






# Dredging on water bodies and margin interventions: effects on fish\*

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## ABSTRACT

The urbanization process deeply affects rivers and streams, with numerous impacts, such as the discharge of sewers, dams, and pipework, causing profound changes in the water bodies characteristics and in their biota. In this scenario, the silting of rivers suffers one of the most impactful changes, as it undergoes a reduction in the depth and width of the rivers, triggering physical and chemical changes in the water, as well as in the structure of fish population, its feeding and reproduction habitats. As a palliative measure, it is normal to carry out the desilting (dredging) of rivers, an activity that is also very impacting. Floodings are one of the main factors that demand dredging to be carried out. This review was made to analyze desilting activities, their effects on biota and migratory fish, as well as to evaluate the best management strategies and mitigation of impacts on fish population. The shifting and removal of sediment from the riverbed can cause burial and massive death of eggs and larvae, in addition to interfering in the upward and downward migration of eggs, larvae, and adults of migratory fish. In addition, breeding and feeding sites can be impacted by sediment movement, dredging, and deposition. Some actions minimize the impacts of the silting activity recovering riparian forests, inspect the use of soil on the banks, move urban settlements away, assess the dredging site, consider the spawning sites and reduce the suspension of bottom sediments, as well as choose the best equipment and time for the performance of activities. Therefore, the development of research on the effect of dredging of water bodies on fish would contribute to a better management of the activity.

**Keywords:** silting; review; ichthyofauna; urban river; permanent preservation area.

## Dragagem de corpos hídricos e intervenções em margens: efeitos nos peixes

### RESUMO

O processo de urbanização afeta diretamente os rios e riachos com inúmeros impactos, como lançamento de esgotos, barramentos e canalizações, que causam profundas alterações em suas características e também na sua biota. O assoreamento dos rios se caracteriza como uma das mais impactantes alterações, pois acarreta redução da profundidade e largura dos rios, pode provocar alterações físicas e químicas na água, bem como na estrutura de habitats de alimentação e reprodução dos peixes. Como medida paliativa, é normal realizar a execução de desassoreamento (dragagem) dos rios, atividade esta também muito impactante. As enchentes é um dos principais fatores que fazem com que a dragagem seja executada. No intuito de analisar as atividades de desassoreamentos, seus efeitos na biota e nos peixes migradores, bem como avaliar as melhores estratégias de gestão e mitigação dos impactos nos peixes, foi elaborado a presente revisão. Como constatado a movimentação e a remoção de sedimento do leito do rio podem causar soterramento e morte massiva de ovos e larvas, além de interferir na migração ascendente e descendente de ovos, larvas e adultos de peixes migradores. Além disso, sítios de reprodução e alimentação podem ser impactados pela movimentação, dragagem e deposição do sedimento. Recuperar as matas ripárias, realizar a fiscalização do uso do solo nas margens, afastar os assentamentos urbanos, fazer a avaliação do local de dragagem considerando os locais de desova e diminuindo a suspensão de sedimentos de fundo, bem como escolher o melhor equipamento e época para a realização das atividades, são medidas que minimizam os impactos da atividade de desassoreamento. Sendo assim, o desenvolvimento de pesquisas sobre o efeito da dragagem em peixes contribuiria com uma melhor gestão desta atividade.

**Palavras-chave:** assoreamento; revisão; ictiofauna; rio urbano; área de preservação permanente.

## INTRODUCTION

The human settlement by water bodies was fundamental for our survival over time, encouraged by the need for resources, such as water and fish, in addition to use for transportation, fish farming, and agriculture (Oliveira et al., 2017). Rivers started to be increasingly used for human activities such as fishing, tourism, port activities, industrial activities, and aquaculture (Silva and Lima, 2015); thus, human interventions became frequent, such as the construction of dams (Bylak et al., 2017), dredging of channels

for navigation, plumbing, and rectification (Smith et al., 2019), among other interventions, with considerable impact for the river and its biota, especially fish (Grantham et al., 2019).

Modern urbanization has drastically modified rivers, through runoff of rainwater and effluent discharges produced by human activities, changes in morphology (rectification), canalization, and removal of riparian vegetation (Silva et al., 2020). This situation and its effects on the river, according to Walsh et al. (2005), put these ecosystems in a state of “urban river syndrome,” resulting in an increase in nutrients and contaminants, changing the characteristics of the environment and reducing its biotic richness, and raising the dominance of tolerant species (Marques and Cunico, 2021).

One of the problems in urban rivers is silting (sediment entry); this process triggers a reduction in the depth and width of rivers, alteration of the bed, and all of its geomorphology (Taylor et al., 2008). As a result, it causes flooding (Grantham et al., 2019), impairs navigation, in addition to reducing habitat heterogeneity, and blocks fish migration routes (Smith et al., 2019).

As an attempt to solve the problem is the desilting, although it is a drastic and palliative action as it does not reaches the cause of the problem (floods), as floods are related to erosive processes, such as deforestation, high levels of waterproofing, and inadequate allocation of particulate material (Oliveira and Mello, 2007).

The protection of soil and riparian vegetation on the banks of rivers is fundamental, in that they perform the function of holding sediments, stabilizing the watercourse, and reducing the exposure of these areas to silting. According to Santos (2012) in São Paulo, the large amount of sediment in drainage systems intensified the occurrence of floods, while in the Pardo River, with preserved riparian vegetation, the movement of sediments by erosive processes is low, functioning as a buffer zone (Piroli and Zanata, 2012).

According to Wenger et al. (2017), desilting can impart a drastic impact on aquatic environments, but the direct effects on fish population have not been critically assessed to date. Such interventions cause several changes on the river dynamics, negatively altering the physical, chemical, and ecological composition, and causing damage mainly to the fish communities and benthic organisms (Oliveira and Mello, 2007). In migratory species, interventions caused by silting can obstruct the river, destroy spawning sites, and bury eggs and larvae; there is also the possibility that the disturbed sediment clouds are contaminated with toxic substances or heavy metals (Smith et al., 2019).

To mitigate the impacts of one of the most common problems in urban rivers, namely, silt removal, it is necessary to understand how the soil and water resources are changed, the dynamics of the river, how it changes after the interventions, and propose effective public policies that prioritize a strict, planned urban growth, restricting the occupation of floodplain areas and restoring the river’s ecological functions (Smith et al., 2019).

Thus, we list the main interventions that the rivers have suffered over time and the nature of the occupation of the banks.

We evaluate the best dredging strategies in streams and rivers and the mitigation of impacts on fish communities, which can lead to blocking of migration routes, burial of eggs and larvae, suspension of toxic sediments, etc. In this review, we explore these impacts on neotropical freshwater fish, especially migratory species.

## MATERIAL AND METHODS

This research was elaborated from a systematic literature review carried out on the database “Web of Science – Portal Periódicos Capes” (<http://www.periodicos.capes.gov.br/index.php>), SciELO (<https://scielo.org/>), Scopus (<https://www.scopus.com/>), and Google Scholar (<http://scholar.google.com>), for works related to the desilting of water bodies and dredging, as well as their impacts on ichthyofauna, published between 1990 and 2021. Thus, the following keywords were used: “dredging, suction dredging, wetlands, fish community” in a targeted search in widely circulated scientific media related to the subject (i.e., articles). The articles selected in the research were selected from the reading of the abstracts and those that were not directly related to the topic were excluded.

For verification and selection of articles, the Start version 3.0.3 program was used, which allows organizing all publications inserted in the databases, following pre-selected criteria in the protocol. Aspects mainly related to desilting of rivers, dredging methods, impacts on fish assemblages, especially on migratory species, and mitigation measures were analyzed. A total of 81 articles were collected, of which 37 (45.67%) were considered accepted with the criteria established in this review: impacts arising out from dredging interventions on neotropical freshwater fish, especially on migratory species, in addition to mitigation measures. In this way, it was possible to carry out a compilation of information obtained in the literature, transforming them in this article.

## RESULTS AND DISCUSSION

### Main impacts on Neotropical rivers over time

The development of urban areas brought significant changes in the structure and dynamics of rivers, causing several impacts, such as waterproofing the soil; increase in maximum flow rates and, consequently, in the surface runoff capacity; increased erosion and sediment carrying processes; and deterioration of water and sediment quality (Smith et al., 2019). Interventions in rivers occur as a result of human occupation on its banks and natural phenomena such as floods, in addition to the barriers for obtaining energy and the accumulation of water for supply (Agostinho et al., 2016). Several interventions are carried out to reduce the effect of floods, such as silting up, heightening of adjacent areas, and alterations in river layouts (Smith et al., 2019).

The floods caused by urbanization have several reasons, among which we highlight the excessive parceling and waterproofing of the soil, unsupervised and unplanned occupation of riverside areas, in addition to the floodplains, the obstruction of pipes by debris and sediments, and the inadequate drainage works (Pompêo, 2000). The channeling and buffering of water courses, especially when combined with marginal avenues or paved streets, cause the elimination of most terrestrial and aquatic habitats. Thus, biodiversity decreases, and the natural ecosystem is drastically changed (Marques and Cunico, 2021). Such transformations are also caused by the expansion of areas for agriculture and engineering projects such as road openings and dams (Tundisi and Matsumura-Tundisi, 2011), in addition to unplanned occupations and real estate speculation.

The result of this process is a marked degree of water degradation and, consequently, of the landscape, flooding problems at several points in the drainage system, excessive waterproofing of the soil, and human irregular occupation of areas with severe risks for flooding and landslides, among other urban problems associated with water courses. Table 1 shows the impacts caused on urban rivers with their respective consequences, according to several authors who worked on the subject. Virtually every impact that rivers suffer are linked to urbanization and the increase in the concentration of people living adjacent to these areas. The elements presented in the table explain, therefore, the importance of integrating the urban and regional planning process, with its many related factors, giving emphasis on the management of water resources.

## Desilting activity

To minimize the disturbances resulting from floods and inundations, interventions such as silting or dredging can be carried out for several reasons: increasing the cross section of the river channel, flood containment, and acquisition of navigation draft, making it possible to increase cargo transportation; sediment extraction for civil construction and erosion containment; and area cleaning for the installation of projects, among others (Carvalho et al., 2017; Smith et al., 2019). Dredging or silting operations cause physical and morphological changes in the river (Barletta et al., 2016). One of the main reasons for the silting activities to be impactful is the fact that these activities seek to remove sediments from the bottom, especially from the margins of water bodies, and these places have great ecological importance (Smith et al., 2019).

Desilting is often needed to reverse the negative effects of the silting on water bodies, which also represents changes in the natural conditions of the environment. The reduction of habitat heterogeneity regarding depth and changes in bottom and marginal habitats is caused by silting (Agostinho et al., 2016), reducing the diversity of fish.

According to Scottish Natural Heritage (2017), dredging procedures also result in

1. uniformization of the bed of water bodies,
2. increase in suspended particulate material and water turbidity;
3. changes in the composition of the substrate;
4. damage to the birth of juveniles of fish species due to the removal of the substrate used throughout its life cycle;
5. the fine particulate material can affect the creation and incubation of the ichthyofauna, due to the reduction of habitats and the filling of interstitial spaces;
6. impacts on the ichthyofauna's breathing system;
7. reduction in primary productivity due to the reduction of light in the aquatic environment;
8. reduction in the predation capacity of some species due to turbidity; and
9. reducing the abundance of macroinvertebrates and modifying the structure of their communities.

According to Bray (2008), the most critical issue on the environmental theme is the creation of a layer of residual material, caused using cut and suction dredgers. This residual layer becomes easily suspended in the river water and becomes a long-lasting source for increasing the amount of suspended sediment or turbidity. Figure 1 illustrates two types of equipment commonly used for river silting: suction dredge and settlement (on the right) and hydraulic excavator (left).

## Impacts of silting activities on the environment

In the study by Antunes (2010), the changes in the environment and composition of fish communities in the Paranaguá Estuary were compared before, during, and after dredging operations, and changes in the total average density and biomass were observed, therefore suggesting that there are changes in the demersal fish community during periods when there is a dredging operation. In another study carried out in Paranaguá, in the State of Paraná, Parizotti et al. (2015) sought to assess the influence of dredging activities on ichthyofauna and concluded that zoobenthivorous species are the main responsible for the difference between dredged and non-dredged sectors, which are more abundant in the non-dredged sector.

The movement, rupture, and disaggregation of bottom sediments can cause a wide variety of environmental impacts (Smith et al., 2019), and the dispersion of material can impact the suspension of chemical compounds and contaminated material present in the sediment, resulting in the process of bioaccumulation in aquatic organisms, with fish being most affected by the ingestion of these particles in different species (Mato et al., 2001; Kukuła and Bylak 2020). For Gusmão et al. (2016), the ingestion of suspended materials by fish is probably due to mixing with sediments.

According to Barletta et al. (2016), the type of dredging and the way it is operated can significantly influence the potential damage in terms of dispersion of the material to be relocated (MEMG, 2003). Therefore, the shape and magnitude of the dredged debris plumes are governed by the dredging technique employed, the sensitivity of the dredged material to resuspension,

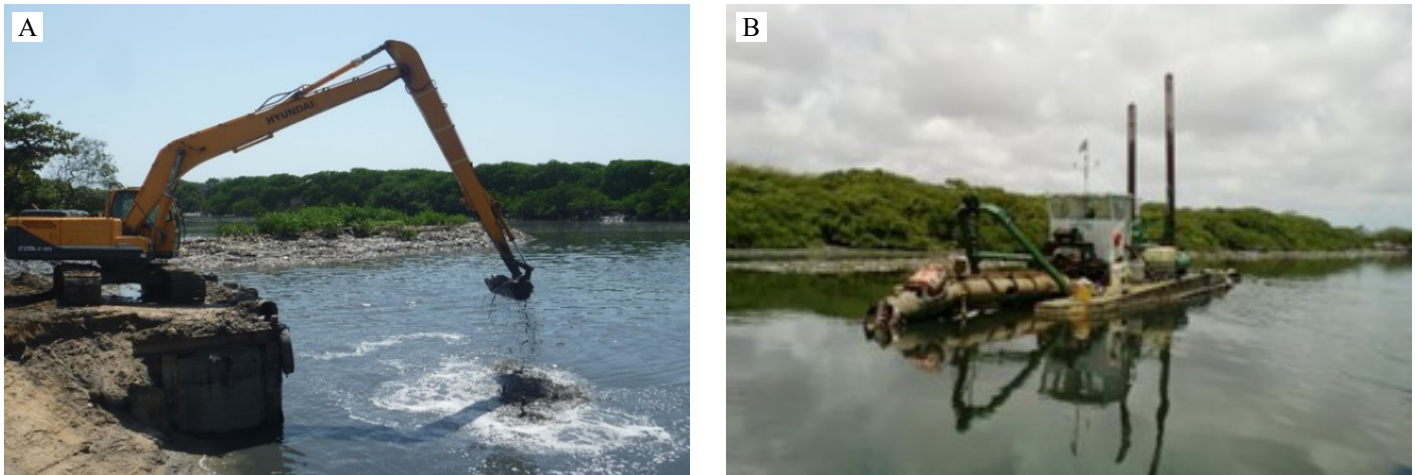
**Table 1.** Relationship between the impacts caused on rivers and their consequences.

Impacts	Consequences	References
Deforestation	<ul style="list-style-type: none"> <li>• Irregular occupation of riverbanks and permanent preservation areas;</li> <li>• Silting up the margins;</li> <li>• Decrease in the rate of infiltration into the soil, increasing the amount of water on the soil surface.</li> </ul>	Carvalho et al., 2017; Smith et al., 2019
Impermeabilization of the soil and the channeling of water courses	<ul style="list-style-type: none"> <li>• Accumulations and changes in the natural flow of water, intense movement of large volumes of land;</li> <li>• Decrease in the flow capacity of urban drainage systems.</li> </ul>	Carvalho et al., 2017
Occupation of floodplain areas	<ul style="list-style-type: none"> <li>• Confinement of rivers;</li> <li>• Landfills;</li> <li>• Deforestation;</li> <li>• Erosion of the margins;</li> <li>• Reduction of the natural space for the flow of flood flux.</li> </ul>	Tucci, 2005; Smith et al., 2019
Grinding	<ul style="list-style-type: none"> <li>• Changes the width and depth of the channel in addition to the characteristics of the wells and rapids;</li> <li>• Natural channel morphology is changed;</li> <li>• Increased flooding.</li> </ul>	Daigle, 2010
Dam	<ul style="list-style-type: none"> <li>• Changes in the natural flow regime;</li> <li>• The environment becomes lentic;</li> <li>• Homogeneity of habitats and fish species;</li> <li>• New limnological conditions.</li> </ul>	Agostinho et al., 2016; Sanchez et al., 2016
Silting activities and interventions	<ul style="list-style-type: none"> <li>• Drastic and palliative action, does not reach the cause of the problem (floods), as it is not just the depth of the river, normally related to erosion processes, such as deforestation, high levels of waterproofing, and inadequate allocation of particulate material.</li> </ul>	Lemiere et al., 2014; Oliveira e Mello, 2007; Smith et al., 2019
Soil exposure	<ul style="list-style-type: none"> <li>• Increase in temperature in the aquatic environment;</li> <li>• Decrease in the entry of organic matter;</li> <li>• Increased runoff and carrying nutrients;</li> <li>• Erosion;</li> <li>• Lower dissolved oxygen rate;</li> <li>• Eutrophication;</li> <li>• Silting up.</li> </ul>	Ferreira et al., 2006; Daigle, 2010
Accumulation of nutrients carried by rain	<ul style="list-style-type: none"> <li>• Decrease in oxygen dissolved in water;</li> <li>• Changes in the aspect of water;</li> <li>• Increase in the total solids and turbidity content;</li> <li>• Changes in the physical and chemical characteristics of the water;</li> <li>• Inadequate deposition of sediments;</li> <li>• Contamination of water bodies;</li> <li>• Changes in flow.</li> </ul>	Mello et al., 2003; Daigle, 2010
Land occupation and increase of dwellings in APP areas	<ul style="list-style-type: none"> <li>• Domestic pollution;</li> <li>• Population density increases;</li> <li>• Changes in the urban climate;</li> <li>• Flood control problems;</li> <li>• Surface runoff increases.</li> </ul>	Tucci, 2005

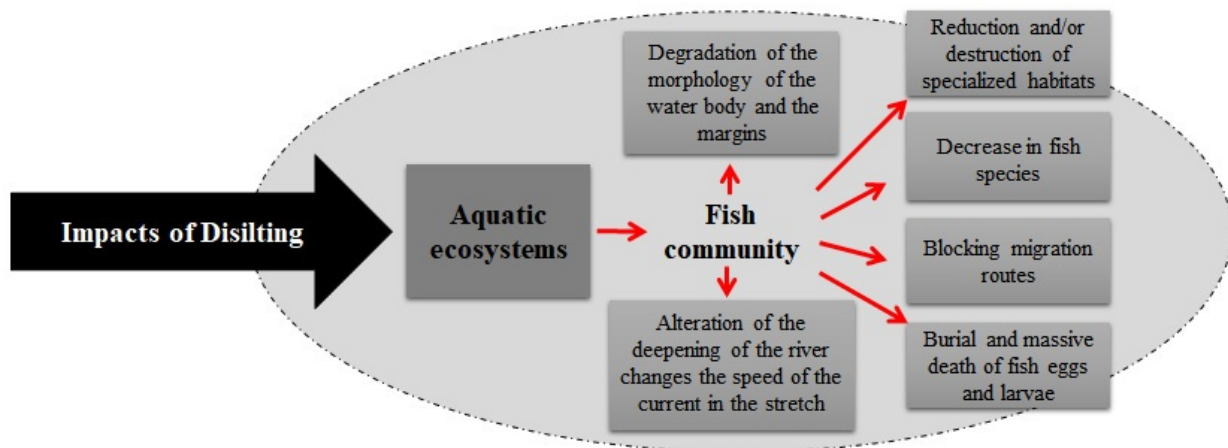
and the hydrodynamics of the overlying water. Plumes vary in horizontal extension from some 100 m to tens of km. The life span of a plume is measured on an hourly scale, but the lower transport of deposited sediment can last for weeks after disposal (Smith et al., 2018).

### Impacts of desilting on migratory fish species

According to Porto and Teixeira (2002), the environmental impacts resulting from dredging, with a direct or indirect effect on the environment and ichthyofauna, generate changes in water



**Figure 1.** Examples of equipment used in the process of desilting a water body. **(A)** Uncrossing with hydraulic excavator on river. **(B)** Suction and settlement dredger (Personal Archive).



Source: Adapted from Oliveira and Mello (2007).

**Figure 2.** Impacts on the fish community and water body resulting from the silting intervention.

characteristics, such as salinity, turbidity, currents, and flow, thus changing the conditions of the dump site of the dredged material, the natural conditions, and pollution due to the various substances in the sediments that alter the quality of the water, in addition to the effects on aquatic flora and fauna, especially fish.

The effect resulting from the dredging process contributes to generate the movement of contaminants and nutrients during the suspension of the sediment, which may deteriorate the quality of the water, in addition to which, when dredging the sediment, a large part of what was buried is stirred and it comes back in contact with water, exposing the fish to these pollutants (Torres, 2000).

The physical impacts resulting from the dredging activity directly influence the reproduction of migratory species (Figure 2). The deepening of the riverbed alters the speed of the current, resulting in the carrying of the sediment and erosion of

the margins, which are deposited in the bottom again (Peixoto, 2019). This activity can cause bed degradation, narrowing of the channel, and reduction or increase in sand banks and islands, leading to a decrease in the diversity of fish species (Antunes, 2010). Also, uncritical unsanding may also cause the migration routes to be blocked, obstructing access to private habitats that are located mainly in the middle of Sorocaba, which are important places for certain stages of life, and may reduce population recruitment (Smith et al., 2019).

According to Smith et al. (2019), the silting can result in damage to the existing ichthyofauna, because when carrying out this type of intervention, the movement and removal of sediment from the riverbed can cause burial and massive death of eggs and larvae, in addition to destroying specific habitats for the spawning of these species and of others that do not migrate. It is

a conceptual model depicting usually happens to fish species, taking into account the destruction of habitats, which reflects homogenization at a local scale, leaving fish more exposed to other predators and, with less food resources, leading to a decrease in species diversity and an increase in the occurrence of species that are more tolerant and resistant to these types of changes and impacts.

For years, public funding has provided opportunities for the development of major projects aimed at optimizing the supply of water, energy, and protection against floods (Grantham et al., 2019). The fragmentation of fluvial systems, flow modification (Bylak and Kukuła, 2018), unsustainable water collection, and floodplain grounding (Smith et al., 2019) simplified the physical structure of the river (Bylak et al., 2009), reducing the environmental heterogeneity adequate to maintain the aquatic ecosystem, resulting in ecosystem loss and biodiversity decline in global scale (Grantham et al., 2019).

It is estimated that since 1900s, more than half of the world's wetlands have disappeared (Davidson, 2014), mainly due to flood control constructions, which allowed the "recovery" of floodplains for human use and agriculture, causing the declining populations of migratory fish in several tropical rivers (Agostinho et al., 2005). Bailly et al. (2008) stated that the success of species that perform reproductive migrations is related to the presence of development sites and the connectivity between these and spawning sites.

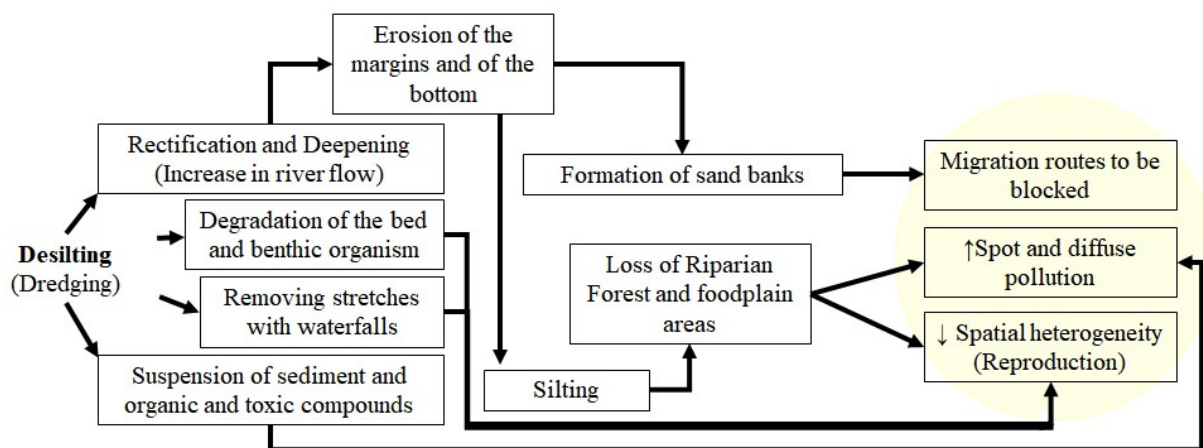
The removal of encapsulated stretches and modification of the riverbed are also aspects that impact ichthyofauna, especially migratory fish. The transformation of enchanted stretches of rivers into reservoirs probably has a highly pernicious effect on species, which require locations with rocky bottoms and rapid current (ICMbio and MMA, 2018). The creation of barriers also impacts the migration routes, since the increase in the speed or flow of the river causes the sediment that would normally be deposited in that location to be moved to another, in addition to the increase in erosion processes (Kukuła and Bylak 2020).

Changes caused by anthropic activities, such as dams, cause changes in the natural flow regime, limnological conditions, and spatial heterogeneity, selecting species that are pre-adapted to new environmental conditions, usually non-native, and affecting assemblies with lower tolerance or preventing the reproduction of migratory species (Agostinho et al., 2016). The removal and degradation of riparian vegetation leads to an increase in inorganic material and accelerates the erosion process, causing the entry of sediments from agrobusiness activities and drainage of urban soil emitted by automobiles, industries, and deforestation (Taylor et al., 2008). Figure 3 illustrates the environmental impacts on migratory species from the desilting of rivers.

### Mitigating measures and solutions

In Brazil, the lack of robust norms does not provide effective protection for the river and fish when silting is carried out. As the intention of this type of intervention is to increase the depth of the river channel, it is essential to analyze the need for this. Dredging of the riverbed can cause sediment transport from urban and agricultural activities, narrowing of the channel (erosion), degradation of the bed, alteration of the river flow, and reduction or increase in sandbanks and islands, leading to a decrease in diversity of fish species (Taylor et al., 2008). According to Paul and Meyer (2008), the most consistent and widespread effect for sediment transport is the increase in impermeable surface coverage within urban basins, which alters the hydrology and geomorphology of water bodies.

The construction of wooded areas and green areas in urban centers and the preservation of vegetation on the banks of rivers and floodplains, which are often deforested, are essential to reduce the silting up of the river (Panizza, 2016). Additionally, inspecting land use on the banks, creating public policies that prevent or control urban development without planning in flood plains, and restoring the river's natural functions are important mitigating measures against desilting (Smith et al., 2019).



**Figure 3.** Scheme of the environmental impact of desilting on migratory species (Taylor et al., 2008; Agostinho et al., 2016; Sanches et al., 2016).

According to Kondolf (2011), providing “space for the river” away from human settlements and infrastructure from the banks, preventing the risks and costs of flooding, and giving space for the river to carry out its natural activities all contribute to environmental heterogeneity and offer support for a diversity of non-migratory and migratory species.

Smith and Barrella (2000) verified the importance of the marginal lagoons on the Sorocaba River in the municipality of Sorocaba for *Prochilodus lineatus*, also emphasizing that they are favorable environments, as they often offer more satisfactory conditions than the river. The lagoons play important roles for the surrounding lotic ecosystem and for the fish community, providing shelter, food, and a place for fry development.

Prioritizing equipment with lesser impact is also a measure that assists in the management of the silting activity, as the type of equipment used also has a direct impact on the effects for river floodplains and migratory fish: mechanical excavation equipment such as excavators and cranes, despite their size, generate more punctual impacts and are closer to the intervention site, in addition to less suspended material and reduced turbidity levels, when compared to equipment that involves sediment suction and repression.

In Brazil, the protection of migratory species is established by Law n. 9.605, of February 12, 1998, article 29, which punishes harmful actions to species, such as preventing the breeding, or modifying or destroying nests, shelters, or natural breeding places, which usually occur in a desilting. The penalty for the offender increases if the affected species are threatened with extinction; therefore, an important action to prevent or minimize the damage caused by silting is the inspection.

The choice of the time for the process must be considered, avoiding the months of October to March, as it coincides with the period of migration and reproduction of fish, such as *P. lineatus* (Valenciennes, 1837) (curimbatá), *Salminus hilarii* (Valenciennes, 1850) (tabarana), and *Brycon orbignyanus* (Valenciennes, 1850) (Honji et al. 2019). Antunes (2010) suggested that dredging should be carried out from the end of the rainy season to the beginning of the dry season, minimizing the effects of dredging due to the dispersion of sediments.

Other measures are cited in the literature, such as the management of macrophytes, as changes in flow conditions produce a growing community of primary producers, especially species of floating macrophytes (Agostinho et al., 2007). After the recovery procedures, the composition of the reservoir's ichthyofauna was similar to that of the upstream stretch. The desilting and handling of macrophytes in the reservoir were beneficial for the diversity of the ichthyofauna, by improving the water quality and expanding the space (Agostinho et al., 2007).

Harvey and Lisle (1998) stated that due to the level of uncertainty about the effects of dredging, where threatened or endangered aquatic species inhabit the dredged areas, the premise that dredging is harmful to aquatic resources should be adopted by fisheries managers. Other studies (Antunes, 2010; Parizotti et al., 2015; Barletta et al. 2016; Smith et al. 2019) also highlight

the need for research on the effects of dredging on fish, which consider the interactive effects of various stress factors related to dredging and their impact on sensitive species of ecological and fishery value. This information will improve the management of dredging projects and, ultimately, minimize its impacts on fish.

## CONCLUSIONS

With strategic planning, urban expansion can be carried out with the premise of preserving water bodies and their margins. In cases where it is not reversible, it is possible to minimize the effects of the silting activity by combining management measures and knowledge about the effects on migratory fish species. The choice of equipment, operation planning, best location considering the river's morphology, time of year for the realization, and rescue and monitoring of the fish carried out during the intervention are essential aspects to be defined prior to their execution. When desilting is necessary, one way to mitigate impacts on migratory species is to assess the dredging site, with less impact on the spawning sites; minimize the suspension of bottom sediments, which may contain toxic substances or heavy metals; preserve margins and floodplain areas, which prevent sediment from entering; and assess seasonality, i.e., choose the time with the least impact on species to carry out the interventions.

## CONFLICT OF INTERESTS

Nothing to declare.

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## AUTHOR'S CONTRIBUTIONS

Soinski, T.: Conceptualization, Data curation, Project administration, Writing - original draft, Writing - review and editing. Gato, C.: Conceptualization, Data curation, Formal Analysis, Investigation. Matsumoto, A.: Conceptualization, Investigation, Methodology. Brazão, M.: Conceptualization, Investigation, Methodology. Smith, W.: Project administration, Supervision, Validation, Writing - review & editing.

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