

Modelling fish recruitment potential of lithophilic fish in restored rivers by means of functional habitat and population dynamics modelling

David Farò, Christian Wolter



Photo from Zauner et al. 2020



Ering-Frauenstein HPP



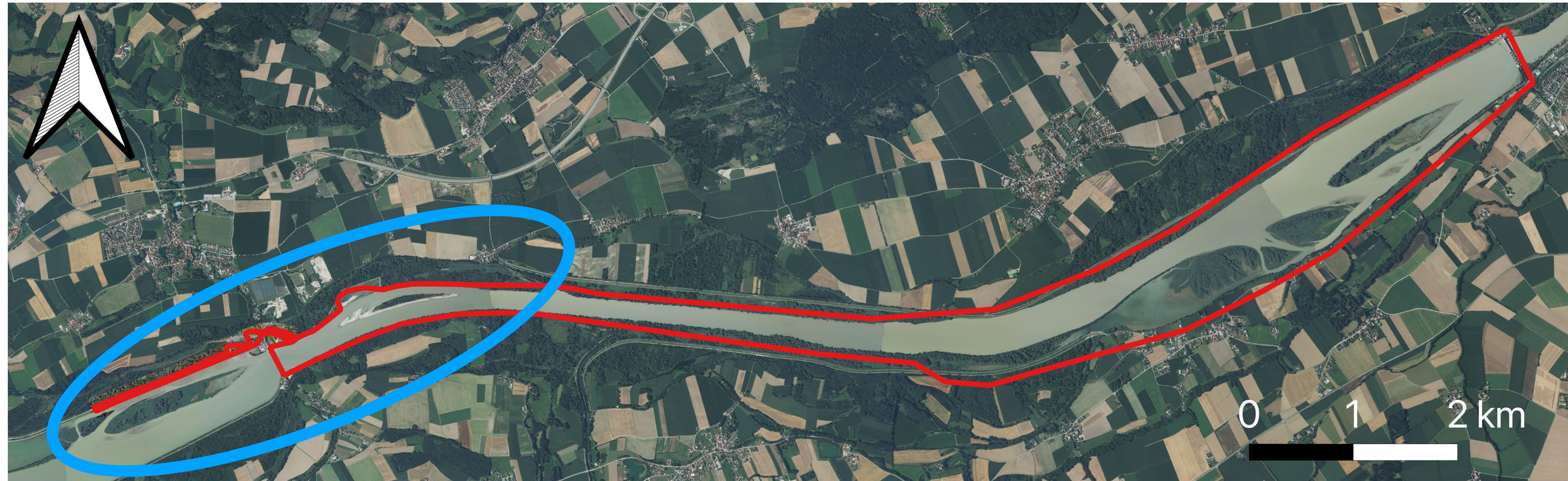
Challenges:

- longitudinal connectivity
- Lack of habitats for rheophilic / lithophilic fish species

Ering-Frauenstein HPP

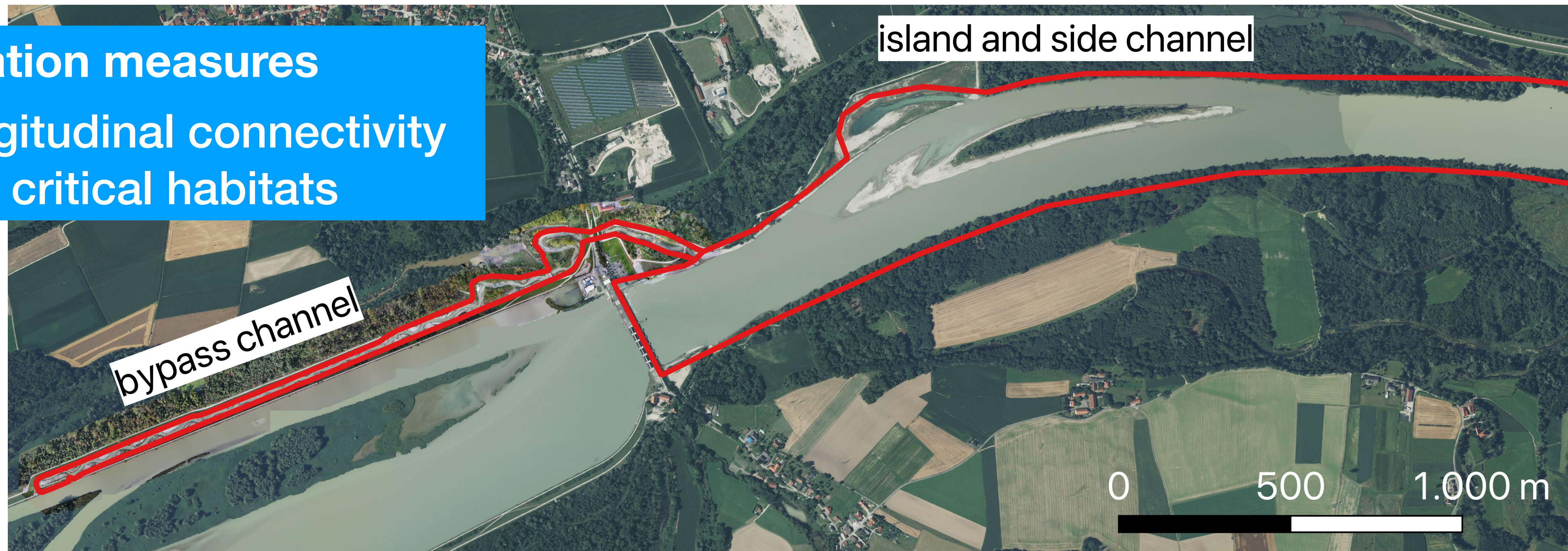
reach ~ 12.5 km / 240 ha

Obernberg HPP



2 restoration measures

- > improve longitudinal connectivity
- > restore critical habitats



2 restoration measures

-> improve longitudinal connectivity

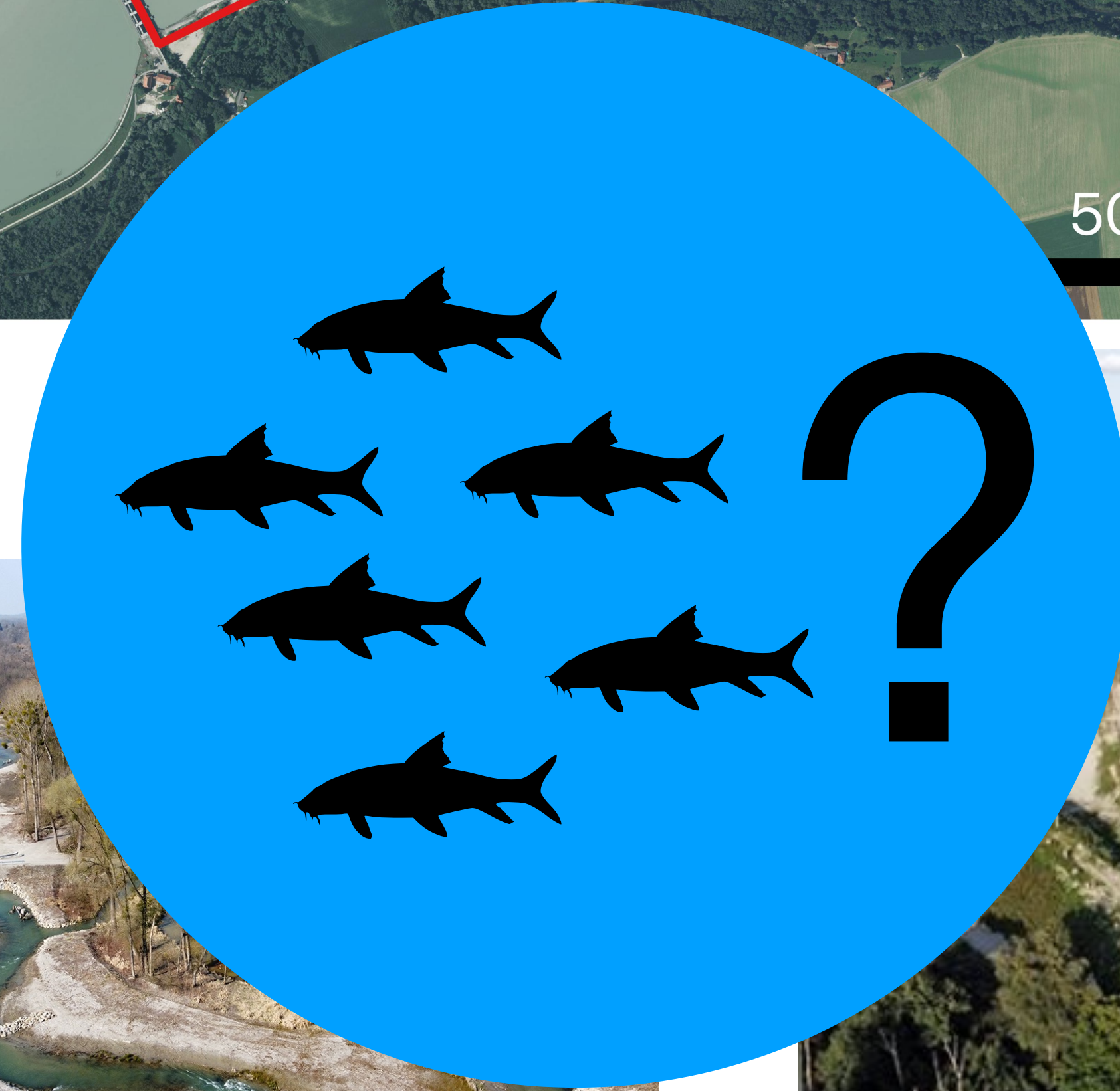
-> restore critical habitats



Zauner et al. 2020

2 restoration measures

- > improve longitudinal connectivity
- > restore critical habitats



Target species



grayling



nase



barbel



chub

- Eggs laid within gravel
- Barbel: Redd clearing
- Eggs deeper in sediment (up to 20-30 cm)

- Gravel surface spawner
- Eggs on surface (only up to 7 cm)

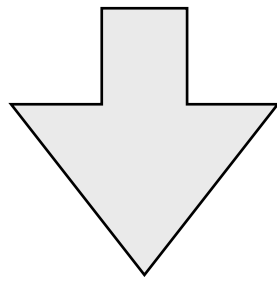
Project objectives

- Quantify quantity and quality of ontogenetically key habitats
- Assess functional connectivity

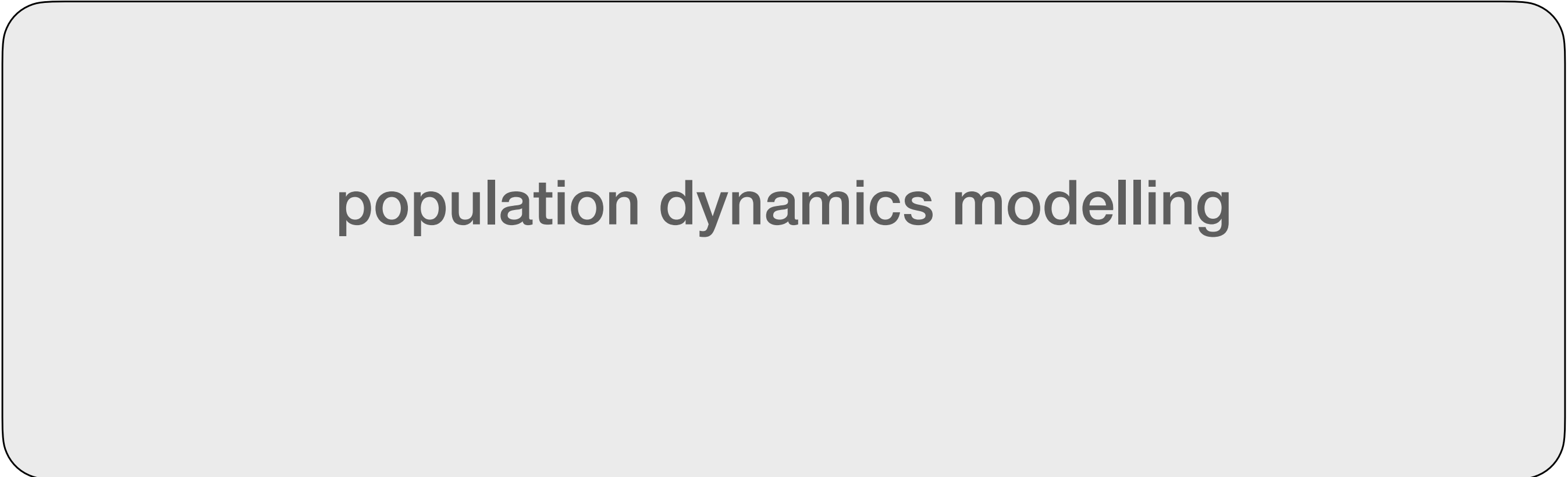
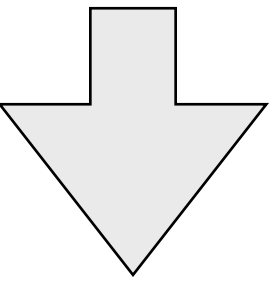


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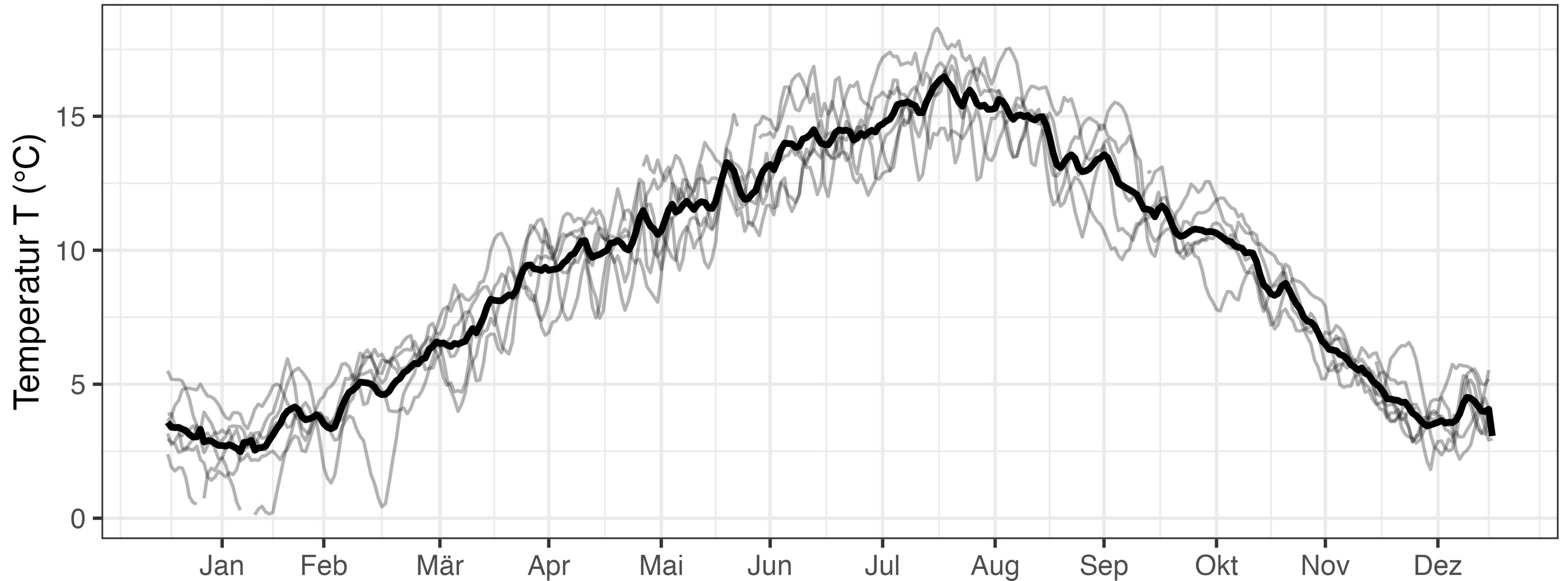
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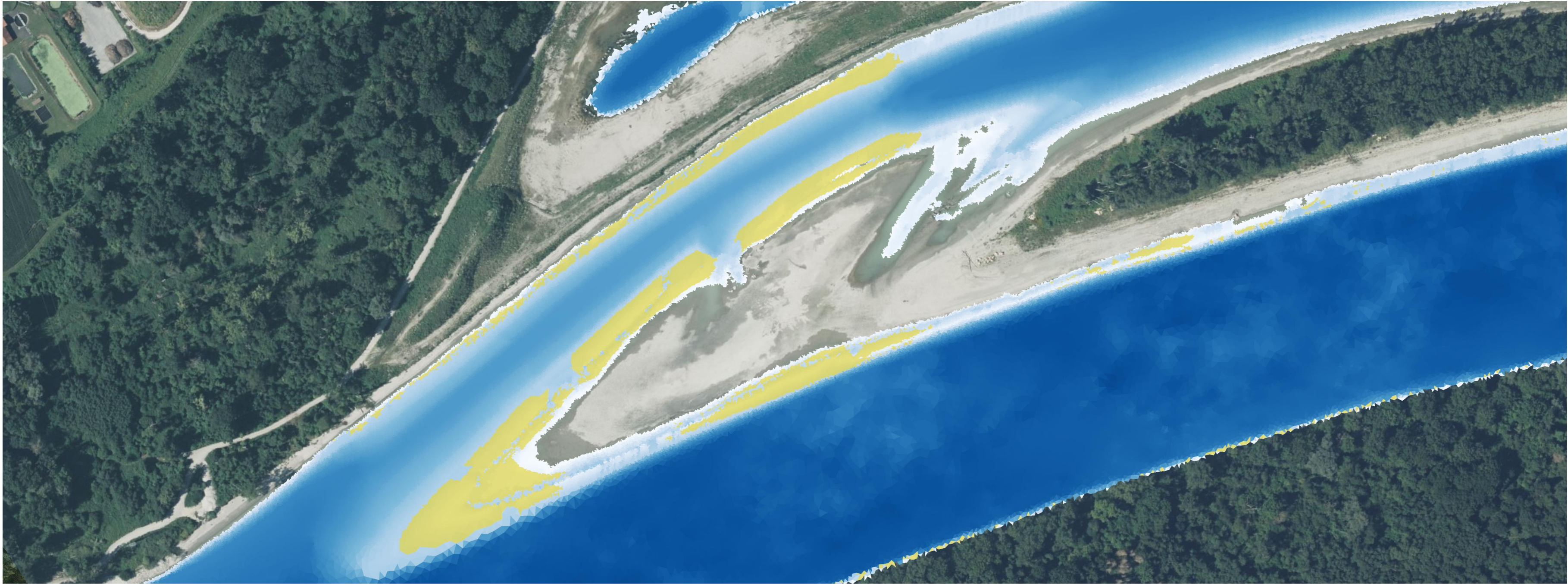
- Assess potential recruitment



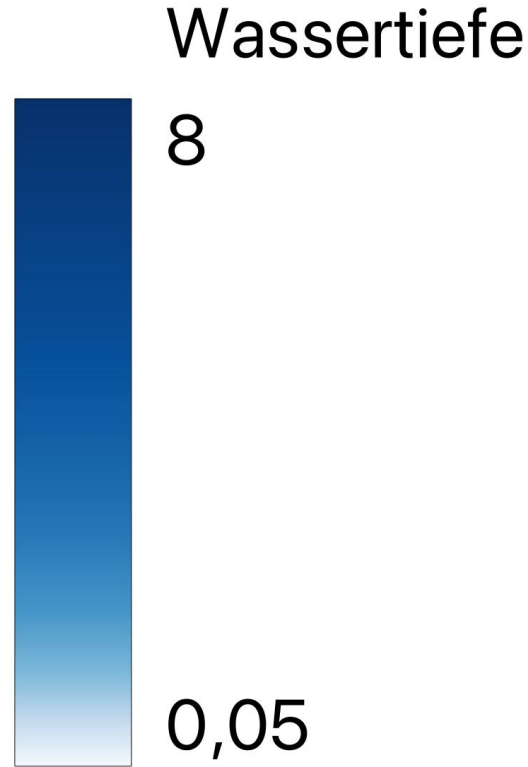
Target species



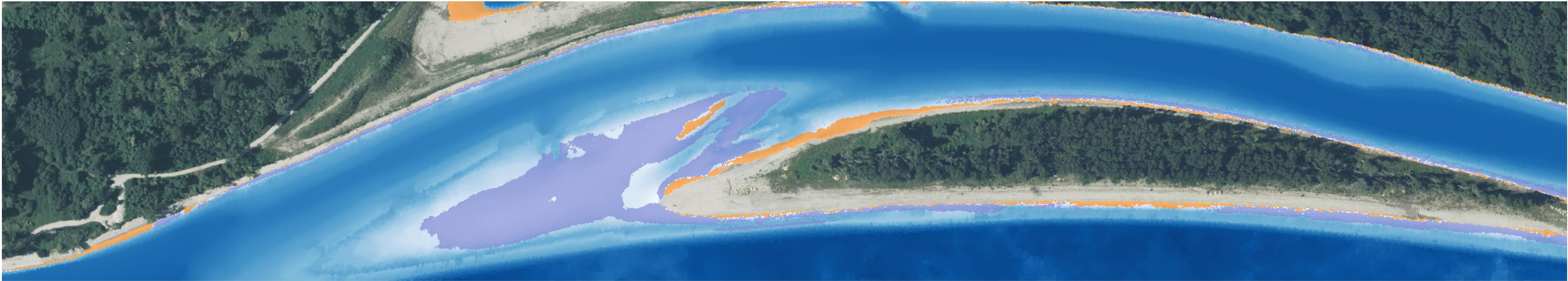
Hydraulic habitat suitability (March)



- Habitats
- Laichen - Äsche
 - Laichen - Nase
 - Laichen - Barbe
 - Laichen - Döbel
 - Brut - alle



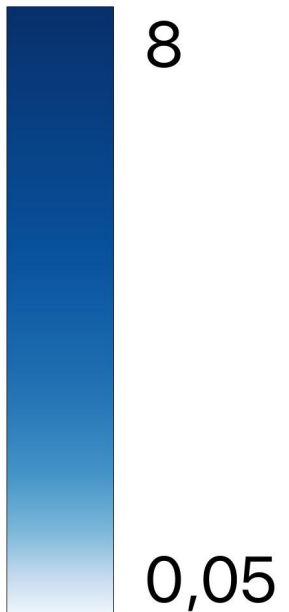
Hydraulic habitat suitability (May)



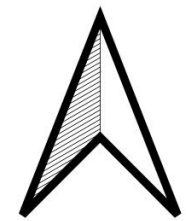
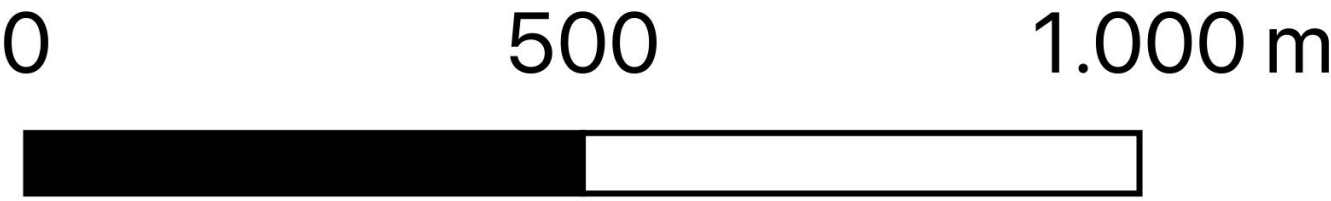
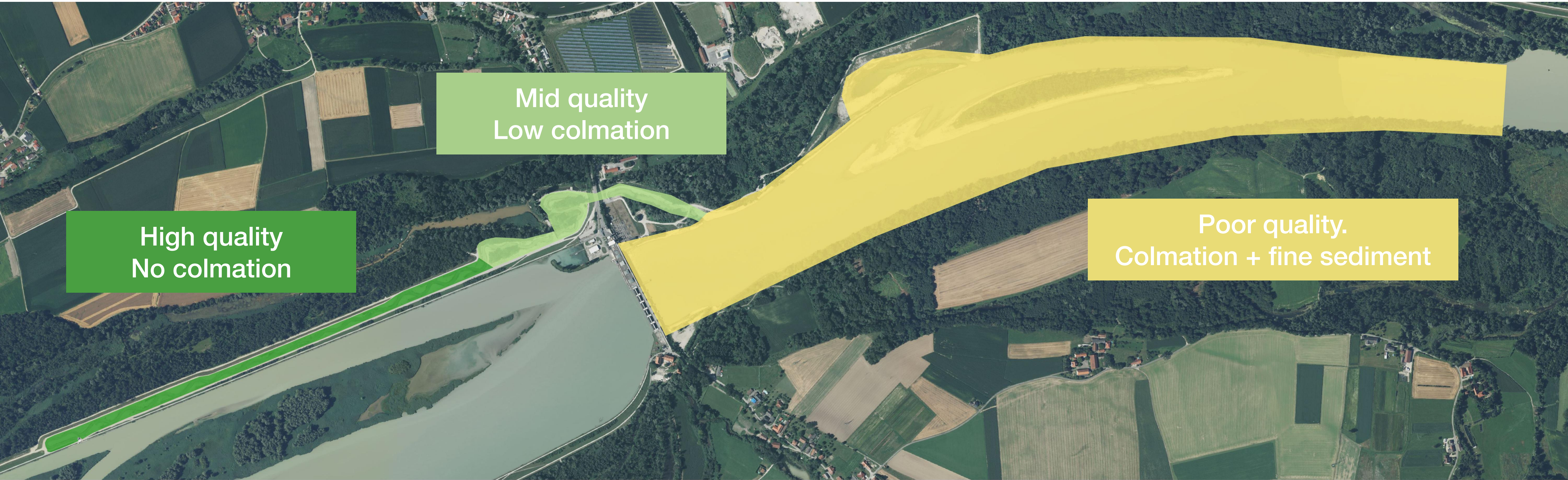
Habitats

- Laichen - Äsche
- Laichen - Nase
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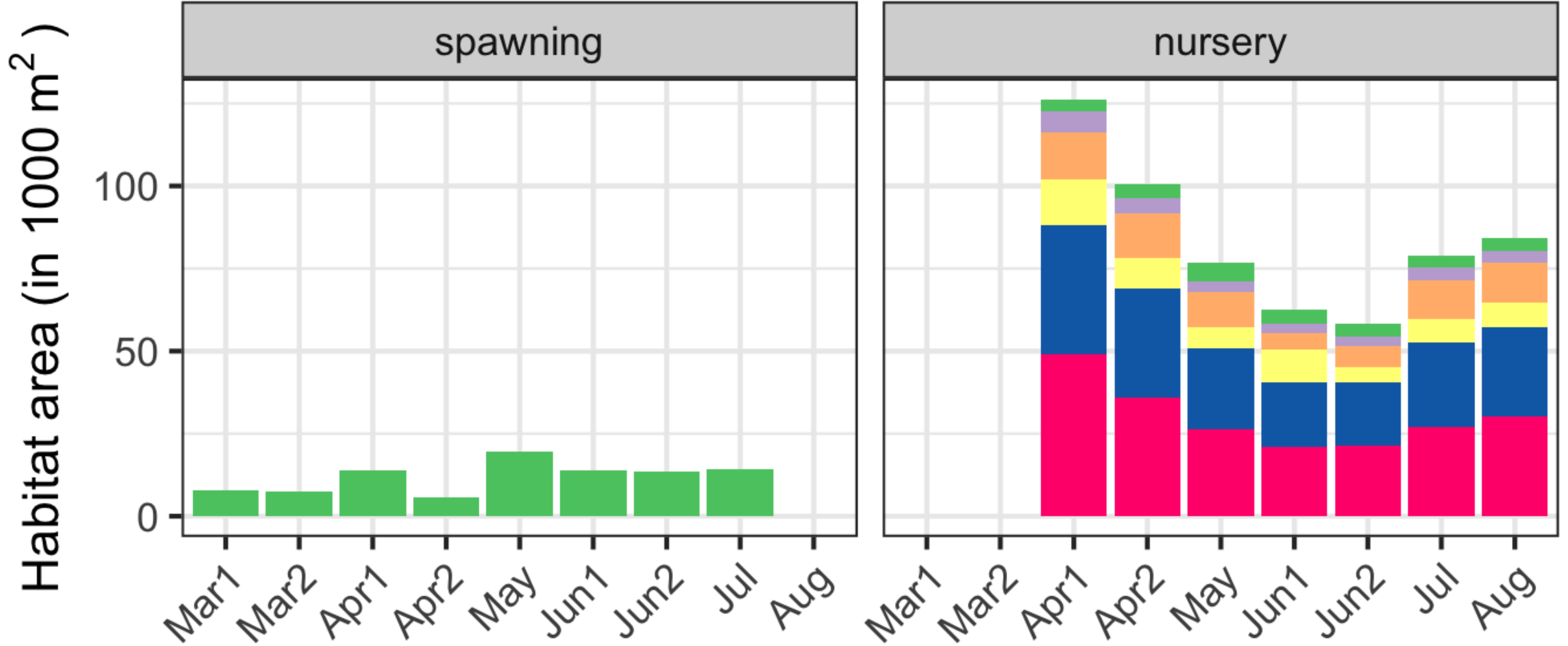
Wassertiefe



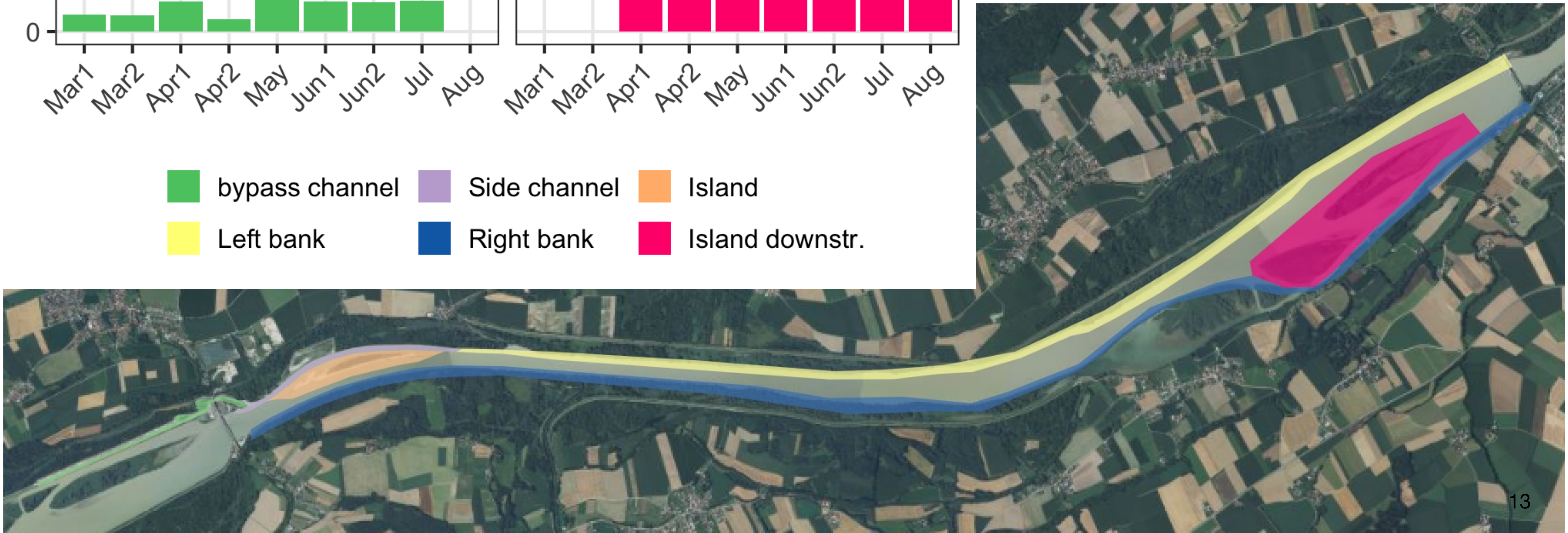
Habitat suitability - substrate quality



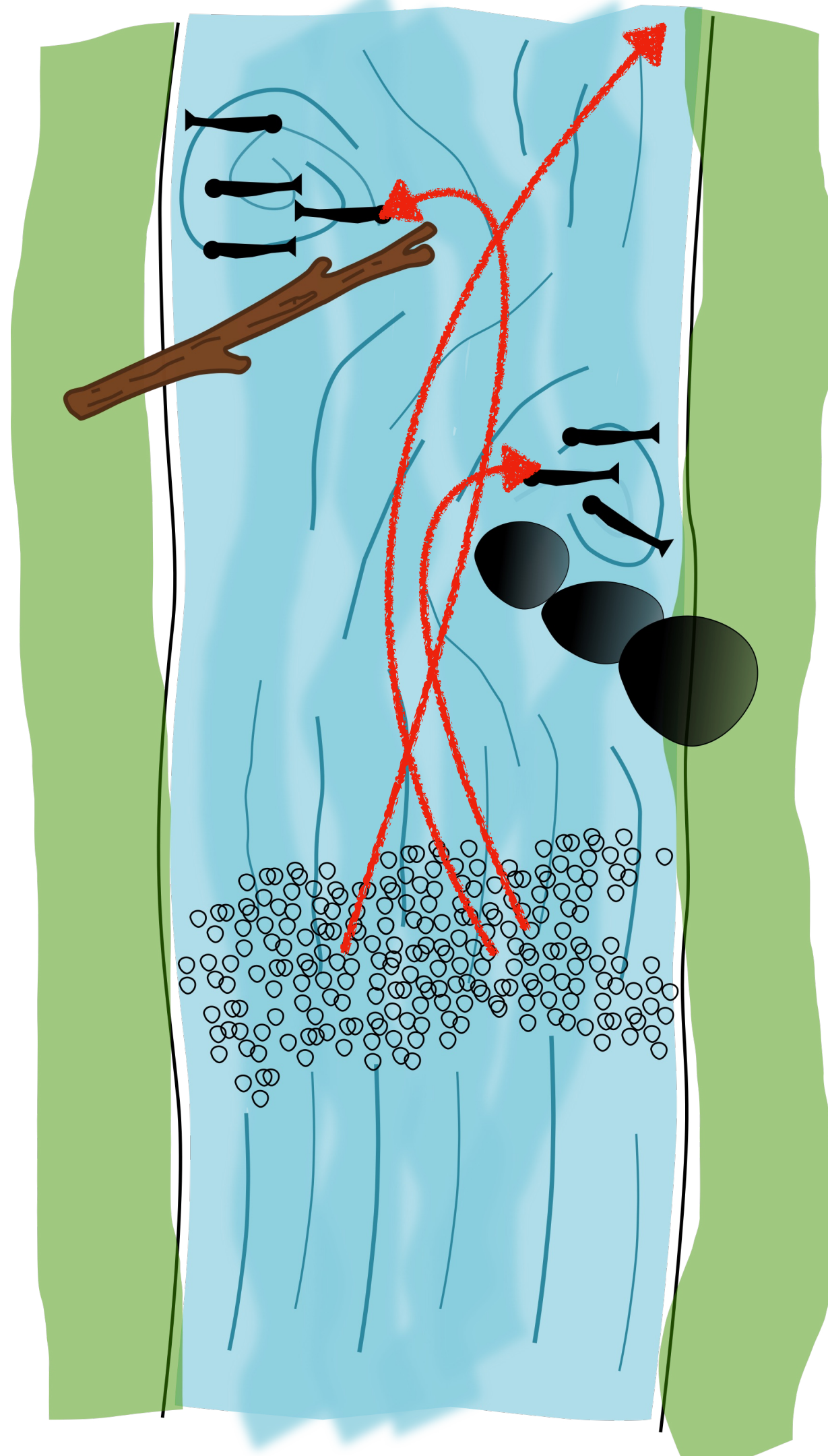
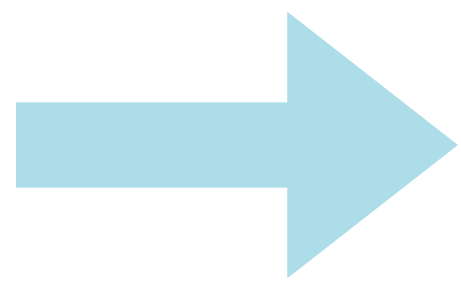
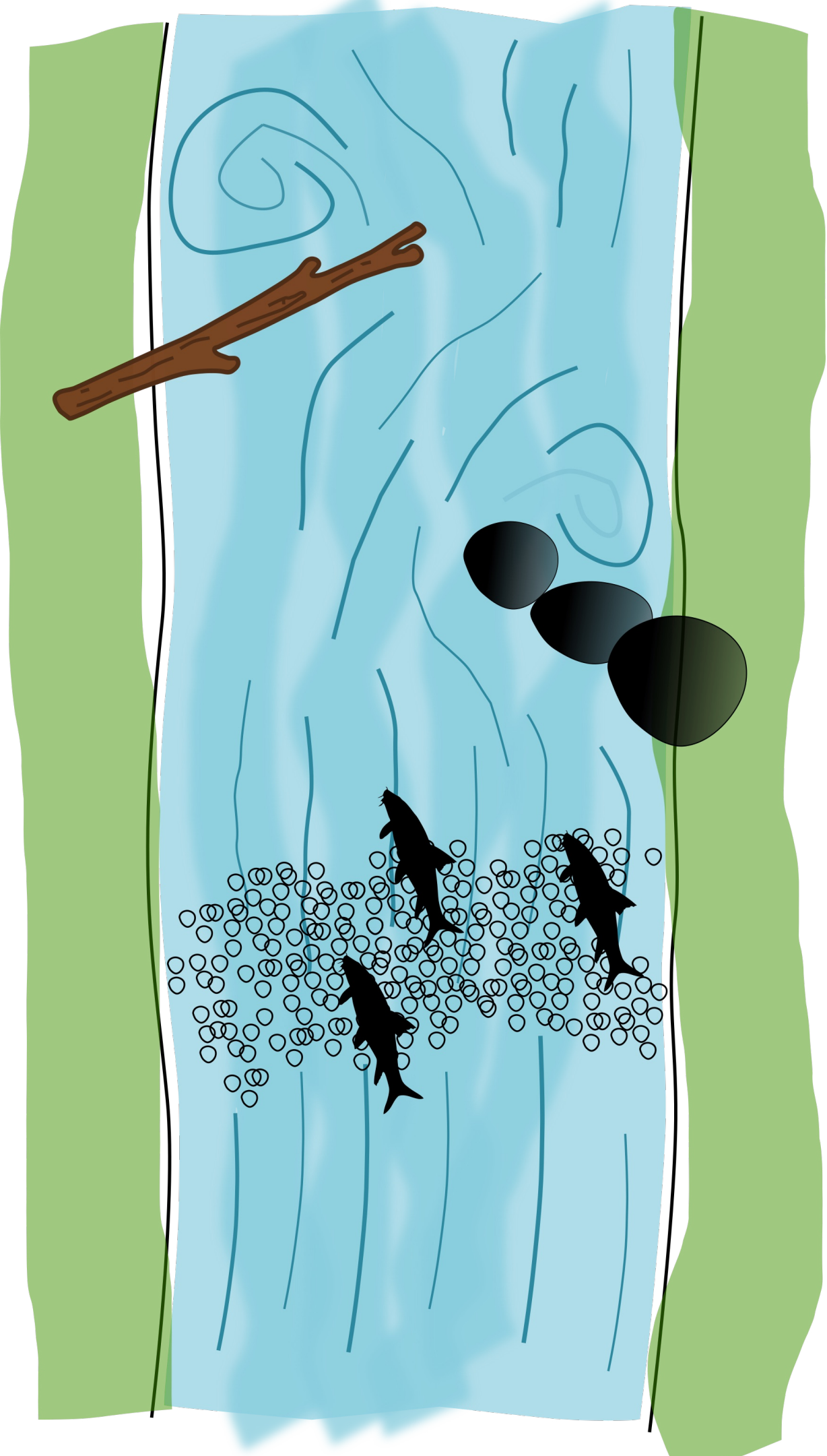
Habitat suitabilities



- bypass channel
- Side channel
- Island
- Left bank
- Right bank
- Island downstr.



Functional connectivity



Larval drift modell

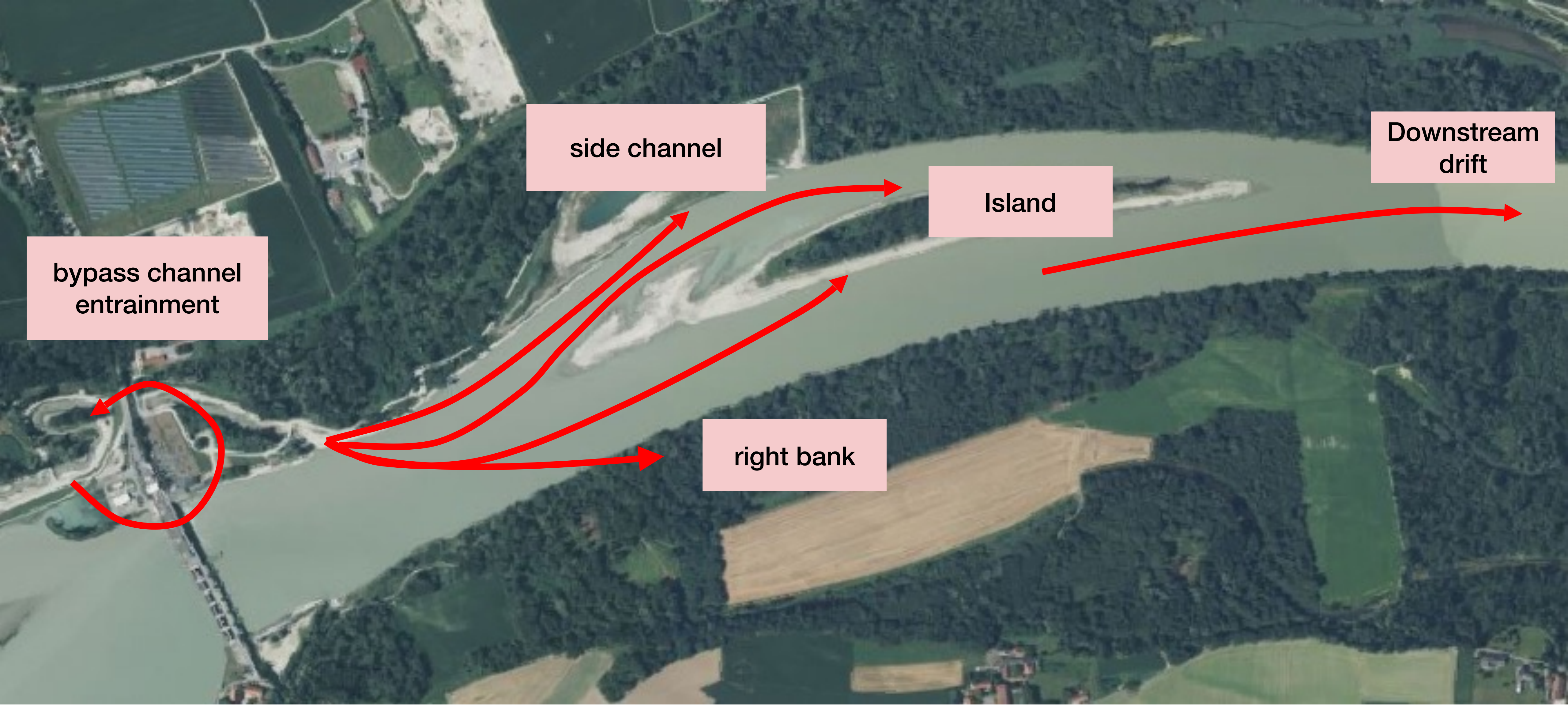
$$x(t + \Delta t) = x(t) + v_x \Delta t + R_1 \sqrt{2D_x \Delta t}$$
$$y(t + \Delta t) = y(t) + v_y \Delta t + R_1 \sqrt{2D_y \Delta t}$$

advection

diffusion ← turbulence

- **Lagrangian particle tracking** (Nelson et al. 2023)
- **Active-passive larval drift**
- Active drift:
 - Position in the water column (ground for grayling; surface for cyprinids)
 - Assumption: nursery habitats reached when $v < 10$ cm/s

Connectivity between spawning and nursery habitats



bypass channel entrainment

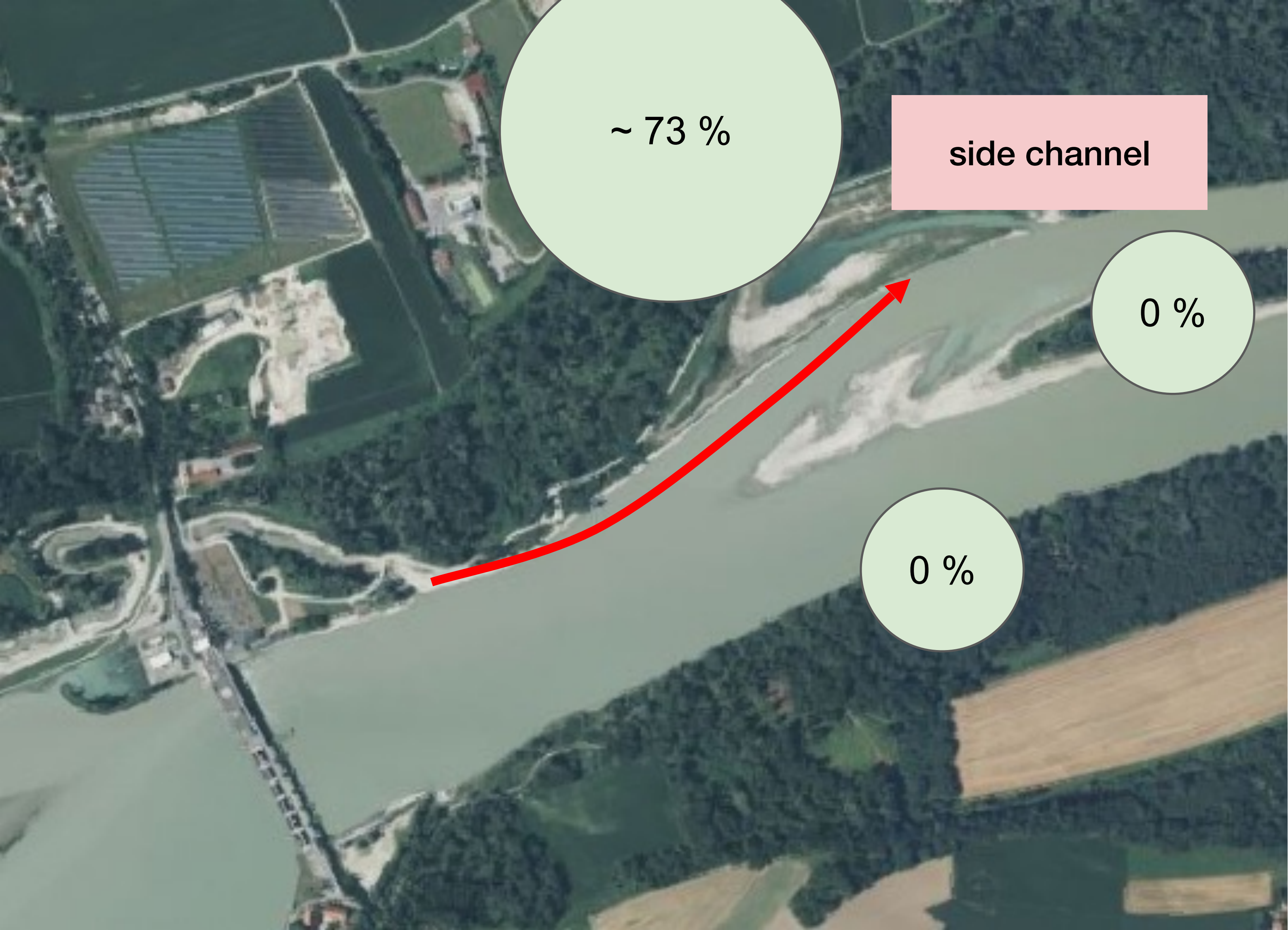
side channel

Island

Downstream drift

right bank

Connectivity between spawning and nursery habitats



~ 73 %

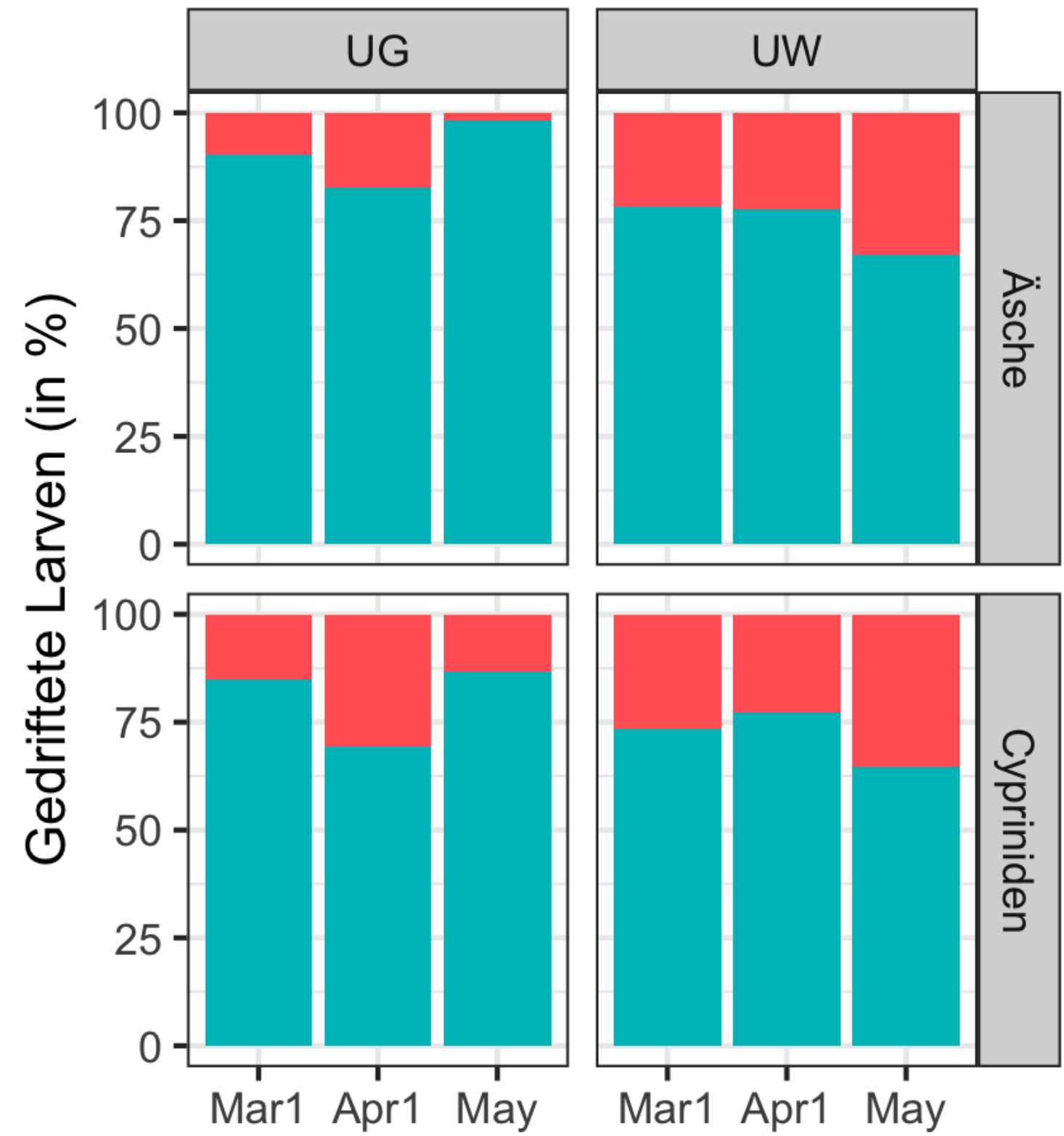
side channel

0 %

0 %

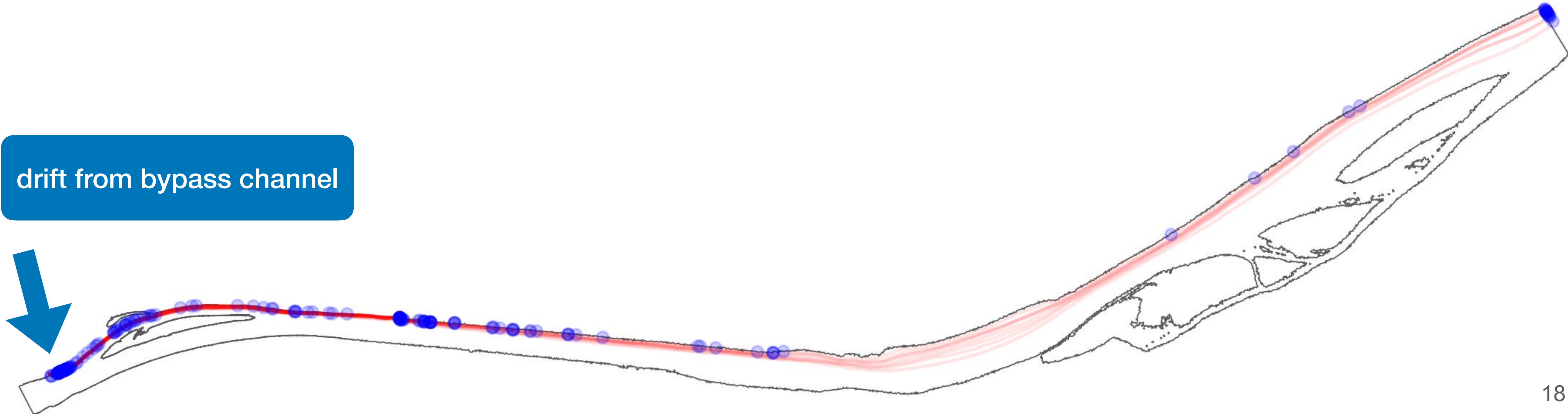
~ 27 %

Downstream drift

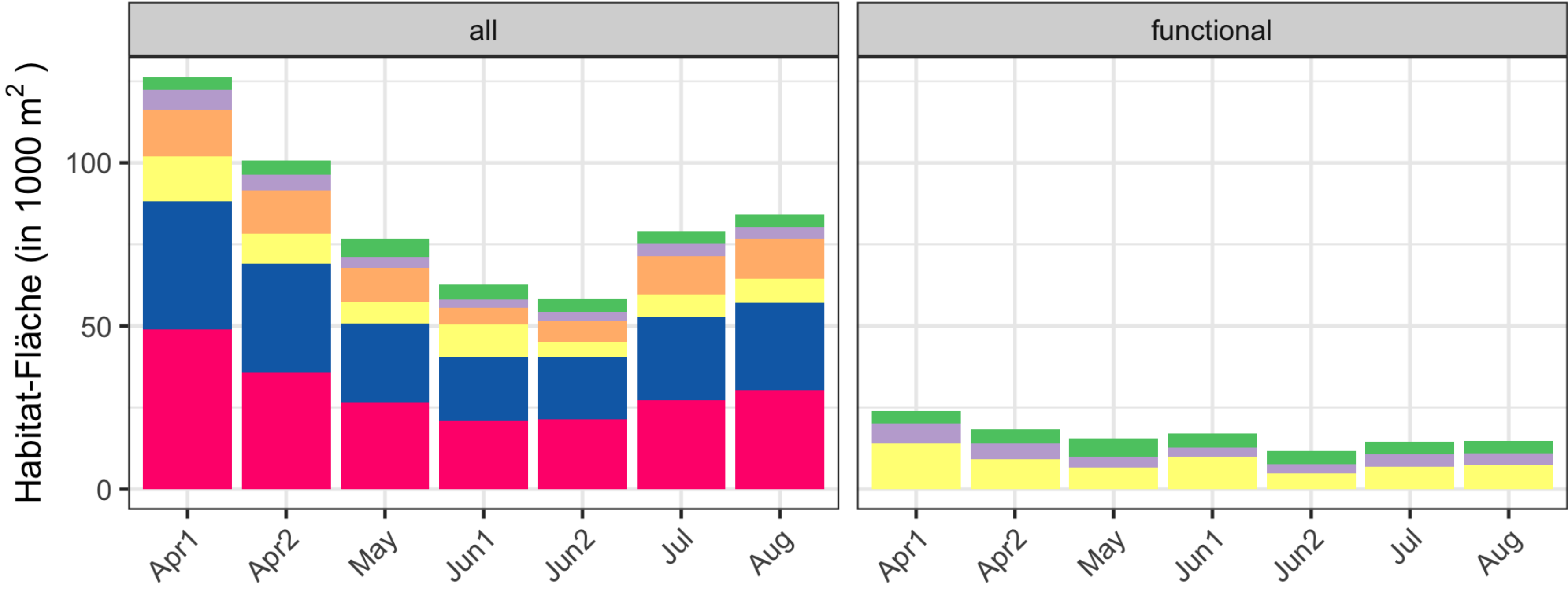


Abfluss Brut

Connectivity between spawning and nursery habitats

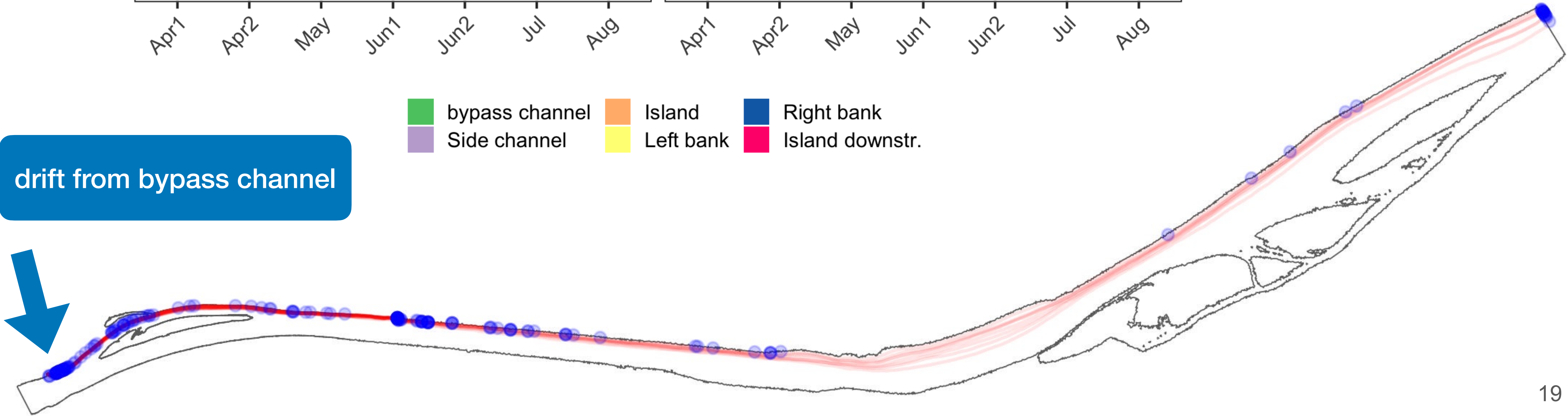


Connectivity between spawning and nursery habitats

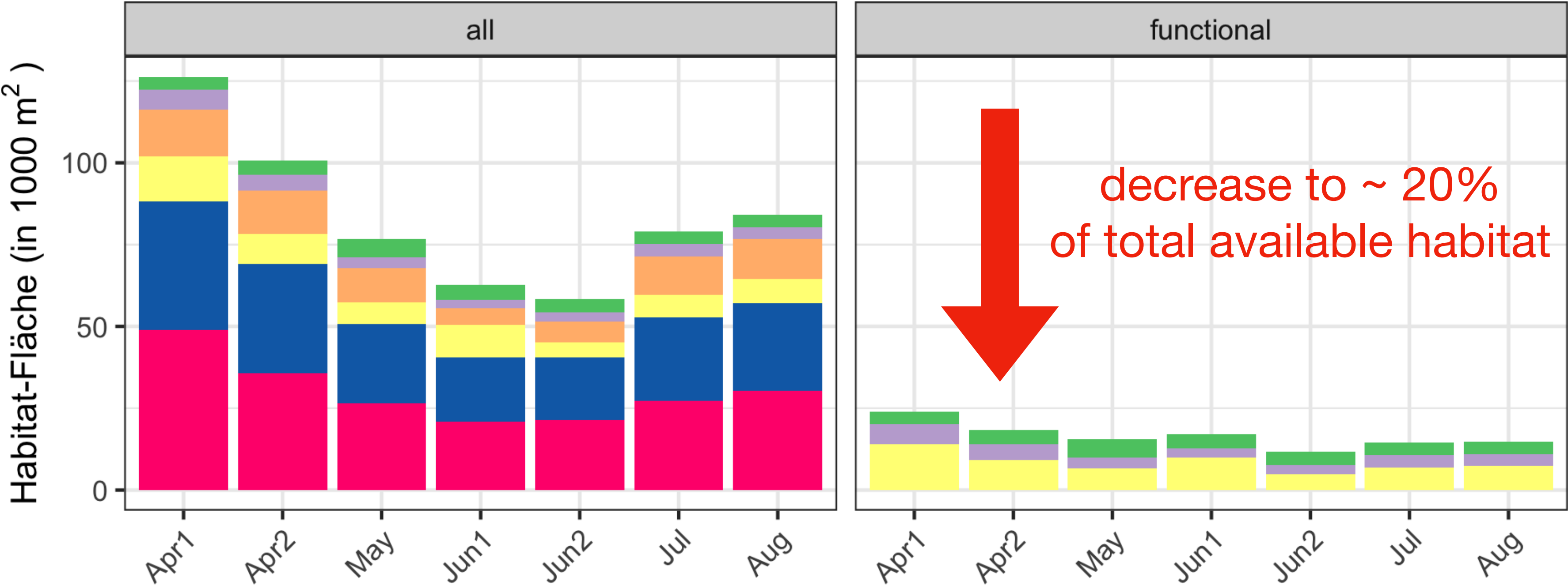


- bypass channel
- Island
- Right bank
- Side channel
- Left bank
- Island downstr.

drift from bypass channel



Connectivity between spawning and nursery habitats

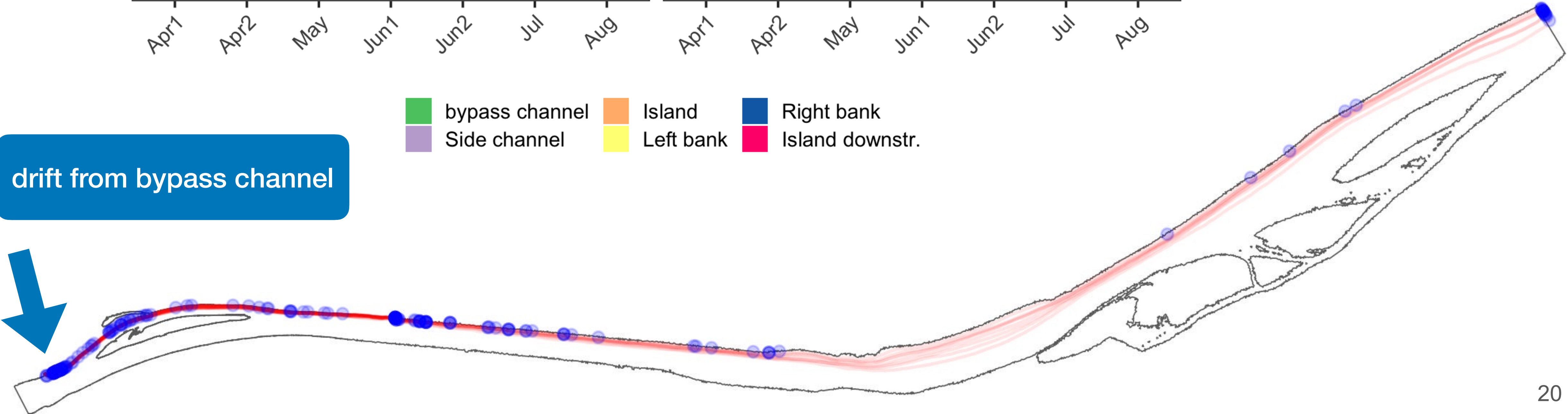


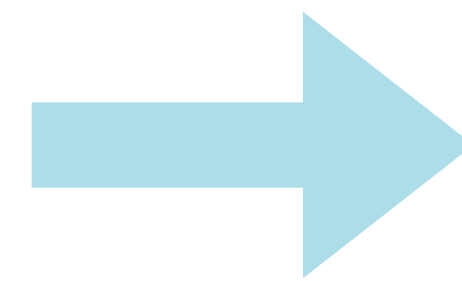
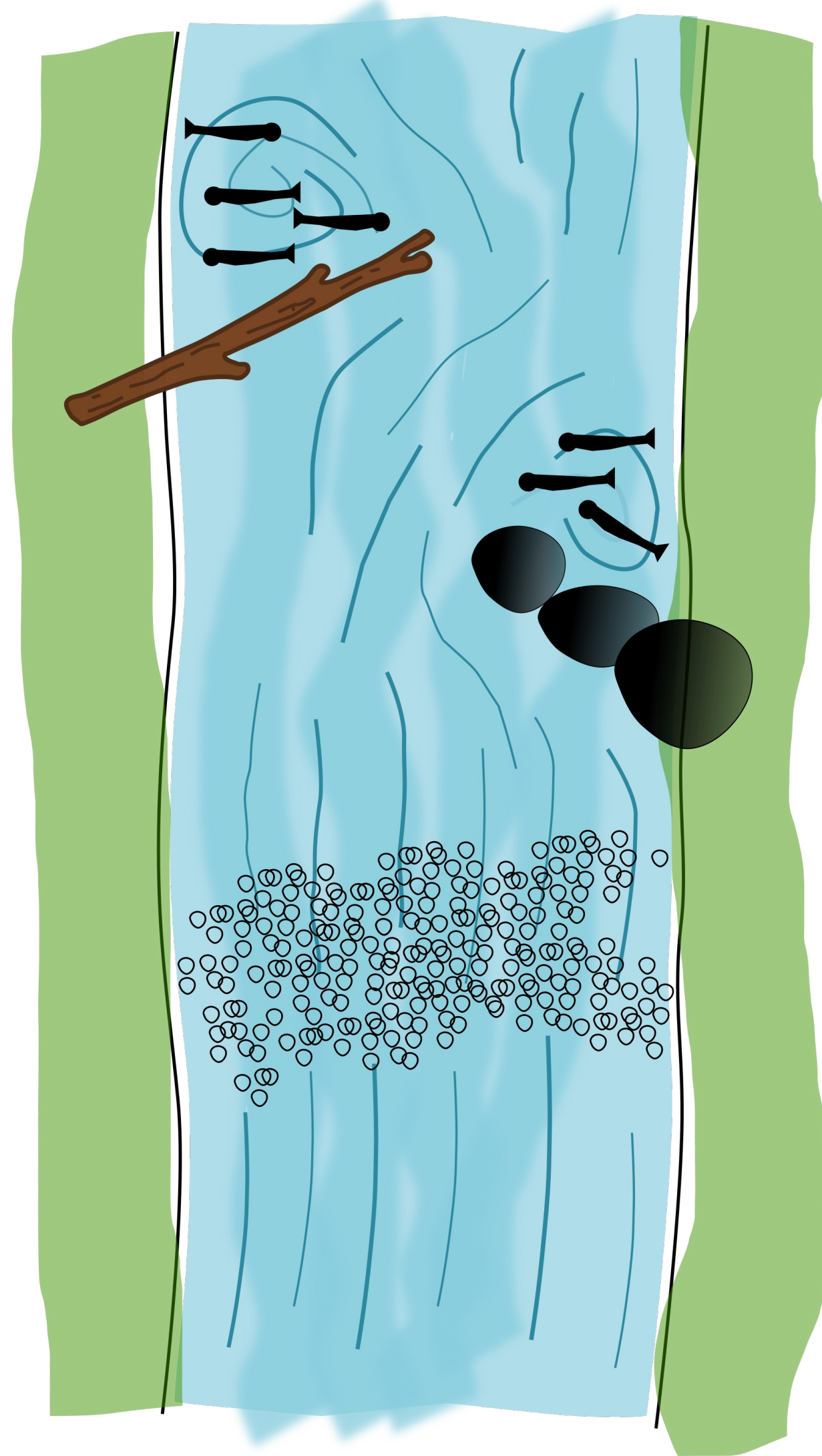
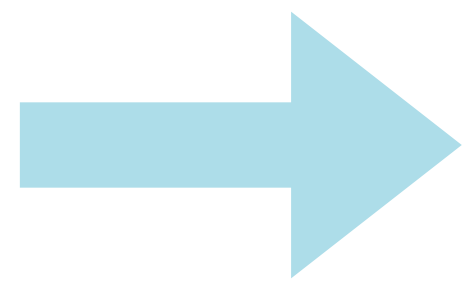
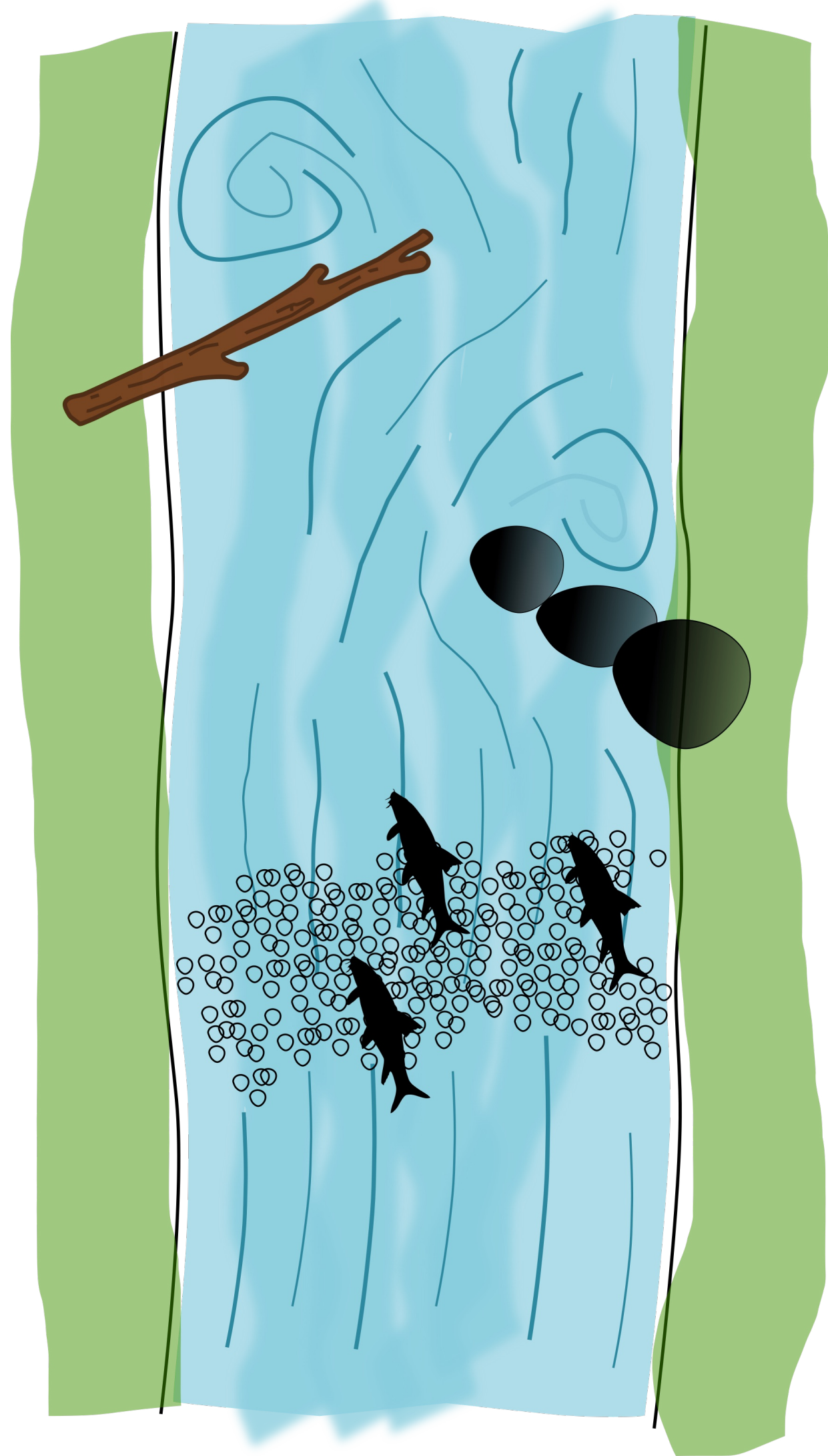
Unused habitats:

- ~ 13 % island
- ~ 67 % right banks and islands system

- bypass channel
- Side channel
- Island
- Left bank
- Right bank
- Island downstr.

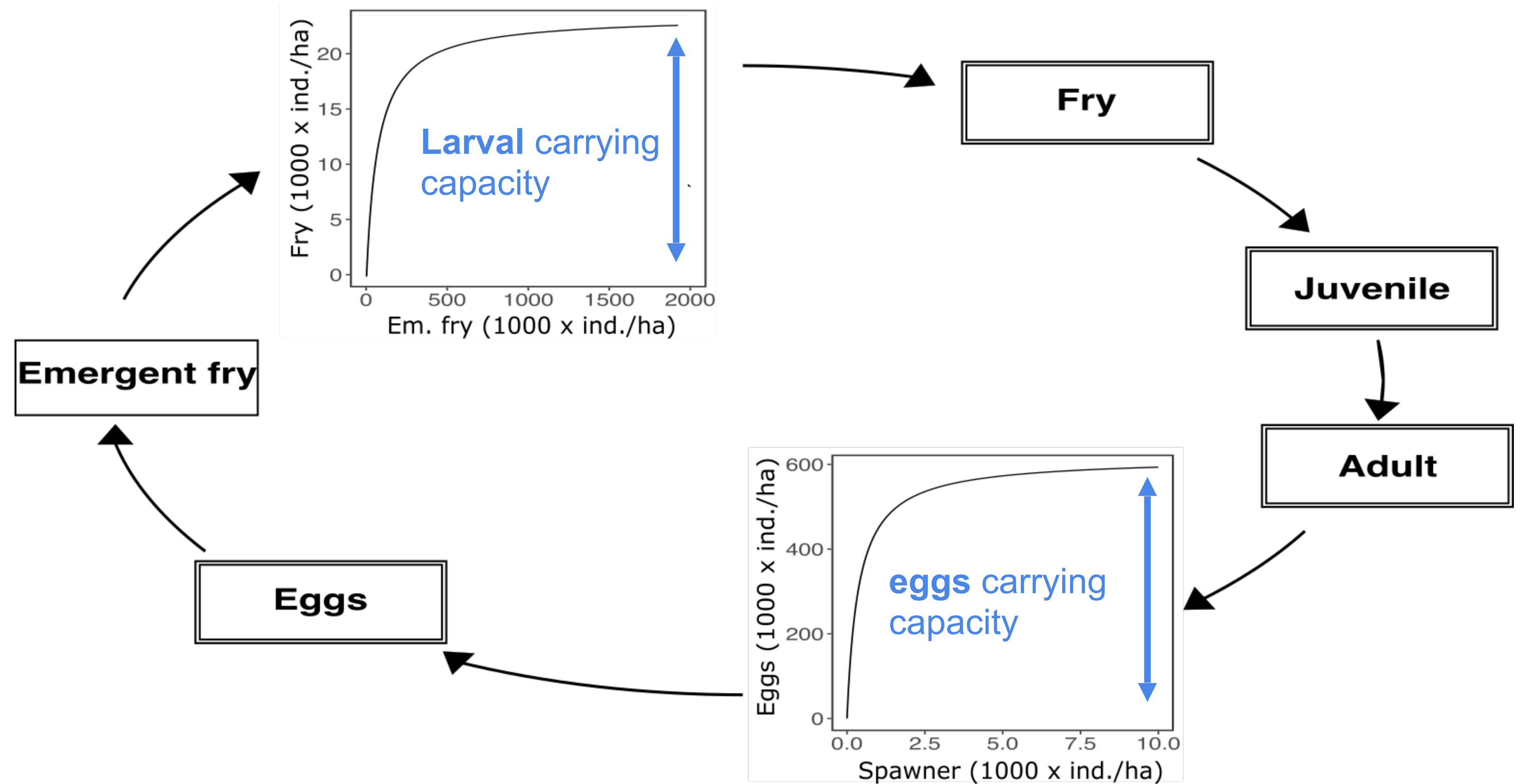
drift from bypass channel



A large light blue question mark is centered. Above it are three black fish silhouettes, and below it is one. The text "recruitment / abundance" is written in light blue below the question mark. At the bottom of the entire diagram is a single black fish silhouette.

recruitment /
abundance

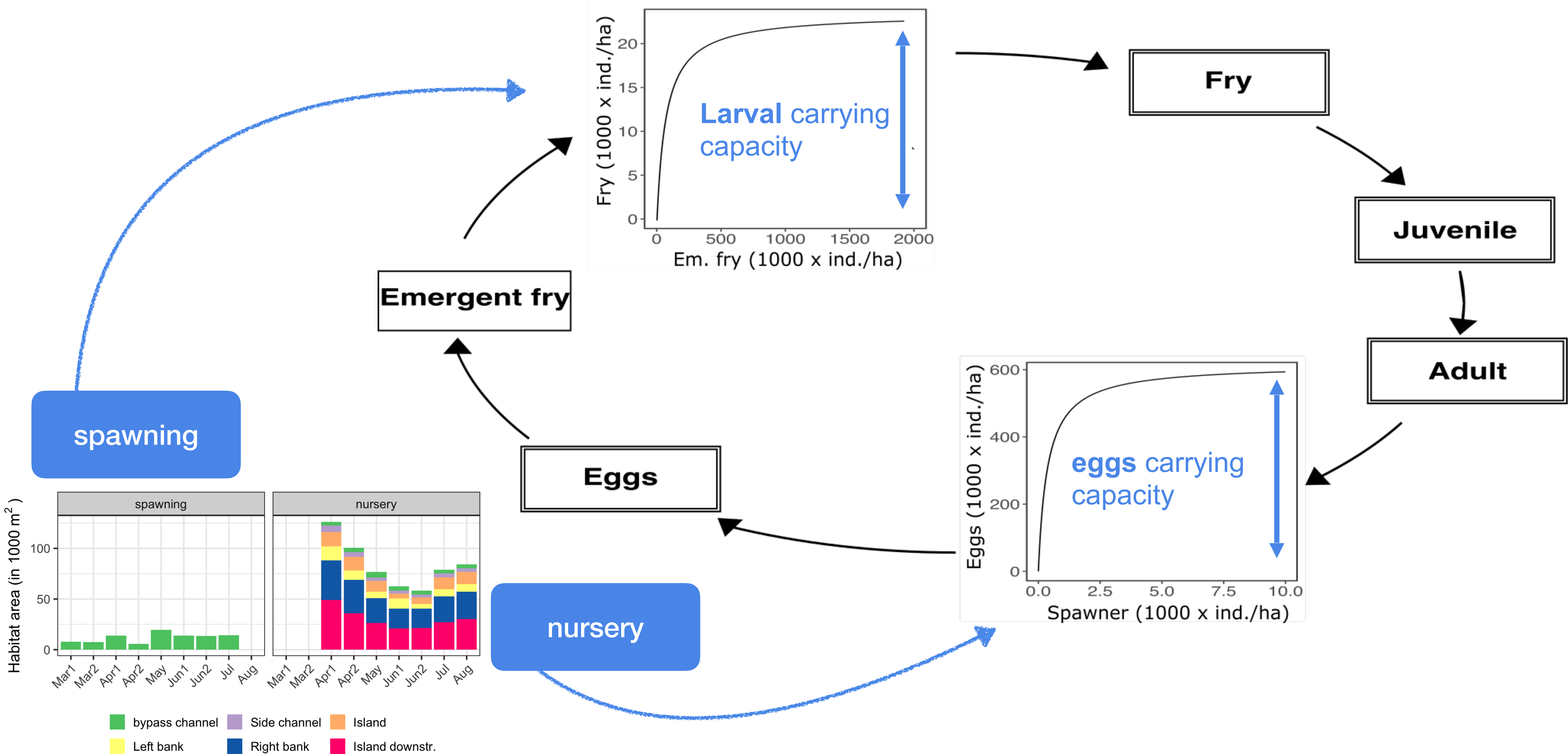
Population dynamics modelling



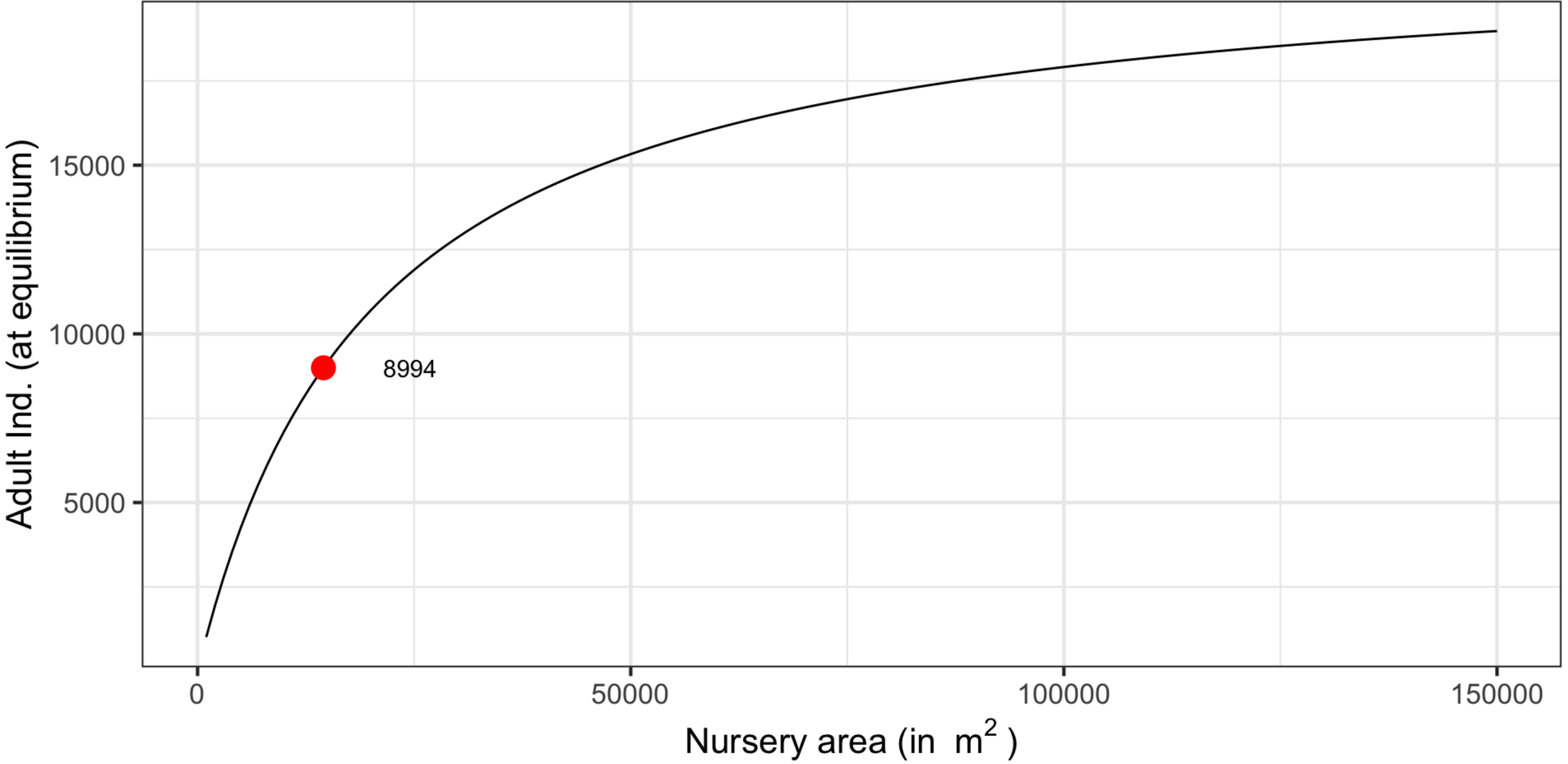
- Spatially-explicit
- Parameters from Literature + Expert knowledge
- Assuming modelled reach as closed system
- Population at equilibrium (100 years)

Farò et al. 2020

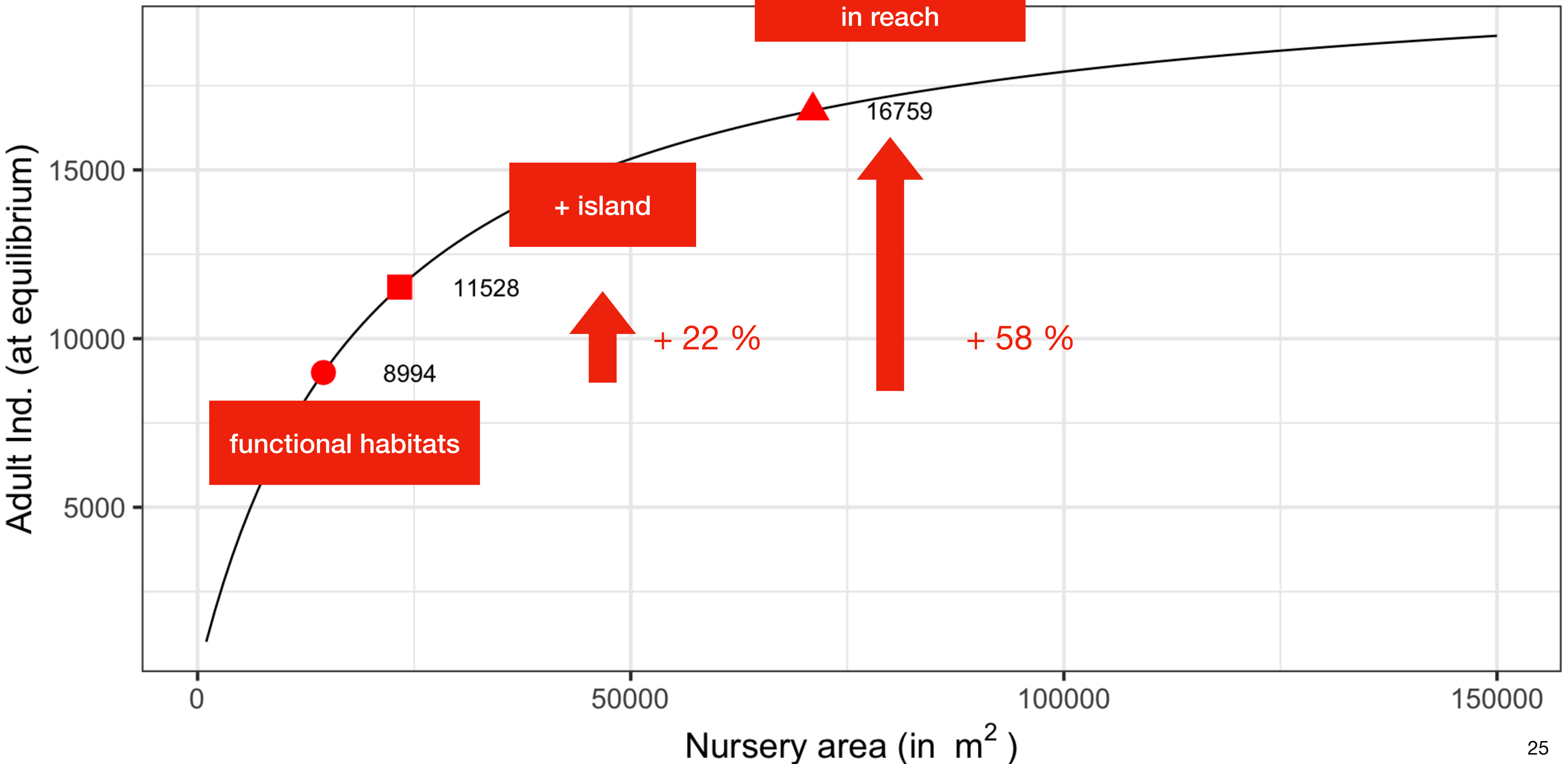
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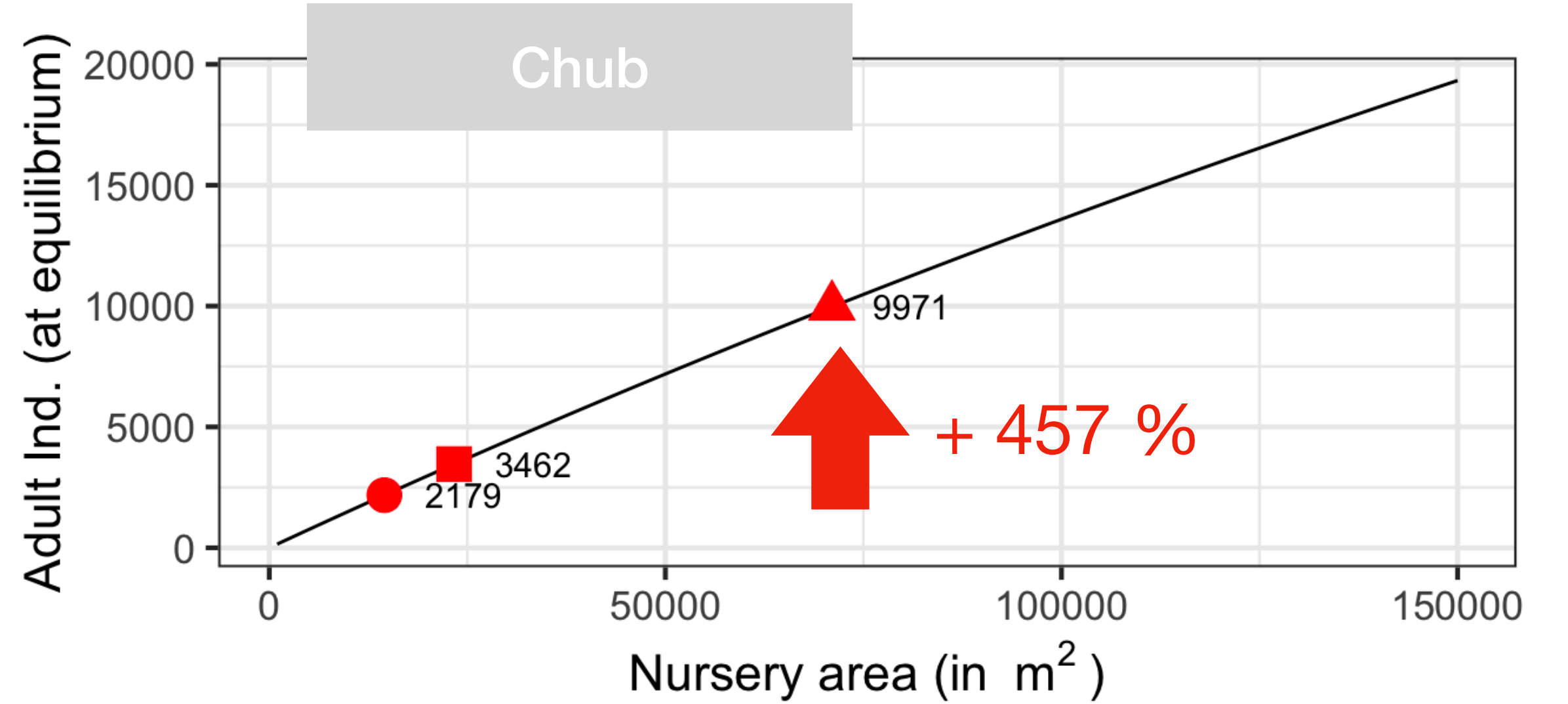
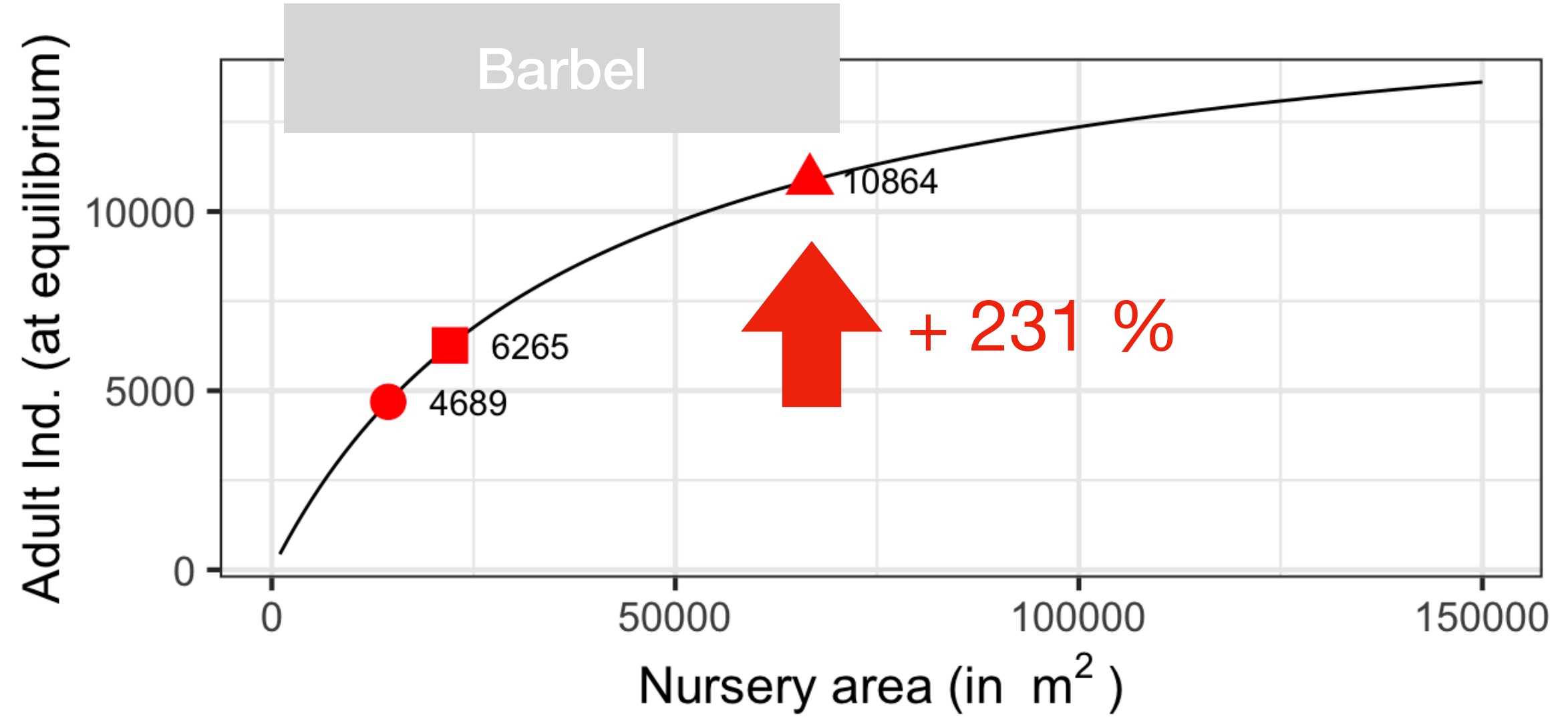
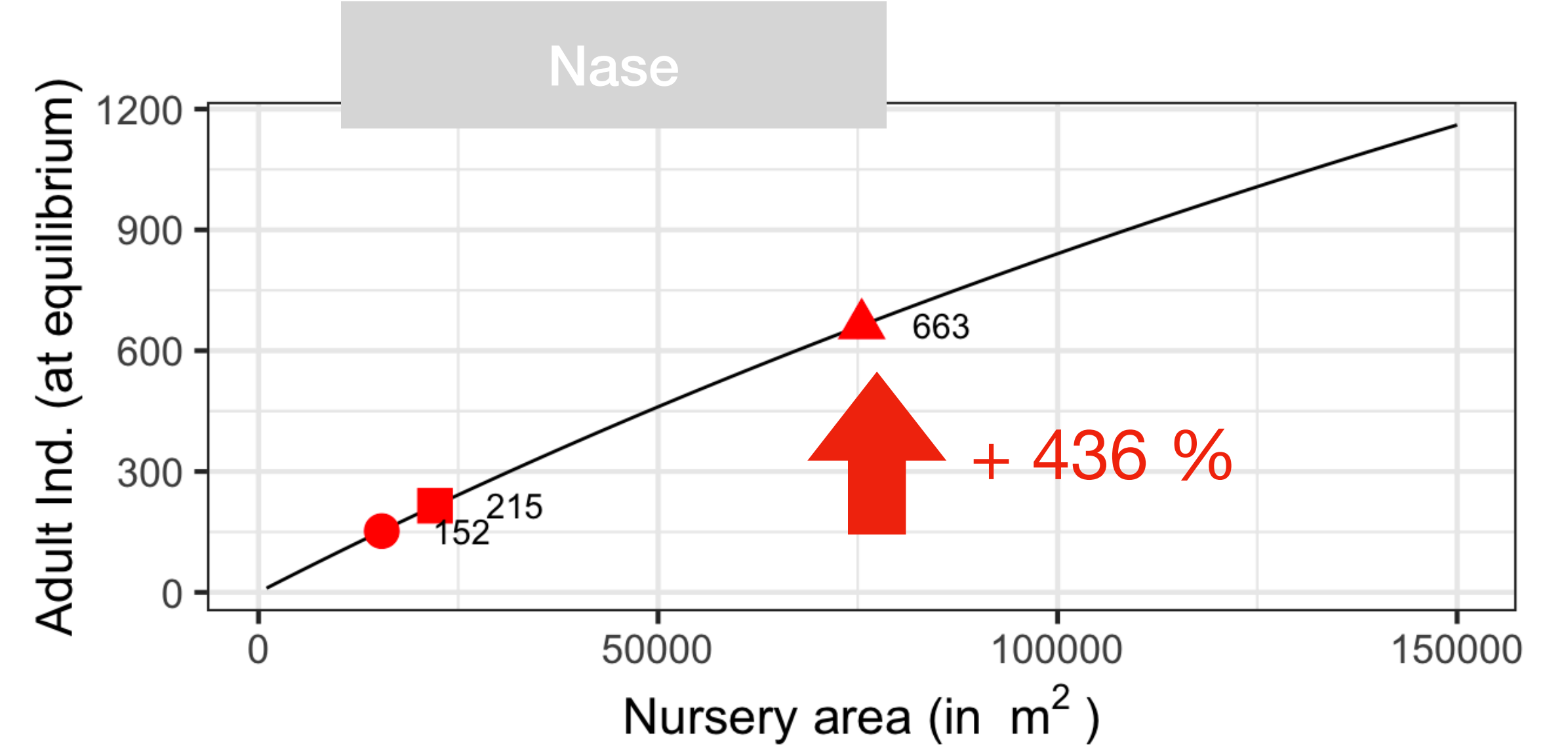
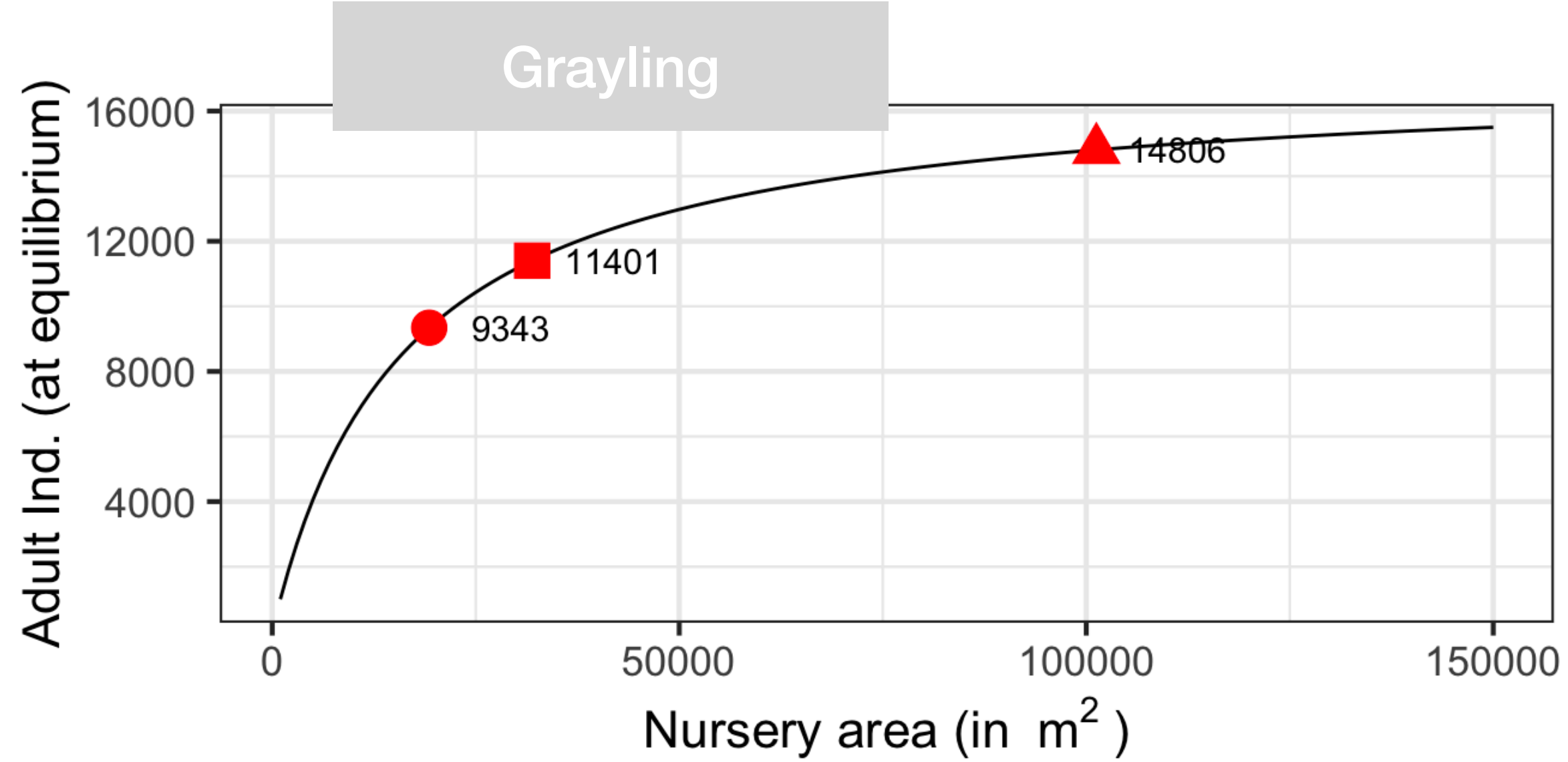
Abundance - grayling



Abundance - grayling



Abundance



● Functional habitats ▲ Potential habitats (all) ■ Potential habitats (island)

Conclusions

- Restoration measures, such as nature-like bypass and side channels, can provide high quality spawning and nursery habitats. However, **functional connectivity** should be considered to increase chances of project success!

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- Use of functional habitat modelling linked with spatially-explicit population dynamics modelling can support **planning, assessment and optimisation** of restoration projects

Conclusions

- Restoration measures, such as nature-like bypass and side channels, can provide high quality spawning and nursery habitats. However, **functional connectivity** should be considered to increase chances of project success!
- Use of functional habitat modelling linked with spatially-explicit population dynamics modelling can support **planning, assessment and optimisation** of restoration projects
- Cyprinids \neq salmonids! \rightarrow **scarcity of data!**

Thank you!



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