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Fish ladders at small hydropower plants and potential contribution to downstream passage of eggs and larvae

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Fish ladders at small hydropower plants and potential contribution to the downstream passage of eggs and larvae

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Introduction

Small hydropower plants (SHPs) (production < 30 MW and reservoir area < 3km²)



Palmeiras SHP, SP, Brazil

sbbengenharia.com.br

Large hydropower plants (production > 30 MW and reservoir area > 3km²)



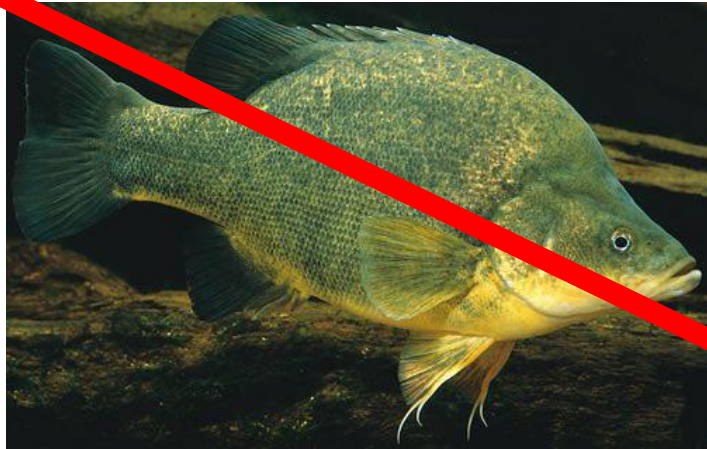
Tucuruí reservoir, PA, Brazil

jornaldetucuruí.blogspot.com

- SHPs construction is increasing worldwide → advantages compared to LHPs

Introduction

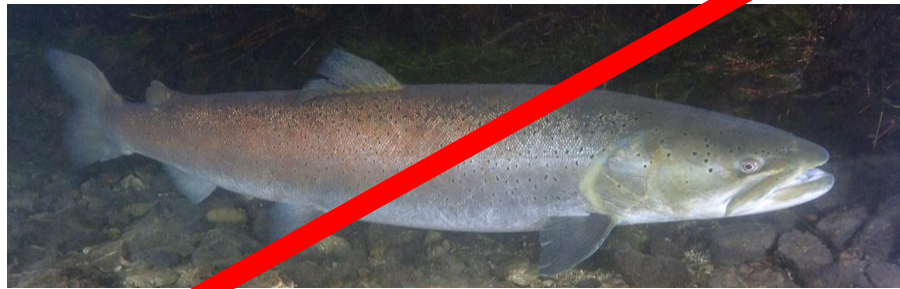
- Impact of hydropower construction on fish fauna



Golden perch (*Macquaria ambigua*)



Dourado (*Salminus brasiliensis*)



Danube salmon (*Hucho hucho*)



Mekong giant catfish (*Pangasianodon gigas*)

Introduction

- Use of fishways to reconnect river segments fragmented by dams



Fish lift – Funil reservoir, Brazil



Fish ladder – Palmeiras SHP, Brazil

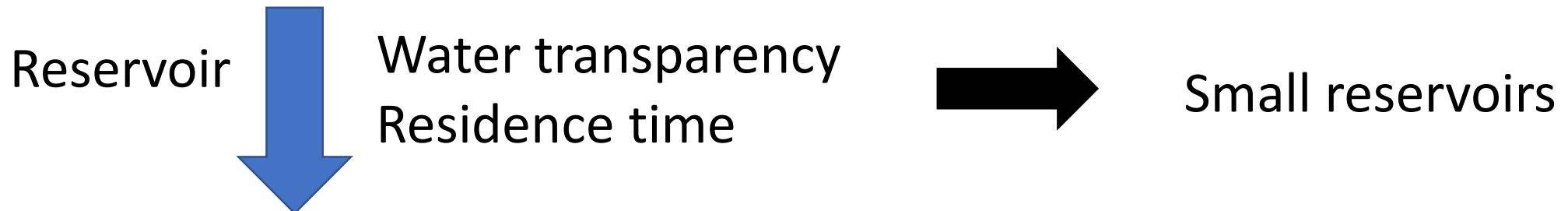
- Fishways are often only constructed for adult fish and only consider upstream movements → failure to successfully recruit and persist

Introduction

- Important approach → downstream passage of eggs and larvae



- Effectively transport larvae and eggs to downstream reaches:



Introduction

- Assuming the eggs and larvae reach the dam, they could pass through different ways: **turbine, spillway or fishway**



Palmeiras SHP, Brazil

Aims

- Evaluate the potential contribution of fish ladders at small hydropower plants to the downstream passage of eggs and larvae
 - (a) identify if fishes with migratory reproductive behaviour are reproducing in the SHPs cascade influenced area
 - (b) evaluate if eggs and larvae can successfully drift downstream reaching the dams and which abiotic factors influence this drift
 - (c) evaluate if downstream passage of eggs and larvae occurs through fish ladders and under which environmental conditions this passage occurs

Material and methods – Study area

- Sapucaí-Mirim River (Southeastern Brazil)
 - One of the main tributaries of Rio Grande River
 - More than 100 fish species, including migratory
 - Three SHPs in cascade, with weir-and-orifice type fish ladders



Retiro SHP (most downstream)



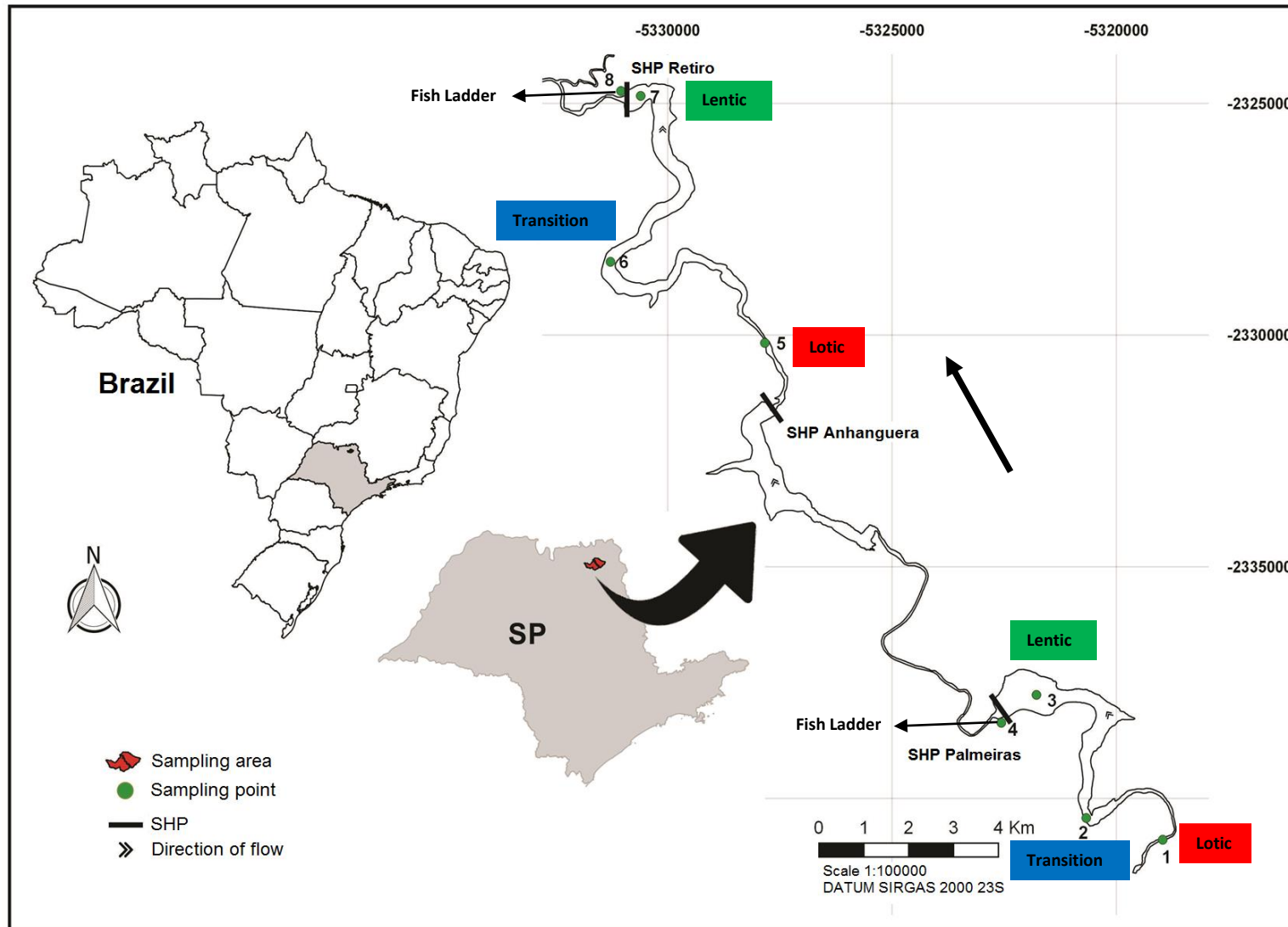
Anhanguera SHP (middle)



Palmeiras SHP (most upstream)

Material and methods - Samples

Fortnightly between November 2016 and February 2017 at night



Material and methods - Samples



Derived Conical-cylindrical plankton net



Limnological variables with water probe
(DO, ORP, TDS, pH, K, Temperature,
Turbidity)

Material and methods

Data Analysis

- Selected only the families of larvae that have reproductive migratory behaviour and external fertilization
- The density of eggs and larvae were standardized as individuals/10 m³ of filtered water
- Palmeiras and Retiro SHPs were analyzed separately
- Two factors:

Section (Lotic; Transition and Lentic zones)

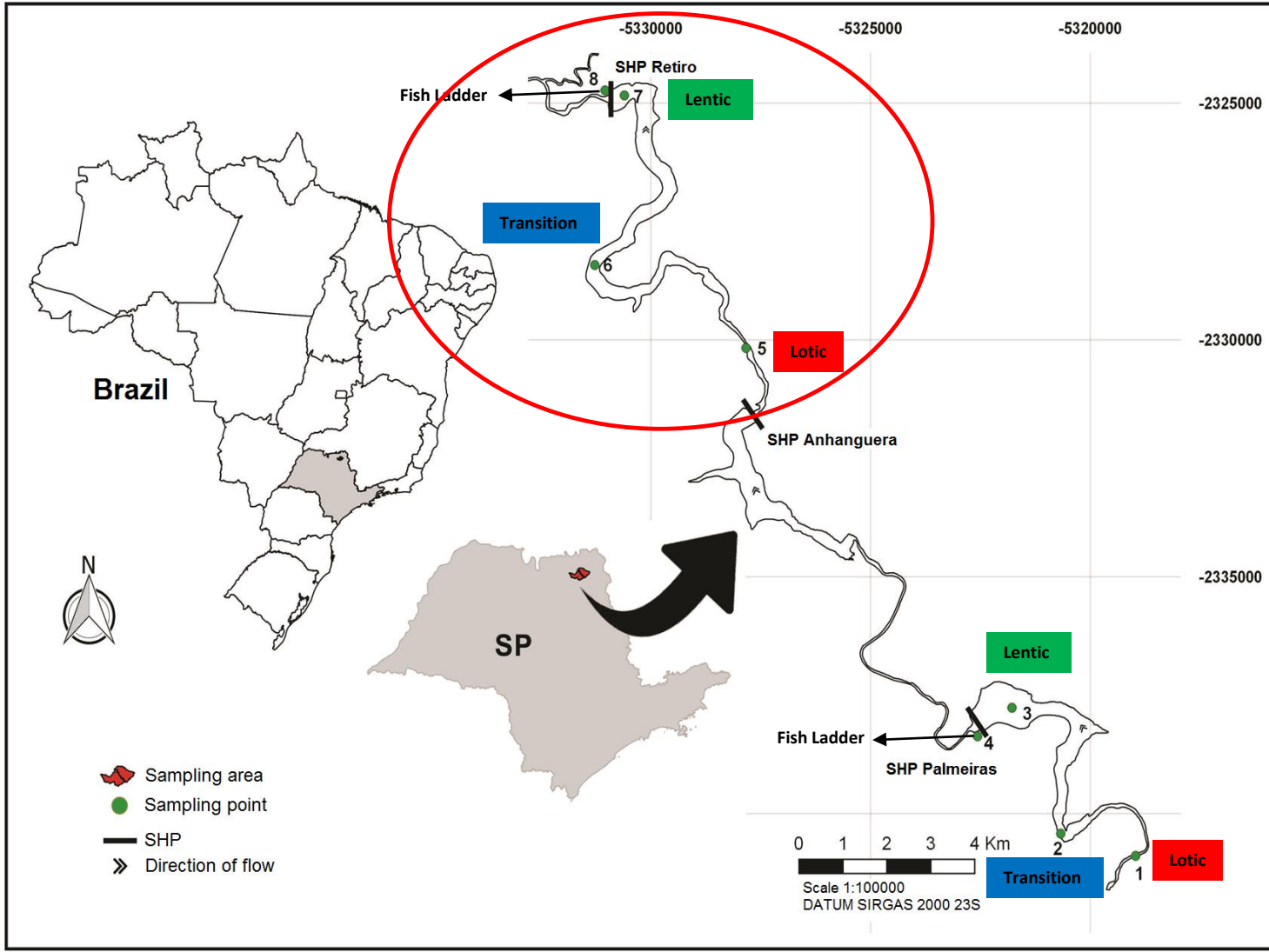
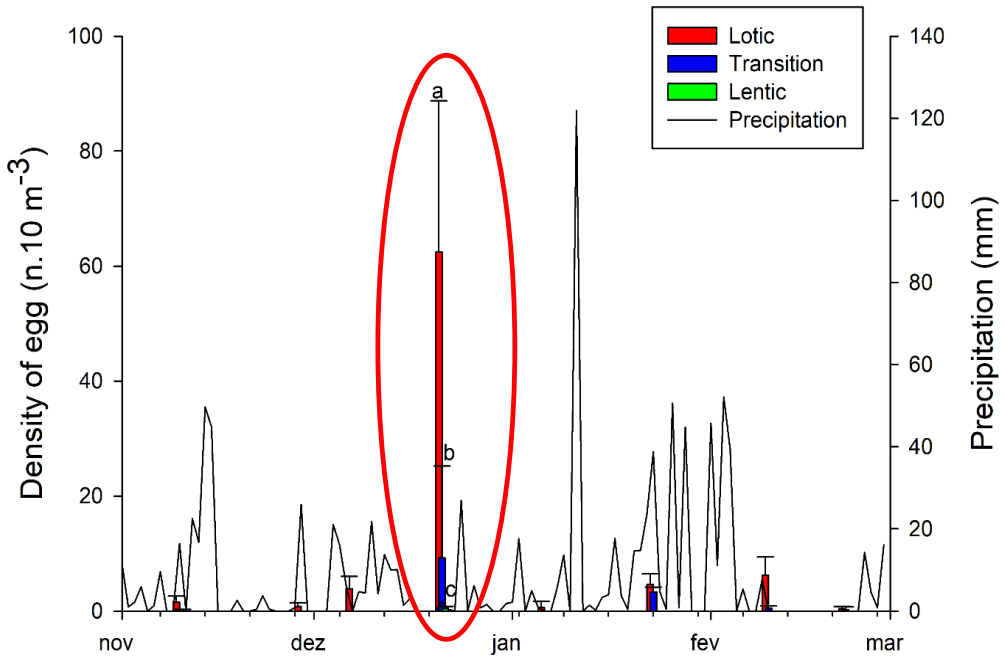
Sample period [November (1); November (2); December (1); December (2); January (1); January (2); February (1) and February (2)]

Results

- Sampled 658 larvae of the selected families and 815 eggs
- Families with migratory behavior and external fertilization:
 - Anostomidae
 - Characidae
 - Heptapteridae
 - Pimelodidae
 - Prochilodontidae

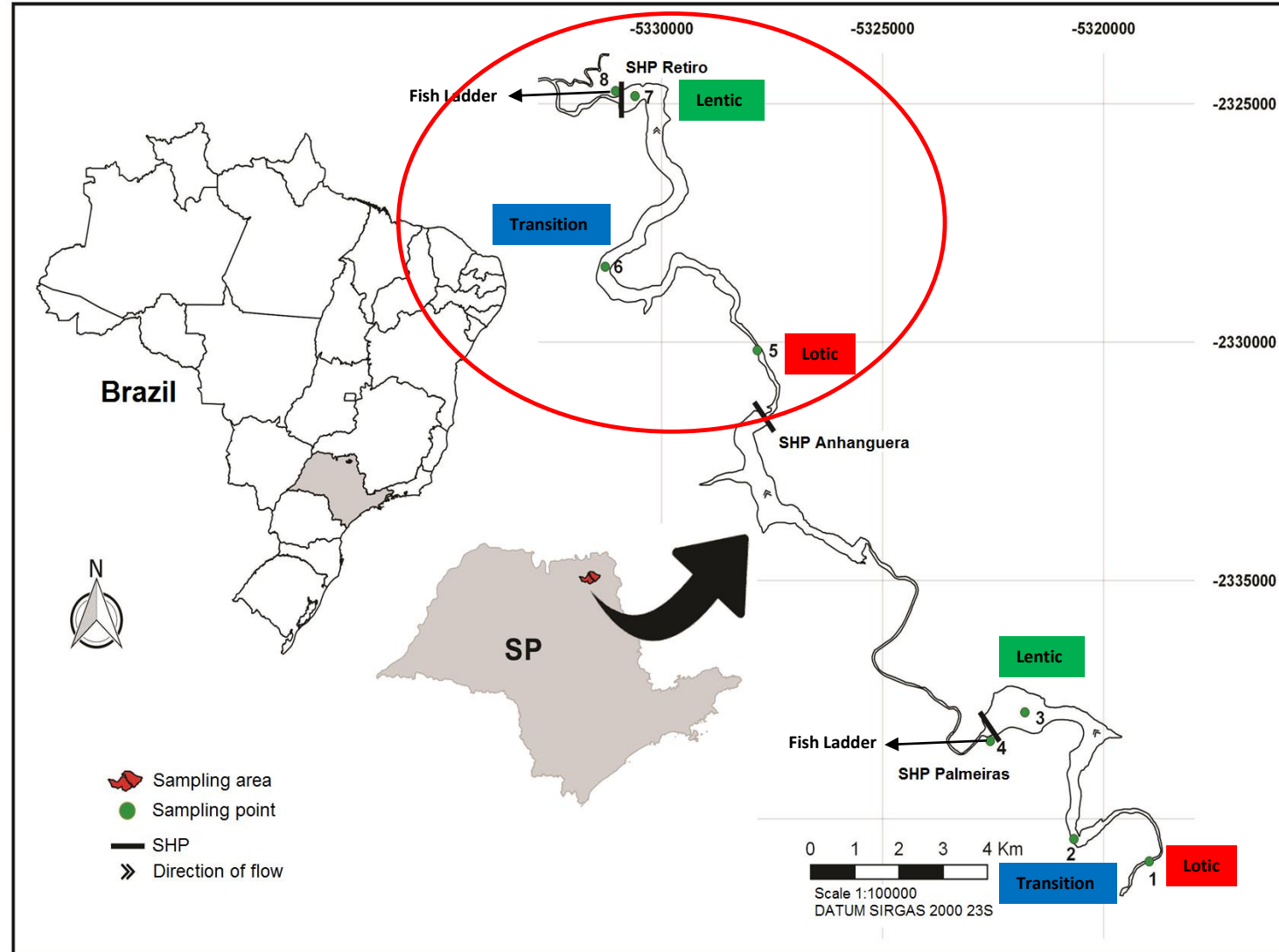
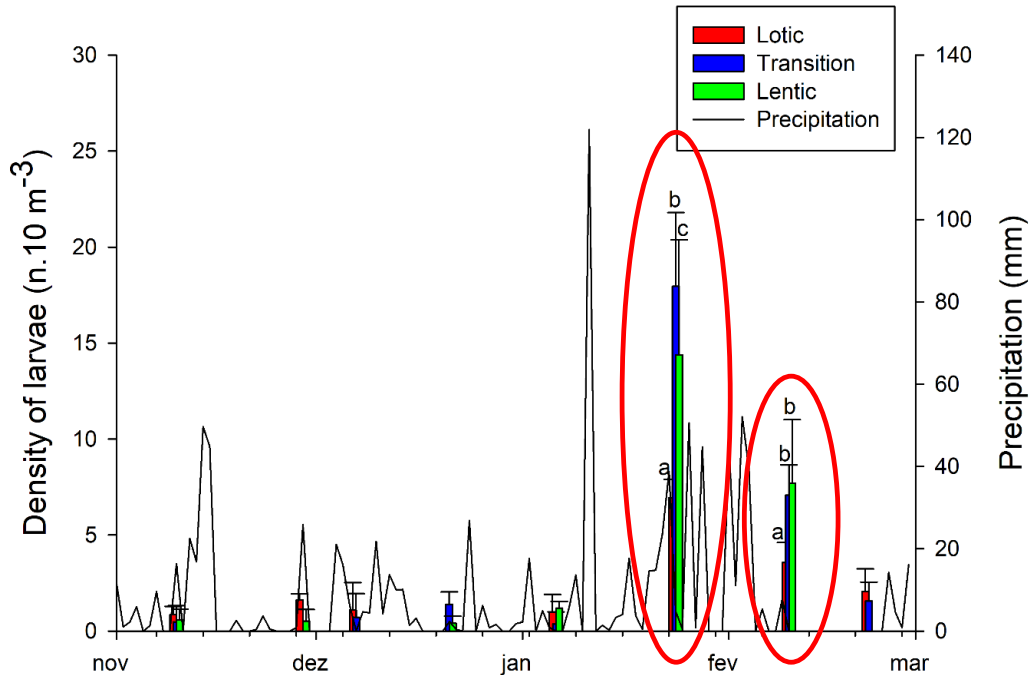
Results – Retiro Eggs

- Differences for the factor **section period** and the **interaction** between both factors
- December 2, higher density in lotic than transition and lentic; higher in transition than lotic
- Temperature(27%), ORP (23%) and Turbidity (23%)



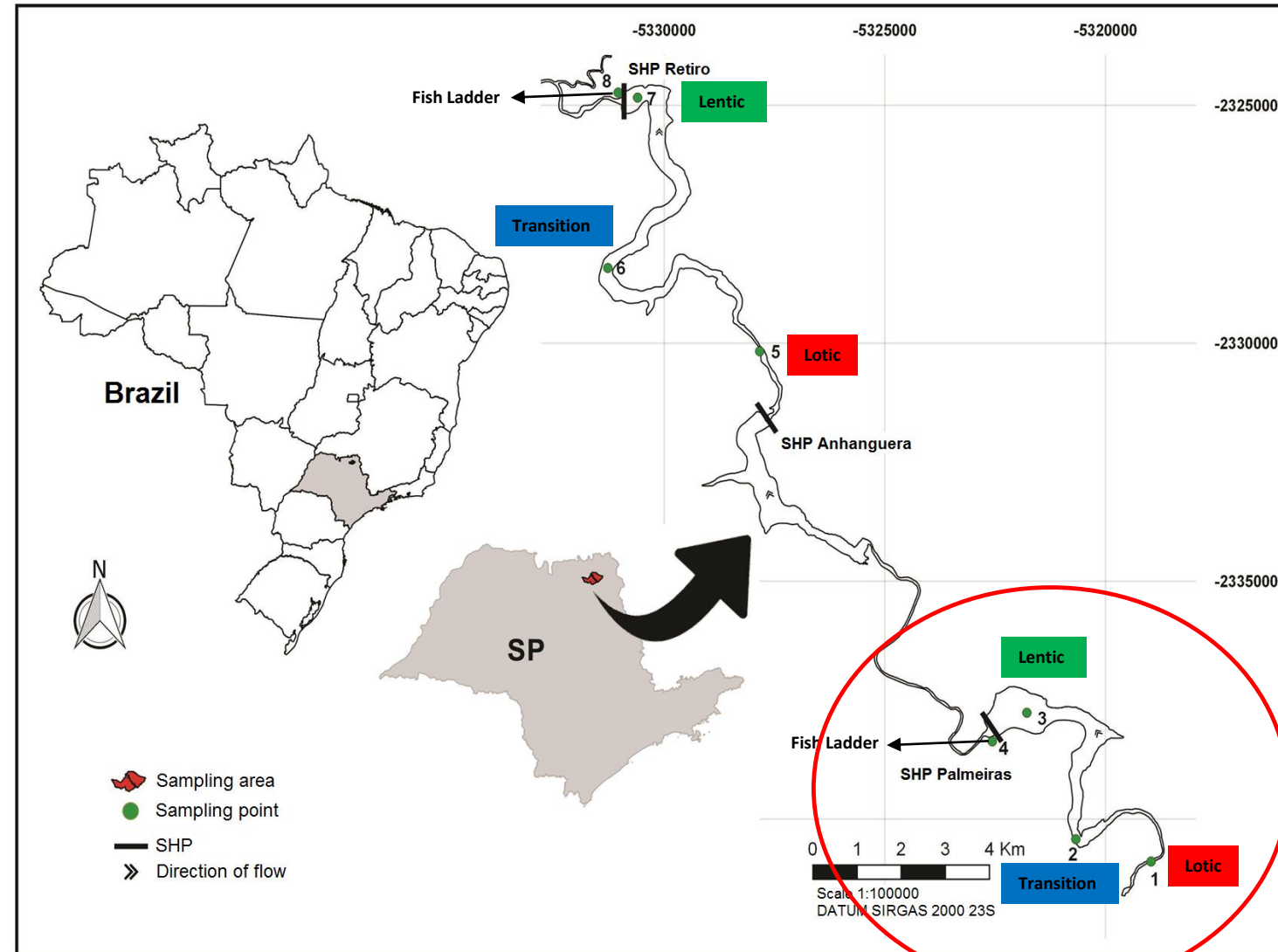
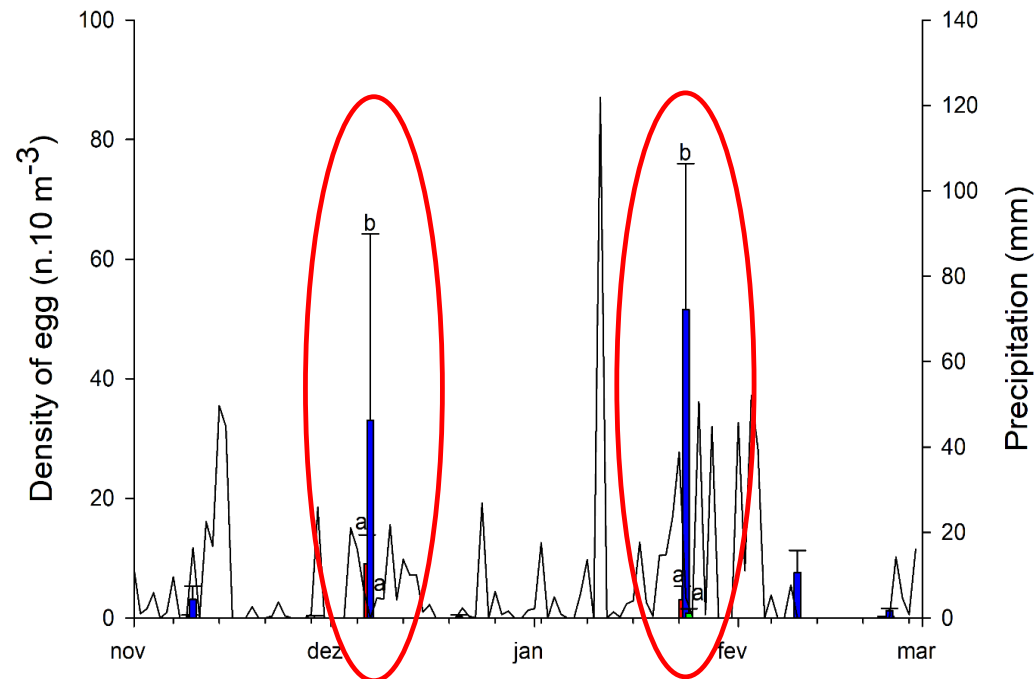
Results – Retiro Larvae

- Differences for the factor **section period** and the **interaction** between both factors
- January (2), higher in transition than lotic and lentic; higher lentic than lotic; February (1) lower in lotic than transition and lentic
- TDS (51%), turbidity (47%) and cumulated rain 5 days before the sample (25%)



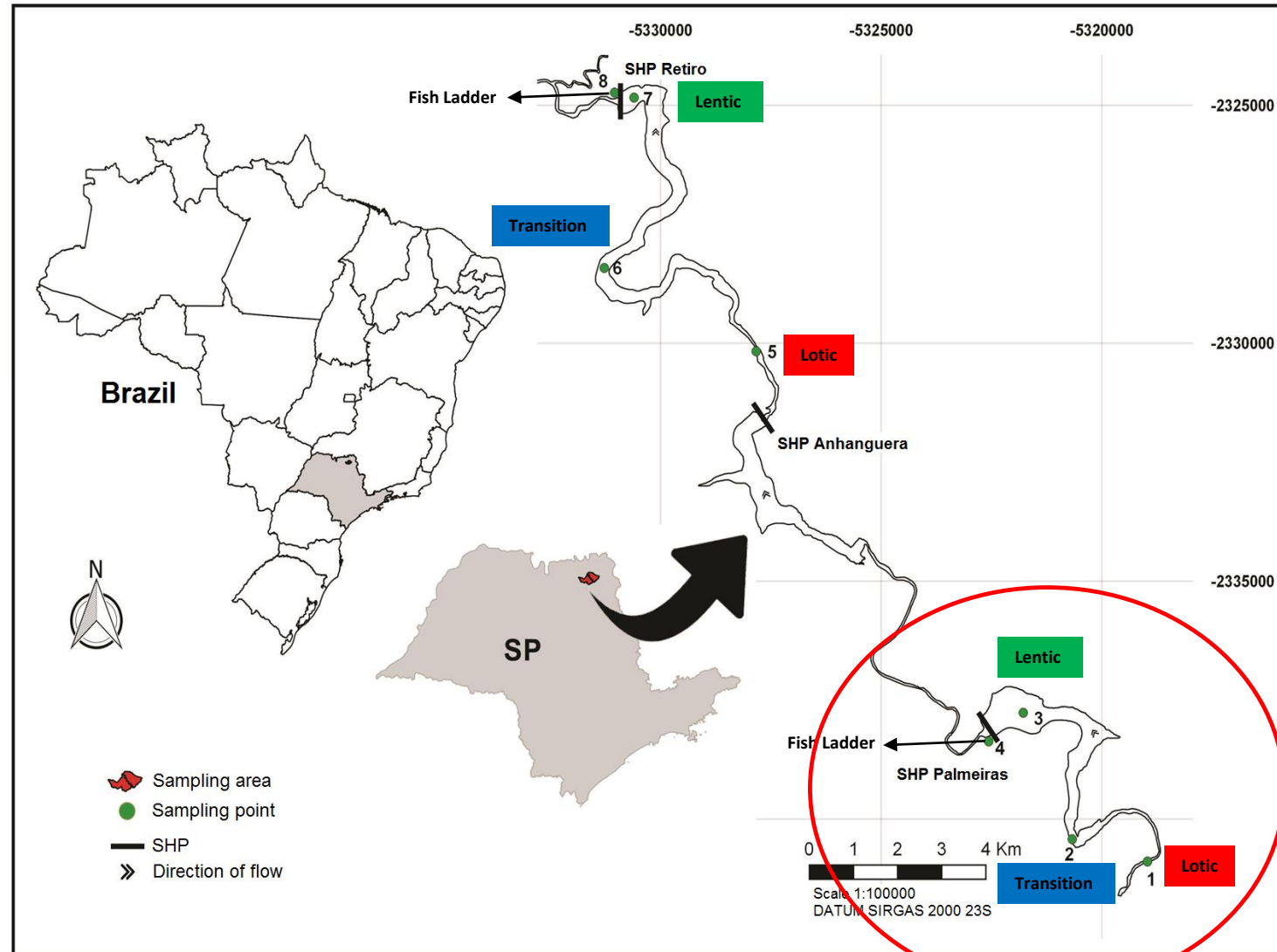
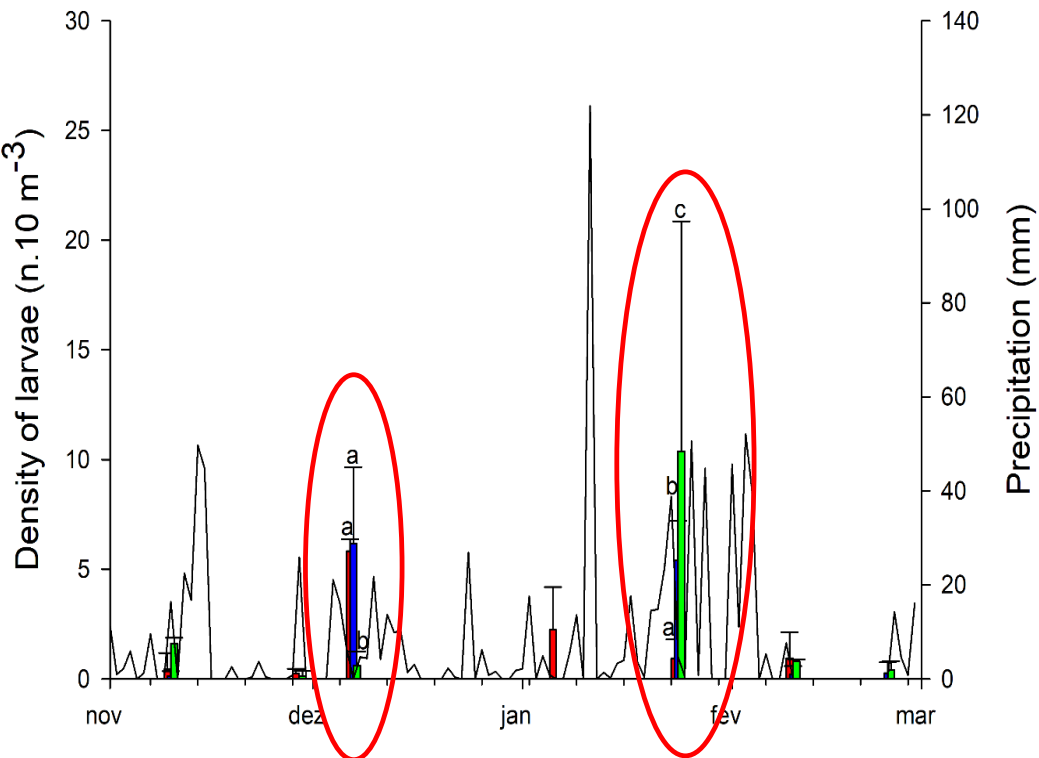
Results – Palmeiras Eggs

- Differences for the factor **section**, **period** and the **interaction** between both factors
- December 1 and January 2, higher density in transition than to lentic and lotic
- Turbidity (42%), precipitation in the day of the sample (30%) and precipitation one day before the sample (26%)



Results – Palmeiras Larvae

- Differences for the factor **period** and the **interaction** between both factors
- December (1), lower density in lentic than lotic and transition; January (2), higher in lentic than lotic and transition; higher in transition than lotic
- Turbidity (45%), precipitation one day before the sample (40%) and precipitation in the day of the sample (25%)



Results

- Presence of eggs and larvae within fish ladder only in few events
- Eggs - No environmental variables can predict the density of eggs within fish ladder
- Larvae - density of larvae in the reservoir predicted the density of larvae within fish ladder

- Percentage of larvae present in reservoir which pass through fish ladder:

Palmeiras SHP 14.6% in January 1

Retiro SHP 65.0% in December 2 and 15.8% in January 1

Discussion

- There is spawning of families with migratory reproductive behaviour in the influence area of the cascade of SHPs in Sapucaí-Mirim River



Pimelodus maculatus



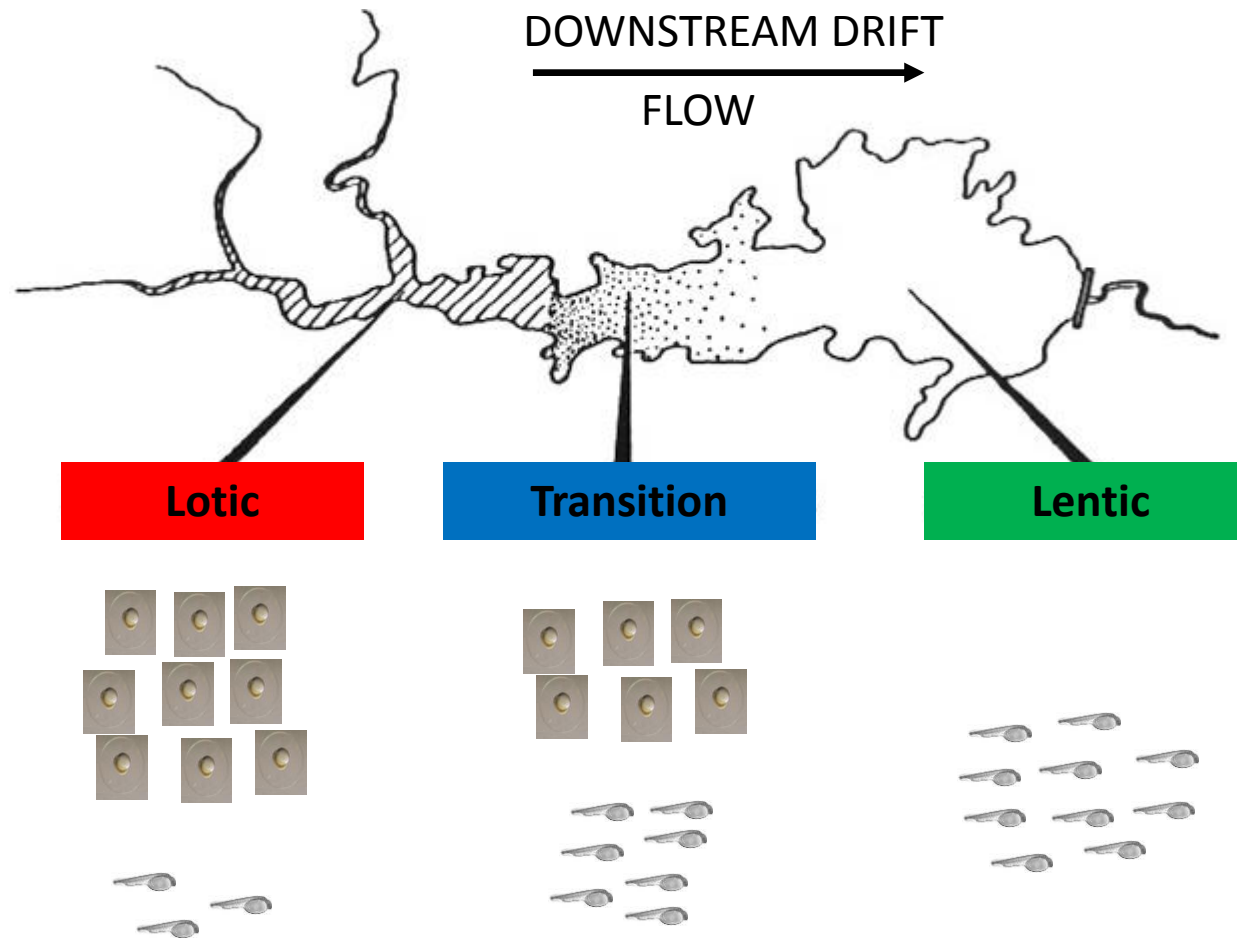
Prochilodus lineatus



Megaleporinus obtusidens

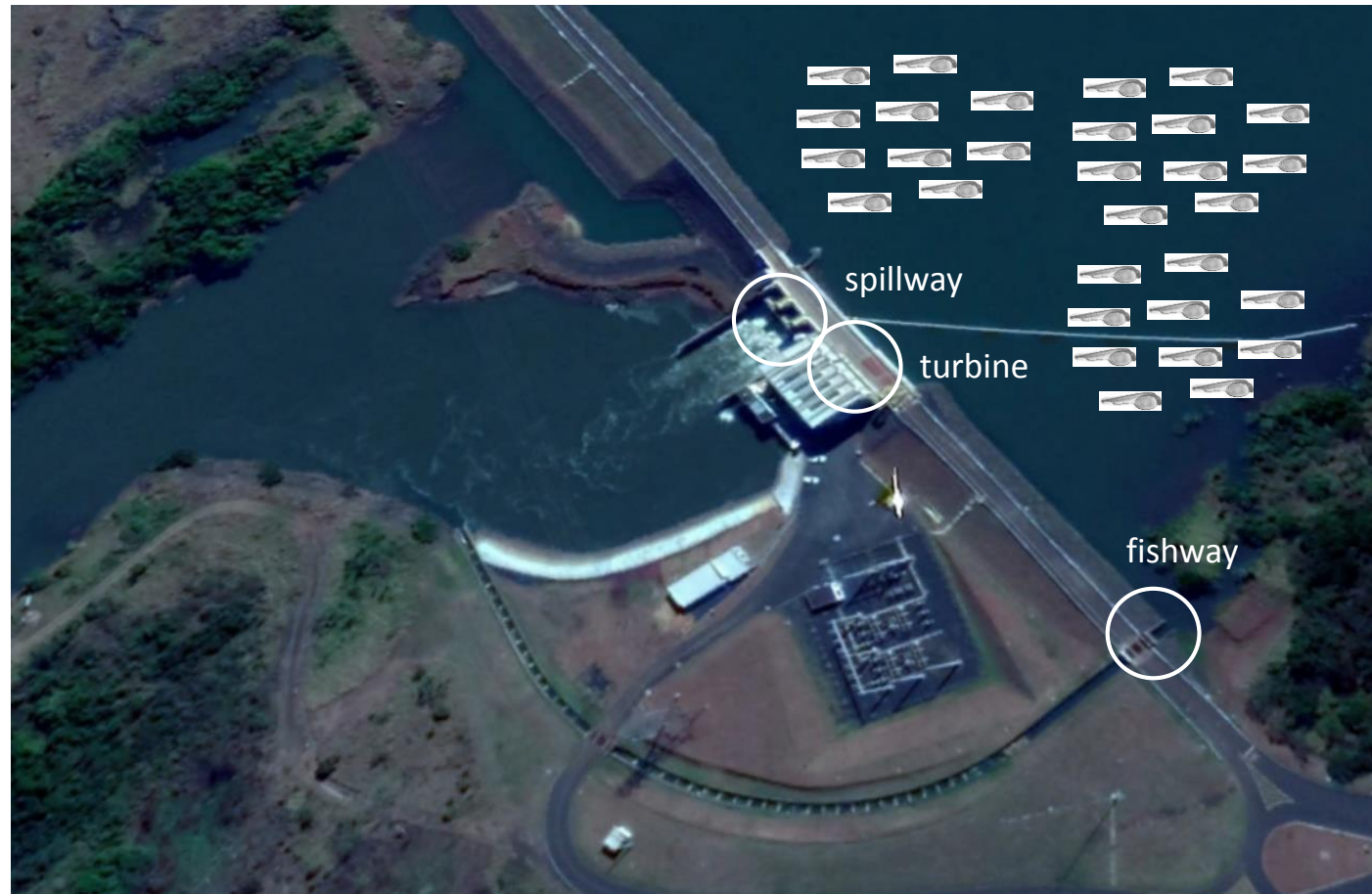
Discussion

- The offspring can successfully drift downstream and reach the dam



Discussion

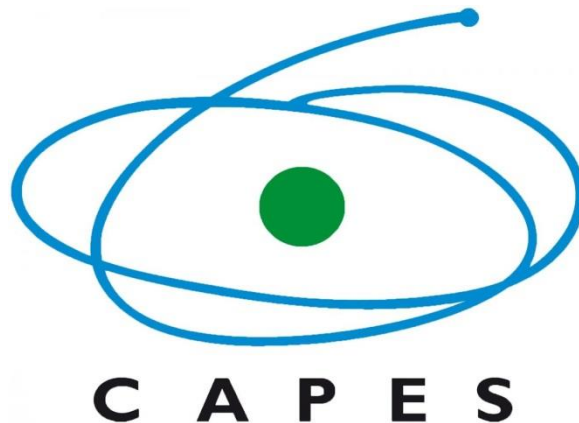
- Once in the dam, the larvae can pass through the fish ladder but only when there is a high abundance of larvae in the reservoir



Conclusion

- The fish ladders of SHPs in Sapucaí-Mirim River have a small contribution to the downstream passage of eggs and larvae of the migratory species
- Migratory species can complete their life cycle, but high rates of recruitment could be achieved with a proper design of fishways, incorporating the downstream passage of egg and larvae of fish

Acknowledgments



THANK YOU!

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