METSÄHALLITUS

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Täktominlahti Bay experimental restoration project as part of the CoastNET LIFE project 2019–2024:

Final report on removal of *Myriophyllum spicatum* from a coastal lagoon by repeated mowing

Anna Arnkil and Tytti Turkia

Cover photo: Täktominlahti Bay photographed from the air, 22 August 2020. The *Myriophyllum spicatum* zone reaches to the surface in some places. Photographer Ari Heinilä / Täktominlahti Management Association.

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Täktominlahti Bay experimental restoration project as part of the CoastNET LIFE project 2019–2024 – Final report on removal of *Myriophyllum spicatum* from a coastal lagoon by repeated mowing

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Summary

Metsähallitus Parks & Wildlife Finland has not previously attempted to restore underwater habitats, such as coastal lagoons, prior to the CoastNet LIFE project. For CoastNet LIFE, we managed to find a site where terrestrial efforts to improve the water quality had already started. Täktominlahti Bay used to be clear with a sandy bottom and open beach areas. However, it can currently be described as a nutrient-rich, eutrophic bay in which the bottom is anoxic and contains a lot of aquatic vegetation, *Myriophyllum spicatum,* that is blocking water flow inside the bay.

The goal of the restoration project in our piloting lagoon was to improve water flow by harvesting the aquatic plant biomass from Täktominlahti Bay. Better water flow reduces the amount of organic matter accumulating on the bottom and helps bottom sediments to recover. Less organic matter means that sandy bottom species can settle and recover.

Based on field observations and multivariate analyses of monitoring data, the repeated removal of aquatic vegetation (three times in 2020–2022) in Täktominlahti bay did not have a significant impact on the amount of *Myriophyllum spicatum*. Sediment samples also did not show the expected decrease in organic matter, suggesting that removal of vegetation did not improve water flow in the bay or reduce the accumulation of organic matter. On the other hand, the removal did not increase the amount of *Myriophyllum spicatum*. The fact that plant material left in the water after mowing could help the plant to spread was identified as a potential risk at the outset of the project.

Monitoring of vegetation in the bay showed fluctuating growth patterns of *Myriophyllum spicatum* throughout the monitoring period. This was potentially influenced by the repeated mowing, natural annual variations, or nutrient load from the catchment area. Clear-cutting in the catchment area during the project (2020–2021) led to visibly browner water in the bay, which was associated with higher nitrogen and phosphorus levels in water samples. Our pilot suggests that the traditional mowing machine used in the restoration project, which was originally designed for reed removal, is poorly suited for removing submerged aquatic vegetation. The current equipment produced uneven results, leaving plant shoots behind. Developing a specific mower for submerged vegetation that is capable of removing plant roots would be essential in terms of achieving long-term results.

The involvement of the local waters management association and the "Minun mereni ry" organisation in restoring the catchment area – including the restoration of drained peatland – offers hope for improving the condition of the inlet. The restoration pilot in the CoastNet LIFE project has provided valuable lessons for the practical implementation of marine restoration efforts, and its findings are being shared with stakeholders, local communities, and environmental authorities. The experiences from Täktominlahti Bay were also included in a report on marine nature restoration methods called "A review of marine nature restoration work and methods in Finland" that was compiled by Parks & Wildlife Finland. This report aimed to provide an up-to-date picture of the experience gained with marine nature restoration methods.

1 Introduction

The CoastNET LIFE project involves managing the nature of coastal and archipelago nature reserves that are part of the Natura 2000 network during 2018–2025. The aim is to create a functional network of habitats. The particular targets of the project are open and semi-open environments typical of the coastal area. The species-rich coastal habitats are threatened by eutrophication of the Baltic Sea, overgrowth, and invasive species spreading to the shores. Nature management measures in the CoastNET LIFE project are tackling the problem by means of clearing, controlled burning and returning semi-natural grasslands to grazing use. This will simultaneously create networks of habitats that are suitable for species, helping them to spread and providing an escape route to new areas as climate change makes old habitats unsuitable. The management targets 41 Natura 2000 sites from the Bothnian Bay to the Estonian coast. The project is led by Metsähallitus Parks & Wildlife Finland and its partners are the Estonian Environmental Board (Keskkonnaamet), the cities of Raahe, Rauma, Tallinn and Turku, as well as the University of Turku, ELY Centre for Southwest Finland, and WWF Finland.

At the planning stage of the CoastNet LIFE project, the experience of restoring marine nature in the Finnish coastal area was almost non-existent. This is because the work input of the Parks & Wildlife Finland marine conservation team allocated to protection of marine nature had primarily been used for baseline surveys of marine nature since 2004. A suitable site for the CoastNet LIFE project was found in Täktominlahti Bay in Hankoniemi, where the restoration of a habitat type classified as a coastal lagoon could be piloted by Parks & Wildlife Finland for the first time.

The following factors influenced selection of the site:

A) The area was part of the network of protected areas: The bay was part of an extensive Natura site called the Tammisaari, Hanko archipelago and Pohjanpitäjänlahti Bay marine protection area (FI0100005, Figure 1), which was a prerequisite for a restoration site in a LIFE-funded project. The aim of the CoastNET LIFE project was to use active and cost-effective restoration and management measures to improve the conservation status of the Natura 2000 biotope network and species protected under EU directive in the coastal zone. Täktominlahti Bay was also part of state-owned lands reserved for nature conservation, from which the Täktominlahti and Svanviken Nature Reserve was established in 2021 (Government Decree on Nature Reserves of the Province of Uusimaa 332/2021, Figure 2). Since the water area was managed by Parks & Wildlife Finland, it was anticipated that the permit processes related to restoration measures would be simpler than in privately owned areas.

B) Measures to improve water quality had already been implemented in the bay catchment area: The local Täktominlahti Management Association (Täktominlahden hoitoyhdistys ry) had noticed deterioration in the status of Täktominlahti Bay before the CoastNet LIFE project. For example, the association built two wetlands in the catchment area in 2010 and 2016 and tested the mowing of submerged aquatic vegetation on a small scale (Operaatio Täktominlahti 2024). Changes in the marine environment are so slow that a single project (duration approximately 6 years) does not provide sufficient time to detect the impact of restoration measures on the habitat of the area. This led to a decision to select a site where restoration activities had already begun and would continue and be monitored for the duration of the six-year project.

C) A clear, limited area: Täktominlahti Bay is a large shallow bay in the coastal zone with a small sill at its entrance, so it is classified as a coastal lagoon (1150) according to the Habitats Directive. In terms of practical measures, restoration of this type of semi-open area that mainly borders on dry land is more likely to be successful than, for example, restoration of an open-sea habitat because nutrient loading can be reduced or eliminated by measures taken in the catchment area.

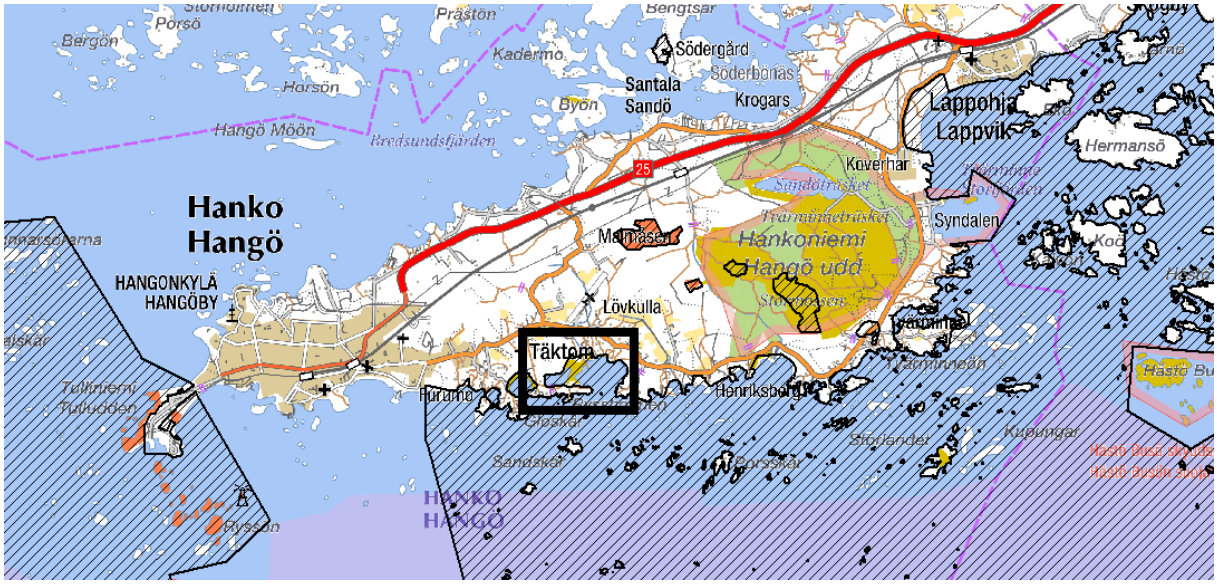


Figure 1. The location of Täktominlahti Bay in Hankoniemi is marked inside the black square. Natura sites are indicated with black backslash lines. Täktominlahti Bay is part of a larger Natura site called the Tammisaari, Hanko archipelago and Pohjanpitäjänlahti Bay marine protection area, which is visible on the right side of the map. © National Land Survey of Finland 1/MYY/2024, © Metsähallitus 2024.

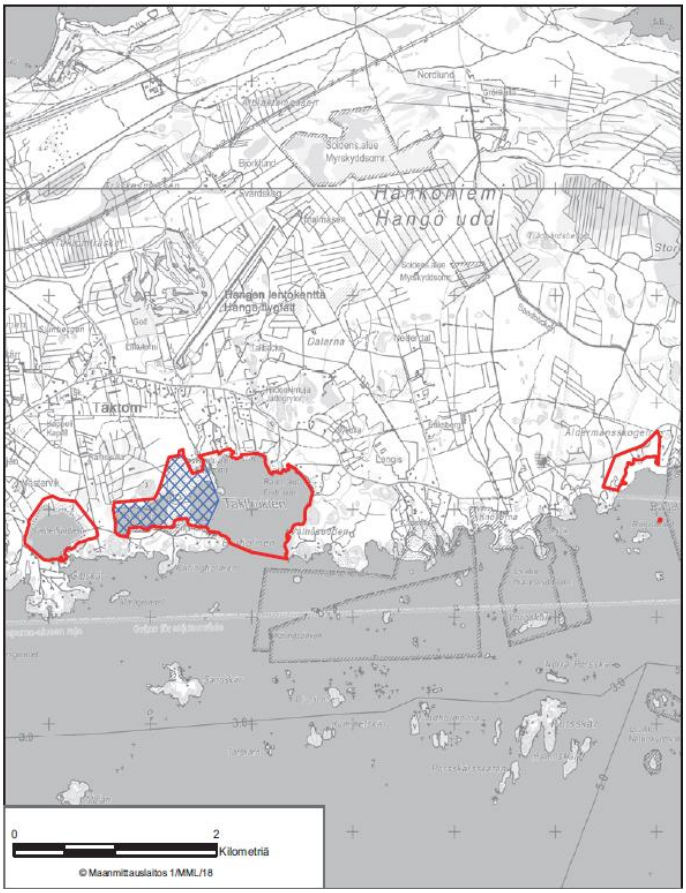


Figure 2. The boundaries of the Täktominlahti Bay and Svanviken Nature Reserve are marked with a red line on the map. In accordance with section 4 (1)(5) of the decree establishing the area, a restricted area has been set during the ice-free season for the Österfjärden gloe lake and flad located west of Täktominlahti Bay. This is indicated by a blue grid on the map. Map appendix Finlex, Government Decree on Nature Reserves in the Province of Uusimaa (332/2021).

2 Background and methods

2.1 The problem in Täktominlahti Bay

The status of Täktominlahti Bay has changed significantly over the decades. It used to be a sandy-bottomed bay with clear waters and little vegetation where, according to local summer residents, trout migrated into the sea outfall to spawn until recently. The bay's depth zone of 0.5–2.5 metres is currently covered by dense growth of *Myriophyllum spicatum* (cover photo and Figure 3). *Myriophyllum spicatum* is not an invasive species but a type of submerged aquatic vegetation commonly found in Finland. It grows quickly in fresh water and low-saline brackish waters. It often occurs in shallow bays. *Myriophyllum spicatum* usually grows to a length of approximately 0.5-2 metres, and can reach up to 3.5 metres in length. It is an effective competitor, as it also secretes plant toxins that prevent or hinder the growth of other plants. The species has become more prevalent and spread rapidly in shallow bays in the Finnish coastal area over the past 10 years. Experts are uncertain about the cause of its spreading. The proposed causes include elevated sea water temperatures and the prolonged growing season

resulting from climate change as well as the general eutrophication trend in the Baltic Sea, which has contributed to the growth and spread of this plant.

In Täktominlahti Bay, *Myriophyllum spicatum* has taken over living space from original species (such as *Charales*, Figure 4), hinders recreational use of the bay (e.g. swimming, boating and fishing) and has disturbed water exchange in the bay. Decreased water flow has caused deterioration in water transparency and sediment – solid material transported and deposited by the water – has begun to accumulate on the sandy bottom. *Myriophyllum spicatum* is a perennial that withers after the growing season and its decomposing biomass has caused eutrophication on the bottom of the bay and on the shores around it. These are becoming overgrown as a result of the additional nutrients. Several bird, insect and plant species that are endangered at the national or regional level are found on the shores of Täktominlahti Bay. The decomposing plant mass that accumulates on the shores during the autumn season is also a constant nuisance for residents living around the bay, as its removal is laborious and requires measures every year.

Despite the degraded state, *Charales* are still found in the shallow zone of the bay (Figure 4) and eelgrass around its inlet. *Zostera marina* is one of the keystone species in the Baltic Sea, providing shelter and food for many fish and small invertebrates. Both flads and gloe lakes (part of the coastal lagoon habitat type) and *Zostera marina* meadows have been classified as vulnerable habitat types in Finland's most recent national classification of threatened species (Kontula & Raunio 2018). *Charales* often thrive in shallow, soft-bottomed bays where they can form dense and extensive meadows. *Charales* meadows are valuable habitats for many animals. They also effectively filter nutrients, which clears the water.

During the planning phase of the CoastNet LIFE project, Metsähallitus did not have any previous experience of restoring sites like Täktominlahti Bay. Previous studies on the removal of submerged aquatic vegetation and *Myriophyllum spicatum* in particular had mainly been conducted abroad and in a lake environment (e.g. Carpenter & Adams 1977, Carson et al. 2018). The results of attempts to eradicate *Myriophyllum spicatum* in lake environments have varied; in some cases the removed vegetation has been replaced by other species, while in others, algae blooms have occurred after its removal. In addition to mowing, other mechanical methods (incl. manual removal, raking, dredging and cutting), biological control (herbivorous fish and insects) and chemical methods (pesticides) have been used to eradicate *Myriophyllum spicatum* outside Finland. However, the results obtained with all methods have been variable, and no fully effective method has been found (Kumwimba et al. 2020).

Figure 3. *Myriophyllum spicatum* photographed underwater in Täktominlahti Bay. *Myriophyllum spicatum* forms dense vegetation that suffocates other plants under it (upper photo). Eutrophication in the bay has also caused an increase in *Cladophora sp*. They increase the accumulation of degradable plant material on the bottom and cause anoxia in the bottom. The *Cladophora sp*. drifting in the photo have caught on the dense *Myriophyllum spicatum* vegetation (lower image). Photos: © Juha Syväranta, Alleco Oy.

Figure 4. The sandy bottom in the shallow zone of Täktominlahti Bay, where *Charales* species are still present. *Chara aspera, Chara baltica, Chara globularis* and *Chara virgata* were found in the monitoring transects. Dense and extensive Charales meadows can form in suitable conditions. Charales meadows are valuable habitats for many animals. They also effectively filter nutrients, which clears the water. Photo: © Juha Syväranta, Alleco Oy.

2.2 Restoration plan prepared for the project application

Repeated removal of *Myriophyllum spicatum* by mowing was selected as the method for piloting in the CoastNet LIFE project. The aim of the restoration project was to improve water flow by repeated mowing and removal of the aquatic plant biomass. Improved water flow and repeated removal of submerged vegetation were expected to affect water transparency and reduce the amount of organic matter accumulating on the bottom, which would promote natural recovery of the bottom. A decrease in the amount of submerged vegetation and organic matter was expected to promote recovery of the original vegetation on the sandy bottom. Improved water flow was also expected to reduce the amount of dying biomass washing up on the shores and subsequently decrease nutrient loading in the shore area. In addition, the removal of vegetation and reeds washed up in the shore area would promote and improve the open sandy shore habitats and the living conditions of the species found in them.

The project application included an entry stating that the lagoon restoration project will start with a baseline survey performed by diving, the purpose of which is to verify the baseline situation (aquatic vegetation in the area, baseline situation concerning aquatic vegetation biomass, amount of sediment). This survey would be used as the foundation for planning a detailed restoration plan and measures once the project had begun.

The following preliminary information on restoration measures was included in the restoration pilot project:

- Aquatic vegetation (*Myriophyllum spicatum*) across an area of approximately 10 hectares would be mowed once a year with a mower/cutter during the summer, and this would be repeated 3-4 times.
- In addition to mowing, the nutrient load would be reduced by removing the roots of aquatic vegetation.
- All the mowed vegetation would be collected and transported away to prevent the accumulation of additional nutrient loads on the shore.
- After completion of the restoration measures, a final report on the results of the restoration pilot project would be prepared. The aim of the final report would be to ensure the transferability and reproducibility of the pilot measures.

2.3. Baseline survey of Täktominlahti Bay 2019

An invitation to tender for implementation of a baseline survey in the bay was sent to two well-known and high-quality consultancy companies that use the same survey methods in their work as the Parks & Wildlife Finland's marine conservation team. Both companies had previously carried out aquatic nature surveys. The consultancy companies were Alleco Oy and Monivesi Oy. Based on the tenders received, Monivesi Oy was selected to carry out the baseline survey.

The purpose of the baseline survey of aquatic vegetation in Täktominlahti Bay was to examine the range and abundance of plant species in the bay. The basis for the occurrence of species is the quality of the bottom, water depth and the openness of the shore.

2.2.1 Dive transects

Two vegetation transects of 100 metres in length were established by diving, and these were designated as transects 1 and 5 (control transect). Transect 1 was located inside the small area mowed by the Täktominlahti Management Association (Täktominlahden hoitoyhdistys Ry) in 2017–2019, and the control transect was located outside the mowed area. The dive transects were established in accordance with the Inventory Programme for Underwater Marine Diversity (VELMU) instructions (2022). The aquatic vegetation species and abundance were determined from areas of 1 square metre located 10 metres apart in a 100-metre bottom transect. A total of 22 squares were surveyed from both transects. The transects were established on 24 August 2019.

Nine aquatic plant species and drifting *Cladophora sp.* were observed in dive transect 1 (mowed area). Six aquatic plant species, one macroalgae and drifting *Cladophora sp*. were observed in the control transect (transect 5). *Myriophyllum spicatum* was the most common species. (Ruuskanen & Musterhjelm 2019, unpublished final report). Appendix 1 lists the species observed at the survey points in the baseline survey of Täktominlahti Bay and monitoring years 2020–2024.

2.2.2 Luther rake method

Seven rake transects (transects 1–7) were established in Täktominlahti Bay using the Luther rake method. A boat was used to travel along the transect, and the rake was thrown in at each monitoring point until no new species were detected. The samples were used to determine the species and their relative proportions as well as the depth of the survey point and the quality of the bottom. When no new species could be found, the boat moved on to the next monitoring point. The location of the next monitoring point was determined on the basis of a significant change in the quality, depth or vegetation of the bottom. In other words, the aquatic vegetation in the area between two monitoring points is unchanged. A total of 79 monitoring points were implemented on 25 August 2019.

The Luther rake method produced observations of 18 aquatic plant species and 5 macroalgae species. The survey revealed one near-threatened species according to the classification of threatened species. This was *Zostera marina*, which occurred as meadows on the sandy bottoms at the inlet of the bay. *Zostera marina* meadows are classified as threatened in Finland (Kontula & Raunio 2018). In other respects, the species observed were similar to those in corresponding water bodies. (Ruuskanen & Musterhjelm 2019, unpublished final report).

2.2.3 Shoot density quadrat

A shoot density quadrat (1 m^2 in size) was randomly calculated at N59,833658 E23,089656 (Figure 5). The depth of the quadrat was 1.7 metres, and it was located in the dense *Myriophyllum spicatum* vegetation characteristic of the shore. The number of stems/shoots inside the quadrat were counted. It was established on 24 August 2019, and there were 242 shoots inside the shoot density quadrat in 2019 (Figure 15).

The final report on the baseline survey summarises the results of the surveys (Ruuskanen & Musterhjelm 2019, unpublished final report). According to the report, the aquatic vegetation in Täktominlahti Bay can be divided into four mowing areas based on the results of the monitoring:

1. An area dominated by *Zostera marina* that is vulnerable in terms of its nature values is located in the inlet to the bay.
2. *Charales, Zannichellia* and *Ruppia* occur on the water surface and at a depth of approximately 0.9 metres along the edges of the bay.
3. A zone of dense *Myriophyllum* occurs at a depth of approximately 1-2 metres along the edges of the bay. In terms of nature values, mowing should target this area.
4. The water depth in the middle of the bay is deeper than at the inlet. The potential drawback of the deeper area is the accumulation of dying aquatic vegetation (as a result of mowing), which was already evident. There is a risk that the degradable aquatic vegetation will remain in the deeper section due to limited water exchange in the bay, subsequently creating anoxic areas as it decomposes.
5. The entire bottom of Täktominlahti Bay is sandy, and over the years the occurrence of *Myriophyllum* vegetation has apparently caused a relatively thin layer of loose sediment to accumulate on top of an area that is approximately one metre deeper than the rest of the bay.

2.4 Action plan

Based on the results of the baseline survey, we decided to continue according to the plan presented in the CoastNet LIFE project application, i.e. by mowing approximately 10 hectares of the area 3–4 times in accordance with the baseline survey summary. This would focus on the densest *Myriophyllum spicatum* zone and utilise standardised monitoring transects and sediment samples to monitor the impact of repeated mowing on the species. In accordance with this plan, an action plan was prepared for the restoration work in the Protected area compartment information system (SAKTI) maintained by Metsähallitus (Sakti site ID 634 CoastNet LIFE_Täktominlahti).

During preparation of the action plan, it became apparent that *Macroplea pubipennis* was observed in the Kobben shore zone of the bay in 2002 (Environmental Information System Hertta, entry made by Jaakko Mattila and Juha Siitonen). This observation was not known when the CoastNet LIFE project plan was being compiled, so further clarifications were initiated as soon as this was noticed.

2.4.1 *Macroplea pubipennis* survey

Macroplea pubipennis is a threatened species subject to special protection in Finland. It is protected under the Nature Conservation Act, listed in Annex II of the European Union Habitats Directive and designated as a species for which Finland is responsible. An adult *Macroplea pubipennis* is a beetle of approximately 6-8 mm in length that spends its entire life cycle under water (Figure 6). It lives in brackish waters and may occur with *M. mutica* or *M. appendiculata*. *Macroplea pubipennis* has only been observed on the Finnish coast and in China, while *M. mutica* and *M. appendiculata* are common, for example, in Europe. The 2002 observation recorded in the Hertta system had to first be verified so that we could apply for a permit for the actual action plan from the ELY Centre, which is the authority responsible for Natura areas and the supervisory authority referred to in section 15 of the Water Act.

The *Macroplea pubipennis* survey was commissioned as an outsourced service from Rami Laaksonen (Nixplore). The survey was carried out by research divers, hydrobiologist Rami Laaksonen, ichthyologist Niclas Perander and hydrobiologist Sanna Saari, who had previous experience in mapping the species in question in Uusimaa (e.g. Espoonlahti), Satakunta and Southwest Finland. On 15 April 2020, the ELY Centre for Uusimaa granted the members of Nixplore and their research assistants a permit to deviate from species protection (UUDELY/3936/2020) for the purpose of carrying out genetic analyses of aquatic beetles.

The field work for the survey was performed on 14–15 June 2020. The search for *Macroplea pubipennis* was conducted by snorkelling and by using compressed air equipment in deeper areas. The divers made observations of plants that *Macroplea pubipennis* feeds on and the vegetation on the bottom. A total of 29 survey points were established in Täktominlahti Bay, with two or three divers in the water at the same time. At each survey point, the, divers searched for *Macroplea pubipennis* for approximately 20 minutes in an area of approximately 300 m^2. Species identification of the aquatic beetles was carried out using a loupe in the terrain, and

specification of the species pair *M. mutica* and *M. appendiculata* was performed with genetic analysis at the University of Turku.

A total of six adult *Macroplea* and one larva were found in the survey. Based on genetic analysis, all the individuals found were identified as *Macroplea mutica*. The beetles were found on the western and eastern sides of the bay. No *Macroplea* were observed in the deeper parts of the bay where mowing was planned, and all the *Macroplea mutica* were found at a depth of less than 0.7 metres. The final report of the *Macroplea* survey (Laaksonen 2020, unpublished final report) states that if there are *Macroplea pubipennis* in Täktominlahti Bay, their number must be small based on the survey. Based on the number of individuals observed, the population of *Macroplea mutica* also appears to be small.

The action plan was finalised after the *Macroplea* survey. On 20 August 2020, the ELY Centre for Uusimaa acknowledged the results of the *Macroplea* survey, and we received permission to proceed according to the action plan. A notification of mowing pursuant to Chapter 2, section 15 of the Water Act (587/2011) was also submitted for mowing, i.e. the mechanical removal of aquatic plants. The ELY Centre for Uusimaa granted a permit for the measure on 10 September 2020 (UUDELY/9488/2020). The approved action plan was published on the CoastNet LIFE project website (https://www.metsa.fi/projekti/rannikko-life-hanke/rannikko-life-hankkeen-aineistot/).

Figure 5. *Macroplea pubipennis*. Photo: Jyri Tirroniemi / Parks & Wildlife Finland.

2.5 Monitoring of the restoration pilot project

The monitoring of mowing measures played an important role in the project due to the small amount of experience with marine nature restoration and the great potential for the spread of *Myriophyllum spicatum*. Monitoring was based on standardised dive transects and vegetation squares in Täktominlahti Bay (changes in vegetation and their abundance ratios), monitoring the development of organic matter in bottom sediments, and observing the development of vegetation in the mowed area in aerial photographs.

Divers established seven 100-metre vegetation monitoring transects around the planned mowing area in the bay (Figure 6). The dives to establish these monitoring transects were made by Alleco Oy in 2020–2024 to monitor changes in vegetation. A standardised shoot density quadrat was established in 2019 as part of the baseline survey of the bay carried out by Monivesi Oy. Changes in the shoot density of vegetation were monitored in this square until 2024 (Figure 6). Sediment samples were repeatedly taken from the bottom at the shallow and deep ends of two dive transects (transects 1 and 5) to monitor the development of sedimentation, i.e. the amount of organic matter, using ignition loss (550°C, % of average) and amount of dry matter (105°C). Ignition loss in a sediment sample is the decrease in weight occurring when the soil burns, and it roughly corresponds with the concentration of organic matter in the sample (Salonen et al. 2006). The temperature used when testing ignition loss in sediment samples is 550 degrees Celsius. Dry matter analysis was used as a support analysis for ignition loss. The amount of water in the samples can be determined by means of moisture and dry matter concentration. Dry matter concentration refers to the amount of solid matter remaining in the sample dish after drying.

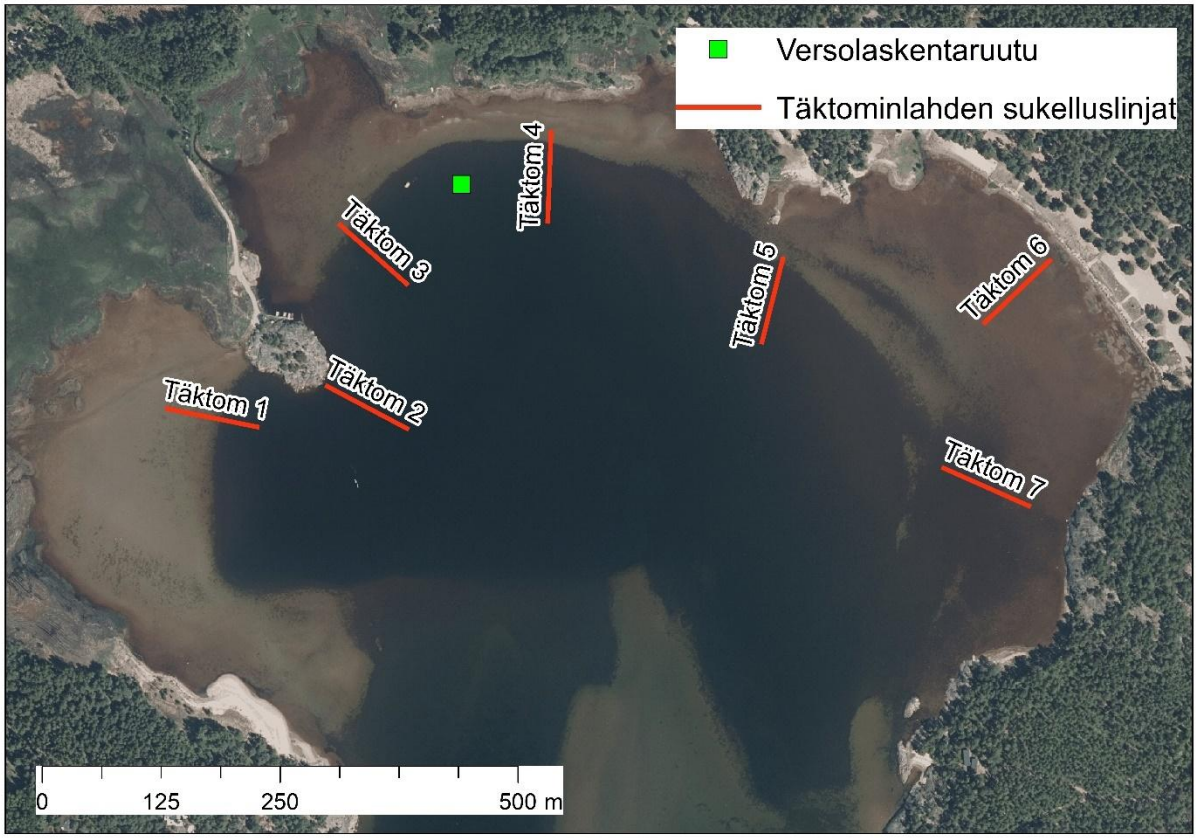


Figure 6. The 100-metre monitoring transects (Täktom 1–7) established in Täktominlahti Bay are marked with red lines. The standardised shoot density quadrat is marked with a green square. Sediment samples were taken from the shallow and deep ends of transects 1 and 5 each year in 2019–2024. Photo: Tytti Turkia / Parks & Wildlife Finland.

Sediment samples were taken with a tube (Figure 7) that was 7 centimetres (cm) in diameter. The tube was pushed approximately 7 centimetres (cm) into the bottom. Sediment samples were taken from the shallow and deep ends of transects 1 and 5 at points where there was no vegetation. Transects 1 and 5 were established in 2019 as part of the baseline survey of the bay, and sediment samples were taken annually until 2024. The samples were frozen, and their analyses ordered from ALS Finland Oy as an outsourced service.

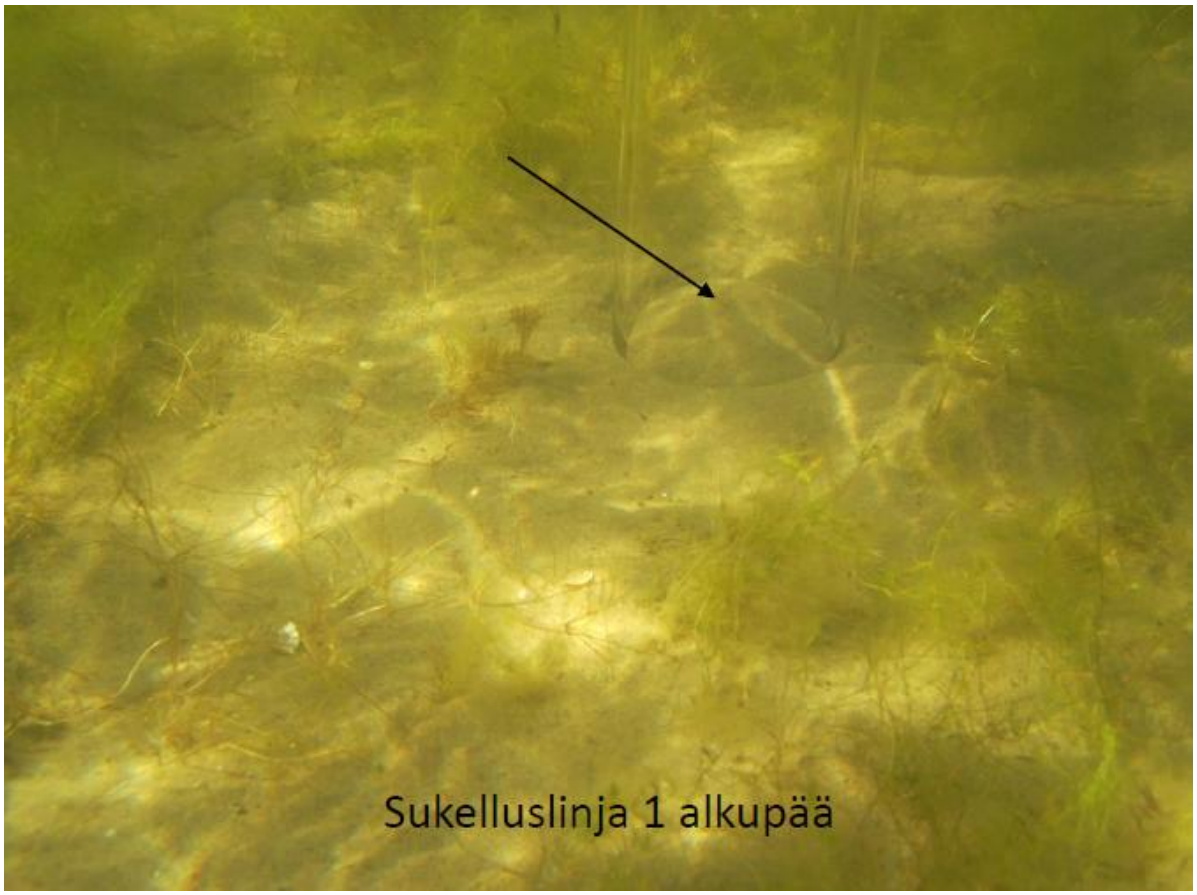


Figure 7. Sediment sample tube at the shallow end of dive transect 1 (sukelluslinjan 1 alkupää) before being pushed into the bottom. Photo: Ari Ruuskanen / Monivesi Oy.

2.6 Competitive tendering for mowing and monitoring in Täktominlahti Bay

The mowing in Täktominlahti Bay and related monitoring in Hankoniemi was put out to tender together with marine nature surveys carried out in the CoastNet LIFE project in Archipelago National Park and Bothnian Bay National Park and the Bothnian Bay islands (CoastNet LIFE project surveys 2020 and mowing work 2020–2024, MH 1810/2020. The procurement was divided into eight areas, of which area 7 applied to mowing of aquatic vegetation in Täktominlahti Bay, and area 8 to monitoring of the mowing work. A tender could be submitted for one or more areas. Based on the competitive tendering, one contracting party was selected for each area. The tendering process was carried out in accordance with the Act on Public Procurement and Concession Contracts (1397/2016) under the direction of Metsähallitus procurement experts.

Area 7, Täktominlahti, Hankoniemi - CoastNet LIFE mowing of aquatic vegetation, description of the procurement: The purpose is to repeatedly mow an area of approximately 10 hectares in a shallow eutrophic bay in Hankoniemi to remove aquatic vegetation that has taken over the bay and is growing under the water surface at a depth of 0.5–2.5 metres. The mowing will take place in 2020–2023. The mowing waste will be brought to shore and transported elsewhere.

A contract on mowing aquatic vegetation was concluded with Tmi Asmo Paloniitty. The contract was valid from 31 July 2020–30 September 2022. The contract provided the contractor with the right to extend the contract on the same terms and conditions for two one-year option periods (1+1 year).

Area 8, Täktominlahti, Hankoniemi - CoastNet LIFE monitoring of mowing work, description of the procurement: A shallow, eutrophic bay in Hankoniemi will be restored by repeated mowing of the aquatic vegetation that has taken over the bay. In 2020–2024, the impact of restoration measures on the area will be monitored annually by means of vegetation monitoring transects, a shoot density quadrat, and drone photography of the area. Development in the amount of sediment will be monitored with tube samples taken from the bottom. Based on the data obtained from monitoring, Parks & Wildlife Finland will assess the effectiveness and impact of the restoration measures and, if necessary, take corrective measures.

A contract for monitoring of mowing was concluded with Alleco Oy. The contract was valid from 31 July 2020–30 November 2024.

3 Progress of the work

3.1 The year 2020

During the planning stage, an unforeseen old observation of *Macroplea pubipennis* and the required species survey in the terrain and sample analysis delayed the planned permit process for the first year with the ELY Centre, which subsequently delayed the planned schedule for mowing and monitoring. The original aim was to have the monitoring and mowing work carried out at the beginning of August immediately after the end of restrictions to safeguard the bird nesting season and when the *Myriophyllum spicatum* biomass is at its highest. Mowing at that time would have simultaneously improved the conditions for recreational use by summer residents.

The monitoring work carried out by Alleco was eventually implemented on 7 September and 16 September 2020. Transects 1–4 were done on 7 September 2020 and transects 5–7 on 16 September 2020. The monitoring was performed in two parts due to stormy weather and other work.

Tmi Asmo Paloniitty carried out the first mowing of *Myriophyllum spicatum* on 23–27 September 2020. During the week prior to the mowing, a SUP board was used to move through the terrain and mark the planned mowing area with buoys and weights. The indicative mowing area was marked in aerial photographs and delivered to the mowing entrepreneur in advance.

Two mowing machines were used (Figure 8). One mainly performed the mowing, while the other was used to bring the mowed vegetation to shore. The total amount of mowing waste was approximately 60 cubic metres (m^3) and the estimated mowing area approximately 8

hectares (ha) in size. The mowing waste was laid on the rocks at Kobben to dry for about a week, and later transported to a local farmer's field for use as fertiliser. The same further processing of mowing waste was repeated in the following years.

Figure 8. Mowing work with two machines in Täktominlahti Bay in 2020. The mowed *Myriophyllum spicatum* was laid on the shoreline rocks to dry before being transported to a nearby field. Photo: Asmo Paloniitty / Tmi Asmo Paloniitty.

3.2 The year 2021

Annual monitoring was performed on 31 July 2021 (transects 1–4) and on 2 August 2021 (transects 5–7).

The mowing was carried out on 17–20 August 2021. The total amount of mowing waste was 35 cubic metres (m^3) and the estimated mowing area approximately 8 hectares (ha) in size. The amount was considerably smaller than in the previous year (difference approximately 25 m^3). The smaller amount of mowing waste was probably influenced by the very high level of sea water (+40 cm) during the mowing work, which meant that the mowing area targeted a shallower area where there was less *Myriophyllum spicatum* than in the previous year.

3.3 The year 2022

Annual monitoring was performed on 1–2 August 2021. Transects 5–7 were surveyed on the first day, and transects 1–4 on the following day.

In contrast to previous years, mowing was carried out on a single day (15 August 2022) with four mowing machines. The total amount of mowing waste was 50 cubic metres (m^3) and the estimated mowing area was approximately 6 hectares (ha) in size, which was smaller than in the two previous years. Examination of the mowing results with aerial photographs revealed that no signs of the mowing machine were visible in the eastern part of the mowing area in particular, indicating that the area had not been mowed for some reason.

Mowing carried out on one day provided us with a new observation and problem: although two mowing machines focused only on the removal of mowing waste, not all mowing waste could be removed from the mowing area on a single day. This became apparent during an inspection visit on the following day, when a large patch of drifting mowed plant mass was observed in the north-western parts of the area east of Kobben. As an emergency solution, a 6-person volunteer group of Parks & Wildlife Finland's employees was assembled on 18 August 2022. They used rakes, a rubber boat and SUP boards to move the drifting plant mass to the shoreline rocks where the mowing entrepreneur had collected the mowing waste on the day of mowing. With help from the chair of the Täktominlahti Management Association, information on the results of the mowing work and the corrective measures was communicated to local residents. Not all the plant mass could be removed manually during one day, so the mowing entrepreneur returned to finish cleaning the area on 22 August 2022.

Based on the experience gained in 2022, it seems that the *Myriophyllum spicatum* will sink immediately after mowing and only float back to the surface during the following days. This situation did not occur in previous years, as mowing and collection of mowing waste in Täktominlahti Bay was carried out over a period of several days.

3.4 The year 2023

Annual monitoring was performed on 31 July 2023 (transects 5–7) and on 1 August 2023 (transects 1–4).

The project application and action plan stated that mowing in Täktominlahti Bay would take place 3–4 times during the project. However, the mowing entrepreneur was not willing to exercise the option recorded in the mowing agreement, which would have applied to the fourth and last mowing in 2023. As monitoring showed that the removal of aquatic vegetation using the mowing method had not proven to be a very effective method in Täktominlahti Bay, we did not start a competitive tendering process to find another mowing entrepreneur for the last mowing.

Parks & Wildlife Finland examined the possibility of testing a newer technique in Täktominlahti Bay (Clewat Oy, https://clewat.com/haittakasvien-kerays/), which only became available on the market after the start of the CoastNet Life project. According to Clewat's marketing material,

their Cleansweep vessel would remove submerged plants, such as *Myriophyllum spicatum* (and possibly also its roots), using a suction method instead of a traditional harvesting blade. Parks & Wildlife Finland was very interested in the method, but it was not possible to order a service package from the company that would have met Parks & Wildlife Finland's needs. However, we had the opportunity to become familiar with the device and technology at another restoration site.

3.5 The year 2024

Annual monitoring was performed on 1–2 August 2024. Transects 1–4 were surveyed on the first day, and transects 5–7 on the following day.

3.6 Water samples

During implementation of the measures of the CoastNet LIFE project, clear-cutting was being carried out on private land in the catchment area of the bay in 2020–2021. The impact of this was visible in Täktominlahti Bay: the water in the bay became browner due to humus in the runoff water. As a result, water samples were taken from the sea outfall (Täktominpuro brook) draining into the bay (Figure 9) after heavy rains in spring 2021. The samples were taken by a local excavator entrepreneur on 31 March and 27 May. Postdoctoral Researcher Matias Scheinin from the City of Hanko's Department of Environmental Protection also took six samples from Täktominlahti Bay on a recurring basis as part of the Havsmanualen 3 -project (Figure 10). The samples were taken once a month on 23 April, 25 May, 2 July, 6 August, 17 September, and 24 October 2021 as part of the Coastrider monitoring rounds (Prolitore 2024). The samples were frozen and analyses of them ordered as an outsourced service from the Lahti laboratory of Eurofins Environment Testing Finland.

Monitoring the development of total nitrogen and phosphorus in the sea outfall draining into Täktominlahti Bay and the area in front of the bay was not planned as part of the CoastNet LIFE project and no money had been allocated for this in the project. However, water samples were taken during a single growing season due to the observed change in the colour of the water in the bay. In hindsight, we can conclude that monitoring of nutrient concentrations should always be included when measures are implemented in an aquatic environment, because water is a soluble element that disperses nutrients over a very large area.

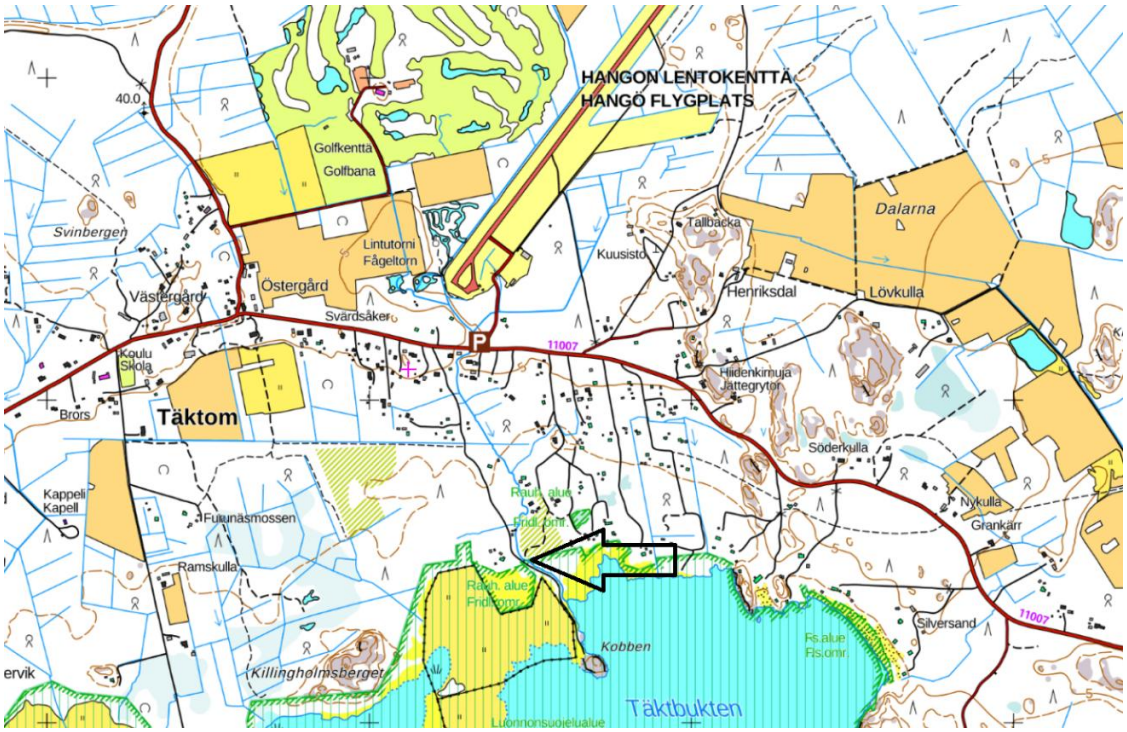


Figure 9. A sampling point from which water samples were taken from a brook flowing into Täktominlahti Bay in March and May 2021 is marked with a black arrow, © National Land Survey of Finland 1/MYY/2024, © Metsähallitus 2024.

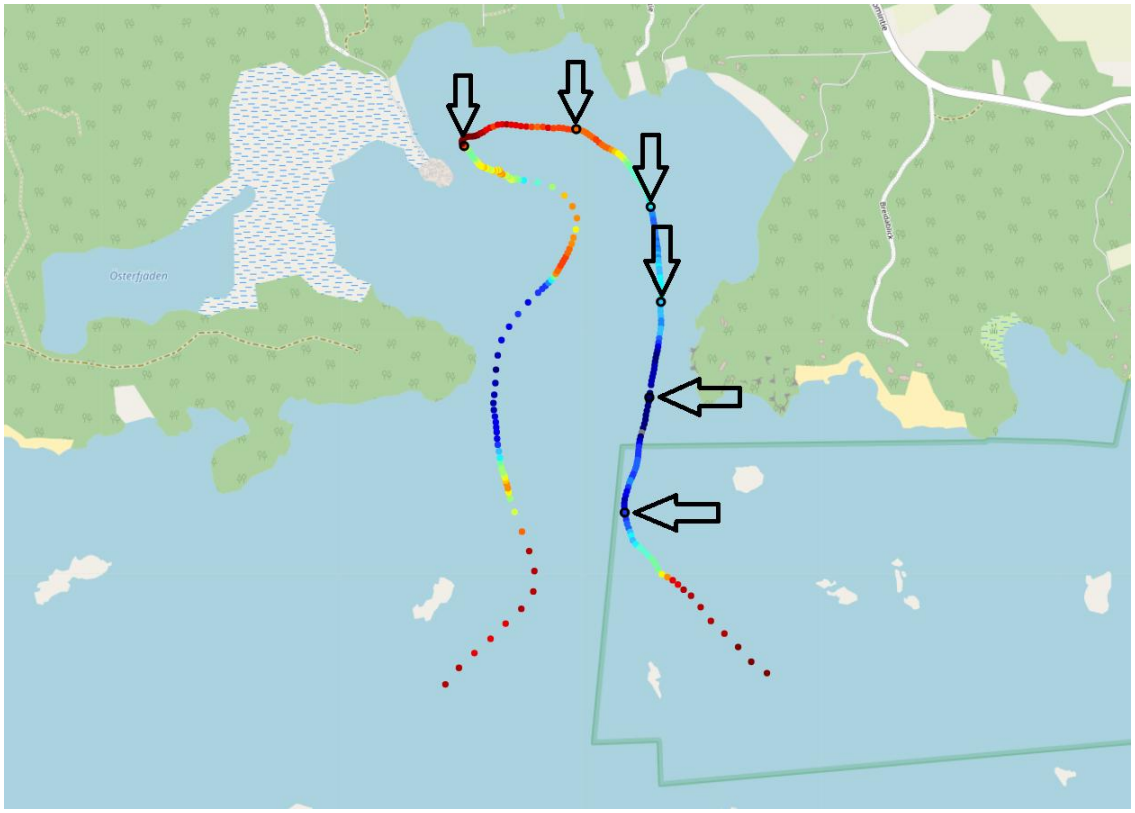


Figure 10. Black arrows indicate six sampling points in and in front of Täktominlahti Bay from which the Havsmanualen 3 project took recurring water samples (total nitrogen and phosphorus) between March and October 2021 as part of its Coastrider monitoring rounds. The line of dots shows the standardised route of the Coastrider monitoring round and the total nitrogen concentration values measured along it in April 2023. The nitrogen concentration scale was not included in the image, as those measurements were carried out in 2021 in the CoastNet LIFE project. Photo: Matias Scheinin.

4 Results

4.1 Dive transects

4.1.1 Ordination

Ordination is a multivariate method that can be used to visually present data consisting of observations of several species made at the same site in simple 2D format. Rather than examining the occurrence of many different species, two ordination axes are used to describe the total occurrence of the species. The stress value of ordination describes how well the occurrence of all species can be described using these two axes. A stress value of more than 0.2 indicates that the results of the ordination cannot be considered reliable.

The source data was seven vegetation transects established by diving (Figure 6) in 2020–2024. The original monitoring data contains several dive squares per transect. For the analysis, a version of the data was produced in which one row represents a single transect, and the species values are averages for the assessment squares in each transect. As a result, one point in the ordination images corresponds to one year of surveying one transect, which makes it easier to interpret the results than if the data was square-specific and the squares grouped hierarchically inside the transects. The editing and analyses of the data and their explanations were done by Tytti Turkia, Senior Specialist in Parks & Wildlife Finland's marine conservation team.

The ordinations were run using the metaMDS function of the vegan R package. In technical terms, the ordination was very successful because the stress value is approximately 0.1. Ordination was performed for abundance data without any modifications.

4.1.2 Differences between dive transects

The transects are clearly grouped in the ordination diagram, in other words, there is less species variation within the transects than between them (Figure 11). Regardless of the year, clear differences can be seen between the transects (Figure 12). Variation between the years is minor and unclear, and this is less related to the amount of *Myriophyllum spicatum* than to other species changes (Figure 13). Based on the analyses, it appears that repeated mowing of aquatic vegetation has not impacted the species in the area or the amount of *Myriophyllum spicatum* (Figure 14) in the monitoring transects. Only *Chara aspera* seems to have disappeared from the monitoring transects in 2024, and in general the number of *Charales* observed in Täktominlahti Bay decreased during our monitoring period. One possible reason for the decline in *Charales* may be a deterioration in water quality.

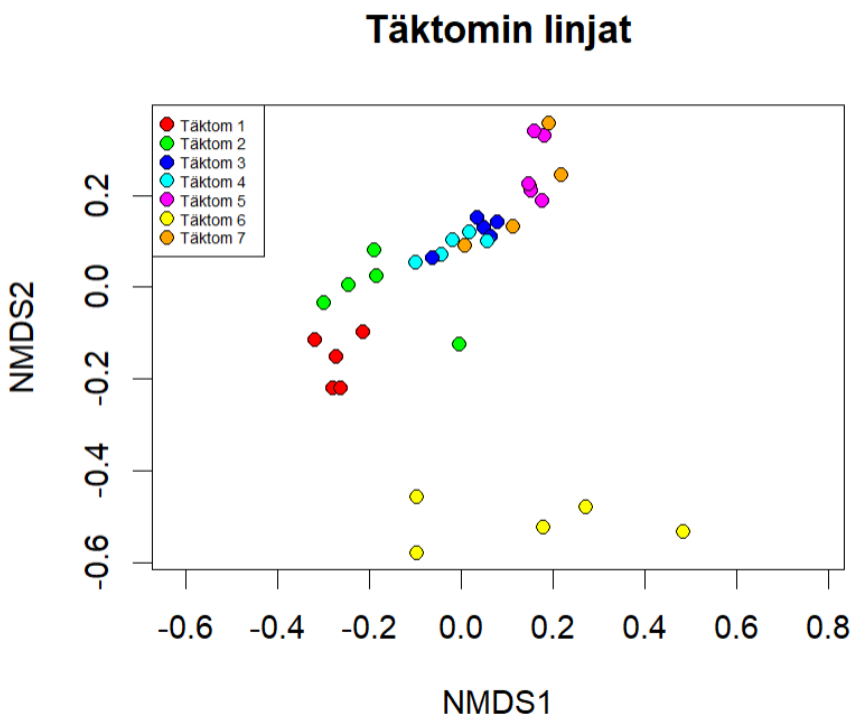


Figure 11. Täktom transects. Location of transects 1-7 (different-coloured dots) in the ordination diagram during the monitoring years 2020–2024. One dot represents one monitoring year, and one colour represents one monitoring transect. The transects are clearly grouped by colour in the ordination diagram, which means that the transects differ from each other in terms of species regardless of the year. Photo: Tytti Turkia / Parks & Wildlife Finland.

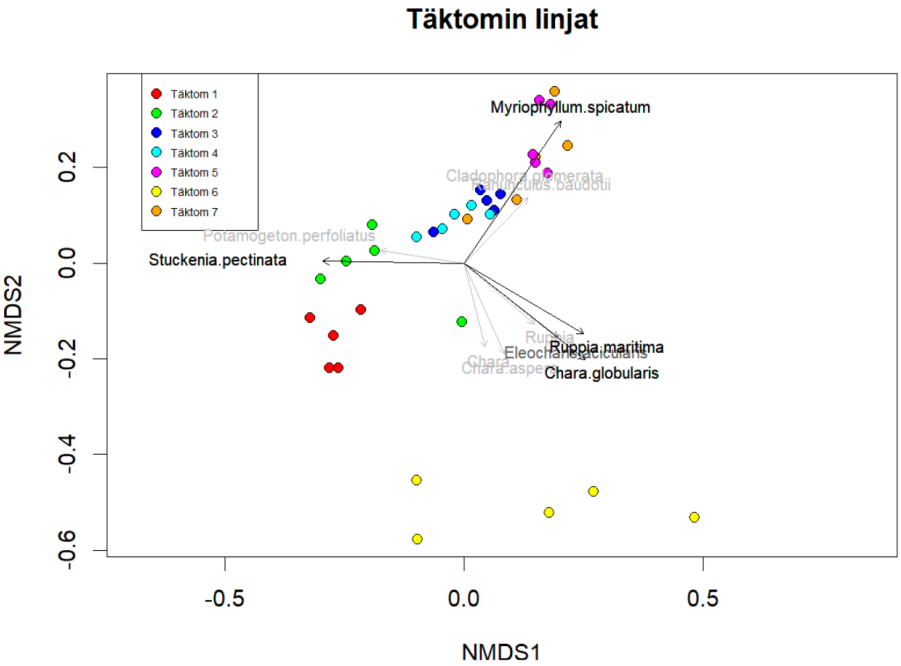


Figure 12. Täktom transects. Regardless of the year, there are clear differences between the transects. The least amount of *Myriophyllum spicatum* occurs in transect 6 (yellow dots) and the most in transect 5 (pink dots). More *Chara sp.* and *Ruppia maritima* are growing in transect 6 than in the other monitoring transects. Photo: Tytti Turkia / Parks & Wildlife Finland.

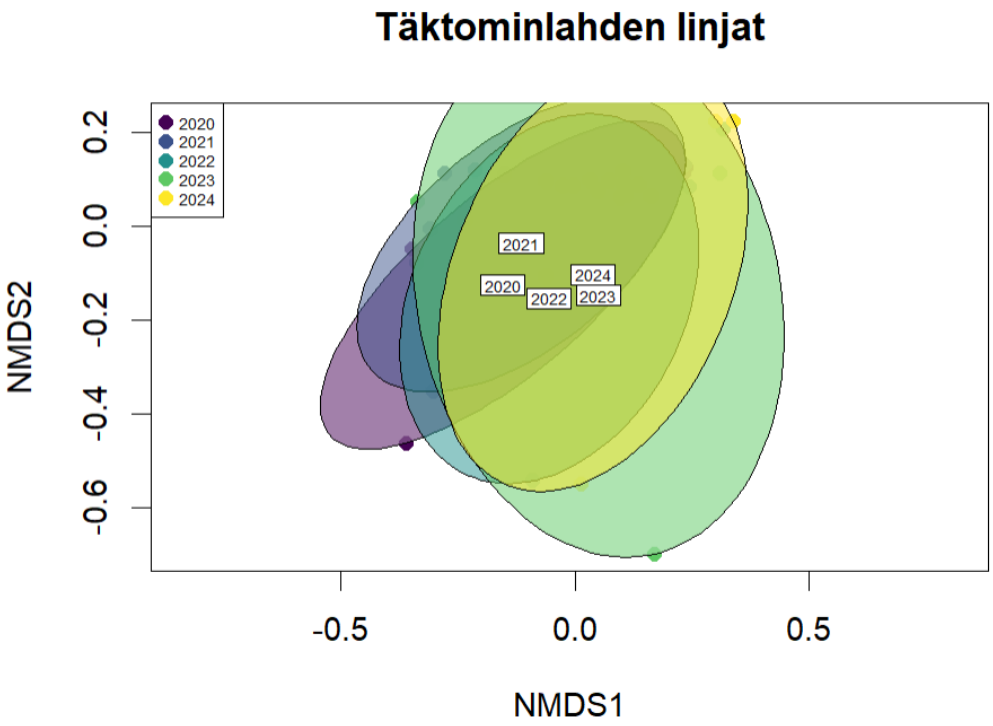


Figure 13. Täktominlahti Bay transects. The data from different years (2020–2024 in different colours) mostly overlap. In other words, there is more species variation within years (between transects) than between years. Photo: Tytti Turkia / Parks & Wildlife Finland.

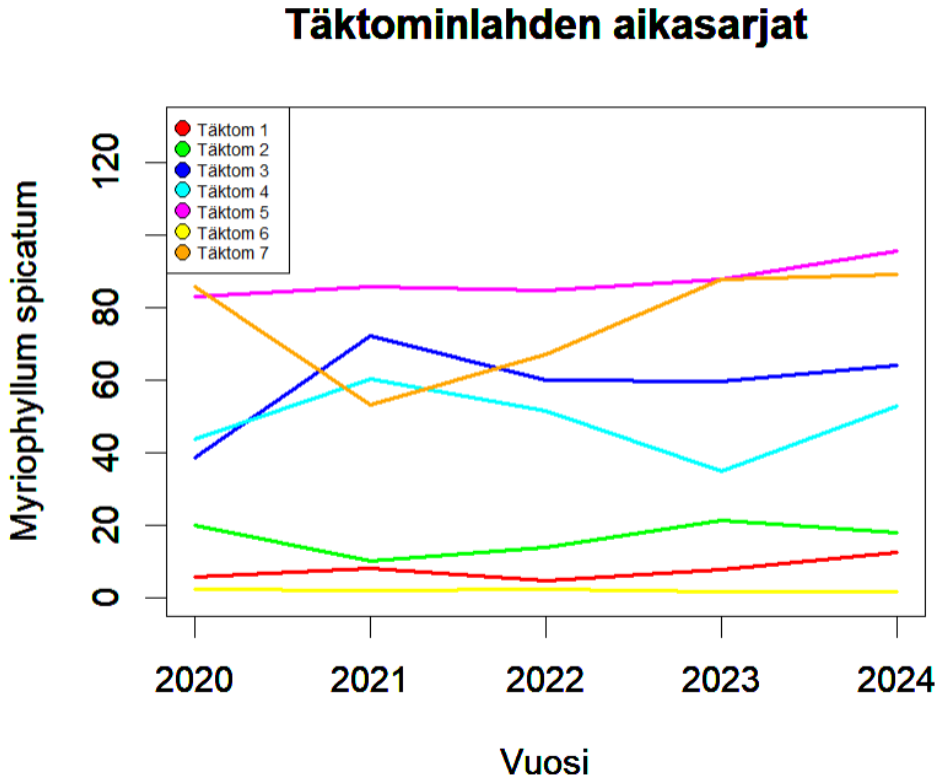


Figure 14. Täktominlahti Bay time series. Development in the amount of *Myriophyllum spicatum* in the monitoring transects in 2020–2024. Repeated mowing does not appear to have impacted the amount of *Myriophyllum spicatum* in the monitoring transects. Photo: Tytti Turkia / Parks & Wildlife Finland.

4.2 Shoot density quadrat

A standardised shoot density quadrat was located outside the monitoring transects (Figure 6), and this was used to count the number of *Myriophyllum spicatum* shoots annually. The time series in the shoot density quadrat differs from the time series in the monitoring transects. The shoot count remained fairly stable in 2019–2021, increased in 2022, and then began to slowly decrease while still remaining at a higher level (Figure 15). None of the dive transects showed the same trend in the amount of *Myriophyllum spicatum*.

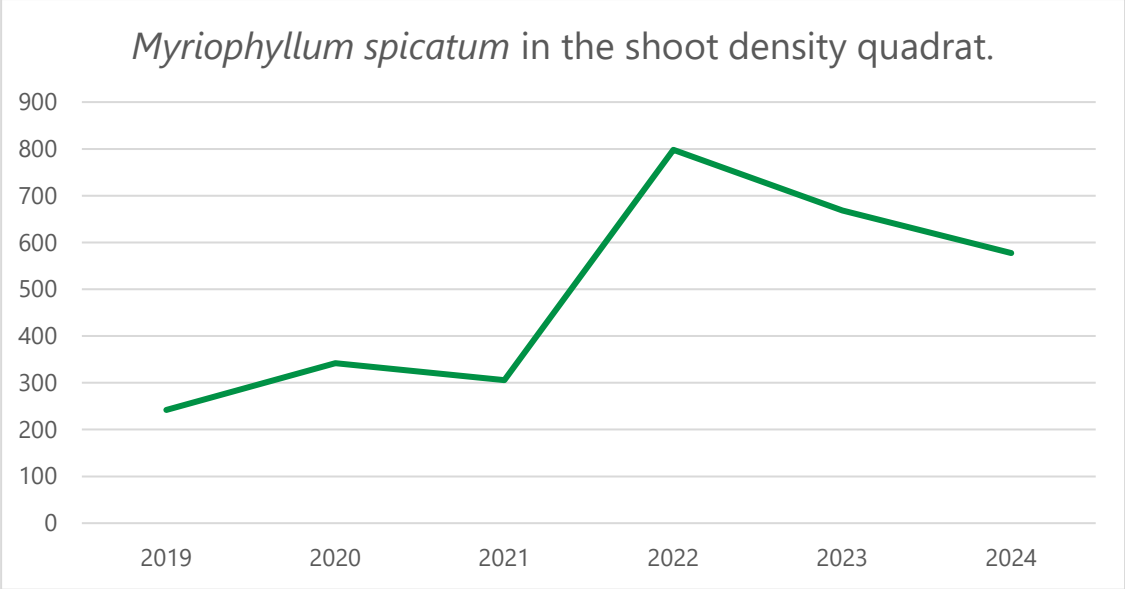
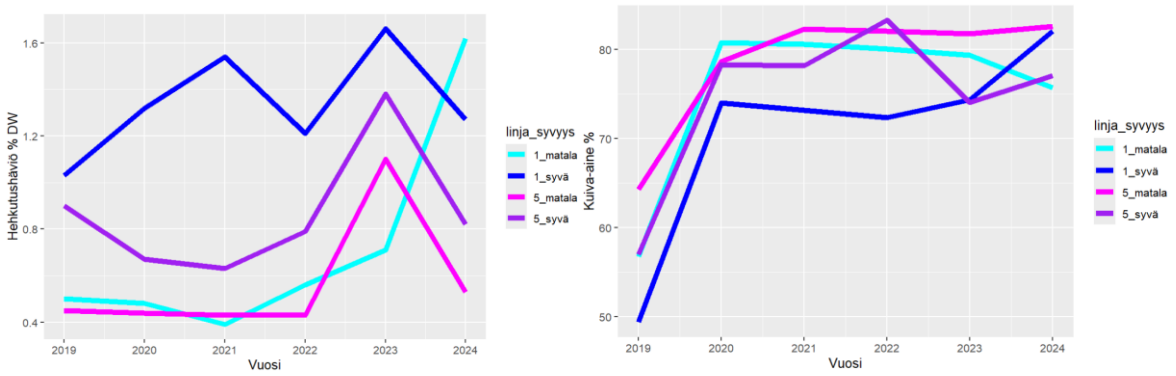


Figure 15. Development of the number of *Myriophyllum spicatum* shoots in the standardised monitoring quadrat in 2019–2024. The number of shoots increased during the monitoring period in 2022 and then began to slowly decrease. Photo: Tytti Turkia / Parks & Wildlife Finland.

4.3 Development of the amount of organic matter in samples taken from the bottom

The development of organic matter accumulating on the bottom, or sedimentation, was also monitored in the area of monitoring transects 1 and 5. Samples from the bottom were taken from the shallow and deep ends of transects 1 and 5 each year in 2019–2024.

Ignition loss is usually higher at the deep end than at the shallow end of the transects (Figure 16), which means that the concentration of organic matter was less in the shallower shore zone than in the deeper zone. This is a logical result, because the water movement caused by waves is greater in the shallower shore zone and this keeps the bottom clean. Water movement is less at the deep end of the transects, and the dense and abundant vegetation occurring in some places promotes the accumulation of organic matter on the bottom. There was a significant rise in ignition loss in 2023, which means that the concentration of organic matter increased in 2023 (Figure 16). The increase took place after the mowing measures ended, but the organic matter concentration decreased again in 2024, so the end of mowing measures cannot be considered an explanatory factor. The dry matter concentration increased already in 2020 and has remained high since then (Figure 16). The samples were taken by a different operator in 2019 (Monivesi Oy) than in 2020–2024 (Alleco Oy), which may explain the differences between the initial situation and the following years.



Figures 16. In order to monitor the development of organic matter, ignition loss 550°C (% DW, dry weight, figure on the left) was measured and dry matter 105°C (%, figure on the right) was used as ignition loss support analysis in two monitoring transects. The results for the shallow end of transect 1 are shown with a turquoise line and the results for the deep end of transect 1 are shown with a blue line. The results for the shallow end of transect 5 are shown with a pink line and the results for the deep end of transect 5 are shown with a purple line. Photo: Tytti Turkia / Parks & Wildlife Finland.

4.4 Water samples

The results of the water samples are attached as Appendix 2. During the measurement period, the concentrations of total nitrogen and phosphorus (µg/l) were higher in April in the inner parts of the bay near the sea outfalls (sample points 5 and 6, Figure 10) than they were near the inlet of Täktominlahti Bay (sample points 2-4, Figure 10) or outside the bay (sample point 1, Figure 10). Water samples taken from the sea outfall in March and May 2021 (Figure 9) contained significantly higher concentrations of total nitrogen (1,200 and 1,600 N µg/l, Appendix 2). Samples taken at joint observation points monitored by the Association for Water and Environment of Western Uusimaa (Asp & Tanttu 2021) in April of the same year showed 330 (N µg/l) total nitrogen and 35 (P µg/l) total phosphorus at the observation station located closest to Täktominlahti Bay (H1B Hankoniemi, south 156). In June, total nitrogen at this monitoring point was 250 (N µg/L) and total phosphorus 10 (P µg/L) and in August total nitrogen was 280 (N µg/L) and total phosphorus 17 (P µg/L). (Asp & Tanttu 2021).

5 Review of the results

Based on field observations made in Täktominlahti Bay and multivariate analyses of the monitoring data, repeated mowing of aquatic vegetation did not reduce the amount of *Myriophyllum spicatum* in Täktominlahti Bay. Furthermore, the results of sediment samples taken from the two monitoring transects to assess the development of organic matter concentration did not correspond to the expected results concerning a decrease in organic matter concentration. As a result, mowing the vegetation does not seem to have improved water flow in the bay in a manner that would reduce the accumulation of organic matter on the bottom.

Based on the monitoring transects, mowing did not increase the amount of *Myriophyllum spicatum*, which was identified as one of the risks associated with the mowing measure prior to starting the activities: if the mowing waste could not be completely removed from the bay, *Myriophyllum spicatum* might spread further in the bay as it can propagate asexually from dispersed plant parts. Monitoring of the standardised shoot density quadrat indicated that the number of *Myriophyllum spicatum* shoots in the bay first increased and then decreased during the monitoring period, remaining at a higher level in comparison to the initial situation. This may be due to mowing, natural year-to-year variation, or nutrient loading in the catchment area. During the project, clear-cutting was being carried out on private land in the catchment area of the bay in 2020-2021. The impact of this was visible in Täktominlahti Bay: the water in the bay became browner due to humus in the runoff water. The impact of the catchment area on the situation in Täktominlahti Bay is supported by water samples taken in March and May 2021 from the sea outfall flowing into Täktominlahti Bay. These showed a total nitrogen concentration between 1,200-1,400 µg/l. Nitrogen enters water bodies with wastewater, runoff water and rainwater. According to the guidebook on interpreting water body results (Oravainen, R. 1999), the total amount of nitrogen in humus-rich waters varies between 400 and 800 µgN/l, but the amount of nitrogen in very brown waters is naturally more than 1,000 µg/l. Total phosphorus varied between 31 and 69 µg/l in the outfall samples. According to Oravainen's guide (1999), waters containing more than 50 µg/l of phosphorus are already classified as very eutrophic.

6 Conclusions

Based on the experience we obtained in the CoastNet LIFE project, the traditional mowing machine used in Täktominlahti Bay that was primarily developed for mowing lake reeds is poorly suited for the removal of submerged water vegetation. Although a mowing cutter with a longer reach was built to meet the needs of the Täktominlahti restoration project, the removal results were uneven. A "stubble" of plant shoots of varying length remained on the bottom in the mowing area. There is a clear need to develop a mower that is specifically designed for the removal of submerged vegetation. In terms of achieving a more lasting outcome, it would also be important to remove the roots of the vegetation in order to permanently weaken the growth of the perennial plant. The intention in Täktominlahti Bay was to remove the roots of *Myriophyllum spicatum* manually by diving, but this proved impossible: the delicate root system formed a very hard and compact mass on the sandy bottom that was impossible to cut through even with a knife.

Parks & Wildlife Finland has little opportunity to influence the situation in the catchment area, as there are no state-managed land areas in which the status of the Täktominlahti catchment area could be improved. Fortunately, the contribution of the local waters management association has led to the creation of a larger and more influential organisation of Baltic Sea supporters called Minun meri ry. Among other things, it is working to promote a restoration project targeting a drained peatland located in the Täktominlahti Bay catchment area. The aim of the Minun mereni organisation is to use funding from the ELY Centre and the Ministry of the Environment's water protection programme to restore a drained peatland called

Täktomträsket located in the upper reaches of the brook flowing into Täktominlahti Bay (Minun Mereni ry 2024). Implementation of the Täktomträsket restoration project and ensuring that water management is properly implemented at the HanGolf golf course located in the bay catchment area will provide better possibilities for recovery of the underwater marine environment in Täktominlahti Bay. As the authority responsible for management of the Täktominlahti Bay water area and the more extensive Täktominlahti and Svanviken Nature Reserve, Parks & Wildlife Finland will continue to monitor the status of marine nature in the area and plan new restoration methods to improve its status if the nutrient load in the catchment area can be reduced.

6.1 Lessons learned and observations from the Täktominlahti Bay pilot project

While the removal of aquatic vegetation by repeated mowing proved ineffective in terms of removing *Myriophyllum spicatum* or improving the status of Täktominlahti Bay, the restoration pilot and monitoring of a shallow bay carried out in the CoastNet LIFE project provided Parks & Wildlife Finland with a great deal of experience concerning the practical implementation of a marine nature restoration project. The restoration project in the shallow bay at Täktominlahti was one of the first marine restorations carried out by Parks & Wildlife Finland's marine conservation team, so the work was performed while simultaneously learning from each phase. The restoration work required familiarisation with procurement and competitive tendering of various work packages outside Parks & Wildlife Finland, increased experience of drawing up internal action plans in Parks & Wildlife Finland's Protected area compartment information system (SAKTI), permit process handling for measures implemented in Natura 2000 areas with the ELY Centre, stakeholder cooperation and communication with local and summer residents living around the bay and local water management associations, and maintaining contact with entrepreneurs. The project also increased understanding of the complexity of the aquatic environment and the importance of monitoring the restoration measure as well as a comprehensive survey of the initial situation.

Over the past few decades, the volume of *Myriophyllum spicatum* has increased in shallow bays along the Finnish coastal area, especially in the shallow eutrophic bays of the Archipelago Sea and the Gulf of Finland. For this reason, mowing work in Täktominlahti Bay and repeated removal of *Myriophyllum spicatum* by mowing has been a topic of interest during the entire CoastNet LIFE project, as many people living near the coast share a similar problem. The progress of the restoration pilot in Täktominlahti Bay as part of the CoastNet LIFE project, its results and the lessons learned have been presented at various events since the project planning stage, and the experiences gained in the project have also been discussed by telephone and e-mail with individual citizens. The CoastNet LIFE restoration pilot and its observations were included in the Review of Marine Nature Restoration Work and Methods Used in Finland report compiled as part of the LIFE-IP Biodiversea project (2021–2029) led by Metsähallitus Parks & Wildlife Finland (Arnkil et al. 2024), which aimed to summarise the current situation in terms of experience gained from marine nature restoration methods. The report was published in the Nature Protection Publications of Metsähallitus series in Finnish (link) and English (link) in 2024.

The restoration pilot in the shallow bay at Täktominlahti as part of the CoastNet LIFE project has been presented at the following events:

- A discussion event organised by the City of Naantali at Naantali City Hall and remotely, 6 November 2024
- Autumn meeting of the coastal water restoration network in Tammisaari and remotely, 1 October 2024
- Excursion to Hanko as part of the Nordic-Baltic LIFE Platform, 13 September 2023
- Minun mereni ry public event in Hanko, 10 November 2022
- Kotivesistöt kuntoon webinar, 26 October 2022
- CoastNet LIFE project public event in Turku, 7 May 2022
- Restoration of small coastal water bodies and sheltered bays webinar, 20 April 2021
- Water restoration exhibition at the annual water restoration network seminar in Mikkeli (poster), 5 June 2019
- World Oceans Day public event at Tammasaarenlaituri pier in Helsinki, 8 June 2019
- CoastNet LIFE project steering group field visit in Hanko, 14 November 2019
- Adult students in the nature and environmental studies programme at Helsinki Vocational College (Stadin AO), 29 November 2019
- Annual meeting of the Täktom water cooperative, 12 July 2018

These events reached several hundred people, including citizens, environmental students, local residents, nature conservation authorities, city representatives, water protection actors and entrepreneurs – both in Finland and in other Nordic countries.

As the project progressed, the following checklist was compiled for other parties launching a water restoration project.

Checklist for parties planning to mow aquatic plants / lessons learned from the CoastNet LIFE project:

- The nutrient load in the catchment area must be addressed or the effects of restoration measures will only be temporary!
- Remember to submit a mowing notification to the ELY Centre in accordance with Chapter 2, section 15 of the Water Act. Based on the notification, the ELY Centre will assess if a permit is needed for the measure in question and provide more detailed instructions for carrying it out.
- If you are working in a nature reserve: The work should be performed outside the bird nesting season (1 April – 31 July). Contact the authority responsible for managing the area concerning this matter.
- The results of mowing *Myriophyllum spicatum* around the world and in lake environments vary – suitable techniques for removing submerged plants are still inadequate.
- Remember that *Myriophyllum spicatum* can spread from plant parts left behind, so it is important to focus on removing the mowing waste and ensuring that mowing waste is not left to drift into the water environment. If possible, *Myriophyllum spicatum* should be removed repeatedly from the entire area, preferably with its roots.

- Check the reach of the available traditional mowing equipment > a depth in excess of 1.8 metres impairs the mowing result.
- Plan a further use for the mowing waste > good fertiliser for fields. However, remember to take into account any heavy metal accumulations in the aquatic vegetation if the mowing area is located in an area impacted by a catchment with a high load.
- The bottom quality affects the results of the removal and should be tested in advance.
- If a species is removed by mowing, efforts to collect the plants must continue for several days, making it possible to also remove the plants that initially sink under the surface. It is advisable to set aside time and labour resources for follow-up work. Not all mowing waste can be caught immediately from the water column. Use of booms in the mowing area could be a potential solution for collecting plant waste and preventing its spread.
- If you are working in an open area affected by wind and waves: make use of a wind direction that facilitates the collection of mowing waste.
- Our experiences in Täktominlahti Bay: The mowing method is poorly suited for removing *Myriophyllum spicatum*.
- Monitoring: There is still little experience of marine nature restoration and, in particular, long-term monitoring of the impacts of restoration measures in the marine environment is insufficient. If possible, it is also worth allocating time and money to monitoring the impacts of the measures and surveying the initial situation in order to gain an understanding of the impact and cost-effectiveness of the measures. It is particularly important to monitor water quality and nutrient concentration.

New development ideas arising from the project:

- Use of booms in the mowing area to prevent M*yriophyllum spicatum* mowing waste from spreading uncontrollably and unintentionally in the mowing area.
- Could suction dredging of the bottom be a potential and effective method of removing *Myriophyllum spicatum* outside protected areas?
- Permanent eradication of a harmful plant if the so-called problem area is demarcated and clear: Can harmful vegetation be smothered by covering it with a material that can tolerate the environmental conditions and the bottom then ‘re-established’ with a layer of purified sand/silt?

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Appendices

Appendix 1 Species observed during baseline survey and monitoring dives performed at Täktominlahti Bay in 2019–2024

Vague taxons, such as drifting macrophyte, as well as fish and gastropods have been removed from the data. Some sub-species have been combined at the species level. Synonyms have been combined. The scientific and common names were checked on the Laji.fi website maintained by the Finnish Biodiversity Information Facility.

Scientific name	Common name in Finnish
Amphibalanus improvisus	Merirokko
Callitriche hermaphroditica	Uposvesitähti
Ceratophyllum demersum	Tankeakarvalehti
Chara	Näkinparrat
Chara aspera	Mukulanäkinparta
Chara baltica	Itämerennäkinparta
Chara globularis	Hapranäkinparta
Chara virgata	Sironäkinparta
Cladophora glomerata	Viherahdinparta
Dictyosiphon foeniculaceus	Isoluppolevä
Elachista fucicola	Haurunturkki
Einhornia (Electra) crustulenta	Levärupi
Eleocharis acicularis	Hapsiluikka
Eleocharis uniglumis	Meriluikka
Eleocharis parvula	Pikkuluikka
Fucus vesiculosus	Rakkohauru
Hildenbrandia rubra	Meripunakalvo
Myriophyllum spicatum	Tähkä-ärviä

Potamogeton filiformis	Merivita
Potamogeton perfoliatus	Ahvenvita
Potamogeton pusillus	Hentovita
Pylaiella littoralis / Ectocarpus siliculosus	Lettiruskohahtu / Litupilvilevä
Ranunculus baudotii	Merisätkin
Ranunculus circinatus	Pyörösätkin
Ruppia	Hapsikat
Ruppia (cirrhosa) spiralis	Kiertohapsikka
Ruppia maritima	Merihapsikka
Stuckenia	Kaitavidat
Stuckenia filiformis	Merivita
Stuckenia pectinata	Hapsivita
Ulva	Suolilevät
Zannichellia	Haurat
Zannichellia major	Isohaura
Zannichellia palustris	Pikkuhaura
Zostera marina	Meriajokas

Appendix 2 Total nitrogen and phosphorus concentrations (µg/l) at Täktominlahti Bay sampling points in 2021

Samples from the sea outfall draining into Täktominlahti Bay were taken twice in March and May, and samples from in front of the bay were taken six times between April and October. During the August monitoring round, the measuring devices malfunctioned at the last sampling point 6.

Sampling site	Date	Total nitrogen (N µg/l)	Total phosphorus (P µg/l)
Sea outfall, sample 1	31 March 2021	1,200	32
Sea outfall, sample 2	31 March 2021	1,200	42
Sea outfall, sample 1	25 May 2021	1,600	69
Sea outfall, sample 2	25 May 2021	1,600	64
Täktominlahti 1	23 April 2021	260	12
Täktominlahti 2	23 April 2021	260	14
Täktominlahti 3	23 April 2021	260	12
Täktominlahti 4	23 April 2021	260	12
Täktominlahti 5	23 April 2021	260	20
Täktominlahti 6	23 April 2021	280	28
Täktominlahti 1	25 May 2021	310	12
Täktominlahti 2	25 May 2021	360	16
Täktominlahti 3	25 May 2021	490	19
Täktominlahti 4	25 May 2021	260	12
Täktominlahti 5	25 May 2021	270	15
Täktominlahti 6	25 May 2021	260	19
Täktominlahti 1	2 July 2021	320	24
Täktominlahti 2	2 July 2021	290	21
Täktominlahti 3	2 July 2021	320	32
Täktominlahti 4	2 July 2021	280	20
Täktominlahti 5	2 July 2021	300	29
Täktominlahti 6	2 July 2021	260	15

Täktominlahti 1	6 August 2021	300	20
Täktominlahti 2	6 August 2021	290	16
Täktominlahti 3	6 August 2021	330	42
Täktominlahti 4	6 August 2021	270	23
Täktominlahti 5	6 August 2021	290	20
Täktominlahti 6	6 August 2021	malfunction in measuring device	malfunction in measuring device
Täktominlahti 1	17 September 2021	250	11
Täktominlahti 2	17 September 2021	260	9.8
Täktominlahti 3	17 September 2021	290	11
Täktominlahti 4	17 September 2021	260	8.7
Täktominlahti 5	17 September 2021	240	8.6
Täktominlahti 6	17 September 2021	260	13
Täktominlahti 1	24 October 2021	280	24
Täktominlahti 2	24 October 2021	280	27
Täktominlahti 3	24 October 2021	270	23
Täktominlahti 4	24 October 2021	270	28
Täktominlahti 5	24 October 2021	280	32
Täktominlahti 6	24 October 2021	270	31

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METSÄHALLITUS