Swedish University of Agricultural Sciences
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EU-Water Framework Directive, Reference Conditions & Public Participation: A comprehensive directive with antagonistic poles or a harmonious monopole?

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Abstract

The European Union accepted and approved the European Water Framework Directive (WFD) in 2000 through the European Parliament (WFD 2000/60/EC). It was seen as a joint decision to improve the water quality within the Union's borders. The overall goal for water management is given as 'good ecological status' (GES) 15 years after implementation of the WFD.

Two different scientific disciplines and often contradicting epistemologies lie at the heart of the WFD. Firstly, the classification of ecological status is with respect to a reference condition (RC), and RC is thought of as being the same as it was prior to significant human activity or disturbance, referred to as an "undisturbed state". Secondly, public participation (PP), where it is explicitly argued that the success of the directive rested much on the outcome of PP. Information sharing from the decision makers seem to be the foremost important task when it comes to use of PP in the WFD.

This study examined the relationship between RC and PP in the WFD through estimations of RC for 20 Swedish lakes with different input data, and a lake specific case-study in which perceptions of stakeholders in relation to what they believed was important for "their" lake. Furthermore, this study has explored the origin of the phrase 'undisturbed state' in relation to water bodies and explored the relationship between science and policy in the WFD.

The results indicate that there is no direct relationship between PP and RC when considering the public's perception. This study shows that the local people posses a great knowledge on specific events that they have visually experienced. The link between RC and PP in the WFD is clearer when the uncertainties for science are too large and classification of a lake cannot be made. Then local knowledge bought out through public participation could help in the classification of a lake and the establishment of the RC. This study supports the difficulties and uncertainties of determining RC for Swedish surface water, however, the basic values people hold about clean and unpolluted water corresponds well with the overall goal of GES for Swedish lakes. This raises the questions, should we keep our focus mainly on RC or use more of the basic values and local knowledge to focus on human benefits.

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Salar Valinia, Uppsala, June 2011

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1. Introduction

The European union accepted and approved through the European Parliament the European Water Framework Directive (WFD) in 2000 (WFD 2000/60/EC) as a joint decision to improve the water quality within the union's borders. The overall goal for water management is good ecological status (GES) 15 years after implementation of the WFD. As a whole, WFD is an unambiguous and important piece of legislation that sets out new concepts that could change the practice of traditional water management towards a new paradigm. The WFD is moving away from the traditional sector-based water management towards promoting a transdisciplinary, holistic and integrated approach towards water management placing ecological criteria as the focal point of the legislation (Futter et al 2011). The goal of WFD with transdisciplinary water management will need consideration from a wide range of different actors; economical, social and environmental aspects need to be taken into consideration, and under these conditions, the multiple interests of stakeholders create a complex societal structure (Rault and Jeffrey 2008; Collins et al 2007).

Two different scientific disciplines and often contradicting epistemologies lie at the heart of the WFD. Firstly, the classification of ecological status (Annex V) implies that all the water bodies should be classified as high, good, moderate, poor and bad ecological status. The classification of ecological status is with respect to a reference condition (RC), and RC is thought of as being the same as prior to significant human activity or disturbance referred to as an "undisturbed state" in the ecosystem. The present ecological status is compared with the RC to determine whether the water bodies reach the overall goal of GES. Secondly, public participation (PP) is at the heart of the WFD (Article 14). In the WFD it is explicitly argued that the success of the directive relies on the shoulders of PP. Information sharing from the decision makers seem to be the foremost important task when it comes to use of PP in the WFD.

There has been criticism towards the implementation and formulation of the WFD, in particular to the overall goal of GES and PP. For GES, three major points of criticism has been argued in the scientific community: (I) Most of the waters within the border have been altered by human activities i.e. RC might not exist. (II) There is a lack of definition in WFD of how to determine the RC and there is room for interpretation on

what RC is. (III) Are undisturbed state and RC appropriate goals for water management? (Bishop et al 2009; Moss 2008; Stoddard et al 2006; Bennion and Battarbee 2007; KSLA 2006). The scientific community has argued three main points of criticism for PP in WFD. (I) In the WFD no clear indications on how, who and when PP should are given. (II) PP by itself is not a goal of WFD, rather a process that should be implemented. (III) Public involvement is encouraged in the implementation phase in the WFD, not in the goal setting or planning stages (Rault and Jeffery 2008; Collins et al 2007; Futter et al 2010; Steyaert and Ollivier 2007).

Given the discussions in the scientific community on the shortcomings of the WFD: (I) From an epistemological perspective, whereas the correspondence between social and natural science is lacking. (II) The lack of definitions for the implementation of WFD both when it comes to RC and PP and (III) Is RC and undisturbed state an appropriate goal for water management. With these shortcomings, there is a need to explore the transdisciplinarity of the WFD. Using the scientific disciplines within natural and social sciences this study seeks to find the link on how RC and PP can complement each other. How can the citizens that are using the lake help in goal setting, prioritizing and the implementations phase? The other aspect of importance that will be explored in this study is what perceptions do the citizens have and what might be the appropriate goal for their lake.

1.1 What is the link between public participation and reference condition in EU-WFD?

As mentioned in the introduction the two cornerstones of WFD derive from entirely different epistemologies and views of science and knowledge. One of the most fundamental aspects for this study is to try to understand how the two cornerstones are linked in the WFD, no certain answer can be given but indications of how these two cornerstones are linked can be described. Describing the two cornerstones in brief terms, WFD states that PP should be used more or less to inform the general public before final decision on the measures taken to achieve GES. The information to the public is given in the implementation phase of the work so that the general public has a chance to give their view on the specific measures taken. RC in brief, is used to define the undisturbed state, the undisturbed state is seen as without or minimal human disturbance to the water bodies and surrounding land (WFD 2000/60/EC). In the implementation process of WFD, RC is used as the initial step and PP is used as

the final step before a decision is taken. The framework by itself does not give a direct indication of how these two processes could be linked which eventually would lead to implementation of actions to achieve GES. As mentioned in the beginning of this chapter both the concepts of PP and RC have been criticized, not by the same critical audiences but from different scientific branches.

To understand the link between RC and PP it is important to understand how RC is determined. In practice, RC can be defined using (I) spatially based RC including historical data, (II) modelling empirical or dynamical data, (III) a combination of I and II, and (IV) expert judgement. In the end how we determine the RC will be a political decision due to the fact that no direct definition exists of how much the deviation between pristine conditions and undisturbed state should be (Andersen et al 2004). These different methods of determining the RC have uncertainties that need to be taken into consideration, the modelling of pre-industrial lake water chemistry is done with many assumptions, historical data is often not comparable with contemporary data due to practice shift and expert judgement is based on contemporary data and knowledge from an advisor. For some lakes the uncertainties for modelling data are too large, historical data is absent and the expert cannot make a proper judgement of the RC using contemporary data, when these factors of one cornerstone in the WFD is missing the other cornerstone of WFD, namely PP comes into place. This way of using PP is argued in CIS PP (2003) pp. 59 "*Experience in the water resource sector has shown that generic 'expert' solutions have often been inappropriate for local conditions and have had unintended negative effects. Many of these could have been avoided if scientific expertise had been combined with local knowledge and experience. This is not least likely to be case with regard to defining the reference conditions, where knowledge on historic conditions - being equally distributed with authorities and other parts of society - may turn out to be of crucial importance, e.g. previous physical appearances of rivers and wetlands*". In the guidance document for PP, it is argued that the local knowledge is an important aspect for determining the RC. Using expert knowledge and non-expert knowledge (referred to as local knowledge) will create a better understanding of the root causes of the issues in the catchment area and create a better informed and relevant plan of action (CIS PP 2003). Continuing with the CIS PP the authors state that it is difficult to determine what type of knowledge can be seen as evidence or proof and it is argued that there will be situations were the uncertainties or the scientific evidence of a determined consequence or action process is missing. They propose "*We suggest that competent*

authority should try to ensure that decisions are based on all the available evidence by accepting that non-scientific information can be a legitimate form of knowledge about the environment and can be used to compliment and inform expert opinion. In conditions of uncertainty, it will be necessary for the degree of uncertainty to be made explicit"(CIS PP 2003 pp. 60). In this section of the guidance document that local knowledge, "non -scientific" facts should be a taken into consideration to help in expert judgement in the basis of decision-making. Newig et al (2005) state that using local knowledge in decisions-making processes where the uncertainties are high would give the authorities the possibility to gain insights to the social system of the implementation actions. The two cornerstones of the WFD are linked when the uncertainties of a proper classification of individual water bodies occur, when the other options in form of empirical modelling, historical data and expert judgement is lacking, and the use of PP becomes important to use the local knowledge, local expertise and non-scientific evidence to properly classify the water body to achieve the goal of GES.

1.2 Aim

The aim of this study is bipartite, from the standpoint of WFD; firstly, the aim is to examine if good ecological status and reference conditions are applicable goals for Swedish surface waters explored from the publics' perception. Secondly, the aim is to determine if the precision of calculated reference conditions could be improved using historically inferred data in comparison with the MAGIC model used today to determine reference conditions.

1.3 Research formulation and research question

The EU-WFD contains of two main cornerstones, Public Participation and Good Ecological Status. Conceivably these two cornerstones have contradicting perceptions of achieving and defining the goals of the WFD for Swedish surface waters. The main research question for this study is: What relevance do reference conditions and good ecological status have to the general public, stakeholders and public participation and does the existing calculated reference conditions of good ecological status correspond to the perception of stakeholders in the catchment?

1.3.1 Sub research questions

- Where does the concept of "undisturbed state" derive from? Why is this term used in a legislative sense and as comprehensively as in the WFD?

- What is the relationship between science and policy and how does it function within WFD? In particular how has the role of science and policy functioned to validate the technical annexes and use of undisturbed state and RC?
- What is the link between defining the undisturbed state and "push" for public participation?

1.4 Study delimitation

Calculation of the RC, a case study for 20 lakes located across Sweden, from Remmarsjön in Västerbottens county to Lillesjö in Skåne county (Fig 4). These 20 lakes are part of a national monitoring program were there has been substantial data monitoring on water chemistry from 1983 to present. Reconstructions of inferred pre-industrial data in the form of TOC_{NIRS} and diatom- pH has been done for all 20 lakes, due to the fact that method reconstructions of TOC_{NIRS} and diatom-pH are time consuming and expensive to perform the reconstruction had to be delimited to these 20 lakes. The 20 lakes in this report will not give a general representation of all Swedish lakes when it comes to calculation of RC, but it will still give an overview of the complexity of determining RC. To answer the second part of the aim, one focus lake (Rotehogstjärnen) has been chosen where interviews with the general public will be conducted. To grasp a deeper understanding of the multiple perceptions, understanding and values of the general public several visits will be conducted to one lake. Within the timeframe of this study, interviews and visits can only be done accurately for Rotehogstjärnen.

1.5 Plan of the thesis

1. Introduction - in this chapter the subject is presented. The aim, research questions as well as the study delimitations is held in this chapter.

2. Theoretical background – in this chapter a background will be given to participation, participation in the WFD and reference conditions

3. Methodology – this chapter holds the methodology for the interviews, case study and calculation of the reference condition.

4. Concepts and polices in EU-WFD – this chapter discusses the origin of the concept of undisturbed state and the role of science and policy in the WFD.

5. Results– This chapter holds interview answers and the results from the calculated reference condition.

6. Analysis – In this chapter the results are discussed and put into the context of the research questions asked in this study.

7. Conclusion – This chapter holds the conclusions drawn from the results and analysis as well as ideas for future research.

2. Theoretical background

2.1 Deliberative democracy and participation

One cornerstone of the WFD is the notion and use of public participation to effectively manage water bodies within the union borders. WFD states that the success of the implementation of the directive relies on active participation from the public (preamble 14 and 46). Leaving the WFD, the understanding of what participation is as a democratic process is as well as the different levels of participation are important aspects that are highlighted in this section. Growing demands for citizens' involvement from a democratic perspective has evolved in recent years where the concept of public and citizen participation has been a focal point (Abelson et al 2003). In short, deliberative democracy is a political ideal that is based on a political autonomy where practical reasoning of citizens should invoke a heightened democratic procedure. It could be seen as a decision making process where internal reflection, considerations and discussions with others are used to choose the appropriate means of action instead of picking them, taking decisions on the basis of reflection (Abelson et al 2003: Goodin & Niemeyer 2003; Bohnman & Rehg 2002; Bohnman 1999). Bohnman and Rehg (2002) define deliberative democracy as "*... the idea that legitimate lawmaking issues from the public deliberation of citizens. As a normative account of legitimacy deliberative democracy evokes ideas of rational legislation, participatory politics and civic self-governance*" (pp. 9). Using the theory of deliberative democracy whereas the concept of citizen participation is a focal point in a decision making process could be used for many different reasons, for example: (I) using the concept of participation as a democratic ideal where legitimacy, transparency and accountability are significant points. (II) Creating support for more pragmatic decisions where support is needed for unpopular decisions. (III) Collaborative problem solving, capacity building and two-way interaction between decision makers and society (Abelson et al 2003).

Arnstien (1969) argues that participation is a term for citizen power, that the people that are excluded from the political and economical processes to be deliberatively included in the decision making of the society. At the same time as participation is a way of citizen power the authors argues that there are many different levels of participation (Fig. 1). In short, Arnstien (1969) argues for eight different levels of participation from "non-participation" to "degrees of citizen power". On the bottom

level, *manipulation* and *therapy* are shown as non-participation, the objectives for this type of participation are for power holders to educate or cure participants. The participants have no voice to participate in the process. At the third and fourth and fifth levels *informing, consultation* and *placation* the participants have a voice that can be heard but without the power to know if their views and deliberations will be taken into consideration by decision makers. Levels six, seven and eight represent *partnership*, *delegated power* and *citizen control*. In the highest level of participation the citizens can engage in negotiations and trade-offs as well as the have possibility to engage in decision-making with traditional power holders (Fig 1).

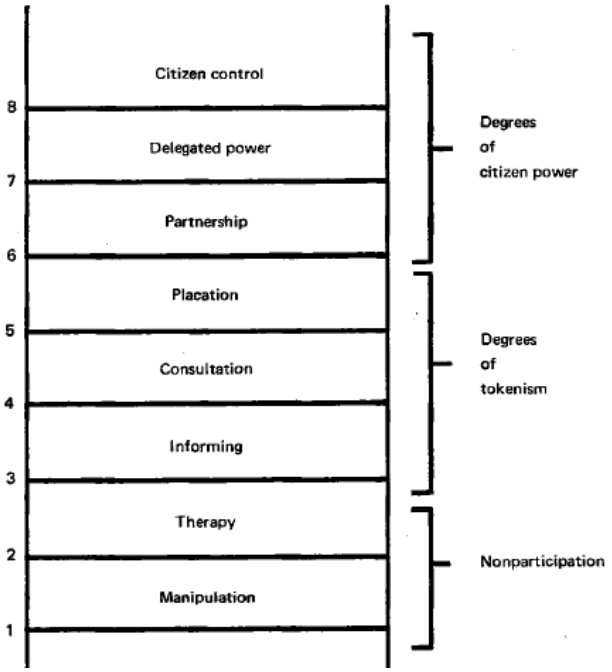


Fig 1. Different levels of participation by Arnstein (1969)

Science plays and has played an important role in decision-making, whereas the science is used to validate polices presented by politicians or structuring science as a scientist to improve their legitimacy or concepts to the political sphere. Two major fields are important to identify for this study when looking at the role of science and decision-making. Political decisions based on technocratic model where "scientification" of specific problem is the main objective, there is a strict separation between science and politics. The role of science is to formulate the new problems and be called upon as advisors to legitimate the problems formulated in political areas. The scientification of a political decision will render the legitimacy problems faced in difficult or unpopular decision to the general public (Weingart 1999). The other major field of science in policy is the democratic or "pragmatism" of science

and decision making where the process of decision-making is based on an integration between science and politics instead of a separation. The available technologies in the form of science, politics are combined with the values, norms and shared interests of the general public (Bohman 1999). This approach would yield in better democracy and transparency of the decision made as well as a greater anchoring is created with the civil society, those that the effect will affect.

2.2 Public participation in WFD

Given the discussion in section 2.1, it is important to understand what the role of PP is in WFD. In the legislative document of the WFD, PP by itself is not a goal, but it is seen as a tool for information sharing to stakeholders and general public before the implementation phase of necessary actions, the actual goal setting and is left to science evidence and political decisions. *"To ensure the participation of the general public including users of water in the establishment and updating of river basin management plans, it is necessary to provide proper information of planned measures and to report on progress with their implementation with a view to the involvement of the general public before final decisions on the necessary measures are adopted"* (WFD 2000/60/EC pp. 23). The WFD does in preamble 14 and 46 state that the very success the WFD relies on the active participation of stakeholders and the general public. There are some aspects of importance that may be seen as major challenges with public participation in WFD; the participation itself is not a goal. So the member states decide the degree of participation and how to legislate it. A complement to the quite vague formulation of PP in the WFD is the Common Implementation Strategy document N. 8 on Public Participation (CIS PP 2003). CIS is designed so that the member states are to implement PP as an integrative and effective part of WFD. CIS PP, which by itself is not a legally binding document gives guidelines on where integration of the general public is needed, in contrast to the main text of WFD, PP should be used in all steps of the management process (Table 1). The main purpose of PP according to CIS PP (2003) is "*…of public participation is to improve decision-making, by ensuring that decisions are soundly based on shared knowledge, experiences and scientific evidence, that decisions are influenced by the views and experience of those affected by them, that innovative and creative options are considered and that new arrangements are workable, and acceptable to the public*" (CIS PP 2003 p. 14). This ambitious purpose for WFD and PP is heavily dependent on the political will of the competent authorities, in particular how to manage public participation throughout national, regional and catchment levels were the actual change will occur and affect (Rault and

Jeffrey 2008; Jonsson 2005). Several studies have displayed the importance and the need for increasing public participation and awareness for the succession of the implementation of such a large project as WFD actually is (Hanchey 1998; Jonsson 2005).

The WFD view on PP differ from what is discussed in the scientific literature, namely to improve decision making process, democratically sound decision making processes, awareness rising, transparency and so on (see for example Priscolli 1998; Jonsson 2005; Hanchey 1998). This is argued due to the fact that the actual deliberation, the processes that could create the above-mentioned advantages is missing in the WFD. What the WFD does imply in its official document that the information should be made available for the general public, stakeholders and interested parties before a final decision is taken on the classification of different water bodies (WFD 2000/60/EC Article 14). It is stated in the WFD (article 14, 2) that member states shall allow six months for comments of the implementation strategies from the general public in order to allow active involvement and consultation. The CIS (2003) for PP have more similarities with the overall literature on PP (Table 1) where integration of the general public and stakeholders should be done in the whole processes of goal setting, implementation etc. but it is important to note that the CIS is not a legally binding document but merely a guideline for the member states to use when implementing the WFD.

Table 1. The Common Implementation Strategy document N. 8 on Public Participation (2003) on where integration is needed

Goal for The Common Implementation Strategy document N. 8	Description of the measures needed
Integration of environmental objectives,	Combining quality, ecological and quantity objectives for protecting highly valuable aquatic ecosystems and ensuring a general good status of other waters;
Integration of all water resources	Combining fresh surface water and groundwater bodies, wetlands, coastal water resources at the river basin scale.
Integration of all water uses, functions and values	Into a common policy framework, i.e. investigating water for the environment, water for health and human consumption, water for economic sectors, transport, leisure, water as a social good
Integration of water legislation into a common and coherent framework.	The requirements of some old water legislation (e.g. the Fish water Directive) have been reformulated in the Water Framework Directive to meet modern ecological thinking. After a transitional period, these old Directives will be repealed. Other pieces of legislation (e.g. the Nitrates Directive and the Urban Wastewater Treatment Directive) must be co-ordinated in river basin management plans where they form the basis of the programmes of measures;
Integration of all significant management and ecological aspects	Relevant to sustainable river basin planning including those which are beyond the scope of the Water Framework Directive such as flood protection and prevention;
Integration of a wide range of measures, including pricing and economic and financial instruments, in a common management approach	For achieving the environmental objectives of the Directive. Programmes of measures are defined in River Basin Management-Plans developed for each river basin district;
Integration of stakeholders and the civil society in decision making	By promoting transparency and information to the public, and by offering an unique opportunity for involving stakeholders in the development of river basin management plans
Integration of different decision-making levels that influence water resources and water status,	The local, regional or national, for an effective management of all waters;
Integration of water management from different Member states	For river basins shared by several countries, existing and/or future Member States of the European Union.

2.3 Determining the reference condition

The RC is and important part of the WFD and is embedded in the concept of good ecological status (GES) as the overall goal (WFD 2000/60/EC). In the overall goal for Swedish environmental objectives for surface waters the concept of undisturbed aquatic ecosystems is embedded, which more or less means that the water quality should be restored to a undisturbed state. This undisturbed state which is a important part of the WFD is determined by a RC. Different questions can be asked on the relevance and use of the concept of overall goal for water management in the WFD could be asked, but the most important for this study are: (I) what constitutes as undisturbed state? (II) How can we define undisturbed state and what is the appropriate target? (III) Who should determine the undisturbed state? (Bishop et al 2009).

A challenge of the WFD is to determine what RC is, different methods have been put forward like modelling the pre-industrial water chemistry, use of historical data or using historical data or expert judgement. Sweden uses RC to classify the undisturbed state for water bodies. These methods of determining the RC have limitations and some of those factors important for this study are: (I) trying to identify sites where no human disturbance has occurred (II) historical measurements can be are usually absent and if there are available the measurements are hard to compare with contemporary measurements due to method uncertainties and change in field praxis and (III) The variability in lakes is hard to foresee because natural variability varies both in space and time at different scales (Fölster et al 2007; Durfour & Piégay 2009; Erlandsson et al 2008; Bennion & Battarbee 2007).

Determining the change from the undisturbed state to contemporary conditions is an important part of GES as well as in the Swedish environmental quality criteria (EQC) for acidification assessment. Significant acidification is defined in EQC as an alteration from reference pH of more than 0,4 units i.e. $\Delta pH=pH_0-pH_t>0,4$ (Fölster et al 2007). Erlandsson et al (2008) has shown that natural variability of lake water pH exceeds the EQC criteria used to determine significant acidification $\Delta pH >0.4$. Sweden uses a geochemical model (MAGIC) for determining the RC for acidification assessment. The MAGIC model has 100 lakes within the national monitoring programs using 1997 contemporary conditions (Moldan et al 2003). The MAGIC model uses the year of 1860 represent pre-industrial lake water chemistry and the model assumes steady state conditions are assumed for Total Organic Carbon (TOC) and Partial Pressure of Carbon Dioxide (pCO_2) within this timeframe. Erlandsson et al (2008) have shown that there is variability in these two parameters and that there is an importance of natural changes in TOC and pCO_2 for determining pH_0 as RC for acidification assessment.

Lake sediments can be used as a historical archive to assess changes in the environment across decal to millennial timescales. Studies have shown that there is correlation between the visible to near infrared spectra (VNIRS) from sediment and lake water TOC concentrations (Rosén 2005; Cunningham et al 2010). This correlation can be used to infer lake water TOC beyond the instrumental records. The different sediment layers can be dated by different techniques, for example Pb-210,

radiocarbon dating and spheroidal carbonaceous particles (SCP) (Wik and Renberg 1996). This type of sediment dating can be used to correlate changes in inferred TOC and known historical changes.

3. Methodology

3.1 Case study

Yin (2003) states that "*a case study is an empirical inquiry that investigates a contemporary phenomenon within its real life context"* (pp.13), he also states that case studies are relevant when the research question is based on "how" and "why" context to cotemporary events. One of the strengths when conducting a case study is the multiple ways of collecting and using data as well as conducting interdisciplinary research of a specific phenomena (Christiansen 2001; Yin 2003). There are some limitations towards the case study methodology one of them is that possibilities to compare with other methodologies. Another source of criticism is that the case studies are not seen as systematic procedures and biased views can affect the results (Yin 2003).

Two different forms of case studies are used in this study, a single case study deepen a understanding for one specific lake and use this case to illustrate the divergent opinions, values that stakeholders might have. The other type of case study is multiple case studies to work as the replication logic (Yin 2003) whereas 20 Swedish lakes are analysed to calculate the RC for these lakes. The two case study methods will be combined to answer the research questions posed for this this study. The single case will be the specific case where a particular problem with the two cornerstones of the WFD will be addressed using interviews to identify perceptions of people living or using Rotehogstjärn. The multiple case studies are for calculating the RC for 20 lakes (Fig 4). The calculations of the RC will be used to determine the effects of using lake specific reconstructions of long time series of data to improve the calculation of the RC. The single case study is combined with the multiple cases in an interdisciplinary matter used in a broader context of the possible contradictions of the WFD.

3.2 Methodology for qualitative interviews

Qualitative research, where interviews are a central part is aimed towards understanding the world from the worldview of the subject. To understand and unfold there experiences, views and perspective on a particular matter. Interviews are could be seen as regular conversations that are adaptable and flexible depending on what characteristics the respondent is as well as what turn the interview answers take. The flexibility of interview methodology can in some cases be an issue of concern, no

blueprint of conducting research interviews are available and the methodology needs to be adapted to the specific situation (Kvale 2009).

Kvale (2009) argues for seven stages of an interview inquiry that needs to be considered to effectively plan and carry out the interviews. Namely, *theme*, *design*, *interview*, *transcribe*, *analyse*, *verify* and *report*. When constructing the theme the aim is to formulate a purpose with the interview. During the design part the whole interview should be taken into consideration, particularly the moral and ethical considerations. After the interview transcription of the oral speech should be done. Analysing the interviews is dependent on the purpose and topic formulated in the first step. Verifying the interview is based on validity, reliability and generalization of the findings of the interview. The last step is the reporting of the findings of the study based on the methods applied in the analysing part of the seven steps.

The interviews in this study were at a semi-structured form, where different themes and planning before the interviews where conducted to have a base of questions related to the research question presented for this study. The questions for the interviews were flexible and depending on the answers and relation of the subject to the lake the questions were changed during the process and additional questions were added. The interviews were booked in advance, the municipality of Tanum gave the contact information on landowners and two visits to the field were done during the spring of 2011. A total of six interviews with seven persons was done during the field visits to the lake, the persons who was interviewed were trough given contact information as well as recommendations from the persons interviewed during the first visit (Table 2). The aim of the interviews for this study is to lift the different perceptions and values stakeholders have in the catchment area to further elaborate on the two cornerstones of the WFD.

Table 2. Overview of the interviewees and some specific information on their relationship towards the lake.

Interview ID:	Sex	Age	Other
Land owner 1 (LO 1)	Male	80	Close relationship towards the lake
Land owner 2 (LO 2)	Female	66	Relationship trough father
Land owner 3 (LO 3)	Male	62	Relationship trough father
Land owner 4 (LO 4)	Male	85	Close relationship towards the lake
Forest Farmer (FF)	Male	-	Bordering land with lake and good local knowledge
Hunter	Male	64	Good local knowledge and involved in hunters association
Governmental worker (GW)	Male	-	Good local knowledge

3.2.1 Transcribing of interviews

The interviews were recorded using an Olympus voice recorder DS-2000, the software used to transcribe data was DSS player software. Transcribing the interviews will give a opportunity to move from somewhat unstructured "messy" form of data to a way of getting an overview of and structure the interviews for further analysis. For this study all interviews held were transcribed (Kvale 2009).

3.2.2 Categorising interviews

The interview transcripts has been analysed using the method of meaning coding. This type of coding means that sections of interview transcripts are coded under a specific theme (Fig 2). The main aim of this type of interview analysis is to break down, examine, compare and categorize data for further comparison of the diverse perceptions of the actual studied area (Burnard 1991; Kvale 2009). The coding of the interview transcripts has been done in the software product Nvivo9.

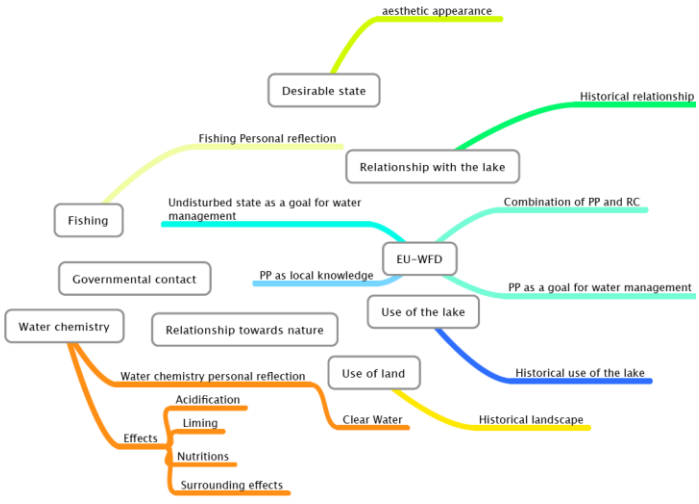


Fig 2. Overview of the coding categories for the interviews.

3.2.3 Analyses of interviews

For this study transcript coding has been done on three different levels, namely *Facts*, *Personal reflection*, and *interpretation of facts and reflections* (Fig 3). The fact levels is based on answers the interviewee gives that are possible to re-examine, for example if the interviewee states the fish population has decreased over a large time period it is possible to examine this statement with historical data.

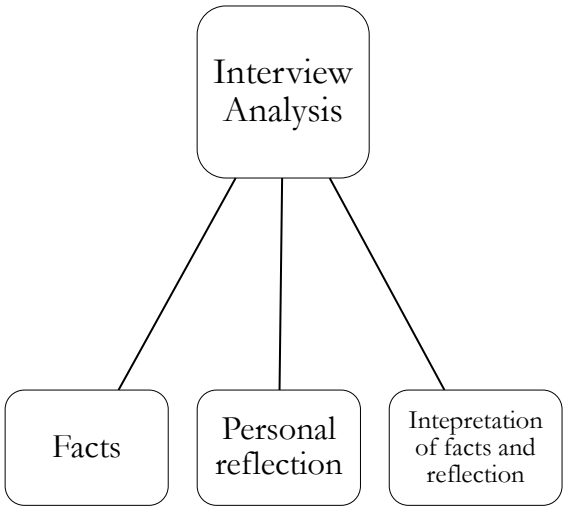


Fig 3. The different levels for coding analysis of the interviews

The second level of the interview analysis is the interviewee's personal reflection of reality. How the interviewee experiences and interprets the specific subject. The third level is to interpret the facts and personal reflections given by the interviewees for possible contradictions and comparison between different stakeholders perceptions of their situation.

3.2.4 Key Questions for interviews

For the semi-structured interviews with the general public the following questions will be foundation for answering the research questions (section 1.3). The emphasis will be on understanding the interviewees perception, understanding and priorities for "their" lake as well as identification of possible problems and causes. The main purpose of these questions are to identify values, and in this study the word values is used as a combining word for multiple perspectives, worldviews and visions for the concept of undisturbed state and RC for Swedish lakes.

- How do you see your lake today?
  - If you identify any problems with the lake, what problem is there?
  - What do you think is the cause of the problems you identified?

- How do you use your lake today?
  - What is your relationship to your lake?
- In your opinion, what is the desirable state for your lake?
  - Why is this state desirable?
  - Do you think that this desirable state is achievable?
- In your opinion, how should this lake be managed?
  - What aspects should be prioritised and what actions should be taken to manage this lake effectively?
- How do you think your lake was before human influence?
  - Do you think that this concept of "undisturbed state" is an appropriate goal?
- What is in your view the natural state for you lake?

The questions above were a form of foundation for the interviews, the questions varied and different leads were followed depending on the discussion between the interviewer and the interviewees. Not all interviewees had great knowledge on specifically Rotehogstjärnen but their knowledge on the change of the landscape and referring back to lakes that they have great knowledge about has been used in this study.

3.2.5 Interview uncertainty

The interviews where held in Swedish and the translation process into English can be a source of error due to the fact that it not possible to give back exactly what was said by the interviewee. Some dialectal words and local expressions cannot be exactly translated into English so the meaning of the statement can be lost from translation into interpretation. Another aspect of importance is that the respondents might say what they think that the interviewee wants to hear, what they know is the correct answer. This was addressed by asking the respondent to further explain their thoughts.

3.2.6 Confidentiality

All interviewees in this report was promised confidentiality and therefore has the interviews been coded with names that represent what relation and occupation the interviewee has towards the lake. By doing so it might improve the quality of interview by making the respondents comfortable when the results are not published with their name.

3.3 Methodology for calculating reference conditions

In this study the RC will be calculated using reconstructed values of pH (diatom-pH) and TOC (NIRS-TOC). The primary results of the RC will include pH_0 and ANC_0 these outputs will be compared with the MAGIC model that is currently used to determine the RC in Swedish lakes. The methodology calculations of RC is quite extensive and therefore a summary of the most important factors will be given in this report and detailed information is referred to a written report (Valinia et al 2011) where the reader can gather more and detailed information like equations, sensitivity runs, TOC_{NIRS} optimisation and much more of calculating the RC for Swedish lakes.

3.3.2 Modern Water Chemistry Data

National monitoring of reference lakes started in 1983, and lake water chemistry has been routinely measured since 1987 (SLU 2010). The parameters that have been sampled include Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, tot P, tot N, pH, Cl^{-}, SO_4, Alk (alkalinity), TOC and Al_{tot} (Table 3). For detailed information of selection, priorities and calculations given to lake water chemistry parameters see Valinia et al 2011.

3.3.3 Partial pressure of carbon dioxide (pCO_2)

The MAGIC model assumes a steady state value for pCO_2 of 0.63matm. In this study pCO_2 has been calculated using contemporary time series of pH, Alk and TOC. The calculated $pCO_{2(calc)}$ is a combination of ion balance and tri-protic model for organic acids given by Köhler et al (2000). For detailed information on equations, sensitivity parameters and analysis done see Valinia et al 2011.

3.3.4 Hydrogeochemical model MAGIC

MAGIC is a lumped-parameter model for estimations of long-term effects of acid depositions on water chemistry. MAGIC predicts annual average concentrations of major ions in the lake, in this case on an annual basis (Cosby & Wright 1998; Cosby et al 1985). In Sweden, MAGIC model input is from contemporary data set to 1997 and the MAGIC simulations estimate the pre-industrial condition (RC) that is referred to as 1860 (Moldan et al 2003; Cosby et al 2001). The output of the MAGIC model that is used in this study is pH, ANC and SO_4 (Table 3). In this study the MAGIC model is primarily used to compare diatom and NIRS reconstructed values of pH and ANC with the model used today for determining RC in Swedish lakes.

Lake	X-SMHI	Y-SMHI	Acidification status
Remmarsjön	708619	162132	**N**
Tväringen	690345	149315	**N**
Sangen	686849	145214	**N**
Hällsjön	667151	149602	**N**
Siggeforasjön	665175	157559	**A**
Tärnan	660749	161885	**N**
Överudssjön	659105	133982	**N**
Djupa Holmsjön	656263	156963	**A**
Älgsjön	655275	153234	**A**
Rotehogstjärnen	**652902**	**125783**	**A**
Gryten	652840	151589	**N**
Grissjön	651578	146163	**A**
Fjärasjö	638725	146677	**A**
Lilla Öresjön	638665	129243	**A**
Skärsjön	637260	128728	**A**
Harasjön	632231	136476	**A**
Svartesjön	630558	134327	**A**
Tomeshultagölen	629026	147562	**A**
Örsjön	624038	143063	**A**
Lillesjö	623161	142148	**A**

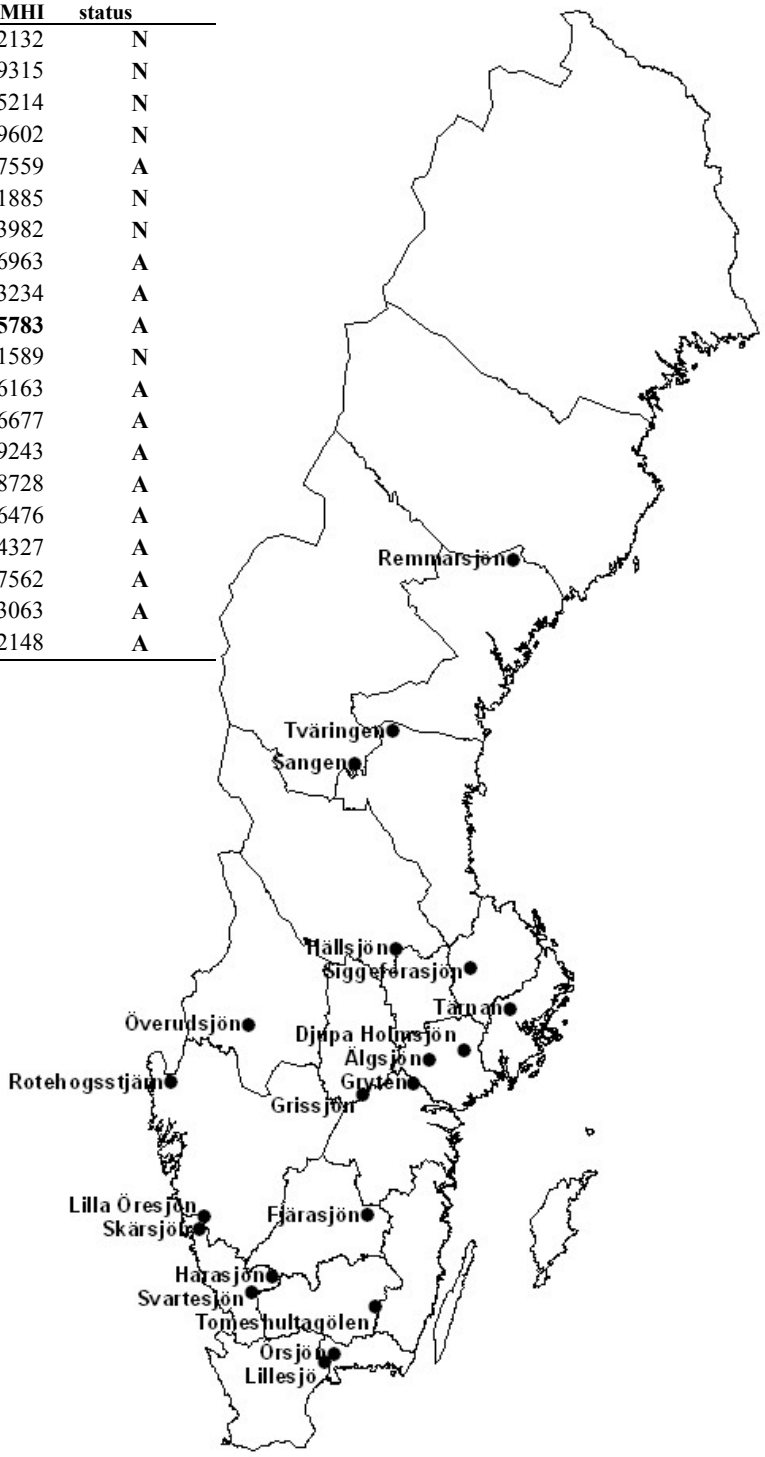


Fig 4. Overview of the lakes analysed in this report and their acidification status according to MAGIC pH. N; non-acidified and A; acidified.

3.3.5 Paleolimnological reconstruction of lake water pH

Diatom community composition has been used to infer lake water pH in Swedish lakes. The pre-industrial pH value has been estimated by using a calibration model that can translate the diatom community preserved in sediment to lake water pH (Guhrén et al 2003). For detailed information on the depth, method, calibration models and uncertainty intervals see Valinia et al 2011 (Table 3).

3.3.6 Lake specific transformation of MAGIC ANC to pH

ANC is one of the primary results of the MAGIC model, a conversion of ANC to pH is done by using the concept of electro neutrality in combination of estimation of organic acids and buffering by the bicarbonate system to calculate the pre-industrial pH (Erlandsson et al 2008). As the MAGIC model assumes steady state conditions of TOC and pCO_2, this study uses a calculated pCO_2 and TOC_{NIRS} and $ANC_{0,\ MAGIC}$ to compare the pre-industrial given by MAGIC with diatom-pH. For detailed information of calculations of ANC see Valinia et al 2011 and for further details on the conversion from ANC to pH see Erlandsson et al 2008.

Table 3. Summary of pH used in this study, MAGIC pH, datiom-pH represent pre-industrial time (1860) and pH_t is contemporary pH (year median 2005).

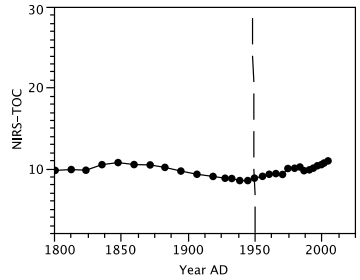
Sjönamn	X-SMHI	Y-SMHI	MAGIC pH_0	Diatom-pH_0	pH_t	MAGIC $pH_{0,\ NIRS}$
Remmarsjön	708619	162132	6.6	6,3	6,2	6.4
Tväringen	690345	149315	6.8	6,4	6,7	6.7
Sangen	686849	145214	6.8	6,7	6,9	6.8
Hällsjön	667151	149602	6,6	6,1	6,2	6.4
Siggeforasjön	665171	157559	7.3	6,7	6,7	-
Tärnan	660749	161885	-	7,1	8.0	-
Överudssjön	659105	133982	7	6,9	6,9	6.4
Djupa Holmsjön	656263	156963	6.5	6,4	6,0	6.8
Älgsjön	655275	153234	7,2	6,5	6,5	-
Rotehogstjärn	**652902**	**125783**	**6.5**	**5,8**	**5,2**	**6.3**
Gryten	652840	151589	7.2	6,7	6,9	6.9
Grissjön	651578	146163	6.1	5,9	5,7	5.9
Fjärasjö	638725	146677	7.1	6,7	6,9	7.1
Lilla Öresjön	638665	129243	6.8	6,1	5,4	6.9
Skärsjön	637260	128728	7,4	6,9	5,4	-
Harasjön	632231	136476	6.3	6	5,1	5.7
Svartesjön	630558	134327	6,3	5,9	4,7	6.3
Tomeshultagölen	629026	147562	5.9	6,1	5,4	5.4
Örsjön	624038	143063	6.7	6,6	6,1	6.5
Lillesjö	623161	142148	6.7	5,7	5,0	6.8

3.3.7 Total organic carbon inferred from Near-infrared spectrometry (NIRS-TOC)

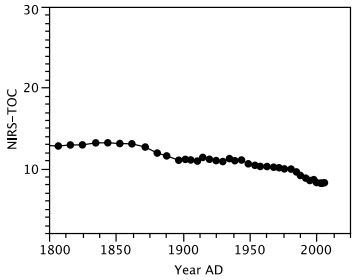
NIRS exploits that the sediment can be used as an historical archive for TOC concentrations (Fig 5). The organic portion of the sediment has a complex structure and a distinctive NIRS signature that can be summarized using multivariate statistics (Rosén 2005; Cunningham et al 2010). By using PLS regression the NIRS spectra of surface sediment and contemporary lake water TOC can be summarized into a few orthogonal components (Wold et al 1998). The sediment has been dated with Pb-210 using gamma spectrometry (Appleby 2001). In this study, TOC_{NIRS} is used to calculate pH_0 and ANC_0 to compare with the MAGIC model (Table 4). For detailed information on NIRS calculations and optimisation of calibration models see Valinia et al 2011.

Table 4. Summary of TOC values, $TOC_{0,NIRS}$ reconstructions represent pre-industrial TOC values, $TOC_{t,NIRS}$ contemporary reconstructed values (1990-2005) and TOC_t contemporary TOC values (1990-2005).

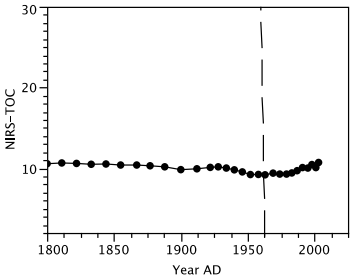
Name of lake	$TOC_{0\ NIRS}$	TOC_t	$TOC_{t\ NIRS}$
Remmarsjön	10.8	9.5	8.3
Tväringen	8.9	7.6	9.0
Sangen	6.7	6.9	5.3
Hällsjön	11.0	8.0	10.6
Siggeforasjön	14.9	14.9	11
Tärnan	8.3	8.5	7.2
Överudsjön	6.7	9.6	5.5
Djupa Holmsjön	10.5	12.4	10.6
Älgsjön	20.7	17.8	16.2
Rotehogstjärnen	**12.5**	**11.7**	**10.3**
Gryten	18.1	16.6	11.1
Grissjön	10.4	9.9	10.4
Fjärasjön	12.9	9.2	8.2
Lilla Öresjön	10.9	5.3	3.6
Skärsjön	4.0	1.9	2.9
Harasjön	22.1	13.9	13.9
Svartesjön	11.5	15.8	9.7
Tomeshultagölen	28.0	18.8	16.6
Örsjön	7.6	7.3	8.5
Lillesjö	7.0	9.5	3.6



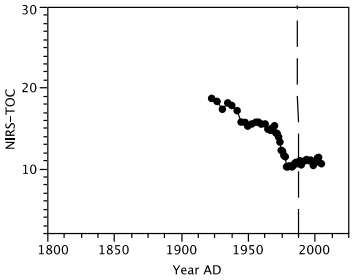
Plot for Lake=Djupa Holmsjön



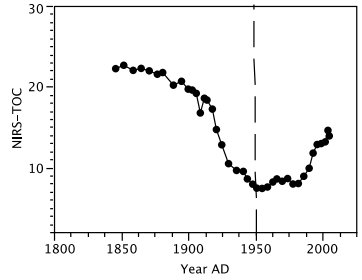
Plot for Lake=Fjärasjön



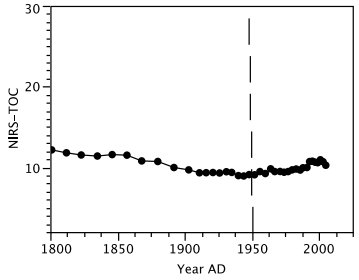
Plot for Lake=Grissjön



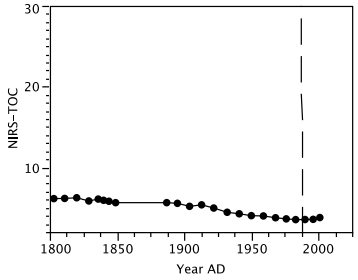
Plot for Lake=Gryten



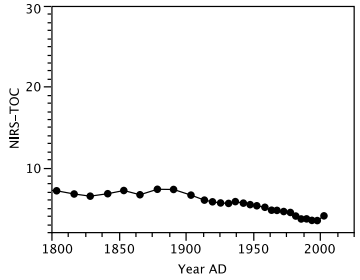
Plot for Lake=Harasjön



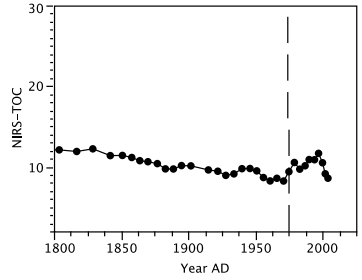
Plot for Lake=Hällsjön



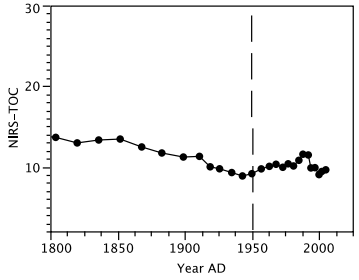
Plot for Lake=Lilla Öresjön



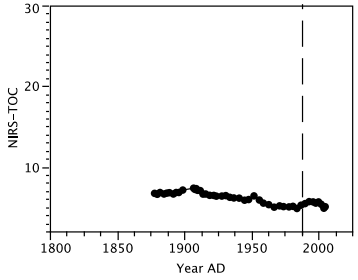
Plot for Lake=Lillesjö



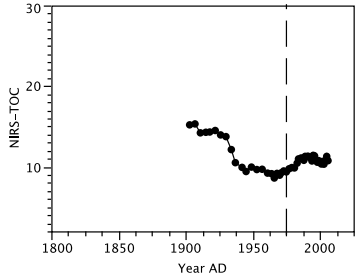
Plot for Lake=Remmarsjön



Plot for Lake=Rotehogsstjärn



Plot for Lake=Sangen



Plot for Lake=Siggeforasjön

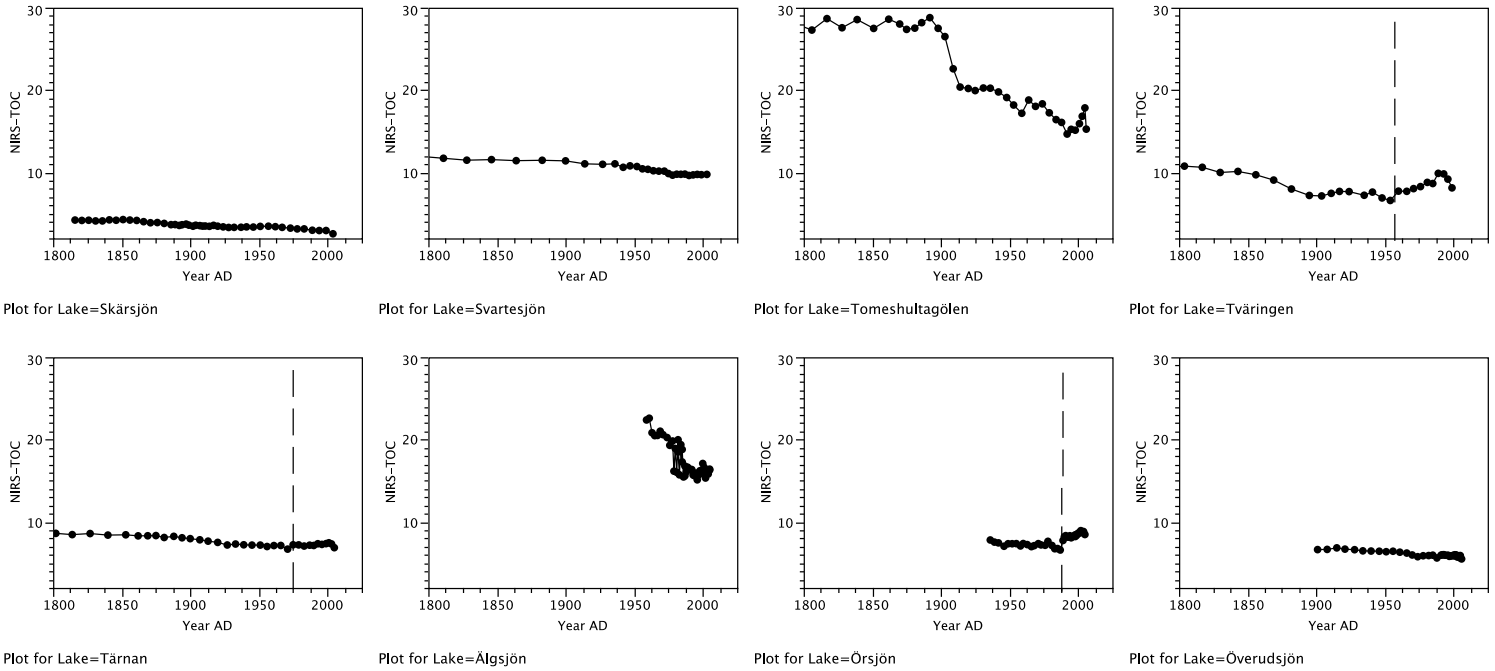


Figure 5. Lake water TOC inferred from near-infrared spectroscopy. Long-term time series of $TOC_{NIRS-Alt}$ for all lakes analysed in this report. The graphs show the time scale 1800 to 2020 AD. TOC expressed in mg/l.

3.3.8 Acid neutralizing capacity (ANC)

Calculating ANC_0 can be a complement to pH in determining RC and the MAGIC model has ANC as one of its primary results. ANC is the difference between base cations and strong acid anions. ANC functions as the lakes buffer system towards acidification. In this study pre-industrial reconstruction of diatom-pH, TOC and pCO_2 has been used to determine the RC and comparing it with the MAGIC model. For further information on calculations, equations and data used see Valinia et al 2011.

Table 4. Overview of calculated ANC with different TOC and diatom-pH reconstructions. The ANC data is presented as µeq/l.

Name of lake	$ANC_{0,\ MAGIC}$	$ANC_{0\ diatom\text{-}NIRS}$	$ANC_{0\ diatom\text{-}TOC}$
Remmarsjön	158	140	129
Tväringen	186	139	129
Sangen	187	155	159
Hällsjön	135	108	86
Siggeforasjön	354	284	284
Tärnan		494	0
Överudsjön	311	348	375
Djupa Holmsjön	151	152	167
Älgsjön	499	309	285
Rotehogstjärn	**21**	**108**	**103**
Gryten	466	332	318
Grissjön	98	94	91
Fjärasjön	378	217	184
Lilla Öresjön	165	100	57
Skärsjön	108	95	77
Harasjön	149	199	139
Svartesjön	163	117	150
Tomeshultagölen	174	265	194
Örsjön	149	157	155
Lillesjö	117	52	18

3.3.9 Statistical methods

Change over time was quantified by Theils-slope and the statistical significance of the slopes was tested by Mann-Kendall approach (Helsel and Hirsch 1992). A level of significance ($p<0,05$) was accepted when determining long-term trends of TOC. Linear regression was performed to determine strength and variation in pH and ANC for RC.

4. Concept and Polices in EU-WFD

4.1 Origins of the words undisturbed state and good ecological status

To fully grasp the complication of using the concept of "undisturbed state" a deeper understanding of where the word/concept origins from is needed. No "definitive" answer can be given but there are clear indications going back to Swedish Environmental Quality Criteria (EQC) for surface waters developed by Swedish environmental protection agency (SEPA) from 1969 *"... and additionally a classification system indicating the degree to which the water deviates from the natural conditions*" (SEPA 1969). Sweden was together with the Nordic countries leading to develop indicators for assessment criteria for surface waters in Europe (pers. com. Johansson 2011). The further development of the EQC continued and another set of EQC was produced in 1990 by SEPA for surface waters. The 1990 EQC follow the chain of determining the "natural conditions" but use the word undisturbed state instead "*with regards to reference conditions, the state that would have prevailed in an unaffected, natural landscape, essentially only affected by natural erosion and with natural addition from the atmosphere*" (SEPA 1990 p.7). The report also states that reference areas without disturbance and/or historical data can establish the undisturbed conditions (SEPA 1990). A more comprehensive study of the EQC was released in 1999 and implemented for Sweden´s surface waters but also for other fields like agriculture, groundwater etc. The 1999 EQC puts a lot of emphasis on comparison value (jämförvärde) " *compare value of a parameter represents the ideal natural state without human influence"* (SEPA 1999 p.13). Further evolving the concept of comparison value the document states to determine the amount of human influence is calculated by a deviation between the comparison value and the measured value i.e. Deviation=Measured value/Comparison value.

Comparing the history and development of Swedish EQC a clear similarity to WFD is recognisable. WFD uses concepts of undisturbed state and RC very frequently in the official text, WFD defines RC as "*… no, or only very minor, anthropogenic alterations to the values of the physic-chemical and hydromorpholohical quality elements for the surface water body type from those normally associated with that type under undisturbed conditions*" (Annex V, 1.2). The 1999 EQC also states that there is a clear resemblance between Swedish EQC and WFD. Another aspect that shows great resemblance between EQC and WFD is the classification of different parameters. In the 1999 Swedish EQC (SEPA 1999) a five-

degree scale is used to classify anthropogenic load on the comparison value (pristine conditions), 1, no deviation from comparison value and 5, extreme deviation from comparison value. The WFD uses a classification system very similar to Swedish EQC, High ecological status, "*The values of the physico-chemical elements correspond totally or nearly totally to undisturbed conditions*" and moderate status "*The values of the biological quality elements for the surface water body type deviate moderately from those normally associated with the surface water body type under undisturbed conditions. The values show moderate signs of distortion resulting from human activity*" (Annex V, 1,15). Analysing the resemblance between the Swedish EQC and WFD it could be argued that Sweden and the Nordic countries early development of EQC is the foundation of the concepts of RC and undisturbed state in WFD. This argument appears even stronger when looking at the initiating steps and the development of WFD. It can be identified that Sweden was one of the countries that was very involved and active in the classification of environmental indicators and technical annexes (Lagacé et al 2008; pers. com. Kjell Johansson 2011).

4.2 The role Science and Policy in the WFD

The WFD as a whole is a very ambitious and important piece of legislation not only for protection of waters but also the change in water management traditions, placing ecological stability in focus (Futter et al 2011). One important aspect is the role of science in policy and decision-making of WFD. The policy behind a unique legislation as the WFD is a complex and intangible system, WFD uses the concept of evidence-based policymaking when designing the directive. Decisions and assertions are justified by scientific evidence and understanding and it is perceived that this will lead to effective legislation and decisions appropriated on facts. It is also supposed that decision-making based on scientific evidence will lead to, and derives from transparency and rational process that would eliminate biases (Ballantine 2005). The decision- making based on science has its limitations and it is important to highlight these limitations. Not only are there pure knowledge limitations but also structural limitations for implementation using evidence-based decision-making (Allio et al 2006). As the WFD uses trans-disciplinary approach i.e. technical, natural, social objects expressed in knowledge and norms in water management, the validation of these aspects come from science but also having the understanding of "non-scientific" factors of managing water according to the WFD (Steyaert and Ollivier 2007; Allio et al 2006). There are some important aspects in the design and policy behind the WFD

that needs to be highlighted. The scientific and technical annexes (II and V) display the normative definitions for assessment but leave out definitions on practical objectives and on how to carry out the technical definitions to guidelines (for example REFCOND 2003). The definitions of ecological parameters (technical annexes) are rather narrow and show what parameters that should be considered to determine "GES". In contradiction to these narrow definitions, a broad definition of the governance structures and responsibilities of implementation is used in WFD. This broad definition could give room for interpretation of who should be responsible for the trans-disciplinary approach of the competent authorities whether local or national, the open-ended approach for governance structures and the overall goal of the WFD "GES" will in many situations depend on political will and scientific work (Lantz and Scheuer 2001; Steyaert and Ollivier 2007; Moss 2008). It could be argued that the greatest criticism towards WFD is the gap between science and policy, in particular when looking at the scientific capacity to determine RC for implementation of WFD (Lagacè 2008; Lantz and Scheuer 2001). The scientific input from experts to WFD has been discussed in the scientific community and it has been argued that the policymakers had difficulties grasping the scientific and technical input of the WFD, not really being able to grasp the practical aspects RC and GES. When drafting the framework the technical experts expressed worries that the use of GES was ahead of science, in particular using biological parameters as key indicators. The scientific knowledge that was available to perform this task was not sufficiently evolved for understanding of the cause and effects of its implementation (Lagacè 2008). The Royal Swedish Academy of Agriculture and Forestry (2006) concluded in a workshop between member states that the implementation of WFD is dependent on political processes rather then scientific evidence *"Obviously, defining the reference conditions is a very important step, from scientific as well as a political point of view. From a scientific point of view the reference conditions seems to be like the Holy Grail: you can search for it forever but you will never find it. Politically, on the other hand, it seems like the reference conditions and good ecological status are more like rubber bands that can be extended as much or as little as you like*" (KSLAT 2006 p. 40). The benchmark between science and policy in the WFD is on two different levels, whereas the science is still working on determining and validating the RC and policy is using this uncertainty to be "flexible" on the implementation of WFD in respective country.

5. Results

This section of the thesis starts with the results from the interviews with the local people and governmental worker in Rotehogstjärn. The respondents are referred to as table 2, landowners 1-4 are stated as LO 1-4, governmental worker as GW, ecological forest farmer as FF and hunter as hunter. The interview coding (Fig. 2) functions as a overall structure for the interview results. In the latter part of the results section, calculations of the RC will be presented to illustrate different methods as well as the uncertainties in calculating RC.

5.1 How does the public perceive the goal of undisturbed state?

Given the great importance of the overall goal of GES for water management in the WFD, the concept of undisturbed state and RC will follow the same great deal of acknowledgement when implementing this strategy. The role and concept of undisturbed state has followed Swedish water legislation for around half a century, in different forms and formulations (today with a RC). It is important, for this study to understand if the people, stakeholders and the general public perceive the concept of undisturbed state as an appropriate and applicable target for water management in Sweden. The overall impression for the undisturbed state by the interviewees, LO 2 states that the goal of undisturbed state is a very good idea for water management. This for one of the landowner is because people "*should be able to enjoy the lake and swimming, and you don't want it to be polluted or so*" (LO 2). LO 1 is not as sure as LO 2 to if undisturbed state is an appropriate target for water management and LO 3 reflects back on the fish directives in particular on cod ban in the Baltic Sea "*Yes I think so, with regards to the constant cod ban in the Baltic Sea and that has of course declined the possibility to fish there, then maybe there is a possibility to go back in time with the water and fish as it was before, it's a good goal*" (LO 3). LO 3 sees undisturbed state as the goal as the fish regulations in the Baltic Sea, whereas the concept of limiting the fish quota would bring the water chemistry and fish population back to as it was before. The perception of the FF follows the same chain of thoughts as the landowners, the FF sees the problem with constructing houses lakeside along the cost as a problem and the concept of undisturbed state would make it harder to build in the archipelago. " *As far as possible, of course its great, if the regulations tweak and it starts to become easy to construct, there is a lot of discussions on that around the cost, it will be bad and ruin the essence of the coast. Its probably good*

that is kept as undisturbed as possible" (FF). In contrast to the other landowners, the farmer sees that it might be difficult to achieve the undisturbed state and expresses in the value of as far as it possible to achieve the target for undisturbed state. The hunters' perception on the concept of undisturbed state is different from what the other interviewees have stated. The hunter sees the concept of undisturbed state as an unrealistic goal for water management, mainly due to the fact that having unrealistic goals will not give the sense of satisfaction with respect to that we will never reach that state. The hunter argues that "*No, I am confident that having utopian goals is not good because then you never get the satisfaction of the fact that you are actually getting somewhere, so you'll need to be a realist in the whole. The earth will never be what is was, even with the fact that we shouldn't be here, the world does spin around. But certainly its not easy, but really, its easy, it's a development, but if I like it or not it is what it is, so you may well have just a bit realistic goals*" (Hunter). For the hunter feeling the sense of accomplishment of an actual improvement of the water quality is of greater importance then reaching the undisturbed state. The GW discusses that the concept of undisturbed started for them in the 1990s with directions from central level discussing nutrients in streams. The results gave a very low phosphorus (P) level in the streams and it was that level the streams should be at "*we wondered my goodness what is this based on, we found that it was some kind of software or calculations where someone had been sitting and fiddling with and came up with this extremely low P value. When we started to question this at a local level against the administrators at county level, we noticed that the administrators at the county board felt that it was questionable to talk about an undisturbed state, the undisturbed state does not exist*" (GW). The GW states that the concept of undisturbed state has been discussed during a long time and it's not only the WFD that has used this concept, he also feels that the concept is questionable for local administrators, quite easily because he does not feel that the undisturbed state exist.

5.1.1 Can the goal of undisturbed state be reached? - From the public view

For most of the interviews done in this study the question on can we reach the undisturbed state was asked as a complement to what their view on the goal of undisturbed state was. The FF discusses that it might be difficult to reach the undisturbed state for water bodies but he also states that it might be possible in tarns. "*No, I doubt it, in tarns it might be possible but otherwise they have changed it with*

dams and power plants so I don't think that we can get back to the natural state. I don't think that tarns have been changed that much, something very special needs to happen to lower, drain or change tarns maybe if they need to get hold of more land. The changes in the forests around tarns have mostly been fertilizers to get more biomass to use for something" (FF). The FF sees the surrounding effects, in particular the role of landscape alteration as a key point for the difficulties of reaching the goal of undisturbed state. LO 3 exemplify the reaching the undisturbed state by "*to use but not abuse the lake, where that lines is drawn is individual*" (LO 3). The concept of being a part of nature without abuse the privilege is seen as a point to reach this undisturbed state. LO 2 follow the same idea whereas she discusses that humans have affected and are a part of nature "*of course the human impact and we live in a changing world and humans need to take place without destroying nature*" (LO 2). LO 2 see humans as a part of nature as well as nature changes naturally, humans should interact with nature without destroying it might yield in reaching the undisturbed state. The hunter argues that we will never reach the goal of undisturbed state "*No, I am convinced that we will never reach that stage*" (Hunter). The GW feels the complications of undisturbed state from a perspective, going back to late 19th century is still a landscape that has been heavily affected by humans "*It is ridiculous, because, what is a undisturbed landscape? We have to go back to stone age, when we were collectors and hunters, then we can speak about the natural landscape. When once we settled and began farming the land as grazing and then with agriculture, we have a influence from the people*" (GW). The GW see the issue of how different our landscape is today compared with what he sees as undisturbed state, where he argues that late 19th century the landscape around the lake had been changed very much, the impact on alternation in the landscapes was substantial. A general trend of the perceptions of the interviewees was that it would be difficult reach the goal of undisturbed state. The alterations in land and the landscape were seen to be a factor that was expressed by the interviewees and the natural variability cannot be left out.

5.1.2 What is important for you? A desirable state from the publics view

The discussions with the interviewees touched on what they believed is important with respect to what their desirable state would be like. LO 1 discusses that the desirable state is for him the lake´s condition when he was young. "*It is the recollection I have of when I was around 15-20 years old, you could stand on land*

and see the pike far out in the lake, I cannot do that today, something has happened in the lake and it would be very nice if it could return as it was before, that would be my pipe-dream" (LO 1). LO 1 desirable state is related to the water chemistry in the lake, whereas the clear water he experienced in the lake when he was young is what he would like to go back to. LO 2 states that the desirable state for here is to keep the lake as it is today, that the fish and plants that have been her over a long period of time stay in the area without being polluted. The views of LO 2 follow her view on RC as well, that nature and humans would live in harmony. The hunter feels that the undisturbed state is going back in time around 1930s before the large emissions started and affected the water bodies. The hunter exemplifies this by "*I grew up in Tanumshede and my uncles had a farm a few minutes from here, I remember that we went fishing trout in a small river that eventually ran out in the sea, we where angling from the shore and caught salmon. They constructed a waste disposal plant near by and just a few years later the creek was dead, leachate and shit just ran straight out in the creek, its sad*" (Hunter). The FF has his values the desirable state in a similar way as the other interviewees, "*to function as it should do, as untouched as possible*" (FF). LO 4 sees the desirable state from a different perspective then the other interviewees, whereas he states that the desirable state would be when the lake was used by the people in the community, farming activities was present and people actually used the lake in a constructive way. He sees the problem of the lake not be used and the local collaboration and fellowship has disappeared. The discussions on the desirable state between the interviewees follow the same trend, that the water should be healthy and that pollution, waste would not affect the lakes.

5.1.3 Historical changes in water chemistry from the publics perception

During the interviews, questions on what have they seen as any changes in the quality of the water was asked, the interviewees identified some factors that were common between them and acidification was an aspect that almost all interviewees brought up as a factor of importance for the water chemistry. LO 1 states that the deterioration of the water chemistry is due to atmospheric deposition, "*there are no buildings above the lake that leach sewage to the lake, its my understanding that it must be from the air, deposition. Acidification is in my opinion the cause*" (LO 1). The view of LO 1 is that the physical landscape by itself do not affect the water chemistry, the effects of the deterioration is based on atmospheric deposition. The FF discusses the changes in

water chemistry by relating it to the fish population in the lake " *My uncle, who had this place before me, told me that there was a lot and large perch in the lake and then they disappeared, quite simply it got acidified so it was not any food available to them and they where not larger then 5-6 cm. Today it is different, there are large perch down there and the change went fast, it corrected itself very quickly*" (FF). The FF sees acidification as the main cause of water chemistry worsening and from his perspective that would have affected the fish population negatively. Asking the hunter the same question, acidification is brought up once again, "*the first thing I can think of is the acidity problems, I can not remember if it was the 70s or 80 but is was a doomsday feeling here, I feel for nature, and this made me a little sick. Life moved on and it has gotten a lot better, we have managed to get grip or large emissions, at least the acidifying emissions and that's positive*" (Hunter). The GW worker discusses that the acidification has been a problem for both the government and the local people and acidification phenomena has been acknowledged and experienced from both the community and from central level. " *I mean, so much misery that was from the 60s when acidification was acknowledged the lakes have changed character to the better*" (GW). A common aspect between the interviewees is that the acidification has been acknowledged for a long time period and the effects have been experienced in the community. Another common aspect is that they have seen and experienced the recovery and improvement from the acidification problems in the 70s and 80s.

Another aspect of importance asked specifically on Rotehogstjärn is if they have experienced any differences in the colour of the water or/and turbidity for a long period of time. Two of the four LO had experienced a shift in turbidity (LO 1 and LO 4) while LO 2 and LO 3 have not identified any differences. A possible explanation might be that LO 1 and LO 4 have lived next to the lake their entire life while LO 2 and LO 3 have the relationship through their father and have not been around the lake as much as the other two LO. LO 1 states that the water was much clearer when he was young, he said that it was possible to see the fish swimming around in the lake and that is not possible today. He exemplifies how clear the water was "*I am going to tell you something that should not be told, just to make the point of how clear the lake was in the past. When I was growing up I had an uncle who fished and hunted a lot, he went down to the lake one day and saw a large pike lying in the water, do you now what he did, he had a shotgun and fired towards the pike and the pike floated up of*

course. What I want to point out is that the visibility in the lake was much better in the past, in parentheses you are not allowed to do like my uncle did" (LO 1). LO 4 sees for the same development of the turbidity of the water as LO 1 does. "*The water was clearer when I was young, when we swam small fish came around to try to find food so you could see the fish in the lake but that's not possible today*" (LO 4). The LO that have long experience of being near the lake see a clear historical deterioration from their view in lake water chemistry.

5.1.4 Experienced historical changes in fish population

Information from the interviewees on how the use their lake today as well as how they have used it historically, fishing was a common thread for most interviews. LO 1-4 have all stated that the activity around the lake has been reduced in comparison to when they where young and that there have been more fish in the lake when the activity has been reduced. LO 4 states that it has been an increase in the fish population the last 10-15 years, in particular that the increase of spawns. "*I sat on the hill watching over the lake and saw a lot of small fish, that has not happened in a long time, the small fish was gone before but now it has returned*" (LO 4). From the perception of the LO 4 there has been an increase of fish and he believes that the increase of fish could be due to decrease of activity in the lake.

5.1.5 Public participation in the WFD, publics' (my) role is?

Discussing the role of PP with the GW some factors of importance came up, one of the main aspects discussed GW is that is difficult for them to work with PP mainly because it is difficult to communicate the classifications and that the concept is abstract "*the downside with the directive is, after all, that it is abstract and has been forced and rushed as usual with EU directives. PP by itself is a cute thought, I think, and locally we have tried doing to as much as we can, inviting different actors to meetings and so*" (GW). The GW continues with the discussion that it is difficult for the locals to actually understand what the government is working on both from a pure knowledge perspective whereas the classifications of the water bodies are to abstract to understand as well as the basic values between locals and governmental workers can differ and they do not understand each other. He also states that the classifications became a foundation for discussion between the governmental employees and the locals, which is obviously a good thing he argues. He states that it is difficult for the person who did the classifications to explain on what basis the lake has received that

particular status, partly due to the knowledge gap between them as well as the classifications are so abstract that the GW themselves have difficulties understand. "*It becomes such a large knowledge gap, the WFD by itself and all the parameters that should be explained are very abstract. It becomes so abstract that us that work at an agency hardly have a grip of everything*" (GW). Asking the GW if the concept of undisturbed state the raise the awareness of the locals and trying to improve the understanding for the classifications of a specific lake, the GW did not see that connection "*I think that's nonsense, it does not work against the public. It becomes once again a value base discussion on what an unaffected landscape is, whether it is this, that or the iron age, äh [sic], that does not work. It is just to accept that we humans are in and impacting the quality and what quality we should have based on mg/l or what species we should have is something different, it can be difficult for the general public here as well, I agree on that. To speak about a RC in 1860´s, that type of landscape or speak about untouched or undisturbed does not work you cannot exclude humans. That becomes completely wrong, I think*" (GW). Asking the hunter what he believes would be a good way gathering people and using their knowledge, he exemplifies this with water council Enningdalsälven as well as a small fishing conservation group. The states that, sure, people are interested that someone takes care of our small lakes and fishes, but it always difficult to get people to engaged in the meetings and so on. But some people really like participating and being engaged and some will listen with interest to someone who has been there and explained what came up. "*It is a strive to get people who live hear involved, I cannot say if has been successful or not. We have a small fishing association in these small lakes around and we have a meeting next week and I am on the board there. People are interested because someone has taken the initiative and cares about our small lakes, which is good, but there are not many who want to dawdle off to the meetings but there some act like that and that will always be the case. The others listen to someone who has been there and taken part in the discussions*" (Hunter).

This concludes the findings presented from the conversations with stakeholders in the field, the findings will be further discussed in the analysis part of this thesis.

5.2 Determining reference conditions

The RC is a very important part of the WFD, as discussed in the introduction of this study, the calculation of the RC is a difficult assignment and the methods do have

uncertainties in them. In the WFD the link between RC and PP are when the uncertainties are large and this section shows different methods of determining the RC. It is important for this study to see how different methods correspond to each other when setting credible targets for Swedish surface waters.

5.2.1 Determining Reference Conditions with ANC_0

ANC_0 was calculated using a trip-tonic model for organic acids and a chemical equilibrium calculation (section XX). The data used for the calculations is diatom-pH and TOC. Two different types of TOC were used in the calculation, this to determine the effects of TOC on RC. TOC_t assuming constant TOC levels (mean lake value 1990-2005) similar condition as in the MAGIC model ($ANC_{0,diatom\text{-}TOC}$). The other method is to use long- term time series of TOC_{NIRS} (Fig. 6) assuming a change in TOC ($ANC_{0,\ diatom\text{-}NIRS}$). These calculations of ANC will be compared with ($ANC_{0,\ MAGIC}$) to determine if the calculations using long time series of TOC_{NIRS} can give different result then $ANC_{0,\ MAGIC}$ and what effects can be expected for management of Swedish surface waters.

$ANC_{0,diatom\text{-}TOC}$ shows when comparing with $ANC_{0,MAGIC}$ an R^2 0,63 (Fig 6). An uncertainty factor of ± 0.3 for diatom pH was taken into account and is shown as error bars (Birks et al 1990). The regression shows that 13 of 19 lakes of $ANC_{0,\ MAGIC}$ is within the uncertainty interval. There is a mean difference between $ANC_{0,\ MAGIC}$ and $ANC_{0,diatom\text{-}}$ TOC of -45 µeq/l with lakes in the uncertainty interval. The six lakes outside the uncertainty interval show a mean difference between $ANC_{0,\ MAGIC}$ and $ANC_{0,diatom\text{-}TOC}$ of -108 µeq/l.

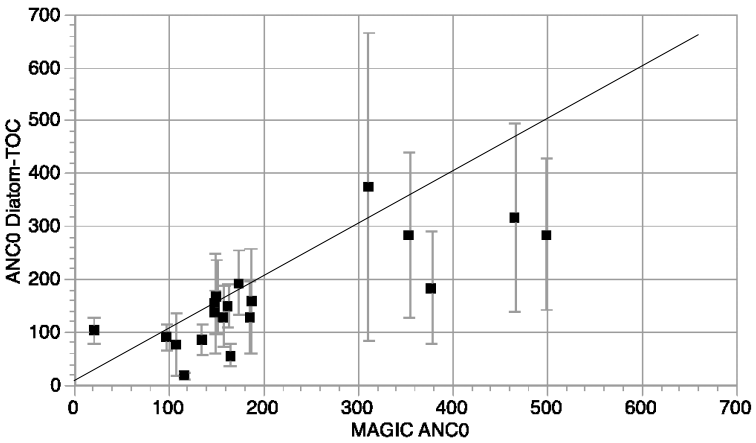


Figure 6. ANC calculated with $ANC_{0,\ diatom\ -TOC}$ plotted against $ANC_{0\text{-}MAGIC}$, the error bars show the diatom-pH uncertainty interval of ±0.3 pH units. The 1:1 line is shown in the plot. ANC is expressed in µeq/l.

Different results are shown when comparing $ANC_{0, MAGIC}$ with $ANC_{0, diatom\text{-}NIRS}$ (Fig 7). A linear regression shows R^2 of 0.68 between $ANC_{0, MAGIC}$ and $ANC_{0, diatom\text{-}NIRS}$, the calculations show that eight of the 19 lakes are outside the uncertainty interval of ± 0.3 diatom pH units. The mean difference between $ANC_{0, MAGIC}$ and $ANC_{0, diatom\text{-}NIRS}$ for lakes in inside the uncertainty interval is -31µeq/l. The lakes outside the uncertainty interval show a small variation from the lakes within the uncertainty interval with a mean difference of -38µeq/l. the analysis shows that $ANC_{0, MAGIC}$ shows higher results then $ANC_{0, diatom\text{-}NIRS}$.

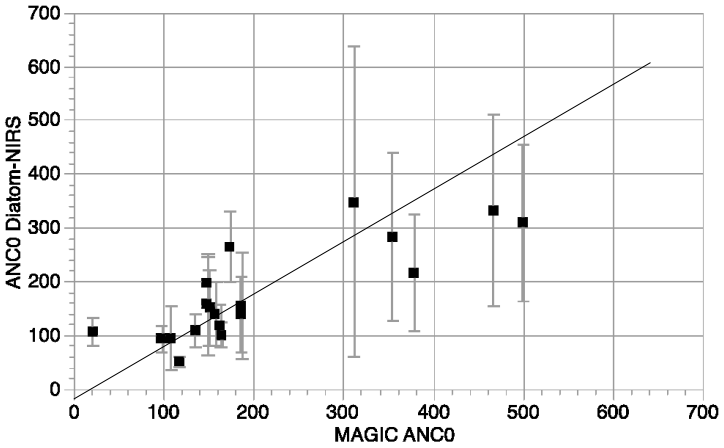


Figure 7. ANC calculated with $ANC_{0, diatom\text{-}NIRS}$ plotted against $ANC_{0\text{-}MAGIC}$, the error bars show the diatom-pH uncertainty interval of ±0.3 pH units. The 1:1 line is shown in the plot. ANC is expressed in µeq/l.

5.2.2 Determining Reference Conditions with pH_0

The calculation of pH_0 from ANC, TOC and pCO_2 as the MAGIC model does with the significant difference of TOC and PCO_2 whereas the MAGIC model assumes steady state conditions for these two parameters this study uses reconstructed values of TOC_{NIRS}, a calculated pCO_2. These results will be directly compared with diatom-pH to identify if the precision can be improved using long time-series of TOC.

A linear regression between MAGIC $pH_{0, uni. TOC \& pCO2}$ and MAGIC $pH_{0, TOC\text{-}NIRS \text{ and } spec. pCO2}$ shows an R^2 0.38 (Fig 8). The results show that MAGIC $pH_{0, uni. TOC \& pCO2}$ shows higher pH then MAGIC $pH_{0, TOC\text{-}NIRS \text{ and } spec. pCO2}$ with an mean difference of 0.18 pH units.

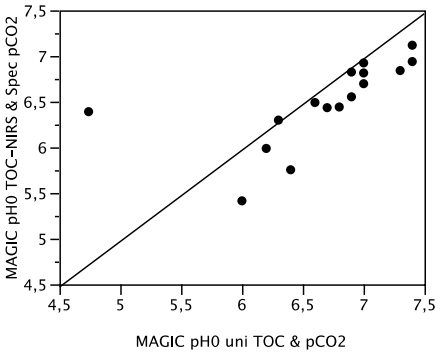


Figure 8. MAGIC $pH_{0,\ uni.\ TOC\ \&\ pCO2}$ assuming steady state conditions for pCO_2 and TOC plotted against MAGIC $pH_{0,\ TOC\text{-}NIRS\ and\ spec.\ pCO2}$ that are representing pre-industrial reconstructions of TOC and pCO_2. The 1:1 line is shown in the plot.

A linear regression between MAGIC $pH_{0,\ TOC\text{-}NIRS\ and\ spec.\ pCO2}$ and diatom-pH shows R^2 of 0,26 (Fig. 9). MAGIC $pH_{0,\ TOC\text{-}NIRS\ and\ spec.\ pCO2}$ shows higher pH values then diatom-pH with a mean difference of 0,21 pH units.

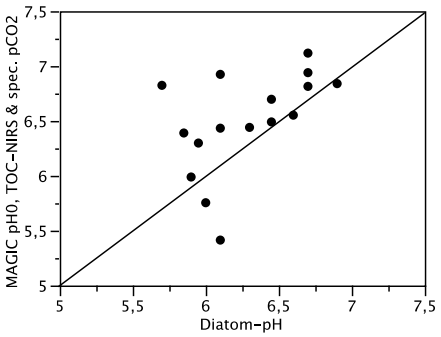


Figure 9. MAGIC $pH_{0,\ TOC\text{-}NIRS\ and\ spec.\ pCO2}$ assuming a long term change in TOC and a calculated pCO_2 plotted against diatom-pH that are supposed to show pre-industrial values of pH. The 1:1 line is shown in the plot.

A linear regression between MAGIC $pH_{0,\ uni.\ TOC\ \&\ pCO2}$ plotted against diatom-pH shows an R^2 of 0,43. MAGIC $pH_{0,\ uni.\ TOC\ \&\ pCO2}$ shows higher pH values then diatom pH with a mean difference of 0,38 pH units.

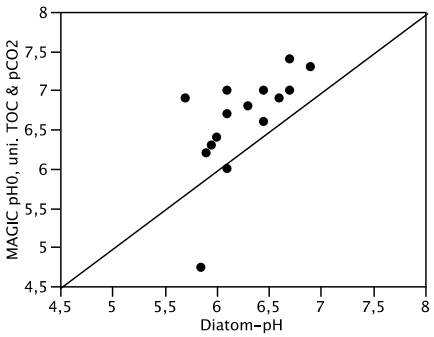


Figure 10. MAGIC $pH_{0,\ uni.\ TOC\ \&\ pCO2}$ assuming steady state conditions for pCO_2 and TOC plotted against diatom pH. The 1:1 line is shown un the plot

6. Analysis

6.1 Seeing, feeling and reaching the undisturbed state as a goal for water management

The legislative mandate of EU and the WFD have stipulated that lakes in Sweden and rest of the nations in the European Union need to reach the overall goal of GES for surface waters. The inquiry of this study has shown that the goal of undisturbed state seen from the public's perception is in most cases a good idea. The aspects that could be discussed, depending on how the public perceive the goal of undisturbed state, might be connected to the basic values and their relationship towards nature and the lake. The ideal aspect has, for many of the respondents, been that they would like to reach the same state as it was when they were young, being able to swim and fish, in the lake without necessarily seeing and experiencing the human disturbances as part of their view of nature at the time. Keeping the naturalness and the calmness of nature as an undisturbed state without human influence was their view of nature. It could be considered that the goal of undisturbed state could be a way for stakeholders to identify how nature and humans interact but also more importantly imagine a way of reaching their personal view on how nature and humans should interact. The respondents that did not feel that the goal of undisturbed state was something to pursue, saw the difficulties in setting unrealistic goals. They argued that this would lead to the dissatisfaction of never reaching the goals. They also identified the scientific difficulties in finding areas without human disturbance, arguing that the role of humans in nature cannot be negated, nor can natural variability, as the earth changes. Striving for a state that does not exist would just lead to disregarding the problems we have in our surface water, especially if there is no satisfaction to be gained from some kind of improvement. The respondents saw the problems of having undisturbed state as a goal might have values that conflict because they can see the direct implications of the relationship between humans and nature. They are facing the reality of how much we have changed nature and believe that we cannot return to that state, prior to humans influence again.

In contrast to what most respondents felt, that the goal of undisturbed state is a good goal for water management, most of the respondents see the difficulties of actually reaching the undisturbed state from their perspective. What was argued, as the reason for not being able to reach the undisturbed state, was how much humans have

changed the landscape in the catchment areas. Humans have changed the landscape around the lakes for centuries and we cannot reverse this influence that man has had on nature. An important aspect expressed from the respondents is that we cannot neglect the human influence in the area but we can aim for being a part of the natural system without overusing our resources. Dafour and Piégay (2009) state that the past conditions should not be used as a reference due to the fact that one historical state cannot be justified in preference to another. They argue that it cannot be stated if a state is more natural then some other, because all historically known states have been influenced by humans. The statements given by the public follow the same chain of thoughts that the scientific community argue, it will be difficult to reach the undisturbed state.

Reflecting on the main research question for this study, what relevance does the concept of RC and undisturbed state have to the general public and stakeholders, the inquiry in this study has shown that there is a relevance in the sense that they expressing what their relationship is with nature. Having the concept of undisturbed state as a goal for water management is in fact how they would like the lake to be. Even without having the scientific knowledge of what it means to go back to an undisturbed state, their perception of that goal meshes well with their own values and memories. What is important to state here is that using the concept of undisturbed state and trying to define it by a RC does not really matter much to the public. They will still have their perceptions and understanding of a RC that has no direct significance with modelling or expert judgement. Their view would be one of living in harmony with nature, having the aesthetic appearance that nature brings, and more or less seeing nature, in the words of the GW employee state, as something romantic.

6.1.2 Desirable state for the lake, from the publics perception

A key aspect for this thesis is to understand how the public perceive a desirable state, with regards to how they would like their lake to be and what would be important for them. The values and perceptions followed each other quite well. The basic values are that the lakes should be free from pollution and to be as they were intended from the beginning, without human alterations. Some of the respondents wanted the lakes to go back to a state as they remembered it when they where young (around 1920-1940). The reason for this aspect is due to the fact that they have experienced and seen

deterioration in the lake. Acidification is in particular named as a factor that has worsened the quality in the lakes. Another aspect to take into consideration is that people felt that there was more life around the lake during the 1900-1960s, more activities and the lake was used for everyday life. The public's perceptions, on what they believe is a desirable state, do in fact follow what WFD has determined through a RC, undisturbed state and GES to be the overall goal for water management in Swedish lakes. It does not mean that all stakeholders want to go back to a state before human impact but it still gives an indication of the basic values of people´s perceptions and what they thought was important.

Connecting these findings on what the desirable state is through the publics perception to the main research question in this study, leads to the second part of that question, namely, does the calculated RC corresponds with the perception of stakeholders in the catchment area. Bearing in mind that the calculations or models of the RC have not been shown to the public, it could be argued that the people's perception of the main aspects, which is hindering their view of a desirable state, corresponds to what the RC has identified. Of course the people cannot make direct observations of pH or ANC but they are able to observe if the lake water has shifted in colour, if algae bloom has occurred and if the fish population has increased or decreased. For Rotehogstjärn the RC has shown that the lake is acidified and this has been confirmed trough the observations of the stakeholders in the catchment. It is more important to figure out a way of using this non-scientific knowledge that the public possesses in order to give a great deal of specific and important information to help in classification of lakes.

6.1.3 Public participation inside or outside the WFD

As this study has shown both from the qualitative data collected and the literature review that the concept of PP in the WFD is quite abstract and that the role of PP is contradicting and undefined. The fact that it is stated that the success of the directive lies in the hands of active participation (preamble 14 and 46) but the framework states that PP should be used to inform general public before final decision is taken (WFD pp. 23). The uncertainty of what PP means to the WFD is verified by the perception of the GW interviewed in this study. He argues that the use of RC is not a successful way of giving information to the general public due to the fact that the knowledge gap

between pure science and for example a LO is very significant. The GW also states that using the concept PP to raise awareness with regards to the undisturbed state does not work, basically because the understanding that we should go back to before human impact is not possible and it becomes a discussion on basic values. Another aspect of importance is that the message of the undisturbed state is very difficult to convey to the basic values of the public. Rault and Jeffrey (2008) conclude their study arguing that the success of PP is based on the adaption of political and institutional frameworks to enable competent authorities and stakeholders to develop a learning approach to PP. WFD by itself does not define what the relationship between RC and PP is, the link found in this study is more or less a paragraph in the CIS PP (2003). It is stated in this document that PP can be used to minimize uncertainty in determining the RC and that the local knowledge should be accepted as expert (non-scientific) knowledge in classifications of the lakes (section 1.1).

Reflecting on the main research question in this study again, what relevance does RC and GES have to the general public, stakeholders and public participation in the WFD, focusing on PP? It could be argued that the relevance between GES and PP is minimal or that PP will be relevant for RC and GES when all other methods including modelling, historical data and expert judgement have too many uncertainties and a scientific interpretation of the undisturbed state fails, then the PP becomes relevant for the overall goal of the WFD.

6.1.4 The public as expert (non-scientific) knowledge holders

The inquiry of this study has shown that the local people have a great deal of knowledge, in particular when discussing changes in the landscape, fish population and visible changes in water chemistry. The respondents that have a close relationship to the lake, not only through their lifetime but also when the land has been in the family for generations, the amount of information they possess through direct observations as well as stories from older generations is very valuable information. As seen in section 5.1.3, LO 1 states and gives stories on how the water was clearer around 1920-1940s where he could see the pike in the water and after this he has seen a worsening in his view to the turbidity in the water. What is interesting to see with the RC is that this study can confirm the statement that the lake water TOC was lower in 1920-1940 than it is today and it is an indication of the turbidity in the water. If we

look at Fig. 5 and the plot of TOC_{NIRS} for Rotehogstjärnen we can identify a decrease of lake water TOC late in 19th century to a identified breaking point around 1950 when the TOC starts increasing in the water again and the water will not be as clear as it was before. The desirable state that LO 1 states, which is the state when the water was clear around 1920 from his perception, actually corresponds with the quantitative data with the observation of how the lake was many years ago. This can in some cases be very difficult to validate but having the benefit of reconstructions of historical data, it gives yet another dimension to the perceptions of the public. What is important here is that by confirming the statements that the public make, the validation of their knowledge and what I would argue is that the knowledge locals possess is a key for setting credible environmental objectives for Swedish surface waters. Using their knowledge of the undisturbed state and what their view of desirable state is can give the possibility to use the local peoples acceptance of the implemented measures, awareness raising and reducing the uncertainties with determining RC by validating the modelling with local non-scientific knowledge. Olsson and Folke (2001) have analysed the use of local knowledge for crayfish management in Sweden. The authors argue that the use scientific information combined with locally generated observations and knowledge results in management practices that are constantly re-evaluated and reshaped for improved implementation. The great knowledge that the local people in this study possess could be used in the same fashion to minimize the knowledge gap as well as improve the role of PP in the implementation process of the WFD.

6.1.5 The use of the word natural condition, undisturbed state and comparison value in water management.

The view of natural state, undisturbed conditions and comparison value has followed Swedish environmental quality criteria for half a century. The view of nature as a natural state has been present within both science and policy for a very long time. Section 4.1, in this study has shown the similarities between WFD and Swedish environmental quality criteria as well as where the concept of undisturbed state was derived from. It is quite evident that the concept of naturalness has followed EQC in Sweden and this is reflected in the goals for Swedish surface waters over a very long time period.

Reflecting on the research question, where does the concept of undisturbed state derive from and why is it used in the WFD? The answer to where the concept of

naturalness came from can only be speculated about but the historical view on the Swedish EQC gives a good indication of how it has evolved in Sweden for approximately 50 years. Yet, it has managed to keep its view that the natural state or undisturbed state is the state we should reach. The reason why it is used in the WFD can only be speculated on. This concept has been around for a long time in Sweden and is well established, it could be argued that the Swedish view on the naturalness has influenced the specifications of the technical annexes in the WFD. The above statement has been discussed in Lagacé et al (2008) where the appendix (Appendix I) shows that Sweden was one of the countries that were very active in development of the technical annexes. It could perhaps be argued that it is the Swedish (as the GW states) romantic view of nature that has framed the concept of undisturbed state and RC in the WFD. Further investigation is needed to with certainty argue the origin of the word undisturbed state.

6.2 Comparison between calculated and modelled reference conditions for ANC_0

On of the main outputs of the MAGIC model is ANC_0 and it is of importance to use precise calculations of this parameter for acidification assessment for Swedish lakes. As mentioned above, the MAGIC model (Moldan 2003) assumes steady state conditions for TOC and pCO_2 equal to the levels of 1997. Figure 4 shows that the levels of $TOC_{0\text{-}NIRS}$ for the analysed lakes have changed during the time series. When comparing $ANC_{0,\ MAGIC}$ with $ANC_{0,\ diatom\text{-}NIRS}$ and $ANC_{0,\ diatom\text{-}TOC}$ some clear distinctions can be made.

Comparing $ANC_{0,\ MAGIC}$ with $ANC_{0,\ diatom\text{-}TOC}$ $ANC_{0,\ MAGIC}$ shows higher ANC_0 values. Of the 20 calculated lakes 14 show lower ANC_0 values then $ANC_{0,\ MAGIC.}$ Six of the 20 lakes are outside the uncertainty interval ± 0.3 diatom-pH (Fig. 6). A different result is shown when comparing $ANC_{0,\ diatom\text{-}NIRS}$ with $ANC_{0,\ MAGIC}$ whereas eight lakes fall outside the uncertainty interval ± 0.3 diatom-pH (Fig 7). The calculation shows that 15 of the 20 lakes show higher ANC_0 values with $ANC_{0,\ MAGIC}$ then $ANC_{0,\ diatom\text{-}NIRS}$.

Some conclusions can be drawn from using historically inferred values of TOC_{NIRS} in calculation ANC_0 for acidification assessment for Swedish lakes. When calculating ANC with $ANC_{0,\ diatom\text{-}TOC}$ a lower ANC is show in comparison with $ANC_{0,\ MAGIC}$ but

the mean difference between the two calculation methods are still high so the fit is not optimal. Comparing $ANC_{0,\ diatom\text{-}NIRS}$ with $ANC_{0,\ MAGIC}$ a better fit is generated between the two calculations but still MAGIC shows higher ANC_0 values. It is argued that it is important to use reconstructed pre-industrial reconstructions in the form of TOC_{NIRS} and diatom- pH when calculating RC for ANC. It could be further discussed if the MAGIC model overestimates the ANC for the analysed lakes, in reality this overestimation of ANC would lead to an exaggeration on the effects of acidification of Swedish lakes.

6.2.1 Comparison between calculated and modelled reference conditions for pH_0

Calculation of pH_0 for acidification assessment in Swedish lakes determined trough ΔpH and ΔpH is the difference between undisturbed conditions and contemporary pH i.e. $\Delta pH=pH_0-pH_t$. Significant acidification is defined as $\Delta pH=pH_0-pH_t > 0{,}4$ pH units. In this study the importance of reconstructed pre-industrial TOC_{NIRS} is discussed in comparison with steady state conditions as it is assumed in the MAGIC model. This is then compared with the reconstructions of diatom-pH.

When comparing $pH_{0,\ uni.\ TOC\ \&\ pCO2}$ and $pH_{0,\ spec.\ TOC\text{-}NIRS\ \&\ pCO2}$ a mean difference of 0,18 pH units are shown in the analysis. When comparing the two calculations done in MAGIC with diatom-pH a substantial difference between the two calculations are identified. MAGIC $pH_{0,\ uni.\ TOC\ \&\ pCO2}$ shows a mean difference of 0,38 pH units while MAGIC $pH_{0,\ uni.\ TOC\text{-}NIRS\ \&\ pCO2}$ shows a mean difference of 0,21 pH units. The mean difference between MAGIC $pH_{0,\ uni.\ TOC\ \&\ pCO2}$ and diatom-pH are at the same level as the determination whether the lake is significantly acidified or not. For the lakes in this study, using MAGIC $pH_{0,\ uni.\ TOC\ \&\ pCO2}$ to determine RC, 13 of 16 lakes would be classified as significantly acidified, which is 81%. When using reconstructed values of TOC_{NIRS} and calculated pCO_2 seven of 16 lakes would be classified as significantly acidified, which is 44 %. Six of the 16 lakes would not been classified as acidified when using MAGIC $pH_{0,\ uni.\ TOC\text{-}NIRS\ \&\ pCO2}$ in comparison with if MAGIC $pH_{0,\ uni.\ TOC\ \&\ pCO2}$ would have been used. This is an important comparison when classifying lakes to reach the overall goal of GES in the WFD.

6.2.2 The relationship between science and policy in determining the reference condition

Given the above discussion on the substantial differences in methods and input for defining the RC, it becomes clear that the methods chosen have an influence on the decision whether a lake would be classified as acidified or not. In this fairly small-scale investigation, six lakes would have reached GES if another input was given to the MAGIC model (only looking at ΔpH). The discussions in section 4.2 on how science and policy interact in the WFD, where the WFD uses the concept of evidence-based policy making, science has the role of legitimising the decisions taken by politicians. This way of taking decisions would lead to transparency and decisions taken on the basis of facts. From a scientific perspective, the concept of RC has been criticised quite substantially and there is still a gap between the role of science and political decision-making that has somewhat set its faith on RC. As seen in this study there are quite large uncertainties in determining the undisturbed state, and still, 11 years after the implementation of the WFD, science appears to be struggling with this. Therefore, we cannot with confidence say what the RC is for Swedish lakes and we might never be able to. This study has shown that different inputs to the model would results in different conclusions regarding the classifications of significant acidification. The statement above (from the authors perspective) are of course made with a great deal of caution around it, because the calculations of RC in this study are not without uncertainties. Therefore, but the point is that the uncertainties in science need to be taken into consideration when political decision are made.

Lagacé (2008) states, "*It is the balance between how much a scientist needs to produce to be happy with the outcome and how much science a policymaker needs to be supported in making a political decision*" (pp. 429). There have been alternatives in the scientific literature to the RC. Stoddard et al (2006) propose an alternative way of using the concept of RC, namely minimally disturbed conditions (MDC) that refers to areas that only show a slight sign of human disturbances. Least disturbed conditions (LDC) refer to lowest sign of human disturbance in an area with extensive human disturbances. Best attainable conditions (BAC) refers to a state that is a state better than any in existence in a heavily modified region. BAC differs from the above mentioned conditions because they might not be achievable. It is important to state that there are alternatives to the use of RC in the WFD. The interaction between

science and policy might have, due to a "*romantic view of nature*" (as the GW states), lead to an unwarranted use of RC instead of using an alternative applicable and effective guideline to manage waters in Europe.

One of the sub-research questions for this study was about the relationship between science and policy and how the role of science and policy functioned within the WFD. As shown in the above discussion as well as in section 4.2 there is a clear indication that the political role has overwhelmed the scientific capacity in determining the RC for surface waters. The view of keeping nature, in a natural, pristine condition is not something that just has been in WFD but is has followed Swedish ECQ for more then 40 years (section 4.1). It is shown in this study that it is very difficult to determine the RC. Two different models gave different results and when the results of two model showed a mean difference as large as the definition of significant acidification. The uncertainties of using the concept of RC, as it is defined in the WFD, make it difficult to foresee that complexity it brings on the scientific knowledge. In any event, whether it is science that has promoted itself enough to validate the technical annexes or if it is the political decision making that overestimated the capability of science, it remains important to highlight the uncertainties of using RC as a way of measuring the quality of water.

7. Conclusions

This study has analysed the two cornerstones in the WFD, public participation and good ecological status. The two cornerstones could conceivably have contradicting perceptions of defining the goals of the WFD. This study raised as its main research question what relevance reference conditions and good ecological status have to the general public, stakeholders and public participation, and it went on to ask if the existing calculated reference conditions of good ecological status corresponded with the perception of stakeholders in the catchment. The study has shown the difficulties of calculating RC and how significant the uncertainties in the calculations are for classification of Swedish lakes.

This study has shown that the two cornerstones in the WFD, which supposedly should work as a unit to support effective management of Swedish surface water today, are in fact two separate cornerstones without an effective connection.

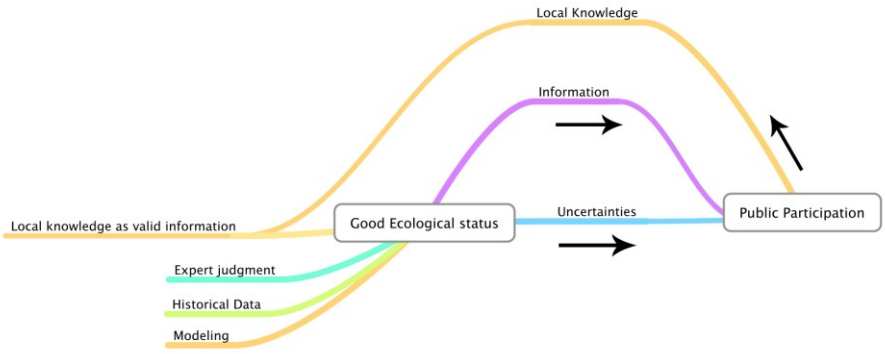


Figure 11. The relationship between the two cornerstones of the WFD.
[The definition of GES is in the initial step and if a classification can be confirmed, then its the connection to PP is trough information. If there are to many uncertainties and science cannot estimate the RC the connection between PP and GES is to use local knowledge as valid information to help in classifying the undisturbed state according to the WFD]

Calculating the RC with the different methods to determine GES to classify a surface body is in the first step of the WFD, if a proper classification can be made, this will be information given to the stakeholders as public participation. If the uncertainties are too substantial and the mentioned methods cannot determine a RC, the role of the public becomes more evident, their local expertise will be used to help in determining the RC and accordingly classify the lakes with the participation of the general public. This is illustrated in Fig. 11. As shown in this study the uncertainties associated with calculating the RC can be large enough to influence the classification towards

significant acidification depending on which method is chosen. What is important to state is that the local people in a catchment area do have great knowledge of historical conditions and the visual understanding of what specific deterioration had taken place, and even posses ideas about what might have caused them. The concept of local knowledge could in many cases be used for setting credible and acceptable targets where by the understanding of the locals might contribute to effective management of Swedish lakes.

The overall interpretation of the relevance and correspondence of RC for the general public in this study has shown that no such relevance exist. However, the basic values people hold about clean and unpolluted lakes correspond well with what the overall goal of GES for lakes is, even thought in this study most of the respondents felt that this goal was not achievable. From a governmental approach too the concept of undisturbed state or RC is not an appropriate way of convey the information due to the knowledge gap between the understanding of the locals and the classification of the WFD.

The final statement of this thesis in relation to the research question is that the two cornerstones in the WFD exist today, as antagonistic poles. Given that the RC is based on scientific knowledge the issue starts to become complex when locals without scientific base are expected to participate. WFD places an emphasis on local knowledge as the last accepted form of knowledge when the uncertainties in the other approaches are too large. This would support the idea that we should stop placing so much focus on discussing RC and start focusing on basic values, such as healthy and clean water, and then maybe we will have a directive that will present itself as a harmonious monopole.

7.1 Future research

This study is far from being a complete study. More research is needed to explore the connections between GES and PP in the WFD. This study was performed during a short time in a small municipality in Sweden, and I believe a larger study needs to be contacted in other areas to be able to identify the different perceptions, looking beyond representation done in this study and one lake.

I am well aware that this study has been a small-scale investigation, in particular the sample size and representation of the interviews done in the field. There is a need to explore representation of the study to include more stakeholders and even more lakes to have the possibility to critically investigate the role of PP and GES with in the WFD and how these two cornerstones could be held together. However, even with the sample size and representation it still reveals a first glance of public perception, what they believe is important and the great knowledge the public posses.

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Personal comments

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I. Appendix I

Questions asked to the interviewees in the interview language Swedish

- Hur upplever du din sjö idag?
  - Om du identifierar några problem med sjön, vilka problem finns det?
  - Vad tror du orsakar dessa problem?
- Hur använder du din sjö idag?
  - Vad har du för relation till din sjö?
- Enligt din åsikt, vad är det önskvärda tillståndet för din sjö?
  - Varför är detta tillstånd önskvärt?
- Enligt din åsikt, vilka aspekter bör prioriteras och vilka åtgärder bör vidtas för att uppnå god ekologisk status?
- Hur tror du att tillståndet på din sjö var före mänsklig påverkan?
  - Anser du att själva konceptet av ”ostört tillstånd” är ett lämpligt mål?
- Vad tror du är det naturliga tillståndet i din sjö?