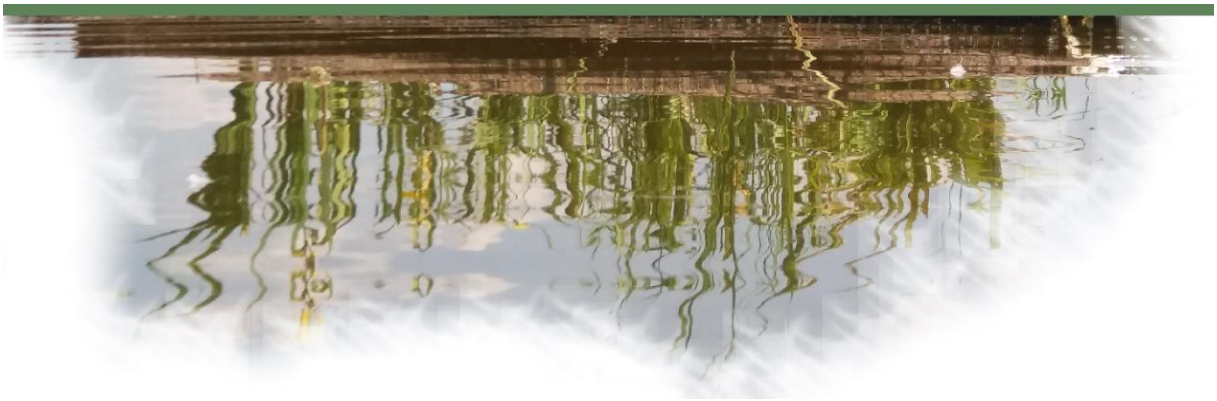
Best practice Guidelines for installation and maintenance of floating islands and nets



LiveLagoons project

2021

These Best practice guidelines are prepared within the implementation of project LiveLagoons „The use of active barriers for the nutrient removal and local water quality improvement in Baltic lagoons", No. STHB.02.02.00-LT-0089/16, a cross-border coopeeration project of the Interreg South Baltic Cross-border Cooperation Programme 2014-2020

Part-financed by the European Union (European Regional Development Fund)

http://www.balticlagoons.net/livelagoons/

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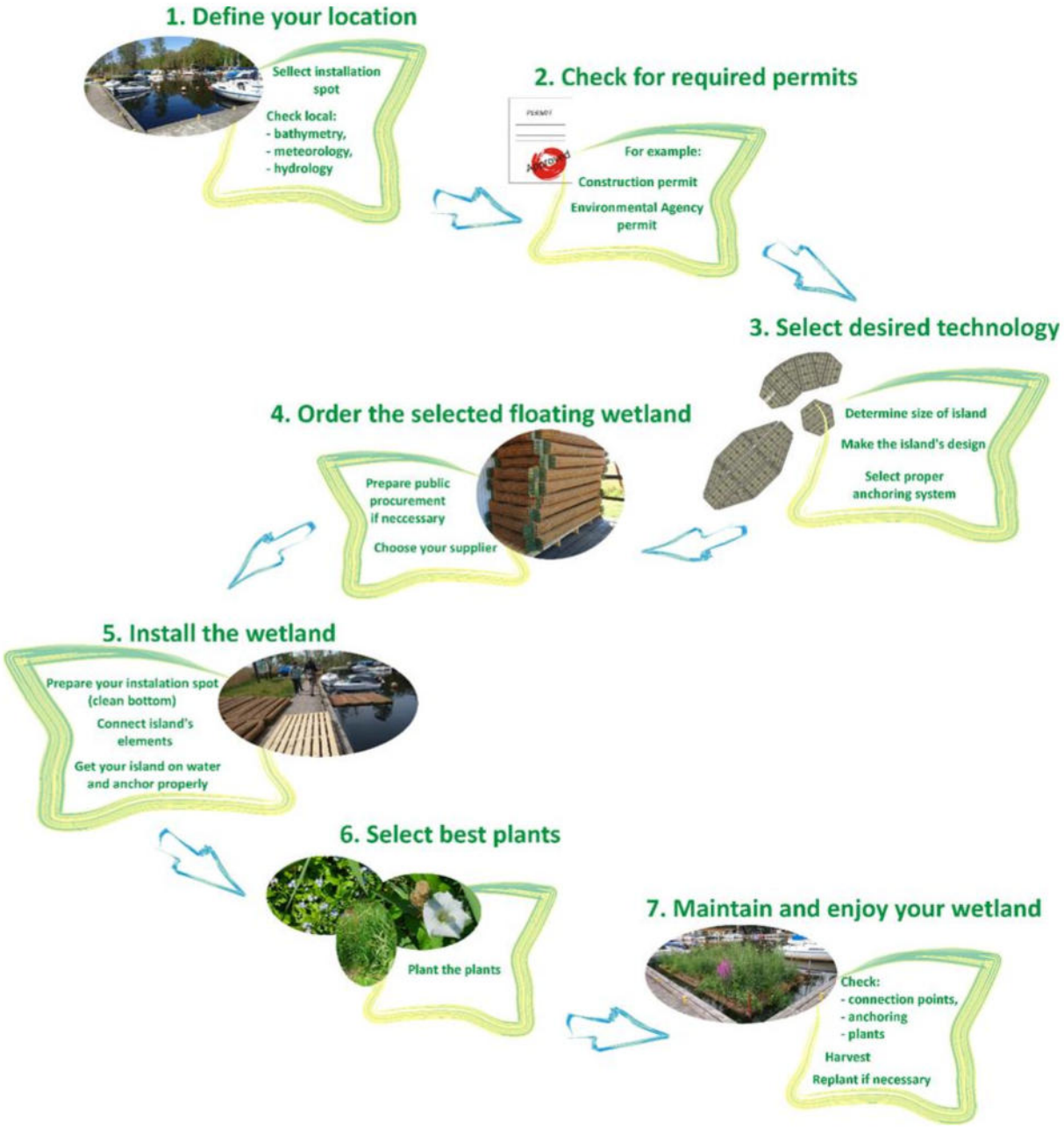
2. Introduction

The following guidelines have been elaborated based on experience and results of LiveLagoons project financed by Interreg South Baltic Programme.The LiveLagoons project aimed at testing different technical solutions of the islands' construction and their efficiency for water clean-up. Furthermore, the potential to use these islands as a coastal protection tool was analyzed (case of Curonian Lagoon). Other benefits of floating macrophyte islands manifested in landscape and biodiversity improvement.

Floating islands or wetlands constitute offer an ecological and efficient option for local water improvement. Thanks to the LiveLagoons project floating macrophytes islands have been adapted to coastal conditions and deployed in three South Baltic locations: Curonian Lagoon (Juodkrante) and Klaipeda city,Lithuania, Szczecin Lagoon (Wolin National Park -Łunowo Marina and closed branch of Stara Świna), Poland and Darss-Zingst-Bodden-Chain (Born), Szczecin Lagoon (Vogelsang-Warsin) and Warnow estuary (Rostock), Germany. Our goal was to use the fact that plants' roots remove nutrients from the water, thus limit algal growth and improve consequently the water improving its transparency and, quality and limiting algal growth. In that way we could contribute to healthier and cleaner environments in heavily eutrophicated lagoons.

However, one should be aware that the islands have a very local water quality improvement impact. Floating islands tend to be most effective directly behind point-sources, e.g. at outlets of aquaculture effluents or drainage stations. Due to mixing in lagoons some positive nutrient removal effects can be noted only in enclosed areas, like marinas or enclosed small bays. However, in all possible locations increase of biodiversity is visible.

3. Getting your island step by step



4. Location of the floating island

Selection of a location for your island is an important step. Climate, salinity and hydrology influence the plant choices, the type of anchoring and the shape of the island, but these environmental factors do no limit the choice of installation sites per se. Floating islands can be adapted to almost all coastal environments. However, limitations regarding suitable sites exist and depend inter alia on legal requirements and social acceptance. Therefore, prior to installations, research regarding site selection needs to be carried out. The purpose of the island will also determine the location. You may already have a specific spot in mind, for example a coastal lagoon suffering from excessive nutrient loadings, an urban pond needing environmental remediation or artificial river banks in need for an aesthetic upgrade. Then you need to look carefully for the right spot taking into account hydrodynamic conditions, morphological conditions, climate, access to the island, as well as legal constraints. In such case selection of proper location and acquisition of installation permits may require even up to one year. In some cases when the waters for the installation are owned by national parks the procedure is shorter and 6 months should be enough. At the same time review of existing technologies and selection of the best one should be made. Some of the existing technologies are listed in pages 9-10.

Before the island installation it is recommended to make review of hydrodynamic, wave and meteorological conditions in the location. Also, it is required to have bathymetry overview both for anchoring design purposes, as well to monitor local coastline changes in case the shore protection is the purpose for the island installation.

5. Local legislation and required permits

Depending on country and specific location different legislation is applicable. Therefor before you decide to purchase and install the floating island, you need to check what permits will be required. Then you need to apply for them. So, the permits differ based on geographical / political location and based on environmental conditions. In private territory, the owner is responsible for the location and grants permission. It is different if the location is a public spot under governmental jurisdiction. Then you may need to apply to environmental agency according to local law, you may need to get construction permit, etc. Examples of applicable laws in few selected countries and locations are listed in Annex 1.

Annex 1 - Comparison of European laws and permit processes regarding the installation of floating islands (Table modified after Marine Policy 97 (2018) 51-60, https://doi.org/10.1016/j.marpol.2018.08.030, Copyright Elsevier)

Case study	Needed permits (national language):	Needed permission (english translation):	Relevant laws / fereral acts:	Responsible state authority (national language):	Responsible state authority (english translation):
Szczecin Lagoon, Mecklenburg-Vorpommern, Germany	Naturschutzrechtliche Genehmigung	Permission issued under environmental law	§13-18 BNatSchG, §40 NatSchAG M-V	Untere Naturschutzbehörde Landkreis Greifswald-Vorpommern	Nature conservation authority of the district LK Greifswald-Vorpommern
	Wasserrechtliche Erlaubnis	Permission issued under water law	§8/9/43 WHG + §23/89 LWaG	Untere Wasserbehörde StALU Voprommern	Lower level water authorities StALU Vorpommern
	Strom-und schifffahrtspolizeiliche Genehmigung	License of the river and shipping police	§31 WaStrG	Wasserstraßen-und Schifffahrtsamt WSA Stralsund	Waterways and Shipways Office
Puck Bay Pomorskie, Poland	Pozwolenie na wznoszenie i wykorzystywanie sztucznych wysp, konstrukcji i urządzeń	Permit for construction and usage of artificial islands, constructions and devices (law of 21 March 1991 on marine waters of the Republic of Poland and maritime administration)	Ustawa z dnia 21 marca 1991 r. o obszarach morskich Rzeczypospolitej Polskiej i administracji morskiej - Art. 23	Urząd Morski w Gdyni	Maritime Office in Gdynia
	Zgoda na zajęcie obszarów morskich wód wewnętrznych	Permit for use of internal marine waters area	Prawo Wodne, art. 20 ust. 1, pkt. 4	Urząd Morski w Gdyni	Maritime Office in Gdynia
	Uzgodnienie sposobu oznakowania wyspy	Agreement on a way (method) of marking the island	Rozporządzenie Ministra Transportu, Budownictwa I Gospodarki Morskiej z dnia 4 grudnia 2012 r. w sprawie oznakowania nawigacyjnego polskich obszarów morskich	Kapitanat portu we Władysławowie	Władysławowo harbour authority

Szczecin Lagoon, Wolin National Park, Poland	Zgoda Dyrektora Wolińskiego Parku Narodowego	Approval from the Director of the Wolin National Park	Ustawa o Ochronie Przyrody z poprawkami: Dz. U. z 2020 r. poz. 55, 471, 1378.	Woliński Park Narodowy	Wolin National Park
Curonian Lagoon Neringa, Lithuania	Leidimas	Permit for the construction in the coastal zone	LR vidaus vandenų transporto kodeksas	vidaus vandenų kelių valdytojais (Neringos savivaldybė)	Neringa municipality
	Leidimas	Permit for the construction in the waterways and port areas	LR vidaus vandenų transporto kodeksas	Aplinkos Apsaugos Agentūra	Environmental Protection Agency
	Poveikio aplinkai vertinimas	Environmental Impact Assesement	LR Planuojamos ūkinės veklos PAV įstatymas	Klaipeda Regioninnė Aplinkos Apsaugos Agentūra	Klaipeda Regional Environmental Protection Agency
Venice Lagoon, Veneto, Italy	Domanda di rilascio di concessione e di eventuale contestuale anticipata occupazione - richiesta di destinazione di zone demaniali marittime ad altri usi pubblici	Permission for the concession and the occupation of the publicly owned water	National Law n. 366 of 05/03/1963; Ministry decree 5 June 2009, n. 10/09	Provveditorato Interregionale alle Opere Pubbliche per il Veneto, Trentino A.A., Friuli Venezie Giulia, Ministero delle infrastrutture e die trasporti (ex magistrato delle Acque)	Interregional Superintendence of Public Works - Ministry of Infrastructure and Transport (former Venice Water Authority)
	Valutazione di impatto ambientale	Enviornmental Impact Assessment	Regional Decree1400 (29/08/17) Legislative decree n. 104 of 16.06.2017	Regione del Veneto	Venice region
Arcachon Bay, Gironde, France	Demande d'autorisation d'occupation temporaire (AOT) du domaine public maritime	Temporary occupation permit for the public maritime domain	Article L2122-1 & R2122-2 of the general code on public property	Direction Départementale des Territoires et de la Mer de la Gironde (DDTM)	Gironde Departmental Division of Territories and Sea
	Evaluation d'incidences Natura 2000	Natura 2000 impact assessment	Article L414-4 & R414-19 of the environment code	Direction Départementale des Territoires et de la Mer de la Gironde (DDTM)	Gironde Departmental Division of Territories and Sea

6. Selection of the desired technology and design

Based on defined purpose of the island and specifics of the location you can select the best technology fitting to your needs. For instance, in case of stormy, open water location where cold winters occur it is recommended to go for strong technologies, resistant to ice drifts and able to withstand high waves. Our in-depth review of available floating island technology showed that only Biomatrix islands meet the required standards for installations in harsh coastal environments where stormy conditions occur from time to time. In case ice drift gets too severe during winter, floating islands need to be removed from the water. However, in case the island is located in marina and protected from ice drift, it can stay in water over the whole year. In case native plants are planted, they can survive winter as well and there is no need to replant them.

Table 1. Overview of some existing floating islands manufactures (modified after Karstens et al. 2021).

Company	Country	Material	Website link
Beemats	USA	PVA foam	http://www.beemats.com/
Frog Environmental BioHaven	USA/UK	Polyurethane foam (PU)	https://frogenvironmental.co.uk/biohaven-floating-wetlands/
Biomatrix	Scotland	Thermo fused high-density polyethylene (PE)	http://www.biomatrixwater.com/floating-islands/
AquaBiofilter	Australia	Polyuethane filter foam?	http://www.aquabiofilter.com
Clarity Aquatics	Australia	UV-resistant LDPE	https://clarityaquatic.com
Ökon-Vegetationstechnik	Deutschland	Stainless steel & reed stems	https://www.oekon-vegetationstechnik.de/produkte/roehrichtinseln
Aquaterra Solutions	France	Polyethylene (PE)	http://www.aquaterra-solutions.fr/
Marcanterra	France	Wood & cork	http://www.marcanterra.fr/2-bois-plantes/8-radeaux-vegetalises.html
Floating island solutions	USA	Aluminum and polyurethane closed cell marine foam	https://floatingwetlandsolutions.com/floating-wetland-designs/
Spel environmental integrated water solutions	Australia	recycled PET	http://spel.com.au/products/spel-wetlands/
Harris environmental consulting	Australia		http://harrisenvironmental.com.au/services/harris-floating-wetlands/
Terrapin Water	Canada	High density polyethylene (HDPE)	http://terrapinwater.com/floating-treatment-wetlands/
Blue Mater	Portugal	cork & polyurethane paste (PU)	http://www.bluemater.com/cork-floating-island/

Examples of technologies applied in the LiveLagoons project

Wolin National Park, Poland

Matrixes made of recycled and UV-resistant hollow plastic (HDPE) pipes, covered with coconut coir fiber and fastened using a plastic (PP) mesh

Juodkrante, Lithuania

Matrixes made of recycled and UV-resistant hollow plastic (HDPE) pipes, covered with coconut coir fiber and fastened using a plastic (PP) mesh

Nida, Lithuania

A custom-made floating net with mesh size > 11 cm, 200 m length and 1 m height, placed at 1 m depth

Klaipeda city, Lithuania

Matrixes made of recycled and UV-resistant hollow plastic (HDPE) pipes, covered with coconut coir fiber and fastened using a plastic (PP) mesh

Born, Darss-Zingst-Bodden-Chain, Germany

Made of a stainless steel mesh which is filled with dry reed stems and hollow stainless steel buoys to enhance the buoyancy effect

Born, Darss-Zingst-Bodden-Chain, Germany

Floating matrix is made out of thermowood. With this thermally modified spruce wood the durability and buoyancy is enhanced

Vogelsang-Warsin, Szczecin lagoon, Germany

Floating matrix is made out of thermowood. With this thermally modified spruce wood the durability and buoyancy is enhanced

Rostock, Warnow Estuary, Germany

Two islands, one made out of glass gravel framed in xylitol and basalt nets, the other one made out of thermowood. Both plastic-free.

7. Tender procedure

Tender procedure to get your island may be required in case you are a public body / organization. In case of private institution this issue depends on internal regulations and usually tender is not required.

Tender procedure may take 2 -3 months. As there are number of different producers please be very specific to carefully and in detail describing your expectations of the island and especially safety features related to location and environmental requirements.

After successful selection of producer, still another up to 2-3 months may be needed for production and delivery of the island. This depends on the size of the island and what is actually on stock at the producer.

8. Preparing the installation spot for your island

In many cases the preferred location may require some additional adjustments like: bottom cleaning (from rubbish, plastics, etc.), looking for proper mooring spot and equipment.

Prior to installation you should make some research on variations of water level in the installation area to adapt anchoring, wind velocities, wave height and currents. All these factors impact anchoring and information about them is vital to establish proper mooring system.

In order to get proper plant species you may need to have knowledge on water parameters like: salinity, temperature fluctuations, nutrient concentrations. You should also inform yourself about birds and other animals active in your installation area, as they might threat vegetation growth in the beginning when plants just start to grow. Fencing can be an option to protect you plants the first weeks during growth period. Then select your plants accordingly, based on their environmental preferences. In Chapter 9.1 you will find more on plants selection.

9. Installation of the floating islands and planting

When your installation spot is ready and the ordered island arrived, you may finally install your island!

Please follow carefully manufacturers guidelines. In most cases it will be possible to prepare / mounts elements of your island on land. You may also plant it before it gets into the water. Some examples are presented at the end of the chapter.

Choice of the right macrophyte species depend on the purpose of the floating island. Plants are purchased from the suppliers.

In natural protected areas only native plants could be selected:

- Perennial plants (the annual plants will grow spontaneously);
- Species resistant to local environmental conditions, e.g. salinity and climate.
- For nutrient removal choose plants with high biomass growth rates, e.g. Carex acutiformis, Typha, Iris pseudocarous, Juncus sp., Sagittaria, Phragmites ausralis.
- For biodiversity enhancements integrate endangered species, e.g. Iris pseudacorus, Aster tripolium,
- For aesthetic enjoyment integrate flowering plants such as Lythrum salicaria;
- For medicinal use, include herbal collections (e.g. Acorus calamus, Petasitis hybridus, P. spurius, Valeriana).
- Remember that invasive emergent macrophytes (e.g. Spartina anglica) cannot be planted.

In the urban green areas exotic ornamental plants could be selected:

- Exotic flowering species (e.g. Iris, Ligularia dentata)
- Some flowering species that need to be removed for the winter period in the cold climate (Canna, Colocasia)
- Trees and ornamental bushes (e.g. swamp cypress Taxodium distichum, Viburnum, Hibiskus mosquetos).
- Greens and vegetables for horticulture (salad, cucumber, bazilicum, mint)

9.1. Selection of plants

Suitable macrophytes for floating islands in lagoons along the Southern Baltic Sea

Acorus calamus (Sweet flag)

Max height: 150 cm

Flowering time: early summer

Ellenberg's indicators: F 10, S 0, N 7

Bidens cernua (Nodding beggartick)

Max height: 150 cm

Flowering time: high summer

Ellenberg's indicators: F 9, S 0, N 9

Photo source: https://commons.wikimedia.org/wiki/File:Bidens_cernua.jpeg

Bistorta major/Polygonum bistorta (Common bistort)

Max height: 80 cm

Flowering time: early summer

Ellenberg's indicators: F 7, S 0, N 5

Photo source:
https://commons.wikimedia.org/wiki/File:Bistorta_officinalis_syn._Polygonum_bistorta_Rdest_w%C4%99%C5%BCownik_200905-24_03.jpg

Butomus umbellatus (Flowering Rush)

Max height: 150 cm

Flowering time: high summer

Ellenberg's indicators: F 10~, S ?, N 7

Photo source:
https://commons.wikimedia.org/wiki/File:Atlas_roslin_pl_%C5%81%C4%85cze%C5%84_baldaszkowy_8414_6505.jpg

Carex acuta (Slender Tufted-sedge)

Max height: 150 cm

Flowering time: mid summer

Ellenberg's indicators: F 9, S 0, N 4

Photo source: https://pixabay.com/pl/photos/carex-acutiformis-turzyca-pospolita-855416/

Carex pseudocyperus (Cyperus-like Sedge)

Max height: 100 cm

Flowering time: early summer

Ellenberg's indicators: F 9, S 0, N 5

Photo source: https://commons.wikimedia.org/wiki/File:Carex_pseudocyperus_plant_(01).jpg

Equisetum fluviatile (Water horsetail)

Max height: 150 cm

Flowering time: late spring

Ellenberg's indicators: F 10, S 0, N 5

Photo source: https://commons.wikimedia.org/wiki/File:EquisetumFluviatile.jpg

Filipendula ulmaria (Meadowsweet)

Max height: 200 cm

Flowering time: high summer

Ellenberg's indicators: F 8, S 0, N 5

Glyceria maxima (Great Manna Grass)

Max height: 200 cm

Flowering time: mid-summer

Ellenberg's indicators: F 10, S 0, N 9

Photo source: https://commons.wikimedia.org/wiki/File:Glyceria_maxima54_flowerhead7_(8685225066).jpg

Iris pseudacorus (Yellow flag)

Max height: 100 cm

Flowering time: early summer

Ellenberg's indicators: F 9, S 0, N 7

Juncus effuses (Common rush)

Max height: 120 cm

Flowering time: early summer

Ellenberg's indicators: F 7~, S 0, N 3

Photo source: https://commons.wikimedia.org/wiki/File:Juncus_effuses.jpg

Lysimachia nummularia (Moneywort/creeping Jenny)

Max height: 50cm

Flowering time: mid-summer

Ellenberg's indicators: F 6~, S 0, N x

Photo source: https://commons.wikimedia.org/wiki/File:Lysimachia_nummularia_138484656.jpg

Lysimachia vulgaris (Yellow loosestrife)

Max height: 150 cm

Flowering time: high summer

Ellenberg's indicators: F 8~, S 0, N x

Photo source: https://commons.wikimedia.org/wiki/File:4814-lysimachia_vulgaris-20110711.JPG

Lythrum salicaria (Purple-loosestrife)

Max height: 200 cm

Flowering time: high summer

Ellenberg's indicators: F 8~, S 1, N x

Polygonum amphibium (Water knotweed)

Max height: 100 cm

Flowering time: mid-summer

Ellenberg's indicators: F 11, S 0, N 4

Photo source: https://commons.wikimedia.org/wiki/File:Polygonum_amphibium_1-sdickens_(5097347159).jpg

Phalaris arundinacea (Reed canarygrass)

Max height: 200 cm

Flowering time: high summer

Ellenberg's indicators: F 8~, S 0, N 7\

Photo source: https://commons.wikimedia.org/wiki/File:Phalaris_arundinacea_RF.jpg

Phragmites australis (Common reed)

Max height: 300 cm

Flowering time: high summer

Ellenberg's indicators: F 10, S 0, N 7

Sagittaria sagittifolia (Arrowhead)

Max height: 100 cm

Flowering time: mid-summer

Ellenberg's indicators: F 10, S 0, N 6

Photo source: https://commons.wikimedia.org/wiki/File:Sagittaria_sagittifolia_BOGA.jpg

Salix viminalis (Basket willow)

Max height: 1000 cm

Flowering time: early summer

Ellenberg's indicators: F 8, S 0, N x

Photo source: https://commons.wikimedia.org/wiki/File:Salix_viminalis_008.jpg

Schoenoplectus lacustris (Lakeshore bulrus)

Max height: 400 cm

Flowering time: high summer

Ellenberg's indicators: F 11, S 1, N 6

Schoenoplectus tabernaemontani (Softstem bulrush)

Max height: 250 cm

Flowering time: high summer

Ellenberg's indicators: F 10, S 3, N 6

Photo source: https://commons.wikimedia.org/wiki/File:20190603Schoenoplectus_tabernaemontani1.jpg

Scirpus sylvaticus (Wood Club-rush)

Max height: 100 cm

Flowering time: mid-summer

Ellenberg's indicators: F 8, S 0, N 4

Typha angustifolia (Narrowleaf cattail)

Max height: 200 cm

Flowering time: high summer

Ellenberg's indicators: F 10, S 1, N 7

Photo source: https://commons.wikimedia.org/wiki/File:Typha_angustifolia_(habitus)_1.jpg

Typha latifolia (Broadleaf cattail)

Max height: 200 cm

Flowering time: high summer

Ellenberg's indicators: F 10, S 1, N 8

9.2. Experiences from Germany

First floating islands in Germany were installed in Born at the Darss-Zingst Bodden Chain in May 2018 with our cooperation partner – the Federal State Institute of Agriculture and Fishery MV. The islands are located directly behind the outlet of an aquaculture pond (sturgeon cultivation). The first islands were made out of stainless steel mesh filled with reed stems. They were planted with a pre-cultivated coir mat with a variety of native emergent macrophytes: *Lythrum salicaria, Bolboschoenus maritimus, Iris pseudacorus, Carex acutiformis* and *Schoenoplectus lacustris*.

FIGURE 1: INSTALLATION OF FIRST FLOATING ISLAND IN BORN, MAY 2018.

Most floating island designs use polyethylene, polypropylene, polyurethane or polyvinyl alcohol foam to ensure the buoyancy. Our aim for the German case study site was to develop an artificial polymer free island. However, buoyancy of the first floating islands was not sufficient. A modified new island made out of thermowood was installed in April 2019. Buoyancy of this island is still sufficient and vegetation is thriving (Figure 2).

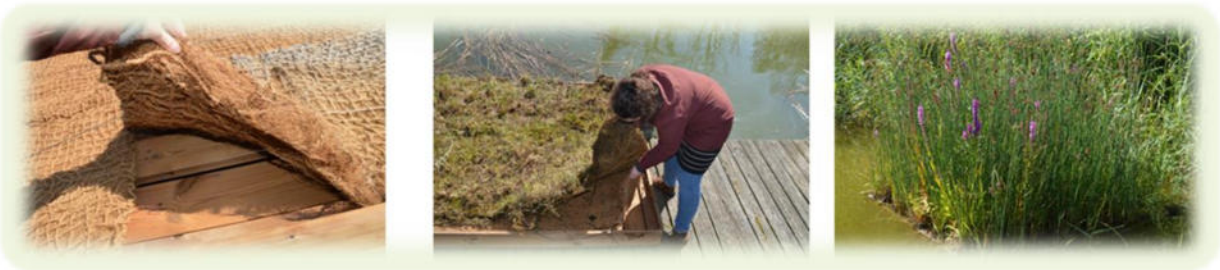
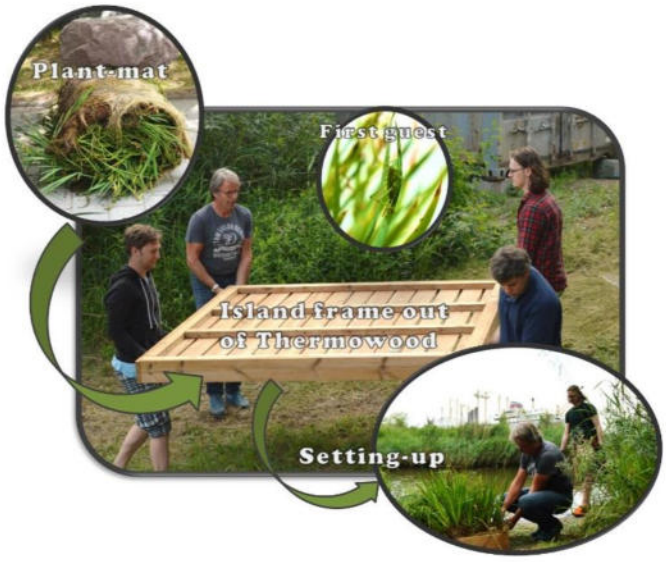


FIGURE 2: INSTALLATION OF THERMOWOOD ISLAND IN BORN, APRIL 2019.



Based on our success-story with the thermowood island in Born, we installed another floating island in Vogelsang-Warsin at the Szczecin lagoon (Figure 3). This coastal municipality repeatedly suffers from high loads of E.Coli bacteria at their bathing site. Studies in rivers and urban ponds showed that floating islands are not only capable of reducing excess nutrients but also bacterial contamination. Whether this also works in coastal waters is now being tested within the LiveLagoons project. A floating island with Carex acutiformis, Carex acuta, Lythrum salicaria and Iris pseudacorus was installed within a drainage channel close to the beach in December 2020. Impact monitoring will be carried out together with the local environmental agency.

FIGURE 3: INSTALLATION OF ANOTHER THERMOWOOD ISLAND IN VOGELSANG-WARSIN, DECEMBER 2020

Two more floating islands were installed in Rostock in summer 2021. The islands are located in the a local recreational park in a sheltered bay off the Warnow estuary with salinities around 8.5 PSU and a water depth of up to 1.5 m. At this site, frequent visitors can appreciate the beauty of a floating wetland that adds dashes of colour into the monotonous reed bed with the purple *Lythrum salicaria* or the yellow *Iris pseudacorus*. We will monitor how the macrophytes cope with these different environmental conditions (e.g. higher salinity) and make comparisons to the other study sites.

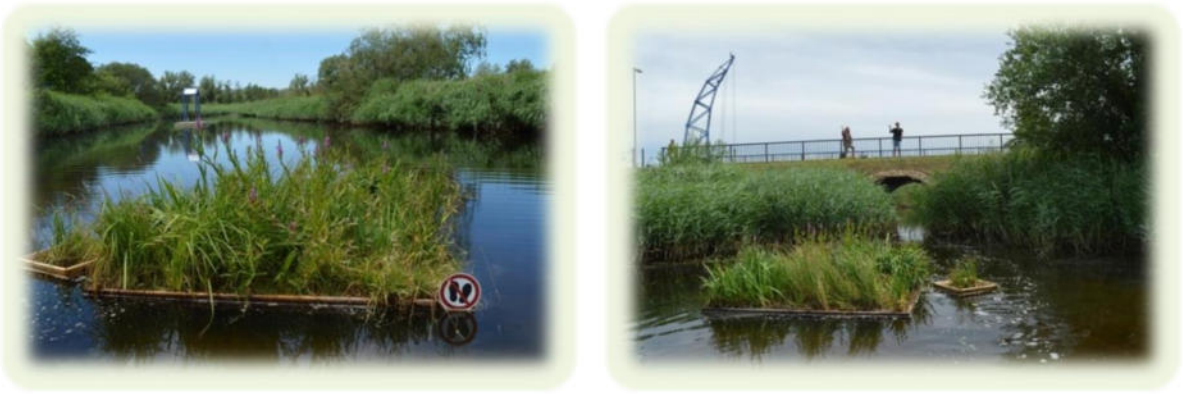


FIGURE 4: THERMOWOOD ISLAND IN IGA PARK, ROSTOCK, JULY 2021.

9.3. Experiences from Poland

For the localisation of floating island in Poland, the Łunowo Marina on Wicko Lake, was chosen (Figure 5). The marina area is located in the Szczecin Lagoon within the Wolin National Park. The installation was conducted in April 2019 (Figure 6).

FIGURE 5: ŁUNOWO MARINA ON WICKO LAKE, LOCALIZATION OF THE FLOATING ISLAND IN POLAND (FROM DESIGN TO BLOOMING FLOATING ISLAND)

FIGURE 6: INSTALATION OF THE FLOATING ISLAND IN WICKO LAKE (ŁUNOWO MARINA), POLAND, APRIL 2019

After the installation and anchoring of the island the native plants were planted. The choice of indigenous plants turned out to be a good one because the spectacular flora grew very quickly (Figure 7).

A) B) C)

FIGURE 7: THE GROWTH OF THE PLANTS ON FLOATING ISLAND IN WICKO LAKE (ŁUNOWO MARINA), POLAND, A) JUNE 2019, B) JULY 2019, C) SEPTEMBER 2019

However, each year composition of plants was changing and the most striking feature was domination of Phragmites over other species. Typha was almost not represented in 2021. The same happened to Schoenoplectus of which only 4 stems survived. Instead Convolvulus arvensis started to colonize the island (Fig. 8).

FIGURE 8: COLONIZATION WITH CONVOLVULUS ARVENSIS – ŁUNOWO MARINA IN WICKO LAKE.

9.4. Experiences from Lithuania

Floating net installation

The 'net' i.e. custom-made floating rig of 200m length and 1m height was placed at ~1m depth between the two moles in the end of May 2018. Two types of plants and different fixation methods have been used. The common reed (Phragmites australis) was planted in to the cylindrical PVC containers filled in with expanded clay. While single branches of the willow (Salix, ~1-1.2m length) have been fixed directly to the net. The plants were taken from the close coastal area at Juodkrante site and have already developed fresh leaves.

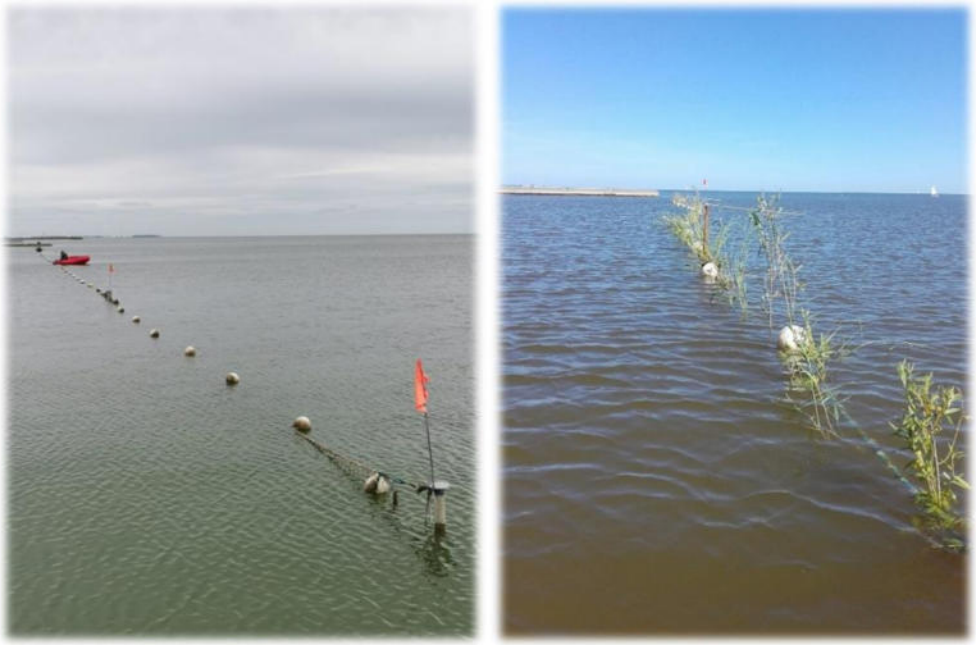


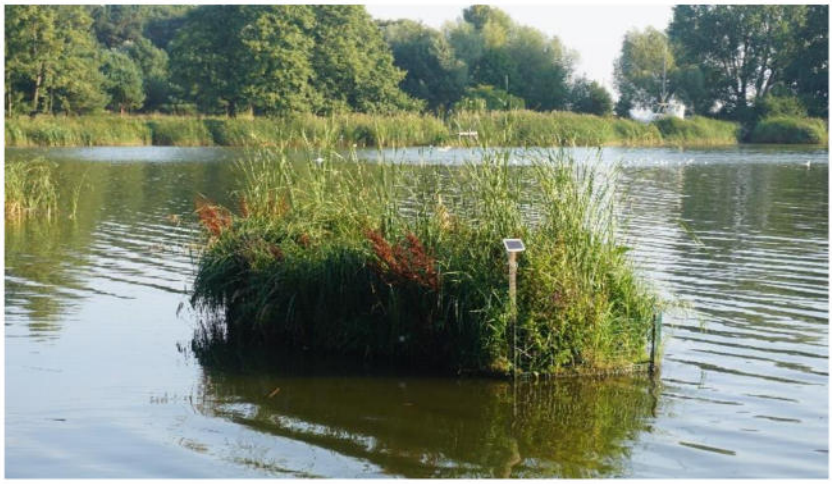
FIGURE 8: FLOATING NET INSTALLATION IN NIDA

Both species survived the waving and water level fluctuation conditions. Within two months Salix stems produced a significant root biomass, while above ground growth was not significant.

The net has its structure disposed at whole cross-section of the water column. Zebra mussel *Dreissena polymorpha* attached to the rig itself and the plants fixed to the net at ~40cm below water surface, presumably avoiding waving and ultraviolet radiation. Below this depth, 60cm of the willow stem was fully covered with the newly settled zebra mussels.

Floating island installations

There were four islands installed in Lithuania - two in the Curonian lagoon and two in the Klaipeda city in urban locations.

Curonian Lagoon Gintaro (Amber bay)	Island area 24m^2 Producer: Biomatrix Water Installed in 2019 Dominant plant species: *Carex acutiformes*, *Typha angustifolia* Harvesting in September	

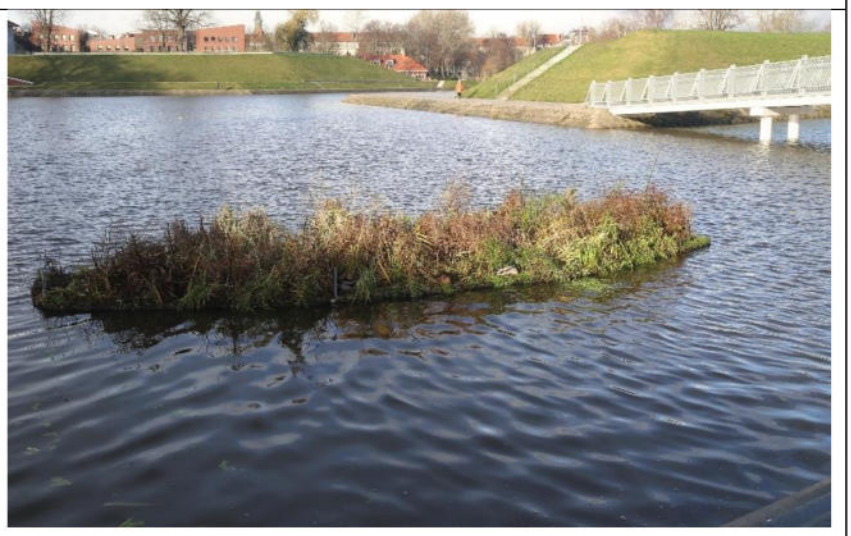
Curonian Lagoon 14km	Island area 28m^2 Producer: Biomatrix Water Installed in 2019 Dominant plant species: *Carex acutiformes*, other Harvesting in September	
Klaipeda city	Island area 24m^2 Producer: Biomatrix Water Installed in 2020 A selection of ornamental plants was used	

FIGURE 8: ISLAND TYPE INSTALLATIONS IN LITHUANIA

In Gintaro island the initially high density of plants, resulted in a dense grass stand dominated by *Carex acutiformes*, *Typha angustifolia*. Other planted species such as *Scirpus sylvaticus*, *Shoenoplectus lacustris*, *Iris pseudacorus*, *Rumex crispus* become largely overshadowed and represented only by few specimens. There was no free space for colonisation of spontaneous species on Gintaro island. Single sprout of a tree *Alnus glutinosa* was recorded in 2020, but did not survive the next season.

In Juodkrante 14km island the initial plant density was lower and the total island area little higher. Moreover, the significant wave damage resulted in death of some plants. Therefore, as a result some open spots on the island occurred and where occupied by spontaneous colonists: *Eupatorium cannabinum*, *Rumex palustris*, *Petasites* and many smaller species. Less dense stand of *Carex acutiformes* resulted in better growth of *Shoenoplectus lacustris* and *Iris pseudacorus*.

Island installed in the Klaipeda city was planted by exotic ornamental plant species including Swamp mallow (Hibiscus moschetos), Bald cypress (*Taxodium distichum*) and Pickelweed Pontederia cordata.

10. Maintenance of the island and plants. Harvesting and preparation for next season

Once the island is installed it has to be regularly technically monitored (checked for breaks, damages, plants, etc.). It is recommended to do it once every 1 month and additionally after storms or other severe meteorological events;

In case there is an interest in monitoring water quality change due to installation of a floating island it is recommended to take water samples from locations around the island at least 3 times a year (beginning of vegetation season, in the middle of the vegetation season and at the end of the season) for nutrients analysis. It is recommended to measure transparency as well;

At the end of the vegetation season it is recommended to harvest the plants in order to remove nutrients accumulated in upper parts of plants boost nutrient removal. Harvesting of above ground tissues needs to be ensured before the start of vegetation decay. The biomass is cut and removed from the floating island manually. Alone the nutrient removal by aboveground harvest of the standing biomass was up to 0.50 g phosphorus per m^2 and up to 10.25 g nitrogen per m^2 (Razinkovas-Baziukas et al. 2021). The floating construction of 24m2 can hold 1-3 adult persons weight. It is recommended to think about biomass transportation and utilization (e.g. fodder, energy, compost) before harvest, or even prior the setting of planted species assemblage. Volunteers, local communities, students could be involved in this activity. However, in case the floating island is installed for decorative and aesthetic purposes, one may leave plants for winter or remove them and plant again in spring, depending on the plants requirements. Even without biomass removal, remediation occurs on several levels: Plant roots attenuate wave energy and water flow and are consequently able to enhance particle settling and nutrient burial (Pavlineri et a. 2017). Furthermore, the associated microbial diversity impacts denitrification. Some studies even identified macrophyte root-associated denitrification as the main nitrogen removal pathway (e.g. Choudhurya et al. 2019). After harvesting (or not, in decorative cases) the construction could be kept in water year round, as freezing and thawing cycles do not seem to harm the islands. The floating island could be moved to sheltered area before the water body is covered by ice.

11. References

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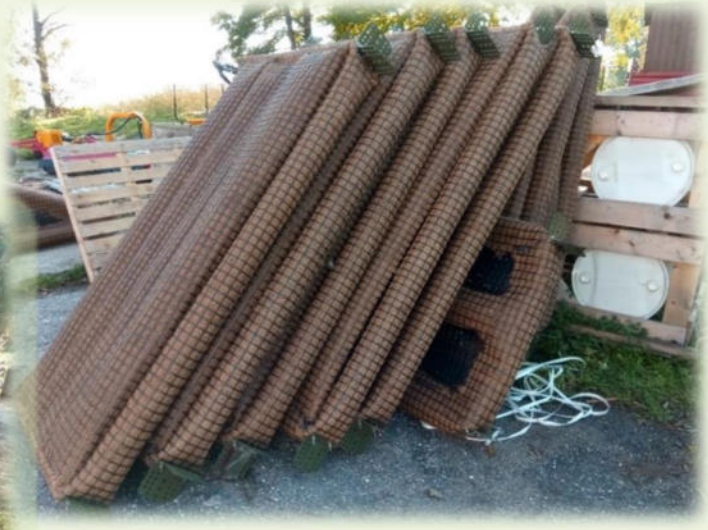
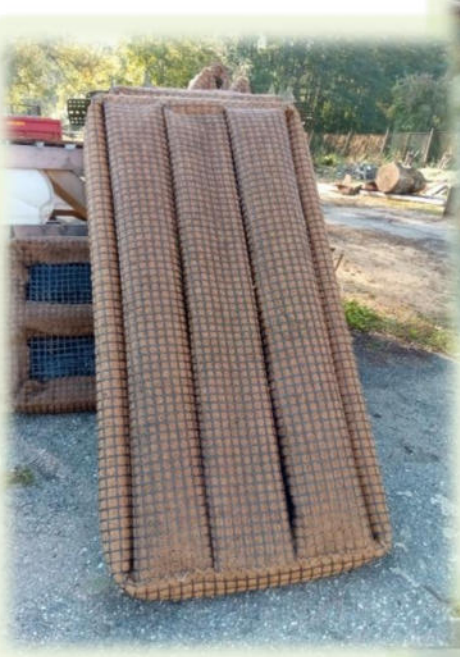
Karstens, S., Nazzari, C., Bâlon, C., Bielecka, M., Grigaitis, Z., Schumacher, J., Stybel, N., Razinkovas-Baziukas, A. (2018): Floating wetlands for nutrient removal in eutrophicated coastal lagoons: Decision support for site selection and permit process. Marine Policy 97, 51-60. https://doi.org/10.1016/j.marpol.2018.08.030

Karstens, S., Langer, M., Nyunoya, H., Čaraitė, I., Stybel, N., Razinkovas-Baziukas, A., Bochert, R. (2021): Constructed floating wetlands made of natural materials as habitats in eutrophicated coastal lagoons in the Southern Baltic Sea. Journal of Coastal Conservation 25(4), 1-14. https://doi.org/10.1007/s11852-021-00826-3

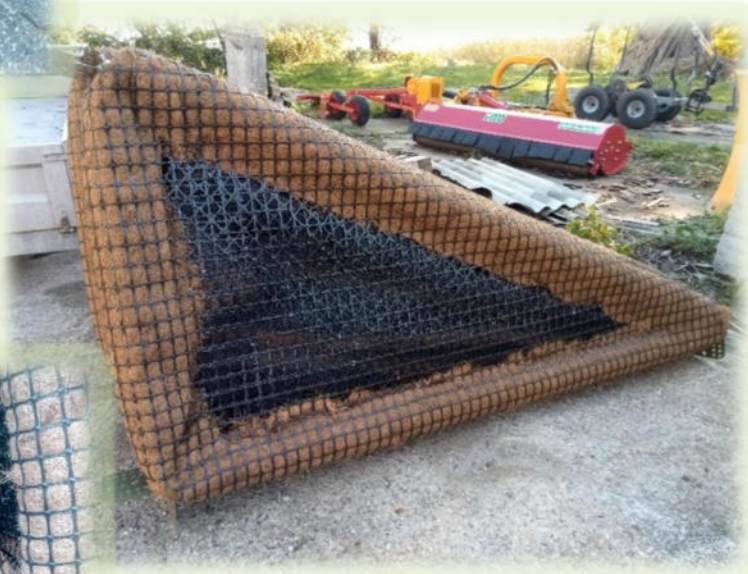
12. Photo Gallery

Examples of different technologies used in project



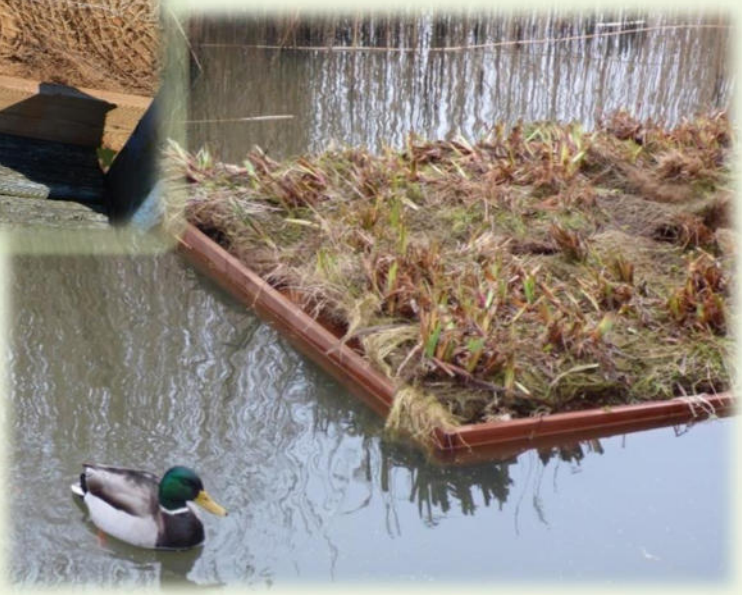


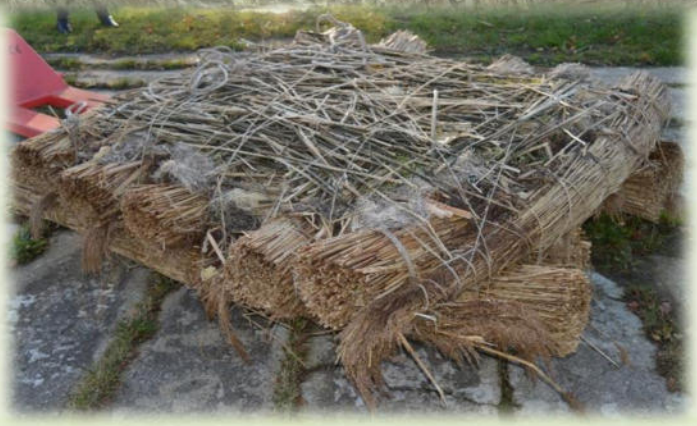
Floating matrixes made of recycled and UV-resistant hollow plastic (HDPE) pipes, covered with coconut coir fiber and fastened using a plastic (PP) mesh



Thermowood island

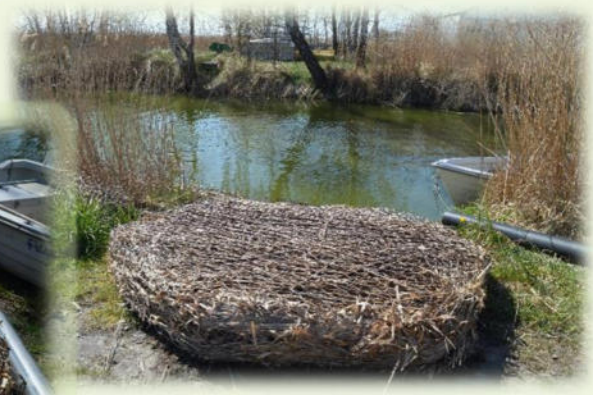
free of artificial polymers

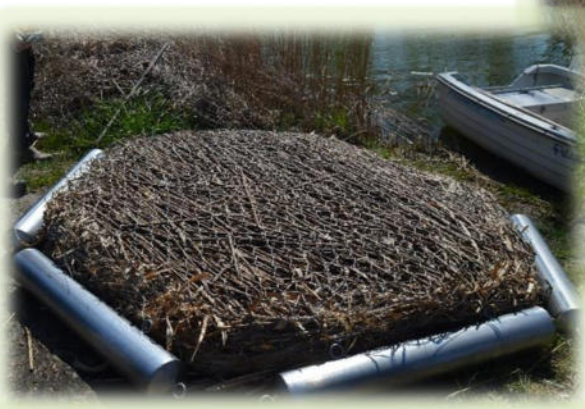


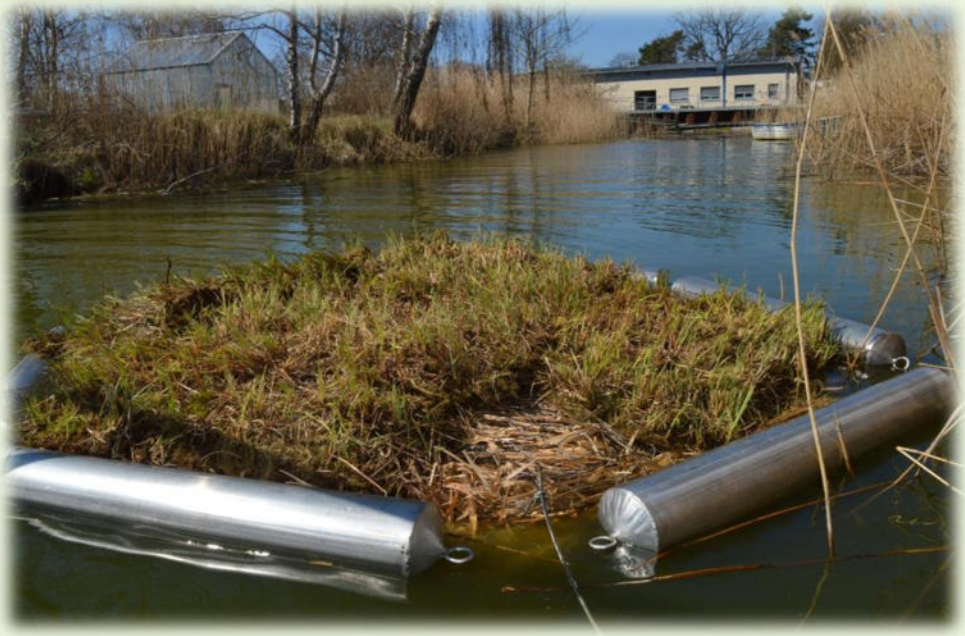


Reed stems

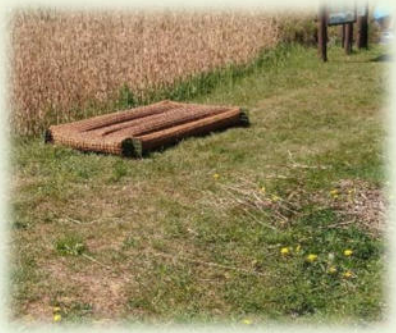
Stainless steel & reed stems

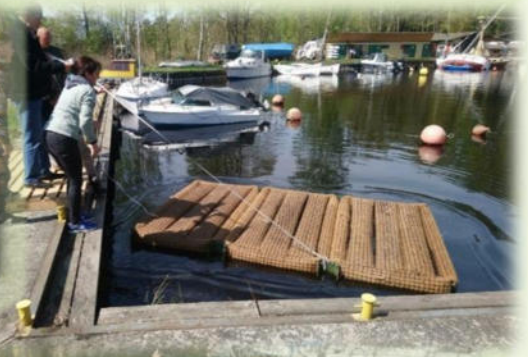


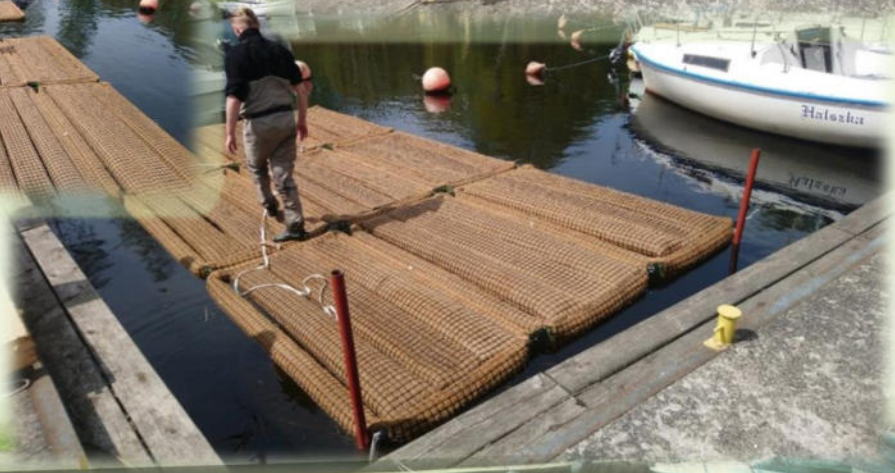


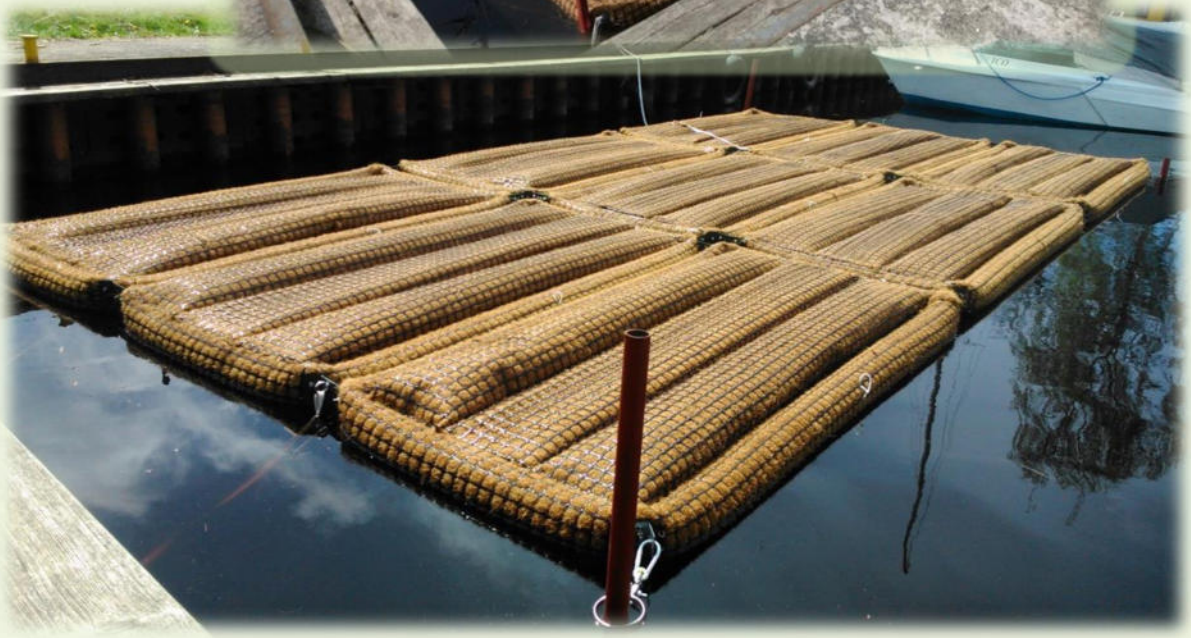


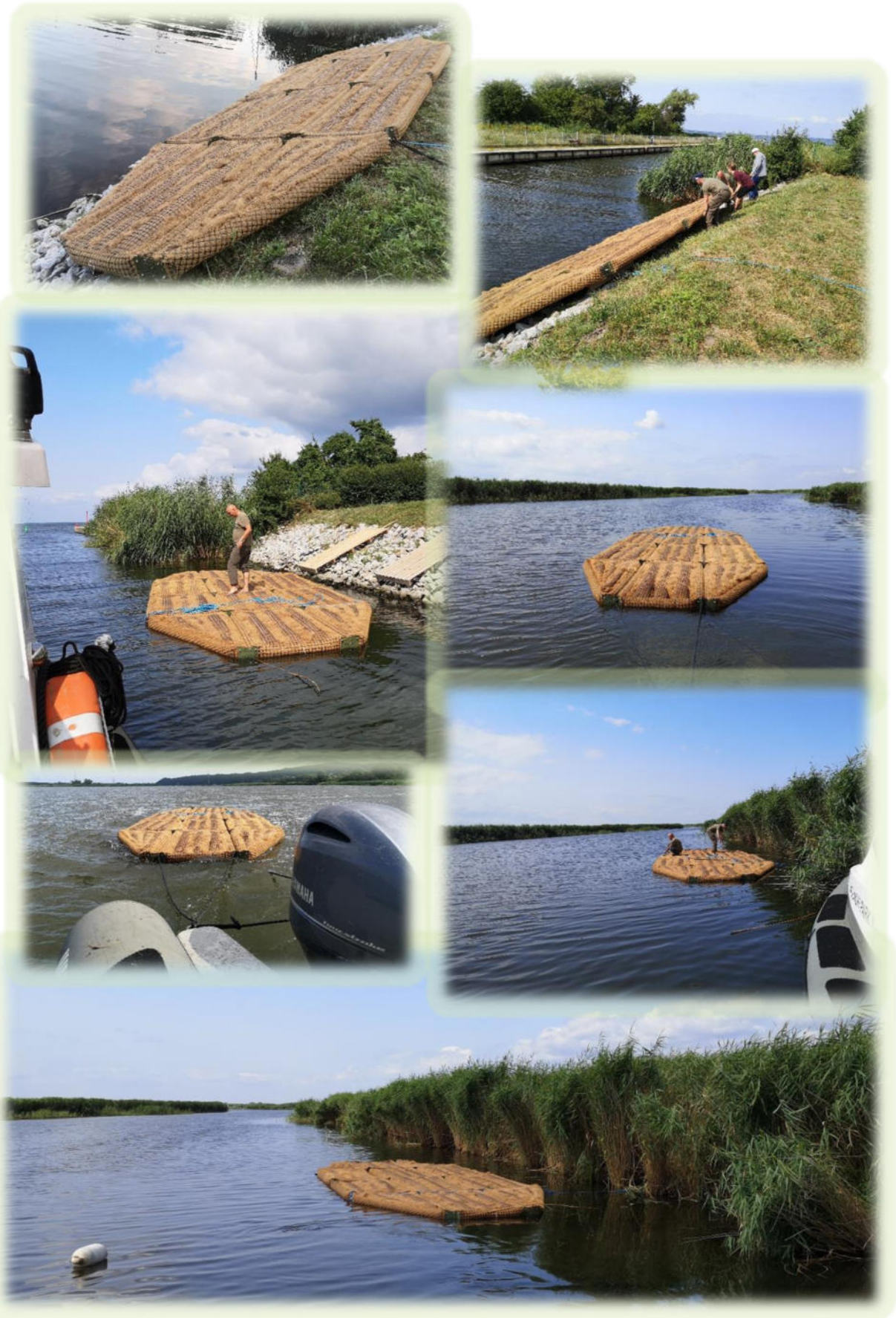
Installation process

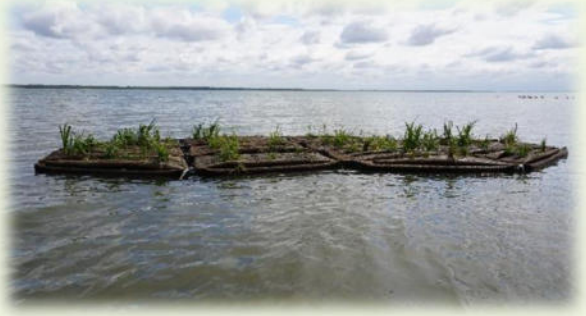


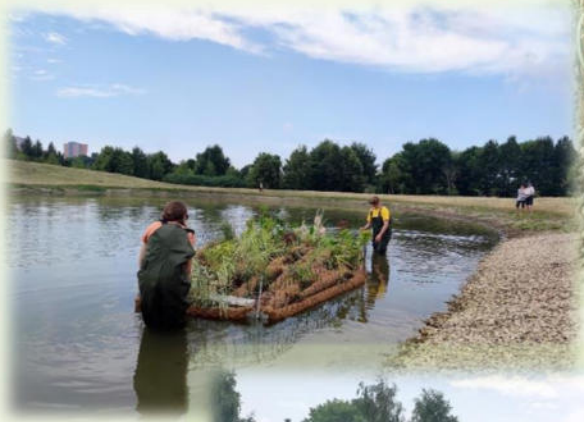


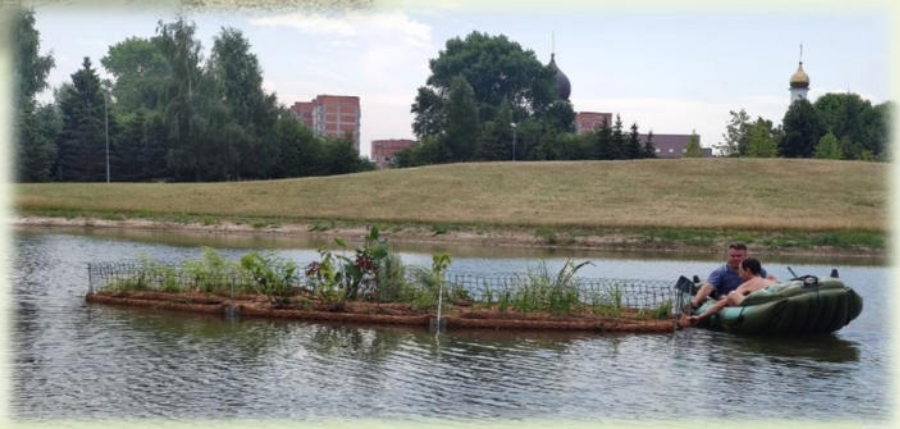


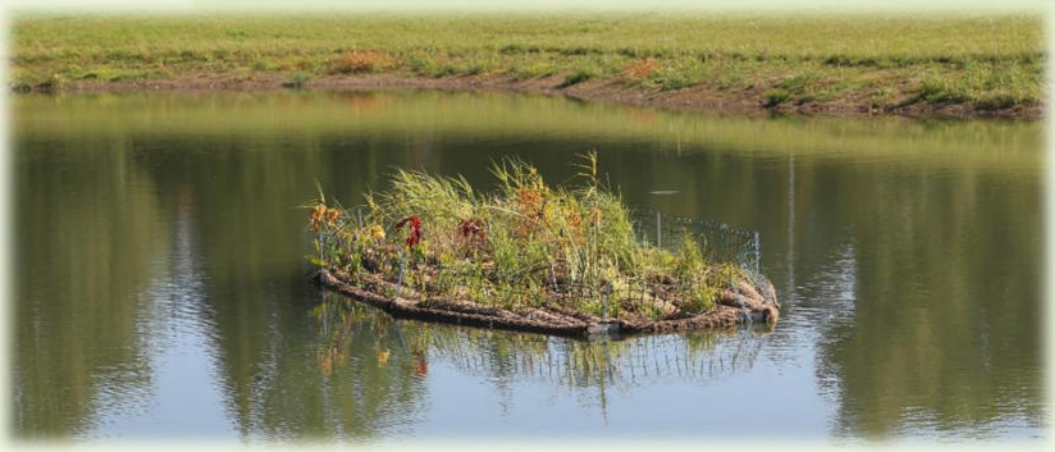


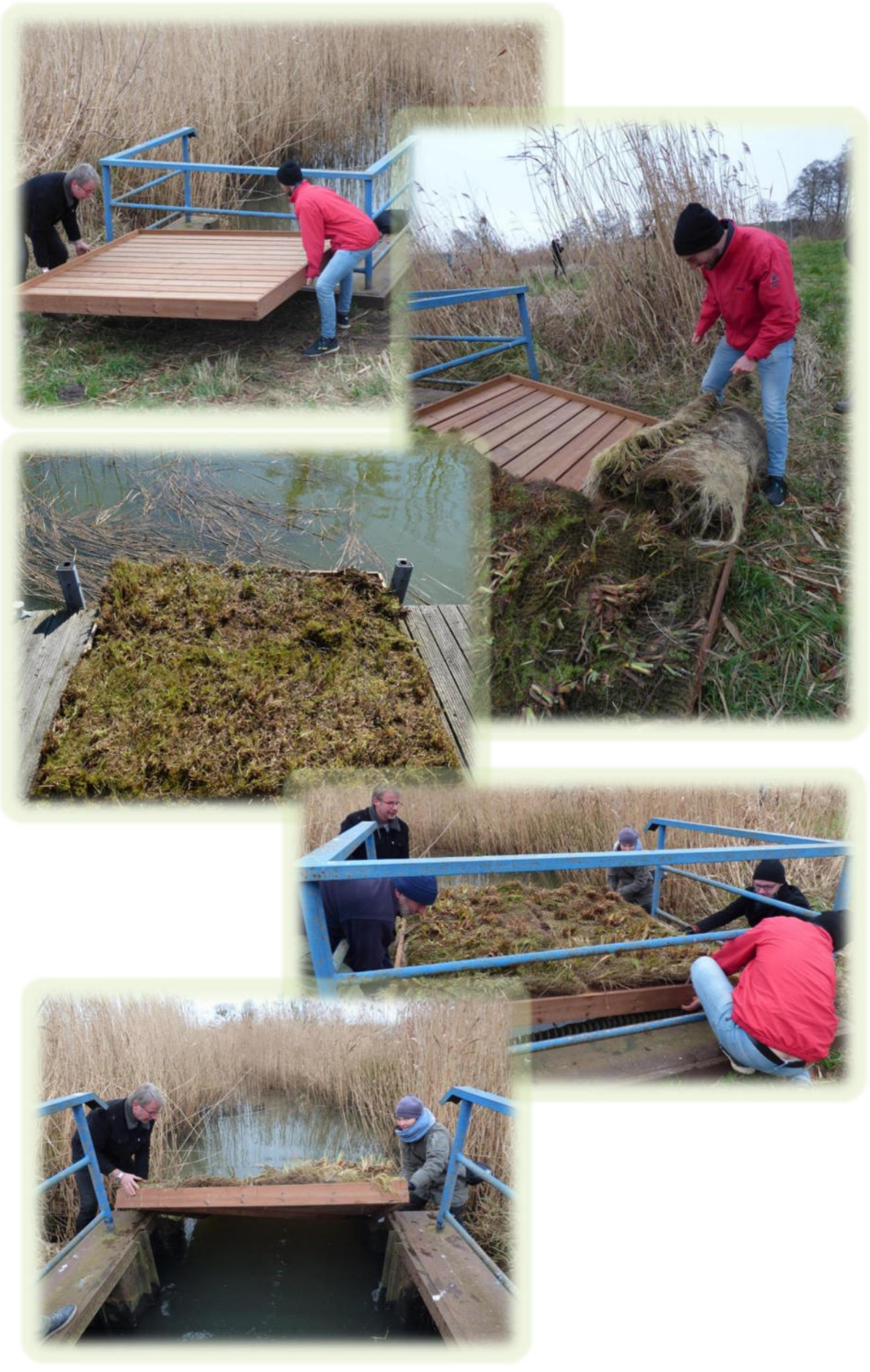


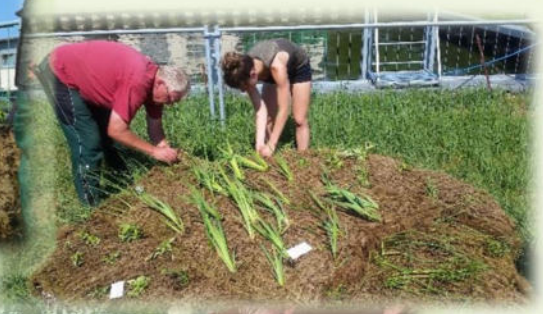
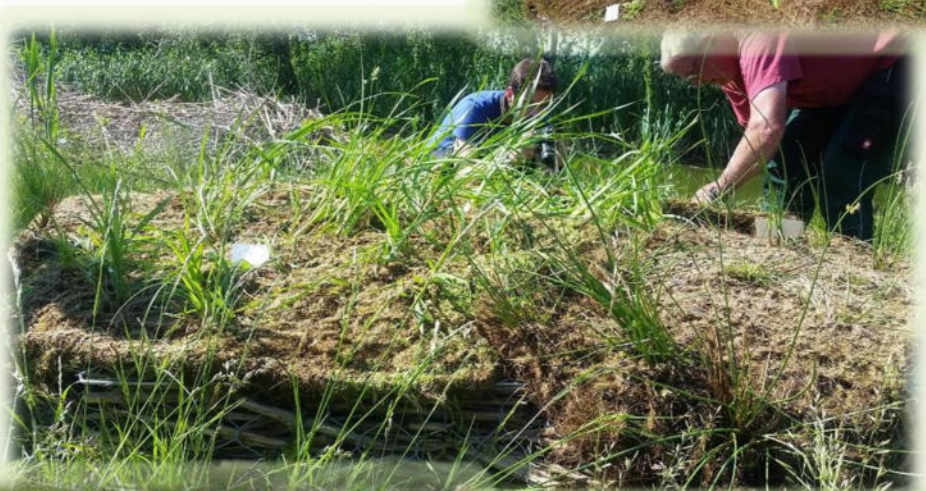


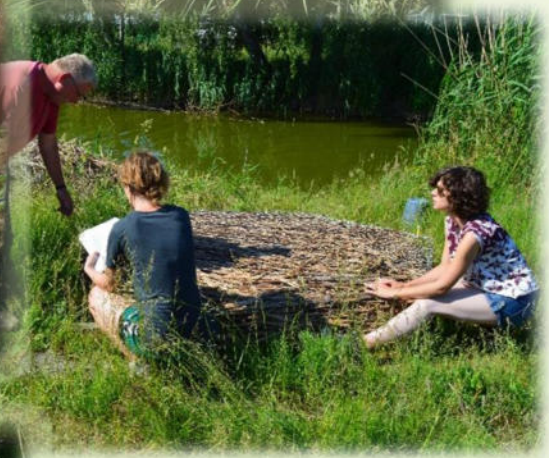
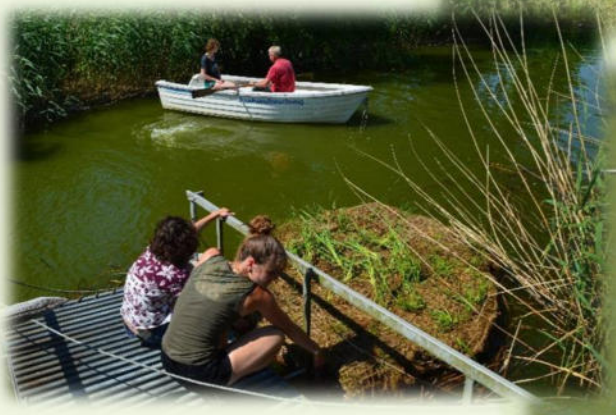
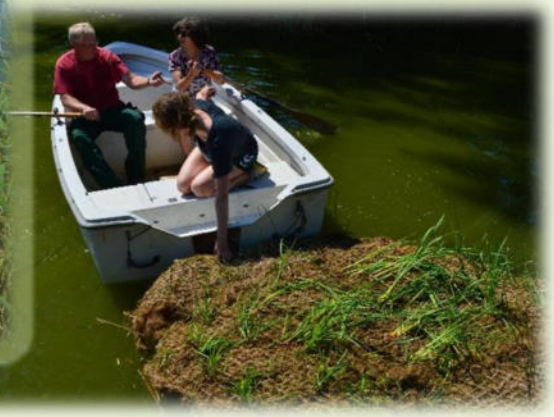




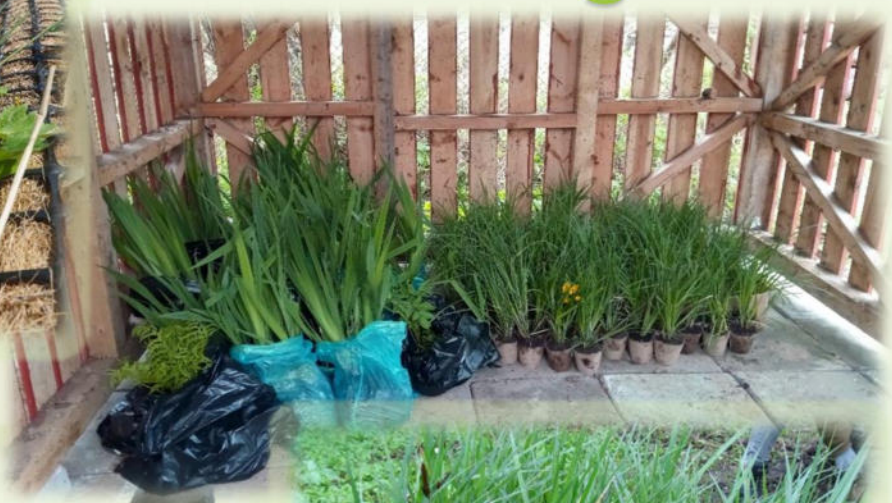


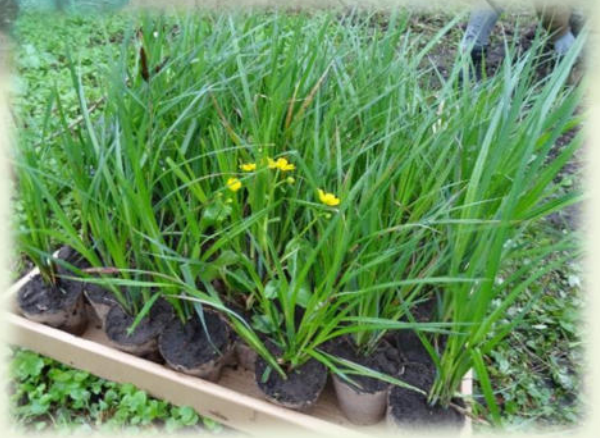


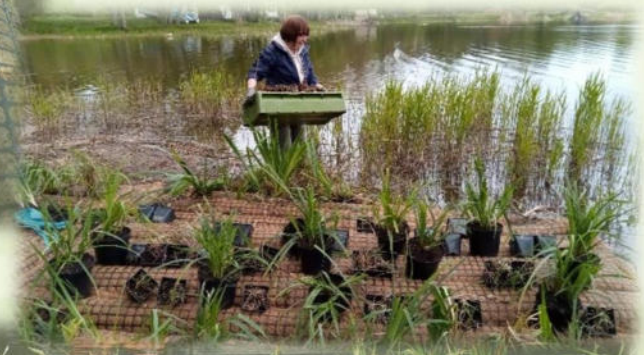




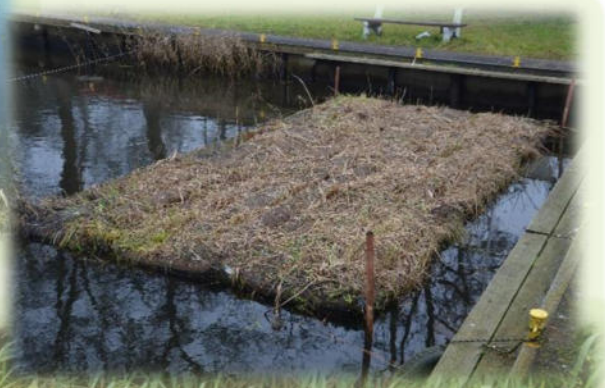
Planting

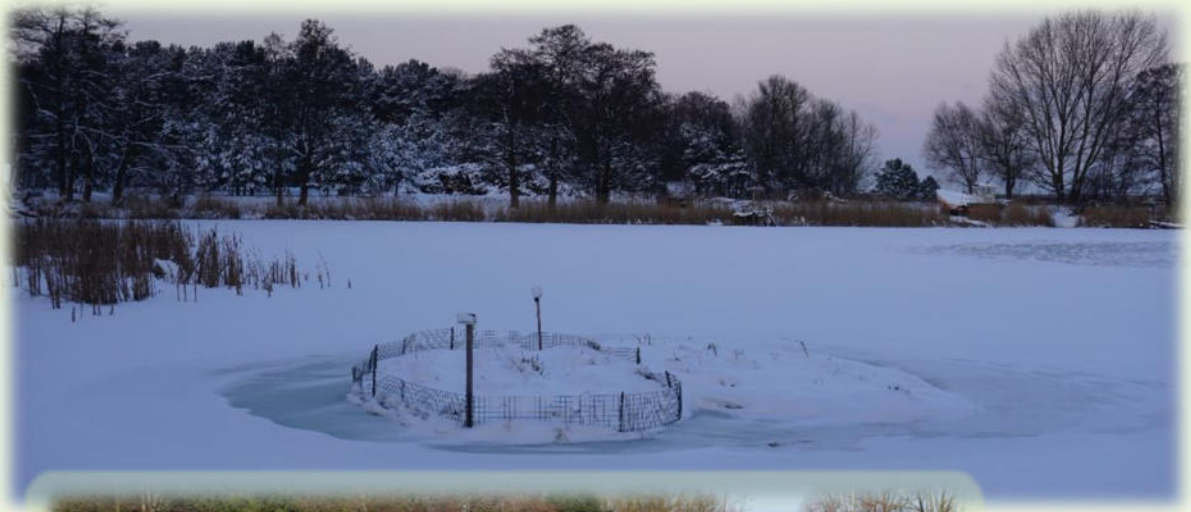


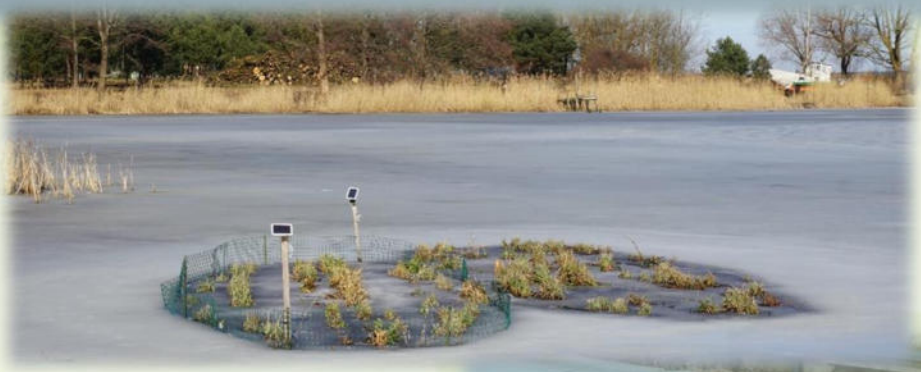




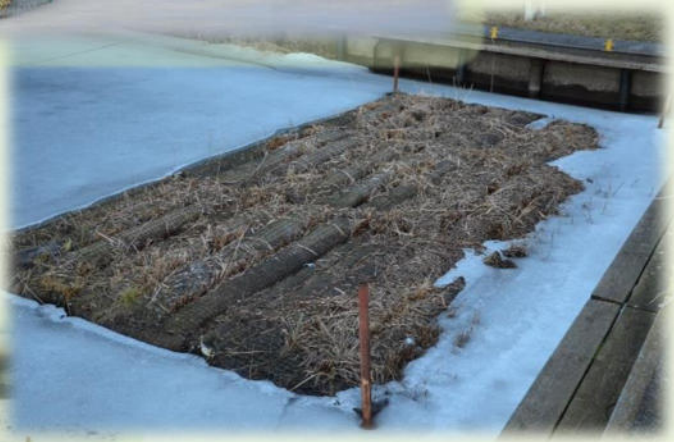
Harvesting

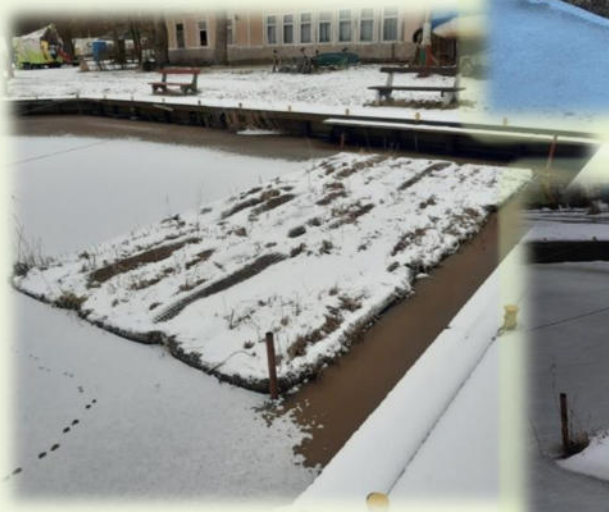


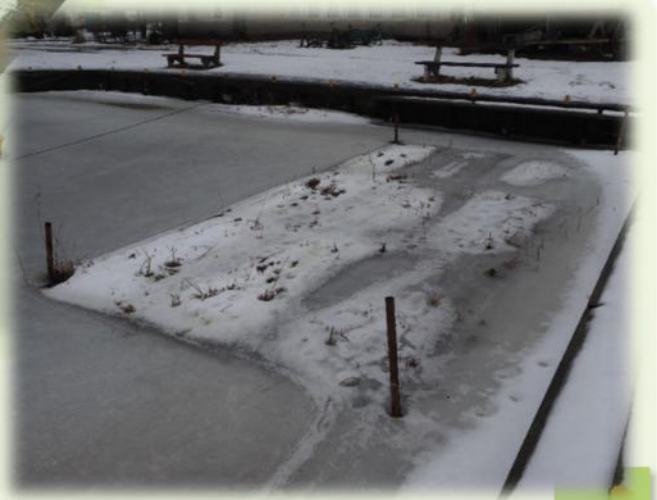




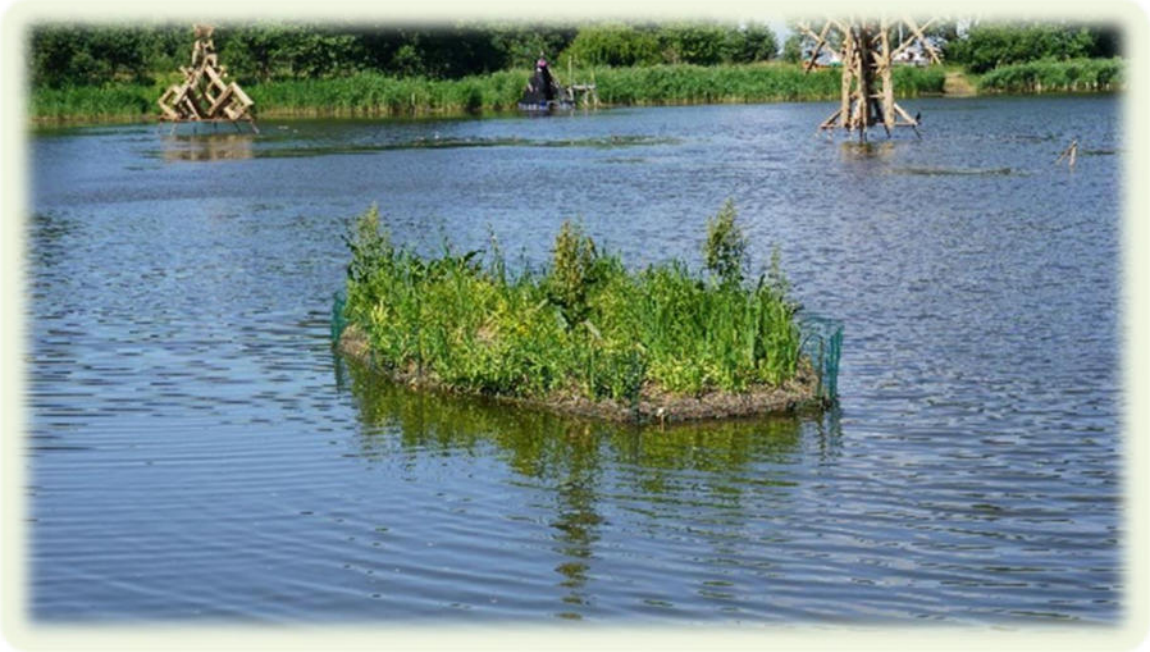
Winter







Roots



Enjoying your island