
Rhine
for everyone!
IKSR
CIPR
ICBR

Imprint

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Paintings of Michael Apitz „Rüdesheim im Gewitter" and „Rheininsel"
The river landscape of the Rheingau and Middle Rhine is familiar to the artist since his childhood and is a basis for his experimental search for new imagery (see apitz-art.de).

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The Rhine

- is 1,233 km long and connects the Alps with the North Sea
- is an old settlement axis with rich urban culture since Roman times
- today represents the most important economic axis in Central Europe
- with its natural treasures and unique cultural landscapes it fascinates visitors from all over the world
- and its tributaries cover a **catchment area** of about 200,000 km²
    - all sources, brooks and rivers in this catchment pour into the North Sea
    - 60 million people are living in the 9 states of this catchment
    - 30 million people drink treated Rhine water.

30 years ago, following a chemical accident near Basel, life in the Rhine was extinct along large stretches.

How clean is the Rhine today?

Which animals and plants are living in the Rhine today?

© Donald A. Swanson / USGS

EU-pictograph for environmentally hazardous substances

© R. Hald dpa

After the Sandoz accident in 1986, tons of eel were disposed of and Rhine alarm was raised until downstream in the Netherlands

Looking back on: Disasters along the Rhine

First traces of human settlements in the Rhine valley date back to more than 13,000 years. In the late ice age, hunter-gatherers used primitive vessels on the Rhine. The primeval Rhinelanders experienced a **natural disaster:** In the Eifel, a volcano erupted where the Laacher Lake is located today. This eruption was much stronger than that of Mount Vesuvius in 79 AD or that of Mount St. Helens in the United States in 1980 (above). Streams of lava flowed down to the Rhine and, together with erupted pumice stone and ashes it created an impressive dam. The Rhine dammed up into a great lake - until the dam broke! A gigantic flood- and sludge wave rushed through the Rhine valley until where Cologne is located today ...

Thirty years ago, a man-made **chemical disaster** occurred along the Rhine. in 1986, a warehouse for chemicals of the Sandoz works near Basel in Switzerland burnt down. Highly toxic, pesticide-containing wastewater flowed into the Upper Rhine, turned the water blood-red and caused the worst fish death in the history of the river. For weeks, the riparian waterworks from Germany to the Netherlands could not use Rhine water for drinking water production. This chemical accident marked a turning point for the Rhine. People in the Rhine basin were stirred up.

Only man experiences disasters, as far as he survives; nature does not know any disasters

Max Frisch (1979)

Z'Basel an mi'm Rhi,
io dört möchti sy!
Weiht nit d'Luft so mild und lau,
und der Himmel isch so blau
an mi'm liebe Rhi

Johann Peter Hebel (1760-1826)

When growth becomes the ultimate good and is not being controlled by an independent and moral instance, a disaster will rapidly occur

Yuval Noah Harari (2015)

States in the Rhine catchment

ICPR headquarters in Koblenz

Insight International Rhine

9 states share the Rhine catchment with its countless sources, brooks and tributaries.

The **ICPR - International Commission for the Protection of the Rhine** - faced two challenges:

1. How can 9 states be brought together around one table?
2. How can water use and water protection be reconciled?

The ICPR was founded in 1950 and, to begin with, it above all fought against using the Rhine as a sewer. In 1963, the riverine states instructed the Commission to closely investigate into the pollution of the Rhine, to propose measures aimed at protecting the Rhine and to prepare international treaties. In 1976, the European Union joined the Commission as Contracting Party. High officials from the states along the Rhine take turns in the presidency of the ICPR. Conferences of Ministers are regularly staged and experts participate in the about 20 international working groups meeting periodically. The work is coordinated by the secretariat in Koblenz.
Thanks to the contribution of the ICPR, the Rhine is connecting people and countries in Europe: Victor Hugo's vision may still become true.

Le Rhin à tous! - The Rhine for everyone!
"Let us be the same Republic, let us be the United States of Europe, let us be the continental federation, let us be European liberty, let us be universal peace!"

Victor Hugo
(Speech to the National Assembly, 1871)

Sustainable development

In 1987, after the chemical disaster the states along the Rhine triggered the **Rhine Action Programme.** The target was to cut the pollutant load by half, to revitalize the ecosystem and to enable salmon to return to the Rhine. Additionally, a Warning and Alarm Plan aimed at rapid reporting of accidents.

The European Union boosted the project: With the **Water Framework Directive** in 2000 and with the **Floods Directive** in 2007. In these directives, river districts are considered as entities, respectively as ecosystems and the target is set for all water bodies to achieve the "good status" and to reduce flood damages. The public is to participate in achieving these objectives. The corresponding comprehensive ICPR programme is **Rhine 2020.**

Based on inventories, monitoring programmes and management plans the states along the Rhine aim at jointly achieving three targets:

1. Rhine water is to become **cleaner.**
2. The Rhine ecosystem is to recover **biologically**
3. **Flood prevention** is to be improved.

Sustainable development is the guiding principle. We aim at managing the Rhine and its banks with such respect that future generations may still be able to use it: For recreational purposes, as a navigation lane, as a source for drinking water, cooling water and energy and, not least, as a receiving water for treated wastewater.

Europe … is in urgent need of a strong vision uniting the old and valuable ideals such as peace, humanism, enlightenment, international friendship, and the welfare state bundled with the ideal of sustainability in such a way that all together may develop an outstanding profile

Reinhard Loske (2016)

Iffezheim fish passage on the Upper Rhine

Rhine 2020

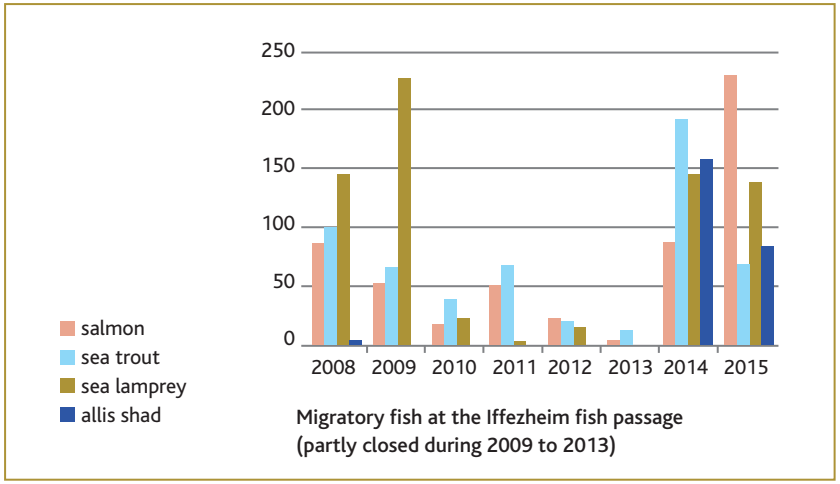
Drawings: Bibliothèque nationale de France, Lamprey: E. Edmonson + H. Chrisp

ICPR Master Plan Migratory Fish
Migratory fish alternate the waters they live in. Many species migrate from the sea into the river to spawn, the eel migrates downstream to spawn in the sea. Salmon, sea trout, sea lamprey and allis shad are supposed to be able to migrate upstream the Rhine as far as Switzerland.

Rhine & Salmon 2020

The Rhine Action Programme was very successful and the aim was achieved to enable migratory fish such as salmon to return to the Rhine and its tributaries.

We must now head for a new, demanding goal, which is the development of stable populations of migratory fish capable of natural reproduction and maintenance of stock without any stocking exercise. Hence, the programme Rhine 2020 is targeted at the biological diversity of the Rhine system. Apart from migratory fish, many typical plants and animals which used to colonize or colonize the river today, its tributaries and alluvial areas belong to the ICPR fosterlings. Other fish species follow in the wake of the salmon, as do water fowl, fish otter, beaver and the river pearl mussel.



Migratory fish at the Iffezheim fish passage (partly closed during 2009 to 2013)

Actions

1. Restore biotopes
2. Reconnect alluvial areas
3. Improve river structures
4. Remove migration barriers and connect biotopes as close to nature as possible, e.g. by creating bypasses or fish passages.

From the green depths of the offshore Atlantic many paths lead back to the coast. They are paths followed by fish …

Rachel Carson (1962)

1 Clean Rhine? – Chemistry

Is today's Rhine water cleaner?
Yes, during the last decades the water quality has clearly improved!
The pollution caused by wastewater has distinctly decreased. It is not possible to directly drink Rhine water, but 30 million inhabitants use Rhine water treated in water treatment works.

Can we bathe in the Rhine?
No - not as far as the main stream downstream of Basel is concerned, as it does not meet the hygienic requirements for EU bathing waters. Also, strong currents and navigation may threat the lives of the swimmers.

Is fish from the Rhine edible?
Yes, but not all and only to a certain extent. Often, fish from the Rhine contain toxins such as dioxins and mercury, e.g. originating from historic contamination and burning charcoal. Therefore it is not recommended to eat great quantities of Rhine fish. Salmon are protected all year long and there is a ban on salmon fishing.

Is the water being completely cleaned in wastewater treatment plants?
No - there are some pollutants which most treatment plants do not completely eliminate today, such as residues of pharmaceuticals contained in urine and hormone active odiferous substances from detergents. The concentrations of these trace substances or **"micropollutants"** in the Rhine are very low and approximately correspond to the concentration of a pill dissolved in a swimming pool. However, little is yet known about their effect on water ecology. But scientists are warning: Traces of analgesics may harm fish kidneys and oestrogens in wastewater may feminize male fish.

Water is the principle of all things; all things are created from water and all things return to water.

Thales of Milet
(625-545 BC)

Industry & power plants
Heavy metals (lead, cadmium, nickel, mercury)
Stable organic substances (e.g. PAH, PFC)
Plasticisers (phthalates)
Biocides

Historic pollution
Chlorinated hydrocarbons (e.g. HCB, PCB) PFC

Households & hospitals
Pharmaceuticals, hormones
Radio-opaque agents
Sweeteners
Pesticides, incl. biocides (e.g. the herbicide glyphosate, wood and fassade protection)
Plasticisers

Agriculture
Fertilizers (nitrogen + phosphorus)
Pesticides (herbicides, fungicides, insecticides)
Antibiotics, hormones

Navigation
Oil, PAH, benzene

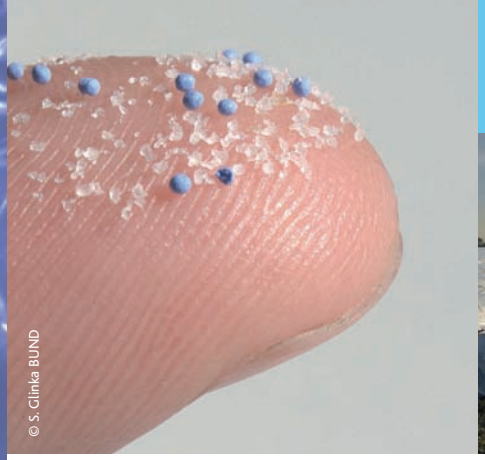
1a Problematic substances

Why does the list of noxious substances become ever longer?
- because it has become easier to detect pollutants
- because new pollutants are being produced.

These substances accumulate in the tissues of plants and animals and even penetrate the germ cells to shatter or alter the very material of heredity upon which the shape of the future depends.

Rachel Carson (1962)


© Fraunhofer Umsicht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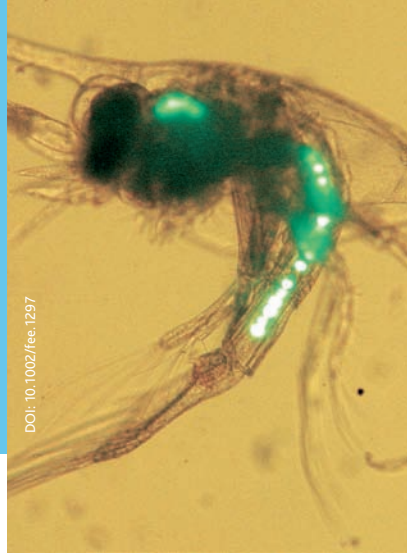

DOI: 10.1002/fee.1297

Microplastics in zooplankton

The amount of synthetic materials we have produced since the beginning of the plastic age is already sufficient to wrap the entire Earth into six layers of plastic film.

Werner Boote (2009)

1b Plastic waste

Worldwide, the production of synthetic materials has increased. We use synthetic materials in many objects of everyday usage. Today, macro- and micro plastics are to be found in all waters of the Earth, and in the Rhine. Rivers are transporting plastic waste into the seas where it increasingly poses a threat to ecosystems. Every year the Rhine carries several tons of plastic particles into the North Sea.

Where does this plastic come from? After all, waste sorting is a standard the population along the Rhine has lived up to for years. But there are still people, who do throw plastic packaging or bigger plastic objects into nature or directly into the waters. Plastic is "indistructable". And that is the main problem: it is hardly biologically degradable. It takes 10 to 20 years for a plastic bag and 450 years for a plastic bottle to be degraded into ever smaller particles - which however remain in the waters.
Micro plastics in water bodies does not only originate from packaging. Often, plastic spheres are added to cosmetic products. When washing synthetic clothing, synthetic fibres are detached. This micro plastic flows into the wastewater and then into the water bodies, as most wastewater treatment plants are not capable of retaining it.

Plastic waste in the Rhine is a phenomenon, which has not been investigated into for a long time.

I declare the plastic waste in the seas
to be art
...
I thank plankton
to stow my art
that my art reaches the food chain
that everybody may share it
I thank the washing machines
that they flush fibres from fleece
and other synthetic clothing
into the wastewater and thus into my art

Arne Rautenberg (2014)

Philippsburg nuclear power plant

Shutting down some nuclear power plants between Karlsruhe and Mainz (e.g. Philippsburg block I) has already led to a perceivable reduction of Rhine water temperatures near Mainz.

Frozen Rhine near Worms 1929

1c Thermal pollution & climate change

When industry and power plants take in water from the Rhine and discharge it back into the Rhine at higher temperatures, the river temperature will rise. However, during the last few years, Rhine water has been less used for cooling water purposes, as some nuclear power plants along the Rhine and the Neckar have been shut down.

But it is proven that climate change also leads to higher air and water temperatures. During the last decades, higher air temperatures have increased the average water temperature of the Rhine by 1 to 1.5 °C. During the past decades, the number of days with water temperatures in excess of 22 °C considerably increased. This may have a detrimental impact on the Rhine water quality. With rising water temperatures, the oxygen content will fall. This harms sensitive organisms in water bodies, e.g. the larvae of mayflies as, with rising temperatures, their metabolism needs even more oxygen. On the other hand, due to the thermal pollution, heat-tolerant new species (→ 2c) may spread to a greater extent in the river.

Climate change not only affects water temperatures, but the entire water cycle. More frequent floods and low waters are to be expected (→ 3c).

Some day our grandchildren will hike through Alps almost bare of ice

Mauro Fischer (2015)

Emscher wastewater treatment plant

Port of Rotterdam (satellite photo)

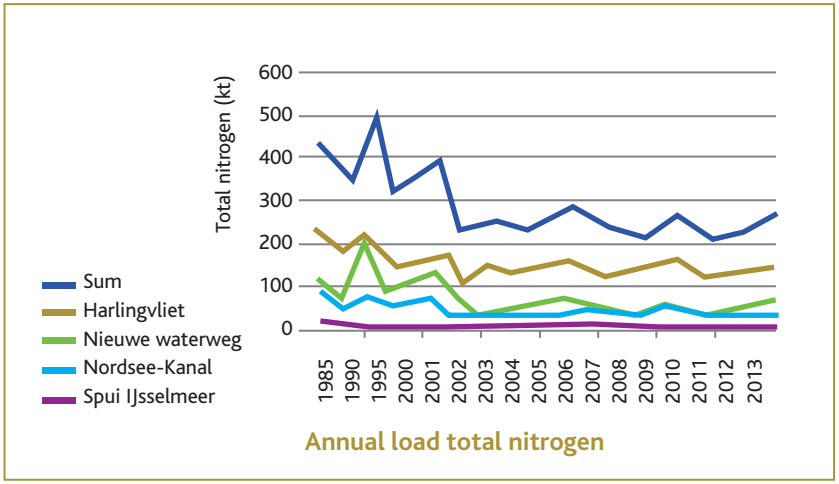
1d Treatment Plants

Success for Water Quality

- Today, 96 % of the households of the 60 million inhabitants in the Rhine catchment are connected to treatment plants.
- The oxygen content of Rhine water and the species number of small animals living on the river bottom have distinctly risen.
- Nitrogen and phosphorus discharges have been heavily reduced.
- The quantities of further pollutants which the Rhine carried into the North Sea have been clearly reduced, as these substances are eliminated more effectively in wastewater treatment plants or as they have been substituted (e.g. heavy metals and AOX) or their production has been stopped.
- Also, international conventions to reduce certain pollutants or national bans on substances (e.g. atrazine) have entered into force.
- Formerly, the city of Rotterdam had to dispose of 10 million cubic meters of polluted Rhine sludge from the harbour basin into the hazardous waste landfill "de Slufter" every year, today this quantity has sunk to about 1 million cube meters per year.

Of all our natural resources water has become the most precious.

Rachel Carson (1962)



The nitrogen load of the Rhine has sunk from 500,000 tons in 1995 to below 300,000 tons in 2013.

Following the Sandoz accident, a new monitoring station jointly operated by Switzerland and Germany was established in Weil am Rhein near Basel in 1993.

Applying manure with drip hose booms reduces nutrient losses and unpleasant smell

1e Less is more

The laws of the European Union and Swiss laws require the good chemical and ecological status for all water bodies. The ICPR states: By 2015, these goals were not achieved. Thus, a certain number of measures must still be taken to protect surface and groundwater bodies. Basically, it is quite simple: **Less discharges into water bodies is more for water quality.**

... is it possible that, in future we might find it too expensive to use the Rhine as an abundant source of good drinking water?

Ragnar Kinzelbach (1979)

What remains to be done?

- Point source inputs of pollutants must be reduced by improving wastewater treatment from industry and households
- The inputs of diffuse, thus widespread origin - in particular of agricultural origin - must be reduced by:
  - spreading less nitrogen and phosphorus with manure and fertilizers and keep these substances away from the river by applying agricultural measures such as catch crop cultivation, erosion protection and river bank strips;
  - using less and only targeted and appropriate chemical plant protection agents;
  - bringing historical waste to landfill sites for hazardous waste.
- Reduce the input of micropollutants by:
  - not authorising noxious substances;
  - reducing their use in industry and households;
  - not flushing pharmaceuticals in the toilet and largely do without chemical plant protection in gardens;
  - add a further treatment stage to the most important wastewater treatment plants (e.g. active carbon filter, ozonization, etc.).

Biology Monitoring Programme:
Periodic inventories of the biocoenosis in the Rhine document and assess their state.

European sturgeon ***Acipenser sturio***
Bibliothèque nationale de France

2 Living Rhine? – Biology

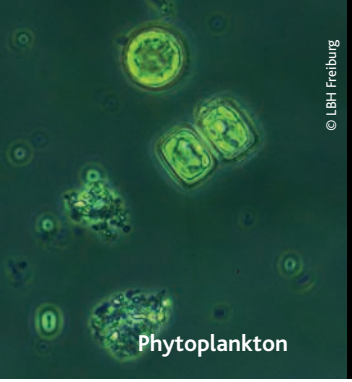
How many fish species are living in the Rhine today?
64 - all but the sturgeon have returned! The species number is almost complete, but the species composition is different from what it used to be. Today, two immigrated goby species and carp species such as roach are dominating.

Are there other animals in the Rhine?
Apart from fish, the Rhine fauna consists of worms, mussels, snails, crustaceans, insects, birds and mammals. From the Alpine Rhine until the North Sea, more than 500 invertebrate species - called macrozoobenthos were detected on the bed of the Rhine.

What plants are living in the Rhine?
Algae, the so-called phytoplankton, such as green algae and cyanobacteria are floating in the water. Diatoms live on the river bed. Higher species of water plants, mosses and stoneworts are living on the river banks and in side waters.

Do you know how many ...?
... little flies play
In the bright summer heat?
How many little fishes cool themselves
In the clear water tide?

Lullaby by Wilhem Hey (1837)

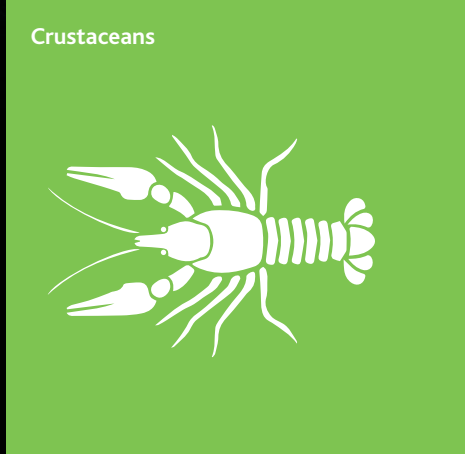


Algae floating in the water multiply when the nutrient content e.g. of nitrogen and phosphorus rises.

Water flea and copepods feed on phytoplankton algae.

The river nerite ***Theodoxus fluviatilis*** lives on diatoms browsed from stones. Its spreading in the Rhine indicates ecological improvement.

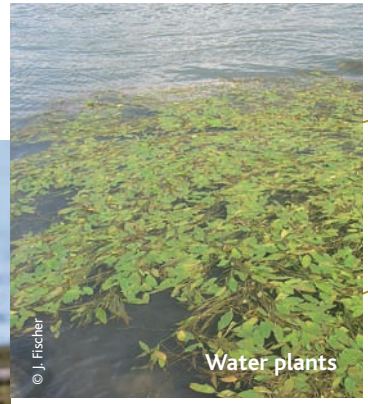
The mayfly ***Ephoron virgo*** only flies for one summer evening, and then there are swarms of them. For a year, its larvae live on the sandy-gravelly river bottom of the Rhine and filter the smallest food particles from the Rhine water.



Crayfish are omnivorous, they feed on insect larvae, molluscs, fish and plants.

2a Biological diversity

The Rhine ecosystem consists of a large variety of plant and animal biocoenosis and species interconnected by food chains and other relationships. Here are some examples for such relationships:



Potamogeton nodosus disappears with rising nutrient pollution.

In the swamps and the alluvial forests along the Rhine there is a species-rich birdlife, e.g. the gray heron ***Ardea cinerea***, feeding on fish, frogs, mice and insects.

The roach ***Rutilus rutilus*** feeds on invertebrates, such as amphipods and zooplankton.

Fish passage near Gambsheim

Stocking salmon smolts

The Atlantic salmon is back in the Rhine.

Salmon used to be an important species for commercial fishing in the Rhine and, as the many field names such as Salmengrund, Salmenwört, Salmenwiese along the banks indicate, salmon used to be caught in great quantities everywhere along the Rhine …

Robert Lauterborn (1917)

2b Hiking is the salmon's delight …

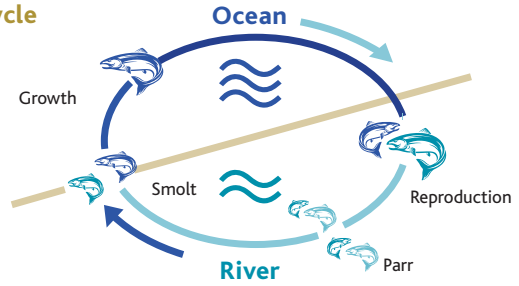
As late as the 18th century, the Rhine was considered to be the most important and the biggest salmon river in Europe and salmon was an important species for commercial fishing. With the beginning of the 19th century, hydraulic engineers constructed more and more weirs, dams and barrages in the Rhine and its tributaries. That was a good thing for navigation, power plants and flood control, but a bad thing for migratory fish. During the 19th century, the pollution of the Rhine with wastewater from households and industry increased and reached its peak in the mid-20th century. Rhine salmon died out in the 1950s.
After the Sandoz accident and the great fish death in 1986, the ICPR and its Rhine Action Plan developed its full effect to revitalize the river basin.

Master Plan Migratory Fish
In future, salmon and other migratory fish species such as sea trout, sea lamprey and allis shad are supposed to be able to migrate upstream into Switzerland, reproduce naturally and thus be self-sustaining. By 2012 and with a view to achieving this target:

- Some 500 barriers in the Rhine system were made passable for fish
- About 80 alluvial water bodies were reconnected to the river
- About 20 % of the spawning habitats were again accessible.

Since about the year 2000, annually several hundreds of salmon again migrate upstream as far as the Upper Rhine and reproduce naturally in the accessible salmon waters of the Lower, Middle and Upper Rhine. This gives hope to achieve stable stocks of wild salmon.

Salmon Cycle



In springtime, salmon hatch from the roe in the gravel bed of small brooks in Europe and North America. After 1 to 2 years, they have developed to silvery smolts and migrate downstream into the sea. In the Atlantic Ocean they travel to the feeding grounds around Greenland, where they feed on crustaceans and smaller fish and grow rapidly. Salmon which are mature to spawn swim thousands of kilometres through the Atlantic Ocean and back into their home rivers and migrate upstream into the waters where they once hatched.

Via the Rhine-Main-Danube Canal the **round goby** *Neogobius melanostomus* (photo eggs) has immigrated from the Black Sea into the Rhine system.

The **Egyptian goose** *Alopochen aegyptiacus* has fled from European zoos and is spreading from the Netherlands upstream the Rhine system.

For some time, the **Asian clams** *Corbicula* were the most common mussel species in the Rhine but are today declining, which might be due to reduced thermal discharges.

Nuttall's waterweed *Elodea nuttallii* is of North American origin.

The **spinycheek crayfish** *Orconectes limosus* originally came from North America and is crowding out the European crayfish.

2c New Rhine species

Numerous non-indigenous species - so called alien species have immigrated into the Rhine system by canals from far away countries or attached to the hulls of ships and have been released by fishkeeping stores. At first, many new species reproduce massively and then decline.

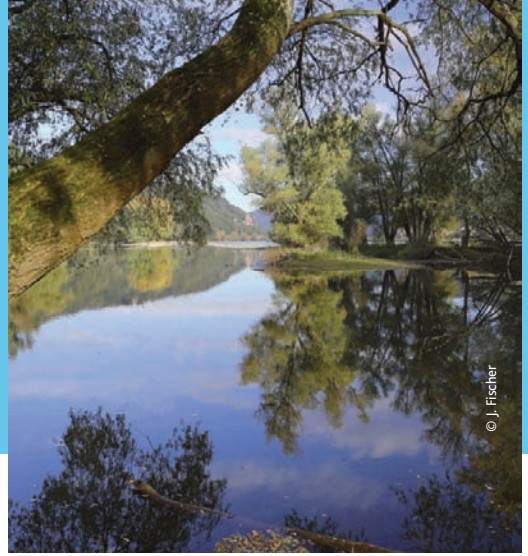
Invasive animal and plant species (at times) crowd out native species and may be a threat to natural ecosystems.
Some of the new species in the Rhine are considered to be **invasive**, such as the round goby. The goby benefits from the stone blocks of artificial bank stabilization structures where it oviposites. Superfluous stone blocks in shallow banks and slip-off slopes along the Rhine and its tributaries could be removed, thus also removing the spawning grounds of gobies. As a matter of principle, invasive new species have less chances to settle in undisturbed or restored, nature-near biotopes.

Since the last ice age, Central Europe has been characterized by immigrants. Therefore, wildlife has again and again been forced to cope with newcomers.

Ragnar Kinzelbach (2010)

Small animals and fish may use such rough ramps for upstream migration.

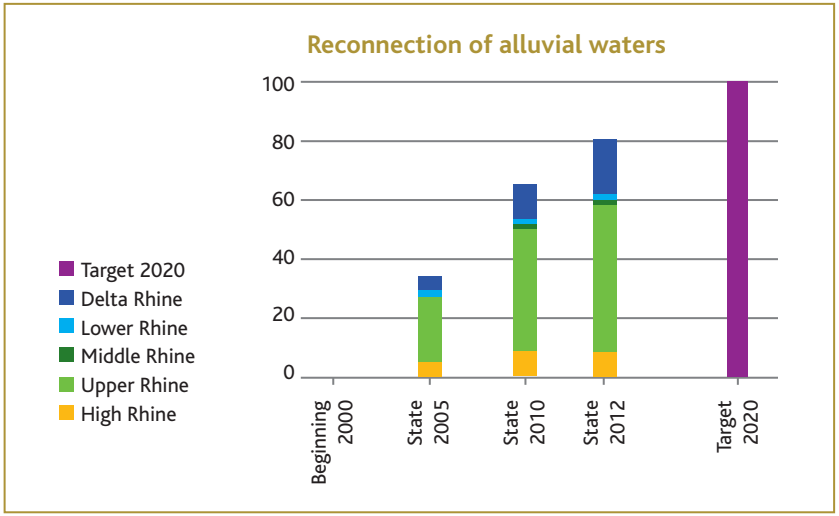
A good Sign
In 2015 and compared to previous years, the biomass of plankton algae in the Rhine has sunk,
- as less nutrients enter the river
- because indigenous and immigrated species, such as mussels filter out the algae



2d Ecological Balance

The range of fish species in the Rhine is almost complete again. Many small animals and water plant species have also returned to the Rhine. Thus, the ecological network is in a distinctly better state than in the 1980s.
This result was achieved by improved wastewater treatment and more river continuity. For the first, less nutrients and pollutants are being discharged into the Rhine and secondly, obstacles have been removed or opened in order to enable the migration and natural exchange of biocoenosis.

Today's biological diversity in the Rhine is different from that in former times, as many new species have settled, which will remain part of the future water system. Measures aimed at restoring waters and removing obstacles to migration will favour indigenous species and strengthen the ecosystem.



Between 2000 and 2012 many alluvial areas were reconnected with the river.

Groynes along navigation lanes can be designed in an ecologically effective way.

Screens are supposed to keep fish away from hydropower turbines.

Freely flowing section of the High Rhine at the Thurspitz: confluence of the R. Thur and the Rhine

Most of the processes involved in the structure and function of river ecosystems are controlled by floodplain forests

Henri Décamps (1996)

2e Protect nature

The ecological balance has shown: Much remains to be done. Along the main stream of the Rhine, the possibilities for nature protection are less than along some tributaries in the Rhine system, as many structures are determined by river works. But we can still do a lot.

In the years to come, further oxbow lakes of the Rhine and old floodplains will be reconnected with the river. This means more room for the river and its organisms. At the same time, this means improved flood prevention for people. Monotonous river banks along the main stream may be broken up. Groynes may secure the navigation channel and the banks. Groynes are short dams established from the banks and perpendicular to the flow direction. They may serve as replacement for natural biotopes in the river, as, between the different groynes the current and lapping of waves calm down, sand and gravel banks establish and water plants will settle. Juvenile fish and small animals living on the river bottom thrive in such groyne fields.

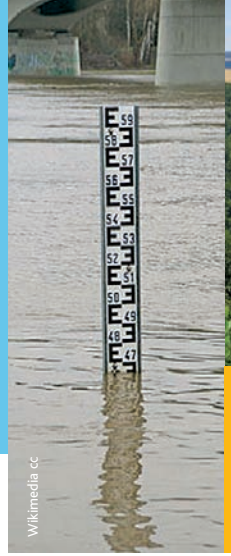
Many weirs out of use have been removed and at the barrages in the Rhine system bypasses and fish passages have been constructed which the river fauna may use for upstream migration (→2b). For the time being, the downstream migration remains problematic, as fish are injured or die in the turbines of hydropower plants. Protective screens and „fish-friendly" turbines are already being tested.

What remains to be done?

- Protect and restore freely flowing sections and habitats in alluvial areas and on the islands in the Rhine
- Make the structure of river banks and riverbed more natural
- Remove superfluous stabilization structures, e.g. riprap fills at slip-off slopes
- Protect downstream migrating salmon, eel and other fish against getting into the turbines
- Remove additional migration obstacles
- Change to more extensive agriculture along the banks and in the floodplain

Matthäus Merian 1645

Bacharach on the Middle Rhine in 1645, engraving by Matthäus Merian



Wikimedia cc

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Commercial shipping may today pass the bottleneck at the Loreley.

3 Wild Rhine? – Physics

What did the Rhine valley look like formerly?
In the 19th century, when the first tourists discovered the romantic Middle Rhine, the river was wild and untamed. In 1800, Clemens Brentano wrote the ballad of Lore Lay "In Bacharach on the Rhine". The shallows and currents at the Loreley rocks dangerous for boatmen led to further variations of the tale and lastly to the famous song by Heinrich Heine. Since then, the rocks in the river have been blasted away and the riverbanks have been stabilized. The training of the Upper Rhine began as early as 1817 (→3b).

Why do floods occur?
Varying water levels are normal in running waters. During the different seasons floods and low water are caused by precipitation and snow melt or dry periods.

What room does the river need?
In natural rivers, floods spread to the floodplains. Floodplains are valley areas which are naturally flooded, retain water and reduce flow velocity. Vast floodplains did not exist along the High and Middle Rhine, but along the Upper and Lower Rhine and in the Rhine delta.

The floodplain in the area of influence of inundations acts as contact area between the river and the land. Biocoenoses of floodplains and rivers are interconnected by a diversified network. Together with the Wadden Sea, the rivers and their floodplains used to be among the most species-rich and productive ecosystems in Europe.

Wild braust der Rhein über tief verborgne Klippen und spitzige Felsenriffe, schäumend brechen seine Wogen sich an den uralten Mauern der Stadt und toben gegen sie an …

Johanna Schopenhauer (1834)
über den Rhein bei Bacharach

© B. Froehlich-Schmitt

Alluvial forests of the Rhine - here the Hördter Rheinaue - fill up underground aquifers, retain floods and are an oasis of biological diversity.

Naumann (1901), Naturgeschichte der Vögel

Wikimedia cc

Strasbourg 1720

3a Dynamics is part of the river

In 1770, when Goethe looked down from the cathedral in Strasbourg, he saw an ecological wealth of Rhine floodplains which no longer exists today. Of the former 2000 square kilometres of floodplain forest along the Upper Rhine some 150 square kilometres of riverside forest have survived. Along the Lower Rhine and in the Rhine delta, floodplain forests were turned into meadows centuries ago.

Floodplains and riparian zones of untrained rivers are exposed to a continuous change from humidity to drought, sedimentation to erosion, nutrient inputs to leaching. Plant and animal communities have adapted to such dynamics; they not only tolerate them, but they even depend on them.

... die weitumherliegenden, mit herrlichen dichten Bäumen besetzten und durchflochtenen Auen, diesen auffallenden Reichthum der Vegetation, der dem Laufe des Rheins folgend, die Ufer, Inseln und Werder bezeichnet.

Johann Wolfgang Goethe (1811-12)

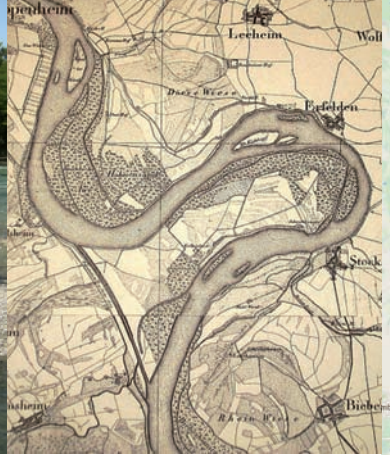
... The height of a flood wave can be reduced by letting water expand to the sides. To be able to do so, the river must be given back its original flooding area, the floodplains, at least parts of it.
... It is the very nature of water to always flow downhill. So, when returning room to the river upstream, the effect will be obtained downstream.

Emil Dister (2013)

View from the Isteiner Klotz upstream towards Basel
(painting, Peter Birmann, around 1800)

© Regierungspräsidium Freiburg – Integriertes Rheinprogramm

Old bed of the Rhine near Istein



Breakthrough of the Rhine at Kühkopf 1829

Today, the Kühkopf on the Upper Rhine is an island

3b As his bed has been made...

The formerly winding and braided river has been straightened, trained and cut off its alluvial areas and oxbow lakes. However, the trained bed of the Rhine is not capable of coping with high flood levels. That means that flood water will then flow into former alluvial areas where people are living and working today. Also, in the main stream, the flood wave flows more rapidly than it would be natural.

The regulation of the Upper Rhine by the engineer Tulla began in 1817. When water workers forced the torrential stream into a stable bed and fixed its course to gain land, they more or less improved navigation as a by-product. Already the Celts and Romans navigated on the Rhine in rowing boats and first cargo vessels. River training for commercial vessels has turned the Rhine into one of the busiest waterways in the world.

Towards the end of the 19th century, Switzerland and Germany started turning the High Rhine into a succession of lakes. The barrage weirs of 11 hydroelectric power plants drowned waterfalls and cataracts. The development with a view to exploiting 10 hydroelectric power plants on the Upper Rhine started in 1928. In both sections of the Rhine the weirs acted as barriers obstructing the way of migratory fish towards upstream regions. Barrages turn rivers into a series of lakes and hinder fish migration. Downstream of weirs, rivers dig deeper, which makes the groundwater level sink in the area, if no countermeasures are taken. Also, many Rhine tributaries were impounded and canalized. Embankments and construction activities in the floodplain lead to higher flood waves downstream and tear apart ecological networks between the Rhine and the surrounding land.

The technical design, the training of brooks and rivers really changes everything that can still be called natural - apart from the element water.

Wolfgang Erz (1936 -1998)

Low water of the Middle Rhine

Before the dike relocation Lent-Nimwegen, formerly

After the dike relocation Lent-Nimwegen, today

3c Flood control

During the 1990s, great floods along the Middle and Lower Rhine caused damages worth millions of euros. That is why, in 1998, the ICPR drafted and implemented an **Action Plan on Floods.**
The Action Plan on Floods applies a "win-win strategy". Ideally, the protection of people and goods along the Rhine and its tributaries is linked to ecological improvement in the floodplains in a manner serving both nature and man.
In 2015, the Action Plan on Floods was updated into the **Flood Risk Management Plan.** It consists of required agreements of all states in the Rhine catchment aimed at being prepared for flood risks.
Today, all EU member states must coordinate their flood prevention in the different river districts. Also, effects of climate change are to be taken into account. Floods and low water are expected to occur more frequently.

What are the targets along the Rhine?

1. Protect people, goods, the environment and cultural heritage against adverse consequences of floods
2. Reduce the risk of flood-related damages
3. Lower flood levels
4. Increase awareness (e.g. risk maps)
5. Improve forecasting and information systems

More room for the river:

= create retention areas along the river

- Open old alluvial areas to the river
- Relocate dikes
- Create controllable retention areas

Der Himmel sendet Regengrüße;
den Leinpfad sperrt der Vater Rhein …

Lieselotte Nerlich (2007)

Flood in Koblenz

Extract of the ICPR Rhine Atlas

Von den Wellen am Rhein
konnte eine nicht ohne die andere sein

Ulla Hahn (1985)

3d Wild Rhine - a balance

Successful flood prevention

- Since 1995 the states in the Rhine catchment have invested more than 10 billion Euro into flood prevention measures.
- The population is being warned at an earlier stage and information has improved.
- By the end of 2014, retention areas had been created on the Upper and Lower Rhine with a capacity of 250 million cubic meters. These areas may be flooded in a targeted manner, hold water and lead it back into the river at a later stage.
- In the Rhine delta, foreshores have been digged off to widen the river bed.
- Certain sections have been restored along tributaries.
- Dikes have been rehabilitated, strengthened or relocated.

Since 1995, the flood risk has been distinctly reduced. Extreme flood levels can be lowered due to retention measures. Maps of flood hazard and flood risk contribute to improve the risk awareness in areas at risk. The information systems have been improved. International cooperation and data exchange have considerably extended forecasting periods.

The Rhine-Atlas

available under **www.iksr.org** (above) indicates the settlements and industrial areas at risk of floods as well as EU nature protection areas and cultural heritage sites along the entire Rhine. It enables a realistic estimation of flood hazard in settlement areas.


© Michael Apitz


© ICPR


Drawing R. Risse 1872

Johanna Sebus.
Nach seinem Oelgemälde auf Holz übergezeichnet von R. Risse in Düsseldorf.

3e All is in flux

Much water has flown down the Rhine since Goethe wrote the ballad of Johanna Sebus who carried her mother through the floods of the Lower Rhine after the breach of a dike and who died, when she tried to help others.

Ich trage dich, Mutter, durch die Fluth,
Noch reicht sie nicht hoch, ich wate gut.

Johann Wolfgang Goethe (1809)

What is the aim of the ICPR for future flood prevention?

- Extend alluvial and retention areas to 535 million cubic meters by 2030
- Improve flood forecasting and grant good information of the public

Locally, additional measures can be taken in the Rhine system which may equally help in cases of heavy rainfall. Precipitation should preferably be retained where it falls, instead of being discharged by canals, as rainwater seeping into the groundwater or slowly flowing into brooks and rivers will lead to less floods.

What remains to be done?

- Avoid constructions in the floodplains of brooks and rivers or adapt construction to flood hazards
- Restore surfaces so that rainwater may seep into the groundwater
- Wherever possible running waters should be given a more natural shape
- Rainwater from roofs and sealed surfaces should not directly be led into the sewer but should be separated.

Falls of the Rhine at Schaffhausen

Conclusion

This brochure points out that the Rhine is in a much better shape today than 30 years ago.

The ICPR programmes (Rhine Action Programme, Rhine 2020) **are successful!**

1. The water quality has improved. Discharges of nitrogen, phosphorus and untreated wastewater from industry and municipalities have distinctly decreased.

2. The Rhine ecosystem is recovering. River continuity has been restored at almost 500 transverse structures. Salmon and other migratory fish can migrate from the North Sea and upstream into the Rhine tributaries south of Strasbourg on the Upper Rhine. Many banks, floodplains, oxbow lakes and sections of tributaries have been restored.

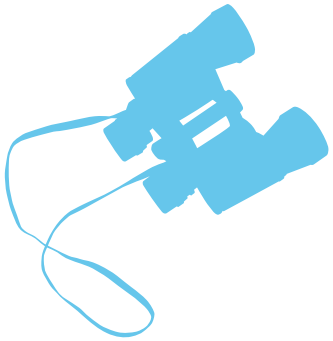
3. Flood prevention is being improved. Many measures create more room for the river and serve floodplain protection at the same time.

Wer will mit uns treiben
auf singenden Wellen,
wer will sich verschreiben
dem strudelnden, hellen
Herzen des Rheins?

Stefan Andres
(1906-1970)

Lebwohl, lebwohl, du schöner,
Du jugendgrüner Rhein!
In's Leben, ach! in's Leben
Muss ruhlos ich hinein.

Carmen Sylva (1884)

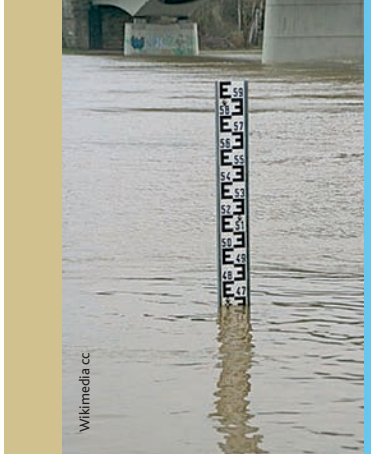


Outlook

The **good status** required by the European Union for surface waters and groundwater since 2000 **has not yet been achieved everywhere.**

There are new challenges, e.g. micropollutants from households, industry and agriculture. Due to climate change, floods and low water are expected to occur more often in future; in addition, regionally heavy rainfall is expected. Much remains to be done by the ICPR and the states in the Rhine catchment in order to complete "Rhine 2020".

1. The spreading of pollutants in the environment must be avoided and wastewater treatment must be improved.
2. Waters in the Rhine system must become more natural. Fish passages are to be built at further barrage weirs on the Upper Rhine and river continuity is to be restored in further tributaries.
3. Climate change requires further flood mitigation measures as well as measures aimed at avoiding ecological and economic damage caused by low water and rising temperatures.



Glossary

Alien species	Non-indigenous plant species (neophytes), animal species, fungus and microorganisms occurring in an area due to the influence of man after 1492 (discovery of America)
AOX	Adsorbable organic halogen compounds (x) are toxic and partly very persistent, e.g. chloroform, DDT, → HCB, HCH, → PCB, PCP, different → pesticides. Industrial chemicals; application: Solvants, propellants, dry cleaner, disinfection, conservation etc.; their presence in the Rhine is caused by point and diffuse sources
Atrazine	Plant protection agent, resp. → herbicide; during the Sandoz accident in 1986, 400 l of a compound containing atrazine and the firefighting water poisoned the Rhine; since then, there is a ban on atrazine in the EU and in Switzerland;
Benthos	Biocoenosis on the bottom of waters
Biocides	Belong to → pesticides; disinfecting agent, material protection product, pest controller
Biotope	Habitat of a species community of plants and animals
Catchment area	River basin or drainage system; surface drained by a river and all its tributaries and their tributaries
Dioxins	Chlorinated organic compounds, persistent pollutants hardly degraded in the environment and accumulating in the food chain; by-product of many thermal processes
Erosion	Abrasion (Latin erodere) of stones and soil due to water and wind. It may be natural or caused by land cultivation
Floodplain	Lowlands along a river which may be flooded periodically. Its characteristic flora and fauna is adapted to these periodic floodings.
Floods Directive (FD)	The purpose of the EC directive on the assessment and management of flood risks (Directive 2007/60/EC) which entered into force on 26 November 2007 is, to reduce the adverse consequences of floods for human health, the environment, cultural heritage and economic activity.
Fungicide	Agent against fungal diseases; → pesticides
HCB	Hexachlorobenzene is a by-product generated during the synthesis of chlorinated hydrocarbons and was formerly used as a → plasticiser agent and fungicide.
Herbicide	Agent against wild plants or weeds, particularly used in agriculture and on sealed surfaces; → pesticides
Hydrocarbons	Organic compound of carbon and hydrogen; chlorinated hydrocarbons (organochlorines) in which hydrogen has been replaced by chlorine (→ AOX), belong to the → priority substances
ICPR	International Commission for the Protection of the Rhine; founded in 1950; Bern Convention 1963, 1999; Contracting parties: Germany, France, Luxembourg, the Netherlands,

Flood in Cologne 1995

	Switzerland, EU; Delegates: Higher representatives from administrations, experts and observers of the states; head office: Koblenz
Insecticide	Agent against insects; → pesticides
Macrozoobenthos	Invertebrate animal species, apparent to the eye, living on the bottom of waters (e.g. snails, mussels, crustaceans, insects); → benthos
Organophosphates	Phosphoric acid ester, highly toxical nerve agent and many → insecticides flowed into the Rhine during the fire disaster in 1986
Oestrogens	Female sex hormone
PAH	Group of polycyclic aromatic → hydrocarbons
PCB	Polychlorinated biphenyls, used to be applied as plasticisers in plastics, transformers and hydraulic fluids; persistent and accumulating in the food chain and in → sediments
Pesticides	Plant protection agent and/or → biocide; mostly artificially produced organic substances, above all used for "plant protection" in traditional agriculture against bacteria, algae, fungus, plants and animals appearing to be detrimental; chlorinated → hydrocarbons and → organophosphates are → priority substances
PFC	Per- and polyfluorinated chemicals, hardly degradable, accumulating in the environment and organisms, detrimental to human health; contained in outdoor and working clothing, papercups, pizza boxes, fire-fighting foams, construction material, → pesticides
Phytoplankton	Floating algae, plant → plankton, e.g. green algae and single-cell organisms, e.g. diatoms and bacteria
Plankton	Organisms floating in the water, which are not able to move against the current
Plasticisers	Phthalates among others, added to plastics, e.g. → PVC, contained in cables, soles of shoes, toys, etc.; → HCB, → PCB
Population	Reproduction community of a species in a defined habitat
Prioritary	Urgent, derived from Latin prior; the → Water Framework Directive includes a list of prioritary substances, to which strict environmental quality standards apply, as they pose a threat to water ecosystems and drinking water supply
PVC	Polyvinyl chloride, producing → dioxins during combustion
Sediment	Sand and sludge settling on the river bottom
Water Framework Directive (WFD)	Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy
Zooplankton	Animal → plankton, e.g. water flea

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Peter Birmann


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for everyone
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