Impacts of Ship Traffic on the Ecology of Navigable Rivers and Waterways in Germany

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Federal Institute of Hydrology, Koblenz, Germany

Structure of this talk:

- Our Institute
- My Department
- Our duties and activities
- How we do things (Methods)
- Ship traffic on rivers and waterways in Germany
- Its impact on animal ecology (case studies)

1. German Federal Institute of Hydrology, Koblenz

Referat U4 Tierökologie

Basic duties:

- Subordinated to the German Federal Ministry of Transport, Building and Housing

- Research in aquatic sciences and hydrology

- acts as consultant for the Federal Ministries and their subordinate authorities (local Waterways and Shipping Administrations and Offices)

- staff: about 300

Field of responsibility

Federal Institute of Hydrology

Bundesanstalt für Gewässerkunde

Referat U4 Tierökologie

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Director and Professor

Secretariat
IHP/UNESCO
OHP/WMO

Department C
Controlling, Public Relations

Division M
Quantitative Hydrology

Department M1
Water Quantities, Water Levels, Runoff Models

Department M2
Water Balance, Forecasting Methods, GRDC

Department M3
Groundwater, Geology, River Morphology

Department M4
Physics, Instruments and Measurements

Department M5
Geodesy

Division G
Qualitative Hydrology

Department G1
General Water Quality Issues

Department G2
Aquatic Chemistry

Department G3
Bio-Chemistry, Ecotoxicology

Department G4
Radiology

Division U
Ecology

Department U1
General Ecol. Issues, Environmental Protection

Department U2
Ecological Interactions

Department U3
Floristic Studies, Landscape Planning

Department U4
Animal Ecology

Project Group
River Ecology Elbe

Administration

Department Z1
Administration

Department Z2
Information Technology

International Involvement

Secretariat
IHP/UNESCO
OHP/WMO

Global Runoff Data Center (GRDC)

http://www.bafg.de/grdc.htm

EurAqua

http://www.euraqua.org/

Status: June 2003

Department U4
Animal Ecology

Department U4 Animal Ecology

Head: Dr. Koop **Staff: 18**

Duties and responsibilities

U41: **Basic ecology of aquatic animals**
Lab for animal- and aquatic ecology, workshop

contact: Dr. Koop

U42: **Animal ecology of regulated waterways and channels**

contact: Dr. Schleuter

U43: **Animal ecology of unregulated waterways (Rhine, Weser, Elbe, Oder)**

contact: Dr. Anlauf

U44: **Animal ecology of coastal waterways**

contact: Dr. Leuchs

U45: **Mathematics and statistics**

contact: Dr. Nöthlich

Our Field methods in large rivers and waterways

Macrozoobenthos

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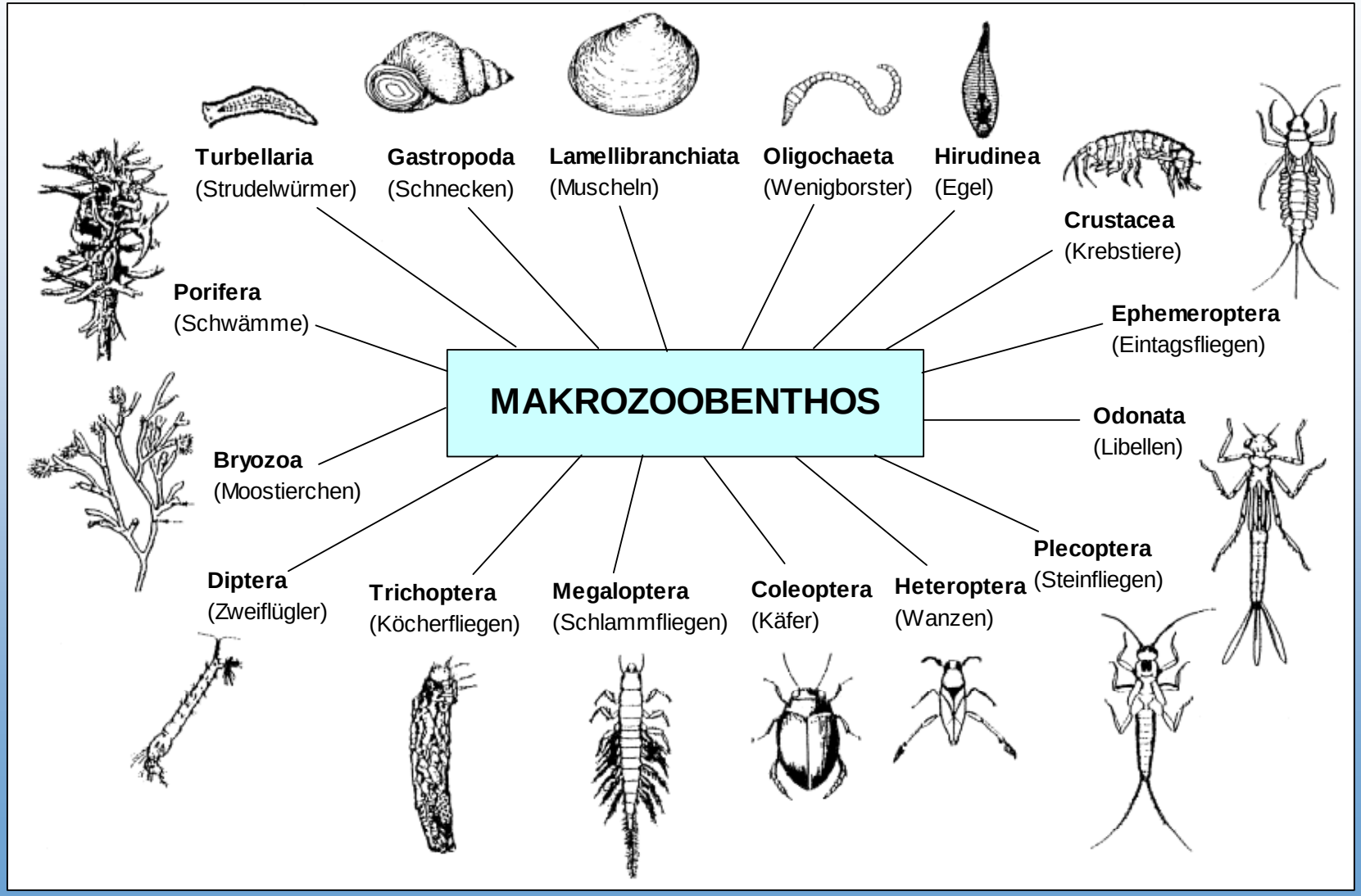

Dredge sampling

Dredge sampling

Sample preparation

Quantitative hard substrate sampling

Size fractionating (sieving)

Samples

Different grain size fractions

Sampling devices for hard substrate and mud

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Suction sampler

Caisson Ship

Caisson Ship “Carl Straat”

Inside the Caisson

Sampling of benthos material

Freeze coring

Freeze coring within a caisson

Freeze coring

Airlift-Sampler

Taxonomy

Ecophysiology

SCUBA -Diving

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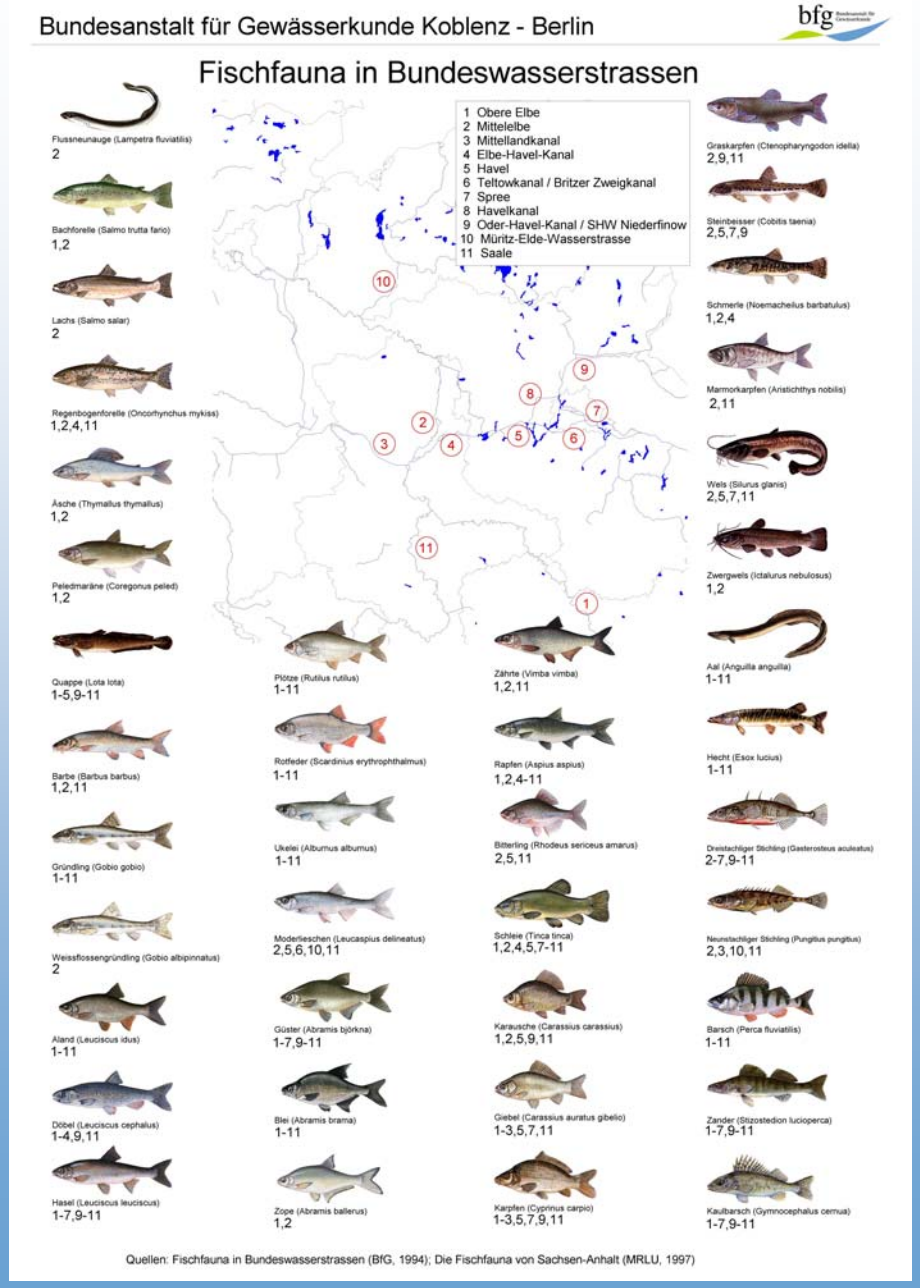

Fish species in German Waterways

Electro Fishing

Ship traffic in Germany

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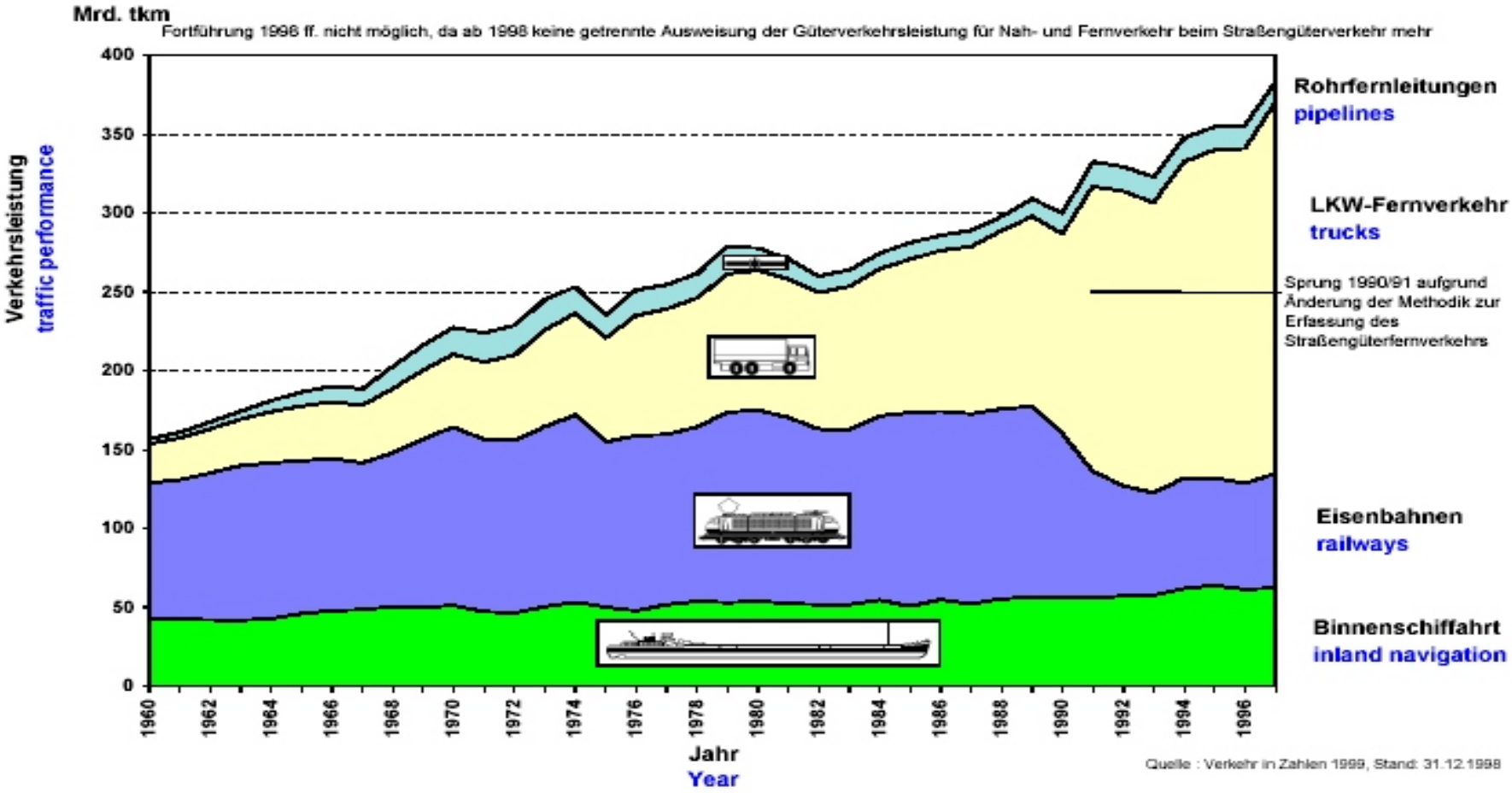
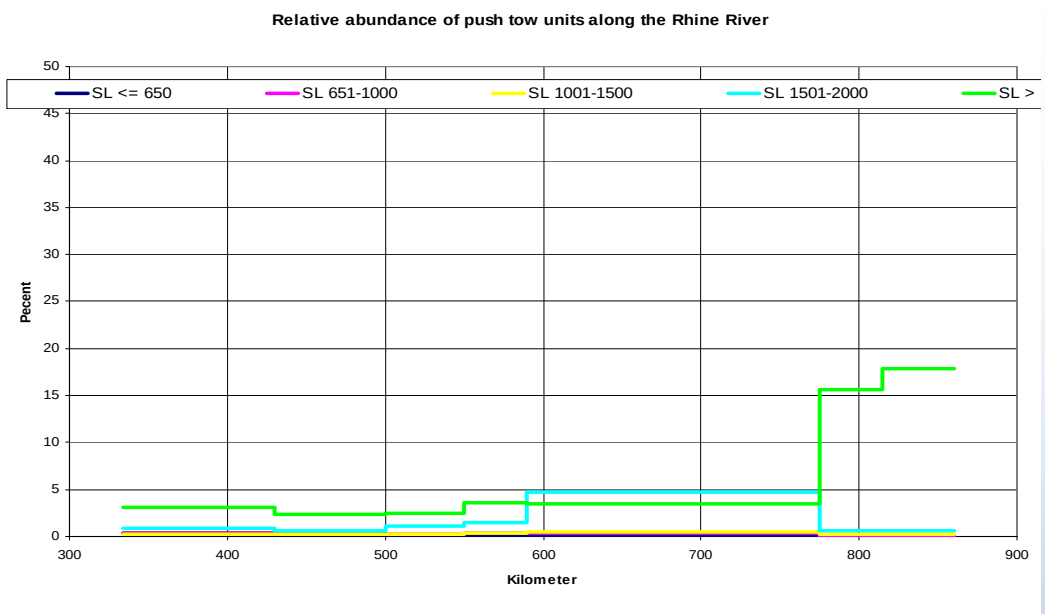
Entwicklung des Verkehrsmarktes im binnenländischen Güterfernverkehr in Deutschland

Share of the main transports modes in the total volume of long - distance services in Germany

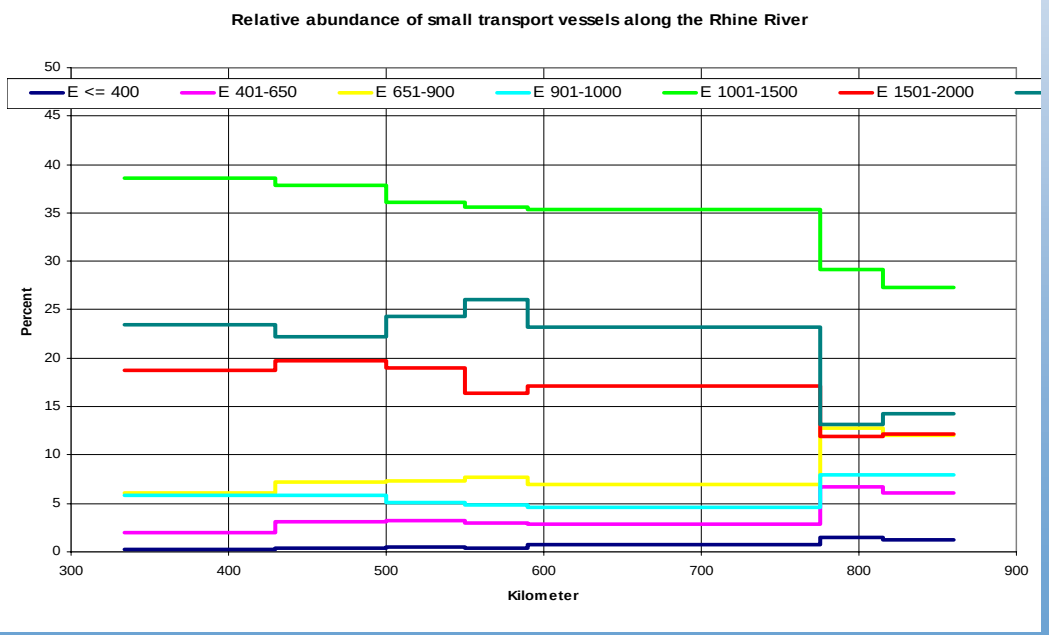


Federal waterways

Frequency of inland ship traffic in 1997

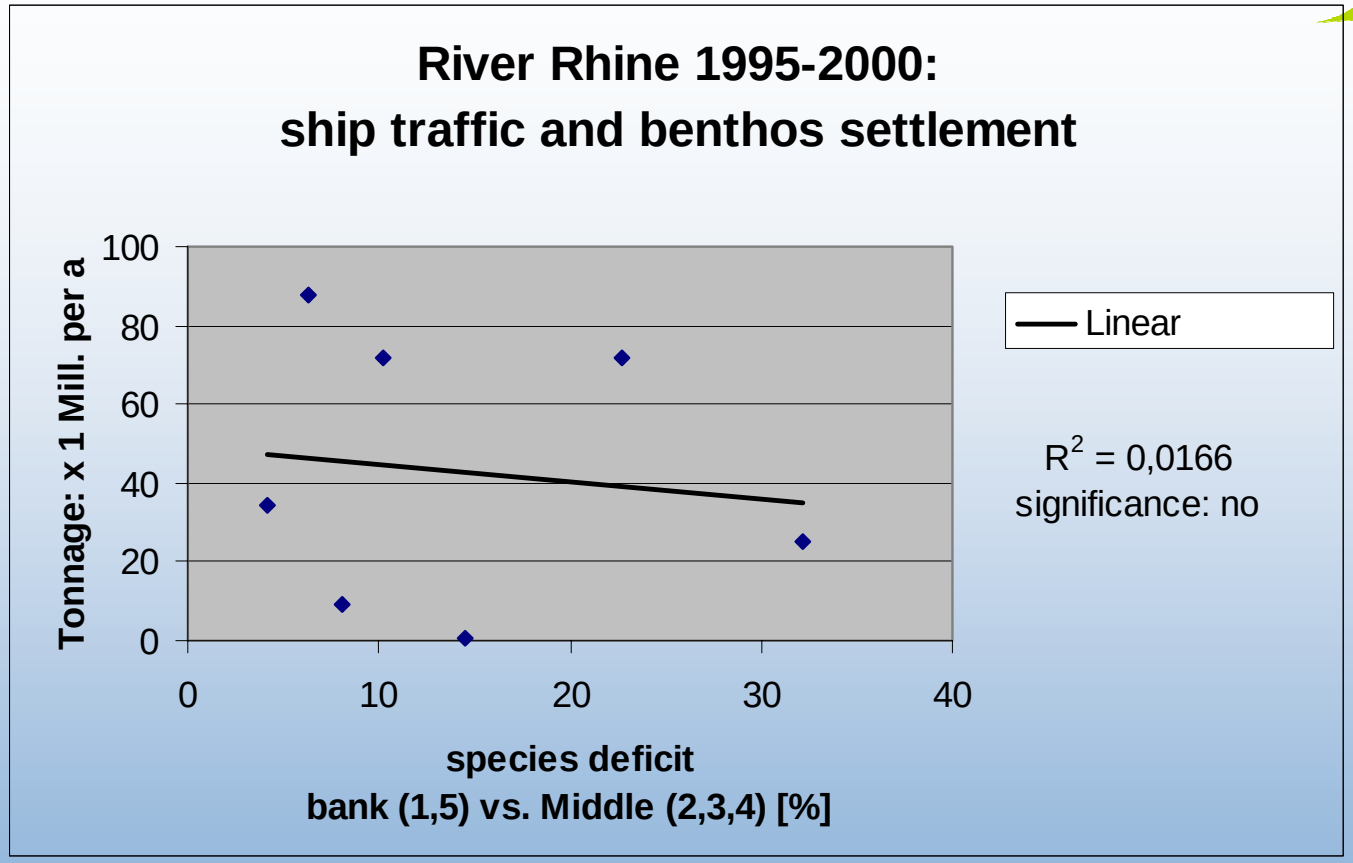


Relative abundance of push tow units along the Rhine River



Relative abundance of small transport vessels along the Rhine River

BAW unpublished results



Direct influence of ship traffic seems to be small in waterways. There is no significant correlation between the tonnage of ships and the deficit of the middle reaches in comparison to the settlement of the banks.

Changes in the hydrological regime (dredging):

Over the past we were mainly concerned about influence of changes in the hydrological regime (e.g. by dredging or construction) on the animal ecology

Recently we have started also to investigate the direct influence of the ship traffic on the ecology of aquatic animals.

Constructions along shipping routes:

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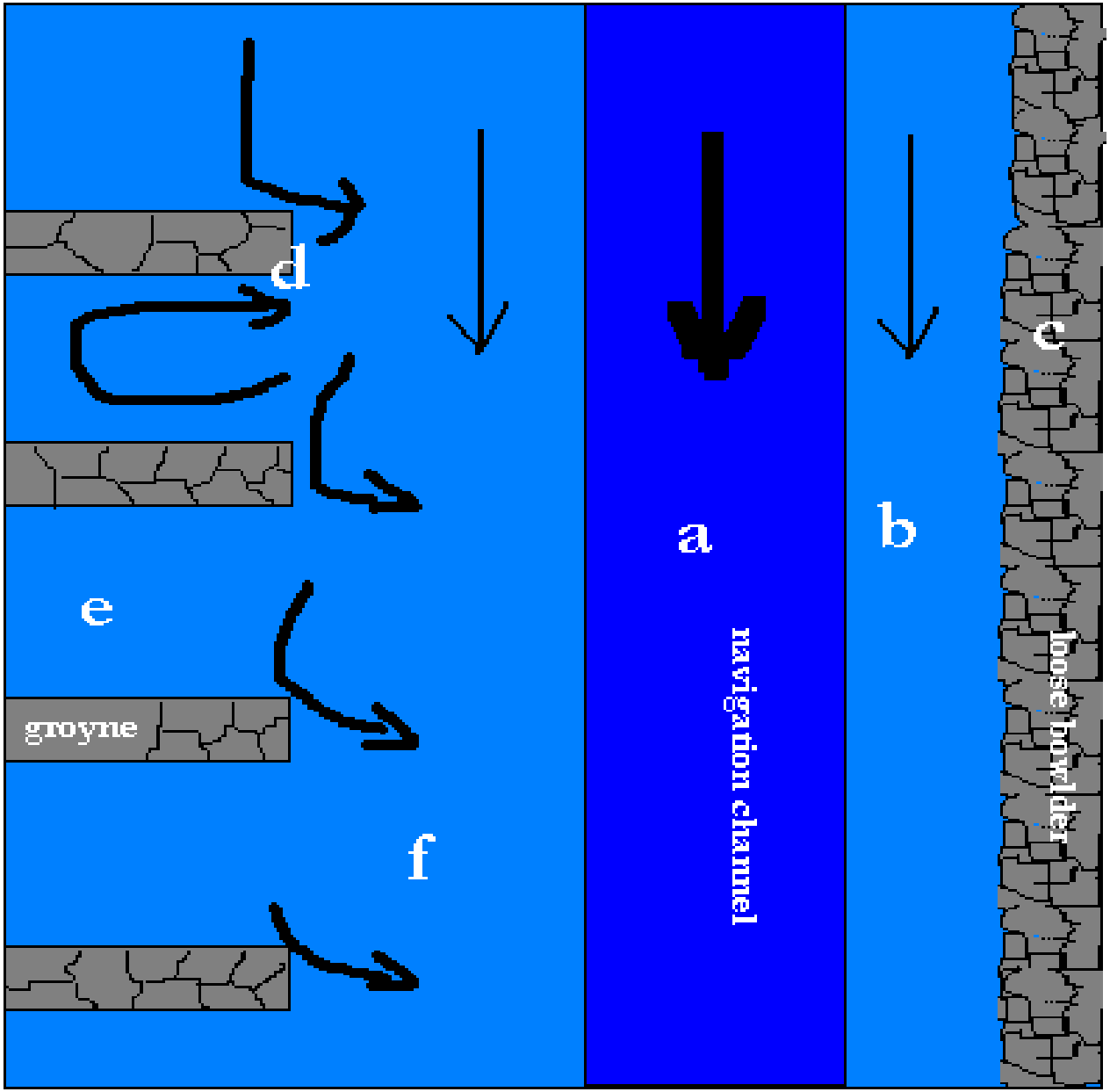

Scheme of a typical regulated river

with its main habitats (a-f).

Main difference between habitats is mainly the grain size distribution and the current velocity.

Groynes and jetties in the River Elbe

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Since 1880 groynes were used to establish the River Elbe

Today we have approx. 6900 groynes in the River Elbe

Groyne fields as habitats

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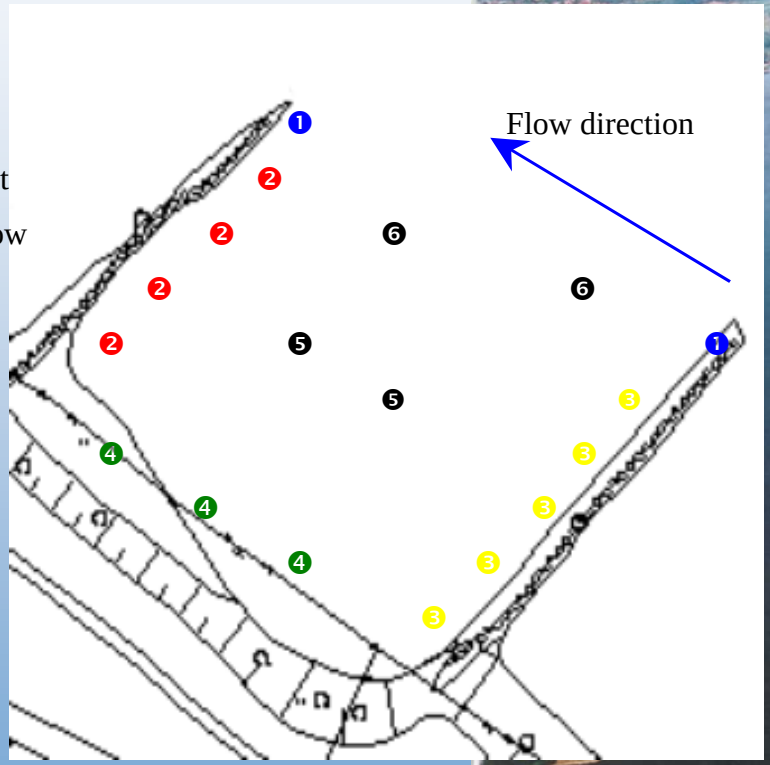
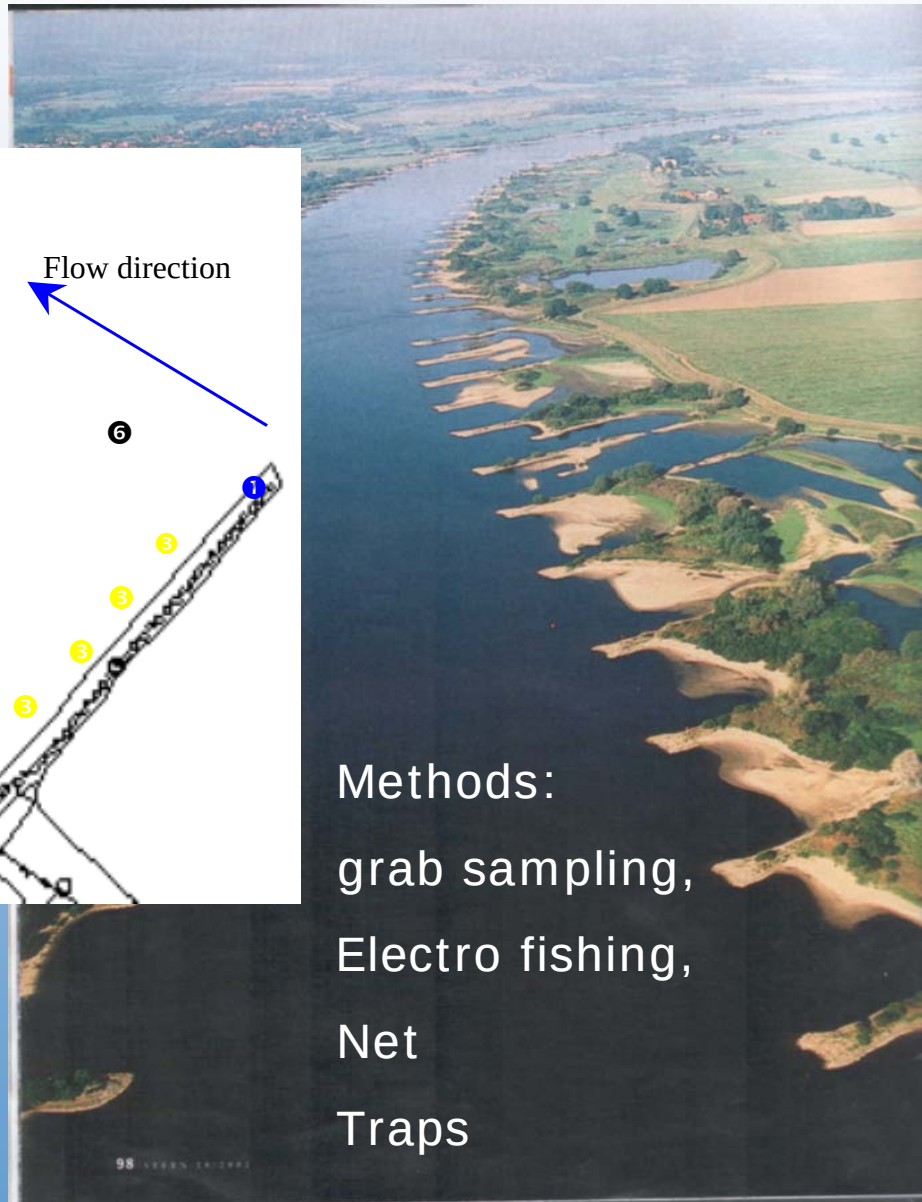
1. Groyne head
2. Groyne saddle exposed to current
3. Groyne saddle not exposed to flow
4. Aggradation zone
5. Sedimentation zone
6. Navigation channel



- stone, high flow velocity
- stone, medium flow velocity
- mud, low flow velocity
- sand, low flow velocity
- free-water, changing flow conditions



Methods:

grab sampling,

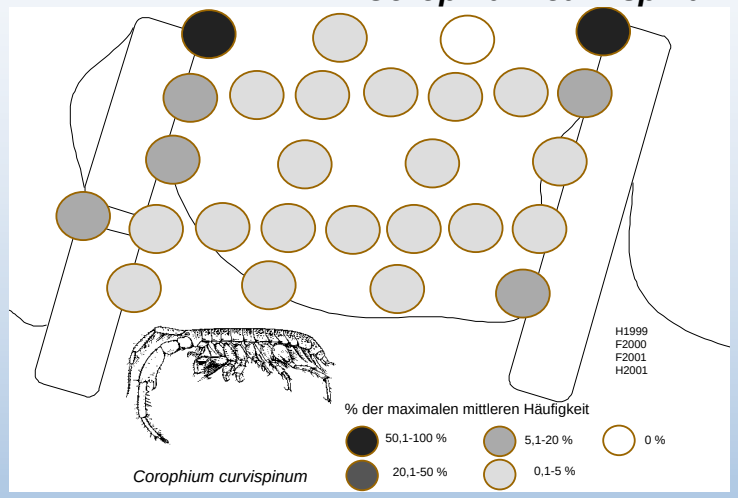
Electro fishing,

Net

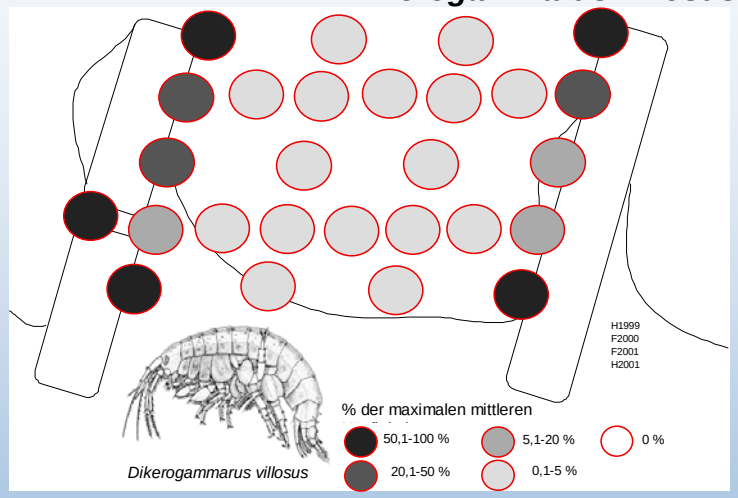
Traps

Macrozoobenthos along groynes

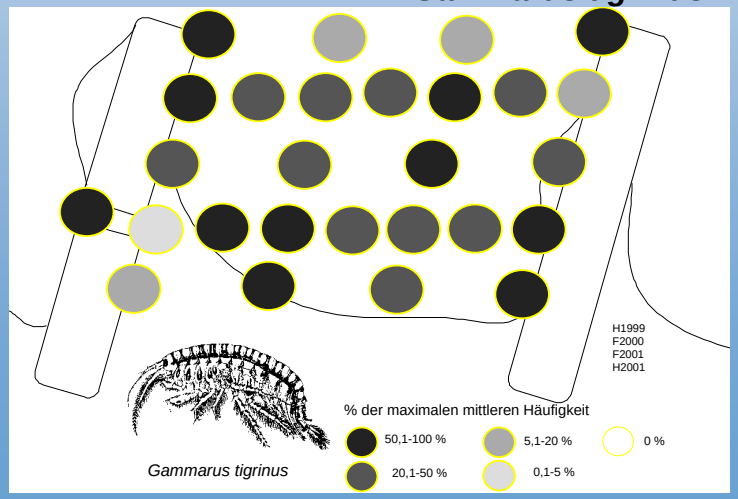
Corophium curvispinum



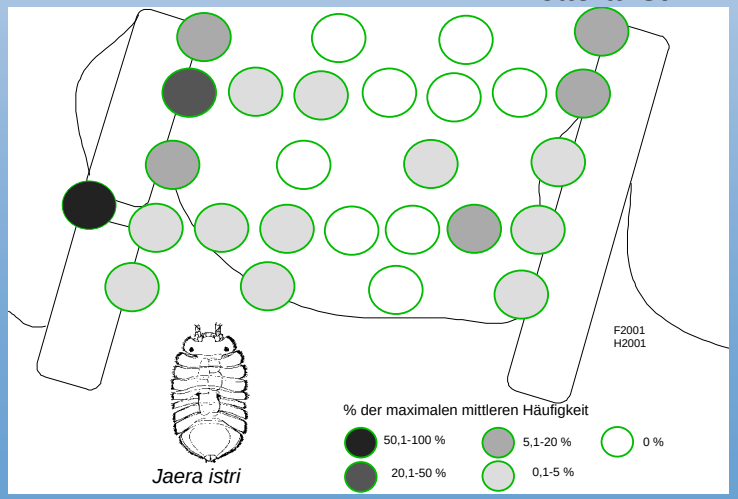
Dikerogammarus villosus



Gammarus tigrinus



Jaera istri



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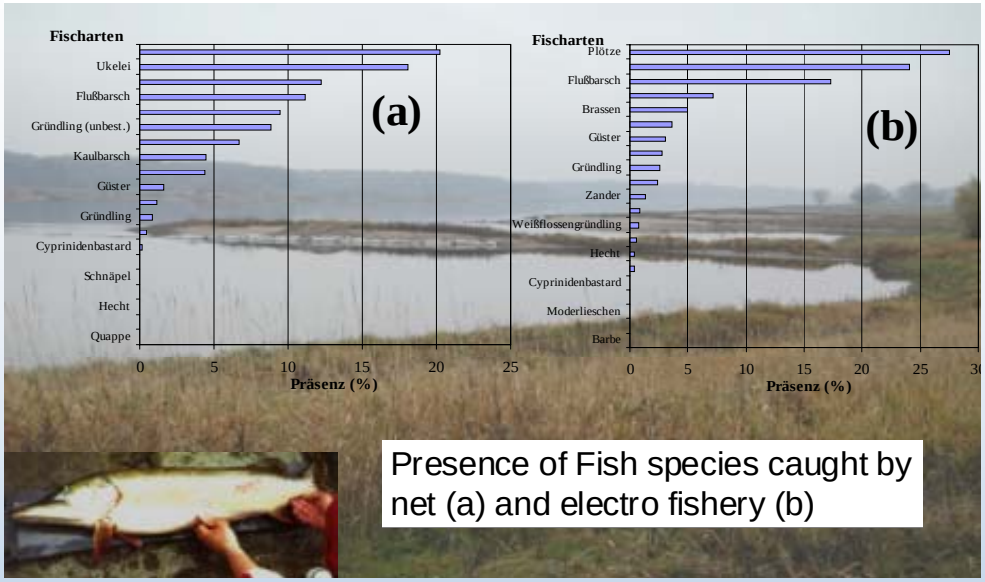
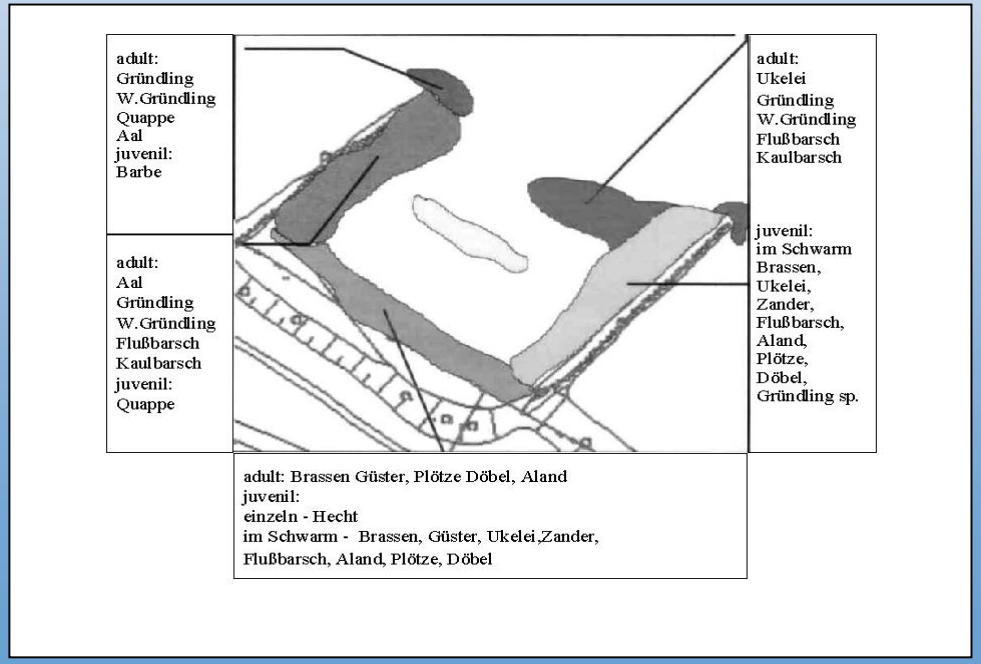
Fish fauna of groyne fields



Presence of Fish species caught by net (a) and electro fishery (b)



Ukelei - bleak

Flußbarsch - perch

Gründling - gudgeon

Kaulbarsch - ruff

Hecht - pike

Quappe - burbot

Barbe - barbel

Moderlieschen - sunbleak

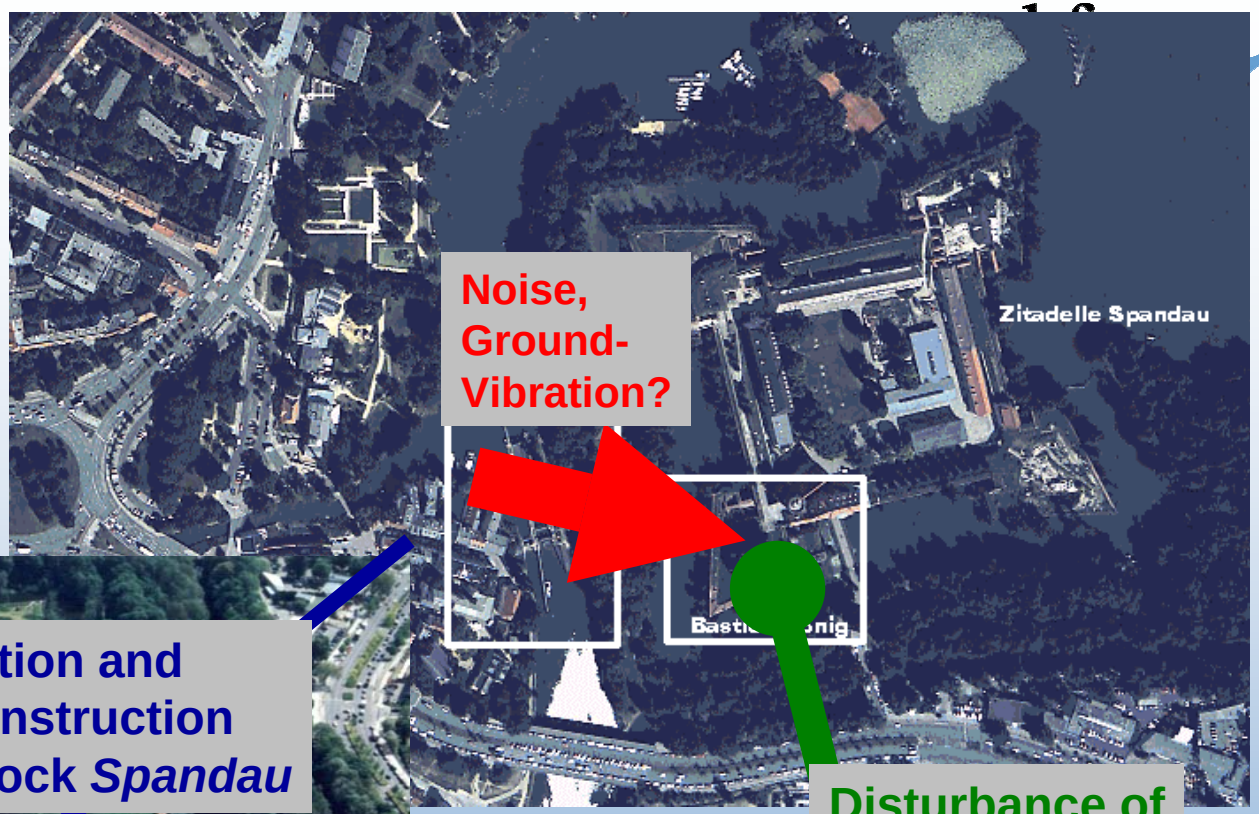
Plötze - roach

Brasse - bream

Zander - green pike

Noise and vibration caused by ship traffic and construction sites along shipping channels and water ways

Noise: Case study 1 Demolition and construction of a lock and bat activity



Noise, Ground-Vibration?

Demolition and new construction of the lock *Spandau*

Disturbance of bat habitats?

Noise: Case study 1

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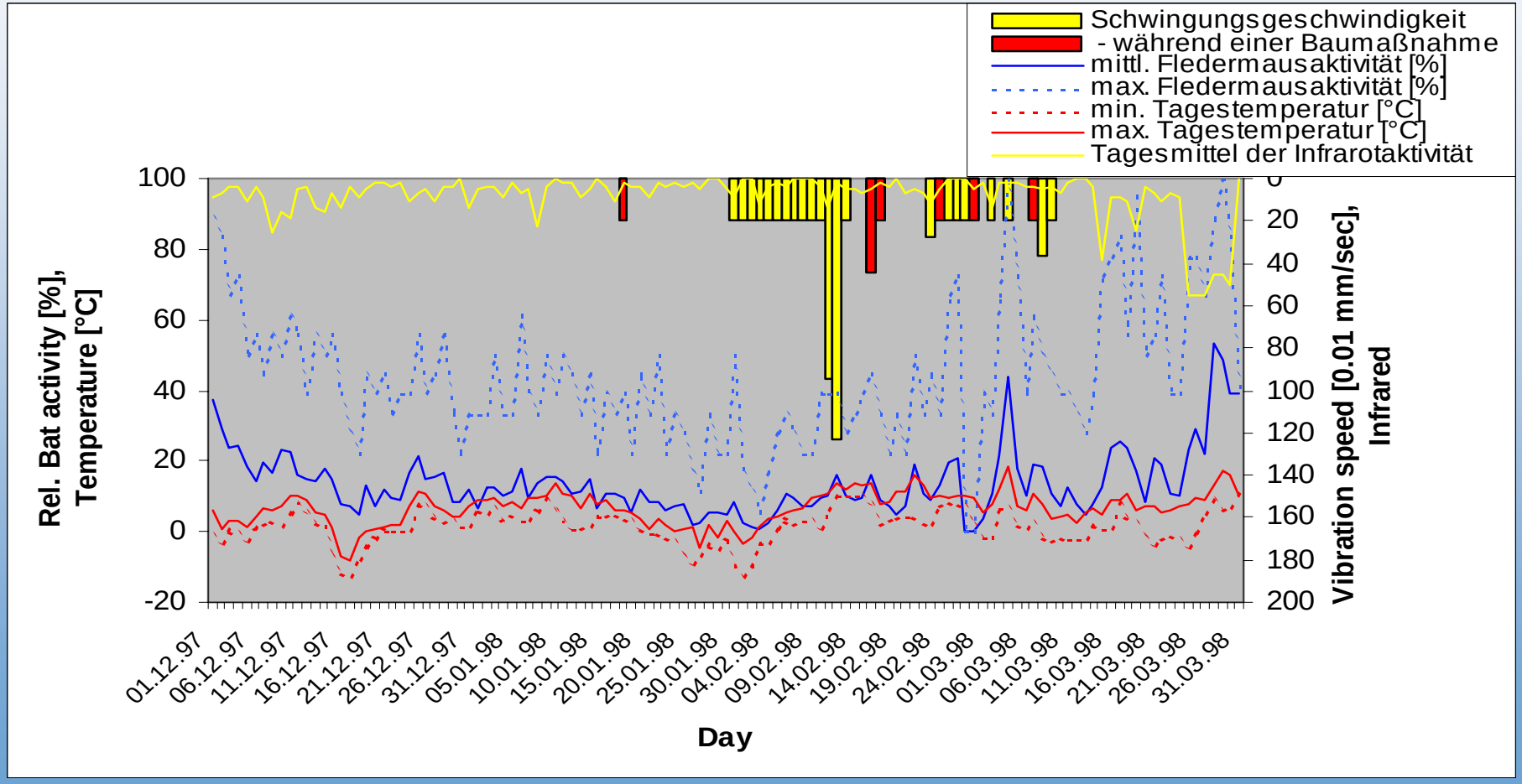
Daily bat activities in relation to temperature, vibration velocity, and infrared measurements



Noise: Case study 2
Ship traffic and its influence on fish

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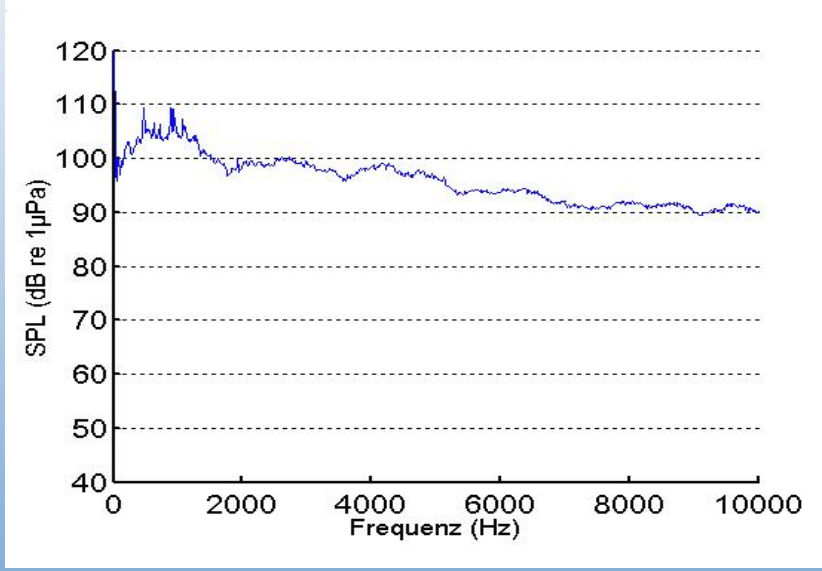
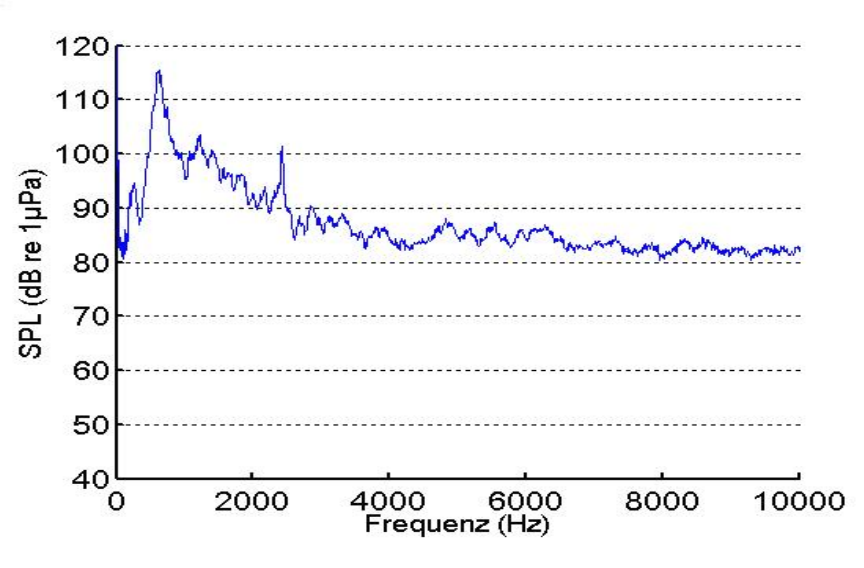
Noise from ships (left) and bucket dredges (right) extend over the entire frequency spectrum ranging from 0.1 Hz to at least 10000 Hz. The noise level extended up to 115 dB (rel. to 1 µPa).



Frequency analysis of ship noise



Frequency analysis of a dredge (Bucket Dredge)

(Rüter, Koop, Bleckmann 2003, unpublished results)

Noise: Case study 2
Can fish hear or feel this noise?

In cooperation with the University of Bonn (Prof. Bleckmann) measurements of hearing thresholds in native fish species have been carried out.

Noise: Case study 2
Can fish hear or feel this noise?
Hearing threshold levels in native fish species

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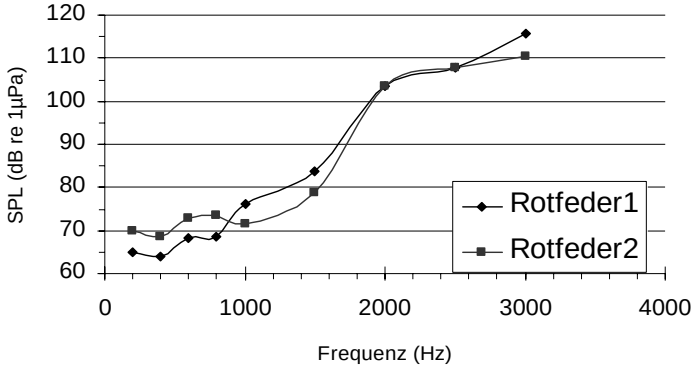
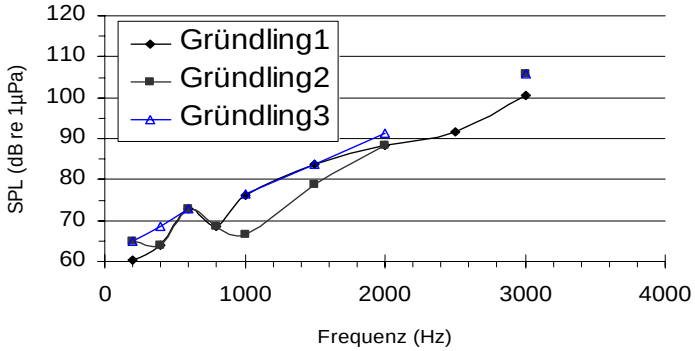
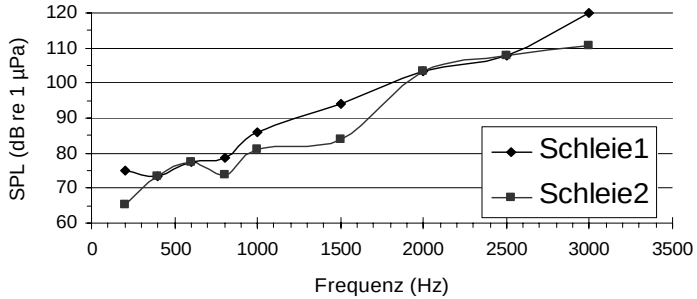


Rudd (*Scardinius erythrophthalmus*)

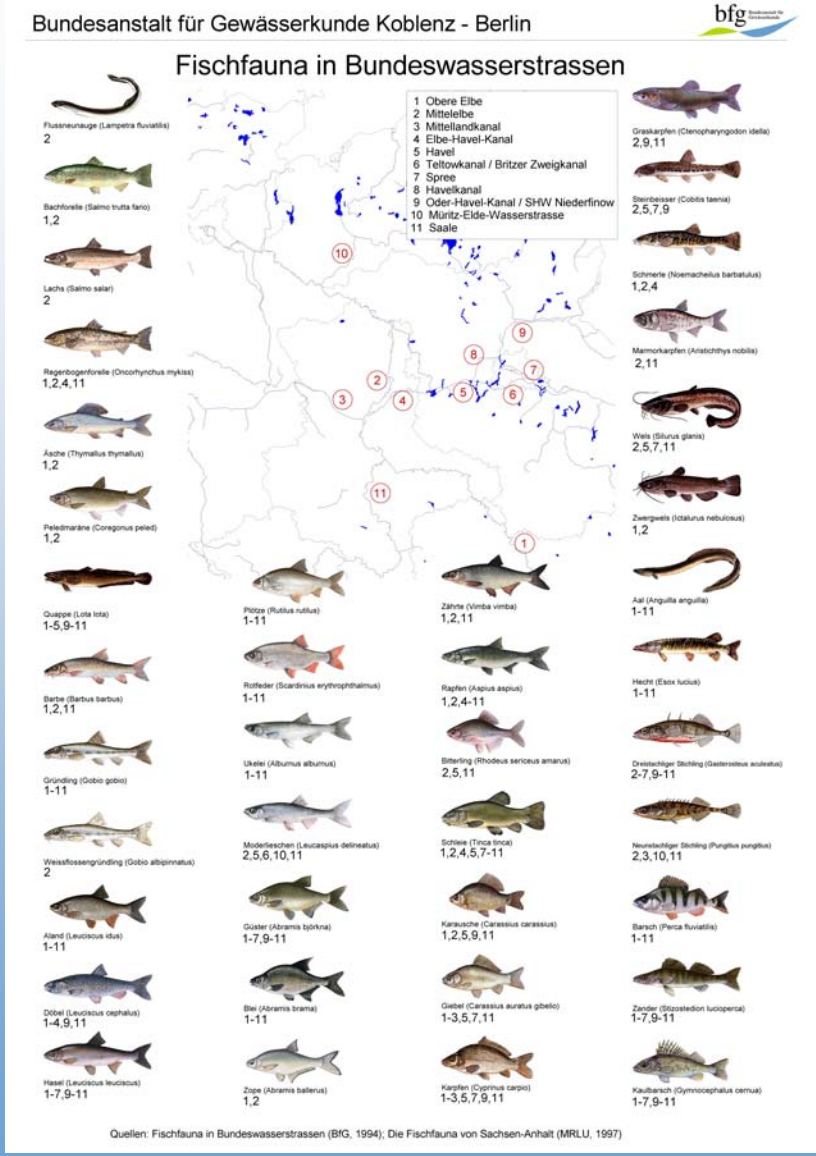


Gudgeon (*Gobio gobio*),



Tench (*Tinca tinca).*

Rüter, Koop, Bleckmann 2003
unpublished results



In the near future we will provide similar measurements for the majority of native fish species and we will investigate different noise sources and evaluate their influence on the fish fauna.

Indirect (sustainable) ecological consequences of ship traffic

Sustainable effects of ship traffic on macrozoobenthos densities

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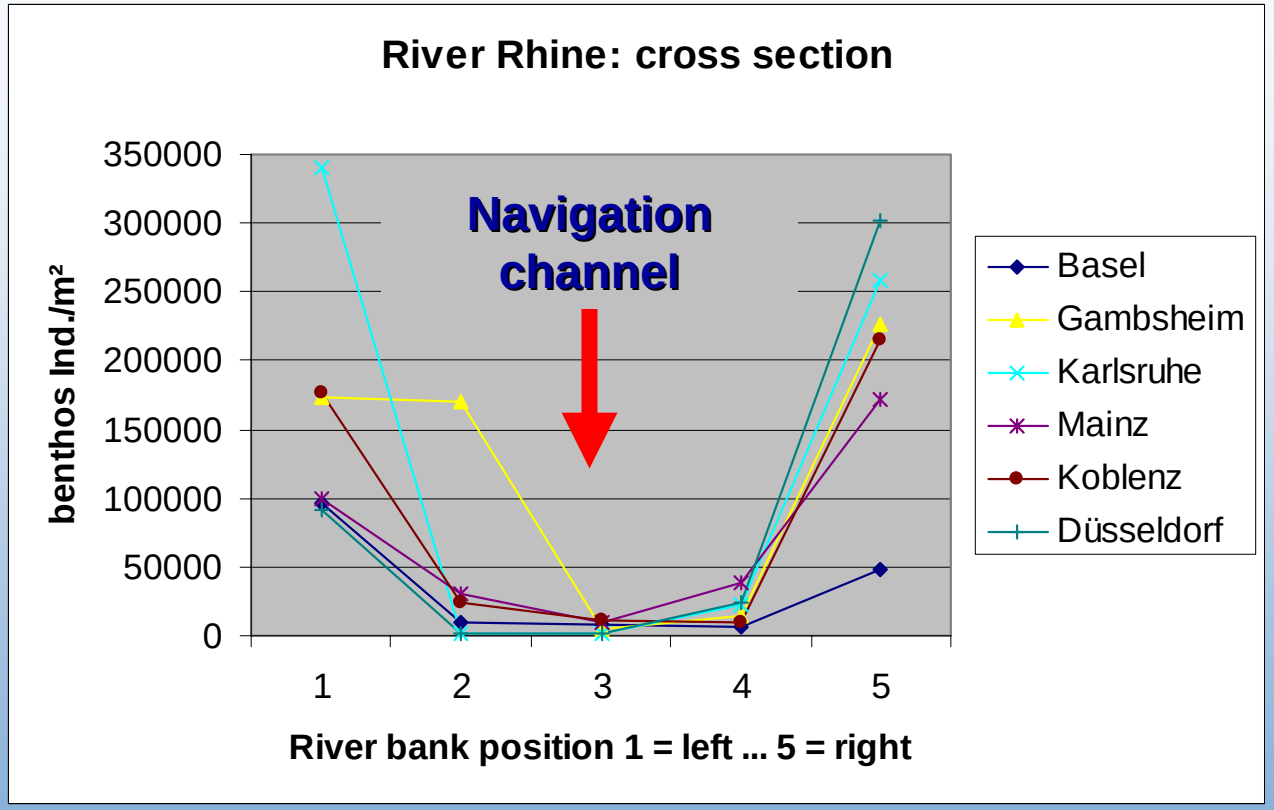

Density of benthos on large stones on the banks (1,2) is on average 20 x the density on the unstable pebbles and sands in the middle (2,3,4).

Rhine

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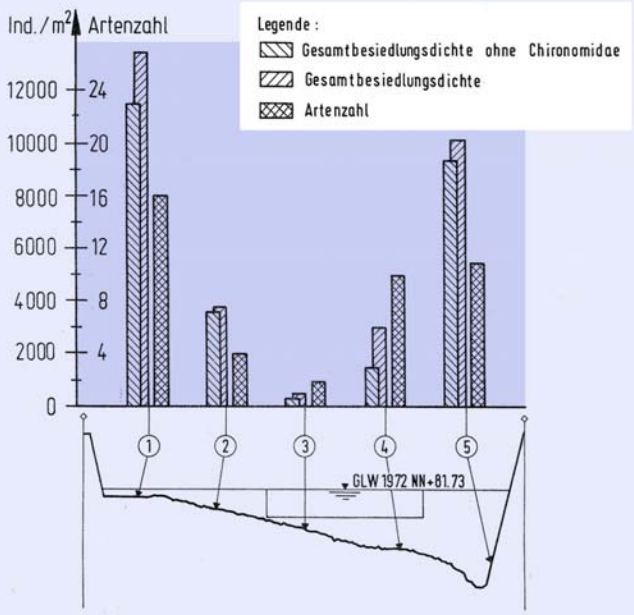
unregulated

regulated

Faunistisches Besiedlungsgebiet

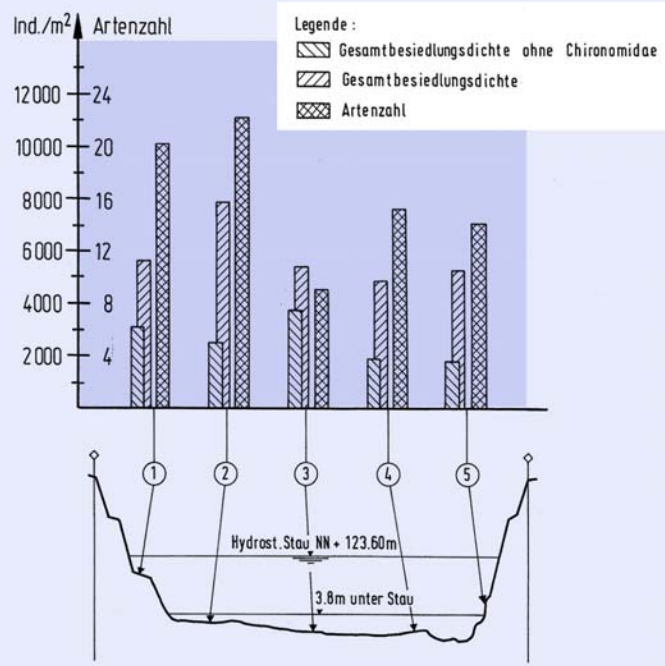
Querprofil bei Rhein – km **479,5**
April 1987



Substrat [%] :	1	2	3	4	5
Grobstein	100	-	-	100	100
Mittelstein	-	-	-	-	-
Feinstein	-	-	-	-	-
Kies	-	30	30	-	-
Sand	-	40	40	-	-
Schluff	-	30	30	-	-

Entfernung vom li. Hst. 0 50 100 150 200 250 300 350 m

Querprofil bei Rhein – km **313,0**
August 1988



Substrat [%] :	1	2	3	4	5
Grobstein	100	-	-	-	100
Mittelstein	-	-	-	-	-
Feinstein	-	10	-	-	-
Kies	-	30	40	40	-
Sand	-	60	60	60	-
Schluff	-	-	-	-	-

Entfernung vom li. Hst. 0 50 100 150 200 250m

Ship traffic: case study

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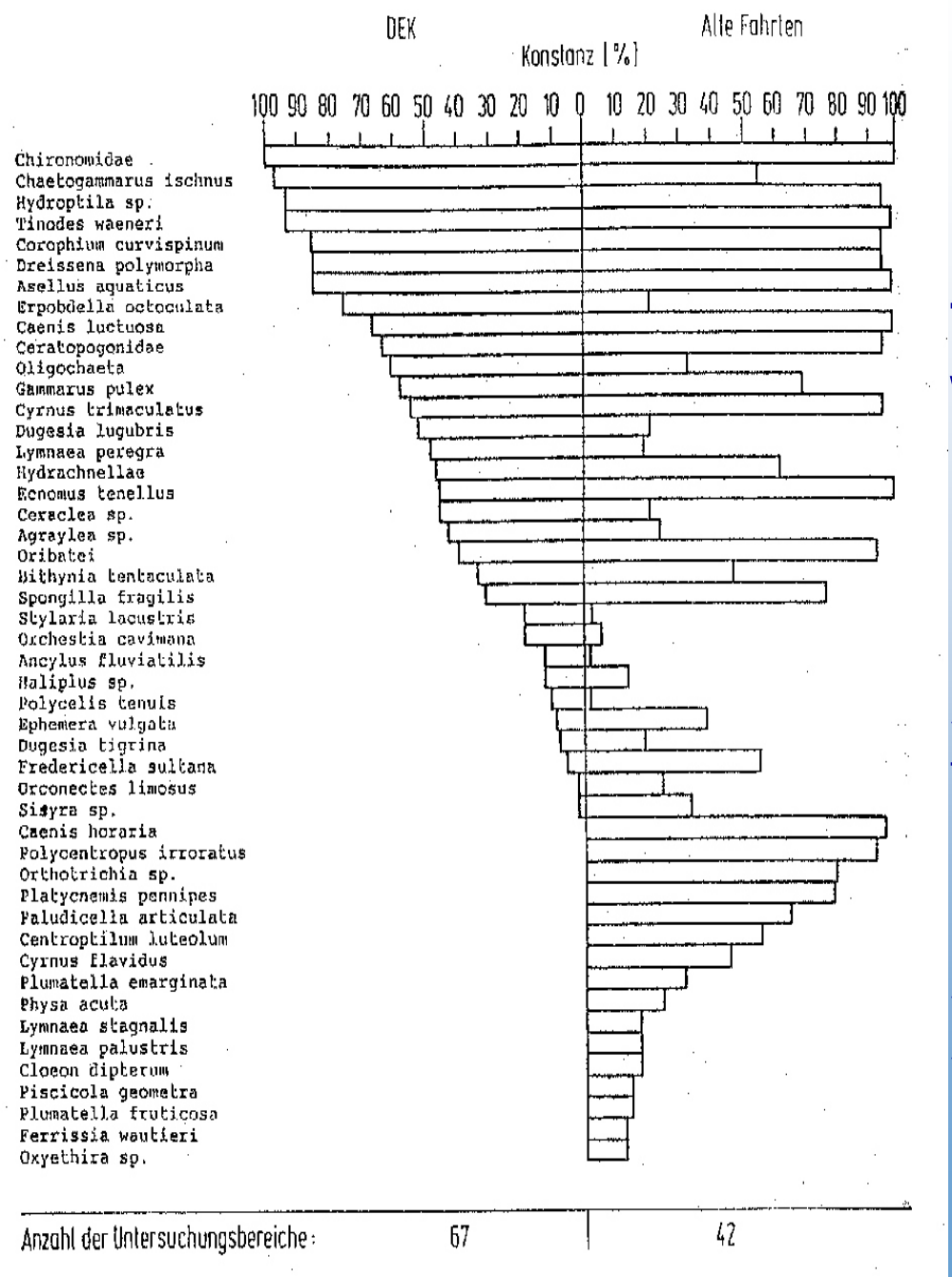
The influence of ship traffic on macrozoobenthos a valuation using biological features (traits)

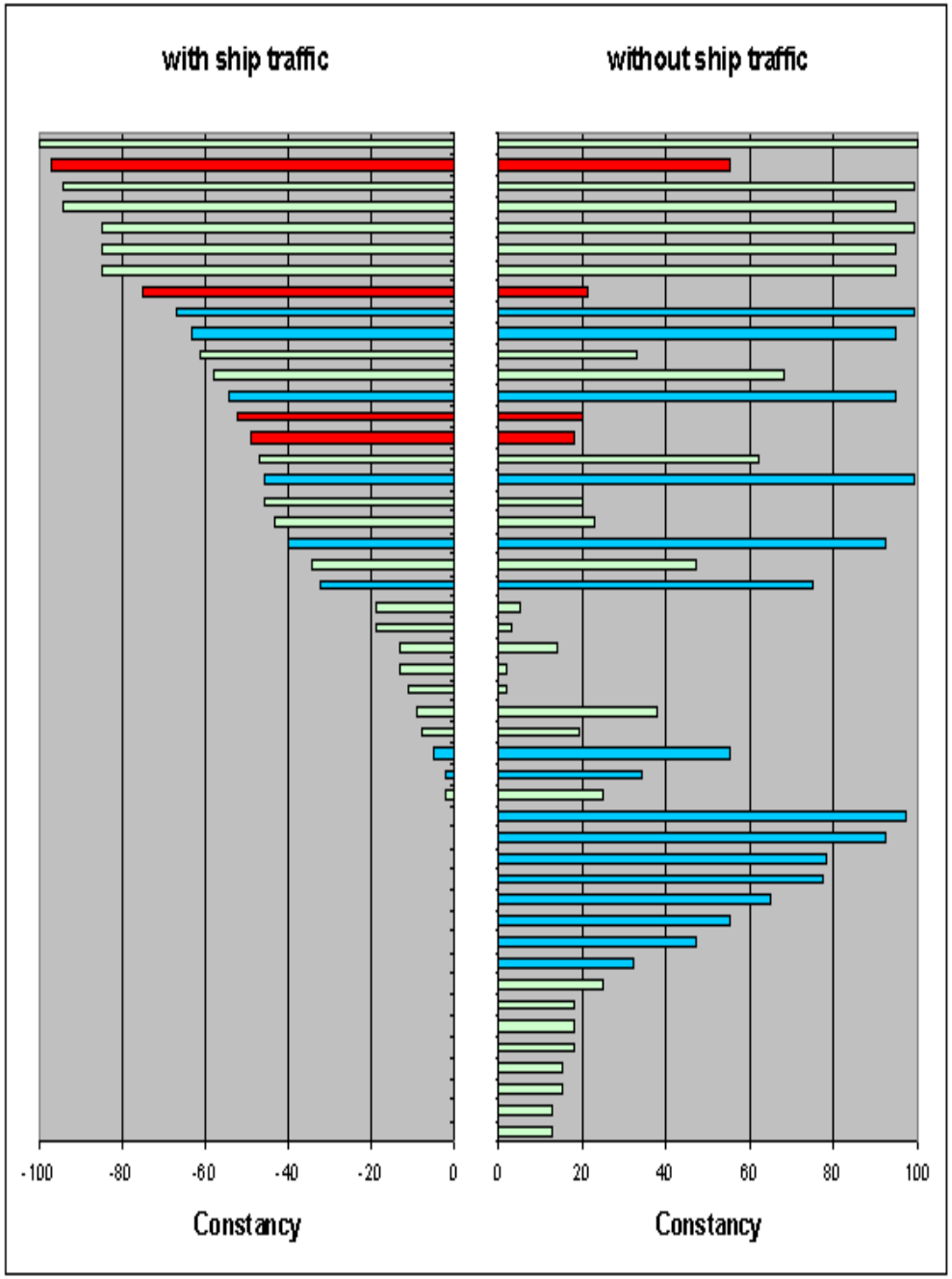


Relative abundance of benthic invertebrates along the Dortmund-Ems-channel with (left) and without (right) ship traffic

Left: Constancy's of species in sections of the channel with ship traffic.

Right: Constancy's of species in a section of the channel (old shipping lane) without ship traffic.

(RÜTTEN, unpublished results)



Red:
Species benefit from ship traffic

Blue:
Species are handicapped by ship traffic

Biological traits

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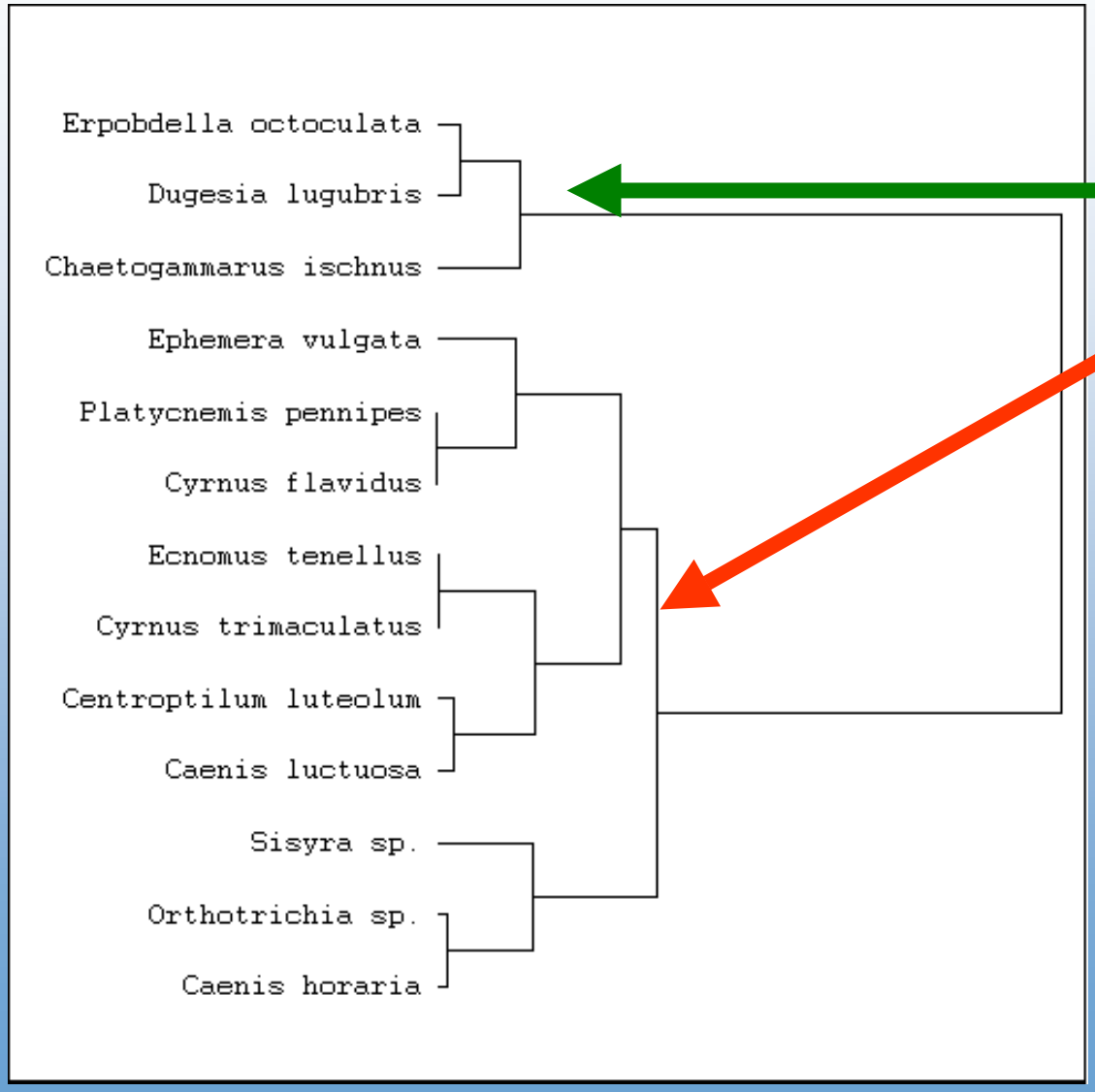
Trait classification of species extended according to Charvet et al. 1998

Abr.	Category
E	Live span of adults
B	Offspring per reproductive cycle
K	Body form
L	Feeding type
H	Dispersal ability (in water)
J	Body flexibility
A	Size [mm]
N	Respiration
G	Brood care
M	Food
I	Attachment to substrate (Larves and adults)
C	Reproductive cycles per year

E	Live span of adults
E2	> 1-10 days
E3	> 10-30 days
E4	> 30-365 days
E5	> 365 days

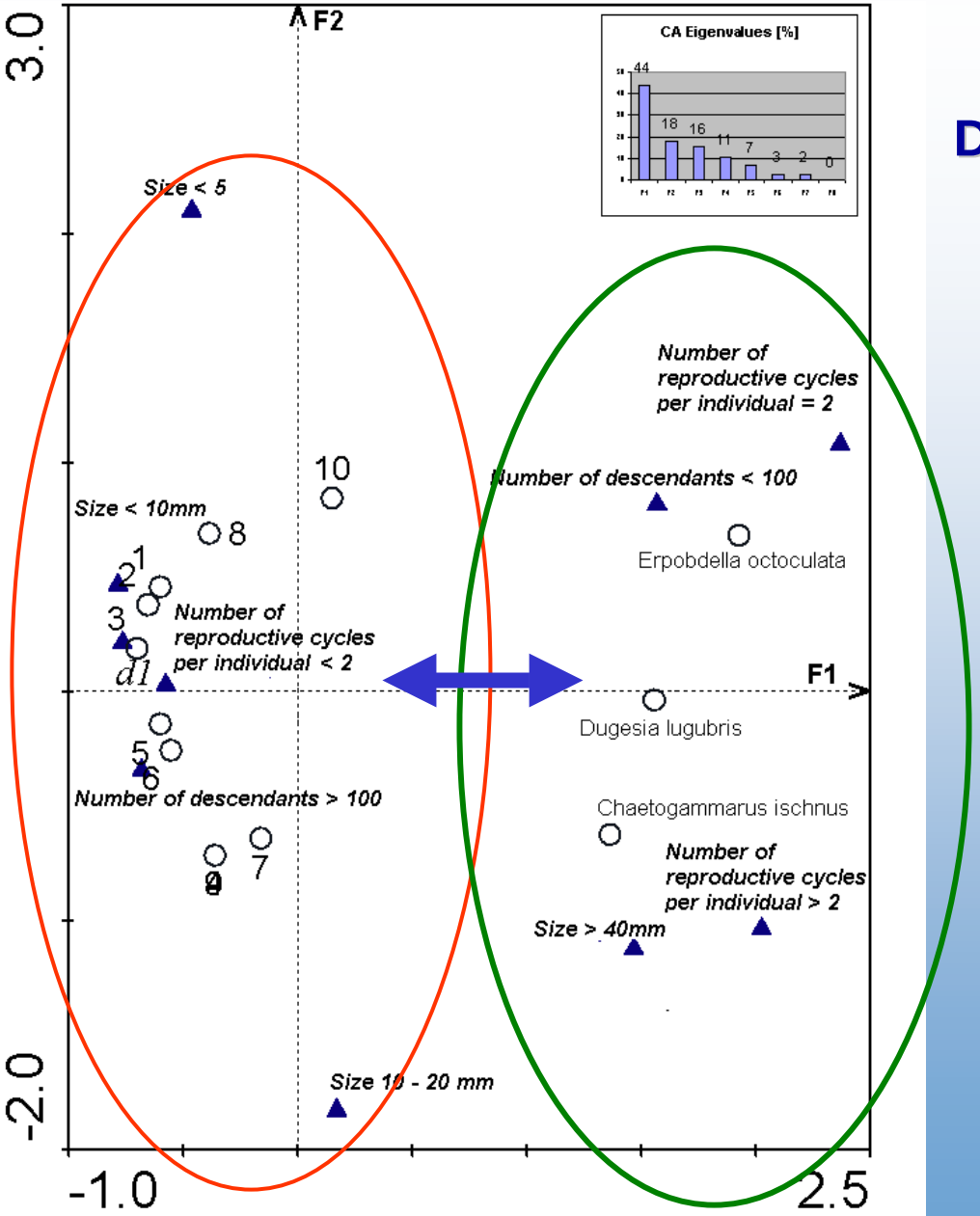
B	Offspring per reproductive cycle
B1	≤ 100
B2	> 100-1000
B3	> 1000-3000
B4	> 3000

Clusteranalysis (Methode according to Ward)



These traits separate species which benefit from ship traffic from species which are handicapped by ship traffic

What is the difference between species that profit from ship traffic and species which are handicapped by it?



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Distance-Biplot

Correspondence analysis
(CANOCO 4.0, Ter Braak & Smilauer, 1998)
of characteristic traits after a discriminative analysis.

handicapped by ship traffic

benefit from ship traffic

Conclusions

1. Over the long run species handicapped by ship traffic will decrease in abundance

- These species are characterized by their small body size (< 10mm), few reproductive cycles per individual, and a high number of offspring's per reproductive cycle.

2. Biological traits can be used as a powerful tool in order to analyze such differences.

Thanks for Your attention