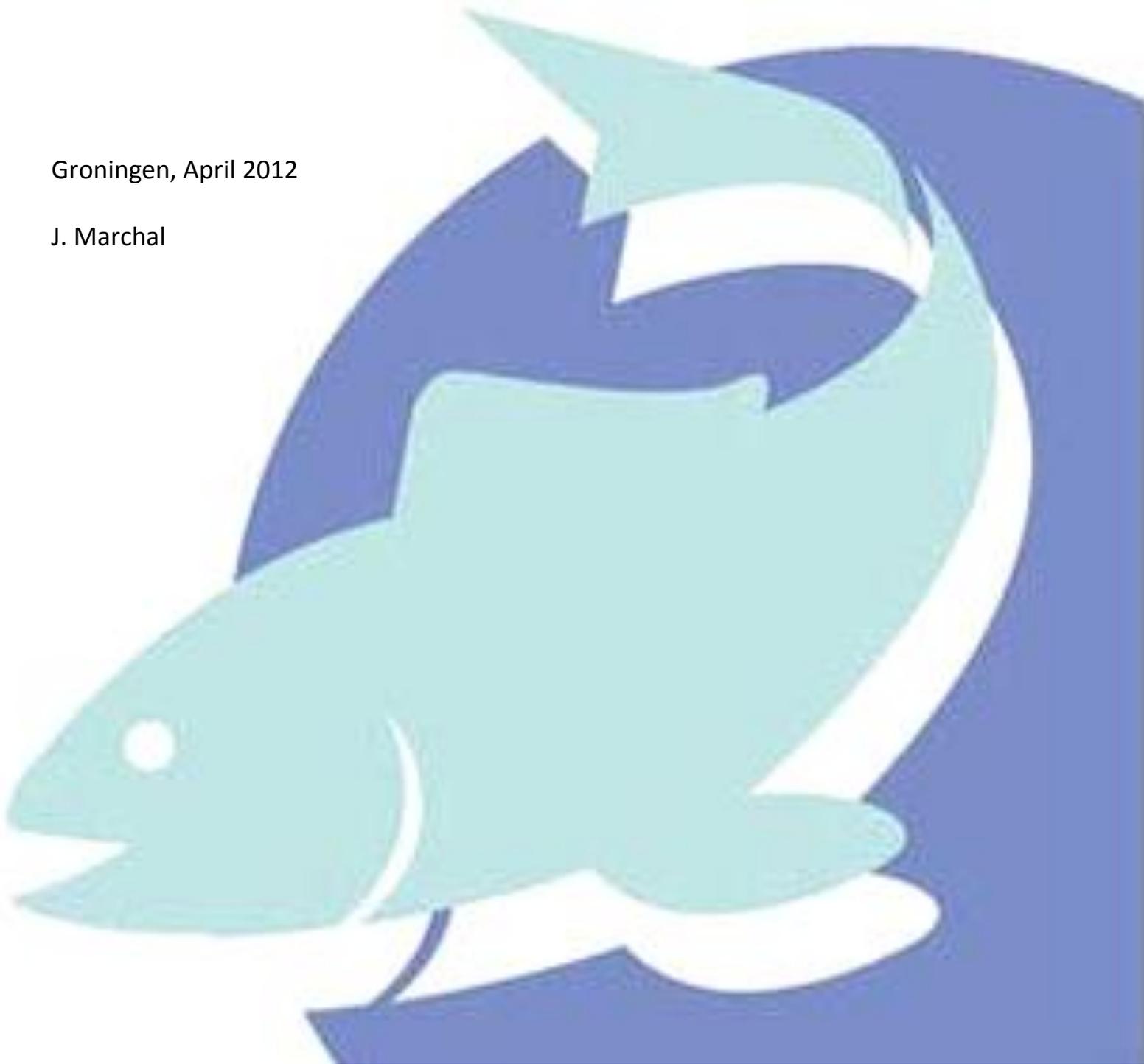


**Socio-economic valuation of European eel (*Anguilla Anguilla*)  
Atlantic salmon (*Salmo salar*) and sea trout (*Salmo trutta trutta*) in  
four pilot areas around the North Sea Region**

Final thesis

Groningen, April 2012

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Final Thesis

Groningen, 10 April 2012

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Illustration on cover by LNS, 2012



## **Preface**

As product of my final thesis, this report will finish my study Environmental Science, minor Nature & Environment. It concerns a socio-economic valuation commissioned by water board Noorderzijlvest in Groningen. This research is part of the Interreg project Living North Sea, a project between fifteen partners of seven countries around the North Sea.

Supervision of the Van Hall Larenstein in Leeuwarden was done by S. Bottema and D. Goldsborough. Many thanks mister Bottema and mister Goldsborough to make time to supervise me during the research, especially in the beginning when we started working out the subject.

Supervision of the water board Noorderzijlvest was done by Jeroen Huisman. Many thanks mister Huisman for this opportunity, the working place at the water board and the extra activities where I could join. Also thanks for your comments and helping during this research.

Many thanks to all the partners of the Living North Sea project for your input, supply of information and nice contact during the full partner meeting in Hamburg. I really enjoyed the meeting, it were three interesting, useful and amusing days.

Finally, my fellow intern Marc Bartelds. Thanks for the feedback, discussions and fun during stress times. Good luck with your report and in the future.

I hope this research will be useful background information for the Living North Sea project. During the research period I learned a lot what will help me in the future. I hope you will enjoy reading the report.

Groningen, 10 April 2012  
Jessica Marchal

## Summary

The four pilot areas Groningen, River Odense on the island Funen, river Ätran with the municipality of Falkenberg and River Tweed differ in several respects from each other. Groningen covers a whole province of the Netherlands, the other three areas include one main river and its catchment area. Land use in all four areas is dominated by agriculture/ farmland, influencing the water quality by enrichment of the water with nutrients. Only water of river Ätran has a good chemical and ecological water quality, water of the other areas is generally insufficient. Different types of water can mostly be found in the catchment area of the Tweed. Each area seems to have suitable habitat for the species of focus to grow up and for salmon and sea trout to reproduce. Still many barriers are present in each area affecting migratory fishes. The accessibility of barriers differs per area: in Groningen only a small amount of the barriers is constructed with a bypass while the main streams of River Tweed are all accessible by fish passages. Important is the efficiency of the fish passages; one river with many inefficient passages still cause a high smolt loss. Information of their efficiency is not available.

In Groningen five professional eel fishermen are present and three aquacultures. Two of them generate annual three ton eel in the catchment area of the Eems. River Odense, river Ätran and River Tweed do not have professional fishermen. River Ätran and River Tweed do have aquacultures but only produce fish for these own rivers.

Angling is done a lot in all four areas. In Groningen angling is directed by the Angling federation Groningen – Drenthe (Hengelsport Federatie, HSF). In the areas of River Odense, river Ätran and River Tweed many tourists visit the place for fishing on salmon and/ or sea trout. More fishes are caught and removed from River Tweed compared with river Ätran. There are no amounts of catches found for Groningen and River Odense by anglers. Local demand is for all four areas absent or present on a very small scale.

Expenditures by tourism fishing on eel in Groningen are not known. The assumption can be made for anglers in Groningen – Drenthe by data of Smit *et al.* (2004) that anglers spend annual more than 29 million euro on fishing gear in the two provinces. Annual more than one million euro is generated by selling licenses for sport fishery. HSF gains €384,155 and Sportvisserij Nederland (the national angling organization) gains €713,230.

The municipality of Falkenberg does not have data of jobs generated by general tourism and fishing tourism. A comparison can be made of the jobs generated by fishing tourism per area for Funen and River Tweed. Funen: 1 job per 107 km<sup>2</sup>, Tweed: 1 job per 10 km<sup>2</sup>. According to the amount of licenses, fishing on sea trout seems to be much more popular in Syddanmark (38,314) compared to River Tweed (1000). Salmon fishing seems to be more popular in River Tweed than sea trout fishing. The amount anglers pay to the HSF for a fishing license in Groningen – Drenthe, is mostly spent to improve conditions for anglers instead of the ecology of the water for better conditions for the fish species. Tourists visiting River Odense, river Ätran or River Tweed to fish on salmon or sea trout spend money in the area, which is income for companies. There is no information or money is spent and of the amount of money that is spent to improve the ecology of the water for each area.

The Regional Eel Management Plan tries to make an estimation of the eel population in Groningen and North Drenthe, finishing in 2012. Population numbers of species in the other areas are estimated, except for River Odense. River Odense and river Ätran do not reach their potential smolt production. Improvement of the area can stimulate spawning.

Species composition differs per area. Ide, pike, eel, trout (sea trout/ brown trout) are species present in all four areas but many other species are found in one or two areas. The list of present species may not be complete so most probably more species can be found in the areas compared to the ones who are mentioned.

## Table of Contents

1. Introduction.....	7
1.1 Background information.....	7
1.2 Definition socio-economic value .....	8
1.3 Problem description .....	9
1.4 Aim research.....	10
1.5 Research questions.....	11
2. Method .....	12
2.1 Description concept socio-economic .....	12
2.2 Selection model.....	12
2.3 Features.....	13
2.4 Data collection.....	13
2.5 Pilot areas .....	13
3. Species introduction.....	15
3.1 Eel .....	15
3.2 Salmon .....	15
3.3 Sea trout .....	16
3.4 Position ecosystem.....	16
4. Groningen .....	17
4.1 General area description .....	17
4.2 Current value .....	21
4.2.1 Employment .....	21
4.2.2 Tourism.....	26
4.2.3 Developments .....	27
4.3 Potential value.....	28
4.4 Eel in Groningen .....	28
5. Odense.....	30

5.1 General area description .....	30
5.2 Current value .....	34
5.2.1 Employment .....	34
5.2.2 Tourism.....	35
5.2.3 Developments .....	37
5.3 Potential value.....	37
5.4 Sea trout in River Odense.....	37
6. Ätran.....	39
6.1 General area description .....	39
6.2 Current value .....	42
6.2.1 Employment .....	42
6.2.2 Tourism.....	43
6.2.3 Developments .....	44
6.3 Potential value.....	44
6.4 Salmon and sea trout in the Ätran .....	45
7. River Tweed.....	46
7.1 General area description .....	46
7.2 Current value .....	49
7.2.1 Employment .....	49
7.2.2 Tourism.....	50
7.2.3 Developments .....	51
7.3 Potential value.....	51
7.4 Salmon in River Tweed .....	52
8. Comparison areas.....	53
8.1 General area description .....	53
8.2 Employment .....	53
8.3 Tourism.....	54

8.4 Population .....	55
9. Discussion .....	56
10. Conclusion .....	58
11. Recommendations.....	59
12. Epilogue .....	60
Literature list .....	61
Internet.....	64
Appendix I.....	68

# 1. Introduction

## 1.1 Background information

Human activities currently are responsible for the extinction of many species, however different measures are taken to halt the decline of biodiversity (Rijksoverheid, 2010). It is assumed that the current rate of biodiversity decline will not have adverse effects on the functioning of ecosystems (Haring, 2011). However, plant and animal species are not self-regulating organisms but flora and fauna are connected to each other and this connection gives give balance to ecosystems (Biodiversiteit, 2011). This function of species and ecosystems is of vital concern for human (Soortenbescherming, 2010). Ecosystems affect food webs upon which humans depend, therefore extinction of species can alter the complex food web composition starting a chain reaction of changes with ultimately repercussions for humans (Hartman *et al.*, 2010).

### North Sea Region

Although the North Sea is often seen as an uniform area, it includes a divers ecosystem with different streams, depths, sediment types and a complex foodweb (Stichting De Noordzee, 2008). The North Sea Region covers an area of 664,000 km<sup>2</sup> (fig. 1.1) and is connected to surrounding European countries and regions (LNS, 2011). It consists of the whole of Norway and Denmark, the south western region of Sweden, the north western regions of Germany, the northern and western parts of the Netherlands, parts of the Flemish Region of Belgium and eastern parts of the United Kingdom. Various activities take place in the sea, such as shipping, fishery and sand extraction (Rijkswaterstaat, year unknown).



Figure 1.1 The North Sea Region Source: INTERREG, 2007

### Diadrome fish species

To complete their lifecycle, migrating fish species utilize different habitats during different life stadia to grow in, to survive (by giving protection) and to reproduce. Depending on the fish species, migration takes place on annual or daily basis, within one river system or between inland waters and marine environment by swimming a few meters till thousands of kilometers. (Northcote, 1984)

Potadrome and diadrome fish species can be distinguished, based on their migration behavior, as described by Hartman *et al.* (2010). Potadrome fish species migrate within the inland river system, whereas diadrome fish species migrate through both fresh and salt water. Diadrome fish species are separated in katadrome, anadrome and amphidrome species. Katadrome species live in fresh water and reproduce in salt water, anadrome species live in marine environment and reproduce in freshwater and amphidrome species move freely between fresh and salt water. Examples of diadrome species of the North Sea are salmon (*Salmo salar*), sea trout (*Salmo trutta trutta*), European eel (*Anguilla anguilla*), twait shad (*Alosa fallax*) and houting (*Coregonus oxyrinchus*) (RIVO, 2004). They partly feed on plant material, small organisms and adult fishes also feed on small fishes (Soortenbank, 2011). They are positioned on a higher tropic level so effects on these species can have a strong influence on the foodweb (Soortenbank, 2011).

## 1.2 Definition socio-economic value

Fish can have different values on ecological, social, economic or socio-economic scale for the area they inhabit. The concept socio-economic combines the two words social and economic. Social describes the nature of interaction or relation between people, and economic is related to economy which comprises the nature of monetary and business interactions in a given group, community or organization (Economics Definition, 2011). According to Emerson *et al.* (2001) social value and economic value are created. Social value is created by combining resources, inputs, processes or policies to generate improvements in the lives of individuals or to the society as a whole. Economic value is created by taking a resource or set of inputs. By giving extra inputs or processes that increase the value of those inputs, a product or service will be generated that has a greater market value at the next level.

Socio-economy is used in different topics, such as socio-economic status (social position), socio-economic value (for an individual or group of people), socio-economic effect (of a product/ activity), socio-economic class (in society) and various other categories (Wilterdink & Heerikhuizen, 2007). From an economic point of view, socio-economy relates to the way in which society interacts economically or through the use of monetary compensation (Economics Definition, 2011), however it has several additional approaches;

- An entity creates socio-economic value by making use of resources and increase the value of these inputs to generate cost savings for the public system or environment of which the entity is part of (Emerson *et al.*, 2001)
- Socio-economic value is the study to the relation of economics to social values (Benhabib *et al.*, 2010)
- Socio-economic involves social as well as economic factors; socioeconomic status (WordNet, 2011)
- Socio-economic is directly related to money (MOA, 2012)

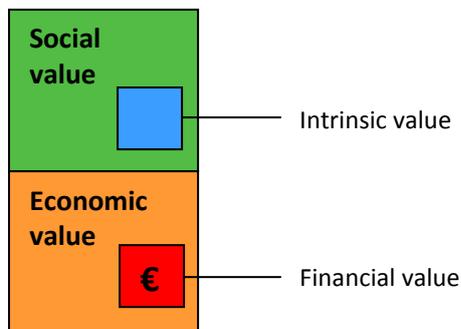
The descriptions illustrate the different principles of the definitions, their context-dependence and how socio-economic can be interpreted differently in the context of this report. The definition of Benhabib *et al.* (2010) 'Study to the relation of economics to social values' is chosen as principle as it connects in an appropriate way to the aim of this research. The definition supports the socio-economic valuation of the fish species in the areas.

Benhabib *et al.* (2010) describes the goal of a socio-economic study as follows. The goal of a socio-economic study is generally to bring socio-economic development, usually in terms of improvements. Socio-economists focus on the social impact of some sort of economic change. Social effects can be wide-ranging in size; from local effects on a small community to changes on an entire society. Examples of causes of socio-economic impacts include new technologies such as modifications in laws but also ecological changes.

### Economic value versus financial value

The intrinsic value, value of itself without its value for human (Ruijgrok *et al.*, 2004) is part of the social value (Emerson *et al.*, 2001) but it can be difficult to agree upon or qualify it. The intrinsic value of the fish species will therefore be excluded in this research.

The economic value includes concrete income as well as indirect income. A fish for example can have economic value for society's welfare (indirect income) as well as its specific (direct) income. Ruijgrok *et al.*, (2004) distinguished between economic value and financial value (fig. 1.2). The financial value is part of the economic value and consists of concrete market prices; income of the market. Economic value is a much broader concept. The economic value includes income but also other flows of prosperity such as clean air. It is difficult to value these prosperities as they do not have a concrete market price. Values consist of estimations or approaches.



Socio-economic value: welfare for human, direct as well as indirect

Intrinsic value: welfare flora and fauna

Financial value: Income

**Figure 1.2 Socio-economic: intrinsic value versus financial value**  
 Source: Ruijgrok *et al.*, 2004 modified by J. Marchal

Although the intrinsic value is not taken into account in this research, the ecology of the fish species is of importance. Fish species are restricted to certain ecological conditions (Kroes *et al.*, 2006), which need to be present in the areas. Therefore ecology is closely linked to social and economical factors.

### 1.3 Problem description

Fish species are important elements of river systems ecology. Due to the presence of many barriers, rivers are fragmented which affects migration (Kroes *et al.*, 2006). Fragmentation can generate ecological and behavioural changes, physiological problems, genetic degradation and aggravation of habitat structure of rivers (Kroes *et al.*, 2006). However, multiple factors are responsible for a decline in numbers of many migrating and non-migrating species (Maltby, 2010; Aarestrup *et al.*, 2010), such as:

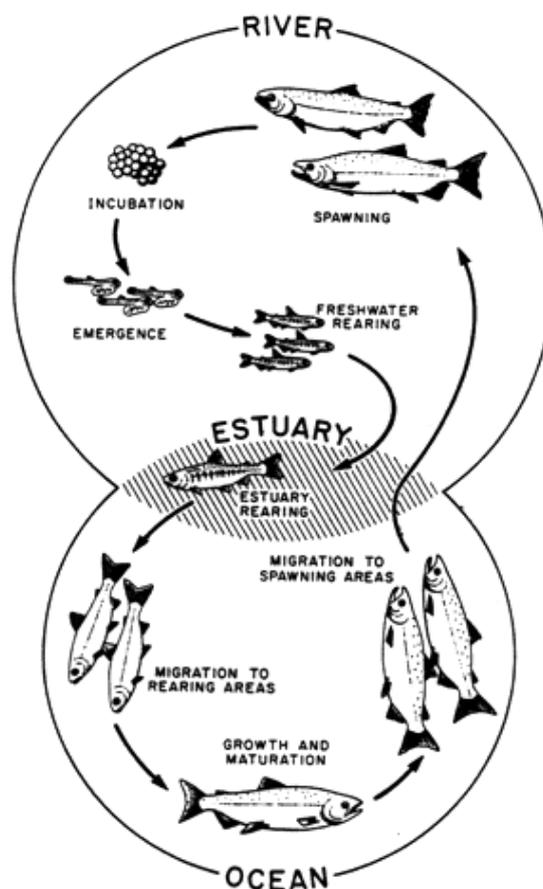
- Man-made barriers (weirs, dikes, sluices)
- Hydropower
- Exploitation
- Canalization
- Land-use change
- Flood management
- Water quality
- Water quantity
- Climate change
- Habitat loss
- Habitat degradation

Fundamental in this cycle is the natural mouth of a river and its estuary zone, with different salt concentrations and temperatures where fishes have the opportunity to adapt to physiological changes for the migration between river and sea (Kroes *et al.*, 2006).

Life cycles, in this case illustrated for salmon (fig. 1.3), forms a fundamental aspect for understanding migration (Aarestrup, 2010). For a fish to be able to reproduce, it is important that their lifecycle is completed, otherwise it can have major consequences for stock survival. They can decrease in numbers and potential (local) extinction (Jager, 1999).

#### Relevant legislation and policy

Effective legislation and policy are crucial to protect species and their natural habitats. On European level there is significant legislation directly relevant to the restoration of fish migration in river systems. Within the European Union (EU) modern regulation of environmental threats and problems seems to be increasingly effective. New international law seems to



**Figure 1.3 Life cycle of salmon. The different stages illustrates the use of different habitats and exemplifies the importance of migration**  
 Source: CHEM, year unknown

create positive ecological status, including the re-establishment of migrating fish populations. The EU subsidizes in many cases direct funding of facilities. EU directives are converted into national legislation, serving national interest according to the management of flora and fauna and economical interest.

Local law and policy implement international and national laws, which may lead to target national funds attending to the local need for environmental management including migrating fish. Relevant EU legislation for all four areas, according to migrating fish, consists of the Water Framework Directive, Treaty of Bonn, Treaty of Bern, Regulation 92/43/EEG of the council of European communities and Treaty of the Committee of ministers of the Benelux Economical Union. These laws contain background information of the legislation for all pilot areas. Relevant legislation or policy applicable in the specific area is elaborated in the area chapter.

Water Framework Directive (WFD): provides a framework for the protection of inland surface water, transitional waters, coastal water and groundwater. Although the directive is valid for all Members states of the EU, they have some freedom by integrating the WFD in their own national legislation. Since all pilot areas are European Union Members States, the WFD is applicable in all areas and therefore an important legislation. The WFD mentions 2015 as target year to have a good ecological status of the water systems (Riemersma & Kroes, 2004).

Treaty of Bonn: concerns the protection of migrating wild animal species, recognizing the importance of migrating fish species and requires measures to insure the maintenance of migrating species.

Treaty of Bern: Concerns the preservation of wild animal- and plant species and their natural habitat they depend on.

Regulation 92/43/EEG of the council of European communities: Concerns the preservation of natural habitats of wild flora and fauna. This directive aims to establish a 'favourable conservation status' for selected habitat types and species of EU interest, by creating a Natura 2000-network.

Treaty of the Committee of ministers of the Benelux Economical Union: Concerns the free migration of fish species in the hydrographical basins of the Benelux- countries, to ensure the free migration of fish species in all river basins. (Kroes *et al.*, 2006)

### **Living North Sea**

Living North Sea (LNS) is an Interreg project. Interreg is a community initiative which aims to stimulate interregional cooperation in the European Union (Maltby, 2010). The LNS project includes fifteen partners of seven countries around the North Sea. The goal of the Living North Sea project is 'free fish migration from sea to source to keep our waters alive', and deals with three essential aspects on the management of migratory fish:

- migration routes;
- threats such as man-made barriers and fish migration measures; and
- influencing future policy at a regional, national and international level and informing the general public.

European eel (*Anguilla anguilla*), Atlantic salmon (*Salmo salar*) and sea trout (*Salmo trutta trutta*) will be used as key species explaining their migration routes, however this will be applicable to many other species. The produced reports discuss the North Sea Region, but the outcome of this research will also be applicable in other regions. The target group of the project includes river managers, stakeholders, decision makers, colleagues and other interested groups, involved in influencing regional, national and European policies. (LNS, 2011; LNS partner meeting, 2012)

### **1.4 Aim research**

This research contributes to the Living North Sea project. The aim is to select and apply a socio-economic method in four pilot areas to determine the current and potential value of the areas in relation to the present migrating fish species. This valuation and comparison of the areas are lessons for the entire LNS project of the situation in the areas and how they deal with it.

The end product consists of a report with a description of features describing the socio-economic value of eel, salmon and/ or sea trout in the pilot areas Groningen, River Odense, river Ätran and

River Tweed with a comparison of the situation between the areas. The focus is on the current and potential value of the migrating fish to emphasize the importance of free migration. The current value will give a description of the employment in the area, tourism and its income and developments. The potential value gives a description of opportunities in the area for migrating fish. These opportunities can consist of the removal of barriers since they contribute to a decrease in population numbers (Maltby, 2010), creating by-passes or other developments positively affecting migration. Implementing these opportunities can create improved conditions for the fish population, such as improving the quality of their environment, so that living conditions are enhanced to sustain an increase in fish numbers.

### **1.5 Research questions**

A description of the socio-economic value will be given by answering the main research question:

What is the current and potential socio-economic value of eel, salmon and/ or sea trout in Groningen, River Odense, river Ätran and River Tweed?

In order to answer the main research question the following sub questions are formulated:

- What is the current and potential socio-economic value of the eel, salmon and/ or sea trout in Groningen, Netherlands?

- What is the current and potential socio-economic value of the eel, salmon and/ or sea trout in River Odense, East-Denmark?

- What is the current and potential socio-economic value of the eel, salmon and/ or sea trout in the river Ätran, Sweden?

- What is the current and potential socio-economic value of the eel, salmon and/ or sea trout in River Tweed, Scotland?

## 2. Method

Four pilot areas are investigated, namely the province Groningen, Odense River with the island Funen, the catchment area of river Ätran and the municipality of Falkenberg and River Tweed with its catchment area (fig. 2.1).

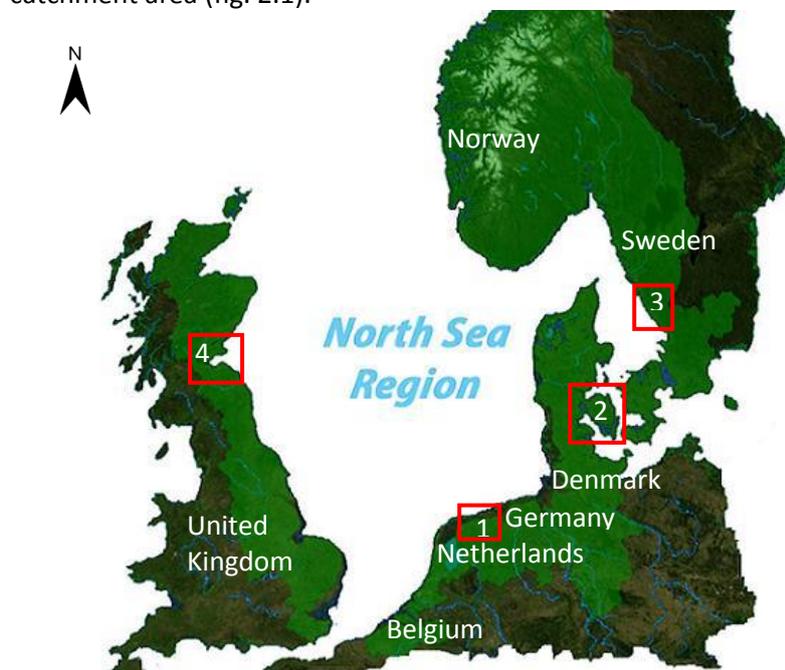


Figure 2.1 Overview North Sea region with participating countries. Four pilot areas are selected to focus on: (1) Groningen in the Netherlands, (2) River Odense in East-Denmark, (3) river Ätran in the Municipality of Falkenberg in Sweden and (4) River Tweed in Scotland (United Kingdom) (red frames). Source: Living North Sea, 2011 (scale unknown) Modified by J. Marchal

### 2.1 Description concept socio-economic

The description of socio-economic value and the definition of Benhabib *et al.* (2010) given in the introduction will function as baseline during the research, giving support by constructing the research.

### 2.2 Selection model

Several models are investigated to control their ability in describing the socio-economic value. Three were selected for a further investigation.

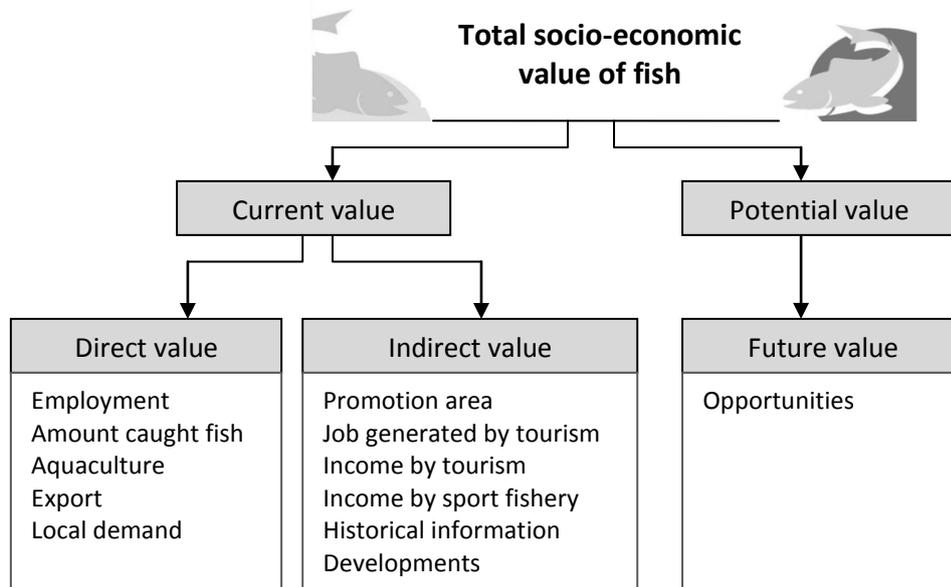
One model described the production-factor-method (Ruijgrok *et al.*, 2004). The model illustrates how the environment produces human prosperity, to determine the socio-economic value of nature, water and soil by a social cost-benefit analysis. Changes or aspects were quantified and valuated into monetary value.

IUCN (year unknown) described the Total Economic Value (TEV). TEV emphasizes the economic value of nature within an ecosystem, encompasses direct values, indirect values, optional values and non-use values. In this way the economic costs and benefits of ecosystems are represented.

The third model focused on quantifying and describing utility (Cook *et al.*, 2009). The most basic division in the taxonomy separates the two main uses of social science models in ecology and conservation: predicting human behaviour and assessing human welfare. Many of the techniques in these two branches make use of the concept of utility and so methods are classified for quantifying and describing utility. Cook *et al.* (2009) analyzed several models, whereby almost all models used utility as a measure of welfare. They were divided into categories, with focus on one category: Private profit. The private profit model illustrates the economic value on human welfare. The model

is first used for forestry and range management. The ecological aspects of these two systems are related to production, their value can be expressed in terms of the market value of production.

The model of IUCN (year unknown) is chosen as principle, and combined with concepts of the model of Cooke *et al.* (2009) (fig. 2.2). The features are added to the direct or indirect value to which they belong. The potential value is a description of opportunities present in the area which can influence the value of fish for the area.



**Figure 2.2** The model which is used by the description of the socioeconomic value. The future value focuses on present opportunities for migrating fish. Source: IUCN, year unknown; Cooke *et al.*, 2009; modified by J. Marchal

### 2.3 Features

The following features were used to describe the socio-economic value of the fish species in the pilot areas. A selection is made according to indicators widely used in reports, however the features are partly chosen on an experimental basis to test whether the areas can be assessed on their socio-economic value with use of current methods. The chosen features are quantified and if possible, an economic value is given. A more detailed description can be found in Appendix I.

#### Direct use:

- Employment
- Amount of captured fish
- Aquaculture
- Export of fish
- Local demand

#### Indirect use:

- Promotion area for tourism
- Jobs generated by tourism
- Income by tourism
- Income by sport fishy
- Historical information
- Developments

### 2.4 Data collection

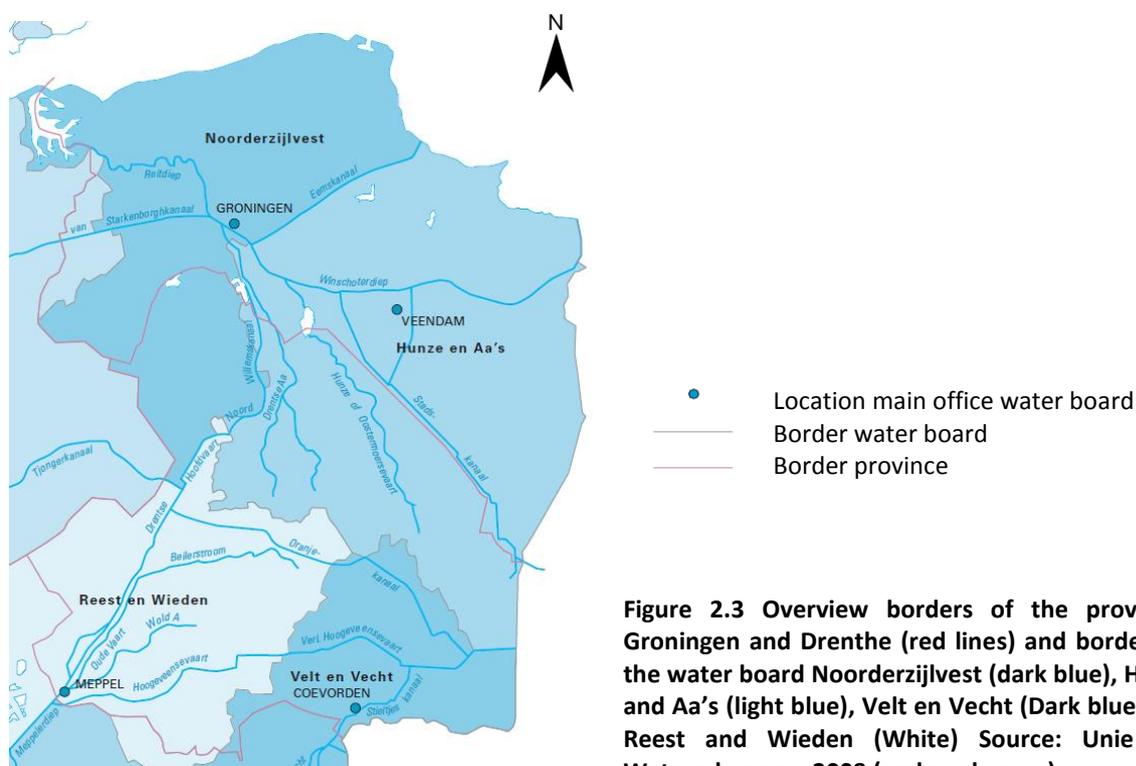
Data is collected through a literature study as well as through interviews with members of the Living North Sea project during the full partner meeting in Hamburg. The Living North Sea site was an important source of information.

### 2.5 Pilot areas

Every pilot area is described according to presence of fish species eel, salmon and/ or sea trout in one or more streams. Additional relevant subjects are described relevant for each area concerning the migrating fish.

## Groningen

Noorderzijlvest and Hunze & Aa's are the responsible water boards in the provinces Groningen and Drenthe. They have their own borders corresponding with water streams which do not correspond to the borders of the provinces, so the north- western part of Drenthe is part of Noorderzijlvest and northern- east and eastern part of Drenthe is part of the management area of Hunze en Aa's (fig. 4.3). The management area of Noorderzijlvest and Hunze & Aa's which is located in the province Groningen is taken into account, based on the presence of professional inland fishery companies in Groningen and absence of professional inland fisheries in the province Drenthe (Combinatie van Beroepsvissers<sup>1</sup>, 2011). The province Drenthe is also of importance because it is included by the Angling Federation. However, due to the fact that the area of the province is divided by four water boards (fig. 2.3), by dividing information per management area will result in too complex outcomes, therefore focus will only be on the province of Groningen. The capital of province Groningen is also called Groningen. Whenever, during this research a description of Groningen is given, the province Groningen is mentioned instead of the capital.



**Figure 2.3 Overview borders of the provinces Groningen and Drenthe (red lines) and borders of the water board Noorderzijlvest (dark blue), Hunze and Aa's (light blue), Velt en Vecht (Dark blue) and Reest and Wieden (White) Source: Unie van Waterschappen, 2008 (scale unknown)**

## River Odense

River Odense within Odense River Basin is the focus of the pilot area. Its natural borders are used. Data found was sometimes applicable on a bigger area than the basin. It is mentioned when data relevant for the whole basin or for the island is used.

## Ätran

The catchment area of river Ätran is used as pilot area by making use of its natural borders. The whole river is included in the research although some data is only applicable on the municipality of Falkenberg. It is mentioned when data is relevant for the whole catchment area or the municipality.

## Tweed River

The catchment area of Tweed River is the fourth pilot area. Its natural borders are used. Some data was relevant for a bigger area than the catchment area of the river. It is mentioned when data relevant for the whole catchment area or even for a bigger area is used.

### 3. Species introduction

Eel, salmon and sea trout are key species in this research. First an introduction is given with a description of their required habitat and reproduction area, followed by some historical information of their population in the North Sea Region. (LNS partner meeting, 2012)

#### 3.1 Eel

Eels (fig. 3.1) are not very selective regarding their fresh water environment and can be found in different kinds of water; bright, turbid, high and low saline, oligotrophic and eutrophic. The life cycle of the katadrome eel (fig. 3.2) differs from the life cycle of salmon and sea trout (fig. 1.3) Research on the reproduction of eels has been conducted but the spawning place has yet to be determined. In the Sargasso Sea the smallest larvae are found, which indicates a probable spawning area. Spawning takes place at the end of the winter/ spring. Larvae are called leptocephalus larvae by their shape and transparency. (McCleave, 1998) During their journey which can take up to three years (Tesch, 1997), the larvae change into glass eels. Warm currents bring the glass eels to the coast of Europe where they enter the inland fresh waters through estuaries. In the inland waters glass eels metamorphose into elvers, yellow eel and later on to silver eels. Inland waters are used as growing area and therefore crucial for the glass eels. Silver eels migrate again to the Sargasso Sea for reproduction. During their journey they do not eat but they make use of their fat reserves. (Winter & Jansen, 2006).



Figure 3.1 Picture of an European eel Source: Eeliad, 2008

Nowadays the eel population is not doing well, the number of glass eel accretion decreasing last years (fig. 3.3). Migration obstacles can be responsible for their decline (Winter *et al.*, 2007).

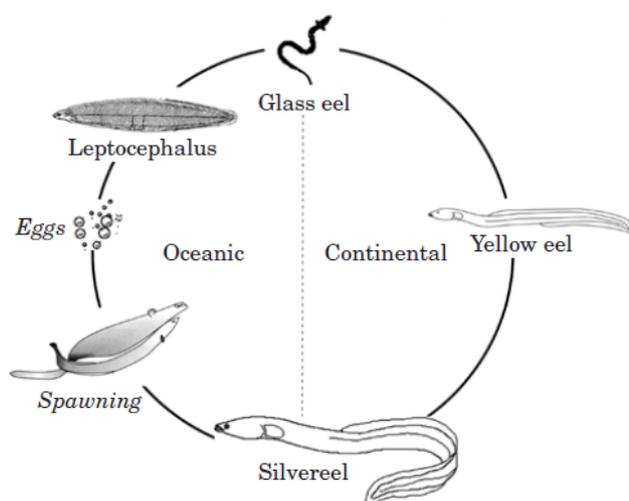


Figure 3.2 Life cycle of the European eel. Spawning and eggs have never been observed in the wild so they are given cursive Source: Dekker, 2000

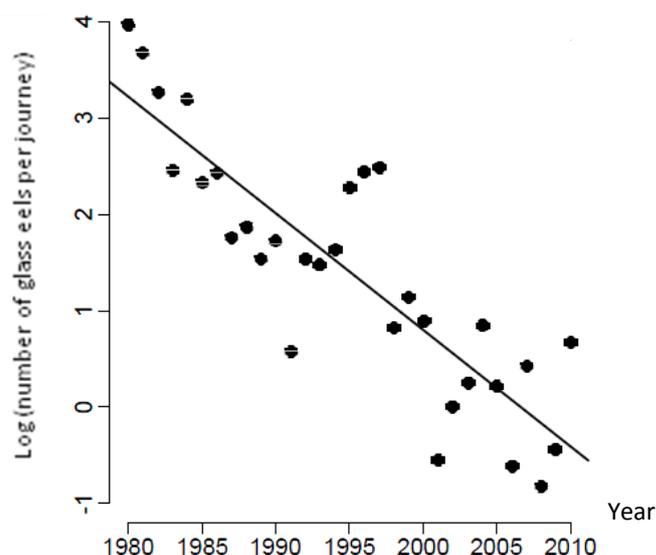


Figure 3.3 Perceived (dots) and estimated (line) trend of glass eel accretion near Den Oever, Netherlands expressed in number of glass eels per journey on a log scale Source: IMARES, 2011

#### 3.2 Salmon

Salmon (fig. 3.4) live in seas and migrate to fresh inland waters for reproduction. They require a gravel soil to cover their eggs. Upstream migration consists of two periods; the spring salmon (June-August) and autumn salmon (late October). In spring the salmon eggs hatch in the river, where the

young fish stay between one till three years in their parr- stadium before changing to smolts and migrate downstream to sea. (Sportvisserij Nederland, 2006)



**Figure 3.4 Picture of a salmon**  
Source: Sportvisserij Nederland,

#### *Smolts*

Juvenile salmon and sea trouts are referred to as smolts. Smolts weigh around 37 grams and reach up to approximately 15 cm in length. The fish undergoes physical changes as preparation for a life in salt water. It changes, for example, its shade from brown to shiny silver, to make itself less conspicuous. They live in large groups during their migration to the sea. (Havoerred Fyn, 2009)

In the past large numbers of salmon could be found in the North Sea Region, which reached its highest point at the end of the 19<sup>th</sup> century. The amount of salmon caught was large so the fish was considered food for poor people. After that period, the numbers caught salmon decreased until considered rare after 1950, followed by local extinction. Nowadays measures are taken to stimulate the growth of salmon population by, for example, prohibiting fishing. (Ecomare<sup>1</sup>, year unknown)

### **3.3 Sea trout**

Sea trout (fig. 3.5) live in sea water and migrate to fresh inland water for their reproduction. Upstream migration takes place between the end of the summer and early autumn. They have some habitat requirements; they require a gravel soil in which larvae can hide after birth for two till three weeks. In contrary to salmon, sea trout eat during spawning season. Most sea trout die after hatching, however some can return after several years.



**Figure 3.5 Picture of a sea trout**  
Source: Sportvisserij Nederland,

Young sea trout are referred to as parrs and stay between one and five years in the river before they change to smolts and migrate to sea. After four to seven years, smolts reach sexual maturity. (Kustgids, 2010)

The disappearance of sea trout and salmon in, for example, the Netherlands and Belgium is for example caused by the disappearance of suitable reproduction habitat. The removal of the trees caused a deposit of clay and loam on the gravel sediment of the rivers. Many rivers now have a thick layer of loam which makes them unsuitable for reproduction. (Coeck personal communication, 2012) Programs are needed to stimulate the salmon and sea trout population and bring them back to the waters they were present.

### **3.4 Position ecosystem**

Sustainable ecosystems include both single celled organisms and high predators on the top of the food chain. Fish function as key indicators of healthy aquatic ecosystems. Eels, salmon and sea trout have a long history of occurrence in the North Sea, and are part of its ecosystem. They have their own niches which characterizes their position in the ecosystem. Their niches are not stable and forever; both can change due to the environment and species. Corresponding on environmental changes, biotic and a biotic effects species affect their own niche and the niche of other organisms.

The spawn and growth habitat of eel, salmon and sea trout in the North Sea Region are disrupted by manmade barriers, which causes a decline in their numbers. Disappearance of a fish species will disturb the ecosystem. Disrupted areas can change in species composition. A dominant species or an immigrant can colonize the area, using the resources and increase in numbers, and thereby consequently expand its niche. Local species can be outcompeted by a new dominant one. Ultimately, local species distribution can become fragmented which can end in local extinction. (Polechová & Storch, 2008)

**Groningen**  
 Current situation: -  
 Focusing species: Eel

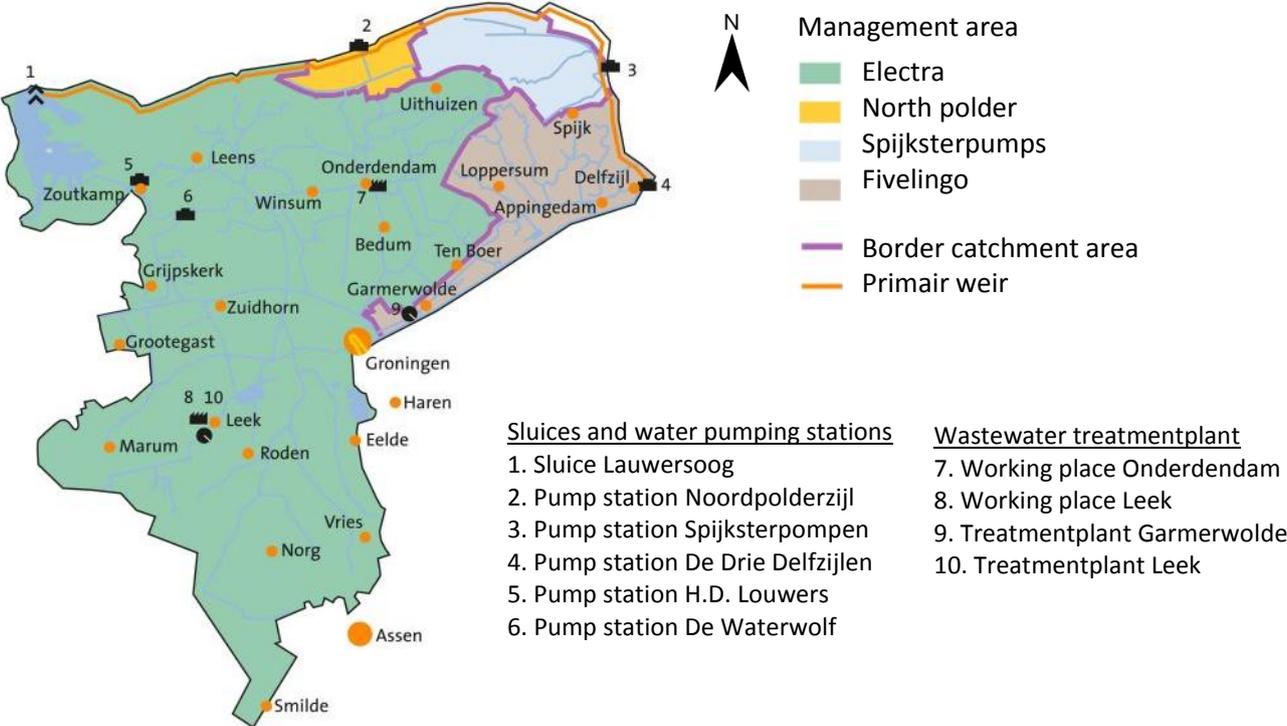
**4. Groningen**

Tidal barriers and pumping stations were placed by humans to control the land. The consequences of these barriers were unforeseen; peat layers shrunk which lowered the land. (LNS partner meeting, 2012). The land was used for agriculture and the rivers and sea for fishery. A known fishery village in Groningen is Zoutkamp. At the beginning of the previous century the village Zoutkamp, located on the Lauwerszee, functioned as important protector for the city Groningen. At the end of the sixteenth century they started fishing with small boats on the sea. Little is known about the development of the fishing place between the Middle Ages until the beginning of the nineteenth century. Fishing activities were ended in Lauwerszee, which forced the people to move their fleets to Lauwersoog. Nowadays, a small number of fishing ships are left, but it still has its fishery reputation. (Zoutkamp, 2012)

**4.1 General area description**

Geography

Noorderzijvest and Hunze & Aa's are the responsible water boards in the area. An overview of the management area of both water boards is given (fig. 4.1 and 4.2) including present weirs, sluices, water pumping stations and treatment plants. The water boards are located in the catchment area of northern part of the Rijn (Rijn – Noord) and the Eems (fig. 4.3). Hengelsportfederatie Groningen-Drenthe (HSF) (Angling Sport Federation) directs all professional, sport and recreational fishing in the area (HSF, 2012). They retain all fishing rights for almost all surface water suitable for fishing in the provinces Groningen and Drenthe. The federation coordinates 180 angling sport clubs with in total almost 51.000 members. The federation is connected to Sportvisserij Nederland, (Angling Association Netherlands), a society on national scale with as goal to create optimal possibilities to practice sport fishery in the Netherlands (Sportvisserij Nederland, 2012). Sportvisserij Nederland is partner of the Living North Sea project.



**Figure 4.1 Overview management area water board Noorderzijvest. The colours indicates the different basins, the numbers indicates the locations of sluices, water pumping stations and purification plants. Especially the water pumping stations and sluices form bottlenecks for migrating fish. Source: Noorderzijvest, 2012 (scale unknown)**



**Figure 4.2** Management area water board Hunze and Aa's. The coloured lines indicates the water ways. Red: water for professional fishing including the Winschoterdiep and Noord-Willemkanaal. Blue: water for recreational use, mainly regional routes. Green: water for local recreation. Source: Hunze en Aa's, 2012 (scale unknown)



**Figure 4.3** Catchment area Eems and Rijn (Noord) Source: Noorderzijlvest, 2008 (scale unknown)

#### Land use

The province Groningen covers an area of 2960 km<sup>2</sup> and is divided in seven different types of land use, mainly represented by agricultural land (63.8%) (CBS, 2011). The remaining 36.2% is divided in: 2.2% roads, 5.2% cultivation, 1.3% semi-cultivation, 1.3% recreation, 21.4% water and 4.8% forest and open natural area.

#### Kind of water

Water board Noorderzijlvest manages fifteen different water bodies, consisting mainly of canals, several streams and three lakes. The lakes are very different from each other, Lauwersmeer contains brackish water, Leekstermeer is a shallow buffered lake and the Paterswoldsemeer is an isolated shallow lake in peaty area (Huisman, 2008).

#### Water quality

The water boards are responsible for the water quality according to standards of the European Water Framework Directive. The chemical and ecological quality is measured separately for every water body. The management area of Noorderzijlvest is located in the basin Eems (fig. 4.3). The overall water quality is insufficient. A river, canal and a lake all used for professional fishery are given as example (Noorderzijlvest, 2008).

#### *Reitdiep*

The ecological water quality of the river Reitdiep (fig. 4.4) is low; currently all water plants, insects and fish live in compromised habitats. The chemical water quality is moderate. The river is eutrophicated which is primarily caused by agriculture but also shipping industry.



**Figure 4.4** Reitdiep Source: Blaauw, 2011

### Damsterdiep

The ecological water quality of the canal Damsterdiep (fig. 4.5) is poor; the environmental conditions of water plants, insects and fishes are currently insufficient. The chemical water quality is moderate. Phosphor and nitrogen input originates mainly from agriculture however this may vary with dry and wet years.



Figure 4.5 Damsterdiep Source: Eissens, 2011



### Leekstermeer

The ecological water quality of the lake Leekstermeer (fig. 4.6) is poor; the environmental conditions of water plants, insects and fishes are currently insufficient. The chemical water quality is moderate due to eutrophication mainly caused by agriculture. It is expected that measures on other water bodies will also positively influence the lake.

Figure 4.6 Leekstermeer Source: Own collection, 2011

### Water quantity

The water boards Noorderzijlvest and Hunze en Aa's are responsible for the water quantity. It is their responsibility to keep the water between a minimum and maximum level by making use of the weirs and sluices, so the waters are accessible for boats and fauna as fish are able to make use of it.

### Possible occurring species,

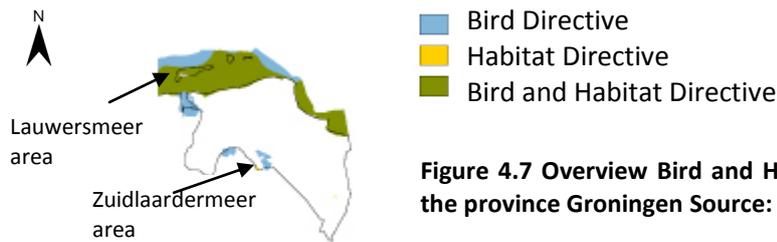
Although fish species have disappeared from the waters in Groningen, many fish species can still be found (Hengelsportweb, 2010). An overview of possible occurring species is given as well as three examples of species that disappeared (table 4.1). Appearance and habitat preference can differ between species.

Possible occurring fish species in the Netherlands	
Eel	Flounder <i>Platichthys flesus</i>
Chub <i>Leuciscus cephalus</i>	Nose carp <i>Chondrostoma nasus</i>
Ide <i>Leuciscus idus</i>	Pike – perch <i>Stizostedion lucioperca</i>
River Perch <i>Perca fluviatilis</i>	Lampern <i>Lampetra fluviatilis</i>
Barbel <i>Barbus barbus</i>	Atlantic sturgeon <i>Acipenser sturio</i>
Rudd <i>Rutilus erythrophthalmus</i>	Allis shad <i>Alosa alosa</i>
Smelt <i>Osmerus eperlanus</i>	Houting <i>Coregonus oxyrinchus</i>
Dace <i>Leuciscus Leuciscus</i>	Trout <i>Trutta</i> : Brook trout <i>Salvelinus fontinalis</i> ; Rainbow trout <i>Oncorhynchus mykiss</i> ; Brown trout <i>Salmo trutta fario</i> (disappeared); Arctic char <i>Salvelinus alpinus</i>
Tench <i>Tinca Tinca</i>	
Pike <i>Esox lucius</i>	
Grayling <i>Thymallus thymallus</i> (disappeared)	
Atlantic salmon <i>Salmo salar</i> (disappeared)	

Table 4.1 Possible occurring fish species in the Netherlands of which three disappeared Source: Hengelsportweb, 2010

### Status area

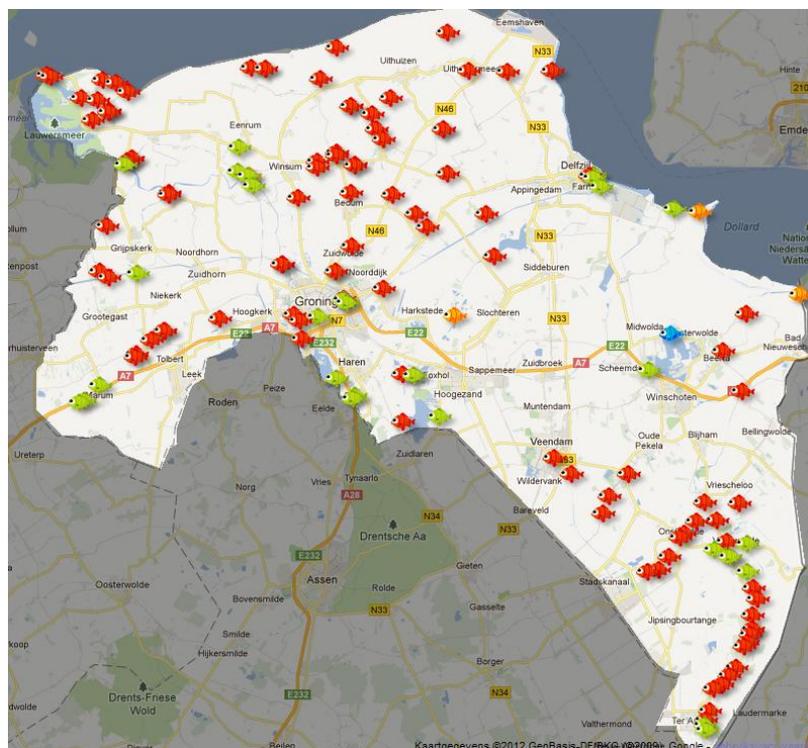
Areas indicated as Bird Directive and Habitat Directive are categorized as Natura 2000 areas (Synbiosys, year unknown). Bird Directive areas located in the province Groningen are Zuidlaardermeer area and Lauwersmeer area (fig. 4.7) (WUR<sup>1</sup>, 2010).



**Figure 4.7 Overview Bird and Habitat Directives found in and around the province Groningen Source: WUR, 2010 (scale unknown)**

### Barriers

Barriers are responsible for the fragmentation of rivers and affect migrating fish (Kroes *et al.*, 2006). To give an indication of the size of the problem in the province Groningen an overview of migration bottlenecks for fish are given (Muskens, 2010). A difference is made between current bottlenecks, partly solved bottlenecks, solved bottlenecks and possible bottlenecks for the future. Although measures are already taken to stimulate migration, the bottlenecks dominate in the area instead of free migration possibilities, especially in estuary zones (fig. 4.8).



**Figure 4.8 Migration bottlenecks in the province Groningen. Red fish: current bottleneck Orange: Bottleneck is partly solved Green: Bottleneck is solved Blue: Possible bottleneck in the future Source: Muskens, 2010 (scale unknown)**

### Historical information

Eels have a long history in the Netherlands. Archive documents showed that eels were exported from the Netherlands to England from 1364. The income of the western part of the Netherlands was for 25% generated by inland fishery in 1373. Migratory fish captured by sluices were an important part of this amount, especially eels who survived in the dirty water of the Middle Ages. In 1650 it was forbidden to export eels, the fatty fish served as food for the nation, as it was nutritious and relatively cheap. (NeVePaling,2012)

Around 1886 a game was introduced in the Netherlands with eels. They were bonded to a rope over the water by which the people should remove the eel by pulling on it. The game was prohibited due to its cruelty. Despite the prohibition, an eel-pull-game was organized in Amsterdam in 1886. Commotion came when the police tried to stop the games, which took 25 human lives. (NeVePaling,2012)

### Current eel population

Due to the lack of information, it is very difficult to estimate the eel population size in Groningen. It is known that eel population has been declining during recent years. Data of eel numbers obtained by fish stock samples and catches of professional fishermen are variable, and do not always correspond with the national trend. This can indicate a density variation of eels present in the inland water and along the coast. At the moment the precise density of eels in the province Groningen and its potential carrying capacity is unknown, but the data would be helpful by taking measures to stop their decline. (Schollema & Huisman, 2011)

### *Regional Eel Management Plan*

Development and management of the eel stock in the Netherlands is now coordinated on a national level and implemented on a regional scale. Due to variable situations on regional scale, it has been proposed to decentralize eel management and to let the regional managers be responsible for the management and measures for a sustainable eel stock. Waterboard Noorderzijvest and Hunze en Aa's, HSF and professional fishermen have indicated their advantages for a Regional Eel Plan. The plan will attempt to give insight into the influence of water management on eel stock, the present eel population, how many eels are removed annual et cetera. A grant of the Waddenfonds and cooperation of several organizations makes it possible to realize a Regional Eel Management Plan for Groningen and North Drenthe. The plan should be finished by the end of 2012. (Schollema & Huisman, 2011)

### **Main problem**

Including all background information of Groningen, the main problem for migrating fish in the area are the barriers. To control the land, Groningen is dependent on many weirs, sluices and power stations which affect fish migration. It is very expensive to construct fish passages at every barrier and the water board is restricted to a limited budget. (Huisman personal communication, 2012)

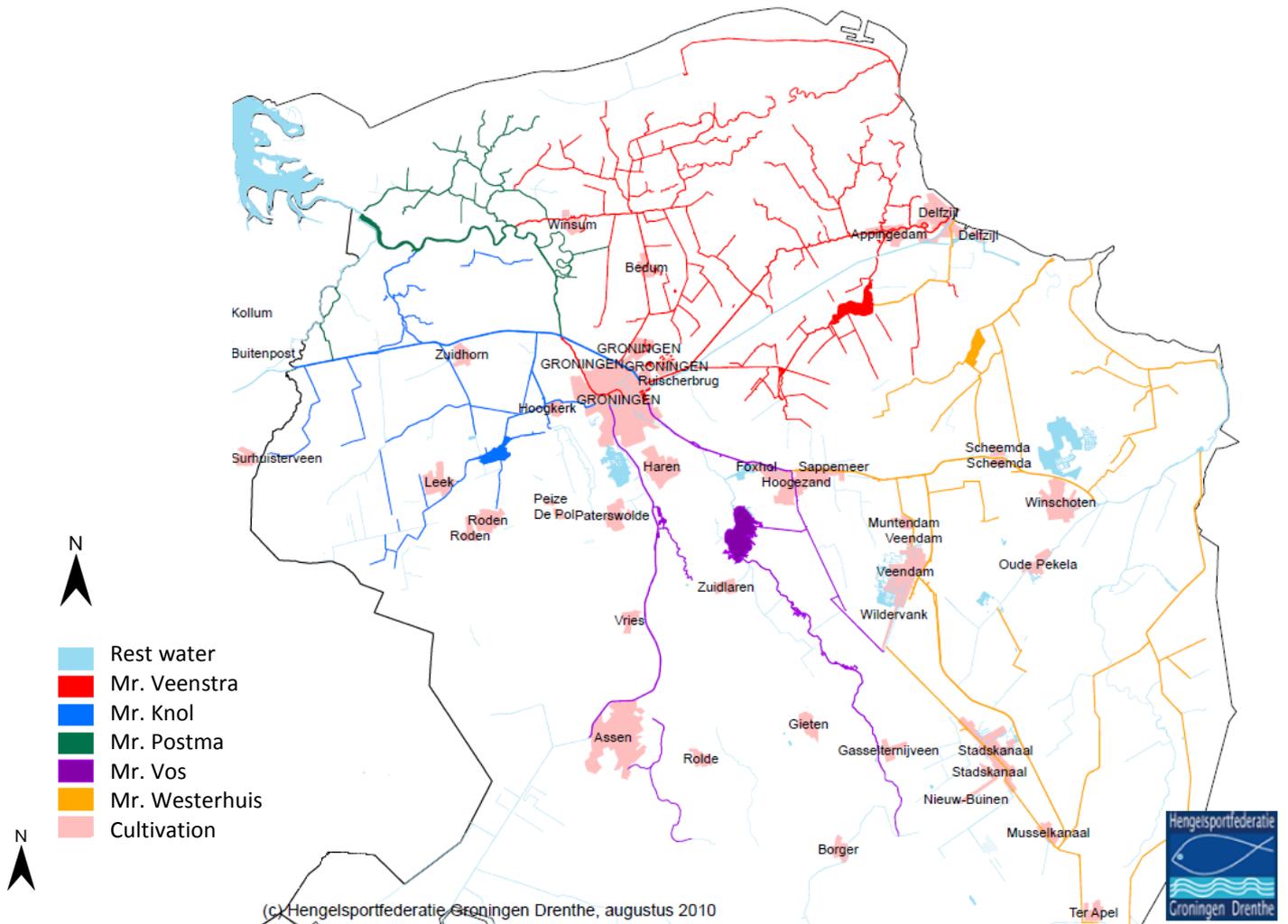
## **4.2 Current value**

According to the model given in the method, features for the direct as well as indirect value are used to describe the current value of the fish species. They are subdivided in different sections.

### **4.2.1 Employment**

#### Professional fishermen

There are five of the 250 national professional inland fisheries are located in Groningen which are directed by Hengelsportfederatie Groningen-Drenthe (fig. 3). These fisheries mainly fish on eel and pike perch, but also on other species (Sportvisserij Nederland, 2012). Three companies also smoke eels (fig. 4.9).



**Figure 4.9 Overview province Groningen and the fishing waters of professional fishermen. Green waters: Professional fishermen Postma, Zoutkamp Professional fishermen and company for smoking eels. Red waters: Professional fishermen Veenstra, Sebaldeburen. Blue waters: Professional fishermen Knol, Groningen Professional fishermen and company for smoking eels and other fresh water species Purple waters: Professional fishermen Vos, Noordlaren. Professional fishermen and eel smoker. Yellow waters: Professional fishermen Westerhuis, Borgsweer. Source: HSF, 2010 (scale unknown)**

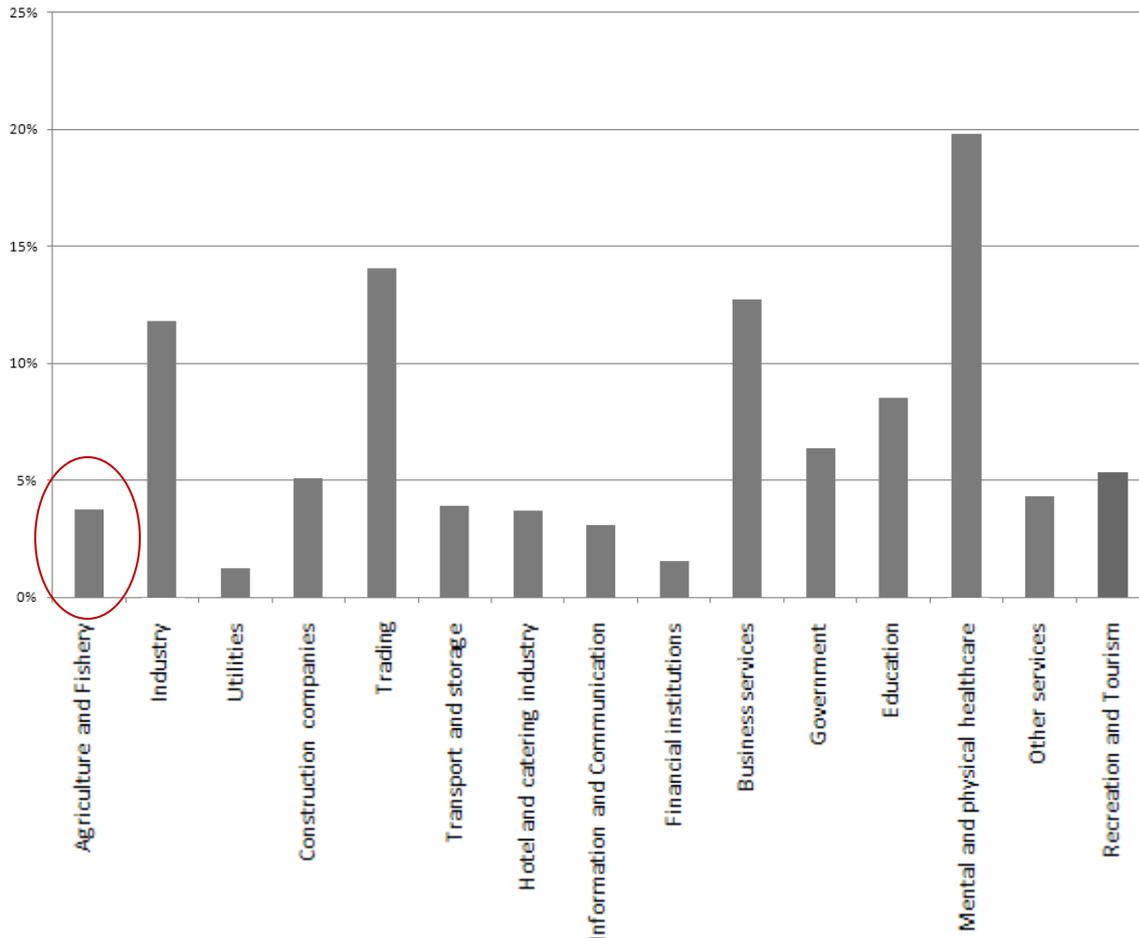
According to the law on fishery (Visserijwet) every professional inland fishermen should rent or own at least 250 hectare water and their yearly income of fishery should be more than 8500 euro gross (Sportvisserij Nederland, 2012). According to this amount, the income of professional fishermen in Groningen should at least be  $€8500 \times 5 = €42,500$  gross.

#### Anglers

Other than the professional fishers in Groningen, Hengelsportfederatie Groningen-Drenthe also directs many sport and recreational fishers: 50,945 members were registered by the organization in 2011 (HSF, 2012).

#### Agriculture & Fishery

The amount of eel related jobs that are created is unknown (excluding professional fishermen and fish farms). An overview of the employment percentage per sector in the area is given (fig. 4.10) to indicate the contribution per sector regarding their employment.



**Figure 4.10 Employment in Groningen per sector. Notable is the small amount of employment in the agriculture and fishery sector (red circle). Source: Toerdata Noord, 2011**

Although the Groningen area is mainly covered with agricultural land (64%) the agriculture and fisheries sector, which includes only professional fishermen, are responsible for only 4% for the employment in the Groningen province. The recreation and tourism sector includes all tourism combined and does not distinguish between general tourism and fishing tourism.

#### Amount captured fish

Professional inland fishermen were not obligated to report the amount of fish they captured which makes it very hard to give precise numbers (Dekker *et al.*, 2008). Several estimations of this amount of fish captured have been made, for the Netherlands as well as for the Dutch part of the Eems basin, present in the province Groningen (fig. 4.3).

IMARES, 2011 made use of real data and estimated annual catch of eel in the Netherlands on 640 ton red eel and 280 ton silvereel (table 4.2). Dekker *et al.* (2008) supports these estimations based on their collected data. Estimations were also made for rivers in the Netherlands. Relevant is the 38 km<sup>2</sup> surface of catchment area of the river Eems in the province Groningen. The catch of two professional fisheries on this river is estimated at three ton silvereel, based on results of EU journals (Dekker *et al.*, 2008). The Rijksoverheid (year unknown) estimated the annual profit of the inland professional fishery approximately €15 million.

Source	Whole Netherlands	Eems catchment area
IMARES, 2011	640 yellow eel 280 silver eel	
Dekker <i>et al.</i> (2008)	Widely 920 ton	Three ton silvereel (by two companies) in 2004
Rijksoverheid (year unknown)	Annual profit around € 15 million	

**Table 4.2 Estimated numbers of caught eel by professional fishermen Sources are given in the table**

The estimated numbers vary from each other. For this research the amount of caught eels in the catchment area of the Eems is most important, due to the position of Groningen located in the area. The number of two professional fishermen companies corresponds with number of fishermen registered in this area (fig. 4.9).

Fishing for eel by professional fishermen is prohibited for several months each year. In 2010, it was for three months, and in 2011 for two months. This measure was initiated by the government to protect eel during its migration and give them a better opportunity to migrate (Rijksoverheid, year unknown).

#### *Anglers catch*

Although sport fishermen are not allowed to take caught eels, their extraction is of a serious amount. Eels and trout are popular species to keep: based on internet interviews and previous researches the removal of eel by anglers is estimated for anglers fishing in the inland water as well as anglers fishing along the coast/ on sea (Vriese *et al.*, 2007). The removal of sea anglers is estimated around 150 ton. The removal by inland anglers is difficult to define due to the fishing intensity varying from moderate to intensive angler fishing. The total removal is estimated between 65 and 200 ton. Total removal by anglers in the Netherlands is estimated at 200 to 400 tons per year. The actual number is most likely closer to 200 ton. Wolkers (2011) estimated the total eel removal by anglers at 200 ton.

Fishing rules exist for anglers according to their fishery. It is forbidden to remove certain species such as eel, however other species are allowed to be fished and are only prohibited during certain closed months of the year (table 4.3). Fish would need to be a minimum size of: Chub - 30 cm; Ide - 30 cm; River Perch - 22 cm; Barbel - 30 cm; Rudd - 15 cm; Grayling - 35 cm; Dace - 15 cm; Tench - 25 cm; Pike - 45 cm; Flounder - 20 cm; Nose carp - 30 cm; Trout - 25 cm; Pike perch - 42 cm (Sportvisserij Nederland, 2012).

Fish species	Closed time during the year
Pike	1 March – 30 June
Barbel, Chub, Dace, Nose carp, Ide, Grayling	1 April – 31 Mei
Pike- perch, perch	1 April – last saturday in May
Brown trout, Arctic Charr, Brook trout	1 October – 31 March
Sea trout, salmon, eel	Whole year

**Table 4.3 Fish species and the months of the year catching is forbidden**

Source: Sportvisserij Nederland, 2012

#### Aquaculture

For a long time aquaculture on eels has existed in the Netherlands, and has been increasing during recent years in numbers and amount. 57 companies are estimated in 2005. Nowadays, Dutch aquacultures produce a serious amount of eel of the European eel production, almost 60%. Cultivation of eels is according to their volume and number of companies the biggest part of the Dutch Fish cultivation sector. (Van Diemen & Van Dongen, 2008) It is not possible yet to stimulate eel to reproduce in captivity (WUR<sup>2</sup>, 2010), glass eels are still needed for the aquaculture. They are

captured in the sea and transported to aquacultures. Therefore, eel aquaculture is still an unsustainable way for eel production (WNF, 2010). In the northern part of the province Groningen three eel aquacultures can be found in De Marne, Winsum and Bedum (EVF, 2009) (fig. 4.11). Also aquacultures in Leek producing Barramundi (*Lates calcarifer*) and Marum producing Catfish (*Silurus glanis*) are present.

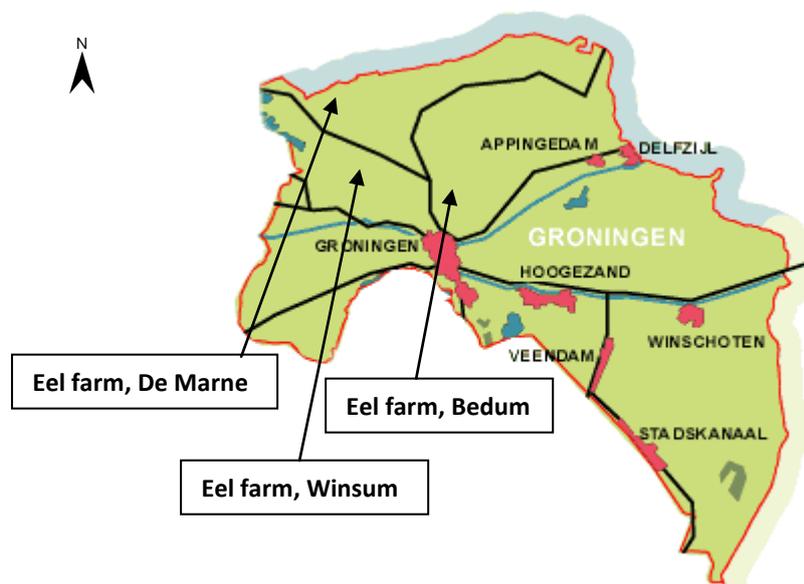


Figure 4.11 Location of eel farms in the province Groningen Source map: Prijt-priet, year unknown (scale unknown) Source farms: EVF, 2009 Modified by J. Marchal

Recirculation systems are most common by fish farming, described by Schram *et al.* (2006). The polluted water is purified and reused, only a small amount of 5-20% of the water is discharged and replaced by fresh water. The discharged water contains residues of dissolved and suspended material from food or excreted products of the fish.

#### Annual profit

Annual production of aquacultures is estimated by Dekker *et al.* (2008) based on data of the FAO (The Food and Agriculture Organization of the United Nations) as an average for 1995 – 2004. The results show a production of 3291 ton eels per year (fig. 4.4). Also numbers of estimations as addition of the FAO data are given, with a production of 3404 tons per year.

#### Export

There is no detailed data available of market statistics of eels (EIM & OVB, 2004), but information can be found of the export of eels (Dekker *et al.*, 2008). Dutch eel consumption is only a small amount of the production by aquaculture; a large amount is exported (Dekker *et al.*, 2008). Averages are used of raw reported data by the FAO from 1995 – 2004. The export is given with an amount of 1826 ton per year (fig. 4.4). Also numbers of estimations as addition on the FAO data are given, with an amount of 3652 ton per year. These two numbers vary widely, which indicates that estimated numbers are still inaccurate.

	Agriculture	Export
FAO data	3291 ton/ year	1826 ton/year
Addition on FAO data	3404 ton/ year	3652 ton/ year

Table 4.4 Production aquaculture and amount of export of eels per year. Data based on FAO data including an addition of estimations Source: Dekker *et al.*, 2008

### Local demand

The professional fishermen in the province Groningen also sell caught eels privately. Restaurants make use of this opportunity (Combinatie van Beroepsvissers<sup>2</sup>, 2010). The amount fishermen privately sell to local restaurants is not known.

### **4.2.2 Tourism**

#### Jobs

The amount of jobs generated by fishing tourism is unknown.

#### Promotion area

Selling eels or fishing on eels are the main eel related activities in Groningen. The village Zoutkamp has a long fishery history with a fishery museum since 1994, offering several activities such as a guided museum tours, boat trips, smoking eels, as well as suitable for hosting children parties and receptions. (Zoutkamp, 2012).

#### Income tourists

The spending of tourists in Groningen is recorded for different categories for 2010 (table 4.5). The overview includes all tourists, also the non-fishing tourists. In total tourist spent 2,263,000 nights in Groningen, divided over different accommodations.

Accommodations	Amount
Hotel/pension	530,000
Lodges and breakfast	38,000
Camping sites (touristic)	450,000
Camping sites (permanent)	462,000
Group accommodation (rent)	53,000
Recreation house (rent)	437,000
Second house	125,000
Water sport	168,000
Total nights	2,263,000

**Table 4.5 Number of night per category for 2010 Source: Toerdata Noord, 2011**

In total 31,100,000 day tours are given. Tourists spent daily €14.73, annual spending is €458,000,000 (table 4.6).

Amount day tours	31,100,000
Daily spending	€14.73
Spending yearly	€458,000,000

**Table 4.6 Day tourists expenditures, 2010 Source: Toerdata Noord, 2011**

#### Income sport fishery

There are no numbers of the profit of sport fishery in Groningen, but the sport is sufficient to a wide public: young, old, poor or rich (Scheper personal communication, 2012). Qualitative good equipment is available from €300 - €500 (Visclub Lint, 2012), however lower priced equipment is also available.

#### *Fishcard*

Anglers need to be member of an organization connected to the HSF before they are allowed to fish in waters of the Groningen province. They have to buy a fish card to get permission for their activities. Fish card prices differs between adults and youth (fig. 4.7). There are in total 1707 youth members in the category up to 13 years and 14 - 18 years. Youth up to 13 years are also able to fish

for free with one angle and one of the selected baits, therefore the assumption is made that all 1707 youth members are 14 - 18 years old. The total income of license for sport fishing in Groningen and Drenthe is €1,097,385 by which HSF Groningen and Drenthe gain €384,155 and Sportvisserij Nederland gains €713,230. (Scheper personal communication, 2012)

Data of 2011		Price fish card		Income HSF	Income Sportvisserij Nederland
Angler members	50,945				
Adults	49,238	€21.75		€381,594.5	€689,332
		HSF:	€7.75		
		Sportvisserij Ned.:	€14		
Youth 14 – 18 year	1707	€15.50		€2560.5	€23,898
		HSF:	€1.5		
		Sportvisserij Ned.:	€14		
Youth t/m 13 year		Fishing mostly for free			
Total profit				€384,155	€713,230
Total profit HSF and Sportvisserij Nederland €1,097,385					

**Table 4.7 Profit anglers of HSF Groningen – Drenthe of license by the fish card Source: Scheper personal communication, 2012**

#### National profit

Netherlands' fresh water angling associated employment produces between 1460 and 2505 fulltime jobs and has a total profit of €363 - €601 million (Smit *et al.*, 2004). Most of the anglers buy their material by angler sport shops which have an annual retail of €58 - €83 million (Van Es, 2002). Anglers spent €577 annual in different categories (table 4.8).

Category	Amount per year
Fish food and artificial bait	€156
Unsustainable angle material	€98
Sustainable angler material	€93
Traveling costs	€69
Food and drinks	€69
Use of the boat	€58
Rest	€34
Total	€577

**Table 4.8 Expenditure sport fishermen in the Netherlands Source: Smit *et al.*, 2004**

As the data are based on averages per angler, an assumption can be made for expenditures of anglers in Groningen- Drenthe: 50,945 x €577= €29,395,265 annually.

#### 4.2.3 Developments

The vision of the Marien Stewardship Councils is that the world's oceans are full of life and seafood supplies are to be safeguarded for this generation of for the future. MSC-labelled seafood originate from and can be traced back to a sustainable fishery. For eel fishery it is not possible (yet) to fish in a sustainable way since the population is threatened and numbers have been declining for years now. (MSC, 2012)

Fisheries can influence the composition of species. Big and older individuals are the most vulnerable for fishery, which means that fishery can cause rejuvenation of the population and increase the amount of younger fish (Werkgroep Vistand Beheer, 2003).

### *Cooperation for fish stock*

The Dutch Besluit Binnenvisserij, policy for professional inland fishery, is an important policy document. The aim of this policy is to involve fishermen to manage the fish stock. In contrast to Groningen where the HSF directs the fish licenses, the government directs fish license of inland water in the rest of the Netherlands. Several waters now have committees to manage the fish stock: visstandbeheercommissies (VBCs). According to the fishery, combined with professional fishermen and sport fishermen, responsible for a good management of the inland waters (Pvis, 2011)

### Monitoring

Since eels are threatened species in the whole of Europe and it is not (yet) possible to let them reproduce in captivity, there is no sustainable way to catch them (WNF, 2010). To gain more knowledge of eel biology and use this information for conservation of the European eel stock, a scientific research project has been started named Eeliad (Eeliad, 2008). Previously, satellite tags used for migrating animals were too big for eels. A new designed satellite tag gave new perspective for eel research since it is suitable for eels larger than 90 centimeters.

According to research of the University of Leiden, different tunnels are built with varying temperature, air pressure and currents to investigate eels energy use and swimming behaviour by measuring oxygen use and recordings in the tunnels. This data will be used to improve suitable transmitters used in eels swimming to the Sargasso Sea. (Universiteit Leiden, 2012)

### **4.3 Potential value**

The main migratory fish problem of water board Noorderzijlvest was that migration possibility between inland water (rivers) and the sea are not optimal or not present. It is impossible to remove obstacles, such as pumping stations and weirs, however constructing fish passages is a solution. Yet, financial limitation remains an obstacle as they are restricted to a limited budget.

The potential value for Groningen are efficient fish passages at their barriers. Water board Noorderzijlvest set itself as goal to solve migration bottlenecks in the prior waters of their management area before 2015 (Kroes, 2006). Target species includes species of standing water as well as streaming water. The water board contributes also in the project for free access for fish species such as the project supported by the Waddenfonds (Waddenfonds) (Noorderzijlvest, 2008), by making three pumping stations at sea with its weirs accessible for migrating fish. These measures improve the ecological conditions for fish. The amount of fish can increase by a better ecology and generates more income.

### **4.4 Eel in Groningen**

The area Groningen has suitable area for eels although the general water quality is insufficient. The agricultural land is mainly responsible for the enrichment of the water. According to monitoring data and information of professional fishermen information of the eel population is gathered.

There are five professional eel fishermen active and three eel aquacultures (export) (EVF, 2009). Anglers need to be member of an organization connected to the HSF before they are allowed to fish in water of the province Groningen and Drenthe. Their fish card allows them to fish on eel and other fish species, although they have to release caught eels again (Scheper personal communication, 2012). The income of license for 50,945 angler members generated more than one million euro. Material expenditures are known for anglers in the Netherlands, they spent annual €577 on material. The assumption can be made of angler expenditures in Groningen – Drenthe:  $50,945 \times €577 = €29,395,265$  annual.

Potential for eels is mainly generated by fish passages by barriers to stimulate migration and lower the amount of harmed eels.

Although anglers have benefit of a good ecological status of the water, the angler organization focuses more on anglers and angler federations. Federations serve the interests of the anglers, who

would like to fish with as less limits as possible is as many waters as possible. Sportvisserij Nederland, 2012 The money federations receive, is mostly spent on better conditions for anglers instead of the ecology of the water for better conditions for the fish species.

The assumption of expenditures of anglers in Groningen – Drenthe (Smit *et al.*, 2004) with an amount of €29,395,265 annual, is spent in different categories as income for companies and not specific on the ecology of the water.

The socio-economic value of eel for Groningen is generally based on anglers. A relation to the social value of eel can be seen by its cultural position. In the past (1373) income of western Netherlands was for 25% generated by inland eel fishery (NeVePaling,2012). Nowadays the sector fishery and agriculture contribute for only 4% to the employment in Groningen (Toerdata Noord, 2011).

Since eels have a strong cultural position, money and effort is given and programs are developed to stop their decline and restore the eel stock.

River Odense  
 Current situation: +/-  
 Main species: sea trout

## 5. Odense

An important species for Funen is sea trout. In the beginning of the twelfth century people wanted to control water by building dams and use the water force for mills. These developments prevented sea trout to reach their natural spawning sites upstream and with that their possibility to reproduce. Later, habitat for sea trout has been destroyed by the expansion of the industry and more intense agriculture. Polluted water by industry entered the rivers and water courses were straightened and made deeper to discharge water of the land without taking into account the consequences for plants and fish in the watercourses. It also gave trouble to sea trout; the fish had disappeared in one third of the rivers and only a few could be found in the rest of the watercourses during the sixties. Sea trout Fyn, a project between the ten municipalities on Funen started in 2007, has the vision to develop the best place for coastal sea trout fishing. Their strategy is to maintain the positive impact on the people of Fyn from sea trout and to extend the project. (Kjeldsen, 2011)

### 5.1 General area description

#### Geography

Odense is a city of 15 km<sup>2</sup>, located on the island Funen of 2985 km<sup>2</sup> (in Danish Fyn) (fig. 5.1). Through the city flows the River Odense, in Danish Odense Å, which has a total length of 60 km (Hasler *et al.*, 2009) and a catchment area of 485,9 km<sup>2</sup> (Kronvang *et al.*, 2003) (fig. 5.2). It passes Odense and flows the last 2,5 km until it mouths in the Odense Fjord which is connected to the Kattegat (Hasler *et al.*, 2009). The two islands Langeland and Ærø, south of Funen, are part of the region Funen.



Figure 5.1 Overview of the region Funen, Denmark (within the red circle). Source: Hotelara, 2007



Figure 5.2 Overview of Odense with the River Odense (yellow) streaming through, mouting in the Odense Fjord. Source: Hasler *et al.*, 2009 (scale

#### Land use

Dominant land use in Odense River Basin is represented by farmland (68%); about 1800 farms are registered of which 900 are live stock farms, mainly having pigs and cattle. The other 32% is divided in urban areas (16%), woodland (10%) and semi-natural area (6%). (Dubgaard *et al.*, 2007)

#### Kind of water

Odense River Basin encloses 1046 km<sup>2</sup> divided in 1100 kilometer open water course and 2600 lakes and ponds (Hasler *et al.*, 2009), three lakes occupy already an area more than three hectare each (Country of Funen, 2003). River Odense covers an area of 630 km<sup>2</sup> (Dubgaard *et al.*, 2007). 98% of the

streams are canalized (Aarestrup *et al.*, 2010) causing excess erosion and sediment transport (HELCOM<sup>1</sup>, 2011).

#### Water quality

Water of River Odense (fig. 5.3) is classified as poor to moderate quality, most of the river is in a moderate state, although the moderate water quality and the size of sea trout stock has increased during the last decades, for example due to the regulation of the sea fishery. By this the river does not fulfill the Water Framework Directive requirements of a good ecological status. The environmental status of lakes found within the river basin also have a poor quality and stay below the good ecological status of the WFD. (Hasler *et al.*, 2009)



**Figure 5.3 River Odense Source: Hostick, 2005**

#### Water quantity

Discharge of the River Odense is between the minimum of 0.25 m<sup>3</sup> per second till a maximum of 36.5 m<sup>3</sup> per second. The average flow is 5.36 m<sup>3</sup> per second.

#### Possible occurring species

Suitable habitat places for fish species are for example created by differences in discharge in River Odense. Also the brackish water originated where River Odense mouth into the fjord creates suitable area for many different species. Migrating species use this water to adapt to salt concentration differences (Kroes *et al.*, 2006). Examples of fish species that can be found are the spined loach (*Cobitis taenia*) and brook lamprey (*Lampetra planeri*) both species of protection (Dubgaard *et al.*, 2007). Other species present in River Odense are ide (*Leuciscus idus*), pike, roach (*Rutilus rutilus*), eel, sea-trout, trout and zander (*Stizostedion lucioperca*) (Visit Denmark, year unknown).

#### Status area

The river does not belong to the Natura 2000-network or is not classified as an index river. The area is used as research area for several projects. Two examples are the Fjord Water Management Plan (BERNET, 2006) and the project by which economic benefits and ecological status of the water is assessed for Odense River Basement (Hasler *et al.*, 2009).

Relevant legislation for Denmark according to fishery are the Ministry of Fisheries and Ministry of the Environment (Aarestrup *et al.*, 2010).

#### Barriers

Barriers impede migrating fish (Kroes *et al.*, 2006). The bottlenecks are showed to give an overview of the problem on Funen (fig. 5.4). A difference is made for current obstacles for fish and fauna and the established free passages/ removed obstacles. In the main streams of the island 219 obstacles are registered, 189 obstacles are already removed or passage is established (76%) and 450 km of the 580 km main stream is accessible. Close to the place where River Odense mouths in the fjord, is the combined heat and power plant Fynsværket located. It uses large amounts of fjord water as cooling water. This heated salt water is afterwards released into the lower reach of the River Odense. (Kjeldsen, 2011)

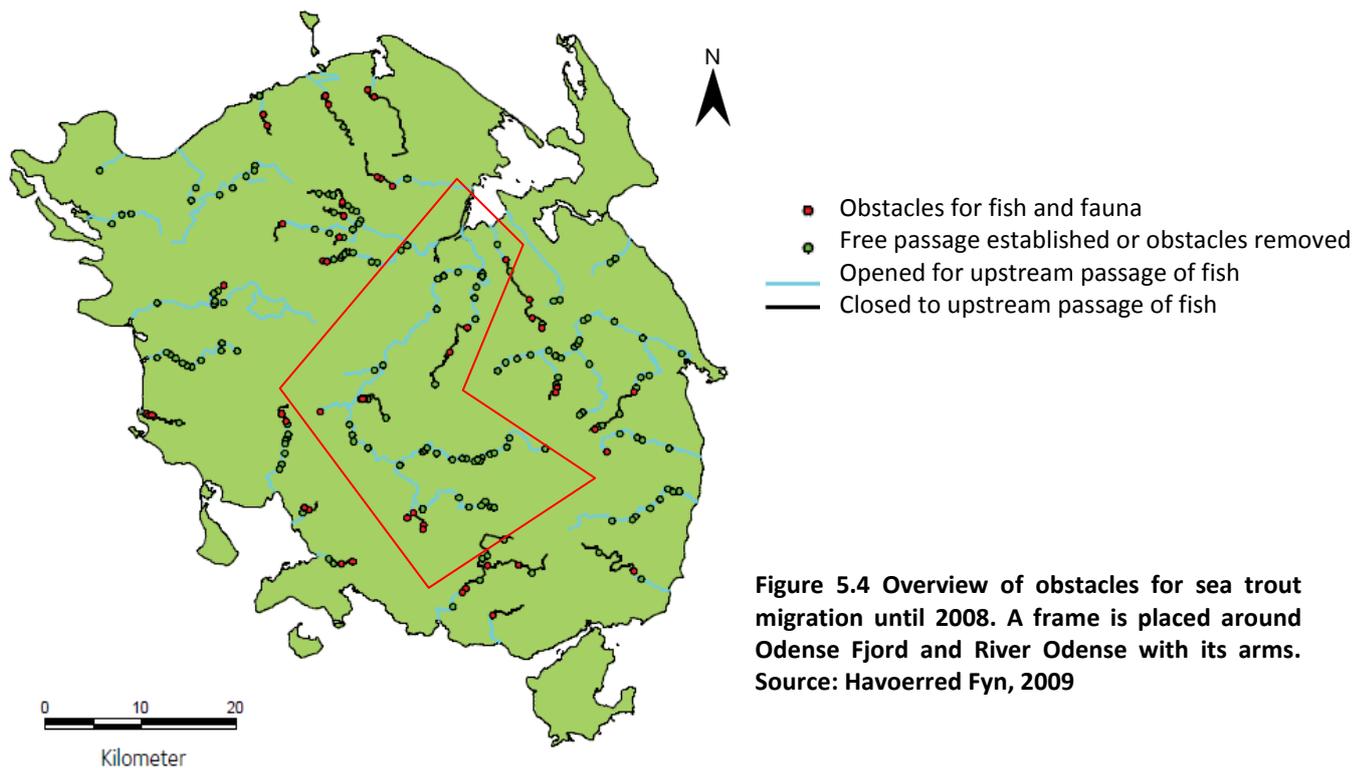


Figure 5.4 Overview of obstacles for sea trout migration until 2008. A frame is placed around Odense Fjord and River Odense with its arms. Source: Havoerred Fyn, 2009

### Loss of smolts

In the past many water mills were built into the area causing migration obstacles for sea trout. Many obstacles does till exist, especially in smaller rivers on the island Fyn. (Hasler *et al.*, 2009). Aarestrup *et al.* (2010) investigated the average loss of smolts by three different barriers (table 5.1; fig. 5.5), forming bottlenecks for migrating fish. Especially smolt loss at hydropower stations is high.

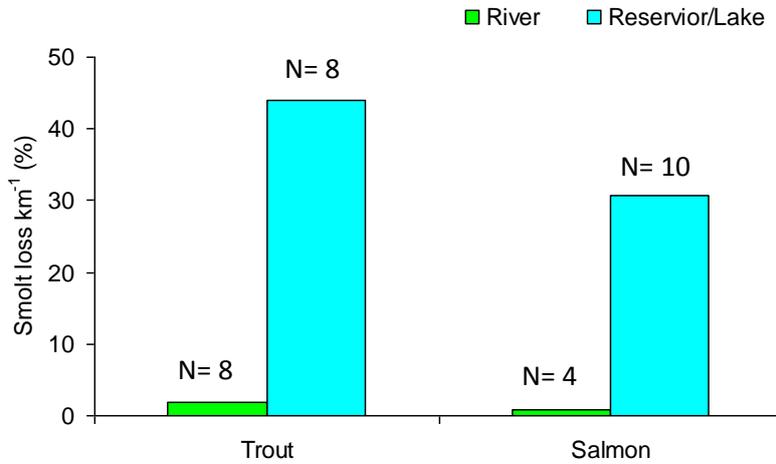
Types	Number investigated	Average smolt loss (%)
Mills	5	30
Hydro Power stations	7	82
Fish farm	38	42

Table 5.1 Smolt loss at barriers Source: Aarestrup *et al.*, 2010



Figure 5.5 Picture of a mill, Denmark Source: Kjeldsen, 2011

Besides average loss of smolts due to barriers, also average smolt loss per kilometer in rivers and reservoirs/ lakes is investigated (fig. 5.6) (Aarestrup *et al.*, 2010). Remarkable is the loss of trout in reservoirs/ lakes. Smolt loss in rivers is for both trout and salmon low.

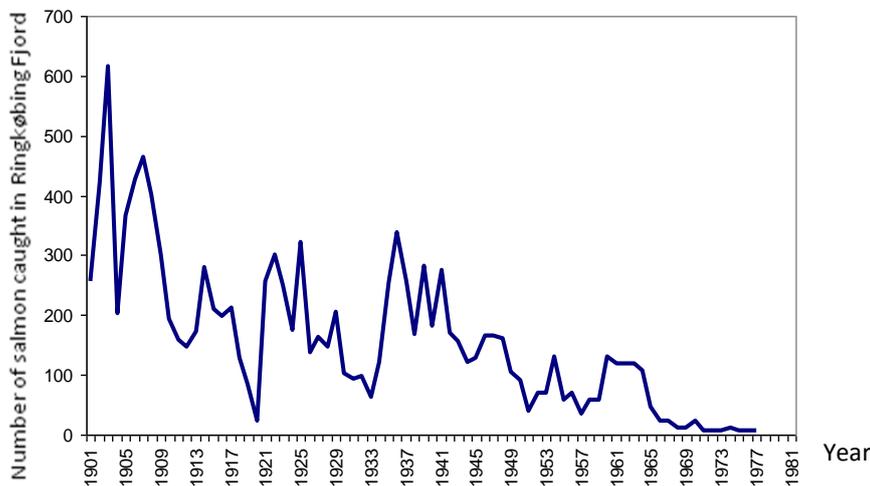


**Figure 5.6 Smolt loss at barriers Source: Aarestrup *et al.*, 2010**

Historical information

In the past, sea trout could move freely upstream only meeting natural barriers. Man made barriers were placed by mills in 1000 till 1850. Later hydropower development came, in 1920 till 1970, overlapping with presence of fish farms, 1894-1975. These barriers took many smolts and caused habitat loss, habitat degradation and damaged migration. (Aarestrup *et al.*, 2010)

Since long sea trout and salmon are captured in Denmark. A trend of salmon catch is given in the Ringkøbing Fjord located at the west coast of Denmark (fig. 5.7). Salmon catch decreased drastic over years, a signal that measures has to be taken to stop this decline and pretend the local extinction of the species.



**Figure 5.7 Trend of salmon catch in Ringkøbing Fjord at the west coast of Denmark Source: Aarestrup *et al.*, 2010**

Current population

Sea trout reproduced in more places in Funen water compared with the years before. Although, the population status of sea trout did not improved in a number of sites so improving migration possibilities still needs to be done. Reasons for the absence of status improvement can be the barriers which disturbed migration and spawning possibilities for sea trout. (Hasler *et al.*, 2009)

HELCOM<sup>1</sup> (2011) investigated Danish salmon and sea trout rivers flowing in the Baltic Sea, including River Odense. The reproduction area for sea trout covers 118.6 hectare with an annual production of 93.92 smolts. The recent wild smolt production is thereby estimated on 96%.

Seatrout Fyn (Havoerred Fyn, 2009) is responsible for the release of approximately 3.5 million trout smolts during the period 1999 to 2009. This was done to stimulate the trout population. The smolts were all produced at the Funen plant Fyns Laksefisk released into the mouths of the watercourses of Funen. Release in this place of the river mouth is essential to let the fish return to this place for spawning because migrating smolts make an association with specific watercourses. All trout released by Fyns Laksefisk after 2001 have been 'wild'; they are offspring of wild captured trout in watercourses of Funen, a requirement of DTU Aqua since 2006 to realize "Fish from Funen in the waters of Funen".

### **Main problem**

According to the description of the River Odense and its catchment area, the main problem for migrating fish species are the barriers in the river. Many are constructed with a fish passage but the efficiency is not 100%. When several barriers have a smolt loss of 5%, the total smolt loss in the river can be very high even though fish passages are established. Another problem is the stowing of water on the river. To control water a dam is placed, controlled by a power station by which a small lake is created. A fish passage is made to give migrating fish the opportunity to pass safely, but the lake gives problems to downstream migrating smolts. It disorientates them so they cannot find the fish passage and are not able to pass the dam. (Kjeldsen personal communication, 2012) This corresponds with the investigation of Aarestrup *et al.* (2010) indicating a high smolt loss for trout and salmon in reservoirs/ lakes (fig. 5.6).

## **5.2 Current value**

According to the model given in the method, features for the direct as well as indirect value are used to describe the current value of the fish species. They are subdivided in different sections.

### **5.2.1 Employment**

#### Professional fishermen

There are no professional fishermen on Funen fishing on sea trout, the fish is only captured as by catch. There are now two fishermen of the Odense fjord registered (Kjeldsen personal communication, 2012).

Sport- and recreational fishing is done a lot on Funen (Kjeldsen, 2012). To ensure good angling, the focus changed more to natural trout spawning to enhance the sea trout population instead of releasing large numbers of young sea trout fishes into the river mouths what was done before (Andersen, 2010).

#### Amount captured fish

There are now two professional fishermen registered fishing in Odense fjord who do not necessarily have to report the whole catch (Kjeldsen personal communication, 2012) which makes it not easy to give the total amount of captured fish.

Anglers have a catch limit they are able to keep; maximum of three trout per fisher per day with a minimum length of 45 centimeters (national length is 40 centimeters) (HELCOM<sup>1</sup>, 2011). A survey (Sparrevohm *et al.*, 2011) on the recreational fishing in Denmark investigated captures for whole Denmark for both sea trout and eel:

*Sea trout:* For anglers in Denmark sea trout is the most important species, both caught in marine and fresh water. Although in Denmark 734,000 sea trout's were released, 600 ton (about 330,000 fishes) are landed in 2010.

*Eel*: Recreational eel fishing in freshwater does exist but it mainly takes place in salt water by which fishermen make use of fyke nets. Also commercial eel fishery captures are low; captures from lakes are only 2% till 3% compared to the total removal. Since eel fishing can be carried out legally for all landowners along rivers and lakes, the intensity of the freshwater fishing is unknown.

### Aquaculture

Fyns Laksefisk is the only place cultivation of fish is accomplished, there are no fish farms in the area (Havoerred Fyn, 2009; Kjeldsen personal communication, 2012). The hatchery is build to obtain fish for release in the watercourses of Funen over a period of 20 year. The hatchery is in use since 2001. All sea trout for Funen waters are produced here. The nutrient enrichment water of the hatchery is used on surrounding fields so the plant is non-polluting. It is also used as visitors centre for fishermen, politicians and professionals of the aquaculture industry. Also (foreign) tourists visit the plant for which some guided tours are organized. (Havoerred Fyn, 2009)

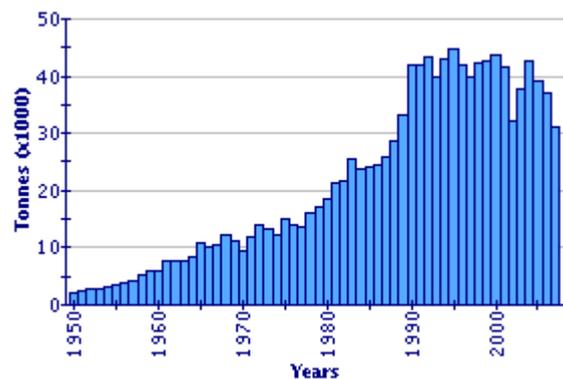
### Export

Sea trout produced in the fish hatchery Fyns Laksefisk is only used for watercourses on Funen, not for export (Havoerred Fyn, 2009). Production of fish on farms is done in other places in Denmark. All freshwater fish farms in Denmark are located on Jutland (fig. 5.8) in the western part with the most abundant flowing streams. (FAO, 2012) Denmark had about 140 trout farms in 1994, primarily producing for export. The two great wars destroyed the production but afterwards farming came back; there were 337 freshwater pond farms again in 2003. (FAO, 2012)



**Figure 5.8 Overview of Denmark with Jutland and Fyn Source: Wheelchair holiday, 2012**

Nowadays, the bigger part of the Danish freshwater trout production is sold with a size of 250-350 grams weight. Fish juveniles are also produced in special hatcheries and sold for further growing in fresh water ponds, marine culture units, for restocking purposes and a small amount for angling. An indication of the amount of tones fish of aquaculture production over the years is given for Denmark (fig. 5.9). (FAO, 2012)



**Figure 5.9 Tons trout produced by aquaculture in Denmark Source: FAO, 2012**

### Local demand

Since aquacultures in the area only produces fish for the water course (Havoerred Fyn), expected is that there is no market for local demand. It is possible that local restaurants buy fish from the professional fishermen fishing in the fjord but there is no data of this.

## **5.2.2 Tourism**

### Jobs

Tourism in Funen generates in total 28.3 full time jobs in different trades (Havoerred Fyn, 2009).

### Promotion area

Funen profiles itself as a really fine fishing area, with rivers, lakes and coast line suitable for angling. Angling is free for persons younger than eighteen years and older than 65 years, persons with the age between eighteen and 65 needs a fishing permit for fishing in natural waters. Angling holidays are offered including sea fishing. Three star camping sites offer special tables for cleaning own fresh caught fish. (Visit Odense, 2012)

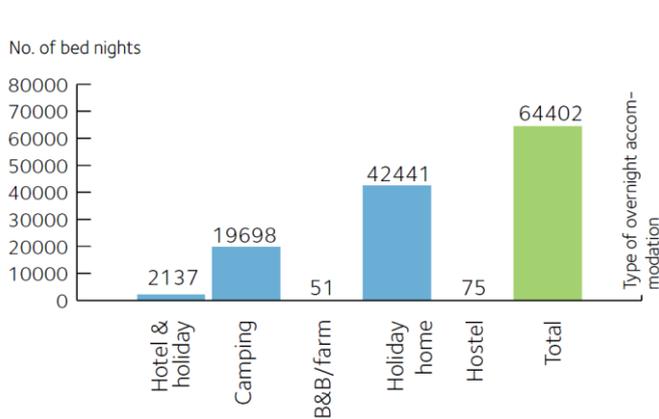
### Income tourists fishing on sea trout

Odense municipality is an important place for tourists, which can be seen at expenditures of tourists in municipalities on Funen (table 5.2) including the two little island located south of Funen: Langeland and Ærø (fig. 5.1). 39% of the expenditures of tourists on Funen, Langeland and Ærø is spent in the municipality of Odense. The other ten municipalities contribute which a much lower amount.

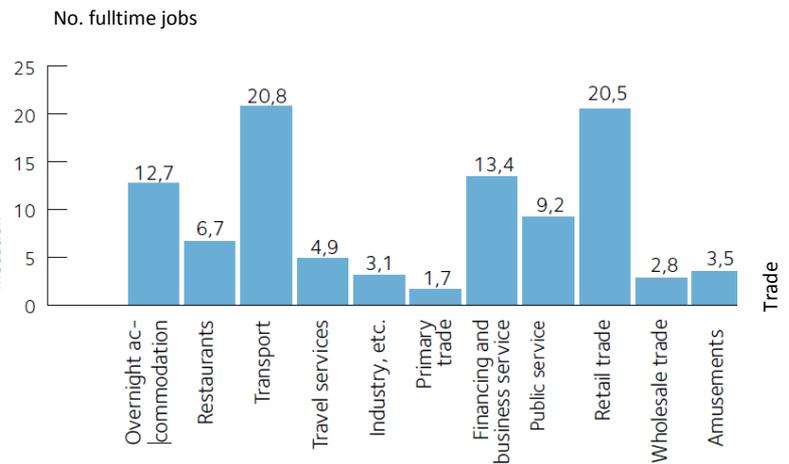
	2007	2009
Total expenditure of tourists in the region of Funen: Funen, Langeland and Ærø	3,616,000 DKK	3,800,000 DKK
	€486,376.27	€511,125.50
Expenditures divided by the number of inhabitants in the municipality of Odense	1,410,000 DKK	-
	€189,654.46	-

**Table 5.2 Total expenditure of tourists in the region of Funen: Funen, Langeland and Ærø and the expenditure divided by the number of inhabitants in the municipality of Odense Source: Havoerred Fyn, 2009**

A study (Evaluation, 2008) on the generation of tourists fishing for sea trout on Funen, shows that tourists used at least 64,400 bed night in 2007 (fig. 5.10). Annual 28 fulltime jobs are created in 11 compartments (fig. 5.11), dominated by transport (20.8%) and retail trade (20.5%).



**Figure 5.10 Number of sea trout anglers staying overnight analyzed by type of accommodation for the year 2007 Source: Evaluation, 2008**



**Figure 5.11 Tourism on Funen generates in total 28 fulltime jobs. Contribution of different sectors to the turnover is given for the year 2007 Source: Evaluation, 2008**

Other key figures of tourists fishing on sea trout are given over different subjects (table 5.3). The total spending is divided in spending per vacation, daily spending and spending on fishing gear. The turnover for whole Funen for 2007 is € 5 million creating over 28 fulltime jobs.

Subject	Amount
Bed nights	64,400
Spending per vacation	€ 650
Daily spending	€ 95
Spending fishing gear	€ 30 per day
Turnover	€ 5 million (+unknown)
Job creation	28.3 full time

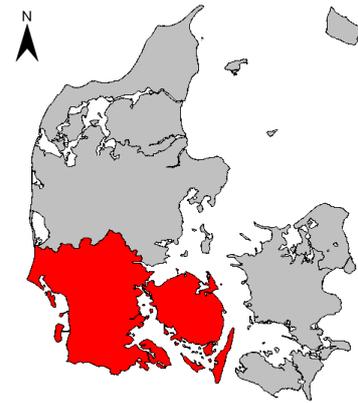
**Table 5.3 Tourism key figures for Funen, 2007 Source: Evaluation, 2008**

### Income sport fishery

Funen is part of the region Syddanmark (fig. 5.12). The numbers given (Ebert personal communication, 2012) are therefore relevant for a bigger area than only the island Funen. In total 38,314 anglers in the region Syddanmark had a license for 12 months in 2010, which corresponds with 25% of whole Denmark (The Directorate of Fisheries, 2011 by Ebert personal communication, 2012). Besides that, week- or day license are bought by approximately 50,000 persons in Denmark.

Total income for whole Denmark was 25,6 million DKR (€3,443,287) for 2011. The income will be higher for 2012 due to the rise in price for the license with an estimated profit of €4,371,360.4 for whole Denmark for 2012.

Corresponding with the amount of license of 25% regarding whole Denmark, the assumption can be made that also 25% of the total profit counts for Syddanmark, which can be calculated on €860,862.



**Figure 5.12 Region Syddanmark including Funen Source: Valentinian, 2006**

### **5.2.3 Developments**

Since there are no professional sea trout fishermen present in River Odense a health mark for sustainable fishery cannot be practiced. Sea trout is captured as by catch and on an illegal way (Kjeldsen personal communication, 2012). There is no information about the amount.

### Monitoring

ICES (International Council for the Exploration of the Sea) investigated sea trout populations in the Baltic Sea, where sea trout is mainly captured as by catch. Most of them are captured in the first two years of their lives, before they did reach sexual maturity. Tagging data indicated that less than 5% was three sea-winters old or older of the catch in the last 15 years. Data of recreational catch is mainly unknown but can be of a considerable amount. (ICES, 2010)

After tagging sea trout, telemetry can be carried out. This method knows its advantages and limitations. The advantage is the gathered data, however this method is the only way that this data can be collected. The results are clear and easy to explain. Limitations of the method are the low numbers of investigated sea trout. The fishes are also affected: the tagging and handling can affect their welfare. Finally, it is very expensive and intensive work. (Aarestrup *et al.*, 2010)

### **5.3 Potential value**

Although many barriers are already removed or made accessible (76%), many barriers are still present (fig. 5.4). The reproduction of wild sea trout smolts does not reach yet their production capacity, there is high potential to increase wild sea trout production. HELCOM<sup>1</sup> (2011) investigated that the potential annual smolt production can reach an amount of 853 smolts compared with the current annual production of 93.92 smolts. 96% is estimated to be wild smolt production.

Most potential are the barriers and their efficiency. Also downstream migrating smolts should find their way to the fish passage when they reach the dam with its lake (Kjeldsen personal communication, 2012). Measures has to be taken which lowers their loss in the lakes.

### **5.4 Sea trout in River Odense**

In summary, the water of River Odense has a poor to moderate water quality. Sea trout does reproduce in the catchment area although many barriers are still present. Especially hydropower stations are responsible for a high smolt loss.

No professional fishermen or aquacultures are active in River Odense. Syddanmark sold 38,314 sport fishery licenses with a profit of 860,862 euro. Sea trout fishing tourists generates annual 28.3 fulltime jobs with an income of annual five million euro.

The investigated reproduction area is 118.6 hectare with an annual reproduction of 93,92 smolts. Potential reproduction capacity is calculated on 853 smolts annual, but restocking of smolts of wild captured sea trout is also done in the water courses by Sea trout Fyn.

The €5 million spent by tourists visiting Funen to fish for sea trout is divided by subjects (Evaluation, 2008). There is no information or the money is spent to improve the conditions for sea trout such as improving the ecology of the water conditions.

Besides tourists expenditures, income of licenses is generated. The purpose of this money, assumed to be €860,862 for Syddanmark, is not given (Ebert personal communication, 2012).

The socio-economic value of sea trout in River Odense is generally based on tourism visiting the area for fishing on sea trout. From cultural point of view sea trout has a strong position (Aarestrup *et al.*, 2010); since long they can be found in the river which is also used to promote the area (Havoerred Fyn, 2009).

## Ätran

Current situation: +/-  
Main species: salmon & sea trout

## 6. Ätran

Farming and salmon fishing were the major trade in the town Falkenberg into the mid 19th century. Fishing was in all likelihood carried out in the river Ätran. The good fishing opportunities brought many English men to the town, described in a book in 1884. At the end of the 19<sup>th</sup> century 20% of the income in the town was gained by fishery. Nowadays the river still offers good salmon angling, amplifying the local economy. (Falkenberg, year unknown).

### 6.1 General area description

#### Geography

On the south – west coast of Sweden the municipality of Falkenberg can be found. Through the city Falkenberg (fig. 6.1) the river Ätran flows (fig. 6.2). The Ätran is a medium-sized salmon and sea trout forest river with a total length of 243 km mouthing in the Kattegat. It has two tributaries Högvadsån and Fagerredsån. The river is fed by Lake Lönnern, passing Lake Åsunden and flows through a narrow valley to Falkenberg. (HELCOM<sup>2</sup>,2011)

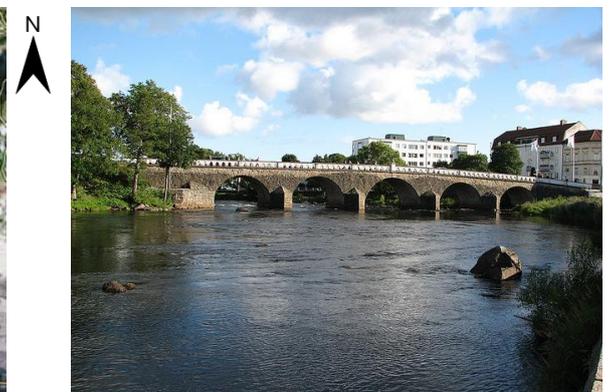
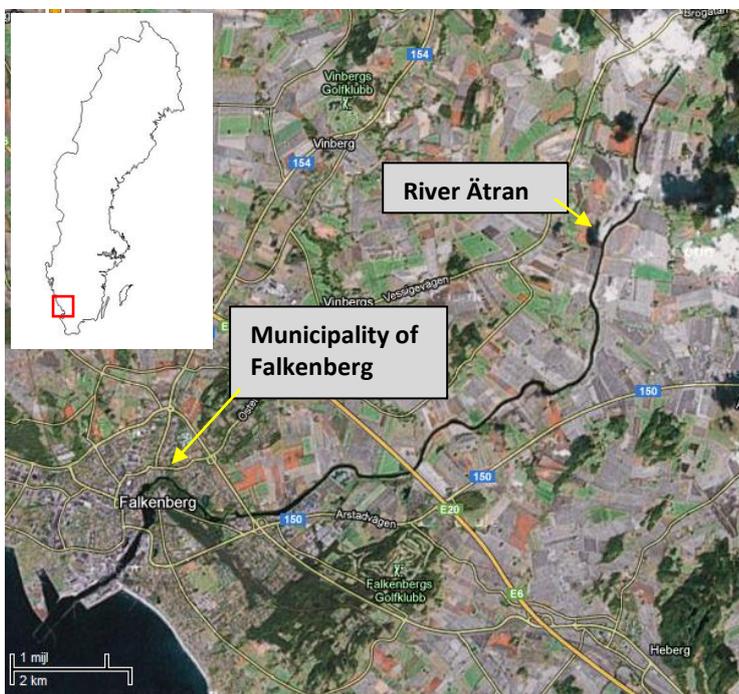


Figure 6.2 River Ätran Source: Galdramadur, 2008

Figure 6.1 In the left corner an overview of Sweden with an indication of the location of Falkenberg. The picture gives an overview of the municipality of Falkenberg, Sweden. River Ätran flows through the city and mouths in the Kattegat. Source: Google Maps ©, 2012 & Maps gps, 2011 (scale unknown) Modified by J. Marchal

#### Land use

Total catchment area of river Ätran is 3342 km<sup>2</sup> divided in forest (57%), agricultural lands (17%) and lakes (6%) (HELCOM<sup>2</sup>,2011).

#### Kind of water

Along the Ätran river many lakes can be found (Municipality of Falkenberg, 2011). The rapid streams in its way are used for hydropower production (HELCOM<sup>2</sup>,2011).

#### Water quality

River Ätran functions as index river for the west coast of Sweden (IP, 2007). The water of the river is acidified and infected with the ectoparasite *Gyrodactylus salaris* since the early 1990's. Acidification is the most strong in the upper parts of the catchment area; intensively liming takes place in lakes, wetlands and tributaries which are connected to the Ätran to stop this acidification (HELCOM<sup>2</sup>, 2011). Estimations show that approximately 75% of the natural salmon smolt production would be lost without liming (Fiskeriverket, 1999). Although the acidification, river Ätran got an good chemical

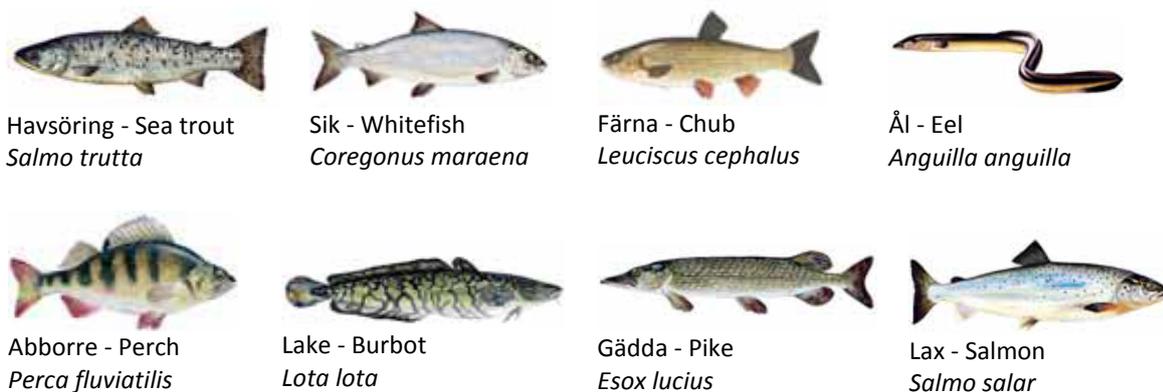
status (excluding mercury) and a good ecological status (HELCOM<sup>2</sup>, 2011). The municipality of Falkenberg also use the river for drinking water (Municipality of Falkenberg, 2011).

#### Water quantity

The average flow of river Ätran is 51 m<sup>3</sup> per second, the daily lowest flow is much lower: 2.25 m<sup>3</sup> per second (HELCOM<sup>2</sup>,2011).

#### Possible occurring species

Many species can be found in different parts of the river Ätran (fig. 6.3). Differences can be found between species in habitat preference or appearance during the year. Most likely more fish species can be found. Especially the brackish water where the Ätran enters the Kattegat creates suitable area for many different species. (Brochure Falkenberg, 2010) In the past also many local Cod *Gadus morhua* were present in large amounts. Local populations disappeared almost completely by overfishing (Alenäs personal communication, 2012).



**Figure 6.3 Overview of fish species which can be found in different parts of the Ätran river. The Swedish, English and Latin name is given. Source: Svensk fisk, 2010**

In the beginning of 1900 eel fishery was very important for local people along river Ätran. Lots of people living in the upper part of the river, in the woodland, were dependent on eels. Now only a small amount is left. In the upper part of the Ätran fishing on eel is still allowed because glass eel area is not affected. (Alenäs personal communication, 2012)

#### Status area

Due to extensive protection the salmon stock remained successfully. The Ätran is due to its unique salmon stock chosen as indicator river by the Swedish Board of Fisheries, the arm Högvasån is protected within the Natura 2000-network. (HELCOM<sup>2</sup>, 2011)

No official water management plan is established, but measures will be taken to continue liming and to improve the functioning of fish ways. (HELCOM<sup>2</sup>, 2011). The Rivers Database NASCO (2000) indicates that river Ätran is not threatened with loss.

Aquaculture, fish transfers and stocking (including that of crustaceans and mollusks) are regulated by several different authorities: there is no specific national legislation for this which makes the responsibility for issuing of the various permits quite complex (Carlstrand & Lettevall, 2009).



**Figure 6.4 Dam at Herting Source: Municipality of Falkenberg, 2011**

### Barriers

Salmonids used to be able to migrate freely from the Kattegat 31 km upstream until they meet a natural obstacle at Yngeredsfors, which they can only pass at high water. Today salmonids are only able to migrate 26 km upstream until the power plant at Ätrafors. The plant does not have passages so fish cannot pass the plant. In the city Falkenberg another power plant, Herting (fig. 6.4), can be found. (HELCOM<sup>2</sup>, 2011). A fish way is placed here since 1945, making passing possible, but fish still die due to the presence of the power plant (Municipality of Falkenberg, 2011).

Further upstream after the powerplant Ätrafors is a small fish farm located (Ekeberga kvarn), also being a barrier for migrating fish. The production is mainly brown trout (Carlstrand & Lettevall, 2009).

### Historical information

From cultural point of view salmon is an important species, especially because fishing on salmon takes place since the 18th century (Falkenberg, 2012). The river and its tributaries offer good spawning sites for salmon and sea trout. Since smolts make a specific association with a watercourse during migration and generally return to that place for spawning (Havørred Fyn, 2009), salmon and sea trout return every year to the river for spawning.

### Current population

Years ago, around 1920 – 1940 the amount of glass eel entering river Ätran was estimated on one million. Only a small proportion of the amount of glass eels entering the river is left; their number is estimated on 12,000. (Alenås personal communication, 2012)

There are 23 rivers on the Swedish west coast producing wild salmon. The present total reproductive area for the whole west coast is assessed to be 250 hectare. Calculated is that it will be possible to include another 50 hectare. To make annual reproduction possible in all potential spawning areas measurements are planned such as habitat rehabilitation, control the amount of water flow and reestablishing the areas. (IP, 2007)

River Ätran and its tributary Högvadsån keeps unique salmon stocks: Ätran salmon reproduces along the main river and in the tributaries Högvadsån, Fagerredsån and Hjärtaredsån. The salmon may reach weight up to 15 kg (SLRG, 2011). Although stocking was carried out previously, the salmon are probably virtual unaffected with elements of exogenous external genes. Restocking (release of fish) has been carried out from 1965 till 1985. It was even done on a river flowing into the Baltic Sea in 1923 but because Ätran is the only index river at the west coast of Sweden research on salmon is focused on this river. Due to liming in the river the number of salmon increased but rapidly decreased again in 1990's, most probably due to a combination of factors. Responsible can be the outbreak of the ectoparasite *Gyrodactylus salaris*, drought, lower survival rate at sea and sporadically high aluminum levels. (HELCOM<sup>2</sup>, 2011)

All 23 rivers are investigated on present salmon smolts in 2007, including river Ätran (table 6.1). The mean wild smolt production between 2005 – 2009 is estimated for salmon on 27,500 in an area of 54.9 hectare and for sea trout on 1500 individuals in an area of 27 hectare (table 6.1) (HELCOM<sup>2</sup>, 2011). Salmon production does not reach the possible capacity of 54,870 salmon smolts.

	Salmon	Sea trout
Reproduction area <sup>(1)</sup>	54.9 hectare	27 hectare
Number of smolts (2007) <sup>(2&amp;3)</sup>	37,600	-
Estimation of mean wild smolt production between 2005-2009 <sup>(1)</sup>	27,500	1500
Production capacity <sup>(1)</sup>	54,870 smolts	-

**Table 6.1 Salmon and sea trout production numbers Source: 1: HELCOM<sup>2</sup>, 2011; 2: IP, 2007; 3: Carlstrand & Lettevall, 2009**

An estimation of the production potential of a river gives information of the population of fish but is also of importance for funding. A basic requirement for local organizations in western Sweden for receiving government funding for habitat protection and restoration in a river, is that the estimated production potential should be at least 1000 wild salmon smolts per year (Carlstrand & Lettevall, 2009).

### *Parasite*

Infection of the ecoparasite *Gyrodactylus salaris* was first documented on salmon in the western part of Sweden in 1989. A monitoring program started in 1990, noticing an increase of infected rivers namely on the southern part of Sweden. To prevent spreading of the infection to new rivers, restrictions on fish farming, fish transport and stocking were introduced in 1999 and 2003. (Carlstrand & Lettevall, 2009) River Ätran is part of the monitoring program started in 2011, checking big rivers annually (IP, 2007).

### **Main problem**

The main problem of river Ätran is located 26 km upstream of the river: the power plant at Ätrafors. The municipality of Falkenberg does not have permits of the plants, as they do have for the plant Herting located in the municipality. The plant at Ätrafors does not want to change, move or construct a fish passage, although it closes the entrance to suitable area for salmon, sea trout, eel and other fresh water species.

The hydropower station pays in total 60,000 SEK (€6717.8) to landowners as compensation for their dam and barrier by releasing British elvers (stage between glass eel and yellow eel) upstream of the river. The unforeseen consequence of moving the eels is that it disturbs their compass. They are disorientated and are not able to find their way out of the river to migrate to the Sargasso Sea. On the other hand, the station pays 5 SEK per eel (€0.56 per eel) to release them in lakes of land owners where they naturally not appear. This measure is taken to keep the landowners satisfied by fishing on eels. The best would be a bypass at the hydropower station so they do not have to pay annual for releasing eels, but as it seems that the hydropower station is not willing to realize a fish passage. (Alenäs personal communication, 2012)

## **6.2 Current value**

According to the model given in the method, features for the direct as well as indirect value are used to describe the current value of the fish species. They are subdivided in different sections.

### **6.2.1 Employment**

#### Professional fishermen

No professional fishermen are present in the river Ätran (Alenäs personal communication, 2012). Since long salmon fishing takes place in the river; in the 18th century it was one of the most important sources for income in the area. Now it has been exploited by commercial and recreational fishing. The open season for fishing is dependent on the river location. In general fishing on big salmon is carried out from the end of April until beginning of June. After that period the smaller salmons are fished until September (Falkenberg, 2012).

#### Amount captured fish

Since no professional fishermen can be found on the river Ätran, no data is available of caught. It is possible that salmon, sea trout and maybe other species are caught illegal but there are no numbers of estimations of this (Alenäs personal communication, 2012).

The open season for fishing is dependent on the river location; below the bridge Tullbron from the first of March or above the bridge Tullbron after 29 March, where sea trout is the main fish species to catch. Later in April/ May, the larger salmon is popular. Mid June the hunting on smaller salmon starts, entering the river at this time. Allowed fishing techniques are spinning and fly-fishing. Autumn

fishing for salmon is not allowed after late September, when they are protected to stimulate spawning. (Falkenberg, 2012)

Sport fishermen caught 375 salmon in the southern part of river Ätran in 2011 (Molander personal communication, 2012).

Many different rules and legislation can be found in Sweden, changing per region. Since September 2012 anglers are not allowed to keep caught eels. (Alenäs personal communication, 2012) Sport fishermen are allowed to keep other catches (Falkenberg, 2012), although there are some rules. Kelts (salmon that has spawned) must be released immediately and there is a limit of two anadromous fish, salmon or sea trout, per day.

#### Aquaculture

Due to the lack of suitable sites for salmon farming, the Atlantic salmon was not criticized to be an important species in the Swedish aquaculture industry; there are no salmon farms present in the sea or river mouths of the river Ätran (Carlstrand & Lettevall, 2009).

The two present small fish farms mainly produce trout. There is a small fish farm present in the Ätran behind the power plant Ätrafors, mainly producing brown trout (Carlstrand & Lettevall, 2009). In the upper part of Ätran at Åsarp, Ekeberga, another small fish farm on trout is located mainly farming to preserve genetically important strains of the local trout population (Alenäs personal communication, 2012).

Stocking measures and aquaculture activities are under strict control of qualified authorities to minimize possible effects on wild stocks and the risk of spreading diseases. A permit is required of The Count Administrative boards for all stocking and aquaculture activities. New aquaculture business in salmon rivers is banned by regulations of the Swedish Board of Fisheries. (IP, 2007)

#### Export

There is no export of salmon from the Ätran River (Alenäs personal communication, 2012).

#### Local demand

There is no local demand for salmon from the Ätran (Alenäs personal communication, 2012).

### **6.2.2 Tourism**

#### Jobs

Key figures on tourism cannot be divided in general tourists and fishing tourists. 1570 full time jobs are generated by tourism, but in reality the amount of jobs is very high in summer and low in winter including many part time jobs. (Molander personal communication, 2012)

#### Promotion area

The Ätran is classed as a valuable nature area with a great variety of species. Together with its tributaries, the Ätran forms the most important area for salmon spawning on Swedish west coast, offering one of the best places for salmon fishing. (Municipality of Falkenberg, 2011)

#### Income general tourism

The yearly income of the city Falkenberg generated by tourism on salmon fishing is estimated on 5 million SEK ( $\approx$  €568,899.00) (Municipality of Falkenberg, 2011).

The turn over generated by general tourism is 2,400,000 SEK (€267,358.64). This amount increased with 81% regarding the period 2003 till 2010. This growth is mainly caused by the department store, attracting people from a wide region. (Molander personal communication, 2012)

### Income sport fishery

300,000 licenses are sold annual for sport fishing on salmon in the municipality of Falkenberg. The average price is about 100 SEK (€11.20). The profit can be calculated on 30,000,000 SEK (€3,359,128). The prices for licenses are kept low on purpose, to give everybody the opportunity to fish. (Alenäs personal communication, 2012)

### **6.2.3 Developments**

Along the coast salmon species of different stocks are captured. The way of capturing is not sustainable (Alenäs personal communication, 2012). Important are illegal catches, there is no data of the amount what is removed illegal.

#### *Cooperation*

The municipality of Falkenberg cooperates with several organizations such as the University of Karlstad, Board of Fisheries, County of Halland and even more organizations (Alenäs personal communication, 2012).

The Swedish Board of Fisheries (SBF) organizes a range of seminars to demonstrate and encourage the restoration of the salmon rivers in the west of Sweden. Habitat restoration seminars are offered twice each year. A seminar with excursion took place to relate to the ongoing restoration in the river Rolfsån in 2007. A similar meeting took places and was related to the ongoing restoration of the upper parts of the river Nissan in 2008. These seminars are attended by consultants, university staff and regional and local authority staff. A seminar was arranged in the town of Falkenberg in 2009 focusing on river Ätran. (Carlstrand & Lettevall, 2009)

#### Monitoring

Besides the monitoring program of *G. salaris* in the Swedish west coast other national monitoring programs are extended, also including small rivers. Considered will be the comparison of populations in some rivers to find out or the present rate of fishery is acceptable for the populations. New data from the river Ätran will be reported annual to the Swedish board of fisheries. (Carlstrand & Lettevall, 2009)

### **6.3 Potential value**

The power plant at Ätrafors is now the first artificial obstacle for upstream migrating fish (HELCOM<sup>2</sup>, 2011). Fish are not able to pass this plant at the moment. The next obstacle is five kilometers further upstream, formed by a natural obstacle. The best would be an efficient fish passage at the power plant at Ätrafors, but it is very hard to realize this since they have their permits already a very long time and they compensate their damage in an inefficient way.

Besides that, the current estimated reproduction is much lower than the estimated potential (table 6.2), although essential elements already are implemented in the Ätran such as trapping, surveys and salmon fishery controls in the river. An estimation is carried out for the amount of salmon after four years (2011) when more measurements are applied to improve migration and reproduction. (IP, 2007). As far as available data is accessible, the population numbers are not estimated again, so the effect of the measurements cannot be investigated yet.

	Present (2007)			Future (2011)		
Ätran	Number of smolts	Area (ha)	Smolt/100 m <sup>2</sup>	Smolt	Area (ha)	Smolt/100 m <sup>2</sup>
	37,600	54,9	6,9	91,500	64,8	14,1

**Table 6.2 Estimated numbers of salmon smolt present (2007) and estimated numbers after applying measurements (2011) Source: IP, 2007; Carlstrand & Lettevall, 2009**

The statement of the municipality of Falkenberg is to give everybody the opportunity to fish. Therefore they keep the prices for fishing license low. Not everybody agrees with this; it is a good aim but the amount of permits sold is very high (300,000) and anglers are allowed to keep two anadromous fishes each day, resulting in many fishes being removed annually.

#### **6.4 Salmon and sea trout in the Ätran**

The catchment area of the Ätran consists mainly of forest (57%). The river is acidified but has a good chemical and ecological water quality. Its arm Högvadsån is protected within the Natura 2000-network. The river contains an unique salmon stock but also sea trout and eels can be found. The area offers suitable habitat for reproduction, including suitable growing habitat for eels (Alenås personal communication, 2012). There are no professional fishermen, only two fish farms producing trout for genes, so there is no export or local demand. Fishing tourism generates annual €568,899 to the municipality of Falkenberg.

The area does have more potential according to available spawning sites for salmon and sea trout (IP, 2007; Carlstrand & Lettevall, 2009). Investigated number of salmon smolts present are 37,600. In the available reproduction area the current salmon reproduction of 27,500 does not reach its estimated production capacity of 54,870. Expansion of the populations can strengthen the local economy and with that their economic value. Opportunities are present by the power plant at Ätrafors, but it is not expected that they construct a fish passage and contribute to fish migration in another way (Alenås personal communication, 2012).

Another opportunity is situated in the license for fishing tourism. The price of a license is cheap to give everybody the opportunity to fish. The amount of sold licenses is very high. A higher price will support the local economy. The money can also be used to improve the ecology of water of the river Ätran.

Tourism in general generates €568,899 to the municipality of Falkenberg. These expenditures are done in different categories and companies and not specific to improve the water quality for fishes. There is no information of the spending of the money generated by the sale of licenses to sport fishing tourists, but the municipality of Falkenberg does spent money to improve conditions for migratory fish since they are member of the LNS project. Assumed can be that a certain amount of the income by licenses is spent to improve the ecology of the water but there is no information of the amount.

The socio-economic value of salmon and sea trout in river Ätran is generally based on tourism fishing in the area generating income for the municipality. Both are the main species of the river (Municipality of Falkenberg, 2011), used to promote the area. In the past people were dependent on fishery upstream of the river, giving them a strong cultural position.

## 7. River Tweed

River Tweed has the reputation to be one of the greatest places for salmon fishery. History of sport fishing reaches back to the 17<sup>th</sup> century where anglers have been sport fishing for salmon run. An important step in this history was the arrival of the 'loose line' which made it possible to land even bigger salmon. (Fish Tweed, 2012) Today, the Tweed is still known for its salmon, emphasizing to have one of the best wild stocks of Atlantic salmon in Europe (Bissett *et al.*, 2010).

Different organizations take care of the River Tweed; to decrease pollution of the river and improve the water quality (JNCC, year unknown). They also work on the access for salmon, sea trout and other fresh water species by make it more easy to pass artificial obstacles. (Tweed Foundation<sup>1</sup>, 2012). The management structure is described for better understanding (Tweed Foundation<sup>2</sup>, 2012).

### *River Tweed Commission (RTC)*

The RTC is the only Fishery Board in Scotland, charged with the general conservation and increase of trout, salmon and sea trout as well as other freshwater fish species. They represent the controlling commission including representatives of fresh water fishing associations and clubs or persons concerned with the use of waters of the River Tweed.

### *The Tweed Commission*

The Tweed Commission is the leading body which consists of 81 members. 38 of them are chosen each year by the Fishery Proprietors. The other 43 are selected by the local authorities: Scottish Borders Council and Berwick Upon Tweed Borough Council, 23 from local angling clubs and 20 not from an organization but with independent interests. The Commission meets four times a year, giving annual assessment on the Owners of all Fisheries used to employ Water Bailiffs and offers the back-up equipment and administration.

### *The Tweed Committee*

The Tweed Committee is generally planned to represent different interests in the River, assist and give advice to the chairman of the Commission. The membership of the Committee contains minimum eight and maximum twelve man, representing different parts of the River Tweed.

### *The Tweed Foundation*

The Tweed Foundation is a charitable organization set up by the River Tweed Commission in 1983. Their aim is to promote and develop salmon and trout stocks in the Tweed River System.

## 7.1 General area description

### Geography

The River Tweed is the second largest river basin in Scotland, with a total catchment area of 5000 km<sup>2</sup> (fig. 7.2) representing with its catchment area about 15% of all spawning water available to Atlantic salmon in Scotland (Bissett *et al.*, 2010).

The River Tweed (fig. 7.1) and its tributaries offer a wide diversity of habitats, supporting several flora and fauna. Different composition of the Tweed is caused by the different characters of the main tributaries, due to differences in topography and geography. (Bissett *et al.*, 2010)



Figure 7.1 River Tweed Source: Walley, year unknown



**Figure 7.2** The catchment area of the River Tweed before it mouths into the North Sea, with the names of the villages along the river. The Tweed is partly border between Scotland and England Source: Tweed Forum, 2005 (scale unknown)

Land use

Only 1% of the River Tweed is covered with broad-leaved deciduous woodland (JNCC, 2011). Tweeds catchment area contains for 81% agricultural land. The lower part of the Tweed valley is mainly covered by farmland, while the upper part of the valley is dominated by sheep- and beef farming. Especially agricultural land influences the water quality. Tweed catchment area was chosen by the Forestry Commission as one of the first area for large scale conifer planting after the Second World War. In combination with tax regulation, area covered with forest increased from 4.6% in 1947 till 17.4% today. This forest is heavily dominated by foreign species such as Sitka Spruce. (Bissett *et al.*, 2010)

Kind of water

The catchment area of the River Tweed contains different kinds of water; tidal rivers, estuaries, mud and sand flats and lagoons. The inland water bodies are standing, running and contains bogs and fens. (JNCC, 2011)

Water quality

The Scottish Environment Protection Agency (SEPA) is responsible for the water quality of the Tweed and measures the water. A good water quality is important for fish species but also for many touristic activities, recreation and other water supply purposes. Monitoring results found that 56% of the river water bodies in the catchment area of the River Tweed have a good or high water quality, 31% have a moderate quality and 13% have a poor till bad quality (fig. 7.3). Water bodies with a moderate, poor or bad quality are affected by nutrient enrichment on different degrees. (Bissett *et al.*, 2010)



**Figure 7.3** Overview water quality in Tweed catchment area, data of 2008. Colours indicate the water quality. Red: bad Blue: poor Yellow: moderate Green: good Blue: high Source: Scottish Environment Protection Agency, 2012

### Water quantity

The average flow of the River Tweed is 16m<sup>3</sup> per second in the upper part of the river and 65m<sup>3</sup> per second in the lower part of the river. SEPA (Scottish Environment Agency) is responsible for the water flow and water level. A reduction in the river flow can cause habitat loss, hinder for migrating fish or a reduction in available spawning sites. (Bissett *et al.*, 2010)

### Possible occurring species

Possible occurring fish species in the River Tweed are brown trout, grayling, Atlantic salmon, sea trout and lampreys (Bissett *et al.*, 2010).

### Status area

According to the Habitat Directive, special areas of conservation (SACs) are selected forming a network. A strict requirement relies on the selection, designation and protection of these areas. River Tweed is selected as SAC. (Tweed Catchment, 2005; Bissett *et al.*, 2010). Within that SAC is the river classified with an Atlantic biogeographically status (JNCC, 2011).

Relevant legislation (Bissett *et al.*, 2010) for the catchment area are:

Local Biodiversity Action Plans	Tweed & Eye Fisheries Management Plan
Scottish Borders Tourism Action Plan	Northumberland's Area Tourism Management Plan
Scottish Borders Woodland Strategy Till	Catchment Abstraction Management Strategy

### Barriers

In the main stream caulds (dam in river or stream) are present that remain from industrial use; such as the dam on river Ettrick, a main tributary of the Tweed from where most of the early returning salmon breed (Young personal communication, 2012). This one will be repaired, paid by a new hydro turbine with new fish pass (see also the section 'cultural position').

The RTC took care of migration obstacles for free access for salmon to their spawning areas. Almost all obstacles in the larger streams are open now since 190 years. Concentration will now be on the smaller streams, also the ones only used by trout. (RTC<sup>1</sup>, 2012)

### Historical information

Fisheries Management on the Tweed began in 1805, called "The Western Association of Noblemen and Gentlemen for procuring due observance of the Laws respecting Fisheries in the River Tweed, nowadays known as River Tweed Commission. Realizing the importance of smolt run already, access for upstream migrating salmon was and is one of their major concerns.

The experimental Committee, 1852 – 1875, was born to collect information about the habits and nature of the different kinds of salmon attending the rivers and the bordering sea-coasts.

There was some confusion about the different stages of smolts changing to adult fish those days. It took many years to find out it was the same species and convince anglers. (Tweed Foundation<sup>2</sup>, 2012)

The dam at river Ettrick, already mentioned as barrier, is a dam remaining from industrial use. It has been in the river for 150 years now and its condition is very poor. Under some conditions the run of fish is hindered, however a repair is very costly and people are concerned about moving it above the town of Selkirk. As compromise the dam will be repaired, paid by the development of a hydro turbine including a new fish pass. (Young personal communication, 2012)

### Current population

Detailed information of the River Tweed is given according to a Standard Data Form for SACs, including its salmon population by which four different criteria are used (JNCC, 2011).

*Population:* This criterion evaluates the relative size or density of the population in the River Tweed regarding the national population of salmon.

*Conservation:* Conservation takes two criteria into account; conservation degree of features of habitat important for the salmon and restoration possibilities. Both are important for the final degree for conservation of salmon in the River Tweed.

*Isolation:* This criterion is a measure of contributing salmon in the River Tweed to the genetic diversity of and the fragility of this salmon population.

*Global:* This criterion refers to the global value of the area according to the conservation of the species.

Assessing the salmon population gave a high score (table 7.1). The river contains 0% till 2% of the national population. Their conservation is good, not isolated and with a excellent global value.

Criteria	Category	Explanation category
Population	C	0% - 2% of the national population can be found in River Tweed
Conservation	B	Good conservation: elements well conserved independent of the grading of the possibility of restoration
Isolation	C	Population not-isolated within extended distribution range
Global	A	Excellent value

**Table 7.1 Value criteria River Tweed as SAC area Source: JNCC, 2011**

#### *Parasite*

No infectious disease, or the ektoparasite *Gyrodactylus salaris*, was found in fish of River Tweed. There was found a disease, affecting the covered layer of the skin. Most probably the fishes entered the river already infected with the disease. It was thought that factors responsible for the rise of the bad skin condition were the warmth of the water with the many fish of August and September together for a longer period than usual. (RTC<sup>1</sup>, 2012)

#### **Main problem**

The main problem for migrating fish species in the River Tweed are present barriers. The River Tweed Commission takes care of fish passages but these are not 100% efficient. Improvement of passages is necessary to let as many fishes as possible pass safely. (LNS partner meeting, 2012)

## **7.2 Current value**

According to the model given in the method, features for the direct as well as indirect value are used to describe the current value of the fish species. They are subdivided in different sections.

### **7.2.1 Employment**

#### Professional fishermen

There are 150 salmon fisheries on the River Tweed. Employment is given to less than 60 people directly as the majority are sport fisheries (Young personal communication, 2012).

#### Amount captured fish

The River Tweed Commission reported salmon and sea trout catch. Not all captured fish is taken from the rivers; in total 8926 salmon and 4488 sea trout were removed for 2011 (table 7.2 and 7.3).

Salmon 2011			
<b>Total caught:</b>	20,836 by net and rod & line		Amount:
<u>net:</u>	4154	In-river nets 100% returned	567
		Taken:	<b>3587</b>
<u>rod and line:</u>	16,682	68% of rod catch returned	11,343
		Assumed to be taken	<b>5339</b>
		Spring rod caught <sup>1)</sup> :	3072
		97% returned:	2991
<b>Total number of salmon removed from the river:</b>			<b>8926</b>

Table 7.2 Caught salmon in River Tweed in 2011 Source: RTC<sup>1</sup>, 2012

1) Spring rod caught is done till the end of June

Sea trout 2011			
<b>Total caught:</b>	5608 sea trout by net and rod & line		Amount:
<u>net:</u>	3109	Assumed to be taken	3109
<u>rod and line:</u>	2499	45% of rod catch returned	1120
		Assumed to be taken	1379
<b>Total number of salmon removed from the river:</b>			<b>4488</b>

Table 7.3 Caught sea trout in River Tweed in 2011 Source: RTC<sup>1</sup>, 2012

### Illegal

Important also is the amount of illegal catch. There are no estimated numbers of fish of this amount, although the amount of illegal nets is increasing (RTC<sup>1</sup>, 2012): 78 nets were recovered mainly from estuary.

### Aquaculture

There are three registered fish farms in the area (Yonge personal communication, 2010). There is no detailed information available of the farms.

### Export

There is no export of salmon of the Tweed but illegal rod captured salmon is sold. The amount of this catch is unknown. (Yonge personal communication, 2010)

### Local demand

There is a local demand but it is very small (Yonge personal communication, 2010). Exact numbers are not known.

## 7.2.2 Tourism

### Jobs

Salmon fishing on Tweed generates over 500 full time jobs to the local community (Bissett *et al.*, 2010; Young personal communication, 2012).

### Promotion area

The portion of tourism to the areas economy is of an important amount, by which the Tweed catchment attracts international, national and local visitors (Bissett *et al.*, 2010). The area offers several outdoor activities visitors can do on themselves or guided such as guided fish tours (Tweed guide, 2011). There is still a great potential for more visitors, who will also improve the economy of the area (Bissett *et al.*, 2010).

### Income fishing tourism

Investigations are done on the expenditures of anglers in the Tweed catchment, for their daily expenditures, gross expenditures and their total local gross expenditures (table 7.4).

Average Daily Expenditure	Gross expenditure generated	Local expenditure generated	Expenditure Multiplier	Total local gross expenditure
£34	£3,499,452	91.7%	1.2	£3,850,798
€40.45	€4,163,176			€4,579,315

**Table 7.4 Overview of angler expenditures in the Tweed catchment area Source: Mackay Consultants, 1989 by report Radford *et al.*, 2004**

### Income sport fishery

Licenses are necessary for sport fishermen fishing in the Tweed area. There are different types of license for different species, used fishing technique, number of rods and valid times. On annual basis, more license for salmon fishing were sold than for trout fishing (table 7.5). There is a notable amount between the prices, differing in location along the River Tweed and during the seasons (table 7.6).

	Salmon	Trout
Day tickets	36,000	1000
Season tickets	-	1000

**Table 7.5 Annual average amount of license sold for rod angling on salmon or trout along the River Tweed. Source: Yonge personal communication, 2012**

Season	Amount in pounds (£)	Amount in euro's (€)
Spring	£17 and £115	€20.2 and €136.8
Summer	£17 and £235	€20.2 and €279.6
Autumn	£35 and £810	€41.7 and €963.9

**Table 7.6 Prices for rod angling on salmon and sea trout varying between season and location along the River Tweed. Source: Tweed Salmon Fishing, 2012**

The variation in prices makes it hard to come to a profit. The total annual contribution of Tweeds salmon fishery to the local economy is £18 million (€ 21,427,395.75) (Bissett *et al.*, 2010).

### **7.2.3 Developments**

The Tweed Foundation has a forefront position for bringing a more professional and scientific approach to salmonid management. They are part of extensive programs of biological research, monitoring and habitat restoration to protect valuable fish stock and maximizing the rivers natural production. (Tweed Foundation<sup>2</sup>, 2012)

### Monitoring

An investigation showed that barely enough spring salmon reach their spawning sites. To allow fish to achieve their best spawning potential, all caught fish should be unharmed returned to the water during spring time: first of February till 30 June. Previous tagging showed that only a very small proportion of released fish was captured a second time. (RTC<sup>2</sup>, 2012)

### **7.3 Potential value**

Present caulds remain from industrial use (Young personal communication, 2012). The River Tweed Commission took and takes care for free access for salmon and other fresh water species to their spawning areas. They now concentrate on the smaller streams, also the ones only used by trout. (RTC<sup>1</sup>, 2012) Besides available spawning sites, the quality of the habitat and the water is also of importance for the fishes (LNS partner meeting, 2012); 44% of water of River Tweed can be improved (Bissett *et al.*, 2010).

#### 7.4 Salmon in River Tweed

Summarized can be said that the catchment area of River Tweed is dominated by agricultural land. Different types of water can be found by which 56% of the water has a good till high water quality, the rest is heavily influenced by nutrients. The Tweed is selected as special area of conservation (SAC) and offers suitable spawning sites for salmon and sea trout (Bissett *et al.*, 2010). Salmon is present with a healthy population (JNCC, 2011); up to 2% of the total national salmon population can be found in the River Tweed. The fish is very popular by angling which strengthens the local economy (Young personal communication, 2012). Barriers at the main streams are already accessible (RTC<sup>1</sup>, 2012), focus is now on barriers in the smaller rivers.

Employment is given to less than 60 people in the River Tweed. Sport fishery is an important activity. It generates annual 500 fulltime jobs. Sport fishermen remove annually 8926 salmon fishes and 4488 sea trout fishes from the river gaining annual €4,579,315. The number of sold sport fishing licenses is for salmon: 36,000 and for sea trout 1000. Because prices vary between season and place along the river, the profit cannot be calculated.

Many licenses are sold to fishing tourists in the catchment area of River Tweed. The River Tweed Commission does spent money to improve the ecology of Tweeds water, taking care of general conservation and increase of trout, salmon and sea trout as well as other freshwater fish species (Bissett *et al.*, 2010). The amount of money spent to improve the water is not unknown.

The socio-economic value of salmon and sea trout in River Tweed is generally based on tourism visiting the place for salmon fishing, mainly on salmon. The area is a well developed place for fishing, offering different permits for different locations along the river. Salmon, but also sea trout, has a strong cultural position in River Tweed.

## 8. Comparison areas

The elaborations of the selected features are summarized per category, given for each area for its main fish species. This gives an overview of the current circumstances for migrating fish which can be used to describe its value for the area. The comparison also indicates the situation of one area apropos of the other areas; knowledge can be gained of each other's situation, how they are organized and how they deal with problems such as barriers for migratory fish. Groningen differs in spatial position and available data from River Odense, River Ätran and River Tweed and will therefore be distinguished by this comparison. The available data is not complete for all feature, therefore unknown data is given with the mark -.

### 8.1 General area description

The catchment area of river Ätran is the largest (table 8.1). Of all four areas, land use is mainly dominated by agriculture/ farmland. This type of land use influences the water quality by enrichment of the water with nutrients, affecting the ecology. Water of Groningen, River Odense and 44% of water in River Tweed is insufficient. Only water of river Ätran has a good chemical and ecological quality and is remarkable mostly covered with forest. The water flow of the rivers also differs from each other. River Odense has a low speed compared to river Ätran and the Tweed. Different water types can mostly be found in the catchment area of the Tweed. Each area seems to be suitable for the fish species of focus. There is suitable habitat available for eel to grow up and for salmon and sea trout to reproduce. However, every area still contains barriers for the migrating fishes. River Ätran got only two barriers and seems to have a good access, but one barrier already can block the entrance of river causing serious trouble. The hydropower plant at Ätrafors is the barrier blocking river Ätran after 26 km upstream affecting migrating fishes. River Tweed seems to have the best access, the main streams are almost all accessible by fish passages. Focus will now be on the smaller rivers, also the ones only used by trout. Funen, and also Groningen, still contains many barriers. A problem present in rivers with many fish passages is that these passages are not 100% efficient. Many barriers in one river constructed with a bypass, can still cause in this way a large smolt loss.

	Groningen Eel	River Odense Sea trout	River Ätran Salmon & sea trout	River Tweed Salmon and sea trout
Size catchment area	2960 km <sup>2</sup>	485.9 km <sup>2</sup>	3342 km <sup>2</sup>	5000 km <sup>2</sup>
Main land use	Agricultural land 63.8%	Farmland 68%	Forest 57%	Agricultural land 81%
Kind of water bodies	Canals, streams, lakes	Open water course, lakes and ponds	Rivers and lakes	Tidal rivers, estuaries, mud and sand flats and lagoons
Water quality	Insufficient	Poor to moderate quality	Good chemical and ecological quality	50% of river good or high water quality
Water quantity	-	Average 5.36 m <sup>3</sup> / sec.	Average 51 m <sup>3</sup> / sec.	Upper part 16 m <sup>3</sup> / sec. Lower part 65 m <sup>3</sup> / sec.
Status river	No	No	Index river for the west coast of Sweden	SAC (special area of conservation)
Barriers present	Yes, many	219 on whole Funen	2	Yes but small amount

**Table 8.1 Comparison of the general area description of the four pilot areas**

### 8.2 Employment

The employment in the areas by professional fishermen and generated by tourism is very diverse (table 8.2). In Groningen five professional fishermen are active and three aquacultures are present. The sectors fishery and agriculture contributes for only 4% to the employment in the province. Two fisheries capture in the Dutch part of the catchment area of the Eems three ton eel. Angler captures are not known for the area.

There is hardly any data of the amount of captured fish, only for captures by anglers. The highest caught and numbers removed fish are in River Tweed. Remarkable is the national catch by sport

fishery; catch in Denmark is three times higher compared with the Netherlands, while the estimated production is 100 times higher for the Netherlands compared to Denmark.

The aquacultures present in River Odense and river Ätran only produces for their own rivers, so the fish is not sold or exported. Aquacultures in Groningen does not reproduces specific to release eels in the rivers; they sell the eels. The production of the eel farms in unknown. Local demand is for all four areas absent or present on a very small scale.

	Groningen Eel	River Odense Sea trout	Ätran Salmon & sea trout	River Tweed Salmon & sea trout
Professional fishermen	5	0	0	150 salmon fisheries Employment to <60 people
Employment by sector	Agriculture & Fishery 4%	-	-	-
Income professional fishermen	Min €42,500 gross	-	-	-
Amount of captured fish	Eems basin: 3 ton (2004)	-	-	-
Catch of sport fishery	- Neth. annual estimated on 200 (till 400) ton by sea- and inland anglers	- Whole Denmark 600 ton (2010)	375 salmons southern part Ätran (2011)	Captures of 2011: 20,836 salmons, 8926 taken 5608 sea trouts, 4488 taken
Profit of captured fish	Neth. annual €15 million	-	-	-
Aquaculture	3 eel farms	None	2 small trout farms	3 farms
Production aquaculture	- Neth. annual 3291 ton <sup>(1)</sup>	- Denmark: 31 ton (2007)	-	-
Export fish	- Neth. annual 1826/3652 ton	None	None	None
Demand market	Very small	-	No	Very small

**Table 8.2 Employment data for the areas (1):** Average of 1995-2004

### 8.3 Tourism

There is no data available of expenditures of tourism fishing on eel in Groningen. Important for the area are the fishing license and its income, generated by the HSF (table 8.3). According to data of Smit *et al.* (2004) anglers do spend annual €577 on fishing gear. The assumption can be made that every angler in Groningen – Drenthe spend the same amount annual, giving a income of more than 29 million euro a year. These expenditures are done by shops et cetera so it is apart from the income of HSF generated by fishing licenses. Income by licenses is annual more than one million euro, by which the HSF gains €384,155 and Sportvisserij Nederland (national angling organization) gains €713,230.

The number of jobs generated by fishing tourism are not known for the municipality of Falkenberg, the high amount of jobs generated by tourism in general can be caused by the placement of a new department store. A comparison can be made of the jobs generated by fishing tourism per area for Funen and River Tweed. Funen: 1 job per 107 km<sup>2</sup>, Tweed: 1 job per 10 km<sup>2</sup>. This data indicates the high number of jobs fishing tourists generate in the catchment area of River Tweed. Fishing tourists spend the most on Funen and in the catchment area of River Tweed. According to the amount of licenses, fishing on sea trout seems to be much more popular in Syddanmark (38,314) compared to River Tweed (1000). Salmon fishing seems to be more popular in River Tweed than sea trout fishing. Money anglers pay to the HSF for a fish license in Groningen – Drenthe, is mostly spent to improve conditions for anglers instead of the ecology of the water for better conditions for the fish species. Tourists visiting an area to fish on salmon or sea trout spend money for a sleeping place, food, fishing gear et cetera, which is income for companies. There is no information or money is spent and of the amount of money that is spent to improve the ecology of the water for each area.

	Groningen Eel	River Odense Sea trout	Ätran Salmon & sea trout	River Tweed Salmon & sea trout
Generated jobs	-	28.3 on Funen by sea trout fishing tourism	1570 by tourism in general	500 by salmon fishing tourism
Bed nights	2,263,000	64,4	-	-
Daily expenditure	€14.73	€ 95	-	€ 40,45
Spending per vacation	-	€ 650	-	-
Annual spending	€458,000,000	Odense Municipality €189,654.46	-	-
Spending on fishing gear	Annual €29,395,265 by anglers	€30 per day	-	-
Income by fishing tourists	-	Funen €5 million	Municipality Falkenberg €568,899	Tweed area €4,579,315
Amount sport fishing license	Groningen-Drenthe: 50,945 (2011)	Syddanmark 38,314 (2010)	300,000 (2011)	Salmon 36,000 Sea trout 1000 (2011)
Income sport fish license	€1,097,385	Syddanmark €860,862 Whole Denmark €3,443,287	€3,359,128	Too much variation

**Table 8.3 Key figures of tourists and their expenditures**

## 8.4 Population

The Regional Eel Management Plan tries to make an estimation of the eel population in Groningen and North Drenthe. The report should be finished at the end of 2012. Eels make use of the habitat to grow in, they do not use inland waters for reproduction. Therefore the categories are not relevant for Groningen (table 8.4). Population numbers of species in the other areas are estimated, except for River Odense. River Odense and Ätran also estimated the potential capacity. The production numbers differ in relation to the amount of reproduction area; River Odense offers more hectare reproduction area compared to river Ätran but the current and the potential production is much lower. The production of wild sea trout smolts per hectare can be calculated for both areas. River Odense: 0.79 sea trout smolts per hectare. River Tweed: 55.6 sea trout smolts per hectare. River Odense and river Ätran both do not reach their potential production which means that improvement of the area can stimulate spawning.

	Groningen Eel	River Odense Sea trout	Ätran Salmon & sea trout	River Tweed Salmon & sea trout
Present population size	-	-	Salmon smolts 37,600 (2007)	0% till 2% of national population in Tweed
Size reproduction area	Not relevant	Sea trout:118.6 ha	Salmon: 54.9 ha Sea trout: 27 ha	-
Estimation of mean wild smolt production	Not relevant	Sea trout smolts 93.92	Salmon: 27,500 <sup>(1)</sup> Sea trout: 1500 <sup>(1)</sup>	-
Annual potential smolt production	Not relevant	Sea trout smolts 853	Salmon smolts 54,870	-

**Table 8.4 Data fish populations in the areas** (1): Average of 2005 - 2009

### Fish species

Ide, pike, eel, trout (sea trout/ brown trout) are species present in all four areas. Most probably more species can be found in all four areas. Many other species are only mentioned in two areas as lamprey: River Tweed and River Odense; perch: River Ätran and Groningen and grayling: Groningen and River Tweed. The most species are listed for Groningen, which will not conclude that most of the species can be found in Groningen. Most probably more species can be found in the areas compared to the species that are mentioned

## 9. Discussion

The socio-economic value of salmon, sea trout and/ or eel is described in four different pilot areas according to gathered and supplied data. Partners of the project gave already many of data but not everything was present. Gaps are filled with data from reports found on the internet. It is possible that available data is not found during the research period or the data is not available for public. It is also possible that researches are carried out for the area by which the data is only used intern.

### Available data

The most recent data is always used, but these data was not always related to the same year. The disadvantage of comparing these data is that numbers or trends could have changed during the years. Nevertheless, the used data represents the current situation in the areas and could therefore be used as principle. Historical data used to indicate the cultural position of the fish species was not present in large amounts, so it is possible that more historical data could be found.

Population numbers are based on estimations. It is very hard to estimate a population number especially of migrating species. The species are affected by several factors which influences are very hard to express. Also the amount of caught fish is hard to estimate especially due to the presence of illegal fishery. Anglers are restricted to rules according to their permits but they cannot be controlled constantly which makes extraction of fishes in an illegal way possible and hard to express in numbers.

### Comparison areas

The area Groningen is in relation to space and available data different compared to the areas River Odense, river Ätran and River Tweed. The focus is not on one river with different tributaries, but on an area with many rivers. This makes the comparison on the degree of the value of socio-economic features difficult. Therefore the area is distinguished from the other areas. The comparison between River Odense, river Ätran and River Tweed is based on observations of data of the areas. There is no statistical analyses used to prove relations, conclusions are based on assertions.

For all areas it is clear that several barriers are present affecting migratory fish. Maps are used to give an indication of the barriers for Groningen and River Odense. The location of the hydropower station located in river Ätran is clear, for River Tweed only one location is known. Except for the hydropower station in river Ätran at Ätrafors, the areas are active in placing bypasses at the barriers to stimulate fish migration. However, there is no information of the efficiency of the passages so it is not known or they really solves the migration problem. These data are really important by describing the potential value for the areas.

The amount of captured fish is not known for rivers, even as the production of aquacultures. These data are important by gaining knowledge of the population and estimating the population size especially when the aquacultures only produces fish for the river applicable for River Odense and river Ätran.

By calculating the income generated by anglers in Groningen – Drenthe an average of the expenditures of anglers of the Netherlands is used. Expenditures of anglers in Groningen – Drenthe is an assumption because the amount can diverge from this average.

Fishing tourists generate an important amount of income for the areas River Odense, river Ätran and River Tweed. Expenditures per compartment are not known for river Ätran and River Tweed. Information of tourist expenditures can give more knowledge of their behaviour. Responding on this can strengthen the local economy. River Ätran sells the most fish licenses. Different factors can influence the sale of licenses such as the attractiveness of the fish location, price of the license, present fish species et cetera.

There is no information of the amount of money that is spent to improve the ecology of the waters. This money can be generated by income of licenses paid by sport fishermen. This information can be very useful to describe the organization and money circulation in an area. It could be possible that anglers are willing to pay more for their fishing license when they know that a certain amount of the money is spent to improve the quality of the water and with that the conditions for fish species.

River Odense and river Ätran already investigated their present fish population of salmon and sea trout. Results of both areas concluded that they do not reach their potential smolt production which can be influenced by different factors. River Tweed does not have an estimation of salmon or sea trout population numbers so it is unknown or the fish species already reach their potential production.

The socio-economic valuation is done for all areas, Groningen separated from the other areas. This makes the valuation of Groningen difficult because the data could not be compared with another equal area. Different factors can influence the degree of the value. By this research only the selected features are used. Missing data can influence the valuation because there is less knowledge of the area, therefore the socio-economic value for each area is not stringent but a result within the frame of this research.

#### **Potential value**

The partners of the Living North Sea project helped a lot by giving relevant information. Pictures of the areas were also useful to obtain a good impression of the areas and their geography, but the areas are never visited. This can limit the description of the potential value because not all opportunities are known and information of pictures is also limited.

## 10. Conclusion

According to all gathered and supplied data concluded can be that the socio-economic value of eel, salmon and/ or sea trout varies between the pilot areas Groningen, River Odense, river Ätran and River Tweed. After comparing the areas the following lessons can be learned.

- The socio-economic value of eel in Groningen is generally based on anglers buying their licenses to be allowed to fish. Income of these licenses is divided to the HSF (36%) and the national Angler organization Sportvisserij Nederland (64%). The socio-economic value of salmon and sea trout in River Odense, river Ätran and River Tweed is generally based on the income by tourism visiting the areas to fish for salmon or sea trout. River Tweed is the most progressive area; all main streams are accessible for salmon and sea trout. The area is attractive to tourism visiting the place for fishing on salmon or sea trout generating income and jobs.
- Most fishing licenses are sold for river Ätran for a low price. Increasing the prices can generate more income what can be spend to improve the area with benefit for tourism as well as for fish.
- In all areas there is no information of the amount of money generated by licenses or other sources that is spent to improve the ecology of the water and with that improving the conditions for fish.
- In every area, there are still barriers present affecting migratory fishes. Some barriers are constructed with fish passages but the efficiency of these passages is unknown, so the efficiency of these passages for migratory fishes cannot be given.
- The smolt production per area is much higher for river Ätran compared to River Odense. However, both areas currently do not reach their potential smolt production. Reasons for this difference are unknown.
- Although man made barriers and other circumstances cause a decrease of the amount of eel, salmon and sea trout in an area, protection of the fishes is still worthwhile. The cultural position of eel, salmon and/ or sea trout in every area makes them important for the area. Nowadays, income generated by selling licenses to locals or tourism for fishing on them gives them their socio-economic value which still is valuable.

## 11. Recommendations

For every pilot area recommendations are given which can be used to improve the area and areas can verify the approach of another area.

### Groningen

The size of the eel population is important data to know before measures can be taken to protect the population (Vriese *et al.*, 2007). Professional fishermen were not obligated to report the amount of caught (Dekker *et al.*, 2008). It would be helpful if they do so this data can be used by estimating the population size. Also anglers can be questioned to write down the amount of eels they capture, although they are obligated to release them immediately (Sportvisserij Nederland, 2012).

Employment per sector in Groningen is given for professional fishery and general tourism. There is no distinguish made between general tourism and fishing tourism. This data are very important by giving the income of fishing tourism for the area. Recommended is to separate employment and income of general tourism and fishing tourism.

### River Odense

Although the relative high available production area, the reproduction of wild smolts (0,79 sea trout smolts per hectare (HELCOM<sup>1</sup>, 2011)) is low compared to the production in river Ätran (55.6 wild smolts per hectare (HELCOM<sup>2</sup>, 2011)). Research to the quality of the spawning sites such as the river beds is recommended to investigate why the smolt production does not reach its potential.

Many barriers are present in the river. The effectiveness of constructed by-passes is not available. Recommended is the investigate the effectiveness of the by-passes and if necessary improve them to decrease the smolt loss.

### River Ätran

Smolt production numbers are estimated for salmon and sea trout for 2007. The production is also estimated after implementing measures, for 2011. No research is done yet to control the effects of the measures on wild smolt production and or the estimations are correct. A study is recommended to estimate the population numbers again and use the data to control the effectiveness of the measures.

Although many fishing permits are sold each year (Alenås personal communication, 2012), there is no data available of the expenditures of the fishing tourists. This data can give insight in the contribution of fishing tourism to the total income of the local economy. It can help by describing the economic value of the fish species for the municipality of Falkenberg.

A third recommendation is the price of the permits. To give everybody the opportunity to fish prices are kept low. Higher prices will give more income to the municipality. Maybe less people will have the opportunity to fish but that will also lower the extraction by anglers because they are allowed to keep two anadromous fish species each day.

### River Tweed

There is at the moment no information of the current production and the production capacity of salmon and sea trout in River Tweed. An estimation of these numbers gives more knowledge of the populations which can help improving the area. Also for River Tweed, there is no information available of the effectiveness of the by-passes constructed in the rivers. This information will give more knowledge of the effectiveness of the measures taken to improve fish migration.

## **12. Epilogue**

This research is a first elaboration of a method of describing the socio-economic value of eel, salmon and/ or sea trout in different areas. Now this study is completed and the conclusions are made, it can be said that the method is effective.

The selected features were useful by the description of the areas and the comparison gave a good overview of the situation in each area and how they are organized. Partners of the Living North Sea project can use the report as background information by their own reports.

However, the method can still be developed. Bottlenecks are given and discussed in the discussion which can be used in a further research to carry out a socio-economic valuation.

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## **Appendix I**

### **Operationalisation of the features**

#### **Direct use**

- Employment: Number professional fisheries
- Amount of captured fish: Amount of fish caught by professional fishermen and anglers
- Aquaculture: present fish farms and their produce
- Export fish: money earned from the export of fishes
- Local market: amount of money what is earned by selling fish to local restaurants

#### **Indirect use**

- Promotion area for tourists: fish can give an identity to the area, functioning such as a business card
- Jobs generated by tourism: number of jobs tourism generates. General tourism and fishing tourism are separated
- Income by tourism: money that is earned by expenditures of general tourism and/ or fishing tourism
- Income by sport fishery: money that is earned by sport fishery such as selling sport fishing licenses
- Historical information: information of the history of fish species, regarding their population size or activities done in the past
- Developments: Information of researches and monitoring activities. Also the possibility of sustainable fishery is mentioned: sustainable caught fish is sold with a health mark. Customers know how the fish is captured. It is not for all species possible to capture it in a sustainable way