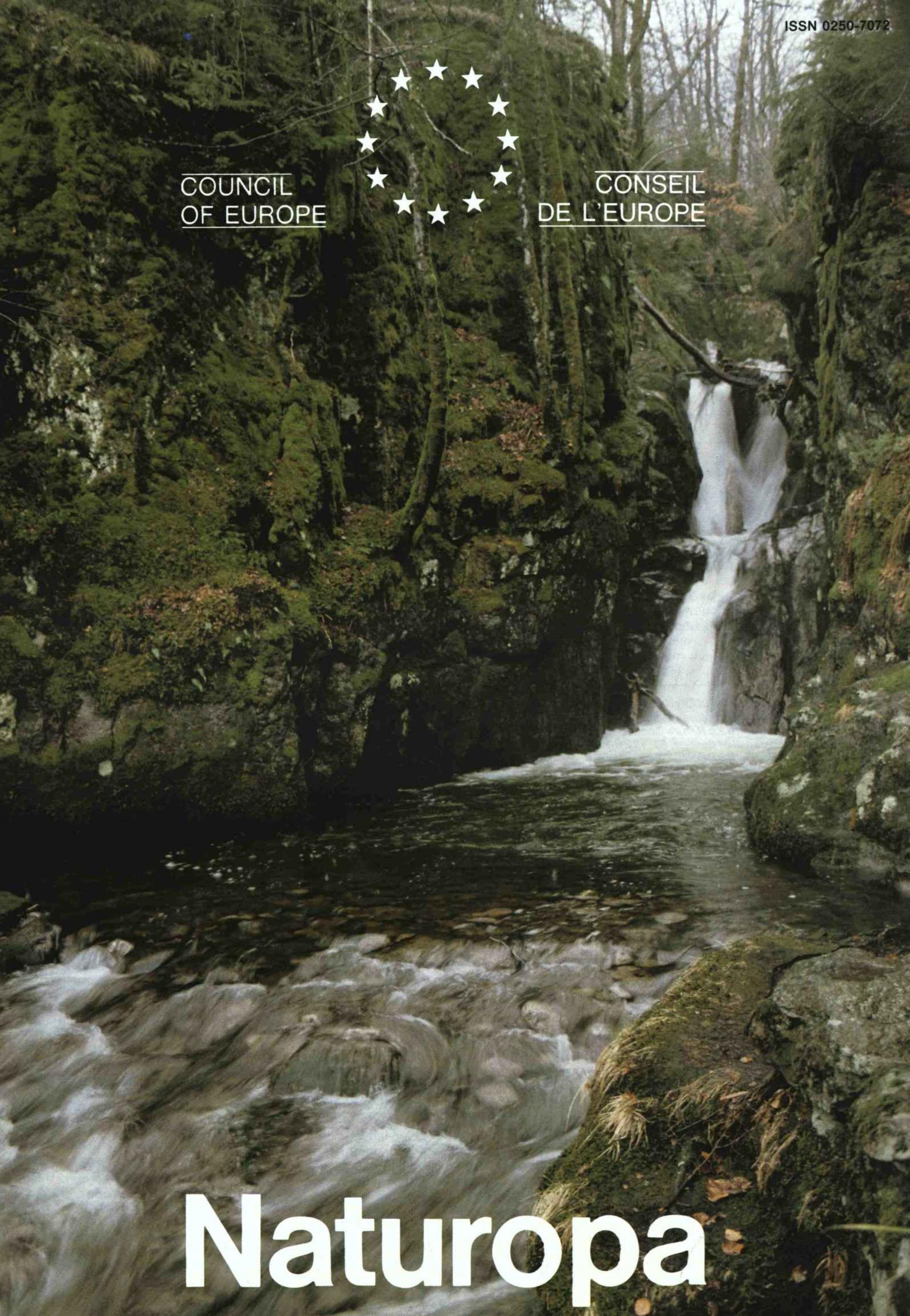
ISSN 0250-7072

COUNCIL
OF EUROPE

CONSEIL
DE L'EUROPE



Naturopa

european
information
centre
for
nature
conservation

Symbol for the Council of Europe's nature conservation activities.

Naturopa *is published in English, French, German and Italian by the European Information Centre for Nature Conservation of the Council of Europe, BP 431 R6, F-67006 Strasbourg Cedex.*

Editor responsible: Hayo H. Hoekstra

Conception and editing:
Annick Pachod
Gérard Lacoumette

Adviser for this issue:
Dr. A. Lelek,
Forschungsinstitut Senckenberg
(Federal Republic of Germany)

Printed by: Georges Thone,
Liège (Belgium)

Repros: Gam Grafic,
Herstal (Belgium)

Front cover: Photo G. Kraczkowski

Captions to colour illustrations p. 16-17

1. *Dytiscus marginalis*
   (Photo Anne and Jacques Six)
2. *Natrix maura*
   (Photo Jean-Paul Ferrero/Jacana)
3. *Pandion haliaëtus*
   (Photo Bengt Lundberg/Natur Fotograferna)
4. *Mustela lutreola*
   (Photo Bengt Lundberg/Natur Fotograferna)
5. *Fly-fishing*
   (Photo J. C. Chantelat)

Naturopa

No. 47 - 1984

Fishes

Although nearly always hidden from view, the fish of our lakes and rivers are none the less important for that, if only as indicators of the healthy condition of the waters where they are to be found. Over-fishing, destruction of biotopes and pollution have been the immediate causes of the perils facing species whose finest specimens once graced the tables of the crowned heads of Europe.

Fish have always attracted man, as much because of their "secret" life beneath the water's surface as because of their sought-after flesh.

Once many people made a living fishing mountain streams for trout, lakes for carp and rivers for salmon and sturgeon. Such fishing has declined considerably, but millions of anglers have taken over from the professionals.

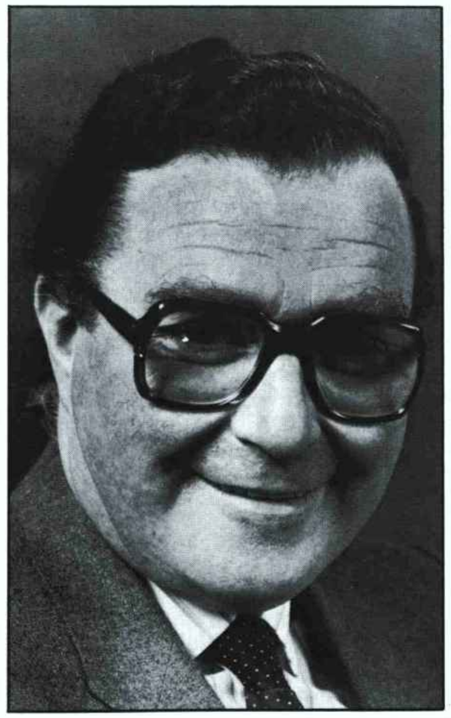
As the last of three issues of *Naturopa* on the "Water's Edge" campaign, this one is concerned with Europe's freshwater fish.

This year's final issue will be devoted to "Nature and the computer", a field of growing importance to the Council of Europe. H.H.H.

Editorial

(Photo G. Kraczkowski)

Schubert's "Trout" must be one of the most widely known and loved themes in European music. The trout—fish and music—conjures up thoughts of brilliance, purity and freedom: the sparkle of a mountain stream and the wildness of a leaping fish.



Those of us who have followed rivers to their sources, or spent peaceful days fishing, boating or swimming know the value of water—or believe we do. The industrialist whose factory needs many tonnes of water every day and the farmer whose crops face disaster in times of drought also believe in the miracle of water. Yet, we complain when the rain falls; too often the industrialist takes the water and renders it unusable for the rest of the community; farmers beg their governments to drain away surplus water.

These contradictory views of the benefits of water make it difficult for us to comprehend its value. Those who actively work to preserve it are relatively few and are regarded by many as belonging to the lunatic fringe of conservationists. Somewhere there must be a point of balance between the extremists on the one hand who say "Our waters are too precious to allow anyone to interfere with them" and those on the other who argue "Our business brings so much employment that we are entitled to do what we wish with the water".

The earliest Europeans had an especially close affinity with water. They were hunter-gatherers who had learned the skills of the fisherman. Fish such as the salmon, easily caught in winter when other food was scarce, sustained our forefathers. Modern Europeans can live without fish but do not want to. The numbers who fish for a living have declined as easier ways of raising an income have increased; in their place are millions of recreational fisherfolk who follow their sport with fervour.

Concern over the quality of water has in a great many cases been spearheaded by the sport fishing community. It is obvious that fish need water, but the chemical and physical nature of the water is of equal importance to their well-being. Fishery scientists have shown how the trout needs water of the highest quality if it is to survive at all. The level of dissolved oxygen must be close to its maximum value and the water must be free from excessive quantities of silt in suspension. Other fish, such as carp, bream and eels, are tolerant of less oxygen and more dirt but even they cannot survive serious pollution.

If the disappearance of fish from lakes and rivers were the only ill effect of water pollution, it might be possible to ignore the complaints of fishermen; but the welfare of fish is of infinitely greater importance to the community than at first appears.

The oxygen in water does much more for the benefit of humanity than keep fish alive. The bacteria which recycle our waste products, turning them back again to water, carbon dioxide and simple chemicals, also require oxygen. Here there is two-way traffic: water with the help of its oxygen purifies the sewage but the sewage uses up the oxygen. If there is too much waste, all the oxygen is used and the waste can no longer be made safe. In that event the water becomes unfit for use by man, beast or industry. Long before this occurs, the fish die and the fishermen complain. Their complaints must be given the most urgent consideration because the death of fish is the precursor of the death of the water itself.

Today, after centuries of study of water and of every creature that lives in it, our scientists can tell us what we need in the form of water quality. What is more, they know not only how to maintain our water supplies in their ideal state but how to restore watercourses which have been spoiled by indifference in the past.

But knowing what to do is not enough. The public must be prepared to pay the cost of maintaining water supplies in a clean and unpolluted state. The demands for immediate cheap energy, food and consumer goods conflict with the long-term needs of maintenance of clean water supply. The costs of dealing with the causes of acid rain and other forms of water contamination will undoubtedly be high but our failure to act may prove more costly.

The future can be bright. In this issue of Naturopa one article tells the success story of the restoration of two of our great rivers, the Rhine and the Thames. There have been many less spectacular but equally successful undertakings.

Today we rejoice in the certain knowledge that pollution can be conquered. What we need is the will to do it.

Paddy O'Toole
Minister for Fisheries
and Forestry
Ireland

A very special environment

Ignacio Claver Farias

Fishing, an indispensable source of subsistence
(Photo J. C. Chantelat)

Spain's deeply rooted and traditional involvement in fishing is well known. This is due both to the great length of its coastline and its many rivers, as well as to the considerable surface area covered by still, natural water (lagoons, lakes, etc.) and by reservoirs. The existence of other unusual expanses of water should not be forgotten either; these include the "rías" of Galicia and the Asturias, the Andalucian estuaries, the Valencian Albuféra, the Mar Menor in Murcia and the Ebre delta.

Moreover, the geographical situation, relief and climate of our peninsula have always allowed reasonable exploitation of various species of fish, some more sought-after than others. This is why the local population has always been very involved in every kind of fishing.

Where inland fishing is concerned, it should be noted that our legislation considers inland waters as including all springs, lagoons, lakes, streams, reservoirs, artificial lakes, canals, albuféras and rivers, whether their water is fresh, brackish or salty, until it enters the sea.

Fishing as a source of employment and livelihood

Since man's appearance on Earth, fishing, like hunting, has been one of his indispensable sources of subsistence. Today it retains this basic function of providing food in the less developed countries where it always has been, and will continue to be, the only available source of animal protein.

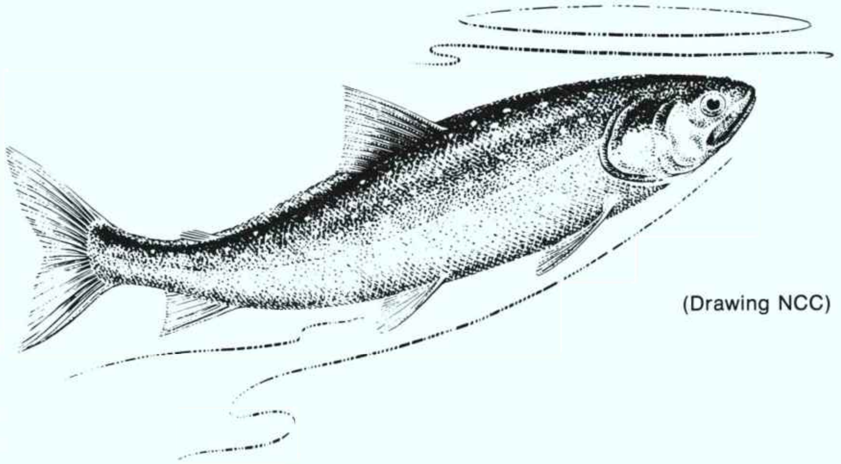
In Spain, as in many other countries, this function of providing food is almost totally fulfilled by professional sea fishing, and inland fishing survives only in certain areas. At the same time, there has been a rapid increase in fishing for sport, which is very popular in our country, given that one in every 45 Spaniards is an angler.

However, a whole range of factors leads us to believe that this situation will change again. World politics and the pressure which is being put on fishing at the moment have caused a real problem. The number of fish caught throughout the world at present exceeds the natural reproductive capacity and, in addition, the extension of legal waters to 200 nautical miles has greatly affected our fishing industry by preventing Spanish vessels from fishing in most of their traditional maritime fishing grounds.

This is why the past 20 years have seen a renaissance, with even greater energy, of inland fishing, which can provide very good, cheap food by the introduction and development of modern intensive fish-farming to satisfy consumer demand.

Fish farms in Spain can be divided into two different types, public-service and commercial. The first, which belong to the State, are basically to provide fish for sporting and conservation needs. The most commonly bred fish include: Atlantic salmon, river trout, rainbow trout, brook trout, pike, carp, largemouth black bass and tench.

The present level of production in commercial fish farms is more than 15,000 t with a turnover in excess of 13 milliards pesetas; more than 5,000 jobs have been created. These commercial farms concentrate mainly on breeding and marketing rainbow trout and, to a lesser degree, river trout, brook trout, tench and eel.



(Drawing NCC)

Inland ichthyological fauna

In Spain, the river network is 72,000 km long and the surface area of still water is more than 250,000 hectares. Twenty families and fifty-nine different species of fish live in them. From this information alone, it may be seen that the wildlife is somewhat limited. The number of fishing species in our inland waters is, in fact, less than that of other European countries, mainly for climatic and geographical reasons.

However, because we are practically isolated from the rest of Europe by the Pyrenees, we have a highly characteristic fish population, with fish as heterogenous as the Atlantic salmon—king of the river—and the flounder *Flesus flesus* a flat asymmetric fish.

Zoogeographically, our wildlife is situated between that of central Europe, which is eminently palearctic, and that of Africa, which is tropical or ethiopic. This is why Spain is quite often the most northern limit of the geographical distribution of typically ethiopic species or the southern limit of certain typically palearctic species; moreover, often the sub-species of the ethiopic or palearctic species represented in Spain are not those typical of the species.

The development of fish farming

Fish farming in Spain can be traced back through the centuries, but it may be said that salmonid farming began in the 12th century, in the monastery known today as Santa Maria de Conxo, in the province of Coruna.

The incubation of trout eggs in the 14th century, although it is not known whether this included artificial fertilisation, and the discovery of the latter in the 18th century, led to the establishment of special fish breeding centres.

As early as 1866, the first ichthyogenical laboratory was built in Spain at La Granja de San Ildefonso (Segovia). The same year saw the first work of the piscicultural establishment of the Monasterio de Piedra de Alhama de Aragón (Saragosse).

The Spanish revolution in 1868 put a stop to work on fish farming, which was not resumed until 14 years later. By about 1950 there were 12 state fish farms in Spain. Today we have some 200, both state- and privately-owned.

Its natural conditions make Spain ideal for fish farming, especially the temperature of the water which may be either cool or warm.

Cold water has been used only for breeding salmonids, especially rainbow trout. It still has great potential for breeding other types of fish. However, much of our water is within the temperate range. This, in theory, is the best, because it favours more rapid growth.

One of the numerous warm water species is the eel, for which there is a market of many millions of kilogrammes in central Europe and, aside from the very important fact that the natural environment is suitable, we are also able to obtain large quantities of elvers as seedstock.

To close on a note of optimism, Spain can look forward to varied and prosperous development of its fish resources for conservation, for sport, and for intensive farming. I.C.F.

Portrait of a fish

Pike (Photo G. Kraczkowski)

Wilhelm Harder

Of all vertebrates, fish form the group with the largest number of species: one in two vertebrate species is a fish. Of the at least 20,000 species, well over 19,000 are bony fish; some 600 are sharks or rays. The remainder is accounted for by cyclostones: lampreys, hagfish and a number of "relicts" such as lungfish, lobefins, gars, mudfish and sturgeon. Of these only lampreys and sturgeon are found in European waters. All the rest are bony fish: some 130 species —a tiny number in comparison with the rest of the world's fish fauna. Europe's seas account for some 650 more species; all in all, our fish fauna are not exactly very varied.

Nor are European waters particularly varied in biotopes. Moreover, a large proportion of them have been colonised only recently (in geological terms), i.e. since the ice age. This applies especially to our mountain regions, where no striking examples of adapted species, such as occur in the mountain streams of the Andes or the Himalayas, are to be found.

Life in the water

The typical fish's body is perfectly adapted to its mode of movement. Fish are very hydrodynamically shaped, so that energy consumption is kept to a minimum. This applies especially to pelagic species, i.e. those which swim virtually non-stop, such as salmon, trout, whitefish and most carp. The less active species that keep to the bottom and swim only intermittently have less hydrodynamic shapes: flounder, ruffle, miller's thumb, catfish and the like.

Water is where life originated—which is not to say that it is a particularly hospitable environment. It is indispensable for all the biochemical reactions that take place in the body, but it is also very constricting. For example, it contains only very limited amounts of the oxygen necessary to all higher forms of life. It affords a high degree of buoyancy because of the small difference in density between it and organisms, but by comparison with air it has a very high density and viscosity (1,000 times more) and offers much greater resistance to movement. This is particularly important in running water, where current and bodily movement may oppose each other. This determines the limits within which the fish's body must be adapted in terms of shape, anatomy and, not least, physiology.

Its body must be able to overcome the current, which exerts its force especially on the head region. To put it crudely, the current presses against the head from the front, the body's muscular power from the rear. The structure of the skull takes this into account. But the head is not only a current-divider. In abstract terms, it is not only a "pole of movement"; it is also, in order to be able to direct movement, a "sensory pole": it accommodates all the major sensory systems. In addition, it is the "nutritional pole", the point of entry for food and for the oxygen that supplies energy. The control of movement, direction, feeding, breathing and special, e.g. reproductive, behaviour necessitates accommodation of the main bulk of the central nervous system, the brain, in the head.

Where food is concerned, our fish fauna is very varied: the spectrum ranges from plankton-eaters to consumers of fresh or dead plant matter and lower forms of animal life, whilst some fish species prey on others. Jaws have to be adapted accordingly. Food is chewed small only by carp species, which have gullet teeth next to the rearmost gill arch. Jaw teeth, where they occur, serve only to hold prey fast.

The sensory organs

The sensory organs resemble those of terrestrial animals. However, the eyes have to have a spherical lens in order to develop sufficient refracting power. The cornea which most land animals use to project an image on the retina cannot work for water animals because the refractive index of water and cornea is too similar. As the eyes are located on the side of the head, binocular sighting of prey is not possible; all objects have first to be perceived parallactically against the background before they enter the usually very narrow field of binocular vision.

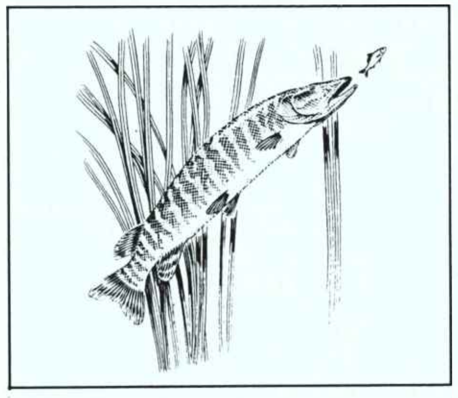
The sense of smell is located in the nose, but the nasal cavity is not involved in the breathing function and is separated from the respiratory tract. The sense of taste works through sensors in the mouth cavity, but which are often also distributed all over the body. The sense of balance so important for organisms that move in three planes is highly developed. Statoliths provide information about orientation in space. Three semicircular canals can detect angular acceleration. Sense of touch and of temperature are also present. Whether fish can feel pain is a matter of controversy, though this of course does not give a licence to do as one pleases with them. Fish also have a further sensory system denied to terrestrial species; it is developmentally related closely to the sense of hearing, which they also possess. The sensors of the "lateral line system" respond to the build-up of pressure in the water due to the fish's own movement, the movement of other fish or obstacle resistance to current flow. It is not a sense of flow: a fish can detect a change in its position in relation to the bottom only by eye. The sensors of the lateral line system are located in channels around the head and along the body and can be seen from outside through pores.

The gills

The head also accommodates the respiratory organs: the gills. There are usually four gill arches, each with a double row of gill-filaments. These filaments are covered with lamellae through which gas exchange takes place. Water is, as we have said, a poor respiratory medium; at best, i.e. at 0 °C, it contains 10 ml of oxygen per litre, barely 1/20th of the amount available to a land animal. To obtain the same quantity of oxygen, a fish accordingly requires much more of its respiratory medium and must be much better able to extract the available oxygen from it than air-breathing animals. Land animals live in conditions of affluence where oxygen is concerned and can afford to breathe out 80 % of their oxygen supply unused. That would be impossible for a fish. A fish is able to extract at best 60-80 % of the available oxygen, during fast breathing only 20 %. Furthermore, water has higher density than air and is hence heavier and more "sticky" due to its high viscosity. This means that it takes a great deal of energy to move it. Consequently, a fish has to use up to 1/6th of its energy resources for breathing.

Disposing of the by-product carbon dioxide poses less of a problem. It is much more readily soluble in water than is oxygen and is easily taken up by the ambient water. The same applies to another, more dangerous metabolic product, ammonia, which results from the breakdown of protein. It too is excreted via the gills. The gills are very good exchangers, working on the countercurrent principle. Water with a high oxygen content flows in the opposite direction to the low-oxygen-content blood in the gill lamellae. This produces a constant difference in concentration which guarantees optimum exchange. Carbon dioxide and ammonia are discharged according to the same principle, and so is metabolic heat. (Very few fish, e.g. some shark and tuna, are "warm-blooded". By means of countercurrent heat exchangers in their muscles and liver they are able to retain metabolic heat in their bodies.)

A further effect of the gills' exchange capacity is that water can also penetrate freely through the necessarily thin epithelium of the gills. This has considerable consequences for the fish's water and mineral husbandry and in turn causes high energy expenditure. Freshwater fish, whose blood and tissue fluid contain larger quantities of dissolved particles, mainly salt ions, than the surrounding water, continuously—passively—absorb water via the gills. Their kidneys accordingly have to excrete large quantities of water in order to keep their body-fluid concentration constant. Since vital ions are lost in the process, these have to be replaced. This is done by special cells, ionocytes, located on the gills. Seafish, on the other hand, have to compensate for constant water loss via the gills, because their body fluids contain fewer dissolved substances than the surrounding seawater. To do so they have to drink, i.e. absorb a strong salt solution. The ions which are inevitably absorbed in the process are excreted via the gills. Bony sea fish have sharply reduced active water excretion via the kidneys and hence the number of kidney corpuscles. Fish able to change environments such as salmon, flounder and eels, have to gradually adapt in estuaries.



Design NCC

These peculiarities of water and mineral husbandry show why the gills cannot be bigger in order to make better use of precious oxygen. Owing to the many functions of the gills, water pollution affects them particularly, for it is through the gills that harmful substances can most easily penetrate the body. Then, of course, not only the gills, but the whole body is damaged.

Space does not permit dealing with the anatomy of the internal organs here, but it is worth mentioning that research has shown only recently that fish have a dual artery system and no lymphatic system.

The locomotive system

Fishes' locomotive system is also determined by their environment. Corresponding to the fore and hind legs of terrestrial vertebrates are the pectoral and ventral fins. However, the fins are rarely used for actual movement, but rather for positional stabilisation, for adjusting height and for braking. Most free-swimming fish have a swim bladder, though it is not used for upward or downward movement, because it cannot be quickly expanded or contracted at will. It is a hydrostatic organ to prevent sinking, the fish's body being heavier than water. The bladder compensates for this difference. It permits rapid diving, in the course of which it is compressed by the water pressure and loses buoyancy. This process then has to be reversed by "pumping" back gas from the blood. This expends energy, but probably less than would be needed to provide hydrodynamic buoyancy by constant swimming. On the other hand, it makes rapid upward movement difficult, because the gas expands more quickly as the pressure falls than it can be reabsorbed from the bladder. Fish accordingly avoid rising quickly because of the considerable strain it places on the organism.

In addition to their paired fins, virtually all fish have a number of others, viz between one and three dorsal and one or two anal fins supported by fin rays which are stiff and pointed, or flexible and branching. Sometimes these unpaired fins form a continuous row. Dorsal and anal fins serve mainly for sideways steering but usually also as display organs with which bony fish show their moods: aggressiveness, fear, readiness for mating. The main propulsive organ is the tail fin which helps transmit the mechanical forces developed by the body muscles. The fin is usually self-cambering to produce the best hydrodynamic effect.

The locomotive apparatus also includes, in addition to the motor—the musculature—the skeleton, i.e. the vertebra and the skin. The muscles are attached to both, so that the wave-like contractions of the muscles are converted into undulating movements of the body.

Fish muscle is not directly comparable to that of land animals. Its well-known pale colour is due to the absence of myoglobin. Its blood irrigation, and hence its oxygen supply, is low. The greater part of the fish's muscle works without consuming oxygen, but only for a short time. Energy is generated by converting glucose into lactic acid, a fermentation process in which no oxygen is necessary. The lactic acid can be converted back again later, using oxygen, but must not be produced in too large quantities, since it would disturb the whole metabolism, in particular respiration.

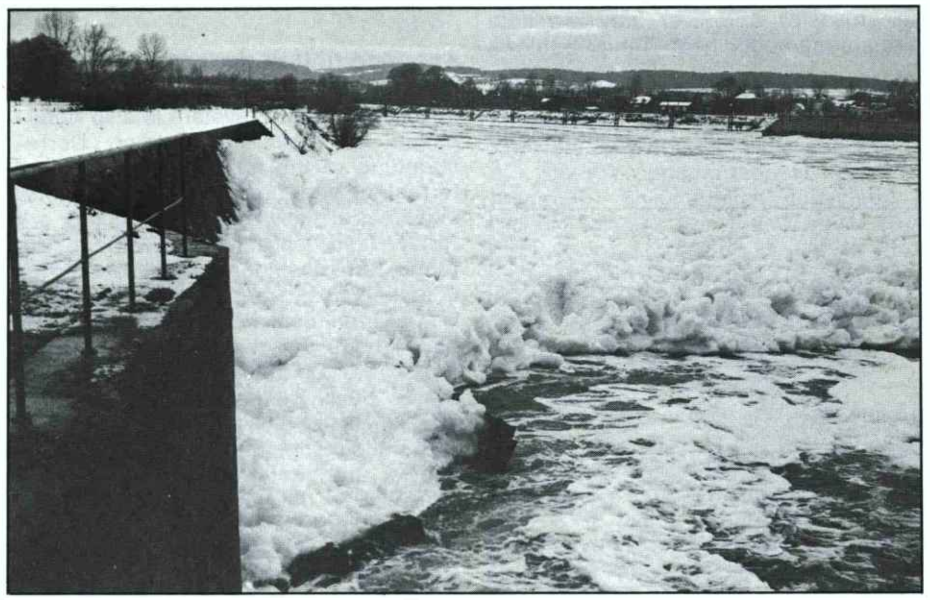
White muscle can accordingly only be used when there is special need: escape, defence, capture of prey. An extreme example is the pike. In sports terms, the pike is a sprinter. Constant swimming at a steady speed requires "staying power" and relies on a small proportion of "red" muscle. This muscle is generally found just beneath the skin, as can be seen from any fish fillet. This muscle is well irrigated, because it needs a constant supply of oxygen and nutrients, mainly fat. It also contains myoglobin, which helps remove oxygen from haemoglobin in the blood. It is this red muscle which enables the trout, for example, to withstand the current of a mountain stream or salmon to make their way upstream from the sea. To surmount obstacles, they have to rely on their white muscle. But even more sluggish fish like carp have strong red muscle. Their low-calorie diet obliges them to be constantly searching for food. The greater bulk of their muscles, if they needed oxygen, would be of no use to them, since such great quantities of oxygen could not be extracted from the water.

Colouring

Fishes' colouring either camouflages the fish in its surroundings or serves to give signals, in either territorial or mating behaviour. The banks of European waters are not exactly colourful if compared, for example, with coral reefs. Our fish are accordingly also rather dull in colouring. Exceptions are the wedding dress of the three-spined stickleback and minnow but they are displayed for only a short period of the year. Our fish mostly have dark backs and silvery flanks. Their back colouring renders them invisible against the dark background of deep waters. Over the lighter-coloured bottom of a stream the colour cells of the skin can concentrate their pigment in small areas and so make their overall colouring paler.

The silvery glint of fish skin is produced by complete reflection of light from very thin flakes of guanine. These crystals are themselves colourless, but they alternate in the skin cells with thin layers of cytoplasm. The thickness of the guanine and cytoplasm layers is such that all wavelengths of light are uniformly reflected, producing a silvery metallic shine. The guanine stack is so angled as to reflect the same amount of light as if there were no fish there. To an observer from the side or form below, the fish is virtually invisible.

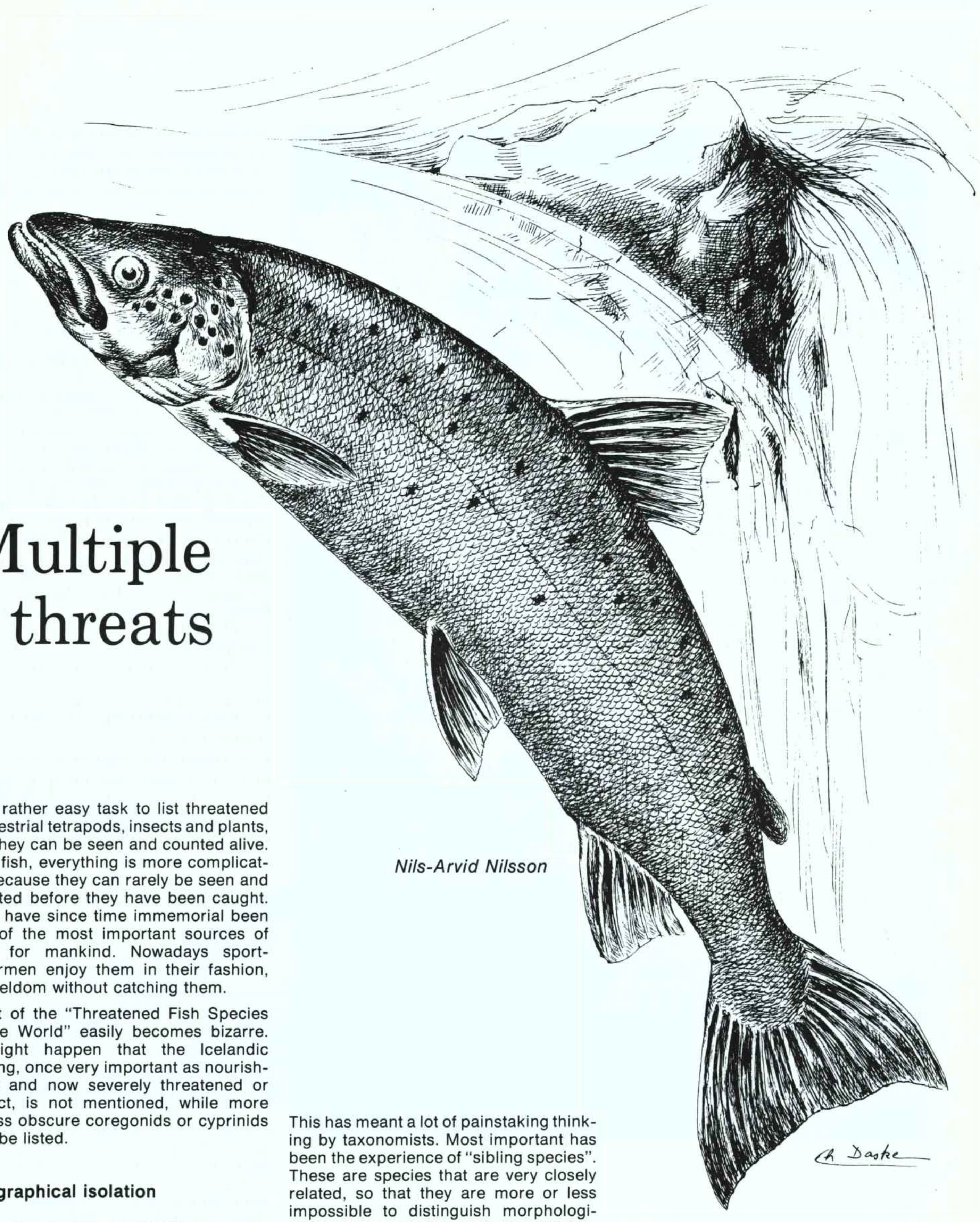
Fish—like the other water creatures—have made the best of their living conditions. Water is not a particularly hospitable medium; its inhabitants have managed to adapt to it only over an unimaginably long time. The natural factors to which the organisms have had to adapt include: oxygen supply, density, viscosity, acidity, mineral content and temperature, to name but a few. Human action is changing several of these factors and pollution from sewage, toxins and waste of all kinds cannot but have a harmful effect. It is incredibly naïve to assume that living creatures can adapt quickly to such new conditions. And that does not only apply to water creatures. W.H.



Such scenes should disappear forever (Photo Verney)

Multiple threats

Nils-Arvid Nilsson



Salmon
(Drawing Christiane Daske)

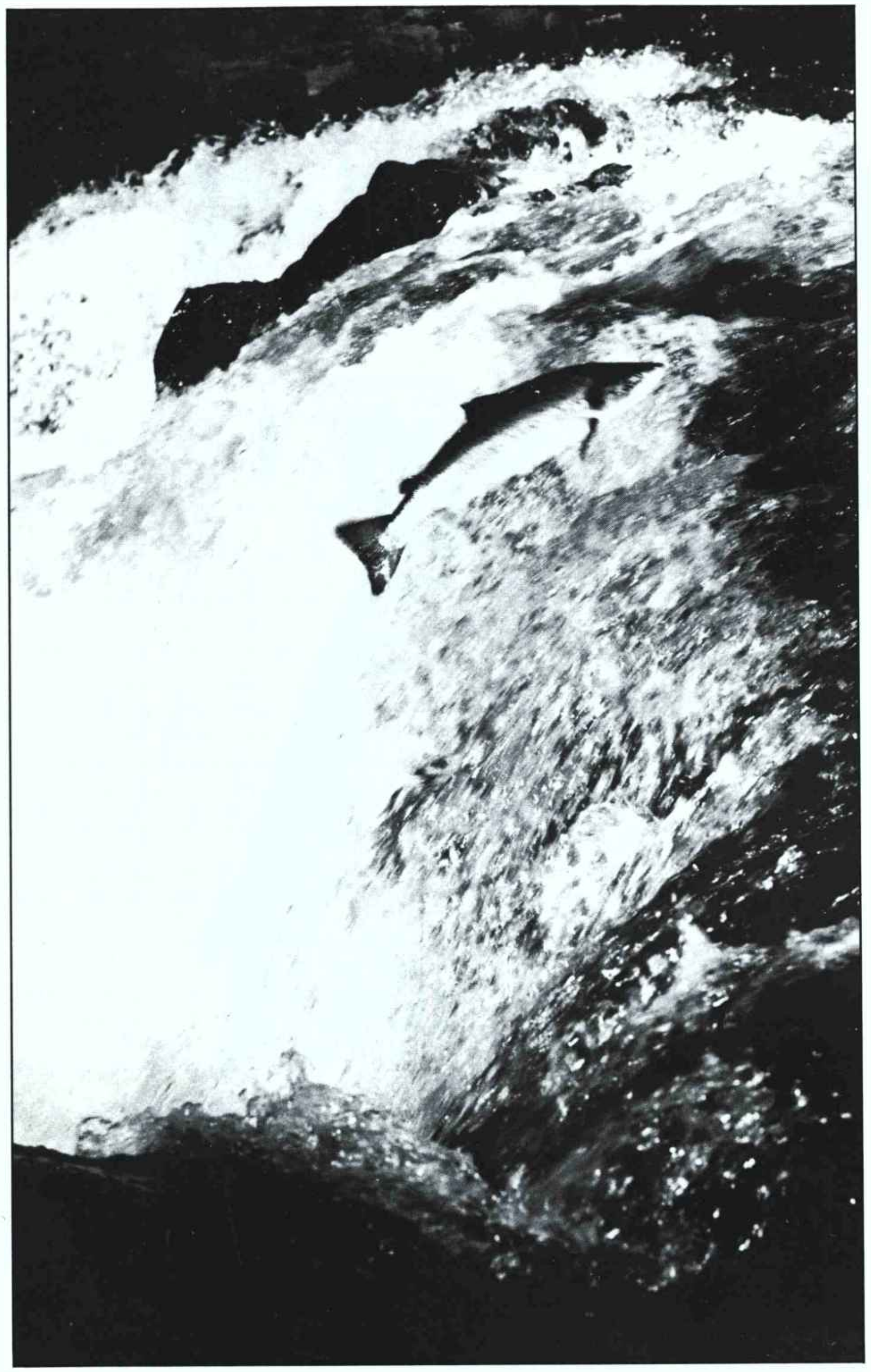
It is rather easy task to list threatened terrestrial tetrapods, insects and plants, as they can be seen and counted alive. With fish, everything is more complicated because they can rarely be seen and counted before they have been caught. They have since time immemorial been one of the most important sources of food for mankind. Nowadays sportfishermen enjoy them in their fashion, but seldom without catching them.

A list of the "Threatened Fish Species of the World" easily becomes bizarre. It might happen that the Icelandic herring, once very important as nourishment and now severely threatened or extinct, is not mentioned, while more or less obscure coregonids or cyprinids may be listed.

Geographical isolation

According to Mayr and other experts in speciation geographical isolation plays the main role in the origin of species. No vertebrates other than freshwater fish could be better examples of the significance of geographical isolation, enclosed as they have been in lakes or river systems for thousands of years. In fact, every isolated population is unique because of its adaptation to the biotope of its origin.

This has meant a lot of painstaking thinking by taxonomists. Most important has been the experience of "sibling species". These are species that are very closely related, so that they are more or less impossible to distinguish morphologically, except, for instance, by physicochemical means, such as the electrophoresis of enzymes, etc. However, they are different in general ecological patterns, and thus different in their response to changes in their environment. In Europe, whitefish (*Coregonus*) and Arctic charr (*Salvelinus*) in particular have been the subject of careful analysis both regarding physical and ecological differences.



A Salmon on its way to spawn...
(Photo Hjalmar R. Bardarson)

Still more crucial is the phenomenon of "subpopulations", "stocks", "races" or "subspecies" of species that are able to interbreed, but still remain separated because of geographical isolation, homing behaviour, etc.

For instance, homing is a very important factor in keeping subpopulations of Atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*) apart. It is a well-known fact that salmon return from the Baltic to the rivers where they were once born or released as smolt. Brown trout often appear to retain outlet- and inlet-spawning populations that probably never interbreed. One of the most interesting examples in Europe is that of the land-locked salmon of Lake Vänern, Sweden. This salmon appears nowadays as two distinct populations, one originating from the main inlet, the River Klarälven, the other from the River Gullspångsälven. Both populations are severely threatened by hydroelectric development and pollution. They differ in many ways, having different feeding areas and above all, very different growth rates. The survival of the Gullspångsälven salmon is now subject to intense conservation efforts, in particular by preserving its spawning sites, as well as securing spawning products for artificial breeding, followed by the release of smolt.

In a similar way most salmon populations of Sweden are being protected by artificial means.

The aims of nature conservation have for long basically been as follows:

1. To conserve plant and animal populations as undisturbed as possible, to enable future scientists to compare them to future populations (e.g. those affected by human activities).
2. To conserve populations that could be of future value, as food or for recreation, and
3. To ensure that the environment will be tolerable to surviving species, human beings included.

Many species of fish are threatened just on the borderline of their geographical distribution. For instance, in a recent list of threatened freshwater fish in Sweden, the following species were mentioned: *Leucaspius delineatus,* Gudgeon (*Gobio gobio*), *Pelecus cultratus, Aspius aspius,* Stone Loach (*Nemachilus barbatulus*) and *Silurus glanis.* All of these species have an eastern distribution and are not threatened at all except in south-eastern Scandinavia.

Apparently we have to reconsider the concept of "threatened species" in this context. Which species or subspecies is more worth of protection: the rare salmon population in the River Gullspångsälven in Sweden, the valuable Danube salmon (*Hucho hucho*), the interesting Yugoslavian *Salmothymus*, or all Mediterranian endemic cyprinids. Apparently they are all worthy of protection, at least from a scientific point of view, but personally I prefer to stress point 2 above, especially as fish will become more and more important in the future as food for the ever-growing population of the Earth.

What threatens our freshwater fish populations?

It was mentioned earlier that the construction of hydroelectric power plants often severely damages anadromous fish species, in particular, by disturbing migration or making it impossible. The dams not only hinder upstream migration, but are also often built in spots which were formerly important spawning sites for the fish.

The interference with upstream migration is sometimes partly compensated for by the construction of fish ladders, but the main means of compensation is fish culture, in which the fish are raised from eggs to a stage of downstream migration (the "smolt" stage). It has, for instance, been calculated that every fifth salmon caught in the Baltic has been hatched and bred artificially in hatcheries and released in the mouth of the river to which it is meant to return after 2-3 years in the sea.

In contrast to the lower reaches of the rivers, the uppermost reservoirs are subject to heavy water-level fluctuations. This means that the soft sediment, plants, animals, etc. are eliminated within the regulated zone, which in turn means an important loss of nourishment and spawning sites within this area. An attempt was made to compensate for the loss of food organisms by transplanting glacial relicts *Mysis relicta* into the damaged areas. They are as a rule not dependent on the more shallow, regulated areas of the reservoirs, quickly form very dense populations and provide an excellent source of food for some species of fish that suffer from the loss of food caused by the water-level fluctuations.

Pollution is a very complex concept that really requires a chapter of its own. Simply speaking, pollution is an adverse effect consisting of many different factors, such as releasing excess nutrients (phosphorous, sulphate, nitrogen, chloride, etc.) into a recipient lake. Some of these, such as sulphate, are poisonous in large amounts. In addition, more or less alien toxic substances have polluted our waters, for instance DDT and sulphuric acid originating from western European industries.

The addition of excesses of nutrients is very much a matter of equilibrium: waters poor in nutrients (oligotrophic) sometimes benefit from the addition of nutrients, while nutrient-rich lakes (eutrophic), may easily die because of an overproduction of plants, oxygen deficits, and the production of toxic hydrogen sulphide (H_2S).

...sometimes with man's help (Photo Mario Broggi)

The most catastrophic effect on not only freshwater fish, but nature in general, is the increasing acidification of land and water due to the emissions of sulphur from urban areas and heavy industry. This means that industrial smoke, containing large quantities of sulphur dioxide (SO_2) is spread all over Europe. Because of prevailing southwestern winds Scandinavia has been especially damaged by the deposition of sulphur in the form of sulphuric acid (H_2SO_4).

Characteristically, different species of fish die at specific pH-values:

Species	Critical pH-value
Rutilus rutilus	5.5
Phoximus phoximus	5.5
Salmo gairdneri	5.5
Salvelinus alpinus	5.2
Salmo trutta	5.0
Coregonus albula	5.0
Salvelinus fontinalis	4.5-5.0
Esox lucius	4.4-4.9
Perca fluviatilis	4.4-4.9
Anguilla anguilla	4.0-4.4

Apparently, roach (*Rutilus rutilus*) are the first fish to die, while perch (*Perca fluviatilis*) and eel (*Anguilla anguilla*) are more resistant. Crayfish (*Astacus fluviatilis*) are particularly sensitive, with a critical pH-value of 6.0.

The effects of acid rain, with consequent decreases in pH, are problems that still need much further research. Acidification of catchment areas results in increased leaching of heavy metals to surface waters. High concentrations of cadmium (Cd), mercury (Hg) and aluminum (Al) have, for instance, been observed in acidified lakes.

Thus, I would conclude by saying that freshwater fish are greatly threatened.

N.A.N.

The Thames is alive

Derek Gren

The River Thames once supported commercial fisheries of considerable economic importance. Smelts from the Thames were plentiful at Billingsgate fish market; 30 or 40 boats working between Wandsworth and Hammersmith only a few miles upstream from Westminster might catch 50,000 in a day. Thames shads, flounders, eels and whitebait were caught for food and over one million lamperns were sold annually to Dutch fishermen for use as bait. Even the occasional sturgeon was taken in the tideway.

1810 - The fisheries destroyed

At the beginning of the nineteenth century several factors combined to destroy these fisheries.

From about 1810 water closets became increasingly used in London, causing cesspits to overflow into town drains which resulted in considerable pollution of the London Thames and many of its tributaries.

The growing number of industrial premises in London including slaughter houses, brew houses, coal wharfs, cow houses, tan pits, gun spinners and fish markets, all put their polluting wastes into the river.

Another important factor which affected species such as lamperns, shads, salmon and sea-trout was the construction of weirs at and above Teddington preventing these fish from easily reaching their spawning grounds up river. Pollution in the river became so severe that it was impassable to migratory fish. New methods of treating London's sewage made an improvement to the quality of the river water during the late nineteenth century but sadly this improvement was short-lived. From about 1920 the river became so polluted that fish and marine life could not survive in the metropolitan river from Gravesend to Westminster. For the next 40 years or so no fish were recorded in the London Thames.

1953 - The clean-up began

Realising the unsatisfactory condition of the country's most famous river, in 1953 the London County Council embarked on a mammoth scheme to rebuild and extend London's major sewage treatment works, the chief polluters of the Thames.

The scheme was to take over 20 years to complete, during which time the Greater London Council, and since 1974, Thames Water carried through the project which, at present day prices cost some £200 million.

This work has resulted in a greatly improved river and is recognised as the most successful campaign in the world to combat water pollution.

The river today

The success of this clean-up campaign was demonstrated initially by a gradual return of fishes and other marine life. The community as a whole has since stabilised into a complex network of interdependent species.

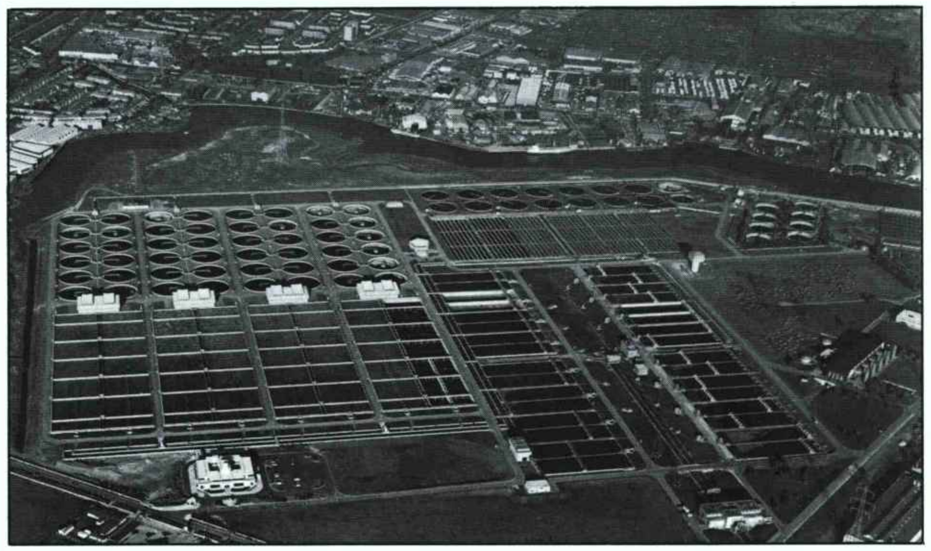
Of the 104 fishes recorded, all but six have been found by Thames Water biologists since 1974 during routine surveys of river life. Five species plus the roach-bream hybrid were discovered by earlier workers around 1970.

During the peak periods, catches on a power station's intake screens a short distance below London's major sewage works outfalls can total 10,000 fishes in a morning's sample and include over 30 different species. Where possible, these fish are returned live to the river to join the other millions of living creatures in a stretch of river where less than 20 years ago no fish or large invertebrate animals could survive.

Thames Water's role is now one of pollution control. On board a floating laboratory, teams of scientists and biologists make regular sorties to sample, analyse and record the condition of the river water and river life.

It is now Thames Water's task to maintain the tidal Thames as the cleanest metropolitan estuary in the world. D.G.

Sewage treatment works at Beckton, East London (Photo A. Handford)



Can we succeed, at least partly, in making good the damage we have done? Salmo salar, *the Atlantic salmon, which disappeared from the Rhine some decades ago, may be poised for a come-back. Experts near Basle in Switzerland have started a 5-year scheme to release some 20,000 marked young salmon a year from fertilised Swedish eggs. After descending the Rhine to the sea, these salmon might, in two or three years' time, return to spawn* (Photo W. Hermann)

New life for the Rhine

Helga Inden

The Rhine is one of mainland Europe's busiest waterways. It is also a living environment whose once rich and varied flora and fauna have, alas, greatly diminished since the turn of the century.

It flows through a part of Germany where both economic activity and population density are above average.

To the pollution which this causes (discharge of sewage, heavy metals and chemicals, residue heat from power stations), engineering works designed to improve navigability by straightening the river's course and regulating its flow have added further harmful effects.

Animal species, especially fish, have suffered badly from this degradation of their environment.

The only species that survive in relatively large quantities are those of the "white fish" varieties little prized for food (roach) and a few moderately-rated species (bream, perch, beaked carp). The more sought-after species, eel, trout, pike, grayling, carp and tench, are no longer found in commercial quantities, except in a few stretches of the river. Yet, as commercial fishing has declined, so recreational angling has constantly grown.

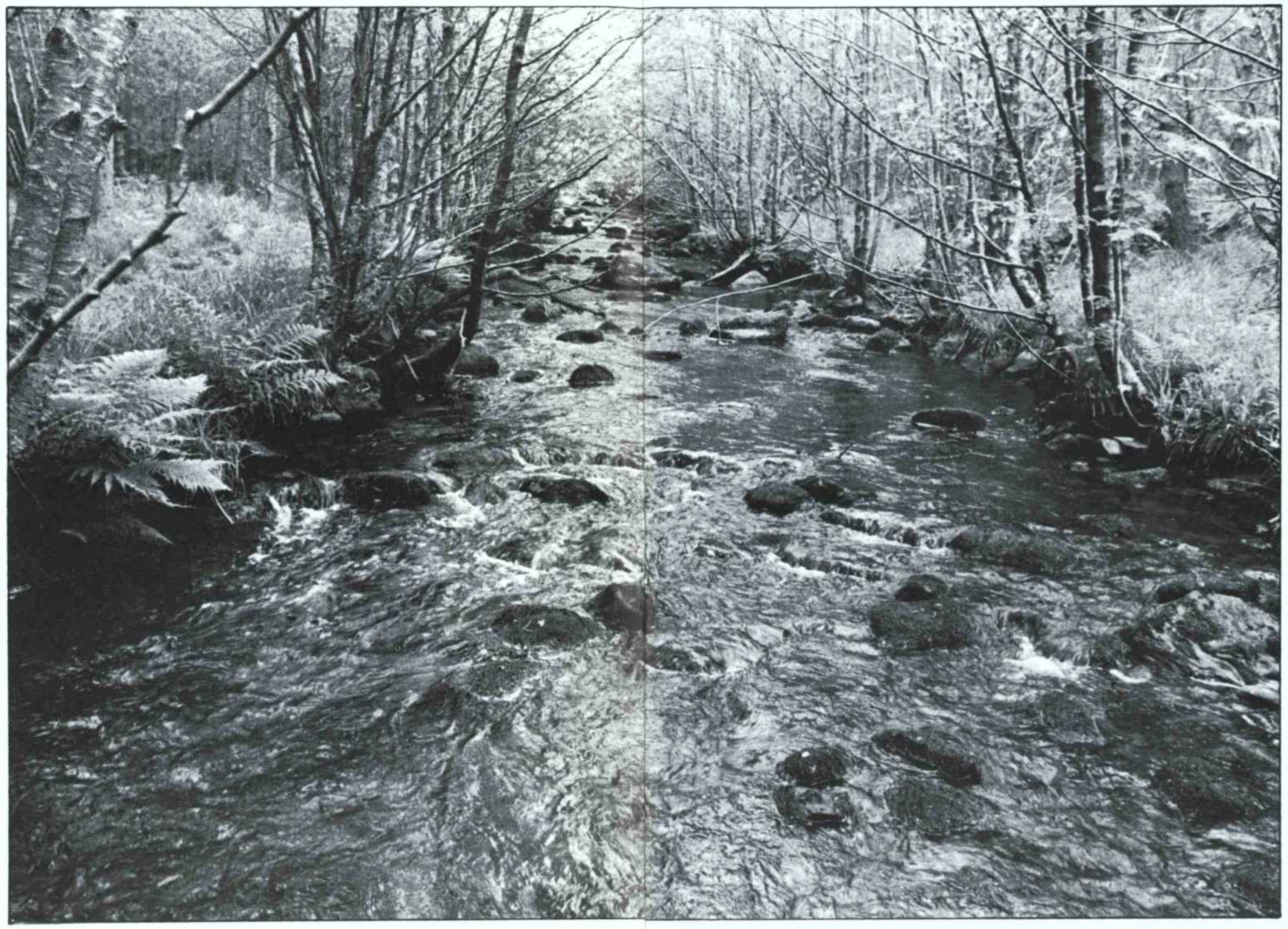
In order to halt the gradual destruction of the Rhine ecosystem and restore conditions in which a diversified fauna can thrive, a number of laws and regulations have been enacted concerning sewage discharge, the use of detergents, non-biodegradable effluent. These laws exist, it remains to enforce them firmly and consistently. H.I.

Biotopes

Anton Lelek

It is common knowledge that fish cannot live out of water. Books intended for the general public usually show brightly coloured fish swimming in crystal-clear water. Such pictures are generally very striking, but give the reader the impression that a fish has to be big, colourful, healthy and lively. Many publications aimed at people with a special interest in fish—fishermen, nature-lovers, aquarium-keepers, or fish-eaters—set the picture of the fish against a foreground or background: the pike in a pond with water lilies floating on the surface, the brown trout in the rushing water of a stream, etc. Although these pictures are often largely accurate, they show only a tiny fraction of the environment in which a fish must remain from the beginning of its life to its death. An egg measuring about 1-5 mm produces a larva some 15 mm long which can develop into an adult fish of some considerable size. To guarantee this development at every stage of the fish's life a wide variety of aquatic biotopes is essential. Rivers' seasonal changes are particularly important. They have a special appeal: romantic poets and composers were early observers of the diversity of a river in its various forms, which they described in their own inimitable fashion.

In extremely simplified terms, a river starts as a tiny stream whose source lies somewhere in the mountains. Swollen with rainwater and melted snow, it merges with other streams and eventually becomes a small river, usually running through a fairly narrow valley. Finally it becomes a full-sized river, reducing its speed of flow according to the volume of water and the terrain and meandering slowly towards the sea through a flat landscape with wide floodplains. From both the hydrological and the limnological point of view, the upper and lower reaches of a river are two quite different worlds, although there is a transitional zone in which they overlap. The differences include the amount of water carried, the speed of the current, the chemical make-up of the water, its temperature, the river profile, and the shape of the river bottom or bed. Similarly, changes are to be observed in the banks of a river, including the vegetation and, not least, the surrounding countryside. An additional factor is the variation of the water level according to rainfall and the season. The creatures living in a river, including fish, have adapted to these various environmental conditions. What this description of the changing face of a river fails to point out, however, is that here in Europe a skeleton is all that remains of what only decades ago was a fully functional ecosystem.



(Photos G. Kraczkwoski)

What is known about the environment of fish?

Although a great deal is already known about the environment of fish, it is not enough to enable us to preserve all the fish in our lakes and rivers reliably and lastingly. The most important parameters of water are now measurable to the point of perfection; but their effects in ecological terms are not fully understood, and the same applies to the influence of some harmful substances on the health of fish.

A whole series of methods have been developed for breeding particular fish species, e.g. rainbow trout, carp and salmon. In many cases, reproduction in hatcheries has progressed to the point that fry or larger fish are used for stocking free-flowing stretches of rivers and lakes, e.g. pike, brown trout, pike-perch, catfish, tench and some whitefish. These practical results are very important from the point of view of fishery. If we look at fish life as a whole, however, such breeding and stocking measures have in most cases been only marginally useful and, unfortunately, all too often harmful.

It is known that most fish can live and grow in moderately polluted water. The tolerance limits have been identified in many cases. The lasting existence of many fish species is not guaranteed, however, if one concentrates exclusively on the quality of the water. The difficulty is that the fish at each stage of its development requires different aquatic and environmental conditions, and these can often differ considerably. To give an idea of the many different requirements of the various species, an attempt will be made below to describe the life cycle of fish. The findings of fundamental research have made a major contribution to this. It has been discovered that particular morphological structures reveal themselves throughout the development of every fish species and enable fish to survive in their respective biotopes. For example, fine structures on the surface of fish eggs and their biochemical composition have

1

They need fish!

3

2

4

5

been described, and the morphology of the respiratory organs of fish larvae has been studied and explained. In many species, the process whereby the larva becomes a young fish has been observed. It has emerged that every stage requires a different environment; this might be an aquatic plant or gravel bed, or it might be a question of water depth, water temperature, current or the amount of oxygen in the water. The habitat or ecotope of fish species is composed of a multitude of physical (properties of the water and form of the substratum) and biological (suitable food) parameters, whose significance can change according to the period of life.

The life cycle of fishes can be divided into five periods: embryonic, larval, juvenile, adult and senescent. The embryonic period begins with the fertilisation of the egg; its characteristic feature is endogenous feeding from the ovum. The larval period is typified by the transition from endogenous to exogenous feeding. This period lasts until the metamorphosis into a fish. The first bone tissue forms during this time. The continuous fin disappears and is replaced by actual fins. Similarly, the larva's temporary respiratory organs (e.g. blood vessels in the continuous fin) recede when gill development makes them superfluous. The juvenile period is marked by the fact that fully developed fins are present and all temporary organs have been replaced by permanent ones. It lasts until gonad maturity. The characteristic features are rapid growth and often a juvenile colouring. The adult period begins with the attainment of sexual maturity. The often complex behaviour in this stage of life is usually influenced by the highly complex reproductive instinct. Body growth now slows down. In the senescent period, body cells are renewed only to a moderate extent, gamete development comes slowly to a halt and growth is minimal.

As reproduction marks the beginning of a new generation of fish, a suitable spawning ground must at the same time offer favourable conditions for the first period of life. Studies of the conditions governing successful reproduction have shown that many fish species require a series of very similar parameters, on the basis of which they can be divided up into specific reproductive groups. Here are some examples: the alosa species are pelagic spawners, sturgeons and some coregonidae rock and gravel spawners, carps plant spawners, gudgeons sand spawners, and pike-perches and sticklebacks nest spawners.

For this reason, the spawning ground should be regarded as a primary condition for natural reproduction. Let us not forget that the kinds of lake and river beds existing today are only a fraction of what used to be available; many habitats have disappeared altogether. The turning of stretches of river into drainage channels should be regarded as the primary cause of the decline and gradual disappearance of many fish species. Efforts to improve water quality are by themselves insufficient to achieve far-reaching success in such cases.

What can be done?

Fish were already regarded as useful products of nature in ancient times. In practical fishery today they represent a resource that is constantly renewed. When the very existence of the freshwater fishing industry became increasingly threatened by polluted and contaminated bodies of water, it endeavoured to preserve some useful species. The eel seemed to be best suited for this purpose, and its widespread introduction proved very successful. After the last few years, in which efforts to improve water quality have, locally at least, produced their first positive results, the intensive introduction of eels suddenly appears in quite a different light; in some biotopes where remnants of the original fauna have been able to continue reproducing naturally, the eel population has become so dense that a large proportion of the fish yield is decimated by them. This applies not only to the few remaining backwaters, but also to the upper reaches of smallish rivers, the habitat of graylings and trout. There it has been found that eels account for 20 % to 40 % of the total fish population. They not only compete with many fish species for food, but also make a substantial contribution to the depredation of the "smaller" species (loaches, bullheads, minnows and, to some extent, lampreys) and the young of the brown trout. One solution would be to change conservation methods, which have so far concentrated too heavily on fish stocks. The eel was mentioned here only as an example.

If we want to change the, in many cases, highly unfavourable conditions affecting fauna composition in individual bodies of water, environmental engineering is the proper approach. The first requirement is that water quality in polluted rivers should be improved. Unlike this perfectly attainable goal, the idea of returning all rivers to their original state is unrealistic. It has been shown in practice that it is possible to restore individual habitats and even increase the range of species present. The intensity with which work is proceeding in this field is apparent from a list of publications (800 papers, US Department of Agriculture, 1982) describing possible ways of improving or reorganising habitats in trout waters. Once again we are concerned here with fish species that are attractive to people as objects of sport or sources of food.

At every stage in the fish's life a wide variety of aquatic biotopes is essential
(Photo G. Kraczkowski)

Habitats can almost certainly also be created for those species which are less well-known and unattractive from the point of view of fishery. The first step in this direction should be to carry out an extensive survey of endangered fish species and describe their habitats in the light of the needs of the individual species in its life cycle. A universal model for all the various kinds of habitats is not to be recommended. It seems more useful first to fill in the gaps still remaining in our knowledge of the life history of certain fish species (e.g. the zingel or the groundling). The appropriate species should be introduced into habitats which seem suitable for permanent settlement. In the majority of cases they have already lived in these biotopes, and so it is usually a question of reintroduction in the course of environmental engineering projects combined with improvements to water quality. The provision of new, semi-natural habitats is a further requirement.

It would seem that this problem could be solved most easily in fast-flowing stretches of rivers (upper reaches or trout region). In the way of illustrative material, there is still an abundance of natural biotopes in the mountains of Europe which could be used as models for the rehabilitation of spoilt stretches of rivers. In the middle stretches of rivers, known as the grayling and barbel region, there are often already limited opportunities for favourably influencing or transforming the condition brought about by human activity. Rivers were usually dammed up here in the past to produce energy. The relics, e.g. water mills and sawmills, now lie abandoned in many cases. The weirs have been preserved, however, and for reasons of hydrology and water management their demolition is virtually inconceivable. In these cases, inordinately long slackwater habitats should be interrupted by stretches with a stronger current, e.g. through the creation of more gently sloping river beds (rock fills). The lower reaches of rivers are often navigable and fringed with human settlements; hence they cannot be returned to their former state. Nevertheless, even here there are numerous possibilities for preserving habitats or creating new ones, e.g. by reconnecting artificially separated backwaters and ponds to the river.

In the last analysis, it should be left to fishery biologists to draw up environmental engineering projects and take responsibility for managing groups of species in their proper biotopes. A.L.

All is not lost

Henri Hoestlandt

That the living world of which we are part has evolved with the passage of time is an accepted fact and one which scientists have clearly proved. That biological evolution is continuing is also accepted in theory, although in practice we think we live in a biological world which is stable and fixed, in other words, changeless. It is true that natural evolution is slow and that it is difficult to observe specific examples of evolution during a human lifetime or even over a few hundred years. Furthermore, the evolution caused directly or indirectly by mankind is practically on a human scale; this is particularly the case as regards a number of vanishing species in many biotopes.

Among the threatened species of freshwater fish in Europe, a distinction may be drawn between those of little or no value as food and the rest. The former are of interest only to ichthyologists, while the latter are of interest to the consumers we all are.

We shall mention very briefly the species in the first group and go into greater detail on those in the second, beginning with general biological aspects, then pointing to the causes for the reduction in their numbers, and finally mentioning ways of trying to conserve them.

Sturgeon (Photo Jean-Louis Duzert)

Fish declining in numbers

We shall give two examples of fishes with no value as food.

The first is the bittlering (*Rhodeus amarus*), found in central and western Europe. A particular characteristic of this small fish (6-7 cm long) is that it deposits its eggs in freshwater mussels (*Unio* and *Anodonta*), were the fry remain for three to four weeks before swimming away. These large mussels are declining in numbers as a result of the deterioration in the natural environment, pollution and, in particular, predation by the coypu and musk rat. This is therefore leading indirectly to the slow disappearance of the bitterling.

The second example is the river blenny (*Blennius fluviatilis*), which is distributed throughout the periphery of the western Mediterranean. This fish, 10 cm long, needs pure water on a stony or rocky bed. Because of its ecological demands and the vulnerability of its spawn, this species is vanishing.

Among the species of interest to us as food we shall give three main examples —the sturgeon, the salmon and the shad. All three are anadromous migrating species, in other words they reproduce in fresh water but spend most of their growing time at sea.

There are seven species of European sturgeon, but six are all but confined to the USSR; only one (*Acipenser sturio*) lives in the Atlantic, the Mediterranean and the Black Sea. This sturgeon ascends freshwater rivers in spring to spawn; the eggs (known as caviar) are deposited on gravelly riverbeds at a depth of 6 to 8 m and attach themselves to stones or aquatic plants. The young fish live in freshwater rivers or estuaries until the age of three years, before going downstream to the sea. Growth at sea, in water 20 to 50 m deep, is rapid; the sturgeon reaches a length of 2.5 m in about 40 years. Males are mature at about 14 years, females at about 18. After spawning, the adult fish return to the sea.

This sturgeon has become rare, if not extremely rare. It is still found in the Gironde estuary, the Guadalquivir, Lake Ladoga and the Black Sea. Its rarity is illustrated by the fact that 250 sturgeon were caught in the Gironde estuary in 1953 and only 4 in 1983; it is understandable that fishing for sturgeon is forbidden in France at present.

The Atlantic salmon (*Salmo salar*) enters fresh water in Europe and North America to spawn, usually in winter. The female hollows out a "nest" in the gravel bed and the male fertilises the eggs shed by the female. Few adult fish (approximately 5 %) return to the sea to begin a second or third spawning cycle.

The dark-coloured young salmon, called parr, spend one to eight years in fresh water, depending on latitude; they then go down to the sea in spring, taking on a silver livery—they are now called smolts and are 12-16 cm long. It has been known for a number of years that salmon grow at sea for a period of one or two years in special "fattening areas", three of which are well known and account for 80 % of all salmon. They are located off the west coast of Greenland, in the Norwegian Sea, and near the Faeroe Islands. When going upstream to spawn, the salmon use their keen sense of smell to return to the freshwater area where they were hatched ("homing"); the memory of the smell is "registered" during the smolt stage. Navigational errors are very rare.

In the past salmon were abundant around the coast of Europe. The following fact is always quoted in this respect: in Brittany, agricultural workers' contracts used to stipulate that salmon could not be served at meals more than two or three times a week. That was quite understandable in the 18th century, when 4,000 tonnes of salmon were caught off Brittany, but in 1970 the total French catch was less than 30 tonnes; it is true that French fresh water now has one of the lowest salmon stock in Europe; the total European catch is of the order of 13,300 tonnes.

There are ten species of shad in Europe, but eight of them are only found in the internal waters of the USSR. Of the two species found in the Atlantic and Mediterranean, we shall mention only the most important, the Allis shad (*Alosa alosa*).

This shad enters fresh water in spring to deposit eggs in the clear water of gravel-bottomed streams. Most kelts die after spawning. The young fish grow rapidly (9-13 cm in one year) and go down to the sea at the age of one or two years. Growth continues at sea (at depths of 200-300 m) over a period of 3-5 years and sometimes more.

This shad has become rare in the rivers of northern and northwestern Europe and around the Mediterranean. It is still fairly common in the west and south-west of Europe—in the Loire, Dordogne, Garonne, Guadalquivir, Minho, Douro and Tagus rivers. For example, 500 tonnes of shad were caught in the Dordogne and Garonne rivers in 1978.

Of the species which are still abundant but diminishing in numbers, mention may be made of the common eel which lives in fresh water and reproduces at sea (20,000 tonnes caught in 1963, and 13,000 tonnes in 1981). Other examples are the common pike and the European brown trout (*Salmo trutta*), which are still found in our freshwater rivers thanks only to fish farming.

Sturgeon are protected in France since 1982. When accidentally caught, they are either released or transferred to fishponds in the hope that they reproduce
(Photo Jean-Louis Duzert)

Causes of diminishing numbers

These apply mainly to the three anadromous species described but to a large extent to the other dwindling species too.

The first cause relates to the spawning grounds in gravelly or rocky riverbeds in well-oxygenated clear water. There are fewer and fewer such areas; they tend to become choked because of the numerous dams which slow down the current further upstream and cause silting, because of the many gravel workings which give rise to the formation of silty or muddy riverbeds, and because of the eutrophication of the water which increases organic and algal deposits. The consequence is the death of many eggs, which become coated with silt, mud or organic deposits and are therefore starved of the oxygen necessary for their development.

The second cause is a slowing down in growth caused by the impoverishment of the benthos. This is due to the growing scarcity of rocky or stony riverbeds and to physical and chemical pollution. The benthos provides a considerable proportion of the food of young migrating fish.

Mention should also be made of the considerable obstacles to migration caused by the many dams whose effects are only seen at a later stage. While fish ladders are often provided, even the best of them do not allow all spawning fish to pass; the result is the more or less rapid decrease in numbers of anadromous species.

Lastly, mention should be made of overfishing on both an individual and more particularly an industrial basis; increasingly sophisticated equipment is used for the latter—for example, Danish fishermen catch salmon in the fattening area off Greenland with extremely effective nets made of single-strand nylon which are almost invisible to the fish.

Hopes for recovery

Our hopes may be pinned on human activity in three main directions: fish farming, water purification, and national and European regulations.

Firstly we must be able to reproduce threatened species artificially and often must make provision for the early development of the young fish; this can be done by placing the fertilised eggs or young fish in a suitable aquatic medium. This method has already been used for trout (using Vibert boxes, for example), salmon and pike, but should be developed further. Improved techniques should make this possible for the shad and even the sturgeon.

Secondly, water purification techniques must be intensified through more effective anti-pollution measures. It is essential to reduce urban and industrial pollution by more stringent water treatment. Care must also be taken to prevent agricultural fertilisers, pesticides and herbicides from seeping into our fresh water. As a consolation, we may mention the example of the Thames where no salmon had been caught for 160 years but where, in 1973, one was taken 16 miles upstream from London Bridge.

Fishing regulations are called for at both national and European level and should take account of recent biological knowledge of the species in question. To take just one example, the salmon: we know that its rarity in France is largely due to the inadequacy of regulations in the relatively recent past, but that present regulations augur a brighter future. On a European scale, it is gratifying that the Danes have agreed to reduce their fishing in the salmon fattening area off Greenland (1,191 tonnes at present); this will ensure the salmon's continuing presence in the rivers of Europe and hence in the fattening areas.

It is extremely fortunate that at present the European Community is aware of the problem of reconstituting fish stocks. While it is not possible to hope for a complete return to the past (evolution is not a backwards movement), we may nevertheless achieve a new biological balance as a result of the work of various scientific and administrative bodies in order to satisfy human requirements both in terms of food and leisure.

H.H.

Pollution

Enrico Gelosi

The galaxy of ecosystems making up our planet is amazingly well-equipped, with its biological chain, atmospheric agents and transformation and regeneration cycles, to cope with all pollution processes of natural origin. The mechanisms essential to its biological equilibrium are now under serious threat, however, from a form of chemical and biological warfare that is an iniquitous by-product of progress.

One of the most harmful practices is the use of large quantities of detergents containing a high concentration of phosphates, not so much for washing purposes as to counteract the salts in hard water and soften it for household use.

Admittedly, immediate results are assured, but the consequences are much more drastic than the initial problem: the excessive level of phosphorus-containing compounds causes algae to proliferate, giving rise to a state of eutrophication which kills off living organisms in lakes and seas. The damage definitely outweighs the benefits, as is all too often the case with production processes (there are well-known examples). Such processes are accepted with alarming short-sightedness for the sake of progress and what is taken for well-being, while the high price that man will pay for the damage to the environment is overlooked.

The need for political awareness

The toxic effects of environmental pollution, which has now spread to all parts of the biosphere, have been known for some time and are being widely investigated. Their study has given birth to the new science of ecotoxicology, one of the aims of which is to further our as yet incomplete knowledge about the extremely complex operation of ecosystems and their interdependence—for they are obviously interrelated. On the other hand, we have yet to see the emergence of a political awareness of the problem, which has inherent social and hence political implications, and the resources available for the development of this science and for environmental protection are almost always modest and invariably inadequate and badly distributed. Yet the usefulness of such research and the urgent need to expand and co-ordinate it and translate its findings into practical projects are undeniable.

The toxic effects of pollution

As we have briefly seen, many extremely complex factors and numerous substances are responsible for water pollution, with varying effects on the environment. They include oxygen concentration, pH (which I shall mention briefly since the importance of acid rain cannot be overlooked), carbon dioxide, surface tension, osmotic pressure, toxic substances, organic waste, and so forth, not to mention a factor of vital importance to fish—temperature.

Once this has been understood, we can boil down the assessment of the capacity of water to support life to the evaluation of three fundamental factors, for it is not possible to analyse them all here:

- the quantity of dissolved oxygen;
- temperature and its fluctuations;
- the presence of toxic substances of various kinds.

We shall therefore examine the toxic effects of pollution on fish, taking account of two parameters crucial to the survival of aquatic organisms: temperature and the dissolved oxygen concentration. These parameters are, moreover, closely interrelated since, as the temperature rises, the quantity of oxygen which can normally dissolve in the water decreases. That is why cool water is more highly oxygenated than warmer water.

The water temperature, which has a definite effect on the oxygen concentration, is of crucial importance to the metabolism of the various species of fish, for fish are cold-blooded—that is, their body temperature varies with that of the water. Consequently, it is only within specific temperature ranges that their enzymatic processes can function efficiently, and their metabolism and very survival therefore depend heavily on the temperature of the environment in which they live.

A distinction can be drawn here between eurythermal species, which readily adapt to temperature fluctuations, albeit within limits, and the more numerous stenothermal species, which can survive only within a very restricted temperature range.

As far as respiration is concerned, it should be pointed out that oxygen diffuses very slowly in water and that the oxygen content of saturated water is about 20 times lower than that of air. In order to extract and use the oxygen, fish therefore have to take in a much greater volume of water through their gills than the volume of air required by land vertebrates. Furthermore, since the density and viscosity of water are infinitely greater than those of air, fish have to make an enormous effort to extract oxygen from water for respiration.

In fact, respiration accounts for about 20 % of the total oxygen consumed for the vital processes: about 10 times as much as in the case of land mammals, for instance.

If we continue to bear our basic parameters in mind, it becomes obvious that a protracted temperature rise will, since less oxygen can dissolve in the water, force the fish to speed up its respiratory process at precisely the time when the oxygen level is decreasing.

The acceleration of the respiratory process increases the intake of any toxic substances present in the water. The very presence of these substances can affect the mechanisms of respiration. In fish the exchange of gases takes place mainly at the membranes of the gills by the ordinary mechanism of respiration, which can be summed up as the permeation of biological membranes by gases.

All surfactants, e.g. detergents, affect the permeability of these membranes. The result is a faster intake of such substances as pesticides and heavy metal salts, which become life-threatening even at concentrations not considered critical under normal conditions.

(Photo F. Bibal, Unesco)

The high price that man will have to pay for damage done to the environment is often overlooked

(Photo G. Kraczkowski)

The concentration of organic waste can thus reach levels damaging to the delicate oxygen requirement equilibrium and the strenuous respiratory process, and can become lethal.

By virtue of the natural oxidation and oxidation-reduction processes performed by the micro-organisms which break down organic matter, organic waste depletes the water of the oxygen essential to the survival of fish, while at the same time the exothermic reactions of the oxidation processes actually raise the temperature of the water. As the concentration of organic waste rises, it becomes difficult, if not outright impossible, for the fish to survive: asphyxia occurs.

In connection with respiratory processes, we must not forget that toxic substances interfere with the transport of oxygen to the tissues since they directly affect the blood pigments, just as nitrites affect haemoglobin.

Fluctuations in pH, even if they remain within limits acceptable to fish (normally between 5 and 9), affect the toxicity of certain pollutants by accelerating their dissolution. This is true in the case of ammonium salts, the toxicity of which increases as the pH rises, and cyanides, which are more toxic at low pH values.

Damage to fish and the fishing industry

This brief review cannot be concluded without a reference to the damage to the fishing industry. Fish which have come into contact with acids, suspended matter, caustic substances, etc., may suffer skin lesions and abrasions which, lacking a protective layer of mucus, are rapidly invaded by fungi and bacteria which irreversibly damage their viability and appearance.

Damage is also caused by mineral oils, phenols, ethers, sulphides, mercaptans, etc., which although they do not, at low concentrations, threaten the survival of the fish, give it such an unpleasant smell and taste that it is certainly not to be recommended as food. Moreover, the fish keeps less well and, being quickly perishable, loses still more of its commercial values.

These assertions are fully borne out by one current example of damage to fish in the natural environment, in Lake Nemi.

Lake Nemi

Lake Nemi is a small volcanic lake in the group of craters in the Alban hills near Rome.

It is surrounded by woods and farmland. It has no tributaries: all its water comes from the catchment basin and from underwater springs, which are not always active.

At the beginning of the century the lake was classified as oligotrophic; the oxygen concentration was at saturation point virtually throughout the mass of water, the levels of nutrient nitrogenous and phosphorus-containing salts were within normal limits and there was little plankton.

The fish present in the lake included many temperate-water cyprinids, eels, pike, perch and a stenothermal Nordic species of whitefish (Coregonus) introduced in 1925, which thrived in the lake, since in summer it was able to find cooler, adequately oxygenated deep water which suited its living requirements.

Between 1928 and 1932 the water level was lowered by about 20 metres in order to salvage two ancient Roman ships. It was then gradually allowed to rise again. The new physical and chemical conditions resulting from the drainage of the lake made it more eutrophic than before.

In 1969 the Rome Ichthyogenic Establishment (Stabilimento Ittiogenico di Roma), embarking on a series of studies of the fish in the lake, found that conditions in general were still within normal limits and that conditions in summer were still suitable for whitefish, which could find cool, sufficiently oxygenated water at a depth of 15 metres.

The productivity of the lake, which was fished to the full, was the highest in Italy for natural waters: about 200 kg of fish per hectare per year, 80 % of it accounted for by whitefish alone. This excellent yield quickly fell off, however, as a result of the ever-increasing input of organic waste from the sewers of Nemi and Genzano and sewage from a 1,200-bed geriatric hospital. This proved definitely too much for the small lake, which was also receiving water that had leached fertilisers and pesticides out of the surrounding farmland.

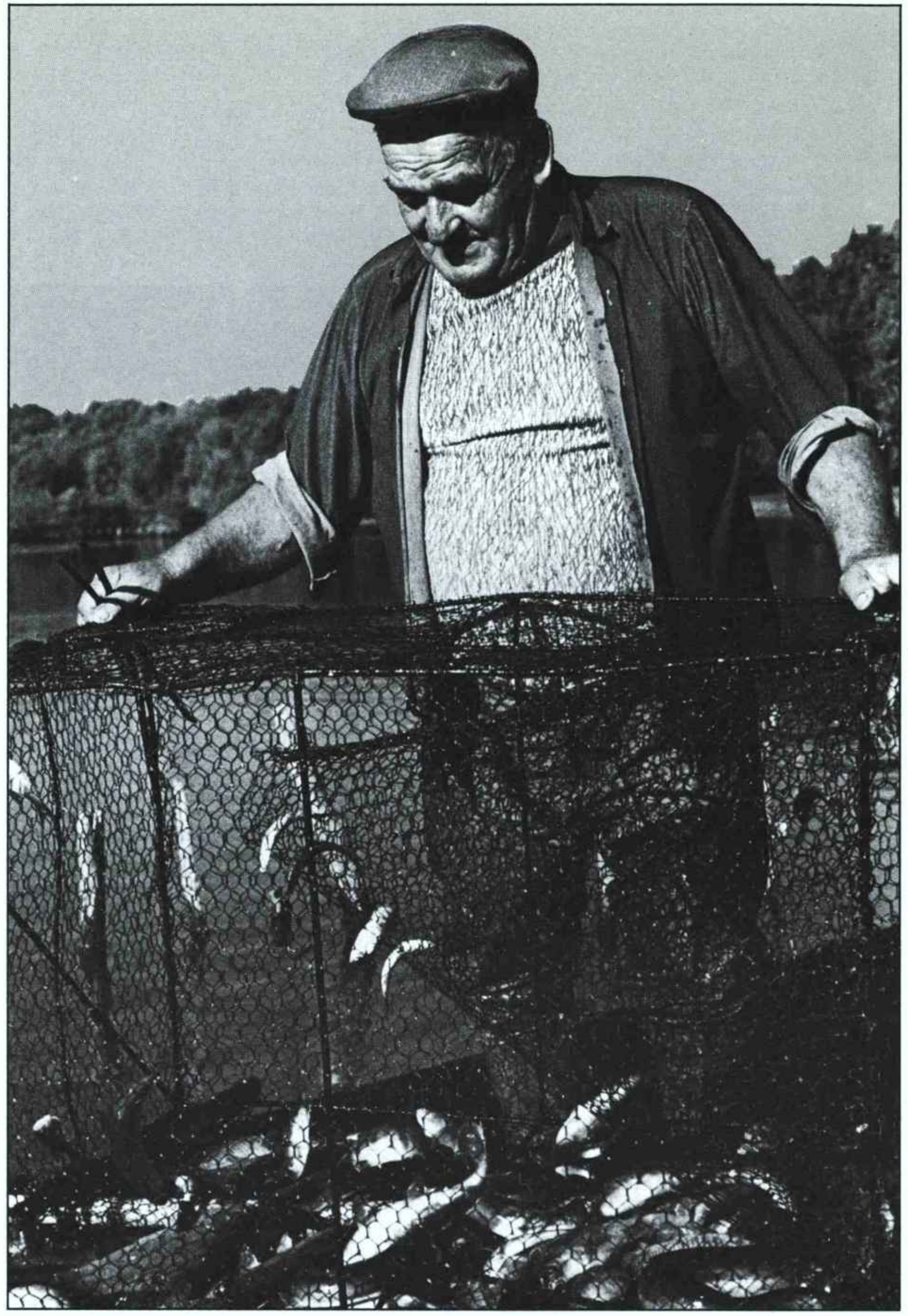
The first visible sign that the hydrobiological balance had been destroyed appeared in 1974, when the surface of the lake began to turn red as a result of a phenomenon known as "water bloom", caused by the proliferation of the blue-green alga "*Oscillatoria rubescens*". The situation worsened the following year: there was a massive proliferation of algae, whose decomposition and fermentation had virtually depleted the water of oxygen below a depth of a few metres by summer 1975. As a result, virtually all the fish were killed off. All the whitefish died and only a few fish of the more resistant species survived in a weakened state which made them prone to attack by fungi and bacteria, present in abundance in the severely damaged environment.

In the years that followed there were periodical improvements as a result of the introduction of restrictions on polluting discharges, but organic pollution is now a constant feature of Lake Nemi, the oxygen depletion in summer being such that whitefish can no longer survive. Among other things, this has seriously affected the fishing industry.

The Ichthyogenic Establishment is experimenting with the introduction of a South American species of fish, *Odontesthes bonariensis*, with a view to repairing the damage, at least in part.

This fish, which belongs to the Atherinidae family, is eurythermal and extremely resistant to change in environment, and has good organoleptic properties. The results have been encouraging, but the deterioration of the environment last year caused the loss of a large proportion of the lake's stock of this species. Nevertheless, the modest number of survivors will breed and it will be possible to repopulate the lake and follow up the results of the experiment, which were encouraging.

E.G.



This fisherman still has a nice catch but for how long?
(Photo Alain Kayser)

Life-giving rain?

William Dickson

Ground and inland waters in Sweden have been exposed to rapidly increasing supplies of acid for at least twenty years. This is primarily due to the increased burning of fossil fuels. The greatest atmospheric acid fallout takes place in the south-west. Here the precipitation is at least ten times more acid than it is assumed to have been before industrialisation.

The bedrock in the greater part of Sweden offers poor protection against acid fallout, so many lakes and rivers have become acidified.

Acidification can be divided into three phases. During the first phase, the pH value is fairly high and stable. The hydrogen ions in the precipitation are absorbed by the bicarbonate buffer system. The second phase begins when this buffer system no longer functions all the time and the pH values fall below 5.5. Organisms living in the waters are now affected and episodic deaths occur in fish populations. During phase three the pH value stabilise at about 4.5 even if the precipitation is more acid. Aluminium and humus in the soil and water act as a buffer system at this stage. With the decreasing pH values, there is an increase in the content of many metals in the waters, especially the aluminium content. These indirect chemical changes in the acidified waters may cause more severe biological effects than the increase of the hydrogen ion itself.

Acidified areas

The majority of the acid lakes (pH value less than 5) are situated in the south-western part of the country. With few exceptions, these must be regarded as acidified. In the west coast area, about 75 % of the lakes have pH values lower than 5.5 during at least some part of the year and 33 % have reached the third phase (pH value less than 5 during summer). In other sensitive parts of southern Sweden, about 50 % of the lakes are acidified.

In the northern part of the country, the percentage of acid lakes is lower. The extent of the acidification, however, is more difficult to estimate here, primarily because pH fluctuations in smaller lakes and running water can be very large. During periods of melting snow, fatally low pH values can occur for a short time even in normally well-buffered waters.

The total number of acid lakes in Sweden is at least 14,000 in phase 2, and about 4,000 in phase 3.

The most sensitive lakes in southern Sweden probably became acid during the period 1950-1970, i.e. when the atmospheric deposits of sulphur increased most. The pH values have in most cases decreased in the sensitive lakes, even during the seventies, but the rate of acidification seems to have been somewhat reduced.

Biological effects

Acidification leads to a decreasing number of species of organisms at all trophic levels in the ecosystem.

Typical effects are a massive invasion of species of sphagnum, and an increasing accumulation of organic debris reduces mineralisation, especially in the littoral areas.

The most sensitive species in fish in Sweden are roach and minnow (*Phoxinus phoxinus*), for which pH values around 5.5 seem critical to reproduction. Somewhat less sensitive are many species of salmonids. Pike, perch and above all eel seem to be the most resistant.

Effects of acidification may be observed at pH values which are not toxic to most freshwater organisms. Aluminium, however, has been proved to cause fish mortality even in rather low concentrations and to have maximum toxicity at pH levels slightly above 5.0.

If certain key organisms are wiped out by aluminium poisoning, or by some other agent, this will have an effect on the whole ecosystem. Therefore many effects of acidification are believed to be secondary effects, caused by changing nutrient, competitive and predatory conditions.

According to local consultants, acidification has caused the Swedish crayfish (*Astacus astacus*) to decline in as many as 20 % to 30 % of the total number of lakes in south-western and central Sweden. The total lake area which is known to be affected has been calculated at about 115,000 hectares, plus about 150,000 hectares which are assumed to be affected.

In the south-west, the sensitive and formerly very common roach has declined in about 2,000 lakes larger than one hectare, which means in about 5 % of all the lakes in that area.

In southern and central Sweden, fish stocks in about 2,500 lakes have been damaged by acidification and in a further 6,500 the stocks are assumed to have declined. This number (9,000) corresponds to about 10 % of all the lakes in Sweden and 10 % of the total lake area of the country.

A thorough knowledge of the effects of acidification in lake-rich northern Sweden is still lacking. We know, however, that many small and normally well-buffered streams in that area may have very low pH values and high concentrations of aluminium during the period of melting snow.

Liming against acidification

In an attempt to combat acidification, a large-scale liming programme has been started. About 3,000 lakes have been limed over the last few years. Much of the cost is met by the State: this year 70 million Swedish kroner (8.5 million US dollars) is being spent. Although the biological effects are positive, this chemical treatment can only be regarded as a temporary solution. The problem can only be finally solved by a sharp reduction in acid emissions to the atmosphere. The deposits of sulphur must be reduced to less than 0.5 g per square metre/year.

W.D.

Lake of Geneva

(Photo Ludwig Bernauer)

Bernard Büttiker

Lake Geneva is the largest mass of water in central Europe. It is up to 300 m deep, with a surface area of 582 km^2 and it contains 89 km^3 of water. However, the variety of fish in its waters, 25 species, is very low compared to other regions of Europe, especially the Danube basin or the Iberian peninsula. Many species which inhabited central Europe before the last ice age, when there was a much greater variety of fish than there is today, disappeared when the continent was invaded by glaciers. Then geographical barriers hindered the restocking of the region. The Lake Geneva basin was especially isolated because several migratory species were not able to swim up the Rhône to the lake.

On the other hand, 11 species have been introduced into the Lake Geneva basin over the last few hundred years. Two indigenous species (or races) of coregonus of significant economic value, the "féra" and the "gravenche" disappeared because of over-fishing at the beginning of the century. These were replaced by the powan (*Coregonus lavaretus*) from Lake Neuchâtel.

Two salmonids, the lake trout and the char are surviving well at the moment. However, the natural spawning grounds of these two species, both of which are very valuable as wildlife and for fishing, are under threat: those of the char are likely to be buried under mud as a consequence of eutrophication, whilst the trout's migration route through affluents to its breeding areas may be cut off by the construction of dams and other developments.

Trends in fishing

The perch is the species most sought-after by fishermen, especially in Switzerland. The powan, the lake trout, the pike and the char are also caught regularly. Because of eutrophication (the enrichment of the lake water by domestic and agricultural fertilisers) and considerable improvements in fishing methods, the yield from professional fishing increased regularly for decades to reach some 1,500 tm in the years 1971 to 1975 (23.7 kg/ha). This progression, due mainly to a dramatic increase in perch-fishing, was brought to a sudden halt in 1977. The fish yield, especially that of professional fishermen, plummeted. The perch population only re-established itself in 1983 and more so in 1984.

Franco-Swiss co-operation

Before the Franco-Swiss Agreement on fishing in Lake Geneva entered into force in 1983, the authorities in the two countries agreed on co-ordinated action to control fishing in Lake Geneva. Measures especially designed to restrict perch fishing were decided upon. These will come into effect in 1985. A working group of scientists from both countries was also formed. Its brief is to establish better co-ordination in research into the fish of Lake Geneva, and to provide the necessary scientific basis for fishing management.

Prospects for the future

A better knowledge of the biology of these fish must be gained, so that their numbers may be controlled, to ensure a good long-term yield. This will prevent the lake from being over-fished. But how is the consumer to be convinced that fish other than perch, all equally tasty, live in Lake Geneva? In the past, such attempts to inform the public have often met with failure.

The authorities are also concerned with protecting the lake's environment. Deterioration in the quality of the water has reached a critical stage, and the state of the lake must be improved immediately, before a point of no return is reached. Finally, the remnants of the natural shore-line must be saved, and the fishes' spawning grounds preserved.

B.B.

Stocking and re-stocking

M. P. Grimm

Stocking natural waters with hatchery-reared individuals of autochthonous species has rocketed in popularity since World War II. The maintenance and enhancement of fishery yields is the goal aimed at in general. Or in other words: to maintain the population density at a maximum carrying capacity of a water system or at least to prevent this density decreasing below a certain limit often set according to economic criteria.

At first stocking was practised to counteract the negative impact caused by habitat modifications due to human influence. More recently, the fishing pressure being such that populations can be overfished, to prevent depletion. In general the lowest cost/benefit ratio is aimed at; thus, individuals stocked are of the smallest ecologically acceptable size and the natural productivity of a water system is used to achieve, by growth, the aforementioned carrying capacity.

Recently we know of stockings where these cost/benefit ratios are considered less important, e.g. the stocking of artificially propagated individuals to conserve a threatened species, the repopulation of water systems after environmental disasters, such as the spilling of toxic substances.

Salmon fry in the Rhine

The release of salmon fry in the river Rhine tributaries was one of the first large-scale stockings in natural water systems in Europe. These stockings took place from the second half of the last century, but without achieving their objective which was to stop the declining numbers of adult salmon returning in the home-run to their rivers of origin. After World War II the practice of stocking migratory young +2 year old salmon ("smolts") near the mouth of the river proved highly successful. Stocking with "smolts" is now practised worldwide. Other reputedly successful stockings are those of elvers, common carp and, in some countries, coregonus. These successes, most of which concern species which no longer reproduce successfully under prevailing natural conditions, possibly led to the feeling that stocking in general is a successful tool in fishery management.

Whatever the reason, nowadays practically all European countries practise stocking with a wide variety of species. Evaluations however are few and the assessment of success or failure is often controversial.

The introduction of allochthonous species

The oldest large-scale introduction in Europe concerns the distribution of the common carp. Most introductions of allochthonous species have been much more recent, occurring mainly over the last two or three decades. The management goal is to improve fishery revenues. Often it is supposed that an ecosystem, whether or not changed by man-made factors, harbours vacant niches and therefore is not fully exploited by the fish population present. The introduction of salmonid species in Arctic lakes in Sweden, where no predator fish species was present, and the introduction of silver carp (a phytophagous species) in the heavily eutrophicated Lake Balaton are instances of such attempted niche-filling introductions.

Fish-breeding facilitates the re-stocking of lakes and watercourses
(Photo O. V. B.-Foto)

Unintended introductions also occur. The penetrations of the two marine species sea lamprey and alewife in the Great Lakes (US) is a notorious accidental introduction. Introductions by negligence established abundant roach populations in Ireland (continental pike anglers released the remains of their imported live-bait stock). The release of ornamental fishes established local populations of such fish as guppies and pumpkinseed (*Eupomotis gibbosus*). An intentional, illegal introduction established a pike-perch population in East Anglia (UK).

The effects of introductions or stocking

As with introductions of allochthonous species in general, those of fish species also vary in their effect from complete disaster (as was the case with the penetration of sea lamprey and alewife into the Great Lakes) to occasional complete success. Introduced allochthones unable to reproduce in their new environment (the white amur in north-west Europe) belong to the former category.

Often the beneficial and/or detrimental effects are disputable but it appears that deleterious effects on native fish communities can all too often be observed.

Acknowledging these disadvantages member countries of the European Inland Fisheries Advisory Committee adopted—in close co-operation with the International Council for the Exploration of the Sea—a code of practice by which the risk of adverse effects of introductions can be reduced to tolerable levels.

History proves that once a species has passed a border it should be considered as having been introduced in a country. In this respect the large-scale uncontrolled transfer of ornamental fishes which is common practice in most countries is of great concern.

As mentioned before, the effects of introductions are often uncertain and debatable. The same holds for stocking with autochthonous species. Due to our lack of knowledge of the population dynamics of virtually all fish species, the amplitude of the numerical yearclass-strength in time is unpredictable. Thus the effects of stocking cannot be quantified. The importance of this biological information is illustrated by an evaluation of the stocking of artificially propagated Northern pike fingerlings by the Organisation for the Improvement of Inland Fisheries in the Netherlands.

Measured as the frequency of occurrence of marked mature individuals, originally stocked as fingerlings, the stocking of pike was considered successful by European and American fishery managers.

(Photo O. V. B.-Foto)

The numerical decline of the Dutch pike population and the shrinking of its distribution area were attributed to a marked reduction of the preferred spawning habitat, the freshly inundated vegetation of grasslands, due mainly to the strict regulation of the water level preventing spring floods.

By monitoring numbers per age-and-length classes over an 8-year period and by determining their habitat preference, another picture of the pike was built up. Within natural populations pike up to 40-60 cm are associated with the aquatic vegetation to such a degree that at the end of each summer a constant biomass of 80-150 kg/ha vegetated area of these pike is present.

The biomass of pike smaller than 40 cm, that of one-summer-old individuals (15-35 cm) especially, is highly negatively correlated with the biomass of older and larger ones. This quantitative relationship demonstrates that the stocking of pike was useless. The high aforementioned frequency of occurrence of individuals stocked as fingerlings turned out to be a displacement of natural recruited pike by stocked individuals. A displacement—no contribution.

The results of this long-term research showed that the bottleneck in the recruitment of young pike is the surface vegetated area—the growing-up habitat. Thus the decline in pike populations can be stopped by protection of the aquatic vegetation—immersed plants, especially.

The highest density of pike often wanted in fishery management is likely to be reached in shallow waters with a surface vegetated area spread over 25 % of the total surface. Thus efficient pike management entails effective protection of aquatic vegetation.

As mentioned earlier the effects of stocking are in general not quantifiable, not only on the autecological, but especially on the synecological level. It should be realised that, given the economic interest prevailing in most fisheries, managers will often stock a species reasoning that it is useful unless proved otherwise.

Both from the point of view of effective nature conservation and of efficient management of fish stocks this standpoint is questionable. Realising this, the member countries of the European Inland Fisheries Organisation established a Working Party on Stocking. The terms of reference include "encouraging co-operation in research". Hopefully the need for this research will also be understood by other interested parties and to such an extent that funds can be made available. M.P.G.

Man-made lakes

Jan Kleinert

Water is, undoubtedly, one of the essentials to life on the Earth's surface. A pond, or for that matter any body of still water is, or could be, an example of a self-sufficient climax ecosystem, occupied by a wide scale of producers and consumers. It is often the only place left for wildlife, an oasis of stillness.

Nevertheless, this function of water bodies may be compromised if they are located in suburban areas, in easily accessible, frequently visited sites, or in the vicinity of sources of pollution, eutrophication and other kinds of disturbance. The coastal zone often shows signs of the indifference of visitors, including fishermen, who carelessly leave their rubbish about, or even use the water to wash their cars. The importance of environmental education, or rather the lack of it, is evident here, though a few ponds, lakes and watercourses are already equipped with nature trails, facilities for bird-watching and so on...

The importance of fishing

Fishing for food in running as well as in still waters has been practised since prehistoric times. The history of stew ponds or fish farming in Europe apparently began in the 13th century, when fishing became commercial and fish became something that could be exchanged or sold in the market. This encouraged the building of artificial ponds where larger, faster-growing, productive fish species, which also tasted good, could be selected, studied and bred. Nevertheless, consumption is expected to at least double in Czechoslovakia, where at present it is 0.7 kg per inhabitant and the annual yield reaches 10,000 tonnes.

Fish farming is developed in exploited gravel pits, old river beds and other hollows filled by surface or ground water. As an example, Slovakia has now almost 30,000 hectares and Bohemia more than 50,000 hectares of artificial still water reservoirs. (They are mostly under the control and management of fishing associations, though some are state-owned.) Intensive and controlled farming allows the production of 460 kg of fish per hectare per year.

To increase the productivity of the pond ecosystem and the fish stock, water is sometimes fertilised with manure, or improved by lime. This is usually done

Artificial ponds often become sites of great natural value
(Photo Jan Baltus)

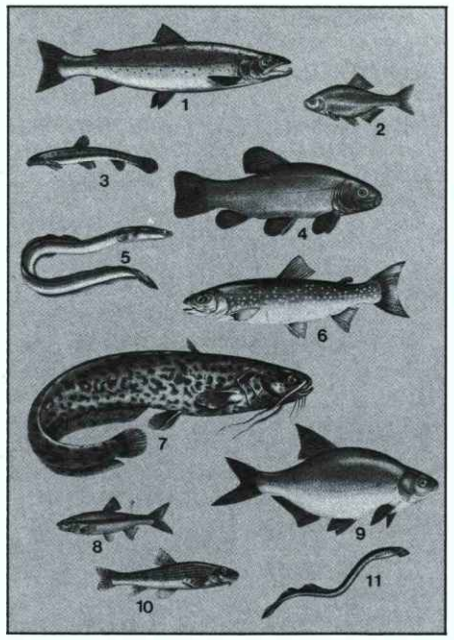
in the spring to promote the growth of phytoplankton and to adjust the pH and chemical balance.

Fishing as a hobby is allowed for those who hold a permit, which can be bought; that is, members of the fishing association. There are limits on the months in which fishing is allowed, depending on the type of waters (between May and December in reservoirs, for example), and on the species, number and minimum weight or length of the captured fish.

According to the Nature Conservation Act, 14 species of fresh-water fish are fully protected, including several species of lamprey, the sterlett and the Danubian salmon (*Hucho hucho*).

Only one, the last, is artificially bred and reintroduced to pollution-free flowing waters. All the others, particularly those that live in rivers, face an uncertain fate because of permanent water pollution: approximately 5,000 km of watercourses are completely denuded of any fish. The fishing association (a private organisation) is deeply interested in preserving fresh waters against pollution. There are intensive training courses for inspectors who ensure the monitoring of water quality and ascertain sources and consequences of pollution. Regional authorities, police and the courts are expected to be helpful in the prevention and restriction of pollution accidents, which here number about 300 a year.

It would be advisable to build more (small) reservoirs in suitable sites. They would also be, though not perfect, replacements for wetlands that have been drained, or destroyed by the expansion of our civilisation. J.K.



1. *Salmo salar*
   50-120 cm, Salmon
2. *Rhodeus sericeus amarus*
   10 cm, Bitterling
3. *Cobitis taenia*
   7-10 cm, Loach
4. *Tinca tinca*
   30-50 cm, Tench
5. *Anguilla anguilla*
   40-90 cm, Eel
6. *Salvelinus alpinus*
   25-40 cm, Charr
7. *Silurus glanis*
   1-2 m,
8. *Leuciscus souffia*
   15 cm,
9. *Abramis brama*
   40-60 cm, Bream
10. *Gobio gobio*
    15 cm, Gudgeon
11. *Lampetra planeri*
    15 cm, Sand-piper

The illustrations on the back cover are taken from the poster "Fish of Swiss waters" published by WWF Switzerland, CH-8037 Zürich, *Panda* magazine No. I/83

Contributors to this issue:

M. Paddy O'Toole
Minister for Fisheries and Forestry
Leeson Lane
IRL - Dublin 2

M. Ignacio Claver Farias
Direccion General del Medio Ambiente
Ministerio de Obras Publicas y Urbanismo
Paseo de la Castellana 67
E - Madrid 3

Prof. Dr. Wilhelm Harder
Universität Tübingen
Lehrstuhl Zoophysiologie
Institut für Biologie III
Auf der Morgenstelle 28
D - 7400 Tübingen 1

Mr Nils-Arvid Nilsson
Institute of Freshwater Research
S - 170 11 Drottningolm

Mr Derek Gren
Thames Water
New River Head
Rosebery Avenue
GB - London ECIR 4TP

M^me^ Helga Inden
Deutscher Naturschutzring e.V.
Bundesverband für Umweltschutz (DNR)
Geschäftsstelle, Kalkuhlstr. 24
D - 5300 Bonn 3

Dr. Anton Lelek
Forschungsinstitut Senckenberg
Senckenberganlage 25
D - 6000 Frankfurt 1

M. Henri Hoestlandt
8, Contour de l'Eglise
F - 59380 - Bergues

Dr. Enrico Gelosi
Stabilimento Ittiogenico
di Roma, Regione Lazio
Via della Stazione Tiburtina
I - Roma

Mr. William Dickson
National Swedish Environment
Protection Board, Box 1302
S - 17125 - Solna

M. B. Büttiker
Service des forêts et de la faune
Conservation de la faune
Chemin du Marquisat 1
CH - 1025 Saint Sulpice

Drs. M. P. Grimm
Head, Research Department
Organisatie ter Verbetering
van de Binnenvisserij
Postbus 433
NL - 3430 AK Nieuwegein

Dr. J. Kleinert
Slovak Society of Nature
and Landscape Guardians
CS - 97602 Stare Hory

National Agencies of the Centre

AUSTRIA
Univ.-Prof. Dr. Franz WOLKINGER
Österreichische Akademie
der Wissenschaften
Institut für Umweltwissenschaften und Naturschutz
Heinrichstraße 5/III
A - 8010 GRAZ

BELGIUM
Eaux et Forêts
29-31, chaussée d'Ixelles
B-1050 BRUXELLES

CYPRUS
Nature Conservation Service
Ministry of Agriculture and
Natural Resources
Forest Department
CY - NICOSIA

DENMARK
Miss Lotte BARFOD
National Agency for the
Protection of Nature,
Monuments and Sites
Ministry of the Environment
Fredningsstyrelsen
13 Amaliegade
DK - 1256 COPENHAGEN K

FRANCE
M^lle^ Isabelle RAYNAUD
Direction de la Protection de la Nature
Ministère de l'Environnement
14, boulevard du Général-Leclerc
F-92524 NEUILLY-SUR-SEINE Cédex

FEDERAL REPUBLIC OF GERMANY
Deutscher Naturschutzring e. V.
Bundesverband für Umweltschutz
Kalkuhlstraße 24
Postfach 32 02 10
D - 5300 BONN-OBERKASSEL 3

GREECE
M. Byron ANTIPAS
Secrétaire général
Société hellénique pour la
protection de la nature
9, rue Kydathineon
GR - 10558 ATHENES

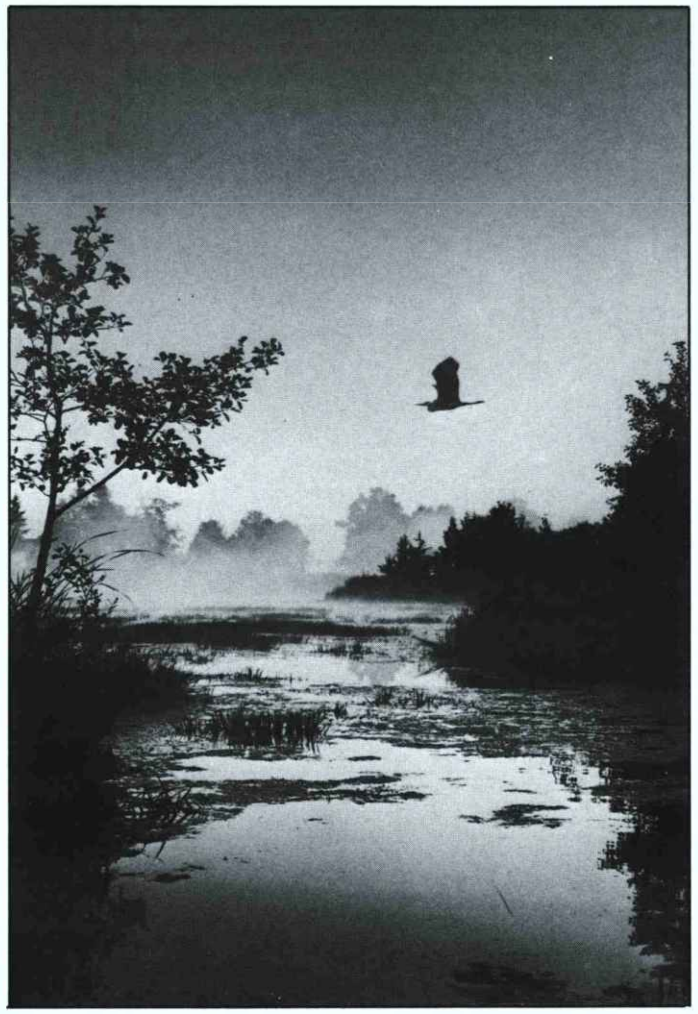
ICELAND
Mr Gisli GISLASON
Director
Nature Conservation Council
Hverfisgötu 26
ISL - 101 REYKJAVIK

IRELAND
Mr John McLOUGHLIN
Department of Fisheries and Forestry
Forest & Wildlife Service
Leeson Lane
IRL - DUBLIN 2

ITALY
Dr ssa Elena MAMMONE
Ministero dell' Agricoltura
Ufficio delle Relazioni internazionali
18, via XX Settembre
I - 00187 ROMA

LIECHTENSTEIN
Ing. Mario F. BROGGI
Liecht. Gesellschaft
für Umweltschutz Auslandsreferat
Heiligkreuz 52
FL - 9490 VADUZ

LUXEMBOURG
M. Charles ZIMMER
Direction des Eaux et Forêts
34, avenue de la Porte-Neuve
B.P. 411
L - LUXEMBOURG-VILLE



(Photo W. Lapinski)

MALTA
Mr Joe SULTANA
Health Department
Merchants Street
M - VALLETTA

THE NETHERLANDS
Mr D. A. HUITZING
Ministry of Agriculture and Fisheries
Chief Directorate for Nature
Conservation and Outdoor Recreation
Postbus 20401
NL - 2500 EK THE HAGUE

NORWAY
Mrs Irene SIGUENZA
Ministry of the Environment
Myntgaten 2
P.O. Box 8013
N - OSLO 1

PORTUGAL
M. Rui FREIRE DE ANDRADE
Presidente da Direcção
Liga para a Protecção da Natureza
Estrada do Calhariz de Benfica, No. 187
P - 1500 LISBOA

SPAIN
M. Joaquin ROS VICENT
Centro de Estudios de Ordenación
del Territorio y Medio Ambiente
Ministerio de Obras Públicas y
Urbanismo
Paseo de la Castellana 63
E - MADRID 3

SWEDEN
Mrs Anne von HOFSTEN
National Swedish Environment
Protection Board
P.O. Box 1302
S - 171 25 SOLNA

SWITZERLAND
Dr Jürg ROHNER
Ligue suisse
pour la protection de la nature
Wartenbergstraße 22
Case postale 73
CH - 4020 BÂLE

TURKEY
Mr Hasan ASMAZ
President of the Turkish Association
for the Conservation of Nature
and Natural Resources
Menekse sokak 29/4
Kizilay
TR - ANKARA

UNITED KINGDOM
Miss Shirley PENNY
Chief Librarian
Nature Conservancy Council
Great Britain Headquarters
Northminster House
Northminster Road
GB - PETERBOROUGH PE1 1UA

Information concerning Naturopa, the European Information Centre for Nature Conservation or the Council of Europe may be obtained from the Centre or the National Agencies listed above.