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ORIGINAL PAPER

Assessment of management practices regarding genetic biodiversity in Baltic Sea marine protected areas

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Abstract The aim of this study is to examine, and tentatively explain, how genetic biodiversity is handled in the management of Baltic Sea Marine Protected Areas (MPAs). Genetic biodiversity is critical for species' adaptation to changing environmental conditions and is protected by international agreements. Nevertheless, recent research indicates that genetic biodiversity is neglected in marine environments and in the management of MPAs. This study focuses on Sweden and Finland, which together govern a substantial part of Baltic Sea MPAs, and builds on in-depth interviews with regional conservation managers that are responsible for establishing and managing these areas. The empirical findings confirm that genetic biodiversity is absent, or plays a minor role, in contemporary MPA management. The findings also provide several possible explanations to this situation: unclear understandings of formal policy, lack of resources, deficient knowledge base, and the managers' own policy beliefs. Policy makers and high-level managers need to consider these aspects in their efforts to protect biodiversity.

Keywords Biodiversity · Convention on Biological Diversity (CBD) · Genetic variation · HELCOM · MPA · Marine management · Marine policy · Implementation resources · Policy beliefs

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Introduction

Conservation research describes genetic biodiversity as essential for long-term species viability, ecosystem productivity, resilience and adaptation (Barshis et al. 2013; Hellmair and Kinziger 2014; Reusch et al. 2005). In the species-poor environment of the Baltic Sea, which is the most well-investigated and thoroughly managed brackish water sea situated in northern Europe, these functions of genetic biodiversity are considered particularly critical for the protection from human-induced pressures on the environment (Johannesson et al. 2011; Laikre et al. 2008). The three levels of biodiversity—ecosystem, species and genetic—are defined, elaborated and protected by the international Convention on Biological Diversity (CBD 1992), the EU Habitats Directive (Council Directive 92/43/EEC 1992) and by a broad spectrum of environmental legislation and policies on the national level (e.g. Bill 2013/14:141; Finnish Government 2012, 2013; SEPA 2012). The establishment of different types of area protection, such as nature reserves, constitutes a main strategy for conserving biodiversity and is commonly prescribed by international and national conservation policies on both terrestrial and marine environments (c.f. CBD Strategic Plan and Aichi Targets COP10 Decision X/2 2010; European Comission 2007; HELCOM Recommendation 35/1 2014; Semmens et al. 2010).

The far-reaching aspirations of international agreements notwithstanding, genetic biodiversity remains a neglected aspect in contemporary conservation policy and management (Laikre 2010; Laikre et al. 2010). This is especially true in regards to the aquatic environment (Ryman et al. 1995). Recent studies exemplify how the genetic component of biodiversity is significantly downplayed in written policies on the marine environment and is largely missing in the management plans governing the protected areas in the Baltic Sea (Borgström et al. 2015; Laikre et al. 2016). These findings are well in line with previous studies (Sandström 2010, 2011; Sevä 2013) acknowledging the lack of genetic biodiversity in Baltic Sea fishery management.

This study explores how genetic biodiversity is handled in the context of Baltic Sea marine protected areas (MPAs). This is done by focusing on the conservation managers that work with the establishment and management of MPAs at regional authorities in Finland and Sweden. Finland and Sweden were chosen as focal countries because they have long coastlines adjacent to the Baltic Sea and together they govern a substantial part of the protected areas in the Baltic Sea. For example, adopting the widely used definition of the Baltic Sea proposed by Johannesson and André (2006), where the Baltic Sea is limited by underwater ridges between Falsterbo in Sweden and Travemünde in Germany, there are in total 64 HELCOM MPAs (i.e. MPAs following the Helsinki Convention 1992) of which 53 are located in Finnish and Swedish waters (Online Resource 1). The crucial role of low-level public managers, typically referred to as street-level or front-line bureaucrats, for the implementation of public policy has long been emphasized by scholars of public administration (cf. Cairney 2012; Hill 2009; Lipsky 1980). The location of these managers at the end of the policy chain places them in a position to influence the interpretation of centrally imposed policies and translate them into practical management strategies and concrete action. The aim of this study is to examine, and tentatively explain, how regional conservation managers handle genetic biodiversity in the management of Baltic Sea MPAs. The following questions guide the study:

1. What is the role of genetic biodiversity when Baltic Sea MPAs are established and managed?

2. What factors could tentatively explain the observed role of genetic biodiversity in the management of Baltic Sea MPAs?

It should be acknowledged that the study does not develop a legal analysis but aim to present conservation managers point of view and the way they implement law and policies. The findings are believed to provide a good illustration of how Baltic Sea MPAs are managed in regards to the genetic component of biodiversity given the large proportion of MPAs situated within the two selected countries. Moreover, the study adds to previous research by providing possible explanations to current management practices and possible implementation deficits. This information can support the development of recommendations to policy-makers and conservation managers in their efforts to protect biodiversity. In the next section, an analytical framework to guide the empirical study is developed.

Theory

The study is based on the idea that low-level managers or bureaucrats are critical in environmental governance, for the implementation of public policy and the formulation of regional practice (cf. Lipsky 1980; Sevä and Jagers 2013). Conservation of biodiversity and environmental protection are embedded in a complex institutional framework with policies on multiple levels and are characterized by great so-called "substantive uncertainties", which arise from insufficient knowledge as well as different interpretations of available knowledge (c.f. Koppenjan and Klijn 2004). For example, policies are often vaguely formulated and the definition and function of, in this case, genetic biodiversity is poorly elaborated, including how it should be regarded in MPA management (Laikre et al. 2016; Sandström 2011; Sevä 2013). These circumstances increase the importance of the regional conservation managers and underline their relevance as analytical units in the study of how formal policy turns into practice. Therefore, this study focuses on the regional conservation managers in the aim to examine and explain how genetic biodiversity is considered in the establishment of new MPAs and the management of existing MPAs (see *regional practice* in Fig. 1).

The analytical framework that guides the empirical analysis is presented in Fig. 1. The framework draws on previous work (Lundquist 1987; May and Winter 2007; Sandström 2011; Sevä 2013, 2015) and specifies three factors that, separately or combined, influence the operational decisions made by the regional conservation managers in regards to MPA management: (1) their understanding of formal policy, (2) their implementation resources,

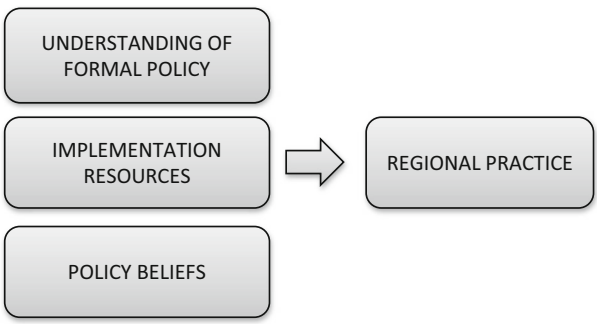

Fig. 1 The analytical framework identifying three factors that presumably influence regional management practices, namely understanding of formal policy, implementation resources and policy beliefs

and (3) their policy beliefs, i.e. the managers' personal understandings of the focal policy problem (Sabatier and Jenkins-Smith 1999; Weible and Sabatier 2009).

The first factor, *understanding of formal policy,* refers to the managers' comprehension of official policies and regulations that govern MPA management. Given the great uncertainty surrounding conservation policy, the ways in which regional conservation managers read and interpret these rules matter significantly (Hill 2003). The assumption is that their perceptions of policy and notions of what is expected from them in order to work in line with the instructions affect their performances. The extent to which regional managers perceive policy as clear and as stipulating that genetic biodiversity should be taken into consideration, likely influences the extent to which genetic biodiversity is handled in the management of Baltic Sea MPAs.

Implementation resources constitute the second factor in the analytical framework (Fig. 1). The concept is normally understood as individuals (or organizations), i.e. the network of resource providers, that assist in the implementation of policy, for example by providing information, knowledge and good examples to the managers (Hill 2003). Thus, the characteristics of the regional managers' networks of advice—where and to whom they turn to for guidance—are considered influential, especially in decision-making situations characterized by uncertainty and when there are many possible interpretations of policy. In this study, other types of resources, such as time, financial and personnel support, are included in the concept because such factors might affect priorities made and thus influence regional practice.

The third factor encompasses the managers' *policy beliefs* (Sabatier and Jenkins-Smith 1999). Sabatier and Jenkins-Smith (1999) order beliefs in a three-level hierarchy ranging from deep core beliefs, via policy core beliefs (normative and empirical; Weible 2008) to more shallow secondary aspects. The framework (Fig. 1) applied here captures the managers' empirical policy core beliefs, which refer to their understanding of the problem in focus. The concept assembles the managers' views on the basic *causes* of the problem in question, its *seriousness*, as well as the *appropriate means* for correcting it, thus including beliefs on the proper role of government, the balance of market and governmental activity, preferences for different types of policy instruments, etc. (Sabatier 1988; Sabatier and Jenkins-Smith 1999). The basic idea is that the policy beliefs function like a filter through which both formal policy and new information passes before decisions are made (cf. Schön and Rein 1994; Weible 2008). Thus, the regional managers' policy beliefs—their appreciation of how important genetic biodiversity is, to what extent genetic biodiversity is threatened and what appropriate management solutions to the problems are—might influence regional practice (see Fig. 1). The method for how to study the factors in Fig. 1 is presented next.

Method

The empirical case

Baltic Sea MPAs are managed on the regional level in both Sweden and Finland. In Sweden, the County Administration Boards (CABs) are the responsible authorities, while the Finnish system is based on two public agencies: the Metsähallitus and Centres for Economic Development, Transport and the Environment (ELY Centres). The former

agency manages coastal and marine areas that are privately owned while state-owned land is managed by the latter (Online Resource 2).

The MPA concept encompasses a broad range of different institutional arrangements, such as marine national parks and marine nature reserves that are governed by different rules that reflect various degrees of protection. Thus, the balance between conservation and use differs significantly. For the purpose of this study, two types of MPAs were initially selected as study objects: HELCOM MPAs (formerly known as Baltic Sea Protected Areas) and Natura 2000 areas (with identified marine habitats). This choice was made for two primary reasons. First, both types of MPAs are supranational, i.e. governed by regulations defined above the nation-states, thus applying to the two Baltic Sea countries studied here. Second, they reflect two different types of institutional arrangements when it comes to the formal degree of protection. Natura 2000 areas are part of the EU regulation, the Habitats Directive (Council Directive 92/43/EEC 1992), the Birds Directive (Council Directive 2009/147/EC), and integrated in the national legislation (e.g. Finnish Nature Conservation Act 1096/1996; Swedish Environmental Code SFS 2015:232). Accordingly, Natura 2000 MPAs have the formal status as protected areas while HELCOM MPAs that emanate from the Helsinki Conventions are less formally protected (SwAM[1] 2013).

The study was originally designed to capture and comparatively analyze the management processes related to these two different types of area protection in search for differences and similarities. However, since Natura 2000 areas and HELCOM MPAs often overlap geographically and share common management plans, it was not possible to distinguish any clear differences in management (Laikre et al. 2016). Thus, the case study presented in this paper addresses the management of HELCOM MPAs, and the Natura 2000 areas included in these HELCOM MPAs, in Finland and Sweden without any ambition to distinguish between the two types of institutional arrangements in the forthcoming analysis. Moreover, it should be recalled that the study illustrates management practices, and its circumstances, as perceived by the regional conservation managers.

Data collection

An in-depth interview study was performed with conservation managers working with marine protection in Sweden and Finland. The respondents were selected from the regional public authorities responsible for the management of coastal and marine areas adjacent to the Baltic Sea: the Centres for Economic Development, Transport and the Environment (ELY Centres, Finland), Metsähallitus (Finland) and County Administration Boards (CABs, Sweden) (Online Resource 1). More specifically, 12 interviews with 13 individuals at 12 different authorities were carried out. Eleven of these interviews were conducted over the phone. In one case (in Sweden) the authority suggested that two persons should be interviewed together and this interview was thus performed face-to-face and the answers obtained were treated together (referred to as S5/6) in the forthcoming section).

Thus, 13 conservation managers participated in the study, one ELY Centre manager, six regional managers of the Metsähallitus[2] and six managers at five different CABs. Together, these represent half of the Swedish CABs (with Baltic Sea coastlines) and all concerned regional authorities in Finland (Online Resource 2). In our contacts with the regional

[1] SwAM stands for Swedish Agency for Marine and Water Management.

[2] The Metsähallitus govern most MPAs in Finland while the ELY Centres are responsible only for a minor part.

authorities we learnt that no more than one to three managers were engaged with MPA management at each organization, which is why we consider our sample of interviewees as sufficient. The interviewed managers were knowledgeable in the field of marine conservation and the average respondent had worked with marine protection for 11 years (there was a range between four and 30 years). All respondents had a natural science background and all but one (with an expertise in agriculture and forestry) were trained biologists. Several were specialized in the marine environment. The group included managers who had worked with the establishment of new area protection as well as with the management of existing MPAs on a daily basis, as planning managers, team leaders, conservation managers, and conservation biologists. All but two respondents claimed that the information they shared during the interview was representative of their organization. The two respondents with divergent views explained that their own view likely leaned more strongly towards conservation and protection than their co-workers' at other departments within their organizations.

The interviews were semi-structured and guided by a questionnaire with open-ended questions, about regional practice, such as how genetic biodiversity is considered in their work, their understanding of formal policy, their implementation resources and their policy beliefs (Online Resource 3). The interviews lasted between 35 and 75 min and were recorded and transcribed for qualitative analysis.

Results

The empirical observations are summarized in tables and we also use direct citations to illustrate the views shared by the managers. We refer to the Finnish interviewees as F1–F7, and the Swedish ones as S1–S5/6.

Understanding of formal policy

The regional managers refer to a long list of rules and regulations on various political-administrative levels when asked about what formal policies that MPA management adheres to, and these references often differ between managers (Table 1).

According to 8 out of 12 interviews existing policy is perceived as providing clear and helpful guidelines for how to work with MPA management. However, several of the interviewees add that the rules and regulations are open for interpretations and that there is a continuous learning process on how to understand them. The regional managers were also asked about how the issue of genetic biodiversity is dealt with in the formal policy. The answers are presented in the fourth column of Table 1. A majority of the interviewed actors respond that they cannot answer the question or that the genetic component is missing, as exemplified by the answer below:

> If we consider the formation of Natura [2000] areas, I have never heard that it has been done based on genetic biodiversity. And I doubt that such [genetics] is even written there somewhere; at least not in our guidelines for the local-level management (F3).

According to five interviews, formal policies do, or are believed to, incorporate genetic biodiversity:

Table 1 Understanding of formal policy among seven Finnish (F1–F7) and six Swedish conservation managers (S1–S5/6)

Understanding of formal policy governing MPA establishment and management			
Manager(s)	Policies on MPA establishment and management	Clearness of policy	Genetic biodiversity in policy
F1	Laws and commandments, Metsähallitus instructions, Management plans, Regional regulations	Cannot tell	Incorporated
F2	EU directives, Finnish Environment Institute guidelines, Zoning guidelines	Cannot tell	Cannot tell. The Marine Strategy Framework Directive incorporates genetic biodiversity
F3	Finnish Environment Institute guidelines, Ministry of the Environment, Park management plans	Internal guidelines are clear	Missing
F4	Regional Sea Plan, Legislation, Nature Conservation Act, National park legislation, Metsähallitus guidelines, Regional plans, Zoning guidelines	Clear	Likely incorporated
F5	EU directives, Finnish Environment Institute guidelines, Metsähallitus administrative laws, Nature Conservation Act, Natura network objectives, Nature protection legislation	Clear	Incorporated
F6	Nature Conservation Act, Regional decree	Clear	Missing
F7	Metsähallitus guidelines, Ministry of the Environment, Project guidelines	Clear	Missing
S1	CAB policy, Government regulations, International conventions, SwAM prescriptions, SEPA prescriptions	Clear	Missing, or merely incorporated in general terms
S2	Environmental Code, Environmental Quality Objectives (national), Municipality planning regulations, SwAM, SEPA	Unclear in regards to MPA establishment; clear in regards to management plans	Missing
S3	Natura 2000 regulations, Other regulations	Cannot tell	No answer was provided
S4	SEPA guidance and manuals, Regulations on nature reserves	Clear	Cannot tell, likely incorporated
S5/6	Environmental Code, Government regulations and assignments, Natura 2000 guides, SEPA guidance, SwAM guidance	Clear (but general)	Missing

EU European Union, *CAB* County Administrative Boards (apply in Sweden), *SEPA* Swedish Environmental Protection Agency, *SwAM* Swedish Agency for Marine and Water Management

> Oh! I cannot answer that directly, actually. I actually don't know. I believe so, but I don't know off the top of my head (S4).

One of the interviewed managers suggests that there is a possible difference between marine and terrestrial conservation management, implying that genetics is better acknowledged in terrestrial conservation management as compared to the marine environment (F4).

To summarize, the interviewed managers in both countries perceive formal policy as clear and supportive of their work with marine conservation. Genetic biodiversity is, according to them, largely missing, or merely dealt with in general terms, in existing policy. There is a great uncertainty in regards to what formal policies actually imply when it comes to genetic biodiversity in MPA management.

Implementation resources

To explore which implementation resources that support MPA management, the regional conservation managers were asked, first, to whom they turn to for advice in cases of uncertainty and, second, whether they find that the resources they have at their disposal are sufficient for their work with MPAs. The answers are summarized in Table 2.

Analyzing the managers' networks of advice, it can be noted that a broad range of actors assists the regional managers in their work depending on the particular management issue. The cooperation and, at times, overlapping responsibilities between Metsähallitus och ELY Centres in Finland, depending on property rights (Online Resource), is visible in Table 2. Moreover, the central roles of the Finnish Environmental Institute (SYKE; 5 out of 7 turn to the SYKE) and the Swedish Agency for Marine and Water Management (SwAM; all managers turn to SwAM) as a provider of guidance are clearly illustrated. Most often, however, the task of finding complementary information and straightening out possible questions starts by making use of the various competences within the own organization. As exemplified by one of the Finnish managers:

> First I would ask my colleagues, and usually I get an answer from them. Thereafter, the ELY Centre. Of course I also search the Internet, and if we have some new issues or research questions, I ask the universities or other researchers at the Finnish Environment Institute or at the Game and Fisheries Research Institute (F4).

Universities are mentioned to be part of the networks of advisors only during three interviews. All managers describe a working situation characterized by a great shortage of resources in terms of money, time and knowledge (Table 2). The particular challenges of marine management are emphasized in regard to this aspect as several respondents (F4, S2, S4) underline the particular shortage of resources for the marine environment in comparison with terrestrial conservation:

> So the knowledge has increased but it is still in great need. If one compares with the knowledge on land, for example on forestry areas, the knowledge is significantly less for the sea (S4).

Policy beliefs

Policy beliefs (Fig. 1) consist of three interrelated aspects that are handled in the subsections below and then summarized in a joint table.

Table 2 Implementation resources stated to be available among seven Finnish (F1–F7) and six Swedish conservation managers (S1–S5/6)

Implementation resources with respect to MPA establishment and management		
Manager(s)	Network of advice	Other resources
F1	ELY Centre, Local organizations (birdwatchers), Metsähallitus, Ministry of the Environment	Lack of knowledge/money/time
F2	ELY Centre, Metsähallitus, SYKE	Lack of money
F3	ELY Centre, Metsähallitus, Ministry of the Environment, SYKE	Lack of money/personnel
F4	Associations of Finnish Local and Regional Authorities, ELY Centre, Internet, Local/regional authorities, Metsähallitus, Municipalities	Lack of knowledge
F5	ELY Centre, FGFRI, Geological survey of Finland, Metsähallitus, Municipalities, SYKE, Research/Universities	Lack of knowledge/money/time
F6	National authorities, National research organizations, Polytechnics, SYKE, Universities	Lack of money/personnel
F7	ELY Centre, Marine biologists, Metsähallitus, Ministry of the Environment, SYKE	Lack of money/time
S1	CAB, Coast guard, Fishery industry, National authorities, SwAM, SEPA, Universities	Lack of money/time
S2	CAB, Consultants, Local residents, Municipalities, SwAM	Lack of knowledge/money/time
S3	CAB, SwAM	Lack of knowledge/money/time
S4	Biologists, CAB, Ministry of the Environment, SwAM	Lack of time
S5/6	CAB, SwAM	Lack of money/time

CAB County Administrative Boards (Sweden), *ELY-Centre* Centres for Economic Development, Transport and the Environment (Finland), *FGFRI* Finnish Game and Fisheries Research Institute (since 2015 part of Natural Resource Institute Finland), *SEPA* Swedish Environmental Protection Agency, *SYKE* Finnish Environmental Institute, *SwAM* Swedish Agency for Marine and Water Management

The importance of, and threats to, genetic biodiversity

Eleven of the interviewed managers express that genetic biodiversity is—or probably is—important for the marine environment (Table 3). The managers that hesitate do so with reference to deficient knowledge (cf. S2). Some respondents (e.g. F2, F4) underline the importance of genetic biodiversity more than others, and elaborate on its function for certain species. There is substantial variation, however, in *how* threatened genetic biodiversity is believed to be and *what* the major threats are. For example, four managers state that there is no urgent threat to genetic biodiversity while three managers describe genetic biodiversity as endangered for some species and five of them believe that genetic biodiversity probably (or likely) is endangered. The translocation and spread of alien species are identified as influential threats to genetic biodiversity (F4, F6–F7, S2–S4):

> As a geneticist you can understand, that if it [releases of reared fishes] would have been taken care of professionally and not by mixing stocks from different rivers, it could work. But it is not taken care of by researchers or even state organizations, but by representatives from local fishing districts, who earn money by doing it (F6).

Table 3 Policy beliefs among seven Finnish (F1–F7) and six Swedish conservation managers (S1–S5/6)

Manager(s)	Policy beliefs with respect to genetic biodiversity and marine management		
	The importance of, and threats to, genetic biodiversity	How to handle genetic biodiversity in management	The effectiveness of MPAs
F1	Genetic biodiversity is important and probably threatened (as part of other levels of biological diversity) in some cases. Lack of knowledge is the major threat	Increase knowledge about populations. Concentrate more on species and biotopes/habitats instead (indirectly protect genetics). Public authorities, the Ministry of the Environment, national and regional authorities are responsible. Legislation and information can be used	MPAs can be effective by enabling restrictions and providing funding for investigations. Protection alone does not provide any guarantees
F2	Genetic biodiversity is important but not so threatened. Dammed rivers pose a threat to certain fish species	By preserving local populations. But management should concentrate on bigger issues (e.g. eutrophication). National authorities, the Ministry of the Environment, the Finnish Environmental Institute and regional level authorities are responsible. Legislation is the primarily management tool, combined with information	MPAs are effective since they enable protection
F3	Genetic biodiversity is important and, at least for some species, threatened. Not enough knowledge to assess the extent, but genetic biodiversity is challenged by disappearance of species/habitats, by dredging, and eutrophication	Genetic knowledge is important but knowledge is deficient and practical implications are lacking; more information is needed. The issue is international, and national authorities are responsible to include genetics into decision-making. The precautionary principle should be applied. Reduce eutrophication	MPAs protect against human activity but do not solve problems with eutrophication, water quality, filamentous algae, and poisonous substances that also affect genetic biodiversity
F4	Genetic biodiversity is intrinsically important and important for adaptation. Hard to tell if genetic biodiversity is threatened but it is important for Baltic sea species and migrating fish. Eutrophication, climate change and translocations of species pose potential threats	Genetic biodiversity should be recognized and acknowledged. More information is needed. Protection of endangered populations is as important as protection of species. It is an international issue but national authorities are responsible for implementation, by means of legislation and information	MPAs are most effective in protecting habitats of many species, even though shortcomings with MPAs exist

Table 3 continued

Manager(s)	Policy beliefs with respect to genetic biodiversity and marine management		
	The importance of, and threats to, genetic biodiversity	How to handle genetic biodiversity in management	The effectiveness of MPAs
F5	Genetic biodiversity is very important for the existence of species and likely endangered, but does not know how threatened or to what extent. Isolated species, excessive usage, climate change, land use and pollution threaten genetic biodiversity	Genetic biodiversity should be discussed and clarified, research should emphasize its importance. It requires international cooperation and efforts on national and local levels. Political decision-makers are responsible. Legislation, sharing information and transmission of objective knowledge are the most important means	Protection of endangered species and their well-being is needed. MPAs are important in doing so
F6	Genetic biodiversity is very important and, for some fish populations (economic important and artificially fertilized), strongly threatened. Fish stocking, decreased water quality, climate change and salinity changes pose threats to genetic biodiversity	Information about genetics, and a strategy for information, is needed. Preservation should be focused on a meta-level (network level) and not on single areas. The whole society and the government are responsible. It is an international and national (government) issue	A comprehensive MPA network with effective management, i.e. areas that are truly protected. Could be effective but are not in present forms (merely pseudo-protected)
F7	Genetic biodiversity is absolutely important for adaptation and it is threatened, however, cannot value the threat in relation to other aspects. The threats come from invasive species, decrease of populations, inbreeding, habitat reduction, overfishing (selective) and hunting	Existing information must be better used. Unsure about how important it is. It is an international issue. The Ministry of the Environment via ELY Centres is responsible. Public information, legislation and resources for monitoring are needed	The effectiveness of MPAs depends on the regulations, how strong they are in the area
S1	Genetic biodiversity is important, life depends on the survival of the genes, but it is a complex issue. Genetic biodiversity is not threatened	Generate knowledge, definitions and guidelines for management. Not on the top of the priority list. Conserve species rather than genetic populations. The state and authorities are responsible, through regulations. There is also an individual responsibility. Regulations and surveillance are most efficient	MPAs might be effective in some cases (if it concerns certain species in delimited areas) but not in others cases

Table 3 continued

Manager(s)	Policy beliefs with respect to genetic biodiversity and marine management		
	The importance of, and threats to, genetic biodiversity	How to handle genetic biodiversity in management	The effectiveness of MPAs
S2	Knows too little but assumes genetic biodiversity is important and that it is highly threatened due to large scale ecological changes, e.g. eutrophication, trophic changes in fish, alien species and threats caused by human activity	Knowledge review and genetic inventories are needed. The issue has lower priority in relation to other issues. CAB, national authorities and ministries should be responsible. Regulations of fishery, eutrophication and spread of alien species are most important. Resources for inventories are needed	MPAs are not the most effective instrument (e.g. do not handle eutrophication)
S3	Lacks knowledge about genetic biodiversity but it is generally considered important. There is probably a risk of genetic degradation but knows too little and cannot tell to what extent. Risk related to hatchery-reared fish	Cannot answer how genetic biodiversity should be dealt with in management nor what priority it should have. More knowledge is the first step. CABs should be involved (but not play the primary role). Regulations could be used	MPAs could be effective in protecting genetic unique species but have not done so yet, due to lacking knowledge. Many problems are not solved by MPAs, related to e.g. eutrophication and fishery
S4	Genetic biodiversity is important. Unsure about how endangered it is; but alien species pose a threat. Humans are responsible via maritime traffic and fish-stocking (alien spices)	Cannot tell if genetic biodiversity should be a prioritized issue. National level is responsible for developing and spreading knowledge. Regulations around alien species are most effective	MPAs partly effective, e.g. restrictions of stocking within an area
S5/6	Genetic biodiversity is important. Unsure about if, how, or by whom or what it is threatened	Start by increasing knowledge, thereafter decide if it should be prioritized or not (does not know today). Concerned public authorities are responsible. Unsure about effective policy measures	MPAs are not automatically effective, depends on regulations and management plans

The information presented in the table is not citations

Others point at the large-scale ecological changes affecting the marine environment such as climate change (F4–F6), degrading water quality (F6), change in salinity (F6) and eutrophication (F4, S2) as the major threats to the genetic biodiversity. On a general note, it can be concluded that the interviewed conservation managers identify genetic biodiversity as important but they are unsure of if and how this diversity is threatened.

How to handle genetic biodiversity in management

Ambiguity exists also in regard to how the issue of genetic biodiversity ought to be dealt with by management. The managers present no concrete strategies (see Table 3) besides the development of more knowledge and better definitions (F1, F3–F6, S1–S3, S5/6). Several managers refer to their lack of knowledge and claim that they do not know if genetic biodiversity ought to be a prioritized issue in management or not (F7, S3–S5/6). Others clearly express that it is more important to focus on large-scale problems such as species or habitat levels (F1–F2, S1–S2):

> Because genetic biodiversity ultimately is the foundation for species survival and distribution, of course it is important. But I'm not sure how it could be incorporated into decision-making while we are at the level of finding out what and where species exist under water. That's why genetics is not quite yet of highest priority (F3).

One manager diverges by taking a more serious stance in regards to genetic biodiversity and claims that endangered populations should be protected like species (F4).

The managers acknowledge the protection of genetic biodiversity as an international concern while emphasizing the responsibility of national and regional public authorities in the implementation of the international agreements (cf. F4; Table 3). Legislation is considered as the most efficient method to protect biodiversity while some actors also emphasize knowledge exchange.

In summary, the vague notion of the importance of, and threats to, genetic biodiversity, previously presented is reflected in the respondents' perceptions on what ought to be done by management. The interviewed managers emphasize the generation of new knowledge rather than concrete management actions, and that they find no real support behind the idea to give genetic biodiversity a higher priority in marine management.

The effectiveness of MPAs as a management tool for genetic biodiversity

The managers diverge in regard to how they perceive the effectiveness of MPAs as an appropriate tool to protect genetic biodiversity (see column 3 in Table 3). Several respondents question the efficiency of area protection and underline that there are many problems that cannot be solved by a MPA (F3, S2–S3).

> But the problem is that things like eutrophication, water quality deterioration, increase of filamentous algae, all kinds of poisonous substances and such, do not necessarily follow any specific areas (F3).

Others are more positive towards protected areas and consider MPAs as an effective tool to conserve the genetic biodiversity, at least under certain conditions (F1–F2, F4–F7, S1, S4).

> If it concerns an endangered, or critically endangered, species within a delimited area, then the answer is yes (S1).

There is no consensus on the effectiveness of MPAs as a tool for protecting genetic biodiversity. Yet, most actors believe that area protection can be efficient, depending on the problem and management regulations in force.

Regional practice: genetic biodiversity in MPA management

The process of establishing new MPAs is normally coordinated by a smaller core group of people including both marine and terrestrial competence within the studied regional authorities. Other experts, such as consultants and researchers, are included when needed and some stages of the processes usually involve consultation with concerned stakeholders such as property owners, hunting and fishing organizations, and the general public. The management plans should be evaluated every 10–15 years. According to the interviewed managers, however, the actual realization of these ambitions is wanting. One interviewee emphasized that there are no resources to follow up on protected areas (S1).

High natural values, and known threats towards these values, are the main motivation in creating new MPAs. Outspoken desires to enhance human use and attract visitors are also important motivations. Thus, existing MPAs are the results of several drivers and various overall management goals. External factors such as waterways and property rights greatly influence the boundaries of new MPAs. While all interviewed managers agree that biological diversity is the major criterion for new marine protection, only four of them mention the genetic component as part of their definition of biological diversity.

Half of the interviews indicate that the genetic component is incorporated, and taken into consideration, when working with MPAs (Table 4). This, however, is only in situations when there is information available, when it is possible, or for particular species (F4, F7, S1–S5/6):

> When we have the knowledge, as in the case of salmon, we do consider it [i.e. genetic biodiversity] (S5/6).

Table 4 Regional practices with respect to genetic biodiversity (a) in the establishment of new MPAs and (b) in the development and evaluation of management plans among seven Finnish conservation managers (F1–F7) and six Swedish conservation managers (S1–S5/6)

Manager(s)	Regional practice with respect to MPA establishment and management	
	Role of genetic biodiversity when establishing new MPAs	Role of genetic biodiversity in the development and evaluation of management plans
F1	None (some exceptions exist)	None (some exceptions exist)
F2	Cannot tell	None
F3	None	None
F4	Present, to some extent	None
F5	None (unsure)	Present, indirectly via species
F6	None	None
F7	Present, when information exists	None
S1	Present, when knowledge exist (fish), but no role in MPA management	Present
S2	None, possibly in regards to fish	None
S3	Present, when possible (fish)	None
S4	Present, when possible	Present, in regards to transfer of equipment and alien species
S5/6	None (exception for salmon)	None, unless knowledge exists (salmon)

One manager (F7) states that genetic diversity is considered when establishing new MPAs, to the extent that information exist, but that the genetic level component plays no part in the making of management plans, partly due to the organizational culture:

> And there is probably also some legacy, a traditional thing, that we follow our old habits and do things as they have always been done […]. We have a bit of a culture that it [genetic biodiversity] is ignored completely (F7).

Some actors are more cautious to say whether or not genetic biodiversity is integrated in the work (F2, F5). Others are confident in their answers, stressing the void of genetics in the management of MPAs:

> I think it's rather exceptional that genetics could affect our opinions of establishing protected areas because we don't have that information (F1).

In addition to the insufficient knowledge base, and organizational culture, the managers also refer to lack of practical implications of such genetic information (F3, S1). Insecurity as to how existing knowledge should be interpreted and translated into daily management exist, which is why other aspects than genetics, are prioritized in MPA management:

> We barely have an understanding of the species level and the distribution of habitats either, so we are rather far away from any genetic levels (S2).

To summarize, the general impression is that the genetic aspect is considered important but largely constitutes a missing, and negligible, part of MPA management in the two investigated countries. The few examples when the genetic component is considered relate foremost to certain fish species and the problems that fish stocking and spread of alien species bring.

Discussion

The two research questions posed in the introduction are now discussed in light of the empirical presentation in previous sections. *What is the role of genetic biodiversity when Baltic Sea MPAs are established and managed?* The study illustrates that the role of genetic biodiversity is downplayed in the establishment and management of MPAs in both Finland and Sweden, compared to other aspects of conservation. More than half of the interviewed actors claim that they do not consider the genetic level (or cannot tell if they do) when establishing new MPAs, and a majority of the interviewed managers do not include the genetic component in the development and refinement of management plans for these areas. The conservation managers that answer in a more affirmative manner explain that they do consider genetics to the extent that they can, when possible, or when information exists. Thus, their answers are vague and primarily express an intention rather than actual practice to incorporate the genetic level in the marine-protection working process. The exceptional situations when genetic biodiversity are considered are all related to issues of fishery management. These results indicate that genetic biodiversity is better acknowledged in fishery management than in the management of other aquatic species. The general trend, however, is that the genetic level constitutes a neglected aspect in the work with Baltic Sea MPAs.

What factors could tentatively explain the observed role of genetic biodiversity in the management of Baltic Sea MPAs? The interviewed managers emphasize lack of

information and poor knowledge base as the primarily reasons for why they do not pay greater attention to genetic biodiversity when working with MPAs. Genetic information is described as resource intense and several respondents share the view that existing information lacks practical implications for management. This contributes to the fact that other aspects of biodiversity, habitats and species, are given higher priority in regional practice than genetic biodiversity.

Previous research has identified managers' understanding of formal rules, their networks of advice (implementation resources), as well as their policy beliefs as explanations to the lack of implementation in policy and regional practice (cf. Sandström 2011; Sevä 2013). The interviewed actors in this study generally consider policy on MPAs as clear and as providing support in their work. According to their understanding, however, the issue of genetic biodiversity is not handled, or merely dealt with in general terms, in current policies. Thus, this understanding of the policy framework likely contributes to the fact that genetics is significantly downplayed in regional practice.

The utilized implementation resources include colleagues within the organization, other public authorities, and universities. Based on the empirical analysis, no correspondence between the type of networks of advice and regional practice in terms of the role of genetic biodiversity could be noticed. All actors agree, however, that time, money, and personnel resources are deficient in the field of marine protection. This resource deficit is one likely explanation to why the interviewed managers choose to focus on other issues than genetics when forming new MPAs and when working with the management of these areas.

The low level of priority given to genetic issues can also be seen in the underlying policy beliefs expressed by the regional managers: to what extent genetic biodiversity is considered as important for the marine environment; to what extent it is regarded as endangered; and whether MPAs constitute an appropriate management tool to mitigate these threats. When asked about these issues, the interviewed managers hesitate in their answers, which indicates that their lack of genetic knowledge is reflected in their problem definition. They all express that genetic biodiversity is important for the marine environment, but there is great uncertainty in regards to what extent it is considered as threatened. Following this, the regional managers present no ready-made answers on what management strategies they think are appropriate and their views on the effectiveness of MPAs are cautious. Thus, the policy beliefs held by the regional managers matches regional practice.

An emergent theme from the interviews concerns the experienced difference between conservation management of marine and terrestrial environments. Several managers emphasize that marine management lags behind terrestrial management in regards to several aspects. According to these interviewees, there is less guidance for how to work with marine conservation than terrestrial conservation (S4), MPAs are less managed than protected areas on the land (S2), and the state of knowledge regarding genetic biodiversity is sparser for the marine environment (S3, F2, and F4).

Concluding remarks

The aim of this paper is to examine and explain how biodiversity on the genetic level is handled in the management of Baltic Sea MPAs. The findings show that:

- Formal policies on MPA management are generally perceived as clear, but not in regard to how genetic biodiversity should be handled.

- The managers experience lack of time, money, and knowledge in their work with MPAs.
- The managers consider genetic biodiversity important. They hesitate, however, in regard to how important it is, how threatened it is, and how to address the issue in management.
- Genetic biodiversity is rarely incorporated in the management of Baltic Sea MPAs.

The study implies that genetic biodiversity is downplayed in contemporary Baltic Sea management and indicates possible explanations to this situation. Future efforts, with the ambition to give genetic biodiversity a more prominent position in management, should thus aim at influencing these factors. By clarifying formal policy, assisting in its interpretation, and sustaining necessary resources, policy makers and high-level managers can improve regional practice in this regard. Moreover, the regional managers' policy beliefs—i.e. their notion of the problem and its solutions—can be influenced by information and by securing a consistent knowledge exchange, bridging the gap between science, and policy and practice through the formation of new networks. Platforms for knowledge transfer, discussion, and exchanges of ideas are urgently needed to safeguard adaptive potential of Baltic Sea species.

Finally, the empirical results suggest that contemporary marine conservation has the potential to learn from experience and knowledge developed in land-based conservation management. Several managers in this study claim that the management of the seas generally lags behind terrestrial management in several aspects related to biodiversity. This observation is consistent with previous scientific findings (Laikre et al. 2016; Ryman et al. 1995).

The results are worrying in the light of biodiversity conservation. They clearly show that international and national agreed policy is not implemented in Baltic Sea MPAs. The Aichi targets of the CBD Strategic Plan 2011–2020 include a particular and explicit goal for genetic biodiversity (Target 13; COP10 Decision X/2), and this goal is far away from being fulfilled. Here is an urgent need for further research on how international and national policy on biodiversity can be transferred to the regional level more efficiently than it is today.

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