UNIVERSITY OF GOTHENBURG

DEPARTMENT OF MARINE SCIENCES

EMPHASIZING *COMMUNITY* IN BLUE COMMUNITY GARDENS

Exploring the capacity of community-led regenerative ocean farming to contribute to equitable social-ecological resilience

Greta Lotta Kirstein

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Supervisor:	Per Knutsson
Examiner:	Sam Dupont

Photo: Ingvar Eliasson, Havskolonin i Helsingborg

Abstract

The current state, the governance connected to, and our use of the oceans have become increasingly complex and dynamic. Ecological and social circumstances are heavily interrelated (Berkes et al., 2003), but this is seldom regarded as a factor when developing new projects within the realm of the blue development. Regenerative Ocean Farming (ROF) is an emerging concept focused on low-trophic aquaculture, the reduction of negative environmental impacts, and the regeneration of marine habitats (Yong et al., 2022). The aim of this degree project is to explore the capacity of community-led ROF (clROF) to contribute to equitable social-ecological resilience. Informed by previous research on low-trophic aquaculture and empirical data collected through qualitative interviews, the focus lies on social components of clROF and their transformative potential. The Social-Ecological Systems Framework (Ostrom, 2009; McGinnis & Ostrom, 2014) provided a well-suited heuristic to explore the interrelatedness between ecological and communal wellbeing in clROF. With the added emphasis on equitability aspects of resilience the focal points of analysis were capacity for self-organization, social-ecological knowledge sharing and cohesion building. Findings suggest that while clROF could provide many benefits pertaining to equitable resilience, in order for them to enable transformative change, further research and adaptive governance must accompany further development.

Keywords: community-led regenerative ocean farming, SESF, equitable resilience

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Relevant abbreviations:

CB – COOL BLUE (community ocean farms and local business clusters)

BCG – Blue Community Garden

LTA – Low-Trophic Aquaculture

ROF – Regenerative Ocean Farming/ Farms

ROFarmers – Regenerative Ocean Farmers

SES – Social Ecological Systems

SESF – Social Ecological Systems Framework

UNDP – United Nations Development Programme

1. Introduction

The current state, the governance connected to, and our use of the oceans have become increasingly complex and dynamic. Ecological and social circumstances are heavily interrelated (Berkes et al., 2003), but this is seldom regarded as a factor when developing new projects within the realm of the blue development. Anthropogenic dependency on the ocean for an array of ecosystem services has been shaped by exploitative and unsustainable practices. (Bennett et al., 2021). Future development needs to put adequate focus on just and inclusive processes in order to align with international goals for sustainability and equitable resilience. This will facilitate sustainable blue development that diminishes the gap between relieving pressure on the (marine) environment while ensuring equitably distributed socio-economic benefits (Österblom et al., 2023; Raworth, 2017; UNDP 2021, UNDP 2025; UN 2015). Social-ecological sustainability is often facilitated by bottom-up processes rather than by externally imposed solutions disregarding local circumstances and knowledge (Ostrom, 2009), highlighting the need to enable community-led development in times of global change and crises to ensure a just transformation to a more sustainable future (UNDP 2018).

Regenerative Ocean Farming (ROF) is an emerging concept focused on low-trophic aquaculture, the reduction of negative environmental impacts, and the regeneration of marine habitats (Yong et al., 2022). Coined by GreenWave[1], a Non-Governmental Organization (NGO) committed to the expansion of more sustainable blue food alternatives, the terminology of ROF is most frequently found in academic and technical accounts related to the concept (Stuchtey et al., 2023). However, more accessible wording such as marine allotments, sea gardens and Blue Community Gardens (BCG) are commonly used to describe the concept of farming regenerative species, when considering community aspects. Community-led Regenerative Ocean Farming (clROF) has become an increasingly popular form of ROF, with several projects exploring natural science questions surrounding monitoring and ecological impact of small-scale seaweed and mussel farms. This has led to the increasing portrayal of ROF as a promising approach to combat excess nutrients in polluted marine areas, to facilitate contribute to carbon sequestration and to produce high quality seafood without heavy impact on the surrounding environment (Krause et al., 2022; Stuchtey et al., 2023; Yong et al., 2022). While these are hopeful aspirations, there is a need to explore the concept of ROF in general and clROF specifically in relation to social vulnerabilities and (in)justices to prevent potential exacerbation of existing inequalities through exclusionary factors embedded in social, physical or monetary requirements (Krause et al., 2019). Given the novel nature of the concept in Northern Europe, a lack of encompassing governance and permit structures that monitor social

[1] https://www.greenwave.org/, last accessed 27.05.2025

and environmental impacts of (community-led) ROF could accelerate development without adequate prior evaluation of potentially harmful outcomes. Equally, hasty development could hamper potential benefits of, and transformative change enabled by clROF.

Equitable Blue Growth coined by Bennett et al. (2021) under the term Blue Justice provides a relevant scholar context and perspective to contextualize blue development with questions of social vulnerabilities and environmental justice. Against this background, the predominant scientific focus on ecological aspects of ROF does not suffice. Stemming from this lack of knowledge about clROF as complex social-ecological systems (SES) impacted and constructed by overarching social, political, and ecological settings, this degree project aims to generate a greater understanding of the social components of clROF. Approaches such as these are needed as concrete responses to consequences of climate change, ocean acidification and changes in coastlines, to inspire a just transition that ensures environmental sustainability and social equity in terms of access to resources and livelihoods (Scoones et al., 2020).

Building on the Social-Ecological System Framework (SESF) (McGinnis & Ostrom, 2014; Ostrom, 2009) and Social-Ecological Systems (SES) research, the transformative capacity of clROF to contribute to equitable social-ecological resilience will be explored. Social-ecological resilience describes the capacity of systems to adapt and develop with external pressures while still retaining core functions relevant to the system (Berkes et al., 2003), whereas equitable resilience expands the focus to encompass questions of power, access to resources and social vulnerabilities.

This paper takes inspiration from previous scholars stressing the importance of connecting resilience thinking and Blue Growth with perspectives and questions of access and agency, inclusion and justice (Bennett et al., 2021; Cote & Nightingale, 2012; Fitzgibbons & Mitchell, 2021; Matin et al., 2018; Raworth, 2017).

The hypothesis going forward is that while ROF is portrayed as an innovative and advantageous tool to bring forth a more sustainable and just transformation of people's consumption and exploitation patterns, there is a need for adequate social and ecological monitoring and assessment prior to scaling clROF out or up. The exclusionary nature of highly complex permit processes, financial burdens as a consequence of installation, and maintenance of ROF and potential social barriers of access might cause community-led ROF to add to the ongoing privatization and commodification of coastal resources and to displacement or exclusion of certain groups of people from using them as common resources (Bennett et al., 2021; Ounanian & Howells, 2024).

This degree project thus seeks to explore the capacity of community-led regenerative ocean farming to contribute to equitable social-ecological resilience, capacity and community building guided by the following research questions:

RQ1: *What are the social components needed in order for community-led regenerative ocean farms to act as transformative socio-ecological systems?*

RQ2: *To what extent can community-led regenerative ocean farms contribute to equitable social-ecological resilience?*

While the first question is focused on identifying the social factors that are key in the context of the transformative potential of clROF as SES, the second question aims at more evaluative results as it probes the capacity of clROF to deliver equitable resilience.

2. State of the Art and Theoretical Framework

The following presents the theoretical baseline of this degree project. It seeks to facilitate a baseline of knowledge about the state of the art in low-trophic aquaculture, as well as potential benefits of community-based approaches to food production and conservation. Finally, the conceptual framework and focus of this thesis are described.

2.1. State of the Art of Low-Trophic Aquaculture

Aquaculture has historically been a useful way for people to farm food in the oceans and is considered a practice deeply rooted in humanity's cultural heritage that connects people to nature (Costa-Pierce, 2022). Low-trophic aquaculture (LTA) presents a way to farm blue foods in ways that are striving to enable a transformative change of food production toward more sustainability by alleviating pressure from the fishing industry and land-based farming (Krause et al., 2022; Stuchtey et al., 2023; Suplicy, 2020). LTA encompasses the process of farming of low-trophic species such as bivalves and seaweed. ROF is a form of LTA, expanding the focus on farming low-trophic species to encompass the objective to enable positive change and benefit surrounding habitats (Yong et al., 2022). Depending on the conditions of the marine environment, different key species are farmed which will be further described in the following subchapters.

In contrast to fish aquaculture, seaweed and bivalves have several benefits as they do not need additional feed, and they take up the required nutrients from their surroundings. Bivalves and seaweed have been noted to contribute to regenerating local habitats, carbon sequestration and decreasing eutrophication (Kotta et al., 2020; Yong et al., 2022).

LTA has been named to hold economic potential in times of changing oceans and diminishing fisheries (Barrett et al., 2022). Especially for traditional blue industries such as small-scale

fishing, LTA could present a way to diversify or supplement income (Jagtap & Meena, 2022). However this adaptation needs to be supported with external funding or capacity building opportunities, as "fishers are not farmers" (Krause et al., 2019, p. 331). Current developments in LTA are also not adequately reflected in or accompanied by policies, leading to a policy-people gap (Bradford et al., 2020; Krause et al., 2019; Yong et al., 2022).
Through mismanagement of natural occurrences leading to lost material, LTA could contribute to marine litter, as many farming set-ups for both bivalve and seaweed culture include the use of plastic components (Barrett et al., 2022; Campbell et al., 2019; Suplicy, 2020). The introduction of alien or invasive species through the cultivation of non-native species negatively impacts local ecosystems and is a potential risk surrounding LTA (Barrett et al., 2022; Campbell et al., 2019; Yong et al., 2022).

It is to be noted that the research on LTA is not homogenous, the assessment of bivalve and seaweed aquaculture and their impact in terms of positive potential as well as associated risks varies in optimism. The following will thus give an outline of the state of knowledge on potential benefits and challenges connected generally to bivalve or seaweed aquaculture.

2.1.1. Bivalve Farming

Bivalve farming provides many services benefiting people and the environment. Bivalves provide low-fat, high-protein food sources and potential medicinal uses (Grant & Strand, 2019), as well as providing ecosystem services, such as improving eutrophicated environments by taking up excess nutrients such as nitrogen and phosphorus, e.g. from agricultural run-off, thus creating potential synergies between land- and sea-based farming (Kotta et al., 2020; Yong et al., 2022). However, social-economic conflicts can arise concerning competition for space and common resources "between the stakeholders involved - farmers, nature conservationists, recreation/tourism, fisheries, shipping (commercial/private) and people aesthetically impacted by installations" (Krause et al., 2019, p. 325). Certain aquaculture sites could provide local habitat for other species, deeming them especially beneficial in "areas where structured habitats such as seagrass and shellfish reefs have historically been lost" (Barrett et al., 2022, p. 3). Bivalves may also contribute to carbon sequestration through the calcification of the shells (Van Der Schatte Olivier et al., 2020). However, the claim that bivalve farms hold high capacity to remove atmospheric CO_2 be from the ocean is contested by (Pernet et al., 2025), emphasizing the challenges associated with deeming specific species or ecosystems as CO_2-sinks. Complex biogeochemical and physical processes, and interactions with the surrounding environment factor into the capacity of bivalve farms to be CO_2 sinks. Further, a need for more comprehensive research assessing impacts of bivalve farming along the value chain and the life-cycle is evident (Pernet et al., 2025).

Further, bivalve farming can also potentially offer an array of cultural services including economic benefits, capacity building, space- and meaning-making, as well as preserving local heritage and (re)connecting communities and nature (Krause et al., 2019; Saurel et al., 2019; Van Der Schatte Olivier et al., 2020).

Risks and challenges surrounding bivalve farming have been found to be connected to disease outbreaks resulting in loss of crops and potential economic distress of the farmers(Barrett et al., 2022). There is also a risk of overwhelming local systems due to high density or intensity of farming endeavors, favoring several small-scale farms over large industries (Suplicy, 2020). Bivalve farms could impact local benthic life directly beneath the farm structures through dislodged mussels, which accumulate and decompose on the seafloor and raise local levels of alkalinity (Suplicy, 2020). Moreover, current processing methods of shells as by-products of bivalve farming require further development. An approach to this would be to reintroduce discarded shells into their local marine environment to facilitate the natural pH-balancing processes of formation and dissolution of the shells (Barrett et al., 2022; Pernet et al., 2025). The key species farmed in clROF in the scope of this degree project are *Mytilus edulis* (blue mussels). The standard method to cultivate bivalves such as these entails collecting naturally occurring larvae, deeming it dependent on wild stocks (Wijsman et al., 2019).

2.1.2. Seaweed Farming

Seaweed farming is widely regarded as one of the most environmentally sustainable forms of aquaculture (Pessarrodona et al., 2024; Stuchtey et al., 2023; Visch et al., 2020). Seaweed offers many benefits to the surrounding marine environment, such as providing habitat and shelter for fish (Visch et al., 2020)**,** and potentially contributing to carbon removal processes (Kotta et al., 2022; Pessarrodona et al., 2024; Yong et al., 2022). However, emissions from (commercial) farming activities currently outweigh the potential benefits in contribution to carbon dioxide removal through seaweed farms (Pessarrodona et al., 2024).

Seaweed farms can be beneficial in areas that are impacted by climate change (and could dampen wave activity in exposed coastal areas (Yong et al., 2022). The placement of a farm needs to be assessed beforehand to prevent negative environmental impact on existing ecosystems such as seagrass meadows through shading or increased human activity (Araújo et al., 2021; Yong et al., 2022). Offshore cultivation could potentially offer more stable farming conditions as well as a less contested area in terms of use conflicts (Araújo et al., 2021). Small-scale seaweed sites have been found to have low impact on the surrounding marine environment, while some concerns exist with larger scales (Campbell et al., 2019), emphasizing the need for localized assessments of carrying capacity of systems as part of permit processes.

Currently, the macroalgae primarily farmed in clROF in the scope of this degree project, are several species within the *Ulvaceae* family such as *Ulva intestinalis* (Rörhinna/ Gutweed) in less exposed and lower salinity areas and *Saccharina latissima* (sugar kelp) in conditions of higher salinity. Sugar kelp is mainly cultivated with seeded lines draped around ropes hanging freely attached to buoys in open water. Cultivation is done seasonally, with the ropes deployed in fall and harvest times ranging from late spring to early summer. (Hasselström et al., 2018). Moreover, kelp farms have been shown to enhance local biodiversity (Visch et al., 2020).

Further research and attention need to be focused on the entire production chain of farmed seaweed in order to improve the sustainability of seaweed products (Pessarrodona et al., 2024; Yong et al., 2022). Indirect capabilities of farmed seaweed to lower emission include their role as supplementary or replacement-products in certain industries, for instance as food (supplements), animal feed, pharmaceuticals, cosmetics or biostimulants (Araújo et al., 2021; Jagtap & Meena, 2022; Pessarrodona et al., 2024). Synergies between ocean and land farming are emphasized by the potential of using seaweed as fertilizer or soil supplements on agricultural crops (Stuchtey et al., 2023).

Other benefits include the relatively low initial costs, omitting the use of fertilizers, freshwater or land area (Araújo et al., 2021; Jagtap & Meena, 2022; Yong et al., 2022), and the potential to produce biomass that are demanded in the aforementioned industries. Recent studies have shown that seaweed farming could contribute to a just blue economy by enhancing livelihood and food security, gender equality, decreasing pressure of land-based food production (Yong et al., 2022).

2.2. Community-led Development

Community-led development holds high potential for sustainable and transformative change, creating spaces for social cohesion (Wesselow & Mashele, 2019) and political empowerment (Di Paola, 2017), while enhancing environmental stewardship (Bradford et al., 2020; UNDP 2018). Forming networks of small-scale grassroots efforts would provide ideal grounds for adaptive, resilient and sustainable common resource management (Berkes et al., 2003) as well as enabling community-led transformation (Scoones et al., 2020). The following showcases such approaches by describing examples of community-led development in blue and green spaces that foster knowledge co-creation, coproduction and sustainable behavior.

Land-based community gardens provide many benefits for its members and surroundings. The capacity to organize around a common goal strengthens social cohesion by transcending potential conflicts over differences and fostering spaces of trust between members (Di Paola, 2017; Wesselow & Mashele, 2019). Further, community gardens create a sense of attachment

to and pride in the local environment, empowering environmental activism and “fostering democratic values, interpersonal and intercultural respect, and citizen engagement" (Di Paola, 2017, p. 52).

Allotment gardens on land have historically been responses to food shortages which seems to be reflected in current harvesting and cultivating activities. Memory of and knowledge about ecological processes as well as social codes are intrinsically connected to the community gardeners practice and habits, the significance of the community garden and connected ecosystem services providing a subconscious guideline of use (Barthel et al., 2014).

Community-based marine aquaculture has been identified as strengthening the connection to the participants’ cultural heritage, thus upholding community ties to the ocean. If embedded in adaptive policy decisions and continuous social and environmental assessments, community-led efforts in marine aquaculture could offer an arena for participation, environmental stewardship, and shaping democratic processes (Bradford et al., 2020). Enhanced environmental stewardship and ocean awareness have been named as inducing changes in behavior of participants and enveloping communities, inspiring more sustainable practices and environmental activism (Bradford et al., 2020; McKinley et al., 2023).

By and large, enabling community-based resource management and creating spaces for deliberation processes facilitates transformative change balancing human and environmental well-being (Scoones et al., 2020; Stuchtey et al., 2023; UNDP 2018).

2.3. Theoretical Framework

2.3.1. Equitable Resilience

Resilience research and thinking developed out of the research gap at the nexus of social and ecological systems (Berkes et al., 2003). Additionally, resilience thinking can be a facilitating tool in bridging science and policy, creating arenas for local and indigenous knowledge to become integral parts in addressing global challenges (Cote & Nightingale, 2012).

The current disconnect or dichotomy between people and ‘nature’, is counterproductive to resilience building processes as ecosystems and societies are undeniably intertwined through relational and structural patterns of services and use (Berkes et al., 2003; Ostrom, 2009). Social systems are defined as governance mechanisms determining property rights and access, surrounding knowledge of resource and environment as well as moral and human-nature frameworks (Berkes et al., 2003), while ecological systems were deemed as “self-regulating communities of organisms interacting with one-another and with their environment” (Berkes et al., 2003, p. 3).

In the context of social-ecological systems (SES), resilience research and thinking suggests that adaptive management, self-organization and (local) knowledge are determining factors of a sustainable and resilient system. However, in order to forgo the parallel and disconnected evolvement of natural and social sciences in assessing the resilience of SES, a theoretical framework is needed to enhance a comprehensive approach to research (Berkes et al., 2003; Ostrom, 2009). The aim of such SES resilience research is to adequately inform adaptive management systems, to enhance social-ecological innovation, knowledge as well as the capacity to enable equitable change (Berkes et al., 2003), deeming it an important tool to inform further blue development.

While factors of equitability and environmental justice in terms of secure livelihood and well-being are mentioned in initial definitions of social-ecological resilience (Berkes et al., 2003), the focus of resilience research needs to be broadened to encompass social vulnerabilities (Calderón-Contreras & White, 2020; Cote & Nightingale, 2012; Fitzgibbons & Mitchell, 2021; Matin et al., 2018). Without acknowledging aspects of equitability and the need for just transformation, ambitions to build resilience run the risk of exacerbating current inequalities. Thus, normative questions of power dynamics, social vulnerability and agency of individuals or communities are imperative aspects for the analysis of this thesis. Resilience-building efforts need to ensure efficient and differentiated outcomes targeted at empowering most vulnerable individuals and groups (Calderón-Contreras & White, 2020; Cote & Nightingale, 2012; Scoones et al., 2020). Social-ecological resilience is defined by aspects of self-organization and memory, denoting the ability of the SES to develop and function without external interference and based on social and ecological memory within the SES; adaptability of the SES to external changes; and the transformative capacity of the SES (Berkes et al., 2003). This paper recognizes the intricate challenges that transformation and resilience-building efforts must overcome and acknowledge and will place this as a focal point of reasoning toward transformed clROF as target SES.

Against the backdrop of climate change and anthropogenic destruction of the oceans, the need for a shift in thinking and recognizing human-ecosystem interdependence and differentiated resilience outcomes is particularly apparent in the rapidly growing blue economy. In line with international Sustainable Development Goals (UN 2015), the current UN Ocean Decade[2] and resilience-based development guidelines of the United Nations (UNDP 2021, UNDP 2025), prospective blue development needs to take questions of ecological and social vulnerability into account. Further, it needs to elevate adaptive management approaches in order to prevent

[2] https://oceandecade.org/challenges/, last accessed 27.05.2025

exacerbating current inequalities such as processes of privatization of coastal areas, spatial displacement of local communities and the overexploitation of common marine resources. In their claim for Blue Justice, Bennett et al. (2021) emphasize the need for stakeholder participation as well as social and economic assessments prior to and during blue development endeavors. Further, the importance of transparency and participation is underscored by the connection between cultural heritage, identity, meaning-making and access to local resources. (Bennett et al., 2021; Bradford et al., 2020; Krause et al., 2019). Moreover, identity is to be seen as an important factor in the social construction of community relations and ultimately facilitates processes of differentiated resilience, following questions of who will be empowered by, or suffer from resilience building measures and to what extent (Calderón-Contreras & White, 2020; Cote & Nightingale, 2012).

Against the backdrop of the aforementioned notions of Blue Justice raised by Bennett et al. (2021), this paper recognizes the gravity of a lack of focus on social justice questions in new blue development and will assess clROF through the lens of equitable resilience. In a comprehensive literature review on resilience in the context of social equity, Matin et al. (2018) define four key concepts connected to equitable resilience in order to highlight the need for inclusive approaches focusing on vulnerability, power structures and transformative aspects of resilience, namely Subjectivities, Inclusion, Cross-Scale Interactions, and Transformation.

Subjectivities encompass individual perceptions, identity and agency and are fundamentally determined by one's own "cultural, racial, ethnic, gender and other social attributes" (Matin et al., 2018, p. 200), deeming certain aspects of resilience as inherently subjective (Cote & Nightingale, 2012). Existing inequalities lie at the heart of subjectivities as determinants of power distribution and wellbeing shaped by individuality that is rooted in historical, cultural and societal context. Within blue development, subjectivities could refer to prerequisites for the access to common-pool resources in increasingly privatized coastal areas and different levels of dependency on marine resources. If such different claims to resources and levels of agency to adapt and advocate for oneself are disregarded, they could result in the displacement of local communities and potential detrimental effects of hasty commodification of local cultural and ecological resources. A small-scale fisher for instance could depend on the access to the ocean as their livelihood, while a seasonal coastal dweller might place more value on aesthetics and commodities of waterfronts (Bennett et al., 2021; Ounanian & Howells, 2024). This underscores the importance of disaggregating needs and involving all relevant stakeholders in blue development processes. Subjectivities thus refer to intersectional factors shaping individual agency, perception and general world view, defining individual and collective power over common resources. In this degree project, this will be slightly broadened to underscore the

importance of individual needs and motivations to drive forward community development. Individual drivers in this sense encompass current perceived and lived benefits of blue development, to disaggregate needs and claims informing the baseline for potential equitable change.

Questions of access to SES are integral in discussing equitable resilience, as the definition of access is not just the right to, but rather "the ability to derive benefits from things" (Ribot & Peluso, 2003, p. 153). Access is broadly characterized by power relations shaped by physical, institutional, social and economic mechanisms such as: "technology, capital, markets, labor, knowledge, authority, identity, and social relations" (Ribot & Peluso, 2003, p. 173). Thus, the well-being of SES and especially the individuals who play a role in their resilience is not solely shaped by the access to natural resources but further through individual needs and social-economic factors (Calderón-Contreras & White, 2020).

Inclusion emphasizes the efforts to ensure equal participation and access and value different needs, interests and knowledge levels in development as to not exacerbate current inequalities, such as the gender divide in traditional marine occupations (Bennett et al., 2021). This concept aids to highlight and incorporate power imbalances within and between communities, local circumstances, and social-ecological memory into evaluation. Social memory refers to local knowledge of community habits and resources within the SES, fostering resilience and capacities for self-organization; ecological memory describes the capacity of ecosystems to adapt and apply learnings from previous pressures (Berkes et al., 2003). This further stresses the importance of including local knowledge in governance, or relying on bottom-up solutions for sustainable common resource management. (Ostrom, 2009; Ounanian & Howells, 2024). Thus, ensuring inclusion and ensuing diversity of actors, groups and roles defines levels of equitable resilience within SES (Kotschy et al., 2015), as ecological as well as social diversity facilitate adaptability and capacity building potential of SES (Berkes et al., 2003). In the blue context, the evaluation of potential exclusionary factors of development could benefit efforts of marine conservation (Stuchtey et al., 2023), foster long-term social acceptability of prospective blue development (Cavallo et al., 2023), and ensure "equitable sharing of benefits arising from the exploitation of common marine resources" (Cavallo et al., 2023, p. 2).

Cross-scale interactions describe processes within and between SES and encompassing settings on several levels. Moreover, they evaluate the communication and inclusion of several perspectives retaining to resilience building, further stressing the importance of differentiated resilience (Cote & Nightingale, 2012). Increasing resilience for one group of actors could result in exacerbating inequalities of another (Matin et al., 2018). A lack of cross-scale participation

and local context in the top-down development of offshore wind-power for instance could provide opportunities for more sustainable energy and employment on one hand, while enclosing access to certain marine areas for fishing or shipping activities on the other (Cavallo et al., 2023). This emphasizes factors of cross-scale connectivity through network structures and self-organization as a resilience building tool (Berkes et al., 2003; Cote & Nightingale, 2012; Ostrom, 2009).

Transformation defines the capacity for adaptation and revolutionary change (Matin et al., 2018). It can be seen as the culmination of potential of the previously discussed themes of equitable resilience and a direct response to points of social or ecological crises (Scoones et al., 2020). Further, transformation is described as something inherently political, enabling changes in policy, behavior and power dynamics (Scoones et al., 2020).

Important facilitators for transformative change are knowledge-sharing networks where individuals or communities can learn from one another, to democratize development and governance processes (Matin et al., 2018). In the context of this degree project, this connects to the concept of Ocean Literacy, which refers to capacity building efforts concerning the understanding of human-ocean interdependencies (Payne & Marrero, 2021). This awareness-raising tool in its foundation has since evolved to be understood as "a mechanism of change […] to transform ocean knowledge into meaningful behaviour change and action for ocean sustainability" (McKinley et al., 2023, p. 2).

These four themes are contextualized within the aim of this thesis and exemplified by a case of a marine protected area (MPA) in the Philippines built on community-based managed access and self-organization. Local fishing communities, supported by external NGOs and universities, were enabled and incentivized by grassroots processes and their subjective claims to the ocean to collectively work towards rehabilitating and protecting the local marine environment. Based on reciprocal trust and exclusive access for local fishing communities conditioned on valuing the MPAs "that are designed to replenish and sustain fish populations and protect habitats and biodiversity" (Stuchtey et al., 2023, p. 802), this case set an example for successful marine conservation balancing social and environmental wellbeing. Disaggregated claims and drivers for the exploitation of marine resources were continuously valued in participatory processes that integrated different levels of governance. Further, the community-based nature of these conservation efforts resulted in a variety of social, ecological and environmental benefits. Financial and food security, as well as fisheries increased, higher levels of perceived social equity were noted after 7 years of work. This showcases the potential power of grassroots efforts in blue development to enable equitable and environmentally sound

change across scales; the community-based protection empowering social and political engagement recognizing "the central role of coastal fisheries to the health, cultural coherence, resilience and wealth of coastal communities" (Stuchtey et al., 2023, p. 802).

2.3.2. Social-Ecological-Systems Framework

The complexity and abstract nature of the themes of equitable resilience necessitated an instrument to substantiate these claims. The Social-Ecological-Systems Framework (SESF) developed by Ostrom (2009) and later revised by McGinnis and Ostrom (2014) aims to provide a structure and common language to interdisciplinary research on complex social-ecological systems (SES). Therefore, the SESF aided in contextualizing the emphasis of the aforementioned critical concepts of equitable resilience in social-ecological systems research within a coherent framework.

Factors of self-organization and collective action around sustaining common resources are at the heart of the SESF. Moreover, perceived costs and benefits act as deciding variables in the motivation of common resource management (Ostrom, 2009). Ostrom (2009) stresses the need for and benefits of self-organization to promote sustainable social-ecological systems (SES) as opposed to government-imposed policies that can lead to negative impacts on resource systems.

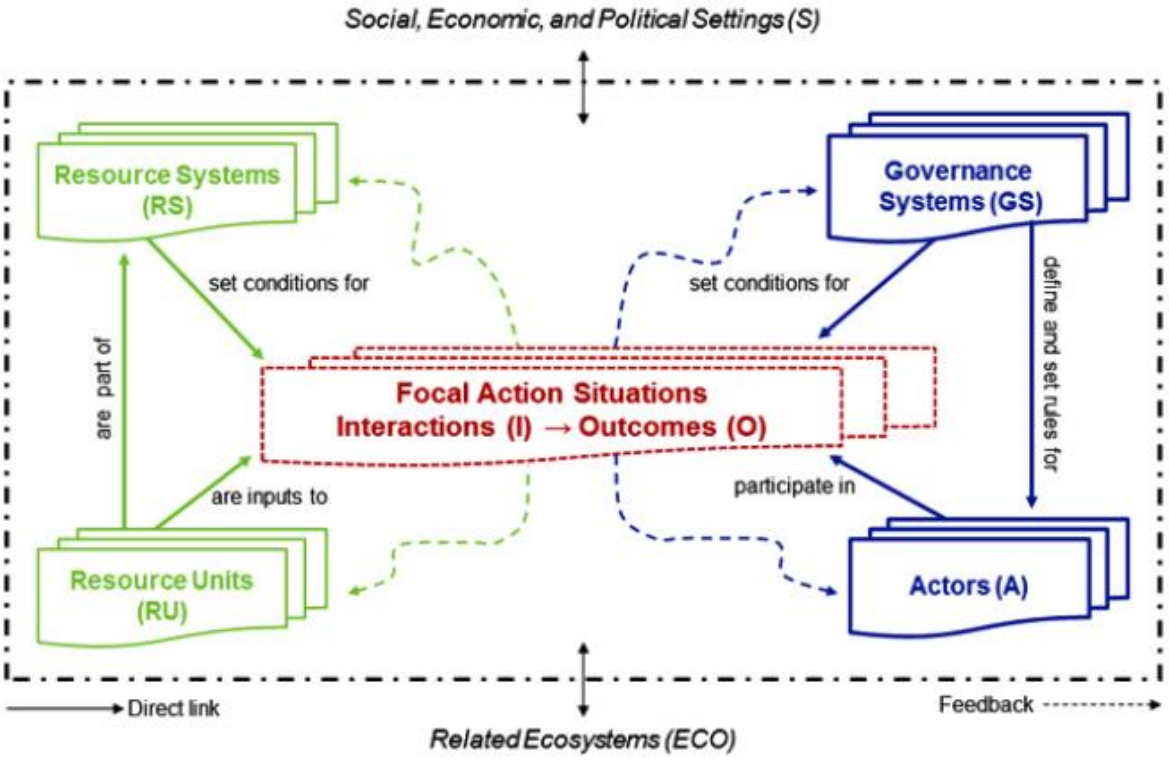

Figure 1 *revised structure of the SESF by McGinnis & Ostrom (2014)*

The focal point of the SESF are action situations that directly impact the structure of the SES (Fig. 1). Action situations denote interactions between individuals or groups motivated by their

respective goals “within the context of ubiquitous social dilemmas and biophysical constraints, as well as cognitive limitations and cultural predispositions.” (McGinnis & Ostrom, 2014, p. 2), connecting to differentiated levels of agency that determine individual or collective capacities to prompt self-organization (Kotschy et al., 2015)

Action situations define governance, resource, and social systems, and in turn, their manifestation is shaped by environmental, social and institutional settings which cater to or hinder collective action and collective knowledge production (Thiel et al., 2015).

In a continuously evolving and ongoing process, such action situations are formed through individual or communal *interactions* (I). These are transformed within the system context into *outcomes* (O) that in turn impact the four core subsystems *Resource Systems* (RS), *Resource Units* (RU), *Governance Systems* (GS), and *Actors* (A). Lastly, these categories are contextualized within broader social, economic and political settings (S) as well as related ecosystems (ECO), showcasing the interrelatedness of SES. The SESF provides a tier-system of variables describing the aforementioned categories (*Figure 2*) which is characterized by and criticized for its simplified and vague nature (Thiel et al., 2015). The ambiguity of second-tier variables describing focal action situations and subsystems allows for flexibility in interpretation and focus of SES research, giving room to exploring and highlighting implicit themes of equitable resilience. Factors of subjectivities are reflected in the subsystem *Actors* (A), levels of inclusion are primarily informed by the *Input* (I) dimensions. Transformative capacity of the SES relates to 2nd tier output variables. The importance of exploring cross-scale interactions as determinants of equitable resource management is implied in the general connections and contextualization of the framework. This degree project will assess clROF guided by select second-tier variables that aid the understanding of clROF as SES along the red thread of environmental impacts and equitable access to clROF.

This paper recognizes the framework’s limitations and critical voices surrounding the lack of clarity concerning ecological factors (Vogt et al., 2015), as well as the missing explicit focus on equitability and power structures (Calderón-Contreras & White, 2020; Cote & Nightingale, 2012), and general ambiguity of variables (Thiel et al., 2015). Nonetheless, the application of the SESF as a heuristic provides a necessary baseline for deepening the understanding of the intricate social-ecological connections and processes within clROF, while creating space for exploring questions of access and equitable resilience potential. The framework will be applied as a tool to analyze questions of use, self-organization and agency embedded in processes of clROF in order to determine desirable states of the SES.

3. Methodology

This degree project is grounded in literature findings on environmental aspects of ROF and empirical data collected through interviews conducted with relevant stakeholders. As a way to combat key challenges that SES research faces the SESF aids in bridging the gap between two different scientific approaches. One focusing on more objectivist ecological aspects, the other exploring interpretive findings from a critical social science perspective. An interdisciplinary framework facilitated the necessary structure to explore clROF as SES, while the call for an emphasis on equitable resilience guided the investigation of the transformative capacities of clROF.

The focus on community-led regenerative ocean farms thus offered a fitting arena to analyze the social components and community focus of the practice of seaweed and mussel farming to showcase human-nature interdependencies by going beyond isolated environmental factors.

3.1. SESF variables as indicators for equitable resilience

Select second-tier variables of the SESF (*Figure 2*) guide the exploration of the research questions, contributing to a broader understanding of intricacies and connections in different clROF systems. Building on the aforementioned themes of equitable resilience, the chosen variables are used as indicators to inform aspects of social-ecological resilience connected to access, actors and participatory processes, dependent on and embedded in factors of ecological resilience, environmental knowledge on and characteristics of seaweed and mussel farming. Relevant variables used are introduced in each subchapter and, if pertinent to the finding, indicated in the main body of writing as an abbreviation in paratheses.

First-tier variable	Second-tier variables
Social, economic, and political settings (S)	S1 – Economic development
	S2 – Demographic trends
	S3 – Political stability
	S4 – Other governance systems
	S5 – Markets
	S6 – Media organizations
	S7 – Technology
Resource systems (RS)	RS1 – Sector (e.g., water, forests, pasture, fish)
	RS2 – Clarity of system boundaries
	RS3 – Size of resource system
	RS4 – Human-constructed facilities
	RS5 – Productivity of system
	RS6 – Equilibrium properties
	RS7 – Predictability of system dynamics
	RS8 – Storage characteristics
	RS9 – Location
Governance systems (GS)	GS1 – Government organizations
	GS2 – Nongovernment organizations
	GS3 – Network structure
	GS4 – Property-rights systems
	GS5 – Operational-choice rules
	GS6 – Collective-choice rules
	GS7 – Constitutional-choice rules
	GS8 – Monitoring and sanctioning rules
Resource units (RU)	RU1 – Resource unit mobility
	RU2 – Growth or replacement rate
	RU3 – Interaction among resource units
	RU4 – Economic value
	RU5 – Number of units
	RU6 – Distinctive characteristics
	RU7 – Spatial and temporal distribution
Actors (A)	A1 – Number of relevant actors
	A2 – Socioeconomic attributes
	A3 – History or past experiences
	A4 – Location
	A5 – Leadership/entrepreneurship
	A6 – Norms (trust-reciprocity)/social capital
	A7 – Knowledge of SES/mental models
	A8 – Importance of resource (dependence)
	A9 – Technologies available
Action situations: Interactions (I) → Outcomes (O)	I1 – Harvesting
	I2 – Information sharing
	I3 – Deliberation processes
	I4 – Conflicts
	I5 – Investment activities
	I6 – Lobbying activities
	I7 – Self-organizing activities
	I8 – Networking activities
	I9 – Monitoring activities
	I10 – Evaluative activities
	O1 – Social performance measures (e.g., efficiency, equity, accountability, sustainability)
	O2 – Ecological performance measures (e.g., overharvested, resilience, biodiversity, sustainability)
	O3 – Externalities to other SESs
Related ecosystems (ECO)	ECO1 – Climate patterns
	ECO2 – Pollution patterns
	ECO3 – Flows into and out of focal SES

Figure 2 *Second-tier variables of a social-ecological system (McGinnis & Ostrom, 2014)*

As aforementioned, the operative definition of subjectivities within the scope of this thesis engulfs individual drivers for the involvement in clROF encompassing the interviewees' perceived and factual benefits surrounding clROF. This is motivated both by time and scale limitations to gather detailed accounts of socio-demographics, personal history and cultural characteristics of each interviewee as well as by the heuristic aim of this thesis to evaluate transformative potential derived from clROF. The focus on subjective motivations informs the baseline of services provided by current clROF. 2nd tier variables guiding the analysis of individual drivers are pertaining to Actors (A), Action Situations: Input (I) Social, Economic,

and Political Settings (S), Governance Systems (GS), Resource Units (RU), and knowledge of the interviewees on Related Ecosystems (ECO). Overall, this is following questions of reasons for involvement and how subjectivities could be transformed by and influential to clROF.

These drivers are then contextualized within factors hampering or fostering inclusion, guided by questions of dependencies on and access common resources within clROF. This part of the analysis is informed by 2nd tier variables of Actors (A), Input Action Situations (I), and Resource System and Units (RS/RU).

The theme of cross-scale interactions is used to analyze internal and external patterns of communication, governance and interaction within clROF (networks). Analyzing how current clROF function, this section of the analysis seeks to inform social components such as levels of participation, network, self-organization. Additionally, this is centered around harvesting activities and resource allocation as the core practice of clROF directly related to using the environment. 2nd tier variables guiding the analysis of organizational patterns of clROF are pertaining to Actors (A), Input Action Situations (I), Governance Systems (GS), and Resource Units (RU). As a way to guide the understanding of RU, 3rd tier variables proposed by (Vogt et al., 2015) are applied (See Figure A1).

Transformational aspects of clROF can be seen as the culmination of and being informed by the baseline information gathered in previous sections of the analysis. Based on portions of the interview process revolving around the interviewees' visions and aspirations for the future of both clROF in general and their respective projects, the findings are assessed with a focus on 2nd tier variables of output dimensions within the SESF, namely O1 – *Social performance measures* and O2 – *Ecological performance measures*.

3.2. Interviews and participant observation

The novelty of clROF and the lack of comprehensive research on clROF as SES deemed it necessary to broaden the research scope and allow for more dynamic and organic interview processes. Semi- and unstructured interview facilitated an open dialogue between the interviewees and I, provided adaptability in terms of language and foci of the conversations and allowed me as the researcher with the necessary flexibility to gather adequate findings. The scope of interviewees encompassed founding members of community-led ROF, facilitators helping the creation of ROF, and actors within ROF, in order to gather insights from as many different people as possible to either reflect the potential diversity of clROF or highlight the lack thereof.

An interview guide (See Table B1) was established prior to conducting the interviews, to ensure a coherent structure in line with the research focus. Building on guidelines proposed in the Routledge Handbook of Research Methods for Social-Ecological Systems (Shackleton et al., 2021) this provided me with insights on five dimensions of clROF as SES:

1. Social-ecological dimensions (e.g. organization of harvest, questions of ocean literacy and stewardship, resource use, social-ecological memory)
2. Institutional dimensions (e.g. external/ internal governance, permit processes, (support) networks)
3. Social-relational dimensions (e.g. collaboration and community building, social structures of the clROF, power dynamics, shared responsibilities (e.g. working groups) and knowledge exchange, etc.)
4. Contextual dimensions (e.g. history, ecological knowledge and cultural systems surrounding the foundation of the ROF project)
5. Individual dimensions (e.g. agency, incentive to get involved in/ initiate a clROF, perceptions, sense- and place-making, aspirations for clROF)

Within the span of approximately 8 weeks a total of 7 interviews were conducted ranging from 45 minute telephone-interviews to several hours of interviews supported by participant observation (Moser & Korstjens, 2018) during which I was shown the physical set up of the ROF or surrounding community spaces. This facilitated an honest and informative dialogue and provided me with the opportunity to physically experience aspects such as visibility and access to the projects. The interviews were documented through field notes and transcripts, if the surrounding conditions allowed. Finally, these were compiled, categorized and analyzed guided by the aforementioned themes and variables.

Table 1 *– list of interview partners*

#	**Date**	**Site visit y/n**	**Base of the interviewee**	**Interviewee**	**Transcript y/n**
1	05.03.2025	**Y**	Flensburg, DE	Founder: Flensburger Meeresgarten	**N**
2	13.03.2025	**Y**	Gothenburg, SE	Marine Biologist and Project coordinator: Marine Science faculty, University of Gothenburg (affiliation: ROF Flytevi)	**Y**

3	16.03.2025	**N,** **N/A**	Gothenburg, SE	Founder: KOASTAL	**Y**
4	19.03.2025	**N**	Simrishamn, SE	Innovation and research coordinator: Marint Centrum; Scientific advisor: Kivik Tång	**Y**
5	09.04.2025	**N**	Copenhagen, DK	Co-Founder: Havhøst	**Y**
6	11.04.2025	**Y**	Kivik, SE	Co-initiators: Kivik Tång	**N**
7	16.04.2025	**Y** **Y** **N**	Flensburg, DE Kollund, DK Sønderborg, DK	BCG/ROF network meeting (FMG, mussel farmers from Kollund, Sønderborg, other actors working with small-scale algae and/or mussel farming	**N**
8	25.04.2025	**Y**	Tjörn, SE	Founder: Stigfjordens Andelsodlingar	**N**

The interview partners reflect a diverse range of use patterns, motivations and organizational structures of community-led regenerative ocean farming, with a focus put on the initiators and facilitators of clROF. This elevated social components of active clROF and allowed me to gather information on subjective aspects of the interviewees' interests concerning clROF and when or how those manifested into active involvement, fostering an understanding of access to clROF.

Interview 1 was conducted on-site with the cofounder of a German clROF-project called *Flensburger Meeresgarten* who has been involved in many interregional projects connecting ROF actors. Further, he has been working with several EU-funded projects about the sustainable development of clROF under the umbrella name of *COOL BLUE: Community Ocean Farms and Local Business Clusters*. His expertise and network granted me access to several events and potential key interview partners for further information. This offered an increased understanding of connections within this emerging concept of clROF and insights into the first interregional clROF network event and workshop in Germany. The aim of this event was to connect German and Danish actors in ROF to workshop a potential network structure for clROF in the regions where I was able to gather insights through conversations and informal interviews (Shackleton et al., 2021). Prior to this, some attendees had been (financially) involved in or started their own clROF-projects or played a role in advancing farm design and crop choices in experimental or research farms in Germany. Insights gained at this event are grouped under the reference of **Interview 7**. This will encompass conversations with all attendees and two site visits to clROF in Denmark as part of the networking event.

The COOL BLUE (CB) projects provided a frame and scope for this degree project. Most interview partners have been or are currently involved in CB to varying degrees, either as lead partners or in a more general role, offering pledges and support to the Manifesto of ROF developed as an output of the project. Content and network provided within the realm of CB will be further discussed in chapter **4.**

Interview 2 was conducted with a marine biologist at the university of Gothenburg, Sweden. She has been spearheading the development of ROF on the Swedish west coast and acts a national facilitator involved in COOL BLUE, offering guidance to people who are interested in (cl)ROF. Currently, she is part of a group maintaining the marine allotment *Flytevi* in Gothenburg where she is co-organizing educational programs surrounding marine biodiversity and ROF. This interview provided insights on ecological aspects of ROF and on the development of ROF in Sweden, surrounding governance structures, and harvesting and knowledge sharing activities.

Interview 3 was held with the founder of *KOASTAL*, a Swedish company leasing lock-and-key seaweed farms with a buy-back-guarantee of harvested biomass to interested actors. This interviewee offered expertise on permit processes, aspirations for commercialization of seaweed farming and connecting (community-led) seaweed farms. This interview informed on permit processes, design, and the potential of support networks.

Interview 4 was conducted with a marine biologist and research and innovation coordinator at *Marint Centrum*, in Simrishamn, Sweden who acts as the scientific advisor for *Kivik Tång*. She provided expert knowledge on ecological aspects, challenges and potential of developing community-led and commercial small-scale seaweed farming in the Baltic Sea, having initiated the first trial-seaweed-farm on the Swedish East Coast.

Interview 5 was held with the co-founder of *Havhøst*, a Danish NGO devoted to connecting and amplifying clROF in Denmark through a membership network, facilitating information sharing and providing support. Having been involved in clROF for over a decade, inspiring several *spin-off* projects such as the COOL BLUES, and acting as a national facilitator for COOL BLUE, he offered valuable insights into processes of democratization of local food production, communication and support networks of clROF.

Interview 6 was conducted onsite in Kivik, Sweden, with the two initiators of *Kivik Tång* the first community-led regenerative ocean farm in Sweden with the intent of consuming their harvest. This served as a way to gather a more subjective understanding of clROF, its organization patterns and farmers. *Kivik Tång* consists mainly of retirees pioneering seaweed cultivation and education on ROF on the Swedish coast of the Baltic Sea

Interview 8 was held onsite on Tjörn, Sweden, with the founder of *Stigfjordens Andelsodlingar*, a clROF embedded in the local community and history. The founder had bought an already existing mussel-farm-structure and is focused on revitalizing local blue food production. He provided insights on self-organization, information sharing, harvesting and monitoring activities.

3.3. Methodological Limitations and Critical Reflections

The focus on various clROF projects was deemed suitable to the explorative nature of this degree project than one in-depth case study. This limitation in size might

The scope of this degree project did not allow for several in-depth case studies of clROF, however, the heuristic nature of this study deemed. Moreover, the novelty of clROF in Northern Europe limited the number of potential interviewees to be included. More time and resources would have been needed to allow for a more encompassing and detailed account of participants of clROF, disaggregated by socio-economic indicators and subjectivities such as gender, age, occupation, and financial capital.

Prior to the interview process, the interviewees were informed of my research aim in order to ensure informed consent to their responses being used in my degree project. During the interviews and participant observation I adhered to ethical considerations and treated my interview partners and their information with respect and sensitivity.

I recognize a potential researcher's bias as I have been involved with the COOL BLUE projects in different roles. This provided me with the necessary access points for data collection, however, my proximity and prior knowledge of the overall topic of this thesis is to be acknowledged.

The SESF provided me with a relevant frame of reference, however, the shortcomings stated in chapter **2.4.** have not been neglected during the process of this degree project.

AI tools were not used in writing this thesis.

4. Analysis of Equitable Resilience in Community-led Regenerative Ocean Farms

As described in the introduction, community-led regenerative ocean farming (clROF) is an emerging form of ROF centered around the collective marine cultivation of low-trophic, regenerative species. The clROF explored in this degree project primarily cultivated blue mussels, as well as certain brown algae, namely sugar kelp and Rörhinna or gut weed. The social structures and organizational patterns of the clROF projects discussed in this chapter vary

given different external context and motivations of people involved. However, the underlying objective of all interview partners has been to reconnect people and the marine environment, to learn from and use the ocean in a potentially more sustainable way.

In the following sections, interview findings are presented in four categories, **individual drivers for clROF**, **Inclusion**, **Cross-Scale Interactions**, and **Transformation**.

4.1. Individual Drivers for clROF

In the scope of this thesis of exploring resilience building capacities of clROF, subjectivities play an important role in accounting for several perspectives, needs and social vulnerabilities within the SES. The following presents different needs for and intentions of involvement in clROF as described by the interview partners. Individual drivers for one's involvement in clROF are defined by different characteristics of the actors (A), such as past experiences (A3), social capital (A6), their prior knowledge of (A7) and dependance on ROF (A8).

The interviews conducted within the scope of this degree project revealed patterns of objectives and preconditions that favored the implementation of clROF projects. The findings are categorized into the main motivators for the interviewees, namely **Community-building**, **Ocean literacy and stewardship**, and **Local culture, heritage and sustainable blue production.**

4.1.1. Community Building

Community-building and other social aspects such as local engagement, outreach, and reconnecting people and the ocean are described in every interview as strong and focal motivators for initiating ROF projects within larger networks. Several interviewees stress the need for community spaces and how valuable the joint experience of clROF has been in keeping people engaged (Interviews 1,4,5,6,8). The entirety of clROF within the *Havhøst* network are non-commercial projects with a focus on community and outreach (Interview 5). The emergence and endurance of clROF in Denmark seems to have been partially due to the focus on community-building aspects and reciprocal inspiration between people and projects. Moreover, community in a broader sense through networked support structures facilitated higher engagement and thus decreased barriers of entry, as pointed out by cofounder of *Havhøst* and facilitators within COOL BLUE (Interview 1,2,4,5). People tend to be more eager to get involved in an already existing clROF rather than having to individually take on the responsibility of initiating a project (Interview 2,4,8), which might be combatted by external support and more accessible bureaucratic processes (Interview 2,3,4,5,6,7). These aspects of organization and accessibility will be further discussed in chapters **4.2. and 4.3.**

Currently, coastal environments and identities as well as traditional blue occupations are diminishing under external pressures such as commodification, climate change and reduced fisheries (Ounanian & Howells, 2024). Against this backdrop, clROF take on a function of pride- and identity-building spaces through their focus on community and stewardship building activities. This finding is supported if connected to longstanding benefits of land-based community gardens as cohesion-, place-, and identity-building places (Di Paola, 2017). Founders, facilitators and ROFarmers alike point out the importance of reconnecting people to their social-ecological environment and providing a sense of belonging and purpose (Interview 1,2,4,5,6,8). This emphasizes an interconnectedness of SES in general and clROF in particular that goes beyond provisioning and regulatory services but rather focusses on creating a meaningful connection between individuals as well as communities and their environment.
Underscoring this, the cofounder of *Havhøst* highlights a practice that they have adopted:

> "Every chance we get, we try to remind them that they're also a part of something much, much bigger and that they're ambassadors for an entirely new way of (…) addressing the need to combine human food production and ocean regeneration. That they are pioneers, and we try to (…) remind them of that and make them proud of that." (Interview 5)

Other established clROF projects and associated actors use similar messages in their internal and external communication (Interview 4,8). The founder of *Stigfjorden Andelsodlingar* on Tjörn spoke of the members of his community mussel farm as a "proud taskforce" and "children of the mussels" (Interview 8), highlighting the project's focus on community spirit and social aspects. In order to nurture engagement and motivation in light of lengthy permit and trial-and-error processes of clROF in the particular environment of the Baltic Sea, the scientific advisor at *Marint Centrum* highlights the progressing engagement of *Kivik Tång*: "They have developed a lot […], but sometimes they don't see that and I try to encourage them: 'you are the pioneers and you have done so much'" (Interview 4). Given the grave differences in local marine environment in relation to clROF projects on the Swedish west coast and Denmark that inspired *Kivik Tång*, their continuous development is particularly interesting to note. The high amount of exposed sites due to differing geological conditions of the eastern Swedish coastline and lower salinity of the Baltic Sea necessitated experimental harvests and designs of their ROF, to assess sustainability and feasibility of different crops (Interview 4,6).

4.1.2. Ocean literacy and stewardship

The capacity of clROF to build a sense of belonging and engagement is reflected and further established in another strong focus that all interviewees and their respective projects shared, which was placed on enhancing ocean literacy and stewardship.

While the occupational backgrounds of the interview partners ranged from marine biology (Interview 2,4,7) to engineering (Interview 3,6), a commonality between many of them was a passion for or previous working experience in pedagogical endeavors (Interview 1,2,6,7,8). This is underscored in the case of the three founders of the *Flensburger Meeresgarten*, who had studied to become or worked as teachers but had found education outside of the traditional structures of school-systems to be more meaningful (Interview 1,7). Their ROF acts as an adventure classroom and playground, inspiring enthusiasm and interest of any general spectators or participants (Interview 1).

Several of the interviewees' projects revolved to varying degrees around educational programs directed at schoolchildren or (future) ROFarmers (Interview 1,2,4,5,6,8). *Havhøst* developed an educational offer in cooperation with existing extra-curricular school programs (Interview 5); the marine allotment *Flytevi* in Gothenburg is centered entirely around teaching school classes and the general public about marine topics and ROF (Interview 2); *Kivik Tång* and *Marint Centrum* have been organizing several outreach events, lectures, and school visits (Interview 4,6); the founder of *Stigfjorden Andelsodlingar* creates a stage for discussing ocean-welfare, making use of his deep rootedness in the local community and interest in local food production to inform people about the local history, benefits and context of (cl)ROF (Interview 8).

Further, the aspect of increased ocean literacy through practical experiences and exploring one's own curiosity seemed to have played an important role in the establishment of several fundamental clROF setups that would in turn inspire further projects (Interview 1,2,4,5). The expertise and curiosity of the interviewee at *Marint Centrum* to become a scientific advisor and explore possibilities of ROF in the Baltic Sea facilitated the establishment and longevity of the clROF of *Kivik Tång* (Interview 4). One of the co-initiators of *Kivik Tång* highlighted the educational aspects of their seaweed farm as a pivotal factor of his long-term engagement and motivation, deeming it an especially valuable capacity building opportunity for retirees and school classes alike (Interview 6).

Some interview partners named clROF as a way for them to actively engage in ocean protection (Interview 1,5,6,8), highlighting that increased awareness on ocean issues factors into enhancing stewardship and inspiring more sustainable behavior related to the ocean (McKinley et al., 2023). The main motivation for initiating the clROF project in Flensburg was the lack of other opportunities for active ocean protection that would not require a diving license and to utilize the proximity to the sea in a meaningful way. This led to the concept of starting a seaweed and mussel garden in the city center as an educational platform to improve environmental

stewardship and potentially decrease perceived barriers of entry to engaging in ocean protection and clROF (Interview 1).

4.1.3. Local culture, heritage and sustainable blue food production

Farming and harvesting make up some of the core activities of clROF and while some projects within the scope of this thesis are not able (Interview 1,2,5,7) or not aiming to eat their harvest (Interview 3), the idea of local food production is a driver shared by most (Interview 1,2,4,5,6,8, some participants of 7). Further, connotations to the established concept of community-led allotment gardens on land facilitate a tangible point of entry into an otherwise novel concept (Interview 5), deeming the interest in local blue food production one of the core motivators if not outcomes of clROF projects (Interview 2,4,5,6,7,8).

Aspects of cultural and individual identity and past experiences connected to the consumption of mussels and oysters factor into several founding drivers of the interview partners (Interviews 5,6,8). Co-founder of *Havhøst* connected his love for oysters and associated childhood memories to the "urban gardening trend" (Interview 5). The initial motivation for his involvement in ROF having been to "make more people fall in love with oysters" and explore possibilities of cultivation of blue food in the Copenhagen harbor. During the 12 years of working with the development of clROF and through processes of inspiration by and collaboration with actors such as *GreenWave*, the concept evolved. The prevailing focus of *Havhøst* and COOL BLUE as a spin-off is placed on democratizing the sustainable production of food and amplifying the image of ROF as a facilitating tool in shifting exploitative use of the ocean toward "trying to invigorate it" (Interview 5). In this context, Regenerative Ocean Farming is defined as "the cultivation of edible aquatic species in such a way that the farming has an overall net positive impact on the surrounding marine ecosystems [balancing] considerations between environmental and social sustainability in the context of a sound and healthy economy" (COOL BLUE FUTURE, 2024, p. 2).

Moreover, the interview with the co-initiators of *Kivik Tång* suggested the importance of reconnecting to local history in blue spaces by their focus on returning to using the ocean in a way that is different from former traditional fishing activities in Kivik. While their harvest is not yet of significant amount, the theme of local blue food is evident in their community's activities centered around preparation, experimentation with new recipes or communal dinners. (Interview 6).

In talking to the founder of *Stigfjordens Andelsodlingar*, it became evident that a majority of his motivations for buying the already existing mussel farm and endurance to turn it into a community-led project stem from a deep and personal connection to mussels, oysters, and the

small-scale use of the sea (Interview 8). This is further highlighted by the interest in reconnecting to historical and cultural roots of the region the mussel farm is located in. As a described “Oyster central”, the historical context of the location of the clROF is centered around local blue food. Thus, historical landing dock functions as an inspiration for community events and cooperations with the aim of raising awareness on and reconnecting to local knowledge and context: “you can’t have a dock without telling the story about it” (Interview 8).

The trial-and-error nature of several of the regenerative ocean farms demonstrates that the potential of food production, especially regarding seaweed crops, is yet to be fully exhausted, shedding light on the varying dependencies on the resource units of clROF. Interview findings suggest a lower dependency on the harvest as a source of food and highlight the importance of surrounding activities related to the aforementioned themes. However, connections drawn to geopolitical circumstances and readiness to food shortages present potential benefits from clROF through local blue food production (Interview 1,2,8).
Against the backdrop of equitable resilience and Blue Justice themes (Bennett et al., 2021), this in turn showcases the importance of including different stakeholders and regarding their needs in the development and facilitation of clROF. If clROF could potentially improve food security, connections between equitable possibilities for participation and dependencies on the provided opportunities for food production and the scale of clROF need to be explored.

Finally, aspects of community standing, level of education and perceived financial security seem to determine the type of motivation and capacity of someone to initiate a clROF-project. In this sense, capacity does not solely refer to knowledge levels or financial capital, but rather the entirety of intersectional aspects of access related to subjectivities.

4.2. Inclusion: potential barriers of access to clROF

The following will accumulate potential physical, material, and social access barriers ascertained from challenges raised and advantageous learnings emphasized during the interviews. Further, accompanying solutions implemented or envisioned by the interviewees, are used to contextualize their aforementioned drivers, and showcase the (dis)similarities of the interviewees’ perceptions of inclusion in clROF. Knowledge sharing (I2), deliberation processes (I3), conflicts (I4) and characteristics of the clROF members (A1-8) surrounding access to harvesting activities (I1, GS4) and services (RS7, RU3-5,7) factor into levels of in- or exclusion.

4.2.1. Accessing clROF

Access to clROF is defined by several factors ranging from physical barriers of enclosure and water to social components of power dynamics within, perception and purpose of the clROF. The following will describe similarities and differences of factors defining the accessibility of the clROF in terms of physical and material barriers (i.e. (land)ownership, bodily abilities, financial requirements) as well as social barriers, including aspects of potential required knowledge, community standing, age and gender.

In terms of public access to the farm structure, both the *Flensburger Meeresgarten* and the show-room-platform of the *Havhøst* headquarters in Copenhagen present as the most accessible and visible (Interview 1,5). Both structures are placed in central areas of the city, deeming them open for passers-by to explore at any time.

The marine allotment garden in Gothenburg, *Flytevi*, holds many of those characteristics which seem to facilitate the projects' focus on education and outreach. It is centrally situated in a former industrial harbor area, where it is visible to external spectators. However, the platform is enclosed by a fence due to reoccurring instances of vandalism. Nonetheless, the purely educational platform serves as an outdoor classroom, designed to be partially accessible by wheelchair as a compromise between protection and accessibility. In the context of physical accessibility, challenges to balance environmental and social wellbeing concerning the placement of prospective clROF were raised. The objective to adhere to beach-protection measures, to prevent negative impact on eelgrass meadows and ensure optimal ROF conditions requires the structure to be placed relatively offshore. (Interview 2).

Moreover, clROF with a higher focus on food production tend to be less accessible as they are more often placed offshore and thus only reachable by boat (Interview 3,4,6,8, Havhøst ROFarmers in 7). Interview findings suggest a potential for collaboration between clROFarmers and stakeholders with access to blue spaces, such as marinas or sailing clubs, as a way to use existing infrastructure and knowledge. This apparent proximity is showcased by efforts of the first commercial ROF project in Germany to educate sailors on ROF techniques to be used in the vacant berths during winter (Interview 7); objectives of the *Flensburger Meeresgarten* to initiate collaborations between land- and sea based allotment gardens in and around marinas (Interview 1); and members of a marine allotment within the *Havhøst* network describing the majority of the community as hobby sailors (Interview 7). While this kind of collaboration can be beneficial to revitalize certain areas, it could potentially hold some exclusive properties connected to sociodemographic characteristics associated with sailing as a leisure activity and further enclose or privatize coastal landscapes.

Further potentially exclusionary processes concerning the offshore placement of ROF disconnected from structures accessible from land include difficulties (Interview 4) or even

safety hazards regarding weather and water conditions (Interview 8), required swimming or other physical abilities (Interview 2,8), and heavy physical workload surrounding harvest activities (Interview 4,6,8).

Levels of support and knowledge sharing processes between members of clROF and surrounding networks could factor into de- or increasing potential barriers of access which is emphasized by the varying degrees of embeddedness of the interview partners. All interviewees have been affiliated with or aided in support networks such as COOL BLUE, *Havhøst* or informal knowledge sharing related to environmental and technical aspects of clROF initiation. (Interview 2,3,4,5,7,8). Furthermore, interview findings suggest that diverse knowledge prerequisites of ROFarmers could be beneficial during the establishment of a clROF. Some interviewees had prior experience with or expert knowledge on the marine environment (Interview 1,2,4,7,8), while others had been working within different fields but saw potential or found interest in ROF (Interview 3,5,6).

Against this backdrop, a rather promising commonality of almost all interviewees was the shared inexperience in seaweed or mussel farming before their initial involvement in (cl)ROF, proving a low barrier of access in terms of knowledge requirements. The majority of interviewees (all except some members of 7) had been motivated by curiosity and ocean stewardship stemming from an emerging idea of local seaweed and mussel farming. While their capacity and other resource levels in terms of money, time and institutionalized support varied, the overwhelming trial-and-error nature of the respective projects suggests that practical knowledge on farming techniques and the environmental impact of ROF was less important than being persistent (Interview 4,5,6,8), having bureaucratic language proficiency (Interview 4,8), and community support through shared harvesting material, knowledge, and acceptance (Interview 1,2,3,8). This underscores that perception and a lack of support can be more hampering to inclusive involvement clROF than factual knowledge of the initiators.

Moreover, many of the clROF projects within the scope of this thesis have been jointly initiated by several people (Interview 1,2,4,5,6,7) which underscores the importance of and potential for a diverse group of actors be involved in different roles within clROF. Emphasizing the advantages of a diverse group of members to relieve individual workload, the founder of KOASTAL indicated having to be “an expert in everything” (Interview 3) in his service and support of installing and leasing ROF. Diversity among actors within the SES enhances the ability of the community as a whole to detect and understand ecological changes due to various perspectives and knowledge levels constituting the communal local knowledge and enhance social-ecological resilience (Kotschy et al., 2015). The community-led emergence of ROF thus

offers potential resilience building opportunities in terms of inclusive collaboration in any step of clROF, given the (perceived) factors of exclusion be addressed.

Nonetheless, the interview findings suggest certain prevalent social demographic characteristics that seem to favor a successful initiation of and involvement in clROF. Interviewees acting as facilitators of clROF observed an increased interest or higher likelihood to seek information of people of higher levels of education (interview 1,2,4,6,7), in more technical or applied occupations (Interview 3,4,6), and involvement in academia (Interview 2,4,8) or EU-funded projects supported by partners within academia (Interview 1,3,5,6,7). This presents a certain dichotomy between required levels of knowledge in practice and theory and highlights a consecutive risk of exclusive academic structures in clROF. Additionally, initiation of and involvement within the discussed ROF projects is dominated by men (Interview 1,3,5,6,8, Havhøst ROFarmers in 7), with many clROF with the focus of local blue food production in the *Havhøst* network as well as *Kivik Tång* being made up predominantly of retired men (Interview 4,5,6), echoing current trends of gender imbalances in blue industries (Bennett et al., 2021; Stuchtey et al., 2023).

However, some interview partners described a perceived change in patterns of participation in clROF, shifting toward more diverse actors and interests, in line with perceived societal processes of heightened awareness on ocean and sustainability issues (Interview 2,3,4,5,8).

> "In the beginning it was very dominated by grey haired people who had retired and who were eager to still contribute in a meaningful way to the world and to their communities and they are still the dominant force in the community gardens. But we're increasingly also seeing young people getting attracted to it. We're working with the youth schools, with scouts, with a lot of different sorts of organizations and also non organized […] individuals who want to try it out." Cofounder of *Havhøst* (Interview 5)

This experience of change within the Danish clROF movement is echoed by the Swedish national CB facilitator as increasingly younger audiences contact her, motivated by personal connections to the ocean and topics of sustainability (Interview 2). In continuously exploring and researching the concept of clROF, she indicates the variety of potential points of access to a well-designed and transparent clROF:

> "I didn't see the potential in the beginning, I didn't really think about it. But when I started to work, I saw it. [ROF offers so many possibilities that] you can work with, the Blue Community Gardens for one, just to cultivate for eating […] but also the knowledge, the ocean literacy around it. To invite people to a meeting place. […] you can do whatever you like, there are no limits" (Interview 2).

In order to foster this type of versatility and openness, interviewees 2 and 6 developed a Swedish handbook to guide the deployment and conceptualization of a clROF (Interview 2). This is underscored by the objective raised by several interview partners of developing a guideline to

facilitate more accessible involvement and ensure environmental soundness and safety of prospective ROF (Interview 1,2,4,7,8).

4.2.2. Financial and time requirements

Processes of conceptualization, installation, and implementation of clROF endeavors have been named as the most time extensive and thus potentially excluding factors of ROF (Interview 1,2,3,4,6,7,8). Further, lengthy and complex permit applications could hamper motivation (Interview 1,4,7,8), and, pertaining to Swedish and German ROF, are cost inefficient and do not adequately account for small-scale projects or clROF (Interview 4,8). Regulatory structures and bureaucratic processes in those regions do not adequately reflect the realities of use and impact and lack scale and adaptability to (cl)ROF. This is evident in a lack of distinction between a permit application for a small-scale algae cultivation site and one for the construction of a wind farm in Swedish waters (Interview 4).

Continuous financial requirements connected to the implementation and management of a clROF could include rent, costs associated with permits, installation, farming, outreach and education, membership fees and monitoring. The costs are determined by a variety of factors depending on the region, farming set up and focus of the ROF. Monitoring activities (I9) are named as the most cost intensive (Interview 4,5,7), while the conceptualization of clROF projects and delays relating to permit or grant processes are suggested as requiring the most amount of time and patience (Interview 1,2,3,4,6,7,8).

Interview findings show that collaboration and support networks aid in decreasing costs and time required; the *Flensburger Meeresgarten* is using a platform owned by the city, thus saving on rent and insurance cost related to public events connected to their marine allotment (Interview 1,7); several actors are sharing financial burdens of sampling efforts through joint grant applications or membership fees and structure, putting less financial pressure on an individual (Interview 2,4,5,6,7); some clROF are (re)using existing permits, structures and knowledge networks to save time and money (Interview 1,2,4,8).

Further, prior experience with or knowledge on bureaucratic and funding processes is highlighted to be a useful facilitator concerning complex grant processes as a way to fund a clROF (Interview 4). Some interview partners have named established support structures and more accessible social funding opportunities as unexpected benefits aiding the initiation of their farms in Germany and Denmark (Interview 1,5,7).

4.3. Cross-Scale Interactions

The following sub chapter describes patterns of internal organization of clROF and networks of communication surrounding them. It explores questions of power and distribution of resources, which in the case of clROF encompasses in- and external governance systems (GS1-7), hierarchies (A5) and other characteristics of actors (A1,6,7), information sharing as well as self-organizing (I7) and networking activities (I8).

4.3.1. Internal organizational structures

The clROF assessed within the scope of this degree project vary greatly in terms of their organizational structure, ranging in size, harvesting activities, location and focus.

More established clROF exhibit more defined organizational structures governing their activities, such as membership offers (Interview 4,5,6,8), working groups (Interview 6,8) or leadership/ board structures (Interview 6,7).

Depending on their focus of activities, namely education or food production, time and resource allocation, as well as placement of the clROF differ between projects. Those clROF in which the harvest is not meant for human consumption are located within central areas of a city, facilitating public engagement and visibility (Interview 1,2,5). Cofounder of *Flensburger Meeresgarten* describes their marine allotment as being set up on a city-owned platform which is "built like a stage" deeming it a great space to showcase and amplify their foundational message of engaging in ocean protection and education (Interview 1).

General harvesting activities in clROF aiming at consumption of the crops seem to be a communal responsibility, with the interviews suggesting a shared workload or working groups according to personal interest, physical abilities, or access to the necessary equipment such as boats and waders (Interview 4,5,6,8, Havhøst ROFarmers in 7). Some projects use harvest processes as arenas for education and knowledge sharing (Interview 1,3,8), or community building (Interview 1,3,6,8).
Shared practices and knowledge networks that build on historic and past experiences within SES inform and improve the adaptability and resilience capacity of the system (Barthel et al., 2014; Berkes et al., 2003). In the context of the clROF within the scope of this thesis, this refers to cultural ties to ocean activities, community building and (blue) food production. Interview findings suggest that social-ecological memory in clROF is maintained and built through shared habits and activities, such as "Harvest parties" organized by KOASTAL to connect their ROFarmers (Interview 3); collaborations between local knowledge and historians revitalizing the identity of Tjörn as a former mussel and oyster hub (Interview 8); as well as annual (Interview 5) or weekly (Interview 4,6) meetings to internally connect the members of the respective clROF (network).

Thus, while social memory does not always directly imply historical ties to seaweed or mussel farming, it is nonetheless important to emphasize the importance of knowledge sharing and contextualization as resilience building characteristics. Social and ecological memory play a significant role in the successful reorganization and thus resilience building of a system, stressing the need to preserve existing aspects of local knowledge. Interview findings suggest that an imperative factor facilitating the initiation and conceptualization of clROF is the involvement of a community leader or key person with intrinsic knowledge about the SES, either concerning social context (Interview 2,6,8) or ecological factors of Resource Units and Systems (Interview 1,4), as well as the cooperation with local communities and activities already occupying the space (Interview 1,2,3). This underscores the importance of creating inclusive spaces for participation in all phases of the development and common resource management to improve the capacity for self-organization.

4.3.2. (External) Patterns of interaction

Building on the notion that cross-scale connectivity of SES enhances resilience (Cote & Nightingale, 2012), the following explores levels of networking activities between the presented clROF signified by collaboration, information sharing and support structures.

Currently, the Danish clROF network *Havhøst* counts 34 ROF individually organized by the respective members. A network coordinator supports interested actors and existing clROF with questions surrounding ecological factors and design of a new farm, thus facilitating a lower entry hurdle to and decreased environmental downfalls associated with ROF. (Interview 5). The scale and success of the *Havhøst* network have been named as motivating factors for testing possibilities of ROF in Sweden and Germany (Interview 1, 2, 4, 6).

Moreover, COOL BLUE (CB)was initiated by the cofounder of *Havhøst*, aiming to connect ROF endeavors and test economic and social feasibility of clROF. As an objective of CB a Manifesto of ROF was created, defining key characteristics that prospective ROFarmers should abide by focusing on balancing between environmental and social sustainability within a just economy (CBF 2024).
CB provides an international network of knowledge and support for people who seek guidance on topics surrounding clROF, focusing on a variety of components such as economic feasibility, social and environmental impact. Project outputs aim at showcasing different aspects of (cl)ROF allowing a broader audience to get involved or at the least acquainted with clROF (Interview 2, 5).

The interconnectedness and self-organization activities of the clROF within the scope of this degree project emphasize to what extent more informal processes of deliberation and

implementation contribute to the longevity of clROF. Connections and synergies with relevant stakeholders and existing infrastructure are suggested to foster a swift initiation of a clROF (Interview 1,2,5), highlighting the benefit of networked grassroots processes as opposed to externally imposed structures (Ostrom 2009).

4.4. Transformation

This section presents potential transformative aspects of clROF as suggested by interviewees which are then contextualized and connected with aspects of community-led development defined in chapter **2.2** as well as objectives and aspirations of the interviewees. The following describes the potential for equitable resilience building that clROF holds against the backdrop of the prevailing social-ecological disconnect and (risk of) unequitable blue growth, which will be presented in two underlying themes that were discerned: **Reclaiming coastal areas** and **Empowering community action**.

4.4.1. Reclaiming coastal areas

clROF could potentially enable communities to reclaim coastal and marine environments, through its cohesion- and place-making capacities, aiding self-advocacy and adjacency as a way to resist unjust blue development (Ounanian & Howells, 2024). Reclaiming the ocean for local collective use is described by interviewees as a way to "bring back the blue" into policy and local community discourses (Interview 8) and prevent further commodification of coastal landscapes through external actors (Interview 7).

Interview partner 2 disclosed plans for a prototype clROF that would amplify community voices through enhanced cross-scale collaboration between actors in academia, the municipality and locals, and produce tangible results on environmental benefits and drawbacks of clROF. The clROF will be deployed offshore an island on the west coast of Sweden, connected to local culture and history of the island. The external support network enables the clROF to access scientific knowledge and monitoring structures, preventing potential negative impact on seagrass meadows or further environmental risks such as contributing to marine litter. (Interview 2). Additionally, the close involvement of local communities and their knowledge rooted in the island's history and culture could enable local distribution of benefits, foster a network of trust (Di Paola, 2017; Wesselow & Mashele, 2019), and spaces for inclusive participation. This showcases potential aspects of local pride, place and identity making through collectively working with and for the (marine) environment, raising awareness on the shared responsibilities of ocean stewardship and protection (Interview 2,8). However, contextualizing this with mechanisms of displacement and outmigration of coastal communities (Ounanian & Howells, 2024), questions of about inclusion and diversity within such prospective projects

should be raised. If coastal communities are increasingly homogenous in income, social status, and values of aesthetic waterfronts removed from local social memory, clROF could lead to further privatization of ocean resources. This risk was raised by interviewee 1, drawing the connecting to potential gentrifying capabilities of ROF. Contrasting this, an attendee of Interview 7 mentioned prospects of engaging coastal communities along the German Baltic coast. Expansion of nature protection sites and the commodification of the coastline for tourism activities has led to the diminishing vitality of local communities (Interview 7). Prior and continuous monitoring of social components within and surrounding clROF was suggested to ensure equitable participation and prevent potential conflicts of co-use or space (Interview 3,5), highlighting a need for social impact assessments as prerequisites for ROF permits.
While this does not seem to be prevalent in permit application processes of the explored clROF, *Kivik Tång* were urged by the municipality to prevent physically or perceptually enclosing public beaches located near their ROF, so as to not create a perception of exclusion (Interview 4).

Showcasing this element of preventing enclosure and uplifting community-led management of common resources, Interviewee 1 has determined an aspiration of the clROF project in Flensburg to incentivize people in town to become communal owners of the platform currently owned by the city to turn it into a true community garden and meeting point (Interview 7). This follows a question raised in the ROF network meeting in Flensburg and highlights a focal point of this thesis: “How can they be community gardens if they are not owned by the community?” (Interview 7).

Using existing infrastructure, building on ecological and social memory, and collaborating with other actors such as in Flensburg are common strategies the clROF have applied (interview 1,2,4,5,7,8) offering benefits as well as dependencies on external factors that could hamper resilience-building capabilities of the clROF.

The city-owned platform leased by the *Flensburger Meeresgarten* lay vacant, offering them a simple, low-cost access point that benefits them as well as the city. However, the platform is set to be disassembled in 2029, creating a sense of uncertainty and unpredictability (Interview 1). Interviewee 8 purchased an already installed mussel farm, benefitting from the previous owner’s experience and local knowledge. Building on social and ecological memory of the historical connection to and abundance of oysters and blue mussels on Tjörn fostered the farm’s resilience and smooth initiation (Interview 8). clROFarmers exclusively farm local species, contributing to social-ecological memory thus preventing negative effects of introducing alien species. The motivation behind this seems less to be connected to environmental awareness

than the fact that local species can build on ecological memory adapted to their specific environment, deeming them a less complicated and more resilient crop to cultivate (Interview 5,6).

Some interviewees suggest the potential of clROF to provide local food security, enhancing self-sufficiency and readiness of coastal communities (Interview 2,8). This could hold high value in light of possible prospective food shortages, as a way to provide locally accessible high protein seafood. As the current focal activity of clROF is not centered around food production, there is potential and need for more efficient harvesting and monitoring techniques. Given that future development will be economically, socially and environmentally feasible, clROF could enable more democratic and equitable local food production and security.

Aspirations to develop business models around the practice of small-scale ROF are mentioned in most interviews (1,2,3,5,7) as a response to time and financial expenditure connected to permit processes, harvesting and monitoring activities. The livelihoods of people currently involved in clROF do not depend on the connected material outputs and resources, i.e. seaweed and mussels. However, the possibility of enhanced ocean stewardship and social cohesion through clROF emphasizes opportunities for developing feasible and ecologically sound business models. This showcases the potential trajectory of clROF and the ensuing necessity of acknowledging social vulnerabilities in the future development to prevent ROF businesses from becoming factors of enclosure and commodification of coastal and marine resources.

4.4.2. Empowering community action

The in chapter **4.1.** described drivers of people to get involved in or initiate clROF are in and of themselves factors empowering individual action that can in turn inspire community action. Reasons why people get involved with clROF can be seen as factors in sustaining their involvement. The following encompasses examples of action situations surrounding capacity building through information sharing (I2), harvesting (I1), grassroots/ self-organizing (I7), and deliberation processes (I3) that define shortcomings and potential of transformative output dimensions (O1,2) and social-ecological resilience of clROF.

As discussed in previous chapters knowledge sharing and capacity building provide societal benefits through enabling transformation. This will further be contextualized with examples of grassroot processes that shaped clROF or surrounding settings.

Specific points of reference and entry provide tangible and equitable opportunities for people to become active and informed members in clROF. These encompass a variety of support mechanisms such as the *Havhøst* network coordinator providing support on-site and over the

phone (Interview 5); the creation of a baseline handbook for ROFarmers in Sweden and Denmark (Interview 2); efforts into developing citizen science monitoring projects (Interview 2); and harvesting kits, providing spat collectors, mussel socks, and seasonal guides on mussel farming (Interview 5).

The motivation behind the harvesting kits was to provide people with the necessary tools to participate in and democratize local (blue) food production. While the financial burdens of such kits could be high for an individual person, they proved well-suited for novel clROF, the cost shared between prospective members or carried by *Havhøst*. By selling such low-barrier toolkits online, *Havhøst* sparked a grassroots tactic to put pressure on authorities, inspiring applications for around 200 small-scale ROF. Local administrative bodies could not cope with this high amount as they had to be evaluated in the same manner as large commercial aquaculture companies. As a response solution to this, Hobby Licenses were developed, allowing for quick and simple permit processes for small-scale clROF in Denmark. Such licenses were "a big step in (…) trying to make [small-scale regenerative ocean farms] accessible and democratize cultivation" (Interview 5), highlighting the potential power in collective and grassroots organization and need for adaptive governance.

In contrast to this, some interviewees stress the need for thorough and conservative authorities and permit processes in order to ensure the well-thought-out development of clROF and highlight the collective responsibility to consider ecological downfalls in blue development, however small-scale. (Interview 4,8). However, it is to be noted that structures and communication within and between different agencies seem to fall short in terms of transparency, clarity and organization (Interview 8). Higher levels of support on the side of authorities and regulation about which information is required at what stage of the permit process could result in more efficient and faster procedures (Interview 4). Interviewee 8 suggested that this could be a more deliberate and interactive process, stating that governmental policies should consult those who would be affected by prospective changes, in order to establish fair processes based in experience and reality (Interview 8).

Similarities in aspirations or objectives of the members of clROF center around building a network structure to facilitate sustainable growth of ROF (Interview 1,2,3,5,8). Network structures further foster self-organization capacities and could therefore empower the transformative development of communities within and around clROF. Several interviewees highlight possible benefits of creating a network of small-scale ROF, connect people and clROF through data and knowledge sharing (Interview 2), make clROF more diverse and accessible (Interview 1), to develop small "production units" in marinas, run by local communities or

fishers where harvest is a shared responsibility (Interview 3), and to bring back the "self-obvious proximity to the sea" (Interview 8).

5. Conclusion and Outlook

This degree project sought to explore the capacity of community-led regenerative ocean farming to contribute to equitable social-ecological resilience. Informed by previous research on low-trophic aquaculture and empirical data collected through qualitative interviews, the focus lay on social components of clROF. The SESF provided a well-suited heuristic to explore the interrelatedness between ecological wellbeing and equitable communities by focusing on the social-ecological circumstances needed to achieve transformative resilience potential of clROF.

The following promptly summarizes the exploration of the research questions. Findings suggest that social components needed in order for clROF to act as transformative SES include spaces of collaboration and support, efforts to ensure inclusive participation, shared responsibilities and benefits, and capacity building and grassroots activities connected to local social-ecological knowledge. Seeing these components as prerequisites for the potential of clROF to contribute to equitable social-ecological resilience, clROF could extent to enhanced ocean literacy and in turn environmental stewardship, revitalizing and reclaiming coastal landscapes in an equitable way through cohesion building and thus sustaining local social-ecological memory.

By and large, clROF potentially holds many benefits that could contribute to equitable social-ecological resilience. It enhances community cohesion and assigns meaning to places, harvesting activities and nature that can contribute to the conservation and creation of local social-ecological memory. Members of clROF have named the capacity building opportunities concerning ocean literacy and environmental stewardship as some of the most important learnings of clROF, including the practice of (primarily) trial-and-error-based development. Awareness of social-ecological interdependencies in ROF and general ecological knowledge among the ROFarmers are supported by networked structures between different actors in- and outside of clROF.

The low dependance on harvested crops for human sustenance highlights the versatility of clROF and the intricate human-nature interactions that go beyond provisioning.

Further, in clROF that do harvest for human consumption, the production for especially blue mussels increases provision of local seafood, thus providing dietary benefits and cultural services surrounding farming and preparation of food. However, monitoring for food safety is too cost intensive for small-scale clROF, posing some potential risks for human and environmental wellbeing.

Support structures such as COOL BLUE facilitators, services provided by KOASTAL, the network coordinator of *Havhøst* aiding questions on environmental factors as well as permit processes are equally beneficial in deciding on the design, placement and crop of a prospective ROF.
The potential of clROF acting as grassroots movements with low environmental downfalls is showcased by the bottom-up change through the collective pressure put on Danish policy makers inspired by *Havhøst*.

However, the relative predominance of highly educated, mostly male, retirees as members of clROF emphasizes the motivation of this degree project to showcase the need to address questions of differentiated resilience and access to clROF. Without prior social impact and status quo assessments, it cannot be ensured that clROF will be accessible to diverse communities and evenly distribute environmental, social and potential economic benefits. Management and governance systems should acknowledge this risk and include local knowledge systems to prevent unjust development, privatization or further exacerbation of disparities. clROF operates on a fine line between the potential to empower local communities through capacity and self-advocacy building and the risk to further enclose ocean spaces and common marine resources.
The concluding takeaway of these risks is, however, that access to ROF could potentially be equitable and just, if embedded in adequate social and environmental monitoring and support networks.
Without monitoring of environmental impact, ROF could in itself be a disruptive factor that impacts the local system through lost farming equipment polluting the water and dislodged mussels impacting benthic life.

A prototype of an equitable and environmentally sound clROF would be beneficial to inform future projects, with adaptive governance structures, regular evaluations and monitoring of social and environmental factors conducted by all relevant stakeholders. Levels of participation and self-organization could inform aspects of equitable access to clROF creating arenas for deliberation processes pertaining to sustaining common resources.
Additionally, the perceived difficulties of starting and enduring lengthy permit processes open the need for further research and focus in future clROF establishment while simultaneously offering high potential accessibility of clROF in terms of level of education and (physical) abilities. Perceived barriers or requirements for participation thus need to be addressed in order to transform levels of inclusion and diversity of members in clROF. Further clROF research would benefit from a stronger focus on gathering disaggregated data on subjectivities and motivations to inform more individual resilience building capacities. In order to foster equitable

resilience through and within clROF, all members of the surrounding communities need to be given opportunity and agency to participate.

To conclude, in order for clROF to be transformative in a way that is equitable and resilient and that goes beyond exclusive local communities, further development needs to happen in collaboration between actors and adapted to local needs and circumstances. We need to simultaneously ensure that equal and equitable access is guaranteed while making sure that environmental impacts are understood and monitored. In order for that to be possible, feasible monitoring procedures need to be developed as well as networks connecting actors and ROFarmers to work together and share the financial and time-burdens and risks. clROF should thus not to be seen as an all-encompassing solution, but rather as a potential contributing tool to equitable resilience.

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Appendix A

SESF 3rd tier variables

These 3rd tier-variables proposed by Vogt et al. (2015) facilitated the analysis to gain a deeper understanding of environmental components of clROF.

Figure A1

3rd tier variables (Vogt et al., 2015)

Resource systems (RS)
RS1 Sector (e.g., water, forests, pasture, fish)
RS2 Clarity of system boundaries
- RS2-a Ecologically defined boundaries of the resource system (e.g., watershed, ecological zone boundaries, etc.)
- RS2-b User-defined boundaries of a resource system
- RS2-c Contiguity of resource system to adjacent ecosystems of the same type (e.g., type and quality of matrix ecosystems)

RS3 Size of resource system
- RS3-a Extent of resource system in geographic area
- RS3-b Resource system shape or configuration (e.g., edge to interior ratio)
- RS3-c Fragmentation dynamics
- RS3-d Size of different habitat or ecosystem types within the resource system (mosaic features)

RS4 Human-constructed facilities
- RS4-a Facilitation of ecological movement (e.g., sewage outflows, species corridors)
- RS4-b Impediments to ecological movement (e.g., dams, fences, roads)

RS5 Productivity of system
- RS5-a Resource dynamics (e.g., water, light, nutrient availability)
- RS5-b Community/species composition

RS6 Equilibrium properties
- RS6-a Successional stage/trajectory
- RS6-b Existence of alternative stable states and thresholds between states
- RS6-c Frequency/timing of disturbance(s)
- RS6-d Extent of disturbance(s)
- RS6-e Magnitude/intensity of disturbance(s)

RS7 Predictability of system dynamic
- RS7-a Stochasticity/uncertainty of driving forces (e.g., disturbances, populations dynamics)
- RS7-b Probability of driving forces leading to a given outcome (or intermediate outcome)
- RS7-c Variability (range of) of driving forces
- RS7-d Time period that may be predicted

RS8 Storage characteristics
- RS8-a Nutrient source-sink dynamics
- RS8-b Spatial and temporal patterns in storage

RS9 Location
- RS9-a Connectivity of resource system to nearby ecosystems of similar and different types

RS10 Ecosystem history†
- RS10-a Relevant geologic history
- RS10-b Natural disaster history‡
- RS10-c Human use and disturbance history‡

(con'd)

Resource units (RU)
RU1 Resource unit mobility
- RU1-a Mobile resource units§
  - RU1-ai Outflows
  - RU1-aii Inflows
- RU2-aiii Patch dynamics
- RU2-b Stationary resource units§

RU2 Growth or replacement rate
- RU2-a Length of time to reproductive maturity|
- RU2-b Source-sink population dynamics (incl. migration patterns)|
- RU2-c Effective population size and reproductive rate

RU3 Interaction among resource units
- RU3-a Competition within species (intraspecific competition)|
- RU3-b Competition between species (interspecific competition)|
- RU3-c Predation (incl. herbivory, parasitism)
- RU3-d Mutualism|
- RU3-e Multilevel trophic interactions/cascades

RU4 Economic value
- RU4-a Subsistence value|
- RU4-b Absolute economic value|
- RU4-c Relative economic value|

RU5 Number of units
- RU5-a Population (and subpopulation) dynamics
- RU5-b Absolute size
- RU5-c Relative size (of the population or of individuals in the population)

RU6 Distinctive markings
- RU6-a Natural distinctive markings§
- RU6-b Artificial distinctive markings§

RU7 Spatial and temporal distribution
- RU7-a Spatial patchiness (heterogeneity of resource or habitat distribution over space)
- RU7-b Temporal patchiness (heterogeneity of resource or habitat distribution over time, i.e., phenology)

† A new attribute that we believe is a necessary addition to the framework in order to understand the ecology of an SES.
‡ Attributes where the frequency, magnitude/intensity, and extent of activity or disturbance should be considered.
§ Modified from Ostrom (2007*a*).
| Modified from Ostrom (2007*b*).

Appendix B

Interview Guide

The interview guide functioned as an aid to structure the main themes of the conducted semi- and unstructured interviews. This allowed for an open dialogue and adaptability while ensuring relevancy to the research aim.

Table B1

Guideline for semi- and unstructured interviews

Interview theme	***Motivation***	***Insights on (mainly): Factors of Equitable Resilience***	***Insights on: SESF***
About the project (clROF, ROF, other)	To gather information on (self-)organizational patterns, harvesting activities	Cross-Scale Interactions	A, I, GS, RU
About you	To gain a deeper understanding of perceived and lived benefits of clROF and create a baseline of knowledge about the transformative potential of clROF	Subjectivities & Drivers	A, GS, RU, (S & ECO)
Challenges & Recommendations	To gather information on deliberation processes, questions surrounding access to and dependency on the resources provided by clROF	Inclusion	A, I, RS & RU
Future Vision	SES research as action oriented and bridging gaps between policy and science: To gain an understanding of the aspirations of people involved, what do they want? How can this become reality? Should it?	Transformation	All, but mostly O
Other	To allow for flexibility within the interview process	All	All