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The connectivity dilemma in freshwater management: exploring the role of street level bureaucrats in water governance

Carina Lundmark

Luleå University of Technology, Luleå, Sweden. E-mail: carina.lundmark@ltu.se

Abstract

Connectivity is key in freshwater management, e.g. to ensure viable populations of fish, but restoring it may cause the spread of invasive species. Goal conflicts of this kind are common in freshwater management, and the burden of addressing them rests on the shoulders of street-level bureaucrats, i.e. public officials at the end of the policy chain. This study uses a theoretical framework to explore their management choices employing previous research on natural resource management. The findings, based on qualitative semi-structured interviews with street-level bureaucrats from all water districts in Sweden, show that the three factors explored – their understanding of formal policy, their implementation resources, and their policy beliefs – matter when anthropogenic connectivity barriers are considered in ongoing management. Additionally, the factors are interrelated in a way that can obstruct the implementation of policy goals. While connectivity issues rank high and are considered a great problem all over the country, invasive species are regarded as a relatively small problem. If this should change in the future, the level of preparedness is low, primarily due to restricted implementation resources, but also due to the absence of guidance and formal responsibilities.

Keywords: Connectivity; Freshwater governance; Freshwater management; Implementation resources; Invasive species; Policy beliefs

Highlights

- The study shows how policy incoherence between promoting connectivity and preventing the spread of invasive species is handled in freshwater management.
- Explanations are offered as to why some migratory barriers are removed, while others are not.
- As political agreements call for ecological restoration of watercourses, studies are needed on how to address competing interests.

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Introduction

Dealing with connectivity in freshwater management is a difficult task that requires consideration of a large number of conflicting objectives and interests. Natural and anthropogenic barriers in the water systems, from large-scale dams and power structures to simple culverts, can have detrimental effects on biodiversity as upstream migration of various species is prevented (e.g. Fagan, 2002; Englund *et al*., 2009). When faced with a reduction in connectivity, populations of fish and other organisms risk isolation and eventual collapse, which over time, may cause loss of genetic biodiversity at a regional level (Reusch *et al*., 2005). Efforts to improve biological functionality by removing the barriers, however, can cause other problems. In particular, the spread of invasive species are a huge threat to freshwater species (e.g. Perkin *et al*., 2015). Besides the environmental considerations that need to be addressed when considering the removal of a dam or weir, there are a large number of economic and social aspects as well, including revenue from hydropower, availability of sports-fishing, and historical/cultural, recreational and aesthetic values (Jørgensen & Renöfält, 2013; Stage, 2018).

The conflicts in freshwater connectivity management are visible also in policy and legislation. For instance, connectivity is key to achieving a good ecological status when following the EU Water Framework Directive (WFD, Directive 2000/60/EC), while Target 5 of the EU Biodiversity Strategy of 2020 points to the need to prevent the spread of invasive species. As these international policy objectives are translated into national goals, previous research has shown that the main policy content largely stays the same (cf. Laikre *et al*., 2016). Thus, policy incoherence remains also at lower administrative levels, where it needs to be addressed.

Previous research on natural resource management stresses the crucial role of street-level bureaucrats in environmental policy implementation, i.e. public officials at the end of the policy-chain with substantial discretion to match the complexity and uncertainty of the issue areas (Sevä & Jagers, 2013; Sandström *et al*., 2016; Sevä & Sandström, 2017). While traditional street-level bureaucrats, such as teachers or police officers, have tended to have close interactions with citizens (cf. Lipsky, 1980; Hill, 2003), the public managers in natural resource management generally have sparse contacts with citizens and educational backgrounds that make them experts (cf. Sevä & Sandström, 2017). Due to the key role of street-level bureaucrats in the implementation of environmental policies, Sevä & Jagers (2013) pointed at the need to study how these bureaucrats perceive their commission, their room for discretion, and how they act upon it. This study explores the arduous weighing of goals and competing interests in Swedish freshwater management. The aim is to explore how street-level bureaucrats have dealt with trade-offs between management goals concerning anthropogenic connectivity barriers.

Recent efforts to explore and explain the management choices made by street-level bureaucrats in natural resource management have pointed at the need to investigate a limited number of factors: (a) the bureaucrats' understanding of formal policy and regulation, (b) their perceived implementation resources, and (c) their policy beliefs, briefly defined as their views on the policy problem and possible solutions (Sandström, 2011; Sevä, 2015; Sandström *et al*., 2016; Sevä & Sandström, 2017). For instance, Sandström *et al*. (2016) noted that restricted implementation resources, primarily insufficient knowledge, but also shortages of personnel and financial resources explains why genetic biodiversity has been given little attention in the management of Baltic Sea Marine Protected Areas. Furthermore, while the regulatory framework has generally been interpreted as clear and concise, this was not the case regarding genetic biodiversity, which offers another explanation as to why the issue has not

been high on the agenda (Sandström *et al*., 2016). Sandström *et al*. (2016) also showed that street-level bureaucrats are hesitant in their answers about the seriousness of the problem of genetic biodiversity, suggesting that policy beliefs can explain their management choices. These previous studies have offered important insights into the decision-making of street-level bureaucrats in various areas of marine and freshwater management, yet the current knowledge has been restricted in terms of issue areas, and little is still known regarding the impact of the respective factors (e.g. in terms of coherence and clarity as proposed by Sevä & Sandström, 2017) and their relative importance (Sandström, 2011).

This study adds to the field of targeted implementation studies on freshwater connectivity management. While most previous studies have focused on ecological aspects, e.g. the status of various species (Fjeldstad *et al*., 2012; Nyqvist *et al*., 2017; Huusko *et al*., 2018; Tamario *et al*., 2019), this study includes all major aspects of sustainable development (ecological, economic and social) in freshwater connectivity management. Broad studies on the removal of anthropogenic connectivity barriers have been urgently called for as the functional and economic value decreases in these aging structures (Hart *et al*., 2002), and political agreements such as the WFD also call for ecological restoration of streams and watercourses (Fjeldstad *et al*., 2012). Thus, the study offers insights into the drivers of management practice and provides input to both policy-makers and authorities as to what can be done to support street-level bureaucrats in their work.

Sweden offers an interesting empirical setting with its large number of physical barriers – nearly 20,000 – in its stream-lake networks (www.viss.se). The Swedish case also includes substantial variation within it. Large-scale hydropower structures are primarily located in the sparsely populated north, while older/historic structures are common in the more densely populated south. Similar to other EU countries (cf. EU Commission, 2015), Sweden's implementation of the WFD has not been straightforward. A new administrative structure was added alongside that already established, with unclear distributions of power and weak formal steering (Ek *et al*., 2017; Söderasp, 2018). Further, the lack of connectivity is one of the reasons Sweden did not achieve good ecological status according to the WFD in 2015 (Ek *et al*., 2017).

Theoretical framework

The analytical framework applied in this study relies on the work of Sandström *et al*. (2016) outlining three interrelated factors that, based on previous research (e.g. Lundquist, 1987; Hill, 2003; May & Winter, 2007; Sandström, 2011; Sevä, 2015), has influenced the management choices made by street-level bureaucrats: (a) their understanding of formal policy, (b) their implementation resources, and finally, (c) their policy beliefs.

Understanding of formal policy refers to the street-level bureaucrats' understanding or reading of the regulatory framework that surrounds the policy area in question, including official political objectives and ways to achieve them (Sandström, 2011). Sevä & Sandström (2017) divided this factor into two dimensions: clarity and cohesion. Whether the street-level bureaucrats perceive the meaning of the policy as clear has a significant impact on their willingness to act, and they are more inclined to follow old routines or develop their own practices when the policies are perceived as vague or otherwise unclear. Policies can also be seen as more or less coherent (Sevä & Sandström, 2017). In our study, we recall that there are both political objectives and regulations supporting the removal of barriers in freshwater systems and regulations that advise against it. Thus, we know beforehand that the street-level bureaucrats in our study face policy incoherence when dealing with migratory barriers. How they perceive the goal conflict,

therefore, is of utmost importance as they may need to prioritize among the objectives and find ways to justify their actions. This phenomenon is known as selective implementation (Lipsky, 1980).

Implementation resources are those that support street-level bureaucrats in their efforts to interpret and implement a policy (Hill, 2003). For instance, a supportive network can be both internal, involving colleagues and superiors within their organization and external, such as state agencies, universities, municipalities, and interest organizations that provide knowledge, examples on best practices, and other forms of decision-making support (Sevä & Sandström, 2017). A supportive knowledge network should be particularly important when making decisions on matters in which there is policy incoherence (Sandström *et al*., 2016), as in the case of freshwater connectivity management. If the bureaucrats rely more on their internal support structure, the decisions and actions generally correspond with existing practices, which may be more or less consistent with official policy (Sevä & Sandström, 2017). Sevä & Sandström (2017) also recommended identifying the affiliation of external actors in the knowledge network. The Swedish system of water governance involves a large number of officials who are assigned a role in providing information and advice and can thereby be expected to have views more in line with the official policy than officials and other actors without such an affiliation. As a result, there is likely a strong interrelationship between the implementation resources and policy understandings and, thus, street-level bureaucrats with a rich supporting network can be expected to be more secure on how to interpret the formal policy and to translate it into action. Finally, implementation resources also include more tangible resources, such as personnel and financial resources, as well as available time (Sandström *et al*., 2016).

The third aspect, policy beliefs, refers to the street-level bureaucrats' understanding of the management problem itself: what caused the problem, how alarming it is, what should be done to address it, and who should be responsible for taking action (Sabatier, 1988; Sabatier & Jenkins-Smith, 1999). Using the words '*should* be done' makes it clear that policy beliefs have normative connotations and signal the views of the holder (Weible, 2008). Policy beliefs form a hierarchy in which some are substantially more stable and difficult to change than others (Sabatier, 1988; Weible *et al*., 2009). As changes in beliefs are not addressed in this study, this part of the theory is left aside, yet all components of the beliefs' hierarchy (from the stable policy core beliefs to the most changeable secondary aspects) are nevertheless included in the interview guide to enable future studies (see Methods).

The above analytical framework and its three interrelated factors will be used to find tentative explanations as to how street-level bureaucrats deal with trade-offs between management goals concerning anthropogenic connectivity barriers in Sweden. How does the street-level bureaucrats' *understanding of formal policy* and their views on *implementation resources* and *policy beliefs* influence their considerations of anthropogenic connectivity barriers?

Methods

Guided by the principles of Integrated Water Resource Management (IWRM), the Swedish administrative system of water management is divided into five large administrative districts. A County Administrative Board (CAB) is assigned authority over the water system in each district with responsibility for water management, including collaboration with relevant administrative authorities and stakeholders according to the WFD. The CABs monitor the ecological and chemical status of the water and pursue the supervision of water operations, such as hydropower plants and other structures, which may impair connectivity (Government Official Report, SOU, 2002).

To ensure that the selected respondents in this study reflected the full range of relevant officials, i.e. the sufficiency criterion recommended by Seidman (1998), the goal was to include at least one public manager from each water district. This objective was fulfilled as ten individual semi-structured interviews were conducted, four from the water district of the Bothnian Bay, three from the Bothnian Sea water district, and one each from the three remaining districts (the North Baltic Sea, the South Baltic Sea, and the Skagerrak and Kattegat water district). Seven respondents worked as street-level bureaucrats at the CABs, while three respondents provided a more overarching regional perspective of the Water Authority.

The interviewees were selected by using the snowball technique (a form of convenience purposive sampling), meaning that one respondent recommended other potential respondents who had the relevant experience (Miles & Huberman, 1994). The snowballing started with a person who was known to have the requested experience, having worked with connectivity issues at a CAB for several years. Saturation was obtained after the seventh interview, indicating that no new information on key aspects was obtained (Seidman, 1998). To include respondents from the two most southern districts, two additional individuals were recruited through a direct question to the last respondent identified through the snowball technique.

The interview guide consisted of thematic questions designed to capture the respondents' understanding of formal policy, views regarding implementation resources, and their policy beliefs encompassing their problem perceptions and their views on responsibility and management measures (see Supplementary material). Open-ended questions were used to enable the inclusion of unexpected information and follow-up questions allowed for fuller descriptions of the inquired topics (Kvale, 1996). The interviews were conducted either in person or by telephone from June to December 2018. They lasted from 30 to 90 minutes, were recorded, and then transcribed after consent from the respondents. Qualitative content analysis of interview data, in the form of idea analysis, was utilized (Bergström & Boreus, 2012), based on the theoretical framework outlined above.

Results

The presentation of the results will follow the theoretical framework guiding this study, beginning with the street-level bureaucrats' understanding of formal policy. When referring to the respondents' views, a two-digit code is used to ensure anonymity. The letter (A–E) refers to the water districts in which he/she works, while the number(s) refers to the interviewed individual(s) within that district (A: the Bothnian Bay; B: the North Baltic Sea; C: the Bothnian Sea; D: the Skagerrak and Kattegat Water District; and E: the South Baltic Sea). Translated quotations are used to verify the interpretations.

Understanding of formal policy

The interviewed street-level bureaucrats had a shared understanding of formal policy and regulations surrounding connectivity barriers in Swedish water management. When considering restoring connectivity in a particular water system, a decision was first made as to whether or not there had been a natural barrier before the artificial one. If full connectivity had not existed before the anthropogenic barrier, the regulatory framework, including guidelines from the Swedish Agency for Marine and Water Management (SwAM), clearly stressed that connectivity should not be created (e.g. A1 and D1).

When evaluating an anthropogenic barrier, respondents reported that there were several criteria to consider. Passability was considered key, e.g. which fish species and in what numbers can be expected to pass the barrier after removal or after the implementation of other measures such as fish ladders (B1). The possible spread of invasive species or species native to Sweden but not present in the relevant water system was considered, even though the CAB managers were not mandated to do so (A4). In this case, they used lists over invasive species and registered their effects (A1). Respondent C3 reported a few 'special cases,' when they had refrained from removing connectivity barriers to prevent unwanted species (mainly lake trout and smelt) to migrate upstream to lakes that are part of the Natura 2000 network of protected areas. D1 reported a similar case when escaped farmed salmon was prevented from spreading upstream. There were no guidelines to ease the evaluation of trade-offs of this kind (e.g. A2, A4, C2, C3 and E1). The same concerned evaluations of trade-offs between management goals relating to ecology, economy and social aspects. As C3 puts it, 'It's up to the CAB to weigh the different goals against each other …' The street-level bureaucrats' policy understanding is summarized in Table 1.

Views on implementation resources

The interviewed street-level bureaucrats had similar experiences regarding implementation resources, but there was considerable variation depending on the scale of the barrier and whether considering efforts to increase connectivity or to prevent the spread of invasive species.

The large-scale barriers in Sweden are commonly linked to hydropower. When assessing them, knowledge input often is required from the power companies (A2 and A4). The most common type of migratory barrier was, however, small in scale, including remnants from log driving and a large number of malfunctioning culverts. In these cases, the street-level bureaucrats relied on knowledge generated within their organization, at times supplemented by input from municipalities (A2 and C2). In CAB A, they had made recurrent inventories of dam sites since the mid-1980s, which now cover about a thousand sites (A1). Also in region C, most of the dams have been subjected to inventories (C3). Besides the inventories made at the CABs, they also had access to databases from other authorities, such as the Swedish Transport Administration and the Swedish Meteorological and Hydrological Institute (e.g. A2 and A4). One of the respondents working at the water authorities, however, reported that there was little or no time to keep the databases updated (B1).

When making the inventories, CAB bureaucrats used a fixed protocol following the biotope survey method. The function of the barrier was assessed, how obstructing it was for different species, and at different water levels. The assessment of large structures, primarily related to hydropower, was referred to as quite simple (A2). Road barrels, on the other hand, were more difficult to assess, as each crossing between water and road needed to be considered. As most of the regions were very large with numerous

Table 1. The street-level bureaucrats' understanding of formal policy.

	Connectivity	Invasive species
Clarity	Clear criteria on how to evaluate anthropogenic barriers	Protocols are used for monitoring. Bureaucrats at regional level lack formal responsibility to deal with invasive species
	No guidelines on how to make trade-offs between different interests	No guidelines on how to make trade-offs between different interests
Coherence	Policy incoherence is recognized	Policy incoherence is recognized

lakes and watercourses, there were not enough resources to inspect each barrier at its site. As one of the respondents noted, 'an enormous budget would be needed to obtain exact knowledge and to make correct assessments everywhere' (A2). Furthermore, water barriers change over time. 'We don't have resources to follow-up that kind of change (C2).' Instead, the CAB bureaucrats judged the barriers either based on the biotopes mapping (is a barrier passable or not, and to what extent?, B1) or work with models to make estimations (e.g. A3 and E1). More detailed and specific assessments of the status of the water were made on-demand, e.g. when implementing restorations or when permits for water related activities are to be tried in court (A1 and A2). In these cases, the respondent in region E reported on established cooperation with external actors such as municipalities, consultants, and landowners (Table 2).

In comparison with native species, knowledge about invasive species was considerably more limited. In every region, a small number of species were observed. For instance, in region A, there were occurrences of lake trout (*Salvelinus namaycush*), brook trout (*Salvelinus fontinalis*), signal crayfish (*Pacifastacus leniusculus*), American waterweed (*Elodea canadensis*) and Chinese mitten crab (*Eriocheir sinensis*) (A1, A2, and A4). Knowledge about the occurrence of such species was generated primarily within each organization (Table 2). Some (A1 and A2) also referred to scientific studies, sometimes performed by previous colleagues during PhD studies. As for future threats by invasive species, A1 and A4 stressed that such threats were largely unknown to them.

The focus was on ecology when assessing the connectivity in freshwater systems, along with assessments of whether it was economically reasonable or technically feasible to take measures. C2 noted that often it was possible to find information about the economic aspects related to hydropower constructions in operation. As for small and old structures, on the other hand, the economic value tended to be little or none (C3). When considering malfunctioning culverts, it was much more difficult to assess the economic aspects (C2). The economic interests of sport fishing primarily were considered concerning management measures such as fish ladders (see below). In this regard, knowledge was most thorough concerning economically important fish species (A4).

When interests between ecology, social, and cultural values clashed, the street-level bureaucrats sought compromises. This process generally took place among different divisions within the CAB itself (A1, A2, A4, C3 and E1). Depending on who owned the barrier structure, discussions also could involve municipalities and private landowners (e.g. A1, A2, C2 and E1). Even though the problems were described as complicated and difficult, the process of finding solutions seldom was described as conflicted. Respondent A1, for example, referred to 'interesting discussions.' In this regard, however, population density had a strong impact on how difficult it was to reach compromise solutions.

'It's a huge difference to work in Norrland [the sparsely populated northern parts of Sweden] and to work down here! … I've been working with this for thirty years, and I've never come across a dam

Table 2. The street-level bureaucrats' views on implementation resources.

	Connectivity	Invasive species
Internal	Knowledge within the own organization with support from national databases. Not enough resources for onsite data collection	Knowledge within own organization
External	Municipalities, power companies, consultants and landowners	Universities

that nobody cares about. A dam can be located in the middle of the forest …, but there's always someone who likes it and wants to keep it' (E1).

Policy beliefs

Problem perceptions. All respondents ranked connectivity high when asked what priority they gave to connectivity, in relation to other problems in water management. Some even saw connectivity as the most important issue (A1, C1 and E1). Nobody ranked it lower than one of the top three.

'I believe that it is one of the most important issues to solve, and it is a problem that affects virtually all waters in Sweden, more or less' (C2).

The perceived challenges differed substantially depending on the scale of the barrier. As for small-scale barriers, the number represented the largest problem with restrictions posed by limited implementation resources. A1 and E1, representing one district in the north and one in the south of Sweden, respectively, report that they had over a thousand such migratory barriers.

On a general note, invasive species are not regarded as a problem. In the words of C1, 'I know that we have discussed the issue, but I don't think it was considered particularly risky.' Signal crayfish (*Pacifastacus leniusculus*) is the main example (A1, A2, A4, B1, C2, C3 and E1). If there is a risk for the spread of signal crayfish upstream, where the native form of crayfish (*Astacus astacus*) has been established, the barrier will not be removed, as it can bring a crayfish plague that eradicates the native species. In region A, North American trout species, mainly lake trout (*Salvelinus namaycush*) and brook trout (*Salvelinus fontinalis*) have been introduced, but their effect on domestic populations of fish species seems to be limited (A2). In terms of future threats, a lack of preparedness was highlighted.

'We don't yet see the spread of invasive species as a problem, but as I said, we have insufficient preparedness and flawed thinking in this respect' (A1).

Views on responsibility. The interview question on the distribution of responsibility turned out to be problematic. It was intended to measure the respondents' beliefs so it was phrased in a normative fashion: 'which societal actors should be responsible for promoting connectivity?' Most respondents paid no attention to the critical word *should*, rather reporting on the *formal* distribution of responsibility. Considering the CAB bureaucrats' official responsibility to supervise connectivity in the region's water systems, the interpretation of this question perhaps is not surprising. Notably, the other interview question on responsibility relating to invasive species worked as intended, although it was phrased in the same way: 'Which societal actors should be responsible for preventing the spread of invasive species?' In this case, the respondents' views on the ideal distribution of responsibility differed from the current formal distribution. We recall from above that the regulatory framework surrounding Swedish water management does not give authorities at the regional level responsibility to deal with invasive species.

'At the end of the last water management cycle, an EU decision came on invasive species. This is described in each management plan, in a separate section. It is the same in all five [management

plans]. Here it became clear that [regional] water management would not handle certain species [e.g. invasive ones]. This ended up with the SwAM …' (A4).

The interviewees agreed that some responsibility for preventing the spread of invasive species should rest with the national authorities (A4, B1, C1, C2, C3 and E1), primarily the SwAM. However, as the SwAM does not work with concrete restoration efforts, a majority of the respondents (A1, B1, C1, C3 and E1) thought that responsibility should be extended to regional authorities. Some wanted to extend responsibility even further to municipalities (A1, A2, C2, C3 and E1).

Views on management measures. When considering management measures on the national level, to prevent the spread of invasive species, the street-level bureaucrats recommended regulation (A4, B1, C1, C2, C3 and E1). Even though it is not formally in their mandate, a majority of the respondents thought that regional authorities should take responsibility for dealing with challenges related to invasive species. The suggested management measures were two-fold – to decide on restrictions and to inform the public on the dangers involved when moving fishes and other species (A1, B1, C1, C3 and E1). Thus, preventive measures stood out about invasive species, as it was held to be very difficult to remove them from a water system once they have entered (C3). The CAB managers gave some examples of when they had tried to remove the invasive species manually, but it was costly and tended to be of limited effect (e.g. A1 and C3).

The most effective management measures to promote connectivity varied widely and the reported beliefs differed between different types of migratory barriers and between the regions. The large hydropower plants in regions A and C are important in the Swedish energy system. In combination with the low natural value of the regulated rivers, environmental benefits related to improved connectivity seldom outweigh the estimated benefits to society (A3 and C1). When management measures of large-scale artificial barriers were considered, the options tended to be fish ladders and other bypass channels (e.g. A4, C1, C2, C3 and D1).

For smaller barriers, the most effective management measure was removal (A2, A3, A4, C2, C3, D1 and E1), which is not always possible due to social or cultural reasons. An old dam may have lost its original function, but it still regulates the water level and offers an appreciated surface of water or benefit to cabin owners who commonly have wooden piers for their boats (C3). One solution could be to build a threshold instead of removing the barrier, enabling fish to pass through (A1). On historical sites, the structures that are underwater can be removed while leaving the parts that are visible (A1). Old water structures also have safety aspects so that removing them provides social benefits in terms of reduced accident risks (C3). The street-level bureaucrats' policy beliefs are summarized in Table 3.

Table 3. The street-level bureaucrats' policy beliefs.

	Connectivity	Invasive species
Seriousness	Lack of connectivity is considered a serious problem	Not yet a serious problem
Responsibility	The bureaucrats refer to their formal responsibilities rather than to their policy beliefs	Responsibility should be divided between national and regional levels. Some want to extend responsibility to the local level as well
Measures	Removal and various technical measures	Regulation and information

Even if the managers gave examples of compromise solutions, they noted that the integration of cultural values into water management was difficult to achieve, as guidelines on how to weigh it into the norm-setting are missing (A4). In A4's opinion, integration nevertheless had improved in recent years. Also in region C, there were reports on the difficulties addressing these issues. 'We should value … culture against energy and environment, but we have not been able to do so so far, but hopefully in the future' (C1). Management costs in relation to fairness were also raised. Additional funding was called for to compensate for private landowners.

'The vast majority of the dams in the county are owned by private landowners … Most of the time, the present owners … have not built the dams; they have bought it or inherited these facilities in some way … It does not feel right and reasonable … that they should pay to remove something that someone else has built …' (E1).

Discussion

Generally, the interviewed street-level bureaucrats reported that in terms of connectivity, Sweden had a well-functioning management situation. Official policies and regulations were considered clear: connectivity was highly prioritized in the regulatory framework and also considered to be a sizeable and important problem to address in all parts of the country. The distribution of responsibility between various actors was well-defined, but not entirely satisfactory. There were, however, substantial differences depending on the scale of the barrier, as summarized in Table 4.

While the evaluation of the large structures related to hydropower production was considered to be relatively straightforward, having sufficient resources in terms of knowledge, time and personnel, the opposite was the case for the small, but multiple, migratory barriers. In these cases, the street-level bureaucrats reported that it was not possible to collect data from all the smaller streams to make connectivity assessments. The situation however differed between the regions. In the northern parts of the country, the small-scale barriers were dispersed across vast geographical areas. On the other hand, the restoration of small-scale barriers in water systems in the northern parts of the country seldom met competing interests since the course of the streams commonly were not altered much.

Table 4. The street-level bureaucrats' policy understandings, views on implementation resources and policy beliefs with regard to migratory barriers of different scale.

		Large-scale barriers	Small-scale barriers
Policy understandings	Clarity and coherence	Policy and regulations are held to be clear, but there are no guidelines on how to make trade-offs between different interests. Policy incoherence regarding connectivity goals is recognized	
Implementation resources	Internal	Knowledge within the own organization	Knowledge within the own organization and national databases. Not enough resources for onsite data collection
	External	Power companies	Municipalities, consultants, and landowners
Policy beliefs	Seriousness	Lack of connectivity is considered a serious problem	
	Responsibility	The bureaucrats refer to their formal responsibilities rather than to their policy beliefs	
	Measures	Technical measures	Removal and technical measures

Additionally, there often were anticipated benefits for sport fishing. In the more densely populated southern parts of the country, the situation was entirely different, with many competing interests.

We noted a strong influence from street-level bureaucrats' policy understanding as they consider different management options. However, the possibility of intervening varied across the scale of the barrier (Table 4). While removal was considered the most effective action to promote connectivity, it was not an option for large-scale hydropower structures due to strong economic interests. In these cases, the bureaucrats evaluated different technical solutions to enable the migration of fish and other species. For small-scale barriers, removal was often the best choice, but different technical solutions were also considered to meet societal interests.

Most management choices require compromises between competing interests. When evaluating different trade-offs, the street-level bureaucrats were largely left to their own devices, particularly when it came to small-scale migratory barriers. Whether this is a problem can be debated. On the one hand, great discretion offers flexibility to meet varying local conditions, as well as the possibility to adjust to new ecological knowledge, which is a central feature of adaptive management of natural resources (Koppenjan & Klijn, 2004; Sandström, 2011). On the other hand, the lack of formal support can hamper the decision-making process, particularly in instances where high levels of uncertainty surround the decision-making. At present, the managers did believe they had a satisfactory network of advice, but the level of uncertainty varied across species.

The interviewed street-level bureaucrats were all aware of the policy incoherence between increased connectivity and the prevention of invasive species. While connectivity issues ranked high on the respondents' agendas and were considered to be a major problem all over the country, the existence of invasive species was regarded as a relatively small problem. When considering future threats, the level of preparedness was low.

The managers unanimously reported that they had little or no formal guidance on how to proceed when it came to invasive species, or, indeed, species native to Sweden not previously found in their local water systems. This absence of guidelines can be explained by the distribution of formal responsibility in Swedish water management, where the main responsibility for these matters relies on the SwAM at the national level. Even so, the CAB managers have an informal responsibility to prevent the spread of invasive species, and they wished to see an altered distribution of responsibility in the future with responsibilities extending down to both the regional and local levels.

Conclusions

Policy incoherence in water management between connectivity goals and the prevention of invasive species was the starting point for this paper, which aimed at exploring how street-level bureaucrats in Sweden made trade-offs among management goals when evaluating anthropogenic connectivity barriers. A theoretical framework previously applied in other areas of natural resource management was used (Sandström, 2011; Sevä, 2015; Sandström *et al.*, 2016; Sevä & Sandström, 2017). The findings, based on qualitative semi-structured interviews with street-level bureaucrats from the five water districts in Sweden, showed that all three factors in the theoretical framework – the understanding of formal policy, their available implementation resources and their policy beliefs – are of consequence when anthropogenic connectivity barriers were considered in ongoing management. Furthermore, the study suggests that the factors are interrelated.

The link between street-level bureaucrats' policy understanding and policy beliefs was manifested in two different ways. First, the study points at a link between policy understanding and problem perception. The street-level bureaucrats acknowledged that there was policy incoherence between connectivity and invasive species, but since the threat from invasive species at present is low, and the case for connectivity is high, the focus has been on promoting connectivity when considering migratory barriers. The main exception was the case of the signal crayfish, which does need to be stopped from spreading as it is a carrier of the crayfish plague to the native crayfish.

The second link between policy understanding and policy beliefs concerned views on management measures. As there were no formal guidelines on how to make trade-offs – e.g. between ecological and social factors – these officials relied primarily on their own assessments and at other times with support from other contacts, both within and beyond their organization. The respondents did not portray this in a negative light. On the contrary, they were comfortable in reaching compromise solutions. In natural resource management research, this discretion can be highly beneficial because it enables solutions that are adapted to local circumstances (May & Winter, 2007; Sandström, 2011; Trusty & Cerveny, 2012; Hysing, 2013; Sevä & Jagers, 2013).

The study also indicated that the street-level bureaucrats' policy beliefs were connected with their views regarding implementation resources. Implementation resources were limited, particularly when considering the numerous small-scale barriers where insufficient knowledge impedes the implementation of connectivity measures. A similar conclusion concerns invasive species where the preparedness to deal with future threats is low due to a lack of knowledge and formal responsibility.

A relationship between the factors in the analytical framework has been suggested in other studies (Sandström *et al*., 2016; Sevä & Sandström, 2017). Nevertheless, since both this and previous studies were based on a qualitative research design and involved a restricted number of respondents, conclusions cannot be made about either causality or the strength of the identified relationships. To specify the relationship between the explanatory factors, more research is necessary, preferably using surveys and statistical analyses to, in the words of Sevä & Sandström (2017, p. 84), '… disentangle the interactions and causalities …'.

This study has highlighted the similarities and differences on a general level in Swedish freshwater management. The pronounced differences between anthropogenic barriers of varying scale, as well as the identified differences between the northern and southern parts of the country, strongly indicated at the importance of context, an explanatory factor that was not included in this analytical framework. Future studies would benefit from closer and more site-specific investigations that can offer more detailed insights into the trade-offs involved (Ek *et al*., 2017). The analytical framework may also benefit from adjustments. Context can be either included as a general circumstance surrounding the entire analytical framework or specified in a way that is relevant to the study (Sevä, 2015).

The analytical framework was developed to explore variation within one case (Sandström, 2011), rather than between cases as pursued here (small-scale and large-scale migratory barriers). The pronounced similarities in results between this study and others suggest that the framework is usable across cases, at least when they are situated within the same context, here represented by river basins, including migratory barriers of varying scale. Overall, the formal policies and regulations are the same, and the street-level bureaucrats whose beliefs are explored are also, at least in this study, the same individuals. Further investigations are needed to explore the possibilities of applying the analytical framework in multiple cases.

The focus on one specific country is a limitation of this study. Nevertheless, the findings are likely to have relevance in other institutional contexts, particularly within the EU with its shared regulatory framework. Even so, cross-country comparisons, e.g. of how street-level bureaucrats deal with trade-offs between management goals on either small- or large-scale connectivity barriers, would offer interesting insights into the relative importance of policy understandings, implementation resources, and policy beliefs.

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Data availability statement

All relevant data are included in the paper or its Supplementary Information.

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