Central Baltic Programme

BalticReed

D.1.3.1

Monitoring of coastal bays following reed harvesting

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1. Summary

The BalticReed monitoring program was designed to evaluate the short-term ecological effects of reed harvesting in shallow coastal bays, with a primary focus on ensuring that such management practices do not cause environmental harm. Given the short duration of the project relative to ecological response times, the expectation was not to detect measurable improvements, but rather to try to confirm that reed harvesting can be conducted safely.

The results show no evidence of short-term negative impacts on water quality, biological communities, or habitat structure in the monitored areas. This indicates that reed harvesting, when carried out using precautionary and site-adapted practices, can be implemented without ecological degradation. Although no measurable improvements were observed during the project period, harvested areas were actively used by wading birds, suggesting potential benefits for maintaining open, shallow habitats valuable to bird communities.

The monitoring further revealed that water quality conditions were strongly influenced by precipitation and hydrological variability. Changes in nutrient levels, turbidity, and oxygen conditions were primarily driven by rainfall and freshwater inflow, often exceeding any possible detectable effects of reed harvesting. This highlights the importance of considering climatic and catchment-related factors in environmental assessments.

The findings support reed harvesting as a safe and complementary management measure in eutrophication-affected coastal waters. However, they also emphasize the need for long-term monitoring to capture delayed ecological responses and to better distinguish management effects from natural variability. Integrating reed harvesting with broader nutrient reduction strategies and considering its role in supporting bird habitats are key recommendations for future management.

2. Introduction

About Interreg BalticReed

BalticReed is a transnational cooperation project aimed at developing, testing and evaluating reed harvesting as a management measure to mitigate eutrophication and restore degraded coastal ecosystems in the Baltic Sea region. The project brings together regional authorities, research institutions, environmental organizations and private-sector actors from several Baltic Sea countries, creating a multidisciplinary partnership that links environmental management with innovation and bioeconomy development.

Many shallow coastal bays in the Baltic Sea are heavily affected by eutrophication, which has resulted in extensive reed expansion, reduced water exchange, loss of open shallow habitats and declining ecological functions, including fish spawning and nursery areas.

Reed harvesting is tried out as a nature-based solution that potentially removes nutrients bound in reed biomass while hopefully simultaneously improving habitat structure and ecological connectivity. By physically exporting accumulated biomass, nutrients are removed from the aquatic system, potentially contributing to nutrient reduction. At the same time, reed harvesting reopens overgrown bays, improves light conditions and water circulation and restores shallow, warm and sheltered habitats that are crucial for coastal fish reproduction.

A central component of BalticReed is the development of value chains for harvested reed within a circular economy framework. The biomass is utilized in products such as straws, feed, bedding material, insulation materials, soil improvement and other bio-based applications. This creates economic value from an environmental management measure, enabling local businesses and landowners to participate in nutrient removal while strengthening local economies.

Through integrated ecological monitoring and cross-sector collaboration, BalticReed develops best-practice harvesting methods, safeguards biodiversity and supports the long-term restoration of coastal ecosystems in the Baltic Sea region.

2.1 Background and problem description

Shallow coastal bays and shoreline meadows are among the most biologically productive and valuable ecosystems in the Baltic Sea region. These environments provide critical ecosystem services, including nutrient retention, sediment stabilization, carbon sequestration and, most importantly, key habitats for fish reproduction, bird breeding and feeding and diverse aquatic and terrestrial species (Kautsky, 2000).

Over recent decades, many coastal areas have undergone extensive degradation driven primarily by eutrophication, hydrological alteration and land-use changes (HELCOM, 2014). Elevated nutrient inputs from surrounding catchment areas have contributed to excessive growth of reed and other vegetation (Kraufvelin et al, 2025). As a result, large areas of previously open shallow bays and coastal meadows have become overgrown, leading to reduced water circulation, increased sediment accumulation and declining light availability. (HELCOM, 2018)

Simultaneously, the traditional grazing of coastal meadows has largely ceased due to a decline in traditional grazing practices. The absence of grazing has further accelerated vegetation overgrowth, causing the loss of open shoreline meadows. This has resulted in a significant reduction of suitable habitats for wading birds that depend on open, wet grasslands for foraging and breeding (Naturvårdsverket, 2011).

The overgrowth of reed in shallow bays has also caused a major decline in fish spawning and nursery habitats. Many coastal fish species rely on warm, shallow, well-oxygenated and vegetation-rich but open environments for successful reproduction. Dense reed belts restrict water exchange, alter temperature regimes and reduce access to spawning grounds, thereby weakening fish recruitment and coastal food webs (Sundblad & Bergström, 2024).

In addition, eutrophication-driven overgrowth contributes to internal nutrient loading, oxygen depletion and increased turbidity, reinforcing a negative ecological feedback loop (HELCOM, 2014).

Protecting and restoring shallow coastal ecosystems is therefore essential for biodiversity conservation, sustainable fisheries and the overall ecological resilience of the Baltic Sea.

2.2 Reed harvesting as an environmental measure

Reed harvesting is tried out as a nature-based environmental measure to mitigate eutrophication and restore ecological functions in shallow coastal ecosystems. In nutrient-enriched bays, reed (Phragmites australis) often forms dense, tall belts that trap sediments and nutrients, reduce water circulation and shade submerged vegetation (Sand-Jensen, 2000). While reeds are important for structural habitat and shoreline stabilization, their overgrowth can lead to a loss of open, shallow habitats that are crucial for fish spawning, juvenile development and wading bird foraging (HELCOM, 2018).

By mechanically harvesting reed biomass, nutrients bound within the plant are physically removed from the aquatic system, potentially contributing to a reduction in nitrogen and phosphorus loads. This could help to counteract the internal nutrient loading that often perpetuates eutrophication even when external inputs are controlled (Kraufvelin et al, 2025). Additionally, harvesting opens up overgrown bays, improves light penetration and water circulation and restores shallow, warm and sheltered habitats that support biodiversity and ecosystem services.

Reed harvesting can be combined with site-specific management plans to minimize potential ecological disturbance (Kraufvelin et al, 2025). Precautionary measures—such as avoiding sensitive periods for fish and birds, maintaining buffer zones and limiting the spatial extent of harvest—ensure that the intervention supports ecosystem restoration rather than causing harm.

2.3 Objectives of the monitoring program

The primary objective of the BalticReed monitoring program is to assess the ecological effects of reed harvesting in shallow coastal bays and to ensure that the applied management measures do not cause short-term negative environmental impacts. The program is designed to provide a consistent dataset that enables the detection of changes in water quality, biological communities and habitat structure over time. Given the relatively short duration of the project in relation to ecosystem response times, the monitoring also aims to establish baseline conditions and to verify that no adverse effects occur as a result of harvesting activities. This includes evaluating impacts on water chemistry, submerged and emergent vegetation, benthic fauna, fish spawning and nursery habitats and wading bird use of coastal meadows.

Additionally, the program supports adaptive management by providing data that inform best-practice harvesting methods, timing and spatial planning. By integrating ecological monitoring with precautionary harvesting practices, the program contributes to the long-term restoration and sustainable management of eutrophication-affected coastal ecosystems.

2.4 Different reed habitats

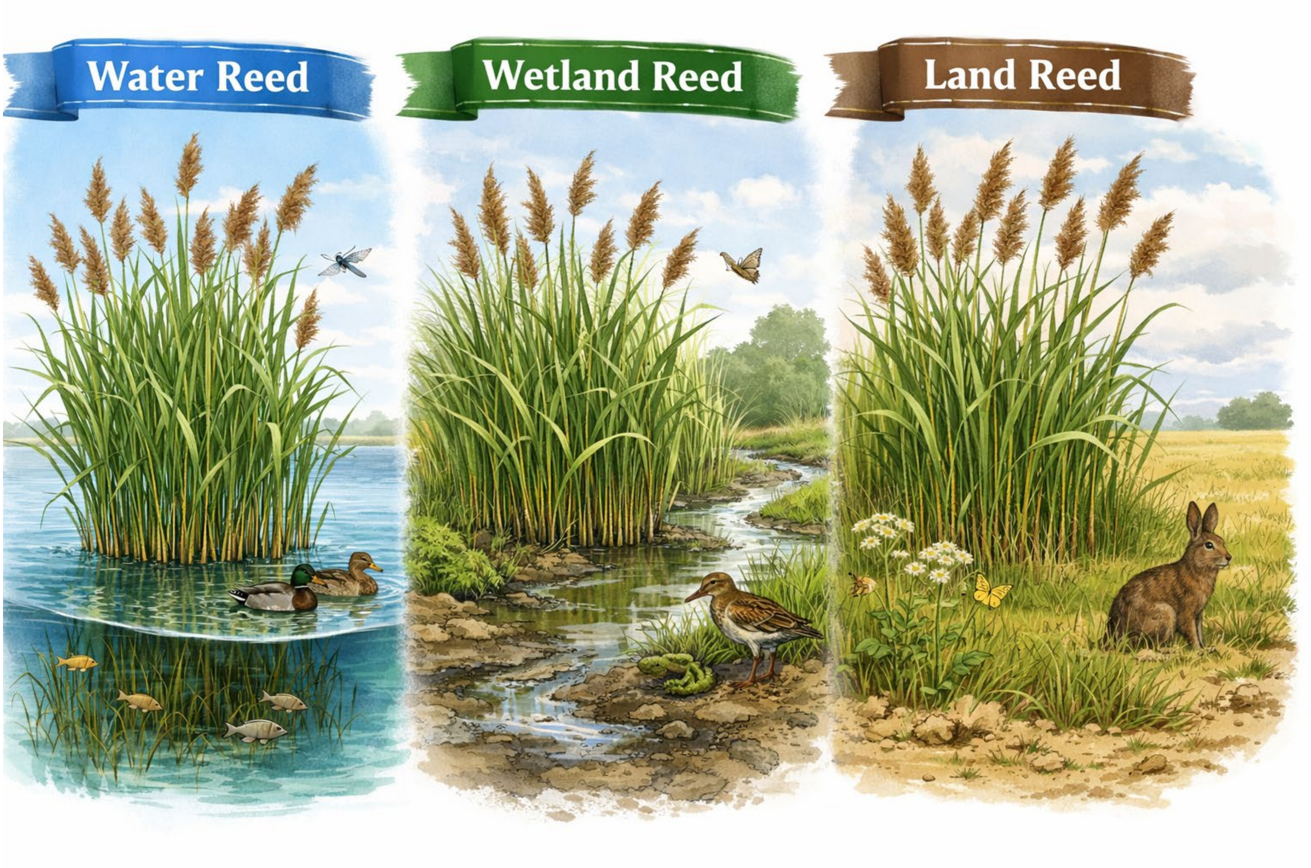

Figure 1. The difference is defined by water exposure over time – permanent (water reed), periodic (wetland reed), or none (land reed). This image is ai-generated.

Please observe that all kind of reed habitats refers to different reed <u>habitats</u>, not different kinds of reed.

Reed (Common reed- Phragmites australis) grows in different environments, from water to land and its role in nutrient dynamics changes along this gradient (Geurts, 2020). *In aquatic environments, reed is linked to internal nutrient cycling through interactions between sediments, porewater and the water column* (Findlay, 2003). *In wetland environments, reed stands and vegetation can both capture nutrients coming from land and take part in internal nutrient cycling* (Geurts, 2020). *In more terrestrial areas, reed growth is mainly controlled by soil nutrients, with less direct connection to aquatic nutrient processes* (Geurts, 2020).

This difference is important when evaluating reed harvesting as a way to remove nutrients and when planning effective management strategies (Hansson, 2004) (Köbbing, 2013).

<u>Definition of different reed habitat</u>

Water reed

Reed growing in permanently flooded areas (i.e. the bay). It stands in water year-round and is directly connected to the aquatic environment, taking up nutrients from sediments.

Water reed → interacts with sediment + water → important for internal nutrient loading

Wetland reed

Reed growing in shoreline or wet areas. It is periodically flooded (e.g. during high water levels or near inflows) but may be dry during parts of the year. It forms a transition zone between water and land.

Wetland reed → interacts with runoff + fluctuating water → important for external and internal nutrient retention

Land reed
Reed growing on dry land where water does not reach under normal conditions. It is mainly influenced by soil moisture and precipitation rather than water level fluctuations in the bay.

Land reed → interacts mainly with soil→ important for biodiversity, limited nutrient removal effect

2.4.1 Water reed

Water reed could play an important role in nutrient dynamics in shallow coastal bays due to its direct connection to both the water column and underlying sediments. Growing in permanently flooded environments, water reed has continuous access to dissolved nutrients and nutrient-rich sediments, making it particularly relevant in the context of eutrophication management.

The pathway for nutrient uptake occurs through the root and rhizome system, which is embedded in the sediment. In eutrophicated coastal systems, sediments often act as a significant internal nutrient source, leaking nitrogen and phosphorus into the water column. Water reed can potentially intercept part of this internal loading by assimilating nutrients directly from the sediment, incorporating them into plant biomass (Brix, 1994); (Vymazal, 2011)). The uptake allows water reed to function as a nutrient sink during the growing season, temporarily storing nutrients in aboveground biomass (Kraufvelin et al, 2025).

However, the potential long-term effect on nutrient removal depends on biomass export. If reed biomass is left unharvested, a large proportion of the nutrients will be returned to the system through decomposition, hence contributing to internal nutrient cycling. In contrast, harvesting water reed could remove nutrients from the aquatic system, making it a potential eutrophication measure.

Water reed also influences nutrient dynamics indirectly. Dense stands reduce water movement, trap suspended particles and promote sedimentation of organic material. While this can enhance nutrient retention locally, it may also contribute to sediment accumulation and internal loading over time if not managed (HELCOM, 2018).

Water reed represents a key interface between sediments and the water column in coastal ecosystems. When combined with harvesting, it has the potential to contribute to nutrient removal by extracting nutrients. Its effectiveness as a potential eutrophication measure is therefore highest when biomass is harvested at peak nutrient content and physically removed from the system.

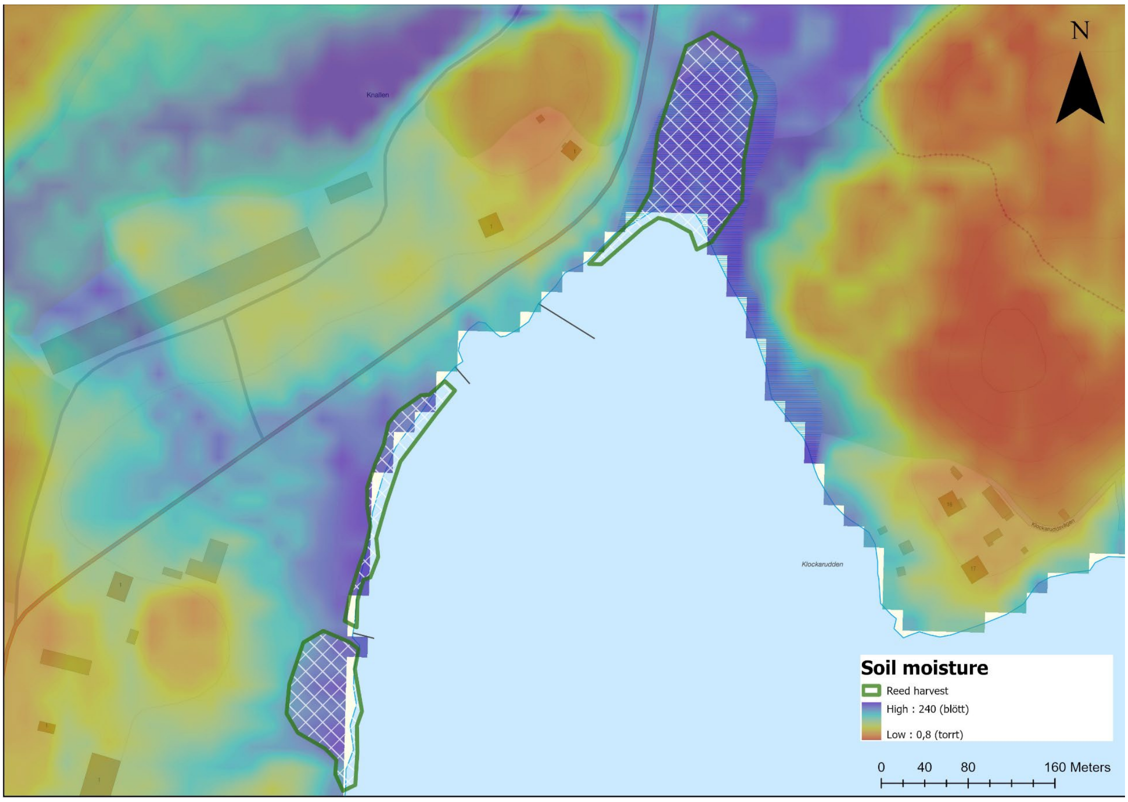

Figure 2. The map shows spatial variation in soil moisture in Kyrkviken, Sweden, from dry (orange-red) to wet conditions (blue-purple). The outlined and hatched area indicates the reed harvesting site, which is located in water and wetter zones. In these areas, water reed was harvested.

Figure 3. Kyrkviken, Sweden. Picture is showing part of the reed that was harvested.

2.4.2 Wetland reed

Wetland reed fills transitional zones between aquatic and terrestrial environments, where water levels fluctuate seasonally. These areas are often influenced by both surface runoff and periodic flooding, making wetland reed an important component in intercepting nutrients transported from land to coastal waters.

Nutrient uptake in wetland reed happens primarily through the root system in moist soils, which are frequently enriched by incoming nutrients from surrounding catchments. During high water levels or runoff events, wetland reed can take up nutrients from flooded soils. This makes it particularly effective in capturing externally derived nutrients before they enter open coastal systems (Vymazal, 2011) (Mitsch, 2015).

In addition to direct uptake, wetland reed plays a key role in slowing water flow and promoting sedimentation. This enhances the retention of particulate-bound phosphorus and organic matter, reducing nutrient transport further downstream (Mitsch, 2015) (HELCOM, 2018).

As with water reed, the long-term potential removal of nutrients depends on biomass harvesting. Without harvesting, nutrients stored in plant biomass will largely be recycled back into the system. However, when harvested, wetland reed has the potential to contribute to reducing external nutrient loading by removing nutrients that originate from land-based sources (Vymazal, 2011).

Wetland reed functions as a buffer zone that intercepts and retains nutrients at the land–water interface, playing a key role in reducing nutrient transport to coastal waters.

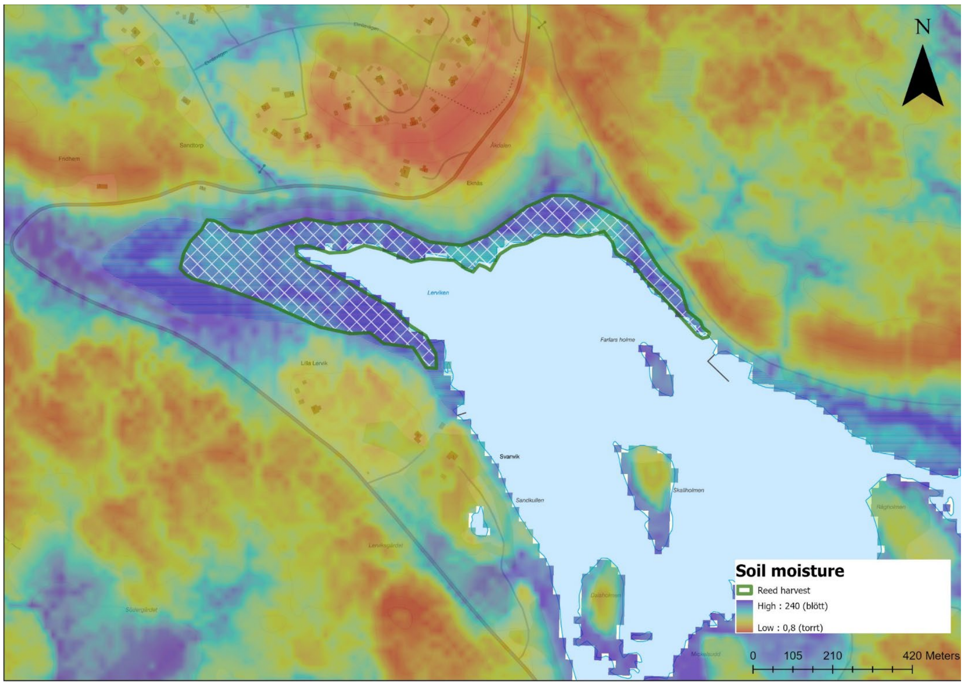

Figure 4. The map shows spatial variation in soil moisture in Lervik, Sweden, from dry (orange-red) to wet conditions (blue-purple). The outlined and hatched area indicates the reed harvesting site, which is mainly located in wetter zones. In these areas, wetland reed was harvested.

Figure 5. Photo shows Lervik, Sweden, before reed harvest.

Figure 6. Lervik, Sweden. A harvested wetland area which gets flooded during some parts of the year and is dry for some parts.

2.4.3 Land reed

Land reed grows in areas that are not regularly influenced by standing water and are instead characterized by relatively dry conditions. In these environments, nutrient uptake is primarily linked to soil processes and terrestrial nutrient cycling rather than direct interaction with aquatic systems.

Nutrient availability for land reed is mainly controlled by soil properties and decomposition of organic matter. As a result, its role in eutrophication in close water bodies is limited compared to water and wetland reed. While it can take up nutrients from the soil, these nutrients are generally part of a terrestrial cycle and are not directly removed from aquatic systems (Brix, 1994) (Vymazal, 2011).

However, land reed still has important ecological functions. It contributes to maintaining open or semi-open habitats, particularly in coastal meadows where it can otherwise outcompete lower-growing vegetation. Management of land reed through harvesting or grazing can therefore be important for biodiversity conservation, especially for species dependent on open grassland habitats (Naturvårdsverket, 2011).

From a nutrient management perspective, harvesting land reed does not significantly reduce nutrient loads in coastal waters, but it may prevent nutrient accumulation in soils and support the maintenance of valuable terrestrial habitats

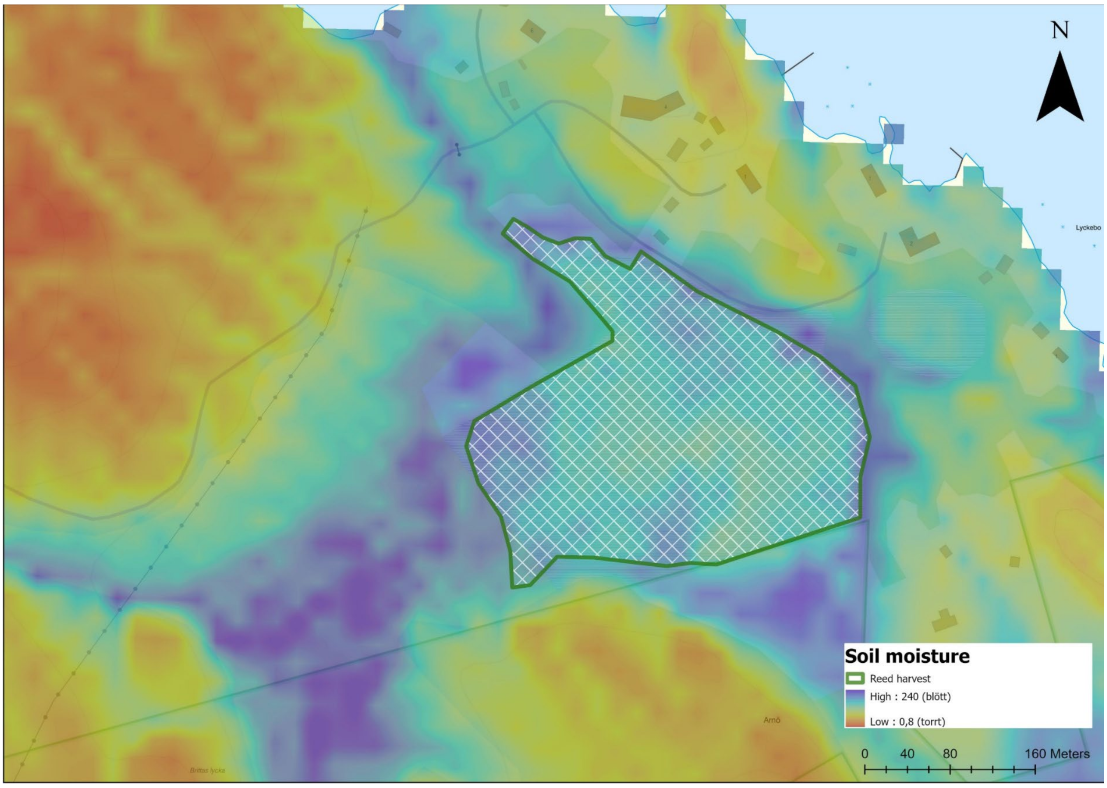

Figure 7. The map shows spatial variation in soil moisture in Bankeböte, Sweden, from dry (orange-red) to wet conditions (blue-purple). The outlined and hatched area indicates the reed harvesting site, which is mainly located in drier zones. In these areas, land reed was harvested.

Figure 8. Photo shows Bankeböte, Sweden, after reed harvest.

2.5 Scope and timeframe

The monitoring program was conducted from 2023 to 2025 and focused on assessing the ecological effects of reed harvesting in shallow coastal bays. Four sampling sites were established in harvested bays, one site in an unharvested bay and four reference sites in unaffected locations to enable robust comparisons. Repeated measurements of water quality, biological communities and habitat structure were carried out throughout the monitoring period, providing a foundation for evaluating both short-term responses and baseline conditions.

3. Description of study area

3.1 Location and physical characteristics

Monitoring was conducted in most project areas where reed harvesting was conducted in aquatic environments. Sites with exclusively land-based reed (i.e. coastal meadow restoration only) were not included in this approach. For this report, three sites with contrasting characteristics have been selected to illustrate how harvesting can be adapted to different ecological conditions.

Lervik

Lervik is a shallow coastal bay located in the Gryt archipelago. The bay is characterized by high internal nutrient loading and generally turbid water conditions. There is no major inflow of fresh water to Lervik. The southern part of the bay is grazed and supports high biodiversity, with open habitats that provide favorable conditions for both birds and aquatic communities. This grazed area serves as a reference for the desired ecological state.

In contrast, the remaining parts of Lervik are currently not grazed and are dominated by dense reed stands. To address this, a long-term management strategy was developed based on continuous and spatially targeted reed harvesting. The objective is to gradually recreate more open and heterogeneous habitats, similar to those found in the grazed southern section, through the establishment of blue zones combined with recurring management interventions.

Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

Figure 9. Lervik, Sweden, before reed harvesting, summer 2023.

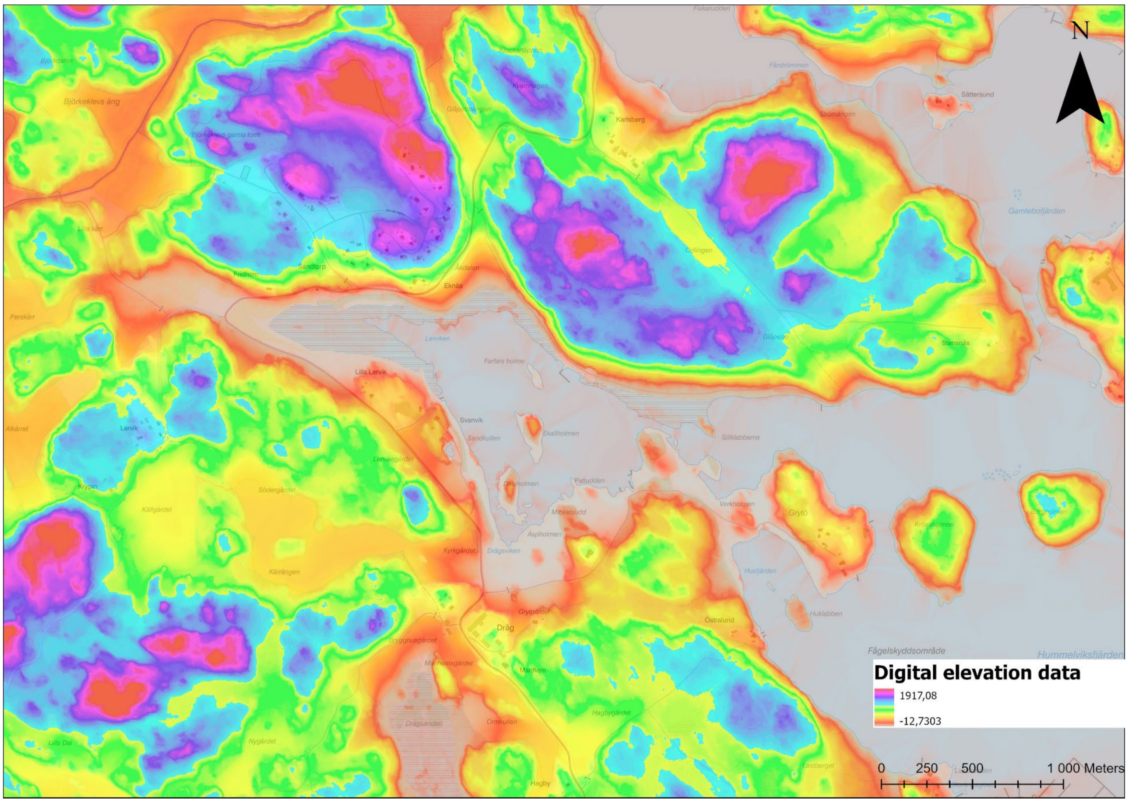

Figure 10. The map shows elevation variation across Vålön, Sweden, with lower areas displayed in blue-purple and higher areas in yellow-red.

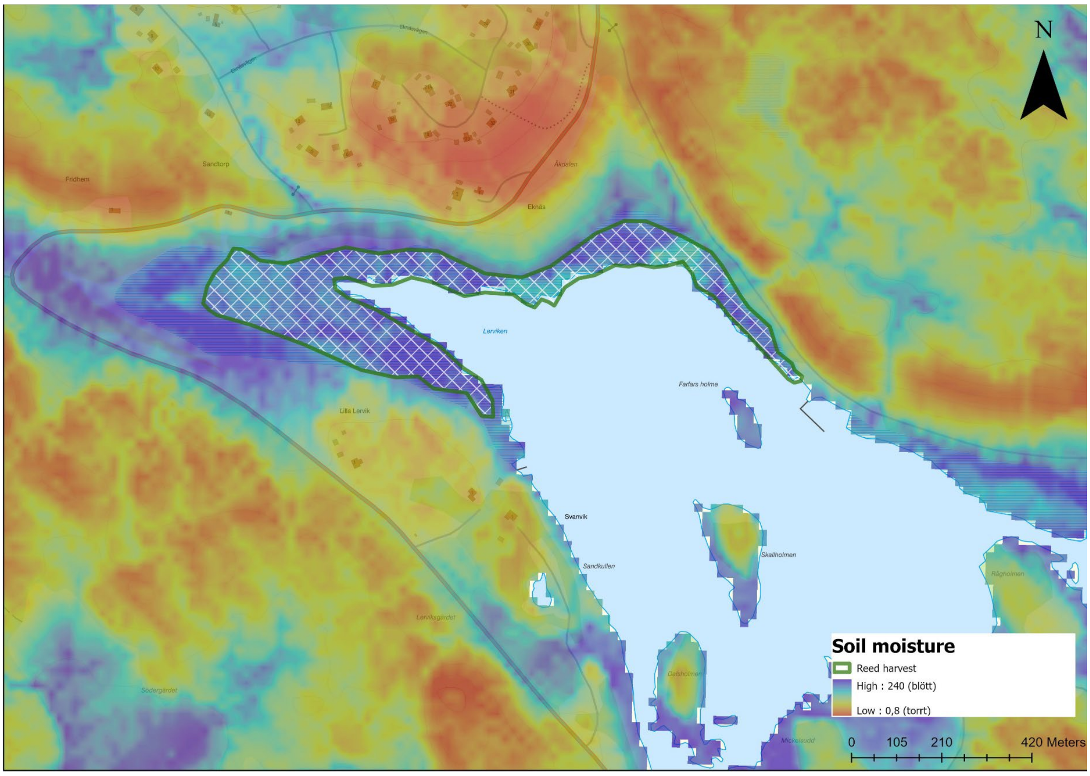

Figure 11. The map shows spatial variation in soil moisture in Lervik, Sweden, from dry (orange-red) to wet conditions (blue-purple). The outlined and hatched area indicates the reed harvesting site, which is mainly located in wetter zones.

Vittvik

Vittvik is influenced by external nutrient inputs, primarily through drainage from surrounding agricultural land. This results in elevated nutrient levels and contributes to vegetation growth in the bay.

Unlike Lervik, Vittvik is currently grazed and is planned to remain under grazing management in the future, with livestock accessing the shoreline as far as conditions allow. The management strategy in Vittvik has therefore focused on combining short-term reed harvesting with long-term grazing.

Reed harvesting was carried out during an initial phase to open up overgrown areas and facilitate access for grazing animals. The intention is that grazing will gradually take over as the main management measure, maintaining open habitats and preventing renewed overgrowth.

This approach aims to create a gradual transition from coastal meadow to aquatic environments, forming a continuum of grazed shoreline, blue zones, reed patches, and open water. Such a gradient supports high habitat diversity and strengthens ecological connectivity within the bay.

Figure 12. Vittvik before harvesting, spring 2023.

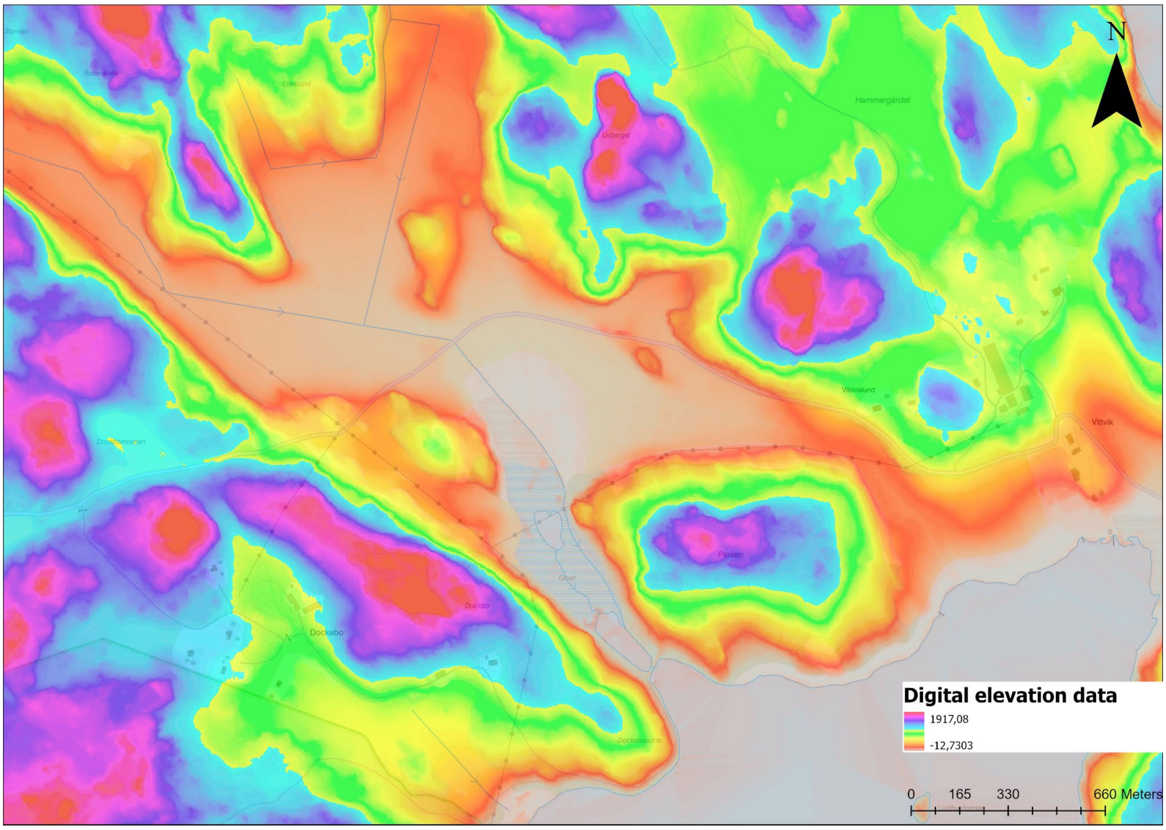

Figure 13. The map shows elevation variation across Vittvik, Sweden, with lower areas displayed in blue-purple and higher areas in yellow-red.

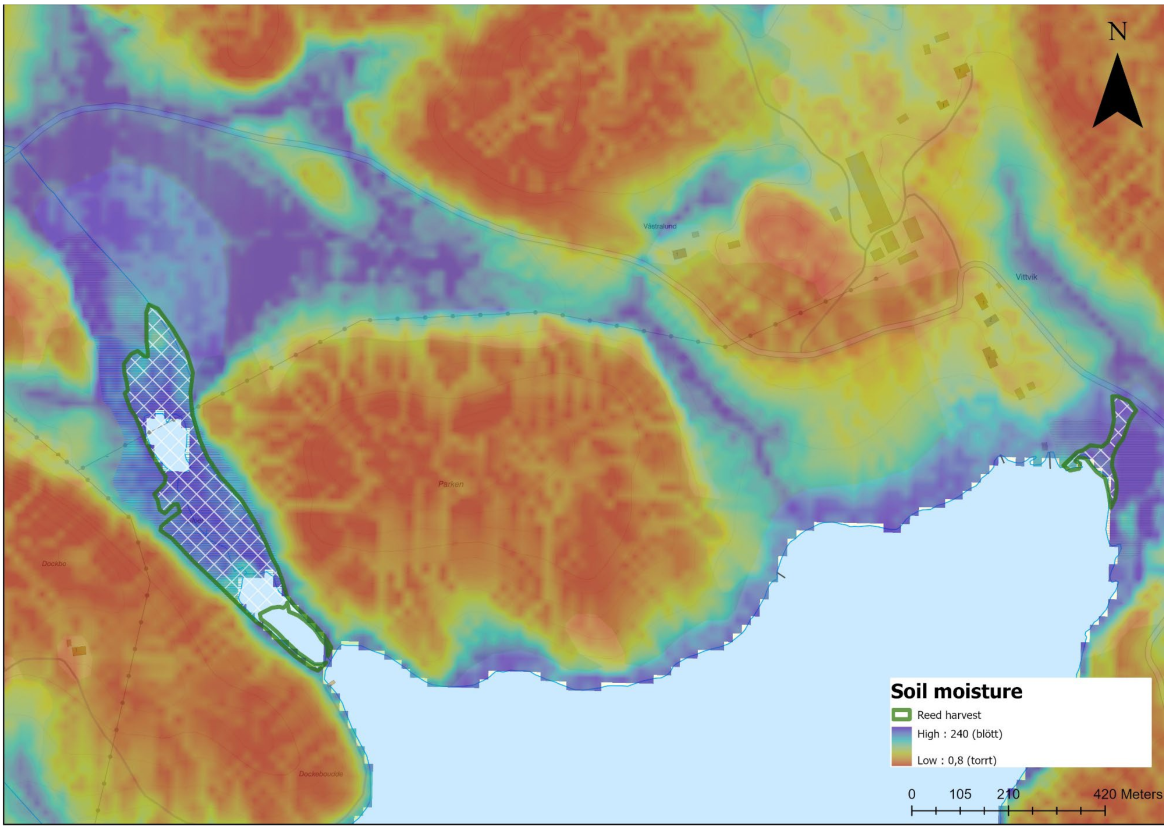

Figure 14. The map shows spatial variation in soil moisture in Vittvik, Sweden, from dry (orange-red) to wet conditions (blue-purple). The outlined and hatched area indicates the reed harvesting site, which is mainly located in water and wetter zones.

Vålön

Vålön is a coastal bay currently managed through grazing and influenced by a stream that flows through the area. The incoming water is of relatively good quality compared to more eutrophicated sites, but can become highly turbid during periods of high flow, affecting water clarity and local conditions.

Grazing is ongoing and is planned to continue in the future, with livestock accessing the shoreline as far as conditions allow. As in Vittvik, the management approach combines initial reed harvesting with long-term grazing.

Reed harvesting was carried out during an initial phase to open up dense vegetation and improve accessibility for grazing animals. The intention is that grazing will subsequently maintain the open conditions and prevent reed expansion.

The long-term goal is to create a gradual ecological transition from grazed coastal meadow to aquatic habitats, including blue zones, reed patches, and open water. This continuum supports habitat diversity, improves connectivity, and contributes to more resilient coastal ecosystem functioning.

Figure 15. Vålön before harvesting 2024.

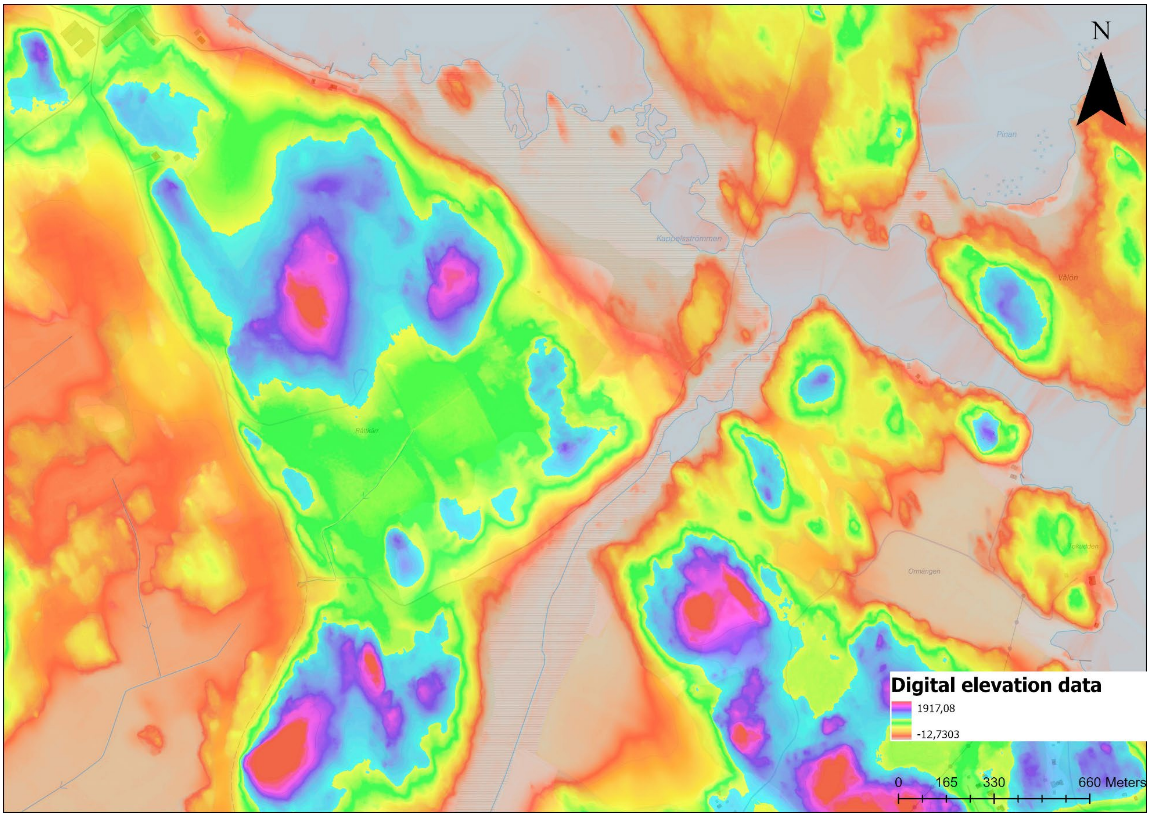

Figure 16. The map shows elevation variation across Vålön, Sweden, with lower areas displayed in blue-purple and higher areas in yellow-red.

Figure 17. Vålön, march of 2025, before reed harvest.

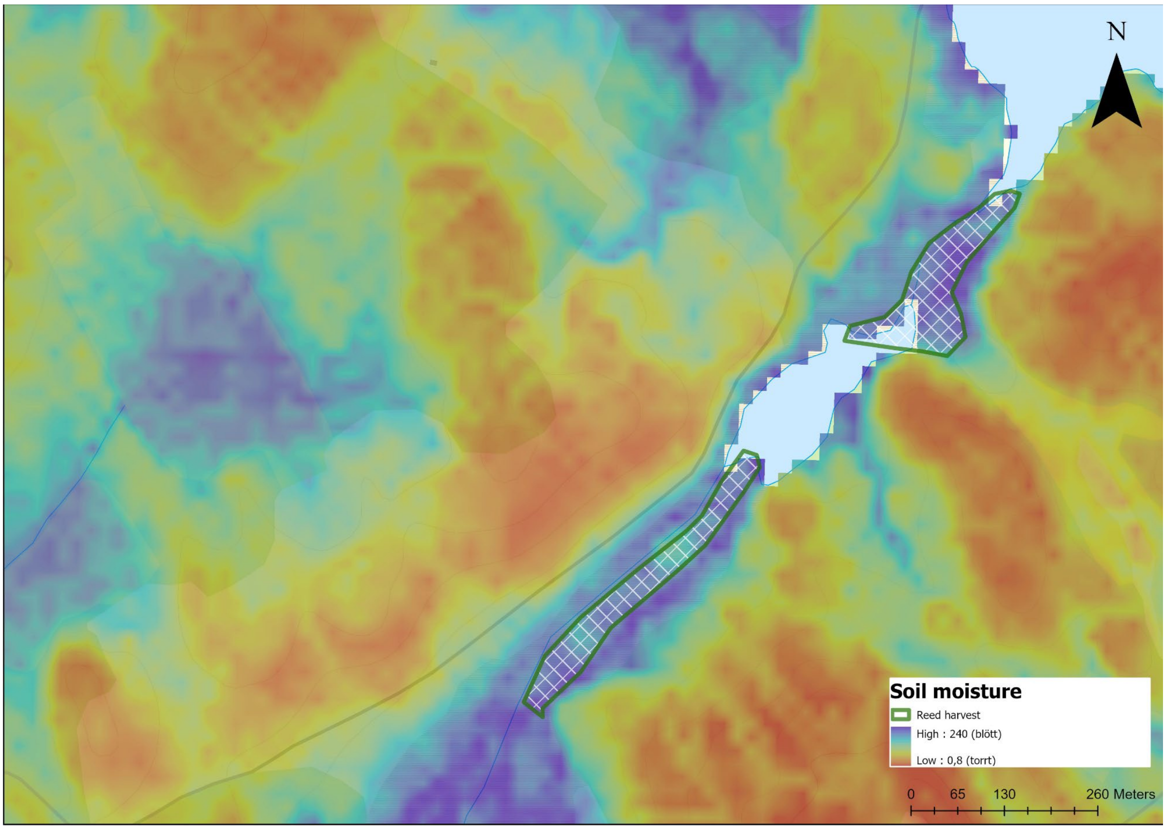

Figure 18. The map shows spatial variation in soil moisture in Vålön, Sweden, from dry (orange-red) to wet conditions (blue-purple). The outlined and hatched area indicates the reed harvesting site, which is mainly located in wetter zones.

Figure 19. Vålön, spring of 2025, before reed harvest. The area is normally grazed yearly.

3.1.2 Sediment Characteristics

Vålön

Sediment characteristics in Vålön were assessed based on field observations and environmental sampling, as no detailed sediment analysis was conducted. The site is strongly influenced by a substantial inflow, which appears to be the primary driver of sediment dynamics in the bay.

Clear signs of sediment deposition were observed, with distinct sediment banks visible in the water during calm and clear conditions. These formations indicate continuous transport and accumulation of material originating from the inflowing water.

In contrast to other sites, the sediments in Vålön did not appear to be significantly influenced by wind exposure or sea level fluctuations. Instead, sediment distribution and composition seem to be largely governed by the input of new material from the inflow.

Vålön can be described as a system dominated by external sediment input, with ongoing deposition and formation of sediment structures linked to the main inflow.

Kyrkviken

Sediment characteristics in Kyrkviken were assessed based on field observations and environmental sampling, as no detailed sediment analysis was conducted. The bay reaches depths of up to approximately 12 m, indicating a relatively deep system compared to the other study sites.

In the harvested areas, sediments were perceived as more consolidated and firmer, suggesting a lower proportion of easily resuspended fine material. This indicates more stable bottom conditions compared to shallower and more exposed sites.

Observations further suggest that the sediments in Kyrkviken are not strongly influenced by wind exposure or short-term sea level fluctuations, likely due to the greater depth and more protected conditions.

Kyrkviken can be described as a relatively deep and stable system with firm sediments and limited resuspension.

Lervik

Sediment characteristics in Lervik were assessed based on field observations and environmental sampling, as no detailed sediment analysis was conducted. The bay is shallow, with depths generally ranging between 1 and 1.5 m and even shallower areas occurring locally.

The sediments appeared to be easily resuspended, as the water column became noticeably turbid during periods of wind exposure. This indicates relatively fine and mobile sediments, likely dominated by silt and finer fractions.

Unlike more enclosed systems, Lervik does not receive significant inflow from surrounding catchment areas, suggesting that sediment inputs are primarily driven by in situ processes and coastal dynamics. The bay is also influenced by sea level fluctuations, which may contribute to periodic resuspension and redistribution of sediments.

Lervik can be described as a shallow, wind-exposed system with dynamic sediment conditions and a high degree of sediment mobility.

Vittvik (Gloet)

Sediment characteristics in Vittvik (Gloet) were assessed based on field observations and environmental sampling, as no detailed sediment analysis was conducted. The site is characterized by relatively deep water in parts of the harvested area, which likely limits sediment resuspension during harvesting activities.

Observations indicate that the bay functions as a depositional environment, effectively trapping incoming material from surrounding catchment areas. The sediments were predominantly fine-grained, with a high proportion of clay, suggesting low hydrodynamic energy and continuous accumulation of particles.

The site appeared to be largely sheltered from wind exposure and showed limited sensitivity to water level fluctuations, further supporting the interpretation of stable, low-energy conditions. Vittvik (Gloet) can be described as a sheltered accumulation basin with fine, clay-rich sediments and low levels of physical disturbance.

3.1.3 Shoreline and Habitat Structure

Shoreline and habitat structure at the studied sites were described based on field observations, as no detailed habitat mapping was conducted. The four bays differed in shoreline configuration, exposure, water depth and likely sediment dynamics, all of which are expected to influence local habitat conditions.

Vittvik (Gloet) is a sheltered and relatively stable bay with deeper water in parts of the harvested area. Based on observations, the site appears to function as a depositional basin with limited physical disturbance from wind and water level fluctuations. These conditions likely promote the accumulation of fine sediments and organic material, creating structurally stable habitats.

Lervik is a shallow bay, generally around 1–1.5 m deep, with even shallower areas occurring locally. The bay is clearly influenced by wind exposure and the water becomes turbid during windy conditions, indicating dynamic sediment resuspension. In combination with its sensitivity to sea level fluctuations, this suggests a more physically variable habitat structure than in the more sheltered bays.

Kyrkviken differs from the other sites by being considerably deeper, reaching approximately 12 m at its deepest point. In the harvested areas, sediments were perceived as firmer and more consolidated and the bay did not appear to be strongly influenced by wind or sea level fluctuations. These observations suggest comparatively stable habitat conditions and less frequent physical disturbance of the shoreline zone.

Vålön is strongly shaped by a substantial inflow, which appears to be the main factor influencing both shoreline processes and habitat structure. Sediment banks associated with the inflowing water were visible under clear-water conditions, indicating ongoing deposition of transported material. In contrast to Lervik, habitat conditions in Vålön seem less influenced by wind and sea level and more by the continuous input and redistribution of material from the inflow.

The studied bays represent different types of nearshore environments: a sheltered depositional bay (Vittvik), a shallow and dynamic wind-influenced bay (Lervik), a deeper and more stable bay (Kyrkviken) and an inflow-dominated depositional system (Vålön). These differences in shoreline and habitat structure are likely important for ecological functioning and may also influence how the sites respond to reed harvesting.

3.2 Description of reed harvesting activities

Reed harvesting is tried as a nature-based environmental measure to lighten the effects of eutrophication and restore ecological functions in shallow coastal ecosystems. In nutrient-enriched bays, reed (Phragmites australis) often forms dense, tall belts that trap sediments and nutrients, reduce water circulation, and shade submerged vegetation (Sand-Jensen, 2000). While reeds are important for structural habitat and shoreline stabilization, their overgrowth can lead to a loss of open, shallow habitats that are crucial for fish spawning, juvenile development, and wading bird foraging (HELCOM, 2018).

By mechanically harvesting reed biomass, nutrients bound within the plant are physically removed from the aquatic system, hopefully contributing to a potentially reduction in nitrogen and phosphorus loads. This could help to counteract the internal nutrient loading that often perpetuates eutrophication even when external inputs are controlled (Kraufvelin et al, 2025). Additionally, harvesting opens up overgrown bays, improves light penetration and water circulation, and restores shallow, warm, and sheltered habitats that support biodiversity and ecosystem services.

Reed harvesting can be combined with site-specific management plans to minimize potential ecological disturbance (Kraufvelin et al, 2025). Precautionary measures—such as avoiding sensitive periods for fish and birds, maintaining buffer zones, and limiting the spatial extent of harvest—ensure that the intervention supports ecosystem restoration rather than causing harm.

With in the project, **ecological guidelines** for reed harvesting have been produced. In summary, the report provides guidelines for sustainable harvesting of common reed in coastal environments. Reed beds play a key role in supporting biodiversity, nutrient retention, carbon storage, and shoreline protection, but unmanaged expansion can negatively affect ecosystem diversity. The guidelines emphasize site-specific planning, clear management objectives, and the use of mosaic cutting patterns to balance ecological benefits and impacts. Timing and harvesting methods are critical: summer harvesting maximizes nutrient removal, while winter harvesting minimizes disturbance. The report also highlights the need to consider protected species and habitats, obtain necessary permits, and minimize impacts on sediments and erosion. Overall, sustainable reed harvesting can function as an effective tool for ecosystem management, restoration, and resource utilization.

More information about the Ecological guidelines in the BalticReed project can be found here:

centralbaltic.eu/project/balticreed/

4. Monitoring design and methods

4.1 Monitoring strategy

The monitoring program was designed to assess the short-term ecological effects of reed harvesting and associated restoration measures, including the establishment of blue zones, reed islands and recruitment areas. The program follows a before–after–control–impact (BACI-inspired) approach, combining pre-studies with long-term follow-up at both intervention sites and reference bays.

A total of up to eight bays and reference sites are included in the study design, consisting of a five pilot sites where measures are implemented and four reference sites without actions. Initial mapping and site selection ensure that study areas are comparable in terms of environmental conditions while capturing relevant gradients in habitat structure and exposure.

Baseline data collection (pre-studies) began in spring 2023 and includes multiple ecosystem components. The monitoring focuses on:

- Fish communities, including adult fish and recruitment success
- Bird communities, with particular attention to early-season surveys
- Vegetation, both emergent (reed) and submerged macrophytes
- Water quality, including nutrients, chlorophyll-a and plankton (phyto- and zooplankton)
- Sediments, including nutrient content and accumulation
- Ecotoxicological parameters, through screening and potential follow-up analyses (e.g. dioxins, TBT, PFAS)

Follow-up monitoring is conducted repeatedly after implementation to evaluate both short-term and long-term ecological responses. Particular emphasis is placed on detecting changes in:

- habitat structure
- biodiversity and species composition
- fish recruitment success
- nutrient dynamics and water clarity

The program integrates monitoring of both direct effects (e.g. biomass removal, changes in vegetation) and indirect ecosystem responses (e.g. improved nursery habitats for fish or shifts in trophic dynamics).

All monitoring is carried out in a coordinated framework across partners, ensuring standardized methods and enabling comparative analyses between sites and measures. The results formed the basis for evaluating the effectiveness of different restoration approaches and will directly feed into the development of practical guidelines for coastal management.

4.2 Sampling sites and reference areas

Figure 20. Map of the Baltic Sea region showing the location of the study area along the Swedish coast. Orange markers indicate the selected sampling sites (pilot bays) where restoration measures are implemented. Nearby reference areas without action are I are included for comparison to assess ecological effects of the measures.

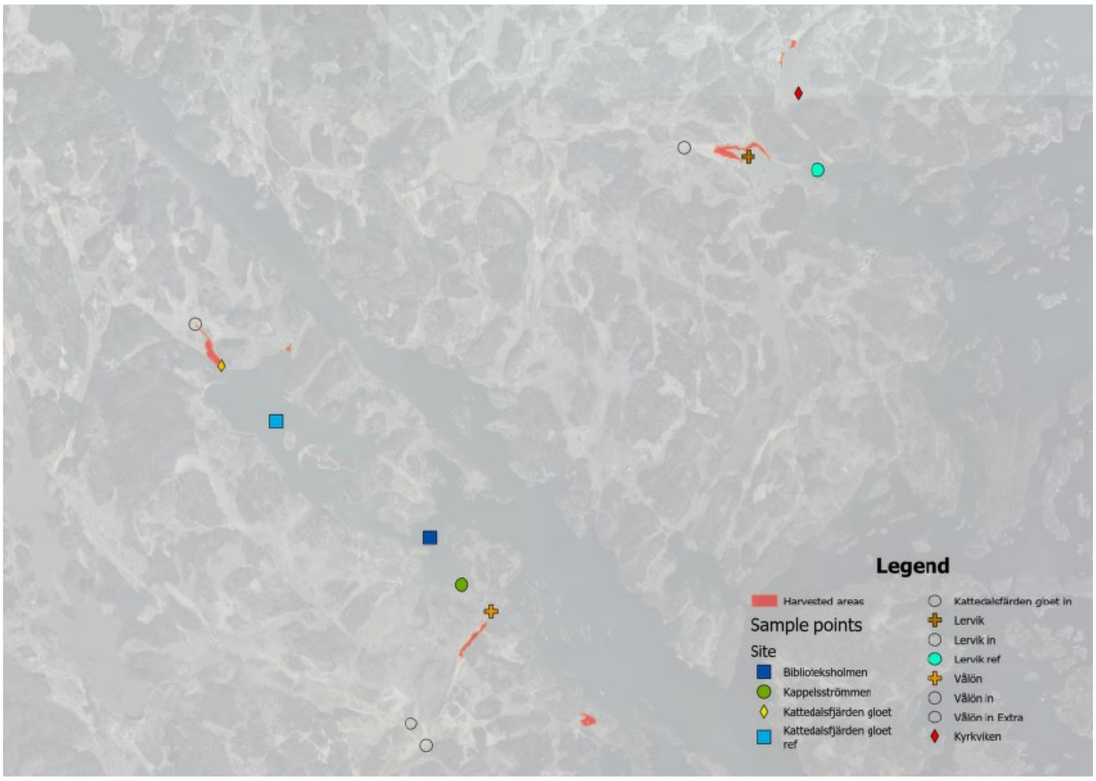

Figure 21. Map of the study area showing the spatial distribution of sampling sites, reference locations and harvested reed areas. Red shaded polygons indicate areas where reed harvesting has been carried out. Colored symbols represent different sampling sites, including both pilot (intervention) sites and reference sites, distributed across multiple bays and sub-basins. The map illustrates the spatial relationship between sampling points and harvested areas, enabling assessment of local ecological responses to the implemented measures.

4.3 Monitoring frequency and timeline

The monitoring program is structured to capture both seasonal dynamics and short-term ecological responses to reed harvesting and associated restoration measures. It combines baseline (pre-restoration) monitoring with repeated post-restoration monitoring over the full project period.

Baseline data collection (pre-studies) was initiated in spring 2023, prior to the implementation of restoration measures. These surveys establish reference conditions for all key ecological components across both pilot sites and reference bays.

Following implementation, monitoring is conducted at regular intervals with a focus on biologically relevant periods:

- Spring (April–June):
  Monitoring of fish recruitment, early bird surveys and the start of the water chemistry and zooplankton sampling program, capturing critical breeding and spawning periods.
- Summer (June–August):
  Surveys of vegetation (including submerged macrophytes), fish communities and continued water chemistry and zooplankton monitoring, reflecting peak biological activity. Phytoplankton sampling is conducted in August to capture seasonal bloom conditions.
- Late summer / autumn (August–October):
  Follow-up sampling of fish communities, vegetation status and sediment conditions, together with continued water chemistry and zooplankton monitoring, allowing assessment of seasonal development and accumulated effects.
- Water chemistry (April–October):
  Water quality sampling is conducted throughout the ice-free season each year (April–October), including nutrients and chlorophyll-a.
- Plankton sampling:
  Zooplankton is sampled repeatedly from May to October, covering the main productive season, while phytoplankton is sampled in August, targeting peak biomass conditions.
- Additional sampling:
  Targeted sediment and ecotoxicological sampling (e.g. PFAS, TBT, dioxins) is conducted at selected time points, including both screening and follow-up analyses.

Monitoring is repeated annually throughout the project (36 months), enabling the detection of both short-term responses (e.g. immediate effects of reed removal) and longer-term changes in habitat structure, biodiversity and nutrient dynamics.

The timeline follows a Before–After–Control–Impact (BACI-inspired) design, where:

- Pre-intervention data provide baseline conditions
- Repeated post-restoration surveys allow temporal comparisons
- Reference sites enable separation of treatment effects from natural variability

This structured and repeated monitoring approach ensures robust evaluation of restoration measures and supports the identification of causal relationships between management actions and ecological outcomes.

4.4 Field methods

Field sampling was conducted in accordance with standardized Swedish monitoring protocols to ensure consistency across sites and sampling occasions. All sampling followed established procedures for coastal and marine environments, with harmonized methods applied at both pilot sites and reference areas.

Water sampling

Water samples for chemical analyses were collected during the ice-free season (April–October) at predefined stations within each bay. Sampling was conducted using appropriate water samplers (e.g. integrated water samplers or depth-specific samplers depending on site conditions) to obtain representative samples of the water column.

Samples were collected for analysis of nutrients (total nitrogen, total phosphorus) and chlorophyll-a, as well as supporting parameters where relevant. All samples were handled following standard protocols, including appropriate preservation, cooling and transport to the laboratory within recommended holding times.

Phytoplankton

Phytoplankton samples were collected in August, targeting peak biomass conditions. Sampling was performed using integrated water sampling of the euphotic zone to obtain a representative sample of the phytoplankton community.

Samples were preserved in the field (using Lugol's iodine solution) immediately after collection and stored in dark and cool conditions prior to laboratory analysis. The methods applied are consistent with standard procedures used in Swedish coastal monitoring programs.

Phytoplankton analyses in brackish water analyses and index calculations were carried out in accordance with:

- The Swedish Agency for Marine and Water Management regulations on classification and environmental quality standards for surface waters, **HVMFS 2019:25**.
- The Swedish Agency for Marine and Water Management assessment criteria for surface water bodies.
- The Swedish Agency for Marine and Water Management (2016). *Programme Area Coastal and Marine Waters, monitoring protocol: Phytoplankton, version 1:3 (2016).*
- Swedish Environmental Protection Agency (2007). *Assessment Criteria for Coastal Waters and Transitional Waters (Report 2007:4).*
- **SS-EN 15204:2006**.
- **HELCOM COMBINE Manual**, Biovolume file 2023. http://www.helcom.fi/helcom-at-work/projects/PEG

Zooplankton

Zooplankton sampling was conducted repeatedly from May to October to capture seasonal dynamics. Samples were collected using plankton nets with appropriate mesh size, through vertical or oblique hauls depending on water depth and site characteristics.

Collected samples were concentrated and preserved (using Lugol's iodine solution) directly after sampling. Sampling effort and methodology were standardized across sites to allow quantitative comparisons of abundance and community composition.

Zooplankton analyses in brackish water analyses and calculations were carried out in accordance with:

- The Swedish Agency for Marine and Water Management (2016). *Zooplankton – trend and regional monitoring, Version 1:2, 2016-12-07. Programme Area: Coastal and Marine Waters.*
- The Swedish Agency for Marine and Water Management (2022). *Zooplankton in Lakes, Version 2.0, 2022-05-02. Programme Area: Freshwater.*
- **HELCOM COMBINE Manual**. *Guidelines for Monitoring of Mesozooplankton (Annex C-7).*
- **SS-EN 15110:2006.**

Where possible, at least 100 individuals from the three dominant taxonomic groups within rotifers and mesozooplankton were counted.

Biomass is presented as milligrams dry weight per litre (mg DW L^{-1}) and abundance as individuals per litre (ind. L^{-1}).

Ecotoxicological sampling

Sampling of sediments and water for ecotoxicological analyses (e.g. PFAS, TBT, dioxins) was conducted at selected sites and time points. Sediment samples were collected using suitable coring or grab sampling equipment to obtain undisturbed surface sediments.

All samples were handled using contamination-safe procedures, including the use of clean equipment and appropriate containers (e.g. PFAS-free materials where required). Samples were stored and transported under controlled conditions in accordance with standard protocols to preserve sample integrity prior to analysis.

Electric boat fishing

Boat electrofishing was conducted following established European standards for electrofishing (SS-EN 14011:2006), with methodological adaptations based on field experience to optimize catch efficiency and minimize fish disturbance. While standard protocols recommend daytime sampling under good light conditions with continuous current application, practical experience has shown that a pulsed and intermittent current can improve catch efficiency. Continuous current tends to displace fish ahead of the boat, reducing capture success, whereas a variable current application increases the likelihood of effective stunning.

In this study, electrofishing was conducted during daylight using intermittent current, applied approximately 60–80% of the sampling time. The method targets fish by generating an electric field in the water, which temporarily immobilizes individuals, allowing for capture.

The electrofishing was carried out using a purpose-built boat equipped with an onboard generator producing alternating current (AC). This current was converted into pulsed direct current (DC) via a rectifier unit, as pulsed DC is considered less harmful to fish than AC. The system allowed adjustment of key electrical parameters, including pulse frequency, voltage and current intensity, enabling optimization of capture efficiency while minimizing physiological stress and injury to fish. These settings were adapted primarily based on water conductivity.

Figure 22. Boat used for electrofishing.

In brackish water environments, the higher conductivity presents challenges for fine-tuning electrical output. Effective settings were achieved at approximately 120 Hz pulse frequency, 120 V and low power output, resulting in an average power of approximately 1000–1200 W. These parameters represented operational limits of the equipment while maintaining adequate catch efficiency.

Fish were collected by one or two operators positioned at the bow of the boat using hand nets. The boat was equipped with forward-extending electrodes (anodes), which created an electric field that attracted fish toward the surface. Captured fish were temporarily held in an onboard water tank to recover.

Figure 23. CABÖ personal capturing pike.

Sampling was conducted along shoreline habitats, with the boat navigating parallel to the shore and, where appropriate, in alternating transects extending between nearshore and slightly deeper areas. Focus was placed on structurally complex habitats, such as areas with emergent or submerged vegetation, where fish are commonly concentrated.

Each sampling stretch was fished for a minimum of 600 seconds of active current application. Due to the intermittent use of current, total sampling time per stretch was longer (e.g., 14 minutes of active current corresponded to approximately 20 minutes of total sampling time). The length of each stretch varied depending on habitat characteristics and fish abundance.

At each sampling site, environmental variables including water temperature, water clarity (Secchi depth) and dominant substrate type (classified as soft, intermediate, or hard) were recorded to support interpretation of fish distribution and catch data.

Captured fish were identified to species, measured and allowed to recover before being released back into the water.

Figure 24. CABÖ personal capturing pike.

Fish fry/recruitment

Fish fry monitoring was conducted to assess recruitment success and the function of shallow coastal bays as nursery habitats. The method follows established Swedish monitoring protocols for coastal fish recruitment surveys.

Sampling is typically carried out in late summer (August), when young-of-the-year fish are sufficiently developed to be identified to species and representative of the season’s recruitment.

At each study site, a number of sampling stations are selected to represent the spatial variability of the bay, including differences in depth, vegetation, and substrate. Sampling is conducted in shallow nearshore habitats, which are known to be important nursery areas for warm-water fish species.

Fish fry are sampled using small-scale active fishing methods, explosive charges (“shots”). Each sampling effort covers a defined area, allowing quantitative estimates of fish abundance (e.g. individuals per station).

Following each sampling event:

- All fish are collected within the sampling area
- Individuals are identified to species
- Abundance is recorded as number of individuals per station
- In some cases, size measurements are taken to confirm age class

Sampling is standardized across stations to ensure comparability between sites and over time.

In addition to fish sampling, environmental variables are recorded at each station, including:

- water depth
- temperature
- salinity

- turbidity
- substrate type
- vegetation cover

These parameters support the interpretation of recruitment patterns and habitat quality.

The collected data are used to assess:

- species composition of young fish communities
- recruitment success of key species (e.g. perch, pike, roach)
- ecological status of nursery habitats

The method provides a robust and widely used indicator of coastal ecosystem function, particularly in shallow, sheltered bays where recruitment processes are critical.

4.5 Laboratory analyses

All laboratory analyses were conducted in accordance with established Swedish standard methods and national monitoring guidelines for aquatic environments. Sampling, handling and analytical procedures followed standardized protocols to ensure consistency and comparability across sites and over time.

Water chemistry parameters, including nutrients (e.g. total nitrogen and total phosphorus) and chlorophyll-a, were analyzed using accredited methods commonly applied within Swedish environmental monitoring programs. Plankton samples (phyto- and zooplankton) were processed and analyzed according to relevant standardized methodologies for taxonomic identification, abundance and biomass estimation.

Sediment and ecotoxicological analyses (e.g. PFAS, TBT, dioxins) were performed using validated analytical techniques following national and international standards where applicable.

All analyses were carried out by accredited laboratories and qualified personnel, ensuring that methods, instrumentation and procedures meet the requirements for environmental monitoring. Laboratory staff involved in analyses participate in regular intercalibration exercises, with consistently approved results, to ensure analytical accuracy and comparability between laboratories and over time.

4.6 Quality assurance and data handling

Quality assurance procedures were applied throughout the entire monitoring program, from field sampling to laboratory analyses and data processing.

Field sampling followed standardized protocols with consistent methodologies across all sites and sampling occasions. This includes harmonized procedures for sample collection, preservation, transport and storage, minimizing variability and risk of contamination.

Laboratory analyses were performed under accredited conditions, with internal quality controls, calibration routines and participation in external intercalibration programs. Only data from analyses meeting predefined quality criteria were included in further assessments.

All data were subject to systematic quality control, including validation of outliers, consistency checks and documentation of any deviations from standard procedures. Metadata describing sampling conditions, methods and analytical details were recorded and stored alongside the data.

Data handling and storage followed established practices for environmental monitoring, ensuring traceability, reproducibility and long-term accessibility. The dataset enables robust comparisons between pilot and reference sites, as well as across years, supporting the evaluation of ecological effects of the implemented measures.

5. Monitored parameters and results

The monitoring program focused on a set of physical, chemical and biological parameters to evaluate the ecological effects of reed harvesting in shallow coastal bays. The selection of parameters reflects the key ecosystem components affected by reed expansion and eutrophication, as well as the functions that reed harvesting aims to restore, including water quality, habitat structure and biodiversity (HELCOM, 2018).

Given the relatively short duration of the project, it was not expected that measurable positive ecological changes would be detected within the project period. The primary aim was to ensure that reed harvesting did not cause negative impacts on the ecosystem.

Water chemistry was monitored to detect potential changes in nutrient concentrations, oxygen levels, temperature, water transparency and the presence of environmental toxins and heavy metals. These variables provide direct indicators of the nutrient status and overall chemical quality of the bays and help assess whether harvesting activities influence pollutant dynamics.

Biological parameters were included to assess responses of primary producers, consumers and habitat-forming species. Phytoplankton and chlorophyll-a indicate productivity and potential eutrophication effects, while zooplankton, macrophytes, benthic fauna and fish, including recruitment, reflect ecosystem health, trophic interactions and the availability of essential habitats (HELCOM, 2014) (HELCOM, 2018).

Physical and habitat parameters such as reed coverage, biomass, sediment characteristics and shoreline structure were monitored to evaluate the direct effects of harvesting on habitat openness, structural heterogeneity and the quality of shallow-water environments used by fish and birds (Kraufvelin et al, 2025). These measurements allow the assessment of both immediate impacts and longer-term ecological trends resulting from management restoration.

This integrated monitoring approach provides a understanding of how reed harvesting influences coastal ecosystem structure, function and resilience, while prioritizing precautionary management to avoid short-term negative effects.

In this section, we first present the aggregated monitoring data collected across all sampling sites during the project period. This overview provides a general understanding of the ecological conditions and variability among harvested, unharvested and reference areas.

For a more detailed assessment, the analysis then focuses specifically on two bays that have been subjected to reed harvesting twice, allowing a clearer evaluation of management effects. Lervik is not currently grazed, while Vittvik continues to be grazed today. Each of these bays is paired with their corresponding reference sites, enabling comparisons between harvested and unharvested conditions and providing insight into both ecological responses and habitat use.

5.1 Water chemistry

For water chemistry several parameters were measured:

pH

pH describes the acidity or alkalinity of the water and influences chemical processes, nutrient availability and the survival of aquatic organisms. Deviations from natural pH ranges can affect fish, invertebrates and microbial activity (Wetzel, 2001).

Conductivity (Cond_25)

Conductivity reflects the concentration of dissolved ions and is an indicator of salinity and overall mineral content in the water. It is useful for detecting changes in freshwater–brackish water balance and external inputs (APHA, 2017).

Colour (mg/L Pt)

Water colour indicates the amount of dissolved organic matter, primarily humic substances, originating from soils and vegetation. High colour can reduce light penetration and affect primary production (Wetzel, 2001).

Absorbance (ABS 420 filtered)

Absorbance at 420 nm is a measure of coloured dissolved organic matter (CDOM) and provides information on terrestrial organic matter inputs and water browning processes (Hansen, 2004).

Turbidity (FNU)

Turbidity describes the amount of suspended particles in the water and reflects sediment resuspension, algal biomass and runoff. High turbidity reduces light availability and can impair aquatic habitats (Davies-Colley, 2011).

Total phosphorus (P-tot)

Total phosphorus represents the total amount of phosphorus available in the water and is a key driver of eutrophication. Elevated levels increase the risk of algal blooms and oxygen depletion (Schindler, 1977).

Phosphate (PO_4-P)

Phosphate is the bioavailable fraction of phosphorus directly accessible for algal and plant uptake. It is closely linked to short-term algal growth and bloom development (Wetzel, 2001).

Nitrate + nitrite nitrogen N023-N

Nitrate and nitrite nitrogen represent the oxidized and biologically readily available forms of inorganic nitrogen in the water column. These fractions reflect external nutrient inputs from the catchment as well as internal nitrogen cycling processes such as nitrification and denitrification. Elevated concentrations indicate increased nutrient loading and contribute directly to phytoplankton growth and eutrophication in coastal ecosystems (APHA, 2017), (Wetzel, 2001).

Ammonium nitrogen NH_4-N

Ammonium nitrogen is the reduced and most immediately bioavailable inorganic nitrogen form. It originates from decomposition of organic matter, sediment release under low-oxygen conditions and external inputs (APHA, 2017). Elevated NH_4–N levels may indicate oxygen deficiency, high organic matter mineralisation, or internal nutrient loading and can rapidly stimulate primary production and oxygen consumption in shallow coastal environments (APHA, 2017) (Rysgaard, 1996).

Total nitrogen (N-tot)

Total nitrogen includes all nitrogen forms in the water and is an important nutrient controlling productivity and eutrophication in coastal ecosystems (Howarth, 2006).

Chlorophyll a

Chlorophyll a is an indicator of phytoplankton biomass and overall primary production. High concentrations signal elevated algal abundance and potential eutrophication effects (OECD, 1982).

Total organic carbon (TOC)

Total organic carbon represents the amount of organic matter dissolved and suspended in the water. It reflects inputs from surrounding catchments and internal production and influences light conditions, microbial activity, oxygen consumption and nutrient cycling in the ecosystem (Tranvik, 2009).

5.1.1 Nutrients

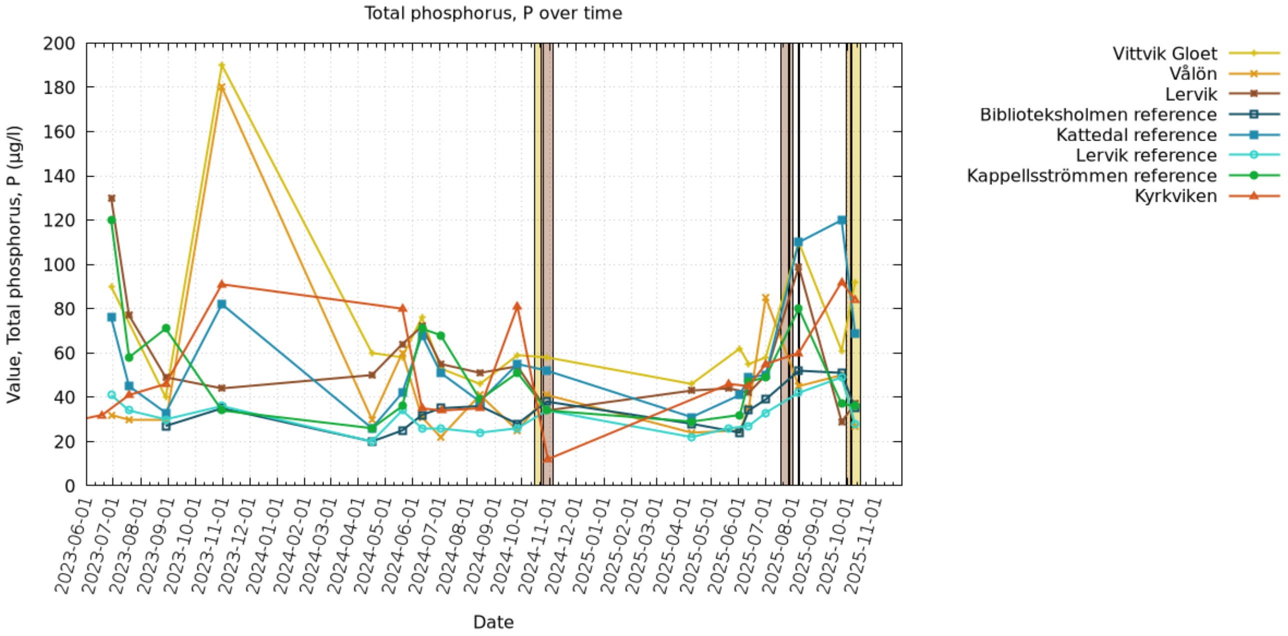

Figure 25.Total phosphorus (P, µg/L) over time (2023-2025) across study sites and reference locations; vertical bars represent harvesting periods, with colors corresponding to the respective sites as indicated in the legend.

Total phosphorus concentrations varied considerably across sites and over time. Peaks in phosphorus corresponded with late autumn and mid-summer, indicating strong seasonal and hydrological influences. Following reed harvesting events in 2024 and 2025, no immediate reductions in phosphorus were observed and concentrations remained within the natural variability of the system. The data suggest that while reed harvesting did not cause any negative impacts, short-term effects on phosphorus levels are difficult to detect due to the high year-to-year and seasonal fluctuations.

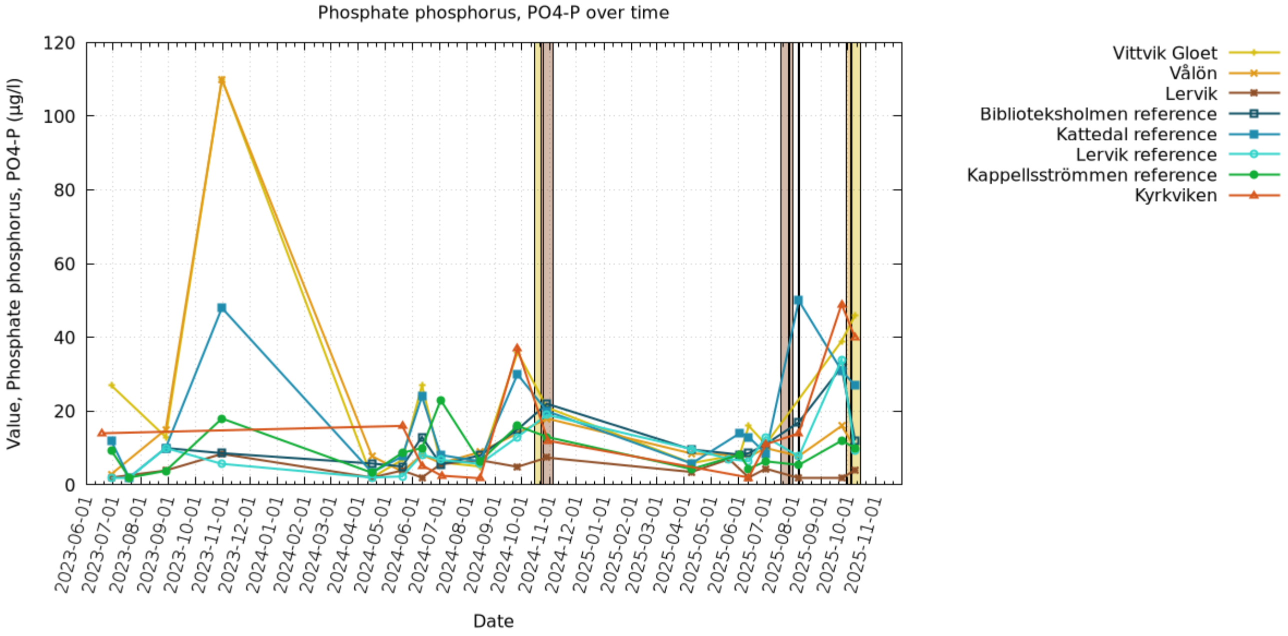

Figure 26. Phosphate phosphorus (PO_4-P, µg/L) over time (2023-2025) across study sites and reference locations; vertical bars represent harvesting periods, with colors corresponding to the respective sites as indicated in the legend.

Phosphate phosphorus concentrations varied considerably across sites and over time during the monitoring period. Several pronounced peaks were observed, most notably during late autumn 2023 and again during late summer and autumn 2025. Elevated PO_4-P concentrations occurred in both harvested and reference sites, indicating strong temporal and spatial variability.

In harvested bays such as Vittvik, Gloet, Vålön and Lervik, PO_4-P levels frequently exceeded those at reference sites, although similar short-term peaks were also recorded in reference locations. After the reed harvesting events in 2024 and 2025, no consistent or immediate decrease in PO_4-P concentrations was observed. Instead, concentrations fluctuated within a broad range that overlapped between harvested and reference sites.

Seasonal patterns suggest that hydrological conditions and freshwater inflow have a major influence on phosphate dynamics, with increases often coinciding with periods of high runoff and water exchange.

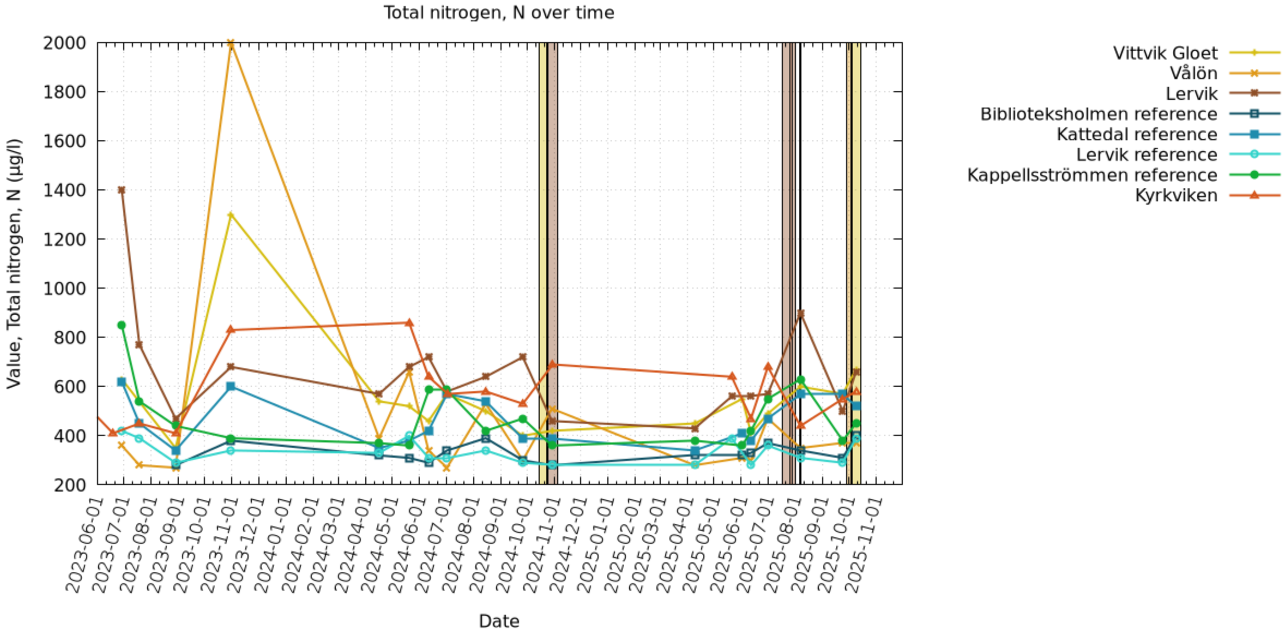

Figure 27. Total nitrogen (tot-N, µg/L) over time (2023-2025) across study sites and reference locations; vertical bars represent harvesting periods, with colors corresponding to the respective sites as indicated in the legend.

Total nitrogen concentrations showed pronounced temporal and spatial variability across all monitored bays and reference sites during the study period. Elevated nitrogen levels were particularly evident during autumn and early winter 2023, when several sites, including Vittvik Gloet, Vålön and Lervik, recorded markedly high concentrations. Peak values exceeding 1,000 µg/L were observed in harvested bays, while reference sites generally remained at lower but still variable levels.

Following the initial high concentrations, nitrogen levels declined and stabilized during 2024, remaining within a narrower range across both harvested and reference sites. During late summer and autumn 2025, a renewed increase in total nitrogen was recorded in multiple locations, affecting both harvested bays and reference sites simultaneously.

No consistent differences in nitrogen concentrations were observed between harvested and reference sites over time. Concentration ranges largely overlapped and no systematic reductions were detected following reed harvesting events.

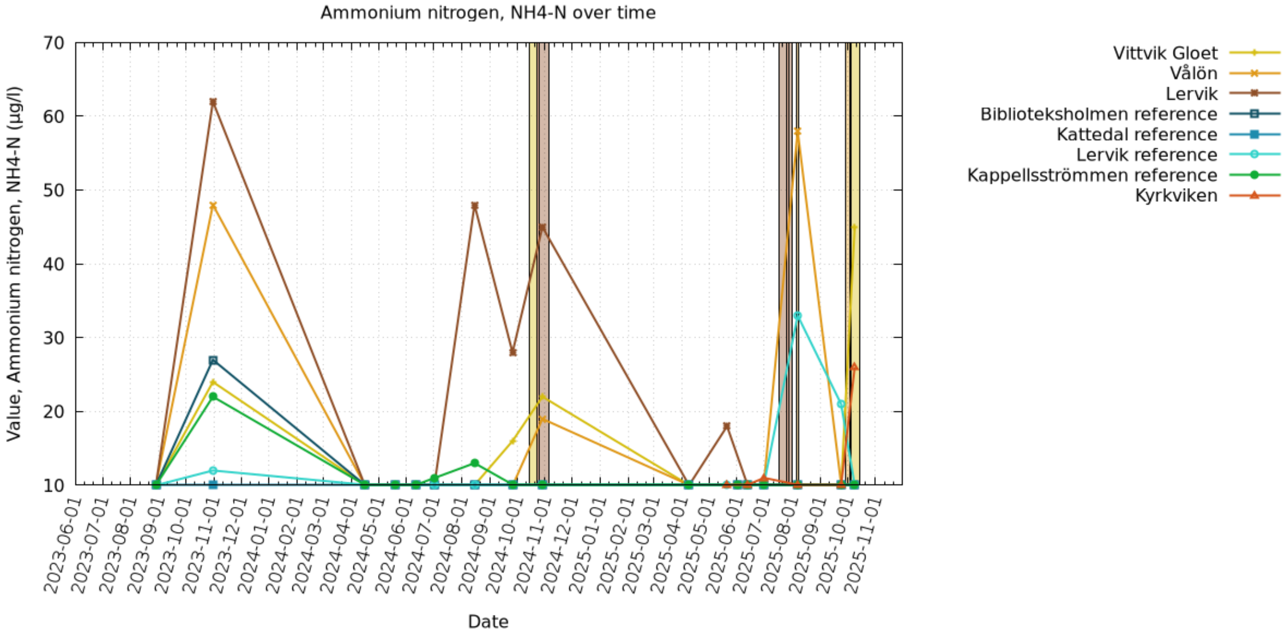

Figure 28. Ammonium nitrogen (NH4-N, µg/L) over time (2023–2025) across study sites and reference locations; vertical bars represent harvesting periods, with colors corresponding to the respective sites as indicated in the legend.

Ammonium concentrations were generally low at all stations, with most measurements remaining close to the analytical detection limit (≈10 µg/l) during large parts of the monitoring period. This indicates that the coastal bays normally function under well-oxygenated conditions with effective nitrification and limited accumulation of reduced nitrogen.

Distinct short-term peaks occurred intermittently, most clearly in autumn 2023 and autumn 2024 and again in late summer–autumn 2025. These peaks were observed both in harvested bays (Vittvik Gloet, Vålön and Lervik) and at reference stations, although the magnitude varied between sites. The highest values were recorded at Lervik and Vålön, reaching approximately 50–60 µg/l on individual occasions.

Between peak events, concentrations rapidly returned to low background levels, indicating that elevated ammonium conditions were temporary rather than persistent.

5.1.2 Oxygen, TOC and temperature

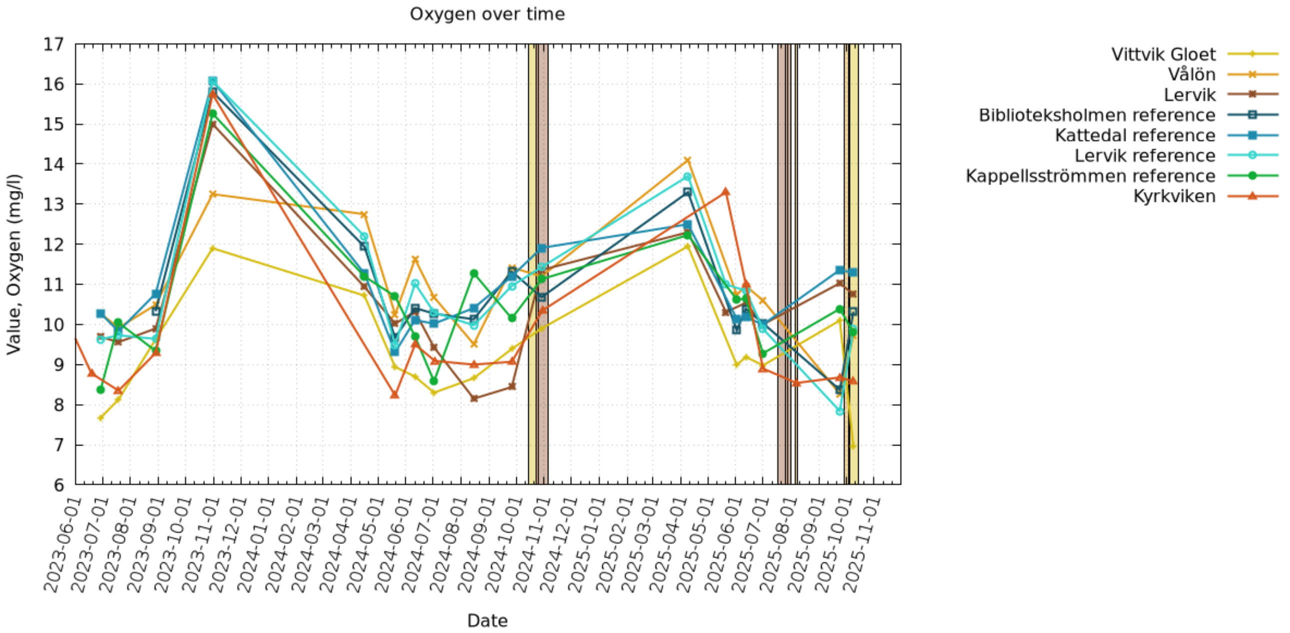

Figure 29. Oxygen (mg/L) over time (2023–2025) across study sites and reference locations; vertical bars represent harvesting periods, with colors corresponding to the respective sites as indicated in the legend.

Dissolved oxygen concentrations remained within moderate to good levels at all monitoring sites throughout the study period. Values generally ranged between approximately 8 and 16 mg/l, indicating predominantly well-oxygenated conditions in all bays.

A clear seasonal pattern was observed. Oxygen concentrations were highest during autumn and winter, when lower water temperatures increase oxygen solubility and wind-driven mixing enhances water exchange. Lower values occurred during late spring and summer, reflecting higher temperatures and increased biological oxygen consumption related to primary production and organic matter decomposition.

Short-term minima were observed during summer–early autumn 2024 and 2025 at several sites, including both harvested bays and reference locations. These declines were temporary and were followed by recovery to higher oxygen levels later in the season. Importantly, similar temporal patterns were observed at harvested and reference sites.

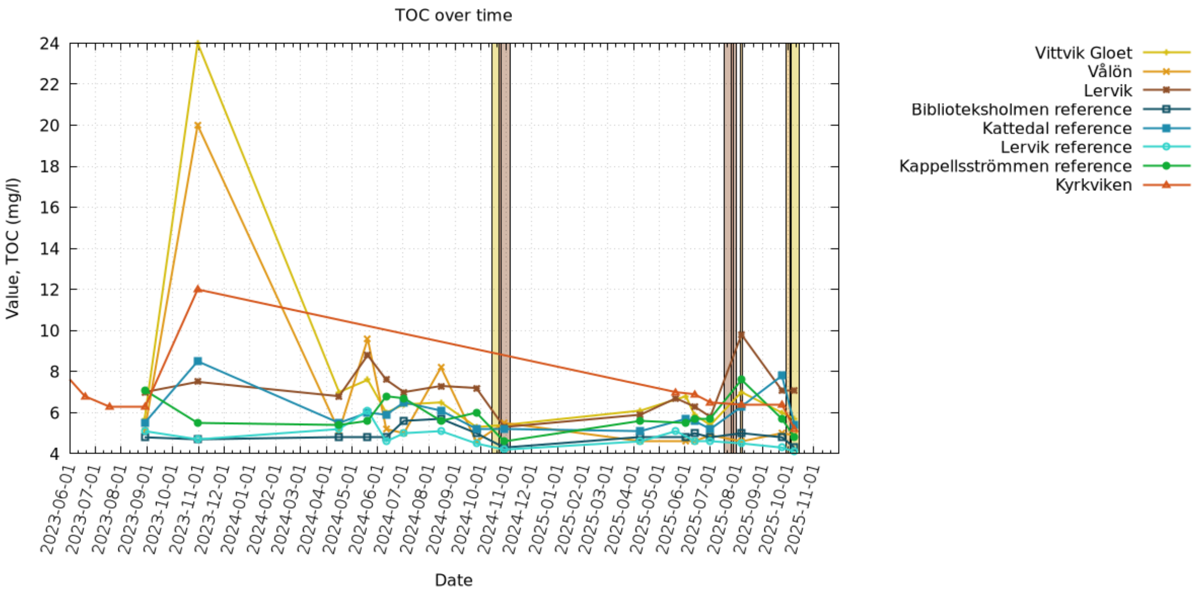

Figure 30. Total organic carbon (TOC, m/L) over time (2023–2025) across study sites and reference locations; vertical bars represent harvesting periods, with colors corresponding to the respective sites as indicated in the legend.

TOC concentrations were generally low to moderate across all sites during the monitoring period, with most values ranging between approximately 4 and 7 mg/l. This indicates relatively clear coastal waters with moderate organic matter inputs and internal production.

Pronounced short-term peaks were observed mainly in autumn 2023 and spring–summer 2024 at several sites, particularly at Vittvik Gloet and Vålön, where values temporarily reached approximately 20–24 mg/l. smaller peaks were also recorded at Kyrkviken and Lervik. These peaks were transient and followed by rapid declines back to background levels.

From late 2024 onwards, TOC levels were comparatively stable and low at all sites, including both harvested bays and reference locations, with only minor seasonal increases during summer–early autumn 2025.

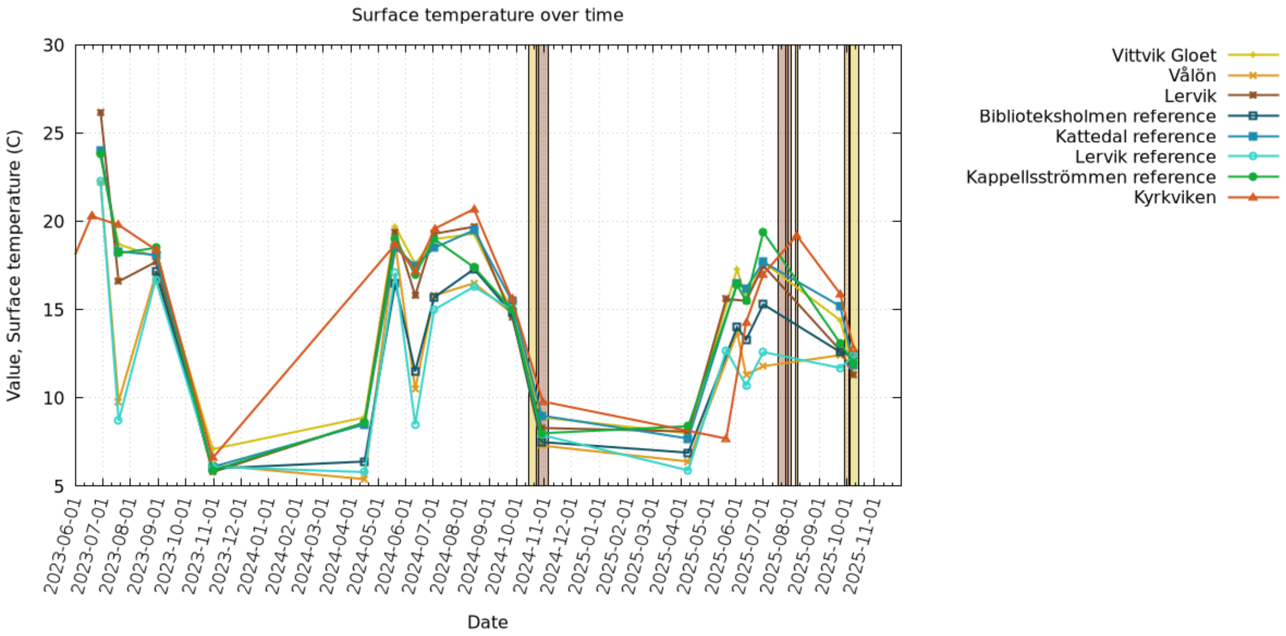

Figure 31. Surface temperature (C) over time (2023–2025) across study sites and reference locations; vertical bars represent harvesting periods, with colors corresponding to the respective sites as indicated in the legend.

5.1.3 Turbidity and secchi depth

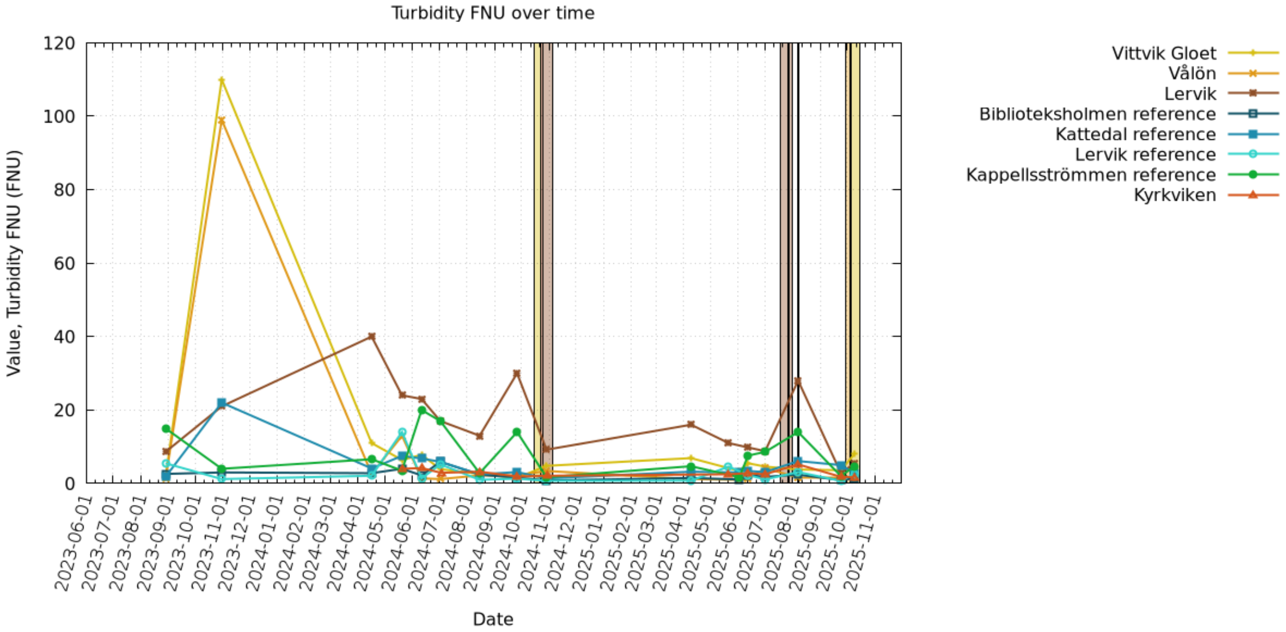

Figure 32. Turbidity (FNU) over time (2023–2025) across study sites and reference locations; vertical bars represent harvesting periods, with colors corresponding to the respective sites as indicated in the legend.

Turbidity values were generally low at most sites during the monitoring period, with the majority of measurements below approximately 10 FNU, indicating relatively clear water conditions in the monitored bays.

Marked short-term peaks occurred mainly in autumn 2023 and, to a lesser extent, during spring–summer 2024. The highest turbidity values were recorded at Vittvik Gloet and Vålön, where levels temporarily exceeded 100 FNU. Elevated values were also observed at Lervik, reaching approximately 40 FNU during individual sampling occasions. These events were short-lived and followed by rapid declines.

From late 2024 onwards, turbidity remained consistently low and stable across all sites, including both harvested bays and reference stations, with only minor increases during summer–early autumn 2025.

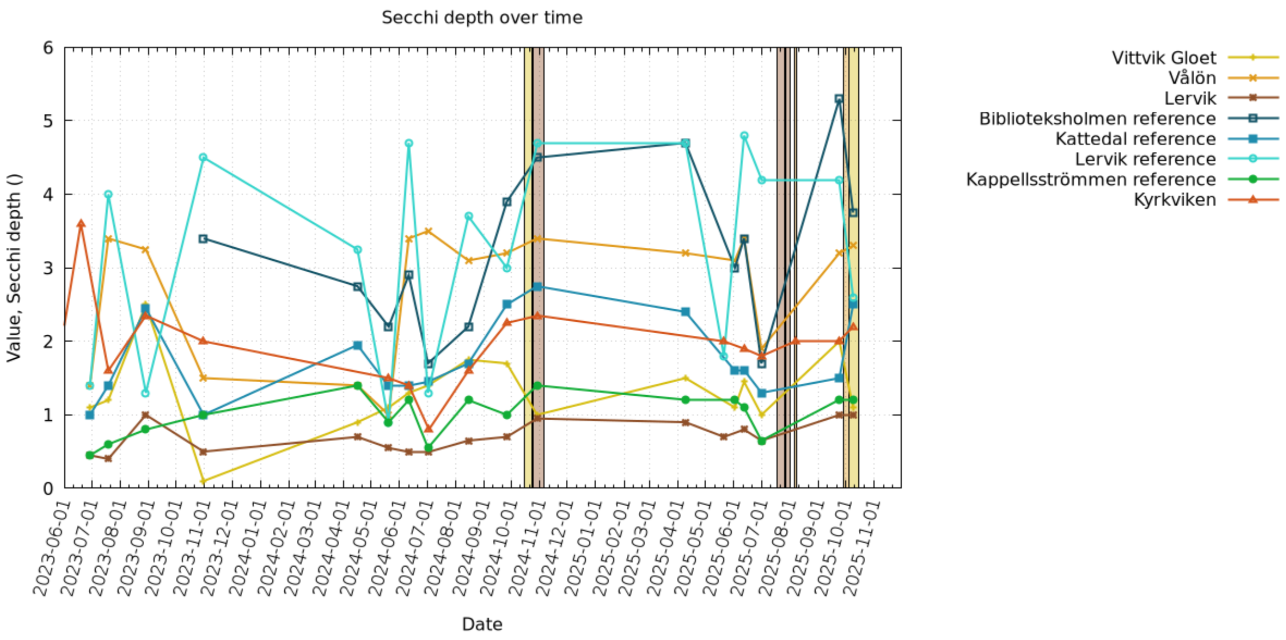

Figure 33. Secchi depth (m) over time (2023–2025) across study sites and reference locations; vertical bars represent harvesting periods, with colors corresponding to the respective sites as indicated in the legend.

Secchi depth varied considerably among sites and over time, reflecting differences in water clarity between bays and seasonal conditions. Values generally ranged from approximately 0.5 to 5.5 m, with lower transparency typically observed in more enclosed bays and higher values at reference sites with greater water exchange.

Seasonal patterns were evident, with shallower Secchi depths commonly recorded during spring and summer, coinciding with increased phytoplankton production and higher turbidity and deeper Secchi depths during autumn and winter when biological activity decreases.

Intermittent increases in Secchi depth were observed at several sites during 2024 and 2025, including both harvested and reference locations. These improvements were not consistent across all sites and did not show a clear temporal relationship with reed harvesting events.

5.1.4 Environmental toxins and heavy metals

Analytical Parameters

Surface water samples were analyzed for PAHs (polycyclic aromatic hydrocarbons), metals and PFAS (per- and polyfluoroalkyl substances). Sediment samples were analyzed for metals, dioxins and dioxin-like PCBs (polychlorinated biphenyls), non-dioxin-like PCBs, TBT (tributyltin) and PAHs.

Assessment Criteria – Surface Water

To evaluate the measured concentrations in surface water, comparisons were made with the Swedish Agency for Marine and Water Management’s regulations on classification and environmental quality standards for surface water. (HaV, Havs- och vattenmyndighetens föreskrifter om klassificering och miljökvalitetsnormer avseende ytvatten (HVMFS 2019:25), u.d.)

Results Sediment

The measured TOC-normalized concentration of tributyltin (TBT) at the Lervik sampling point exceeds the limit specified in HVMFS 2019:25. All other sampling points and parameters with sediment limit values in HVMFS 2019:25 (lead, cadmium, copper, anthracene and fluoranthene) are below the threshold.

According to the "Classification of Organic Contaminants in Sediments" (SGU, u.d.)TBT concentrations at Lervik and Vålö, as well as one PCB (2,2',4,4',5,5'-HxCB, #153) and several PAHs at Vålö, fall into class 3 (moderate level) out of five classes ranging from very low to very high. Other measured concentrations fall into class 1 (very low) or class 2 (low), or are below the reporting limit.

Benz[ghi]perylene exceeds HaV's indicative sediment value at all sites. However, HaV notes that QS values, particularly the marine value, should not be used due to significant uncertainties and the associated risk may be overestimated. (Metaller och miljögifter - Effektbaserade bedömningsgrunder och indikativa värden för sediment, Havs- och vattenmyndighetens rapport 2018:31, u.d.) Therefore, this exceedance can be disregarded. Other analyzed parameters are below the respective thresholds.

Dioxin concentrations are below the guideline values proposed by the County Administrative Board of Dalarna and fall within class II (Good) out of five classes in the Norwegian assessment framework for dioxins (Miljødirektoratet, u.d.)

Measured metal concentrations are above pre-industrial background levels (HaV, SGI Vägledning 10 – Bakgrundshalter i sediment (SGI, 2024). , u.d.) but do not reach class 5 (very large deviation) in marine sediment deviation classes, which would indicate influence from a point source.

Water

Measured concentrations of the PFAS compound PFOS (perfluorooctane sulfonic acid) and calculated concentrations of ammonia nitrogen (NH_3-N) exceed the annual average environmental quality standards in HVMFS 2019:25 at all sampling sites. However, the maximum allowable concentrations are not exceeded. PFOS levels are comparable to those measured in other coastal areas in Östergötland.

Elevated concentrations of arsenic and uranium are observed at several sampling sites. Annual average values exceed guideline values, but maximum allowable concentrations are not exceeded. According to the assessment procedure, natural background concentrations should be subtracted from measured values when exceedances occur. However, regional background concentrations are unknown for the area and no nationally established background values exist for arsenic or uranium in Swedish coastal waters.

The Swedish Water Authorities propose a background concentration of 0.2 µg/L for arsenic in Baltic Sea coastal waters, although this value is uncertain and may be as high as 0.5 µg/L. Arsenic concentrations may also be overestimated due to analytical interference from chloride in ICP analyses. For uranium, no sufficient data exist to establish natural background concentrations.

All other analyzed parameters are below the environmental quality standards specified in HVMFS 2019:25. For some PAHs, however, the reporting limits are too high to allow comparison with the assessment criteria.

Tabell 1. Measured concentrations of the PFAS compound PFOS in water.

ANALYS	LERVIK	KAPPELSTRÖMMEN	VÅLÖN	VITTVIK	ENHET	METOD/REF
BENS(A)ANTRACEN	<0.010	<0.010	<0.010	<0.010	µg/l	SPI 2011
KRYSEN	<0.010	<0.010	<0.010	<0.010	µg/l	SPI 2011
BENSO(B,K)FLUORANTEN	<0.020	<0.020	<0.020	<0.020	µg/l	SPI 2011
BENSO(A)PYREN	<0.010	<0.010	<0.010	<0.010	µg/l	SPI 2011
INDENO(1,2,3-CD)PYREN	<0.010	<0.010	<0.010	<0.010	µg/l	SPI 2011
DIBENS(A,H)ANTRACEN	<0.010	<0.010	<0.010	<0.010	µg/l	SPI 2011
NAFTALEN	<0.010	<0.010	<0.010	<0.010	µg/l	SPI 2011
ACENAFTYLEN	<0.010	<0.010	<0.010	<0.010	µg/l	SPI 2011
ACENAFTEN	<0.010	<0.010	<0.010	<0.010	µg/l	SPI 2011
FLUOREN	<0.010	<0.010	<0.010	<0.010	µg/l	SPI 2011
FENANTREN	<0.010	<0.010	<0.010	<0.010	µg/l	SPI 2011
ANTRACEN	<0.010	<0.010	<0.010	<0.010	µg/l	SPI 2011
FLUORANTEN	<0.010	<0.010	<0.010	<0.010	µg/l	SPI 2011
PYREN	<0.010	<0.010	<0.010	<0.010	µg/l	SPI 2011
BENSO(G,H,I)PERYLEN	<0.010	<0.010	<0.010	<0.010	µg/l	SPI 2011
SUMMA CANCEROGENA PAH	<0.035	<0.035	<0.035	<0.035	µg/l	SPI 2011
SUMMA ÖVRIGA PAH	<0.045	<0.045	<0.045	<0.045	µg/l	SPI 2011
SUMMA PAH MED LÅG MOLEKYLVIKT	<0.015	<0.015	<0.015	<0.015	µg/l	SPI 2011

5.2 Biological parameters

5.2.1 Chlorophyll-a

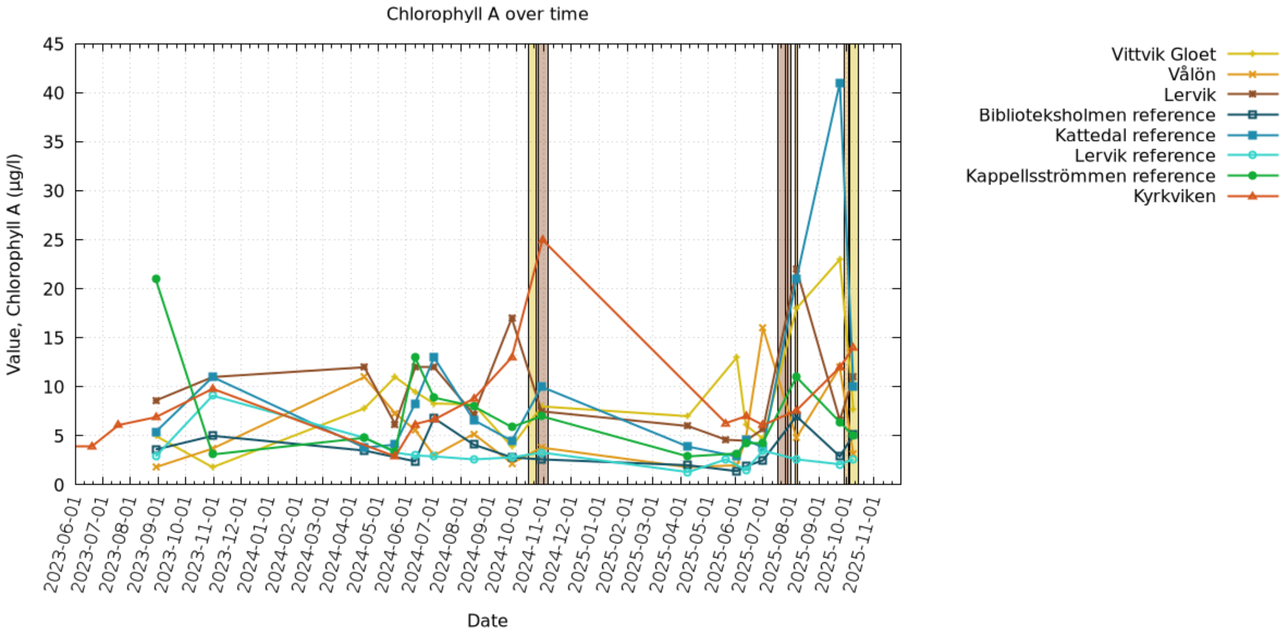

Figure 34. Chlorophyll a (chl-a, µg/L) over time (2023-2025) across study sites and reference locations; vertical bars represent harvesting periods, with colors corresponding to the respective sites as indicated in the legend.

Chlorophyll-a concentrations varied considerably over time and between sites, reflecting changes in phytoplankton biomass and primary production. Most values ranged between approximately 2 and 10 µg/l, indicating generally moderate phytoplankton levels in the monitored bays.

Pronounced short-term peaks occurred at several sites, particularly during late summer and autumn. Elevated concentrations were observed in autumn 2024 and again in late summer–autumn 2025, with the highest values recorded at Biblioteksholmen reference and Vittvik Gloet, where concentrations temporarily exceeded 20–40 µg/l. Similar but lower peaks were also observed at other harvested and reference sites.

Seasonal patterns were evident, with higher chlorophyll-a concentrations typically occurring during warmer periods, coinciding with increased light availability, temperature and nutrient uptake. Periods with low chlorophyll-a were mainly observed during winter and early spring.

5.2.2 Zooplankton

Tabell 2. Summary of total biomass across all sites in 2024 for mesozooplankton and rotifers, presented in mg/L

PLACE	MESOZOOPLANKTON	ROTATORIES
VITTVIK 2024-05-20	0,010628	0,00134
VITTVIK 2024-06-11	0,199492	0,007378
VITTVIK 2024-08-15	0,181291	0,001755
VITTVIK 2024-09-26	0,015328	0,004337
VÅLÖN 2024-05-20	0,00125	0,003265
VÅLÖN 2024-06-11	0,0515	0,013894
VÅLÖN 2024-07-26	0,024042	0,013989
VÅLÖN 2024-08-15	0,006565	0,002198

The zooplankton data from 2024 show moderate seasonal variation.

At Vålön, overall biomass remains low throughout the season, with only a modest increase in June (~0.05 mg/L mesozooplankton) followed by a decline towards late summer. No clear late-summer peak is observed, and both mesozooplankton and rotifers remain at relatively low levels. This suggests limited production and a weak seasonal succession.

At Vittvik, biomass is substantially higher, particularly in June and August (up to ~0.18–0.20 mg/L mesozooplankton). The community is dominated by copepods (*Acartia*), indicating a more developed trophic structure. However, biomass declines markedly by September, suggesting a seasonal reduction in production.

Compared to Vålön, Vittvik shows a more productive and copepod-dominated system, while Vålön appears low-productive and less dynamic.

The 2024 data indicate a system where Vittvik maintains higher and more stable zooplankton biomass, whereas Vålön remains low in biomass with limited seasonal development.

Tabell 3. Summary of total biomass across all sites in 2025 for mesozooplankton and rotifers, presented in mg/L

PLACE	MESOZOOPLANKTON	ROTATORIES
VÅLÖN 2025-06-02	0,010500	0,009176
VÅLÖN 2025-06-12	0,027260	0,042904
VÅLÖN 2025-07-01	0,203209	0,033744
VÅLÖN 2025-08-07	0,348434	0,002210
VÅLÖN 2025-09-24	0,000801	0,000291
VITTVIK GLOET 2025-06-02	0,070679	0,059607
VITTVIK GLOET 2025-06-12	0,069992	0,051791
VITTVIK GLOET 2025-07-01	0,025533	0,007909
VITTVIK GLOET 2025-08-07	0,067603	0,000875
VITTVIK GLOET 2025-09-24	0,060413	0,003228

The zooplankton data for 2025 show clear seasonal dynamics, with increasing biomass from early summer to late summer, followed by a decline in autumn. However, the patterns differ between the two sites.

At Vålön, a pronounced seasonal succession is observed. Biomass is low in early June, increases through July, and peaks in August, driven mainly by copepods (*Acartia*). This indicates a shift from rotifer dominance in early summer to larger mesozooplankton later in the season. In September, biomass drops sharply, suggesting a seasonal collapse in production.

In contrast, Vittvik shows a more stable pattern. Biomass levels are relatively high already in June and remain fairly consistent throughout the season, with no distinct late-summer peak. Mesozooplankton biomass remains relatively high even in September, unlike at Vålön.

These differences suggest that Vålön represents a more dynamic, seasonally driven system, while Vittvik appears to be more retentive and stable, potentially with higher nutrient availability and slower water exchange.

The community structure reflects a typical shift from rotifers (e.g., *Keratella*, *Synchaeta*) in early summer to copepods later in the season, indicating a progression towards a more developed trophic structure.

5.2.3 Phytoplankton

Tabell 4. Summary of total biomass for both sites in 2024 for phytoplankton presented in mg/L and µg/l.

PLACE	DATE	BIOMASSA (MG/L)	BIOMASSA (NEK)	CHL A (µG/L)	CHL A (NEK)	SAMMANVÄGD STATUS
VITTVIK	240702	14	0,03	8,2	0,22	0,12
VÅLÖN	240702	2,5	0,2	5,2	0,38	0,29

The phytoplankton data from 2024 indicate relatively high productivity, particularly at the coastal sites.

At Vittvik, biomass is high (~14 mg/L), suggesting nutrient-rich conditions and elevated primary production, while Vålön shows lower but still moderate biomass (~2.5 mg/L).

The community composition reflects a mixed assemblage, including:

- Diatoms and cryptophytes, indicating productive conditions
- Cyanobacteria (e.g., *Microcystis*, *Dolichospermum*), including potentially toxin-producing taxa
- Dinoflagellates and euglenophytes, often associated with nutrient-rich and more stagnant environments

It is noted that the presence of large amounts of zooplankton in the samples may have influenced the phytoplankton results to some extent.

Tabell 5. Summary of total biomass for both sites in 2025 for phytoplankton presented in mg/L and µg/l.

PLACE	DATE	BIOMASSA (MG/L)	BIOMASSA (NEK)	CHL A (µG/L)	CHL A (NEK)	SAMMANVÄGD STATUS
VITTVIK	250807	0,33	0,54	18	0,10	0,32
VÅLÖN	250807	0,47	0,45	4,80	0,34	0,4

The phytoplankton data for 2025 should be considered preliminary, but some general patterns can be observed.

Overall, the community appears to show seasonal variation, with indications of increased biomass and/or shifts in composition during summer. This likely reflects typical responses to temperature, light availability, and nutrient conditions.

There are signs of a transition from smaller, fast-growing taxa (e.g., flagellates and small cyanobacteria) earlier in the season towards a more developed summer community, potentially including larger taxa and bloom-forming species.

Differences between sites suggest that local conditions (e.g., water exchange, nutrient availability, and exposure) influence phytoplankton dynamics. However, given the preliminary nature of the data, these patterns should be interpreted with caution.

5.2.4 Macrophytes

Three action sites and one reference site, CAB Östergötland monitored macrophyte abundance both before and after the reed harvesting activities. Surveys were conducted in late August and early September–October to capture seasonal growth patterns

Macrophyte coverage was assessed along transects positioned more or less perpendicular to the shoreline. At each transect, seven sampling points were evaluated at 5-meter intervals over a total length of 30 meters. In Gloet, Kapellströmmen and Vålö, two transects were surveyed, while in Lervik five transects were assessed.

At each sampling point, macrophytes were collected using a 50 cm wide rake covering 1 meter and coverage was estimated according to a 1–7 scale:

1 = 1%, 2 = 5%, 3 = 10%, 4 = 25%, 5 = 50%, 6 = 75%, 7 = 100%.

In the graphs below, macrophyte abundance is presented as the sum of coverage across all transects at each locality. Orange bars represent 2025 (after harvesting) and blue bars represent 2024 (before harvesting). Actions were carried out at Gloet, Vålö and Lervik, while Kapellströmmen served as a reference site.

A total of ten macrophyte species were recorded. Most species, with the exception of Potamogeton perfoliatus, have low phosphorus indicator values, indicating tolerance to relatively high phosphorus concentrations.

Tabell 6. Overview of recorded aquatic vegetation at the study sites, including vegetation codes, Swedish names and corresponding English common names.

VEGETATION DESCRIPTION	SWEDISH NAME	ENGLISH NAME	LATIN
PHR AUS	vass	Common reed	Phragmites australis
BOL MAR	havssäv	Sea club-rush	Bolboschoenus maritimus
NAJ MAR	havsnajas	Widgeon grass	Najas marina
CER SUB	vårtsärv	Rigid hornwort	Ceratophyllum demersum
MYR SPI	axslinga	Eurasian watermilfoil	Myriophyllum spicatum
STU PEC	borstnate	Sago pondweed	Stuckenia pectinata
POT PER	ålnate	Perfoliate pondweed	Potamogeton perfoliatus
CHA HOR	raggsträfse	Rough stonewort	Chara horrida
RAN CIR	hjulbladsmöja	Fan-leaved water-crowfoot	Ranunculus circinatus
ELO CAN	vattenpest	Canadian waterweed	Elodea canadensis
FUC VES	blåstång	blåstång	Fucus vesiculosus

Vålön

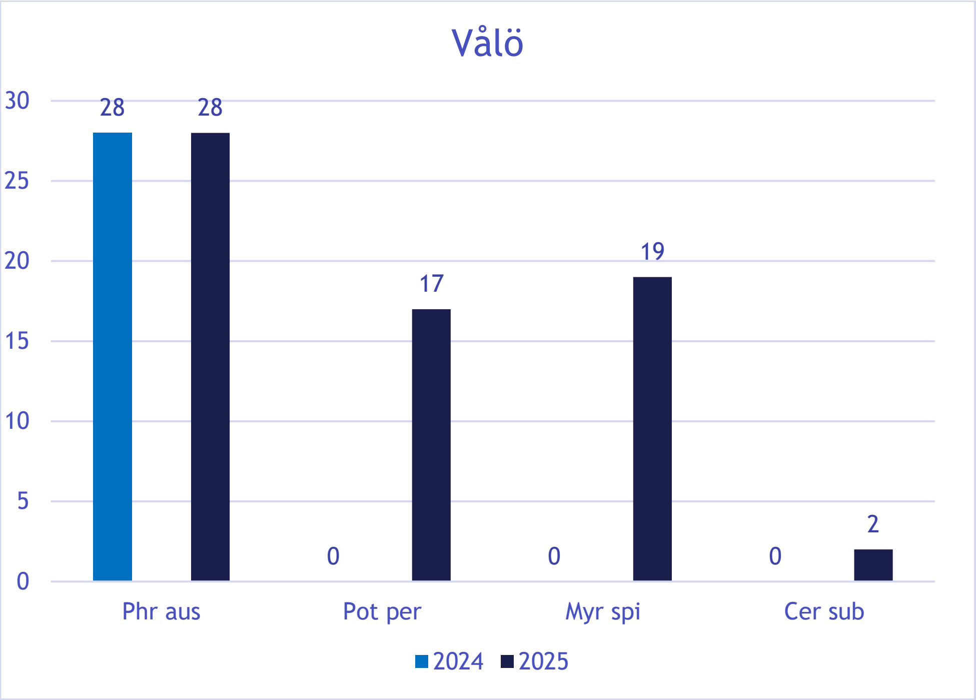

Figure 35. Occurrence of macrophyte species in Vålö in 2024 and 2025; values indicate abundance per species, with no records in 2024 except for Phragmites australis and vertical comparison showing increased species presence in 2025.

Lervik

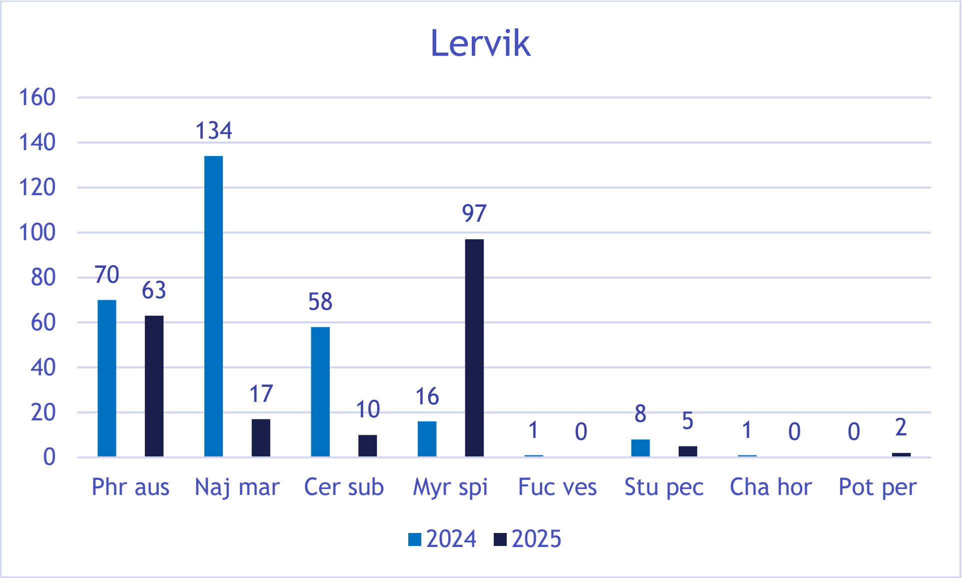

Figure 36. Occurrence of macrophyte species in Lervik in 2024 and 2025; values indicate abundance per species, showing shifts in species composition and a decrease in Najas marina alongside an increase in Myriophyllum spicatum in 2025.

Vittvik (Gloet)

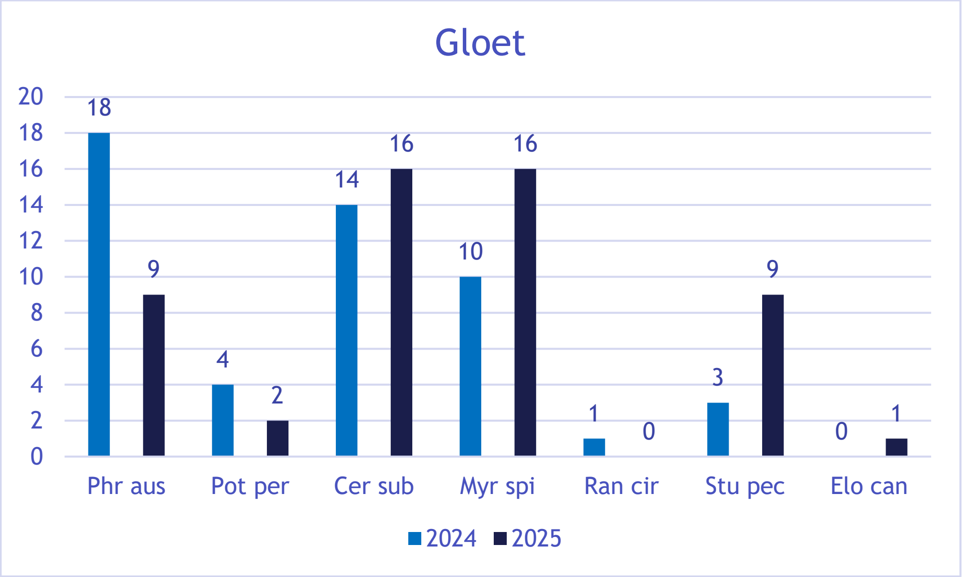

Figure 37. Occurrence of macrophyte species in Gloet (Vittvik) in 2024 and 2025; values indicate abundance per species, showing a general increase in several species (e.g. Myriophyllum spicatum and Stuckenia pectinata) and a decrease in Phragmites australis in 2025.

Kapellströmmen reference

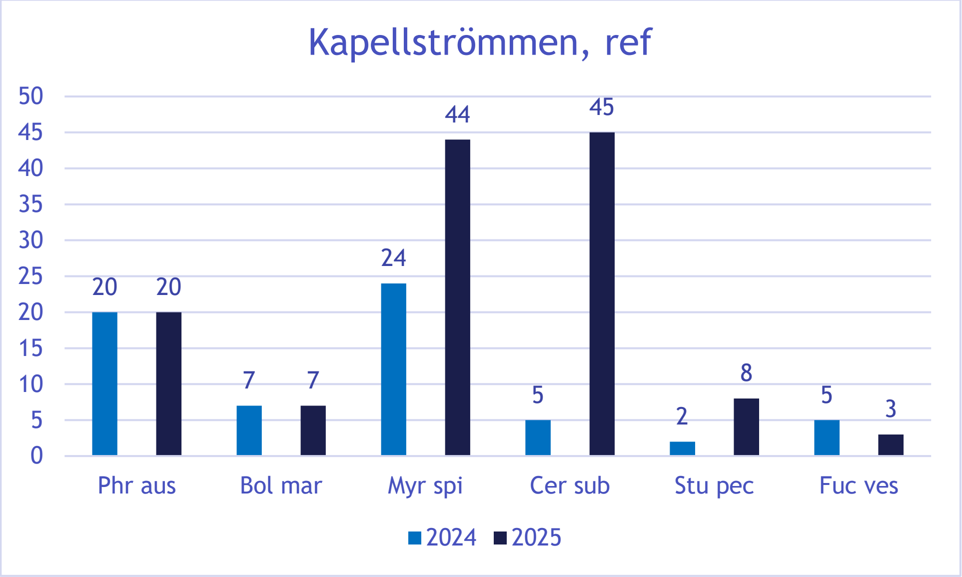

Figure 38. Occurrence of macrophyte species at the reference site Kapellströmmen in 2024 and 2025; values indicate abundance per species, showing increased abundance of Myriophyllum spicatum and Ceratophyllum submersum in 2025, while Phragmites australis remained statble.

5.2.4 Fish recruitment

At these action sites, CAB Östergötland hired the consultant Naturvatten I Roslagen AB to monitor fish recruitment before and after harvesting activities.

Fish recruitment surveys were carried out in late August and early September. The method used involved a controlled detonation of a 10 g charge at the water surface, which temporarily paralyzed small fish within a 5-meter radius. In Gloet and Kapellströmmen East, three detonation stations were sampled; in Lervik four stations; and in Kyrkviken eight stations. Captured fry were identified to species and measured.

The graphs below present the mean number of first-year fry per species per station. Green bars represent 2025 (after harvesting) and blue bars represent 2023 (before harvesting). Reed harvesting was conducted at Gloet, Vålön and Lervik. Kapellströmmen West served as a reference for Kapellströmmen East and Kyrkviken served as a reference for Lervik. The Kyrkviken reference site, however, was last investigated in 2020.

Kappelströmmen west

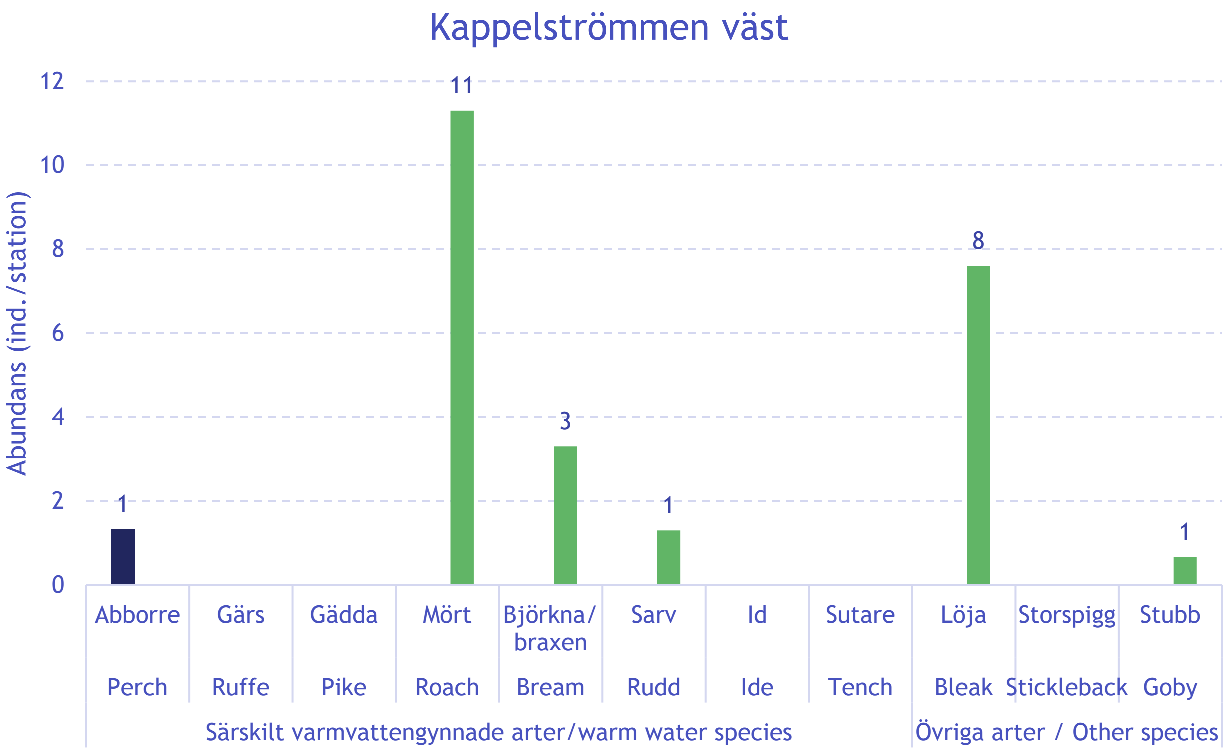

Figure 39. Fish abundance (individuals per station) in Kappelströmmen west; community dominated by white fish specis, particularly roach (Rutilus rutilus) and bleak (Alburnus alburnus), with few individuals of other species.

Vålön

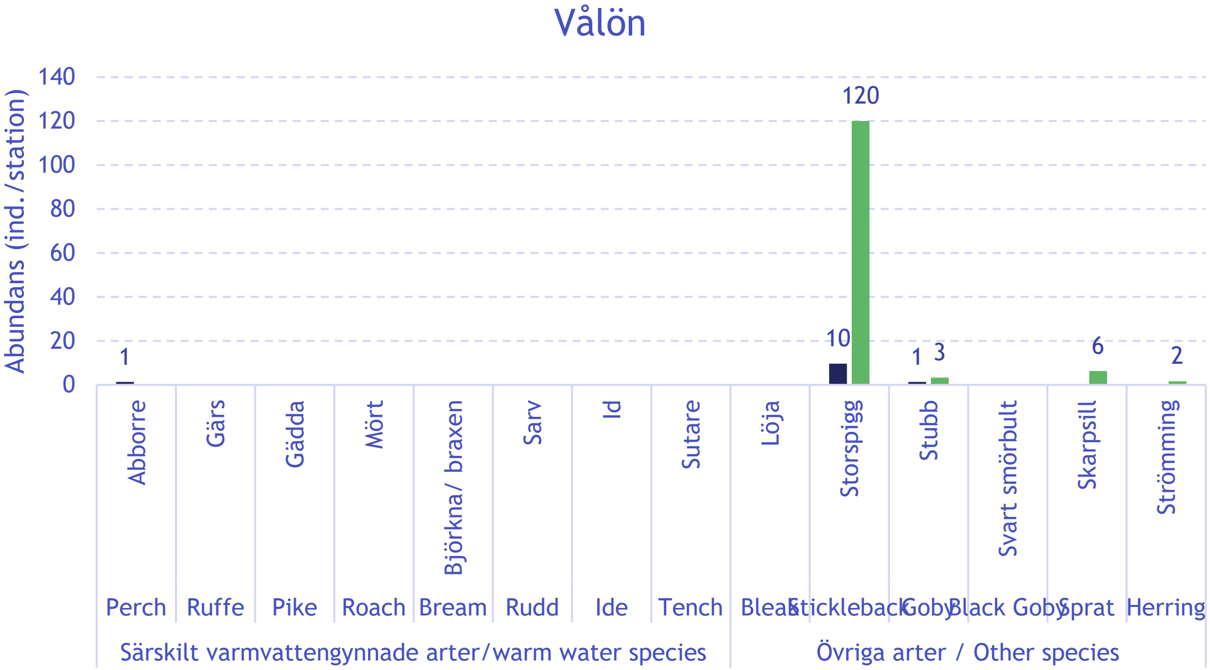

Figure 40. Fish abundance (individuals per station) in Vålön; the community is strongly dominated by stickleback, with only a few individuals of other species recorded.

Lervik

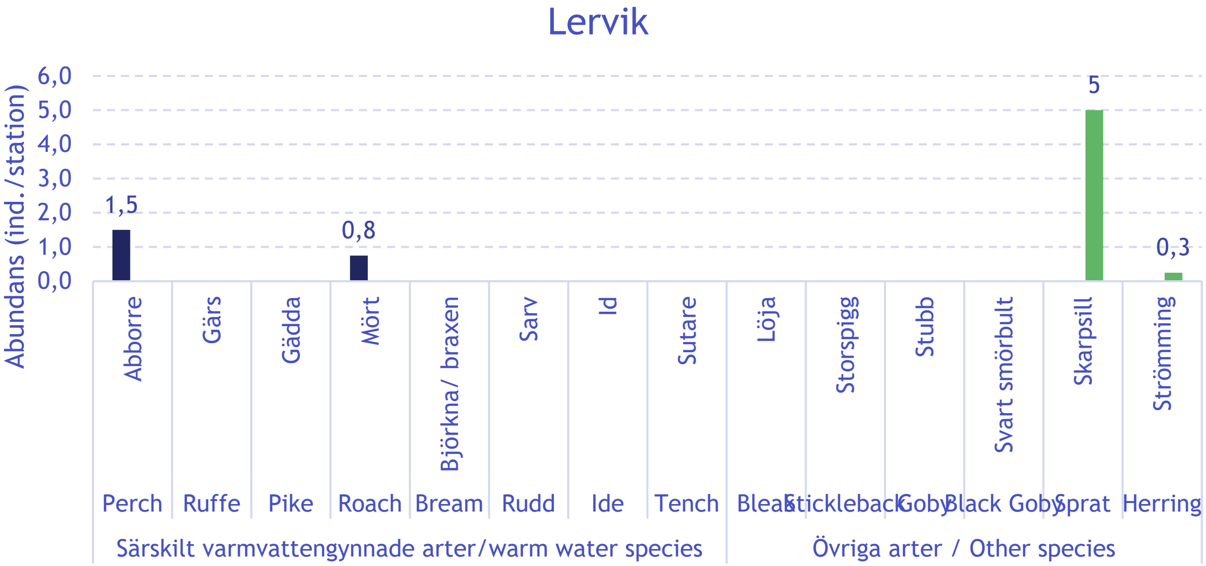

Figure 41. Fish abundance (ind./station) in Lervik; overall low abundances were recorded, with a few individuals of perch and roachs and higher occurrence of sprat.

Vittvik (Gloet)

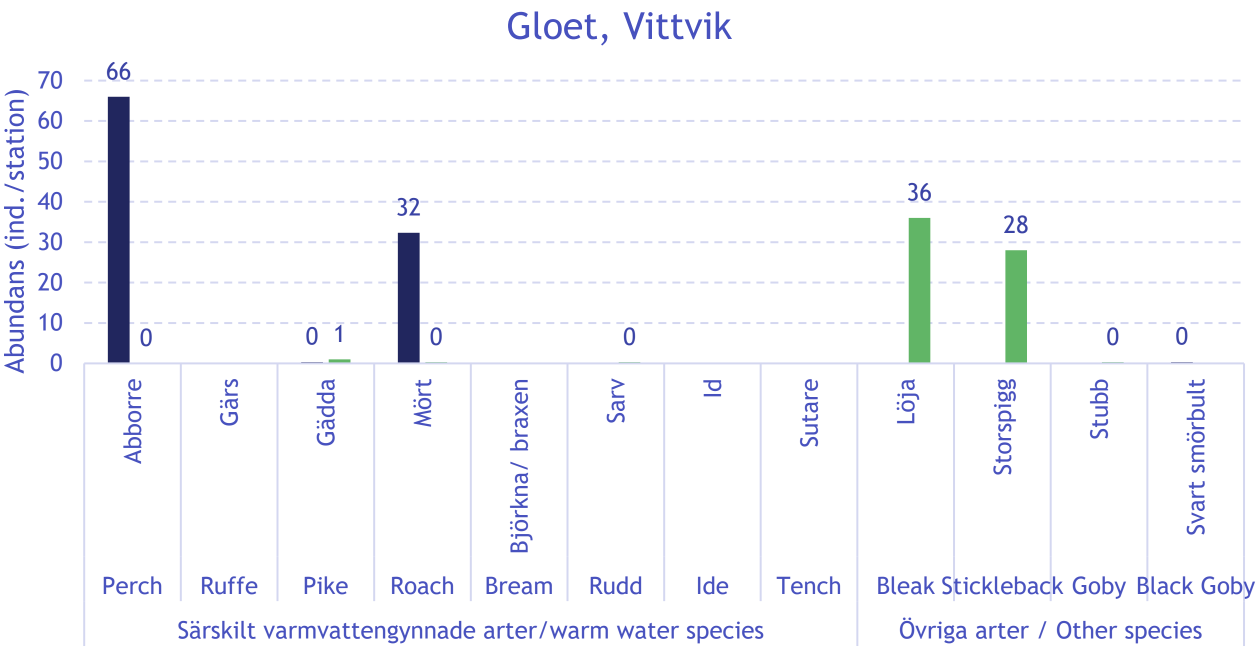

Figure 42. Fish abundance (ind./station) in Gloet (Vittvik); the community is dominated by perch and roach and by bleak and stickleback.

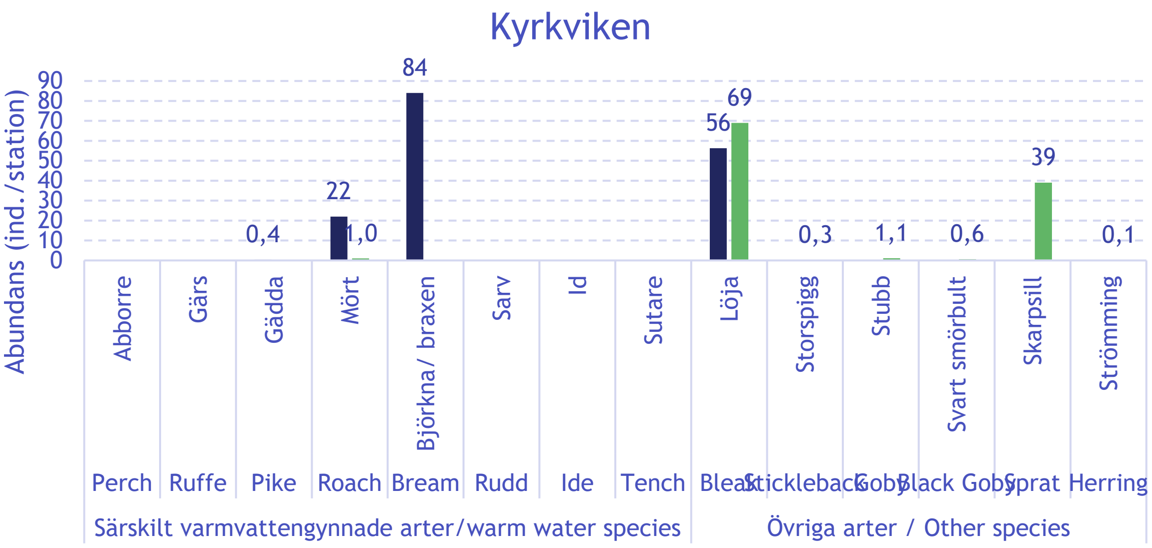

Figure 43. Fish abundance (ind./station) in Kyrkviken; the community is dominated by bream and bleak, with notable contributions from sprat and roach, while other species occurred in low abundances.

5.2.5 Fish

Lervik

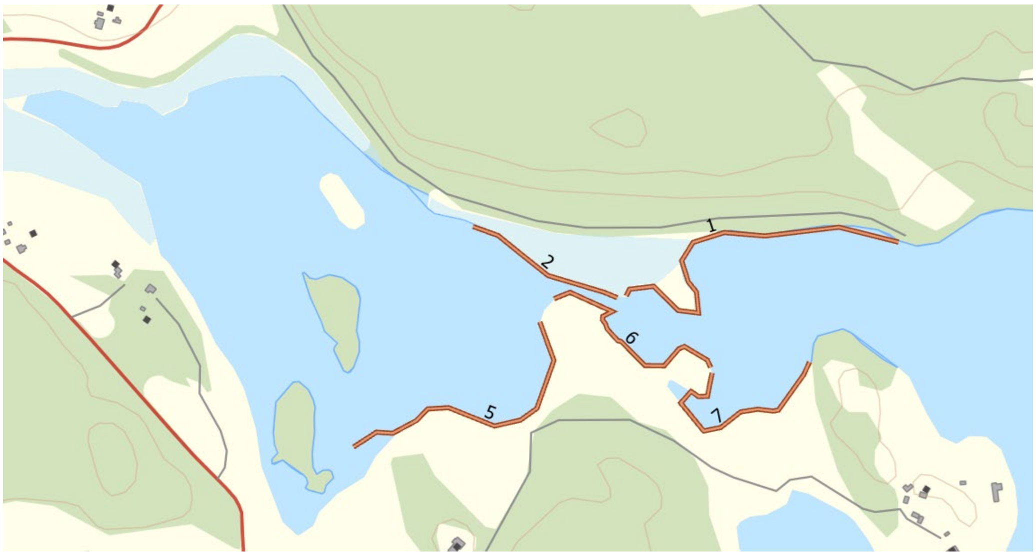

Figure 44. Map of the study area in Lervik showing the electrofishing route divided into segments (1-7) along the shoreline.

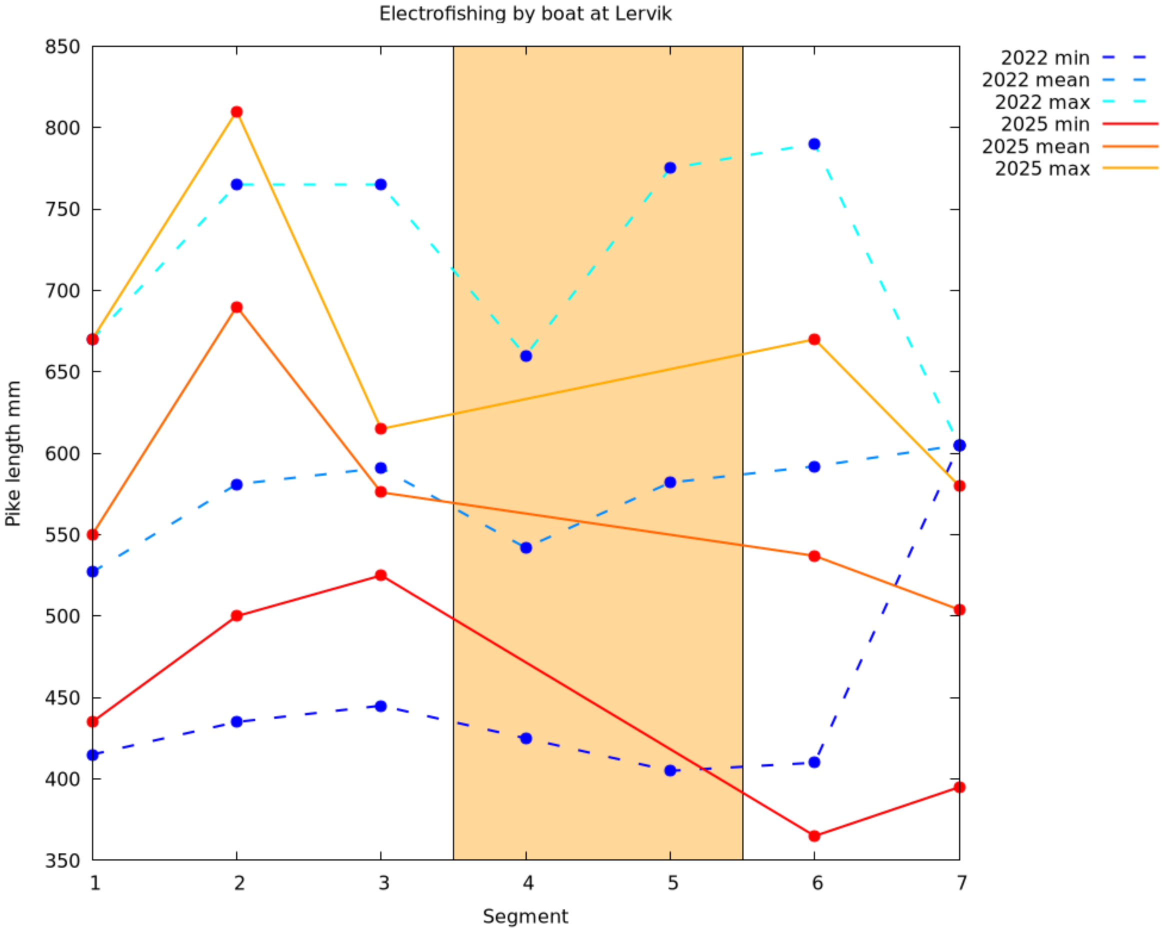

Figure 45 Pike length (min, mean and max) per segment (1-7) from electrofishing in Lervik in 2022 and 2025; generally smaller fish in 2025, with a clear decrease in segments 4-5 (highlighted area).

The results indicate that pike in 2025 were generally smaller compared to 2022, with lower mean and minimum lengths across most segments. However, the presence of large individuals remained in some areas (e.g. segment 2), suggesting that older fish are still present but less dominant. The increased occurrence of smaller individuals in 2025 may indicate successful recruitment. Notably, segments 4-5 showed a clear shift towards smaller size classes, suggesting potential changes in habitat conditions or population structure.

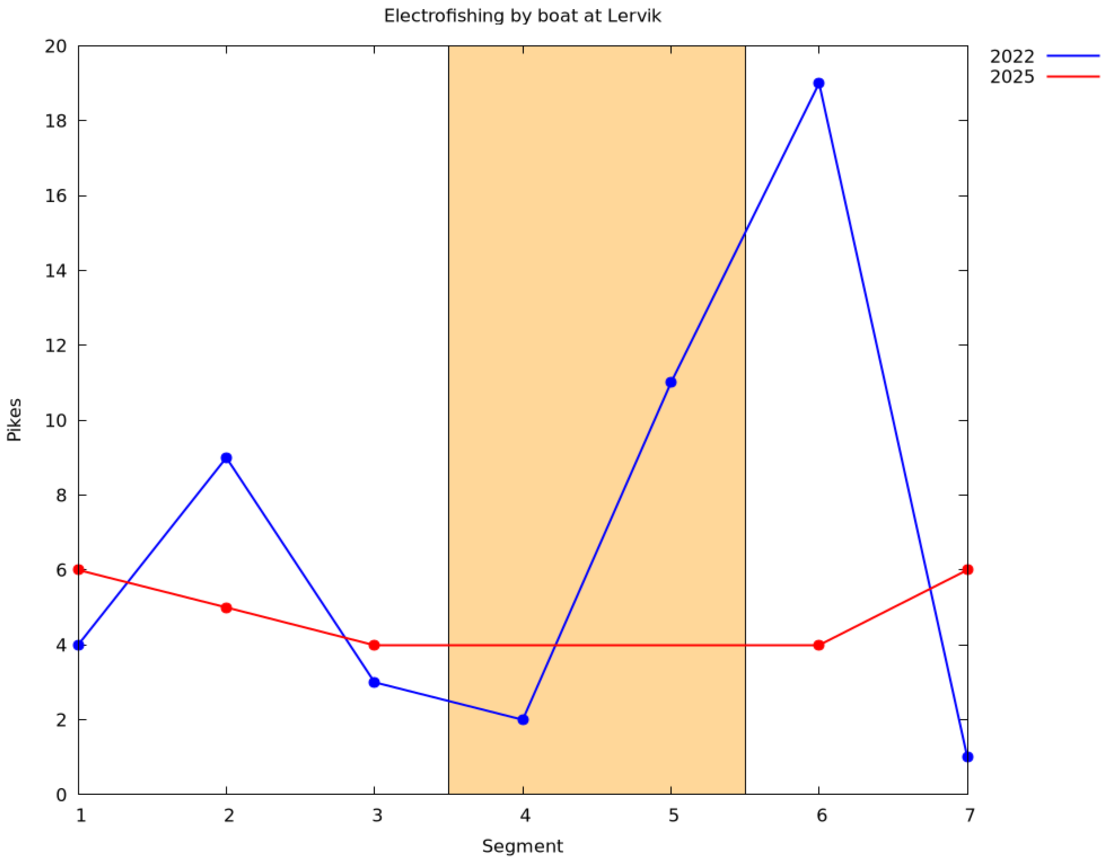

Figure 46. Number of pike per segment (1-7) from electrofishing in Lervik in 2022 and 2025; catches were more variable and peaked in segments 5-6 in 2022, while 2025 showed a more even distribution across segments, including the highlighted area (segments 4-5).

The number of pike varied between years and among segments. In 2022, catches were highly uneven, with pronounced peaks in segments 5 and 6, while low numbers were recorded in segments 3, 4 and 7. In contrast, catches in 2025 were more evenly distributed across all segments, including the highlighted area (segments 4-5), with relatively similar numbers of individuals throughout. This suggests a shift from a more aggregated distribution in 2022 to a more uniform spatial distribution of pike in 2025.

Vittvik

Figure 47. Map of the study area in Vittvik showing the electrofishing route divided into segments (1–9) along the shoreline.

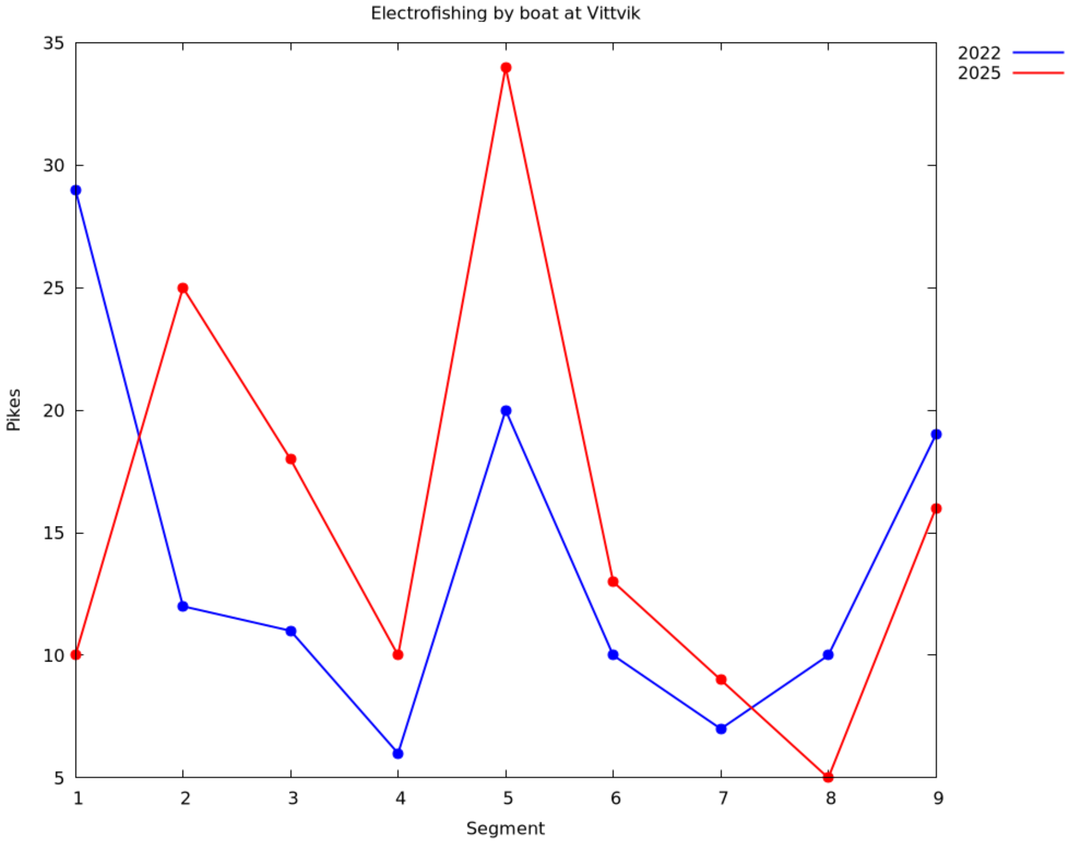

Figure 48. Number of pike per segment (1-9) from electrofishing in Vittvik in 2022 and 2025; catches varied between years, with higher peaks in segments 2 and 5 in 2025, while 2022 showed higher catches in segments 1 and 9.

The number of pike varied between segments and years in Vittvik. In 2022, catches were highest in segments 1, 5 and 9, while lower numbers were observed in the central segments. In contrast, 2025 showed higher catches in segments 2 and especially segment 5, where the highest number of individuals was recorded across both years. Several segments (e.g. 3, 6 and 7) showed relatively similar patterns between years, while others differed markedly.The results indicate spatial variability in pike distribution, with some shifts in peak abundance between years rather than a consistent increase or decrease across the area.

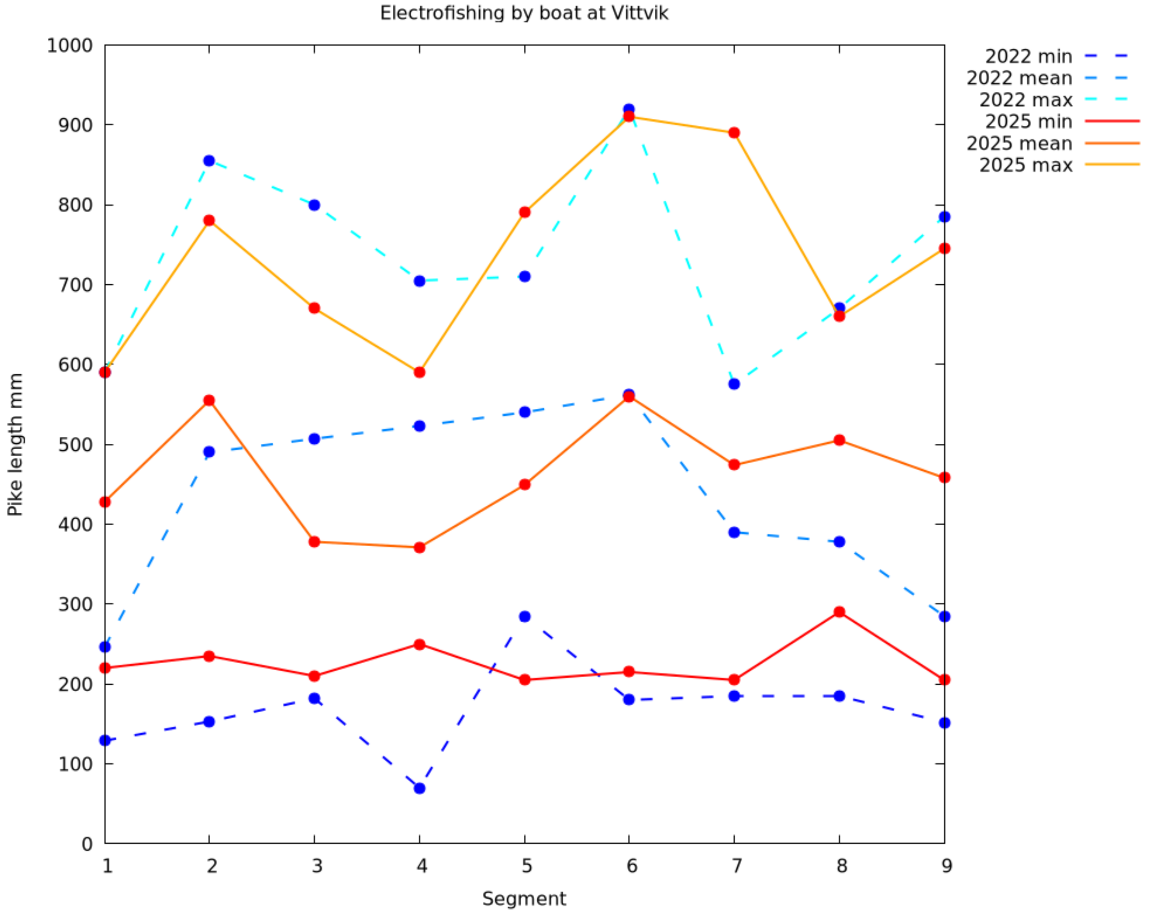

Figure 49. Pike length (min, mean and max) per segment (1–9) from electrofishing in Vittvik in 2022 and 2025; lengths varied between segments, with generally higher maximum values in segments 5–7 in both years and lower minimum values in 2025.

Pike length varied across segments and between years in Vittvik. In both 2022 and 2025, the largest individuals were recorded in segments 5–7, indicating these areas consistently support larger pike. Mean lengths followed a similar pattern, with peaks around segment 6 in both years. However, minimum lengths were generally lower in 2025, suggesting a higher proportion of smaller individuals. While maximum lengths were relatively similar between years, the overall size distribution in 2025 appears shifted towards smaller fish, indicating potential differences in population structure or recruitment between years.

Kappelströmmen (Fågelvik) (reference)

Figure 50. Map of the study area in Fågelvik showing the electrofishing route divided into segments (1-6) along the shoreline.

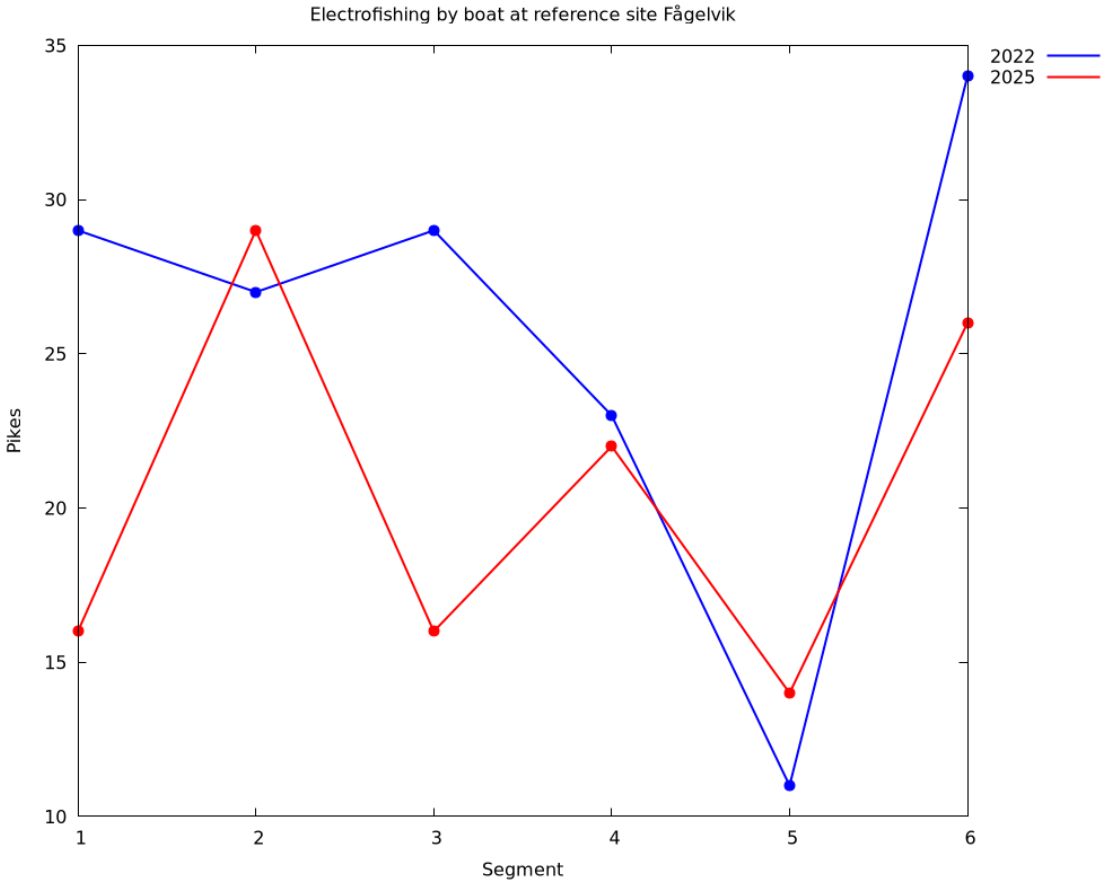

Figure 51. Number of pike per segment (1-6) from electrofishing at the reference site Fågelvik in 2022 and 2025; catches were generally higher in 2022, with both years showing variability among segments.

The number of pike at the reference site Fågelvik varied between segments and years. In 2022, catches were generally higher and more consistent across segments, with peaks in segments 1, 3 and 6 and a notable dip in segment 5. In 2025, catches were lower overall and more variable, with a peak in segment 2 and relatively low numbers in segments 1 and 3. Both years showed a dip in segment 5, indicating consistently lower abundance in this area. The results suggest a reduction in pike abundance in 2025 compared to 2022, while maintaining a similar spatial pattern across segments.

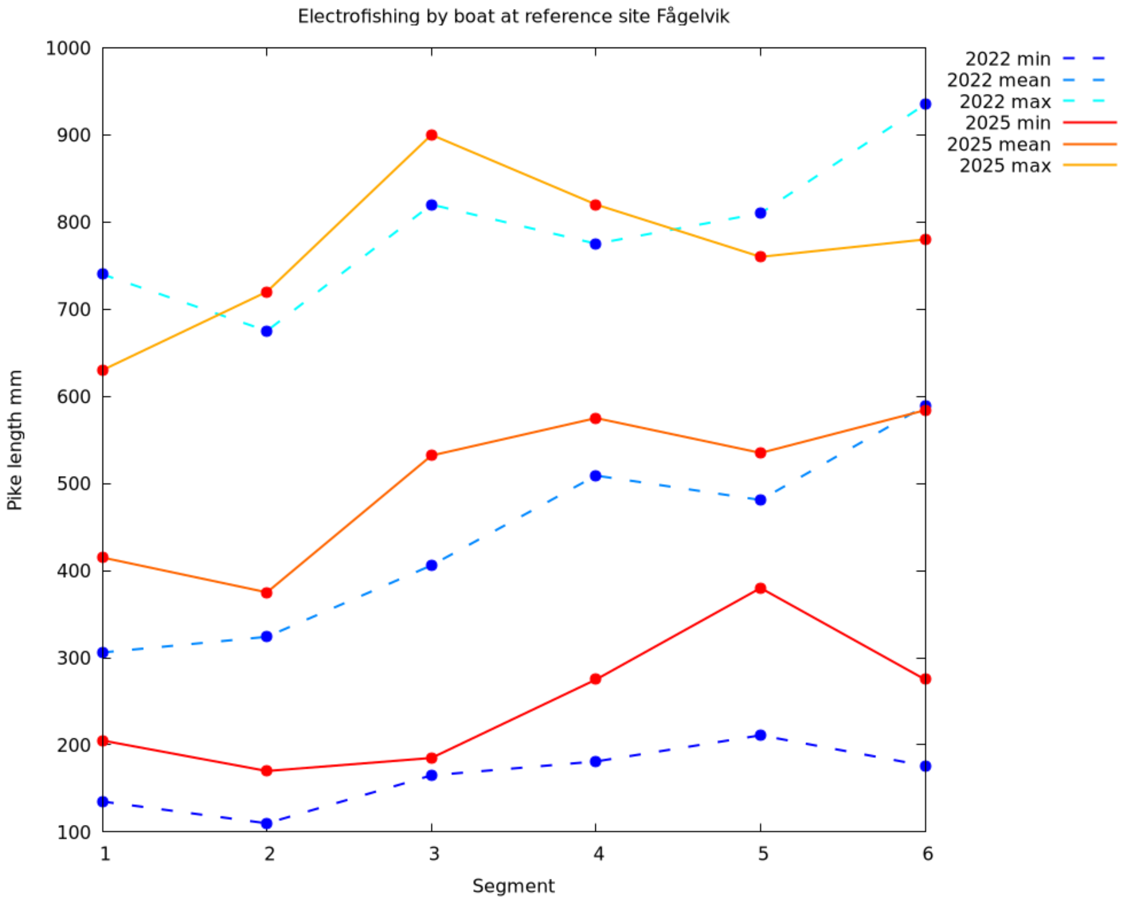

Figure 52. Pike length (min, mean and max) per segment (1-6) from electrofishing at the reference site Fågelvik in 2022 and 2025; lengths were generally similar between years, with some variation in minimum values.

Pike length at the reference site Fågelvik showed relatively similar patterns between 2022 and 2025. Maximum lengths were consistently high across segments in both years, with peaks in segments 3 and 6. Mean lengths followed a comparable pattern, with slightly higher values in 2025 in several segments. Minimum lengths, however, were generally higher in 2025, suggesting a lower proportion of very small individuals compared to 2022. The size distribution appears relatively stable between years, with only minor shifts in minimum and mean values.

Gropviken (reference)

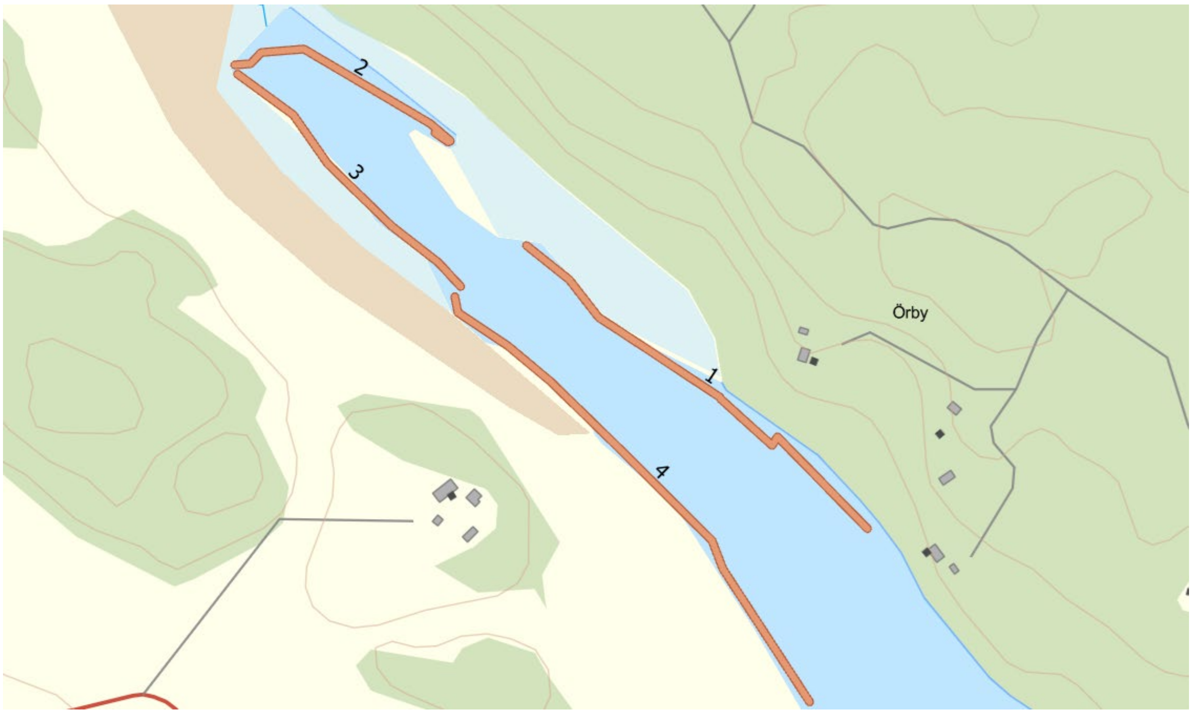

Figure 53. Map of the study area in Gropviken showing the electrofishing route divided into segments (1-4) along the shoreline.

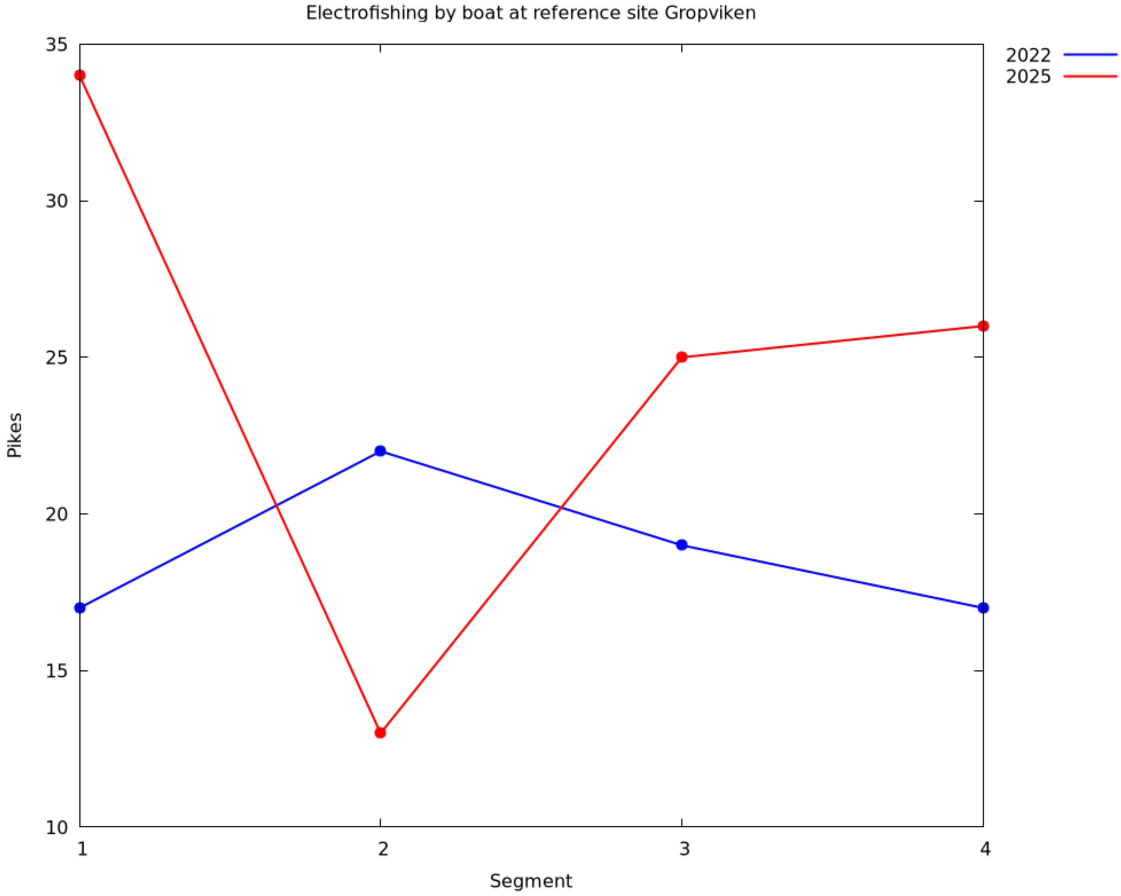

Figure 54. Number of pike per segment (1-4) from electrofishing at the reference site Gropviken in 2022 and 2025; catches varied between years, with higher numbers in segments 1, 3 and 4 in 2025.

The number of pike in Gropviken varied between segments and years. In 2022, catches were relatively even across segments, with slightly higher numbers in segment 2. In contrast, 2025 showed greater variability, with a high number of individuals in segment 1, a marked dip in segment 2 and increased catches again in segments 3 and 4. Pike abundance was higher in most segments in 2025 compared to 2022, although the distribution was less even across the area.

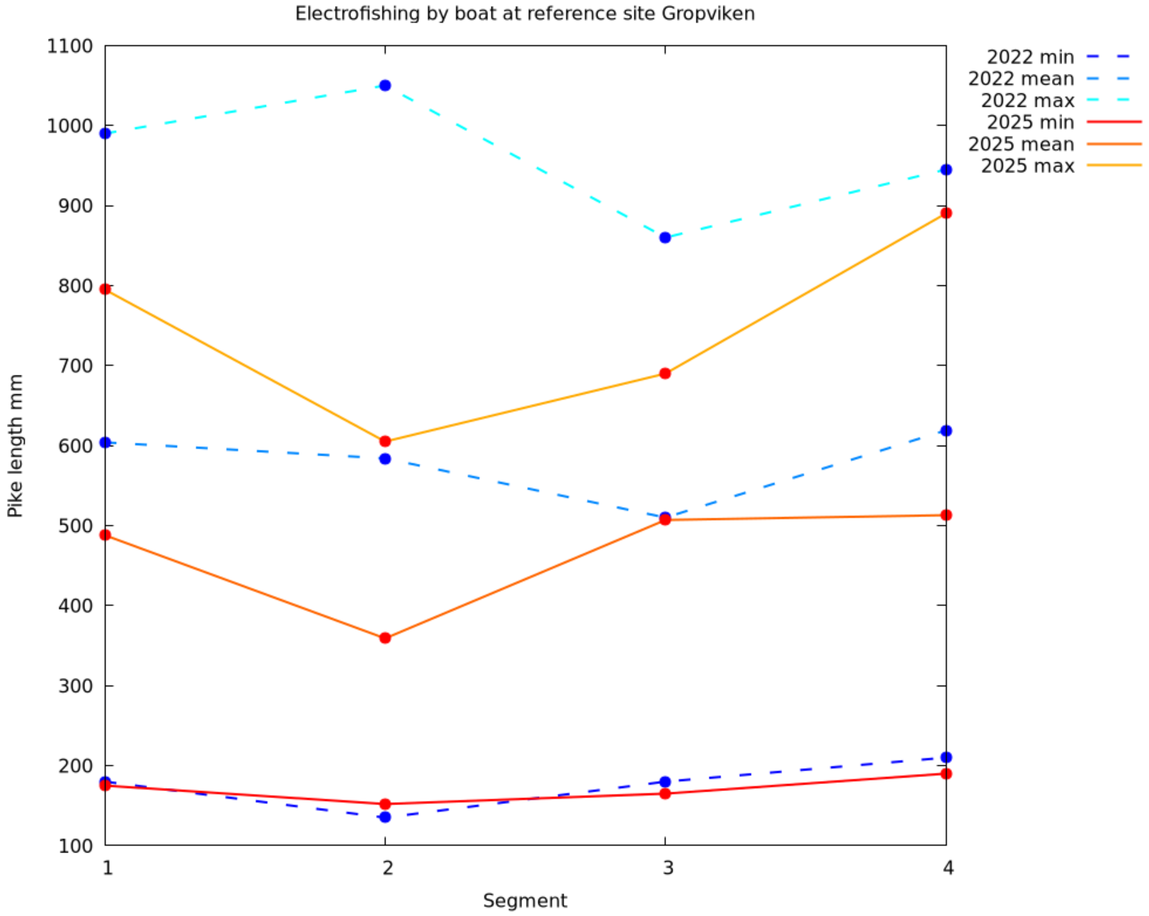

Figure 55. Pike length (min, mean and max) per segment (1–4) from electrofishing at the reference site Gropviken in 2022 and 2025; lengths were generally high in both years, with slightly lower maximum values in 2025.

Pike length in Gropviken was generally high in both 2022 and 2025, with large individuals present across all segments. Maximum lengths were consistently higher in 2022, particularly in segments 1 and 2, while 2025 showed somewhat lower peak values but still relatively large fish. Mean lengths were similar between years, with only minor variation among segments. Minimum lengths were also comparable, indicating a similar presence of smaller individuals. The size distribution appears relatively stable between years, with a slight reduction in maximum size in 2025.

Kyrkviken

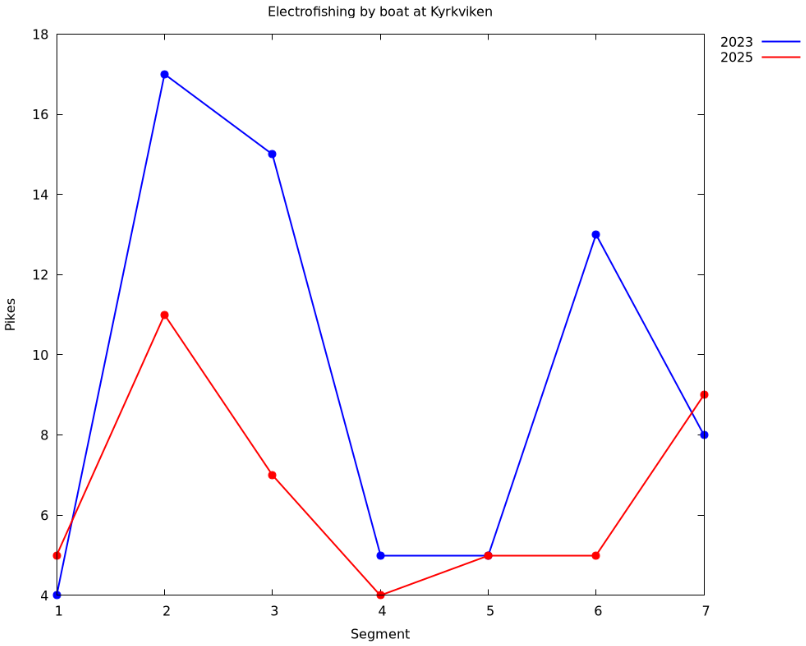

Figure 56. Number of pike per segment (1–7) from electrofishing in Kyrkviken in 2023 and 2025; catches were generally higher in 2023, with a pronounced peak in segment 2.

The number of pike in Kyrkviken varied between segments and years. In 2023, catches were generally higher, with clear peaks in segments 2, 3 and 6 and lower numbers in segments 1 and 4–5. In contrast, 2025 showed consistently lower catches across most segments, with a less pronounced peak in segment 2 and relatively even distribution in the remaining segments. Both years showed low numbers in segments 4 and 5. The results indicate a decrease in pike abundance in 2025 compared to 2023, along with a less variable spatial distribution.

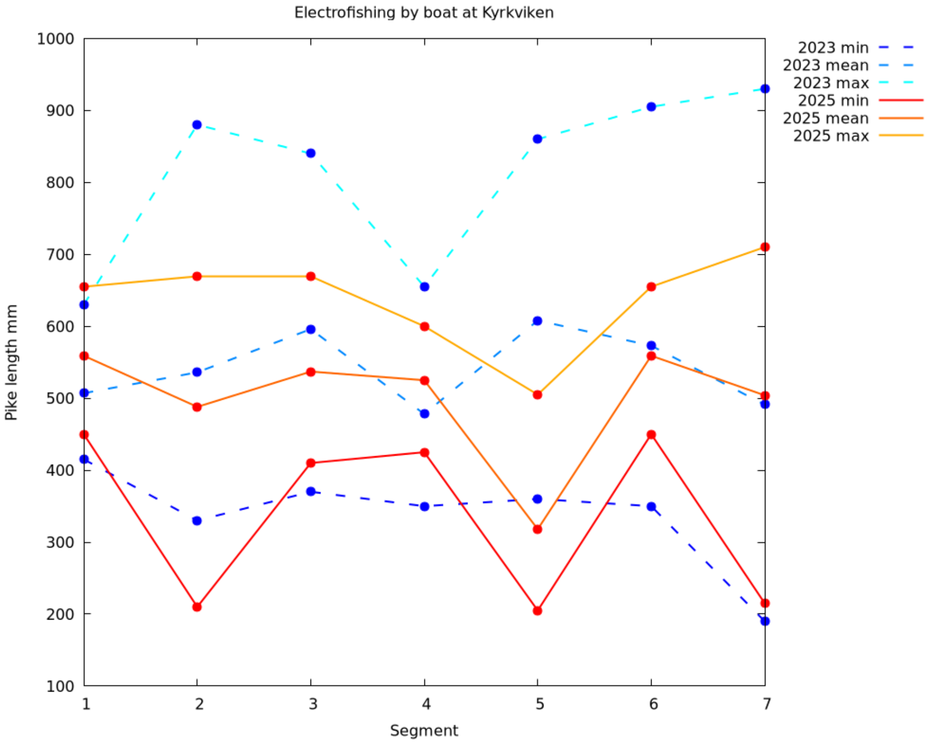

Figure 57. Pike length (min, mean and max) per segment (1–7) from electrofishing in Kyrkviken in 2023 and 2025; lengths were generally higher in 2023, particularly for maximum values.

Pike length in Kyrkviken varied between segments and years, with generally larger individuals recorded in 2023. Maximum lengths were consistently higher in 2023 across all segments, with peaks in segments 2, 6 and 7. In contrast, 2025 showed lower maximum values and more variability between segments. Mean lengths were relatively similar between years in some segments but tended to be slightly lower in 2025, particularly in segment 5. Minimum lengths were also more variable in 2025, with several segments showing lower values compared to 2023. The results suggest a shift towards smaller size classes in 2025, indicating potential changes in population structure.

5.2.6 Birds

Lervik

The reed beds at Lervik had a few pairs of territorial Reed Warbler and Reed buntings before the harvest in spring 2024. These localities were avoided for harvesting. In the bay we observed 4 pairs of Crested Grebes, one pair of Mute Swan, one pair of Gadvall, one pair of Mallard and one pair of Grey-lag Gosse. Feeding birds observed includes Kingfisher, Common Gull, Arctic Tern and Caspian Tern and Sea Eagle. After harvest two territories of Reed Warbler and one territory of Reed Bunting were located at the harvested sites. After harvest we noted 5 pairs of Crested Grebe and one pair of Lapwing, breeding at the harvested zone. After harvest in October, we observed 80 Goldeneyes and 120 Mallards foraging as well as two Kingfishers.

Vittvik (Gloet)

Very few territorial birds were observed in Gloet. Before harvest we noted 3 Goldeneyes and one Mute Swan. After harvest we noted somewhat more birds, e.g. 10 Teal, 8 Mallards, 2 Wood Sandpiper and one Kingfisher. Later in October, three more Kingfishers was seen.

Vålön

Territorial birds before harvest includes Common Crane one pair, Reed Warbler one pair, Canada Goose one pair. After harvest we noted Canada Goose and Common Sandpiper and Mallard, two pairs. Others feeding were 50 Tufted Ducks, 3 Caspian Terns, Osprey and Kingfisher.

Kappelströmmen (reference)

Kapellströmmen host a lot of feeding ducks as well as Terns and Gulls. 300 to 800 Tufted Ducks, 100 Goldeneyes and 30 Teals were foraging here. A few of Common Gull, Arctic Tern and Caspian Tern were noted.

5.3 Hydrological and precipitation influence

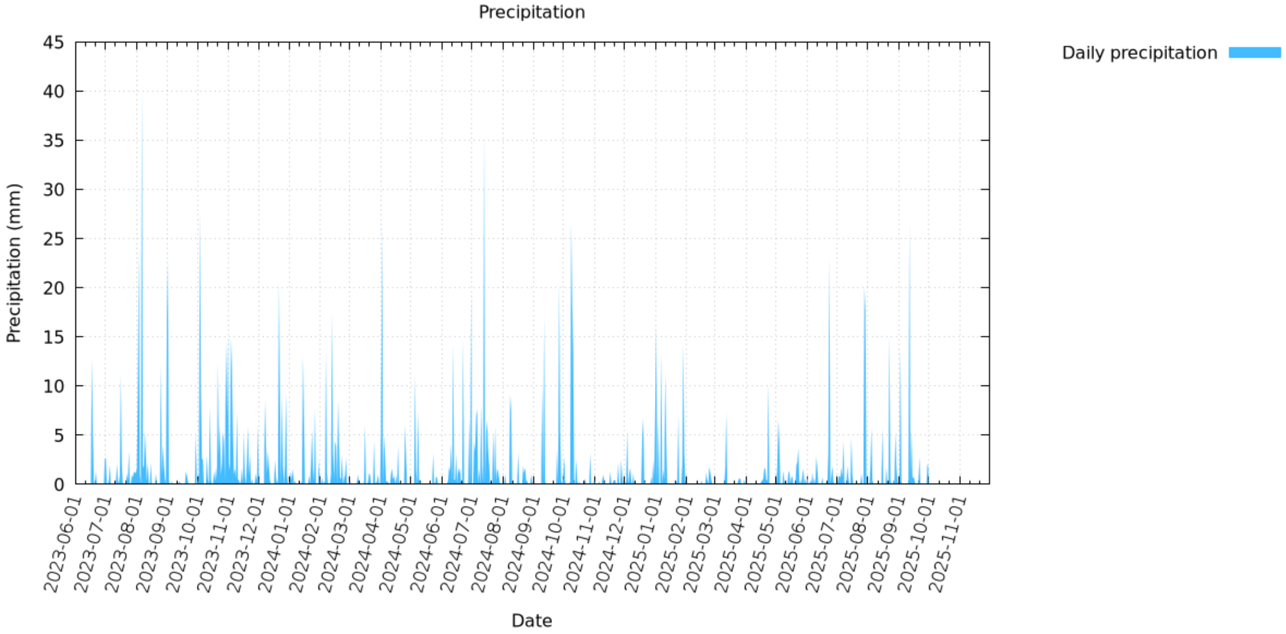

Figure 58. The graph shows daily precipitation (mm) from summer 2023 to autumn 2025. Each bar represents an individual precipitation event, ranging from low-intensity rainfall to occasional high-intensity events.

Results and interpretation

Precipitation exhibits a clear episodic and seasonal pattern, with short but sometimes intense rainfall events occurring throughout the monitoring period. Higher-intensity precipitation is most common during summer and early autumn, while winter and spring are characterized by lower and more sporadic rainfall.

No long-term increasing or decreasing trend in precipitation is evident over the period. Instead, variability is dominated by individual rainfall events. Periods of elevated precipitation coincide with several of the observed peaks in nutrient concentrations, turbidity and chlorophyll-a in other parameters, indicating that precipitation-driven runoff, freshwater inflow and mixing are important drivers of short-term water quality variability.

The graph illustrates that weather and hydrological conditions vary strongly on daily to seasonal timescales, providing important context for interpreting changes in water chemistry and biological parameters. This supports the conclusion that observed variability in water quality is primarily driven by natural precipitation-related processes rather than by reed harvesting activities.

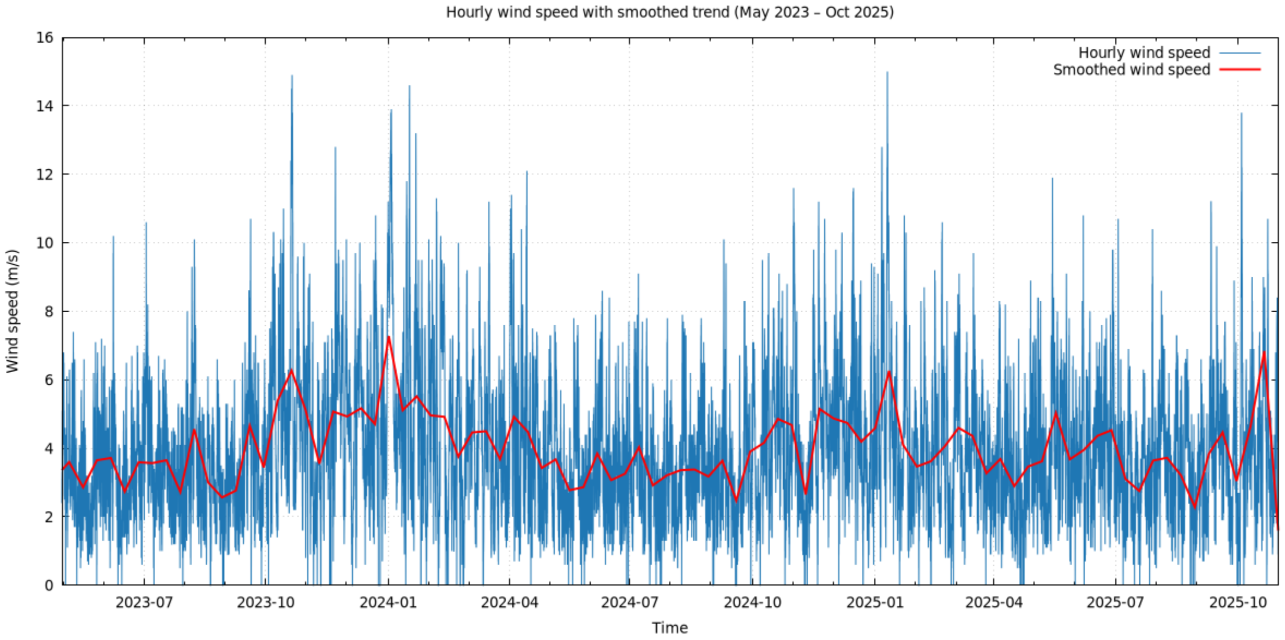

Figure 59. Hourly wind speed (m/s) from May 2023 to October 2025, with a smoothed trend line; the smoothed curve highlights seasonal variation and periods of higher wind intensity.

Wind conditions during the monitoring period show clear temporal variability, with recurring periods of elevated wind speeds. These periods coincide with increased variability in several water chemistry parameters, particularly turbidity, total phosphorus and TOC, suggesting that wind-induced processes influence water conditions in the studied bays.

In shallow and wind-exposed systems, such as Lervik, the effect is especially pronounced. Lervik is characterized by shallow depths and mobile sediments, making it highly sensitive to wind-induced resuspension. Peaks in turbidity and associated increases in nutrient concentrations observed in Lervik correspond well with periods of higher wind speeds, indicating that sediment resuspension likely contributes to short-term increases in suspended material and internal nutrient release.

Similar, but generally weaker, patterns are observed in other bays, particularly those with more sheltered conditions or greater depth, where wind influence is less pronounced.

The results indicate that wind is an important driver of short-term variability in water chemistry, especially in shallow systems. This effect can in some cases overshadow potential impacts of reed harvesting, highlighting the importance of considering physical forcing factors when interpreting monitoring results.

6. Summary of results

Reed harvesting in this project did not seem to in short-term measurably harm water quality, sediment, or key biological communities. Natural seasonal and hydrological processes seems to be the main drivers of observed changes, indicating that the applied management practices are compatible with healthy coastal bay ecosystems.

Water Quality

Reed harvesting showed no consistent short-tem negative effects. Variations in phosphorus, nitrogen, oxygen, organic carbon, turbidity, Secchi depth and chlorophyll-a seems to be mainly driven by seasonal and hydrological factors. Water conditions remained stable, with no increased nutrient loading, oxygen depletion, or sediment disturbance linked to harvesting.

Environmental Toxins

Some sediments contained elevated TBT, PCB, PAHs, cadmium and copper, but levels were below regulatory limits. Surface water occasionally exceeded PFOS and ammonia guidelines, reflecting regional background rather than local contamination. Care is advised to minimize sediment disturbance during harvesting.

Biological Responses

Fish populations varied yearly, with no clear short-tem effects from harvesting. Birds continued to use harvested areas, including reed-associated species and some bays showed increases in open-water or edge species. Bird activity reflected habitat and seasonal conditions rather than harvesting.

6.1 Development of water quality

Phosphorus

Total phosphorus concentrations varied considerably between years and between sites across all monitored sites during the project period. Higher concentrations were generally observed in the harvested bays compared to reference sites, but similar patterns of variation were also present at the reference locations. No consistent or immediate changes in phosphorus concentrations were detected following reed harvesting events. Instead, seasonal conditions and hydrological factors, such as precipitation and freshwater inflow, appeared to exert a stronger influence on phosphorus dynamics than the management actions. Importantly, no indications of increased phosphorus levels attributable to reed harvesting were observed, suggesting that the applied harvesting practices did not cause negative effects on water quality.

Phosphate Phosphorus (PO_4-P)

The results indicates that phosphate phosphorus levels are primarily driven by seasonal and hydrological variability rather than by reed harvesting activities. No consistent positive or negative short-term effects of reed harvesting on PO_4-P concentrations could be detected within the project period. Importantly, no increases in phosphate levels attributable to harvesting were observed, indicating that the applied harvesting practices did not cause short-term negative effects on dissolved phosphorus dynamics in the monitored bays.

Total nitrogen

The results indicate that total nitrogen concentrations are dominated by seasonal and hydrological variability rather than by reed harvesting activities. No consistent effects of harvesting on nitrogen levels were detected and no signs of short-term negative impacts attributable to harvesting were observed. Nitrogen dynamics appear to reflect broader catchment and climatic influences rather than local management measures within the monitored bays.

Ammonium nitrogen (NH_4-N)

NH_4-N shows strong temporal variability and pronounced short-term peaks, but no sustained increase over time at any of the monitored sites. Importantly, similar peak patterns occurred at both harvested and reference locations, suggesting that these events are primarily driven by natural hydrological and biogeochemical processes (e.g. temperature, oxygen conditions, sediment release and freshwater inflow) rather than by reed harvesting.

The results do not indicate any short-term negative effect of reed harvesting on ammonium levels. The consistently low background concentrations further support that the bays generally maintain good oxygen conditions and stable nitrogen cycling during the monitoring period.

Dissolved oxygen

No persistent oxygen depletion was detected at any of the monitored bays during the study period. The seasonal fluctuations and temporary declines observed are typical for shallow coastal systems and were not linked specifically to reed harvesting.

The similarity in oxygen dynamics between harvested and reference sites indicates that reed harvesting did not negatively affect oxygen conditions. The monitoring results suggest that oxygen availability remained sufficient to support aquatic organisms and that reed harvesting did not lead to increased risk of hypoxia in the studied coastal bays.

TOC

TOC shows clear short-term and seasonal variability, but no sustained increasing trend was detected over the monitoring period. Importantly, similar temporal patterns occurred at harvested and reference sites, indicating that fluctuations in organic carbon are primarily driven by natural hydrological and biological processes rather than reed harvesting.

The results do not indicate any short-term negative impact of reed harvesting on organic matter conditions. TOC concentrations remained within a stable and moderate range, suggesting that reed harvesting did not increase organic loading or oxygen-demanding processes in the monitored coastal bays.

Turbidity

Turbidity exhibits substantial short-term and seasonal variability, but no long-term increase was detected over the monitoring period. Similar turbidity patterns were observed at harvested and reference sites, indicating that observed peaks were not directly related to reed harvesting activities.

The results do not indicate any short-term negative effect of reed harvesting on water clarity. Turbidity conditions remained stable and generally low, suggesting that reed harvesting did not increase sediment resuspension or reduce light conditions in the monitored coastal bays.

Secchi depth (water transparency)

Secchi depth shows pronounced spatial and temporal variability, but no consistent long-term trend toward either improved or reduced water transparency was detected during the monitoring period.

The similarity in variability patterns between harvested bays and reference sites indicates that changes in water clarity are mainly driven by natural seasonal processes and hydrological conditions rather than reed harvesting.

The results suggest that reed harvesting did not short-term negatively affect water transparency in the monitored coastal bays and no reduction in light conditions was observed as a result of the restoration actions.

Chlorophyll-a

Chlorophyll-a shows substantial temporal and spatial variability, but no consistent long-term trend was detected during the monitoring period. Importantly, peaks and seasonal patterns were observed at both harvested and reference sites, indicating that phytoplankton dynamics were primarily driven by natural seasonal conditions and nutrient availability rather than by reed harvesting.

The results do not indicate any short-term negative effects of reed harvesting on phytoplankton biomass. While episodic algal blooms occurred, these were not systematically associated with harvesting activities and chlorophyll-a concentrations remained within ranges typical for eutrophication-affected coastal bays in the Baltic Sea region.

Zooplankton

Interannual comparison

A clear difference can be observed between the years, particularly at Vålön.

At Vålön, zooplankton biomass is consistently low in 2024, with no clear seasonal peak. In contrast, 2025 shows a strong increase in biomass, especially in late summer, driven by copepods. This indicates a more developed plankton succession and higher productivity in 2025. Since reed harvesting at Vålön occurred after the 2025 sampling, this increase cannot be linked to harvesting effects.

At Vittvik, which was harvested, the pattern is less clear. Biomass is relatively high in both years, but:

- 2024 shows higher peak values (especially early summer),
- 2025 shows a more stable but generally lower biomass, particularly for rotifers.

This suggests that interannual variation in zooplankton may influence fish recruitment, while potential harvesting effects are secondary and not clear.

Phytoplankton

Interannual comparison

Some differences in phytoplankton dynamics can be observed between the two years, although the 2025 data should be considered preliminary.

In 2024, phytoplankton biomass is relatively high, particularly at Vittvik, indicating nutrient-rich conditions and elevated productivity. The community includes several bloom-forming and potentially toxin-producing taxa, suggesting a more eutrophic system.

In 2025, the data suggest a more variable and less consistently high biomass, with indications of stronger seasonal dynamics rather than sustained high levels. This may reflect differences in environmental conditions such as nutrient availability, temperature, or water exchange.

At Vittvik (harvested), there are indications of reduced or less pronounced biomass peaks in 2025, which could suggest a potential effect of harvesting on phytoplankton dynamics (e.g., through altered nutrient cycling or light conditions).

At Vålön (harvested after sampling in 2025), differences between years are more likely driven by natural interannual variability rather than management effects.

6.1.2 Environmental toxins

Sediment

High TBT levels are present at Lervik and moderate levels of one PCB and several PAHs are found at Vålö. Cadmium and copper at Vålö fall into the second-highest deviation class (large deviation), but these concentrations are still well below HVMFS 2019:25 regulatory limits. The Baltic Reed project could potentially mobilize sediment-bound substances into the water column during reed harvesting. It is therefore recommended to consider these results when planning measures, for example by implementing precautions to reduce sediment disturbance.

Water

PFOS and ammonia nitrogen exceed annual average guideline values at all sampling sites, although not the maximum allowable concentrations. PFOS levels are consistent with those observed in other coastal areas in the region, suggesting that the concentrations reflect regional background conditions rather than a local point source.

Apparent exceedances of arsenic and uranium are associated with significant uncertainty due to unknown natural background levels and analytical limitations and should therefore be interpreted with caution.

Surface water quality is generally within applicable regulatory thresholds and no clear indications of significant local contamination sources are observed based on the analyzed parameters.

6.2 Biological responses

6.2.1 Fish and fish recruitment

Differences between years were observed at most localities, including the reference sites. In general, higher abundances of clupeids (herring and sprat), stickleback and bleak were recorded in 2025 compared to 2023, while abundances of species such as roach, perch and pike were lower in 2025. An exception was Kapellströmmen West (reference site), where roach, bream and rudd, were observed.

These observations indicate a high degree of year-to-year variability in fish recruitment, a pattern that was consistent across all sites. Further monitoring and investigations are required to make a more definitive assessment of long-term trends and potential effects of reed harvesting on fish communities.

6.2.2 Birds

Bird observations indicate that reed harvesting did not have negative effects on bird occurrence or use of the bays. Breeding and feeding birds were recorded both before and after harvesting and several species were observed establishing territories or breeding within harvested areas.

At harvested sites, reed-associated species such as Reed Warbler and Reed Bunting were still present after harvesting, including territories located directly within harvested zones. In some bays, an increase in the number of breeding pairs of open-water or edge-associated species (e.g. Great Crested Grebe, Lapwing) was observed following harvesting. Feeding activity by ducks, waders and fish-eating birds (e.g. Kingfisher, terns, raptors) was recorded at both harvested and reference sites, often with higher numbers after harvest, particularly during autumn.

Bird assemblages appeared to respond primarily to habitat structure and seasonal conditions rather than negatively to reed harvesting. The results suggest that the applied harvesting practices maintained suitable habitat conditions for both reed-dependent and open-water bird species.

6.3 Comparison with reference sites

The comparison between harvested bays and reference sites shows no consistent differences in water quality or biological parameters during the monitoring period. Nutrient concentrations (total nitrogen, total phosphorus and phosphate), turbidity, chlorophyll-a and oxygen levels largely overlapped between sites, indicating that observed variability was primarily driven by natural seasonal and hydrological factors rather than reed harvesting.

Similarly, biological communities, including phytoplankton, zooplankton and fish recruitment, did not show clear or systematic deviations between harvested and reference areas. Short-term peaks and fluctuations occurred across all sites, further supporting the conclusion that external drivers such as precipitation, inflow and temperature had a stronger influence than management measures.

The results indicate that reed harvesting did not cause short-term negative ecological impacts when compared to reference conditions, but also that measurable positive effects could not yet be distinguished from natural variability.

6.4 Inter-annual trends

Inter-annual comparisons (2023–2025) show substantial variability in both water chemistry and biological parameters, with no clear directional trends attributable to reed harvesting. Nutrient concentrations, turbidity and chlorophyll-a exhibited strong year-to-year fluctuations, often linked to hydrological conditions such as precipitation and runoff.

A general pattern can be observed where elevated nutrient levels and turbidity occurred during periods of high inflow (e.g. autumn 2023 and late summer–autumn 2025), followed by more stable conditions during 2024. These patterns were consistent across both harvested and reference sites.

Biological parameters also showed inter-annual variability. For example, zooplankton dynamics differed between years, with 2025 showing a more pronounced seasonal succession compared to 2024. However, these differences appear to reflect natural ecosystem variability rather than management effects.

The monitoring period is too short to detect long-term ecological trends. The results highlight the importance of continued monitoring to distinguish potential delayed effects of reed harvesting from natural inter-annual variability.

7. Evaluation of effects of reed harvesting

Reed harvesting is being tested as a restoration measure in eutrophic bays. It is important to distinguish between reed removal conducted within a bay and reed harvesting carried out in the surrounding catchment area or coastal meadows, as the objectives and ecological effects differ. Reed harvesting may serve two main purposes: potential nutrient removal from aquatic systems and restoration of coastal meadow habitats. Measures implemented directly in the water should primarily have the potential to influence internal nutrient dynamics and habitat structure within the bay, whereas harvesting on land mainly targets landscape management, biodiversity conservation and long-term ecosystem functioning rather than water quality improvements.

When reed is harvested during summer or late summer from the aquatic zone (“water reed”), nutrients stored in plant biomass are physically removed from the bay and its sediments. In this context, reed harvesting has the potential to function as a measure to reduce internal nutrient loading by exporting nitrogen and phosphorus that would otherwise be released during plant decomposition. In addition to nutrient removal, harvesting can improve habitat heterogeneity by creating open water areas, transition zones and increased light availability. Such structural changes may benefit aquatic insects, feeding and breeding birds and fish by improving access to spawning and foraging habitats. Reduced shading may also support submerged macrophytes, which in turn can stabilize sediments and contribute to clearer water conditions.

When reed harvesting is conducted in shallow wetland areas adjacent to bays, the effects may extend beyond nutrient removal. These transitional habitats often function as important nursery and spawning areas, particularly for predatory fish species. Opening dense reed stands can improve water exchange, increase habitat complexity and create suitable conditions for fish reproduction and juvenile development. In this way, harvesting may indirectly strengthen trophic interactions and support ecological balance within coastal ecosystems.

Reed harvesting in the catchment area or on coastal meadows (“land reed”) cannot generally be quantified as direct nutrient removal from the bay, since nutrients exported from terrestrial vegetation are not necessarily part of the aquatic nutrient pool. However, restoration of coastal meadows is an important management measure from a broader ecosystem perspective. Maintaining open coastal grasslands prevents succession into dense reed monocultures, supports high biodiversity values and preserves habitats for meadow-dependent birds, pollinators and grazing species. Furthermore, well-managed coastal meadows can improve hydrological connectivity and reduce long-term nutrient leakage by promoting stable vegetation communities and sustainable land use practices.

The potential ecological effects of reed harvesting depend strongly on location, timing and management objectives. When carefully planned and combined with precautionary practices, reed harvesting has the potential to contribute both to nutrient management and to improved habitat quality without causing short-term negative impacts on coastal ecosystem functioning.

7.1 Nutrient removal efficiency

The BalticReed project explores reed harvesting as a potential measure for nutrient management in shallow coastal ecosystems. The outputs of the project show that nutrient removal is strongly influenced by seasonal dynamics, with the highest concentrations of nitrogen and phosphorus occurring during the growing season. Harvesting during mid to late summer therefore appears to provide the greatest potential for effective nutrient removal.

The literature findings indicate that harvesting in water and wetland areas directly connected to coastal bays has the clearest link to reducing nutrients in the aquatic system. At the same time, reed harvesting on land may contribute more indirectly, for example through effects on nutrient retention and habitat management, although these pathways require further investigation.

Reed regrowth was observed after harvesting, suggesting that the system can continue to function as a recurring nutrient sink if sufficient recovery time is allowed. This highlights the importance of long-term and adaptive management strategies.

The study suggests that reed harvesting can be a useful complementary measure for potentially addressing eutrophication, particularly when carefully targeted in time and space and when integrated with broader catchment-based management approaches.

More information about nutrient results in the BalticReed project can be found here:

centralbaltic.eu/project/balticreed/

- ✓ *Evaluation of reed harvesting as a restoration measure in eutrophic coastal bays*

7.2 Effects on biodiversity

Reed harvesting can influence biodiversity in multiple ways depending on where, when and how the measures are implemented. Dense reed stands often appear as structurally uniform habitats suitable for a limited number of specialized species. Carefully planned harvesting may therefore increase habitat heterogeneity by creating a mosaic of open water, reed edges, shallow vegetated zones and coastal meadow habitats. Increased structural diversity is generally associated with higher biodiversity, as it provides a wider range of ecological niches for plants, invertebrates, fish and birds.

In aquatic environments, partial removal of reed can improve light penetration and water circulation, which may promote the establishment and expansion of submerged macrophytes. A more diverse macrophyte community can support higher abundances of aquatic invertebrates and provide shelter and feeding areas for juvenile fish. Improved access between open water and vegetated habitats may also benefit fish spawning and nursery functions, particularly for species dependent on shallow coastal environments.

Bird communities may respond positively to increased habitat variation created by reed harvesting. While reed-dependent species may continue to utilize remaining reed patches, open-water and edge-associated species often benefit from newly created feeding and breeding habitats. Maintaining unharvested refuge areas is important to ensure that specialist reed species retain suitable nesting environments while allowing other species to exploit newly available habitats.

In coastal meadow and wetland areas, reed removal can prevent ecological succession and maintain open habitats with high conservation value. Coastal meadows are among the most species-rich environments in many Baltic coastal landscapes and support a wide range of plants, insects and ground-nesting birds. Restoration through reed harvesting may therefore enhance biodiversity at a landscape scale by preserving habitats that would otherwise decline due to encroachment.

However, biodiversity responses depend strongly on management practices. Large-scale or poorly timed harvesting may temporarily disturb wildlife or reduce habitat availability. Adaptive management, spatial variation in harvesting intensity and avoidance of sensitive breeding periods are therefore essential to ensure positive ecological outcomes.

Reed harvesting has the potential to enhance biodiversity when implemented selectively and with ecological considerations, primarily by increasing habitat diversity and maintaining a dynamic coastal ecosystem structure.

7.3 Fish nursery function

Shallow coastal bays and vegetated nearshore environments play a crucial role as nursery areas for many fish species in the Baltic Sea region. These habitats provide shelter from predators, suitable spawning substrates and high availability of food resources for early life stages. Dense reed stands can contribute positively to nursery function by offering protection and structural complexity; however, excessively overgrown areas may reduce habitat quality by limiting water exchange, oxygen availability and access to shallow spawning grounds.

Reed harvesting can influence fish nursery function by restoring habitat heterogeneity and improving connectivity between open water and vegetated zones. The creation of openings and edge habitats may facilitate movement of adult fish into shallow areas used for spawning, while also improving conditions for juvenile fish by increasing light penetration and promoting the development of submerged vegetation and invertebrate communities. These factors can enhance feeding opportunities and growth conditions during critical early life stages.

In wetland and transitional zones adjacent to bays, reed removal may be particularly beneficial for predatory fish species such as Perch and Pike, which depend on shallow, vegetated environments for reproduction. Restoring semi-open habitats can improve spawning success by maintaining suitable water depths, vegetation structure and oxygen conditions. Improved recruitment of predatory fish may in turn contribute to ecosystem balance through trophic interactions, potentially supporting long-term resilience of coastal ecosystems.

At the same time, nursery functions are sensitive to disturbance and extensive or poorly timed harvesting could temporarily reduce shelter availability or disrupt spawning activities. Therefore, maintaining unharvested refuge areas and avoiding harvesting during key reproductive periods are important management considerations.

Reed harvesting has the potential to support fish nursery function when implemented in a targeted and precautionary manner, primarily by restoring habitat diversity, improving ecological connectivity and maintaining suitable spawning and juvenile habitats in shallow coastal environments.

7.4 Potential negative impacts

Potential negative impacts include the loss or degradation of habitat structure, which reduces the availability of shelter, feeding areas, and spatial complexity essential for juvenile fish. As vegetation and structural habitats decline, young fish become more exposed to predators, leading to increased mortality during sensitive early life stages. Degradation of shallow, vegetated zones may also reduce suitable spawning and nursery areas, resulting in lower reproductive success. Changes in macrophyte communities can further decrease food availability by affecting associated invertebrate populations, limiting growth and survival of juvenile fish. Over time, reduced nursery quality may lead to lower recruitment and weakened population resilience. In addition, increased turbidity and sediment resuspension caused by vegetation loss can impair feeding efficiency and egg survival, ultimately contributing to reduced biodiversity and decreased ecosystem stability.

A lot of research is being conducted regarding coastal ecosystems and carbon dynamics and the results are still ambiguous. Reed contains substantial amounts of carbon: the carbon content of fresh reed sprouts ranges from 44–47% of dry matter, depending on habitat conditions (Eller, 2021). In addition to the above-ground parts of the plant, carbon is also stored in the below-ground parts (the root system). Their relative contributions to total carbon storage depend on factors such as stem density, dry bulk density, the presence of competing species, water level, and salinity (Williamson, 2025). Carbon sequestration in reed increases sharply during the growing season, particularly in the stems and leaves. In contrast, below-ground sequestration is negative during the growing season and increases only after the season has ended (Wang, 2022).

8. DISCUSSION

The monitoring results show that ecological conditions in the studied bays were mainly driven by seasonal and weather-related hydrological variability rather than by reed harvesting. Similar temporal patterns were observed at harvested and reference sites across all monitored parameters.

No consistent short-term negative effects of reed harvesting were detected on water quality, including nutrients, oxygen conditions, organic matter, water clarity or phytoplankton biomass. Observed variability was largely explained by precipitation, freshwater inflow, temperature and seasonal biological processes.

Bird, macrophyte and fish recruitment data also showed strong natural variability, with no evidence that reed harvesting negatively affected species occurrence, habitat use or reproduction. Reed-associated birds remained present after harvesting and macrophyte communities and fish recruitment levels were comparable before and after management actions.

The results indicate that reed harvesting, when conducted with precautionary practices, did not cause adverse effects on ecosystem functioning in the monitored coastal bays.

8.1 Interpretation of results

8.1.1 Nutrient and water quality parameters

Across all monitored parameters, the results consistently show that water quality dynamics were primarily governed by seasonal conditions and hydrological variability rather than by reed harvesting activities. Variations in nutrient concentrations, oxygen conditions, organic matter, water clarity and phytoplankton biomass were observed at both harvested and non-harvested (reference) sites, with similar temporal patterns across all locations.

Phosphorus and nitrogen concentrations displayed substantial temporal and spatial variability, with occasional higher levels in harvested bays. However, comparable fluctuations were also observed at reference sites and no consistent or immediate changes could be linked to reed harvesting events. Instead, precipitation, freshwater inflow, temperature and seasonal biological processes appeared to exert a stronger influence on nutrient dynamics than local management measures.

Reduced nitrogen forms, particularly ammonium, showed short-term peaks at several sites, but these occurred at both harvested and reference locations and were transient in nature. The consistently low background concentrations and absence of sustained increases indicate stable nitrogen cycling and generally good oxygen conditions throughout the monitoring period.

Oxygen levels remained within ranges typical for shallow coastal systems, with seasonal fluctuations but no persistent hypoxia at any site. Similarly, TOC, turbidity and Secchi depth showed short-term and seasonal variability, but no long-term trends or differences between harvested and non-harvested bays. Water clarity and organic matter conditions remained stable, indicating that reed harvesting did not increase sediment resuspension, organic loading or light limitation.

Chlorophyll-a concentrations varied seasonally and episodically, reflecting natural phytoplankton dynamics driven by temperature, light and nutrient availability. Peaks occurred at both harvested and reference sites and were not systematically associated with harvesting activities.

The results demonstrate that reed harvesting, as implemented within the project and combined with precautionary practices, did not cause negative effects on water quality or ecosystem functioning. The observed variability across parameters is best explained by seasonal and weather-related factors rather than by differences between harvested and non-harvested bays.

8.1.2 Birds

The birds associated with reed habitats at the monitored localities were not especially rich in numbers or species from start, which was a reason for picking the localities. Accordingly, we conclude that restoration actions at these localities would not interfere negatively with the biodiversity and abundance of reed birds. Nevertheless, the actions were adapted to preserve the present birds.

Bird observations indicate that reed harvesting did not have negative effects on bird occurrence or use of the bays. Breeding and feeding birds were recorded both before and after harvesting and several species were observed establishing territories or breeding within harvested areas.

At harvested sites, reed-associated species such as Reed Warbler and Reed Bunting were still present after harvesting, including territories located directly within harvested zones. In some bays, an increase in the number of breeding pairs of open-water or edge-associated species (e.g. Great Crested Grebe, Lapwing) was observed following harvesting. Feeding activity by ducks, waders and fish-eating birds (e.g. Kingfisher, terns, raptors) was recorded at both harvested and reference sites, often with higher numbers after harvest, particularly during autumn.

Bird assemblages appeared to respond primarily to habitat structure and seasonal conditions rather than negatively to reed harvesting. The results suggest that the applied harvesting practices maintained suitable habitat conditions for both reed-dependent and open-water bird species.

8.1.3 Macrophytes

Macrophyte surveys showed pronounced spatial and seasonal variability in vegetation coverage across sites and years. Comparisons between pre-harvest and post-harvest conditions did not reveal any consistent decline in macrophyte abundance attributable to reed harvesting.

A total of ten macrophyte species were recorded, with most species exhibiting low phosphorus indicator values, suggesting tolerance to nutrient-rich conditions typical of eutrophication-affected coastal bays. Changes in macrophyte coverage between years were observed at both harvested and reference sites, indicating that variability was largely driven by natural seasonal growth patterns and local environmental conditions rather than by harvesting.

The results suggest that reed harvesting did not negatively affect submerged macrophyte communities. Vegetation coverage remained stable within the range of natural variability and no loss of macrophyte diversity or systematic reduction in abundance was observed following harvesting.

8.1.4 Fish recruitment

Fish recruitment monitoring showed substantial interannual and site-specific variability in the abundance of first-year fry. Comparisons between pre-harvest and post-harvest surveys revealed no consistent negative effects of reed harvesting on fish recruitment at any of the action sites.

At harvested locations, fry of multiple species was recorded both before and after harvesting and post-harvest recruitment levels were generally comparable to those observed prior to management actions. Similar variability patterns were also observed at reference sites, indicating that broader environmental factors (e.g. temperature, hydrology, spawning success) likely exert a stronger influence on recruitment dynamics than local reed harvesting.

The results do not indicate that reed harvesting impaired fish reproduction or early life stages. Fish recruitment appears to be driven primarily by natural variability rather than by the applied management measures.

8.3 Uncertainties and limitations

Several uncertainties and limitations should be considered when interpreting the results of the monitoring program.

Short monitoring period

The project timeframe (2023–2025) is short in relation to ecological response times in shallow coastal ecosystems. Potential positive effects of reed harvesting, such as improvements in water quality, sediment conditions or biological communities, may require longer time spans to become detectable. Consequently, the absence of measurable positive effects should not be interpreted as evidence that such effects will not occur in the long term.

Strong influence of seasonal and hydrological variability

Water quality parameters were strongly influenced by seasonal patterns, precipitation, freshwater inflow and temperature. These drivers can mask or override potential management effects, making it difficult to distinguish subtle impacts of reed harvesting from natural variability. Interannual differences in weather conditions further increase uncertainty when comparing results between years.

Limited number of sampling sites and replication

The monitoring design included a limited number of harvested bays and reference sites. While reference stations were used, natural differences in morphology, water exchange, catchment influence and exposure may reduce comparability between sites. This limits the statistical power to detect small or site-specific effects of reed harvesting.

Sampling frequency and temporal resolution

Sampling was conducted at discrete time points, which may not fully capture short-lived events such as nutrient pulses, sediment resuspension or brief oxygen depletion. As a result, some transient impacts may have occurred between sampling occasions without being detected.

Complexity of coastal ecosystems

Shallow coastal bays are influenced by multiple interacting processes, including internal nutrient cycling, sediment–water interactions, biological feedbacks and external catchment inputs. This complexity introduces uncertainty when attributing observed changes to a single management action such as reed harvesting.

Reference site limitations

Although reference sites were included, they may also have been affected by regional processes such as weather events, water exchange with surrounding areas or long-term eutrophication trends. Therefore, reference conditions cannot be regarded as entirely unaffected controls.

Overall assessment

Despite these uncertainties, the consistency of patterns across harvested and non-harvested sites, together with the absence of sustained negative trends, provides robust support for the conclusion that reed harvesting did not cause adverse environmental effects during the monitoring period. Continued long-term monitoring with higher temporal resolution would improve the ability to detect delayed or cumulative effects and reduce uncertainty in future assessments.

8.4 Implications for water management

It is important to distinguish between reed removal conducted within a bay and reed harvesting carried out in the surrounding catchment area or coastal meadows, as the objectives and ecological effects differ. Reed harvesting may serve two main purposes: nutrient removal from aquatic systems and restoration of coastal meadow habitats. Measures implemented directly in the water primarily influence internal nutrient dynamics and habitat structure within the bay, whereas harvesting on land mainly targets landscape management, biodiversity conservation and long-term ecosystem functioning rather than immediate water quality improvements.

When reed is harvested during summer or late summer from the aquatic zone (“water reed”), nutrients stored in plant biomass are physically removed from the bay and its sediments. In this context, reed harvesting can function as a measure to reduce internal nutrient loading by exporting nitrogen and phosphorus that would otherwise be released during plant decomposition. In addition to nutrient removal, harvesting can improve habitat heterogeneity by creating open water areas, transition zones and increased light availability. Such structural changes may benefit aquatic insects, feeding and breeding birds and fish by improving access to spawning and foraging habitats. Reduced shading may also support submerged macrophytes, which in turn can stabilize sediments and contribute to clearer water conditions.

When reed harvesting is conducted in shallow wetland areas adjacent to bays, the effects may extend beyond nutrient removal. These transitional habitats often function as important nursery and spawning areas, particularly for predatory fish species. Opening dense reed stands can improve water exchange, increase habitat complexity and create suitable conditions for fish reproduction and juvenile development. In this way, harvesting may indirectly strengthen trophic interactions and support ecological balance within coastal ecosystems.

9. Management implications and recommendations

In the Baltic Reed project, we have published ecological guidelines, which can be found here: website: *centralbaltic.eu/project/balticreed/*

In summary:

Sustainable reed harvesting requires clear objectives, site-specific planning, and careful consideration of ecological trade-offs. Harvesting is generally preferable to mowing, as it removes nutrients from the system and prevents negative effects from decomposing biomass. Timing is critical: summer harvesting maximizes nutrient removal, while winter harvesting minimizes disturbance and can support reed regrowth.

To support biodiversity, management should aim for mosaic-like reed structures, including uncut patches, buffer zones, and open "blue zones." Harvesting must avoid sensitive periods such as bird breeding seasons and account for habitat requirements of protected species. Site assessments and consultation with local environmental authorities are essential, particularly in protected or ecologically sensitive areas.

Minimizing environmental impact requires the use of appropriate, low-impact methods and equipment, especially in shallow or erosion-prone areas. Maintaining parts of the reed belt is important for shoreline stabilization, as reeds play a key role in reducing erosion and supporting water quality. Harvested biomass should be promptly removed and stored away from water to prevent nutrient leakage.

Finally, effective management depends on regulatory compliance, stakeholder coordination, and long-term planning. Obtaining permits, securing landowner consent, and integrating reed harvesting into broader coastal management strategies will help ensure that interventions enhance ecosystem resilience, improve water quality, and support biodiversity over time

9.1 Recommendations for future monitoring

Based on the experiences from this monitoring program, several recommendations can be made to improve future monitoring of reed harvesting and coastal restoration measures.

First, it is essential to maintain a long-term monitoring perspective. Many ecological responses, particularly changes in vegetation structure, sediment processes, and fish communities, occur over multiple years. Continued monitoring beyond the project duration is therefore recommended to capture delayed and cumulative effects.

Second, the use of a Before–After–Control–Impact (BACI) design proved highly valuable and should be retained and further strengthened. Ensuring well-matched reference sites and sufficient replication across environmental gradients increases the ability to distinguish management effects from natural variability.

Third, the monitoring program would benefit from increased temporal resolution for certain parameters. While seasonal sampling captured overall trends, higher-frequency sampling—particularly for water chemistry and plankton dynamics—could improve the understanding of short-term variability and ecosystem processes.

Fourth, integrating additional indicators of ecosystem functioning is recommended. This could include:

- Continuous sensors (e.g. temperature, oxygen, turbidity)
- Habitat structure metrics (e.g. reed density, patchiness)
- Food web indicators, linking plankton, fish, and higher trophic levels

Such additions would strengthen the interpretation of causal mechanisms behind observed changes.

Fifth, further development of standardized methods across regions and countries is important to ensure comparability and enable larger-scale assessments within the Baltic Sea region. Harmonization of protocols, including sampling frequency and analytical methods, would facilitate joint analyses and knowledge transfer.

Finally, improved integration between monitoring and management is recommended. Monitoring results should be continuously fed back into planning and implementation processes, enabling adaptive management of reed harvesting and restoration measures. This includes refining the design, timing, and spatial extent of interventions based on observed ecological responses.

Overall, future monitoring programs should aim to be long-term, adaptive, and methodologically harmonized, while maintaining sufficient flexibility to address site-specific conditions and emerging knowledge.

10. CONCLUSIONS

The monitoring carried out within the BalticReed project provides a comprehensive assessment of the short-term ecological effects of reed harvesting in shallow coastal bays. Overall, the results demonstrate that reed harvesting, when implemented with precautionary and site-adapted practices, does not cause short-term negative ecological impacts on water quality, biological communities, or habitat structure.

No measurable improvements in water quality or biological parameters were detected during the project period. This was expected, given the relatively short timeframe in relation to ecological response times in coastal systems. The results therefore highlight that detectable ecological improvements from reed harvesting are likely to occur over longer timescales and require continued monitoring.

Despite the absence of short-term measurable effects, the study provides important information that reed harvesting could be considered as a relatively safe management measure in eutrophication-affected coastal environments. The absence of short-term negative impacts is a key prerequisite for scaling up and integrating such measures into broader water management strategies.

The monitoring also shows that hydrological variability and precipitation patterns are major drivers of water quality, often exceeding the influence of local management actions. This underscores the importance of interpreting monitoring results within a broader environmental context and highlights the need to combine local measures with catchment-scale nutrient reduction efforts.

In terms of ecological function, the observed use of harvested areas by wading birds indicates that reed harvesting can contribute to maintaining or restoring open and heterogeneous habitats, which are important for biodiversity. This suggests that habitat-related benefits may occur earlier than measurable improvements in water chemistry.

The BACI-inspired monitoring design, including reference sites, proved essential for distinguishing management effects from natural variability. The study also demonstrates the importance of integrated, multi-parameter monitoring, combining physical, chemical, and biological indicators to capture ecosystem responses.

In conclusion, reed harvesting represents a promising complementary measure for coastal ecosystem management. While short-term effects on nutrient concentrations and biological communities were not detected, the measure can be implemented without ecological harm and may contribute to habitat improvement. To fully evaluate its effectiveness, long-term, adaptive monitoring and integration with other management measures are required.

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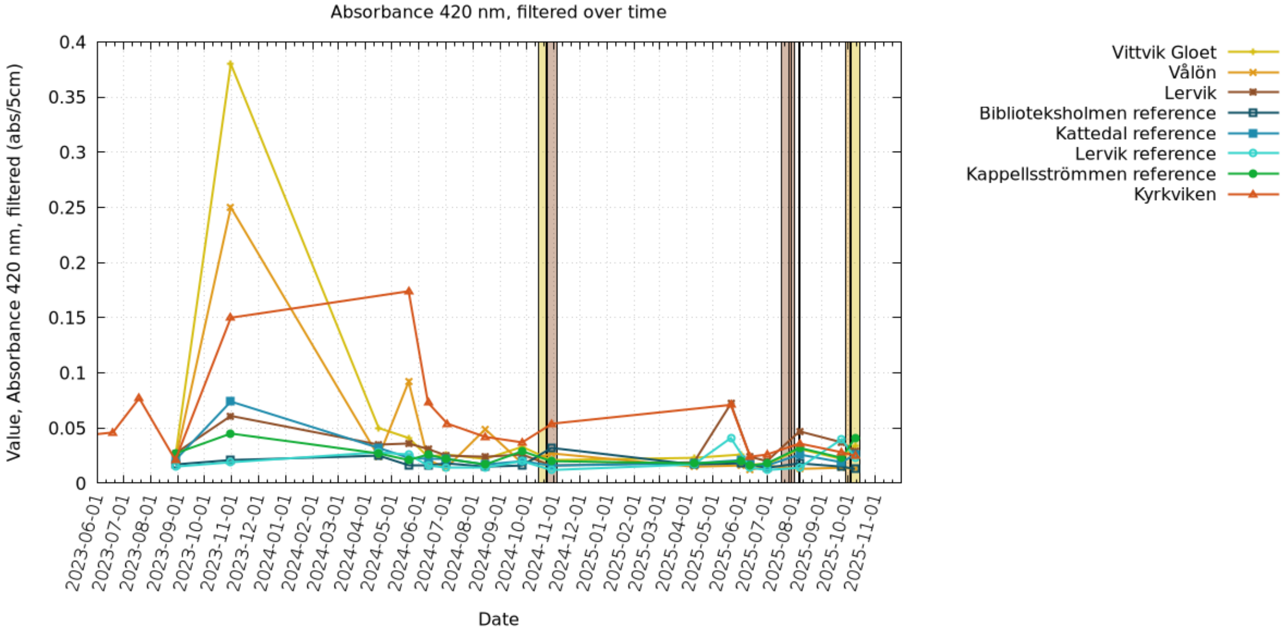
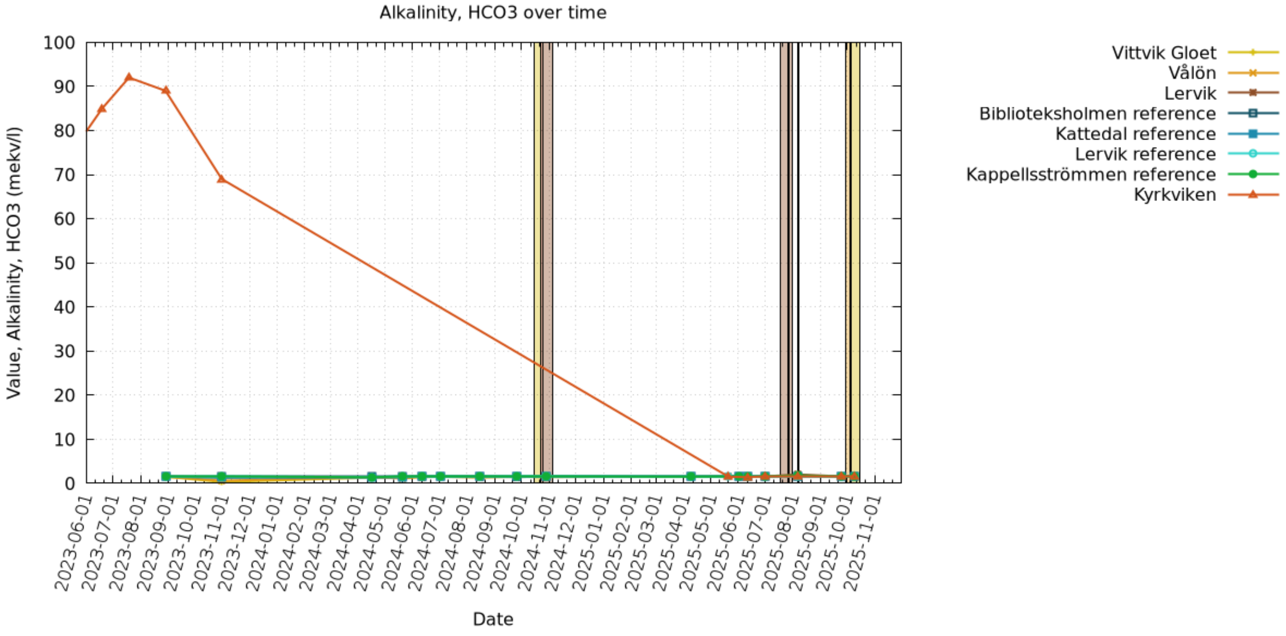
12. APPENDICES

A. Monitoring

a.1 Monitoring- Water chemistry





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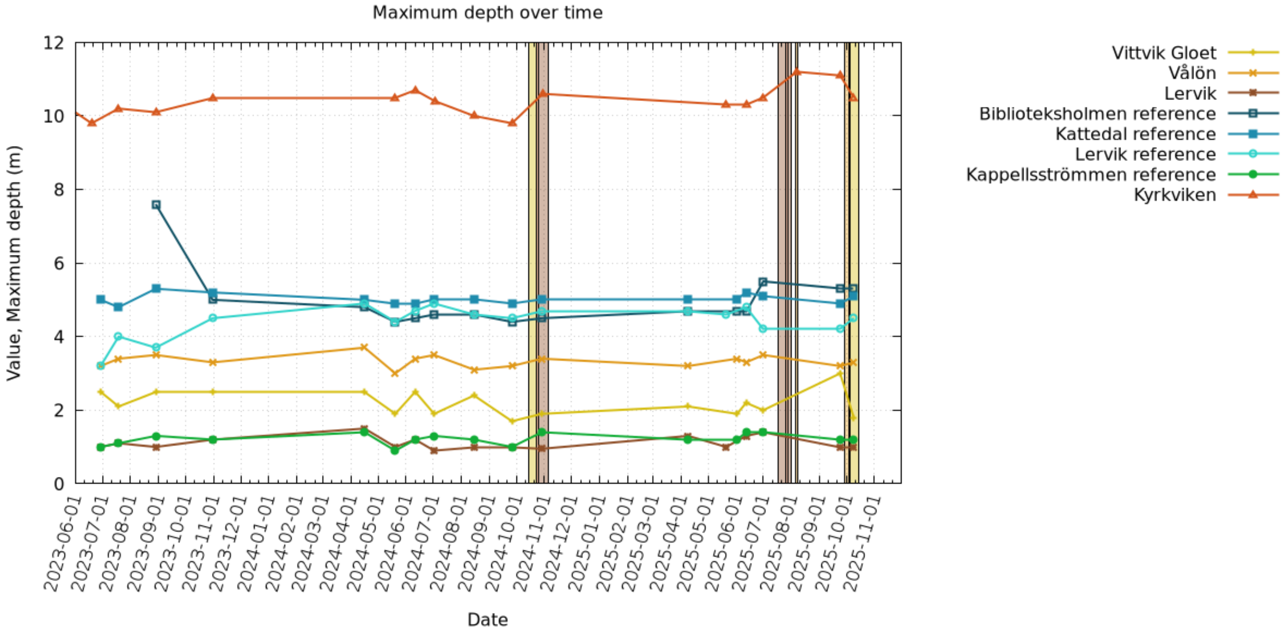
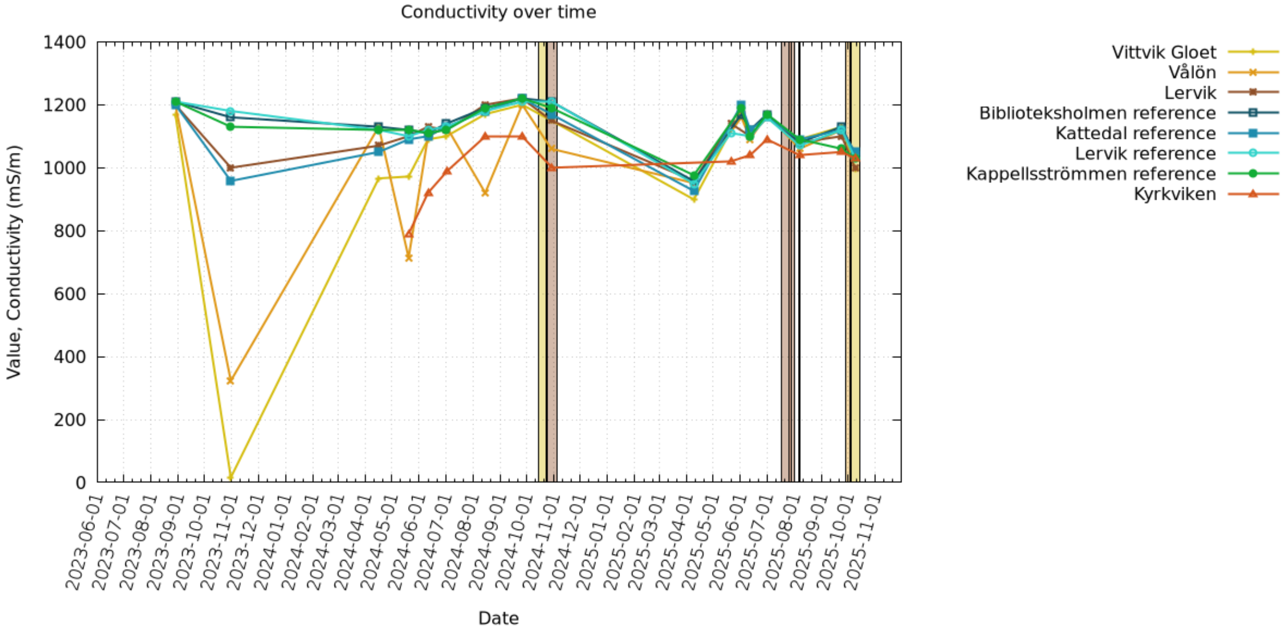
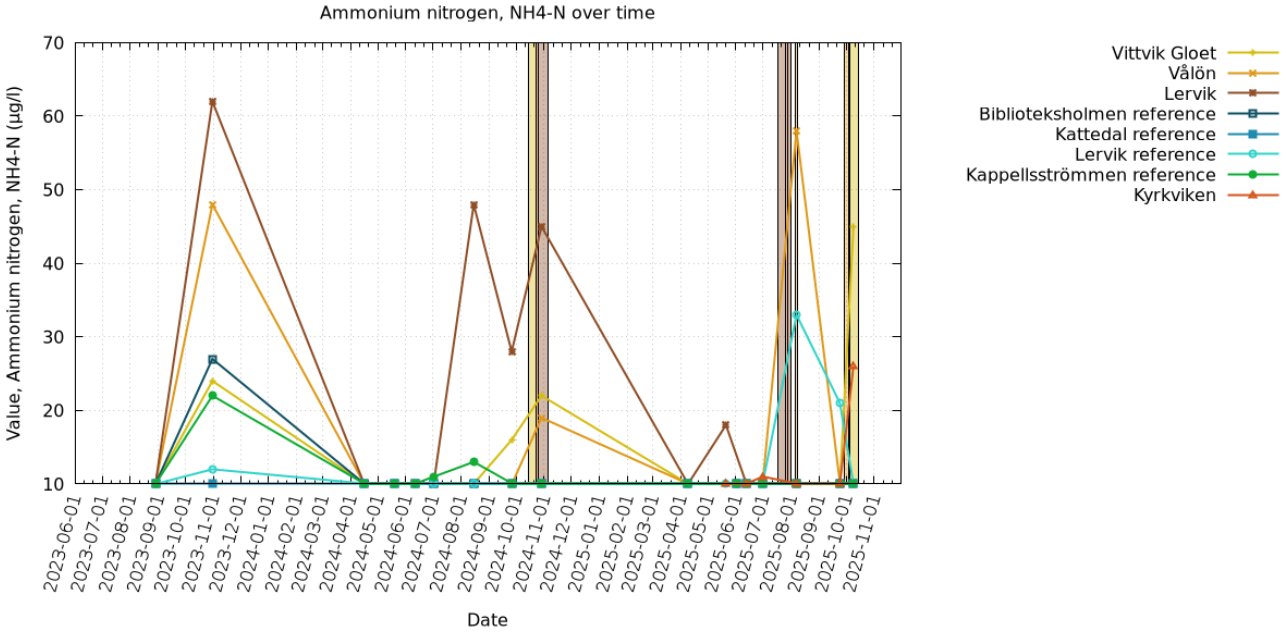
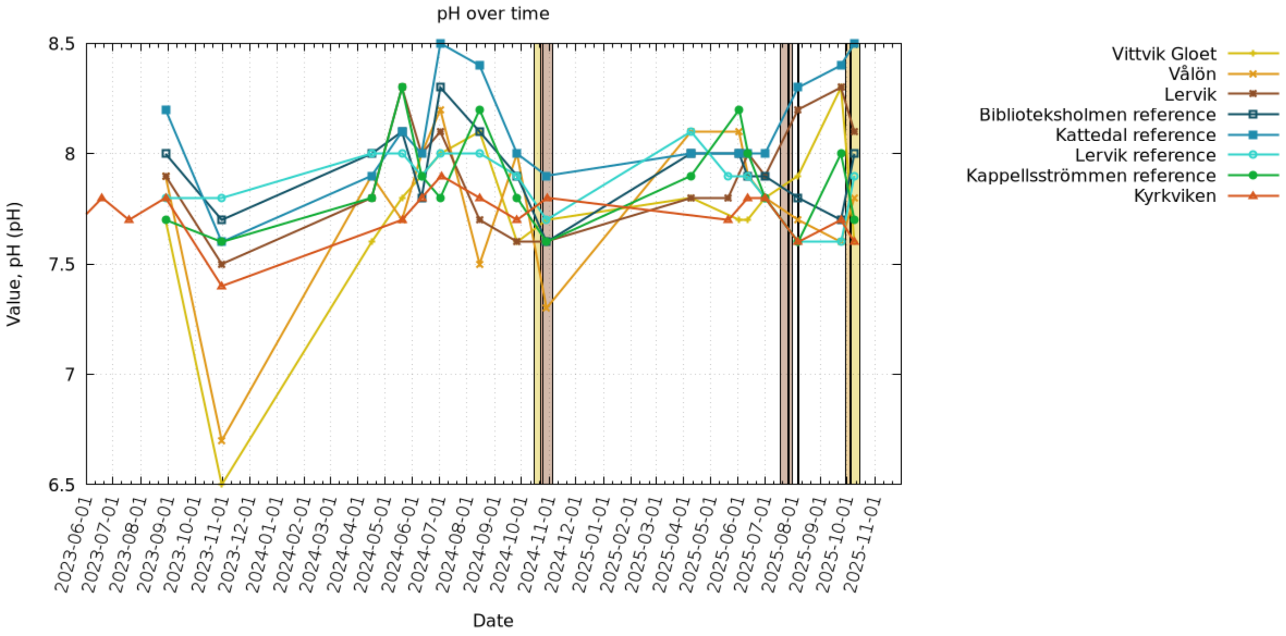




Interreg
Co-funded by the European Union
Central Baltic Programme
BalticReed


Ammonium nitrogen, NH4-N over time
Value, Ammonium nitrogen, NH4-N (µg/l)
70
60
50
40
30
20
10
2023-06-01
2023-07-01
2023-08-01
2023-09-01
2023-10-01
2023-11-01
2023-12-01
2024-01-01
2024-02-01
2024-03-01
2024-04-01
2024-05-01
2024-06-01
2024-07-01
2024-08-01
2024-09-01
2024-10-01
2024-11-01
2024-12-01
2025-01-01
2025-02-01
2025-03-01
2025-04-01
2025-05-01
2025-06-01
2025-07-01
2025-08-01
2025-09-01
2025-10-01
2025-11-01
Date
Vittvik Gloet
Vålön
Lervik
Biblioteksholmen reference
Kattedal reference
Lervik reference
Kappellsströmmen reference
Kyrkviken


pH over time
Value, pH (pH)
8.5
8
7.5
7
6.5
2023-06-01
2023-07-01
2023-08-01
2023-09-01
2023-10-01
2023-11-01
2023-12-01
2024-01-01
2024-02-01
2024-03-01
2024-04-01
2024-05-01
2024-06-01
2024-07-01
2024-08-01
2024-09-01
2024-10-01
2024-11-01
2024-12-01
2025-01-01
2025-02-01
2025-03-01
2025-04-01
2025-05-01
2025-06-01
2025-07-01
2025-08-01
2025-09-01
2025-10-01
2025-11-01
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Lervik
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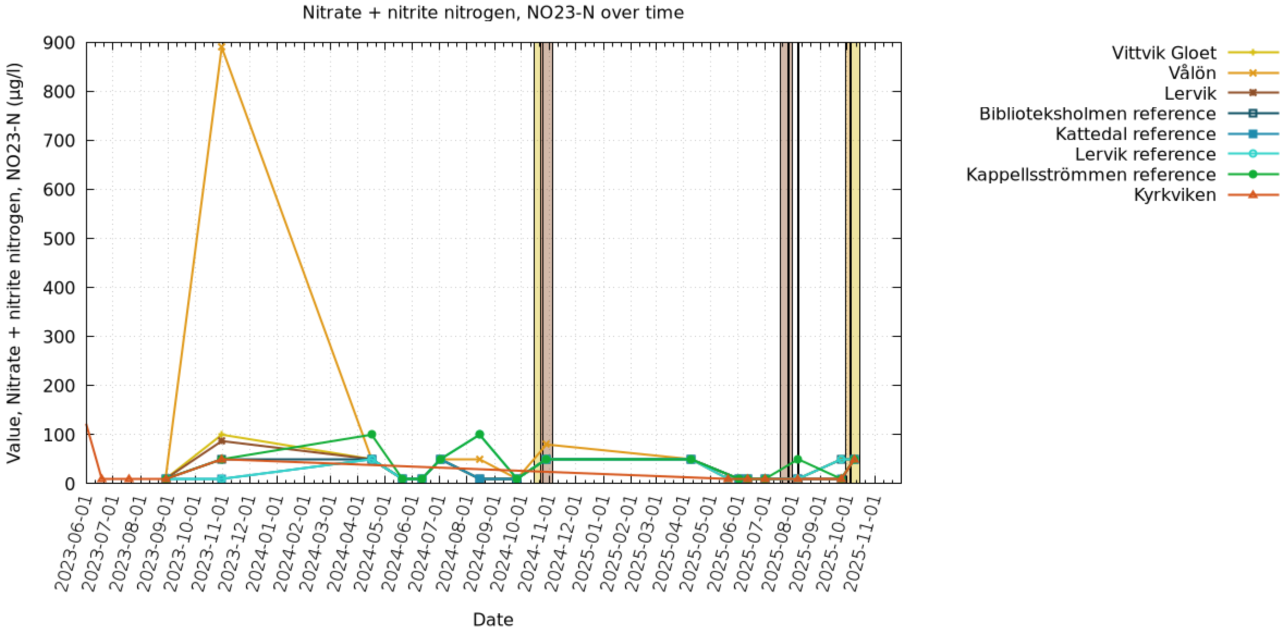
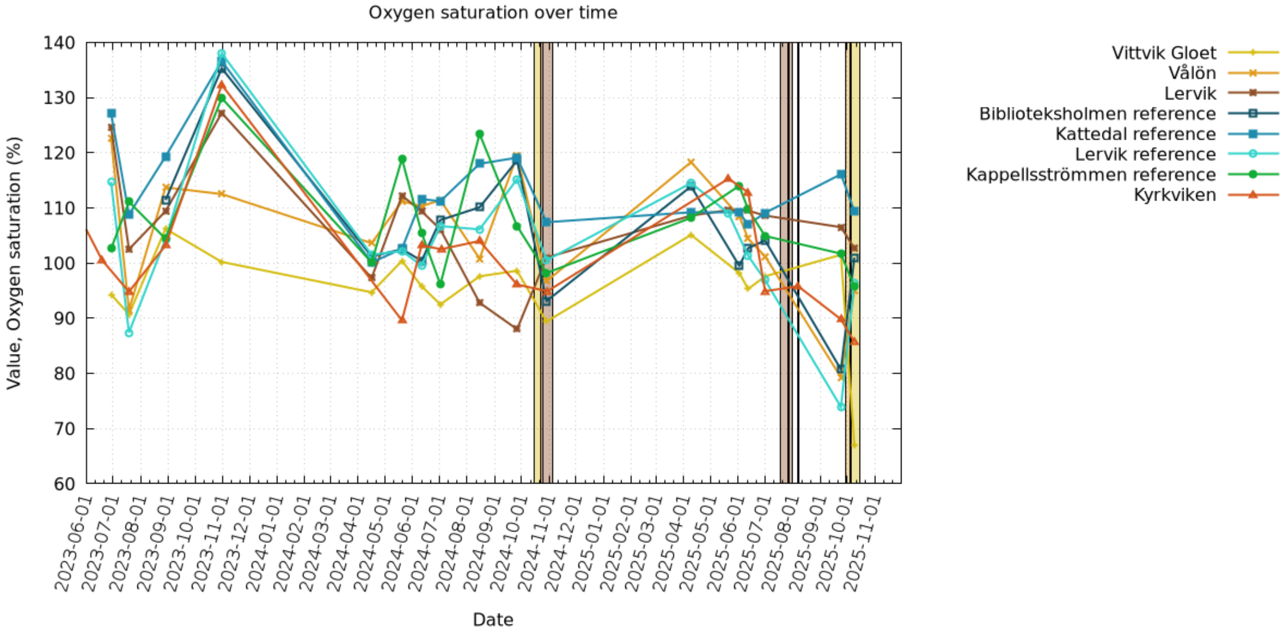


Nitrate + nitirite nitrogen N023-N


Oxygen saturation over time
Value, Oxygen saturation (%)
140
130
120
110
100
90
80
70
60
Date
2023-06-01
2023-07-01
2023-08-01
2023-09-01
2023-10-01
2023-11-01
2023-12-01
2024-01-01
2024-02-01
2024-03-01
2024-04-01
2024-05-01
2024-06-01
2024-07-01
2024-08-01
2024-09-01
2024-10-01
2024-11-01
2024-12-01
2025-01-01
2025-02-01
2025-03-01
2025-04-01
2025-05-01
2025-06-01
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2025-09-01
2025-10-01
2025-11-01
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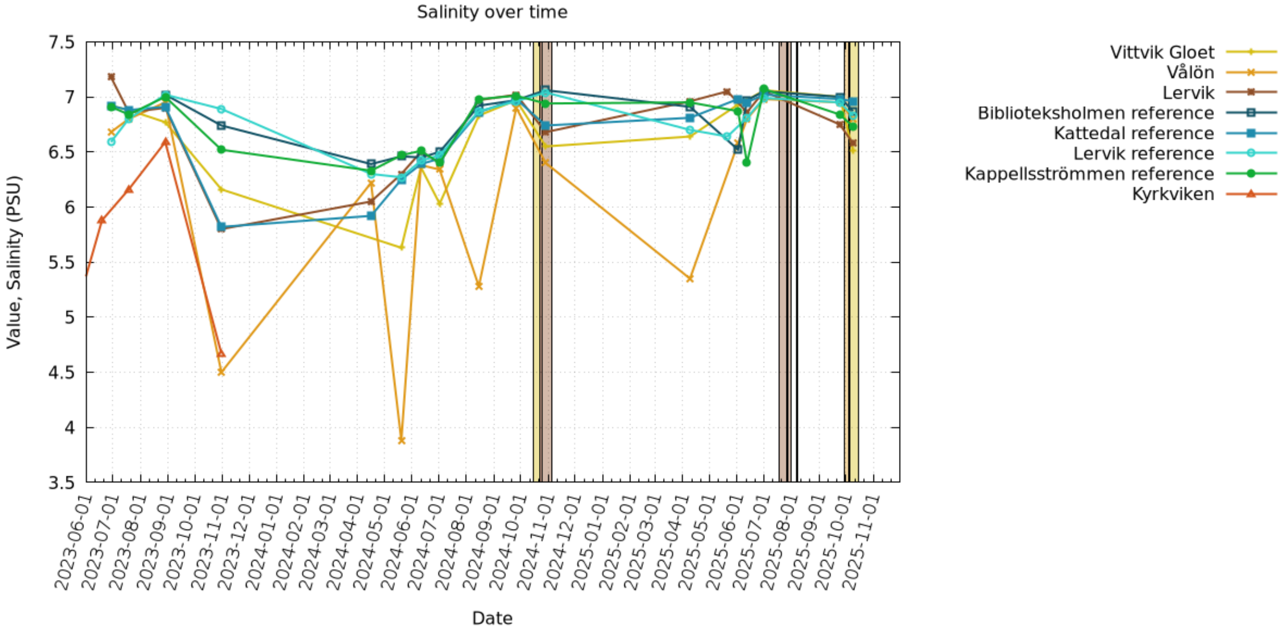
Vålön
Lervik
Biblioteksholmen reference
Kattedal reference
Lervik reference
Kappellsströmmen reference
Kyrkviken


Salinity over time
Value, Salinity (PSU)
7.5
7
6.5
6
5.5
5
4.5
4
3.5
Date
2023-06-01
2023-07-01
2023-08-01
2023-09-01
2023-10-01
2023-11-01
2023-12-01
2024-01-01
2024-02-01
2024-03-01
2024-04-01
2024-05-01
2024-06-01
2024-07-01
2024-08-01
2024-09-01
2024-10-01
2024-11-01
2024-12-01
2025-01-01
2025-02-01
2025-03-01
2025-04-01
2025-05-01
2025-06-01
2025-07-01
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2025-09-01
2025-10-01
2025-11-01
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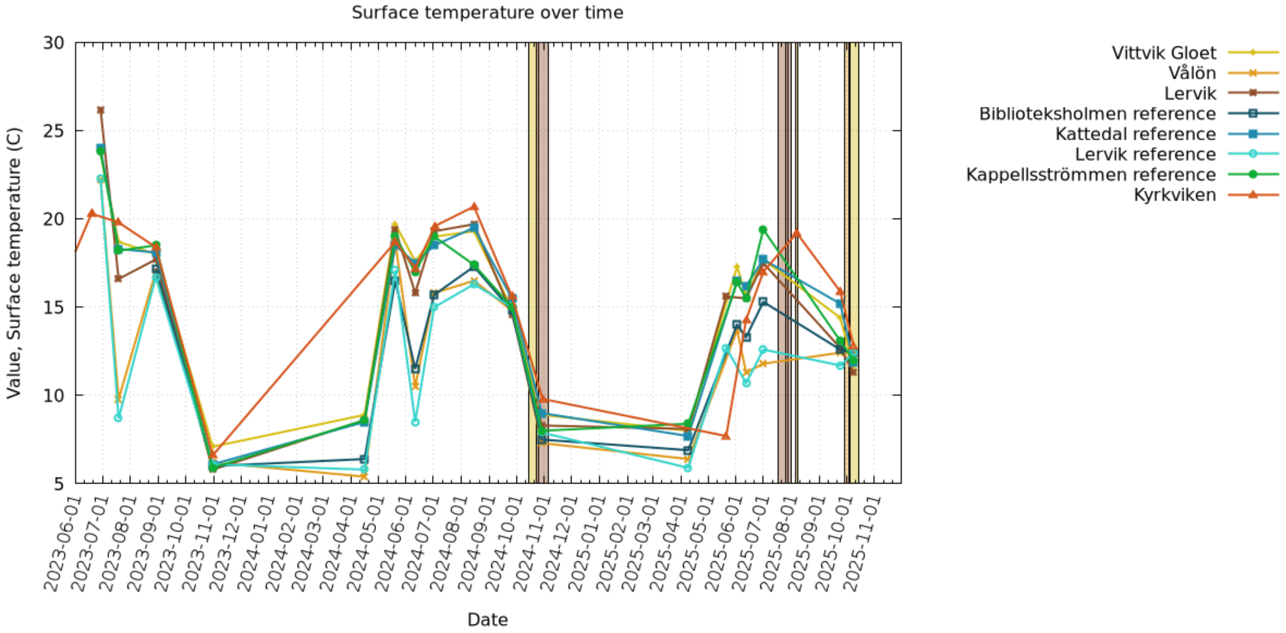
Kattedal reference
Lervik reference
Kappellsströmmen reference
Kyrkviken



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a.2 Birds

Lervik 2024

16 april: vigg 70 rastande, knölsvan 5, skäggdopping 9 i östra lagunen.

20 maj 11:40-12:30:

Fiskmås 2, havstrut 1, gräsand 1 p., grågås 3 kullar, snatterand 1 par, knölsvan 1 på bo lilla ön samt 6 ex., skäggdopping 1 p., rörsångare och sävsparv (se karta nedan).

Rörsångare (röda) och sävsparv (gröna) 20 maj.

2 juli 14:00:

Knipa 2, snatterand 1, knölsvan 1 familj, skäggdopping 3 par + 1 (1 unge) , rörsångare 5 sjungande (se karta), fiskgjuse 1, havsörn 1 ad, gräsand 15 ex., silvertärna 2 födosökande.

Sjungande rörsångare 2 juli.

Lervik 2025

29 maj 10:00 – 10:30

Fiskmås 2, gräsand 4 hanar och 2 honor, knölsvan 2, skäggdopping 5 par, tofsvipa 1 par på det skördade området, rörsångare och sävsparv (se karta nedan).

Rörsångare (röda) och sävsparv (gröna) 29 maj.

9 oktober: gräsand 120, knipa 80, vigg 50, kungsfiskare 2.

Gloet 2024

16 april: 3 knipor

20 maj 13:30: inget

2 juli 12:00: Knölsvan 1

Gloet 2025

14 april 10:30: Kricka 10, gräsand 8 par, skogssnäppa 2 varn.

2 juni 14:30: Knölsvan 2, fisktärna 2. Mkt småfisk.

9 oktober: Kungsfiskare 1

24 september: Kungsfiskare 3

Vålön 2024

16 april: Norr om mynningen – Vigg 50, storskrake 2 hane 1 hona, fiskgjuse 1 p, skräntärna 1

I och vid översvämningsyta vid ån: trana 1 par, knipa 1,

20 maj 14:45: skräntärna 3

2 juli 13:00: rörsångare 1 sj. vid lagunen uppströms., kanadagås 2 familjer med ungar.

26 september: kungsfiskare 1

Vålön 2025

14 april: knipa 1

2 juni 15:30: Drillsnäppa 1, gräsand 2 hane 1 hona, kanadagås 2, silvertärna 1.

Kapellströmmen 2024

16 april: Vassen i stora delar avskavd av isen i lagunen. Tofsvipa 1, kricka 30, skräntärna 2, 300 vigg norr om Biblioteksholmen

20 maj 14:00: Knipa 2, knölsvan 1 på bo, silvertärna 2, skräntärna 1, fiskmås 1

2 juni 12:30: Knölsvan 1, häger 1

Kapellströmmen 2025

14 april 11:00: 100 knipor, 800 vigg !

2 juni 14:00: Knipa 1, silvertärna 1.

9 oktober: vigg 300

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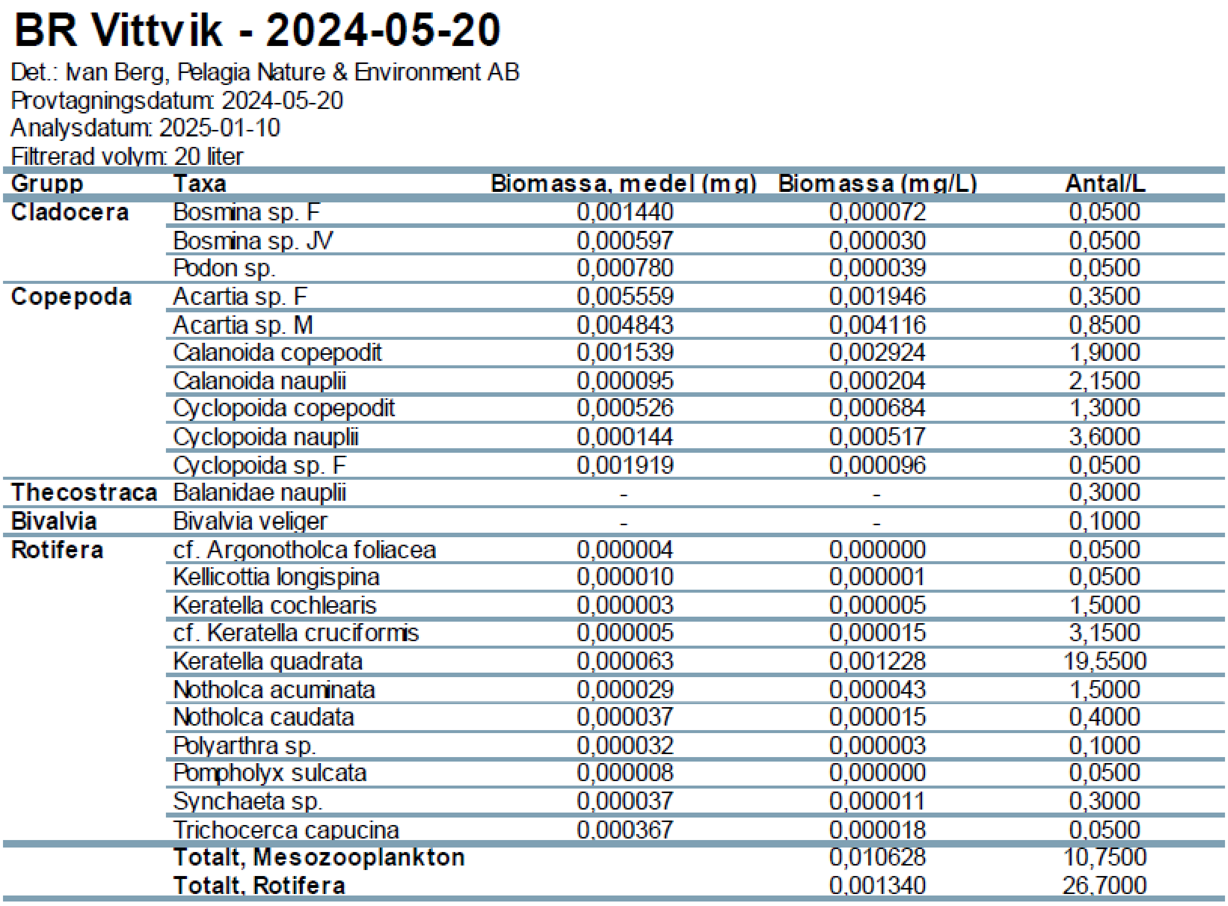
BalticReed

B.3 Zooplankton



BR Vittvik - 2024-05-20

Det.: Ivan Berg, Pelagia Nature & Environment AB
Provtagningsdatum: 2024-05-20
Analysdatum: 2025-01-10
Filtrerad volym: 20 liter

Grupp	Taxa	Biomassa, medel (mg)	Biomassa (mg/L)	Antal/L
Cladocera	Bosmina sp. F	0,001440	0,000072	0,0500
	Bosmina sp. JV	0,000597	0,000030	0,0500
	Podon sp.	0,000780	0,000039	0,0500
Copepoda	Acartia sp. F	0,005559	0,001946	0,3500
	Acartia sp. M	0,004843	0,004116	0,8500
	Calanoida copepodit	0,001539	0,002924	1,9000
	Calanoida nauplii	0,000095	0,000204	2,1500
	Cyclopoida copepodit	0,000526	0,000684	1,3000
	Cyclopoida nauplii	0,000144	0,000517	3,6000
	Cyclopoida sp. F	0,001919	0,000096	0,0500
Thecostraca	Balanidae nauplii	-	-	0,3000
Bivalvia	Bivalvia veliger	-	-	0,1000
Rotifera	cf. Argonotholca foliacea	0,000004	0,000000	0,0500
	Kellicottia longispina	0,000010	0,000001	0,0500
	Keratella cochlearis	0,000003	0,000005	1,5000
	cf. Keratella cruciformis	0,000005	0,000015	3,1500
	Keratella quadrata	0,000063	0,001228	19,5500
	Notholca acuminata	0,000029	0,000043	1,5000
	Notholca caudata	0,000037	0,000015	0,4000
	Polyarthra sp.	0,000032	0,000003	0,1000
	Pompholyx sulcata	0,000008	0,000000	0,0500
	Synchaeta sp.	0,000037	0,000011	0,3000
	Trichocerca capucina	0,000367	0,000018	0,0500
	Totalt, Mesozooplankton		0,010628	10,7500
	Totalt, Rotifera		0,001340	26,7000

BR Vittvik - 2024-06-11

Det.: Ivan Berg, Pelagia Nature & Environment AB
Provtagningsdatum: 2024-06-11
Analysdatum: 2025-03-17
Filtrerad volym: 20 liter

Grupp	Taxa	Biomassa, medel (mg)	Biomassa (mg/L)	Antal/L
Cladocera	Bosmina longispina F	0,001171	0,001791	1,5296
	Chydorus sp.	0,000119	0,000061	0,5099
	Daphnia cucullata	0,000487	0,000124	0,2549
	Evadne sp.	0,000780	0,000199	0,2549
	Podon cf. polyphemoides	0,000780	0,000597	0,7648
Copepoda	cf. Acartia clausi F	0,005563	0,114880	20,6498
	Acartia sp. M	0,004916	0,048872	9,9425
	Calanoida copepodit	0,002497	0,029287	11,7271
	Calanoida nauplii	0,000183	0,002891	15,8060
	Cyclopoida nauplii	0,000172	0,000660	3,8240
	Harpacticoida sp.	0,000514	0,000131	0,2549
Thecostraca	Balanidae nauplii	-	-	1,2747
Bivalvia	Bivalvia veliger	-	-	1,5296
Gastropoda	Gastropoda veliger	-	-	1,0197
Rotifera	Filinia sp.	0,000010	0,000003	0,2549
	Kellicottia longispina	0,000008	0,000002	0,2549
	Keratella cochlearis	0,000004	0,000393	107,0732
	Keratella cruciformis	0,000006	0,000030	5,3537
	Keratella quadrata	0,000054	0,006941	127,4680
	Pompholyx sulcata	0,000008	0,000008	1,0197
	Totalt, Mesozooplankton		0,199492	69,3426
	Totalt, Rotifera		0,007378	241,4245

Vittvik - 2024-08-15

Det.: Ivan Berg, Pelagia Nature & Environment AB
Provtagningsdatum: 2024-08-15
Analysdatum: 2025-01-23
Filtrerad volym: 20 liter

Grupp	Taxa	Biomassa, medel (mg)	Biomassa (mg/L)	Antal/L
Cladocera	Bosmina longispina JV	0,000597	0,000190	0,3187
Copepoda	cf. Acartia clausi F	0,004366	0,134952	30,9110
	Acartia sp. F	0,004712	0,006007	1,2747
	Acartia sp. M	0,004178	0,006657	1,5934
	Calanoida copepodit	0,001446	0,023955	16,5708
	Calanoida nauplii	0,000112	0,005477	48,8627
	Cyclopoida copepodit	0,000619	0,001972	3,1867
	Cyclopoida nauplii	0,000131	0,002081	15,9335
Bivalvia	Bivalvia veliger	-	-	0,3187
Rotifera	cf. Brachionus quadridentatus	0,000052	0,000016	0,3187
	Brachionus sp.	0,000019	0,000006	0,3187
	Euchlanis dilatata	0,000050	0,000095	1,9120
	Keratella cochlearis	0,000002	0,000112	47,1632
	Keratella quadrata	0,000046	0,001526	33,1417
	Totalt, Mesozooplankton		0,181291	118,9702
	Totalt, Rotifera		0,001755	82,8542

BR Vittvik - 2024-09-26

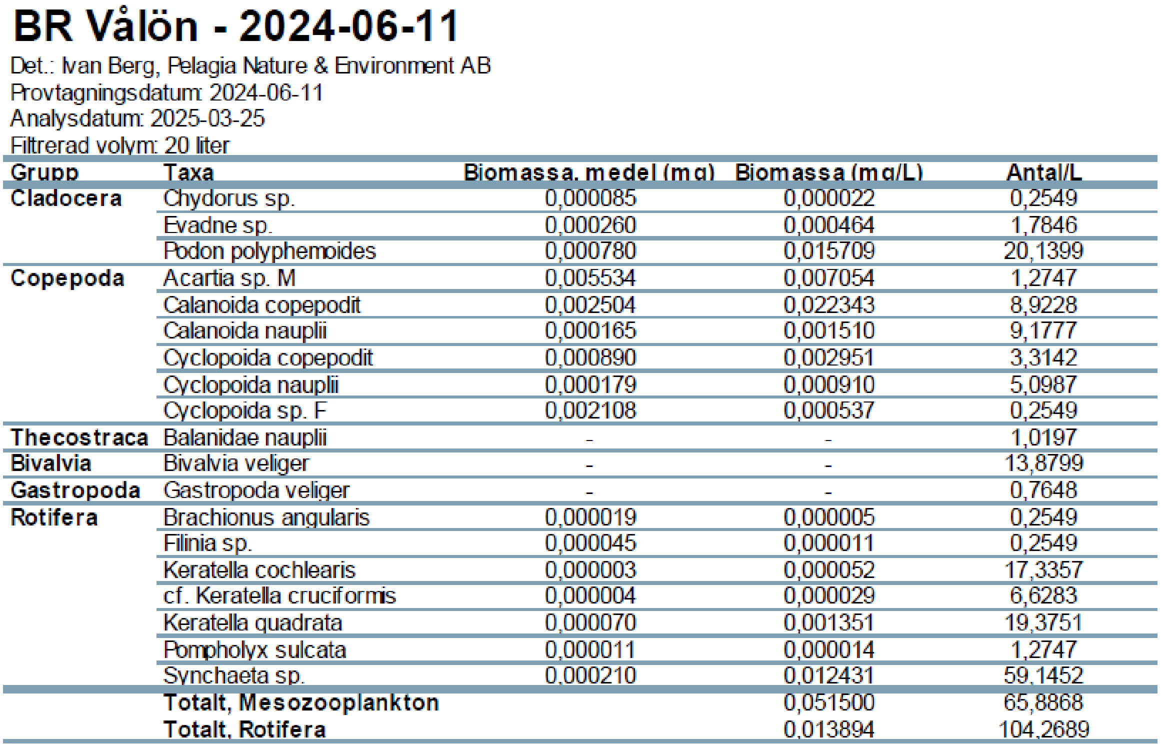
Det.: Ivan Berg, Pelagia Nature & Environment AB
Provtagningsdatum: 2024-09-26
Analysdatum: 2025-01-31
Filtrerad volym: 20 liter

Grupp	Taxa	Biomassa, medel (mg)	Biomassa (mg/L)	Antal/L
Copepoda	cf. Acartia clausi F	0,005477	0,002327	0,4249
	Calanoida copepodit	0,001690	0,008618	5,0987
	Calanoida nauplii	0,000139	0,004250	30,5923
	Cyclopoida nauplii	0,000157	0,000134	0,8498
Gastropoda	Gastropoda veliger	-	-	0,4249
Rotifera	Argonotholca foliacea	0,000005	0,000008	1,6996
	Keratella cochlearis	0,000002	0,000231	110,4723
	cf. Keratella cruciformis	0,000003	0,000155	45,4636
	Keratella quadrata	0,000039	0,002702	70,1074
	Synchaeta monopus	0,000030	0,000777	25,9185
	Synchaeta sp.	0,000052	0,000419	8,0730
	Trichocerca similis	0,000090	0,000038	0,4249
	Trichotria sp.	0,000017	0,000007	0,4249
	Totalt, Mesozooplankton		0,015328	37,3906
	Totalt, Rotifera		0,004337	262,5842

BR Vålön - 2024-06-01

Det.: Ivan Berg, Pelagia Nature & Environment AB
Provtagningsdatum: 2024-06-01
Analysdatum: 2025-01-24
Filtrerad volym: 20 liter

Grupp	Taxa	Biomassa, medel (mg)	Biomassa (mg/L)	Antal/L
Copepoda	Calanoida copepodit	0,002158	0,000688	0,3187
	Calanoida nauplii	0,000168	0,000428	2,5494
	Cyclopoida copepodit	0,000268	0,000085	0,3187
	Cyclopoida nauplii	0,000077	0,000049	0,6373
Bivalvia	Bivalvia veliger	-	-	0,3187
Rotifera	Brachionus angularis	0,000029	0,000018	0,6373
	Kellicottia bostoniensis	0,000005	0,000002	0,3187
	Kellicottia longispina	0,000010	0,000003	0,3187
	Keratella cochlearis	0,000002	0,000004	2,5494
	Keratella quadrata	0,000055	0,000053	0,9560
	Keratella sp.	0,000004	0,000007	1,9120
	Rotifera sp.	-	-	39,1964
	Synchaeta monopus	0,000014	0,000117	8,2854
	Synchaeta sp.	0,000060	0,002177	36,0097
	cf. Synchaeta sp.	0,000010	0,000883	87,3156
	Totalt, Mesozooplankton		0,001250	4,1427
	Totalt, Rotifera		0,003265	177,4992



BR Vålön - 2024-06-11

Det.: Ivan Berg, Pelagia Nature & Environment AB
Provtagningsdatum: 2024-06-11
Analysdatum: 2025-03-25
Filtrerad volym: 20 liter

Grupp	Taxa	Biomassa, medel (mg)	Biomassa (mg/L)	Antal/L
Cladocera	Chydorus sp.	0,000085	0,000022	0,2549
	Evadne sp.	0,000260	0,000464	1,7846
	Podon polyphemoides	0,000780	0,015709	20,1399
Copepoda	Acartia sp. M	0,005534	0,007054	1,2747
	Calanoida copepodit	0,002504	0,022343	8,9228
	Calanoida nauplii	0,000165	0,001510	9,1777
	Cyclopoida copepodit	0,000890	0,002951	3,3142
	Cyclopoida nauplii	0,000179	0,000910	5,0987
	Cyclopoida sp. F	0,002108	0,000537	0,2549
Thecostraca	Balanidae nauplii	-	-	1,0197
Bivalvia	Bivalvia veliger	-	-	13,8799
Gastropoda	Gastropoda veliger	-	-	0,7648
Rotifera	Brachionus angularis	0,000019	0,000005	0,2549
	Filinia sp.	0,000045	0,000011	0,2549
	Keratella cochlearis	0,000003	0,000052	17,3357
	cf. Keratella cruciformis	0,000004	0,000029	6,6283
	Keratella quadrata	0,000070	0,001351	19,3751
	Pompholyx sulcata	0,000011	0,000014	1,2747
	Synchaeta sp.	0,000210	0,012431	59,1452
	Totalt, Mesozooplankton		0,051500	65,8868
	Totalt, Rotifera		0,013894	104,2689

Tabell 7. vittvik 20240702

GRUPP	TAXA	STORLEK (MM)	BIOVOLYM (MM³/L)	POT. TOXIC
BACILLARIOPHYCEAE	Aulacoseira ambigua	3-4x8-12	0,0127	
BACILLARIOPHYCEAE	Bacillaria paxillifera	4-6x70-120	0,2299	
BACILLARIOPHYCEAE	Chaetoceros wighamii	10-11x6-8	0,03569	
BACILLARIOPHYCEAE	Chaetoceros wighamii	15-17x8-10	0,00812	
BACILLARIOPHYCEAE	Chaetoceros wighamii	15-16x15-16	0,02952	
BACILLARIOPHYCEAE	Diatoma tenuis	4x70-90	0,08618	
BACILLARIOPHYCEAE	Gyrosigma fasciola	14-16x60-140	0,09468	
BACILLARIOPHYCEAE	Melosira nummuloides	12-16x25-30	0,03626	
BACILLARIOPHYCEAE	Nitzschia longissima	4-6x85-110	0,0039	
BACILLARIOPHYCEAE	Pennales	7-9x70-100	0,02003	
BACILLARIOPHYCEAE	Pennales	7-9x35-50	0,00495	
BACILLARIOPHYCEAE	Synedra ulna	5-10x180-240	0,01988	
BACILLARIOPHYCEAE	Tabellaria flocculosa var. Asterionelloides	6-8x80-90	0,1577	
CHLOROPHYCEAE	Chlorophyceae	2-4	0,00187	
CHLOROPHYCEAE	Chlorophyceae	4-6	0,0108	
CHLOROPHYCEAE	Monoraphidium minutum	1-2x5-7	0,00315	
CHLOROPHYCEAE	Pediastrum duplex	60-80x10-12	0,1781	
CRYPTOPHYCEAE	Hemiselmis	2,5-3x4-4,5	0,00129	
CRYPTOPHYCEAE	Plagioselmis	3-4x5-7	0,01271	
CRYPTOPHYCEAE	Plagioselmis	4-5x7-9	0,0009	
CRYPTOPHYCEAE	Plagioselmis	5-7x7-9	0,01539	
CRYPTOPHYCEAE	Teleaulax	4-5x8-11	0,00591	

CYANOPHYCEAE	Aphanizomenon	4x100	0,2008	
CYANOPHYCEAE	Dolichospermum	3-4x100	0,2266	
CYANOPHYCEAE	Merismopedia warmingiana	0,5-1,2	0,00034	
CYANOPHYCEAE	Nodularia spumigena	10-12x100	0,1199	X
DINOPHYCEAE	Dinophyceae	15-20	12,78	
LITOSTOMATEA	Mesodinium rubrum	14-16	0,00929	
TREBOUXIOPHYCEAE	Oocystis	4-5x7-8	0,00656	
UNICELLS CLASSES INCERTAE SEDIS	Unicell	<2	0,00816	
UNICELLS CLASSES INCERTAE SEDIS	Unicell	2-3	0,0567	
UNICELLS CLASSES INCERTAE SEDIS	Unicell	3-5	0,01327	
	Flagellates	3-5	0,00031	
	Flagellates	7-10	0,00896	

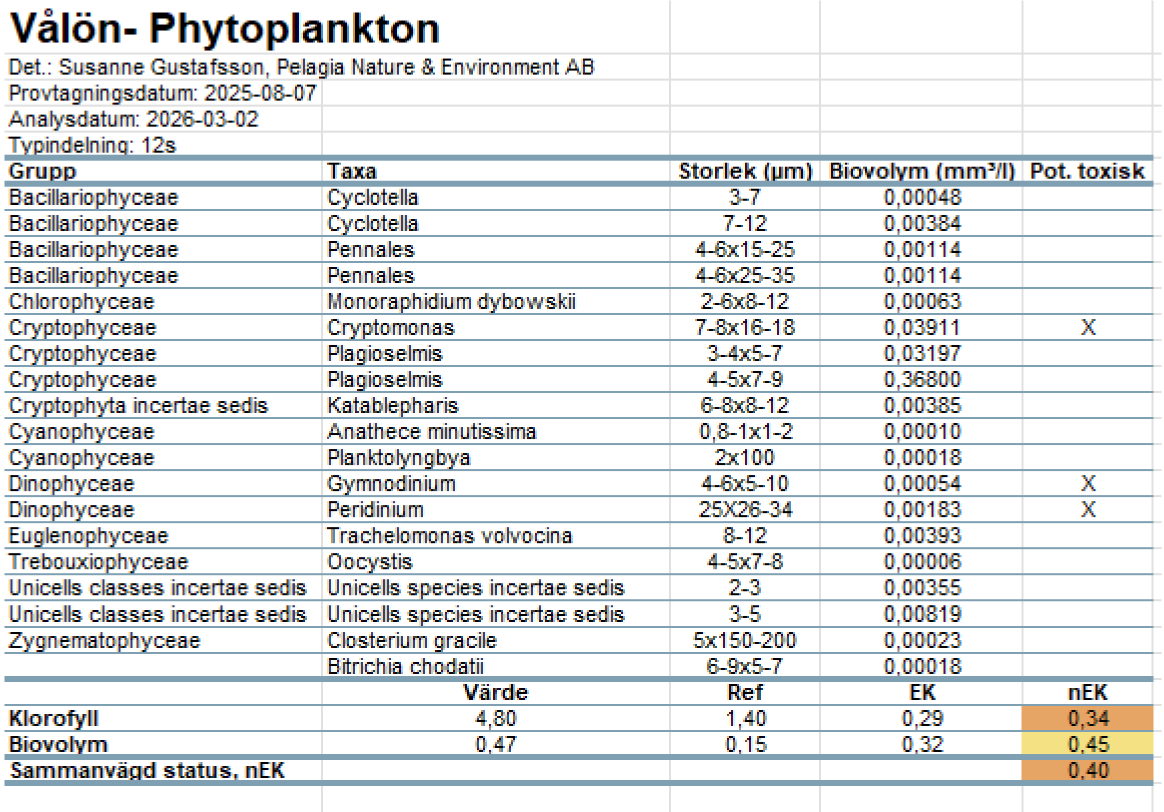
VÄRDE	**Ref**	**EK**	**nEK**	
KLOROFYLL	**8,2**	**1,4**	**0,17**	**0,22**
BIOVOLYM	**14,4**	**0,15**	**0,01**	**0,03**
SAMMANVÄGD	**status,**	**nEK**	**0,12**	

Tabell 8. vålön

GRUPP	**TAXA**	**STORLEK (μM)**	**BIOVOLYM (MM^3/L)**	**POT. TOXIC**
BACILLARIOPHYCEAE	Asterionella formosa	3-4x80-100	0,00075	
BACILLARIOPHYCEAE	Asterionella formosa	3-4x100-120	0,00567	
BACILLARIOPHYCEAE	Aulacoseira italica	7-9x23-27	0,00127	
BACILLARIOPHYCEAE	Aulacoseira lirata	6x10-15	0,0112	
BACILLARIOPHYCEAE	Chaetoceros wighamii	21-22x6-10	0,00294	
BACILLARIOPHYCEAE	Chaetoceros wighamii	7x7	0,00023	
BACILLARIOPHYCEAE	Cyclotella	3-7	0,00105	
BACILLARIOPHYCEAE	Fragilaria crotonensis	4-5x80-100	0,0677	
BACILLARIOPHYCEAE	Melosira moniliformis	18-22x18-22	0,2114	
BACILLARIOPHYCEAE	Nitzschia longissima	3-5x25-30	0,00006	
BACILLARIOPHYCEAE	Pennales	7-9x70-100	0,0008	
BACILLARIOPHYCEAE	Pennales	7-9x35-50	0,0004	
BACILLARIOPHYCEAE	Tabellaria flocculosa var. Asterionelloides	6-8x80-90	0,184	
CHLOROPHYCEAE	Chlorophyceae	2-4	0,00093	
CHLOROPHYCEAE	Chlorophyceae	4-6	0,00324	
CHLOROPHYCEAE	Desmodesmus bicellularis	2-3x4-6	0,00054	
CHLOROPHYCEAE	Monoraphidium minutum	1-2x5-7	0,0007	

CHOANOFLAGELLATEA	Choanoflagellatea	2-3	0,00014	
CRYPTOPHYCEAE	Hemiselmis	2,5-3x4-4,5	0,00515	
CRYPTOPHYCEAE	Plagioselmis	3-4x5-7	0,00574	
CRYPTOPHYCEAE	Teleaulax	4-5x8-11	0,01968	
CRYPTOPHYCEAE	Teleaulax	6-7x13-16	0,0063	
CYANOPHYCEAE	Aphanizomenon	5x100	0,3716	
CYANOPHYCEAE	Dolichospermum	4-5x100	0,2364	
CYANOPHYCEAE	Dolichospermum	5-7x100	0,1744	
CYANOPHYCEAE	Nodularia spumigena	10-12x100	0,00642	
CYANOPHYCEAE	Romeria	1x1-3	0,00018	
CYANOPHYCEAE	Snowella litoralis	2,4-4	0,00227	X
DINOPHYCEAE	Dinophyceae	<10	0,01728	
DINOPHYCEAE	Dinophyceae	10-15	0,1181	
DINOPHYCEAE	Dinophyceae	15-20	0,2779	
DINOPHYCEAE	Dinophyceae	20-25	0,1968	
DINOPHYCEAE	Dinophysis acuminata	48-52	0,01592	
DINOPHYCEAE	Gymnodinium	4-6x5-10	0,00479	
EBRIOPHYCEAE	Ebria tripartita	27-33	0,00167	X
EBRIOPHYCEAE	Ebria tripartita	37-43	0,04933	
EUGLENOIDEA	Eutreptia	5-7x15-20	0,01633	
EUGLENOIDEA	Eutreptia	7-9x20-30	0,1382	
LITOSTOMATEA	Mesodinium rubrum	45-55	0,2753	
PYRAMIMONADOPHYCEAE	Pyramimonas	4x3	0,00198	
PYRAMIMONADOPHYCEAE	Pyramimonas	5-7x5	0,00793	
TREBOUXIOPHYCEAE	Oocystis submarina	4-5x6-8	0,00367	
UNICELLS CLASSES INCERTAE SEDIS	Unicell	<2	0,01106	
UNICELLS CLASSES INCERTAE SEDIS	Unicell	2-3	0,03294	
UNICELLS CLASSES INCERTAE SEDIS	Unicell	3-5	0,04977	

	Värde	**Ref**	**EK**	**nEK**
KLOROFYLL	5,2	1,72	0,33	0,38
BIOVOLYM	2,54	0,21	0,08	0,2
SAMMANVÄGD STATUS,				0,29

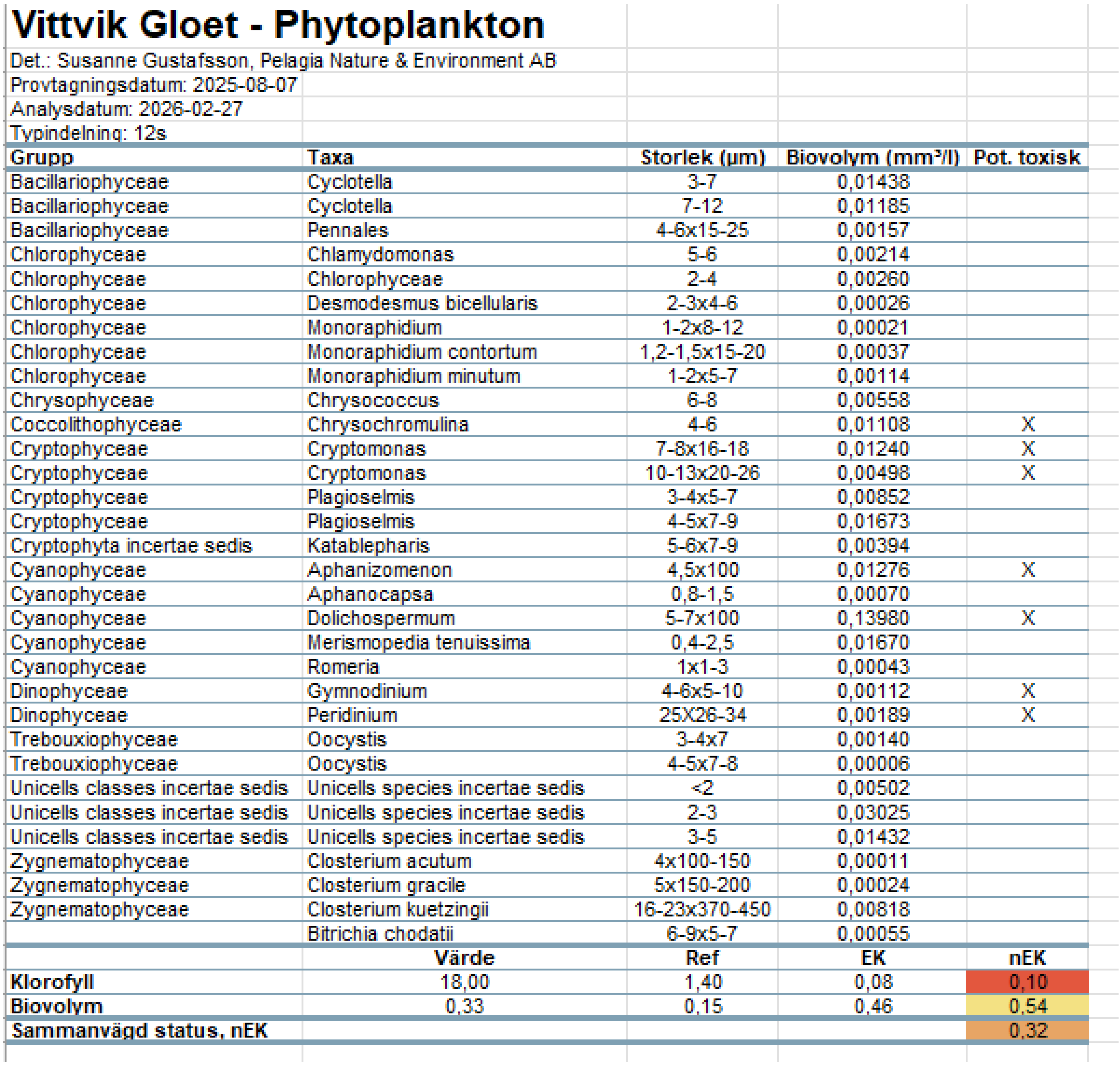


Vålön- Phytoplankton

Det.: Susanne Gustafsson, Pelagia Nature & Environment AB
Provtagningsdatum: 2025-08-07
Analysdatum: 2026-03-02
Typindelning: 12s

Grupp	Taxa	Storlek (µm)	Biovolym (mm³/l)	Pot. toxisk
Bacillariophyceae	Cyclotella	3-7	0,00048	
Bacillariophyceae	Cyclotella	7-12	0,00384	
Bacillariophyceae	Pennales	4-6x15-25	0,00114	
Bacillariophyceae	Pennales	4-6x25-35	0,00114	
Chlorophyceae	Monoraphidium dybowskii	2-6x8-12	0,00063	
Cryptophyceae	Cryptomonas	7-8x16-18	0,03911	X
Cryptophyceae	Plagioselmis	3-4x5-7	0,03197	
Cryptophyceae	Plagioselmis	4-5x7-9	0,36800	
Cryptophyta incertae sedis	Katablepharis	6-8x8-12	0,00385	
Cyanophyceae	Anathece minutissima	0,8-1x1-2	0,00010	
Cyanophyceae	Planktolyngbya	2x100	0,00018	
Dinophyceae	Gymnodinium	4-6x5-10	0,00054	X
Dinophyceae	Peridinium	25X26-34	0,00183	X
Euglenophyceae	Trachelomonas volvocina	8-12	0,00393	
Trebouxiophyceae	Oocystis	4-5x7-8	0,00006	
Unicells classes incertae sedis	Unicells species incertae sedis	2-3	0,00355	
Unicells classes incertae sedis	Unicells species incertae sedis	3-5	0,00819	
Zygnematophyceae	Closterium gracile	5x150-200	0,00023	
	Bitrichia chodatii	6-9x5-7	0,00018	

	Värde	Ref	EK	nEK
Klorofyll	4,80	1,40	0,29	0,34
Biovolym	0,47	0,15	0,32	0,45
Sammanvägd status, nEK				0,40

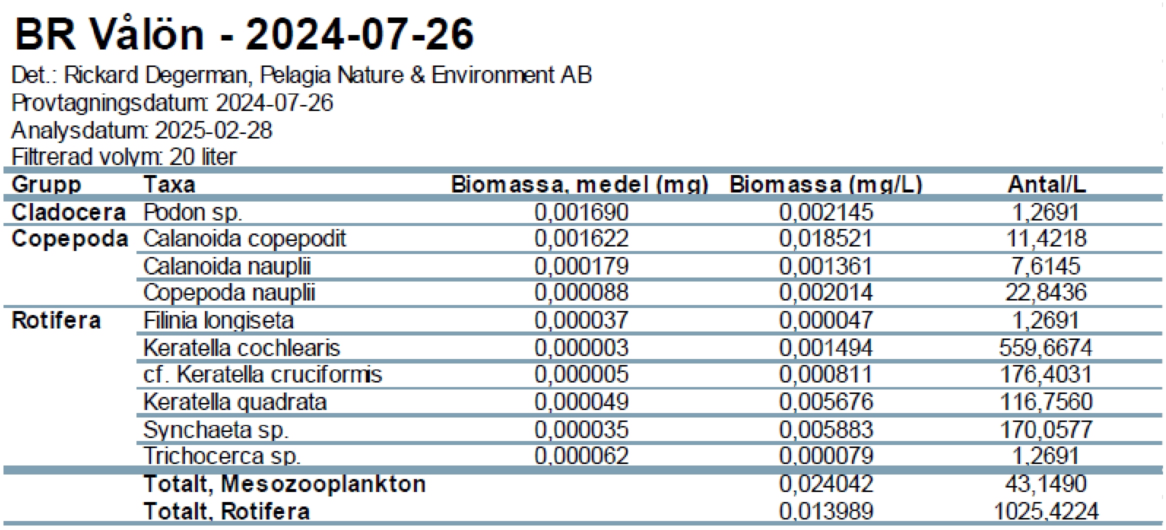


Vittvik Gloet - Phytoplankton

Det.: Susanne Gustafsson, Pelagia Nature & Environment AB
Provtagningsdatum: 2025-08-07
Analysdatum: 2026-02-27
Typindelning: 12s

Grupp	Taxa	Storlek (µm)	Biovolym (mm³/l)	Pot. toxisk
Bacillariophyceae	Cyclotella	3-7	0,01438	
Bacillariophyceae	Cyclotella	7-12	0,01185	
Bacillariophyceae	Pennales	4-6x15-25	0,00157	
Chlorophyceae	Chlamydomonas	5-6	0,00214	
Chlorophyceae	Chlorophyceae	2-4	0,00260	
Chlorophyceae	Desmodesmus bicellularis	2-3x4-6	0,00026	
Chlorophyceae	Monoraphidium	1-2x8-12	0,00021	
Chlorophyceae	Monoraphidium contortum	1,2-1,5x15-20	0,00037	
Chlorophyceae	Monoraphidium minutum	1-2x5-7	0,00114	
Chrysophyceae	Chrysococcus	6-8	0,00558	
Coccolithophyceae	Chrysochromulina	4-6	0,01108	X
Cryptophyceae	Cryptomonas	7-8x16-18	0,01240	X
Cryptophyceae	Cryptomonas	10-13x20-26	0,00498	X
Cryptophyceae	Plagioselmis	3-4x5-7	0,00852	
Cryptophyceae	Plagioselmis	4-5x7-9	0,01673	
Cryptophyta incertae sedis	Katablepharis	5-6x7-9	0,00394	
Cyanophyceae	Aphanizomenon	4,5x100	0,01276	X
Cyanophyceae	Aphanocapsa	0,8-1,5	0,00070	
Cyanophyceae	Dolichospermum	5-7x100	0,13980	X
Cyanophyceae	Merismopedia tenuissima	0,4-2,5	0,01670	
Cyanophyceae	Romeria	1x1-3	0,00043	
Dinophyceae	Gymnodinium	4-6x5-10	0,00112	X
Dinophyceae	Peridinium	25X26-34	0,00189	X
Trebouxiophyceae	Oocystis	3-4x7	0,00140	
Trebouxiophyceae	Oocystis	4-5x7-8	0,00006	
Unicells classes incertae sedis	Unicells species incertae sedis	<2	0,00502	
Unicells classes incertae sedis	Unicells species incertae sedis	2-3	0,03025	
Unicells classes incertae sedis	Unicells species incertae sedis	3-5	0,01432	
Zygnematophyceae	Closterium acutum	4x100-150	0,00011	
Zygnematophyceae	Closterium gracile	5x150-200	0,00024	
Zygnematophyceae	Closterium kuetzingii	16-23x370-450	0,00818	
	Bitrichia chodatii	6-9x5-7	0,00055	

	Värde	Ref	EK	nEK
Klorofyll	18,00	1,40	0,08	0,10
Biovolym	0,33	0,15	0,46	0,54
Sammanvägd status, nEK				0,32



BR Vålön - 2024-07-26

Det.: Rickard Degerman, Pelagia Nature & Environment AB
Provtagningsdatum: 2024-07-26
Analysdatum: 2025-02-28
Filtrerad volym: 20 liter

Grupp	Taxa	Biomassa, medel (mg)	Biomassa (mg/L)	Antal/L
Cladocera	Podon sp.	0,001690	0,002145	1,2691
Copepoda	Calanoida copepodit	0,001622	0,018521	11,4218
	Calanoida nauplii	0,000179	0,001361	7,6145
	Copepoda nauplii	0,000088	0,002014	22,8436
Rotifera	Filinia longiseta	0,000037	0,000047	1,2691
	Keratella cochlearis	0,000003	0,001494	559,6674
	cf. Keratella cruciformis	0,000005	0,000811	176,4031
	Keratella quadrata	0,000049	0,005676	116,7560
	Synchaeta sp.	0,000035	0,005883	170,0577
	Trichocerca sp.	0,000062	0,000079	1,2691
	Totalt, Mesozooplankton		0,024042	43,1490
	Totalt, Rotifera		0,013989	1025,4224

BR Vålön 2024-08-15

Det.: Ivan Berg, Pelagia Nature & Environment AB
Provtagningsdatum: 2024-08-15
Analysdatum: 2025-02-19
Filtrerad volym: 20 liter

Grupp	Taxa	Biomassa, medel (mg)	Biomassa (mg/L)	Antal/L
Copepoda	cf. Acartia clausi F	0,006684	0,001704	0,2549
	Calanoida copepodit	0,001325	0,002703	2,0395
	Calanoida nauplii	0,000090	0,002129	23,7091
	Cyclopoida nauplii	0,000118	0,000030	0,2549
Bivalvia	Bivalvia veliger	-	-	0,7648
Gastropoda	Gastropoda veliger	-	-	1,0197
Rotifera	Brachionus sp.	0,000025	0,000006	0,2549
	Keratella cochlearis	0,000004	0,000411	113,8714
	Keratella cruciformis	0,000005	0,000261	52,2619
	Keratella quadrata	0,000056	0,001250	22,1794
	Lecane sp.	0,000031	0,000024	0,7648
	Synchaeta sp.	0,000064	0,000246	3,8240
	Totalt, Mesozooplankton		0,006565	28,0430
	Totalt, Rotifera		0,002198	193,1566

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