Effect and consequences of the reactor-accident in Tschernobyl on the fish population in Bavaria

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After the reactor-accident in Tschernobyl radioactive fission products reached during the night on April, 30th,1986, the south bavarian region. They were washed out by heavy rains in the early hours of the afternoon, causing a contamination of the total biosphere.
It is known from radio-eclogical studies, that radionuclides concentrate in fish meat. Ionising radiation may lead to an internal radiation exposition of human beings via food chains. It was for that reason necessary to follow up the temporal development in order to prevent injures through ionising radiation.
The Bavarian Institute for Water Research started on May, 5th, a project in connection with fish consumption and investigated fish meat for radioactivity, originated from 3 different biotopes:

a) rivers
b) fish-farms
c) lakes in the prealpine region

Altogether approximately 700 fishes were examined until the end of October. Fish-meat contained until the middle of May besides Cs 134 and Cs 137 also the short-living radionuclides J 131 and Te132 (20 - 30 Bq/kg fresh meat). After that date could only Cs 134 and Cs 137 be demonstrated. Since both cesium-isotopes in the Tschernobyl-fallout occur in a 1:2 ratio, only the result of Cs 137 are reported.

to a and b

During the whole investigation period Cs 137 concentrations of 0 - 50 Bq/kg in fresh meat could be demonstrated in fishes of rivers all over Bavaria, only occasionally values occured up to 100 Bq/kg. In fish-farms 0 - 20 Bq occured in Trouts, 0 - 50 Bq in carps; the concentration of radionuclides in fish-farms depends however to a certain extand on the flow-rate and mainly on the amount of non-contaminated additive food.

Also in fish of prey (pikes from the rivers Isar, Lech and Main) no higher concentrations than in their prey could so far be demonstrated.

to c

The concentration of radionuclides is mainly a problem of standing waters. Very early already, at the beginning of May, a quick increase of radioactive products in meat of plankton-eating white-fishes in Lake Starnberg could be detected. Therefore the investigations were extended, besides water and sediments, on plankton. The investigations were, furthermore, extended on all major prealpine lakes. Not only white fishes but also other fish species were investigated. Not only the quantity of concentration was of interest but also the relationship between the different waters, fish species, living- and consumption behaviour on one side and the radionuclid concentration rate on the other side.

The high radionuclide concentration in white-fishes depends on their eating behaviour. Measurements of plankton revealed a sudden high radioactivity of 27000 Bq/kg Cs 137 in dry substance in the Lake Starnberg already at the beginning of May, which resulted in an increase of 1000 Bq/kg Cs 137 in fresh white fish-meat (Fig. 1).
"Mairenken" (Cypriniden: Chalcalburnus chalcoides), which live extremely under the surface, showed values up to 1500 Bq/kg.

In comparision: During the last ten years fish-meat of bavarian fish species revealed only in few cases a maximum of 1 Bq/kg Cs 137. Fish of North Sea and Baltic Sea showed an average activity of 3 - 4 Bq/kg, probably depending on the radioactive emissions of the reprocessing power plants Sellafield and LaHague (Feldt, 1986). Caesium, originating from Tschernobyl, did not cause the radionuclide concentration in fish of North and Baltic Sea. Higher amounts of radioisotopes were only detected in the sixties due to the superficial nuclear tests. Fish of Lake Starnberg showed at the same time 150 Bq/kg Cs 137. These results correspond to results obtained by Finnish colleagues in Lappland and South Finland in 1961 to 1963 (Häsänen, 1963).

The white fishes from Lake Starnberg as well as the white fishes from Lake Staffel belong besides the fish of prey (i will report about them later) to the highest incriminated fishes in Bavaria, while the white fishes in Lake of Kochel only contain a Cs 137 maximum of 40 Bq. The concentration of radionuclides in meat of white fish of the other prealpine lakes, i.e. Waginger See, Chiemsee, Königsee, Tegernsee, Schliersee, Ammersee, Walchensee, Wörthsee ranged between these values.
The explanation for these different radiologic incriminations in white fishes of the same age (3 years, weight between 250 and 400 g) are to find in the specific physical and hydrological conditions of these waters. Besides the different direct input of radionuclides by the rain are the important causing factors the renewing time and mainly the rate of vertical mixing and overturn of waters and the early growing up of surface plankton.
The renewing of water within 20 years and the maximum of only one overturn yearly cause in Lake Starnberg as well as in Lake Staffel a very early stabile epilimnion. Due to the strong behaviour of radionuclides for absorption at fine particles, the already present surface plankton was immediately contaminated at the beginning of May.
The lake Kochel in contrast possesses by a very strong flowing through only an instabile epilimnion with an instabile surface plankton. The absorption to plankton is, therefore, not as strong as in the previously mentioned case. The high flow-rate caused in addition a high decrease of contaminated particles.
The hydrological conditions of the other lakes are very different, but they are lying between these two just explained conditions, which results in concentration values inbetween.
These radiological determinations show, that you are able, to estimate approximately the concentration in fishes only on account of the knowledge of the special conditions of a water.

Different radionuclide concentrations in the same fish species also depend on age, living- and eating behaviour.
Caused by the less contaminated food from the sediment of lakes in white fishes, which are living at the ground of lakes and breams only very low concentrations of nuclides could be demonstrated in comparison with the plankton-eating fishes at the surface, they only reach 1/5 of the values, i.e. 200 Bq/kg.
Very prominent is the dependance on the size of fishes, in particular in breams, where the small fishes show an up to ten times higher concentration. This is not only caused by the higher metabolism. Investigations of the stomach contents show as well as in white fishes, that they eat also eat plankton in contrast to the great breams at the ground(Fig. 2).

Due to some recent alarming reports in respect to fish of prey (10000 Bq) I will briefly report on the situation in pikes and perches (Fig. 3 and 4).
These fishes of prey find a similar contaminated food in their prey fishes as the white fishes do in plankton. So far the fishes of prey do not show very high radioactivity concentrations as the end-link of the aquatic food chain.The values of both fish species range inbetween the values of their prey fishes. The maximum value in perches was 1600 Bq/kg Cs 137.
The occasionally demonstrated concentrations of 10000 Bq and more are not representative and could never be detected in the examined fishes of Bavarian waters, but only in two small lakes with extreme specific hydrological conditions- with heavy wash-in and low outflow - in Baden-Württemberg.
There is no reason for to talk about a dramatic situation according to the media in the fish food sector.
A successive accumulation about several links of the food chains, so-called biomagnification, could so far not be demonstrated due to the Tschernobyl-fallout.

The consumption of radioactive contaminated fish meat with a total content of 1000 Bq/kg Caesium results in an effactive equivalent dose of 90 μ Sv or 9 mrem, respectively, if from the beginning of May until the end of October 200 g fishmeat would have weekly been eaten.

The biological half-life of Caesium takes according to reference appr. 220 days. This could not be confirmed by own investigations. Due to various factors as reduction of metabolism by decreasing water-temperatures, reduction of or no food consumption during the winter season, a definitive knowledge about the half-life of Caesium under natural conditions cannot be obtained. One can assume, that fish species which live of food on the ground will according to so far investigation retain their Cs-concentration for the next time. Fish, living in the free water, however, will show a reduction of the contamination. This is confirmed by the reduction of the Cs-content in organs of white fishes by 50 %, which not occured at that rate in fish meat. Remobilisation processes seem to take place from organs to meat. This assumption is supported by an increase of the Cs-concentration in fish-meat during a starving period, which actually should lead to a decrease.

The development of radionuclide concentration in fishes of prey will be followed up. It is, however, doubtful, that the concentrations will increase, while contaminated food is reduced.

According to extensive investigations can be concluded, that Cs-concentration of several thousand Bq will not occur, except in those waters with special extrem hydrological conditions. I only know two small lakes in Germany, as I mentioned before, but they can not be regarded as representative.

This leads to the following conclusions and recommandations. What actually results from the Tschernobyl reactor accident? The most important point is: It is impossible to prevent the contamination of the biosphere. The questions, however, is: What can be done to prevent the contamination of food in general. In case of fish, there are only limited possibilities to prevent heavy contaminations. In fish of lakes, where most probably higher contamination can be expected, we have the only possibility to catch and to store many fishes as possible before the heavier contamination of radionuclides starts to develope. According to own investigations in fish farms the danger of contamination is very limited. Here exists the possibility, however, to keep the nuclide concentrations low by additional feeding of non-contaminated food. This can in particular be recommended for carp farms, since carps feed also on the contaminated sediment.

These are to my experience the only two possibilities for preventing higher nuclide-concentrations.

In case of contamination, as we experienced after Tschernobyl, a decontamination cannot actively be attained. The decrease of concentrations depends on the emitted nuclides. In case of short-living nuclides an radiological exposition of human beings can be prevented by a temporary prohibition of fishing by short-termed storage of fish. The storage of fish in case of long-living nuclides, however, is completely useless. In those cases a decontamination can only be attained by long-termed prohibition of fishing due to the long biological half-life of the nuclides, until the cut-off values are reached according to the demands of radiologists.

Due to the fact of the long-lasting half-life also the fish-stock of contaminated fishes in a non-contaminated environment does not help to attain a decontamination. In contrast: the fish-stock can reveal a contrary effect.The fish-stock can result in a starving period which leads to a remobilization of nuclides from organs to meat and thus to a further increase of the concentration. This effect could be observed in fishes of lake Starnberg and finally in own fish-stock investigations.

You may have noticed, that our possibilities are very limited to recommend effective measures for preventing contaminations of fish in case of radioactive emissions.

However, it is our duty to seek for solutions in case of nuclear accidents. I, therefore, recommend a cooperation between radiologists and food hygienists because of their professional knowledge about biological conditions of animals, of their living and feeding behaviour. Food hygienists should contribute through

1. Collection of specimens (kind of specimen, amount)
2. Guaranty of certain parameters (cleanness, regularity, exclusion of accidentalness)
3. Cooperation in program development (for specimens)
4. Support in evaluation and judgement of results (interpretation)
5. Advice and recommendations in special cases.

Such a cooperation could guaranty a more precise interpretation of results and a prospectus on the present and future effects of radiological contamination, resulting instructions and evaluations criteria in the sence of the radiation protection act.

Dr. W. Lünsmann
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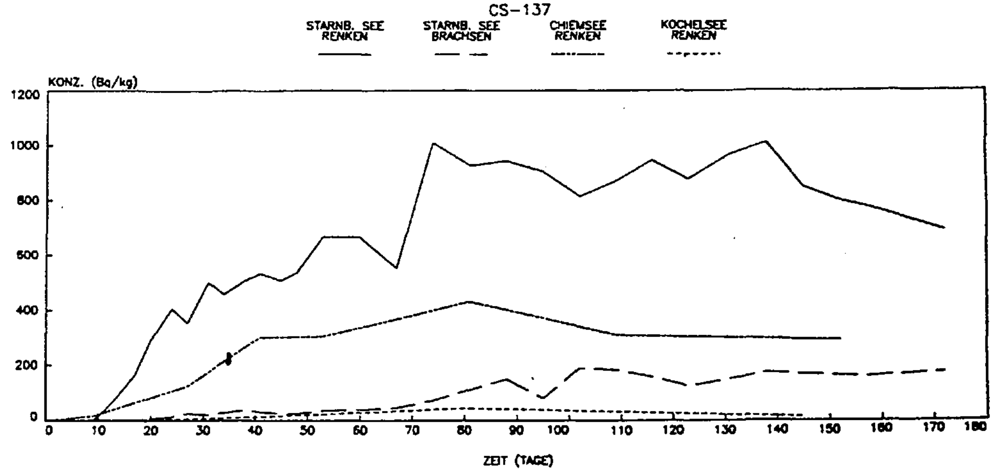
Abb. 1

AKTIVITÄTS-KONZENTRATIONEN IN FISCHEN
CS-137



AKTIVITÄTSKONZENTRATION IN PLANKTON
STARNBERGER SEE

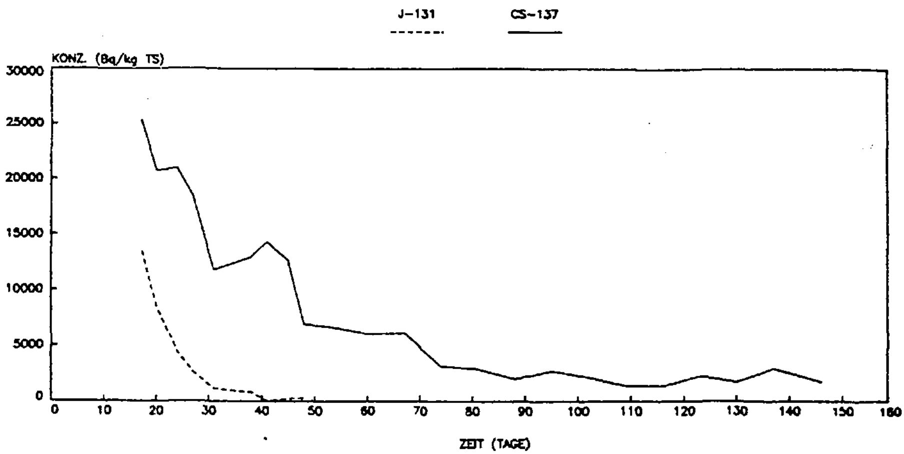


Abb. 2

Abhängigkeit der Aktivitätskonzentrationen von der Größe und der Lebensgewohnheit

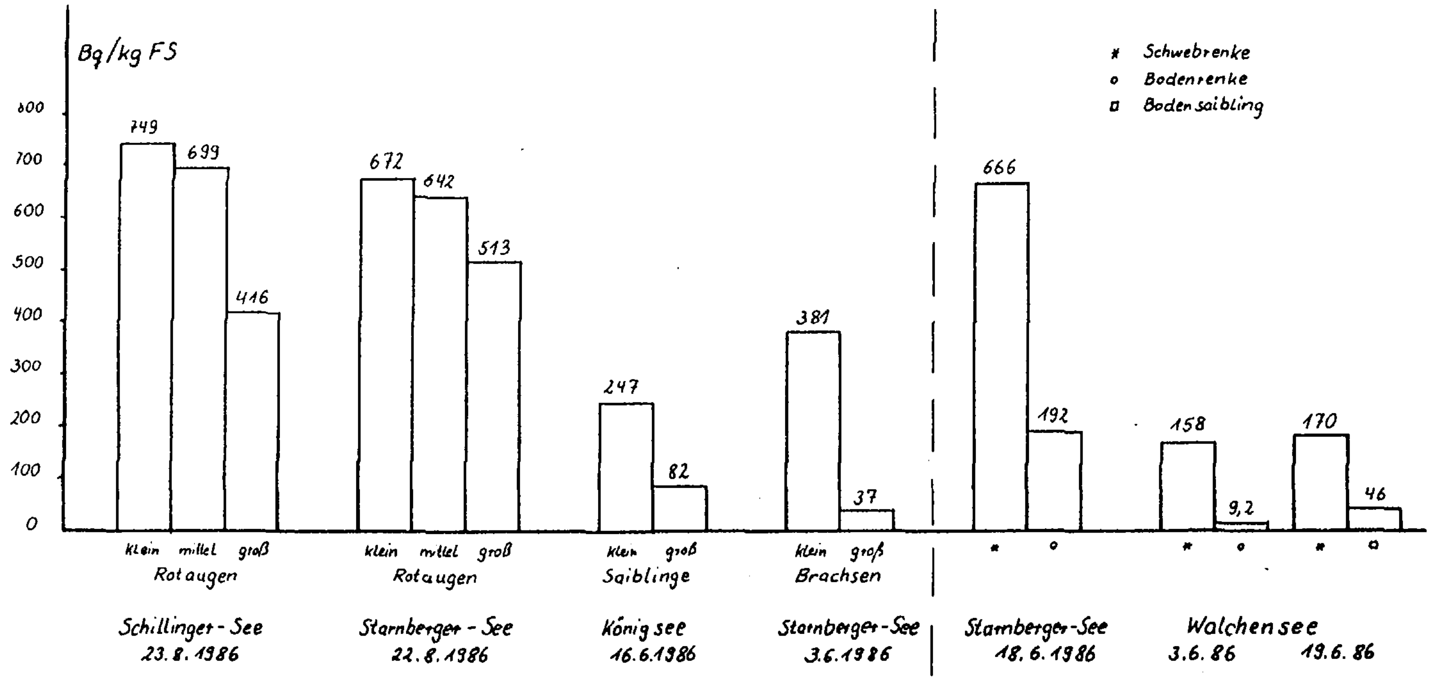


Abb. 3

Aktivitätskonzentrationen bei Raubfischen: Hechte

(im direkten Vergleich mit Futterfischen ▨)

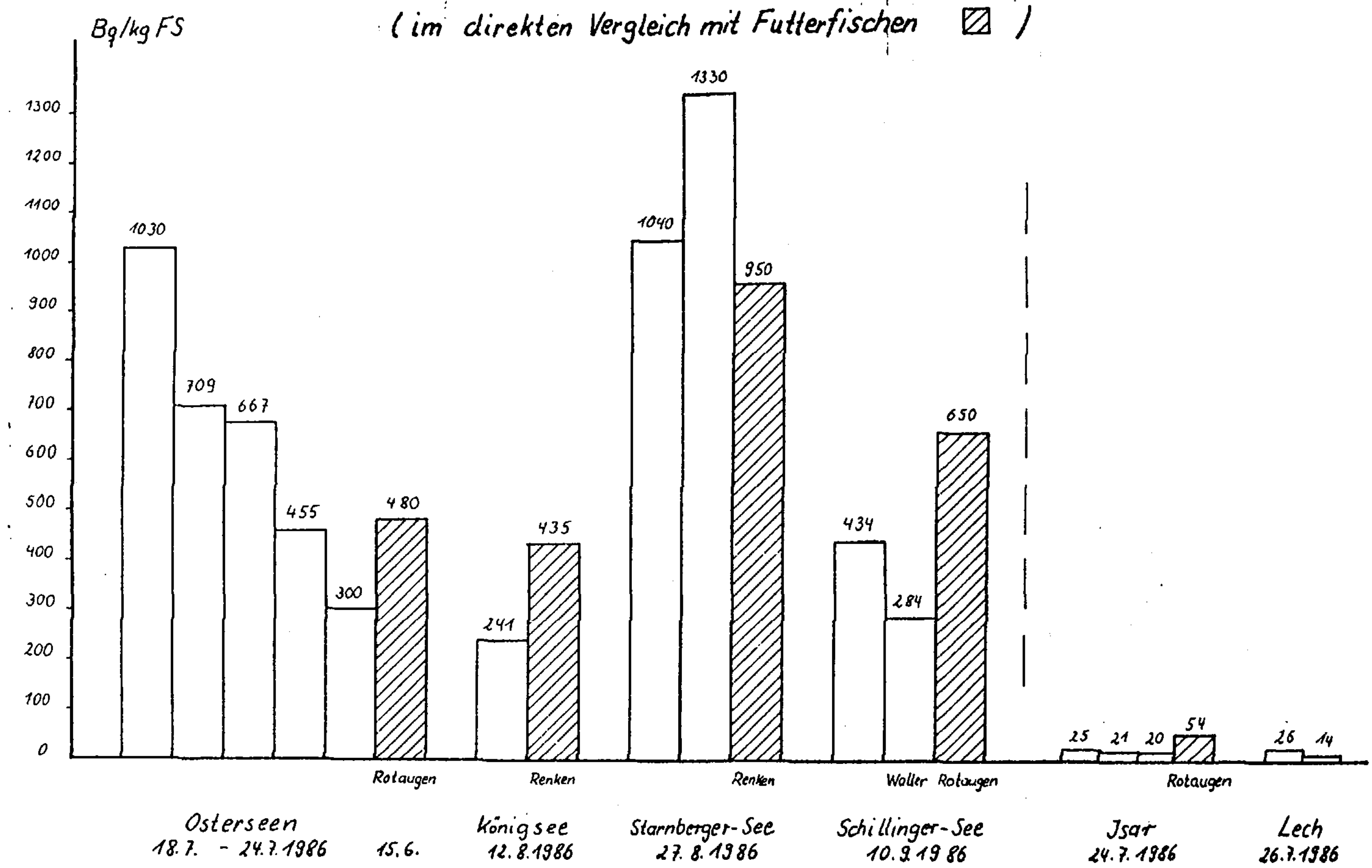
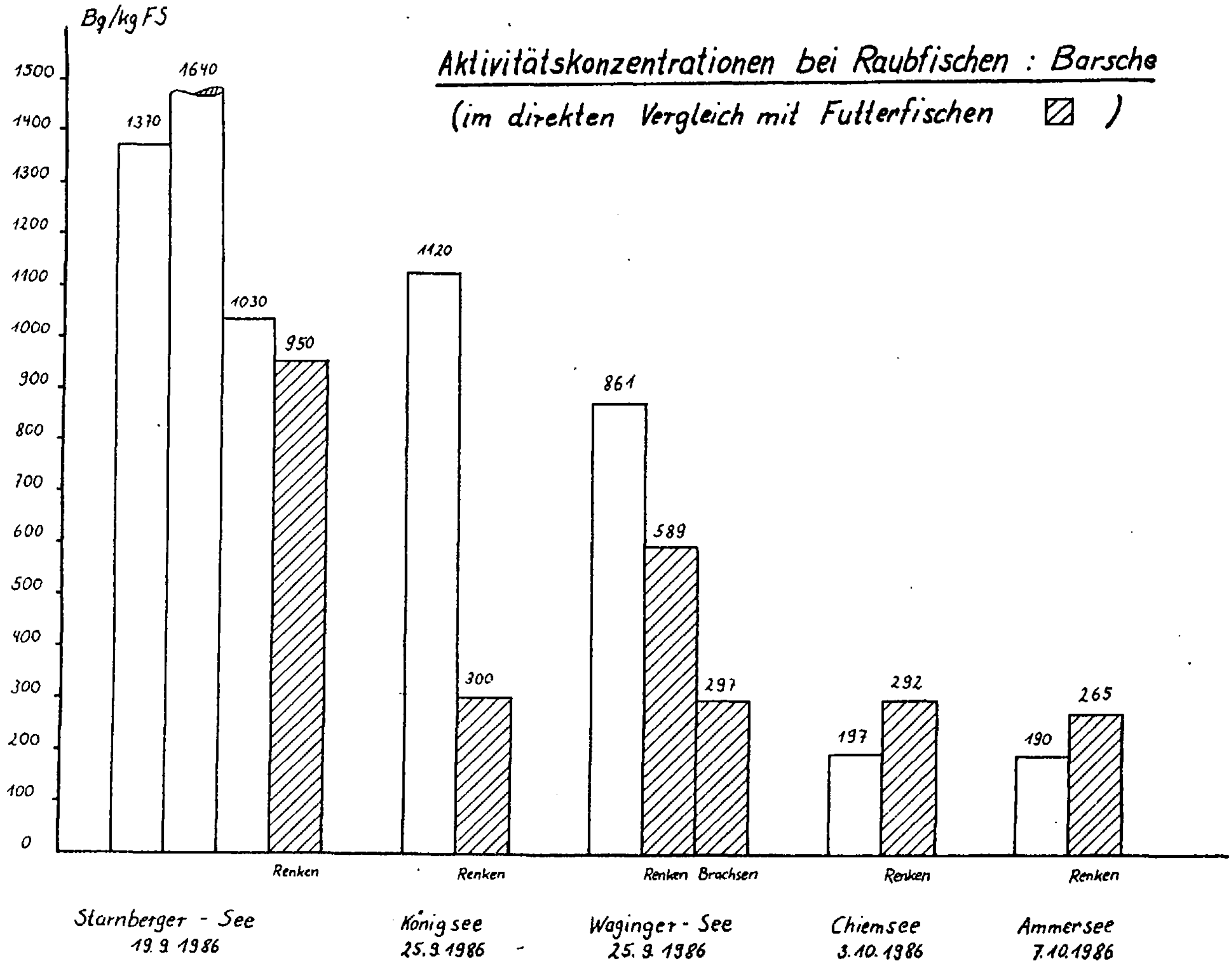


Abb. 4


Bq/kg FS
Aktivitätskonzentrationen bei Raubfischen : Barsche
(im direkten Vergleich mit Futterfischen ▨)
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
1370
1640
1030
950
1120
300
861
589
297
197
292
190
265
Renken
Renken
Renken
Brachsen
Renken
Renken
Starnberger - See
19.9.1986
Königsee
25.9.1986
Waginger - See
25.9.1986
Chiemsee
3.10.1986
Ammersee
7.10.1986