Fish-Passage Facilities as Ecological Traps in Large Neotropical Rivers

FERNANDO MAYER PELICICE*‡ AND ANGELO ANTONIO AGOSTINHO†

*Graduate Course in Ecology of Inland Aquatic Ecosystems, Maringá State University, Maringá, Paraná, Brazil
†Department of Biology/NUPELIA, Maringá State University, Maringá, Paraná, Brazil

Abstract: *At present most of the large rivers of South America are impounded. Management plans historically have relied on the construction of fish passages, specifically ladders, to mitigate the impact of these waterway blockages on fisheries and biodiversity. Nevertheless, the design of these facilities is not ecologically sound and they are not monitored continually. Consequently, the real role of South American fish passages in fisheries and biodiversity management is unclear and the results of some studies suggest that ladders are problematic in fish conservation. We examined the characteristics and negative aspects of fish passages within a larger context and considered the notion that these facilities are ecological traps in some Brazilian impoundments. Four conditions are required to characterize a fish passage as an ecological trap: (1) attractive forces leading fish to ascend the passage; (2) unidirectional migratory movements (upstream); (3) the environment above the passage has poor conditions for fish recruitment (e.g., the absence of spawning grounds and nursery areas); and (4) the environment below the passage has a proper structure for recruitment. When these conditions exist individuals move to poor-quality habitats, fitness is reduced, and populations are threatened. To exemplify this situation we analyzed two case studies in the upper Paraná River basin, Brazil, in which the four conditions were met and migratory fish populations were declining. If passages work as ecological traps, regional fisheries will be in danger of collapse and conservation policies toward biodiversity will become more difficult and ineffective. The situation demands the closing of the passage in conjunction with alternative management actions to preserve system functionality, especially the conservation of critical habitats downstream and the restoration of damaged habitats in the region.*

Keywords: biodiversity conservation, dam, fish ladder, fishery management, migratory fish, South America

Instalaciones para el Paso de Peces como Trampas Ecológicas en Ríos Neotropicales Grandes

Resumen: *Actualmente, la mayoría de los ríos de América del Sur tienen represas. Históricamente, los planes de manejo han confiado en la construcción de pasajes para peces, específicamente escaleras, para mitigar el impacto de estos bloqueos sobre las pesquerías y la biodiversidad. Sin embargo, el diseño de estas instalaciones no es ecológicamente sano, y no son monitoreadas continuamente. En consecuencia, el verdadero papel de los pasajes para peces sudamericanos en las pesquerías y el manejo de biodiversidad no es claro, y los resultados de algunos estudios sugieren que las escaleras son problemáticas en la conservación de peces. Examinamos las características y aspectos negativos de los pasajes de peces en un contexto más amplio y consideramos la noción de que estas instalaciones son trampas ecológicas en algunos embalses brasileños, Se requieren cuatro condiciones para caracterizar a un pasaje para peces como una trampa ecológica: (1) fuerzas atrayentes que hacen que los peces asciendan por el pasaje, (2) movimientos migratorios unidireccionales (río arriba), (3) el ambiente arriba del pasaje tiene condiciones pobres para el reclutamiento de peces (e.g., la ausencia de áreas para el desove y para el cuidado de crías) y (4) el ambiente abajo del pasaje tiene una estructura apropiada para el reclutamiento. Cuando estas condiciones existen, los individuos se mueven a hábitats de baja calidad, se reduce la eficiencia biológica y las poblaciones están en riesgo. Para ejemplificar está situación, analizamos 2 estudios de caso en la cuenca alta del Río Paraná, Brasil, en el que se cumplían las*

‡*Current address: Bloco H90, 5790, Avenida Colombo, Maringá, Paraná, 87020-900, Brazil. 87020-900, email fmpelicice@gmail.com*
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4 condiciones y las poblaciones de peces migratorios estaban en declinación. Si los pasajes funcionan como trampas ecológicas, las pesquerías regionales estarán en peligro de colapsar y las políticas de conservación se tornarán más difíciles e ineficientes. La situación demanda el cierre del pasaje conjuntamente con acciones de manejo alternativas para preservar la funcionalidad del sistema, especialmente la conservación de hábitats críticos río abajo y la restauración de hábitats dañados en la región.

Palabras Clave: América del Sur, conservación de la biodiversidad, escalera para peces, manejo de pesquerías, peces migratorios, presa

Introduction

The impoundment of rivers is a major practice in South American hydrographic basins, especially for the production of electricity. At present practically all large basins are impounded or influenced to some degree by dams and reservoirs. Recent surveys estimate there are more than 700 large reservoirs in Brazil alone (Agostinho et al. 2007*a*).

These dams intercept migration routes used by several fish species (Petrere 1996; Agostinho et al. 2005). Long-distance migratory fishes are known to migrate several hundred kilometers to complete their life cycle, traveling among different basins toward suitable habitats for spawning, usually in sediment-loaded headwaters (Carolsfeld et al. 2003). As has occurred with other migratory fish species around the world (Larinier & Marmulla 2004), the blockage of migration routes has obstructed access to particular habitats that are paramount to specific life stages, and this may reduce population recruitment. For example, although impoundments favor the spread of sedentary and non-native species (Agostinho et al. 2007*a*), migratory fish populations have declined markedly (Petrere et al. 2002; Freeman et al. 2003; Agostinho et al. 2005; Okada et al. 2005).

In Brazil authorities are concerned about the consequences of the blockage of migration routes on fisheries, and they have taken measures to address the problem (Agostinho et al. 2004*a*). The building of fish passages, specifically fish ladders, has become popular among technicians, politicians, and the general public. As a result, many Brazilian dams are equipped with ladders and other such facilities, copying strategies used to manage salmon populations in North America and Europe (Larinier & Marmulla 2004). There is great pressure from the public and government agencies to install new fish passages in Brazilian dams and in some states their installation is mandatory.

Although the impoundment of rivers has changed the structure of Neotropical ichthyofauna in remarkable ways (Petrere 1996; Freeman et al. 2003; Agostinho et al. 2007*a*), fish passages have not worked as managers intended. Their construction in South America is not based on ecological science and fish-monitoring programs quantify only those fishes present inside the ladder. As a result there has been no rigorous technical assessment for almost a century and few have studied the role of ladders in fish conservation programs. Initial results suggest that ladders fail to preserve fish migratory patterns in several key ways and may be damaging Neotropical migratory fishes (Agostinho et al. 2002). The negative impacts of the unidirectional flow of individuals (upriver), the strong species and numerical selectivity, the high predation pressure throughout the ladder, and mainly the impoverishment effect (genetic and demographic) on stocks from below the dam are reasons to reassess the value of fish passes and doubt their beneficial role in fishery management programs (Oldani & Baigún 2002; Agostinho et al. 2004*a*; Fernandez et al. 2004; Agostinho et al. 2007*b*, 2007*c*; Makrakis et al. 2007).

We combined some of the characteristics and negative aspects of fish passages within a larger context and examined the notion that these facilities can work as ecological traps in some South American impoundments. An ecological trap is a habitat with poor conditions for feeding, cover, and reproduction that is chosen by organisms even though there are better habitats available. Consequently, the fitness of individuals living in an ecological trap is decreased (Schlaepfer et al. 2002; Battin 2004). Poor-quality habitats may be chosen because some of their cues, recognized by organisms when assessing habitat quality, are modified to increase attractiveness, usually as a consequence of human influences (Robertson & Hutto 2006). We determined the conditions under which fish passages develop into ecological traps. We show how the attractiveness of passages in areas below the dam, together with the unidirectional flow of individuals upriver and the environmental characteristics that surround the impoundment, may lead fish populations to poor-quality habitats beyond the fish passage (i.e., the reservoir). To illustrate this process we examined two case studies of fish passages in two Brazilian basins in which the necessary conditions were met. Attaching an ecological concept to the fish-passage puzzle may help determine the conservation role of existing facilities and guide the installation of future passages in the Neotropics.

Ecological Traps and Fish Passages

To understand the interaction among dams, passages, and ecological traps it is important to understand the requirements of Neotropical migratory fishes. Because the dynamics involved are described elsewhere (Carolsfeld et al. 2003), we present only briefly some key aspects. Migratory fishes travel long distances during the reproductive season in search of habitats suitable for spawning and the development of young. The movement is mostly upstream and coincides with the wet season, when the hydrometric level is increasing. After spawning, which usually occurs in the confluence of small tributaries, adults drift or migrate back to their downstream habitats in main rivers. Eggs are then carried by sediment-loaded currents and gradually develop into larvae. In lower reaches they drift into protected habitats, usually marginal lagoons and backwaters, taking advantage of the increased water level. These environments become connected with rivers in times of flooding and they are crucial for young fish development because they provide adequate shelter and food. Floodplains also have a special role because lagoons, channels, and backwaters are common, and the regularity of seasonal flooding increases the chance of successful reproductive events. Juvenile cohorts develop within these marginal lagoons for 1–2 years until they ingress into adult populations (recruitment).

During reproductive migration the presence of a dam constitutes an insurmountable obstacle for upstream movement. It has been demonstrated, however, that fish passages can partially connect stretches of rivers fragmented by dams, although aspects of their efficacy are still obscure (Agostinho et al. 2002). Fish passages have caused unexpected impacts on fish populations (Agostinho et al. 2002; Agostinho et al. 2004*a*), and the combined effect of some characteristics and negative aspects may cause these passages to develop into ecological traps. But when do fish passages become ecological traps? Not all such facilities are. Roberttson and Hutto (2006) suggest three conditions under which ecological traps occur. One of these is that the habitat is not conducive to survival and reproduction, but cues exist that make the habitat attractive. Following this rationale we devised a framework in which four conditions must be met to characterize passages as ecological traps for fish. The following ideas apply especially to Neotropical migratory fishes because of their particular behavior and life-history patterns (Carolsfeld et al. 2003).

First, there must be attractive forces leading fish to ascend the ladder, that is, the facility has to actually pass fish upstream. Fish are less likely to ascend a passage if it is located near tailwaters, influenced by spillway releases, or if the water quality is poor. Such difficulties can be overcome if they are considered before a management plan is implemented (Larinier & Marmulla 2004). In addition, passages simulate environmental conditions similar to natural physical cues that guide fish under migration, such as water flow and turbulence (Larinier & Marmulla 2004). Because fish normally crowd below dams, the water flow produced by ladders usually works as an effective attractor.

Second, fish transference needs to be primarily unidirectional. Once fish have passed into the reservoir they hardly ever return to downstream reaches. The one-way movement (upward) is a major feature of fish passages constructed in South America, largely due to behavioral aspects of migratory species (Gomes & Miranda 2001; Agostinho et al. 2002; Agostinho et al. 2007*c*). For example, migratory fishes are strictly reofilic (riverine) and tend to avoid lentic stretches of large reservoirs. When they get into the reservoir, with the exception of those who immediately return downriver through turbines and spillways, they travel swiftly toward upper lotic areas (Antonio et al. 2007).

Third, environments located above the dam must have poorer conditions for fish recruitment, such as the absence of spawning grounds and nursery areas. Impoverished habitats are created, for example, when reservoirs are connected in a series and fish become trapped in stretches without tributaries. In this case fish ascending the lower ladder migrate upstream toward the next dam. If this obstacle lacks passage facilities, fish crowd together at the base of the dam and reproduction cannot occur. Alternatively, reservoirs may permanently flood marginal lagoons or stabilize the seasonal water-level dynamics, which decreases hydrological connectivity. In this case adult fish may travel to tributaries and successfully spawn, but larvae and juveniles do not have access to critical habitats for development (Agostinho et al. 2007*c*).

The fourth condition is the presence of spawning grounds and nursery areas below the dam. In this situation the region below the impoundment has a proper structure for fish recruitment in which fishes avoid the dam and stay downstream. The flexibility of the migratory behavior of some South American species is exhibited in their ability to use tributaries located below the dam (Sato et al. 2005; Godinho & Kynard 2006; Antonio et al. 2007). Once these pathways are found, migration is carried on toward other upper stretches. Therefore, if populations are removed from these good-quality areas and transferred to the reservoir, the probability of successful reproduction and recruitment decreases.

Combined, these four conditions create fish passages that work as ecological traps (Fig. 1). Fish are given incentive to pass facilities by a competitive flow velocity. Once they successfully pass to the reservoir, it is unlikely they will make their way back. The inferior quality of habitats located above the dam, compared with those below the impoundment, reduces individual fish fitness; fish either cannot spawn or their young cannot reach adequate habitats for development. As long as the ladder remains operational fish populations will be inclined to select poor-quality environments.

Declines in migratory fish abundance may occur due to different disturbance sources (e.g., non-native species,

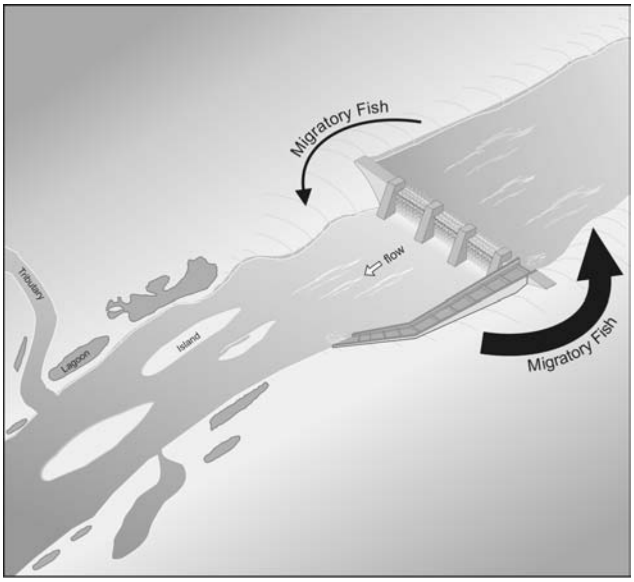

Figure 1. Illustration of how fish passes work as ecological traps in impounded rivers. The region below the dam is characterized by a high diversity of habitats, but the region above lacks critical environments. Fish that pass to the reservoir hardly ever return to areas downriver (arrow size suggests the amount of fish that pass), which ultimately decreases individual fitness.

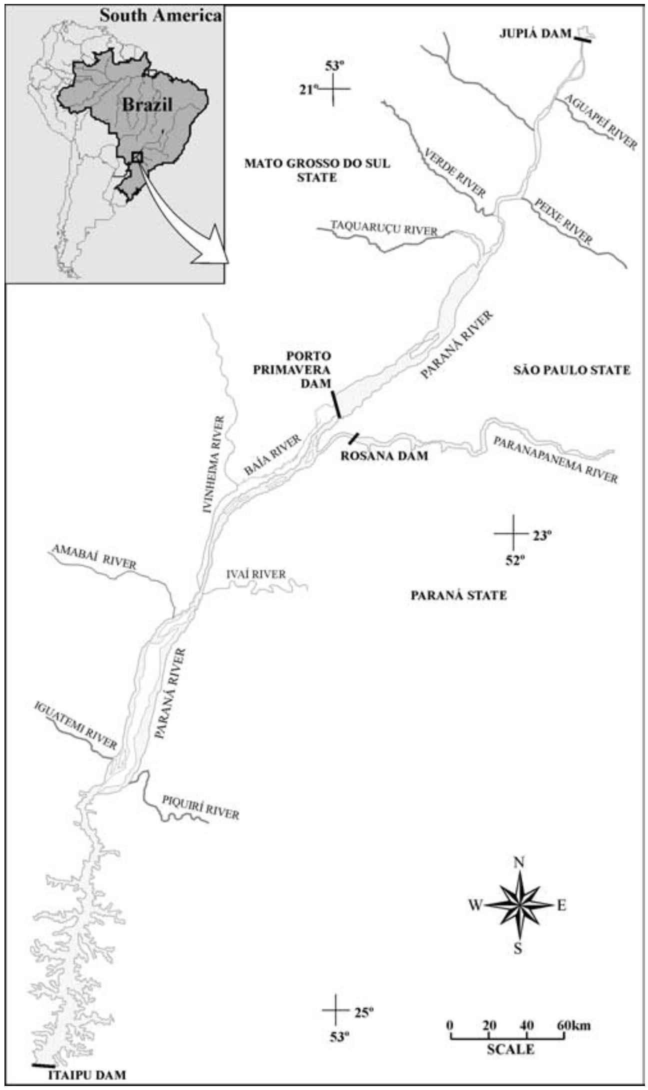

Figure 2. The area influenced by Porto Primavera Dam and the floodplain located downstream (between Primavera Dam and Itaipu Reservoir) in the upper Paraná River basin.

overfishing, damming), but we expect some particular trends when passages work as ecological traps. The most important indication is the annual absence (or low abundance) of migratory fish eggs, larvae, and young in some stretch above the dam and a repeated arrival of reproductive adults. Another indicative pattern is the gradual decline of adults and new recruits in the good-quality environment (downriver) and progressive, but not permanent, increases in fish abundance in upper regions of the reservoir. Another expected trend is a gradient of declining abundance of eggs and larvae along the reservoir, from upper stretches to the dam, which suggests that adults are spawning in headwaters, but eggs and larvae are lost before reaching lagoons (Agostinho et al., 2007*c*).

Ecological Traps in South American Waters

There is a lack of appropriate data with which to explore this perspective, but we gathered some evidence to demonstrate how fish passages can work as ecological traps. We examined two areas—Porto Primavera Dam and a series of hydroelectric impoundments on the Paranapanema River—in the Paraná River basin, Brazil, the second largest river basin in South America and the one most affected by hydroelectric impoundments.

PORTO PRIMAVERA DAM

The Porto Primavera Dam is located in the upper region of the basin between the Jupiá and Itaipu reservoirs (Fig. 2) and was completed in 1998. The impoundment blocked the main course of the Paraná River and flooded 2250 km^2, which permanently submerged the floodplain area that existed along the western margin of the river (originally this floodplain extended more than 400 km). As a result, a diversity of habitats was lost including backwaters, channels, and lagoons with differing degrees of hydrological connectivity.

The remnant region below this impoundment is the longest stretch of river free of dams in the upper Paraná basin (Fig. 2). It extends 230 km into the upper regions of the Itaipu Reservoir. Although heavily influenced by flow regulation and nutrient and sediment retention imposed by Porto Primavera and other reservoirs upstream (Agostinho et al. 2004*b*), the region downstream still has its original floodplain ecosystem, which includes, among the mentioned habitats, several sediment-loaded tributaries (Fig. 2). Seasonal floods (October–March) temporarily connect all these habitats and homogenize abiotic conditions, offering a pathway of dispersion for the biota (Thomaz et al. 2007).

Many large migratory fishes, such as the dourado (*Salminus brasiliensis*), pintado (*Pseudoplatystoma corruscans*), piracanjuba (*Brycon orbignyanus*), pacu (*Piaractus mesopotamicus*), and curimba (*Prochilodus lineatus*), use the region for spawning and nursery grounds. The main tributaries used as spawning grounds include the Ivinheima, Iguatemi, Piquiri, Ivaí, and Amambai rivers (Baumgartner et al. 2004; Nakatani et al. 2004). After spawning in headwaters, larvae drift down to floodplain habitats, especially the lagoons that remain isolated during dry seasons (Agostinho et al. 2004*b*). The region is so vital for the maintenance of harvestable fish and biodiversity that protected areas and a state park were created. In addition, the loss of floodplain habitats above Porto Primavera Dam remarkably increased the conservation value of this remnant stretch.

A fish lift and an experimental ladder were constructed at the Porto Primavera Dam, and these became functional in November 1999 and October 2001, respectively (CESP 2005). The facilities operate during spring and summer seasons, which coincide with the reproductive migration of several fish species. Since their construction more than 40 fish species have passed regularly from the floodplain area to the reservoir, including nonmigratory species (CESP 2005; Makrakis et al. 2007). Precise data on number and biomass transferred annually are not available, but large schools of migratory fishes have been reported within the facilities (CESP 2005). In the summer of 2007, for example, large schools of adults and juveniles were observed every day ascending the passages (A.A.A., personal observation).

Some tributaries occur above the dam and are located in the upper region of the impoundment (e.g., the Taquaruçu, Pardo, Aguapeí, Peixe, and Verde rivers). The closest tributary is 120 km away from Primavera Dam, yet some migratory fishes travel this distance just after passing Primavera (Antonio et al. 2007). The presence of these rivers, however, does not assure successful reproduction. Studies conducted in areas above Porto Primavera Dam have failed to detect spawning grounds and nursery areas used by migratory species (CESP 2000; Vilela 2001). Surveys of fish eggs and larvae indicate low reproductive activity of migratory species in these tributaries (CESP 2000). Practically all larvae captured were from sedentary or resident species. Similarly, in samples taken in remnant lagoons few juvenile fishes were caught (Vilela 2001), and the fishes were primarily small species. These lagoons served as nursery grounds before the closure of Porto Primavera Dam, the same role played by lagoons and backwaters located in the remnant floodplain area (Agostinho et al. 2004*b*). Therefore, these results suggest that recruitment is now lower in the region above the dam. For some reason adult fish are not using these tributaries to spawn or young are not able to access these marginal habitats. Further studies are needed, but in comparison with reproductive dynamics documented in the floodplain below Porto Primavera Dam, individual fish fitness is presumably lower in the artificially flooded area between Porto Primavera Dam and Jupiá Reservoir.

If specific studies dealing with fitness and recruitment support our narrative, the fish passages could be considered ecological traps because, on the basis of the few data we have, (1) fish that reach Porto Primavera Dam are regularly attracted by fishways, (2) except for those fish that immediately return thought turbines and spillways, all others tend to remain trapped between Porto Primavera and Jupiá (the latter does not have fish passes), and (3) fish are removed from high-quality habitats (floodplain) and delivered into low-quality habitats (reservoir). Because fish recruited in the floodplain have sustained important fishery activity for the entire region, including the Itaipu Reservoir (Okada et al. 2005), the continued operation of such facilities threatens the maintenance of fisheries on a regional scale. Extensive surveys throughout the region, including fish passes and areas above the dam, are needed to estimate the proportion of populations that are being removed from the floodplain area. We know that flow regulation imposed by Porto Primavera is already affecting migratory fish populations in the region (Agostinho et al. 2004*b*), so if a significant number of individuals pass through fish passages, these populations may reach dangerous demographic thresholds, making conservation policies more difficult and ineffective.

IMPOUNDMENTS ON THE PARANAPANEMA RIVER

The Paranapanema River, one of the main left-margin tributaries of the Paraná River, has a series of hydroelectric impoundments along its entire course. In the middle reaches, between Capivara and Salto Grande dams (Fig. 3), schools of large migratory fishes migrate every year during the reproductive season (Dias et al. 2004; Agostinho et al. 2007*a*). Even though the free-flowing stretch was only about 80 km long these populations were probably recruited annually within its reaches because the region has been impounded for more than 30 years and none of the dams have fish passages. In addition, important tributaries present near the riverine zone of the Capivara Dam, such as Tibagi, Congonhas, Capivara, Cinzas, and Laranjinha rivers, preserve lotic conditions that favor migratory species (Hoffmann et al. 2005) and probably act as spawning grounds (Dias et al. 2004).

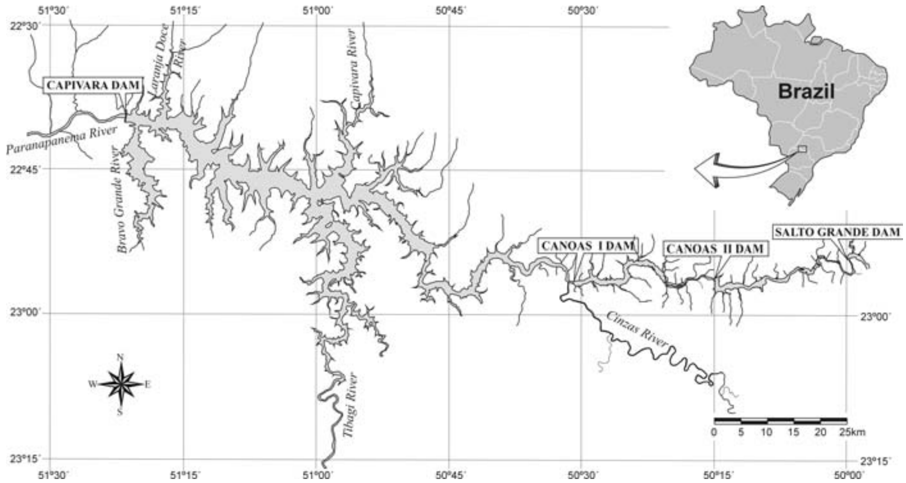

Figure 3. The cascade of reservoirs in the middle Paranapanema River, one of the main left-margin tributaries of the Paraná River.

In 1998 the construction of two other dams, Canoas I and Canoas II (Fig. 3), notably reduced the size of the free-flowing stretch that existed between Capivara and Salto Grande. These new impoundments cover an area without major tributaries because the larger ones became restricted to the area contained by Capivara Reservoir. Both Canoas dams are equipped with fish ladders that opened in 2000. In the summer of 2000–2001 schools of several fish species, mainly migratory, ascended the ladder in Canoas I, leaving the area influenced by the Capivara Reservoir. Soon after, these fish were observed in the ladder positioned in Canoas II Dam, ascending to the reservoir (Duke 2002). Concomitantly, a remarkable increase in fishery catches occurred just below Salto Grande Dam, a result of fish schools that migrated upriver and crowded below the dam. In the next summer (2001–2002), however, a lower number of migratory fishes were observed ascending the ladders, whereas fishery catches in Capivara Reservoir decreased (Duke 2002). In the following summers the number and biomass of transferred fish continued to decline in both ladders (Britto & Sirol 2005). Because the fishery below Salto Grande Dam sustained much higher yields after the ladders were opened, stocks from Capivara Reservoir are likely leaving the region and performing a one-way upstream movement (Lopes et al. 2007). A total of 42 fish species (7 migratory) were registered in the ladders, and more than 10,000 fish were sampled ascending each facility in the reproductive season of 2001 and 2002.

There is no major tributary in the short extension (about 50 km) between Canoas I and Salto Grande Dam; thus, populations transferred by ladders may have difficulty recruiting their young. In addition, these stocks have been intensely and illegally fished below Salto Grande Dam (Duke 2002). Considering that important tributaries are in the area contained by Capivara Dam, populations of migratory species have historically persisted in this area, and the stretch above Canoas I Dam lacks such critical habitats, it is very likely that fishes are being passed to lower-quality environments. In addition, eggs, larvae, and juveniles of migratory species have not been registered in the region above Canoas I Dam (Britto & Sirol 2005; Lopes et al. 2007). On the basis of these findings, it seems likely that these ladders are working as ecological traps. Existing information indicates that (1) the ladder in Canoas I actively attracts fish schools from Capivara Reservoir, (2) the fish flow is unidirectional and upstream, and (3) there is no evidence suggesting that these fishes are reproducing in areas above Canoas I Dam (Duke 2002; Britto & Sirol 2005; Lopes et al. 2007). The effects of fish passages on populations and biodiversity of the entire region need to be evaluated quantitatively.

OTHER REGIONS

Although we lack appropriate data to infer the existence of ecological traps in other South American basins, two circumstances may favor their development. First, cascades of reservoirs constitute a special case in which the frequency of ecological traps is magnified because of the greater likelihood of entrapping fish between inhospitable river stretches. Therefore, ecological traps are more likely in intensely impounded basins that contain passages, such as the Uruguay, São Francisco, and Tocantins rivers, but especially tributaries of the upper Paraná River (Agostinho et al. 2007*a*). Second, ecological traps may appear when passages are installed in impoundments located in upper regions of the basin. For example, Manso Dam is located in the upper Paraguay River basin, above one of the most important floodplain areas of South America, the Pantanal biome (Junk et al. 2006). Migratory fish populations have declined in the reservoir (A.A.A., unpublished data), and the construction of fish passages in this case would lead migratory fish toward areas that lack critical habitats.

As for other continents most fish passages are in North America, Europe, and Asia. These facilities have been designed specifically to manage salmonid populations in that they successfully allow up and downward migration. Other diadromous species may have trouble migrating downstream and, depending on surrounding characteristics of the region, ecological traps may appear. For example, managers have developed fish passes that allow the upstream migration of eels (*Anguilla* spp.), but mortality is high when adults migrate downstream through hydroelectric stations (Feunteun 2001; Larinier & Marmulla 2004). Consequently, if eels ascend impounded rivers in the presence of alternative routes that are not dammed, passages would work as ecological traps.

In addition, the problem of downstream migration may be magnified when fish become disoriented after they have passed upstream and may then immediately return downriver through turbines and spillways (Antonio et al. 2007). These fishes may experience severe injuries or die (Larinier & Travade 2002), and in the case of high mortality rates in the dam, the choice to ascend a passage may lead fish to ecological traps.

Conclusions

We have attempted to show how fish passages, originally designed to conserve fish populations, may develop into ecological traps for migratory fish species in South America. The key point behind our thesis is the transference of populations from high-quality (riverine) to low-quality (reservoir) environments, a process that ultimately decreases individual fitness. Although we lack empirical data about trap effects on population levels, we predict that recruitment and population size will decline over time if ladders remain operational. These declines were evident in the Paranapanema River, where a significant proportion of fish populations have moved to poor-quality habitats. Regional fisheries may be in danger of collapse or subject to large shifts. In the end, declines in migratory fish diversity may cause severe changes in ecosystem functions and services (Freeman et al. 2003).

Some researchers stress the necessity of unambiguously determining the real meaning of ecological traps in nature (Battin 2004; Robertson & Hutto 2006). Only focused studies can determine if fish passages are creating ecological traps, but we have hypothesized how these facilities become ecological traps and suggest that such phenomena may be underway in some Brazilian rivers. For example, the observance of a permanent pattern of high abundance but low recruitment in some habitats, as seen below Salto Grande Dam, strongly suggests the existence of an ecological trap (Battin 2004). There are several difficulties that arise when trying to evaluate the prevalence of ecological traps in the real world and we agree with those who call for better-designed experiments (Battin 2004; Robertson & Hutto 2006). Nevertheless, a precautionary approach is needed when empirical evidence points to the existence of an ecological trap, even if the data are lacking to perform accurate tests.

Because most large South American Rivers are impounded in series, there is an urgent need to detect which fish passages are working as ecological traps. What is needed primarily is a thorough survey of spawning grounds and nursery areas in the entire stretch so that the presence and pervasiveness of ecological traps can be determined. Data on annual recruitment and the quantity of fish passed seasonally are also needed in conjunction with an assessment of fish stocks and reproductive dynamics. Once deleterious impacts due to trap effects are verified, what to do about the passages needs to be determined (i.e., control the number of individuals that pass or close the passage). The continued operation of ladders with trap effects is so damaging that it could endanger the success of other management actions, such as the establishment of protected areas (Battin 2004), as the cases of Porto Primavera and the floodplain strongly suggest. Thus, if a trap is identified, the situation demands closing the passage in conjunction with alternative management actions. For instance, operational procedures should be devised that help maintain natural hydrological connectivity and guarantee necessary floods in the downstream stretch. In addition, plans to restore and conserve critical habitats downstream and upstream, together with fishery control on these areas, may enhance fish recruitment.

To avoid creating ecological traps and other negative effects, fish passages should be built for the purpose of conservation and not simply as a bureaucratic formality (Agostinho et al. 2007*a*). Decisions of why, where, and how to install a fish pass must always be based on sound ecological information, and long-term monitoring and surveys are paramount after installation. Management plans need a large-scale approach and a deep understanding of the whole system, information that requires much effort and financial support. Passages cannot be managed in a trial-and-error fashion and cannot be based solely on the assumption that fish have to migrate. Proper management requires careful and regular financial support, planning, and understanding (Agostinho et al. 2004*a*).

The sequence of ladders on the Paranapanema River is damaging fish populations because the fish passages have been designed and managed without ecological advice, just to be in accordance with legal resolutions. Consequently, the government has been unable to legally authorize the closing of fish passages even though the negative environmental impacts are evident and recognized by all stakeholders (Duke 2002). The Brazilian government has, as have many other governments in developing countries, historically adopted programs that give primacy to economic development to the detriment of sound environmental protection. Conciliating both perspectives is not simple and often requires costly management measures, and the balance between these forces determines the conservation of a healthy environment.

Together with other severe shortcomings resulting from standard protocols historically applied to fishery management programs (Pauly et al. 1998; Birkeland & Dayton 2005), ecological traps have the potential to permanently affect fish stocks and biodiversity. Many migratory species that are affected by fish passages are charismatic and have been the most appreciated historically in artisanal, commercial, and recreational fisheries. These species have a high conservation value and may play a significant role in conservation programs (umbrella species; Agostinho et al. 2005). Consequently, the disassembling of ladders in which empirical evidence points to their negative effect on fish populations and overall biodiversity should be carried out promptly.

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