

I.C.E.S. C.M. 1996

CM 1996/M:7



**THE CLOSURE OF COMMERCIAL NETTING IN R. HVITA, ICELAND.
- Effects on rod catches of salmon (*Salmo salar* L.) in the tributaries.**

by

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ABSTRACT

Since 1991, there has been no commercial net fishery of salmon in the R. Hvita in Borgarfjörður, west Iceland, due to a temporary agreement to lease the net fishing rights to fisheries associations of the tributaries of R. Hvita. The aim of the agreement is to enhance the rod fishery of salmon in the tributaries.

To estimate the effect of the commercial net fishery closure on rod fishery catches, rod fishery catches in the tributaries were correlated to the catch of salmon in a nearby river, R. Langa for the period 1974-1990 showing highly significant correlation ($r^2 = 0,89$, $P < 0,001$). A model was developed, based on regression analysis to predict rod catches in the tributaries of R. Hvita from the relationship between rod catches in R. Langa and rod catches in the tributaries of R. Hvita, with the aim to estimate the effect of net fishery closure on rod catches during the period 1991-1995.

The results show that rod fishery catches in the tributaries of R. Hvita in 1991-1995 are 20,6 % higher on average than predicted values indicating positive effect of the net fishery closure for the period investigated.

Key words: Atlantic salmon, net fishery closure, effect on rod catches.

INTRODUCTION

The total average catch of salmon in Iceland in the period 1974-1995 was approximately 51,000 fish. The resource is mainly harvested by rod and line, around 35,000 fish on average. The rest of the catch is taken in the commercial gill net fishery which mainly takes place in glacial rivers and a limited number of coastal nets at five locations in west Iceland (Gudbergsson 1996). There is a ban on ocean fishery of salmon in Icelandic waters and salmon from Iceland has only been detected in low numbers in ocean fishery at Greenland and the Faroes (Anon 1996, Scarnecchia et.al 1989a, 1989b, 1991). From 1974 there have been little changes in fishing gear and effort in the salmon fishery and catch records are considered very accurate (Gudbergsson 1996).

Catches of Atlantic salmon from Icelandic rivers are known to vary severalfold between years (Scarnecchia 1984). The source of this variation can be attributed to fluctuations in the natural smolt production in the rivers, to variable survival of smolts during the marine phase of the salmon life cycle and how accurately angling effort reflects the number of spawners entering the rivers. Studies on catch statistics and actual counts of salmon runs in Icelandic rivers have furthermore provided that the rod and line fishery reflects the actual abundance of spawning runs (Mundy et.al 1978, Scarnecchia 1984 and Gudjonsson et.al 1995, Gudjonsson et.al 1996). Generally Icelandic rivers are thought to support healthy salmon stocks and there is no evidence of low spawning stocks limiting recruitment.

In the 1980s a downward trend in catches was observed in the Icelandic salmon fishery. Due to the high values of rod caught salmon, river owners of the tributaries to R. Hvita in west Iceland have leased the net fishing rights in R. Hvita since 1991 to improve salmon runs to the tributaries.

The aim of this study is to estimate the effect of the commercial net fishery closure on rod catches in the tributaries of R. Hvita.

STUDY AREA

The R. Hvita in Borgarfjordur, west Iceland (Fig. 1) is one of the largest rivers in the country. Its origin has been classified as a mixture of direct run-off, spring fed and a glacial water (Rist 1990) which gives R. Hvita its whitish color. The total catchment area is 3880 km² and mean annual discharge is estimated 190 m³/s (Rist 1990) at the estuary. Several tributaries join R. Hvita. The largest are R. Grimsa, R. Tvera and R. Nordura. Smaller rivers are R. Andakilsa, R. Flokadalsa, R. Reykjadalsa and R. Gljufura (Fig. 1). All these rivers support populations of Atlantic salmon.

The net fishery took place in the lower reaches of R. Hvita below the tributaries (Fig. 1) and only negligible fishery in the upper reaches above the tributaries indicating that R. Hvita produces insignificant part of the salmon runs. The average catch in the net fishery in R. Hvita in the years 1974-1990 was 5391 fish and in the rod and line fishery 5497 fish (Table 1). Of the tributaries R. Tvera had the highest average catch or 1922 salmon, but the lowest catches are recorded from R. Reykjadalসা or 99 fish (Table 1). The salmon catch in the R. Hvita river system (Fig. 2) was on average 10.888 fish in the period 1974-1990, which was 23.4% of the total salmon catch in Iceland during the period.

The fisheries associations of the tributaries of R. Hvita leased the net fishery licenses from the fishermen in R. Hvita and since 1991 no net fishery has taken place. This became possible after prices of wild salmon dropped due to increased competition from farmed fish and furthermore to the fact that the rod and line fishery generates an income that is estimated to be 15 -20 times higher per fish than income from the commercial fishery.

MATERIAL AND METHODS

To analyze the effect of the rod fishery closure in R. Hvita on rod catches in the tributaries, the correlation coefficients between total catch of salmon in individual tributaries of R. Hvita were calculated for the period 1974 - 1990 to investigate whether the rivers fluctuated in harmony. This period was used since during this time little changes have occurred in fishing effort and fishing gear. Total catch was used for the analysis, since the grilse component usually constitutes 80 -90% of the runs in this area, and for some of the years records on grilse/salmon ratio was not available. The correlation between the net fishery in R. Hvita and total rod fishery was also calculated to examine the closeness of the fluctuation. Total rod catches in the tributaries of R. Hvita were pooled for each year for the period 1974 - 1990 and compared to total catches of salmon in five rivers in western Iceland to analyze the correlation in the catches by calculating correlation coefficients. This method was chosen to investigate if neighbor rivers significantly fluctuated with rod catches in the tributaries to R. Hvita. Linear regression methods were used to find the relation of catches in neighbor rivers to catches in the tributaries of R. Hvita for the period 1974 - 1990. The most significant relationship found was used to calculate predictive catch values in the tributaries and compare against actual catches for the period 1991 - 1995.

RESULTS

A significant correlation was found between the net catches in R. Hvita and total rod catch in the tributaries ($r= 0,69$, $p<0,01$) which indicates that the net catch and the rod catch are proportional (Fig.2).

Generally rod catches of salmon in the tributaries of R. Hvita fluctuate together and correlation coefficients of catches between individual rivers are in all cases significant to highly significant (Table 2) with the exception of the R. Reykjadalসা which has relatively a small proportion of the total catch. When fluctuation in rod catches in the tributaries were correlated to various neighbor rivers in west Iceland, fluctuation in catches (Table 3) were most closely related to fluctuations in the rod catches of the R. Langa ($r^2=0,89$, $P<0,001$, Fig. 2) for the period 1974 - 1990. The Langa river lies close to the west of R. Hvita and drains into the Borgarfjordur bay (Figure 1). A linear regression analysis was used to calculate the relationship between rod catches in R. Langa and total rod catches in the tributaries for the period 1974 - 1990 to be able to predict rod catches in the tributaries from catches in the R. Langa (Figure 3) and is represented by equation of the form:

$$Y = 1516,35 + 3,019 * X \quad (r^2 = 0,89, P < 0,001)$$

where Y = predicted rod catch in the tributaries of R. Hvita and X = rod catch in R. Langa.

In the period 1991-1995 average predicted catch in the tributaries was 4744 salmon. Actual catches in the tributaries in this period were on average 5719 salmon or 20,6% higher than the predicted value (Table 4). Actual catches were higher than predicted catches in four out of five years and in two years actual catches were outside the upper 95% confidence limits (Fig. 4).

DISCUSSION

The results show that net catches in R. Hvita and rod catches in the tributaries fluctuate closely together indicating that the net catch and the rod catch are directly proportional. There is negligible catch of salmon in R. Hvita above the tributaries indicating that production of salmon is very low in R. Hvita and that the origin of the net catch is salmon produced in the productive tributaries of R. Hvita.

The high correlation coefficient between salmon catches in the R. Langa and the tributaries of R. Hvita suggests that environmental conditions affecting smolt production and marine survival

of smolts are very similar for the stocks investigated in this area. These results are supported by other studies in Iceland which have shown that fluctuations in salmon catches are closely related in many districts. The fluctuations in catches have been linked to changes in the oceanic conditions off Icelandic coasts (Scarnecchia 1984a, 1989a, Guðjonsson et.al 1995).

The results indicate that the closure of the commercial net fishery in R. Hvita has resulted in around 20% increase in rod catches in the tributaries of R. Hvita in the period 1991-1995. The analysis showed that catches in the tributaries were higher in all years but 1995, when actual catches were lower than the predictive value. In 1995 there was no fishing in a coastal net at Tursstadir close to the estuary of R. Langa where average catches in the period 1974-1990 were 325 fish (Einarsson 1996). The closure of the coastal net fishery at Tursstadir may have increased catches in R. Langa and therefore affected predictive values calculated for the year 1995. It is clear that the model is very sensitive to catches in the R. Langa and the use of the model depends upon that no drastic changes occur that affect R. Langa in other way than the tributaries.

In the period 1981-1990 catches in the net fishery were on average 5049 salmon. Assuming that for the period 1991-1995 the number of spawners in the tributaries available to the rod fishery were increased by this number, the rod fishing effort in the tributaries managed to catch approximately 20% of the increased run. -During the period no changes occurred in fishing effort or gear in the tributaries. In Iceland recent studies on exploitation ratio of rod caught salmon in relation to total salmon runs in R. Ellidaar, R. Nupsa and R. Blanda (Guðjonsson et.al 1996) have shown that the exploitation ration varied from 0,36 - 0,75 respectively in the rivers and the ratio is generally higher in years with small salmon runs than in years with large runs.

In Iceland buying or leasing net fishery rights to improve the rod and line fishery in the salmon rivers has been a large issue for the last few years. A method to estimate the effects of net fishery closure on the rod and line fishery is crucial for cost-benefit analysis of such acts.

ACKNOWLEDGEMENTS

The authors thank Ingi R. Jonsson for statistical assistance and drawing of maps, the various fisheries associations of R. Hvita for cooperation in this study and Thorolfur Antonsson for reviewing the manuscript.

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Table 1. Average, minimum and maximum catch of salmon in different parts of the R. Hvita river system in the period 1974-1990.

	Average catch	Min. catch	Max. catch.
<i>Rod and line:</i>			
Andakilsa	157	69	331
Grimsa	1322	717	2116
Flokadalsa	332	181	613
Reykjadalsa	99	33	275
Tvera	1922	1082	3558
Nordura	1440	856	2132
Gljufura	225	73	522
Total	5497	3741	8538
<i>Net fishery:</i>			
Hvita	5391	2993	8558

Table 2. Correlation coefficients of the relationship of total rod catch of salmon between 6 tributaries of R. Hvita in Borgarfjordur west Iceland for the period 1974 - 1990. (Level of significance $p < 0,05 = *$, $p < 0,01 = **$, $p < 0,001 = ***$, ns= not significant).

	Anda- kilsa	Grimsa	Flokadalsa	Reykja- dalsa	Tvera	Nordura	Gljufura
Andakilsa	X						
Grimsa	0,71***	X					
Flokadalsa	0,81***	0,77***	X				
Reykjadalsa	0,64*	0,23ns	0,50*	X			
Tvera	0,50*	0,54*	0,67**	0,32ns	X		
Nordura	0,59*	0,61**	0,74***	0,42ns	0,88***	X	
Gljufura	0,76***	0,67**	0,77***	0,40ns	0,78***	0,82***	X

Table 3. Correlation coefficients of the relationship of total rod catch of salmon between eight river systems in western Iceland for the period 1974 - 1990. (Level of significance $p < 0,05 = *$, $p < 0,01 = **$, $p < 0,001 = ***$, ns= not significant).

	Tribut. combined	Ellidaar	Laxa in Kjos	Laxa in Leirarsv.	Langa	Haf-fjardara	Straum-fjardara	Hauka-dalsa
Tributaries combined	X							
Ellidaar	0,34ns	X						
Laxa in Kjos	0,30ns	0,70**	X					
Laxa in Leirarsv.	0,50*	0,52*	0,71***	X				
Langa	0,94***	0,25ns	0,26ns	0,57*	X			
Haf-fjardara	0,46ns	0,08ns	0,31ns	0,64**	0,56*	X		
Straum-fjardara	0,80***	0,40ns	0,25ns	0,39ns	0,77***	0,21ns	X	
Hauka-dalsa	0,48*	0,55*	0,75***	0,64**	0,47ns	0,45ns	0,48*	X

Table 4. Predicted rod catch with 95% confidence intervals and actual rod catch in 6 tributaries of R. Hvita for the period 1991-1995.

Year	Predicted catch	Lower 95% C.I.	Upper 95% C.I.	Actual catch	% difference
1991	4388	3015	5696	5352	+ 22,0
1992	5412	3843	6893	6943	+ 28,3
1993	3863	2590	5082	5627	+ 45,7
1994	4315	2596	5611	5356	+ 24,1
1995	5744	4111	7281	5317	- 7,4
Average value	4744			5719	+ 20,6

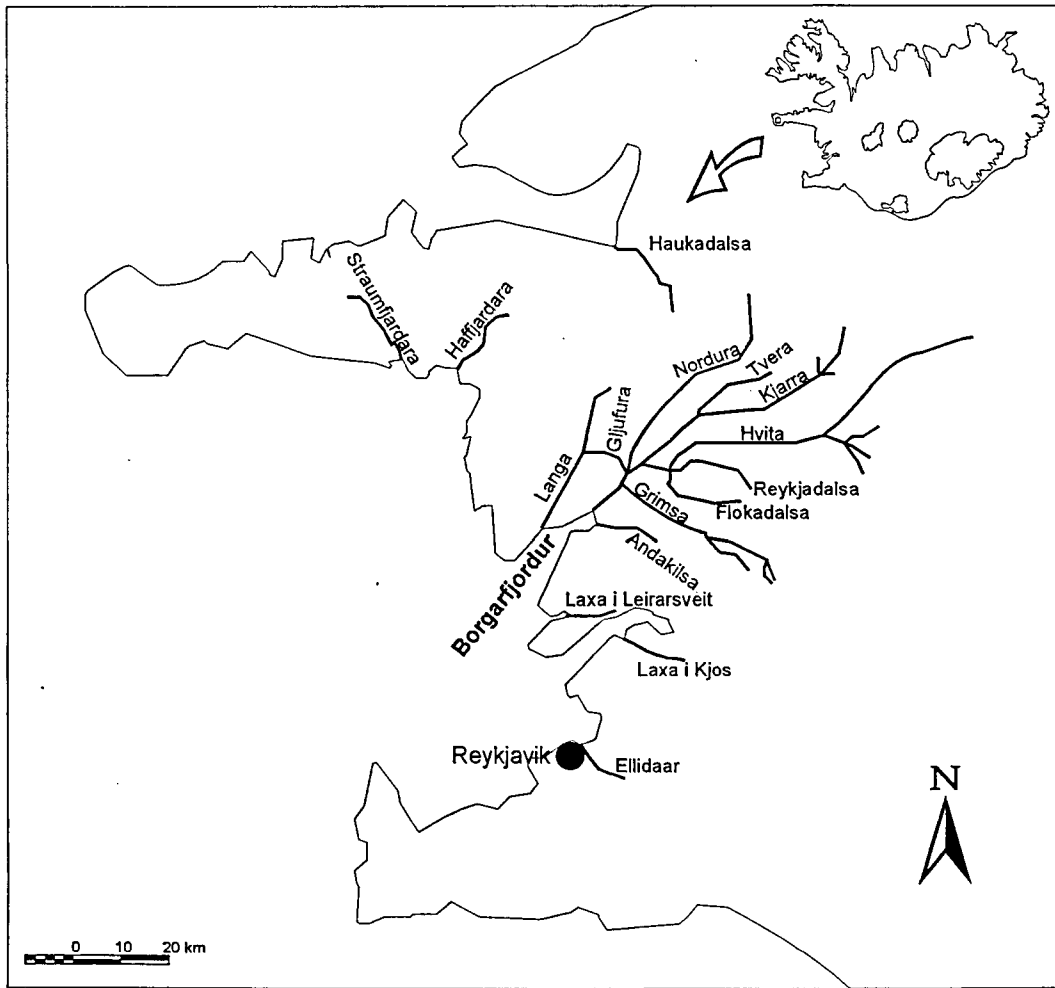


Figure 1: Location of the study area.

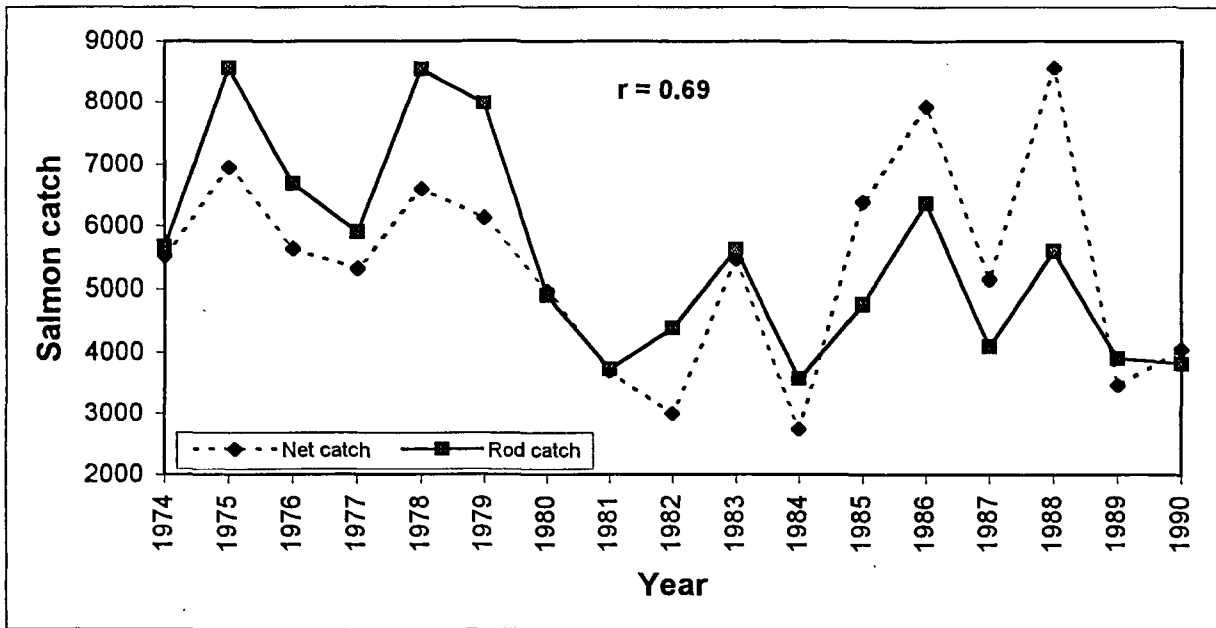


Figure 2: Total commercial net catch of salmon in R. Hvita and combined rod catch of salmon in tributaries of R. Hvita for the period 1974-1990.

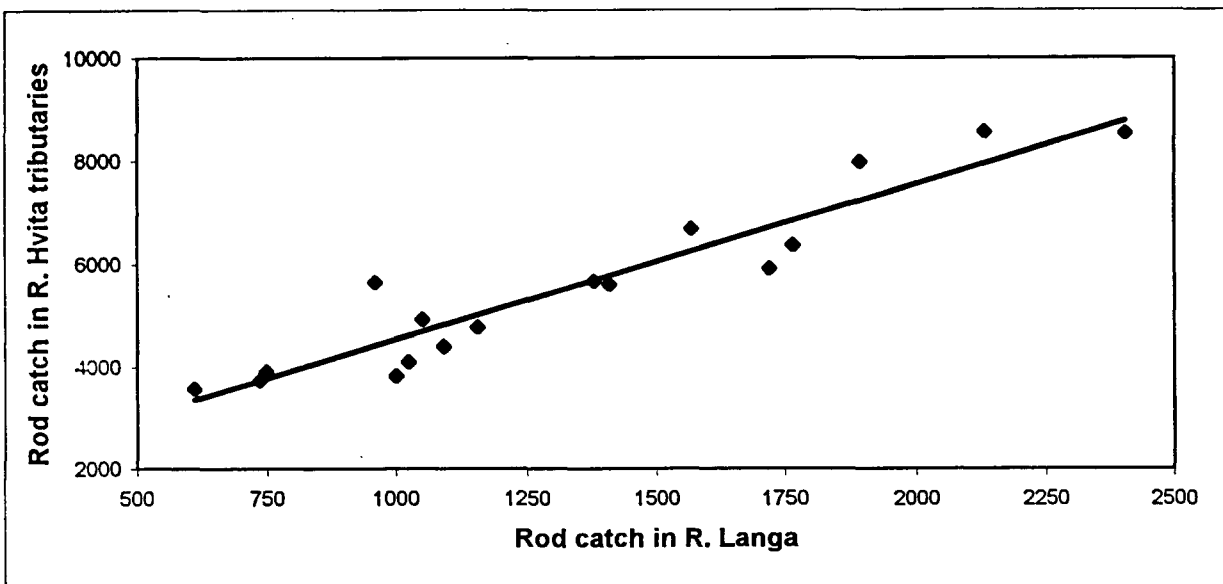


Figure 3: Line fit plot of rod catches in R. Langa versus combined rod catches of salmon in the tributaries of R. Hvita for the period 1974-1990.

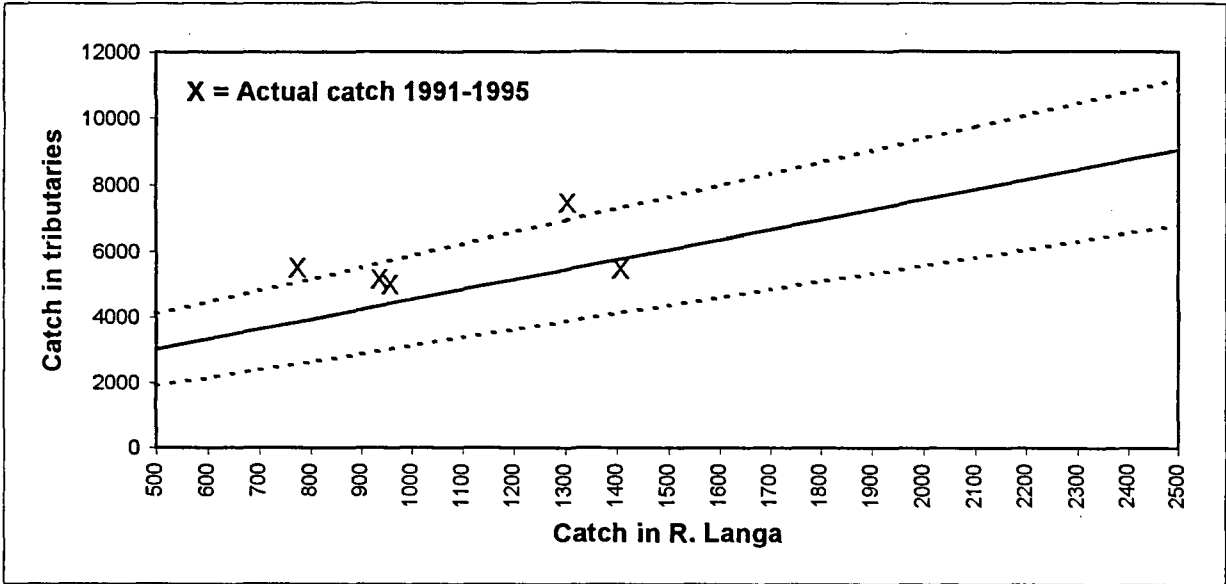


Figure 4: Linear regression line with 95% confidence intervals of salmon catch in R. Langa versus salmon catch in tributaries of R. Hvita for the period 1974-1990. Actual salmon catches in tributaries are shown for the period 1991-1995.