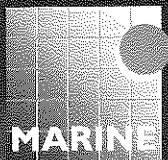


Zebra Mussels in Ireland

by Dan Minchin and Christopher Moriarty



MARINE INSTITUTE
FORAS NA MARA

ZEBRA MUSSELS IN IRELAND.

by

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SUMMARY

The zebra mussel was reported for the first time in Ireland during 1997. It may have been introduced during or before, 1994. Information, based on eye-witness accounts from 1995 and the age structure of zebra mussels sampled during October and November 1997, suggests they first became established in the region between southern Lough Derg and Limerick Docks. The species expanded its range during 1996 to include most of Lough Derg and by 1997 had settled in the remaining north-eastern region of the lake.

The mussels could have reached Ireland in several ways. The most likely vectors are boats carried on trailers directly from Britain and one recently imported barge carrying live mussels was found. There may have been a number of introductions. It is possible that some arrived in ballast water from shipping in Limerick Docks.

Mussels foul a wide range of structures and easily settle on firm surfaces, including water supply pipes. For this reason their presence is of serious concern to amenity and industry. In the Shannon they have formed dense concentrations on the dock gates in Limerick and the sluice gates and pillars of the Parteen and Ardnacrusha dams. Piped water to a hatchery was blocked with a subsequent loss of fish. Densities on the hulls of vessels were up to 53,000 per m². They were most frequently found attached to the hulls of barges and private craft not slipped annually. Few hire cruisers were fouled. Some mooring have sunk under the weight of attached mussels. Fresh-water mussels *Anodonta anatina*, rocks, stones and some aquatic plants were found with attached zebra mussels. It is likely there will be changes to the ecosystem. The overall effects cannot be predicted and will require careful monitoring.

It is inevitable that mussels will spread throughout the navigable waterways of the Shannon and Erne and to the Barrow via the Grand Canal. The spread to other waterbodies can be curtailed if boats are cleaned before being transported. Because mussels can survive up to three weeks under damp and dull conditions special care is necessary to ensure that transfers are avoided. Leaflets have been distributed to boatowners and anglers to advise on precautionary measures.

INTRODUCTION

The zebra mussel *Dreissena polymorpha* is native to the rivers that drain into the Caspian and Black seas. The species rapidly expanded its distribution to northern Europe with the building of canals. By 1824 mussels were found in Britain associated with timber that had been carried on ships from the Baltic, an area where they were already established. The species has more recently been introduced to the North American Great Lakes, probably by ballast water. It was established there by 1986 and has become naturalised throughout most of the navigable waters east of the Rocky Mountain chain.

Because the mussel reproduces rapidly and attaches itself tenaciously to firm surfaces, it is a fouling organism that can form dense incrustations. The main problems for industry arise from their attachment to the insides of pipe systems thereby reducing water flow and causing blockages. Fouling can be so extensive that serial settlements may settle on each other to form accumulations of up to 30cm depth. The weight of mussel settlement causes some navigation buoys and moorings to sink and can result in additional mechanical wear to lock gates. Obstruction and reduced flow to small pipe systems can cause water-cooled engines to overheat and cause problems for heat exchange systems of power plants. Management of mussels using a variety of chemical and mechanical methods has been achieved in North America, but at a cost. Biological control is unlikely to reduce their numbers to a level where they do not become a problem; however, diving ducks are known to cull large numbers in the wintertime in Europe and fish, such as roach *Rutilus rutilus*, are known to feed on them.

Because mussels occur at high densities and can filter large volumes of water, areas where they have recently become abundant often have clearer water, and in some lakes phosphorous levels have declined. Once established, mussels are likely to modify their own numbers by filtering their own larvae and by depletion of food in the water column. The energy accumulated by mussels becomes concentrated in the benthos by means of their own waste.

When first identified in Ireland, mussels were already present in high concentrations in Lough Derg and Limerick Dock¹. Their appearance on the hulls of boats north of Lough Derg and on the Grand Canal may result in the development of populations in these locations. Should this happen, the overall expansion of the species is likely to be rapid. This *Fishery Leaflet* describes the current status of the mussel in Irish waters and shows how it is likely to expand its range. A copy of a handout is appended, which outlines control measures to avoid the development of populations in regions outside of the main navigable water system.

SURVEY METHODS

Specimens were obtained by scraping immersed hulls, wharves, piers and dock gates and removal of clusters from the inside of pipes. A hoe with a 6 mm mesh collection bag attached to an extension handle was used to remove samples from submerged surfaces including boat hulls. Samples from slipped vessels and other collected objects were removed using a paint scraper. In Meelick Bay mussels were sampled from benthic material including maerl and *Anodonta* shells by snorkelling to depths of 3.5m. All specimens were placed either within vials in ethanol or placed alive in bags for later study.

Between 14 October and 22 November 1997, sampling took place from Foynes in the Shannon Estuary upstream to Lough Key on the upper Shannon, on the Grand Canal as far east as Lowtown and on the Barrow Navigation as far south as St Mullins. In January 1998, a sample was taken from Terryglass pier (Figure 1). More than 8,000 specimens were examined. Sampling took place in areas where small vessels were either moored or berthed and also in regions where few vessels were present.

Vessels were sampled near quay sites. Several were examined in northern Lough Derg before the 1997 October holiday weekend when some of them moved to marina and boatyard sites north of Lough Derg and in the Grand Canal. These vessels were traced using local knowledge to their overwintering sites.

¹ McCarthy, T.K., Fitzgerald, J., Cullen, P., Doherty, D. & Copley, L. 1997. Zebra mussels in the River Shannon. A report to ESB Fisheries Conservation, November 1997, 49pp.

Estimates of density were based on counts from unit areas of 30 x 30 cm or 50 x 50 cm. Substrates included a fouled board removed from Limerick Docks and the hulls of boats that had been removed from the water. Salinities were determined using a refractometer. Shell length was measured by callipers to nearest mm and rounded upwards.

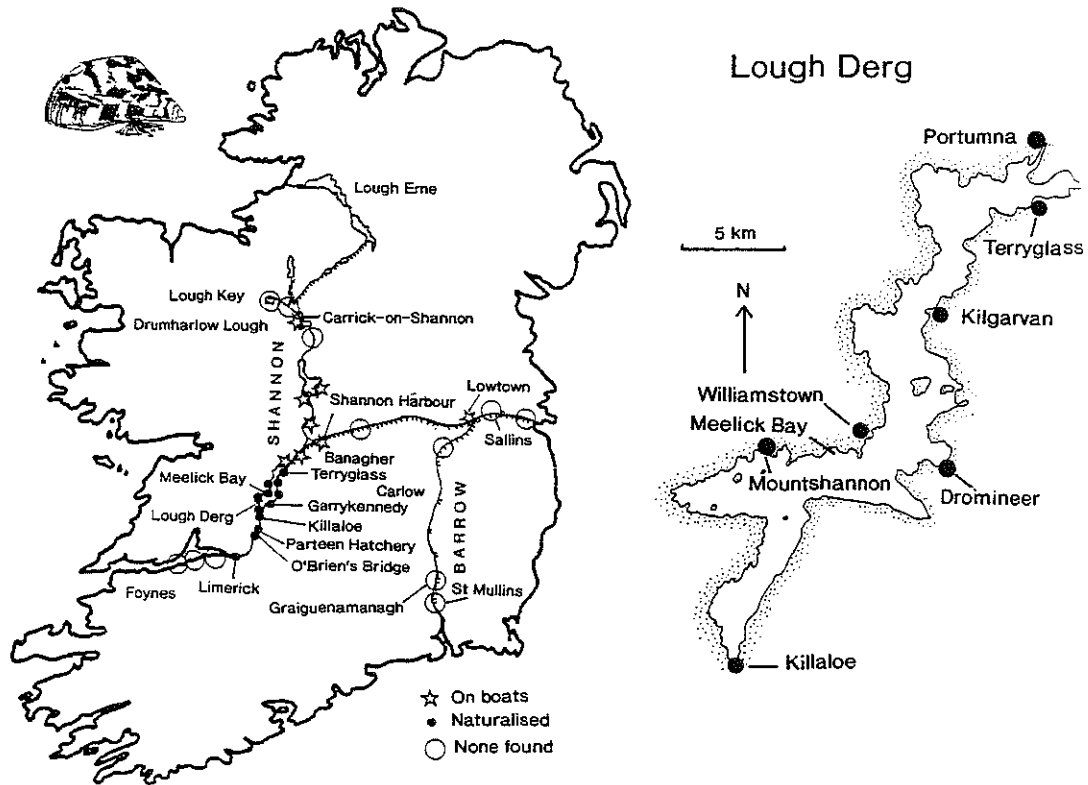


Figure 1. Ireland showing zebra mussel distribution and sites where no specimens were found.

RESULTS

DISTRIBUTION

No mussels were found at Foynes, salinity 22 ‰, or at Ringmoylan Quay, salinity 14 ‰. South of Limerick Docks there are few shore sites with hard surfaces. The most downstream specimens observed were attached to fixed structures at the Limerick Docks. This included air-exposed but splashed portions of the sill and sluice door for the dry dock, within the basin. Here salinities were <1 ‰. Sunken timber with mussel densities of 4,970 per m² and an outboard motor with attached specimens showing three length modes were recovered by the dredger *Curraghour II*. Specimens of up to 32 mm were recovered from a depth of 4 m attached to the outside of the dock gates by a diver in January 1998.

Further upstream mussels had fouled dam structures at Ardnacrusha. Sluices raised since May 1997 had more than one modal size, the largest mode was 24mm and specimens measured up to 32mm. During the summer of 1997 the lock-keeper noticed a dense covering of mussels in the deep lock, but at the time of sampling in October 1997 few were seen there. The water reaches Ardnacrusha dam by means of a headrace canal diverted 15 km upstream by sluices at Parteen. The pillars and sluices here

were covered with a single dense layer of mussels at the water surface level and mussels could be seen to extend at least 50cms below the water surface. At Parteen water is delivered through a series of pipes of decreasing diameter to supply water for tank-reared salmon. Some of these pipes had been recently blocked with mussels of up to 28mm. Mussels had also attached to an outer screen in front of the supply pipe.

Within Lough Derg, mussels were found attached to rocks, stones, maerl fragments, aquatic mosses and macrophytes, shell and fresh-water mussels *Anodonta* sp. Not all structures sampled at the edge of the Lough had mussels: in some backwaters or shallow sandy bays none were retrieved, even from *Anodonta* shells.

At the Coolbaun water treatment works on the lakeshore north of Dromineer, some thousands of small (1 – 3 mm) mussels were found attached to the walls of the water intake tank. These walls were coated by a calcareous slime

North of Lough Derg 7 live specimens, 16 to 23 mm, were found attached to the inside of a dry dock gate in Shannon Harbour, at the western end of the Grand Canal. No mussels were found at any of the adjacent stone walls beside lock gates above or below this dry dock and none were found on the outside of the dock gates. Several recently dead and dessicated specimens, 13 to 24 mm, were found within scrapings on the bottom of the dry dock. No specimens were found in the culvert draining it. No mussels were found on quay or bridge pillars between Lough Derg and Lough Key.

A total of 199 boats on the Shannon River between Killaloe and Roosky were examined. They comprised barges, yachts, cruisers, hulks, houseboats and dinghies from 3.5 m to >20 m overall length. Of 95 private boats known to have been on Lough Derg during 1997, 41 were fouled. Boats used by cruise lines seldom had attached mussels and then only in small numbers and of a small size. Of 67 examined while slipped, 2 were fouled. A further 17 private boats were examined at Lowtown on the Grand Canal and on the Barrow navigation. Attached mussels were found on two of these at Lowtown and one on the Barrow. These boats were subsequently lifted and cleaned.

The largest mussels were generally found on barges or on private vessels that had remained in the water for some years. Settlement was observed on all hull surfaces examined, including wood, fibreglass, plastics, concrete and steel. An antifoulant is used at the waterline of many boats to inhibit algal growth. Consequently, the region of the waterline was frequently free from mussels which settled on lower parts of the hull. The majority of fouled vessels were based in Lough Derg. Two cabin cruisers, recently imported from the Broads in Britain, were examined at Banagher. Neither of these had mussels on their hulls. Densities varied considerably, with lowest numbers being found on the hulls of line cruisers.

Nine vessels fouled with mussels, which had left Lough Derg, were traced to destinations ranging as far north as Carrick-on-Shannon and eastwards to Lowtown on the Grand Canal. The marina authorities where they were berthed for overwintering were advised that these vessels were fouled and a request was made to have the mussels removed. Those contacted were warned about the potential for the development of new populations from fouled hulls and were asked to ensure that, when vessels were being cleaned, the mussels were not returned to the water.

One cabin cruiser examined at Williamstown, and due to go to Lowtown, had a mussel density of 53,000 per m². It was cleaned the following day in Williamstown and when examined one week later at Lowtown on the Grand Canal was free from mussels.

A 3.5 m dinghy, used as a tender for a cruiser, was brought to a garden in Dublin directly from the north-east region of Lough Derg by trailer in October. A sample of mussels was collected from it in Dublin. The mussels were dead and dessicated. Their density was 3,570 per m².

MEASUREMENTS

Specimens ranged in length from <1 mm to 38 mm. The largest were found in Limerick Docks and in the southern region of Lough Derg. The larger and more conspicuous length group ranged from 15 to 25 mm. In some localities in the middle and southern part of Lough Derg smaller shells from <1 to 3 mm were abundant. Shells in the north-eastern region of the lake ranged from 2 to 12 mm only.

Lough Derg

The length frequencies of specimens found at quay sites throughout Lough Derg were compared with those removed from boats launched and remaining in the same locality. At the Kilgarvan and Terryglass quays there was a single length mode which corresponded with those found on boats launched in the spring of 1997 (Figure 2).

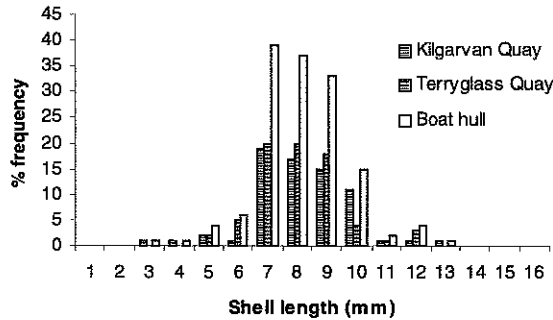


Figure 2. Samples from north-east region of Lough Derg. (Kilgarvan n = 109, Terryglass n = 73, Boat hull n = 129).

Similarly the smallest mode found at quay sites in Dromineer corresponded to boats launched at the same time (Figure 3). Samples from boats which had been in the water since launching in the spring of 1996 had two modes closely resembling those found at quay sites in the middle and lower Lough Derg. (Figure 4) Mussels attached to *Anodonta* shells and maerl in Meelick Bay had two modal sizes (Figure 5). *Anodonta* in this area were commonly seen with attached mussels.

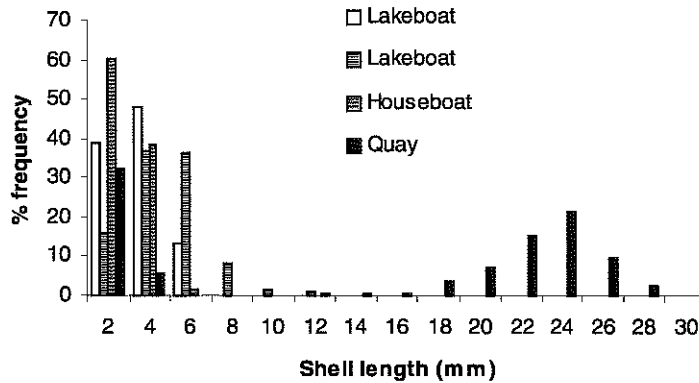


Figure 3. Sample from boat hulls and quay at Dromineer (Lakeboat s n = 114, 193 houseboat n = 119, quay n = 429).

The sample from one vessel, a wooden hulk in Killaloe, had a third mode at 33 mm with specimens as large as 38 mm (Figure 6). No samples from Lough Derg quay sites were found with mussels of this size. Specimens from the outside of the dock gates in Limerick attained sizes to 32mm. From a pipe at Parteen, mussels up to 28 mm were recovered and up to 31 mm from sluices at Ardnacrusha lifted in May 1997.

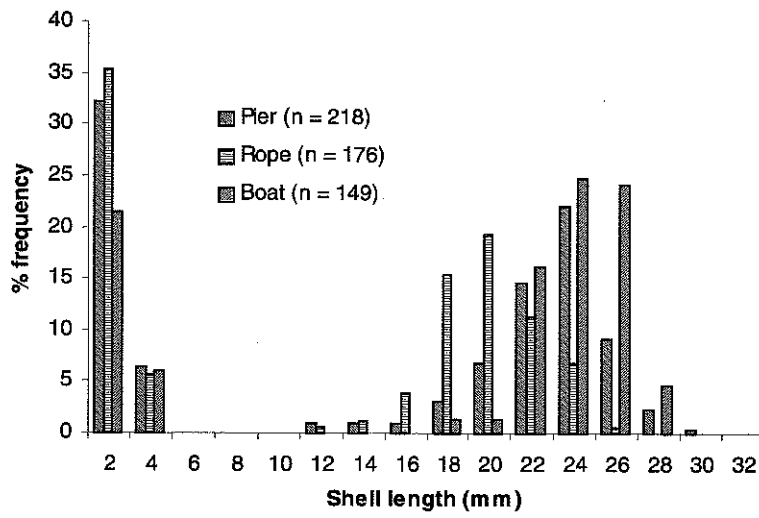


Figure 4. Samples from Dromineer on structures.

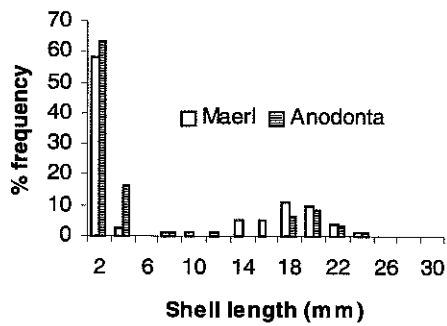


Figure 5. Samples from benthos and fauna in Meelick Bay (maerl n = 82, Anodonta n = 97).

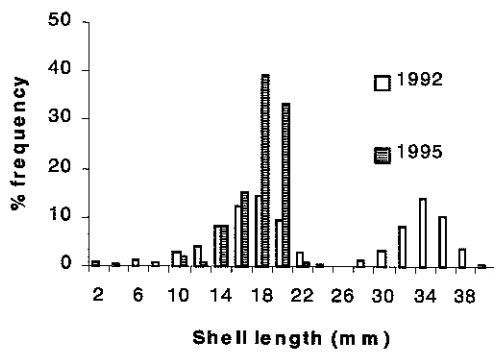


Figure 6. Lengths of shells from barges moored at Killaloe since dates shown. (1992 n = 651, 1995 n = 99).

There were two settlements in Lough Derg during 1997, an early localised settlement in the region of Kilgarvan and Terryglass and a later one that took place throughout the rest of the Lough. Settlement was greatest in the region of Dromineer, where each adult bore recently settled mussels at a mean of 62 per shell (Table 1). Some mooring ropes in this region were obscured by the numbers of mussels attached. Recently deployed synthetic ropes and suspended chain near Dromineer had dense settlements.

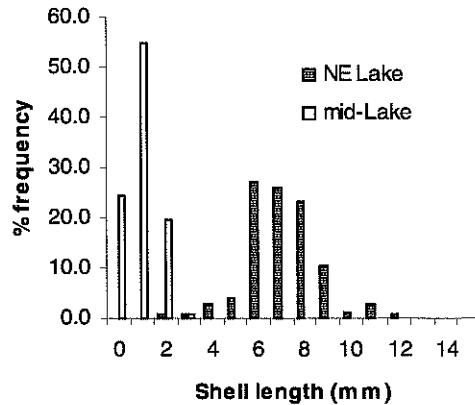


Figure 7. Small specimens from Lough Derg samples, November 1997 (mid lake n = 253, NE lake n = 182).

The small (<15 mm) mussels sampled in Lough Derg showed two modes. Those from the north-east of the lake were larger (Figure 7) than the much greater numbers present in the mid-region. Samples from boats at Kilgarvan and Dromineer showed two distinct length frequencies while the lengths from a sample from a boat which had moved between the two in the course of the summer had an overlapping distribution (Figure 8).

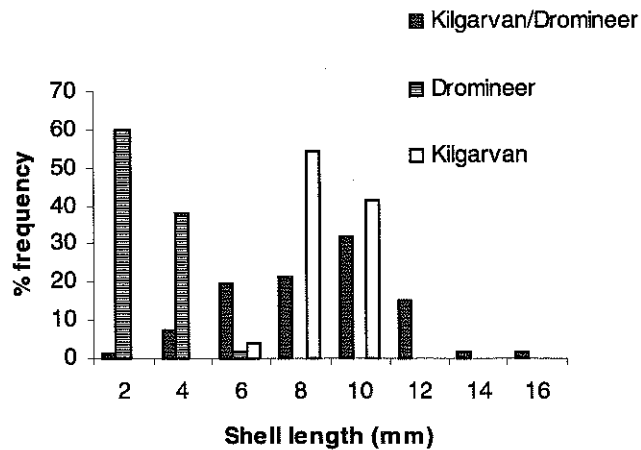


Figure 8. Shell lengths of mussels from boats with known ranges in Lough Derg (Kilgarvan/Dromineer n = 129, Dromineer n = 192, Kilgarvan n = 37).

Population on a barge in Grand Canal

Mussels were sampled from the hull of a recently imported barge at Lowtown on the Grand Canal on 5 November. It had been carried by trailer from near Bristol, and craned-in at Sallins on the evening of 6 August 1997. It was then brought to Lowtown, a region where mussels were not established. The length distribution (Figure 9) of these mussels was greater than could have been attained if they had settled after its importation. The shell length of dead mussels on this barge had a mode smaller than the living ones. A check mark was found on the living mussels at the modal size which corresponded to

that of the dead mussels, suggesting that some had died during the overland journey while the others had continued to grow.

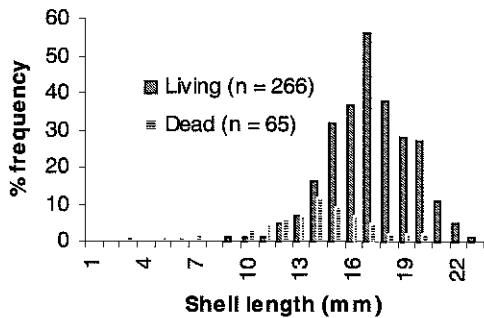


Figure 9. Shell lengths of mussels from canal boat recently imported from England.

Samples collected outside Lough Derg

Lengths of samples collected from boats moored upstream of Lough Derg, a cruiser at Banagher and a barge at Athlone are shown in Figure 10 together with data from the dinghy carried by trailer from Lough Derg to Dublin. The sample from the barge at Athlone had two length modes, the other samples had one.

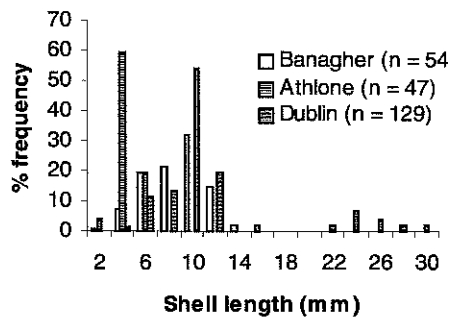


Figure 10. Samples from outside Lough Derg.

Growth

Figure 11 shows length frequencies from Lough Derg samples collected in October, November and January. The increases suggest that growth takes place even during the winter. The group of small shells collected in January suggests that there was a late autumn settlement

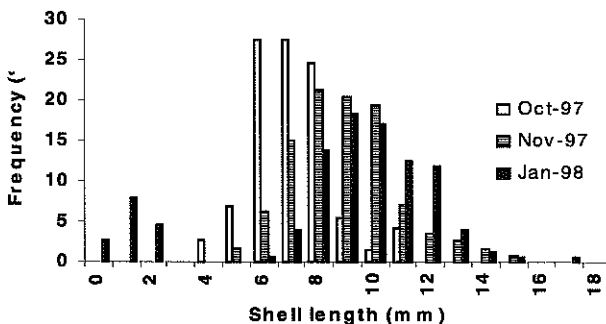


Figure 11. Length frequencies of Lough Derg samples taken on successive dates.

DISCUSSION

The zebra mussel forms extensive and locally dense populations in Lough Derg. In the most southerly part of the lake at Killaloe, 3 year classes were observed, 2 between Killaloe and a line from Portumna to Dromineer and one in the north-east region. This suggests that they first became established in the south and expanded northwards. Lengths of the small mussels, which evidently belonged to the 1997 year class, showed two modes: smaller in the north-east and larger in the mid-region, implying two periods of spawning. The size range of sample from Terryglass in January 1998 suggested that settlement may take place late in the year and that there were two settlements in the north-east region of the lake.

The lake population is unlikely to spread upstream except when carried on boats. Several vessels with attached mussels have dispersed to overwintering areas upstream and elsewhere and this is likely to result in the establishment of new populations. Indeed this may have already happened: mussels were attached to the hull of a vessel that had remained in the upper Shannon, based at Drumharlow Lough. The sample from this boat was made up of crushed individuals of about 5-8mm.

Mussels grow rapidly in Irish waters and may attain 33mm in their third year, however most do not appear to survive longer than two summers of growth. The rapid growth and settlement intensities during 1997 suggest that there will be a significant increase in biomass in 1998.

Operators at marina sites first noticed mussels on boat hulls in 1996 and so populations may have become established upstream since that time. Those vessels found with the greatest number of mussels were generally barges; these are not regularly slipped and because they have a large surface area and slow cruising speeds are prone to acquiring large numbers of mussels. Private vessels that remain idle for long periods and are not annually slipped, may also carry large populations. Hence barges and some private vessels pose the greatest risk of establishing new populations elsewhere. The few line cruisers found with mussels had small numbers of small individuals. This is probably because they are slipped and cleaned each year.

Small boats, such as dinghies, can carry several thousand mussels. Consequently seasonal movements of small boats, such as those used by anglers, pose a risk for the introduction of mussels to new areas. This may be significant when a number of boats may be moved at a particular time, for example during mayfly fishing in lakes such as Corrib and Sheelin. Fishermen about the shores of Lough Derg recall small numbers of mussels attaching to their keep nets and these could introduce mussels to other catchments.

Overwintering areas for boats especially those where there are facilities to slip boats are regions where mussels can accumulate either by dropping from boats' hulls or being scraped off and brushed back into the water. The seven specimens found at Shannon Harbour on the inside of the dry-dock gates may have survived after being removed from the hull of a barge. Populations could have developed in areas on the Shannon arising from the cleaning of vessels in the autumn of 1996, with scraped-off mussels being returned to the water. Presumably there were large numbers present at that time on boat hulls, since several marina operators remarked about them being seen for the first time.

The source of the Irish population remains unknown. The two most likely are introduction in ballast water to Limerick Docks and on boats carried on trailers from Britain or the continent. There are several other ways in which they may have become established, including being carried on migrating birds, with fish for the aquarium trade, in eel transporters from Britain or the continent, on imported and used fishing equipment, or a deliberate introduction.

Limerick imports timber from the Baltic Sea and mussels are generally established in the less saline ports of this region. Recently there have been new range extensions of the species into brackish water of 5‰ salinity in Lithuania and Finland (Leppäkoski & Olenin, pers comm.). This extension may have increased the risk of importing mussels. Although, vessels carrying timber may require only small amounts of ballast water, a small volume of ballast once discharged into the comparatively small area of Limerick dock could result in a new population.

Larvae are presumed to have been released from ballast water in the Great Lakes region in 1985/6 after being transported from the Black Sea. The distance from the Baltic Sea to Ireland is very much less and so could result in a larger number of larvae surviving. While this is a possible source for the population found in the Limerick Docks, the mussels which have invaded the lower Shannon and Lough Derg would have needed one or more boats to carry them upstream from Limerick.

Introduction by importation of boats carried by trailer from either Britain or the continent is one of the most likely sources. Since 1993 VAT on importation was lifted for boats built before 1985 and for second-hand boats which had already paid VAT within the EU. Many second-hand boats have been imported since that time. Should they be lifted directly and put on trailers and then brought to Ireland, substantial numbers of mussels could be imported. Crane-in sites for boats are distributed about the main navigation areas from Graiguenamanagh on the Barrow, Sallins and Lowtown on the eastern section of the Grand Canal to the main towns along the Shannon and Erne. The presence of a mussel population and its length distribution on a recently-imported barge strongly suggested that overland transport of boats is a viable means of introduction and establishment of a population in Ireland.

The number of pleasure craft that berth in Limerick docks for extended periods is small, as is the traffic between Lough Derg and Limerick Dock. Vessels moving upstream are subject to tidal constraints and many operators of pleasure craft are reluctant to visit Limerick for this reason. On these grounds it is suggested that it is more likely that the freshwater population was derived from pleasure boats imported by trailer from waterways in England or continental Europe.

All preliminary data sets and observations indicate that there are likely to be problems for water users and that the large population biomass is likely to lead to changes in the trophic structure of lake and river systems. The alkaline environment favoured by this species would indicate that there is potentially a wide geographic range for it within Ireland. Relevant water users and conservation bodies are being advised of the potential and likely problems and encouraged to aid in reducing the rate of spread of this species where this is possible.

In July-August 1998 it is planned to survey the Shannon and Barrow navigations, the Grand Canal and several other likely sites where mussels may be established. The presence of larvae and relative settlement intensity will be examined, together with semi-quantitative studies of established populations to determine the overall impact and distribution of mussels.

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Table 1. Numbers of mussels sampled at each quay site. Estimates for small specimens at Dromineer and Mountshannon were made by extrapolation from subsamples (small = < 16mm, large >17 mm).

Locality	small	large	Ratio small : large
Portumna	7	1	7.0
Terryglass	73	0	-
Kilgarvan	70	0	-
Rossmore	429	55	7.8
Williamstown	98	11	8.9
Dromineer	16,433	265	62.0
Mountshannon	4,530	177	25.6
Garrykennedy	64	65	1.0
Killaloe	14	69	0.2
Limerick	376	62	6.1

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