Participation in Workshop on Aquatic Invasive Species in Belo Horizonte, Brazil April 26 – 28, 2005; Review of CEMIG hydroelectric facilities; Review of invasive aquatic species in the Pantanal Region of Brazil.

Work done under contract 05-RC-2 to World Fisheries Trust, April - May 2005 by Renati Clark, RNT Consulting

Introduction

Limnoperna fortunei, the golden mussel, invaded South America in the early 1990s. The mussel is presumed to have come in ballast water from Hong Kong to Argentina. It became established in the Rio de la Plata estuary, from which it has been spreading into other waterways of South America, including Brazil. As far as the author is aware, very little effort has been made to contain the spread of this mussel up to April 2005. Some information pamphlets have been produced, primarily by the electric utilities of Brazil, on the golden mussels. The workshop in Belo Horizonte was the first effort by the government of Minas Gerais to collect information on the various aquatic invasive species in Brazil and to have a meaningful discussion between industry, government and academia on the extent of the problem and possible solutions.

Trip Report

April 25-28th, Travel to Brazil; Attend workshop; present paper on the importance of public education in control of aquatic invasive species; present paper on the technologies likely to control the golden mussel in industrial setting. Meeting with Monica Campos (CETEC Research Institute,Belo Horizonte regarding her thesis on golden mussel. Meeting with Maria Edith Rola (CEMIG) on possible outreach strategies.

April 29th Site visit to CEMIG's headquarters in B.H.

May 2nd Site visit to Sao Simao hydroelectric plant

May 3rd Site visit to the Três Marias hydroelectric plant and to CODEVASF the fish research station. Present were Yoshimi Sato (chief biologist at CODEVASF), Marilia (IBAMA-UFRJ prof. and Sato's wife), Albino (IBAMA), Sgt. Eduardo and Cabo Marques (Military Police TM), Raimundo Marques (State Fisheries Federation), Norberto dos Santos (local fisherman and key contact), Barbara Johnsen (Três Marias), Roberto Carlos (municipal Secretary of Environment)

May 4th Site visit to Piripora. Met with Marinha do Brasil: Capitania Fluvial do São Francisco (Brazilian Navy: Port and River Authorities of the São Francisco) in the morning and with Janeir Soares Barbosa, Projects and Environment

Manager, SAAE Pirapora (Servico Autonomo de Agua e Esgoto - Autonomos Water and Sewage Service)

May 5th Site Visit to the Empresa Brasileira de Pesquisas Agropecuário (Embrapa) office in Corumbá. Meeting with Emiko Kawakami de Resende, the General Director.

May 6th Site visit to Marcia Divina's sampling sites in the Pantanal en-route to the National Park headquarters.

May 7th Continued with more sampling site visits and review of the aquatic invasive species problem in the Pantanal

May 8th Tour of the National Park and review of ecotourism opportunities

May 9th Travel to Cuiabá with IBAMA personel

May 10th Tour of Cuiabá

May 11th Depart Cuiabá and arrive in Toronto on May12th at 7 a.m.

Technical Report

Overview

The distribution of *Limnoperna*, while centered on the Parana River, is increasing rapidly. A number of industries are now having to cope with infestation. From the information coming from the south of Brazil, the golden mussel will be as much of a problem, if not a greater one, as zebra mussel has been in North America. The primary vectors of distribution within Brazil are commercial and recreational boating. Aquaculture stocking efforts are also a contributor. Very little effort is currently being done on education of stakeholders, government departments, as well as general public on the various vectors which may transfer *Limnoperna* and why it is important to prevent spread of the mussel.

The Brazilian electric power industry sector will suffer the greatest economic losses if *Limnoperna* is allowed to spread. This will be followed by other industrial facilities which use fresh water for cooling or industrial processes. Aquaculture and fishing sectors are likely to be impacted to various degrees. Municipal drinking water intakes, irrigation channels and private water intakes are already being affected.

Environmental impact will also occur, but it is harder to predict and quantify. Generally negative impact may be expected on any native clams and mussels due to Limnoperna using them as settling substrate and suffocating them. The *Limnoperna* is a filter feeder and if the infestation reaches high density in a particular body of water, the structure of the plankton community will be affected

with the rest of the food chain to follow. By filtering large volumes of water, *Limnoperna* is likely to transfer energy from the pelagic layer to the benthos. This will favour bottom dwelling fish as opposed to pelagic fish. At the same time, the cycling of toxins may be affected. It is expected that the clarity of water may be expected to increase as particles are removed from the water column and deposited on the bottom. This may lead to increased growth of aquatic weeds causing a change to the current fish habitat in many locations. Already we have seen that at least two fish species which do not normally feed on mollusks have been feeding on the golden mussel (Pacu and Armal).

Other aquatic invasive species are being distributed throughout Brazil, mainly fish and aquatic weeds. Although there is a good body of knowledge in the academia, the problem of invasive species is not widely recognized by the public or by the government.

The key priority at this time is to slow, if not prevent, the spread of *Limnoperna* and of other invasive species in Brazil. This can only be accomplished with the help of the government at the federal and state level. Such action will minimize economic and environmental impacts and allow time for research. The energy sector, which is facing the greatest economic penalty from the golden mussel, is in the best position to insist that the government take regulatory action to help prevent spread and assist in stakeholder and public education.

The Pantanal region which has just begun to exploit ecotourism opportunities would also suffer greatly if aquatic invasive species are not prevented from establishing. The rich flora and fauna of this region could be particularly vulnerable to invasion. Fortunately, although the golden mussel has been in this are for almost a decade, the annual flooding of the region, which depresses both oxygen and pH have limited the population size of the golden mussel in many regions of the Pantanal.

Outcomes of site visits, interviews, and workshop

WORKSHOP

Tuesday, April 26

The morning was the seminar official opening period at the COPASA lecture theater.

There were 5 speakers from various state organizations as well as welcoming addresses from three host organizations, CEMIG, COPASA and FURNAS. Did not see these five speakers for the rest of the workshop except the moderator, Dr. Magda Barcelos Greco (State Ministry of Science, Technology and Higher

Learning) who was moderating and who was one of the organizers of the seminar.

Maria Edith suggested Dr. Magda Greco could be a very useful contact in terms of accessing future funding or partnerships for awareness and education initiatives.

The remaining 2-1/2 days of the seminar were scientific and technical presentations that dealt with the problems of invasive species. The seminar was organized into thematic periods: exotic fish species, macrophytes, *limnoperna*, plankton and finally the summarizing workshop

The Tuesday afternoon theme was exotic fish species. It would appear that there are a lot of exotics being introduced fairly indiscriminately into the various watersheds. Amazonian species, prized as sports fish are being dispersed without permit by “bucket” biologists. Aquaculture species such as tilapia are everywhere in the natural environment. I think some segment of the population and some of the regulators and researchers are now aware that this is a problem for the indigenous fish, but I did not get the sense that this is considered a huge problem. The mindset seems to be that fish is fish and people like to fish.

Wednesday, April 27

The morning session of the seminar was devoted to invasive macrophytes.

Excellent presentation by Robinson A.Pitelli, ex University professor (faculty of agrarian veterinary sciences at UNESP, Jaboticabal). Robinson is now a consultant. He is an excellent presenter, speaks very good English, very knowledgeable. Brought the issue of aquatic weeds home. Due to the favorable climate of Brazil and the nutrient rich rivers, the problem of invasive weeds is potentially enormous. It would seem invasive weeds are a far greater problem than anything we have experienced in Canada. There is some economic impact being felt by industry coping with aquatic macrophytes and some impacts for agriculture from terrestrial weeds.

The afternoon was devoted to Limnoperna issues. Dr. Maria Cristina Mansur (PUC Rio Grande do Sul) gave a presentation on the state of *Limnoperna* infestation in Rio Grande do Sul. Huge populations seem to be building up. She is doing some monitoring and is supposed to be getting some money from the Federal Ministry of Environment to do work on coatings and repeat some of the control experiments Canada (Ontario Power Generation) did on *Dreissena*. She is a taxonomist by training. It would be very helpful if she has somebody with some industrial experience on her team. The team appears to be made up only of students at present. She has asked for a copy of the Monitoring and Control Guide which was mailed to her. She is interested in future co-operation on mussel issues.

The money for Dr. Mansur's monitoring work was later confirmed in the presentation by Robson Calixto from the ministry of Meio Ambiente. He came under a lot of criticism from the audience for the inaction by the ministry on *Limnoperna*. His responses were clearly excusatory and intended to spread fault elsewhere. The audience seemed clearly disappointed with his responses. He left the meeting after this session.

Carla Kanzi from Itaipu did not attend. Apparently the plant is being re-organized and travel is difficult.

Evandro Colares (Municipal Dept. of water and sewage for city of Porto Alegre, Rio Grande do Sul) presented on the programs in his drinking water utility. Appears they are treating with copper sulphate, apparently because they are afraid of trihalomethane levels if they used chlorine. Not sure copper sulphate is better for humans than trihalomethanes. Evandro spent a lot of time talking to Tom asking for detailed information. He is very open to new ideas but may not be in the right position to implement them. Evandro was interested in exploring the use of ozone as a substitute for the copper sulphate approach. He was given a product brochure from a Canadian company named Ozocan so he can learn a little more and contact them if he wishes. During the discussion period following his presentation, Evandro indicated that he is not sure how bad the problem of mussels in the drinking water intake pipe is as the pipe is very long and they have not been able to inspect it. There is a good opportunity here for some firm with a submersible camera to help Evandro's utility inspect their pipes (see later comments on UFMG). Tom will follow up with Evandro about this topic. Tom also offered to send Evandro some information on recent studies of a technology using high energy ultrasonic pulses through pipes. This technology was originally developed in Canada but it languished for lack of funding. It is now being developed by a firm in Boston named Phoenix. Renata has been helping Phoenix with the biology aspects of the Phoenix technology.

Renata presented on the outreach and education efforts directed at *Dreissena* around the Great Lakes. Brought three copies of each item available in Canada and US on aquatic invasive species and left the collection with Maria Edith. Had lots of people come and speak to me after the presentation asking how they should get their communication program started. I think Maria Edith has a great opportunity to launch a public education program for boaters, based at each reservoir which needs to be protected. Special effort should be made in the São Francisco basin.

Promised her a copy of the Ontario Zebra Busters Program on which she could model it.

Tom presented on available control technologies for zebra mussels. The audience was very different from the one that I presented to 2 years ago, plus he

was a male engineer and therefore vastly more credible. The presentation was very well received and some people were using digital cameras to copy his slides (FURNAS rep in particular).

Thursday, April 28

Morning sessions focused on Cyanobacteria/blue green algae. This is obviously a big problem in a number of different locations due to eutrophication/poor water quality. The toxins released by some of the species are worrying. Fernando Luiz do Rego M.Starling (PUC Brasilia and CAESB) described how the reservoir in Brasilia recovered after tertiary sewage treatment plant was constructed. We chatted to him about constructed wetlands since he did not seem to know very much about them. Could be a good opportunity to introduce the topic, would seem to us that Brazil would greatly profit from constructed wetland technology, leading to improved water quality in many areas.

Fernando is working in Brasilia. Currently he is not in research but rather is working in a management role in a state or municipal firm (CAESB – could be water and sewage treatment center in Brasilia?). He did his PhD in Scotland and speaks very good English. He indicated that he is interested in promoting some research into using natural fauna (probably native mussels) for tertiary treatment of sewage. As the warm climate with limited temperature extremes in Brazil lends itself to constructed wetlands, there may be some opportunity for Canadian firms to follow up and help Brazilian public utilities explore and introduce this technology.

In the afternoon Renata spent an hour with Monica Campos (was at CETEC, now studying at UFMG) going over her PhD thesis proposal. So far the thesis is very descriptive. Suggested some experiments possibly tying together pH, *Limnoperna* and cyanobacteria. Also suggested that on rivers with no reservoirs, *Limnoperna* would disappear due to downstream transport of veligers within three years, provided no boating access was allowed to the river. This could be used to establish headwater refugia for species likely to be impacted by *Limnoperna*. Suggested to Monica she tests this as part of her thesis. She did not think she could set up such a situation. Asked Alison if she could help Monica do this. Monica was concerned that her topic is very much like Marcia's.

The latter part of the afternoon was for preparation of a document that would outline the recommendations of the seminar attendees to the stake holders. Some time was spent identifying the stake holders. To maximize the use of people and time the group agreed to identify the main topics to be addressed by the document. The process was to split into groups. Each group was to prepare an outline and main points for their assigned area. After some discussion (much of it very heated) four topics were agreed: Regulations, Identification, Control and Awareness Initiatives. Following the group break out sessions, most people had left but about 30 individuals remained and together they put together the

summary. Maria Edith was not satisfied with the document, and felt people were too tired to work on it. Maria Edith, Magda and Norma Dulce (consultant) agreed to prepare a more complete document using the input prepared by the groups. Will send us a copy of the finished document.

In summary, it would seem that this seminar brought together local government, industry and academia and covered a wide range of invasive species. There were two articles in the local papers and I believe that it was very educational for many of the attendees and hopefully the path forward document created on Thursday afternoon will be implemented.

CEMIG

The Companhia Eletrica de Minas Gerais is the principal hydroelectric company in the state of Minas Gerais - originally a government monopoly, but now partly privatized. It is experiencing early stages of mussel invasion in some of its more southern dams, and for several years has been working on monitoring and control strategies – effort led primarily by Maria Edith Rola and Vasco Torquato under the supervision of Procópio Rezende. Although Vasco Torquato has since retired, CEMIG has the advantage of having a small, central group clearly in charge of the issue, coordinating research and distributing information to the various CEMIG facilities. They need to develop site specific response plan for each of the dams if and when *Limnoperna* be found at those locations. Such plans would include tracing the cooling water in each facility from the point of entry, through all the cooling circuits to the point of exit and identifying components which might be impacted by *Limnoperna*. So far this has only been done at São Simão, which is the largest and most important CEMIG plant. It is also the most likely plant to be invaded by *Limnoperna* this year.

Friday, April 29 - Visited CEMIG headquarters in BH

Met the Superintendent of Maria Edith, boss of Procopio, Evandro. Very heads up, very interested in what we are doing and what Maria Edith was doing and how the seminar went.

Met the staff of the environmental department, though Procopio was not present.

Visited the control center at the bottom of CEMIG. CEMIG is the largest utility in MG and has the responsibility of managing the load on the state grid. The manager did not describe how the total power supply is shared fairly to all the utilities. The system is very modern and fully integrated with the national grid. The control center is manned by 2 operators and a supervisor 24 hours a day based on 3 shifts. On the day shift and engineer is also in the control room. They predict their daily load based on historical data. They monitor the load every 4 seconds and as they approach an increase or decrease in the predicted load demand curve, they alert the power stations so they are prepared to alter

their power capacity. They are connected to advanced weather services so that they know when storms are approaching and can be prepared in the event a plant or distribution center goes offline. The station at Sao Simão provides approximately 40% of the state supply and is the pride of the utility. This station almost always runs at capacity. There is facility at Sao Simão to add 4 more turbines designed to be used as peaking turbines. However, they did not say if or when they planned to install the additional capacity. Overall the CEMIG control system seemed very much state of the art and their grid should be very stable.

Met with Teresa, the manager of the dam safety department. She is concerned that the earth dams may have the drainage water exits plugged by mussels. These dams have a clay liner and we are of the opinion that the mussel veligers cannot penetrate the liner. The water that seeps through the liner encounters a sand barrier and then trickles down to the base of the dam where there are ducts that drain the water to the toe of the dam on the down stream side. On some of the dams, the toe of the dam is covered with water from the next reservoir downstream. There are areas of the toe that are covered all year round. These areas could become mussel covered and block the flow of the drainage water. If this occurs, the stability of the toe of the dam could be jeopardized resulting in loss of dam stability. We will inspect the dam at São Simão and advise further.

Equipment Safety

We met with Nelson Benicio Marques Araujo, Gerente de Engenharia de Operação e Manutenção da Geração (manager of operational engineering and generator maintenance) and several of his staff concerning the protection of the equipment inside the power station. There are six units and each has a separate service water flow of 220 l/s. The service water intakes are part of the penstock intakes. Maria Edith's prediction is that the mussels will arrive at this dam sometime time this year as they are already at a dam short distance down stream from São Simão. There is not much time to install protection systems at São Simão. We advised them on a possible temporary solution this being portable chlorine injection systems to protect against the mussels and strainers to filter out the shells that slough off from the penstock intake area. They are planning a permanent solution that consists of a closed loop service water system using cooling towers. We suggested that they look at a sand filter as this would be simpler, less costly and would avoid the operating problems with water chemistry in the cooling towers. They have plenty of space for such a sand filter system, which could deal with both veligers and shells. It would need to have low pressure drop and high efficiency.

UFMG

In the afternoon of April 29th we visited the CEMIG-sponsored hydrology lab at UFMG managed by Professor Carlos Martinez. We observed the equipment they use to design and test fish ladders. They are also doing some work on fish barriers for the dam discharge race area, which has low flow when the turbine shuts down, thus permitting fish to enter the turbine and penstock areas. They are testing electric fish barriers. They are also developing a remote controlled submersible with a video camera to use for dam inspection. The students and staff are a nice mixture of biology and engineering. We advised them that such a device could possibly be used by municipal water treatment plants to inspect their intake tunnels. Prof Martinez did not think his equipment was ready to do such a task yet. He did not seem interested in the opportunity such use would provide for extra funding for the university. His lab will receive part of the funding from Maria Edith's project, which was just approved after one year. Maria Edith has been offered two trucks from CEMIG which can be modified as flow through labs for use in the field. Martinez and crew are likely to do the design and construction of this. Seems that CETEC is out of favour with CEMIG at this time, also confirmed by Monica. Carlos Bernardo Alves Mascarenhas works with Carlos Martinez in the lab supervising students. High energy and creative individual.

Monday, May 2, 2005

Picked up at 7 am by Newton Jose Schmidt Prado – Manager of environmental programs and actions. Drove to the airport and took CEMIG plane to Sao Simao. With us came a person from Teresa's branch and from the mechanical equipment branch. At the airport in São Simão we were met by João Magalhaes Lopes, a biologist based in Volta Grande who gave me my tour there two years ago. At the dam we were met by the station manager and many other people and offered refreshments. We were shown drawings of the station. The station manager was unable to answer our detailed questions. He called upon a more junior engineer to help and then take us on a tour of the dam and of the system.

We observed that the service water intake is at the base of the penstock just prior to where the water enters the turbine casing. Unit based piping takes the service water up one level to a small cramped room where there is a strainer with openings that we were told were 10 mm in diameter. The filter has never been opened. The filter has a manual backwash and this is only used on rare occasions when a flow problem is suspected. There is no pressure sensing device across the filter. There is a flow meter. The heat exchangers for the turbine bearing oil coolers are in this room. They consume only a small portion of the service water flow. The main service water flow proceeds one level further up. Here the service water provides the generator cooling. We were not able to

see inside the generator room as it was locked. The generators are from Mitsubishi Electric.

Figure 1: The concrete spillways of the dam at São Simão

Figure 2: Service water take-off from penstock (penstock is large black pipe at top of photo)

Figure 3: Bio-box at service water take-off. There is one bio-box for each of the 6 units.

Figure 4: Service water filter. Inlet from above, outlet on left side.

Figure 5: Fire water take-off (red piping) from service water common header (green piping)

Figure 6: Drain piping from toe of dam.

The service water also connects to a common header. The fire water is taken off this header. The technician indicated that he is certain that the service water flow has no leakage and no make up is required. The fire water system is tested 2 times per year. On this level there is much more space. There would be room for a sand filter here. Would need approximately 6 x 220 l/s unit sand filters.

We were provided with a flow diagram of the service water piping. The piping is sized for a flow of 700 l/s. This means that if a sand filter is sized for 220 l/s there may be a requirement for a by pass line in the event the full 700 l/s is needed for some occasional or emergency operation. Another option would be to use a single sand filter at the common header and back feed to the common header.

We looked at the dam safety issues. The rock filled section of the dam that is protected by a sand barrier drains to concrete tubes, approximately 10 per side. These tubes discharge into the downstream side of the dam. Some of them are submerged during periods of high water. We inspected some. They are large (approx 30 inches) and would be easy to inspect. These tubes would not have mussels translocating upstream and only the inlet would be at risk. The inlets are easy to inspect and could be cleaned manually.

The concrete portion of the dam has relief holes drilled into the base rock beneath the concrete. We felt that it was unlikely that mussels could get into these holes but if they did they could be killed with a steam lance.

We would strongly advise that the station set up a monitoring program to inspect for mussel presence as there are undoubtedly some areas that have not been considered as a problem. There is a bio-box at the service water intake in each unit. The bioboxes should be examined on weekly basis by plant personnel as the arrival of mussels appears to be imminent. Contingency plan should be put in place immediately so that it can be implemented as soon as mussels are discovered. More overall monitoring within the dam is needed. There is currently no monitoring plan.

We believe that it is essential that every CEMIG plant installs a biobox and monitors for mussels on weekly basis.

<u>Tres Marias and Pirapora</u>

On Tuesday, May 3, 2005 we were in Tres Marias. We had a 9 am meeting at CODEVASF the fish research station. Present were Yoshimi Sato (chief biologist at CODEVASF), Marilia (IBAMA-UFRJ prof. and Sato's wife), Albino (IBAMA), Sgt. Eduardo and Cabo Marques (Military Police TM), Raimundo Marques (State Fisheries Federation), Norberto dos Santos (local fisherman and key contact), Barbara Johnsen (Três Marias), Roberto Carlos (municipal Secretary of

Environment), Renata, Tom, and Alison Macnaughton. The group was much more interested in the dead surubim which have been found in the river and which Alison was attempting to get analyzed in Belo Horizonte, than in the *Limnoperna* or the issue of invasive species. Renata attempted to impress upon the group that prevention of mussel invasion was worth a shot and that possibly creating fewer access points to the reservoir would give them more control over boats coming in from other basins. This was taken as a non-starter as the reservoir has no trees around it and anybody can basically drive up to the shore. Tom suggested that planting trees and other vegetation around the reservoirs, strategically, to both improve water quality by blocking agricultural run-off and preventing trailered boat access would be worthwhile. Y.Sato was resigned to the golden mussel invading and not particularly interested in dwelling on the topic. He pointed out that fish are dispersed from hatcheries where golden mussel is present, and that the mussel will travel with them. In N.America we require fish hatcheries to certify that their water is free of zebra mussel larvae. This was pointed out but it had little effect. Barbara took note of this.

Some interest from Barbara, particularly when Renata suggested that there should be some funding for education and outreach from companies likely to suffer economic harm if the mussel invades (CEMIG, drinking water plants, other industries). The meeting then turned to the dead surubim and other related issues.

Roberto Carlos at the end of the meeting announced that he has some money to fund a project for earth day. This could be used to fund the planting of the reservoir shore.

Regarding the dead surubim, some samples were taken for analysis to B.H. The problem I see is that the lab does not know what kind of chemical it is looking for. A land use survey could narrow down what the chemical might be, but there is no background data on any pollutant in any fish from Sao Francisco basin. In other words, we do not know what loading of chemicals the fish have normally therefore it is hard to say if whatever they find in the dead fish was actually the cause of death. If you do find a suspiciously high level of any substance in the samples you have submitted, I think it would be wise to do the same analysis on the same body parts taken from “healthy fish”. Also, if you suspect a particular discharge point of putting out a certain toxin, running a test on native bivalves collected in the proximity of the discharge would give you a good idea if there is a problem or not.

Discussed the dead surubim briefly with Jose Augusto in Pantanal. He is a very good contact re fish physiology. Might be able to suggest other knowledgeable academic who could help out. He felt both the brain and the liver should be analyzed. He hypothesized that the death might be related to habitat destruction and lack of deep cool refuges in the river where surubim actually like to spend time.

Seems to me that background toxicology needs to be done as soon as possible. I feel that composite samples, made up of single fish species in a single size category and combined would provide the most data for the least amount of money.

One of the other topics of discussion was the new dam that is being planned for the Sao Francisco basin. Vasco and Norma are consultants on this project**. It would be worth having them construct it in such a way that golden mussel would not be an issue and they would not have to use chemicals to protect the cooling water. This is the time to incorporate these features into the design.** Perhaps Yogi could approach them through Vasco. We could offer input on what needs to be done.

During lunch we discussed the bare zinc smelter tailings sitting across the river from the restaurant. We suspect they are a constant source of number of pollutants entering the river. We suggested that the owner of the smelter be presented with a straightforward plan on how to cover up the tailings and immobilize the material, together with a proposed budget and promise of much favourable press if he does it.

The sewage outfall from Tres Marias is also visible from the restaurant. The location and configuration of the outfall would lend itself nicely to a constructed wetland method of dealing with sewage.

In the afternoon we visited the dam at Tres Marias. We gave a short power point presentation on mussel fouling to the individual giving us the tour. We tried to impress upon him that mussels can arrive at any time courtesy of recreational fishermen. He felt this was not his problem, the issue was to be solved by head office and if there was any monitoring to be done it should be done by Sato from CODEVASF.

We believe that it is essential that every CEMIG plant installs a biobox and monitors for mussels on weekly basis.

On our way out of the plant we observed a large group of fish leaping against the dam, trying to get up river. Apparently the current hypothesis is that there is no point in a fish ladder as the reservoir is too cold and the fish would not spawn in there anyway. As far as we know there is no data to support this theory. Considering the value the community places on being able to fish it would seem worth investigating. **We would suggest removing the fish from below the dam manually, tagging them with a radio tag, placing them in the reservoir and then following them in the reservoir to determine if they can reach spawning areas or not. If they spawn successfully over several experimental seasons, a permanent fish passage would be warranted.**

On **Wednesday, May 4th** 2005 we drove to Pirapora. The first meeting was at 10 a.m. with Marinha do Brasil: Capitania Fluvial do São Francisco (Brazilian Navy: Port and River Authorities of the São Francisco)

We set up the meeting with Lieutenant Captain (Capitão-tenente: Agente da Autoridade Marítima) Ricardo Reis Rebelo, who then called together everyone in the building (25 people) for a powerpoint presentation.

They're really interested in promoting prevention strategies, suggested they could offer some awareness building during the regular boat pilot licensing courses which they give every year. They'd really like a copy of the presentation (in Portuguese please – which I said WFT could do translation for) as well as whatever other information we can offer them about prevention strategies, whatever help we can offer on them setting up a multi-partner strategy with the colonies, the SAAE people, the city to promote awareness and prevention strategies.

Ricardo Reis Rebelo 02@cfsf.mar.mil.br, 38-3741-1507(fax), 38.3741.1855(phone)

2nd mtg – Janeir Soares Barbosa, Projects and Environment Manager, SAAE Pirapora (Servico Autonomo de Agua e Esgoto – Autonomos Water and Sewage Service)
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Janeir didn't invite anyone else to the meeting, as he felt it was rather short notice, but did seem relatively interested, and of course, mostly unaware, of the risks of golden mussel invasion to the water treatment facility. Probably not motivated at this point to work hard or put money into prevention (though we could keep working on him, and if we could get to Helder - his boss, I bet we'd have a good shot of convincing them to support education and prevention initiatives.) This was the place where they said they have two water intakes – one at the margin, where a sand filter could be useful, the other through pumps in the middle of the river which would be more difficult. An infiltration gallery would solve the potential mussel problem as well as improving the water quality they have to deal with.

We should also send presentation materials and other information to these guys.

From Pirapora we took the bus back to B.H. Jason Emmert came with us to translate for the rest of the trip.

Pantanal

On Thursday, May 5th, we traveled by plane to Corumba. Arrived mid-afternoon. We were met by EMBRAPA driver and taken to a hotel. After dropping our luggage the driver took us to the EMBRAPA building in Corumba to meet with Emiko Kawakami de Resende, the General Director. The Empresa Brasileira de Pesquisas Agropecuário (Embrapa) is one of the leading government organization for agricultural research, but also addresses water and fisheries management issues through its research station in the Pantanal wetlands (Mato Grosso do Sul). Márcia Divina heads an Embrapa research program on *Limnoperna* in the Pantanal, and, with WFT assistance, participated in the International Conference of Invasive Species in Windsor, Ontario, June 2003. Marcia is currently on leave to finish her PhD in Belo Horizonte.

With Emiko Kawakami we chatted about Pantanal, the uniqueness of the region and how quickly the golden mussel became established. Emiko showed us a report with picture of a dissected pacu. The intestine was entirely filled by golden mussels. The shells appeared whole. This fish is a bit of an omnivore, normally likes to feed on fruit that falls into the water. The switch to a mussel-based diet is unusual. We toured the rest of the lab, as well as the lab of Marcia Divina. There a couple of students were analyzing plankton samples containing golden mussel veligers.

On **Friday, May 6th**, 2005 we left with Marcia Divina and an EMBRAPA technician at 6 a.m. for a trip into the Pantanal. We travelled along the Paraguay river, stopping along the way to inspect various sampling sites which were being used by Marcia.

Castelo Lake was the first stop. The substrate of the lake is basalt. During the seasonal flood the lake has low pH, 5.5 and very low dissolved oxygen levels. We saw no sign of mussels, the water was still relatively high. There are some mussel present in this lake during the low water period. Asked Marcia to check if those present are all the same size and fairly small. This would suggest re-colonization from other areas of the Pantanal with only a single year class present.

In 2005 the oxygen levels measured at Castello lake were higher then normal. In September there may be higher mussel densities then in previous years (5/m2). Artificial substrate will be installed at the lake in September so that it can be checked during high water period. All physical parameters will be recorded at each visit.

Next stop was Mandiore Lake. During low water the pH is between 6.5 and 7 and the dissolved oxygen is 6 to 7 mg/L. The oxygen can fall to 0 during the high water cycle. The surrounding rock appears to be quartz and granite. The lake

has two interconnections to the Paraguay River. There are cow pastures on the edge of the lake. The cows are brought there by boat, possible source of infestation.

It would be very good if any shipping or boat traffic entering Pantanal had antifouling coatings applied to the hulls.

Mussels of all sizes are present on the rocks during low water cycle.

Site we did not visit is on Miranda river. There were numerous golden mussels at that site. During the 2004 flood season, the pH and oxygen were very low and all the mussels died. This included mussels Marcia was keeping in a growth box.

We arrived at the National Park in the late afternoon.

May 7, 2005 we left the National Park site and traveled to an eco-lodge called Ecotropica located just outside of the park boundaries. There the IBAMA people from the park set some gill nets and caught pacu and armal. Specimens of each were dissected and the intestines were examined. Both fish species had intestines packed with shells of golden mussel. In the case of Pacu, many of the shells were crushed, some however were whole and still alive. In the case of Armal, the gut content looked like an indiscriminate “vacuuming” of shells from the bottom, many were probably empty when ingested. Each digestive tract was stored in a separate jar and preserved with alcohol.

Figure 7: Pacu intestines filled with golden mussels.

For both fish species the golden mussel represent a new food source. In the case of the Pacu, golden mussel represents a big departure from the traditional diet. This may affect the cycling of nutrients as well as of pollutants in the Pantanal. The taste of the Pacu, fish that is enjoyed by many may also change because of the change in diet.

From Ecotropica we proceeded to Gaiva lake. The lake has a quartz rock substrate and can fluctuate by as much as 20 meters during the flood season. There was no settlement on the artificial substrate attached to a buoy in the middle of the lake. On shore we found rocks in depth of 2 to 3 meters which had very low densities of small golden mussels attached to them. These mussels could only have settled as water started to rise during the flood season in February. The size of the mussels suggests that reproduction is taking place in April. This was not recorded previously, but as the rate of growth in this lake is not known, we were not able to pinpoint accurately how old these mussels were.

In the area of the lake that remains permanently submerged, even in the dry season, there are no records of golden mussel colonies. Divers would be required to do this sampling and they have not been available.

May 8th we examined the digestive tracts of both fish in greater detail. As noted previously, there were many shells in both digestive tracts which had no signs of flesh. This would suggest a large die-off of mussels in the mussel beds during

the flood season. Marcia and I reviewed the data she has collected to-date and spent considerable time discussing data collection difficulties and the overall direction of her thesis. She has very few data points to cover a huge area. Within this area there are major physical differences between sampling sites. These differences are not well documented. The seasonal fluctuations at the sampling sites are huge and again the samples are not collected often enough to be able to establish a profile of a site to pinpoint what may lead to the seasonal mortality of the mussels.

At the site of the National Park headquarters, no mussels have been recorded in the river. As many boats travel past this area, the lack of mussels is likely to be connected to the physical qualities of the river. **I suggested that a continuous data sampling device be located at this site to monitor the physical properties of the river.**

Similar tracking of physical parameters should be done at locations where mussel are abundant and at a site where there is know seasonal mortality of the mussels.

Another idea would be to ask for the cooperation of the commercial fishermen in the area. Ask some of the local fishing guides to preserve the digestive tracts of the fish they have caught and the location of the catch. This would serve as an informal sampling device of where the mussel are present and map the area that way.

May 9th, Jose Augusto took us for an early morning tour of the immediate area around the headquarters. During breakfast we discussed the possibility of having the International aquatic invasive species conference in Brazil. He was in full support and pledged IBAMA support for the conference.

He also agreed to host a water sampling station for Marcia.

He then outlined his plans for the National Park as an Ecotourism destination and a possible research site for foreign and domestic academic. Jose Augusto struck me as a very dynamic individual, able to deal with the red tape and not afraid to go up against big business. Considering the unique area that Pantanal represent, it is good to know it has such an able champion.

Follow-up from trip

Various promised information has been forwarded to a number of individuals we have been in touch with. Antonio Procopio Rezende and Joao de Magalhaes Lopes, both from CEMIG have visited Ontario and have been on tour of several of the power plants in the Toronto area.