The Potential of Marine Protected Areas in Marine Conservation: Is the Wadden Sea an Effectively Protected Area?

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Abstract

In this thesis we investigate which factors are important for the constitution of an effect Marine Protected Area (MPA). With this knowledge we then try to answer the question if the Dutch Wadden Sea is an area with effective protection measures. The ocean provides valuable ecosystem services, but due to several anthropogenic stressors it is becoming a degraded ecosystem. MPAs are protected parts of the ocean where human activities are limited allowing ecosystems to recover in the absence of human exploitation pressures. Therefore, MPAs can play a key role in the protection of the ocean as they can integrate conservation and commercial interests. However, most MPAs fail to reach their goals due to ineffective management. Key features of MPA management are divided in a biological and a socioeconomic component. An MPA must balance both components to be effective overall. Biologically successful MPAs are: no-take, highly enforced, old, large, and isolated. Socioeconomically successful MPAs actively engage and inform stakeholders, integrating their cultural/economic interest into their design, thereby creating a broad support base. The Dutch Wadden Sea is an ecologically invaluable ecosystem being part of the world's largest continuous intertidal flats. However, just as the rest of the oceans, the system is under pressure from anthropogenic stressors. To protect the ecosystem, many rules and regulations are in place. We examined the factors that were determined to be important for MPA success. The system scores well on enforcement, age, and stakeholder engagement. Size, isolation, and fishing regulations are acceptable. Stakeholder perception of the protected area must be improved as this was quite negative. Therefore, we conclude that the Dutch Wadden Sea must be seen as a relatively effective protected area.

Introduction

The ocean provides valuable ecosystem services to humans such as: global food security; natural products, medicine; oxygen production and storm protection (Homlund & Hammer, 1999; Worm et al, 2006; Sandifer & Sutton-Grier, 2014). Furthermore, the ocean's fish provides the animal proteins for 17% of the world population (Kriegl, Ilsovay, von Dorrien & Oesterwind, 2021). Also, fisheries provide jobs, directly and indirectly, for many people as the value of the fisheries sector is estimated to generate between 225 and 240 billion dollars per year (Dyck & Sumaila, 2010). It is safe to say that the ocean plays an invaluable role in human society.

Through our extensive exploitation of the ocean, we have directly and indirectly influenced it. Nowadays, fisheries are one of the biggest drivers behind ecological and evolutionary changes in the ocean (Worm & Branch, 2012). With advances in technology, we are now able to fish in places we have never been able to reach before, resulting in almost no parts of the ocean remaining free from anthropogenic influence (Pauly, Watson & Adler, 2005; Halpern et al, 2008). A study on long-term fishery biomass trends showed a consistent decline in fish and invertebrate biomass from 1950 in almost all climate zones (Palomares et al, 2020). Various fishing techniques destroy different habitats and are detrimental to benthic communities (Jennings & Kaiser, 1998).

Besides overfishing, there are other anthropogenic stressors threatening the ocean. Striking examples include: global warming, ocean acidification and eutrophication. Global warming threatens coral reefs, which are diversity hotspots (Jackson, 2008). Ocean acidification causes reduced calcification in marine plankton (Riebesell et al, 2000). Nutrient rich land runoffs degrade and cause eutrophication in the water, creating anoxic "dead zones" (Diaz & Rosenberg, 2008). These are some of the more direct and measurable effects but less is known about the indirect effects, such as trophic cascades, of these stressors on marine ecosystems.

Even though we do not know the total scope of these indirect effects yet, we keep on exploiting our oceans to and beyond its limits. Evidently, we need to protect the ocean more to keep its ecosystem services intact.

Historically it has been difficult to protect the ocean as large parts are not necessarily anyone's property (Lodge, 2012). This can lead to a "tragedy of the commons" situation where everybody wants to profit from a resource that is common property. As everybody wants to profit nobody limits themselves as to how much they can take of the resource, eventually leading to its depletion and the situation where nobody can profit anymore (Berkes, 1985). To avoid this scenario rules and regulations are needed.

In 1982 several rules and regulations were established in the United Nations Law Of the Sea Convention (LOSC). They aimed to establish "a legal order for the seas and oceans which will facilitate international communication, and will promote the peaceful uses of the seas and oceans, the equitable and efficient utilization of their resources, the conservation of their living resources, and the study, protection and preservation of the marine environment" (Churchill, 2015). Among other things, the LOSC provided a framework for the exploitation of Living Marine Resources (e.g., fish). It binds states to limit their fisheries' harvest in their exclusive economic zone and on the high seas to the maximum sustainable yield, to prevent the collapse of populations (Matz-Lück & Fuchs, 2015).

Marine Protected Areas (MPAs) are another protecting measure for the oceans. These are: "designated parts of the ocean that restrict human activities to a certain degree" (Kriegl et al, 2021). The concept of MPAs had been around for almost a century but it started gaining importance with the first World Congress on National Parks in 1962. The number of studies on MPAs increased and in 1992 a global goal was established at the Rio Earth Summit that by 2010 10% of the world's oceans should be protected by MPAs (Humphreys & Clark, 2020). This goal was not attained and at the 2010 Convention on Biological Diversity it was postponed

until 2020 (Fox et al, 2011). Currently, at the beginning of 2021, according to two different databases which use slightly different definitions, 7.7% or 6.4% of the oceans are being protected by MPAs (Kriegl et al, 2021). So, although measures are being taken to protect the oceans, we still have a long way to go as they are far from perfect.

The potential of MPA's is very promising. If managed well the utility of an MPA is undeniable. MPAs provide animals a refuge from fishing, and other stressors, allowing populations to recover (Bohnsack, 1998). It has been reported that inside marine reserves populations increase in size, age, and reproductive potential (Gell & Roberts, 2003). But many areas that are labeled as an MPA on paper fail to achieve their goals due to several reasons (Edgar et al, 2014).

In this thesis I will explore what constitutes an effective MPA. Which features are important for either the success or the failure of an MPA? We start by studying the functioning of MPAs after which we will look at features important for success. We will then apply the knowledge gained to the protected areas that are in place in the Dutch Wadden Sea, trying to answer the question if the Dutch Wadden Sea is an effective protected area.

What Are MPAs and How Do They Work?

MPAs are "designated parts of the ocean that restrict human activities to a certain degree" (Kriegl et al, 2021). This is one of many definitions given to MPAs. However, the name MPA is a little ambiguous because it encompasses areas with different levels of protection that provide different levels of ecological benefits. An area where exploitation is strictly prohibited can be called an MPA but an area where exploitation is allowed with only light protection can be called an MPA as well (Lubchenco & Grorud-colvert, 2015). The definition by the IUCN is the one that I will use for this thesis. The IUCN defines MPAs as "any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and

cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (Kelleher, 1999). The IUCN also defines different categories for MPAs dependent on their management objectives reducing the ambiguity. These six categories range from strictly enclosed and protected areas with level of biodiversity and conservation goals to multi-use areas that allow sustainable exploitation (Dudley, Shadie & Stolton, 2013). These two extremes are also represented by two distinct types of MPAs: no-take MPAs (sometimes called "marine reserves") and multi-use MPAs.

No-take MPAs are areas where no exploitation is allowed, and public access is very limited (Rife, Erisman, Sanchez & Aburto-Oropeza, 2012; Costello & Ballantine, 2015). Multi-use MPAs are areas where management tries to integrate conservation with commercial purposes such as tourism and fishing. Multi-use MPAs are usually large areas with some restrictions on exploitation that contain small strictly no-take areas within them (Kelleher, 1999; Rife et al, 2013). Currently, MPAs are spread all throughout the world, in different habitats and

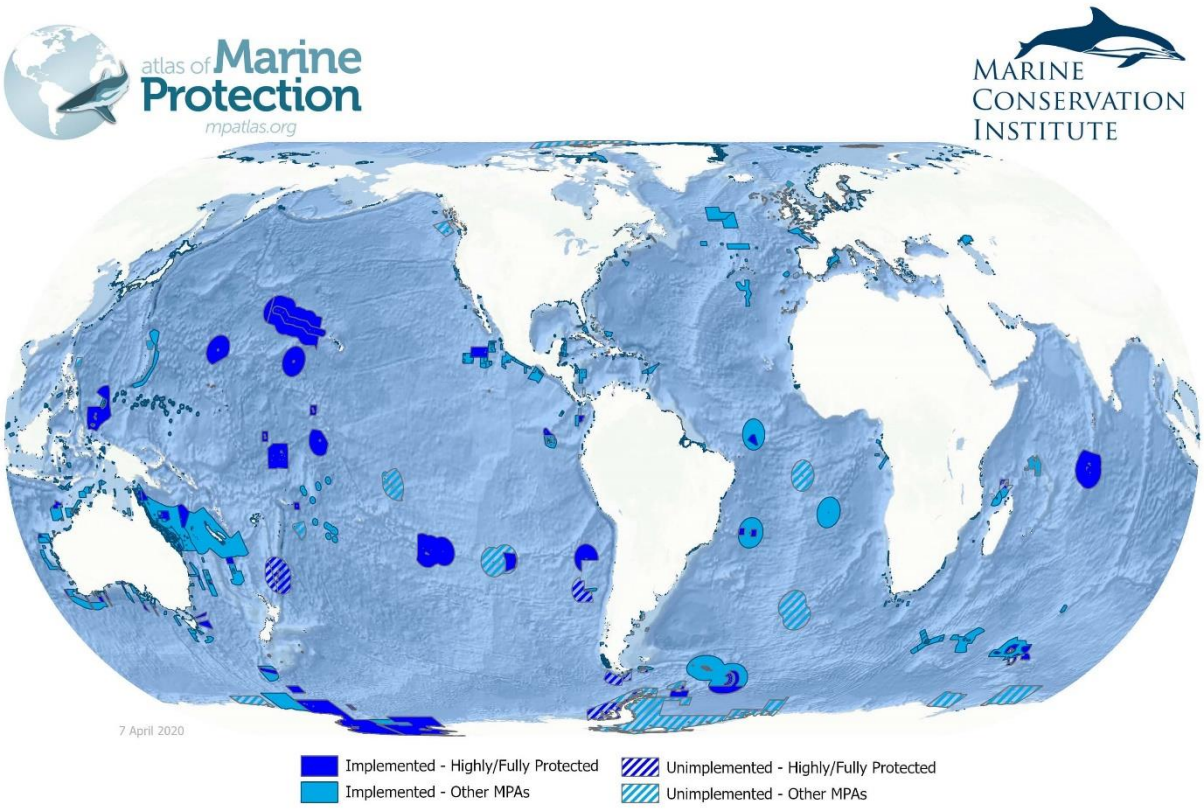

Fig. 1. Marine Protected Areas around de world. Dark blue: Fully protected MPAs; Light blue: Other MPAs. Lines indicate that MPA is unimplemented. (MPAatlas, 2020)

climate zones (Fig. 1.). However, from these MPAs less than 1% of consists of strictly no-take areas, which is not enough (Kriegl et al, 2021).

Having discussed the definition, the types, and the current situation of MPAs we now examine their functioning and the effects they have on the life and habitats within them. To understand this, we will be looking at the functioning of a no-take MPA. We look at a no-take MPA as there are less factors to take into consideration, providing a clear picture of MPA functioning and effects.

No-take MPAs are areas that exclude human activities, this provides organisms with refuge from human exploitation (Bohnsack, 1998). This absence of humans and human exploitation has several direct and indirect effects. Direct effects are the imminent results from the cessation of exploitation. Indirect effects develop over a larger time period as a consequence of the direct effects (Claudet, Guidetti, Mouillot, Shears & Micheli, 2011)

Direct effects can include: longer organism life span, greater densities, greater biomass, greater spawning biomass, and greater size due to absence of fishing. Furthermore, the absence of bottom trawling can increase the habitat quality (Halpern, 2003; Rodwell, Barbier, Roberts & McClanahan, 2003; Mosquera, Côté, Jennings & Reynolds, 2006). A 2009 study on 124 no-take marine reserves showed: a 28% increase in average size; a 166% increase in average density; and a 446% increase in biomass within the marine reserves (Lester et al, 2009). Several studies also reported an increase in species richness after the establishment of the reserve (Côté, Mosqueira & Reynolds, 2005; Harmelin-Vivien et al, 2008). This was however disputed by other meta-analyses which yielded no significant differences, possibly due to lacking sampling methods, so this effect remains ambiguous (Claudet, 2008; Claudet et al, 2011). These large direct effects can yield indirect effects from the changes in population structure.

Trophic cascades are indirect effects that can arise from predator prey relations. They can be described as “Indirect trophic interactions resulting from changes at trophic levels two or more trophic levels higher” (Fig. 2.) (Babcock et al, 2010). Fisherman usually start fishing the higher trophic level before moving on to lower levels, also known as “fishing down the food-web” (Pauly, Christensen, Dalsgaard, Froese & Torres, 1998). In fishing free no-take MPAs, the abundance of many upper trophic level predators has increased largely (Claudet et al, 2011). This increase in upper trophic level predators influences the abundance of their prey. With each trophic level in turn influencing the next. This way, trophic cascades can have profound effects throughout the whole community. For example, a 2003 study showed that through the recovery of urchin predators the grazing pressure from sea urchins was reduced in a no-take marine reserve. This resulted in a shift from an area with “urchin barrens” to new kelp forests (Shears & Babcock, 2003).

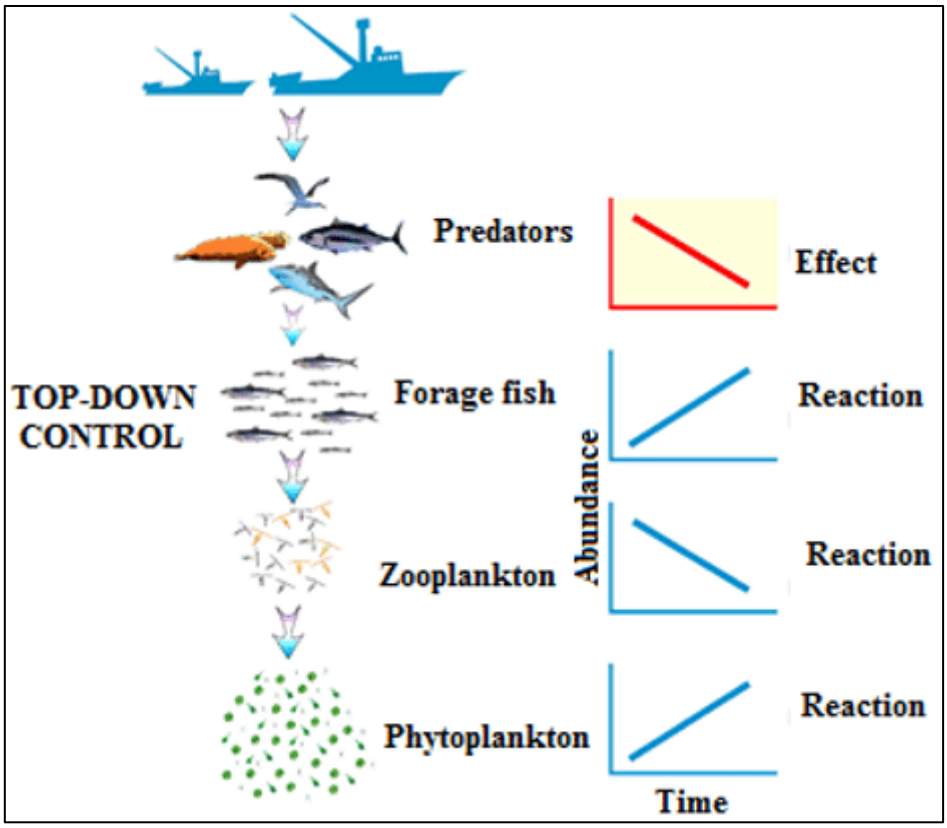

Fig. 2. A trophic cascade induced by fishing. (Cury et al, 2016)

Besides trophic cascades, there are more indirect effects which are also highly interesting for sustainable fishing purposes as they can influence areas adjacent to the no-take zone. These effects include the migration of adult individuals across MPA borders ("spillover") and the net export of eggs and larvae out of the MPA into the adjacent oceans (Gell & Roberts, 2003). Spillover occurs when the abundance of species inside the MPA increases and individuals start to leave the MPA, supplying the surrounding fished waters with a net export of adults and juveniles of commercially interesting species (Halpern, Lester & Kellner 2009) The export of eggs and larvae from the MPA is an indirect effect that can arise from the direct increase in spawning adult biomass. This effect is suggested to represent a greater benefit for fisheries than spillover effects (Jennings, 2000). However, as it is hard to gather empirical data on the exact amounts of export it has not yet been clearly shown (Russ, Maypa, White, Alcala & Calumpong, 2004). So, by effectively protecting one area fisheries could profit in the adjacent areas.

If we look at the combined direct and indirect effects, we can see the conservation and socioeconomic potential of well-managed and functioning MPAs. But this is where the subject becomes less clear. When is an MPA functioning as it should be? Do these effects also hold up for multi-use MPAs? In short, what constitutes a successful MPA?

Features for Success or Failure

To understand what makes an MPA successful, we first must look at the causes preventing them from reaching their full potential. After that we will look at several features that should be considered for a successful MPA.

Up until now most MPAs have failed to meet their goals. In the rush to attain the CBD's goal to protect at least 10% of the oceans, important factors are often disregarded by parties involved in the establishment of MPAs (Rife et al, 2012). Illegal exploitation due to lack of

enforcement (Byers & Noonburg, 2007), legal exploitation not in line with conservation goals (Edgar, 2011), and community resistance due to perceived negative effects (Sowman & Sunde, 2018), are all challenges that MPAs face. Also, many MPAs are "paper parks" which are "protected areas that do not effectively exist beyond the initial government declaration, providing only an impression of marine conservation" (Pereira da Silva, 2019). For all these factors there must be a balance between conservation and socioeconomics.

In the following section we will delve into these pitfalls and examine how stakeholders, "anyone who is invested in the outcome of management actions or decisions related to an MPA" (Himes, 2007), can avoid them, analyzing the factors that are suggested to be important for the MPA's success. Where we first only looked at no-take MPAs we now look at the whole range of MPAs, from completely no-take to multi-use areas. We divide the factors we look at into two components. A component with factors important for biological success and a component with factors important for socioeconomic success. As they are interdependent on each other they are both equally important in the establishment and management of an effective MPA. However, neither component can ensure MPA success.

The Biological Component

We will examine the biological component using the "NEOLI" features (No-take, Enforced, Old, Large, Isolated) (Edgar et al, 2014). In this study on 87 MPAs, which were both no-take and multi-use, it was shown that effectiveness (e.g., species biomass) increased if more of the NEOLI features were adhered to in an MPA. These features were categorized at low, medium, and high levels which are shown in table 1 for the purpose of clarification and the later comparison in the case study of the Dutch Wadden Sea.

Table 1. Classification criteria of the different NEOLI features

	Low	**Medium**	**High**
No-Take (fishing regulations)	Site openly fished	Some fishing methods allowed	No fishing allowed
Enforcement	Little control	Moderate control	well enforced
Old (age)	Regulations implemented <5 years ago	Regulations implemented 5-10 years ago	Regulations implemented > 10 years ago
Large (size)	MPA area < 1 km^2	MPA area 1-100 km^2	MPA area > 100 km^2
Isolated	Continuous habitat, not isolated	Boundary zone occasionally (1-20%) breached by continuous habitat	Isolated habitat by depth (>25 m) or sand barrier (>20 m in width)

No-Take (Fishing Regulations)

Before, we only looked at the functioning of no-take MPAs. In reality, many MPAs are multi-use, which makes it important to know if the positive effects of no-take MPAs also hold up for multi-use MPAs. However, several studies conclude that multi-use MPAs are less effective than no-take MPAs (Lester & Halpern, 2008; Edgar et al, 2011; Edgar et al, 2014). They show that no-take MPAs provide more conservation benefits than multi-use ones. This is due to multiple reasons.

Firstly, even a low fishing pressure can reduce the recovery potential of fish populations (Edgar, 2011). This is problematic seen as 94% of MPAs allow fishing and less than 1% is completely no-take (Costello & Ballantine, 2015).

Secondly, the tendency from fishermen to first catch the large fish still has impact on the area through trophic cascades, even though the fishing pressure is limited. This is shown in, for example, coral reefs in protected areas. Where through the absence of large predatory fish, habitat-modifying macroinvertebrates exert detrimental effects, such as grazing on corals, on coral cover (Mora et al, 2006; Edgar et al, 2011).

This shows us that even low fishing pressures in multi-use MPAs can have damaging effects on conservation. This also illustrates why it is very easy to establish an MPA that allows exploitation above levels in line with its conservation goals, as even limited exploitation can have detrimental effects.

Enforcement

Around the world many no-take MPAs lack in enforcement (Guidetti et al, 2008). The second NEOLI-feature underlines the significance of this. Without the proper enforcement an MPA is no more than a paper park. This leaves the door open for illegal exploitation, which can have detrimental effects on the conservation potential. Paper parks give us a false sense of MPA success (Rife et al, 2012). Therefore, enforcement plays a key role in the success of MPAs.

Old (Age)

Many new MPAs are established with the expectations that the effects will become apparent quickly. But as a lot of the effects only work over a longer time period, many MPAs might first appear to be unsuccessful (Claudet et al, 2011; Edgar, 2011). Here we come back to the direct and indirect effects. A study showed that direct effects can appear relatively quickly (5.13 ± 1.9 yr.), whereas indirect effects usually take much longer to show (13.1 ± 2.0 yr.) (Babcock et al, 2010). This makes sense as indirect effects include trophic cascades which are

reported to still continue after 25 years (Shears & Babcock, 2003). Therefore, it is very important to think about the age of an MPA before dismissing it as unsuccessful as many effects may be still in progress.

Large (Size)

MPA size has yielded some ambiguous results over the years. Sometimes showing a positive effect but sometimes showing no effect at all (Vandeperre et al, 2011). But several studies do show that increasing size has a positive effect on general MPA effectiveness (Edgar et al, 2014; Claudet et al, 2008). These finding were mostly true for highly mobile species, which benefit less from small MPAs, as they have large home ranges moving out of small MPA quickly (Edgar, 2011; Claudet et al, 2008). Although the size effects are less clear they should be considered when designing an MPA, especially as they can have effects on certain species.

Isolated

An area is isolated when it has a border zone that is not breached by continuous habitat. The 2014 study showed that with highly isolated MPAs the community-level biomass and richness increased more than with any of the other NEOLI features (Edgar et al, 2014). This might be since they are more easily recognized by fisherman and more easily guarded than MPAs in an intricate continuous habitat, raising compliance. (Edgar et al, 2014). Another study also points out that isolation could be a barrier to dispersal, keeping mobile fish within the borders of the MPA (Edgar, 2011). Therefore, the isolation of a habitat is also a factor that should be taken into account with the establishment of an MPA.

These factors in the biological component all play an important role in the success of an MPA. However, with MPAs, biological success is only one side of the coin, they are also dependent on the socioeconomic component.

The Socioeconomic Component

Within the socioeconomic component there are two important factors to consider: the local community and the commercial exploitation interest in the area. The establishment and the management of an MPA can drastically influence the people involved. People are forced to change their behaviour to comply with the new set of rules in place (Kriegl et al, 2021). In this instance, MPA stakeholder can be groups such as: the local community, fishermen fishing in/around the MPA, and the organization creating the MPA. It is easy to see that there can be large variation in interests in the MPA by the different groups. It is thus very important for the organization designing and managing the MPA, to try and incorporate all the stakeholders interests to get the support needed for an effective MPA (Brown et al, 2001). We will first look at the importance of the local community. Thereafter we look at the commercial exploitation interests.

For local communities, the establishment an MPA can have many negative effects: more poverty due to loss of livelihood; decreased food security as a result of more restricted access to food sources, and loss of autonomy due to the increased restrictions are but a few of the consequences possible (Bennet & Dearden, 2014). But if managed well, MPAs can have the opposite effects where the benefits outweigh the disadvantages. Studies report: decreased poverty (Tobey & Torrel, 2006), increased food security (Cabral et al, 2019) and more livelihood options, for example by increased eco-tourism (Fabinyi, 2008) in effectively managed MPAs.

One of the most important things that MPA managers need to do to gain the local community's support, is change the perception of the impacts from negative to positive (Webb, Maliao & Siar, 2004; Chen, Lin & Chuang, 2018). This is important as MPA success and support depend on the positive perception of the impacts (Bennet & Dearden, 2014). Another important factor for an effective MPA is stakeholder engagement. A study using 27 case studies

showed it to be the most important factor, from the factors they considered, in determining MPA success. They also showed that the absence of stakeholder engagement was the most influential factor determining MPA failure (Giakoumi et al, 2018).

The second important factor within the socioeconomic component is the commercial exploitation interests in the area that is being closed off. This will be mainly fishermen who would lose a part or all their usual fishing grounds. Therefore, fisherman usually voice concerns and resist the establishment of MPAs (Himes, 2003; Chuang, Chen, Chang, Hung & Liu, 2013). As was shown before, this is not needed as MPAs can benefit fisheries as well as conservation goals at the same time. It is thus important to provide adequate information and involve stakeholders in the process of establishment, as with higher involvement fishermen felt more comfortable with reserve managers (Himes, 2003).

In short, to avoid community disapproval and attain conservation goals managers need to make sure that: stakeholder interests are incorporated in the design; the local community profits from the MPA; and that stakeholders are engaged with the MPA. This allows for a broader support for MPAs by stakeholders which can result in higher compliance to the rules. Consequences of what can happen if this is not done are illustrated by a 2006 study that showed that poverty could move people to break the MPA rules (Tobey & Torell, 2006). For MPA managers it can be a difficult task to intertwine the biological goals with the socioeconomic needs in the establishment of an MPA. Adding to this is the fact that until recently the importance of socioeconomic was less recognized (Ban, Hansen, Jones & Vincent, 2009) But, as was shown, it is imperative that both components are considered to attain the MPA's goals

We have seen what successful MPAs have to offer us. Both conservation and socioeconomic problems can be solved if an MPA is managed effectively. We have looked at the problems they face and the most important factors for success. We now take the knowledge gathered and try to apply it to what is currently in place in the Dutch Wadden Sea.

The Wadden Sea: Case Study

With this case study we try to further our understanding of what constitutes an effective MPA by examining a real-world example of a system with protection measures in place. We start with a general overview of the Wadden Sea. We look at the ecological and socioeconomic importance as well as the efforts made to protect the ecosystem. After this we zoom in on the Dutch part of the Wadden Sea and examine in what ways it is protected and at what kind of protected areas are in place. Finally, we compare this to what we already know and try to draw a conclusion about the effectiveness of the protected areas.

Fig. 3. Map of the Wadden Sea area including the World Heritage Area borders. (CWSS, 2021)

The Wadden Sea is a wetland area along the coasts of the Netherlands, Germany, and Denmark (Fig. 3.). It contains habitat types such as: tidal flats, saltmarshes dunes and islands (Enemark, 2005). It covers 8,000 km^2, ranging for 500 km along the coast, from Den Helder

(Netherlands) to Esbjerg (Denmark) (Van der Aa, Groote & Huigen, 2004). Being the world's largest continuous intertidal flats, the Wadden Sea area is of great ecological importance. The ecosystem consists of 4,700 km^2, of usually submerged area, emerging at low tide supporting millions of birds with its rich benthic fauna (Kabat et al, 2012). This is the reason that the Wadden Sea is extremely important for migratory birds who use it to rest (Alberts, 2015). Beside birds, 2,300 plant and animal species can be found in the salt marshes and the waters contain another 2,700 species (CWSS, 2017). All and all, we can safely say that the Wadden Sea is indispensable to nature.

Humans too, use the Wadden Sea area in many ways. Natural resources for energy, shipping lanes, tourist destinations, fisheries and military exercises are some of the ways that the Wadden Sea is important to humans (Kabat et al, 2012; Alberts, 2015). It is also home to many, with 75,000 people living on the Wadden islands and 3.7 million people living along the Wadden Sea coast (CWSS, 2017). However, with many human activities in the area it is no surprise that the Wadden Sea is under pressure from the same stressors threatening the rest of our oceans.

The current Wadden Sea area is a degraded ecosystem, compared to what it was in the past, in terms of animal diversity and habitat quality. Just like other oceans the area is suffering from stressors such as fishing, pollution, and habitat destruction amongst others (Holm, 2005). Also, many important species have been lost due to intense fishing pressure (Lotze, 2007). It is clear that the Wadden Sea needs protection like the rest of our oceans to safeguard this important ecosystem.

Since 1978, Denmark, Germany and The Netherlands have been working together to protect and conserve the Wadden Sea in the Trilateral Wadden Sea Cooperation (TWSC). The TWSC committed itself to "guarantee the natural functioning of the ecosystem through the proper regulation of human activities" (Moser & Brown, 2007). From the TWSC came the

Wadden Sea Plan (WSP) in 1997, which was revised in 2010. The plan aims to create a healthy environment which respects the ecological integrity and diversity while allowing for sustainable use. It also emphasizes a management approach that integrates socioeconomic and ecological values (CWSS, 2017). Besides protection from WSP the Wadden sea has also been listed as a UNESCO world heritage site (UNESCO, 2021[1]). This listing can provide financial benefits as well as raise awareness about the importance of the site (UNESCO, 2021[2])

Dutch Wadden Sea (DWS)

We now zoom in on the Dutch part of the Wadden Sea and look at the ways it is protected and the protected areas that are in place.

The DWS covers an area of about 3,000 km^2 situated on the northern coast of the Netherlands (de Jonge, Essink & Boddeke, 1993). The area is protected in multiple ways, but the main policies come from the Key Planning Decision Wadden Sea (Planologische Kernbeslissing [PKB]). The PKB has been in place since 1980 and provides a "physical planning instrument with a strong legal basis" which binds authorities to its objectives (fig. 4.) (Turnhout, Hisschemöller & Eijsackers, 2008; CWSS, 2017). Besides The PKB the area has laws on the environment, mining, shipping, fisheries and more (Turnhout et al, 2008). The area also enjoys protection as a Ramsar site and as a Natura-2000 site (Boere & Piersma, 2012). These designations bind authorities to protect the area (European Commission, 2021; "The Ramsar Convention on Wetlands", 2021).

Within the DWS we also find areas that are closed off, part or all of the year, to some or all human uses. Article 2.5 (previously known as article 20) areas are closed off to recreational boating ("Nautin - Artikel 2.5-gebieden - Overzicht", 2021) (fig. 4.). There are also areas, sometimes overlapping with article 2.5 areas, that are closed off to the shrimp and mussel fisheries, which are the two largest fisheries in the Wadden Sea (Baer, Smaal, Reijden & Nehls, 2017) (Fig. 5, Fig. 6.). The DWS also has a reference area that has been completely closed off

since 1993. This 7,400-ha area serves as a reference point for monitoring and scientific research. (CWSS, 2017) (Fig. 4.). These will be the protected areas used for the scope of this thesis.

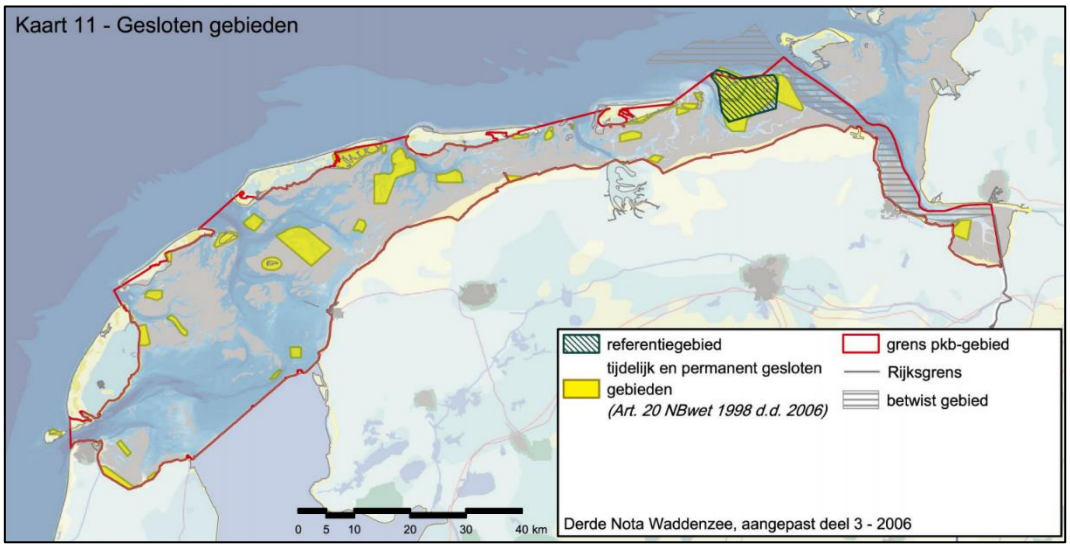

Fig. 4. Map of: reference area (horizontal lines), article 2.5 (20) areas (yellow), PKB-area border (red line) (VROM, 2007)

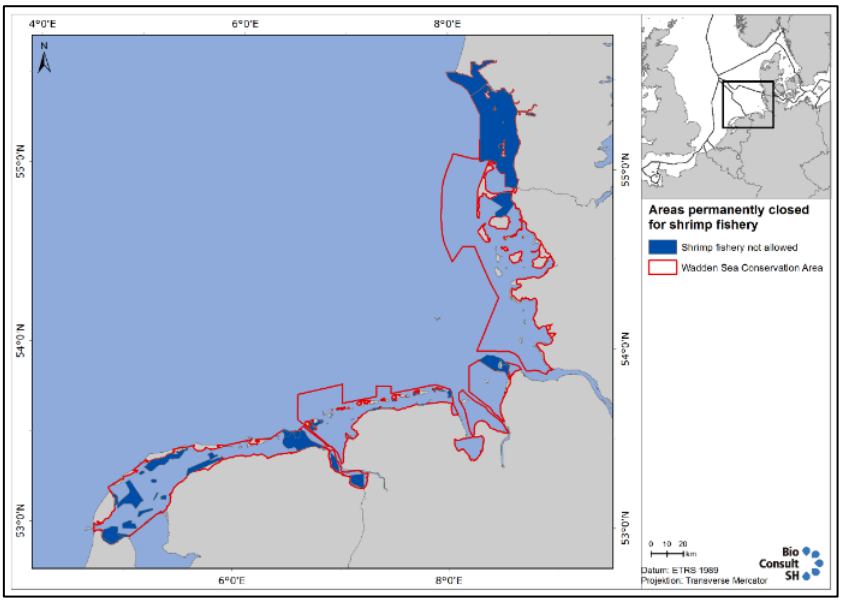

Fig. 5. Map of areas permanently closed off for shrimp fisheries (blue area) (Baer et al, 2017)

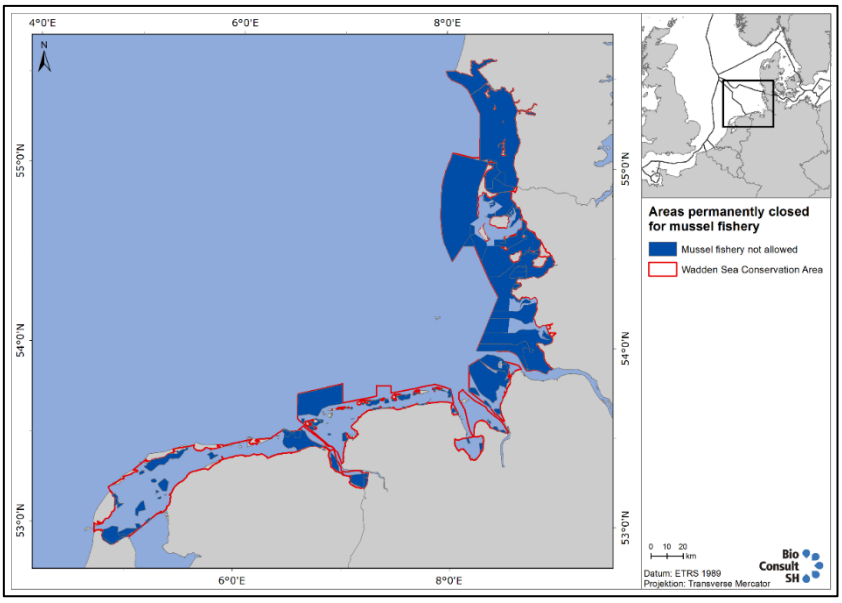

Fig. 6. Map of areas permanently closed off for mussel fisheries (blue area) (Baer et al, 2017)

We now start with examining the biological component whereafter we will examine the socioeconomic component in the DWS.

The Biological Component in the Dutch Wadden Sea

We know that the NEOLI features are important for MPA success. With each feature added to an MPA the effectiveness of the area increases (Edgar et al, 2014). Know knowing wat is in place in the DWS, we will work our way through each feature and classify them according to the criteria posited in the study (table. 1).

No-Take (Fishing Regulations)

The DWS has the characteristics of a multi-use MPA, a large, protected area with multiple smaller areas where exploitation is more restricted as can be seen in figure 4, 5 and 6. Outside these smaller areas exploitation and other human activities are allowed within the limits of the PKB and other laws. This is in line with the IUCN who say that the Wadden Sea is mostly an IUCN category VI area: an area that includes more protected areas within its boundaries (IUCN, 2009). Something that must be noted are the concerns voiced in the 1998 Waddenbulletin that the protection of the Wadden Sea ecology is compromised, by for example

permitting fisheries, as soon as money is involved (Van der Aa et al, 2010). However, as there are some fishery restrictions in place even though the DWS is not exclusively no-take, we classify it at as a medium level for the no-take feature.

Enforcement

Enforcement is a difficult thing to quantify. Edgar et al. (2014) study categorized the level of enforcement by talking to park managers and through observations of number of rule violations while in the field. In the IUCN's World Heritage evaluation report from 2009, enforcement is mentioned to be done effectively via local police, coastguards, and naval police with patrolling and inspections (IUCN, 2009). An example of this is the Waddenunit who patrol the Wadden Sea with four ships to monitor and enforce regulations. ("Samen met de Waddenunit de Waddenzee beheren", 2021). Another study using GPS data from ships shows that also in practice regulations such as the speed limit and restricted areas are followed relatively well (Meijles, Daams, Ens, Heslinga & Sijtsma, 2021). These reports lead us to classify the DWS as a high level for enforcement. A word of caution with this classification, as we had to rely on limited sources the situation may be different in reality.

Old (Age)

The DWS has been protected with the PKB since 1980 (CWSS, 2017). Article 2.5 areas have been protected since their establishment (as article 20 areas) by the nature protection law of 1998 ("wetten.nl - Regeling - Wet natuurbescherming - BWBR0037552", 2021). Mussel fisheries stopped in 1991 to move on to the less damaging collection of mussel seeds. In 2009 also subtidal mussel beds were closed for seed fisheries (Baer et al, 2017). Shrimp fisheries face less restrictions than their mussel counterparts as there are currently no regulations or quotas. However, in 2013 the VISWAD Covenant aimed to reduce the impact of shrimp fishing on the Dutch Wadden Sea by 50% by 2020 (Baer et al, 2017). All in all, these areas and the DWS score as high for the age feature as they have been protected for more than 10 years.

Large (Size)

As said before the Dutch Wadden Sea covers 3,000 km^2. This falls into the medium category for the size classifications and therefore we classify it as such.

Isolated

Even though the DWS is part of the world's largest continuous intertidal flats it is relatively isolated from other systems due to shelter provided by natural borders such as the Wadden islands. As we were not able to find exact data on the percentage of the border breached by continuous habitat, we will assume that it falls in the medium category (1-20%). We do this as the main reasons why it is important that a MPA should be isolated is to make it easily recognizable to enable policing and raise compliance, which the DWS is due to the characteristic islands, and to decrease dispersal which we assume to be happening to some extent due the barrier islands.

Having examined all the features we will now consider what this means for the potential success of the biological component. Edgar et al. (2014) report that there is no real difference between sites with none of the NEOLI features and sites with one or two of them. From three to five features the effectiveness increases steeply. For example, with three features total fish biomass went up with 30% whereas this was a 244% increase with five features. The DWS has good enforcement and is relatively old. For size, no-take, and isolation the DWS was classified as a medium level. With two of the features at a high level and the other three at a medium level we conclude that the DWS is effective as a conservation area for a biological standpoint.

The Socioeconomic Component in the Dutch Wadden Sea

From the biological component we move on to the socioeconomic component. Earlier we saw that it is important that stakeholders are engaged and that their perception of the conservation area is positive. We will look at these two factors for the DWS and try to draw a general conclusion for the socioeconomic component.

Stakeholder Engagement

The Wadden Sea Forum was created in 2002 to increase/raise stakeholder engagement. It is a platform for governmental and non-governmental stakeholders to influence development and implementation of strategies for the Wadden sea. This was also a way to explicitly recognize the socioeconomic factors in the region (De Jong, 2005). With the Wadden Sea forum many stakeholders and people gained representation and as of 2005 more than 300 organizations take part (De Jong, 2005). Another thing that shows that stakeholders are being engaged is the mention of "exceptional level of public consultation" in the IUCN report regarding the nomination for the Wadden Sea as a world heritage site (IUCN, 2009).

Stakeholder Perception

The DWS harbors many different stakeholder interests, ecological and economic ones can often collide. Stakeholder support is influenced by how they perceive the protection measures in the DWS. First off, it should be clear that Dutch people have a very positive perception of the Wadden Sea itself as it was declared the most beautiful nature area of the Netherlands in 2016 by the public (NOS, 2016). However, this tells us very little about the perception of the protection measures which are more difficult to gauge. For this purpose, we will examine the sentiments surrounding the Wadden Sea's UNESCO World Heritage nomination.

The nomination incited quite heavy resistance among stakeholders with more people opposing it than people being in favor of it. Among opposing stakeholders were groups such as the Wadden Association and the Natural Monument Association who generally support conservation. Via consultations of stakeholder groups such as: inhabitants of nearby areas, conservation groups, the tourism sector, and the fisheries sector, two main views of stakeholders came to light. They had the feeling of loss of autonomy by more interference from outside the area itself and uncertainty about the impacts of the World Heritage listing (Van der Aa et al,

2010). Another interesting finding that these consultations brought to light was the feeling that the current protection measures were inadequate and that further regulations would not improve this (Van der Aa et al, 2010). The perception of the measures at this time was quite negative.

It appears that stakeholders are being engaged adequately. Via the Wadden Sea Forum and consultations, stakeholders can actively participate if they so desire. Stakeholder perception of the protection measures however, is less positive as many feel that the measures are not adequate and will not be improved in the near future.

Conclusion

We have looked at the biological component and the socioeconomic component in the DWS. We saw that from a biological standpoint the DWS does very well with many of the NEOLI features present to some degree. In the socioeconomic component we saw that even though many stakeholders are being engaged the perception of the protection measures is quite negative. Having considered both components we conclude that the DWS is a relatively effective protected area as it has many of the features of a successful MPA. However, progress can always be made, and we propose an increased focus on stakeholder perception to create a broader support base for future measures and policies.

The DWS shows us how protection measures are being used in practice to protect the ocean against the many anthropogenic stressors. This underlines the important role MPAs can play in the protection and restoration of our oceans on which so many people depend.

As was shown MPAs can be a very successful management tool if managed effectively. MPAs directly protect the species within its boundaries by providing them a place safe from human exploitation. These initial direct effects can eventually be seen throughout the whole system that is being protected. Through trophic cascades MPAs were able to return complete

ecosystems to their original form before human stressors took their toll. This shows why MPAs are highly interesting management tools in degraded ecosystems such as the DWS.

Another very important thing that is within the potential of MPAs is the integration of nature conservation and commercial exploitation interests. By spillover and the export of larvae and eggs across the borders of MPAs they can provide adjacent areas with an increase in fish stock. This integration can play a huge role in marine conservation as it can change the idea that conservation always coincides with negative economic effects. In areas that are intensely used by humans this integration could be the only way to get enough support from stakeholders and to shift the negative perception to one that is more positive. Effective management is however not a given as we have seen that most MPA's do not attain their goals.

To see what constitutes an effective MPA we looked at the factors that are important for MPA success. First, we saw that size, isolation, age, degree of enforcement, and amount of fishing regulations are all important for biological success. Secondly, we looked at factors important for socioeconomic success and showed that all stakeholders should be engaged, and that their perception of the MPA should be positive. However, the socioeconomic component is often left unaddressed even though both components are interdependent on each other. This lack of attention to socioeconomic factors can reduce the compliance of stakeholders to the regulations, thereby negating the positive effects of MPAs.

In short, it was shown that if managed correctly MPAs can have a very real effect on the conservation outcome of an area. They can be used as a management tool at the crossroad between conservation and socioeconomic interests as the can both conserve and provide exploitation potential. With our world's ocean in dire conditions and its ecosystem services and intrinsic value at stake, effectively managed MPAs should be an integral part of the solution.

Literature:

Alberts, H. C. (2015). The wadden sea: an intertidal ecosystem of global importance. *Focus on Geography*, *58*(1), 27–35. https://doi.org/10.1111/foge.12046

Babcock, R. C., Shears, N. T., Alcala, A. C., Barrett, N. S., Edgar, G. J., Lafferty, K. D., McClanahan, T. R., Russ, G. R., & Gaines, S. D. (2010). Decadal trends in marine reserves reveal differential rates of change in direct and indirect effects. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(43), 18256–18261. https://doi.org/10.1073/pnas.0908012107

Baer J., Smaal A., van der Reijden K. & Nehls G. (2017) *Fisheries*. In: Wadden Sea Quality Status Report 2017. Eds.: Kloepper S. et al., Common Wadden Sea Secretariat, Wilhelmshaven, Germany. Last updated 21.12.2017. Downloaded *04.07.2021*. qsr.waddensea-worldheritage.org/reports/fisheries

Ban, N. C., Hansen, G. J. A., Jones, M., & Vincent, A. C. J. (2009). Systematic marine conservation planning in data-poor regions: socioeconomic data is essential. *Marine Policy*, *33*(5), 794–800. https://doi.org/10.1016/j.marpol.2009.02.011

Bennett, N. J., & Dearden, P. (2014). Why local people do not support conservation: community perceptions of marine protected area livelihood impacts, governance and management in Thailand. *Marine Policy*, *44*, 107–116. https://doi.org/10.1016/j.marpol.2013.08.017

Berkes, F. (1985). Fishermen and 'the tragedy of the commons". *Environmental Conservation*, *12*(3), 199–206. https://www.jstor.org/stable/44520413

Boere, G. C., & Piersma, T. (2012). Flyway protection and the predicament of our migrant birds: a critical look at international conservation policies and the dutch wadden sea. *Ocean & Coastal Management*, *68*, 157–168. https://doi.org/10.1016/j.ocecoaman.2012.05.019

Bohnsack, J. A. (1998). Application of marine reserves to reef fisheries management. *Australian Journal of Ecology*, *23*(3), 298–304. https://doi.org/10.1111/j.1442-9993.1998.tb00734.x

Brown, K., Adger, W. N., Tompkins, E., Bacon, P., Shim, D., & Young, K. (2001). Trade-off analysis for marine protected area management. *Ecological Economics*, *37*(3), 417–434. https://doi.org/10.1016/S0921-8009(00)00293-7

Byers, J. E., & Noonburg, E. G. (2007). Poaching, enforcement, and the efficacy of marine reserves. *Ecological Applications*, *17*(7), 1851–1856. https://doi.org/10.1890/07-0067.1

Cabral, R. B., Halpern, B. S., Lester, S. E., White, C., Gaines, S. D., & Costello, C. (2019). Designing MPAs for food security in open-access fisheries. *Scientific reports*, *9*(1), 1-10. https://doi.org/10.1038/s41598-019-44406-w

Chen, J., Lin, Y., & Chuang, C. (2018). Improving the management of taiwanese fishery resource conservation zones based on public perceptions and willingness to pay for ecosystem services. *Journal of Coastal Conservation: Planning and Management*, *22*(2), 385–398. https://doi.org/10.1007/s11852-017-0586-5

Chuang, C. T., Chen, J. Y., Chang, K. C., Hung, L. W., & Liu, T. K. (2013). Critical success factors analysis of implementing MPA at the Yilan Gueishan island, Taiwan. *Journal of Marine Science and Technology*, *21*(4), 423-429. DOI: 10.6119/JMST-012-0628-4

Churchill, R. (2015). The 1982 United Nations Convention on the law of the sea. In *The Oxford handbook of the law of the sea*. DOI:10.1093/law/9780198715481.003.0002

Claudet, J., Guidetti, P., Mouillot, D., Shears, N. T., & Micheli, F. (2011). ECOLOGY – Ecological effects of marine protected areas: conservation, restoration, and functioning. In J. Claudet (Ed.). *Marine protected areas: a multidisciplinary approach* (Chapter 2, 37-63). Cambridge: Cambridge University Press.

Claudet, J., Osenberg, C. W., Benedetti-Cecchi, L., Domenici, P., García-Charton JA, Pérez-Ruzafa A, Badalamenti, F., Bayle-Sempere, J., Brito, A., Bulleri, F., Culioli, J. M., Dimech, M., Falcón JM, Guala, I., Milazzo, M., Sánchez-Meca J, Somerfield, P. J., Stobart, B., Vandeperre, F., …

Planes, S. (2008). Marine reserves: size and age do matter. *Ecology Letters*, *11*(5), 481–9. https://doi.org/10.1111/j.1461-0248.2008.01166.x

Costello, M. J., & Ballantine, B. (2015). Biodiversity conservation should focus on no-take Marine Reserves: 94% of Marine Protected Areas allow fishing. *Trends in ecology & evolution*, *30*(9), 507-509. https://doi.org/10.1016/j.tree.2015.06.011

Côté I, Mosqueira, I., & Reynolds, J. (2001). Effects of marine reserve characteristics on the protection of fish populations: a meta-analysis. *Journal of Fish Biology*, *59*, 178–189. https://doi.org/10.1111/j.1095-8649.2001.tb01385.x

Cury, P., Bertrand, A., Bertrand, S., Coll, M., Gros, O., Kifani, S., Le Loch, F., Maury, O., Menard, F., Renaud, F., Shannon, L., & Shin, Y. (2016) The Ecosystem Approach to Fisheries: Reconciling Conservation and Exploitation. In A, Monaco., P, Prouzet (Eds.). Tools for Oceanography and Ecosystemic Modeling (Chapter 7, 221-311). London: ISTE

CWSS (2017) *Introduction*. In: Wadden Sea Quality Status Report 2017. Eds.: Kloepper S. et al., Common Wadden Sea Secretariat, Wilhelmshaven, Germany. Last updated 01.03.2018. Downloaded *03-07-2021*. qsr.waddensea-worldheritage.org/reports/introduction

CWSS (2021) Wadden Sea World Heritage site [Map]. waddensea-worldgeritage.org. https://www.waddensea-worldheritage.org/

De Jong, F. (2005). The Wadden Sea Forum: the relevance of stakeholder participation for sustainable planning. *Sustainable Development and Planning, 2, 1291-1300.* https://www.witpress.com/elibrary/wit-transactions-on-ecology-and-the-environment/84/15628

De Jonge, V. N., Essink, K., & Boddeke, R. (1993). The dutch wadden sea: a changed ecosystem. *Hydrobiologia: The International Journal of Aquatic Sciences*, *265*(1-3), 45–71. https://doi.org/10.1007/BF00007262

Diaz, R. J., & Rosenberg, R. (2008). Spreading dead zones and consequences for marine ecosystems. *Science*, *321*(5891), 926–929. DOI: 10.1126/science.1156401

Dudley, N. (Ed.)., Shadie, P., & Stolton, S. (2013*). Guidelines for Applying Protected Area Management Categories*. Gland: IUCN.

Dyck, A. J., & Sumaila, U. R. (2010). Economic impact of ocean fish populations in the global fishery. *Journal of Bioeconomics*, *12*(3), 227–243. https://doi.org/10.1007/s10818-010-9088-3

Edgar, G. J. (2011). Does the global network of marine protected areas provide an adequate safety net for marine biodiversity? *Aquatic Conservation: Marine and Freshwater Ecosystems*, *21*(4), 313–316. https://doi.org/10.1002/aqc.1187

Edgar, G. J., Banks, S. A., Bessudo, S., Cortés, J., Guzmán, H. M., Henderson, S., Martinez, C., Rivera, F., Soler, G., Ruiz, D., & Zapata, F. A. (2011). Variation in reef fish and invertebrate communities with level of protection from fishing across the eastern tropical pacific seascape: mpa effectiveness in the eastern pacific. *Global Ecology and Biogeography*, *20*(5), 730–743. https://doi.org/10.1111/j.1466-8238.2010.00642.x

Edgar, G. J., Stuart-Smith, R. D., Kininmonth, S., Barrett, N. S., Berkhout, J., Buxton, C. D., Cooper, A. T., Davey, M., Soler, G., Thomson, R. J., Willis, T. J., Baker, S. C., Banks, S., Becerro, M. A., Bernard, A. T. F., Campbell, S. J., Edgar, S. C., Forsterra, G., Galvan, D. E., Irigoyen, A. J., Kushner, D. J., Moura, R., Parnell, P. E. Shears, N. T., & Strain, E. M. A. (2014). Global conservation outcomes depend on marine protected areas with five key features. *Nature*, *506*(7487), 216–220. https://doi.org/10.1038/nature13022

Enemark, J. (2005). The Wadden sea protection and management scheme—towards an integrated coastal management approach? *Ocean and Coastal Management*, *48*(11), 996–1015. https://doi.org/10.1016/j.ocecoaman.2005.03.009

European Commission. (2021). Natura 2000 - Environment - European Commission. Retrieved 8 July 2021, from https://ec.europa.eu/environment/nature/natura2000/index_en.htm

Fabinyi, M. (2008). Dive tourism, fishing and marine protected areas in the calamianes islands, philippines. *Marine Policy*, *32*(6), 898–904. https://doi.org/10.1016/j.marpol.2008.01.004

Fox, H. E., Mascia, M. B., Basurto, X., Costa, A., Glew, L., Heinemann, D., Karrer, L. B., Lester, S. E., Lombana, A. V., Pomeroy, R. S., Recchia, C. A., Roberts, C. M., Sanchirico, J. N. Pet-Soede, L., & White, A. T. (2012). Reexamining the science of marine protected areas: linking knowledge to action. *Conservation Letters*, *5*(1), 1-10. https://doi.org/10.1111/j.1755-263X.2011.00207.x

Gell, F. R., & Roberts, C. M. (2003). ge. *Trends in Ecology & Evolution*, *18*(9), 448–455. https://doi.org/10.1016/S0169-5347(03)00189-7

Giakoumi, S., McGowan, J., Mills, M., Beger, M., Bustamante, R. H., Charles, A., ... & Possingham, H. P. (2018). Revisiting "success" and "failure" of marine protected areas: a conservation scientist perspective. *Frontiers in Marine Science*, *5*, 223. https://doi.org/10.3389/fmars.2018.00223

Guidetti, P., Milazzo, M., Bussotti, S., Molinari, A., Murenu, M., Pais, A., Spanò, N., Balzano, R., Agardy, T., Boero, F., Carrada, G., Cattaneo-Vietti, R., Cau, A., Chemello, R., Greco, S., Manganaro, A., Notarbartolo di Sciara, G., Russo, G. F., & Tunesi, L. (2008). Italian marine reserve effectiveness: does enforcement matter? *Biological Conservation*, *141*(3), 699–709. https://doi.org/10.1016/j.biocon.2007.12.013

Halpern, B. S. (2003). The impact of marine reserves: do reserves work and does reserve size matter? *Ecological Applications*, *13*(1), 137. https://doi.org/10.1890/1051-0761(2003)013[0117:TIOMRD]2.0.CO;2

Halpern, B. S., Lester, S. E., & Kellner, J. B. (2009). Spillover from marine reserves and the replenishment of fished stocks. *Environmental Conservation*, *36*(4), 268–276. https://www.jstor.org/stable/44520024

Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V., Micheli, F., D'Agrosa, C., Bruno, J. F., Casey, K. S., Ebert, C., Fox, H. E., Fujita, R., Heinemann, D., Lenihan, H. S., Madin, E. M. P., Perry, M. T., Selig, E. R., Spalding, M., Steneck, R., & Watson, R. (2008). A global map of human impact on marine ecosystems. *Science*, *319*(5865), 948–952. DOI: 10.1126/science.1149345

Harmelin-Vivien, M., Le Diréach, L., Bayle-Sempere, J., Charbonnel, E., García-Charton, J. A., Ody, D., Pérez-Ruzafa, A., Reñones, O., Sánchez-Jerez, P., & Valle, C. (2008). Gradients of abundance and biomass across reserve boundaries in six mediterranean marine protected areas: evidence of fish spillover? *Biological Conservation*, *141*(7), 1829–1839. https://doi.org/10.1016/j.biocon.2008.04.029

Himes, A. H. (2003). Small-scale sicilian fisheries: opinions of artisanal fishers and sociocultural effects in two mpa case studies. *Coastal Management*, *31*(4), 389–408.

Himes, A. H. (2007). Performance indicator importance in mpa management using a multi-criteria approach. *Coastal Management*, *35*(5), 601–618. https://doi.org/10.1080/08920750701593436

Holm, P. (2005). Human impacts on fisheries resources and abundance in the danish wadden sea, c1520 to the present. *Helgoland Marine Research*, *59*(1), 39–44. https://doi.org/10.1007/s10152-004-0205-3

Holmlund, C. M., & Hammer, M. (1999). Ecosystem services generated by fish populations. *Ecological Economics*, *29*(2), 253–268. https://doi.org/10.1016/S0921-8009(99)00015-4

Humphreys, J., Clark, R. W. E. (2020). Chapter 1 - A critical history of marine protected areas. In J, Humphreys, R. W. E, Clark (Eds.). *Marine Protected Areas – Science, Policy and Management* (1st ed. 1-12). Amsterdam: Elsevier

IUCN. (2009). *World heritage nomination - IUCN technical evaluation: The Wadden Sea* (Report No. 1314). IUCN. https://whc.unesco.org/document/152335.

Jackson, J. B. C. (2008). Ecological extinction and evolution in the brave new ocean. *Proceedings of the National Academy of Sciences of the United States of America*, *105*, 11458–11465. https://www.jstor.org/stable/25463364

Jennings, S. (2000). Patterns and prediction of population recovery in marine reserves. *Reviews in Fish Biology and Fisheries*, *10*(2), 209–231. https://doi.org/10.1023/A:1016619102955

Jennings, S., & Kaiser, M. J. (1998). The effects of fishing on marine ecosystems. *Advances in Marine Biology*, *34*, 203–203. https://doi.org/10.1016/S0065-2881(08)60212-6

Kabat, P., Bazelmans, J., Dijk, J., Herman, P. M. J., Oijen, T., Pejrup, M., Reise, K., Speelman, H., Wolff, W. J. (2012). The Wadden Sea Region: Towards a science for sustainable development. *Ocean and Coastal Management*, *68*(68), 4–17.

Kelleher, G. (Ed.). (1999). *Guidelines for Marine Protected Areas.* Gland: IUCN.

Kriegl, M., Ilosvay, X. E. E., von Dorrien, C., & Oesterwind, D. (2021). Marine protected areas: at the crossroads of nature conservation and fisheries management. *Frontiers in Marine Science*, *8*. https://doi.org/10.3389/fmars.2021.676264

Lester, S. E., & Halpern, B. S. (2008). Biological responses in marine no-take reserves versus partially protected areas. *Marine Ecology Progress Series*, *367*, 49–56. https://doi.org/10.3354/meps07599

Lester, S. E., Halpern, B. S., Grorud-Colvert, K., Lubchenco, J., Ruttenberg, B. I., Gaines, S. D., Airamé Satie, & Warner, R. R. (2009). Biological effects within no-take marine reserves: a global synthesis. *Marine Ecology Progress Series*, *384*, 33–46. https://doi.org/10.3354/meps08029

Lodge, M. W. (2012). The common heritage of mankind. *International Journal of Marine and Coastal Law*, *27*(4), 733–742. https://doi.org/10.1163/15718085-12341248

Lotze, H. K. (2007). Rise and fall of fishing and marine resource use in the wadden sea, southern north sea. *Fisheries Research*, *87*(2), 208–218. https://doi.org/10.1016/j.fishres.2006.12.009

Lubchenco, J., & Grorud-Colvert, K. (2015). Making waves: the science and politics of ocean protection. *Science*, *350*(6259), 382–383. https://doi.org/10.1126/science.aad5443

Matz-Lück, N., & Fuchs, J. (2015). Marine living resources. In *The Oxford Handbook of the Law of the Sea*. DOI:10.1093/law/9780198715481.003.0022

Meijles, E. W., Daams, M. N., Ens, B. J., Heslinga, J. H., & Sijtsma, F. J. (2021). Tracked to protect-Spatiotemporal dynamics of recreational boating in sensitive marine natural areas. *Applied Geography*, *130*, 102441. https://doi.org/10.1016/j.apgeog.2021.102441

Mora, C., Andréfouët, S., Costello, M. J., Kranenburg, C., Rollo, A., Veron, J., Gaston, K. J., & Myers, R. A. (2006). Coral reefs and the global network of marine protected areas. *Science*, *312*(5781), 1750–1751. DOI: 10.1126/science.1125295

Moser, M., & Brown, A. (2007). *Trilateral Wadden Sea Cooperation–External Evaluation Report*. Common Wadden Sea Secretariat (CWSS). https://www.waddenseaworldheritage.org/sites/default/files/2007_evaluation%20report.pdf

Mosquera, I., Côté, I. M., Jennings, S., & Reynolds, J. (2006). Conservation benefits of marine reserves for fish populations. *Animal Conservation*, 4, 321–32. https://doi.org/10.1111/j.1469-1795.2000.tb00117.x

MPAtlas. (2020). Global MPAs [simple] [Map]. MPAtlas.org. https://old.mpatlas.org/data/map-gallery/

Nautin - Artikel 2.5-gebieden - Overzicht. (2021). Retrieved 4 July 2021, from https://www.nautin.nl/wb/pages/vaarweginformatie/vaargebieden/wadden-

Palomares, M. L. D., Froese, R., Derrick, B., Meeuwig, J. J., Nöel S.-L, Tsui, G., Woroniak, J., Zeller, D., & Pauly, D. (2020). Fishery biomass trends of exploited fish populations in marine ecoregions, climatic zones and ocean basins. *Estuarine, Coastal and Shelf Science*, *243*. https://doi.org/10.1016/j.ecss.2020.106896

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., & Torres, F. (1998). Fishing down marine food webs. *Science*, *279*(5352), 860–863. DOI: 10.1126/science.279.5352.860

Pauly, D., Watson, R., & Alder, J. (2005). Global trends in world fisheries: impacts on marine ecosystems and food security. *Philosophical Transactions: Biological Sciences*, *360*(1453), 5–12. https://www.jstor.org/stable/30040873

Pereira da Silva, A. (2019). Brazilian large-scale marine protected areas: other "paper parks"? *Ocean and Coastal Management*, *169*, 104–112. https://doi.org/10.1016/j.ocecoaman.2018.12.012

Riebesell, U., Zondervan, I., Rost, B., Tortell, P. D., Zeebe, R. E., & Morel, F. M. (2000). Reduced calcification of marine plankton in response to increased atmospheric co2. *Nature*, *407*(6802), 364–7. DOI: 10.1038/35030078

Rife, A. N., Aburto-Oropeza, O., Hastings, P. A., Erisman, B., Ballantyne, F., Wielgus, J., Sala, E., & Gerber, L. (2013). Long-term effectiveness of a multi-use marine protected area on reef fish assemblages and fisheries landings. *Journal of Environmental Management*, *117*, 276–283. https://doi.org/10.1016/j.jenvman.2012.12.029

Rife, A. N., Erisman, B., Sanchez, A., & Aburto-Oropeza, O. (2012). When good intentions are not enough … insights on networks of "paper park" marine protected areas. *Conservation Letters*, *6*(3), 200–212. https://doi.org/10.1111/j.1755-263X.2012.00303.x

Rodwell, L. D., Barbier, E. B., Roberts, C. M., & McClanahan, T. R. (2003). The importance of habitat quality for marine reserve - fishery linkages. *Canadian Journal of Fisheries and Aquatic Sciences*, *60*(2), 171–181. https://doi.org/10.1139/f03-009

Russ, G. R., Maypa, A. P., White, A. T., Alcala, A. C., & Calumpong, H. P. (2004). Marine reserve benefits local fisheries. *Ecological Applications*, *14*(2), 597–606 https://doi-org.proxy-ub.rug.nl/10.1890/03-5076

Samen met de Waddenunit de Waddenzee beheren. (2021). Retrieved 5 July 2021, from https://www.beheerautoriteitwaddenzee.nl/actueel/nieuws/2021/04/22/samen-met-de-waddenunit-de-waddenzee-beheren

Sandifer, P. A., & Sutton-Grier, A. E. (2014). Connecting stressors, ocean ecosystem services, and human health. *Natural Resources Forum*, *38*(3), 157–167. https://doi.org/10.1111/1477-8947.12047

Shears, N. T., & Babcock, R. C. (2003). Continuing trophic cascade effects after 25 years of no-take marine reserve protection. *Marine Ecology Progress Series*, *246*, 1–16. https://doi.org/10.3354/meps246001

Sowman, M., & Sunde, J. (2018). Social impacts of marine protected areas in south africa on coastal fishing communities. *Ocean and Coastal Management*, *157*, 168–179. https://doi.org/10.1016/j.ocecoaman.2018.02.013

The Ramsar Convention on Wetlands. (2021). Retrieved 8 July 2021, from https://www.environment.gov.au/water/wetlands/ramsar

Tobey, J., & Torell, E. (2006). Coastal poverty and mpa management in mainland tanzania and zanzibar. *Ocean and Coastal Management*, *49*(11), 834–854. https://doi.org/10.1016/j.ocecoaman.2006.08.002

Turnhout, E., Hisschemöller M, & Eijsackers, H. J. P. (2008). Science in wadden sea policy: from accommodation to advocacy. *Environmental Science & Policy*, *11*(3), 227–239. https://doi.org/10.1016/j.envsci.2007.07.004

UNESCO. (2021[1]). Wadden Sea. Retrieved 5 July 2021, from https://whc.unesco.org/en/list/1314/

UNESCO. (2021[2]). What does it mean for a site to be inscribed on the World Heritage List? - Frequently Asked Questions (FAQ) - UNESCO World Heritage Centre. Retrieved 8 July 2021, from https://whc.unesco.org/en/faq/20

Van der Aa, B. J. M., Groote, P. D., & Huigen, P. P. P. (2004). World heritage as NIMBY? the case of the Dutch part of the Wadden Sea. *Current Issues in Tourism*, *7*(4-5), 291–302. https://doi.org/10.1080/13683500408667986

Vandeperre, F., Higgins, R. M., Sánchez-Meca, J., Maynou, F., Goñi, R., Martín-Sosa Pablo, Pérez-Ruzafa, A., Afonso, P., Bertocci, I., Crec'hriou, R., D'Anna, G., Dimech, M., Dorta, C., Esparza, O., Falcón, J. M,. Forcada, A., Guala, I., Le Direach, L., Marcos, C., … Santos, R. S. (2011). Effects of no-take area size and age of marine protected areas on fisheries yields: a meta-analytical approach. *Fish and Fisheries*, *12*(4), 412–426. https://doi.org/10.1111/j.1467-2979.2010.00401.x

VROM (2007). Ontwikkeling van de wadden voor natuur en mens: Deel 4 van de planologische kernbeslissing Derde Nota Waddenzee, tekst na parlementaire instemming. VROM. https://waddenzee.nl/fileadmin/content/Dossiers/Overheid/pdf/Derde_Nota_Waddenzee_deel_4.pdf

Webb, E. L., Maliao, R. J., & Siar, S. V. (2004). Using local user perceptions to evaluate outcomes of protected area management in the sagay marine reserve, philippines. *Environmental Conservation*, *31*(2), 138–148.

wetten.nl - Regeling - Wet natuurbescherming - BWBR0037552. (2021). Retrieved 4 July 2021, from https://wetten.overheid.nl/BWBR0037552/2017-09-01

Worm, B., & Branch, T. A. (2012). The future of fish. *Trends in Ecology & Evolution*, *27*(11), 594–599. https://doi.org/10.1016/j.tree.2012.07.005

Worm, B., Barbier, E. B., Beaumont, N., Duffy, J. E., Folke, C., Halpern, B. S., Jackson, J. B. C., Lotze, H. K., Micheli, F., Palumbi, S. R., Sala, E., Selkoe, K. A., Stachowicz, J. J., & Watson, R. (2006). Impacts of biodiversity loss on ocean ecosystem services. *Science*, *314*(5800), 787–790. DOI: 10.1126/science.1132294