Lepeophtheirus salmonis* Krøyer, 1837) in 2014, there was widespread skepticism about whether it could serve as a viable alternative to conventional treatments. However, the principle is straightforward: laser energy is absorbed by the louse, converted into heat, and causes thermal damage to the parasite (Breivik, 2011; European Patent Office, 2019).

involvement from Stingray itself. The study observed no reduction in lice counts over a 54-day period in snorkel cages. However, the system was not used as intended, and the study did not test whether lice were killed by laser exposure, it only assessed whether lice levels on treated fish differed from untreated fish. As no difference was observed, the study could not reject the assumption that optical delousing had no measurable effect under the specific conditions examined.

Documenting the effect of controlling measures against sea lice under commercial conditions is challenging. In commercial operations, production must run continuously, and lice levels can differ significantly between pens (Morefield & Hamlin, 2025). Hence, generalizing findings from experiments on a particular set of sites and conditions to the realistic conditions and scale of production is limited. Moreover, such studies fail to account for the performance of optical delousing when it is operating under optimized conditions, or for how results improve as the technology and best-practice routines mature.

Over time, many companies have established dedicated laser control centers (see chapter Laser Centers), where continuous monitoring and follow-up help maintain the effect of optical delousing in routine operations. Stingray has also analyzed several million video recordings from commercial net pens to document laser hits on salmon lice. These findings are confirmed by the identification of laser-damaged lice during routine on-site counts, providing direct evidence of effective lethality and target detection under normal production conditions.

The adoption of the Stingray method by the industry was largely driven by positive field results obtained on pioneering farm sites (Larsen et al., 2025). Still, more robust scientific documentation of the laser effect has been routinely requested by both stakeholders and academic institutions.

Until recently the only peer-reviewed study of optical delousing was conducted by the Norwegian Institute of Marine Research (Bui et al., 2020), without any

Stingray has steadily increased presence along the Norwegian coast, and in 2023 optical delousing supported more than ten percent of all production weeks in Norway. This increased market share has made it possible to look beyond the limitations of small-scale trials and evaluate large

scale data. Such data can provide broader insight and strengthen documentation by comparing whole farm sites based on whether they use the technology, independent of the specific conditions at individual farms.



Statistics is most rewarding when models extract interesting or unexpected results from data – especially when revealing high-impact effects, such as how technology contributes at scale to improving an entire industry.

PROFESSOR JAN BULLA

Department of Mathematics, University of Bergen

A national-level comparison of treatment frequency

Aquaculture sites in Norway are required to report operational data to the authorities once a week. This includes lice counts, sea temperature, and lice treatments. This information provides time series with weekly granularity for all sites with active production, and it is freely available to the public through the web portal Barentswatch (Barentswatch, 2026). Since each production week can simultaneously be a treatment week, i.e. a calendar week with at least one performed sea louse

treatment, it is possible to compare the proportion of production weeks with optical delousing to the proportion of treatment weeks that became necessary despite the use of lasers.

In 2023, laser sites represented almost 11% of production weeks in Norway, but just under 6% of the treatment weeks. This indicates that sites equipped with lasers required substantially fewer treatments compared with all other sites.

50%

Fewer lice treatments required for laser sites

To investigate the contribution of optical delousing to lice control, Stingray collaborated with the Mathematical Institute at the University of Bergen. Specifically, we modelled the weekly probability that a site requires treatment in Norway during the year 2023. The model incorporated two predictors: whether a site was using optical delousing, and the sea temperature that was reported for that week. Since sea temperature varies substantially between production areas, and lice development is strongly temperature-dependent, warmer regions will generally experience higher infestation pressure and therefore require more treatments than colder regions. It is therefore essential to account for the effect of sea temperature when comparing farm sites.

Considering a sea temperature of 10 °C as reference, the model estimated a weekly treatment probability of 10% for sites without optical delousing compared with only 5% for laser sites. In other words, laser sites required 50% fewer lice treatments compared with all other sites at the national level. This effect was observed for mechanical treatments, medicinal bath treatments, and medicinal food treatments.

The magnitude of the difference in delousing probability varied between regions. However, in all production areas where Stingray had sufficient market share to run model-based comparison, the same pattern emerged: farms relying on optical delousing required significantly fewer treatments against salmon lice.

Because statistical models rely on large-scale data analyses rather than controlled experiments, it is essential to ensure that there are no other factors that could have explained the observed differences in treatment probabilities between sites with or without optical delousing. Therefore, when comparing treatment probabilities across the same sites prior to the commercial introduction of optical delousing, the sites were shown to require comparable levels of treatment. This indicates that there were no systematic underlying site-specific factors influencing treatment intensity before optical delousing was introduced. Finally, despite performing fewer treatments and using substantially fewer or no cleaner fish at all (see chapter “Cleaner Fish”), laser sites did not report higher lice numbers than other sites. They maintained comparatively low lice levels during the outmigration period for wild Atlantic salmon smolts in spring.

In summary, these findings demonstrate that optical delousing has gained widespread acceptance and is successfully used as an alternative to conventional methods of lice control in Norway. These results have recently been published as a peer-reviewed scientific article in the journal *Aquaculture* (Worm et al., 2026) and were presented at the annual conference of the European Aquaculture Society in Valencia. The study is openly accessible online and contributes to a better understanding of the impact of optical delousing on lice control among stakeholders and in the scientific community.

<https://doi.org/10.1016/j.aquaculture.2025.742910>



Stingray results 2025

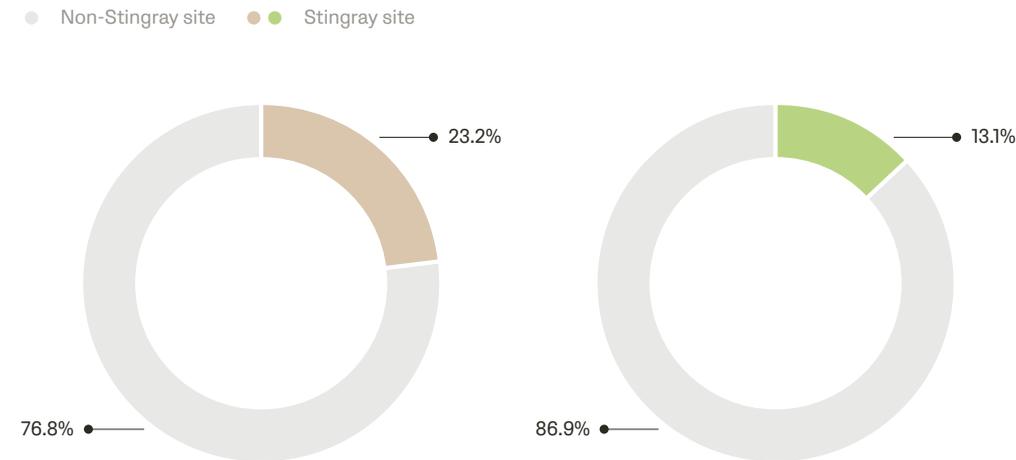
Building on the peer-reviewed results from 2023, this section focuses on Stingray's 2025 operational performance. Results from 2024 are omitted, as they were documented in detail in the previous Fish Health Report (Stingray Marine Solutions AS, 2025).

100%
Increase of Stingray's market share in Norwegian aquaculture since 2023

Throughout 2025, Stingray has continued its roll out of laser systems along the Norwegian coast and the number of sites that use optical delousing as a controlling measure against sea lice continued to grow considerably. Measured in production weeks (weeks when a site is in operation) per site, the Stingray's market share in Norwegian aquaculture has more than doubled from 10.9% in 2023 to 23.2%

by the end of 2025. At the same time, the proportion of treatments weeks, in this context, weeks where treatment was necessary despite the use of lasers at a site, was only 13.1% concluding 2025 (Figure 10). This aligns with the results from 2023, indicating that sites using lasers to control lice outbreaks needed on average fewer reactive treatments to maintain legal lice levels.

FIGURE 10. Comparison of production weeks (left) and treatment weeks (right) for Norwegian aquaculture sites with and without lasers. The proportion of laser sites is greater for production weeks than for treatment weeks, highlighting the contribution of optical delousing to lice control along the Norwegian coast



The extent to which optical delousing was used to control salmon lice still varied widely among the 13 production areas in Norway (Figure 11). The comparison of production weeks and treatment weeks per PA shows without exception that

sites that relied on Stingray represented a larger proportion of production weeks than treatment weeks within a respective area. In other words, Stingray sites needed fewer treatments compared with all other sites in 2025.

● Production weeks
● Treatment weeks

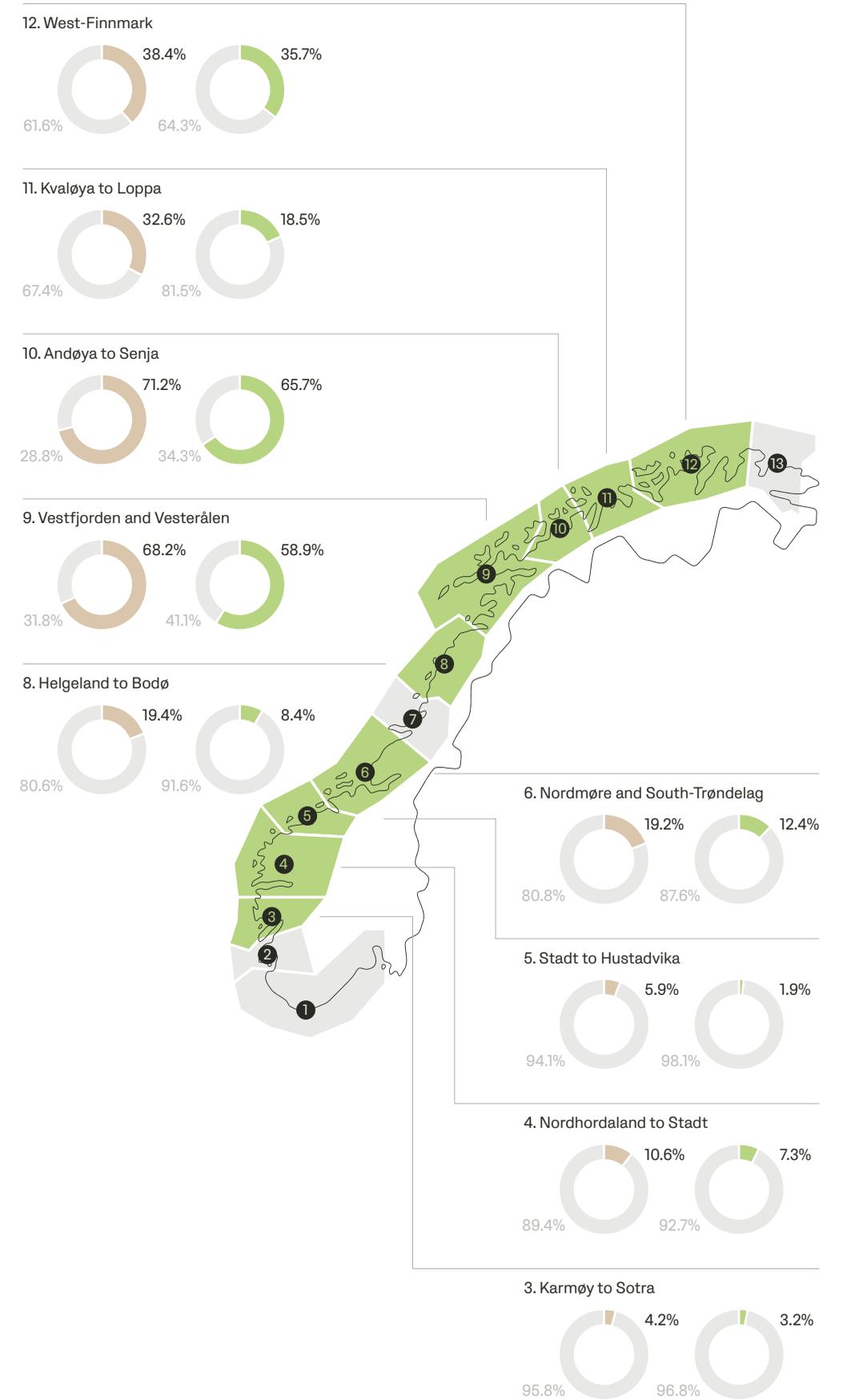


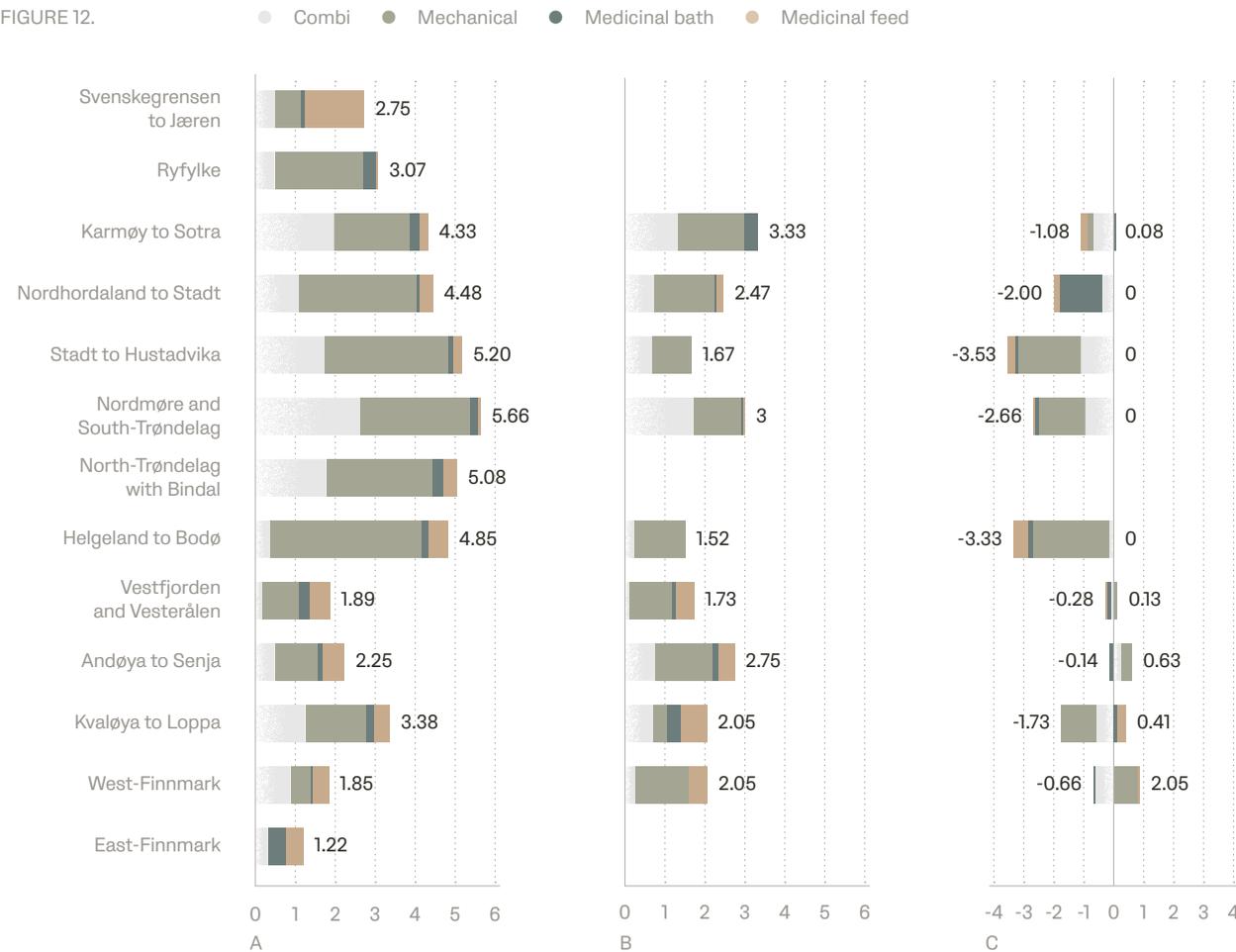
FIGURE 11. Subdivision of the Norwegian coast into 13 PAs color-coded based on whether Stingray operated within an area. Donut charts show the proportion of production weeks and treatment weeks for sites with and without optical delousing. The proportion of production weeks corresponds to the Stingray market share within the respective PA

Treatment frequency

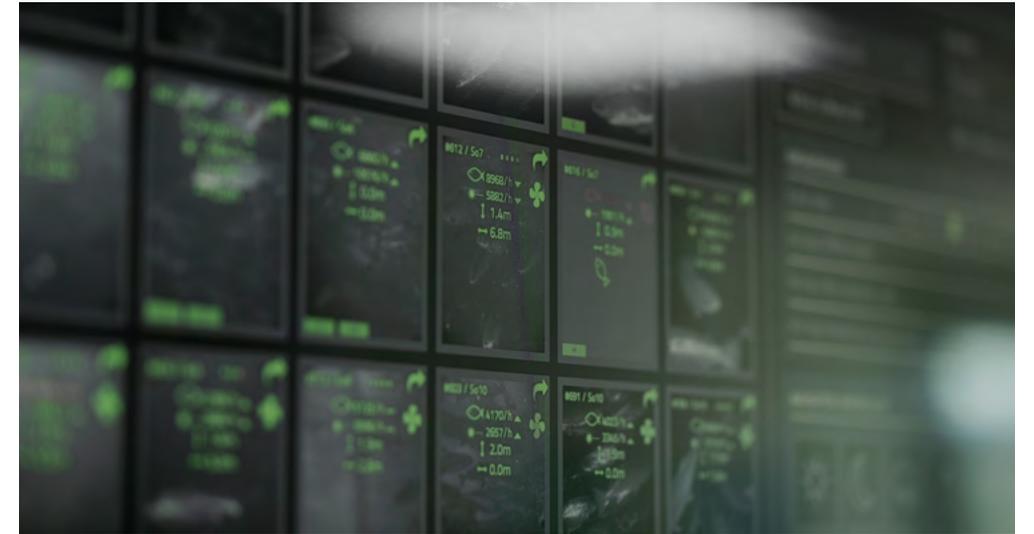
How often reactive treatments against salmon lice were necessary varied considerably both within and between PAs. Figure 12 shows the average number of treatment weeks per site (Figure 12A) and PA, differentiated based on the type of treatment performed. In 2025, most treatments were required in PAs 5 and 6. The differentiation of treatments by category also shows that mechanical delousing operations still represent the majority of conventional

interventions. However, combination treatments involving more than one treatment type have become much more frequent compared to previous years. Figure 12B shows the average number of treatment weeks exclusively for laser sites, and Figure 12C displays the difference between laser sites and all other sites per treatment category. Here, negative values represent the average number of avoided reactive treatments within the respective PA.

FIGURE 12.



Average number of treatment weeks per site in 2025 per PA and treatment category. 12A shows the average number of treatment weeks per site for all sites. 12B shows the corresponding averages only for laser sites. 12C displays the difference between sites with and without lasers



30%

Lower weekly probability of treatment at Stingray sites

The difference in treatment frequency between sites with and without lasers was further analyzed by estimating the weekly probability of treatment. As salmon lice develop faster at higher temperatures (Hamre et al., 2019), sea temperature was included in the statistical model. Assuming a sea temperature of 10 °C, the model estimated weekly treatment probabilities of 8% for sites with optical delousing and 12% for sites without.

This indicates that weekly treatment probability was about 30% lower at Stingray sites compared with other Norwegian sites in 2025. The results show that optical delousing provided a clear advantage for Stingray's customers, although overall treatment needs were higher than in 2023 (Worm et al., 2026). The increased need for reactive treatments was mainly driven by higher sea temperatures in 2025 compared to 2023 (Figure 13).

FIGURE 13. Weekly average of sea temperature in Norway





Salmon lice abundance

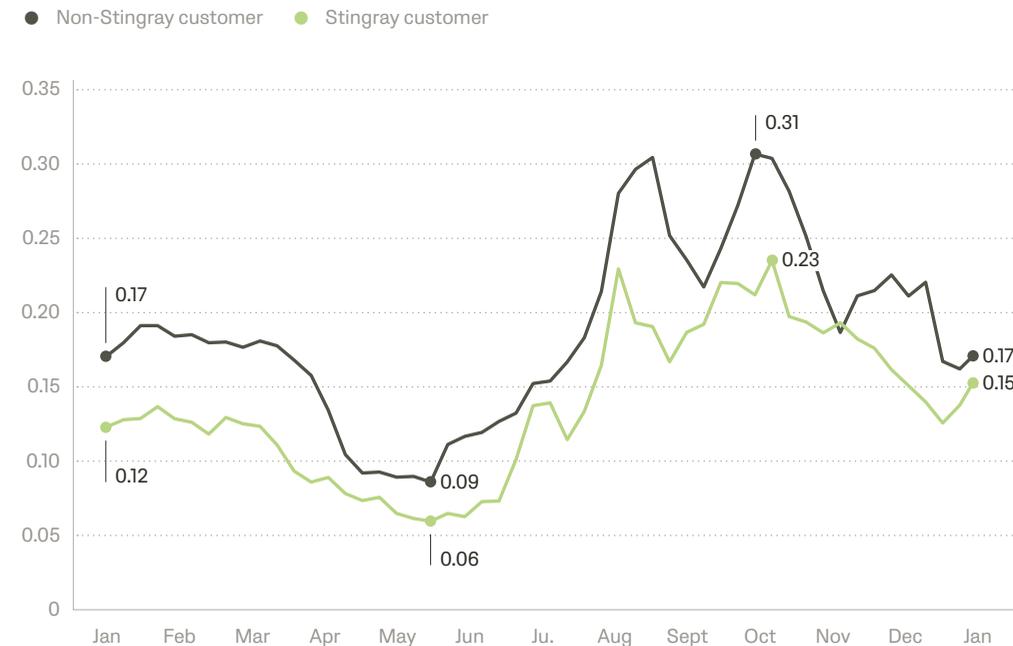
In addition to reduced treatment requirements, Stingray customers also reported lower lice abundance at their sites in 2025. Figure 14 shows the average reported number of adult female salmon lice per fish per week at sites with and without optical delousing. Lice abundance followed a clear seasonal pattern, which is expected due to seasonal variations in sea temperature (Figure 13) and the introduction of stricter delousing thresholds in spring. Figure 13 also shows that 2025 began with relatively high sea temperatures compared to previous years, indicating that elevated temperature conditions were already present early in the production cycle.

These elevated early-year temperatures reflect an increasingly persistent trend of more frequent and intense marine heatwaves. The extreme events observed in 2024 and 2025 show that elevated sea temperatures are becoming a structural driver of sea lice pressure, disease risk, and fish welfare challenges in Norwegian

aquaculture, a development likely to continue. Early 2025 data—including record sea temperatures in Western Norway and high lice levels on farmed and wild salmonids—underscore the need for proactive, temperature-informed management and stronger preventive lice control strategies (Grefsrud et al., 2025; Nilsen et al., 2024; Smith et al., 2021).

Although all sites, both with and without optical delousing, were affected by seasonal changes in lice abundance, average reported lice levels were lower at sites with laser, particularly during the first half of the year when sea temperatures were still low. This had positive implications for Stingray’s customers, as laser-based control helped maintain low lice levels ahead of the enforcement of stricter lice thresholds, while other sites required more spring delousings to remain compliant. For fish at sites with laser, this meant reduced or no handling during a critical period of low sea temperatures.

FIGURE 14. Comparison of reported counts of adult female lice per fish on sites with and without Stingray



Cleaner fish

21%

Overall reduction in cleaner fish use in 2025

Cleaner fish, such as lumpfish (*Cyclopterus lumpus* Linnaeus, 1758) and various wrasse species (*Labridae*), have traditionally served as biological delousers in salmon aquaculture, removing salmon lice directly from the host fish with little risk to the environment (Powell et al., 2017; Treasurer, 2002). The use of cleaner fish has been in decline in recent years due to welfare

challenges, variable delousing efficiency, and increasing adoption of alternative control technologies, as described in the Stingray Fish Health Report 2024 (Stingray Marine Solutions AS, 2025).

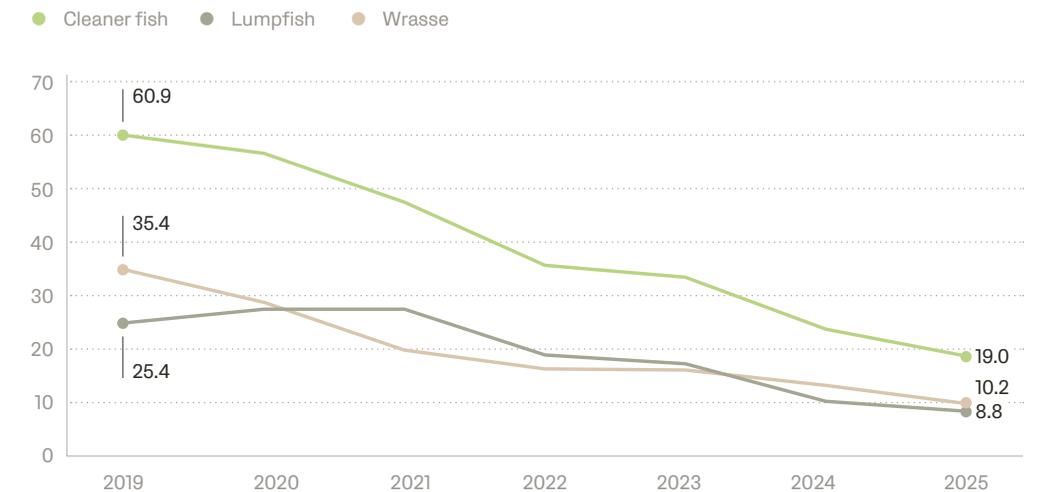
In 2025, this decline continued at a steady pace. By the end of the year, a total of 19.1 million cleaner fish were stocked in Norwegian aquaculture sites, accounting for 18.6% of all sites in Norway, compared with 24.1 million in 2024 and 60.9 million in 2019 (Figure 15) (Fiskeridirktoratet, 2025). This represents an overall reduction of 69% in six years, and 21% from last year, marking 2025 the lowest use of cleaner fish since the early 2010s.

Stingray keeps lice and cleaner fish away

PER GUNNAR KNUTSHAUG

CEO, Knutshaug Fisk

FIGURE 15. Cleaner fish use declining in Norwegian aquaculture from 2019 to 2025 (shown as individuals stocked), source: Fiskeridirktoratet



The use of both lumpfish and wild-caught wrasse has been steeply reduced (Figure 15). Lumpfish use has declined by more than half since 2023, reflecting reduced willingness from salmon farmers to use these fish as biological delousers, and due to stricter welfare scrutiny (Brooker et al., 2018; Powell et al., 2018). The wild wrasse fishery has

similarly experienced tighter national quotas due to expected decline in wild populations, and reduced catching activity along the Western coast, with national catches falling from 12.8 million in 2023 to 9.9 million in 2024 (Halvorsen, 2023; Nærings- og fiskeridepartementet, 2024).

These reductions are seen as a direct result of limited willingness from the aquaculture industry to invest in a product with potentially reduced welfare and high mortality rates.

Cleaner fish use in 2025 is geographically limited and seasonally constrained.

2.3%

Stingray customers' share of national cleaner fish deployments

Wrasse deployments occur almost exclusively in the Southern and Mid-coastal PAs 1 to 5, peaking in July to September, while lumpfish remained in moderate use through PAs 4 to 7 early in the year (Fiskeridirektoratet, 2025). From PA 8 and Northwards, cleaner fish (lumpfish) use has effectively ceased, reflecting both environmental limitations as well as strengthened welfare and handling requirements (Mattilsynet, 2023). Together, these reductions confirm that cleaner fish have shifted from a cornerstone of salmon lice control to a supporting, transitional tool in modern aquaculture.

Among Stingray's customers, accounting for approximately 25% of the market share, cleaner fish are used at only a few

sites within PA 3, PA 7 and in Iceland. These sites accounted for a total of approximately 260,697 individuals used during 2025 and represent an insignificant proportion (2.3%) of the national total. This confirms that the company's customers largely operate without the use of biological delousing. By the end of 2025, only three sites were actively using cleaner fish in combination with the Stingray system, showing that optical delousing has truly been accepted as a successful alternative to cleaner fish.

To promote consistent and humane practices among farmers that still use cleaner fish, Stingray collaborated with Gildeskål Forskningsstasjon in Bodø and published the open-access Lumpfish Standard (Reynolds & Lemmens, 2025). This standard provides unified, evidence-based guidance for the ethical and effective use of lumpfish as cleaner fish in Atlantic salmon farming. It represents the first industry-wide welfare framework of its kind and is openly available to the sector. The Lumpfish Standard serves as the reference document for all future biological delousing operations, ensuring that welfare, health, and performance are balanced under transparent management principles.

The ethical debate on cleaner fish welfare should drive improvement. High mortality, especially among lumpfish, led to regulatory warnings that their use could be restricted if conditions did not improve. Inconsistent practices highlighted the need for evidence-based standards to protect welfare, reduce mortality, and optimize sea lice control. Clear guidelines were therefore developed to accelerate improvements and strengthen ethical responsibility across the industry.

PAT REYNOLDS

Research Scientist, Gifas

Outlook and future use

The current trajectory suggests that cleaner fish will remain part of salmon lice management in the near foreseeable future, albeit on a much-reduced scale. Their continued use will likely be limited to site-specific deployments, restricted to farms with environmental conditions that support acceptable welfare and well documented efficacy.

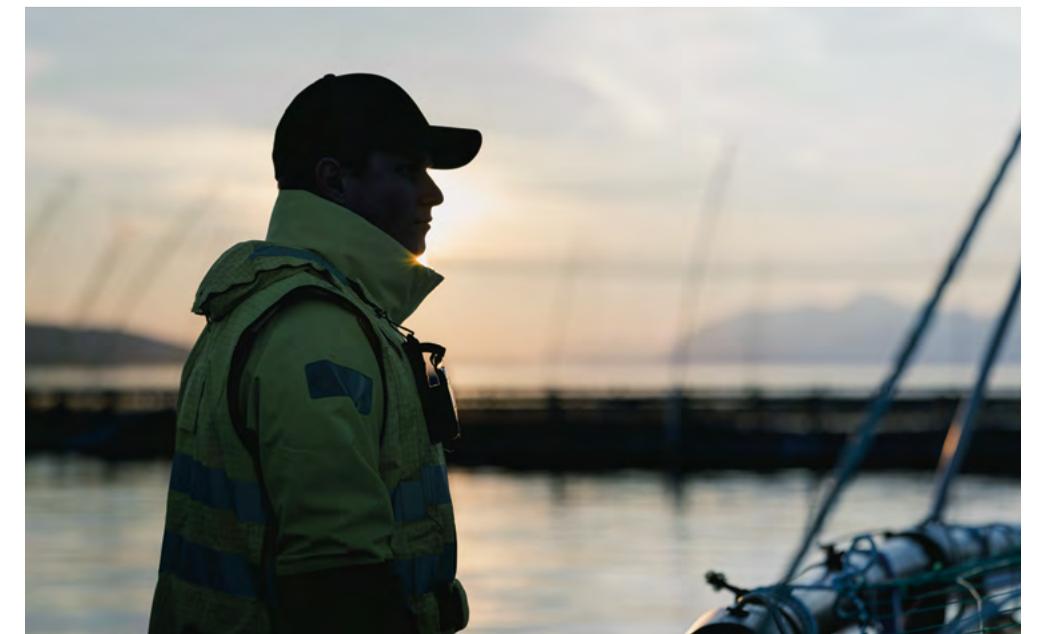
Technological advancements such as continuous optical delousing are progressively reducing reliance on live biological control. In this context, the role of cleaner

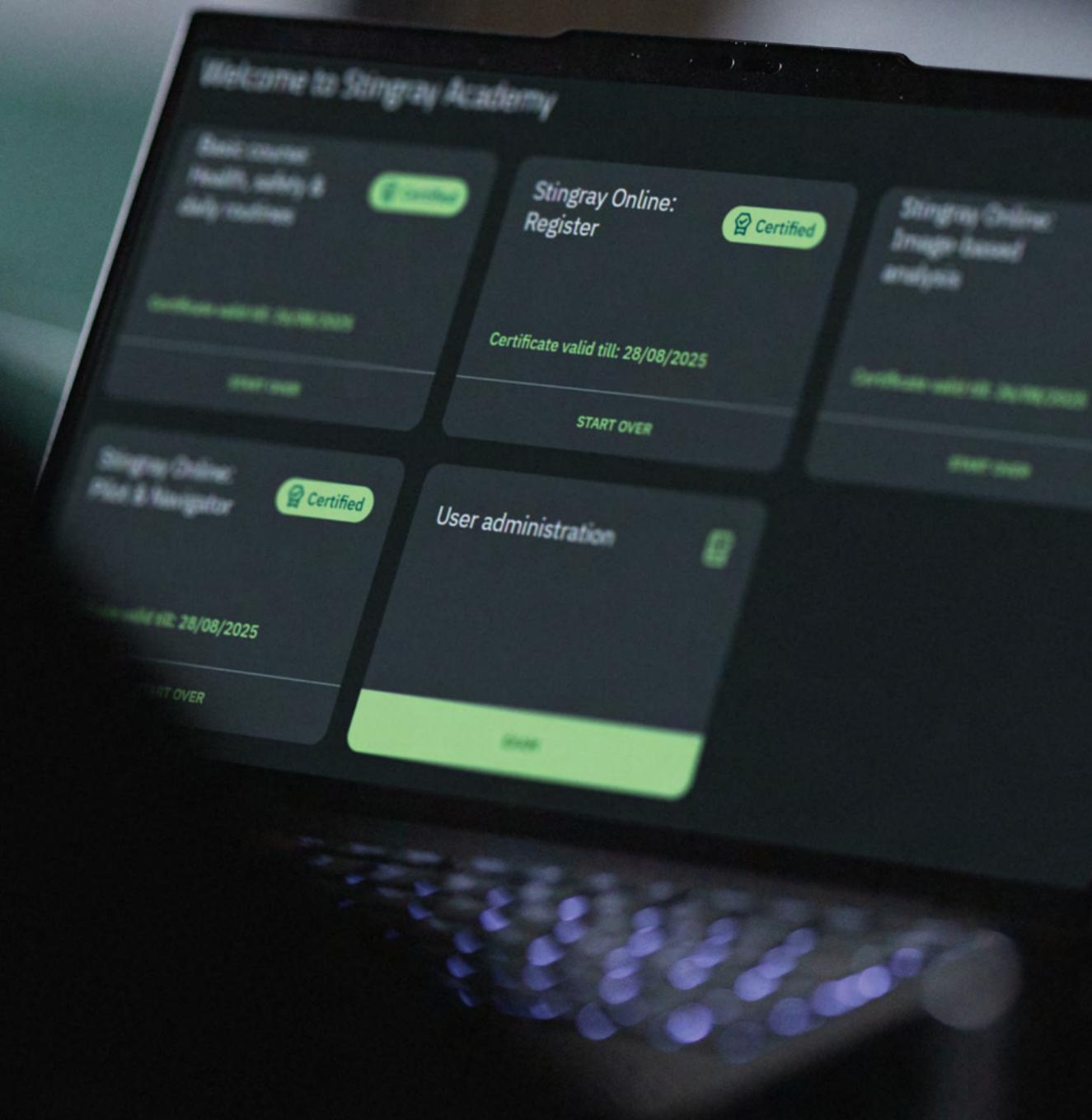
fish will no longer be defined by numbers stocked, but by the standards applied. This represents a shift from volume-based implementation to knowledge-based utilization, guided by evidence, ethics, and welfare accountability. Stingray supports the recommendation that the use of cleaner fish should be phased out as soon as possible, and no later than 2029, as proposed by the Veterinary Institute (Sydnes, 2025). Stingray contributes expertise to support the transition from cleaner fish to technological control methods.

Based on our experience with cleaner fish and lasers, laser-based lice control is a more robust and long-term solution, enabling zero use of cleaner fish while improving fish welfare and sustainability without increased biological risk.

OVE KNUTSHAUG

Shift Supervisor, Knutshaug Fisk





4.0

Production and control

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Improvements in technology, operations, and access to data and training have made it easier for customers to use the Stingray system effectively across different operational contexts. Together with centralized laser centers and applied research, these developments support improved fish welfare, more efficient operations, and more informed decision-making.

Customer success



Through Stingray Online, the customer platform, the Stingray system delivers consistent functionality and value across operations from small, family-owned enterprises to large, multi-site organizations with extended staff. Regardless of size, all customers receive equal access to the platform's full range of applications. As a result, the use of Stingray nodes and software is not limited by operational scale.

Through ongoing, systematic development, both the functionality and accessibility of Stingray Online have steadily increased. Enhancements and new features (Figure 16) are introduced in response to evolving industry requirements, supporting customers in achieving improved outcomes, such as a steadily increasing number of fish passing the system within operational range (Figure 17).

FIGURE 16. Stingray Online development timeline

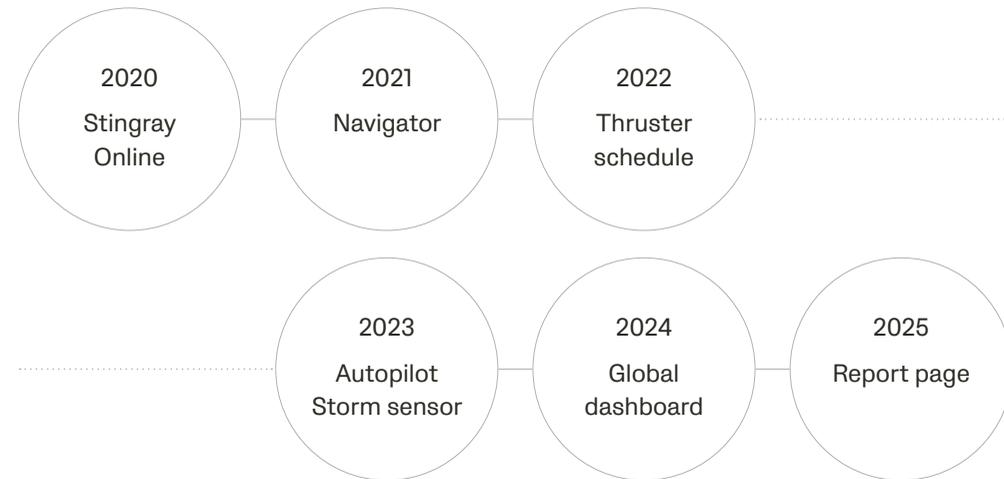
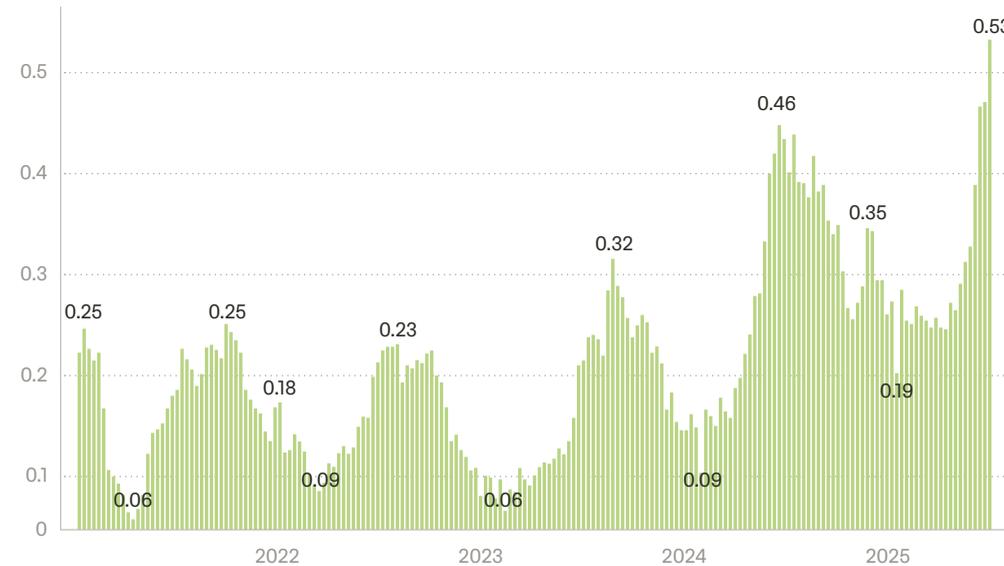


FIGURE 17. Trends in fish passings per node from 2021 to 2025



Laser centers

Maintaining a consistent presence of fish within each node's camera field of view is essential for system performance. Stingray operates control centers in both Oslo and Fauske, and during 2025, eight additional resources were hired to strengthen operational capacity. In addition, an increasing number of customers are dedicating resources to maximizing fish passage frequency throughout operational hours. This is achieved by employing dedicated laser operators who continuously adjust and optimize node positioning to ensure reliable and consistent results. The role laser operator is a specialized profession developed by Stingray.

Since its introduction, the number of laser operators in Norway has grown steadily, and by 2025 more than 100 full-time equivalent operators were employed outside of Stingray.

From 2020 onwards, customers increasingly established centralized laser centers, where dedicated operators monitor and manage multiple sites from a single operational hub. This organizational model provides a focused working environment that supports collaboration, knowledge sharing, continuous learning, and contributes to stronger and more consistent performance across sites.

We professionalized the laser operator role through a dedicated in-house laser center. Our operators combine biological insight, technical expertise, and real-time decision-making to deliver consistent, high-quality results. Assigning one or two sites per operator, aligned with site capacity, ensures stable operations and strong fish welfare.



ALEKSANDER YTTERGÅRD
Manager laser operations Cermaq Norway

Stingray's customer support and tailored training materials are high quality and regularly integrated into our daily laser operations. Strong results require dedicated in-house laser pilots with continuous focus on the key success factor: fish in front of the camera.



LARS ARNE LIEN
Manager laser operations SalMar Farming Midt



Fish don't take vacations, and Stingray operations have run smoothly through July, returning to full capacity from Monday, August 4th. Around 250 colleagues are supporting improved fish welfare and reduced unwanted mortality for more than 100 million salmon and trout at sea. Across the coastline, producers see that continuous, preventive laser-based delousing improves fish health with less handling. The Fish Health Hub™ enables better control throughout the production cycle.

JOHN ARNE BREIVIK
CEO, Stingray



Stingray Academy 2025

89-97%

Stingray Academy's completion rate for 2025

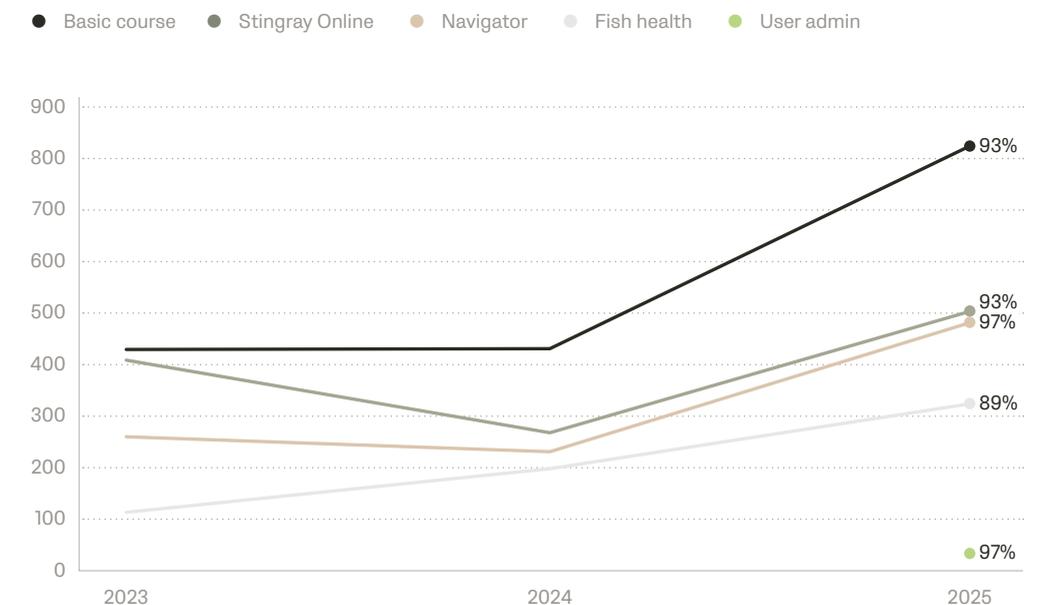
Academy is Stingray's dedicated learning platform, designed to provide our customers with applicable and accessible training. The training portfolio covers the full customer journey, from core software use to administrative oversight. This ensures accurate access rights/levels, up-to-date user lists, and improved compliance with security and privacy standards.

As Stingray's customer base expands, manual handling of user administration would become increasingly unsustainable. By enabling customers to manage these processes themselves, Academy supports faster onboarding of new employees and smoother day-to-day operations. This addition strengthens customer independence while maintaining efficient control of the Stingray platform.

To this end, the platform was expanded in 2025 with a new course, "User Admin",

which enables customers to independently manage employee access and usage in Stingray Online. The course reduces reliance on Stingray's support team and empowers customers with direct control of their own platform administration. The addition of the User Admin course reflects Academy's commitment to addressing both technical and operational learning needs. Figure 10 shows the development in course completions across Academy's portfolio from 2023 to 2025. All courses demonstrate steady growth in completion during this period, with particularly strong increases in the Basic and Navigator courses in 2025. The completion rate as of 2025 is high, ranging from 89% to 97%. By the end of 2025, Stingray registered 852 individual customer users actively participating in Stingray Academy.

FIGURE 18. Course completions over time (2023-2025), with completion rates shown in numbers for 2025

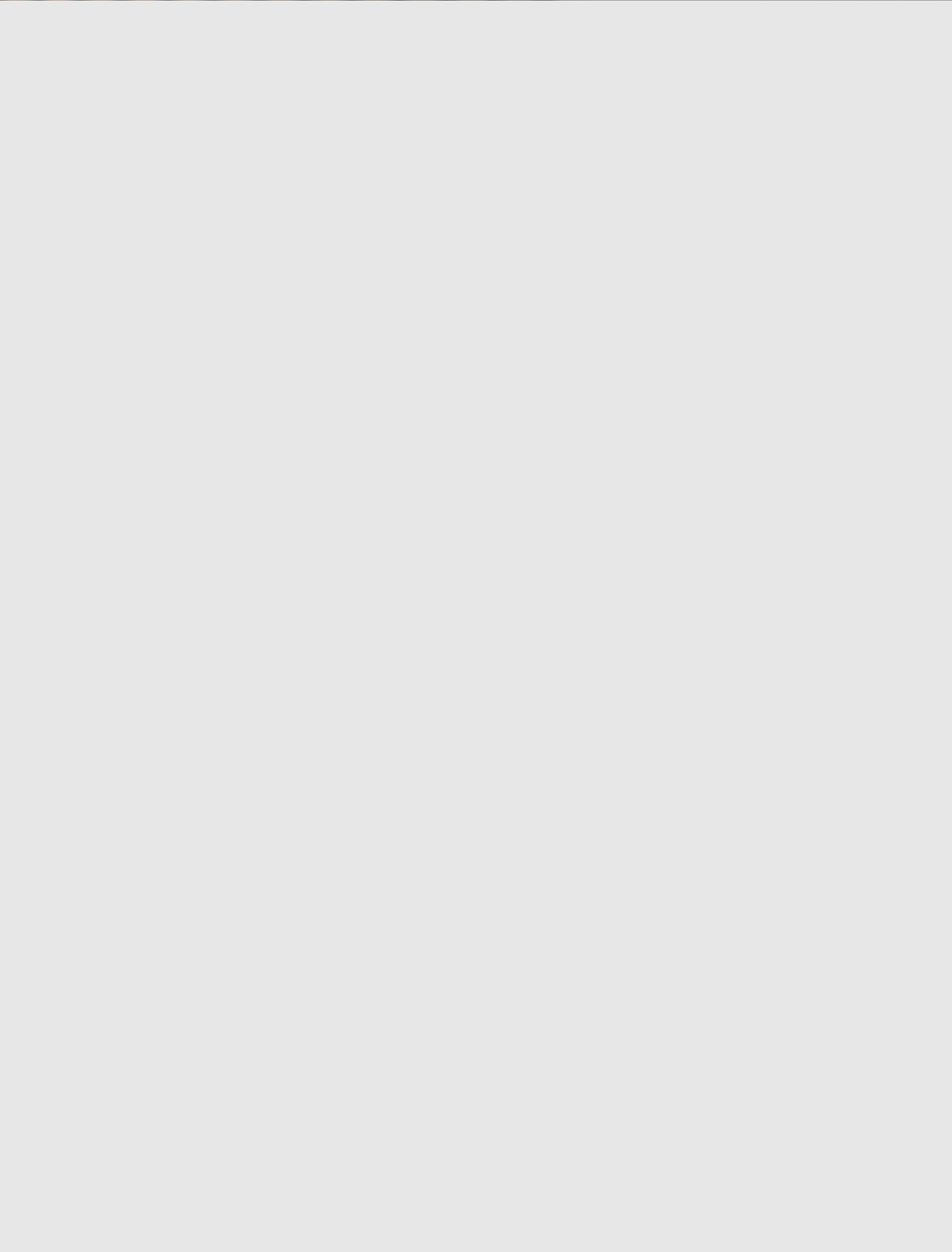




5.0

Fish health

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Continuous, automated welfare monitoring in 2025 reveals clear links between sea temperature, wound prevalence and sexual maturation across Norwegian production areas. By combining large-scale biological data with standardized scoring and comparisons to harvest outcomes, our results demonstrate how objective, data-driven welfare indicators can support early intervention, improved planning, and consistent welfare management throughout the production cycle.

Wounds

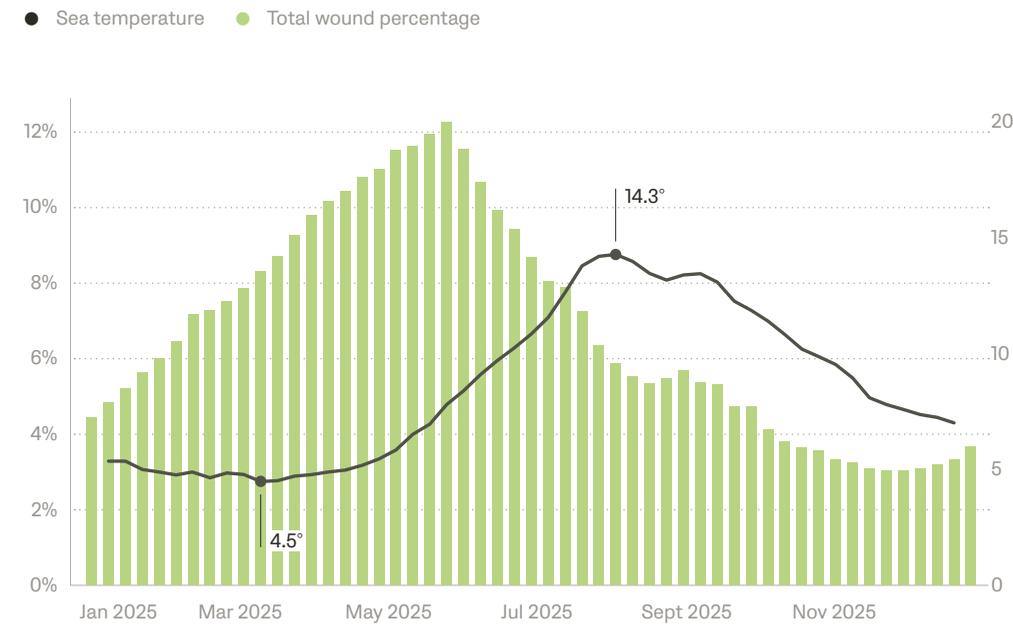
Wound development reflects environmental, health, and operational stressors and is central to fish welfare assessment. Stingray’s continuous, standardized wound monitoring provides objective site-level insight, supporting preventive management and reduced risk of disease and avoidable mortality.



As part of the Fish Health Hub™, wound status is monitored daily across all Stingray-equipped sites, covering all sites where Stingray systems were deployed during the year (Figure 19). While absolute sea temperatures vary substantially along the Norwegian coastline, they follow

a consistent seasonal pattern and are a key driver of wound development. Aggregating data across production areas by sea temperature therefore provides a robust national-level basis for assessing wound prevalence.

FIGURE 19. Weekly sea temperature and total wound percentage from all Stingray sites



7-8°C

Critical threshold for wound development/healing

At the start of 2025, wound prevalence was approximately 4%, with average sea temperatures slightly above 6 °C. Across sites, decreasing sea temperatures toward the annual minimum of approximately 4.5 °C were associated with a steady increase in wound prevalence (Figure 11).

Wound prevalence reached a peak of approximately 12.5% when sea temperatures increased towards 8 °C. As sea temperatures increased further through spring and summer, wound prevalence declined and stabilized at around 5% or lower during late summer. During the subsequent cooling period in autumn, wound prevalence remained low at approximately 3-4%, with only a modest increase observed toward the end of the year.

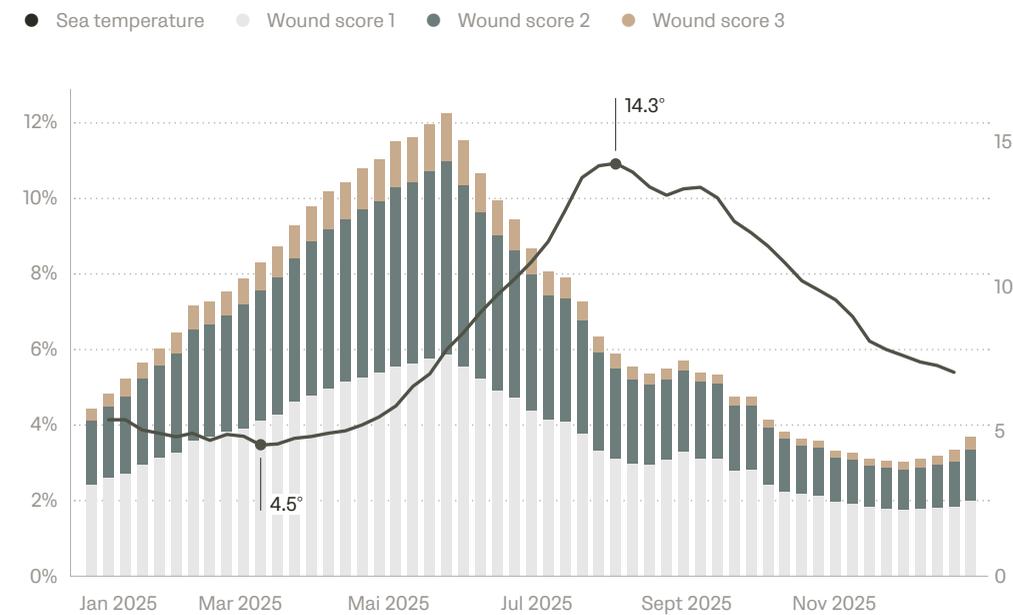
Across sites, the data identify sea temperatures in the range of 7-8 °C as a critical threshold for both wound development and healing. Wound prevalence increases as temperatures decline toward this range during early winter, while increasing temperatures above this threshold in spring are associated with wound healing, consistent with previous findings on temperature-dependent healing processes in salmonids (Jensen et al., 2015). Owing to latitudinal differences along the Norwegian coast, the timing of these processes varies regionally. In PA 4, wound healing is most pronounced from May to July, while in PA 10 it occurs primarily from June to August.



In addition to registering the presence of wounds, the Fish Health Hub™ records wound severity, measured by the wound size relative to the width of the tail base of each fish. Wounds are scored from 1 to 3 following the Laksvel standard (Nilsson et al., 2025; Nilsson et al., 2022) where higher scores reflect greater severity and welfare impact. Larger or multiple wounds result in higher total scores and constitute a larger share of observed wounds during periods of high overall wound prevalence.

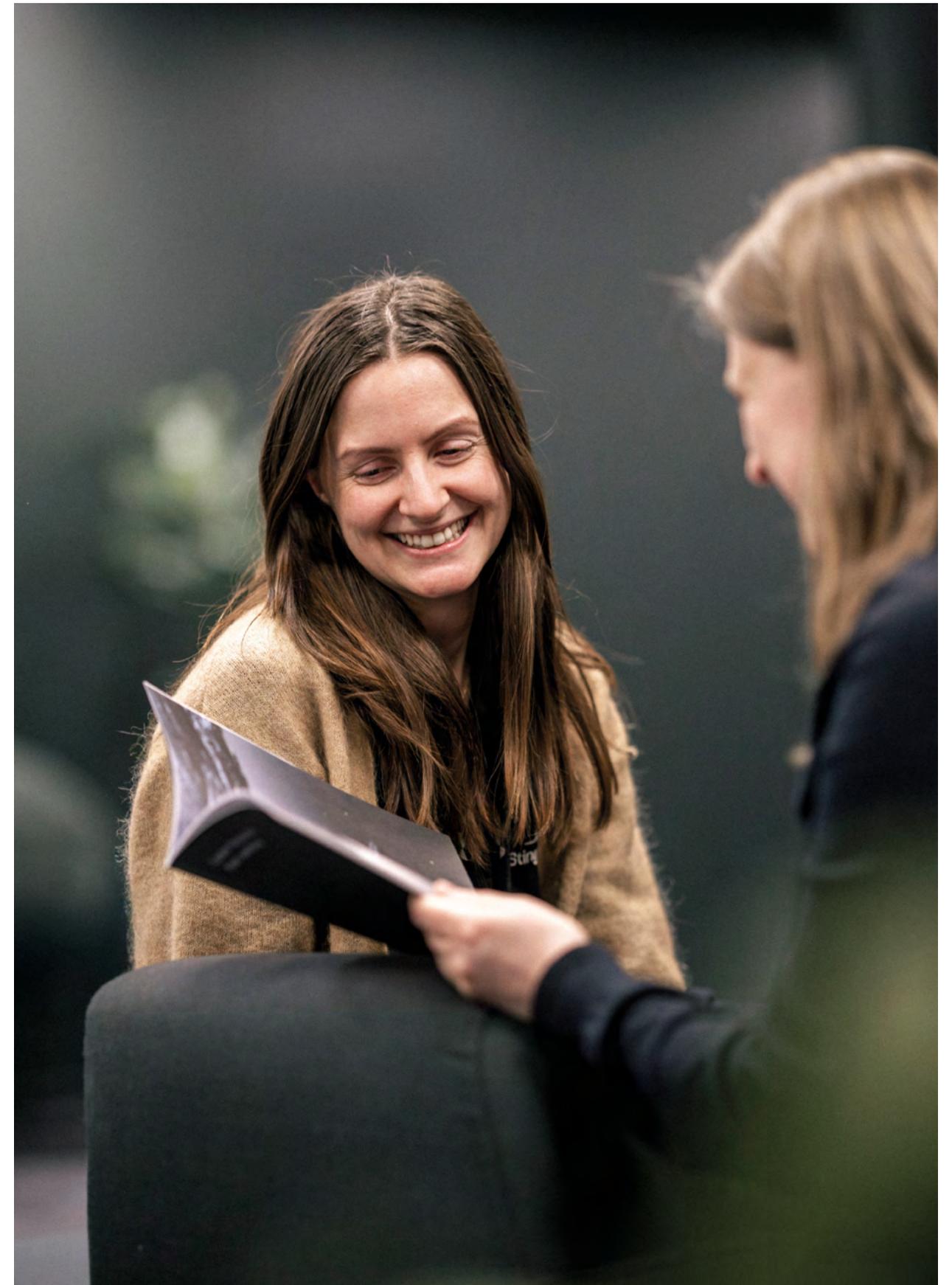
From winter through spring 2025, all wound scores increased in parallel with total wound prevalence, peaking in late May. Weekly data show that 50–60% of wounded fish were classified as score 1; score 2 represented 35–40%, and 4–7% classified as score 3, the most severe category. During periods of low overall wound prevalence, wounds with score 1 dominated, while colder periods were characterized by a higher relative contribution of score 2 and score 3 wounds (Figure 20).

FIGURE 20. Weekly sea temperature and wound scores from all Stingray sites



Linking wound prevalence and severity to sea temperature at high temporal and spatial resolution reveals predictable patterns of elevated welfare risk across regions and seasons. This enables more targeted guidance on operational planning, including timing of handling, reactive delousing, and other routine activities during periods

when fish are most vulnerable. In addition, continuous wound monitoring allows deviations from expected patterns to be detected early at the site level, supporting preventive measures and contributing to improved fish welfare, reduced disease progression, and lower avoidable mortality.



Vertical distribution of Atlantic salmon (*Salmo salar* L.) with skin ulcers in sea cages

A bachelor's thesis was conducted in collaboration between the Norwegian University of Life Sciences (NMBU) and Stingray. The aim of the study was to assess whether a clear association between the presence of skin wounds and the vertical distribution of farmed Atlantic salmon within sea pens could be observed. The study was conducted at a Mortenlaks AS site in PA 9 between the

15th and 31st of January 2025. Three Stingray systems were deployed at depths of 2, 8, and 14 meters to record fish passings and the presence of skin wounds. Bespoke positioning and data analysis applications were used to manage system placement and to process the data. The dataset comprised two groups of wound scores, one based on manual review and one generated through automated classification.



8 m

Depth with most fish passings

During the study period, an increase in the presence of skin wounds was observed, although most cases were minor (score 1), assessed according to the wound scoring standard described in Section 5.1 Wounds. The highest number of fish passings was recorded at 8 meters depth, indicating

a clear preference for the main salmon shoal to occupy this depth. In contrast, fish with visible skin wounds were most frequently observed at 2 meters depth (Figure 21), indicating an association between the presence of skin wounds and a shallower vertical distribution.

FIGURE 21. The percentage of skin wounds at different depths during the experimental period. Data collected through manual registration, including 150 sequences per depth and a total of 450 sequences per day



The findings are consistent with previous studies linking salmon behavior to environmental and physiological factors such as temperature (Korus et al., 2024; Oppedal et al., 2011; Sandrelli et al., 2025), light intensity and feeding behavior (Fernö et al., 1995), depth preferences (Fernö et al., 1995; Noble et al., 2018; Oppedal et al., 2011), and altered behavior in compromised fish, such as emaciated “pin-head” fish (Sauphar et al., 2024). Understanding how wounded fish are distributed vertically within sea pens provides additional context for interpreting

wound data and fish behavior at the site level. For Stingray, this insight can be used to refine system placement, monitoring strategies, and data interpretation, ensuring that observations remain representative of the broader fish population. For Stingray customers, this improves the ability to detect and follow up on welfare-related deviations early, supports more informed operational planning, and contributes to better fish welfare outcomes by reducing the risk that compromised fish go unnoticed within the production environment.

Sexual maturation in fish

Sexual maturation during the sea phase represents a welfare and production challenge in salmonid aquaculture, as mature fish divert energy from growth to reproduction, resulting in reduced product quality and increased harvest downgrading. Although sexual maturation is typically documented at harvest, continuous monitoring during production provides detailed information on when and where maturation develops during the sea phase.

This chapter presents the occurrence, timing, and distribution of sexual maturation in 2025 across regions, stocking strategies, and production phases. The results are based on daily observations from Stingray systems and reveal clear temporal and spatial patterns in maturation during production. Sexual maturation emerges at consistent times of year, while its progression varies across regions and stocking times (Mobley et al., 2021).

Sexual maturation in early autumn

Daily, automated observations from Stingray systems enable site-level analysis of sexual maturation across production areas during 2025. In the following analyses, stocks consisting of G24 fish are included. G24 fish refer to the year class 2024, grouped across multiple sites and separated by stocking strategy into autumn-stocked (S0) and spring-stocked (S1) groups. S1 groups were deployed to sea mainly in May, while the S0 groups

Continuous monitoring enables maturation to be tracked as it develops during the sea phase, providing detailed insight into maturation dynamics within and across production areas. The increasing availability of continuous production data further supports a shift from retrospective documentation toward earlier identification of sexual maturation during the sea phase.

In the context of rising biological pressure and tighter operational constraints, understanding when and where maturation tends to emerge is increasingly important for planning and risk management. Over time, repeated observations of seasonal and regional patterns provide a basis for anticipating periods of elevated maturation risk and for adapting operational decisions, accordingly, grounded in observed production data.

were deployed in July and August. Sexual maturation is assessed at site level. A site is classified as exhibiting sexual maturation when site-level prevalence exceeds Stingray's defined significant maturation threshold, which is based on welfare evaluations in combination with other relevant parameters.

The results showed that the development of sexual maturation was geographically concentrated rather than evenly



distributed along the coast. Sexual maturation was observed in 13 sites in PAs 9 and 10 during early autumn (August to September) 2025. Sexual maturation was not observed in other PAs during the same period.

The increase in sites with sexual maturation was more pronounced in PA 10 than in PA 9, and a higher proportion of sites with sexual maturation was observed among spring-stocked (S1) fish.

Even though spring- and autumn-stocked fish are compared, by early autumn 2025 both groups had spent comparable time in the sea, placing them at similar stages of biological development. The comparable results between the two stocking strategies suggest that maturation onset at this stage was linked to cumulative development during the sea phase rather than to stocking strategy alone. The coinciding timing across stocking groups points to seasonal factors (such as a declining photoperiod) as a common driver of maturation onset, with regional differences reflected mainly in the rate of progression.

The first site-level occurrence of sexual maturation was observed in mid-September for both autumn- and spring-stocked fish.

Among autumn-stocked fish (S0), seven of 26 stockings in PAs 9 and 10 showed sexual maturation, with prevalence doubling from September to October at these sites. Among spring-stocked fish (S1), six of 17 stockings showed sexual maturation.

Temperature effects

The relationship between sea temperature and sexual maturation is shown in Figures 22 and 23. The figures show average sea temperature together with site-level occurrences of sexual maturation above the defined threshold for PAs 9 and 10.

In both PAs, the initial increase in sexual maturation occurred at similar times of year, coinciding with seasonal transitions. Although sea temperatures were

declining during this period, maturation emerged despite differences in absolute temperature levels, suggesting that timing rather than temperature per se may be the dominant factor. Environmental cues that follow consistent seasonal patterns, particularly photoperiod, should therefore be considered as potential drivers of sexual maturation in future analyses.

FIGURE 22. Average sea temperature and sexual maturation in sites using the Stingray system in PA 9. Data source: Stingray Marine Solutions and Barentswatch

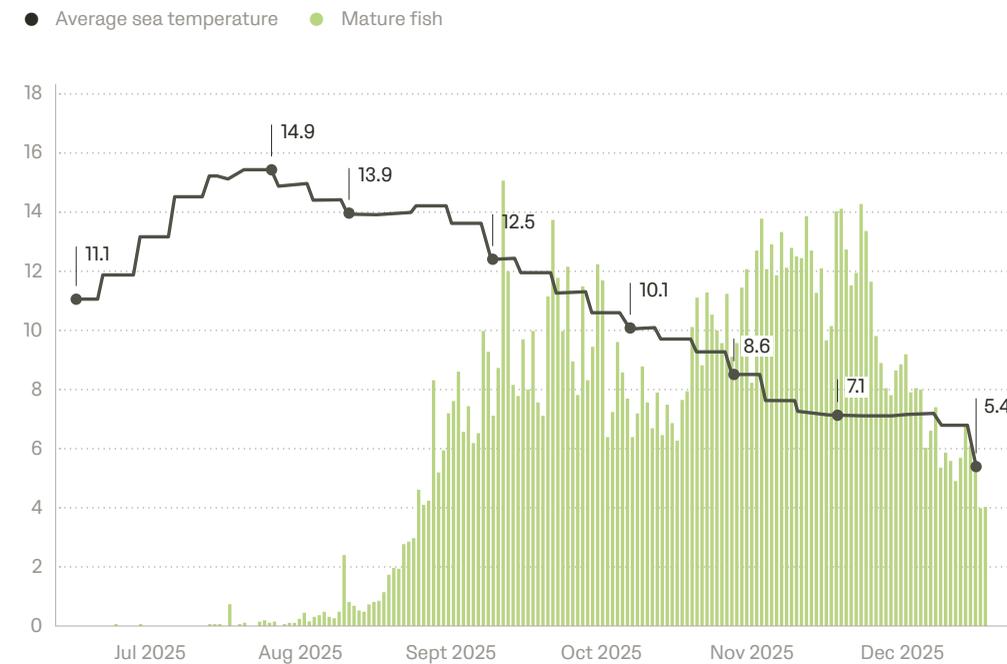


FIGURE 23. Average sea temperature and sexual maturation in sites using the Stingray system in PA 10. Data source: Stingray Marine Solutions and Barentswatch



Sexual maturation in late autumn

Sexual maturation exceeding the defined threshold in PAs 8 and 11 were observed later in the season. From mid-October through the end of December, site-level maturation was limited to these two PAs.

The later onset coincided with the seasonal changes observed across the coast, suggesting a similar seasonal driver with delayed site-level expression in these regions.

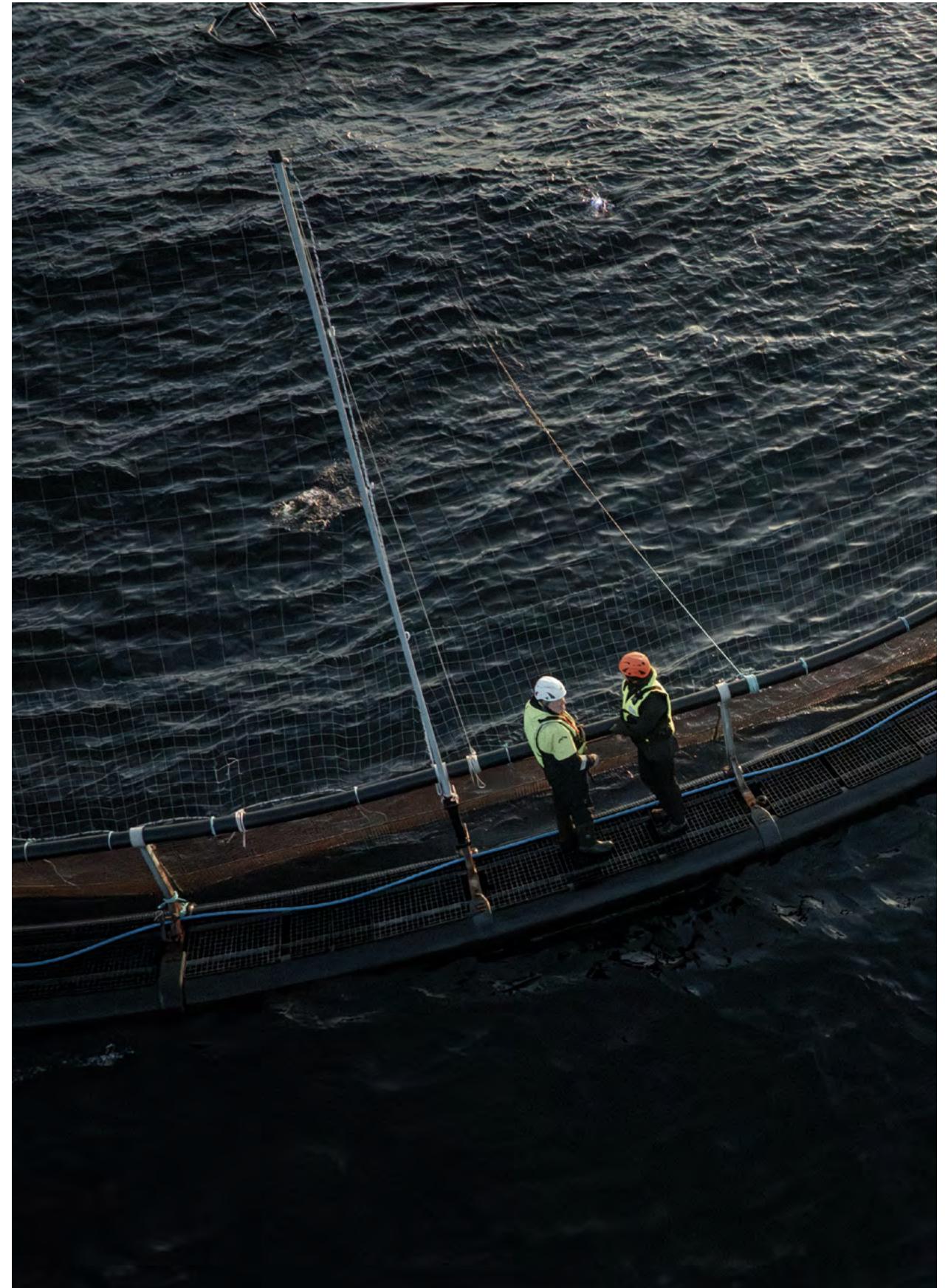


Pen prevalence

While site-level sexual maturation in early autumn was limited to PAs 9 and 10, pen-level maturation was observed across most PAs between 1 August and 28 December. In total, 176 of 950 pens (18%) equipped with the Stingray system nationally exceeded the maturation threshold, including pens at sites with low overall site-level prevalence. PAs 6, 9, and 10 recorded the earliest occurrences of maturation at pen level in August, followed by PAs 4, 8, and 11 in September. Both the number of affected pens and the degree of sexual maturation increased through autumn and winter. These patterns indicate that maturation often develops unevenly within sites, with individual pens showing clear signs of maturation before it becomes evident at the site level.

In conclusion, sexual maturation during the sea phase in 2025 developed with

a clear seasonal structure. Site-level maturation first emerged in PAs 9 and 10 during early autumn, with later site-level occurrences in PAs 8 and 11. Pen-level maturation was more widespread and increased steadily from late summer into autumn and winter. Across PAs, sexual maturation coincided with periods of declining sea temperature and occurred at similar times of year despite differences in absolute temperature levels. Continuous monitoring enabled detection of both early site-level events and more gradual pen-level developments, providing insight into how sexual maturation progresses during production. These observations improve understanding of when maturation risk increases during the sea phase and support better situational awareness during biologically sensitive periods of the production cycle.



Comparison of Stingray data and harvest reports

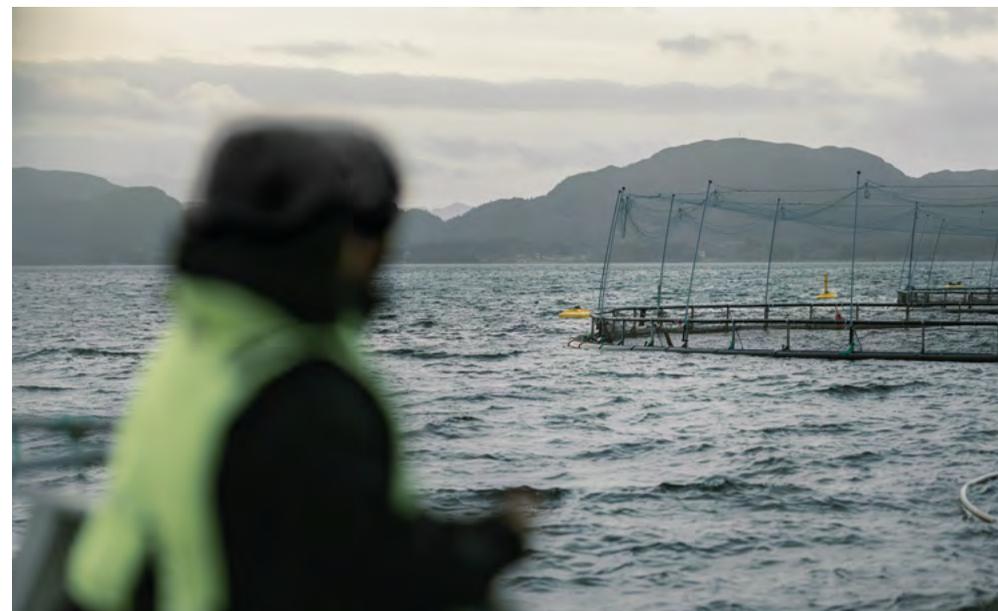
Harvest downgrading is where fish welfare and economic outcomes ultimately converge. Because many welfare-related defects are only detected at harvest, opportunities for intervention during the sea phase are limited. Linking welfare signals observed during the sea phase to harvest outcomes may allow downgrading to be anticipated earlier, enabling more informed production planning and risk management.



Harvest grading of fish is a key determinant of market value in Norwegian aquaculture (Myrland, 2020). Downgrading refers to the classification of harvested fish into lower quality categories due to welfare- or quality-related defects, resulting in reduced product value and, in some cases, restricted market use.

Downgrading is based on factors such as wounds, deformities, melanin spots, and sexual maturation, in accordance with the Norwegian industry standard NBS 10-01 (Prosjekt Bransjestandard for fisk, 1999).

The ability to assess harvest downgrading risk prior to harvesting has direct value for producers. Early indications



-2.75%

Difference between Stingray downgrading estimates and harvest-reported downgrading

of elevated downgrading risk improve predictability and enable more informed production planning, including decisions related to harvest timing, logistics, market allocation, and handling intensity. By linking welfare indicators observed during the sea phase to expected harvest outcomes, producers can reduce uncertainty, mitigate economic risk, and better align operational decisions with both welfare objectives and market requirements.

In practice, grading outcomes are influenced by facility-specific routines, manual assessment, economic considerations, and customer agreements, resulting in substantial variation between fish processing plants. These factors limit direct comparability and introduce uncertainty when harvest data are used as reference values for individual welfare parameters.

Stingray records the occurrence of wounds and sexual maturation continuously during the sea phase using automated image analysis, while harvest reports

provide aggregated quality distributions assessed post-harvest at fish processing plants. Data for this analysis was collected from 118 matched harvest events across nine companies between January 2023 and March 2025.

Despite the subjectivity and facility-specific nature of grading practices, harvest reports are used as the most relevant available reference, while acknowledging their inherent variability. When comparing Stingray's automated sea-phase observations with the corresponding harvest reports, Stingray estimates showed a lower average level of downgrading than reported at harvest, with a mean difference of -2.75% and substantial variation between individual observations (Table 1).

Excluding harvest categories associated with ordinary downgrading reduced the mean difference, although variability remained high, reflecting both biological heterogeneity and differences in grading practices.

TABLE 1. Statistical measures comparing Stingray data (wounds and maturation) with quality distribution from harvest reports

COMPARISON TYPE	TOTAL DOWNGRADING VS. TOTAL DETECTION	PRODUCTION FISH VS. TOTAL DETECTION	TOTAL DOWNGRADING VS. TOTAL DETECTION (ONLY SUITABLE DATAPOINTS)
Number of data points	118	118	37
Mean deviation	-2.72%	-0.93%	-2.41%
Mean absolute deviation	7.47%	6.76%	6.43%
Standard deviation	9.75%	9.44%	8.66%
Minimum (-1 SD)	-12.47%	-10.37%	-11.06%
Maximum (+1 SD)	7.03%	8.51%	6.25%

Agreement by welfare level and season

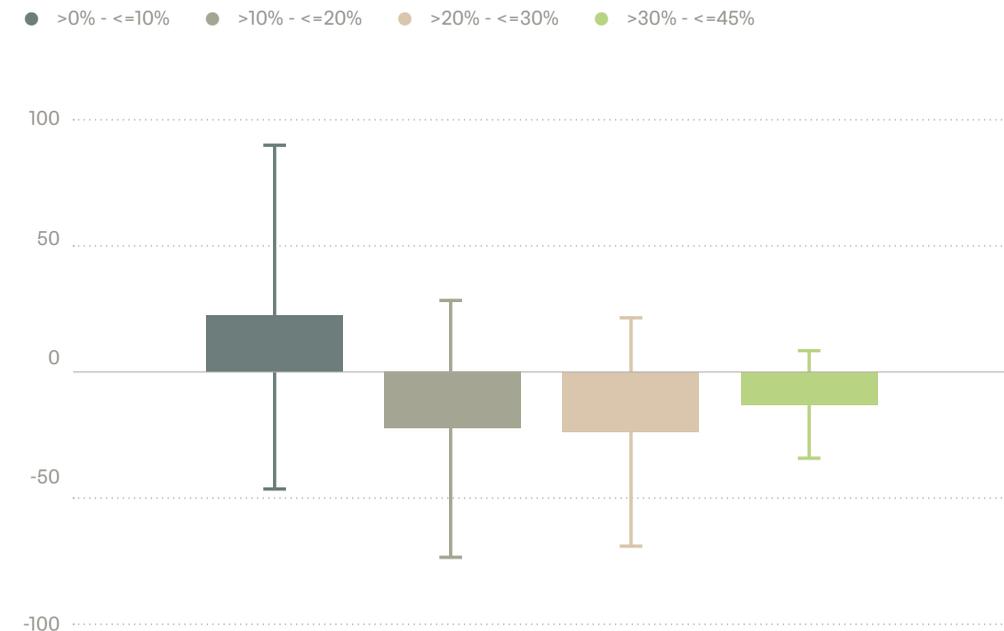
To examine whether agreement between Stingray estimates and harvest outcomes varies with fish welfare status, data were grouped into four categories based on the proportion of downgraded fish reported at harvest (Figure 24). These groups represent increasing degrees of welfare deviation, ranging from sites dominated by healthy fish to sites with more extensive welfare-related quality loss.

In the group with the lowest level of downgrading (0–10%), Stingray estimates were, on average, higher than harvest reports. The system consistently registers a baseline number of wounds even in the absence of true quality defects.

This effect is most evident in groups with a low prevalence of wounds, where the spread of values is large. At such low absolute levels of downgrading, even small percentage-point differences between methods translate into large relative deviations (Figure 24).

Across increasing downgrading categories, Stingray estimates showed a tendency to underestimate harvest outcomes. Agreement improved with higher downgrading levels, with the smallest average deviation and reduced variability observed in the group exceeding 30% downgrading (Figure 24).

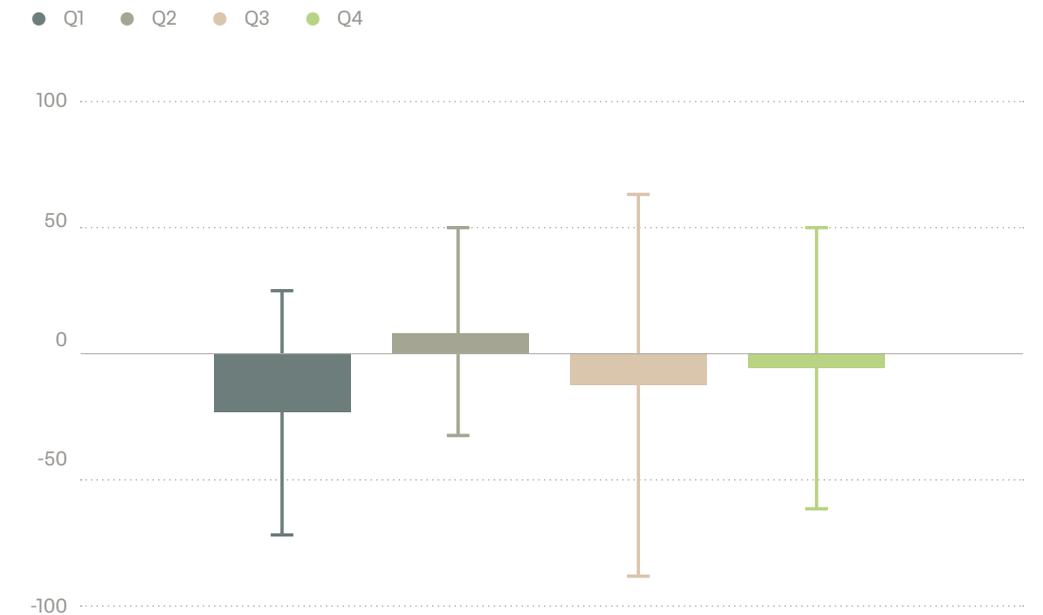
FIGURE 24. Percentage deviation between Stingray estimates (sexual maturation, wound occurrence), and downgrading, grouped by downgrading percentage. Error bars show ± 1 SD. Data with 0% downgrading excluded



Seasonal grouping further demonstrated that agreement varies across the year (Figure 25). Percentage deviation was highest in Q1, while the lowest variability was observed in Q2. Alongside the sources of uncertainty already discussed, the limited number of available harvest reports

represents an additional constraint on drawing firm conclusions. Nevertheless, the observed seasonal structure indicates that Stingray data are most informative when interpreted within a biological and temporal context, particularly when compared with harvest outcomes.

FIGURE 25. Percentage deviation between Stingray estimates (maturation and wound occurrence) and harvest downgrading, grouped by date of harvest. Error bars show ± 1 SD. Data with 0% downgrading excluded



Q1

Period with the highest deviation between Stingray estimates and processing plant downgrading

The comparison between Stingray data and harvest reports highlights both the complexity of harvest grading and the value of continuous welfare monitoring during the sea phase. Harvest grading is influenced by manual assessment practices and facility-specific routines, reflecting a low degree of standardization across the industry, while Stingray provides standardized, automated observations based on defined welfare indicators recorded over time. These differences explain part of the variation observed between methods and underline the importance of interpreting results in context. In addition, harvest grading reflects aggregated, post-harvest outcomes, whereas Stingray observations are based on repeated sampling of live fish during production,

introducing systematic differences in sample size, scope and resolution that should be considered when comparing the two data sources.

Across all comparisons, the analysis shows that Stingray generally underestimates total downgrading, with the degree of deviation varying by downgrading level and season. Agreement between methods improves at higher levels of downgrading, while groups with low downgrading exhibit greater relative variability, where small absolute differences translate into large relative deviations. Seasonal effects further influence correspondence, with the strongest alignment observed during the second and fourth quarters, indicating that biological timing plays an important role in the observed patterns.



Despite these limitations, Stingray data captures biologically relevant production-phase signals that align with harvest quality outcomes.

Continuous monitoring enables early identification of periods and sites with elevated risk of welfare-related quality loss

This is valid particularly during biologically sensitive periods, providing actionable insight well before harvest. In practice, this allows producers to anticipate quality challenges, adjust operational decisions, and reduce uncertainty related to harvest timing, handling intensity, and market planning.

Current technical limitations include the fact that Stingray detects only a subset of downgrading causes, that imaging is limited to two dimensions, capturing only one side of each fish and that the system does not resolve cases where multiple downgrading factors (e.g. wounds and sexual maturation) may co-occur, although

the likelihood of such overlap is considered low due to their differing seasonal occurrence. Together, these factors may contribute to systematic underestimation of total downgrading. In addition, harvest reports often lack sufficiently detailed documentation of the underlying causes of downgrading, limiting more granular validation of individual welfare indicators.

Taken together, the results show that Stingray identifies production-phase trends in welfare indicators that align with harvest downgrading patterns, particularly at higher levels of downgrading and during biologically sensitive periods. These trends provide producers with early, site-specific indications of increased quality risk, enabling more informed decisions on harvest timing, handling intensity, and market planning, with direct relevance for both fish welfare and economic outcomes. While Stingray is not intended to replicate harvest grading, the results demonstrate its value as an early-warning and decision support tool, complementing existing assessment practices by shifting welfare evaluation upstream in the production cycle, where management actions remain possible.

Stingray's Total Welfare Score

The Total Welfare Score introduces a standardized, automated approach to pen-level welfare monitoring by combining established welfare frameworks with continuous data from Stingray systems. By structuring welfare information into a clear, trackable score, the tool enables farmers to move from fragmented observations toward systematic, data-driven welfare management in daily operations.

The Total Welfare Score is Stingray's newest tool for automated, pen-level welfare monitoring, consolidating multiple welfare indicators into a single operational overview. Each cohort receives a weekly updated score from 0-100% reflecting overall welfare, where higher scores indicate better welfare (Figure 26). The score provides both a summary and an explanation of the

underlying indicators, enabling farmers to track welfare trends over time, compare pens and cohorts within a site, and review historical welfare data across the full production cycle—from sea transfer to harvest—or for any selected period. The score follows the cohort even if fish are moved between pens, ensuring continuity in welfare assessment.

FIGURE 26. Illustration of different welfare scores in one site





Challenges and possibilities

Norwegian Food Safety Authority's audit reports from 2024 and 2025 reveal challenges across different fish farming companies in how welfare is assessed and managed (Mattilsynet, 2025). While several companies carry out evaluations of fish welfare, there is limited or no structured documentation. Welfare data is often not used for trend analysis or long-term insights, while mortality, lice levels, and feed intake currently are the dominant metrics. Although other welfare data is collected, it is rarely applied in practice as a basis for

evaluating risk (Mattilsynet, 2025). In other words, the existing data and observations are not used to their full potential.

With the Total Welfare Score, Stingray aims to provide a better overview and enable active use of welfare data in daily operations and to follow changes within the different cohorts over time. A clear score can help prioritize and plan based on actual conditions and help close gaps pointed out in Norwegian Food Safety Authority's audit reports.

The Total Welfare Score is built on shared knowledge and collaboration across multiple departments, and the project aims to make welfare assessment easier.

RENATE FOSSBEKK
Veterinarian, Stingray



Combining Laksvel and SWIM for more accurate welfare scoring

The Stingray Total Welfare Score combines the relevant components of the Laksvel standard (Nilson et al., 2022) and the SWIM (Salmon Welfare Index Model 1.0) (Stien et al., 2013) providing a framework to generate a meaningful welfare score based on available data. Laksvel is recognized as the industry standard for monitoring welfare (Stien et al., 2025), which is why it serves as the starting point for Stingray's model. However, as the Laksvel standard only provides separate scores for each welfare indicator, it is combined

with SWIM to produce a Total Welfare Score. SWIM contains many of the same welfare indicators as Laksvel and applies weighted values according to their importance for health and welfare (Stien et al., 2013). While SWIM scores are traditionally applied to individual fish (Stien et al., 2013), the intention is to adapt the model for cohorts to fit Stingray's detection system. This will require certain modifications, and the combination of Laksvel and SWIM provides a solid basis for calculating welfare scores at pen level.

Implementing the Total Welfare Score model in Stingray Online

The model is expected to integrate parameters collected automatically through machine vision with additional data obtained from customer APIs (Application Programming Interface) (Table 2). The parameters are separated into two categories, pen-level and fish-level. Pen-level data includes environmental and group-based welfare indicators and fish-level includes individual welfare indicators. The initial release will comprise seven welfare indicators and will

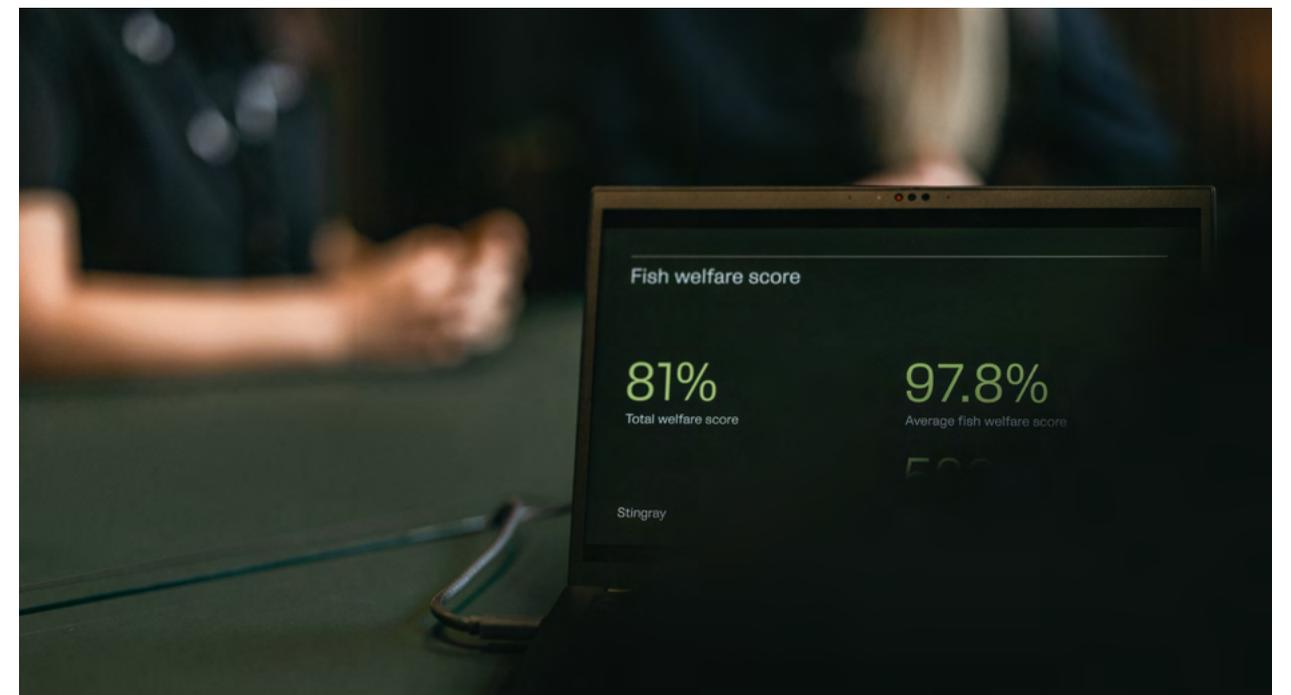
be made available to customers through Stingray Online upon completion.

As Stingray develops additional detectors, new parameters will be included, strengthening the data foundation and improving the precision of the score. Altogether, Stingray aims to make welfare assessment easier and more accessible in Stingray Online, ready for implementation in daily operations.

TABLE 2.
Overview of parameters included in the first version of Total Welfare Score

PEN-LEVEL*	FISH-LEVEL
Temperature	Lice
Mortality	Wounds
Appetite	Maturation
	Condition factor

*Collected through API





Fish health summary



Continuous monitoring in 2025 shows that salmon welfare follows a repeatable annual cycle linked to seasonal environmental variation. Measurable parameters such as sea temperature act as practical integrative indicators, correlating with changes in wound development and healing, sexual maturation, and harvest quality. Together, these factors define predictable periods of elevated biological and economic risk.

Recognizing the complexity of these interacting biological and environmental processes, Stingray has evolved from a system primarily associated with sea lice control into a comprehensive welfare monitoring platform. It now provides early-warning signals across the entire production cycle, enabling proactive, welfare-based decision support well in advance of harvest.

Despite high sea temperatures in 2025, our customers carried out nearly half as many treatments as others, a clear win for the fish. With two new team members, our fish health expertise continues to grow as we further refine our laser strategy to reduce reactive treatments. A lower prevalence of ulcers this winter has been rewarding and confirms that preventive measures make a difference.



NIVES VOJVODIC

Head of Fish Health, Stingray

Making Stingray's evolution visible

Sea lice control remains the core focus of Stingray's operations and product development, with laser delousing delivering robust, steadily improving results under commercial conditions and a growing record of measurable impact. The system has proven reliable across diverse production environments, supporting consistent delousing outcomes in practice.

Building on this, Stingray has expanded from automated lice detection to a broader platform for continuous welfare

monitoring. Monitoring now includes wounds, sexual maturation, biomass, mortality, and temperature, showing how these factors interact throughout the year. The Total Welfare Score formalizes this by combining multiple indicators into a single pen-level metric, enabling proactive, season-aware decisions. Together, this shifts welfare assessment from reactive harvest documentation to early warning and in-production risk management, where actions can still influence outcomes.



Winter (January–March)

During winter, sea temperatures reach their annual minimum (~4.5–6.0 °C). This period is characterized by increasing wound prevalence and severity, with a higher proportion of score 2–3 wounds and reduced healing capacity. Fish are

particularly vulnerable to handling and mechanical stress, while sea lice pressure remains low due to temperature-limited lice development. Wounded fish are more frequently observed at shallower depths, indicating altered behavior.

Risk profile: High welfare sensitivity, low lice pressure, high consequence of disturbance.



Spring (April–May)

As temperatures rise and pass the 7–8 °C threshold, wound healing accelerates and overall wound prevalence peaks before declining. At the same time, sea lice development rates increase, particularly for non-Stingray customers, while Stingray

customers may continue to benefit from decreasing lice levels due to the Stingray system. Spring marks the start of the annual lice season and is a crucial period for wild smolt migration.

Risk profile: Transitional period with coinciding wound recovery and increasing lice risk, requiring careful operational timing. During this period, proactive lice reduction provides the greatest benefit by preventing the need for delousing operations and avoiding a shift of risk into the following quarter.



Early–mid summer (June–August)

With temperatures above 10 °C and peaking around 13–14 °C, wound prevalence remains low and healing capacity is high. In contrast, sea lice pressure increases

steadily, becoming the dominant welfare and management challenge. The first pen-level signs of sexual maturation may appear from August in some regions.

Risk profile: Low risk of wound development but increasing risk of lice-driven intervention and sexual maturation.



Early autumn (September)

Sexual maturation first emerges at site level, particularly in PAs 9 and 10. Both spring- and autumn-stocked fish show similar timing, indicating strong seasonal

drivers. Lice pressure peaks during this period and remains elevated while biological resilience starts to decrease.

Risk profile: Converging risks from maturation onset, lice pressure, and reduced robustness.



Late autumn–winter (October–December)

Continued decreases in water temperature are associated with reduced sea lice pressure, while handling increasingly represents a significant welfare risk. Maturation is peaking and wounds may increase at the pen level, even when site-level averages

remain low. During this period, the risk of welfare-related harvest downgrading increases and may be more driven by the biological state of the fish rather than by management interventions.

Risk profile: Handling represents an elevated welfare risk, maturation prevalence continues to increase, and the development of wounds accelerates, adversely affecting both fish welfare and harvest outcomes.



Quotes from Stingray employees

Throughout 2025, we nearly doubled our presence with more than 2,500 nodes operating across 170+ sites. While delivering reliable 24/7 data-intensive services, the Stingray Software team continuously improved the ecosystem. Looking ahead, we remain focused on scalability, robustness, and innovation to support growth and sustainable fish farming.

ESPEN BØRRUD

Software Manager, Stingray

In 2025, we produced 1,250 nodes, an increase of more than 70% from 2024. Despite higher volumes, node quality also improved. We are well underway with construction of a new factory and look forward to its completion in August 2026.

ØYVIND FJELD

Hardware Manager, Stingray

Deploying 150 nodes in a single week is high-level fieldwork, long days, tight logistics, and full focus on safe, correct installation. That customers remain satisfied under such pace speaks volumes about the team behind it.

MARTIN INGDAHL

Head of Installation & Support, Stingray

2025 marked a clear step forward for the Analysis team. We scaled the team, invested heavily in training, and built the foundations needed to support continued development.

ELIN ERSVÆR

Head of Analysis, Stingray

Our department works closely with customers' laser pilots on 112 million fish every day. In 2025, we strengthened the team with eight new employees to ensure strong customer and fish follow-up and trained 852 users across Stingray Academy modules. We look forward to continued strong collaboration with our customers in 2026.

HÅVARD JOHANSEN

Head of Positioning, Stingray

With more than 2,500 operational nodes deployed along the coasts of Norway and Iceland, Stingray now generates a continuous, large scale observational dataset that increasingly enables decision making and supports empirical research to advance our scientific understanding of modern aquaculture systems.

MARTIN WORM

Head of Research, Stingray

Local presence are key to integrating Stingray in Iceland, lowering the barrier to engagement and supporting the establishment of a strong foothold and brand comparable to Norway. A clear presence among farmers, supported by dedicated local staff and a staffed service center, makes Stingray appear less distant and more familiar.

VICTORIA PETERSEN

Special Advisor Aquaculture, Stingray

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