# Recovery of the European eel (*Anguilla anguilla*) population in acidified Norwegian rivers by liming

**BJØRN MEJDELL LARSEN, TRYGVE HESTHAGEN & EVA B. THORSTAD; E-post: (bjorn.larsen@nina.no)**
**Norwegian Institute for Nature Research (NINA), NO-7485 Trondheim, Norway**

## INTRODUCTION

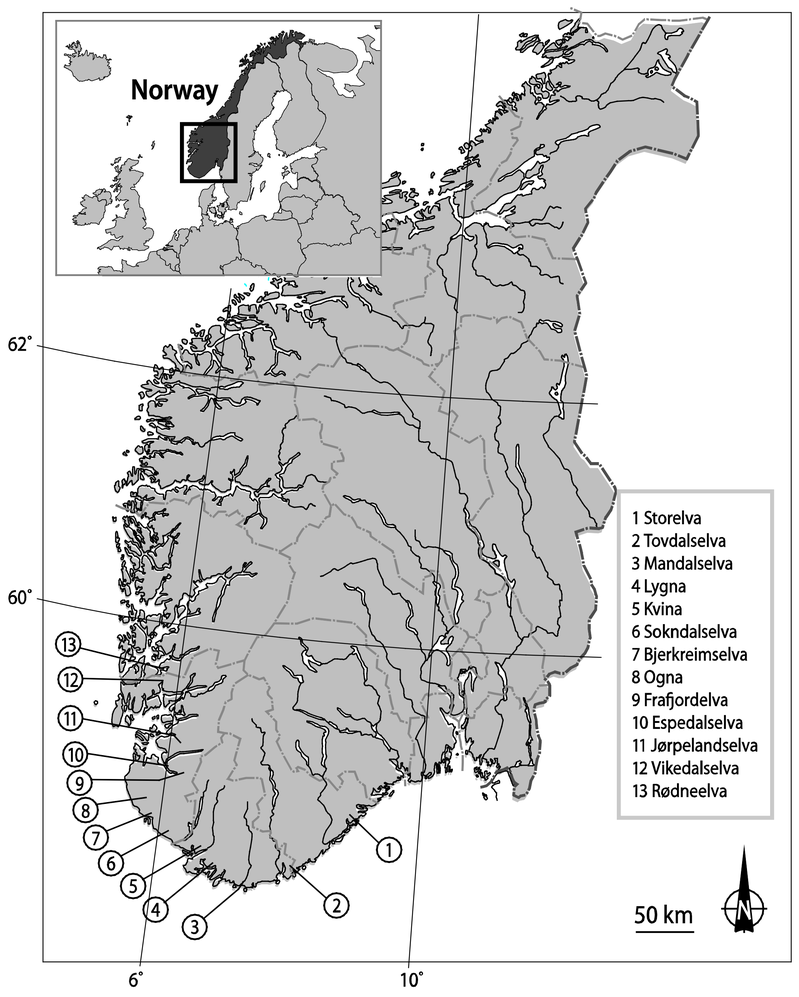
The European eel (*Anguilla anguilla*) is undergoing a severe decline in almost every European country since the 1980s, and it is currently listed on the Norwegian Red List of species as Critically Endangered. The European eel is found in coastal rivers and lakes in most parts of Norway, although its main range of distribution is in the south and south-west of the country. Acidification of surface waters has been a major threat to fish populations for several decades in this area. However, no data appear to exist regarding changes in the abundance and distribution of European eel during this period of freshwater acidification, which has eliminated or reduced populations of Atlantic salmon (*Salmo salar)* in more than 50 rivers in southern and south-western Norway.

## CONCLUSION

The recovery and enhancement of European eel in formerly acidified Norwegian rivers by means of liming is making an important contribution to their conservation. Liming in acidified rivers has reversed the steady decline in the number of European eel observed in time series in other parts of their distribution range.

## STUDY AREA

In Norway, since the 1980s, attempts to restore fish populations in formerly acidified rivers and lakes have been based on systematic liming. This study provides the first extensive report on the effect of liming on densities of European eel, based on data from 13 rivers in southern Norway (**Figure 1**). Eleven of the study rivers are limed continuously with limestone powder from dosers which are controlled by water flow and pH below the liming sites. In the remaining two river systems, the liming is carried out by lake treatment. The liming has usually produced a satisfactory water quality during the spring snow melt, in terms of both pH, with values > 6.2, and concentrations of inorganic aluminum of less than 10 µg $L^{-1}$.




*River Tovdalselva*

*River Sokndalselva*

*River Ogna*

*River Espedalselva*

***Figure 1.*** *Locations of limed Atlantic salmon rivers in the present study.*

## METHODS

European eel was sampled annually in all rivers by means of a portable back-pack electrofishing apparatus (**Figure 2**). Although the sampling period varied between rivers because of the different dates of the start of liming, all the rivers were sampled between 1995 and 2005. In each river, between 6 and 20 stations were established, each with a sampling area of 100 - 150 $m^2$. In our study rivers, we used data from one year prior to liming and up to 8 - 12 years after liming started. The number of eel 100 $m^{-2}$ after three fishing runs was used as a density index. The distribution is defined as the proportion of stations at which eels were found, relative to the total number of stations sampled in each year.



***Figure 2.*** *Sampling of European eel by means of a portable back-pack electrofishing apparatus.*

## RESULTS

European eel was present in 12 of 13 investigated rivers prior to liming, but both distribution and density were low.

Distribution and density of European eel were lower in rivers with lost Atlantic salmon stocks compared to rivers with formerly reduced salmon stocks, assuming that both their distribution and density were affected by acidification.

The distribution of European eel increased from 37% in 1995 - 1996 to 53% in 2004 – 2005 (Regression line: Distribution = -0.350year² + 6.358year +27.270; $R^2$ = 0.68; p < 0.01).

Mean densities rose from 1.2 to 2.0 specimens 100 $m^{-2}$ in the same period (Regression line: Density = -0.018year² + 0.344year + 0.540; $R^2$ = 0.54; p < 0,05).

Looking at the period starting one year prior to liming and up to 12 years after liming, regardless of calendar year, we found an even stronger significant effect of time after liming:

The density increased from 0.7 one year before the start of liming to 2.1 - 3.4 100 $m^{-2}$ after 8 - 12 years of liming (**Figure 3**).

Eel distribution increased significantly during the study period, in that they were found on 31 and 57 - 65% of all stations surveyed one year before and 8 - 12 years after liming, respectively (**Figure 4**).

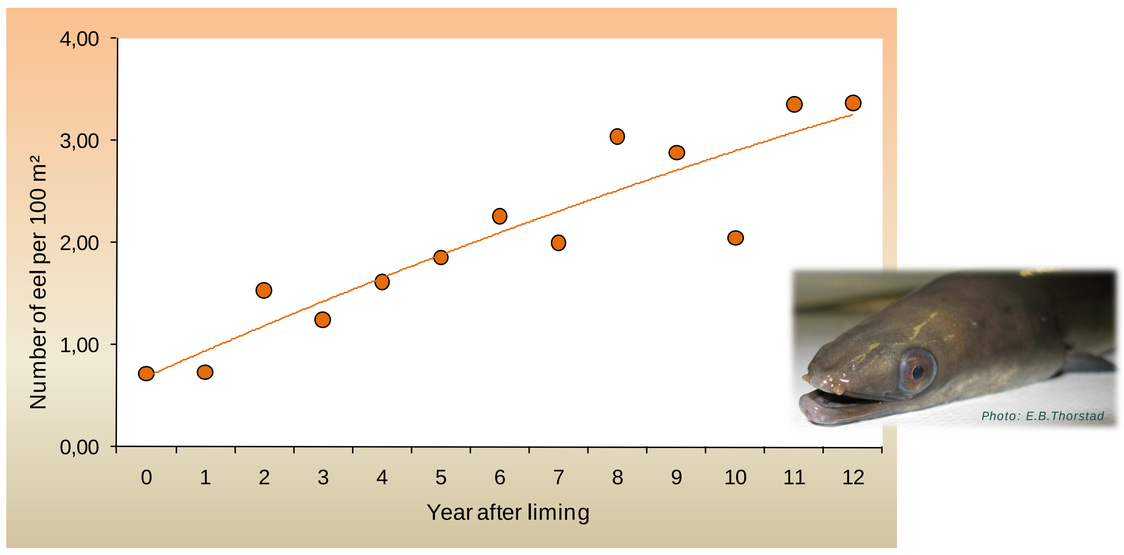



***Figure 3****. Annual mean densities (DE) of European eel in 13 limed rivers, 1 year prior to liming and 12 years after liming. Density is given as number of eel per 100 m². Regression line: DE = -0.003year² + 0.263year + 0.428 ($R^2$ = 0.85; p < 0.001).*

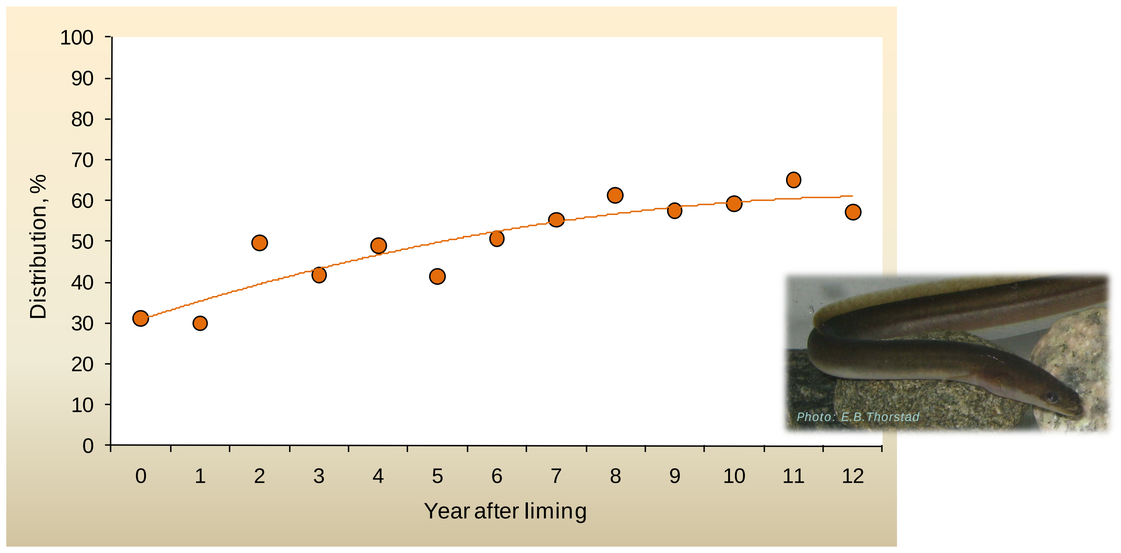



***Figure 4****. Mean distribution (DI) of European eel in 13 limed rivers, 1 year prior to liming and 12 years after liming. Regression line: DI = -0.181year² + 5.041year + 26.040 ($R^2$ = 0.82; p < 0.001).*

## ACKNOWLEDGEMENTS

The monitoring programme in limed rivers was financed by the Norwegian Directorate for Nature Management (DN). The data from the eel survey was treated with financial support from the Norwegian water resources and energy directorate (NVE).