

Cargo vessels

River cruises

Sport boats

# The effects of recreational and commercial navigation on fish assemblages in large rivers

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*Dept. IV: Biology and Ecology of Fishes*

# Contents

0. some introductory slights

**1. Inland navigation among multiple pressures**

**2. Effects of recreational navigation**

# Centuries of river modifications...

**~1750**

Large floodplain  
with  
side-channels

regulation

channelization

straightening

shore stabilization

levees

floodplain loss

damming

water pollution

dredging

**today**

One straightened  
channel,  
surrounded by  
agricultural and  
urbanized land  
instead of a  
floodplain

... resulted in multiple pressures today

In European running waters,  
pressures related to alterations of..

Cargo vessels

hydrology,  
morphology,  
connectivity,  
water pollution

...matter most  
*Schinegger et al. 2012*

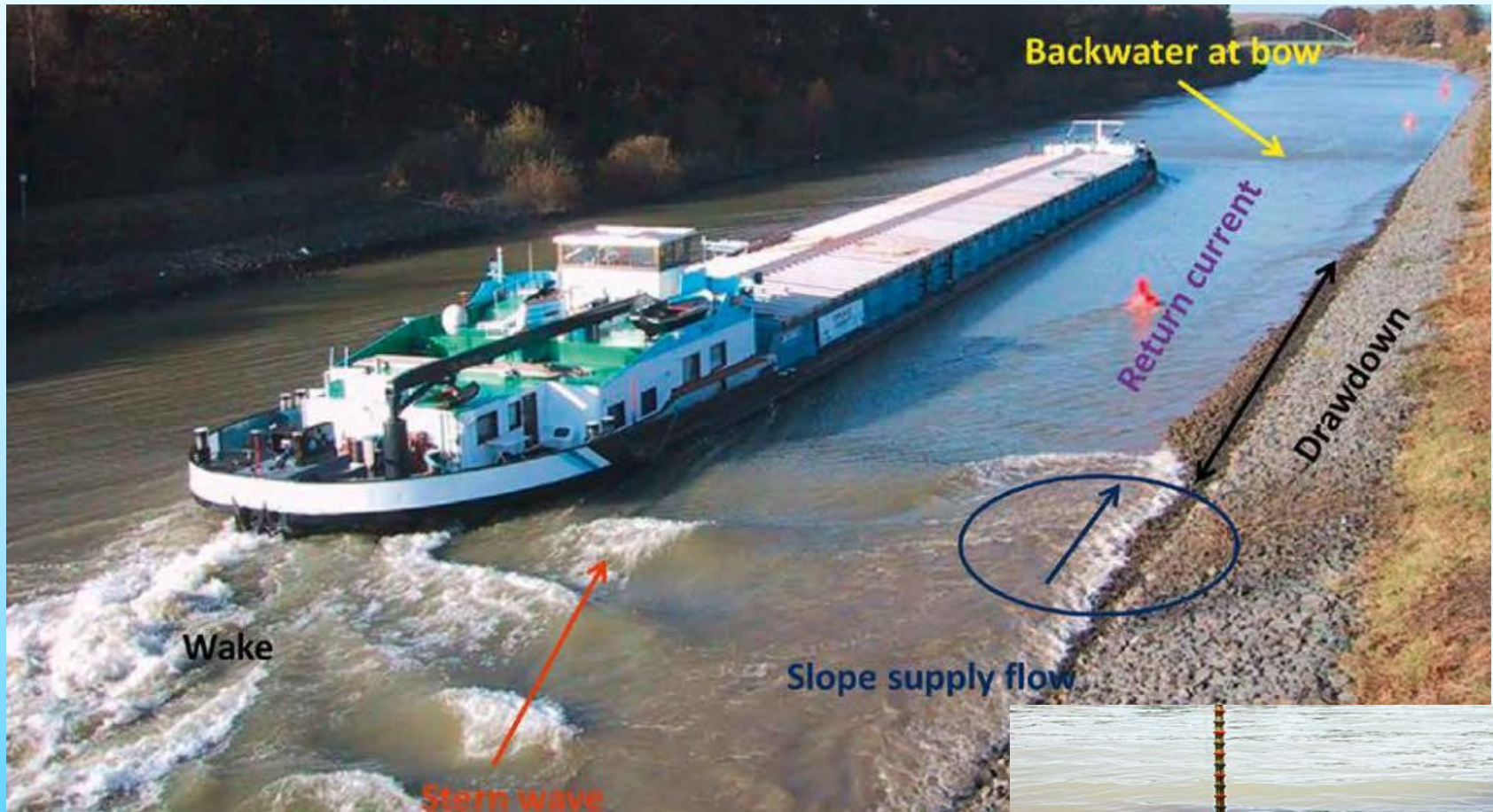
**..but large rivers were underrepresented and understudied!**

*Hering et al. 2015; Schinegger et al. 2012*

**..and inland navigation has not been considered at all!**

*e.g., Schinegger et al. 2012, 2013, 2016, 2018; Trautwein et al. 2013*

# Passing vessels cause hydraulic forces..



BAW 2016

..that discharge at shallow areas  
..and cause a habitat-bottleneck

*Huckstorf et al. 2011; Wolter & Arlinghaus 2003*

*Schiemer et al. 2001*



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# Many fishes need shallow areas to reproduce, nurse, live..



## **eurytops**

(tolerant, insensitive, "everywhere")



## **Roach,**

*Rutilus rutilus*



## **rheophils**

(**flow**, oxygenated open water)



## **Burbot,**

*Lota lota*



## **lithophils**

(**gravel**)



## **Barbel,**

*barbus barbus*



## **phytophils**

(**vegetation**)



## **Spined Loach,**

*Cobitis taenia*



## **psammophils**

(**sand**)



## **Gudgeon,**

*Gobio gobio*

Guilds

Example fish species

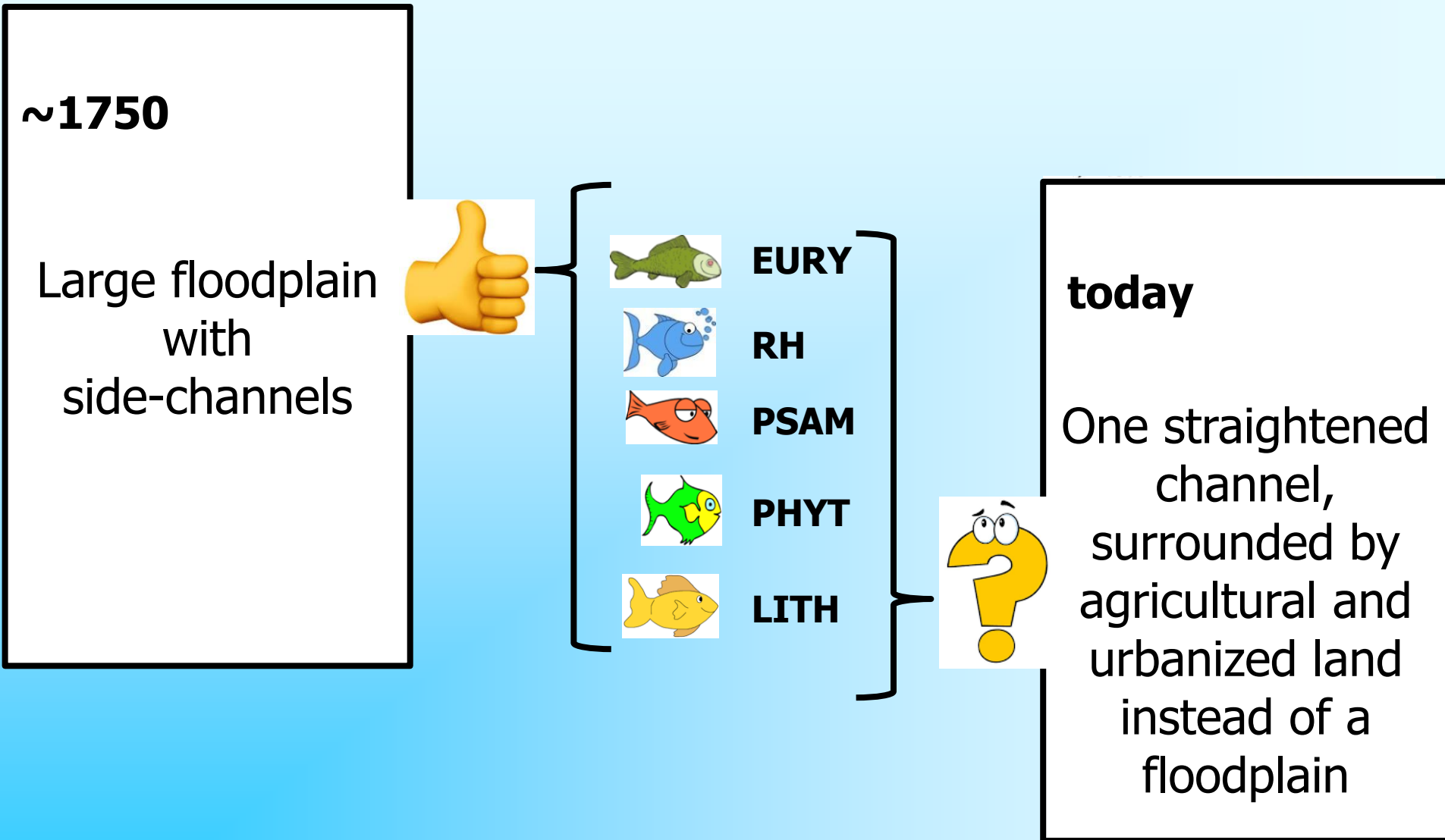


Obligatory need  
for specific  
habitats in  
shallow areas

*Balon 1975, 1981; Dußling et al., 2004; Welcomme et al., 2006; Wolter et al., 2016; Wolter and Vilcinskas, 1997*



# Consequences of multiple pressures on fish assemblages?



## Objective 1: Inland navigation among multiple pressures

- Which pressures have the greatest influence in large rivers?
- To which extent does inland navigation matter (cargo vessels) among the other pressures in large rivers?

## Objective 2: Effects of recreational navigation

- Are there distinct effects of recreational and commercial navigation?
  - recreational, motorized sport boats
  - commercial river cruises



# Large River fish Database



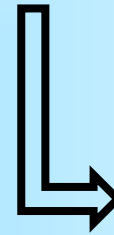
16 European large rivers

>2500 fish samplings  ➤ Densities of



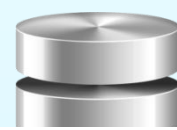
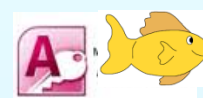
>350 sampling sites

➤ including site descriptors on human alterations



= ranked pressure variables

5: high  
3: intermediate  
1: low



Eurytopic guild	TC [%]	Rheophilic guild	TC [%]	Lithophilic guild	TC [%]	Phytophilic guild	TC [%]	Psammophilic guild	TC [%]
Abramis brama	3.6	Abramis brama	0.06	Aspius aspius	0.83	Blicca bjoerkna	3.38	Barbatula barbatula	0.11
Alburnus alburnus	11.12	Aspius aspius	0.83	Barbus barbus	0.93	Carassius carassius	0.01	Romanogobio belingi	0.81
Ameiurus nebulosus	0.03	Barbatula barbatula	0.11	Chondrostoma nasus	0.3	Carassius gibelio	0.03	Gobio gobio	4.67
Anguilla anguilla	4.59	Barbus barbus	0.93	Hypophthalmichthys nobilis	< 0.01	Cobitis taenia	0.8	<b>TOTAL:</b>	<b>5.59</b>
Blicca bjoerkna	3.38	Chondrostoma nasus	0.3	Lampetra fluviatilis	< 0.01	Cyprinus carpio	0.04		
Carassius gibelio	0.03	Cobitis taenia	0.8	Leuciscus cephalus	5.19	Esox lucius	0.98		
Cyprinus carpio	0.04	Cottus gobio	0.06	Leuciscus leuciscus	2.24	Leucaspis delineatus	0.03		
Dicentrarchus labrax	< 0.01	Ctenopharyngodon idella	< 0.01	Oncorhynchus mykiss	0.01	Misgurnus fossilis	0.01		
Esox lucius	0.98	Gobio gobio	4.67	Petromyzon marinus	< 0.01	Sabanejewia aurata	< 0.01		
Gasterosteus aculeatus	0.09	Hypophthalmichthys nobilis	< 0.01	Phoxinus phoxinus	< 0.01	Scardinius erythrophthalmus	0.33		
Gymnocephalus cernuus	1.54	Lampetra fluviatilis	< 0.01	Salmo salar	0.02	Silurus glanis	0.05		
Osmerus eperlanus	< 0.01	Leuciscus cephalus	5.19	Salmo trutta fario	0.02	Tinca tinca	0.03		
Perca fluviatilis	15.76	Leuciscus idus	8.05	Salmo trutta trutta	< 0.01	Umbra pygmaea	< 0.01		
Proterorhinus marmoratus	0.01	Leuciscus leuciscus	2.24	Salvelinus fontinalis	< 0.01	<b>TOTAL:</b>	<b>5.69</b>		
Pseudorasbora parva	< 0.01	Lota lota	4.73	Thymallus thymallus	0.01				
Pungitius pungitius	< 0.01	Oncorhynchus mykiss	0.01	Vimba vimba	< 0.01				
Rutilus rutilus	28.72	Petromyzon marinus	< 0.01	<b>TOTAL:</b>	<b>9.55</b>				
Sander lucioperca	0.38	Phoxinus phoxinus	< 0.01						
Silurus glanis	0.05	Platichthys flesus	0.4						
<b>TOTAL:</b>	<b>70.32</b>	Romanogobio belingi	0.81						
		Sabanejewia aurata	< 0.01						
		Salmo salar	0.02						
		Salmo trutta fario	0.02						
		Salmo trutta trutta	< 0.01						
		Salvelinus fontinalis	< 0.01						
		Thymallus thymallus	0.01						
		Vimba vimba	< 0.01						
		<b>TOTAL:</b>	<b>29.24</b>						

→ Most migratory fish are rheophilic / lithophilic



Catadromous



Anadromous



Amphidromous



Potamodromous

# Large River fish Database



16 European large rivers

>2500 fish samplings → ➤ Densities of



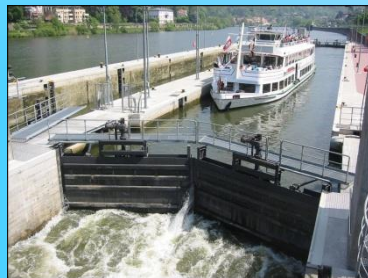
>350 sampling sites

➤ including site descriptors on human alterations

➤ navigation intensities

↳ = ranked pressure variables

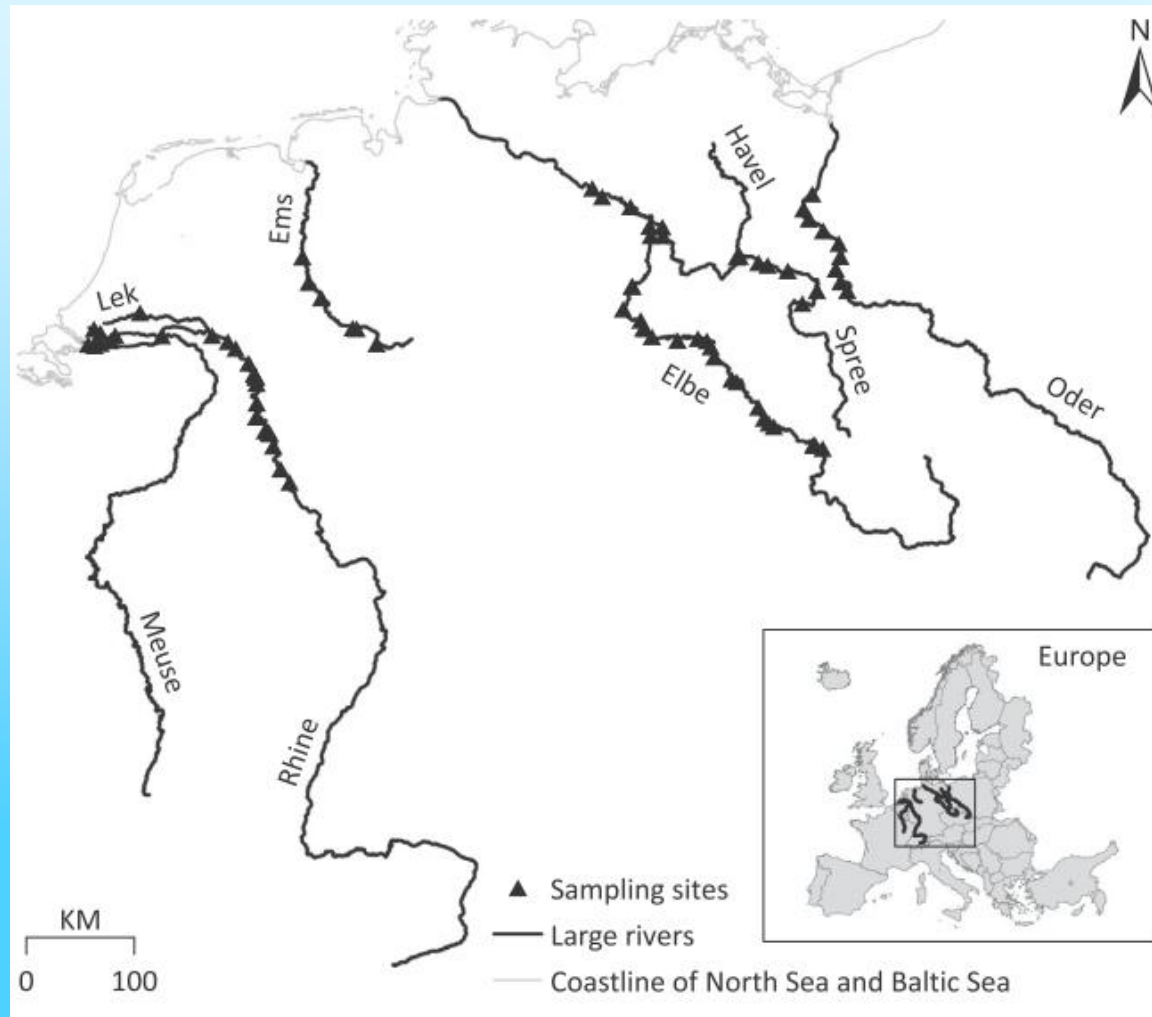
5: high  
3: intermediate  
1: low



# Objective 1: Inland navigation amongst multiple pressures

250 fish samplings  
76 sites  
8 large rivers

all described by 11 pressure variables  
including inland navigation



# Objective 1: Inland navigation among multiple pressures

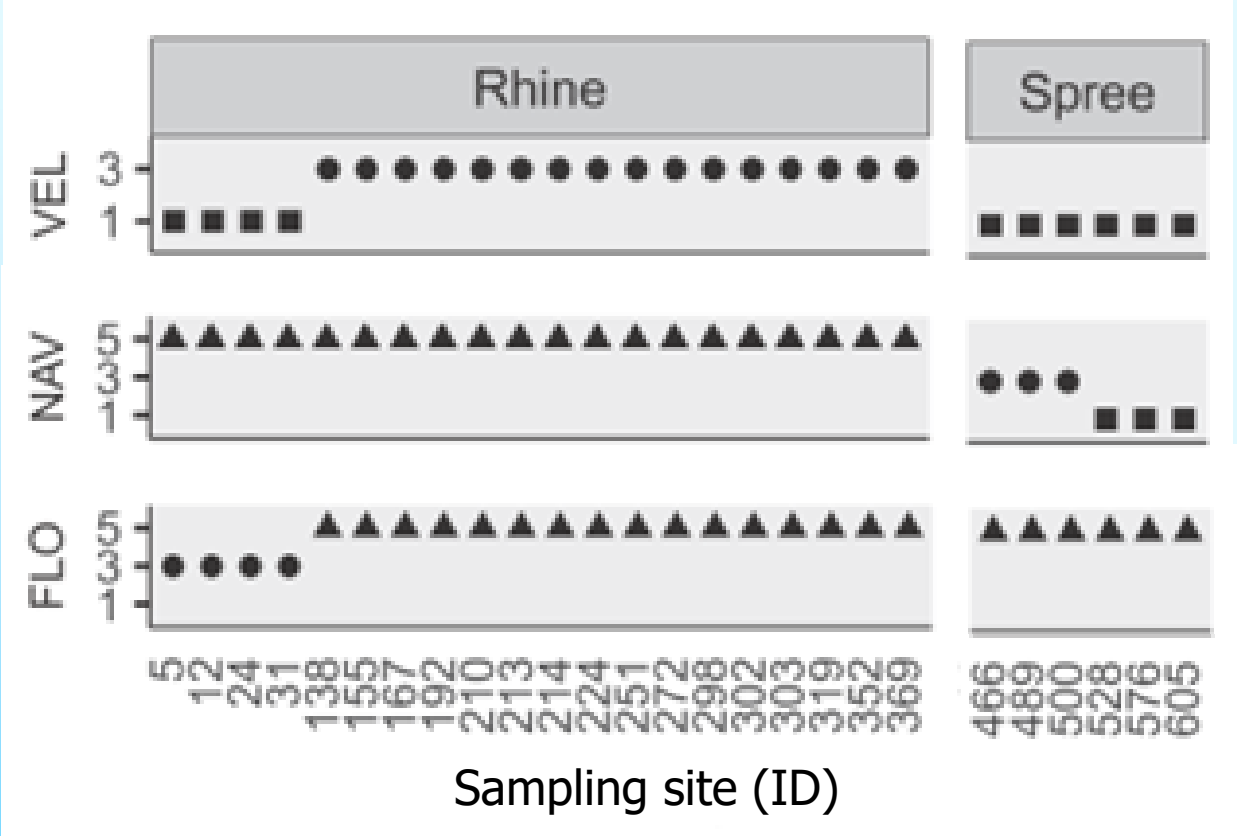
increased flow **VE**LOCITY

**NA**Vigation intensity

loss of **FLO**odplains

.....  
**11 pressure variables**  
**analyzed in total**

**boosted regression tree models**



5: high (▲), 33,001 – 133,000  
3: inter-mediate (●), 3001 – 33,000  
1: low (■) 0 – 3000

Cargo vessels per year

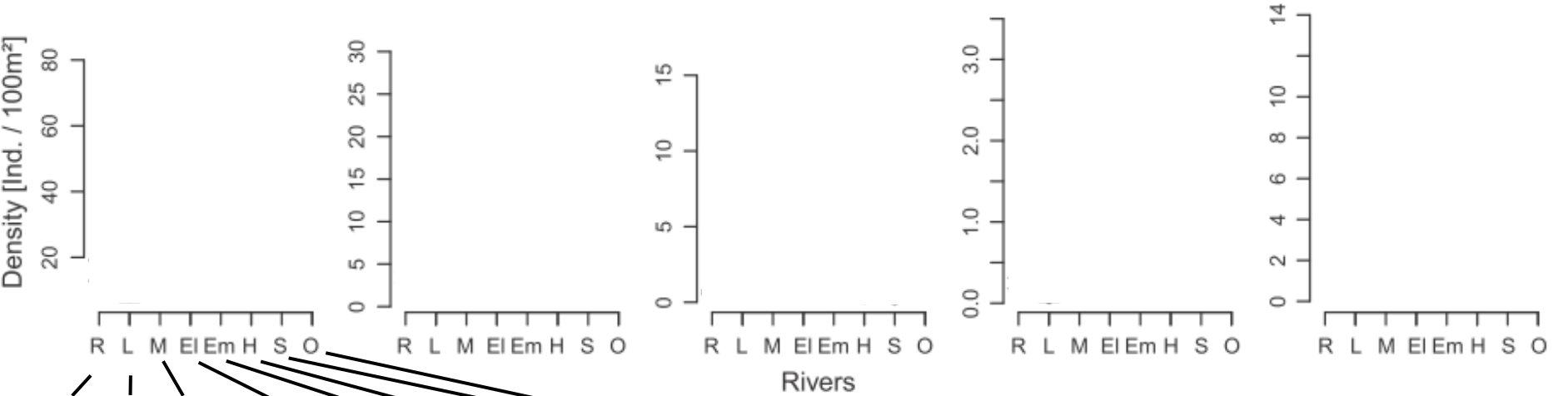
# Results 1: Inland navigation among multiple pressures

250 samplings  
76 sites  
8 large rivers  
  
~150,000 fishes  
55 species

## Fish densities per guilds and rivers..



Eurytops                      Rheophils                      Lithophils                      Phytophils                      Psammophils



Rhine   Lek   Meuse   Elbe   Ems   Havel   Spree   Oder

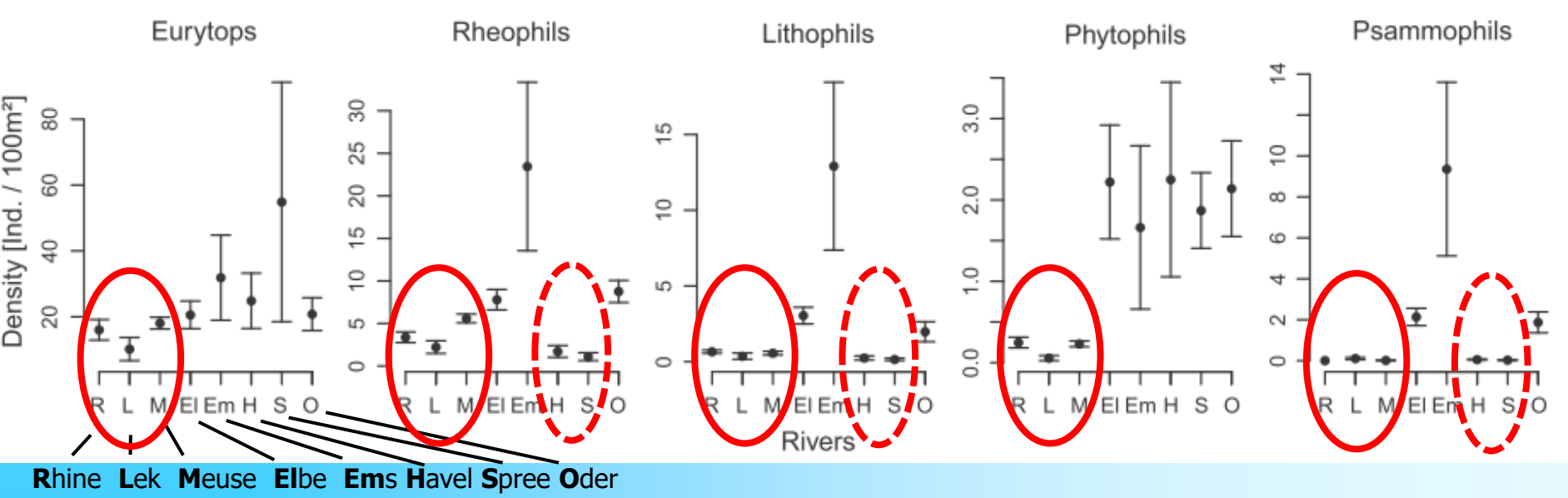


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# Results 1: Inland navigation among multiple pressures

250 samplings  
76 sites  
8 large rivers  
  
~150,000 fishes  
55 species

## Fish densities per guilds and rivers..



Rhine Lek Meuse Elbe Ems Havel Spree Oder



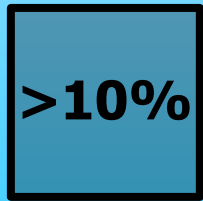
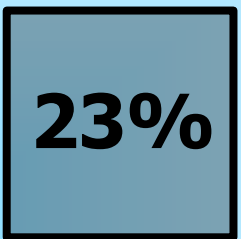
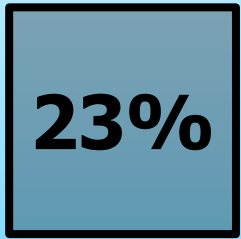
Relative influence of pressures on..



increased velocity

inland navigation

loss of floodplains



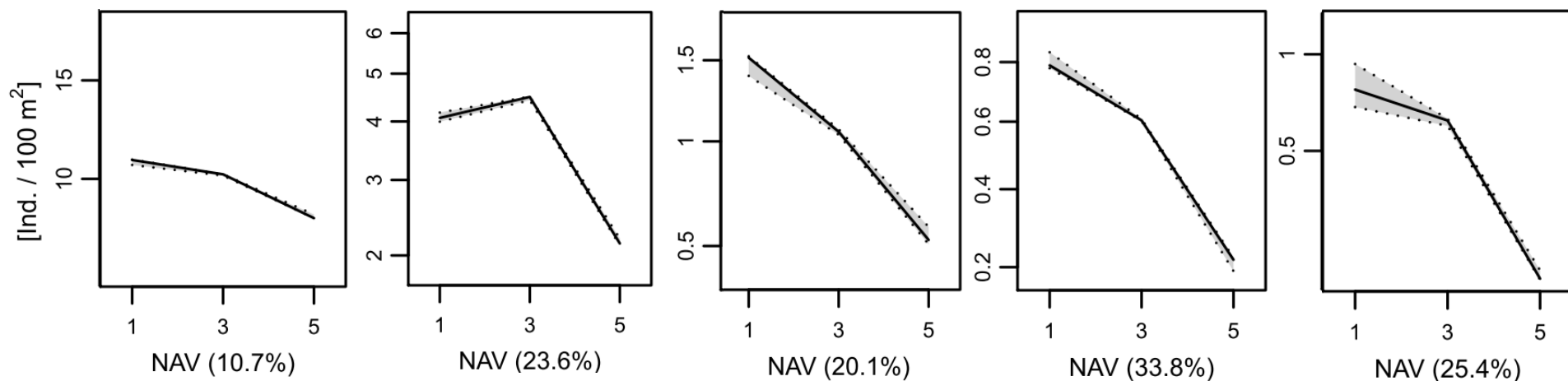
increase of sedimentation  
artificial embankment

channelization  
barriers up -and  
downstreams

organic siltation



## Effects of inland navigation on..



- decline of most guild densities at intermediate ship traffic  
= starting with 8 cargo vessels per day
- most severe declines for habitat-sensitive spawners

Cargo vessels

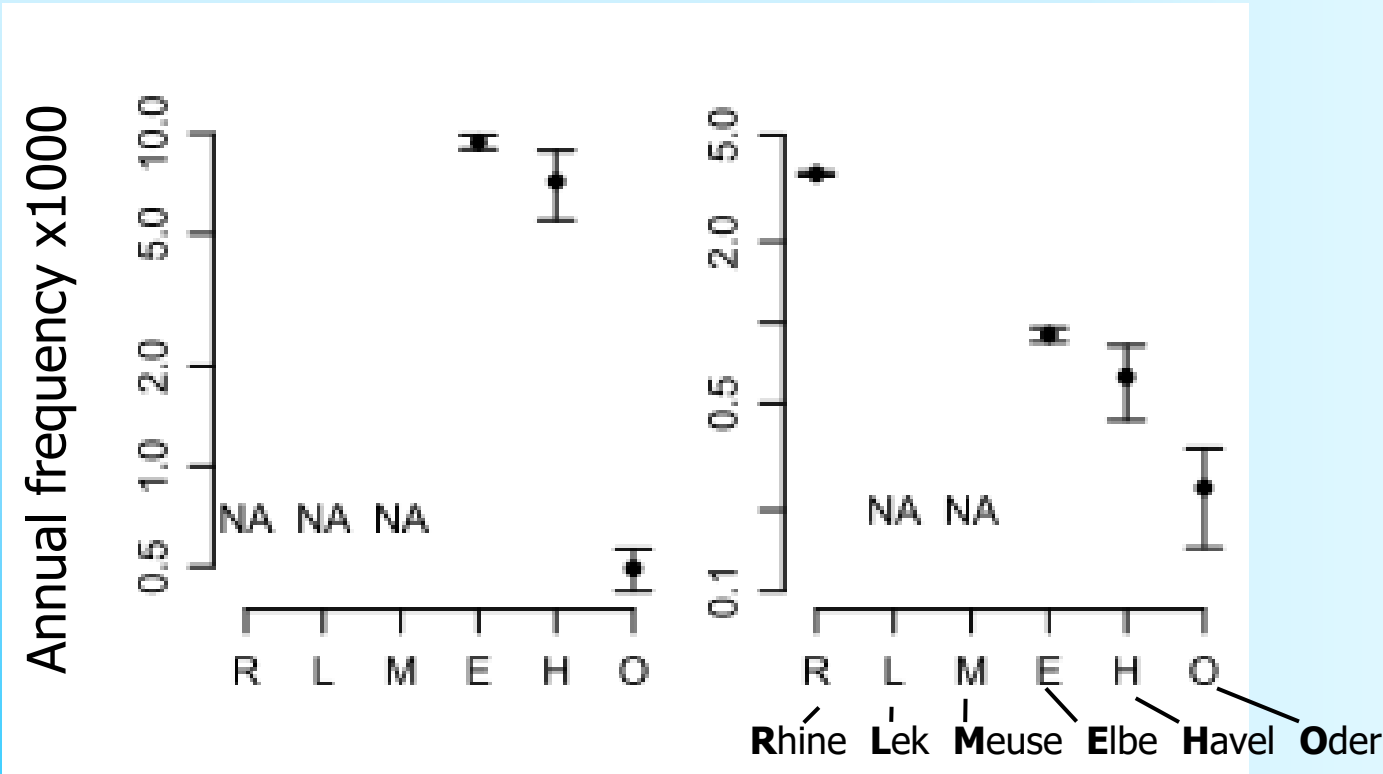
### **Inland navigation..**

- **.. is a specific pressure in large rivers**
- **.. is as relevant as hydromorphological degradation**
- **.. offers additional potential for the rehabilitation of large rivers**
- **Are other forms of inland navigation such as sport boats likewise detrimental for fish?**
  - **Is ecological success of the Blue Band initiative endangered?**

# Objective 2: Effects of recreational navigation

Sport boats

River cruises



NA = No data available

# Objective 2: Effects of recreational navigation

369 fish samplings  
88 sampling sites  
6 large rivers

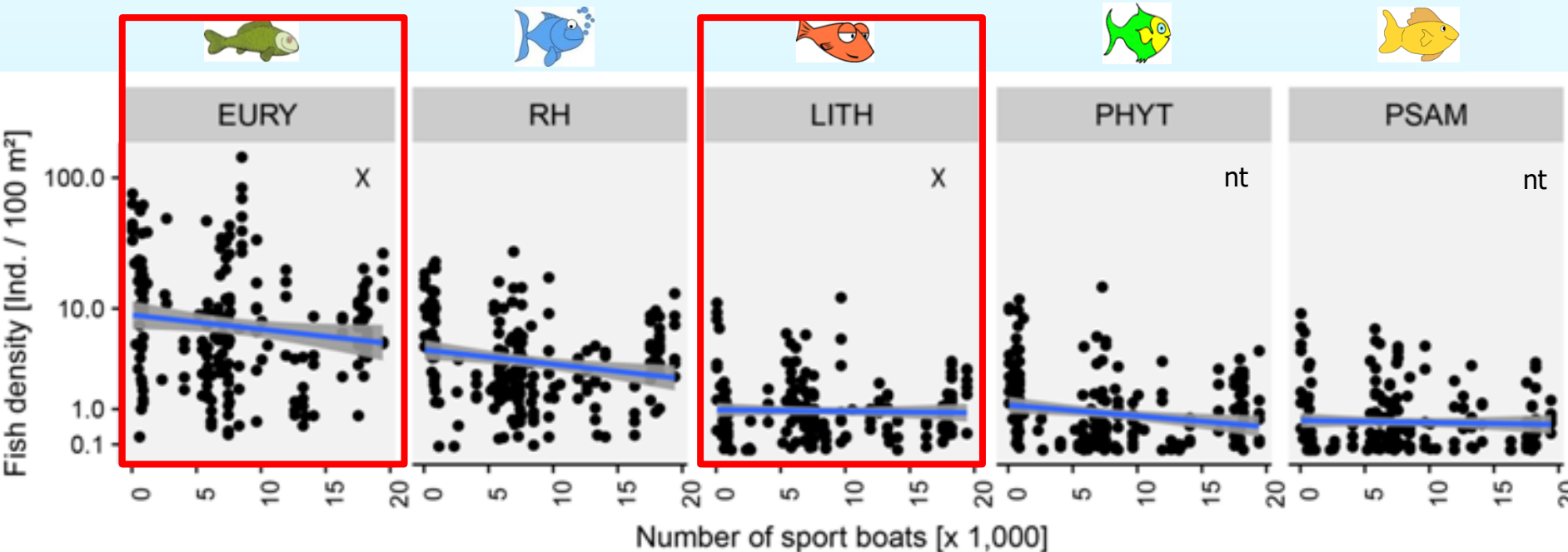
~ 230,000 fishes  
56 species

	eurytopic fish	100%
	rheophilic fish	99.7%
	lithophilic fish	94%
	phythophilic fish	84%
	psammophilic fish	62%

**mixed effects models**

↓  
frequency of captures  
in samples

# Results 2: Effects of recreational navigation

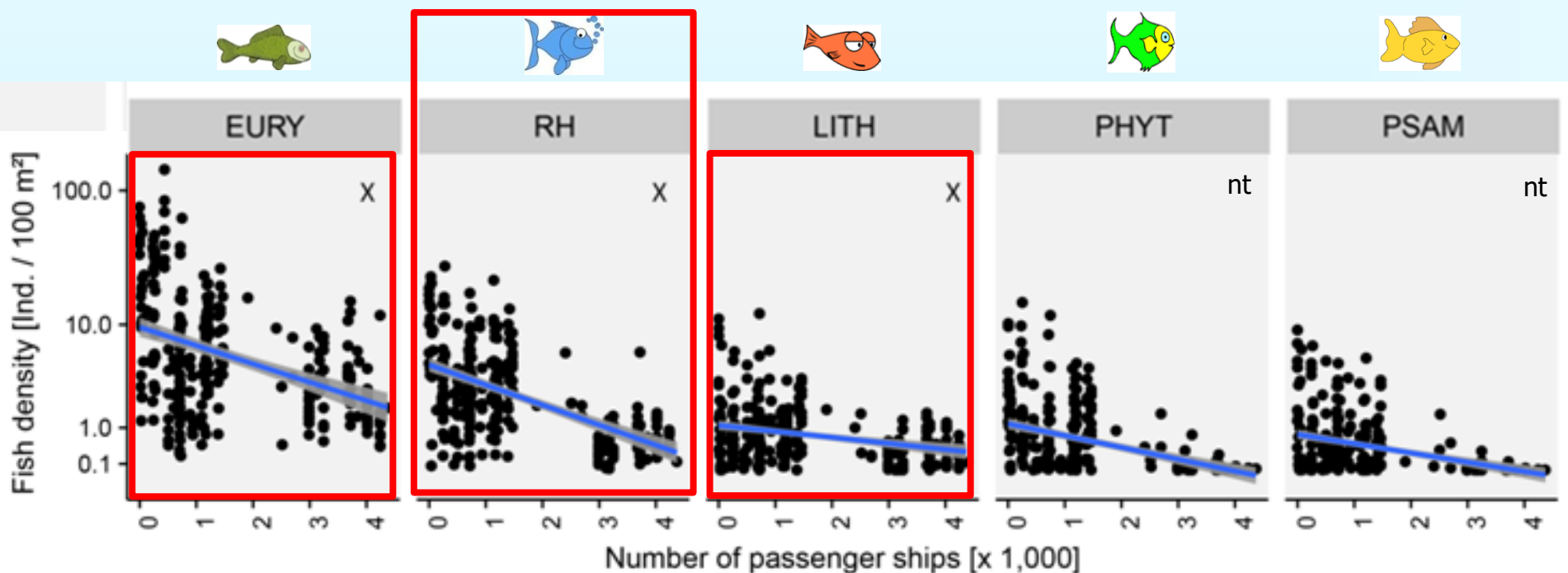


X = significant negative effect of navigation

nt = not tested

Sport boats

# Results 2: Effects of recreational navigation

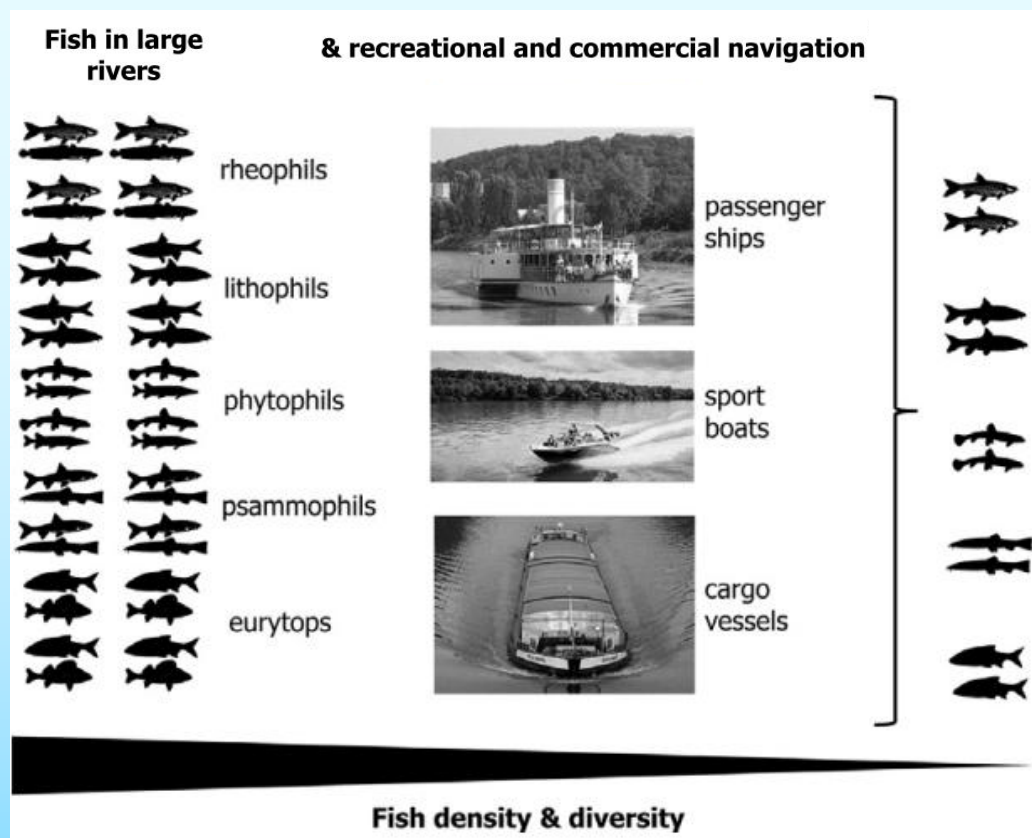


X = significant negative effect of navigation

nt = not tested

River cruises





- **Recreational navigation is as detrimental as cargo navigation**
- **Motorized sport boats & river cruises can outcompete rehabilitation of minor waterways (Blue Band initiative in Germany)**
- **Any form of motorized ship traffic requires attention in river management & additional mitigation measures in river rehabilitation**
- **Habitat-sensitive fish, including migrators, suffer most**

Zajicek, P., Radinger, J., Wolter, C., 2018:

**Disentangling multiple pressures on fish assemblages in large rivers.**  
*Science of The Total Environment* 627, 1093–1105.

Zajicek, P., Wolter, C., 2019:

**The effects of recreational and commercial navigation on fish assemblages in large rivers.**  
*Science of The Total Environment* 646, 1304–1314.

Zajicek, P., Wolter, C., 2018:

**The gain of additional sampling methods for the fish-based assessment of large rivers.**  
*Fisheries Research* 197, 15–24.