TRIP REPORT

12th International Conference on Aquatic Invasive Species

Windsor, Ontario, June 8th – 14th, 2003

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The "12th International Conference on Aquatic Invasive Species" held on June 09 to 12, 2003, in Windsor, Canada provided me the opportunity to gather information and improve my understanding of Zebra Mussel research. I presented a paper entitled "Invasion of Golden Mussel, *Limnoperna fortunei* in the Pantanal Wetland, Brazil", in which I discussed the invasion of the Golden Mussel in Brazil, with a case study in the Pantanal wetland region.

At the conference I was able to collect valuable research materials, including a book, entitled "Zebra Mussel monitoring and Control", from World Fisheries Trust and a CD containing a database on the Zebra mussel that was distributed by the US Army Corp of Engineers. I was also able to spend some time at the University of Windsor library, where I found and photocopied several pertinent scientific papers.

In addition, my trip to Canada provided a valuable opportunity to visit an English speaking country and improve my language skills, which is very important for the exchange of scientific knowledge. I also appreciated the experience of visiting another culture and found the city of Windsor, a very different urban space, very interesting.

CONFERENCE SUMMARY

Countries participating in the conference included Italy, New Zealand, China, USA, Canada, Brazil, Philippines, England, India and Netherlands. The conference was separated in sessions on the following issues:

- Science, Policy and politics
- International perspectives on AIS management
- Control options for industry I, II
- Ecosystem interactions and impacts I, II
- Implications for Human and Ecosystem Health: Pathogens, toxins and toxics
- Economic impacts
- Shipping as a vector for new species introductions I, II
- Tolerances and Physiology of invasive species
- Management case studies
- Control of AIS in non-industrial settings
- Education and outreach
- Techniques and risk assessment
- Unauthorised Fish Introductions
- Developing an International response to prevent the spread of Zebra Mussel in North America the 100th Meridian initiative

Conference presentations covered topics such as: ballast water introductions and management issues, current technologies for the control of organisms in ballast water, and various aspects of Zebra Mussel invasion, biology and control in the US and Canada. Discussions focussed on

Zebra Mussel, the introduced species that causes the most economic and environmental impact in the US and Canada.

100TH MERIDIAN INITIATIVE

One important initiative highlighted during the conference was the 100th Meridian Initiative (www.100thmeridian.org). The initiative was established to define the risk of the accidental introduction of Zebra Mussel into the western waters of the US and Canada by tourism boat traffic and includes many projects designed to stop the spread of the Zebra Mussel in the US and Canada. The initiative has 2 main objectives: 1) to prevent the spread of Zebra Mussel and other invasive species and monitoring, and 2) control of Zebra Mussel and other invasive species in these areas.

The following steps are being taken to meet these objectives:

- Information and Education: Inform and educate the public about the ecological and economic impacts of Zebra Mussels, the pathways by which they spread, and what actions can be taken to prevent their spread.
- Voluntary Boat Inspections and Boater Surveys: Prevent the spread of Zebra Mussels in the 100th meridian jurisdictions and west through voluntary boat inspections and boater surveys.
- Commercially Hauled Boats: Prevent the spread of Zebra Mussels in the 100th meridian jurisdictions and west by boats being hauled commercially and/or for professional fishing tournaments.
- **Monitoring:** Establish monitoring sites on waters in the 100th meridian jurisdictions and west to determine if Zebra Mussels and other invasive species are present.
- **Rapid Response:** Eradicate or contain Zebra Mussels immediately following detection.
- **Identification and Risk Assessment of Additional Pathways:** Establish a program to identify additional pathways by which Zebra Mussels and other invasive species could be introduced west of the 100th meridian. Evaluate these pathways and develop an action plan for those having potential risks.
- **Evaluation:** Ensure the effectiveness of the 100th Meridian Initiative in preventing the westward spread of Zebra Mussels and other invasive species.

BALLAST WATER MANAGEMENT

Brazil is one of the 6 participants in the Global Ballast Water Management Program (GloBallast), however, at this time, no management plan or national strategy is in place in Brazil.

An inventory and monitoring program for invasive species following International Marine Organisation (IMO) recommendations and protocols was conducted in Sepetiba Port. A group of leading scientists from IEAPM/Navel Service of Brazil researched oceanic change and concluded that 95% of ballast water can be changed by dilution method. However, a national strategy based on IMO recommendations is necessary for the realisation of this concept. One

possible strategy, which includes the ports in the planning and execution of action plans, is that used by Agência Nacional de Vigilância Sanitária (ANVISA, national agency of sanitary vigilance). This type of strategy would use questionnaires to gather information about the origin of the vessel, making it possible to make decisions about ballast water discharge, if necessary. It will also be necessary for Brazil to study biological and chemical ballast water control methods.

In two recent events, the "1st International Workshop on Guidelines and Standards for Invasive Aquatic Species Surveys & Monitoring" in Rio de Janeiro and the "First Course on Ballast Water Management", institutions from Brazil and other countries discussed the topic of invasive species and ballast water control. I was able to participate in both events, along with many other scientists, port managers, environmental agencies and sanitary agencies, to name a few.

As discussed at the 12th International Conference on Aquatic Invasive Species, for ballast water management plans to be effective, federal, state and municipal agencies must be involved. This is often particularly difficult in Brazil due to priority differences for each level of government. Many management plans in place in both the US and Canada have not been very effective because they are either not properly implemented or are not sufficient enough to control ballast water discharge. This demonstrates the complexity of the ballast water issue.

One of the main ballast water control issue discussed at the conference was sediment, as it is not completely removed during ocean exchange. Mario Tamburri of the University of Maryland presented on the de-oxygenation method, a promising and interesting solution to ballast water control. Unfortunately, this method is both expensive and requires more research. While the treatment of ballast water is recommended, no method presented at the conference was efficient and economically viable enough to install on a large scale in Brazil.

GOLDEN AND ZEBRA MUSSEL BIOLOGY

Research on the biology of the Golden Mussel is just beginning in Brazil. Understanding the relationship between the Golden Mussel and water quality characteristics (pH, temperature, dissolved oxygen) and the behaviour of the Golden Mussel in different environments is necessary so that control options can be identified. It is also important to understand the reproductive cycle of Golden Mussel, because the use of various treatments may be dependent on this information.

Research conducted in Argentina found that 50% of *L. fortunei* individual died within 57 to 61 hours when exposed to air, depending on their size, and by day eight, mortality was 100%. Exposure to air may therefore represent one alternative to control the spread of the Golden Mussel (Darrigran & Damborenea, 2001). However, it will be necessary to repeat this experiment in Brazil, due to differences in air temperature and humidity.

Darrigran et al. (2001) also analysed the response of Golden mussel larvae to various concentrations of quaternary ammonium polymer, collected in La Plata River for the prevention/control of *L. fortunei* larvae. The results obtained demonstrated the efficiency of this

technique, despite the fact that the concentrations used in this experiment did not induce 100% mortality in 24 hours. The same authors analysed the effectiveness of biocide (BULAB 6002®) on juvenile and adult Golden Mussels as a method for cleaning industrial cooling systems and for use by hydroelectric companies. They found that 20 mg/l is sufficient to obtain 100% of mortality for adults in 144 hours.

Invasive mussel species, such as the Zebra Mussel and the Golden Mussel, have similar biological characteristics, such as a reproductive cycle with free-living larvae, the presence of byssus for fixation, and tolerance to different environments conditions, which make them good invaders. For example, the release of Zebra mussel gametes into the water column occurs at temperatures of about 12 °C in North America (Claudi and Mackie, 1994). They can survive in temperatures from about 0 to 30 °C, for short periods of time, with the optimum temperature generally below 25 °C (Machon, R.E., Britton, D.K.2003 – Conference). For the Golden Mussel, the peak for larval survival occurs in temperatures between 24 and 28 °C, with a decrease in activity below 16 °C (Cataldo & Boltovskoy, 2000).

Mihuc et al. (1999) studied the acclimatisation of zebra mussel populations. They observed that mussels from colder zones can survive in warmer climates, and that the upper tolerance limit can change after years of selection pressure. Similarly, in the Pantanal region, research indicates that several environmental factors, such as the dissolved oxygen concentration in the water, temperature, pH, and calcium, may control the population density in the river. However, more time is necessary to make any conclusions, as selection may occur over time.

Temperature also has a significant effect on mussel growth. The minimal temperature for growth and development of the Zebra Mussel is approximately 10 °C (Karatayev et al. 1998). High feeding rates are directly correlated to high growth rates. Aldridge et al. (1995) reported that: 1) the feeding rates of Zebra Mussel declined by 73% when the temperature was between 20 and 32 °C, and 2) above 28 °C, feeding activity ceased (data from Zebra Mussel information system). Therefore, individuals can exist in the environment in low densities, limited by an environmental factor.

GOLDEN MUSSEL CONTROL OPTIONS IN BRAZIL

Several methods currently being used for Zebra Mussel control should be considered for testing on Golden Mussel populations in Brazil. These methods include both preventive and reactive strategies. Preventive methods include: toxic construction materials, anti-fouling coatings, chemical treatment, thermal treatment and mechanical filtration. Reactive methods, those applied after an infestation has been detected, include: mechanical cleaning, high-pressure jets of water (pressure washing), carbon dioxide pellet blasting, freezing and desiccation. Thermal treatment and chlorination can be used initially as a reactive treatment to clean a system, then preventively as regular maintenance to prevent further incrustations.

Reasons for accepting or rejecting Zebra Mussel control methods are varied. All control strategies have advantages and disadvantages. Criteria for selecting an appropriate control

method include environmental and economic concerns and ease of application. Given the nature of the strategy, one type of control method may be more appropriate for a particular habitat or situation than another. Multiple control strategies may be applied depending on the extent of the Zebra Mussel infestation, although the strategies chosen will be the most cost-effective, environmentally sound, and easy to apply. Careful attention must be given to existing physical habitat conditions, facility characteristics, desired results, water chemistry, water flow rates, temperature, and the types and numbers of vulnerable structures within the raw water system.

Particular attention must be given to any effluent water or system discharge that has been treated with chemical or thermal methods to avoid the release of contaminated water. These contaminants need to be carefully disposed of or dispersed prior to their release into downstream waters and the surrounding environment. Although very little is known about the biology of the Golden Mussel in Brazil, it is probable that chemical controls are being used in the Itaipu Dam and in Rio Grande do Sul State for fouling control. However, Industry doesn't divulge their control strategies, the chemicals used, or the economic costs.

Chlorine is the most common chemical used to control zebra mussel infestations in Europe, the US and Canada as it is effective for larvae and adults, is cheap when compared to other methods, and can be used for large areas. More recently, chloramines have been recommended because they do not form trihalomethanes, a product formed by the combination of chlorine and organic compounds (Claudi & Mackie, 1994). On the Paraquay River, the use of chlorine is not recommended during the flooding phase due to high concentrations of organic materials available for the formation of trihalomethanes.

It is important to pursue studies on non-chemical methods of control such as sand filters, UV, Electroshock, flux speed (Claudi & Mackie, 1994), deoxygenating, thermal shocks, and the use a bacterial toxins (method developed by Molloy et al 2002, in experimentation). Biological methods are very limited by cost and the size of the area to be cleaned.

CURRENT BRAZILIAN SITUATION

In the Paraguay River, the Golden Mussel will most likely spread in the north of the basin of the high Paraguay, due to the intense commercial navigation between Corumba and Caceres. These ships stay in the Paraguay River long enough for encrustation to occur. Navigation is also principally responsible for the spread of Golden Mussel into and within the Paraná River, which contains many reservoirs and dams for the generation of power. Special attention should be paid to the Tocantins and the São Francisco Basin. The potential of Golden Mussel introduction in these basins is high due to occurrences in adjacent basins. Dispersal will likely be caused by tourist boats, which are frequently moved from one place to another. The Amazon basin must also be monitored for exotic species because there is a potential for invasion via ballast water from ships from others places in Brazil and from other countries that enter freshwater ports from Manaus and Belem.

The 1st South American Meeting of Integrated Actions for Golden Mussel Control (*Limnoperna fortunei*) took place at the Itaipu hydroelectric plant, on the July 4, 2003. The objective of this meeting was to exchange experience and knowledge about Golden Mussel control and to prepare recommendations for the next meeting of the Development and Integration Council for the South (CODESUL) (Porto Alegre, RS, July) and the International Water Forum/UN, in October. A technical-scientific co-operation between Brazil, Paraguay and Argentina was established to study the Golden Mussel. During the event I did a presentation on the experience of studying the Golden Mussel in the Pantanal and made recommendations related to reducing the spread.

In order to execute these recommendations in the Upper Paraquay basin I intend to form a working group that includes scientists Argentina, the Catholic University of Rio Grande de Sul (PUC/RS), the Nucleus for Fisheries and Aquaculture Research (NUPELIA), the Federal University of Mata Grosso (UFMT) and the State Technological Research Foundation (CETEC), which will meet in Corumbá, probably in September 2003. Monica Campos (CETEC) and I are interested in combining our field and laboratory expertise and capabilities to better meet our research goals. However, as is common with all researchers in this area, financial support is needed to conduct current research and establish new projects. In September we will submit a proposal to the National Environmental Foundation/Environment Ministry (MMA). In addition, the Technological Centre at Itaipu will present our proposal to various Brazilian agencies in the hopes of obtaining funding. However, we are not confident that these avenues will be fruitful.

RECOMMENDATIONS

The cost of prevention has been estimated to be much less than the cost of controlling existing invasions. The hydro companies and governmental agencies in Brazil should therefore spend more time and money on the study of golden mussel biology and on prevention as a means of control. Although the total area invaded by golden mussel in Brazil is still small, considering the large amount of habitat available for invasion, these invasions occurred very quickly. On a positive note, there is still time to invest in education and awareness to slow the spread of Golden Mussel in Brazil.

The following steps need to be taken to prevent the spread of the Golden Mussel into the rivers and reservoirs of Brazil:

1. Establish a working group including scientists, federal, state and municipal agencies, stakeholders, technical employees of hydroelectric and water treatments plants, representatives of aquaculture activity, and a risk analysis specialist to develop an action plan for the management of the Golden Mussel in Brazil.
2. Establish new projects to study the biology of the Golden Mussel to improve understanding of their survival potential in different aquatic habitats.
3. Continue the study in Guaiba River system and Pantanal region. These studies are dependent on temporal series and results are not expected until 2004-2005.

4. Map the area of occurrence of Golden Mussel in Brazil. The Golden Mussel project co-ordinated by the Institute for Studies of the Admiralty Sea Paulo Moreira (IEAPM) and the MMA plans to accomplish this goal by 2004.
5. Establish a monitoring program for locations with an increased likelihood of invasion by the golden mussel (as concluded by risk analysis).
6. Establish a public information/education program that targets boaters, fishers and aquaculturists in areas where Golden Mussel occur.
7. Establish a method for boat inspection, train people for this function and establish boat inspection stations where boat traffic is most intense.
8. Conduct a risk analysis of Golden Mussel invasion in Brazilian watersheds. Unlike the Zebra Mussel, the water characteristics and requirements for the Golden Mussel are still poorly known. This will make the development of a risk analysis for the Golden Mussel more difficult then those being developed for the Zebra Mussel. For example, in a presentation at the 12th Conference of Aquatic Invasive Species, Michelle Babione of Silvio National Fish and Wildlife Refuge/USA, used limnological variables to determine the potential for Zebra Mussel invasion in a Connecticut basin. Such studies will, however, provide valuable guidelines for future studies in Brazil.

CONCLUSIONS

The knowledge obtained during the Conference, mainly about the ecology and control of the Zebra Mussel in the US and Canada, will be very important for the development of basic research and the preparation of Golden Mussel control strategies in Brazil. A group of specialists in Brazil, co-ordinated by IEAPM and MMA, have been discussing these issues in several meetings and I intend to inform them about the issues discussed during this conference.

Although the environmental requirements for the Zebra and Golden Mussel are different, mainly in terms of water characteristics, their behaviour is similar. Therefor the North American Zebra Mussel experience can provide crucial guidance for the control the Golden Mussel in Brazil. We need to better understand the characteristics of aquatic environments in Brazil and the behaviour of the Golden Mussel in order to analyse the risk of invasion of Golden Mussel to new areas, and the risk of a Zebra Mussel invasion in Brazil.

Corumbá, MS, Brazil, July 5, 2003

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