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REPORT 2

Metadata

Mussels in Råstasjön

Picture 1: Line assessment at Råstasjöns eastern outlet

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1.General Background

Freshwater ecosystems provide many benefits for humans and the urban society (referred to as ecosystem services), such as fresh water supply, flood damage reduction and improved conditions for wildlife. Lakes are one of the most important water sources for human use, and the ecosystem services derived from them have enormous value for people and society (Reynaud & Lanzanova 2017). Water bodies located in urban environments (lakes being a common one) have shown to provide both ecological and social benefits in terms of urban ecosystem services (Völker & Kistemann 2011). However, a continuously increasing urbanisation and unpredictable conditions due to climate change pose a threat to these urban blue surfaces and increasing management efforts are needed in order to sustain the functions of these ecosystems (Matthews 2016).

Råstasjön is a lake situated in the urban district Råsunda, Solna stad. The lake is relatively shallow (mean depth 2,2 m), with an area of 19,8 ha and a volume of 435 600 m^3. High levels of nutrients, mainly phosphorus, have caused algal blooms in the lake. The sediments are very rich in nutrients as well as pollutants, such as heavy metals (Solna stad 2014). The lake, along with the surrounding area, also holds a high biodiversity and is highly renowned for its rich birdlife. Råstasjön is also a known recreational area with a lot of people visiting every day. The catchment area that Råstasjön is a part of includes two other lakes; Lötsjön (to the east) in Sundbybergs stad and Brunnsviken (to the west) in Stockholms stad. Together, the three municipalities are responsible for the management of the water quality throughout the catchment area (Länstyrelsen 2015). Another stakeholder with great interest in issues concerning the lake is the civic engagement group *Rädda Råstasjön*. The network was formed in 2012 due to proposed building plans close to the lake, which caused around 25000 people to sign a digital petition against it. Since then, they have protested against further exploitation around the lake on social media and with actual protests at the lake.

A partly invisible and largely unexplored component of the Råstasjön ecosystem are the freshwater mussels hidden under the water surface. They carry out important ecological functions, such as water filtration, which can improve the water quality of the lake (Bergengren et al. 2016). A single mussel is able to filter approx. 40 litres of water per 24 hours and thereby can have a great effect on water turbidity during summer. This filtering function has earned the mussels the name “ecosystem engineers” (Lundberg & Österling 2016, p.5).

2. Research Question and Research Design

The main purpose of this study is to [1] assess the social-ecological values of Råstasjön and [2] how these can be preserved and enhanced by administrative and civil society actors.

In order to reach the set aim of the study, the following research questions were formulated: [1] To what extent can mussels in Råstasjön provide the ecosystem service of water purification? [2] What social and ecological values are recognized by users of the area around Råstasjön? [3] What are the major administrative obstacles and benefits regarding cooperation in reaching the goals required by the EU Water Framework Directive (Directive 2000/60/EC)?

To answer these research questions a variety of methods were used. Firstly, an assessment of the mussels within the lake was conducted in order to calculate the water filtration capacity the mussels perform. Secondly, different stakeholders were interviewed; users, experts and a civic engagement group. The selected experts consist of a number of key persons identified and contacted.

3. Methods

3.1 Mussel Assessment

After choosing a sample site at the eastern outlet of Råstasjön we divided the site into an area of the open lake and a part between a bridge and a small dam where the water flows out towards Brunnsviken. Two methods were used to assess the mussel population. Firstly, aquascopes were used whilst wading through the water between the bridge and the dam to find mussels and collect them for measuring (Bergengren et al. 2016, p.13). Secondly, line assessment paired with free-diving was used to take samples of mussels within Råstasjön (Bergengren et al. 2016, p.8). To conduct the line assessment a 25m tape-measure was put into the lake. Along the tape-measure a metal frame covering an area of $0.25m^2$ was placed on the bottom of the lake at a distance of 5, 10, 15, 20 and 25m from the shore. Then the mussels within the frame were collected and taken to shore for measurement where the total length, height and thickness of the mussels were measured. All alive mussels were later placed back where they were collected.

After the collection the total mussel population was estimated based on the number of individuals, both dead and alive, collected in the sample area. Two calculations were made: one excluding the mussels collected in the area between the dam and the bridge and one including these individuals (see Appendix 1).

3.2 Semi-structured interviews

Interviews were carried out with both experts involved in the management of the catchment area and people passing by Råstasjön during the sampling of mussels. The bypassing people were taken as respective users of the locality. Interview questions were formulated having the research questions in mind (see section 2). The experts interviewed included Linda Svensson (water strategist) at Solna stad, Pia Ekström (environmental administrator) at Sundbybergs stad, Håkan Häggström (environmental analyst) at the County Administrative Board in Stockholm and Ulf Mohlander (environmental analyst) at Stockholms stad. Henrik Persson, active at the network Rädda Råstasjön, was also interviewed. The expert interviews were carried out in Swedish by three to four people and later translated into English.

The people passing by the lake were interviewed at random when passing by the location where the sampling of mussels took place. These interviews were as well carried out in Swedish by one or two people and later translated into English.

4. Data Presentation

4.1 Water Filtration Capacity of Mussels in Råstasjön

Based on the mussels collected in the sampling area during the line assessment the water filtration capacity of the mussels was calculated. Apart from one Duck Mussel, *Anodonta anatina*, all individuals collected were Swan Mussels, *Anodonta Cygnea*. This species can, according to the IUCN Red List of Threatened Species, be found throughout Europe, parts of the Middle East as well as Russia and lives in small ponds or lakes and is not endangered (Lopes-Lima 2014). It is to be noted that predominantly larger and therefore older individuals were collected. Since no young mussels were found no conclusion can be made on the health and reproduction capacity of *Anodonta Cygnea* population in Råstasjön.

Based on an average of 28 mussels per square meter within the sample site of the lake using the method of line assessment (counting of dead and alive individuals), it was calculated that approximately 5.54 million mussels exist in Råstasjön. These would be able to filtrate 221 million litres of water per 24 hours (see Appendix 1: Calculation 1). Thereby the

mussel population of Råstasjön can filter approx. 51% of the lake's water volume every 24 hours. When counting only those individuals alive, the numbers look quite different as only 1.18 million individuals are calculated to be living in the lake. However, those mussels found dead during sampling are very likely to have lived until last winter, as supervisor Stefan Lundberg (Vattenakademien) noted, and were therefore included in these calculations. When including those mussels collected in the outlet basin (between bridge and dam) whilst wading and using aquascopes, the calculation showed that, with an average of 29.33 mussels per square meter, 5.8 million mussels live in the lake. These are able to filter 232.3 million litres of water per 24 hours, which equals 53% of Råstasjön's volume (see Appendix 1: Calculation 2).

However, when looking at the variance of the samples collected during the line assessment, which was calculated to be Var(X)=0.4 (see Appendix 1.3), it becomes apparent that the samples taken cannot be used as being representative as the variance is quite high. Furthermore, only 1.25m^2 of the lake's area (whilst the lake covers a total area of 198 000m^2) were actually used as sample area. Thereby the sample area only accounts for 0.0006313% of the lake's area, which is too small to generate representative data. However, if further research had been conducted using the line assessment method in several other sample sites more representative data could have been generated. Nonetheless, when calculating the abundance using the variance it became clear even when using the lower number of 5.22 million mussels in the lake, that the water filtration capacity was 209.08 million litres/24h. When looking at the higher estimation of 5.86 million mussels the filtration capacity was even at 234.43 million litres/24h.

The impacts of this assessment on the ecosystem and the mussels contribution to the ecosystem service of water filtration will be discussed in chapter 1.1 of the third report *Result Reflection*.

4.2 Expert Interviews

A common ground for the experts were that they all perceived cooperation on the public servant level to be well functioning, but that political support and resources allocated for environmental and water issues differs greatly between municipalities (for referencing, see report 1). As an example, Solna stad has one person focusing on water issues while Stockholms stad has a project group of approximately ten people (Ulf Mohlander, Stockholms stad).

One way in which the municipalities cooperate is through the development of local action programmes (LAPs) for specific water bodies. Since Råstasjön is too small to be considered a water body, it is incorporated in the LAP created for Brunnsviken. The municipality responsible for initiating and financing a LAP depends on the context and varies from case to case. As an example, Stockholms stad has developed and financed the LAP for Brunnsviken and its catchment area. The LAPs are operationalized by each involved municipality into local implementation programs with measures for the specific municipality in question (Håkan Häggström, Länsstyrelsen).

Through the detailed development plans (DDP) the municipalities work towards the County Administrative Board (CAB) in Stockholm. The DDP's have to reach the criteria for "good ecological status" according to what is stated in the Water Framework Directive (WFD) in order to be approved. A problem that the experts perceived with DDP's is that the criteria to be met and its formulations are not always connected to the actual building and implementation of the plan. There is a long chain of command from the CAB to the constructors on the ground and information and consequence thinking is often lost on the way (Pia Ekström, Sundbybergs stad).

Most of the experts had not previously reflected on to what extent the mussels could provide the ecosystem service of water purification. Linda Svensson at Solna stad was the only expert aware of the mussels' water filtration capacity and had contemplated over their potential. Although the other experts were positive to the idea of using this regulating ecosystem service, they questioned the extent to which mussels could actually contribute to an improvement of the water quality, emphasizing other factors as more important to focus on (Pia Ekström, Sundbybergs stad; Ulf Mohlander, Stockholms stad).

The cooperation between municipalities and the public takes place mainly during public consultation in association with the creation of new DDP's, such as when new buildings and nature reserves are to be created. Communication also takes place through other platforms, such as a contact center in Solna stad and the website Miljöbarometern run by Stockholms stad. However, according to Linda Svensson at Solna stad, the degree to which the public can influence plans are very limited. None of the municipalities had any active cooperation with local NGO's regarding water quality and the management of it. According to Henrik Persson at Rädda Råstasjön, building plans near the lake and the lack of influence from the public have created a tense relationship between the municipality and the citizens forming the local network of Rädda Råstasjön. Linda Svensson at Solna stad

acknowledges that the previous conflict in Solna also has affected the municipality's attitude towards the cooperation negatively, thus creating a grid-lock.

4.3 Passersby Interviews

During the collection of mussels, interviews with bypassing pedestrians were conducted. A total of eleven (11) individuals were interviewed, five women and six men. The average of the approx. ages is 54 years old, the youngest participant being approx. 25 years old while the oldest participant being approx. 70 years old. The amount of individual visits to Råstasjön range from "once every other week" to "five times a week, all year round". Two interviewees even visited for the first time that day. The reason for the interviewees to visit the lake was "to take a walk", for "walking and birdwatching" or to "enjoy nature, get away from the computer." The values perceived by the passersby "makes me relax", and got described as "lovely and calm", "nice and cosy", "beautiful and peaceful", "really beautiful and soothing" or "fantastic".

However, a few less positive comments like "it is good on this side of the lake [northeast], the other side is more of a park landscape which I don't think has much value" were made. As well as some negative comments, for instance "it is a shame you can hear the traffic from the roads closeby." Regarding animal sightings the answers ranged from pointing out exact species like "canada geese", "black headed gulls", "swans, geese", "Canada geese, swans, gulls, ducks and rats", "swans, ducks (...)" to more general observations such as "mostly birds, occasionally rats in the winter, fish", "birds", "mostly birds" and "birds". The thoughts about the animals sighted varied, such as "there are too many of them [Canada geese]", "I wonder why they are so abundant [gulls]", "I enjoy the birds", "I am very amused by birds" and "I love birds."

Three of the eleven total participants stated they had seen mussels in Råstasjön before. As of thoughts about mussels the usual answer seemed to be "none". However one participant knew some freshwater mussel species. When asked about water quality the answers were various such as "I believe it [the lake] is suffering from eutrophication", "I don't know. Can you actually swim here?" and "I think it has improved since I lived here." For the last question on attributes of Råstasjön they disliked, the interviewees referred mostly to the surroundings and the traffic around the lake. Further interpretation of these summed up participant answers is to be found in the third report *Result Reflection*.

5. Limitations

Using quantitative as well as qualitative methods includes dealing with various limitations to the generation of data. When conducting the mussel assessment at Råstasjön on Monday, May 8 2017, the conditions at the location were not ideal. The bottom of the lake consists of fine sediments such as gyttja and clay that was disturbed during the wading and resulted in a significantly decreased visibility. This resulted in difficulties locating mussels on the bottom of the lake as well as collecting them. If visibility had been better, it might have been possible to collect more mussels in total. Additionally, limiting the assessment to one sample site increases the probability of picking a site that is not representative for the lake, that either has a higher or lower population than the actual average mussel population within Råstasjön. If the project phase had been longer in total, mussel assessments at various sample sites and on various days could have been conducted.

Secondly, regarding the passerby interviews, there must be an acknowledgement of a selection bias as the passersby showing interest in the mussel inventory are the ones already interested in nature. Those willing to be interviewed were typically of older age (assuming retired people have more time). Also, the relatively bad weather (occasional snow and rain) may have had an impact on the amount of people visiting the lake that day, thus limiting the selection further.

Thirdly, different interviewers in teams of three to four were conducting the expert interviews different. This variety of interviewers may have influenced the information elicited through different use of language, body language etc. Furthermore, the interviews were not transcribed in total due to the limited time used for this project. If transcripts would have been generated a terminology analysis, i.e. counting specific word, could have been conducted as well. Limitations concerning the translation of interviews from Swedish into English should also be acknowledged, since the translation process itself might result in a loss of precision.

6. Literature

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Appendix 1:

Calculation of water filtration capacity of mussels (dead and alive)

Area of Råstasjön: 19.8ha = 198,000m^2
Volume: 435,600m^3 = 435,600,000L
Filtration capacity of mussels $F_{(M)}$= 40 L/24h

1) Calculation for lake without outlet between dam and bridge

a) *Average of mussels per square meter*: $n_{(i)}$= 28

(1) Distance (m)	(2) Individuals on Sample Site (0.25m^2)	(3) Individuals per m^2 ((2) times 4)
5	7	28
10	8	32
15	6	24
20	7	28
25	7	28
		Average= 28

b) Estimation of mussels within Råstasjön:
(area of lake times average of individuals counted)

198,000m^2 x 28= 5,544,000 mussels

c) Total amount of water filtered by mussels within 24h:
(Total number of individuals times filtration capacity)

5,544,000 x 40 L/24h= 221,760,000L

d) *Percentage of water filtered by mussels per 24hr in relation to total volume of Råstasjön*:
(Total amount of water filtered by mussels divided by total volume of lake)

221,760,000L ÷ 435,600,000L = 0.51 => 51%

e) Calculation of water price for water filtered (Average Price for drinking water: SEK 0.018)

221,760,000 x 0.018 = SEK 3,991,680

2) Calculation including individuals collected between dam and bridge

a) *Average of mussels per square meter*: $n_{(i)}$= 29.33

(1) Distance (m)	(2) Individuals on Sample Site (0.25m^2)	(3) Individuals per m^2 ((2) times 4)
5	7	28
10	8	32
15	6	24
20	7	28
25	7	28
Bridge to dam	9	36
		Average= 29.33

b) Estimation of mussels within Råstasjön:

(area of lake times average of individuals counted)

198,000m^2 x 29.33= 5,807,340 mussels

c) Total amount of water filtered by mussels within 24h:

(Total number of individuals times filtration capacity)

5,807,340x 40 L/24h= 232,293,600 L

d) *Percentage of water filtered by mussels in relation to total volume of Råstasjön*:

(Total amount of water filtered by mussels divided by total volume of lake)

232,293,600L ÷ 435,600,000L = 0.53 => 53%

e) Calculation of water price for water filtered (Average Price for drinking water: SEK 0.018)

232,293,600L x 0.018 = SEK 4,181,284.8

3) Calculation based on Variance [Var(X)] of Mussel Samples taken in Råstasjön

a) Variance and abundances:

Distance (m)	Individuals on Sample Site (0.25m^2)	Variance
5	7	0
10	8	1
15	6	1
20	7	0
25	7	0
	Average: 7	Var(X)= 0.4

A(neg) Abundance negative: 7-0.4 = 6.6

A(pos) Abundance positive: 7+0.4= 7.4

A(neg) Abundance negative per m^2: 6.6x 4= 26.4

A(pos) Abundance positive per m^2: 7.4 x 4 = 29.6

b) Estimation of mussels within Råstasjön:
(area of lake times average of individuals counted)

A(neg): 198,000m^2 x 26.4= 5,227,200 mussels
A(pos): 198,000m^2 x 29.6= 5,860,800 mussels

c) *Total amount of water filtered by mussels within 24h:*
(Total number of individuals times filtration capacity)

A(neg): 5,227,200 x 40L/24h=209,088,000 L
A(pos): 5,860,800 x 40L/24h=234,432,000L

d) *Percentage of water filtered by mussels in relation to total volume of Råstasjön*:
(Total amount of water filtered by mussels divided by total volume of lake)

A(neg): 209,088,000L ÷ 435 600 000L = 0.48=> 48%
A(pos): 234,432,000L ÷ 435 600 000L = 0.54 => 54%

e) Calculation of water price for water filtered (Average Price for drinking water: SEK 0.018)

A(neg): 209,088,000L x 0.018 = SEK 3,763,584
A(pos): 234,432,000L x 0.018 = SEK 4,219,776