Upstream
Outcome of the Rhine Action Programme

Internationale Kommission zum Schutz des Rheins

Commission Internationale pour la Protection du Rhin

Internationale Commissie ter Bescherming van de Rijn

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Contents

Lazy and indifferent
shaking space easily from his wings
the heron passes ...
beneath the sky.

Virginia Woolf (1921)

Summary

Formerly, it was quite justified to call the Rhine "the sewer of Europe", as the river was chronically polluted by waste water. In 1986, a chemical accident severely poisoned the river and caused a massive death of fish between Basel and Koblenz. The riparian states of the Rhine were forced to act. Their governments charged the International Commission for the Protection of the Rhine (ICPR) to draft a plan aimed at saving the river. One year later the Rhine Action Programme (RAP) was ready for approval. It was designed to thoroughly rehabilitate the Rhine by the year 2000.

With the beginning of the new millennium it is time to strike a balance. The results are impressive: things are looking up for the Rhine.

1) **Water quality has considerably improved** as less polluted waste water is discharged into the Rhine. In plain English: between 1985 and 2000 the point source inputs of most pollutants figuring on the "list of priority substances" have been reduced by 70 to 100 per cent. The percentage of municipalities and industrial plants connected to waste water treatment plants rose from 85 % to 95%. Nitrogen sieving from agricultural soil into the Rhine and fertilizing the North Sea continues to be problematic.
   Some pollutants, e.g. some heavy metals and pesticides do not yet comply with the ambitious ICPR targets values.

2) **Accidents implying substances dangerous to water have been considerably reduced** since the companies along the Rhine are much better prepared for emergency situations. They have implemented the ICPR Recommendations on the Prevention of Accidents and the Security of Industrial plants.

3) **The Rhine fauna has recovered.** Apart from eel, fish caught in the Rhine are again edible. Today, 63 fish species are living in the Rhine, which means that, apart form the still missing sturgeon, the former fish fauna of the Rhine has been re-established. Thanks to recently constructed fish passages at the weirs, migratory fish such as salmon and sea trout may again migrate upstream from the North Sea into the Upper Rhine and some of its tributaries in Alsace and the Black Forest, where they will spawn. However, they can still not reach Basel. The species diversity of the microfauna, e.g. of snails, mussels and insects has risen, even though often undemanding species and recent species predominate.

The successful Rhine programme is being continued. The ICPR and the Rhine bordering countries have a new vision of more room for the Rhine. They plan to open the old alluvial areas to the river and to thus combine nature protection and flood prevention. **"Rhine 2020", a programme aimed at the sustainable development of the Rhine** is meant to implement these targets. At the same time, it serves the EU water framework directive and its main objective, to achieve a "good chemical and ecological state" of the European water bodies.

Since the 1950s, the Rhine had been playing the sad role of being "Europe's greatest sewer". The reverse of the economic boom and of population growth became evident. From the mid-seventies on, when the first waste water treatment plants were put into service, there were first signs of a slight improvement. But still, due to regular inputs and to additional accidents the river continued to cope with large amounts of noxious substances. Then, a major accident occurred. On 1st November 1986 a warehouse of the chemical production site Sandoz at Schweizerhalle near Basel burnt down. Some 20 tons of highly toxic pesticides gained the Rhine together with the fire extinction water and caused the death of fish and the micro-fauna as far as Koblenz. Water intake from the Rhine and from riverbank filtrate serving drinking water purposes was stopped right down to the Netherlands.

The public was deeply shocked. The media criticised that "along the Rhine, an accident is part of every day life". Shortly after the accident the Ministers in charge of the Rhine met, first in Zurich, then in Rotterdam and charged the ICPR to draft a plan which would ultimately eliminate the image of the Rhine as a sewer.

In 1987, the Rhine Ministers approved of the Rhine Action Programme (RAP) in Strasbourg. It was designated to achieve the following targets by the year 2000:

- Fauna species which had vanished from the Rhine, such as the salmon, should again return to live in the Rhine
- Drinking water production from Rhine water should continue
- The pollutant contents of river sediments should be reduced.

Sandoz warehouse fire, 1986

The Rhine Ministers and the Representative of the EU

... unanimously assessed that the warehouse fire in Schweizerhalle had considerably damaged the Rhine ecosystem, which is probably disturbed over a longer period of time. They are deeply concerned and share the concern of the public. The implementation of appropriate measures is aimed at avoiding such accidents in future, or at least at avoiding their consequences for the Rhine by applying the best technical means.

Declaration of the Rhine Ministers on 12 November 1986 in Zurich

Quotation from the Rhine Action Programme

Measures are designed to

- *accelerate the reduction of permanent pollution from direct and diffuse discharges*
- *reduce the risk of accidents, and*
- *to improve hydrological, biological and morphological conditions*

ICPR (1987): RAP, page 3

Conference of Rhine Ministers in Rotterdam, 1986

With the Rhine Action Programme the Rhine Ministers started off the rehabilitation of this great river. Until early 1990 they had the RAP targets put into concrete terms and measures were partly tightened up. The outcomes of periodic conferences of Rhine Ministers were landmarks in model water protection policy on a European scale.

Reduce accidental spills and chronic pollution

After having started off the RAP in 1987, the Bonn conference of Rhine Ministers in 1988 adopted a list of measures aimed at securing industrial plants along the Rhine and at reducing **accidental spills**. These measures concerned

- the stocking of dangerous substances
- the construction of basins collecting fire extinction water
- warning and alert installations

Furthermore, the Rhine Ministers adopted "Minimal requirements for **municipal inputs**" aimed at the further reduction of the chronic river pollution due to waste water inputs.

Protect the North Sea and the Rhine ecosystem

The conference of Rhine Ministers in Brussels in 1989 reacted to the North Sea catastrophe of summer 1988 when enormous algal mats caused by large amounts of nutrients from waste water blanketed the sea. The Ministers added the **protection of the North Sea** to the targets of the RAP and decided to add those substances to the RAP list of priority substances the inputs of which were to be reduced by 50 % until 1995.

In addition, they entrusted the ICPR with the drafting of an **Ecological Master Plan** for the Rhine concerning the river bed, its banks, alluvial areas, oxbow lakes and tributaries as well as the return of the target species, the salmon.

In 1991, the EC Council of Ministers adopted two directives aimed at reducing pollution by nutrients from municipal waste water and inputs from fertilizers applied in agriculture (directive municipal waste water 91/271/EEC and nitrates directive 91/676/EEC).

Logo designed for the ICPR Conference of Rhine Ministers, Brussels, 1989

Combine the protection of alluvial areas with flood prevention

As a result of co-ordinated measures, water quality steadily improved and, in the aftermath of the 1992 World environmental summit of Rio on **sustainable development**, the 1994 Conference of Ministers in Bern rather concentrated on the ecology of the Rhine, with a view to using the Rhine and its landscape socially acceptable and compatible with nature. Under the impression of the great floods of the Rhine in 1993 "More room for the Rhine", the **protection of alluvial areas** and the habitat patch connectivity were declared as new targets for Rhine protection policy.

With a view to **assessing water quality**, the ICPR presented target values taking into account drinking water production, fishery, problems related to dredged material as well as requirements of life in the Rhine on a par.

After the great floods of the Rhine in 1993 and 1995, the ICPR drafted the **Action Plan on Floods** on the basis of the Ministerial Declaration of Arles dated 4 February 1995. This Action Plan aims at protecting the population against damages and at creating more room for the river.

ICPR-logo after 1994 when the programme on migratory fish was subsidised by the EU-LIFE fund

Flooding in Koblenz

Sustainable development of river districts

The Action Plan on Floods was adopted in Rotterdam in 1998. The ICPR was assigned to draft a new programme on the sustainable development of the Rhine for the period following 2000. A new Convention integrated ecology, water quality, water quantity and the protection of ground water near the surface in the alluvial areas.

In 2000, the European Parliament and the Council adopted the **water framework directive** (WFD – 2000/60/EC) designed to achieve exhaustive European water protection policy in the river districts. The ICPR was the model.

In 2001, the Rhine Ministers adopted the new **Programme on the sustainable development "Rhine 2020"** in Strasbourg.

Since 1998 the ICPR is trilingual

IKSR
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3. **Stocktaking** – RAP results

Loreley

The Rhine Action Programme was extremely successful. There were several reasons for this success.

The targets had been defined with precision. The salmon proved to be a suitable draw. The Rhine Ministers in charge kept at it for 13 years. All Rhine bordering countries implemented their decisions. There were periodical reports on progress and deficits. As a consequence, the political willingness arose to put the required public means at the disposal in order to implement the programme and to submit strict recommendations to industry.

The representatives of the different ICPR member states established a highly committed and trusting co-operation. More than 150 experts co-operated in specifying common targets, in coming to agreements and in success control. The ICPR secretariat co-ordinated their meetings, informed the public and established contacts with non governmental organisations in the economic sector, in municipalities and nature protection. Thus, a river commission turned into the nucleus of modern water protection. The ICPR was the model for further river commissions founded in the 1990s, in 1990 for the River Elbe, in 1994 for the Rivers Danube, Meuse and Scheldt and in 1996 for the River Odra.

All Rhine bordering countries, the Länder, the municipalities and industry joined forces and implemented the rehabilitation measures. For the sole period from 1989 to 1995 the expenses for the implementation of the RAP were estimated to some 13 billion Euro, the sole improvement of wastewater treatment plants was estimated to cost 9 billion Euro.

The RAP set targets in the field of chemistry, technique and biology. Therefore, the report at hand separately takes stock of the three working areas: water quality, prevention of accidents and biology of the Rhine.

Point source inputs

The Rhine Action Programme was split up into three phases.
In **phase 1** (1987-89), the ICPR drafted a list of "priority substances", took stock of the source and amount of inputs and submitted proposals for their reduction. It demanded the implementation of the "state of the art" in industrial production and municipal wastewater treatment plants.

Properties of priority substances, e.g. they
- harm organisms in water
- accumulate in river sediment
- accumulate in fish
- endanger drinking water production

In **phase 2** (until 1995), the discharges of priority substances were to be reduced by 50 per cent, for some heavy metals even by 70 per cent. The starting point chosen was the amount discharged in 1985. Additionally, in this phase, the ICPR was invited to draft a concept for the reduction of diffuse inputs from large surfaces.

In **phase 3** (until 2000) additional measures were to be implemented after an intermediate stocktaking. These measures even included the interdiction of dangerous substances in order to achieve the aims of improved Rhine water quality.

The 3 phases of the RAP
- 1987-89 inventory of "priority substances"
- until 1995 reduction of inputs by 50-70 %
- until 2000 eventual fine tuning

The RAP target of improved water quality was achieved.
In particular the discharges of noxious substances by municipalities and industry fell distinctly. Inputs of most priority substances were reduced by 70-100 % or were no longer detectable in 2000. Today about 95 % of the population in the Rhine catchment are connected to municipal waste water treatment plants. In 1985, no more than 85 % had been connected. It's the little things that still cause problems: there are still a few substances of which too great amounts flow down the Rhine and into the North Sea. Recently, others have become the focus of attention, such as pharmaceutics and certain substances with hormonal effects.

Quote from the Rhine Action Programme
Discharges associated with production means effluent originating from certain production processes in industry which is discharged into a private purification plant or else a communal effluent treatment plant.

ICPR (1987): RAP, page 9

3.1 Chemical stocktaking – improved water quality

With a view to improving water quality, the ICPR fixed an international state of the art in the field of production and effluents applicable to the following four industrial sectors:

- paper pulp production
- organic chemistry
- surface treatment
- production of paper and cardboard

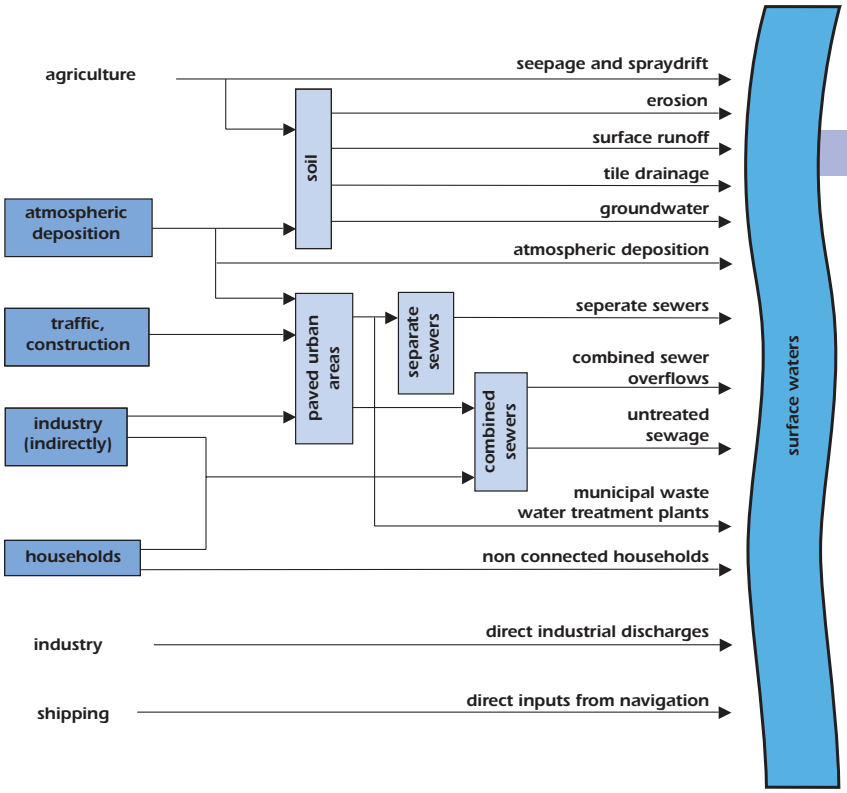
Reduction of point source inputs between 1985 and 2000

30-49 %	50-69 %	70-100 %	No discharges**
total nitrogen (N)	1,1,1-trichloroethane*	ammonium	dioxins (1990-1992)
arsenic	2-chlorotoluene*	total phosphorous (P)	atrazin (2000)
	4-chlorotoluene*	lead	azinphos-ethyl (1990-1992)
	trichlorobenzenes*	cadmium	azinphos-methyl (1992-2000)
	hexachloro-cyclohexane (HCH)*	chromium	DDT (1990-1992)
		copper	dichlorvos (2000)
		nickel	fenitrothion (1992-2000)
		mercury	malathion (1992-2000)
		zinc	parathion-ethyl (1992-2000)
		benzene*	parathion-methyl (1990-1992)
		1,2-dichloroethane*	simazine (1992-2000)
		tetrachlorethylene*	trifluralin (1990-2000)
		tetrachloromethan*	
		trichloroethylene*	
		trichloromethane (chloroform)*	
		aox	
		chloroanilines*	
		chloronitrobenzenes*	
		hexachlorobenzene (HCB)*	
		hexachlorobutadien*	
		polychlorinated biphenyls (PCB)*	
Inventory from 2000 on		azinphos-methyl	
benzo(a)pyren		bentazon*	
4-chloroaniline		drins*	
3,4, dichloroaniline		endosulfan	
PAH		fenthion	
diuron		parathion-ethyl	
isoproturon		pentachlorophenol (PCP)*	
		tinorganic compounds	

* = last inventory in 1992 or 1996 since the reduction target and ICPR target values were achieved

** = no discharges detected during inventory, year of inventory indicated in brackets

= nutrients
= metals
= pesticides
= volatile hydrocarbons
= non volatile hydrocarbons



Quote from Rhine Action Programme

Diffuse discharges means pollution resulting from other uses of priority substances in industry (i.e. other than in production processes) or private households (e.g. household chemicals and solvents) or from their use in agriculture for instance (e.g. manure and pesticides). This category also includes pollutants entering the water via the atmosphere.

ICPR (1987): APR, page 9/10

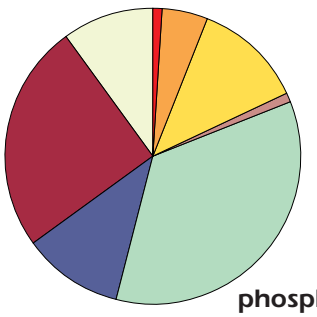
Diffuse inputs

During the past 25 years the construction of waste water treatment plants at a cost of more than 50 billion Euro has had very positive effects on the Rhine. Since distinctly less pollutants flow through the industrial and municipal sewers and into our brooks and rivers, diffuse pollution increasingly becomes the focus of attention. Through numerous pathways large amounts of substances of diffuse origin reach our waters, through the air and through rain water acting as rinsing water. Nutrients and plant protection agents are washed out of the agricultural soil or are washed away by eroded soils in slope position. Foul water is washed off the streets and squares. Combined sewers equally receiving rain water flow over after heavy rainfall, as they are not conceived for large amounts of rain water.

The **nutrient phosphorous** is mainly transported into the water bodies due to soil erosion and drainage.

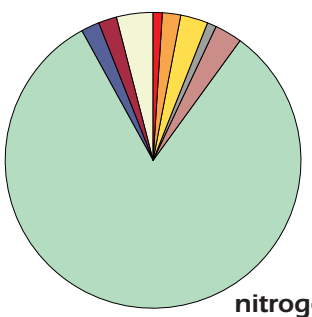
Drainage and ground water are the most important diffuse pathways for the input of the **nutrient nitrogen** into the Rhine. Even in 2000, and in all Rhine bordering countries, most of these nitrogen inputs mainly had their origin in agriculture. Nitrogen sieves from heavily fertilized fields into the ground water and slowly moves in the direction of surface water bodies. Even though, these past years, distinctly less fertilizer has been applied to many agriculturally used surfaces, this does not yet have any effect upon the Rhine. Nitrates are considerably retarded before they reach the river (see page 16).

Pathways of pollutants input into river systems



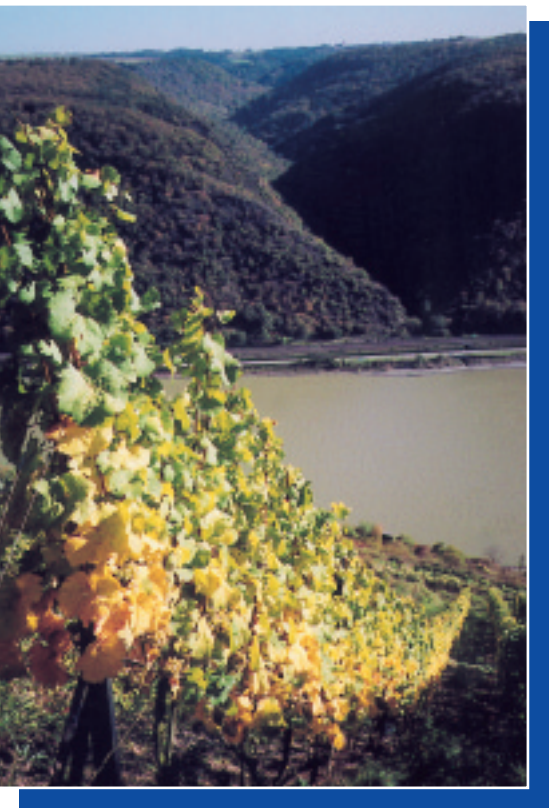
phosphorous %

- seepage and spraydrift
- erosion
- surface runoff
- tile drainage (+ groundwater for N and P)
- atmospheric deposition
- separate sewers
- untreated sewage / overflow during rainfall
- combined sewers / untreated input
- non connected households



nitrogen %

3.1 **Chemical stocktaking** – improved water quality



vineyards along the Middle Rhine

Pesticides of agricultural origin, such as herbicides, insecticides and fungicides are washed off the soil or carried away by rain, often they also reach the surface waters through the drains when spraying equipment is cleaned or refilled. During application procedures they may also be carried off by the wind. Some pesticides are applied on sealed surfaces and are washed off by the rain.

In different ICPR member states several priority pesticides have in the meantime been forbidden. Uses of some licensed substances have been restricted. The application of **tributyltin** (TBT), an anti-fouling coating, on private boats has been forbidden in all Rhine bordering countries.

Pesticide license

	1985				2000			
	CH	D	F	NL	CH	D	F	NL
atrazin	+	+	+	+	+	-	+	-
azinphos-methyl	+	+	+	+	-	-	+	-
dichlorvos	+	+	+	+	+	+	+	+
diuron	+	+	+	+	+	+	+	-
endosulfan	+	+	+	+	+	-	+	-
fenitrothion	+	-	+	+	-	-	+	+
fenthion	-	+	+	-	-	-	+	-
isoproturon	+	+	+	+	+	+	+	+
malathion	-	+	+	+	-	-	+	+
parathion-ethyl	+	+	+	+	+	+	+	+
parathion-methyl	-	+	+	+	-	+	+	+
simazine	+	+	+	+	+	-	+	-
tributyltin (TBT)	(+)	+	+	+	(+)	(+)	(+)	(+)
trifluralin	+	+	+	+	+	+	+	-

CH = Switzerland, D = Germany, F = France, NL = Netherlands

\+ = licensed - = not licensed (+) = Interdiction for private boats < 25 m

\+ in CH = licensed and used
\- in CH = not licensed or not used

The original list of priority substances only included some of the biocide agents found in the water bodies and which were of agricultural and other origin. Others, such as **diuron** were added to the list in 2000.

Today, the amount of **heavy metals** of diffuse origin in the Rhine is about two to four times as high as that of point source origin. About half of these non point source inputs originate from storm sewers or sewer overflows. Erosion and drainage of agricultural soil figure among the further pathways. **Lead** inputs into the Rhine are dropping, which is, among others, due to the introduction of unleaded motor fuel.

Surveillance

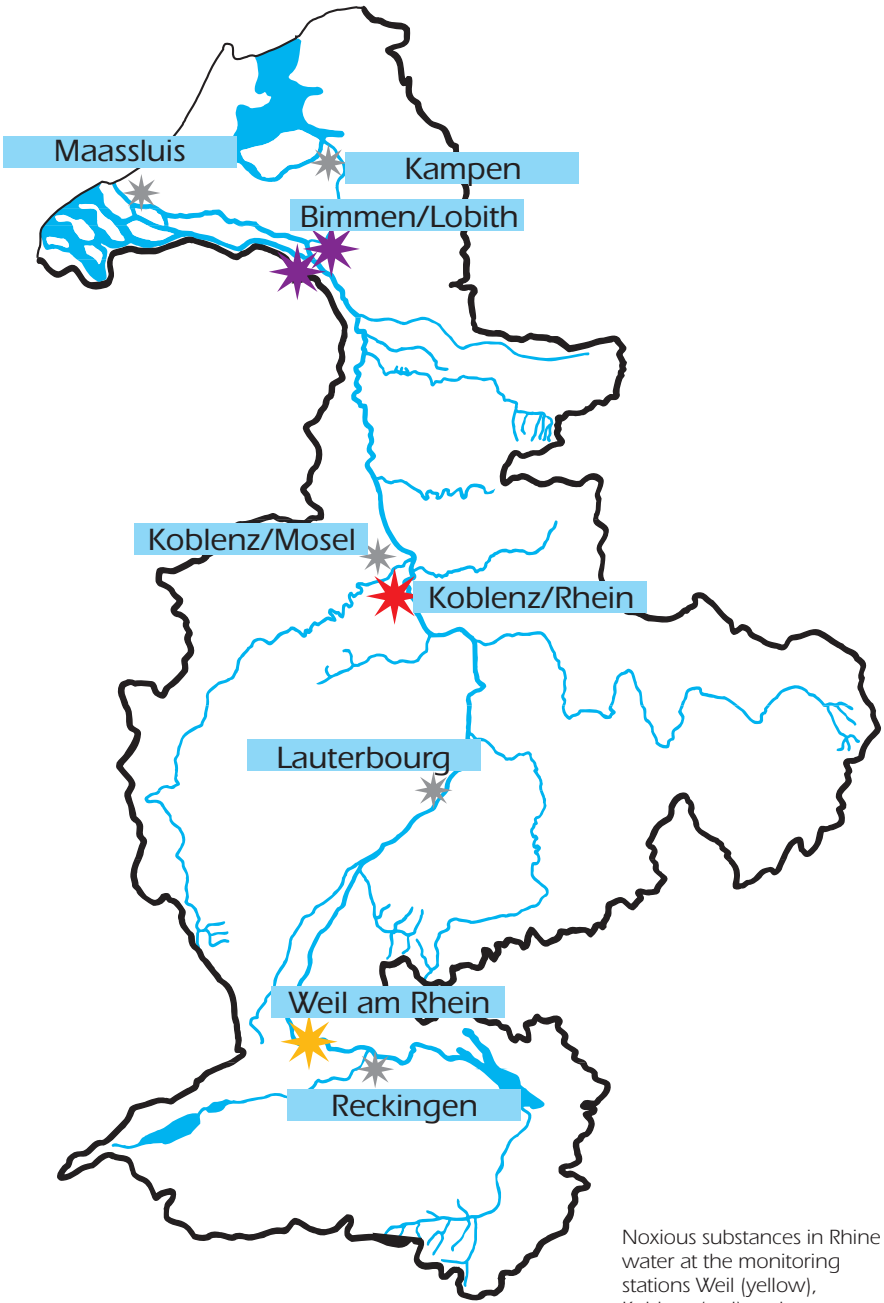
So far, we have concentrated on the inputs of substances into the Rhine. It must be controlled on-site how the river is able to cope with them. Nine monitoring stations continually monitor the **pollutant concentrations** in Rhine water. The monitoring of international water bodies is exemplary: since 1993, the Swiss and the Germans work side by side in the monitoring station at Weil am Rhein near Basel. Since 2001, the Netherlands and Germany jointly operate the monitoring stations Lobith and Bimmen on the Lower Rhine.

Quotation from the Rhine Action Programme

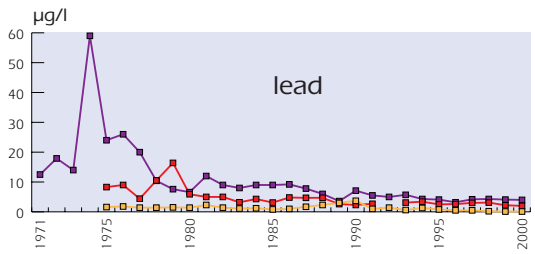
In view of this, a uniform minimum control programme must be drawn up by the ICPR which will enable the Rhine riparian states to monitor the progress of the action programme, as regards both the dischargers and the quality of Rhine water.

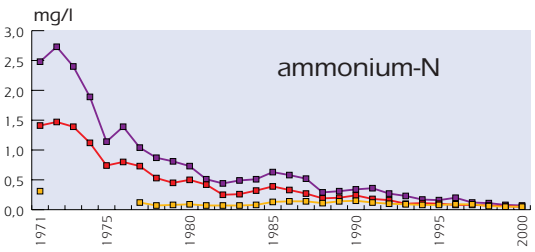
ICPR (1987): RAP, page 11

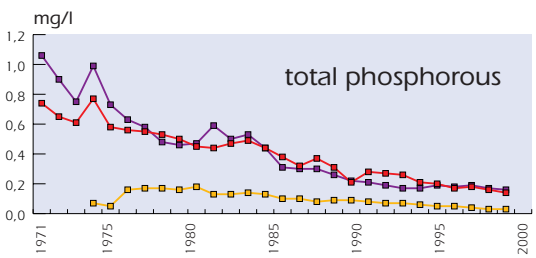
Bimmen/Lobith



Noxious substances in Rhine water at the monitoring stations Weil (yellow), Koblenz (red) and Bimmen/Lobith (violet)







3.1 **Chemical stocktaking** – improved water quality

Target values help to assess the pollutant concentrations. "Target value achieved" means: the substance does not exceed a fixed maximum concentration. The maximum concentrations take into account the following resources worth protection as well as their use:

- fauna and flora
- fishery
- drinking water production
- suspended matter and sediments
- marine environment

According to measurements at the international monitoring stations only few substances have not achieved the target values. Results are presented in the table of results of 66 substances or groups of substances. Those substances which today continue to cause trouble mainly reach the Rhine via diffuse pathways.

Target values for priority substances in Rhine water have ...*

not been achieved	almost been achieved	clearly been achieved
cadmium	ammonium-nitrogen	benzene
copper	total phosphorous	1,2-dichloroethane
zinc	arsenic	tetrachloroethylene (PER)
hexachlorobenzene (HCB)	lead	tetrachloromethane
PCB (7 substances)	chromium	1,1,1-trichloroethane
diuron	nickel	trichloroethylene
fenitrothion	mercury	2-chloroaniline
lindane (γ-HCH)	aox	3-chloroaniline
	benzo(a)pyren	1-chloro-2-nitrobenzene
	atrazin	1-chloro-3-nitrobenzene
	bentazon	1-chloro-4-nitrobenzene
	isoproturon	2-chlorotoluene
	tributyltincation (TBT)	4-chlorotoluene
	Not detectable as under limit of determination	3,4-dichloroaniline
	1,4-dichlorobenzene	hexachlorobutadien
	2,4-dichlorophenoxyacetic acid	1,2,3-trichlorobenzene
	trichloromethane (chloroforme)	1,2,4-trichlorobenzene
	4-chloroaniline	1,3,5-trichlorobenzene
	azinphos-methyl	adrin
	dichlorvos	azinphos-ethyl
	endosulfan	DDT-group
	fenthion	dibutyltincation
	mecoprop-P	dieldrin
	parathion-ethyl	endrin
	parathion-methyl	α-HCH
	trifluralin	β-HCH
		δ-HCH
		isodrin
		malathion
		pentachlorophenol (pcp)
		simazine
		tetrabutyltin
		triphenyltincation (tpt)

= nutrients

= metals

= volatile hydrocarbons

= non volatile hydrocarbons

= pesticides

*= based on monitoring data 1990 to 2000 (ICPR 2002: report no. 123)

Estimate of loads

Loads may be estimated on the basis of concentrations measured.
How many kilos of a given substance does the Rhine transport annually?
Since the volume of water transported by the Rhine varies to a great extent, annual loads may only be estimated. There are dry years during which the average discharge is around 2000 m^3/sec. and there are wet years with an average discharge of around 2800 m^3/sec. (1985 and 1995 at Bimmen/Lobith).

Point source discharges are diluted by high average discharges, those originating from diffuse sources, such as heavy metals, increase with rainwash.
Flood waves stir up polluted sludge and transport it downstream.

In spite of these reasons for inaccuracy, the following result is rather reliable: between 1985 and 2000 the annual amount of discharges fell for most priority substances.

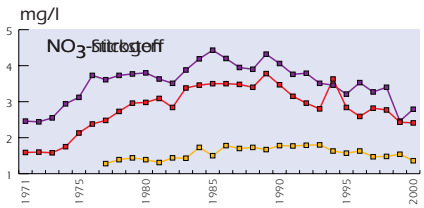
In 2000 the Rhine still transported 7.000 tons of ammonium nitrogen, compared to almost 40.000 tons in 1985. During the wet year of 1995, the loads of the heavy metals chromium, copper, nickel and cadmium increased, but fell distinctly until 2000.

Since 1991, following the interdiction to apply atrazine in Germany, the Rhine bordering country with the largest surface, atrazine concentrations distinctly fell. HBC loads vary a lot, as each flood stirs up older and polluted sediment layers, but on the whole HBC loads fell. PCB loads in the Rhine equally fell distinctly.

Annual loads of substances at Bimmen-Lobith

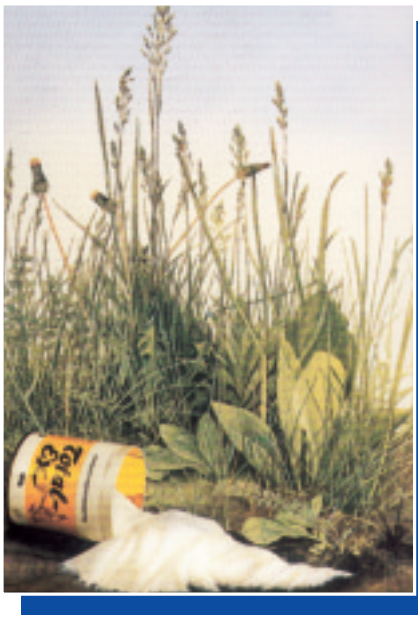
	Unity	1985	1995	2000
discharge	m^3/s	1967	2773	2.500
ammonium nitrogen	t	37.000	14.000	6.800
total phosphorous	t	32.000	17.000	13.000
aox	t	4.700	1.300	1.100
zinc	t	3.600	3.000	1.400
chromium	t	500	530	150
copper	t	600	630	510
nickel	t	400	440	230
lead	t	550	500	250
arsenic	t		190	130
atrazine	kg	10.000	6.900	1.200
cadmium	kg	9.000	9.700	5.100
mercury	kg	6.000	3.500	1.600
sum PCB	kg	390	240	90
hexachlorobenzene	kg	240	200	100

3.1 Chemical stocktaking – improved water quality



Development of the nitrogen pollution at the monitoring stations Weil (yellow), Koblenz (red) and Bimmen/Lobith (violet)

Foaming caused by algal bloom in the North Sea



Albrecht Dürer/Klaus Staeck (1503/1987): The great lawn

Problem causing substances

Nitrogen

In 1985, more than 500.000 tons of **nitrogen** flowed down the Rhine. In 2000, nitrogen loads still amounted to 360 000 tons, one third of which originated from sewers, two thirds from diffuse discharges.

In the North Sea, nitrogen in combination with phosphorous acts as fertilizer for alga which may regionally reproduce in masses and, when dying, will consume the oxygen content.

The target fixed with a view to North Sea protection, that is to cut down inputs by 50 %, has not been achieved. Due to measures taken in industry and to the construction of denitrification zones in municipal wastewater treatment plants, it has been possible to reduce point source inputs.

However, diffuse nitrogen inputs as a result of leaching from agricultural fertilized soil via drainage and the ground water almost remained unchanged. Reduced fertilizing will only show its effects after several years, as soil and ground water passage are slow (see page 11).

Heavy metals

Even though all heavy metal contents in Rhine water have dropped the contents of some heavy metals in suspended matter of the Rhine is still too high.

The contents of **lead** and **mercury** are near the ICPR target values. But **cadmium**, **copper** and **zinc** have failed to achieve the target. These heavy metals go back to numerous, in particular diffuse sources, e.g. roofs, water supply lines, inorganic fertilizer, abrasion of car tyres, mining activities and flue gas. Cadmium accumulates in organisms, e.g. in algae and mushrooms.

Pesticides

The contents of many chemical substances used as herbicides, fungicides and insecticides have dropped in the Rhine. Three substances, however, have not achieved the target values.

Diuron is a persistent herbicide which is only interdicted in the Netherlands. Further to its application for weed removal on paved surfaces, such as in farmyards and on parking areas it is washed into the sewer with the rain water, flows through waste water treatment plants and is discharged into the rivers.

Fenitrothion is an insecticide which also got into the Rhine after the Sandoz warehouse fire and which is toxic for many water organisms. Organophosphates such as fenitrothion act as neurotoxins. Low concentrations in the water are sufficient to change the salmon's food seeking and its learning behaviour (FENT 1998, p. 211).

Lindane is an insecticide which is above all – today much less than what used to be the case – applied in agriculture and forestry. It causes a dysfunction in the nerve tracts of insects. The substance is persistent and, due to accumulation in the adipose tissue it accumulates via the food chain. In 2000, the annual load in the Rhine was estimated to 120 kilos.

Non volatile hydrocarbons
Seals and birds of the polar region contain comparatively high concentrations of persistent chlororganic compounds, such as lindane, HCB and PCB, since these chemicals accumulate in the trophic web.

In laboratory tests, lindane and different PCB have proved to have a hormonal effect. Ecosystems polluted with such substances may give evidence of perturbated reproduction and development of animals. In the North Sea, certain fish species gave evidence of a shift in sex composition in favour of females (SRU 1996, p. 205).

Hexachlorobenzene (HCB) is above all a by-product of the pentachlorophenol (PCP) production and used to be applied as softening agent and as fungicide. Even though this persistent organic pollutant has been interdicted in all Rhine bordering countries since long and is no longer produced, it is still found in Rhine sediments and in eel.

Polychlorinated biphenyls (PCB) used to be applied as softening agent in plastics, in transformers and hydraulic oils. They are persistent and accumulate in the food chain and in sediments. Some eel rich in fat are still too highly contaminated.

Other substances than those mentioned may prove to be or to become problematic. Thus, Rhine water surveillance remains a permanent task of Rhine water protection.

Quotation from the Rhine Action Programme
The action programme is designed first and foremost to reduce the input of dangerous substances, but the need to limit other problem substances should not be ignored.

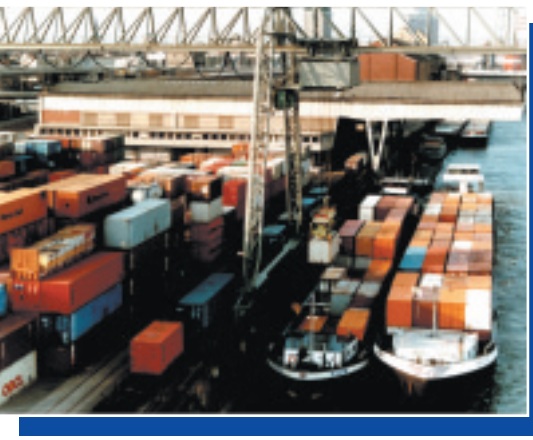
ICPR (1987): APR, p.8

Eels

Quotation from the Rhine Action Programme

Special attention should be given to the handling of dangerous substances which may directly or indirectly enter the water and to everything associated with this.

ICPR(1987): RAP, p. 10



Prevention of Accidents and Security of Industrial Plants

The fire near Basel which, in 1986, for several days immobilised drinking water production plants and fishery along the Rhine right downstream to the Netherlands, at a distance of some 1000 kilometres, triggered the Rhine Action Programme. Therefore, when beginning with the Rhine Action Programme, careful handling of dangerous substances which, due to an accident, might get into water bodies as well as the security of industrial plants were focal points of action. To begin with, the ICPR inventoried warehouses and production plants in the Rhine catchment and issued recommendations concerning the "**Prevention of accidents and the security of industrial plants**".

Fire safety regulations are designed to avoid fires, to prevent them from spreading by taking adequate measures of construction and to avoid resulting damage by providing storage facilities for fire extinction water.

Concerning the **licensing process for plants in which accidents are liable to occur** the ICPR recommended close co-operation between the authorities, applicants, citizens concerned and associations with a view to improving the prevention of accidents.

All recipients receiving dangerous substances must be equipped with **overflow safety devices** which automatically interrupt the filling process or which trigger off an audible alarm. **Pipelines** receiving substances dangerous for the water environment must be impermeable and resistant and must be unmistakably identified.

Industrial plants must construct **retention systems** including collection tanks etc. in case of leakage and accidents.

Substances, a mixture of which may be dangerous, p. ex. explosive, may **not be stored together**. Large amounts of burnable materials must be stored apart.

Waste water split flows isolating industrial waste water, rain water and cooling water are recommended. Waste water should be avoided or minimised, e.g. with the help of closed circuits.

During **the transfer** of goods from ships, lorries or railway carriages to warehouses or vice versa dangerous substances must not be able to flow into water bodies.

On site, the **surveillance of industrial sites** must allow timely detection if dangerous substances are accidentally released.

On site plans of alert must contain a precise list of safety measures in case of accidental spills.

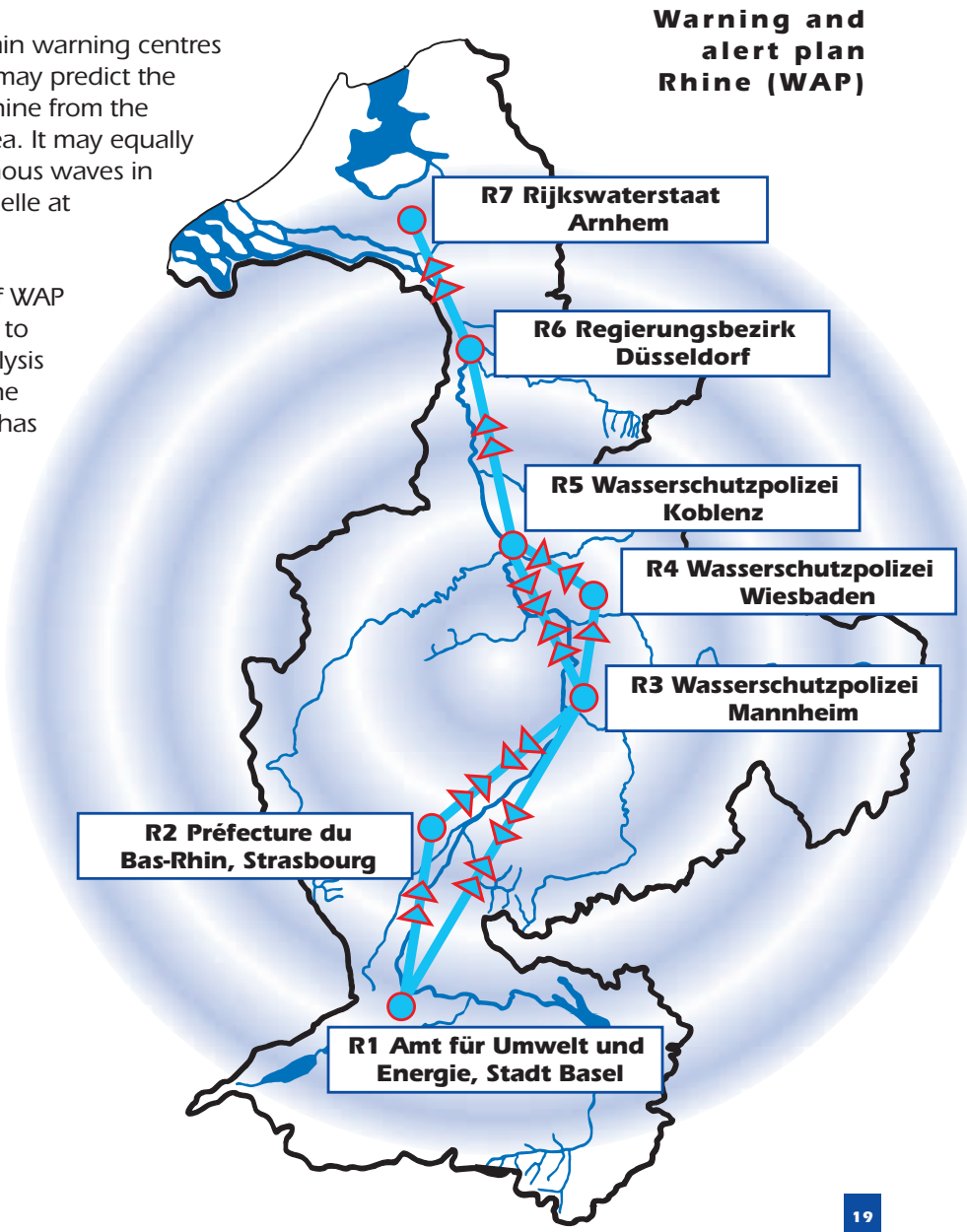
Warning and alert plan Rhine

If, in spite of all these precautionary measures, an accident occurs and considerable amounts of noxious substances flow into the Rhine, the international **Warning and Alert Plan Rhine (WAP)** is applied, informing all Rhine bordering countries, particularly those downstream the site of the accident. The polluter is in charge of informing about the accident. Following his information, one of the seven main warning centres along the Rhine between Basel and Arnhem passes on the information to the warning centres located downstream, to local authorities and to water distribution companies. Within the implementation of the RAP the WAP has been extended by methods of close surveillance. The ICPR monitoring stations as well as those of the Rhine bordering countries carry out a continual chemical monitoring of Rhine water, which is partly completed by **biological tests**.

In bioassays water flea react to low concentrations of toxic substances

The **Rhine Alarm model** applied by all main warning centres completes the WAP. This computer model may predict the development of a pollutant wave in the Rhine from the outflow of Lake Constance to the North Sea. It may equally be used to calculate the passage of poisonous waves in the tributaries Aare, Neckar, Main and Moselle at different discharge rates.

Since the end of the 1980s, the number of WAP reports has distinctly fallen from almost 60 to some 15 per annum. A more in depth analysis of accidents along the Rhine shows that the number of spills and accidents in industry has clearly fallen since on site precautionary action has become an evident obligation. Normally, if due to an accident noxious substances flow into the Rhine, it is the polluter himself who informs about the accident. On the other hand, the origin of oil pollution incidents caused by navigation is rarely known.



3.3 Biological stocktaking – more life in the Rhine

Rare fish species detected in the Iffezheim fish passage in the year 2000

- brook trout
- thwaite shad
- allice shad
- sea trout
- sea lamprey
- white-eyed bream

During the 1970s, the Rhine was considered to be the sewer of Europe. In the aftermath of the chemical accident near Basel in 1986 we saw a dying river. What results would it be possible to achieve with the Rhine Action Programme? What is the ecosystem like today? – It almost sounds like a miracle: today, we and the river may have a sigh of relief: the Rhine is a living river.

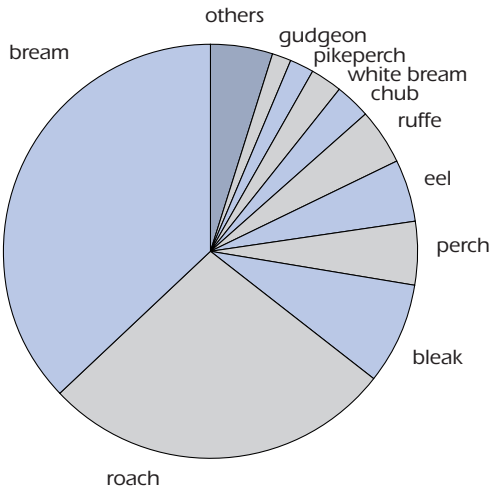
Since 1990, the ICPR has taken stock of the fish in the Rhine, the invertebrates living on the river bottom and the plankton every five years. Therefore, comparisons with earlier biological results are hardly possible.

Edibleness of fish of the Rhine

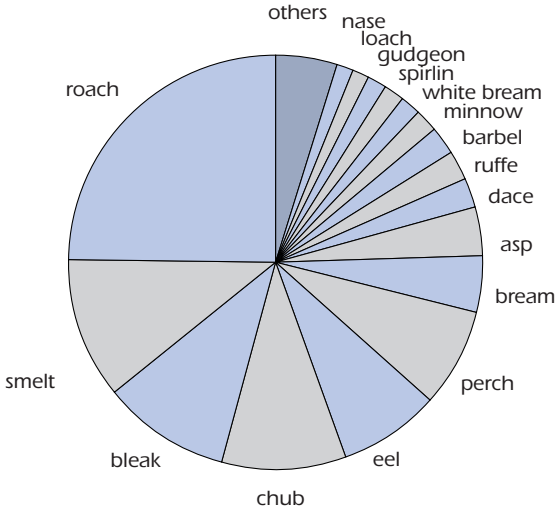
In 2000, the ICPR took the initiative to examine the contents of some 30 pollutants in eel and roaches, from the Rhine. The result is comparable to that of the analysis in 1995. Today, roaches, that is the major part of the fish in the Rhine are apt for human consumption.

In parts of the analysed eel the chlorinated organic substances HCB and PCB are still found in too high concentrations and food control estimates them to be alarming. Due to their high fat content, these pollutants particularly accumulate in eel. The highest HCB-concentrations were found in eel caught in the Upper and Middle Rhine. The other pollutant contents were comparatively low in the fish analysed.

Fish species in 1995



Fish species in 2000



Variety of fish species

The roach is the most common fish species in the Rhine. But how many fish species do live in the Rhine? Between 1996 and 2000 63 species were inventoried! That means, that the number of fish species formerly living in the Rhine has almost been reached, only the common sturgeon is missing. In 2000, the distribution of individuals is better than in 1995, but it does not reach the level it originally had. Three quarters of the fish caught belong to 7 species: roach, smelt, bleak, chub, eel, perch, and common bream (in 1995 they belonged to 3 species). Some of these species are neozoa, that is, they have immigrated, such as the pumpkin-seed, pikeperch and the mottled Black Sea goby, detected since 2000 and which is believed to have immigrated via the Main-Danube-Canal, as well as the gobio albipinnatus. The rare fish species of the High Rhine, such as spirlin and the very rare fish of the Lower Rhine, such as flounder and burbot have increased in number. Since 1996, rare fish species belonging to the former Rhine fish fauna have been detected in the Upper Rhine as well as in the Rhine delta: migratory fish such as allice shad and houting. Even the most rare loach species spined loach and weatherfish have been detected in the Upper Rhine.
The number of the long distance migratory fish species salmon and sea trout has further increased.

Juvenile fish

The amount of juvenile fish in a water body is an ideal indicator for its aptitude as habitat, as larva and juvenile fish have complex demands to their habitats and frequently move between habitats during their first year of life. Therefore, studies concerning the occurrence of juvenile fish in the Rhine complete the fish inventory.

Since 1994, the **salmon**, an anadromous migratory fish moving from the sea into the upper reaches of rivers and brooks for spawning and which has returned to the Rhine is increasingly reproducing naturally in some Rhine tributaries.

In the course of the renewal of the concession of the Kembs power plant due in 2007 and with a view to disposing of more juvenile fish habitats, e.g. for salmon, it is planned to increase the natural discharges of the **old bed of the Rhine** parallel to the canalised Rhine in the Upper Rhine area.

The catadromous **eel** migrating to the Atlantic Sargasso Sea for spawning is giving rise to concern. Young eel, the elver, migrate from the sea upstream the Rhine. In all sections of the Rhine the number of elver was insufficient. Several reasons are under discussion: overfishing of elver in the marine environment, death of eel in the turbines of hydroelectric power plants during their downstream migration, parasites etc. For years, the stock of eel has been supported by stocking exercises, a measure which reduces adaptability since natural selection is eliminated.

Formerly, the reophile **barbel** was the key indicator fish species in the Northern Upper Rhine and in the Middle Rhine. Today, its natural reproduction is quite successful. The migratory **nase** was the dominant juvenile fish species of the Lower Rhine in 2000.

A great number of the juvenile predatory **pikeperch** was found in the water intake of a nuclear power plant on the banks of the Rhine. The undemanding species **roach**, **bleak** and **bream** dominate the stock of juvenile fish, particularly in the Rhine tributaries. Species preferring standing water bodies, such as **rudd**, **tench** and **crucian carp** were rarely found, as there are only few appropriate old river branches and backwaters left along the Rhine.

old bed of the Rhine

roach

barbel

nase

pikeperch

Migratory fish

Last but not least, the Rhine Action Programme with its initiative "Salmon 2000" also fought for the return of migratory fish to the Rhine. In 1993, once the Rhine water quality had been distinctly improved, the Rhine bordering countries turned towards well defined habitat projects under the leadership of the ICPR and with support from sides of the EU. Above all, these projects concerned the revitalising of Rhine tributaries and the construction of fish passages at weirs.

The salmon is an ideal species for revitalising the Rhine since it represents the life form of migratory fish and the habitat patch connectivity from the Alps to the Atlantic Ocean. Its stock gives immediate evidence of the effectiveness of protection measures in the spawning areas in the upper reaches of rivers, at weirs in rivers and in the marine hunting areas.

International Salmon treaty 1885:
With a view to increasing the stock of salmon in the Rhine area it must be taken care of that

1. *natural salmon spawning grounds in the tributaries are reopened and made accessible to upstream migrating salmon.*

(Reichsamt 1886)

Salmon at the weir across the Sieg at Buisdorf

***Target species** in nature protection represent certain life forms and types of habitat and serve success control of protection measures. In their wake other species of the biocoenosis are protected at the same time.*

(MEYER-CORDS et al. 1999)

Target species migratory fish

- atlantic salmon
- sea trout
- allice shad
- thwaite shad
- houting
- nase
- common sturgeon †
- sea lamprey
- river lamprey

Which species are returning

- individuals returning
- natural reproduction
- increasing stocks

Since June 2000 migratory fish use the new fish passage at the Iffezheim barrage weir on the Upper Rhine. By the end of 2002 the 24h video surveillance of the fish passage gave evidence of about 240 **adult salmon**, 920 **sea trout**, 260 **sea lamprey** and some **allice shad** migrating upstream.

Fish passage at the Iffezheim barrage

Since this fish passage has been opened, migratory fish may again reach the Ill-Bruche river system in Alsace and move upstream the rivers Acher and Rench which both drain the Black Forest. By the end of 2003, a comparable fish passage will be constructed at the Gambsheim barrage, thus opening the access to the Black Forest river Kinzig.

Increasingly, the river lamprey is spotted in the Rhine tributaries Sieg, Lahn and Saynbach, individuals have even been detected in the Upper Rhine. In the Middle Rhine, **river lampreys** and even **sea lampreys** have been spotted.

Since June 2000, the German Länder North-Rhine-Westphalia and Rhineland Palatinate run a common monitoring station and fish trap located at Buisdorf on the R. Sieg, a tributary to the Lower Rhine. By the end of December 2002, some 630 **salmon** and 270 **sea trout** had been caught there.

More and more evidence is given of naturally reproducing salmon returning to the accessible spawning grounds of the rivers Sieg, Saynbach, Ahr and Ill.

In the Dutch Rhine delta, the number of migratory fish has distinctly increased during the past five years. In the Lek, one of the arms of the Rhine, a fishway has been built at the Driel barrage. By mid-2004, the fishways at Hagestein and Amerongen are supposed to be operational.

From 2006 the management of the sluices at the Haringvliet closure embankment will again permit the development of a brackish water zone so that migratory fish may migrate from the sea and into the Rhine delta.

In 2000, the Dutch government issued an all-year interdiction to catch salmon and sea trout in inland and coastal waters. Thus the two main target species of the ICPR Salmon 2000 programme are now protected in the entire Rhine watershed as well as in the marine Rhine delta area.

With a view to pursuing the successful programme for migratory fish within the Rhine 2020 programme, measures aimed at improving fish habitats are under implementation in many Rhine tributaries.

Rhine delta

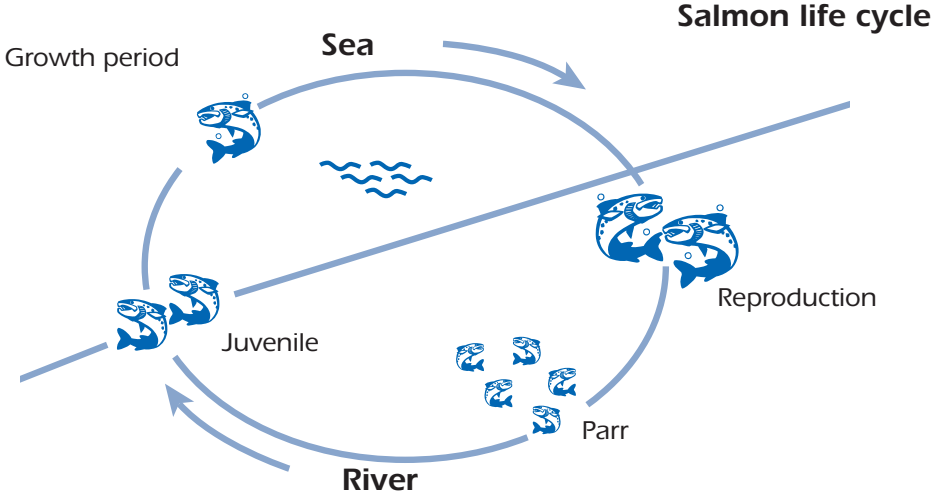
Quotation from the Rhine Action Programme

The targets of the RAP … require an improvement in

- *the physical, chemical and biological state of the Rhine and*
- *the biological potential of the Rhine, which will have to be achieved by means of measures to return the river to its natural state.*

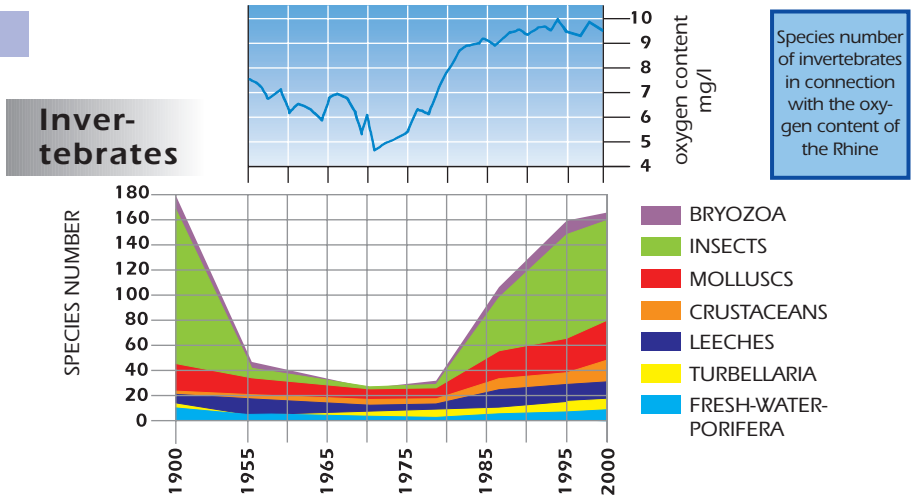
ICPR (1987): RAP, p. 7

Salmon life cycle



3.3 Biological stocktaking – more life in the Rhine

Larva of the mayfly
Oligoneuriella rhenana



Species number of invertebrates in connection with the oxygen content of the Rhine

Anisoptera
Gomphus vulgatissimus

Basket clam
Corbicula fluminea

In 2000, some 300 invertebrate species were registered in the Rhine, most of them in the High and southern Upper Rhine. In 1990 and 1995, scientists had discovered some 200 species. Does this mean there is an upward trend for life in the Rhine? – The answer is not quite as simple as that. It is quite true that the invertebrate fauna has recovered, but in some sections of the Rhine the species number dropped – presumably as a result of river structure deficits. Also, most of the invertebrates found are undemanding, many insect species which were abundant in the Rhine only 100 years ago are still missing, such as the mayfly **Oligoneuriella rhenana**.

But species characteristic of the river environment which had largely vanished from the Rhine, are expanding. The latest example is that of the anisoptera, larva of which have several times been detected in the Rhine.

Species typical of the river return to the Rhine

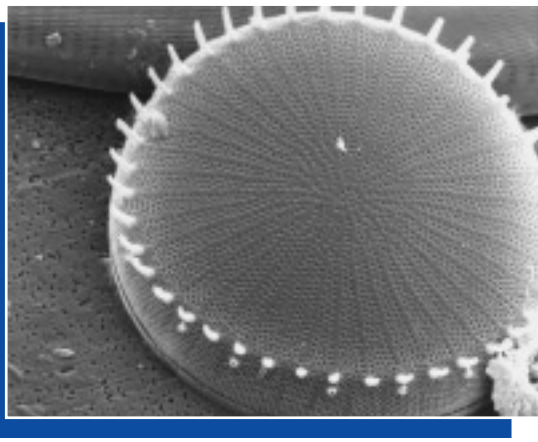
- Ephoron virgo (mayfly)
- Heptagenia sulphurea (mayfly)
- Psychomyia pusilla (caddis flies)
- Aphelocheirus aestivalis (heteroptera)
- Unio tumidus (mussel)
- Gomphus flavipes (anisoptera)
- Gomphus vulgatissimus (anisoptera)

Many new species have immigrated, particularly during the 1990s and, in certain sections, they dominate the traditional species. In some sections of the Rhine their share is up to 90 %. Some of the **neozoa** immigrate through the Main-Danube-Canal opened in 1992 or by other means. In 1988, the **basket clam** originating from Asian and African regions appeared in the Lower Rhine, in 1994 it had spread as far upstream as Basel and today it figures among the most common mussel species of the Rhine.

Plankton

The inventory of Rhine plankton in 2000 shows that, compared to 1995, there is a slight improvement in the **trophic degree** of Rhine water samples, a conclusion drawn from the reduction of the chlorophyll-a level. The nutrient content has less influence on the development of the phytoplankton of a river such as the Rhine than physical and hydrodynamic factors, such as flow velocity have.

The **phytoplankton** composition was as follows: with respect to mass, the diatoms prevailed, with respect to number of cells, the filamentous cyanophyta prevailed. Since 1995, the **zooplankton** tends to decline. Everywhere in the Rhine the most important groups were the primary standards and the rotifers. Microcrustaceans, e.g. water flea and copepoda only occurred in the Rhine delta.



Typical diatoms from the Rhine (magnified)

Water fowl

Pochards and tufted ducks voluntarily dive for mussels in the Rhine, such as the migrating mussel Dreissena polymorpha. During the winter 2000, the stock of water fowl along the Rhine counted some 2 million individuals belonging to 42 species. Herbivores, such as white fronted goose, coot, mallard and the mollusc consumers such as pochard and tufted duck were most common. Piscivores, such as great crested grebe and cormorant represent less than 5 % of the stock of water fowl.

From Lake Constance to the delta region the Rhine represents an important resting and hibernation area for water fowl. It equally serves as guideline for migrating bird coveys, such as cranes.

Habitat patch connectivity

In 1991, the ICPR drafted the "Ecological Master Plan for the Rhine" which was followed by preparatory work for a "habitat patch connectivity". In 1998, the ICPR published the "Rhine Atlas – ecology and flood protection" with maps on the valuable habitats in the lowlands of the Rhine. In the meantime, the habitats have been assigned to 8 different groups of types.

Groups of habitat types in the lowlands of the Rhine

- Aquatic and amphibian reaches of flowing water bodies
- Natural alluvial water bodies
- Swamps, reed fields and tall herbaceous vegetation
- Greenland
- Low moisture habitats
- Alluvial forests in the present floodplain
- Forests in the former floodplain
- Other types of habitat of importance for species protection

Many measures aimed at re-naturation and habitat patch connectivity are currently under implementation along the Rhine, its backwaters and tributaries. They aim at increasing the surface of alluvial areas, reconnecting oxbow lakes and cutoff meanders, giving more room to the Rhine and enhancing an ecological network. At the same time, these renaturation measures improve water retention in the sense of the Action Plan on Floods.

Alluvial forest on the Rhine

4. A new vision

Rhinelanders' dreams
- eat Rhine eel
- bathe in the Rhine
- observe beavers in the Rhine floodplains

The Rhine Action Programme's balance proves: a vision may become true, if its fulfilment is worked at energetically following realistic steps.

The RAP was concluded in 2000 and its targets were achieved. Rhine water is distinctly cleaner, accidents are less frequent, salmon have again begun migrating upstream as far as the Upper Rhine and spawn in its tributaries. – And now, what is next?

There is a new vision of the Rhine: a green stripe of floodplains edges the river, absorbs floods and is teeming with amphibian life. The diversity of fauna and flora species typical of the Rhine continues to increase. Salmon migrate upstream as far as Basel and maintain their stock without artificial stocking measures. Fish and crustaceans from the Rhine are a delicacy very much in demand ...

With a view to realizing this vision, the ICPR presented a new programme at the outset of the 21st century: "**Rhine 2020**". This programme focuses on ecology, nature protection, flood prevention and ground water protection. Furthermore, monitoring and improvement of water quality will be continued and improved.

In January 2001, the Rhine Ministers adopted this "Programme on Sustainable Development" of the Rhine. It will implement the requirements of the EU water framework directive and the Swiss water policy of the same kind in the entire watershed of the Rhine.

The EU water framework directive (WFD) of the year 2000
- considers the river catchment as an entity
- demands an integrated assessment and management
- lists priority substances
- focuses on biological indicator organisms
- defines the good chemical status
- defines the good ecological status
- fixes the deadline for achieving the good status in all European water bodies to 2015.

With a view to realizing targets and visions, the Rhine 2020 programme lists several well defined actions, precise surface indications and deadlines.

The actions are complementary and reinforce one another. Low intensity farming in the floodplains enhances nature protection and water quality, since less nutrients and pollutants sieve into the ground and surface waters.

Flood protection and floodplain development are to be closely interlinked. Increased water retention in former floodplains and in the entire watershed improves flood protection for people. At the same time, more room for the river enhances biological diversity in the floodplain and thus the wealth of natural resources along the Rhine.

Actions aimed at the habitat patch connectivity and nature protection

- Preserve sections of freely flowing water
- Permit water dynamics
- Permit varied structures of river banks and river bottom
- Open floodplains to the river (room for the river)
- promote low intensity farming in the floodplain
- eliminate migration obstacles for the river fauna
- reconnect cutoff meanders and torrents

Actions aimed at flood prevention

- Open old floodplains to the river (room for the river)
- Technical retention due to polders
- Reinforce dikes
- Improve forecasting and risk awareness

Actions aimed at improving water quality

- Reduce inputs of heavy metals, nitrogen and pesticides
- Reduce inputs of pharmaceuticals and other new dangerous substances

Once flood waters have receded, amphibians like the tree frog like to spawn in the remaining puddles

Abbreviations and glossary

Anadromous	Upstream migration of fish for spawning in the upper reaches of a river (e.g. salmon, sea trout)
Antifouling compound	Substance used for the coating of ships hindering the growth of mussels, barnacles and algae
AOX	Sum parameter for **a**dsorbable **o**rganic halogenated compounds (**x**) which are toxic and partly highly persistent, e.g. chloroform, DDT, → HCB, → HCH, → PCB, → PCP, various → pesticides, chemical substances used in industry; applied as: solvents, propellants, dry cleaning, disinfection, conserving agents, etc. enter the Rhine through point and non point inputs
Benthos	Community on the bottom of a water body
Biotope	Habitat of a species community of plants and organisms
Catadromous	Migration of animals from fresh to salt water for reproduction purposes (e.g. eel, Chinese crab)
Chlororganic compounds	Chlorinated → hydrocarbons
Denitrification	Cleavage of nitrate with the help of bacteria in wet low oxygen soil and in the denitrification process in waste water treatment plants, a process during which gaseous nitrogen escapes into the air.
Floodplain	Valley bottom of a flowing water body which is periodically inundated and which presents a characteristic flora and fauna adapted to these features.
Fungicide	Substance used for fungus control
Habitat	Characteristic living space or site for a species
HCB	**H**exa**c**hloro**b**enzene is a by-product resulting from the synthesis of chlorinated hydrocarbons and used to be applied as softening agent or as fungicide.
HCH	**H**exa**c**hlorocyclo**h**exane, → insecticide in several forms, e.g. γ-HCH = lindane
Herbicide	Substance used in weed control, above all in agriculture and on traffic ways, see → pesticides.
Hydrocarbons	Organic compounds consisting of carbons and hydrogen; chlorinated hydrocarbons (organic chlorinated compounds) in which hydrogen has been replaced by the halogen chlorine (→ AOX), belongs to the → priority substances.
ICPR	**I**nternational **C**ommission for the **P**rotection of the **R**hine **Founded** in 1950, Bern Convention 1963, 1999 **Contracting parties**: France, Germany, Luxembourg, Netherlands, Switzerland, EU **Delegates**: Leading civil servants and experts form all contracting parties **President**: Mathias Krafft (2002 - 2004) **Headquarters**: Koblenz

Insecticide	Substance used for insect control; → pesticide
Macrozoobenthos	Macroscopic invertebrates living in/on the river bed (e.g. snails, mussels, crustaceans, insects); → benthos
Neozoa	Fauna species immigrated after 1500
Organophosphate compounds	Phosphate ester, extremely toxic chemical warfare agents and many → insecticides were washed into the Rhine with the fire extinction water used for fighting the warehouse fire in 1986
PAH	Group of substances belonging to the **p**olycyclic **a**romatic → **h**ydrocarbons
PCB	**P**oly**c**hlorinated **b**iphenyls used to be applied as softening agents in plastic material, in transformers and in hydraulic oils; they are persistent and accumulate in the food chain and in sediments.
PCP	**P**enta**c**hloro**p**henol used to be a common → pesticide, applied above all as wood preservative, forbidden to produce, to sell and to apply in Germany
Pesticides	= biocides ; in most cases artificially produced organic substances serving above all to combat seemingly noxious bacteria, algae, fungus, plants and organisms within plant protection in conventional agriculture; chlorine → hydrocarbons and → organophsophoates are priority substances in the Rhine
Phytoplankton	Plant → plankton, such as green algae, blue algae
Plankton	Organisms floating in water; due to lacking or little spontaneous movement they passively drift with water
Population	Reproductive community of a species in a defined habitat
Priority	Latin: prior, the ICPR list of priority substances in the Rhine includes substances endangering the aquatic ecosystems and drinking water production.
Sediment	Masses of sand and sludge deposited on the river bottom
RAP	**R**hine **A**ction **P**rogramme
Trophic level	Amount of biomass and conversion of autotrophy organisms (bacteria, plants) of a water body
Watershed	River catchment or drainage system; the surface drained by a river and all its tributaries, limited by the water divide
Zooplankton	Referring to organisms → plankton, e.g. rotifers.

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Lazy and indifferent
the heron returns;
the sky veils her stars
then bares them.

Virginia Woolf (1921)

IKSR
CIPR
ICBR

Internationale Kommission zum Schutz des Rheins

Commission Internationale pour la Protection du Rhin

Internationale Commissie ter Bescherming van de Rijn