Monitoring of zebra mussels in the Shannon-Boyle navigation, other navigable regions and principal Irish lakes, 2000 & 2001.*

November 2002

Dan Minchin[1], Frances Lucy[2] & Monica Sullivan[2]

[1]Marine Organism Investigations, 3 Marina Village, Ballina, Killaloe, Co. Clare.
[2]Environmental Services Ireland, Aughamore, Lough Allen, Co. Leitrim.

Marine Institute
Marine Environment and Health Services Division
Abbotstown
Dublin 15

ISSN:1649-0053

*Note: This paper represents a summary of the original reports submitted to the Marine Institute. Copies of the original reports for 2000 and 2001, which contain raw length-weight data and additional images, can be seen in the Marine Institute Library.

Marine Environment and Health Series, No. 5, 2002

ABSTRACT

The zebra mussel (*Dreissena polymorpha)* population has been closely monitored in Ireland following its discovery in 1997. The species has spread from lower Lough Derg, where it was first introduced, to most of the navigable areas of the Shannon and other interconnected navigable waters. This study took place in the summers of 2000 and 2001 and investigated the relative abundance and biomass of zebra mussels found in the main navigations of the Shannon and elsewhere in rivers, canals and lakes where colonisation was likely.

During 2000 zebra mussels were found for the first time in Carnadoe, Kilglas and Grange Loughs on the River Shannon. In 2001, they were discovered on the Ballinasloe Navigation at Poulboy Lough and in Ballinasloe Harbour. For the first time outside of the Shannon-Boyle navigation, established populations were discovered in Garadice Lough on the Shannon-Erne Waterway and in Ringsend Basin and Tullamore Harbour on the Grand Canal. Zebra mussels continue to have their greatest densities in lakes and large reservoirs of the Shannon-Boyle navigation. A maximum biomass of 4.1kg m^{-2} was recorded in Lough Key.

No zebra mussel larvae or their attached stages were found in the larger lakes outside of the Shannon-Boyle and Erne Navigations. Larvae were found however, in Tullamore Harbour for the first time. In separate studies approximately two hundred adults were found in Lough Bo, Co. Sligo and less than ten specimens were found in Lough Gill, Co. Sligo.

The only living population of native freshwater mussels (*Anodonta spp*.) presently known in the lake regions of the Shannon is in the Carnadoe Cut, between Carnadoe Lough and Kilglas Lough. This population of *Anodonta spp.* is fouled with zebra mussels. Freshwater mussels were also found in Garadice Lough and Assaroe Reservoir. These were also fouled with zebra mussels.

CONTENTS

INTRODUCTION

Zebra mussels are native to the larger river systems that drain into the Caspian and Black seas. They spread throughout much of northern Europe in the late 1700's in tandem with the building of canals, which link different river basins (Olenin *et al*., 1999). Additional transfers to ports not connected to the canal system were most probably due to damp timber being stored in freshwater, prior to being exported from the Baltic region. Zebra mussels spread to the Thames River in Britain by 1824 (Kerney & Morton, 1970) and to Dutch and other north European ports by 1826 (Kinzelbach, 1992). In 1986 the species was found in the Great Lakes, USA.

The spread of zebra mussels to Ireland most probably took place with imports of leisure craft from Britain or the Netherlands (Minchin & Moriarty, 1998). Based on the evidence of established zebra mussels in Limerick Docks in the spring of 1995, zebra mussels would have become established in Ireland during 1994, or earlier. The most likely place of the initial inoculation in Ireland was in the southern region of Lough Derg. From here the zebra mussels would have spread to the upper reaches of the Shannon and to Lower Lough Erne (Rosell *et al*., 1999) having been carried attached to the hulls of leisure craft. These craft would have dispersed the species throughout all Irish navigable regions. Zebra mussels foul subsurface screens, pipework, boat engine coolant pipes, hulls and can also attach to aquatic vegetation. In lakes, the native freshwater mussels, *Anodonta* spp. are endangered due to fouling by zebra mussels.

Overland transfer of zebra mussels by boat or commercial fishing equipment, to other waters, carries a high-risk of spread of zebra mussels to enclosed water systems. Angling boats are the most regularly transported craft between water bodies. Consequently, anglers have been approached in a management campaign that has included the issuing and distribution of leaflets to inform: a) how the species may be spread and b) how risks of their transmission may be reduced.

Information on the presence of zebra mussels in the Lower Shannon did not become available until October 1997 (Electricity Supply Board, 1997; McCarthy *et al*., 1997; McCarthy *et al*., 1998; Minchin & Moriarty, 1999). Consequently the first in depth surveys did not begin until the summer of 1998 in the Shannon-Boyle system (Lucy, 1998, Lucy, 2000; Minchin, 2000) and in Lough Erne (Rosell *et al*., 1999). A more in depth survey followed in 1999 (Lucy & Sullivan, 2001) which included areas examined in 1998 and larger lakes, rivers and canals outside of the Shannon-Boyle navigation.

Our study examined freshwater bodies for the presence of zebra mussels during the summers of 2000 and 2001 (Minchin *et al*., 2000, 2001a). The Shannon-Boyle Navigation, other navigable regions and the principle Irish lakes were examined for the presence of zebra mussels by looking for their larvae and settled stages.

MATERIALS AND METHODS

This report is divided into two distinct studies. The first was an intensive study of the Shannon-Boyle Navigation based on sampling vertical surfaces e.g. walls piers and posts, from Limerick Dock to Lough Key. The second study was a more widespread shore-based study of other areas likely to contain zebra mussels, looking for both settled and larval stages of zebra mussels. All regions sampled are shown in Figure 1.

Study 1: Shannon-Boyle-Suck Navigation.
In July 2000 and June-July 2001, fifty-three and fifty-two sites respectively were examined for the presence of zebra mussels. The Suck River, from the Shannon River to Ballinasloe Harbour was examined for the first time in 2001.
Sites were selected, taking into account:

- where vertical surfaces could be scraped (quaysides, bridge buttresses, navigation poles, marina support poles and lock walls) (Plate 1)
- where selected sites would represent different regions within lakes, canals and rivers.
- sites that could be visited by road or by water.

Snorkelling and diving took place at some sites on the Shannon-Boyle navigation to recover *Anodonta* spp, plants and other materials. In some shallow water regions collections of stones and shell were made using a rake.

Study 2: Areas outside Shannon-Boyle-Suck navigations
In August of 2000 and 2001 many of the larger lakes in Ireland that are important for angling and that exceeded 500 hectares were visited. In some cases the rivers draining from these lakes were also sampled. Some additional rivers, small lakes and canals were also examined.

Vertical surfaces were scraped where possible. Otherwise a 4m long extendable rake was used to extract stones, plant material and *Anodonta* spp. In the 2000 study submerged plants were also collected. All recovered materials were examined for the settled stages of zebra mussels.

Plankton samples were obtained using a small 6 cm diameter, 63 μm bar-mesh plankton net (Plate 2). Larval sampling took place in August, a time when larvae are normally abundant, based on studies in Lough Key (Lucy & Sullivan, 2001) and Killinure Lough. For shallow rivers a 30 cm diameter net (120 μm mesh) was used in the 2000 study, and a 6 cm diameter (63 μm) net was used in 2001. After each sample the nets were placed in acetic acid, as described by Kraft and Johnson (2000), to dissolve the shell of any larvae that may adhere to the net.

Samples of adult zebra mussels were obtained from 32 and 39 stations and plankton samples from 40 and 41 stations, covering 23 large lakes in 2000 and 2001 respectively.

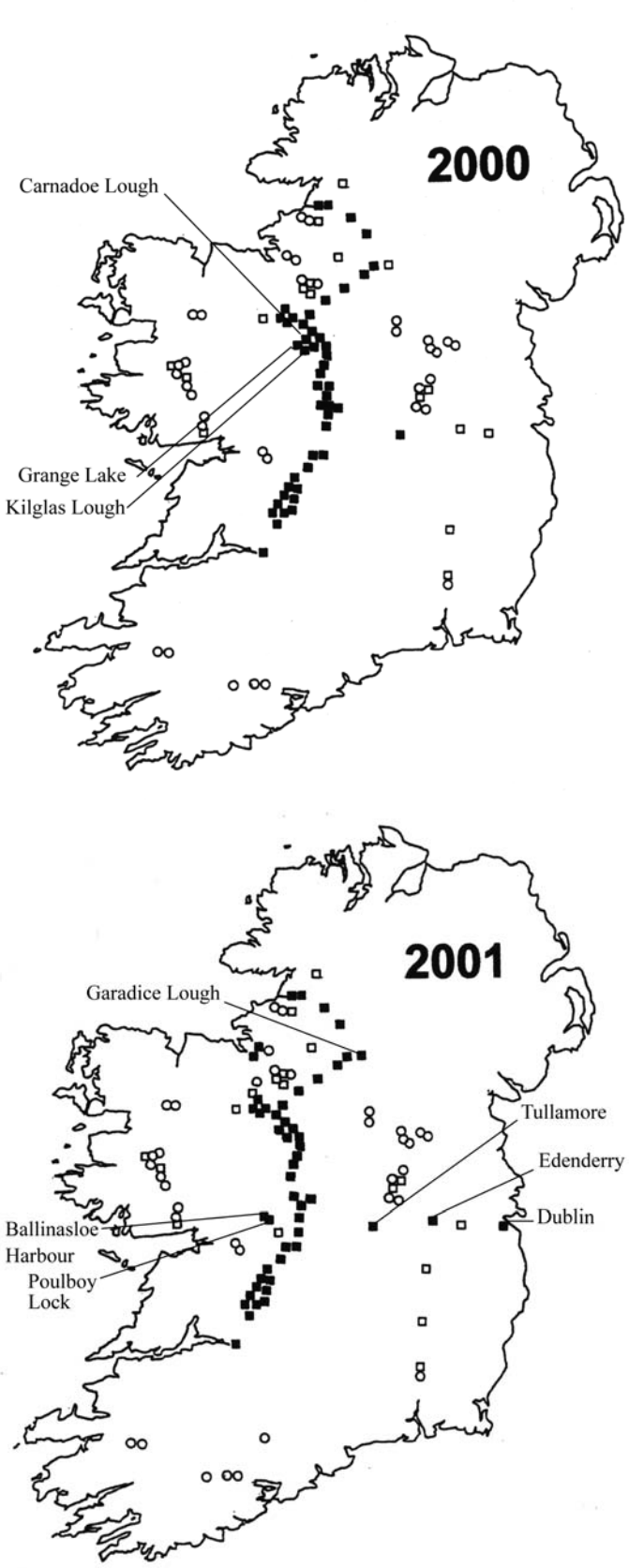

Figure 1. Regions sampled in 2000 and 2001. Squares indicate where a scraper was used for adults. Circles indicate where a plankton net for used for larvae. Dark squares or circles indicate the presence of zebra mussels. Place names indicate areas where Zebra mussels were found for the first time.

RESULTS

Study 1: Shannon-Boyle-Suck Navigation

There was an overall trend of continued range expansion of zebra mussels on the River Shannon at sites from Lough Key to Limerick (Figure 2). Increases were mainly seen in the upper Shannon region north of Rooskey. In 2000 zebra mussels were found for the first time in Carnadoe, Kilglas and Grange lakes (Figure 1).

The biomass of zebra mussels at river sites was generally < 200g m^{-2} (N=< 350 m^{-2}) and near the river inflow regions of Lough Ree and Lough Derg was <450g m^{-2} (N= < 500 m^{-2}). No zebra mussels were found either at Acres Lake, Drumshambo Lock or on the eastern side of Lough Allen.

The density of zebra mussels varied within different regions of Lough Derg, Lough Ree and Lough Key (Figure 3). The density in 2001 varied from 0.2 to 3.0 kg m^{-2} in Lough Derg; 0.5 to 1.0 kg m^{-2} in Lough Ree and 0.15 to 4.2 kg m^{-2} in Lough Key. The lowest density values found in lakes are similar to those found in rivers and canals (normally 0 to 0.5kg m^{-2}) (Figure 4). The smaller lakes on the Shannon River between Lough Key and Lough Ree (Drumharlow, Bofin, Boderg, Forbes, Carnadoe, Kilglas and Grange) had high densities of zebra mussels. Lough Bofin and Killinure had a density of 0.4 kg/m^{-2} to 2.6 kg m^{-2} and 1.5 to 3.6 kg m^{-2} respectively

The only living specimens of *Anodonta spp.* found in the Shannon-Boyle navigation were found in the Carrigeen Cut, which connects Carnadoe Lough to Kilglas Lough. These were heavily fouled with zebra mussels. In the adjacent Carnadoe Lough zebra mussels covered 80-100% of stones, cobbles and discarded materials. Plant rhizomes (Plate 3) and stems of *Phragmites australis* had zebra mussels attached.

Suck River and Canal
Zebra mussels were found attached to the lock walls in old Ballinasloe Canal lock and in the small canal section of Pollboy Lock. In Ballinasloe Harbour small numbers of zebra mussels were found in 2001 (Figure 1).

Study 2: Areas outside Shannon-Boyle-Suck navigations

Grand and Royal Canals
In 2000, zebra mussels and in 2001 zebra mussel larvae were found at Tullamore on the Grand Canal. In 2001, a single adult was found in Edenderry Harbour and adult zebra mussels (3 m^{-2}) were found in the Ringsend Canal Basin, Dublin (Figure 1)

Shannon-Erne Waterway
A significant zebra mussel population was found at Garadice Lough (Figure 1) where zebra mussels were attached to emergent plants (*Equisitum* sp., *Phragmites australis*), *Anodonta spp*, rocks and stones. Living *Anodonta spp.* were found in the shallows of the lake margin to a depth of 2 m (Plate 4). In 2001, small numbers of zebra mussels were found attached to living *Anodonta spp.* in Derrycassan Lough.

Lough Erne

In the Assaroe Reservoir, downstream of Lower Lough Erne, zebra mussel numbers have increased in successive years since 1998, and here living *Anodonta spp.* remain. Zebra mussel larvae were found in Assaroe Reservoir in both years of this study.

The larger lakes

The Loughs Allen, Arrow, Conn, Corrib, Cullen, Derg (Co. Donegal), Derryvara, Ennel, Erne, Gara, Gowna, Leane, Loughrea, Mask, MacNean, Melvin, Oughter, Owel, Ramor and Sheelin as well as the Inishcarra Reservoir were sampled and no larvae were found in either 2000 or 2001.

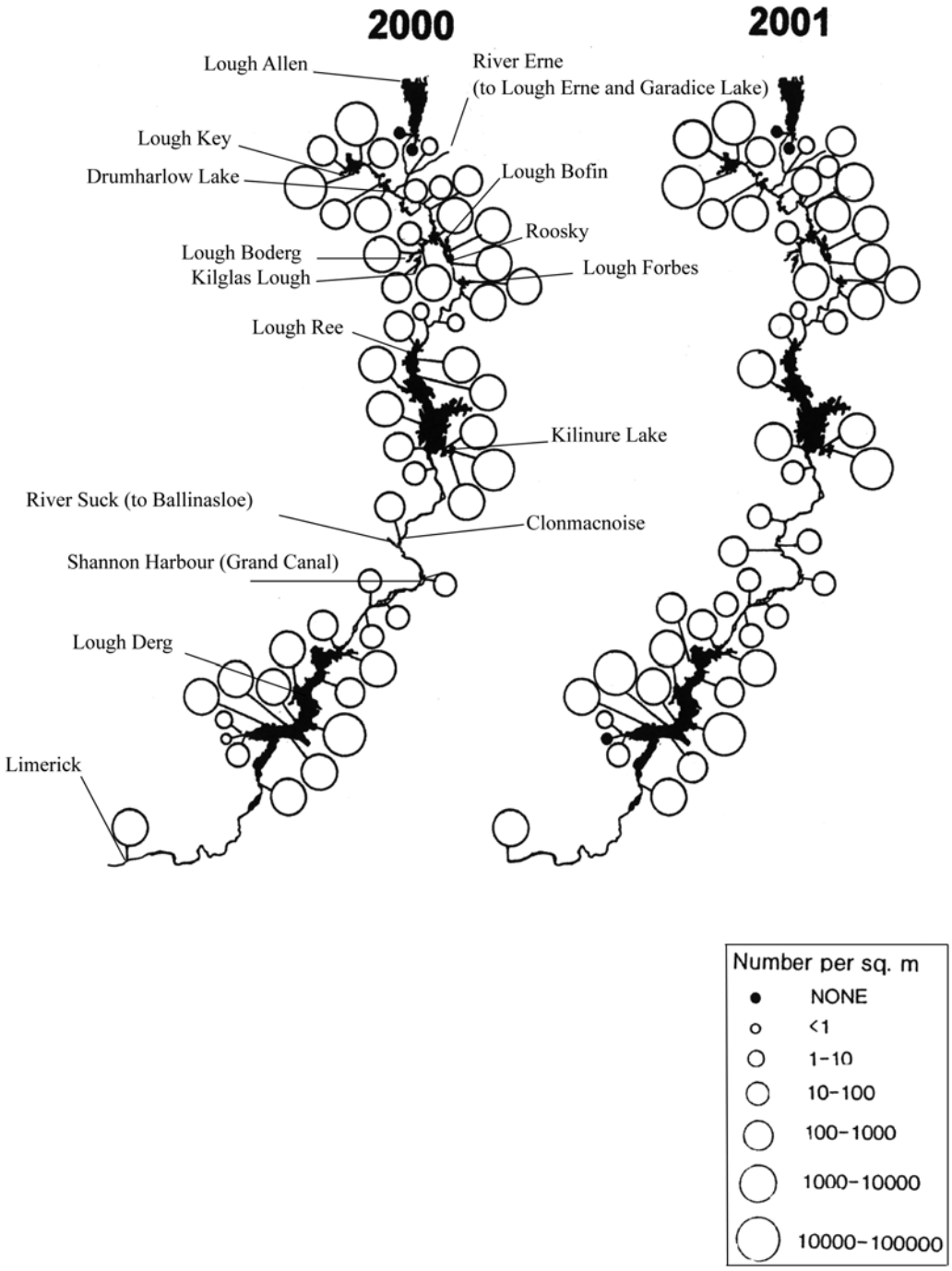

Figure 2. Relative density of zebra mussels on the Shannon-Boyle navigation in 2000 and 2001.

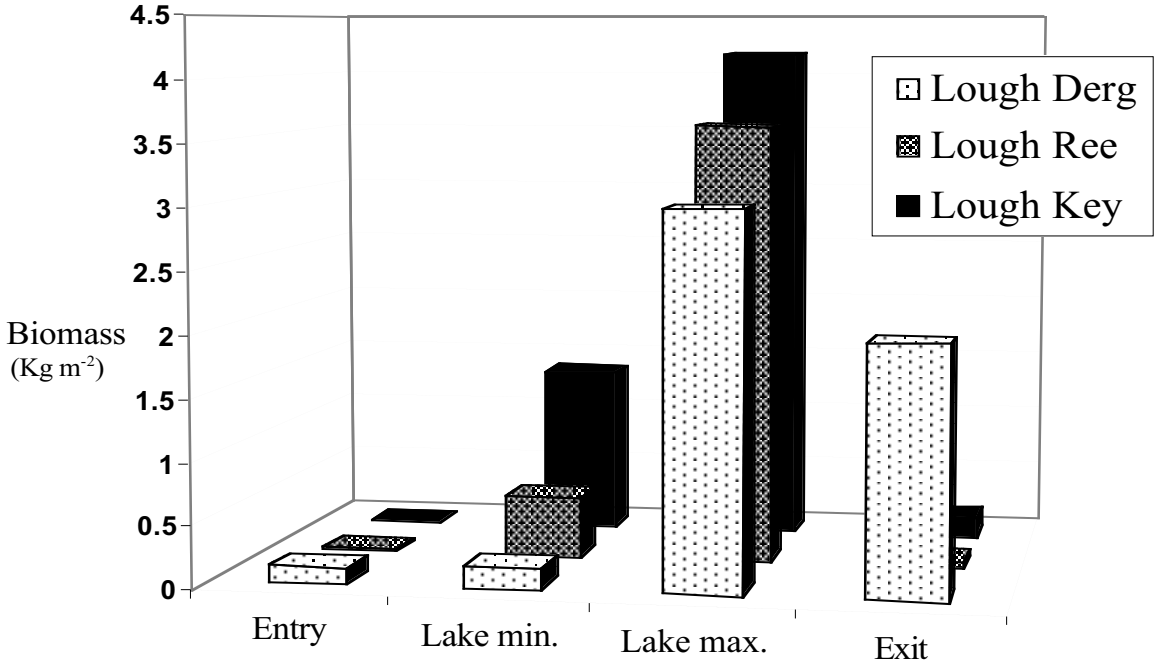

Figure 3. The biomass of zebra mussels within different regions of Lough Derg, Lough Ree and Lough Key in the 2001 study.

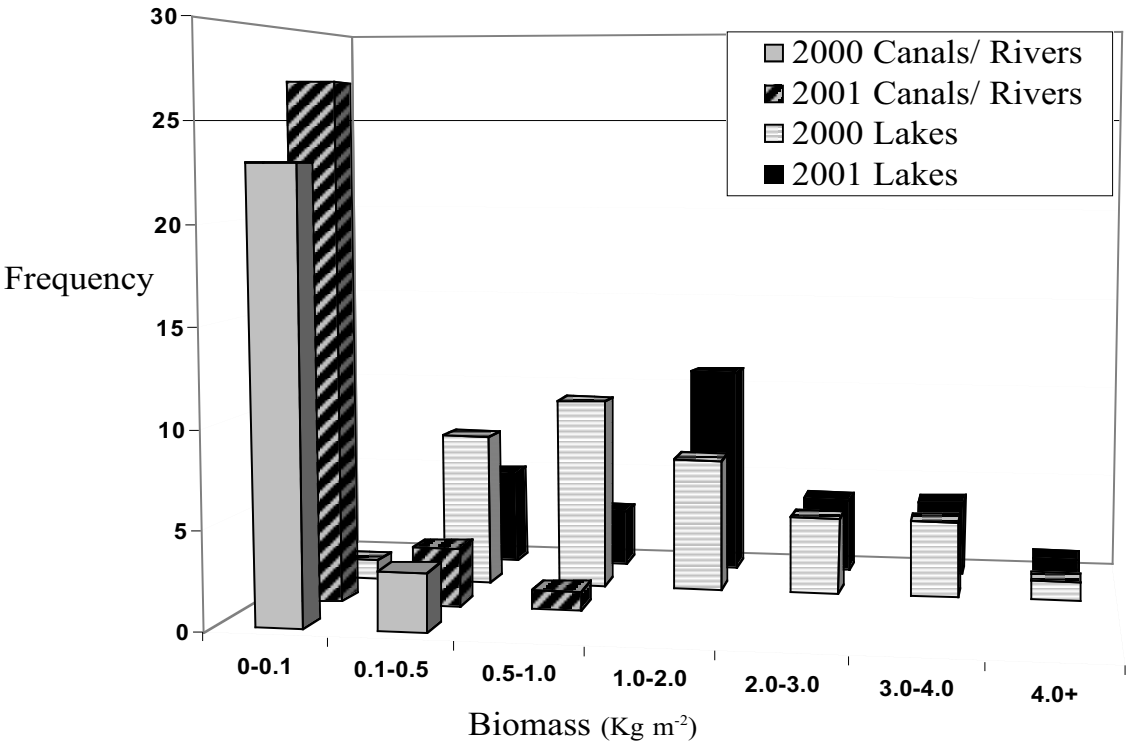

Figure 4. Zebra mussel biomass frequencies from sampling stations in canals and rivers in 2000 and 2001.

DISCUSSION

Current distributions of zebra mussels

The zebra mussel continues to expand its known range in Ireland. In areas where it has already established, zebra mussel densities vary. Estimates of biomass were collected in 2000 and 2001 for the first time so as to provide a more meaningful data set in terms of ecological impact.

Shannon Boyle Navigation

The zebra mussel continues to be abundant in all previously colonised lakes of the Shannon-Boyle Navigation system. It also continues to expand its range and abundance in new areas within the inland navigation system. Zebra mussel biomass varied throughout the Shannon-Boyle system. Maximum estimates were obtained in lakes, with lower values from rivers and canals. Maximum values of ≥3kg m^{-2} were found in Loughs Derg, Ree and Key. Over the past few years there has been an expansion in the zebra mussels range to areas not previously colonised, e.g. the north-west regions of both Loughs Ree and Derg. Values for stations where rivers enter and leave lakes were similar to the minimum values found in the lakes. Biomass values for both rivers and canals were usually less than 0.2kg m^{-2}, consistently lower than those found in lakes.

The variability of numbers and biomass in lakes may, in part, be due to meteorological conditions during the more intensive settlement periods with selective distribution of larvae resulting from residual water flow and or wind induced currents (Lewandowski, 1976; Hunter & Bailey, 1992). Low abundance may arise from low settlement intensities of larvae, a low level of immigration of attached stages on drifting plant materials, lower levels of leisure activity or a higher mortality. In shallow lake regions there are frequent stands of reeds and rushes and submerged aquatic macrophytes. In such places the movement of larvae may be impeded, thus reducing their dispersal. Although zebra mussel densities were low within rivers, it appears that larvae are capable of being transmitted downstream, to settle and form populations in lakes, reservoirs or marina/harbour regions. Conditions in rivers are different partially on account of the more pronounced water flow. In addition sponges and other encrusting species may overgrow settled zebra mussels. These factors may have consequences for zebra mussel survival in Ireland as has been found in North America (Riccaradi *et al*., 1995; Early & Glonek,1999).

It may be expected that the new harbour facilities provided for leisure craft in Limerick will lead to an increase in biomass in this area of the River Shannon.

The Suck Navigation.

In recent years leisure craft have been able to navigate to Pollboy Lock on the Suck River. In Pollboy Lock zebra mussels were found concentrated on the sluice gratings. The additional *ca.* 3 km upstream passage to the new Ballinasloe Harbour was not opened until the summer of 2001. Small numbers of sparsely distributed zebra mussels were found in Ballinasloe Harbour. Zebra mussels were not found downstream in the Suck River but may be expected in the future as larvae are carried downstream. In studies in North America larvae have shown reduced settlements, and/or survival, with progression downriver (Horvarth *et al* 1996).

The Grand Canal

Despite the presence of millions of adult zebra mussels attached to the hulls of craft in Shannon Harbour, no settlements are known in this region and no larvae were found in August surveys in 1998 to 2000. However, in the canal basin in Tullamore adult zebra mussels were found in 2000 and larvae were found in August 2001, indicating establishment of a breeding population. In Edenderry Harbour, a single large zebra mussel was found and was the first record from this region.

Boats in the eastern region of the Grand Canal (from Lowtown to Hazelhatch) can have dense settlements of zebra mussels. No larvae or recently settled stages were found in this region. In the Ringsend Canal Basin in Dublin, zebra mussels were found for the first time. These were at low densities and were associated with mats of green filamentous algae.

The Shannon-Erne Waterway

No zebra mussels were found in Lough Scur at the highest water level or at Kiltybardan Lough near the top of the watershed, draining towards Lough Erne. Large individuals were found at densities of <1 m^{-2} at the quay in Ballinamore. Zebra mussels were present in Garadice Lough.

Lough Erne

Lower Lough Erne was first colonised in 1996 (Rosell *et al*., 1999) and it is likely this followed the movement of infested craft. There are recent and significant expansions on the Erne, although their abundance does not approach the levels generally found in Loughs Key, Ree and Derg. The colonisation of Assaroe most probably arose from larvae being transported into Assaroe Reservoir from Lower Lough Erne. In 2001 a dense settlement of the 2000 year class was found in Upper Lough Erne (Minchin, 2002).

Lough Erne is navigable to Belturbet and accounts of zebra mussels in this location have been reported by anglers. The species was found for the first time in 2001 near Belturbet Bridge. The absence of young zebra mussels in this area and lack of larvae in plankton samples taken from the lake-shores around Lough Gowna, indicate an absence of upstream colonisation.

Co. Sligo lakes

Small numbers of zebra mussels were found in Lough Gill (Minchin *et al*., 2001b) in a survey undertaken for the North West Regional Fisheries Board. In addition less than two hundred individuals were found in Lough Bo (Minchin & Sullivan, 2001). These were removed and further colonisation may not happen. These occurrences are almost certainly due to boats arriving from infested areas. Angling boats can carry several thousand zebra mussels. It is very likely that other small lakes have been colonised by zebra mussels as has recently happened in North America (Johnson & Carlton, 1996).

Decline of native freshwater mussels in lakes

Zebra mussels settle on the shells of the native freshwater mussels, *Anodonta* spp. This is consistent with observations of fouling of unionids in North America (*Schloesser et al*., 1996). The occurrence of zebra mussels has resulted in declines of the two species of mussel (*Anodonta anatina, Anodonta cygnea)* in the Shannon-Boyle navigation. No

living *Anodonta spp.*, were found in Loughs Derg, Ree and Key during 2000 and 2001 studies. A small number were found in the cut between Kilglas and Grange lakes. As the range of zebra mussels expands to previously uncolonised lakes further populations of freshwater mussels may die out, due to competition with zebra mussels.

Substrates and natural dispersal mechanisms

Zebra mussels appear to spawn once the water temperature attains 15 °C. The larvae first occur in June and remain in the water column until October. Smaller numbers could persist to later in the year (Minchin & Kluttig, unpublished).

In lakes zebra mussels attached to three principal substrates, hard surfaces (rocks, stones, masonry and concrete), large freshwater mussels (*Anodonta anatina, Anodonta cygnea*) and aquatic plants. Zebra mussels are known to attach to a wide range of plants (Grigorovich & Babko, 1997). In this investigation drifting stem fragments of *Shoenoplectus lacustris* and *Phragmites australis* and also leaves of *Nuphar lutea* have been found with attached zebra mussels. These may easily be dispersed about lakes in the same manner as reported by Horvarth & Lamberti (1999) in North America. For the first time the significance of *Cladophora sp.* was revealed. The alga becomes buoyant with pockets of gas and attached zebra mussels can be carried away. This transferral of mature zebra mussels may increase the opportunity for their establishment in new areas.

CONCLUSIONS

Zebra mussels continue to expand their range in Ireland. Currently they are found in the navigable regions connected to, and including, the River Shannon. They are abundant in most of the associated lakes, where they attach to a wide range of plants, native freshwater mussels and hard surfaces. Apart from Lough Gill and Lough Bo, no zebra mussel larvae or any of their attached stages were found in lakes and rivers outside of the navigable regions. However, it is expected that other populations will become established in small lakes.

Zebra mussels were found for the first time in the Suck River navigation and in the Ringsend Canal-Basin, extending their known range in Ireland. It is almost certain that these new localities were from hull-fouled craft using the navigable waterways.

In Garadice Lough, zebra mussels were also found for the first time. It is likely that the *Anodonta spp.* population in this small lake will die out over the next few years as the population density of zebra mussels increases. An expansion of zebra mussel abundance is expected in the recently developed berthing area for leisure craft in Limerick City. Larvae were collected in Tullamore Harbour indicating that the mussels here represent a recruiting population.

Zebra mussel densities at stations on rivers are consistently low, whereas in lakes they are highly variable but may attain high concentrations, with values exceeding 3kg m^{-2}.

ACKNOWLEDGEMENTS

We would like to thank Mr Ray Dunne of Dúchas for arranging the relevant permits, Ms Caitriona Millard for assisting with the investigations, Mr Paul Murphy for his diving observations and Mr Michéal O'Cínneide, Marine Institute for supporting the investigation.

REFERENCES

Early, T.A. & Glonek, T., 1999. Zebra mussel destruction by a lake Michigan sponge: Populations, *in vivo* ^{31}P nuclear magnetic resonance, and phospholipid profiling. *Environmental Science and Technology*, **33**(12): 1957-1962.

Electricity Supply Board, 1997. Fisheries Conservation Report January 1996 - April 1997. Electricity Supply Board, 59pp.

Grigorovich, I.A. & Babko, R.V., 1997. Sessile invertebrates in beds of aquatic macrophytes. In: *Zebra mussels and aquatic nuisance species*. (ed. D'Itri, F.M.) Ann Arbor Press. Michigan, pp 87-97.

Horvarth, T.G., Lamberti, G.A., Lodge, D.M. & Perry, W.P., 1996. Zebra mussels dispersal in lake stream systems: source-sink dynamics? *Journal of the North American Benthologists' Society*, **11**: 341-349.

Horvarth, T.G. & Lamberti, G.A., 1999. Recruitment and growth of zebra mussels (*Dreissena polymorpha*) in a coupled lake-stream system. *Archiv für* Hydrobiologie, **145**: 197-217.

Hunter, R.D. & Bailey, J.F., 1992. *Dreissena polymorpha* (zebra mussel): colonisation of soft substrata and some effects on Unionid bivalves. *Nautilus*. **106**: 60-67.

Johnson, L.E. & Carlton, J.T., 1996. Post-establishment spread in large-scale invasions: dispersal mechanisms of the zebra mussel *Dreissena polymorpha*. *Ecology* **77**(6): 1686-1690.

Kinzelbach, R., 1992. *The main features of the phylogeny and dispersal of the zebra mussel Dreissena polymorpha*, In: D. Neuman and H.A. Jenner (eds.). The zebra mussel *Dreissena polymorpha*. Ecology, Biological Monitoring and First Applications in Water Quality Management. Gustav Fischer, Stuttgart, pp 5-17.

Kerney, M.P. & Morton, B.S., 1970. The distribution of *Dreissena polymorpha* (Pallas) in Britain. *Journal of Conchology* **27**: 97-100.

Kraft C.E. & Johnson, L.E. (2000) Regional differences in rates and patterns of North American inland lake invasions by zebra mussels *(Dreissena polymorpha*) *Canadian Journal of Aquatic Sciences* **57**: 993-1001.

Lewandowski, K., 1976. Long-term changes in the fauna of family Unionidae bivalves in the Mikolajskie Lake. *Ekol. Pol*. **39**: 265-272.

Lucy, F., 1998. Zebra Mussel monitoring programme, Lough Allen. Enterprise Ireland mini-project (Unpublished).

Lucy, F., 2000. Establishment of a monitoring survey for zebra mussels *(Dreissena polymorpha)* in Lough Allen and Lough Key. Proceedings of 1999 Institutes of Technology Colloquium in Science and Computing, Letterkenny .

Lucy, F. & Sullivan, M., 2001. The investigation of an invasive species, the zebra mussel *Dreissena polymorpha* in Lough Key, Co. Roscommon, 1999. Environmental Protection Agency. Wexford.

McCarthy, T.K, Fitzgerald, J., Cullen, P., Doherty, D. & Copley, L., 1997. Zebra mussels in the River Shannon. Zoology Department, University of Galway, November 1997. 49pp.

McCarthy, T. K. , Fitzgerald, J. & O'Connor, W., 1998. The ocurrence of the zebra mussel *Dreissena polymorpha* (Pallas. 1771), an introduced biofouling freshwater bivalve in Ireland. *Irish Naturalists' Journal*, **25**(11/12): 413-415.

Minchin, D. & Moriarty, C., 1998. Zebra mussels in Ireland. *Fisheries Leaflet No 177*, Marine Institute. 11pp.

Minchin, D. & Moriarty, C., 1999. Distribution of the zebra mussel *Dreissena polymorpha* (Pallas) in Ireland, 1997. *The Irish Naturalists' Journal.*

Minchin, D., 2000. Dispersal of zebra mussels in Ireland. *Verhandlungen Internationale Vireinigung Limnologie,* **27**: 1576-1579.

Minchin, D., Lucy, F. & Sullivan, M., 2000. Monitoring of zebra mussels in the Shannon-Boyle navigation, other navigable regions and principal Irish lakes, July-August 2000. A survey undertaken for the Marine Institute. Marine Organism Investigations Report 09/2000, 54pp.

Minchin, D., Lucy, F. & Sullivan, M., 2001a. Monitoring of zebra mussels in the Shannon-Boyle navigation, other navigable regions and principal Irish lakes, July-August 2000. A survey undertaken for the Marine Institute. Marine Organism Investigations Report 16/2001, 57pp.

Minchin, D., Sullivan, M. & Lucy, F., 2001b. Investigation in loughs Gill, Glenade and Belhavel, Co, Sligo for zebra mussel veligers*, 12 & 19 August 2001*. A survey undertaken for the North-west Regional Fisheries Board. Marine Organism Investigations Report 14/2001, 11pp.

Minchin, D. & Sullivan, M., 2001. Investigation into the presence of adult zebra mussels in Lough Bo, Co Sligo, 9 August 2001. Marine Organism Investigations Report 15/2001, 10pp.

Minchin, D., 2002. *Zebra mussels in the Erne Navigation, June 2001*. Marine Organism Investigations Report 18/2002: 12pp.

Olenin, S., Minchin, D. & Orlova, M., 1999. *Dreissena polymorpha* (Pallas, 1771) Dreissenidae, Bivalvia. : In case history studies, H. Rosenthall, D. Minchin, S. Gollasch & M. Voight (eds), *Testing Monitoring Systems for Risk assessment of Harmful Introductions by Ships to European waters,* EU Concerted Action (MAS3-CT97-0111) 4pp.

Riccardi, A., Snyder, F.L., Kelch, D.O. & Reiswig, H.M., 1995. Lethal and sublethal effects of sponge overgrowth on introduced dreissenid mussels in the Great lakes – St. Lawrence River system. *Canadian Journal of Fisheries and Aquatic Sciences* 52: 2695-2703.

Rosell, R., McCarthy, T.K. & Maguire, K., 1999. First settlement of zebra mussels *Dreissena polymorpha* in the Erne system, Co. Fermanagh. Northern Ireland. *Biology and Environment: Proceedings of the Royal Irish Academy* **98**B (3): 191-193.

Schloesser, D. & Nalepa, T. & Mackie, G.L. 1996. Zebra mussel infestation of unionid bivalves (Unionidae) in North America. *American Zool*ogist, **36**: 300-310.

Plate 1. Scraper used to remove zebra mussels from vertical surfaces.

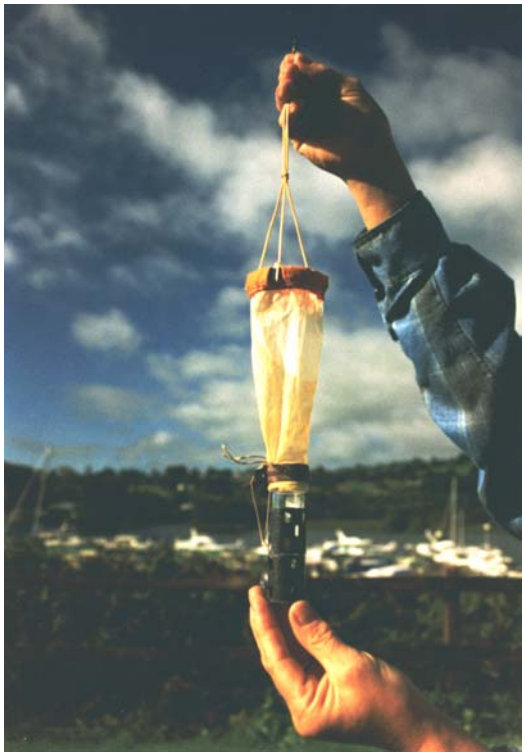

Plate 2. Plankton net used to catch zebra mussel larvae.

Plate 3. Rhizomes of *Phragmites australis* with surfaces extensively covered with zebra mussels.

Plate 4. Zebra mussels attached to freshwater mussels (*Anodonta spp*) in Garadice Lough.