ON THE TRAIL OF
DECLINING FISH STOCKS

CONTENTS

PROJECT “NETWORK DECLINING FISH YIELDS SWITZERLAND”: **SUMMARY**

OVERVIEW

Trout catches in Switzerland have fallen by 60% since 1980. At the same time, health problems were identified for fish in different streams. These findings were viewed by the Federal Institute for Environmental Science and Technology (EAWAG) and the Agency for the Environment, Forests and Landscape (SAEFL) as sufficient grounds for launching the “Fischnetz” (fish net) project in 1998. Its objectives were to document the health status and the decline in catch, to track down their reasons and to suggest measures for correction. All 26 cantons, the Principality of Liechtenstein, the Swiss Fisheries Association (SFV), the Swiss Society of Chemical Industries (SGCI) and the University of Bern joined the project and around CHF 3 million were invested.

The investigations conducted in 77 sub-projects were based on a dozen separate hypotheses. Was the fact that fewer fish were being caught attributable to a decline in angling activity? Are cormorants and goosanders devouring all the fish? Are the fishes’ habitats progressively disappearing? Are the fish being poisoned with chemicals? Has the supply of food declined or is climate warming to blame? The “Fischnetz” project has looked into all of these possible causes.

The catch statistics clearly show that fewer anglers are buying permits, which has reduced the angling effort. This does not, however, fully explain the decline in total catch. A more detailed analysis of catch statistics reveals that the fish stocks have also declined. The project leadership concludes that the principal reasons for the decline in stocks are poor quality of habitats and an infectous illness called the proliferative kidney disease (PKD). Poor habitat quality includes deficiencies in both morphology (for example missing shelter in constructed stream courses or uniform river banks) and water quality (chemical pollution).

LACK OF HABITATS

In some cases, the straightening of rivers, the artificial reinforcement of riverbanks and the destruction of riparian vegetation took place decades ago. And yet these measures still have consequences (in the form of monotonous and fragmented habitats, for example) today. They hinder the efforts of fish to escape adverse conditions and block their access to spawning grounds. The isolation of habitats also restricts the genetic diversity of populations.

INSUFFICIENT WATER QUALITY

The pollution of the watercourses by chemicals has decreased markedly over the past 30 years. Nevertheless, after heavy rain the concentrations of nitrogen compounds such as nitrite and ammonia reach peaks which are dangerous for aquatic wildlife. Pesticide inputs are still too high in intensively cultivated areas of the Central Plateau. Furthermore, effect concentrations of natural and synthetic hormones are attained in densely populated zones of the Central Plateau. Probably, fish health is impaired by the combined effects of these substances (“chemi-cocktail”).

INFECTIOUS ILLNESS

PKD – first identified in Switzerland in 1979 – has been intensively investigated in the course of general research into fish health. In 2000 and 2001, this infectious disease was detected at 190 out of 462 locations investigated – most notably in the waters of the Swiss Central Plateau. PKD leads to swollen kidneys and is often fatal. Catch figures are lower in PKD positive river stretches than in waters without PKD. PKD therefore might be one of the main factors having led to the observed decline in catch.

COMBINED EFFECTS OF INFLUENCING FACTORS

The decline in fish stocks is greatly influenced by the combined impact of the various contributory factors. An example of this is the temperature-dependent outbreak of PKD, which becomes manifest only when the water temperature remains above 15°C for longer than two weeks. Between 1978 and 2002, the temperatures in Switzerland’s watercourses rose by around 1°C. Apart from promoting the spread of PKD, the rise in temperature also leads to a reduction in the availability of habitats suitable for trout, since the waters of the Central Plateau are becoming too warm for this cold-adapted species.

TAILOR-MADE MEASURES NEEDED

It is important to note that the relative importance of the causes varies from one water body to another. Measures must, therefore, be tailored suit the local conditions. First and foremost it is necessary to improve the habitats. Connectivity must be enhanced along the entire longitudinal course of a running water, riverbank vegetation is to be promoted, and steps must be taken to ensure that water levels are always sufficient. Quality standards need to be defined and met for all relevant substances. Enforcement and monitoring of the Water Protection Law must be more consistent. Furthermore, water-body management must be optimized. Fish from PKD-infected waters must not be released into PKD-free or non-inspected waters. Restocking must only be undertaken in a planned fashion. Systematic surveillance of fish stocks is also necessary so that long-term development and the effectiveness of measures can be monitored.

FOLLOW-UP PROJECT AND ADVISORY SERVICE

The measures necessitate more comprehensive information, training and support. “Fischnetz” will therefore support the cantons and fisheries organizations in their implementation of the measures by means of the follow-up project “Optimisation of fish catch yields and water quality”. As of April 2004, the anglers will also be able to call upon the angling consultancy, FIBER, which will be jointly funded by EAWAG, SAEFL and the SFV.

Where have the fish gone? For five years, the experts from "Fischnetz" have searched for answers. Over 100 experts researched the health of fish, their habitats, water pollution, anglers' behaviour and much more. Are there any answers? Yes! The possible causes of a decline in fish stocks are diverse and closely related to each other. A few important interfaces are known – for example, the influence of habitat on the fish. However, the significance of further aspects remains open and must be researched further.

WHAT IS **THE MATTER WITH FISH?**

Empty nets, unhappy anglers, reports about more fish with diseases or organ mutations – for some years now signs are on the increase that all is not well with fish in Swiss waters. The recent figures of the Swiss Agency for the Environment, Forests and Landscapes (SAEFL) show, for example, that in Swiss rivers and streams fewer trout are being caught since the beginning of the eighties. This decline in catch, however, began at different times and the rates of catch decline differ in individual waters. The numbers of grayling being caught fluctuates – there appear to be phases where they increase as well as decrease. The anglers' catch numbers are only an indirect measure of a decline in fish stocks; we'll speak again about this aspect in the section 'the influence of management' on page 5. Direct measurements of fish stocks also point to a decline. Scientists found out, for example, that since the beginning of the eighties there are fewer roach in the Upper Rhine and that in different rivers and streams the stocks of nase declined. There are several reasons for taking the silent disappearance of fish seriously and thinking about the consequences:

- Unhealthy fish and declining stocks show that ecological conditions in the water are poor. This is a warning, for streams and rivers are interconnected with each other and with their surroundings – they are, we might say, the ecological backbone of the countryside. An ecologically healthy condition of the streams and rivers is essential for an intact environment and thus is also laid down in law.
- Biological diversity: Already only twelve out of the 54 indigenous fish species are unthreatened, eight species have died out in recent decades.
- Health: declining densities of fish and poor states of health may indicate that the waters are affected by harmful substances. As many people drink riverbank-filtered water, which comes from surface waters, any infringement of fish health also has a bearing on the health of human beings and should be examined.
- Fishing management: if the hook is too often empty, then many anglers don't renew their fishing permits. That means loss of income for the cantons' fishing administrations and problems for the care and management of the fishing areas.

A FISH NET IS SPUN

At the end of 1998 the Swiss Federal Institute for Environmental Science and Technology (EAWAG), SAEFL and some cantons founded a project to document changes in fish catch for the whole of Switzerland. The project should also establish the causes of the decline in fish stocks and develop means for its reversal. It is the Project "Network Declining Fish Yields Switzerland", in short "Fischnetz" (Fish Net). A short time later all the remaining cantons, the Principality of Liechtenstein (FL), the Swiss Fishing Association (SFV) and the Swiss Society of Chemical Industries (SSCI) joined the project. Over 100 experts from science, authorities, environmental consultancies, angling associations and the chemical industry co-op-

erated in the 77 individual research projects of “Fischnetz”. Never before had the fish stocks and catches, above all of river trout, in the Swiss streams and rivers been so intensively researched. The project ended in December 2003 with the production of a 180-page final report, in which the results of the five-year long examination are explained. This brochure aims to summarise the most important findings of the final report.

EAWAG, SAEFL, the Principality of Liechtenstein, the cantons and the SSCI spent in total around 3 Million Swiss Francs on “Fischnetz”. Integral to the success of the project was also the great personal commitment of co-workers of the SAEFL, the EAWAG, the cantons, the Centre for Fish and Wildlife Health, the chemical industry and the SFV.

A steering committee operated as a political overseeing body. The project was led by experts from the fields of fisheries, fish biology, ecotoxicology, sewerage technology and chemistry. These experts were responsible for the planning, scientific control and technical realisation of the guidelines issued by the steering committee.

The problem of decline in fish stocks was dealt with in different research projects. Various approaches and means of proceeding have been chosen: in monitoring studies many streams and rivers were observed in order to obtain an oversight of the spread of certain phenomena. Case studies complemented the oversight gained by the monitoring studies: here a few selected streams and rivers, where abundant data was already available, were comprehensively examined. Additionally, data about fish catches, stocking, as well as distribution of fish were brought together. Finally, the scientists evaluated already completed studies in order to draw their final conclusions and therefore obtain indications beyond the project and regional level. The major portion of the projects financed by “Fischnetz” lay in the area of these evaluations, for here the available data could be networked – with relatively little expenditure – and combined with the application of international expertise and the important questions facing Switzerland.

“Fischnetz” was also a network of experts: people involved in the different projects met and discussed at six project leader conferences with a total of 185 participants. External experts from the spheres of fisheries, research, the authorities or private enterprise also became involved in “Fischnetz”. At six national and four international expert hearings with a total of 137 participants “Fischnetz” co-workers directed special questions at experts, discussed procedures and developed common suggestions on correction measures to be taken.

POSSIBLE REASONS FOR THE DECLINE IN FISH STOCKS

Anyone who looks for answers must first put forward the right questions. “Fischnetz” has therefore established and examined various working hypotheses:

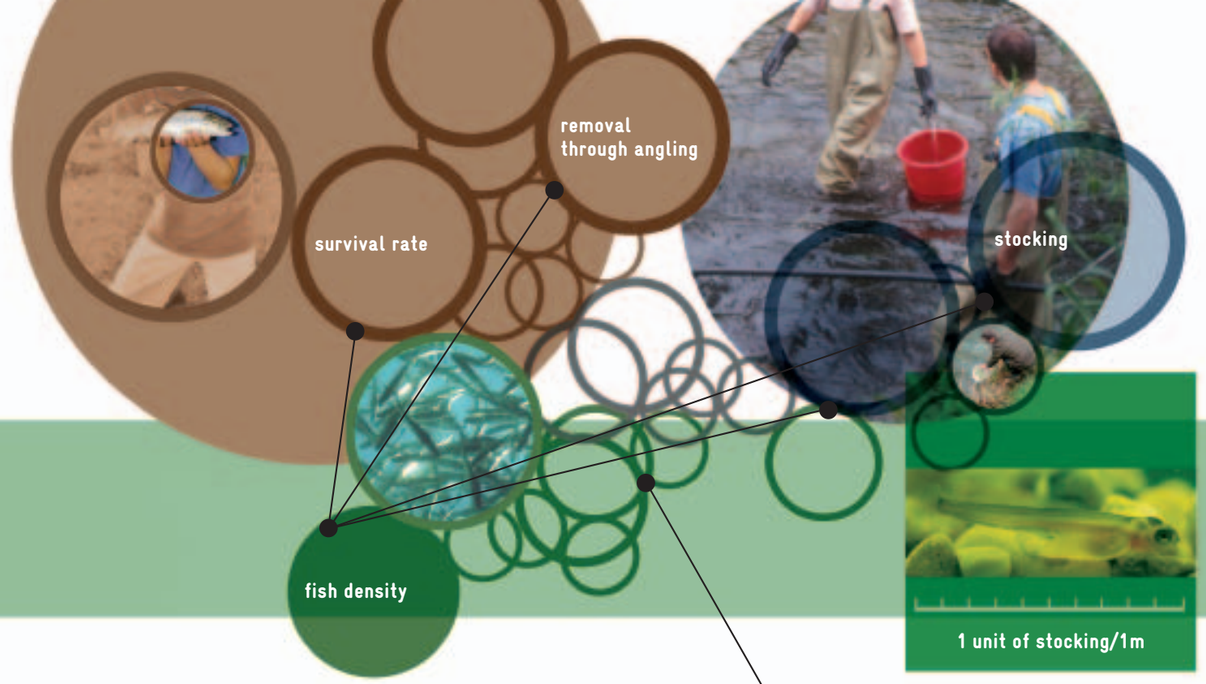
- The fish suffer from reproductive difficulties.
- The fish stocks are lacking sufficient young and newborn fish.
- The decline in fish stocks is due to a poor general health state of the fish, which possibly even causes premature death.
- The chemical pollution of streams and rivers impinges on the health of the fish and therefore leads to a decline in fish stocks.
- The causes of the decline are disappearing or inadequate habitats.
- An increased proportion of fine sediments is responsible for the decline.
- The fish cannot find enough nutrition.
- The decline is due to an inadequately adapted fishery management policy.
- The decline in trout catches is the result of decreased fishing intensity.
- An increased number of fish-eating birds is responsible for the decline in stocks.
- Changes in water temperature have led to a decline in stocks.
- The decline is the result of altered runoff and stream bed erosion.
- Various, regionally differing, factors cause the decline of fish stocks and fish catches.

Some of these various possible influential factors may be directly to blame for the decline in fish stocks. These include the deficient condition of the habitat, chemicals, fine sediments, fishery management policy, fishing intensity, fish-eating birds, water temperature, and runoff. Other hypotheses, however, look at intermediate effects of the actual causes – for example, when reproduction, offspring, fish health and nutrition are examined. The incidence of these indirect effects does not indicate the causes of a problem. On the contrary, frequently many reasons for the decline in stocks come into question.

The hypotheses dealing with fine sediments, water temperature and change in runoff apply predominantly to river trout; these animals need cool waters, spawn in gravel and reproduce in winter – too much fine sediment in the stream bed, increased water temperatures and stronger winter floods can therefore be particularly dangerous for them.

The connections between the influential factors make it more difficult to recognise the cause-effect linkage, because resulting effects can partly bring about an unexpected chain effect. For example, an increase in fine sediments in the stream bed not only has an effect on the trout spawning in the gravel, but also on the quantity and composition of species of prey living in the stream bed. A lack of prey may lead to a poor general health state of the fish and therefore make them more susceptible to disease. Overlapping research initiatives and analyses, as they were formulated in the last hypothesis, were thus important to “Fischnetz”. The decline in fish stocks and catches is not the result of one single factor but many individual effects, which differ in importance between regions. Consequently, there is also no single solution for the actual problems.

Some possible influences could be excluded, while other causes only applied to certain waters or seasons – details can be found in the final report. Crucially, “Fischnetz” could identify certain factors which have a considerable influence on fish stocks in many Swiss streams and rivers. The following chapter deals with these.



IN SEARCH OF **CAUSES**

Empty anglers' nets were an important reason to cast out the scientific net and search for the causes of the decline in fish stocks. Included in the scientific endeavor is putting into question apparently obvious connections – and so "Fischnetz" also examined the connection between a decline in catch and in the stocks. Does the catch decline because there are fewer fish? Or are there perhaps fewer anglers, who then catch correspondingly less? Many streams and rivers are stocked with fish. The level and timing of stocking, as well as the age of stocked fish all affect fish populations locally. The first section of this chapter is therefore about fishery management of the streams and rivers, while the second section deals with important reasons for a decline in fish stocks.

THE INFLUENCE OF **MANAGEMENT**.

The annual angler catch is undoubtedly in decline: While in 1980 the number of trout caught was recorded at 1.2 million, in 2001 it was only about 400,000. "Fischnetz" investigations show that the intensity of fishing and its geographical and chronological distribution substantially affect the catch. Thus the catch generally declines after an intensification of regulations; in neighbouring waters with differing fishing regulations unequal quantities will be caught on each side of the dividing line, and on Sundays and public holidays, catch numbers increase because more people go fishing. Between 1980 and 2000, the number of angling permits sold for streams and rivers decreased by 23% and those for combined lake and river fishing by 46%. On the other hand, the number of lake permits rose by 26%. In addition, a representative survey of anglers concerning stream and river fishing showed that the number of angling trips per permit declined from an average of 27 in 1980 to 22 in 2000. Alongside these signs of a decline in fishing intensity there are indications of a reduction in fish stocks between 1980 and 2000: successful angling trips declined from 87% to 49% and the number of fish caught declined from 49 to 25 per year. What do these figures mean? The "Fischnetz" experts make the following deduction: initially it was due to the decline in fish stocks. In the course of time, anglers reacted against the increasing failure of their fishing trips – so that fewer anglers are active now. Therefore, the catch numbers cannot be used directly as an indicator of the fish stocks in a stream or river. Nevertheless, these figures are very important reference points to get an impression of the state of the fish stocks. An alternative is direct stock measurements – however these also reveal difficulties: the decline in fish stocks in Swiss streams and rivers could be scientifically confirmed in individual cases but not generally, as too few data on the changes in fish densities are available.

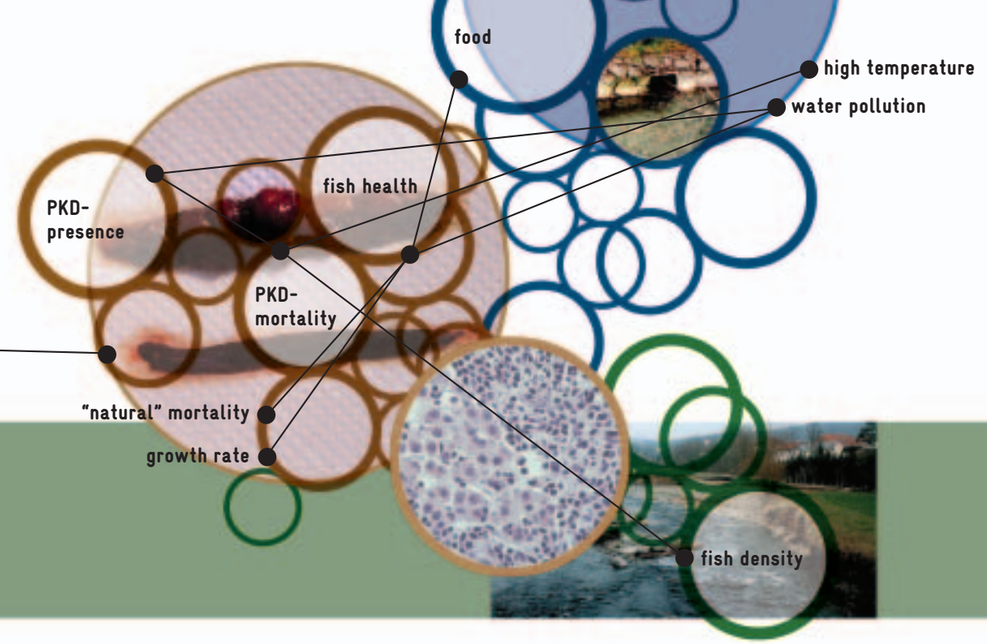
One further aspect must be included in the considerations: man not only removes fish from the rivers and streams, he introduces them as well: thus river trout are introduced into most streams and rivers in Switzerland. Investigation into the survival rate of stocked fish in Switzerland and other countries shows that only a small proportion of these fish grows to maturity and lands in anglers' nets. An increasing rate of stocking with young fish between 1970 and 1982 also did not lead to correspondingly higher catch rates. In general terms, the positive effects of stocking with young fish have presumably been overestimated. Improper stocking methods (for example, exaggerated quantities, wrong age, and unsuitable origin of the fish as well as incorrect stocking concepts) can even damage and cause a decline in the wild fish stocks at a local level.

CAUSES OF THE **DECLINE IN STOCKS**

No ecosystem is like any other: the differences result from many influences, which may be geographically and chronologically different. Therefore, there are no valid causes common to the decline in the whole of Switzerland. "Fischnetz" has succeeded in identifying those causes which play a decisive role.

Man is a big fish in the water: through removal – i.e. angling – and stocking, we influence fish stocks. Investigations by "Fischnetz" have, however, shown that fish stocks also affect the anglers: in the course of time the latter have reacted to the increasing lack of success on their trips – with the result that fewer anglers are active now. Fewer fish and fewer anglers have in common led to a clear annual decline in the catch figures – which was an important reason for setting up the "Fischnetz" project.

PKD is the name of a kidney disease, widespread in Switzerland, and which for many fish is fatal. It is a direct cause of the decline in fish stocks in many rivers and streams, but also a symptom of living conditions that cause illness. Deficient foodstuffs and wastewater pollution contribute to this. PKD breaks out in infected fish only above a certain temperature – rising water temperatures due to a general climate change therefore accentuate the problem.



THE INFECTIOUS DISEASE PKD

Our concept of happy fish in the water is muddied by a disease which is becoming ever more prevalent and is, according to "Fischnetz" results, a demonstrable reason for the decline in fish stocks in Swiss streams and rivers. The so-called Proliferative Kidney Disease (PKD) has so far been traced to river trout, rainbow trout and grayling. The instigator of this infectious disease is a single-celled parasite which causes an excrescence of the kidney in affected fish eventually leading to kidney failure and death. PKD was first discovered in Switzerland in 1979. The progression of PKD is dependant on temperature: if the water is above 15°C for longer than two weeks, then an outbreak of the disease occurs in infected fish, which is often fatal. Especially young fish are affected – as a consequence fish stocks lack offspring. This also shows up in the catch: an evaluation of catch data in five cantons showed that in rivers where PKD was present, fewer fish were caught per angling trip. Under the auspices of "Fischnetz" the distribution of PKD among river trout in the whole of Switzerland in 2000 and 2001 was examined. It was established that PKD occurred above all in the waters of the Central Region (Mittelland). Outside the Central Region, PKD was only found in isolated cases.

EXAMPLE: LANGETEN (CANTON OF BERN) AND VERSOIX (CANTON OF GENEVA)

In ponds into which waters from the Langeten flowed, almost 90% of the river trout died from PKD, as the water temperature during one summer was above 15°C for longer than two weeks. On the other hand, fewer than 10% of the fish died in the Versoix, in which the river trout were also infected by PKD, but where the water temperature constantly remained below 13° to 14°C. The importance of temperature also becomes clear over the length of the Langeten: fish in the colder upper reaches display PKD symptoms to a lesser degree than fish in the warmer lower reaches. Alongside temperature, other environmental factors, especially water quality, may well influence PKD.

Altogether, of 462 tested points, 190 were PKD-positive. PKD is therefore widespread in river trout in Swiss waters. This finding is critical for those waters, or sections of water, in which the temperature exceeds 15°C for longer than two weeks.

If this critical temperature threshold is only reached in the lower parts of the waters, then only the fish there die from PKD, while the infected fish in the colder upper reaches don't show visible signs of illness. Losses in the lower reaches can possibly be compensated by migration from the upper reaches. An outbreak of PKD does thus not necessarily have to lead to a measurable decline in fish stocks or catches.

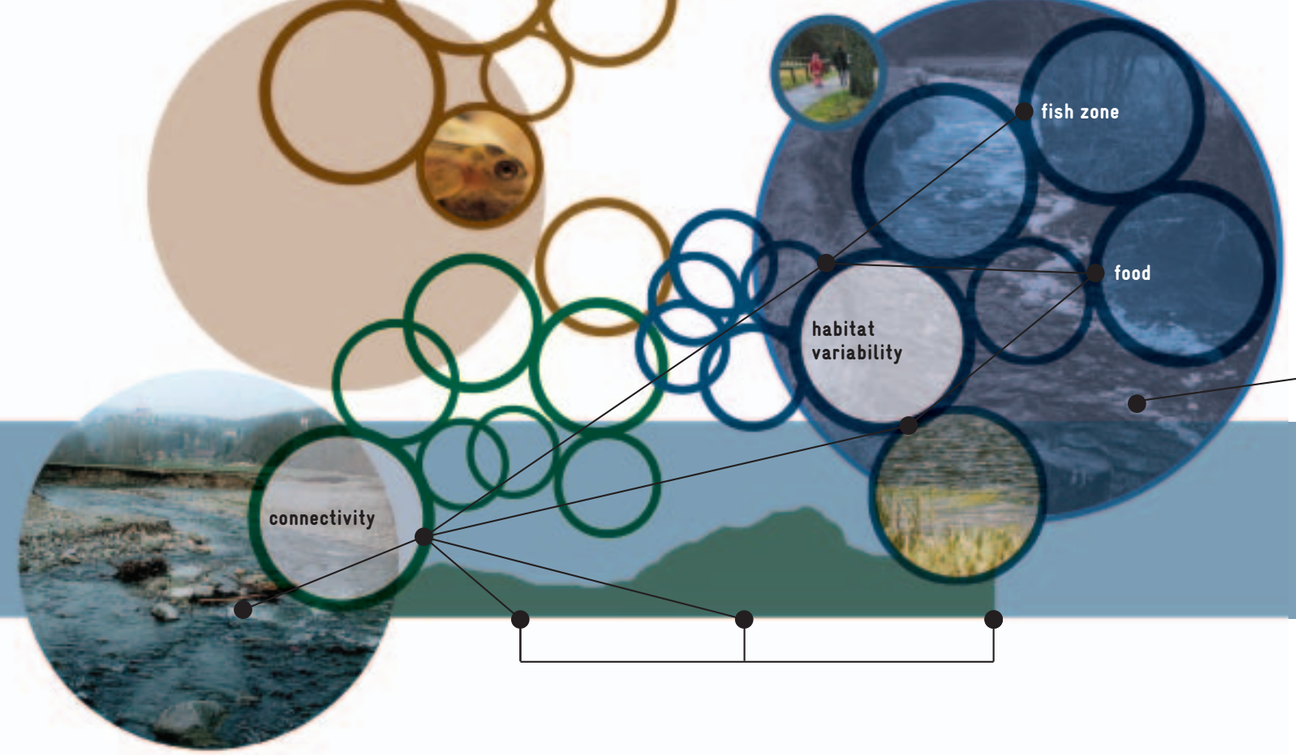
The increasing importance of PKD could be due to changes in water temperature, also examined by "Fischnetz": in the past 25 years, as a result of climate change, the streams and rivers have warmed. With this increase in temperature, some streams and rivers have recently reached PKD's temperature threshold.

A poor general state of health in fish has been observed in a series of Swiss waters, above all in the Central Region. The causes of organ damage are not uniform; in individual cases there are, for example, signs of a correlation with discharges from sewage treatment plants. Medium to acute organ changes have a detrimental effect on survival, growth and reproduction of the fish and therefore contribute to the decline in stocks. Here also there are mutual effects: different pieces of evidence show that in contaminated waters even more fish die from PKD than in good quality waters.

HABITAT

During industrialisation and with increasing population, streams and rivers became a critical economic factor for mankind: water power is used for energy production, water is abstracted from natural watercourses, used and put back in the rivers as sewage. Settlements draw ever closer to river banks and the desire for effective protection against flooding increases correspondingly. This development, which began about 100 years ago, has significantly affected Swiss waters. Of 61,000 kilometres of rivers and streams in Switzerland, some estimated 12,500 kilometres are considered to be far from their natural state.

Massive interferences in the form of straightening river courses, construction of obstacles and water outlets, or removal of riparian vegetation continue to act on the rivers



In recent decades, rivers have been adapted to meet human requirements: straightening, structural intrusions of river banks, drainage and the use of water power have given many streams and rivers a different profile. However, what is practical for humans does not suit the fish: they need varied waters with fast flowing stretches but also with rest areas and opportunities for retreat. Connectivity of waters is indispensable for the migration of fish upstream to the spawning grounds. In uniform, constructed stream courses, both the variety and the connectivity are missing.

and streams, although they sometimes go back several decades. The effects are homogeneous, poorly linked habitats. Fish need – according to their species, age, the season and even sometimes the time of day – varied habitats (see box). They must be able to migrate in order to escape from flood and drought or to reach the areas where they lay their eggs or find food – but also to get from the breeding areas to less densely populated parts of a river. How do the waters appear from the fish's perspective?

Man-made obstacles: In the canton of Berne there are, for example, more than 13'600 obstacles in a length of 6'800 kilometres of streams and rivers. This equates to two obstacles per kilometre which prevent the fish from moving up or down a river. The streams and rivers in the canton of Zurich (3,620 kilometres of mapped length) show more than 38,900 barriers (10.7 per kilometre). Almost 70% of all barriers are artificial. In the Ticino 44%, in the Aare below the lake Biel/Bienne 20% and in the Rhone now only 19% of river lengths are free flowing.

Height differences between the main waters and tributary streams represent a further problem: as most of the larger rivers have been straightened and narrowed, the flow rate has increased, with the result that the river deepens its bed. Smaller tributaries are thus slowly separated from the main river, until fish can no longer climb from the main waters into the tributaries. Various "Fischnetz" projects demonstrated the great importance of these small tributary streams for young fish.

River banks: It's not just the shape of the river bed which is decisive for the well-being of fish – the connections between water and land play an important role. Completely sealed or too narrow banks lead to a structural impoverishment of this important ecological zone, in which, for example, branches of roots hanging into the water provide important shelters for fish. Insects and other creatures, which fall from the bank, represent an important food source. If the river bank is uniform or sealed, then the corresponding animal life is absent from the water's edge. Various investigations have shown that in stretches of water with variegated banks more young fish can be seen. In addition, if the bank zone is missing, then the buffer, which, for example, protects a stretch of water from entry of fine sediments and chemicals used in agriculture, is also missing.

Fine sediments: In the last decades, the erosion of agricultural areas has increased. The very fine suspended matter, which passes from the fields into streams and rivers, can, according to theory, harm fish directly (through a high concentration of suspended matter in the water) or indirectly (through deposits on the bed). The results from "Fischnetz" show that it is improbable that suspended matter has a direct influence on the health of fish. However, increased fine sediment particles can also lead to a clogging of the river bed by sedimentation under corresponding hydraulic conditions. This sedimentation can disrupt the reproduction and the development of eggs of gravel-spawning fish: on the one hand, because the clogged stream bed is no longer suitable for the siting of trout redds, and on the other hand, because the eggs covered with sediment are inadequately supplied by oxygen-rich water and the metabolic products are not washed away. Consequently, the eggs die. This is possibly another reason for the decline in fish stocks, which must be further investigated in the coming years.

The use of hydroelectric power, which contributes to around 60% of Swiss energy production, does not only affect the fish adversely by the erection of barriers. Around 25% of the medium and large hydroelectric power stations produce surge-like outflow fluctuations: when power stations discharge particularly high quantities of water from reservoirs at certain times of day and when they reduce the turbine operation under reduced demand and consequently low energy prices, the outflow and water level in a river or stream changes rapidly. River trout fry can be washed away by the strong current during the surge operation and end up on dry land during the slump.

Surge operations result in a reduced and altered composition of organisms living in the water in most of the rivers and streams examined. This stands in direct proportion to the condition of the habitat: the more uniform a stream or river is, the stronger the effects of power station operations can be.

There is a further correlation between habitat change and another possible cause of fish stocks decline investigated by "Fischnetz": a rise in temperature in the lower regions of the Central Region leads to greater temperature-stress for the river trout, which prefers cold water, and puts it at a disadvantage against fish which prefer warmer water. The moderate rise in temperature of ca. 1°C in the last 20 years has lead to a recent shift to

HABITAT REQUIREMENTS OF RIVER FISH

The various species of fish in streams and rivers need different habitats. In order to preserve the typical species communities for the appropriate rivers, it is therefore crucial to maintain well-connected and varied habitats with sufficient water quantity. The small side streams are, for example, of decisive importance for the natural reproduction of river trout. As the trout's eggs develop in the gravel, the porosity of the gravel bed is also important. According to age and size fish seek out different areas of a river. While smaller trout, for example, prefer shallow surface-flowing waters with a coarse substrate, the larger fish live predominantly in deeper waters with a lot of shelter. Specifically, in winter all age groups look for protection under shelter, in gravel or in slowly flowing waters.

100 to 200 metres higher of the ideal river trout habitat. A migration to more suitable sections of river is, however, made more difficult or impossible by natural and artificial obstacles. These effects were only hypothesised until now because the corresponding scientific investigations were still missing. Through the stocking carried out in many places, the fish catch figures also only conditionally allow such conclusions to be made.

If many streams and rivers are made more uniform through building work and thus less negotiable for fish, then these changes cannot be the only reason for the decline in stocks in recent years, for the interference in question frequently goes further back. In the last 25 years, for example, hardly any straightening work has been undertaken in the Central Region. The effects of such changes can be noticed gradually and only after a definite delay. As, however, decreasing catches and stocks have also been registered in waters with good habitats, there must still be other influences which make life difficult for the fish. In a few river sections it is most probable that the poor water quality is still responsible for the decline in fish stocks.

WATER QUALITY

Since 1955 Swiss waters are protected by Law (Gewässerschutzgesetz). Since then many sewage treatment works have been built all over the country. These prevent a large part of the harmful substances in the wastewater entering rivers and lakes. However, in spite of all these efforts, chemicals continue to get into the waters via avulsions from fields and roads and even from wastewater treatment plants (WWTP). As many of these substances are not completely degradable, they occur with their degraded products in the water and sediment. Additionally, there are traces of naturally occurring substances (for example phosphates from the drainage of urban sanitation), whose content in many waters, above all in smaller streams, is still high. Therefore waters are polluted with hundreds of substances, of which only a few have been chemically identified or even toxicologically examined. Toxic substances, which adversely affect an ecosystem, can be hazardous to human health. The total pollution through chemicals in the last 30 years has been markedly reduced. Peak concentrations and unknown substances or unsought effects still continue, however, to represent a risk for the ecosystem. According to “Fischnetz” the following three groups of substances have an effect on fish stocks: nitrogen compounds, pesticides and endocrine disruptors.

Nitrogen compounds: According to the protection of waters regulations, the water must be of such quality that nitrate and ammonium concentrations do not impinge on the reproduction and development of sensitive organisms. In many waters of the Central Region, the concentration is still high and does not fulfil the water quality requirements of these regulations. In particular, downstream from the WWTP an increase in the nitrate concentration and consequently a deterioration in water quality is noticeable. The requirements are practically only met in the unpolluted upper reaches of streams and rivers and directly below lake outlets.

Pesticides: The amount of applied pesticides has gone down by almost 40% between 1988 and 2000. The use of insecticides and herbicides fell in particular. All the same, the effective strength has increased because of further development of the products. Pesticides can get into surface waters as a result of diffuse entries, through inappropriate procedures and in small measures via WWTP. In surface waters, these substances may have a detrimental effect on fish prey or the fish themselves.
Particularly during the delivery of pesticides to the fields and heavy rain there is a risk of high concentrations in the waters. For some years, the EAWAG and the cantons have been conducting pesticide tests in streams and rivers and WWTP effluents. Hardly any active ingredients have been found in rivers in the alpine foothills, while in rivers of the Jura and the Central Region pesticides have regularly been detected. The results from the canton of Aargovia, for example, show that of 76 routinely tested active ingredients, 33 were found to be present. Similar

EXAMPLE: THE THUR (CANTONS OF ST GALL, APPENZELL AI AND AR, THURGOVIA AND ZURICH)

The Thur was straightened and markedly narrowed. The typical river dynamic has therefore been abolished and its course and structure have become uniform. The various age ranges of many kinds of fish can no longer find an appropriate habitat. In extreme runoff conditions and correspondingly high rates of flow there are no or only few places for the fish to retreat. Impassable building works in the upper reaches of the Thur make fish migration impossible. The accessibility of side streams is also partly restricted. Additionally, fish can often no longer reach the Thur’s tributary streams because they no longer flow into the Thur but into a canal, or because the climb has become impossible for fish due to the height difference. In recent years these deficiencies have started to be removed. In the revitalised section of the Thur, the nase, for example, has reappeared.

First the good news: chemical pollution has significantly gone down in the last 30 years. Sewage treatment works prevent a large part of the harmful substances from reaching the rivers and lakes. However, peak concentrations, unknown chemical compounds and unresearched effects of the interaction of substances continue to pose a threat to fish. Above all, the researchers have focused on three groups of substances: nitrogen compounds, pesticides and hormones. While there have been significant improvements in agriculture, trade and industry, the use of chemical products in private households is rising.

EXAMPLE: THE DEGRADATION PRODUCTS OF SURFACTANTS CONTAINED IN DETERGENTS AND CLEANING AGENTS

Before the introduction of the Swiss Regulation for environmentally harmful substances in 1986, about 5000 tonnes of non-ionic tensides of the nonylphenol polyethoxylate type were used annually. These surfactants are biologically degraded in WWTP, whereby poisonous degradation products are formed. Nonylphenol especially is regarded as a critical environmental pollutant due to its relatively high toxicity and estrogen activity. The EU risk assessment for nonylphenol resulted in a critical concentration of 0.33 µg/l being imposed. Already in the early eighties, the EAWAG thoroughly examined pollution in streams and rivers, wastewater and sewage sludge. Especially in the rivers receiving large amounts of wastewater, concentrations up to one hundred fold over the critical value were recorded. After various measures to reduce the use of nonylphenol polyethoxylates, about 500 tonnes per year, predominantly in industrial cleaning, are still used in Switzerland today. The present concentration of nonylphenol measured in Swiss rivers is less than 0.33 µg/l at most test points. Between 1997 and 2001 this value was only exceeded in 18 out of 220 tests, whilst during the test campaign in the eighties there were 164 cases out of 220 tests.

results were reported in the cantons of Zurich and Vaud. Investigations by “Fischnetz” in Venoge and Emme confirmed increased pesticide pollution.

Endocrine disruptors: Environmental hormones directly or indirectly affect the hormone systems of fish. They are responsible for a series of effects and among others lead, not only in female but also in male fish, to the ovary protein vitellogenin being formed.

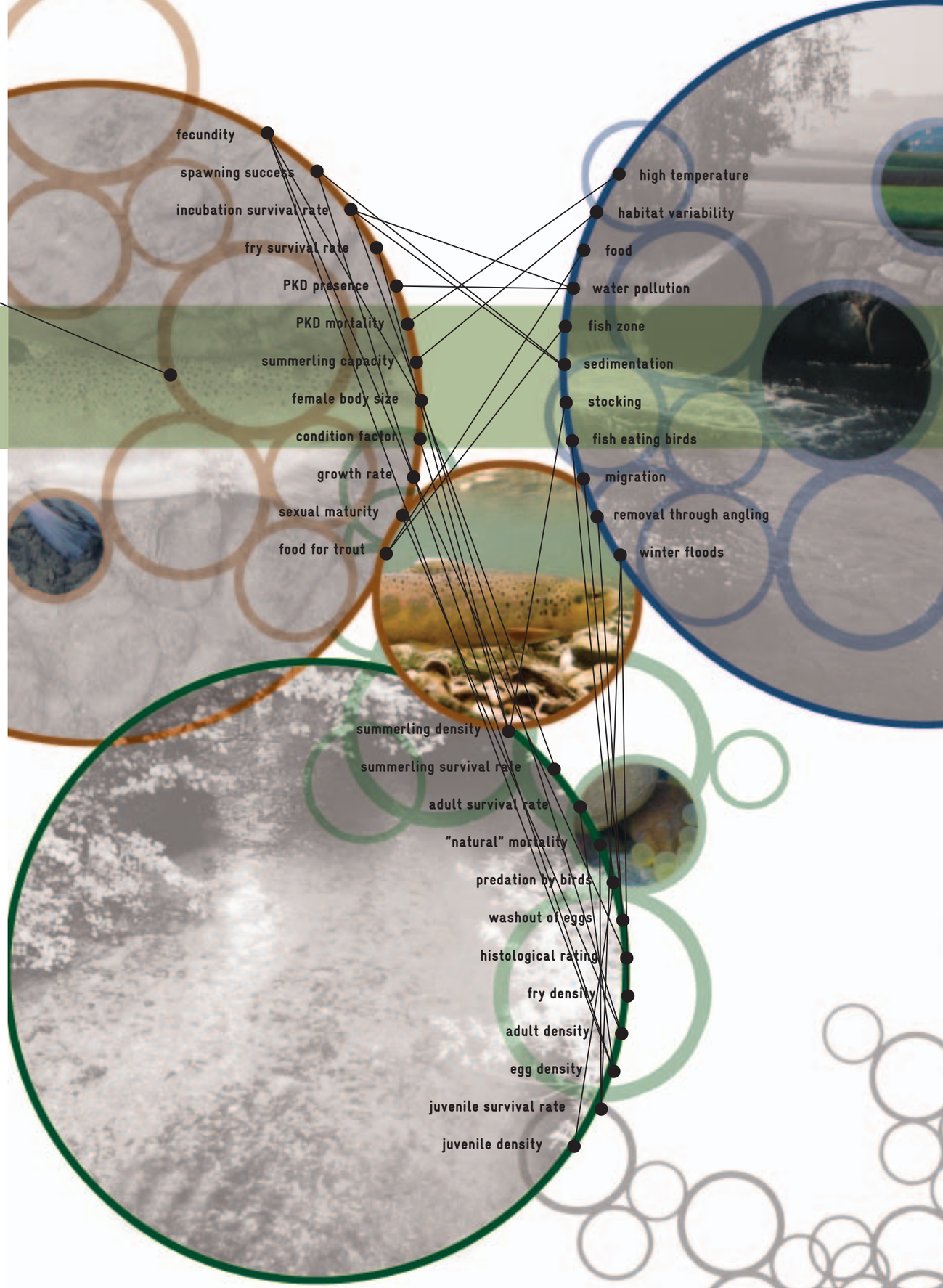
Several “Fischnetz” projects showed that estrogenic substances were present in WWTP effluents. The naturally occurring steroid hormones estron, estradiol, estriol, the synthetic ethinylestradiol (an active ingredient of hormonal prophylactics) and the industrial chemicals nonylphenol, nonylphenolmono- and diethoxylate were identified. The pollution of Swiss waters with steroid hormones is slight when the WWTP effluent is sufficiently diluted. It can, however, have an effect on fish, particularly downstream from sewage treatment works.

Spot sources and diffuse entries: It is difficult to establish a direct link between the kind and extent of chemical pollution and decline in fish stocks. Examples of heavily polluted streams and rivers are known where there is no decline in fish stocks, and others of less polluted streams and rivers where there is a pronounced decline. The partially disrupted fish stock populations occur mainly in Central Region waters that are polluted by spot sources (sewage treatment works) and diffuse applications (agriculture). However, also in the less polluted alpine foothills and alpine waters the decline in fish catch can be noted.

Many waters in the vicinity of sewage treatment works outlets are still far from an ecologically required condition. The survival rate of fish eggs below WWTP is lower than above. The hormonal effects found in fish below some WWTP can mainly be traced to pollution by natural estrogen and synthetic hormonal analogues (ethinylestradiol). Investigations by “Fischnetz” and others have shown that high acute concentrations of toxic nitrogen compounds like nitrates and ammonium occur during heavy rainfall in WWTP outlets as well as during the application periods of high pesticide concentrations. This shows that the existing measures for protection against harmful incursions are not always successful. However, it is not only applications, which get into streams and rivers via sewage treatment works, that continue to be critical: pesticides in arable areas can run off directly into streams and rivers particularly after rainfall and endanger organisms living in the water. Additionally there are persistent chemicals as well as poorly classified chemical substances from roof and street drainage, which similarly can pass into streams and rivers along their whole length.

Although the importance of these effects has not yet been fully revealed, it is assumed that such influences in certain stretches can seriously impinge on fish populations. Due to the poor data on chemical pollution of streams and rivers in Switzerland and on its long-term effects, the majority of substances cannot be comprehensively assessed. In recent decades, the application of agricultural and industrial chemicals on the environment has decreased. Substances recognised to be a problem have been replaced by more acceptable substances, and the degradable effectiveness of sewage treatment works has been improved. These improvements in agriculture, trade and industry contrast with an increasing use of chemical products (‘chemi-cocktail’) in private households.

Now just imagine that the connecting lines in this picture are woollen threads. What happens when a weight is hung on a joining point? Exactly. Everything starts moving, a new balance must be found. Similarly – but in a more complex way – the influences investigated by "Fischnetz" take their effect on fish. If one factor – for example, a deterioration in water quality – becomes more prominent, then after-effects and feedback mechanisms change the whole system. This multi-layered picture should not, however, make us lose heart. With the help of the measures suggested by "Fischnetz" the plight of the fish should be decisively improved.



A QUESTION OF **COMBINATION**

Results of "Fischnetz" show that none of the factors examined can alone be held responsible for the decline in fish catch figures. Some factors are mainly locally or regionally important – the fish-eating birds reduce, for example, the fish stocks in those places where birds congregate in large numbers. Other factors, e.g. habitat deterioration, apply to all Swiss waters and were determined by "Fischnetz" as a decisive reason for declines in fish stocks. The combined effect of influential factors are very important, as shown by the case of PKD. In waters with PKD, river trout can survive at water temperatures below 15° C – if the water temperature rises any more, then the disease breaks out. A PKD outbreak is all the more devastating if the fish's health is already affected by poor water quality. In well-connected waters, such losses can be balanced out by immigration of healthy fish from the upper reaches or from PKD-free side waters. In heavily built up waters or those cut off from side streams this is hardly possible. Similarly, different contaminants in combination with each other or with other factors can affect the health of fish, although the substances or factors on their own show no recognisable adverse effects. Likewise, the effect of chemical cocktails can be stronger than the sum of the effects of single substances. Additionally, the susceptibility to toxic substances increases with oxygen deficiency or raised water temperatures.

Many of the changes noticed today are the result of long-term developments which are only gradually taking effect on the stocks and the catch. For example, it has not been conclusively stated what long-term consequences the sedimentation and clogging in of the stream or river beds have on the habitat of young fish. Scientists must continue in their research here.

Even when some things are uncertain, from the results of "Fischnetz" concrete measures can be derived to improve the living conditions of fish. Suggestions by "Fischnetz" are directed not only at federal authorities, cantons and municipalities, but also directly at power station operators, farmers and anglers. All those involved must play their part in order to make these measures a success.

WHAT CAN WE DO?

The problems connected to the decline in fish stocks are varied. There are concrete results – but also many new aspects that must be researched. At this point, measures will be summarised which can demonstrably improve the living conditions of fish in Swiss waters.

In previous chapters, it has already been mentioned that the important factors for an ecosystem are interconnected and form an intricate network. These factors can mutually weaken or strengthen each other. Improvement measures are above all meaningful if they simultaneously act positively on several factors. There is no sense in undertaking something to solve one problem and in so doing enlarge another one. Only a few measures can be recommended for all situations. In most cases, the measures must be adapted to the local conditions. We cannot bring anything about to combat one major influential factor at present: there is no therapy for the disease PKD – but there are preventative measures.

The measures described are of varying efficiency and act at different levels. Measures aimed at the source of the problem are particularly effective but also particularly difficult to carry out. Often a longer preliminary period is necessary – for example, a change in law or a fundamental ban on substances. Many measures don't tackle the cause but the symptoms of a problem. These measures, as for instance the stocking with fish, can temporarily improve a situation. They are in any case of limited use as long as the actual causes are not discovered and as far as possible cleared up. Temporary measures can be useful to bridge a gap until the actual problem is solved. In connection with the individual measures, respondents are listed under whose remit the measures fall.

CORRECT MANAGEMENT

- No stocking with fish from PKD waters into PKD-free or unspecified waters. The spread of PKD must be regularly compiled. Respondents of this measure: cantons, the Swiss Federal Veterinary Office.
- Thorough planning of stocking procedures, which should only be carried out with spawn from parents from the same catchment area. Before stocking it should be determined if there aren't already enough young wild fish in the stream or river. The aim is not to unnecessarily disturb the naturally occurring reproduction and growth of young fish with stocking measures. Respondents: cantons, angling associations.
- Adaptation of fishing, the actual fish stocks and the productivity of a stream in view of a sustainable management. Respondents: cantons, angling associations.
- Implementation of the new management guidelines of the Swiss Fisheries Association for the promotion of fish stocks. Respondents: cantons, angling associations.

VARIED HABITATS

- Priority measure: the connectivity of rivers and streams along their length as well as with their side waters must be improved in order to enable fishes to migrate and reach spawning grounds and/or retreats and to promote genetic diversity. Above this river bed displacement will be ensured and erosion combated. Respondents: cantons, municipalities, SAEFL, Federal Office for Water and Geology (FOWG).
- Second priority: Increase the structural diversity of rivers and streams, which are already networked. In this way, more valuable and diverse habitats for the different kinds and age-ranges of fish with their various requirements are created. For example, a well-balanced interchange between slow and fast flowing stretches and leaving or introducing dead wood as well as other shelters in the water should be the aim. Respondents: cantons, municipalities, SAEFL, FOWG.
- Reconstitution of the river bank strip as a structural feature. An improvement in the food supply is also thereby created. A well-structured river bank zone minimises incursions of fine sediment and in particular also agricultural substances (for example, pesticides and liquid manure). The vegetation shades the water and protects it against further warming. Respondents: cantons, municipalities, SAEFL, FOWG, agriculture, residents.
- Improvement of drainage systems. The object of this measure is to improve river bed maintenance and water retention and counteract the negative effects of hydroelectric plants (insufficient water residues, surge-slump operations, flushing of reservoir basins). These aims can be achieved through an optimised control of water abstraction and replacement, adapting the opportunities for retaining water, a reduction in river bed clogging as well as a revitalisation of stretches with frequent winter flooding. Respondents: cantons, municipalities, agriculture, power station operators.

CLEAN WATER

The aim is to guarantee a quality of the surface water which neither acutely threatens the life of fish and other organisms nor in the medium or long term has a negative effect on their general state of health. The following measures are recommended by "Fischnetz":

- Priority measure: establishment and maintenance of quality standards for all relevant substances which could impinge on the ecosystem and fish. Incursion of substances into waters in harmful concentrations must be avoided (precautionary principle). Respondents: Swiss Federal Authorities
- Better supervision and consistent application of the Water Protection Regulations in agricultural areas with an arable area of 10% or more, to reduce pollution from pesticides or other harmful substances. An enlargement of organic farming areas should be aimed for. The examination and, as appropriate, the optimisation of agricultural drainage systems as well as the establishment of river bank strips help to reduce flooding and the incursion of harmful substances connected with it. The maintenance of measures of good agricultural practice (for example, the proper disposal of residues) should also be examined and applied. Respondents: federal, cantonal and local authorities, sewage treatment associations, agricultural associations, agricultural schools.
- Replacement of substances which are hard to degrade by biologically fully-degradable substances, above all in mass-produced chemicals which are used in household products like washing powder and dry-cleaning fluids or in cosmetics. Respondents: manufacturers and dealers of such products, consumers.
- Optimisation or restoration of critical sewage treatment plants and reduction of the effects of rain runoff on the main effluents. Respondents: WWTP operators, WWTP associations, cantons.

BETTER DATA

Some hypotheses on the decline in fish stocks could not be satisfactorily answered because the appropriate information was missing. The following data should be systematically collected:

- Catch and fishing intensity. The statistics from the cantons should be unified so that the data can be compared. Respondents: cantons, fishing organisations, SAEFL.
- Fish stocks. Comprehensive information on fish stocks, age, size, weight, species, organ mutations and incidence of PKD in the individual waters is needed. Respondents: cantonal and federal authorities.
- Biological and chemical condition of the waters (including clogging of river beds) as well as risk assessment of relevant substances, for example pesticides, environmental hormones and others. Respondents: cantons.
- The eco-morphological condition of streams and rivers is to be monitored according to the Modular Stepwise Procedure. Thus, the present condition can be established and the appropriate action can be determined with respect to official provisions of the Water Protection Regulations. The measures to be taken should be arranged according to their importance. Documentation and communication of the results when a stream or river is returned to its near-natural condition. Respondents: cantons.
- Achievement records for all measures implemented through documentation of the relevant data, for example state of waterways, water quality, fish stocks and catch. Respondents: cantons.

FURTHER KNOWLEDGE

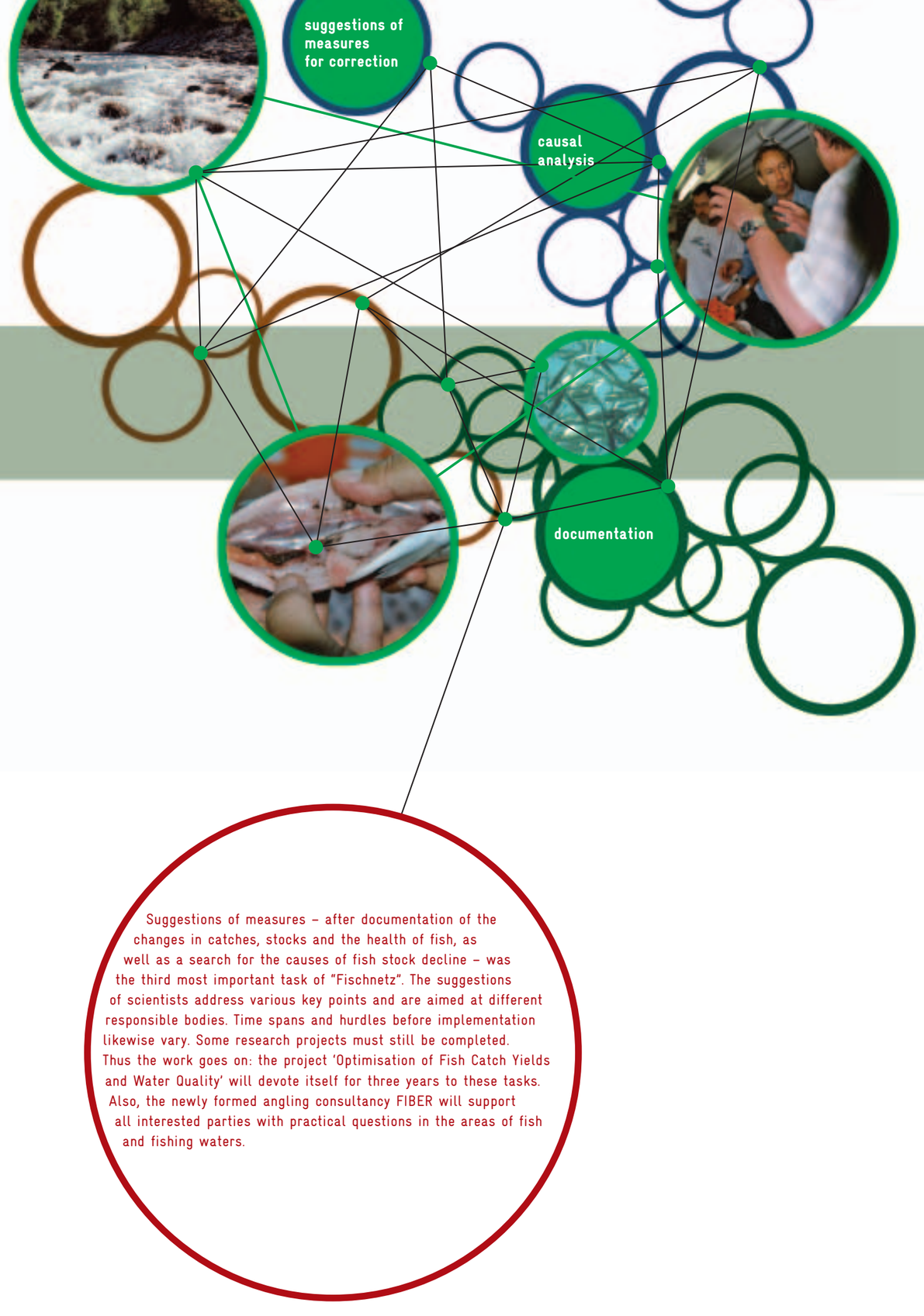
Scientific investigations into the fundamental questions of fish biology, in particular, health, genetics, reproduction and ecological aspects are required. This is foremost the province of the research institutions (for example, university departments and research institutes). "Fischnetz" considers that the following investigations are important:

- Continuing investigations into the effect of chemicals on the hormone, immune and nervous systems of fish. What effect do lower concentrations have over longer periods? What happens to fish and other aquatic organisms when exposed to combinations of different substances and irregular application?
- Better research into extent, distribution and development over time of fish diseases. Investigations into PKD are especially necessary in order to better understand the role of this disease in the decline of fish stocks and develop appropriate preventive measures.
- Better documentation and research of the theme 'surge-slump' and its effects on fish.

CONTINUOUS TRAINING

The recommended measures can only be planned and implemented in the properly designated way if all those involved also have the appropriate knowledge. Of importance here is:

- Training of members of authorities in the application of the methods (for example, measurement of sedimentation, collection of catch and population data, stocking guidelines).
- Training and support of those responsible for the implementation of the measures (for example, implementation of the legal principles, planning and achievement records).
- Training anglers in the implementation of the new management guidelines of the Swiss Fisheries Association for the promotion of fish stocks.



Suggestions of measures – after documentation of the changes in catches, stocks and the health of fish, as well as a search for the causes of fish stock decline – was the third most important task of "Fischnetz". The suggestions of scientists address various key points and are aimed at different responsible bodies. Time spans and hurdles before implementation likewise vary. Some research projects must still be completed. Thus the work goes on: the project 'Optimisation of Fish Catch Yields and Water Quality' will devote itself for three years to these tasks. Also, the newly formed angling consultancy FIBER will support all interested parties with practical questions in the areas of fish and fishing waters.

OUTLOOK

After the conclusion of the "Fischnetz" project, various research schemes have to be brought to a close. The network created is to be secured and the evaluated results passed on. An archive is to be overseen and the implementation of the measures is to be assisted. Through the support of all the institutions involved in "Fischnetz" new advisory bodies have arisen which will take on these tasks.

Project 'Optimisation of Fish Catch Yields and Water Quality'.

This three-year project will be financed by all cantons, Liechtenstein and the EAWAG. Its task is to coordinate the research work of "Fischnetz" coming to an end after 2003, to ensure national and international communication of the results, to support the cantons in the implementation of the measures suggested and with the achievement records and secure a transfer of the evaluated knowledge to the Angling Consultancy FIBER.

Angling Consultancy FIBER

EAWAG, SAEFL and Swiss Fisheries Association have decided to construct an angling consultancy (FIBER) and to finance it jointly. FIBER should help to answer the unsolved questions of anglers in the areas of fish and fishing waters.

Masthead
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