FITFISH

Fish Migration: concepts, definitions and mechanisms

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Fish Migration: contents

- o Importance of migration, basic concepts and definitions
- o Costs and benefits of migration
- o Variation in migratory patterns: concepts redefined
- o Mechanisms of migration




Movements: migration & dispersal

Spatial use:

Areas used by populations: how separate are populations?

Insight in scale and patterns of underlying movements

Migration:

Cyclic movements in which a large part of the population takes part (time scale: from diel, seasonal to life cycle)

Dispersal:

Movements of individuals away from each other (nett distance between individuals increases)

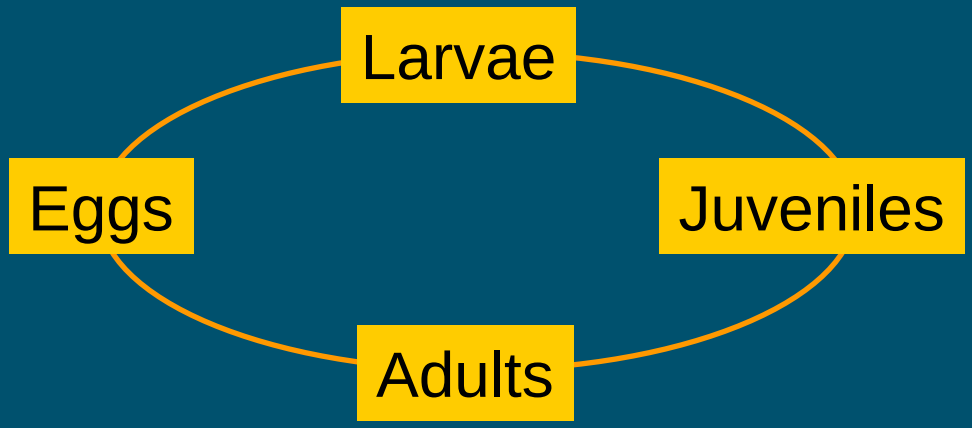
Predictability: from fixed to opportunistic (nomadic)

→ Important consequences for management of ‘stocks’

Migratory shifts in habitat use

Life cycle (ontogenetic shifts):

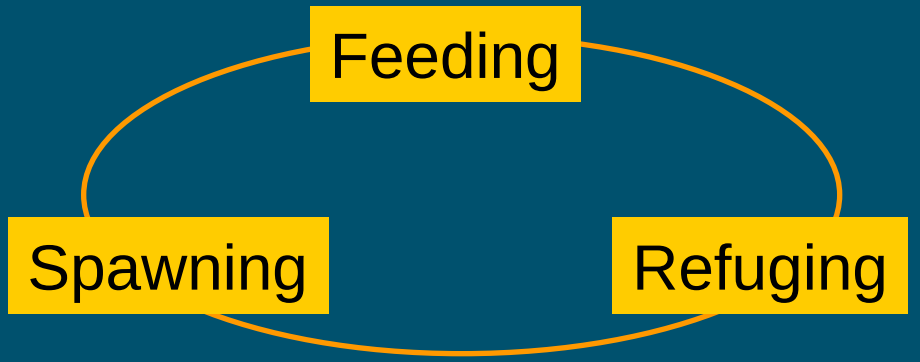
Requirements change



Temporal cycle (shifts in habitat favourability):

Day-night

Seasonal:
- summer-winter (temperate)
- dry-rainy (tropical)

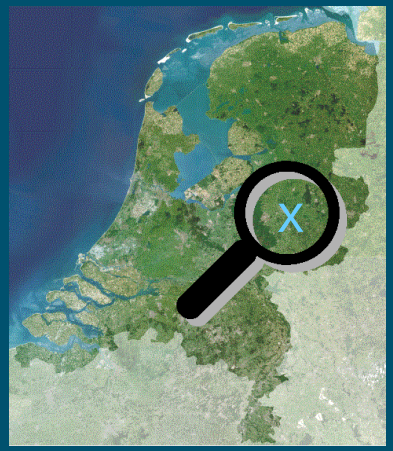


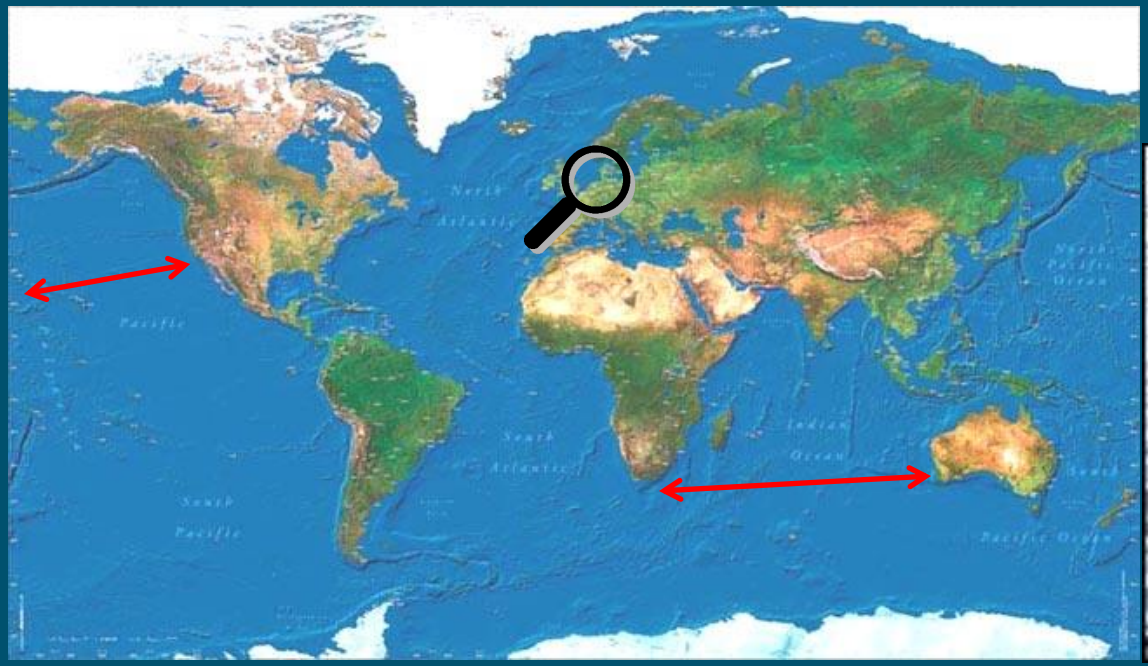
Habitats (end goals) and corridors (connections between habitats)

Variation in migratory patterns is huge!

Between species (from extremely sedentary to trans-oceanic)

Bullhead: < 10 m

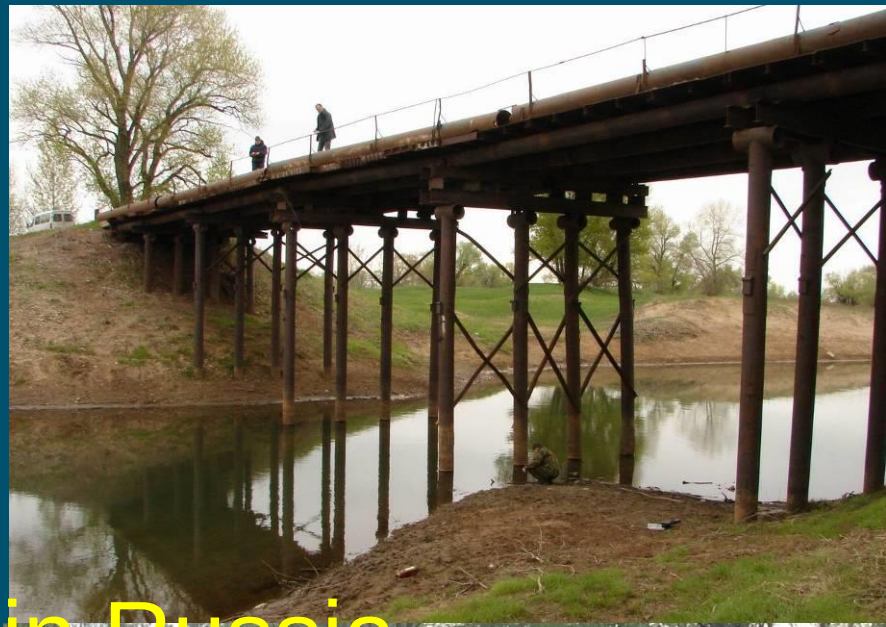




Great white shark:
Roundtrips of
> 20.000 km !

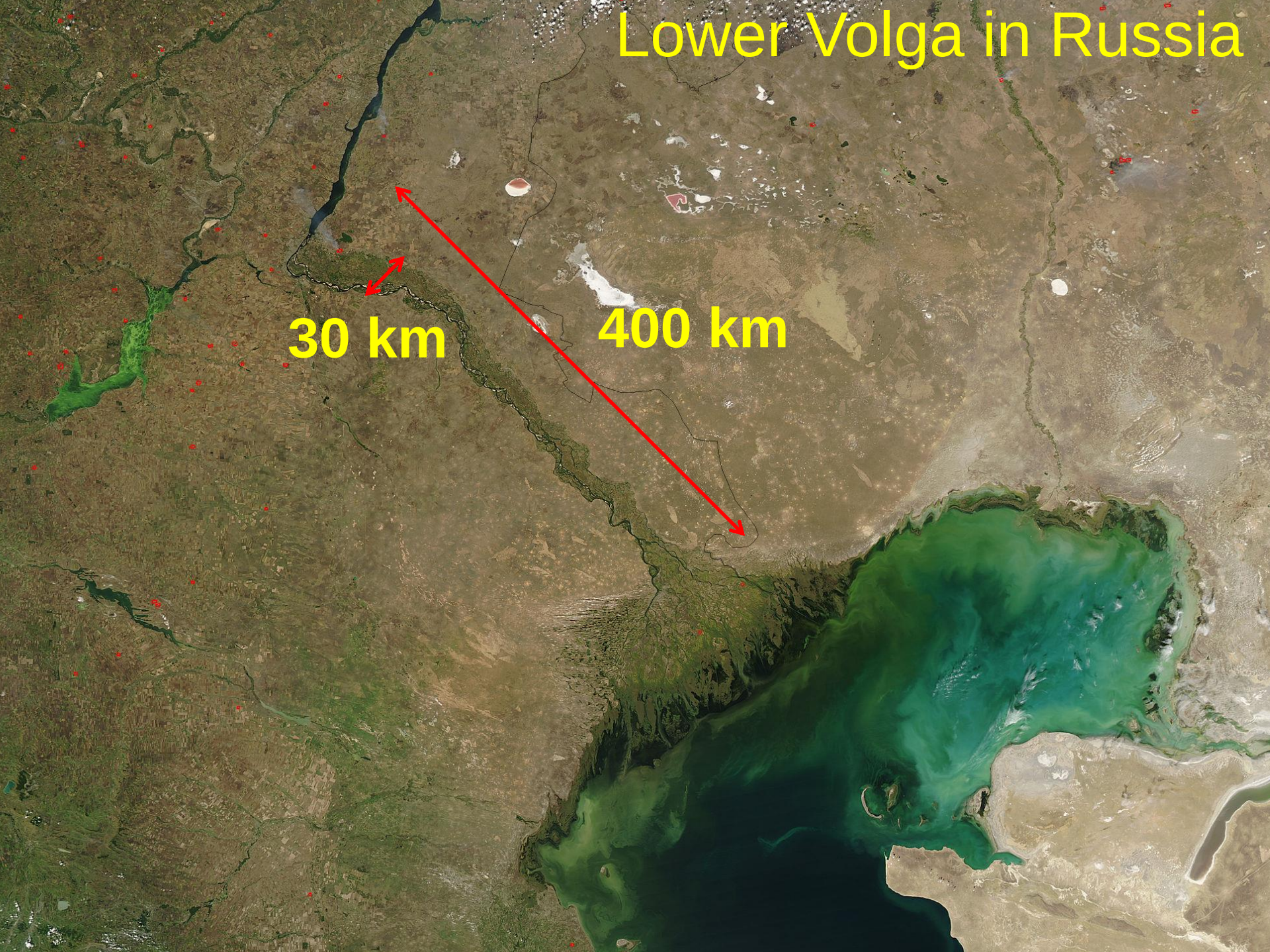
Migratory patterns in Salmon (anadromous)

Lateral migration: flood plains

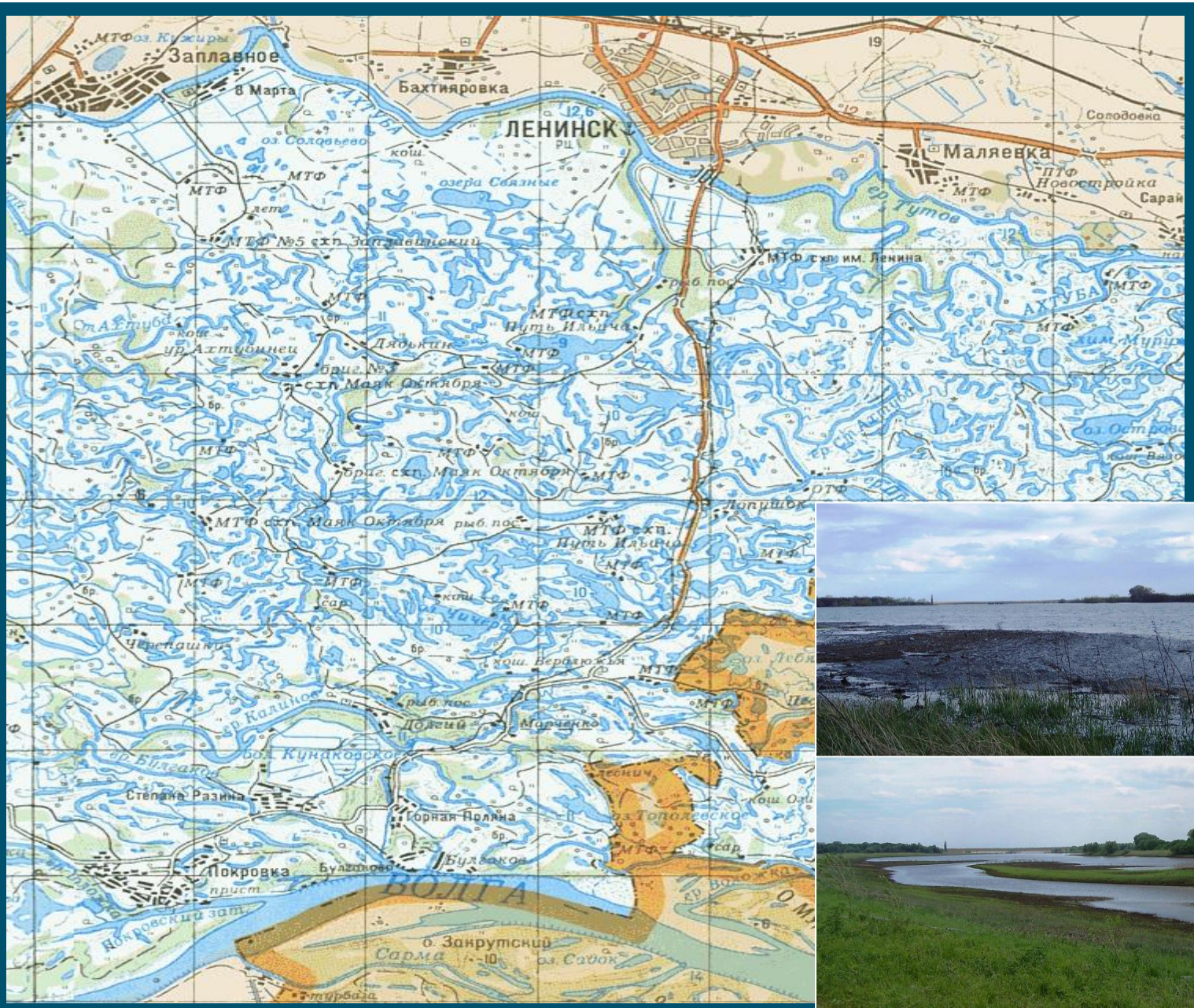


Lower Volga in Russia

Photos: Konrad Gorski


Lower Volga in Russia
30 km
400 km

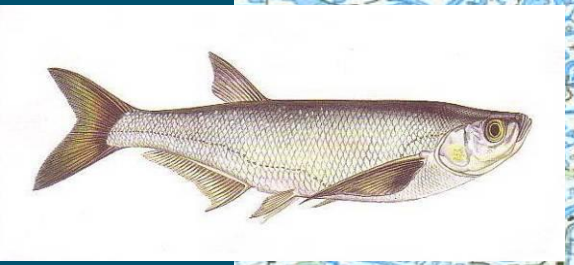
Lower Volga in Russia



Lower Volga in Russia

4-year field study to test FPC:
Wageningen Univ, Utrecht univ. IMARES

For spawning fish: within floodplain lateral movements appear to dominate



Lack of migration: Lake Victoria

Life history traits cichlids:
Mouth-breeding (parental care)
No migration (resident)
No dispersal
Strong sexual selection

Local circumstances:
Rocky ‘islands’ in sandy ‘sea’
Relatively young system
Lack of lacustrine species

Extreme separation between populations
->
species flock formation

Migratory variation in Salmon

Between populations:

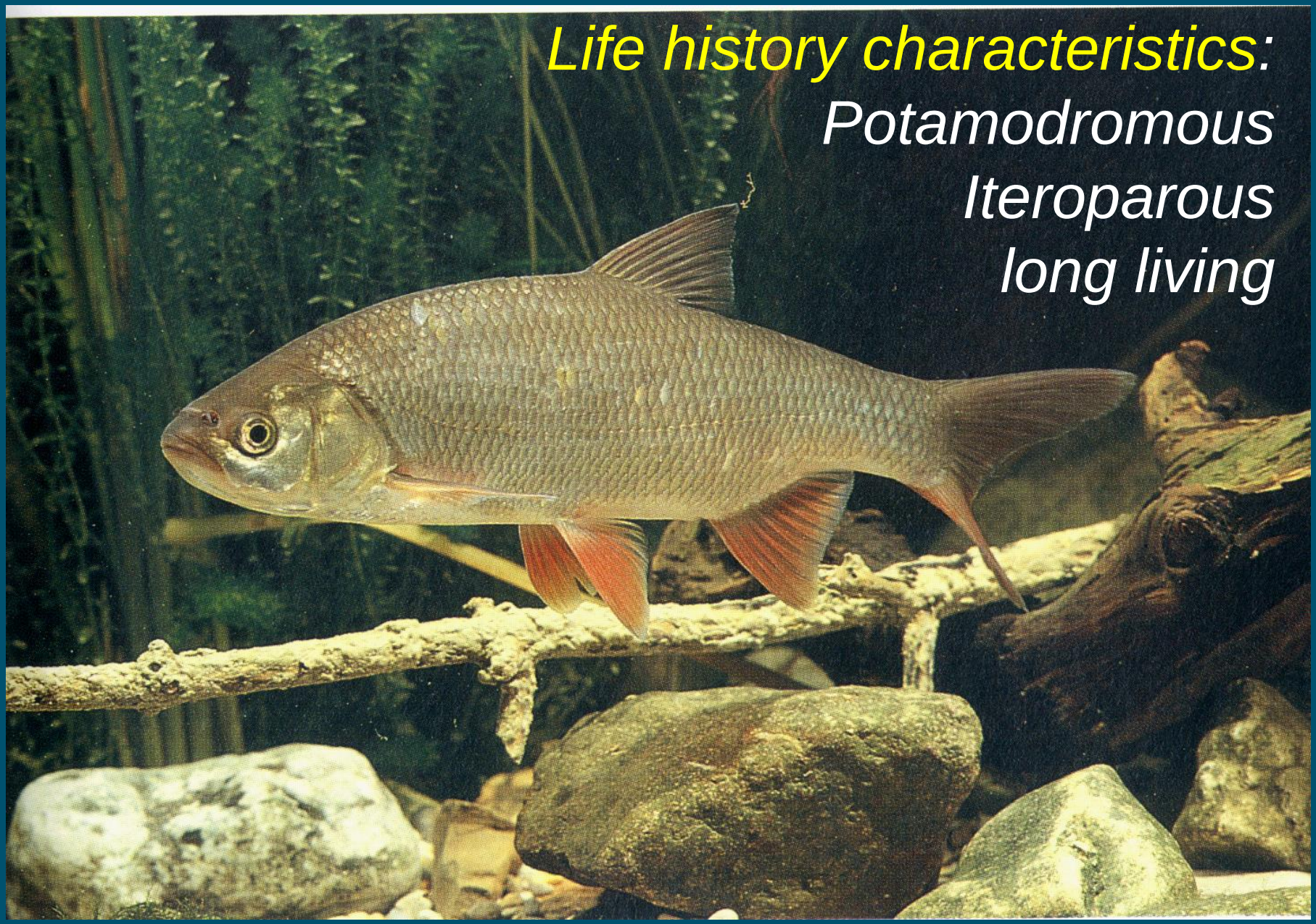
Land-locked (no sea-phase)
vs.
Migratory (anadromous)

Within population (alternative strategies):

Migration (females and large males)
vs.
Sedentary (small ‘sneaking’ males)

this semelparous species: individual patterns genetically based

Migratory variation in ide (cyprinid)



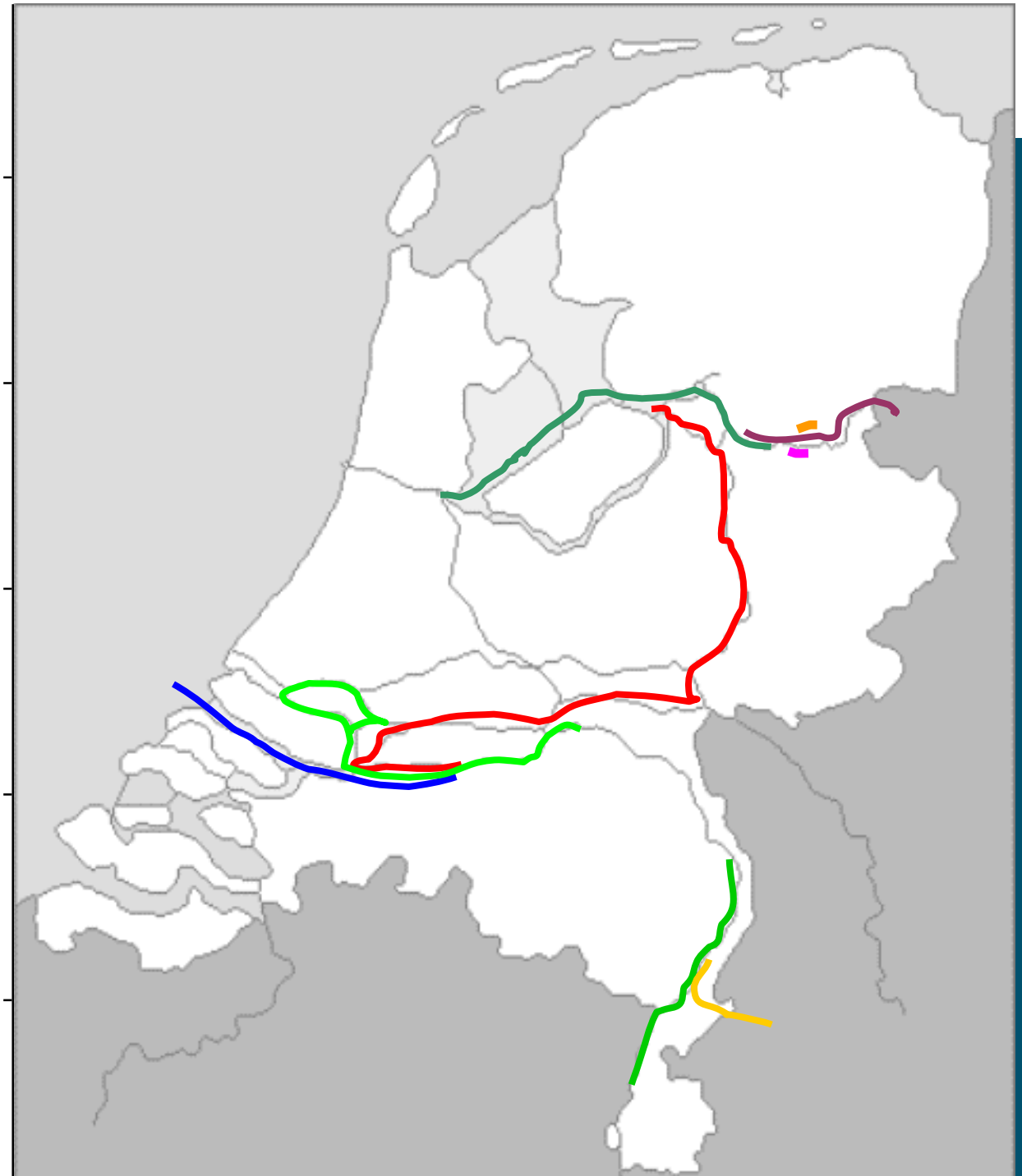
RIVO

Examples of individual patterns

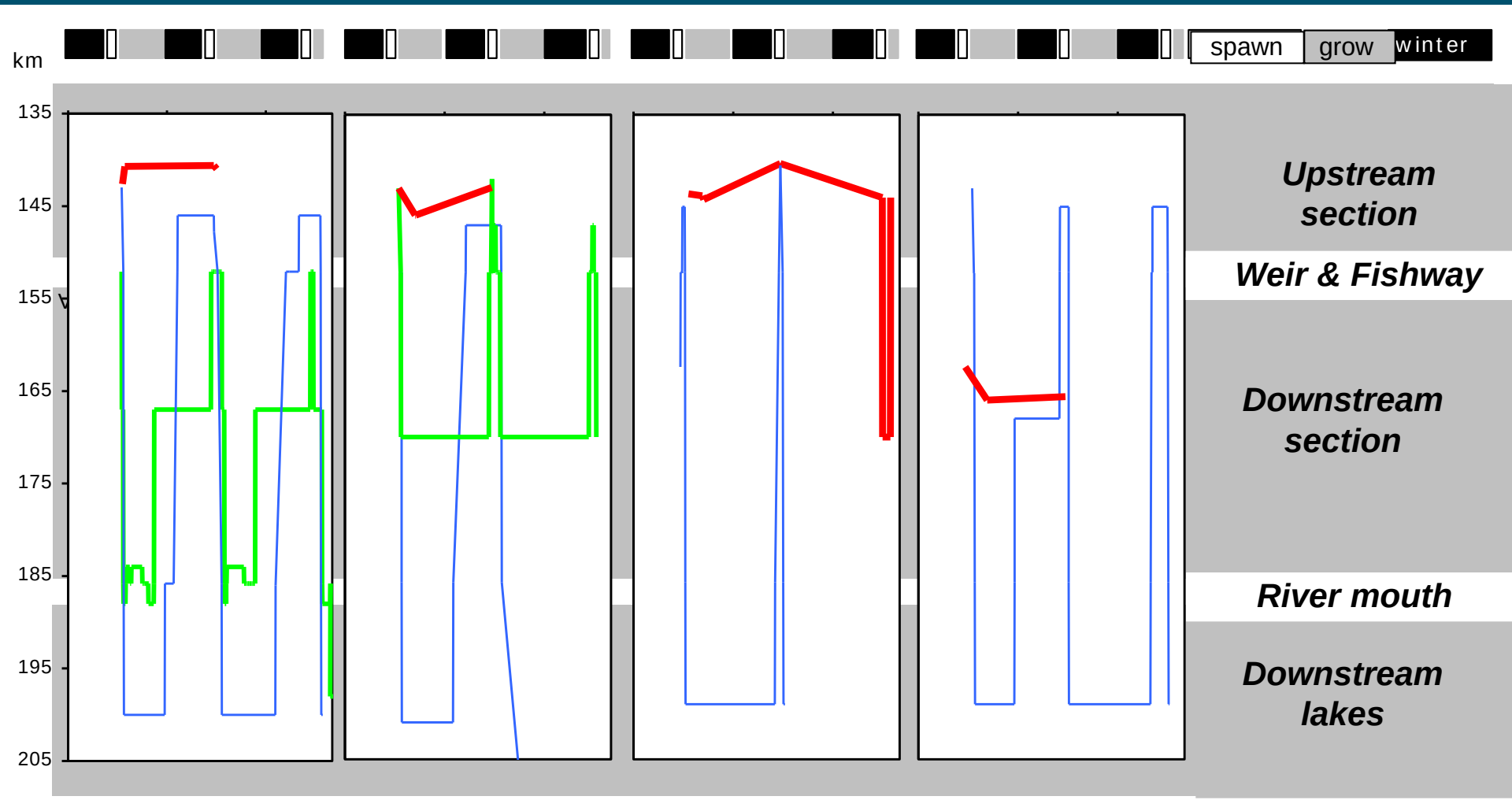
Highly variable

Continuum from resident to >200 km

(as in River Elbe F. Fredrich)



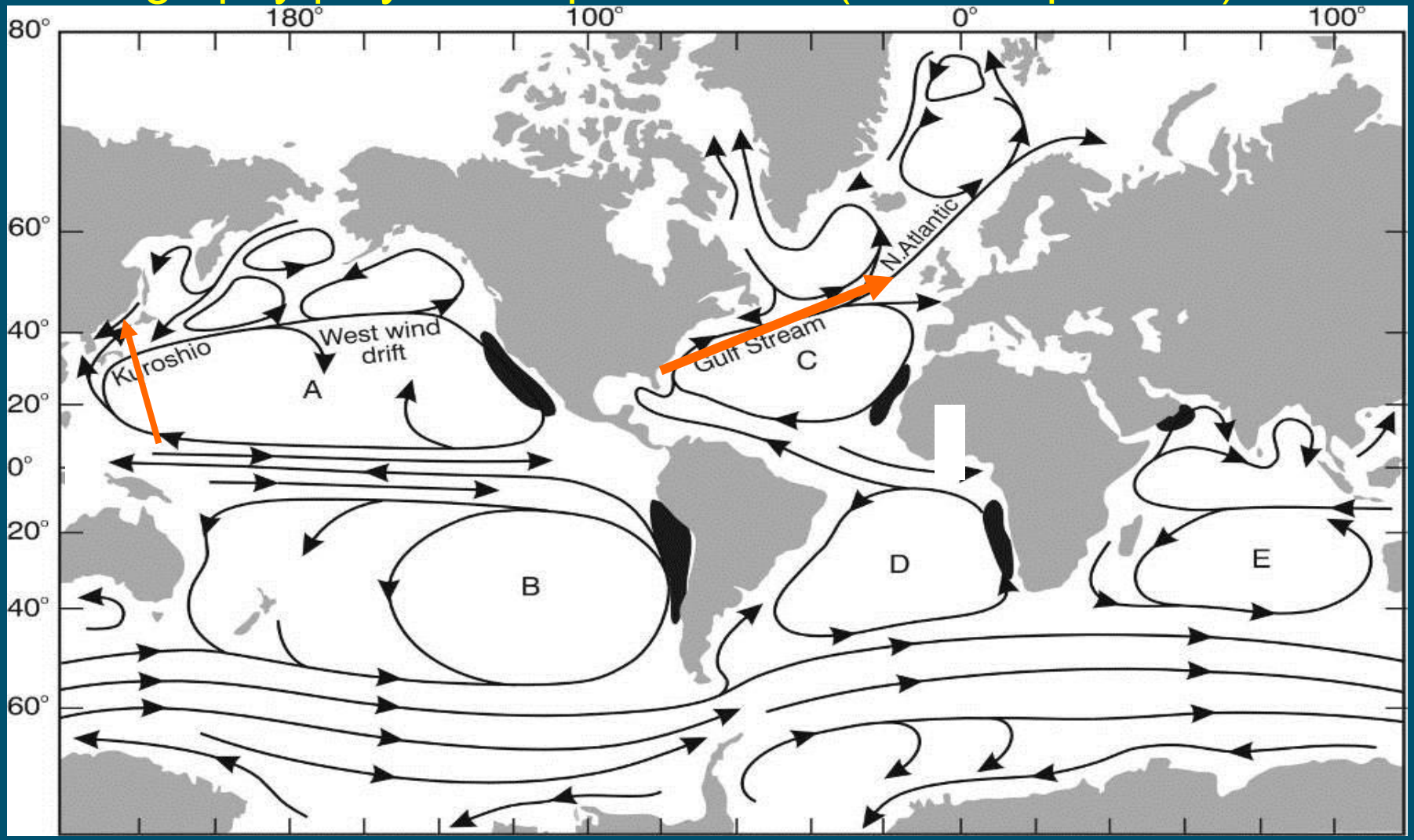
Long-term individual patterns (3 years):
each individual behaves different from others …



… but very similar in each year!

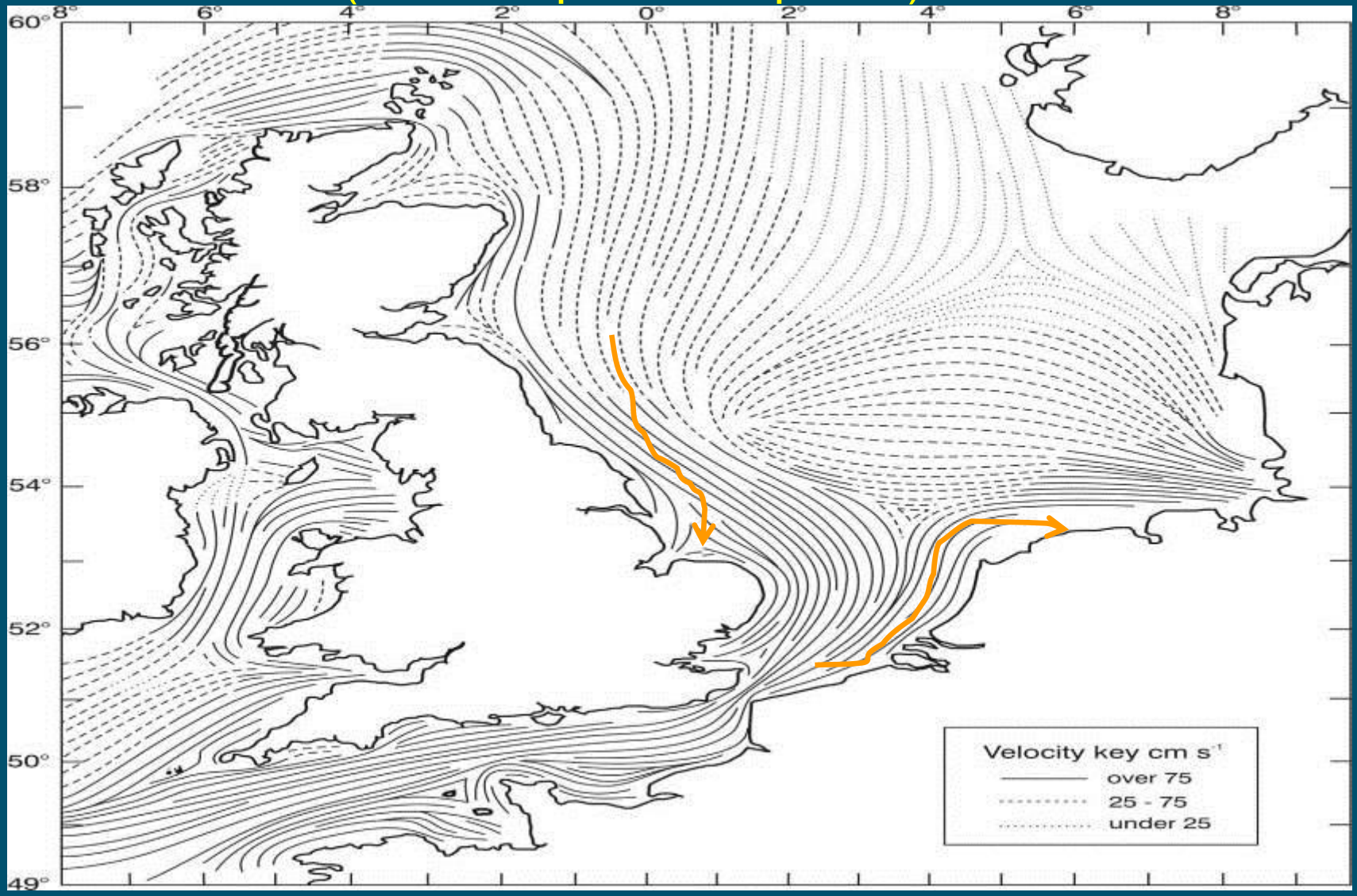
Mechanisms of migration (water currents)

Oceanography plays an important role (for example eels)…



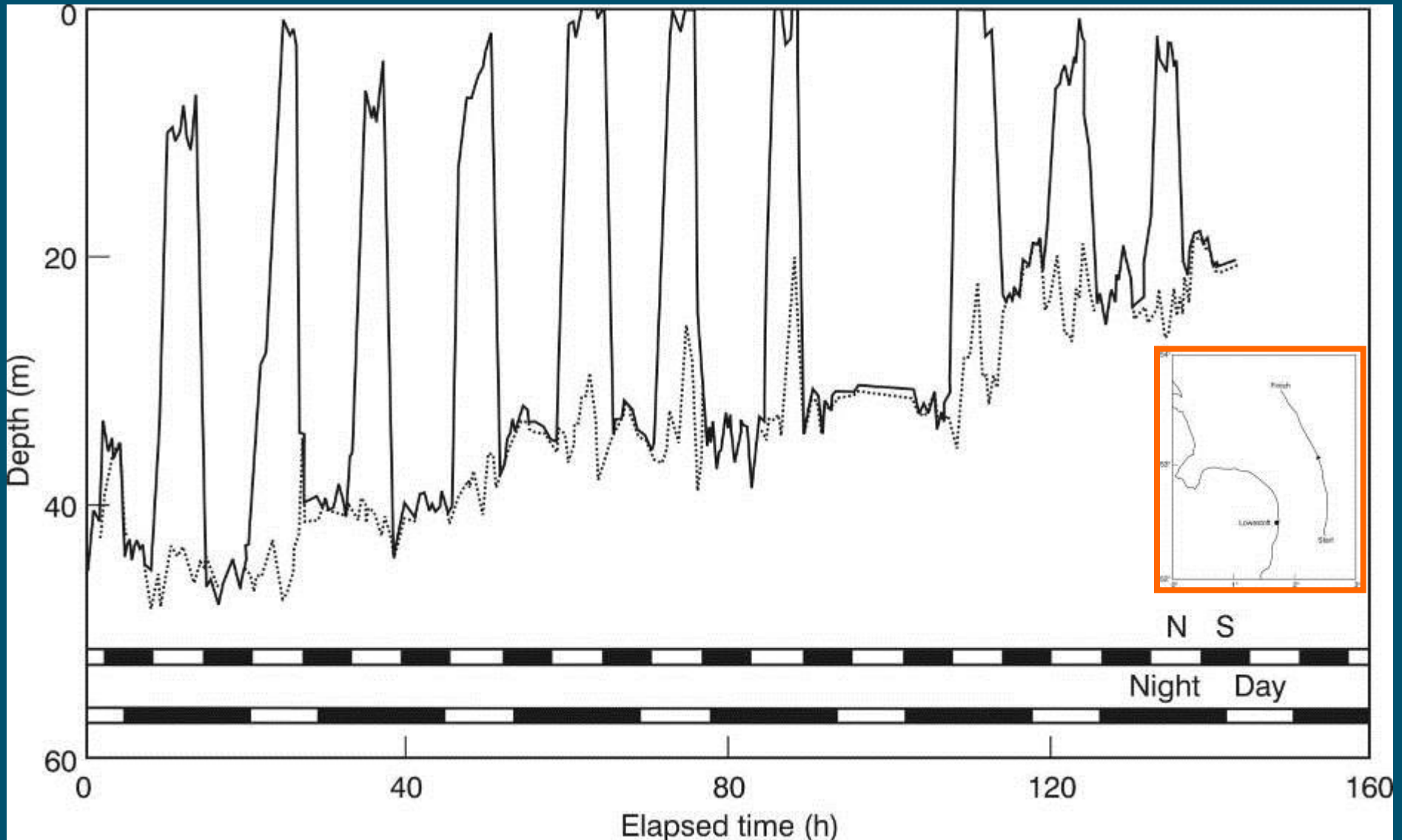
Mechanisms of migration (water currents)

In coastal areas (for example larval plaice)…



Mechanisms of migration (water currents)

Where larval plaice shows a remarkable pattern:

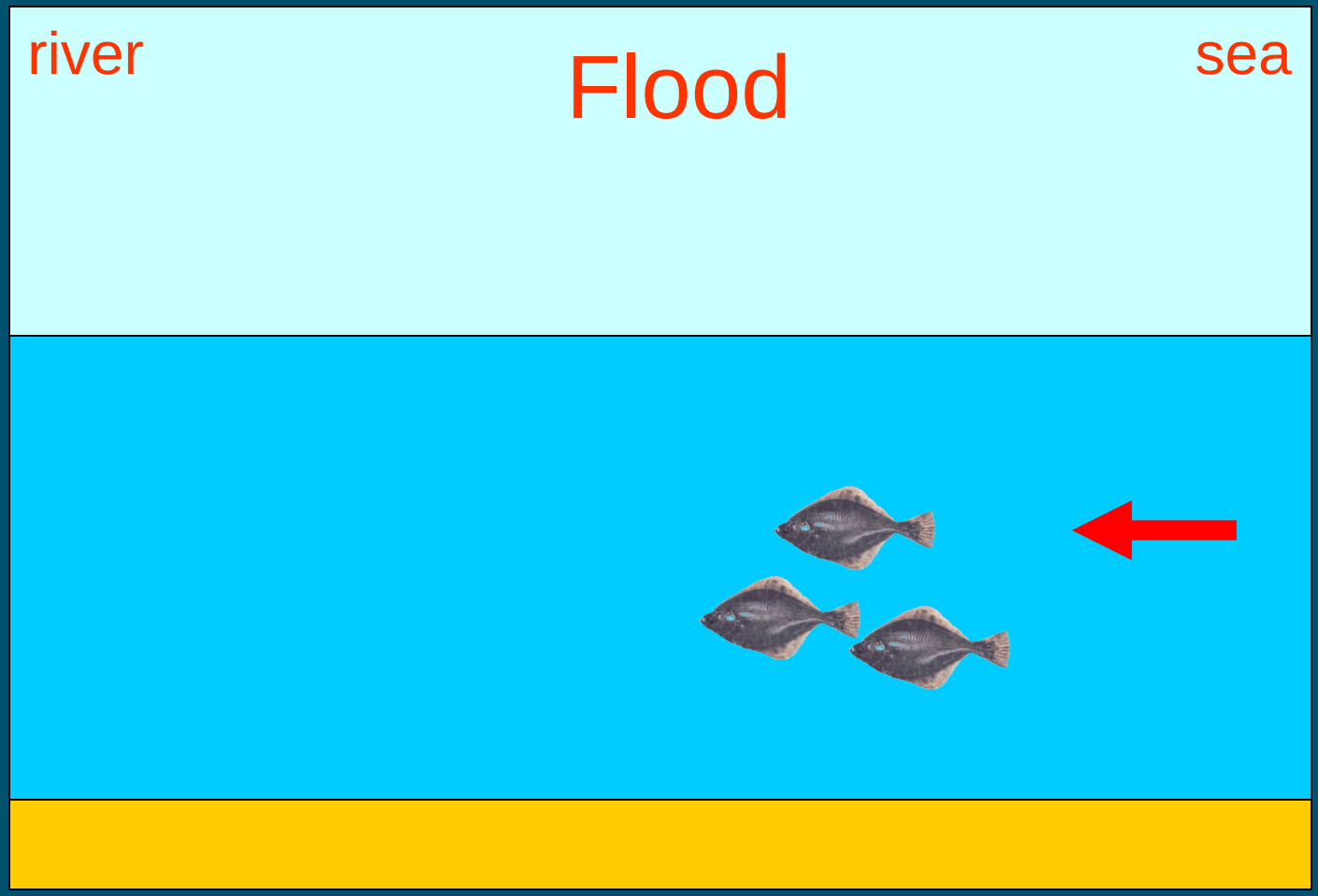


From sea to rivers for poor swimmers

Selective tidal transport

From sea to rivers for poor swimmers

Selective tidal transport



From sea to rivers for poor swimmers

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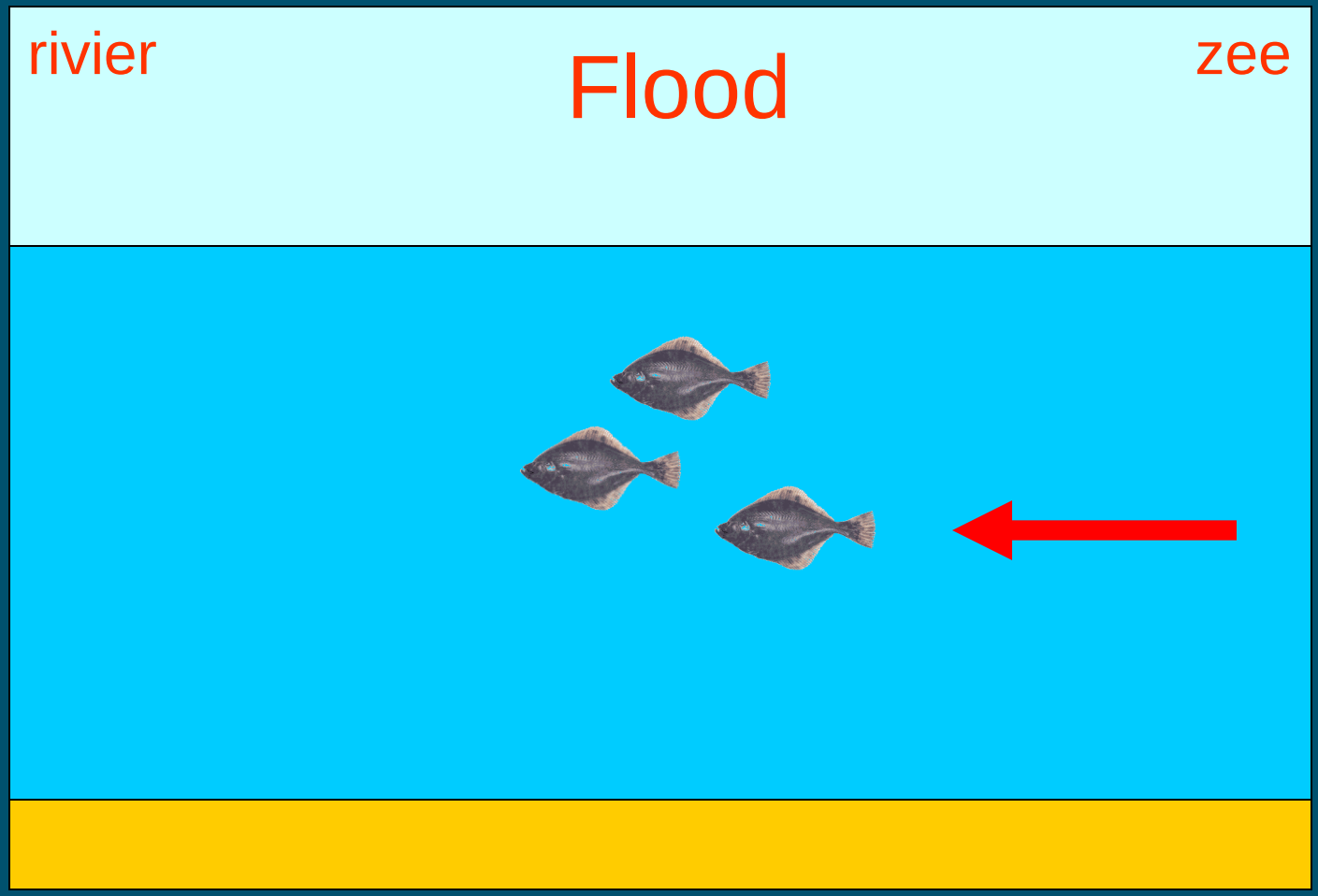

From sea to rivers for poor swimmers

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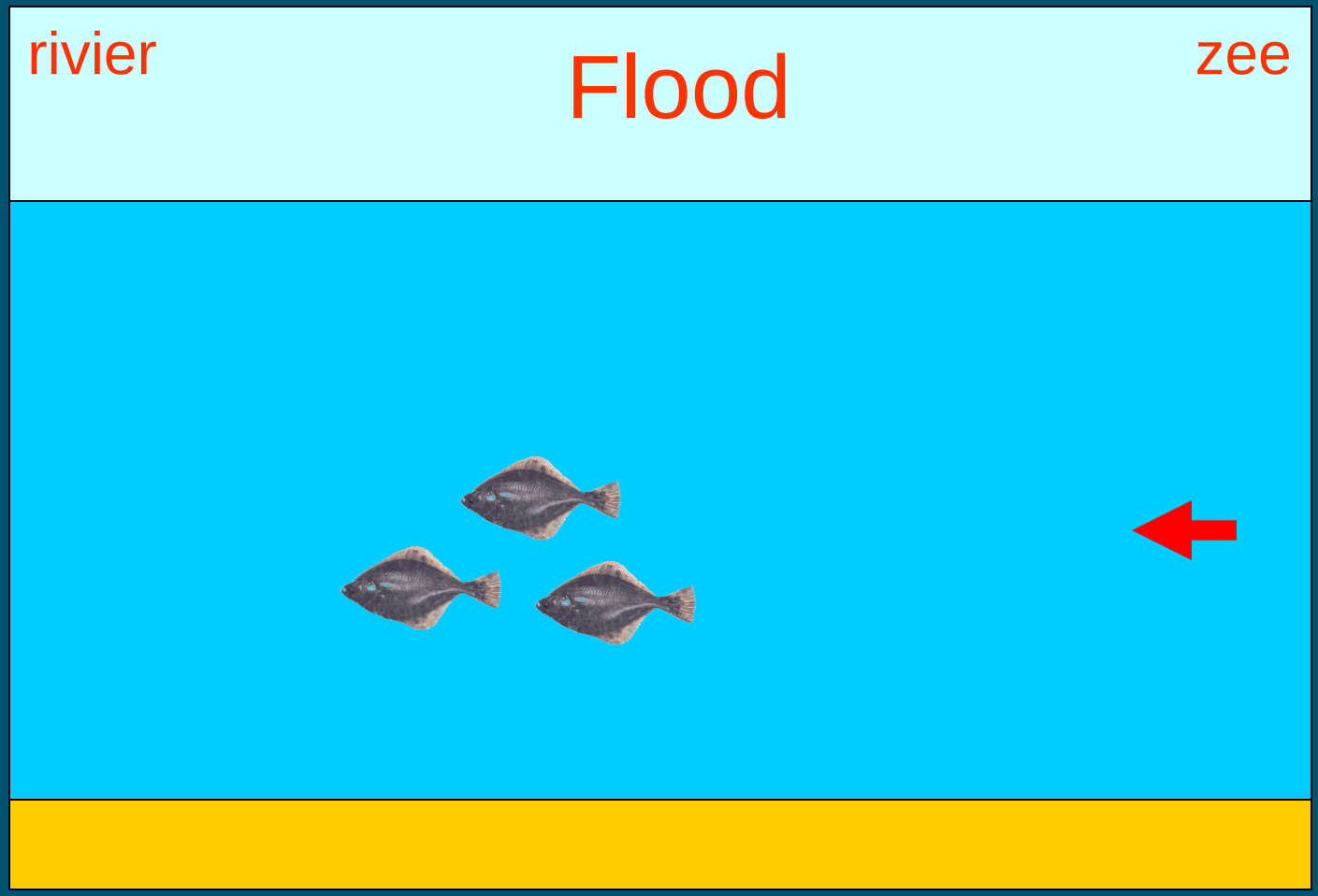

From sea to rivers for poor swimmers

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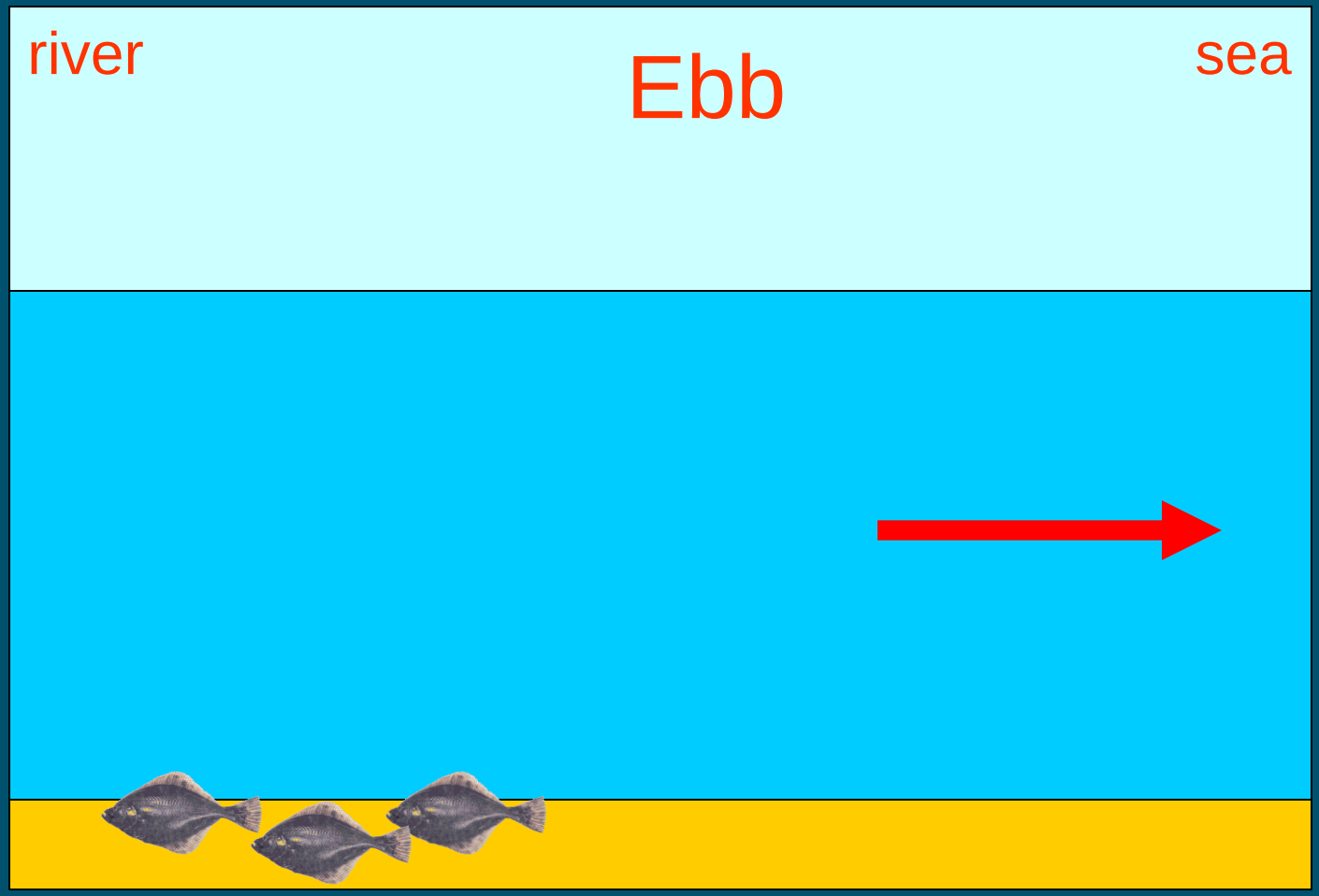


Swimming capacity to overcome distances and barriers

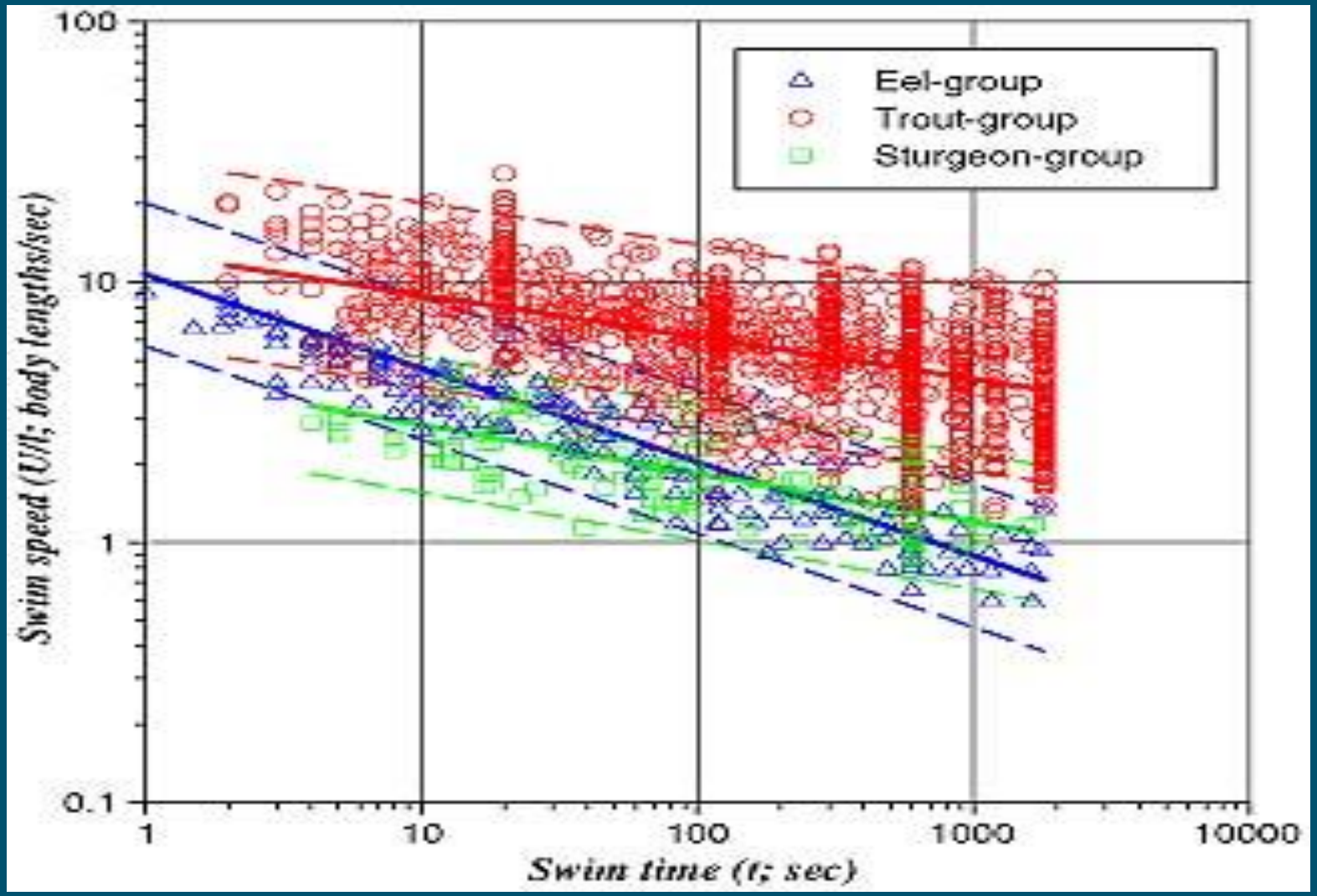
Three categories of swimming capacities:

Sustained: long duration without fatique

Prolonged: intermediate duration resulting in fatique → dependent on Temperature and Oxygen

Burst speed (<15 s): only for emergency → increased vulnerability (rebuilding stored glycogen) dependent on temperature (anaerobic)

Swimming capacity



From Katopodis & Gervais (2012)

Burst swimming capacity

Swimming stride by stride

For lenght x and temperature y and tail beat frequency $F_{xy}(s^{-1})$, then F_{lt} at other lenghts l an temperature t burst speed can be calculated (Videler & Wardle 1991):

$$F_{lt} = F_{xy} (0.87^{(l-x)/10)} (2^{(t-y)/10})$$

Maximum burst speed U_{lt} (m s^{-1}) for other lengths l and temperatures t can be determined if species specific stride length Sl is known:

$$U_{lt} = Sl.F_{lt}$$

Mechanisms of migration (cues)

Navigation and oriëntation cues

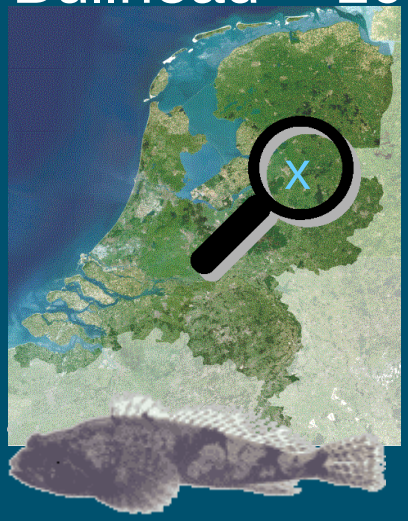
Taxes = directed movements

- Physical:
  - → Phototaxis : light direction
  - → Geotaxis : gravity
  - → Rheotaxis : water currents
  - → Magnetotaxis : earth magnetic field
  - → Sound : coral reefs, shorebreak
- Scalar: gradients in
  - → Salinity
  - → Temperature
  - → Turbidity
  - → Olfactory clues

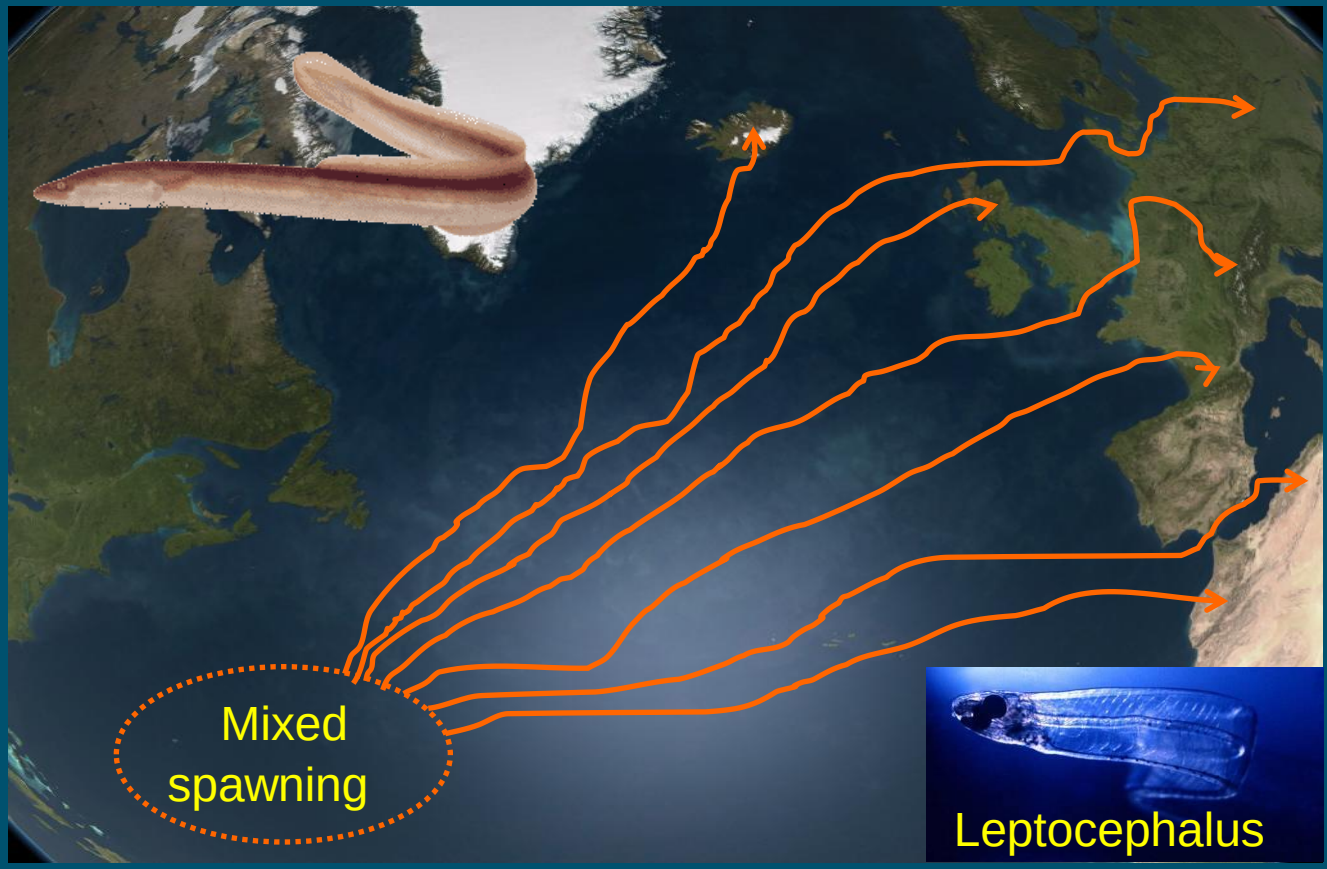
Variation in migratory patterns is huge!

Between species (from extremely sedentary to trans-oceanic)

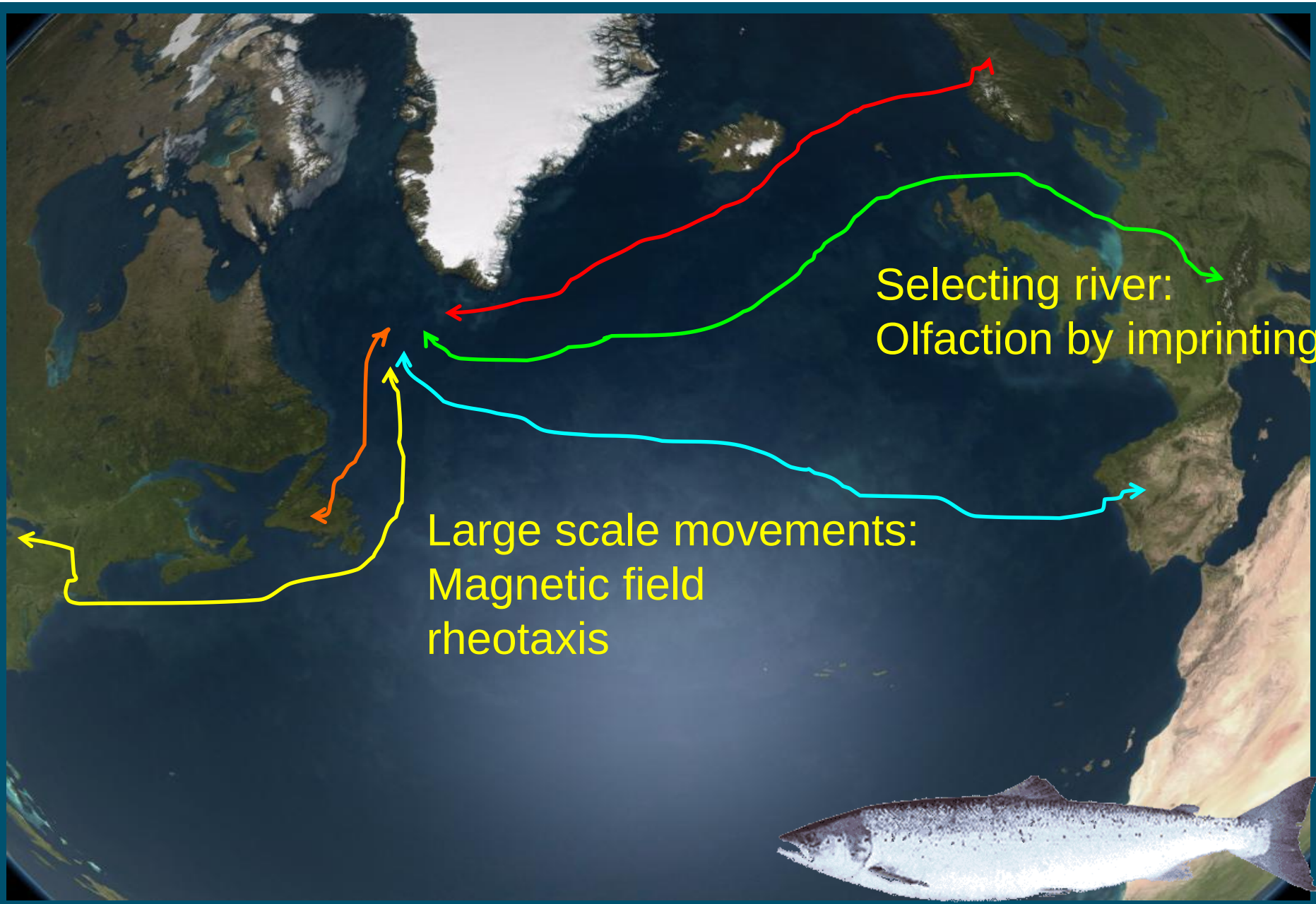
Bullhead < 10 m



European eel > 6000 km



Many cues used simultaneously (salmon)



Sea lamprey (specific pheromone!)

Bizarre life cyle:

Eggs in gravel rivers

Larvae (ammocoetae) in sediments

After 6-8 year (15-20 cm) to sea

Rapid growth as parasite on fish

Migrate upstream rivers to spawn

Selection of the river?

Adult lamprey (up to 1 m) choose rivers that contain pheromones released by larvae (not necessarely natal river, but a suitable river)

Mechanisms of migration (role of learning)

- o Imprinting of substances in water of juvenile anadromous fish
- o Sun compass and magnetic field most likely for long-distance navigation (salmon, eels)
- o Learning by experience (in ide?)
- o Learning the route from other fish: "cultural transmission"

  Juvenile grunts follow fixed migration routes stable over generations in evening movements from shelter to feeding ground; herring migrations

  Routes based on landmarks? Routes learned?

  Experiments show that naïve individuals learn from experienced individuals through dummy migrations

Much is still unknown !!!

ANIMAL SCIENCES GROUP
WAGENINGEN UR

Management issues & Research methods on migration and dispersal

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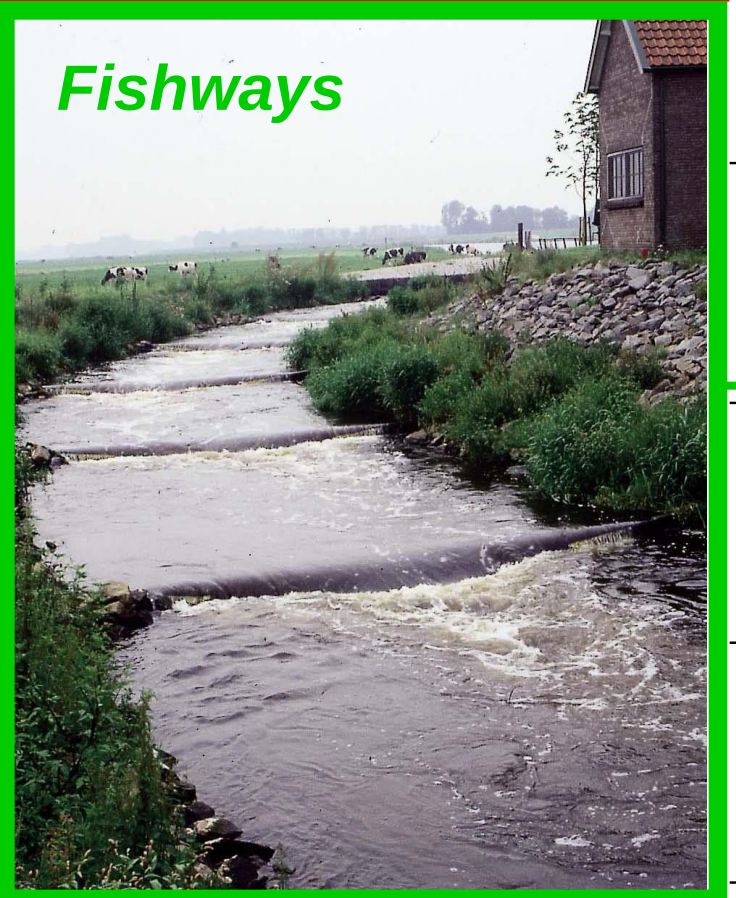
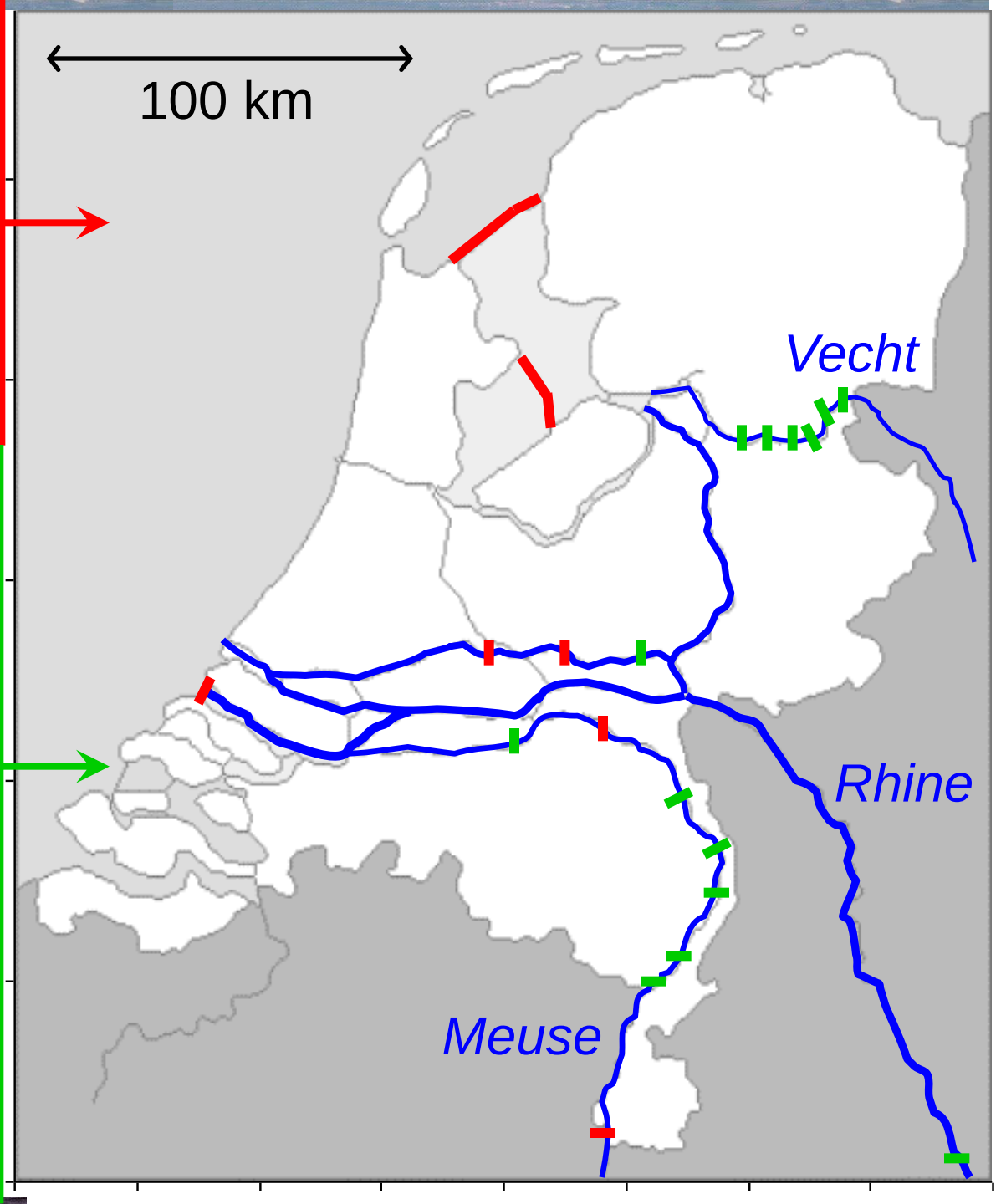
Netherlands Institute for Fisheries Research
Animal Sciences Group, Wageningen UR

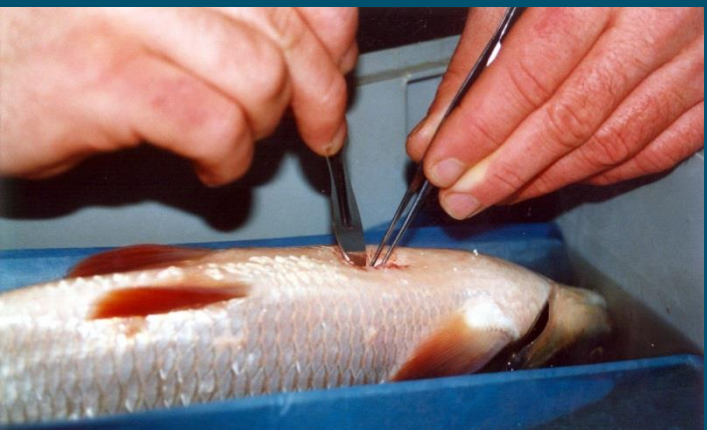
11 Oktober 2005


Dams & Weirs


Fishways

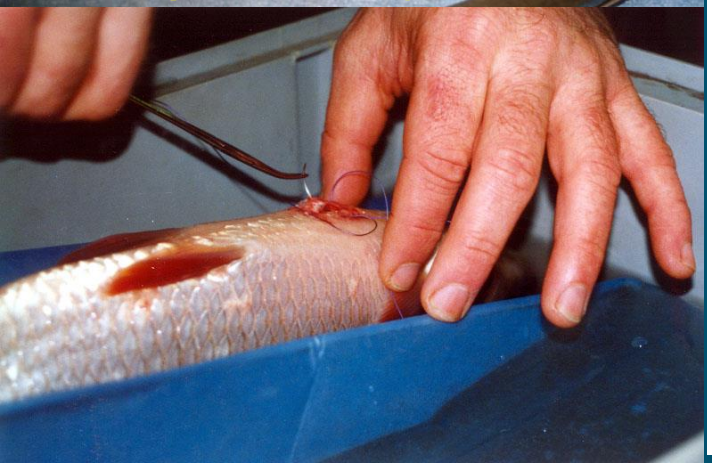

100 km
Vecht
Rhine
Meuse

Telemetry experiments 1998-2004



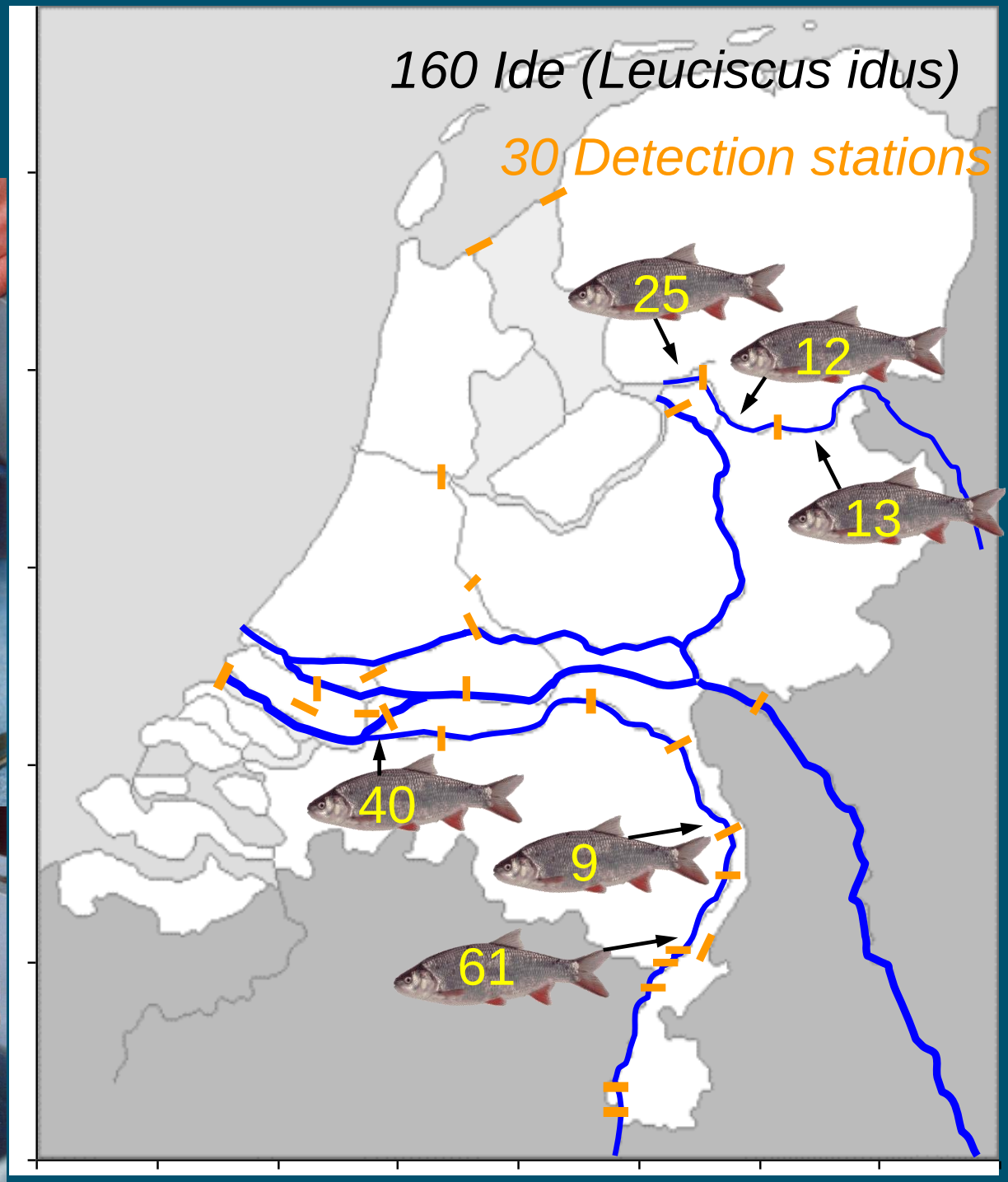
NEDAP-transponders

Life span 3-4 years

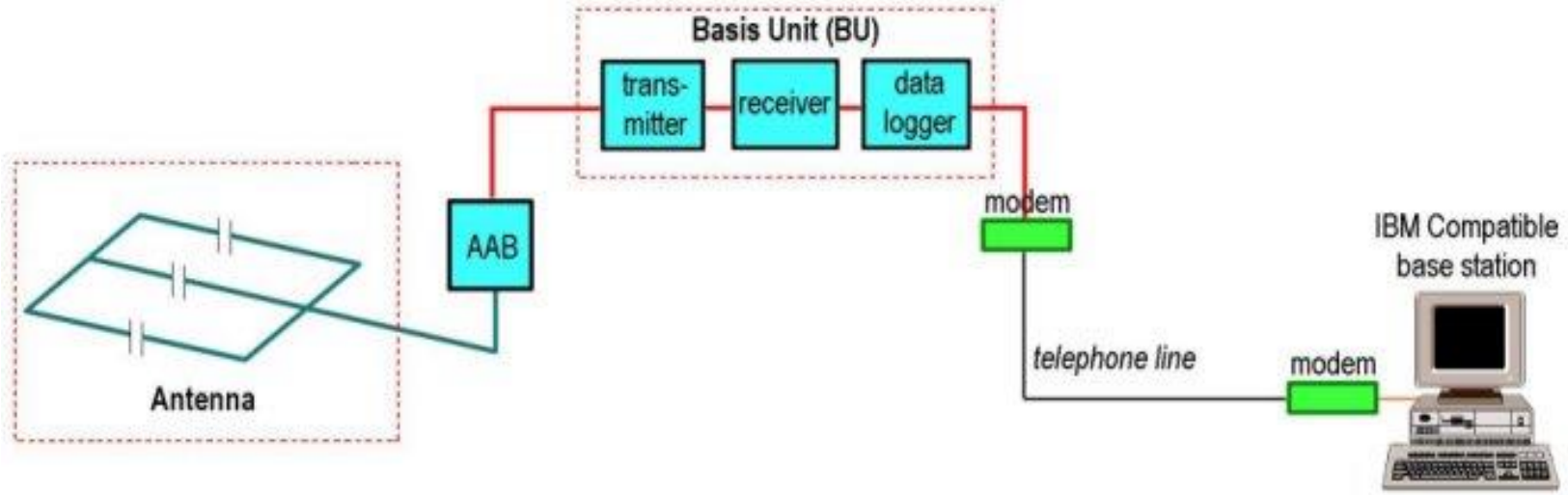


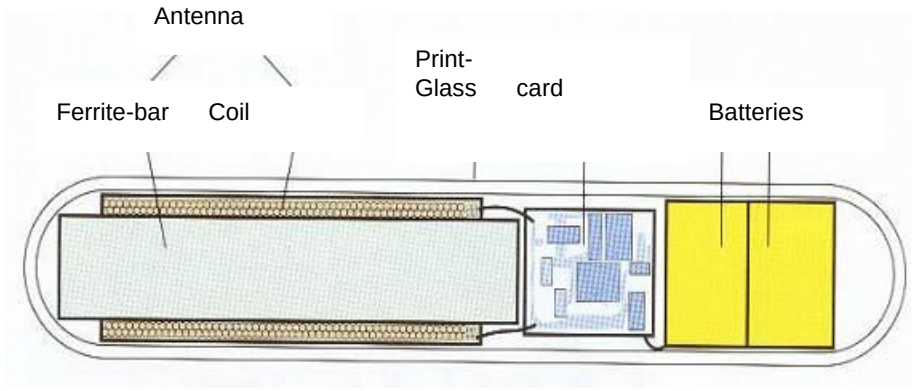
160 Ide (Leuciscus idus)

30 Detection stations

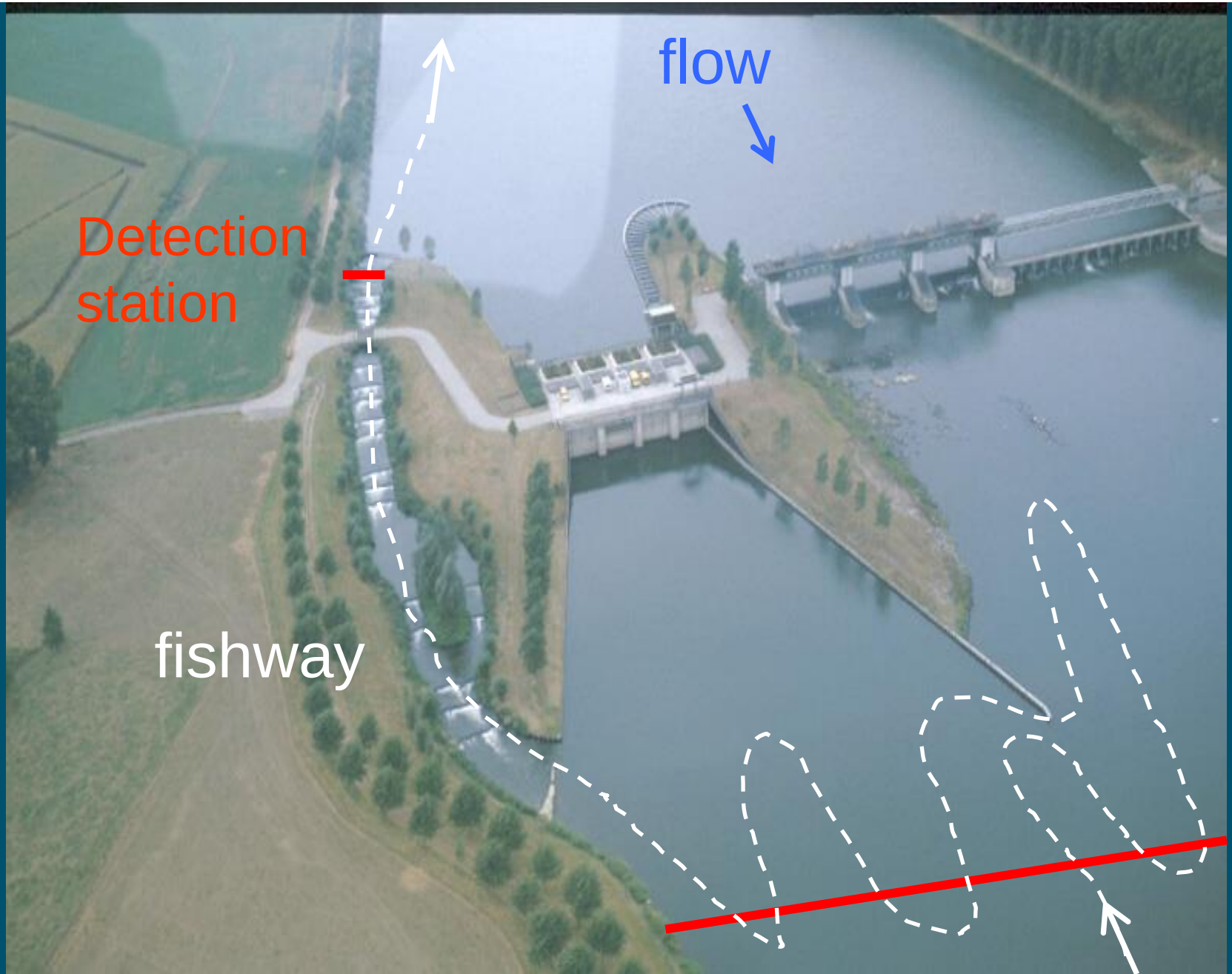


NEDAP-RIZA transponder systeem



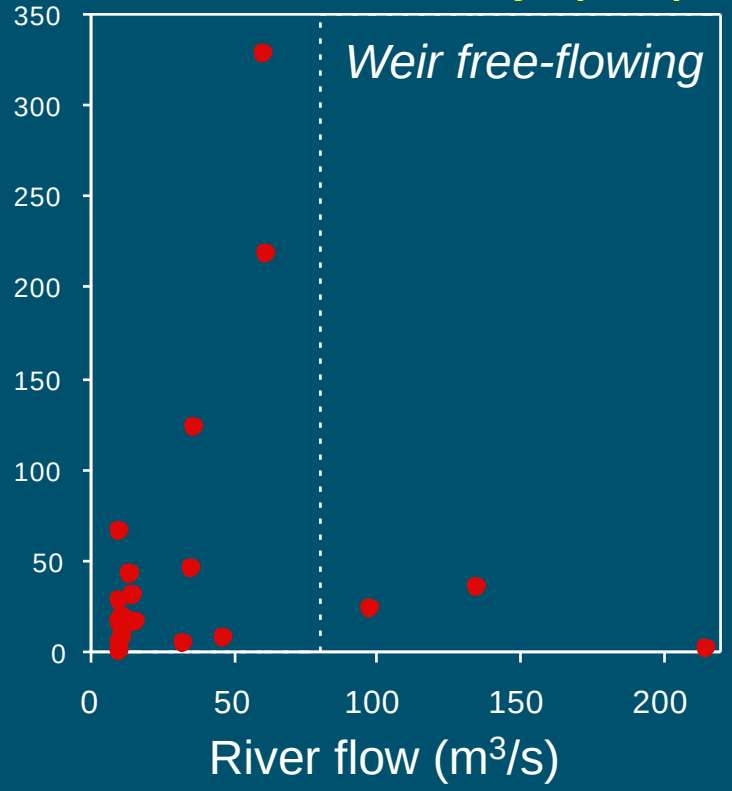


Passage behaviour at fishways

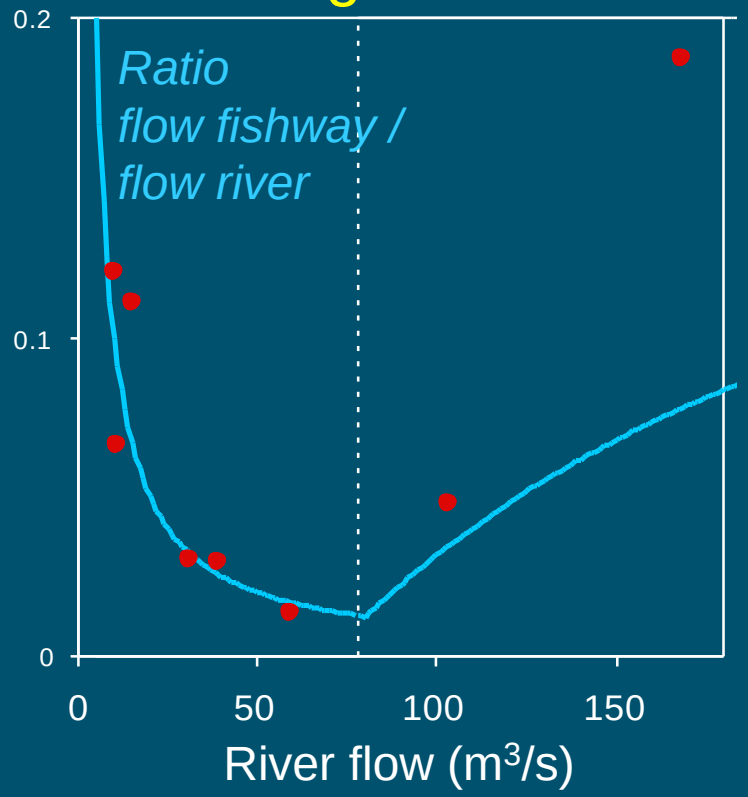


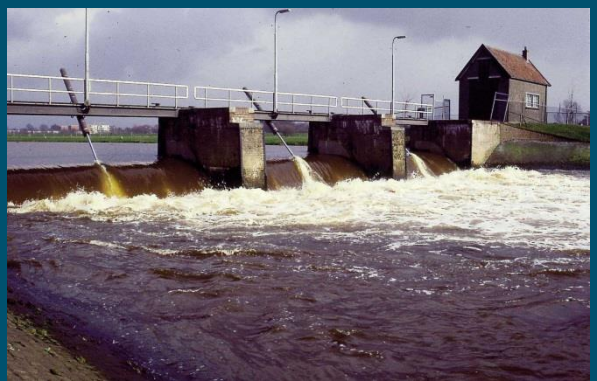
Passage success & attraction flow

Individual delay (hrs)

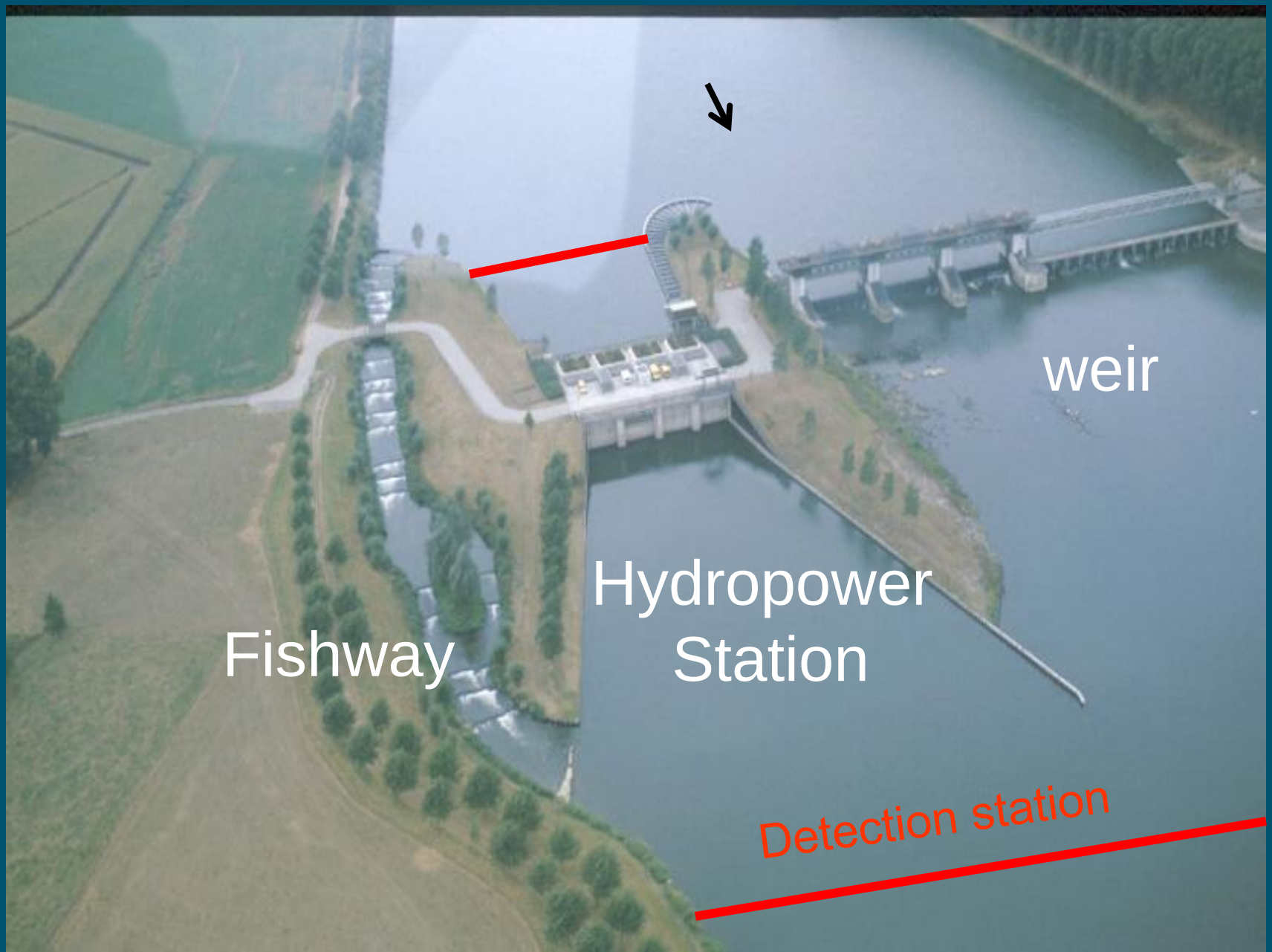


Passage success

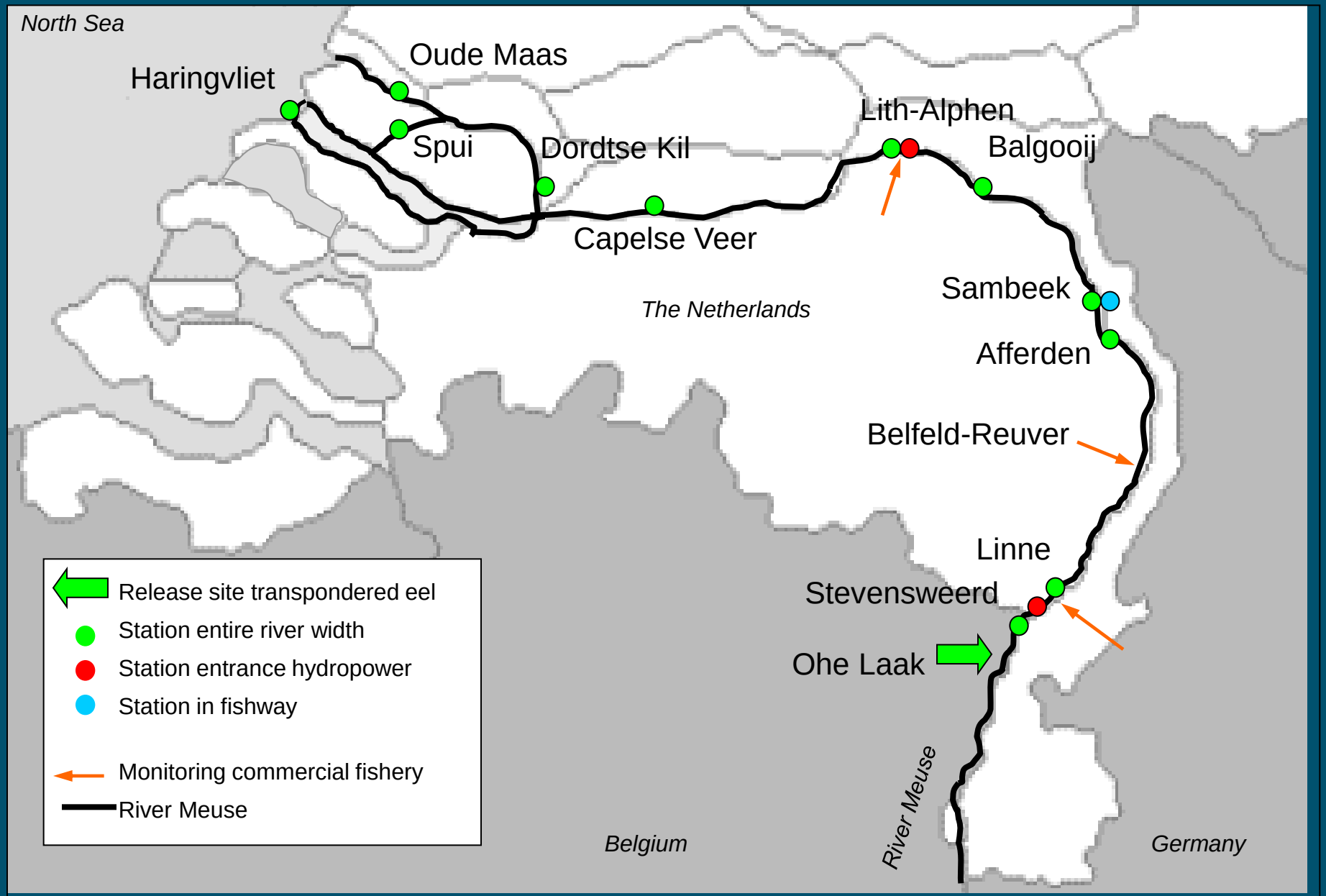




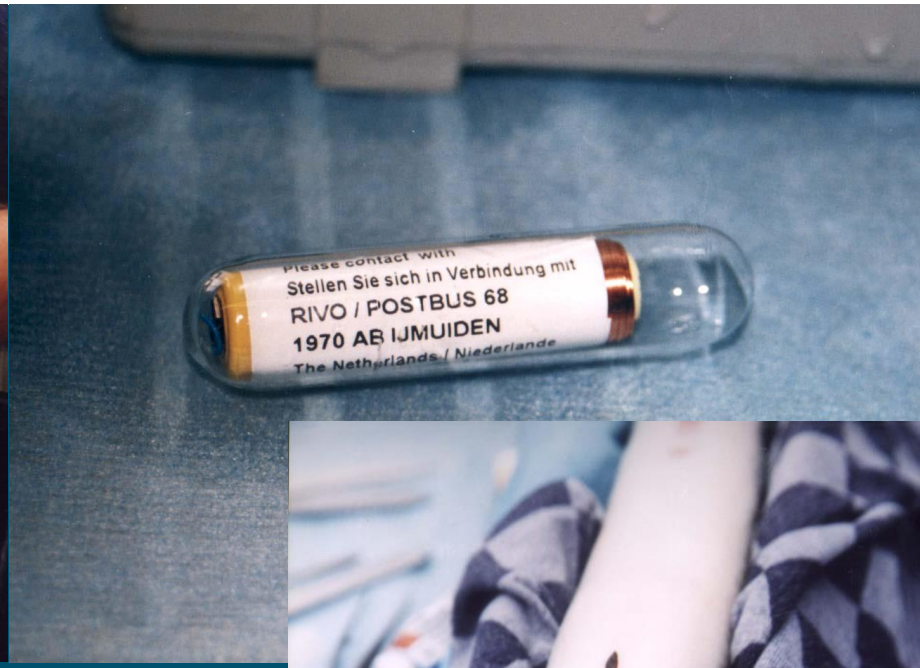
Detection stations at Linne and Lith



Transponder experiment 2002



Transponders and surgical procedure



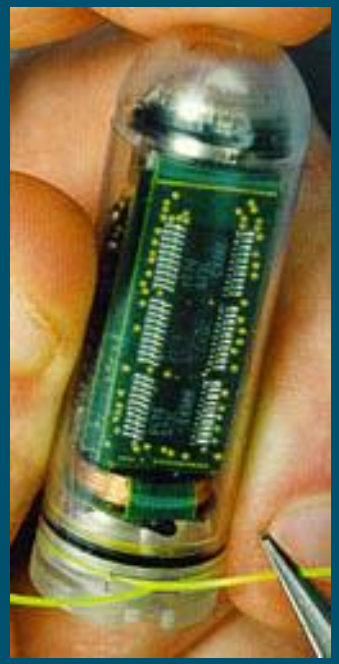
Transponder NEDAP-TRAIL, RIZA
63x14 mm, 26.5 g (air), 16 g (water)

Anaesthesia: 2-phenoxy-ethanol (0.9 ml l^{-1})

Mid-ventral incision: 2-3 cm (in body cavity)

Wound closing: Cyanoacrilate adhesive & biological bandage (*Baras & Jeandrain 1998*)

Hightech tags



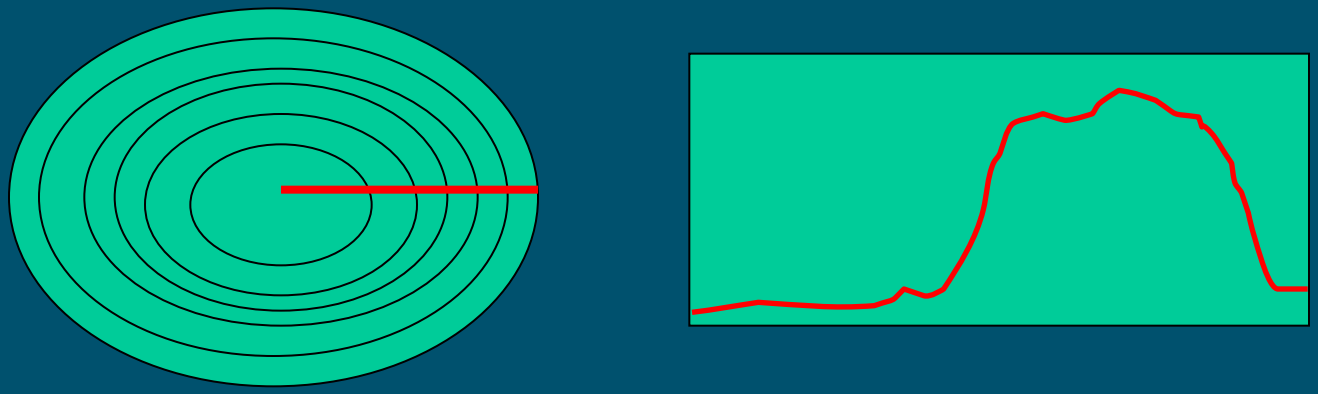
Archival tags:
Stores data on temperature, pressure etc.
Read out after recapture

Combination acoustic/radio tags:
Can be used in wide range of habitats, sea-river

Markers

- Biological:
  - Genetic
  - Fatty acids
  - Isotopes

- Chemical:
  - Strontium-calcium to determine sea vs. freshwater habitats



  - Tracers, e.g. contaminants

Gaps in knowledge and methods

- Juveniles/small fish:
  individual tagging methods mostly lacking

- Tropical fish:
  very species rich
  hardly any information on role migration for most fishes
  difficult to handle, perform surgery

Fishway at Amerongen