Jun 24th, 8:50 AM - 9:35 AM

Plenary Speaker: Conciliating fish ecology and river fragmentation in South American large rivers: Are fish passages appropriate tools?

Claudio Baigún
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Conciliating fish ecology and river fragmentation in South American large rivers: Are fish passages appropriate tools?

Claudio R. M. Baigún

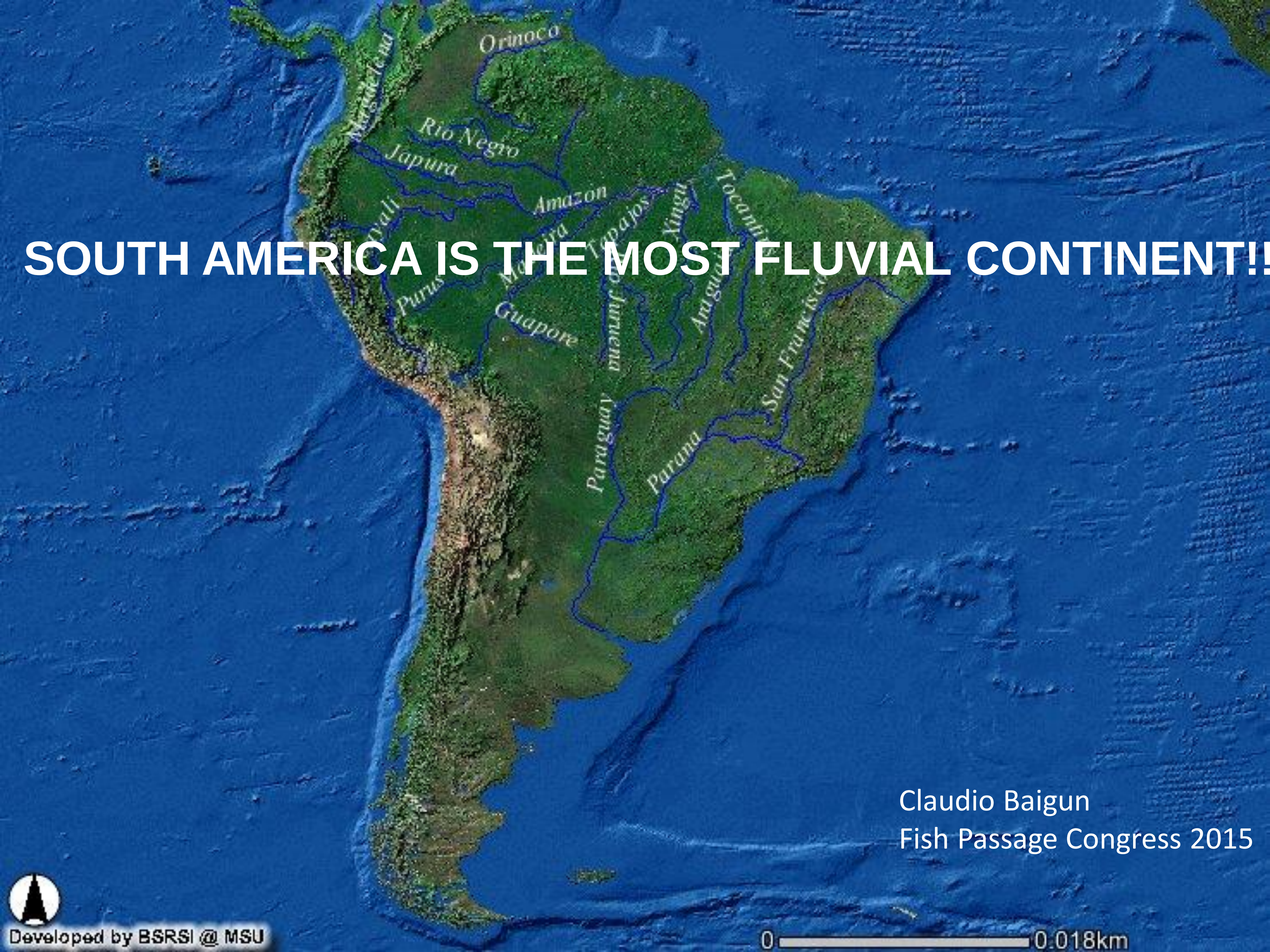
INTECH- CONICET-UNSAM, Argentina

ACKNOWLEDGMENTS

- Herman Wanningen
- Pao Fernández
- KerryBrink

- The aim of this presentation is to review and discuss some of the main characteristics related to dams development and fish passes challenges in main South American basis

SOUTH AMERICA IS THE MOST FLUVIAL CONTINENT!!



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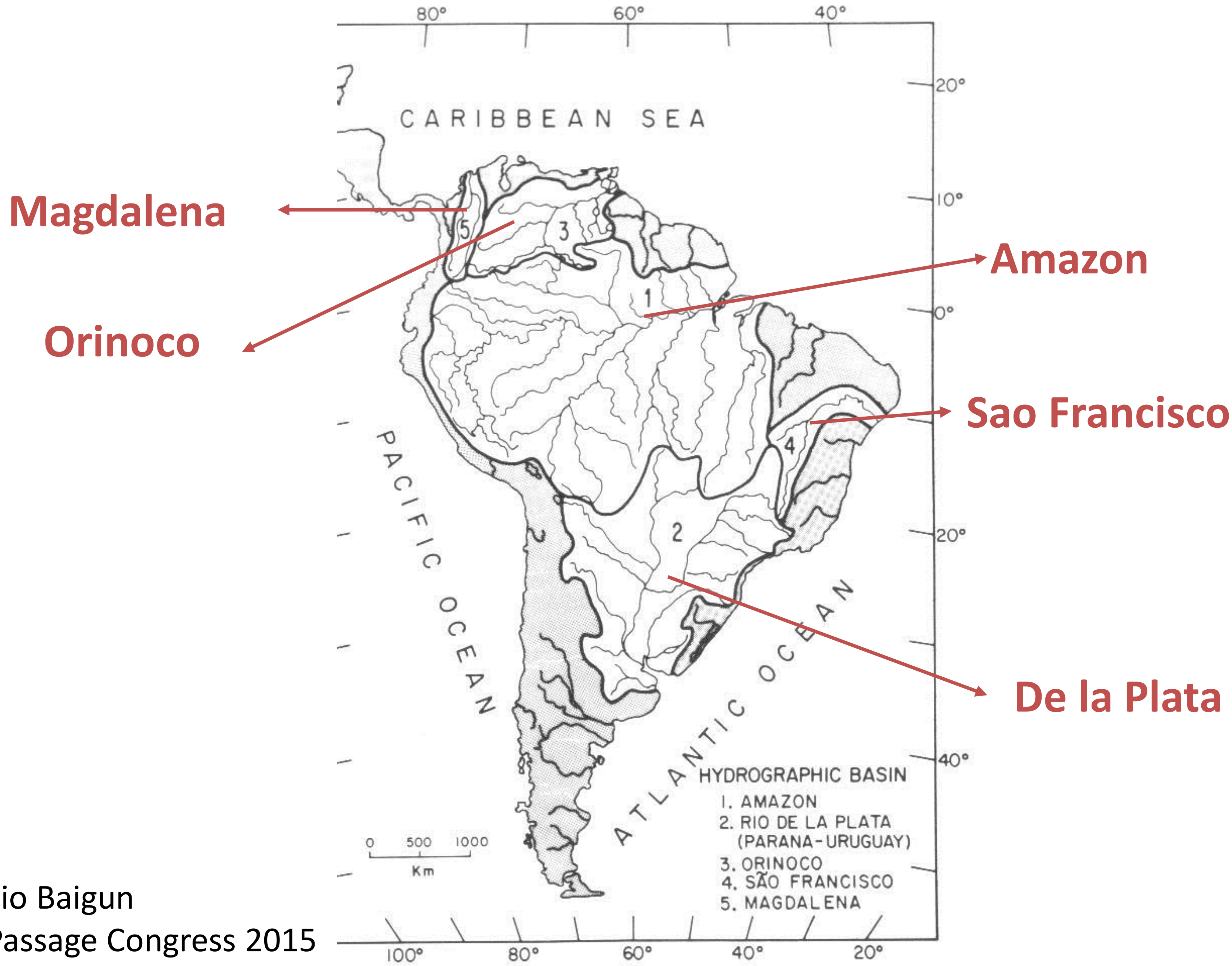

Figure 5.1 Map showing South America's major river basins

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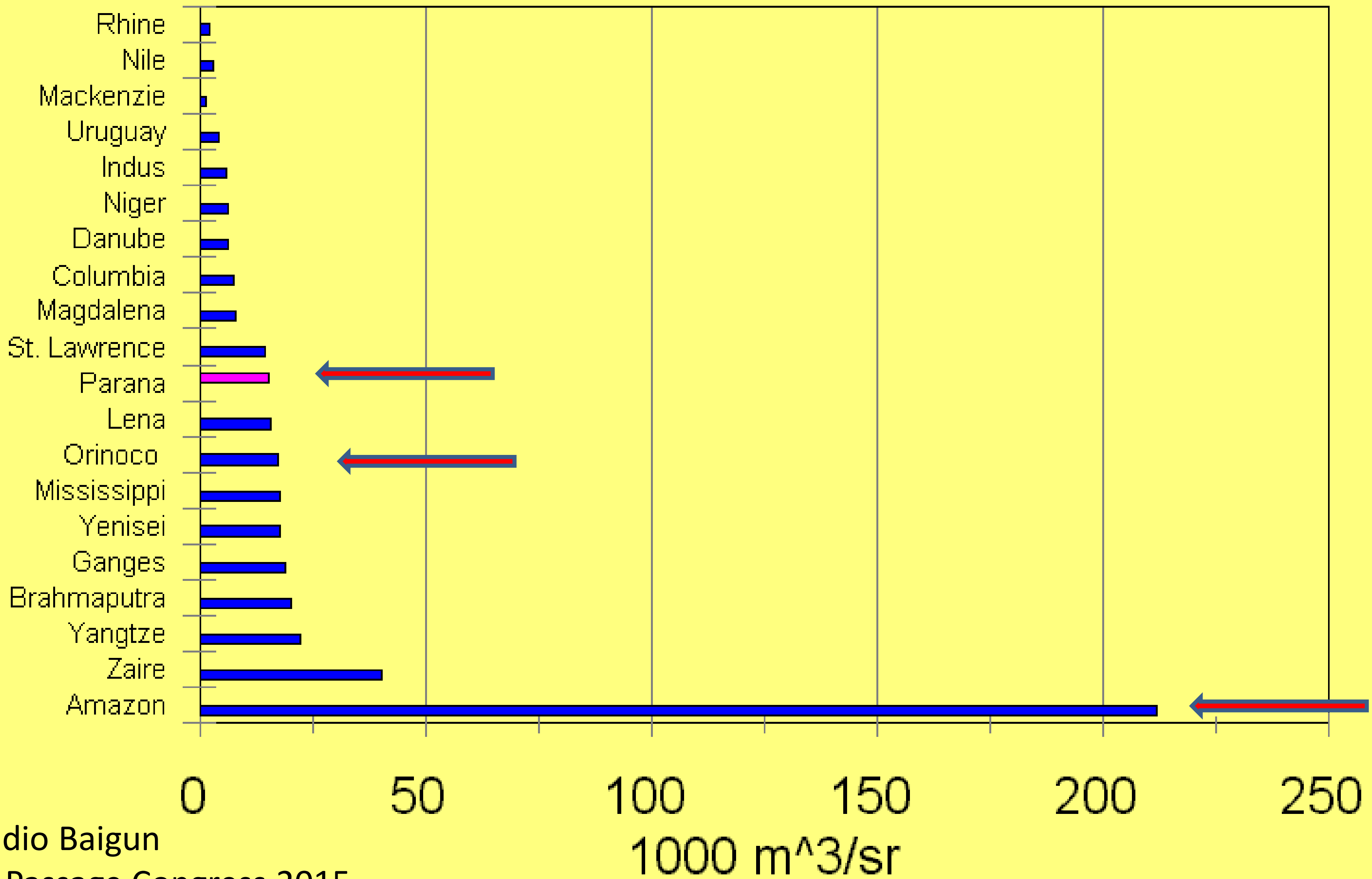
Mean Discharge



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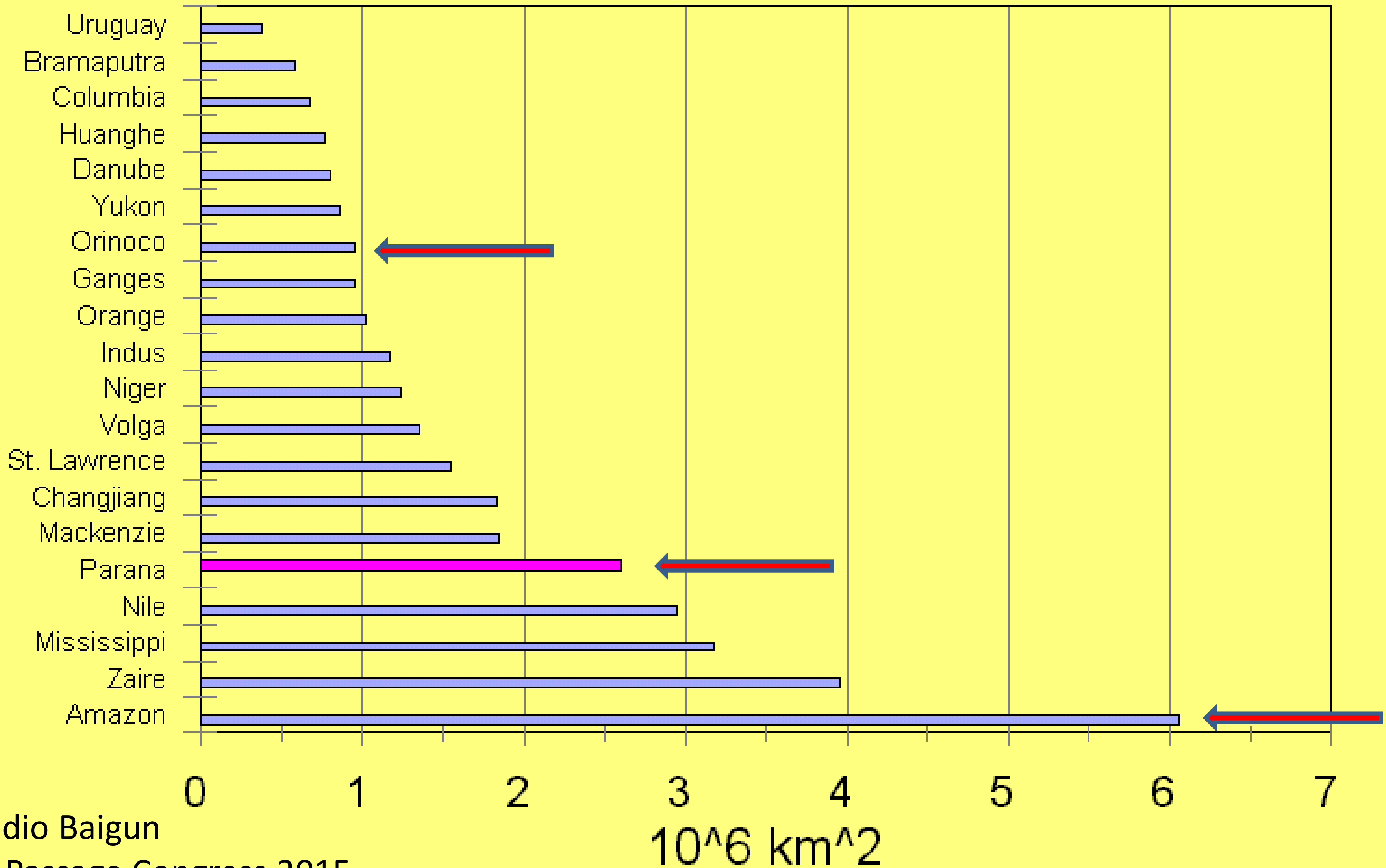
Watershed area



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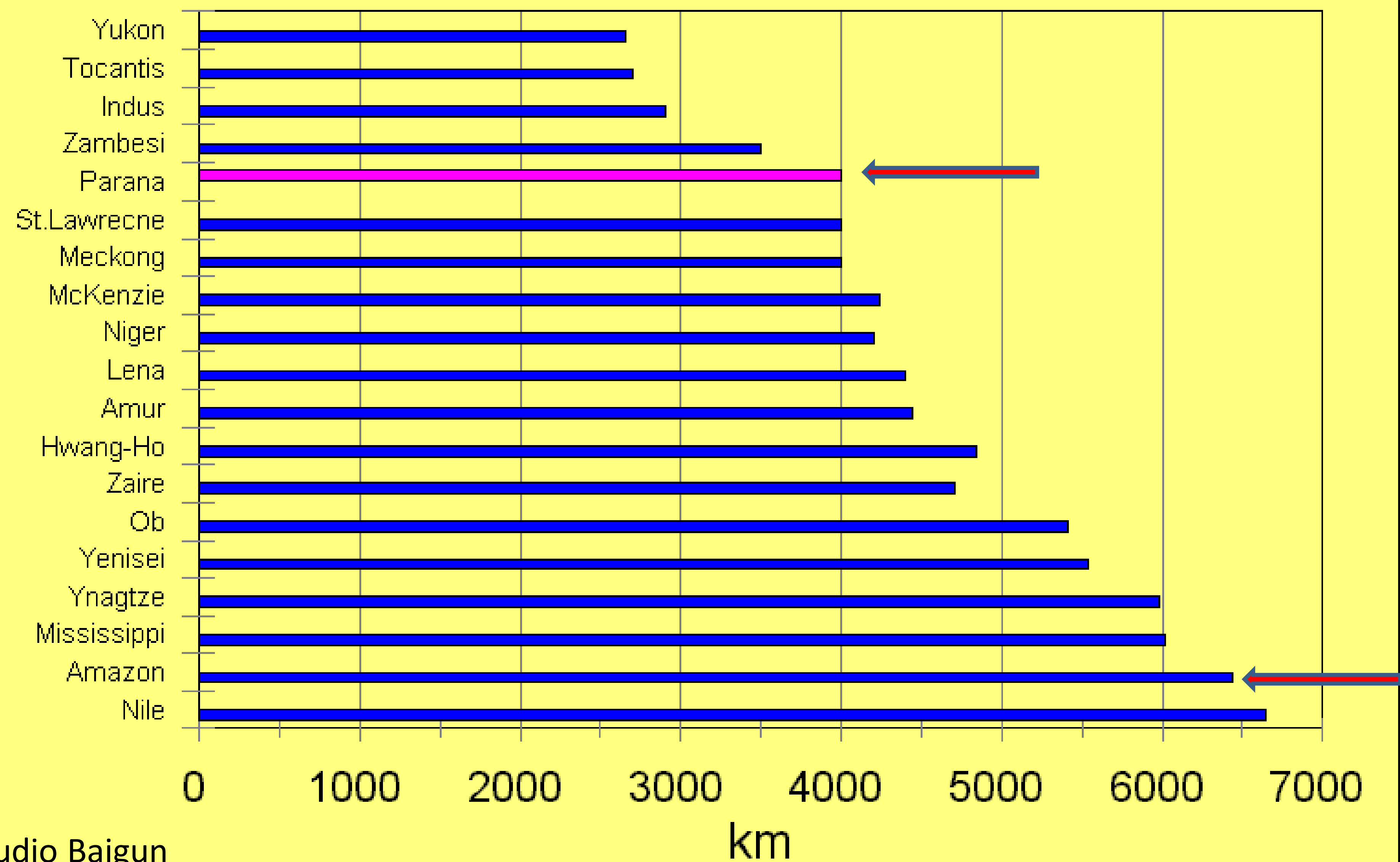
Length



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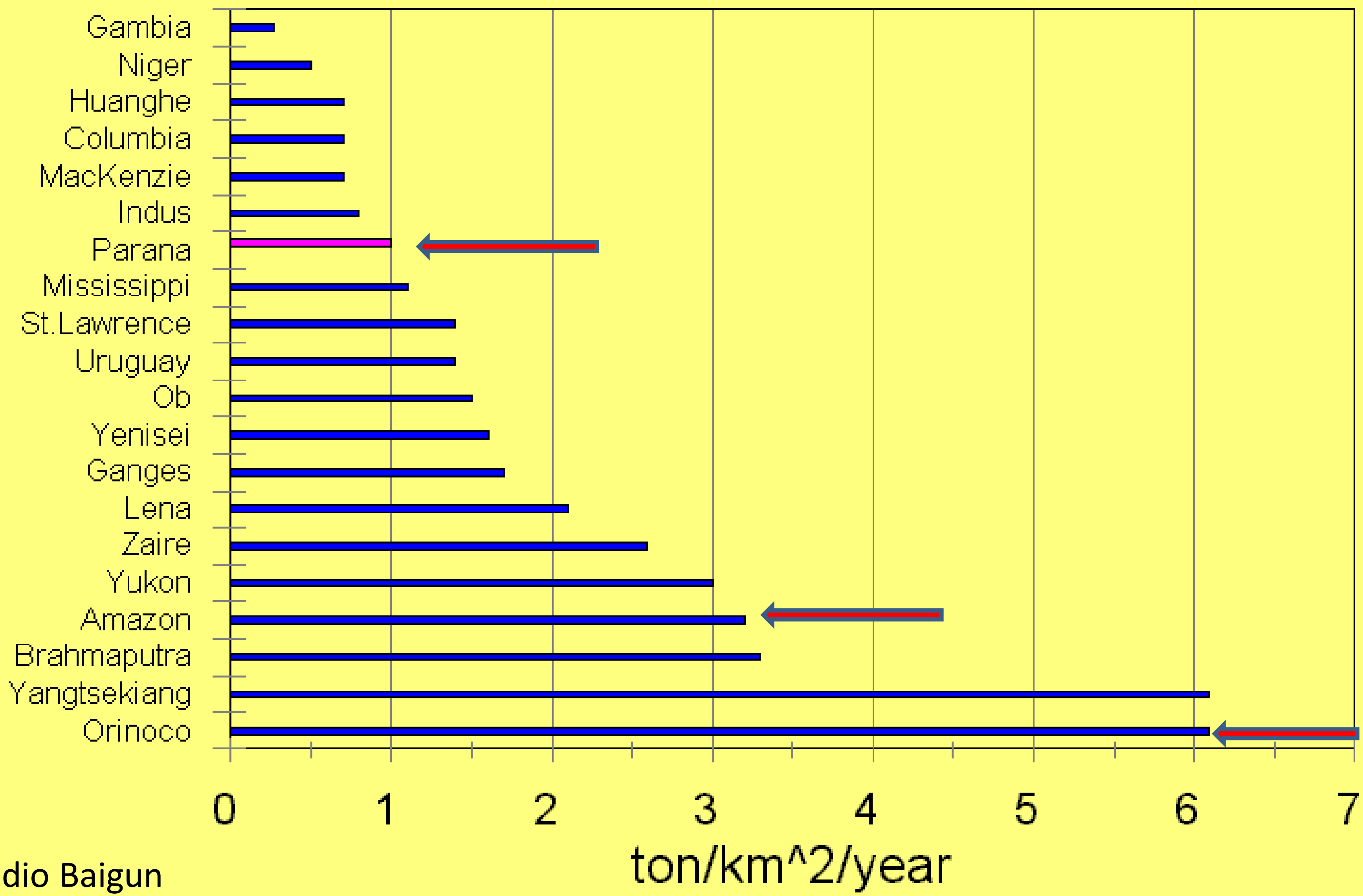
Dissolved Organic Carbon



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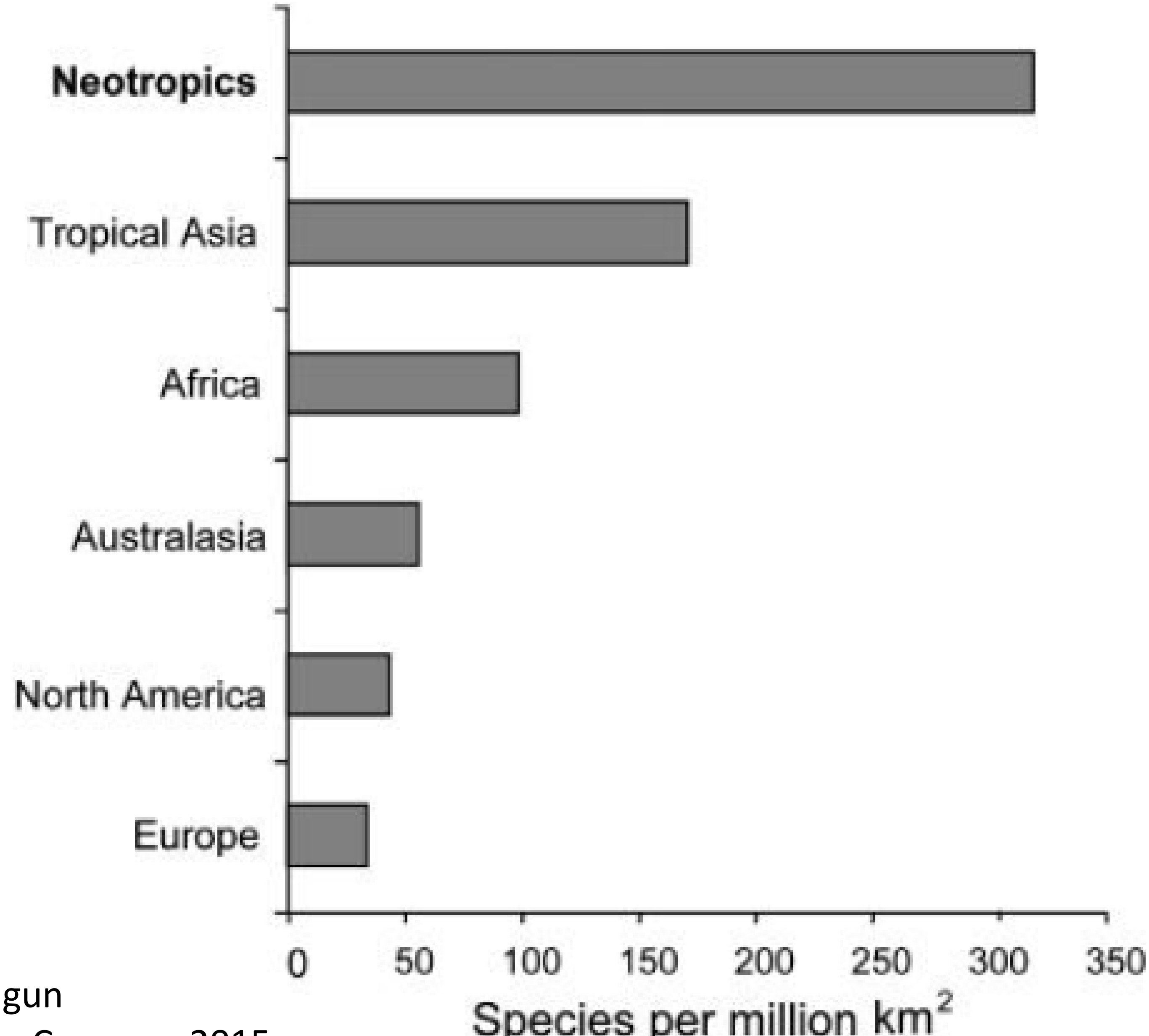
Albert &Reis 2011



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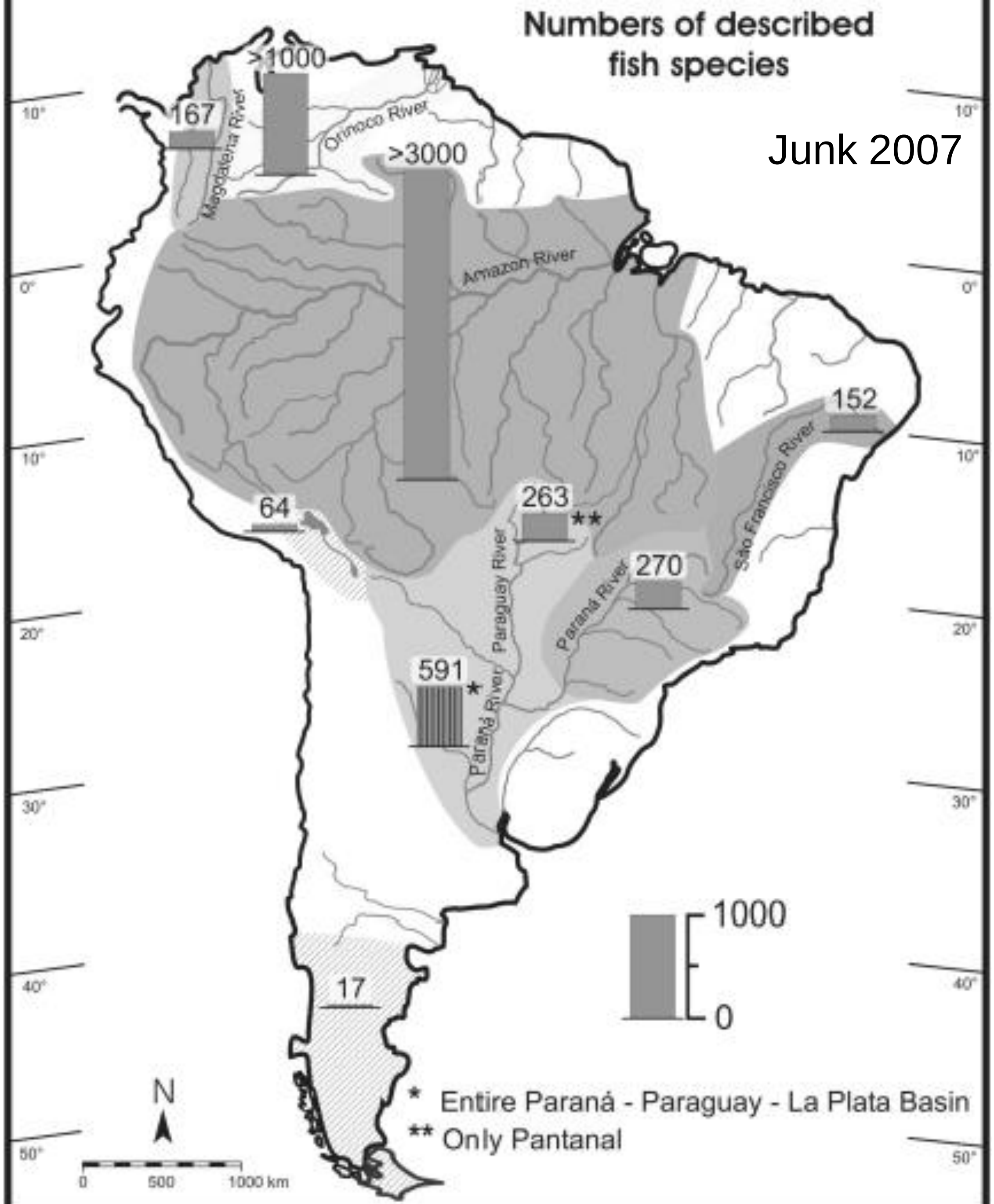

Numbers of fish species described in the studied regions of South America.

Junk 2007

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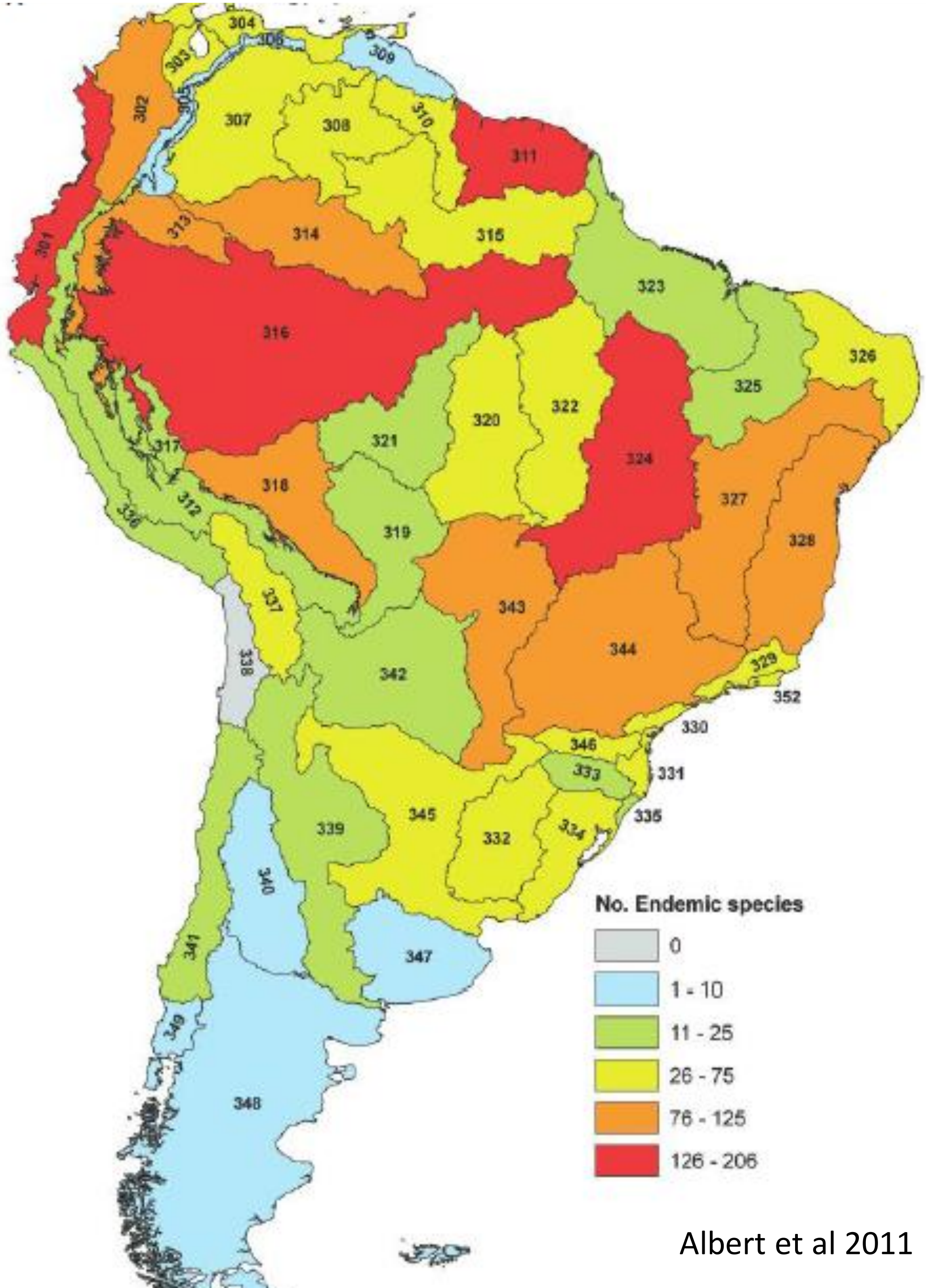

Albert et al 2011

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South American fish

- All Iteroparous
- Almost all potadromous
- Life cycles well adapted to cope with high hydrological variability
- Migratory species comprise between 20-45% of fish fauna most of them exhibiting a periodic strategy: free spawning, high fecundity, strong river pulses-recruitment relationships
- Migrations of different types and length

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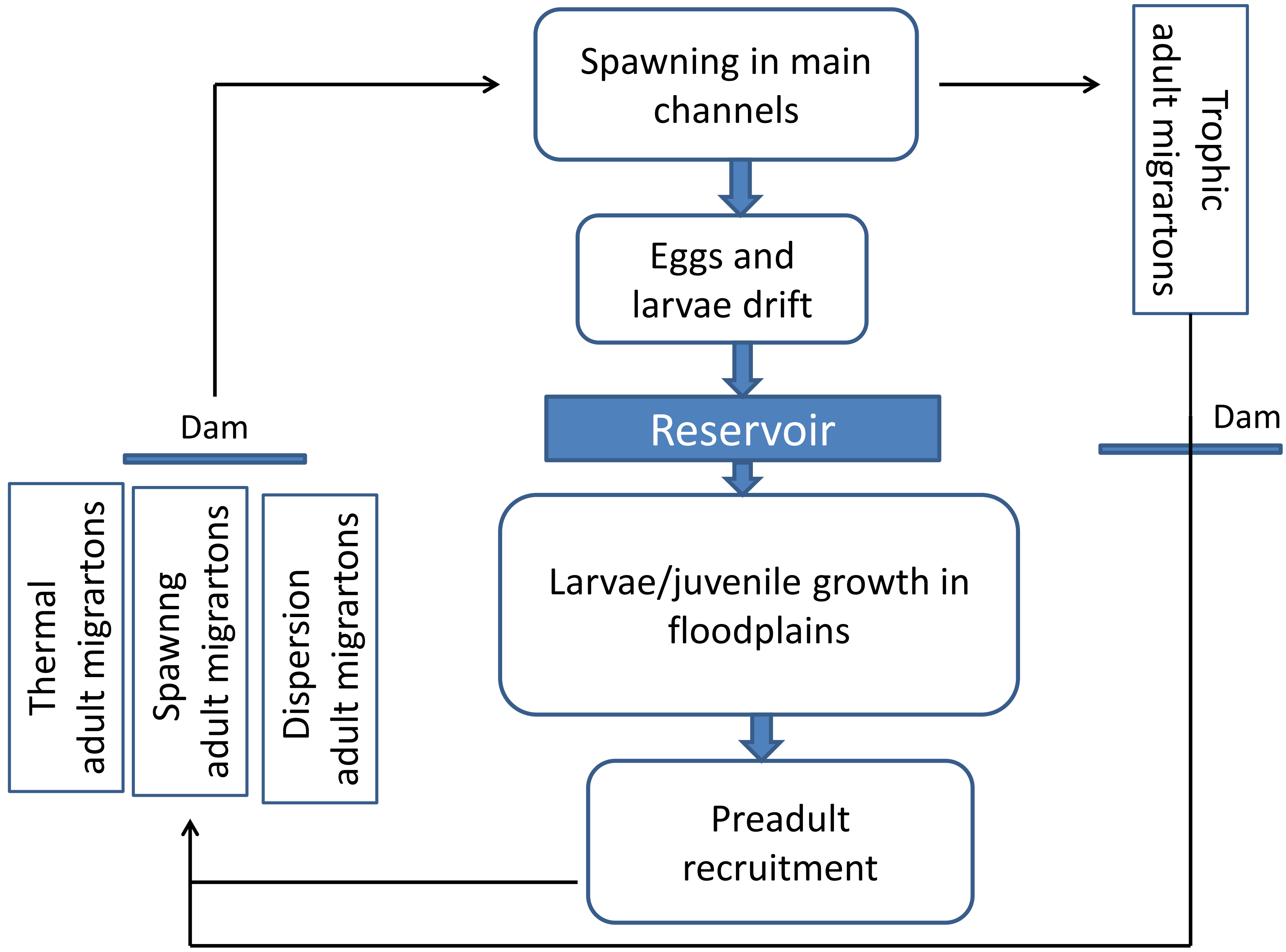
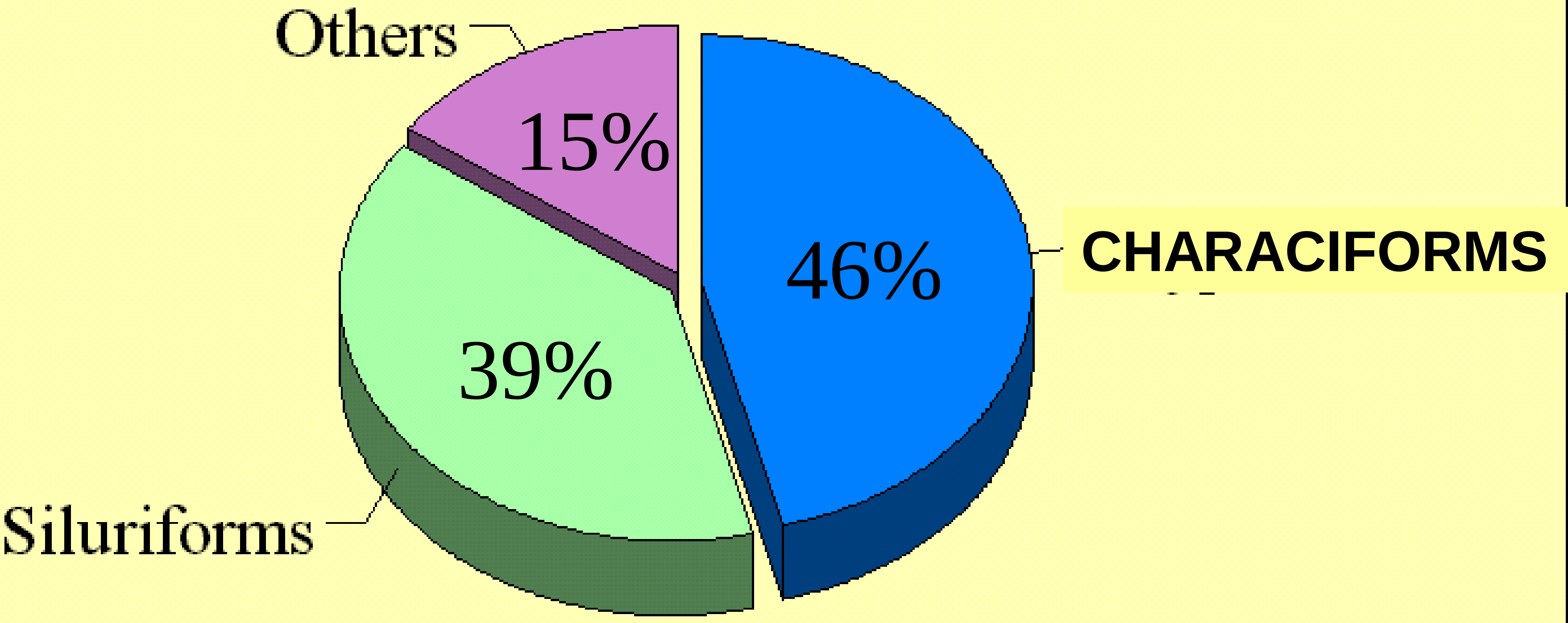


Spawning in main channels
Trophic adult migrartons
Eggs and larvae drift
Reservoir
Dam
Dam
Thermal adult migrartons
Spawnng adult migrartons
Dispersion adult migrartons
Larvae/juvenile growth in floodplains
Preadult recruitment

Fish composition in Neotropical rivers



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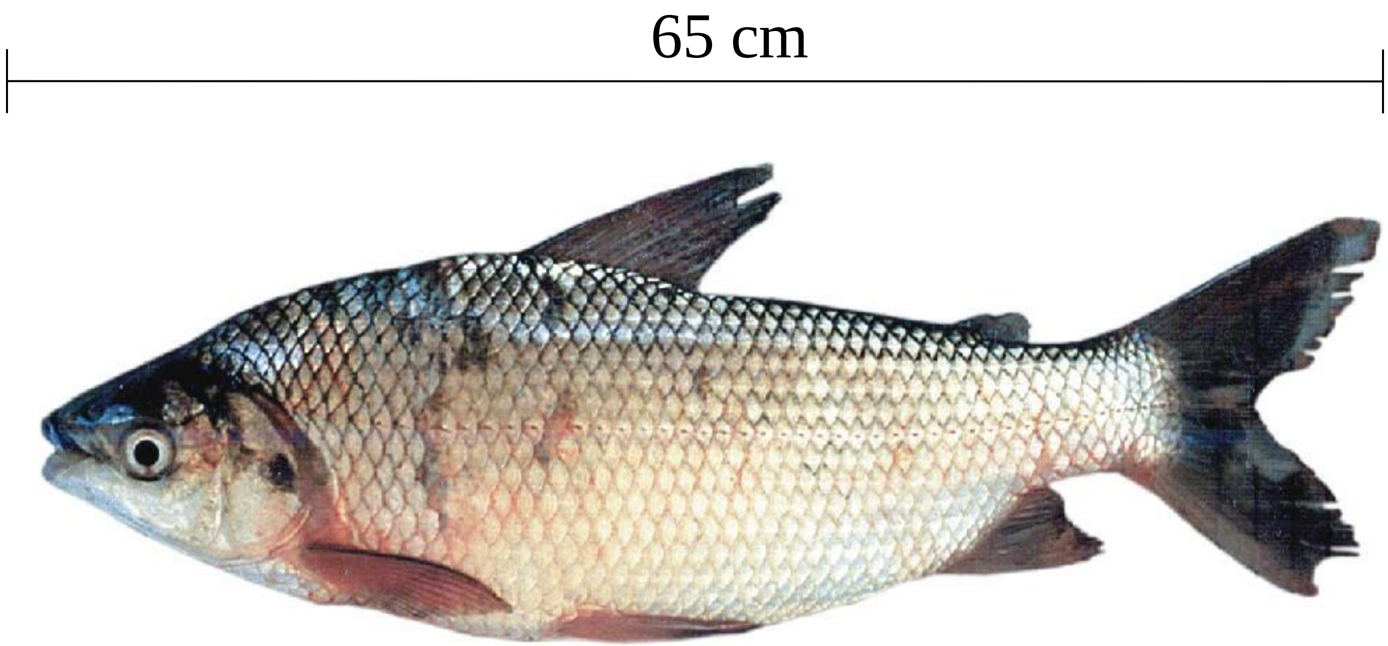
Prochilodus lineatus



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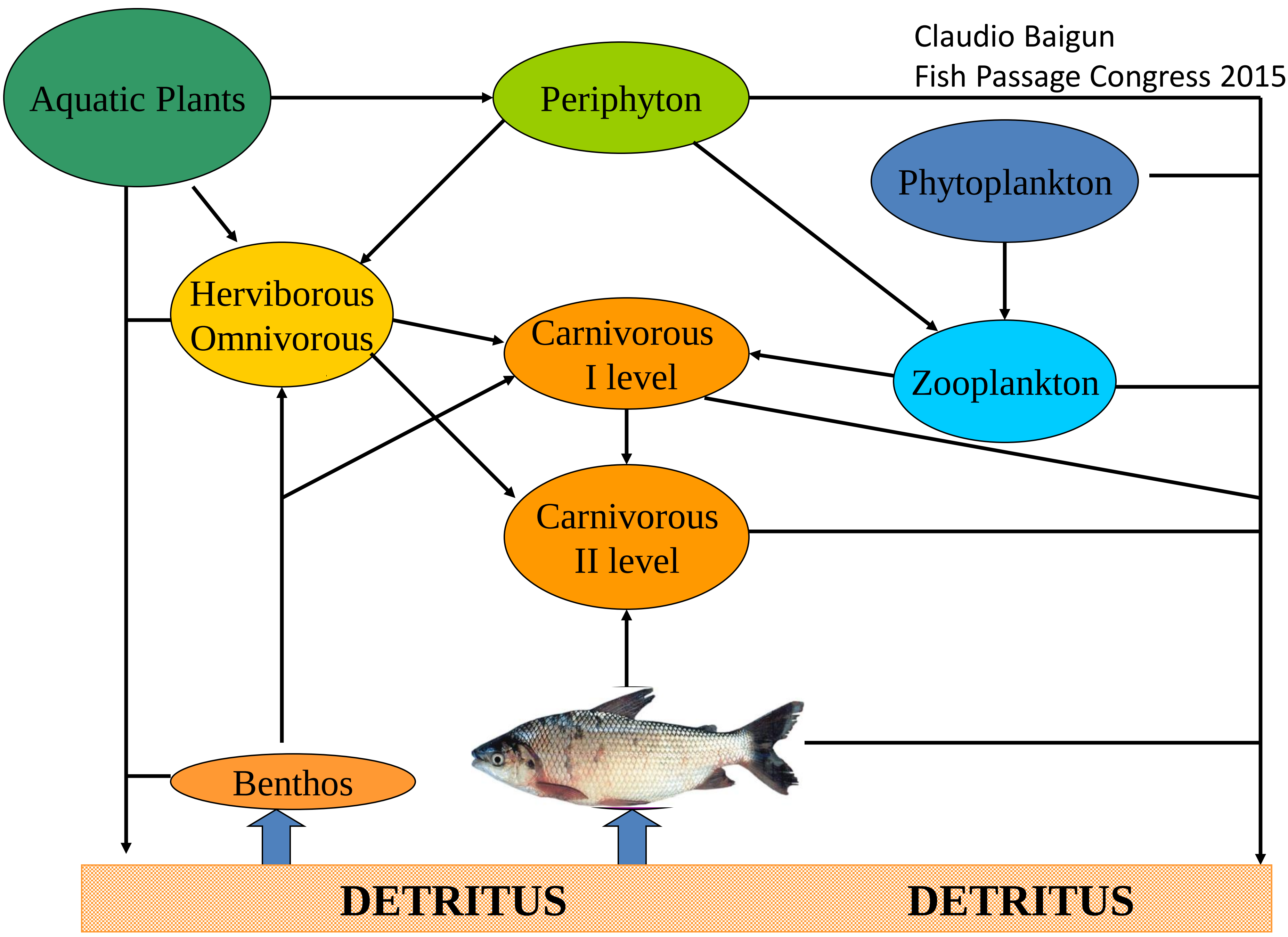
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Aquatic Plants
Periphyton
Phytoplankton
Herviborous Omnivorous
Carnivorous I level
Zooplankton
Carnivorous II level
Benthos
DETRITUS
DETRITUS

Piaractus mesopotamicus

70 cm

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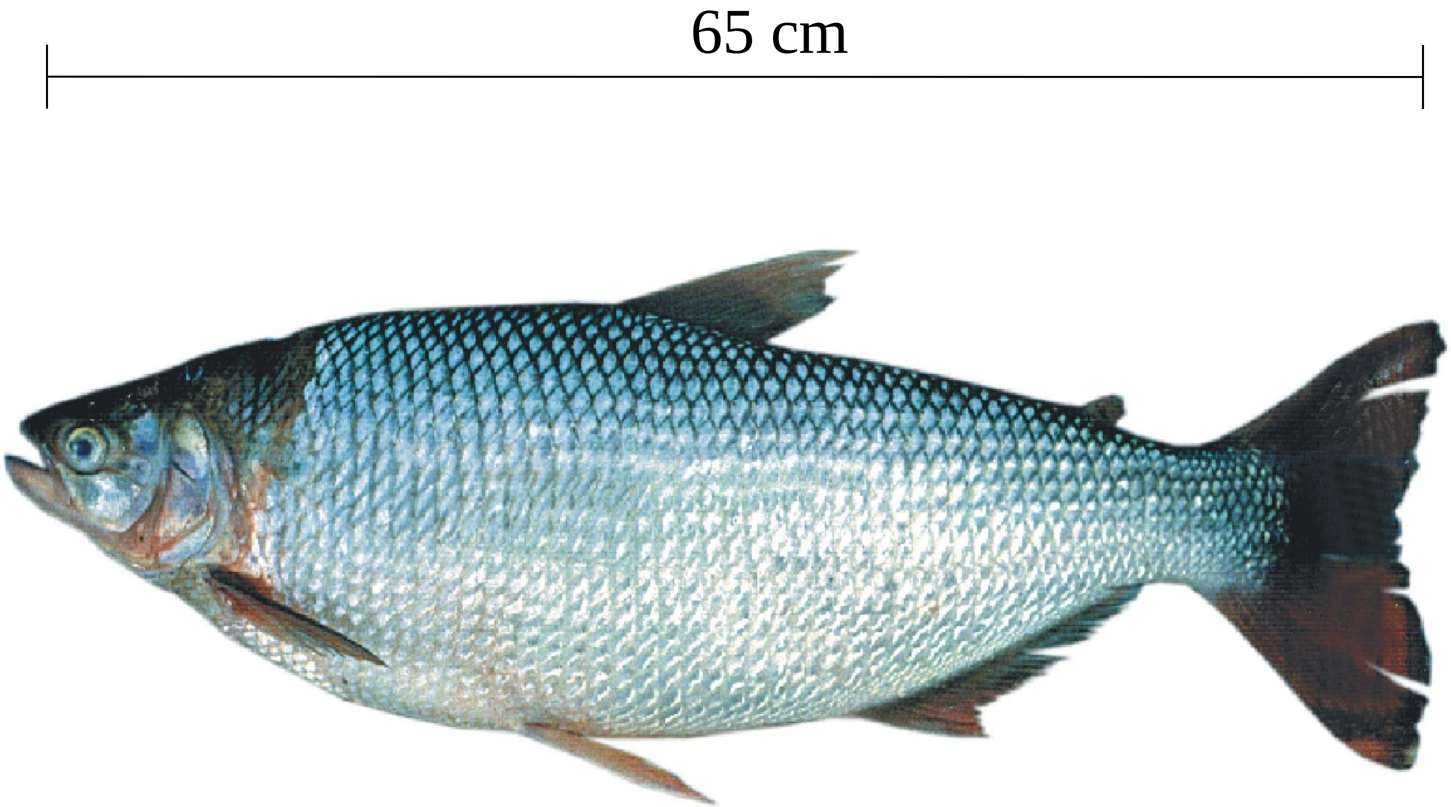
Brycon orbygnianus



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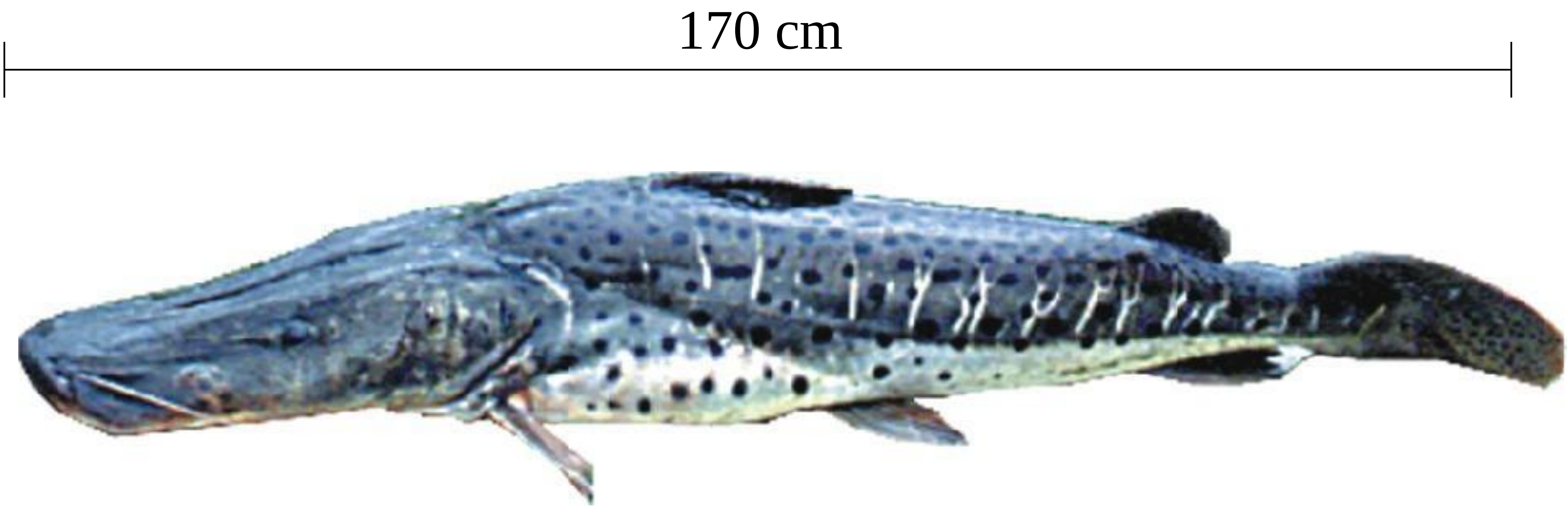
Pseudoplatystoma coruscans



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Pseudoplatystoma fasciatum

150 cm

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Paulicea lutkeni

90 cm

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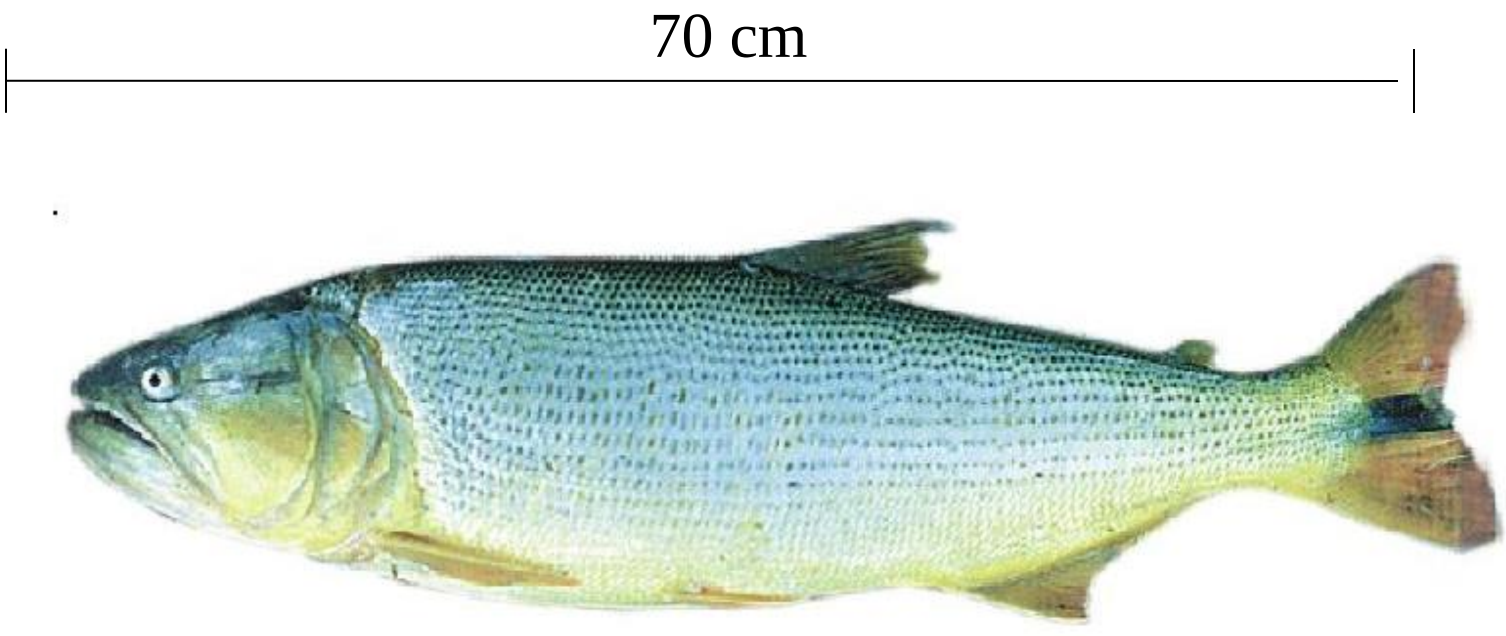
Salminus maxillosus



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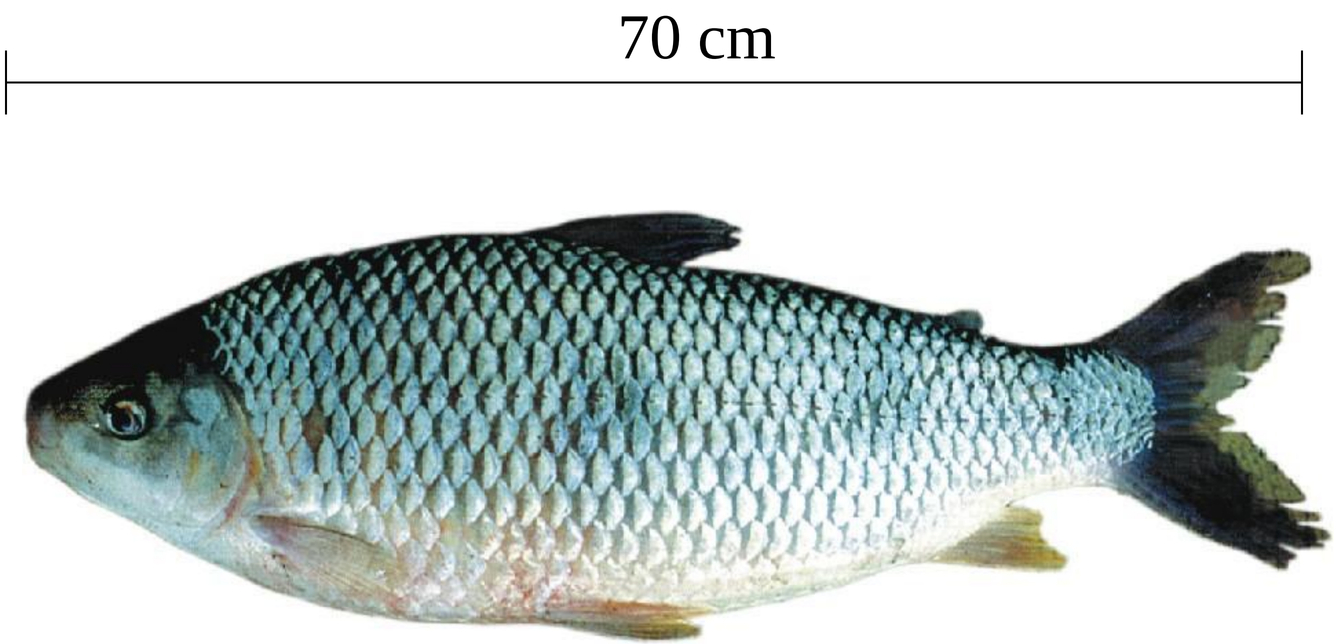
Leporinus obtusidens



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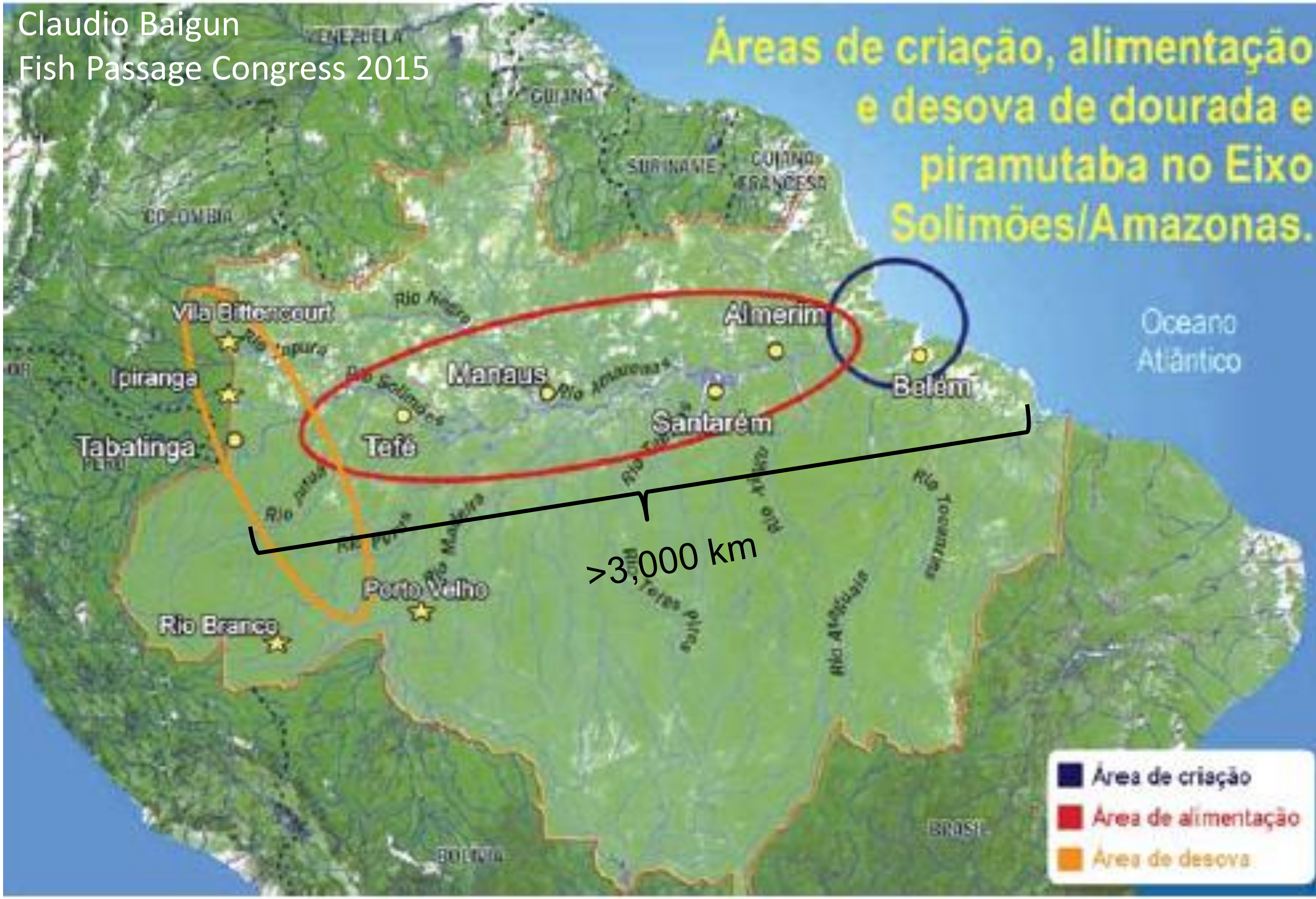

Figura 1. Áreas de criação, alimentação e desova de dourada e de piramutaba no eixo Solimões-Amazonas (Barthem & Goulding, 1997).

- Migratory movements are complex and they comprise not only reproductive migrations but also thermal, trophic and dispersive movements
- Same species in different basins can exhibit different bionomic adpatations according to flow regime

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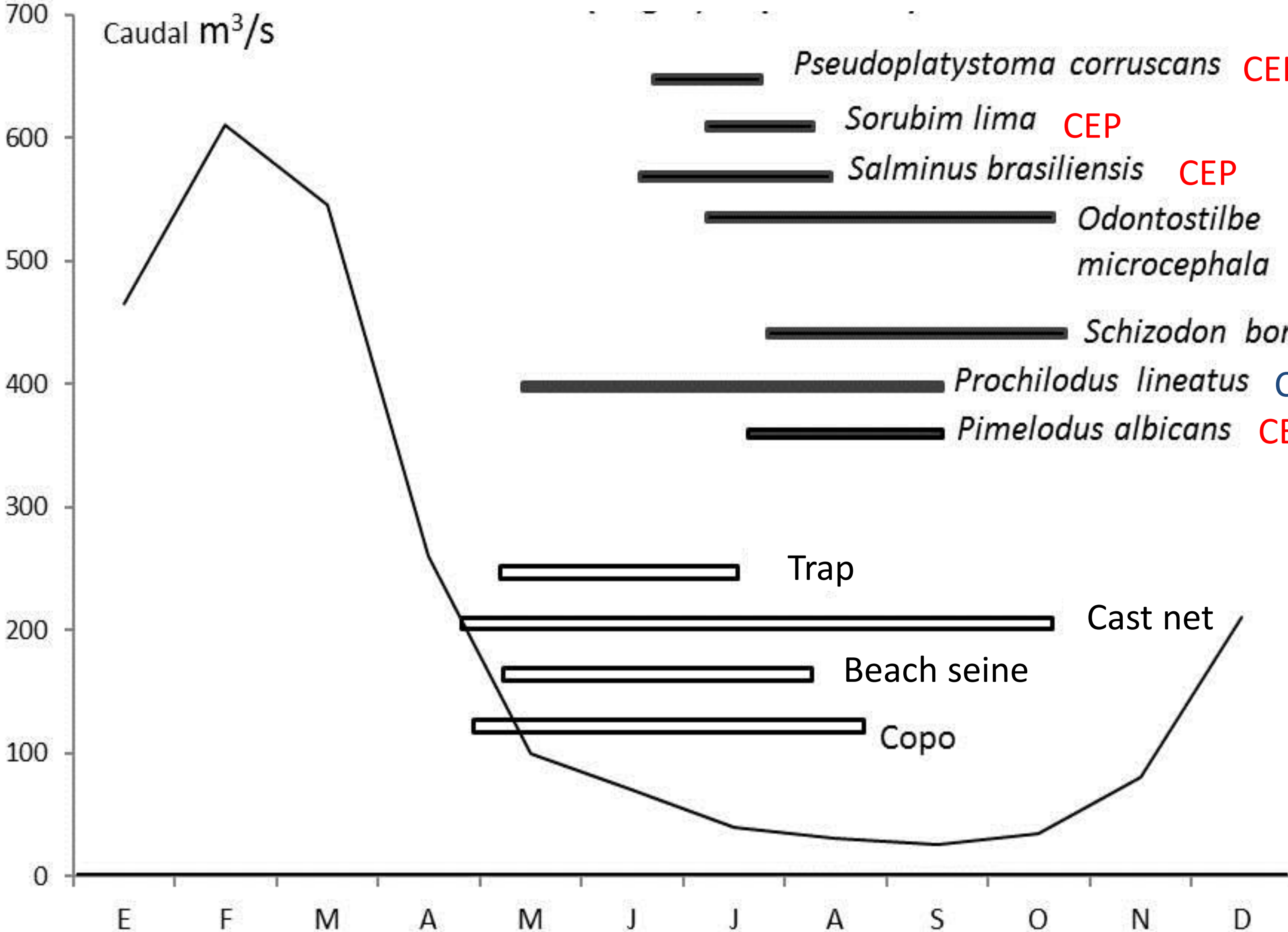

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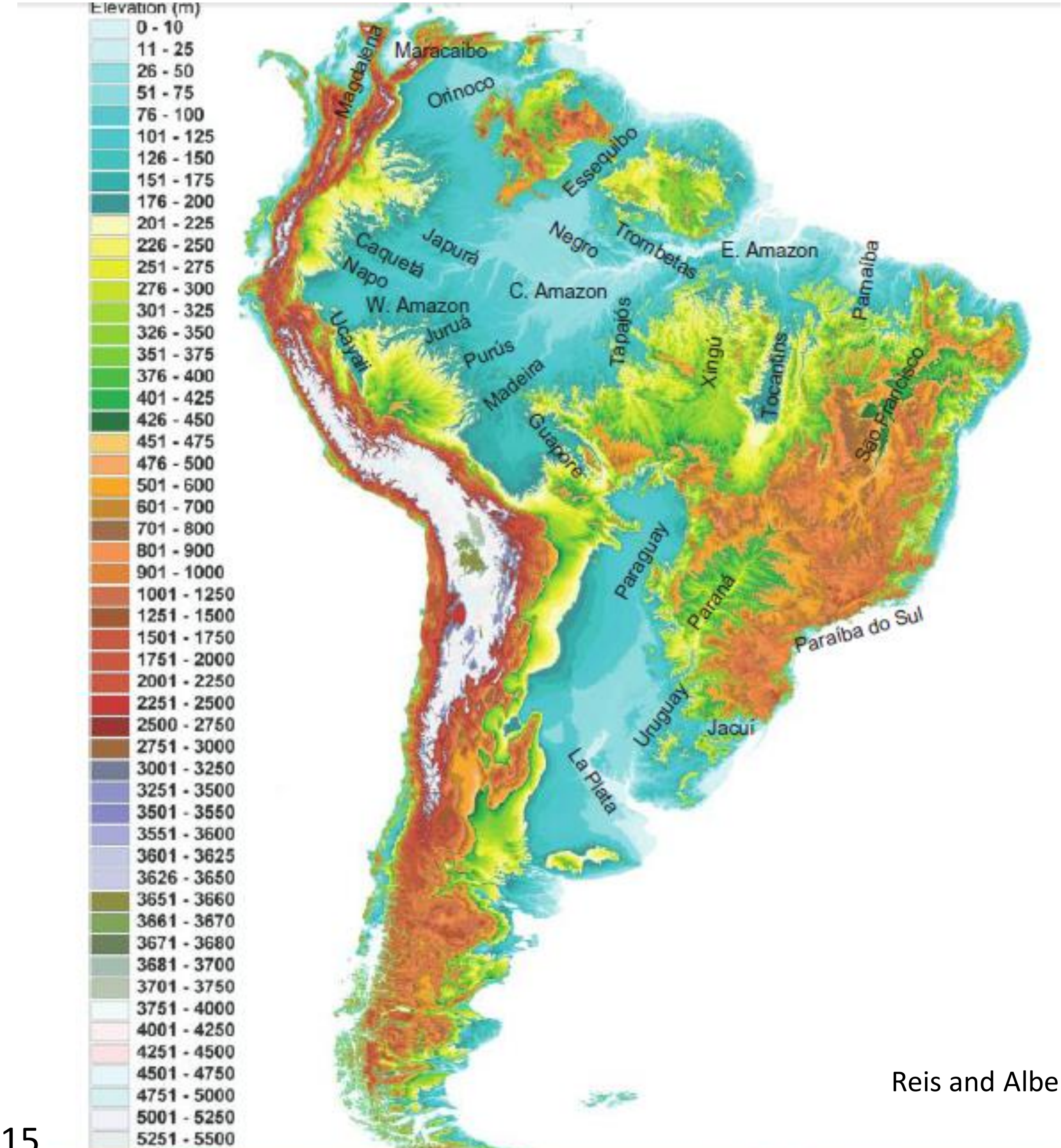

Reis and Albert 2011

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Overview large dams per continent

(UNEP, 2001).

	World (incl. China)	Europe	Asia	North and Central America	South America	Africa	Austral-Asia
Total number of large dams	47655[a]	5480	5480	8010	979	1269	577
Average height (m)	31[b]	33	33	28	37	28	33
Average reservoir area (km^2)	23[b]	7	44	13	30	43	17
Avg. reservoir capacity (million m^3)	269[b]	70	268	998	1011	883	205

[a] *The primary source of data is ICOLD World Register of Dams (1998, 2000) and estimates by the World Commission of Dams (WCD, 2001).*

[b] *The ICOLD 1998 database was used to calculate the average dam height, reservoir capacity and surface area by region.*

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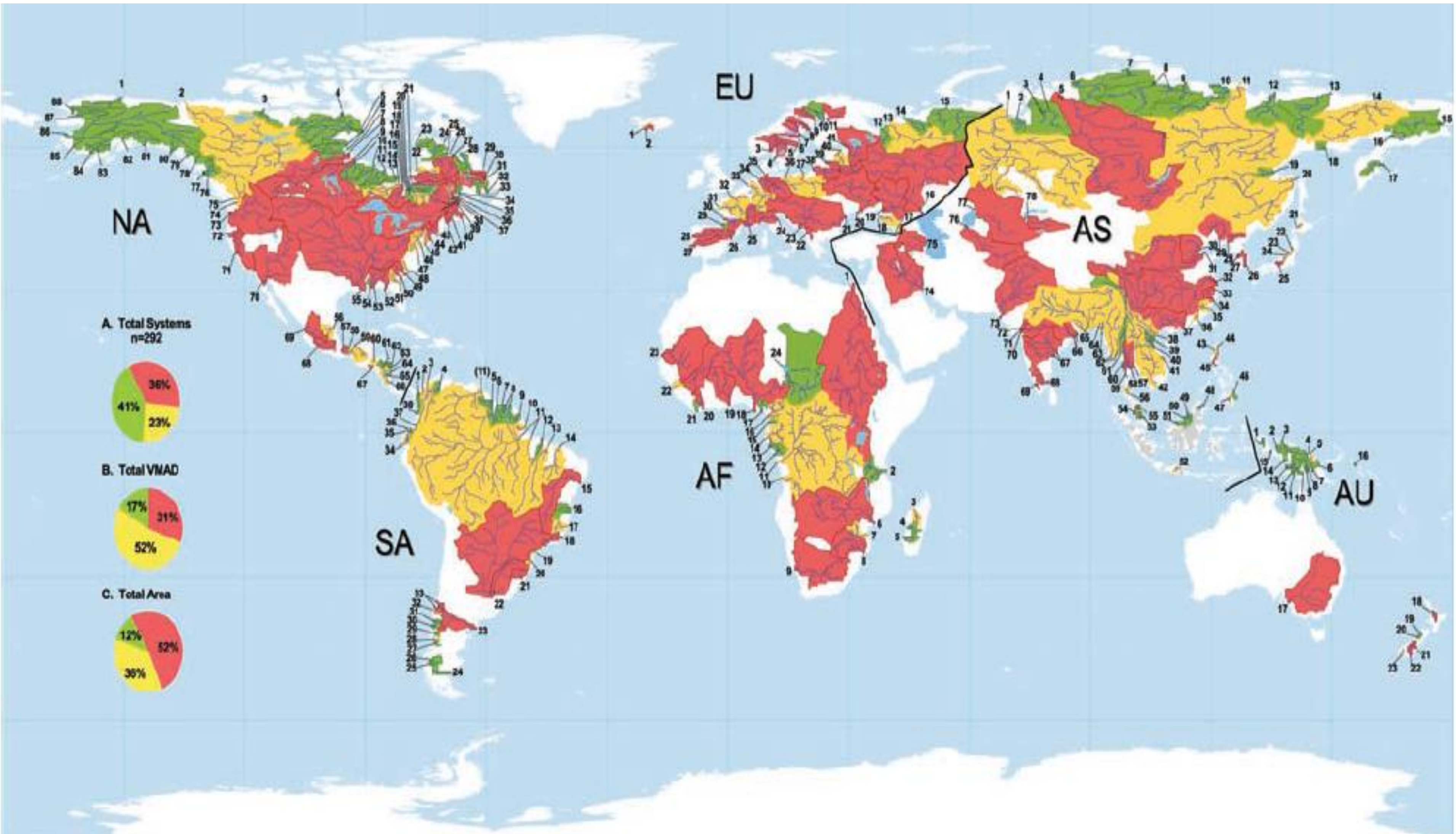
Basin status



Nilsson et al 2005

Figure 5.1 Map showing South America's major river basins

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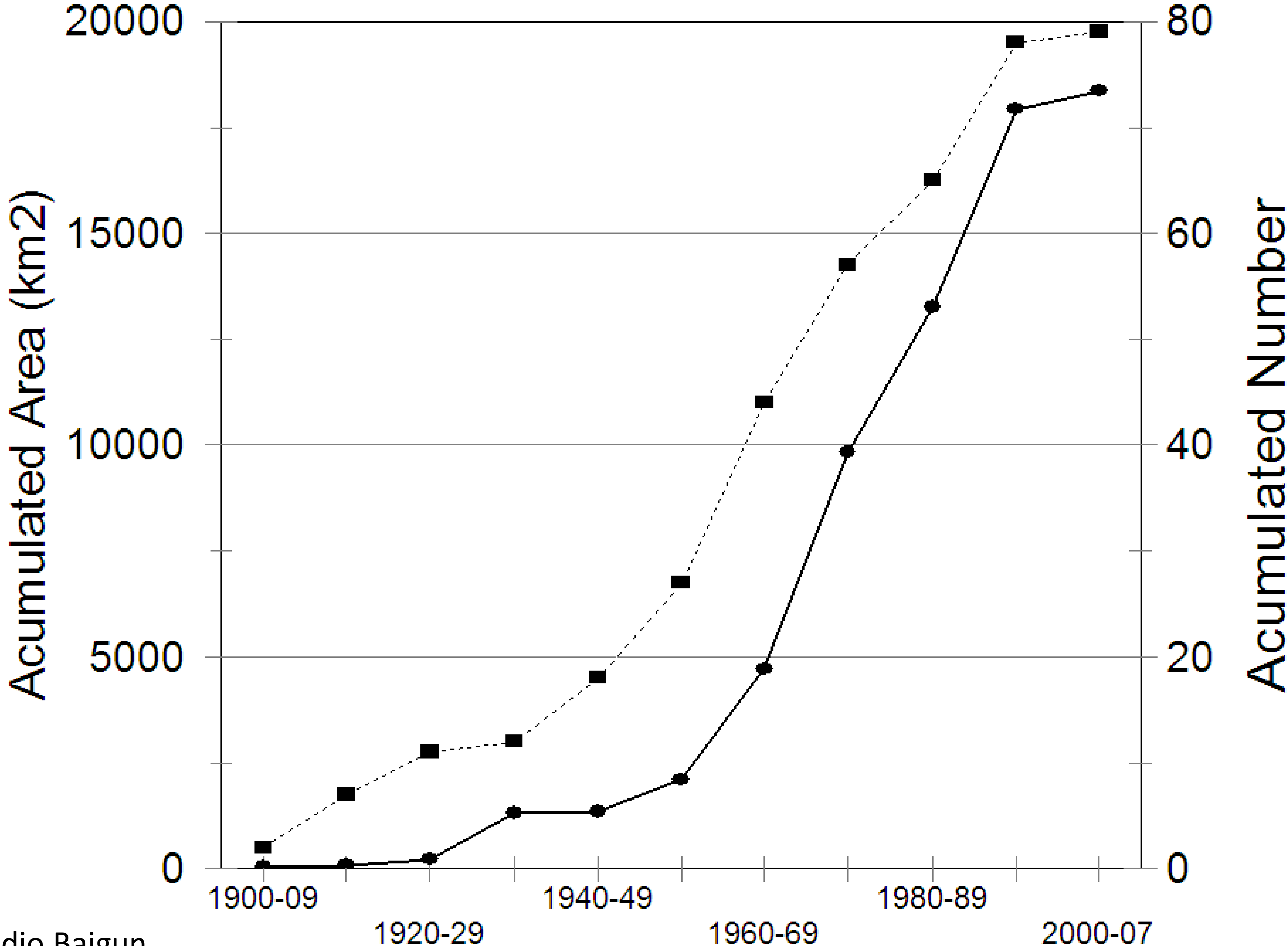

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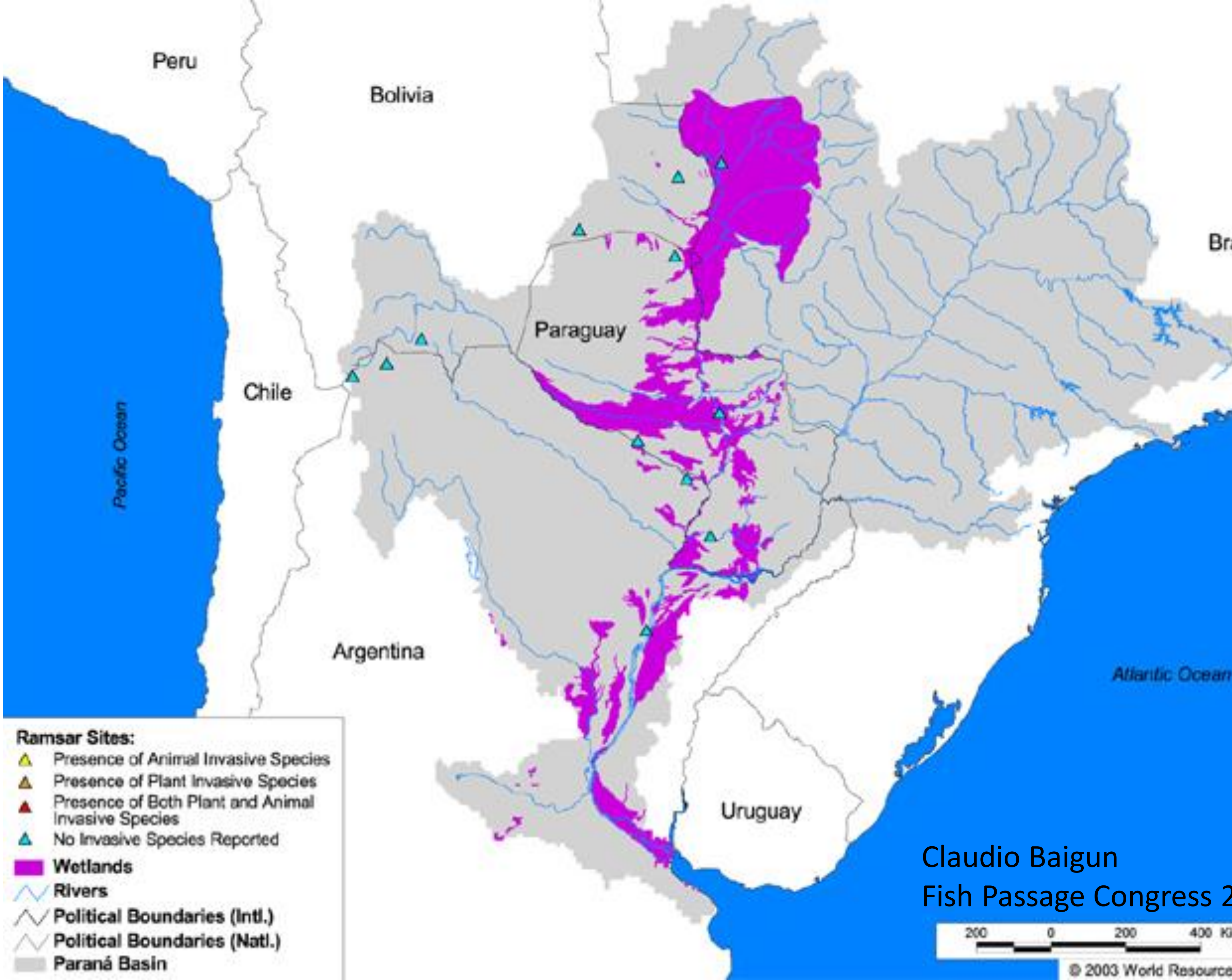

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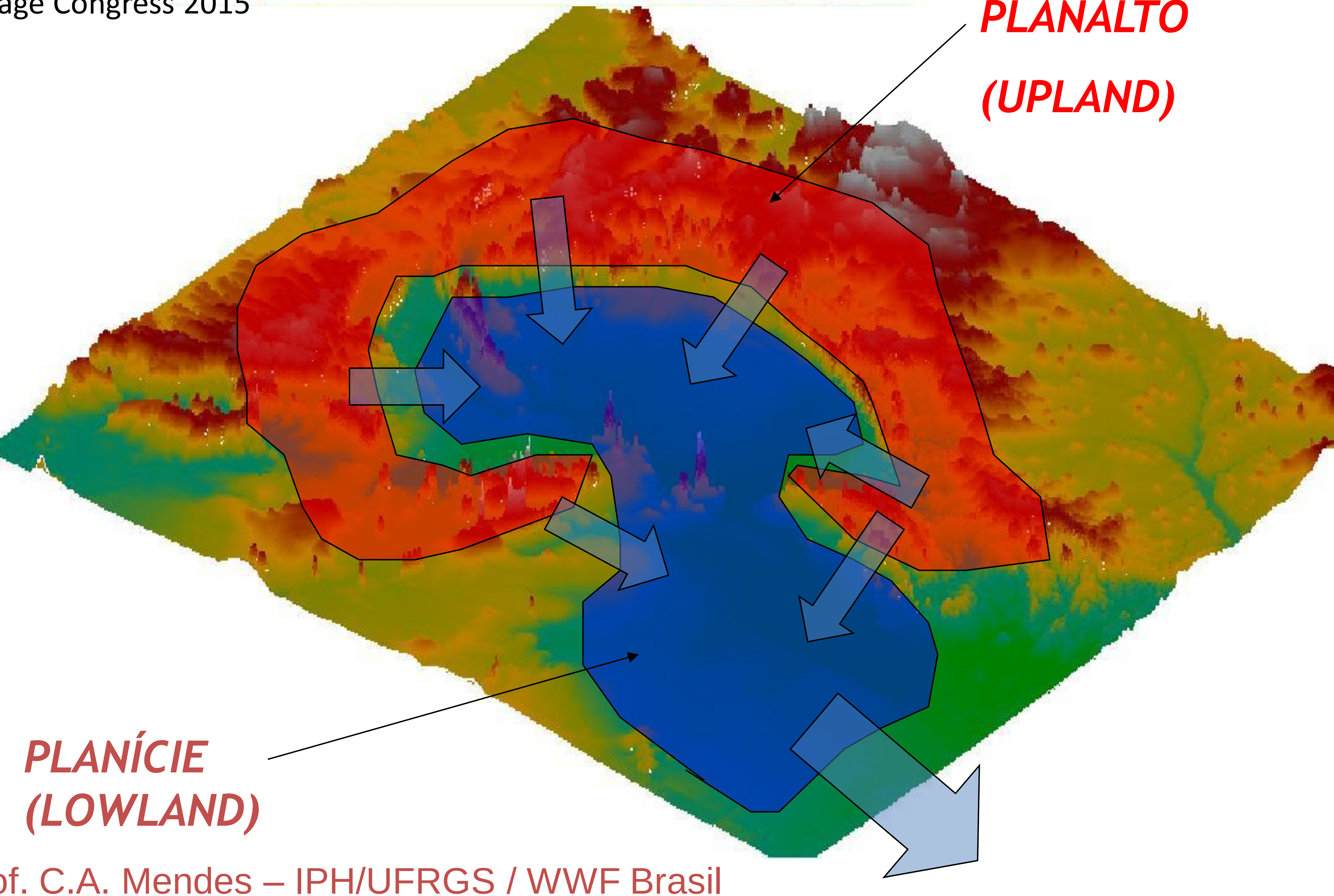

of. C.A. Mendes – IPH/UFRGS / WWF Brasil


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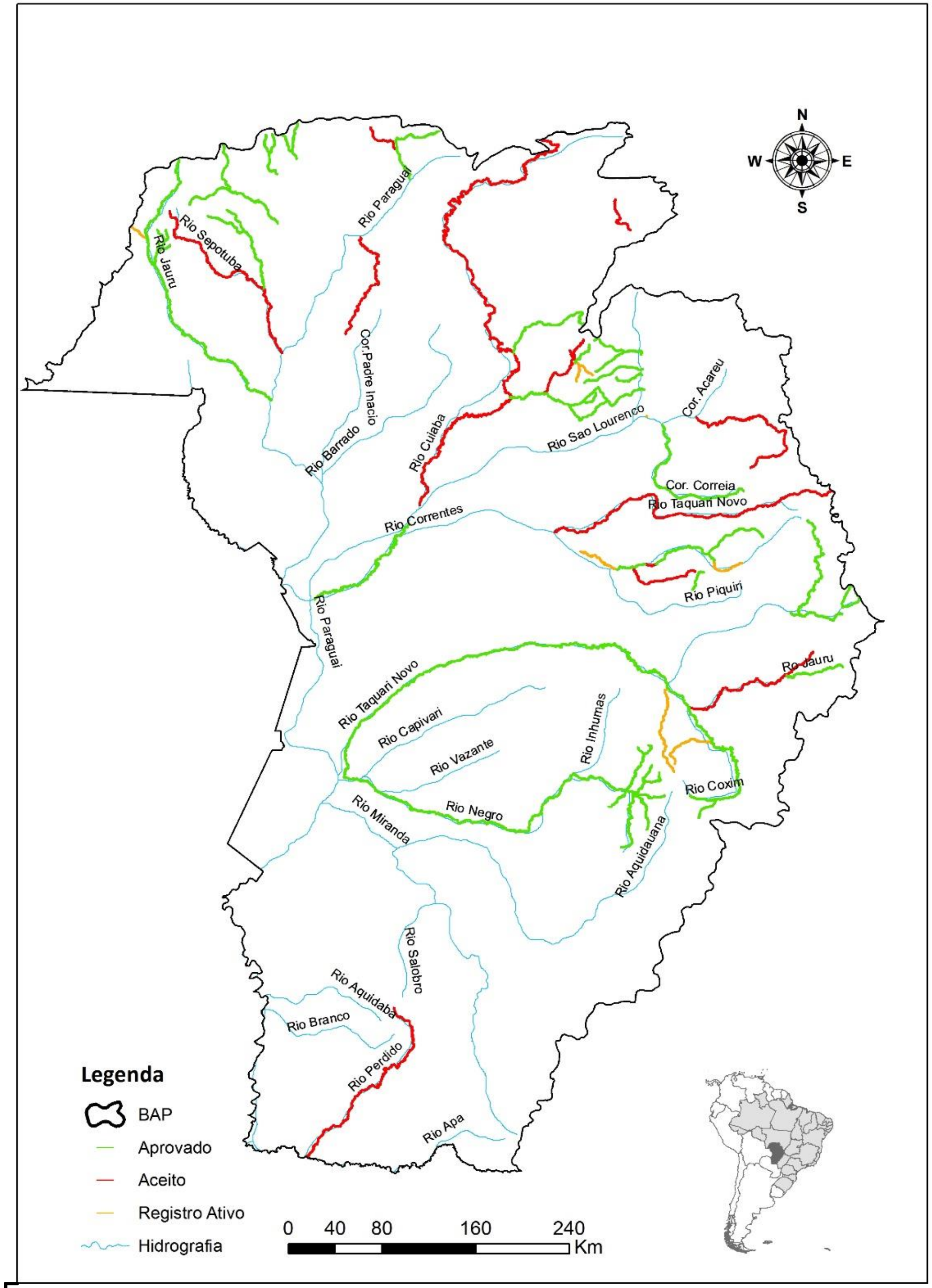
SIGEL/ANEEL



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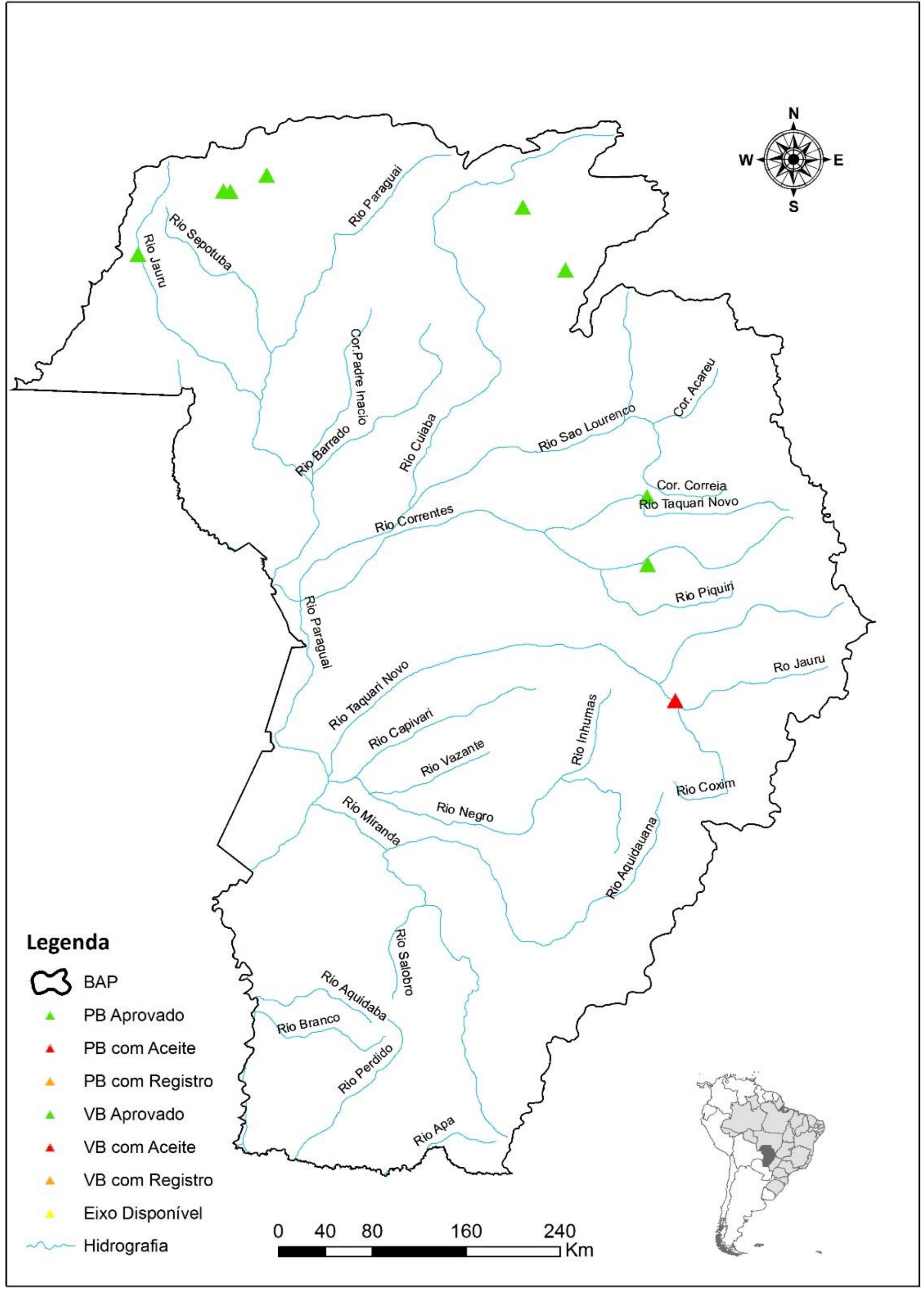
UHEs
SIGEL/ANEEL



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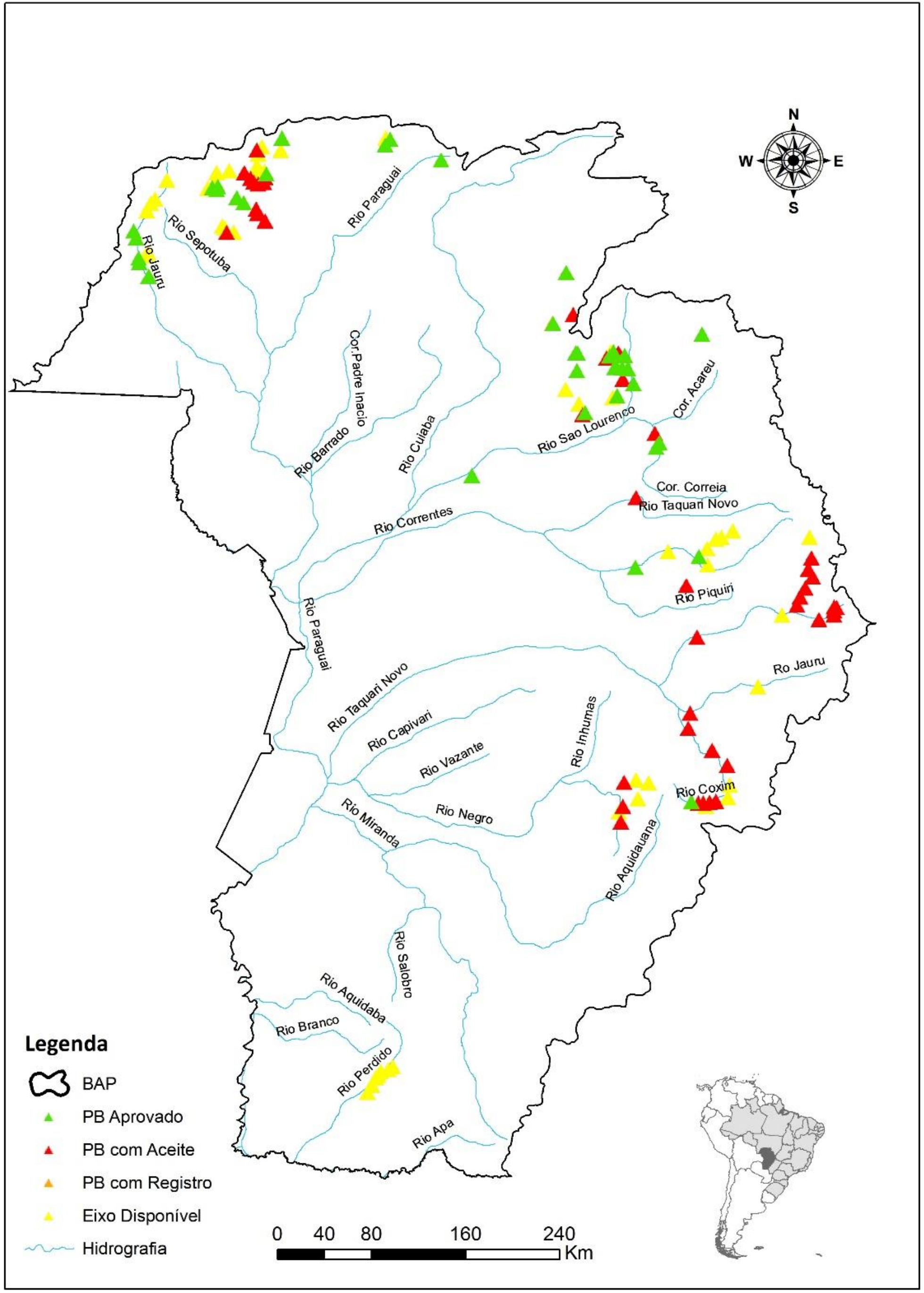
PCHs
SIGEL/ANEEL



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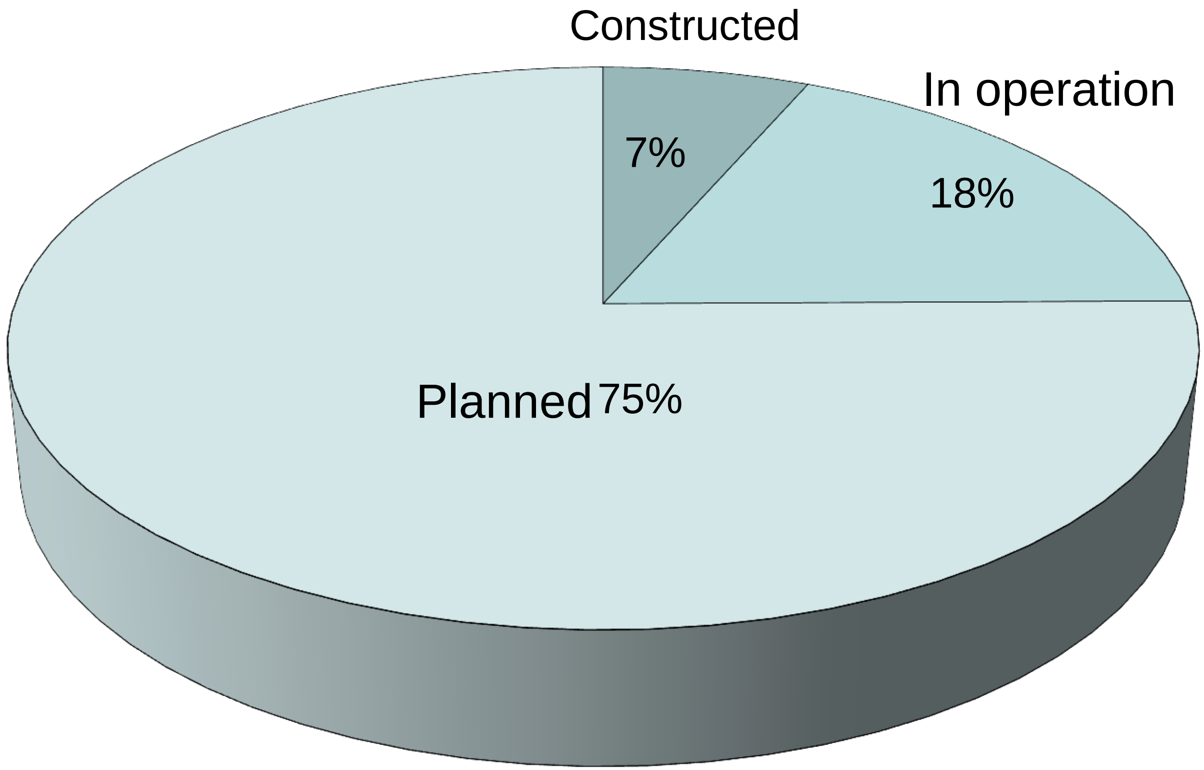
- New dams will represent an additional 2,5 % of energy at national scale
- Recreational fisheries represent the second income resource in the Pantanal: 22,000 employments mobilizing 67,000.000 U$D per year
- Artisanal fisheries encompass almost 10,000 families mobilizing 35,000.000 U$D

Amazon basin



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Inventoried dams

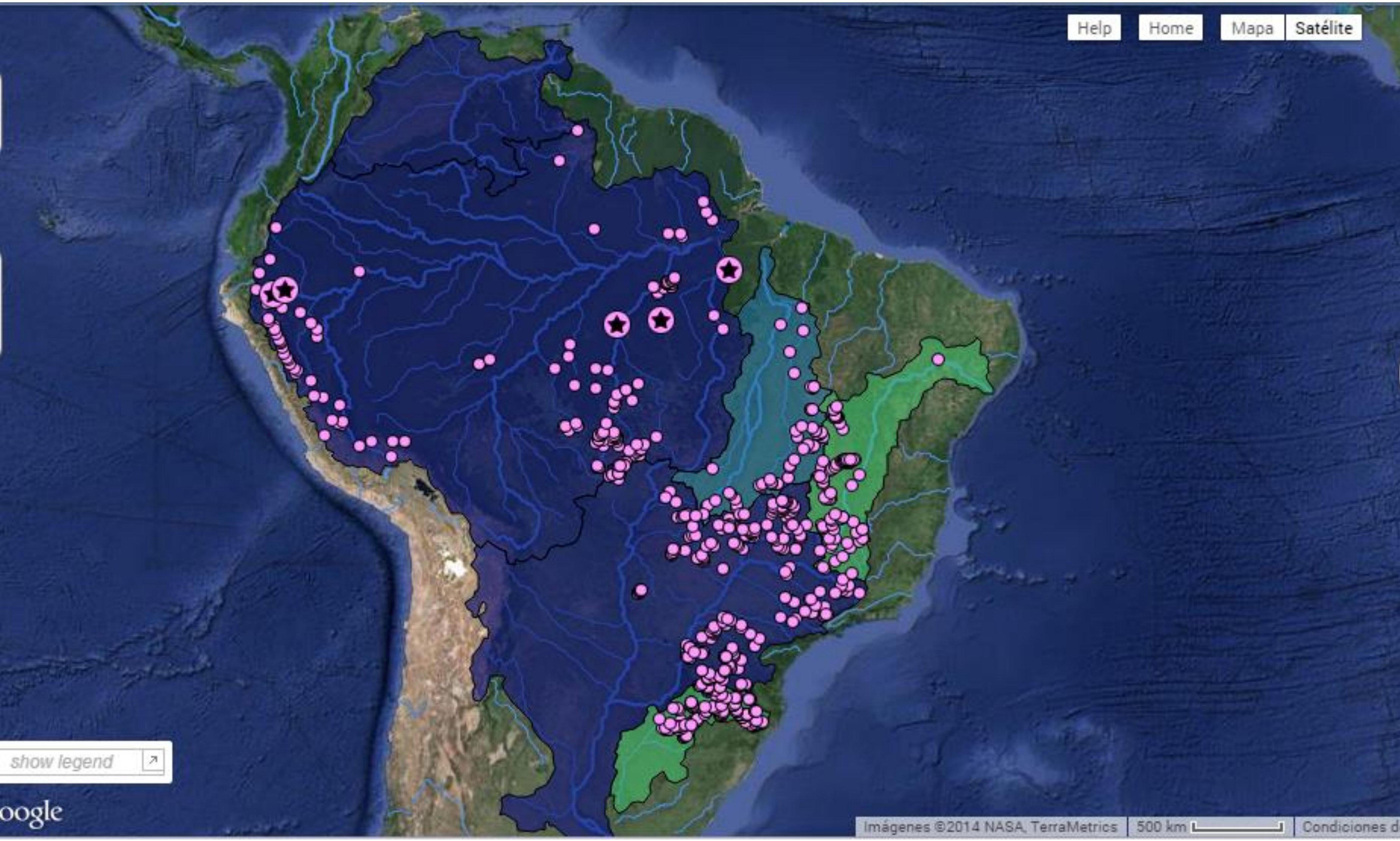

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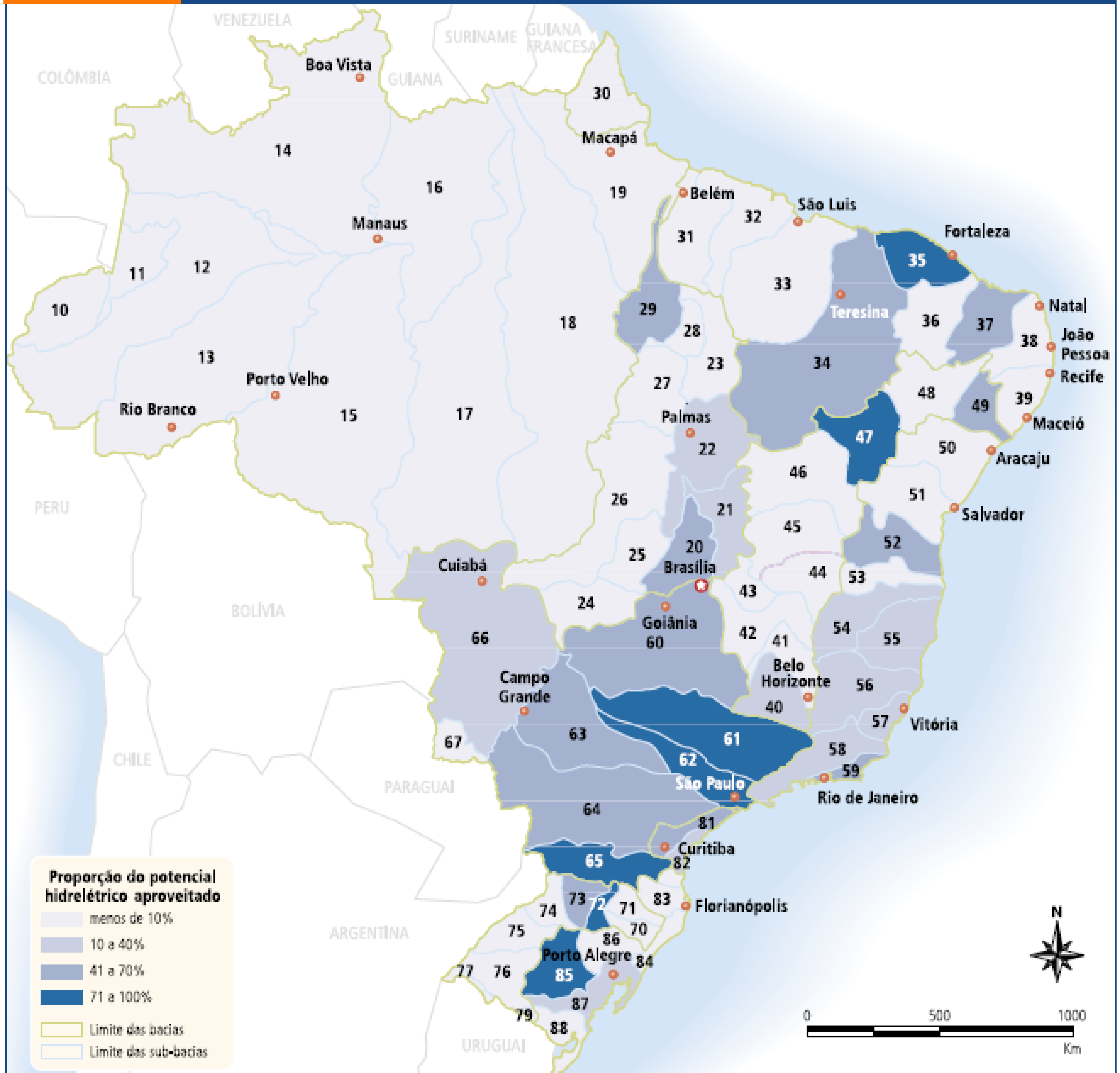
FIGURA 4.10 Índice de aproveitamento do potencial hidrelétrico brasileiro - situação em março de 2003



Fonte: Elaborado a partir de CENTRAIS ELÉTRICAS BRASILEIRAS – ELETROBRÁS. Sistema de informação do potencial hidrelétrico brasileiro – SIPOT. Rio de Janeiro, abr. 2003.

Nota: Os números correspondem aos códigos das sub-bacias, como indicado na Tabela 4.4.

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- There are currently 48 dams greater than 2 MW capacity in the Andean Amazon, but plans for an additional 151 such dams over the next 20 years. 80 of new dams Fifty-three would be100 MW or greater.

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Planificadas: Con estudios de prefactibilidad realizados

Make your Query and Find Dams

Name

Countries
Add Filter ▼

Operational Status
Add Filter ▼
Planned

Basins
Add Filter ▼

Capacity / MW
Add Filter ▼

Flooded Area / Km2
Add Filter ▼

Companies Involved
Add Filter ▼

Funders Involved
Add Filter ▼

Investment Plans
Add Filter ▼

137 Dams Found | Apply Filters

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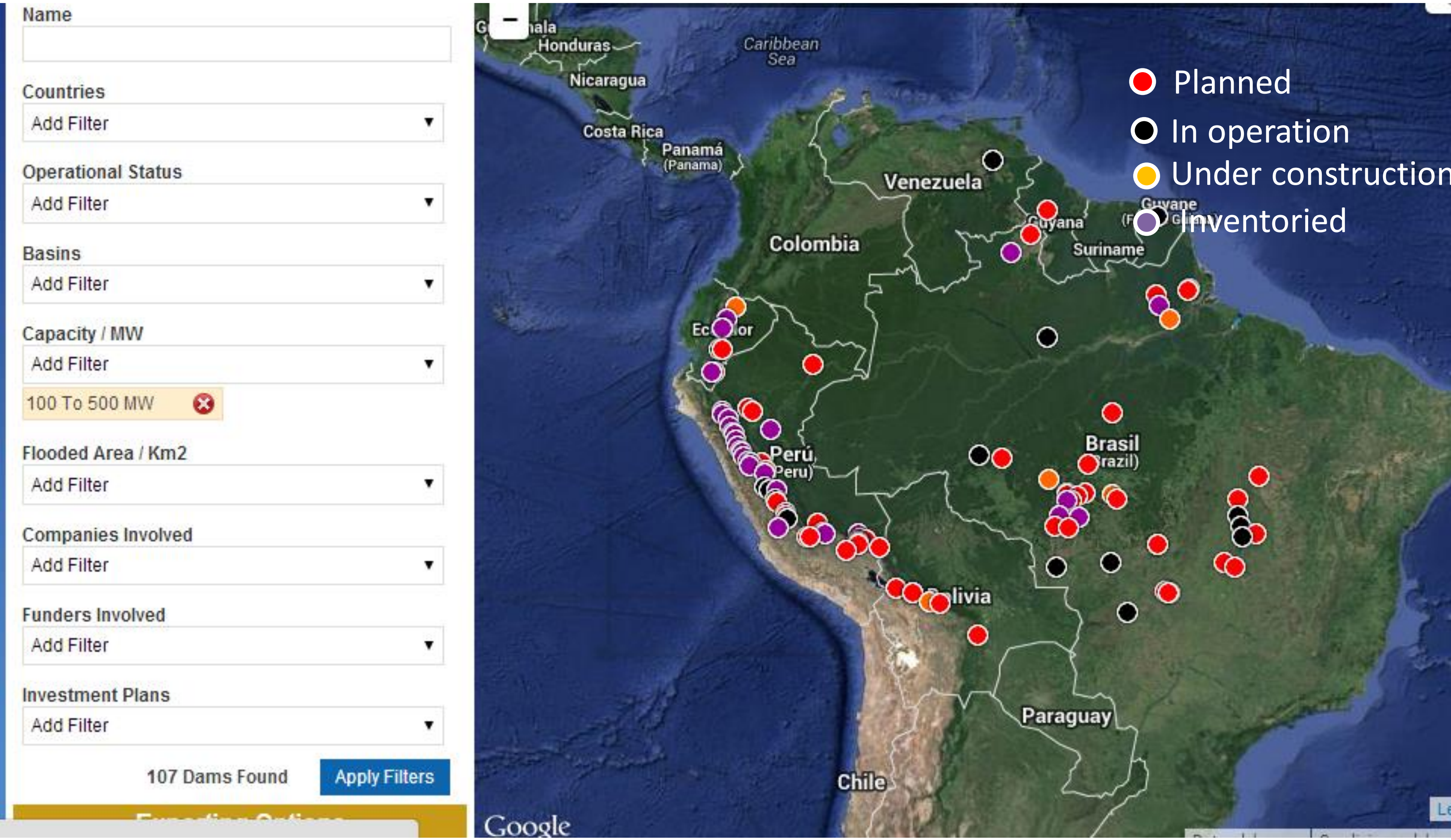

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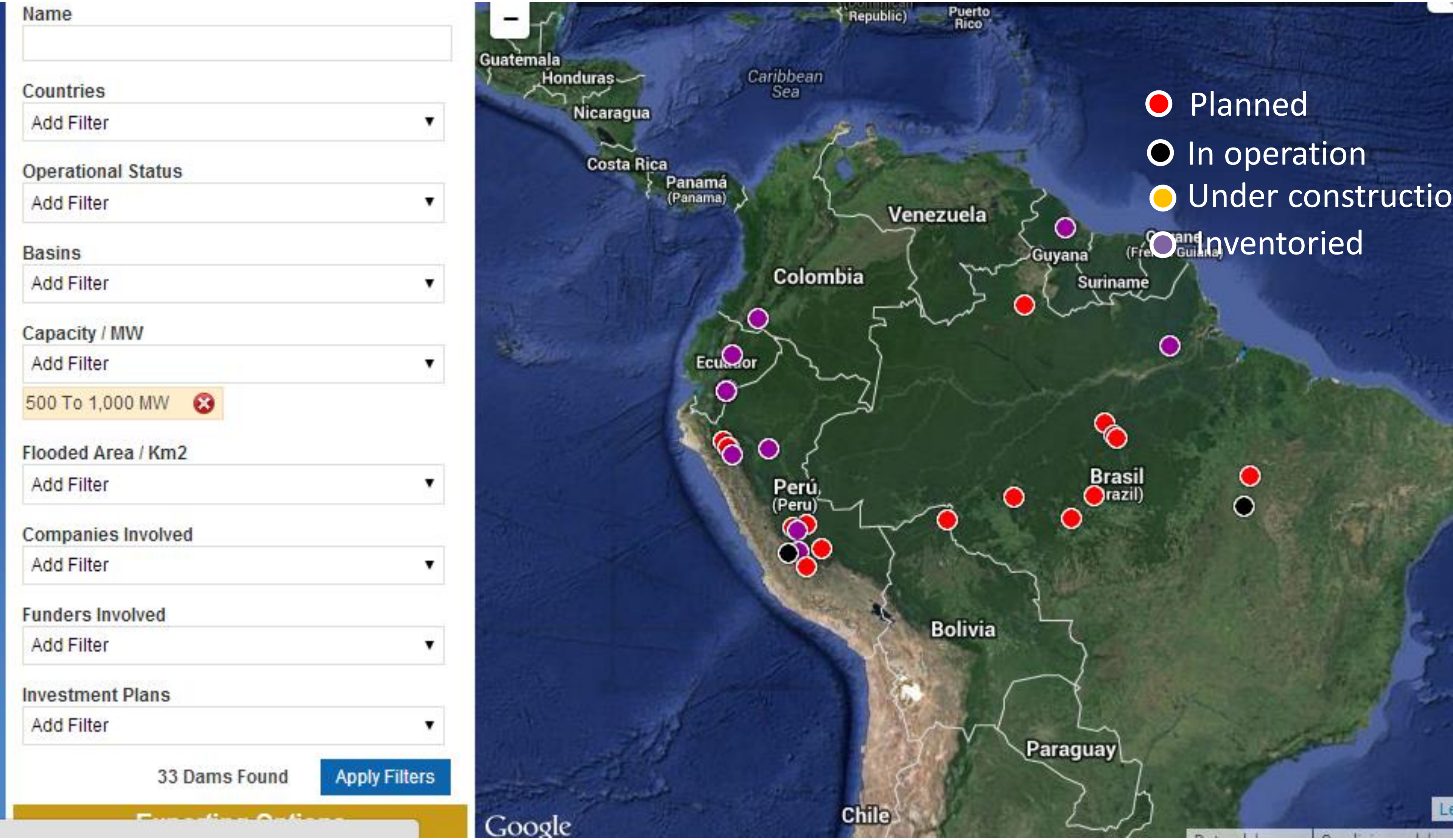

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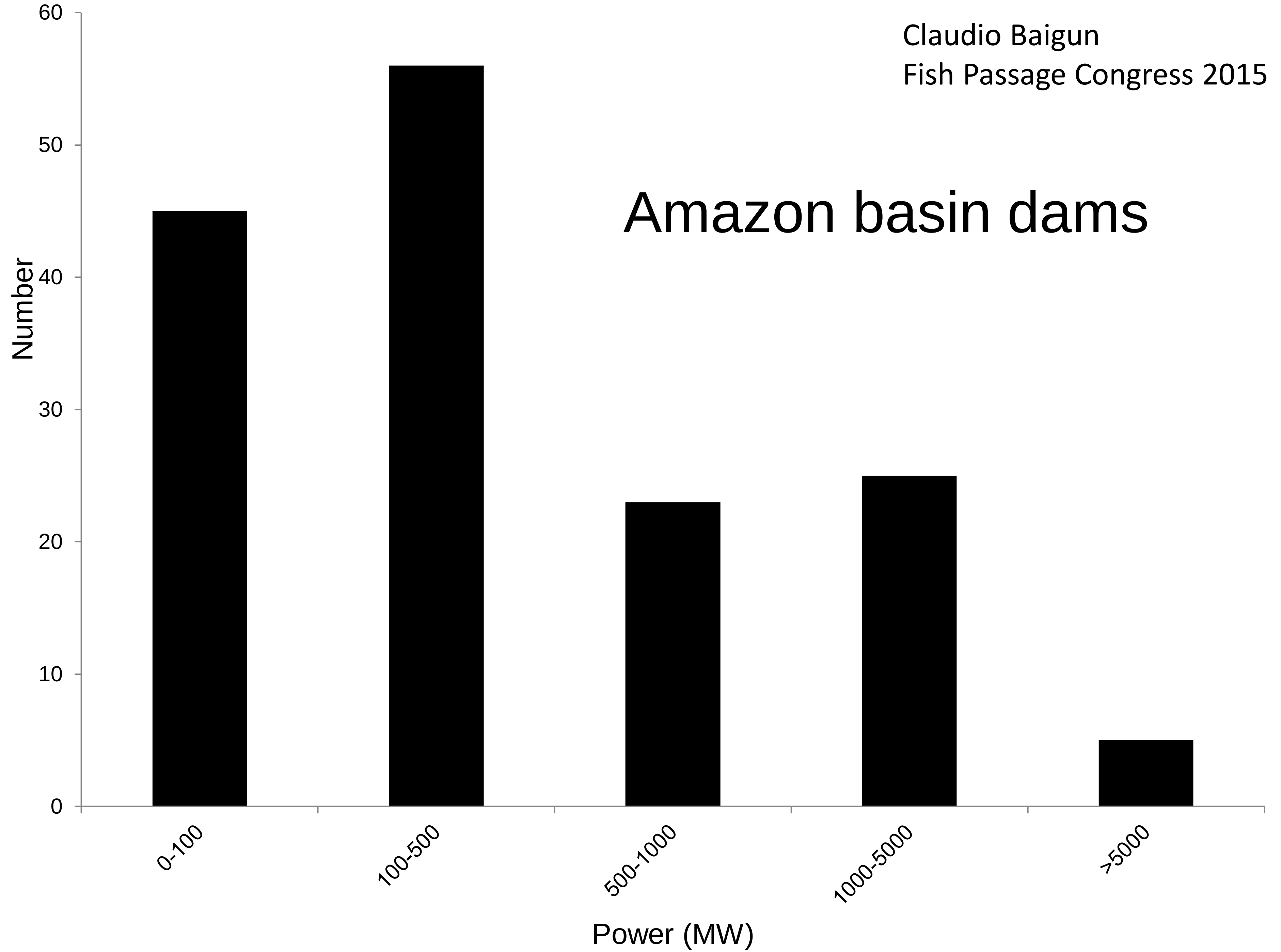
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Amazon basin dams
Number
60
50
40
30
20
10
0
0-100
100-500
500-1000
1000-5000
>5000
Power (MW)

Estimated impacts in the Upper Amazon Basin(Finer and Jenkins 2012)

doi:10.1371/journal.pone.0035126.g002

Table 2. Summary of estimated ecological impact and potential energy capacity from low and moderate impact dams in relation to projected 2020 demand.

	Ecological Impact (No. of dams)			Low Impact (MW)	Mod Impact (MW)	New Demand by 2020 (MW)	2020 Demand met by low/mod
	Low	Mod	High				
Peru	18	19	42	1473	3565	3526	143%
Ecuador	10	26	24	1074	1015	3200	65%
Bolivia	1	5	4	127	3662	650	583%
Colombia	0	1	1	0	2	-	-
TOTAL	29	51	71	2674	8244	7376	148%

doi:10.1371/journal.pone.0035126.t002

- How to deal with river fragmentation and damming for the current and next century?
- Could knowledge from other world systems provide valuable clues?

Type	N	Attraction Efficiency (%)	Passage efficiency (%)	Height (m)	Slope (15%)
Denil	6	31	32	2	15
Vertical slot	6	83	20	1.48	7
Pool & Weir	14	58	48	11	7
Naturelike bypass	19	27	79	11	3
Lifts and Locks	7	85	55	11	73

(adapted from Bunt 2009)

Species	N	Attraction Efficiency (%)	Passage efficiency (%)	Height (m)	Slope (15%)
Centrarchidae	5	68	42	1	7
Salmonidae	11	35	83	9	4
Percidae	4	28	42	11	4
Lotidae	1	83	60	14.5	3
Esocidae	3	31	63	5	3
Cyprinade	6	25	74	14.5	3
Clupeidae	17	70	34	13	46
Catostomidae	9	80	28	1.5	16

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(adapted from Bunt 2009)

Efficiency in South American dams:

Yacyreta (lifts): 2 %

Santa Clara (truck and traps): 7%

An open debate:Why do we need fish passages and when they are necessary?

- To mantain biodviersity?
- To sustain migratory species?
- To mantain genetic flux?
- To allow that species can reach spawning areas?

Caocheira de Emas (Mogi-Guassu River) instaled in 1920-22 and removed in 1942

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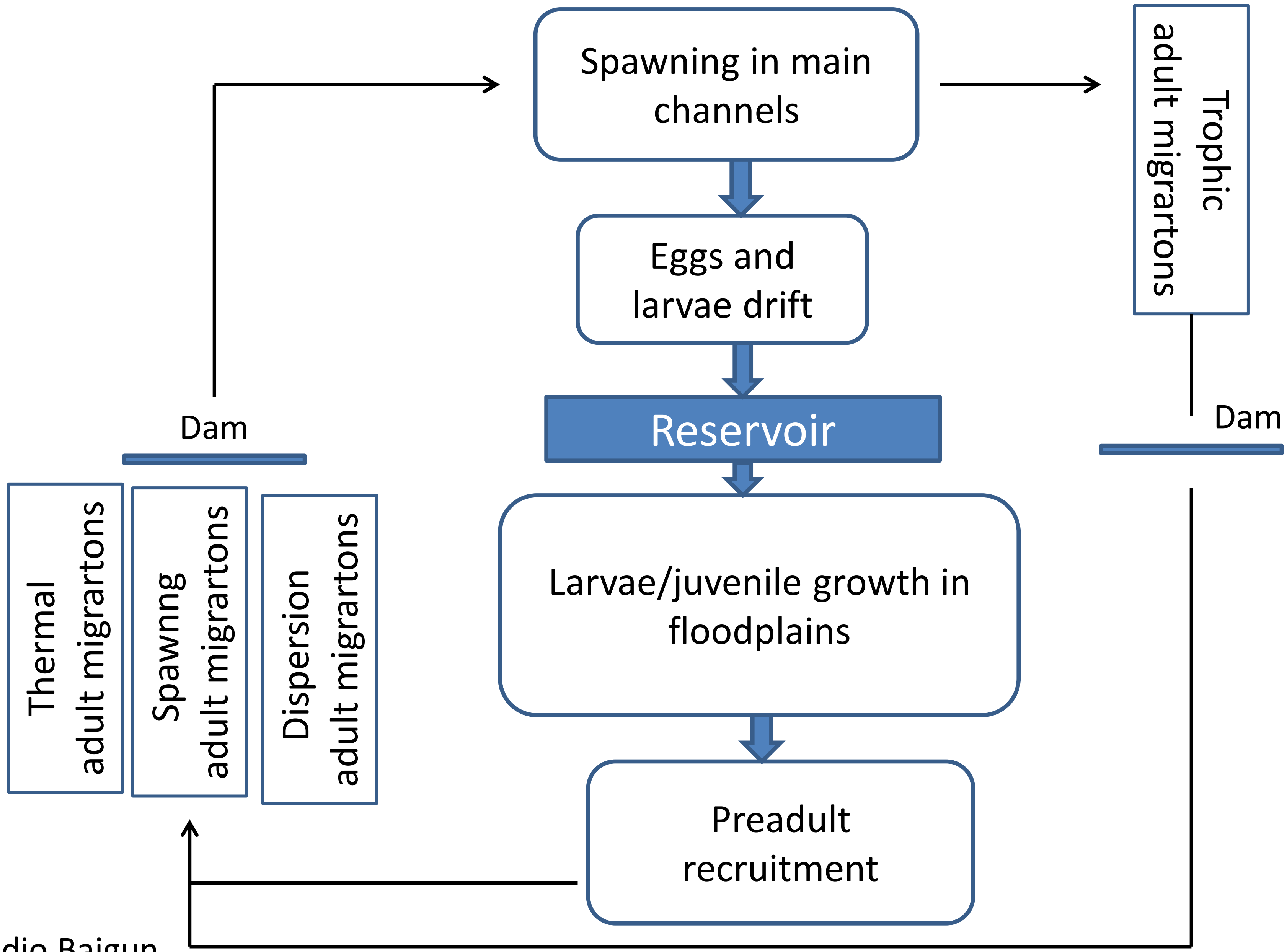

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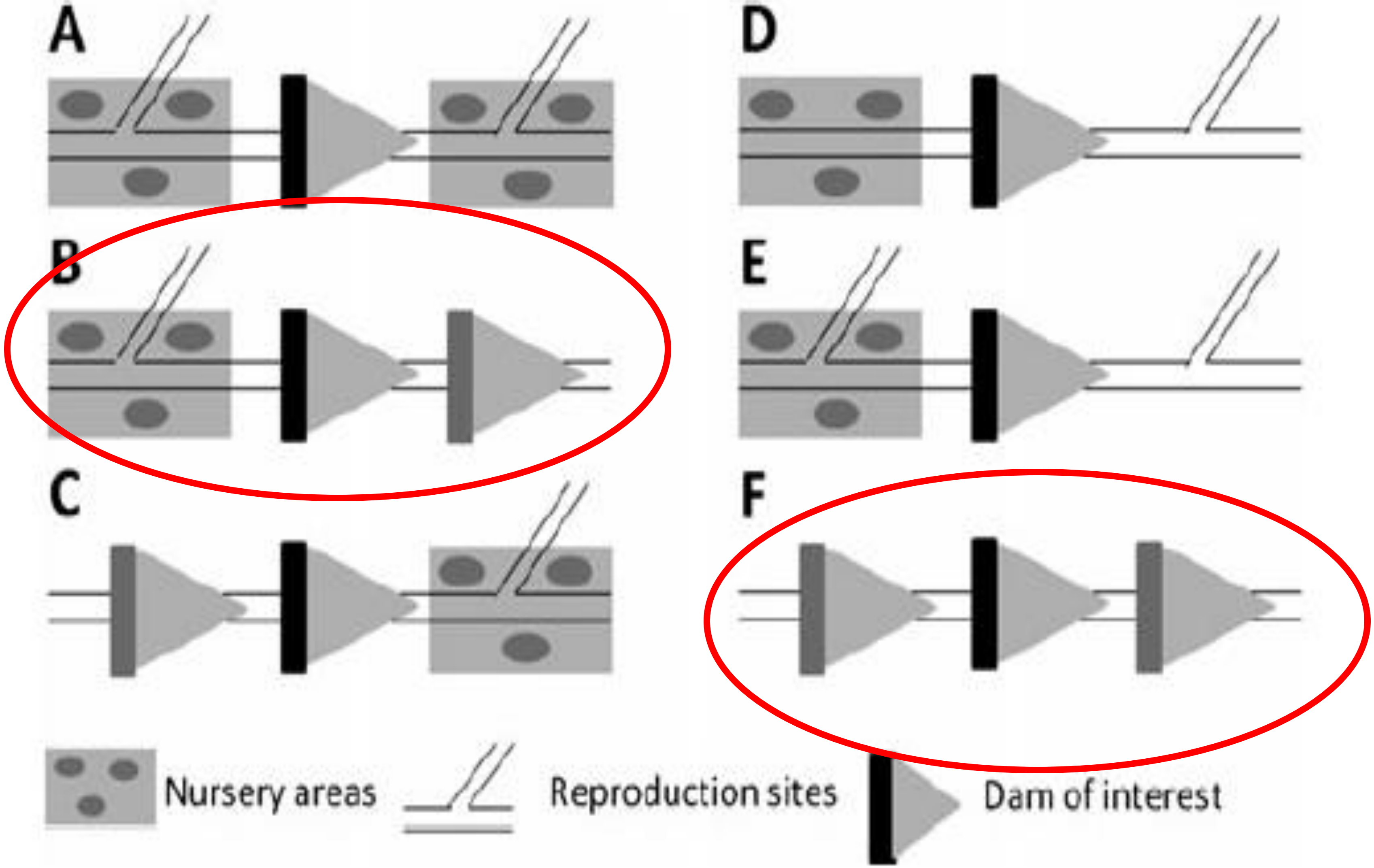

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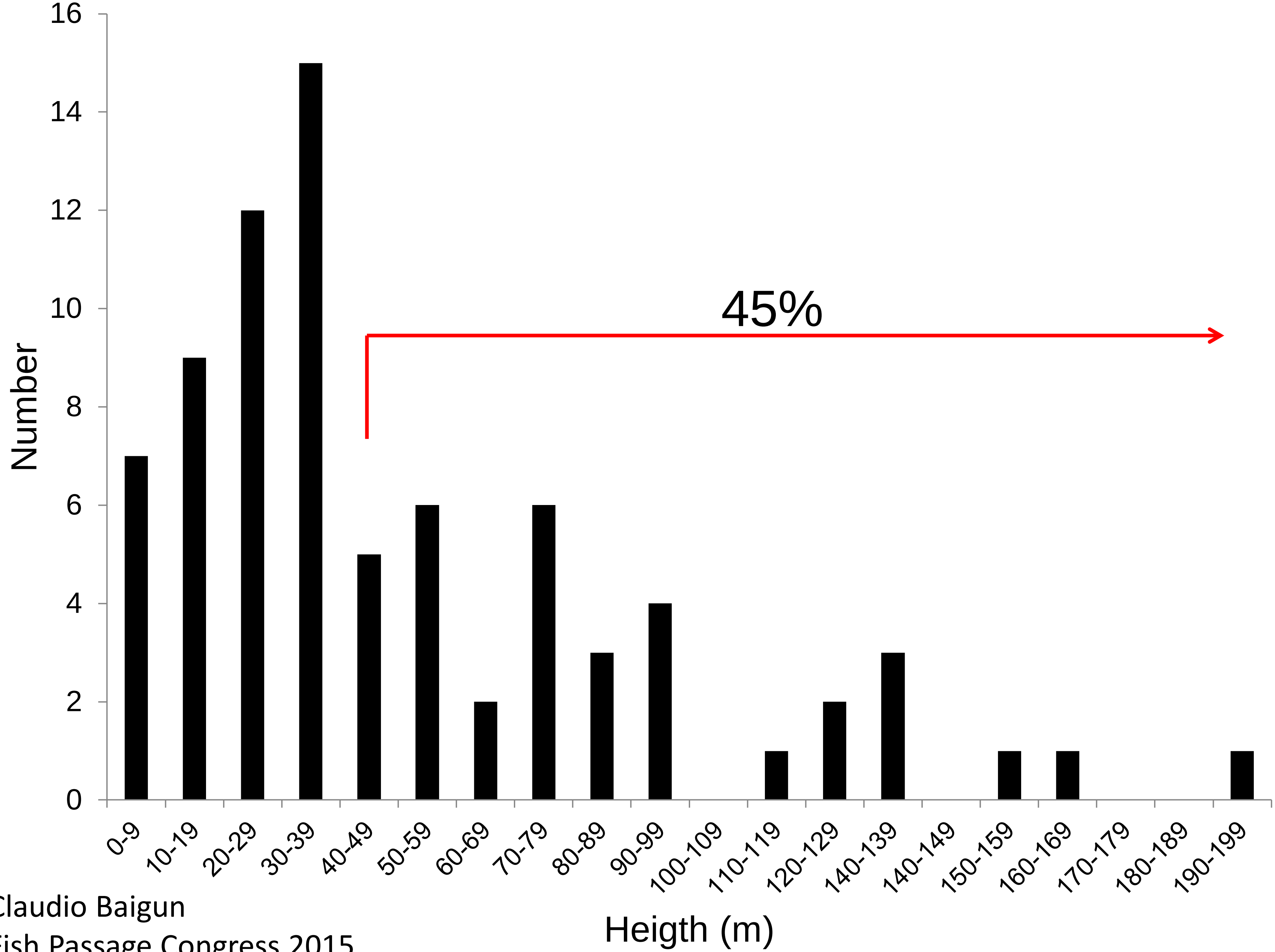
Pompeu et al 2012



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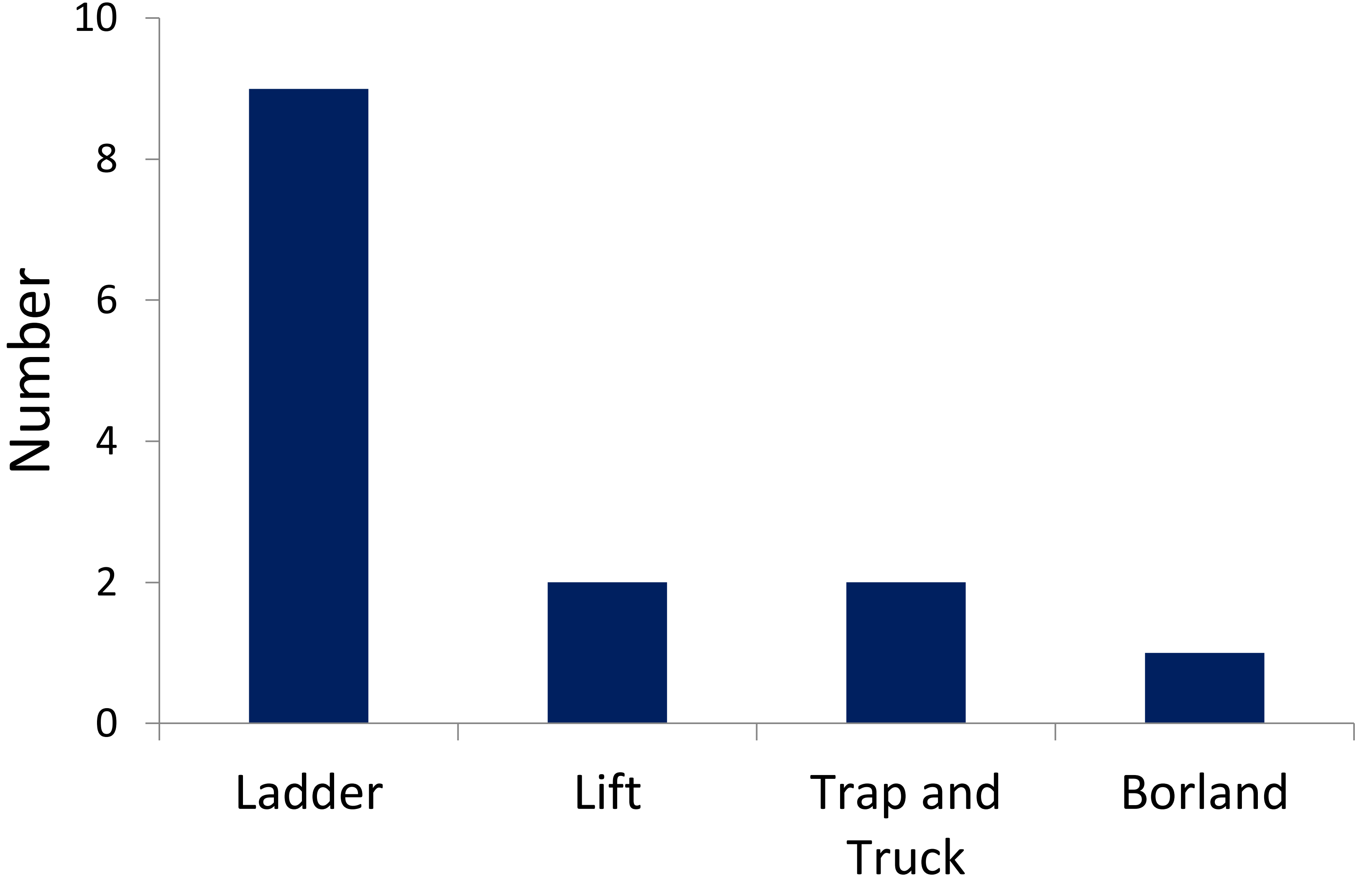

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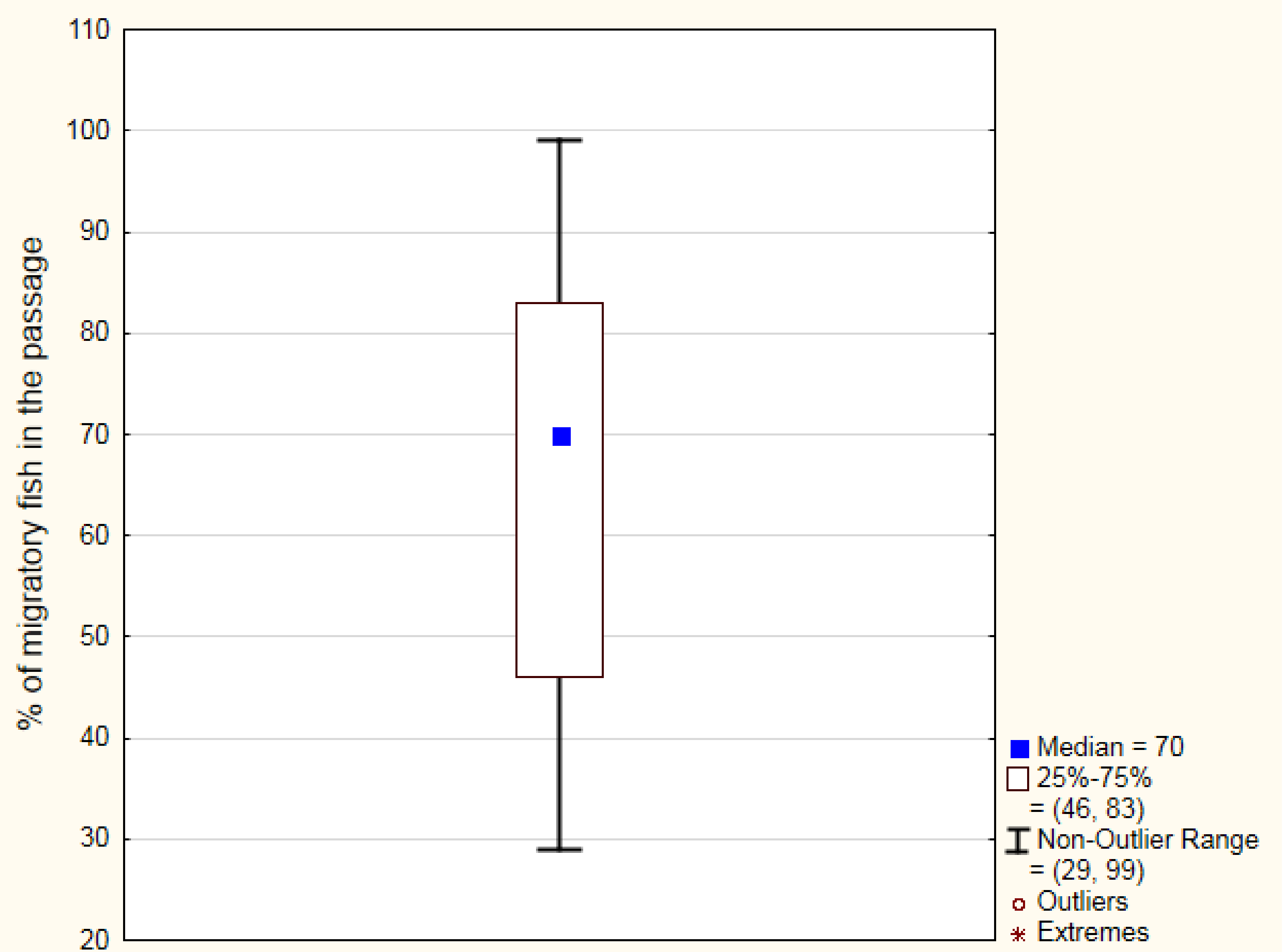
(adapted from Pompeu et al 2012)

- Almost all fishway studies have focused on efficacy instead of efficiency as the key parameter

South American fishways efficacy



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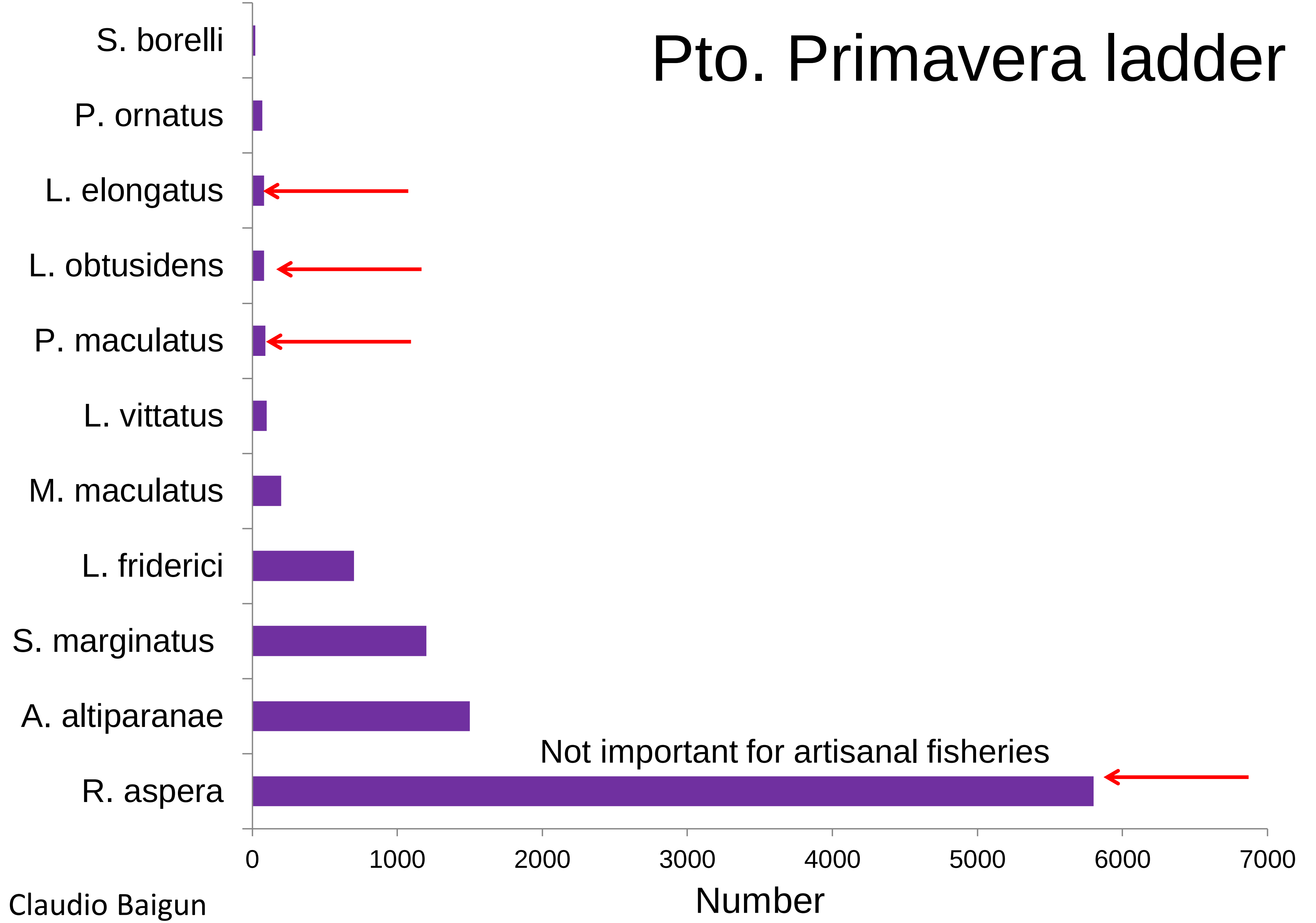

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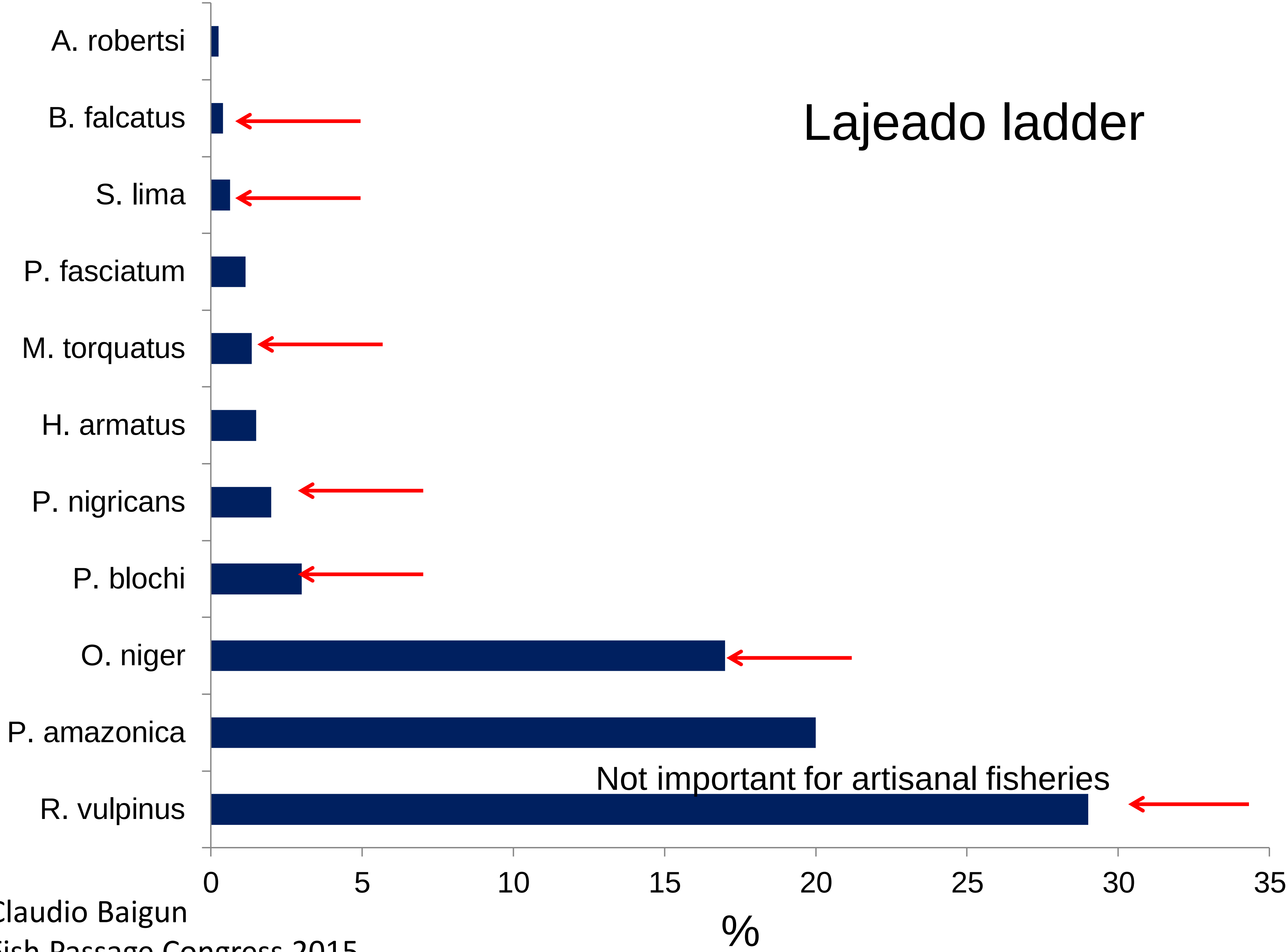

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Paraná River → **Itaipu Reservoir**

Bela Vista River	-CABV; -LAIN-	-CAIN; -LAIN-	-CAAA; -LAGR-	-CATR; -DIRE-	- Itaipu reservoir
B. hilarii					
B. orbignyanus					*B. orbignyanus*
H. platyrhynchos					
L. elongatus	*L. elongatus*	*L. elongatus*	*L. elongatus*		*L. elongatus*
L. macrocephalus		*L. macrocephalus*	*L. macrocephalus*		*L. macrocephalus*
L. obtusidens	*L. obtusidens*	*L. obtusidens*			*L. obtusidens*
P. corruscans		*P. corruscans*	*P. corruscans*		
P. fasciatum					
P. granulosus		*P. granulosus*			*P. granulosus*
P. lineatus	*P. lineatus*	*P. lineatus*	*P. lineatus*		*P. lineatus*
P. maculatus	*P. maculatus*	*P. maculatus*		*P. maculatus*	*P. maculatus*
P. mesopotamicus		*P. mesopotamicus*			
P. ornatus					
P. pirinampu		*P. pirinampu*			*P. pirinampu*
R. vulpinus	*R. vulpinus*	*R. vulpinus*	*R. vulpinus*	*R. vulpinus*	*R. vulpinus*
S. brasiliensis	*S. brasiliensis*	*S. brasiliensis*		*S. brasiliensis*	*S. brasiliensis*
	Z. jahu				
6.8	7.0	7.7	9.4	10.1	10.3
Distance (km)					
I	II	III	IV	V	Reservoir
Segments					

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Makrakis et al 2007

Adapated from Oldani & Baigún

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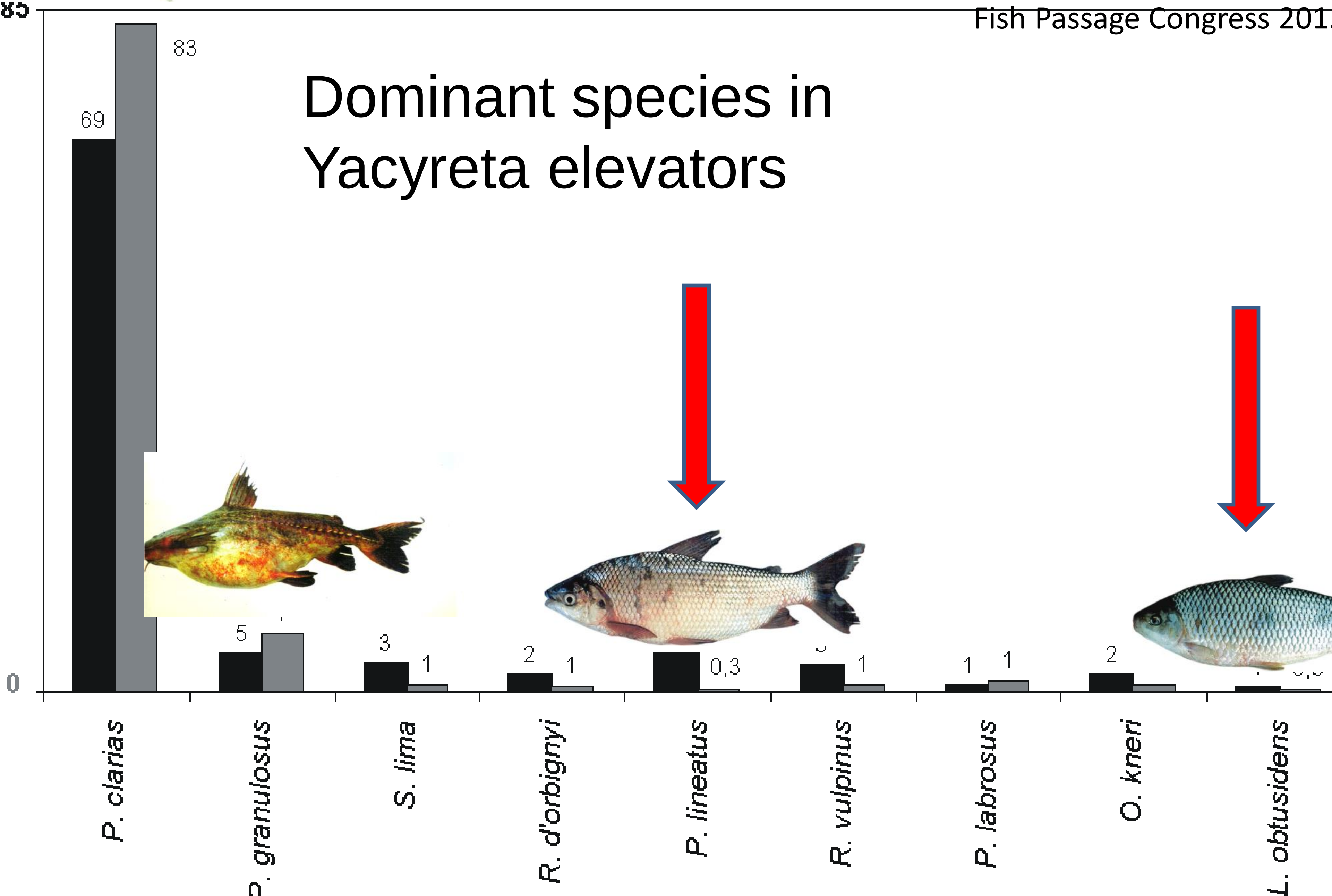
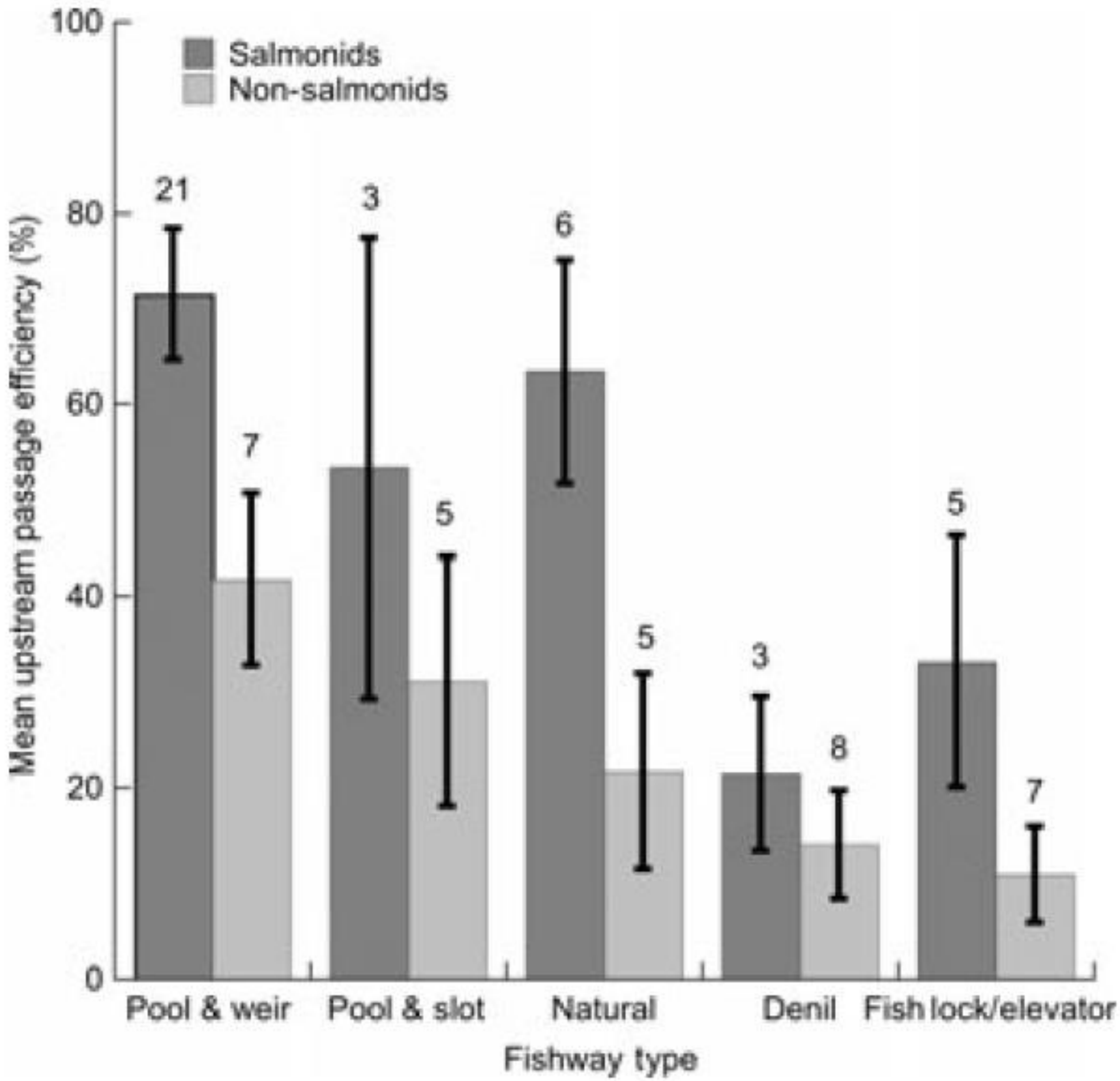
Dominant species in Yacyreta elevators





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Noonan et al 2011

- Whereas hydraulics has been of concern the hydrodinamic environment at the tailrace or inside the passages has been barely considered

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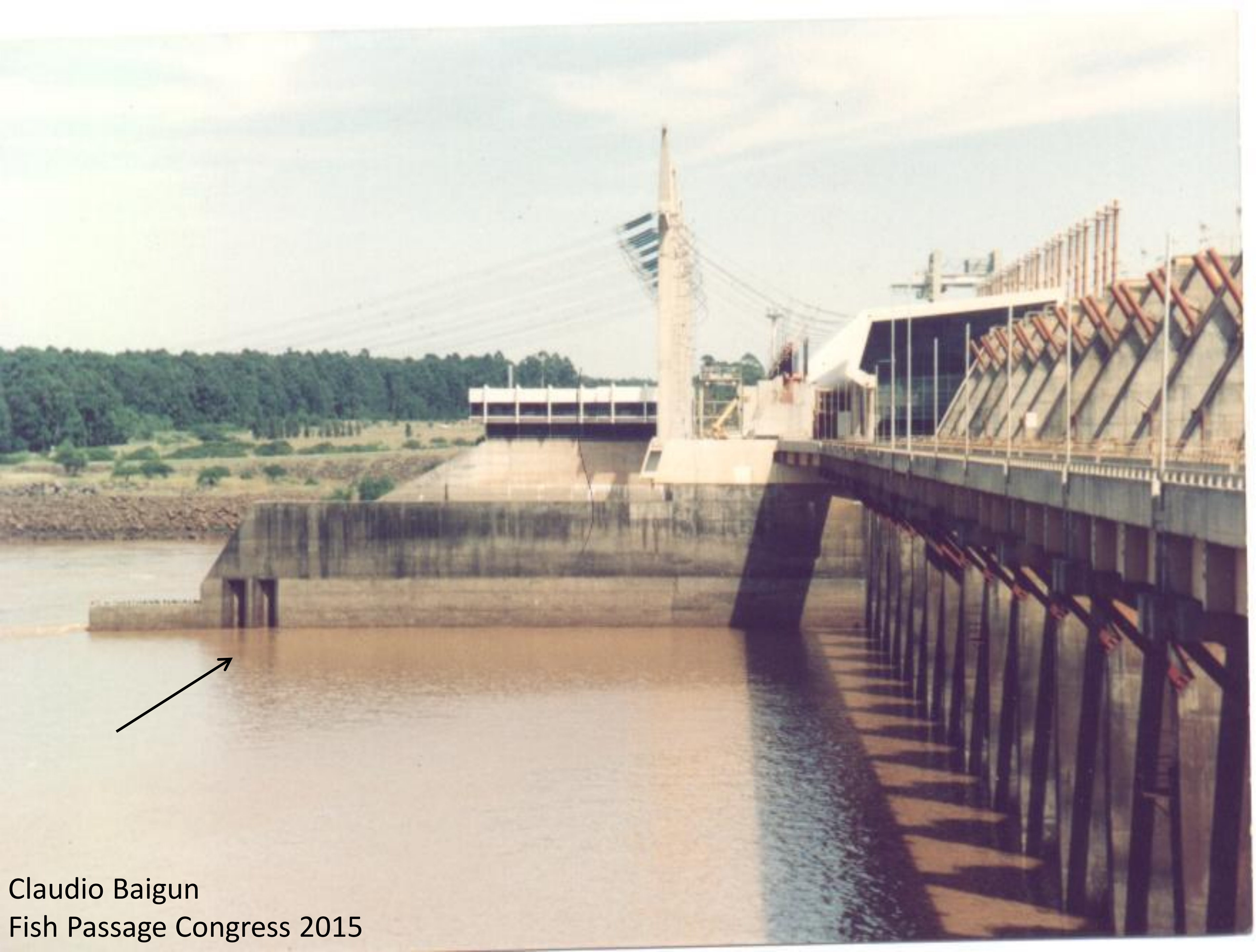

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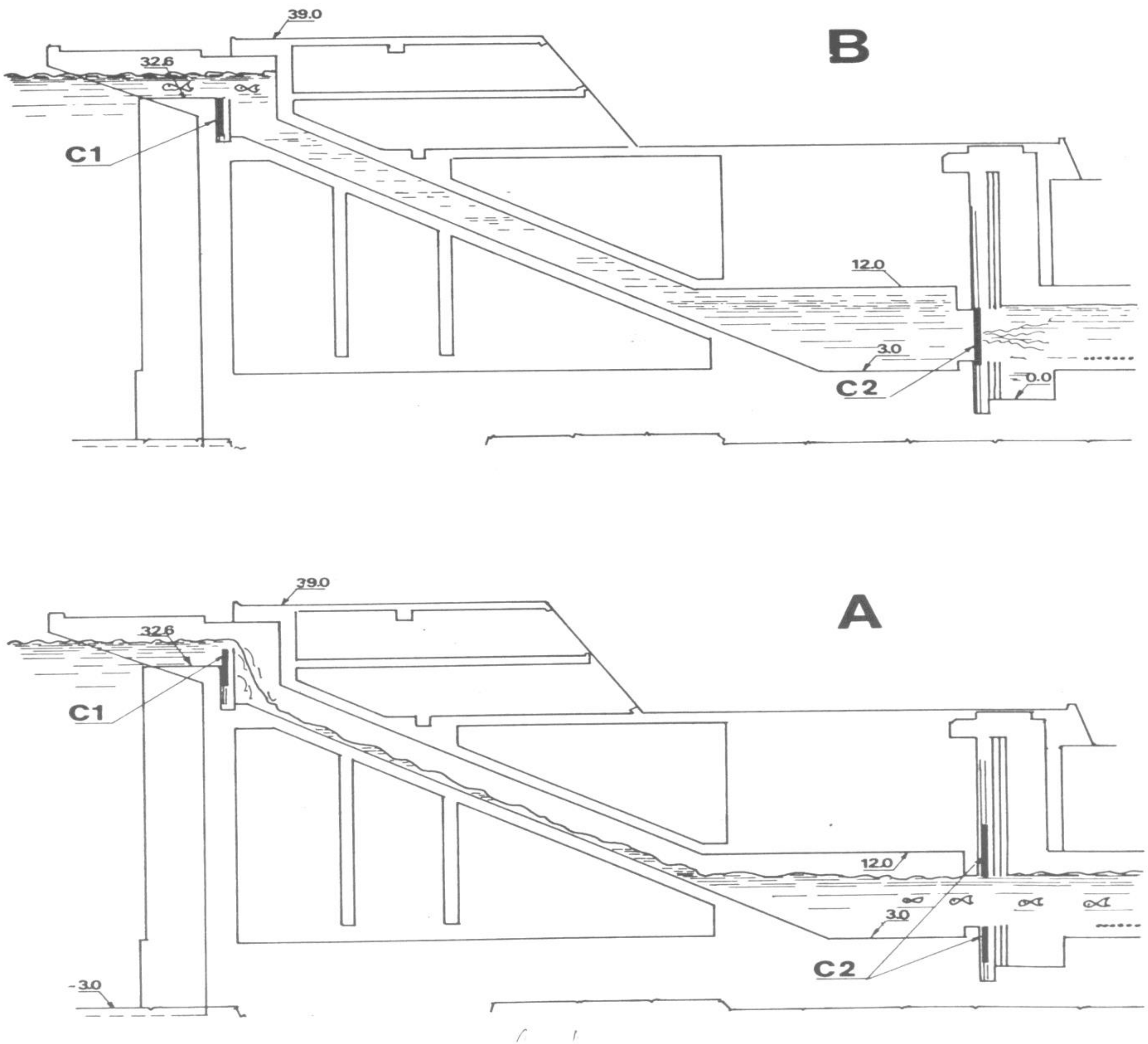

Figure 9 Borland lock operation.
A. Fish entering the lock
B. Fish leaving the lock
C1. Upper sluice-gate
C2. Lower sluice-gate

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Vertival slot in Igarapava dam (Grande River, Brazil)

Tocantis River

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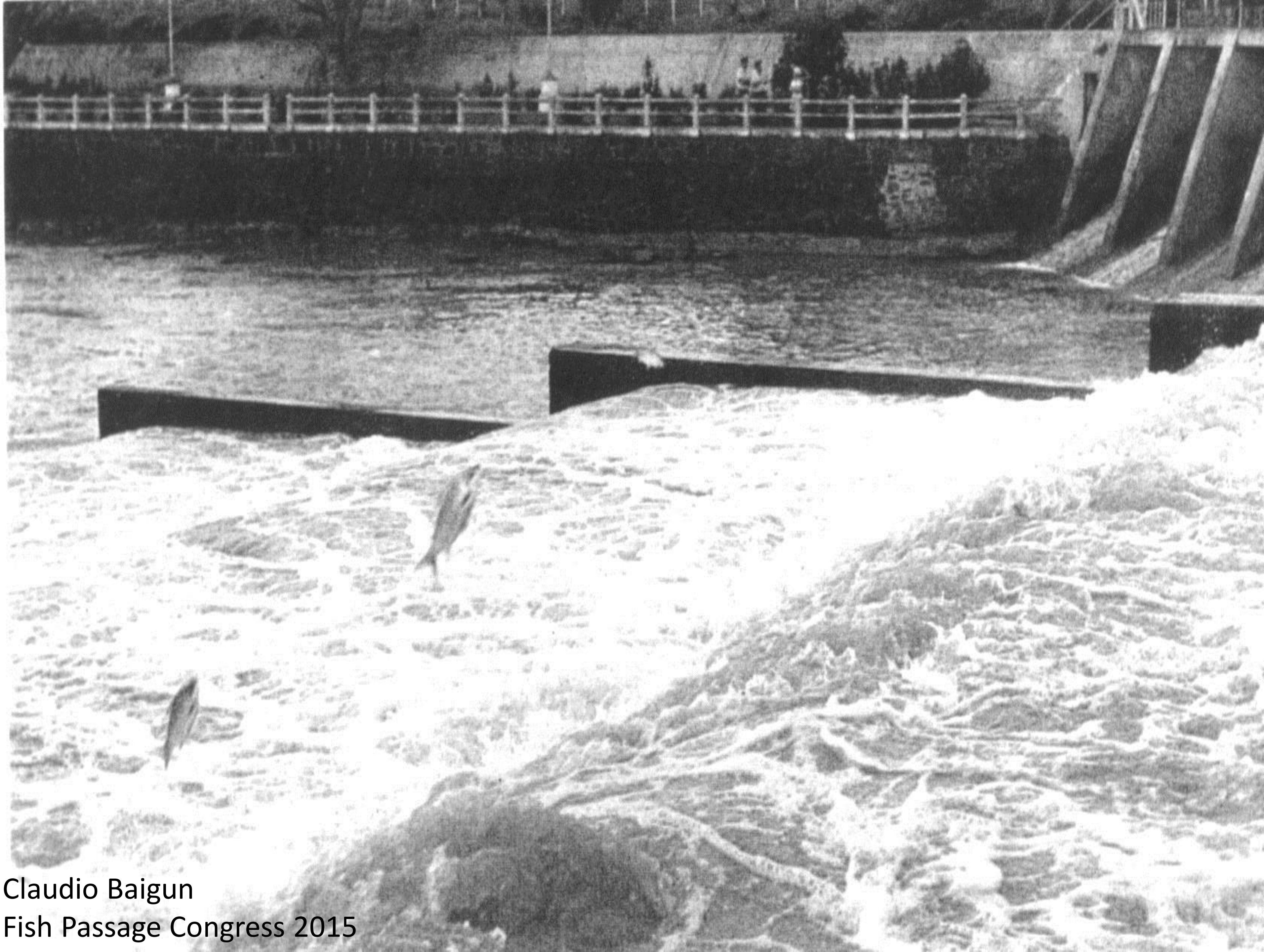

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ARIAL VIEW OF THE PIRACEMA CANAL
(© Itaipu Binacional).

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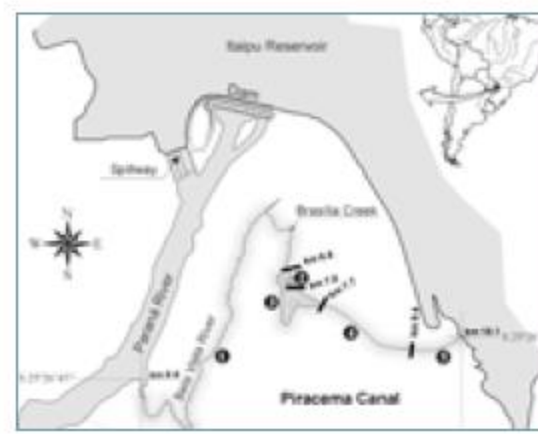

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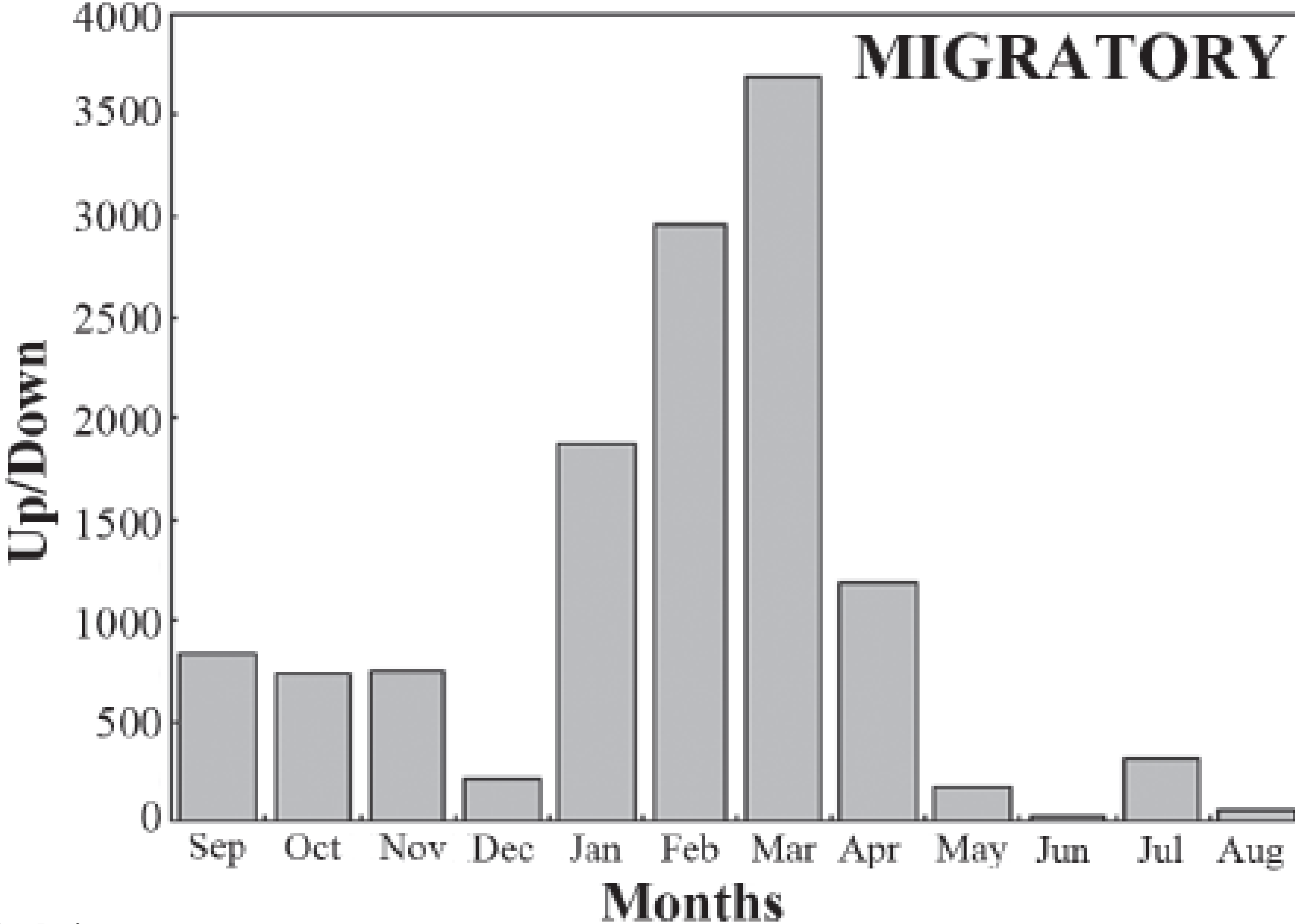
Peixe Angical Dam (Tocantins River)



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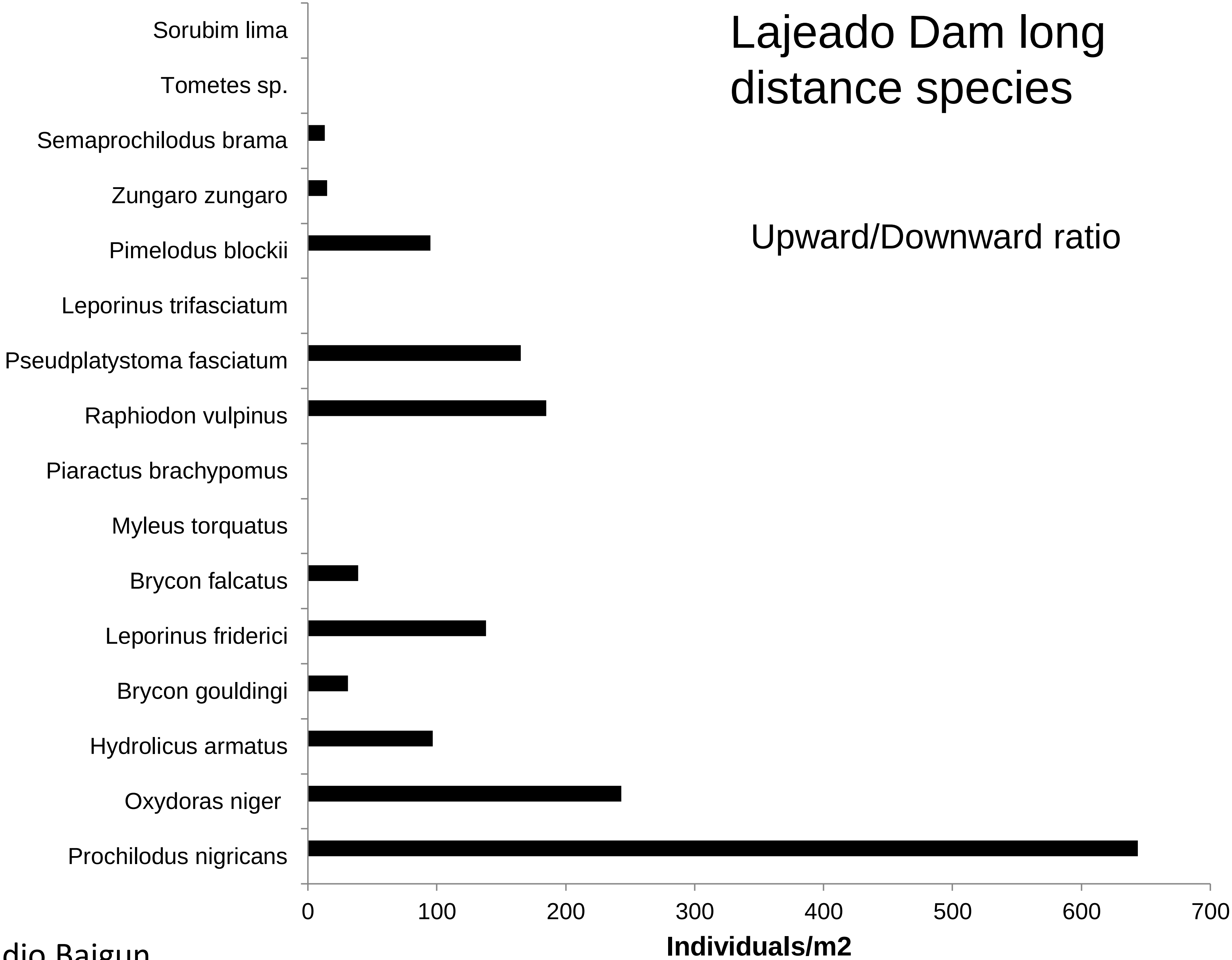
Pelecice and Agostinho 2012

Lajeado Dam long distance species



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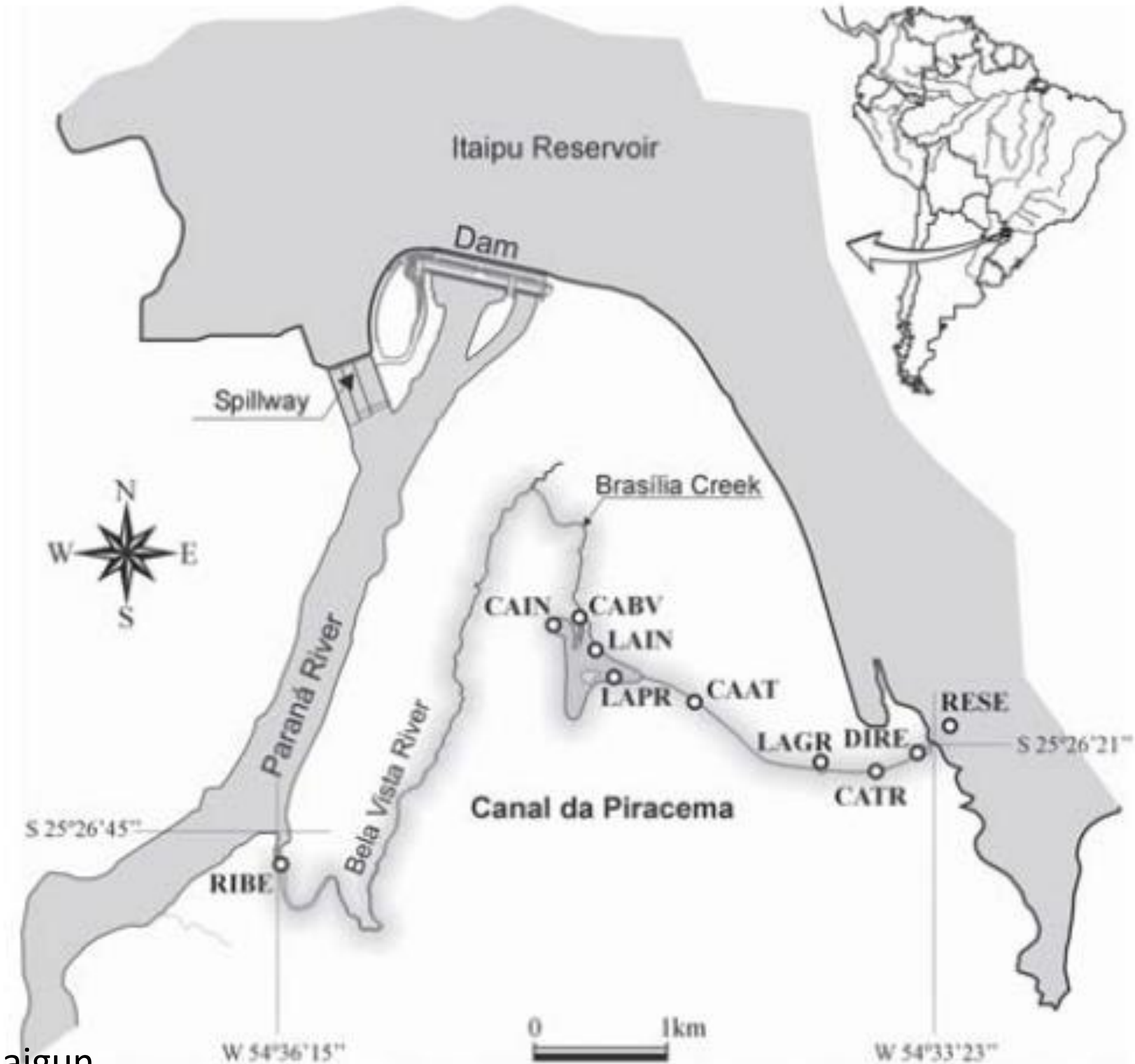

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Some important questions still without clear answers

- Are classical “rule of thumb” guidelines applicable for rivers with much more flow and dimensions?
- Where fishways entrances should be located based on potential turbine interferences?
- What dimensions should have the entrances?
- What number of fishways we need in very large rivers?
- How many attraction flow is needed for rivers with more than 10,000 m3/s (is the 1-5% rule valid for South American large river dams?)

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Two elevators of only 15 m3 each
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Entrance to colect
channel and lift
Entrance to colector channel
and lift

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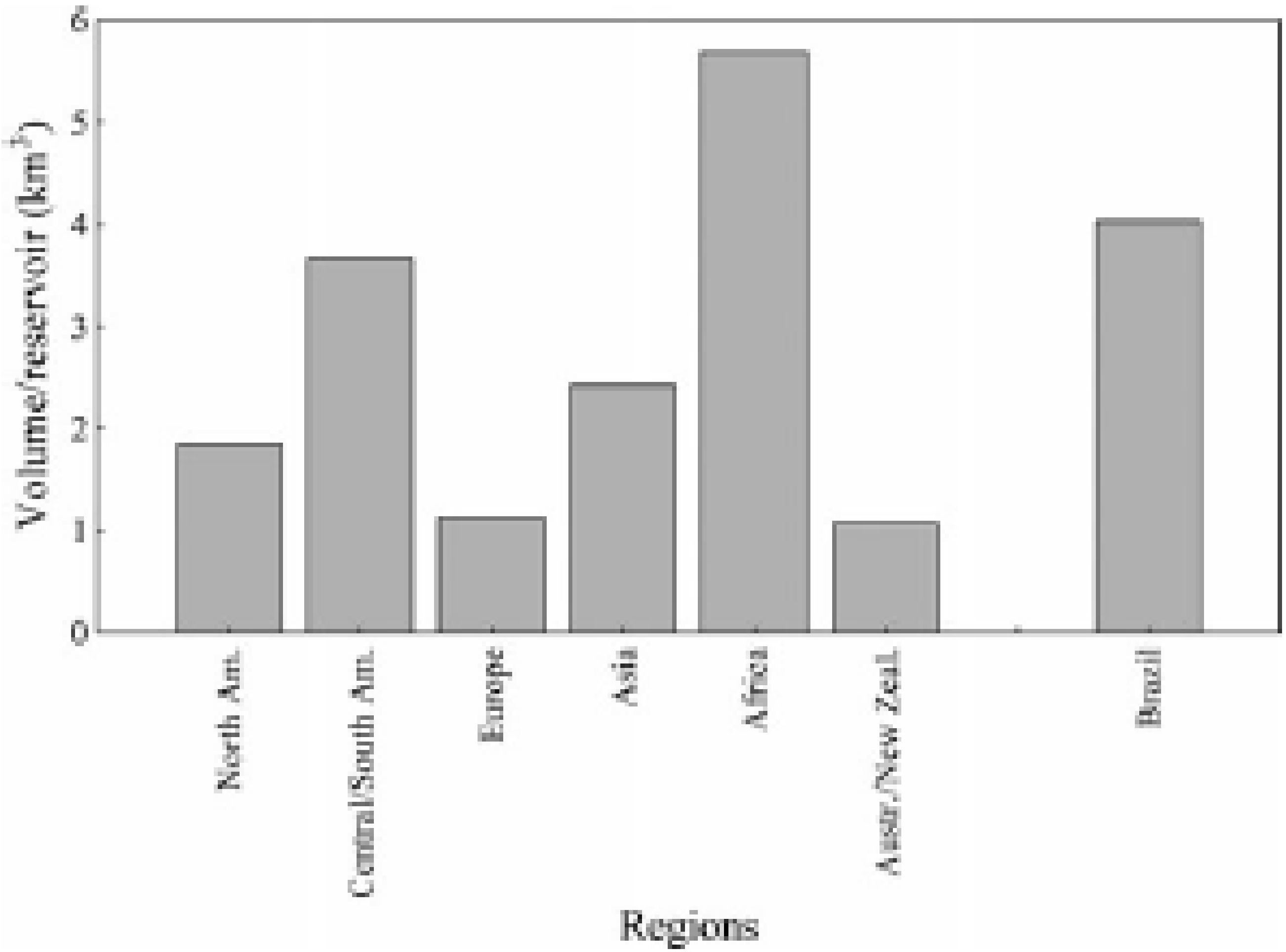
- Think in big: Dams are not the only problem. Reservoirs could be even worst!

- Large reservoirs usually promote irreversible riverscape changes affecting community structure that cannot be restored by stocking.
- Large reservoirs destroy upstream large floodplains that act as valuable growth and rearing habitats for several migratory species and promote high mortality on drifting eggs and larvae



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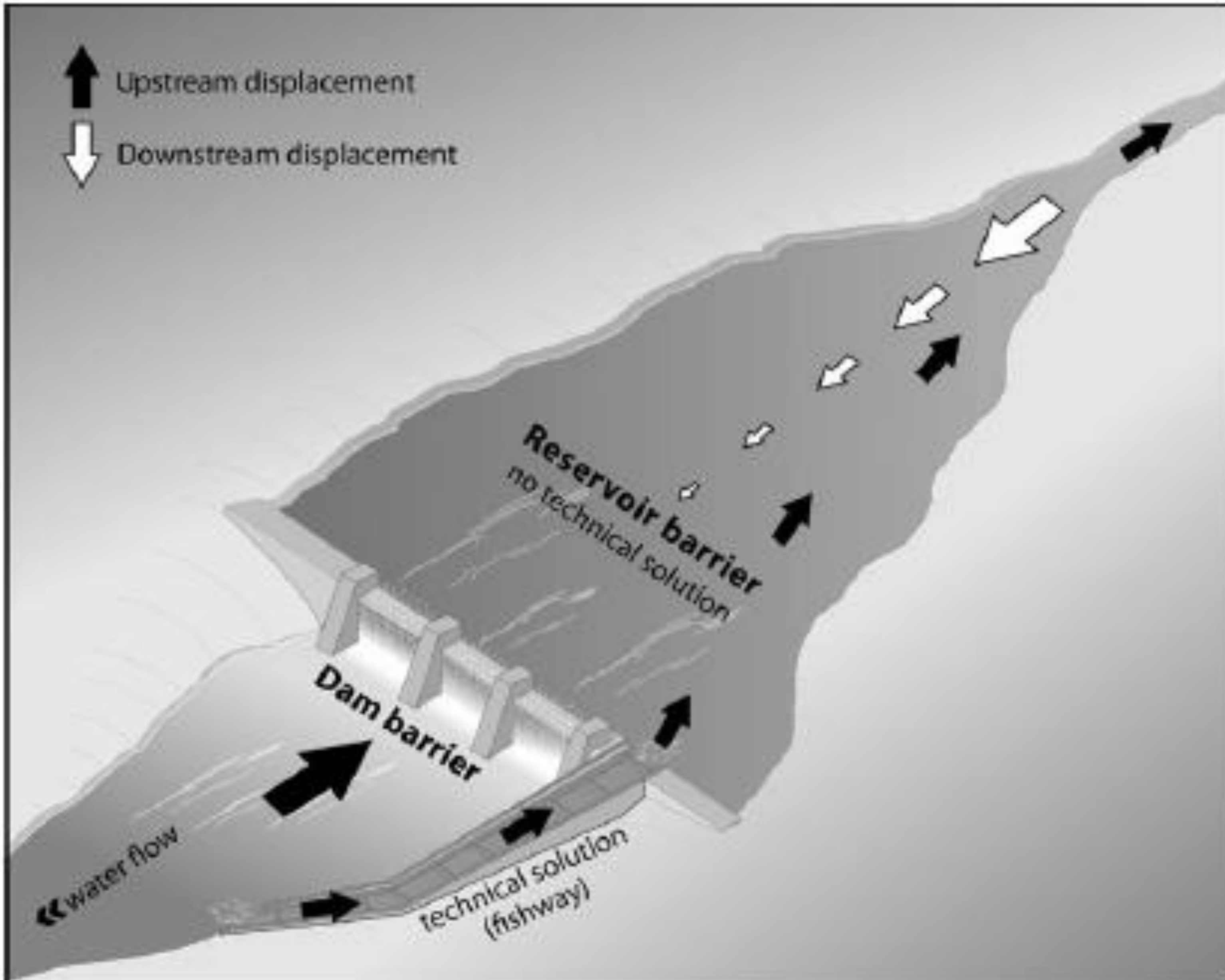
Pelecice et al 2014)



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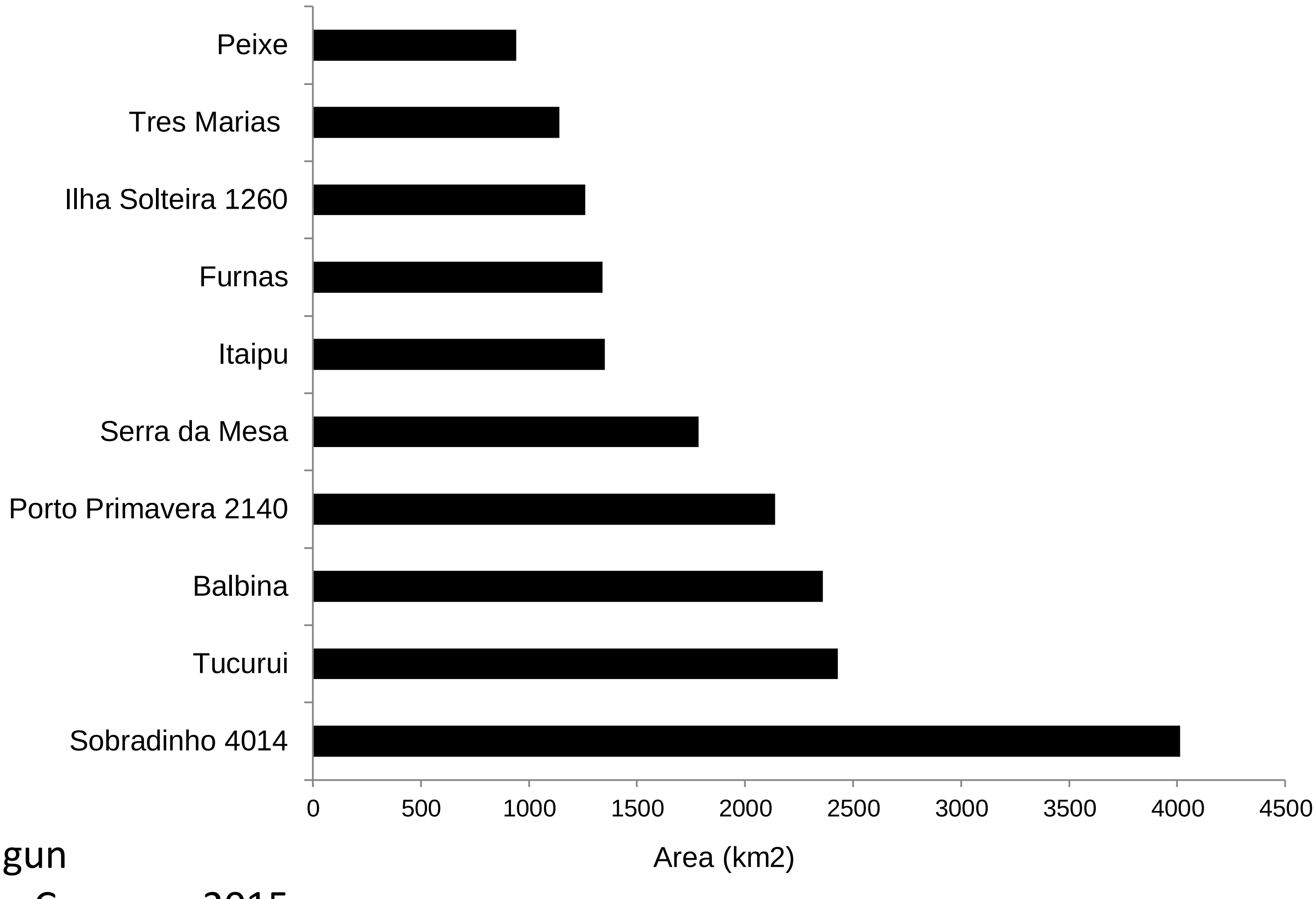
From Pelecice et al 2014

Largest Brazilian reservoirs



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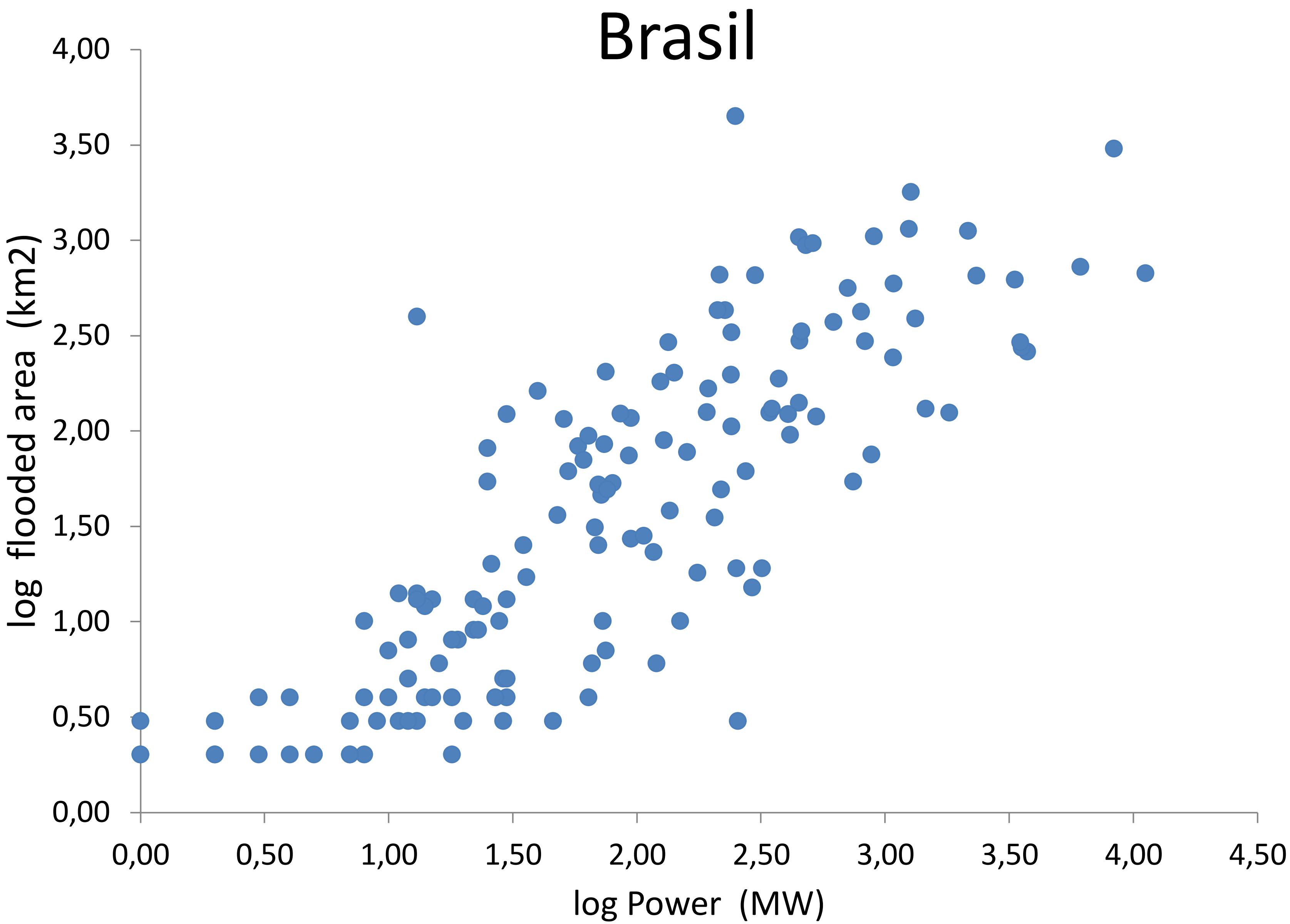

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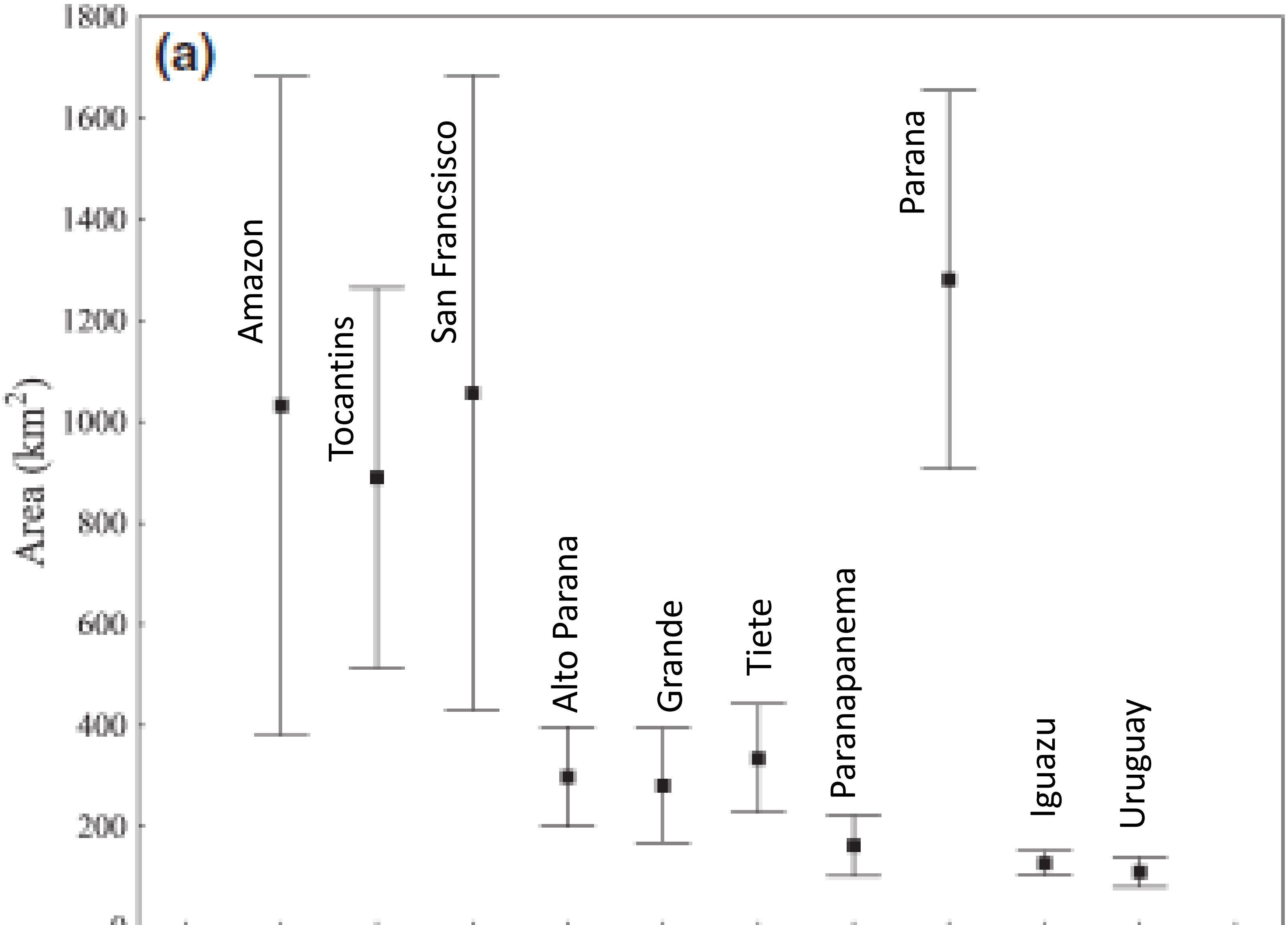
(adapted form Pelecice et al 2014



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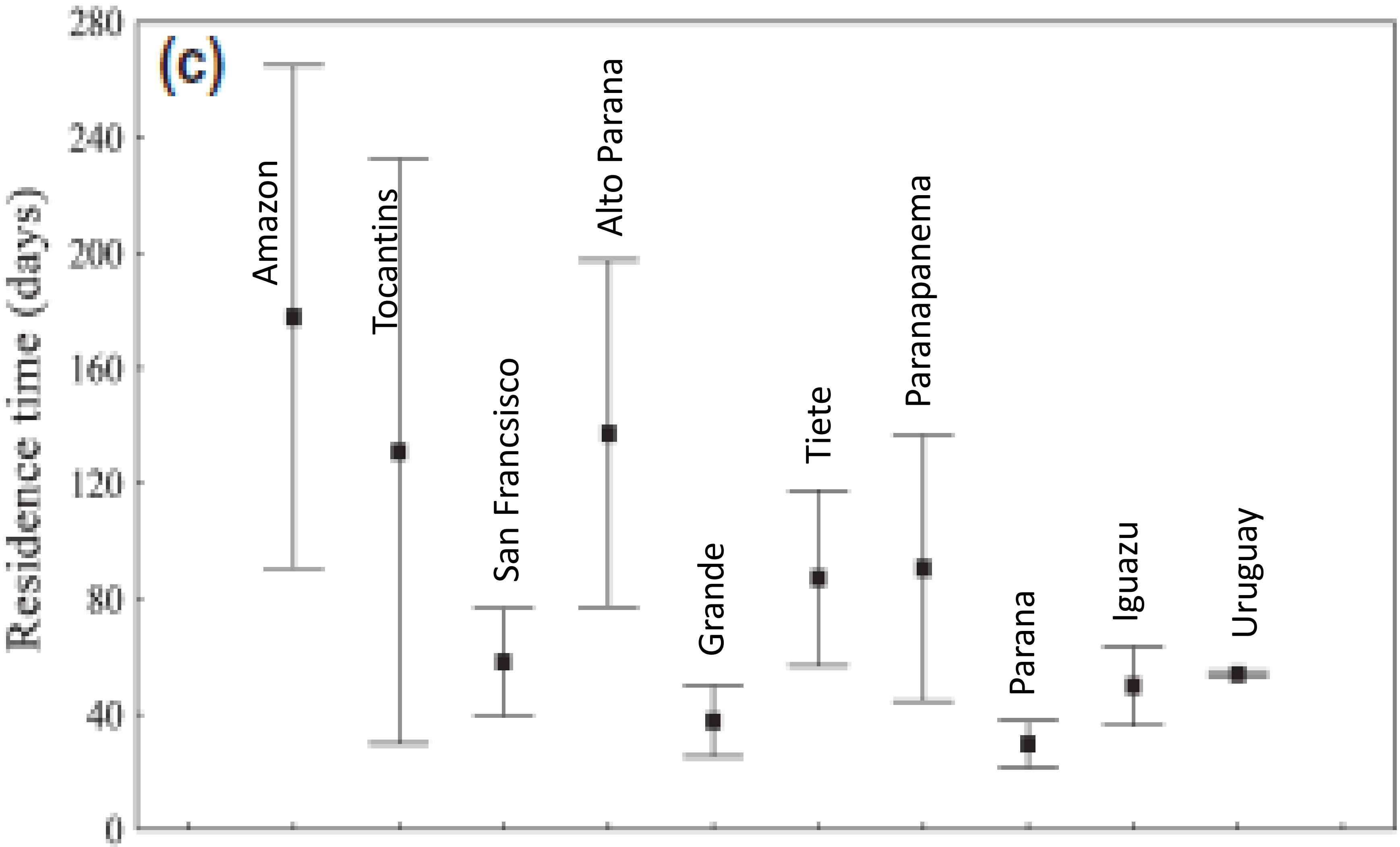
(adapted form Pelecice et al 2014)



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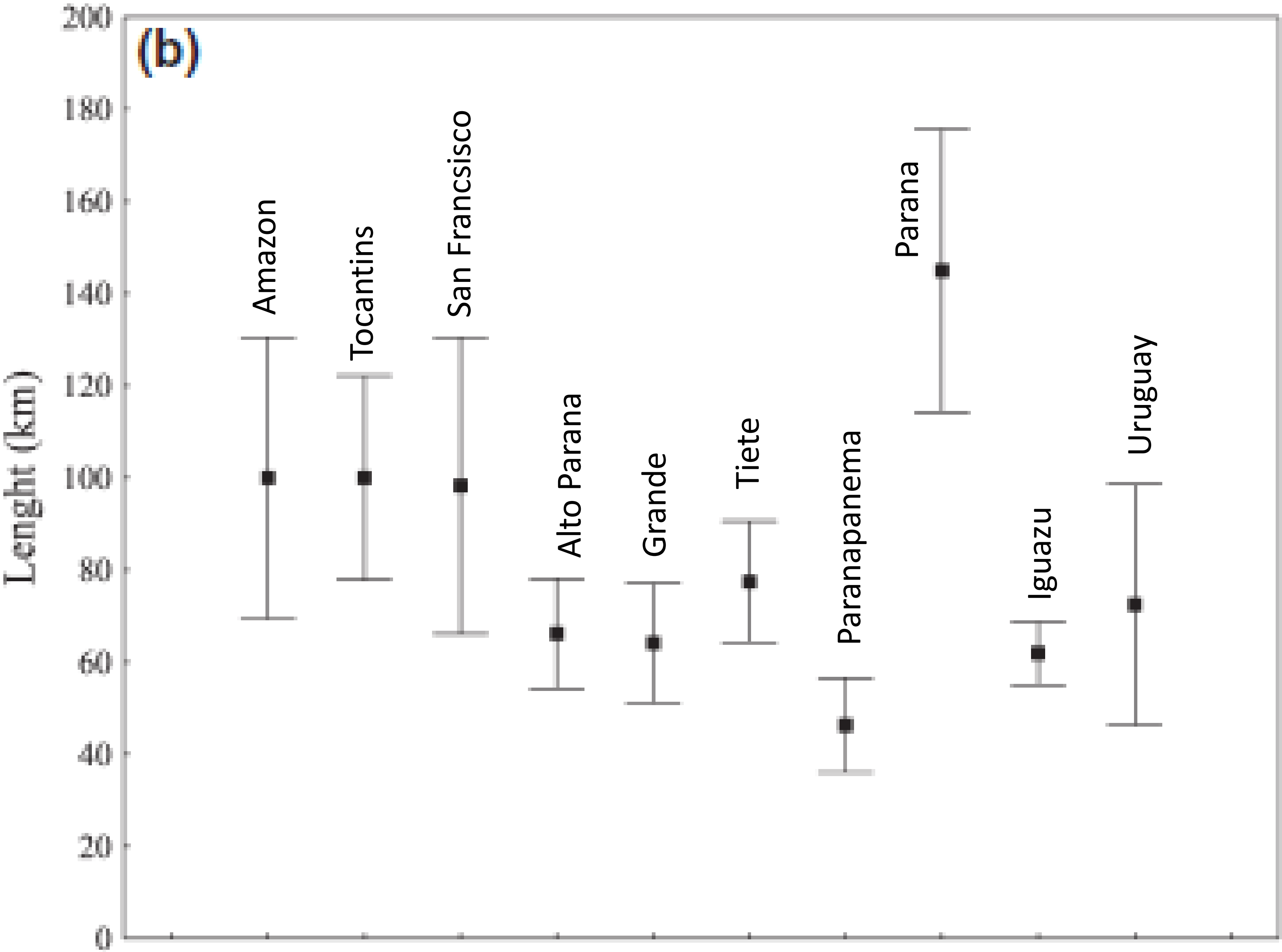

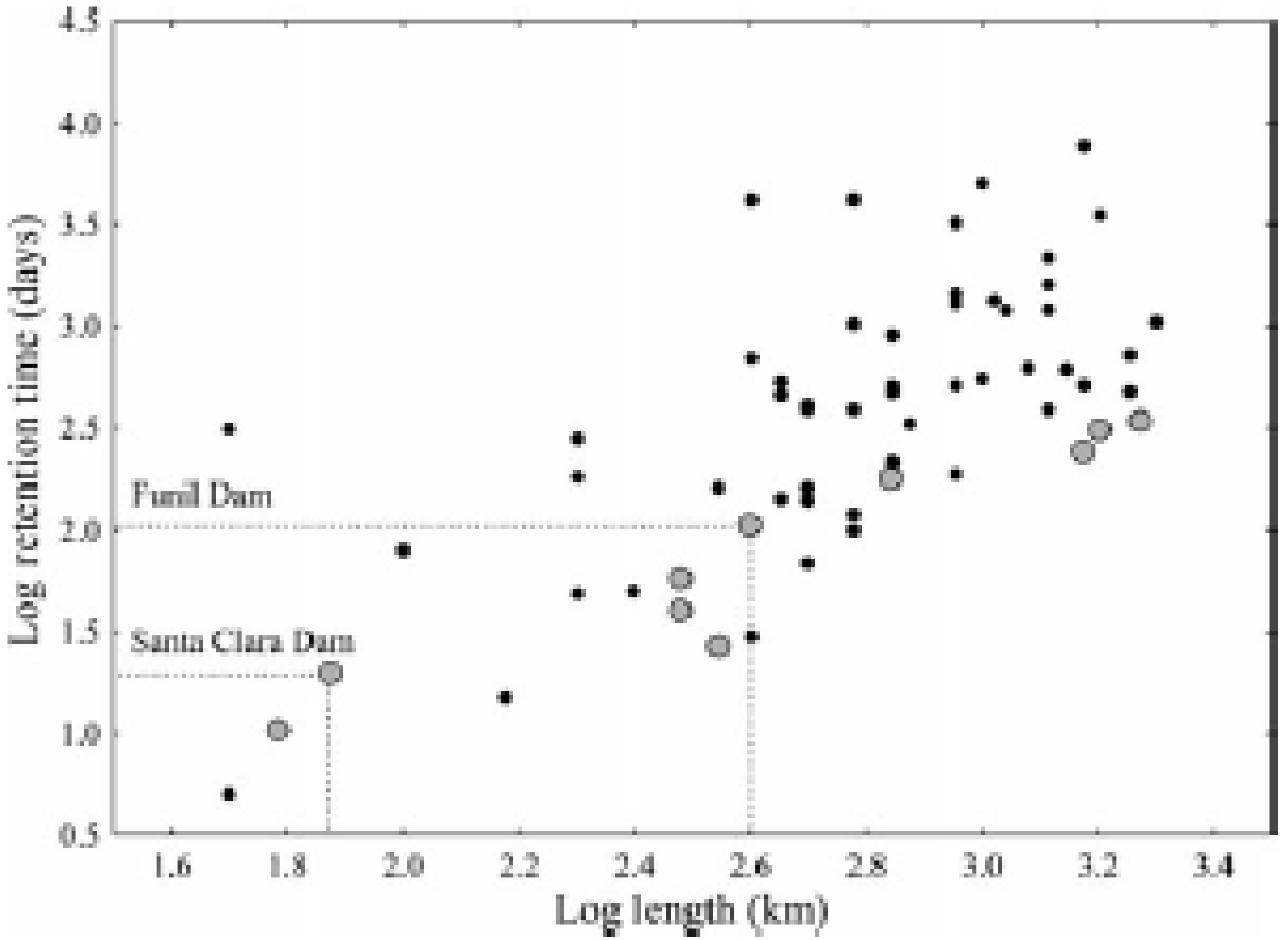

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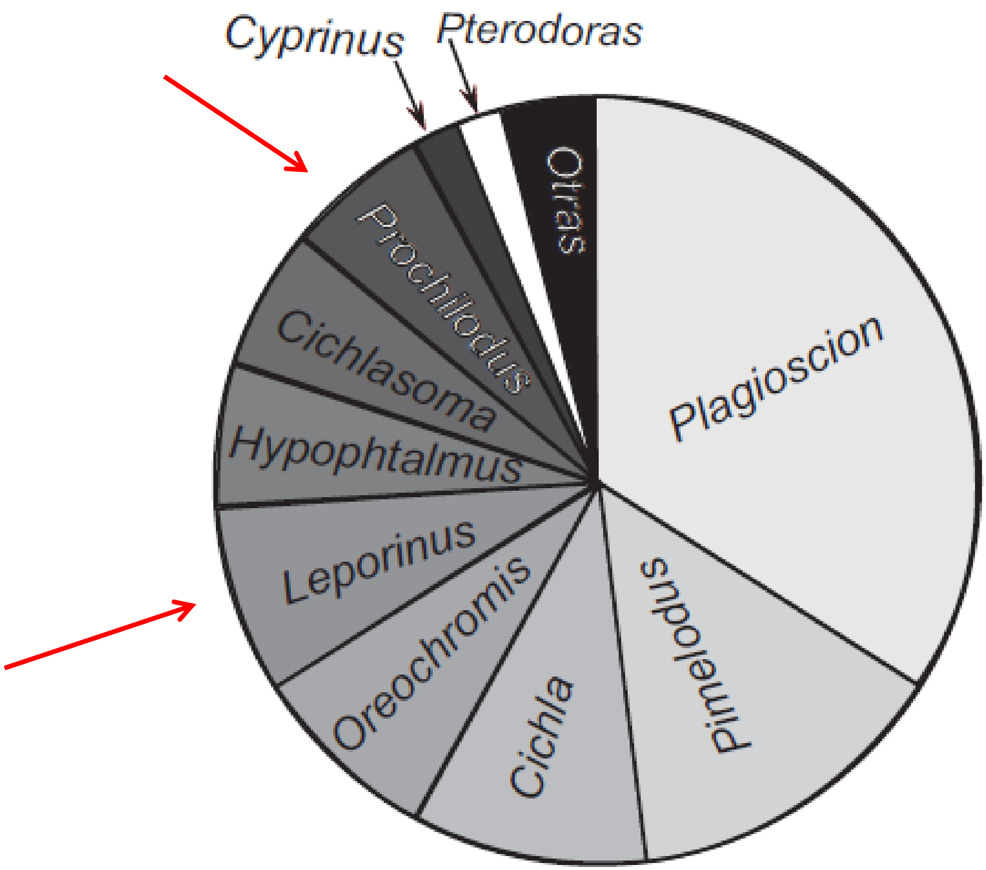
From Pelecice et al 2014

Species composition in Brazilian reservoirs after stabilization



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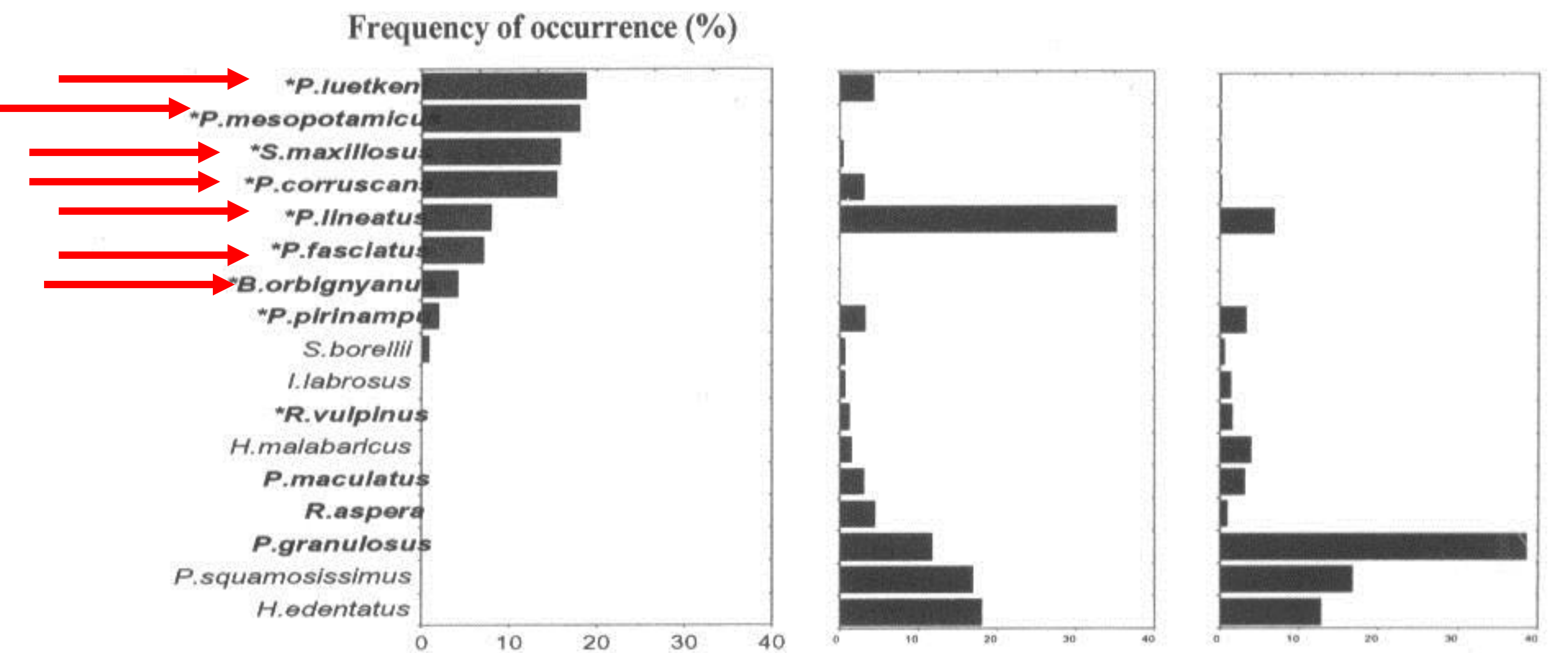
Baigun et al 2011

ITAIPU

Figure 4. Fish species composition in the landing of artisanal fishery in Itaipu Reservoir, before (1977) and after impoundment (1987 and 1997). [3]



Migraotry species:
50% of capture

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Agostinho et al 2001

Figure 1. Dominant species by biomass in artisanal fishery landings of the Upper Paraná River before and after impoundment of Itaipu Reservoir. Dominant species prior to impoundment: (a) jaú, Zungaro zungaro, *(b) dourado,* Salminus brasiliensis, *(c) pacu,* Piaractus mesopotamicus, *(d) pintado,* Pseudoplatystoma corruscans. *Dominant species following impoundment: (e) armado,* Pterodorus granulosus, *(f) curimba,* Prochilodus lineatus, *(g) perna-de-moça,* Hypophthalmus edentatus, *(h) curvina,* Plagioscion squamosissimus. *Photographs by E.K.O.,*

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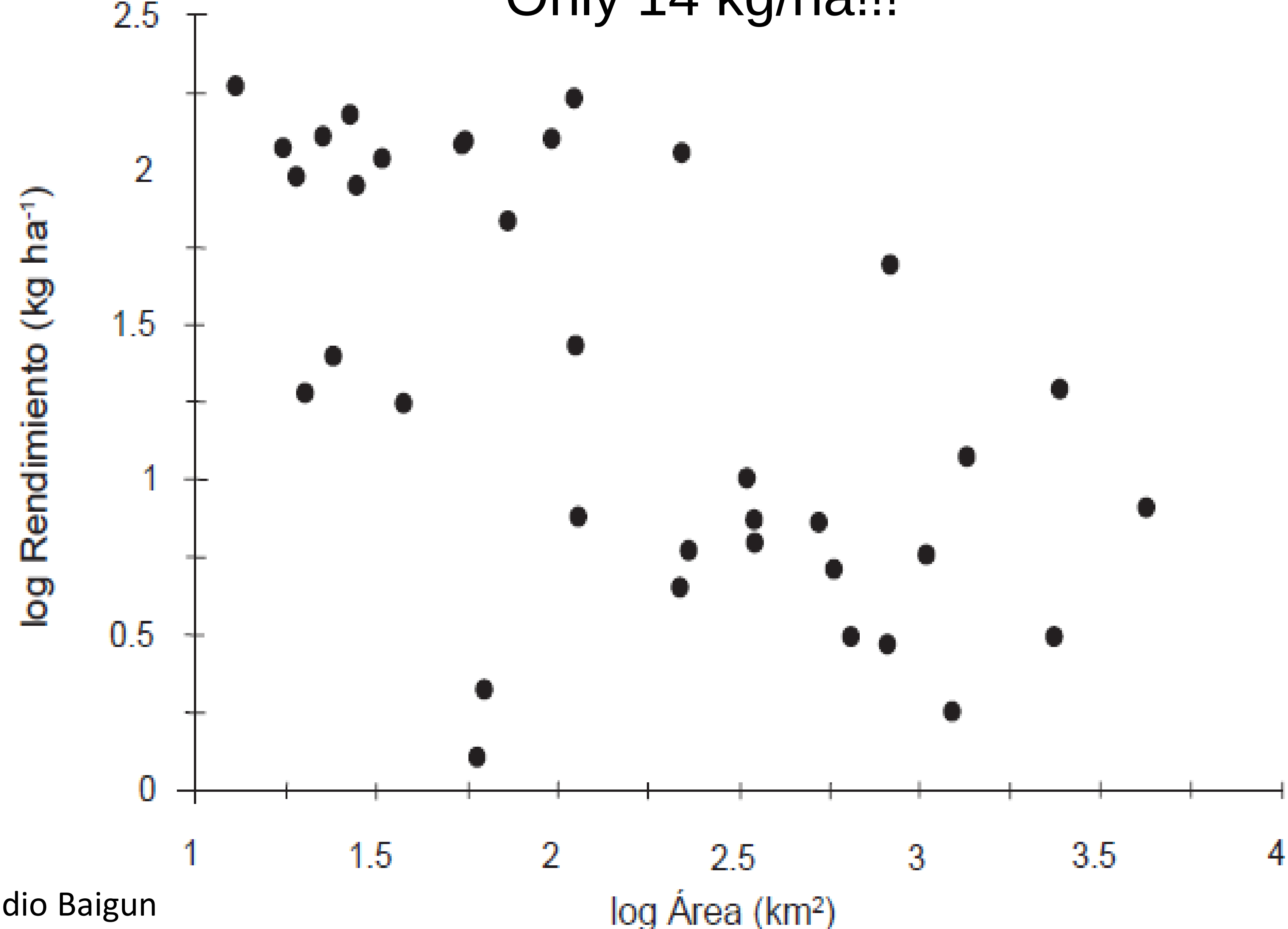
(fuente: Hoeninghaus et al 2009

Mean yield in the upper Parana dams:
Only 14 kg/ha!!!



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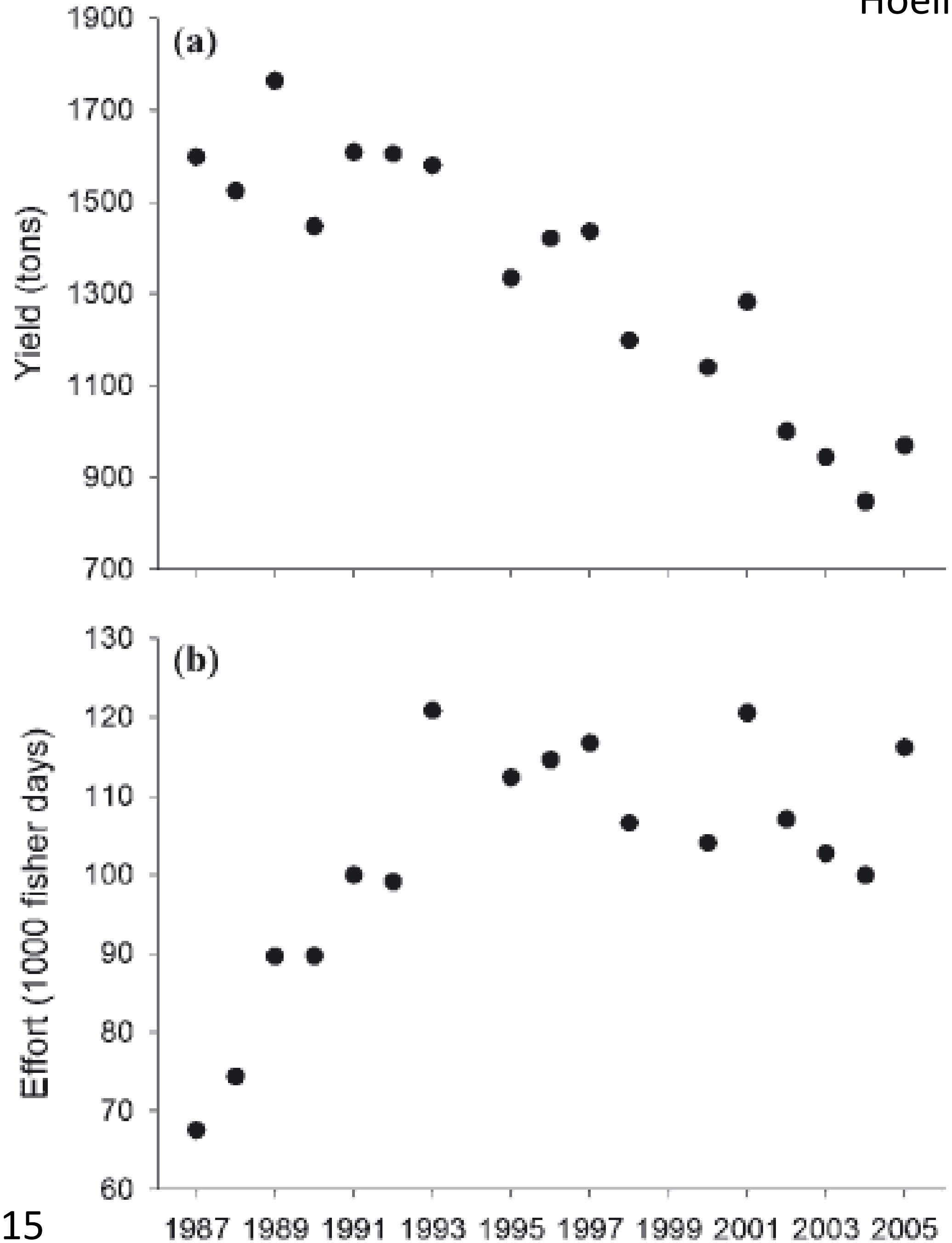
Baigun et al 2011

Hoeinghaus et al 2009



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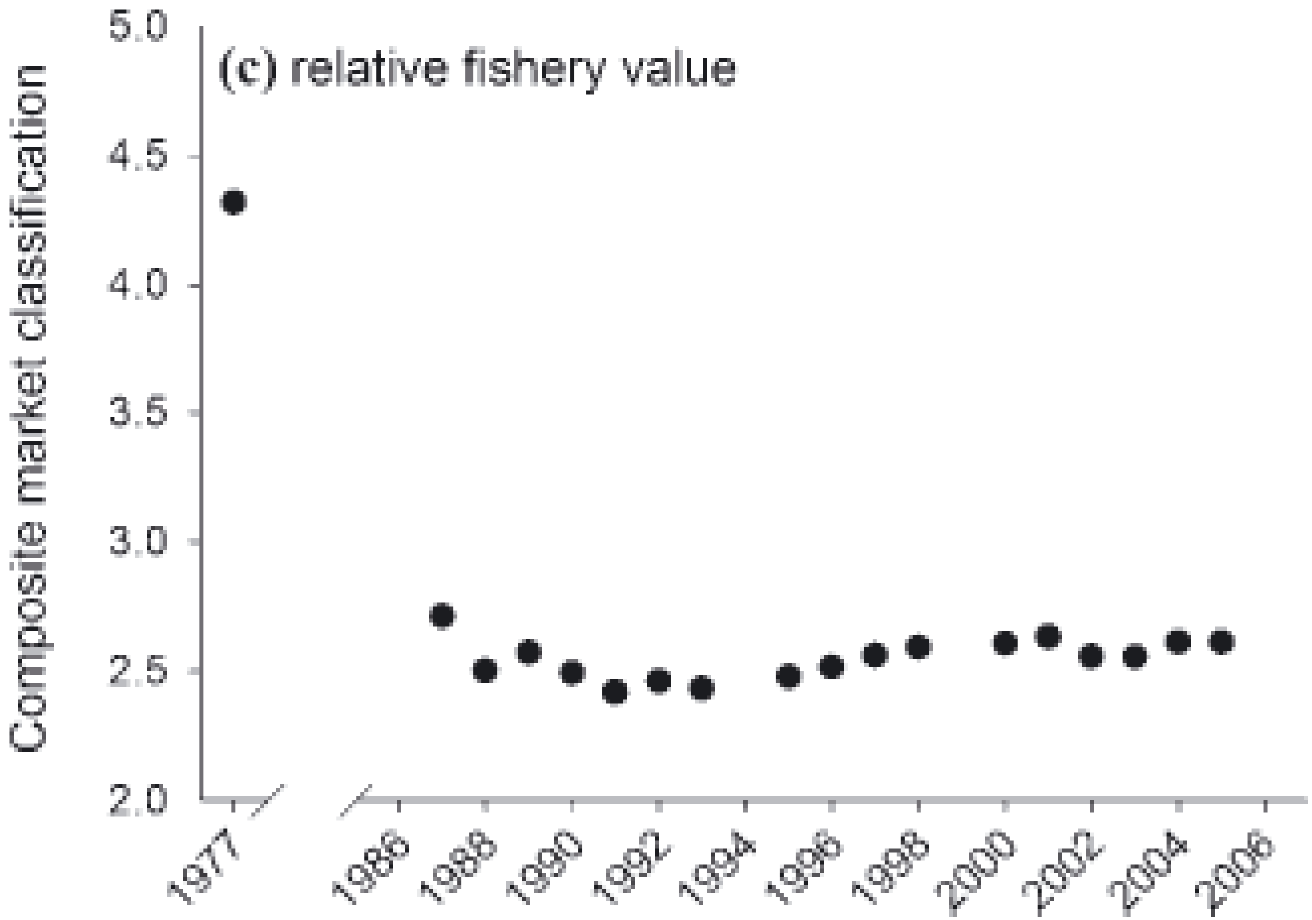
Hoeinghaus et al 2009



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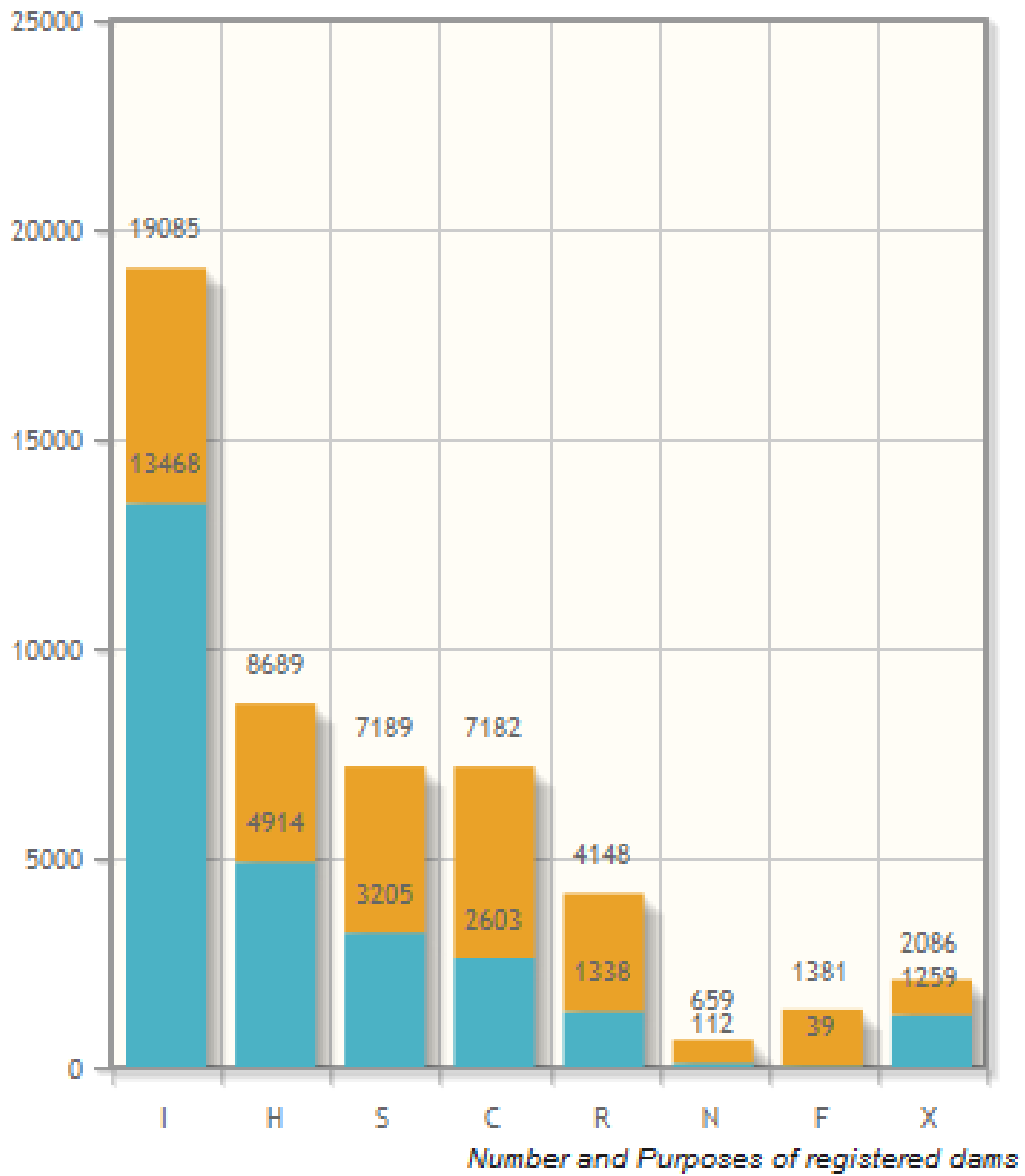
- Think also in small!!

- Small dams (mostly directed to irrigation purposes) are big problems too!
- Small dams are “invisible” as they usually do not have environmental studies or do not consider migratory fish problems .
- Most of small dams are understimated and built without considering bioengineering criteria



Codes

H Hydropower
S Water Suply
C Flood control
I Irrigation
N Navigation
R Recreation
F Fish breeding
X Others

37641 Dams data corresponding to registered dams only

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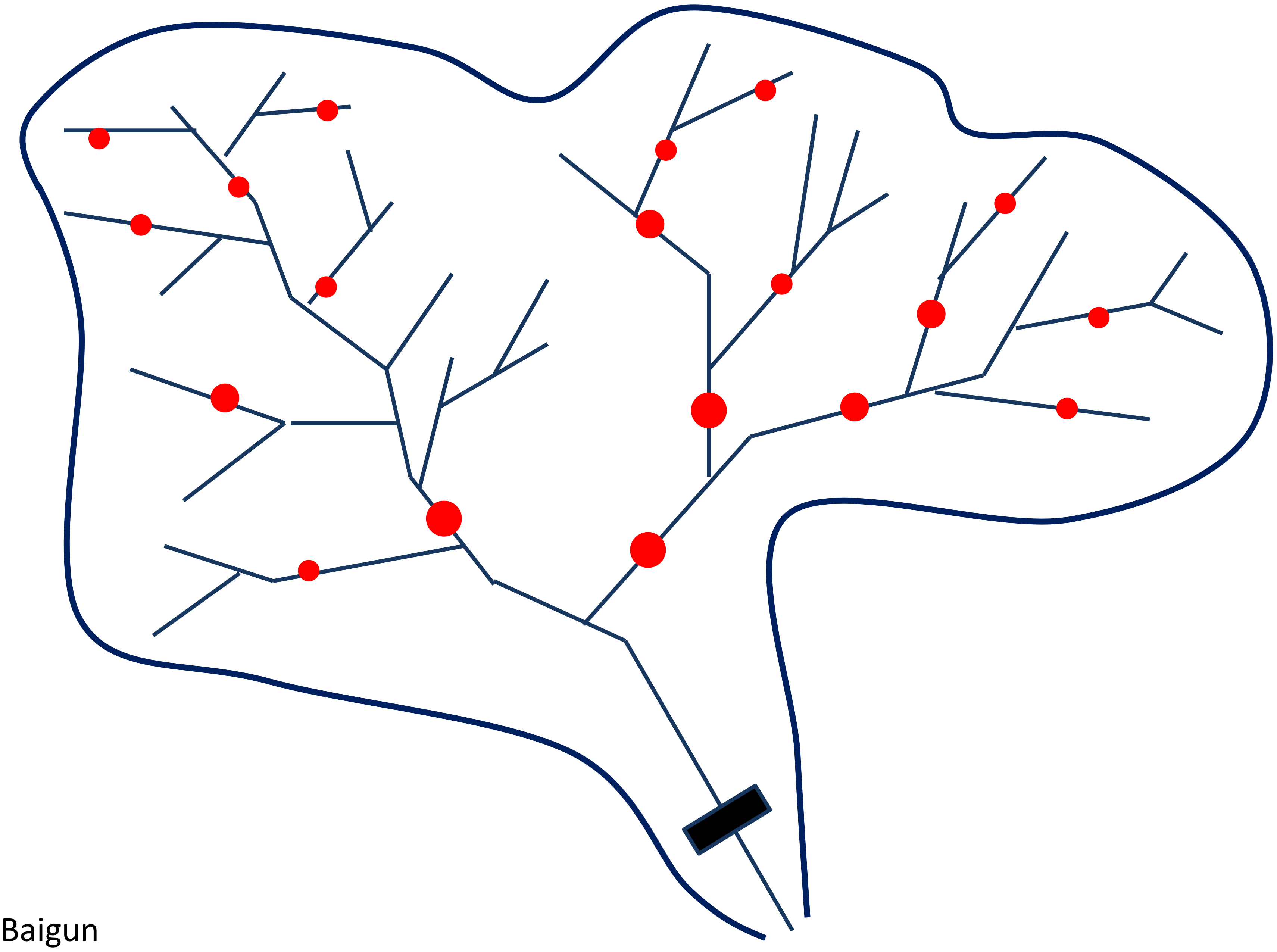
- In South America is yet not clear or has not been properly assessed how low heigth dams could affect fish movements and when fishways are needed.

- However small dams are by far more numerous and could also exert catastrophic effects at a basin scale



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Final concerns

- How representative are the available fishways efficiency considering that most of past fishways design were not based on specific bioecological characteristics of neotropical fish?
- When fish passage efficiency should be considered successful in South American large rivers?
- What number of fish do we need to pass to assure a reliable genetic flux and to sustain viable populations?
- Are biologists, engineers and hydrologists in South American countries be prepared to cope with fish passage challenges for incoming dams?
- How to match “engineer scales” with “biological scales” required to gather appropriate information about fishways design?

- What type of modifications should be introduced to improve fishways design taking into account large size migratory species? (location, number, dimensions, hydrological and hydrodinamic characteristics)
- Are adult downstream migrations critical to maintain viable populations?
- Can tributary be effective to sustain fish reproduc tion when main channels are replaced by reservoirs?
- Which order rivers should be protected or remain unfragmented regarding fish life cycles?
- How can reservoir barriers effects be reduced?
- How to deal with small dams impacts?

- How to match dams requirements (energy and performance) with land use and climate change in transboundary basins?
- How to match dams requirements (energy and performance) with land use and climate change in large transboundary basins?

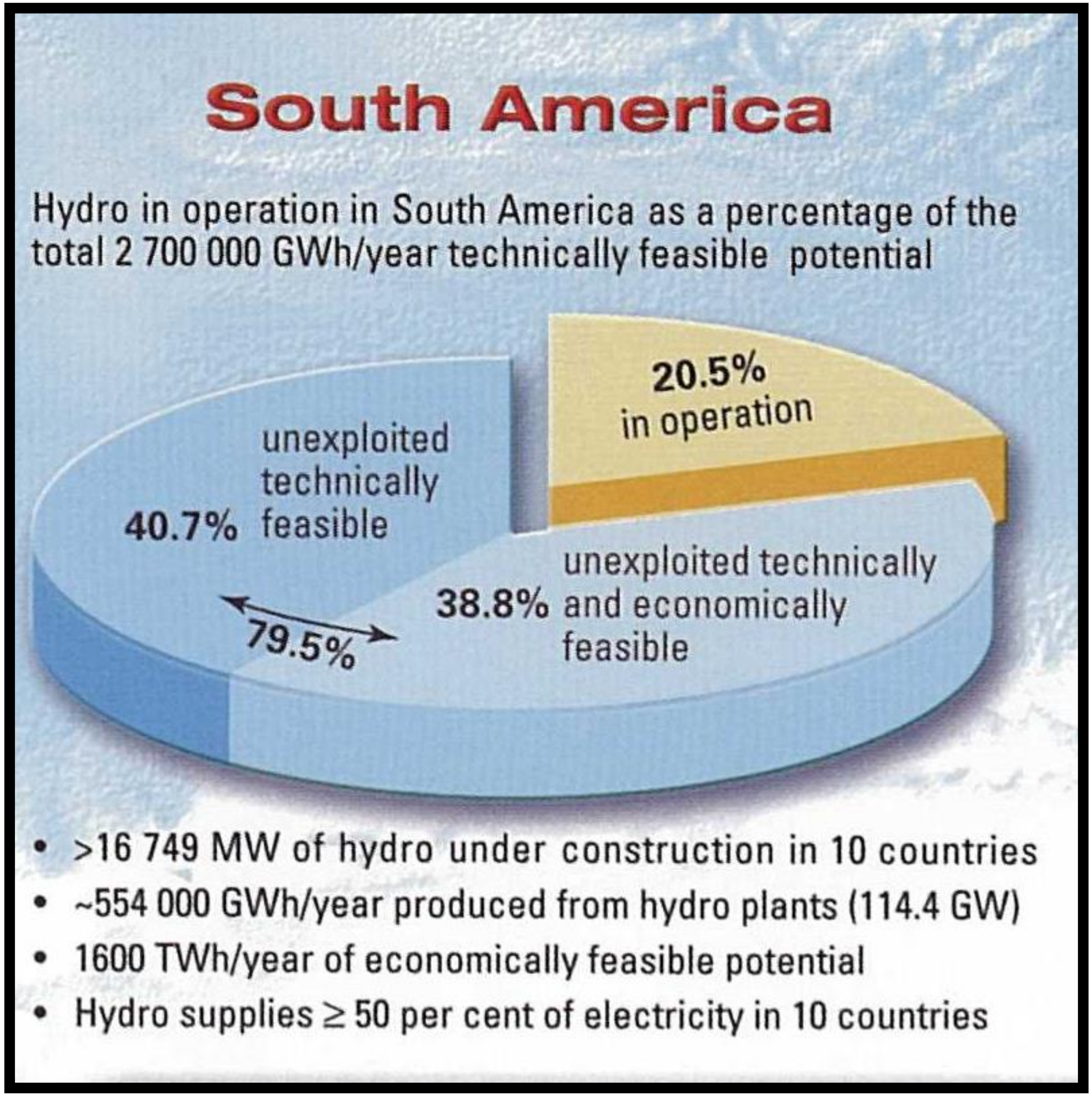

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Fig. 2 Global spatial distribution of future hydropower dams, either under construction (*blue dots* 17 %) or planned (*red dots* 83 %)

Zarfl et al 2015

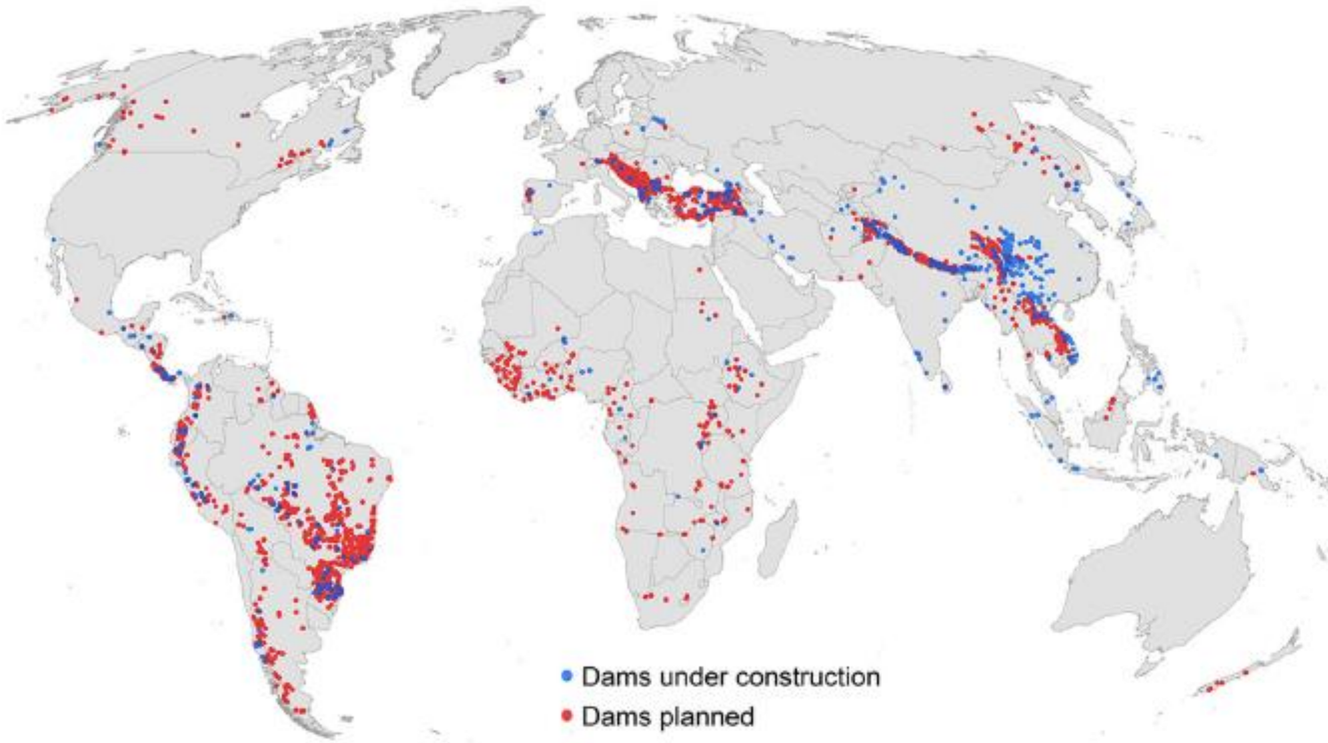

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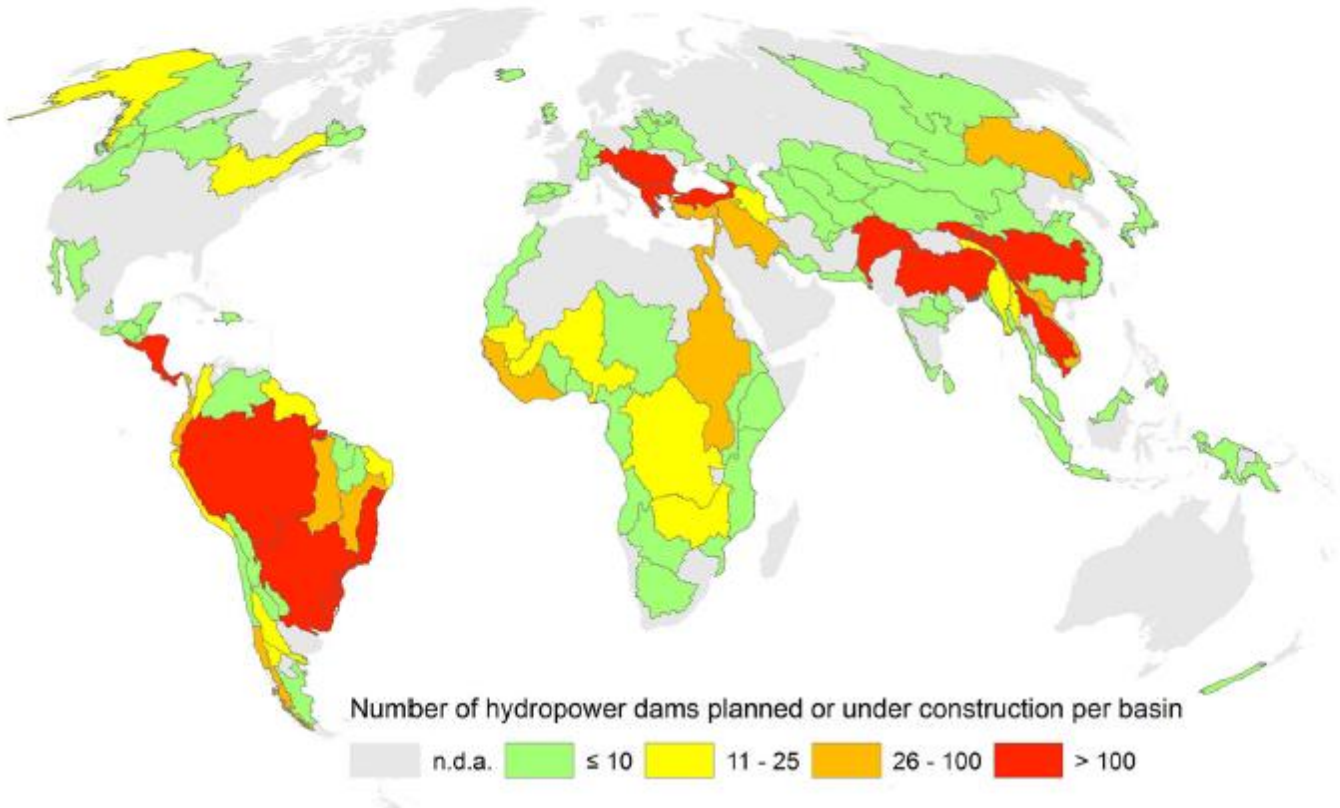
Fig. 3 Number of future hydropower dams per major river basin. *Red* >100, *Orange* 26–100, *Yellow* 11–25, *Green* ≤10, *Gray* no data available

Zarfl et al 2015



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The future?: Maybe good for biologists and engineers, but bad for fishermen and fish!

THANK YOU!!

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