European Environment Agency

European Topic Centre
Inland, coastal, marine waters

Hydromorphology
draft for EEA 2012 state of water assessment

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Contents

Abbreviations used

<to be completed>
AWB – Artificial water body
EEA – European Environmental Agency
ETC / ICM – European Topic Centre on Inland Coastal and Marine Waters
EU – European Union
GEP – Good ecological potential
HMWB – Heavily modified water body
MS – Member States
WFD – Watre Framework Directive
WFD-CIS – Water Framework Directives Common Implementation Strategy

0. Guidance to the reader

Europe's surface freshwaters are affected by major modifications, such as water abstractions, water flow regulations (dams, weirs, sluices, and locks) and morphological alterations, straightening and canalisation, and disconnection of flood plains. These are called hydromorphological pressures. Hydromorphological pressures comprise all physical alterations of water bodies modifying their shores, riparian and littoral zones, water level and flow. Examples of such pressures are damming, embankment, channelization, and change to the natural hydrological regime. The extent of hydromorphological alterations in European river basins has been significant over the past centuries. Hydromorphological pressures and altered habitats are the most commonly occurring pressure and impact in rivers, lakes and transitional water; affecting half of river and transitional water bodies and 30 % of the lake water bodies.

To maintain and improve the essential functions of our water ecosystems, we need to manage them well. This can only succeed if we adopt the integrated approach introduced in the Water Framework Directive (WFD) and other water policies. Many European water bodies are at risk of failing to meet the aim of the WFD of achieving good status by 2015, due to problems in the management of water quality, water quantity, modifications of the structure of river banks and beds and the connectivity of rivers. Full implementation of the WFD throughout all sectors is needed to resolve these potential conflicts and to commit all users in a river basin to focus on the achievement of healthy water bodies with good ecological status.

0.1. EEA 2012 State of water assessments

2012 will be the European year of water in which the EU Commission will publish its "Blue-print to safeguard European waters" comprising reviews of the WFD, Water scarcity and drought and vulnerability and adaptation policies; In addition in March 2012 the 5th World Water Forum will be held in Marseille, France and in May the 3rd European Water Conference will be held during Green Week, Brussels. .

To accompany and inform these events and policy processes EEA plans for 2012 a set of reports on the "State of Europe's water". Two of these reports are based on information reported in 2010 via River Basin Management Plans and supplemented with assessments of information from other sources. It will be developed in close cooperation and coordination with the DG Environment's assessment of the RBMPs and the development of the blueprint (impact assessment, reports; communication, staff working documents). The format of the EEA 2012 State of Europe's water assessment is planned to consist of four thematic assessments and an overarching synthesis and integrated report. In terms of communication, the several assessments are planned to be published on several occasions throughout 2012. EEA are currently working on the following thematic assessments with indication of when they are to be published:

1. Efficient Use of Water Resources (World Water Forum, Marseilles, March 2012)
2. Vulnerability (Water scarcity and drought, floods, water quality) – Autumn 2012
3. WFD: Ecological and chemical status and pressures – Autumn 2012
4. WFD: Hydromorphology – Summer 2012

The last two thematic assessments are based on information reported via the RBMPs and present results on status and pressures.

First reporting of the River Basin Management Plans (RBMPs) under the Water Framework Directive (WFD) was due end 2009. Most Member States (23 out of 27 Member States) have reported their RBMPs and delivered a huge amount of data on status, pressures and measures to the WISE-WFD database. According to Article 18 of the WFD the *EU Commission shall publish a report on the im-*

plementation of this Directive at the latest 12 years after the date of entry into force of this Directive (two years after the Member States have delivered the RBMPs). The report shall among others include the following:

- *a review of progress in the implementation of the Directive;*
- *a review of the status of surface water and groundwater in the Community undertaken in co-ordination with the European Environment Agency;*

The current draft report on hydromorphology aims at providing an overview of the results on status and pressures from the River Basin Management Plans (RBMPs). The parallel thematic assessment on ecological and chemical status, pressures and impacts has more detailed information on data reported via the RBMPs, data handling methodology etc. For more detailed information see chapter 1 to 3 of the draft of this thematic assessment (this report is also out for consultation during February and March 2012). The current draft contains the following chapters.

- Chapter 1 presents general information on the WFD and WFD aspects related to hydromorphological pressures and alterations.
- Chapter 2 provides an overview of the designation of heavily modified and artificial water bodies.
- Chapter 3 presents results on ecological status and potential and compares the status by natural and heavily modified water bodies.
- Chapter 4 provides an overview of the proportion of surface water bodies affected by hydromorphological pressures.
- Chapters 5 to 8 present results, information and assessment on different hydromorphological pressures.
    - Chapter 5 provide an overview of barriers and other transversal structures
    - Chapter 6 presents results on pressures related to abstraction and flow regulation and water level regulation.
    - Chapter 7 provide an overview of results related to morphological changes including aspects of channelized streams; disconnecting floodplains and rivers and land reclamation.
    - Chapter 8 presents information on hydromorphological pressures in coastal and transitional waters;
- Chapters 9 to 12 present results, information and assessment on sector activities related to hydromorphological pressures including hydropower production, navigation activities and flood defences. These chapters are not fully developed. It is the intention to add more results on measures. These chapters will be developed on basis of the analysis done by EU Commission DG Environment.

We hope that Member States and relevant stakeholders will read and comment on the current draft reports. We hope that Member States can check the information included from their country/RBDs and in case of missing information update the information reported.

The current draft includes some case studies that partly have been copied from RBMPs or other country document. We hope Member States can revise and update the case studies and we would be pleased by new contribution of case studies, text boxes expressing their views on the aspects raised in the respective chapters.

Comments and suggestions to the current draft are very much appreciated. Thanks in advance.

Disclaimer
The current draft is based on data delivered by the Member States via WISE up to February 2012 and in some cases information available in digital version of RBMPs. Where Member States did not deliver data or the RBMPs are not yet available, information from the specific Member State or RBDs are not presented.

Where data are available, it has been dealt with, and is presented, to the best of our knowledge. Nevertheless inconsistencies and errors cannot be ruled out. *Comments and remarks on results are very much appreciated*.

The current draft is partly based on copy and paste of text from the multitude of documents produced on the WFD (Commission and national WFD guidance documents, RBMPs and Article 5 reports etc.). Sources have in most cases been listed (to be improved in next draft).

1. Introduction

1.1. The Water Framework Directive

The Water Framework Directive (WFD), which came into force on 22 December 2000, establishes a new framework for the management, protection and improvement of the quality of water resources across the European Union (EU). The WFD established new and better ways of protecting and improving our water environment with the overall objective of achieving co-ordinated and integrated water management across Europe.

The WFD calls for the creation of River Basin Districts. In case of international districts that cover the territory of more than one EU Member State the WFD requires coordination of work in these districts.

EU Member States should aim to achieve good status in all bodies of surface water and groundwater by 2015 unless there are grounds for derogation then achievement of good status may be extended to 2021 or by 2027 at the latest. Good status means that certain standards have been met for the ecology, chemistry, morphology and quantity of waters. In general terms 'good status' means that water only shows slight change from what would normally be expected under undisturbed conditions. There is also a general 'no deterioration' provision to prevent deterioration in status.

Text box 1.1: Water Framework Directive - the backbone of EU Water Policy

- Introducing the river basin approach
- Protecting all water bodies, including transitional waters and coastal waters
- Covering all impacts on waters
- Achievement of good status in all water bodies and no deterioration of status

The Water Framework Directive establishes a legal framework to protect and restore clean water in sufficient quantity across Europe. It introduces a number of generally agreed principle and concepts into a binding regulatory instrument. In particular, it provides for:

- Sustainable approach to manage an essential resource: It not only considers water as a valuable ecosystem, it also recognises the economy and human health depending on it.
- Holistic ecosystem protection: It ensures that the fresh and coastal water environment is to be protected in its entirety, meaning all rivers, lakes, transitional (estuaries), coastal and ground waters are covered.
- Ambitious objectives, flexible means: The achievement of "good status" by 2015 will ensure satisfying human needs, ecosystem functioning and biodiversity protection. These objectives are concrete, comparable and ambitious. At the same time, the Directive provides flexibility in achieving them in the most cost effective way and introduces a possibility for priority setting in the planning.
- Integration of planning: The planning process for the establishment of river basin management plans needs to be coordinated to ultimately achieve the WFD objectives.

- The right geographical scale: The natural area for water management is the river basin (catchment area). Since it cuts across administrative boundaries, water management requires close cooperation between all administrations and institutions involved. This is particularly challenging for transboundary and international rivers.
- Polluter pays principle: The introduction of water pricing policies with the element of cost recovery and the cost-effectiveness provisions are milestones in application of economic instruments for the benefit of the environment.
- Participatory processes: WFD ensures the active participation of all businesses, farmers and other stakeholders, environment NGOs and local communities in river basin management activities.
- Better regulation and streamlining: The WFD and its related directives (Groundwater Daughter Directive (2006/118/EC); Floods Directive COM(2006)15) repeal 12 directives from the 1970s and 1980s which created a well-intended but fragmented and burdensome regulatory system. The WFD creates synergies, increases protection and streamlines efforts.

Implementation of the Directive is to be achieved through the river basin management (RBM) planning process which requires the preparation, implementation and review of a river basin management plan (RBMP) every six years for each river basin district (RBD) identified. This requires an approach to river basin planning and management that takes all relevant factors into account and considers them together. There are five main elements of the process:

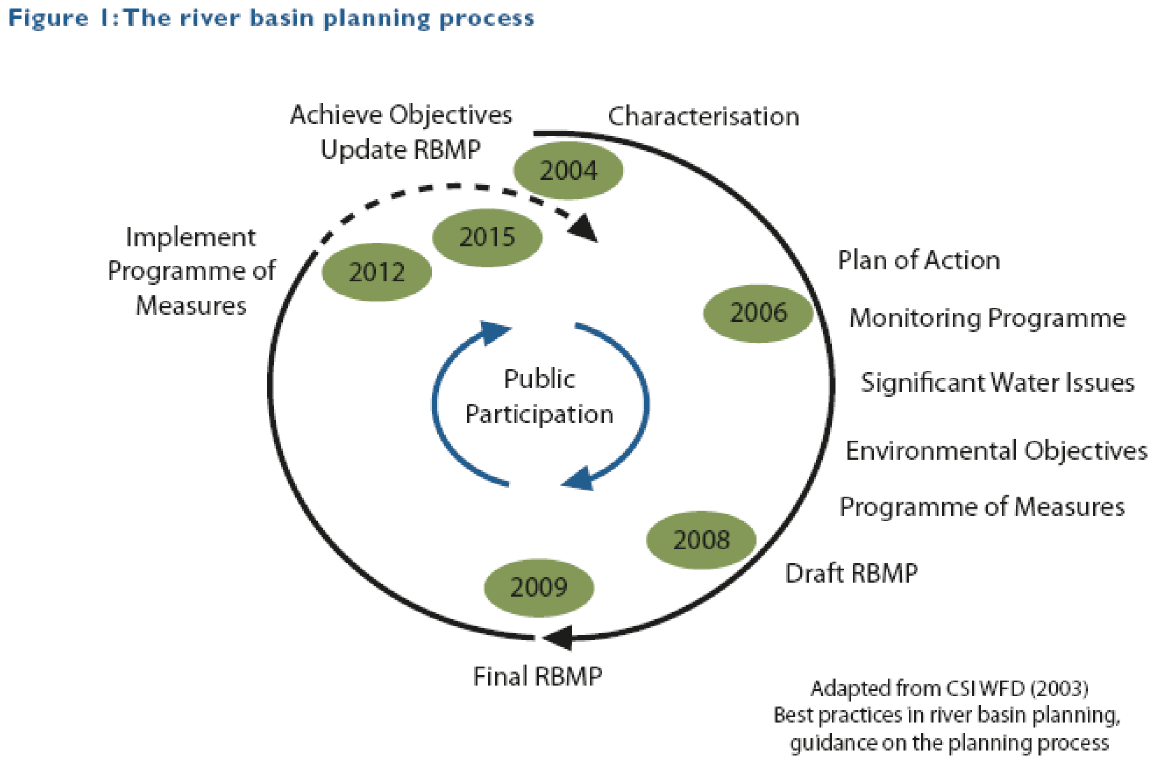
- Governance and public participation;
- Characterisation of the river basin district and the pressures and impacts on the water environment;
- Environmental monitoring based on river basin characterisation;
- Setting of environmental objectives; and
- Design and implementation of a programme of measures to achieve environmental objectives.

1.1.1. River basin planning process

River Basin Management Plans are plans for protecting and improving the water environment and have been developed in consultation with organisations and individuals. River basin planning is a strategic decision-making process that integrates the management of land and water within river basin districts. The river basin management planning process aims to improve and support sound and sustainable water management to deliver the requirements of the WFD while balancing the environmental, social and economic needs within the river basin district.

- The river basin planning process started more than ten years ago with implementation of the WFD in national legislation and establishing the administrative structures.
- The river basin planning process resulted in 2004 with an analysis of the pressures and impacts affecting the water environment in the river basin district. The findings were published in March 2005 in the characterisation report required by Article 5 of the WFD.
- River basin planning is a gradual cyclical process that involves public participation throughout. Characterisation is followed by a series of steps shown in Figure 1.1.

Figure 1.1 The WFD river basin planning process



Source: Adapted by CIS WFD (2003)

1.2. Hydromorphological pressures and habitat alterations

Europe's surface freshwaters are affected by major modifications, such as water abstractions, water flow regulations (dams, weirs, sluices, and locks) and morphological alterations, straightening and canalisation, and disconnection of flood plains. These are called hydromorphological pressures. Hydromorphological alterations are human pressures to the natural structure of surface waters such as modification of bank structures, sediment/habitat composition, discharge regime, gradient and slope. The consequence of these pressures can impact aquatic ecological fauna and flora and can hence significantly impact the water status.

Hydrological alterations refer to pressures resulting from water abstraction and water storage affecting the flow regime such as change in daily flow (hydropeaking) and seasonal flow. In addition, river stretches may dry up and water levels of lakes and reservoirs may be heavily regulated. The flow regime of a water body may be significantly altered downstream of an impoundment or an abstraction, and the biology may impacted. Alterations to the flow regime degrade aquatic ecosystems through modification of physical habitat and of erosion and sediment supply rates.

Morphology is the physical structure of a river, lakes, estuary or coast including, for example, the banks and bed of a river and the shore of lakes or coastal waters. Engineering or the way the land is managed can change the morphology of these waters. This has a direct impact on animals and plants and can lead to increased flooding or erosion.

Land reclamation, shoreline reinforcement or physical barriers (such as flood defences, barrages and sluices) can affect all categories of surface waters. Weirs, dams and barrages can alter water and sediment movements, and may impede the passage of migratory fish such as salmon. Using water for transport and recreation often requires physical alteration to habitats and affects the flow of water. Activities such as maintenance and aggregate dredging and commercial fishing using towed bottom-fishing gear can also damage physical habitats.

There are many human activities that result in hydromorpholgical pressures:

Agricultural activities have in many places affected the hydromorphological status of European water bodies. Water storage and abstraction for irrigated agriculture have, in particular in Southern Europe changed, the hydrological flow regime of many river basins. Intensification of agriculture included many land reclamation projects affecting transitional and coastal waters and affected many rivers that were straightened, deepened and widened to facilitate catchment drainage and to prevent local flooding.

Reservoirs are human-made lakes created by the damming of rivers to serve one or more purposes, such as hydropower production, water supply for drinking, irrigation and flood protection.

Inland waterway transport plays an important role in the movement of goods in Europe. More than 4 000 kilometers of waterways connect hundreds of cities and industrial regions.

Flood defence works may cause significant pressures on hydromorphology. Today many sections of the major rivers have dykes. The building of dykes resulted in the loss of floodplains as retention spaces for flood water.

In many cases, *minerals are extracted* from surface water. Sand used to reinforce the coast is extracted from other sea areas, while clay and sand used for concrete and building are usually extracted from the flood plains of rivers. Gravel mining have occurred in several European river basins.

Hydromorphological pressures, often connected with *construction, marine transportation and tourism*, and alter coastal zone, causing considerable changes in physical features of the coast including sediment transport and erosion.

Figure 1.2: Conceptual overview of the change from natural waters to different activities resulting in pressures and altered habitats

Source: Raimund Mair, ICPDR

1.3. WFD and hydromorphological pressures

To maintain and improve the essential functions of our water ecosystems, we need to manage them well. This can only succeed if we adopt the integrated approach introduced in the WFD and other water policies. Many European water bodies are at risk of failing to meet the aim of the WFD of achieving good status by 2015, due to problems in the management of water quantity, modifications of the structure of river banks and beds and the connectivity of rivers, or unsustainable flood protection measures. Full implementation of the WFD throughout all sectors is needed to resolve these potential conflicts and to commit all users in a river basin to focus on the achievement of healthy water bodies with good status.

The WFD defines "good ecological and chemical status" in terms of low levels of chemical pollution as well as a healthy ecosystem defined as at least good ecological status. Classification of ecological status or potential is based upon the biological elements (phytoplankton, macroalgae, benthos and fishes), hydromorphological, physico-chemical quality elements and non-priority pollutants.

Hydromorphological quality elements
The ecological classification system required under the WFD describes hydromorphological elements as 'supporting the biological elements'. This means assessing pressures and impacts on:

- hydrological regime (quantity and dynamics of flow, connection to groundwater);
- continuity (ability of sediment and migratory species to pass freely up and down rivers and laterally with the floodplain);
- morphology (i.e. physical habitat – compositions of substrate, width/depth variation, structure of bed, banks and riparian zone).

For high status to be achieved, the WFD requires that there are no more than very minor human alterations to the hydromorphological quality elements. At good, moderate, poor and bad status, the required values for the hydromorphological quality elements must be such as to support the required biological quality element values for the relevant class Each of the four surface water categories is ascribed specific hydromorphological quality elements.

- Rivers - depth and width variation; structure and substrate of the river bed; structure of the riparian zone; river continuity.
- Lakes - depth variation; quantity, structure and substrate of the bed; structure of the lake shore.
- Transitional waters (estuaries) - depth variation; quantity, structure and substrate of the bed; structure of the intertidal zone.
- Coastal waters - depth variation; structure and substrate of the coastal bed; structure of the intertidal zone.

The Water Framework Directive (WFD) allows Member States (MS) to designate some of their surface waters as *heavily modified water bodies* (HMWB) or *artificial water bodies* (AWB), for heavily modified and artificial water bodies the ecological potential should be determined. Member States will need to meet the good ecological potential (GEP) criterion for ecosystems of HMWBs and AWBs rather than good ecological status as for natural type water bodies. The objective of GEP is similar to good status but takes into account the constraints imposed by social and/or economic uses.

A heavily modified water body (HMWB) refers to a body of surface water that as a result of physical alteration by human activity is substantially changed in character. A surface water body is considered as artificial (AWB) when created by human activity. According to WFD Article 2 and 4(3), EU MS may designate a body of surface water as artificial or heavily modified, when:

- its hydromorphological characteristics have substantially changed so that good ecological status cannot be achieved and ensured;

- the changes needed to the hydromorphological characteristics to achieve good ecological status would have a significant adverse effect on the wider environment or specific uses;
- the beneficial objectives served by the artificial or modified characteristics of the water body- reasonably cannot be achieved by a better environmental option, which is:
    - technical feasible and/or
    - not disproportionate costly.

The designation of a water body as heavily modified or artificial means that instead of ecological status, an alternative environmental objective, namely ecological potential, has to be achieved for those water bodies, as well as good chemical status.

2. Heavily modified and artificial waters

2.1. Introduction

The WFD allows Member States to designate some of their surface waters as heavily modified water bodies or artificial water bodies whereby they will not need to meet the same quality criteria required of other surface waters. They will need to meet the "good ecological potential" criterion for these ecosystems rather than "good ecological status". However, artificial and heavily modified bodies will still need to achieve the same low level of chemical contamination as other water bodies.

A heavily modified water body refers to a surface water body that as a result of physical alteration by human activity is substantially changed in character (WFD Article 2 (9)). A surface water body is considered as artificial when it was created by human activity (WFD Article 2 (8)). Member States may designate a body of surface water as artificial or heavily modified, when:

- its hydromorphological characteristics have substantially changed so that *good ecological status* cannot be achieved and ensured;
- the changes needed to the hydromorphological characteristics to achieve *good ecological status* would have a significant adverse effect on the wider environment or specific uses*;*
- the beneficial objectives served by the artificial or modified characteristics of the water body cannot, for reasons of technical feasibility or disproportionate costs, reasonably be achieved by other means, which are a significantly better environmental option.

In the United Kingdom, for example, upper stretches of the Thames River remain largely in their natural state. But the lower stretches of the Thames, which are modified by embankments and other public works as they flow through London. Other example is in Germany, where heavily modified water bodies dominantly comprise shipping routes and impounded river reaches, whereas artificial water bodies can be, for example, canals or open-cast mining lakes. Table 2.1 gives examples of those types that are considered as artificial water bodies.

Table 2.1 Examples from United Kingdom of water bodies that are considered as artificial water bodies

Category	Types	Includes
River	Canal	Completely artificial dug canals
	Surface water transfers (open channels only)	Water diversions
		Leats
		Reservoir feeders
Lake	Lake	Flooded gravel pits
		Flooded surface mine workings
		Flooded clay pits
		Flooded peat workings
		Large ornamental lakes
		Pumped storage reservoirs
		Drainage ditches/channels
Transitional and coastal waters	Docks and harbours	Dug docks
		Flooded clay pits (which experience some saline intrusion)
		Storage reservoirs

Member States will need to meet the good ecological potential (GEP) criterion for ecosystems of HMWBs and AWBs rather than good ecological status as for natural type water bodies. The objective of GEP is similar to good status but takes into account the constraints imposed by social and/or economic uses. Good ecological potential provides a sustainable balance between the socio-economic heritages and/or conservation interests that cause hydromorphological pressures versus doing all that can to improve the ecological condition of the water body.

A HMWB or AWB is at GEP when the hydromorphological characteristics have been improved to the fullest extent, but without a significantly adverse impact on the use or wider environment. However, heavily modified and artificial bodies will still need to achieve the same low level of chemical contamination as other water bodies.

2.2. European overview of HMWB / AWB

2.2.1. Key messages

- There is a wide range of differences in the number of designated surface water bodies among the countries.
- Overall, 17.8% of European river water bodies and 16 % of lake water bodies are designated by the Member States as either heavily modified water bodies or artificial water bodies.
- In the Netherlands majority of the river water bodies are heavily modified while in Sweden almost all river water bodies are in natural condition.
- The Netherlands, Czech Republic and Belgium, Flanders designated nearly all of their lake water bodies as being either heavily modified or artificial.
- A total of 18 EU Member States have on average identified around 6.1 % of their coastal water bodies as heavily modified (6.1 %) and artificial (0.5 %).
- The share of transitional water bodies identified as heavily modified and artificial in 15 EU Member States is much larger (25 %), of which 2 % are artificial.
- Two sea regions of Europe (Greater North Sea and Black Sea) and six Member States (the UK, Spain, Malta, the Netherlands, Romania and Poland) have more than 10 % of their coastal water bodies identified as heavily modified or artificial.
- About 60 % of transitional water bodies are identified as heavily modified or artificial in the Greater North Sea and Black Sea regions. In other sea regions this percentage is 25 % or less.
- Six Member States (the UK, Bulgaria, Poland, Belgium, Germany and the Netherlands) have more than 25 % of their transitional water bodies identified as heavily modified or artificial.
- Heavily modified and artificial water bodies are clearly associated with densely populated, urbanised areas with industrial areas and ports as well as low-lying or mountainous regions.

2.2.2. Assessment

Overall, 17.8 % of European river water bodies and 16.0 % of lake water bodies are designated by the Member States as either heavily modified water bodies or artificial water bodies (Figures 2.1). The situation varies widely between Member States.

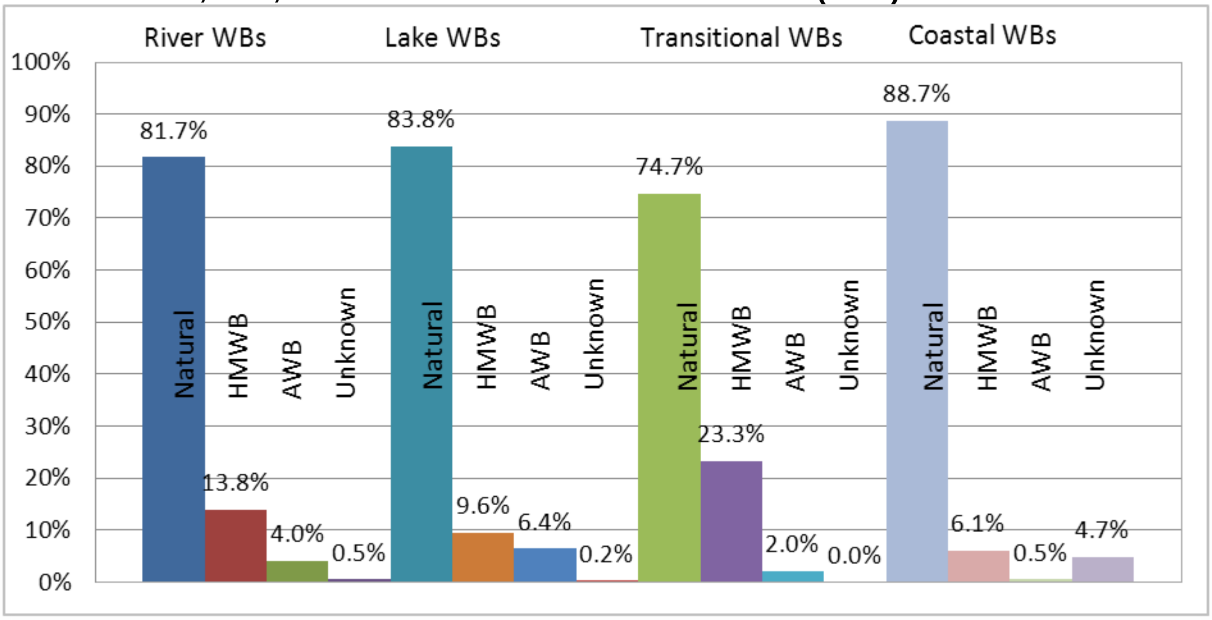
The countries with the highest percentage (more than 50%) of HMWBs and AWBs for rivers are the Netherlands, Belgium, Hungary and Germany, while countries, such as Finland, France, Slovakia, Sweden and Ireland designated only 5% or less of their river water bodies in these two types (Map 2.1.a).

In case of lakes the highest percentage (above 60%) of designated HMWBs or AWBs are in Belgium, Czech Republic, The Netherlands, Bulgaria, France, The United Kingdom, Hungary and Italy. The lower end of such rank (less than 5%) is represented by Sweden, Estonia, Latvia, Ireland and Finland (Map 2.1.b).

In general, heavily modified and artificial water bodies are clearly associated with densely populated, urbanised areas as well as low-lying or mountainous regions (Map 2.1). In sparsely populated river basin district (RBD) nearly all river water bodies are natural, while in river basin districts with population density higher than 100 inhabitants per km^2 around one third to 40 % of the river water bodies have been identified as being heavily modified or artificial.

The Netherlands, for instance, has very few natural water bodies; more than 95% are HMWB or AWB. The low-lying position, the intensive land use and the transport over water have drastically changed the water system in many places. Particularly in the low-lying part of the Netherlands, most of the smaller surface waters were excavated by humans. There is large-scale damming up of tidal outlets and embankments of large rivers to protect the country from flooding.

Figures 2.1 Percentage of natural, heavily modified (HM), artificial (A) and unknown status for river, lake, transitional and coastal water bodies (WBs)



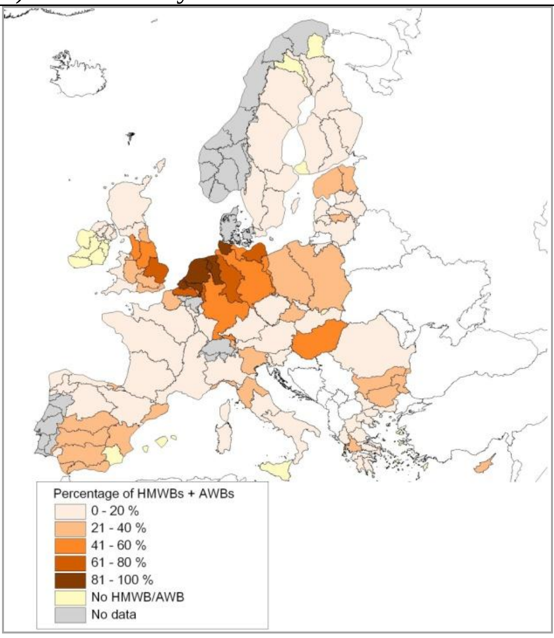
Source: WISE-WFD database – (03/02/2012)
Note: The figure represents 85686 river water bodies from 22 countries and 17977 lake water bodies. There are 954 transitional water bodies and 2807 coastal water bodies.

Around 6.6 % of the coastal water bodies in EU18 Member States are identified as heavily modified and artificial. One fourth of the transitional water bodies in EU15 Member States are identified as heavily modified (23.3 %) and artificial (2 %). This accounts for 184 HMWB/AWBs out of 2 807 coastal water bodies and 241 HMWB/AWBs out of 954 transitional water bodies in EU (Figure 2.1).

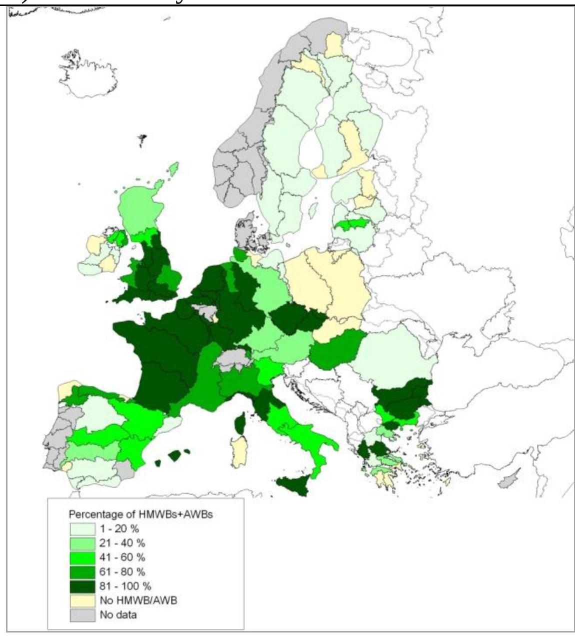
The situation varies widely between Member States in case of transitional and coastal water bodies, as well. Malta, Netherlands, Romania and Poland designated more than 20 % of their coastal water bodies as heavily modified or artificial. Artificial water bodies in coastal waters are designated only in the United Kingdom and the Netherlands. Belgium, Germany and the Netherlands identified all their transitional water bodies as heavily modified or artificial, although the numbers of them are low, 6 or less. In the Netherlands, for example, major proportion of water bodies has been morphologically altered during the last thousand years. Land reclamation was a large-scale activity in coastal parts of the Netherlands. Flood protection is a major pressure as well, aim of which is to protect millions of people.

Map 2.1 Percentage of heavily modified and artificial water bodies

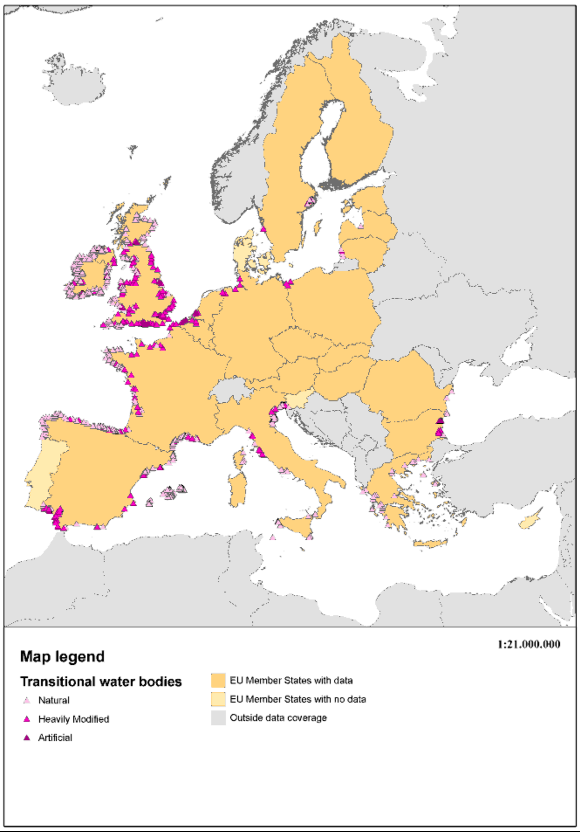
a) river WBs by river basin districts



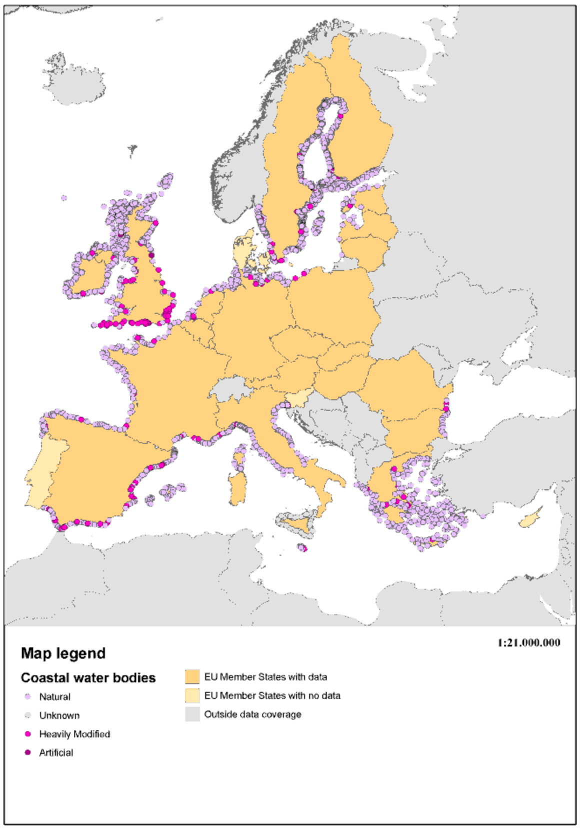
b) lake WBs by river basin districts



c) transitional WBs



b) coastal WBs



Source: WISE-WFD database – (02/09/2011)

Note to c): 323 water bodies (natural and unknown type) are not presented on the map due to missing coordinates. All are located in Italy (Sardinia and Southern Apennines).

Note to d): 69 water bodies (natural and one artificial) are not presented on the map due to missing coordinates. All are located in Italy (Sardinia and Southern Apennines).

About 60 % of transitional water bodies are identified as heavily modified or artificial in the Greater North Sea and Black Sea regions (Maps 2.1c). In other sea regions this percentage is 25 % or less. Six Member States (the UK, Bulgaria, Poland, Belgium, Germany and the Netherlands) have more than 25 % of their transitional water bodies identified as heavily modified or artificial.

The largest number of coastal and transitional HMWB/AWBs can be found in the United Kingdom (65 and 107, respectively), followed by Greece (10), France (10), Finland (13), Sweden (23) and Spain (33) for coastal water bodies, and Ireland (10), Bulgaria (10), Italy (16), France (24) and Spain (50) for transitional water bodies. In contrast, no heavily modified or artificial coastal water body has been identified in Belgium, Bulgaria, Latvia and Lithuania. No transitional water body is designated as heavily modified or artificial in Greece, Latvia and Romania (Maps 2.1c and d).

Two sea regions of Europe (Greater North Sea and Black Sea) and six Member States (the UK, Spain, Malta, the Netherlands, Romania and Poland) have more than 10 % of their coastal water bodies identified as heavily modified or artificial (Map 2.1d).. The Greater North Sea and Black Sea regions have more than 10 % of coastal water bodies identified as heavily modified or artificial. In the Celtic Seas, Bay of Biscay and the Iberian Coast region, the percentage is approximately the same as for EU. About 5 % of coastal water bodies are heavily modified or artificial in the Mediterranean Sea and Baltic Sea regions

Common features for the North-East Atlantic Ocean coasts are rich biodiversity, growing tourism and recreation use as well as heavy traffic. Especially in the Greater North Sea, sediment extraction, world's largest harbours and growth of both industry and population cause pressures for coastal zone (OSPAR Commission 2011, Laukkonen, 2011). The Greater North Sea coastal zones of Belgium, the Netherlands and Germany are almost uninterruptedly covered by protecting structures, leading to extensive habitat fragmentation. These countries have a long tradition in coastal protection. Mostly hard structures have been used, such as dikes, groyne fields and seawalls. However, the length of soft defences, such as beach nourishment schemes, is increased each year and already significant parts of the Belgian, Dutch and Danish North Sea shores are defended using these techniques. On the contrary, countries with long coastlines, including cliffs and rocks, protect only a small portion of the coastline. This protection against erosion is generally restricted to hard defence techniques near harbours and cities (OSPAR Commission 2009:2, 10, 14).

As one of the most heavily transported sea, many coasts of the Baltic Sea have been altered due to harbours, but also flood protection, bridges and underwater cables and pipes have changes hydromorphology of Baltic Sea coastline.

The Mediterranean is one of the most popular tourist destinations in the world, which causes significant pressures in coastal zone (Stanners & Bourdeau 1995:116, cited by Laukkonen, 2011). As Mediterranean tourism is predominantly of a seaside character, all installations constructed specifically on the coastline contribute to the artificial coasts cover. The development of boating also contributes in exacerbating this phenomenon via the construction of ports and of marinas, both of which are large area consuming. These impacts are strongly aggravated by seasonal and spatial concentration of tourism activities. Thus, the high population density on holiday sites exerts pressure on water resource and natural medium (UNEP/MAP-Plan Bleu 2009:101).

2.3. Water uses for which water bodies are identified as Heavily Modified Water Bodies (HMWB)

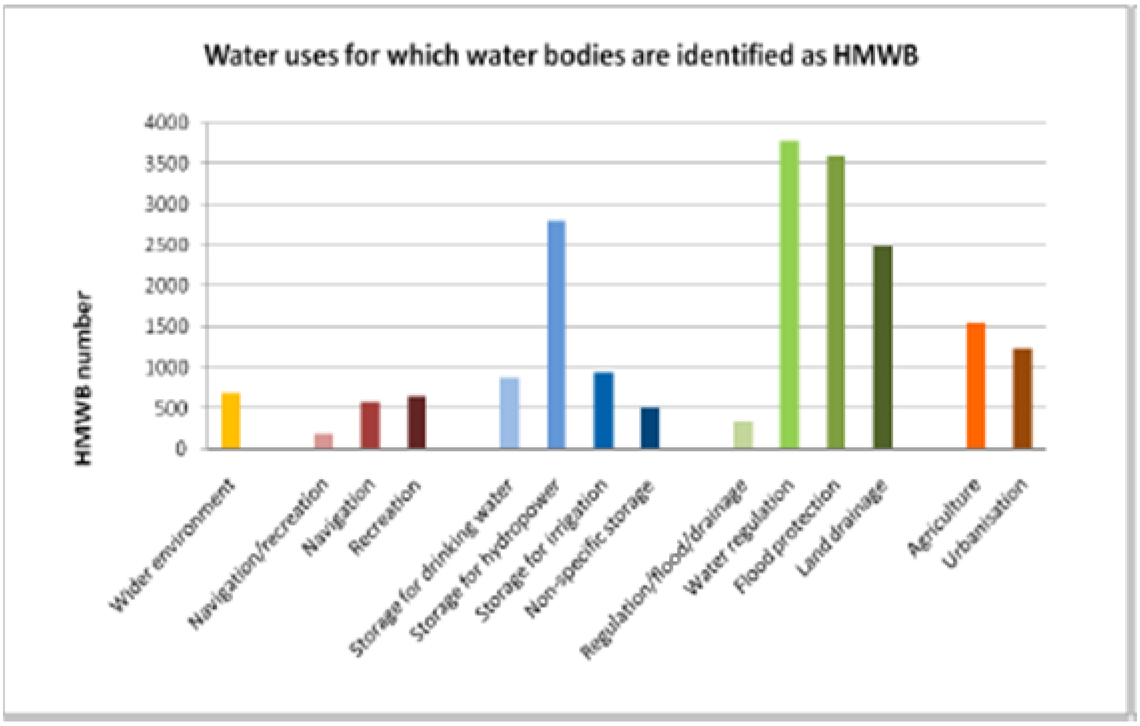
In 2009 a questionnaire to Member States on water uses for which water bodies are identified as HMWB resulted in answers from 24 countries (EU27 Member States except (Denmark, Greece, Italy and Malta) and Norway). Member States reply relates to designation of all categories of surfaces water bodies and it has not been possible to split the results by rivers, lakes, transitional and coastal waters. The 2009 questionnaire reply is based on information from 12 148 HMWBs via the RBMPs Member States have ultimo 2011 reported 13 950 HMWBs.

According to WFD Article 4(3) for a water body designated HMWB different may be accepted, such as:

- the wider environment;
- navigation, including port facilities, or recreation;
- activities for the purpose of which the water is stored, such as drinking water supply, power generation, irrigation and other water storage;
- water regulation, flood protection, land drainage; or
- other equally important sustainable human development activities.

These uses may change or have already changed the hydromorphological characteristics of that water body. A water body designated as heavily modified should still achieve good ecological status. Figure 2.2 summarises the absolute HMWB numbers per water use.

Figures 2.2 Absolute numbers of designated heavily modified water bodies per water use



Note: Based on questionnaire replies from 23 Member States and Norway in 2009.
Source: Discussion paper: http://ecologic-events.eu/hmwb/documents/Discussion_Paper_Updated.pdf

On the major uses for designation of HMWB it may be concluded:

- Water regulation, flood protection, and land drainage are the most common uses for designating HMWB.
- Water storage for power generation follows in terms of importance as water use for HMWB designation.
- Agriculture and urbanisation, which have been defined as equally important sustainable human development activities, follow in the order of importance as uses related to HMWB designation.
- Navigation (including port facilities), recreation and the wider environment are the uses with the lowest number of designated HMWB.

In terms of regional and sector variation, the following may be noted:

- Navigation (total 583 WBs): The three Member States (United Kingdom, Germany, Spain) which reported the highest numbers of HMWB for navigation account for about 57% of all navigation-HMWBs;
- Recreation (total 642 WBs): The five Member States (DE, UK, PL, CZ, LT) which reported the highest numbers of HMWB for recreation account for about two-thirds of all recreation-HMWBs;
- Storage for drinking water (total 874 WBs): The four Member States (UK, NO, ES, FR) which reported the highest numbers of HMWB for drinking water storage account for about 70% of all drinking-water-storage-HMWBs;
- Storage for power generation (total 2793 WBs): The five Member States (NO, SE, DE, AT, UK) which reported the highest numbers of HMWB for hydropower account for about 70% of all hydropower-HMWBs;
- Storage for irrigation (total 941 WBs): The five Member States which reported the highest numbers of HMWB for irrigation storage (PL, BG, CY, ES, PT) account for about 82% of all irrigation-storage-HMWBs;
- Water regulation (total 3784 WBs): The three Member States which reported the highest numbers of HMWB for water regulation (NO, DE, PL) account for about 79% of all water-regulation-HMWBs;
- Flood protection (total 3598 WBs): The four Member States which reported the highest numbers of HMWB for flood protection (UK, DE, AT, PL) account for about 72% of all flood-protection-HMWBs;
- Land drainage (total 2488 WBs): The four Member States which reported the highest numbers of HMWB for land drainage (DE, UK, LT, EE) account for about 96% of all land-drainage-HMWBs;
- Agriculture (total 1222 WBs): Germany alone accounts for 96% of the HMWB designated due to agriculture including forestry;
- Urbanisation (total 1543 WBs): Germany and United Kingdom account for 91% of the HMWB designated due to urbanisation.

It should also be noted that water bodies can be designated as heavily modified for more than one uses. Two-thirds of the designated HMWBs have only one water use, while 19 % had two uses and 13 % had multiple uses.

2.4. Case studies

2.4.1. HMWBs / AWBs in Germany

Source: UBA 2010:
Heavily modified water bodies in Germany comprise shipping routes and impounded river reaches, whereas artificial water bodies can be, for example, canals or opencast mining lakes. Less than half of German surface waters are classified as natural one, while 37 % and 15 % of the surface waters were classified as heavily modified and as artificial ones, respectively. Most of the HMWBs are located in the North West of the country, in the low-land part of the Rhine, Weser, Ems, Elbe, and Eider RBD (Map 2.2).

In the Alpine region and highland generally more than two thirds of the river water bodies are in natural state while in the lowlands streams and rivers and large rivers the majority of river water bodies have been designated as HMWBs (Figure 2.4).

Map 2.2 Map of natural, HMWBs and AWBs in Germany

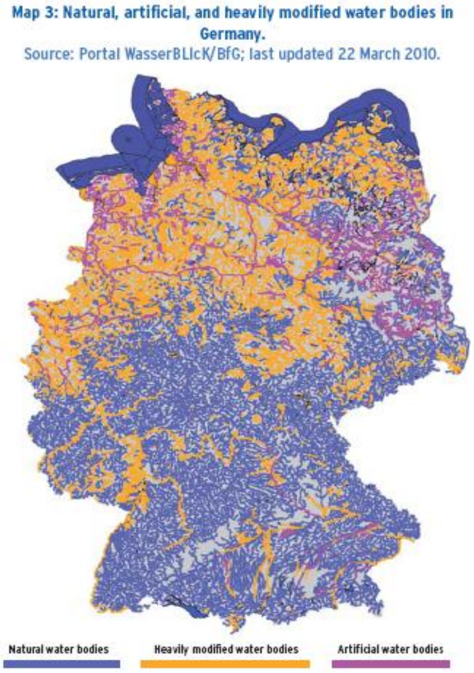
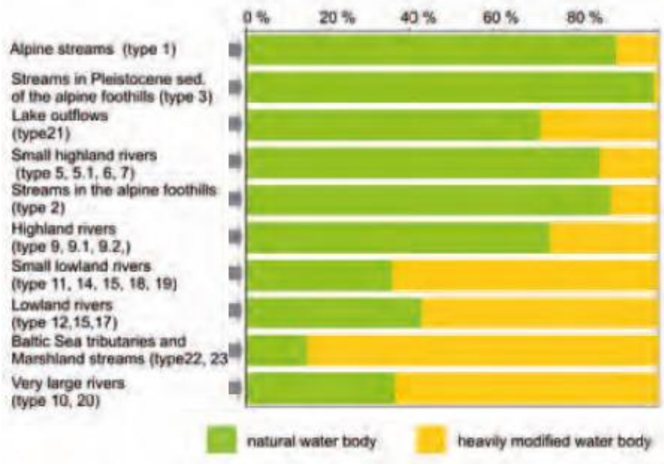


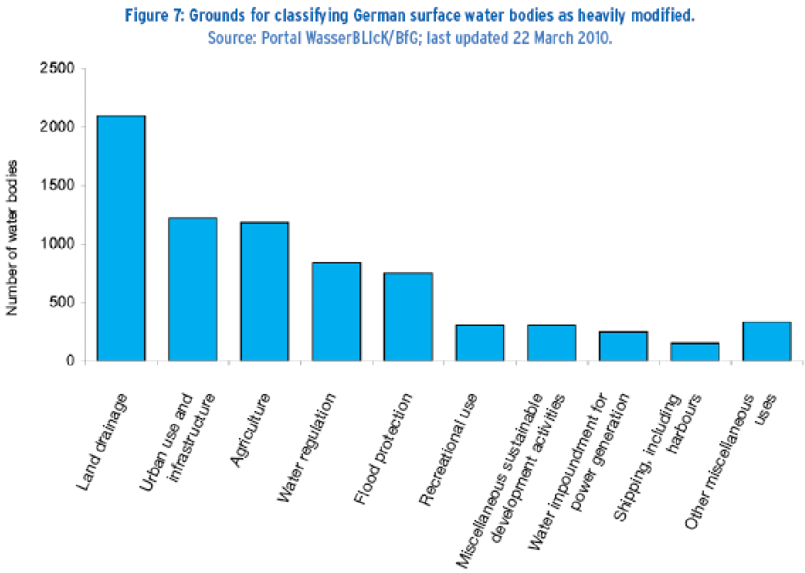
Figure 2.4 Classification into natural and heavily modified water bodies of different German river types



Source: http://www.uba.de/uba-info-medien-e/4021.html Source: UBA 2010

The main reasons for classifying German water bodies as heavily modified are land drainage, urban and infrastructure use, agriculture, but also water regulation and flood protections are important causes for designating water bodies as heavily modified (Figure 2.5).

Figure 2.5 Main grounds for classifying German water bodies as heavily modified



2.4.2. Danube International RBD

The Danube Integrated River Basin District Management Plan[1] provide a detailed overview of the final designation of heavily modified and artificial water bodies which have catchment area larger

[1] http://www.icpdr.org/icpdr-pages/river_basin_management.htm

than 4000 km^2 . Out of overall 681 river water bodies in the entire DRBD (Danube River and DRBD Tributaries) a total number of 270 are designated as heavily modified (241 final and 29 provisional HMWBs). These are 40 % of the water bodies. Further, 21 water bodies are AWBs. This means that 9,835 km out of 25,117 river kilometres are heavily modified (83 % final HMWBs and 17 % provisional HMWBs) due to significant physical alterations causing a failure of the *good ecological status*. 1,592 km of the Danube River itself are designated as HMWB – this is 56 % of its entire length (83 % final and 17 % provisional). Table 2.2 summarises the designation of HMWBs for all DRBD rivers, the Danube River itself and the three transitional water bodies in the DRB indicating absolute numbers and length of water bodies designated as HMWB.

Table 2.2 Designated HMWBs in the Danube River and all rivers of DRBD

Rivers – Danube River Basin District (DRBD)		
Total WB length (km): 25 117	Total HMWB length (km): 9 835	Proportion HMWB (length): 39%
Total number of WBs: 681	Total number of HMWBs: 270	Proportion HMWB (number): 40%
The Danube River		
Total WB length (km): 2 857	Total HMWB length (km): 1 592	Proportion HMWB (length): 56%
Total number of WBs: 45	Total number of HMWBs: 26	Proportion HMWB (number): 58%

Source: Danube River Basin District Management Plan, ICPDR, 2009.

Out of a total of 45 Danube River water bodies, 21 water bodies were designated as finally heavily modified by the EU MS. 5 were designated as provisionally heavily modified by the Non EU MS. Therefore, 1,592 rkm of the entire Danube River length (56%) have been designated as HMWB. No artificial water body has been designated.

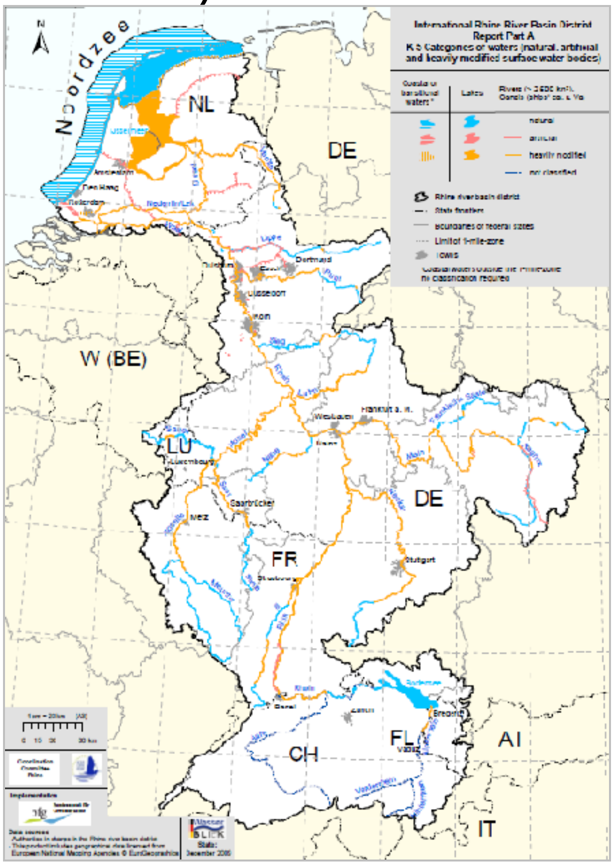
The harmonised designation of HMWBs for the Danube River was encountered with difficulties as the agreed criteria were not applied by all riparian Danube countries. Due to the fact that the intercalibration exercise has not yet been completed for all countries in the DRB only Austria, Germany and Slovakia can provide water status assessment results *(ecological status / ecological potential)* with high confidence and perform a final HMWB designation according to the agreed criteria. Although clear cut situations (such as impoundments) have been identified to enable a harmonised final designation of HMWBs, the exercise has not been completed successfully. Therefore, the HMWB designation for the Danube River reflects only partly a harmonised outcome based on the agreed ICPDR criteria. It can be concluded that the final HMWB designation still needs further validation.

In the DRBD out of seven lake water bodies (one of them being transitional), none was designated as finally heavily modified. No lake water body was identified as artificial. Out of the five coastal water bodies, two were designated as finally heavily modified. No coastal water body was identified as artificial.

2.4.3. Rhine RBD

The Internationally Coordinated Management Plan for the International River Basin District of the Rhine provides information on the classification of the water bodies of the main stream of the Rhine. The sections of the river as of heavily modified, artificial or natural character are shown in Figure 2.5 which indicates the percentages of water bodies in the main stream of the Rhine. 12% of the water bodies are classified as natural, 76% as heavily modified and 12% artificial type calculated by the number of water bodies. Closer to the mouth of the river water bodies are dominantly artificial or heavily modified.

Figure 2.5 Categories of waters (natural, artificial and heavily modified surface water bodies) in the Rhine River Basin District



Source: Internationally Coordinated Management Plan for the International River Basin District of the Rhine, ICPR, December 2009.

2.4.4. Heavily modified water bodies in selected coastal areas

Heavily modified and artificial water bodies in Malta

The coastal waters around the Maltese Islands have been divided into nine distinct water bodies of which two are heavily modified. A water body has been designated as heavily modified water body by applying the following criteria:

- The failure to achieve good status results from physical alterations to the hydromorphological characteristics of the water body and not due to chemical pollution.
- The water body must be substantially changed in from its natural condition such that the change in character is extensive/widespread or profound and therefore permanent and irreversible (Malta Resources Authority, 2011a).

Two water bodies include two major industrial coastal harbours (Il-Port Il-Kbir and Il-Port ta' Marsamxett (MTC 105) and Il-Port ta' Marsaxlokk (MTC 107) along the NW-NE coast of Malta (Figures 2.6 and 2.7). As expected, hydromorphological changes within these major inlets consisting of extensive marine constructions and land reclamation, were considered to have had a significant impact on the ecosystems. For this reason, these water bodies were identified as heavily modified water bodies (HMWB) (Malta Resources Authority, 2011b).

The harbours are subject to continuous morphological change, not to mention the historical impacts on the morphology of the harbours ever since the Knights of St. John used the harbour as the major point of defence during the 16th Century. Dredging continuously takes place; land has been reclaimed for the building of weirs, platforms, quays and also for the carrying out of ship repairs. The port of Marsaxlokk has also been subject to intensive physical alteration with the development of the Freeport and oil terminals. Changes to the coastline within established port areas are inherent for their continued commercial operation especially in order to retain competitiveness within the Mediterranean (Malta Resources Authority, 2011a).

In case of water body at port of Kbir and port of Marsamxett (MTC 105), historical and contemporary coastal reclamation linked to industrial and tourism and related to port development and transformation has inevitably led to a change in the hydrological dynamics of water and sediments and transformation of the biological communities (particularly the benthic biological communities). Dredging works is related to capital projects. In case of water body at port of Marsaxlokk (MTC 107), large-scale marine constructions and land reclamation activities is related to the construction and operation of Malta Freeport at the mouth of the harbour. Periodic operational dredging activities are associated with Malta Freeport operations. Quay development is related to the development of the Delimara power station. Quay development in inner-harbour area is related to fishing harbour activities. There is beach reclamation at Birzebbugia (inner harbour area) at Pretty Bay (Malta Resources Authority, 2011b).

Small-scale marine constructions, land reclamation and recreation (boating) affect one natural water body (L'Irdumijiet t'Għawdex - MTC 101). Various coastal developments along the accessible coastline and within the many inlets and bays related to urban development, tourism and recreation affect another natural water body (Il-Mellieħa/Tas-Sliema - MTC 104). However, impact is not considered important on the large-scale because of open nature of coastline. There are also beach replenishment projects (Malta Resources Authority, 2011b).

Transitional and coastal HMWBs I the Thames RBD (the UK)
The Thames RBD stretches from the source of the River Thames in Gloucestershire through London to the Greater North Sea. Dominated by Greater London, the eastern and northern parts of the river basin district are heavily urbanised. The estuaries and coastline provide varied biodiversity, recreation and industrial opportunities for the people living and working in the Thames RBD. But this has lead to many environmental pressures being concentrated in this area. The estuaries and coastlines have been the subject of physical modification over the years. Continued development has been identified as a need within this catchment, particularly associated with the 'Thames Gateway' growth area. Future development and associated infrastructure includes flood defences and provision of drinking water and sewerage. Estuaries and coasts are also physically managed to facilitate navigation to ports and to enable commercial fisheries activities (Environment Agency, 2009: 79-80).

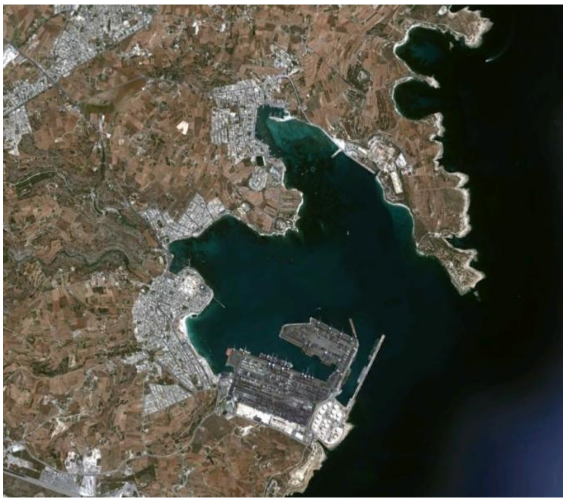
There are eleven transitional water bodies in the Thames RBD stretching from the upper Thames estuary in London to coastline (Figure 2.8). All are designated as heavily modified or artificial water bodies except for one small natural water body. The Thames RBD includes one coastal water body identified as heavily modified. The neighbouring coastal water bodies are heavily modified as well. The lower Thames estuary and coastline of the bay is defended by coastal erosion defence structures.

RBD Scheldt (Belgium and the Netherlands)
RBD Scheldt encompasses parts of Belgium and the Netherlands and a small part of NW France. The river flows into the Scheldt estuary, the Westerschelde. This estuary has a large tidal range and consists of a mixture of channels and large tidal flats that are exposed during low tide. Starting from as early as the year 1000 the first dikes were constructed in this estuary for land reclamation. This practice of land reclamation and modification of the water bodies has continued since.

Figure 2.8 HMWB/AWBs in the RBD Thames (the UK)

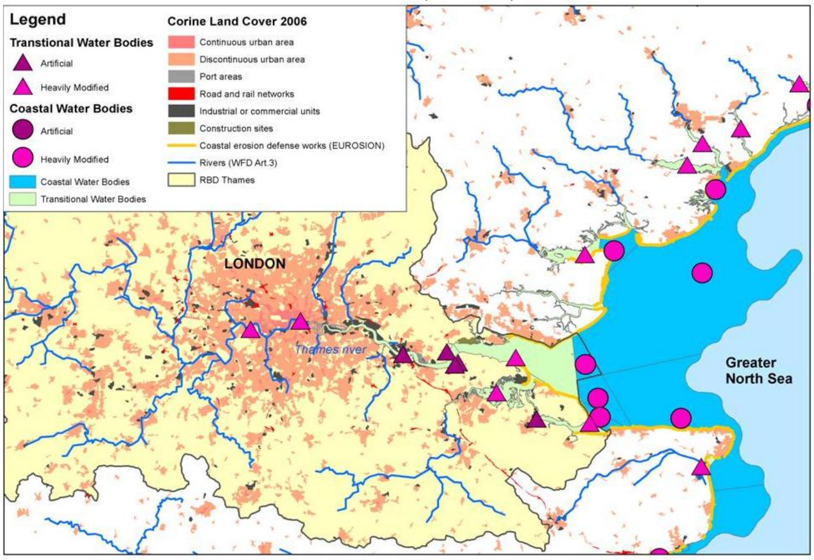
Arial photos of the **two Maltese HMWB/AWBs**

Source: Google Earth, 2011

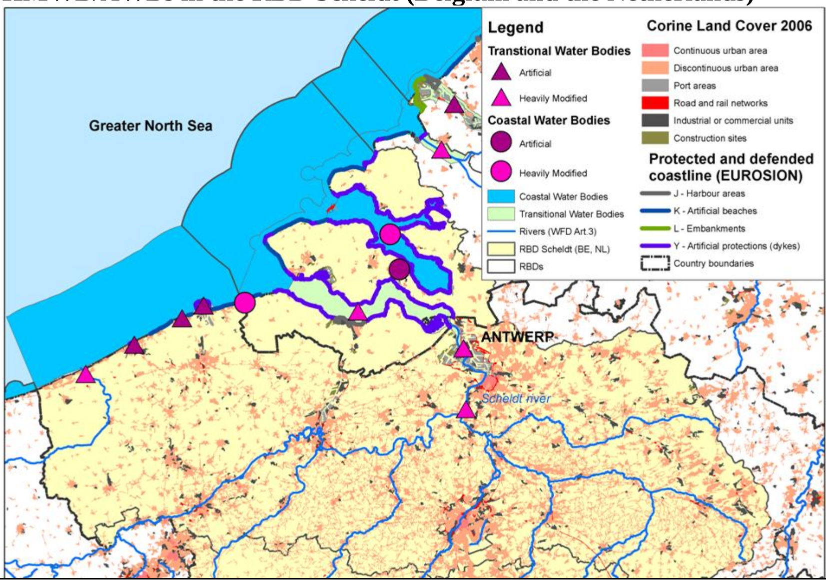


Source: Google Earth, 2011

HMWB/AWBs in the RBD Thames (the UK)



HMWB/AWBs in the RBD Scheldt (Belgium and the Netherlands)



Note: The two lower maps based on WFD Art.13 reporting, Corine Land Cover 2006 and Eurosion data.

After the flood disaster of 1953 in which 1836 people and 30 000 animals lost their lives, it was decided to improve flood protection in the Scheldt estuary. As part of the Delta Project, new dams, flood barriers and dikes were constructed. This drastically changed the Delta area in the SW Netherlands. Almost all transitional water bodies with exception of the Western Scheldt, have been closed off completely or have reduced exchange with the North Sea. Therefore these water bodies were converted into basins with a strongly regulated hydrological regime. Salinity differs between basins and ranges from freshwater to brackish water to fully saline water. The preferred salinity and water level of each compartment are managed using sluices and weirs. (Ministry of Transport…, 2009: 19).

Pressures and impacts
The majority of the coastline in the Dutch part of the RBD as well as parts of the Belgian RBD are protected and armored mainly by hard infrastructure for coastal protection and erosion management. This changes the flow dynamics and shore geomorphology resulting in loss of habitat and biodiversity. Next to using hard structures, in 1990 The Netherlands adopted a dynamic coastal management strategy on beach and foreshore nourishments to strengthen the natural flood defense system of the coast. These sand nourishments counteract erosion and allow for natural dune growth. For the years 2011/2012 over 2 million m3 of sand will be used for nourishments within the RBD Scheldt. More recently, the "Building with Nature" principles are adopted, in which natural processes, such as siltation, the role of organisms and ecosystem services are incorporated in planning and designing innovative ecodynamic protection works.

The transitional and coastal waters in the Dutch and Belgian parts of the Scheldt RBD are among the most heavily navigated in the world, containing two major shipping routes in the North Sea with an average traffic density exceeding 45 ships per 1000 km2. The port of Antwerp, the second largest sea port in Europe is situated in the upper Scheldt estuary. To keep this port accessible for large container ships, the estuary has to be dredged on a regular basis to maintain a channel depth of 13.1m. Deepening of the main shipping channel alters the hydrodynamic properties of the Scheldt and also impacts various habitats within the estuary. Additionally, boating is very popular in Dutch and Belgian transitional and coastal waters (FOD Volksgezondheid... 2009:33, 36).

Hydromorphological status
The Western Scheldt estuary in the Netherlands is designated as a heavily modified transitional water body (HMWB), while the neighboring Eastern Scheldt estuary is designated as heavily modified coastal water body. The canal that connects both estuaries (about 7 km) is designated as artificial coastal water body (AWB). One port along the Belgian coast is heavily modified and three others are artificial. The large port in the upper Scheldt estuary (Antwerp) is also a heavily modified transitional water body. The Belgian part of the tidal inlet on the border between Belgium and the Netherlands is identified as a natural coastal water body, while the Dutch part is heavily modified.

Ecological status
As a result of the hydromorphological and other pressures and the extensive modifications of the water bodies of the Scheldt RBD, there is hardly any water body with a good ecological status/potential. The hydromorphological conditions constrain the ecological status due to reduced tides, hard structures for coastal protection and dredging of the channel. It should be noted, however, that there is presently no standard frame of reference to determine the ecological status of HMWB/AWB's. Therefore, the risk assessment for these waters was done using the ecological status scale for natural waters. In the coming years a standard frame of reference will be set up to effectively evaluate the HMWB/AWB's of the Scheldt using metrics appropriate to modified water bodies.

2.5. References

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3. Ecological status and potential

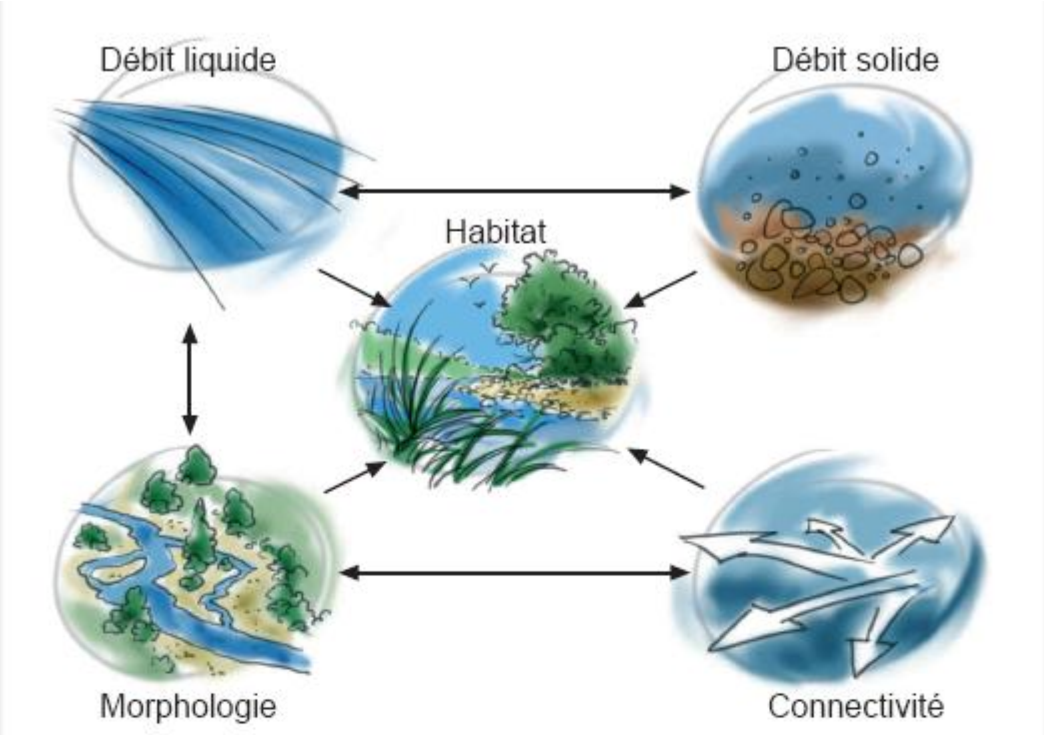
3.1. Introduction

Water Framework Directive (WFD) defines “Ecological status” as the quality of the structure and functioning of aquatic ecosystems associated with surface waters. *Ecological status* results from assessment of the biological status of all WFD biological quality elements (fish, macroinvertebrates, phytoplankton, phytobenthos, macrophytes) and the supportive physico-chemical parameters (general and specific ones). According to ecological status water bodies can be classified into five categories, such as high, good, moderate, poor and bad.

For heavily modified water bodies (HMWB) and artificial water bodies (AWB) WFD defines “Good ecological potential” status. *Ecological potential* includes the same biological and physico-chemical components and reflects given hydromorphological changes. Ecological potential is assessed for heavily modified as well as artificial water bodies and aims for alternative environmental objectives than *ecological status*. Both *ecological status* and *ecological potential* for surface water bodies are assessed on the basis of specific typologies and reference conditions

The ecological classification system required under the WFD describes hydromorphological elements as 'supporting the biological elements'. This means assessing pressures and impacts on:

- hydrological regime (quantity and dynamics of flow, connection to groundwater);
- continuity (ability of sediment and migratory species to pass freely up and down rivers and laterally with the floodplain);
- morphology (i.e. physical habitat – compositions of substrate, width/depth variation, structure of bed, banks and riparian zone).



Source: France Hydromorphology http://www.documentation.eaufrance.fr/entrepotsOAI/AERMC/R156/66.pdf

Each of the four surface water categories is ascribed specific hydromorphological quality elements (Table 3.1).

- Rivers - depth and width variation; structure and substrate of the river bed; structure of the riparian zone; river continuity.
- Lakes - depth variation; quantity, structure and substrate of the bed; structure of the lake shore.
- Transitional waters (estuaries) - depth variation; quantity, structure and substrate of the bed; structure of the intertidal zone.
- Coastal waters - depth variation; structure and substrate of the coastal bed; structure of the intertidal zone.

Table 3.1: Hydromorphological quality elements to be used for the assessment of ecological status or potential based on the list in WFD Annex V. 1.1.

Morphological conditions	
Rivers • river depth and width variation • structure and substrate of the river bed • structure of the riparian zone Lakes • lake depth variation • quantity, structure and substrate of the lake bed • structure of the lake shore	Transitional waters • depth variation • quantity, structure and substrate of the bed • structure of the intertidal zone Coastal waters • depth variation • structure and substrate of the coastal bed • structure of the intertidal zone
Hydrological regime	
Rivers • quantify and dynamics of water flow • connection to ground water bodies Lakes • quantify and dynamics of water flow • residence time • connection to the groundwater body	Transitional waters • freshwater flow • wave exposure Coastal waters • direction of dominant currents • wave exposure

3.1 Comparison of ecological status and potential of natural, HMWB and AWBS

3.1.1. Key messages

- More than half of surface water bodies in Europe are reported to be in less than good ecological status or potential
- Only few heavily and artificial water bodies have been classified as having high ecological status (blue colour)
- The overall ecological status/potential are generally better for the natural water bodies compared to the heavily modified and artificial water bodies:
    - Nearly half (48 %) of the natural river water bodies have at least good ecological status, while only 16 % of the heavily modified and artificial river water bodies have good ecological potential.
    - More than 60 % of the natural lake water bodies have at least good ecological status, while only 28 % of the heavily modified and artificial lake Water bodies have good ecological potential.
    - Around 40 % of the natural transitional water bodies have at least good ecological status, while less than 30 % of the heavily modified and artificial transitional water bodies have good ecological potential.
    - More than half (53 %) of the natural coastal Water bodies have at least good ecological status, while one third (35 %) of the heavily modified and artificial coastal water bodies have good ecological potential.

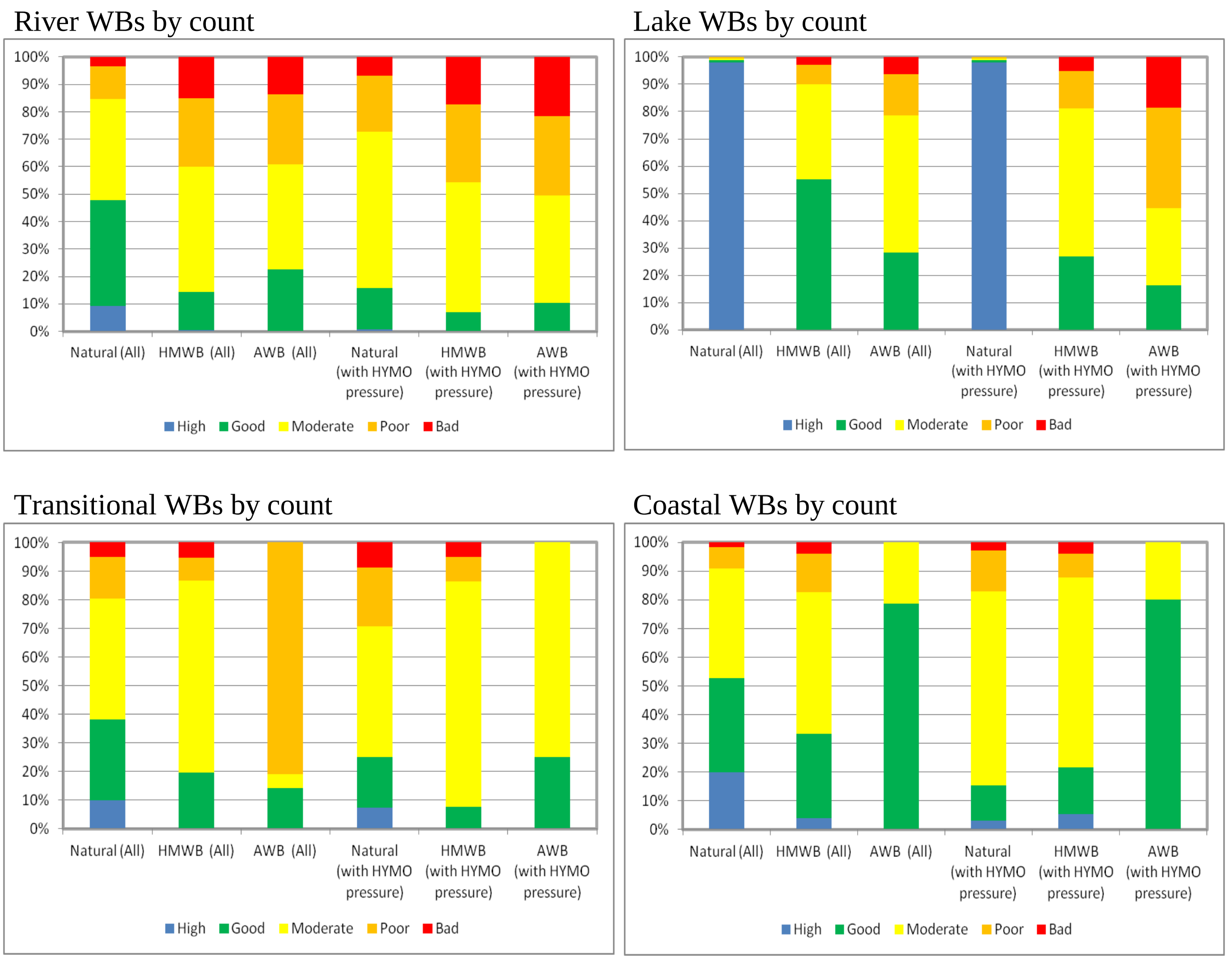
3.1.2. Assessment

Overall, more than half (55 %) of the total number of classified water bodies in Europe are reported to have less than good ecological status/potential (EEA 2012: Thematic Assessment: Ecological and chemical tatus and pressures). All these water bodies thereby need management measures to restore their ecological status or potential to fulfil the WFD objective. A higher proportion of water bodies with moderate or worse ecological status or potential are reported for rivers and transitional waters (60-70 %) than for lakes and coastal waters (40-50 %).

There are only a few river heavily modified surface water bodies which have been classified as high ecological status, while no artificial water bodies of rivers or lakes are having high ecological status (Figure 3.1).

The overall ecological status or potential is generally better for the natural water bodies compared to the heavily modified and artificial water bodies. Nearly half (48 %) of the natural river water bodies have at least good ecological status, while only 16 % of the heavily modified and artificial river water bodies have good ecological potential.

Figure 3.1: Ecological status or potential of natural and heavily modified (HMWB) and artificial water bodies (AWB).



Note: Based on water bodies with classified ecological status or potential (water bodies with unknown status not included).

More than 60 % of the natural lake water bodies have high or good ecological status, while only 28 % of the heavily modified and artificial lake water bodies have good ecological potential status.

Around 40 % of the natural transitional water bodies have at least good ecological status, while less than 30 % of the heavily modified and artificial transitional water bodies have good ecological potential (Figure 3.1).

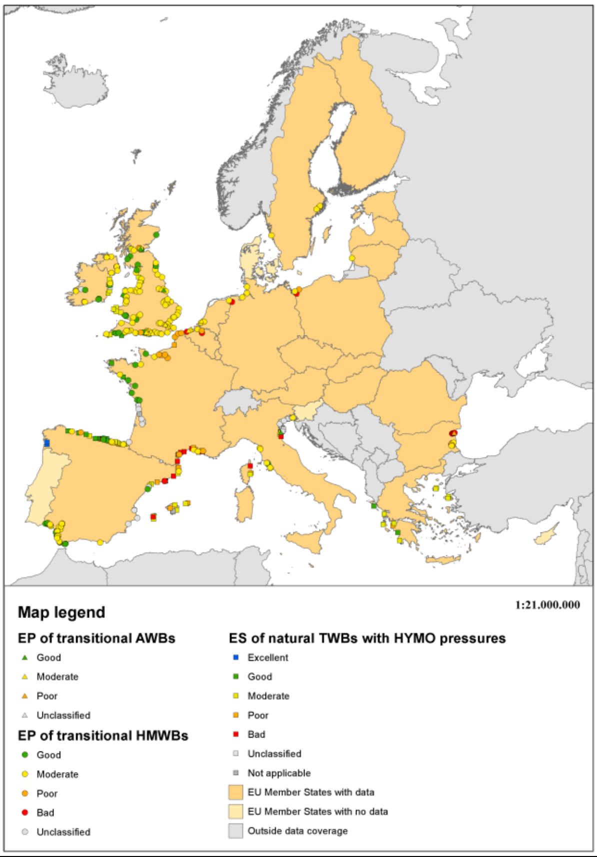
More than half (53 %) of the natural coastal water bodies have at least good ecological status, while one third (35 %) of the heavily modified and artificial coastal water bodies have good ecological potential.

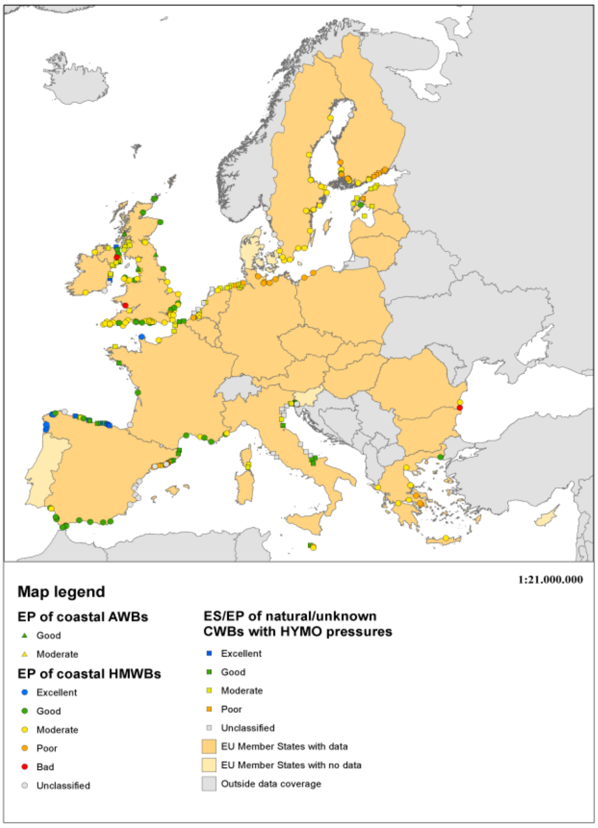
38% of classified coastal waters are in moderate, poor or bad status, meaning that some management measures will need to be taken to improve their status. 62% of transitional waters are in less than good status.

Ecological potential has been reported for overall 777 transitional and coastal water bodies, and around 50% of them are classified as high or good. When only transitional water bodies are considered alone, 68% of classified transitional waters are in moderate, poor or bad status, which also calls for management measures to improve their status by 2015.

Locations of the hydromorphological pressure influenced costal water bodies with less than good ecological status indicate strong relations with industrialized region coastal zones at Northern Adriatic, Catalonia, North Sea and Northern Baltic Sea as shown on Map 3.1. In case of hydromorphological pressure influenced transitional water bodies with less than good ecological status fewer regions are affected, such as Northern Adriatic, Catalonia and Ireland (Map 3.2).

Map 3.1: Overall ecological potential of coastal HMWB/AWBs and overall ecological Status or potential of natural and unknown coastal water bodies with HYMO pressures.





3.2. Case studies on ecological status and potential

3.2.1. Case study of ecological status and potential

A case study illustrating ecological status and potential of rivers and lakes to be included. Member States or RBDs are appreciated.

3.2.2. Ecological status or potential in selected coastal areas

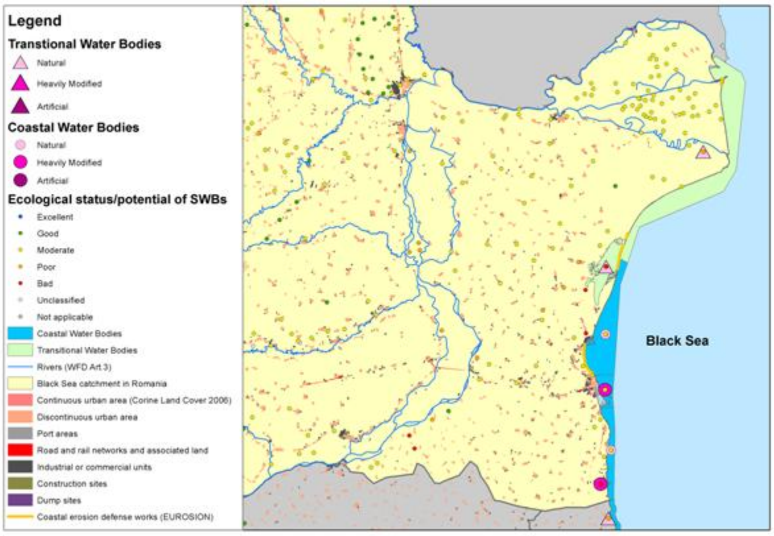
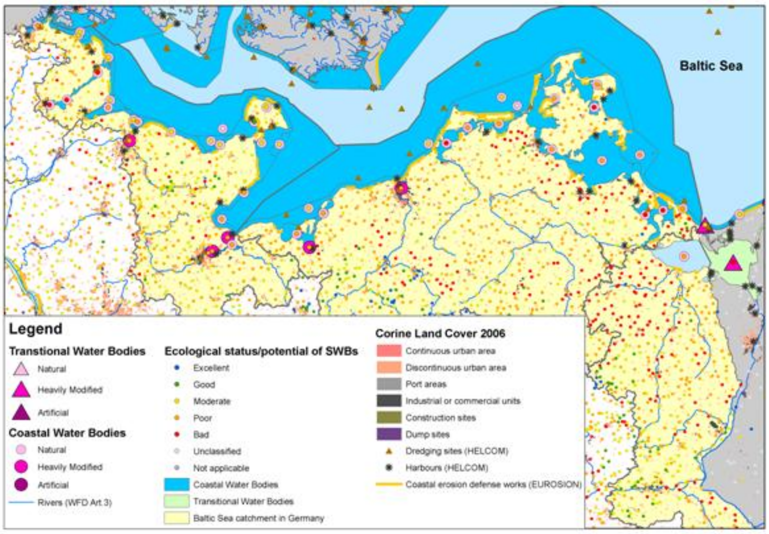
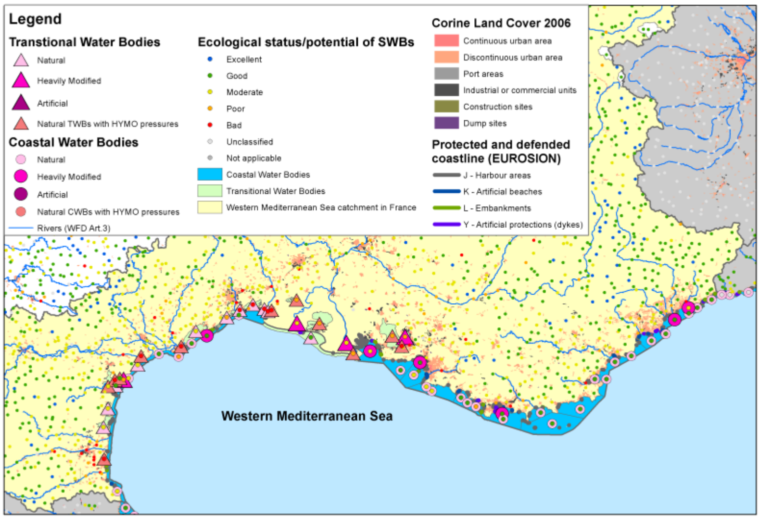
Black Sea region and its catchment (Romania)
In the Black Sea region of Romania, two coastal water bodies are identified as heavily modified and two as natural. Both HMWBs are located along ports (Constanț a and Mangalia). Coastal water bodies have moderate status/potential except for HMWB in long narrow coastal bay (about 7 km) along Mangalia with bad potential. Two natural transitional water bodies are designated in the Danube Delta with lagoons along the northern part of the Black Sea coast of Romania. They are of poor and bad status respectively. Ecological status/potential of freshwater water bodies close to the coastline is manly moderate.

Baltic Sea region and its catchment (Germany)
In the Baltic Sea region of Germany, five coastal water bodies are identified as heavily modified. All are located in bays with ports (Kiel, Lübeck, Wismar and Rostock) and accompanying dredging sites. For two HMWBs in Wismar and Rostock, HYMO pressures and impacts have been reported (water flow regulations and morphological alterations of surface water; altered habitats). All HMWBs have poor ecological potential. Other non-modified coastal water bodies that predominate are of moderate to bad status, except for one water body of good status. HYMO pressures were identified for none of natural water bodies despite the ports, dredging and coastal erosion defence works. No transitional water bodies are designated in German part of Baltic Sea region. Ecological status/potential of freshwater water bodies close to the coastline is manly poor to bad status.

Western Mediterranean Sea region and its catchment (France)
There are many TC water bodies in the Western Mediterranean Sea region of France. Six coastal and four transitional water bodies are identified as heavily modified. In addition, 12 natural transitional water bodies are affected by HYMO pressures and impacts. Coastal HMWBs are located in bays along tourist resorts with ports (Sète, Marseille, Toulon and Nice). They are affected by coastal water management. Four of them suffer HYMO impacts - altered habitats. Four out of six coastal HMWBs have already reached good potential, while other two have moderate potential. Natural coastal water bodies are of good to moderate status with good status prevailing.

Transitional water bodies are located in lagoons and the mouth of the Rhone River and its western branch in the western part of the region. HYMO pressures have been reported for two transitional HMWBs. One of them is used for water abstraction, while other is affected by water flow regulations and morphological alterations resulting in altered habitats. This pressure also affects natural transitional water bodies with HYMO pressures reported. Two transitional HMWBs have reached moderate potential, while two have poor potential. Transitional water bodies that are natural and affected by HYMO pressures have poor to bad status, except for two water bodies with good and moderate status respectively. Ecological status of other natural water bodies ranges from good to bad. Ecological status/potential of freshwater water bodies close to the coastline is manly good to moderate.

Figure 2.7: Ecological status and potential of surface water bodies in three coastal regions.

<table>
<tr><td>Black Sea region in Romania with catchment area.</td><td>
</td></tr>
<tr><td>Baltic Sea region in Germany</td><td>
</td></tr>
<tr><td>Western Mediterranean Sea region in France</td><td>
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Note: Map based on WFD Art.13 reporting, Corine Land Cover 2006 and Eurosion data.

4. Hydromorphological pressures and impacts

4.1. Drivers and pressure of hydromorphological alterations

4.1.1. Drivers and activities

Hydromorphological pressures comprise all physical alterations of water bodies modifying their shores, riparian/littoral zones, water level and flow, (except water abstraction). Examples of such pressures are damming, embankment, channelization, non-natural water level fluctuations. The extent of hydromorphological alterations in European river basins has been significant over the past centuries. Hydromorphological pressures are the consequence of human activities (drivers) in the catchment area including hydropower production, flood defence structures, navigation, agriculture, land drainage, urban development and fisheries. Hydromorphological changes may result from more than one activity (e.g. a multi-purpose dam for hydropower generation, water supply and flood protection).

Hydrological alterations refer to pressures resulting from water abstraction and water storage affecting the flow regime such as change in daily flow (hydropeaking) and seasonal flow. In addition, river stretches may dry up and water levels of lakes and reservoirs may be heavily regulated. The flow regime of a water body may be significantly altered downstream of an impoundment or an abstraction, and the biology may impacted. Alterations to the flow regime degrade aquatic ecosystems through modification of physical habitat and of erosion and sediment supply rates.

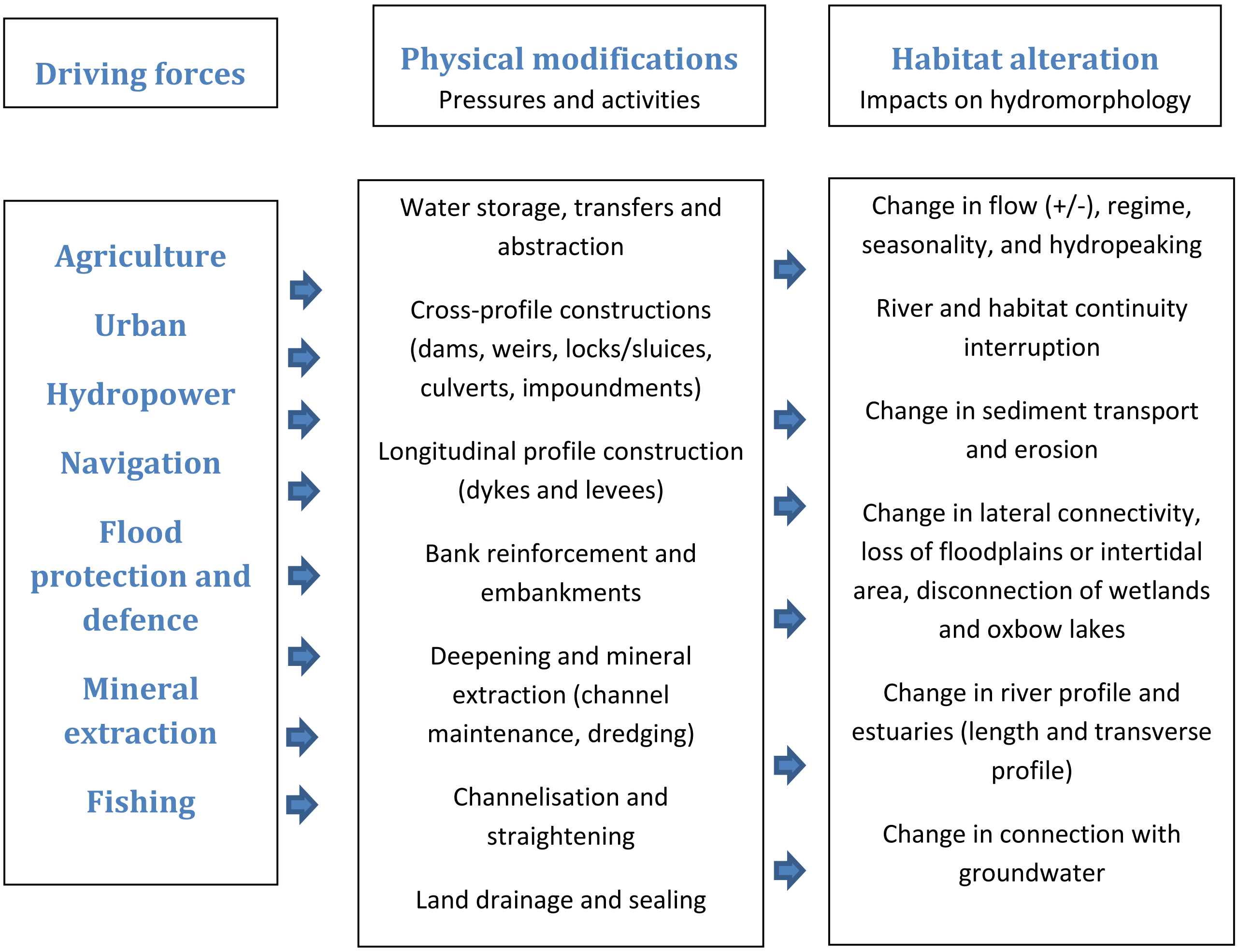
Morphology is the physical structure of a river, lakes, estuary or coast including, for example, the banks and bed of a river and the shore of lakes or coastal waters. Engineering or the way the land is managed can change the morphology of these waters. This has a direct impact on animals and plants and can lead to increased flooding or erosion.

Land reclamation, shoreline reinforcement or physical barriers (such as flood defences, barrages and sluices) can affect all categories of surface waters. Weirs, dams and barrages can alter water and sediment movements, and may impede the passage of migratory fish such as salmon. Using water for transport and recreation often requires physical alteration to habitats and affects the flow of water. Activities such as maintenance and aggregate dredging and commercial fishing using towed bottom-fishing gear can also damage physical habitats.

Agricultural activities have in many places affected the hydromorphological status of European water bodies. Water storage and abstraction for irrigated agriculture have, in particular in Southern Europe changed, the hydrological flow regime of many river basins. Intensification of agriculture included many land reclamation projects affecting transitional and coastal waters and affected many rivers that were straightened, deepened and widened to facilitate catchment drainage and to prevent local flooding.

Reservoirs are human-made lakes created by the damming of rivers to serve one or more purposes, such as hydropower production, water supply for drinking, irrigation and flood protection. During the last two centuries there has been a marked increase in both size and number of large storage capacity reservoirs, especially with the development of hydropower and large basin management. There are currently about 7000 large dams in Europe. In addition, there are thousands of smaller dams. In 2008 hydropower provided 16 % of electricity in Europe and hydropower currently provides more than 70 % of all renewable electricity (Eurelectric 2009).

Figure 4.1: Conceptual overview of the relation between drivers, hydromorphological pressures and habitat and flow alterations.



Inland waterway transport plays an important role in the movement of goods in Europe. More than 4 000 kilometers of waterways connect hundreds of cities and industrial regions. Some 20 out of 27 EU Member States have inland waterways.

Flood defence works may cause significant pressures on hydromorphology. Today many sections of the major rivers have dykes. The building of dykes resulted in the loss of floodplains as retention spaces for flood water. For example, the Upper Rhine 150 years ago had a river bed up to 12 km wide but the river was channel between 200 and 250 m in width. Overall, the natural floodplain area of the Upper Rhine was reduced by 60 %, which in turn entailed considerable expenditure for the associated increased risk of flooding in downstream areas (UBA 2010: Water management part 2).

In many cases, *minerals are extracted* from surface water. Sand used to reinforce the coast is extracted from other sea areas, while clay and sand used for concrete and building are usually extracted from the flood plains of rivers. Gravel mining have occurred in several European river basins e.g. in north-eastern Italy, and some rivers of the Carpathians, resulting in widespread channel adjustments in the last 100 years, in particular incision and narrowing (Rinaldi et al. 2005 ; Surian, 2006; Surian et al., 2008).

Hydromorphological pressures, often connected with construction, marine transportation and tourism, are intensified due to population growth and urbanization. Human activities hydromorphologically alter coastal zone, causing considerable changes in physical features of the coast e.g. by accelerating erosion processes. Erosion is significantly intensified by anthropogenic impacts (e.g. coastal defence, land reclamation, vegetation clearing, river regulation etc.), affecting majority of shoreline in Europe. Loss of sediments and space for coastal processes accelerate erosion, which leads to sea-level rise and flooding, loss of material assets and biodiversity. Large-scale structures such as coastal defence constructions and harbours disturb natural circulation of sediments.

4.1.2. Pressures

Typical *hydromorphological pressures* that arise in response to the uses (drivers) are the need for impoundment, channel modification, navigation structures etc. and result in specific engineering works such as dams, locks and embankments which change the characteristics of the natural flow regime and the shape of the river channel such as water depth, width, alignment, flow velocity and sediment transport. Examples of relationship between activities and hydromorphological pressures are

- Structures such as dams, weirs and sluices interrupt the longitudinal continuity of rivers.
- The use of water resources e.g. for energy production or abstraction for human uses can impact both the hydrology (e.g. reduced residual water, change in seasonality and hydropeaking) and morphology of rivers (e.g. longitudinal continuum interruption, reduced flow velocities, etc.).
- The disconnection of riverine floodplains and disturbance of the natural lateral connectivity of river systems can frequently result in a decrease of status.
- Navigation activities and navigation infrastructure such as cross profile constructions and impoundments; canalisation; straightening; bank reinforcement and deepening are typically associated with a range of hydro-morphological changes with potential adverse ecological consequences.
- Further, the morphology of rivers has been impacted by the channelisation of river stretches for human uses, erosion of the river bottom as a consequence of reduced sediment transport (due do dams) or dredging for navigation.
- Constructions performed as flood protection measures (lateral dykes, weirs, etc.) also impact the morphology of riverine systems.

These alterations can lead to a water body to be designated as a heavily modified water body (HMWB) if the water body shows substantial changes in character which are extensive/ widespread or profound, and the modifications neither temporary or intermittent and in general alter both hydrological and morphological characteristics.

Impacts of hydro-morphological pressures

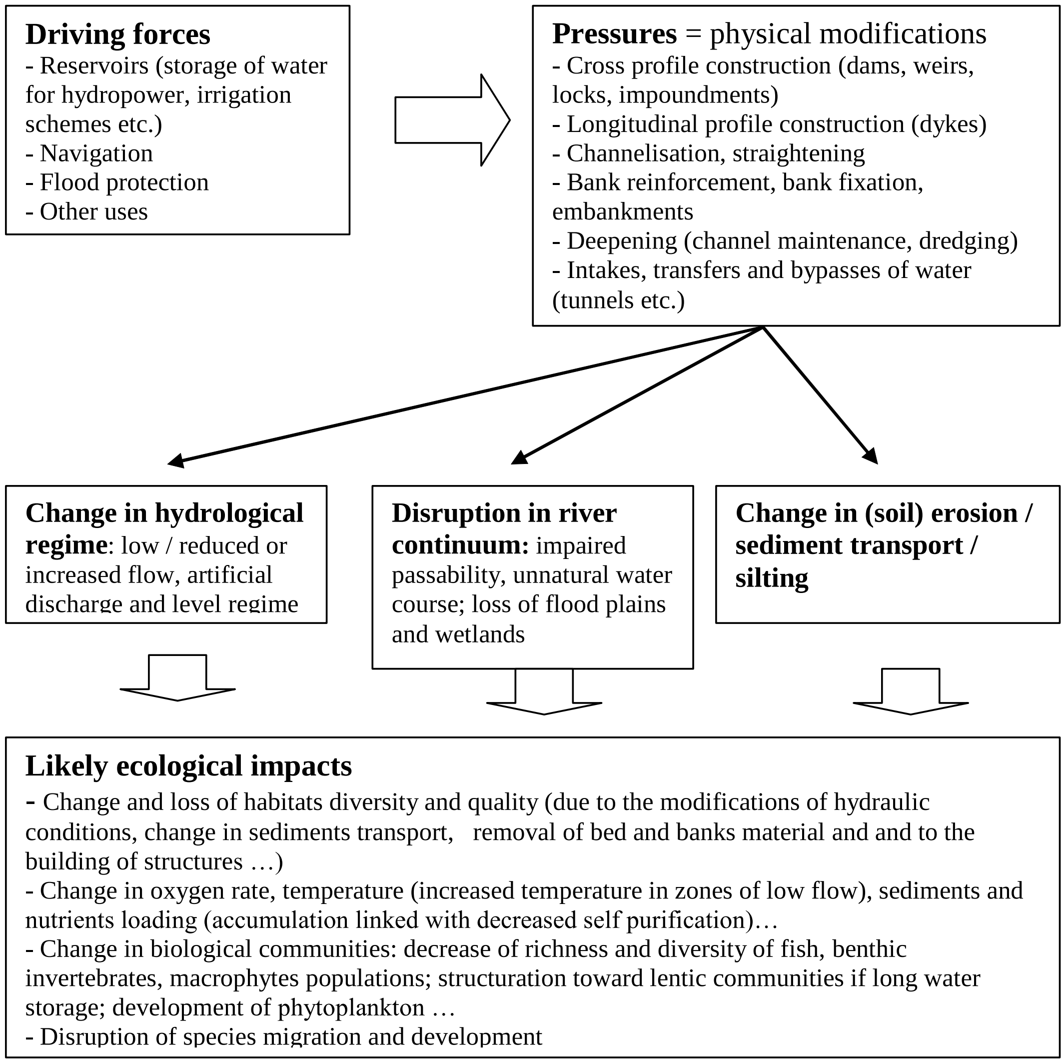
The physical modification of water bodies can affect the hydrology of freshwater systems, obstruct up and downstream migration, disconnect rivers from floodplains and wetlands, and change the water flow. The three key components of hydro-morphological pressure are (Figure 4.2):

- change in hydrological regime;
- interruption of river and habitat continuity and disconnection of adjacent wetlands/floodplains; and
- change in erosion and sediment transport.

All these can have various ecological impacts including change and loss of habitat diversity, disruption of species migration and introduction of exotic species. Although the effects may not always be seen locally, they nearly always extend downstream and may also affect upstream reaches and the surrounding areas.

Hydromorphological alteration causes numerous, steeply studied, impacts in coastal zone. The general impact of hydromorphological alteration is reduction of complexity, dynamism and biodiversity (Elosegi et al. 2010). Alteration of coastal habitats causes physical changes that impact the biological diversity (Orlando-Bonaca et al. 2011:7). Coastal habitats have been altered in many ways; forms of hydromorphological alteration as dredging, land reclamation and reshaping to artificial substrate are activities that have weakened living conditions for natural habitats (Crain et al. 2009:40). There is evidence, that artificial structures and HYMO-alteration would develop new habitats for invasive species, while some of the original species disappear. As a result, no dramatic changes occur in biodiversity, but significant changes in composition of species are evident.

Figure 4.2: Conceptual linkage between water uses (storage of water; inland waterway transport and flood protection) and pressures related to physical modifications resulting in changes in hydrological regime, disruption of river continuum and sediment transport and likely ecological impacts



4.2. European overview of hydromorphological pressures

4.2.1. Methodology issues

Europe's surface freshwaters are affected by major modifications, such as water abstractions, water flow regulations (dams, weirs, sluices, and locks) and morphological alterations, straightening and canalisation, and disconnection of flood plains. These are called hydromorphological pressures. In RBMPs, hydromorphological pressures on surface water bodies were categorized by the Member States into five main pressure groups,

- Water abstraction: modifying significantly the flow regime of the water body,
- Water flow regulations and morphological alterations:
- River management;
- Transitional and coastal water managementother morphological alterations; and
- Other pressures (including land drainage).

In each of the pressure groups Member States had the possibility to report different hydromorphological pressures such as barriers in rivers or dredging of sediment. However, many Member States (e.g. Austria, Germany, The Netherlands, and United Kingdom) did not report details on pressures and only reported that a water body was affected by the a pressure group. In addition, Member States did not report in the same pressure groups.

In the following are presented

- First results for water bodies being affected by at least one of the above pressures groups are presented as percentage of water bodies affected by hydromophological pressures. (i.e. for each water body is checked if it affected by pressures in one of the above pressure groups – these water bodies are identified as being affected by hydromorphological pressures) . A water body may be affected by more than one hydromophological pressure.
- Second results on water bodies affected by pressures in one of the above pressure groups are presented. Due to different reporting by Member States these results are presented as percentage of the sum of water bodies from Member States reporting the particular pressure group.
- To support the assessment are presented results of percentage of water bodies having altered habitats identified as an impact.

4.2.2. Key messages

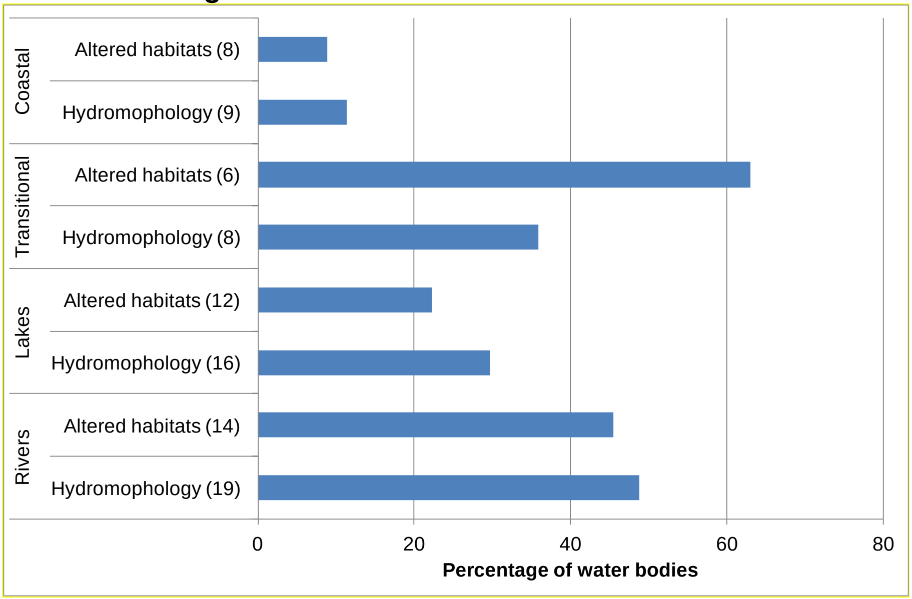
- Hydromorphological pressures and altered habitats are the most commonly occurring pressure and impact in rivers, lakes and transitional waters.
- Hydromorphological pressures affect half of river and transitional water bodies and 30 % of the lake water bodies.
- Coastal waters generally have lower level of hydromorphological pressures and impacts.
- *To be further developed*

4.2.3. European results

Surface water bodies affected by at least one hydromophological pressure

Hydromorphological pressures and altered habitats are reported for a large proportions of water bodies in all the water categories, except in coastal waters, where these pressures and impacts are reported for less than 10 % of water bodies (figure 4.3). The proportions of water bodies exposed to hydromorphological pressures are almost the same as those having altered habitats, except for transitional waters were a higher proportion have altered habitats than hydromorphological pressures. In rivers and transitional waters these pressures and impacts are reported for around half of all classified water bodies, while in lakes ca. 30 % of classified water bodies are affected.

Figure 4.3: Percentage of water bodies being affected by hydromorphological pressures or having altered habitats.



Note: Number of Member States reporting hydromorphological pressures or altered habitats is listed in parenthesis.
Source: WISE-WFD database February 2012;
wfd.atkins.dk/report/WFD_aggregation_reports/SWB_pressure_status

Overall, 50% European river water bodies, out of around 65 000 river water bodies reported by 19 Member States are affected by at least one hydromorphological pressure. Also 45 % of the river water bodies have altered habitats identified as an impact.

Overall, 30 % out of more than 12 000 lake water bodies reported by 16 Member States are affected by at least one hydromorphological pressure. Altered habitats were identified as an impact for 22 % of the lake water bodies. This difference can partly be explained by that Sweden has reported lake water bodies being affected by hydromorphological pressures but no water bodies affected by altered habitats.

Hydromorphological pressures are significant in the transitional water bodies, being the second most important pressure (after point sources) affecting 30 % of the transitional water bodies. More than 60 % of the transitional water bodies have altered habitats as an impact.

Hydromorphological pressures are less important in the coastal water bodies of the regional seas around Europe. One tenth of the coastal water bodies are impacted due to hydromorphological pressures. Also around 10 % of the coastal water bodies have altered habitats as an impact.

The hydromorphological pressures in rivers and lakes are reported to be most severe in RBDs in the Netherlands, Germany, Poland, Hungary and south-east England, and less severe in RBDs in Finland, the Baltic countries, as well as in many RBDs in Spain, Italy, Greece, Bulgaria and Cyprus (Figure 4.4).

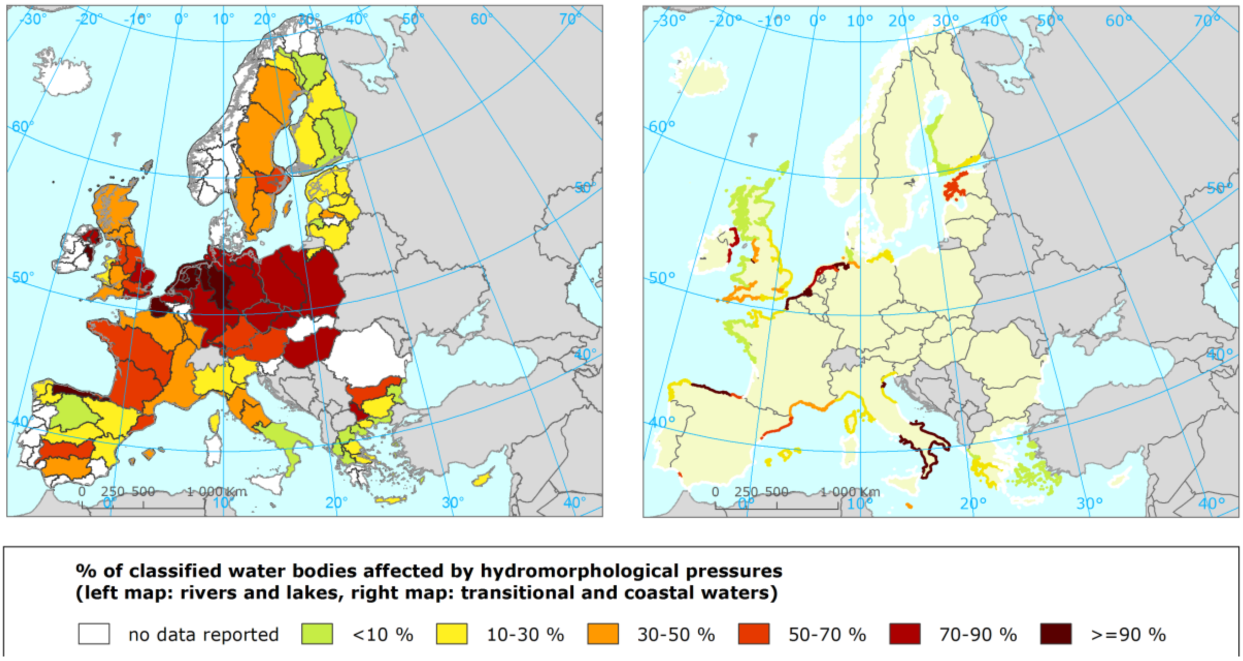
In coastal and transitional waters the hydromorphological pressure is mainly a problem at the Estonian and German Baltic coast; along the Greater North Sea coast of Germany, the Netherlands and Belgium, as well as the in the northern/Basque coast of Spain and southern coast of Italy (Figure 4.4).

The highest share of transitional water bodies with hydromophological pressures has the Greater North Sea region, followed by the Mediterranean Sea region. The Celtic Seas, Bay of Biscay and the

Iberian Coast region has 23 % of such water bodies, which is somewhat below the EU average. No hydromophological pressures were reported in the Baltic Sea and Black Sea regions.

The Mediterranean Sea and the Greater North Sea regions have more than 10 % of coastal water bodies under HYMO pressures (16 % and 13 % respectively). The Celtic Seas, Bay of Biscay and the Iberian Coast region has 9 % of such water bodies, which is slightly below the EU average. The Baltic Sea region has 4 % of such water bodies.

Figure 4.4 Proportion of water bodies in different River Basin Districts affected by hydromorphological pressures for rivers and lakes (left panel) and for coastal and transitional waters (right panel).



Note: percentage, based on number of classified water bodies
Source: WISE-WFD database February 2012;
wfd.atkins.dk/report/WFD_aggregation_reports/SWB_pressure_status

4.2.4. Hydromophological pressures groups

Rivers

Of the 20 Member States reporting pressure information for rivers

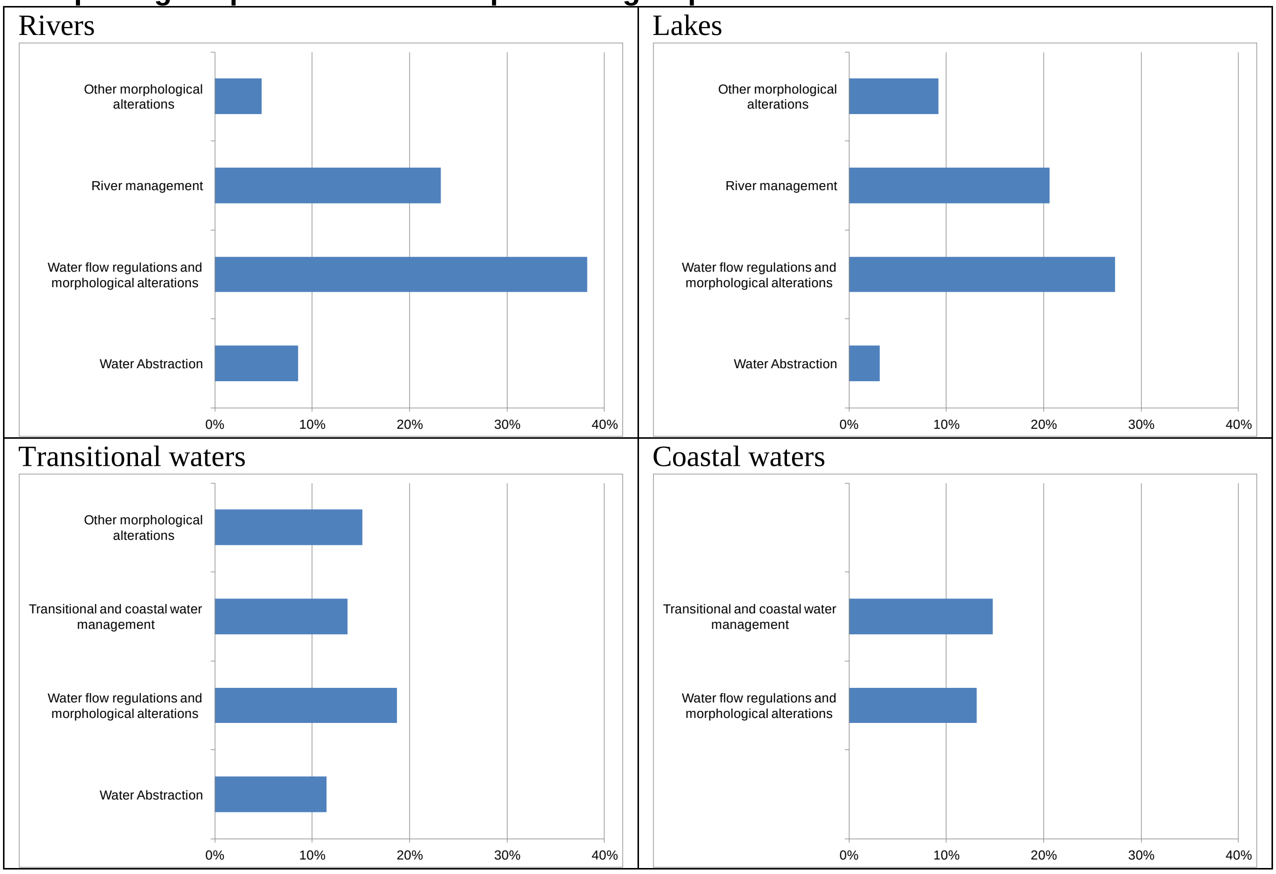
- 17Member States reported water bodies affected by water abstraction:;
- 19 pressure from water flow regulation and morphological alteration;
- 16 reported pressure from river management, and
- 8 reported other morphological pressures (mainly pressures related to barriers).

Nearly 40 % of the river water bodies are affected by water flow regulation and morphological alteration (Figure 4.5). This pressure group includes impacts from storage of water in reservoirs, but also change in hydrological regime and impacts by weirs and locks. Member States has also reported impact of barriers under the other morphological alteration group affecting 5 % of river water bodies.

The second most important pressure group is river management being a pressure affecting 23 % of river water bodies. The pressure group river management includes water bodies physical alteration of the river channel including effects of dredging, land drainage and barriers due to bridges, culverts etc.

Nine percent of the river water bodies are affected by water abstraction (see also chapter 6).

Figure 4.5 Percentage of water bodies per water category being affected by hydro-morphological pressures in main pressure groups



Note:
Source: WISE-WFD database February 2012;
wfd.atkins.dk/report/WFD_aggregation_reports/SWB_pressure_status

Lakes

Of the 20 Member States reporting pressure information for lakes (Sweden has not reported surface water bodies being affected by hydromophological pressures)

- 15Member States reported water bodies affected by water abstraction:;
- 14 pressure from water flow regulation and morphological alteration;
- 9 reported pressure from river management, and
- 6 reported other morphological pressures (mainly pressures related to barriers).

For lakes water flow regulation and morphological alteration and river management were the two most important pressures affecting 27 % and 21 % of the lake water bodies. Only few lake water bodies was affected by water abstractions and other morphological pressures was identified for 9 % of the lakes.

Transitional and coastal waters

Four Member States (UK, France, Spain and Italy) have identified transitional water bodies being affected by water abstraction in the river basin district; accounting for 12 % of the transitional water bodies in these Member States. High water abstraction or water storage in the river basin district may markedly reduce the freshwater inflow, in particular in summer, and the dilution of pollutant discharges.

For transitional and coastal waters 6 to 8 Member States reported water bodies affected by the two main pressure groups water flow regulation and morphological alteration; and transitional and coastal management. The pressure groups generally affected 10 to 15 % of the water bodies. The pressure group transitional and coastal management include pressures related to land reclamation and dredging.

4.2.5. Country results

Countries with a high proportion of river and lake water bodies being affected by hydromorphological pressures are found in central Europe (Figure 4.4). Figure 4.5 shows the percentage of classified water bodies per water category and country the percentage of water bodies being affected by hydromorphological pressures or having altered habitats as an impact.

The Member States are in Figure 4.5 ranked by the percentage of water bodies achieving at least good ecological status or potential, for coastal and transitional waters the ranking are for the sea regions. Estonia has, for example, the highest proportion of river water bodies with good ecological status or potential, while Belgium (Flanders) has the worst status. Both for rivers and lakes there are good agreement between the ranking by proportion of water bodies with good status and the proportion of water bodies affected by hydromorphological pressures and haltered habitats. Member States with high proportion of good ecological status also generally have lower proportion of water bodies being affected by hydromorphological pressures or altered habitats.

Half of the 20 Member States (no pressure and impact data from Luxembourg, Slovakia and Romania) had more than 40 % of their river water bodies being affected by hydromorphological pressures (Figure 4.5); and six countries Poland; Germany; Belgium Flanders; Poland, the Czech Republic and The Netherslands had more than 60 % of river water bodies being affected by hydromorphological pressures. Member States with a high proportion of water bodies impacted by hydromorphological pressures also had a high proportion of water bodies with altered habitats as impact.

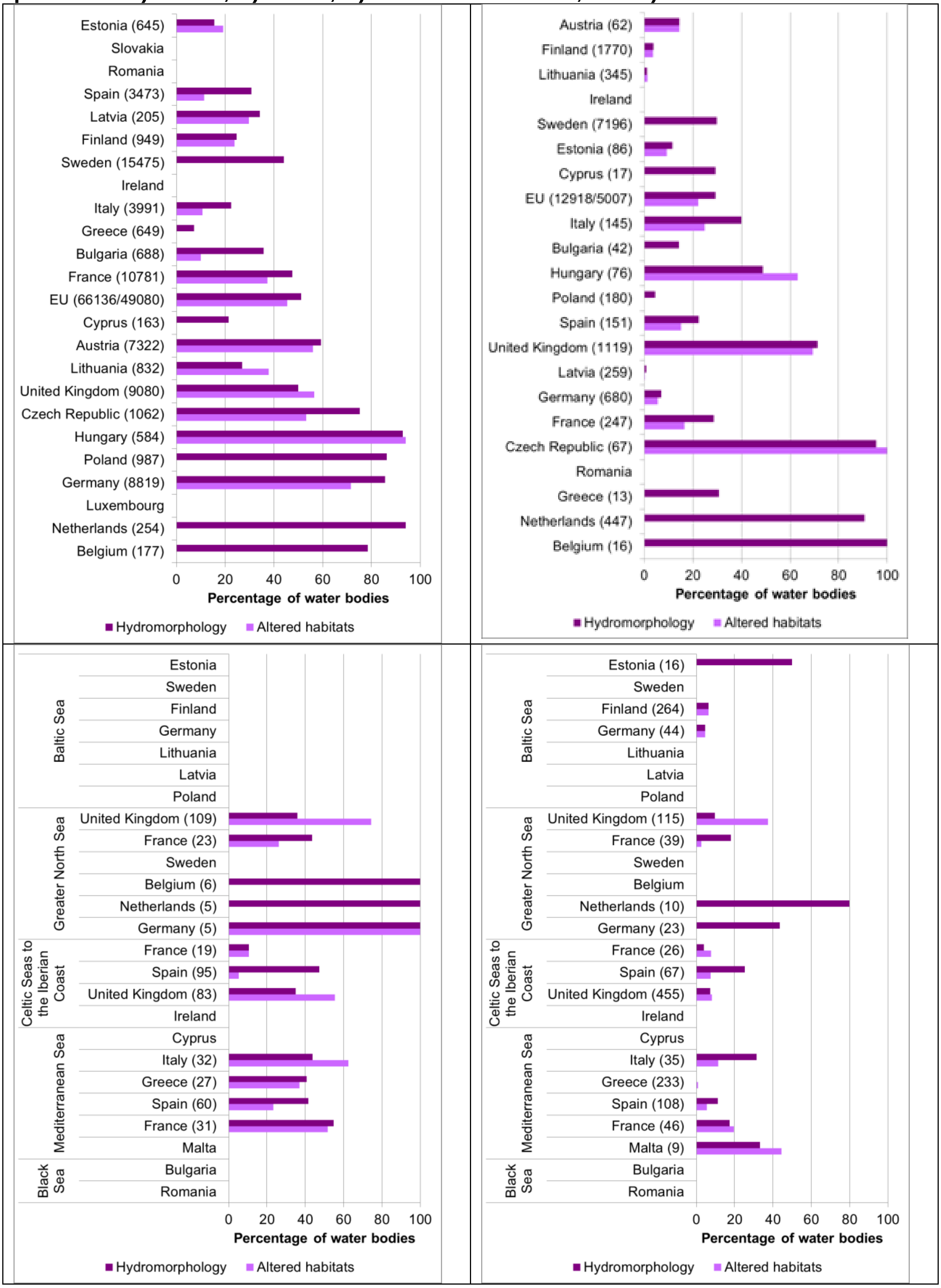
Five Member States, Belgium Flanders, The Netherlands, Czech Republic, United Kingdom and Hungary had more half of the lake water bodies being affected by hydromorphological pressures and altered habitats being an impact. This partly reflects the high number of reservoirs in these countries. Most other Member States report around 20-30 % of the lake water bodies affected by hydromorphological pressures.

Of the few transitional waters in the Baltic Sea no water bodies were reported having hydromorphological pressures or altered habitats (Figure 4.5). All the transitional water bodies in Germany, The Netherlands and Belgium at the Greater North Sea coast have hydromorphological pressures; while 40 % of the UK and French transitional water bodies at the North Sea have hudromorphological pressures.

In the Mediterranean and Celtic Sea and Iberian coast the Member States reporting pressures and impacts at transitional waters identified that around 40 % of these water bodies are affected by hydromophological pressures and altered habitats.

Most countries reported less than 20 % of the coastal water bodies being affected by hydromophological pressures and having altered habitats. In the Netherlands, German North Sea coast, Estonia, Malta and Italy more than a third of the coastal water bodies have hydromorphological pressures or altered habitats.

Figure 4.5 Percentage of surface water bodies being affected by hydromorphological pressures A) Rivers; B) Lakes; C) Transitional waters; and D) Coastal waters



Note: Percentage of water bodies with hydromorphological pressures being a significant pressures and altered habitats being a significant impact

4.3. Case studies

We hope that Member States and relevant stakeholders will comment on the current case studies and contribute with updates and new case studies. The current case studies are partly copy and paste from RBMPs or other relevant documents

4.3.1. Case study: Danube, Rhine, and Rhône rivers heavily impacted by hydro-morphological pressures

Source: ICPDR, 2010 and Umweltbundesamt, 2010

Like many other European rivers, the Danube and Rhine are heavily influenced by human activities including intensive navigation and habitat modification by hydraulic engineering. The natural structure on many stretches of the rivers has been changed, including their depth and width, flow regimes, natural sediment transport and fish migration routes.

Dams and reservoirs have been built in nearly all mountainous areas and some lowland regions of the Danube Basin and navigation channels, dykes and irrigation networks are widespread in the lowlands along the middle and lower reaches of the river.

- more than 80 % of the Danube is regulated for flood protection, and about 30 % of its length is impounded for hydropower generation;
- about half of the Danube tributaries are used to generate hydropower. The generation capacity of all the hydropower plants in the Danube Basin is almost 30 000 MW;
- more than 700 dams and weirs have been built along the main tributaries of the Danube;

along the Rhine, water meadows between Basle and Karlsruhe have shrunk by 87 % following construction of dykes and channels to cut off meanders.

The Rhône River,

Source: Souchon 2007

Over the last 400 years the Rhône was developed in successive phases for different purposes, levees have been built as flood defences; and groins and ripraps were constructed to create a more navigable river. The basin has 19 hydroelectric schemes accounting for 20-25% of the French hydroelectric production. Water abstraction for irrigated agriculture has added to the many river uses. Canals straighten and shorten the watercourse to facilitate navigation, thus by-passing the old river channel ("vieux" Rhône).

Today the flow regime of the Rhone is regulated by several large storage reservoirs that can hold more than 7 % of the annual runoff. Nearly 80% of this storage capacity is located downstream of Geneva.

The Rhône corridor is today a densely populated and industrialized area. The morphology of the river channel has changed from braided to straight and canalized, often eroded and incised; the level of the ground water has been lowered; several natural biotopes disappeared; the riparian forest evolved to hardwood forest due to ground water depletion; and dams block the migration of fish (shads, eel, lampreys), where numerous lateral communications with tributaries or side channels have been modified, sometimes cut off.

4.3.2. Case study: Shannon RBD, Scottish RBD and Irish Estuaries

Shannon RBD

Source: Shannon RBMP

Many of the surface water in the Shannon RBDs have physically been modified for water supply, recreation, transport, flood protection, hydropower, aquaculture and land drainage. There are in the RBD around 95 000 culverts and bridges on our rivers, almost 900 kilometres of river embankments, 19 large water reservoir or hydropower dams, 10 large ports and over 200 kilometres of coastal defences.

Scotland RBD
Source: Scotland RBMP
The Scottish RBMP identified just under 14 % of our surface water bodies as heavily modified water bodies and being substantially changed in character for purposes such as flood protection, hydropower generation, navigation, land drainage or water storage for drinking water supply. These are known as. Another 1% of surface waters are artificial.

Pollution pressures were affecting 18 % of the length/area of surface water bodies while the different hydromophological pressures: Alterations to water flows and levels; Modification of beds, banks and shores and Barriers to river continuity for fish migration affected 18 %; 16 % and 14 % of the surface water bodies, respectively.

In the Scottish RBD five types of morphological impacts have been identified as significant water management issues. Table 33 provides the lengths/areas of water bodies affected by each issue. The number of water bodies is given in brackets.

Table 33: Significant morphology issues in the Scotland river basin district

Pressure type	Key sector	Rivers	Lochs	Transitional	Coastal	Groundwater
Morphology	Historical engineering	2,182 km (185)	49 km² (17)	123 km² (7)	404 km² (5)	–
	Urban development	644 km (60)	–	0.2 km² (1)	–	–
	Agriculture	1,851 km (162)	1 km² (1)	–	–	–
	Electricity generation*	904 km (86)	298 km² (53)	–	–	–
	Land claim	–	–	204 km² (12)	229 km² (5)	–
	Total	**5,063 km (462)**	**339 km² (65)**	**213 km² (14)**	**525 km² (8)**	**–**

*See section 9.1.

Many of Scotland's freshwaters display a history of engineering interventions. Examples include:

- diverting and canalising rivers to utilise floodplains;
- culverting to improve drainage or enable development;
- building embankments to prevent flooding;
- bridging waterways for transportation.

Table 12 below lists the principal pressures that are adversely affecting water flows and levels in Scottish rivers and lochs. There was not identified any significant impacts on water flows in estuary and coastal water bodies. There are two main types of pressure on water flows and levels; impoundment of rivers by damming to create a water storage reservoir; and direct abstraction without impoundment.

The main activities for which reservoirs have been created are drinking water supply and hydropower generation. Water flows and levels in the reservoirs and in the rivers immediately downstream of the reservoir dams are altered by the impoundment of the water in the reservoir and its subsequent abstraction. Reservoirs used for hydropower generation are concentrated in the uplands of the central and northern parts of the Scotland RBD. Those for drinking water supply are typically found nearer to the larger towns and cities towards the south of the Scotland RBD.

The main direct abstractions without impoundment are for irrigating crops or providing drinking water. The impacts of these activities are concentrated along the east and north-east coasts. Direct abstractions are also used for drinks production and fish farming.

Table 12: Principal pressures on water flows and levels in bodies of surface water in the Scotland RBD in 2008

Pressures	Principal activities responsible	Water bodies in which pressure is preventing the achievement of good ecological status [including those designated as heavily modified as a result] (%)	
		Proportion of all rivers	Proportion of all lochs
Abstraction, including abstraction and regulation of river flows at dams	All activities	21	25
	Drinking water supply	3	9
	Hydropower generation	9	14
	Agricultural irrigation	4	0

Hydromorphological alterations of Irish estuaries
Source: Hartnett et al. 2011
Estuaries in Ireland, as elsewhere, have long been subject to the consequences of the full range of human activities. These include reclamation of saltmarsh and mudflat, modifications (e.g. canalisation, dredging) for shipping and transport along with the discharges and dumping from such, extraction of renewable natural resources such as fisheries, and of course the discharge of domestic and industrial wastes. All these changes have impacted on the functioning of estuarine system. The estuaries along the east coast of Ireland show the greatest morphological modification.

4.3.3. River basins in West Balkan heavily affected by hydromorphological presures

Skoulidikis 2008 described the envirironmental state of 15 major Balkan rivers covcring more than 80% of the inflows in Eastern Mediterranean. Many of the rivers are heavily affected by hydromorphological pressures.
In the 1950s, the first large dams were constructed and today most rivers are “strongly fragmented” by dams and flow regulation. The most modified river is the Acheloos. The Evros, Axios, Pinios, Alfeios and Aoos are “moderately fragmented”, while only Sperchios and Evrotas are free-flowing. Over the past 40–45 years, the Balkan rivers have undergone marked discharge reduction, caused by climate variability and change, evaporation from reservoirs and extensive water abstraction for irrigation. For example, i the n Pinios basin, intensive use of water for agriculture deteriorated the water balance, which is strongly negative even in rainy years (Loukas et al., 2007) and resulted in lowering of the groundwater table by tens of meters (Marinos et al.,1997). In summer, river stretches in Pinios may dry out. Since the end of the 1990s, the water level of Lake Doirani has been receding as a result of drought and overexploitation for irrigation (Griffiths et al., 2002). Dam operation smoothes and modifies the hydrological regime downstream of reservoirs. Thus, Acheloos, Nestos and Aliakmon nowadays present high to maximum discharge in July due to peak hydropower production. In Acheloos, 30% of the annual flow occurs during summer (compared to 11% prior to dam construction). In several places reservoirs retain vast masses of sediments thus adversely affecting delta evolution.

Large wetland areas were drained in favour of widespread intensive agriculture. In the past 50 years, huge drainage and irrigation networks were established and inter-basin water transfer projects took place, e.g. from Trebisnjica River to the Neretva and from the Strymon and Nestos headwaters to the Iskar and Evros basins (Knight and Staneva, 1996). Agricultural development and reservoir construction resulted to dramatic morphological modifications in water bodies. Some lakes and extensive marshes related to river deltas have been drained. Thus, Greece lost 60–70%, of its original wetlands (Tsiouris and Gerakis, 1991).

4.3.4. References

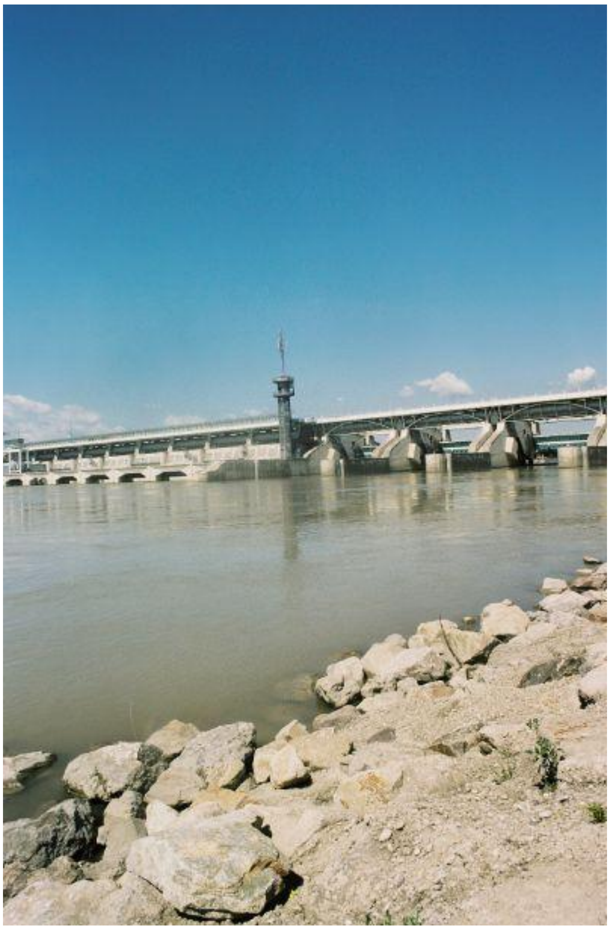
Hartnett, M., Wilson, J. G., and Nash, S. 2011: "Irish estuaries: Water quality status and monitoring implications under the water framework directive," Marine Policy In Press, Corrected Proof (n.d.), http://www.sciencedirect.com/science/article/B6VCD-526YMMH-1/2/e885524f9f4821a7046ea112b6197af3.
ICPDR, 2010
Nikolaos Th. Skoulikidis, "The environmental state of rivers in the Balkans—A review within the DPSIR framework," Science of The Total Environment 407, no. 8 (April 2009): 2501-2516.
Source: Souchon 2007: The Rhône river: hydromorphological and ecological rehabilitation of a heavily man-used hydrosystem. Available at http://www.uicnmed.org/web2007/cdflow/conten/2/pdf/2_1_France_%20MedCS.pdf
Scotland River Basin Management plan available at http://www.sepa.org.uk/water/river_basin_planning.aspx
Umweltbundesamt, 2010

5. Barriers – transversal structures

5.1. Reservoirs, dams, weirs

A river that has been left in its natural state is generally freely passable to migrating aquatic organisms in an upstream and downstream direction. Structures such as dams, weirs, barrages and other in-stream structures alter the natural hydromorphological form of a channel, with impoundment of water and reduced velocity profile on the upstream side and may act as a sediment trap. Since dams interrupt the natural continuity of rivers and reservoirs and change the hydrological cycle, their ecological consequences can be manifold. For example, access to spawning sites for migratory fish may be prevented. This is a particular problem for fish such as salmon, trout, eel and sturgeon, but also invertebrate species may be affected. However, even small dams cause problems, as they are impassable to most species of fish. Bypass rivers, fish ladders or fish passes at such structures may maintain or improve the continuity. Dams and weirs have an effect on the natural transport of sediment, resulting in its retention upstream of dams and loss downstream, so that material may have to be imported to stabilise the river bed and prevent incision.

The WFD anticipates that restoration of "high" and "good" water quality would include ensuring that the continuity of the river is not disturbed by anthropogenic activities and that undisturbed migration of aquatic organisms and sediment transport can occur.



Source: www © Photo: BMLFUW/Rita Newman

ARE FISH ABLE TO MOVE ALONG RIVERS?

The presence of structures blocking passage along a river, such as dams and weirs, makes it difficult and at times impossible for fish to migrate upstream and downstream. This is a particular problem for those species which migrate in order to breed, either from the river to the sea (catadromous species, such as the eel) or from the sea upstream (anadromous species, such as twaite shack and sturgeon).

Those stretches of river most affected by the presence of transversal barriers include 2.9% of river water bodies, covering the mid section of the Muga, the upper course of the Ter beyond Ripoll, the River Freser, the mid course of the Llobregat and the mid and lower courses of the Cardener. This information is available on the ACA website. ■

Damms and locks surveyed	Number of fish channels
334	31

Weir without fish ladders

Figure 5.1: Examples of barriers and transverse structures in European rivers.

www © Photo: BMLFUW

www © Photo: BMLFUW/Rita Newman

www © Photo: BMLFUW/Rita Newman

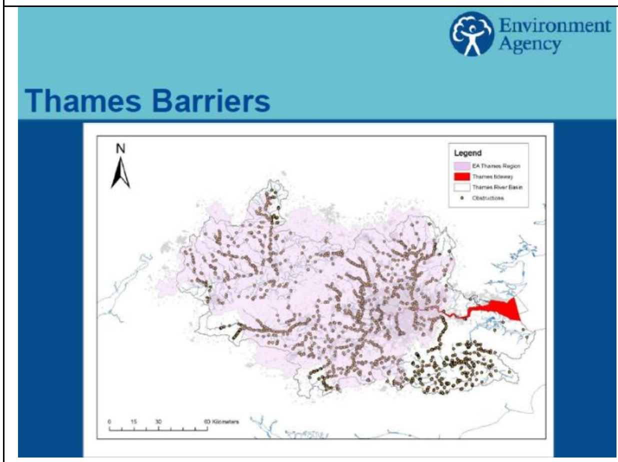
Damm i Laverbäcken. Foto: Länsstyrelsen i Norrbottens län.

Foto: Länsstyrelsen i Norrbottens län.

5.2. European overview

Comments: *The data reported on significant pressures and stored in WISE-WFD database are not fully suited for illustrating water bodies having barriers and transversal structures as a significant pressure.* In many of the individual RBMPs there are sections and maps and graphs describing water bodies being affected by transversal structures. It is an aim to provide an overview of this information in selected of river basin districts, see the examples on barriers in the table below.

There are several hundred thousands of barriersand transverse structures in European rivers. Some of them are large dams for hydropower production or irrigation storage reservoirs, but the majority are smaller. In Germany, for example, it has been estimated that there are some 200 000 transverse structures. In relation to the overall length of Germany's network of rivers of around 400,000 km, therefore, the continuity of the rivers is interrupted every second kilometre by a technical structure. Several of the RBMPs have identified a large number of barriers in the river basin district. Figure 5.2 illustrates the large number of barriers the Thames RBS and the Seine-Normandy RBD. For both river basin districts large part of the river system is affected by barriers.

<table>
<tr><td>Thames Barriers</td><td>Seine-Normandy barriers</td></tr>
<tr><td>


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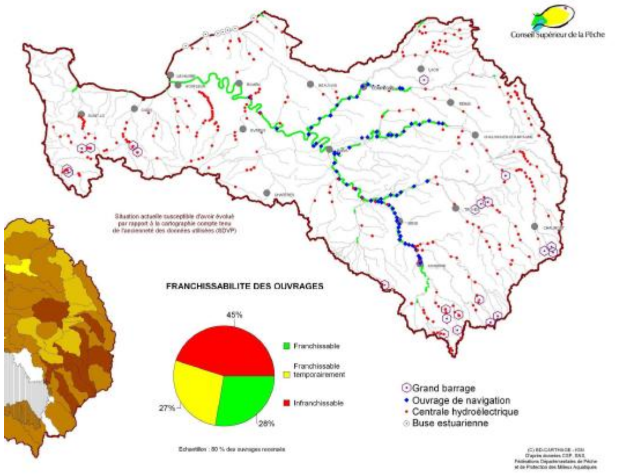


</td></tr>
</table>

During the last two centuries there has been a marked increase in both size and number of large dams and the storage capacity reservoirs, especially with the development of hydropower and irrigation reservoirs. There are currently about 7000 large dams in Europe. In addition, there are thousands of smaller dams.

A section describing small barriers to be included.

Table 5.1: Barriers in river basins

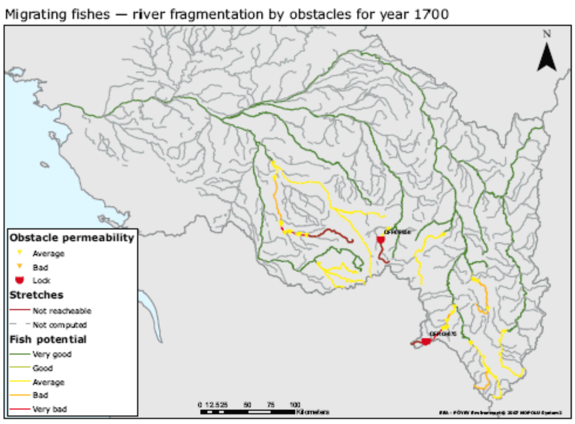
1 688 barriers are located in the **large Danube rivers** with catchment areas greater than 4 000 km2. 600 of the 1 688 continuity interruptions are dams/weirs, 729 are ramps/sills and 359 are classed as other types of interruptions. 756 are currently indicated to be equipped with functional fish migration aids. Therefore, 932 continuity interruptions (55%) remain a hindrance for fish. Source: International River Basin Management Plan of the Danube
There are currently thought to be some 200 000 transverse structures in **Germany**. In relation to the overall length of Germany's network of watercourses of around 400,000 km, therefore, the continuity of the rivers is interrupted every second kilometre by a technical structure. Source: UBA 2010: Water resource management in Germany, part 2 Water quality (p. 49) The **German Elbe RBD** notes that 91% of river length is failing GES due to hydromorphological pressures. 276 transversal structures out of 11.000, such as dams and weirs, are found to significantly disrupt fish migration in rivers that were identified as basin-wide priority for fish migration. Source: EEB 2010: 10 years of the Water Framework Directive: A Toothless Tiger? http://www.eeb.org/?LinkServID=B1E256EB-DBC1-AA1C-DBA46F91C9118E7D&showMeta=0
The Loire-Bretagne RBMP (SDAGE 2009) identifies over 10,000 infrastructures which reduce longitudinal river continuity and have negative impacts on the ecological status. Around 90% of this infrastructure is obsolete. 1430 infrastructures are listed for priority action. Source: EEB 2010: 10 years of the Water Framework Directive: A Toothless Tiger? http://www.eeb.org/?LinkServID=B1E256EB-DBC1-AA1C-DBA46F91C9118E7D&showMeta=0
There are over 2,500 weirs and impoundments, and 5,000 culverts on Scottish rivers. Source: SEPA, Significant Water Management Issues (SWMI) www
The **Czech** article 5 report identified around 6000 barriers above 1 m with 2153 in the Danube RBD; 2805 in the Elbe RBD and 1065 in the Odra RBD. Source WFD Article 5 Characterization chapter http://heis.vuv.cz/_english/data/spusteni/projektydat/vodniutvary/dokumenty/cz/Part_2.pdf
In the **Slovak RBMP** 779 barriers inpassable to fish have have been identified, only 84 of these have functional fish passes. Source: SK RBMP p. 45 http://www.vuvh.sk/rsv2/download/VPS/VPS.pdf
The **Dutch Rhine RBMP** identified over 9 000 dams, including over 700 in flowing waters and the Duthch Meuse RBMP identified more than 2 000 dams, half of them in flowing waters. The weirs and dams are needed for flood protection and for regulation water levels to different functions (such as urban, agriculture and nature). Only a small part is made passable for fish. Source Rhine RBMP and Meuse RBMP (5.1.5 Regulation of water movement and morphological changes).
In **Belgium 779 barriers** have been identified on a 3000 km long priority network of rivers (Rivers in contact with the sea and those considered to have greatest value and strategic importance). In addition many barriers are found on other rivers. Source : Biodiversity Indicators, 2011. Fish migration barriers.
In **Sweden** 3875 out of 15 598 river water bodies (25 %) and 1372 of 7252 lake water bodies (19 %) are affected by continuity interruptions. In Northern Baltic Sea RBD, for example, there are identified 945 dams, 2825 other barriers and nearly 5000 road crossings that may act as barriers. Source: Swedish RBMPs

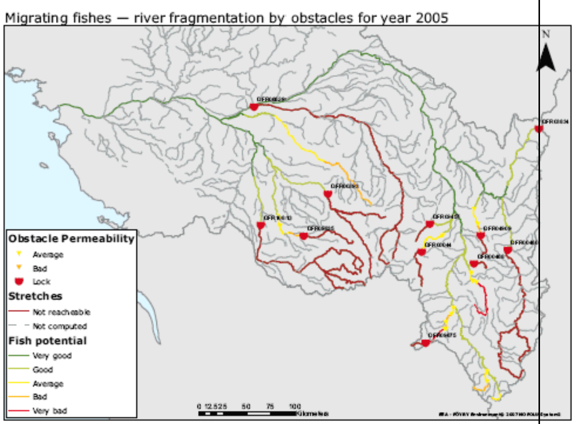
5.3. Case studies

We hope that Member States and relevant stakeholders will comment on the current case studies and contribute with updates and new case studies. The current case studies are partly copy and paste from RBMPs or other relevant documents

5.3.1. River fragmentation, Loire River, France and recovery of fish species in the River Rhine

River fragmentation in the Loire River, France by obstacles in 1700 and 2005, affecting adult salmon migrating upstream.





Source: EEA, 2007

Almost all fish species have returned to the Rhine, but access to habitats for salmon should be improved.

Measures targeted at improving water quality in the Rhine have enabled many fish species to return to the river. However, some specific measures are required to enable salmon to really re-colonize the Rhine basin, in particular to improve access from the sea past the sluices of the Haringvliet, Netherlands. The target year for this improvement and for improved access to the salmon habitats in the tributaries of the Upper Rhine is 2015. (ICPR, 2009)

5.3.2. Ireland barriers

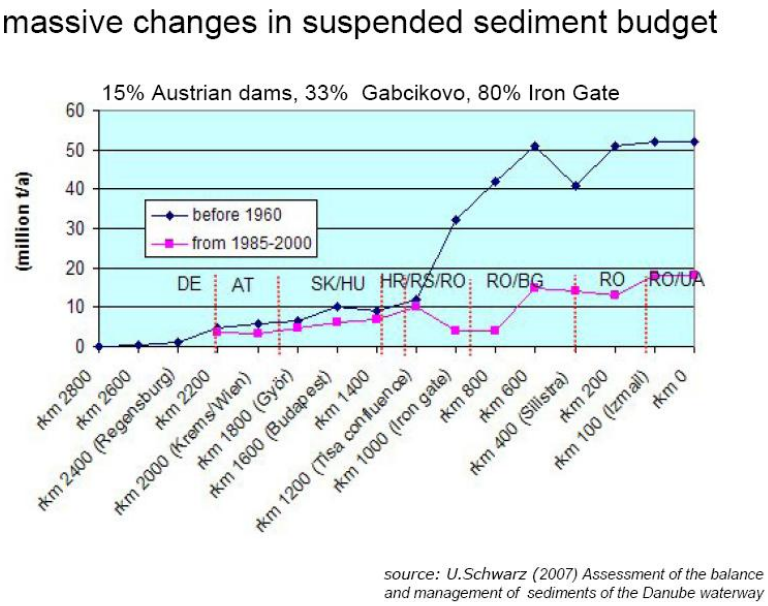
Source: Gargan et al. 2011

In Ireland, regulation of rivers via dams and weirs took place extensively in the 18th and 19th centuries. These structures generally consisted of a full-width barrier across the channel with a “mill race” leading water to a mill wheel installation and a tail race returning the water downstream to the channel. In other cases, a series of lock gates were involved in facilitating navigation. For mills, the barrier height was designed to obtain maximum value from the available stream power, trapping an optimal length of backwatered channel without forming an excessively high weir.

In Ireland, the Water Framework Directive (WFD) Freshwater Morphology Programme of Measures and Standards (POMS) identified barriers to fish migration as one of the principal issues placing channels “at risk” in terms of failing to achieve good hydromorphology status.

5.3.3. Sediment retention in reservoirs

Source: UBA 2010: Water resource management in Germany, part 2 Water quality
Hydrological changes, interruptions to the river continuum and intervention into the watercourse structure all disrupt the sediment regime. Large dams and weirs have an effect on the natural sediment transportation, resulting in the retention of sediment upstream of dams and the loss of sediment downstream of dams. The river is only able to compensate for this deficit of sediments by gathering material from the bottom, causing it to "dig into" the landscape more extensively along certain sections. As a result of such intervention, for example, the Rhine has become up to 7 m deeper, the Isar up to 8 m, and the Elbe up to 1.7 m deeper. This trend towards further deepening is continuing. It can be assumed that the majority of rivers in Germany exhibit an unnaturally high level of depth erosion.



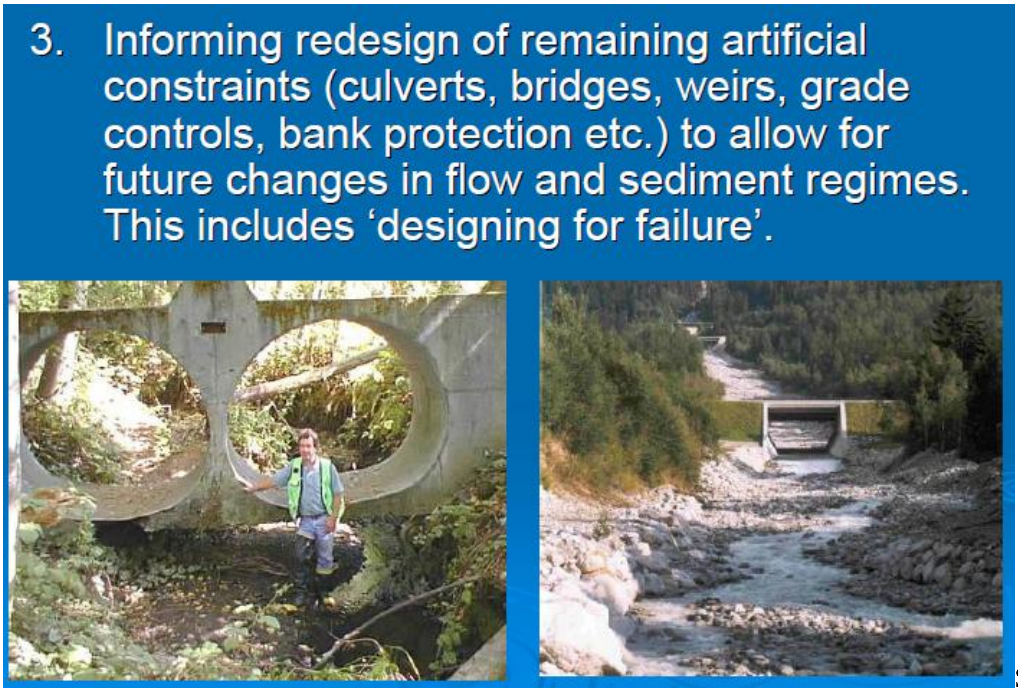
Source WWF based on Schwarz U. 2007: Assessment of the balance and management of sediments of the Danube pdf

Text box: Reduced sediment transport and Ebro delta

The delta of the Ebro River is a site of high economic and environmental importance. Almost 50,000 people live on the delta, and several economic activities (fisheries, aquiculture, agriculture (rice farms) and tourism) are associated with the ecosystems of the delta.
Existing dams in the Ebro River currently trap approximately 95% of the suspended sediment load as compared to measurements from the beginning of the 1900s. In the last forty years, low flows past the town of Tortosa, 40 km upstream of the mouth of the river, have decreased approximately 40 %.
The decrease in river discharge at its mouth also leads to salt water intrusion within the river system and because the sedimentation rate has been reduced from 3-15 mm/year to 0.1-4 mm/year, the lack of accretion is leading to coastal retreat and land subsidence. A situation that may be aggrevated with increasing sea level rise due to climate change.

5.4. Measures on barriers and transverse structure

A description of measures in relation to barriers and transverse structures to be included.



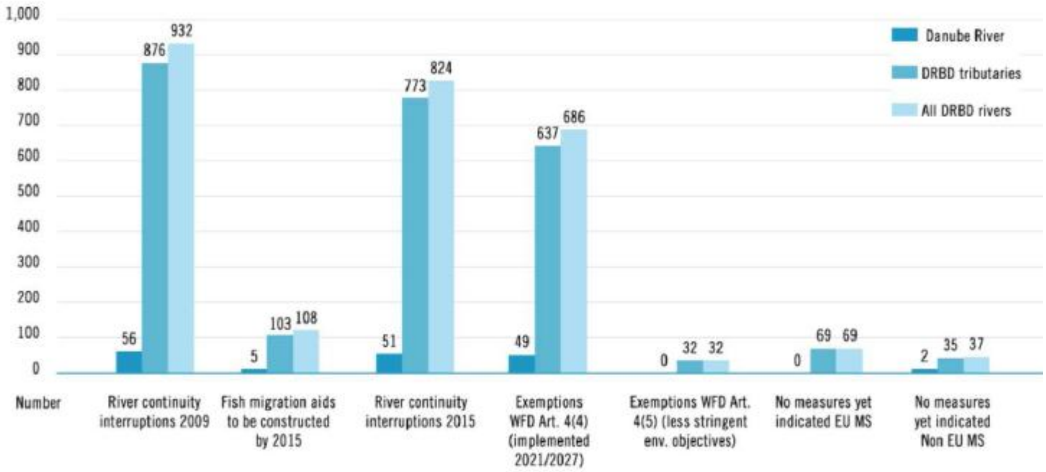
Source: Thorne 2011 http://www.macaulay.ac.uk/hydroworkshop/ThorneOpeningkeynote.pdf

Figure 3: Two types of functioning fish passes – the more natural- like bypass channel is more costly in this case but provides useful additional spawning ground.

Source: http://circa.europa.eu/Members/irc/env/wfd/library?l=/working_groups/hydro-morphology/technical_finalpdf/_EN_1.0_&a=d

5.4.1. Case study: Measures to remove barriers in the Danube River Basin district

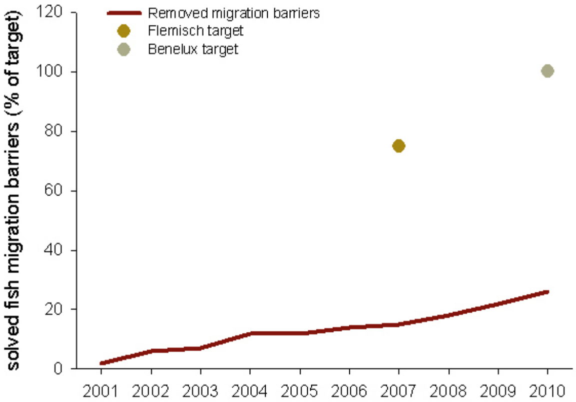
The current diagram and table illustrate how measures related to remove barriers will be implemented in the RBMP planning period up to 2015 in the international Danube RBD.



5.4.2. Case study: Indicator: Defragmentation of rivers

Source: Biodiversity Indicators, 2011.

The text box below illustrate progress in removing fish migration barriers along a 3000 km long priority network of rivers in Belgium.



This indicator shows the number of fish migration barriers that must be removed on a 3000 km long priority network of rivers in Belgium.

Analysis and Policy goal

In 1996, Belgium, The Netherlands and Luxemburg agreed to take all measures necessary to allow free fish migration through all hydrographic basins by 2010. A postponement to 2015 (90%) and 2021 (100%) is under preparation, synchronising the target with the European Water Framework Directive.

Trends and distance to target

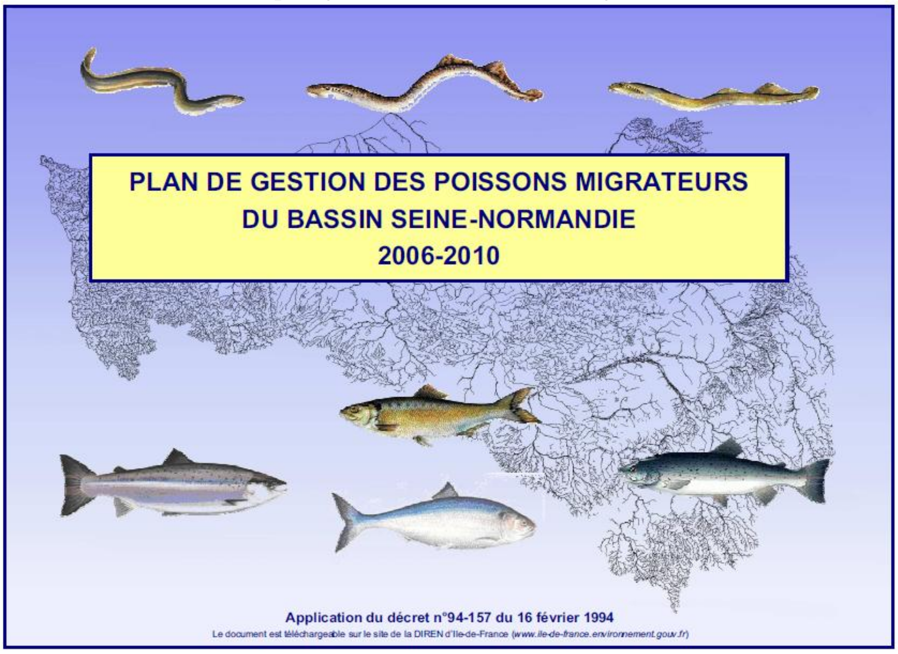
By the end of 2009, 171 of the 789 fish migration barriers (22%) had been removed. Others are being processed at different administrative levels. Nevertheless, progress is still far behind schedule

Expectations

At the current speed of the mitigation of river fragmentation (fish migration barriers) the target will not be reached. With the current policy only 20% of the fish barriers will be solved till 2010.

5.4.3. Fish conservation plans

Plans for getting fish species (e.g. Salmon (Rhine, Thames, Meuse etc); sturgeon (Danube); eel (French rivers) and lampreeys) back into the river systems to be included here.



5.4.4. References

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http://www.natuurindicatoren.be/indicatorenportal.cgi?detail=567&id_structuur=54&id_categorie=&lang=en&jump=yes
Gargan et al. P. G,2011: "Comparison of field- and GIS-based assessments of barriers to Atlantic salmon migration: a case study in the Nore Catchment, Republic of Ireland," Journal of Applied Ichthyology 27 (December 1, 2011): 66-72.
ICPR, 2009
UBA 2010: Water resource management in Germany, part 2 Water quality

6. Abstraction and flow regulation and water level regulation

6.1. Introduction

The flow regime and water level fluctuations are one of the major determinants of ecosystem function and services in river and wetland ecosystems. Many European rivers have had their seasonal or daily flow regimes changed by various uses that have a significant impact on ecosystems. Many lakes and rivers have their water level regulated.

The water level regulation depends on the uses. With hydropower production water levels are normally high or rising during summer period, while during the winter period, when the need for electricity is normally at its highest, the water level is strongly lowered. Flood prevention regulation follows a similar pattern during winter time, but in summer time some storage capacity is left empty to catch flash floods. When the major objective of the regulation is recreation or navigation, then regulated water levels are often more stable than natural ones. If the water level is regulated for water supply use, the water level fluctuation is more irregular and depends on the specific use of raw water. In reservoirs used for storage of water for irrigation

Abstracted water is used for a diverse range of processes including public water supply, water for agricultural irrigation and livestock management, domestic supply for individual dwellings (Figure 6.1), cooling for power stations, water supply for industry as well as many other purposes.

Figure 6.1 A) Reservoire used for water supply (Hasznos, Hungary) and B) Dam on River Rába at Nick for irrigation water abstraction and partly hydropower generation

Irrigation reservoirs generally store water during wet seasons and release it during dry seasons. Release of water from hydropower reservoirs depends on electricity demand. Flows downstream of hydropower plants may fluctuate daily when increased water volumes are channelled through turbines during periods of high electricity demand (Figure 6.1b). The effects of changes in the seasonal flow regime below dams and reservoirs and reduction in flow caused by water abstraction and diversion, upon lotic and riparian ecosystems have been demonstrated for rivers in a range of geographical regions.

The main challenge in managing abstraction is to meet the reasonable needs of water users, while leaving enough water in the environment to conserve river, lake and wetland habitats and species.

Dry river stretches may appear downstream of some reservoir dams; where whole streams are diverted into reservoirs; or during periods of dry weather in summer where abstractions can suck out the remaining river flow. More commonly, water abstraction during dry weather can reduce the wetted width of rivers. This loss of habitat can result in a loss of species and decreased abundance of others. It can also increase the vulnerability of water plants and animals to pollution and high summer temperatures.

Variation in flows and water levels is also important in all surface waters to maintain their characteristic ecological diversity. In lakes serving as reservoirs, extreme variation in water levels between winter and summer can result in the lake margins becoming a hostile environment for water plants and animals and the creation of a scar zone of bare sediments. In rivers, higher flows provide a trigger for migratory fish like salmon to make their runs upstream and successfully navigate waterfalls and other obstacles to migration. They also move fine and larger sediments around as well as detritus and other food sources. This creates the diversity of shifting habitats on which different water plants and animals depend. An estuary without the ebb and flow of the tide or inputs of river flows will not provide the conditions necessary for a natural complement of estuarine plants and animals.

6.2. European overview of abstraction and rivers with regulated flow

WFD required river basin management plans report on hydromorphological pressures on water bodies. Five groups of hydromorphological pressure on surface waters (rivers and lakes) were included in the WISE-WFD database, namely (1) Water abstractions; (2) Water flow regulations and morphological alterations of surface water; (3) River management; (4) Other morphological alterations; (5) Other pressures. In the reporting system hydromorphological pressures comprised of several subcategories of pressures. In case of *Water abstractions* subcategories include pressures from Agriculture, Public Water Supply, Manufacturing, Electricity cooling, Fish farms, Hydro-energy, Quarries, Navigation, Water transfer, and Other; while in case of *Water flow regulations* and morphological alterations of surface water include pressures from Groundwater recharge, Hydroelectric dam, Water supply reservoir, Flood defence dams, Water Flow Regulation, Diversions, Locks, and Weirs.

6.2.1. Key messages

- 8% of European river water bodies are affected by water abstraction pressures.
- The most water abstraction affected river basins are in Bulgaria, France, Italy, and Spain.
- Only 2% of the lake water bodies are affected by water abstraction pressures.
- The predominant HYMO pressure type in the EU coastal water bodies is coastal water management. Water flow regulation and morphological alterations of surface water are the second most important pressure type. Other pressures can be found in lower extent.
- Water flow regulation and morphological alterations of surface water are the most significant HYMO pressure type in the EU transitional water bodies, followed by transitional water management. Water abstraction and other morphological alterations are less important.

6.2.2. Assessment

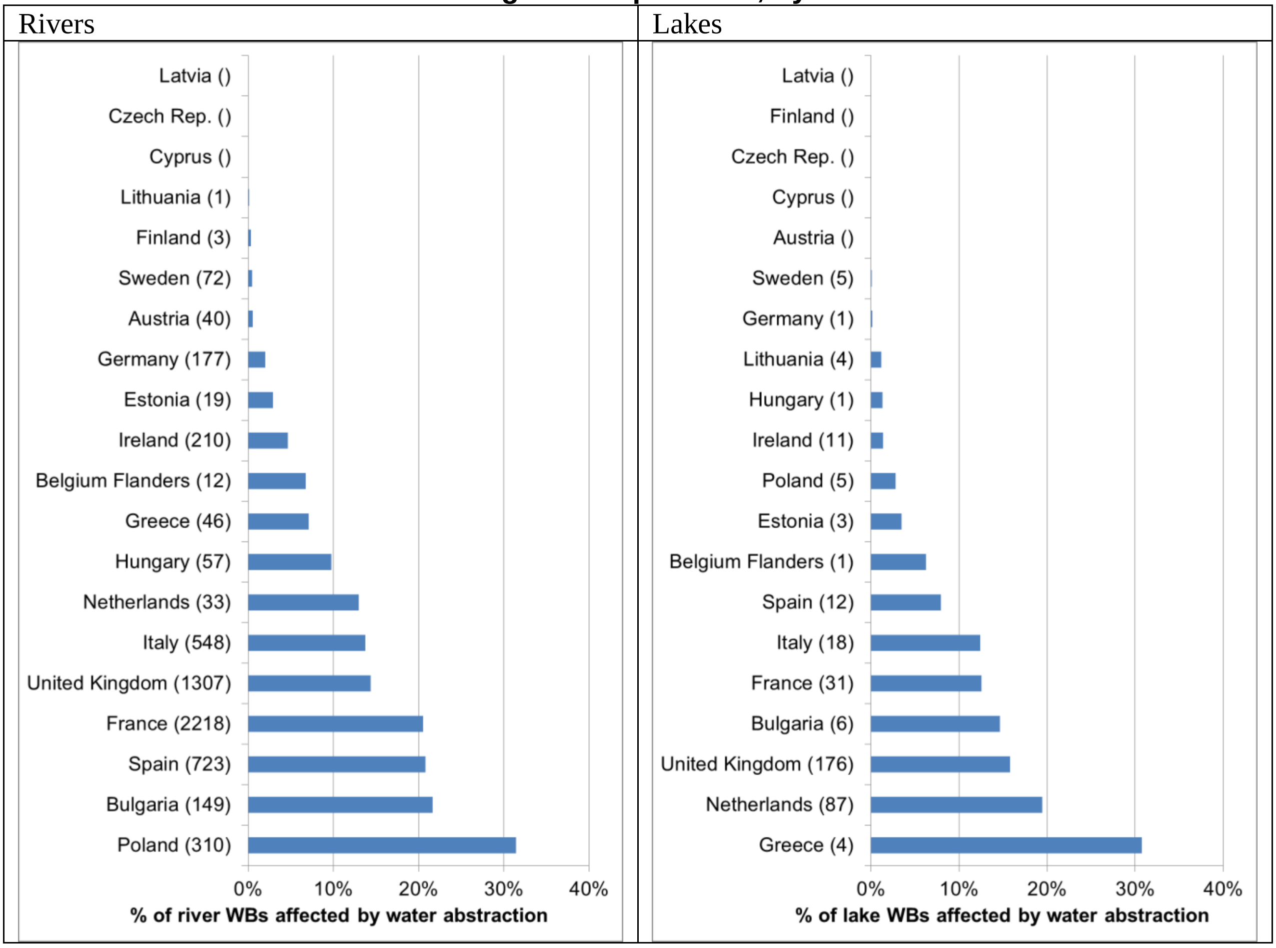
Out of 23 Member States that have reported to the WISE-WFD database three (Luxemburg, Romania and Slovakia) have not reported hydromorphological pressures.

Surface water bodies affected by direct water abstractions
17 out of 20 Member States reported river water bodies affected by water abstraction. Cyprus, the Czech Republic and Latvian did not report any river water bodies affected by water abstraction. Nine percent of the river water bodies are affected by water abstraction. Overall, 8% of European river water bodies are affected by water abstraction pressures. Countries with the highest percentage of water abstraction pressure are Italy, Spain, France and Bulgaria; all of them belong to the Mediterranean region (Figure 6.1).

Most Member States (17 out of 20 Member States) reported lake water bodies being affected by water abstraction, however only 400 lake water bodies were identified as affected by water abstraction, which represent only 3% of the lake water bodies. This fact maybe read in a way that only few lakes are used as source for water supply for public water supply or irrigation or fish farming. The highest percentage of water abstraction affected lake water bodies are located in Greece, The Netherlands, United Kingdom and Bulgaria while in Austria, Czech Republic, Finland, Latvia and Sweden no lake water body is under water abstraction pressure (Figure 6.2).

Four Member States (UK, France, Spain and Italy) have identified transitional water bodies being affected by water abstraction in the river basin district; accounting for 12 % of the transitional water bodies in these Member States. High water abstraction or water storage in the river basin district may markedly reduce the freshwater inflow, in particular in summer, and the dilution of pollutant discharges.

Figure 6.1: Percentage of river (left panel) and lake (right panel) water bodies having water abstraction identified as a significant pressure, by countries



Note: Number of water bodies affected by water abstraction are given in parenthesis. Percentage of affected water bodies is calculated as percentage of water bodies with known ecological status/potential
Source: WISE-WFD database February 2012;
fd.atkins.dk/report/WFD_aggregation_reports/SWB_pressure_status

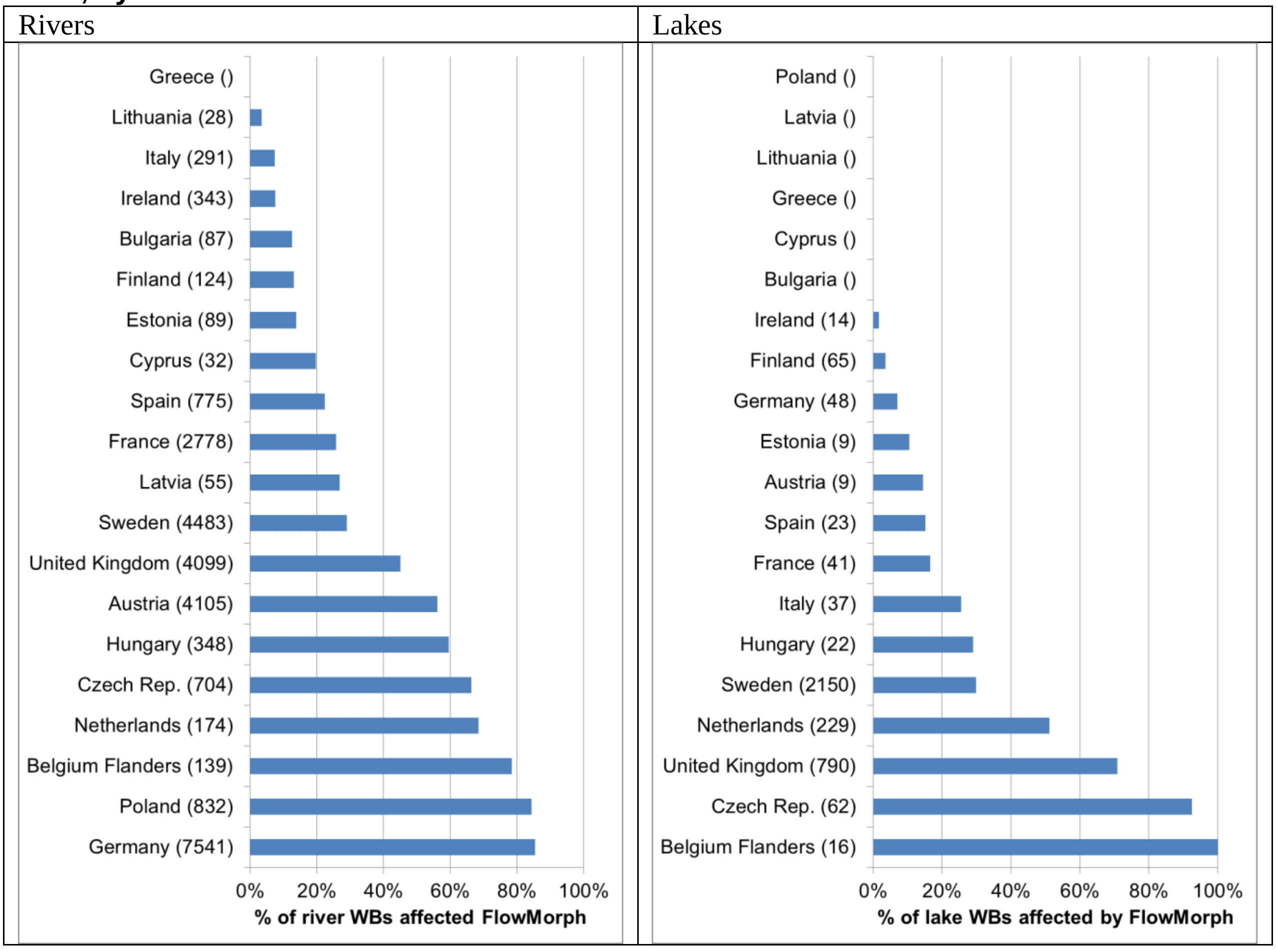
Water bodies affected by water flow regulation and morphological alteration
Most Member States reported water bodies being affected by the pressure group water flow regulation and morphological alteration. Nearly 40 % of the river water bodies are affected by water flow regulation and morphological alteration. This pressure group includes impacts from storage of water in reservoirs, but also change in hydrological regime and impacts by weirs and locks. For lakes pressures from water flow regulation and morphological alteration were affecting 27 % of the lake water bodies.

For transitional and coastal waters pressures related to water flow regulation and morphological alteration generally affected 18 % and 12 % of the water bodies.

In central Europe generally more than half of the river water bodies have water flow regulation and morphological alteration as a significant pressure (Figure 6.2). In Germany, Poland and Belgium Flanders more than three quarters of the river water bodies have water flow regulation and morphological alteration as a significant pressure.

In Belgium Flanders, the Czech Republic, United Kingdom and the Netherlands more than half of the lake water bodies have water flow regulation and morphological alteration as a significant pressure. In Sweden 2150 lake water bodies have water flow regulation and morphological alteration as a significant pressure; accounting for 30 % of the Swedish lakes.

Figure 6.2: Percentage of river (left panel) and lake (right panel) water bodies having water flow regulation and morphological alteration identified as a significant pressure, by countries



Note: Numbers of water bodies affected by water flow regulation and morphological alteration are given in parenthesis. Percentage of affected water bodies is calculated as percentage of water bodies with known ecological status/potential
Source: WISE-WFD database February 2012; wfd.atkins.dk/report/WFD_aggregation_reports/SWB_pressure_status

6.3. Case studies

We hope that Member States and relevant stakeholders will comment on the current case studies and contribute with updates and new case studies. The current case studies are partly copy and paste from RBMPs or other relevant documents

6.3.1. Rivers being affected by high abstraction rates

Case: Water bodies affected by abstraction in Catalonia

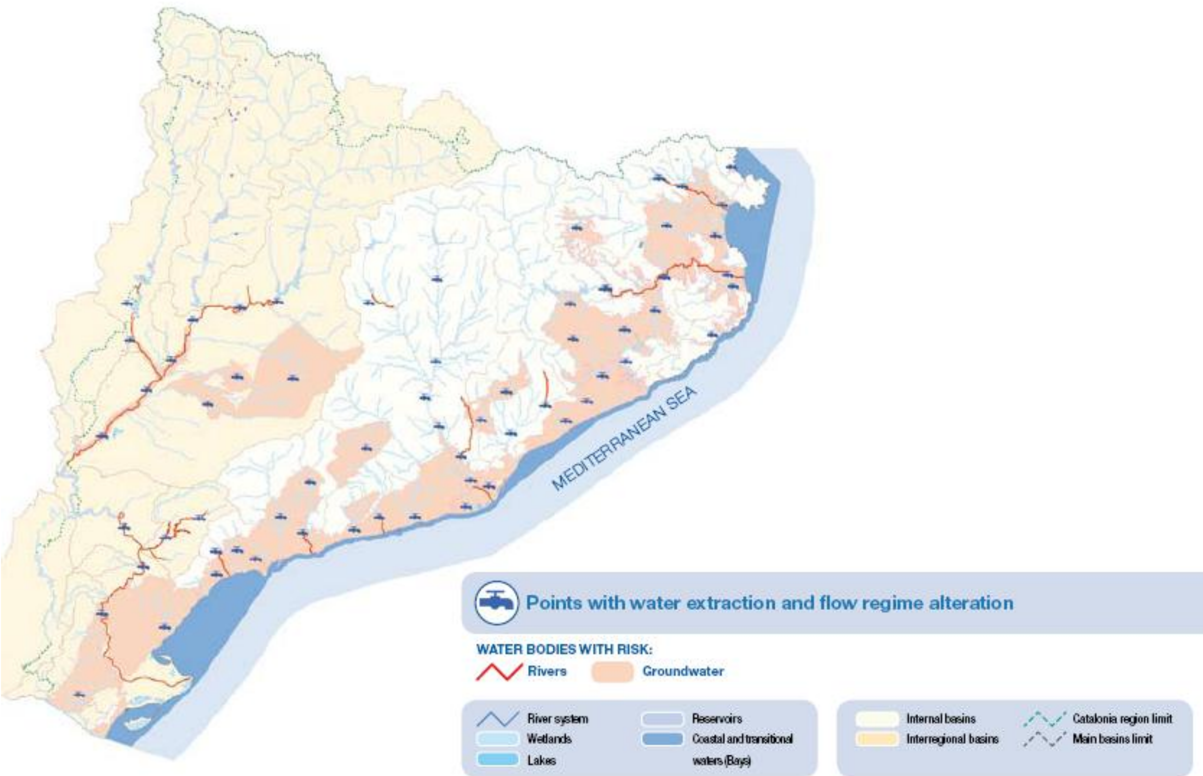
Source: Catalonia Water Agency, 2010

The extraction of water for urban and agricultural use, the regulation of the rate of flow of rivers (in order to satisfy demand for water using reservoirs), and the proliferation of plantations of phreatophytic trees (with deep roots which reach down to the phreatic level) are all activities which reduce the quantity of available water and directly affect the quality of 8.9% of rivers and 58.8% of groundwater.

Those areas most affected by water extraction and river flow regulation are the basins of the Muga, the Ter, the Llobregat, the Cardener, the Noguera Ribagorçana, the Segre and the Ebro, with particular problems being experienced in the final sections of the Foix, the Gaià and the Riudecanyes stream, with practically non-existent flows as a result of reservoir regulation.

The groundwater systems most affected by extraction for irrigation, water supply or industrial uses include most of the aquifers close to the coast (but also inland areas, such as Carme-Capellades and the Moianès, the alluvial fan of Terrassa and the Tàrrega limestones), while the effect of phreatophytic tree plantations is particularly significant in the basins of the Tordera, the Onyar and the lower sections of the Ter.

Map 6.2 River and groundwater bodies at risk due to water abstraction and changed flow regime in the Catalonia RBMP



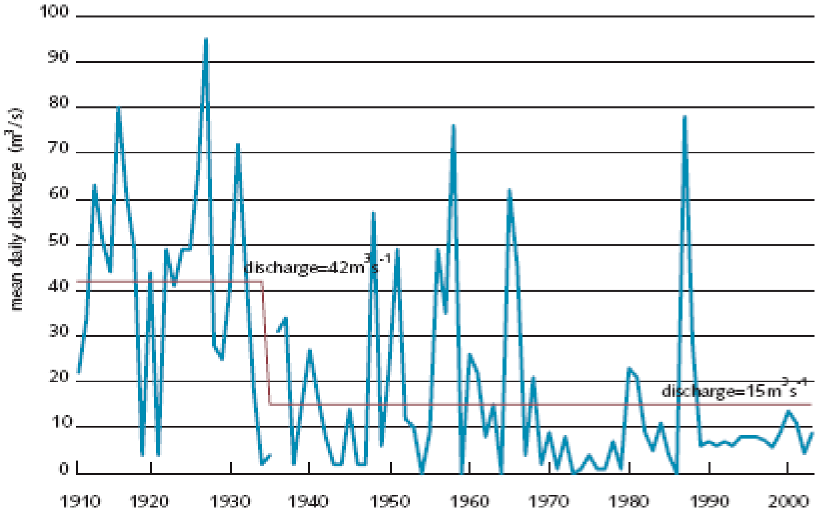
6.3.2. Change in hydrological regime due to water transfer and reservoirs

Case: Change in flow due to canals

Source:

Opening of the Albert canal (1935) and the Juliana canal (1939) has resulted in a decrease of low-discharge levels. In 1990 the weir at Borgharen has been automized and discharges below 10 m^3/s are mostly prevented

Figure 6.3: Lowest discharge per year on the river Meuse (Borgharen)



To prevent too low discharge in the Grensmaas, the Netherlands and northern Belgium ratified the Meuse Discharge Treaty in 1995, which comprises agreements on water distribution. This has since ensured the restriction of discharge into canals during periods of drought, and the surplus lockage water is pumped back into the river. The aim of this treaty is to prevent the Grensmaas discharge from falling below 10 m^3/s. This minimal discharge seems to be sufficient to keep aquatic life in the Grensmaas healthy, provided that it does not occur too often.

Case: Changed low regime of the Júcar river

Source: Sánchez Navarro et al. 2007

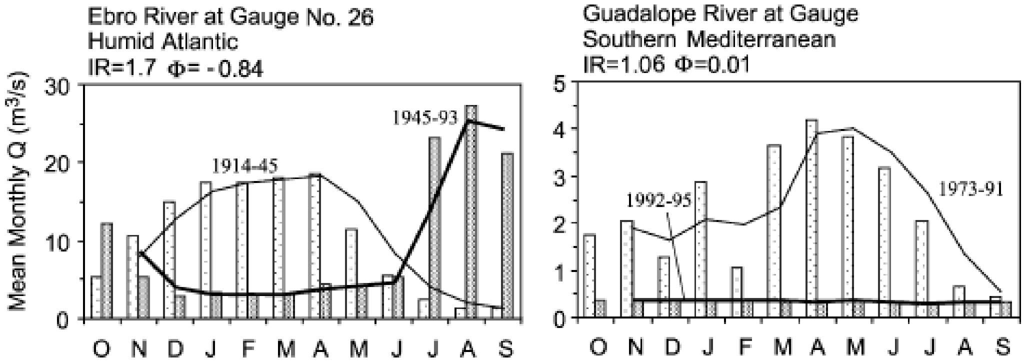
The natural flow regimes of Mediterranean streams have strong seasonal and inter-annual flow variations. This pattern of flow contrasts with agricultural water needs. The Júcar River and its main tributary the Cabriel River provide a typical example of water management in Spain. The Alarcón Reservoir on the Júcar River and the Contreras Reservoir on the Cabriel River have been operated for irrigation water supply since 1954 and 1970, respectively. Flow regimes downstream of these reservoirs show an inverted seasonal pattern.

Case: Ebro River Basin – change in flow regime

Source: Bartalla et al.

The Ebro River and its tributaries (North-Eastern Spain) are regulated by over 187 dams, with a total capacity equivalent to 57% of the total mean annual runoff. Annual runoff did not show strong trends, but the variability of mean daily flows was reduced in most cases due to storing of winter floods and increased baseflows in summer for irrigation. Monthly flows ranged from virtually no change post-dam to complete inversion in seasonal pattern, the latter due to releases for irrigation in the summer, formerly the season of lowest flows.

Figure 6.4: Illustrative plots of mean monthly flows pre and post dam for Guadalope and Ebro (below Ebro Dam near headwaters)



Note: IR is the ratio of reservoir capacity to annual runoff; *Φ* is the correlation coefficient between pre and post dam monthly flows.

6.3.3. Case: Regulated water levels of lakes

Regulated lakes in the Nordic countries

Source: Martunnen et al. 2006:

There are hundreds of regulated lakes in Finland, Norway and Sweden (Table 2). For instance, in Sweden, there is 563 lakes larger than 1 km2 with water level regulation vary from 0.1 m to 35 meters. In Norway, there are approximately 800 reservoirs registered in NVE's database, and a further 100 are assumed to exist without being registered so far. In half of these reservoirs, the water level fluctuation is more than 5 metres. The highest regulation amplitude is 140 m. In Finland, the water levels from 100 regulation projects of the total 350 projects have been analysed. Finnish regulations are usually relatively mild in terms of annual water level fluctuation. Half of these projects show that the annual water level fluctuation is less than 1 metre. The maximum water level fluctuation in the most heavily regulated lake in Finland is 7 metres.

Relative proportions of regulated lakes to the total number of lakes is the lowest in Finland (8 %) and the highest in Scotland (46 %), where the combination of high altitude and high precipitation favours establishment of reservoirs. However, in Finland, most of the largest lakes are regulated and consequently one third of the total lake area (about 11 000 km2) is regulated.

Table 2: Number of water bodies used for regulation purposes and main reasons for water level regulation based on interview.

	Number of water bodies			Main purpose of water level regulation projects (%)					
	Lakes (> 50 ha)	Regulated lakes and reservoirs	Share of regulated lakes and reservoirs (%)	Hydropower	Flood prevention	Recreational use	Water supply	Navigation	Timber floating
Austria	62	13	21	100					
Finland	4 500	350	8	40	25	4	25	1	
Norway	4 491	> 900	> 20	95			3	1	1
Sweden	7 260	-	0	-	-	-	-	-	-
Scotland	324	118*	46	91	5	2		3	

* estimation, - data is missing

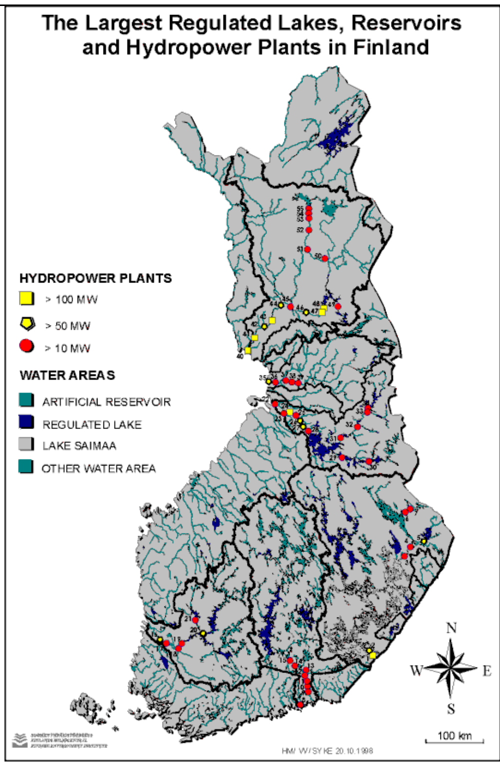
In summary, many Swedish and Norwegian reservoirs are much more heavily regulated than Finnish ones. However, the regulation amplitude itself does not directly describe the magnitude of ecological impacts of regulation. For instance, in Finland lakes are generally much shallower and their water is more coloured and consequently the productive zone is narrower than in Norwegian and Swedish lakes. Furthermore, there is a big difference in the use of regulated watercourses between Finland, Sweden and Norway. In Sweden and Norway most reservoirs are located in remote areas where recreational use of the watercourse is usually of minor importance, whereas in Finland the regulated lakes are almost always important for recreational purposes.

Finland – Regulated lakes and rivers
Source: Finnish Environment Institute

The water levels and flows in many of Finland's inland waters are regulated with the help of dams, weirs or other structures connected to hydropower plants. Most of this water level regulation work was done between the 1950s and the 1970s in order to reduce flooding, to produce hydropower, to facilitate water transportation, and to improve the water supply.

Around 220 water level regulation projects have been carried out in Finland, affecting water levels in more than 300 lakes with a combined area of around 10,100 km2 - or about a third of all the country's surface water. There are also 22 artificial reservoirs in Finland, with a total area of 610 km2 (2% of Finland's surface water), while seven bays around the Finnish coast have been dammed to create freshwater reservoirs.

Almost all of Finland's major rivers have been harnessed to generate hydropower, with dams controlling their flow and water levels. There are a total of 250 hydropower plants in Finland, around 60 of which have a capacity of more than 10 MW. About 15 % of Finnish electricity is generated by hydropower.



6.4. Measures in relation water regulation and water level fluctuations

Measures to be described here, including

- Reduce demand for water and abstraction of water
- Evaluate impacts of water transfers
- Ensuring minimum flow/environmental flow
- Evaluate sector activities impacts such as inland navigation and hydropower operation
- Other measures to rehabilitate the flow regime
- Reducing human-induced peak flows
- Enhancing natural water retention
- Restoring wetland
- Reduce the impact of water level fluctuations in lakes

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The quantity, quality and timing of water flows needed to sustain ecosystems and the services they provide are called environmental flows. The different components of an environmental flow regime contribute to different ecological processes. For example, base flows help maintain water table levels in floodplains and soil moisture for plants, high pulse flows shape the character of river channels, and large floods recharge floodplain aquifers. (SIWI, 2009).
To use environmental flows as sustainable criteria can help to evaluate the environmental impacts of hydropower and high/excessive water use in a river system (World Bank 2009).

Minimum flow
In order to meet the criteria of good ecological status or potential, the minimum flow should at least leave water in the river (except in naturally dry falling rivers) and aim at maintaining and restoring the river's type-specific aquatic community; promote the continuity of the original river bed, as well as the bypass at its termination; achieve nearly natural flow dynamics and groundwater status in flood-plain; and maintain distinct water exchange zones. Instead of gathering statical data on minimum flow, the feasibility of implementing an ecological control mechanism for minimum dynamic flow should be ascertained. This mechanism should maintain a constant and inflow-driven minimum flow, or should at least be seasonally controlled and meet the aforementioned criteria. A river's ecological status or potential can be ameliorated through the realization of measures that upgrade watercourse structures along original riverbeds in the light of site-specific characteristics, management goals, and minimum flow data, consideration should be given to site-specific characteristics.

Discharge regime:
Rapidly varying flows can be generated in a hydropower facility (hydro peaking). This gives rise to conditions that are deleterious to watercourse hydromorphology and aquatic biota downstreams, thus jeopardizing the goal of achieving good ecological status or potential. Hence, such artificial discharge regimes should be avoided for ecological reasons. However, if artificial discharge regimes cannot be avoided entirely, the ecological status of the water body/water bodies affected can still be improved through operational modifications (e.g. downstream "buffer" reservoirs) that attenuate the volume and frequency of artificially generated abrupt waves and avoid unduly precipitous water level fluctuations.

References
Batalla, R.J., Gomez C., nd Kondolf M. 200xRiver impoundment and changes in flow regime, Ebro River Basin, Northeastern Spain. Available at http://www2.uah.es/econ/Papers/BatallaGomezKondolf03.pdf
Finnish Environment Institute: Regulated lakes and rivers Available at http://www.environment.fi/default.asp?contentid=356128&lan=EN
Martunnen et al. 2006: http://www.ewaonline.de/journal/2006_05.pdf
Rafael Sánchez Navarro et al., "Hydrological impacts affecting endangered fish species: a Spanish case study," *River Research and Applications* 23, no. 5 (June 1, 2007): 511-523.

7. Morphological alterations

7.1. Introduction

This chapter should describe different morphological alterations of European water bodies including

- Channelized streams
- Disconnecting floodplains and rivers
- Land reclamation

<*this introduction has to be improved*>

In the past it wasn't unusual to channelize or straighten the streams meandering through agricultural lands. By straightening a stream, landowners increased the speed of water flowing downstream and the discharge at which water drained away from their land. Straightening the channel also made their fields more farmable because they could farm along a straight waterway (Figure 8.1).

Figure 8.1: Straightened and regulated shape streams flowing through agricultural fields

Source: Eider RBMP p. 30

However, channelization often makes things worse in the long run. By increasing the velocity of water moving in the channel, the flowing water scours the stream bed and deepens the channel (Figure 8.1b). The banks get higher and often more unstable.

Channelization increases stream bank erosion, more sediment enters and clogs the stream. In addition, channelization reduces the amount of vegetation along the stream bank, which means less food and cover for wildlife. Increased sedimentation makes it difficult for some fish to feed and spawn, and the increased velocity of the stream drives out fish that cannot tolerate fast-moving water.

River channels are fundamentally conduits for water and sediment, but the specific processes of water and sediment movement vary widely among channels. These processes create unique habitats and patterns of nutrient exchange to which the local in-channel and floodplain communities of plants and animals are adapted.

www © Photo: BMLFUW/Rita Newman

Photo: Rebecca Müller

The morphology of transitional and coastal waters is influenced, inter alia, by the following anthropogenic interventions:

- Land reclamation and polders;
- Dredging; sand and gravel extraction; and sand replenishment and similar coastal protection measures;
- Flood barriers in estuaries, and dams and diversion structures;
- Marine structures incl. offshore wind farms, transformer substations etc.; shipyards and harbors; and
- Bottom-trawling.

Many coastal and transitional waters are impacted as a result of the expansion of the navigable channels. The position of channels is fixed by dredging and the construction of stream deflectors and groins, preventing the previous dynamic shifts. In addition to these larger measures, various local encroachments have occurred and are still occurring in the coastal waters, such as beach replenishment or the reinforcement of smaller harbors.

7.2. European overview

Historical bends were lost to channel straightening projects, as it is well documented on many rivers and streams in Europe (Brookes 1987, Goldi 1991, Iversen et al. 1993). Moreover, hundreds of kilometres of small streams and ditches have been replaced by under-drainage systems both in Denmark and other parts of Europe (Brookes, 1987; Wingfield & Wade, 1988; Iversen et al., 1993).

Many lowland rivers in Western Europe have been substantially modified to aid land drainage and support the intensification of agriculture (Harrison et al., 2004). Low-gradient rivers flowing through the agricultural and urban landscapes of north-west Europe have long been subjected to intensive management (Purseglove 1988; Moss 1998; Rackham 2000). Probably more than 95% of lowland river channels in south-east England and Denmark have been modified to enhance land drainage, river navigation and flood prevention (Iversen *et al.*,1993; Brookes 1995). As a result, many have highly simplified and uniform channels, unnaturally steep banks and little dynamic connectivity with their flood plains.

River modification accelerated in the twentieth century, largely associated with the intensification of agriculture, when many rivers were straightened, deepened and widened to facilitate catchment drainage and to prevent local flooding (McCarthy 1985; Brookes 1988). Instream gravel deposits and most instream woody debris were often dredged from such rivers, further reducing their physical heterogeneity (Swales 1989; Brookes 1988). The characteristic longitudinal and lateral sediment deposition pattern of actively meandering channels was then replaced by a more uniform and diffuse deposition of finer material in constrained channels. The physical complexity of natural marginal and riparian habitats was also usually greatly simplified. Water quality changed to reflect a greater input of nutrients and organic material from more-intensively managed catchments (Sweeting 1996; Riis & Sand-Jensen 2001).

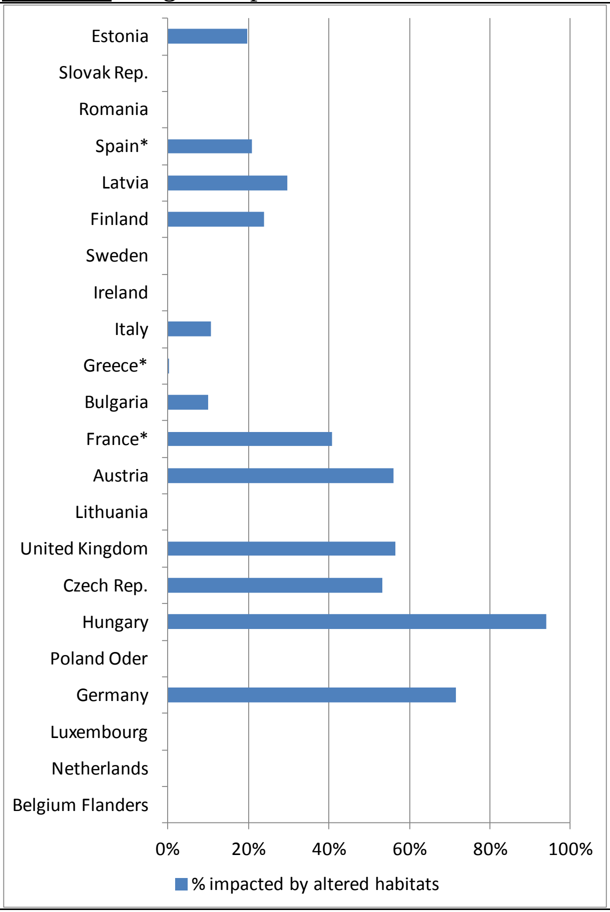
Medium-sized and large mountain rivers are among the most degraded river types in Europe and numerous river restoration projects are currently carried out to achieve ‘good ecological status’ (Jähnig et al., (2009).

The WFD required river basin management plans report on hydromorphological pressures on water bodies. Five groups of hydromorphological pressures on surface waters (rivers and lakes) were included in the analysis, namely (1) Water abstractions; (2) Water flow regulations and morphological alterations of surface water; (3) River management; (4) Other morphological alterations; (5) Other pressures. Each of the five groups of hydromorphological pressures comprised of several subcategories of pressures, such as (1) Water abstractions include pressures from Agriculture, Public Water Supply, Manufacturing, Electricity cooling, Fish farms, Hydro-energy, Quarries, Navigation, Water transfer, and Other; (2) Water flow regulations and morphological alterations of surface water include pressures from Groundwater recharge, Hydroelectric dam, Water supply reservoir, Flood defence dams, Water Flow Regulation, Diversions, Locks, and Weirs; (3) River management include pressures from Physical alterations of channels, Engineering activities and Dredging; (4) Other morphological alterations include pressures from Barriers and Land sealing, while (5) Other Pressures group includes pressures from Sludge disposal to sea, Exploitation/removal of animals/plants, Introduced species and Other subcategories. The data reported on significant pressures and stored in WISE-WFD database are not fully suited for illustrating channelized streams and issues on disconnecting the flood plains. As data are not supporting a comprehensive analysis, thus an European overview can be given through case studies.

Assessment below to be updated and improved

- Six out of 15 Member States had more than 40 % of their river water bodies being subject to impact by altered habitats (Figure 8.2) and two countries. Hungary and Germany had more than 60 % of river water bodies being subject to impact from altered habitats.
- In the Czech Republic, United Kingdom and Hungary more than 60 % of lake water bodies has altered habitats as a significant impact.

Figure 8,2 Percentage of river WBs and lake WBs with habitat alteration being an impact

<table>
<tr>
<td>Rivers – percentage of water bodies with <u>altered habitats</u> being an impact</td>
<td>Lakes – percentage of water bodies with <u>altered habitats</u> being an impact</td>
</tr>
<tr>
<td>
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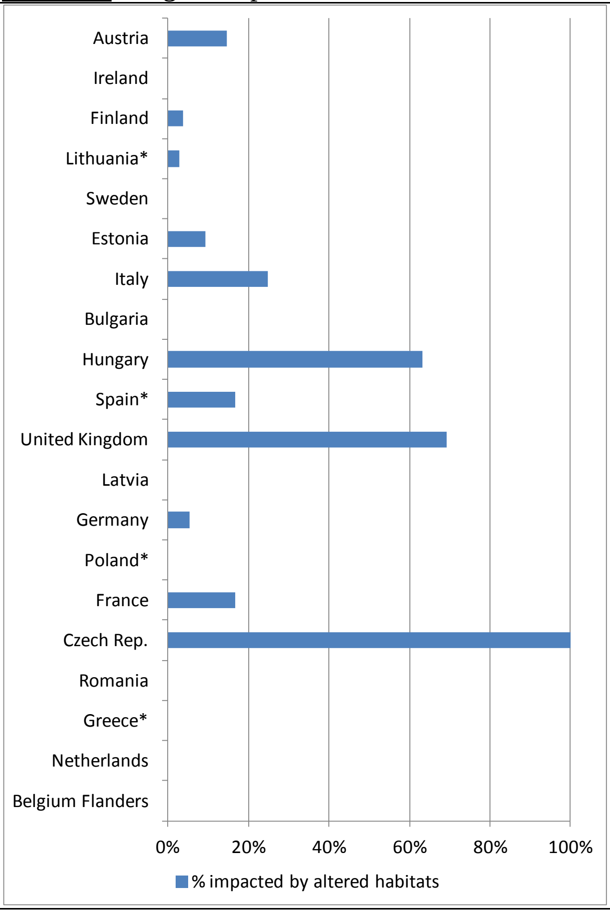
<td>
</td>
</tr>
<tr>
<td>Excel sheet: impact_rivers.xlsx
Notes: Based on rWBs with classified ecological status, total 61415 (water bodies from 15 EU Member States: Austria; Belgium Flanders; Bulgaria; Czech Rep; Estonia; Finland; France; Germany; Greece*; Hungary; Italy; Lithuania; Spain*; Sweden & United Kingdom.
No impact data from Ireland; Lithuania, Luxembourg; The Netherlands, Poland, Romania & Slovak Rep.
Sorted by percentage of water bodies with at least good status</td>
<td>Excel sheet: impact_lakes.xlsx
Notes: Based on lWBs with classified ecological status, total 11723 water bodies from 15 EU Member States: Austria; Belgium Flanders; Bulgaria; Czech Rep; Estonia; Finland; France; Germany; Greece*; Hungary; Italy; Lithuania; Spain*; Sweden & United Kingdom.
No lake water bodies reported for Luxembourg and Slovak Rep.
Sorted by percentage of water bodies with at least good status</td>
</tr>
</table>

8.3 Case study

We hope that Member States and relevant stakeholders will comment on the current case studies and contribute with updates and new case studies. The current case studies are partly copy and paste from RBMPs or other relevant documents.

7.2.1. Country examples of altered river habitats

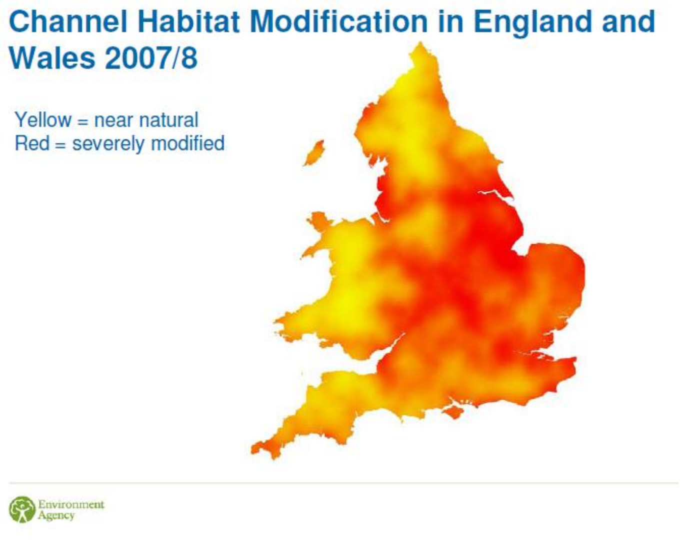
In Europe many rivers and streams were channelized and straightened, total stream length was shortened, many connected side-arms got lost, and the number of oxbow lakes reduced. There are many national examples illustrating that a large proportion of waters have been significantly modified. On the following pages is listed a number of country assessments of the state of river habitats.

England and Wales

Source: Environment Agency 2011

The Environment Agency published in 2011 a report on the state of river habitats in England and Wales. The main results are:
River channels are extensively modified across England, Wales and the Isle of Man.

Over many centuries, rivers have been straightened, widened, deepened and dammed, mainly to improve drainage of land for housing, industry and farmland, and to reduce the risk of local flooding. As a result, river and bankside habitats have become impoverished and the variety of wildlife they support has declined.



Denmark

A survey of Danish stream channels indicates that 97.8 % of Danish watercourses have been artificially straightened and that only 2.2 % (880 km) have natural morphological characteristics. The density of channel works is 300 times greater than in the U.S.A. and 15 times greater than in England and Wales (Brookes et al. 1987).

Finland

Source: Laitinen and Jormola 2008

Almost every ditch and stream in Finland has been altered: Many natural streams have been widened to increase drainage, deepened and straightened for agriculture. Drainage of agricultural areas is a prerequisite for cultivation in the Finnish climate and lowland conditions. Almost all brooks and ditches in farming lands have been widened, deepened and straightened to allow sufficient drainage depth and prevent local flooding. Regular dredging has weakened the ecological condition of brooks and increased erosion, sedimentation and invasion by aquatic plants of the downstream sections. Decreased water flow and poor water quality also cause problems. In addition, biodiversity suffers and the form of the streambed becomes monotonous. Only few species can live in straightened and deepened streams.

Text box: Channelized rivers for timber floating in Finland and Sweden

Most Finnish rivers were channelised during the 19th and 20th century to facilitate timber floating. By the late 1970s, extensive programmes were initiated to restore these degraded streams (Muotka and Syrjänen, 2007).

In Sweden, rivers of all sizes have been channelized to facilitate timber floating (Törnlund & Östlund 2006). Figure 8.4 shows the streams used for timber floating in 1930. Timber floating was gradually abandoned after the 1950s as the road network was developed (Törnlund & Östlund 2002).

Finnish river affected by timber floating

Rivers in Sweden used for timberfloating in 1930.

Source: Naturvårdsverket

During the first half of the 20th century forest industry grew strongly in Finland and other countries in the boreal zone. One prominent feature of this development was the increasing exploitation of forest resources in remote areas. Therefore, the majority of running waters was dredged to facilitate water transport of timber, especially in the northern and eastern parts of the country. In the 1950s and 1960s, this network of floatways was further expanded, and almost all streams wide enough for log floating (often no more than 4–5 m) were dredged, mainly using excavators (Jutila, 1992; Yrjn, 1998). At its maximum, the total length of dredged channels in Finland amounted to approximately 40 000 km, of which 13 000 km were in use by the 1950s (Lammassaari, 1990). In the 1970s, water transport of timber was eventually replaced by road transportation. This marked a turning point in stream management, with a strong and continuously growing interest in the restoration of dredged stream channels. A similar sequence of phases from intense dredging to restoration can be identified in northern Sweden, north-western Russia and forested parts of the northern U.S.A. and Canada (Sedell, Leone & Duval, 1991; Törnlund & Östlund, 2002).

The development of the export-oriented forest industry played an essential role in the industrialisation of Sweden at the end of the nineteenth century. A very important factor was the available watercourses: these could be used to transport timber from inland forests to the saw mills on the coast.

Austria

Source: Poppe et al. 2008

Up to 80% of the large rivers in Austria (n=53) are moderate to heavily impacted. The main pressure types are channelisation, continuum disruption, impoundment, water abstraction, hydro peaking and land use. Data of near natural as well as anthropogenically altered catchments in Austria were compiled. The main pressures were identified through pressure-specific indices.

Up to 80% of the large rivers in Austria are moderately to heavily impacted (Muhar et al., 2000). As water pollution is not the main problem anymore, the main impacts on Austrian running waters concern hydromorphological alterations.

In Austria only about one third of the total length of the main rivers remains free flowing. The remainder has been impounded or otherwise modified for hydroelectricity generation or flood protection and erosion control (Lebensministerium, 2010).

International Danube River Basin Management Plan

80% of the former flood plains/wetlands in the Danube river basin district have been lost during the last 150 years.

Switzerland

In Switzerland below elevations of 600 m 46 % of watercourses are heavily impacted in terms of structural diversity and there are about 101 000 artificial barriers with a height difference of more than 0.5 m (FOEN, 2010).

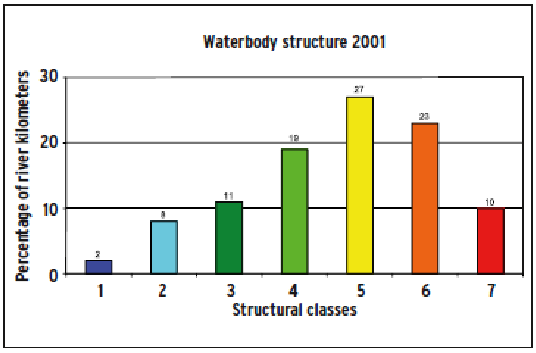
Germany

Source: UBA 2010

The morphological changes of rivers in Germany are recorded directly for an assessment of structural water body quality.

As shown by the 2001 morphological water structure map prepared by LAWA in collaboration with the Federal Environment Agency (UBA), morphological deficits with structure class 4 or below exist in around 79 % of cases (Figure 30). Only 21 % of Germany's rivers and streams – predominantly in less populated regions – are still in a semi-natural state, i.e. with little to moderate modification by humans (structure classes 1 to 3).

Figure 30: Structural quality classification – River kilometres as a percentage of the water network (approx. 33,000 km)



Source: LAWA

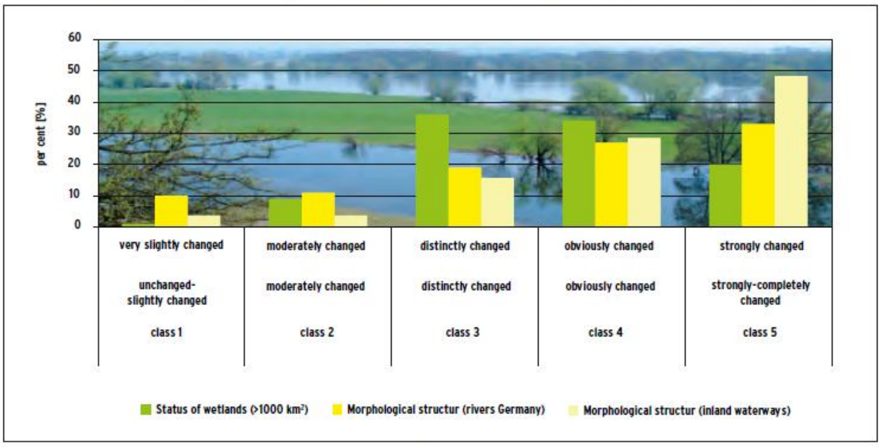
The reference (class 1) represents the potential natural status. The further stages from slightly modified (class 2) to completely modified (class 7) characterize the degree of anthropogenic structural changes.

Floodplains along the large German rivers

Source

The large German rivers have generally been technically modified with weirs and locks for the benefit of navigation and hydropower use. Furthermore, large parts of their floodplains have been separated off from the river and restricted by dykes. Installations and interventions for the purpose of flood alleviation may cause significant pressures on hydromorphology. Today nearly all sections of the major rivers have dykes. The building of dykes resulted in the loss of floodplains as retention spaces for flood water. For example, the development of the Upper Rhine resulted in a river bed up to 12 km wide giving way to a channel between 200 and 250 m in width; the Rhine floodplains between Basel and Karlsruhe decreased by 87 %. Overall, the natural floodplain area of the Upper Rhine was reduced by 60 % or 130 km2, which in turn entailed considerable expenditure for the associated increased risk of flooding in downstream areas.

Figure 25: Distribution of floodplain status assessments (rivers with a catchment area > 1000 km²), the structural quality of watercourses (33,000 km as at 2001), and the structural quality of Federal waterways



Source: Compiled by the Federal Environment Agency (UBA) using figures supplied by LAWA and the BfN

Only 10-20 % of the former floodplains on major rivers are now available to retain flooding. Only 10 % of the floodplains analysed in river basins > 1000 km2 can be described as slightly or moderately changed (Figure 25). Most of the rivers covered by floodplain mapping are Federal waterways. The usage pressure on the major rivers is also reflected in their structural quality. Over 90 % of Federal waterways have had their natural structure “distinctly” to “completely changed” (structure classes 4-7, Figure 25).

The Netherlands – Vecht River

Source: http://edepot.wur.nl/176364

Canalisation of the river Vecht went along with changes in land-use and took place during three major time-intervals: ±1895-1905, 1925-1935, and 1955-1965. The area of heather and moorland peat decreased dramatically as the agricultural, urban and other human uses increased. The percentage of forest remained the same over the whole period. In general, the morphological features of the streams in the Vecht catchment show degradation over the last one hundred years.

The total stream length was shortened by about 20% while the valley length remained about the same. Forty percent of the connected side-arms got lost and the number of oxbows increased in the thirties due to straightening of the major streams but decreased until today with about 38%. In general, most streams were meandering around 1900, in the thirties and sixties some were still slightly meandering, and currently most are straight.

Gravel extraction from rivers

Rivers in north-eastern Italy, as other Italian rivers and some rivers of the Carpathians, have experienced widespread channel adjustments in the last 100 years, in particular incision and narrowing (Rinaldi et al. 2005 ; Surian, 2006; Surian et al., 2008). Channel width has been reduced by 50-70 % and bed-level has been lowered of 2-3 m on average, but locally up to 8.5 m. Gravel mining and channelization works have been the main causes of channel changes and it have altered fluvial processes, in particular sediment fluxes. Gravel mining was very intense between the 1950s and the 1980s. During the 20-30 years large volumes of sediments were removed from the channels.

Urban areas

Source: Binder 2008

During the last 150 years rivers in urban areas of Europe were sealed in concrete, habitats got lost, the hydro morphological processes within such system are even today often strongly interrupted. Better sewage treatment during the last 30 years and the improvement of the water quality, was the basic for urban river restoration projects. There are many good examples of river restoration in urban areas. Urban streams have become increasingly important in the planning of urban ecology and green areas in European towns and cities in recent years. Today river restoration, in connection with other projects for city development and urban planning are offering win-win situations: to improve flood control and the ecological functions, to keep people in town, to offer recreational value and to raise the quality of living in urban areas.

Text box: Urban development and river regulation

The River Liesing is Vienna´s third largest river after Danube and Wienfluss. Its catchment basin is 115 km²; the whole river length is 30 km, with 52 km² and 18 km of it in Vienna. The Liesing is famous for her fast rising, heavy floods. Heavy flood events in the past led to a regulation system such as lowering and stretching of the riverbed. Meanders have been cut off and refilled and high bed drops interrupted the flow. Loss of wildlife, disturbance of the ecosystem and bad water quality in the new channel were of no interest at that time.

A pilot project funded by LIFE-environment with the objective to achieve “maximum ecological potential” for the Liesing River resulted in: for a length of 5.5 km, a concrete channel located in an urban area was re-designed into a semi-natural type-specific river, which also meets the relevant flood protection requirements.

Figure 1. Heavy flood events in 1954

Figure 2. After the flood in 1954 the Liesing was pressed into a u-shaped concrete bed.

Revitalisation activities include construction measures to restore the river continuity by re-building bed drops, restoration of semi-natural morphological conditions by integrating bays and shallow water zones, restoration of former meanders, construction of a semi-natural river bed with a gravel substrate, and the restoration of the river’s natural transport capacity.

Source: Based on Goldschmid and Schmid 2006 pdf

Status of channel water bodies in Hungary

Hungary is one of the few countries in Europe with a geography that is completely landlocked, meaning it has no coast. A great proportion of the geographical land of Hungary is taken up by the Great Plains located in central and eastern Hungary, where the lie of the land is generally low and flat. Hydrographically Hungary can be divided into two roughly equal parts: one part belongs to the Danube and the other one is in the Tisza Basin. In the late nineteenth century, during the large-scale river regulation works on the Tisza River and in smaller extend on the Danube River, canal systems were also created partly as artificial waterways, partly to help the agricultural landuse, and partly to draine inland excess water away. The most important canal of theTransdanubia part of the countryis the 100 km long Sió Channel connecting Lake Balaton and the Danube River.

As a consequence of large scale river regulation works and construction more than 4500 km long flood protection levee system nowadays roughly one forth of the territory of the country is under 100 year probability flood level (Figure 8.5).

Figure 8.5 Flood basins and inland excess water in Hungary

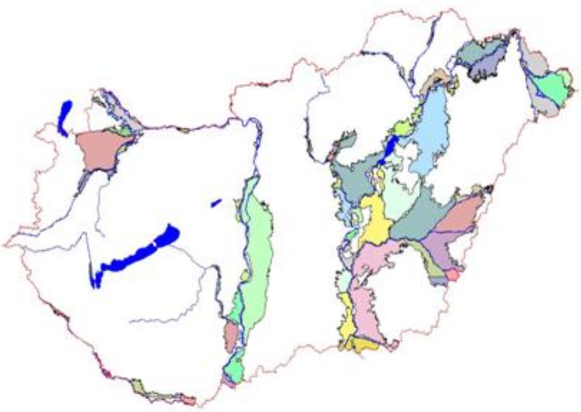
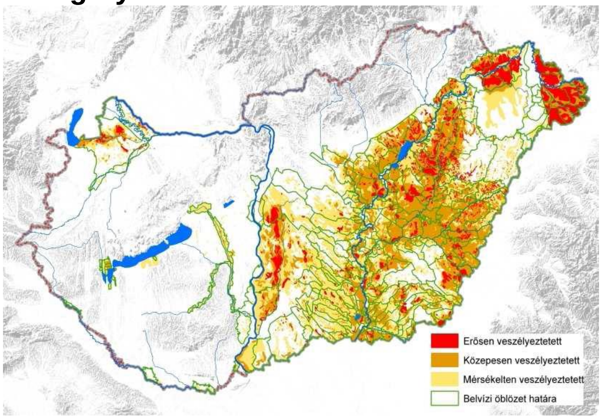


Figure 8.6 Inland excess water risk area in Hungary



There are about 43 000 km long inland excess water drainage channels in Hungary dominantly on the areas at inland excess water risk. This is one of the reasons that while Hungary designated 869 river water bodies, out of them 255 water bodies are called channel.

In the WISE-WFD database there is no code to distinguish channel type river water bodies. However, 255 river water bodies could be identified by their name as channel type water bodies. Figure 8.6 illustrates examples of the channel types.

Figure 8.5: Regulated channels and streams

Regulated shape open drainage channel

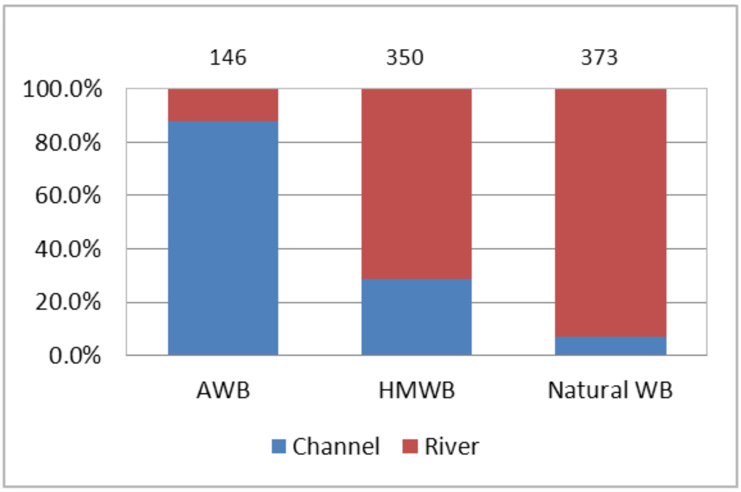
Outlet sluice of an irrigation channel


Outlet sluice of a drainage channel


Stream bank protection

Out of the total 869 RWBs 350 were classified as HMWBs from which 101 are channel type, while from the 146 AWBs 87.7% is also channel type (Figure 8.6). 26 WBs called channel were classified as natural type, which fact raises question that either the name of the water body does not fit tto the reality or the classification is wrong. There are 819 RWBs with at least one identified hydromorphological pressure. Out of them there are 235 water bodies with channel name.

Figure 8.6 Ratios of channel and river water body types in Hungary



There are only 50 river water bodies which have no hydromorphological pressure. Out of the 819 RWBs with at least one hydromorphological pressure 235 were channel type.

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8. Hydromorphological issues in transitional and coastal waters

8.1. ntroduction

European coastline comprises rich biodiversity, at the same time being vulnerable and sensitive environment. Simultaneously, coast of Europe faces strong anthropogenic pressures. The European coastline is of the most altered coastlines in the world (Kull et al. 2006:251). Human activities have altered significantly natural coastal landscape, since coastal areas are favourable living environments due to several advantages. Although coasts have been altered by human activities for centuries, there are still areas with natural coast left. Coastal zones are densely inhabited by a large percentage of the EU citizens (Figure 1.).

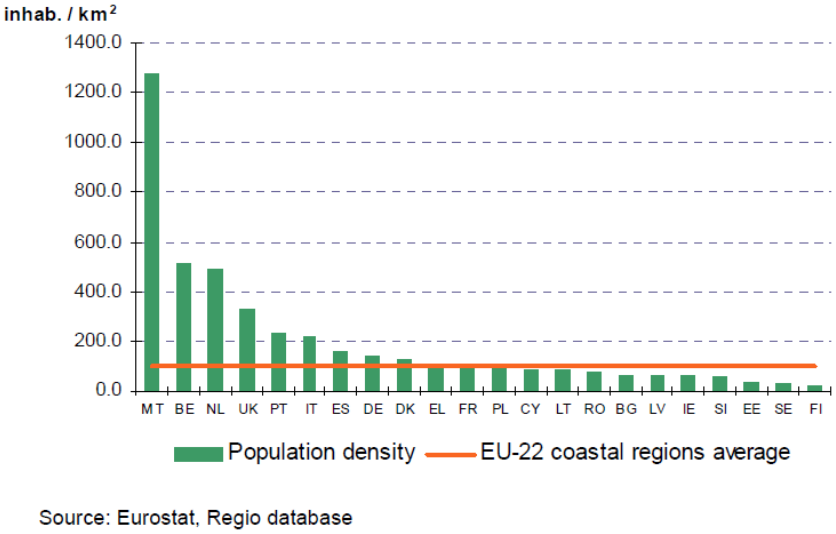


Figure 1. Coastal regions population density, by country, 2005 (from 47/2009 — *Statistics in focus, EUROSTAT)*

Anthropogenic pressures cause different impacts in different coastal environments due to special features of habitats (Viles and Spencer 1995:13). Those are also a major source of food and raw materials, and a vital link for transport and trade. Some of our most valuable habitats as well the most favoured destinations for our leisure time are in the coastal zones. Coastal zones are facing serious problems due to a number of human pressures, such as water contamination, coastal erosion, habitat destruction and resource depletion.

The importance of coastal tourism in a country implies an interest in the maintenance of beaches (Figure 1b, c) (DEDUCE, 2011).

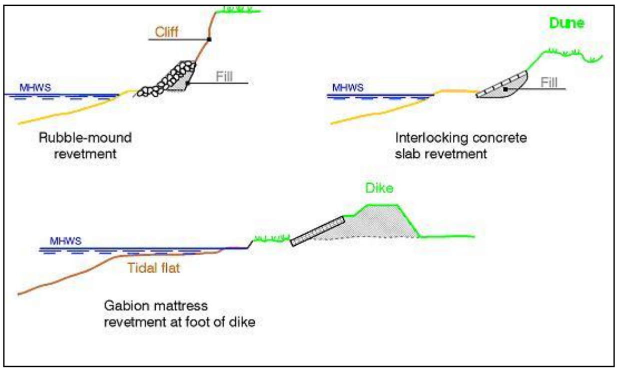
Human are causing hydromorphological changes in the coastal zone that are both due to pressures in the marine as well as in the terrestrial side of the coastal zone. Hydromorphological changes, such as construction of harbours, urban dwelling and developments, underwater constructions for energy activities, dredging for navigation as well as abstraction of gravel and other materials from the sea bed are leading to increasingly frequent conflict between uses, such as between nature protection and development for urban dwellings and other human activities.

Important long term goals for the EU coastal zones are the sustainable development of coastal zones and the conservation of dynamic habitats, especially on the remaining undeveloped coast. This requires a protection, and in many cases restoration of, the natural habitats and functioning of the coastal system and hence sustaining the natural resilience of coastal zones to impacts of hydromorphological changes, such as erosion.

Anthropogenic pressures cause changes to coastal hydromorphology affecting the physical features as geomorphology and hydrological regime. Often these pressures become more obvious along with population growth, urbanization, and development of tourism and industry (Kull et al. 2006:252). Coastal defence constructions are becoming more common in European coastal zone due to sea level rise, erosion and concentration of economic activities to the coasts. Flood protection constructions have negative impacts on coasts by fragmenting continuous coastline and changing habitats (Laukkonen, 2011).

Across Europe, economic development has physically altered coastal and transitional waters for navigation, trading activities, flood and erosion control, urbanisation and tourism. These activities are driving forces for hydromorphological alterations. Natural structural and functional elements such as habitat composition, sediment and water flow of coastal and transitional waters have been modified with bank and flood protection structures, dams, land reclamation, dredging, port and marine facilities construction.

The impact of global warming and climate change is becoming increasingly important in coastal areas due to expected sea level rise and due to increased probability of storm surges and associated coastal floods. People are increasingly occupying low-lying areas that are exposed to flooding, thus exacerbating the vulnerability of coastal systems to extreme events. The importance and scale of coastal defences will thus increase, with potentially commensurate environmental impacts (OSPAR Commission, 2009:14).



Note: An overview of coastal erosion management techniques (hard and soft) is presented in EC DG ENV publication of EUROSION project (Annex II), 2004. Data from this project is used in this report.

Figure 1a: Revetments (Danish Coastal Authority, 1998; Scottish Natural Heritage, 2011)	Figure 1b: Breakwaters in front of a public beach (Source: EUCC - The Coastal Union. Copyright Stefanie Maack, 2002) Source: OSPAR Commission, 2009
	
Figure 1c: Groynes to protect the beach (Source: EUCC - The Coastal Union. Copyright EUCC-Deutschland) Source: OSPAR Commission, 2009	**Figure 1d**: Seawall in Kent, UK Source: Channel Coastal Observatory
	
Figure 1e: Storm Surge Barrier, the Netherlands Source: Deltawerken, 2011 .	**Figure 1f**: Artificial transitional water body with port, Zeebrugge, Belgium Source: Google Earth, 2011
	

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8.2. European Overview

See chapter 4

8.3. Case studies

Missing

We hope that Member States and RBDs can provide case studies on hydromophological pressures and alterations in coastal and transitional waters.

9. Sector and activity chapters

9.1. Introduction

Text is missing –

A number of 3-5 pages sector chapters will be added on

- Hydropower
- Navigation and inland water ways
- Flood protection
- Agricultural activities (land drainage, buffer strips etc.)
- *More to be added*

The will generally be structured with

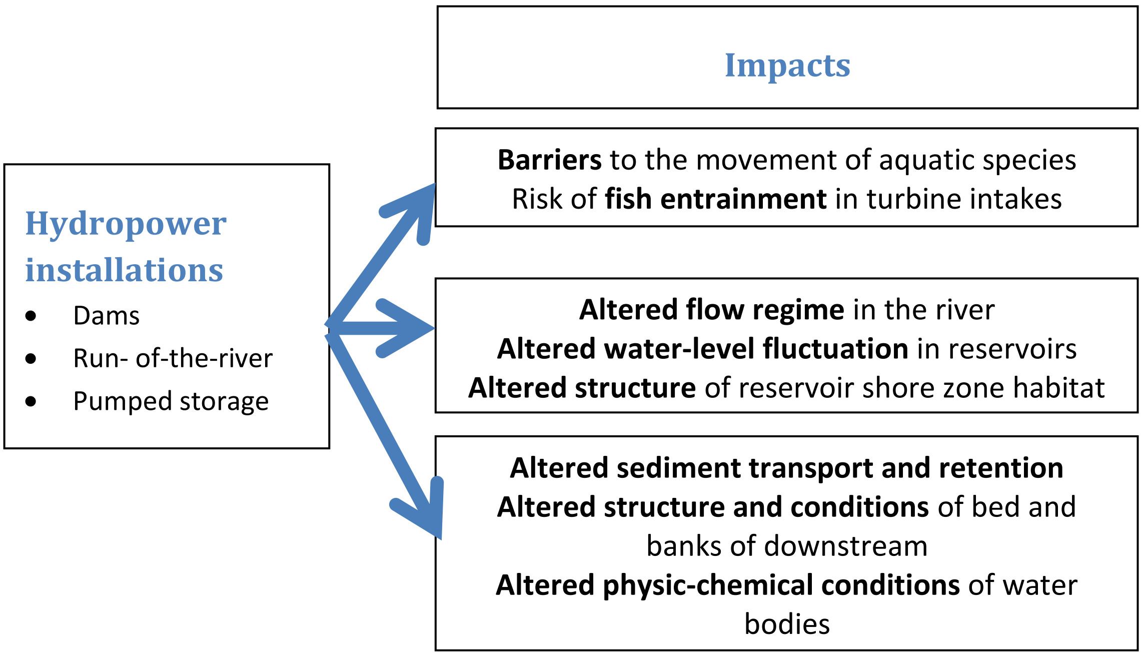
- An introduction (setting the scene) describing the main sector activities , its pressures and impact on the HYMO status.
- A brief overview of the sector in Europe (e.g. the number of hydropower plants)
- A summary of relevant information on the sector in the RBMPs
- A discussion of WFD and sector issues (e.g. Balancing WFD and Renewable Energy Directive (RES) requirements)

10.Hydropower and WFD

10.1. Introduction

In this report hydropower has been identified as one of the main drivers to hydro-morphological alterations, loss of connectivity and to alter water and reduced sediment flow (Fig. 10.1). Pressures related to hydropower may be one of the reasons for many water bodies not to achieve good ecological status by 2015 or the subsequent RBMP cycles.

Figure 10.1: Conceptual overview of different impacts hydropower installations on biology, flow conditions and sediment transport



In the context of the EU Directive on the promotion of the use of energy from renewable sources 2009/28/EC (EC, 2009), hydropower is an important measure for increasing the share of renewable electricity but, depending on its management, hydropower can impact water bodies and adjacent wetlands.

It is important to ensure that existing and forthcoming EU policies to promote hydropower ensure coherence with the Water Framework Directive/other EU environmental legislation and clearly consider the ecological impacts on the affected water bodies and the adjacent wetlands.

10.2. Overview of hydropower in Europe

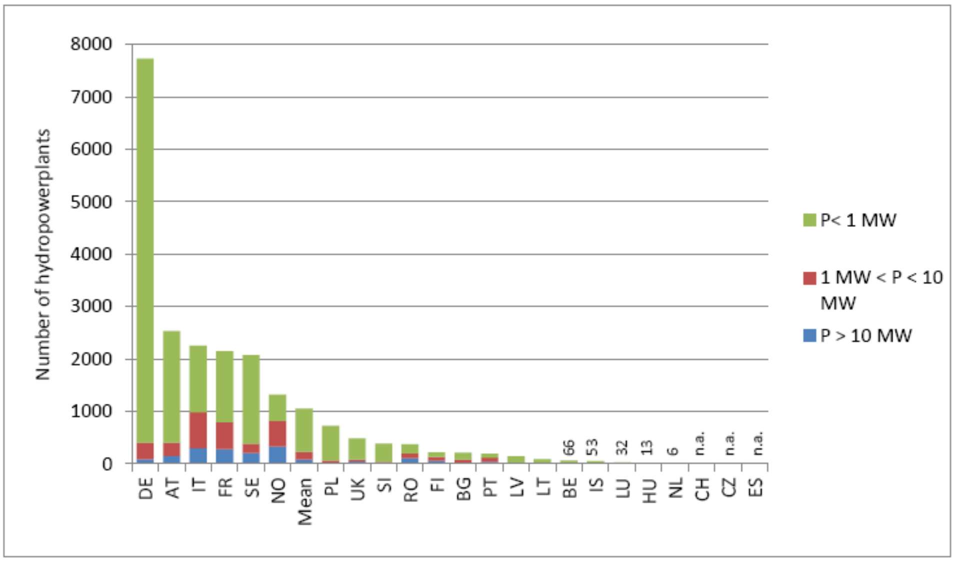
During the last years several reports providing overviews of European hydropower production have been published: DG ENV hydropower report *(*ARCADIS & Ingenieurbüro Floecksmühle 2011)*;* DG ENV/Ecologic (Kampa et al. 2011): Issue Paper Final*)* and State of the Art of Small Hydropower in EU-25. In addition, Eurostat and ENTSO-E Statistical Yearbook have statistics on hydropower production. Below is given a summary of information on hydropower production, more details can be found in the above mentioned publications.

In 2008 hydropower provided 16 % of electricity in Europe and hydropower currently provides more than 70 % of all renewable electricity (Eurelectric 2009), more than 85 % of which is produced by large hydropower plants. The share of hydropower in electricity production is generally high in the northern and Alpine countries.

The total number of hydropower stations in the EU-27 amounts to about 23000. There are about 10 times more small (P < 10 MW) than large hydropower plants (P > 10 MW). However, the electricity generation of small hydropower only amounts to 13% of the total generation of all hydropower stations. Today large hydropower plants account for 87% of the hydropower generation with only 9% of the stations (DG ENV/ARCADIS & Ingenieurbüro Floecksmühle 2011).

In absolute numbers, Germany has most hydropower plants more than 7700 of which 7300 are small plants. Austria, France, Italy and Sweden all have more than 2000 hydropower plants. The highest numbers of large hydropower plants (> 10 MW) are found in Norway (333): Italy (304); France (281) and Sweden (206) (Kampa et al. 2011).

Figure 5: Total number of existing hydropower plants for different plant sizes



Note: 1) Data was not available for CH, CZ and ES. In CH, there are 556 plants > 300 kW and ca. 1000 plants < 300 kW. In the CZ, a different range is followed: P<0.5 MW, 0.5 MW<P<10 MW, P>10 MW (other data is not available).

Source: Kampa et al. 2011

Three types of power stations can be found (DG ENV/ARCADIS & Ingenieurbüro Floecksmühle 2011):

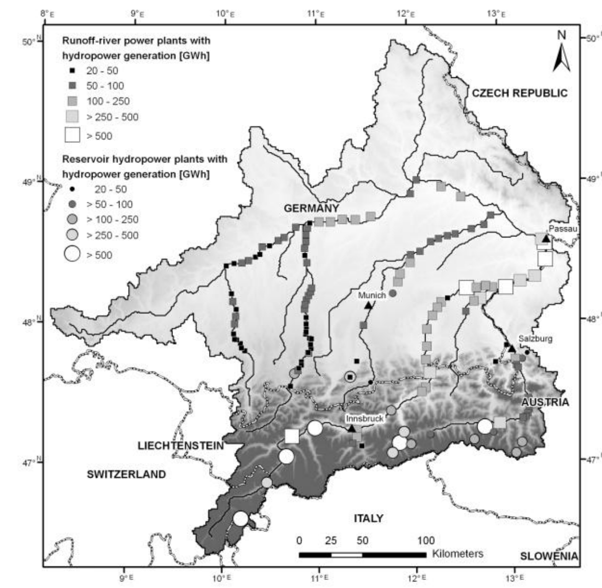
- *Hydropower stations with storage reservoir*. A storage reservoir offers the opportunity to store energy and to meet e.g. the peak electricity demands. Such reservoirs can comprise daily, seasonal or yearly storage. Many of the large HP stations operate with a reservoir.
- *Run-of-the-river stations*. This type of installation uses the natural flow of a water course in order to generate electricity. There is no intention to store water and to use it later on. This type is most common for small hydropower stations but can also be found with large stations.
- *Pumped storage hydropower plants*. Pumped hydropower stations utilize two reservoirs located at different altitudes. Water can be pumped from the lower into the upper reservoir and can be released, if needed, to the lower reservoir producing energy on ts way through the turbines. In times of high demand e.g. during peak hours electricity is produced to satisfy the demand. When there is a surplus of electricity in the system, water can be pumped to the upper reservoir.

The different types of hydropower plants have different effects on the ecosystems and hydromorphology. Generally the hydropower plants with storage reservoirs generate more severe impacts on the river system including loss of connectivity, change in water flow regime and reduced sediment flow. There are unfortunately no European overview of the number of hydropower plants by types and their location. Generally the reservoir type hydropower plants are found in the mountainous areas with steep relief, while the larger run-of-the-river stations are found on the main course of larger rivers and their tributaries. Smaller hydropower plants are often found on relative smaller rivers and with limited storage, but often acting as migrating barriers. However, compared to the impacts generated per electricity production the impacts by many small hydropower plants may be comparable to or larger than one large hydropower plant.

Text box: Location of different types of hydropower plants

In the mountainous Upper Danube watershed (77 000 km²) covering parts of Germany and Austria there are in the alpine headwaters 20 big reservoir hydropower plants (annual hydropower generation of more than 250 GWh) and there are 120 relative smaller run-of-the-river stations hydropower plants (annual hydropower generation of 20 to 500 GWh) mainly situated on the river Danube and its larger tributaries Iller, Lech, Isar, Inn and Salzach.

Source: Koch et al. 2011



RBMPs and hydropower

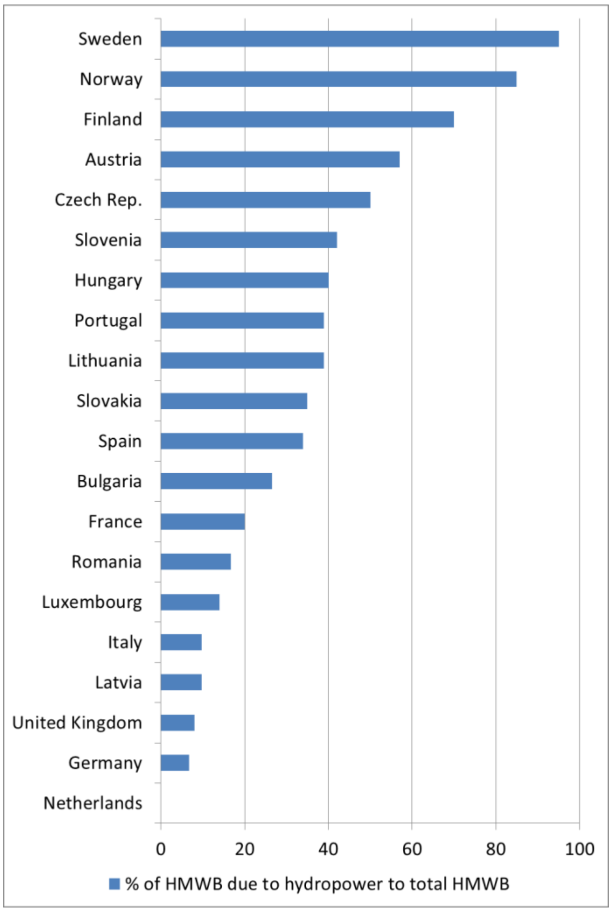
<This section will be updated with the Commissions DG Environment evaluation of measures in relation to hydropower>

The effects of hydropower production are taken up in most of the RBMPs. The plans generally provide an overview of the plants and their location. River basins with hydropower schemes generally have several water bodies designated as heavily modified such as lakes and reservoirs that have their water levels regulated due to operation of the hydropower scheme e.g. storage of water during summer and hydropower production during winter; or river section that are affected by dams and/or changed flow regime.

In 2011 a questionnaire to Member States on WFD and hydropower resulted in answers from 24 countries (EU27 Member States except (Denmark, Estonia, Greece, Ireland and Malta) and Norway and Norway). The results from the questionnaire were presented in an issue paper (Kampa et al. 2011) and discussed at a CIS WFD hydromorphology workshop in September 2011. The main results are summarized below. Figure 10 shows the percentage of HMWB designated as such due to hydropower use in relation to total HMWB.

- Sweden, Norway, Finland, Czech Republic and Austria have the highest percentage of HMWB due to hydropower (above 50% of total HWMB).
- The Netherlands, Germany, United Kingdom, Latvia and Italy have the lowest percentage of HMWB due to hydropower (below 10% of total HMWB)

Figure 6.2: Percentage of HMWB designated as such due to hydropower use in relation to total HMWB.



Note: As the designation of HMWB vary between the countries; (e.g. some countries may only designate few WBs as HMWBs while others designate many) the percentage designated may not give a correct picture.

Measures related to hydropower
The majority of countries (19 of the 23 surveyed) plan to make improvements to water bodies affected by hydropower by 2015. Mainly in the context of the WFD programme of measures, there are new ecological flow regimes being implemented (e.g. Portugal and Bulgaria) and other measures to make hydropower plants more ecological friendly (e.g. via fish ladders in The Netherlands).

In the context of making improvements to water bodies via specific measures, 10 Member States have agreed national or local criteria for determining what impact on hydropower generation is acceptable (i.e. not a significant adverse effect). However, in an equal number of countries, no criteria on impact determination could be determined so far (see table below).

	Yes	No
Are improvements to any water bodies affected by hydropower schemes planned by 2015?	BG, FI, FR, IT, LV, LT, LU, NL, NO, PT, RO, SW, UK, CZ, IS, ES, SI, SK, (*AT*, *DE*)[2)]	CH
Have national or local criteria for determining what impact on hydropower generation is acceptable (i.e. not a significant adverse effect) been agreed?	AT, FR, IT, LV, LT, NL, RO, CH, IS, ES	BG, DE, FI, LU, NO, PT, SE, UK, CZ, SI

Note: 1) No answer by BE, HU and PL; and 2) AT and DE have replied “No” to the making of improvements to water bodies affected by hydropower by 2015. However, for both countries, it is explained in their questionnaires that improvements will be made by 2015 in a selected number of water bodies.

Legal requirements for environmental improvement
Most countries have relevant legislation on national level (in a few, also on regional level) to ensure minimum ecological flow and upstream continuity via fish passes at hydropower plants (see table below summarising legal requirements on key domains for environmental improvement).

For downstream continuity and hydropeaking mitigation, fewer countries have legislative requirements to ensure environmental improvement in this respect. Requirements for measures are rather defined in individual cases (e.g. as a condition of authorisation) and, in some countries, there is generally no relevant legislative means.

For mitigating the disruption of sediment/bedload transport, several countries have no relevant legislative means. Only a few countries have national legislation and, in several countries, mitigation measures are defined in individual cases.

One or two regional/RBD examples may be included

- E.g. a text box from the Alpine Convention on hydropower and WFD in the Alps
- Nordic issues on hydropower

10.3. Balancing WFD and Renewable Energy Directive (RES) requirements

Member States should avoid taking action that could further jeopardize the achievement of the objectives of the WFD, notably the general objective of good ecological status of water bodies. The further use and development of hydropower should consider the environmental objectives of the WFD in line with the requirements of Article 4 (in particular, the requirements of Article 4.7 when new hydropower plants are considered). The requirements of Art. 4.7 for new hydropower include amongst others that there are no significantly better environmental options, that the benefits of the new infrastructure outweigh the benefits of achieving the WFD environmental objectives and that all practicable mitigation measures are taken to address the adverse impact of the status of the water body.

In the same time, the Renewable Energy Directive (2009/28/EC) sets legally binding national targets for electricity and transport from renewable sources (not specifically for hydropower), adding up to a share of 20 % of gross final consumption of energy in the EU as a whole. By June 2010, each EU

Member State had to adopt a national renewable energy action plan (NREAP) setting out its national targets for the share of energy from renewable sources consumed in transport, electricity, heating and cooling in 2020 and describing the way and the extent to which different renewable sources (wind, hydropower, etc.) will contribute to the achievement of targets. In several European Member States, an increase in hydropower generation is needed for the achievement of these targets by increasing efficiency in hydropower generation at existing sites but also by building new hydropower plants.

Most European rivers are already heavily affected by dams and reservoirs and most of the suitable stretches have already been used. However, there are still many plans and studies for new dams, reservoirs and small hydropower projects:

- in the Danube basin there are plans to built dams on the Bavarian Danube, the Sava, and the Drava (ICPDR, 2010);
- in December 2007 the Portuguese government approved the National Programme for Dams with High Hydroelectric Potential (PNBEPH) leading to the construction of ten new dams (PNBEPH, 2008);
- in Turkey, 86 large dams – above 15 m – and 124 small dams are currently under construction or planned. The aim is to increase the area under irrigation by 58 %, hydropower generation by 36 %, and domestic and industrial water supply by 27 % (DSI, 2009);
- in February 2010, the Council of State, Greece's highest administrative court, ordered the suspension of a controversial project to divert the country's second-longest river, the Acheloos, from western Greece to the heavily-farmed Plain of Thessaly, approving an appeal by environmentalists against the plans (Katemerini 2010; WWF 2010)
- a recently-published Scottish government study estimates a potential for more than 7 000 new small hydropower projects (Scottish Government, 2010) and a study by the Environment Agency (EA 2010) identified between 4 000 and 12 000 potential new small hydropower projects in England and Wales;
- In June 2008, the French environment minister announced a plan to boost hydropower by 2020. The government wants to increase production capacity by 30 % by installing more efficient turbines. It does not propose to build more dams (ENDS, 2008 and Gouvernement, 2008).

This list is just a snapshot; it is neither an exhaustive nor a complete overview of planned water infrastructure projects in Europe. Many of the projects are being discussed between governments, local administrations, different user groups, and industrial and environmental organisations. The new projects may conflict with the WFD objectives of achieving good ecological status/potential. Article 4.7 of the WFD requires that all practicable steps are taken to mitigate the adverse impacts of new infrastructures on the status of water bodies and that the projects should have overriding public/societal interest and/or benefits to the environment and society (EC, 2006).

Text Box: State of small hydropower in the Alps

Source: Alpine Convention 2011 (reduced text of draft provided by Alpine Convention Nov. 2011)

In 2010 several hundred applications for new small hydropower stations have been reported across the whole Alpine area (with considerable difference of numbers between countries), thus potentially adding to the high number of facilities already in place. This boom has been triggered in particular by the financial incentives and support schemes in place in all countries of the Alps. It presents a particular challenge for competent authorities in handling the huge amount of applications and deciding on authorisations for new facilities, due to variety of aspects to be taken into account (energy generation, CO_2 emission reduction, ecological impact etc.).

Despite its clear benefits, hydropower generation can also have substantial negative impacts on the aquatic ecology, natural scenery and ecosystems which are not always perceived by the wider public. This is not only the case for large dams, reservoirs and related hydropower facilities but also for small and very small hydropower stations, indeed the high number of such facilities already in place in the Alps, have a cumulative effect which is already impacting on a considerable number of river stretches

From the collected data on hydropower plants it is evident that the larger plants contribute by far the major share of total electricity production from HP , i.e. over 95% of the total production comes from facilities with greater than 1MW power output. Plants with a capacity of less than 1 MW constitute around 75% of all HP plants within the Alpine area but contribute less than 5% to the total electricity production.

The decision on new facilities is still mostly determined for sites individually (with exception that in some countries projects within National Parks, Nature2000-Sites, etc. are subjected to specific rules). Environmental legislation has developed significantly in recent decades. Residual water (or environmental minimum flows) as well as fish passes are now seen as basic provisions of new hydropower plants. However, many old facilities do not meet modern environmental standards. For instance, older hydropower facilities may not provide sufficient residual water or be equipped with fish-passes, hence causing a fragmentation of river stretches and habitats. In such cases, adaptations to the facilities may be required in order to meet environmental objectives.

When licences or authorisations have to be renewed, or when a new one is granted, the conditions for the water use are based on the current environmental legislation. Thus, if existing hydropower facilities request and need a renewal, extension or a new licence or authorisation then they have to comply and adjust to the new requirements of the actual environmental legislation, such as the residual water flow conditions.

However in some countries, once a water licence or authorisation has been granted, this legal right can only be varied during the set period of the licence or authorisation (between 30 to 90 years) if it is economically bearable for the owner or for reasons of higher public interests and against compensation. Furthermore, some water rights from the past do not have a license or authorisation period at all, i.e. the right is for an unlimited time period.

Due to the length of time for which a licence or authorisation is granted, the effectiveness of new regulations on upgrading existing facilities in order to enhance the ecological situation can be limited. In order to allow for progress, some countries have set up promotion schemes and incentives to support operators or licensees in upgrading existing facilities with the aim of fulfilling environmental objectives.

The table below indicates how European States intend to achieve the objectives set for the contribution of hydropower to the 2020 renewable energy targets via construction of new hydropower plants, refurbishment or modernization and maintenance. The table is based on qualitative statements of countries on the level of importance of the contribution of each option to the targets.
The following trends can be detected for specific countries:

- In Austria, Slovenia and the UK, mainly the construction of new plants will contribute to the 2020 renewable energy targets. In the UK, new hydropower development is expected to be dominated (in terms of numbers of schemes) by small (< 1.5 MW) run-of-river schemes. In Austria, modernisation will play a considerable role for small hydropower while in the UK, refurbishment and modernisation are considered negligible contributions.
- On the other hand, in Germany, Spain and Italy, the construction of new hydropower plants is considered a minor contribution, whereas the refurbishment, modernization and maintenance of plants will be the main source of contribution to renewable energy targets. In Latvia, the situation is similar. In Spain, any new constructions will focus on increasing pumping storage capacity.
- France considers all options to be a main source of contribution for achieving the 2020 renewable energy targets. The refurbishment and modernisation targets are to balance the loss of production due to minimum flow rising in 2014 for all existing plants. On the contrary, Luxembourg considers all options to be minor contributions to the 2020 renewable energy targets.

- For Finland, The Netherlands and Romania, the construction of new plants and modernisation and maintenance will be the main contributors to the 2020 renewable energy targets from hydropower.
- For Norway and Portugal, the main source of contribution to the 2020 renewable energy targets from hydropower will come from the construction of new plants and refurbishment.
- Sweden mainly plans to refurbish hydropower plants in order to contribute to the 2020 renewable energy targets.

	Main source of contribution	Minor source of contribution	Negligible source of contribution
Construction of new hydropower plants	AT, BE, FI, FR, NL, NO, PT, RO, UK, SI	DE, IT, LU, CZ	LV, SE, ES
Refurbishment of plants[17]	DE, FR, IT, LV, NO, PT, SE, CZ, ES	AT, LU, RO, IS	FI, UK, SI
Modernisation and maintenance of plants[18]	DE, FI, FR, IT, LV, NL, RO, CZ, ES	AT, LU, NO, PT, SE, IS	UK, SI

Note: 1) No information in the questionnaires of PL, LT, HU, BG. 2) For CH: Refurbishment and modernization: 2.4 TW; New plants: small HP: 1.9 TW; large: 2.4 TW the numbers refer to 2035.

Source: *DG ENV/Ecologic (Kampa et al.) September 2011: Issue Paper Draft 2*

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11. Navigation and WFD

11.1. Introduction

European countries depend on maritime transport. Nearly 90% of the EU's external trade and more than 40% of its internal trade goes by sea. Almost 2 billion tons of freight are now handled in more than 1200 EU ports each year, and volumes are continuing to increase1. As a result, recent years have seen a number of applications and approvals for major seaport developments. Many such developments have been required in order to accommodate the significant global increase in containerised transport, and further increases in such cargoes are anticipated. In addition to rationalised or new cargo handling and transhipment facilities, new container vessels require deeper access channels to certain ports.

Inland waterway transport plays also an important role in Europe today, and shifting more freight transport to water is considered a significant option to improve Europe's transport system as a whole and to deal with constantly growing freight flows. Inland navigation is seen as an environmentally friendly transport mode with compared to other inland transport modes a relative low CO_2 emission. More than 37 000 kilometres of inlandwaterways connect hundreds of cities and industrial regions. Some 20 out of 27 Member States have inland waterways, 12 of which have an interconnected waterway networks.

Navigation activities and/or navigation infrastructure works are typically associated with a range of hydromorphological alterations with potential adverse ecological consequences (Figure 4b). Deepening including channel maintenance, dredging, removal or replacement of material is a major activity. Dredging, in turn, is of vital importance to many of the EU's ports, harbours and waterways - providing and maintaining adequate water depths and hence safe navigational access. Channel works such as channelisation and straightening, training walls or breakwaters often are needed. Bank reinforcement, bank fixation, and embankments (training wall, breakwater, groynes etc.) often have been constructed. Some developments may also involve land claim and/or impoundment. Inland waterways as corridors for spreading invasive species

Potential impacts associated with these modifications can include:

- the physical removal of habitats or species;
- changes to physical processes (erosion, accretion and sediment transport);
- barriers to movement of species or the loss of connectivity between habitat sites (eg. due to impoundment or reclamation)

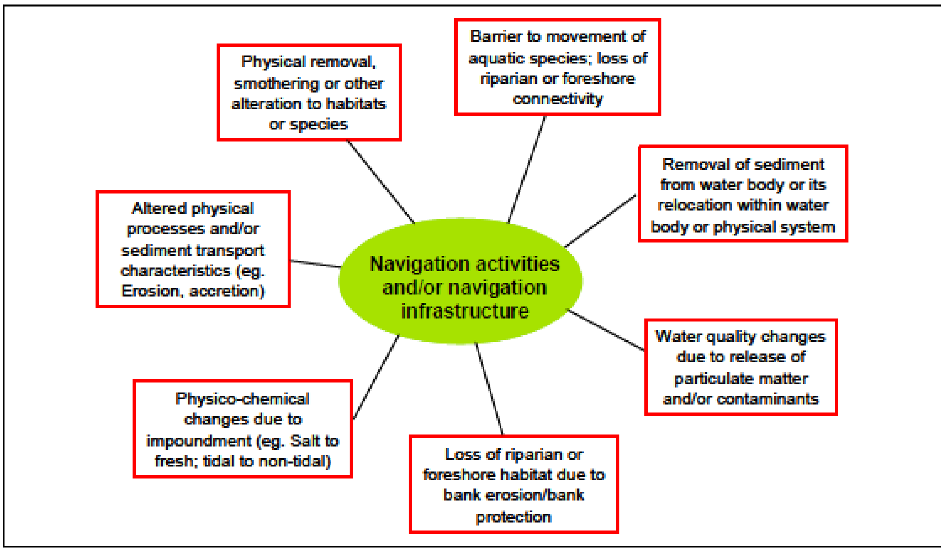

Figure 4b: Illustrative range of possible alterations typically associated with navigation activities and/or navigation infrastructure with subsequent biological alterations.

11.2. RBMP and inland waterway transport

Member States input on pressures related to inland navigation and pressures and impacts are needed.

Invasive species spread through inland waterways
The extensive networks of inland waterways in parts of Europe have allowed species from different bio-geographical regions to mix, altering communities, affecting the food webs and introducing new constraints to the recovery of the native biodiversity .

Text box: Invasion of large European rivers

Invasive species have become a major concern in the Danube. The Joint Danube Survey in 2007 found killer shrimps, Dikerogammarus villosus, at 93 % of the sites sampled along the river, Asian clams at 90 % and carpets of weeds at 69 %. Killer shrimps can adapt to a wide range of habitats and cause significant ecological disruption such as species reduction. The water hyacinth (Eichhornia crassipes) is considered one of the worst aquatic weeds in the world.

Over the past two centuries, the connection of the Rhine with other river catchments through an extensive network of inland waterways has allowed macro-invertebrate species from different bio-geographical regions to invade the river. A total of 45 such species have been recorded. Transport by shipping and dispersal by man-made waterways are the most important dispersal vectors.

Source: Danube Watch, 2008; Bernaur and Jansen, 2006; Leuven et al., 2009.

11.3. WFD and inland navigation

A section on WFD and inland navigation to be included
The current draft is partly based on information from PIANC WFD Navigation Task Group
http://www.pianc.org/euwfd.asp

WFD potentially have significant implications for navigation, both for ongoing port activities such as dredging and disposal, and for new development proposals. The Program of Measures established by the RBMPs could potentially affect ports, navigation and dredging in a number of ways. For example, measures could require the modification of existing structures such as training walls or breakwaters to mitigate their effects. Measures affecting activities or operations are also possible - for example, the introduction of technical or temporal constraints on dredging and disposal activities to meet ecological targets.

Text box with Update of the Danube Regional Strategy aspects of increasing inland water transport by 20 % by 2020 – to be included.

EC calls for more cargo transport on the Danube Cargo transport on the Danube river should be increased by 20% by 2020, according to an EU strategy for the region unveiled by the European Commission on Thursday. The plan follows a consultation with member states in February. Regional policy commissioner Johannes Hahn said the Danube is only using 10% of its shipping potential, pointing out that inland waterways are a greener mode of transport. The Rhine river carried 330 million tonnes of cargo in 2007 compared with just 50Mt for the Danube, a river more than twice as long. Green group WWF accused the commission of focusing too heavily on increasing cargo shipping. This would require a deepening and widening of the river, which could destroy valuable biodiversity and associated ecosystem services. Member states will decide whether to endorse the plan during the Hungarian presidency of the EU in the first half of 2011. They will decide how the proposed targets will be monitored and which of the 14 countries in the basin area, including six non-EU states, will participate. The commission has only a coordinator role.
WWF (Dec. 2010): Danube river to be severely impacted by plans to increase navigation http://wwf.panda.org/what_we_do/how_we_work/policy/wwf_europe_environment/news/?197714/Danube-to-be-severely-impacted-by-navigation

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12. Towards sustainable flood risk management

12.1. Introduction

Chapter to be improved

Millions of European citizens are threatened by flooding events from rivers, estuaries and the sea. Over the past ten years Europe has suffered more than 175 major floods, causing deaths, the displacement of people and significant economic losses. Although many flood defense measures were implemented in the European river basins and coastlines during the last century, the ongoing urban developments and changes in land use, as well as the social and economic development have increased the potential for flood damages. This significant increase of the flood risk is furthermore due to climate change and extreme weather events e.g. heavy rainfalls.

The EU Floods Directive (2007/60/EC) aims to reduce and manage the risks of floods to human health, the environment, cultural heritage and economic activity. The Directive requires Member States to assess what rivers and coast lines are at risk from flooding, to map the possible extent of flooding and the assets and humans atrisk in such areas, and to take adequate and coordinated measures to reduce the risks. All EU Member States have to develop such flood hazard and risk maps by 2013. Using hazard maps, this planning aims to limit increases in potential damage, to avoid aggravating it in risk areas, and even to reduce it in the longer term. European countries outside the EU generally have similar legislation.

The implementation of the Water Framework Directive means a chance for many European countries to combine those measures to reach a Good Ecological Status (GES) with rehabilitation measures.

Working with nature, not against it
For centuries, hard infrastructure, including bank enforcements and dykes, navigation including canals, locks, dredging and bank reinforcement, water storage reservoirs and dams, and drainage through straightening rivers and pumping canals, has been used for flood defences. All these activities are typically associated with a range of hydro-morphological alterations and adverse ecological effects. In many countries, activities in relation to the WFD and flood risk planning have been an impetus for changing the way we manage flooding to enhance the environment and protect people from the damage.

Flood defence works besides their positive effects on flood safety could cause possible ecological alterations and impacts associated with flood defence measures. Figures 12.1 and 12.2 illustrate such alterations and impacts in case of river channelling and application of flood defence dykes.

Figure 12.1: Illustrative range of possible ecological alterations and impacts typically associated with flood defence works – river corridor channelling (straightening and deepening)

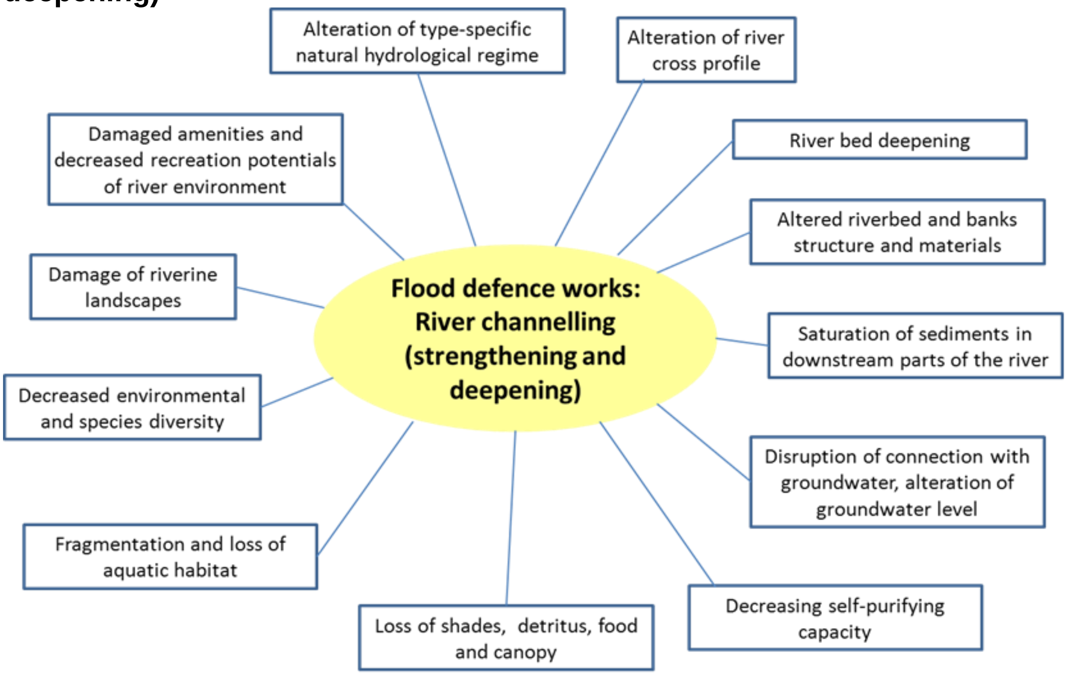
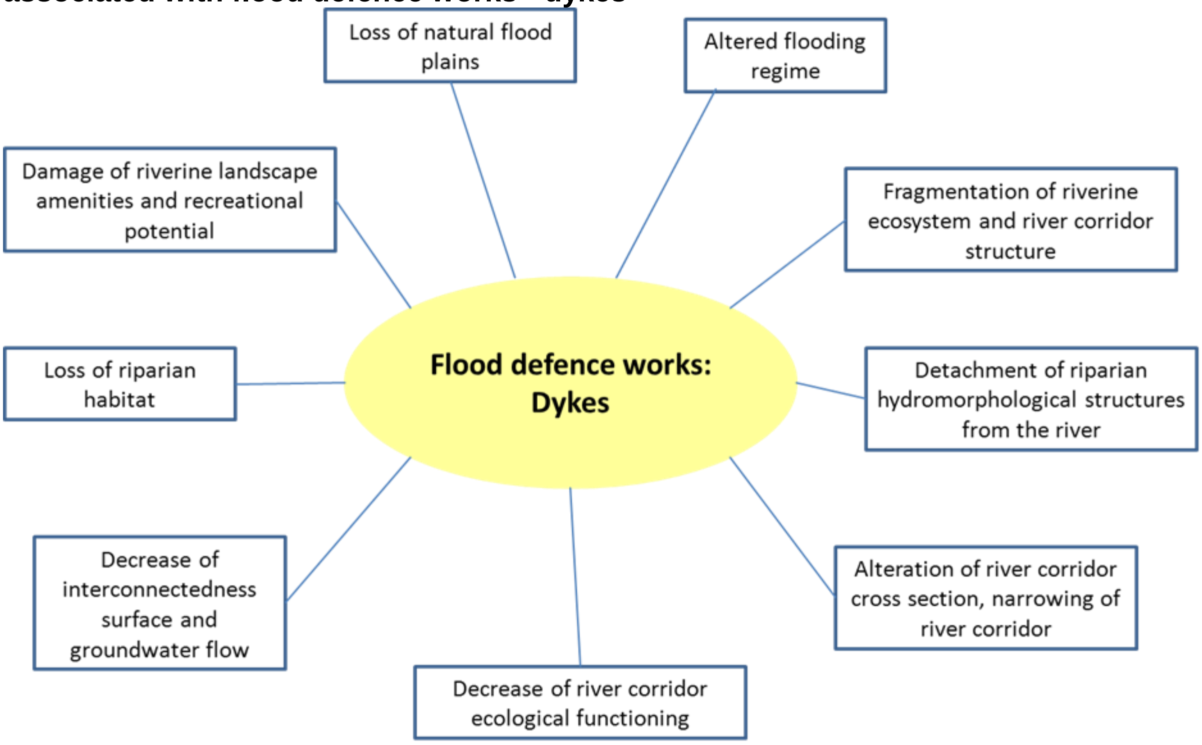


Figure 12.2: Illustrative range of possible ecological alterations and impacts typically associated with flood defence works - dykes



12.2. RBMPs and flood defense activities

Member States input and case studies on pressures related to flood defense and RBMPs are very much appreciated.

Ireland – Flood protection and WFD
Source: Gilligan 2008
The Office of Public Works (OPW) is the lead authority for Flood Risk Management in Ireland. OPW maintains 11,500 km of watercourses for drainage & flood relief purposes and implements an ongoing programme of urban Flood Relief Schemes.

Ireland's Article 5 Initial Characterisation Report under the WFD establishes that Hydromorphology is the 2nd largest pressure behind Diffuse Pollution. Hydromorphology accounts for 40% of the river waterbodies being designated either “At Risk” or “Probably At Risk” of failing Good Ecological Status (GES). Channelisation and Flood Relief structures account for over half of these pressures.

For Drainage/Flood Relief pressures in Ireland, the Programme of Measures under the WFD will focus on enhancement of drained rivers and sustainable flood relief practices. In addition, Ireland is incorporating River Continuity into the hydromorphological criteria, which will set a new framework to manage fish passage obstructions. A recent example of river continuity improvements is where the OPW replaced a weir obstacle with a new Rock Ramp structure as part of an urban Flood Relief Scheme.

Germany increased floods due to morphological changes and loss of flood plains
Source: UBA 2010
The man-made changes to many German rivers were designed to create land for industry and housing, make waters navigable, intensify agriculture, utilise hydropower, and protect against flooding. Owing to the straightening and shortening of river courses, flood waves now travel faster and transport larger volumes of water per unit of time. For example, since the first large-scale straightening of the Rhine in the mid-19th century by hydro-construction master Johann Gottfried Tulla, the number of riverine meadows on the Upper Rhine between Basle and Karlsruhe has diminished by 87 %.

All in all, the flood plain of the Upper Rhine was reduced by 60 % or 130 km^2. River straightening measures lead to a shortening of the run – on the Upper Rhine by approximately 82 km, and on the Lower Rhine by approximately 23 km – which in turn led to an acceleration of runoff. For example, the flow rate of the flood wave in the Rhine on the section between Basle and Maxau has been reduced from 64 to 23 hours.

Restoring flood plains in the Rhine river basin
Source: SDF
The Rhine flows through large areas of Germany and the Netherlands. In the past, measures to straighten the river resulted in an increased risk of flooding in the Rhine Delta. The reclamation of historical floodplains is an important means of flood protection. More room for the river: restored floodplains on the upper and middle sections of the Rhine are intended to reduce the height of the flood waves during future flood events. On the other hand, the aim of the measures taken on the lower stretches and in the Rhine Delta is to ensure that the water drains away quickly. In this case, floodplains are being expanded, lowered or supplemented with new or reactivated side channels.

12.3. WFD and flood risk management

In general, measures for managing flood risk and mitigating hydro-morphological pressures that work with nature rather than against it should be promoted, such as making more room for rivers.

Sustainable flood risk management is a shift away from our predominantly hard-engineering flood defences to a river basin approach, which uses natural processes and natural systems to slow and store water in addition to measures such as flood warning, spatial planning and emergency response. Natural floodplains are allowed to flood and wetlands to act as giant sponges to soak up excess water then release it slowly back into the river.

This is generally a cost-effective way of achieving many objectives, including the good status objective of the WFD and national water policies. For many European rivers, restoring former floodplains and wetlands would both reduce flood risk and improve the ecological and quantitative status of freshwater. Opportunities to enhance the natural environment and improve its capacity to perform ecosystem services should be identified.

There are many national activities in Europe aimed at more sustainable flood management and restoring rivers. Examples include the Dutch Room for the River (Ruimtevoorderivier, 2010), the UK programme for making space for the river (DEFRA, 2008), the Swiss guiding principles for sustainable water management (BAFU, 2010; the SOER 2010 country assessment on Switzerland (EEA, 2010g)), the Austrian Stream Care Scheme (Lebensministerium, 2010) and the Spanish National Strategy for Restoring Rivers (MARM, 2010).
>national examples may be further developed

Text box: Natural flood defenses

Probably the most visible signs of flood risk management are flood defenses. Typical hard defenses include embankments, walls, weirs, sluices and pumping stations. Typical use of natural processes could involve using washlands, mudflats and saltmarshes to provide space for floodwater and prevent flooding from occurring elsewhere. At the same time, this can benefit wildlife by providing areas of habitat and are often used in combination with hard defenses to provide areas for recreation and tourism. Upland areas could be managed by restoring peat bogs or blocking artificial drainage channels. Re-planting forests in floodplains will help to slow the flow of water run-off and help it filter through the soil. In urban areas green roofs, permeable paving, surface water storage areas can be used to reduce flood risk. By working with natural processes alongside traditional hard defences a more sustainable approach to flood risk can be achieved.

Source: Environment Agency

The development of riparian forests is valuable for retaining water in upstream areas of river catchments and therefore to lower the floodwater levels in the river. Another measure, which has an effect on the water level in the main river, is the construction of secondary gullies. But if those are planned very well, the positive effects are dominant.

If densely populated areas are at a risk, still heightening of dikes or the implementation of technical measures is a solution. Especially in urban areas space along the riverbanks is very much limited and therefore, barriers along the river promenade in combination with footpaths or other combination of functions can be a useful option. Cities along rivers should carefully look right now whether planning with the river or water in the city can prevent future problems. Maybe a new consciousness or attitude to floods of the people living in a catchment can contribute to this.

Text box: Germany – flood risk management

From a nationwide perspective, at present, only around 1/3 of the former flood plains can now be used to retain the water in the event of major flooding. In large river basins such as the Rhine, Elbe, Dan-

ube and Oder, in some sections only 10 % - 20 % of the former riverine meadows remain (BfN “Auenzustandsbericht - Flussauen in Deutschland” Bonn, 2009). As well as changes to the rivers and water meadows, climatic factors also influence the scale, frequency and timing of flood events.
In Germany, there are a wide range of measures available in various different sectors for addressing flood risk management:

- Land precautions, e.g. restriction of construction in flood plains, flood-adjusted usage in flood risk areas, representation in regional plans
- Natural water retention, e.g. decentralised rainwater seepage, reduction of land sealing, retention and reintroduction of water meadow sites, recovery of flood plains
- Technical flood prevention, e.g. dykes, dams, retention basins, property protection, protection of oil tanks
- Construction precautions (building to cater for floods)
- Risk precautions, e.g. formation of reserves, insurance policies
- Supply of information, e.g. flood warning
- Behavioral precautions, e.g. public education and preparation for flooding with specific recommended actions for the general public
- Preparation for risk aversion in disaster plans, e.g. alarm and deployment plans, drills and training of rescue teams.

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