Successful restoration of the freshwater pearl mussel population in a Norwegian river by means of liming

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INTRODUCTION

The freshwater pearl mussel (*Margaritifera margaritifera*) is a rare and threatened species throughout its range, and is the subject of recovery programmes in many countries (cf. Degerman et al. 2009). The main reasons for the decline are anthropogenic influences on aquatic systems. The recruitment is failing and many populations are now without juveniles. During their life cycle the freshwater pearl mussel is dependent on the presence of salmonid fish as hosts for its larvae. Acidification has wiped out Atlantic salmon (*Salmo salar*) populations in 25 rivers in Norway. In addition, several salmon populations in south-western and western Norway have been in different stages of decline. One of these rivers is the river Ogna in the south-western part of Norway. In 1982-1990 periodical fish mortality was observed in the river, usually following sudden increases in discharge, and decline in river pH, and the freshwater pearl mussel population was reduced to a low level.

STUDY AREA

The catchment area of River Ogna is 115 km² (Fig. 1). The area consists mainly of slowly weathering rocks. The width of the river ranges from 15 to 30 m, and the average discharge at the river mouth is 6.6 $m^3 s^{-1}$. The three main species of fish in the river are Atlantic salmon, brown trout (*Salmo trutta*) and eel (*Anguilla anguilla*).

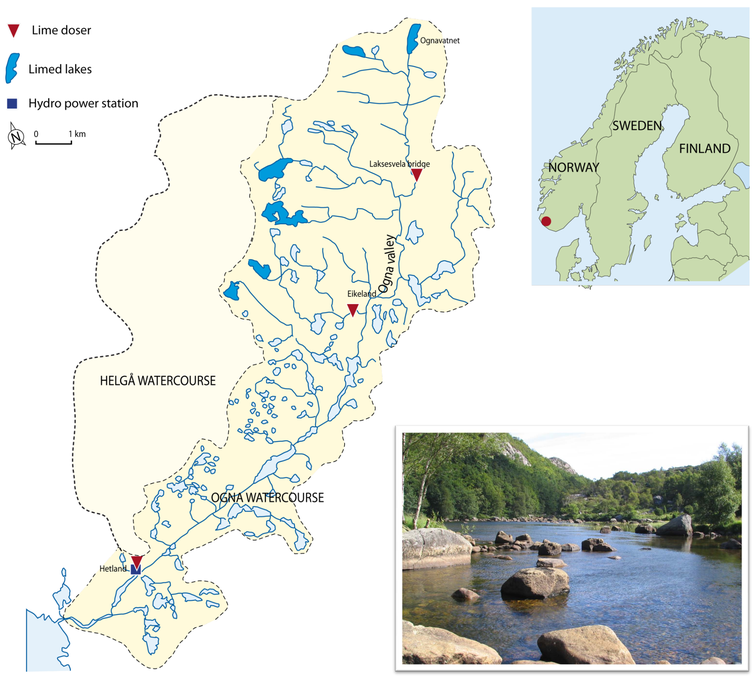

***Fig. 1**. Location of River Ogna showing the catchment area with the lime dosers and limed lakes.*

LIMING PROJECT

In an attempt to restore the Atlantic salmon stock in River Ogna, a liming project was initiated in 1991. The river was limed from two lime dosers controlled by river discharge. In addition, a smaller tributary at Eikeland was limed from a doser, and liming occurs at several of the lakes within the catchment area (Fig. 1).

WATER QUALITY

Prior to liming (1980 – 1987) the mean annual pH level was 5.2 – 5.8 (Fig. 2). Liming resulted in a gradual increase in the mean annual pH level to 6.6 in the late 1990s. An increase in calcium content was also evident after liming, and the annual average exceeded 2.2 mg/l in the first years of liming.

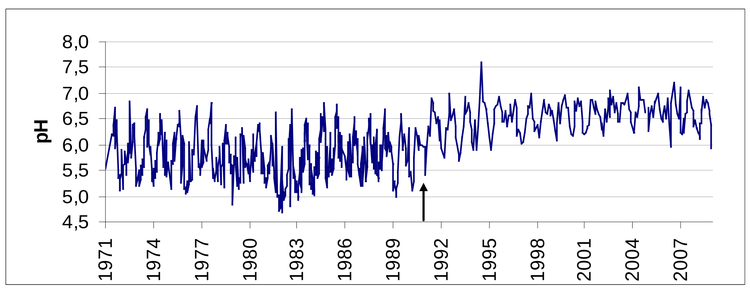

***Fig. 2**. Data on pH from the monitoring programme in River Ogna above Hetland power station in 1971 - 2008. Permanent liming was started in 1991 (marked with the arrow). From Saksgård & Schartau (2009).*

FISH

In spite of fish mortality in the 1980s, the river Ogna sustained a low level of recruitment of salmon throughout the period (Fig. 3). From 1994 there was a notable increase in the density of salmon fry to more than 60 individuals per 100 m² (Fig. 3). This resulted simultaneously in an increase in the density of older salmon parr.

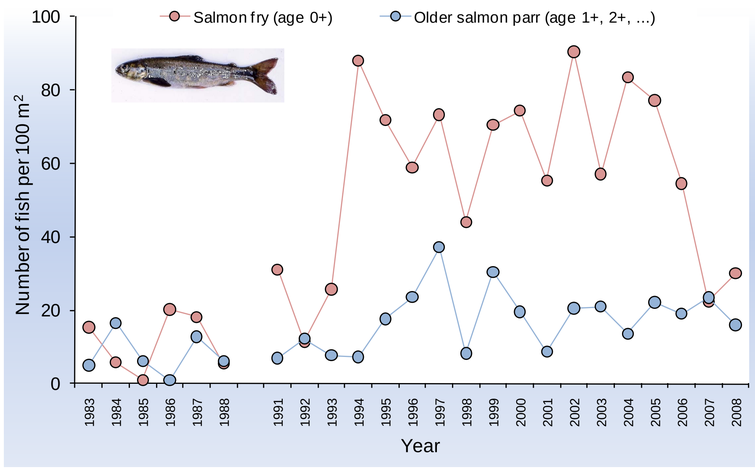

***Fig. 3**. Mean densities per 100 m² for 0+ and ≥1+ age groups of Atlantic salmon (Salmo salar) in River Ogna before liming, 1983 - 1988, and after liming, 1991 - 2008. Data from Larsen et al. (1992), Larsen et al. (2006) and Saltveit et al. (2009).*

FRESHWATER PEARL MUSSEL

Recruitment to the freshwater pearl mussel population was completely absent during many years resulting in a predominance of older individuals (length 110 – 135 mm). Mature specimens, however, have been found and the glochidia survive, attaching themselves to the gills of the salmon host fish. Finds of a few young mussels in 1997 - 1999 (4% of the total number of mussels found) indicated that recruitment was in a stage of recovery (Fig. 4). In 2002, the number of young mussels increased to 36%, and in 2005 and 2008 about two thirds of the mussels were found to be younger than 15 and 18 years respectively (less than 95 mm). Still, only a small number of salmon were infected with mussel larvae. However, the prevalence is increasing as a higher fraction of young mussels are becoming mature. The distribution of the freshwater pearl mussel has increased from 4.0 to 4.8 km of the river. In 2008, young mussels were found at ten of the twelve study sites in the river, and the mean density of mussels has increased by more than 100% from 1999 to 2008 (cf. Fig. 5).

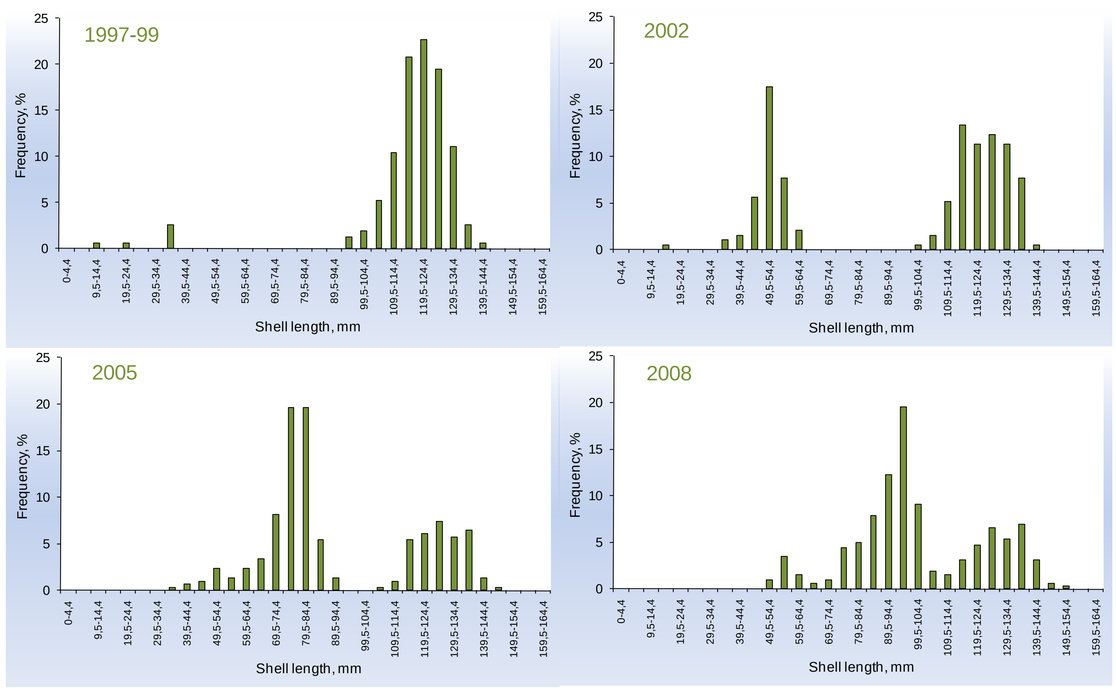

***Fig. 4**. Length frequency diagram of living freshwater pearl mussels in River Ogna in 1997–99 (N = 154), 2002 (N = 194), 2005 (N = 295) and 2008 (N = 318).*

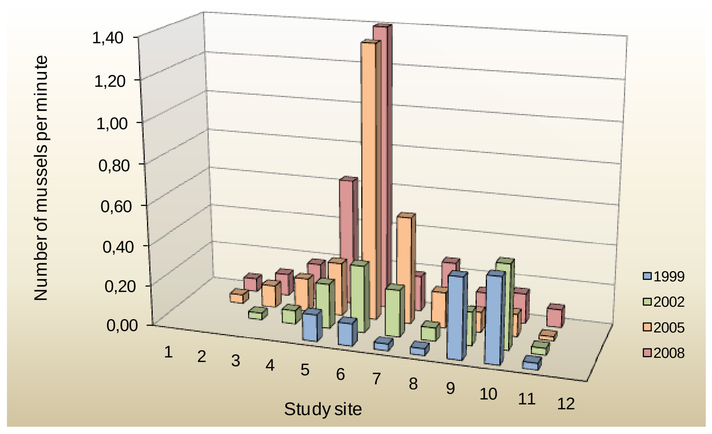

***Fig. 5**. Relative density of living freshwater pearl mussel in River Ogna based on time-restricted counts (given as number of mussels per minute) in 1999 - 2008.*

CONCLUSION

Liming has been an important measure in River Ogna. The development has been positive for the water chemistry, fish and freshwater pearl mussels in the first years of liming. The survey indicated that populations of the freshwater pearl mussel have the potential to recover if the conditions are improved. But the watercourses are still sensitive to acid water and continue to be dependent upon a continual supply of lime.

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