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Microplastic pollution of freshwater fishes - uptake, residence time and level of burden

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Overview

Introduction	1	Introduction to the topic
Microplastic uptake	2	Uptake mechanisms of microplastics in fish and factors affecting them.
Residence time	3	Residence time of microplastics in fish and factors affecting it.
Level of burden	4	Level of microplastic contamination of fish in the environment.
Conclusion	5	Summary of the key points

1 Introduction: Microplastics in fishes

Contents lists available at SciVerse ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Occurrence of microplastics in the gastrointestinal tract of pelagic and demersal fish from the English Channel

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Environmental Science & Technology

Article

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Plastic in North Sea Fish

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Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

No increase in marine microplastic concentration over the last three decades – A case study from the Baltic Sea

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ORIGINAL ARTICLE

FISH and FISHERIES WILEY

Microplastics in freshwater fishes: Occurrence, impacts and future perspectives

Ben Parker | Demetra Andreou | Iain D. Green | J. Robert Britton

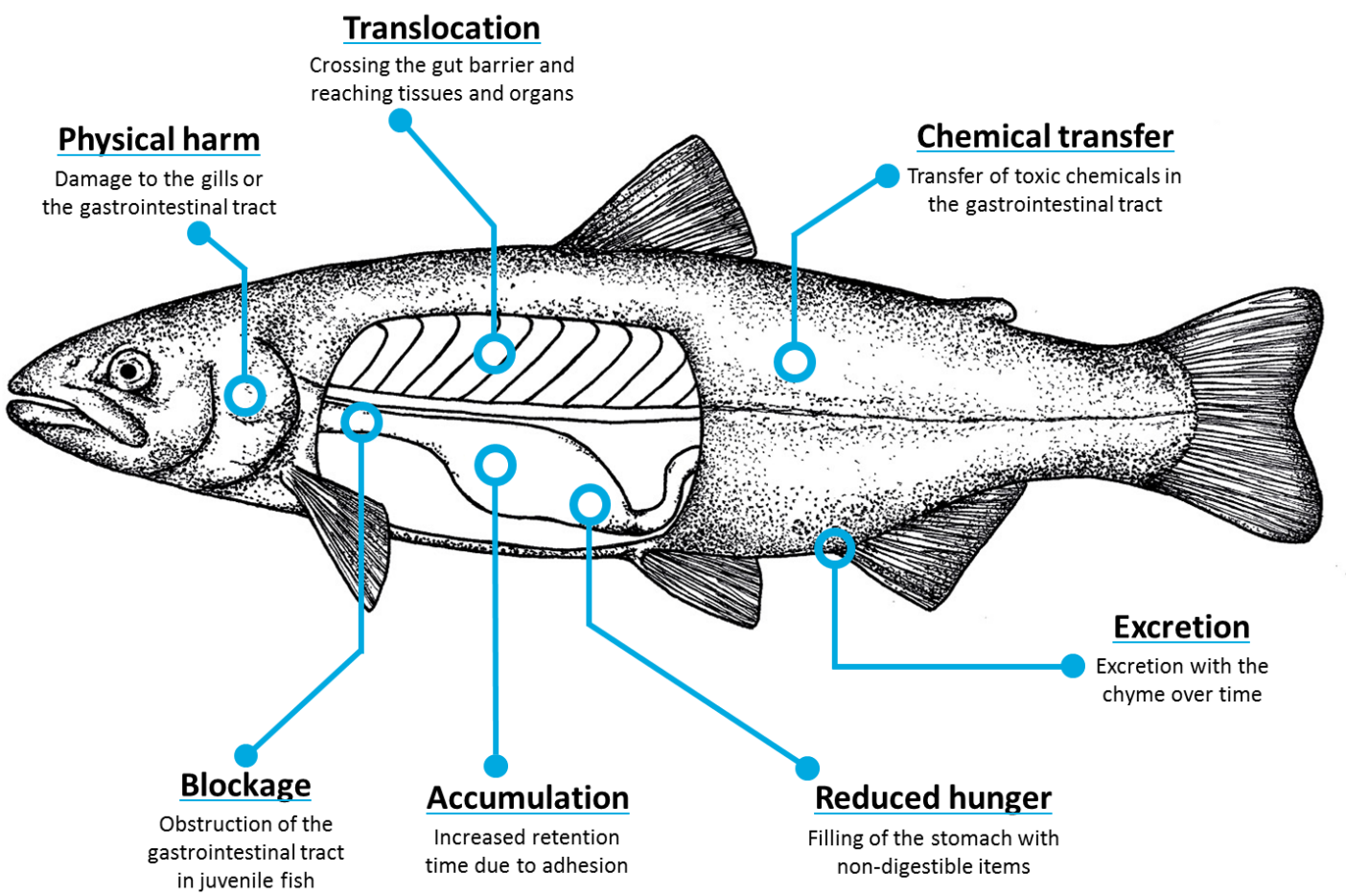
SCIENTIFIC REPORTS

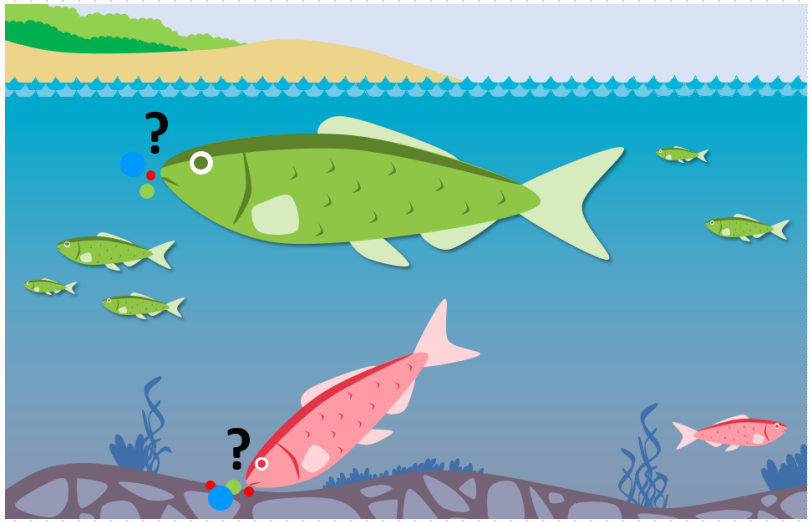
OPEN

Microplastic in riverine fish is connected to species traits

R. E. McNeish[1], L. H. Kim[1], H. A. Barrett[2], S. A. Mason[2], J. J. Kelly[1] & T. J. Hoellein[1]

Potential effects on fish

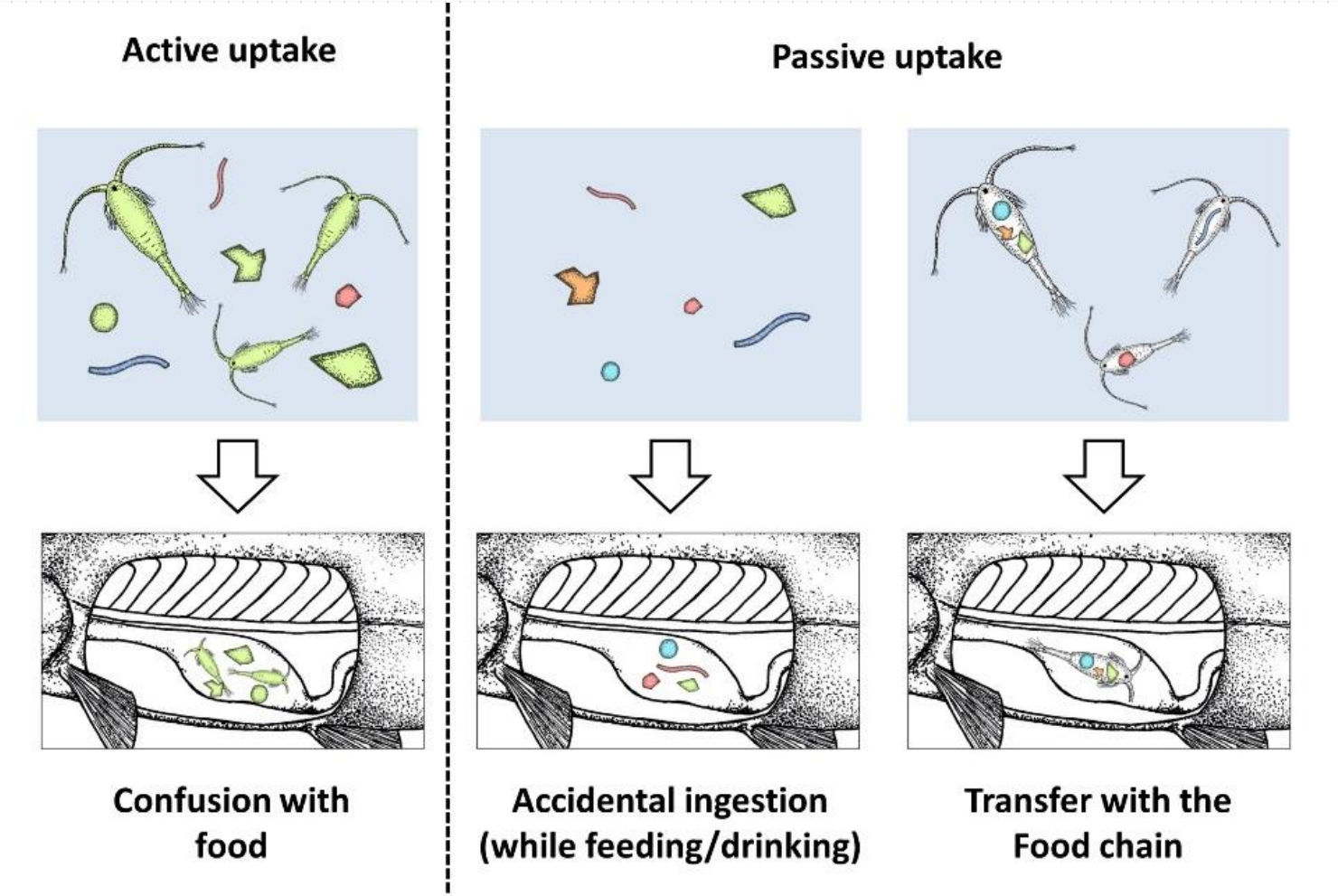




2 Microplastic uptake

Roch, S., Friedrich, C., & Brinker, A. (2020). Uptake routes of microplastics in fishes: practical and theoretical approaches to test existing theories. *Scientific Reports*, *10*.

Uptake pathways



Microplastic uptake

Roch, S., Friedrich, C., & Brinker, A. (2020). Uptake routes of microplastics in fishes: practical and theoretical approaches to test existing theories. *Scientific Reports*, *10*.

Laboratory exposure experiment I

Common carp

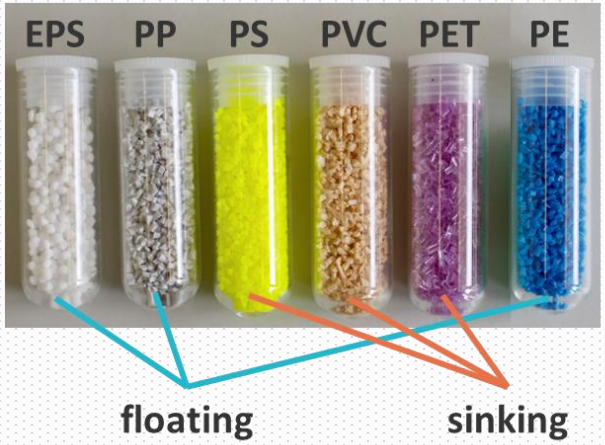
Crucian carp

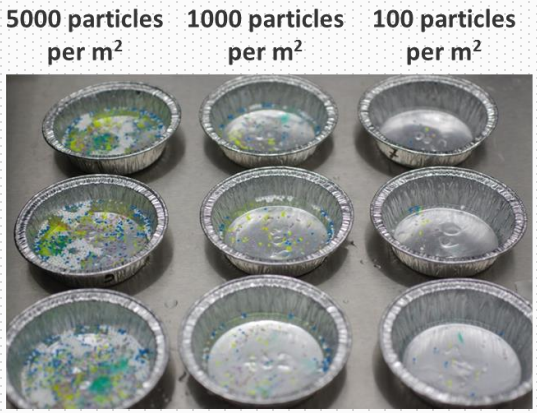
Rainbow trout

Grayling

chemosensory foraging

visual foraging



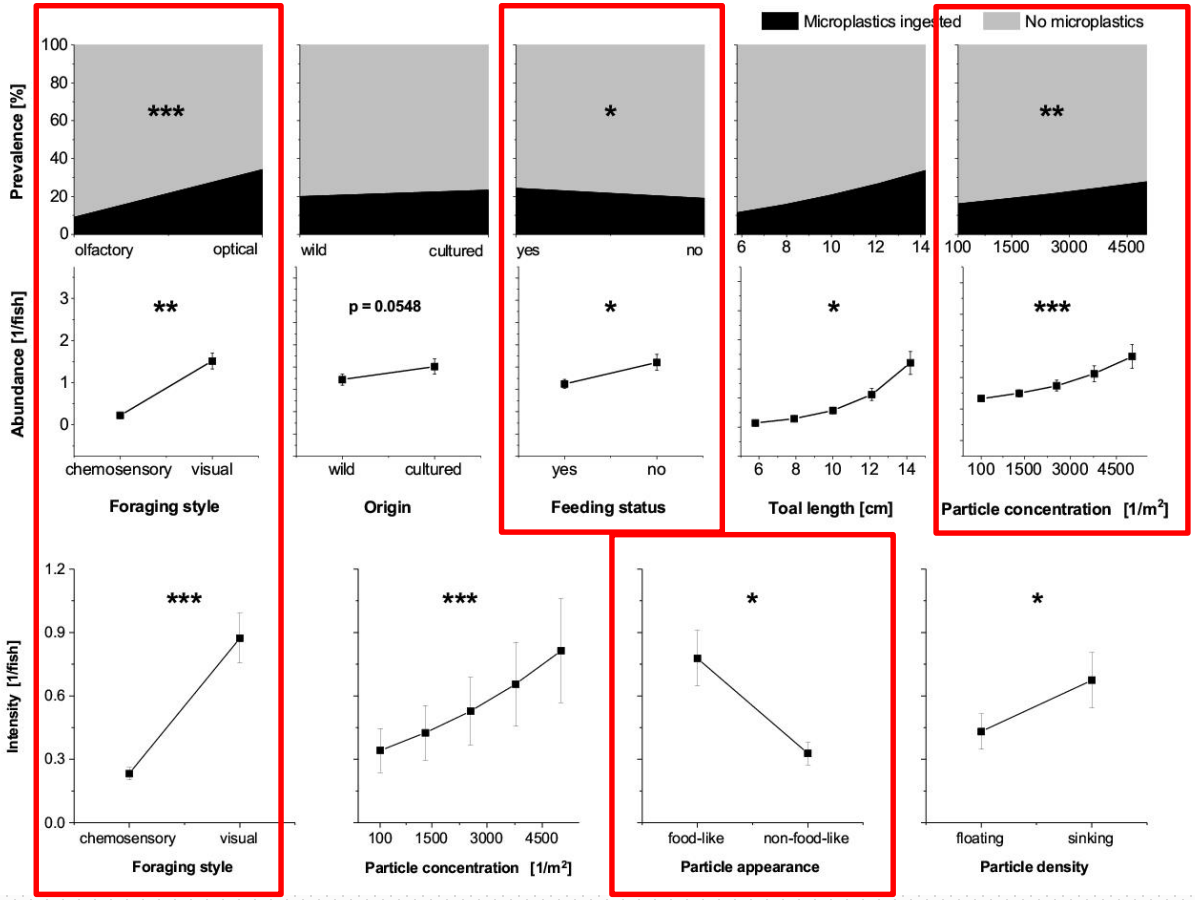


- Experiments with and without simultaneous feeding
- Determination of particle concentration after 0 h, 6 h and 24 h

Microplastic uptake

Roch, S., Friedrich, C., & Brinker, A. (2020). Uptake routes of microplastics in fishes: practical and theoretical approaches to test existing theories. *Scientific Reports*, *10*.

Which factors influence an uptake?

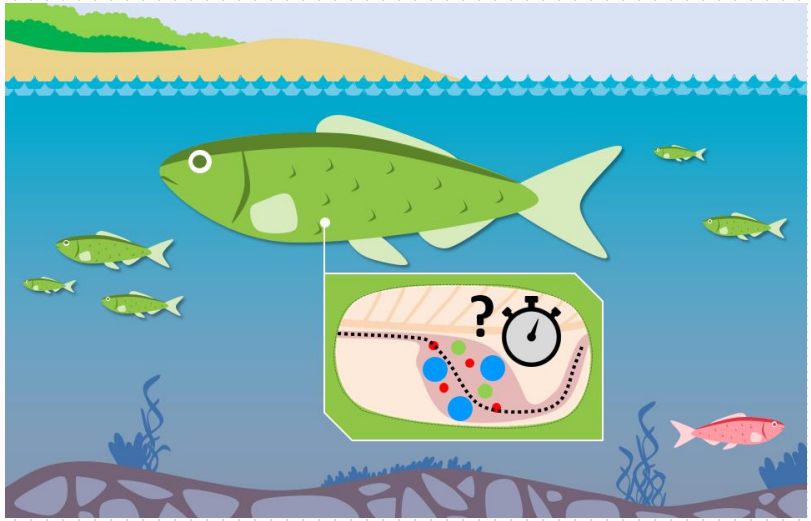


→ Visually oriented fish ingest microplastics more frequently

→ Accidental ingestion during foraging

→ Active ingestion of microplastics when food is not present

→ food-like particles were ingested more frequently



3 Residence time

Roch, S., Ros, A. F. H., Friedrich, C., & Brinker, A. (2021). Microplastic evacuation in fish is particle size-dependent. *Freshwater Biology*, *66*, 926–935.

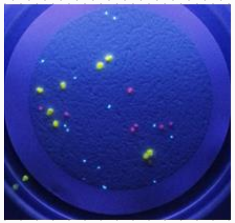
Laboratory exposure experiment II

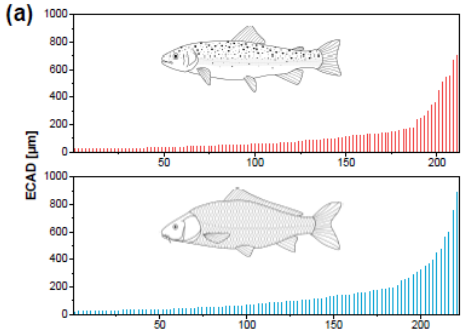
Common carp

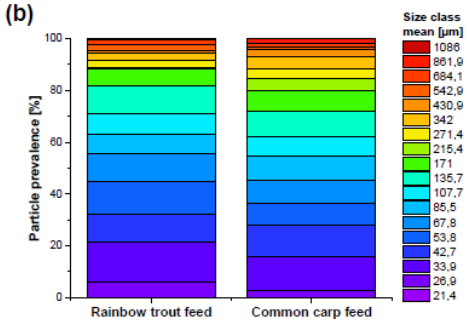
no stomach

Rainbow trout

true stomach







- Exposure to three particle concentrations
  - low (356/373 particles per g feed)
  - medium (891/933 particles per g feed)
  - high (1782/1886 particles per g feed)
- Sampling times
  - carp: 8, 24, 48, 64 h after exposure
  - trout: 8, 24, 48, 56, 72 h after exposure

Roch, S., Ros, A. F. H., Friedrich, C., & Brinker, A. (2021). Microplastic evacuation in fish is particle size-dependent. *Freshwater Biology*, *66*, 926–935.

Which factors influence residence time?

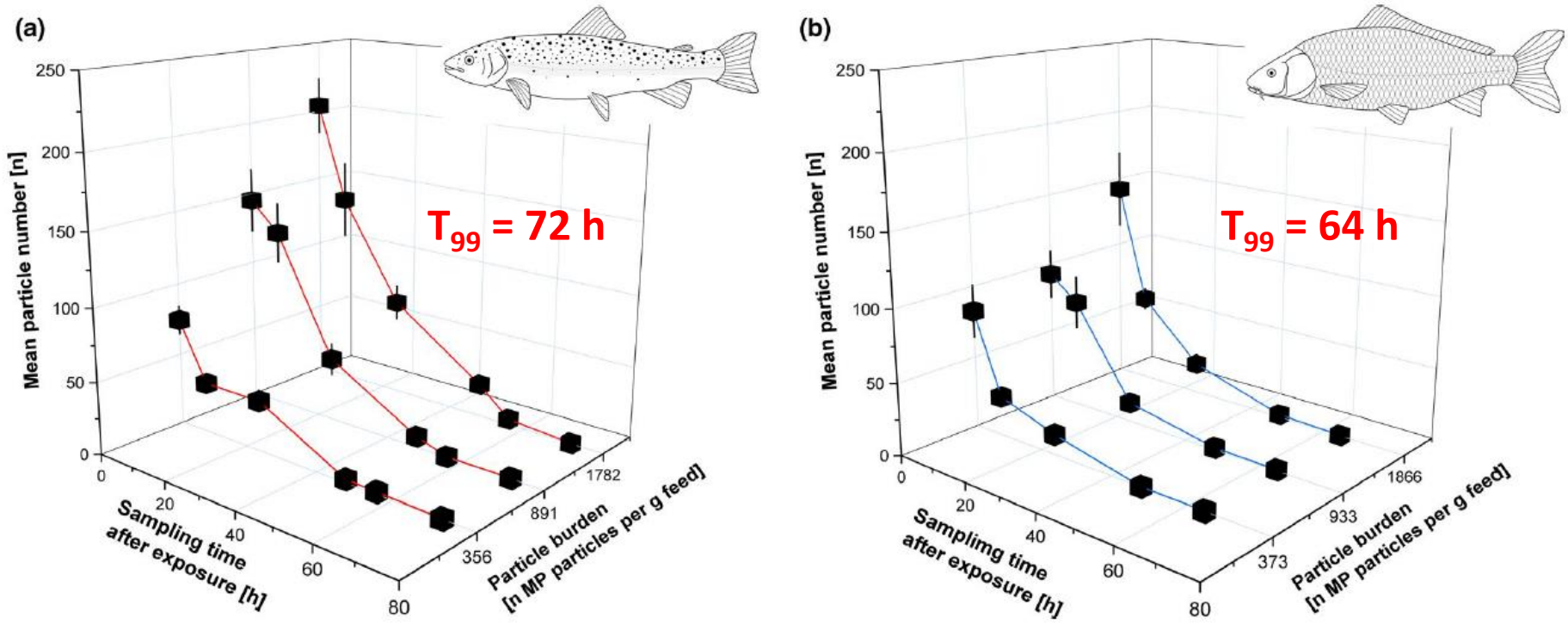


FIGURE 2 Mean microplastic particle numbers (± *SE*) in the experimental fish in relation to time after exposure and particle

→ No accumulation, excretion of the particles over time

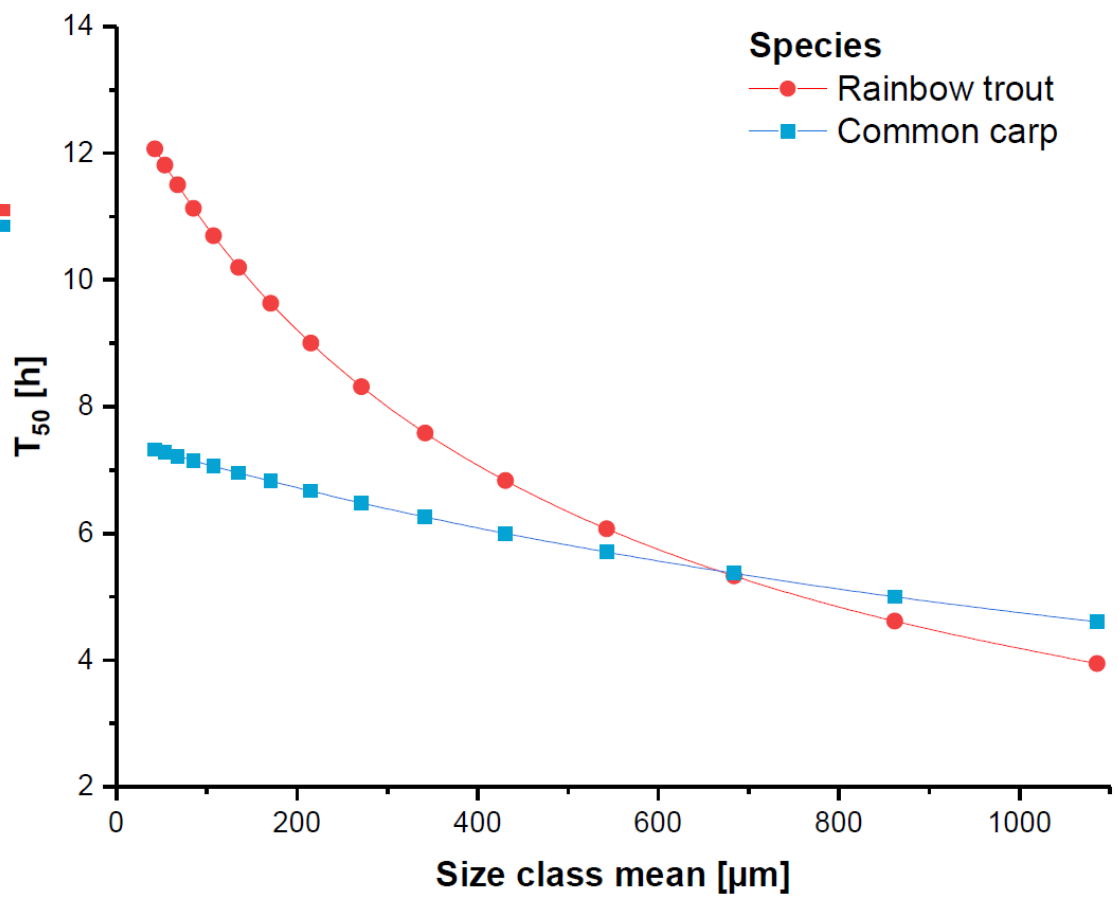
→ Particle concentration has no influence on the particle retention

Roch, S., Ros, A. F. H., Friedrich, C., & Brinker, A. (2021). Microplastic evacuation in fish is particle size-dependent. *Freshwater Biology*, *66*, 926–935.

Size dependent residence time?

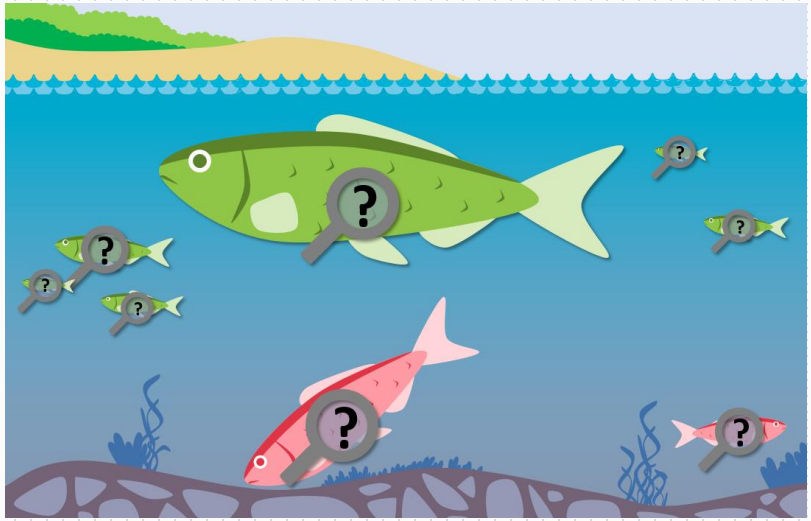
T_{50} food particles

T_{50} food particles



→ **Fish with real stomach**
- active transport of large particles
- passive transport of small particles

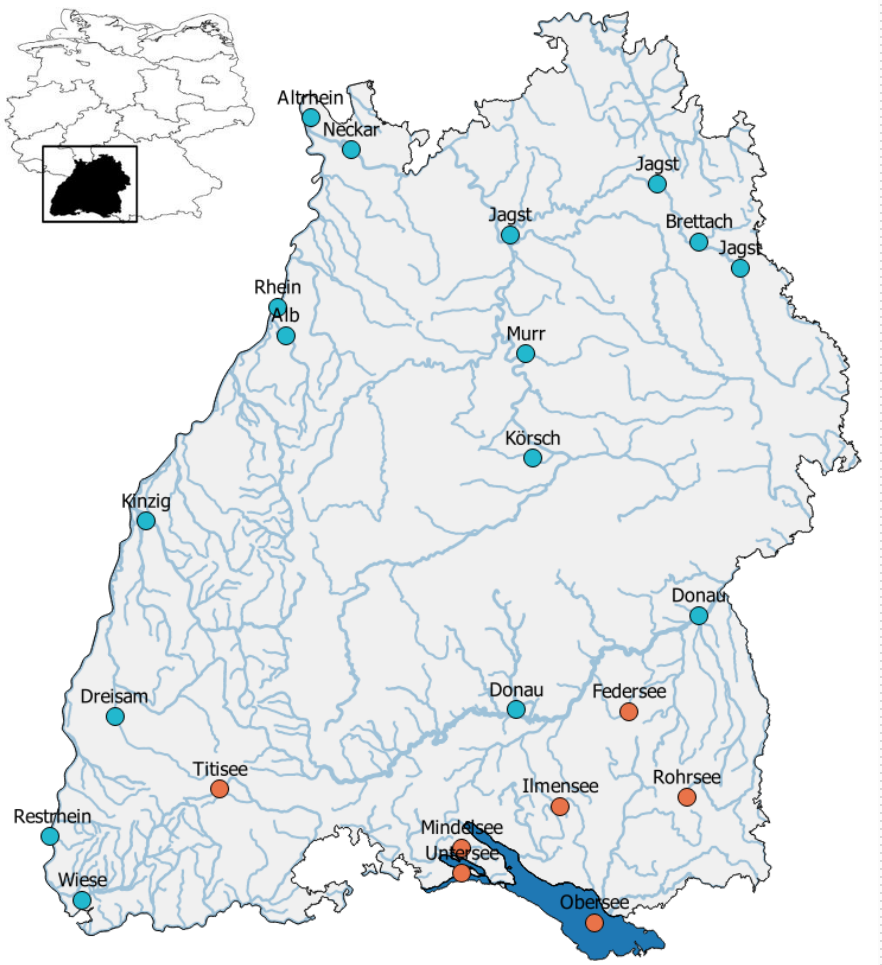
→ **Fish without stomach**
- passive transport of large and small particles



4 Level of burden

Roch, S., Walter, T., Ittner, L. D., Friedrich, C., & Brinker, A. (2019). A systematic study of the microplastic burden in freshwater fishes of south-western Germany - Are we searching at the right scale? *Science of The Total Environment*, *689*, 1001–1011.

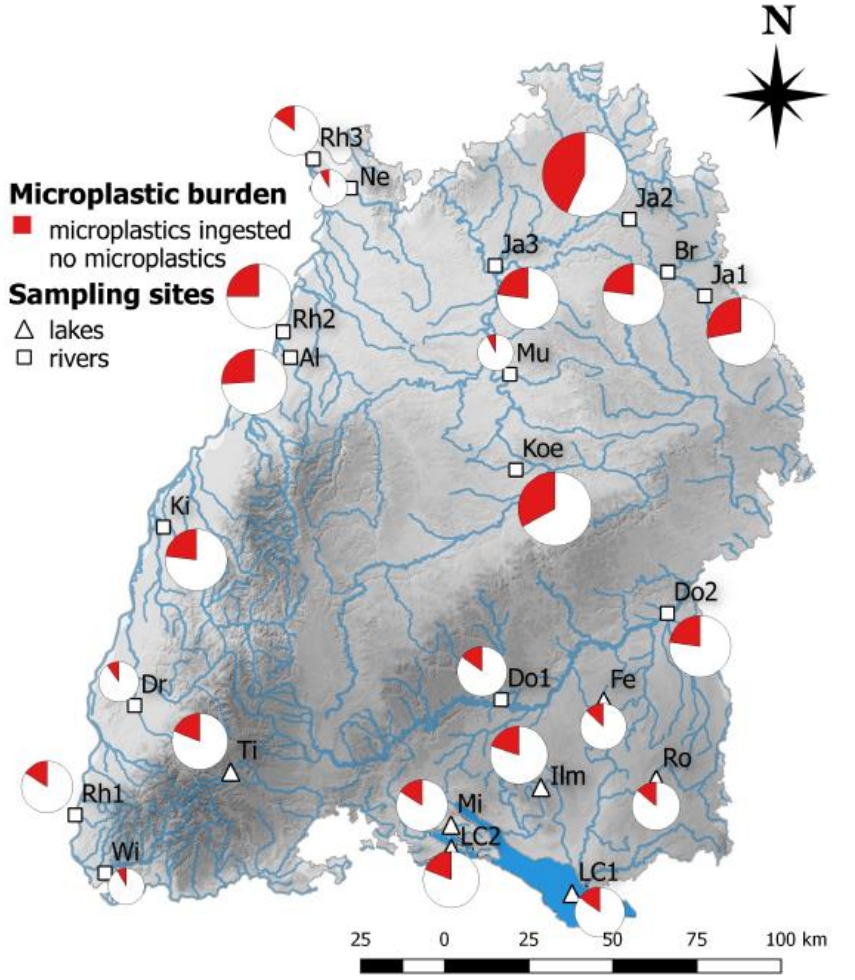
State-wide study



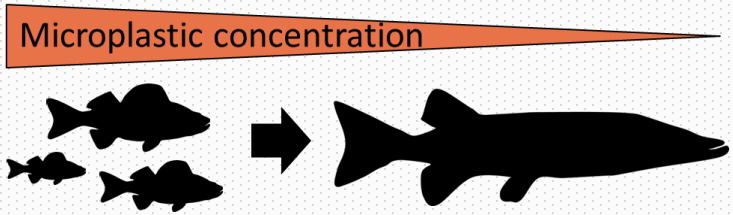
- 16 sampling site in 11 rivers
- 6 lakes (incl. Lake Constance)
- 2 different fish species with diverse habitat preference
- More detailed investigation in Lake Constance
- 1167 fishes were sampled (22 fish species)

Roch, S., Walter, T., Ittner, L. D., Friedrich, C., & Brinker, A. (2019). A systematic study of the microplastic burden in freshwater fishes of south-western Germany - Are we searching at the right scale? *Science of The Total Environment*, *689*, 1001–1011.

Level of burden in Baden-Württemberg



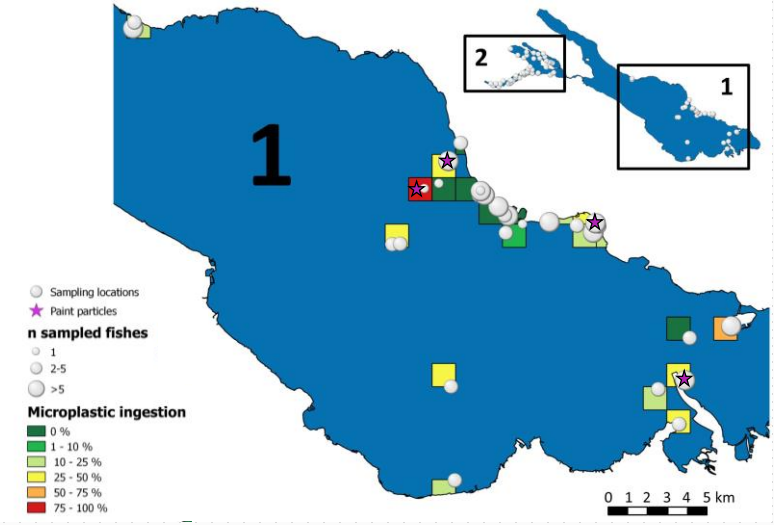
- Around **19 %** of examined fishes were burdened with microplastics
- Microplastic intensity:
  → **1 – 4 particles per fish**
  (mean: 1.2 ± 0.5)
- Fragments and fibers were the dominant plastic types

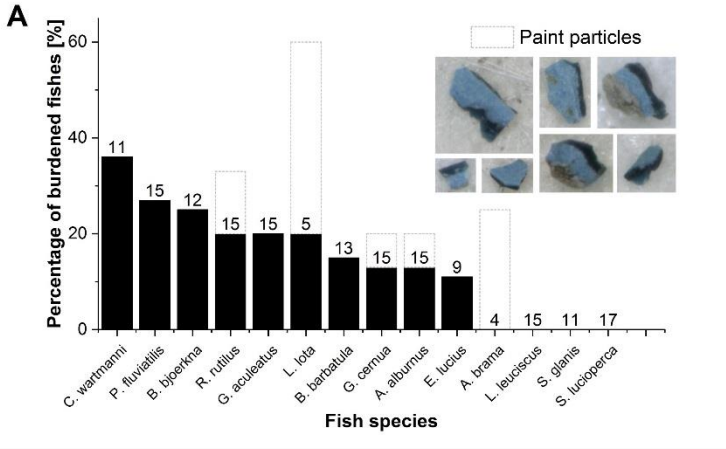


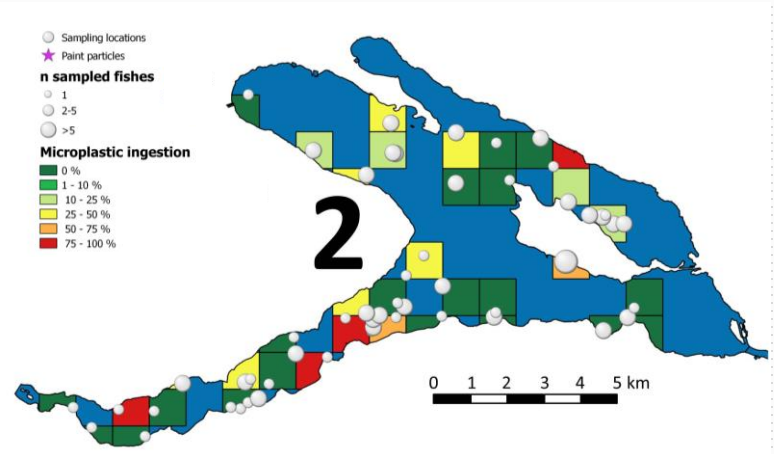
Level of burden

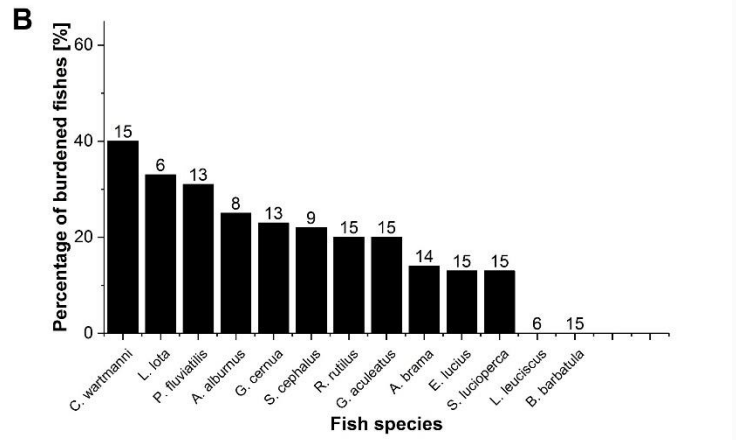
Roch, S., Walter, T., Ittner, L. D., Friedrich, C., & Brinker, A. (2019). A systematic study of the microplastic burden in freshwater fishes of south-western Germany - Are we searching at the right scale? *Science of The Total Environment*, *689*, 1001–1011.

Lake Constance









Level of burden

TABLE 1 Overview of studies accessible before the 15th May 2020 investigating microplastic ingestion in at least one wild freshwater fish (including estuarine/temporarily freshwater fish)

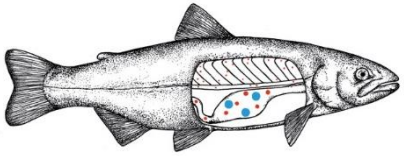
Species	Country	N	FO	Mean	Polymer(s)	References
2	USA	436	45	0.8	–	Peters and Bratton (2016)
1	South Africa	70	73	3.8	–	Naidoo et al. (2016)
1	Brazil	530	64.2	–	–	Ferreira et al. (2016)
2	UK	76	66	0.5	PES, PA, AC, PET	McGoran et al. (2017)
6	China	–	95.7	2.4	CE, PET, PES	Jabeen et al. (2017)
1	Brazil	48	83	3.6	–	Silva-Cavalcanti et al. (2017)
2	Switzerland	25	24	1.15	–	Roch and Brinker (2017)
69	Brazil	2,233	9	1.06	–	Vendel et al. (2017)
13	China	35	25.7	0.86	PE, PA	K. Zhang et al. (2017)
5	Canada	181	73.5	3.28	–	Campbell et al. (2017)
11	Argentina	87	100	19.2	–	Pazos et al. (2017)
4	South Africa	36	100	–	–	Naidoo et al. (2017)
3	Portugal	120	38	1.67	PE, PP, PET, PA, RAY	Bessa et al. (2018)
3	Australia	93	–	1.37	PET, RAY	Halstead et al. (2018)
1	China	30	60	4.3	PP, PE	Cheung et al. (2018)
1	UK	64	32.8	0.69	PE, PP, PET	Horton et al. (2018)
11	USA	74	85	–	–	McNeish et al. (2018)
46	Brazil	189	13.7	1.2	PA, RAY, PE	Pegado et al. (2018)
2	Brazil	125	–	–	–	Silva et al. (2018)
1	France	60	15	0.15	PET, PP, PAN, PEVA	Collard et al. (2018)
21	UK	876	32	–	PET, PA, PP	McGoran et al. (2018)
16	Brazil	172	26.7	0.56	PE, PVC, PP, PA, PMMA	Andrade et al. (2019)
1	Canada	74	59	1.15	–	Collicutt et al. (2019)
1	Belgium	78	9	0.1	PET, EVA, PVC, PP, PVA, PA, CE	Slootmaekers et al. (2019)
2	China	–	–	1.7	PE, PP	Lv et al. (2019)
13	China	217	–	–	PET, PP, PE	Su, Deng, et al. (2019)
2	Brazil	529	> 50	1.4/1.5	–	Ferreira, Barletta, et al. (2019)
9	China	279	50	7	PE, PP, PET	Zheng et al. (2019)
1	China	11	91	7.64	PE, PP	Yuan et al. (2019)
1	Australia	180	19.4	0.6	PET, RAY, PA, PP	Su, Nan, et al. (2019)
3	Brazil	529	58	1.46	–	Ferreira, Barletta, Lima, Morley, et al., 2019

Parker, B., Andreou, D., Green, I. D., & Britton, J. R. (2021). Microplastics in freshwater fishes: Occurrence, impacts and future perspectives. *Fish and Fisheries*, faf.12528.

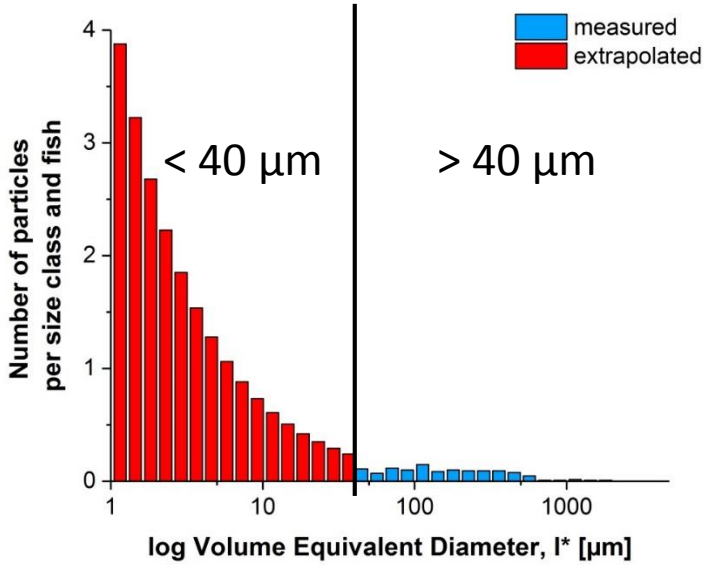
Roch, S., Walter, T., Ittner, L. D., Friedrich, C., & Brinker, A. (2019). A systematic study of the microplastic burden in freshwater fishes of south-western Germany - Are we searching at the right scale? *Science of The Total Environment*, *689*, 1001–1011.

Do size restrictions impede a realistic picture?

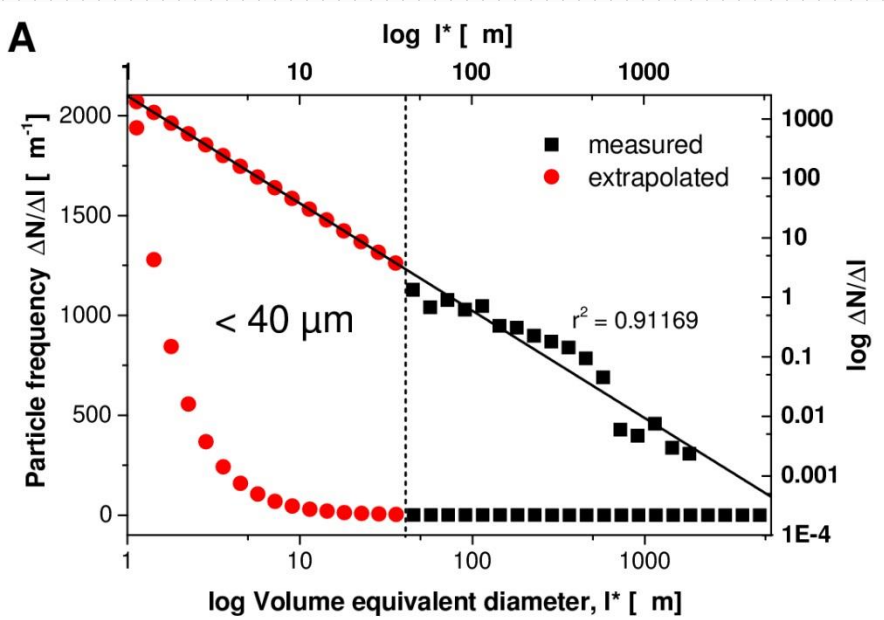
- Particle size distribution analysis was performed



around 23 particles



- Only particles > 40 µm were used **(detection limit)**
- Hyperbolic power law increase with lower particle size



5 Conclusion

- Active and passive ingestion of microplastics in visually oriented fish
- Passive uptake in chemosensory oriented fish

- Generally passive excretion of microplastic particles in fish
- Active transport of large particles in fish with real stomach
- No accumulation, residence time independent from microplastic concentration

- Overall level of burden is low in south-western Germany / Lake Constance
- Current detection limits might impede a realistic picture of the burden
- Comparability of studies difficult, as there are no harmonized protocols


Thank you for your attention!