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DEVELOPMENT AND TESTING OF A NEW LIGHT GATE FISH COUNTER IN RIVERS

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ABSTRACT

A new fish-counter, has been developed for counting upmigrating fish in rivers. The counter can also measure the size of the counted fish. The counter consists of two sets of light emitters facing light sensing elements. By constantly monitoring the outputs from each sensor a picture of an object passing through the counter is obtained. Two microprocessors process the data and record the data of each fish passing through the counter such as its direction of movement, its speed, length and height, the time and date. The information are stored in the memory of a display unit. The counter, using 2 W of power, is battery powered using a solar panel for recharging the battery.

The counter has been tested for the last 3 years in several location in Icelandic rivers. The counter were installed differently depending on the situation in each location.

In the glacier river Blanda, North Iceland, a counter was installed at a entrance of a fish trap. The trap was emptied 4 times a day, where the fish, both Arctic char (*Salvelinus alpinus)* and Atlantic salmon (*Salmo salar*) were counted and each salmon was measured. These information were compared with the data from the fish counter. The accuracy of the total counting was 99 % and the size measurements were 90 % accurate. The counter could distinguish between salmon and grilse, but minor overlapping were between grilse and large sea run char.

Introduction

To be able to manage fishery in rivers with anadromous fish stocks, managers have great need to know the number of fish entering the river, the timing and composition of the run, as well as the size distribution of the fish.

Fish counter is, therefore, very important tool both for management, as well as for research purposes. Fish counters of different types have been available for many years. In Iceland fish traps, where the fish is released upstream have been used to count and measure fish ascending rivers. Traps are very accurate way to count fish, and gather information about the biological composition of the run. On the other hand, the operation of traps need expensive manpower and the traps as well as the handling can harm the fish. Mechanical counter has been used in one river counting fish but no other information are obtained there. Resistivity counters have been used in some rivers most often with poor result, but only very limited information of the fish size can be gathered. The need for accurate fish counter which also can measure fish size is, therefore, apparent. In 1990, scientists at the Institute of Freshwater Fisheries contacted Vaki Ltd, which manufactures fish counters for aquaculture, with the suggestion that Vaki would adapt its counters to use in rivers for counting migrating fish. The idea was met with interest and having studied the technical requirements and applications for such a counter it was decided to test a prototype.

Technical description of the River Stock Counter (RSC)

The RSC sensor consists of an array of light emitters and an array of light sensing elements facing the light emitters. By constantly monitoring the outputs from each sensor a picture of an object passing through the gap between the two arrays is obtained. By adding a second set of arrays, the direction and speed of the object can be calculated (Figure 1). Each set of arrays is equivalent to a line scan camera. There are several advantages to this arrangement. One is that the size of the object as seen by the "camera" is independent of the distance to the object. Another is that the sensor can be made totally insensitive to ambient light. An inherent limitation to this type of sensor is that it relies on the fish to swim through the sensor, preferably at a reasonably steady speed. The RSC sensor is equipped with a microprocessor which controls the light arrays, prefilters

the data and sends the picture information to the display unit. A second microprocessor in the display unit processes the data, i.e. determines if a fish is passing, counts the fish and stores certain key parameters as direction, depth, length, and time and date of passing in memory. This information can later be transferred to a PC computer via an RS232 port. The latest addition to the RSC is an extra memory bank with up to 8M Byte capacity which makes it possible to store the entire image of each fish for later processing. The RSC is most frequently located in areas where electric power from a mains grid is not available. Therefore low power consumption is essential and by using low power circuitry and efficient voltage converters it has been possible to reduce operating power to 2 W. The most common source of power is a 12 V 120 Ah lead acid battery and a solar panel. The battery itself would last for approx. 25 days fully charged. The size of the solar panel would, of course, depend on local conditions, but it has been found that an 18 W panel is marginal in Icelandic conditions, not being able to maintain a charged battery during long (3 weeks) rainy periods in the fall.

The development of the river stock counter

Vaki Aquaculture Systems is a company that was founded in 1985 with the aim to develop a counter for salmon smolts, but at that time Icelandic hatcheries were exporting a large number of smolts to other countries. The counter turned out to be a success and since it was put on the market in 1988 over 500 systems have been sold to 17 countries in most parts of the world. It is used for counting salmon, trout, char, sea bass and sea bream, among other species, in the size range of 3 g to 6 kg and is a market leader in its field.

A prototype of counter for use in rivers was built in the summer 1991. The location chosen for the prototype was in Ellidaar, a river running through Reykjavik with approximately 2500 salmon migrating every year. The river belongs to Reykjavik's municipal electric power company which operates a hydro-electric power plant in the river. At the power plant, a fish trap has been built in the river and a mechanical fish counter developed by the power company's staff is at the entrance to the trap. With the assistance of the power company the prototype counter was built in the exit from the trap which is normally left open. This was considered an ideal place for the counter,

comparisons could be made to the mechanical counter and for exact checks, the fish trap could be closed. Furthermore, travelling distances were short. The prototype was a fairly crude one, for instance it only had one set of light arrays. Thus, there was no way of telling if a fish was going up- or downstream and also the possibility of detecting multiple overlapping fish was quite limited. Also, all information had to be gathered from the counter by a portable computer hooked to it. Despite those shortcomings, the prototype counter worked reasonably well, minor technical problems permitting, giving counting accuracies of better than 90%, as compared to the mechanical counter. Later that summer, the counter was removed from its site in Ellidaar and taken to Blanda, a glacier river in northern Iceland where the Freshwater Fisheries Institute has been doing extensive research since 1981. River Blanda has stocks of Atlantic salmon and arctic char. As mentioned, Blanda is a glacier river with milky white water and at times very low visibility. It was found out that the sensors light sensitivity was far to low for those conditions and further tests were abandoned. Judging from the experience obtained from the prototype counter it was deducted that a counter based on this principle was feasible but a number of improvements had to be made. The improvements were among others;

- Addition of a second set of light arrays.
- Sensitivity of the light sensor improved.
- Addition of a display unit for ease of use.

A counter based on those lines was designed and built in 1992. Two units were installed, in Ellidaar and in Blanda. The main concern was how the counter would cope with the limited visibility in Blanda but the improved sensor circuitry turned out to be fit for the job. In Blanda the counter was located at the entrance to a fish trap which was emptied four times a day and each fish measured. The counters readings could be read from a LCD display and further information (size etc.) was stored in the counters memory. Counting accuracy was within the 95% limit that was aimed at for the first year of operation, but the size readings were not within acceptable range, so that it was not possible to distinguish between salmon and char. Based on this experience it was decided that the main emphasis should be put on improvements in size measurements and further that the power consumption of the counter should be reduced as possible. The first goal was met with more elaborate image analysis software for the counter and the second by

redesigning the counters electronics. This work was carried out during the winter '92-'93. It was possible to reduce the counters power consumption by half, but as to the success or failure of the size measurements only experience could tell. During the summer '93, a total of six counters were installed. As before, the river Blanda was the main testing site.

Testing of the river stock counter

In 1993 testing of the RSC continued in River Blanda. As before the RSC was mounted at the entrance of the trap chest. The testing started 3rd of July and ended 17th of August. During this period over 80 % of the total fish run, both arctic char and Atlantic salmon, in the river occurred. The counting and the size of fish was as measured by the RSC was compared with the measurement done in the trap. Some daily differences were seen in the counting (Figures 2,3,4 and 5), but the total differences during the testing period were low, within 1 % in the case of salmon and within 2 % in the case of arctic charr. Size measurements during the time period were 95 % accurate. Two-sea-winter salmon (salmon) was clearly distinguished but some overlapping occurred between large arctic char and small one-sea-winter salmon (grilse) (Figure 6).

By analyzing the data it was seen and most of the counting disturbances occurred because fish were entering and leaving the light gate several times or even stopped in the gate before entering the chest. Therefore the water current through the RSC was increased in 1994, decreasing this problem.and the counting as well as the size measurements seems more accurate than in 1993.

Ten RSC are now in use in Iceland. Nine of them are installed in fish ladders but a threshold was built in one river where the counter was installed. Each counter need to be installed in its own way depending on the location in the mounting site.

Today the River Stock Counter seems to be an efficient tool to count migrating fish in rivers and streams as well as to measure the size of the fish migrating.

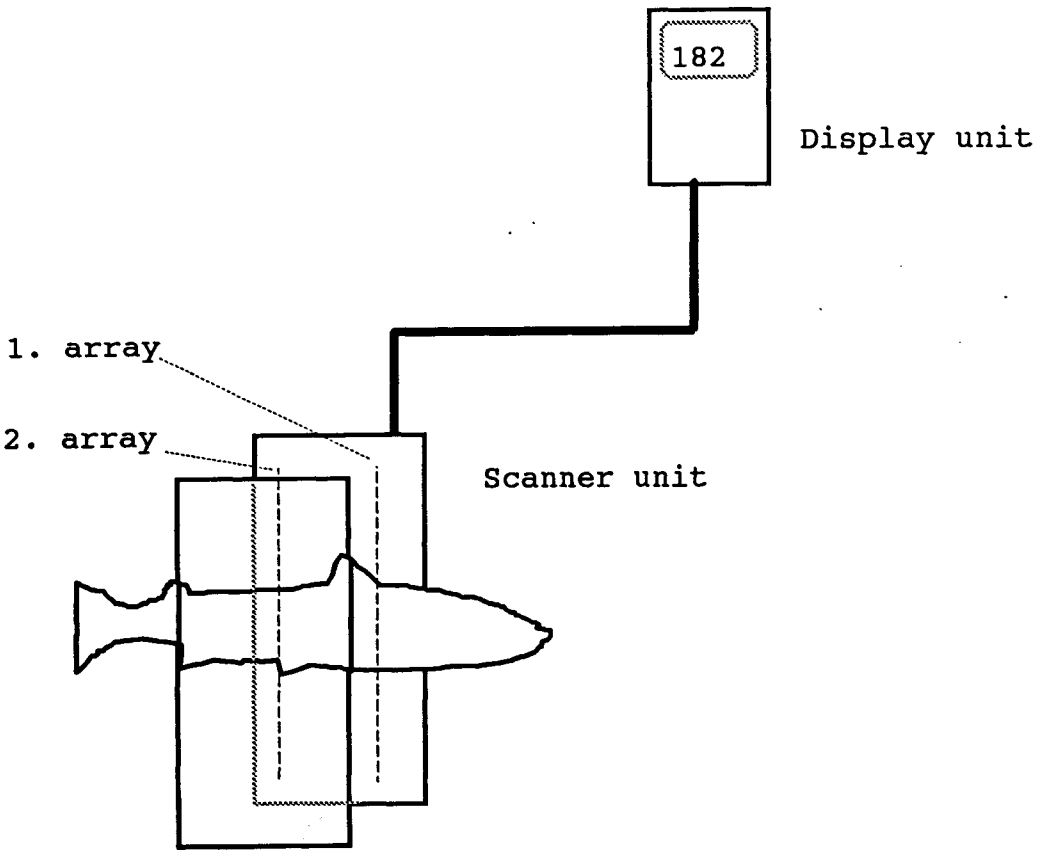

Figure 1. River Stock Counter.

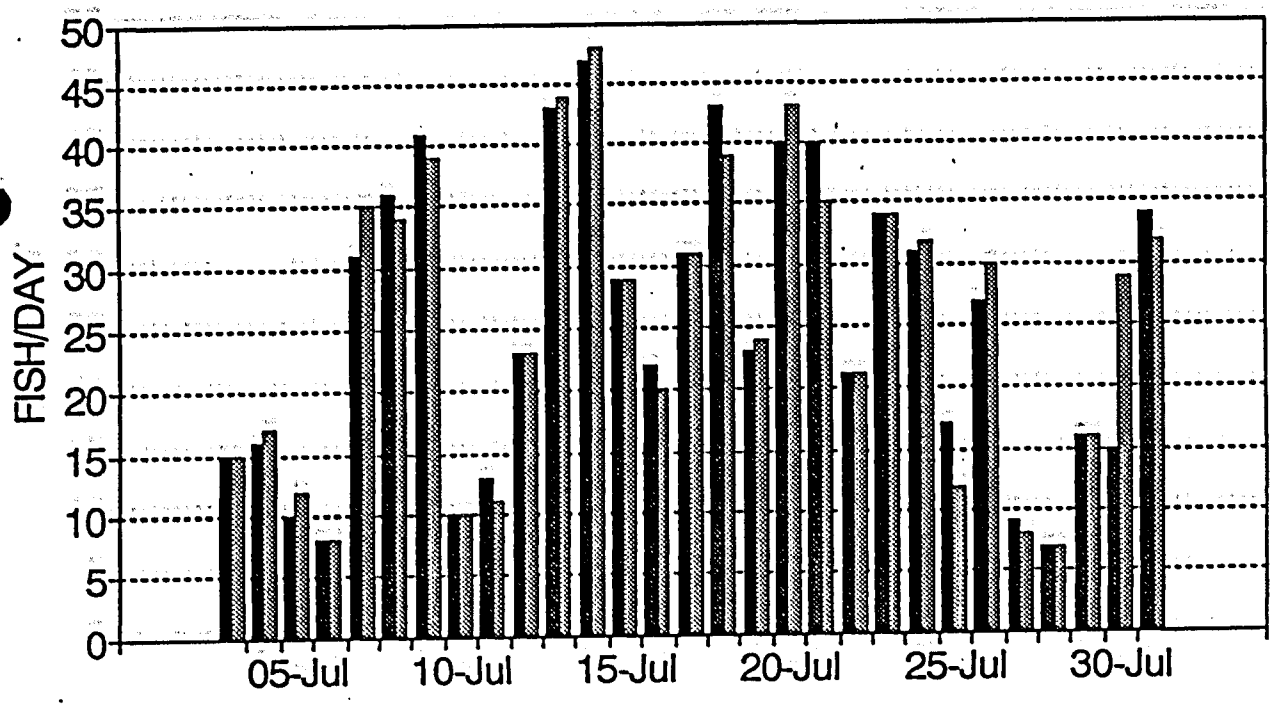

Figure 2. Comparision of number of Atlantic salmon counted by River Stock Counter (Grey columns) and in a fish trap (black columns) in River Blanda in July 1993.

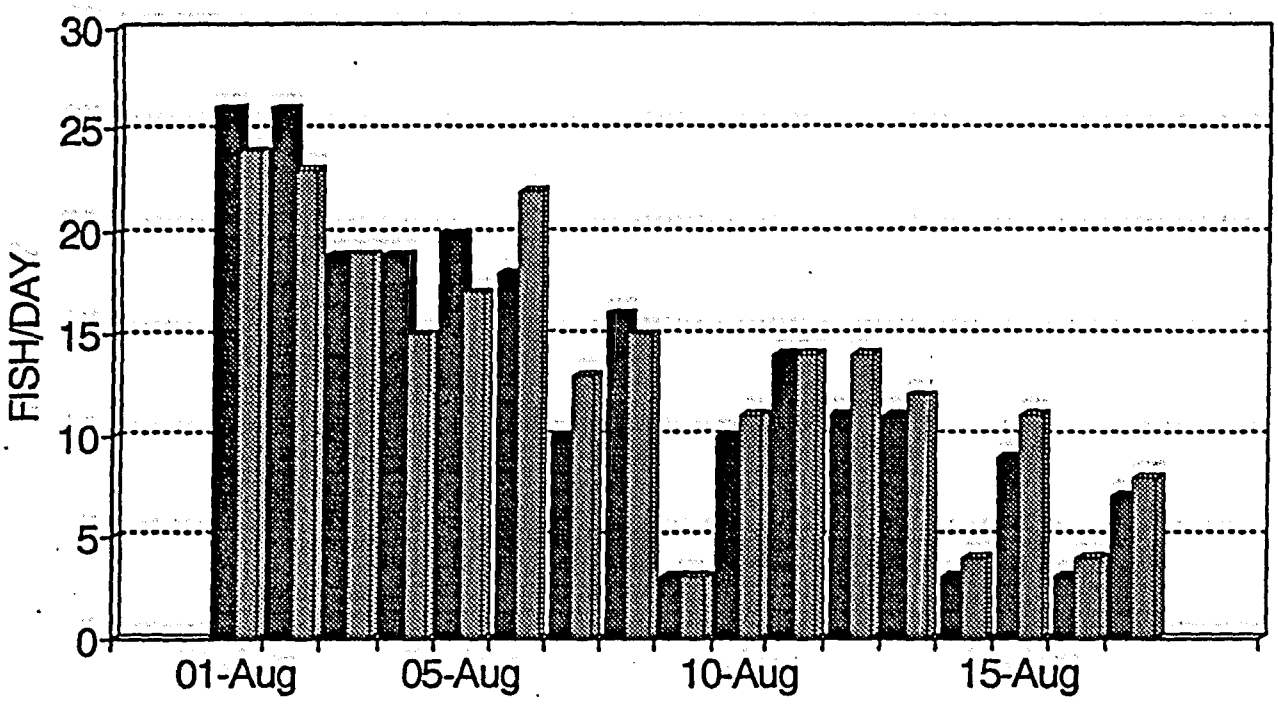

Figure 3. Comparision of number of Atlantic salmon counted by River Stock Counter (Grey columns) and in a fish trap (black columns) in River Blanda in August 1993.

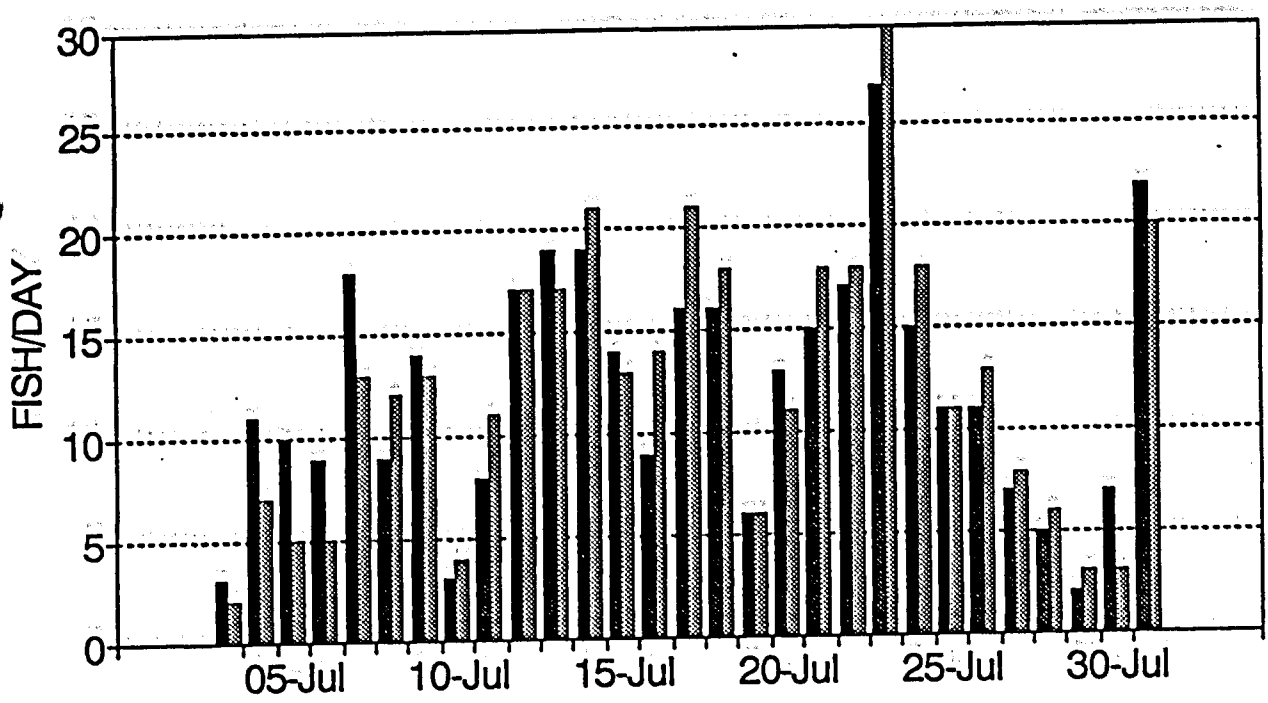

Figure 4. Comparision of number of arctic char counted by River Stock Counter (Grey columns) and in a fish trap (black columns) in River Blanda in July 1993.

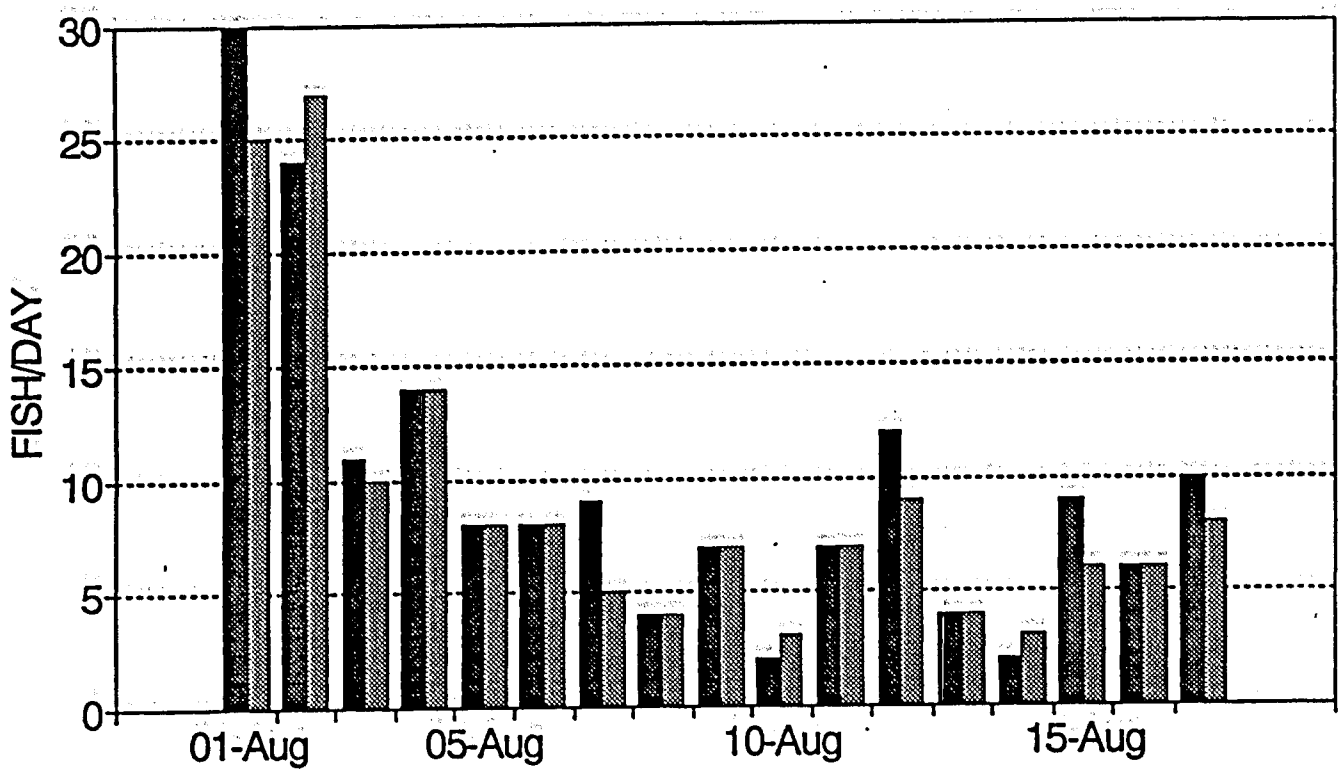

Figure 5. Comparision of number of arctic char counted by River Stock Counter (Grey columns) and in a fish trap (black columns) in River Blanda in August 1993.

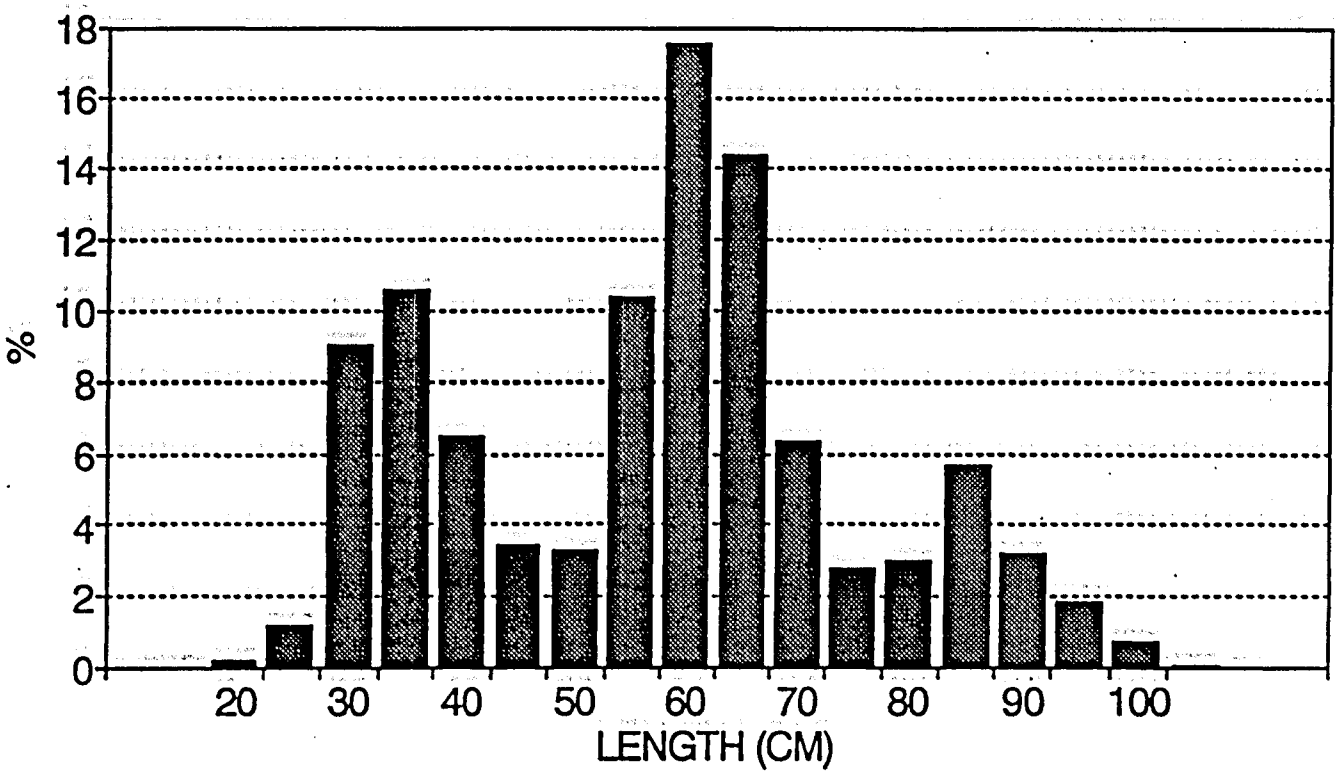

Figure 6. Size distribution of the fish run in River Blanda in 1993 as measured by River Stock Counter. Arctic char is 20 to 50 cm in length, Atlantic salmon being larger than 45 cm, where grilse is 45 to 75 and salmon 75 to 105 cm in length.