Hydromorphology

Zero draft for EEA 2012 state of water assessment

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Prepared by / compiled by: Peter Kristensen & ETC/ICM

EEA Project manager:
Peter Kristensen

Version History

Version	Date	Author	Status and description	Distribution
0.1	22/11/2011	PKR	Zero draft	To Advisory group
1.0	DD/MM/YYYY		First draft for EEA	
2.0	DD/MM/YYYY		Final draft for EEA	
3.0	DD/MM/YYYY		Final version for EEA	

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

The current zero draft of the thematic assessment on hydromorphology aims at providing an indication of the information and results going into the final draft. It is EEA plans to have this first draft well developed over the coming three month and put the chapter for country/member states and country consultation (February/March).

The current draft is structured by a introduction chapter and chapters presenting results from the river basin managements on heavily modified and artificial water bodies, on ecological status and potential and hydromorphological pressures and impacts.

The current draft has mainly results on rivers and lakes but in the next version more results and information on transitional and coastal waters will be included.

The data reported by Member states in relation to the RBMPs on significant pressures and stored in WISE-WFD database are not fully suited for illustrating European overviews of water bodies being affected by significant pressure such as water barriers and transversal structures, water abstraction and flow regulation, channelization etc . We feel that these chapters are important and will partly try to cover the different aspects by case studies. In the consultation process; Member States and Stakeholders will be asked to add case studies. The current case studies are mainly copy and paste from RBMPs or other relevant documents

The current sector and activity chapters are not fully developed and meant as placeholders for text and information to be further developed and markedly improved

We hope that relevant stakeholders and Member States will contribute with text boxes expressing their views on the aspects raised in the respective chapters. Contributions will be asked for during the consultation period during February/March.

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

1. Introduction

2 pages introduction to hydromophology alteration and pressures

1.1. Hydromorphological alterations

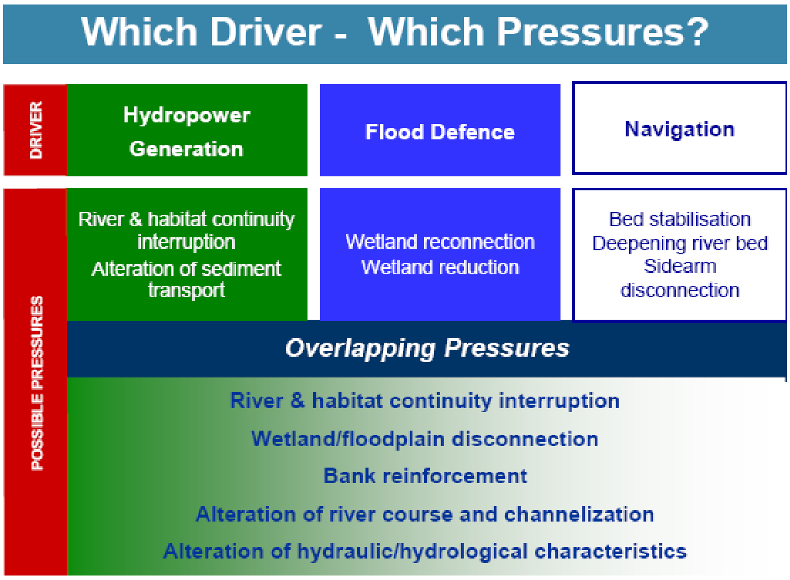
Across Europe, economic development has physically altered rivers and other waters for navigation, flood control and other purposes. Barge canals and hydroelectric reservoirs have been created where no water bodies previously existed.

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.

Source: Raimund Mair, ICPDR

1.2. Hydromorphological drivers and pressures

Brief description of hydromorphological drivers and pressures <text missing>
Other sectors e.g. agriculture, land drainage, dredging etc. to be added to Raimund Mairs conceptual diagram



Source: Raimund Mair, ICPDR

1.3. WFD and hydromorphological alterations

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 ecological status.

Brief text describing HMWB/AWBs and hydromorphological pressures
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.

More text to be added on identification of significant HYMO pressures and impacts

2. Heavily modified and artificial waters

2.1. Introduction

Source: DG ENV note on HMWB and AWB[1] and other material
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 surface body of water is a section of a river, lake, or transitional or coastal water. This means that Member States can decide to designate only specific sections of a river as heavily modified. 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 were identified in the UK's 2005 river basin report as heavily modified.

Description of the different types of heavily modified and artificial water bodies in Europe ½ page
DE: Heavily modified water bodies comprise shipping routes and impounded river reaches, whereas artificial water bodies can be, for example, canals or opencast mining lakes.
UK – Artificial water bodies (See Figure I.3)

Figure I.3 **Water bodies that are considered as provisional artificial water bodies**

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

2.2. WFD and HMWB/AWBs

In the WFD there are the following references to HMWB/AWBs

Article 2 (8) of the WFD defines an artificial water body as a 'body of surface water created by human activity'. Article 2 (9) defines a heavily modified water body as a 'body of surface water which as a result of physical alterations by human activity is substantially changed in character, as designated by the Member State in accord-

[1] DG ENV: Water Note 4: Reservoirs, Canals and Ports: Managing artificial and heavily modified water bodies http://ec.europa.eu/environment/water/participation/pdf/waternotes/water_note4_reservoirs.pdf

ance with the provisions of Annex II (of the WFD).'

Article 4(3) of the Water Framework Directive (WFD) states that water bodies may be designated as artificial or heavily modified in the river basin management plans. The WFD recognises that some water bodies have been significantly physically modified to support various uses which provide valuable social and economic benefits. In many cases these modifications cannot be removed without having a major negative effect on the social and economic benefits that these uses bring. If achieving 'good status' would require changes to a water body's hydromorphology that would have significant adverse effects on the social or economic activity, then it can be designated as a artificial or heavily modified water body. Before designation it also needs to be established that due to technical or disproportionate cost reasons there is no significantly better environmental option for delivering the social and economic benefits (European Union CIS guidance document no. 4, 2003). The WFD also recognises that many artificial bodies of water need to be managed in terms of their environmental quality and hydrology. Artificial and Heavily Modified Water Bodies (AWB/HMWBs) have to achieve an alternative objective of "good ecological potential" (GEP). The objective of GEP is similar to good status but takes into account the constraints imposed by the social and/or economic uses.

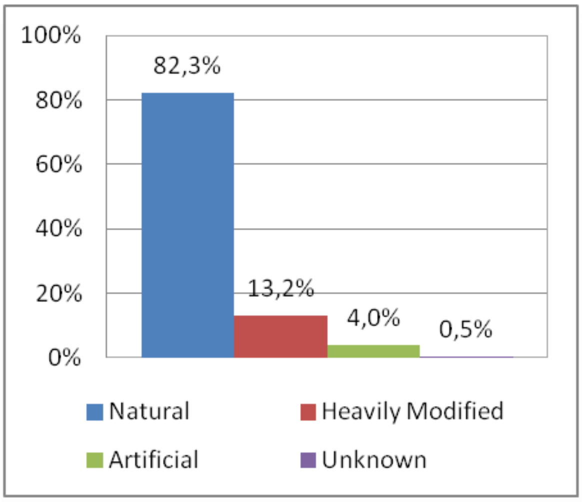
2.3. European overview of HMWB/AWBs

Key messages

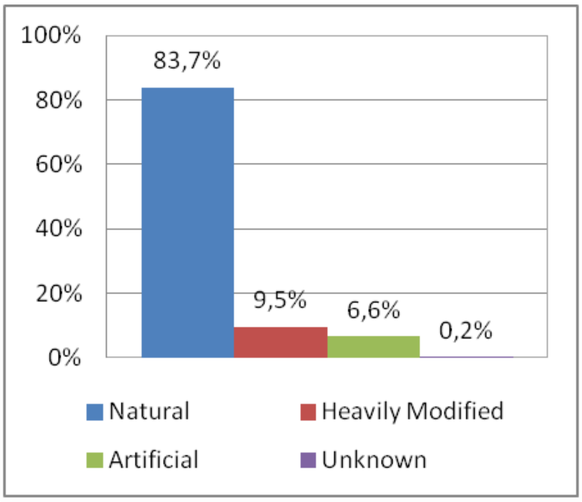
- There is a wide range of differences in the number of designated surface water bodies among the countries.
- Overall, 17.3% of European river water bodies and 16.2% of lake water bodies are designated by the MS as either heavily modified water bodies (HMWB) or artificial water bodies (AWB)
- In NL 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.
- Heavily modified and artificial water bodies are clearly associated with densely populated, urbanised areas as well as low-lying or mountainous regions.

Figure 2.1 a) Distribution of European river water body types. b) Distribution of European lake water body types.

1a)



1b)



Source: WISE-WFD database – (02/09/11)

Note: The figure represents 82811 reported river water bodies from 22 countries and 17477 reported lake water bodies from 20 countries. (LU and SK have not reported data on lakes).

Comments:

Overall, 17.3 % of European river water bodies and 16.2 % of lake water bodies are designated by the MS as either heavily modified water bodies (HMWB) or artificial water bodies (AWB) (Figures 2.1). The situation varies widely between Member States (MS).

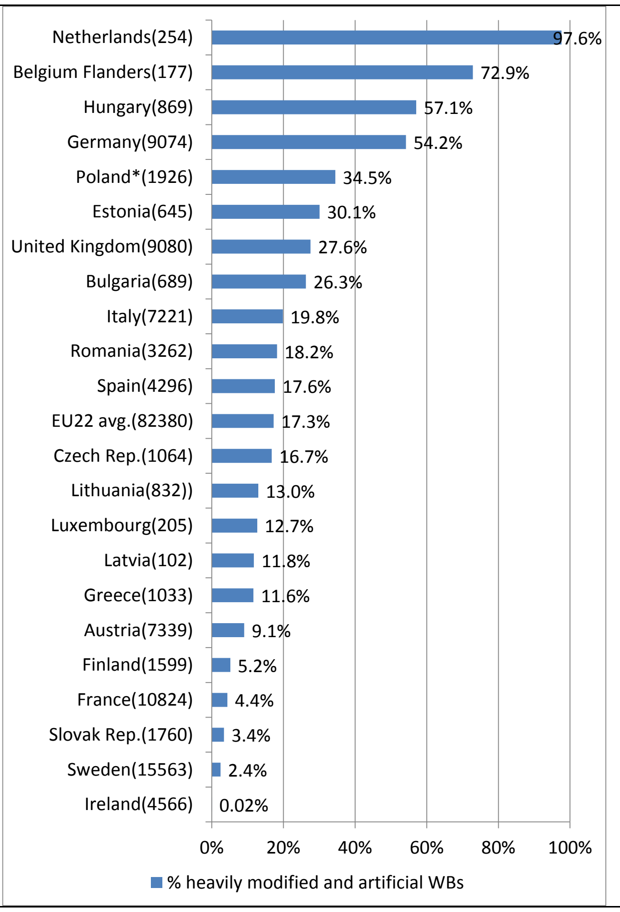
There significant, more than a magnitude difference in the number of designated river and lake water bodies among the group of MS. More than 7300 river water bodies were designated in Sweden, France, Germany, Italy and Austria, while less than 260 lake water bodies are in The Netherlands, Latvia, Belgium and Luxemburg (Figure 2.2).

Besides the absolute number, the relative percentages are more characteristic to represent the impacted river and lake water bodies. 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 5% or less of their river water bodies in these two types (Figure 2.2a and Map 2.1a).

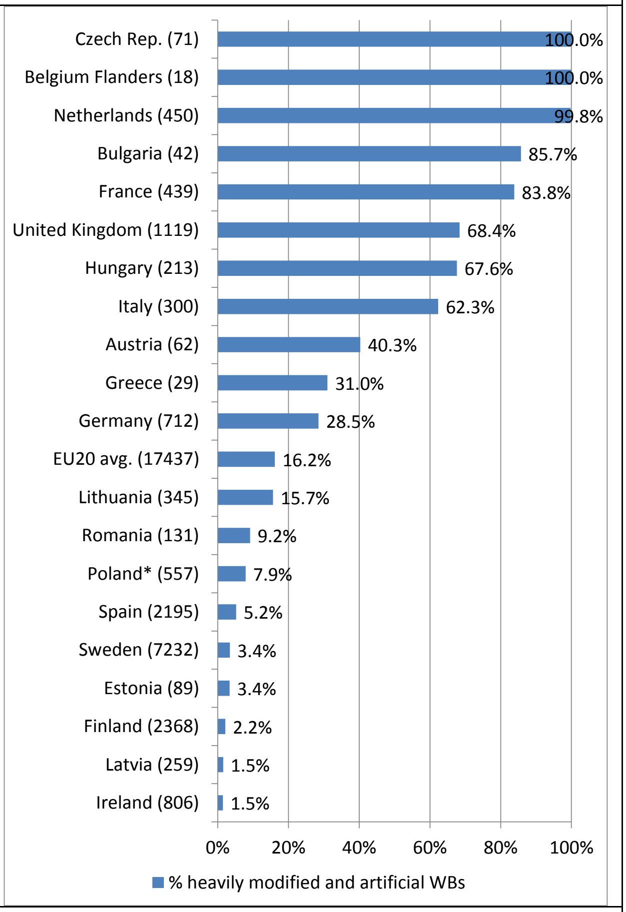
In case of lakes the highest percentage (above 60%) of designated HMWBs or AWBs are in Belgium, Czech Republic, The Netherlands, Bulgaria, France, The United Kingdom, Hungary and Italy. The lower end of such rank (less than 5%) are represented by Sweden, Estonia, Latvia, Ireland and Finland (Figure 2.2b and Map 2.b).

Figures 2.2 Percentage of heavily modified and artificial WBs by category.

a) Percentage of heavily modified and artificial river WBs



a) Percentage of heavily modified and artificial lake WBs



c) Percentage of heavily modified and artificial transitional WBs

Diagram missing

d) Percentage of heavily modified and artificial coastal WBs

Diagram missing

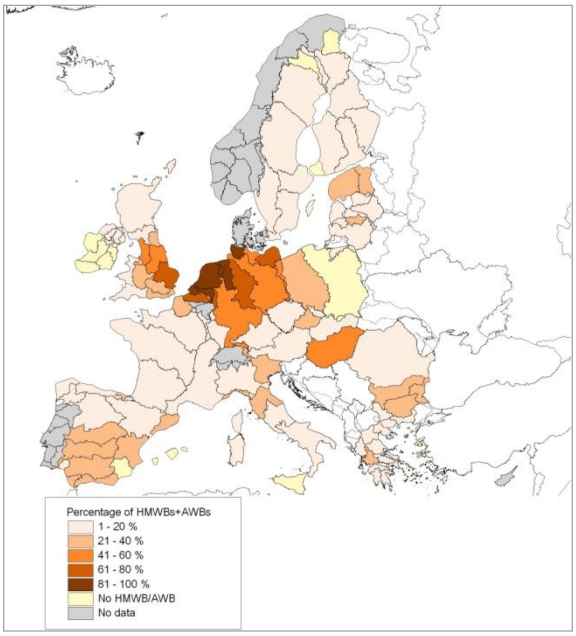
Source: WISE-WFD database – (02/09/11)
Note: The figure represents 82 380 reported river water bodies from 22 countries and 17437 reported lake water bodies from 20 countries. (LU and SK have not reported data on lakes).
Comments:
NOTE:

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).

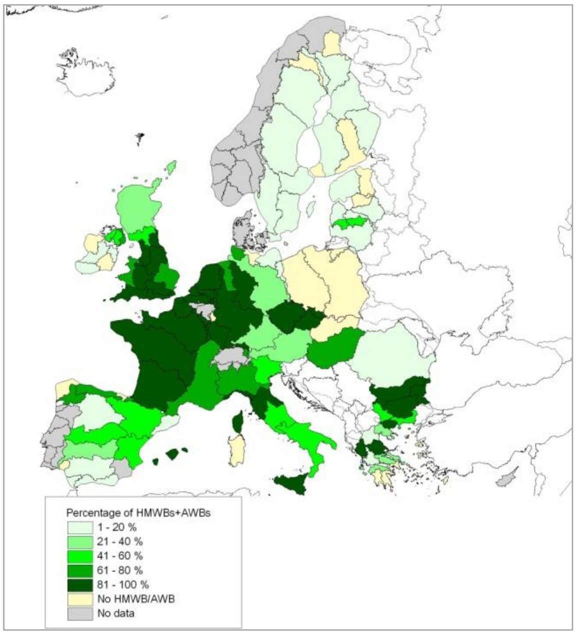
The Netherlands has very few natural water bodies, more than 95% are HMWB or AWB. The low-lying position, the intensive land use and the transport over water have drastically changed the water system in many places. Particularly in the low-lying part of the Netherlands, most of the smaller surface waters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

Map 2.1 Maps of percentage of heavily modified and artificial a) river WBs by river basin districts and b) lake WBs by river basin districts.

a)



b)



Maps on HMWB and AWBs in transitional and coastal waters to be added.
Source: WISE-WFD database – (02/09/11)
Note:

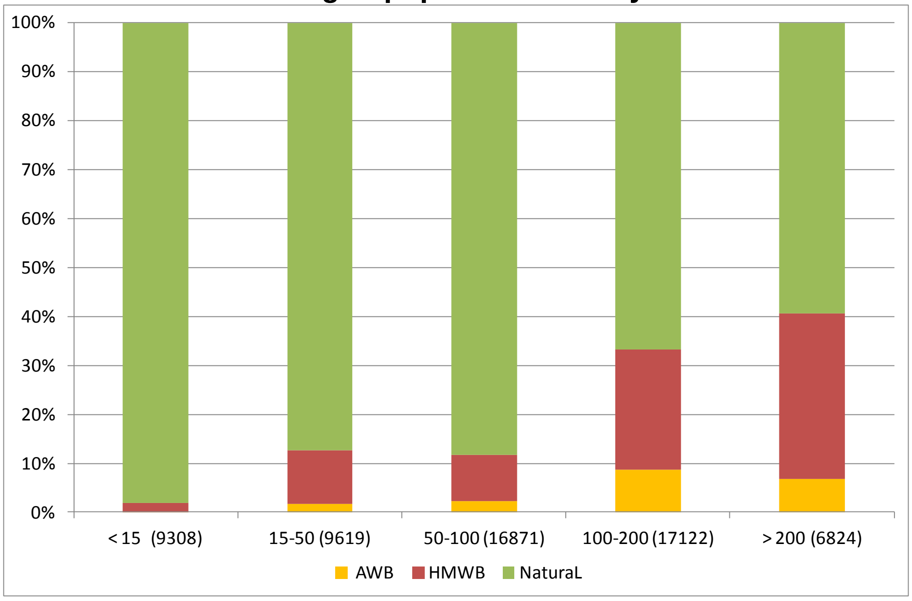
Artificial water bodies

Missing a ½ page description of the different artificial water bodies in Europe

2.3.1. *Heavily modified and artificial water bodies according to population density*

In sparsely populated RBD nearly all river water bodies are natural, while in RBDs with population density higher than 100 inhabitants per km2 around one third to 40 % of the river water bodies have been identified as being heavily modified or artificial.

Figures 2.3 Percentage of Artificial (AWB) , Heavily Modified (HMWB) and Natural river Water Bodies according to population density in river basin district



Source: WISE-WFD database – (02/09/11)
Note:

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

Based on Water Framework Directive and Heavily Modified Water Bodies 12 - 13 March 2009, Discussion paper http://ecologic-events.eu/hmwb/documents/Discussion_Paper_Updated.pdf *<no updated information is available in the RBMP reporting.>*

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 MS except (DK, GR, IT and MT) and Norway).

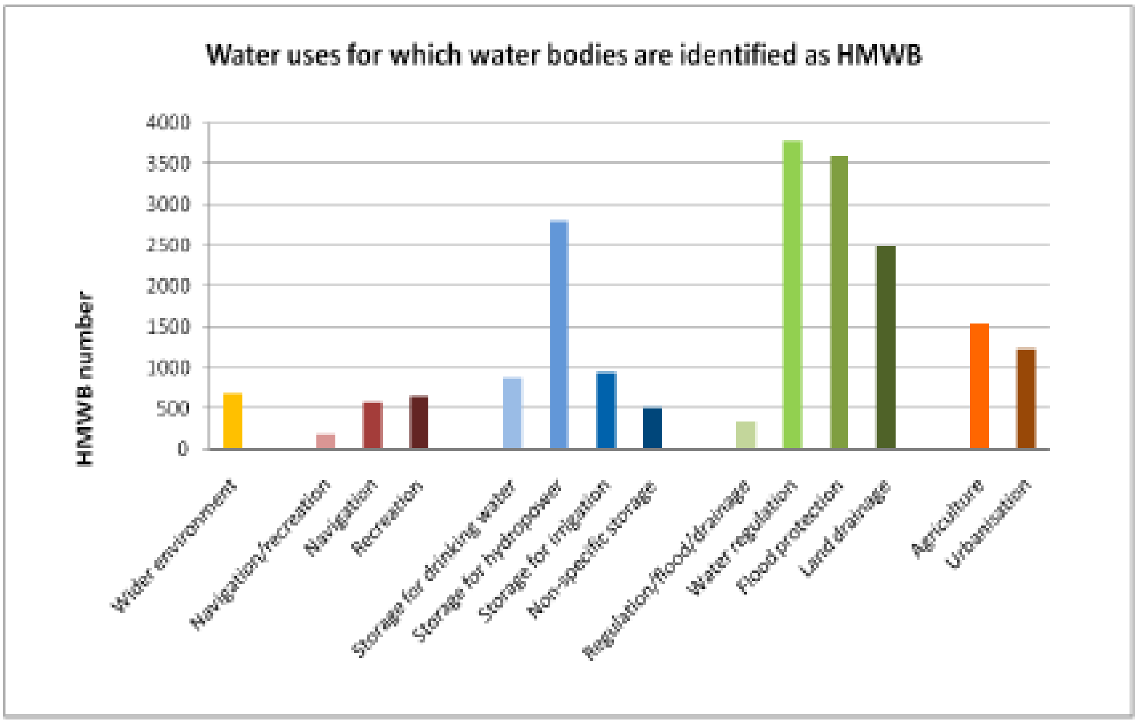
Once a water body has been identified as HMWB different uses (WFD Article 4(3)(a)(i)-(v) may be accepted, such as:

- 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 or irrigation;
- 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 HM should still achieve Good Ecological Status.

Figure 5 summarises the absolute HMWB numbers per water use.

Figure 5 Absolute numbers of designated HMWB per water use (23 MS plus NO)



Source: Discussion paper: http://ecologic-events.eu/hmwb/documents/Discussion_Paper_Updated.pdf

From the above, the following 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.

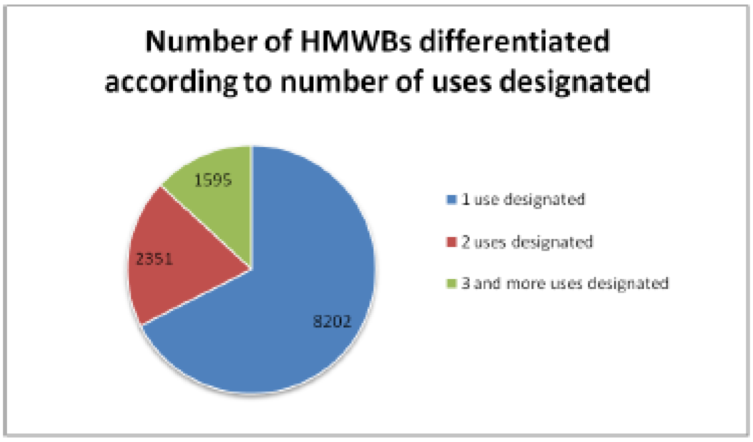
In terms of regional variation, the following may be noted:

- Navigation (total 583 WBs): The 3 MS which reported the highest numbers of HMWB for navigation (UK, DE, ES) account for about 57% of all navigation-HMWBs;
- Recreation (total 642 WBs): The 5 MS which reported the highest numbers of HMWB for recreation (DE, UK, PL, CZ, LT) account for about 66% of all recreation-HMWBs;
- Storage for drinking water (total 874 WBs): The 4 MS which reported the highest numbers of HMWB for drinking water storage (UK, NO, ES, FR) account for about 70% of all drinking-water-storage-HMWBs;
- Storage for power generation (total 2793 WBs): The 5 MS which reported the highest numbers of HMWB for hydropower (NO, SE, DE, AT, UK) account for about 70% of all hydropower-HMWBs;
- Storage for irrigation (total 941 WBs): The 5 MS 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 3 MS 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 4 MS 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 4 MS 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): DE alone accounts for 96% of the HMWB designated due to agriculture including forestry (defined as equally important sustainable human development activity);
- Urbanisation (total 1543 WBs): DE and UK account for 91% of the HMWB designated due to urbanisation (defined as equally important sustainable human development activity).

It should also be noted that water bodies can be designated as heavily modified for more than one uses. Figure 6 illustrates the share of HMWB that have been designated for one use, for two uses and for three or more uses. Although a considerable number of HMWB (3946 in total) are designated for more than one use, the majority of HMWB have been designated for a single use.

Figure 6 Multiple water uses of HMWB



Source: Discussion paper: http://ecologic-events.eu/hmwb/documents/Discussion_Paper_Updated.pdf

2.5. Case studies (countries (MS) or specific RBD

In the consultation process; MS and Stakeholders will be asked to add case studies. The current case studies are copy and paste from RBMPs or other relevant documents

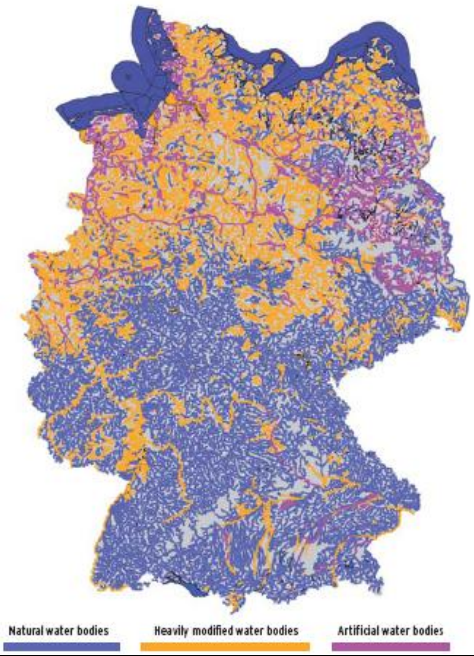
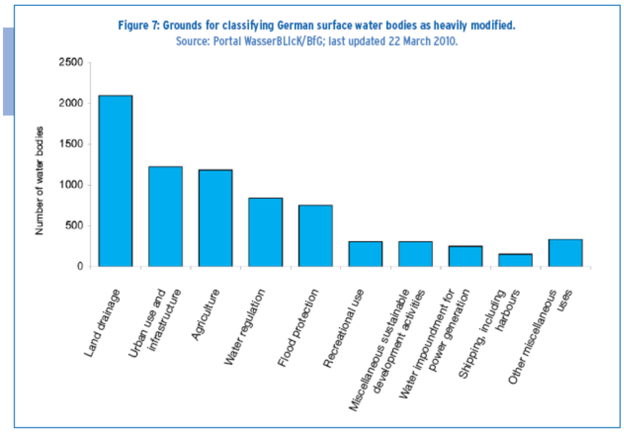
2.5.1. HMWBs/AWBs in Germany

Source: Water Framework Directive. The way towards healthy waters. Result of the German river basin management plans 2009[2]
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 due to 37 % and 15 % of the surface waters being classified as heavily modified and as artificial, 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.

[2] http://www.uba.de/uba-info-medien-e/4021.html

The main reasons for classifying German water bodies as heavily modifies 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.

Map of natural, HMWB/AWBs in Germany	Figure main grounds for classifying German water bodies ad heavily modified
	Figure 7 shows the main grounds for classifying German water bodies as "heavily modified". For such water bodies, measures aimed at achieving "good ecological status" would have a highly detrimental effect on various water body uses, particularly land drainage, agriculture, residential areas, infrastructure elements, water regulation and flood protection. Such water bodies are also heavily used for leisure time activities, shipping and power generation. 

Source: http://www.uba.de/uba-info-medien-e/4021.html
Note:
Comments: add comments

2.5.2. HMWBs/AWBs in RBDs (e.g. Danube, Rhine)

Danube International RBD

Source: Danube IRBMP (roof report)[3]

Out of overall 681 river water bodies in the entire DRBD (Danube River and DRBD Tributaries) a total number of 270 are designated 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 10 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 10: Final designated HMWBs in the Danube River and all rivers of the DRBD (expressed in km, number of water bodies and percentage).

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 (241 final and 29 provisional HMWB)	Proportion HMWB (number): 40%
The Danube River		
Total length (km): 2,857	Total HMWB length (km): 1,592	Proportion HMWB (length): 56%
Total number of WBs: 45	Total number of HMWBs: 26 (21 final and 5 provisional HMWB)	Proportion HMWB (number): 58%

3 Web link

Rhine RBD

Source: Rhine IRBMPs (roof report)[4]

Figure 5 indicates the percentages of water bodies in the main stream of the Rhine classified as "natural" (12 %), "heavily modified" (76 %) and "artificial" (12 %) depending on the number of water bodies.

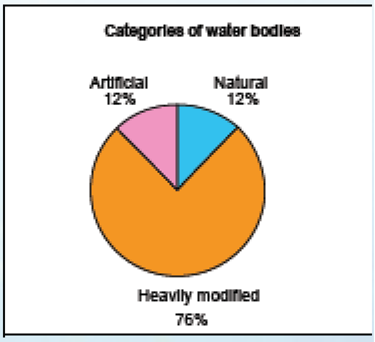
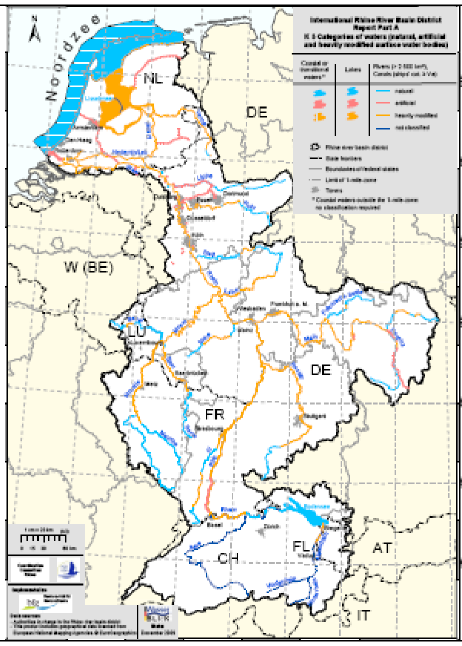


Fig. 5: Categories of the water bodies of the main stream of the Rhine based on the number of water bodies



2.6. Methodology notes

Table 2.3.2 - 1: Overview of reported river and lake water bodies in Europe

Country abbreviations: AT = Austria, BE = Belgium, BG = Bulgaria, CZ = Czech Republic, DE = Germany, EE = Estonia, ES = Spain, FI = Finland, FR = France, GR = Greece, HU = Hungary, IE = Ireland, IT = Italy, LT = Lithuania, LU = Luxembourg, LV = Latvia, NL = The Netherlands, PL = Poland, RO = Romania, SE = Sweden, SK = Slovakia, UK = United Kingdom.

NOTE: Five countries are still to report – Denmark, Portugal, Slovenia, Cyprus and Malta. Belgium, Spain, France and Poland have not reported all their RBDs. *River length will be included when length data are available.*

Country	River water bodies	River water bodies				Lake water bodies		Lake water bodies			
	Nb.	Natural	Artificial	Heavily modified	Unknown	Nb.	Area (km^2)	Natural	Artificial	Heavily modified	Unknown
AT	7 339	6 674	95	570		62	934	37	19	6	
BE	177	48	34	95		18	40		17	1	
BG	689	508	2	179		42	73	6	28	8	
CZ	1 069	886	3	175	5	71	249		1	70	
DE	9 074	4 155	1 387	3 532		712	2 399	509	111	92	
EE	645	451	42	152		89	1 966	86	3		
ES	4 296	3 539	18	739		328	5 281	220	49	59	
FI	1 602	1 516	4	79	3	4 275	28 172	4 178	25	32	40
FR	10 824	10 353	116	355		439	1 964	71	65	303	
GR	1 033	913	25	95		29	889	20		9	
HU	869	373	146	350		213	1 267	69	129	15	
IE	4 566	4 565		1		806	2 528	794		12	
IT	7 644	5 788	699	734	423	300	2 238	113	110	77	

[4] Web link

LT	832	724	5	103		345	4 395	291		54	
LU	102	90		12		N/A	N/A	N/A	N/A	N/A	N/A
LV	205	179		26		259	825	255		4	
NL	254	6	10	238		450	3 046	1	389	60	
PL	1 926	1 262	64	600		557	1 143	513		44	
RO	3 262	2 668	94	500		131	993	119	1	11	
SE	15 563	15 183	12	368		7 232	29 192	6 984	1	247	
SK	1 760	1 700	7	53		N/A	N/A	N/A	N/A	N/A	N/A
UK	9 080		568	1 935		1 119	1 933	354	200	565	
Sum	**82 811**	**68 158**	**3 331**	**10 891**	**431**	**17 477**	**89 626**	**14 620**	**1 148**	**1 669**	**40**

Table 1 shows the number of river and lake water bodies reported in the different countries. In addition to these there are five countries which have not yet reported: Denmark, Portugal, Slovenia, Cyprus and Malta. There are also some countries where some RBDs have not been reported (Belgium: 6, Spain: 1, France: 1 (overseas) and Poland: 2).

The number of river water bodies in the different countries varies a lot, reflecting the size of the countries.

The proportion of lake water bodies in the different countries also varies widely, due to differences in climate and topography. This affects the analysis of lake data, where aggregation to European level will represent some specific countries (in particular Sweden and Finland) to a larger extent than for the river data.

More methodology notes to be added

3. Ecological status/potential of HMWBs

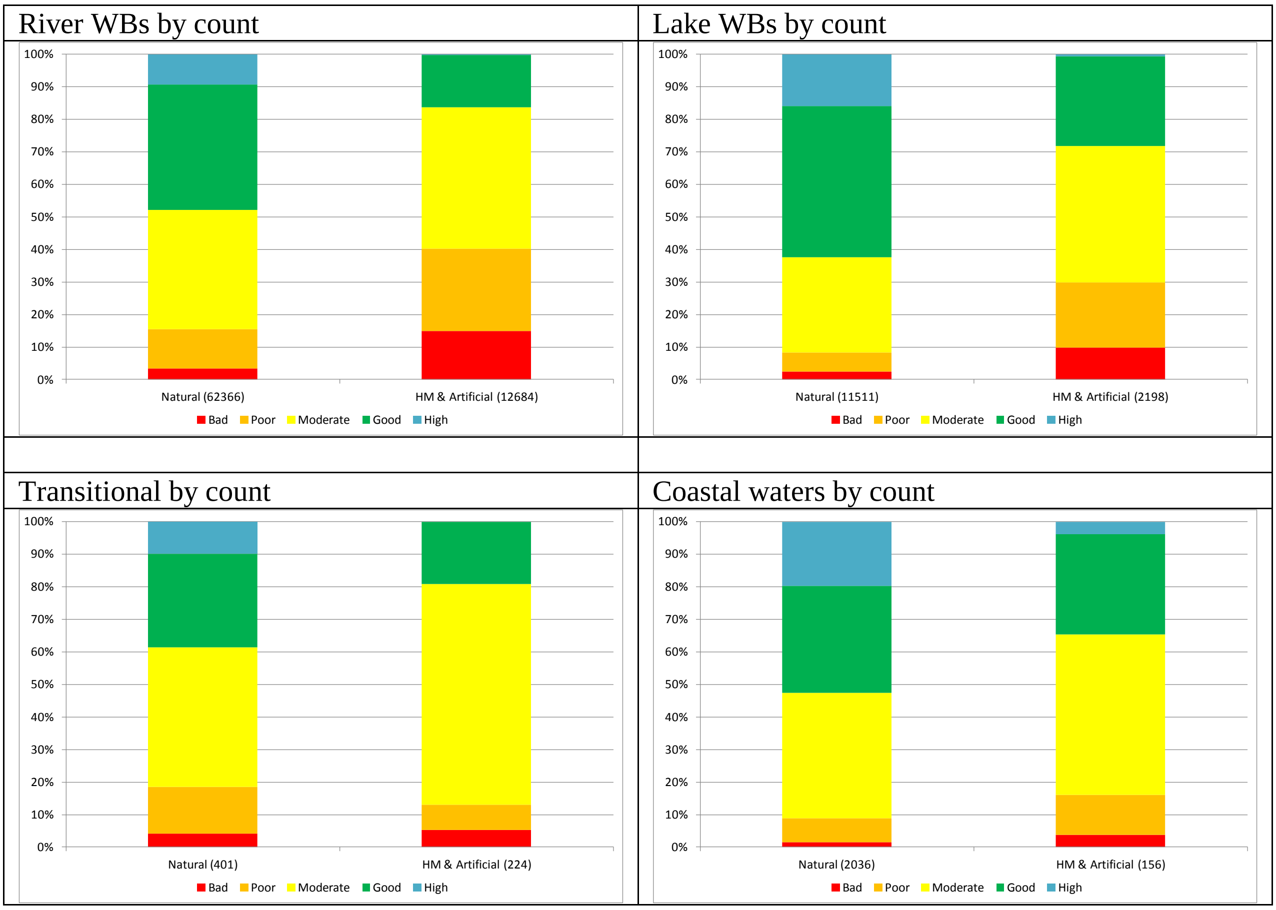
Brief introduction (½ page maximum) to be added

3.1. Overall status (2 pages)

<more text and assessment to be added>
Figure 3.1 presents the overall ecological status/potential for natural WBs and heavily modified plus artificial WBs.

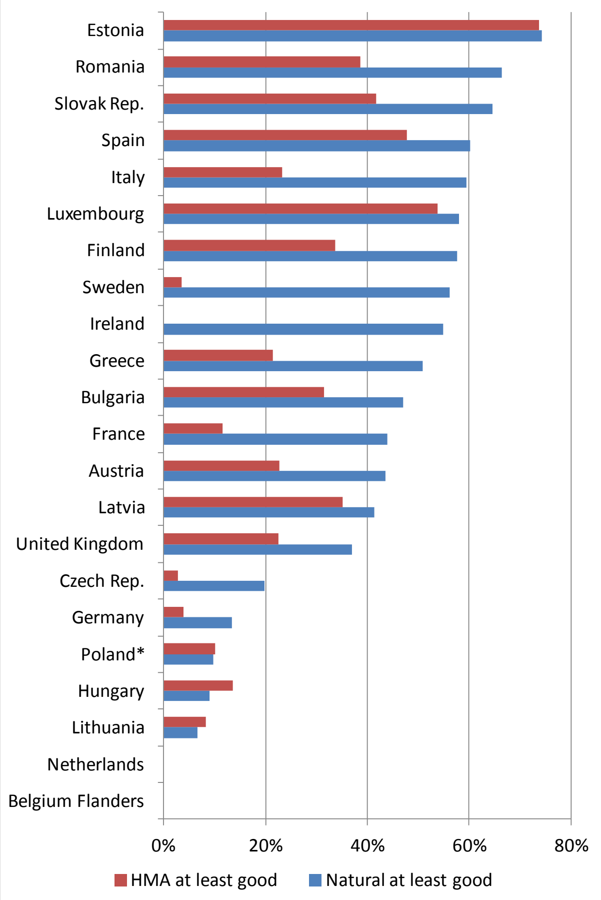
- No (there are a few) heavily and artificial WBs have been classified as having high ecological status (blue colour)
- The overall ecological status/potential are generally better for the natural WBs compared to the heavily modified and artificial WBs:
  - Nearly half (48 %) of the natural river WBs have at least good ecological status, while only 16 % of the heavily modified and artificial river WBs have good ecological potential.
  - More than 60 % of the natural lake WBs have at least good ecological status, while only 28 % of the heavily modified and artificial lake WBs have good ecological potential.
  - Around 40 % of the natural transitional WBs have at least good ecological status, while less than 30 % of the heavily modified and artificial transitional WBs have good ecological potential.
  - More than half (53 %) of the natural coastal WBs have at least good ecological status, while one third (35 %) of the heavily modified and artificial coastal WBs have good ecological potential.

Figure 3.1: Ecological status/potential of natural and heavily modified (HM) and artificial water bodies.



The ecological status/potential are generally better for the natural WBs compared to the heavily modified and artificial water bodies. Figure 3.2 illustrates per Member State the percentage of natural river WBs and HM and Artificial WBs having at least good ecological status/potential.

Figure 3.2: Percentage of natural and heavily modified and artificial (HMA) river WBs having at least good ecological status/potential, by count of water bodies



Note: Belgium Flanders and The Netherlands have no river WBs with at least good ecological status/potential. Similar diagrams may be produced for lake, transitional and coastal WBs.

3.2. Regional or type specific overviews (2 pages)

Missing text and diagrams
(e.g. natural versus HMWB, rivers – versus canals, status of artificial water bodies) – cases e.g. longitude along Danube

3.3. Hydromorphological quality elements

Text and results around HYMO quality elements to be added, e.g. percentatage of MS using hydromorphological quality elements.

Table I.1: Hydromorphological quality elements to be used for the assessment of ecological status/potential based on the list in Annex V, 1.1, WFD.

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

4. Hydromorphological alterations

Structures such as dams for hydropower or supplying water for irrigation have resulted in significant hydro-morphological modifications – physical changes – to many of Europe's waters. Navigation activities and navigation infrastructure such as cross profile construction – dams, weirs, locks, and impoundments; canalisation; straightening; bank reinforcement and deepening are typically associated with a range of hydro-morphological changes with potential adverse ecological consequences.

4.1. Overview of drivers and pressured related to hydromorphology

Hydromorphological elements: *<brief description to be added>*
Hydrological regime

- Quantity and dynamics of water flow
- Connection to groundwater bodies

River continuity
Morphological conditions

- River depth and width variation
- Structure and substrate of the river bed
- Structure of the riparian zone

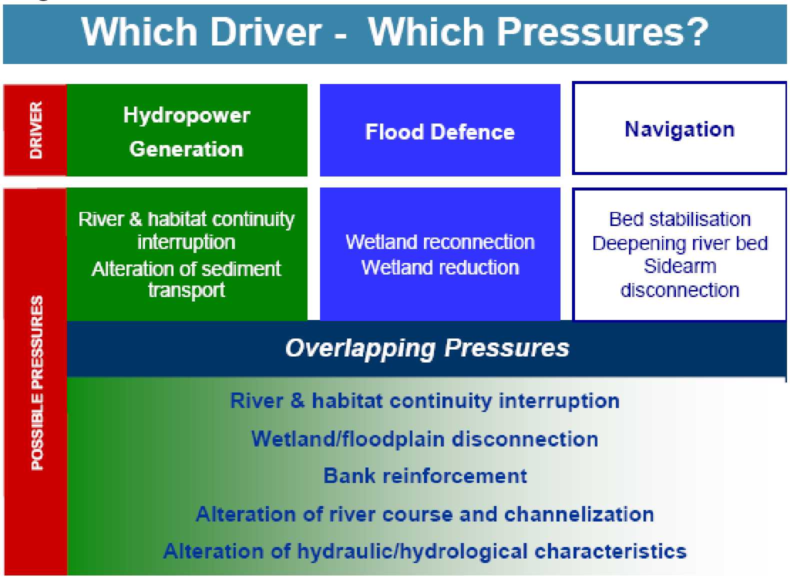
The anthropogenic uses that drive hydromorphological changes include hydropower, flood defence, navigation and agriculture, as well as activities such as outdoor recreation, land drainage and fisheries. Hydromorphological changes may result from more than one reason (e.g. a multi-purpose dam for hydropower generation, water supply and flood protection).

Brief sections describing the main European drivers

- Agriculture drainage
- Hydropower
- Navigation
- Flood defence
- Gravel extraction
- Etc.

Description of driving forces related to land drainage (agriculture and urban); transport infrastructures; and gravel extractions

Figure 4.1: Conceptual overview of the relation between drivers and HYMO pressures.
Other sectors e.g. agriculture, land drainage, dredging etc. to be added to Raimund Mairs conceptual diagram



Source: Raimund Mair, ICPDR

Pressures

Typical *hydromorphological pressures* that arise in response to the uses 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. These alterations can lead to a water body to be provisionally 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.

Source: WFD Hydrological modifications – technical report[5] – available at

Table III.1: Overview of hydromorphological alterations typically associated with different water uses and their subsequent impacts (x = more relevant; (x) = less relevant).

	Specified uses (= driving force)					Impacts on hydromorphology: deteriorations, impairments of hydromorphological conditions (= deficit parameters)						
Physical modifications (= pressure)	Navigation	Water regulation, flood protection	Activities for which water is stored, transferred or bypassed			Disruption in river or estuary continuum & sediment profile	Change in hydrological regime: low / reduced or increased flow, artificial discharge and level regime	Change in (soil) erosion / sediment transport / silting	Change in river profile (length and transverse profile)	Disruption in lateral connectivity, detachment of oxbow lakes / wetlands	Restriction / loss of flood plains or intertidal area	Change in connection with groundwater, alteration of groundwater level
			Power generation	Water supply	Irrigation							
Cross profile construction (dams, weirs, locks, impoundments)	x	x	x	x	x	x	x	x	x	x	x[1]	x
Longitudinal profile construction (dykes)	(x)	x					x		x	x	x	x
Channelisation, straightening	x	(x)	(x)	x	x	(x)	x	x	x	x	(x)	x
Bank reinforcement, bank fixation, embankments (training wall, breakwater, groynes etc.)	x	(x)	(x)	(x)		x	x	x	x	x		
Deepening (channel maintenance, dredging, removal or replacement of material)	x	(x)	(x)		(x)	(x)	x	x	x			x
Intakes, transfers and bypasses of water (tunnels etc.)			x	x	x	x	x					

Data and information from the WISE-WFD database

Hydromorphological pressures represent significant portion of pressures effecting European rivers and lakes. Hydromorphological pressures as an integrated category comprises a wide range of pressures. In RBMPs, hydromorphological pressures on surface water bodies (rivers and lakes) were categorized by the MS into five main pressure groups, such as:

- water abstraction: modifying significantly the flow regime of the water body,
- water flow regulations and morphological alterations
- river management
- other morphological alterations
- 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.

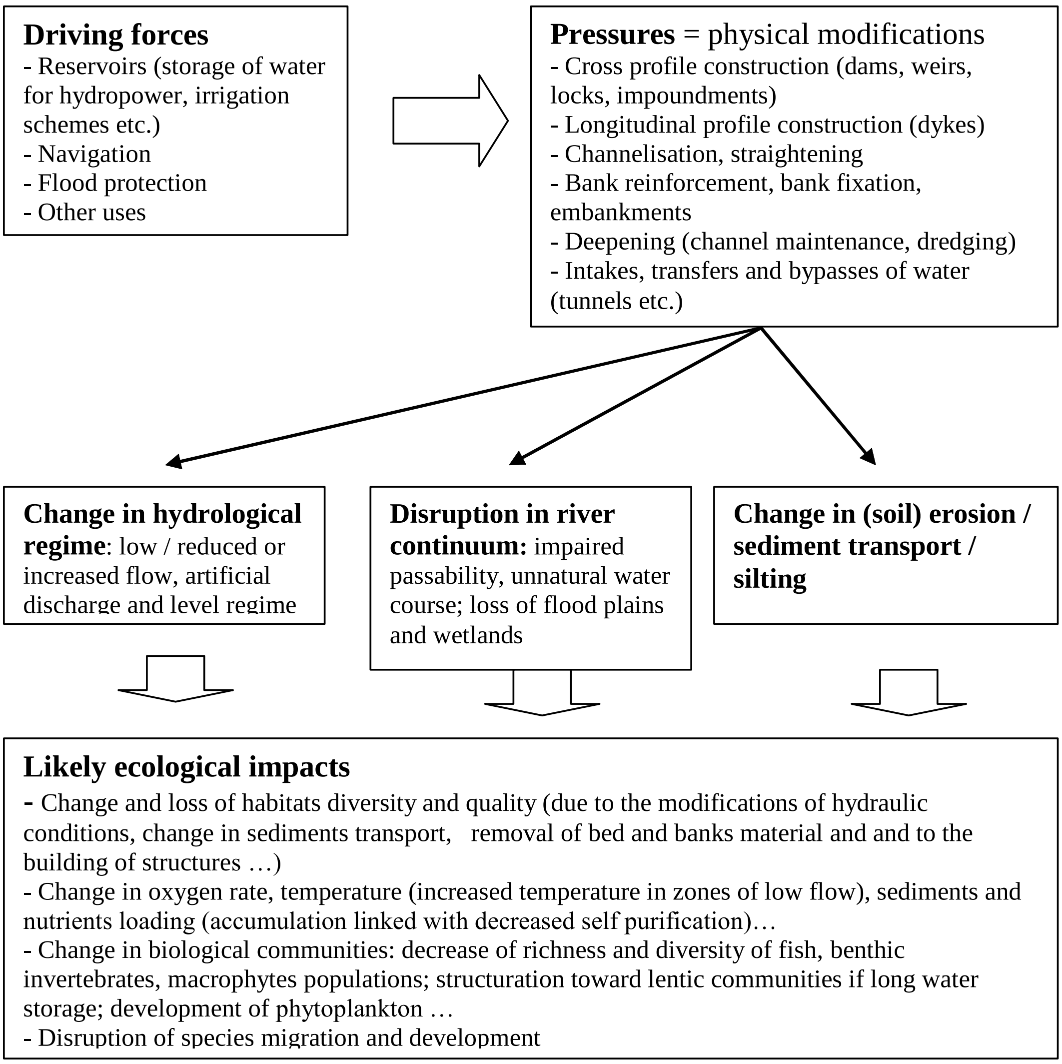
5 http://circa.europa.eu/Members/irc/env/wfd/library?l=/working_groups/hydromorphology/technical_finalpdf/_EN_1.0_&a=d

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 3):

- 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.

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

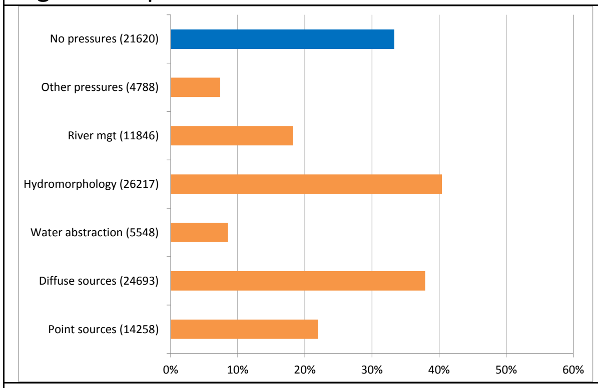
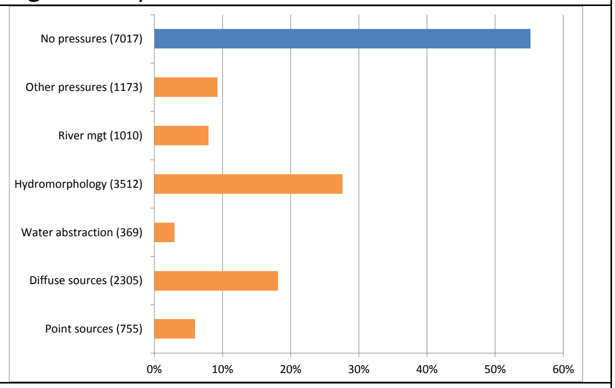
Europe's surface freshwaters are affected by major modifications, such as water abstractions, water flow regulations (dams, weirs, sluices, and locks) and morphological alterations, straightening and canalisation, and disconnection of flood plains. These are called hydromorphological pressures in WFD.

Hydromorphological pressures represent significant portion of pressures effecting European rivers and lakes. Hydromorphological pressures as an integrated category comprises a wide range of pressures. In RBMPs, hydromorphological pressures on surface water bodies (rivers and lakes) were categorized by the MS into five main pressure groups, such as:

- water abstraction: modifying significantly the flow regime of the water body,
- water flow regulations and morphological alterations
- river management
- other morphological alterations
- other pressures.

- The most common pressures in rivers and lakes are coming from the diffuse sources of pollution and hydromorphological pressures.
- More than 40 % and 20 % of the river WBs and lake WBs are affected by hydromorphological pressures.
- Overall, 50% European river water bodies, out of around 65 000 river WBs reported by 22 countries by the time of report writing are affected by at least one hydromorphological pressure.
- In case of European lake water bodies (LWB), the ration of HYMO pressure affected LWBs is lower. Overall, more than a quarter out of more than 12 000 lake water bodies reported by 20 countries are affected by at least one hydromorphological pressure.

Figure 4.2 Percentage of river and lake water bodies being affected by main groups of significant pressures

<table>
<tr><td>Rivers – percentage of river WBs with identified significant pressures</td><td>Lakes – percentage of lake WBs with identified significant pressures</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Excel sheet: pressures_rivers (2).xlsx
Notes: Based on rWBs with classified ecological status, total 64866 water bodies from 18 EU Member States: Austria; Belgium Wallonia; Bulgaria; Czech Rep; Estonia; Finland; France; Germany; Greece*; Hungary; Italy; Latvia; Lithuania; Netherlands; Poland Oder; Spain*; Sweden & United Kingdom.
No pressure data from Ireland; Luxembourg; Romania & Slovak Rep.

For Sweden only include diffuse pressures related to agricul-</td><td>Excel sheet: pressures_lakes.xlsx
Notes: Based on lWBs with classified ecological status total 12723 water bodies from 17 EU Member States: Austria; Belgium Wallonia; Bulgaria; Czech Rep; Estonia; Finland; France; Germany; Greece*; Hungary; Italy; Lithuania; Netherlands; Poland Oder; Spain*; Sweden & United Kingdom.
No pressure data from Ireland; Latvia; & Romania.
No lake data reported for: Luxembourg; & Slovak Rep.

For Sweden only include diffuse pressures related to agricul-</td></tr>
</table>

ture, abandoned industrial and mining and population not connected to sewers,	ture, abandoned industrial and mining and population not connected to sewers,
Pressures related to transitional waters	Pressures related to coastal waters
Diagram to be added	Diagram to be added

Source: WISE-WFD database – (02/09/11) –

Description of the country results (*only river and lake results for the moment*)

- Countries with a high proportion of river WBs being affected by hydromorphological pressures are found in central Europe (Map 4.1)
- Seven out of 18 MS had more than 40 % of their river WBs being affected by hydromorphological pressures (Figure 4.4) and five countries. Poland (Oder RBD); Germany; Belgium Flanders; the Czech Republic and The Netherslands had more than 60 % of river WBs being affected by hydromorphological pressures.
- Member States with relative high proportion of WBs in at least good ecological status/potential also have relative lower percentage of water bodies affected by hydromorphological pressures; (in Figure 4.4 MS are ranked by percentage of WBs in at least good status).
- Four MS had more half of the lake WBs being affected by hydromorphological pressures.

Three countries – Luxemburg, Romania and Slovakia – have not reported HYMO pressure. The countries with the lowest percentage of HYMO pressure affected RWBs are Greece and Ireland, while Belgium, Czech Republic, Poland, Denmark, Hungary and The Netherland have the highest percentage

The countries with the lowest percentage of HYMO pressure affected LWBs are Latvia, Ireland, and Finland, while United Kingdom, The Netherlands, Czech Republic, and Belgium have the highest percentage (Figure 4.x).

Map 4.1 Countries with percentage of river water bodies affected by at least one hydromorphological pressure

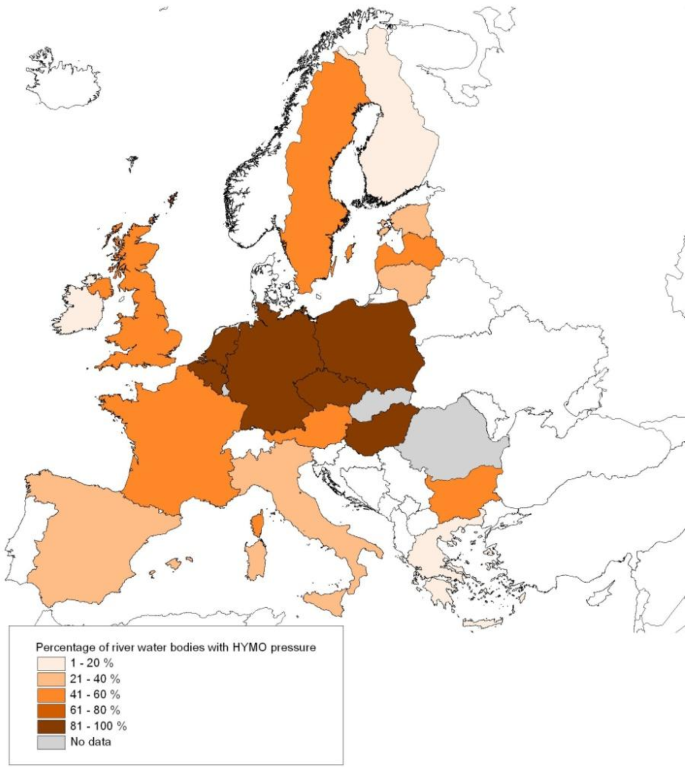
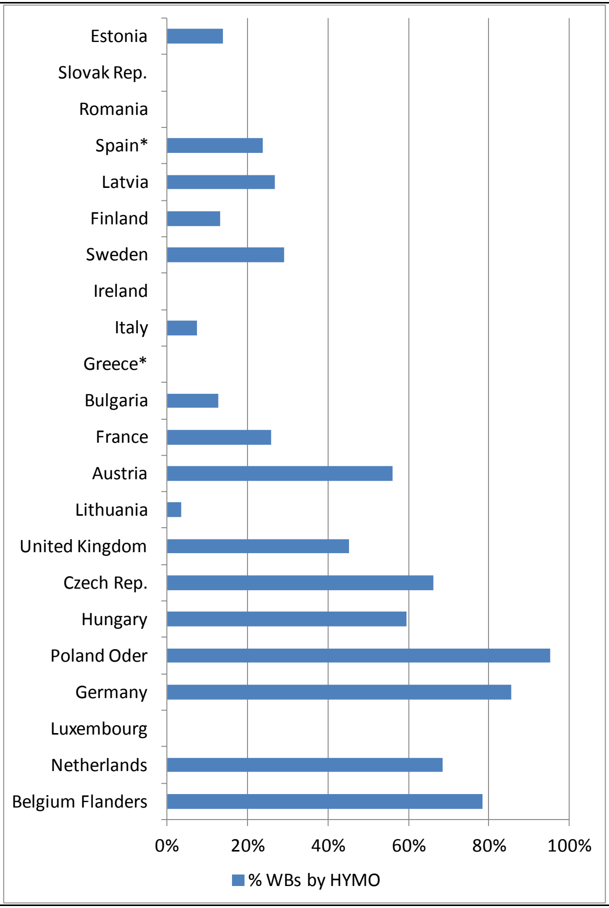


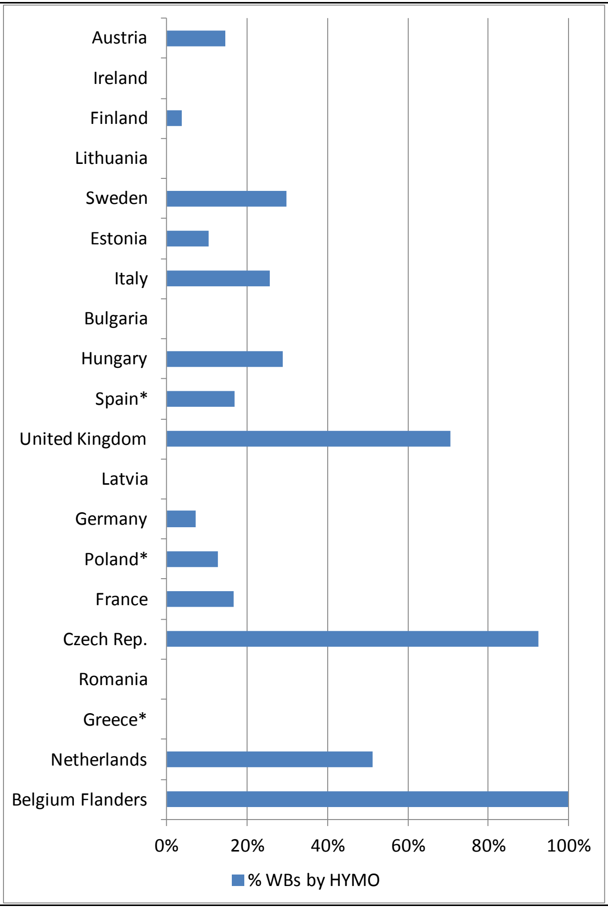
Figure 4.4 Percentage of river WBs and lake WBs being affected by hydromorphological pressures

Rivers – percentage of water bodies with **hydro-morphological pressures** being a significant pressures



Excel sheet: pressures_rivers (2).xlsx
Notes: Based on rWBs with classified ecological status, total 64866 water bodies from 18 EU Member States: Austria; Belgium Flanders; Bulgaria; Czech Rep; Estonia; Finland; France; Germany; Greece*; Hungary; Italy; Latvia; Lithuania; Netherlands; Poland Oder; Spain*; Sweden & United Kingdom.
No HYMO pressure data from Greece, Ireland; Luxembourg; Romania & Slovak Rep.
Hydromorphological pressures: Water flow regulations and morphological alterations
Sorted by percentage of water bodies with at least good status

Lakes– percentage of water bodies with **hydro-morphological pressures** being a significant pressures

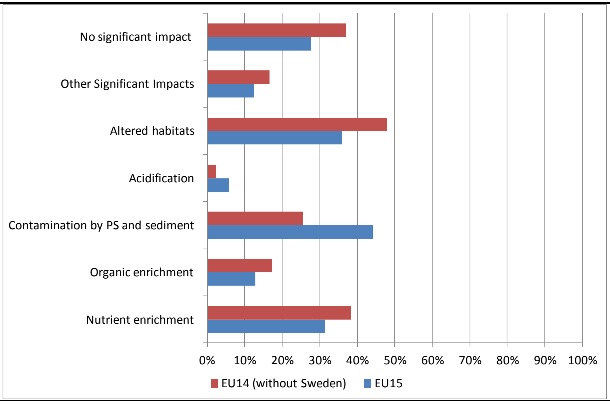


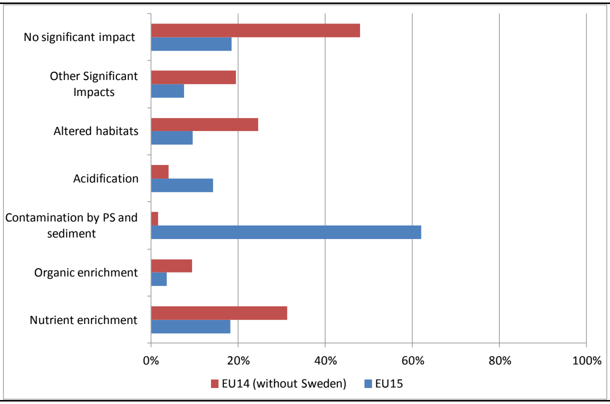
Excel sheet: pressures_lakes.xlsx
Notes: Based on lWBs with classified ecological status total 12723 water bodies from 17 EU Member States: Austria; Belgium Flanders; Bulgaria; Czech Rep; Estonia; Finland; France; Germany; Greece*; Hungary; Italy; Lithuania; Netherlands; Poland Oder; Spain*; Sweden & United Kingdom.
No HYMO pressure data from Greece, Ireland & Romania
No lake data reported for: Luxembourg; & Slovak Rep.
Hydromorphological pressures: Water flow regulations and morphological alterations
Sorted by percentage of water bodies with at least good status

4.2.1. Water bodies being subject to impacts from altered habitats

- The most common impacts in rivers and lakes are nutrient enrichment, altered habitats, and contamination by priority substances.
- Around 40 % of the river WBs and more than 20 % of the lake WBs have altered habitats identified as being a significant impact.

Figure 4.4 Percentage of river and lake water bodies by main groups of impacts

<table>
<tr><td>Rivers – percentage of river WBs with identified impacts</td><td>Lakes – percentage of lake WBs with identified impacts</td></tr>
<tr><td>


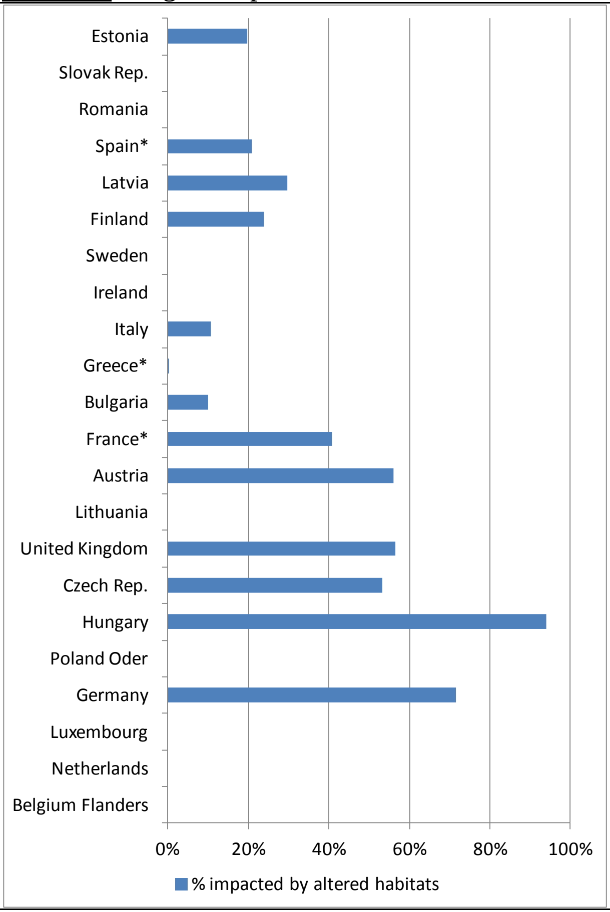
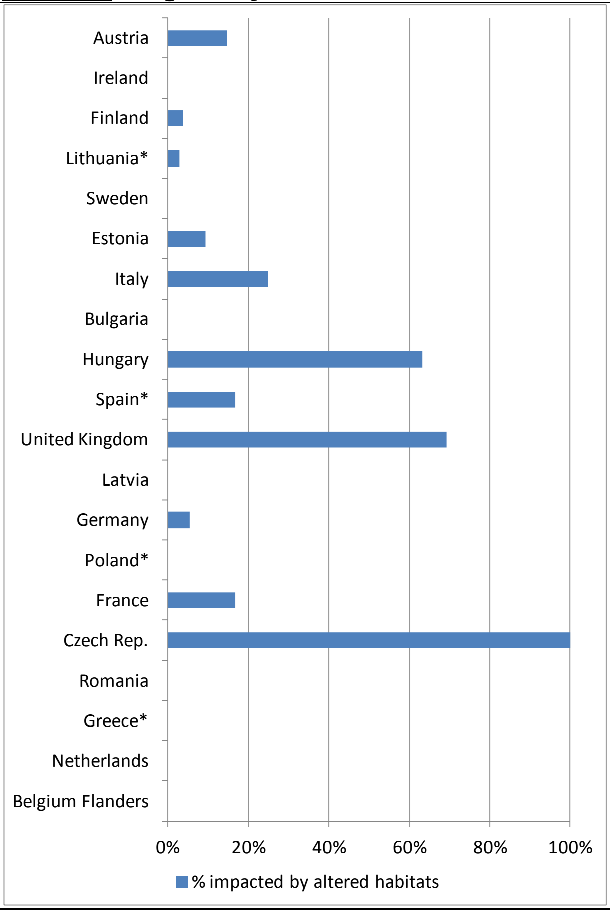
</td><td>


</td></tr>
<tr><td>Excel sheet: impact_rivers.xlsx
Notes: Based on rWBs with classified ecological status, total 61415 (incl. Sweden)/45940 water bodies from 15/14 EU Member States: Austria; Belgium Flanders; Bulgaria; Czech Rep; Estonia; Finland; France; Germany; Greece*; Hungary; Italy; Lithuania; Spain*; Sweden & United Kingdom.</td><td>Excel sheet: impact_lakes.xlsx
Notes: Based on lWBs with classified ecological status, total 11723 (incl. Sweden)/4527 water bodies from 15/14 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.</td></tr>
</table>

Description of the country results

- Six out of 15 MS had more than 40 % of their river WBs being subject to impact by altered habitats (Figure 4.5) and two countries. Hungary and Germany had more than 60 % of river WBs being dubject to impact from altered habitats.
- In the Czech Republic, United Kingdom and Hungary more than 60 % of lake WBs has altered habitats as a significant impact .

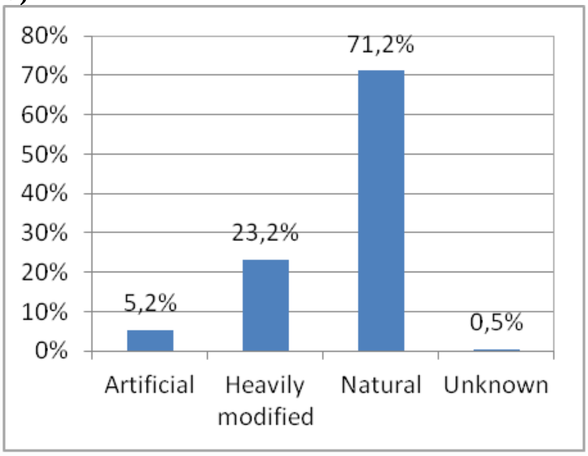
Figure 4.5 Percentage of river WBs and lake WBs with habitat alteration being an impact

Rivers – percentage of water bodies with **altered habitats** being an impact	Lakes – percentage of water bodies with **altered habitats** being an impact
 	
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 Oder, Romania & Slovak Rep. Sorted by percentage of water bodies with at least good status	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

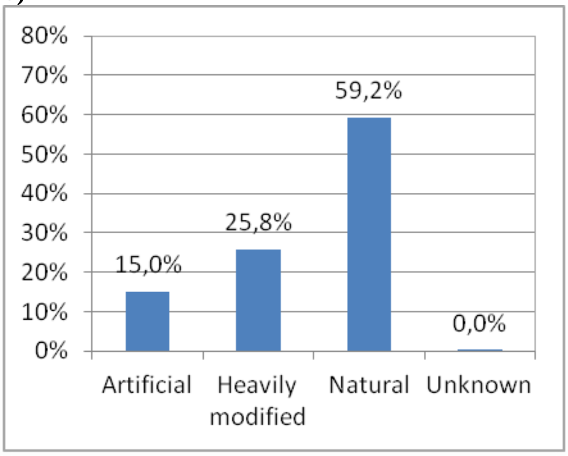
The dominant portion (70%) of hydromorphologicaly affected river water bodies has natural status, while 23% was classified as heavily modified and only 5% as artificial. In case of European river water bodies no direct relationships can be found among the designated type (HMWB, AWB), the ecological status (high, good, moderate, poor or bad) and hydromorphological affects.

Figure 4.6 Designated type distribution of a)river water bodies and b) lake water bodies which have at least one hydromorphological pressure.

4a)



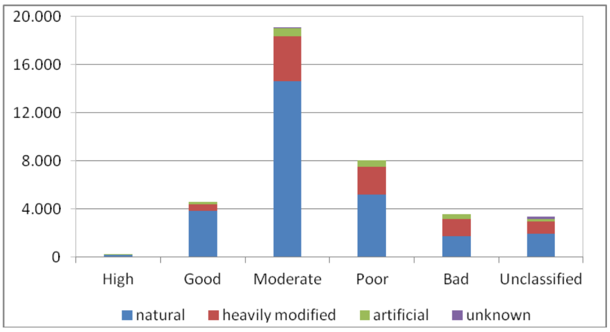
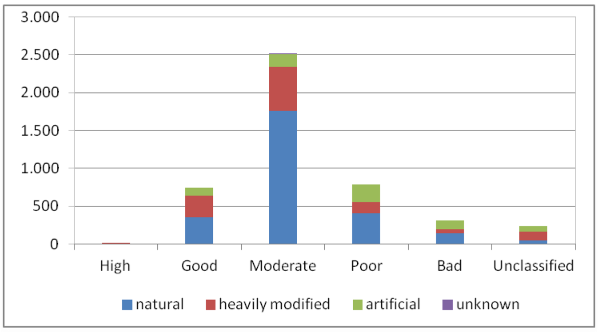
4b)



Note: Out of total 77 687 river water bodies the figure represents 38823 river water bodies. Out of total 17 477 lake water bodies this figure represents 4 607 lake water bodies.

Analysis of hydromorphologicaly affected river water bodies shows that all ecological statuses can be found in all types of water body groups (Figure 4.7). Some of the hydromorphologicaly affected river water bodies which have high or good ecological status their designated types are heavily modified or artificial.

Figure 4.7 Distribution of ecological status/potential for a) river water bodies and b) river water bodies, which have at least one hydromorphological pressure.

a) River water bodies with hydromorphology pressures	b) Lake water bodies with hydromorphology pressures
	
Note: Out of total 77 687 river water bodies the figure represents 38 823 river water bodies.	Note: Out of total 17 477 lake water bodies this figure represents 4 607 lake water bodies.

Overview of the specific driving forces related to hydromorphological pressures
Missing but if possible in the direction of the below diagram
The importance of specific driving forces related to hydromorphological pressures are identified in the 2006 screening assessment on heavily modified water bodies (Ref).

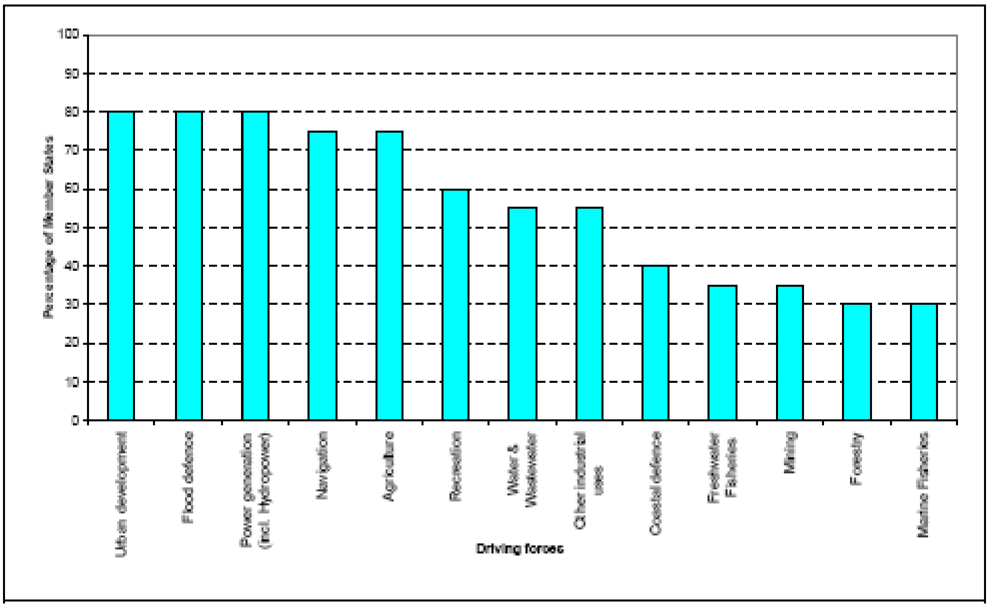


Figure 9: Percentage of Member States indicating a driving force related to hydromorphological pressures as significant. This figure is based on an in-depth assessment in 2006, for which the Article 5 reports of only 20 Member States were taken into account[45]. This was due to a lack of data in the other Member States or the lack of availability of other reports.

A diagram illustrating the HYMO pressures may be included

3 Water Abstraction
4 Water flow regulations and morphological alterations of surface water
5 River management
7 Other morphological alterations

However, for the moment it may be difficult to produce such a diagram due to heterogenous reporting by Member States.

4.3. Case studies (countries (MS) or specific RBD)

In the consultation process; MS and Stakeholders will be asked to add case studies. The current case studies are copy and paste from RBMPs or other relevant documents

Box: Danube and Rhine heavily impacted by hydro-morphological pressures

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.

Source: ICPDR, 2010 and Umweltbundesamt, 2006

Shannon RBD

We have physically modified many of our waters for water supply, recreation, transport, flood protection, hydropower, aquaculture and land drainage. The extent of modification is being systematically assessed for the first time: there are 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

Morphology

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.

Hydrology pressures misses from Scotland (***abstraction and flow regulation***)

West Balkan

Text below to be summarised to a brief overview of the different hydromorphological pressures and alterations in the West Balkans.

Skoulikidis, 2008: The environmental state of rivers in the Balkans—A review within the DPSIR framework.[6] –

Fifteen major Balkan rivers with over 80% of the inflows in Eastern Mediterranean were examined for their environmental state within the DPSIR framework.

Physicogeographic and hydrochemical conditions differ substantially among river basins, which may be roughly classified into three main zones. Despite strong fragmentation, most of the rivers are liable to flash floods and have low summer flow. Decreasing precipitation and (mis)management caused a dramatic discharge reduction over the last decades.

> In the 1950s, the first large dams were constructed. Nowadays, most rivers are "strongly fragmented" by dams and flow regulation. The Evros, Axios, Pinios, Alfeios and Aoos are "moderately fragmented",while only Sperchios and Evrotas are free-flowing.
> The most modified river is the Acheloos. In its headwater and middle sections, four large reservoirs exist and two more are under construction. These reservoirs will cover >150 km2 with a total storage capacity of ~6.6 km3, ~1.5 times the total annual discharge. Moreover, ~0.15 km3/yr is transferred to the Pinios basin and additional 0.6 km3/yr is planned to be transferred to the same basin.
> In the Evros basin, there are 21 large reservoirs, mainly along Bulgarian tributaries (four in Arda and three in Tundja) with a total storage capacity of about 3.4 km3.
> The Drin has two hydropower plants in FYR Macedonia and three in Albania, of which Fierza, covering 97 km2, is the largest in Albania.
> In the middle section of Aliakmon three reservoirs cover 81km2 and can store ~2.9 km3.
> In the Neretva basin, five hydropower plants impound a total area of 36km2 and store ~1.1 km3.
> In Nestos basin, there are six reservoirs in Bulgaria situated on river tributaries, whereas in Greece two large hydropower reservoirs (area 56 km2, storage volume 0.8 km3) (an additional one is under construction) and a small irrigation dam are found along the main stem.
> Two reservoirs situated at lower Arachthos cover 21 km2 and can store ~0.8 km3.
> 17 large dams for irrigation and flood control are located at Axios River tributaries in FYR Macedonia with a total storage capacity ~0.5 km3 and a small irrigation dam at its Delta.
> In the Kamchia basin there are three large reservoirs serving irrigation and drinking water supply.
> In the Bulgarian part of Strymon, 56 multipurpose reservoirs are placed with a total storage capacity of 0.14 km3. In the Greek section, a dam for flood control transformed the former Kerkini wetlands into a large semi-natural lake.
> In Alfeios, there is a small multipurpose dam at the Ladon tributary and in the Aoos headwaters a small reservoir diverts ~10% of Aoos water towards the Arachthos basin.

Change in river flow

> Over the past 40–45 years, the Balkan rivers have undergone dramatic discharge reduction (Table 2—discharge trends), a common phenomenon for the entire Mediterranean region (UNEP/MAP, 2003), caused by climate variability and change, evaporation from reservoirs and extensive water abstraction for irrigation. Dry periods (e.g. at the end of 1980s–beginning 1990s) act cumultive creating major water shortages. After reservoir construction the annual flow of the Kamchia decreased from 0.87 to 0.61 km3/yr (Jaoshvili, 2002). In 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,
> and in Evrotas intermittent flow regime dominates vast portions of the rivernet, as a result ofwater abstraction for irrigation (Skoulikidis et al., 2008). 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). Finally, the Arachthos reservoirs diminish intra-annual flow variations but only slightly alter the relative seasonal flow regime.

…

[6] 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 (2009): 2501-2516.

Large wetland areas were drained in favour of widespread intensive agriculture.

Extensive wetland areas were drained in all Balkan countries to produce agricultural land. In the past 50 years, huge drainage and irrigation networks were established and inter-basinwater transfer projects took place, e.g. fromTrebisnjica River to the Neretva and fromthe Strymon andNestos headwaters to the Iskar and Evros basins (Knight and Staneva, 1996).

Agricultural development and reservoir construction resulted to dramatic morphological modifications in water bodies. Lakes Yiannitsa, Amatovou and Ardjan in lower Axios, Lake Achinos and the marshes of Philippi in Strymon area, Lake Karla in Pinios basin, the Agoulinitsa and Mouria lagoons at the Alfeios outflow, and extensive marshes related to river deltas, were drained out. Thus, Greece lost 60–70%, of its original wetlands (Tsiouris and Gerakis, 1991)

In general, lowland river sections are hydro-morphologically modified and are at the greatest pollution risk, while upstream areas mostly retain their natural conditions.

Reservoirs retain vast masses of sediments, thus adversely affecting delta evolution, while dam operation disturbs the seasonal hydrological and hydrochemical regimes.

Due to reservoir construction, the Neretva, Acheloos, Arachthos, Aliakmon, Nestos and Evros experienced dramatic reduction in sediment transport, deltaic and sand barrier erosion, upstream propagation of the sea, and salinization of aquifers and of coastal lagoons (Glamuzina et al., 2002; Mertzanis,1997; Kapsimalis et al., 2005; Stournaras,1998;
Kanelopoulos et al., 2006).

Flow regulation in the Kamchia has caused degradation of riparian vegetation and localized habitat loss. Other morphological alterations include river channel straightening and embankment The Neretva has been already channelled in the 1880s. The lower parts of Evros, Aoos, Acheloos, Sperchios and Evrotas and almost the entire Strymon River in Greece are straightened and embanked, whereas riparian vegetation has been removed (e.g. the Nestos Delta lost 80% of the virgin Kotza Orman forest, Ministry of Environment Baden-Württemberg 1990).

Finally, extraction of inert material from riverbeds for construction material or for flood control (e.g. at Evrotas) favours bed incision (e.g. at Drin and lower Alfeios).

5. Barriers – transversal structures

5.1. Reservoirs, dams, weirs

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

Reservoir construction may have a number of environmental effects, both during building and following completion. 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. However, even small dams cause problems, as they are impassable to most species of fish.

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.

Structures such as dams, weirs and barrages may seriously interfere with or completely obstruct fish migration in a water body, in particular affecting species that need to migrate between the headwaters of freshwater bodies and the sea to reproduce. Bypass rivers, fish ladders or fish passes at such structures may maintain or improve ecological continuity.

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.*

Hydromorphological pressures on surface water bodies were reported in five main groups, namely (3) Water abstractions; (4) Water flow regulations and morphological alterations of surface water; (5) River management; (7) Other morphological alterations; (8) Other pressures. Pressures caused by transversal structures like reservoirs, dams and weirs were reported under (4) Water flow regulations and morphological alterations while barriers were accounted in (7) Other morphological alterations.

Maps in Figure 5.1 and 5.2 present the percentage of river and lake WBs having *Type 4 Water flow regulations and morphological alterations* identified as a significant pressure.

Concerning pressures from reservoirs, dams and weirs, which belong to (4) Water flow regulations and morphological alterations pressure group Austria and Germany has more than 90% of their HY-MO pressure affected river water bodies in this category. The lowest ratio with less than 20% is in The Netherlands, Italy, Latvia and Greece (Figure 5.1).

The dominant hydromorphological pressures on lakes are the transversal type pressures. These pressure types represent more than 50% of all hydromorphological pressures affecting lake water bodies. In this category river basins with higher ratio than 80% of pressures from transversal structures are located in Austria, Germany, north of France and north of Sweden.

Figure 5.1 Map of water flow regulations and morphological alteration pressures affected rivers basin districts by percentage of river WBs

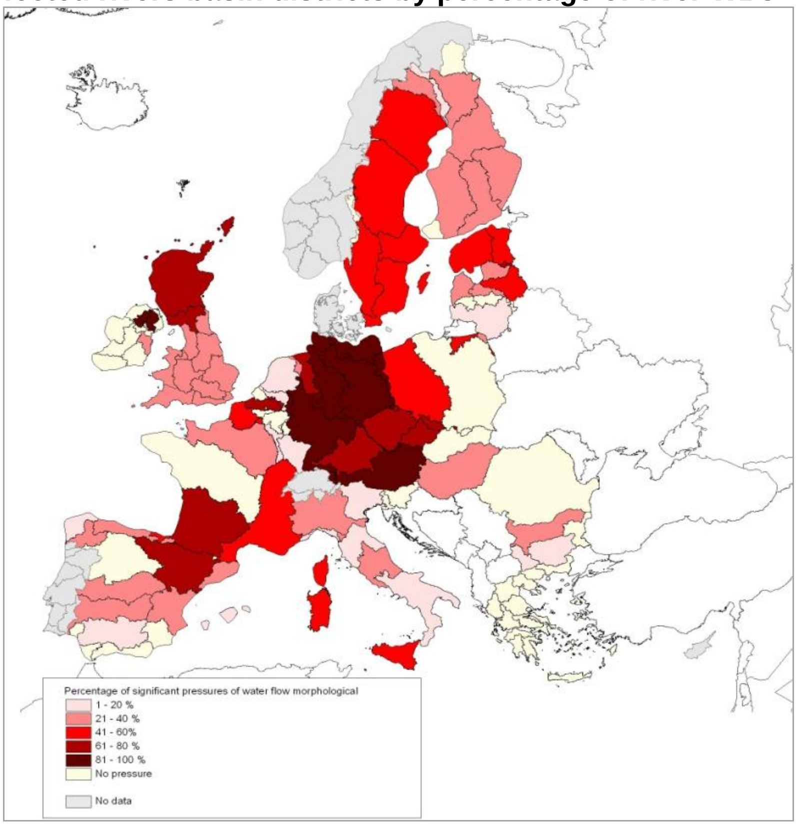
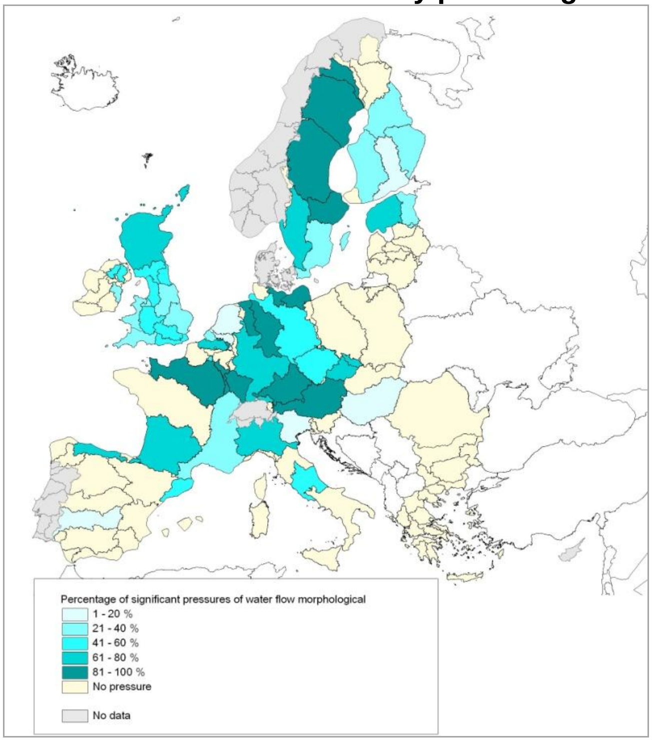


Figure 5.2. Map of water flow regulations and morphological alteration pressures affected rivers basin districts by percentage of lake WBs



Only 2% of the hydromorphologicaly affected river water bodies has (7) Other morphological type pressures, which relates to barriers. Barrier (7) type pressures are affecting European lakes in a bit higher ratio, but not exceeding 7%.

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.

Table: Barriers in River basins

Danube – Source: International River Basin Management Plan 1,688 barriers are located in DRBD rivers with catchment areas >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 migration as of 2009 and are currently classified as significant pressures (see Figure 12 and Map 5).
Elbe RBD, Germany - Source: EEB[7] The RBMP 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.
Loire-Bretagne RBMP Source: EEB[8] 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.
Scotland RBD, Source: SEPA, Significant Water Management Issues (SWMI) www

[7] EEB 2010: 10 years of the Water Framework Directive: A Toothless Tiger? http://www.eeb.org/?LinkServID=B1E256EB-DBC1-AA1C-DBA46F91C9118E7D&showMeta=0

[8] 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.
Czech Republic, Source WFD Article 5 Characterization chapter http://heis.vuv.cz/_english/data/spusteni/projektydat/vodniutvary/dokumenty/cz/Part_2.pd

Table 3.1.1. – 8: Transversal barriers above 1 m

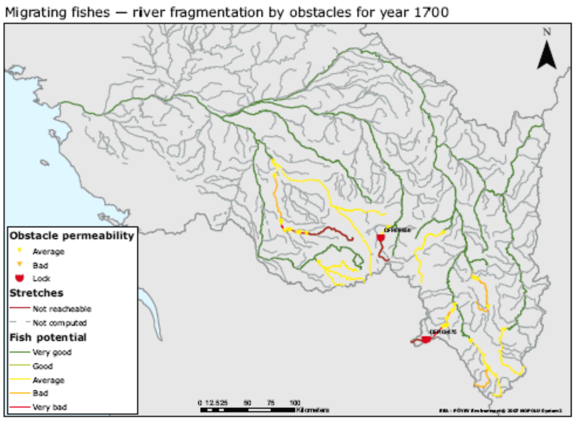
		Danube River	Elbe River	Odra River
Transversal barriers above 1 m	Number	2 153	2 805	1 065

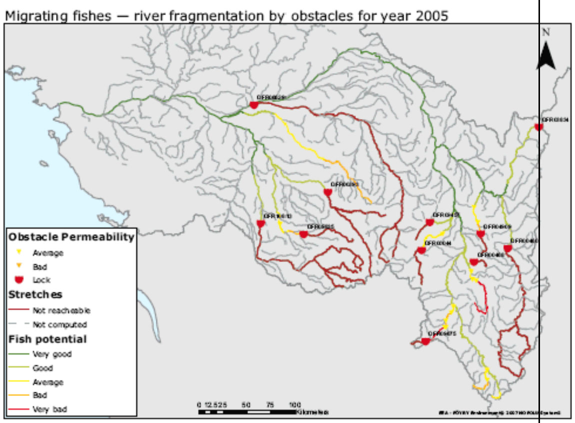
5.3. Case studies

In the consultation process; MS and Stakeholders will be asked to add case studies. The current case studies are copy and paste from RBMPs or other relevant documents

Box 7: River fragmentation, Loire River France and recovery of fish species in the River Rhine

River fragmentation by obstacles for 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)

Barriers in 2-3 river basin districts

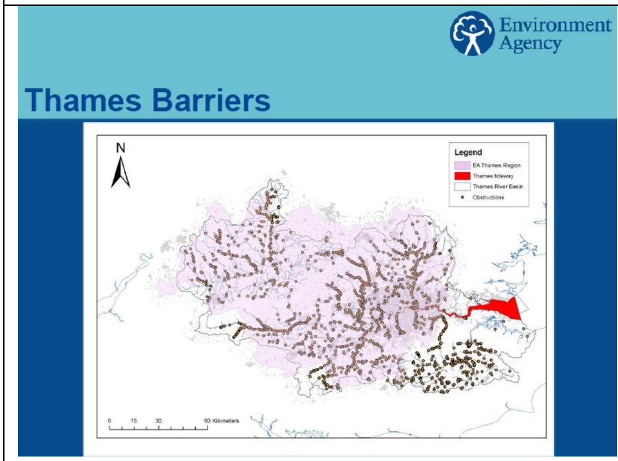
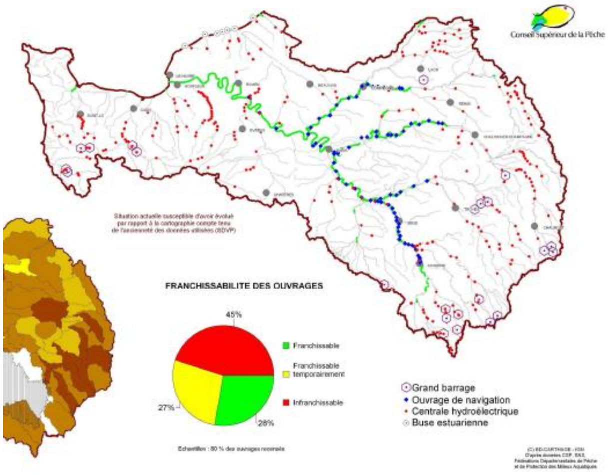
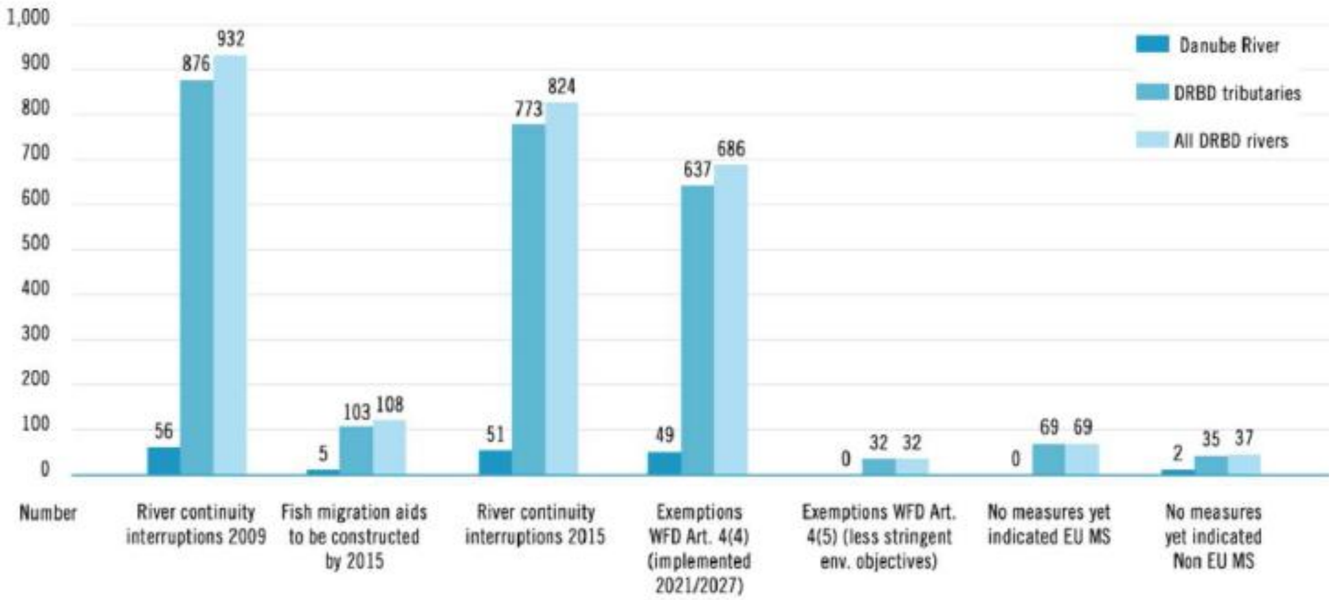
<table>
<tr><td>Thames Barriers</td><td>Seine-Normandy barriers</td></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Foto: Länsstyrelsen i Norrbottens län.

Damm i Laverbäcken. Foto: Länsstyrelsen i Norrbottens län.

5.4. Measures on transverse structure

Assessment text to be added. 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 and in two of the German RBDS.



Tab. 2-5: Anzahl der signifikanten Querbauwerke in Vorranggewässern in der FGE Eider

Planungseinheit	Bauwerke insgesamt	Nicht durchgängige Bauwerke (Fische)	Herstellung Durchgängigkeit bis 2015	Herstellung Durchgängigkeit nach 2015
1. Arlau/ Bongsieler Kanal	106	35	35	0
2. Eider/Treene	197	59	50	9
3. Miele	46	0	0	0
FGE Eider Gesamt	**349**	**94**	**85**	**9**

Tab. 2-3: Anzahl der signifikanten Querbauwerke in Vorranggewässern im deutschen Einzugsgebiet der Elbe im Sinne überregionaler Umweltziele

Anzahl der Querbauwerke	Koordinierungsraum					FGG gesamt
	Tideelbe	Mittlere Elbe/Elde	Havel	Saale	Mulde-Elbe-Schwarze Elster	
nicht durchgängig	75	30	67	39	65	276
Durchgängigkeit unklar	3	-	2	4	-	9
durchgängig bis 2015 (Handlungsziel)	8	10	26	26	65	135

6. Abstraction and flow regulation (rivers)

6.1. Introduction

The flow regime is 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. 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.

Abstraction and flow regulation and assessment of impact
Source: Scotland RBD *What is the issue?*
Water is abstracted from rivers, canals, reservoirs, lochs or underground rocks (aquifers) to provide public water supplies and serve industry and agriculture. 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, loch and wetland habitats and species.

Abnormally low river flows can damage river and estuarine ecology, which may take years to recover. Low river flows may be caused by periods of low rainfall, but the effects can be prolonged or made worse by abstraction at critical periods. Unsustainable abstraction from groundwater can lower groundwater levels and have knock-on impacts on river flows or wetlands.

Flows and levels in surface waters

Dry rivers are rare but they can be found in the Scotland RBD, for example, in rivers 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 levels is also important in all surface waters to maintain their characteristic ecological diversity. 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. 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. In lochs serving as reservoirs, extreme variation in water levels between winter and summer can result in the loch margins becoming a hostile environment for water plants and animals and the creation of a scar zone of bare sediments.

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.

6.2. European overview of rivers with regulated flow

Comments: *The data reported on significant pressures and stored in WISE-WFD database are not fully suited for illustrating water bodies affected by water abstraction and other induced changes in hydrology (e.g. hydropeaking; change in seasonal flows).*

- 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.

Figure 6.1: Percentage of water abstraction pressure affected RWBs by countries.

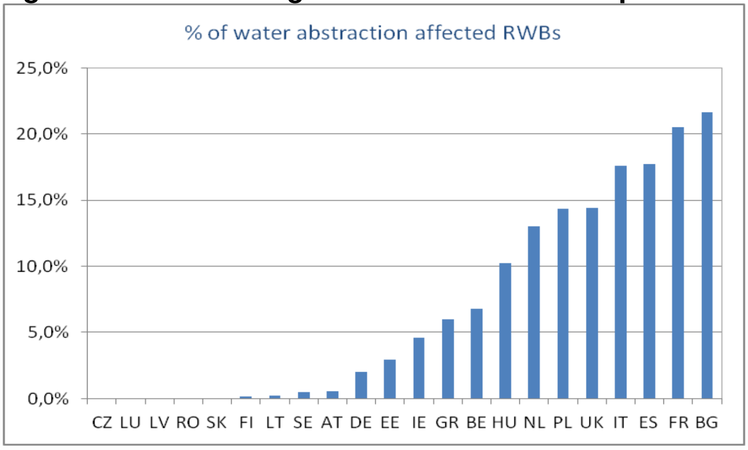
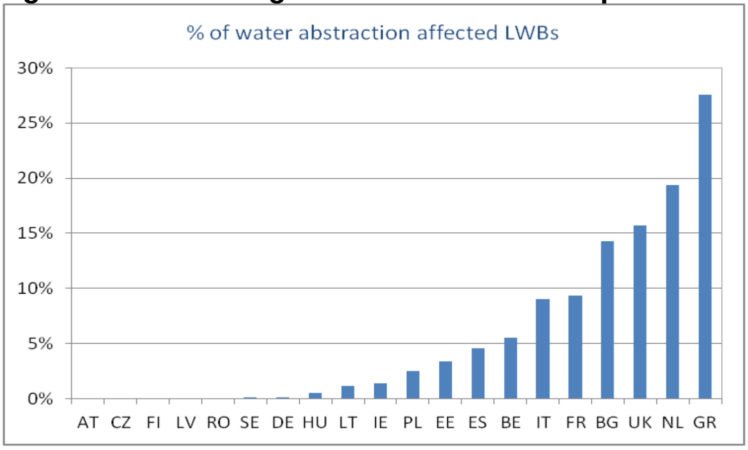


Figure 6.2 Percentage of water abstraction pressure affected LWBs by countries



Out of 22 countries which submitted their RBMPs by the time of report writing three (Luxemburg, Romania and Slovakia) have not reported hydromorphological pressures at all while no water abstraction pressures were identified on Check Republic and Latvian river water bodies.

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 6.2 – 1a and Figure 6.2 – 2).

Only 400 lake water bodies were identified as affected by water abstraction, which represent only 2% of the total 17 477 lake water bodies. This fact maybe read in a way that only few lakes are used as source for water supply or irrigation or fish farming or hydro-power generation.

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. – 1b and Figure 6.2. – 4).

Map 6.1 Map of water abstraction pressures affected rivers basin districts by percentage of RWBs

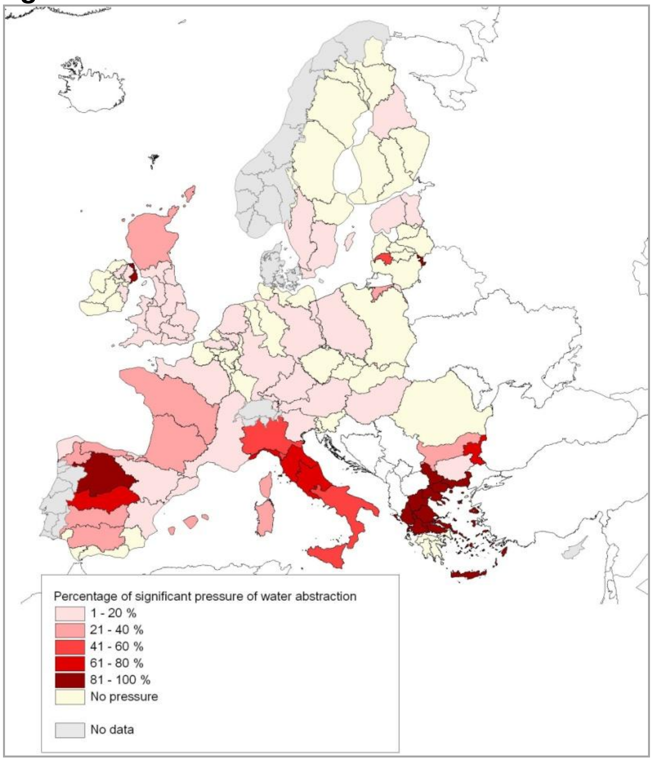
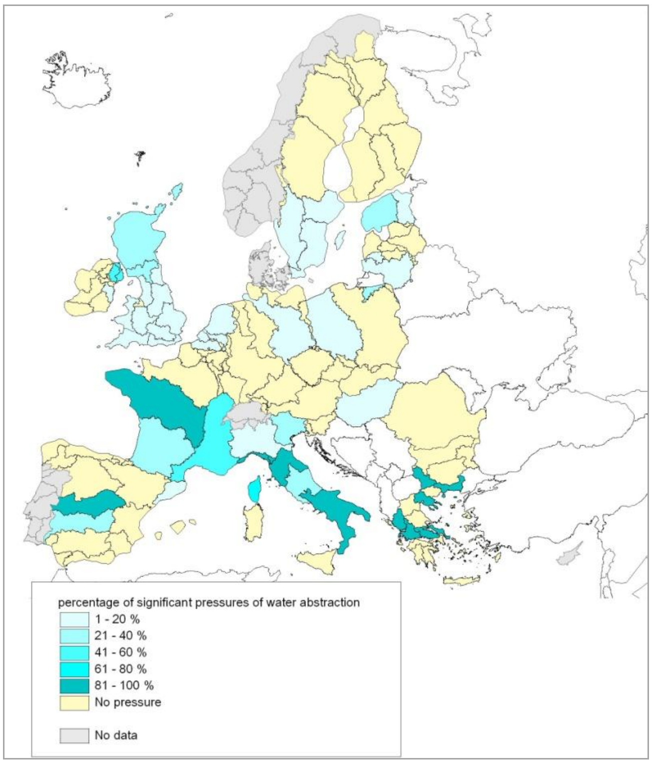


Figure 6.4: Map of water abstraction pressures affected rivers basin districts by percentage of LWBs

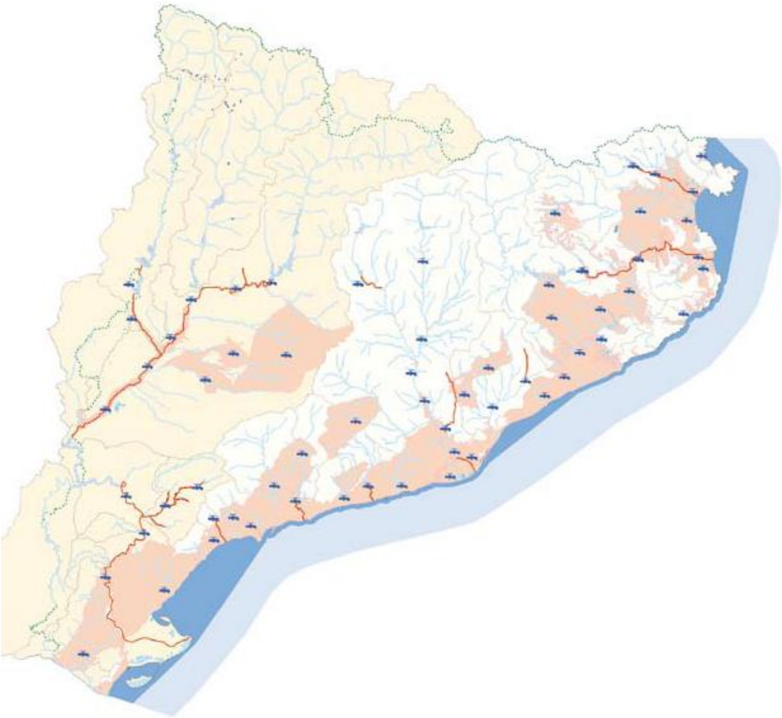


6.3. Case studies

In the consultation process; MS and Stakeholders will be asked to add case studies. The current case studies are copy and paste from RBMPs or other relevant documents

6.3.1. Rivers being affected by high abstraction rates

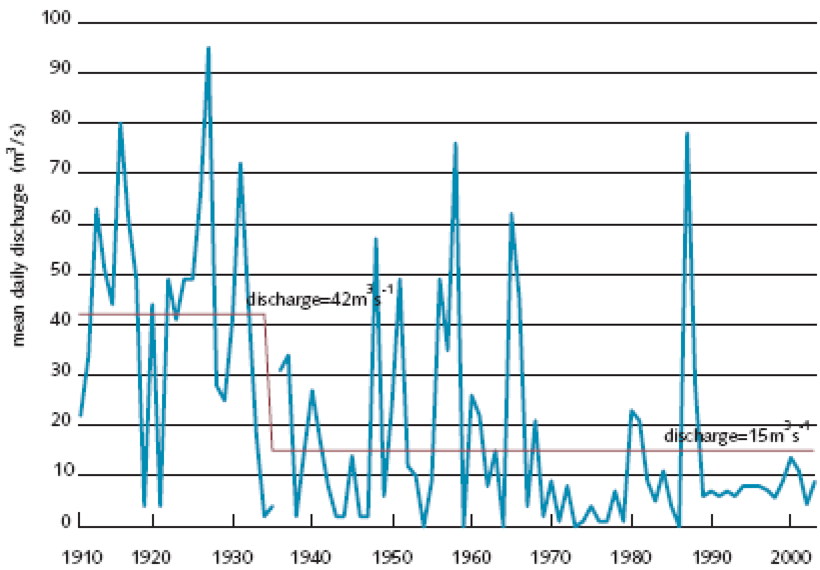
Case studies missing – several of the UK rivers are affected by over-abstraction
Example map: Points with water abstractions & red rivers stretches are being affected by over-abstractions



6.3.2. Change in hydrological regime due to reservoirs; hydropower, navigation

Case: on hydropeaking
Missing text – good example on hydropeaking
In the upper reaches of the Rhine (Alps and their foothills) there are numerous reservoirs and barrages serving power generation; during power consumption peaks, the hydropower plants often regulate the water supply according to the need for power supply ("hydropeaking operation"). That means that flora and fauna are not only impacted by interference with river continuity but also by the surge effects of hydropeaking operation.

Case: Meuse (annual flow) navigation channel:
Source: Rikswaterstaat 2007: Two rivers: Rhine and Meuse. pdf – pages 63-64
Low discharge in the Grensmaas
There are no weirs in the Grensmaas and there is no shipping either: the water level is determined here by 'natural' dynamics. The relatively high flow rates and the gravel bed provide a unique environment for species native to running water. The construction of shipping canals in the Netherlands and Belgium has contributed to the frequent occurrence of low discharges whereby long stretches of the Grensmaas are left entirely high and dry. This can cause problems for fish and other river animals, since the remaining water heats up quickly and the oxygen level can drop to dangerously low levels, and there is insufficient deep water left to which large f sh can retreat.



Lowest discharge per year on the river Meuse (Borgharen). 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 m³/s are mostly prevented.

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 m3/s. This minimal discharge seems to be sufficient to keep aquatic life in the Grensmaas healthy, provided that it does not occur too often.

Hydropower/Reservoirs Ebro; Jucar; Rhône (CH) and Sweden/Norway

Case: Ebro River Basin

Batalla, R.J., Kondolf, G.M., Gomez, C.M., 2004. Reservoir-induced hydrological changes in the Ebro River basin, NE Spain. Journal of Hydrology 290, 117–136.

Abstract and paper www

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.

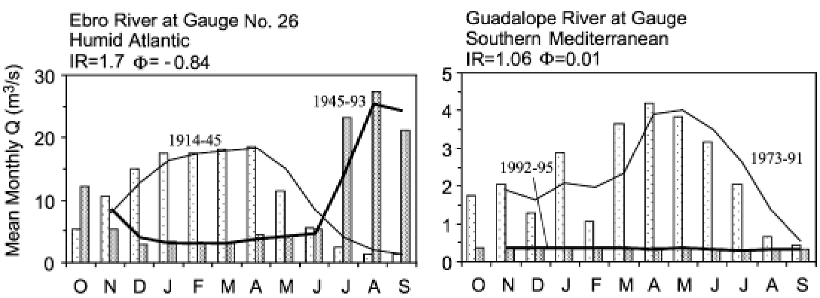


Fig. 7. Illustrative plots of mean monthly flows pre- and post-dam for Guadalope and Ebro (below Ebro Dam near headwaters). IR is the ratio of reservoir capacity to annual runoff; Φ is the correlation coefficient between pre- and post-dam monthly flows (data from Table 5).

7. Regulated lakes

Source: Martunnen et al. 2006: http://www.ewaonline.de/journal/2006_05.pdf
Water level regulation is related to the human need to control the water levels of the lakes and flows of the rivers in such a way that benefits various users of watercourses (Sundborg, 1977). There is a large variation in regulation practices depending on the primary objectives of regulation. However, in slightly or moderately regulated watercourses the natural hydrology has still a central role in defining the actual water level fluctuation.
In a typical hydropower regulation project in the northern hemisphere, water levels during summer period are normally high or rising, 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 Finland, Norway, and Sweden, there are thousands of lakes, both natural and regulated (Table 2). If we consider only those lakes greater than 0,5 km2, Sweden is the most lake rich country with 7 260 lakes (Table 2). In Finland and Norway, the number of lakes which area is more than 0,5 km2 is almost the same, ca 4 500. In contrast to that, in Austria and Scotland there are only few lakes, e.g. in Austria the number is 62.

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.

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

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.

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. For instance, there are thousands of recreational users and fishermen in Lake Kemijärvi, which is the most heavily regulated lake in Finland (Marttunen & Hellsten 2003).

7.1. European overview

Comments: *The data reported on significant pressures and stored in WISE-WFD database are not fully suited for illustrating an European or country overview of regulated lakes.*

7.2. Case studies

In the consultation process; MS and Stakeholders will be asked to add case studies. The current case studies are copy and paste from RBMPs or other relevant documents

1-2 case studies to be included

Text box: Regulated lakes in Finland

Regulation of water flow constitutes the most important hydromorphological burden to Finnish lakes. The total area of regulated lakes is nearly 11,000 km2, equalling one-third of the total area of Finnish inland waters. Extensive research projects have been carried out since the end of the 1980s to find out opportunities to mitigate harmful effects of the regulation of watercourses.[9], [10]

Regulation of lake water level for power production and flood control is among the major anthropogenic disturbances in boreal aquatic ecosystems. In Finland, over 300 lakes, representing one third of the total inland water area of the country, are artificially regulated.[11]

Effects of water-level regulation on the nearshore fish community in boreal lakes.[12]

Many large lakes in Finland have now been reported to be in improved condition after the era of industrial, agricultural and human effluents during the 1960s–1970s and the start of water level regulation in the 1950s (Sarvala 1996; Granberg 1998; Riihimäki et al. 2003). .. Most of the largest lakes in Finland are regulated and one third of the total area of lakes is regulated. Lake regulation originates in Finland mainly from the 1950s and the main purposes for it are flood protection and hydropower energy production as well as acquiring suitable conditions for ship traffic, industry, agriculture and recreation (Marttunen et al. 2001).[13]

Ecological classification of large lakes in Finland: comparison of classification approaches using multiple quality elements[14]

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[9] Keto et al. 2008 http://www.springerlink.com/content/h22t81g2j50757k6/

[10] Antton Keto et al., "Use of the water-level fluctuation analysis tool (Regcel) in hydrological status assessment of Finnish lakes", *Hydrobiologia* 613, no. 1 (2008): 133-142.

[11] Jukka Aroviita and Heikki Hämäläinen, "The impact of water-level regulation on littoral macroinvertebrate assemblages in boreal lakes", *Hydrobiologia* 613, no. 1 (2008): 45-56.

[12] Tapio Sutela and Teppo Vehanen, "Effects of water-level regulation on the nearshore fish community in boreal lakes", *Hydrobiologia* 613, no. 1 (2008): 13-20.

[13] Partanen, Sari & Seppo Hellsten (2005). Changes of emergent aquatic macrophyte cover in seven large boreal lakes in Finland with special reference to water level regulation. *Fennia* 183: 1, pp. 57–79. Helsinki. ISSN 0015-0010. http://ojs.tsv.fi/index.php/fennia/article/viewFile/3738/3529

[14] M Rask, Km Vuori, et al., "Ecological classification of large lakes in Finland: comparison of classification approaches using multiple quality elements", *HYDROBIOLOGIA* 660, no. 1 (February 2011): 37-47.

8. Channelized streams - Disconnecting floodplains and rivers

Abb. 2-11: Begradigtes und querschnittsverändertes Gewässer
Source: Eider RBMP p. 30

8.1. Introduction

Historical bends were lost to channel straightening projects, as is well documented on many rivers and streams in Europe (e.g., Brookes 1987, Goldi 1991, Iversen et al. 1993).[15]
Goldi, C. 1989. Resuscitation programme for flowing waters in the Canton of Zurich. Anthos 2:1-5.
Kondolf, G. M. 1995b. Geomorphological stream channel classification in aquatic habitat restoration: uses and limitations. Aquatic Conservation 5:127-141.

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).[16]

Many lowland rivers in Western Europe have been substantially modified to aid land drainage and support the intensification of agriculture.[17]

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[15] Kondolf, G. M. 2006. River restoration and meanders. Ecology and Society 11(2): 42. [online] URL: http://www.ecologyandsociety.org/vol11/iss2/art42/

[16] Tenna Riis and Kaj Sand-Jensen, "Historical changes in species composition and richness accompanying perturbation and eutrophication of Danish lowland streams over 100 years", *Freshwater Biology* 46, no. 2 (2001): 269-280.

[17] S. S. C. Harrison, J. L. Pretty, et al., "The effect of instream rehabilitation structures on macroinvertebrates in lowland rivers", *Journal of Applied Ecology* 41, no. 6 (2004): 1140-1154.

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.[18]
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).[19]

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'.[20]

8.2. European overview

Comments: *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.*

8.3. Case studies

In the consultation process; MS and Stakeholders will be asked to add case studies. The current case studies are copy and paste from RBMPs or other relevant documents

2-3 case studies to be included

Foto: Rebecca Möller.

[18] Ibid.

[19] Ibid.

[20] Sonja C. Jähnig, Stefan Brunzel, Sebastian Gacek, et al., "Effects of re-braiding measures on hydromorphology, floodplain vegetation, ground beetles and benthic invertebrates in mountain rivers", *Journal of Applied Ecology* 46, no. 2 (2009): 406-416.

Text box: Timber flooding

Ett flottledsrensat vattendrag. Foto: Susanne Backe.

Most **Finnish streams** 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.[21]
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 increased 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 sawmills on the coast.
In Sweden, watercourses of all sizes have been channelized to facilitate timber floating (Törnlund & Östlund 2006). Timber floating was gradually abandoned after the 1950s as the road network was developed (Törnlund & Östlund 2002).[22]

[21] Timo Muotka and Jukka SyrjäNen, “Changes in habitat structure, benthic invertebrate diversity, trout populations and ecosystem processes in restored forest streams: a boreal perspective”, *Freshwater Biology* 52, no. 4 (2007): 724-737.

[22] Johanna Engström, Christer Nilsson, and Roland Jansson, “Effects of stream restoration on dispersal of plant propagules”, *Journal of Applied Ecology* 46, no. 2 (2009): 397-405.

9. Missing 1-2 chapters discussing hydromorphological issues in transitional and coastal waters

10.Sector and activity chapters

10.1. 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)

Chapters on other relevant aspects such environmental flows and plans for getting fish species (e.g. Salmon (Rhine, Thames, Meuse etc); sturgeon (Danube); eel (French rivers) and lampreeys)back into the river systems may also be included.

The current sector and activity chapters are only placeholders for text and information to be further developed and markedly improved

We hope that relevant stakeholders and Member States will contribute with text boxes expressing their views on the aspects raised in the respective chapters. Contributions will be asked for during the consultation period during February/March.

11. Hydropower

11.1. Introduction (setting the scene)

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.

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 sediment flow. Pressures related to hydropower may be one of the reasons for many river and lake/reservoirs water bodies not to achieve good ecological status by 2015 or the subsequent RBMP cycles.

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.
<to be extended>

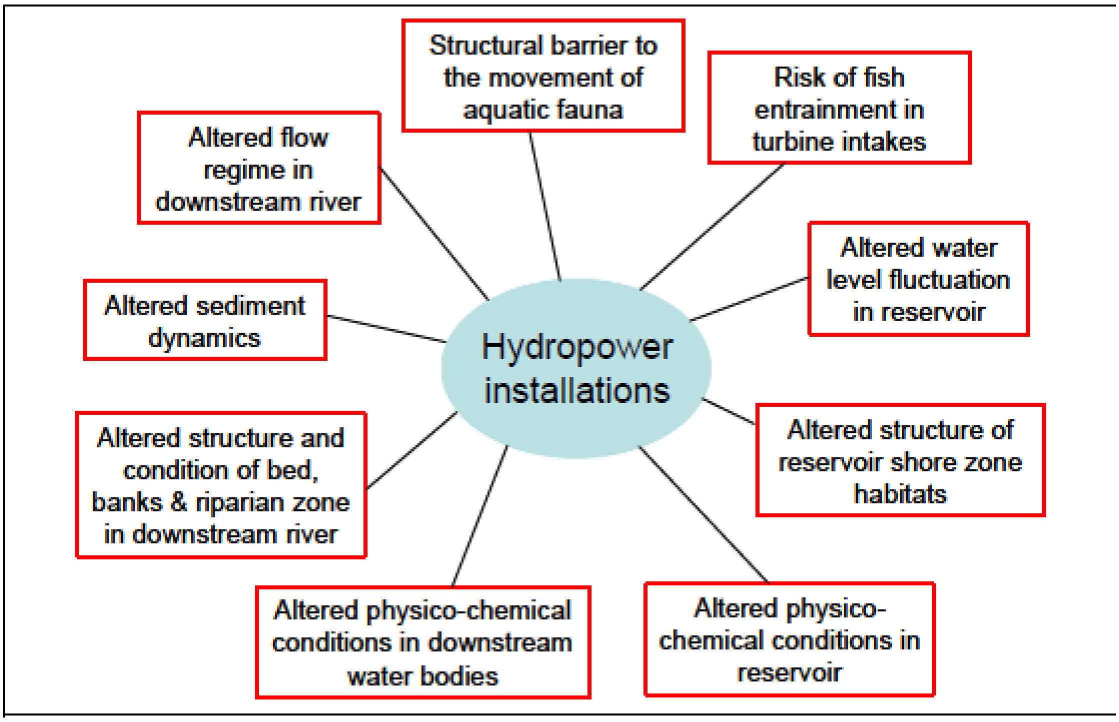


Figure 4a: Illustrative range of possible alterations typically associated with hydropower dams with subsequent biological alterations (More information available in Annex III).

11.2. Overview of hydropower in Europe

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

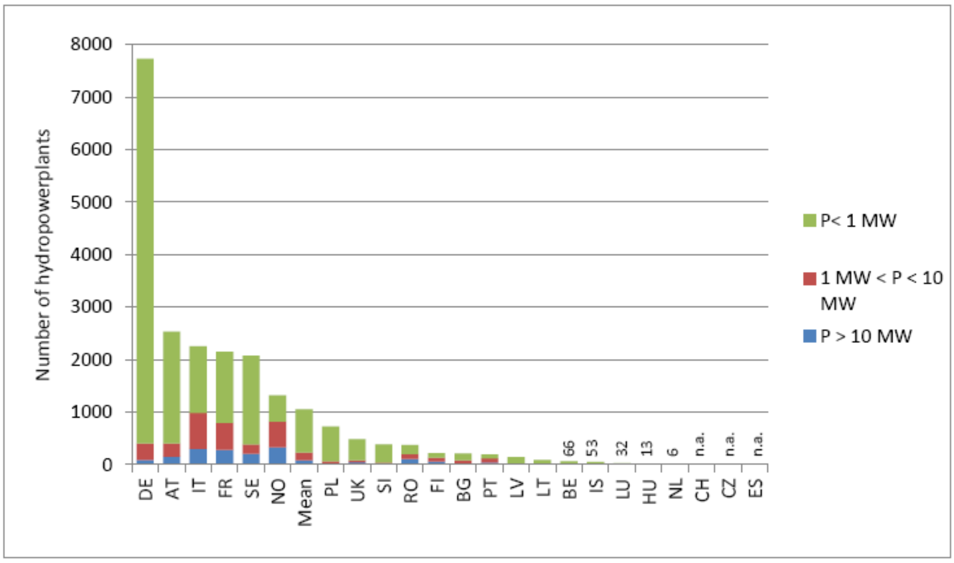
northern and Alpine countries. *<Updated with information from New DG ENV hydropower report*[23] *and DG ENV/Ecologic (Kampa et al.) September 2011: Issue Paper Draft 2*[24] >
Alpine Convention report on small hydropower

To be extended. – below some copy and paste from DG ENV/Ecologic (Kampa et al.) September 2011: Issue Paper Draft 2

- Electricity production by hydropower <text missing>

Number and capacity of different hydropower plant sizes
The highest number of plants in most countries lies in the category of plants smaller than 1MW (see Figure 5). Figure 6 shows that in 14 countries, plants < 1 MW make up for more than 50% of total plants. In LV, DE, PL and LT, these small plants even make up for more than 90%. In absolute numbers, DE has by far most small plants (7.325), which is 44 % of small plants in all countries.

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).

11.3. RBMPs and hydropower

Aspect related to hydropower and

- heavily modified water bodies;
- hydromorphological measures and
- foreseen measures

to be covered.
Text not written yet

HMWB due to hydropower
Source: Ecologic 2011: Water management, Water Framework Directive & Hydropower. Issue Paper (draft 2). Available at

23 http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/implementation_conventio/hydropower_september&vm=detailed&sb=Title

24 http://circa.europa.eu/Members/irc/env/wfd/library?l=/framework_directive/implementation_conventio/hydropower_september/issue_paper&vm=detailed&sb=Title

http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/implementation_conventio/hydropower_september/issue_paper/issuepaper_draft2pdf/_EN_1.0_&a=d

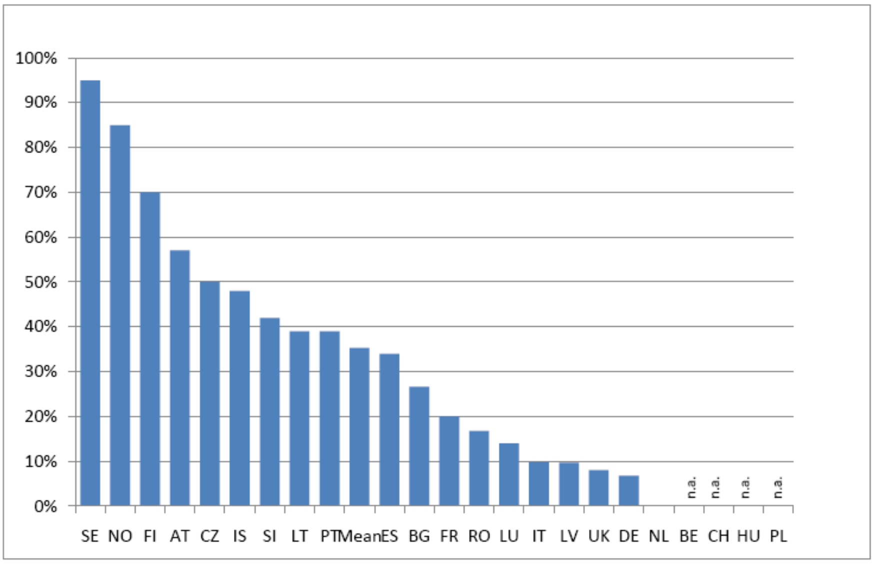
> Comment – *As the designation of HMWB vary between the countries; (e.g. some countries may only designate few WBs as HMWBs while others designate many) the percentage designated may not give a correct picture*.

Text box: Percentage of HMWB designated as such due to hydropower use in relation to total HMWB. <source

Figure 10 shows the percentage of HMWB designated as such due to hydropower use in relation to total HMWB.

- SE, NO, FI, CZ and AT have the highest percentage of HMWB due to hydropower (above 50% of total HWMB).
- The NL, DE, UK, LV and IT have the lowest percentage of HMWB due to hydropower (below 10% of total HMWB)

Figure 10: Percentage of HMWB designated due to hydropower in relation to total HMWB (%)



Note: 1) Percentages were reported in the WFD and Hydropower questionnaires of European States. 2) Data was not available for CH, BE, HU, PL. 3) The mean is calculated based on the percentages provided in the European States questionnaire.

Measures related to hydropower

<results and text to be updated based on DG ENV study on Pressures and measures>

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. PT, BG) and other measures to make hydropower plants more ecological friendly (e.g. via fish ladders in the NL).

In the context of making improvements to water bodies via specific measures, 10 European 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, AT, DE[21]	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.

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

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

Partly copy and paste from DG ENV/Ecologic (Kampa et al.) September 2011: Issue Paper Draft 2
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 a lot of 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: How Member 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 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 AT, SI 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 AT, 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 DE, ES and IT, 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 LV, the situation is similar. In ES, any new constructions will focus on increasing pumping storage capacity.
- FR 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, LU considers all options to be minor contributions to the 2020 renewable energy targets.
- For FI, the NL and RO, the construction of new plants and modernisation and maintenance will be the main contributors to the 2020 renewable energy targets from hydropower.
- For NO and PT, the main source of contribution to the 2020 renewable energy targets from hydropower will come from the construction of new plants and refurbishment.
- SE 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*

11.5. Primary sources:

Pressures and measures in RBMPs (DG ENV project 2011/12)

3b Drivers for hydromorphological alterations
- Hydropower

Activities
- Catalogue on HYMO measures
- Measures classified according to categories
- Evaluate the effectiveness of measures (indicators)
- Modelling
- Stakeholder workshop

Alpine Convention paper on small hydropower

WFD CIS 2011 - Workshop on WFD and Hydropower - Brussels, 13-14 September
http://circa.europa.eu/Members/irc/env/wfd/library?l=/framework_directive/implementation_conventio/hydropower_september&vm=detailed&sb=Title
2011: Issue Paper Draft 2 – Ecologic
http://circa.europa.eu/Members/irc/env/wfd/library?l=/framework_directive/implementation_conventio/hydropower_september/issue_paper&vm=detailed&sb=Title
2011: Study: Hydropower Generation in the context of the WFD – ARCADIS & Ingenieurbüro Floecksmühle
http://circa.europa.eu/Members/irc/env/wfd/library?l=/framework_directive/implementation_conventio/hydropower_september/11418_110516pdf/_EN_1.0_&a=i
WFD CIS 2007 - Workshop on WFD and Hydropower - Berlin, 4-5 June
http://circa.europa.eu/Members/irc/env/wfd/library?l=/framework_directive/implementation_conventio/workshop_hydropower&vm=detailed&sb=Title
Water Framework Directive and Hydropower, 4-5 June 2007, Berlin
http://www.ecologic-events.de/hydropower/presentations.htm
WFD CIS 2005- Workshop on WFD and hydromorphology, Prague 17-19 October
http://circa.europa.eu/Members/irc/env/wfd/library?l=/framework_directive/implementation_conventio/hydromorphology&vm=detailed&sb=Title
WFD CIS Circa: WFD and Hydromorphology
http://circa.europa.eu/Members/irc/env/wfd/library?l=/working_groups/hydro-morphology&vm=detailed&sb=Title

12. Inland water navigation and waterways

12.1. Introduction (setting the scene)

Inland waterway transport plays an important role in the transport of goods in central Europe and is generally seen as more environmentally friendly than road transport. However, navigation activities and/or infrastructure works are typically associated with a range of hydro-morphological changes with potentially adverse ecological consequences.

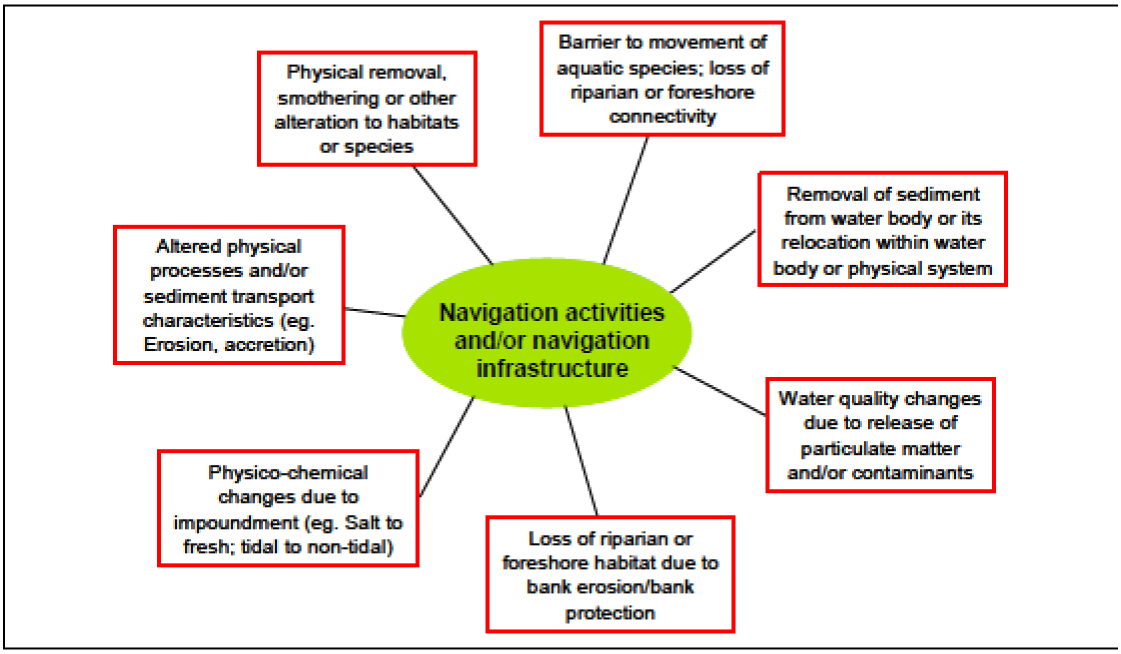


Figure 4b: Illustrative range of possible alterations typically associated with navigation activities and/or navigation infrastructure with subsequent biological alterations.

12.2. Overview of inland waterway transport in Europe

Source: DG Transport Inland Waterway Transport[25]: Inland waterway transport plays an important role for the transport of goods in Europe. More than 37 000 kilometres of waterways 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. (Updated with information from Leuven et al. 2009[26] – see table below)

Table 1 Connections of European rivers via canals (Fig. 2 visualises the European network of inland waterways)

[25] http://ec.europa.eu/transport/inland/index_en.htm

[26] Leuven, Rob S. E. W., Gerard Velde, Iris Baijens, Janneke Snijders, Christien Zwart, H. J. Rob Lenders, and Abraham Vaate. "The river Rhine: a global highway for dispersal of aquatic invasive species." *Biological Invasions* 11, no. 9 (June 2009): 1989-2008.

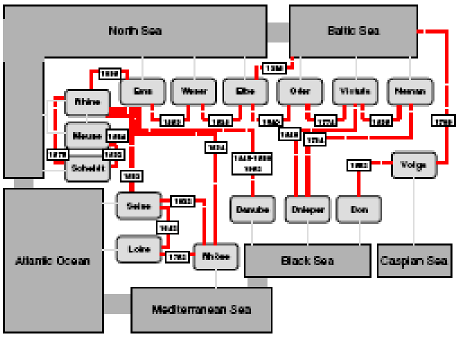
Table 1 Connections of European rivers via canals (Fig. 2 visualises the European network of inland waterways)

Canal	Connection between rivers/seas		Year of opening	References
Elbe-Lübeck Canal[i]	Elbe	Baltic Sea	1398	www.en.wikipedia.org
Havel-Oder Canal	Elbe	Oder	1640[a]	Galil et al. (2007)
Canal de Briare	Seine	Loire	1642[b]	www.belugas-on-tour.de
Friedrich-Wilhelm Canal[j]	Elbe	Oder	1668[c]	www.de.wikipedia.org
Mariinsk Canal System	Volga	Baltic Sea	1709[d]	www.en.wikipedia.org
Bydgoszcz Canal	Oder	Vistula	1774	www.britannica.com
Oginsky Canal	Dnieper	Neman	1784[e]	Karatayev et al. (2008)
Canal de Centre	Loire	Rhône	1792	Galil et al. (2007)
Canal de Bourgogne	Seine	Rhône	1832	www.en.wikipedia.org
Charleroi-Brussels Canal	Meuse	Scheldt	1832	www.en.wikipedia.org
Rhône-Rhine Canal	Rhine	Rhône	1834	Galil et al. (2007)
Ludwig Canal	Rhine	Danube	1846[f]	Galil et al. (2007)
Dnieper-Bug Canal[k]	Dnieper	Vistula	1848	Karatayev et al. (2008)
Rhine-Marne Canal	Rhine	Seine	1853	Galil et al. (2007)
Canal de la Meuse[l]	Meuse	Rhine/Seine	1884	www.de.wikipedia.org
Hunte-Ems Canal	Ems	Weser	1893	www.de.wikipedia.org
Dortmund-Ems Canal	Rhine	Ems	1899	Galil et al. (2007)
Rhine-Herne Canal	Rhine	Ems	1914	Galil et al. (2007)
Meuse-Waal Canal	Rhine	Meuse	1927	www.nl.wikipedia.org
White Sea-Baltic Sea Canal	White Sea	Baltic Sea	1932	Galil et al. (2007)
Mittelland Canal	Weser	Elbe	1938[g]	Galil et al. (2007)
Augustow Canal	Vistula	Neman	1938	www.it.mazury.pl
Volga-Don Canal	Volga	Don	1952	Galil et al. (2007)
Scheldt-Rhine Canal	Rhine	Scheldt	1975[h]	www.rijkswaterstaat.nl
Main-Danube Canal	Rhine	Danube	1992	Galil et al. (2007)

[a] In 1746 re-opened after major constructions
[b] Galil et al. (2007) give 1842
[c] Earlier link between Elbe and Oder via Havel-Oder Canal
[d] Date of first connection, Galil et al. (2007) give 1810/1964 as dates of completion of this canal system
[e] Probably closed in 1915
[f] Closed in 1950
[g] This canal connects the rivers Ems and Elbe through the Weser; in 1893 the rivers Ems and Weser were also connected by means of the Hunte-Ems Canal
[h] After 1986 free of tidal influence
[i] Elbe-Trave Canal or Stecknitz Canal
[j] Müllroser Canal
[k] Krolewski Canal
[l] Links up with Rhine-Marne Canal

Fig. 2 Connections between the river Rhine and large rivers in Europe via canals and sea routes

Fig. 2 Connections between the river Rhine and large rivers in Europe via canals and sea routes (*Light grey boxes*: large rivers; *dark grey boxes*: receiving seas; *continuous lines*: natural discharge; *dotted lines*: main artificial canal systems including dates of completion/opening up of canals)



12.3. RBMP and inland waterway transport

Extract of selected information from inland water way transport and RBMPs
Examples/cases

12.4. WFD and inland navigation

12.5. Primary sources:

WFD Navigation Task Group participation in CIS activities
http://www.pianc.org/euwfdcisactivities.php

Pressures and measures in RBMPs (DG ENV project 2011/12)

3b Drivers for hydromorphological alterations
- Navigation

Activities
- Catalogue on HYMO measures
- Measures classified according to categories
- Evaluate the effectiveness of measures (indicators)
- Modelling
- Stakeholder workshop

13. Towards sustainable flood risk management

13.1. Introduction (setting the scene)

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 water courses 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.

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.

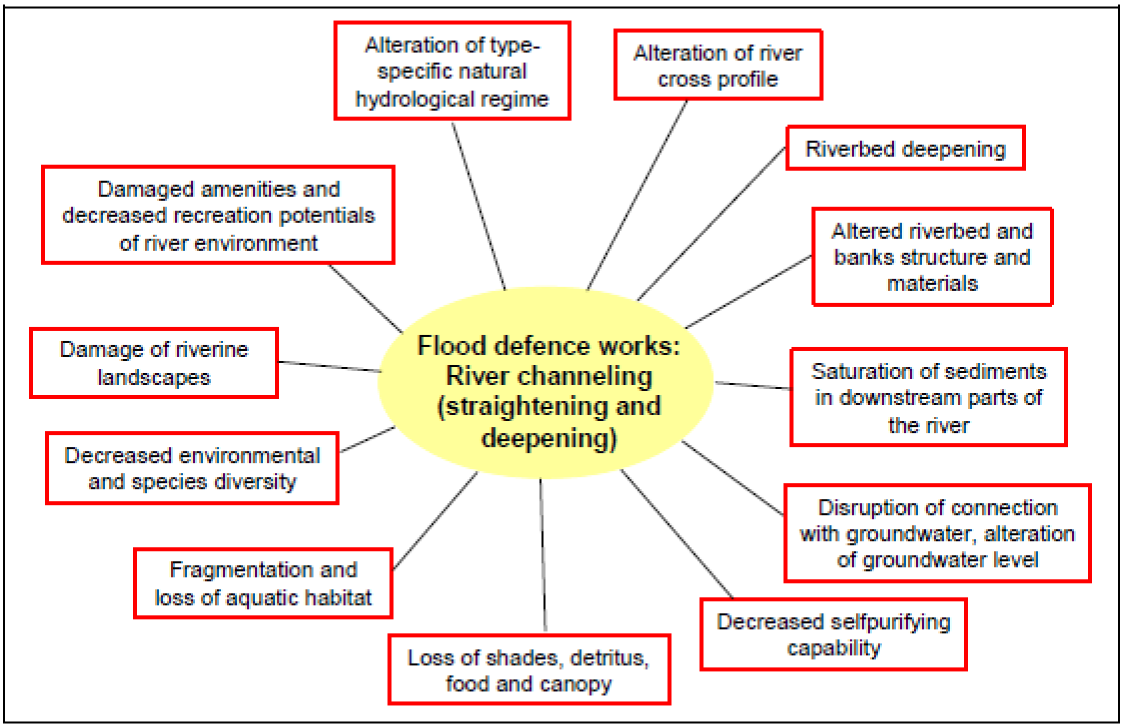


Figure 4c: Illustrative range of possible ecological alterations and impacts typically associated with flood defence works – river corridor channelling (straightening and deepening).

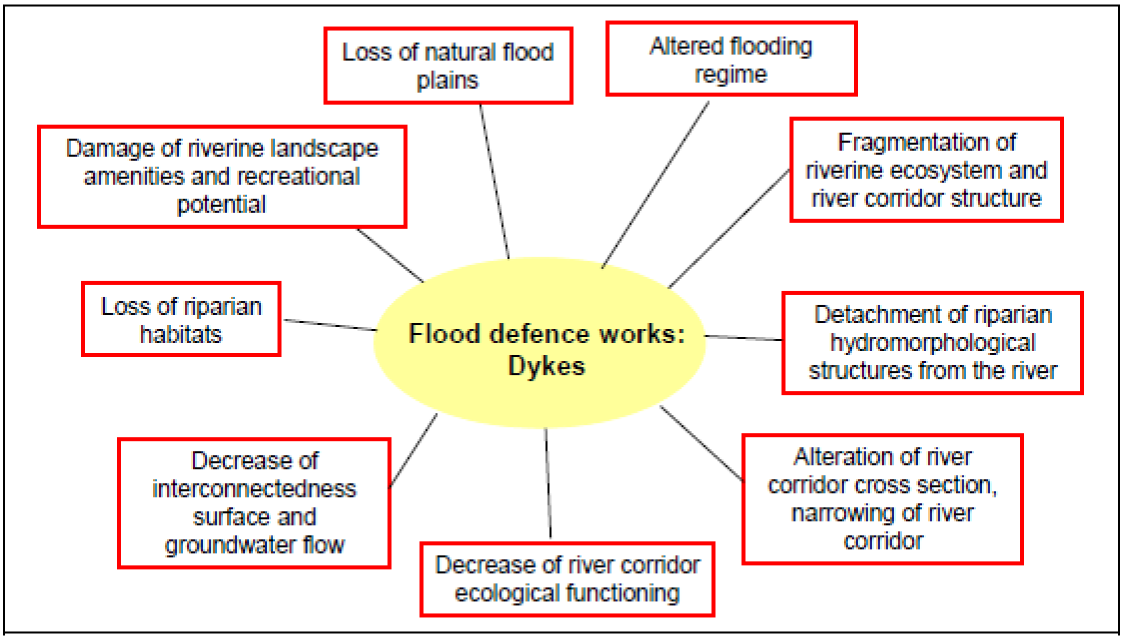


Figure 4d: Illustrative range of possible ecological alterations and impacts typically associated with flood defence works – dykes.

13.2. Overview of flood defense activities (in Europe?)

13.3. 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).

As a spin-off from national activities and EU Life funding, there have been a number of initiatives to restore European rivers and riverine habitats during the past decade. One example is the river Skjern

Å in Denmark, the largest nature restoration project in Northern Europe. Over a period of 3½ years about 40 km of new watercourse have been excavated and regulated. The result is more or less a return to the river bends of the Skjern Å in 1900. Restoration work has included the removal of unnecessary dikes, pumping stations, bridges and roads costing a total of EUR 40 million.

14. Environmental flows

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).

2.2.2 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.

2.2.3 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.

15. 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 (Box 8).

Box 8: 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.

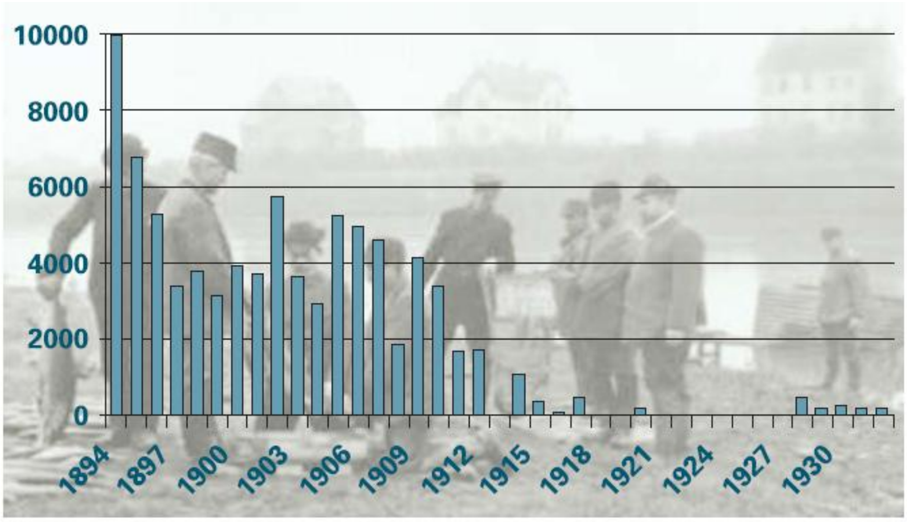
Over the past two centuries, the connection of the Rhine with other river catchments through an extensive network of inland waterways has allowed macro-invertebrate species from different bio-geographical regions to invade the river. A total of 45 such species have been recorded. Transport by shipping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

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

16. 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 should be described here.

Salmon in the Weser



Entwicklung der Lachsfänge in der Weser zwischen Hameln und Elsfleth.
Hintergrund: Abstreifen von Lachsen an der Weser um 1900.