

DISTRIBUTION AND STATUS OF THE FRESHWATER PEARL MUSSEL (*MARGARITIFERA MARGARITIFERA*) IN NORWAY

B.M. Larsen

Norwegian Institute for Nature Research, NO-7485 Trondheim, Norway
bjorn.larsen@nina.no

All available records on the occurrence of the freshwater pearl mussel *Margaritifera margaritifera* in Norway have been collected, and we have information about 504 streams or localities. The freshwater pearl mussel is still found all over the country. In the central parts of Norway there are many and large populations, while in south-eastern and southern parts of the country many populations have become extinct. The total number of streams include some unsubstantiated information (39 localities) and 124 localities (about 25%) where the mussels are believed to be extinct. In spite of several intensive surveys carried out in the country in 2006–2008, there is still incomplete knowledge about the distribution and occurrence of the freshwater pearl mussel in many parts. We have extensive information and population estimates from 56 streams, including various types of habitat – from small creeks with populations of less than 100 individuals to large rivers with more than 6 million individuals. The total number of visually counted mussels in these localities is 22.3 million individuals. Based on this, and assuming that we have 360 streams with living mussels, we may estimate the total number of freshwater pearl mussels in Norway to be 143 million individuals. Based on length distribution and recruitment in 74 streams, recruitment was described as good (mussels less than 20 mm present) in 26 of the streams investigated. There was weak or unsure recruitment in 23 streams with the smallest individuals ranging within 20–50 mm. If we assume that the streams are representative for the situation of the mussels in Norway, two thirds of the populations have some level of recruitment. The calculations above indicate that Norway contains a relatively high portion of the sustainable European populations.

Key words: Norway; freshwater pearl mussel; distribution; status; reproduction

INTRODUCTION

The freshwater pearl mussel is known from major parts of Europe and eastern North America. In Europe, the former distribution was from Portugal/Spain towards the Alps through Eastern Europe and northward through Northwest Russia to the Barents Sea. Currently, this region contains approximately 1250 populations of freshwater pearl mussels (Geist, 2005), of which about 100 populations are sustainable. The estimated number of mussels in all European populations is 130–135 million individuals (Geist, 2005). It has to be noted, however, that there is a lack of reliable information from some geographical regions due to no recent surveys. Norway was one of the countries where the actual numbers of populations remained unclear. Geist (2005) noted 340–350 mussel populations with a total number of individuals estimated in the “millions”.

Historical data can be an important and reliable source in any project mapping the freshwater pearl mussel. We have reliable historical information on the freshwater pearl mussel and mussel-rivers in Norway from the 17th and 18th century. There is information available both in written sources as well as in the oral tradition. Examples are maps, nature descriptions, travelogues, juridical documents, and even folklore songs, poems, anecdotes and tales. Finally, there is information on freshwater pearl mussel rivers and historical distribution data in scientific reports and literature from the late 1800s up to the 1950s and 60s (e.g. Esmark, 1886; Taranger, 1890; Rost, 1952; Økland, 1961).

The main sources of more recent distribution data on the freshwater pearl mussel in Norway are two main mapping projects carried out in the 1970s (Økland, 1975, 1976) and in the late 1980s (Dolmen & Kleiven, 1997, 1999). Professor Jan Økland at the University of Oslo carried out a mapping project under the European Invertebrate Survey (European Molluscs Survey) in the mid-1970s (Økland, 1975, 1976). The resulting distribution map was based on modified 50 km squares and the occurrence was indicated by different symbols for records prior to 1950 and records from 1950 and later (Økland, 1976, 1983). A total of 189 squares cover Norway, and occurrence of the freshwater pearl mussel was reported from 78 (41%) squares. Eleven squares had only records prior to 1950 (Økland, 1983).

The second mapping project was initiated by Assistant professor Dag Dolmen at the University of Trondheim and researcher Einar Kleiven at the Norwegian Institute for Water Research (NIVA). This project was based on a questionnaire which in 1988 was sent to all county governors' offices and all municipal administrations. In addition, they published articles and roll calls in newspapers, radio programmes and even performed telephone interviews. This resulted in a total of more than 270 existing and 100 former localities (Dolmen & Kleiven, 1997, 1999). This covered 96 of the 189 modified 50 km squares in Norway.

By the end of the 1990s, the Norwegian Institute for Nature Research (NINA) initiated a research programme on the biology of the freshwater pearl mussel, and studies of the infection of mussel larvae on the host fish. This brought new information from many rivers and localities all over the country. The national monitoring programme was established in 2000 (Larsen *et al.*, 2000). Finally, in 2001, a project to compile and systematize all old records on distribution was initiated within a national database project on distribution of freshwater fish and invertebrates (VannInfo) (Larsen, 2002).

The freshwater pearl mussel is on the Norwegian red list of threatened species ("vulnerable") (Kålås *et al.*, 2006), and designated as a "responsibility species" for Norway (Larsen, 2005). Consequently, an Action plan for the freshwater pearl mussel was published in 2006 (Direktoratet for naturforvaltning, 2006). Among the measures proposed in the action plan were monitoring, public information, habitat improvement, and improvement of management routines according to acts and regulations relevant for the freshwater pearl mussel. Additional mapping and extended work to establish a database with information on the distribution and status of the freshwater pearl mussel was also proposed.

The County Governor in Nord-Trøndelag has a central role in implementing the action plan in Norway. Anton Rikstad and Kristian Julien at the County Governor's office are responsible for the project, and the main goal is to collect all available records on the occurrence of the freshwater pearl mussel in Norway. In 2006-2008, areas all over the country were picked out for more thorough investigations. The mapping project continued through 2009 and will continue in the years to come.

Geist (2005) stated rightly that "exact distribution, total numbers and juvenile status remains unclear" in Norway. This paper intends to draw together all the available information on the current distribution, and the primary data are analysed to assess a preliminary status of the freshwater pearl mussel in Norway.

MATERIALS AND METHODS

The distribution data presented here are based on several sources, such as the original work of Økland (1975, 1976) and Dolmen & Kleiven (1997, 1999), supplemented with my own records from field work in 1995-2008, and any relevant information on pearl mussel rivers was gleaned from notes, reports and other literature. Finally, data collected in 2006-2008 during the mapping project associated with the Action plan for the freshwater pearl mussel are included. However, the distribution data presented are still preliminary, and more information will be added in the years to come.

Norway's national catchment database, REGINE, is established and maintained by the Norwegian Water Resources and Energy Directorate (NVE). REGINE divides Norway into major and subordinate reference units along the coastline, rivers and catchments. The definition of main rivers and sub rivers in REGINE is used to count the number of streams with freshwater pearl mussel in Norway.

The abundance of the freshwater pearl mussel is shown by a distribution map using the 10 x 10 km units based on the national grid. A dot within a square indicates that the species has been recorded at least once somewhere within that square.

Information on the length distribution and recruitment of mussels is available from 74 streams from all over the country. Data originate from my own field work (32 streams) and 29 reports (covering 42 streams) by several authors (e.g. Lande & Storesund, 1999; Dolmen, 2003; Berger & Lehn, 2008). We distinguish between 1) good recruitment (smallest mussel <20 mm), 2) weak recruitment (smallest mussels ≥20 – <50 mm) and 3) no recruitment (smallest mussel ≥50 mm).

Good population estimates are available from 56 streams from all over the country covering various habitat types. Data originate from my own field work (28 streams) and 19 reports (covering 28 streams) made by several authors (e.g. Lande & Storesund, 1999; Berger & Lehn, 2008). The calculated mean number of individuals in these streams was used to estimate the total number of mussels in the country.

RESULTS

Data from earlier surveys, my own field work and the mapping projects in 2006-2008 have revealed information about 504 streams with present or historical freshwater pearl mussels. The mussels are still found all over the country.

The results indicate that we still have living populations of pearl mussels in 380 streams, while it is extinct in 124 streams. The existing populations are located within 378 10 km squares (Fig. 1), and include uncertain information from 39 streams.

The living populations are found in 18 of 19 counties, and are most numerous in coastal streams in the central and northern parts of the country. Nearly half of the localities are located within the counties of Sør-Trøndelag, Nord-Trøndelag and Nordland (Figs. 2 and 3).

The 124 extinct pearl mussel populations were located within 105 10 km squares, mainly in the south-eastern and southern parts of the country (Fig. 4). The freshwater pearl mussel is totally extinct in 76 10 km squares spread all over the country, in 17 of the 19 counties. Nearly 60% of the localities with extinct populations are located in the counties of Aust-Agder, Vest-Agder, Rogaland and Hordaland (Figs. 2 and 5). In addition, we notice that a higher number of extinct populations is found close to the largest cities in southern Norway – especially near Oslo.

The recruitment is good in 35% of the investigated streams (N = 74; Table I). Weak or uncertain recruitment was found in 31% and no recruitment in 34% of the streams. If we assume that the streams are representative for the situation of the mussels in Norway, two thirds of the populations have some level of recruitment.

The recruitment seemed to be poorer in south-eastern Norway (the counties of Østfold, Hedmark, Oslo, Akershus, Oppland, Buskerud, Vestfold, Telemark and Aust-Agder; 57% of the streams with no recruitment) compared to the central part of the country (the counties of Sør-Trøndelag, Nord-Trøndelag and Nordland; 24% with no recruitment) (Table 1).

The population estimates from 56 streams vary from less than 100 to more than 6 million individuals. The estimated sum of individuals based on visual counts within these streams is 22.3 million freshwater pearl mussels. Assuming that these streams are representative, and that we have 360 streams with living mussels, the total number of freshwater pearl mussels in Norway may be estimated at 143 million individuals (Table 2). However, this number may even be too low as we have preliminary estimates from two large mussel rivers with 15–25 million individuals each (Dolmen, 2003; unpublished data).

Based on the estimates available from the rest of Europe, Norway has about 25% of the remaining streams with freshwater pearl mussels in Western Europe. Including Sweden, the total number of populations on the Scandinavian peninsula constitutes nearly 65% of the living populations in Western Europe. Counting individuals, it may seem that Norway has more than two thirds of the total number of freshwater pearl mussels in Western Europe. Adding Sweden, this proportion increases to nearly 90%.

DISCUSSION

The freshwater pearl mussel has declined significantly in Norway in the last 100 years. In spite of this the mussel remains widespread and is obviously not in danger of extinction in the country as a whole. We have so far information about 504 streams or localities, and the freshwater pearl mussel is believed to be extinct in about 25% of the known localities in Norway. One hundred and thirty new localities have been found during the last ten years (cf. Dolmen & Kleiven, 1999), and presumably there are still mussel populations which are so far undiscovered.

CONSERVATION OF FRESHWATER PEARL MUSSEL *MARGARITIFERA MARGARITIFERA* POPULATIONS IN NORTHERN EUROPE

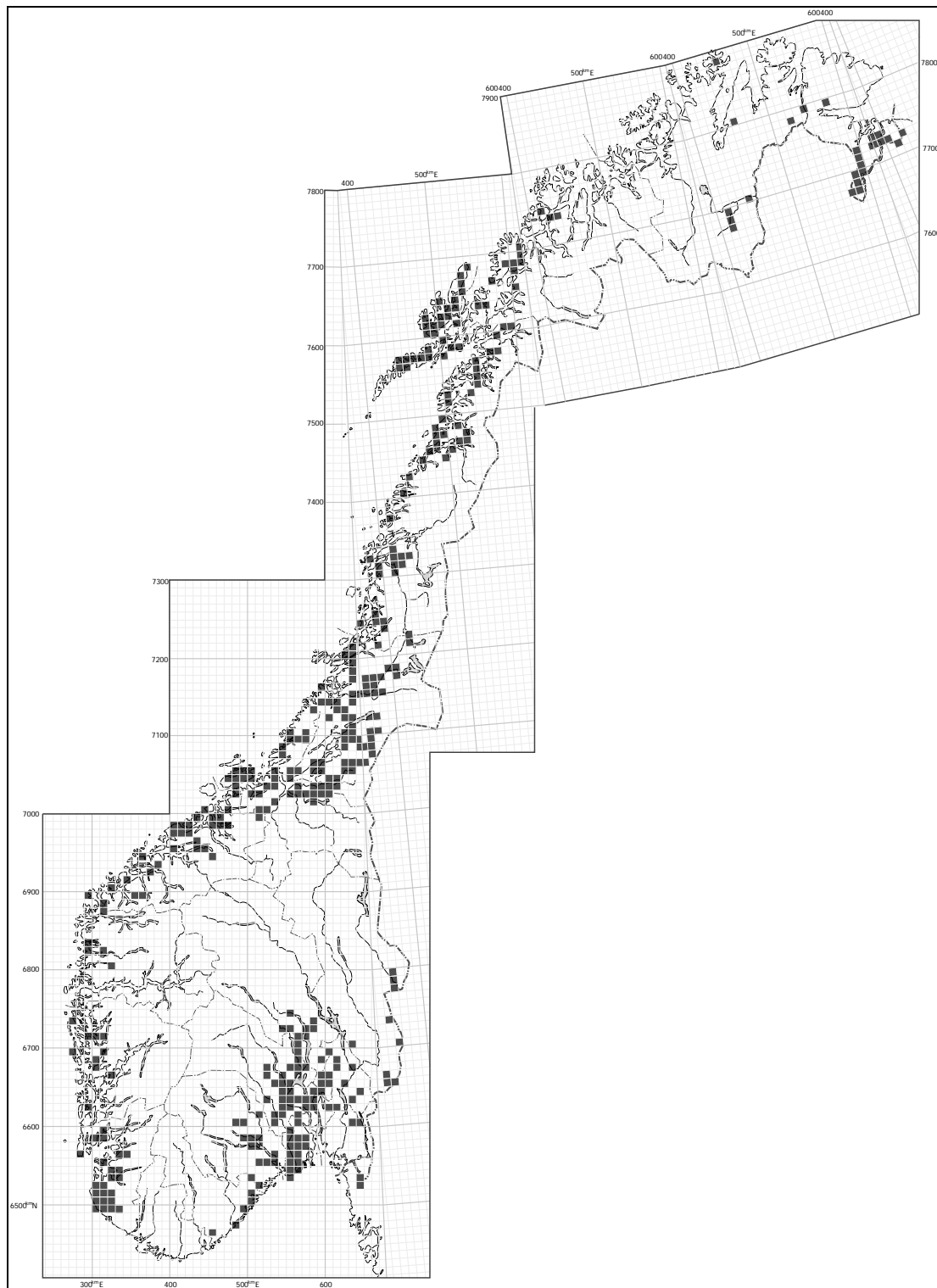


Fig. 1. Distribution of streams with living populations of freshwater pearl mussel in Norway plotted on 10 km squares



Fig. 2. Norway is divided into 19 counties. The map shows the names of the counties given in the text and on Fig. 3 and 5

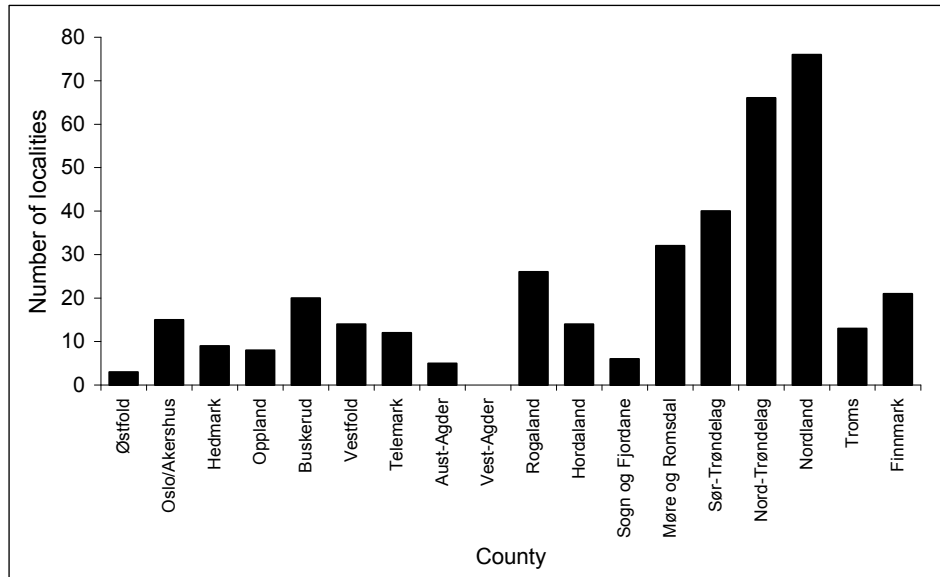


Fig. 3. The number of streams or localities per county with living populations of the freshwater pearl mussel in Norway (N = 380). Cf. Fig. 2

CONSERVATION OF FRESHWATER PEARL MUSSEL *MARGARITIFERA MARGARITIFERA* POPULATIONS IN NORTHERN EUROPE

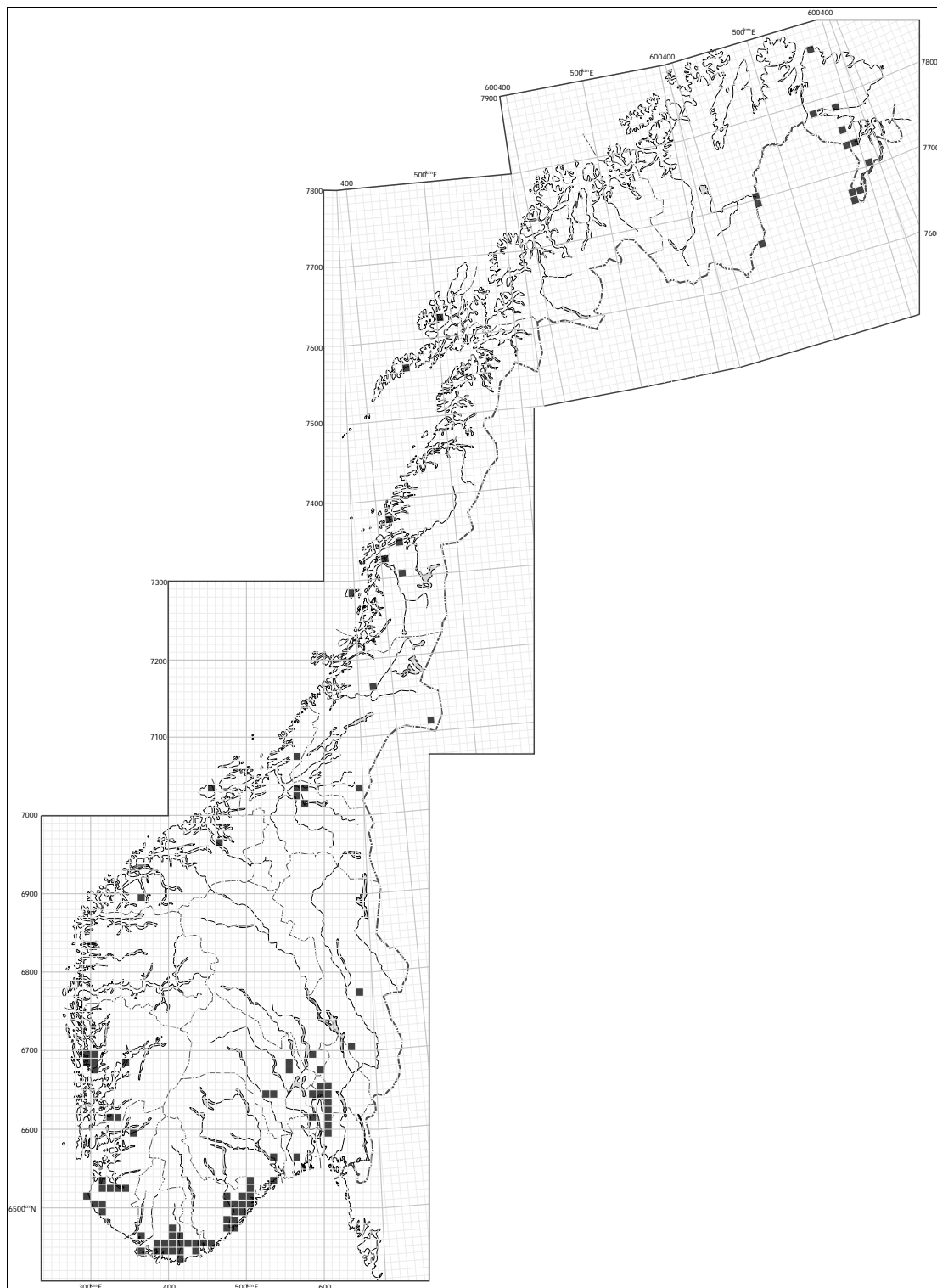


Fig. 4. Distribution of streams with extinct populations of freshwater pearl mussel in Norway plotted on 10 km squares

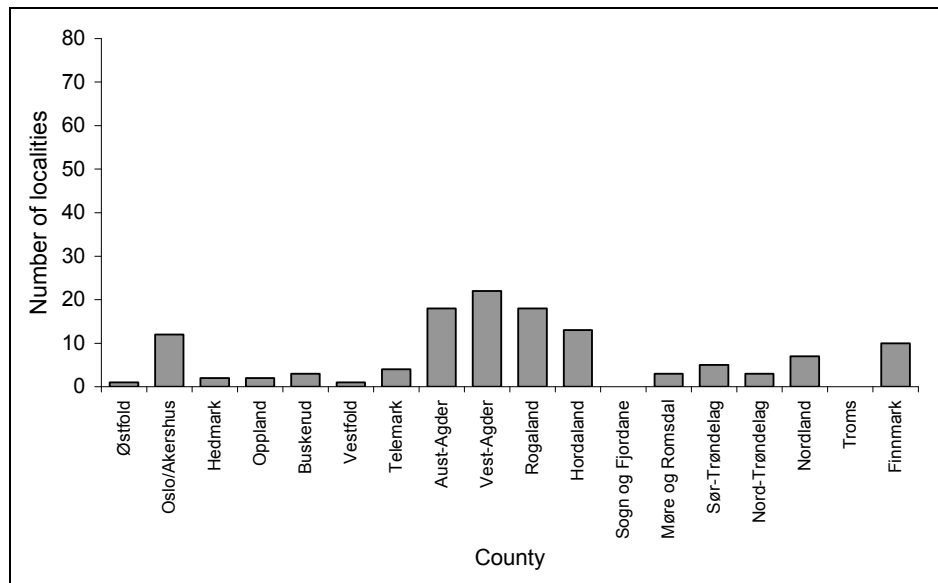


Fig. 5. The number of streams or localities per county with extinct populations of the freshwater pearl mussel in Norway (N = 124). Cf. Fig. 2

Table 1. Information about recruitment in freshwater pearl mussel rivers in Norway (N = 74)

Recruitment	Norway (all streams)	Streams in south-eastern part of Norway	Streams in central part of Norway
No	34%	57%	24%
Weak	31%	29%	31%
Good	35%	14%	45%
No. of streams	74	28	29

Table 2. Revised estimates of current population status of the freshwater pearl mussel in Norway, Sweden and the rest of Europe. The large Russian populations are excluded from the total European estimates due to lack of updated data

Country	Norway	Sweden ¹	Russia ²	Rest of Europe ³	Total ⁴
Estimated numbers of streams/populations	c. 360 (341–380)	551	>8	495–496	c. 1407 (1387–1427)
Part (%) of the total number of streams/populations	26	39		35	100
Estimated number of individuals, millions	143	39 (35–40?)	>100	25	c. 207 (203–208)
Part (%) of the total number of individuals	69	19		12	100

¹ From Söderberg et al. (2008) and Eriksson et al. (1998)

² From Geist (2005). Uncertain estimates. Both number of streams and number of individuals are considerably underestimated

³ From Geist (2005)

⁴ The large Russian populations are excluded

Occurrence and distribution of mussels is normally presented either as number of populations (Geist, 2005) or as number of localities or streams (Söderberg *et al.*, 2008). It is important to notice that the number of populations often differs from the number of streams or localities. In small streams we will normally find only one population. However, in rivers with Atlantic salmon *Salmo salar* L. and sea trout *Salmo trutta* L. in the lower part and resident brown trout in the upper part we may expect to find more

than one population due to the differences in the suitability of the host fish (Larsen, 2006). It may also be possible to distinguish different populations in watercourses which include large lakes.

We observe a substantial decline in the number of populations of freshwater pearl mussel in Norway. The mussels are highly susceptible to acidification, and in addition, acidification has reduced host fish populations in large areas in southern part of Norway (Hesthagen & Hansen, 1991). The freshwater pearl mussel has disappeared from 44 localities in Aust-Agder and Vest-Agder counties, and acidification was assumed to be the main reason (Dolmen & Kleiven, 2004). Threats to the freshwater pearl mussel are more diverse in other parts of the country. Larsen (1997) indicates that, in the past, fishing for pearls had a deleterious effect. Recently, however, factors like river engineering and hydroelectric regulation, erosion and siltation due to drainage and logging, and eutrophication, all have been major causes of decline, especially of juvenile mussels.

Still we have recruitment (smallest mussel less than 50 mm) in approximately 66% of the localities in Norway. But the watercourses are sensitive to several threats in an environment affected by human activities. In acidified rivers liming has been an important mitigation measure benefitting the mussels (Larsen, 2009), and all actions to reduce the leakage of nutrients from farm land and agricultural activities has been shown to be beneficial. The fact that 26% of the freshwater pearl mussel streams and 69% of the individuals in Western Europe are found in Norway means that Norway must take even greater responsibility for this species. The development and implementation of the action plan (Direktoratet for naturforvaltning, 2006) for the species is one important component, but we will also need a more extensive mapping and monitoring programme, and development and implementation of concrete conservation and restoration actions.

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References

- Berger H.M. & Lehn, L.O. 2008. Kartlegging av elvemusling i 7 småelver på Sør-Helgeland i Nordland 2007. Utbredelse, tetthet, lengdefordeling og verneverdi. *Berger feltBIO Rapport* 2008-1 (in Norwegian).
- Direktoratet for naturforvaltning 2006. Handlingsplan for elvemusling, *Margaritifera margaritifera*. *DN-Rapport* 2006-3 (in Norwegian).
- Dolmen D. 2003. Elvemuslingen (*Margaritifera margaritifera*) i Bjøra, Overhalla kommune i Nord-Trøndelag – utbredelse og bestand, samt antatte skadevirkninger ved lita vassføring i elva. *Fylkesmannen i Nord-Trøndelag, Miljøvernavdelingen. Rapport* 2003-1 (in Norwegian).
- Dolmen D. & Kleiven E. 1997. Elvemuslingen *Margaritifera margaritifera* i Norge 1. *Vitenskapsmuseet Rapp. Zool. Ser.* 1997-6 (in Norwegian).
- Dolmen D. & Kleiven E. 1999. Elvemuslingen *Margaritifera margaritifera* status og utbredelse i Norge. *Fauna* 52, 26–33 p. (in Norwegian).
- Dolmen D. & Kleiven, E. 2004. The impact of acidic precipitation and eutropication on the freshwater pearl mussel *Margaritifera margaritifera* (L.) in Southern Norway. *Fauna norv.* 24, 7–18 p.
- Esmark B. 1886. On the land and freshwater mollusca of Norway. *J. Conchol.* 5, 90–131 p.
- Geist J. 2005. Conservation Genetics and Ecology of European Freshwater Pearl Mussels (*Margaritifera margaritifera* L.). Dissertation PhD, Technischen Universität München, Germany.
- Hesthagen T. & Hansen L.P. 1991. Tap av laks i forsuredde lakseelver i Norge. *NINA-Oppdragsmelding* 94 (in Norwegian).
- Kålås J.A., Viken Å. & Bakken T. (eds.) 2006. Norsk Rødliste 2006 – 2006 Norwegian Red List. Artsdatabanken, Norway.
- Lande A. & Storesund, A. 1999. Elvemuslingen i Bøelva, Telemark. Bestand, perlefiske og perlemor på hardingfeler. *Fauna* 52, 34–42 p. (in Norwegian).

- Larsen B. M. 1997. Elvemusling (*Margaritifera margaritifera* L.). Litteraturstudie med oppsummering av nasjonal og internasjonal kunnskapsstatus. *NINA Fagrapport* 28 p (in Norwegian).
- Larsen B.M. 2002. Database for de store ferskvannsmuslingene. Del 1. Elvemusling i fylkene Østfold, Oslo og Akershus, Hedmark, Oppland, Buskerud, Vestfold, Telemark, Rogaland, Hordaland, Sogn og Fjordane, Sør-Trøndelag, Nord-Trøndelag og Finnmark. NINA, Trondheim (in Norwegian).
- Larsen B.M. 2005. Handlingsplan for elvemusling *Margaritifera margaritifera* i Norge. Innspill til den faglige delen av handlingsplanen. *NINA Rapport* 122 p. (in Norwegian).
- Larsen B.M. 2006. Laks, *Salmo salar* (L.), og ørret, *Salmo trutta* (L.), som vertsfisk for elvemusling, *Margaritifera margaritifera* (L.). In *Flodpärlmussla – vad behöver vi göra för att rädda arten? En workshop på Karlstads universitet* (Arvidsson, B. & Söderberg, H., eds), 43–44 p. *Karlstad University Studies* 2006-15 (in Norwegian).
- Larsen B.M. 2009. Kalking i laksevassdrag. Effektkontroll 2008: Overvåking av elvemusling i Ognå, Rogaland. *NINA Rapport* 486 p. (in Norwegian).
- Larsen B.M., Sandaas K., Hårsaker K. & Enerud J. 2000. Overvåking av elvemusling *Margaritifera margaritifera* i Norge. Forslag til overvåkingsmetodikk og lokaliteter. *NINA Oppdragsmelding* 651 p. (in Norwegian).
- Rost H. 1952. Elveperlemuslingen (*Margaritifera margaritifera* L.) i Nord-Norge. *Fauna* 5. 33–37 p. (in Norwegian).
- Söderberg H., Norrgrann O., Törnblom J., Andersson K., Henrikson L. & Degerman E. 2008. Vilka faktorer ger svaga bestånd av flodpärlmussla? En studie av 111 vattendrag i Västernorrland. *Länsstyrelsen Västernorrland. Kultur- och naturavdelningen. Rapport* 2008-8 (in Swedish).
- Taranger A. 1890. De norske perlefiskerier i ældre tid. *Historisk tidsskrift* 3(1), 186–237 p. (in Norwegian).
- Økland J. 1961. Bunndyr fra Hå-elva på Jæren. *Fauna* 14, 154–156 (in Norwegian).
- Økland J. 1975. Utbredelsen av elveperlemusling og andre bløtdyr i Europa - rutenett for Norge. *Fauna* 28, 61–70 p. (in Norwegian).
- Økland J. 1976. Utbredelsen av noen ferskvannsmuslinger i Norge, og litt om European Invertebrate Survey. *Fauna* 29, 29–40 p. (in Norwegian).
- Økland J. 1983. *Ferskvannets verden. 3. Regional økologi og miljøproblemer*. Oslo: Universitetsforlaget (in Norwegian).