Social Dynamics in Eelgrass Transplanting Practises

A case study of the eelgrass transplanting in Gamborg Fjord

Image by Timi Løvholt Banke on 09-05-2023

Written by Sophia Amalie Møller Hansen

Aalborg University

Master thesis

AALBORG UNIVERSITY
STUDENT REPORT

AALBORG UNIVERSITY
STUDENT REPORT

Department of Planning
Rendsburggade 14, DK - 9000 Aalborg
https://www.en.plan.aau.dk

Title:
Social Dynamics in Eelgrass Transplanting Practises

Project:
Master's thesis

Period:
February 2022 - June 2023

Supervisor:
Troels Jacob Hegland

Co-Supervisor:
Sara Bjørn Aaen

Authors:
Sophia Amalie Møller Hansen

Pages: 70
Number of appendices: 3

Abstract:

Eelgrass is a foundation species in Danish waters, but since 1900 more than 2/3 have been lost. In recent years, efforts to restore these ecosystems through eelgrass transplanting have been gaining traction. However, the social dynamics and system around and within eelgrass transplanting remain widely unsurveyed. This thesis aims to map the social dynamics in eelgrass transplanting through a case study of the transplanting in Gamborg Fjord. The social dynamics are understood through a Multi-level-perspective of transition theory. Where Discourse theory is utilised to understand the motives behind the practitioner's engagement in transplanting eelgrass within the socio-technical landscape. And social and socio-ecological networks form the niche of eelgrass transplanting practices. For eelgrass transplanting to become an established and viable practice, it has to enter into the system of the socio-technical regime. In entering the regime, challenges and opportunities arise.

Eelgrass transplanting is driven by motives of enhancing biodiversity, compensating for carbon emissions and gaining knowledge of the ecosystem dynamics and services. However, poor ecological conditions restrict eelgrass transplanting, and barriers arise due to high costs, administration of ecosystem services and a need for authorisation. Utilising voluntary labour can reduce costs and increase awareness amongst volunteers while introducing new variables into the transplanting practice. Accrediting the ecosystem services to the practitioners can incentives municipalities and organisations to engage in the practice of eelgrass transplanting. There is, however, an underlying need to tackle the poor ecological conditions for eelgrass transplanting to become a success.

Preface

The global oceans and coastal areas are under ever-increasing pressures from human activities and environmental - and climate changes. These pressures cause the ocean's declining health and the loss of essential ecosystem services. In recent years there has been growing attention towards ocean-based solutions and management. The united nations even named this decade (2021-2030) *the Decade of Ocean Science for Sustainable Development.* The Ocean Decade aims to reverse the declining health of the ocean and ensure a clean, healthy and productive ocean. Research, actions and collaborations between ocean actors are central.
In Denmark, actions and research on active marine ecosystem restoration through eelgrass transplanting and establishing stone reefs and biogenic reefs are gaining traction.

I, the author of this thesis, have a background in Urban, Energy and Environmental Planning and thereby has a more process-oriented approach to understanding these project. Through several semesters I have worked with different topics within the marine sphere. During an internship at the Archipelagos Institute for Marine Conservation, I became the head of the Seagrass Health team and participated in seagrass transplanting in the Aegean Sea. These experiences enable me to understand different issues and have a basic understanding of the biological aspects related to the topic of eelgrass transplanting.

This thesis focuses on eelgrass transplanting projects and intends to contribute to understanding the dynamics of these projects in a Danish context. To conduct this study and gain insights into a Danish context a case of eelgrass transplanting has been utilised. It is with great appreciation that I have been able to conduct interviews, make observations and participate in the transplanting in Gamborg Fjord. A special appreciation to:

Henriette Højmark Hansen[1] *Geophysicist*

Jakob Martin Pedersen[1] *Biologist*

The research team from South Danish University, and

Participants in the transplanting in Gamborg Fjord.

For providing data foundation for this thesis and doing important work to restore our ocean's ecosystems.

[1]Middelfart Municipality's Department of Nature and Environment

Danish summary

Ålegræs er en nøgleart i de danske farvande. Det er en meget produktiv art, som sammenlignes med regnskov og koralrev, der både optager og lagrer CO_2 og næringstoffer, men også fungerer som habitat for adskillige fiskearter. Desuden er ålegræs en indikator for miljøtilstanden af havmiljøer. Der har været nedgang i bestanden af ålegræs og mere end 2/3 af det samlede ålegræsareal er forsvundet fra de danske farevande siden 1900. I de seneste år er der kommet en tilbagekomst af ålegræs grundet tiltag om at mindske udledningerne af næringsstoffer og andre presfaktorer.

I de senere år har der været en stigende interesse for at forbedre tilstandene i havet og der er blandt forskere en enighed om at der er behov for aktiv genopretning af ålegræs bede. Denne interesse har ført til en stigning i antallet ålegræsudplantningsprojekter i Danmark – men en gennemgang af den tilgængelige litteratur omkring ålegræs har vist, at der mangler viden om de sociale dynamikker indenfor praksis omkring ålegræsudplantning.

Dette speciale har til formål at kortlægge og forstå sociale dynamikker i ålegræsudplantning i Danmark gennem et case studie af ålegræsudplantningen i Gamborg Fjord.

De sociale dynamikker forståes i en teoretisk ramme der er opbygget omkring Multi-level-perspektive transition teori. Hvor diskursteori anvendes til at forstå de bredde udfordringer som ålegræsudplantningsprojekter prøver at adressere. Netværk-aktør teori anvendes til at forstå netværket der enten muliggør eller begrænser ålegræsudplantning. Udfordringer og muligheder kan opstå i mødet med samfundets eksisterende strukturer.

Dokumentanalyse af casedokumenter og artikler er sammen med interview og observationer, datagrundlaget for at identificere motiver og aktør-netværk.

Der er identificeret tre forskellige motiver for ålegræs udplantning;

1. forskning,
2. kompensering for udledning af CO_2, and
3. genopretning af økosystem for biodiversitet.

Syd Dansk Universitet har nærmest monopol på ålegræsudplantningsprojekter, da de som de eneste har kompetencer, viden og det materialemæssige setup. Deres kapacitet til indgå i projekter kan betragtes som en flaskehals for

ålegræsudplantningsprojekter i Danmark, hvorved det forskningsmæssige motive bliver afgørende.

Der er desuden store omkostninger forbundet med ålegræsudplantning hvorved der er behov for financering. Financering til genopretningen af økosystem for biodiversitet og forskningsmæssige formål finder sted gennem fonde og statslige forskningsmidler, mens financeringen til ålegræsudplantning som CO_2-kompensering er udfordret af projekterne indgår i statens miljøregnskab og ikke hos dem der financere udplantningen. Hvilket kan demotivere kommuner og private aktører fra at investere i ålegræs. For at fremmme ålegræsudplantninger som klimavirkemiddel er der, derfor et behov for at kreditere udplanterne med CO_2-optaget fra udplantningen. Ålegræs er omkostningsmæssigt konkurrencedygtig med skovrejsning som klimavirkemiddel og der kan anvendes frivillig arbejdskraft for at yderligere reducere omkostningerne. Der er dog en del flere usikkerheder forbundet med udplantning af ålegræs, som kan påvirke villigheden til at investere i ålegræs som klimavirkemiddel.

Disse usikkerheder er en grundlæggende udfordring for ålegræsudplantning, da store dele at de danske farvande er i en tilstand hvor ålegræs ikke kan udplantes eller trives. Der er derfor behov for at miljøtilstandene forbedres og næringsstofudledninger reduceres for at ålegræsudplantning kan blive en realitet i et større omfang.

Table of content

Introduction 1

Seagrasses are a foundation species in marine ecosystems that are present in shallow marine areas and estuaries in all continents except Antarctica. Foundation species control ecosystem dynamics and shape ecosystem processes (Ellison, 2019). Seagrasses have been regressing since the first records in 1869. Since this initial record, 29% of global seagrass areas have disappeared (Waycott et al., 2009). On a European level, there has been a loss of 33% of European seagrass areas in the period 1869 to 2016 (de los Santos et al., 2019). According to de los Santos et al. (2019), Zostera marina (eelgrass) is the European seagrass species that have had the most significant area loss of 57%.

This thesis focuses on eelgrass which is present across the temperate northern hemisphere (Kelly et al., 2019), from Northern China, Northern America to Northern Europe. It is a flowering marine plant that spreads through vegetative - and sexual reproduction, illustrated in figure 1.1.

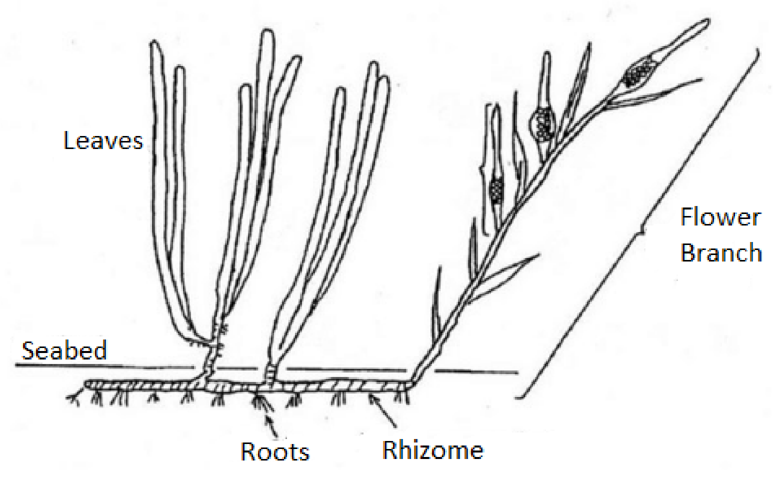


Figure 1.1. Illustration of Eelgrass and terminology for different parts of the plant. Figure by the author.

Around 1900 in Denmark, there was an eelgrass distribution of approximately 6.700 km^2 (Krause-Jensen et al., 2021). Around the 1930s, around 90% of the North Atlantic eelgrass populations perished due to wasting disease, and in the 1970s, the Danish eelgrass populations had another severe decline due to eutrophication, which was and still is especially prominent in the inner fjords (Krause-Jensen et al., 2021; Boström et al., 2014). The ecological condition based on eelgrass as an indicator is, in the Danish coastal waters, in most part between moderate and bad (Ministry of Environment of Denmark and Environmental Protection Agency, 2021). The current distribution of eelgrass in Denmark is modelled to less than 1/3, 2.204 km^2, of the distribution in 1900 (Staehr et al., 2019).

1.1 Importance of eelgrass beds and ecosystem services

Eelgrass beds are highly productive ecosystems, that are comparable to coral reefs and rainforests (Jahnke et al., 2022). This foundation ecosystem host high biodiversity, sequesters vast amounts of carbon, helps to nutrient regulate the waters, improves water quality, and stabilises sediments (Cole and Moksnes, 2016; Tan et al., 2020a; Kelly et al., 2019). Eelgrass beds host many commercialised fish species, that utilise the beds for breeding, feeding, and hideouts. The provisional ecosystem services of commercial fishes in eelgrass beds are estimated to have an average value[1] of 400 USD ha^{-1} yr^{-1} ([2]Approx. 2.700 DKK) (Cole and Moksnes, 2016). Besides hosting fish, the eelgrass beds also provide forage for migrating birds (Shaughnessy et al., 2012).

The stabilising capabilities of eelgrass help protect against erosion, and a study by Walter et al. (2020) show that erosion occurs in more than 90% of the locations where eelgrass beds are lost. Eelgrass also provides regulation services such as nutrient and carbon regulation. Eelgrass beds store nitrogen (N) and carbon (C) in the plant and the sediment. Additionally, there is, over a period of time, an annual sequestration. Over a 50-year period, eelgrass stores 98,6 t C ha^{-1} and over a 20-period, it stores 466 kg N ha^{-1} (Cole and Moksnes, 2016). These ecosystem services can be translated into an economic value[1] adding up to 20.700 USD ha^{-1} ([2]Approx. 139.000 DKK) eelgrass (Cole and Moksnes, 2016). Furthermore, eelgrass also provides cultural ecosystem services such as educational and recreational services and the protection of marine cultural heritage (Krause-Jensen et al., 2019).

1.2 Threats to eelgrass

These highly productive ecosystems depend on various environmental and ecological conditions such as light access, temperature, salinity, sediment type, and physical exposure, and they are sensitive to changes in these conditions. According to de los Santos et al. (2019) and Kelly et al. (2019), the threats to eelgrass beds are mainly caused by coastal modification, degraded water quality, and direct damage.

[1] In a Swedish context

[2] Estimate of danish value based on the valuta of the USD in 2016 from Denmarks National Bank (2023)

Due to climate change, a global trend of rising water temperatures impacts the survival of eelgrass as higher temperatures increase light requirements and, above certain temperatures, heighten the mortality rate of shoots (Nejrup and Pedersen, 2008). In clear water, the temperature rise would result in the retraction of eelgrass to deeper waters, where the temperature is lower. However, the depth limit is determined, amongst others, by the transparency of the water. Nutrient run-off from land is a main driver for eutrophication, which limits the transparency of the water, which reduces the depth limit of the eelgrass (Krause-Jensen et al., 2021).

Other threats can be connected to coastal modification and direct damage from i.e. fishing or boat anchoring (de los Santos et al., 2019; Kelly et al., 2019). Krause-Jensen et al. (2021) highlights that bottom trawling can have several negative impacts on eelgrass either through the direct impact that uproot shoots or indirectly by up-swirling sediments that settle on the leaves, thus limiting the availability of light. Figure 1.2 illustrates, how bottom trawling and eutrophication push the eelgrass into shallower waters where it is exposed to warming, by limiting the depth limit. Thereby highlighting that several pressures interact and limit the area where eelgrass can thrive from both sides.

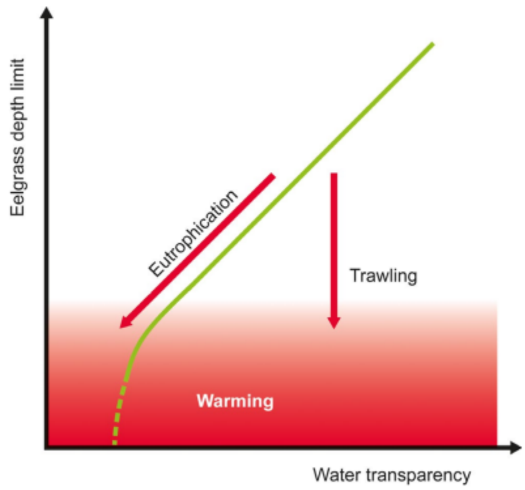


Figure 1.2. Interaction between the impacts of warming, eutrophication and bottom trawling. Figure by Krause-Jensen et al. (2021)

These threats can also lead to a fragmentation of the eelgrass beds. Fragmentation can lead to a regime shift of the ecosystem, whereby the self-protecting abilities of the eelgrass beds are lost. Such regime shifts have been identified in Danish Fjords, where the loss of eelgrass has transformed clear waters into more turbid waters, which create a negative feedback loop by worsening the living conditions for the remaining eelgrass (Boström et al., 2014; Staehr et al., 2019). The fragmentation of eelgrass beds not only impacts the self-protecting abilities but also limits the exchange of genetic material between eelgrass populations (Pastor et al., 2022). The exchange of genetic material is vital for eelgrass beds as it enhances genetic diversity, which is correlated with the health and resilience of the beds (Harenčár et al., 2018). Restoration of Eelgrass beds can help re-establishing connectivity and mitigate fragmentation (Pastor et al., 2022).

1.3 Restoration of Eelgrass beds

Removal of stressors through management interventions and natural recolonisation of eelgrass beds have since the 2000s led to a reversal of the regressing trend, as a rapid recovery of eelgrass and other Zostera species has occurred along the Atlantic coasts (de los Santos et al., 2019). This reversal has also been observed in Denmark, where efforts to reduce nutrient outlets have led to increasing depth limits and recovery of eelgrass (Riemann et al., 2016). However, the removal of stressors is according to Boström et al. (2014) and Center for Marin Naturgenopretning (2023) not necessarily enough to enable full recolonisation. They deem it necessary to engage in active restoration.

1.3.1 Transplantation techniques

There are different way to conduct active restoration of eelgrass beds. These involve either planting seeds or seedlings, or transplanting donor material from existing beds. In Denmark, there has been an extremely low successrate connected to planting eelgrass with seeds. Lange et al. (2020) found an establishing rate of less than 0,02% when planting seeds. Hence it is deemed necessary to engage in transplanting. A review of 1.786 trial transplanting projects, van Katwijk et al. (2016) found an estimated trial survival of 37% after 3 years. Based on this review, it was found that rhizomes anchored with weights had the highest success score, while seedlings without anchoring had the lowest. Furthermore, it was identified that bigger transplanting projects in general had a bigger success compared to smaller transplanting projects as the self-protecting mechanisms will become present at the transplantation, thus improving the chances of survival (van Katwijk et al., 2016). When transplanting, there is a need collect donor material these often harvest from donor beds. This can impact the donor beds' self-protecting abilities. However, up to 40% of eelgrass shoots can be harvested from a healthy donor bed without significant negative effects (Moksnes et al., 2021).

1.3.2 Barriers and drivers of eelgrass transplanting projects

Eelgrass restoration projects are driven by different aspects. Orth et al. (2020) identifies that the drivers of eelgrass restoration have been changing over time. Pre-1933 managers mainly focused on the physical goods that eelgrass beds provided, i.e. ecosystem services contributing to the economy. Although the economic aspect is still present, modern managers also use the regulating capability of eelgrass to justify restoration (Orth et al., 2020).

The cost of eelgrass transplantation is relatively high, the median cost of transplanting projects is 106.782 USD ha^{-1} ([3]671.840 DKK), which is between

[3]Estimate of Danish value based on the valuta of the USD in 2020 from Denmarks National Bank (2023)

10-400 times higher than terrestrial restoration (Tan et al., 2020b), in a Swedish context, the cost is estimated to be between 1.2-2.5 mio. SEK ha^{-1} ([4]880.000-1.8 mio. DKK) (Moksnes et al., 2021). And as the ecosystem services that eelgrass transplanting provides are common-pool resources, it can be difficult to gain funding (Ounanian et al., 2018). As identified in section 1.3, there is a low success rate of transplanting projects, thereby there is no guarantee that the transplants will survive despite the high cost. And although the eelgrass beds are restored this does not necessarily mean that all of the ecosystem services are restored (Boström et al., 2014).

The high cost of eelgrass transplanting is mainly connected to it being a labour-intensive practice. In Sweden, the labour cost constitutes 86-90% of the total expenses of transplanting (Moksnes et al., 2021). By involving volunteers in the transplanting and utilising citizens' science in monitoring it is possible to cut some of the labour costs. In the restoration effort by Orth et al. (2020), more than 3.500 hours of voluntary seed collection was performed, and Sfriso et al. (2021) utilise local stakeholders such as fishermen, hunters, and sports club members to transplant 51.260 rhizomes, while researchers only transplanted 14,451 rhizomes. To motivate volunteers there is a need for awareness and social recognition. Unsworth et al. (2019) identify a general lack of public awareness around eelgrass and limited societal recognition. The lack of awareness and recognition leads to gaps in economic, societal and jurisdictional aspects which are barriers to the effective management of eelgrass beds (Boström et al., 2014).

This year (2023) the first Global Seagrass Day is being held on the 1st of March (United Nations, 2022), this is a top-down approach that aims to increase awareness, and societal recognition and facilitate action. However, there is a need for stakeholders, institutions and civil society to embrace the initiative. Which in turn can be expressed through legislation, funding, volunteerism, behavioural patterns and management efforts (Weinstein, 2008). According to Weinstein (2008) the success of restoration including eelgrass transplanting projects depends upon societal values. Hence there is a need for an interdisciplinary approach to increase societal recognition of eelgrass' importance and increasing public awareness and simulating communication between experts and stakeholders as these aspects are among the most pressing matters to ensure sufficient actions are taken to preserve and re-establish eelgrass beds (Unsworth et al., 2019; Boström et al., 2014).

1.4 Eelgrass transplanting in Denmark

Marine nature restoration is becoming a part of public awareness in Denmark. The Center of Marine Nature Restoration was established at the beginning of 2023 (Center for Marin Natur Genopretning, 2023) and the national committee

[4]Estimate of Danish value based on the valuta of the SEK in 2021 from Denmarks National Bank (2023)

for the UN Ocean Decade established a working group on Coastal Restoration and Ecosystem Services. In Denmark, eelgrass transplanting and establishing stone reefs are Denmark's most prominent marine habitat restoration practices. The earliest eelgrass transplanting identified in Denmark was conducted in the NOVAGRASS project that lasted between 2013 to 2018 (Lange et al., 2020). During this project, trials were conducted to deduce which restoration methods are most suitable in Danish conditions. It was concluded that eelgrass planting in Denmark is not possible (Lange et al., 2020). In 2017 the first large-scale transplanting was conducted in Horsens Fjord, where the transplanted site over the span of 2 years, had a similar shoot density as the donor bed.

Since then the number of applications to conduct transplanting has been rising from one application in 2019 to five applications in 2022. This indicates a growing momentum in eelgrass transplanting efforts in Denmark. Eelgrass transplanting projects that utilise anchoring must apply for and gain a permit from the Coastal Authority. Other agencies and authorities besides the Coastal Authority have fields of responsibility that can also be affected by eelgrass transplanting project and are thus consulted. In a screening within the Coastal Authorities archives the common authorities consulted in eelgrass transplanting projects were the Danish Maritime Authorities, Environmental Protection Agency, Civil Aviation and Railway Authority, Housing and Planning Authority, Fisheries Authority, Ministry of Defence Estate Agency, and the Danish Agency for Culture and Palaces. This review shows that the most prominent authorities who react to eelgrass transplanting projects are the*Maritime Authority*, *Environmental Protection Agency*, and the *Agency for Culture and Palaces*, n.f. appendix A.

However, despite this rising momentum and there is little research and literature on social dynamics within eelgrass transplanting projects. This lack of knowledge is identified through literature reviews, which will be presented in section 4.1.

Research question and design 2

In chapter 1, many aspects of eelgrass and eelgrass transplanting have been presented. There is, however, a lack of knowledge of the social dynamics that drive or limit practitioners, stakeholders, and volunteers in eelgrass transplanting.

To explore these dynamics, this thesis employs a case to explore concrete context-specific dynamics. The case used is the eelgrass transplanting in Gamborg Fjord, described in chapter 5. Case studies are a significant project design employed, in particular, within social science that enables the researcher to gain insights into context-specific knowledge. Flyvbjerg (2006) argues that all knowledge is context-specific in social science. In the case study, the experts are the practitioners and users in the activity of expertise that can adapt to different contexts.

Through the selection of a case, it is possible to influence the type of knowledge that can be extracted, as the aim of this thesis is to understand the dynamics of eelgrass transplanting. It is crucial to either have a case with several aspects present or have several cases.

In the case selection, two case criteria have been set up.

1. The project has been applied for and has gained a permit from the Danish Coastal Authorities.
2. That it is in progress and has yet to be executed when the case is chosen.

Criteria 1 enables the researcher to easily identify cases.
Criteria 2 enables the researcher to gather information as the project progresses and get a better insight into the small complications throughout the process, participate in meetings, and participate in the transplanting.

All projects published by 03-02-2023 and will be executed in the spring/summer of 2023 were contacted. Two projects allowed the researcher to become a part of the projects. However, after participation in a meeting between the practitioners in the Gamborg Fjord case. The case was deemed to be extensive enough to stand alone. Thus the project was limited to the study of transplanting in Gamborg Fjord. The case is a representative case for most transplanting projects in Denmark and will give insights into both case-specific conditions and general observations from the practitioners. In this case, empirical data collected is mainly qualitative data.

This case and data will help cover the problem in the problem statement:

Problem statement

> In recent years, there has been a growing awareness of the ocean and marine restoration. This has led to a rise in eelgrass transplanting projects in Denmark. However, there is a lack of knowledge regarding eelgrass transplanting practices' social dynamics. This thesis aims to map and understand the social dynamics of eelgrass transplanting in Denmark through a case study of the transplanting in Gamborg Fjord.

A theoretical framework is presented in chapter 3 of how these dynamics can be understood. The following research objectives are formulated to look into different levels of the theoretical framework, as there is a need to have insight into each level to understand the dynamics.

Research objective

- Identify the motives behind the transplanting projects in Gamborg Fjord.
- Map actors connected to the transplanting projects in Gamborg Fjord.
- Analyse the uncertainties within the transplanting projects in Gamborg Fjord and identify challenges and opportunities.
- Discuss ways to seize opportunities and address the challenges and uncertainties.

Figure 2.1 illustrated how the research objectives and theories are understood in the MLP theoretic framework. To cover the different research objectives, there is a need for different types of data. The data collection methods are accounted for in chapter 4.

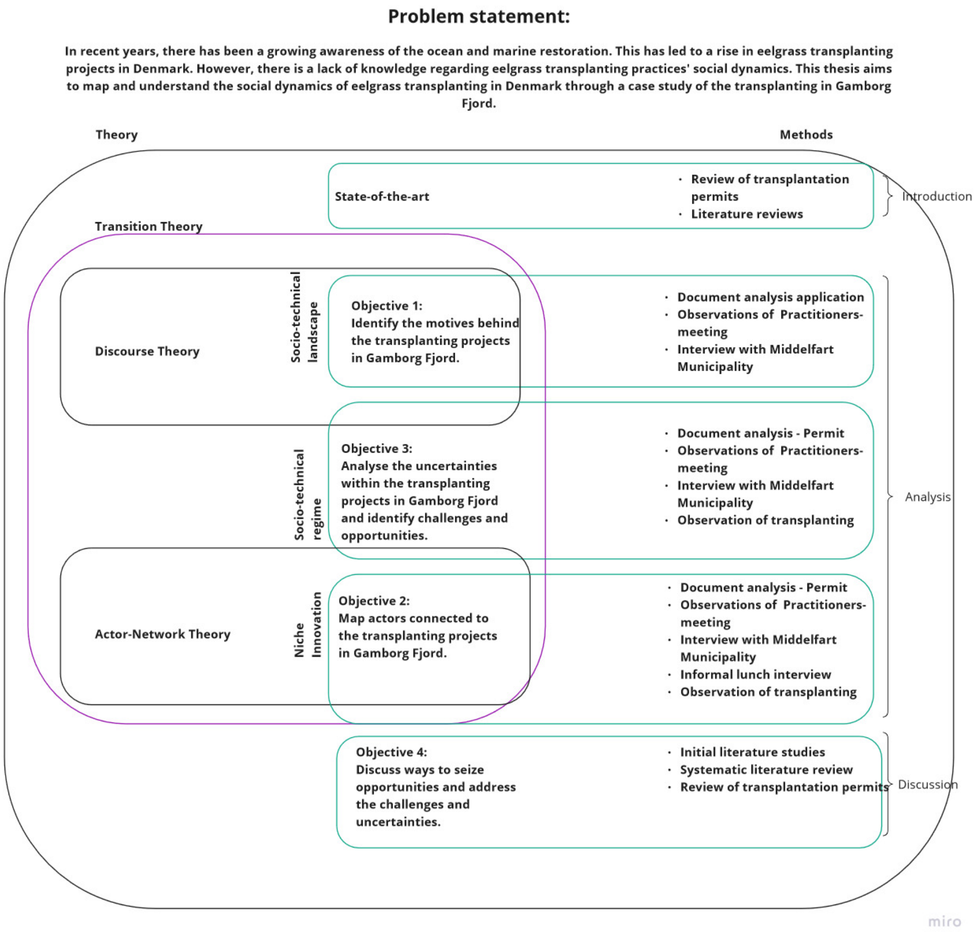


Figure 2.1. Project design of how the ontological framework is set around the theories and which data is utilised to account for the different research objectives. Figure made the author.

Discourse theory is utilised to *Identify the motives behind the transplanting projects in Gamborg Fjord*, which help identify the challenges in the socio-technical landscape that the eelgrass transplanting project aims to address. To identify the motives, a document analysis of the applications for authorisation and an article related to the project's funding has been conducted along with data from an Observation of the meeting between SDU and Middelfart Municipality and the interview with Middelfart Municipality. Actor-network theory is utilised to *Map actors connected to the transplanting projects in Gamborg Fjord* and thereby understand which actors influence the niche innovation of eelgrass transplanting projects. In getting insights into the actors of the project, the data is utilised along with Observations from the transplanting. However, data have also been acquired from document analysis of the permit for the transplanting project and the article of funding. The same data foundation is utilised to *Analyse the uncertainties within the transplanting projects in Gamborg Fjord and identify challenges and opportunities*. This analysis will give insight into the socio-technical regime and how it hinders or promotes different aspects in the eelgrass transplanting.

Framework of dynamics of eelgrass transplanting 3

The dynamics this thesis aims to map are understood through a theoretical framework based on Multi-Level-Perspective (MLP) transition theory as described in the previous chapter, where discourse theory is utilised to understand the challenges that drive practitioners to initiate transplanting. Actor-Network Theory is applied to map actors within the social and ecological systems, thus understanding the networks and uncertainties. This knowledge of the Actor-Network, the discourses and uncertainties are utilised to analyse and discuss the challenges and opportunities of transplanting projects.

3.1 Multi-Level-Perspective Transition Theory

Multi-Level-Perspective (MLP) Transition Theory is a theoretical framework for understanding which dynamics influence transplanting projects. In MLP, three core concepts are utilised to understand a transition: the socio-technical landscape, the socio-technical regime, and niche innovation.

The socio-technical landscape is exogenous structures and tendencies, that are deeply embedded at a macro-level (Schot and Geels, 2008). These structures can be i.e. macro-economics, macro-political developments, or the global climate. Challenges in the socio-technical landscape are, i.e. climate change and loss of biodiversity, which have the potential to destabilise the socio-technical regime.

The socio-technical regime is systems and structures embedded in broader communities through produced and reproduced routines and beliefs, such as market preferences, infrastructure, and cultural meaning (Geels, 2002). Niche innovations start out as small networks of actors that, through alignments and co-learning, create alternatives or add on to the routines and beliefs. The regime can remain if the newly produced routines and beliefs fit within the socio-technical regime. However, the niche does not necessarily fit into the socio-technical regime, whereby it either fails to be reproduced or pressures from the socio-technical landscape destabilise the regime, and the momentum of the niche innovation grows. This pressure can originate from macro-political structures such as the United Nations that, through international agreements and focus, put pressure on the socio-technical regime where the niche can present itself as a way for the socio-technical regime to address the challenges identified in the national agreements, whereby the socio-technical regime can adjust policies, expand markets, i.e. the carbon market, to incorporate the niche into the regime.

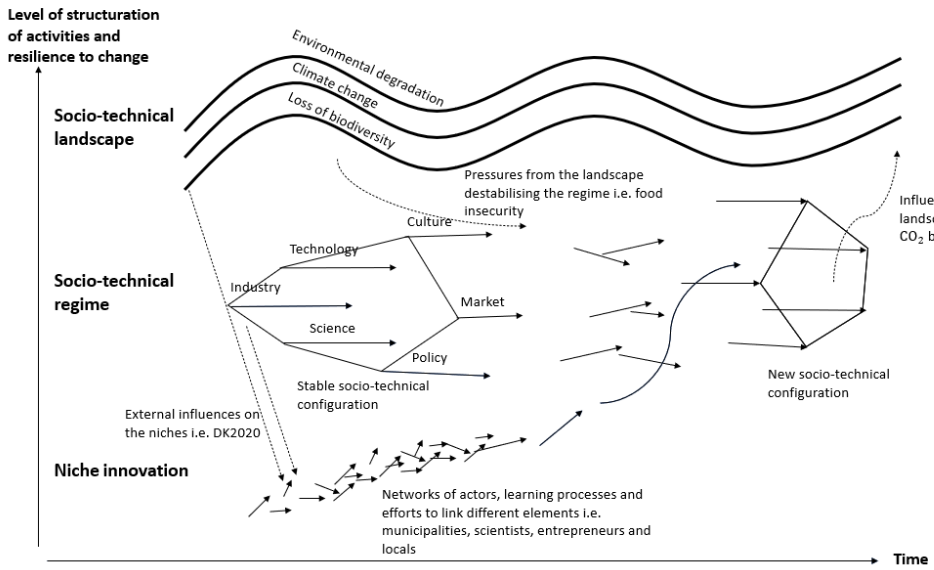


Figure 3.1. System consisting of the socio-technical landscape, the socio-technical regime and niche innovation. Figure by the author inspired by Geels (2002)

In this report, eelgrass transplanting projects is viewed as a niche innovation that is motivated by challenges in the socio-technical landscape. These challenges are expressed in the discourse of the transplanting project. In the meeting with the socio-technical regime, the challenges and opportunities of the transplanting project arise.

3.2 Discourse Theory

Discourse theory is utilised to understand which pressures from the socio-technical landscape motivate and drive eelgrass transplanting projects. Ounanian et al. (2018) identifies the discourses driving marine ecosystem restoration projects. These discourses are defined based on the level of human intervention and the motive for engaging in the project. Ounanian et al. (2018) identifies four types of discourses within marine ecosystem restoration; *Putting Nature First*, *Bringing Nature Back*, *Helping Nature Support Humans*, and *Building with Nature* (Ounanian et al., 2018), illustrated in figure 3.2.

Eelgrass transplanting practices are by nature high human intervention, and there is a recognition that there is a need for active restoration to ensure full recolonisation of eelgrass (Boström et al., 2014; Center for Marin Naturgenopretning, 2023). Thus, low human intervention efforts are seen as insufficient. Therefore, this thesis solely utilises the motives to determine the discourse. The motivations impact how the transplanting project is shaped and who is being involved, thus identifying the discourse is fundamental for understanding how and why actors engage in transplanting projects.

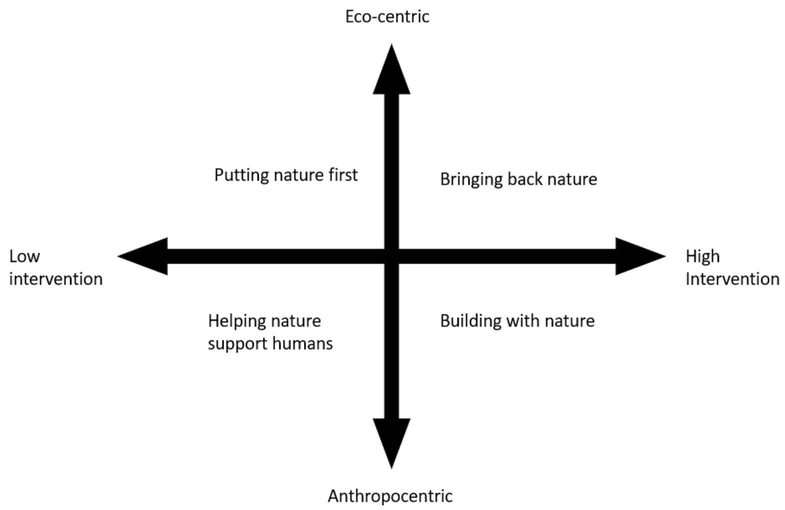


Figure 3.2. The discourses of marine ecosystem restoration, where the horizontal axis is the level of intervention and the vertical axis is the motivation of the project. Figure made the author based on discourses from Ounanian et al. (2018)

According to Ounanian et al. (2018), the dominant discourse amongst restoration practitioners is eco-centric, thus, they can be classified as being a part of the *Bringing nature back*-discourse. The drivers behind *Bringing nature back* are often the positive externalities of the project. In eelgrass transplanting projects are these externalities are both the regulating abilities in the context of carbon and nutrients and enhancing biodiversity. The positive externalities are given value from a societal point of view, whereby there is an underlying anthropocentric motive. Hence no project is solely based on an eco-centric motive. The motivation behind transplanting projects can also have a more anthropocentric driver where it is initiated with a specific societal or economic focus (Ounanian et al., 2018), i.e. coastal protection of a specific area. However, it is debatable how effective eelgrass is for coastal protection in more extreme conditions such as during storms Flindt et al. (2023). Thus if the project was mainly driven by anthropogenic motives other more effective means for coastal protection would be chosen.

3.3 Actor-network theory

Actor-Network theory can be used to understand complex systems. A network consists of nodes and edges, nodes are the network entities, and the edges are the links and connections within the network. However, when using networks to understand a system there is a need to make limitations on what to include in the network otherwise the network can become boundless. Figure 3.3 illustrates a network with a limit, nodes and edges.

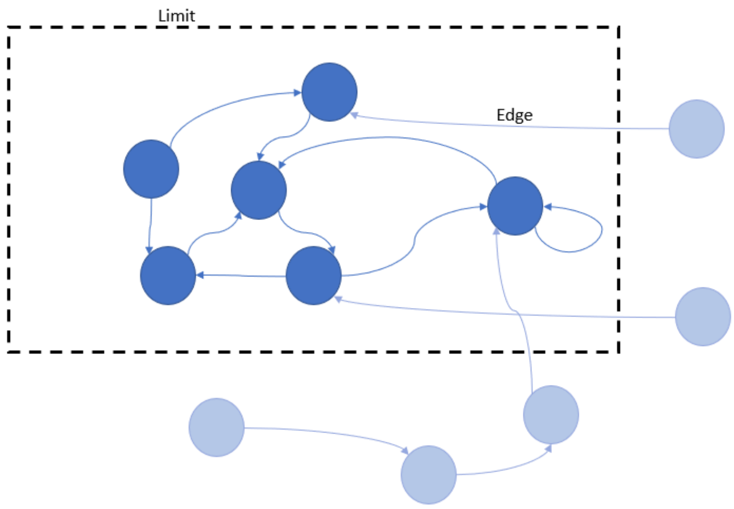


Figure 3.3. The network understanding used in this project consists of nodes, edges and a limitation. There are different kinds of edges which can be differentiated using colour coding. Figure made by the author.

The actor-network of eelgrass transplanting can be considered within a socio-ecological system. The socio-ecological system consists of two dimensions the ecological and the human, and their interactions (Taylor and Suthers, 2021).

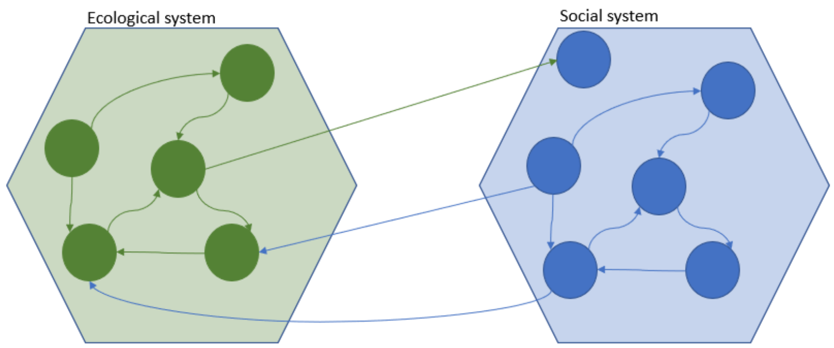


Figure 3.4. The socio-ecological system consist of networks in the ecological system and in the social system that interact with one another. Figure made the author.

Transplanting is an intentional interference by the social (human) system to restore the eelgrass beds in the ecological system. In the social network, several nodes influence eelgrass transplanting. Some nodes are mapped in section 1.3.2. The edges can in the social system be monetary, labour, knowledge or materials that connect the nodes. In the ecological system, the edges can be nutrient uptakes, releases and positive or negative impacts on conditions. However, the social system does not only have intentional edges with the ecological system. Social actors can indirectly impact the success of eelgrass transplanting by impacting the ecological system, i.e. emissions of nutrients from agriculture can severely impact the ecological system.

To limit the area of research these indirect impacts will only be included in the analysis to the extent the practitioners have directly referred to them.

3.4 Uncertainties

Uncertainty is a central concept within marine management and in actions taken on the marine territory due to either knowledge gaps, cumulative effects, or interactions. Ounanian et al. (2018) find that uncertainties can be presented and weighed differently depending on the discourse. While other uncertainties are connected to the specific type of marine ecosystem. Brugnach et al. (2008) identify three kinds of uncertainties: Unpredictability, incomplete knowledge, and ambiguity. Incomplete knowledge is connected to a lack of reliable data. Where unpredictability arises in complex systems where cumulative effects might arise or unexpected dynamics are established. Ambiguity arises when there is a different way of knowing or interpreting (Ounanian et al., 2018). These uncertainties can be present both within the ecological system and the social system and are utilised to understand the challenges of eelgrass transplanting projects.

The niche innovation of eelgrass transplanting is understood through actor-network theory in a socio-ecological system where the actors and links are established. The discourse gives an insight into the challenges in the socio-technical landscape that put external pressures on the socio-technical regime and motivate social actors to engage in transplanting projects. The challenge mostly originates in uncertainties within the ecological system and the social system and becomes apparent in the encounter with the socio-technical regime.

Method 4

4.1 Literature review

Literature has been utilised to map state-of-the-art which is presented in the introduction in chapter 1.

Initially, an unstructured literature search was conducted to gain various input and literature on eelgrass transplanting. This unstructured search was conducted on the search engine Ecosia, where sources from scientific databases were screened firstly on the title, then if deemed relevant, the abstract, introduction, and conclusions were screened.

Following the initial unstructured searches, systematic literature reviews focused on the networks and social science within eelgrass transplanting where conducted. The first structured literature search was conducted the 13-03-23 at *Proquest: Social Science database*. With the keywords:

Table 4.1

	Occurance	Word	Word	Word
Keyword 1	Anywhere	Eelgrass	"Zostera marina"	
Keyword 2	Anywhere	Transplanting	Replanting	Restoration
Keyword 3	Anywhere	Network	Actor	
Result 21 articles				

These articles were systematically screened, but the vast majority was deemed irrelevant, due to a lack of focus on the social aspects and networks in eelgrass transplanting projects.

To gain more insightful literature, the search string was modified for a second structured literature search, which was conducted on 14-03-23 at three data search engines; Aalborg Universitets Bibliotek (AUB), Proquest: Social Science database, and Web of Science Core Collection.

At both AUB and at Web of Science Core Collection only 10 articles were accessible. However, similar to the prior search terms, only a minor part of the articles were relevant in the context of this study. Spiralling in the literature was used to find additional sources in both the unstructured and structured searches. Based on the

Table 4.2

	Occurance	Word	Word	Word
Keyword 1	Description/abstract	Eelgrass	"Zostera marina"	
Keyword 2	Description/abstract	Transplanting	Replanting	Restoration
Keyword 3	Anywhere	Network	Stakeholder	
AUB results 12 articles				
Proquest: Social Science database result 0 articles				
Web of Science Core Collection result 12 articles				

result of these searches, it was concluded that there is a general lack of knowledge of the social dynamics and networks surrounding eelgrass transplanting projects.

4.2 Document analysis and systematic review of permits

A review of the permits for eelgrass projects has been utilised to identify potential cases and get insight into the authorities and actors of transplanting projects.

In Denmark, fixed facilities or anchored devices in the coastal waters with other goals than coastal protection are required to apply for permission according to the Coastal Protection Act §16a no. 2 and make the application public on Coastal Authorities web page (Miljø- og fødevareministeriet, 2020). Thus any legal eelgrass transplanting projects where the shoots are anchored will have published applications and get a permit on the Coastal Authorities web page.

For the case-specific permit and application, a document analysis has been conducted using the data treatment tool NVIVO, which is also employed for the data treatment of the interview and observations, see section 4.5.

Between 2019-2023, there were 17 applications for eelgrass transplanting, and 13 permits were given at the time of the screening. Three projects had yet to be given permission. These publications and permits are used as the raw data for the systematic review of the objections and inputs from consulted parties, presented in appendix A. The authorities which have expressed concerns or requested consideration in the hearing statements regarding eelgrass transplanting are the Maritime Authority, Environmental Protection Agency, Agency for Culture and Palaces, Ministry of Defence Property Agency and Fisheries Agency, cf. appendix A.

4.3 Semi-structured interview with practitioners

A semi-structured interview will be applied to gain an in-depth understanding of the actors and the interactions and transactions within the transplanting project. Kvale (2005) highlight that setting, time and people are all influencing the data which is extracted and the reliability of interviews are thereby often low as efforts to heighten the reliability remove the innovation and reflections of the interviewee. The focus should be on the validity of the data from the interview. This should be done through all of the stages, from preparing to reporting the results of the interview.

The goal of the interview in this thesis is to understand the dynamics within the transplanting project in Gamborg Fjord.

The interviewees of the semi-structured interview were chosen based on their role as practitioners within the project. An interview with the practitioners Henriette Højmark Hansen and Jacob Martin Pedersen from Middelfart Municipality was conducted. The intention was also to interview the leading researcher, Researcher C, from SDU. However, it was not possible to establish contact after the meeting between practitioners.

The objectives of the interview with the practitioners are to:

- Map the stages in the transplanting project.
- Understand the drivers leading to deciding upon transplanting eelgrass.
- Identify the interest that the interviewee represents in the transplanting project.
- Understand the roles that the interviewee attends to in the transplanting project.
- Map the interactions and transactions between the practitioners and other stakeholders.
- Map the uncertainties and worries that the practitioners have regarding the transplanting project.
- Understand the weighting of different stakeholders and uncertainties.

These objectives are translated into guiding questions, cf. appendix C, used in the semi-structured interview. The interview format enables a more open and dynamic conversation with the interviewee, where both parties can influence the direction of the interview. And it is possible for the interviewer to ask follow-up questions where there might be uncertainty. Some interview questions, involving initiating and planning the transplanting project were sent to the interviewees before the interview. This was done to enable the interviewees to reflect and prepare, while other questions on the personal and professional roles, goals and worries, were only asked at the interview to get intuitive reactions and reflections from the interviewees.

Before the interviews, observations from a meeting between the practitioners had enabled the interviewer to gain a slight insight into the roles of the different practitioners; thereby, some questions have been specifically customised to specific practitioners.

4.4 Observation

Observations are utilised to understand a situation, meeting, or process. Ciesielska et al. (2018) suggest five aspects might be relevant when making observations:

- Management of time and space
- Objects
- Social actors
- Interactions
- Routines, rituals or episodes

The main aim of applying observations in this study is to gain insights from the interactions between the practitioners, authorities, stakeholders, and volunteers. These insights will be extracted from direct interactions between parties or how i.e. practitioners talk about other stakeholders. While objects relevant to setting the stage of the interactions will be noted down.

4.4.1 Practitioner meeting

In establishing a connection with the case study, the researcher (observer) was invited to participate in a prearranged meeting between the different parties of the practitioner group on the 22nd of February. The meeting took place in a meeting room at the Institute of Biology at SDU Odense. The observer was allowed to record the meeting. After the observations were conducted, the recording was transcribed. Due to lacking consent to name the practitioners from SDU, the practitioners are referred to as Researcher A, Researcher B and Researcher C.

The setting was hosted by the practitioners from SDU where breakfast was served, and the planning was mainly done through casual conversation. This enabled the observer to gain insights into the planning process and some of the challenges that eelgrass transplanting projects face. The meeting was prearranged, including the settings, participants, and aim. The observer was a partial participant in the meeting, who engaged in the conversation, but mainly to understand the processes and considerations that the practitioners addressed during the conversation.

4.4.2 Transplanting practice

Before the transplanting, a plan was sent out to all volunteers, including the observer. Which contained practical information about time, place, things that will be provided, and what to bring along.

The plan states that the transplanting takes place across four days unless the weather makes it irresponsible.

Table 4.3

Monday 8/5	Tuesday 9/5	Wednesday 10/5	Friday 12/5
11:00-15:00	09:30-15:00	09:30-15:00	09:30-13:00
Preparation	Intro to marine archaeology		

The observations took place from Monday to Wednesday. However, due to unrelated circumstances the observer could not participate from the beginning of Monday, but stayed after the volunteers had left with the practitioners from SDU. Tuesday and Wednesday, the observer arrived and left with the practitioners from Middelfart Municipality. During all the days of observations, there were sunny, which was great conditions for attracting volunteers and made the setting comfortable.

4.5 Data-treatment of qualitative data

The qualitative data and documents of the case are treated in NVIVO, which is a qualitative data-treatment program, that enables systematic categorisation of data. In reviewing and treating the data, it is firstly split into categories of; uncertainties, challenges, opportunities, planning, actors, discourses, experience from other transplantings and other. Data within the categories are afterwards put into sub-categories that give closer insides into i.e. the specific characteristics, see code tree in appendix B.

The files treated are the following:

File name	Type	Person
Application for the transplanting eelgrass on two locations in Gamborg Fjord	-	-
Permit to transplanting eelgrass on two locations in Gamborg Fjord, Middelfart Municipality	-	-
Observation of practitioners meeting	Observ. Meeting	Researcher A, Researcher B, Researcher C, Henriette Højmark Hansen, or Jakob Martin Pedersen
Observation of transplanting	Observ. Transplanting	-
Interview with Middelfart Municipality	Interview	Henriette Højmark Hansen, or Jakob Martin Pedersen
Informal lunch interview	Informal interview	-

In the analysis, references are conducted accordingly:

- Active reference - *Person* (Type)
- passive reference - (Type: Person)

4.6 Method discussion

The reliability and validity of the different methods and the data are assessed based on their ability to answer the research question.

The research question is directly aimed at the transplanting in Gamborg Fjord, thereby the case can be considered highly valid. The practitioners in the case are from SDU and Middelfart Municipality. As the SDU is involved in several transplanting projects across Denmark and in the cases of transplanting, they have insights into various contexts of the practice and big expertise. The practitioners from Middelfart Municipality have also engaged in eelgrass transplanting prior to this and have experience in administration and project management connected to various types projects. Hence their expertise is not limited to the single case of eelgrass transplanting in Gamborg Fjord but is based on various contexts and cases. In the context of analysing the aspects connected to the *Authorisation and authorities*, the comments of "not impacting surveillance transects" from The Danish Environmental Protection Agency and "awareness of national heritage" from The Danish Agency for Culture and Palaces are present in several transplanting projects A. Whereby the challenges and opportunities connected to these comments are highly generalisable.

The qualitative data is largely collected directly from the practitioners of the project. Whereby the validity of the *Interview with the practitioners from Middelfart Municipality* and *Observation of meeting between Middelfart Municipality and SDU* can be considered high. The reliability was low partly due to the nature of the interview and conversations. However the reliability of the interview was further lowered due to the unilateral of the data as it was not possible to set up an interview with the main researcher from SDU. The interviews did, however, not have to stand alone. The data, from the *Observation of meeting between Middelfart Municipality and SDU*, gave insights into some of the objectives of the interview, and by supplying knowledge from the observations with official documents and articles, it was possible to get the needed data. In retrospective interviews with all or any of the practitioners from SDU could have heightened the validity and help test the reliability of the data from Middelfart Municipality. The transcription of the recorded interview and observation was done literally, whereby there is a high validity. However, in reporting and citing the data, the author translated it, and author notes (*...) are added to enhance the readability and give context. In the translation of the citation, some nuances might be less apparent. Thus, there is a risk of lowered validity in the presentation of the data.

The observations done during the transplanting had high validity. However, the data collected based on these observations was notes taken sparingly during the practice, but mostly based on the author's recollection of conversations and observations, which have low validity. The reliability of the observations was low as the observer could only be at one site at a time and activities took place in several places during the transplanting. However, as observations took place over multiple days the reliability was increased. However as the transplanting project in Gamborg Fjord runs from 2023-2025, thus it is not possible to follow the project over the whole project period.

The data collected from the observations and the interview was treated with the qualitative data-treatment program NVIVO. The validity of this data treatment can be considered high due to the systematic and transparent way of data treatment. However, it has not been possible to assess the reliability of the categorisation, as the data treatment has been conducted by a sole researcher who assigned the citation into categories. The reliability could be assessed if multiple researchers had categorised the data and thereby the similarities and dissimilarities in the categorisation could have been assessed.

Case: Eelgrass transplanting in Gamborg Fjord 5

The transplanting project in Gamborg fjord has been permitted by the Coastal authorities by the law of coastal protection, - environmental assessment, and the coastal habitat declaration (Kystdirektoratet, 2023b). Gamborg Fjord is placed inside Natura2000 area 112 consisting of habitat area H96 and the bird-protection area F47 (Middelfart Municipality and SDU, 2022). The sites applied for by Middelfart Municipality are two areas within Gamborg fjord of 12 ha and 7 ha, shown in figure 5.1.

Figure 5.1. Placement of permitted transplantation sites, figure from Kystdirektoratet (2023b)

Figure 5.2. Area of the applied for by the practitioners, figure from Middelfart Municipality and SDU (2022)

1 ha eelgrass will be transplanted as part of the Better BirdLIFE and up to 15 ha by Middelfart Municipality at 1-2,5m depth (Middelfart Municipality and SDU, 2022). The Better BirdLIFE project is run by Middelfart Municipality, Fugleværnsfonden, Kerteminde-, Kolding-, Nordfyns- og Sønderborg municipality, Naturstyrelsen, Stiftung Naturschutz Schleswig-Holstein and Syddansk Universitet (SDU). The project run between 2023-2025. The transplanted eelgrass shoots are to be anchored to the seabed using iron nails (Middelfart Municipality and SDU, 2022).

Analysis of eelgrass transplanting in Gamborg Fjord 6

This chapter is split into two sub-analyses. The first sub-analysis aims to give an insight into the landscape through a discourse analysis based on the motives behind the transplanting projects. The motives originate from challenges of the socio-technical landscape. The second sub-analysis aims to understand the actor-network of eelgrass transplanting at the niche innovation level and identify the uncertainties, challenges, and opportunities in the meeting with the socio-technical regime.

6.1 Discourse analysis

The eelgrass transplanting project in Gamborg Fjord consists of; the Better BirdLIFE project and Middelfart Municipality's Climate Compensation project. Both projects are high in human intervention due to the nature of transplanting. There is in neither of the projects intention of combining the transplanting with tools of conservation.

Better BirdLIFE project
The motivation of the Better BirdLIFE project is to provide breeding and migration birds with forage (Interview: Jakob Martin Pedersen). Better BirdLIFE is a collaborative project where different municipalities, foundations, the Environmental Protection Agency and South Danish University (SDU) aim to improve bird life in the western part of the Baltic Sea (Better BirdLIFE, 2019). The challenges in the socio-technical landscape that drive the Better BirdLIFE project are biodiversity and habitat loss. This challenge motivates the restoration of habitats, which through the food web, support specific bird species. The means of restoration, i.e. stone reefs or eelgrass transplanting, is based on the target bird species. This motive can be considered eco-centric. However, besides restoring habitats and creating forage and breeding grounds, the motive is also to deliver nature experiences to humans, which is more anthropocentric.

The responsible party for transplanting eelgrass in the Better BirdLIFE project is a research group from SDU, consisting of, among others, *Researcher A*, *Researcher B* and *Researcher C*. This research group, hereafter referred to as SDU, is considered the practitioner of the project. However, Jakob Martin Pedersen from Middelfart Municipality is the project manager of the Better BirdLIFE project. The practitioners are obligated to transplant 1 ha of eelgrass for the Better BirdLIFE project in Gamborg Fjord, where the Better BirdLIFE Project cover 60% of the expenses for the transplanting (Interview: Jakob Martin Pedersen). However, SDU also gains funding for the transplanting as a part of a political Agricultural Agreement to research the capacity of eelgrass to remove nutrients and store CO_2 (Miljøministeriet, 2022). This research aims to map whether transplanting of eelgrass can be utilised to achieve a more rapid improvement of the ecological status of the aquatic environments, which can derive from both an eco-centric and anthropocentric drive. The goal of achieving a good ecological status is eco-centric. However, there are anthropogenic motives for setting this goal, as illustrated in § 17 in the Water Framework Directive:

> "*Protection of water status within river basins will provide economic benefits by contributing towards the protection of fish populations, including coastal fish populations.*" - European Parliment and Council of the European Union (2000)

However, the practitioners from SDU are more driven by a scientific motive rather than an explicit eco-centric or anthropocentric motive. This motive is expressed by *Researcher C*, who states:
"*We would also like to have some area where we can develop and research.*" and "*We are not rice farmers. There must be some development for us and consecutive monitoring.*".
Hence SDU's transplants are not for the sole goal of transplanting or providing forage and breeding grounds for birds but to test different transplanting methods and monitor the bio-physical circumstances that influence the transplanted eelgrass's success and survival. These scientific motives link to challenges in the socio-technical landscape. The researchers from SDU have various scientific objectives and aims that can likewise be categorised within a more anthropocentric or eco-centric motive. *Researcher B* (Observ. Meeting) and *Researcher C* (Observ. Meeting) have a more eco-centric motive for their research as they focus on respectively restoration with the intent of reaching a goal of good ecological status and studying the fauna above sediments, including epifauna, in transplanted eelgrass beds. However, as argued previously, the goal of achieving a good ecological status is partly driven by anthropocentric motives. While *Researcher A* (Observ. Meeting) has a more anthropocentric motive with a focus on ecosystem services, which according to the definition, are the benefits people obtain from the ecosystem (Reid et al., 2005). Likewise, stable and thriving ecosystems provide more ecosystem services, whereby eco-centric motives become present.

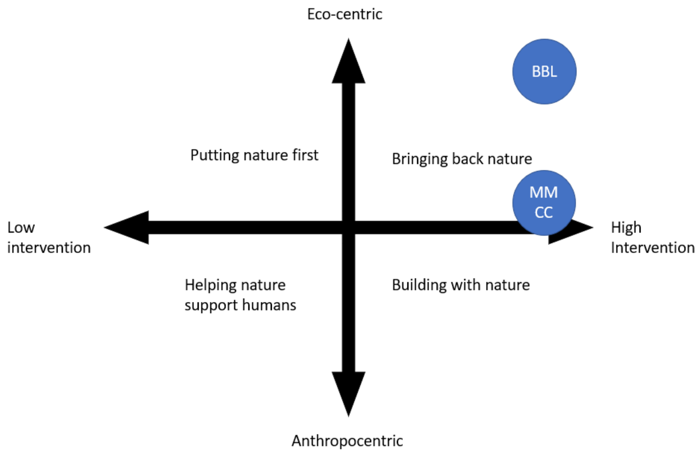


Figure 6.1. The Better BirdLIFE project (BBL) is within the Bringing Nature Back discourse, while the Middelfart Municipality Climate Compensation (MMCC) project is closer to Building With Nature discourse. Figure made the author.

Middelfart Municipality Climate Compensation project

Middelfart Municipality's Climate Compensation project emerged from political and public awareness of the positive climate effects of eelgrass increased through interactions with SDU and in connection with the Better BirdLIFE project (Interview: Jakob Martin Pedersen).

In the Climate Compensation project, the Municipality is the sole entity setting the aim as they are both the financing body and the practitioner responsible for the transplanting. The practitioners within the Municipality are working within the Department of Nature and Environment, and the financing bodies can come from all of the departments in the Municipality. The motive for initiating this project originated in the Better BirdLIFE project, where the Municipality acquired knowledge of the carbon-storing capabilities of eelgrass and thus adopted it as a climate Compensation tool for the Municipality's DK2020 plan (Interview: Henriette Højmark Hansen and Jakob Martin Pedersen). The DK2020 plan is the municipalities' plan to achieve the macro-political long-term goal of reducing greenhouse gas emissions to net zero by 2050. These pressures motivate the Municipality to address the challenge in the socio-technical landscape of climate change.

Ultimately, the goal of Middelfart Municipality's DK2020 plan is to ensure that nature can support humans in the future, as indicated:

> "*The effort is no longer enough, if we want even the slightest chance to hand down the earth in a reasonable state to the future generation.*" - Middelfart Kommune (2020)

The intention of preserving nature in a reasonable state can be considered eco-centric. However, as it is about handing it down to future generations, it becomes a matter of preservation for the sake of human and future humans' interests, which is more anthropocentric, although the motive will still be categorised within the *Bringing back nature*-discourse, cf. figure 6.1. Nevertheless, as argued with the Better BirdLIFE project, it is not unilateral.

However, projects do not have equal opportunity to be executed, as *Henriette Højmark Hansen* (Interview) highlights: "*... right now it really depends on SDU being involved in all projects because they have the set up and they are being pulled from all sides.*", hence the scientific motives, whether based on eco-centric or anthropocentric drives, are decisive for transplanting projects.

6.2 Dynamics in the network of transplanting

This analysis aims to understand networks within the transplanting projects of Better BirdLIFE and Middelfart Municipality's climate compensation. The analysis is split into parts of the process based on where there have been identified uncertainties, challenges, and opportunities are identified. It is relevant to view the transplanting projects separately in some of the subsections, while in other subsections, the projects are analysed in common.

6.2.1 Funding for the eelgrass transplanting projects

Eelgrass transplanting projects are costly multiple studies have already identified it as a challenge, cf. section 1.3.2. This challenge also presents itself within the two transplanting projects in Gamborg Fjord. The high cost requires the practitioners to have a financing body. The practitioners transfer the monetary funding from this body into labour or materials needed for the transplanting. The funding organisations have a significant influence on the overall goals and discourse of the project. However, as eelgrass transplanting projects can address different challenges of the socio-technical landscape, the practitioners mostly have to frame their discourse to the financing bodies.

> "EU is co-financing the LIFE project. They finance 60% of the LIFE project, which is part of what makes it attractive for the university to engage in" - *Henriette Højmark Hansen* (Interview)

SDU gained funding from the Better BirdLIFE project and the agricultural agreement. For the funding to be established, the investors need to gain output in return for the monetary input. SDU has to deliver 1 ha of eelgrass in connection Better BirdLIFE project and knowledge on the uptake of nutrients from transplanted eelgrass and the climate effects connected to the Agricultural Agreement (Erhvervsministeriet, 2021).

SDU can research eelgrass transplanting while delivering the obligations to the Better BirdLIFE project, figure 6.2, and the research results will cover the obligations connected to investments from the agricultural agreement, figure 6.3. Hence there is an alignment between the motive of the practitioners and the obligations to financing organisations. This alignment does not require changes in the social-technical regime, which is part of the regime's toolbox for habitat restoration and acquiring scientific knowledge.

The SDU practitioners are, however, not limited to the obligations of the funding organisation. They do not mind transplanting in the context of Middelfart Municipality's Climate Compensation to the extent that there are resources to do so (Observ. Meeting: Researcher C).

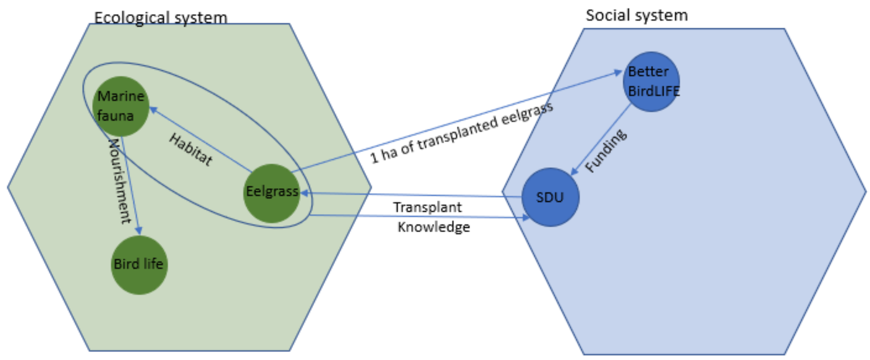


Figure 6.2. The socio-ecological system connected to the investment from the Better BirdLIFE project. SDU gain knowledge of eelgrass connected to the Marine fauna, and the Better BirdLIFE project get 1 ha of eelgrass transplanted, which through the marine fauna provides nourishment for the birds. Figure made the author

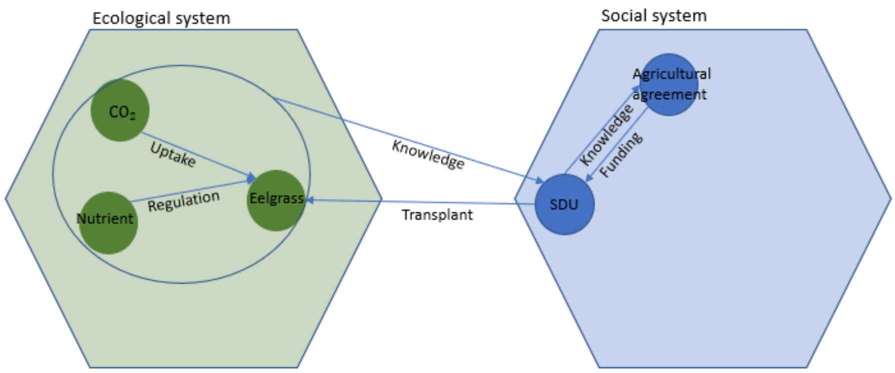


Figure 6.3. The socio-ecological system connected to the investment from the Agricultural agreement. SDU gain knowledge of eelgrass carbon sequestrating and nutrient regulation capabilities, this knowledge is transferred to interested parties involved in the Agricultural agreement. Figure made the author.

In the Middelfart Municipality's Climate Compensation project, the motive is to utilise eelgrass as a tool to compensate for emissions within the Municipality as an alternative and supplement, i.e. afforestation. Where the financing body is departments and projects within the Municipality, as there are currently no private actors offering the service of transplanting eelgrass (Interview: Jakob Martin Pedersen), the Municipality must also undertake the practitioner's role. The lack of actors and markets around eelgrass transplanting makes it challenging to determine the price and value of the effort. In connection to this project, there is no obligation to the amount of eelgrass that needs to be transplanted (Interview: Henriette Højmark Hansen). Thus, the scale of the transplantation depends on the amount of financing and labour that the Municipality can justify spending.

Multiple uncertainties can influence whether the Municipality's departments can justify financing eelgrass transplanting.

> "...the cost is similar to afforestation, but the scientific work is not as sure... I think...
> It is not as well-known a tool as afforestation. With afforestation politicians and others know what they get." - *Henriette Højmark Hansen* (Interview)

This statement exemplifies some of these uncertainties. Such as stakeholders' lack of knowledge of what they get from eelgrass transplanting and uncertainties around the scientific knowledge. Which influences how the social system value eelgrass transplanting. However, *Jakob Martin Pedersen* (Interview) argues that afforestation is oversold as it takes decades to get the proper climate effects and even longer for biodiversity, where you get both almost at once with eelgrass transplanting.

And although eelgrass transplanting is a cost-intensive practice, it is possible to make it cost-competitive to afforestation, if volunteers are engaged. As *Jakob Martin Pedersen* (Interview) addresses:

> "*They approximately balance out, because we don't have to purchase land with eelgrass transplanting in contrast to afforestation. (...)If you can lower the cost of labour, which you can do by receiving local support, who work unpaid. Then the expenses can be reduced.*".

The traffic and road department of Middelfart Municipality considered investing in the eelgrass transplanting to compensate for a bike lane but decided against it (Observ. Meeting: *Henriette Højmark Hansen*). In these considerations, it was not the insecurity connected to the lack of knowledge around the climate effects of eelgrass but whom the benefits of the transplantation would befall.

> "*Because if it is not included in our Municipality's* (*environmental reports) *accounts that we are doing something beneficial, because eelgrass is currently not counted in the accounts. It counts in Denmark's accounts, but not in the Municipality's. Then it kind of falls on that, because the interest was there, and they had spent a long time discussing it.*" - *Henriette Højmark Hansen* (Interview)

This challenge is due to the municipal boundary being the shoreline. Hence the transplanting project is placed in national waters. The carbon uptake of the project thereby does not enter into the Municipality's environmental reporting (Interview: Henriette Højmark Hansen). The Danish state owns the area, but the Municipality has the labour and monetary resources to realise the transplanting. Hence there can be multiple frameworks for understanding whom the carbon credits generated by the transplantation should befall. *Henriette Højmark Hansen* (Interview) points out that "*In principle, it is the responsibility of the state, but they can't manage to do it along the coastline*" and "*... it is equally beneficial, no matter who pays for it.*" and that "*... if it* (*eelgrass transplanting) *becomes a part of the CO_2 reporting, then I'm sure that both municipalities and corporations will find fundings to engage in it.*".

This misalignment, illustrated in figure 6.4, between who gains the benefits of the transplantation poses a major barrier to transplanting.

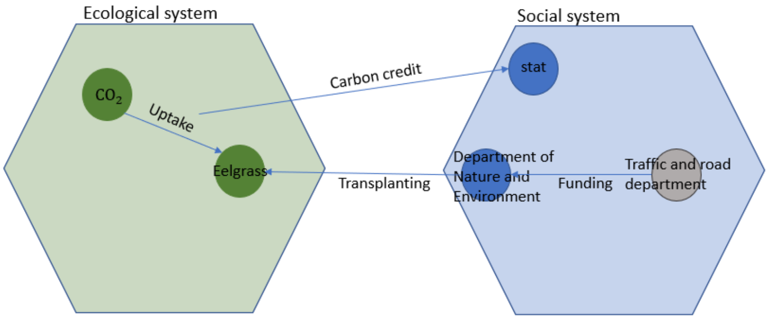


Figure 6.4. The socio-ecological system connected to the investment if the Traffic and Road Department had invested in the transplanting project. The Traffic and Road Department invest in the Department of Nature and Environment. However, the state gets the carbon credits. Figure made the author.

Some of the goals of the Climate Compensation project is also to put bottom-up pressure on the socio-technical regime, in "*... the hope is that the state recognises that they don't have the resources to make these projects, but if the municipalities have an interest in transplanting, then it (*the carbon credits) will become a part of the municipal climate report, at some point in time.*" - *Henriette Højmark Hansen* (Interview)

There are significantly different challenges depending on the drivers of the transplanting project. Where the Better BirdLIFE fits into the socio-technical regime, there is a need for a socio-technical configuration for eelgrass transplanting to become a tool for climate compensation for municipalities and corporations. The challenges identified for the Climate Compensation project are not possible to generalise across all types of anthropogenic motivation, as many other anthropogenic motives.

6.2.2 Placement and uncertainties in the natural system

The bio-physical requirement of eelgrass restricts the placement of where eelgrass transplanting can take place. Some of these restrictions are rooted in challenges within the socio-technical landscape connected to the ocean's degraded environmental and ecological conditions. However, handling the restrictions caused by poor environmental and ecological conditions is a part of the niche innovation and is incorporated into the transplanting project. However:

> "*There is no doubt that currently, the transplanting of eelgrass will not be a huge success because there are simply too many areas that we cannot plant because... (*the conditions are too bad), that is why we cannot get near to large streams, there is simply too much nutrient outlet, there are too much algae. So that's probably the biggest barrier...*" - *Henriette Højmark Hansen* (Interview)

Trial transplanting aims to map the bio-physical condition at a site and help practitioners assess whether the site is compatible with eelgrass transplanting. One of the aims of the Better BirdLIFE project was to shelter the eelgrass from physical exposure using stone reefs. Thus the placement was determined based on the bio-physical requirements of eelgrass and the safety and legislative requirement connected to establishing fixed facilities such as stone reefs. However, the initial trial transplantation, see figure 6.5, failed; "*As the current is too strong in the Little Belt. At one of the stations, the conditions were neither ok for transplanting*" - *Researcher C* (Observ. Meeting).

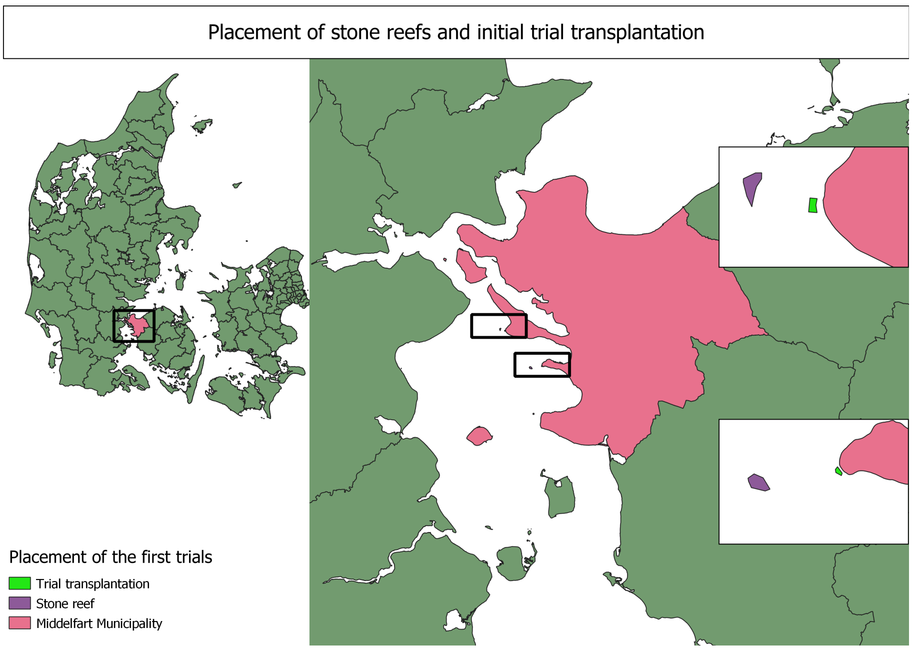


Figure 6.5. Placement of stone reefs and the initial trial transplantation. The map was created based on data received from Middelfart Municipality

Hence, new trials were conducted inside Gamborg Fjord. The trial transplantation inside Gamborg Fjord took place in three locations, where SDU observed varying establishment and survival rates. "*It went well inside the inner fjord... They were doing well up to mid-summer when they vanished. Oxygen depletion tendencies were found.*" - *Researcher A* (Observ. Meeting), "*Meanwhile, the outer station seems to be during well. I think we should focus on the outer station.*" - *Researcher B* (Observ. Meeting). Besides the environmental stressors in the waters, biological activity, especially crabs, has been a challenging as they dig up the shoots, remove the anchorage or simply cut off the leaves (Observ. Transplanting). The practitioners made an arrangement with a professional fisherman who, two weeks up to the transplanting, fished for crabs in the Fjord. In these two weeks, more than 400 kg of crabs were captured (Observ. Transplanting). In tackling the challenge of biological activity, there is an opportunity to involve local stakeholders.

Trial transplanting is an opportunity to map the bio-physical conditions and attempts to limit the uncertainties from the lack of knowledge connected to various ecological and bio-physical conditions that are present. However, there are also uncertainties of unpredictability as: "*It's also sometimes just the conditions, it can easily be windy, there are many of these natural things that you are not in control of*" - *Henriette Højmark Hansen* (Interview), furthermore "*there may also be year-to-year variation*" - *Researcher A* (Observ. Meeting).

During the transplanting in May 2023, the effort solely took place at the outer station in the Fjord, where the conditions were deemed most compatible with transplanting.

6.2.3 Authorisation and authorities

Eelgrass transplanting projects that anchor the transplants, are classified as fixed facilities by the Coastal Authorities. When the coastal authorities classify the nailed transplants as fixed facilities or an anchored devise and thereby subject the transplanting project to the authorisation process, this is a barrier within the socio-technical regime that delays and adds a bureaucratic layer to the transplanting. The nail can, however, also be interpreted as temporary facilities.

> "*What we have often discussed and thought it is a bit silly, the fact that the Coastal Authority must give a permit because the eelgrass shoots must be anchored (...) It makes sense when we throw stones into the water and make stone reefs. But it is a bit odd, as it is only nails. (...) That nails rust away over a few years*" - *Jakob Martin Pedersen* (Interview)

The barrier of long processing time is especially relevant due to the uncertainties of the placement and the need for trial transplanting to determine the suitability of the site. *Jakob Martin Pedersen* (Interview) states that: "*The barrier arises as there is a long case processing time. If we want to be sure that we are planting in the right place, we should preferably plant these test plots out, and there is a lot of work involved if you were to apply to make one or several test plots, which are relatively few shoots where some of them would not succeed.*". There is, however lack of certainty of how trial transplantation is classified and whether these are viewed as temporary facilities (Observ. Meeting: Researcher B) and is therefore not subjected to the same authorisation obligations as a full-scale transplantation.

The trial transplantation inside Gamborg fjord had a better success rate than the transplantation in the little belt and two larger areas were applied for, c.f. figure 6.7. The reasoning for applying for bigger areas was partly due to long processing time (Interview: Jakob Martin Pedersen) and experience from previous projects of being heavily restricted by the applied-for areas, as *Researcher C* (Observ. Meeting) express, "*When we transplanted in the Little Belt, there wasn't a lot of space, if we were to remain lawful, then we couldn't move an inch.*". The size of the area enables SDU to transplant the obligated 1 ha eelgrass connected to the Better BirdLIFE project, and Middelfart Municipality Department

Figure 6.6. Tying a shoot to a nail with a piece of wire at the eelgrass transplanting on the 10-05-2023 - Image by Peter Leth-Larsen

of Nature and Environment to engage in transplanting as a tool for climate compensation (Interview: Jakob Martin Pedersen).

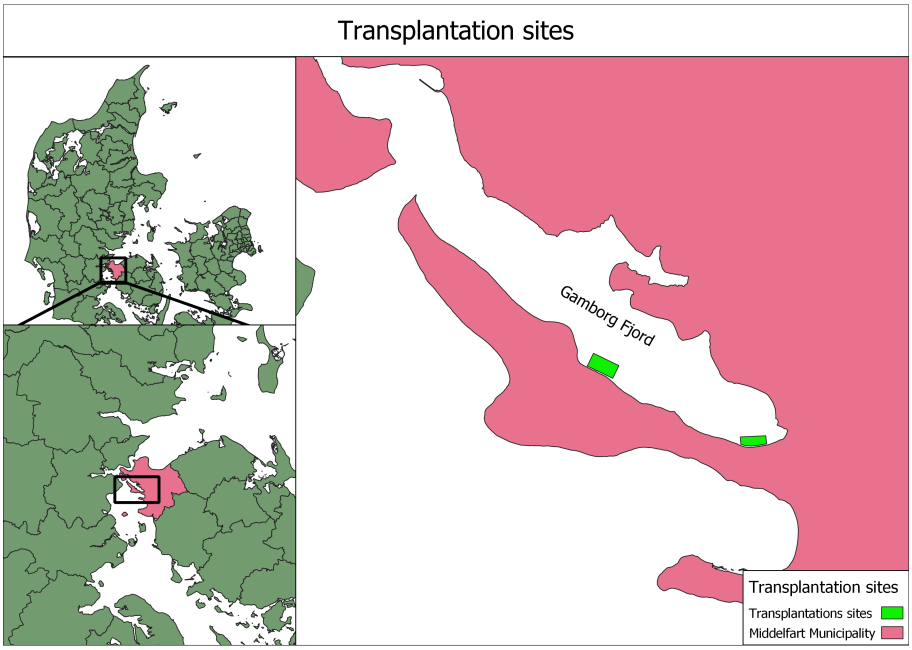


Figure 6.7. The areas where the Better BirdLIFE and the Middelfart Municipality's climate compensation projects have permission to transplant. The map was created based on data received from Middelfart Municipality

The application was sent to the Coastal authorities and pasted to the other parties for hearing. Two authorities had remarks that influenced the project: the *Agency for Culture and Palaces* and the *Environmental Protection Agency*.

The *Agency for Culture and Palaces* requested a need to be aware of national heritages in the area (Kystdirektoratet, 2023b). This remark does not pose any restrictions. However, an archaeologist from Langeland Museum offered to give an introduction to identifying national heritage (Observ. Meeting: Jakob Martin Pedersen). Among the practitioners at SDU, there seemed to be a general interest and as *Jakob Martin Pedersen* (Observ. Meeting) pointed out: "*... in regards to the volunteering divers, whom we would like to involve, this might also be a carrot.*". Involving archaeologists to incentives volunteers is an opportunity to enhance the volunteering and give insights into the conserving capabilities of eelgrass.

The Environmental Protection Agency (EPA) required that the transplantation not disturb the surveillance transects in the area, neither during nor after transplanting (Kystdirektoratet, 2023b). According to *Jakob Martin Pedersen* (Interview) "*It is the only thing we have come across in connection with this authorisation, where eelgrass has been problematic, that they have been concerned about the national surveillance there is.*" This requirement by the EPA is because: "*This could affect the results of the national surveillance and the interpretation in relation to the pressure factors on eelgrass and other rooted vegetation.* - Kystdirektoratet (2023b). However, the EPA does not specify how far the transplantation must be from the transect. This creates uncertainty about how far away the transplantation has to be away from the surveillance transect and when the data is being affected. *Researcher A* (Observ. Meeting) argue that "*I can understand that we are not allowed to plant directly on top, but if we plant a kilometre from there and the eelgrass naturally spreads. They can almost only be happy about that.*". *Researcher C* (Observ. Meeting) imply that data of the NOVANA transects might not reflect the actual environmental conditions, as "*Where they say that the eelgrass depth, where there is 10% cover, is at 2,5 m. But we have success at 4 m. You have to remember that the NOVANA transects represent almost nothing in terms of area.* and *Jakob Martin Pedersen* (Interview) expresses similar concerns "*Ultimately, this means that there will be some suitable locations that we cannot use because there is a transect that they do not want spoiled. And that means that eelgrass just doesn't get there, because it doesn't get there by itself. Then in the long term, it could also be a bit misleading of how the condition actually is.*". Another challenge that *Jakob Martin Pedersen* (Interview) also expresses within his concern is that limiting transplanting along surveillance transect will further limit where it is possible to transplant eelgrass as the ecological conditions in the Danish waters are already heavily restricted.

These uncertainties of multiple knowledge frameworks of what represents the ecological condition best, when the spread of eelgrass from the transplantation is a disturbance of data, and when it can be considered a natural process. There is no definition of how far the transplantation must be from the surveillance transect. The practitioners make a proposal, where the authorities settle whether the distance is sufficient to preserve the data sets. According to *Henriette Højmark Hansen* (Interview), this is standard practice within case management.

In this case of the transplanting in Gamborg Fjord, an agreement has been reached between the practitioners and the authorities as there is a natural eelgrass bed between the transplantation site and the surveillance transect (Interview: Jakob Martin Pedersen). Although the authorities currently accept this, the practitioners intend to negotiate "*... long term, we intend to get closer to utilising the full capacity in the area we have obtained permission for. It should be an ongoing dialogue.*" - Jakob Martin Pedersen (Interview).

6.2.4 Volunteers and labour

Most of the work is connected to pre-assessment, trial transplanting and gaining the permits. This work often starts more than a year prior to the full-scale transplanting (Observ. Transplanting).

During the full-scale transplanting, both SDU and Middelfart Municipality employ waged labour.

Middelfart Municipality employed the practitioners, and on the first day of transplanting, participants from the Municipality's Climate team were present. The primary responsibility of the practitioners from the Municipality was to engage volunteers and facilitate the setting around the transplanting. The Municipality contacted; the diving club "Marsvinet", the neighbourhood committee of Føns, the Vendslyst fishing association and "Middelfart Vilde Kommunee" in the outreach process for engaging volunteers. These associations are through the members linked to a network of other associations. There were mainly volunteers from Føns Seasport association and volunteers who had heard of the transplanting through "Middelfart Vilde Kommune". However, some participants participated in connection to their employment. Representatives from *Naturpark Lillebælt* were present for communication purposes. While representatives from a tourist agency participated, intending to assess whether eelgrass transplanting could be an activity for regenerative tourism. In the volunteering work, the participants could participate in on-shore activities of tying shoots to nails or transplanting and harvesting shoots in the water. Volunteers who wanted to participate in transplanting in the water were asked to give notice prior to transplanting. However, the volunteers and participants at the transplanting solely engage in the on-shore activity of tying eelgrass shoots to nails.

Volunteers were present for four days of the transplanting. However, SDU also worked without volunteer help as they were obligated to deliver 1 ha and had planned to transplant 18.750 shoots for research purposes.

Experience from previous transplanting projects shows that the volunteers' background significantly influences the type of activities they are interested in participating in. As *Henriette Højmark Hansen* (Observ. Meeting) states: "*We have been working with the diving club before, where we had four divers. It was with 3 days notice, and they were ready! And we just had to ask again. They would very much like to help. They also have all the equipment and stuff, they just want to be in the water. They may not be the ones you should ask to be tying (*shoots to nails).*". The expectation for this project is that local volunteers from Føns consist mainly of pensioners and are unlikely to go into the water (Observ. Meeting: Jakob Martin Pedersen).Thus there is an uncertainty connected to the composition of volunteers and the type of volunteering activities they wish to engage in. During the transplanting in Gamborg Fjord, the practitioners from SDU were mainly responsible for the in-water activities, where there was at least one practitioner

Figure 6.8. Volunteers tying eelgrass to nails on the 10-05-2023 - Image by Peter Leth-Larsen

on land to guide and interact with volunteers. However, this configuration of tasks might have to adapt to the composition of volunteers.

The on-shore activities of tying eelgrass shoots to nails are the constraining factor as *Researcher C* (Observ. Meeting) estimates that there needs to be at least 3 people tying eelgrass to nails for each diver transplanting. Selecting volunteers with care is also essential, as productivity can vary vastly. The experience is that "*When we are together with people who burn for something, for and with nature, i.e. Os Om Havet, boy they are productive and they want it!*" - *Researcher C* (Observ. Meeting). However, there is also uncertainty connected to social unpredictability when engaging volunteers, as *Researcher C* (Observ. Meeting) exemplifies:

> "*We have also experienced a 7th grade which was also quite productive. But we have also experienced with high school students where hormones were everywhere, and it ended up being the boys chasing the girls, with no productivity.*" - *Researcher C* (Observ. Meeting)

This uncertainty in productivity can influence how many volunteers are needed or the scale of the transplantation.

In connection to the in-water activities. There are practical challenges connected to the equipment, efficiency, and safety. In the case of transplanting in Gamborg fjord, these challenges were limited as non of the volunteers intended to participate in the transplanting within the water. The actors interested in participating in in-water activities are, i.e. SCUBA divers and sports divers. There are different experiences and challenges connected to these actors. The different kinds of actors might have

Figure 6.9. The author transplanting eelgrass shoots - Image by Timi Løvholt Banke on 09-05-2023

preferences for equipment that can influence efficiency or negatively impact the transplants. As exemplified by *Researcher C* (Observ. Meeting): "*We have a slight edge in connection to classical sports divers, who love wearing fins, and they disrupt more than it is good.*. While SCUBA equipment required more space as *Researcher B* (Observ. Meeting) addresses: "*...those who come with the SCUBA gear, we can only bring two, or you can have four free divers. And if they plant just as fast, you would rather have the freediver.*" and can reduce mobility which can become a challenge, but there is also positive experience as *Researcher A* (Observ. Meeting) exemplify: "*Last year they came from King Fish, when we had it* (*transplanting) *with Os Om Havet, one of whom had a bottle on and his partner was a free diver. So that the freediver supplied the SCUBA diver with shots. They are very experienced.*". As pointed out in this example, the experience level can also influence efficiency.

However, what constrains the transplanting is the participants tying the shoots to the nails rather than the transplanters.

6.2.5 Harvesting and transplanting

The eelgrass is harvested by rake inside of the donor meadow. This method of harvesting creates trails in the meadow, but as *Researcher C* argues, "*We make trails, but we don't make deep craters, by far most of the sediment stays, and that means they can easily grow together again. And the times we have done it, both in the Limfjord, at Dalby, and in Odense fjord, they have grown back together really nicely.*". The scale of these trails is shown figure 6.10b.

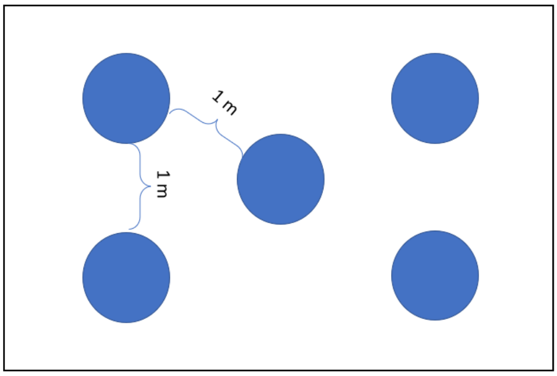
(a) The different types of rakes used to harvest eelgrass - Image by the author on 08-05-2023

(b) The eelgrass meadow where the eelgrass have just been harvested within the red circle. Image from a video by Henriette Højmark Hansen on 09-05-2023

Figure 6.10. Tools for harvesting and area just harvested

The intention was to collect donor material at nearby natural eelgrass beds. However, the nearby bed was assessed to be too small (Observ. Transplanting), whereby the impact of harvesting could negatively impact the donor bed. There is uncertainty connected to unpredictability, how the harvesting could impact this bed. Thus another donor bed was chosen further out in the fjord. The harvested eelgrass was put into baskets where the eelgrass can remain submerged in the colder water of the fjord. The eelgrass is transported onto land in a bucket, tied onto nails and put into another bucket. As the water temperature in the bucket can also stress the shoots, the finished buckets were placed in the shadow or immediately moved out into the fjord, to reduce heat stressors.

The transplantation site was approximately 1 km from the camp where the on-shore activities were conducted. Hence the transplanters were transported by boat from the camp to the transplantation site. SDU experimented with different planting densities based on a standard structure, illustrated in figure 6.11a. The density was adjusted using rings of different diameters, cf. figure 6.11b. In each ring, 20 shoots were transplanted along the side of the ring, and five shoots were placed in the middle.



(a) The planting structure is five rings, where 25 shoots are transplanted within each ring - figure by author

(b) Transplanting diameters a measured using rings of different sizes. Image from a video by Henriette Højmark Hansen on 09-05-2023

SDU is a key actor, as they have the equipment, knowledge and competencies, as *Henriette Højmark Hansen* (Interview) points out: "*... right now it really depends on SDU being involved in all projects because they have the set up and they are being pulled from all sides.*". Hence SDU's capacity to be involved in projects can be considered a bottleneck of eelgrass transplanting in Denmark. As SDUs efforts are based on a scientific motive, transplanting will only occur if the project has a scientific objective.

After the transplanting is conducted and the transplantation is established, the actors have different goals connected to monitorisation. For the Climate Compensation project in Middelfart Municipality, the cost is the main factor, as expressed "*As few work-hours as possible, so that it can be financially viable.*" - *Henriette Højmark Hansen* (Interview). The monitorisation of the climate compensation project will be conducted through aerial or drone photographs, as the carbon sequestration is calculated based on the area that the transplantation cover (Interview: Jakob Martin Pedersen)

While the monitorisation of the transplanted 1 ha in a Better BirdLIFE context is conducted by SDU, where "*we have the full portfolio of loggers that run continuously and log light, salinity, oxygen, and temperature. And we make continuous counts of how it performs.*" - *Researcher C* (Observ. Meeting)

The scale of the transplantation is currently 1 ha, whereby all of the transplantings are conducted in the context of the Better BirdLIFE project.

6.3 Findings

Different motives for transplanting have been identified transplanting projects in Gamborg Fjord. These motives can be put into three overall categories:

- Eco-centric motive of restoring forage for birds and biodiversity.
- Anthropocentric motive of off-setting carbon or gaining carbon credits.
- Scientific motive of researching the best method of transplanting and the influence of different external conditions.

The Eco-centric and the scientific motives can align with the socio-technical regime. In contrast, the anthropocentric motive of gaining carbon credits can only be realised within the municipality through adjustments to the socio-technical regime. This will be discussed in section 7.1.

In identifying the actors influencing the eelgrass transplanting project, looking into the social and ecological actors has been necessary. Where the social actors are prominent regarding funding, gaining permits, and volunteering, the ecological actors are essential for the placement and survival of the transplantation.

The actors involved in funding the projects are highly connected to the discourse. For the investors to give a monetary input, an output is expected. There is an output to the investors connected to the Better BirdLIFE project that is driven mainly by eco-centric and scientific motives. There is only output for the Danish state when investing with the anthropocentric motive of gaining carbon credits. The main motive in the Carbon Compensation project is the anthropocentric aim of compensating for emissions and pushing for a configuration in the socio-technical regime that enables the Municipality to be accredited for the transplantation. The funding is connected to uncertainties of:

- Incomplete scientific knowledge influences investors in the social system.
- Multiple knowledge frameworks within the social system are connected to who gets or should get the carbon credits.

The placement of the transplantation is connected to different ecological actors. However, the most prominent actor is social actors that, through nutrient discharges, indirectly influences several ecological actors and adds to the challenge of poor ecological condition and marine degradation that exists in the socio-technical landscape. Trial transplanting helps map the ecological actors and access site compatibility with eelgrass transplanting.The uncertainties connected to the placement of the transplantation are:

- Incomplete knowledge of the ecological system connected to various ecological and environmental conditions.
- Unpredictability of the ecological system due to year-to-year variations and weather conditions.

The authorisation process connects the transplanting project with various authorities. The main challenge is connected to the long processing time, but eelgrass transplanting is otherwise seen as unproblematic. There were hearing answers from two authorities; Agency for Culture and Palaces, and Environmental Protection Agency. In connection with these hearing answers, there were both uncertainties and an opportunity present:

- Opportunity for connect collecting data for underwater archaeology while eelgrass transplanting.
- Multiple knowledge frameworks of when data is being disturbed and what represents the environmental condition best.

The transplanting is not solely based on voluntary work but is also highly dependent on paid labour involving volunteers, making it possible to reduce the cost. Transplanting is also a place for communication and exploring business opportunities. The opportunities and uncertainties connected to labour and volunteering are:

- Opportunity to make eelgrass transplanting a tourist attraction.
- Opportunity to communicate and increase ocean literacy.
- Unpredictability in the social system is connected to the composition of volunteers and their productivity.
- Unpredictability in the social system of equipment that the volunteers have and their skill level.

SDU is a key actor in transplanting, and due to the lack of private actors, their capacity has become a bottleneck for eelgrass transplanting projects in Denmark. Several ecological stressors can impact the donor material in harvesting, anchoring and transplanting. In harvesting and transplanting, the following uncertainties are identified:

- Unpredictability in the ecological system is connected to how much material can be removed based on the size of the donor bed.
- Unpredictability in the ecological system of how the stressors influence the shoots.

Discussion 7

7.1 Seizing opportunities and tackling challenges

Through the analysis, several opportunities and challenges connected to uncertainties have been identified. Some challenges are already being tackled, and some opportunities are being seized in the case of transplanting in Gamborg Fjord.

7.1.1 The eelgrass transplanting as a regenerative tourist adventure

Creating business models around eelgrass transplanting can be a way to ensure funding, raise awareness and engage participants. During the transplanting in Gamborg Fjord, some of the participants participated to assess the possibilities for creating *Regenerative Tourism* around eelgrass transplanting. Regenerative tourism focuses on creating positive outcomes for local communities, cultures, and ecosystems. Duxbury et al. (2021) suggest five creative tourism business models that can develop toward sustainable and regenerative tourism.

1. Stand-alone offer, repeated
2. Series of Creative Activities and Other Initiatives under a Common Theme
3. Small-Scale Festivals That Include Creative Tourism Activities
4. Localised Networks for Creative Tourism
5. Creative Accommodation

In this discussion, there is a focus on 1, 2, and 3, which are the models deemed most compatible with eelgrass transplanting by the author.

Eelgrass transplanting can be integrated into the business model of the *stand-alone offer, repeated.* This is a business model where the eelgrass transplanting will be offered as an activity in a particular destination, such as Gamborg Fjord, Kolding Fjord or Aarhus Bay, where the location becomes known for these offers. This model is somewhat already applied within some projects in Denmark where almost annual transplanting takes place, i.e. in Vejle Fjord. However, the activity is currently offered to relevant parties and locals who can volunteer rather than a broader segment of tourists.

In the business model of *Series of Creative Activities and Other Initiatives under a Common Theme*, eelgrass transplanting can be integrated into a series of activities focused on the marine areas or marine health. Eelgrass transplanting can be combined with activities of beach clean-ups, fishing and removing ghost nets.

Small-Scale Festivals That Include Creative Tourism Activities are a model that integrates activities into a festival business model. In a Danish context, this type of business model has already been done at the ThyAlive Festival, where outings and activities are a part of the festival program. However, for festivals to include eelgrass transplanting activities, it is important to be aware of safety measures, especially if it involves having people in the water transplanting. Eelgrass transplanting can only be included as an activity if the placement of the festival is compatible.

For all of these business models, there is the challenge of who is responsible for the transplanting and the need for professionals to engage in the transplanting and introduce the tourists. It is possible for transplanting to follow the model that they currently have and utilise tourists in the same order as voluntary work. However, if the aim of engaging tourists is to gain funding and profits rather than additional labour, the *stand-alone offer, repeated* are challenges as expectations of the target group are likely to be influenced by this precedent of current transplanting. The willingness to pay is linked to these expectations (Rehman et al., 2023) and as the work is currently being conducted by volunteers, who are provided food and beverage for free. The willingness to pay is nothing, and if food and beverage are not provided or cost something, this can even negatively influence the tourists' satisfaction and willingness to engage. Combining voluntary work with tourism can be difficult as the tourist will feel unfairly charged. However, other literature asserts that regenerative tourism includes non-monetary exchange Sheller (2021) whereby the labour of tourists, just like the volunteers, is considered valuable and is exchanged for food and beverage and the experience. The type of labour the volunteers can conduct is based on whether they have the equipment to partake in the in-water activities. Whereby rental services could be integrated to enable tourists and volunteers to partake in the transplanting in the water. The *Series of Creative Activities and Other Initiatives under a Common Theme* can better promote itself as a tour, and although the tourist stands together with the volunteers, they are paying for a combined experience. The*Small-Scale Festivals That Include Creative Tourism Activities* can take additional commission fees or incorporate the price of the activity into the festival tickets.

7.1.2 National or local responsibility

In section 6.2.1, it is pointed out that eelgrass restoration, in principle, is the state's responsibility. Still, it is argued that the state does not have the capacity to carry out this responsibility. Nationalising transplanting can thereby lead to fewer eelgrass transplantings. In section 6.2.2, it is identified that ecological and environmental conditions largely constrain the success of transplanting or natural recovery of eelgrass beds, whereby it can be deliberated whether transplanting is simply symptom treatment of a more significant challenge within the socio-technical landscape. Thus the national focus should be on addressing these challenges, indirectly facilitating eelgrass recovery. However, the challenges of poor ecological conditions are already in Denmarks Marine Strategy (Ministry of Environment and Food of Denmark, 2019) and in the Agricultural Agreement Erhvervsministeriet (2021). However, the conditions can not necessarily be changed through a single nation's efforts, as the condition is due to accumulated and continuous nutrient discharge from the whole region around the Baltic Sea (Ministry of Environment and Food of Denmark, 2019). The current model where municipalities and interest organisations engage in local transplanting does not limit national initiatives, but centralised planning can enhance cohesion between national and local transplanting. Pastor et al. (2022) propose a modelling based on connectivity that can help select priority areas for transplantation. Likewise, detailed national mapping of conditions, substrate and activities can enable practitioners to have a more holistic approach to transplanting and managing the area. These different aspects can be integrated into a plan whereby central facilitation can enable local practitioners to be a part of a national network of targeted transplanting. Such a plan could be integrated into the Danish Maritime Spatial Plan, thereby incorporating an ecosystem-based perspective into the planning.

7.1.3 Changing the socio-technical regime

In section 6.2.1, a misalignment is identified when the motive for the eelgrass transplanting is carbon compensation. To align the motives of the niche with the socio-technical regime, the generated carbon credits from the transplantation need to enter into the environmental reporting of the investors or practitioners engaging in eelgrass transplanting. This alignment could incentivise businesses to engage in eelgrass transplanting and create new business models around selling carbon credits from eelgrass transplanting. Whereby eelgrass transplanting projects can enter the sphere of commercialised carbon compensation. As identified in section 6.2.1, the costs are comparable to that of afforestation. If the business models integrate labour through Regenerative Tourism or voluntary labour, it can even become cost-competitive to afforestation. This scenario builds on the assumption that the seabed where the transplanting takes place is free of cost. As the sea territory is officially the state's property, providing free usage can be considered a state subsidy. This challenge has somewhat occurred in the offshore-wind turbine industry, where the *Open-door Procedure* enabled the wind turbine corporation to access a piece of the seabed for free (Øyen, 2023).

The ecosystem services that eelgrass transplanting provides besides carbon sequestration have a societal value, which can be used as an argument for giving free access to a piece of the seabed. The economic value of eelgrass's ecosystem services is estimated to be approx. [1]139.000 DKK ha^{-1}, the climate mitigating value is

[1]Estimate of danish value based on the valuta of the USD in 2016 from Denmarks National

approx. [2]39.000 DKK (Cole and Moksnes, 2016) that the practitioner acquires.

However, it can be argued that this is still anti-competitive as eelgrass competes with afforestation as a climate mitigation tool. As there is a need to acquire land for afforestation, the same should be the case for eelgrass transplanting projects. However, the estimated costs of eelgrass transplanting are approx. 880.000-1.8 mio. DKK ha^{-1}, this cost includes labour, materials and transport across the site selection, harvesting, planting, and monitoring. If volunteers conduct all the labour, the cost still exceeds 120.000 DKKha^{-1} [3] (Moksnes et al., 2021).

Thus, if eelgrass transplanting accesses the socio-technical regime as a tool of climate mitigation for municipalities and private actors, there is a need to enable the practitioners to get the carbon credits and for the seabed to either be free or low cost.

7.2 Eelgrass transplanting versus other active marine restoration efforts

Transplanting eelgrass is a rising practice. However, similar tendencies are present for other active marine restoration efforts in Denmark, such as establishing bio-genic - and stone reefs. Flindt et al. (2023) look into the ecosystem services that the different forms of active marine restoration efforts have the potential to provide. Bio-genic reefs are defined as reefs of concretions, crusts, corallogenic concretions and bivalve banks originating from dead or living animals that are placed in the sublittoral or littoral zone (Center for Marin Naturgenopretning, 2023), where stone reefs are the presents of stone or rock that cover at least 5% of at least 10 m^2 (Center for Marin Naturgenopretning, 2023).

Eelgrass is presented as a means that positively impacts all parameters presented in table 7.1. Bio-genic - and stone reefs have some areas where they do not deliver. However, as mapped in section 1.2 and 6.2.2 eelgrass, is rather sensitive to ecological and environmental conditions. Where bio-genic - and stone reefs can be placed on different substrates (Flindt et al., 2023), eelgrass is limited to soft sandy substrates. Bio-genic reefs and eelgrass beds are habitats based around living organisms and vulnerable to unfavourable conditions or predators. Stone reefs are more reliable in reducing physical exposure and providing coastal protection, especially in more extremes environment or weather conditions, where eelgrass's protective qualities are inadequate (Flindt et al., 2023) and particularly newly transplanted eelgrass beds risk washing away. Stone reefs are also essential for increasing biodiversity and re-establishing the cod stock. The cod stock influences the population of crabs

Bank (2023)

[2]Estimate of danish value based on the valuta of the USD in 2016 from Denmarks National Bank (2023)

[3]Estimate of Danish value based on the valuta of the SEK in 2021 from Denmarks National Bank (2023)

Table 7.1. The potential ecosystem services provided by different types of means for marine restoration. Where (+) indicate that the ecosystem is present and documented for the given means of restoration, (+/-) indicate that there can be variation or lack of knowledge in regards to the effects, (-) indicate that there is no impact or even a negative impact. Table from Flindt et al. (2023) translated by the author.

Ecosystem services - Potentials	Shattered stone reefs	Cave-forming stone reefs	Biogenic reefs	Eelgrass
Nature restoration	+	+	+	+
Immobilising Nitrogen and phosphor in the growth season	+	+	+	+
Permanent storage of nutrients	+/-	+/-	+/-	+
Enhance Biodiversity	+	+	+	+
Light enhancing	+/-	+/-	+	+
Means of climate mitigation - Carbon removal	-	-	+/-	+
Coastal protectopn	+/-	+	+	+

(Link et al., 2008), which, as identified in section 6.2.2, influences the transplanting of eelgrass as crabs dig up shoots, remove anchorage and cut off leaves. Different forms of marine restoration can support each other. Thus tunnel vision on a single form of marine restoration should be avoided.

There can be anthropocentric and eco-centric motives behind engaging in any of these forms of marine habitat restoration. The framework for understanding the dynamics can be applied to all marine habitat restoration projects. However, all the findings of this study can not be generalised across the different types of marine habitat restoration. As the challenges of a misalignment connected to carbon compensation are only relevant in eelgrass transplanting, likewise, challenges connected to labour are most prominent for eelgrass restoration. While challenges in establishing bio-genic reefs and stone reefs are to a greater extent connected to the permit and authorisation, where hard substrate is placed on the sea bed thereby changing the level of the ocean floor, which can have implications for maritime safety and changing existing dynamics.

8 Conclusion

In recent years, eelgrass restoration through transplanting has been gaining traction in Denmark. There is, however, a lack of knowledge in the literature on the social dynamics concerning eelgrass transplanting projects. This thesis maps the social dynamics of eelgrass transplanting in Denmark through a case study of the transplanting in Gamborg Fjord.

In eelgrass transplanting, three motives can be present in the transplanting projects; Eco-centric for the sack of re-establishing the ecosystem; anthropocentric for the sack of offsetting carbon and nutrient loads; and scientific motive for the sack of generation knowledge. Both the scientific and eco-centric motives fit into the current socio-technical regime. The scientific motive is currently decisive for eelgrass transplanting projects, as the involvement of SDU is the bottleneck for eelgrass transplanting in Denmark. Anthropocentric motives of eelgrass transplanting for climate compensation are challenged by incomplete knowledge and misalignment within the socio-technical regime that accredits carbon sequestration to the state rather than the practitioners and investors.

For municipalities and corporations, eelgrass transplanting can only become a viable alternative to afforestation through a socio-technical configuration that enables the practitioners and investors to gain the carbon credits and for the seabed to remain free or low cost. Voluntary labour can lower the costs and make eelgrass transplanting a cost-competitive alternative to afforestation. Regenerative tourism can be a means to engage low-cost labour alongside local and interest-based volunteers. Through the involvement of tourists or volunteers, there is an opportunity to increase awareness and promote ocean literacy regarding marine challenges and restoration. Involvement of voluntary labour is, however, also connected to uncertainties where individual interest, preferences and productivity influence the work composition of the practitioners and the spatial or time scale of the transplanting.

Eelgrass transplanting can help sequester nutrients and carbon, but ecological challenges limit where eelgrass transplanting can take place. The classification of anchored eelgrass transplanting as fixed facilities on the marine territory entails long processing times as a barrier. As the ecological challenges are addressed by conducting trial transplantings to identify whether the area is compatible with transplanting, the lack of compatibility will induce the need for new authorisations and, thereby, another processing. Efforts of habitat restoration for top predators and engaging local fishermen in removing crabs are local initiatives that can be taken to address these challenges. However, the root of these ecological challenges needs to be addressed on a national and multi-national plan.

References

Better BirdLIFE. 2019. *Om Better BirdLIFE – Better BirdLIFE.* URL https://betterbirdlife.dk/om-better-birdlife/.

Boström, C., Baden, S., Bockelmann, A.-C., Dromph, K., Fredriksen, S., Gustafsson, C., Krause-Jensen, D., Möller, T., Nielsen, S. L., Olesen, B., Olsen, J., Pihl, L. and Rinde, E. 2014. *Distribution, structure and function of Nordic eelgrass (Zostera marina) ecosystems: implications for coastal management and conservation.* Aquatic Conserv: Mar. Freshw. Ecosyst., 24. doi: 10.1002/aqc.2424.

Brugnach, M., Dewulf, A., Pahl-Wostl, C. and Tailieu, T. 2008. *Toward a relational concept of uncertainty: about knowing too little, knowing too differently, and accepting not to know.* Ecology and Society, 13.

Center for Marin Natur Genopretning. 2023. *Marin natur - Center for Marin Naturgenopretning.* URL https://marinnatur.dk/.

Center for Marin Naturgenopretning. 2023. *Begreber i relation til marin naturgenopretning.* DTU Aqua and Institut for Ecoscience and Biologisk Institut and Limfjordsrådet.

Ciesielska, M., Boström, K. W. and Öhlander, M. Observation Methods. In *Qualitative Methodologies in Organization Studies*. 2018.

Cole, S. G. and Moksnes, P.-O. 2016. *Valuing Multiple Eelgrass Ecosystem Services in Sweden: Fish Production and Uptake of Carbon and Nitrogen.* Frontiers in Marine Science, 2(121). doi: 10.3389/fmars.2015.00121.

de los Santos, C. B., Krause-Jensen, D., Alcoverro, T., Marbà, N., Duarte, C. M., van Katwijk, M. M., Pérez, M., Romero, J., Sánchez-Lizaso, J. L., Roca, G., Jankowska, E., Pérez-Lloréns, J. L., Fournier, J., Montefalcone, M., Pergent, G., Ruiz, J. M., Cabaço, S., Cook, K., Wilkes, R. J., Moy, F. E., Trayter, G. M.-R., Arañó, X. S., de Jong, D. J., Fernández-Torquemada, Y., Auby, I., Vergara, J. J. and Santos, R. 2019. *Recent trend reversal for declining European seagrass meadows.* Nature Communications, 10(3356). doi: 10.1038/s41467-019-11340-4.

Denmarks National Bank. 2023. *DNVALA: Valutakurser efter valuta, kurstype og opgørelsesmetode (årsobservationer).* URL https://nationalbanken.statistikbank.dk/nbf/100249.

Duxbury, N., Bakas, F. E., de Castro, T. V. and Silva, S. 2021. *Creative Tourism Development Models towards Sustainable and Regenerative Tourism.* Sustainability, 13(2). doi: 10.3390/su13010002.

Ellison, A. M. 2019. *Foundation Species, Non-trophic Interactions, and the Value of Being Common*. iScience, 13, 254–268. ISSN 2589-0042. doi: https://doi.org/10.1016/j.isci.2019.02.020. URL https://www.sciencedirect.com/science/article/pii/S2589004219300549.

Erhvervsministeriet. 2021. *Aftale om grøn omstilling af dansk landbrug*. Erhvervsministeriet.

European Parliment and Council of the European Union. 2000. *Water Framework Directive 2000/60/EC - establishing a framework for Community action in the field of water policy*. Official Journal of the European Communities, (8).

Flindt, M., Jørgensen, T. B., Petersen, J. K. and Stæhr, P. A. 2023. *Marine habitaters understøttelse af vigtige biologiske økosystemtjenester*. Center for Marin Naturgenopretning.

Flyvbjerg, B. 2006. *Five Misunderstandings About Case-Study Research*. Qualitative Inquiry, 12(2), 12–16.

Geels, F. W. 2002. *Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study*. Research policy, 31(8), 1257–1274. ISSN 0048-7333.

Harenčár, J. G., Lutgen, G. A., Taylor, Z. M., Saarman, N. P. and Yost, J. M. 2018. *How Population Decline Can Impact Genetic Diversity: a Case Study of Eelgrass (Zosteramarina) in Morro Bay, California*. Estuaries and Coasts, 41(8).

Jahnke, M., Moksnes, P.-O., Olsen, J. L., Serra, N. S., Jacobi, M. N., Kuusemäe, K., Corell, H. and Jonsson, P. R. 2022. *Integrating genetics, biophysical, and demographic insights identifies critical sites for seagrass conservation*. Ecological Applications, 30.

Kelly, J. J., Orr, D. and Takekawa, J. Y. 2019. *Quantification of damage to eelgrass (Zostera marina) beds and evidence-based management strategies for boats anchoring in San Francisco Bay*. Environmental Management, 64, 20–26. doi: 10.1007/s00267-019-01169-4.

Krause-Jensen, D., Serrano, O., Apostolaki, E. T., Gregory, D. J. and Duarte, C. M. 2019. *Seagrass sedimentary deposits as security vaults and time capsules of the human past*. Ambio, 48, Social Science Database.

Krause-Jensen, D., Duarte, C. M., Sand-Jensen, K. and Carstensen, J. 2021. *Century-long records reveal shifting challenges to seagrass recovery*. Global Change Biology, 27, 563–575.

Kvale, S., 2005, *Interview En introduktion til det kvalitative forskningsinterview*, Hans Reizels Forlag.

Kystdirektoratet. 2023a. *Tilladelse til udplantningen af ålegræs mellem Assens By og Thorøhuse, Assens Kommune.* Miljøministeriet.

Kystdirektoratet. 2021a. *Tilladelse til etablering af stenrev på syv lokaliteter, samt udplantning af ålegræs på tre lokaliteter, i Lillebælt og Flensborg Fjord.* Miljøministeriet.

Kystdirektoratet. 2022a. *Tilladelse til etablering af diffuse stenrev og ålegræsudplantning i lagune ved Gyldensteen Strand.* Miljøministeriet.

Kystdirektoratet. 2020. *Tilladelse til udplantning af ålegræs (Zostera Marina) i 6 lokationer i Horsens Fjord, 8700 Horsens.* Miljøministeriet.

Kystdirektoratet. 2022b. *Tilladelse til udplantning af ålegræs med sømforankring, flere lokaliteter i Horsens Fjord.* Miljøministeriet.

Kystdirektoratet. 2023b. *Tilladelse til udplantning af ålegræs på to lokaliteter i Gamborg Fjord, Middelfart Kommune.* Miljøministeriet.

Kystdirektoratet. 2022c. *Tilladelse til stenrev og ålegræs i Randers Fjord (ved Udbyhøj).* Miljøministeriet.

Kystdirektoratet. 2019. *Tilladelse til udplantning af ålegræs på tre lokationer i Vejle Fjord.* Miljøministeriet.

Kystdirektoratet. 2021b. *Tilladelse til udplantning af ålegræs i Vejle Fjord.* Miljøministeriet.

Kystdirektoratet. 2023c. *Tilladelse til udplantning af ålegræs i Vejle Fjord, Vejle Kommune.* Miljøministeriet.

Kystdirektoratet. 2021c. *Tilladelse til udlægning af ålegræs og stenrev ud for Voerså Havn.* Miljøministeriet.

Kystdirektoratet. 2022d. *Tilladelse til forsøgsmæssig udplantning af ålegræs, Kalø Vig og Ebeltoft Vig.* Miljøministeriet.

Lange, T., Wendländer, N., Svane, N., Steinfurth, R., Nielsen, B., Rasch, C., Kristensen, E. and Flindt, M. R. 2020. *Storskala-transplantation af ålegræs – metoder og perspektiver.* Vand og Jord, 27(1), 12–16.

Link, J. S., Bogstad, B. and Sparholt, H. 2008. *Trophic role of Atlantic cod in the ecosystem.* Fish and fisheries, 9, 1–30.

Middelfart Kommune. 2020. *DK2020 Klimaplan Middelfart Kommune.* C40 and Concito.

Middelfart Municipality and SDU. 2022. *Ansøgning om tilladelse til udplantning af ålegræs på to lokaliteter i Gamborg Fjord.*

Miljø- og fødevareministeriet. 2020. *Bekendtgørelse af lov om kystbeskyttelse m.v.*

Miljøministeriet. 2022. *Nyt forskningsprojekt: Kan ålegræs og tang fjerne kvælstof i havet?* URL https://mim.dk/nyheder/2022/aug/aalegraes-og-tangprojekt/.

Ministry of Environment and Food of Denmark. 2019. *Danish Marine Strategy II: Focus on a clean and healthy marine environment.*

Ministry of Environment of Denmark and Environmental Protection Agency. 2021. *MiljøGIS for marine og grundvands tilstandsdata juli 2021.* URL https://miljoegis.mim.dk/spatialmap?&profile=vandrammedirektiv3tilstand2021.

Moksnes, P., Gipperth, L., Eriander, L., Laas, K., Cole, S. and Infantes, E. 2021. *Handbook for restoration of eelgrass in Sweden - National guideline.* Swedish Agency for Marine and Water Management.

Nejrup, L. B. and Pedersen, M. F. 2008. *Effects of salinity and water temperature on the ecological performance of Zostera marina.* Aquatic botany, 88(3), 239–246. ISSN 0304-3770.

Orth, R. J., Lefcheck, J. S., McGlathery, K. S., Aoki, L., Luckenbach, M. W., Moore, K. A., Oreska, M. P. J., Snyder, R., Wilcox, D. J. and Lusk, B. 2020. *Restoration of seagrass habitat leads to rapid recovery of coastal ecosystem services.* Science Advances, 6.

Ounanian, K., Carballo-Cárdenas, E., van Tatenhove, J. P., Delaney, A., Papadopoulou, K. N. and Smith, C. J. 2018. *Governing marine ecosystem restoration: the role of discourses and uncertainties.* Marine Policy, 96, 136–144.

Pastor, A., Ospina-Alvarez, A., Larsen, J., Hansen, F. T., Krause-Jensen, D. and Maar, M. 2022. *A network analysis of connected biophysical pathways to advice eelgrass (Zostera marina) restoration.* Marine Environmental Research, 179.

Rehman, A. U., Abbas, M., Abbasi, F. A. and Khan, S. 2023. *How Tourist Experience Quality, Perceived Price Reasonableness and Regenerative Tourism Involvement Influence Tourist Satisfaction: A Study of Ha'il Region, Saudi Arabia.* Sustainability (Basel, Switzerland), 15(2), 1340–. ISSN 2071-1050.

Reid, W. V., Mooney, H. A., Cropper, A., Capistrano, D., Carpenter, S. R., Chopra, K., Dasgupta, P., Dietz, T., Duraiappah, A. K., Hassan, R., Kasperson, R., Leemans, R., May, R. M., McMichael, T. A., Pingali, P., Samper, C., Scholes, R., Watson, R. T., Zakri, A., Shidong, Z., Ash, N. J., Bennett, E., Kumar, P., Lee, M. J., Raudsepp-Hearne, C., Simons, H., Thonell, J. and Zurek, M. B. 2005. *Millennium Ecosystem Assessment - Ecosystems and Human Well-being: Synthesis.* World Resources Institute, Washington DC.

Riemann, B., Carstensen, J., Dahl, K., Fossing, H., Hansen, J. W., Jakobsen, H. H., Josefson, A. B., Krause-Jensen, D., Markager, S., Stæhr, P., Timmermann, K., Windolf, J. and Andersen, J. H. 2016. *Recovery of Danish Coastal Ecosystems After Reductions in Nutrient Loading: A Holistic Ecosystem Approach*. Estuaries and Coasts, 39.

Schot, J. and Geels, F. W. 2008. *Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy*. Technology Analysis & Strategic Management, 20, 537–554.

Sfriso, A., Buosi, A., Facca, C., Sfriso, A. A., Tomio, Y., Juhmani, A.-S., Wolf, M. A., Franzoi, P., Scapin, L., Ponis, E., Cornello, M., Rampazzo, F., Berto, D., Gion, C., Oselladore, F., Boscolo Brusà, R. and Bonometto, A. 2021. *Environmental restoration by aquatic angiosperm transplants in transitional water systems: The Venice Lagoon as a case study*. The Science of the total environment, 795, 148859–148859. ISSN 0048-9697.

Shaughnessy, F. J., Gilkerson, W., Black, J. M., Ward, D. H. and Petrie, M. 2012. *Predicted eelgrass response to sea level rise and its availability to foraging Black Brant in Pacific coast estuaries*. Ecological Applications, 22(6), 1743–1761. doi: https://doi.org/10.1890/11-1083.1. URL `https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1890/11-1083.1`.

Sheller, M. 2021. *Reconstructing tourism in the Caribbean: connecting pandemic recovery, climate resilience and sustainable tourism through mobility justice*. Journal of sustainable tourism, 29(9), 1436–1449. ISSN 0966-9582.

Staehr, P. A., Göke, C., Holbach, A. M., Krause-Jensen, D., Timmermann, K., Upadhyay, S. and Ørberg, S. B. 2019. *Habitat Model of Eelgrass in Danish Coastal Waters: Development, Validation and Management Perspectives*. Frontiers in Marine Science, 6(175).

Tan, Y. M., Dalby, O., Kendrick, G. A., Statton, J., Sinclair, E. A., Fraser, M. W., Macreadie, P. I., Gillies, C. L., Coleman, R. A., Waycott, M., van Dijk, K.-j., Vergés, A., Ross, J. D., Campbell, M. L., Matheson, F. E., Jackson, E. L., Irving, A. D., Govers, L. L., Connolly, R. M., McLeod, I. M., Rasheed, M. A., Kirkman, H., Flindt, M. R., Lange, T., Miller, A. D. and Sherman, C. D. H. 2020a. *Seagrass Restoration Is Possible: Insights and Lessons From Australia and New Zealand*. Frontiers in Marine Science, 7. ISSN 2296-7745. doi: 10.3389/fmars.2020.00617. URL `https://www.frontiersin.org/articles/10.3389/fmars.2020.00617`.

Tan, Y., Dalby, O., Kendrick, G., Statton, J., Sinclair, E., Fraser, M., Macreadie, P., Gillies, C., Coleman, R., Waycott, M., van Dijk, K., Vergés, A., Ross, J., Campbell, M., Matheson, F., Jackson, E., Irving, A., Govers, L., Connolly, R., McLeod, I., Rasheed, M., Kirkman, H., Flindt, M., Lange, T., Miller, A. and Sherman, C. 2020b. *Seagrass Restoration Is Possible: Insights and Lessons From Australia and New Zealand*. Frontiers in Marine Science, 7.

Taylor, M. D. and Suthers, I. M. 2021. *The Socio-ecological System of Urban Fisheries in Estuaries.* Estuaries and coasts, 44(7), 1744–1751. ISSN 1559-2723.

United Nations. May 2022. *Resolution adopted by the General Assembly on 23 May 2022 . World Seagrass Day.* UN.

Unsworth, R. K. F., McKenzie, L. J., Collier, C. J., Cullen-Unsworth, L. C., Duarte, C. M., Eklöf, J. S., Jarvis, J. C., Jones, B. L. and Nordlund, L. M. 2019. *Global challenges for seagrass conservation.* Ambio, 48, Social Science Database.

van Katwijk, M. M., Thorhaug, A., Marbà, N., Orth, R. J., Duarte, C. M., Kendrick, G. A., Althuizen, I. H. J., Balestri, E., Bernard, G., Cambridge, M. L., Cunha, A., Durance, C., Giesen, W., Han, Q., Hosokawa, S., Kiswara, W., Komatsu, T., Lardicci, C., Lee, K.-S., Meinesz, A., Nakaoka, M., O'Brien, K. R., Paling, E. I., Pickerell, C. and Ransijn, A. M. A. 2016. *Global analysis of seagrass restoration: the importance of large-scale planting.* Journal of Applied Ecology, 53(2), 567–578. doi: 10.11111/1365-2664.12562.

Walter, R. K., O'Leary, J. K., Vitousek, S., Taherkhani, M., Geraghty, C. and Kitajima, A. 2020. *Large-scale erosion driven by intertidal eelgrass loss in an estuarine environment.* Estuarine, coastal and shelf science, 243, 106910–. ISSN 0272-7714.

Waycott, M., Duarte, C. M., Carruthers, T. J. B., Orth, R. J., Dennison, W. C., Olyarnik, S., Calladine, A., Fourqurean, J. W., Heck, K. L., Hughes, A. R., Kendrick, G. A., Kenworthy, W. J., Short, F. T. and Williams, S. L. 2009. *Accelerating loss of seagrasses across the globe threatens coastal ecosystems.* PNAS, 106(30), 12.377–12.381.

Weinstein, M. P. 2008. *Blackwell Publishing Ltd Ecological restoration and estuarine management: placing people in the coastal landscape.* Applied Ecology, 45, 296–304.

Øyen, M. 2023. *Stop for havvindmøller har kastet "chokbølger": Fem nedslag fortæller hvorfor.* URL `https://www.altinget.dk/artikel/stop-for-havvindmoeller-har-kastet-chokboelger-fem-nedslag-fortaeller-hvorfor`.

A Hearings statements

These figures show the type of hearing statement that different kinds of authorities give and if they give any at all. The figure is colour coded, the meaning of the colour is as followed;
Gray: Only comments about another part of the project, than the eelgrass transplanting (e.i. Stone reefs)
Green: Positive comments and support for the project
Yellow: Need for justification, further knowledge and notifying about legislation
Red: Notifications on things that can negatively impact or be impacted by the project, or objections to the project or requirements of surveys
White: No comments either as a comment or not included in the hearing statements

Table A.1

	Assens 2023 (Kystdirektoratet, 2023a)	Flensborg2021 (Kystdirektoratet, 2021a)	Gamborg2022 (Kystdirektoratet, 2023b)	Gyldensteen2022 (Kystdirektoratet, 2022a)	Horsens2020 (Kystdirektoratet, 2020)	Horsens2022 (Kystdirektoratet, 2022b)
Søfartsstyrelsen						
Trafikstyrelsen/ Trafik-, Bygge- og Boligstyrelsen						
Miljøstyrelsen						
Erhvervsstyrelsen						
Fiskeristyrelsen						
Forsvarsministeriets Ejendomsstyrelse						
Slots- og Kulturstyrelsen						
Bolig- og Planstyrelsen						
Moesgaard Museum						
Relevant municipality						
Danmarks Naturfredningsforening						
Dansk Ornitologisk Forening						
Friluftsrådet						
Fritidshusejernes Landsforening						
EjendomDanmark						
Geodatastyrelsen						
Neighbours						
Harbour						
Marina						

Table A.2

	Kalø2022 (Kystdirektoratet, 2022d)	Randers2022 (Kystdirektoratet, 2022c)	Vejle2019 (Kystdirektoratet, 2019)	Vejle2021 (Kystdirektoratet, 2021b)	Vejle2023 (Kystdirektoratet, 2023c)	Voerså2021 (Kystdirektoratet, 2021c)
Søfartsstyrelsen						
Trafikstyrelsen/ Trafik-, Bygge- og Boligstyrelsen						
Miljøstyrelsen						
Erhvervsstyrelsen						
Fiskeristyrelsen						
Forsvarsministeriets Ejendomsstyrelse						
Slots- og Kulturstyrelsen						
Bolig- og Planstyrelsen						
Moesgaard Museum						
Relevant municipality						
Danmarks Naturfredningsforening						
Dansk Ornitologisk Forening						
Friluftsrådet						
Fritidshusejernes Landsforening						
EjendomDanmark						
Geodatastyrelsen						
Neighbours						
Harbour						
Marina						

Data treatment - Code tree B

Code name	Files	Reference
Actors	6	35
Challenges	5	66
- Actors	1	9
- Alternatives	2	4
- Bio-physical	3	15
- Bureaucracy	3	20
- CO2 budget	2	6
- Funding/cost	2	13
- Lack of expertise	1	2
Discourses	5	27
- Anthropocentric	2	8
- Eco-centric	3	11
- Scientific	2	6
Experience from other transplantings	4	21
Opportunities	5	41
- Access	1	3
- Accountance	1	4
- Benefits	1	5
- Bio-physical	1	5
- Certainty	1	1
- Monitoring	1	1
- No-resistance	1	3
- Permits	2	5
- Volunteers	1	2
Planning	5	42
Uncertainties	4	13
- Different ways of knowing	3	6
- Incomplete knowledge	1	1
- Unpredictability	2	4

Interview Guide C

The questions marked with gray have been send to the interviewee prior to the interview.

Table C.1

Presentation of project			
		English	Danish
Formalities	Permissions	May I record this interview?	Må jeg optage denne samtale?
		Do you wish to be anonymous?	Ønsker du at være anonym?
	Presentation	Will you present yourself and the department that you are a part of?	Vil du give en præsentation af dig selv og den afdeling som du er en del af?
Goal	Research objectives	Interview Questions	Interview spørgsmål
Gain an understanding of the structures and the drivers within transplanting projects.	Identify the discourse	How would you describe your role/roles in this transplanting project?	Hvordan vil du beskrive din rolle/roller i ålegræsprojektet?
		Which motivations, goals and interests do you represent in the project?	Hvilke motiver, mål og interesser repræsenterer du I projektet?
		Is there any conflicting interest in the roles that you undertake and the interest that you represent?	Er der nogle konflikter mellem den/de roller som du har i projektet og de interesser som du varetager?
	Map the stages in the transplanting project.	Can you explain to me the process of the project from initiating it to where you are now?	Kan du forklare mig processen fra projektet blev initieret til hvor I er på nuværende tidspunkt?
		Are there different roles that you undertake in different stages of the process?	Er der forskellige roller som du har påtaget dig i forskellige dele af processen
	Map relevant actors	Who have you/intend to involve in the different stages? And how? And why?	Hvem har du involveret/intentioner om at involvere I de forskellige stadier af processen? Og hvordan? Og Hvorfor?
	Map the interactions and transactions between the practitioners and other stakeholders.	Can you explain the application process and which and how you interactions with the authorities have been towards gaining permission for the project.	Vil du forklare hvordan ansøgningsprocessen og interaktionerne med myndighederne har været?
		Which role have local had in your process? And what role have other stakeholder had?	Hvilken rolle har lokalbefolkningen spillet i jeres proces? Og hvilken rolle har andre interessenter spillet?
		What worries and resistance have you had in the different steps of the process?	Hvilke bekymringer eller modstand har I mødt forbindelse med nogle af trinnene?
		How have you handled this worry/resistance?	Hvordan har I imødekommet/håndteret denne modstand/bekymring?
	Map the uncertainties and worries that the practitioners have regarding the transplanting project.	Which consideration have you had about: 1) placement; 2) labour and fundings; 3) donor material; 4) anchoring; 5) monitoring	Hvilke overvejelser har I gjort jer omkring? 1) placering; 2) arbejdskraft og financering; 3) donor materiale; 4) forankring; 5) monitering
		Have you involved any stakeholder in these considerations and in the assessments?	Har I involveret nogle stakeholders i disse overvejelser og udredningen af disse?
		What are your worries about the project?	Hvilke bekymringer har du/I angående projekt?
		Are there some specific steps or circumstances that worry you in particular?	Nogle bestemte trin? Omstændigheder?
		How/when will you define the project as a success/failure?	Hvordan/hvornår vil du definere projektet som en succes/fiasko?
	Customised Questions	How will you ensure the transplanted eelgrass and that you live up to the obligations from the Better Bird Life project?	Hvordan vil I sikre det udplantet Ålegræs overlevelse? Og sikre at I lever op til de forpligtelser I har iforbindelse med Better Bird Life projektet?
		Can you explain how the climate compensated bike path might be connected to the eelgrass transplanting?	Kan du forklare mig hvordan den klimakompensering af cykelstien er forbundet med ålegræs udplantning? Er der nogle bekymringer udfordringer i den forbindelse?