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Area-based adaptive planning practice and ecosystem-based management.

A comparative analysis of cold-water coral ecosystems in Norway and Chile.

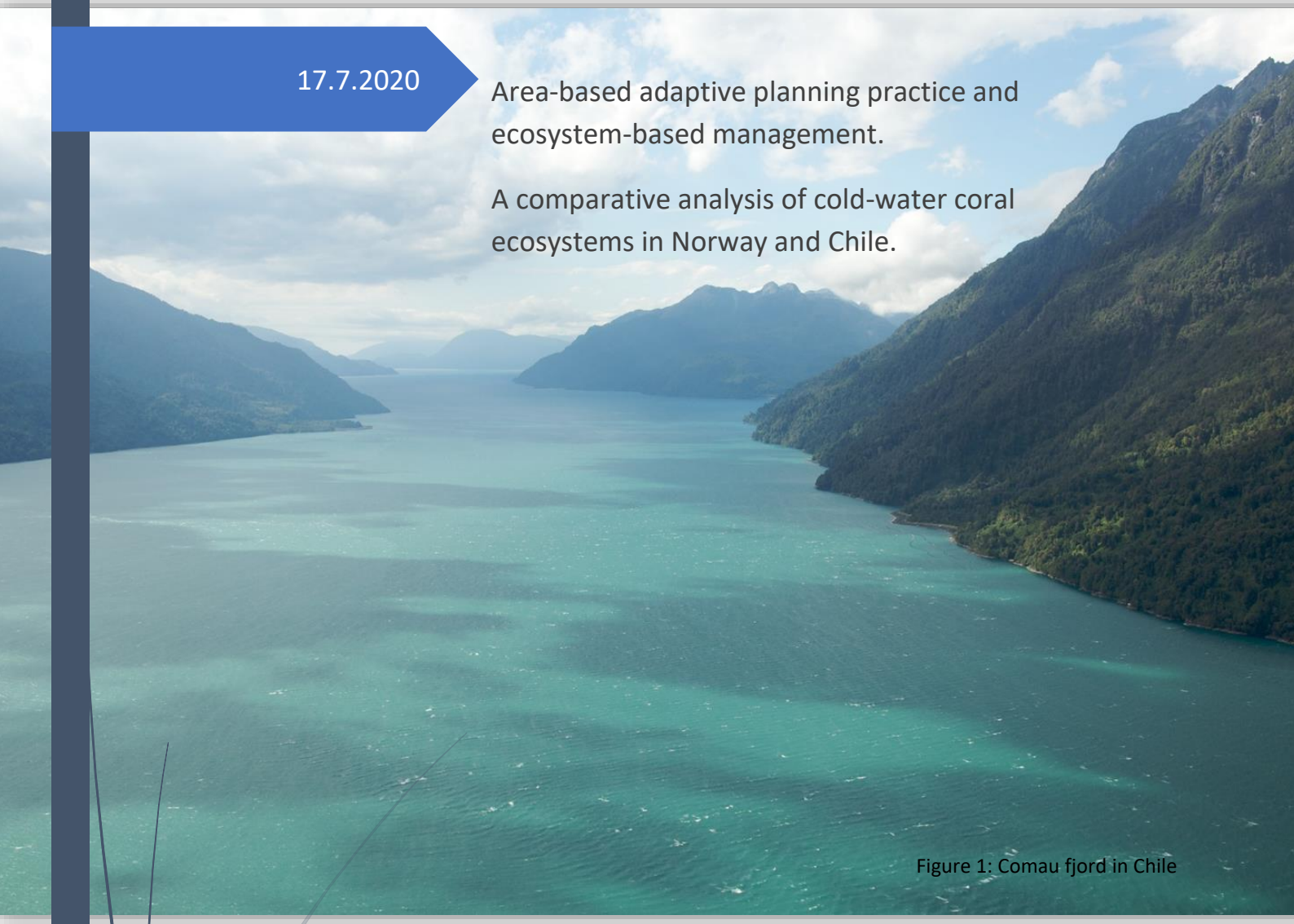

Figure 1: Comau fjord in Chile

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CWC: Cold-water coral

MEBM: Marine ecosystem-based management

CAS*:* Complex adaptive system

1. Introduction

Cold-water coral ecosystems are not very popular, nor very well researched and especially not in the focus of the spatial planning discipline. So far research is in its infancy and much information is still lacking on the importance of cold-water coral (CWC) ecosystems and their role in the marine environment. This thesis will introduce cold-water coral ecosystems as complex adaptive systems (CASs), which are in interdependency with many other CASs and are therefore part of an open system, which needs adaptive planning and ecosystem-based management in order to balance ecological and socio-economic interests.

It is known that areas around the CWCs are stocked with more and bigger fish and that they are therefore beneficial for the economy of a country (Armstrong et al. 2014). But they are also important for biodiversity and have a high ecological value that is threatened by managed, purposeful human interactions in form of fishing, aqua- and agriculture, mining and drilling as well as unmanaged pressure in form of climate change. The goal of this thesis is to shed light on the importance of CWC ecosystems and to help to improve existing planning and management strategies for them in order to create a balance between the exploitation and the protection of the ecosystems. Furthermore, pointers for a possible policy transfer from Norway to Chile are given on which further research could elaborate.

The underlying research question of this work is `*How can adaptive area-based planning and management be implemented in marine ecosystem-based projects for cold-water coral systems in fjords in Norway and Chile in order to create a balance between socio-economic use and environmental protection?´* In order to answer the question, two CWC ecosystems in fjords are compared. The case of the Lophelia pertusa ecosystems in the Norwegian Trondheim fjord and the Desmophyllum dianthus ecosystems in the Comau fjord. The starting point will be planning theory, which will be narrowed down to area based adaptive planning and marine ecosystem-based management. Afterwards, a qualitative case study research will be carried out, relying on a variety on data, such as expert interviews and research data and policy frameworks.

The gathered data will then be analyzed by using four criteria for successful adaptive planning and marine ecosystem-based management, established by Wondolleck and Yaffee (2017): *context matters, linkage matters, people matter and science matters* (Wondolleck and Yaffee 2017c). In order to answer the research question, the cases will be analysed solitary and then in comparison by using a rating system created on the four criteria for successful adaptive planning and MEBM and the qualitative data gathered throughout this work.

The results will show that the Norwegian area-based planning of the Trondheim fjord does include protected areas and zoning plans. The adaptive planning practice does also include restrictions for fisheries and areas in which specific fishing gears are banned due to accumulations of cold-water corals. In Norway there is a high overall awareness of the

importance of the cold-water coral ecosystems. The main threat to the cold-water corals are fisheries and nutrient leaking from aqua- and agriculture into the Trondheim fjord. Mining and climate change can be considered less important in the area. Norwegian marine ecosystem-based management does rely on inclusion of a variety of stakeholders, intensive scientific research and education of the public. Nevertheless, it is lacking evaluation strategies and some cross-sectoral considerations in its strategies (Järnegren and Kutti 2014). In Chile the situation is worse due to very little funding and less advanced research technologies. The main threat is again fishing but also aqua- and agriculture, especially salmon farming, are harmful to the cold-water coral ecosystems. Mining does also play a role in the Comau fjord. The area-based planning does focus on installing protected areas, but Chile fails to apply marine ecosystem-based management to ensure quality of the protection. Little stakeholder involvement, little collaboration and a centralized governance are issues, that stand in the way of successful planning and management practices in the Comau fjord. These results will be brought to light in a detailed analysis of the two cases.

Finally, the thesis will respond the benefits and shortcomings of the two cases, by offering a 6-step strategy for area-based adaptive planning and marine ecosystem-based management, that can help to integrate ecosystem-based approaches into the realm of cold-water coral ecosystems in fjords and lead to a better balance of use and protection of the ecosystems. As a concluding remark, the results will hint at the possibility to use policy transfer and cross-border learning and inspiration in order to improve the planning and management strategies in Chile.

1.2 Key concepts

This research will start off by introducing planning theory and will lead to complex adaptive systems and the way of planning that works best for the CWCs: The area-based adaptive planning practice. The adaptive planning practice is useful for determining areas, that are best suited for becoming marine protection areas, by having a look at a variety of characteristics and facets. In this first stage actual planning practice is needed. Marine protected areas must be conditioned, not only due to a need for conservation, but also by focusing on social, political, economic and institutional factors to ensure a balance between socio-economic interests and environmental protection (Morato et al. 2019). A successful implementation of marine protected areas does also rely on stakeholder involvement in the planning process and evaluation and monitoring throughout the implementation process and beyond (Vásquez-Lavín et al. 2013).

After this first stage with a high spatial planning focus, a second phase, relying on marine ecosystem-based management (MEBM), is needed. The interaction between fjord systems and human users is determined by physical, biological, chemical and spatial and socio-economic complexities, which make the integration of a proper management plan indispensable. The MEBM approach is closely related to the area-based adaptive planning but

focuses on the maintenance and ecological management of a once planned protected marine area. The two stages are closely interwoven and must be constantly adapted to each other.

The next chapter will start the journey through planning theory, in order to give a thorough introduction of adaptive area-based planning practice and MEBM.

2. Theory

This second chapter will guide a tour from the old-fashioned approach of technical rationality, over the first ideas of communicative rationality to the more complex approaches. It is crucial to understand the main different viewpoints and perspectives in planning theory in order to fully grasp the idea of area-based adaptive planning practice and marine ecosystem-based management underlying this work. The most important result of this theoretical introduction will be the recognition that a *differentiated world view* is crucial for a successful adaptive planning practice and the core of what planning practice gains from planning theory (De Roo, 2016). This chapter will also lead to the four categories of successful area-based adaptive planning and marine ecosystem-based management (MEBM) that will be the basis of the data analysis*: context matters, linkage matters, people matter and science matters.*

2.1 Two sides of a coin: one-sided planning practices

This first subchapter introduces two early on planning practices, namely the technical rationality and the communicative rationality. Both differ a lot in terms of their worldview and their practice; furthermore, both are still important for today's planning practice and build the foundation for more recent approaches in the field. The following sections will give a short overview of both and end up bridging the two concepts before moving on to the more recent developments and theories. This introduction into the fundamental planning concepts will help to understand the more complex approaches, which are the basis of the considerations that are taken in the field of cold-water coral (CWC) ecosystems later on.

2.1.1 Technical rationality: The facts

Causal relationships, functionality, facts and a fully comprehensive world are fundamental characteristics of the technical rationality. Technical rationality was most popular from the fifties until the seventies. It is built on the concept of realism (De Roo, 2016). The underlying idea of planning is therefore very functional, standardized and straight-forward and aiming for control. In the technical rational line of thinking uncertainties are meant to be wiped out, which can only be solved by relying on facts and the argumentation is simply object-oriented (De Roo 2016). Since this approach focuses on factual realities it is meant for situations that are foreseeable and straight-forward. The technical rationality works to fulfil human desires in cities but also in the landscape. Polders, deforestation and the design of rivers are some examples of technical planning in the countryside. For a long time, this approach was very well established and the way to create a desired design and functionality of the urban sphere (De Roo 2015). Blue-print planning and standardization were considered the best form of planning and a simple command-and-control mentality was used in order to shape the cities (De Roo 2015). Especially after the world wars there was a need to rebuild the rapidly growing cities. In order to do so planners relied on the technical rationality and aimed to build a perfectly

structured environment on the grounds of functionality (De Roo 2015). The motivation behind this reasoning might just have been the search for peace and order in the daily lives after war.

Nevertheless, change occurred and at the end of the seventies the opinion about technical rationality changed rapidly. Critics argued, that this way of planning would be too simplistic and without any deeper consideration of circumstances (De Roo 2016). Somehow, the developed plans did not always lead to the desired future and the outcomes did not occur as they had been predicted. It seemed that the technical rationality was something planners could no longer put their trust in under all circumstances (De Roo 2015). Consequently, several new approaches, among them the one of a communicative rationality gained popularity.

2.1.2 Communicative rationality: The stories

Communicative rationality is another one-sided approach, that focuses on communication and stakeholder involvement. Communicative planning, consensus building, and collaborative planning are some of the planning approaches related to the communicative rational (Skrimizea et al. 2019). The change away from the technical rationality towards the communicative rationality is called the communicative turn in planning (Skrimizea et al. 2019).

Communicative planning is based in the concept of relativism, acknowledging that there is another reality behind facts and data that relies on people, their feelings and ideas and the experiences they have with a certain issue. Social values, behaviour and cultural differences became important footings of this planning practice. The communicative approach is in several ways the direct opposite of the technical rational. The technical rational is fact and object based, whereas the communicative practice relies on consensus and intersubjective interactions and storytelling (De Roo 2016). The communicative rationality acknowledges – other than the technical rationality – the existence of complexity and recognizes uncertainty, in particular regarding the stakeholders. The stakeholders as humans are erratic thinking and acting beings, in the sense that they have personal wishes, doubts, ideas and needs that cannot be discovered by facts and logic but only through communication with them (Skrimizea et al. 2019). Control and fact orientation are therefore not always useful tools in order to understand human interactions and interests.

But the communicative rationality can also not be considered a flawless approach, since it can lead to situations, where content is simply overlooked by the participating stakeholders (De Roo 2015). In the communicative trajectories much attention goes to the decision-making process, which can lead to cases where each stakeholder likes the outcome of the debate whereupon the debate seems successful, even though not all initial problems might have been solved. Another downside of the communicative rationality is the one of power imbalances. The consensus building and debate can only work properly if every participant has the same power. This might be the case in an ideal world but in the real world there are always imbalances. Money, prestige and other means can easily make one party superior to others (De Roo 2015).

Nevertheless, the two approaches technical rationality and communicative rationality frame the contemporary planning world. They are two very contradictory approaches to planning and help us to sort all the other approaches regarding the dimension of object orientation and inter-subjectivity. Figure 2 visualizes the relationship of the technical rationality and the communicative rationality and shows, that they differ severely in the way they deal with uncertainty and rationality (De Roo 2016). The technical rationality is useful for situations that are certain and the communicative rationality is beneficial for more complex situations. Taken together, the two approaches form the *holy spectrum*, which demonstrates the shift from an object-oriented perspective like area-based planning, towards an intersubjective perspective as situations grow more complex (De Roo 2016). (Roo 2016)Both approaches do matter and allow for differentiation in the planning realm.

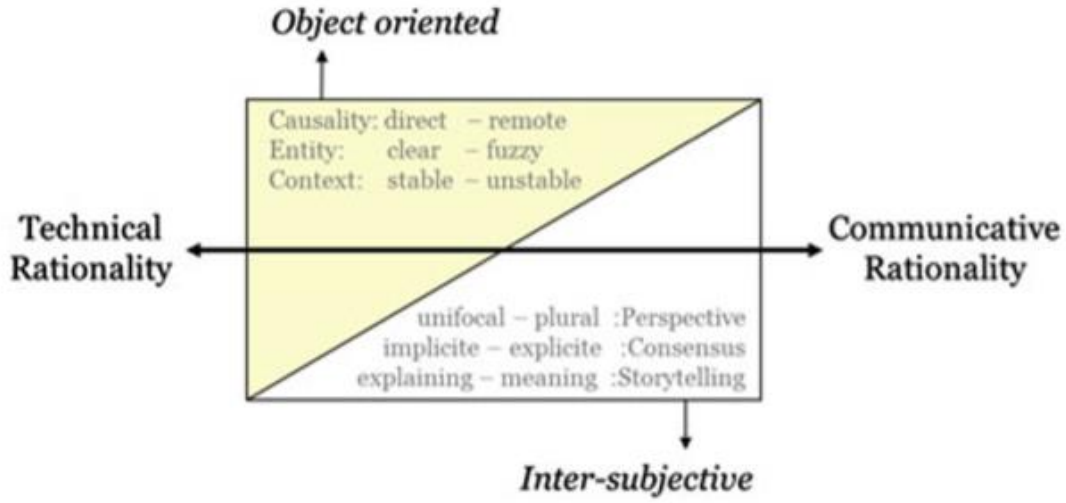

Figure 2: Holy spectrum in planning theory (De Roo 2016)

Both approaches can be considered too one-sided, but they are still not outdated. They are just useful for specific situations and not valid without restrictions (De Roo 2016). Most - but not all - of the planning situations lie somewhere between the two extreme approaches and include both partly. Therefore, it is necessary to lose the idea of a simple duality between technical rationality and communicative rationality in planning and consider a more differentiated view (De Roo 2016). There are several approaches and planning considerations for several very different situations. It can no longer be assumed that one approach can fit all planning problems (De Roo 2015).

Knowing this, we can have a look at one specific type of realm: The complex adaptive systems. Planners are recently confronted with these systems that are neither managed properly by technical nor by communicative rationality due to their complex non-linear nature. These systems gain more importance due to fast technical progress, an interconnected world and fast changes in the living environments of people. Time is the crucial new aspect, that needs to be considered in the context of the planning world. Adding the dimension of time to

technical rationality or communicative rationality results in non-linear development, which leads to systems that adapt between complexity and order. Time and the resulting chaos that comes with it are of the essence in order to cope with complex adaptive systems. In the scope of this work we will focus on the cold-water coral ecosystems, which will be shown to be complex adaptive systems, that are in interconnection with other CASs and can be considered as part of an open system. This work will focus on adequate planning and management strategies for the open system, in which the CWCs can be found, but first the concept of complex adaptive systems needs to be fully understood. The following chapter will introduce the complex adaptive systems. It will be shown how to deal with an increasing amount of uncertainty and fuzziness in the highly complex realm of the planning field.

2.2. Complex adaptive systems

As already mentioned, increasing complexity and unpredictability of the world are reality. Simple linear problems are rare in our international and interconnected world (Skrimizea et al. 2019). The interdependency and intertwined relationships of social actors, networks and organizations make logical predictions in terms of development and spatial needs less and less likely and therefore arises a need to deal with organized complexity and unknown unknowns (Sengupta et al. 2016). Technological innovations and climate change are some of the drivers of the heightened complexity we face (Rauws 2017). Complex systems have first been researched in natural sciences but also gained importance in other fields recently. In the late 1990s the social science started to focus on the idea of complexity and started research on the topic (Skrimizea et al. 2019). In the planning field, the idea of complexity science is characterised by research of concepts of non-linearity in the ongoing planning practice (Skrimizea et al. 2019).

A hallmark of complexity is the permanent possibility of different futures that could become reality. More knowledge is not the key to foresee these possible futures. The core of complexity is to accept that there is and always will be a certain uncertainty (Skrimizea et al. 2019). Complex systems change and we are not able to predict the details of the changes that are to come or into what directions these systems develop.

The complex systems we are looking at can also be considered adaptive: They are out of equilibrium, seeking for balance, which will despite their robust side never be reached, as their dynamic side is sensitive to outside change, through which the whole system will adjust to new contextual situations, which allows it to survive: They are complex adaptive systems (CASs) (Skrimizea et al. 2019).

The most famous example of a CAS is the city. Cities are important living spaces for many humans and have great economic importance. When having a look at CAS the dimensions of space and time are considered most important (Skrimizea et al. 2019).

In the length of this work it will be argued that CWC ecosystems in fjords, are also complex adaptive systems, that are in interdependence with many other factors and an outer environment that can also be considered a CAS. The areas in which the CWCs can be found

should therefore be considered open systems, that are subject to planning and management strategies that incorporate the characteristics of CASs in order to gain a balance between use and protection of the CWC ecosystems.

In conclusion space, time and additionally the human factor are important for the further analysis. Therefore, we will need to have a look on how managed (fisheries, aqua- and agriculture, drilling and mining) and unmanaged (climate change) pressures shape the possible futures and developments in the open systems of CWC ecosystems in fjords (Skrimizea et al. 2019).

This chapter will now have a closer look at the complex adaptive systems and give some insight into their main features and characteristics and connect these characteristics to the CWC ecosystems as CASs.

2.2.1 Robustness and flexibility

First, we will have a look at two main characteristics of CASs `*flexibility and robustness´*.
The first characteristic of complex systems is the one of robustness. Robustness applies to CASs in two ways: On the one hand complex systems stay the same for long periods of time, without being changed to the core, they persist as a system while transforming along the way. Skrimizea et al. (2019) characterise a city also as a `*territorial entity with its own history and specific characteristics that could remain generally unchanged for quite a long time (p.125)* `. On the other hand, in the cases in which they change they do so in form of a metamorphosis or as Byrne (2013) called it, they change `*while retaining systemic integrity*` (p. 174) (Byrne 2003). The robustness refers to an open system, which is open in relation to its surrounding systems and realms, that can adapt to intrusion and external change brought on itself by or through these surrounding systems.
Flexibility is another main characteristic for CASs and refers to the change of the system. Often the system change occurs in a very non-linear, sudden way through something that can be called a tipping point or threshold behaviour (Duit, Andreas: Galaz, Victor 2008). The changes that are then triggered, are hard to foresee and change the existing system in small or big ways. This is due to being adaptable to those new circumstances and can therefore be considered flexible (Duit and Galaz 2008). The change of a CAS does normally refer to the form or structure of the system; the internal set of interrelated terms, the content or function, on the other hand will remain the same. Therefore, flexibility *and* robustness are the two main characteristics of CASs (Yamu et al. 2016).
CWC ecosystems as CASs are very robust over a long time, due to their very slow growth rate and their longevity. On the other hand, they can be very flexible as the specific sub-populations of Lophelia pertusa and Desmophyllum dianthus and their adaptation to climate change and ocean acidification will show later (Magris et al. 2017). Their interdependence with other systems makes the area an open system, with a the CWCs as CASs in its core that fulfil the characteristics of robustness and flexibility.

2.2.2 Agents

CASs do consist out of agents, which can be a variety of instances like cells, social actors or even nations. These agents act and behave according to a specific pattern that is intrinsic to them (Duit and Galaz 2008). For cold-water coral ecosystems as a CAS, the agents are of course mainly the cold-water corals – in the case of this work Lophelia pertusa and Desmophyllum dianthus - but they do interfere with other systems and socio-economic interest by influencing the size and number of fish stocks in the area. As a consequence, also the humans that interfere with the ecosystems and of course the species that live on and in relation with those ecosystems are agents that need to be considered when having a look at the open system and the balance between use and protection of the CWC ecosystems (Magris et al. 2017).

2.2.3 Self-organization

Self-organization is one important trait of CASs and refers to different actions and correlations that change the system from within. The actions and reactions in the system are fuzzy, multi-layered and hard or even impossible to foresee and predict. It is only certain that there is a process of self-organisation present, at each moment the CAS is dynamic and not in an equilibrium (Skrimizea et al. 2019). The self-organisation is the mechanism of the system seeking intern adjustment to external influences to find another good fit with its changed environment. It is furthermore not something that can be controlled, since it occurs spontaneously. It gains most importance in times of symmetry breaks, the system is confronted with, which result in conditional or structural changes in the CAS (De Roo and Boelens 2016). In case of these breaks a spontaneous, transformative change can occur that leads to unforeseen, self-organized outcomes.

The open systems this work focuses on, include more than only the CASs of CWC ecosystems. The cold-water coral ecosystems face intrusive activities steered by human interests and threats related to climate change, to which it must adapt, if possible. Consequently, the rapidly changing environment and external and internal pressure on the ecosystems lead to changes from within in the system, that are unprompted and unforeseen even by scientists (Försterra et al. 2005). This means that, when planning and managing the CASs, there needs to be room for adaptivity of the management practice and a consideration of possible sudden changes. The human responsibility lies in not pushing the cold-water ecosystems outside their robust and flexible, equilibrium seeking trajectory in order to allow for self-organisation of the system.

2.2.4 Co-evolution

Another trait of CASs is the co-evolution, which refers to the interaction between the CASs and other systems within or without the system (Skrimizea et al. 2019). The CAS is also dependent on other systems in the sense that they shape and form each other throughout time (Skrimizea et al. 2019). Path-dependency is a crucial aspect of this co-evolution, since the institutions and planning decisions from the past, as well as the deeper context of the CAS interfere with the development yet to come (Alma 2019). As for the issue of self-organization,

non-linear development or a shifting system behaviour with limited predictability is also closely related to the issues of co-evolution (Duit and Galaz 2008). It means that it is difficult to achieve knowledge about the development of a CAS, since it is uncertain in which direction it will evolve and change in dependency with other systems (Skrimizea et al. 2019). For the open systems, including the CASs of the CWCs this is especially important, since socio-economic interests are rapidly growing, and climate change does interfere with the systems as well. On the other hand, it is obvious, that there are boundaries of the potential co-evolution of CWCs. They can only handle a certain amount of change as a CASs. When pushed too hard, the corals might die out and not be able to co-evolve further. The planners and managers of the open systems and the CASs in them are again responsible to ensure conditions that allow for co-evolution of the CWCs.

2.3 Adaptive Rationality: The new path

After having introduced the CASs and their main features this paper argues that the CASs do neither belong into the technical rationality nor into the communicative rationality and rather into a new category: the adaptive rationality (Skrimizea et al. 2019). This adaptive rationality came to live through something that can be referred to as the `*complexity turn*` (Skrimizea et al., 2019, p. 124). The technical rationality is referring to closed, linear systems with high certainty and an object-oriented focus, that rely on facts and statistical data (De Roo and Porter 2007). The communicative rationality is referring to very complex and unstructured systems that are characterized by uncertainty and an inter-subjective focus that rely on communication (De Roo and Porter 2007). The CASs do not belong to one of these categories, instead they are somewhere in between both. They do rely on the technical rational in planning and managements, as well as the communicative rational. CASs do own parts, that are best defined by uncertainty and parts that are steered by certain social patterns and foreseeable interests. Planners and managers focusing on these systems should therefore rely on an adaptive rationality (Skrimizea et al. 2019).

But what does all this insight into complex adaptive systems and an adaptive rationality imply for the planners and responsible parties that manage these CAS more precisely? That question is now to be answered in the following chapter.

2.4 Adaptive Planning

The adaptive planning practice sees its main goal in navigating the planned system in an evolutionary process through the support of desired consequences and the avoidance of undesirable ones. Adaptive rationality can be considered the frame of reference for the adaptive planning approach.

There are some main features of the adaptive planning and management that are characteristic: First, the introduction of an adaptive rationality states the need to accept the uncertainty that comes along with CASs. Not being able to fully foresee and understand the system that needs to be planned and managed is a core challenge for the adaptive planning

practice (Skrimizea et al. 2019). This means that there cannot be a single fixed plan and management strategy but there needs to be a concept that explains how the system can adapt to change. Consequently, the planning strategy must not try to reduce all uncertainties, but instead generate and apply new adaptive planning strategies, which can co-evolve with the processes happening in the CAS (Haasnoot et al. 2013). For the CWCs and their CAS the planning strategy must focus on ensuring that the ecosystem stays alive and that it is not pushed out of its robustness-flexibility trajectory. The planning strategy must resonate well with the given system and react and act with it and its changes and set limits to outside developments to prevent that the CAS is pushed too far out of equilibrium (De Roo 2007). Therefore, the goal of the planning process can no longer be to achieve a fixed goal but to improve the planning process throughout the foreseen and unforeseen changes and the transforming needs in a flexible and robust manner at the same time (Rauws 2017). In the end it is better to leave some decisions open to change than having a fixed plan that won't work in an uncertain CAS.

Connected to this, the role of the planner is again changing. In the technical rationality perspective, the planner is fact-driven and an expert that pursues linear solutions to a certain planning issue. In the communicative rationality perspective, the planner's role is mostly to be a mediator that helps different stakeholders to reach consensus throughout a debate. But in the adaptive rationality perspective this role changes again and the planner becomes someone, who is capable of navigating uncertainties in order to plan and manage the upcoming changes (Skrimizea et al. 2019). The planners are now slipping into the roles of `*trend-setters, matchmakers, and facilitators alongside their more traditional roles as experts or mediators*` (Rauws, 2017, p. 42), that are supposed to offer proposals for further development, link projects with spatial conditions and needs, and encourage innovation in the planning sector by having an eye for trends and developments that might signal upcoming change (Rauws 2017). In the context of ecosystem planning this leads to planners that come up with nature-friendly solutions that can allow for future uses and protection of the ecosystem.

All that can also be part of the concept of development of dynamic adaptive policy pathways designed by Haasnoot et al. (2013). The approach is built on the two concepts of adaptive policymaking and adaptation pathways and leads to an integrated multi-level and multi-perspective approach and entails all three before mentioned characteristics that are needed for planning and managing CASs (Haasnoot et al. 2013). Figure 3 shows the approach in a visual representation. The process starts with a description of the current uncertainties and a characterization of the situation that needs to be planned or managed. The approach then follows a circle of ten steps and ends with the implementation of a new plan and its evaluation (Haasnoot et al. 2013). This integrated approach is a very suiting way of action to support decision making in planning and management in CASs. The CAS can evolve along various routes and planners of the CWC ecosystems must take this into account in their planning approaches. The concept of Haasnoot is a first theoretical framework for the planning practice of CASs, which will later be elaborated and adapted to the marine ecosystems in particular.

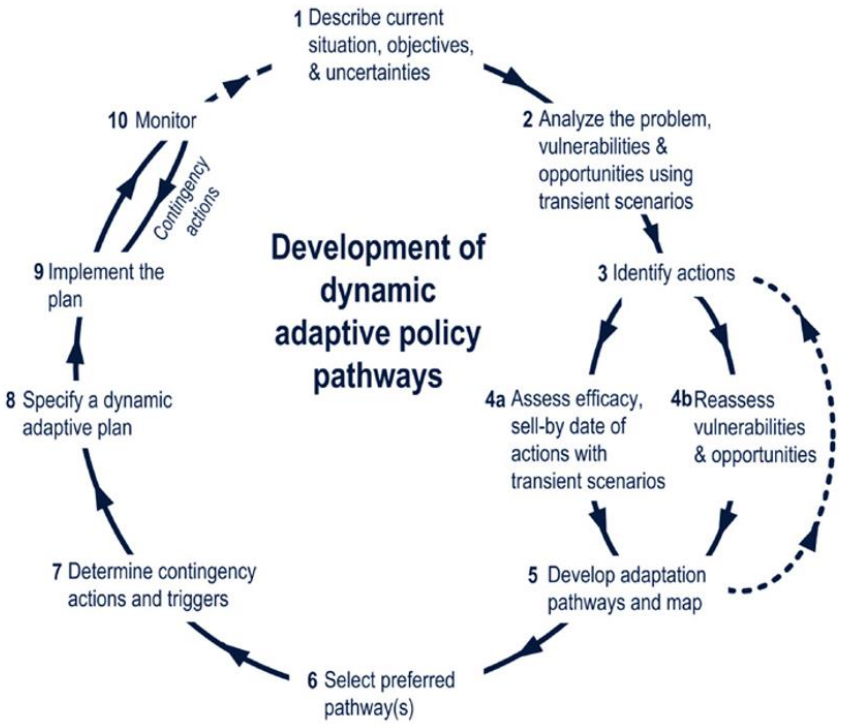

Figure 3: Dynamic adaptive policy pathways (Haasnoot et al. 2013)

In the line of this work we are looking at open systems that contain the CASs of CWCs and their correlating environment. The planning approach that needs to be used is the one of area-based adaptive planning. But we need to narrow the theoretical focus down even further. So far, we have had a look at the holy spectrum with the technical rationality and the communicative rationality. We elaborated that approach further and introduced complex adaptive systems and argued for adaptive rationality, because of a complexity turn. Furthermore, we showed how planning practice can be designed in the environment of complex adaptive systems. The next step is now to introduce a form of management for the open systems, that does focus on the ecosystem and operates as sustainable as possible. The next chapter will therefore focus on the marine ecosystem-based management (MEBM).

2.5 Ecosystem-based management

The chapters before this work introduced CWS ecosystems as CASs, imbedded in an open environment. The open systems, that contain the CASs of CWC ecosystems are best planned and managed in two steps: Step one is the area-based adaptive planning part, which refers to the declaration of protected areas through the evaluation of area-based particularities, which can rely on biochemical and physical aspects of the marine space in question. Step two is then more about the management and conditioning of the cold-water coral ecosystems that have been declared protected. This can be done by incorporating marine ecosystem-based management strategies and approaches in order to target their specific protection needs

(Lister 2008). This chapter will introduce the concept of biodiversity, which can be considered a main goal of ecosystem-based approaches, before it will have a closer look at the core ideas of MEBM.

2.5.1 Biodiversity

Biodiversity is often used in a very broad sense, while talking about species or a genetic diversity in an ecosystem. It entails two components: Richness, that refers to a quantity, an amount of species as an example and equitability, which refers to the quality by describing the balance of something, as an example one can again think of species (Lister 2008). In general, there are three very different perceptions of biodiversity that need to be separated. The first perspective focuses on the form, the ecological structure. The second perspective focuses on the function, the ecological processes and the third perspective focuses on the resources and is therefore value-oriented (Lister 2008). As a result of these different viewpoints on the concept there is no single way to measure or determine biodiversity. Nevertheless, one two key challenges of ecosystem-based management seem to be biodiversity conservation and ecosystem services. The protection of biodiversity includes a scientific but also a sociocultural dimension (Lister 2008). A big issue is often the conflict that results from different understandings and values of biodiversity between different stakeholders (Lawton and Rudd 2014). Especially a simplistic sector-based decision making can have severe impact on the ecosystem in question(Lister 2008). Some stakeholders do only care about economic gain, others focus on the environmental protection. In order to create resilient ecosystems that can ensure biodiversity and a balance between use and protection, it is therefore necessary to in include different stakeholders and sectors in an integrated, transparent and participatory process of establishing a fitting management approach (Wondolleck and Yaffee 2017b).

2.5.2 Marine ecosystem-based management

A few decades ago, decision-making concerning ecosystems was still very much dominated by a control-oriented system of decision making and planning. But as much as it is might be a good solution to consider a complexity turn in the sphere of urban planning, it is also beneficial for the planning of ecosystems (Lister 2008). Ecosystems need to be `planned´ in a flexible, adaptive and participatory manner with concerns about human interventions and exploitation (Lister 2008).

Marine ecosystem-based management is a holistic approach, that considers the structure and processes in an ecosystem and includes the human factor in that process. Due to an increasing human population, technological changes and innovations as well as climate change we observe a loss of biodiversity and a destruction of many ecosystems. Marine ecosystem-based management tries to face these issues by implementing management approaches that can help to sustain the environment in a good status and help to rebuild it where necessary

(Wondolleck and Yaffee 2017a). The definition of MEBM by the Communication Partnership for Science and the Sea (COMPASS) from 2005 creates a solid understanding of what MEBM is. Experts agreed that *`ecosystem-based management is an integrated approach to management that considers the entire ecosystem, including humans. The goal of ecosystem-based management is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. Ecosystem-based management differs from current approaches that usually focus on a single species, sector, activity or concern; it considers the cumulative impacts of different sectors´* (Wondolleck and Yafeee, 2017a, p. 4).

Following this definition, it becomes clear, that the relationship between human needs and the status of the ecosystem is a key feature of MEBM. It does include all kinds of interrelations in the ecosystem: between human and a species, between species A and species B and some much more complex interdependencies along the food web (Steneck et al. 2018). Additionally, it is strongly contextual oriented, with a notion about human influence.

Marine ecosystems are especially challenging ecosystems, since they are not only very complex but also not sufficiently researched. The scientific data is often incomplete, there are many economic interests and values at stake and conflicts are unavoidable (Lawton and Rudd 2014). MEBM does often relate to issues like fisheries and rapid declines in stock numbers, coral destructions, poor water quality or too less quantity and integrates these issues in a broader context (Wondolleck and Yaffee 2017a). In order to really understand the scope of MEBM, we will focus on the main characteristics of MEBM in the following.

1) This paper dealt already a lot with **complexity** and CASs. It is important to acknowledge that marine ecosystems are also complex adaptive systems that need to be planned and managed as such (Wondolleck and Yaffee 2017a).
2) The **scale** of MEBM is different from usual political boundaries and scales, since it focuses on ecologically relevant scales and areas (Wondolleck and Yaffee 2017a). This does already call for a lot of collaboration between different parties.
3) The issue of **balance** is also something that is in the core of MEBM. There is always a need to balance the use and exploitation of the ecosystem and its protection and maintenance (Wondolleck and Yaffee 2017a). As mentioned before there are many stakeholders interested and involved when it comes to marine resources and water bodies. Therefore, a fair balance needs to be kept in order to meet all needs. The balance between use and exploitation does also depend on the resilience of the ecosystems in question. Management practices need to adapt the use to the resilience of the marine ecosystem in order to not destroy it completely.
4) The characteristics of scale and issues lead to another important characteristics: the one of **collaboration** (Wood). Collaboration is needed to manage CAS and especially marine ecosystems, since they go across borders and one single jurisdiction and authority (Wondolleck and Yaffee 2017a).

The characteristics set the frame in which MEBM operates, but there are some very different types of MEBM around the world. Some are top-down, some are bottom-up approaches; some are large-scale and across countries and some are regional and on a national level (Wondolleck and Yaffee 2017a). Section 2.6 will combine the area-based adaptive planning practice and the MEBM and bring together the previous theoretical ideas before this thesis continues with the methodology chapter.

2.6 Adaptive Planning and marine ecosystem-based management

We introduced marine ecosystems as CASs, which is to be understood as a system that is embedded into a broader open system. This observation is the foundation for policy based on a combination of adaptive planning practice and MEBM for the CWC ecosystems.

Now we need to remember that various forms of adaptive planning exist. For the adaptive planning for CWC ecosystems we will focus on a conscious form of adaptive planning that is grounded in an explicit and proactive mindset within an ecological context (Lister 2008). This is pretty much the same approach as mentioned before by Haasnoot. But, since it is very common that climate change literature focuses on a passive adaptive form of management, it is necessary to mention this differentiation explicitly (Lister 2008). In the passive adaptive form of an adaptive management approach, humans are not a part of the system. The ecosystems are something that exits on their own in many climate change related studies (Lister 2008). But in our chosen approach – based in planning theory - they are again part of the open system in question.

Keeping that in mind the biggest difference to the mentioned adaptive planning practice is the deep the connection with the marine ecosystem-based management (Lister 2008). Other than in cities, ecosystems need special protection, since they are not just a space for humans but also for a variety of other species. Figure 4 shows an adaptive planning process especially for an ecosystem-based approach. As it can be seen the ecosystem-based approach does also focus on the same steps as the dynamic, adaptive policy pathway from before and includes the (marine) ecosystem-based management plans (Haasnoot et al. 2013).

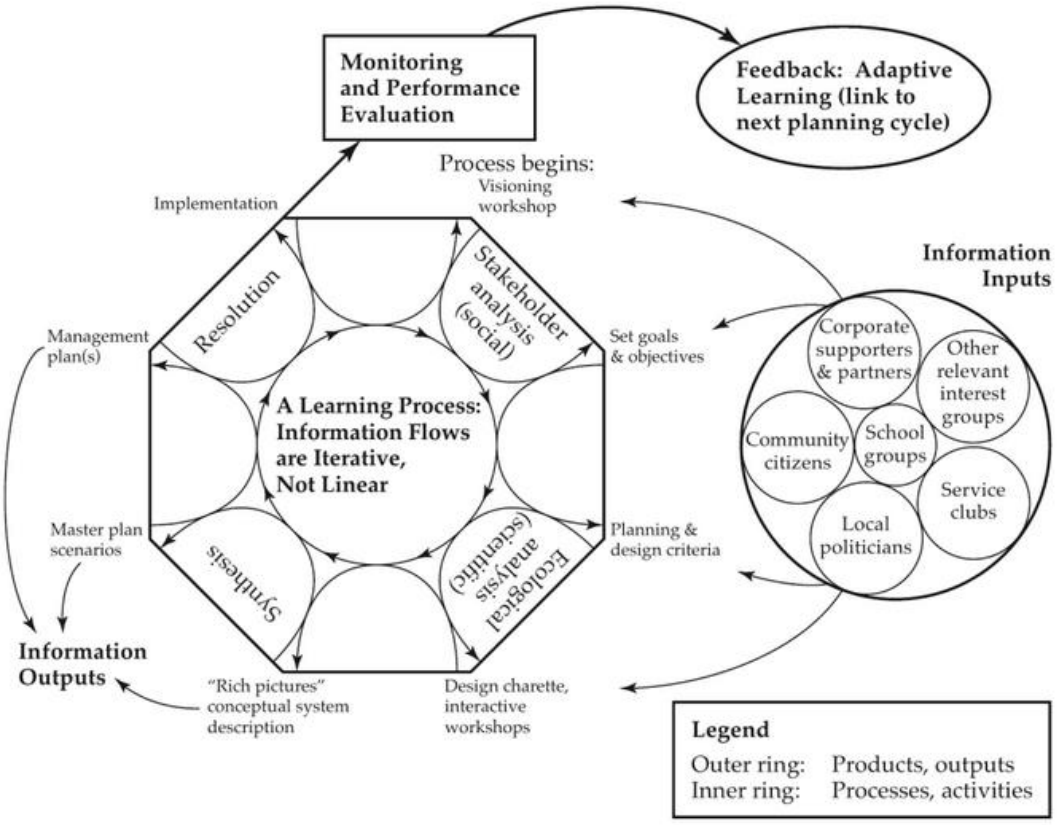

Figure 4: Adaptive planning and MEBM (Lister 2008)

In order to understand the area-based adaptive planning practice and the MEBM better it is useful to think of bricks and mortar. The structures, that frame the planning situation are the bricks and the stakeholders, that are involved in the planning process are the mortar. This image illustrates nicely how the adaptive approach works in practice (Wondolleck and Yaffee 2017b). In ecosystem-based approaches the problem lies in the strong focus on just bricks (the structures) without considering the mortar (stakeholders and their interests) enough in the past. This line of action led to little developed planning solutions and failing MEBM practices (Wondolleck and Yaffee 2017b). Marine ecosystems are CASs, that cope with uncertainty, complexity and diversity and do exist in a non-equilibrium (De Roo 2011). Therefore, they should be treated with the same thoughtfulness as cities and an additional focus on sustainability and ecosystem protection (Wondolleck and Yaffee 2017a). Elaborating on the idea of an area-based adaptive planning practice and MEBM some proposed features are now introduced: As usual for adaptive panning there is not one-size-fits-all solution (Wondolleck and Yaffee 2017c). There are rather some guidelines that can be considered for the adaptive planning practice in the realm of marine ecosystems.

The first one is *context matters*: the marine ecosystems that need to be planned and managed can vary very much in their context in term of interests, stakeholders, scale and potential (Lawton and Rudd 2014). Even though, this work will focus on the fjord systems and therefore on two very related ecosystems with a comparable national scale the individual issues, the

areas specific histories must be considered in order to create working management plans (Wondolleck and Yaffee 2017c). As an example, former use of the ecosystems as well as the past destruction, protection and conservation efforts must be considered.

The second important guideline is *linkage matters:* the linkage between different values and uses is crucial to guarantee a working approach for a marine ecosystem. Different authorities must work together, and different parts and bits of information must be collected in order to have a successful MEBM (Wondolleck and Yaffee 2017c). It is important to reduce the fragmentation of interests and authorities in order to create successful management plans for marine ecosystems that stay dynamic and can be successfully altered if necessary (Douvere and Ehler 2011).

The third guideline is *people matter*: As mentioned before in an adaptive planning practice the people – or stakeholders – are part of the process and they do matter. Planning cannot solely rely on data, politicians and facts but needs to include opinions, stories and people. An important aspect that relates to the people dimension is the one of negotiation and interests. Even if in an adaptive planning approach, the importance of negotiation and different viewpoints is high, in the ecosystem-based approach it must be clear – without any doubt – that the biodiversity conservation and protection is a given goal. Therefore, within all the possible argumentation this main aspect is non-negotiable and set in stone in the adaptive planning approach and the MEBM (Wood 2000).

The fourth characteristic is *science matters*: marine ecosystems are CASs and can benefit from an area-based adaptive planning practice and MEBM. As mentioned before the ecosystem-based approach combines facts and stories. Guideline number three are the people (stories) but of course science (facts) is important as well. Scientific data helps to understand the processes and patterns in a marine ecosystem and to evaluate possible consequences of actions that might be taken (Douvere and Ehler 2011; Wondolleck and Yaffee 2017c).

These four characteristics or guidelines are the ones that get considered in this work, as they reflect on an ecosystem-based approach that combines area-based adaptive planning practice and MEBM in the open systems that build the realm of cold-water coral ecosystems. The next chapter will introduce the methodology of this work.

3. Methodology

So far, the theory has been discussed in detail, but now it is time to establish how it is put to use and what kind of data is received and in which ways that is done.

3.1 Case Study Research

Case study research is a scientific method that is used to gain in-depth, case specific data about a certain research question or a field of interest in its real-life context (Gerring 2019). Cases studies are used in many different scientific fields but are especially popular in social science. In contrast to experimental studies, they can be considered more unadulterated, since they do not change the variables or conditions but evaluate a phenomenon in its real-life context (Crowe et al. 2011). Of course, the researchers are always affected by their research question, hypothesis and known theory as well but the case study can nevertheless be considered less prone to errors in terms of the variables that are researched, than most forms of laboratory, quantitative research.

There are three different kinds of case studies that need to be mentioned: the intrinsic, the collective and the instrumental case study (Crowe et al. 2011). An intrinsic case study focuses on a unique issue or behaviour. A collective case study is based on a variety of cases in order to create a broader more general knowledge about a certain topic. And the instrumental case study – the one that underlies this work – uses a particular case or cases in order to gain a better understanding of a certain topic of interest (Crowe et al. 2011). For example, can an instrumental case study be useful to find causal links between different aspects of a case and demonstrate path dependencies or certain developments in depths (Gagnon 2020).

3.1.1 Justifying Case Study Research

Case Study Research is a qualitative way of research, that has an in-depth perspective. The research question underlying this work is *`How can adaptive area-based planning and management be implemented in marine ecosystem-based projects for cold-water coral systems in fjords in Norway and Chile in order to create a balance between socio-economic use and environmental protection?´*

This work relies on an instrumental case study, which focuses on cold-water coral ecosystems in the Norwegian Trondheim fjord and the Chilean Comau fjord. As explained above, coral ecosystems are considered to be complex adaptive systems and as such, they are flexible and robust, steered by agents and function through self-organization and co-evolution. Furthermore, they are considered to be part of an open system and in high interconnection with external factors. Therefore, a focus on a deep understanding of the single cases seems more beneficial - rather than trying to fit such complex cases into metrical, quantitative measurable data. Such an understanding would easily simplify the content of this work too much in an inappropriate manner (Gerring 2019).

The in-depth work does of course take more effort in terms of data gathering, comparing and analysing data for each case, but the deeper understanding of the essence of the cases seems to be worth this effort. Additionally, there will be an attempt to answer the sub-question *`Can*

there be a policy transfer from Norway to Chile regarding the area-based adaptive planning practice and MEBM of cold-water coral ecosystems?´ at the end of this work. The sub-question again depends on a deep understanding of the cases and their contexts in terms of space, time and the human factor, that can best be won through a case study research (Gagnon 2020).

3.1.2 Preliminary consideration

After discussing the concept of case study research, as well as justifying this form of research regarding the research question, the following steps must be introduced as well as some preliminary considerations. The things that need to be considered are the definition of the cases, the collection of data and the way the gathered data is going to be interpreted throughout this thesis (Gerring 2019).

The two cases (Trondheim fjord and Comau fjord) were instrumentally selected due to the facts that: Norway can be considered a best practice example, with a high amount of available data regarding planning practice and management of the fjord systems and Chile was selected due to personal interest and high access to data due to a pending internship and personal contact to researchers in that area.

The scope of this work will include developments in the CWC ecosystems in the two fjords that are directly related to human behavior (managed), namely fisheries, aqua- and agriculture, as well as mining and drilling and the indirect to human behavior related (unmanaged) effects of climate change. Since this work is focusing on area-based adaptive planning and MEBM, the stakeholders are an important factor as well. Additionally, the former and recent management plans and strategies will be included and evaluated in their success to create a balance between the use and protection of the cold-water coral ecosystems.

The collection of data is another consideration that is very important. In order to get a comprehensive knowledge of the cases, case study work does include a variety of sources and data (Gerring 2019). In this work a variety of scientific research papers and data, grey literature, some policy frameworks as well as two expert interviews are brought together in order to achieve an extensive insight into the cases. The use of a many different sources and forms of data is important, since it increases the internal validity of the work (Crowe et al. 2011). This is due to the assumption, that different sources of the cases should still lead to the same outcome in the end (Crowe et al. 2011).

3.2 Interviews

Interviews are a way to collect qualitative data regarding a certain topic of interest. In the course of this work, two expert interviews were carried out. One for each of the two cases in order to establish a comparable validity for both cases. The expert interviews are a solid way to get specific knowledge on a specific topic from someone, who has expertise in the field of question (Meuser and Nagel 1991). For this work, semi-standardized interviews were used, which were conducted based on a relatively loose guide following nine questions (Appendix

A1, A3). Before the interviews were carried out, the experts were informed about the topics of the interview in order to prepare for the discussion. Because of the large spatial distance between the interviewees and the interviewer, Skype interviews were conducted to keep the interviews as personal as possible. These were then recorded in the process and subsequently transcribed (Transcripts Appendix A2, A4).

The first interview about the Comau fjord was held on the 02.06.2020 with the expert Maximiliano Sepulveda, the senior officer of PEW charitable trusts, and had a length of 00:41:45. Maximiliano Sepulveda has a background in ecology, wildlife management and conservation biology (PEW Charitable Trusts 2020). He has worked for various government agencies and environmental NGOs and is currently dealing with planning and adaptive management tools for effective conservation and works in protected areas with the help of participatory planning processes in Chile.

The second interview about the Trondheim fjord in Norway was held on the 04.06.2020 with Dr. Pål Mortensen, a researcher from the Norwegian marine research institute in Bergen and had a length of 01:00:26.Due to technical issues the interview recoding stopped at a length of 00:54:22. This can also be seen in the transcript. Currently Dr. Mortensen is working in a research group of benthic habitats and shellfish. He has done a lot of work on the cold-water corals and is an expert in the field of Lophelia corals, public awareness and mapping of CWC reefs for management purposes. Furthermore, he has published many scientific research papers on the topic of which some are also integrated into this work (Loop 2020).

3.3 Analysis

The interpretation of the data is the last important consideration. Making sense out of a variety of data from very different sources can be challenging (Gagnon 2020). In a first step the data is therefore organized into some categories for both cases namely: ecological relevance, fishing, aqua- and agriculture, mining and drilling, climate change, stakeholder involvement and current management practice. This first classification of the data makes it easier to analyze it later (Gagnon 2020). In doing so, data from the different sources can be sorted into the single categories to make sense out of it and an inclusive picture (Crowe et al. 2011). Since all the data, besides the interviews is available in written form, the interviews were transcribed first (Gagnon 2020). Data coming from the interviews will also be cited directly throughout this work by referring to the transcript A2 or A4.

In order to evaluate the data, a rating system based on the four criteria for successful adaptive planning in MEBM, which has been established in chapter 2, will be used. The four categories mentioned above were *context matters, linkage matters, people matter and science matters*. These four reflexive perspectives will each be divided in four subcategories as shown in figure 5. The subcategories have been installed throughout the theory research and comparison in order to clarify each of the four categories.

Context matters	Time
	Agents
	Space
	Potential
Linkage matters	Balance
	Adaptivity
	Defragmentation
	Cross-sectoral collaboration
People matter	Biodiversity Conservation as set goal
	Education
	Stakeholder involvement
	Integration of different viewpoints in planning and management strategies
Science matters	Research
	New technologies
	Implementation of research results in planning and management strategies
	Evaluation and monitoring

Figure 5: Guidelines and assessment categories

For both cases a rating will be given out for each of the dimensions by having a look at the different assessment categories. The rating system has a scope from 0 `category not met´ to 4 `category fully met´. The scales in-between are, 1 `category mostly not met´, 2 `category partly met´ and 3 `category mostly met´. The classification into the respective groups is justified by the fulfilment of the sub-categories of each of the four guidelines.

Both cases will first be analysed in detail. Afterwards, the two cases will be compared and similarities and differences of the CWC ecosystems and their planning and management strategies will be discussed in order to answer the research question *`How can adaptive area-based planning and management be implemented in marine ecosystem-based projects for cold-water coral systems in fjords in Norway and Chile in order to create a balance between socio-economic use and environmental protection?´.* In the end a first evaluation for the option of policy transfer will be given, on which further research could focus in the future.

The next chapter will now get into the cases and present the collected data from the variety of used sources.

4. Data and Case Research

4.1 Jumping into cold water - fjords

The open systems, this thesis is focusing on, are clarified by now. But this work does not simply include any CWC ecosystem but exclusively those in fjords. Following the Cambridge English dictionary a fjord is a *`long strip of sea between steep hills, found especially in Norway´ (Fjord Cambridge English Dictionary 2020)*. So, fjord systems are still more or less part of the sea or at the very least connected to the sea directly. But fjords are also partly isolated since there is only a small connection to the oceans and a long reach into the mainland. This leads to some ecological particularities. Furthermore, fjords are characterized by cold water, which makes them a suiting habitat for our CWC ecosystems.

4.1.1 Cold-water corals

The scope of this work entails CWC ecosystems as CASs that are part of a bigger open interconnected system. But what precisely are CWCs to begin with? There is no solid definition for cold-water corals, deep water corals or deep-sea corals, as they are also called. Technically, they all refer to the same scleractinian coral frameworks, that are usually found in depths between 200m and 1500m depths in cold water (Buhl-Mortensen and Buhl-Mortensen 2018; Ankamah-Yeboah et al. 2020). Shallower cold-water coral ecosystems can be found in Norway, New Zealand, Chile and British Columbia (Buhl-Mortensen and Buhl-Mortensen 2018). Since they are more accessible to people and therefore more affected by them, they are in special need of protection. In this work the term cold-water coral will be used in order to make a clear distinction between the corals discussed in this work and their tropical counterparts. We are also not using the terminology of reefs in this work since *`A reef is an individual seabed feature consisting of an accumulation of coral skeleton. A reef may consist of a single or several coalesced coral mounds. A reef-complex is an area consisting of closely located coral reefs that are separated by other seabed substrates´* (Fossa et al., 2005, p.360). CWCs do mostly live solitary and do not build reefs. Even though, Lophelia pertusa is indeed a reef-building coral, the Desmophyllum dianthus is a solitary living coral and does therefore not build reefs. Nevertheless, it is the case that a symbiosis with some algae occurs in Chile, but this has only been discovered recently. And even though there are high accumulations of D. dianthus in tight spaces it would technically be wrong to refer to those accumulations as reefs. Therefore, this work will stick to the term *cold-water coral ecosystems* in order to ensure scientific accuracy.

Referring to the biology of CWCs, most of them are paraphyletic accumulations of beings of the phylum Cnidaria with calcium carbonate skeletons (Armstrong et al. 2014). They include a variety of hexacoral, octocoral, and hydrocoral species around the world (WWF 2020). For them to strive a cold, nutrient-rich environment with little light and high currents is best suited

(Jackson et al. 201; Ankamah-Yeboah et al. 2020). Cold-water corals are not very well researched until now but there is an increasing interest in the ecosystems, since they are of importance for a variety of fish species and some invertebrates and therefore crucial for the marine biodiversity (Morgan et al. 2005). The CWC ecosystems are used as nursery grounds, for protection, and as areas for resting and reproduction (Armstrong et al. 2014). It is therefore important to understand the deep relationship between the habitat, the organisms living in and with it and design protection that considers both (Osenberg et al. 2011). Researcher do also gain interest in CWCs, since it might be possible to understand climate change and the chemistry of the oceans better by analysing the corals. As they are very slow growing beings - with a growth rate of 4.1-25 mm a year - their skeletons might be a documentation of climate data and could be used as means to research the ocean chemistry through many centuries (Risk et al. 2005; WWF 2020).

Protection of CWC ecosystems started in the late 1990s and focused mainly on areas that did not create many conflicts with stakeholder's in order to have an easy fix (Armstrong et al. 2014). Nowadays, the knowledge is increasing, and it becomes obvious that CWCs are severely threatened by managed pressures like fisheries, aqua-and agriculture and drilling and mining, with bottom trawling as the main threat (Jackson et al. 2014; Alaliyat 2014). Bottom trawling can cause reductions in habitat variety and biodiversity as well as lead to changes in the composition of species (Buhl-Mortensen and Buhl-Mortensen 2018). The main challenge can therefore be summarized as the struggle of combining use and protection of the CWC ecosystems (Fraschetti et al. 2009). Unmanaged climate change related pressures, like acidification and temperature rise, are threats for the CWC ecosystems as well and should be considered in the protection efforts (Magris et al. 2015; Jackson et al. 2014). Luckily most CWCs can cope fairly well with aragonite undersaturation and temperature rises, as long as enough nutrition is available to build their calcified skeletons. But since the aragonite saturation horizon (ASH) as well as the amount of nutrients differ in different locations, it is crucial to take the space specific conditions into account whilst creating protection for the corals and the marine biodiversity that is related to them (Topor et al. 2018; Jackson et al. 2014). This is important, to ensure the avoidance of a tipping point, after which the whole CWC ecosystems would collapse, and it would not be possible to go back to the previous situation.

The urgent need for protected areas is nowadays facing a direct conflict of quality and quantity. There is indeed a higher number of protected areas, but many of them are not properly managed (Gill et al. 2017). This issue leads to high amounts of area-based planned protection areas, that do look good on paper but do not seem to bring the needed success for the ecosystem protection and the marine biodiversity (Magris et al. 2017). The concrete different ecological contexts and issues for the cold-water corals in the Trondheim fjord and the Comau fjord will be discussed in detail in the following sub-chapters.

4.2 Norway: The Trondheim Fjord

The Trondheim fjord in Norway is the third longest fjord in Norway and is located at the western part of the country. Is has a length of round about 130 kilometres and a maximal depth of 617 metres (Trondheims Fjord Norway 2020). Around the fjord is some industry located, like a paper mill, and some of the most popular agricultural areas in Norway. The fjord does also entail a variety of fish, of which the salmon is the most popular one. The Trondheim fjord does inhabit also many different CWCs (Buhl-Mortensen and Buhl-Mortensen 2018). The Lophelia pertusa is very widespread and in the focus of this research.

Figure 6: Geographical location of the Trondheim fjord (ViaMichelin 2020)

4.2.1 Ecological relevance of the Lophelia pertusa

Lophelia pertusa is a stone coral from the family of caryophylliidae and belongs to the subcategory of hexacorals. It is one of the most common CWCs worldwide and can be found in many different places (WWF 2003). The growth rate is only around between 1 mm up to 6mm a year (Järnegren and Kutti 2014). The CWCs do build massive structures that can be many kilometres long and up to 30m high (Fossa et al. 2005). The oldest reefs are estimated to be more than 9000 years old (Transcript Appendix A4). The nutrition of the corals is a mixed one, containing zooplankton, phytodetrital material and even phytoplankton material in some cases, since they are opportunistic feeders (Järnegren and Kutti 2014; Buhl-Mortensen et al. 2015c). The shallowest occurrence of the Lophelia pertusa is in the Trondheim fjord in a depth of only 39 metres (Fossa et al. 2002).

The ecosystems build by L. pertusa are a habitat for a variety of marine organisms. CWC ecosystems seem to encourage the diversity of many groundfish species and tend to be beneficial for commercially used fish as well (Risk et al. 2005). So far more than 1300 species are known to live on or in association with L. pertusa in the north-east Atlantic. Especially redfish, demersal species like the ling and tusks seem to rely on the structures build by cold-water corals (Fossa et al. 2005). Additionally, some fauna can be closely related to them. In Norway the polychaetes Eunice norvegica and Harmothoe oculinaru do live closely together with the corals (Buhl-Mortensen and Buhl-Mortensen 2018; Appendix A5). The L. pertusa is beneficial for the over-all marine biodiversity but also a crucial factor for the economy due to its relevance as a habitat for commercial fish (Fossa et al. 2005). An interesting aspect of this species is the fact, that L. pertusa is known to not be constituted by one panmictic population in north-east Atlantic. This was proofed by gene sequencing, which revealed that there are distinct populations in the seas and the fjords (Le Goff-Vitry and Rogers 2005). Furthermore, research between 2002 and 2008 has shown that L. pertusa in the Trondheim fjord does also differ from other populations in its reproductive periodicity (Brooke and Järnegren 2013). This discovery is off high importance for an ecosystem-based management practice. If a species is genetically very uniform the loss of one population does not destroy that much of the biodiversity, since other populations can compensate the loss, since they are all very similar. But in cases with a high genetically distinction between the different populations the loss of one population has more serious consequences for the environment (Le Goff-Vitry and Rogers 2005). In those cases, special protection is needed in order to keep the ecosystem alive.

4.2.2 Fishing

Overfishing of many groundfish species is a common problem worldwide and can be tackled by marine ecosystem-based management (Risk et al. 2005). The L. pertusa ecosystems in Norway are used by tusks as a feeding habitat and by redfish as a resting place for strong currents. The redfish is known to lay on the bottom and save energy in order to not fight the strong currents in the fjords (Transcript Appendix A4). Also, zooplankton does have a higher concentration closely to the ecosystems and during clack tide it becomes valuable prey for the redfish (Buhl-Mortensen et al. 2015c). In general, fish that lives closely with the CWCs growth larger and becomes therefore interesting for fishermen. Local fishermen know about the behaviour of the fish closely to the corals and adapted their fishing practice in alliance with it, in order to catch the fish, when they are not resting in the cold-water corals (Transcript Appendix A4). The traditional fishermen waited until the currents were weak for the redfish to feed and leave the coral structures before they started their fishing efforts. But nowadays, especially with heavy bottom trawling gear, fishing leads to much damage on the CWC ecosystems (Risk et al. 2005). Also, the less damaging longlines, and trap, hook or line gears need to be managed properly in order to not be harmful for the environment (Risk et al. 2005). Passive gear like gillnets and long lines do of course also damage the Lophelia pertusa ecosystems, but in a less crucial way than bottom trawling gear (Fossa et al. 2002). In Norway there is consensus among stakeholders that destructive fishing behaviour has severe impacts

on the environment and the seafloor (Risk et al. 2005). Consequently, the Trondheim fjord is currently protected from trawling (Le Goff-Vitry and Rogers 2005).

4.2.3 Aqua- and Agriculture

CWC ecosystems in the Trondheim fjord do face some threats due to aquaculture, especially since fish is the third most important export product in Norway (Alaliyat 2014; Järnegren and Kutti 2014). The open nets used for salmon breeding lead to high nutrient leaks into the fjord systems in Norway (Järnegren and Kutti 2014). Shellfish aquaculture is also happening in Norway, but it is more sustainable, since it does not leak organic matter into the fjord systems, which salmon farming does (Filgueira et al. 2014). The issue of nutrients is also linked to agriculture, since nutrients from faming – those might be related to cattle, sheep or also to pesticides for crops – leak into the groundwater and can then be transported into rivers and the fjords. If they are already in a fjord, they can severely affect the CWC ecosystems. The magnitude of the pollution does also depend on the water circulation (Filgueira et al. 2014). The proximity of the nutrients leaks as well as the spatial conditions in terms of water circulation and movement are therefore points of interest as well (Filgueira et al. 2014). Both, aqua- and agriculture, do lead to high organic and mineral nutrient levels in the Trondheim fjord, which have an impact on CWCs. The sizes of farms and cages is another important aspect that needs to be considered. Escapes of fish from the cages is a big problem for the natural ecosystems, since it leads to genetic interaction (Alaliyat 2014). The fifth national report to the Convention on Biological Diversity does therefore state that `*Eutrophication in coastal and fjord areas may occur as a result of runoff from agricultural areas, industrial and municipal wastewater, and also discharges of nutrients from fish farming*.´ (Norwegian Ministry of Climate and Environments, 2014).

4.2.4 Drilling and Mining

The institute of marine research in Norway did research on the effects of drilling and its discharges on the Lophelia pertusa ecosystems, in order to improve management of human activities close to the ecosystems (Buhl-Mortensen et al. 2015a). The assumption was, that increased sediment loads due to petroleum drilling might affect the corals. The results did show that L. pertusa is relatively tolerant of high concentrations of particulate substance. But that there is indeed a negative effect on the polyps and their survival. Lophelia pertusa can remove little inorganic matter from its polyps as long as it does not occur simultaneously with nutrition (Buhl-Mortensen et al. 2015a; Järnegren and Kutti 2014). If it does, the coral cannot differentiate between the organic parts they use for nutrition and the inorganic matter from drilling. This can then lead to a waste of energy throughout the digestion, since the corals try to digest both materials and are unable to differentiate them in the process. In the long term this would most likely lead to the starvation of the cold-water coral. Since the carried-out research of the marine research institute did only focus on short term effects of drilling, more studies will be needed for the long-time consequences for L. pertusa (Buhl-Mortensen et al. 2015a). Furthermore, the disposal of mining waste by submarines is another threat to L. pertusa ecosystems in the fjords (Järnegren and Kutti 2014). This kind of disposal does still happen in some cases in Norway and the mineral waste particles released into the fjords can

be transported 1-2 kilometres further than the dumping location and can also be harmful to the CWCs (Järnegren and Kutti 2014).

4.2.5 Climate Change

Lophelia pertusa is capable to cope with acidification and relatively low aragonite saturations (Jackson et al. 2014). Layers and the skeleton are still developing in undersaturated conditions, if enough nutrition is available (Wall et al. 2015). But since the corals occur in shallow waters in the Trondheim fjord, it is likely, that they do not experience too much impact of undersaturation with aragonite in it, since this is more likely to happen in higher depths. On the other hand, L. pertusa seems to be very sensitive to temperature changes. Researches from the Oregon Institute of Marine Biology found out that the upper lethal temperature limit for L. pertusa is near 15-degree Celsius (Brooke et al. 2013). The cold-water coral can cope with the high temperature for a short time period but after one week the high temperature starts to damage the coral. L. pertusa is known to be found between 4 and 14 degree Celsius around the globe (Brooke et al. 2013). In the Trondheim fjord the temperature is currently varying between 6 degree and 12 degree Celsius on average per month (Ltd, Copyright Global Sea Temperatures 2020). The maximum temperature in summer does even reach up to 15 degree. Therefore, the temperature rise related to climate change might become a real issue that can lead to long-term damage of the CWCs in the Trondheim fjord (Morato et al. 2019).

4.2.6 Stakeholder Involvement

Ecosystem-based management approaches rely on knowledge and understanding of the involved parties and stakeholders (Ankamah-Yeboah et al. 2020). The general knowledge of the CWCs is relatively high among the Norwegian public. This might be, since Norway is known to inhabit the most cold-water corals around the world. Therefore, it is not surprising that the public does have an interest in protecting the environment (Ankamah-Yeboah et al. 2020). Also, a general need for protection is acknowledged. A qualitative research from the Marine Resource Economics group in 2015 revealed that a commercial user group (fishers), a recreational user group (sailors) and a group without any relation to the ocean (singers) did all agree on the value of the cold-water coral ecosystems and their need for protection (Appendix A7). But the study also showed that they did not agree on precautionary protection measures in cases, where the corals are not yet located, or a threat is not proven to be existent (Falk-Andersson et al. 2015). A temporary closure in order to do research first was not approved by the stakeholders questioned in the study. When it comes to aquaculture, there are also many stakeholders involved. Some of these are the Directorate of Fisheries, Institute of Marine Research, Ministry of Environment and Ministry of Fisheries and Coastal Affaires (Alaliyat 2014). Since Norway is the biggest exporter of fish in Europe this sector does have some weight in decision making processes (Alaliyat 2014). In general, the stakeholders in question are the research institutes, industry representatives, local government

(municipalities), regional authorities (counties), local communities, farmers, drilling and mining companies (Alaliyat 2014).

4.2.7 Current Management Practice

Researches estimated that between 30 and 50 percent of the L. pertusa reefs in Norway were damaged before any protection happened. In 1997 the Institute of Marine Research in Norway started to map the CWCs and asses their condition. It did so, because of reports of fishermen that stated, that bottom trawling seemed to damage the cold-water coral ecosystems (Fossa et al. 2005). Ecosystems of the L. pertusa are very common and widespread along the coast of Norway and the survey led to an extensive database of these ecosystems. In 1999 the Norwegian Ministry of Fisheries passed the Coral Protection Regulation to protect the CWC ecosystems from fishing activities (Fossa et al. 2005; WWF 2003). The law forbids damage and destruction of the ecosystems and fishermen are forced to be careful when fishing close to the coral structures (Transcript Appendix A4). In Norway there are already some areas that are completely closed for fishing activities dragging gear along the bottom. In 2008 eight locations have been closed for these fishing activities. Namely the Sula Reef, Korallen, Iverryggen Reef, Breisunddypet, Røst Reef, Træna Reefs, Tisler Reef and Fjellknausene Reef. The Selligrunnen Reef and the Trondheim fjord are temporarily conserved and protected trough the *Norwegian Nature Conservation Act* and the status as a marine nature reserve for some of the ecosystems in the fjord (Fossa et al. 2005; Fossa et al. 2002).

Furthermore, Norway does also support international protection beyond the national boundaries and promotes the OSPAR Convention, which is about the protection of the North Sea and the North East Atlantic. The NGO WWF states that *`Norway is the only country that has turned nice words into concrete conservation actions´* (WWF, 2003) and that the Norwegian approach can be considered a pilot project for cold-water coral protection. That is also the reason why the WWF claims the approach to be *`A Gift to the Earth´* a title only given to globally significant conservation projects (WWF 2003). In 2003, a working group was formed to advise the government on future steps to protect CWC ecosystems (Fossa et al.). This working group, as well as The International Council for the Exploration of the Sea (ICES) stated that it is urgently needed to map the cold-water coral ecosystems in order to find areas that need to be closed for bottom trawling (WWF 2003). Mapping and assessments of the CWC areas is a common practice in Norway and leads to a better understanding about the structure, ecological functions, geology, hydrography and geochemistry on the cold-water coral ecosystems (Fossa et al. 2005).

Nevertheless, there is still a lack of knowledge about the ecosystems. This can be solved using new technologies and scientific methods (Buhl-Mortensen et al. 2015b). Norwegian researches at the MAREANO Mapping Programme, which is a programme for mapping depth, topography habitats etc. in Norwegian waters, acknowledge the need for more research and transparency on these ecosystems and value practices of acoustical reef detection, multibeam

mapping and ground-truthing with the help of tethered video camera platforms or remotely operator vehicles (ROVs) in order to do so (Buhl-Mortensen et al. 2015b; Fossa et al. 2005). Furthermore, the researches acknowledge that MEBM is needed to stabilize the environment and that it is not only important to implemented MPAs in the planning process but also to distinguish different fishing gears and apply different zones and using plans for the different fishing practices (Risk et al. 2005). A solution that gets a lot of support is the idea to shift completely from bottom trawls away to traps. This can also have economic benefits sine the caught prawns would not be as injured as they are with other fishing practices. That would also go along with higher market prices (Risk et al. 2005). To achieve this shift incentives and especially a very strict policy plan will be needed in the future. In relation to aquaculture some strict boundaries are already set in place in order to minimize the number of escaping fish. Furthermore, the government uses a well-developed inspection program to oversee the farming processes called MOM (fish farms-monitoring-modelling) method (Alaliyat 2014). The method is used to keep threshold values in check and to monitor the sea floor in order to prevent disease outbreaks and too high nutrient levels in the water (Alaliyat 2014). The fifth national report to the Convention on Biological Diversity does also explicitly state the need for an action plan that includes mapping, planning and monitoring of organic and inorganic pollutants in fjord ecosystems (Norwegian Ministry of Climate and Environments)

The main issue with the current management of the Trondheim fjord is that there are not standard monitoring programs in place in order to evaluate the impact of released nutrients into the fjord on the cold-water corals (Järnegren and Kutti 2014). The zoning idea could also be further improved by creating closed areas. Risk et al. (2005) argued for better mapping of the cold-water corals in order to ensure the uncovering of areas that need protection (Risk et al. 2005). Furthermore, local observatories like used by the Lofote-Vesterale (LoVe) observatory could be used in order to generate more awareness and transparency in the broader public (Transcript Appendix A4).

4.3 Chile: The Comau Fjord

The Comau fjord belongs to the Chilean part of the Patagonia region in the north-western part of the country. The fjord region in Chile does include around 1500 kilometres in length and inhabits many channels, fjords and archipelagos. The Comau fjord itself has a length of 68 kilometres and its exact location is shown in figure 7 (Fillinger and Richter 2013). Furthermore, it is characterized by very high precipitation and therefore a high freshwater inflow (Quiñones et al. 2019). The current state of the data collection leaves the area as one of the least studied regions worldwide. In Chile the most marine data is still acquired by boat and therefore the understanding of the marine environment is still very poor (Försterra et al. 2005). Some scientists even call the Patagonia region therefore *`terra incognito´ (Försterra et al. 2005)*.

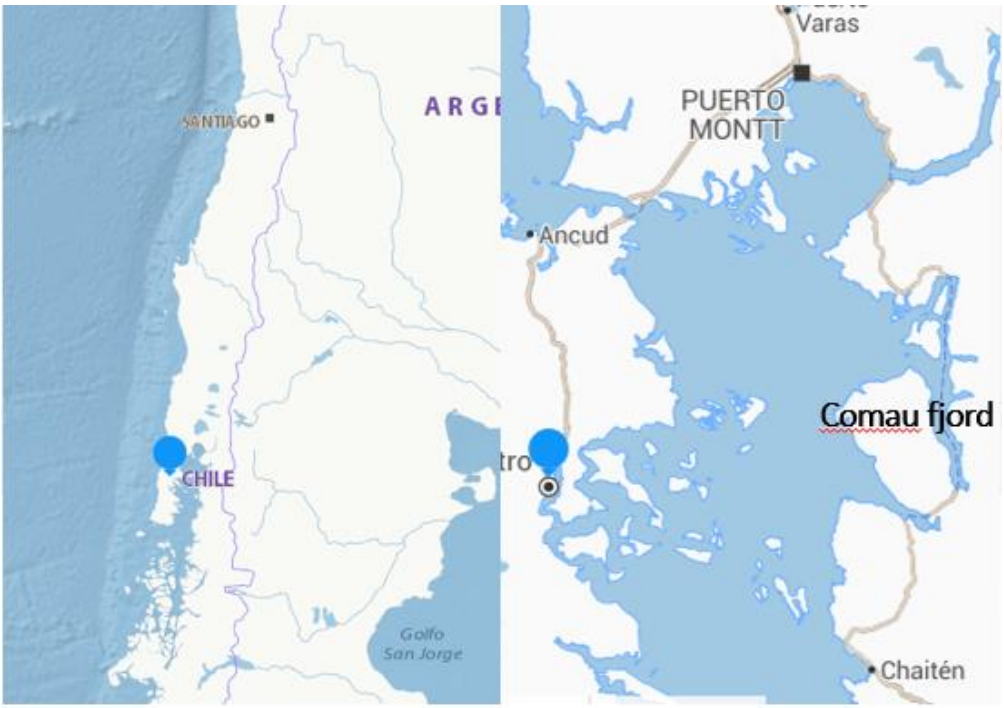

Figure 7: Geographical location of the Comau fjord (ViaMichelin 2020)

4.3.1 Ecological relevance of the coral ecosystems in the Comau fjord

The Comau fjord is a suiting habitat for a specific cold-water stone coral: The Desmophyllum dianthus. D. dianthus is a solitary stone-coral out of the family of caryophylliidae and belongs to the subcategory hexacorals as well (Försterra et al. 2005). It is less common around the globe than L. pertusa. Furthermore, D. dianthus is a solitary living coral and an active filter-feeder (Försterra et al. 2005). It has already been established that CWC ecosystems are indeed worth protecting due to a variety of reasons. The ecosystems formed by D. dianthus are also associated with the amount and size of fish (Försterra et al. 2005). But there is one more reason, that makes the CWC ecosystems in Chile especially important: Normally the coral is found in bathyal waters, which means it is located in high depths down to 2460m (Försterra et al. 2005). But in the Patagonia region and especially in the Comau fjord the D. dianthus can be found in very shallow waters in around 20m depths (Fillinger and Richter 2013). The occurrence of the D. dianthus in the Comau fjord does not only make it easier to examine the corals, it also uncovers some surprising co-existences with other organism like coralline algae, which was considered unlikely before (Försterra et al. 2005).

4.3.2 Fishing

Some years ago, there was little damage caused to the ecosystems by fishing but nowadays, due to bigger vessels and stronger fibres that are used for the fishing gear, the threat in Chile increases constantly (Risk et al. 2005). Patagonia is especially threatened by it due to the little knowledge of the marine environment and its particularities and the occurrences of the CWCs. The rapid economic growth is in sharp contrast to the big environmental knowledge gaps (Petit et al. 2018).

4.3.3 Aqua-and agriculture

Aquaculture is a fast-growing sector in Chile and comes along with many threats for the environment. Habitat losses, genetic interactions between farm fish and wild populations, pollution in general and the quick spreading diseases in the marine environment are some of them (Quiñones et al. 2019). An example for the threats of aquaculture is the Cross-Huinay in the Comau fjord. At this location a leak of sulphide and methane has been recognized. In 2012, 99 percent of the D. dianthus population in the area suddenly died off. It can be assumed that this does relate to aquaculture (Försterra et al. 2005). In the last twenty years the aquaculture has grown rapidly, which led to an increased primary productivity due to nutrient enriched water and increased eutrophication (Transcript Appendix A2). The harmful algae blooms have become more regularly, and the die-offs of these blooms can rapidly use up the dissolved oxygen in the water which then leads to hypoxic events and heightened mortality rates of the D. dianthus (Försterra et al. 2005). The main part of aquaculture focuses on salmon farming for which are only limited regulatory frameworks in place. There is some evidence that there is a link to eutrophication and loss of biodiversity downstream the salmon farms (Quiñones et al. 2019). The farming process includes two phases: the freshwater phase does take place at actual farms and afterwards there is a marine fattening phase in the Patagonian fjords. Additionally, the use of pesticides and antibiotics is also harmful for the marine life. Currently, there are no laws regarding the carrying capacity of maximum salmon biomass in the waterbodies. The Chilean aquaculture industry has grown very fast and relies on the Atlantic salmon, the coho salmon as well as the rainbow trout and has become the second biggest global producer of salmon (Quiñones et al. 2019). But there is not only water pollution from aquaculture, there is also a high amount of organic and inorganic matter from the rivers that flow into the fjord system that comes from rural agriculture (Försterra et al. 2005). Especially extensive sheep farming seems to be a source of agricultural pollution that effects the fjords as well (Transcript Appendix A2).

4.3.4 Drilling and Mining

Mining is a strong economic sector in Chile and falls under the legislation of the National Mining Services, that is responsible for concessions and the regulations on mining (Vásquez-Lavín et al. 2013). Many people depend on it as it generated workplaces and is one of the main sources for the Chilean BPI (Miranda 2003; Transcript Appendix A2). But it does also generate some environmental issues. The waste produced by the mining companies does also harm the marine ecosystems in form of runoff sediments and more acidic water due to dissolved metals (Miranda 2003; Appendix A8). Especially sulphur emissions from copper mining are a threat to the environment and to the people, since it harms not only natural ecosystems but also the aqua-and agricultural sectors. It was common practice in Chile to simply drop the waste of mining processes in the sea or the rivers and fjords (IEA World Energy Statistics and Balances 2012). Since 1970 some progress has been made in order to prevent the waste from getting into the water by building dams. But this is only the case for the bigger mining companies. The smaller ones are not capable to follow the environmental protection goals and lack the money in order to build the proper damns and measures in order to prevent the water pollution (IEA

World Energy Statistics and Balances 2012). Additionally, it is important to recognize that the mining sector is much more valued than ecological protection and the laws for mining are superior to the ones for conservation and protection (Transcript Appendix A2).

4.3.5 Climate Change

Chile in general is very vulnerable to climate change, since its glaciers are rapidly melting. Desmophyllum dianthus can survive in temperature from 4 up to 17.5 degree Celsius. The Comau fjord does have a water temperature varying between 8 up to 12 degree Celsius, which suits the CWCs well. The pH in the fjord does lie between 7.4 and 8.4. Researchers from the Centre of Marine Biodiversity and Biotechnology in Edinburgh did find out that D. dianthus is more susceptible for changes in temperature than for changes in the pH value. Ocean acidification is therefore less a threat than climate change and rising temperatures of the oceans. D. dianthus is capable of coping with the changed pH value under a high enough availability of nutrition, whereas the higher temperatures lead to reduced calcification of the cold-water corals, if the coral is exposed to it over a longer time period (Gori et al. 2016; Morato et al. 2019). The worst possible situation for D. dianthus lies in the combined effects of ocean acidification and climate change, since research on the topic revealed that there is a high possibility that the cumulated effects of the stressors will have long-term consequences for the survival (Morato et al. 2019).

4.3.6 Stakeholder Involvement

The national government is mostly in charge of environmental protection and can do so by declaring marine areas nature sanctuaries, wetland, marine parks, marine reserves or even multi-use marine protected areas (Vásquez-Lavín et al. 2013). The Chilean Environmental Protection Agency (CONAMA 2005) is also a powerful stakeholder in term of conservation and protection of biodiversity in Chile (Vásquez-Lavín et al. 2013). Other important stakeholders are the national fishing service, the ministry of mining, the environmental ministry, artisanal fishers, the sub-secretary of fishing and the industry (Vásquez-Lavín et al. 2013). Furthermore, NGOs like PWE and the Patagonia Mar y Tierra working group (consists out of nine NGOs) are stakeholders of interest (Saenz 2019). Even though, many stakeholders are involved, Chile can be considered a very centralized country and the coordination between the public institutions does lack coordination and expertise (IEA World Energy Statistics and Balances 2012). Local authorities and the public are often not involved in the planning process, even though NGOs try to raise awareness and increase the inclusion of locals in the environmental protection efforts.

`And to create with them, this what we call a virtues connection between parks and local people. So, trying for example to instead of investing into infrastructure inside the park, trying to promote capacities in local people to offer beds, and food and services and using the park only as an attraction where there is only a basic road, or trail, with nice views and activities but moving all the commodities in terms of lodging, food services and others to the local communities. That's what we call the working with communities concept.´

(Maximilano Sepulveda, 02.06.2020, Transcript Appendix A2, p.57)

4.3.7 Current Management Practice

Chile stands out in numbers of protected areas and parks, which differ in titles and legislation (Vásquez-Lavín et al. 2013). The International Convention on Biological Diversity in 2006 set the so-called Aichi Target 11 which aims for protected areas with specific targets. 17% of the terrestrial inland waters and another 10% of coastal and marine waters had to be protected in order to achieve the Aichi Target 11 (Petit et al. 2018). This led to an increase of 360% in MPAs in the following ten years (Petit et al. 2018). Chile does meet the requirements already, but the government plans on enlarging the protected areas of the country even further in the future. So, the quantity is already achieved but what about the quality of the MPAs? The research of Petit et al. (2018) is based on two criteria that evaluate the situation in Chile. First the `last official document´, which refers to the last accessible report of the MPA, assesses whether there is a current management plan in place. Any plan older than ten years is taken out of the research (Petit et al. 2018). The second criteria evaluated the management plan according to the Protected Areas Management Effectiveness Framework (PAME). This framework is based around the six criteria: context, planning, input, process, outputs and outcomes. Therefore, it can be said that the PAME framework highlights more or less the same aspects as our adaptive planning and MEBM approach (figure 4) (Lister 2008). The results of the study are important because they show, that out of 165 protected areas in Chile (from which are 145 terrestrial and only 20 marine) only a fraction meets the second effectiveness criteria (Petit et al. 2018). And more importantly for this research: None of the MPAs meets the requirements for effective management. This might be since Chile started the implementation of MPAs fairly late, only in 1997 (whereas PAs were implemented nearly a century earlier in 1907) but also because the management of the first MPAs was solely resource-based. The first management plans for MPAs in Chile aimed to protect giant mussels for economic gain in the future and gave little attention to the protection of ecosystems or the environment (Petit et al. 2018). Until today the MPAs in Chile are mostly in areas that are without inhabitants to avoid conflicts of interest between stakeholders (Transcript Appendix A2). The biggest issues for a successful management of marine protected areas are a lack of financial support, the fragmented government system and too little cooperation on nearly every level of the planning, management and the evaluation process (Petit et al. 2018). Since studies have also proven that the implementation of protected areas without a sustainable management plan in place, might only lead to high social costs without real environmental benefits (Vásquez-Lavín et al. 2013). In terms of research the D. dianthus has been monitored for around twenty years until now and international research institutes like the German Alfred-Wegener-Institute do also some first research on the CWCs (Försterra et al. 2014). Chile struggles a lot with the financial situation and lacks money for environmental protection projects and faces some technical challenges (Puglise et al. 2005). MEBM is considered on paper but until now there are no resources put into the realisation (IEA World Energy Statistics and Balances 2012).

In the field of fishing the Chilean National Fisheries and Aquaculture Service (SERNAPESCA) is in charge and prepares the environmental information report (INFA), which is delegated to

consultants to monitor aquaculture farms. If a farm can be measured with anaerobic conditions, it is no longer allowed to cultivate fish until the aerobic conditions return (Quiñones et al. 2019). In order to determine an anaerobic condition some concrete measures are available to the consultants. The issue here is, that the measures are not very precise, since only the situation at a farm is considered and since the nutrients – especially in deep steep-sided areas - are swept away, this measurement is not very precise (Quiñones et al. 2019).

This chapter has introduced the two cases of the Trondheim fjord and the Comau fjord in detail. The following chapter will now use this data in order to evaluate the area-based adaptive planning and the MEBM strategies in both areas and to answer the research question of this thesis.

5. Results

After having had a closer look at the relevance of the ecosystems, the impacts imposed on the through fishing, aqua- and agriculture, drilling and mining and climate change and the stakeholders as well as the management practice, we can evaluate the findings in relation to the approach of area-based adaptive planning and MEBM and set the ratings for the evaluation system. This chapter will also be used in order to answer the research question. The results will first be presented separately for both cases and then in comparison by having a look at the four reflexive perspectives: context matters, linkage matters, people matter and science matters.

5.1 Single Case Analysis

First of all, the two cases will be discussed separately and the strongpoints as well as the weakness in the area-based adaptive planning and the MEBM will be shown.

5.1.1 Trondheim fjord evaluation

Norway is one of the forerunners in the field of adaptive planning and MEBM of the CWC ecosystems. But can its approach be considered perfect already? This thesis considers the Norwegian practice to be very efficient and sees only some small areas for criticism. In chapter 1 of this thesis we characterized the adaptive planning and management practice as something, that navigates the planned system in an evolutionary process through the support of desired consequences and the avoidance of undesired ones. In Norway that is exactly what happens in most of the aspects of the four reflexive perspectives. The zoning and fishing laws allow for the use of the ecosystems, but they do so in a manner that helps to avoid undesired consequence of ecosystem destruction and the loss of CWCs. The resilience of the CWCs is considered ant the planning and management approaches allow the CASs to not distance too far from equilibrium.

When it comes to the scoring of *context matters* Norway reaches 4 out of 4 possible points, which means the guideline *context matters is fully met*. This is because the responsible authorities consider the time and history aspect of the Trondheim fjord in their efforts through acknowledging the destruction, that has already happened and the issues, that can occur in the long-term. Furthermore, the agents and the surrounding systems are considered. The CWC ecosystems are not seen as isolated but in their context with other marine beings and the humans that use and destroy the ecosystems. The scale is also considered in creating zoning plans and acknowledging spatial particularities. And at last the sub-category of potential is met, since the responsible parties see the benefits related to climate change studies and possible long-term benefits of CWC protection for fisheries and the economy of Norway.

The scoring of linkage matters is the weakest one for the Trondheim fjord and is valued with 2 out of 4 possible points, since this dimension is about the reduction of fragmentation and the linkage of different needs and uses. In Norway the different stakeholders do communicate and engage in order to create balance in terms of use and protection on the fjords. But in term

of defragmentation there is still some room for improvement. As an example, the NINA report from the Norwegian Institute for Nature research from 2014 states, that, since especially coral larvae seem to be sensitive towards the drill cutting it would be good to avoid drilling in times of spawning from February to April (Järnegren and Kutti 2014). Furthermore, when it comes to aquaculture there is a need to consider the carrying capacity of the fjords water resources and an urgent need to include the spatial particularities of each location that is used for aqua- or agriculture. As a conclusion the cross-sectoral collaboration does have some weak points.

The scoring for *people matter* is 4 out of 4. The stakeholder involvement is very high and there is a lot of education and awareness amongst the different parties. The fact that the fishermen were the once to argue for the need of protection shows already the interconnection and collaboration in the planning and management processes. Education of the stakeholders is integrated in planning and management processes and the different interest are included into the actual management practice.

The last part is the scoring of *science matters.* The area-based adaptive planning and MEBM of the CWC ecosystems reach 3 out of 4 possible points for this aspect. Many research institutes work on the CWC ecosystems and their protection and try to understand the ecological, hydrological and geochemical processes in the fjords. The MAAREANO mapping programme and very progressive technologies lead to an improved understanding of the ecosystems and are then used for planning and management processes. The only issue is, that the evaluation process is not without errors right now. The MOM method for fish farms is a first step in the right direction but there is room for improvement and standardized evaluation processes.

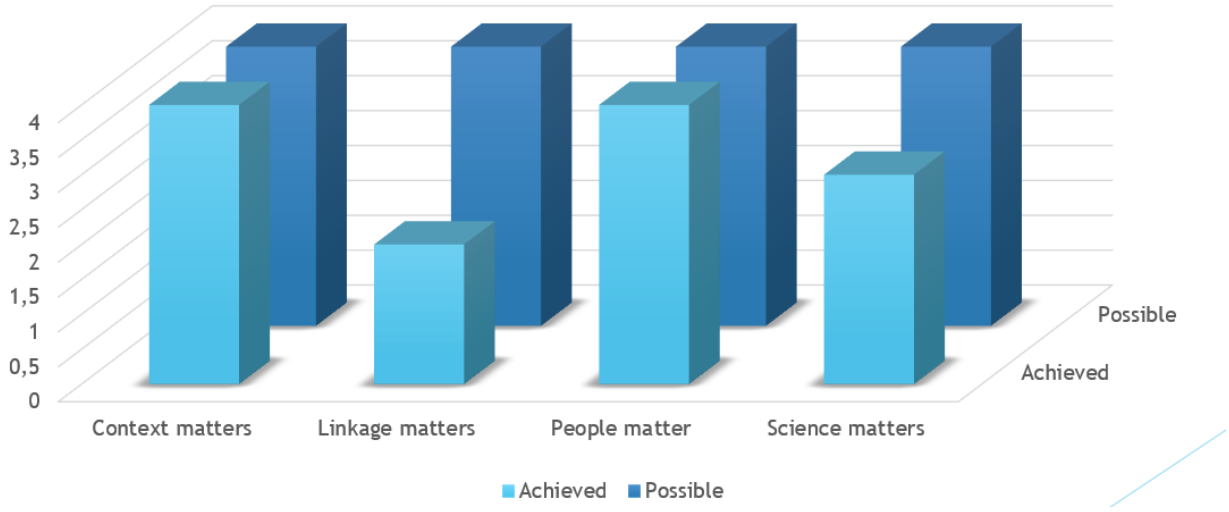

Figure 8: Evaluation results of area-based adaptive planning and MEBM in Norway

Figure 8 gives an overview over the 4 different guidelines and the scoring of adaptive planning and MEBM in the Trondheim fjord. It can be seen, that Norway did reach a very high score in total. This not surprising, since Norway did get honoured by the WWF and is known to be very

progressive terms of technologies, research and environmental protection. The next section will demonstrate the results for the Comau fjord.

5.1.2 Comau fjord evaluation

In Chile many marine environmental problems are closely related to a rapid economic growth and increasing export rates of copper and salmon (IEA World Energy Statistics and Balances 2012). How is the situation for the CWC ecosystems build by D. dianthus and where are the strong and weak points in planning and management of the open systems in the Comau fjord? After having analysed the planning and management situation for the Comau fjord it can be concluded that it cannot be called an adaptive approach at all. The balance between use and protection is not reached and the avoidance of undesirable consequences, namely biodiversity loss, habitat destruction and connected long-term losses in economic gain. In the following the four reflexive perspective will be discussed in detail.

First again the guideline of *context matters*, which can only be scored with 1 out of 4 possible points. In Chile there is a huge discrepancy between the enormous speed of economic growth and the slow growing awareness of the CWC ecosystems. The research on the field has only recently started and is in its infancy so to speak. The agents and especially the human impact on the ecosystems are not considered enough. There is indeed a high amount of protected areas in place, but the quantity does lack quality. The future potential of CWCs and the importance for fisheries are not included into a management practice.

The second guideline, *linkage matters* is again scored with 1 out of 4 possible points. The balance between use and protection is not restored, even though some first steps are taken in order to protect nature. So far, the focus is still on the profit in the management practice of the Comau fjord and its ecosystems (Quiñones et al. 2019). Furthermore, there is a high level of fragmentation in the Chilean government. The different levels to not communicate and collaborate and the different sectors are not even included in the process of managing protected areas. These issues do lead to planned protected areas that are not properly managed and cannot adapt to unforeseen changes and cope with future challenges. Furthermore, there is an urgent need for laws regarding the carrying capacity of salmon farms (Quiñones et al. 2019). So far there has been no real effort to do research or effectively change the legislation for human activities in fjords. Most publications that do focus on the salmon farms seem to prioritize the fish health as an economic agenda, instead of trying to ensure the health of the whole ecosystem (Quiñones et al. 2019). The funding issue for a successful management is hard to solve and even if the government provides financial support to some extent through funding like the Regional Development Fund this is not enough to follow a successful management plan (Vásquez-Lavín et al. 2013). Especially since the fund is only short-term and needs renewal very often. The Ministry of the Environment, research centres, and artisanal fishers are also willing to participate in funding in some areas but since Chile is in economically terms not very well situated the monetary issue is a big one (Vásquez-Lavín et al. 2013).

The third guideline is *people matter* and here Chile reaches 2 out of 4 possible points. In creating protected areas, the responsible parties take biodiversity conservation as a set goal. But they only do so on paper. The planning as well as the MEBM are lacking collaboration and stakeholder involvement from different sectors. There are some NGOs that try to achieve change and educate people but in Chile the integration of different viewpoints into the MEBM practice is not happening until today. Nevertheless, the working with communities concept is a first step in the right direction and justifies the scoring with 2 out of 4 possible points. On a small scale there is the effort to establish a balance between economical use of protected areas through the implementation of touristic encouragements, while ensuring the ongoing protection of the nature.

The fourth guideline is again *science matters* and it achieves one more time only 1 out of 4 possible points in the scoring. Some research is done but the technologies are outdated in many cases and the results that are gained are simply not taken into any use. The planning and management practices do currently not care to adapt their plans based on new scientific data. Furthermore, and that is the same as in Norway, the evaluation and monitoring of existing protected areas and developments is not successful and lacks some effort.

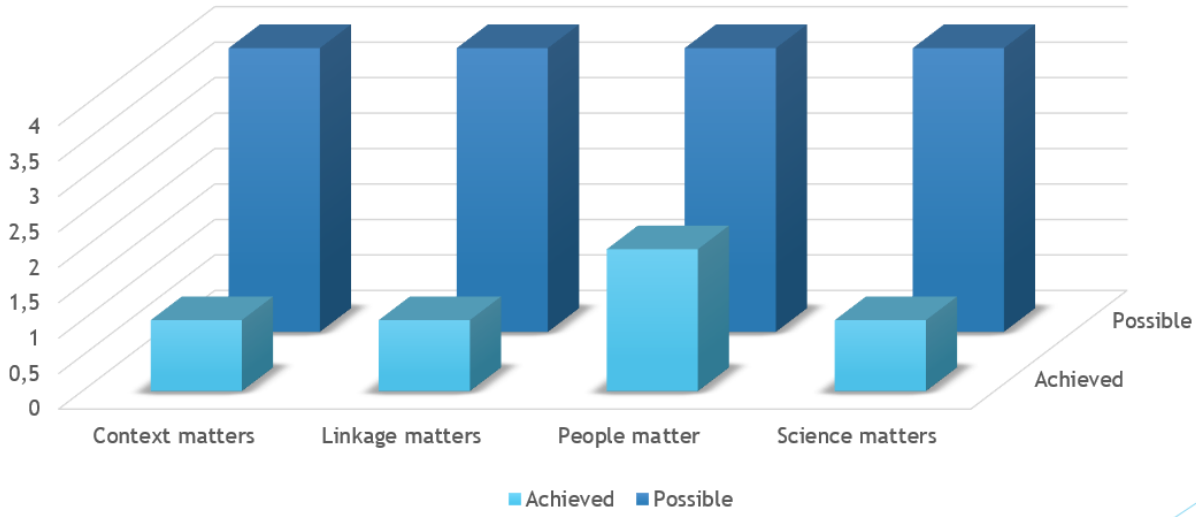

Figure 9: Evaluation results of area-based adaptive planning and MEBM in Chile

Figure 9 visualizes the overall scoring for the Comau fjord. Area-based adaptive planning, as well as MEBM, are not very successfully implemented in the area. Nevertheless, some first attempt towards a more adaptive practice can be seen. The following chapter will compare the two cases and answer the research question underling this thesis.

5.2 Comparative Analysis

This section will compare the two cases underlying this work and give an answer to the research question. Figure 10 shows the different scorings for the different guidelines once again in comparison. The section will analyse each of the guidelines and end with giving an outlook for further research on the idea of transferring some ideas from Norway to Chile.

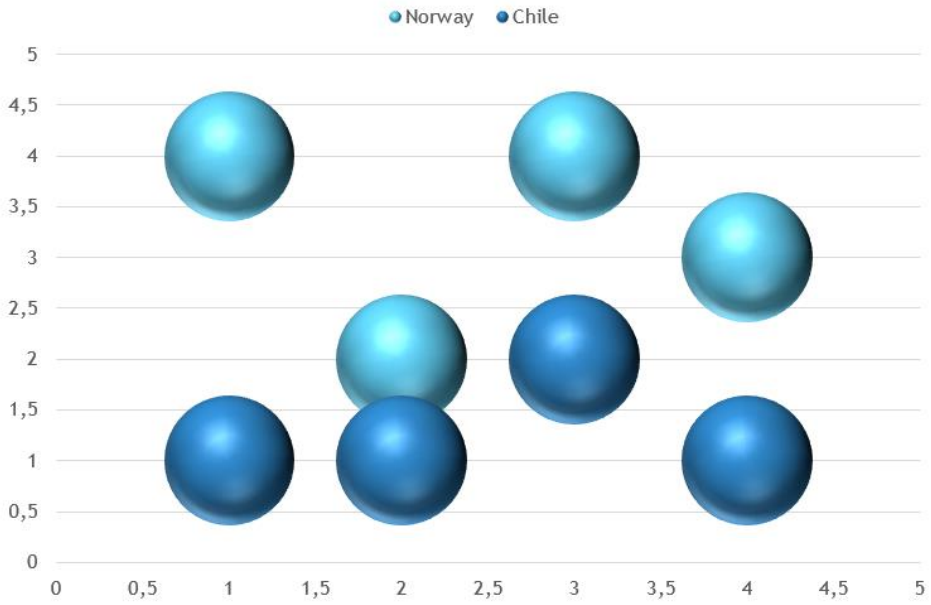

Figure 10: Comparison of the results for the Trondheim fjord in Norway and the Comau fjord in Chile for the guidelines 1. Context matters, 2. Linkage matters, 3. People matter and 4. Science matters.

5.2.1 Context matters

Context, people, space and time do matter. This work established all these aspects already in the theory chapter at the beginning of this thesis. Our two cases differ a lot in that aspect. In Norway we can see a well-integrated approach of area-based adaptive planning and MEBM that considers historical aspects, spatial particularities and the managed and unmanaged pressures that are put on the CWC ecosystems. In Chile this is nearly fully missing. We can see some first attempts to consider the context and more than just the current state of the ecosystems, but it is not enough. This thesis argues therefore to take Norway as a best practice example for the integration of context in area-based adaptive planning and MEBM.

5.2.2 Linkage matters

Fragmentation is a problem that can be seen in both cases. This leads to a loss in efficiency in the use of space and to new problems, like more difficulties in the enforcement of protection measures and higher costs for the management of the protected areas (Fraschetti et al. 2009). Linkage is very much needed between different government levels and between different sectors. This is the main weakness of both cases that can be taken from this thesis! For the

Trondheim fjord and the Comau fjord it has been established that fishing and ecosystem protection are the main rivalling interests. But it has also been argued that there can be a beneficial solution for the economy, as well as the ecology through implementing protected areas for cold-water corals. The interdependence of the fish with the corals leads to an increase in the stock numbers through a protection of the ecosystem (Appendix A6). Therefore, the right way to go would be to seek balance between use and exploitation of the ecosystems through the use of more adaptive planning and MEBM strategies.

5.2.3 People matter

People matter is the third guideline and Norway does again lead the field by offering a collaborative approach to adaptive planning and marine ecosystem-based management that does include a variety of stakeholders and interests, listens to them and includes the findings into actual practice. The inclusion of different interests throughout the whole planning and management process is lacking in Chile. Even though some first attempts in order to include the local stakeholders can be seen, especially in the area of tourism. Nevertheless, the inclusion of different viewpoints into the actual planning and management process is way too little and not in line with MEBM characteristics. This might be due to the high fragmentation in the governance level, but also due to less experience with stakeholder involvement.

5.2.4 Science matters

The fourth characteristic is science matters: It is not only people that matter but also science. This has also been stated a lot throughout this research. Nevertheless, in the field of CWCs research was left out and overseen for a long time. And now there is a need to act, even though not all data is available at this point (Jackson et al. 2014). There is a big knowledge gap when it comes to marine ecosystems and their specifics, especially in the field of cold-water corals (Fraschetti et al. 2009). Research must of course be pushed forward, but the planning and management strategies cannot rely on having all the data before they are out into place (Jackson et al. 2014). Norway does indeed face the challenge very well and manages to speed up the research and implement new technologies in the process. The MEBM is very adaptive and open for corrections. In Chile the research is still behind and it is also not implemented into the MEBM strategies. In cases where Chile is simply not capable of generating own data, it might be a good first step to focus on result that are published by other countries and international research institutes. For both corals it has been shown that climate change and ocean acidification can cause harm to the ecosystems in the fjords. Research on cold-water corals has also shown that slopes and a variety of terrain characteristics influence the distribution of the corals (Morato et al. 2019). In order to protect CWC ecosystems it is therefore not just crucial to manage them and the human impact properly, but to also plan protected areas according to biochemical spatial attributes of the fjords (Morato et al. 2019). In terms of evaluation and monitoring both cases are lacking well developed strategies. There is still room to improve that aspect.

As final answer to the research question *`How can adaptive area-based planning and management be implemented in marine ecosystem-based projects for cold-water coral*

systems in fjords in Norway and Chile in order to create a balance between socio-economic use and environmental protection?' we will have to go back to the adaptive planning and management ideas of Wondolleck and Yaffee (2017) from page 16b and 17 of this thesis and remember the adaptive planning practice and MEBM concept designed by Lister (2008). This thesis concludes, that their concepts are already very well developed but needs some concretisation for the CWC ecosystems in particular. Figure 11 shows the main ideas combined in six important steps.

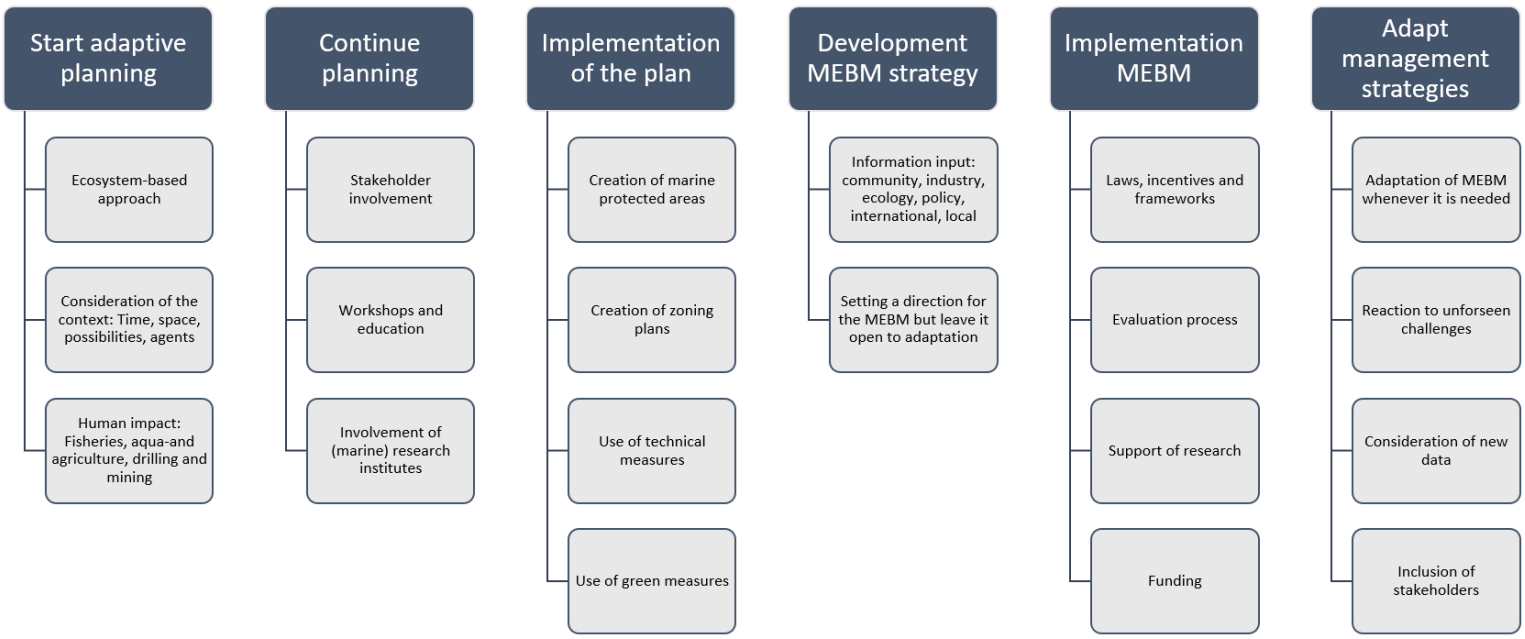

Figure 11: 6-step approach for successful area-based adaptive planning and MEBM for cold-water coral ecosystems

After having done all the research about the two cases and having analysed the strong and weak points it has become clear that a successful implementation of an area-based adaptive planning practice, as well as marine ecosystem-based management is not easy to achieve, since many factors influence the CASs of CWCs and the open system, in which they are found. In order to achieve a successful ecosystem-based approach this thesis proposes a 6-step approach. Planning and Management as the two main steps are each divided into three sub-steps. For the adaptive area-based planning practice the start of the adaptive planning process should be ecosystem-based and consider the context as well as the human impact and socio-economic interests, in a second sub-step refers to the stakeholder involvement, education and inclusion of research institutes. The third sub-step is about the creation of protected areas, zones and relies on technical and green measures. By following these three steps it should be possible to create spatial plans for the CWC areas that are well suited to guarantee

protection, without losing the socio-economic benefits of the ecosystems. This is a first step for seeking balance.

The second step is about the MEBM dimension and starts with the development of the MEBM strategy. The collection of information and the setting of a general target direction for the development of the area are the main aspects of this stage. In the second sub-step the implementation of the MEBM needs to happen through the laws, frameworks. Funding, investments in ongoing research and evaluation must also be part of this step. The third sub-step is then about the adaptation of a current management practice. Sudden changes, new information and new socio-economic or environmental needs must now be considered, and the management plan has to be changed in order to fulfil the target of balancing use and protection of the CWC ecosystems.

The successful implementation of area-based adaptive planning practice and MEBM can be achieved by following these six steps. There is an urgent need to consider the spatial particularities of the CWC ecosystems in fjords that has been left out until now. Cold-water corals are depending on downstream connectivity paths and access to nutrition in order to fight the negative impacts of climate change and ocean acidification and these special features need to be acknowledged (Morato et al. 2019).The planning of protected areas needs to consider negative impacts from fishing, aqua-and agriculture, mining and drilling, as well as climate change related issues. Also surrounding ecosystems and human interest in the fjords must be considered, since the CWCs live in an open system that is influences by others. This can be done through environmental niche modelling and by relying on localized studies in order to get a better understanding of biological and chemical processes, that are influencing the cold-water coral ecosystems in the fjords (Morato et al. 2019). Additionally, it seems to be beneficial to close some areas completely for fishing or at least for a certain time (Stelzenmüllerand Pinnegar 2011. Furthermore, the positioning of aqua-and agriculture around the fjord systems is an important spatial decision that does also depend on the water circulation and connectivity of rivers with the fjords (Filgueira et al. 2014). An ecosystem-based approach that focuses on these aspects does implement area-based adaptive planning and marine ecosystem-based management in ecosystem-based projects for cold-water coral ecosystems in fjords and can create the much-needed balance between use and protection of the valuable ecosystem.

5.3 Further than the Norwegian boarders?

This work did focus on creating a concept that balances use and protection of CWC ecosystems in fjords but did also touch the idea of cross-border learning and possibilities for policy transfer from Norway to Chile. Norway is simply way ahead in terms of research and practice of planning and management of cold-water ecosystems. Therefore, it might be beneficial for Chile to implement some concepts, that are used in Norway. Chile does struggle with the funding and money could be saved by taking some ideas and inspiration from abroad. Especially, in terms of context matters and people matter Norway is on a very good path. Further research should focus on the possibilities to transfer some of the approaches to the

Comau fjord in order to improve planning and management concepts in the area by using some of the Norwegian practices.

5.4 Reflection

This thesis combined the fields of marine biology, planning and management in order to create a comprehensive view of the ecosystems by having a look at the two cases of the Trondheim fjord in Norway and the Comau fjord in Chile. This research was meant to be a comparative research, in which the both cases could learn from each other. In this thesis Norway ended up taking the lead in all areas of interests and therefore the possibilities for cross-border learning and policy transfer are also very limited, in the sense that Norway can offer a best practice example for Chile but not the other way around. It would have been good to have a second example on a similar high standard in terms of adaptive planning and marine ecosystem-based management to compare different but maybe similarly effective approaches. This is something that could have been improved by using a different second case to compare to Norway.

A weak point of this thesis is also the lack of clarity about the actual results of the developed approach. It cannot be proven that the developed approach will work, if it is applied. Therefore, it would be great to have the approach taken into practice and have a long-term study about the success and the possible weak points in the concept. All in all, a lot more research will be needed in order to determine long-term results of the protection efforts of CWC ecosystems in order to create adaptive planning solutions and management plans that can cope with the high complexity and the many interrelated sectors and processes, which need to be taken into account in order to balance use and protection of the ecosystems. Working on the topic, it has become obvious that many aspects are of importance – maybe more than can be covered in one master thesis.

6. Conclusion

The main concern of this thesis was to find a way, to ensure and allow for human use of cold-water coral ecosystems, balanced with protection of the ecosystems and their ecological relevance. It has been shown, that there are many uses of the ecosystems and that a variety of stakeholders' benefits from healthy cold-water corals now and in the long term. Besides other uses, fisheries are still both, the main beneficiaries of and the main threats to the vulnerable cold-water corals. This thesis has also created an extensive picture of the CWCs as part of an open system, that mirrors the complexity and the interdependency of complex adaptive systems. Area-based particularities and scientific knowledge are also important key factors of understanding, planning and managing the systems. Throughout this work the open systems, in which the complex adaptive systems of the cold-water corals Lophelia pertusa and Desmophyllum dianthus, have been researched in detail and under reconciliation of their specific circumstances in the Trondheim fjord the Comau fjord.

Some similarities have been brought to light and a deeper understanding of the areas of interest – namely ecological relevance, fisheries, aqua- and agriculture, drilling and mining, climate change, stakeholder involvement and current management practice - and their variables have been established. Similarities and differences for both areas and ecosystems have been discussed by relying on a scoring system that was created out of the four reflexive perspectives for area-based adaptive planning and marine ecosystem-based management taken from Wondolleck and Yaffee (2017) and additional ideas of other planning theory related research papers (Wondolleck and Yaffee 2017c): *context matters, linkage matters, people matter and science matters*.

The scoring, as well as the results have been discussed in detail and a very extensive six-step approach for successful area-based adaptive planning and marine ecosystem-based management has been designed in order to achieve a balance between use and protection of cold-water coral ecosystems in the future. The approach introduced by this work is very comprehensive but leaves room to adapt a set strategy throughout time, in order to leave the planning and management strategies adaptable to the robust and flexible open systems it is designed for. The proposed approach follows six steps: three relate to the planning dimension and three to the management dimension. The idea is, to follow those steps in order to create a resilient CASs, that will not be pushed out of equilibrium. Socio-economic interests, climate change and ecosystem protection can coexist by applying this practice and in the case of sudden external or internal changes the management strategies can easily be adapted.

At the end of this thesis the idea of a possible policy transfer or at least cross-border learning, for Chile has been discussed. Norway does take the lead in terms of planning and management in an adaptive manner and can therefore be of inspiration for Chile.

Future research should react to this idea and find possible solutions to improve the current area-based planning strategies and MEBM for cold-water coral ecosystems in Chile, in order to ensure an improved balance of use and protection. Right now, Chile lacks expertise and the

rapid economic growth overpowers the protection efforts. Furthermore, it is a good idea to extend this research by integrating another case, which is as successful as Norway in balancing the use and protection of cold-water coral ecosystems, in order to have an equivalent case to compare to the Trondheim fjord. This might lead to some more input for the proposed six-step approach developed in this thesis.

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Appendix

A1) Guideline Maximiliano Sepulveda

Semi-structured interview with Maximiliano Sepulveda, the senior officer of pew charitable trusts – 2.06.2020 (00:41:45 minutes)

1. How many marine protected areas does Patagonia have? What is the history of MPAS in Patagonia? (context matters)

2. How much salmon farming is happening in Patagonia? (linkage matters)

3. Is fishing allowed in the Comau fjord? If so, is any gear allowed or are there restrictions regarding specific practices? Bottom trawling? (linkage matters)

4. Of what importance are the cold-water corals (especially D. dianthus?)? Are they important for the ecosystem? Are they protected in Patagonia? (context matters/science matters)

5. Who is in charge for the protection of nature and the ecosystems in Patagonia? How high is the stakeholder involvement? Does the public care a lot about the nature protection or more about the economic gain from e.g. fishing (public awareness)? (people matter/ linkage matters)

6. Funding is a severe issue for Chile. It is under the 10 most underfunded countries for biodiversity conservation in the world. What can be done to get more funding and raise more money? (linkage matters)

7. Is the Comau fjord under any environmental protection? If so what kind? (context matters)

8. How is research done in the Comau fjord? Are there many new technologies? (Does it deserve the nickname `Terra incognito´? (science matters)

9. How harmful is the inflow of organic and inorganic matter from rivers into the Comau fjord? Is it a severe issue? (people matter)

A2) Transcript Maximiliano Sepulveda

Transcript A1: Maximiliano Sepulveda

Date: 02.06.2020

00:41:45

MS: Maximiliano Sepulveda

LK: Leyla Krebs

The […] is used for moments of breaks and unrelated information to the topic like technical issues. Hesitation sounds like ´ehm´ and `eh` are not transcribed, since they do not add any information to the thesis.

LK: I sent you some question already and I would like to discuss them. I have to additional ones but that refers just to some general information about your work, about what you know. Just so that I get an idea for my work. So far you do know that my topic is adaptive planning practice and management in marine ecosystem-based projects, and I am comparing the work that is done in Norway and the work that is done in Chile.

MS: Why those two countries? I know they share similarities but are you personally interested?

LK: Yeah, very much so, because I would like to do an internship at the Alfred-Wegener-Institute, I am not sure, if you know it, it is a German research institute and they so a lot of work in Chile. So, that is why I am so interested in Chile. And then I wanted to compare at it to something that is, closer to Germany, because I know more about the regulations. And that is how I came to Norway.

MS: So, you are based in Norway, right now?

LK: No, no I am in Germany, but we don`t have any cold-water corals. That's why I chose Norway. […] Good, and I am doing my master's degree. It is a double-degree programme from Groningen in the Netherlands and Oldenburg in Germany. So, there is a combination. […] Okay, my first question would be `How many marine protected areas does Patagonia have and what is the history of marine protected areas in Patagonia in general?´.

MS: I don't have a specific number. I can look for the statistic in some moments for you. But the history, like briefly, in Chile the protected areas have about a hundred years right now. They started terrestrial as in many of the other countries. In Chile the first protected areas weren't in the Patagonia region but during the 60`s there were a huge creation of parks and reserves. In that time the reserves were called forest reserves. But were thought or planned for construction in a sustainable way of the forests but these have been converted to national reserves. I don't know if you know the legal framework in Chile but we do have; we are signatories of the Washington Convention, which is a Convention that comes from the United States and is mostly signed by countries in America, in South America also, like Chile. And that Convention is really useful, if you take a look on that one, because the names indicate, what is a national park, what is a natural reserve, what is a national monument. And the goals, the objective and the overall framework that you have in these areas. […] And in this area of Chile there is a concentration of a higher number of protected areas and the biggest protected areas in the whole country. That means that probably the whole protected area system in represented here in 80% of the country. And that is, as in other countries of the world, that is because it is an area which is very isolated and is very hard to achieve access and because there is a low population density. So that's like the typical variables for the protected areas, like far from everything. And then of course in the past that had a big value, because it has a big wilderness and a lot of opportunities for tourism. Or as water reserves, or it is the area with the highest concentration of glaciers in the whole South America. And also, it is one of the few areas in the world with the component of fjords, which is something we share with Norway. And it is interesting, I was looking for some singularities of the fjord and in case of the southern hemisphere it is like 99% of the word. There is a small dip in Folkland or something, but it is mostly in Chile. And these protected areas that I named before, the national parks, the national reserves and the national monuments are und the Washington Convention and they are ministered by CONAF. CONAF is an institution, it is a mixture between national parks in the United States and National forest services, so it is charge of management of forests native, or non-native like for example pine-plantations or eucalyptus, which are not invasive. But also, the fire combat, which is another big tank of work for this institution. And recently, only recently, I would say the last 10 years there has been a recent development a creation of other figures of protection. Such as marine parks, marine reserves, multiple-use areas in marine parks and other figures that are more related to indigenous governance. That has been developed last 10 years only.

LK: So, it is pretty new?

MS: Yes, pretty new. There are some important areas in Patagonia in the south for example the coral- and marine park or the Paso Drake Marine Park, that is big in terms of size. But most on this region it is very interesting to say, that comes from the old Washington Convention, that was mainly focussed on terrestrial, but the borders have been reviewed and do not include marine portions. There are created big pieces of marine areas und protection.

LK: Okay, that is pretty interesting. So, right now it is recently new that you protect the marine areas. […] But there are not many people in the protected areas. So, how do you work with the stakeholders? Because, there are not many people that depend on the areas of the fjords?

MS: Well, I mean there are just two situations that we can say, there are not many people. One is the population that lives in these territories, like the local people, which is few people. And also, these areas have no park rangers, mostly. Most of them do not even have a management plan. We call them paper parks. So, they were created by a law, but they were not implemented or planned, or they don't have specific finances or funding. And because of that they also don't have any park rangers and because of that they are not implemented, and strategies differ. They go through the environmental impact assessment process, which is an important measure to detect them but also, they are other threats that are not formal in the environmental impact assessment, such as invasive species, free-ranging cattle, illegal extraction of resources, logging etc. that are not managed properly. The good thing is, there is a low population density in these areas. Therefore, those threats are pretty low normally. So, they are in the border, these areas are so huge that normally it is not like a catastrophe, I would say.

LK: So, you have a high quantity of protected areas, but the quality is a little bit lower. And that is because of too little money and funding basically?

MS: Okay, so, I don't want to show an image that is not correct. The parks don't have any money, any management plan. Most of them, I would say probably 90% of the protected areas in the region. And they don't have funding because there is not interest from the government currently. Chile is one of the, I think actually you mentioned it in your presentation, lowest funded countries in the world in conservation, right? And that is true, we suffer from that. Chilean PEW and other NGOs we are working on that, that kind of problem. But I will say that also, I Patagonia, because of the low population density, the threats and the quality of this areas in terms of nature is pretty good.

LK: Yeah, I would agree with that.

MS: So, if you go there you will see that `Wow that is pristine, there is nobody here´. Except current threats, such as currently in the marine pollution, the salmon farms in the northern parts for example. This was the last twenty years, there was a rapid change of the landscape in terms of the marine uses. There are other risks and, you know, especially focused threats, such as mining and also of course tourism, that depends on how many visitors there are in an area. But mostly, more than the tourists per se, the visitors, damaging some ecosystem or something is probably the connected risk of fire. For example, Torres del Paine, which is some of the most visited parks in the whole country, there has been fire for about three or four times, because of the tourists.

LK: So, the tourists light fire and they just burn the area?

MS: Yeah, by accident of course, which is very bad.

LK: Coming back to the marine protected areas, you talked about salmon fishing, so how is the history of that? Is it new? Or just growing bigger? Is it a big threat?

MS: First of all, salmons are not from this hemisphere. They are from the northern hemisphere. So, if you ask the northern counterpart, or if you read from the United States, they are actually protected and their parks are looking for their protection, because at the same time they are also a benefit for local communities, indigenous communities, local and rural economies. There is a whole thing about that, right. In Chile there is this mixture…; so, the first salmons came to Chile for fishing. For fly-fishing or sportfishing. And that was about, let's say, 30 or 40 years ago, where they were released in most of the watersheds in the whole country. And they did pretty well in the south. And our local, our native species of fish are smaller and slower in terms of movement. So, they are very vulnerable to the salmons. We have about four species of salmons, if I think. I think it`s two salmons, well two trouts and two salmons. I can't remember the names. And the trouts, they came from the fly-fishing. There was huge promotion about that kind of sport. And you can probably find the fly-fishing lodge and Chile is actually a good spot to visit, if you are like fly-fishing obsessed. That is kind of the profile that these people have, the fishermen. On the other side, around the 90`s with its peak in the 2000`s, there came the salmon industry as a farming production. And they started in the northern part of Patagonia. I don't know if you are familiar with the process of the salmon farming, but they have a fresh-water cycle and they move the cages to the se, the marine portion. And the fjords are just perfect for raising and the salmon farms. In the north, which is the part more studies, there has been described important impacts in the biodiversity but also in the social component, because those few people, they were farmers, they were rural people. When the farming industry arrived there, they changed the whole social, you know, connections. Like, for example you can imagine, a couple of farmers and that suddenly the landscape changed, because of this and they offer jobs and the men need to go into the farm, into the marine part and they need to stay for two weeks and the women need to go to the other industry, where they are slicing the salmons and creating cages. And that happen very fast and it has been collapsing in not many times but at least twice importantly. The collapse of the system was related to diseases and also to algae blooms. So, it is very vulnerable, and they are also trying to expand to the south. And that is kind of the ongoing history in that we are these days.

LK: Okay that is pretty interesting. So, in the fjords there are the salmons and they are swimming around and the fjords and, when the fisherman come, what do they use as fishing gear? Because, I read, that the trawling nets, bottom nets, tend to destroy the cold-water corals, because they go all the way down to the ground. Is there some research on that or is it an issue or is it not that big?

MS: The people who fish go normally to the rivers. So, you need to divide the salmon problem. On the one side there are the wild salmons that are in the rivers and then you have another problem with those farm salmons, which are in cages, floating in the marine coast. Those salmons, the one on the farms, produce a lot of sediments. And they affect the bottom of the sea. And there is some research and I can probably also try to connect you with some recent studies and research on the impacts of this effects of the salmon industry in terms of industry, of farming. And they are both a little bit connected, because there are escapes also from the farming cages. And when they escape, they probably connect with these other wild populations. But they are also having another impact in terms of predation and competition with the native species. And there is also another, different group of research, where you can explore, what is going on there.

LK: Oh, that's interesting, because I am focusing on the cold-water coral Desmophylum dianthus and I just read, okay fishing is a threat to the corals but what you say sounds very logical and I do have a friend from Chile and he said the same. That there is the wild salmon and there are those cages. So the nutrients from the cages are a threat, and the fishing is only related to the wild salmon. Are there any restrictions for fishermen, when they are in the fjords? Are they allowed to fish there, or do they have to follow a legislation?

MS: Yes, there are restrictions. I mean, you want to fish anywhere in the country, you need a permit. Like a probably in Germany, for hunting and for fishing, you got this licence. And you have a limit. And this is kind of funny and contradictory, because the government, or not the government, the state … well, there is another history, that probably complicates this a little bit more. […] So, there is another environmental problem in Chile, which is related with the legislation, with the laws. When you ask for `What are the legislations, restrictions for salmon or wild salmons?´. Well, salmons are under supervision of the Fishery Service, which is under economy. And there are also the same services in charge of natural marine parks and marine reserves. So, they are in charge for the protection of natural resources but at the same time they are looking for economic incomes, right. From whatever. So, we are in Chile, that is the eleventh year, under a new framework to create a service called the `Service of Biodiversity and Protected Areas´, which is a recommendation from the OECD countries. And this recommendation has created the minister of the environment ten years ago, it has been creating different legal needs and services but we are still missing this service, which means that we not well coordinated in Chile in terms of; okay, it is legal to fly-fish inside a park; yes sometimes it is, but can you strike the salmons, because they are invasive, no you can`t because they are protected. Why? Because, they want to continue the business of promoting Patagonia, or in general Chile, as a good hotspot for to fly-fishing of trouts. Even though, there is proof that trouts are one of the main threats for biodiversity in fresh-water ecosystems. So, you have that kind of crazy things.

LK: That's all very conflicting, I guess. So, it is always economy vs. ecology at some point. Okay, we talked about money, we talked about environment. So, when it comes especially to the Comau fjord, do you know about that, too? Or is it just not your common area?

MS: No, I mean I have been working in different areas of Patagonia. I know, where it is located, I know what it is, more or less but I have never been there or been working with locals particularly from this fjord.

LK: Okay, and just another question. What are you working on, right now? Because I know that you, that PEW, is NGO work. So, what is the latest thing, that you have been working on? Is there something that is maybe interesting for me, too?

MS: Well we are working in Chile, Patagonia for … by using two different strategies, of course connected: One is the creation of protected areas, looking for the integration of the terrestrial and the marine ecosystems in different figures. They could be from the national parks, reserves and monuments that I mentioned to, you before and the Washington Convention but also under the new categories including of course specific components of working with the local communities on this creation. So, looking for a bottom-up process. And in the other strategy, that we are focus on mostly and that is my particular goal, in terms of work. I am focused on improving the standards of the parks or protected areas that are already created. Remember that I mentioned to you that it is no funding, no park rangers, no management plan, that there is no governance? Ok, that is my focus. So, in those that are already created I am looking for funding for them, I am looking for improving or getting park ranger there, with enough capacities and implementing strategies to decrease the threats and also improve the connections between the local people and the connected areas in terms of the benefits, that they can provide.

LK: So, that is pretty much what I was reading, too. It does make sense to use those existing parks and improve just the quality. And you say, you try to raise money. But what can you do to really raise money for those projects?

MS: [laughing] Pray, every morning. And wait for something. No, it is crazy, because the current situation is even worse to be honest, because protected areas are not in the top one priorities of any

politics or the minister of budget. But, because most of the people doesn't see the connection of the well-being from the development of the protected areas. So, one of the strategies, that we use, even not only talking about funding, is to provide information of what are all the benefits that protected areas have for people. That is one thing. And the other one is to be working, to estimate the costs. Because people say `yeah it is one thing, the park doesn't have enough money. But how much money is the money?´. So, I work in estimating the costs of the strategy to create those parks from the current scenario to a minimum standard scenario and costing all the strategies. Once we have an effective costs to accomplish the minimum goals for the protected area, that means, okay, reducing the threats, sustaining the natural resources, providing benefits for the people, a governance structure with the local people, monitoring not only biodiversity but also human well-being and all the different results decreasing threats, how much is that? And once we know how much that is, we look for funding and we look for funding in different strategies. One is the governmental funding. That is defined by law every year. So, we work together with the service that sends the ministers of the parks to create their proposals for this funding. Looking for, putting information into the legal legislators for example. Also, there is a very important source of funding in every protected area probably around the world, that is related to tourism. We try to work in term of predicting in terms of how much revenues will come from visitors, how much are the statistics of the visitors in terms of numbers, how much is a good number in term of not impacting the ecosystems and not impacting the local communities. So, we also work on that input of funding. And finally, we also work with private donors. We had, today we have, we suspend an initiative that was called BFE, that was kind of famous during the last two years in Chile, because we were pretty close to get an agreement between the Chilean government and a group of philanthropies open to donor, to create a donation, a very important donation to fill the gap of Chilean Patagonian parks. But at the same time, they were expecting that the government will put a similar number into the initiation process.

LK: Ah, I read about that, too, yeah!

MS: And because of this situation, not only this one, but also in October we had a social crisis, that started very complex in terms of social, economy, financing expecting to create a new constitution that initiative was suspended. It is put on hold right now.

LK: Okay, what you describe sounds a lot like adaptive planning practice. Because, one of my degrees is environmental and infrastructure planning, my first chapters of the work will be about planning theory. So, what you describe sounds a lot like adaptive planning and that's what my thesis is about. And the whole idea of `education first´ and `raising awareness´ between stakeholders and local people that does sound very solid so far. So that is quite a good input.

MS: Just to close that part of the financing: We are also now moving to the regions, the local regions, not asking for money for the central government, rather going to the local regions to allocate the regions´ funds, because the regions also have finances for funding. And to create with them, this what we call a virtues connection between parks and local people. So, trying for example to instead of investing into infrastructure inside the park, trying to promote capacities in local people to offer beds, and food and services and using the park only as an attraction where there is only a basic road, or trail, with nice views and activities but moving all the commodities in terms of lodging, food services and others to the local communities. That's what we call the working with communities' concept.

LK: Okay, that does sound pretty helpful. And when you talk to the local people: How is the awareness? Do they know about environmental threats? Do they care about fisheries or is it more that they focus on the economy and less on the environment?

MS: Well, the local people in Patagonia are mostly rural, besides the one that live in urban areas. But urban areas are a few and small. So, because rural people normally understand very well, where is the water coming from; it comes from the forests or the glaciers or the river or the lake. They raise cattle, which is one of the main threats. Or it was actually the main threat in the past, because when the colonizers, you know the word `colonisadores´? Like this are the first people that arrive to a place.

LK: Ah, yes. I know the word.

MS: Actually, there were a few from Germany in the south of Chile. In the case of Patagonia, the government had a contract with different countries, particularly with Germans and in the southern part here in Patagonia with Croatians on that time Yugoslavia to raise farms, even if they had to burn first the forest. So, they were huge forest fires in the past. I am talking about a hundred years ago maybe. And currently that huge sheep farms for example in the south or in the northern part of Patagonia with cattle are today a threat but the people understand a lot of the environment. The people know that they can't cut the last tree and they are in the process of getting more sensitive. But at the same time, they do need an economic income from some option. That is kind of the challenge.

LK: You also talked about the cattle farms and some minutes before I said the salmon farms probably release nutrients into the water of the fjord systems. And what about the cattle farms? Are there any nutrients or organic or inorganic matter that go into the water?

MS: For sure. I think so. I don't think there are studies in this area; maybe I am wrong. I am not sure. I don't want to confuse in terms of this is intense cattle farming. In terms of cattle. It is for case of sheep, because in the southern part of Patagonia, sheep is a serious industry. It is very intense and there is like an Australia kind of thing, like huge areas with thousands and thousands of sheep in just one farm. But it is not the case for cattle. Cattle is like small farmers, with mostly like not more than twenty cows or cattle. It is different. But it would probably be the case for the sheep faming. But I don't know if there is any research about the sediments or problems with this.

LK: I just thought about it, because in the Netherlands it is a huge threat, because they have so many nutrients released into the water and now it is a very big discussion what to do about that. Okay, so we had the salmon farms, sheep … what about mining? Is there a threat, too? Is it happening or to what extend?

MS: It is happening. I don't know, if you know but in Chile one of the main sources of the BPI is mining. We are famous for basing our economy on copper mining. And because of that there is a huge legislation, culture and services and companies that are experts on mining. And this is, the copper mining has extremely focused on the northern part of the country and the central part of the country. That means Santiago to the north. But it is been moving the last decades to the south, particularly to Patagonia. So, there a few areas, projects that are taking place in some areas around the parks or inside the parks in some cases. Because of the mining laws. It is one of the superior laws. And you know, I don't know if you know, but laws in different countries, they have like levels. So, a constitutional law is lower than a service law. Something like that. Or an international convention is a huge law. And the mining law is one of the highest ranked laws. So, there is this conflict, is it possible to have a mining operation inside a park? There are actually cases, and they are not that clear why they are occurring. What about recreation; did they accept the mining process? It is, I don't want to say that you will go to a park and you will see like a whole park destroyed because of the mining but it is a threat, that is potentially important.

LK: Okay, so the mining law or the allowance to do that is more important than environmental protection, when it comes to the weighting of the laws.

MS: Yeah and you will need to put that fight on a combat. Because today, to my knowledge, I never see a process where some mining is actually entering in an environmental impact assessment process, and the counterpart is sort of competing which is the most important law. There is a park that has been created and because there is mining interest, the park is modified to have the mining company just beside the park. There are crazy situations, where you can in national parks, which is the highest level of protection, you will see a dam or a mining operation, because it was there before the creation and there was not another way to create a park. And they just have the mining inside the park or that industrial operation inside the protected area. And it was like a long time ago, so nobody is trying to revoke that. There is no way to revoke or to remove a process that has already been approved legally.

LK: Yeah, of course.

MS: I don't want to say that this is like a common scenario in different areas in Patagonia but in a few cases, it occurs, and it is a potential threat.

LK: Okay, that is good to know. Because I didn't have mining so much on my plate before, for the fjord systems. But it might be worth to look into that, too. Do you know anything specific about the Comau fjord? Like any legislation or important news?

MS: Sorry, I don't know any specifics. Let me look, I think I remember and probably you need to search more. Let me look for a map. Yeah, I think it is connected with the history of the Pumalin-Park. So probably you will need to explore a little bit more with some other people. I assume you have heard from the Tompkins Conservation and their big donations to the Chilean government. Recent donations. So, from what I know, I think, the terrestrial part around the Comau fjord was one of the pieces of the puzzle that they missed to complete they connection of different parks in Patagonia. I think the Tompkins Conservation, they didn't make it, because it was already ministered. I don't know the details to be honest.

LK: Yes, it is okay. I just wanted to ask, because you are an expert. And I thought maybe you had some input on that, too.

MS: And in the marine part. In the fjord part, that you are interested in I shall check. I maybe can give you something but once I checked.

LK: Okay, that is great. And I told you I wanted to do an internship at the Alfred-Wegener-Institute, that does a lot of research in the Comau fjord, especially for the Desmophyllum dianthus but due to COVID I couldn't work there. So, I had to reschedule there and start in a few months. So, I had to figure out another way, but it works [laughing]. I think you answered already all of my questions. So, I think I am done. I don't have any more questions.

MS: Excellent. In case you have any more questions or progress or something to share or some ideas, we will be happy to see, how your thesis work is progressing.

LK: I will for sure send you my final work in the end and maybe I will also contact your colleague. You sent me the contact information, so maybe I will try that, too. And you will at latest hear from me, when I am done with my writing.

MS: Okay, Leyla, very good luck with your work and thank you.

LK: Thank you very much.

A3) Guideline Pål Mortensen

Semi-structured interview with Pål Mortensen, senior researcher at the institute of marine research in Norway– 4.06.2020 (00:54:22 minutes)

1. Norway is known to have many fjords. Is there a lot research on the ecosystems done? What are current projects of the marine research institute? (science matters)

2. Of what importance is the cold- water coral Lophelia pertusa? Are the reefs important fish habitats or do they have any other ecological value? (context matters/science matters)

3. Gene sequencing proofed that the Lophelia pertusa populations in the fjord systems have a high genetical distinction from the ones in the oceans. What are the differences? Does that have any impacts on their protection? (context maters/science matters)

4. Is fishing allowed in the Trondheim fjord? If so, is any gear allowed or are there restrictions regarding specific practices? Bottom trawling? (linkage matters)

5. Do nutrients coming from mari-and agriculture have an impact on the Lophelia pertusa reefs? (linkage matters)

6. Is mining an issue in the Trondheim fjord and if so does it have an impact on the cold-water coral reefs? (linkage matters)

7. How high is the impact on climate change on the reefs? Do acidification and temperature rise have an impact on the Lophelia pertusa reefs? (science matters, linkage matters)

8. How high is the stakeholder involvement? Does the public care a lot about the nature protection or more about the economic gain from e.g. fishing (public awareness)? (people matter/ linkage matters)

9. Who is in charge for the environmental protection in the Trondheim fjord? Is marine ecosystem-based planning on the agenda? How do you evaluate the planning approaches regarding their efforts to maintain and use the resources related to the Lophelia pertusa reefs? (context matters)

A4) Transcript Pål Mortensen

Transcript A2: Pal Mortensen

Date: 04.06.2020

00:54:22

PM: Pal Mortensen

LK: Leyla Krebs

The […] is used for moments of breaks and unrelated information to the topic like technical issues. Hesitation sounds like `ehm´ and `eh´ are not transcribed, since they do not add any information to the thesis.

PM: I can start by telling you a little bit about my history of research on cold-water corals?

LK: Yes, I would like that.

PM: So, I actually started up in the early 90s, when the Norwegian company Statoil, as it was called then, now it is called Equinor, they discovered cold-water coral reefs, outside the coast of Norway at different places on the shelf. So, one of the areas, the famous reef area called the Sula reef is located in the middle of the route for a gas pipeline. Going from, I think it was the Heidrun gas field to the shore. And they realized that that was pretty unique and so they started a small project, where I was engaged in 1993. And I made some reports for Statoil based on ROV inspections with video records and later I took some samples with the project crew. A later it became the topic of my PhD. And at the same time professor Andre Freiwald, another professor at that time, he was actually focussing at the same thing. But I published first a paper in 95, based on the findings that came from the Sula reef and different papers came out later, when it was not only the oil and gas industry that had focused on this but also, since local fishers were worried about the destructive effects of the big trawling industry. The local, coastal fishermen, using long line, they wrote worried letters to the institute of marine research in Norway, which is a governmental advisory institute to also doing research not only on this but mainly on fish stocks and the ocean climate etcetera. So, I was contacted, and we wrote an application to the Norwegian research consul and we got a project to study the effect of bottom trawling in areas with coral-reefs. And we went out, did more mapping of new areas and then I finished my PhD in 2001 and my employment at the MRI was not renewed so I went with my family to Canada for three years, because they announced a cold-water coral position mainly based on the same concerns as in Norway; environmental effects. And this was funded by kind of a petroleum fund and of course the main focus was also fisheries, because that is the biggest concern. We also realized that, even today. So, I stayed there for three years and then they announced a permanent position at this institute, institute of marine research, again. And I have been working with cold-water corals but also habitat mapping, seabed mapping in general, since 2004 in this institute. So, I have written a whole number of papers.

LK: Yeah, I saw that [laughing].

PM: A small number of them dealing with human impacts. I have also been involved in a project of evaluation of seabed habitats. And part of that was also evaluation of corals. So, I will see, if that report is available in English but we found out, that we could give attributes to the different individual reefs. We don't know anything about the local, ecological importance or the actual biodiversity. But what we know is the size of the reef. We also know the southern most reefs in Norway they are quite unique and the northern most are actually unique for the whole world. So, we set that as criteria for uniqueness. And we have the shallowest occurrences in the world, so we also used the depth as kind of an uniqueness character. So, we scored the reefs based on that and then also, that was the individual reefs, and then areas were evaluated in more grid cells. So, the number of reefs in a grid cell was also an attribute for evaluation. And I will see, if I can find it in some of my literature. So, that was the evaluation and when it comes to management and protection measures, this evaluation has some … new areas have been identified and defined with in some years intervals and the last time that this was revisited was in 2015, I will send you that report, even if I cant remember, if it was in English or Norwegian. But I will send it anyway, because it is good for you to have the reference and you can see the basic information, even though it is in Norwegian. So, I think we have in the order of, at least fifteen marine protection areas for cold-water coral reefs in Norway. What we don't have so much is coral gardens. And when speaking of coral gardens, I am sure you are familiar with the classification of VMEs

– vulnerable marine ecosystems. I have also been part of the working group for cold-water ecology, since the last twenty years. And this group revises the list of VEM indicators and the classification of VMEs. So, in that context you have three different kind o sources to think about: That is the FAO, the food and agricultural organisation FAO, and then hey have made guidelines for the fisheries in the high seas, so they are, to define VMEs they have their own criteria. And then you have OSPAR, Oslo-Paris-Commission, and they have, I think OSPARs definitions are a little bit older than the FAO criteria. Its an overlap but slightly different terminology and names. And then ISIS – the working group for the deep-water ecology – tries to kind of combine these things but relies basically on the vulnerability criteria defined by FAO. You can read about those but its basically you know fragility, longlivety, ecosystem function, yeah, different criteria. So, this is the basis. I mention this, because I mentioned about coral gardens in Norway. My pint there was first to bring you into the classification of those and then to say that coral gardens with, yeah hard-bottom coral gardens, are typically characterized by large gorgonian corals, like Paragorgia and Primnoa. They are not so common in Norway and actually most occurrence is. These corals occur on coral reefs. And that is of course interesting. What do you call them then? Are they just part of the reef? Or is this a mosaic of habitats? I think we tend to focus on the reefs and not make it problematic by saying coral reef/ coral garden ecosystems but there are some few places with coral gardens on hard bottom. Coral gardens do also occur on soft bottom. And in Norway we have two gorgonian species that can build coral gardens or coral forests, if you like. That is Isidella lophotensis, a kind of bamboo coral. Those are, this species is more or less completely restricted to Norwegian waters. It occurs in some of the fjords and also in the deeper part of Skagerrak, south-west of southern Norway. Oceana, the organisation has been there with an ROV and has filmed the seabed and in connection with – you have heard about res lists? Red lists for species but there are not so many red lists for habitats and ecosystems, but Norway has produced res lists for ecosystems and habitats. And the latest addition was in 2018, if I am not wrong and there, we identified the coral gardens with Isidella lophotensis. It was vulnerable, because this is an area with high intensity of trawling. So, this species, with its occurrence at this location is at the red list of Norwegian marine ecosystems. And also, the other type of soft bottom garden, the Radicibus gracilis, that is also a gorgonian coral living on soft bottom belonging to the, ah what was it, I think it is another group of corals. So, there is only one location in Norway so far that we have located a quite high density of this. In English the group of corals is called pig tail corals, because they are kind of curly. And there was lot of trawl marks in the seabed, so we came to believe that this unique occurrence was also very stressed than. So, this is also on the Norwegian relist. The Lophelia reefs in Norway, I continue to use the old name. You know the Lophelia pertusa, the scientific name is Desmophylum pertusum. But many of my colleagues continue to use Lophelia pertusa. And in Norwegian Lophelia reefs is kind of a common language word. So, we can still accept that the species is Desmophyllum pertusum but we call it Lophelia reefs. The Lophelia reefs are very abundant in Norway. I don't know if you know, or if you realize that Norway has probably the highest abundance of Lophelia reefs is the world. We know, that there are many more reefs, than those that we have verified. We have verified around 1.500 individual coral reefs. But we are sure that there are more than 10.000 reefs and the geologists, and most biologists disagree because the geologists just want to use the topography to identify them and then they get an overestimate. So, if you google this, you can see some sensational news talking about 250.000 reefs in Norway. I think that is an overestimated, because they pick up all the topographic structures that may look like reefs. But there is certainly a huge number of corals reefs or coral mounts, if you like. Yeah, speaking of that, the definition of reef was an issue at the start of this, I would call it, deep sea coral pioneer area. The first pioneer area was in the early nineteen-hundreds with zoologists studying the fauna and rigid material especially in Norway. Lots of publications on the fauna on coral reefs. There is especially one guy, called

Carl Dons, from Norway, he made an excellent overview paper, unfortunately only in Norwegian. Where he discussed and presented, yeah, he presented a location about two hundred individual coral reef locations and tried to relate it to the environment etc. So, then when I started up with my research in this, in 1993, and later my first paper, the referee of the paper said, `no you cannot call this reef you must call it a bioherm´. You know, the coral is also called a hermatypic, it can also be called a zooxanthellate, because they don't have zooxanthella. The shallow water ones are zooxanthellate but not all zooxanthellate corals build reefs but those that than build reefs are called hermatypic. So, there was a big confusion, what it does mean, when we call this coral a hermatypic zooxanthellate. But my referee told me to call it bioherms. Bioherms of Lophelia pertusa. But then quickly after it was accepted in discussions among colleagues that the term reef is not restricted to shallow water even though the word reef comes from the Dutch word `riff´ or something. That is a structure that a ship can be … can go on ground. That is a riff. Borkumriff. So, it was agreed that the reefs are not restricted to shallow water and for my PhD I used the same definition as presented by Wood. I cannot remember the exact definition, but I can send it to you.

LK: I think I used the same definition in my work. I will have to check it.

PM: So, it means that, when the seabed is made of a structure of a bio organism than it is a reef. Therefore, you can also have mussel reefs. But in this case, they are coral reefs. But the reef doesn't need to be alive. It can be a dead reef. And the lower limit is not precisely defined but it needs to be, as you say, a structure on the seabed and not only one colony. But that is a little bit tricky to define, when do we go from individual colonies to a reef. So, therefore, also the Lophelia and other colonial scleractinians, as more solitary colonies and be components of what is called hard bottom coral gardens dominated by coral scleractinians. For instance, where there are not possibilities to build up carbonic structures and everything is just falling down, Lophelia contributes more to what is called a coral garden. But this is also confusing, because some research does like to call the wall reefs. So, it is always to remember that definitions might differ in the different publications for a lot of things. So, those were the definitions of types. Also, I have seen quite a few Norwegian Lophelia reefs. But I have also seen one location, that was totally made up of Madrepora oculate. So, it means that this species can also build cold-water coral reefs. Madrepora oculate is a different colonial scleractinian coral. Quite different. But at some places around the world they build more reefs but normally in Norway they are just scattered. Except very few places, where you have a dominance of Madrepora oculate. This is actually not so very well known or published in scientific reports.

LK: So, I get scientific knowledge per first-hand [laughing].

PM: Yes, it is. But also the Norwegian report by Carl Dons from 1994, he mentions one location, where he only was able to dredge out Madrepora but it is a little bit risky to interpret results from dredging, because you don't know exactly how the dredge was performing and where it was sampling etc. So, I didn't believe in Carl Dons, until I saw it myself at another place that we had Madrepora reefs. So, what more to say? I can say that the northern most reef in the world that is verifies, you will read details in the literature I provide. It is actually surprising healthy and big. You would expect that, approaching the geographical limits of its distribution, then you would enter suboptimal conditions and just find some smaller occurrences but it seems that the conditions are good and present until the water and the occurrences are different and the conditions are not a variable at all. It is a very sharp limit in the north. So, this is the north of a finish island. I can not remember the exact position. But we found the remains of a totally damaged reef a few kilometres further to the north. And we listened to fisherman

that have been explaining that in the seventies they used some old trawling gear to clean some places. And this was very clear from the observations at the northern most reef. I wrote a little bit about that in one of the publications, that I will put in a folder. So, when it comes to management a special thing for Norway is, that when we documented the situation and described the uniqueness and importance of these structures, that are typically between 7.000-8.000 thousand years old, in Norway. But the oldest one, even though there is no exact date, the date of the skeletons is quite precise, but we never know, if we were able to find the oldest pieces in the place, because we haven't been inside the central parts of the reefs, just the outside, So we found out that 9.500 years and it seems like the Norwegian waters , suitable habitats in the Norwegian waters, were habitats quite quickly after the last glaciation. So, the larvae came, and reefs developed simultaneously at many places. So, these oldest reefs they are up to 35m from foot to top and make a coral layer from 10 to 15m thick and they have been growing there, as I said, the last 9.000 years. So, then everybody, including the management bodies in Norway realized that that is very unique and important. So, therefore in 1999 there was this general ban on destroying known coral reefs on purpose with deliberate clear cutting of the bottom. In addition, I wonder how many areas was declared, I don't know, but there was Sulla reef and a couple of others. They were protected under the Norwegian fisheries law to protect them from active bottom gear. That mean trawling and other gear that is dragged along the seabed. So, it means still longlining and gillnetting is allowed. And then, I think at least one are in the Trondheim fjord, it's called Selligrunnen, you will find that in the literature also was protected under a different law dealing with biodiversity. I cannot remember the name. But it means that most of the protection areas are protected under the fisheries law and just very few under the biodiversity law. The one in the fjord that is protected under the biodiversity law is protected against several other activities than fishing, but also fishing of course, but also you need a special permit to sampling there, you cannot dredge or enter, yeah.

LK: So, the Trondheim fjord is under special protection, because it is the biodiversity law, right?

PM: Yeah, so, its just a small area there. But then you have the reefs close to the Swedish border and there are some protection areas, part of a national park. And also, let me see, if I can just open a website. I can share with you my screen. Let me see. […] So, you can see mareano.no. […] If you can go to map and data, for instance coral reefs. […] So, this is actually a quite nice tool. And now I am looking for this protection area in the Trondheim fjord. […]

LK: I will have a look at this, too. Also, I read, that in the Trondheim fjord, there are some special Lopehlia species, because there was gene sequencing and they are very distinct from the populations in the oceans. Is that right?

PM: Can you repeat it one more time?

LK: Yeah, of course. I read, that the Lophelia pertusa population in the Trondheim fjord is very distinct from the ones in the oceans, because they did some gene sequencing in order to find that out and that is why they are even more unique and more special, because they are very rare.

PM: I haven't seen any more recent publications on it but back in the, I think more then twenty years ago, I think it was said that the coastal cold-water coral populations were kind of relicts and unique as you say. But I think there is limited data on it. […] Okay, do you have some question for me, maybe? [laughing]

LK: Yeah, I have some general questions, because I am looking mostly at the Trondheim fjord and the Lophelia pertusa and I am interested in, okay you said bottom trawling is the biggest threat. But are there any other threats? Is nutrient leaking into the water a big problem, a big issue? Or is it more like, small?

PM: Yeah, the other threats are a little bit, not so clear. You can see listed up everywhere in the order: Fishing, typically you would see petroleum- gas exploitation, but what you don't see so often, the next thing would be climate change, and someone would say ocean acidification. But what you seldom see is for instance aquaculture. But you may find it somewhere. And in the fjords of Norway aquaculture can be a local problem. But the problem is, that nobody has documented this very carefully. So, I have tried to kind of increase the awareness of this and would like to see a monitoring programme going on to see, whether there is a trend going on of declining health. So, this is for the coastland fjord populations, which are, I would say, more unique. You will also see from my publications that they are very diverse and you can see from the literature that they are, as you suggested, more unique genetically and they have, some of them should have a local, cultural importance, because local fishers have known about them for years and used them for longlining and this local ecological knowledge, recoding to this old report. By Carl Dons, they know exactly when to fish and how to avoid having the lines into the coral reefs and to fish, when the redfish is up into the water and not resting in the coral structures. We see that on the video. When the tides are either rising or falling. You know even up in the shelfs and everywhere, it is the currents, that is a very important factor. It brings the food and creates the currents, so at times you can have currents of, let's say, 25cm per second, which is half a knot. It doesn't sound very fast, but it is actually quite fast. At that time, when the currents are strong, we see that the redfish is laying on the bottom and saving energy and don't have to swim against the current all the time. Because, they like to stay in the reef.

LK: Yes, that does make sense. Protection …

PM: Yeah, and when the tide is high or low the currents tend to be weak and the fish tend to swim. And this is something the old fishermen knew. And they knew, when to fish at these local reefs.

LK: So, the public awareness about the cold-water coral reefs is there and given and you said at the beginning that especially the fishermen were concerned about the bottom trawling?

PM: Yes, that's right, that's right. But still the general public is not so much aware. The coastal and fjordic populations represent non used potential of for instance establishing local observatories that could be hooked up to the internet. […] Just like, it's about observatories that would not need to cost too much. You would need a cable and a camera and some light. In the fjords the distance is not to long so it should not be too expensive and you can use the power from land and get information back via the cable. So, let me show you. First, I need to share again. Share screen. […] Let me see, I will just google `love observatory´. LoVe stands for Lofote-Vesterale. With love.statoil.com, you can see it is ocean observatory. […] You can look into it, yourself maybe but previously you could go there and look at pictures taken right now. And by registering you could download datasets with images. And this was just for you to know that it is possible. Even with in this case a very long cable which is very expensive. And in the fjords and coasts it would be cheap. And it would be very nice for educational purpose and we can imagine having a display at a service or a museum or something and people could look `How does it look at the local coral reef right now?´.

LK: That is a nice idea.

PM: Yeah, so, that is art of the value of coral reefs of course and it's also part of the idea that coastal cold-water coral reefs are more valuable than the offshore ones. Another part of the value of corals reefs is, that since they are obviously so abounded since it has been though before, they could have potentially an ecological role that has been neglected. You know the differences between 100 coral reefs and 20.000 is great and knowing that each individual polyp can eat, we don't know exactly how much. But in the aquarium, I could feed them as much as they could take. They altogether they eat potentially big amounts of zooplankton. In Norway larger zooplankton is the major food. There is on banks a little deeper, it seems like the concentration of phytodetritus is also very important maybe more important. They have measured these things and found out that they feed a lot on the dead phytoplankton, phytodetritus. But in Norway it seems, I have analysed pictures from the LoVe observatory one time series from April to November one year. And they have a publication on that, and it seems like the behaviour of the polyps, the degree of extraction and detraction of the tentacles seemed to be in phase with the tidals. […]

A5) Lophelia pertusa and her associates

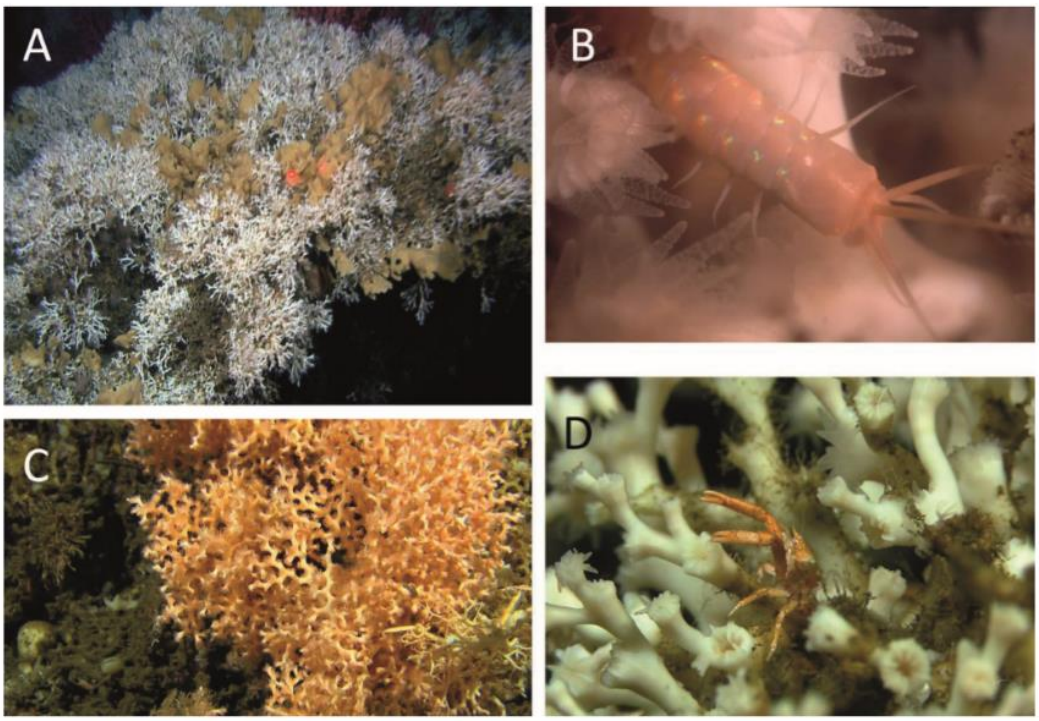

Figure 2. Close associates with *Lophelia pertusa*. A: Living part of a *Lophelia* reef with sponges. B: *Eunice norvegica* is a common polychaet living intimately with the polyps of *Lophelia* that rarely occur in other habitats. C: The scleractinian *Madrepora oculata* with the basket star *Gorgonocephalus* sp. (lower right). D: The squat lobster *Munidopsis serricornis* on the branches of *Lophelia*.

[1]

[1] Buhl-Mortensen and Buhl-Mortensen (2018).

A6) Fisheries and protected areas

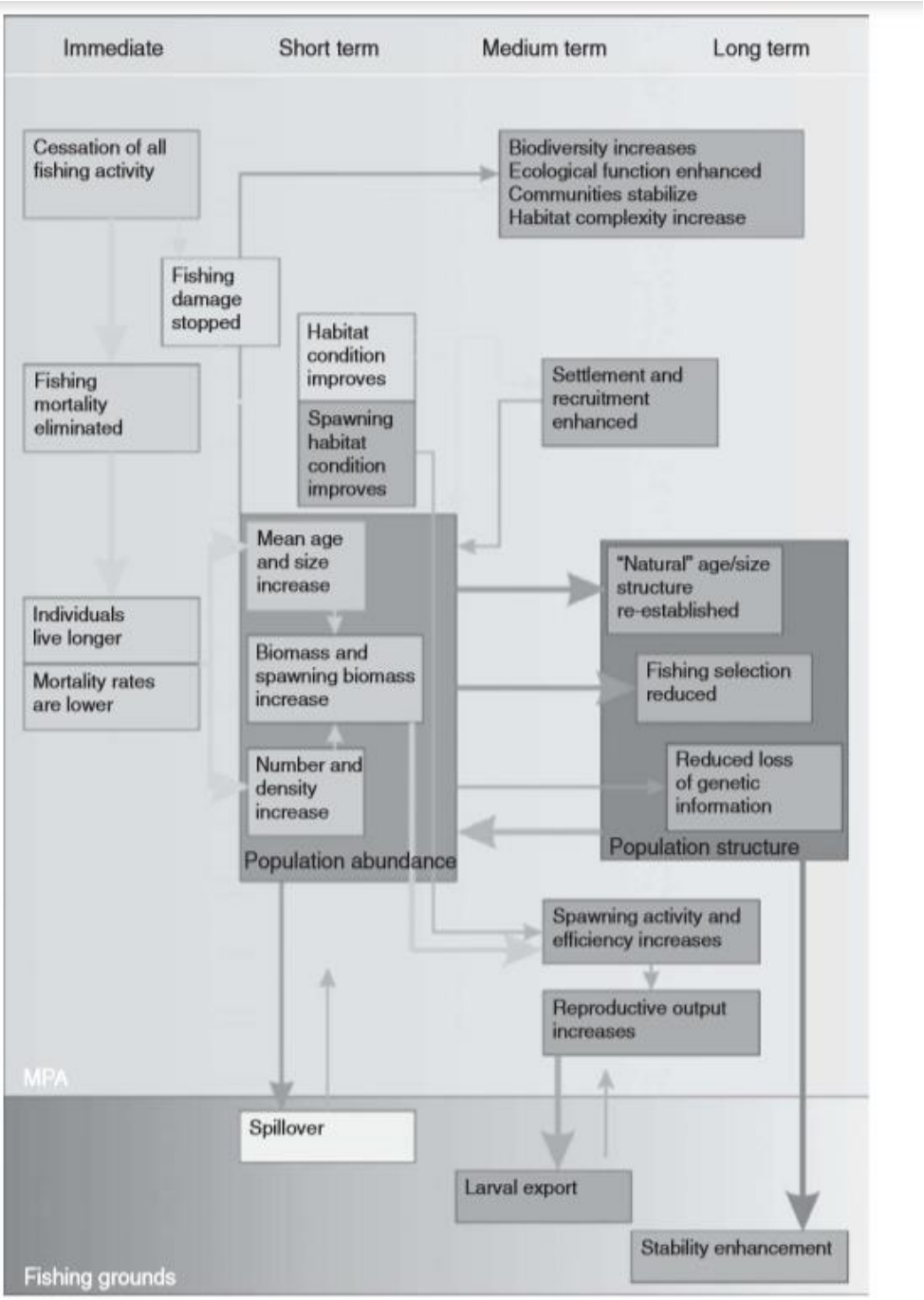

Figure 7.1 This conceptual model shows the pathways by which an MPA establishment could lead to environmental enhancement within the MPA, and potential fisheries benefits outside the MPA through the processes of spillover, larval export, and stability enhancement. The large upper box represents an MPA, and the lower box represents the fished areas outside the MPA. The size of arrows roughly indicates the hypothesized importance of pathway to the potential fisheries [2]

[2] Stelzenmüller and Pinnegar .

A7) Questionnaire Norway: Why should Cold-water corals be protected?

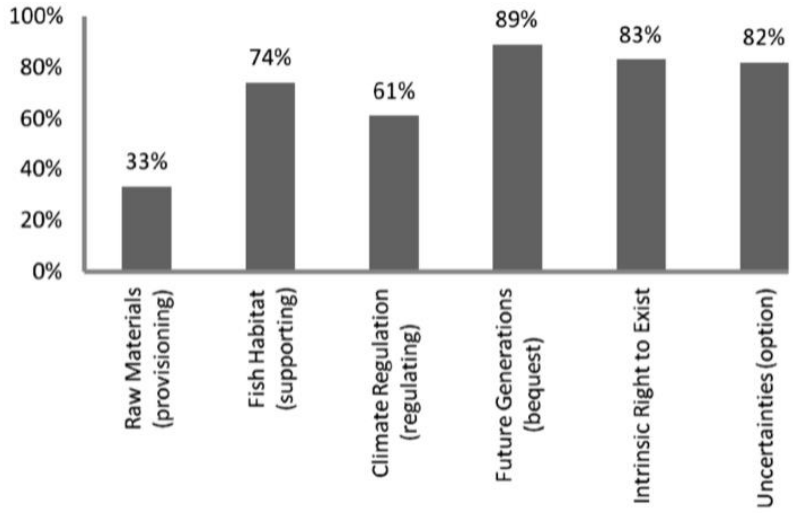

Figure 2 Reasons that CWC should be protected, questionnaire results.

[3]

[3] Falk-Andersson et al. (2015).

A8) Environmental and Social Impacts of Mining

Table 2. Potential Environmental and Social Impacts of Mining

Stage	Activities	Potential Impact
Exploration	▪ Geophysical/ airborne surveying ▪ Drilling/trenching ▪ Trench blasting ▪ Exploration camp development ▪ Road construction	▪ Habitat loss/ fragmentation ▪ Runoff of sediments/ increased suspended sediment load to surface water ▪ Disturbance to wildlife and local communities ▪ Increased demand for local water resources ▪ Spills of fuels and other contaminants ▪ Increased colonization due to road development ▪ Species loss due to hunting
Site Preparation/ Mineral Extraction	▪ Mine construction (vegetation removal, stripping of soils) ▪ Mine infrastructure development (power lines, roads, etc.) ▪ Construction of plants, offices, buildings ▪ Mine camp construction ▪ Creation of waste rock piles ▪ Creation of low- and high-grade ore stockpiles ▪ Blasting to release ores ▪ Transport of ore to crushers for processing	▪ Habitat loss/ fragmentation ▪ Chemical contamination of surface and ground waters ▪ Declining species populations ▪ Toxicity impacts to organisms (terrestrial and aquatic plants and animals) ▪ Altered landscapes ▪ Increased demand for water resources ▪ Increased demand for electrical power ▪ Increased erosion and siltation ▪ Altered patterns of drainage and runoff ▪ Dust/fumes from explosives ▪ Increased colonization due to road development ▪ Species loss due to hunting
Processing/Smelting	▪ Milling/grinding ore ▪ Chemical leaching/concentration of ore ▪ Smelting/refining ore	▪ Discharge of chemicals and other wastes to surface waters ▪ Emissions of sulfur dioxide and heavy metals ▪ Increased demand for electrical power
Transport to final markets	▪ Packaging/loading of final product ▪ Transport of product	▪ Noise disturbance ▪ Dust/fumes from stockpiles
Mine closure/ Post-Operation	▪ Reseeding/ revegetation ▪ Re-contouring waste piles/ pit walls ▪ Fencing dangerous areas ▪ Monitoring seepage	▪ Persistent contaminants in surface and groundwaters ▪ Expensive, long-term water treatment ▪ Persistent toxicity to organisms ▪ Loss of original vegetation/biodiversity ▪ Abandoned pits/shafts that pose hazards and health risks to humans ▪ Windborne dust

Source: Adapted from Miranda et al., 1998; Ashton et al, 2002.

4

[4] Vásquez-Lavín et al. (2013).