Living North Sea

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Reconnecting the North Sea

Innovative solutions for fish migration

FACT SHEETS

The Interreg IVB North Sea Region Programme

Investing in the future by working together for a sustainable and competitive region

Contents

Project objectives	**HA2 Study the effectivity of habitat-restauration and barrier-removal**
LNS Partner	**Regional Water Authority Noorderzijlvest**
Species	Eel, River lamprey (perhaps seatrout)
Methodology	Assessing the effect of remeandering on fish, vegetation and morphology
Issue(s) to be addressed & anticipated benefits to fish populations	Investigate the change in fish-stocks and the change in morphology (sediment, vegetation, flow etc.) after remeandering 4 km of brook. The Oostervoortse diep is small stream to the south of Groningen and forms the beginning of a riversystem called Reitdiep-Peizerdiep. Within this system, because of canalisation, fish like lamprey, dace and other fish of rivers and streams have gone. Information collected during this study will be used to improve fish migration and faihhabitat in this water system and allow migratory fish to move freely to complete their life cycles. We are also investigating if and how this stream should be cleared of weeds and plants. We hope to learn from our partners if seatrout is a possible targetspecies, improving spawning areas, how to clear weeds, etc.
Site location & project pictures	 
Methodology	In order to ascertain if the remeandering was successful. The waterboard is monitoring the change in fish-stocks and the change in morphology (sediment, vegetation, etc.). We are monitoring the development of the brook on 10 fixed points. On these points we measure morphology, fishstock and macrofytes. We measure these every year in order to follow the development of the ecology of the brook. Information collected during this study will be used to improve fish migration and fish-habitat within the watersystem and allow migratory fish to move freely to complete their life cycles. We are also investigating if and how this stream should be cleared of weeds and plants. We hope to learn from our partners if seatrout is a possible targetspecies for the Oostervoortse diep.
Project partners	State forestry department
Further reading	Intention to put in hyperlinks to more detailed project reports, status updates etc.

Project objectives	**HA4 Increase spawning habitat in coastal chalk stream**
LNS Partner Organisation	**Environment Agency**
Species	Brown and Sea trout, Brook and River Lamprey, Eel
Methodology	Creation of riffles as spawning habitat
Issue(s) to be addressed & anticipated benefits to fish populations	The main issue to be addressed in the River Stiffkey, in common with other chalk rivers in North Norfolk and elsewhere is the lack of suitable spawning habitat for rheophilic species including brown trout and sea trout . The tidal flap is the only barrier to migration on this river, so resolving access at this structure will allow migratory fish and eels to move freely to complete their life cycles with improvement in spawning habitat. 17 gravel riffles have been created each up to 30m with low berms adjacent to the riffle to prevent bank erosion. Wooden flow deflectors have been installed to limit sedimentation of the gravel. Monitoring is taking place as a PhD study part financed by LNS.
Site location & project pictures	 Creating riffles  
Project partners	Environment Agency, Wild Trout Trust, CEFAS, Natural England, Holkham Estates, Norfolk Wildlife Trust. University College
Further reading	PhD study, University College London.

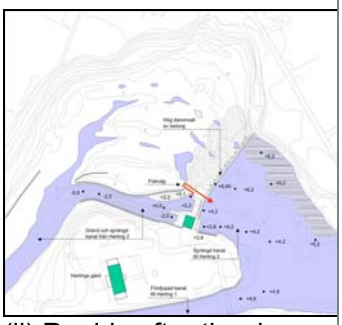
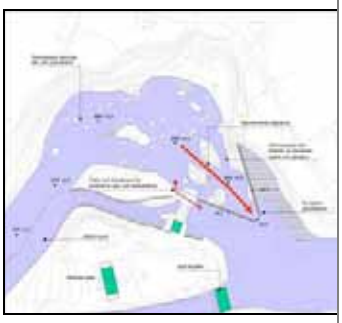
Project objectives	**HA6 Restoration of acidified lakes in Falkenberg, Sweden using new innovative liming products and techniques.**
LNS Partner Organisation	**Municipality of Falkenberg**
Species	Salmon, sea trout, eel, lampreys, roach and other acid sensitive species
Methodology	Helicopter liming with new liming products and techniques in order to mitigate acidification in areas that have been difficult to restore with previously used methods and lack of national resources.
Issue(s) to be addressed & anticipated benefits to fish populations	Thousands of lakes in western Sweden have been acidified due to long distance transport of acid precipitation mainly from other European countries. Restoration of these heavily acidified areas and lakes in western Sweden is a prerequisite to allow migratory fish species as Atlantic salmon, sea trout and European eel, to return to former spawning and growth areas with a renewed good ecological status. This restoration is crucial for migratory fish to move freely without chemical barriers and to complete their life cycles for thriving populations. Otherwise many migratory fish populations will be threatened, endangered or extinct.
Site location & project pictures	  Photo: Ingemar Alenäs
Project partners	Swedish Environment Protection Agency, County Administrative Board, Myrica ab.
Further reading	Henricsson,A and Ljungman,M. 2011. The Effects on Macrobenthic Fauna after Liming with Course Limestone Granules. Medins Biologi AB. Svahnberg,A. 2012. Liming with Course Limestone in nine acidified Lakes in the area of Falkenberg. Myrica ab. In Swedish with English summary.

Project objectives	**HA8 Mitigation of water supply reservoirs on the River Tees**
LNS Partner Organisation	**The Rivers Trust (Tees Rivers Trust)**
Species	Salmon, sea trout / trout.
Methodology	Mitigation for a modified flow regime, loss of natural hydro-geomorphological processes, and loss of salmonid spawning streams. The trust is examining opportunities for replacing, and re-creating spawning areas for migratory fish using green infrastructure, modifying reservoir water release, and opportunities for getting fish around the reservoir dams.
Issue(s) to be addressed & anticipated benefits to fish populations	The River Tees is a highly modified river that is surrounded by other rivers of high importance to migratory salmonids and eel. One of the issues which must be addressed is the large proportion of the river which is cut off by the creation of water storage reservoirs. This not only restricts habitat area, but also causes multiple downstream problems, including vertical erosion to bedrock and loss of spawning gravel. The trust has been exploring the use of green infrastructure, such as the introduction of large woody debris, to maintain introduced gravel in the stream, improve flow diversity, and reform lost habitats.
Site location & project pictures	  
Project partners	Environment Agency and Tees Rivers Trust
Further reading	Tees Reservoir Flows & Gravel Project. Pre-feasibility Report. Royal Haskoning. February 2010. Catchment Fluvial Geomorphological Audit of the Tees Catchment. Environment Agency. June 2004. Tees Salmon Action Plan Review, APEM Ltd, February 2009.

Project objectives	**HA9 The effectiveness of stones in soft banks for smelt and eel in the waterboard of Rijnland**
LNS Partner Organisation	**Waternet**
Species	Eel, Smelt
Methodology	Habitat Restoration by stones For the species of smelt a desk study was carried out. This study made clear that smelt would benefit from a 5 % bank share of stone or a combination of sand/stone, especially at the banks of bigger lakes/larger waters.
Issue(s) to be addressed & anticipated benefits to fish populations	Smelt cannot reproduce optimally if its preferred spawning habitat is not present. Smelt needs large water, preferably a passable connection to sea and a presence of stone or sand banks in the fresh water habitat. For the species of smelt a desk study was carried out. This study made clear that smelt would benefit from a 5 % bank share of stone or a combination of sand/stone, especially at the banks of bigger lakes/larger waters. Also eel will strongly benefit from stone banks. This is because eel can hide in between the stones in the daytime. As a side effect stone banks will prevent fishermen from placing eelfykes. And as it appears from this study, is a easy to take measure for smelt at appropriate (big) lakes, since only 5 % of the bank has to be 'stone' or stone/sand as basic material.
Site location & project pictures	 
Project partners	Waterboard Rijnland, Leiden. Tauw.
Further reading	Goede visstand in Rijnland, Tauw, 2011. Report about measurements needed for meeting the WFD goals for fish.

Project objectives	**HA 10 A habitat measure for Twaite Shad; the Twaite Shad-bay near Den Helder**
LNS Partner Organisation	**Waternet**
Species	Twaite shad
Methodology	An existing connection between fresh and saltwater, was made passable for Twaite shad (and some other species) in both directions. This connection is a tidal lock which was adapted for Twaite shad to enter (fish is let in like a ship in a lock) and secondly a pumping station was adapted to allow the fish to get out again. Besides a *spawning bay* for Twaite shad was created 2 km inland by creating shallow parts.
Issue(s) to be addressed & anticipated benefits to fish populations	Twaite shad needs transitional waters to spawn. Species like Twaite Shad, Allis shad, Herring and other diadrome fish. Especially in The Netherlands lots of connections were cut off by dikes and dams, while suitable spawning areas would still be available, just not reachable. Because of strict safety rules (the dykes protects thousands of people) ir is not easy to solve this, but in this case existing outlet (tidal lock) and pumping stations were used/altered, allowing a passage against reasonable costs.
Site location & project pictures	 
Project partners	Waterboard Noordhollands Noorderkwartier, Netherlands.
Further reading	Email to : H.roodzand@hhnk.nl

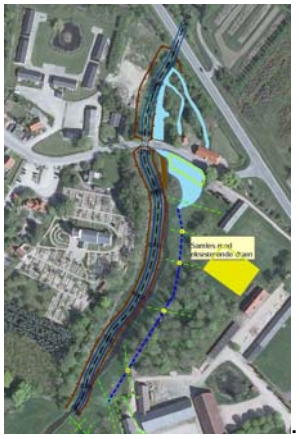
Scheme info HP1	**Country: Sweden.** **Location: HEP at Herting Dam, River Atran.** **Issue: Connectivity** **Solution: Partial removal of dam to restore rapids**
Organisation	**Municipality of Falkenberg** Swedish Environment Protection Agency, County Administrative Board, National Board of Fisheries, Karlstad University, Fiskevårdsteknik AB- in partenership with Living North Sea INTERREG.
Construction	The Hertings Dam (5.25m) is at the mouth of the River Atran on the west coast of Sweden. It was completed in 1904 to store water for two hydropower stations. It also included a fish pass but this was not successful. Despite having the fish pass upgraded in 1945 and the addition of an eel ladder, it's estimated 20% of migrating salmon fry and most female eels die in the turbines. Lamprey also seem to have great difficulty in negotiating their way past the dam. The diagrams below show the Atran (i) before the dam (ii) with the complete dam (iii) restoration of rapids. The Environment Court gave permission in March 2012 for the partial removal of the dam, work is due to start in 2013
Project details	The River Atran supports migratory fish such as salmon, eel, lamprey and sea trout. Salmon fishing alone brings up to SEK 5m to the local economy each year. With the introduction of barriers for hydropower, there has been a reduction in overall stocks. Atran salmon, a genetically unique fish (which is unaffected by fish breeding) and eels have been particularly impacted, natural glass and silver eel migration has been stopped for decades and it is now illegal to fish for eels on the Atran. Thousands of square kilometres of spawning and growth areas suitable for migratory fish in Sweden have been cut off by the hydropower dams. Access to these former areas and restoration of streams is crucial for migratory fish to move freely without physical or chemical barriers in order to complete their life cycles for thriving populations. Restored waters can achieve good ecological status according to the Water Framework Directive. Migratory fish urgently need access to their former original habitats. Otherwise many migratory fish populations will be threatened, endangered or extinct. As part of the **Living North Sea** programme measures were proposed to remove part of the dam and restore the Hertings rapids upstream of the dam to a minimum flow of $11m^3/s$. This would allow fish passage to be restored The Environment Court gave permission in March 2012 to remove Hertings dam. There is a fish ladder and eel run in place but removal of the dam will restore upstream rapids and will enhance the spawning run and smolt migration. Fish migration patterns will be followed by sampling and tagging with elastomers, acoustic transmitters etc.
Technical specifications	The dam will be partially removed to allow a minimum flow of $11m^3/s$ across upstream rapids providing additional fish passage for migration of salmon, trout, lamprey, eels and roach. The older of the two hydropower stations will operate all year round but the newer power station will only operate during winter high flows.

<table>
<tr><td>Project pictures/maps</td><td>  </td><td> 
Herting Dam</td></tr>
<tr><td>Restoration plans</td><td> 
(i) Rapids before the dam</td><td> 
(ii) Rapids after the dam is constructed, 1904. The red arrow shows the fish passage</td><td> 
iii) Proposed restoration of the rapids by partial removal of the dam. Red arrows shows the increased fish passage route.</td></tr>
<tr><td>Results</td><td colspan="3">In addition to the removal of the dam the Herting power plant is to change its operating regime to facilitate fish passage. The older power station, Herting 1, will operate throughout the year but Herting 2 will only operate in the winter at high flows. New screens on Herting 1 will prevent entrainment into the turbines.

Construction is due to commence in 2013. Fish migration patterns will be followed by sampling and tagging with elastomers, acoustic transmitters etc.</td></tr>
<tr><td>Location specific cost indication</td><td colspan="3">The estimated cost is about €1.8 million.</td></tr>
<tr><td>Further reading</td><td colspan="3">Atran river and Migratory Fish

The Herting Project</td></tr>
</table>

Scheme info HP2	**Country: Denmark** **Location: Fyllested Mill on the River Storå** **Issue: Connectivity** **Solution: River bed restoration**
Organisation	Odense community/Seatrout Fyn project to restore fish passage past Fyllstead Mill on the river Storå.
Construction	The mill is a part of Kaersgaard Hovedgaard (1499) Denmark. It has existed for approx. 500 years, first as a flourmill and later, in the 20th century, it was used to generate electricity. In 1976 a fish pass consisting of a series of pools with a head of 2.7m over 30m was built to bypass the mill weir. Despite ceasing to generate in 2002, a small amount of the flow is still directed through the turbine house. Sedimentation and lack of dredging of the mill pond has reduced this flow over the years. This has meant the fish pass hasn't been successful and an estimated 100km of spawning grounds upstream of the mill are underused. The fish barrier also leads to the gathering and increased predation of sea trout smolt that find the pools difficult to navigate. The weir at Fyllested Mill is the only remaining obstacle in the main river. In the tributaries there are still remaining obstacles preventing the whole system from reaching its potential as an ideal trout habitat.
Project details	DTU Aqua and the Fauna Passage Committee usually recommend removal of dams as the first consideration, but the Heritage Agency have expressed concern due to the historical nature of the weir. The area upstream of Fyllested Mill is classed as Water Framework Directive (WFD) high ecological status. Downstream, despite continuing recovery of spawning migratory trout, where especially the first approx. 400 m downstream of Fyllested Mill serves as spawning area, classification is only good ecological status. The WFD demands that continuity is secured by creating better passage for fauna. The planned project will secure full passage for all fauna in the river by removing the current basin ladder and creation a new meandering stream with a relatively low slope. The channel will maintain a head of 2.7m over a distance of 389m by raising the river bed in places with rocks and stones.
Technical specifications	Up and downstream of Fyllested Mill a section of a 270m pass with an overall drop of 1.15m (gradient of 4.3%) will be laid with stone and gravel (16-80mm, 30-40cm deep) to create good spawning and nursery grounds for salmonids, interspersed with 35-40cm large stones to accommodate fry. Downstream a shorter section of 110m with an overall fall of 1.04m (gradient 9.5%) is lined with layers of stone materials (125-250 mm, 40cm deep) for erosion protection. Larger stones of 40-50cm are embedded for fauna such as macro-invertebrates and fry. The required flow of 1m³/s is estimated to occur 97% of the time during the summer and 88% of the time in winter for 110m downstream of the Mill. As the profile decreases and vegetation encroaches the flow is likely to be less than 1m³/s for 90% of the time. Currently there is no production of electricity and due to filling in of the mill pond only a relatively small fraction of the water is flowing through the turbine building. Earlier production happened all year, though the mill owner should secure a free flow of water through half of the weir in October-December. A 10ml screen is in place as required at powerplants to prevent fish entrainment..

Project pictures/maps	 562057 6148782	 Fyllsted Mølle by-pass plan
	 Fish ladder before restoration works	
Results	The Danish Technical University (DTU Aqua) monitors the fish population every seven years and is detecting an increasing population of trout despite the weir. There is consensus that the planned project will allow a substantial increase in the trout population.	
Location specific cost indication	The project is carried out by Middelfart Municipality who is a member of the Seatrout Fyn. The project is financed by LNS, Seatrout Fyn and Middelfart Municipality.	
Further reading	Waterplan 1.12 Little Belt/Funen. http://www.naturstyrelsen.dk/NR/rdonlyres/1154D14B-7DD1-4945-B855-620A4D1FB132/0/1_12_LillebaeltFyn.pdf Full project report: http://ungnu.middelfart.dk/sitecore/content/websites/www,-d-,middelfart,-d-,dk/Global/Nyheder/~/media/Files/Nyheder/Endelig%20rapport%20skitseprojekt%20Fyllested%20moelle.ashx The Danish Government (Danish Nature Agency, The Danish AgriFish Agency and DTU Aqua) monitors the river. http://gis.dfu.min.dk/website/udsfisk/pdf/0901%20-%20Uds%C3%A6tningsplan%20for%20fynske%20vandl%C3%B8b%20-%202009.pdf	

Scheme info HP3:	**Country: England.** **Location: River Trent** **Issue: The potential for effects of multiple hydropower developments on long distance migrating species, using salmon on the River Trent as an illustrative example.**
LNS Partner Organisation	(Environment Agency (EA)) This example illustrates the potential for cumulative effects of multiple hydropower schemes developed along the migration route of fish. Similar scenarios were raised from partner organisations across the North Sea Region.
Overview	This is a theoretical appraisal of the potential for the cumulative effects of hydropower schemes on migratory fish species. The River Trent has been chosen because it has a recovering salmon population and is the location of numerous in-stream impounding structures which act as a barrier to migration. While many of these structures will be unsuitable as a site for hydropower development, others have the potential to house a hydropower scheme. When considering cumulative effects on fish populations it must be recognised that other pressures and activities will play their part. This makes the management of cumulative effects a significant challenge. Similar concerns over the potential effects of multiple hydropower schemes have been raised by other LNS partners on other migratory fish species, for example river lamprey (Belgium), eel (Sweden), salmon (Denmark) and various species in Germany.
Background	The River Trent used to be an important salmon river. Industrial expansion, navigation, weir construction and poor water quality led to their extinction in the 1930s. Improved water quality saw the first stray fish return during the 1980s. A re-establishment programme was started in 1998, concentrating on the River Dove tributary but with the aspiration to expand this to the River Derwent. The first wild juveniles were found during routine sampling in 2003. Barriers to fish migration, such as weirs, are now the main factor preventing a sustainable salmon population. Many of the redundant weirs have the potential for a new use to support hydropower development. Current generation subsidies in the form of Feed-in-Tariff (FITs) further help support these developments. The EA has “Good Practice Guidance” to help developers understand their environmental responsibilities and to aid the permitting process. This guidance includes a presumption to use existing barriers and to install adequate screens and fish passage solutions. Any development within a watercourse will have some effect (positive and/or negative) on the environment. Predicted impacts on the environment are mitigated during the permitting process. There is concern that the consequence of small, acceptable impacts at any given site are greater when considered at the catchment scale, specifically in relation to migratory fish species, which have to negotiate multiple barriers and potentially multiple hydropower schemes. This theoretical case study highlights the potential for slight changes in migration delay or mortality rates of upstream and downstream migrating fish when considered cumulatively through a single catchment. Upstream fish passage is well understood and in many cases a hydropower development allows a fish pass to be installed years before other funding sources would allow. In these cases, and where the impounding structure must be retained, there may be a net benefit to fish populations.

	A particular concern of the LNS partnership is our knowledge gaps on the potential impact of hydropower schemes on downstream migration. Behaviour around barriers is poorly understood, but Danish studies have shown that delays and increased mortality can occur at impounded sections. Where a hydropower scheme is present on an impounding structure, mitigation measures (by-washes, screens etc) lead to flow diversion through the turbine resulting in less water flowing over the original impounding structure. This can result in potential delays to migration. Poorly screened turbines are a source of fish mortality, but even well screened turbines have the potential to have very small impacts. While these impacts may be acceptable locally, migrating fish may pass several such schemes and therefore the impacts are additive in nature. The potential for cumulative effects to migratory species on longer rivers with multiple schemes exists if localised impacts are not fully understood and adequately mitigated. The map below shows existing hydropower schemes (red) and all the other impounding structures in the River Trent catchment area. It should be noted that it is impossible for all the sites to be developed for hydropower, but the potential for multiple sites is high. Understanding the potential effect of such a scenario requires a better knowledge of any additional impacts caused by the hydropower schemes as well as any benefits that might result from improvements to upstream fish passage. In a scenario where the overall effect is a 1% increase in the mortality of downstream migrating fish, the combined effect of several schemes may cause impacts that would be acceptable at the site level, and potentially limit the recovery of salmon populations at the catchment level.
Project pictures/maps	 
LNS Points to Consider	The LNS partnership recommended that the following points need to be taken in to consideration to reduce the possibility of cumulative impacts: **Principal Recommendation:** Development of assessment tool of potential cumulative impacts at the catchment level • Research should be commissioned to better understand the potential for impacts on fish migration caused by hydropower schemes e.g. delays to downstream migration. • Licensing authorities should ensure potential schemes are assessed in respect of all environmental legislation requirements (e.g. WFD, Habitat Directive). • A national strategic approach to hydropower placement should be

	considered. E.g. For catchments with particularly sensitive designations or species the principal of 'no-go' areas for hydropower development might be appropriate. • A mechanism to alter mitigation measures or permit conditions at an appropriate time if new evidence becomes available or legislation changes. • Guidance must be regularly reviewed and updated when new evidence becomes available
Further reading	Environment Agency Good Practice Guidelines Environment Agency Hydropower Interim Advice Notes

Scheme info HP4	**Country: England** **Location: Howsham Mill, River Derwent SAC, Yorkshire, UK** **Issue: Impact of turbine type** **Solution: Installation of Archimedes screw**
Organisation	Heritage Lottery Fund
Construction	The Archimedes screw turbine sits on the left handside of Howsham Mill weir. The weir is 80m wide and 1.8m high. The turbine operates at $2m^3/s$ (of an average daily flow of $15m^3/s$). It operates in reverse, being turned by the falling water. It has a head of 1.7m and a turning speed of 20rpm. Debris is prevented from coming into contact with the turbine by an upstream trash screen.
Project details	A reverse Archimedes screw was introduced to Howsham weir to allow safe passage of lamprey, transformers and amoecytes. Lucas & Bracken, 2010, carried out a study on the downstream migration of river lamprey adults, transformers and amoecytes. Samples were taken from January to June 2009 and November 2009 to May 2010 during the day and night, the latter samples being significantly larger. Amoecytes and transformers caught and tagged and released into the turbine receiving flow were picked up downstream.
Technical specifications	Samples of lamprey transformers and amoecytes were released upstream of an Archimedes screw, captured and checked for injury or mortality.
Project pictures/maps	 472998 462800  Howsham Mill Archimedes screw.
Results	There were significantly higher numbers of fish caught at night than during the day. There were no recorded mortalities. Lampreys, transformers and amoectyes are more likely to be on the move at night. Developers would be reluctant to only operate during the day time. The installation of an Archimedes screw which has been shown to be fish friendly within the operating regime of the Mill is a suitable compromise.
Location specific cost indication	n/a
Further reading	Potential impacts of hydroelectric power generation on downstream-moving lampreys at Howsham, Yorkshire Derwent. **Martyn Lucas and Fiona Bracken, Durham Universtity. 2012.** *Archimedean Screw risk assessment: strike and delay probabilities* September 2011 Toby Coe, Pete Kibel. Fishtek.

Scheme info HP5:	**Country: Norway** **Location: Hydropower schemes in the River Orkla catchment,** **Issue: Connectivity** **Solution: Change to operational regime**
Organisation	The scheme is owned by Statkraft.
Construction	The Orklå catchement has 3 hydropower plants in the section which would normally be utilised by anadromous fish. The furthest upstream, Brattset power station, has a water intake above Stoin dam and reduces Orklå flow over the upper 4 km of anadromous river section. The middle dam, Grana, utilizes water from a tributary, and does not reduce flow in Orkla at all. The lower dam, Svorkmo, abstracts water at Bjørset dam and reduces flow over approx. 20 km. Mine waters draining to Raubekken tributary, upstream of Svorkmo power station, caused a reduction in salmon fishery from a maximum of 22 tonnes of salmon in 1903 to just 4 tonnes in 1947. Diversion of the tributary to the power station where the water becomes diluted has reduced pollution downstream of Svorkmo.
Project details	The Orklå watercourse covers an area of 3092km^2, 39% of which is affected by hydropower. The hydropower schemes, Brattset and Svorkmo, affect the section important for anadromous fish and have led to changes in the water flow, water temperature and increased phosphate loading from the artificial lakes created upstream of the dams, where an increase in phosphate loading temporarily increased salmon production. Reduced flow is a factor in fish taking migration breaks at the barriers. It's believed that salmon smolt production is reduced upstream of Brattset dam. Changes to the hydropower stations operating regimes have mitigated the impact on migratory fish.
Technical specifications	Svorkmo: gates in dam (Bjørset dam) open when upstream migration takes place. Migrating fish are recorded, see reports below. Power production within the Orklå catchment is: Brattset: 400 mill. kWhrs/a, installed effect: 2x40 MW Grana: 280 mill. kWhrs/a, installed effect: 75 MW Svorkmo: 270 mill. kWhrs/a, installed effect: 34 + 20.5 MW
Project pictures/maps	 51.167962, 5.922568
	 Bjørset dam. Photo Eva B. Thorstad/NINA

Results	NINA estimates there has been a net increase in smolt production of 10-30% since the hydropower development, mainly thought to be due to the increased winter flows at the sea confluence. Smolt screens at Svorkmo lead 75% of smolts outside turbines. Among the 25% of smolts that pass the turbines, mortality is 70%. The impacts the scheme has had on smolt production are explained in more detail in a report (http://www.nina.no/archive/nina/PppBasePdf/fagrapport/079.pdf Diversion of the polluted water in 1952 has also increased the catches in salmon considerably, reaching a peak of 35.8 tonnes in 2002. To further support fish passage the operational regime of the power stations changes to accommodate increased flow requirements: Above Brattset: 2 m3/sec from 1 May – 30 Sept., 0.5 m3/sec rest of year Above Svorkmo:20 m3/sec from 1 May – 30 Sept., 4 m3/sec rest of year
Location specific cost indication	N/a
Further reading	http://www.nina.no/archive/nina/PppBasePdf/fagrapport/079.pdf LOV-1917-12-14-17 Lov om vasdragsreguleringer [vassdragsreguleringsloven]. http://www.lovdata.no/all/nl-19171214-017.html LOV-1917-12-14-16 Lov om erverv av vannfall mv. [industrikonsesjonsloven]. http://www.lovdata.no/all/nl-19171214-016.html

Scheme info HP6	**Country: Denmark** **Location: The mills at Orkil in The Copper Stream** **Issue: Connectivity** **Solution: Feasibility study of creating fauna passage**
Organisation	Seatrout Fyn. The project is carried out by The Municipality of Svendborg who is a member of Seatrout Fyn.
Target species and methodology	This fact sheet describes a feasibility study of how to remove the obstacles at the two mill sites at Orkil and opening the culverted lower part (approx.. 400 m) of The Copper Stream. The study focuses on sea trout but the project can benefit the entire stream fauna including eel and river lamprey
Project details	On Fyn a large part of the water courses have been blocked for migratory fish due to establishment of various obstacles; mills, weirs, regulations etc. The Copper Stream in the City of Svendborg on southern Fyn is virtually blocked for migratory fish due to several obstacles on the very lower part. The lower part runs in a pipeline over approx. 400 m before it discharges into the Sea. Furthermore to weirs at two mill sites just upstream from the pipeline is making migration impossible. The aim of the feasibility study is two open the culverted lower part and create full passage for all stream fauna at the two mill weirs. The task is very demanding due to the location in the inner city and harbour in Svendborg. Orkil is a cultural landmark and several large buildings are placed over the culverted part. Establishment of full fauna passage at Orkil will be an important step in securing migratory fish passage to suitable spawning grounds and regeneration areas. The methodology used in this project will leave the cultural environment intact by preserving the main weir and make this project suitable for the demonstration of water course management history. An opening of the pipeline will assist in converting the harbour area from an industrial site to a recreational area.
Project pictures/maps	  
Further reading	http://www.svendborg.dk/nyheder?docid=17870 (only in Danish)

Project objectives	**PS1 Evaluation of fish damage by screw pumps after an fish friendly adjustment in a polder area in Flanders, Belgium**
LNS Partner Organisation	**INBO (Research Institute for Nature and Forest)**
Species	All fish. Special attention for Silver eel (*Anguilla anguilla*)
Methodology	Fyke netting
Issue(s) to be addressed & anticipated benefits to fish populations	The polder waterways in the low-lying area of Flanders are ideal habitat for the European eel (*Anguilla anguilla*). When the grown up silver eels try to reach the sea they are often confronted with screw pumps. When trying to pass these screw pumps the silver eels are often seriously damaged. After a fish friendly adjustment of the screw pumps there was need for an evaluation. By placing fyke nets and closely investigate the silver eels an evaluation on the success of this fish friendly implementation can be made.
Site location & project pictures	 
Project partners	The project is funded by the Flemish Environmental Agency (VMM).
Further reading	

Project objectives	**PS7 Eel passage at pumping station Spiegelplas- NL**
LNS Partner Organisation	**Waternet**
Species	Eel
Information about project site	The Spiegelplas is a large lake, which is separated from the river Vecht via a sluice. Next to the sluice a pumping station is situated which regulates the waterlevel in the lake (and polder). Difference in waterlevel ca 1,3 meter.
Issues studied and results	More than 10 years ago an eel passage was constructed, next to the outlet of the pump, to facilitate migration of glasseel and elver from the Vecht into the lake area. The eel passage has never functioned successfully (*but poor documentation*) and has been out of operation for years. During a LNS worksession suggestions were made to improve the eel pass. In spring 2010 new brushes and a new pump were installed. Monitoring in 2010 did not show any eel successfully passing the ladder. In 2011 the flow over the ladder was also changed in combination with a separate attraction flow of water, creating some vibrations at the waterlevel. Consequent monitoring did show a few small eel passing the construction. This proofs eel are now able to find and pass the ladder. The low numbers caught may be a result of poor attraction of eel, but are more likely an indication that numbers of glass eel in the river Vecht at present are very low.
Site location & project pictures	 
Project partner	-
Further reading	- in preparation

Project objectives	**PS8 Innovative solutions. Fish friendly pumping station "Meerweg" on the river Oude Aa at the poldersystem Lappenvoort, NL**
LNS Partner Organisation	**Regional Water Authority Waterschap Hunze en Aa's, NL**
Species	All
Construction	Fish Flow "fish-way for pumping stations" (venturi system)
Issue(s)	• Pumping station engineered by RWA Waterschap Hunze en Aa's. • Fish friendly bypass (fish-way) developed by Fish Flow Innovations. • The pumping station is located at the polder system "Oude Aa" close to the town of Haren, NL. • Capacity of the main pumps is 2 x 37,5 m^3/min. • Capacity of the separate pump for the "venturi system" is 18 m^3/min. • Head of the discharge is ca. 1.05m. The pumping station is tested "fish friendly". (Witteveen&Bos: GN24-46/bote/020) Total cost estimation: Venturi system: €250,000; Total costs of the pumping station: €800,000.
Site location & project pictures	 
Project partners	Fish Flow Innovations
Further reading	Witteveen+Bos. (2008) Evaluatie van de gemaalvispassage in gemaal Meerweg te Haren.

Project objectives	**PS9 Innovative solutions. Fish friendly pumping station "Ennemaborgh" at the poldersystem Oldambt, NL**
LNS Partner Organisation	**Regional Water Authority Waterschap Hunze en Aa's, NL**
Species	All
Construction	"Landy" Archimedes screw pump, with a partly fixed tube
Issue(s)	• This fish-friendly screw pump is a prototype developed by Landustrie Sneek B.V. and is installed in a new polder system of ca. 620 ha. nearby Midwolda. • The capacity of this pumping station is 2 x 40 m^3/min. • Head of the discharge is ca. 1.95 m. • Costs related to fish friendly measures: € 50.000,-. In total: € 677.000,-.
Site location & project pictures	  
Project partners	Landustrie Sneek B.V.
Further reading	• Bonhof, G.H. (2009). Visstandonderzoek watergangen Gemaal Ennemaborgh. Rapport 2009-063, Koeman en Bijkerk bv, Haren. • Bonhof, G.H. (2010). Monitoring visschade gemaal Ennemaborgh. Project 2009-233, Koeman en Bijkerk bv, Haren. • Kemper, J.H and Vis, H. (2011). Onderzoek naar de visvriendelijkheid van vijzelgemaal Ennemaborgh. Rapport VA2010_47 , Visadvies. • Vis H., Q.A.A. de Bruijn & J.H. Kemper, 2012. Onderzoek naar de visoverleefbaarheid bij vijzelgemaal Ennemaborgh op 23 oktober 2012. VisAdvies BV, Nieuwegein. Projectnummer VA2012_25, 22 pag.

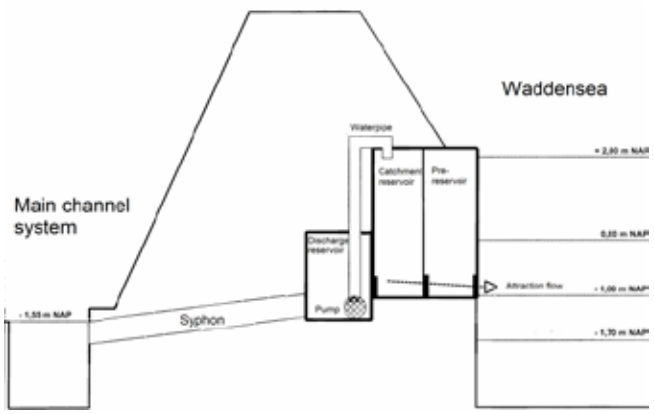
	PS10 Fish friendly pump, Mijndense sluis at the Loosdrechtse Plassen, NL
Organisation	Waternet, NL
Construction	Axial flow pump, developed by Pentair Nijhuis in collaboration with Fish Flow Innovations
Project Information	The sluice of Mijnden is a navigation lock between the Loosrecht Lakes and the river Vecht. The sluice is operated with a pump, which fills the lock with water from the loosdrecht lake, to prevent nutrient rich water from the river to enter the lake system. The original pump was known to cause damage to eel. Dead eel was regularly spotted in the lock and occasionally the original pump was completely jammed because of eel in the pump screw. In 2011 a new fish friendly pump was fitted. This pumptype has won the aquatech innovation award 2011
Technical specifications	The fish-friendly pump features a special impeller and guide vanes that have a special shape, which will create a specific flow, allowing the fish to get through the pumping station safely. The project to replace the pump is carried out for Waternet (by order of waterboard Amstel, Gooi en Vecht), NL. The capacity of this pumping station is 80 m3/min. Head of the discharge is ca. 1.50m.
Site location & project pictures	  
Results	This pumping station is tested and allows more than 97% of fish to pass through unharmed (VisAdvies, F.T. Vriese, 2009-19)
Cost indication	Fish friendly pump: ca €130.000,- Total renovation project: € ca 250.000,-
Further reading	VisAdvies (F.T. Vriese), 2009. Onderzoek naar de visveilige axiaalpomp en buisvijzel. Rapport VA2009_19, in opdracht van FishFlow Innovations. (in Dutch) Aquatech Innovation Award, jury report 2011.

Project objectives	PS12 Fish friendly pass at pumping station ''Abraham Kroes''
Organisation	RWA Hoogheemraadschap van Schieland en de Krimpenerwaard, NL
Construction	Fish Flow Innovations Syphon Fish ladder.
Project details	This Syphon Fish ladder is developed by Fish Flow innovations and is installed on Hollandsche IJssel and the Ring canal, nearby the town of Moordrecht, NL.
Technical specifications	The capacity of this fish pass is between 0,43m³/min and 1.2m³/min. Head is ca. 4.35m.
Site location & project pictures	   **Fish friendly pass at pumping station Abraham Kroes (Hoogheemraadschap van Schieland en de Krimpenerwaard).**
Results	The pumping station is more fish passable and "fish friendly".
Location specific cost indication	In total: € 900.000,-.
Further reading	Schieland en de Krimpenerwaard. (2012). Visvriendelijk maken van gemaal Abraham Kroes.

Project objectives	PS13 Fish pass at pumping station ''Polder Breebaart''
Organisation	RWA Hunze en Aa's, NL
Construction	Archimedes screw pump with return flow, based on gravity discharge. Screen (lights).
Project details	This fish pass is developed by RWA Hunze en Aa's, and was installed in a canal nearby the town of Termunten in 2001. The fish pass allows fish to migrate between the brackish polder Breebaart and the freshwater polder Fiemel. The light line diverts the fish to the fish pass and prevents the going to the main pumping station "Fiemel" at the end of the canal. This main pumping station is not fish friendly.
Technical specifications	• The capacity of the pump is 8.3 m³/min. • Head of the discharge is ca. 2.68 m.
Site location & project pictures	  **Fish pass at pumping station Polder Breebaart**
Results	The fish pass is tested fish passable.
Location specific cost indication	In total: € 318.000,-.
Further reading	Esselink P., Berg G.J., (2006). Beheerplan Polder Breebaart (Concept). Rapportnr. 2005-100. Koeman en Bijkerk BV. WH&A & GRL, (2000). Projectvoorstel vispassage Breebaart. Waterschap Hunze en Aa's, Veendam & Groninger Landschap, Haren. Wintermans, G.J.M., (2001) Monitoringsvoorstel vijzel en vrij verval-passage polder Breebaart, WEB-rapport nr. 01-06. Wintermans G.J.M., Hektor K., Imminga J., Köller K. & Kruit W., (2004). Monitoring vispassage Polder Breebaart 2002 – 2004. WEB-rapport 04-02. Waterschap Hunze en Aa's, Veendam & Wintermans Ecologen Bureau, Finsterwolde.

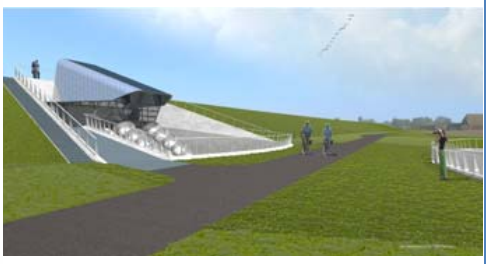
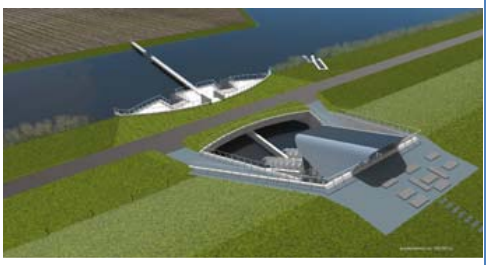
Project objective	PS14 Fish friendly pumping station “Ankeveense Plassen”– Ankeveen
Organisation	Waternet, NL
Construction	Two Hidrostal screw pumps. ‘Kwakernaak’ return flow system.
Project details	Pumping Station Ankeveen discharges water from lake ‘Hollands Ankeveen’ into the ‘s-Graveland canal. It is one of the priority barriers for fish migration in the management are.a of the Waterboard Amstel, Gooi en Vecht (Waternet, 2008). In 2008 it was decided to replace the old pump. The measure to create a solution for fish-passage at this location is included in the Waterplan of AGV for the WFD. Several options to create two way fish passage have been studied (TAUW, 2009). In 2011 it was decided to combine fish friendly hydrostal pumps with a return-flow system for upstream migration. Building starts in 2012.
Technical specifications	The capacity of this pumping station is 2 x 25 m³/min. Two relatively large pumps are used. They will be operated at relatively low speed to improve fish friendly-ness (max capacity 2 x 50 m³/min). Head of the discharge is ca. 1 m. Fish damage of the original screw pump has not been tested (renovation was already decided).
Site location & project pictures	   **Fish friendly pumping station “Ankeveense Plassen“ (Waternet)**
Results	The fish passage will be monitored after completion of realisation.
Location specific cost indication	Fish friendly pump: € 130.000,-. Total renovation project: € 250.000,-.
Further reading	Waternet. (2008). Aan de slag met vismigratie in het beheergebied van AGV, Bijlage 1.1 uitwerking gemaal Hollands-Ankeveen. TAUW. (2009). Aspectenstudie vismigratie gemaal Hollands Ankeveen.

Project objective	PS15 Fish friendly pumping station ''Hoekpolder''
Organisation	RWA Hoogheemraadschap van Delfland, NL
Construction	Screw pump, with a fixed tube.
Project details	This fish-friendly screw pump is a prototype developed by FishFlow Innovations, and is installed in a new pumping station nearby Rijswijk.
Technical specifications	The capacity of this pumping station is 64m³/min. Head of the discharge is ca. 0.8m.
Site location & project pictures	  **Pumping station Hoekpolder** **(Hoogheemraadschap van Delfland)**
Results	The pumping station is tested "fish survivable".
Location specific cost indication	2 x screw pump (pumps, engineering, installation of pumps and electromotor): €200.000,-.
Further reading	Zijlstra, B. Factsheet vismigratie project "Hoekpolder" Witteveen+Bos. (2010). Najaarsonderzoek 2009, DT263-53/bote/006.

Project objectives	PS16 Fish bypass at pumping station ''Rozema''
Organisation	RWA Waterschap Hunze en Aa's, NL
Construction	Fish pass with a freshwater attraction flow.
Project details	This fish bypass is developed by RWA Hunze en Aa's, and is installed in pumping station Rozema in the town of Termunterzijl. The fish pass offers a connection between the estuary of the River Ems and the freshwater canal "Termunterzijldiep".
Technical specifications	The capacity of the Hydrostal pump that is used to deliver the attraction flow is 7.25 m^3/min (this pump is not used to transport any fish!).
Site location & project pictures	  **Fish bypass at pumping station Rozema (RWA Hunze en Aa's).**
Results	The fish bypass is tested fish passable.
Location specific cost indication	Fish bypass: € 140.000,-. Total costs of the pumping station: € 19.500.000,-
Further reading	Wintermans G.J.M. (1997). Advies voor de aanleg van een vispassage bij het gemaal van Termunterzijl. WEB-rapport nr. 97-03. Wintermans Ecologenbureau, Texel. Wintermans, G.J.M., (2001). Monitoringsverslag vispassage gemaal Rozema 2001. 1ste jaar beheersituatie. Wintermans, G.J.M., (2002). Monitoringsverslag vispassage gemaal Rozema 2002. 2de jaar beheersituatie. Wintermans, G.J.M., (2003). Monitoringsverslag vispassage gemaal Rozema 2003. 3de jaar beheersituatie. Wintermans, G.J.M., (2004). Monitoringsverslag vispassage gemaal Rozema 2004. 2de jaar beheersituatie, eindverslag. WEB-rapport nr. 04-03 Stuivenberg, C., (2005). Monitoren vispassage bij gemaal "Rozema" . Waterschap Hunze en Aa's, Veendam.

	PS17 Fish friendly pumping station “t Hemeltje” – Kortenhoef, NL
Organisation	Waternet, NL
Construction	Two fixed wall Arcimedes screw pumps, developed by Fish Flow Innovations. And a ‘Kwakernaak’ return flow system.
Project Information	Pumping Station Kortenhoef discharges water from the Kortenhoef polder into the river Vecht. It is one of the priority barriers for fish migration in the management area of the Waterboard Amstel, Gooi en Vecht (Waternet, 2008). In 2008 it was decided to replace the old pump. The measure to create a solution for fish-passage at this location is included in the Waterplan of AGV for the WFD. Several options to create two way fish passage have been studied (TAUW, 2009). The pumping station was tested in the STOWA research. The results indicated high numbers of silver eel passing through the pumps. More than 30 % were killed (Visadvies, 2010). Monitoring in front of the PS was repeated in autumn 2011. The original pump was the last working example of a half open screw pump and there was discussion about replacing it. Finally in 2011 it was decided to built a new pumping station with fish friendly Archimedes screw pumps. Building starts in 2012.
Technical specifications	The capacity of this pumping station is 2 x 60 m3/min. Head of the discharge is ca. 1.5 m.
Site location & project pictures	  
Results	The fish passage will be monitored after completion of realisation
Cost indication	€335.000,- (costs that are related to fishmigration measures)
Further reading	* Waternet, 2008. Aan de slag met vismigratie in het beheergebied van AGV, Bijlage 1.2 uitwerking gemaal Het Hemeltje (in Dutch) * TAUW, 2009. Aspectenstudie vismigratie gemaal Kortenhoef. (in Dutch) * Visadvies (Kemper et.al), 2010. Onderzoek naar de visvriendelijkheid van 26 opvoerwerktuigen. Bijlagenrapport 8: Gesloten schroefpompen. VA 2009_33 (in Dutch)

Project objectives	PS18 Innovative fish passage at Maelstede pumping station
LNS Partner Organisation	**Waternet**
Species	Glass eel, Stickleback, Smelt, Flounder and Common goby
Methodology	During the monitoring of 9 weeks,it has been found that all goal species migrate into the polder through the fish passage. Monitoring took place from 3-4-2012 until 20-6-2012 with fykes .The findings tells that the fish pass is working for the inward migration because all fishes are physically able to migrate through the passage. Future monitoring will be used to fine-tune the settings of the passage and to get more fish (numbers) through the fish pass as well as to get better understanding of the migration outwards.
Issue(s) to be addressed & anticipated benefits to fish populations	In the situation of Maelstede a fresh water body has been connected with a salt water body by means of an innovative bypass. Function of this bypass is creating a controlled siphon between polder and open water. This enables migratory fishes like Sticklebacks, Glass eel, Smelt, Flounder and Common goby to pass easily through the dike in the spring time and for autumn the migration is the other way around, and especially important for (silver) Eel spawning. Furthermore,in front of (inland side) the pumping station, fishes are deterred by light in order to force them towards the inlet of the fish passage. This prevents emigrating fish crushed by the pumping station. Accordingly, these measures enlarge the habitat a lot for the species concerned and make a safe passage for their migration.
Site location & project pictures	 
Project partners	Waterboard Scheldestromen, The Netherlands
Further reading	Email to : Marius.Wingerden@Scheldestromen.nl

	PSS7 Fish friendly pumping station ''Vijfhuizen'' (to be constructed)
Organisation	RWA Wetterskip Fryslan, NL
Construction	2 Archimedes Screw pumps and an attraction flow pump.
Project details	This pumping station is engineered by RWA Wetterskip Fryslan. The pumping station will be installed at the sea dyke nearby the town of Hallum, NL.
Technical specifications	• Capacity of the main pumps is 2 x max. 111/126 m³/min. • Capacity of the attraction flow pump is max. 48 m³/min.
Site location & project pictures	   Pumping station Vijfhuizen (Wetterskip Fryslan).
Results	Not available, since it still has to be constructed.
Location specific cost indication	Total investment costs are estimated at: € 12.250.000,-.
Further reading	Wetterskip Fryslan. (2011). Ontwerp projectplan gemaal Vijfhuizen / Hallumer Ryt.

	PSS12 Fish friendly pumping station ''Hillekade''
Organisation	RWA Hoogheemraadschap van Schieland en de Krimpenerwaard, NL
Construction	Screw pump.
Project details	This fish-friendly screw pump is installed in a water channel system nearby the town of Ouderkerk.
Technical specifications	• The capacity of this pumping station is 2 x 40 m³/min. • Head of the discharge is ca. 0.12 m.
Site location & project pictures	   Pumping station Hillekade (Living North Sea and RLC Roosterreiniger)
Results	The pump is tested as "fish friendly'.
Location specific cost indication	Not available.
Further reading	STOWA. (2011). Factsheet gemaal Hillekade.

Project objectives	**TB1 Study the effectivity of fish friendly lock management at the IJzer tidal barrier, B**
LNS Partner Organisation	**INBO (Research Institute for Nature and Forest)**
Species	Eel, River Lamprey & Three Spined Stickleback
Methodology	Fyke netting, Stow nets, Lift nets
Issue(s) to be addressed & anticipated benefits to fish populations	Investigate the migratory behaviour of diadromous migratory fish on the IJzer, a small river with a catchment area of 1101 km². Glass eel were sampled during tidal rise with stow nets and lift nets to study their distribution over the study area, while a fyke net was used to evaluate the impact of limited barrier opening on glass eel migration. Glass eel migrating at the barriers appeared to have arrived during a previous tidal cycle, while a density peak was observed in the tidal flow during the last hour before high tide. Analysis of the lift net data indicated that migrating glass eel are attracted by the freshwater flow leaking from the barriers, whereas other variables such as the sampling location only had a small impact on the glass eel density. Adjusted barrier management creating an artificial attraction flow did not cause any significant changes in glass eel densities. Limited barrier opening during tidal rise appeared to be a cost-efficient and effective mitigation option to improve upstream glass eel migration, without significant penetration of sea water. Further research will also focus on other migratory species and the outcomes of the study will be used to improve the possibilities for migratory fish to travel upstream.
Site location & project pictures	  
Project partners	The project is funded by Waterways and Sea Canal (W&Z nv), a Belgian water manager.
Further reading	

Project objectives	**TB2 Study the effectiveness of fish friendly lock management at the Canal Ghent-Ostend tidal barrier, B**
LNS Partner Organisation	**INBO (Research Institute for Nature and Forest)**
Species	Eel, (Smelt, Three Spined Stickleback)
Methodology	Fyke netting
Issue(s) to be addressed & anticipated benefits to fish populations	Investigate the migratory behaviour of diadromous fish on the Canal Ghent-Ostend. Fyke nets were used to evaluate the impact of limited barrier opening on glass eel migration. Glass eel (and other fish species: smelt, three-spined stickleback) were sampled during tidal rise with 2 fyke nets. Limited barrier opening during tidal rise appeared to be a cost-efficient and effective mitigation option to improve upstream glass eel migration, without significant penetration of sea water. Since the adjusted barrier management is easily implementable and could be applied on numerous tidal barriers, the results may contribute to restoration of eel populations worldwide and be of interest to a wide range of river managers and stakeholders.
Site location & project pictures	  
Project partners	The project is funded by: - Waterways and Sea Canal (W&Z nv), a Belgian water manager - Agency for Nature and Forest (ANB), an agency of the Flemish Government
Further reading	Intention to put in hyperlinks to more detailed project description.

Project objectives	**TB5 To study the effectiveness of an orifice on improving fish passage past tide gates in a UK chalk stream**
LNS Partner Organisation	**Environment Agency Anglian Region**
Species	Sea Trout
Methodology	Acoustic Telemetry
Issue(s) to be addressed & anticipated benefits to fish populations	The migration of juvenile sea trout, *Salmo trutta*, past tide gates in a UK chalk stream was assessed over two years; before and after the installation of two orifice passes in the gates. The orifice passes remain open for the duration of the tidal cycle. In early April 2011 and 2012, 30 fish were caught each year via fyke nets set 4.3 km upstream of the tidal limit and surgically implanted with acoustic transmitters. Fish were released at the site of capture and migration downstream was tracked at five acoustic stations; three upstream (750m, 516m and 100m) and two downstream (30m and 90m) of the gates. Fish passage efficiency was high, with 95.8 and 100.0 % of fish that approached the barrier subsequently passing downstream in years 1 and 2 respectively. The gates delayed juvenile sea trout migration in both years, and delay was not decreased by the addition of the orifice passes in year 2, with the median passage time increasing considerably. The orifice passes augmented saline intrusion upstream, offering a shallower salinity gradient for the acclimation of juvenile trout transitioning between fresh and salt water.
Site location & project pictures	  
Project partners	The project is funded by the Environment Agency Anglian Region, University of Southampton and Living North Sea
Further reading	

Project objectives	**TB14 Study on the effectivity of fish friendly lock management at the Nieuwe Statenzijl tidal barrier, NL**
LNS Partner Organisation	**Regional Water Authority Waterschap Hunze en Aa's**
Species	River Lamprey, Tree Spined Stickleback & Eel
Methodology	Fyke netting
Issue(s) to be addressed & anticipated benefits to fish populations	Investigate the migratory behaviour of diadromous migratory on the Westerwoldse Aa, a small river with a catchment area of 80.000 ha. In recent years RWA Hunze & Aa's carried out several fish migration studies on this location in order to improve the effectivity of fish friendly lock management. These studies show that fish migration is not optimal and that further measures (fish pass) will be necessary. During the LNS project RWA H&A has studied the fish migration at several upstream locations (second line barriers): • Weir De Bult • Weir Veelerveen • Weir Wedde • Weir Renneborg • Weir Vlagtwedde • Pumping station Hongerige Wolf • Pumping Station Sans Souci The outcomes of the study will be used to improve the possibilities for migratory fish to travel upstream.
Site location & project pictures	  

Project partners	Angling association Groningen-Drenthe, Koeman & Bijkerk BV
Further reading	• Bonhof, G.H. & G. Wolters. 2011. Bepaling visaanbod Noordoost-Groningen: gemaal Hongerige Wolf en stuw Veelerveen. Rapport 2011-017. Koeman en Bijkerk bv, Haren. In opdracht van Waterschap Hunze en Aa's, Veendam. • Boonstra, H., Bonhof, G.H. & G. Wolters. 2012. Bepaling visaanbod Noordoost-Groningen: stuw De Bult. Rapport 2011-094. Koeman en Bijkerk bv, Haren. In opdracht van Waterschap Hunze en Aa"s, Veendam. • Boonstra, H., Bonhof, G.H. & G. Wolters. 2012. Bepaling visaanbod Noordoost-Groningen: stuw Wedde. Rapport 2011-093. Koeman en Bijkerk bv, Haren. In opdracht van Waterschap Hunze en Aa"s, Veendam. • Bonhof, G.H. & G. Wolters. 2012. Evaluatie vismigratievoorzieningen Ruiten Aa, Vispassage Renneborg. Rapport 2012-037. Koeman en Bijkerk bv, Haren. In opdracht van Waterschap Hunze en Aa"s, Veendam. • Bonhof, G.H. & G. Wolters. 2012. Evaluatie vismigratievoorzieningen Ruiten Aa, Vispassage Vlagtwedde. Rapport 2012-038. Koeman en Bijkerk bv, Haren. In opdracht van Waterschap Hunze en Aa"s, Veendam. • Boonstra, H., Bonhof, G.H. & G. Wolters. 2012. Bepaling visaanbod Noordoost-Groningen: gemaal Sans Souci. Rapport 2011-092. Koeman en Bijkerk bv, Haren. In opdracht van Waterschap Hunze en Aa"s, Veendam.

Project objectives	TB16 Tidal Barrier ''Polder Breebaart''
Organisation	RWA Hunze en Aa's, NL
Construction	Syphon (with 2 sliding doors).
Project details	This Syphon is developed by RWA Hunze en Aa's, and was installed in the sea dyke nearby the town of Termunten in 2001. The syphon creates a connection between the estuary of the river Ems and the brackish polder "Breebaart".
Technical specifications	• Length of the Syphon is 95 m. • Size of the Syphon: 2 m x 1 m.
Site location & project pictures	 Tidal barrier at Polder Breebaart, photo above is inlet from sea side, below is inlet from polder side (G.J. Berg).
Results	Tested as fish passable.
Location specific cost indication	Total project costs: € 657.000,-.
Further reading	Esselink, P., Berg, G.J., (2004). Hoogte- ontwikkeling en slibbalans van Polder Breebaart na invoering in een gedempt getijden-regime. Rapportnr 2004-01. Koeman en Bijkerk BV Esselink, P., Berg, G.J., (2006). Beheerplan Polder Breebaart (Concept). Rapportnr 2005-100. Koeman en Bijkerk BV WH&A & GRL, (2000). Projectvoorstel vispassage Breebaart. Waterschap Hunze en Aa's, Veendam & Groninger Landschap, Haren. Wintermans G.J.M., Hektor K., Imminga J., Köller K. & Kruit W., (2004). Monitoring vispassage Polder Breebaart 2002 – 2004. WEB-rapport 04-02. Waterschap Hunze en Aa's, Veendam & Wintermans Ecologen Bureau, Finsterwolde.

	TBS1 Fish friendly tidal barrier on the “Axe Estuary”
Organisation	Environment Agency, UK
Construction	Williams Self Regulating Tide gate (SRT).
Project details	This SRT gate is developed by Mike Williams of the South West Region of the Environment Agency and is installed on the Axe Estuary, near Seaton.
Technical specifications	The amount of water is regulated by the position of a plate which closes off the opening at a predetermined level. Opening and closing levels and opening period are fully adjustable by adjusting floats and the float and radial arm. The gate is fabricated from stainless steel, with the parts laser cut. Includes a side flap valve to allow discharge from the outfall at low tide.
Site location & project pictures	 Williams Self Regulating Tide gate in the estuary of the River Axe, near Seaton (Environment Agency)
Results	The tidal barrier allows fish passage.
Location specific cost indication	Costs for the SRT gate are between £ 25.000,- and £ 30.000,- (depending on size. Further costs depend on the type).
Further reading	Ridgway, G. & Williams, M. (2011). Delivering benefits through evidence, Self-regulating tide gate: a new design for habitat creation. Environment Agency. Solomon, J. (2010). Eel passage at tidal structures and pumping stations. Environment Agency, Thames Region. Williams, M. (2009). Self-regulating tidegate design facilitates habitat creation: interim report. Science project SC070031 interim report, Environment Agency, Bristol.