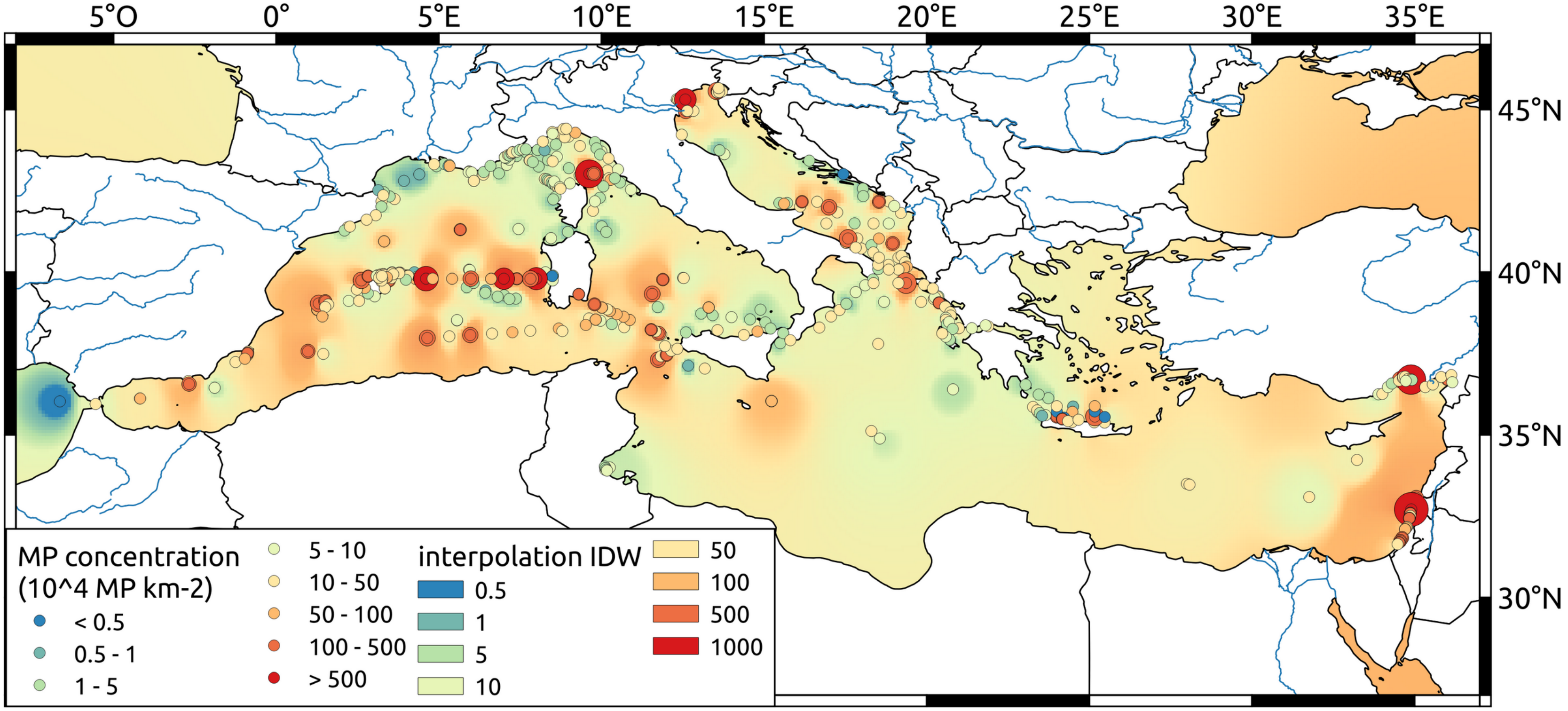
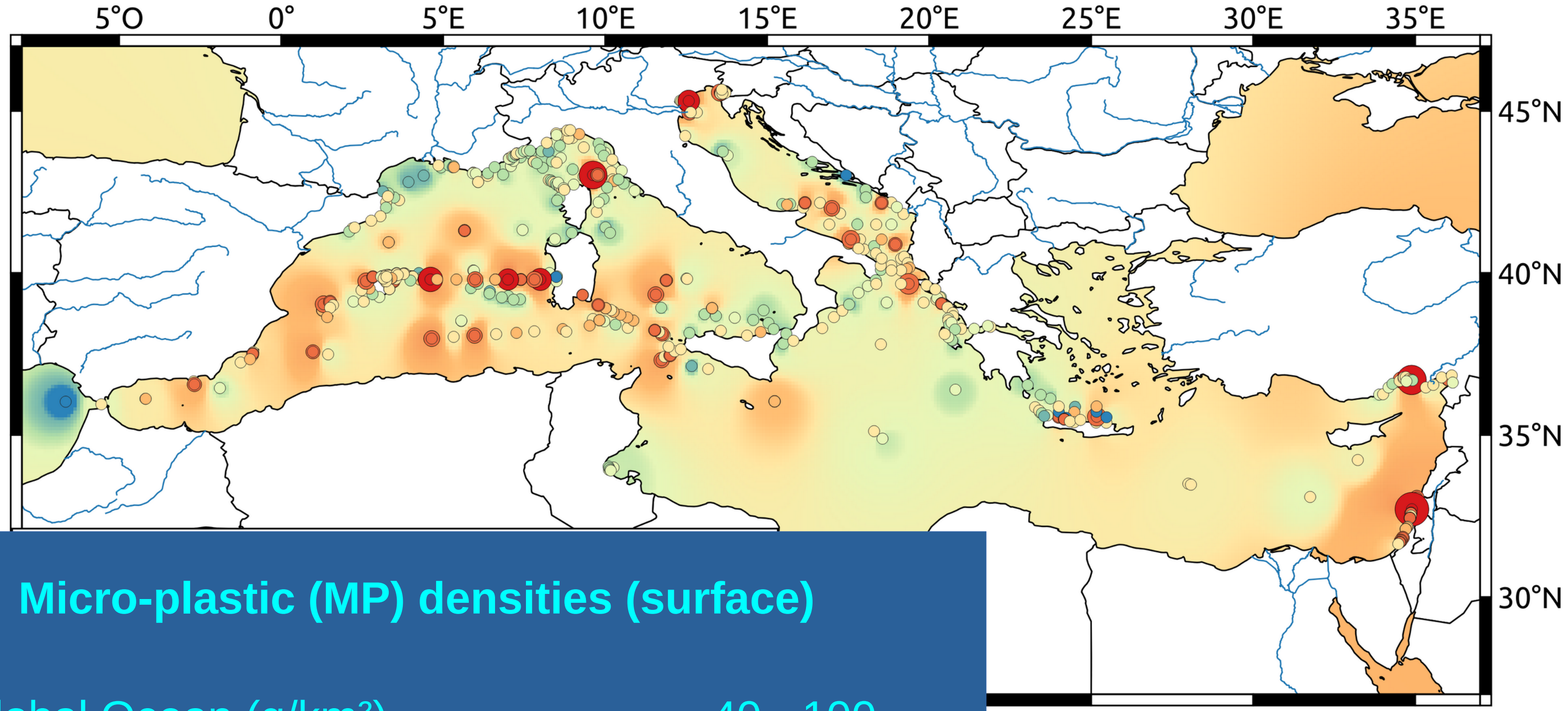
# Micro-plastic abundance in the Mediterranean Sea



*PhD of L. Weiss, 2021*

# Micro-plastic abundance in the Mediterranean Sea



**Micro-plastic (MP) densities (surface)**

| | |
|---|---|
| Global Ocean (g/km²) | 40 - 100 |
| Mediterranean Sea (g/km²) | 300 - 1200 |

*Sources : Eriksen et al., 2014 ; Cozar et al., 2014, 2015 ; Pedrotti et. al., 2022*

*PhD of L. Weiss, 2021*

Why are MP densities at least about 10 times greater on average ?

=> because the Mediterranean is strongly exposed to land-based (riverine) sources

# Monitoring of plastic fluxes in the land-to-sea-continuum : lessons learned, major challenges and future approaches

W. Ludwig*, M. Laverre, M. Constant, L. Weiss, P. Kerhervé, M. Canals and others

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CEntre de Formation et de Recherche sur
les Environnements Méditerranéens
Perpignan, France

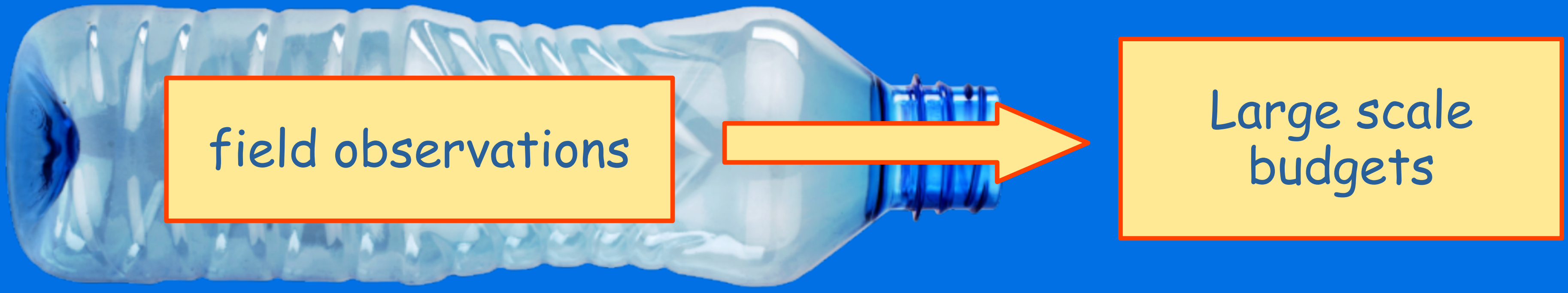
# Some general remarks ...

# floating plastic debris

micro-plastics
(MPs)

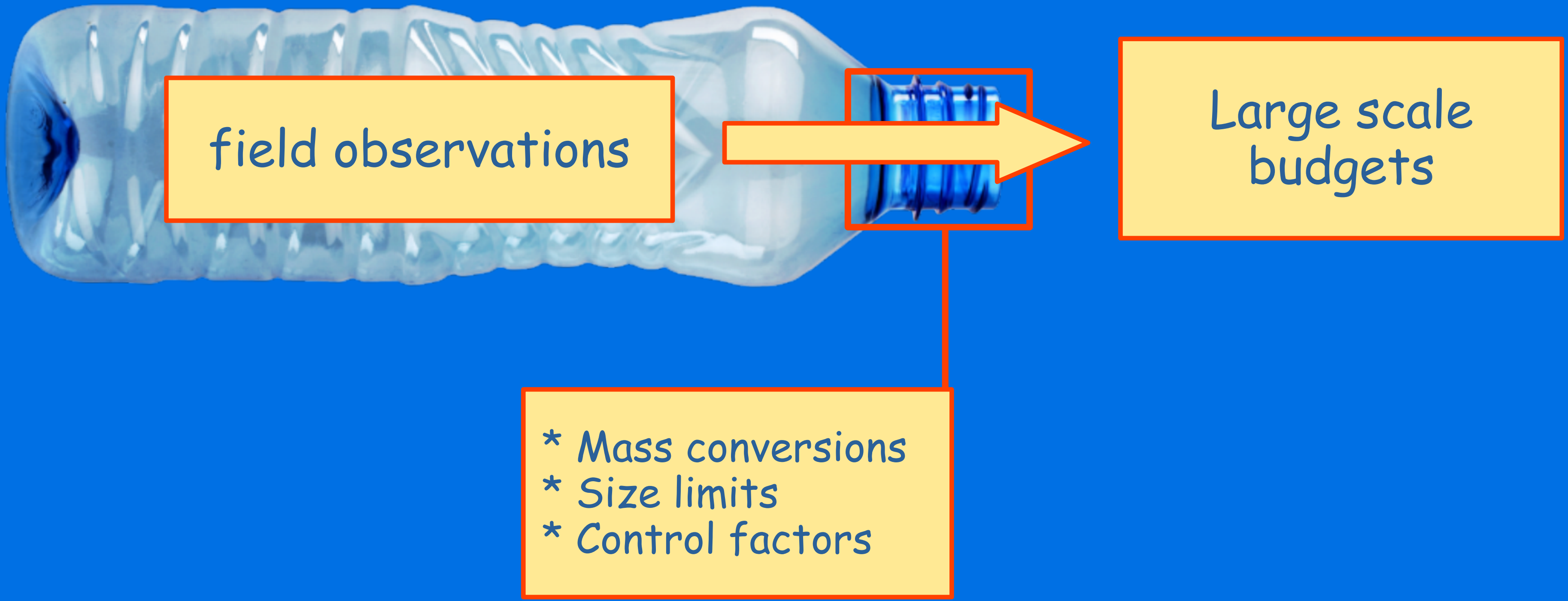
5 mm

macro-plastics



field observations

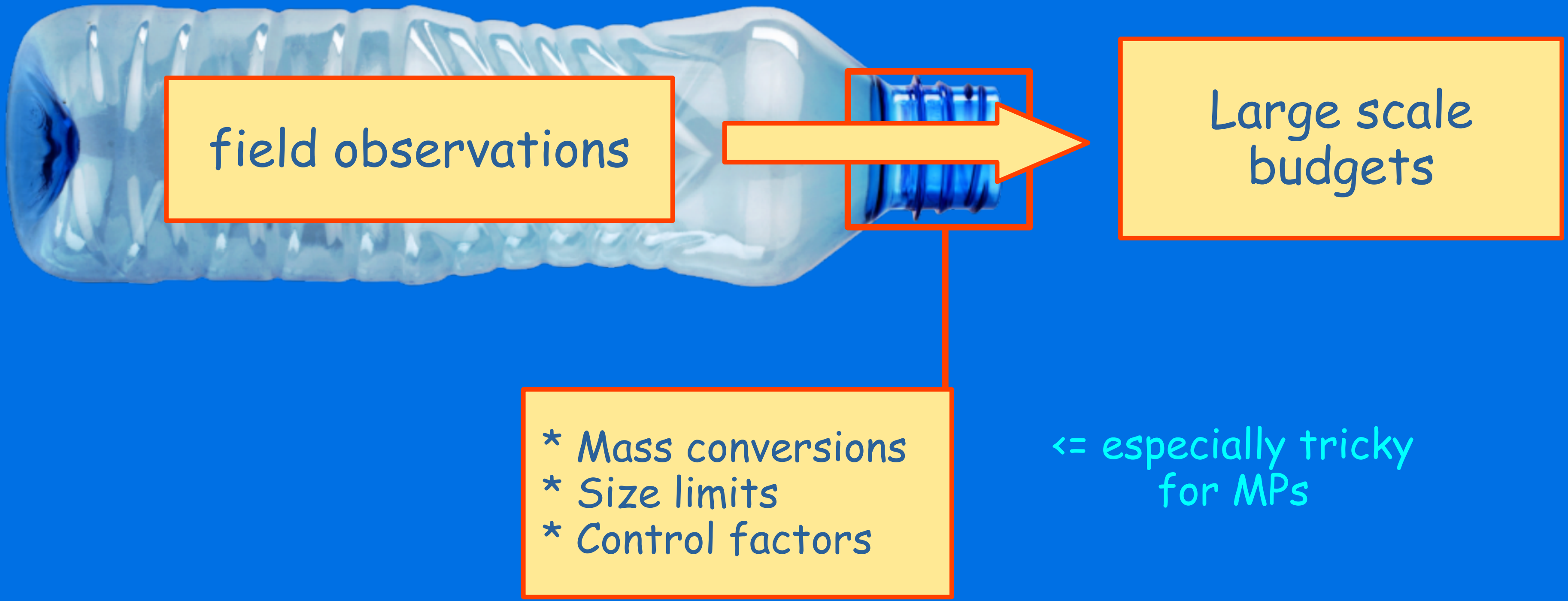
Large scale budgets



field observations

Large scale budgets

- Mass conversions
- Size limits
- Control factors



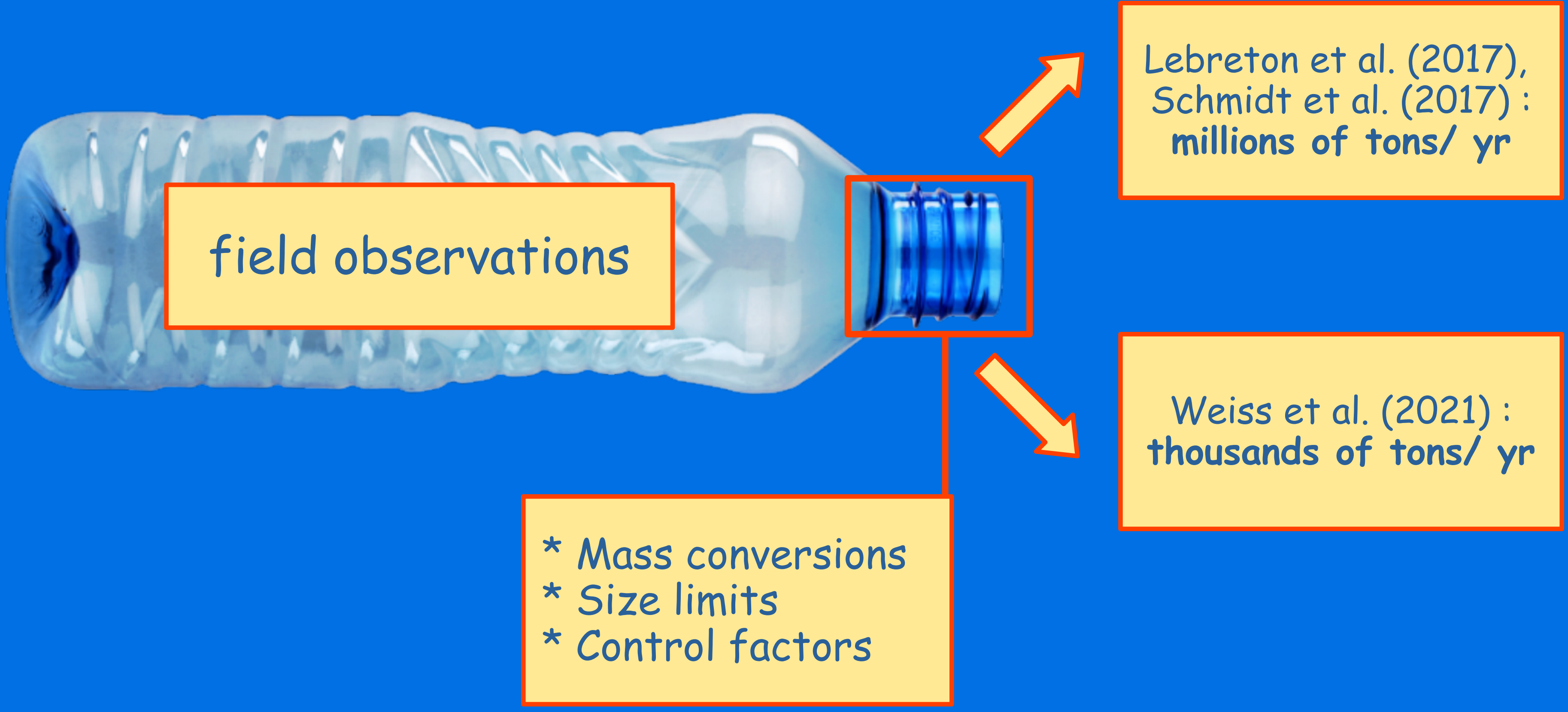
field observations

Large scale budgets

* Mass conversions
* Size limits
* Control factors

<= especially tricky
for MPs

Global estimates of riverine MP fluxes to the sea



field observations

* Mass conversions
* Size limits
* Control factors

Lebreton et al. (2017), Schmidt et al. (2017) : **millions of tons/ yr**

Weiss et al. (2021) : **thousands of tons/ yr**

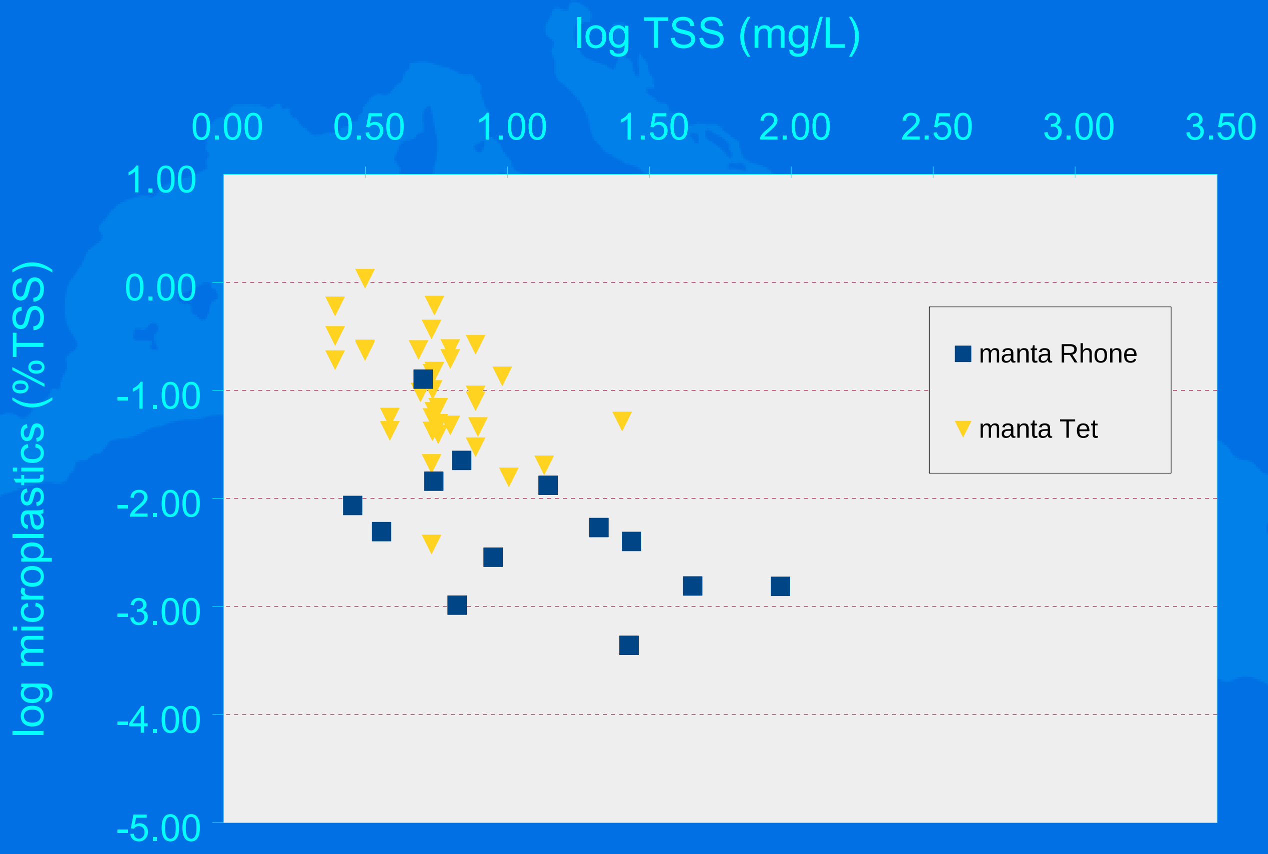
*Weiss et al., 2021*

# Monitoring


France
0
100 km
Rhone
Coastal rivers
Arles
Tet at Villelongue
Gulf of Lions

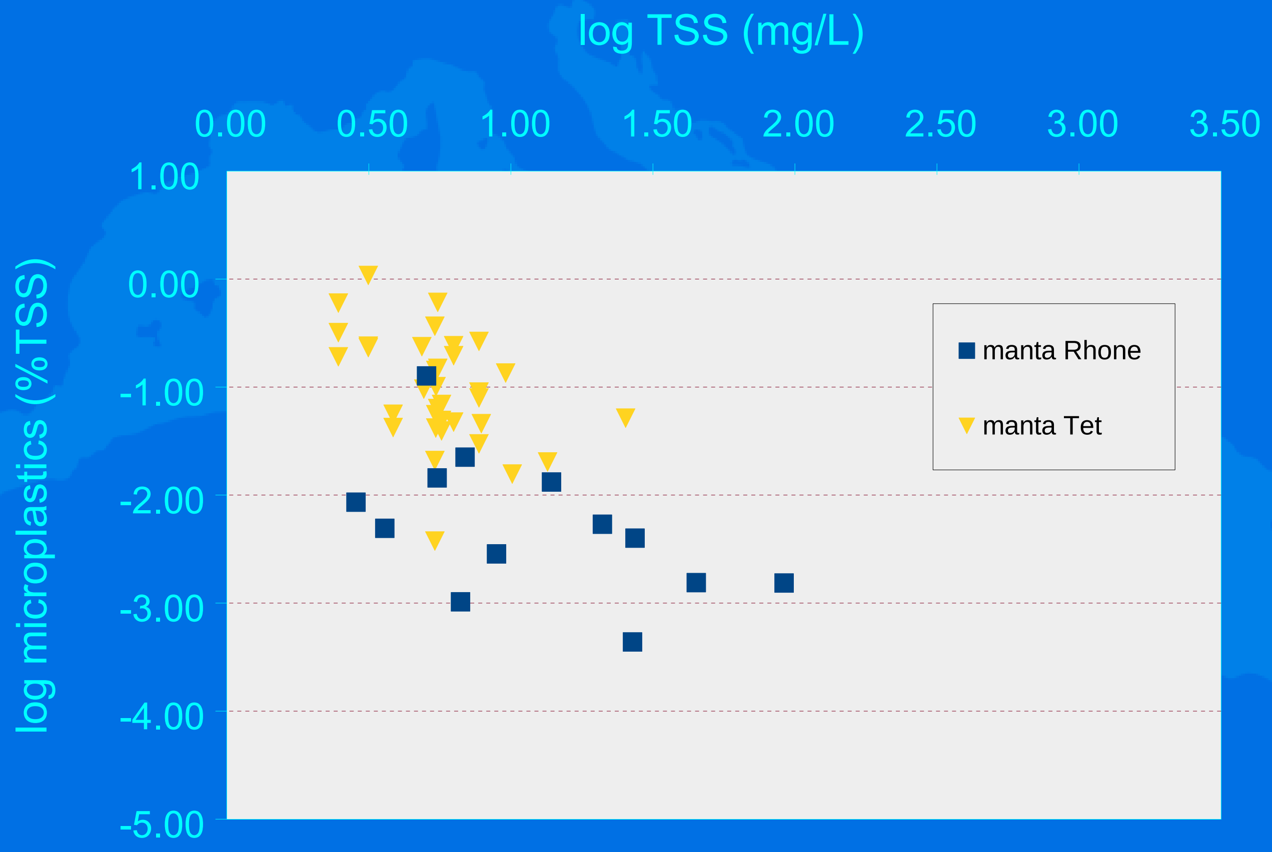
# Monitoring of micro-plastic fluxes

# Microplastics in total suspended sediments (TSS) of the Rhone and the Tet rivers



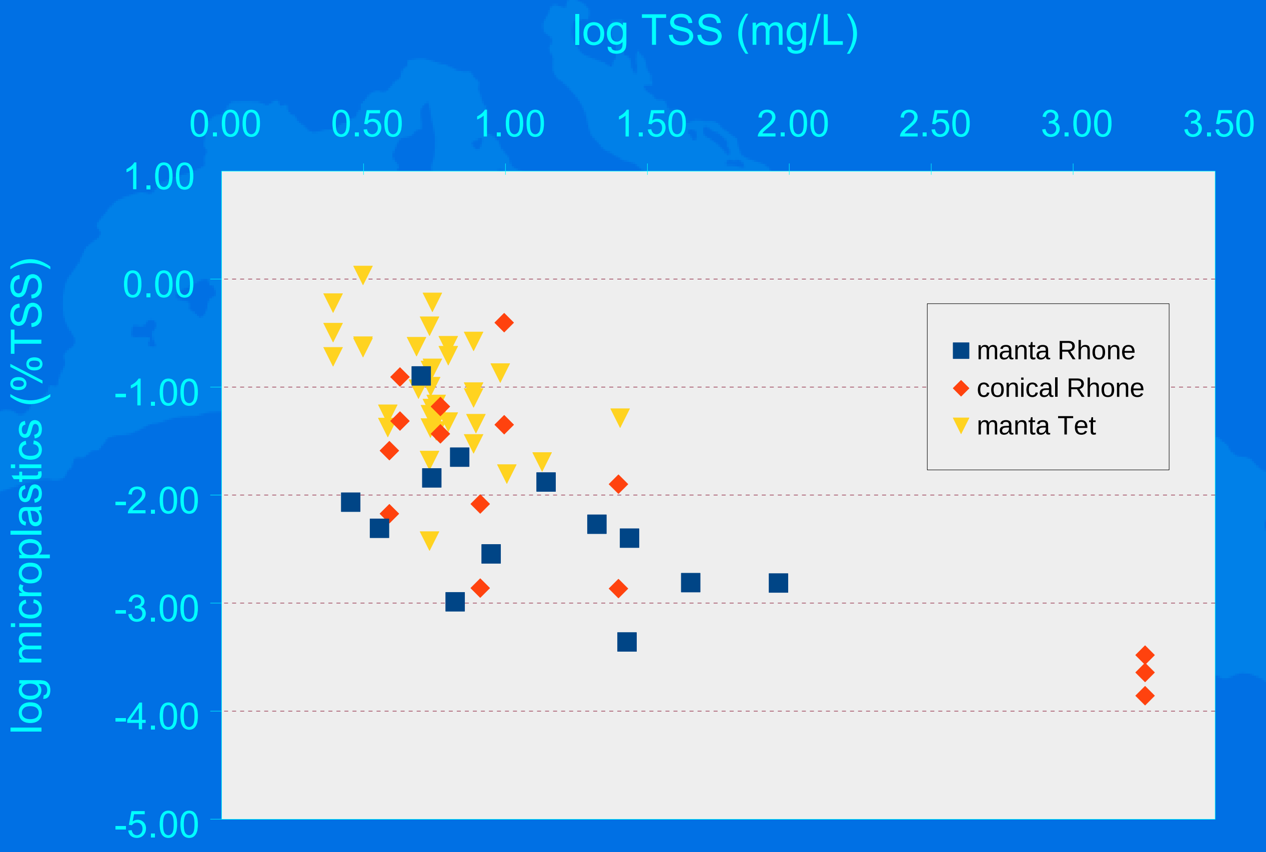
*Constant et al., 2020*

# Microplastics in total suspended sediments (TSS) of the Rhone and the Tet rivers



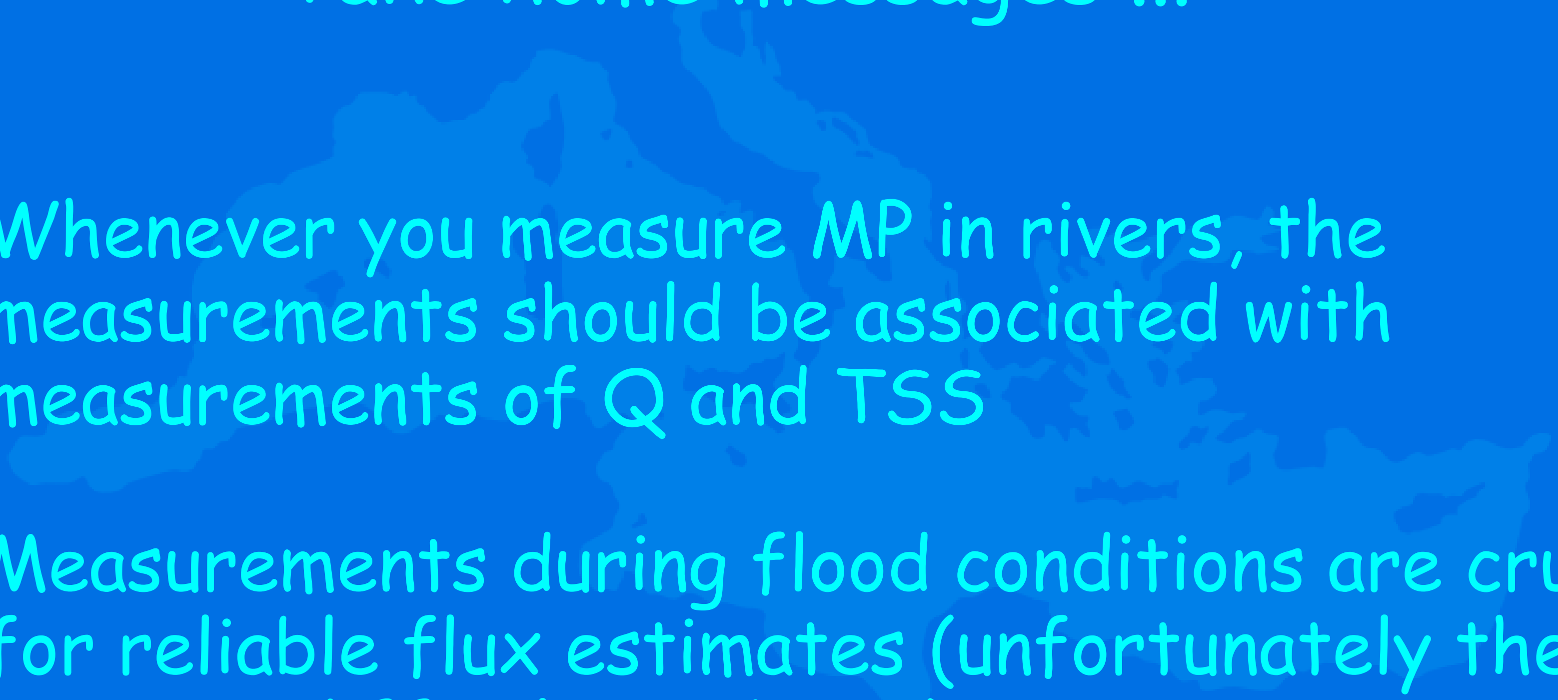
- [Tet] >> [Rhone], but specific fluxes are similar: 76 (Tet) and 61 (Rhone) g km$^{-2}$ yr$^{-1}$. The Rhone has higher specific Q and TSS fluxes!

# Microplastics in total suspended sediments (TSS) of the Rhone and the Tet rivers



➡ Measurements during flooding (only possible for the Rhone) increase the specific fluxes by a factor 3-4 (dilution is not linear)

# Take home messages ...



- Whenever you measure MP in rivers, the measurements should be associated with measurements of Q and TSS
- Measurements during flood conditions are crucial for reliable flux estimates (unfortunately they are very difficult to obtain)

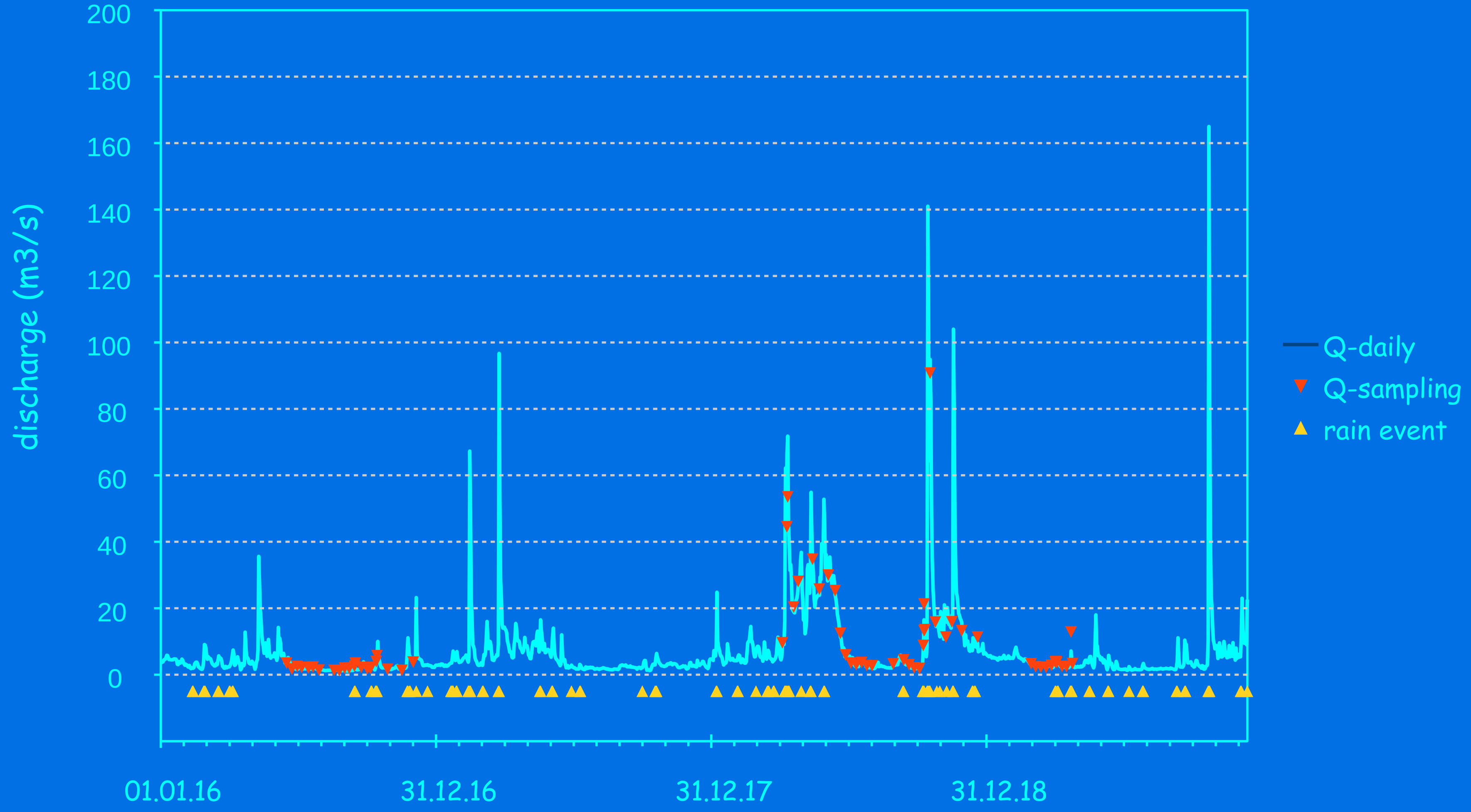
# Monitoring of macro-plastic fluxes

# Monitoring of ~~macro-plastic~~ fluxes

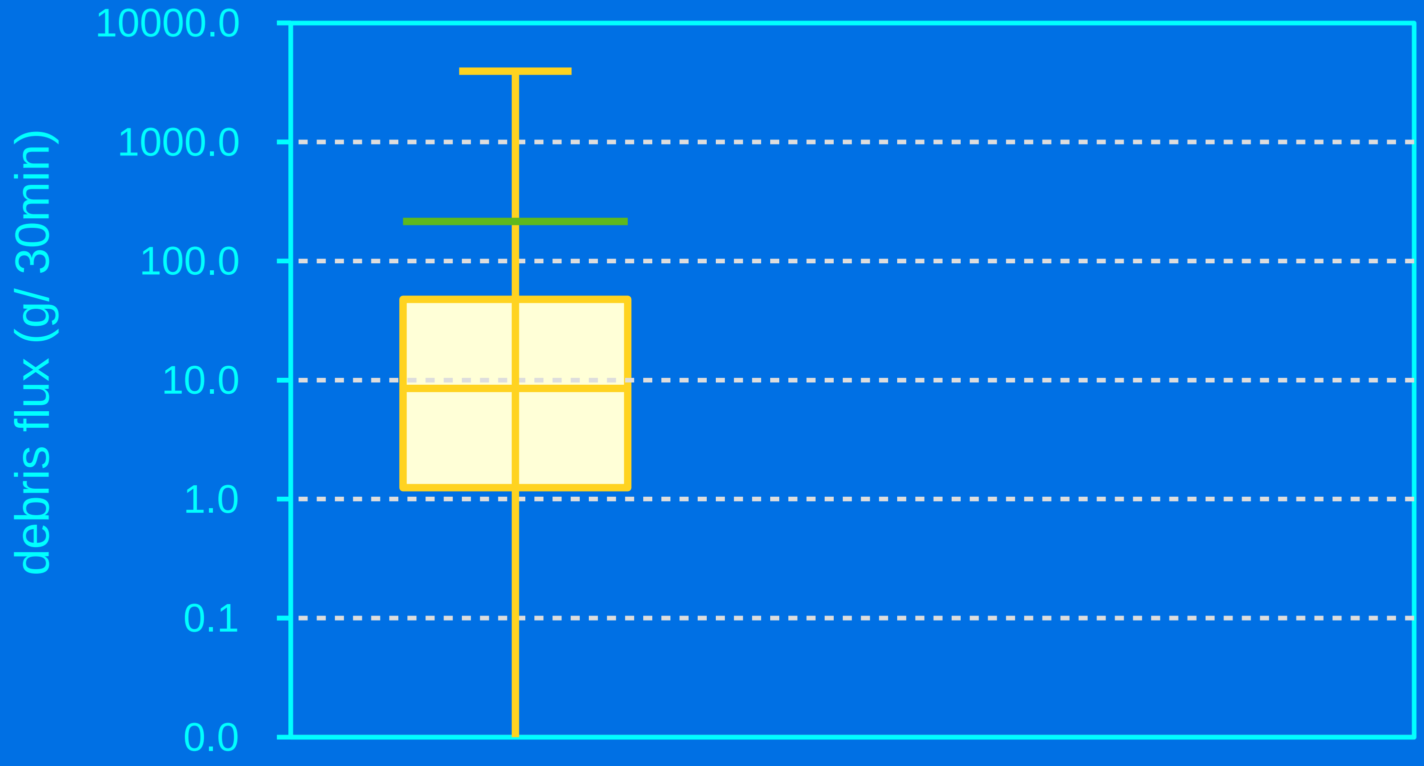
macro-debris

(mostly plastics)

# 4 yrs sampling of macro-debris in the Tet
## (downstream Perpignan, close to the mouth)



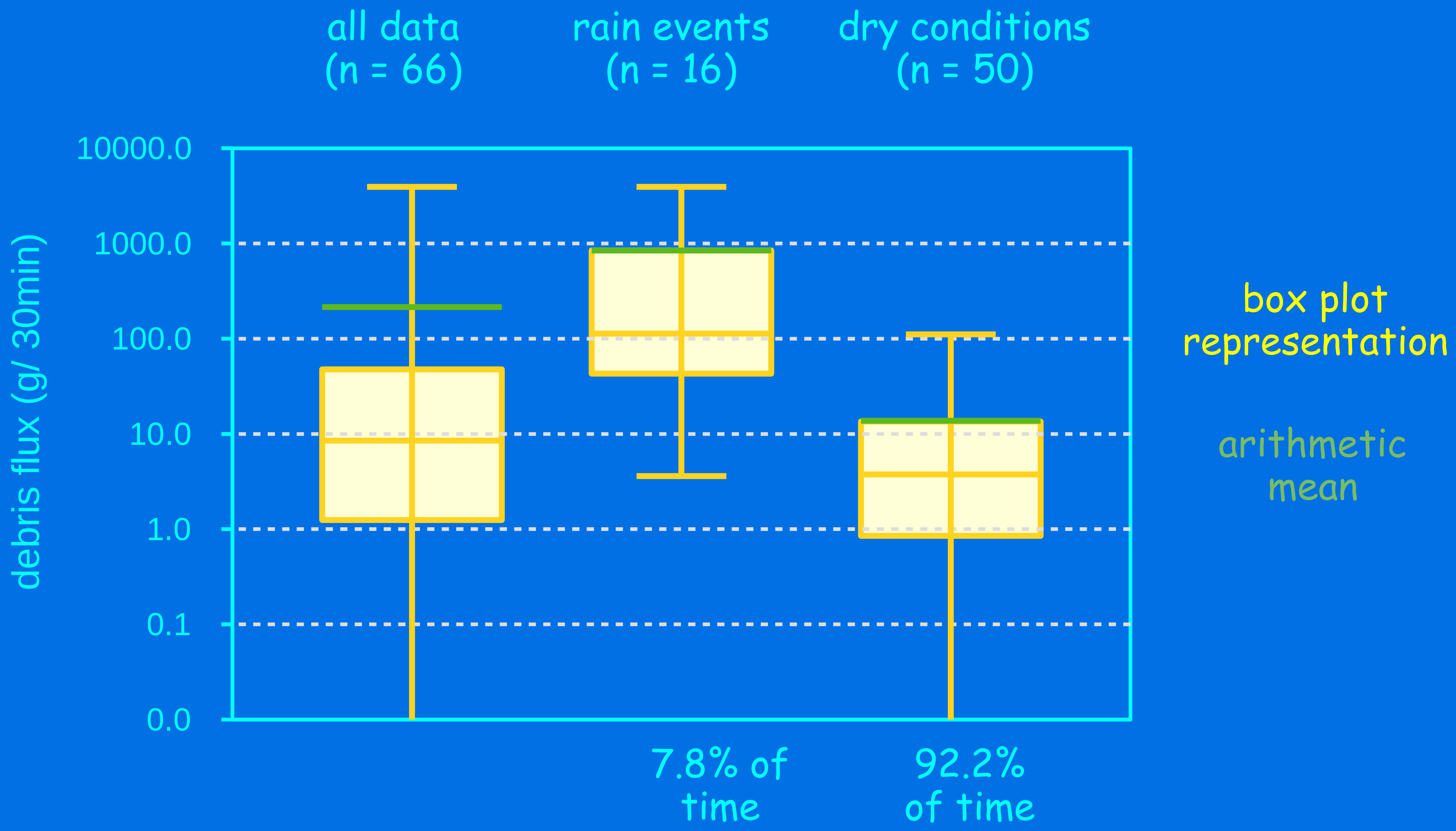
all data
(n = 66)



box plot representation

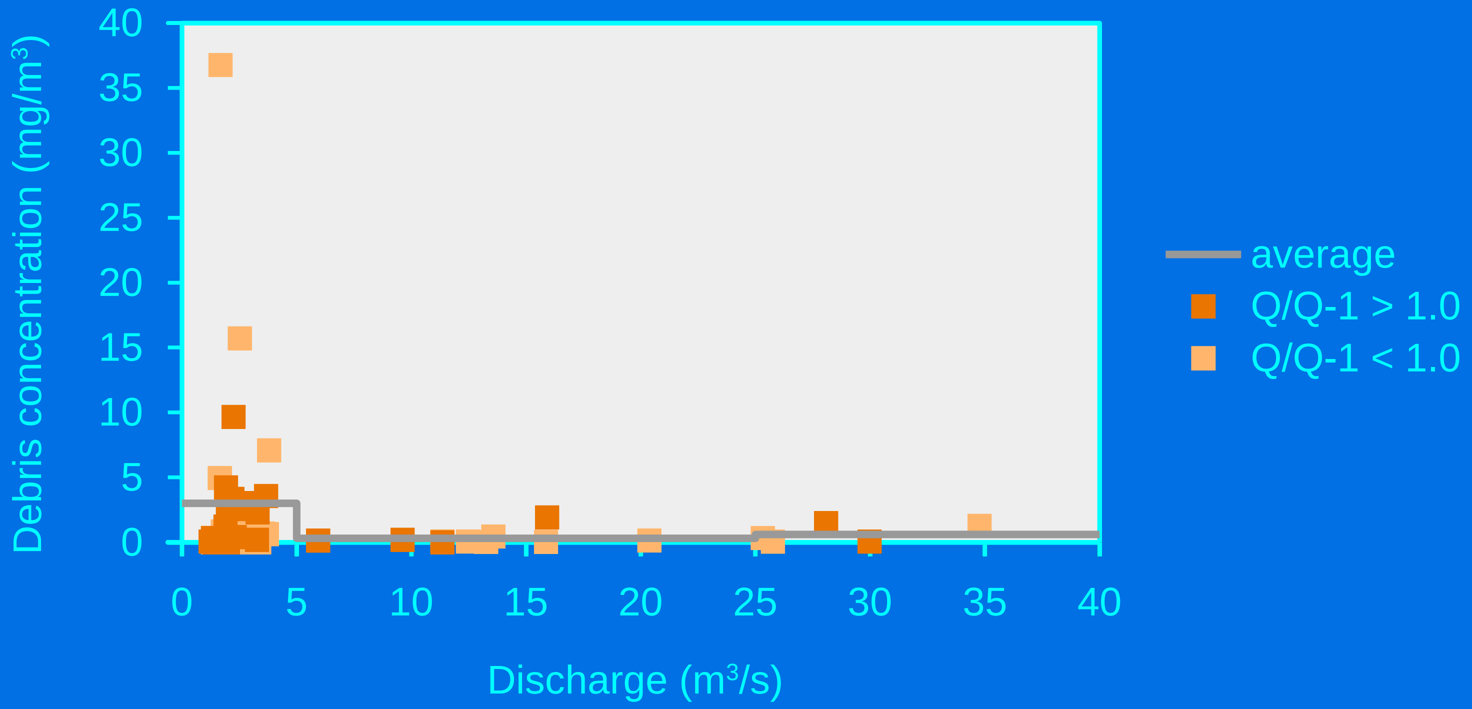
arithmetic mean

| | |
|---|---|
| Flux by means | 3.77 t/yr |
| Flux by medians | 0.15 t/yr |

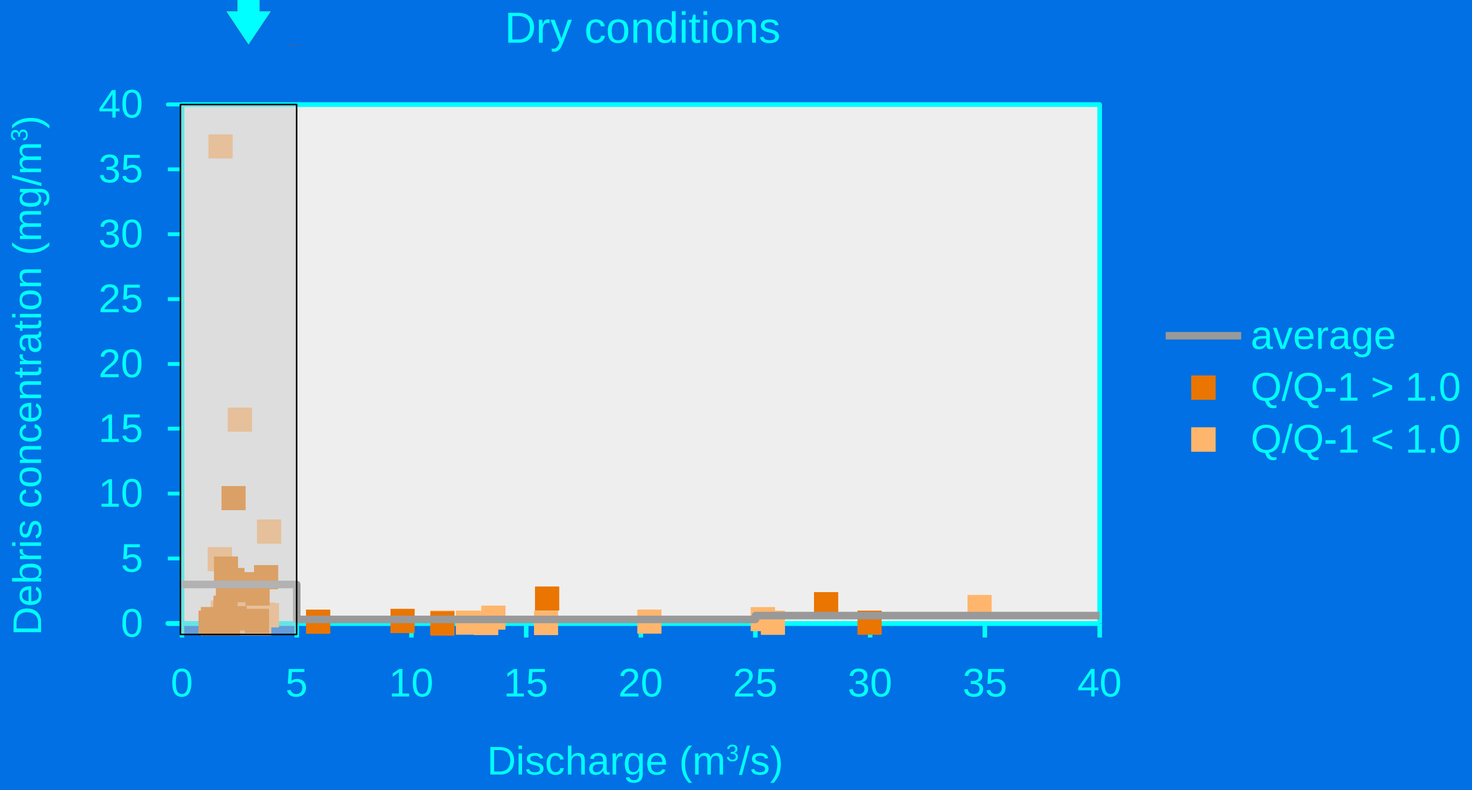


| | | |
|---|---|---|
| Flux by means | 3.77 t/yr | 1.38 t/yr |
| Flux by medians | 0.15 t/yr | 0.22 t/yr |

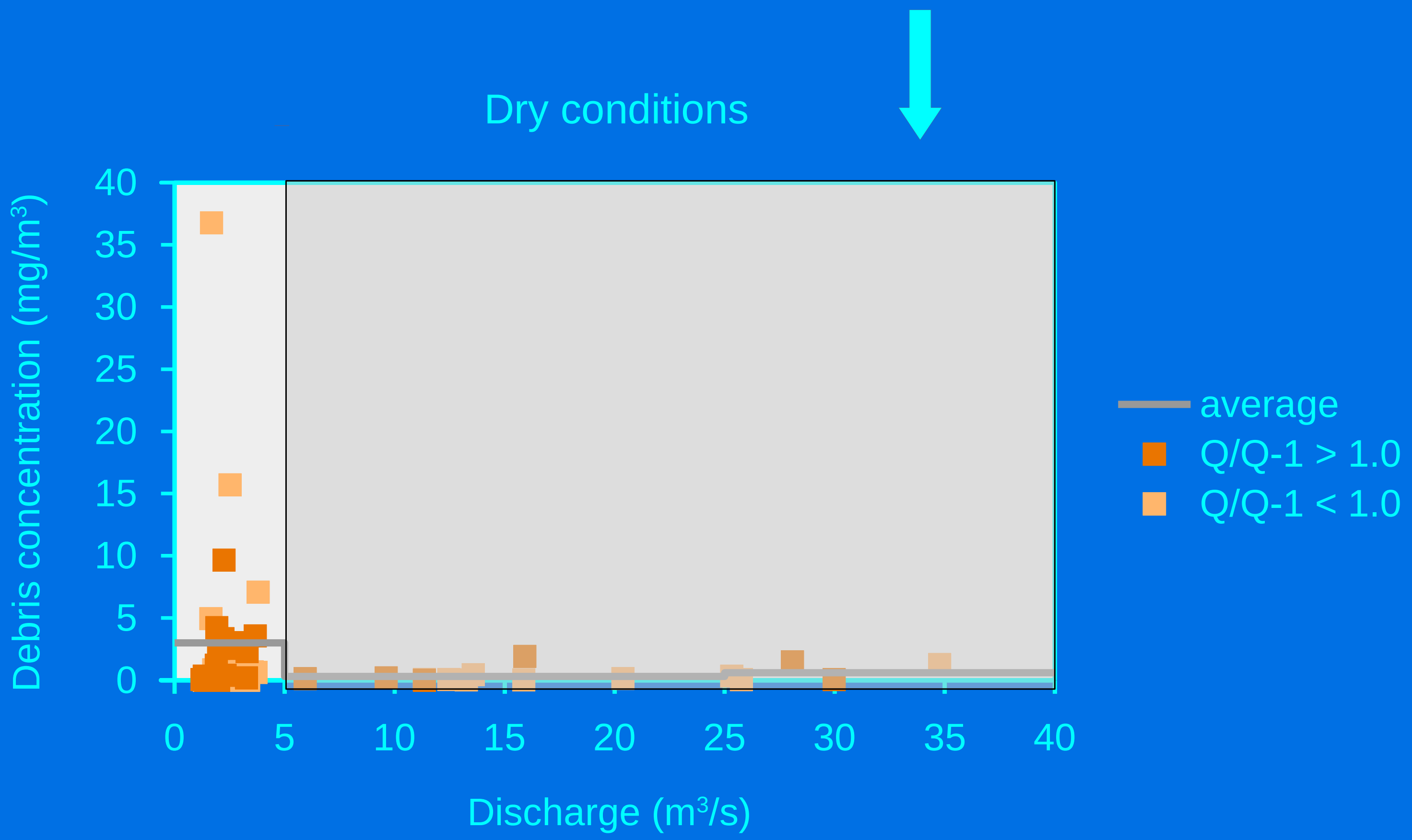
# Dry conditions



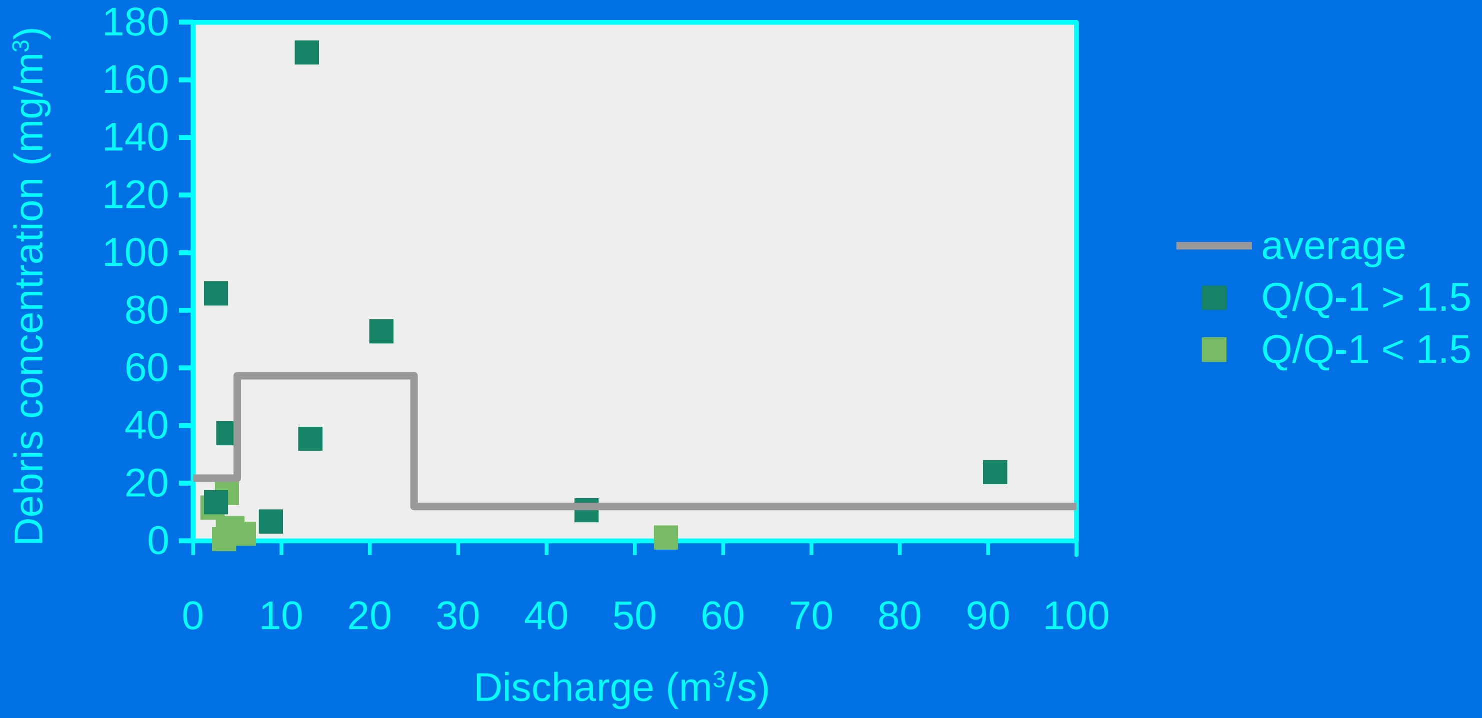
dilution of riverine
debris stocks



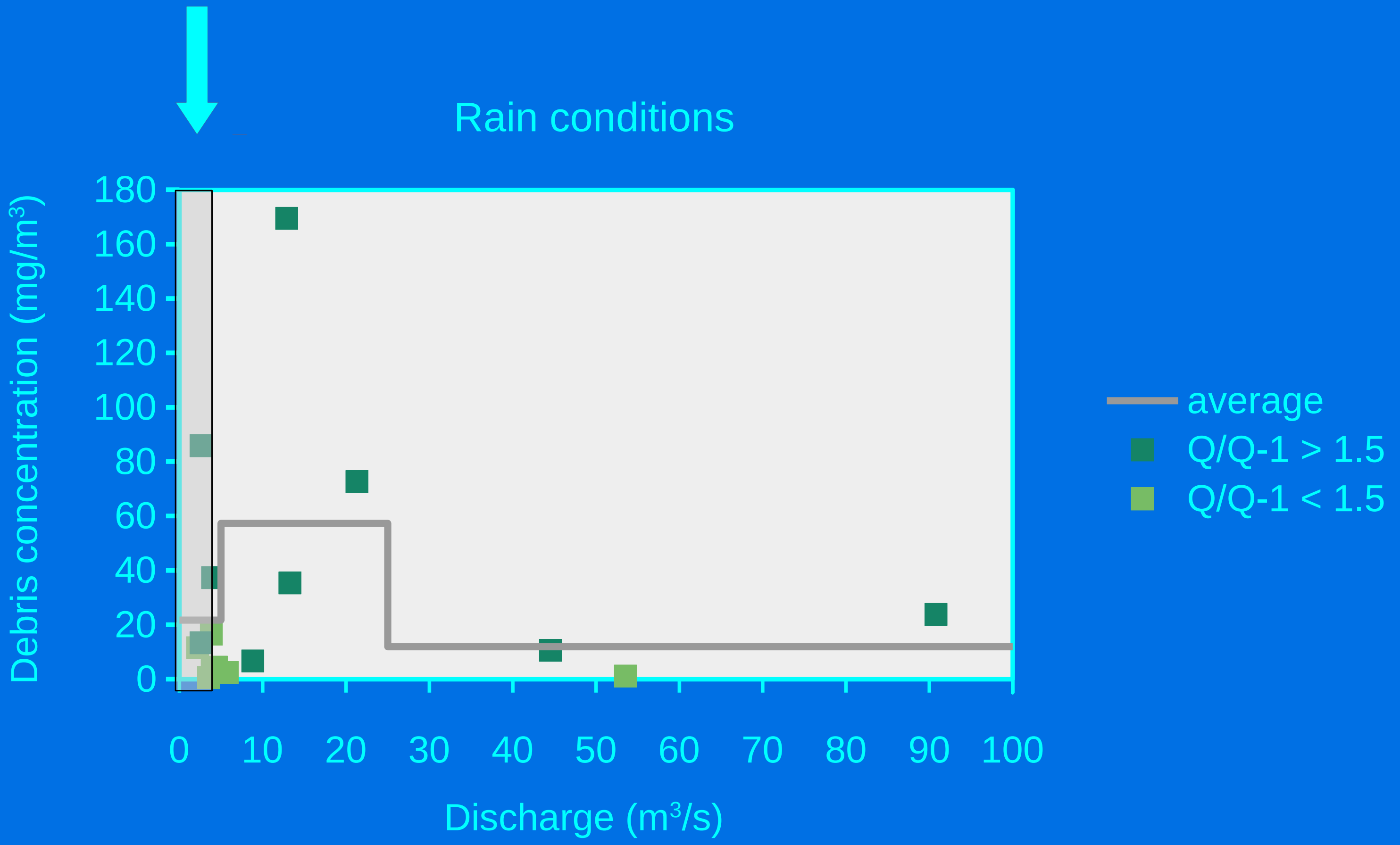
Only weak inputs
from DB sufaces



# Rain conditions

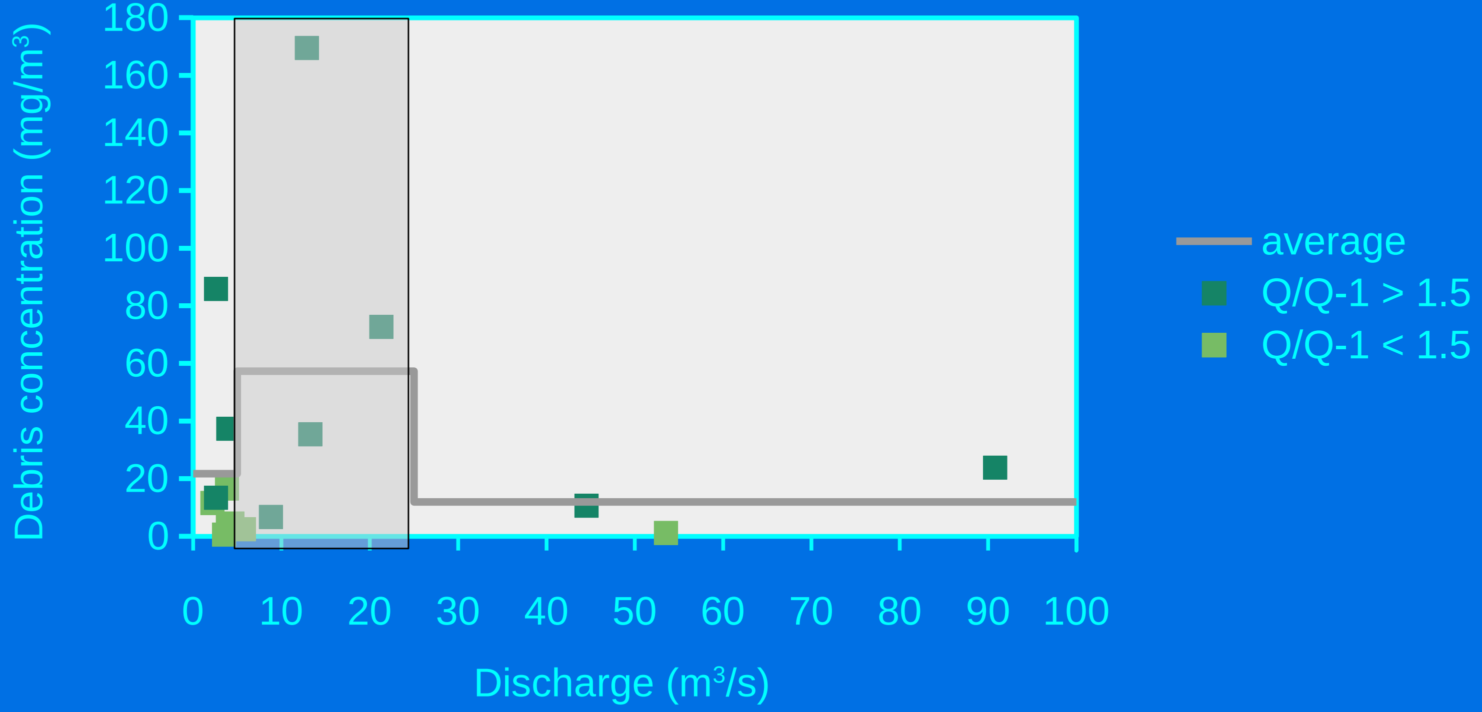


dilution of riverine debris stocks



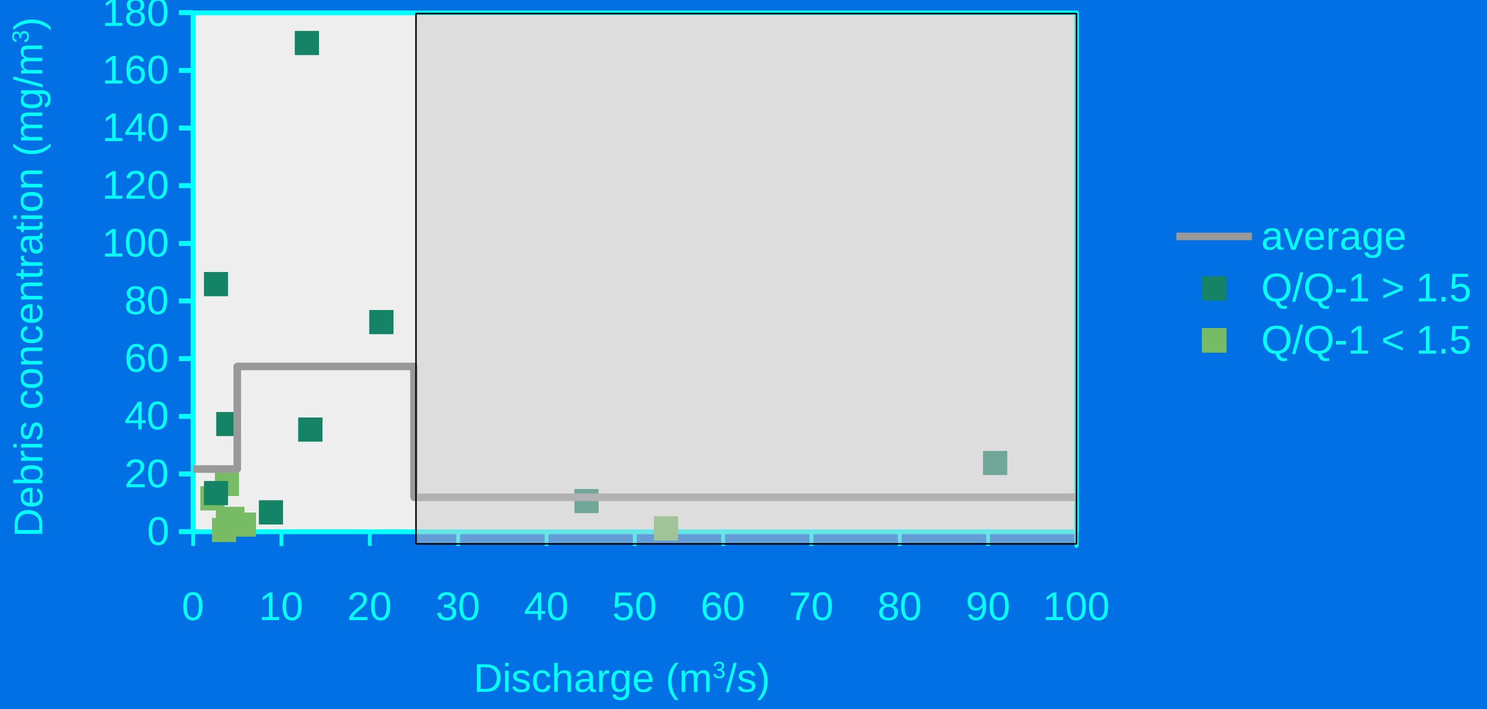
flushing of DB
surfaces

Rain conditions

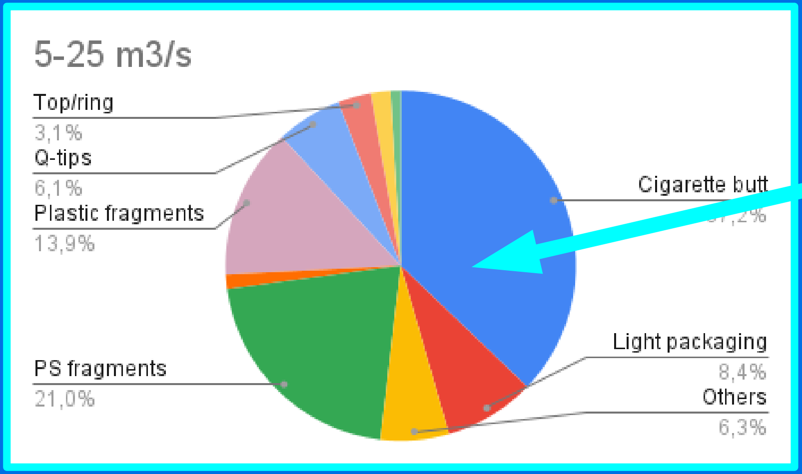


mixture of
flushing/ dilution

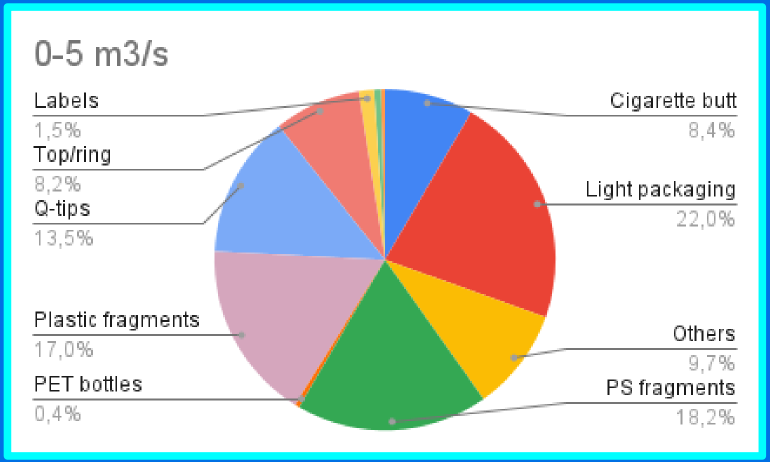
Rain conditions

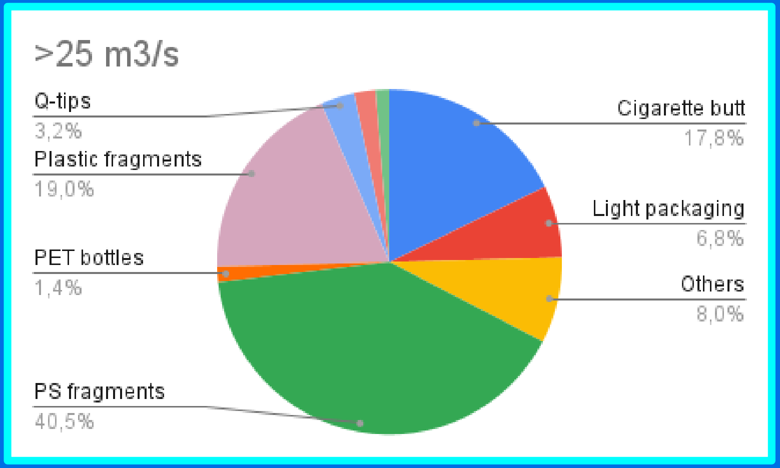


# Rain events

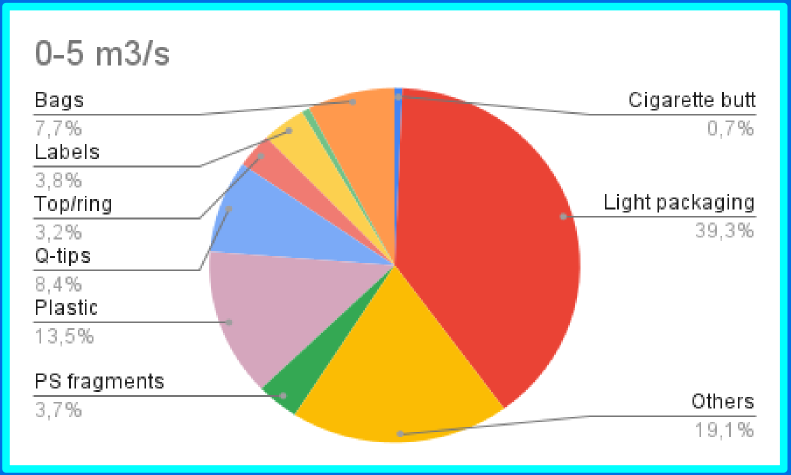


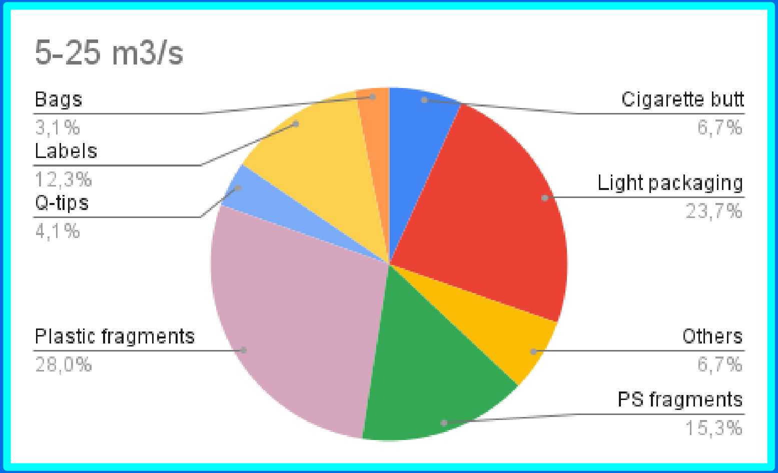
Cigarette filters are good tracers for surface flushing

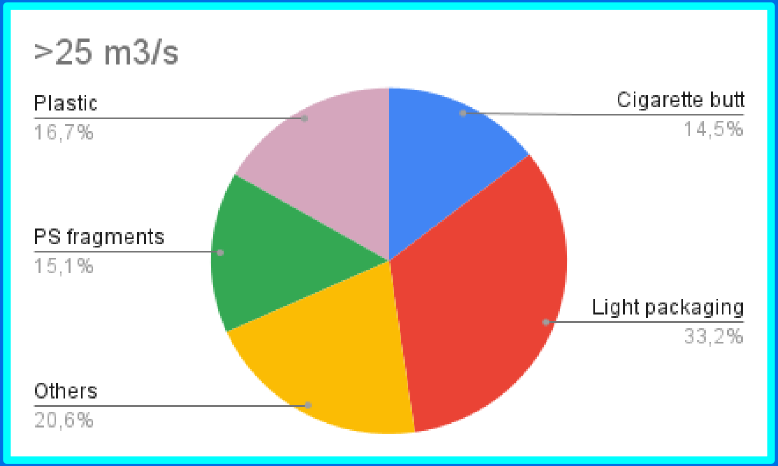




# Dry conditions







# Best estimates

| | | $Q \leq 5 m^3/s$ | $5 < Q < 25 m^3/s$ | $Q \geq 25 m^3/s$ |
|---|---|---|---|---|
| simulation period | 2016-19 | | | |
| average discharge | $7.03 m^3/s$ | | | |
| rain events | 7.8% | | | |
| rain event discharge | 20.8% | | | |
| discharge days | | 63.8% | 31.5% | 4.7% |
| water discharge | | 24.8% | 44.2% | 31.1% |
| average debris flux | 1.26 t/yr | 17.8% | 49.6% | 32.7% |
| median debris flux | 0.81 t/yr | 9.0% | 46.6% | 44.4% |

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80% of fluxes in less than 6% of time !

# Best estimates

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| discharge days | | 63.8% | 31.5% | 4.7% |
| water discharge | | 24.8% | 44.2% | 31.1% |
| average plastic flux | 0.87 t/yr | 13.6% | 54.8% | 31.6% |
| median plastic flux | 0.61 t/yr | 9.3% | 50.4% | 40.3% |

# Best estimates

| | |
|---|---|
| simulation period | 2016-19 |
| average discharge | 7.03 $m^3/s$ |
| rain events | 7.8% |
| rain event discharge | 20.8% |

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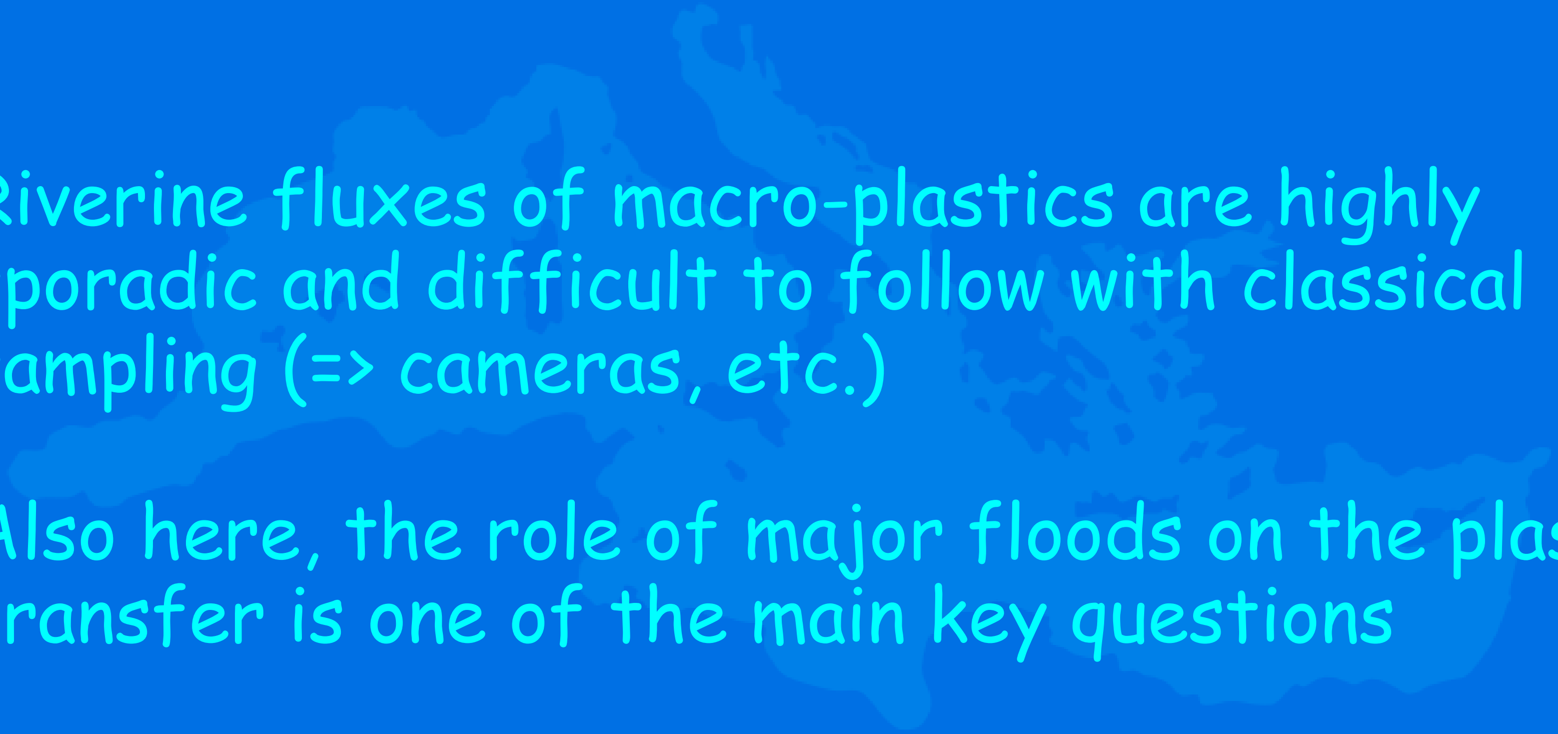
| water discharge | | 24.8% | 44.2% | 31.1% |
| average plastic flux | 0.87 t/yr | 13.6% | 54.8% | 31.6% |
| median plastic flux | 0.61 t/yr | 9.3% | 50.4% | 40.3% |

0.65 t/yr

(high resolution
water discharge)

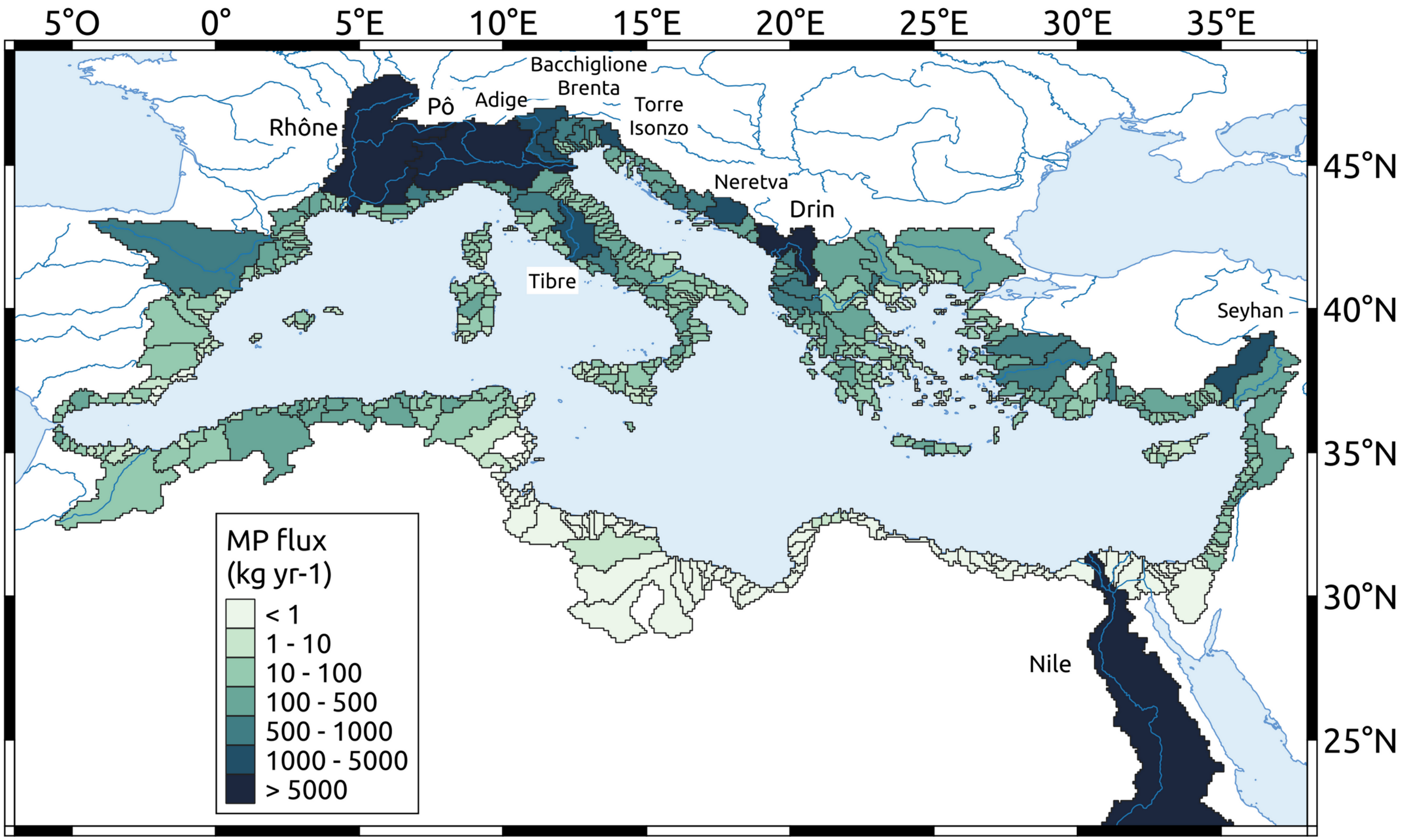
*Laverre et al., submitted to STOTEN*

# Take home messages …



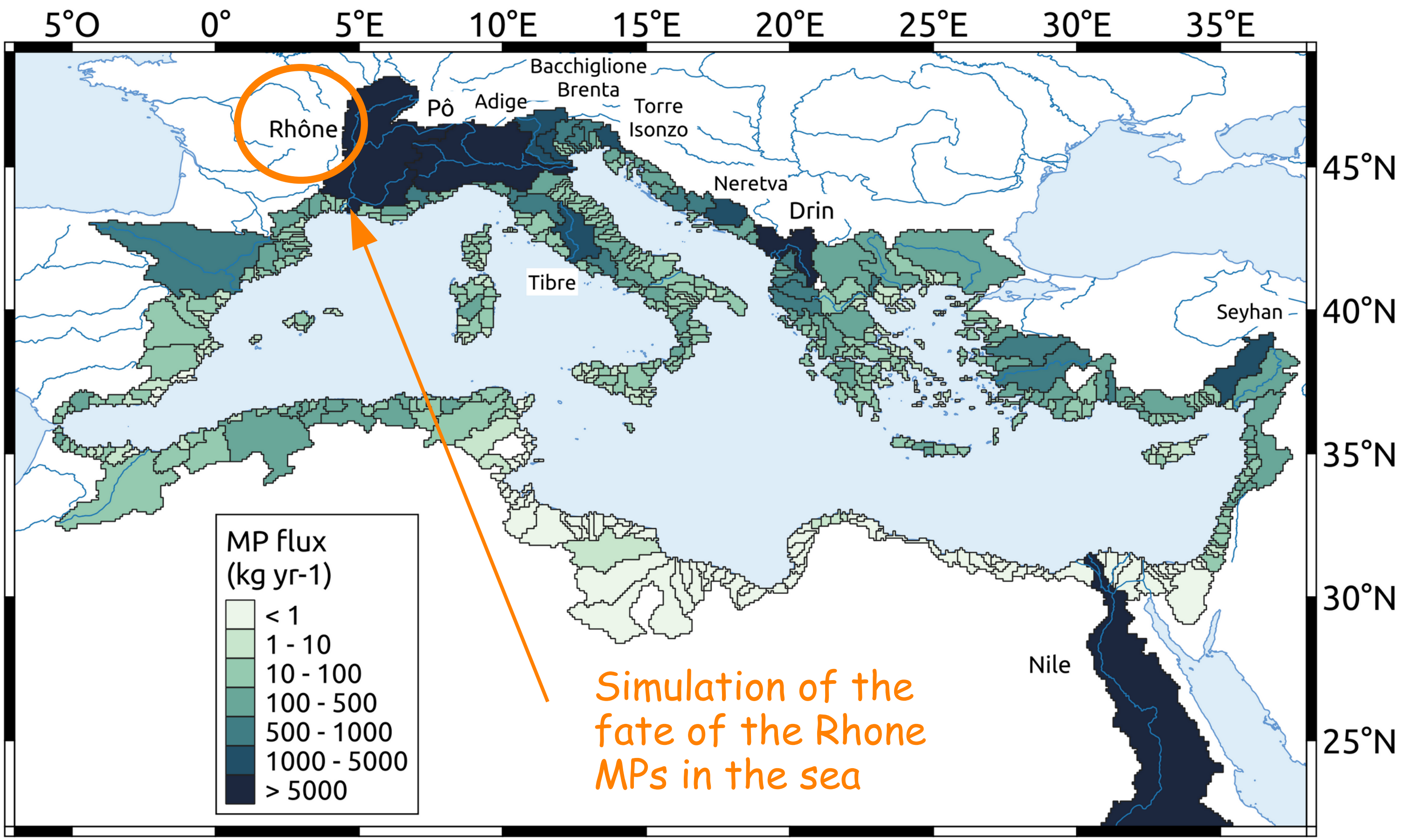
- Riverine fluxes of macro-plastics are highly sporadic and difficult to follow with classical sampling (=> cameras, etc.)
- Also here, the role of major floods on the plastic transfer is one of the main key questions

# Riverine MP fluxes to the Mediterranean Sea



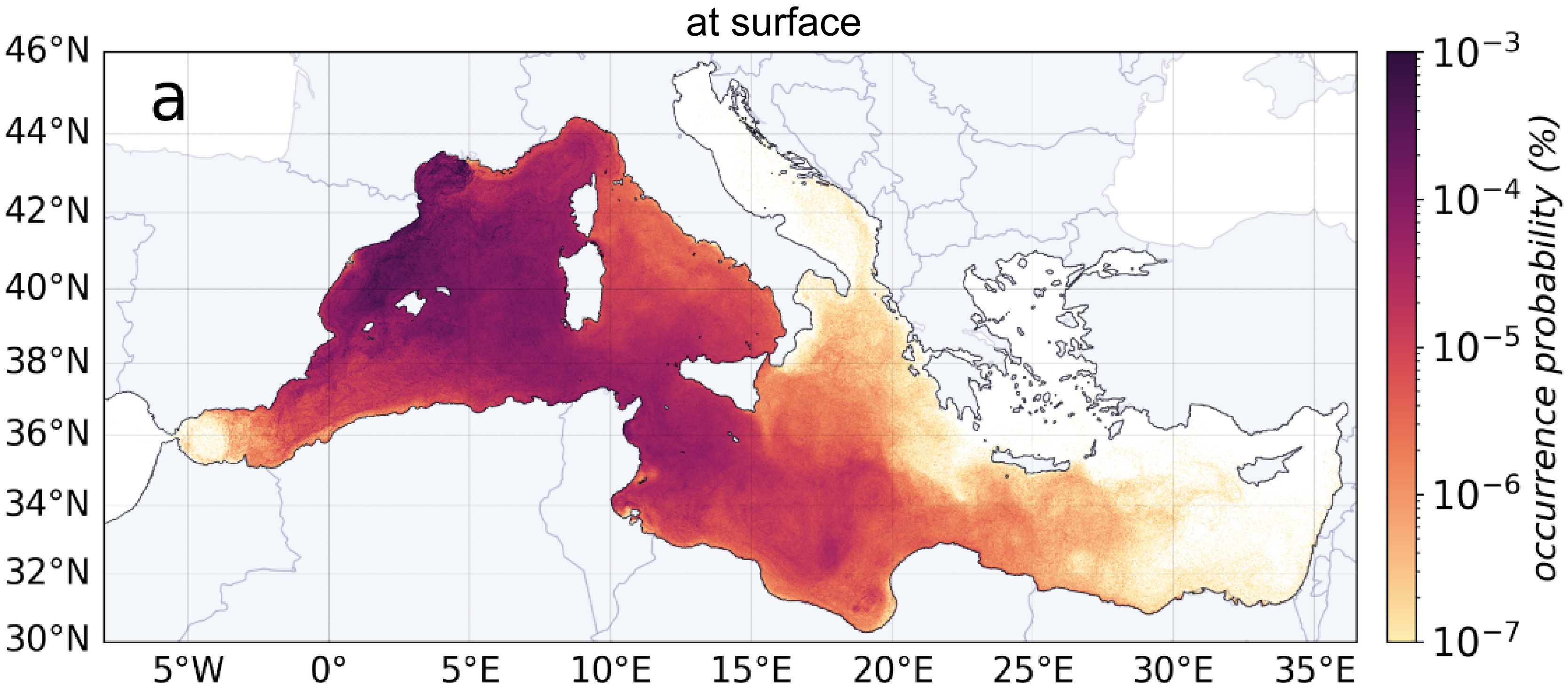
*Weiss et al., 2021*

# Riverine MP fluxes to the Mediterranean Sea



Simulation of the fate of the Rhone MPs in the sea

# Occurence probability after 1 yr of simulation



*Weiss et al., soumis*

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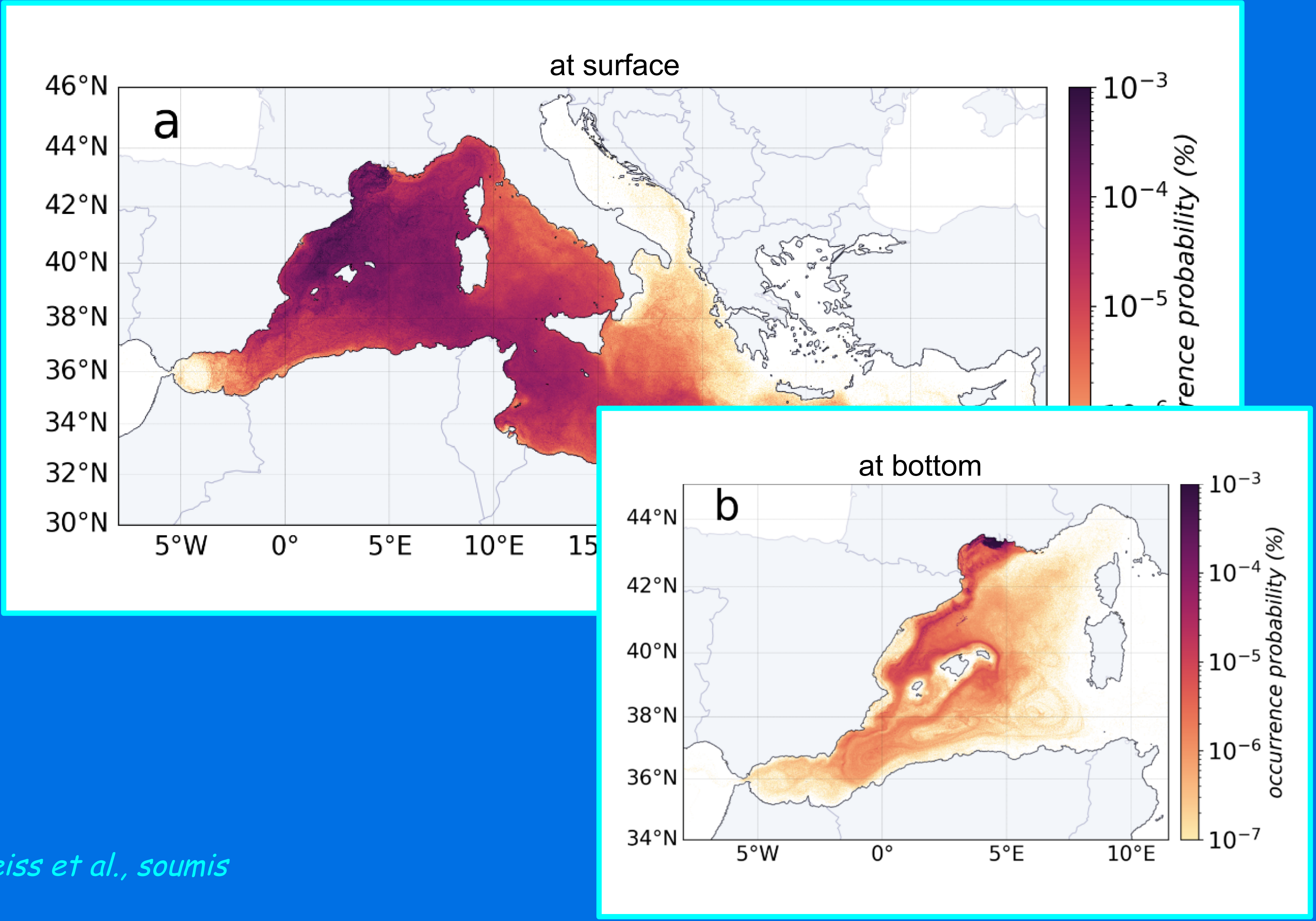
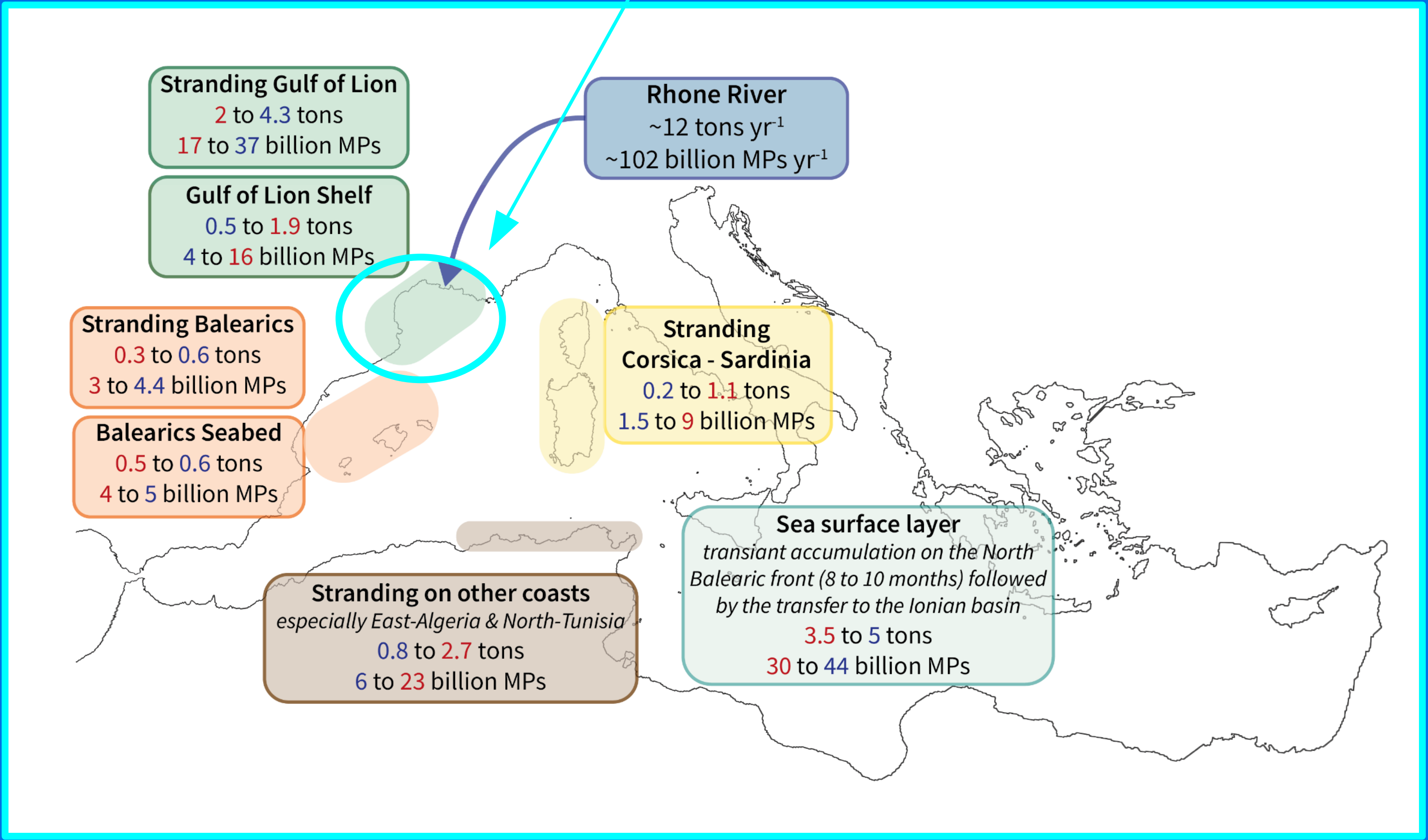


*Weiss et al., soumis*

After 1 year, up to 50 % may remain in the Gulf of Lions



**Stranding Gulf of Lion**
2 to 4.3 tons
17 to 37 billion MPs

**Gulf of Lion Shelf**
0.5 to 1.9 tons
4 to 16 billion MPs

**Rhone River**
~12 tons yr$^{-1}$
~102 billion MPs yr$^{-1}$

**Stranding Balearics**
0.3 to 0.6 tons
3 to 4.4 billion MPs

**Balearics Seabed**
0.5 to 0.6 tons
4 to 5 billion MPs

**Stranding Corsica - Sardinia**
0.2 to 1.1 tons
1.5 to 9 billion MPs

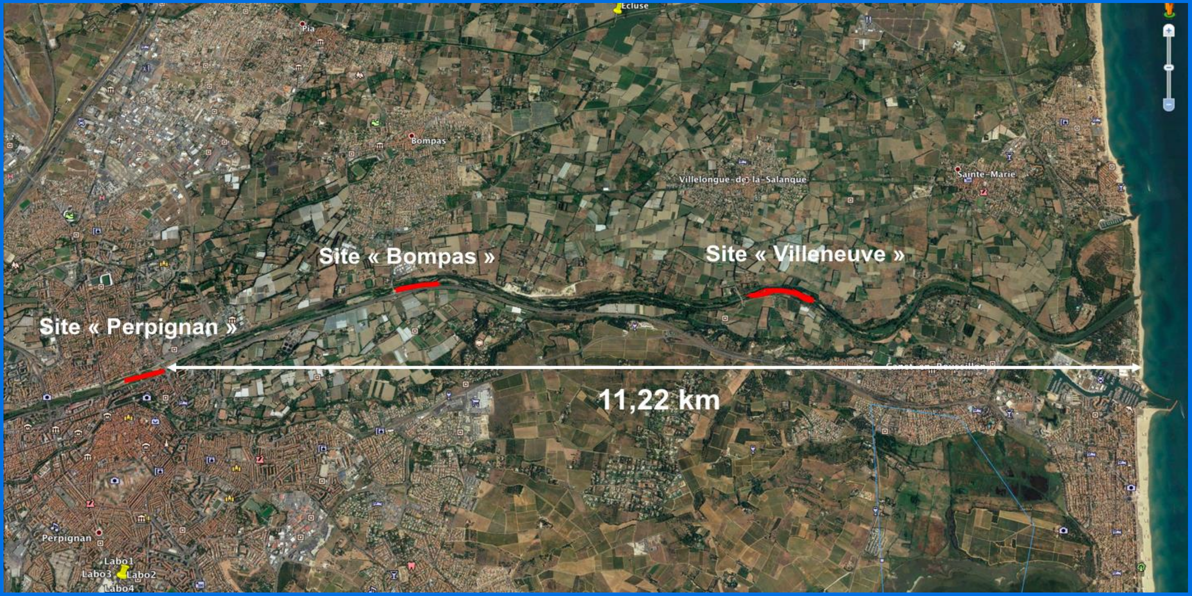
**Stranding on other coasts**
*especially East-Algeria & North-Tunisia*
0.8 to 2.7 tons
6 to 23 billion MPs

**Sea surface layer**
*transiant accumulation on the North Balearic front (8 to 10 months) followed by the transfer to the Ionian basin*
3.5 to 5 tons
30 to 44 billion MPs

*Weiss et al., soumis*

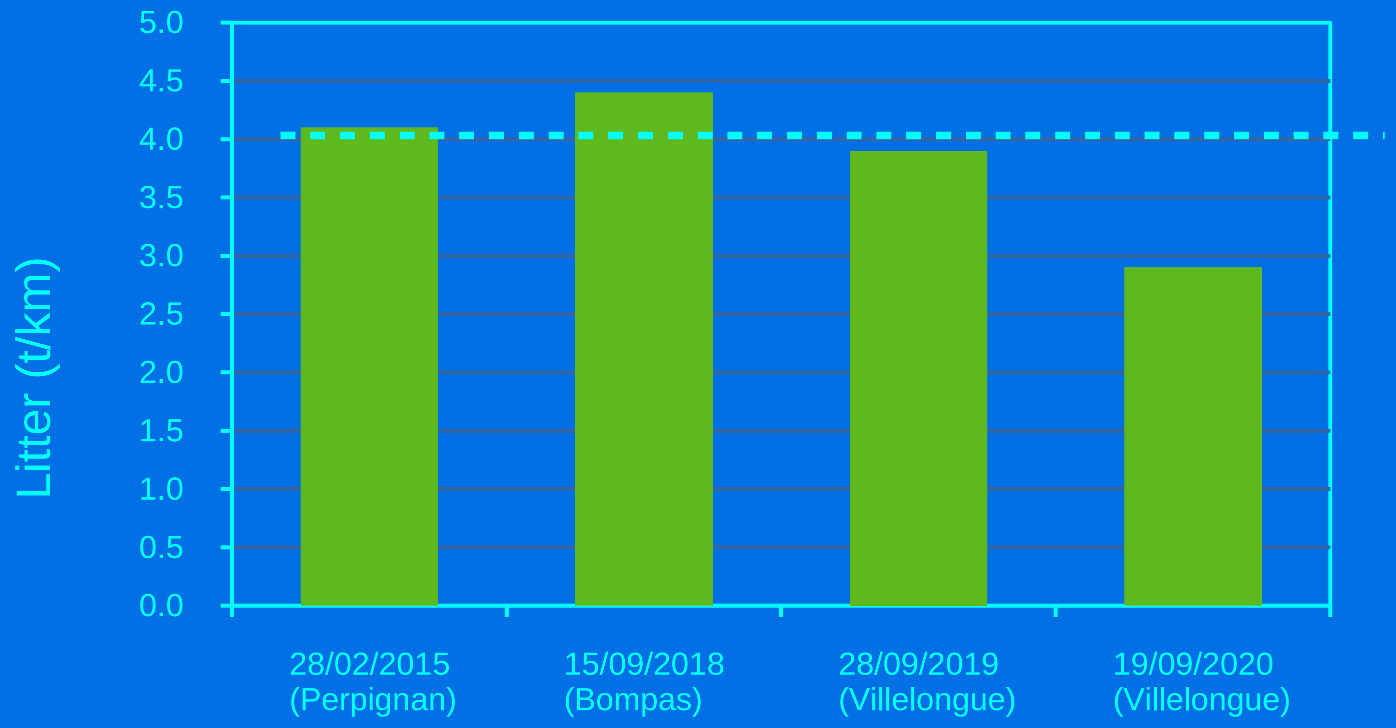
# But what about major floods ?

# Citizen Science Approach



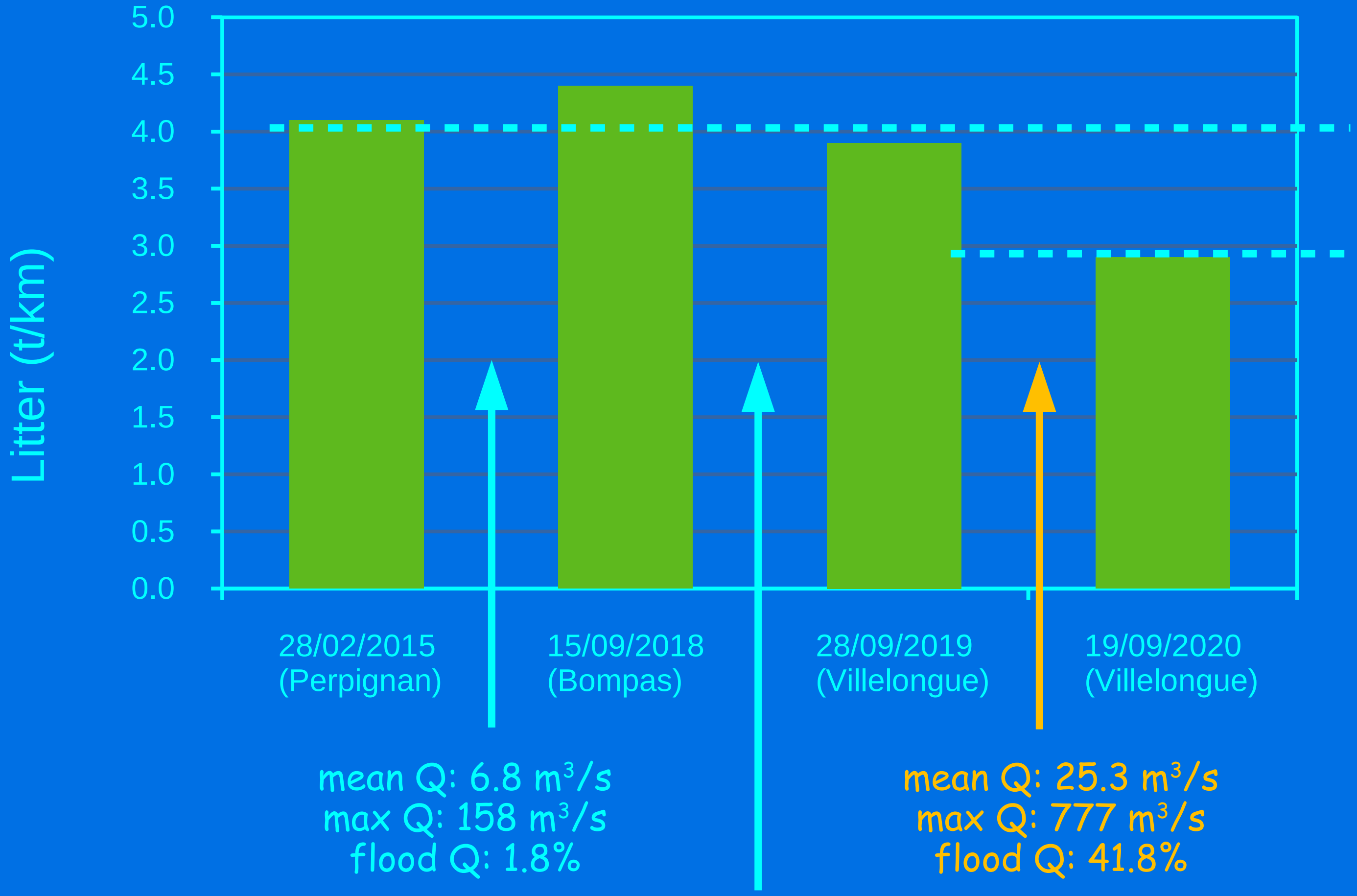
Counting of plastic litter along the lower river leaves

# Estimates litter stock on leaves : ≈ 40 t



on average
4 t/km

# Estimates litter stock on leaves : ≈ 40 t



on average
4 t/km

after flood
3 t/km

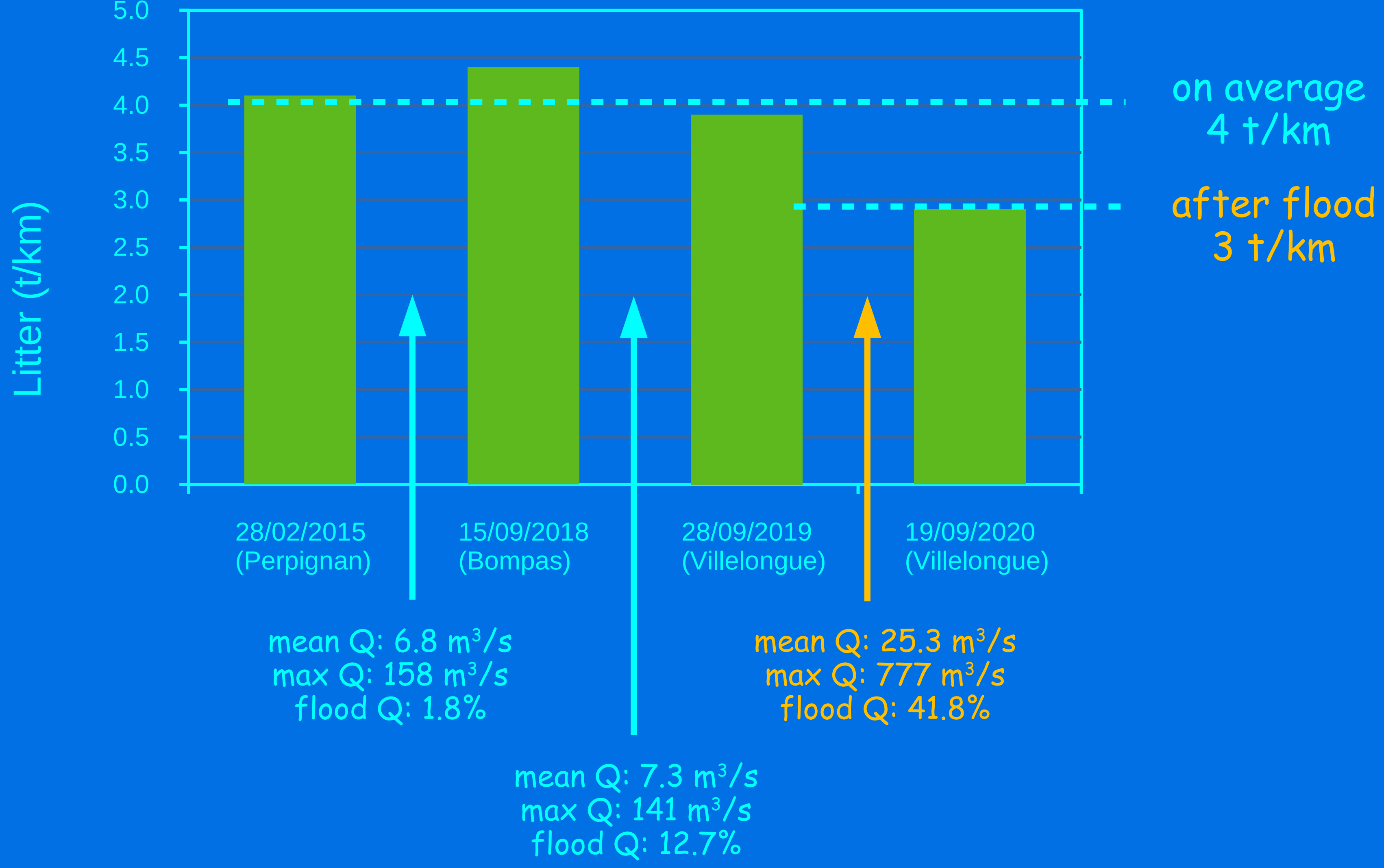
mean Q: 6.8 m³/s
max Q: 158 m³/s
flood Q: 1.8%

mean Q: 25.3 m³/s
max Q: 777 m³/s
flood Q: 41.8%

mean Q: 7.3 m³/s
max Q: 141 m³/s
flood Q: 12.7%

# Estimates litter stock on leaves : ≈ 40 t

=> potential flushing after flood : 10 t



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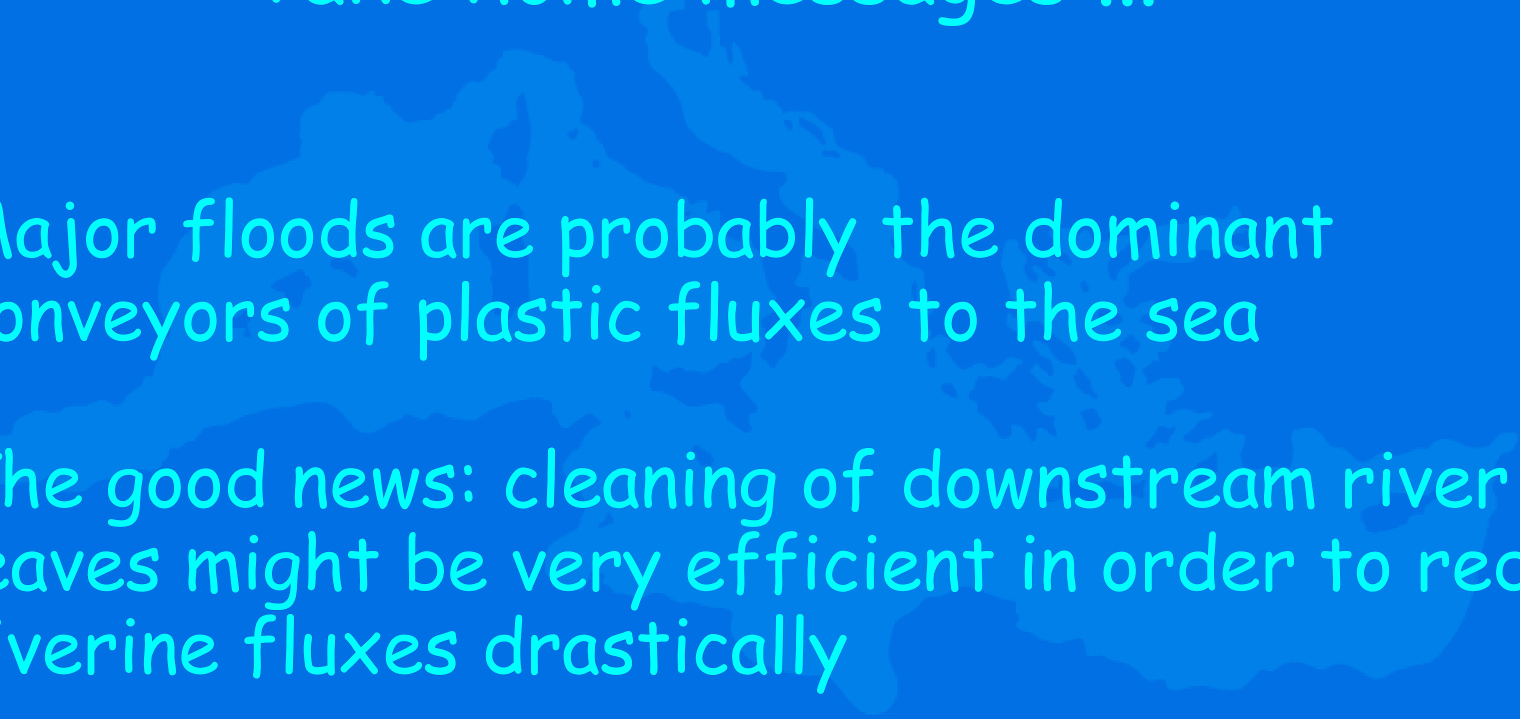
# Take home messages ...



- Major floods are probably the dominant conveyors of plastic fluxes to the sea

- The good news: cleaning of downstream river leaves might be very efficient in order to reduce riverine fluxes drastically