Adaptive Management Plan

European Herring Gull (Larus argentatus)
in Danish cities

Wildlife Ecology and Adaptive Management (515182U004)
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Preface

This is an adaptive management plan developed for the European Herring Gull *(Larus argentatus)* in Danish cities, using Horsens municipality as a case study. This plan was developed as an assignment for the Wildlife Ecology and Adaptive Management Course, offered in the spring of 2020, at Aarhus University, Aarhus, Denmark. This management plan was written by three biology master students; Brittany Wooldridge, Anders Nielsen and Sofie Amund Kjeldgaard. It is an adaptive management plan that is designed to be implemented within Danish cities, to combat the incompatibility between urban Herring Gulls and humans.

This management plan was developed by taking a holistic approach to analyzing this incompatibility and its associated root causes. Priorities were set on establishing an unbiased analysis of the realities surrounding this problem as well as proposing unbiased solutions to mitigate or resolve it. Our plan proposes the implementation of various unconventional as well as conventional management tools to accomplish this. With this holistic approach to developing an adaptive management plan, we hope to inspire those interested in pursuing a sustainable resolution to the incompatibility between urban Herring Gulls and humans in Danish cities.

We would like to acknowledge and thank all the people we interviewed, for their participation and for the valuable information and knowledge they shared with us. We would like to thank our supervisors Jesper Madsen, Hans Peter Hansen and Kevin Clausen for guidance and feedback throughout the development of this adaptive management plan. We would also like to thank Morten Frederiksen for his input on our modelling framework.

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I. Problem Framing

In recent years (especially the last 15-20 years), the amount of complaints and news articles about nuisance from gulls in cities has increased significantly (Aarhus Kommune 2016; Therkildsen and Bregnballe 2016). In a Scottish study, Calladine et al. (2006) found that it was especially the noise and aggressive behavior of gulls that caused nuisance for the public. Since the 1970s the Danish population of European Herring Gulls (*Larus argentatus*) (hereafter Herring Gull) have increased from around 66,000 breeding pairs in 1974 to 86,000 in 2010 (Bregnballe and Lyngs 2014). However, this increase has not been monotonous and there are large regional differences in the population development within Denmark. An overall pattern is that the breeding population in the eastern parts of Denmark has generally been stable or declined in the period, whereas the breeding population in the western parts of Denmark has increased (Bregnballe and Lyngs 2014). The size of breeding population seems to be directly related to the amount of food available for the Herring Gulls, in which case the closure of open landfills would explain the decrease in population size in the eastern part of Denmark whereas the reason for the increased populations in the western part remains unclear (Bregnballe and Lyngs 2014). In Aarhus, it is estimated that the amount of breeding Herring Gulls observed between the years 1985-1999 increased by 27% annually (Lilleør 2000), and then increased overall by 50% in the inner city from 1999-2012 (Aarhus Kommune 2016). This 50% increase is mainly due to a redistribution of breeding pairs from other parts of the municipality leaving the overall breeding population more or less unchanged (Aarhus Kommune 2016). However, it is thought that the number of non-breeding Herring Gulls in Aarhus has increased a lot in this same period, potentially due to migratory individuals coming from areas outside of the city (Aarhus Kommune 2016).

With such an increase in urban Herring Gull populations, economic consequences and costs to human wellbeing arise as a result, which have generated an influx of complaints made by citizens to the local municipalities. In 2018, Horsens municipality received approximately 109 complaints and in 2019 they received approximately 94 complaints (Pers. Comm. Horsens Municipality Representative). Generally, the majority of complaints made by citizens are as a result of noise levels produced by the Herring Gulls, an increase in nesting density on buildings and rooftops, aggressive and violent behavior directed towards humans (Naturstyrelsen 2011), an increase in fecal matter, and the unhygienic spreading and consumption of human garbage (Svendsen and Jensen 2016).

Given that the Herring Gull is a colonial breeding bird, their nesting sites will generally be congregated within the same areas as other breeding pairs, and with a degree of nesting territoriality (Tinbergen 1956). The nests have been reported to clog ventilation grates of buildings due to the nesting material (Therkildsen and Bregnballe 2016; Pers. Comm. Horsens Municipality Representative), which has the potential to create health risks for the building's inhabitants. Additional reports have been made regarding damages to personal property as a result of Herring Gull fecal matter (Jensen 2018; Therkildsen and Bregnballe 2016) in areas where the Herring Gulls congregate. Nesting territoriality of the Herring Gull is associated with aggressive behavior, which can vary throughout the breeding cycle (Burger 1984), and is not only directed towards other Herring Gulls, but also towards humans and their domestic pets, who may approach their nesting site (Cramp and Simmons 1983; Skriver

2011). This aggressive behavior is not only associated with nesting territoriality but also with food acquisition. In the UK, Goumas et al. (2020) found that Herring Gulls use human handling of objects as a cue, specifically in the context of food. This association of humans with food, alongside the kleptoparasitic behavior found in Herring Gulls (Brockmann and Barnard 1979), creates opportunity for violent interactions between the two species. Although Goumas et al. (2019) found that Herring Gull food-snatching behavior is likely to be conducted by a minority of individuals, several anecdotal cases have been documented (Pedersen 2015).

In Denmark, throughout the past 20 years there has been an exponential increase in the number of newspaper articles containing the words "gulls" and "noise" (Therkildsen and Bregnballe 2016). The prevalence of nuisance noises associated with Herring Gulls has become one of the common complaints in recent years (Calladine 2006; Pers. Comm. Horsens Municipality Representative), typically being associated with disturbing human sleeping habits (Pers. Comm. Citizen; Pers. Comm. Horsens Municipality Representative). This vocalization amongst Herring Gulls is generally associated with their breeding behaviors, and conflict avoidance (Cramp and Simmons 1983). Unlike other bird vocalizations heard in Denmark, such as that of songbirds, gull vocalization is of a lower sound frequency, which allows for a better transmission of sound, especially in relation to the surrounding anthropogenic sounds found in the urban landscape, which may be, among other factors, contributing to the level of negative associations with this noise (Pers. Comm. Researcher). Additionally, the local hunting community has voiced their concerns about the potential impact that the Herring Gull might be having on local populations of game species (Pers. Comm. Derogation Hunter). There is currently no empirical evidence to support this, although there has been anecdotal evidence of such impacts (Pers. Comm. Derogation Hunter).

A popular stigma surrounding the Herring Gull is that they are potential carriers of a variety of infectious diseases that could in theory, infect humans through contact with their fecal matter. This infectious disease carrying capacity is primarily due to their diet choices and foraging in and around wastewater discharge and open landfills. However, in Denmark, the pathway of infection from bird to human is greatly reduced with the absence of open landfills (Therkildsen and Bregnballe 2016), and studies suggest that it may be the humans infecting the birds and not the other way around (Rock 2005). Infectious pathways still exist, however, particularly in public areas serving or storing food, where Herring Gulls may congregate and defecate (Pers. Comm. Horsens Municipality Representative), creating unsanitary conditions and opportunity for transmission.

Problem Statement

The increase and redistribution of urban Herring Gull populations in Denmark is resulting in an increased incompatibility between Herring Gulls and humans, and thereby decreasing the opportunity for coexistence between species.

II. Legal and Institutional Framework

IUCN Redlist

The Herring Gull was assessed by Birdlife International in 2018, where it was listed as least concern (LC) on the IUCN redlist (Birdlife International 2020).

Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA/CMS)

The Danish population of the Herring Gull is both migratory and residential (Bønløkke et al. 2006), and can have a foraging distance of up to 100 km (Klein 1994). Individuals may cross international borders to nearby countries, including Germany, the Netherlands, Poland, Norway and Sweden to either overwinter, breed, forage or relocate, depending on the season (Bønløkke et al 2006).

The Herring Gull (categorized by 'North & North-West Europe' and 'Iceland & Western Europe' in AEWA) is listed within AEWA under the Convention on Migratory Species (UNEP) and noted as a 'population with numbers above 100.000 individuals, that is in need of special attention because it is showing long-term decline' (AEWA 2018).

European Birds Directive

The Herring Gull is listed on Annex II, part B, on the European Birds Directive (European Parliament 2010, p.16), which means the species can be hunted in a limited time period, while hunting is not allowed during the breeding period, when the birds are most vulnerable. It is placed on Annex II B specifically, where it is only huntable within certain Member States of the EU, Denmark being one of them (under Article 7(3) of EU Birds Directive) (European Parliament 2010).

National legislation

In Denmark, the international agreements (EU Birds and Habitat Directives, RAMSAR, IUCN and AEWA) are implemented through a series of laws and regulations. For the Herring Gull, the most important laws are "Bekendtgørelse af lov om naturbeskyttelse" (BLN) (Miljø- og Fødevareministeriet 2019a) and "Bekendtgørelse af lov om jagt og vildtforvaltning" (BLJV) (Miljø- og Fødevareministeriet 2019b) including the addendum "Bekendtgørelse om vildtskader" (BV) (Miljø- og Fødevareministeriet 2018a). The internationally important habitats (Special Protection Areas, Article 4 (1) of EU Birds Directive) (European Parliament 2010) are implemented through the BLN, whereas the Birds Directive Annex IIb (hunting is allowed in specified areas) is implemented in the BLJV. Furthermore, the BLJV serves to protect all mammal and bird species, especially in vulnerable seasons as required by the EU Birds Directive. Currently, hunting on the Herring Gull is allowed in Denmark from September 1st to January 31st, with some local exceptions "Bekendtgørelse om jagttid for visse pattedyr og fugle m.v" (Miljø- og Fødevareministeriet 2018b). Furthermore, the BV addendum allows regulation of the Herring Gull throughout the year if certain conditions are met (§2 and §16 as well as §37 and §46 in BLJV) and it allows regulation to take place in populated areas (§31) and near public airfields (§11). The BV is therefore of special interest when it comes to the management of Herring Gulls in cities. The conditions that need to be fulfilled in order to regulate the Herring Gull are as follows (§16):

1) There is a threat to other fauna.
2) There is a danger to humans.
3) Human health is endangered.

Furthermore, regulation of Herring Gulls, their eggs, or nests can only be performed with a preapproved permission (§16).

While it is Miljø- og Fødevareministeren, who is ultimately responsible for the BLN and the BLJV, the administration of the laws are taken care of by Miljøstyrelsen. Formally, the practical administration of regulation permits are taken care of by Naturstyrelsen, however in practice it is often the municipalities who have the direct dialogue with the citizens (Pers. Comm. Horsens Municipality Representative). In some cases the municipality may even assist citizens with applications for Naturstyrelsen to regulate gulls (Horsens Kommune 2018; Pers. Comm. Horsens Municipality Representative).

III. Actor Analysis

This management plan includes a variety of actors who display a great variation in their levels of interests and powers in relation to the incompatibility issue between Herring Gulls and humans in urban areas of Denmark. These actors represent the relevant entities involved with this issue, and are categorized as such. This actor analysis was completed largely through the use of personal qualitative interviews and a diligent analysis of news articles published within Denmark that were related to this issue. We conducted interviews with representatives from the following actor groups; Municipalities, Unorganized Nature Enthusiasts, Hunters, and Non-Property Owners. All of these were from Horsens municipality, so we inserted a subsection for each actor category where we apply real life accounts to the actor description. This application allowed us to dive deeper into the various perspectives that this problem provides.

Naturstyrelsen

Naturstyrelsen is the environmental authority that is able to give permission for regulation of Herring Gulls (Miljøstyrelsen n.d.). This means that Naturstyrelsen holds a lot of power (within the legislation) when dealing with the practicalities regarding regulation of the Herring Gull. Naturstyrelsen is a decentralized organization which means that it is the local units of Naturstyrelsen that will deal with the applications for the regulation of Herring Gulls (Aarhus Kommune 2016). As Naturstyrelsen is a governmental institution under Miljø og Fødevareministeriet, it should act without political biases and not hold any special interests, because they act on behalf of the ministry. Given the fact that Naturstyrelsen handles all applications for the regulation of Herring Gulls, there is a large concentration of knowledge regarding the extent of problems with Herring Gulls and their spatial distribution on a national level as well as knowledge about legislation in this institution. Naturstyrelsen has the highest amount of power amongst the different actor groups, and a relatively high interest, therefore they should be kept involved throughout the management plan implementation process.

Municipalities

The municipality is involved as an actor at different levels. At a higher level the municipality will often be the authority receiving complaints about Herring Gulls from the public (Pers. Comm. Horsens Municipality Representative). The municipality does, however, not hold any formal power regarding the regulation of gulls, as this is managed by Naturstyrelsen. For this reason the municipality is not legally obligated to handle the complaints about gulls even though many municipalities provide guidelines and information leaflets as a service to the citizens (Aarhus Kommune 2016; Hansen 2018; Vesthimmerlands Kommune 2011). In some cases, the municipality (e.g. Horsens municipality) organizes joint applications for regulation of Herring Gulls in specified areas (Pers. Comm. Horsens Municipality Representative). Furthermore the municipality is a site of centralized knowledge about any current local problems with Herring Gulls through complaints from citizens as well as through their administration of the areas they own. The municipalities also have knowledge about or even organize hunters who will volunteer to regulate Herring Gulls (Aarhus Kommune 2016, Vesthimmerlands Kommune 2011). At a lower level, the municipality is a large property owner and is responsible for cleaning the streets, waste management, as well as maintaining public areas (Horsens Kommune 2018b; Pers. Comm. Horsens Municipality Representative). Fecal matter, nest matter and

human garbage that has been spread by gulls will need to be removed from the public space to avoid complaints from citizens. Therefore the Herring Gulls cause a direct cost to the municipality from increased maintenance expenses. As a property owner the municipality has the power to apply for permission for regulation. As the municipality has a high level of power and a high level of interest, they will therefore be kept involved.

Horsens Municipality Case

Horsens municipality has taken on a coordinating and leading role in a "battle against the gulls" (Avnesø 2019) and has dedicated staff to handle complaints about gulls as well as guidance on how to complain to the municipality. This is a leadership role that the municipality is not legally obligated to take on themselves, but they have done this because of a political interest in reducing nuisance from gulls in residential areas (Pers. Comm. Horsens Municipality Representative). When getting a complaint the municipality will guide the citizens on how to avoid attracting gulls as well as help with applications for regulation of Herring Gulls. In some cases the municipality is unable to help the citizens because they are tenants and the municipality has been unable to get in touch with the landlord. Furthermore, the department of the municipality that handles complaints about gulls has expressed a wish for a professional derogation shooter that can be dispatched to help citizens when they receive complaints. The politicians in Horsens are, however, divided on whether derogation shooting in populated areas is acceptable and they currently do not want hunters in residential areas (Pers. Comm. Horsens Municipality Representative).

Hunters

Hunters as actors represent a group of people with a hunting license for hunting in Denmark. Within this group, it is of relevance to distinguish between the average hunter, hunting for leisure, and the voluntary or hired derogation shooters utilized by the authorities for regulation duties. The former may primarily be concerned with hunting opportunities in autumn (e.g. length of the season), while the latter is directly involved with the problematic gulls. Anyone with a hunting license can apply for a regulation permit if they have problematic gulls on their own property, and if there are problems in the public areas, the municipality can apply for a shared permit for a specified area and then recruit hunters as derogation shooters to manage those areas (Aarhus Kommune 2019; Miljøstyrelsen n.d.; Pers. Comm. Horsens Municipality Representative; Pers. Comm. Derogation Hunter). Consequently, any hunter can potentially take on the role of derogation shooter. The regulation permits to cull individuals are obtained via Naturstyrelsen (Miljøstyrelsen n.d.). Hunters are important actors, because they are the only people who are allowed to regulate by shooting the mature birds before egg laying. If a citizen does not have a hunting license but desires regulation, the municipality will in some cases facilitate contact with a hunter (Aarhus Kommune 2019) or contact is established via Jægerforbundet (Danmarks Jægerforbund n.d.). Some hunters think of Herring Gulls as a form of competitor, based on experiences with Herring Gulls predating on smaller quarry species. This may give them an interest in maintaining a low population of Herring Gulls in general (Pers. Comm. Derogation Hunter). As the leisure hunters have a relatively low level of power and interest in this particular problem, they will be monitored, whereas as the derogation hunters have a higher level of power and interest, they will be kept involved throughout the process.

Horsens Hunter Case

In the Horsens case the local hunters were contacted by the municipality and asked to do the derogation shooting (Pers. Comm. Derogation Hunter). According to one of these local hunters, his interest in the derogation shooting was founded in the belief that Herring Gulls had a negative effect on juveniles of huntable game species and he wanted to help improve the hunters' reputation in the local community by helping them manage the local Herring Gull population (Pers. Comm. Derogation Hunter).

Property Owners *disturbed* by Herring Gulls

A property owner can be loosely defined as any individual who claims legal ownership over property, which in this case, may consist of a piece of land or real estate. As mentioned in Section I, the presence of Herring Gulls in urban areas is amounting to physical and/or non-physical disturbance occurring on individuals' and businesses' properties. This disturbance may consist of excessive levels of noise resulting from Herring Gulls occupying their property, or physical disturbance such as damage to car paint, or building infrastructure. Relevant property owners who may be experiencing these disturbances with urban Herring Gulls may consist of; home/apartment owners, restaurant/grocery store owners, car dealership owners, building owners. As the majority of private property holds a monetary value, there is motivation present amongst the property owners to seek out solutions to prevent further physical damage, and potentially even compensation. The non-physical disturbances may also heavily impact the motivation to seek out solutions, but the key element that differentiates this actor from other actors influenced by non-physical disturbance, is the value they hold to their property as well as the associated power that comes with this property ownership, which can be used to potentially take regulatory action. Legally, the property owners have the ability to decide if any form of Herring Gull regulation can occur on their piece of property ("Bekendtgørelse om vildtskader §2 and §16") (Miljø- og Fødevareministeriet 2018a), which puts them in a position of power and influence. It should be noted that, in many circumstances, the property owners may still experience disturbances which are not originating directly on their property, and in this case they lack the previously stated power to take action. Property owners are of interest as they represent a large portion of the people who are directly impacted by the disturbance of Herring Gulls, and may provide valuable information regarding the details of the causes of such disturbances. They may therefore be placed high in priority as actors, thereby requiring involvement throughout the management plan decision making process.

Property Owners *not* disturbed by Herring Gulls

It is relevant to note that there may also be a large portion of property owners involved with this particular problem who do not have the same level of interest as those mentioned above. Those that fall into this category may consist of landlords who own a piece of property that is then rented out to citizens, who may be particularly affected by the disturbances associated with urban Herring Gulls on their residence. In this particular case, there is a high level of power that the property owner has but a low level of interest. These actors are relevant to this management plan because their tenants are still experiencing the disturbances but without the resources to do something about it. This would create a scenario where a third party such as the municipality, might become involved with the property owner and tenants to discuss potential solutions to the problem. As this actor has a higher level of power, but lower level of interest, they will be kept informed throughout the management plan process.

Non-Property Owners disturbed by Herring Gulls

Residents living in urban areas where there are large gatherings of Herring Gulls, either during or outside of the breeding season, have been making reports to the municipalities complaining of the various negative associations they have experienced with the Herring Gull, such as increased sound levels, aggressive interactions, and increased fecal/nest matter (Pers. Comm. Citizen, Pers. Comm. Horsens Municipality Representative). This actor category may consist of individuals who are living or working near an area where there is a high degree of negative associations with the Herring Gull, but do not hold the legal power of a property owner to initiate regulation. For example, this may consist of people who rent their residence, or are employed in a building that they do not directly own. Although they are unable to request regulation, they still make reports of disturbance to the municipalities, where other measures can be taken to mitigate the problem, such as deterring Herring Gulls from the area. (Pers. Comm. Horsens Municipality Representative). This is a group of individuals who have very similar interests to those of disturbed property owners, in relation to the disturbance level that the Herring Gull is causing them, but lack the same level of power and influence. They are of interest because they represent a large portion of those who are affected by urban Herring Gull populations. Therefore, it will be a priority to learn from and consult this actor throughout the entire management process.

Horsens Non-Property Owner Case

For the case study of Horsens we interviewed a local citizen who had been disturbed by Herring Gulls for two years. During the interview, the citizen highlighted the difficulties of being a tenant and experiencing problems with the presence of Herring Gulls on nearby properties. Because they hold no power to take direct action, their only option was to contact the municipality, and hope the municipality could have a dialogue with the owner of the property with Herring Gulls present. The citizen voiced the concern that the property owner had no interest in getting rid of the gulls, because there was no easy way to access the roof. The lack of access meant that a scaffold had to be used, making it very expensive. As the owner did not live in the property, his incentive to help with the problem was therefore lower than that of the concerned citizen. Furthermore the citizen highlighted problems regarding the way garbage was managed, as they often saw people leaving large bags of trash in the street next to the dumpsters (Pers. Comm. Citizen). While the municipality does not have the power to force a landlord to participate in regulation of gulls, they are responsible for the waste management, which makes it possible for the municipality to act in this regard. The effects of actions taken in waste management will, however, also depend on citizen compliance.

Nature Organizations and Unorganized Nature Enthusiasts

While there are many nature organizations in Denmark that will qualify as actors with an interest in Herring Gulls, the analysis will be limited to two nature organisations: Dansk Ornitologisk Forening (DOF) and Danmarks Naturfredningsforening (DN). Both DOF and DN are members of Vildtforvaltningsrådet. As Vildtforvaltningsrådet is the advisory board directly influencing the ministerial decisions about hunting seasons and management in general for all Danish species, this places DOF and DN in a relatively powerful position. Furthermore, both organizations have a member base, which gives them a public voice. DOF has been especially vocal in the public debate about their dissatisfaction with culling gulls in cities (Baltzer and Borbiconi 2016), a view that is shared by DN

(Author Unknown 2013). This reveals a high interest in the subject for both organizations. Furthermore both DN and especially DOF hold a large capacity of volunteers, often with a deep knowledge about birds, that can be mobilized in the need of population counts and monitoring. The database DOFbasen run by DOF and the biologists in DOF are resources that can be helpful if there is a need to design a program for monitoring Herring Gulls in cities. These nature organizations have a relatively high interest and power, and should therefore be kept involved throughout the management plan process.

Unorganized nature enthusiasts consist of a variety of private individuals who do not necessarily affiliate themselves with any particular nature organization or cohesive set of values. This actor is defined because there are still a variety of citizens interested in this problem who may be cognizant of the same level of ecological knowledge surrounding the Herring Gull, but may not have the representative power of a nature organization. As the nature enthusiasts are an unorganized entity, they have little power and a moderate interest in this problem, and should therefore be monitored throughout the management plan process.

Horsens Nature Enthusiasts Case

In an interview with a local birdwatcher and nature enthusiast, he expressed his dissatisfaction with the way the management of Herring Gulls was currently being handled. From his point of view, the general regulation of Herring Gulls was problematic. He recognized that some Herring Gulls had an aggressive behavior that was not tolerable and he would accept a targeted regulation of problematic individuals. With the current management he felt that he as a single individual couldn't do anything, and he would only participate in discussions about Herring Gull if he was asked directly. He was, however, willing to share knowledge and recommendations with the municipality when asked, but would not contact them on his own initiative (Pers. Comm. Local Birdwatcher).

General Public

Although many of the people who are influenced by the Herring Gull in urban environments have been included in the previously mentioned actor groups, there are still some that may have an interest but are not easily categorized into a distinctive actor group. This is the "General Public" which encompasses a wide variety of individuals who may have either a negative or positive interest in the Herring Gull and the associated problems with their presence, but lack a universal relation to one another apart from this interest. This group is differentiated from the other actor groups, because their interest in the Herring Gull and their associated problems is lower, and they may simply just have an opinion regarding the Herring Gull for reasons other than those previously mentioned. For example, people in the general public may appreciate the presence of the Herring Gull in the city landscape for various reasons, one of them potentially being that they feel closer to nature, and have the opportunity to connect with nature by feeding Herring Gulls in the parks, or ponds. These individuals would not necessarily be considered 'Nature Enthusiasts' as such, but just your average citizen who may appreciate nature to a lesser degree. On the other end of the spectrum, there may be individuals who are particularly opposed to the Herring Gull for personal reasons, and they are not fully represented by any of the previous actor groups. At present, the general public seem to have a low level of interest, considering they are not especially vocal regarding the Herring Gull. However, it is noteworthy to mention that this could change throughout the implementation process of the management plan, in particular with actions that more directly involve the general public. Therefore, the purpose in defining

this actor group is to acknowledge that there may be potential for a growth in interest and therefore relative power within this particular group of society. For the initial stages of the management plan implementation, this actor group will be monitored, and further actions will be adapted depending on any relative changes in interest or power.

Horsens Case Summary

Looking at the specific case in Horsens, it seems like two actors (municipality and hunters) have joined forces in order to help out a third type of actor (citizens), whereas the communication with the ornithologists is either not prioritized or present. In the short run, this may seem like an easier solution for the municipality because the actors involved share a common goal. However, in the long run this may hinder the effectiveness of the regulation either because the ornithologists will begin to oppose the derogation shooting and destruction of nests or because the knowledge and organization that is present among ornithologists (e.g. DOF) is not utilized. The current management strategy in Horsens municipality, appears to be missing relevant input from knowledgeable ornithologists, and is therefore potentially lacking advancements in the management plan that could otherwise be achieved.

Power Interest Matrix

In Figure 1 found below, we present a power-interest matrix which depicts each of the actor categories described in the above text, and their associated power-interest rating. This rating is based on a system that values their level of power and interest in relation to the incompatibility between humans and urban Herring Gulls in Denmark. Depending on their combined level of power and interest surrounding this topic, they are categorized into one of four boxes which define the actions to take with each individual actor throughout the duration of the adaptive management plan process. These action categories are listed as 'Monitor', 'Consult', 'Keep Involved' and 'Keep Informed'.

Figure 1: *Power-Interest Matrix; this matrix was built using mybeeye.com's stakeholder analysis generator. Ratings of power and interest were defined using a 0 - 10 numeric scale.*

IV. Objectives and Actions Analysis

In order to successfully define our management plan actions, we must first strictly define our objectives of the management plan, including the strategic objective, fundamental and means objectives. Our strategic objective is to;

Maintain an ecologically favorable population status of the Herring Gull (EU: Birds Directive), while recognizing and minimizing incompatibility issues between Herring Gulls and citizens living in urban environments.

In Figure 2, we present a detailed hierarchy flowchart depicting each category of our management plan's objectives and the respective actions that aim to accomplish these. It is relevant to note that while developing this objectives hierarchy, various other objectives were considered when formulating the analysis. Minimizing overall costs was one of these. We believe that this is an inherent variable to consider when developing any management plan and therefore have not specified it directly in our objectives hierarchy.

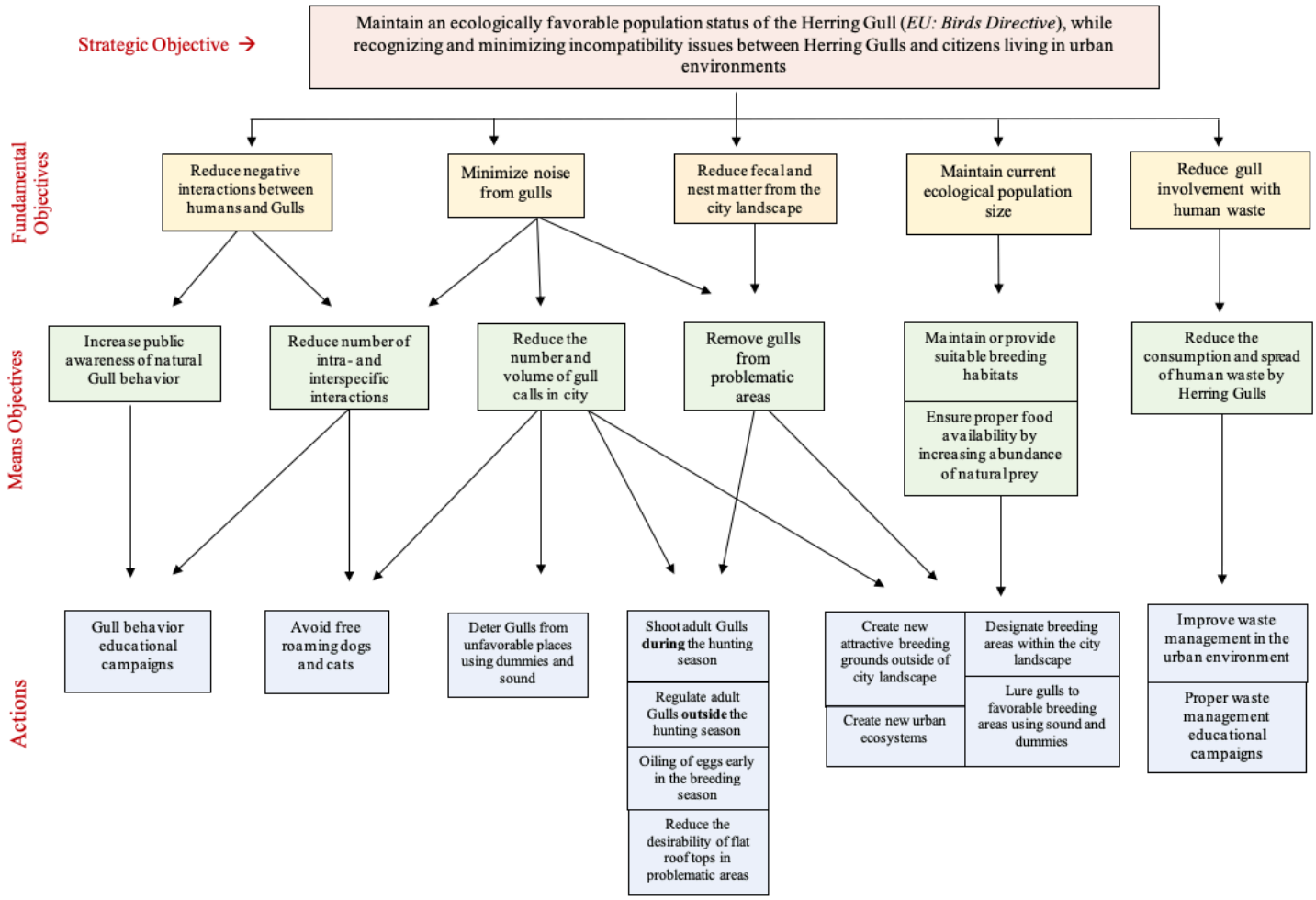

Figure 2: *Objectives Hierarchy; arrows indicate the flow direction of the diagram, and which objectives and actions are associated with one another.*

Actions Analysis:

To better visualize how each of the actions have been formulated for this management plan, we have created a table which exemplifies the key variables associated with action implementation; their associated conflicts, risks and monetary costs. This table will allow for an assessment of these actions alongside the Status Quo. This assessment will allow for different management techniques and approaches to be considered that are well suited for implementing such actions.

Table 1: *Actions Table; this table represents the various actions mentioned in the Objectives Hierarchy (Figure 2) with their associated conflicts, risks and monetary costs. Cost Analysis: 0 - no cost, $ - low cost, $$ - medium cost, $$$ - high cost, $$$$ - very high cost. Risks highlighted in pink are elaborated on in the main text following the table.*

Action	Definition	Conflicts	Risks	Cost
Status Quo	To do nothing in regard to managing the incompatibility between gulls and humans.	The public may be frustrated because they expect the municipality to deal with problems caused by gulls although the municipality has no obligation to do so.	People will continue to experience problems with gulls. These problems may worsen over time, increasing discontent amongst the public and increase the costs of handling problems caused by gulls.	$
Shoot adult gulls during the hunting season	Reducing the number of gulls in problem areas during the hunting season.	May be unacceptable to people with an interest in gulls. Especially because a major reduction in population may be needed for an effect to be seen. Might be in conflict with the fundamental objective of maintaining population levels.	The effect on the breeding population is uncertain because seasonal migrants may be shot instead of breeding birds.	0 - Already done by leisure hunters.
Regulate gulls outside of hunting season	Reducing the number of gulls in problematic areas, right before and during the breeding season.	May be unacceptable to people with an interest in gulls. Might be in conflict with the fundamental objective of maintaining population levels.	May not be realistic and feasible to accomplish. May deter gulls from certain problematic areas, but they may redistribute to other problematic areas instead. Voluntary derogation shooters might lose their interest.	$ - Using voluntary derogation shooters. $$ - Using professional derogation shooters.

Table 1 continued:

Action	Definition	Conflicts	Risks	Cost
Oil eggs early in the breeding season	Oiling of eggs, during the breeding season, in order to minimize the number of chicks hatching.	Might be in conflict with the fundamental objective of maintaining population levels. May be unacceptable to some people with an interest in gulls.	May not be realistic and feasible to accomplish.	$ - If nests are easily accessible. $$$ - If nests are inaccessible (e.g. on roofs).
Lure gulls to favorable breeding areas using sound and dummies	Removing gulls from urban areas by getting them to utilize an alternative breeding area away from residential areas by using other gull sounds and gull dummies.	Might include objects or sounds that will create more problems with neighbouring humans in the period where the gulls are moving.	The effect might only be temporary. May lure in gulls from another colony. It is unknown whether this action will be effective. Potential habituation to dummies or sounds.	$$-$$$
Deter gulls from unfavorable locations using sound and dummies	Removing gulls from unfavorable areas by deterring them by using dummy objects, like predatory animals or predatory sounds that will encourage relocation.	Sounds or objects might create conflict with human neighbours in the period where the gulls are moving.	Might scare them to another unfavorable place. The effect might only be temporary. It is unknown whether this action will be effective. Potential habituation to dummies or sounds.	$$-$$$

Table 1 continued:

Action	Definition	Conflicts	Risks	Cost
Create new attractive breeding grounds outside of city landscape	Provide the gulls with an alternative breeding area outside of the city that is undisturbed and predator free.	May create conflict with landowners who disagree with the action.	May increase overall population instead of serving in translocation. Might not remove gulls from the problematic breeding areas. May not be able to acquire land for such an endeavor.	$$$$
Designate breeding areas within the city landscape	Provide the gulls with an unproblematic alternative breeding area to the currently occupied and problematic areas. (F.ex. factory buildings, harbours).	May create conflict with building owners who disagree with the action.	May increase overall population instead of serving in translocation. May require permissions from building owners that may not be approved.	$
Introduce educational campaign regarding gull behavior	Introduce campaign to be presented to the public regarding natural gull behaviour. May consist of informational signs in areas with a high amount of gulls present.	People could disagree with the campaign and its motives.	May not be received well, depending on how it is executed. People could ignore the campaign and be reluctant to change their behavior.	$$
Introduce educational campaigns regarding proper waste management	Introduce campaign to be presented to the public regarding proper waste management. May consist of informational signs in areas of high human traffic, informing people why waste management is important.	People could ignore the campaigns and be reluctant to change their behavior, which could result in legal ramifications for the citizens.	Compliance may be low if people have an interest in feeding the gulls or don't have an incentive to follow the guidelines. May not be received well, depending on how it is executed.	$$

Table 1 continued:

Action	Definition	Conflicts	Risks	Cost
Improve waste management in the urban environment	Introduce waste disposal systems that control for gull access to human waste. Impose stricter fines or other forms of penalty for those who do not dispose of waste properly. Implement strategies that reinforce positive/desirable waste management behaviour from humans.	People could ignore the law and be reluctant to change their behavior, which could result in legal ramifications for the citizens.	Might make it harder for people to dispose of waste, and therefore they might give up and dispose of waste incorrectly (i.e. by leaving their waste outside of designated waste bins). May be difficult to change legal structures and overcome political and bureaucratic barriers. May not improve waste management habits as anticipated.	$$
Reduce the desirability of flat roof tops in problematic areas	Increase the ease of human access to roofs, and when creating buildings with flat roofs. This should be implemented into the building process. Implement structures on flat roofs that reduce desirability to gulls.		The actions taken to reduce desirability might have a negative effect on neighbor-properties, f.ex. affecting the noise levels. May not be something all property owners are willing to partake in.	$$$
Reduce number of free roaming domestic dogs and cats	Enforce legislation surrounding free roaming pets.	May not be received well by domestic animal owners and they may be reluctant to change their behavior.		$
Create new urban ecosystems	Create an opportunity for alternative habitat use for the gulls. Increase natural prey abundance.	This is an expensive endeavor and often requires permits.	Creating new urban ecosystems, may support urban gull populations but not discourage nesting behaviour on buildings. Gulls may not choose to shift their diet towards natural prey and continue to prefer human garbage.	$$$$

Risk Elaboration

As visualized in Table 1, each action that we propose for this management plan has associated risks with their implementation. We will discuss the risks for a few of the actions, which we feel need further elaboration (those highlighted in pink in Table 1). This has been based on a subjective assessment of the outcomes associated with these risks. These actions consist of the 'Status Quo', 'Create new attractive breeding grounds outside of city landscape', 'Designate breeding areas within the city landscape', 'Create new urban ecosystems' and 'Regulate gulls outside of hunting season'.

The status quo will involve making no efforts to manage the incompatibility between urban gulls and humans, and will therefore result in a potential increase in incompatibility. Given the severity of the incompatibility issue, a complete lack of effort to mitigate the issue will potentially result in the issue growing to such great proportions that mitigation techniques will become far more expensive, controversial, or entirely unmanageable.

Creating new breeding grounds outside of the city landscape is one of the more expensive actions that we have proposed, and also contains a fair amount of uncertainty regarding it's probability of success. This would require the acquisition or designation of land to be protected and modified for the purpose of gull breeding grounds, which may not be a simple task in all parts of the country. In addition, it will be a lengthy process requiring long waiting times for legal decisions to be made. In addition, there is a large amount of uncertainty regarding its efficacy in accomplishing what we have designed the action to do.

Designating alternative breeding areas within the city landscape is an action designed to provide a low cost alternative to the creation of new breeding grounds outside of the city. Ideally, this action will allow Herring Gulls to continue breeding within the urban environment but not cause distress or discomfort to humans living nearby. This makes the assumption that these breeding gulls will not be entering the residential areas of the urban environment to forage and nest. As described in Appendix I, the Herring Gull has a rather large foraging radius, which may influence the possibility of this assumption not being met. The creation of alternative breeding areas may only encourage an increase in the urban breeding population rather than just a redistribution. It is also uncertain as to whether or not this will create an entirely new set of problems in the newly established breeding area, such as causing damage to the buildings or disturbing other property owners.

Creating new urban ecosystems will ideally lead to an increase in biodiversity and therefore natural prey items for the urban Herring Gull. This action makes the assumption that with an increase in natural prey abundance, the urban Herring Gulls will prefer to consume such prey items over that of their typical urban diet which would include human waste among other things. It also makes the assumption that urban Herring Gulls will prefer this form of habitat over their typical urban habitat choice, which is building rooftops and harbors. It is therefore reasonable to argue that these assumptions may not be met, and the Herring Gull will continue to prefer the urban habitat and diet over the newly provided options.

Regulation of gulls outside of the hunting season within problematic areas may not be the solution to the problem and might become the source of another. For example, the process of shooting gulls within

the urban environment, may deter them from nesting and residing in some areas, but this may also fuel a redistribution of gulls to settle in another problematic area. It is also noteworthy that part of this task often includes voluntary or hired derogation shooters shooting birds within the urban landscape, which may cause discomfort and insecurities amongst people living within the residential areas. This task would require approval from the politicians in the municipality and therefore is a valid barrier that would have to be overcome prior to the implementation of such an action.

Consequence Analysis

The actions described in the table above are unlikely to be equally successful in fulfilling the fundamental objectives found in Figure 2. In some cases an action that greatly benefits one objective may be detrimental to another. It is therefore imperative that the effect of these actions are evaluated in relation to all fundamental objectives and not only the one(s) that the action is intended to benefit. The consequences and effects of the actions are usually assessed on an informed background using quantitative analyses or at least a qualitative literature study. In this management report the evaluation of the consequences (Table 2) is primarily based on a discussion between all group members (i.e. expert opinion) and is therefore highly subjective. The only quantitative assessment we have used is the demographic model presented in the next chapter which shows that regulation of adults is a more effective way to reduce the population size than reducing fecundity.

Table 2: *Consequence Table; represents an overview of our fundamental objectives and actions in a qualitative value based manner which puts a particular weight value on each of the relevant actions in relation to how they influence each of the fundamental objectives. The plus sign (+) indicates a positive influence, minus sign (-) indicates a negative influence, and zero (0) indicates no influence on the desired direction of the fundamental objective. In order to better distinguish between the influence of the different actions, we have decided to use a three step scale for the positive and negative ratings.*

Fundamental Objective	Direction (Min/Max)	Actions (+/-/0)						
		Status quo	Educational campaign - gull behaviour	Educational campaign - waste management	Improve waste management	Shooting gulls during hunting season	Regulation of gulls outside of hunting season	Oiling of eggs early in breeding season
Noise	Min	--	+	+	+	0	+++	+
Fecal/Nest Matter	Min	--	0	+	+	0	+	0
Gull involvement with Human garbage	Min	--	++	++	+++	0	+	0
Negative Interactions	Min	--	+++	+	+	0	+	+
Maintain population	0	+++	0	--	---	--	--	-
SUM		-5	6	3	3	-2	4	1

Fundamental Objective	Direction (Min/Max)	Actions (+/-/0)						
		Create new urban ecosystems	Deter gulls from unfavorable places using sound and dummies	Lure gulls to favorable breeding areas using sound and dummies	Reduce the desirability of flat roof tops in problematic areas	Designate breeding areas within the city landscape	Create new breeding grounds outside the city landscape	Reduce number of free roaming domestic dogs and cats
Noise	Min	+	++	++	+++	++	+++	+
Fecal/Nest Matter	Min	0	++	++	++	++	++	0
Gull involvement with human garbage	Min	+	+	+	+	+	+	0
Negative Interactions	Min	+	+	+	+++	++	++	++
Maintain population	0	+	0	0	-	++	++	0
SUM		4	6	6	8	9	10	3

Consequence Table Summary

The development of this consequence table and its associated qualitative ratings determined that the creation of new breeding grounds both in and outside of the urban environment resulted in being the most beneficial actions overall to accomplish the fundamental objectives. In contrast, the status quo and shooting gulls during the hunting season resulted in being the least beneficial actions overall to accomplish all of the fundamental objectives.

As mentioned, the consequences are primarily based on a subjective discussion, and arguments can be put forward to change the rating. As an example we have argued that creating attractive breeding grounds outside of the city would have a positive influence on the gulls' involvement with human garbage (reduce the interaction). Our assumption is that moving the gulls away from the city will reduce the amount of gulls that visit the city even though they are perfectly capable of flying in there to forage. An assumption that could also be made is that all gulls in the new colony would just fly into the city to forage, thereby not reducing their involvement with garbage. This analysis is therefore open to debate.

V. Model Framework and Monitoring

Model Framework

The models described here are based around the geographic region of Horsens, but should be generally applicable for other local populations. In Horsens there is a population of 200 - 400 breeding pairs within the city boundaries and a larger colony of 3000 - 4000 breeding pairs on Hjarnø approximately 10 km east of the city (Pers. Comm. Local Birdwatcher). According to a local birdwatcher, gulls from Hjarnø and Horsens Fjord often forage on agricultural fields west of the city, creating a large influx of gulls over and into Horsens (Pers. Comm. Local Birdwatcher).

The development of a population (ΔP) can be described as a function of the sum of immigration (I), emigration (E), birth (B) and death (D), $\Delta P = I + B - (E + D)$. These parameters can all be affected by some of the actions described in the action analysis as illustrated in the influence diagram (Figure 3). Just as the models, the influence diagram is designed to fit the local region of Horsens. Furthermore, the influence diagram represents the demographic model described below and therefore only contains actions that have the purpose of reducing population size within the city. There may be places where not all actions are possible (i.e. create alternative habitats), but overall it should be generally applicable at the local level. At a national level this will not be the case, as a large reduction in population size will conflict with the international agreements described in the chapter about the legal framework (Chapter II). At the local level this is not a problem because local reductions in population size would be insignificant at the national level.

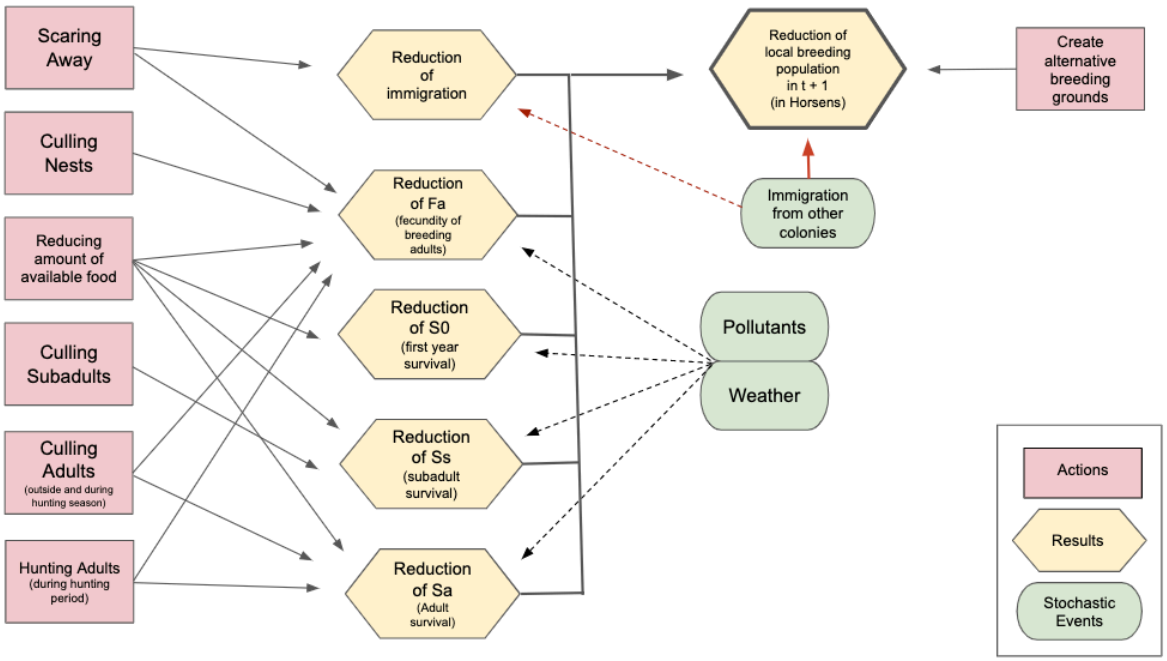

Figure 3: *This influence diagram is focused around the actions associated with the reduction of the breeding population of Herring Gulls within a local urban environment (Horsens) and the stochastic events that could potentially affect this. The black arrows represent a positive influence of the actions/stochastic events on the results. The red arrow indicates a negative influence on the result.*

The demographic parameters are currently unknown for Horsens and the surrounding area. While estimates may be made about birth and death rates based on studies from other areas, the immigration and emigration will depend on source/sink interactions in the local population and these are currently unknown. To improve the accuracy of the model it is therefore essential that the immigration to and emigration from Horsens is assessed. This should preferably be done through repeated monitoring throughout the year to clarify seasonal variation by recapture of (color) ringed birds. However, the cost of such a project may be (too) high if a suitable sample is to be marked (and recaptured) continuously. Alternatively, recapture could be restricted to breeding birds on the nest during the breeding season. While this will not provide data on the total number of immigrated birds as some may not be breeding and there may be seasonal variation, this monitoring would be more economically feasible. Assessing emigration would be analogous to assessing immigration by color ringing the birds in Horsens instead of those in the surrounding areas.

A key assumption in matrix models (Leslie/Lefkovitch matrix) is, that immigration and emigration can be ignored (either because they are not present or because they are completely equal). As is described above, this is likely not the case for the Horsens population as it may be well connected with the larger Hjarnø population. However, the entire regional population around Horsens Fjord may be more isolated from other regional populations although the current knowledge is too sparse to have any certainty regarding this assumption.

Demographic Modelling

Horsens municipality is currently using two methods for regulation: culling of adults or subadults and destruction of nests by oiling eggs (Horsens Kommune 2018a). To assess which method is most effective in reducing the population size we made an elasticity analysis by using a Lefkovitch matrix. We assume the following:

- There is no immigration or emigration between Horsens city and the surrounding areas (this is most likely not true as described above).
- Breeding success and survival is independent of population size (i.e. the population is far from carrying capacity and there is no Allee effect).

As there is no data on demographic parameters available from the area around Horsens Fjord, we used demographic parameters from the literature as well as an expert opinion. This introduces a large uncertainty in the model, which can be minimized through direct studies of demography in the area.

We used the following parameters for the model analyzed in RStudio 1.0.143 with the package "popbio" (Stubben and Milligan 2007):

Survival (Cramp and Simmons 1983)
First year (s0) = 0.78
Second year (s1) = 0.93
Adult (sa) = 0.85

Breeding propensity (expert opinion Pers. Comm. Morten Frederiksen)
Third year (f3) = 0.1
Fourth year (f4) = 0.5
Fifth year (f5) = 0.85
Sixth year and above (f6) = 1

Fecundity
Same for all age classes = 0.86 (Camphuysen and Gronert 2012)
Sex ratio assumed equal

The annual growth rate is λ = 1.035, showing a 3.5 % yearly increase in the population. Furthermore, the generation time is 9.5 years with a stable age distribution where almost 38 % of the population is 6 years or older (Figure 4).

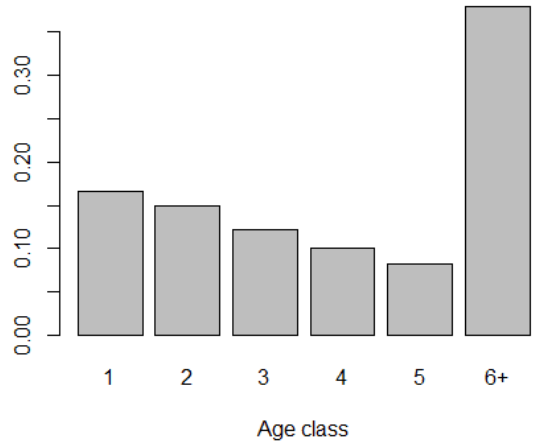

Figure 4: *Histogram of the stable age distribution just before the onset of the breeding season. It is seen that the largest ageclass in the population is 6 years or older.*

Performing an elasticity analysis on the matrix model, reveals that the most efficient way to affect the growth rate is by reducing survival among the birds that are 6 years or older (Figure 5). A reduction in the survival of this group by 10 % would yield a 3.8 % reduction in population growth rate. However, as the Herring Gulls reach adult survival rates at 2 years of age, the combined elasticity of reducing adult survival is 0.78. Therefore, an effort to reduce adult survival (gulls that are 2 years or older) by 10 % would lead to a reduction in growth rate by 7.8 %.

		f3*s0	f4*s0	f5*s0	f6*s0
s1					
	sa				
		sa			
			sa		
				sa	sa

Figure 5: *The matrix model is shown on the left and the elasticity analysis on the right. A low number and light color in the elasticity analysis indicates an ineffective way to change the growth rate whereas a dark color and large number indicates an effective way to change the growth rate of the population.*

The least effective method to affect the growth rate would be to reduce the fertility (the product of breeding propensity and the number of female offsprings surviving the first year) of 3 year old Herring Gulls as only a small proportion of these birds are assumed to breed and the mortality during the first year of life is high compared to the other age classes (Figure 5). Reducing the fertility of the entire population (0.11) by 10% would only decrease the growth rate by 1.1 %.

As the elasticity analysis revealed a reduction in adult survival to be the most efficient way to reduce the growth rate, we ran the model with different adult survivals to estimate the point at which the growth rate would be stable. The result was that an adult survival of approximately 0.81 would result in a population with no growth (Figure 6), hence an adult survival less than 0.81 would lead the population to decline.

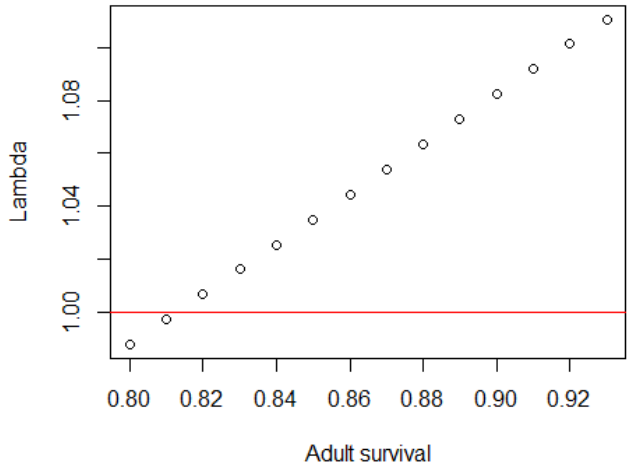

Figure 6: *Growth rate as a function of adult survival. The red line indicates the point at which there is no change in population size. Survivals that are above the red line show a growing population whereas survivals below the red line will lead to a decrease in population size. The adult survivals used for the analysis represent the range of adult survival described in Cramp and Simmons (1983).*

As already stated, this model must be interpreted with extreme care, as the demographic parameters may not be applicable to the populations in and around Horsens. However, the model does provide a strong indication that reduction of adult survival through derogation shooting will have a larger effect relative to destroying nests. Using the model we are, however, unable to say if it is so much easier to oil the nests that this may in practice be a more cost effective way to reduce the population. If the nests are located on easily accessible areas this might well be the case, but within the city the nests are often located in inaccessible places making oiling a lot harder. Therefore it is likely that the combination of ease and effectiveness makes derogation shooting more effective than oiling nests in controlling the population.

Agent Based Modelling

While the problems caused by Herring Gulls may partly be explained by an increase in population size (especially at a local level), demographic change is unlikely to explain the entire problem. Bregnballe and Lyngs (2014) have shown that there has been a major shift in the distribution of Herring Gulls in Denmark over the last approximately 40 years and Aarhus Kommune (2016) states that distribution change at a local level and immigration of non-breeding birds is a larger problem than growth of the breeding population.

In essence the problem is therefore likely to be better described by Agent Based Models (ABM) where changes in distributions can be modelled through the response to changes in the biotic and abiotic landscape at both the individual and population level (McLane et al. 2011). These responses may be founded in behavioral and movement ecology as well as the animal's cognitive abilities.

We will not present a finished ABM in this report, but merely state that we believe an ABM will be a better choice than a purely demographic model (e.g. matrix model) because it allows hypotheses about behavior and movements to be tested in the iterative phase through the optimization of a Markov chain.

Monitoring and Evaluation

System Monitoring

In order to establish a baseline overview of the system that we are working with, various quantitative and qualitative analyses will take place. To start with, estimates of population size of the Herring Gull both at a national and local level will take place. This can for example be done through point counts or a capture-mark-recapture procedure using color banding. A proper assessment of the population dynamics will also be necessary, such as noting the immigration and emigration rates of the local population to be managed. The most effective way to estimate these would most likely be by using GPS-tracking, when looking at a short time scale whereas long term trends in population movements/dispersals are likely best monitored by using resights of color banded birds.

Evaluation of Fundamental Objectives

To evaluate whether or not the management plan's implemented actions contribute to the accomplishment of the fundamental objectives, evaluation protocols will be introduced for each of these objectives within our management plan. In the following section, each fundamental objective is

listed separately, followed by a brief description of what the monitoring protocols will consist of. All of these protocols will be executed more than once following the implementation of the management plan, so as to acquire a continuous overview of the management plan's efficacy.

- *Minimize noise from Herring Gulls in urban areas*

To evaluate the status of noise emission from the Herring Gulls in urban areas, sampling stations will be allocated throughout the city, which will measure sound levels emitted by Herring Gulls. Data will be collected from these noise monitoring stations before the management plan actions are implemented as well as afterwards, to determine if there is any sort of significant difference. In addition, a quantitative analysis will take place measuring the number of official complaints made to the municipality in reference solely to noise from Herring Gulls.

- *Reduce fecal and nest matter from the city landscape*

To evaluate the status of fecal and nest matter from the Herring Gull within the city landscape, assessments will be made through the distribution of surveys. These surveys will primarily be distributed to individuals who within our primary system assessment, indicated that fecal and nest matter was a large problem either on or around their owned/rented property. These surveys will assess to what degree, if at all, there was a reduction in the presence of fecal and nest matter. Within the survey, the individuals will also be able to indicate the monetary damage that may have been associated with fecal/nest matter.

- *Reduce Herring Gull involvement with human waste*

To evaluate the status of the Herring Gull involvement with human waste in urban areas, particular monitoring programs will be implemented around the city that will survey waste containability. This monitoring program may exist in partnership with the municipality and their existing waste management monitoring systems. Certain municipalities have platforms available to their residents where they can cite waste facilities that are not containing waste as they should, which is particularly relevant for pest management (Giv et Praj 2020). We can use these platforms as an element to measure the frequency of reported uncontained waste in the urban environment, in particular areas where newly renovated waste management systems have been updated. As another form of monitoring, we could implement surveys in busy areas, where effective waste management may be more difficult to obtain. People living in areas of the city with a history of poor waste management (such as populated areas that are busy particularly during the weekends) could be surveyed on whether or not they feel that there has been an improvement in waste management.

- *Reduce the occurrence of negative/aggressive interactions between humans and Herring Gulls*

To evaluate the status of negative/aggressive interactions between humans and Herring Gulls in urban areas, surveys will be distributed amongst the city residents. These surveys will include questions that

will measure if these interactions are still occurring and to what degree. They will also include the ability to describe what exact form of interactions are taking place. In addition, the number of formal complaints (regarding negative/aggressive interactions) being made by the city residents to the municipality will be assessed.

- *Maintain current ecological population size at a national level*

To evaluate the maintenance of the current ecological population size at a national level, we must evaluate and monitor both the ecological population sizes at a national and local level. This will take place by assessing the number of breeding pairs. As part of our management plan may include the reduction of a local breeding population, it will be imperative that we continuously evaluate and monitor whether or not this impacts the national breeding population.

Clarification of Uncertainties

Several of the uncertainties are focused around understanding the magnitude of gull related problems. The number of people experiencing problems with Herring Gull behavior and the number of Herring Gulls having problematic behavior. Furthermore, there is a need for clarification of whether there is a relationship between the population size of Herring Gulls and the number of complaints from citizens. It is uncertain whether the problematic gulls are residential individuals or visitors from breeding grounds outside the city area, flying in to forage in the city or just using the city as a minor stop before flying elsewhere to forage.

There is uncertainty about what authority is responsible for doing the management actions and providing the funding for these actions. People in general have the understanding that it is the municipality who are the responsible authority, but it is Naturstyrelsen that have the authority and power to offer solutions for problems and conflicts arising from Herring Gull behavior. This causes an uncertainty for the citizens about who to contact about their problems. The easiest solution would be to have a local gull-hotline managed by the municipality that could be contacted for guidance. This would provide the citizens a single point of entry into the management of Herring Gulls.

There are uncertainties regarding the aspect of controllability. Waste management actions may not ensure complete control over human behavior and therefore will end up having little effect regarding minimizing the problems caused by gull behavior. Additionally, the creation of new breeding grounds may not ensure control over the movement of breeding populations from urban areas to alternative breeding areas, but rather make it possible for gulls to expand their breeding grounds.

There are uncertainties in regard to how the number of individual gulls shot in the hunting period, affects the population size of the breeding populations. This uncertainty is related to local, national and international migration rates and would therefore be reduced through the system monitoring described above.

Active Adaptive Management / Learning from Uncertainties and Actions

In order to have an active adaptive management plan, studies focused on reducing the uncertainties should be designed in addition to the monitoring. The reason an active adaptive management plan would be beneficial regarding the Herring Gull is that there are a lot of uncertainties when it comes to even the most basic information. As an example, there is currently no available knowledge regarding exchange between colonies or even the exact size of the breeding population in Horsens. These are very basic types of information on which loose estimates have to be made in the beginning and then having them monitored to see if the estimates are correct and how they develop. Furthermore, it is uncertain how the Herring Gulls will respond to actions that should change their behavior (e.g. creating new breeding grounds) and designing studies on this would therefore reduce this uncertainty.

To monitor the number of gulls with problematic behavior there is need for a continuous monitoring program, to obtain an overview of the number of problematic gulls and in order to assess the changes each year. Under the assumption that the number of complaints from citizens is proportional to the number of problematic gulls, this could be done by creating a GIS-database where the complaints are referenced over consecutive years. This GIS-database could then be enhanced by drone mapping of nests on roofs in the whole city, or specified problematic areas to clarify if there is a correlation between the number of complaints and number of nests in an area (i.e. are the problems caused by the number of gulls or the behavior of specific individuals).

According to the interviews done with the Horsens municipality representative, a local birdwatcher and a local hunter (Pers. Comm. Horsens Municipality Representative, Pers. Comm. Local Birdwatcher, Pers. Comm. Derogation Hunter), there is an uncertainty regarding the origin of some of the problem birds. In some cases, it is known that the breeding birds are causing problems, but in many cases it is not known if the birds causing problems are local or are coming into the city from the surrounding areas. A fairly cheap way to address this uncertainty would be to add a water-resistant non-toxic dye to all nests in Horsens, which would color the brooding birds. This would make it possible to see how many of the birds causing problems in Horsens during the breeding season are in fact breeding there. This method would still have uncertainties as there may be resident gulls that are not breeding and therefore are not colored. These birds can not be told apart from breeding (or nonbreeding) birds coming into the city from the surrounding areas. The information could also be gathered by color banding but using a dye on the nests would most likely be cheaper and more efficient. This part of the management plan has potential to be a citizen science project as colors are easily assessed by untrained individuals.

VI. Iterative Phase

In the iterative phase of the project, there is a need to continuously monitor, model and evaluate the effects of the actions taken. The iterative wheel in Figure 7 gives an overview of this process where data collected during the monitoring process is used in models describing the system to evaluate how well the objectives are fulfilled. After this, the objectives are reevaluated and decisions are made regarding the actions that should be taken in the next iterative phase, after which this process starts over. The overall purpose of this management plan is an increase in coexistence between humans and Herring Gulls while maintaining an ecologically sustainable population. While we have suggested several actions to reach this goal, it is possible to combine these into six categories: cull the population, move the population (deter and lure), improve waste management, educate the citizens, create alternative habitats and reduce the amount of free roaming cats and dogs. In Table 3, the iterative process for each of the six categories is explained. These categories are not independent, for example, it is very likely that the amount of human waste present for gull consumption in the city will affect how easy it is to move the population. This is also true for the culling of gulls, as it is likely that derogation shooting and destruction of nests in the city may make it more attractive for the gulls to move out of the city and thereby facilitate a population movement.

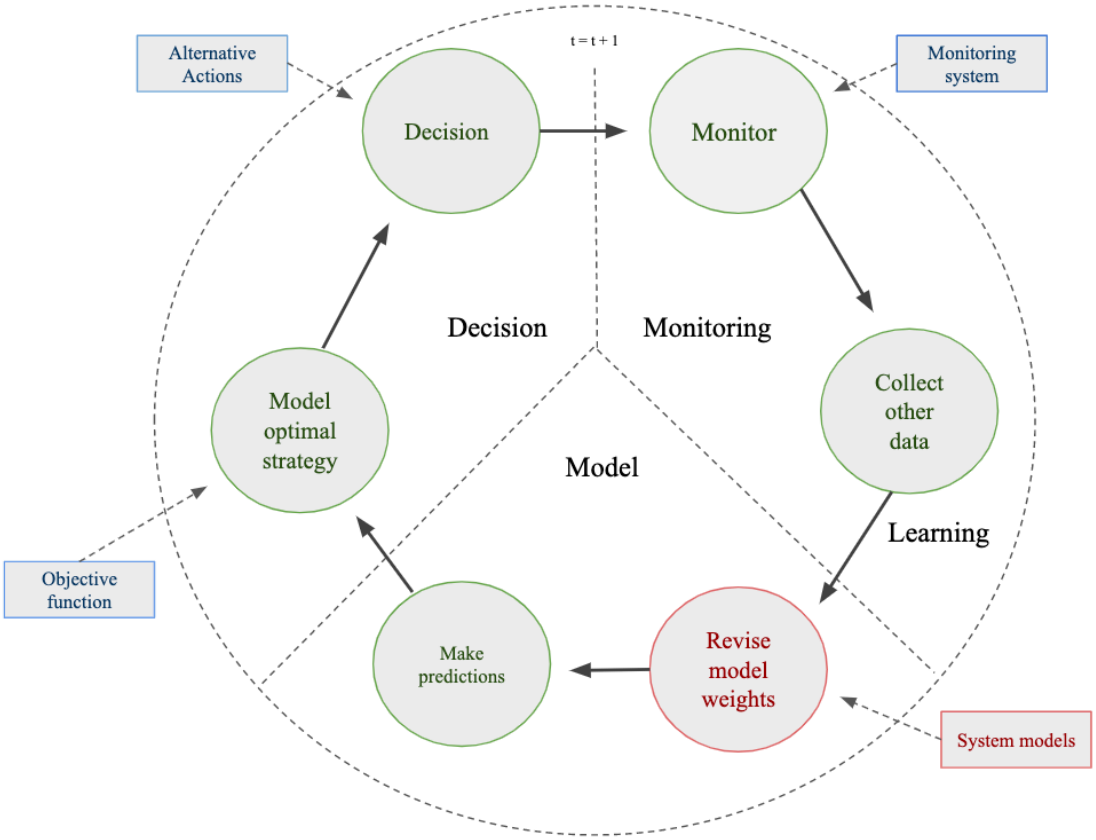

Figure 7: *Iterative Wheel; adapted from a presentation provided by our course supervisors.*

Table 3: *Iterative Process Table; a break-down of each of the proposed action categories and their associated iterative processes*

<table>
<tr><th>Actions</th><th>Iterative Process</th></tr>
<tr><td colspan="2">Reduction of urban Herring Gull population (cull)</td></tr>
<tr><td>Shooting adult gulls during the hunting season</td><td rowspan="3">Evaluation process:
The evaluation process will aim to answer these questions regarding the actions associated with reducing the urban Herring Gull population:

Has there been a reduction in the Herring Gull population as a result of gulls shot during the hunting season as well as outside of the hunting season?
Has there been a reduction in the Herring Gull population as a result of oiling the eggs during the breeding season?

Monitoring and evaluation: For evaluation of the effectiveness of the reduction of the urban Herring Gull population, a collection of the numbers of shot individuals both during the hunting season and during regulation and culling of eggs outside of the hunting season would be required. The data can be collected from Miljøstyrelsen. These are all measures to reduce the population of Herring gulls, and an evaluation of these are in order to gain knowledge about the effect of the different actions.

Frequency of decision: The monitoring should be done yearly in the beginning to gain an understanding that is currently missing. The reevaluation process should be done annually.

Needs for optimization: The effect of the three actions should be optimized using demographic models and/or ABMs.

Participants:
Derogation hunters doing to regulation on gulls
Leisure hunters hunting during the hunting season
People oiling eggs at the breeding grounds
The municipality
Miljøstyrelsen to some extent, because they have data on regulation and gulls killed in the hunting season</td></tr>
<tr><td>Regulation of gulls outside of hunting season</td></tr>
<tr><td>Oiling of eggs early in the breeding season</td></tr>
</table>

Table 3 continued:

Removing gulls from unfavorable areas (non-cull)	
Deter gulls from unfavorable places using **sound** and **dummies**	**Evaluation process:** The evaluation process will aim to answer these questions regarding the actions associated with removing gulls from unfavorable areas: Have the gulls been deterred from unfavorable places using sound? Have the gulls been deterred from unfavorable places using dummies? Has the desirability of the flat roofs been minimized? **Monitoring and evaluation:** These are all actions to remove the population of Herring Gulls from unfavorable areas and an evaluation of these are in order to gain knowledge about the effect of the different actions. A count of the number of problematic gulls, and/or the number of complaints from affected citizens should be gathered. **Frequency of decision:** There should be a yearly evaluation in the beginning. After an initial 3-5 years, surveys will be compiled and analyzed, and decisions regarding the success or failure of gull movements will be made. **Needs for optimization:** This process is best optimized using ABMs. **Participants:** • Municipality • Citizens for supplying the information • Researchers or experts with knowledge on the effect of the sounds, dummies and what makes a roof desirable to gulls

Table 3 continued:

Create Alternative Habitats	
Create new attractive breeding grounds outside of city landscape	**Evaluation process:** The evaluation process will aim to answer these questions regarding the actions associated with creating alternative habitats: Are urban gulls successfully utilizing the new breeding grounds? Are urban gulls utilizing the new urban ecosystems? **Monitoring and evaluation:** If the alternative habitats are successful in attracting gulls, the monitoring process will initially involve the collection of data regarding the number of gulls using the alternative habitats. This will include breeding pairs using the breeding sites and individual gulls using the new urban ecosystems. Surveys of successful breeding for the new breeding grounds will be completed to determine if the breeding grounds are suitable for breeding. Fecundity of breeding pairs will be determined so as to monitor how this newly established breeding colony will affect overall population size. Breeding surveys of gulls within the city will be completed to measure if there is a decrease in urban breeding pairs. Gulls living in the city will be color banded to see if they are in fact the ones moving from the city to the alternative habitats. **Frequency of decision:** Yearly, after all annual surveys have been completed. After an initial 3-5 breeding seasons, surveys will be compiled and analyzed, and decisions regarding the success or failure of alternative habitats will be made. **Needs for optimization:** The actions will need to be optimized based on the gathered information from the breeding surveys every year. This process will yield different weights to the actions actually making the gulls move, as more data is collected. Over time it will most likely be possible to reduce the efforts in some of the actions as the model will deem them ineffective in moving the gulls. This optimization is best done by using ABMs. **Participants:** • Ornithological organizations for doing breeding surveys • Volunteers/researchers for color banding • Legal entities and landowners for the development of new breeding areas and urban ecosystems • Municipality for the permissions of creation of new urban ecosystems

Table 3 continued:

Educate Citizens	
Introduce educational campaign regarding gull behavior	**Evaluation process:** The evaluation process will aim to answer these questions regarding the actions associated with educating citizens: Are people receiving the information well? Has the attitude/understanding towards the gulls changed? Has waste management behaviour of humans changed? **Monitoring and evaluation:** To understand if these campaigns were successful, various surveys will be distributed amongst the target group, to analyze how the information was received. Surveys as well as registered complaints regarding negative interactions between humans and gulls will be analyzed. Reports made by the municipality waste management team regarding the status of resident waste management behaviour will also be analyzed. **Frequency of decision:** Decisions regarding future actions associated with this category will be made annually, in the beginning, so as to allow enough time for any changes associated with the campaigns to take effect. **Needs for optimization:** If the campaigns are successful, and there are positive results directly associated with them, frequency of decisions may be extended beyond an annual basis. Further campaigns, or extensions of the existing campaigns, may also be implemented if the information is received well from the recipients - to further potential improvements. If the campaigns are unsuccessful, their weaknesses will be determined, and altered to improve the campaigns. **Participants:** • Campaign implementation authority (f.ex. municipality, nature organizations) • Ornithologists/experts for developing behavioural campaign information • Municipality waste management department • Recipients of campaign information

Table 3 continued:

Improvement of urban human waste management	
Improve waste management in urban areas	**Evaluation Process:** The evaluation process will aim to answer these questions regarding the improvement of urban human waste management: Are residents disposing of their waste properly? Are the improved waste management systems effective? Has the overall containment of human waste in urban areas improved? **Monitoring and Evaluation:** To understand if the waste management actions were successful in improving waste management within urban areas, assessments will be made in collaboration with the municipality's waste management department and the municipality's legal authorities who distribute fines. People will also be surveyed to analyze if they feel that the new waste management systems are user friendly and encourage proper waste disposal. In addition to surveys, reports made by citizens using designated platforms (f.ex. Giv et praj app), will be compiled to acquire an understanding of the efficacy of the improved systems. **Frequency of decision:** Decisions regarding future actions associated with this category will be made bi-annually, in the beginning. Given the high frequency of waste disposal and management in urban areas, frequency of decision making may need to be increased. Initially, there will need to be a certain amount of time allotted before effects from the introduced changes can be observed. **Needs for optimization:** If the waste management actions are successful, actions to optimize this new system will be made, such as the continuation and potential improvement of the existing system. Continuous collaboration with the municipality's waste management department will exist to ensure optimal maintenance of urban waste, and that the public is in full cooperation with the improvements being made. The effects on gulls could be optimized in both demographic models as reduction in fecundity or survival due to less food or as behavioral change in ABMs. **Participants:** • Police issuing fines and enforcing regulations • Municipality waste management department • The general public using the improved waste systems

Table 3 continued:

Reduce number of free roaming domestic dogs and cats	
Reduce number of free roaming domestic dogs and cats	**Evaluation process:** The evaluation process will aim to answer these questions regarding the reduction in number of free roaming domestic dogs and cats: Is the law being followed? Is the conflict between Herring Gulls and free roaming cats and dogs reduced? Has the number of Herring Gull related complaints decreased? **Monitoring and evaluation:** This is a measure to reduce the conflicts arising from the interaction between gulls, cats and dogs. To evaluate whether this has had the desired effect on noise the number of complaints about Herring Gulls should be monitored and evaluated. **Frequency of decision:** First in order to examine the extent of the problem with conflicts between gulls and free roaming pets, the number of complaints should be reevaluated yearly in the beginning of the process until a level of knowledge is gained, later on in the process the frequency of evaluation should be every second or third year. **Needs for optimization:** If the evaluation of the extent of the problems, the way of enforcing should be optimized, or the action should be terminated depending on the outcome of the evaluation. **Participants:** • Municipality • Citizens for supplying the information Police issuing fines and enforcing regulations

Coupling of models and reduction of uncertainties

As described in the model section (Chapter V), we recommend that Agent Based Modelling should be used to describe the system. As there is a lack of knowledge regarding the gulls' reaction towards the actions, several different ABMs can be created under different assumptions and hereafter weighed in an optimization process. The models will describe the population development and movement as a Markov chain where year x+1 is dependent on year x and the actions taken this year. The reason that the model will have yearly intervals is because the Herring Gull only has one brood per year (Cramp & Simmons 1983). If it turns out during the iteration phase that breeding birds are not the main cause of the problems, it will be possible to have a much shorter interval in the optimization process (e.g. days or weeks).

As described in previous sections there is uncertainty regarding which gulls are causing nuisance (breeding vs. non-breeding birds) and this should be resolved to optimize the efforts in regulating the breeding population. Furthermore studies on connectivity between the different breeding populations should be established. These studies will have the purpose of reducing uncertainty through active learning, thereby making this an active adaptive management plan/strategy. It is unlikely that data collected in one municipality will be enough to evaluate the effectiveness of the actions within a

reasonable amount of time (e.g. 4-5 years). To ensure enough data we therefore recommend that replicates are made in other municipalities experiencing the same problems.

The specific action taken by each municipality should depend on the perceived benefits, costs and associated risks. We assume that municipalities with large problems will be likely to invest more in the actions than municipalities with fewer problems. In the beginning it will be hard to judge the benefits due to a lack of understanding but for each breeding season the benefit will be clearer through optimization of the model. The breeding population and connectivity should therefore be continuously monitored. Furthermore, active learning from additional studies on behaviour and movement ecology of gulls could improve the quality of the different ABMs.

Organization

A management plan like the one proposed here, requires a strategy on who should do what, and when. At the current time there is no legal obligation for the municipalities to take on the leading role, but given the fact that complaints are often made to the municipalities they are an obvious choice as leaders and coordinators. In the following, we therefore assume that the municipality has an interest in doing this, but we recognize that this may not always be the case.

Once every third or fourth year, the municipality should invite all interested/concerned citizens to an information meeting where elaborations on the actions taken and their effects can be communicated to the public. This serves the purpose of acknowledging the legitimacy and interest of all actors, whether they are involved or not. The frequency of this meeting should, however, always be based on an assessment of the public voice (e.g. through news articles). Furthermore the municipality should create a hotline or an app where actors that are not directly involved in the management (e.g. non-property owners) can seek information, and inform the municipality on current problems.

The municipality should arrange a yearly meeting where representatives from the actors that need to be involved in the management are present (property owners, nature organizations, derogation shooters and the municipality - see chapter III). At this meeting the involved actors should discuss, evaluate, and reach a consensus on which objectives need to be prioritized and on the actions that should be taken to achieve these. Furthermore, they will be able to suggest new objectives and actions themselves. This discussion and evaluation should be qualified by the objectives and actions presented in the management plan and on analyses of the previously described models. These analyses could be provided by external consultants on the request of the municipality and should always be presented in a way that requires no expert knowledge.

After the annual meeting the municipality should delegate the assignments for the coming year. As an example the municipality could ask the nature organizations to do a monthly gull census and ask the derogation shooters to regulate Herring Gulls in specific areas.

If the involved actors experience problems in fulfilling the actions, they should have a contact person at the municipality who they can inform at any time during the year. The municipality is then able to assist the actors if possible.

VII. Concluding Remarks

We have in this management plan provided a framework on how to resolve the incompatibility between humans and Herring Gulls in urban environments through adaptive management. As adaptive management progresses, new information is gathered, new ideas arise and the understanding of the system improves. This adaptive management plan should therefore not be considered the final product on how to manage urban Herring Gulls but instead as the first step in a direction where we enable actors to discuss their views, reduce the uncertainties, as well as ensure that the actions taken are based on the best knowledge we have at any point in time.

The nuisances caused by Herring Gulls are not easily solved, but we do believe that active adaptive management will be able to show the way to a solution.

References

AEWA: Agreement on the Conservation of African-Eurasian Migratory Waterbirds (2018) Agreement Text and Annexes. UNEP/AEWA Secretariat: Germany. https://www.unep-aewa.org/sites/default/files/basic_page_documents/agreement_text_english_final.pdf. Accessed on 16 May 2020

Allen CR, Garmestani AS (2015) Adaptive management of social-ecological systems. Adapt Manag Soc Syst 1–264

Author Unknown (2013) Ornitologisk forening: Stop med at skyde måger. In: Fredericia Dagblad. https://frdb.dk/artikel/ornitologisk-forening-stop-med-at-skyde-m%C3%A5ger. Accessed 19 March 2020

Avnesø B (2019) Kommunens kamp mod måger rammer også andre fugle: - Det er decideret tåbeligt. In: Horsens Folkeblad. https://hsfo.dk/artikel/kommunens-kamp-mod-måger-rammer-også-krager-og-skader. Accessed 07 May 2020

Baltzer LK and Borbiconi S (2016) Dansk Ornitologisk Forening undrer sig over mågeproblem. In: DR Sjælland. https://www.dr.dk/nyheder/regionale/sjaelland/dansk-ornitologisk-forening-undrer-sig-over-mgeproblem. Accessed 19 March 2020

BirdLife International (2020) Species factsheet: *Larus argentatus*. http://datazone.birdlife.org/species/factsheet/european-herring-gull-larus-argentatus Accessed on 13 April 2020

Burger J (1984) Pattern, Mechanism, and Adaptive Significance of Territoriality in Herring Gulls (*Larus argentatus*). Ornithol Monogr

Bregnballe T, Lyngs P (2014) Udviklingen i ynglebestanden af Sølvmåger i Danmark 1920-2012. Dansk Orn Foren Tidsskr 108:187–198

Brockmann HJ, Barnard CJ (1979) Kleptoparasitism in birds. Anim Behav 27(2): 487–514

Bønløkke J, Madsen J, Thorup K, Pedersen, K, Bjerrum, M, Rahbek C (2006) Dansk Trækfugleatlas. Rhodos, Humlebæk

Calladine JR, Park KJ, Thompson K, Wernham CV (2006) Review of Urban Gulls and their Management in Scotland. Scottish Executive, Edinburgh, Scotland.

Camphuysen CJ, Gronert A (2012) Apparent Survival and Fecundity of Sympatric Lesser Black-Backed Gulls and Herring Gulls with Contrasting Population Trends. Ardea 100(2): 113-122

Cornell Lab of Ornithology (2019) All About Birds. Species Factsheet: Herring Gull Identification. Cornell Lab of Ornithology, Ithaca, New York. https://www.allaboutbirds.org/guide/Herring_Gull/id Accessed on 20 May 2020.

Cramp S, Simmons KEL (1983) The Birds of the Western Palearctic: Vol III. Waders to Gulls. Oxford University Press 1978-2005, Oxford, England

Danmarks Jægerforbund (n.d.) Find en reguleringsjæger. In: Danmarks Jægerforbund. https://www.jaegerforbundet.dk/kredse/kreds-3/regulering/. Accessed 20 March 2020

del Hoyo J, Elliott A, Sargatal J (1996) Handbook of the Birds of the World, Vol. III: Hoatzin to Auks. Lynx Edicions, Barcelona.

Dofbasen (n.d.) Sølvmåge (*Larus argentatus*). In: Dofbasen; Danmarks fugle. https://dofbasen.dk/ART/art.php?art=05920. Accessed 16 May 2020

Drent RH (1970) Functional Aspects of Incubation in the Herring Gull. Behav Suppl 1–132

Dutcher W, Baily W (1903) A Contribution to the Life History of the Herring Gull (*Larus argentatus*) in the United States. Auk

European Parliament: Council of the European Union. (2010) Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds. Official Journal of the European Union L20: 7-25 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0147. Accessed on 16 May 2020

Fuirst M, Veit R, Hahn M, Dheilly N, Thorne L (2018) Effects of urbanization on the foraging ecology and microbiota of the generalist seabird *Larus argentatus.* PLoS ONE 13(12): e0209200

Gibbons DW, Reid JB, Chapman RA (1993) The new atlas of breeding birds in Britain and Ireland 1988-1991. T. & A. D. Poyser, Calton

Giv et Praj (2020) Giv et Praj: Danmarks landsdækkende praj løsning. https://www.givetpraj.dk/. Accessed 21 May 2020

Goumas M, Boogert NJ, Kelley L (2020) Urban herring gulls use human behavioural cues to locate food. R Soc open sci 7: 191959

Goumas M, Burns I, Kelley LA, Boogart NJ (2019) Herring gulls respond to human gaze direction. Biol Lett 15: 20190405

Hagemeijer WJM, Blair JM (1997) The EBCC Atlas of European Breeding Birds: Their Distribution and Abundance. T & AD Poyser, London

Hansen KR (2018) Nu vil kommune mågeplagen til livs. In: TV Midtvest. https://www.tvmidtvest.dk/holstebro/nu-vil-kommune-mageplagen-til-livs. Accessed 19 March 2020

Horsens Kommune (2018a) Måger i Horsens: Regler og praksis for regulering og nedsættelse af gener fra måger. https://horsens.dk/Bolig/Skadedyr/Maager. Accessed on 08 May 2020

Horsens Kommune (2018b) Evaluering af mågeindsatsen i 2018: Indsatser og økonomi for sæson 2018. In: Plan- og Miljøudvalget - Referet, 4. Dec. 2018. https://horsens.dk/Politik/PolitiskeUdvalg/42/42-1879. Accessed 20 May 2020

Jensen SR (2018) Frustreret bilhandler kan bare se til, mens måger ødelægger hans biler. In: TV Midtvest, TV2. https://nyheder.tv2.dk/lokalt/2018-08-16-frustreret-bilhandler-kan-bare-se-til-mens-maager-oedelaegger-hans-biler?fbclid=IwAR0WzuVmr1aZofpRgNIwAT25bsk3xuW4aX1DbrGggeWXjRwaquvNC6fskR0. Accessed 16 May 2020

Klein R (1994) Silbermöwen Larus argentatus und Weisskopfmöwen Larus cachinnans auf Mülldeponien in Mecklenburg - erste Ergebnisse einer Ringfundanalyse. Vogelwelt 115: 267–286

Lilleør O (2000) Ynglende måger på hustage i Århus og det øvrige Danmark. Dansk Orn. Foren. Tidsskr. 94: 149-156

McLane AJ, Semeniuk C, McDermid GJ, Marceau DJ (2011) The role of agent-based models in wildlife ecology and management. Ecological Modelling 222: 1544-1556

Miljø- og Fødevareministeriet (2018a) Bekendtgørelse om vildtskader. In: Retsinformation.https://www.retsinformation.dk/Forms/R0710.aspx?id=202018#id6ad407d8-8592-4667-8e8e-f4fa826989c6. Accessed 20 March 2020

Miljø- og Fødevareministeriet (2018b) Bekendtgørelse om jagttid for visse pattedyr og fugle m.v.). In: Retsinformation. https://www.retsinformation.dk/eli/lta/2018/1074. Accessed 20 March 2020

Miljø- og Fødevareministeriet (2019a) Bekendtgørelse af lov om naturbeskyttelse. In: Retsinformation. https://www.retsinformation.dk/eli/lta/2019/240. Accessed 17 May 2020

Miljø- og Fødevareministeriet (2019b) Bekendtgørelse af lov om jagt og vildtforvaltning. In: Retsinformation. https://www.retsinformation.dk/eli/lta/2019/265. Accessed 17 May 2020

Miljøstyrelsen: Miljø og Fødevareministeriet (n.d.) Skadevoldende vildt. https://mst.dk/friluftsliv/jagt/skadevoldende-vildt/. Accessed 19 Feb 2020

Morris RD (1987) Time-partitioning of clutch and brood activities in herring gulls: a measure of parental quality? Stud Avian Biol 10: 68–74

Naturstyrelsen: Miljø og Fødevareministeriet (2011) Stadigt flere måger i byerne. https://naturstyrelsen.dk/nyheder/2011/mar/flere-maager-i-byen/. Accessed 16 May 2020

Paludan K (1951) Contributions to the breeding biology of *Larus argentatus* and *L. fuscus*. Vidensk. Medd. fra Dansk naturh. Foren. 114: 1-128.

Paynter JRA (1966) A new attempt to construct life tables for Kent Island Herring gulls. In: Bulletin of the Museum of Comparative Zoology at Harvard College. Cambridge

Pedersen N (2015) Panik på stranden: Måger terroriserer mennesker, stjæler mad og dræber kæledyr. In: Berlingske Media. https://www.bt.dk/udland/panik-paa-stranden-maager-terroriserer-mennesker-stjaeler-mad-og-draeber-kaeledyr. Accessed 16 May 2020

Pierotti R, Good TP (1994) Herring Gull. Birds North Am 124

Rock P (2005) Urban gulls: problems and solutions. British Birds 98: 338–355

Skriver J (2011) Byens måger og byens borgere på kollisionskurs. Dansk Ornitologisk Forening. https://www.dof.dk/om-dof/nyheder?nyhed_id=894. Accessed 16 May 2020

Skriver J (2014) Indsamling af mågeæg gav bøde på 3.000 kroner. In: Dansk Ornitolog Forening: Nyheder. https://www.dof.dk/om-dof/nyheder?nyhed_id=1277. Accessed 16 May 2020

Stubben CJ, Milligan BG (2007) Estimating and Analyzing Demographic Models Using the popbio Package in R. Journal of Statistical Software 22:11

Svendsen M, Jensen L (2016) Måger i beboelsesområder. Videncentret Bolius. https://www.bolius.dk/maager-i-beboelsesomraader-13323. Accessed 19 May 2020

Terres JK (1980) The Audubon Society Encyclopedia of North American Birds. Alfred A. Knopf, New York.

Therkildsen OR, Bregnballe T (2016) De store måger : Bestandenes udvikling og mulige værktøjer til håndtering af konflikter. Notat fra DCE - Nationalt Center Miljø og Energi 1–11

Tinbergen N (1956) On the functions of territory in gulls. Ibis 112: 242-255

Tinbergen N (1960a) The Herring Gull's world, Second edi. Basic Books, New York

Tinbergen N (1960b) The evolution of behavior in gulls. Sci Am 203:118–133.

Vesthimmerlands Kommune (2011) Måger i Vesthimmerlands Kommune. Vesthimmerlands Kommune, Teknik- og Miljøforvaltningen. https://www.vesthimmerland.dk/media/5086348/maager-vesthimmerland.pdf. Accessed 19 May 2020

Aarhus Kommune (2016) Vejledning om indsats mod sølvmåger: Måger i byen – når mågen bliver en uønsket indflytter. https://www.aarhus.dk/media/1539/vejledning-om-indsats-mod-soelvmaager.pdf. Accessed 16 May 2020

Aarhus Kommune (2019) Er du generet af måger? In: Aarhus Kommune: Borger. https://www.aarhus.dk/borger/bolig-byggeri-og-miljoe/for-grundejere/skadedyr-og-uoenskede-planter/er-du-generet-af-maager/. Accessed 20 March 2020

Appendix I

Biology of Species

Population Status

The European Herring Gull *(Larus argentatus)* is today a widely spread species across Europe and is found throughout Denmark (Bregnballe and Lyngs 2014; BirdLife International 2020). Hagemeijer and Blair (1997) estimate that there were approximately 800.000 breeding pairs in Europe at the time of the article in 1997 and according to Bregnballe and Lyngs (2014), more than 10 % of these pairs are breeding in Denmark. Bønløkke et al. (2006) estimates the breeding population to be around 60.000 pairs in 2006 and Therkelsen and Bregenballe (2016) estimates an increase in the breeding population to approximately 100.000 breeding pairs in Denmark. The IUCN Red List of threatened species (BirdLife International 2020) indicates that the European population is currently decreasing in numbers, no new data has been found that supports this decline in the Danish population. In Denmark the population of Herring gulls consists of both breeding, migratory, and stray birds (Bønløkke et al. 2006).

Habitat

Herring Gulls are found in coastal and near-coastal areas (BirdLife International 2020), however, it's more coastal when compared to other gull species (Gibbons et al. 1993). The breeding grounds are primarily in islands and islets, and rarely in locations placed inland (Bregnballe and Lyngs 2014). But the breeding habitat varies a lot overall (del Hoyo et al. 1996). Often the breeding occurs at locations where other species are breeding (Bregnballe and Lyngs 2014).

Feeding Ecology

The Herring Gull is an opportunistic generalist and scavenger with a very diverse diet, including marine and terrestrial invertebrates, fish, earthworms, other birds (from eggs to fledglings and adults), rodents, and plants (Cornell Lab of Ornithology 2019; Dofbasen n.d.; del Hoyo et al. 1996). The gulls diet consists in part of human-generated waste from cities, but also from the harbour and landfills (Bønløkke et al. 2006), and a study shows that they use behavioral cues in order to get food (Goumas et al. 2019). Furthermore, the Herring Gull is a kleptoparasite, stealing food from con- and heterospecifics (Brockmann and Barnard 1979). The feeding range is widespread, a study by (Klein 1994) shows a distance of 70 - 100 km for breeding Herring Gulls in Denmark.

Reproduction and Life History

The Herring Gull has an annual breeding season which they enter in the spring. Individuals reach sexual maturity at around four years of age (Paynter 1966). They are generally monogamous, developing pairs around mid-March before courting and laying their eggs in mid-May (depending on latitude). They exhibit breeding site fidelity, if pairings are successful, and the pairs are established in the male's territory with the nesting site being chosen together (Tinbergen 1960a). The courtship process is brief and consists primarily of regurgitation by the male as an offering to the female, and mating occurs directly after under the condition that she consumes his offering (Tinbergen 1960a). The female will lay an average of 1-3 eggs per clutch and incubate them with the help of the male (Morris 1987) for approximately 31-32 days until hatching occurs (Drent 1970). Chicks are born with

a camouflaged down feather pattern and are semi-precocial – often being observed hiding in nearby brush when the parents are away from the nest (Dutcher and Baily 1903). They fledge at around 6 weeks of age and are continued to be fed by the parents until 12 weeks old, sometimes longer if they are persistent enough with begging behavior (Burger 1984). At fledging they are already at or above the mass of a fully grown adult (Pierotti and Good 1994), which may decline as the juveniles learn to forage on their own. It takes approximately four years for juveniles to develop the plumage associated with a full-grown adult, with a gradual development from a mottled brown plumage to a white and gray variety. Along with plumage, their eye color changes as they age from brown to a golden orange. The lifespan of the Herring Gull can last up to 30 years in the wild (Terres 1980). The primary known cause of death for the Herring Gull in Denmark is from hunting, with the second known cause of death being deliberate population reduction (bekæmpelse) (Børnløkke et al. 2006).

The Danish population of Herring Gulls consists of migratory, residential and stray individuals (Bønløkke et al. 2006). Those who migrate, are migrating during the winter months, primarily to nearby locations, such as Germany (39%), the Netherlands (8%), and Sweden (2%). Certain individuals have been recorded as far southwest as the Iberian Peninsula. Although some individuals are migrating over the winter, an almost equal proportion are remaining in Denmark (47%). If movement is occuring within Denmark during the winter months, it will typically be gulls moving from the Danish Archipelago colonies into the large harbours (Cramp and Simmons 1983). Survivability and fecundity data of the Danish Herring Gull population is sparse (Bregnballe and Lyngs 2014), although Paludan (1951) was able to measure 1st year survival (78%), and adult survival (85%) of the Danish population, as well as their breeding success (55% hatched, but no more than 20% fledged). No representative data has been found regarding the 2nd year survival of the Danish population.

The Ecological Role and Behavioral Ecology

The Herring Gull is territorial during the breeding season and may also establish territories in the winter (Cramp and Simmons 1983). Unmated males usually attract females and fend off conspecific males by using vocal signaling (Tinbergen 1960b). Although the division of labor may be skewed towards a heavier workload for the male, both sexes will actively defend the nest-territory. This defense may result in physical fights between the defending bird and the antagonist, but often a physical conflict is avoided due to the use of vocal signaling in combination with threatening postures (Cramp and Simmons 1983; Tinbergen 1960b). The surroundings may also affect the aggressiveness of the Herring Gull as seen when antagonists are chased more vigorously in open compared to vegetated areas (Cramp and Simmons 1983).

Vocal signaling is not only used to communicate with conspecifics but is also used as a defense against predators (Cramp and Simmons 1983). Both humans and dogs may be considered as predators and although it is fairly rare, the Herring Gull may dive against both in a physical attack (Cramp and Simmons 1983).

The Herring Gull may nest solitarily, but often breeds in colonies of varying size (Cramp and Simmons 1983). Within colonies the pair will uphold a nest territory with a diameter that is usually around 5-25 meters, although they may nest even closer (Tinbergen 1956). This territory is upheld throughout the

breeding season and may be used for several years by the same breeding pair (Tinbergen 1956). The colonies are often located close to the nests of other colonial breeding seabirds and as an opportunistic forager, the Herring Gull may adversely affect the other colonial breeding birds through increased nest predation (Bregnballe et al. 2015). Furthermore, the Herring Gull may outcompete other birds from the best breeding grounds through exclusive competition due to its sheer size (Therkildsen and Bregnballe 2016). The presence of Herring Gulls may therefore reduce the richness and or abundance of other (bird) species (Bregnballe et al. 2015; Therkildsen and Bregnballe 2016).

Relevance to Humans

Some communities have had a long-standing tradition of collecting the eggs of the Herring Gull, but this practice was banned in 1994 (Pers. Comm. Sofie Kjeldgaard; Skriver 2014). Recreational hunting of the Herring Gull is currently allowed from September 1st to January 31st "Bekendtgørelse om jagttid for visse pattedyr og fugle m.v" (Miljø- og Fødevareministeriet 2018b), after a complete hunting ban between 2014 and 2018. Furthermore permission for regulation outside the hunting season can be obtained in cases where the Herring Gull is considered a pest or nuisance "Bekendtgørelse om Vildtskader" (Miljø- og Fødevareministeriet 2018a).

Some of the earliest work on behavioral biology was done on Herring Gulls (Tinbergen 1960a) and with research of the behavior still going on (e.g. Fuirst et al. 2018), the Herring Gull is an important species for this branch of research. Furthermore, the ability to visually identify different ages (Cramp and Simmons 1983) makes the Herring Gull a bird that is suitable for demographic studies and may pose an opportunity for even experienced birders to test their skills. Although the specific species may not be important to (or even known by) people feeding birds in parks, the Herring Gull is present at these locations making it a species that allows people to have close interactions and good experiences.

It has been argued that there has been an increase in the amount of complaints over the Herring Gull residing in Danish cities during the last 20-25 years (Therkildsen and Bregnballe 2016). An increase in the number of news articles concerned with nuisance from gulls seem to support this claim, however, there is a lack of formal studies (Therkildsen and Bregnballe 2016). The complaints are mainly due to nuisance from noise, as the Herring Gull can be very vocal (especially in the breeding season), but concerns over hygiene and attacks on people when the gulls are either defending their nests and nestlings or stealing food from outdoor restaurants have also been raised (Pers. Comm. Horsens Municipality Representative; Pers. Comm. Local Birdwatcher; Calladine et al. 2006). As is also the case with other large birds, the Herring Gull may pose a safety risk for air traffic, if they are present at or near airports where the risk of bird strikes is high (Allen and Garmestani 2015).