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Technology Management with Focus on Fish Transposition System (FTS)

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***Abstract*— *Fish transposition mechanisms have been installed near hydroelectric busses in order to reconnect sections of sectioned rivers and attract fish, offering them a route for the continuity of their displacement, essential for their feeding and reproduction. In this work, a bibliographical study is developed searching for information on a model of Transportation Systems for Fishes (FTS), implemented by a hydroelectric plant located in the Madeira river on the municipality of Porto Velho - RO.It was shown that the type of STP constructed was one of successive fish ladders or basins, and its operational functioning is through monitorization of the tagged fish that pass by the channel through Telemetry and Sonar methodologies. The objectives of the Monitoring Subprogram of the Fish Transposition System (FTS) are being met according to the analyzes and technical suggestions transcribed in the EIA / RIMA, PBA and IBAMA conditioners. The monitoring results show that up to the end of 2014, some individuals of target species within the FTS and upstream of the dam, such as the Bagre Dourada species (Brachyplatystomarousseauxii), were not detected suggesting that these tagged individuals were unable to climb into the system of transposition and to transpose the bus, having Madeira river as a migratory route for these species.*

Keywords*— *Fish transposition mechanisms, Telemetry and Sonar methodologies, EIA / RIMA, PBA and IBAMA conditioners.

I. INTRODUCTION

The process of migration is the displacement of fish species to other parts of the river or basin for the purpose of feeding, reproducing and sheltering. Almost all types of migrations are in some way associated with the hydrological regime, with reproductive displacements being the most relevant for neotropical fish. Reproduction represents one of the most important aspects of a fish's biology since its existence depends on the maximum survival of offspring (AGOSTINHO & GOMES, 2007).

The same authors affirm that the damming of large springs causes, among other interferences, direct impacts to fish communities, namely: isolation of populations, obstruction of migration routes and alteration in the

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structure of the existing assemblies of the damned stretch (AGOSTINHO & GOMES, 2007).

Migratory fish, also known as "piracema" in Brazil, are one of the groups most affected by dams. For these fish, the bus is an obstacle that prevents the free movement between feeding and spawning areas. In order to mitigate this negative effect, fish transposition systems (FTSs) have been implemented, which allow fish to pass through the dams.

The FTSs implanted in Brazil have been only those that provide downstream movements upstream. This is because there is still no known technology that allows the safe and effective passage upstream of the various stages from Brazilian fishes' life (AGOSTINHO & GOMES, 2007).

The Transposition System for Fishes (FTS), implemented by Santo Antônio Energia - SAE, the company responsible for the construction and operation of the Santo Antônio Hydroelectric Power Plant, on the Madeira River, Rondônia, presents the possibility of migration necessary for the spawning of several species of fish and the maintenance of fishing activity in the region, even with the plant in operation. The structure, which has been in operation since December 2011, consists of a corridor that reproduces the natural characteristics of the Madeira River waterfalls and has a proportional flow similar to the river, in order to introduce the fish to an environment as close as possible to its natural habitat (QUEIROZ et al., 2013).

A great advent was observed in the construction of hydroelectric plants and their dams in the Amazonian rivers. Such ventures have innumerous implications for environmental impacts in which we can cite the biological communities of the fauna as the main affected groups. Artificial dams damage the natural process of migrating fish, especially during the breeding season

Thus, the necessity to develop this research, aiming at a descriptive bibliographical review on the implementation of a Fish Transposition System (FTS), as a mitigating measure to minimize the environmental impacts on the fish communities of the Madeira River and their tributaries.

The descriptive review is aimed at the compilation of the presented data, through technical reports by the entrepreneurs responsible by the construction of the plant. Thus, contributing to the knowledge of the Fish Transposition Systems (FTSs), implemented by large hydroelectric projects in the rivers of the Amazon basin, as well as their functioning, feasibility and mitigation of the impacts caused by dams on the local ichthyofauna.

II. OBJECTIVES

The objective of this study is to carry out a literature review on preliminary data regarding the efficiency and selectivity of the mechanisms of a Fish Transposition System (FTS) in the Madeira River by a Hydroelectric Plant in the municipality of Porto Velho-RO. The main objectives of this study were to identify the type of FTS installed in the Madeira River by Santo Antônio HPP and its operation (a), to highlight the main fish species of interest for evaluation of the efficiency of the monitoring of the FTS (b), and to compare analyzes of the Report of the Environmental Impact Study / Environmental Impact Report (EIR / RIMA) and the Basic Environmental Plan (BEP) with the available technical reports on FTS monitoring (c).

III. LITERATURE REVIEW

The Madeira River is one of the main rivers in Brazil and the longest and most important effluents of the Amazon River. In the world, it is one of the five most flowing rivers and the 17th most extensive (3,240 km). In addition, it is one of the major in South America; its watershed has 125 million hectares. With different denominations, the Madeira River bathes three countries: Brazil, Bolivia and Peru. In addition to environmental importance, it is essential for the economy of many regions, as it traditionally provides fishing, waterway transportation and, at its margins, the planting of various agricultural products (SAE, 2014a).

The Madeira River begins in the Andes Mountains and, after travelling 3,240 km (1,425 km in Brazil), it flows into the Amazon River, which flows towards the Atlantic Ocean. It is formed by three Andean rivers: Beni and Mamoré, in Bolivian territory, and Madre de Dios, in Peru. It arrives in Brazil by the south of the state of Rondônia and, besides bathing Rondônia, it crosses the state of Amazonas in the route until the outfall. It is called Madeira only in the Brazilian territory. On the right bank, its main tributaries are the rivers Ribeirão, Mutum-Paraná, Jacy-Paraná, Jamari and Machado. In the left bank, the rivers Abunã, Ferreiros, José Alves, São Simão and Igarapé Cuniã (AGOSTINHO & GOMES, 2007).

The Madeira River, according to Sioli and Klinge (1962), is classified as a whitewater river, due to suspended material that carries a high concentration of mineral salts in solution (electrical conductivity: 60 - 70 µS / cm and near pH to neutral: 6.5 - 7.3). The Madeira River is the main tributary of the right bank of the Amazon River, due to the size of its hydrographic basin and the contribution in the volume of water to the Amazon Basin. In Porto Velho, the average flow of the Madeira River in the historical period (1967 to 2012) is 18,718 m3 / s, and the registered daily maximum flow reached 48,565 m3 565 / s on April 14, 1984. The minimum registered flow occurred on September 10, 2005, reaching 2,588 m3 / s (SAE, 2014a).

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3.1 HYDROELECTRIC POWER PLANT SANTO ANTÔNIO ENERGIA (SAE)

The according to the site, Santo Antônio Hydroelectric Power Plant (HPP) has 3150.4 MW of installed capacity and is located on the Madeira River, 7 km from the city of Porto Velho, Rondônia. The bulb turbine technology adopted at the plant allowed the use of the power generation potential as a function of the river flow, allowing the creation of a reservoir with an area of 354 km2, not considering the backwater effect (2.5 times increment of the area), which represents a small area in relation to its power (area / power ratio = 0.11 km2 / MW)

Santo Antônio Energia is the concessionaire responsible for the construction, operation and commercialization of the energy generated in the hydroelectric plant, an investment of over R $ 16 billion, of which R $ 1.7 billion is directed to social and environmental programs. For the implementation of a project of this size, the entire project was designed to obtain maximum use of water resources, with minimal impact on a region whose preservation is a permanent focus (Queiroz et al., 2013).

According to Queiroz et al. (2013) among the measures adopted by Santo Antônio Energia to implement the plant, is the implementation of the Ichthyofauna Conservation Program, carried out in partnership with the Federal University of Rondônia, with the National Research Institute of the Amazon and with researchers from several other institutions. Based on the consolidation of the information generated in the scope of the Program, which represents an investment of more than R60 million, associated to the knowledge of the researchers involved, generating a publication that further disseminates the knowledge acquired about the Amazon Basin so rich in its biodiversity.

3.2 ENVIRONMENTAL IMPACT STUDY / ENVIRONMENTAL IMPACT REPORT (EIS / EIR) AND BASIC ENVIRONMENTAL PLAN (BEP) FOR THE SANTO ANTÔNIO ENERGIA (SAE) HPP REGARDING THE CONSERVATION OF ICHTHYOFAUNA IN THE MADEIRA RIVER

3.2.1 Ictiofauna Conservation Program referring to the EIS / EIR report produced by LemeEngenharia Ltda.

The objective of this Program is to monitor the changes imposed on aquatic fauna and fishing activity on the Madeira River, as a result of the construction of the Power Plants, which is prolonged by its operation. It is divided into seven sets of activities, all of which must begin 12 months before the start of construction. These activities shall be carried out without interruption during the whole construction period, starting up of the generating units and for 5 years after the last of these units starts operating. Based on the results obtained, the actions and monitoring carried out should be evaluated so that the Program can be re-dimensioned in light of the new environmental scenario that the implementation of the projects will have in the region (LEME, 2005).

According to Leme (2005), the first set of activities is related to the monitoring of fish fauna, with the following objectives:

- To record the variation in richness, diversity, community structure and abundance of fish species in the Madeira River before the works and along the five years after their completion, comparing the results.
- To record the variation in richness, diversity, community structure and abundance of fish species in the Madeira River before the works and along the five years after their completion, comparing the results.
- To monitor changes in reproductive processes and strategies, as well as variations in the reproductive activity of the main species.

For the other sets of activities according to Leme (2005) the objectives are:

- The second set of activities is related to the study of the abundance of eggs and larvae of fish along the Madeira River, whose results will provide consistent evidence on spawning season, breeding sites and natural breeding sites of this fauna.
- The third group of activities will be the genetic characterization of fish populations - a fundamental study for the implementation of strategies to manage this resource and to elucidate questions about the genetic structure of populations.
- The fourth set of activities constitutes the complementation of the fish inventory of the Madeira River and its affluents.
- The fifth set of activities is the monitoring of fishing activity, whose objective is to record the actual environmental and social effects generated by the implantation of the powerhouses on the fishing activity in the section of the Madeira river between Guajará-Mirim and Humaitá.
- The sixth set of activities consists of observing the efficiency and effectiveness of the fish transposition system to be built in the Plant.
- The seventh set of activities of this Program consists of the efforts to rescue the fish fauna, to be carried out in situations in which the operation of the Plant threatens the aquatic fauna.

3.2.2 Monitoring Subprogram of the Fish Transposition System referring to the PBA report produced by Madeira Energia S/A (MESA)

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In an initial environmental diagnosis, executed by Leme (2005), important commercial migratory species were registered in the area of direct influence of the enterprise, and in the main fish landings of the Amazon.

One of the main impacts of the construction of the Santo Antônio HPP is the interruption of the migratory routes of some fish species, which may lead to the isolation between the breeding and growth areas according to Agostinho et al. (2002), especially of species of commercial interest. This isolation can severely compromise the regional fishing activity according to Agostinho et al. (1994), which depends on the abundance of these categories of fish, leading to social and economic impacts according to Agostinho et al. (2004). The EIS / EIR and discussions about the feasibility of the implementation of the Santo Antônio hydroelectric projects on the Madeira River, preceded by the Preliminary License nº 251/2007, addressed questions about the life cycle of long distances migratory, such as Siluriformes (catfish), and the great concern about the impact to be caused, by the buses, on the abundance and regional economy of this category of fish (MESA, 2008).

The Madeira River is a migratory route for many species of fish and a region of rapid rivers, more precisely the waterfall of Teotônio, which apparently represents a natural barrier to the migration of some of them (LEME, 2005).

In this case, the reproduction of some species will suffer less impact from the dam, predicted to be placed where the Santo Antônio waterfall is currently. However, for migratory species of long distances capable of transposing said waterfall, as part of the Siluriformes and Characiformes, the dam will represent an important barrier in their life cycle, which should be mitigated by a transposition system (FTS). It is believed that with the installation of an FTS, the impact on the rise of these migratory species to the spawning, and the decrease of the larvae, eggs and juveniles is mitigated allowing their population maintenance and macro-regional replenishment of fish stocks (MESA, 2008).

Regardless of the type of FTS (ladder, locks, fish lifts or artificial canal), the objective is always to provide, even partially, the transposition of the dam by the migrant shoals. The technology currently available for the construction of FTSs, often based on experience from other countries, cannot be used indiscriminately for any dam, at the risk of failure, as it has already been observed in several previous experiences in Africa, Australia and even in Brazil (MESA, 2008).

After the choice and implementation of the FTS, the efficiency of this mechanism should be monitored (number of species and number of specimens that can reach the reservoir by the time of year, etc.) so that the operating conditions of the system can be adequate and/or corrected whenever necessary. The implementation and operation of the FTS will be subsidized by information on the ecological aspects of the migratory species obtained through the development of the subprograms of the Ichthyofauna Conservation and Rescue Program and pieces of information about the migratory route of some species obtained in the present study. The effectiveness of the FTS will be monitored by the present study, and will show successful responses during the monitoring of subprograms of the Ichthyofauna Conservation and Rescue Program, mainly from the subprograms Ecology and Biology, Ichthyoplankton and Monitoring of Fishing Activity (MESA, 2008).

Besides the efficiency of the chosen mechanism, its effectiveness should be monitored as well, that is, what happens to the specimens that can reach the reservoir. Thus, an FTS can only be considered effective if it is found through monitoring that the specimens have reached spawning areas upstream and that their offspring have survived. On the other hand, the efficacy of an FTS also involves the evaluation of the impacts that the transposition of the shoals entails in the downstream populations since the drift of eggs and larvae upstream is extremely impaired by the conditions imposed by the dam (AGOSTINHO et al., 1992).

According to Mesa (2008), the objectives proposed by the PBA for the conservation program of the ichthyofauna are:

- Define, in conjunction with engineering, the location and characteristics of the most appropriate transposition system (FTS);
- To evaluate the efficiency of the proposed FTS in the transposition of migratory species, identifying critical points for the ascension of species of interest;
- To determine the composition of the ichthyofauna in FTS, identifying the attractiveness of the system and the selectivity of its different components;
- Determine the temporal variation of the species captured in the FTS;
- Determinar os efeitos de variações na vazão e velocidade da água sobre a atratividade e a seletividade do STP;
- Evaluate the movement of eggs and larvae along the channel and determine the density of fish eggs and larvae in the FTS based on the results presented by the Ichthyoplankton Subprogram;
- Identify the migratory routes and seasonal movements of fish species.

Among the goals and expected results, according to MESA (2008), are:

- To reduce the impacts of the project on the migratory fish fauna, based on the adequacy of the FTS to the needs and characteristics of the local populations.

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- To register migratory species patterns, serving as the basis for discussions on the elaboration and adequacy of the FTS.
- FTS adjusted, when necessary, from information generated in monitoring the efficiency of the mechanism.
- Upward and downward migration of adults and offspring of eggs, juveniles and larvae guaranteed, even partially, by FTS, allowing the maintenance of fish stocks upstream and downstream of the dam.

Studies must be performed by the company's engineering team and serve as the basis for discussions and determination of characteristics that must be reproduced in the FTS. It is suggested the collection of information about Teotônio waterfalls, such as depth, flow, speed and oxygen, level and other parameters that are necessary for later reproduction in the lateral artificial canal (MESA, 2008).

According to Mesa (2008), the determination of migratory patterns before the dam will be essential for the definition of structural aspects of the FTS and for the improvement of the sampling design of the FTS monitoring study. To do this, it is necessary to analyze the following aspects:

- Which species pass through the Teotônio waterfall;
- What is the periodicity of the passage of these fish?
- By what region of the TeotônioCachoeira these species are passing, considering the width of the channel, the left and right margins, surface and bottom.

The first two aspects can be evaluated based on the data of the landing of the commercial fishery in the different points of the basin, coming from the subprogram of monitoring of the fishing activity. The definition of the migration site of the species in the Teotônio waterfall should be made with the help of a mobile echo sounder, which will be fixed in a steel cable from one margin to the other of the Madeira River, one upstream and the other downstream. The equipment will be moved along the width of the studied region of the Teotônio waterfall, registering the fish that are migrating (MESA, 2008).

One of the methodologies of success verification of fish migration is the monitoring of the species that ascend the FTS at points of observation, located strategically along the artificial channel in order to allow the capture of samples periodically. In the initial stage of the project, before FTS implantation, different forms of capture and marking (first and second year) that cause minimal damage to the fish should be tested, to better dimension the equipment and to adjust the procedure to be used, as well as of the location of capture points along the FTS (MESA, 2008)

The radio telemetry technique will be used to test the efficiency of the transposition system (FTS) and can be tested to study the behavior of migratory species along the Madeira River if its viability is confirmed by a specialist. It should be pointed out that the team responsible for the Wildlife Conservation Program, the Mammalian Monitoring Subprogram, proposes the same methodology for the monitoring of aquatic mammals and, therefore, it is suggested the joint use of the monitoring stations that will be arranged by this subprogram along the Madeira River (MESA, 2008).

Initially, the most important species in local and regional commercial fishing are indicated for this activity and, according to studies already carried out (EIA / RIMA AHEs Santo Antonio and Jirau, 2005), they will be more likely to have their migratory patterns affected by the enterprise. They are:

- *Brachyplatystomarousseuaxii*(dourada);
- *Brachyplatystomavaillantii*(piramutaba);
- *Brachyplatystomaplatynema*(babão);
- *Colossomamacropomum*(tambaqui);
- *Piaractusbrachypomus*(pirapitinga).

In addition to marking specimens in FTS, specific campaigns should be carried out to capture specimens to be tagged, having a duration of 10 days, occurring in the 1st, 4th and 7th years, and covering the harvest period of each of the selected species minimum 6 months per year). The beginning and periodicity can be reviewed according to the results obtained in the first years of implementation of this subprogram. Different points of capture and marking within the system should be selected, including the reservoir and the upstream and downstream environments of the project (MESA, 2008).

According to condition 2.6 of Prior License n ° 251/2007, repopulation of both endemic species and migratory species should be promoted if their mobility is impaired and FTSs are not effective for these species. In order to meet this constraint, a technical analysis of the situation of migratory and endemic fish populations and the real need for stocking and repopulation should be carried out in the first 8 years of PBA implementation, based on data from the other subprograms of the Program of Conservation and Rescue of Ichthyofauna (MESA, 2008).

It should be emphasized that repopulating fish communities is one of several mitigating alternatives for impacts generated by large enterprises, such as the construction of dams, which in most cases constitute insurmountable obstacles for most species of migratory fish. This type of mitigation action is necessary when environmental changes such as the loss of reproduction and growth sites are observed, which may lead to several negative changes in the fish populations, and consequently in the fishing activity (AGOSTINHO et al., 1992). However, the adoption of this type of management

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strategy without previous knowledge of the diversity and ecological aspects of the species, the environmental support capacity, and the relationships among the species results, in the majority of cases, in damages to the ichthyofauna or in the adoption of harmless measures (MESA, 2008).

In this sense, at the end of 8 years, the Program for Conservation and Rescue of Ichthyofauna should indicate the monitored parameters to support the decision making on the implantation of the fish breeding center, including recommendations on technical and political measures in a way that the eventual implantation of the fish breeding centre will not constitute a new source of impacts for the ichthyofauna of the Madeira River (MESA, 2008).

3.4 FISH TRANSPOSITION SYSTEMS (FTSs)

One of the consequences of dams is the interruption of the migratory flow of fish. Thus, the absence of FTSs in the dam is responsible for the depletion or even disappearance of migratory fish species, as immeasurable consequences to the ecosystem and environment. These devices are basically composed of input, body conductors and output. Under the engineering gaze, it is intended to facilitate the reproductive or trophic migration of fish by overcoming natural or non-natural obstructions by passing a volume of water upstream, favored by the hydraulic gradient, under controlled conditions respecting flow speed, flow line and structure geometry to meet the fish's intrinsic needs without causing excessive fatigue (Martins, 2000).

There are, basically, the following types of FTS: ladder, elevators, sluice, water transport and other alternatives (MARTINS, 2000).

3.4.1 Fish Stairs or Successive Basins

The international denomination for this type of FTS is "fishway", "fishpass", or "fishladder" (MARTINS, 2000).

The fish ladder is chosen more frequently for the small hydroelectric plants and dams, due to its amplitude of attending different species. It is considered the most suitable device for migratory species (SANTO, 2005).

Designed to allow upstream to downstream travel, it can also be used in the reverse direction. In addition to fish, other organisms may use this type of passage, such as some aquatic mammals (SANTO, 2005).

Its operation basically consists of dividing the unevenness created by the dam into a series of reservoirs or tanks staggered sequentially in steps, creating a channel through which the fish can swim or jump from basin to basin. The steps have the purpose of dissipating the energy in a localized way and maintaining the water level in order to favors the rise of the fish with a reduction of fatigue (MARTINS, 2000).

3.4.2 Lifts for fish

These types of FTSs are called "fish lift" or "fish elevator". It consists of tank-buckets positioned in the downstream lake in a way to attract the fish operating in phases of transposition: the opening of the bucket for access of the species, lifting of the bucket with the fish, transportation and deposition of the fish upstream (MARTINS, 2000).

The elevator operates as a conventional lift. Its operation consists in attracting the fish to a compartment located downstream of the dam that is then raised upstream by a mechanical system, and this causes the fish to transpose obstacles without any effort. When the vessel reaches the top of the dam the fish are released into the reservoir. The efficacy of this device depends on the attractiveness at the entrance to the reservoir downstream of the dam (SOARES, 2012).

Still, according to Soares (2012), it is a device that works in cycles that can be divided into three phases:

- **Attraction phase -** where water flows through the catch tank that will take them upstream of the dam.
- **Elevation phase -** in which the lifting tank rises by rails to the upper part of the dam.
- **Fish exit phase -** the tank is tilted the fish are discharged directly into the reservoir or into a channel that will take them to a safe distance upstream, where they will find the best way to continue their migration.

3.4.3 Fish lock

It is a mechanical system that works with an interconnected conductor, upstream, in an appropriate way to attract the fish, operating in phases of transposition: closing of the exit and favoring the access of the species by the entrance, closure of the entrance, consequently entrapment of the fish; opening of the exit with flood of the enclosure and the passage of the species (MARTINS, 2000).

Fish are forced to rise through the elevation of the water level of a camera to which it was attracted; then open the gate that interconnects the chamber with the bayou and the fish are thus released. The operation of the locks should take into account that the time of the operating cycle is closely related to the number and species of fish to be promoted (S0ARES, 2012).

For Soares (2012), the phases of a lock are described as:

- **Attraction Phase**: where the top and bottom sluices are opened and water flows through the locking structure to attract the fish to the capture camera;
- **Filling stage**: where the inlet gate is closed and the water level in the lower chamber rises to balance with the upstream water level, forcing fish to swim to the surface;
- **Fish exit phase**: it starts when the lower sluice is partially open and the upper sluice gate manipulates

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an inflow of water to provide a flow of attraction for the fish to leave the chamber;

- **Emptying Phase:** Occurs when the top door is closed, allowing the camera to empty slowly, providing a new flow of attractiveness.

3.4.4 Bypass Channels

These types of passage resemble the natural attributes of the river, seeking to return the contact between the stretches of the upstream and downstream of the dam. This is why it decreases, usually 2 and 5%, where energy is dissipated through the rapids and the cascades arranged along the course of the water (SOARES, 2012).

For Santos (2005), they are suitable for all types of barriers, as long as there is sufficient space for their construction, and generally do not require changes in the dam. Because they are highly susceptible to variations in flow rates, gates are eventually constructed to maintain it inside the device.

According to Soares (2012), the advantage is that it gets integrated into the landscape, allowing the transposition of small fish and benthic invertebrates, creating new habitats as secondary biotopes for rheophile species; it is less prone to obstructions, which reduces maintenance, it is suitable for already built dams that do not have passage for fish, because normally no changes are necessary for the dam, they make possible for the migratory species to avoid almost the whole area of the reservoir, from the foot of the dam to the limit of the reservoir. However, there is a large demand for surface area, with fairly long channels, sensitive to flow variation, deep cuts may be required in the surrounding terrain.

3.5 FTS LEGISLATION IN BRAZIL

In 1982, the General Assembly of the United Nations, in resolution 37/7, known as the World Charter for Nature, recommends principles 2 and 4 (BRAZIL, 2016)

The genetic viability of the Earth should not be compromised, the population levels of all life forms, wild and domesticated, must be at least sufficient for their survival, and for this purpose habitats need to be safeguarded.

4. Ecosystems and organisms, as well as land, and marine atmospheric resources that are used by man should achieve and maintain optimum sustainable productivity, but not in a way that jeopardizes the integrity of other ecosystems or species with which they coexisted.

The first Law that regulates fish transposition devices is the São Paulo State Law No. 2,250, of December 28, 1927, which establishes in Article 16 measures related to hunting and fishing in the territory of the State

***Article 16.** - All who, for any purpose, dam the waters of the rivers, streams and streams are obliged to build ladders that allow the free rise of the fish.*

***§1.º** - These ladders shall be built through projects approved by the Agriculture Secretariat, which shall supervise their construction with the Animal Industry Board of Directors.*

***§ 2°** - Failure to comply with the provisions of this article shall be punished by a fine of 1: 000 $ 000, which shall be increased to double if the delay in the construction of the stairs exceeds three months counted from the subpoena by the Secretariat of Agriculture. "The fine will be applied every three months until the stairs are built.*

This Law determines the construction of fish ladders in all the impoundments, but without the proper technical knowledge.

For Soares (2012), this was determinant for many devices to be conceived in the wrong way causing many failures and raising doubts about the effectiveness of this type of device. Because of this generalization, fish ladders were mistakenly built up to falls up to 70 meters high, as in stream dos Negros (São Carlos-SP), or in streams where the ichthyofaunawas composed of only sedentary species.

CONAMA Resolution No. 001 of January 23, 1986, established one of the most important instruments of the National Environmental Policy, in which Law 6.938 of August 1981 made the Environmental Impact Study and the Environmental Impact Report mandatory. with potential environmental impacts. However, article 2, point VII presents:

VII- hydraulic works for the exploitation of water resources, such as: dam for hydroelectric purposes, above 10 mw, sanitation or irrigation, opening of channels for navigation, drainage and irrigation, rectification of watercourse, opening of bars and mouths, transposition of basins, dikes;

In this resolution, it is noticed that the subject of FTS and, therefore, the ichthyofauna, were placed in the background since only the dams for the generation of power above 10MW deserve attention regarding the environmental impacts.

Article 20 of Decree 38.744 of April 10, 1997, says that the environmental licensing of new dams, reservoirs and dams for hydroelectric power plants requires the construction of elevators or ladders for fish that propitiate piracema.

In 1998, Law No. 4,630 of Minas Gerais, would make mandatory to implement ladders for fish in dams built in the waterway of the union domain; it was presented to the Chamber of Deputies and after being processed for six years it was filed (SOARES, 2012).

3.6 MIGRATION OF FISH

Numerous species of freshwater fish perform, throughout their life cycle, complex movements known as migration. The simplest migratory pattern consists of the periodic displacement of young and adult fish from one place to

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another, with a subsequent return to the origin or not. The most complex migratory patterns include displacement to a third or fourth site. Reproductive migration consists of displacement between two sites for reproductive purposes, and trophic migration is for food purposes (POMPEU, 2005).

Freshwater fish are classified in potamodromous when they migrate exclusively in freshwater. Diadromes migrate between sea and fresh water. The latter can be divided into catadromous when they live in freshwater and migrate to spawn in the sea, and anadromous when they live in the sea and migrate to spawn in freshwater (POMPEU, 2005).

In Brazil, migratory fish are more important for commercial and sportive fishing, mainly comprising species of the orders Characiformes (eg.Dourado, curimbatás and piaus), Siluriformes (eg.surubins, mandis and jaús), all of them potamódromas (POMPEU, 2005).

Migrating fish, that practice piracema, are extremely important. Curimbatá (*Prochilodusscrofa)*, has more than 30 species in South America and occupies about 50% of the fish stocks of the South American rivers. The famous Dourado (*Salminusmaxillosus)*, an important fish in regular and sports fishing and natural heritage of the Platinum Basin, weighing 30 kg and a length of more than 1.0 m (MARTINS, 2000).

The Madeira River is one of the main migratory routes for the diverse species of migratory fish that can travel from 50 to 5 thousand km to reproduce. This trip begins in the lower Amazon River, goes through Madeira and its tributaries to the headwaters of the Andes, Bolivia (SAE, 2016)

Important migratory fish participate in the economy of Rondônia, such as Bagre (large catfish), known as leather fish, and fish of scales, are of great importance for commercial fishing. These include Jaraquis, Curimatãs, Aracus and Pacus, with distribution in different extensions of the Amazonian rivers (SAE, 2016).

The piracema coincides with the summer rains, which begin in December. At that time, the fish swim against the stream to reach the head of the river and spawn. This is because in these headwaters the chances of survival of the fingerlings are higher (SAE, 2016).

The piracema can take up to 6 months and the fish are exhausted because of the obstacles they have to face. So, they become easy prey and many dies on the way. Those who survive, finished spawning, make their way back, alongside with the fingerlings, which seek the borders and calm waters to grow (SAE, 2016).

3.7 FISH SPECIES EXISTING IN THE MADEIRA RIVER AND THEIR IMPORTANCE FOR THE REGION

With 3 thousand km of extension, between the Andes mountains, in Bolivia, and the mouth of the Amazon River, Madeira is considered the river with the greater number of described species in the world. The diversity equates the number of species known throughout Europe, Oceania and Russia combined. In addition, current studies show that, alone, the river holds almost 20% of all known fish species on the continent (SAE, 2016).

The studies developed by the team of the company Santo Antônio Energy confirmed the existence of more than 970 species, out of a total of 3,000 species estimated for the entire Amazon basin. Some are rare and at least 40 were unknown to scientists. Considering the vocation for migration, these species are divided into 3 types: those of long migration (that search the Amazon estuary and then return); those of small migration (that circulate between the meadow and the channel of the rivers) and the typical fish ofmeadow and igapós, that do not migrate. Of the first case, there are Piramutaba and Dourada. From the second, Tambaqui, Pacu, Jaraqui and Curimatã. Among the fish that do not migrate are Pirarucu, Aruanã, Tucunaré and Piranhas (SAE, 2014).

The most common species in the Madeira River are Tambaqui (*Colossomamacropomum*), which can reach 90 cm in length and reach up to 30 kg; Pirarucu (*Arapaima gigas*), typical of the Amazon basin and Brazil's largest freshwater scale fish, measuring up to 2.10 m in length; Jatuarana (*Bryconamazonicus*), much sought after at sport fishing carried out in the region, being able to reach 1.0 m in length; Pintado (*Pseudoplatystomacorruscans*), is not native to the Amazon basin, however, its importance for Rondônia stems from fish farming (SAE, 2016).

Rondônia stands out as the largest producer of freshwater fish in the country. Fish farming is the fastest growing activity in the state in recent years. In the 2014/2015 harvest, it reached around 100 thousand tons, which corresponds to an increase of 400% compared to 2010. These fish are traded locally and also exported to other states. In addition, several riverside communities practice artisanal fishing for subsistence, recreational fishing is also a typical sport in the region (SAE, 2016).

3.8 MITIGATING AND PREVENTIVE MEASURES FOR THE PRESERVATION OF ICHTHYOFAUNA IN THE MADEIRA RIVER

According to Andrades& Canellas Energy S.A (2010), one of the most sensitive points in the construction of the Madeira River hydroelectric dams is the preservation of the ichthyofauna. At the time the Santo Antônio licensing was under discussion, the catfish preservation caused a national commotion and almost made the project unfeasible under pressure from public opinion. Santo Antônio Energy and Sustainable Energy in Brazil, owner of the Jirau plant, attacked several fronts. The work

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included the monitoring of the migration routes of the main fish species of the Madeira River. The idea is to measure possible changes in schools and fishing during the construction of the plant. The work included marking four thousand fish with identification tags and radio telemetry equipment.

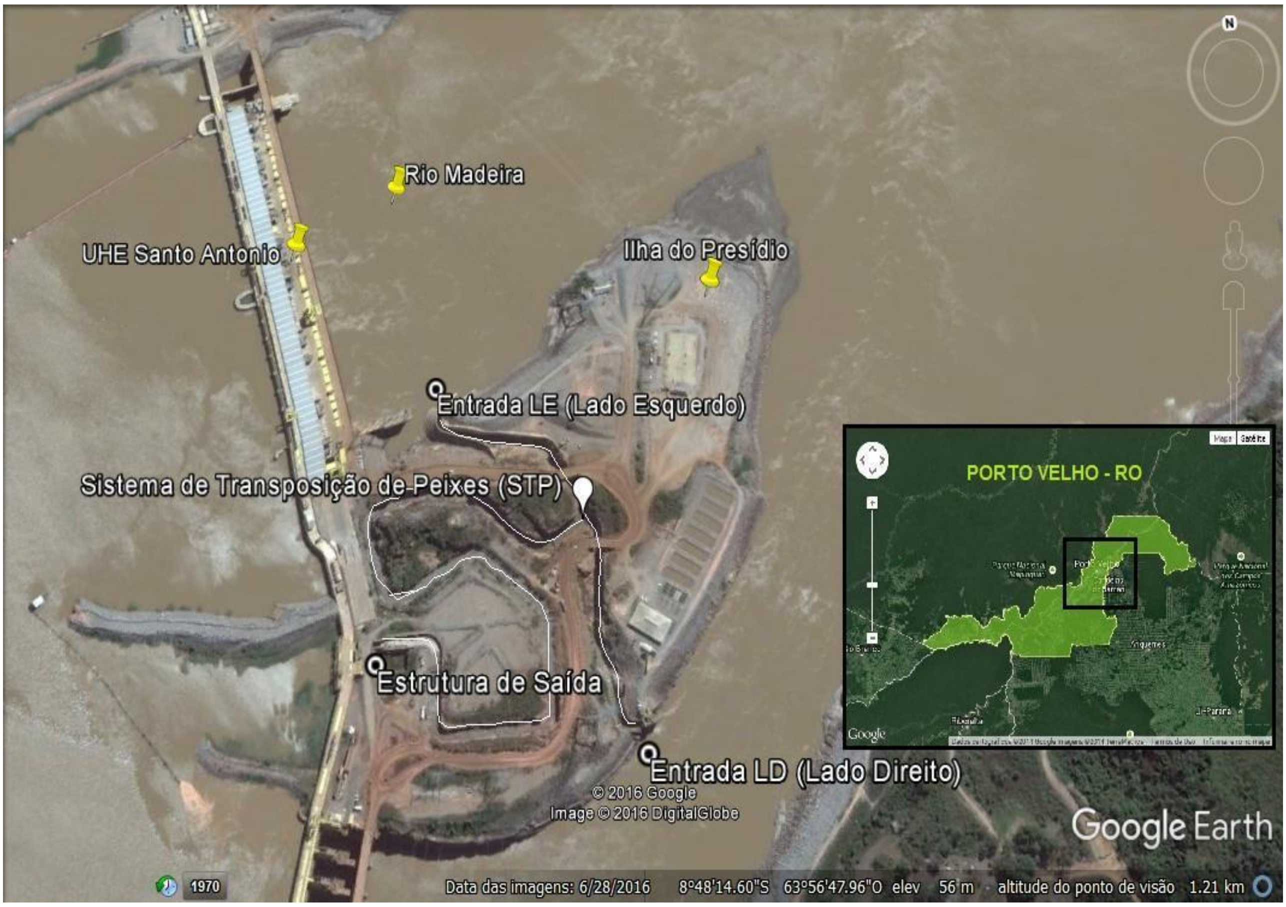
In addition to monitoring the migratory fish routes, the Santo Antônio plant constructed a fish transposition system to prevent their death if they were sucked by the adduction channel and passed through the turbines. The transposition system allows the fish to migrate upstream, passing the hydroelectric dam without the risk of dying. In Santo Antônio, R $ 120 million were invested in the fish transposition system. The system consists of the construction of a channel in which water velocity is regulated by gabions - a type of wire cage filled with stones - that make the water speed ideal for the passage of fish (Doria et al., 2012).

For the development of artificial reproduction and rearing techniques for the repopulation of migrating fish from the Madeira River, a contract was signed in 2013 between the Instituto Tecnológico Peixes do Brasil (ITPB), Project Pacu Aquicultura Ltda. (PP) and Santo Antonio Energy S.A. - SAE. The basic objective of the project is to research and develop breeding techniques for migratory fish from the Santo Antônio HPP insertion area, initially for Dourada (*Brachyplatystomarousseauxii*), Babão (*Brachyplatystomaplatynemum*) and Piraíba (*Brachyplatystomafilamentosum*). There is a program for the artificial creation of fingerlings of the species of catfish mentioned (dourada, piraíba, babão) that have a greater relevance. These fish are being captured and reproduced in a tank for a later release of the fingerlings in the Madeira river (SAE, 2016).

IV. METHODOLOGY

4.1 Studyarea

The study area was focused on the Fish Transposition System (FTS) of Santo Antônio Energia HPP. The structure that is located on the Ilha Do Presídio (prison island), near the right bank of the Madeira River in Porto Velho - RO has been in operation since December 2011, after filling the reservoir, it is about 900 meters long and ten meters wide in its main channel. The structure of the FTS is a fish ladder type. Pictures 01 and 02 consist of a corridor that reproduces the natural characteristics of the Madeira River waterfalls and the proportional flow similar to the river, adapting the fish to their natural habitat.



Picture 1.Satellite image showing the FTS of the Prison Island , with the downstream observed on the right of the image. Source: Google earth (2016).

Picture 2. Picture of one of the channels showing the FTS in the operating period.

Source: Authors of the research, 2015

The FTS of Prison Island (Picture 3) is a 2.5% tilt channel with two fish entrances located on both sides of the island, and a water/fish outlet located between the Complementary Spillway and the Group Generator 04 of Santo Antônio HPP. The FTS was mostly built on excavated rocks, and the stretches close to the entrance and exit are delimited by concrete walls. The passage of water through the sinks is given by a vertical groove in each of the sinks. In the entrance porches, there is a mitre-type gate for primary attraction control, and in the water outlet, there is a wagon-like gate that allows the channel to be drilled. The water outlet is protected by a grid of openings of 0.80 x 0.80 m which prevents the entry of logs at the same time as it allows fish out. The STP also has an additional attraction water system, consisting of two independent water intakes and a water diffuser system that will feed both intake arms (SAE, 2012)

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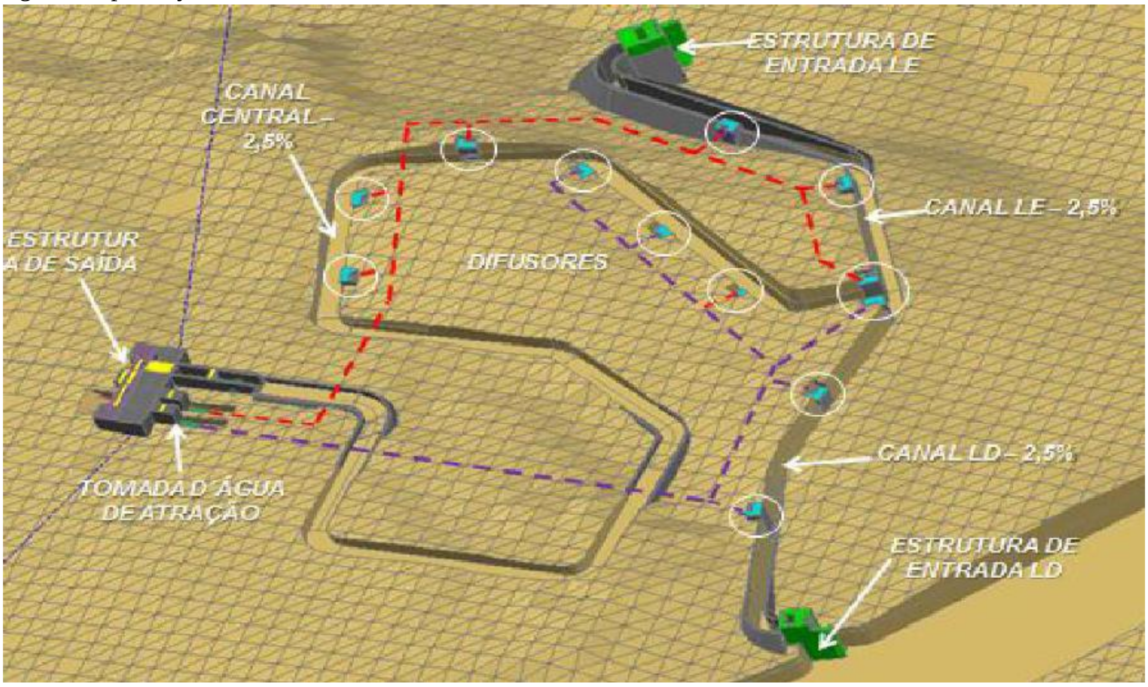

Figure 3. General arrangement of the STP of the island of Prison, in Santo Antônio HPP.

Source: SAE (2012).

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4.2 Materialsand procedures

The descriptive bibliographic review was defined as a methodology, since this method promotes the knowledge of the different scientific contributions about a certain theme, subsidizing support to all phases of the bibliographic research and any other type of research, helping to the define the problem, determine the objectives, construct hypotheses and justify the conclusions of the surveys (MARCONI; LAKATOS, 2010).

The research consisted of a retrospective study, with the bibliographic research method, supported by a quantitative approach. Technical reports on monitoring in a FTS on the Madeira River were analyzed.

The data collection was done through the main technical reports available on the website of the entrepreneur Santo Antônio Energia S/A - SAE and the Brazilian Institute of Environment and Renewable Natural Resources - IBAMA and related to the implementation of the FTS, namely the Environmental Impact Assessment Report / Environmental Impact Report (EIAR / EIR) and the Basic Environmental Plan (BEP).

4.3 Data analysis

Based on available documents on the environmental subprogram of the FTS (environmental report), available technical reports on FTS monitoring in the periods 2011 to 2014, accounting for 07 consolidated reports between monthly, quarterly and half-yearly. The collected data will be organized through tables and analyzed individually.

V. RESULTS AND DISCUSSION

5.1 Pre-operation analysis of the fish transposition system (FTS)

According to data presented by Santo Antônio Energy (SAE, 2016) for the beginning of the filling of the reservoir, SAE performed selective manual capture and transposition of the target species, while the Fish Transposition System was not yet in operation. The SAE submitted the final catch report from July 31 to December 5, 2011, which corresponds to the preoperative period of the Fish Transposition System (FTS) of the Prison Island. The specimens were captured 6 km downstream from the Santo Antônio dam and released upstream from the dam.

The report presents information on frequency, abundance and size class of the transposed target species. Among the orders, Characiformes abundance with 86.3% followed by Siluriformes (13.7%). The richness of Characiformes with 72.2%, Siluriformes with 27.8%. The data presented shows that the captured individuals of the order of Characiformes were adults, with more frequency in the last months of the year, whereas the Siluriformes were captured with a smaller class of sizes, being considered young specimens, mainly in the month of November / 2011 when the water level is highest on the Madeira River.

5.2 Operation analysis of the fish transposition system (FTS)

In compliance with conditions 2.27 and 2.28 of LO nº 1044/2011, the Fish Transposition System of the Santo Antônio HPP Prison Island started operating on December 1, 2011, on January 23, 2012, already operating with its normal quota (SAE, 2012).

After the starting the FTS, SAE undertook monitoring on January 12, 16 and 27, 2012, to identify which species were using the channel. The methodology used was the DIDSON sonar and a 5-meter diameter and 6.0-cm mesh between opposing nodes. The sonar identified the presence of fish in the canal, which was confirmed with the catches on the mesh. Table 1 represents 8 species of fish caught in the 4 slots during the sampling days.

Table 1. Species caught in the 4 slots during the sampling days in 01/2012.

ESPÉCIES	TOTAL
Lithodorasdorsalis	1
Pirinampuspirinampu	5
Sorubim lima	14
Pimelodusblochii	26
Pimelodinaflavipinnis	1
Sorubimicthysplaniceps	1
Calophysusmacropterus	5
Pseudoplatystomafasciatum	1
,	**54**

Source: SAE (2012).

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On 23/02/2012, the SAE realized a new experimental capture in the FTS. Thus according to Table 2, we obtained, as a result, the capture of 27 fish belonging to 10 species, present in the Transposition System as shown.

Table.2. Species captured in the FTS sampled in 02/2012.

ESPÉCIES	TOTAL
Lithodorasdorsalis	8
Pinirampuspirinampu	1
Sorubim lima	2
Raphiodonvulpinus	3
Prochilodusnigricans	1
Pimelodusblochii	3
Pimelodinaflavipinis	4
Calophysusmacropterus	3
Brachyplatystomavailantii	1
Psudoplatystomapunctifer	1
	27

Source: SAE (2012).

In all, 21 species were recorded in the FTS from January to June of 2012. Of these, only the golden fish (Brachyplatystomarousseauxii) was detected by radiotelemetry antennas and was not collected in the samplings.

The list of species and the months in which they were recorded in the FTS are shown in Table 1 (SAE, 2012).

Table 1. Species recorded in the FTS of the Santo Antônio HPP and its months of occurrence.

Scientific Name and Occurrence Months

January February March April May June July

*Arcanthicus*sp.
Brachyplatystomaplatymenum
Brachyplatystomarousseauxii
Brachyplatystomavaillantii
Calophysusmacropterus
Duopalatinusperuanus
Hemisorubimplatyrhynchus
Hypophthalmusmarginatus
Pimelodinaflavippinis
Pimelodusblochii
Pinirampuspirinampu
Platysilurusmucosus
Prochilodus nigricans
Pseudostegophilusnemurus
Pseudoplatystomapunctifer
Pseudoplatystomatigrinum
Pterodorasgranulosus
Rhaphiodonvulpinis
Sorubimelongatus
Sorubimichthysplaniceps
Zungarozungaro

Source: SAE (2012).

The reports presented for the first semester of 2012, demonstrated the capture methodologies used for monitoring, with nets of 5-meter diameter and 6.0cm to 6.5cm mesh between opposing nodes and waiting nets with 25 meters in length, 3 meters in height and 18 mesh. Catches with the aid of a boat, four fishing rods and natural baits, in the drowned part downstream in the FTS. In addition to sonar use (DIDSON). Biometric and telemetric measurements were also taken.

According to the reports, during the monitoring in May / 12, trapped and dead fish were observed between baffles 17 and 32, as there are screwing points on both sides of the FTS and fast water flow. The loss of rocks from the deflectors opens space for entry and entrapment of fish. In the June / 2012 report, it was evidenced that the flow is a

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variable that influences the increase or decrease of fish attraction in the FTS. The graphs suggest that at high flows, provided by the Madeira river, catches are more effective (IBAMA, 2012).

The annual consolidated report of 2012 presented by the SAE shows, in all, 49 species that have been registered in the FTS since January 2012. The species registered inside the FTS through experimental fisheries or radiotelemetry are shown in Table 2.

According to the consolidated technical report of 2012, SAE cites as main results

- All 49 species recorded in the FTS have rheophilicbehaviour. Most have migratory behaviour known to the species or closely related species.
- Of the 48 species caught in the experimental fisheries, 08 were caught in all petrichor, 11 exclusively with pots and 02 with hooks. Gillnetshad no exclusive species;
- From the beginning of the radiotelemetry technique tests for fish of the Madeira River, 292 individuals, most belonging to the species of Dourado(B. rousseauxii) and Babão (B. platynemum), were marked. Another 98 individuals shall be marked before the end of the high-water season. Considering that the batteries of the radio transmitters are still within the useful life, 380 individuals will be monitored by the program;
- The Dourado fish (Brachyplatystomarousseauxii) was detected only by radiotelemetry antennas and was not collected in the samplings. There are monthly records of incursions of individuals of this species in the initial stretch of the FTS channel since May, being detected only by the first two antennas connected to base 0800. In recent months, however, these individuals were detected upstream by the third base antenna 0800 and approaching the antenna detection zone of base 0910; The Babão*(B. platynemum*) and piramutaba*(B. vailantii*) were not detected by radio telemetry antennas, but were collected by the waiting nets and trays within the FTS channel near the exit. These species were also monitored with radio transmitters, but fewer individuals were tagged, compared to the golden fish *(B. rousseauxii)* and filhote (*B. filamentosum*).
- The decision to mark a lower number of individuals of the species Babão*(B. platynemum*) and piramutaba (*B. vailantii)* is due to the smaller size of these individuals, which allows them to be captured using standardized samplings (nets and pots). On the other hand, more specimens of dourada (*B. rousseauxii*) and Filhote (B. filamentosum) - large species that are difficult to capture in experimental fisheries - can be marked by radio telemetry monitoring. At present moment, however, the efforts of marking new individuals are concentrated in the target species of the monitoring: Golden fish (B. rousseauxii) and Babão (B. platynemum);
- In addition to the individuals detected inside the FTS, individuals of Dourada (B. rousseauxii) and Filhote(B. filamentosum) are frequently detected in the entrance of the FTS and in the Escape Channel of the Power House 01, to where the right margin entrance of the FTS is located. This indicates that individuals were able to find the way to the System;
- 02 individuals tagged with radio transmitters and 36 with hydrostatic markings (LEA) were captured by amateur or professional fishers, who returned the marks to the monitoring team along with data on the fish and capture site. Most of these recaptures occurred downstream, some more than 70 km from the release site. All fish marked during manual transposition were recaptured less than 1 year from the release date, with approximately 90% being caught less than 03 months after the release upstream.

Table 2. Species recorded in the FTS of the Santo Antônio HPP, in the Prison Island, from January to December of 2012.

Sort	Family	Species
	Anostomidae	*Leporinustrifasciatus* *Rhytiodusargenteofuscus* *Schizodonfasciatus*
	Characidae	*Triportheusangulatus* *Triportheuselongatus* *Bryconamazonicus*
	Curimatidae	*Potamorhinaaltamazonica* *Potamorhinalatior* *Psectrogaster*sp.
Characiformes	Cynodontidae	*Cynodongibbus*

		Hydrolycusscomberoides *Rhaphiodonvulpinus*
	Hemiodontidae	*Anoduselongatus* *Hemiodus*sp
	Prochilodontidae	*Prochilodusnigricans*
	Serrasalmidae	*Colossomamacropomum* *Mylossomaaureum* *Mylossomaduriventre* *Piaractusbrachypomus* *Serrasalmusrhombeus*
Clupeiformes	Pristigasteridae	*Pellonacastelnaeana*
Perciformes	Cichlidae	*Chaetobranchusflavescens*
Siluriformes	Cetopsidae	*Cetopsis candiru*
	Doradidae	*Oxydorasniger* *Pterodorasgranulosus*
	Loricariidae	*Acanthicus*sp. *Panaque*cf.*bathyphilus* *Squaliformaemarginata*
	Pimelodidae	*Brachyplatystomaplatynemum* *Brachyplatystomatigrinum* *Brachyplatystomarousseauxii* *Brachyplatystomavaillantii* *Calophysusmacropterus* *Duopalatinusperuanus* *Hemisorubimplatyrhynchos* *Hypophthalmusedentatus* *Hypophthalmusmarginatus* *Leiariusmarmoratus* *Phractocephalushemioliopterus* *Pimelodinaflavipinis* *Pimelodusblochii* *Pinirampuspirinampu* *Platynematichthysnotatus* *Pseudoplatystomapunctifer* *Sorubimelongatus* *Sorubim lima* *Sorubimmaniradii* *Zungarozungaro*
	Trichomycteridae	*Pseudostegophilusnemurus*

Source: SAE (2012)

According to the second consolidated report of 2012, the results of the monitoring presented makes it clear that migratory species were present throughout the FTS, although the presence of species along the PTS does not guarantee that they will complete the FTS crossing to reach the reservoir. In this sense, it will be necessary to adopt more effective monitoring measures to verify their passage to the reservoir. Another concern is the target species mentioned in the PBA and IBAMA conditions such as Dourada, Babão and Piraíba, which were not registered in any of the monitoring campaigns in the first year of operation of the FTS.

According to the other semiannual technical reports from 2013 to 2014, SAE cites as main activities and results:

- Continuation of the telemetric monitoring of the fish movement in the surroundings of the HPP and the passage to the FTS through the fixed bases and antennas in boats;
- Evaluation of the presence of fish in the FTS and surroundings with the aid of echo sounder (DIDSON);

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- Recordings of the movement of Bagres (catfish) in front of different structures of the HPP. As the mines were removed and the water reached the new structures, it was possible to observe the exploratory behaviour of the tagged fish that, after a time, began to make regular use of the area;
- Recorded tagged fish remain mostly in the downstream area, and have not left the area downstream or upstream. Most of the records occurred in the mobile tracking downstream stretch, which covers the area from 2.0 km to 10.0 km downstream of the bus;
- In the months of February and March 2014, no downstream mobile telemetry monitoring was performed due to the risks caused by the flood;
- Due to the large flood in the Madeira River that connected the lower section of the FTS to the channel of escape over the channel wall, no experiments of individuals release marked inside the channel were performed;
- There was a return of fish marks, captured by professional fishermen active in the region;
- There were fish rescues carried out in the upper section of the FTS after the preventive closing of the channel, due to the possibility of an order from the National Electric System Operator (ONS) to lower the NA of the reservoir to levels that would not allow water intake through the canal, which would eventually dry up. Aiming at the protection of the ichthyofauna that makes use of the stretch, and that would end up imprisoned in places without water if the water intake of the FTS was interrupted, controlled draining and rescue of fish was carried out (in the first 330m of the canal). From March 06 to 08, 10-15 tons of live fish were released in the stretch downstream of the FTS, where the NA of the escape channel would guarantee water supply. The drainage revealed a big number of large individuals that were not captured during monitoring due to the selection of equipment, mainly Pirarara, Jaú, Surubim and Caparari species, and it was surprising due to the virtual absence of characiforms in the stretch. After confirmation that the order to lower reservoir would not be emitted by the ONS, the normal flow of the FTS was established with the removal of the protection nets. As soon as the nets were removed, a large school of Curimatãs was sighted in the FTS, easily distinguishable due to the behaviour of jumping out of the water when meeting the fast waters in the Gabion slits.
- Due to the large flood in the Madeira River, the deflectors that make up the structure of the canal were damaged and there was a great accumulation of sediment in the canal. Therefore maintenance was scheduled for the period of least interference on fish migration. After the recovery of the channel tests will be carried out on an experimental release of individuals, proposed in the recommendations of the report.

Fish retrieval was performed in the main FTS channel after closing and drainage for maintenance and cleaning after exceptional flooding. It is estimated that 192,900 kg of live fish were released upstream of the dam (with the exception of Piramutaba). The reduction of the attractiveness by the reduction of the flow inside the channel was aimed at reducing the quantity of fish to be rescued. This action reduced the catch of large individuals, who are not attracted by reduced flows compared to the attractiveness of the spillways. Thus mostly medium and small specimens were collected.

According to SAE (2015), the monitoring of the Fish Transposition System of the Prison Island is carried out through radiotelemetry, by experimental fisheries and through the results of rescue activities carried out to prevent the interruption of the water flow due to the exceptional flood occurred in 2014 or for maintenance of the baffles that make up the channel.

With the use of all these methodologies, from January 2012 to December 2014, 65 species of fish have been recorded in the FTS. 85% of the registered species present rheophilic behaviour, being migrators of long or short distance. Only Dourada (Brachyplatystomarousseauxii) was detected exclusively by radiotelemetry antennas, not being collected in the samplings nor in rescue activities (SAE, 2015).

According to SAE's Consolidated Report of 2014, the monitoring of Migratory Fish with Telemetry in the Fish Transposition System of the Prison Island and in the Madeira River downstream of Santo Antônio HPP, 266 individuals were marked with transmitters (SAE, 2015).

In the fixed bases, it was possible to register 212.815 valid detections of 28 individuals of the Dourada, Filhote, Babão, Jaú and Surubim species, downstream of the dam or at the entrance and lower section of the FTS. A total of 903 positions of 51 individuals were registered downstream of the UHESA dam with the use of mobile tracking. Of the 51 individuals detected in the mobile tracking, eleven were also detected in the fixed bases along the UHESA dam. Although there is no record of output per amount of tagged fish (other fish were recorded leaving the FTS upstream with DIDSON since 23/01/2012), the result shows that the fish were able to find the way to the FTS, despite the fact that only one of the inputs is operating (the other input will be operating from the downstream filling of the GG4 enclosure, foreseen for the second half of 2015) (SAE, 2015).

Between January and March 2015, 100 Douradas were labelled with radio transmitters and released downstream in two portions of the STP. Displacement data will be collected by May 2015 and results will be presented in the next consolidation report (SAE, 2015).

The objectives of the Fish Transposition Sistem Monitoring Subprogram are being met according to the analyzes and technical suggestions transcribed in the EIA / RIMA, PBA and IBAMA conditions for the Santo Antônio HPP regarding the conservation of the Madeira River ichthyofauna. The monitoring results show that up to now, some individuals of target species within the FTS and upstream of the dam have not been detected, suggesting that these tagged individuals were unable to climb into the transposition systemand transpose the bus, a partial inviability for migrating species of long distances as the orders Siluriformes and Characiformes, having as Madeira river migratory route for these species.

VI. CONCLUSION

According to the first consolidated annual report from 2012, presented by Santo Antônio Energia (SAE), corresponding to the first year of operation of the Fish Transposition System (FTS), in all, 49 species were recorded in the FTS through experimental fisheries or by radiotelemetry. A total of 292 individuals were identified, most of them belonging to the Dourado species (Brachyplatystomarousseauxii), considered as one of the target fish cited in the Basic Environmental Program (BEP). Individuals such as Dourada (B. rousseauxii) and Filhote (B. filamentosum) were frequently detected at the entrance of the FTS, where the entrance to the right margin of the FTS is located. Some target species, such as The Babão (B. platynemum) and the Piramutaba (B. vailantii), were not detected by radio telemetry antennas but were collected with waiting nets within the FTS channel, even near the exit. The results of the first year of monitoring presented evidence of some migratory species along the FTS.

The data presented through the reports from January 2012 to December 2014 have already registered 65 species of fish in the FTS, and 85% of the registered species have a rheophilicbehaviour, that is, migratory fish of long or short distance. Only the Dourada (Brachyplatystomarousseauxii) was detected exclusively by radiotelemetry antennas, not being collected in samplings nor in rescue activity as methodological forms of monitoring.

According to the technical reports consolidated by SAE, the goals for the monitoring of the FTS are being met according to the analyzes and technical suggestions transcribed in the EIA / RIMA, PBA and IBAMA conditions for the implementation of the Santo Antônio HPP in the Madeira River. However, the first results of the monitoring show that up to now, some individuals of target species within the FTS and upstream of the dam have not been detected, concluding that these tagged individuals are not able to overcome the transposition systemand transpose the bus, making this system at first a partial impossibility for species of long-distance migrating fish such as some Bagres of the Siluriform and Characiform Orders.

However, the use of hydraulic potentials for the generation of electric energy and the use of natural resources must be done in a harmonic way, in a way that one activity doesn't eliminate the possibility of the other. Nonetheless, the expansion of the hydraulic utilization of the Amazon Basin rivers in the construction of dams can change the life cycle of the ichthyofauna that uses the rivers as a migratory route for its displacement, essential for its feeding and reproduction, generating problems for the economy of the region around rivers and for the local ecological balance.

The costs of implementation, maintenance and analysis of the efficiency of installed mechanisms for the continuity of fish migration in rivers, such as FTSs, are insignificant in relation to the value of the electric energy generated, without changing the energy viability nor the operational costs of the hydropower plants projects. Therefore, it is an instrument that, well designed, can mitigate the impacts caused by dams on the local ichthyofauna.

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