



PDG 2023 Section 6 - Fish and Fisheries

Fish Passage - Basis for PDG

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Fish Passage - Basis for PDG

- What is Fish Passage?
- Six Design Principles of Fish Passage
- Application to Mekong mainstream hydropower



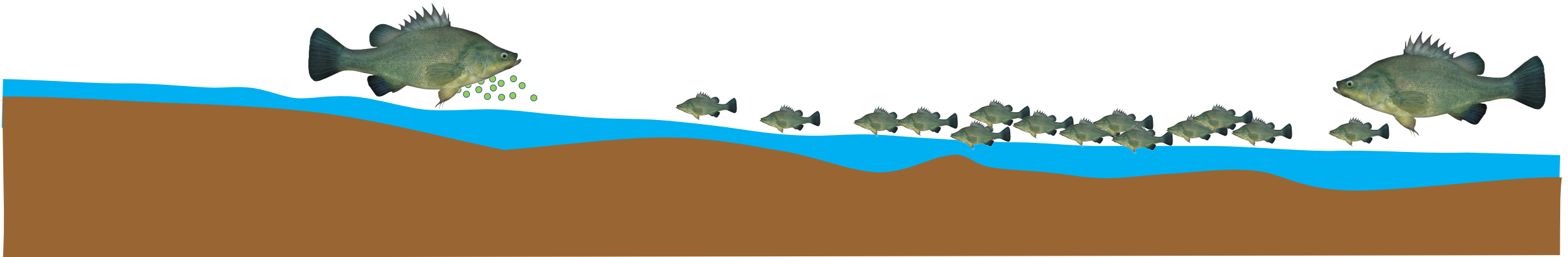
What is Fish Passage?

- It is maintaining the natural migrations of fish *to sustain populations*, for food security, nutrition, livelihoods, and biodiversity.
- Migration:
 - Upstream
 - Downstream
 - Laterally – between rivers, wetlands and floodplains
 - At different scales (10s km to 100s km)

Six Design Principles of Fish Passage

1. Address upstream and downstream migration
2. Integrate biology, hydrology and hydraulics
3. Design for **attraction** (fishway entrance)
4. Design for **passage** (fishway channel)
5. Size the fishway to meet the flows and biomass of the river system
6. Apply adaptive management (monitoring)

1: Address upstream and downstream migration



Fish passage at hydropower dams in the Mekong:

Adults *upstream* and *downstream*

Eggs and larvae *downstream*

Juveniles *upstream*

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2: Integrate biology, hydrology and hydraulics

Biology

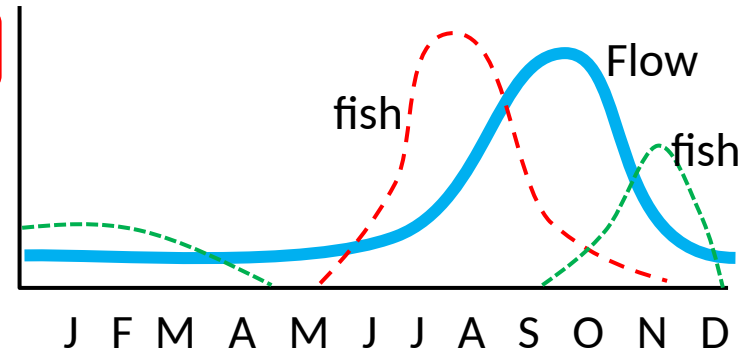
Smallest fish



Largest fish



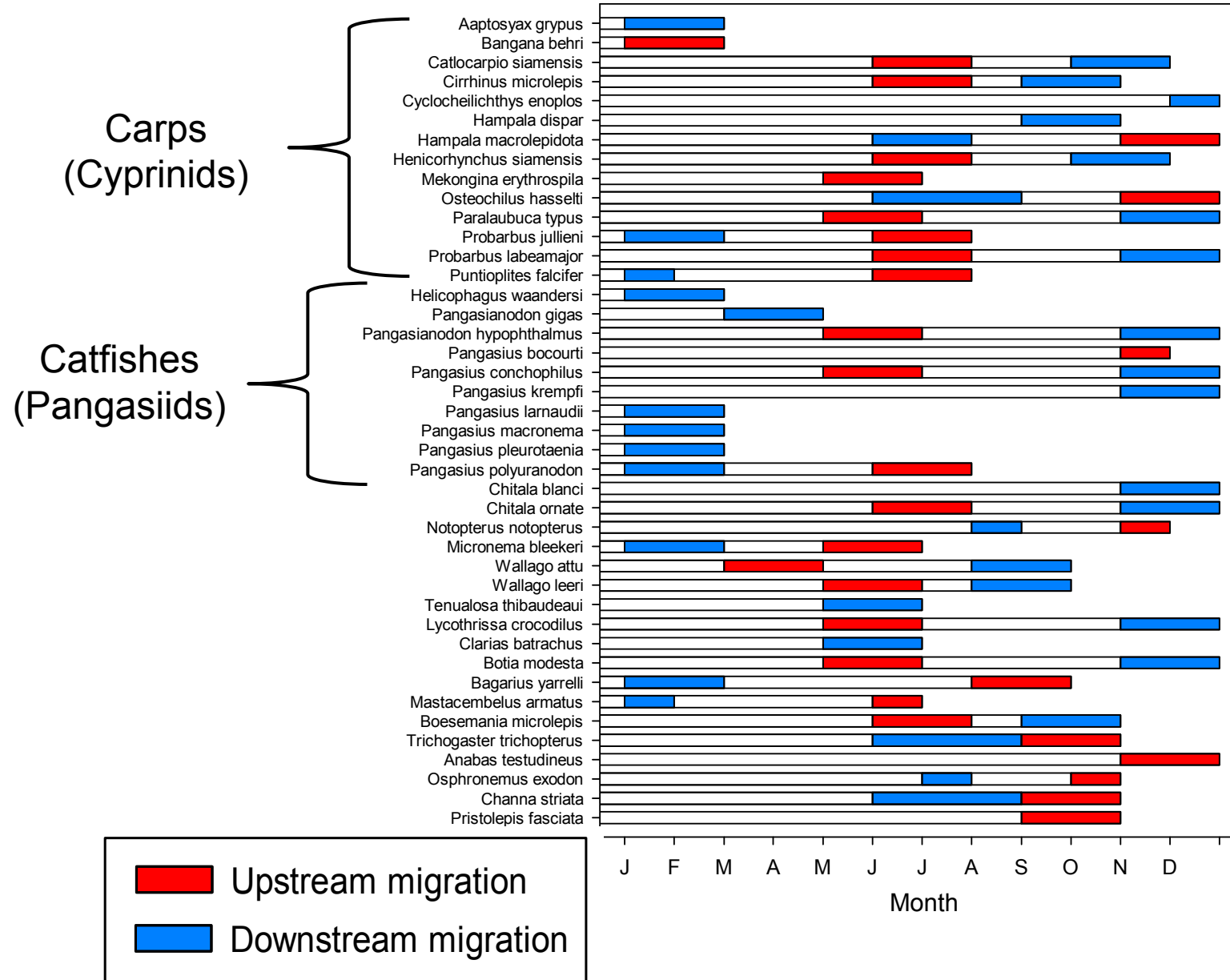
Migration Season and Flows



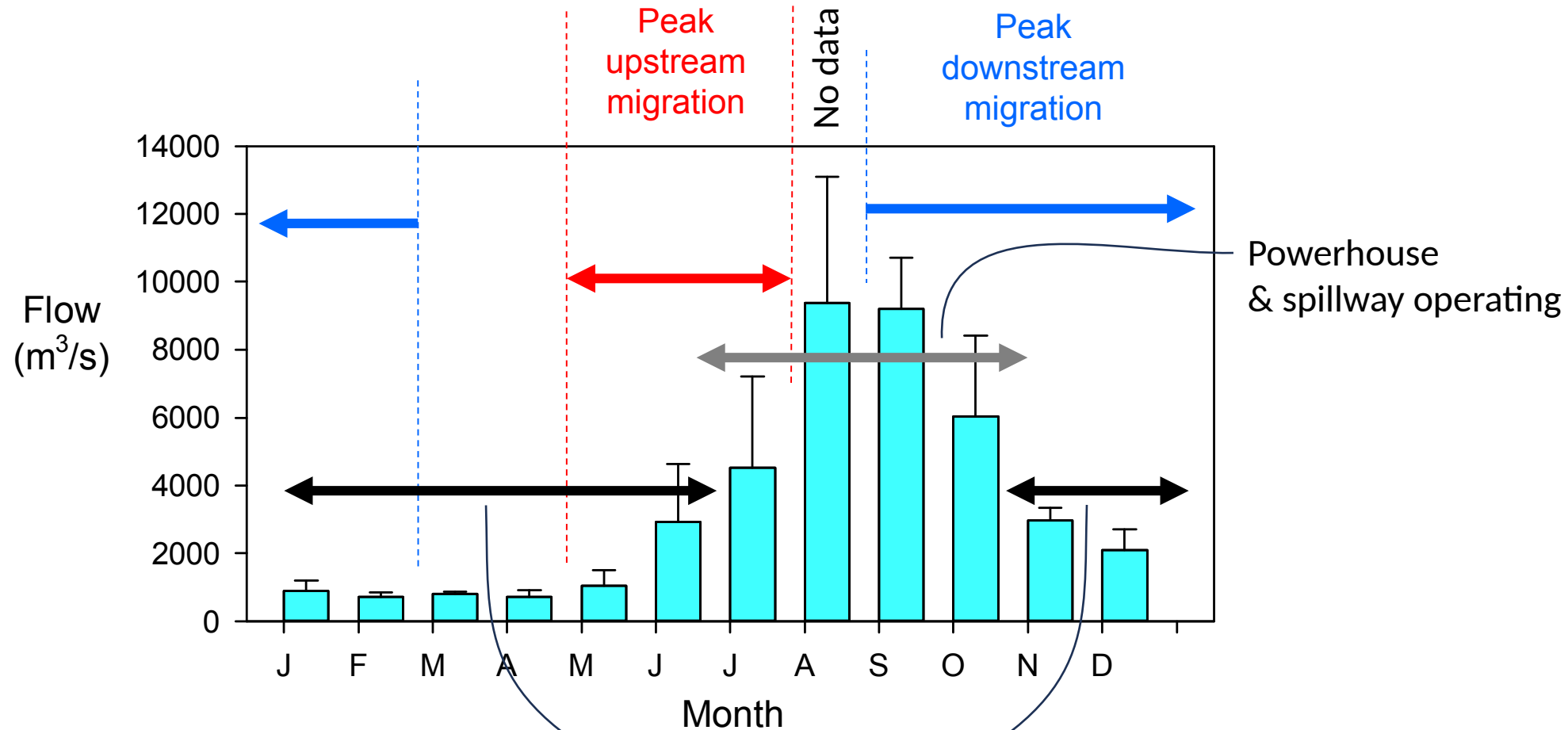
Biomass



Migration Season and Flows

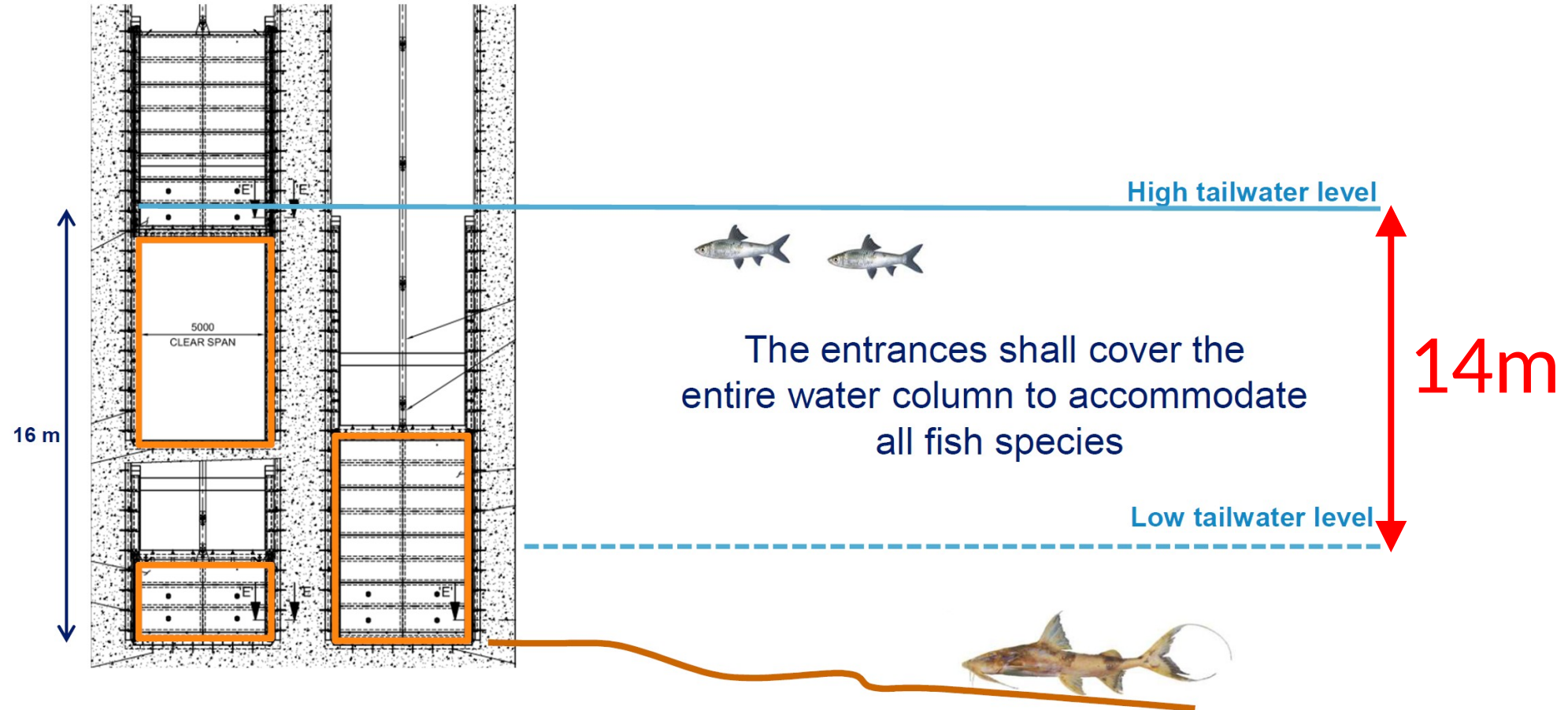


Migration Season and Flows



- **Upstream & downstream migration during powerhouse and spillway flows**
- **Wide range of tailwater levels**

Case Study: Xayaburi tailwater range for fishways



Case Study: Xayaburi tailwater range for fishways



2: Integrate biology, hydrology and hydraulics

Biology

Smallest fish

Largest fish

Migration Season and Flows

Biomass

Fishway Hydraulics & Design Criteria

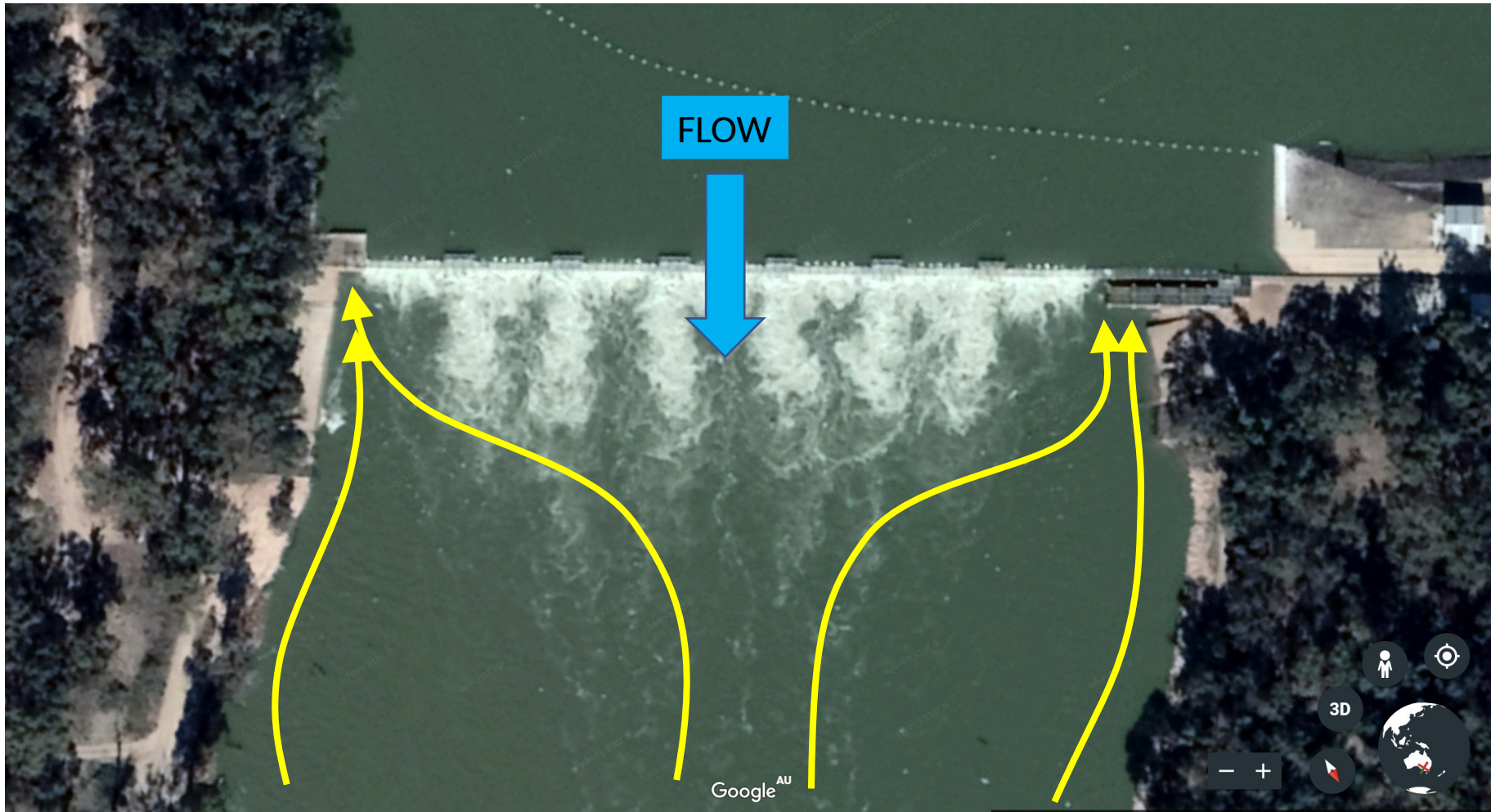
- Water velocity
- Turbulence
- Pool / channel size
- Channel depth
- Fishway discharge

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3: Design for **attraction** (fishway entrance)

Locate entrance at the upstream limit of migration



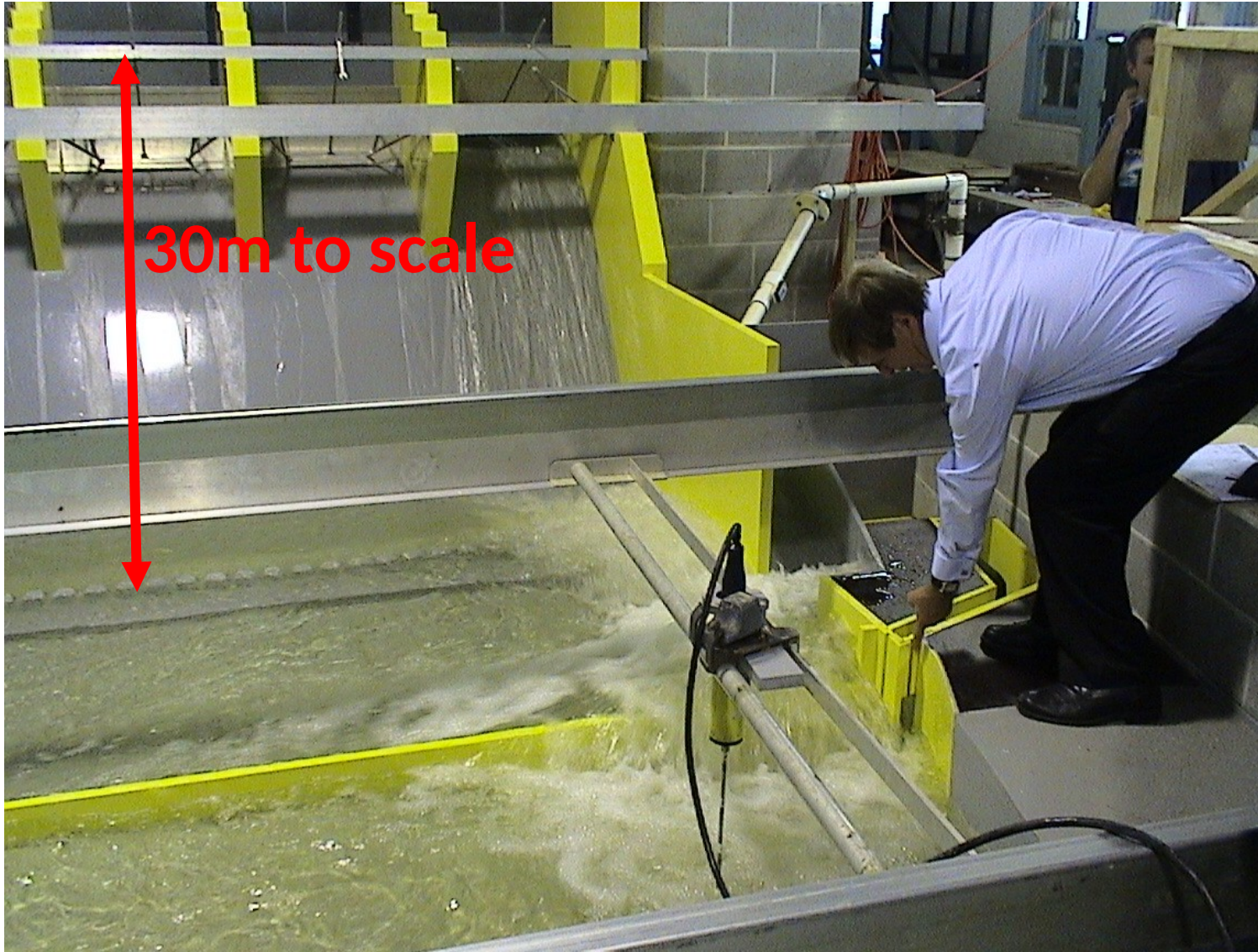
3: Design for **attraction** (fishway entrance)

- Use physical models



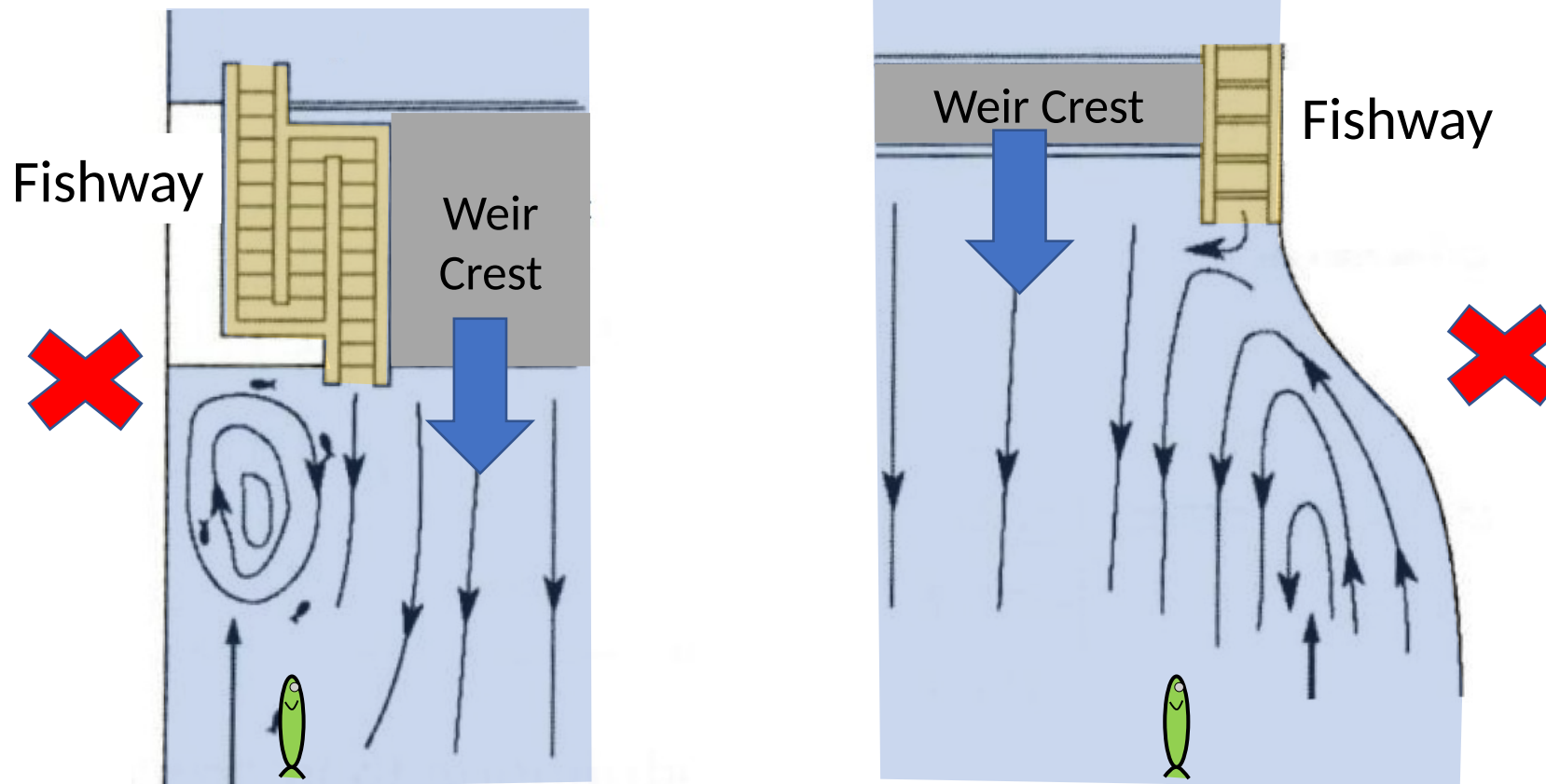
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3: Design for **attraction** (fishway entrance)

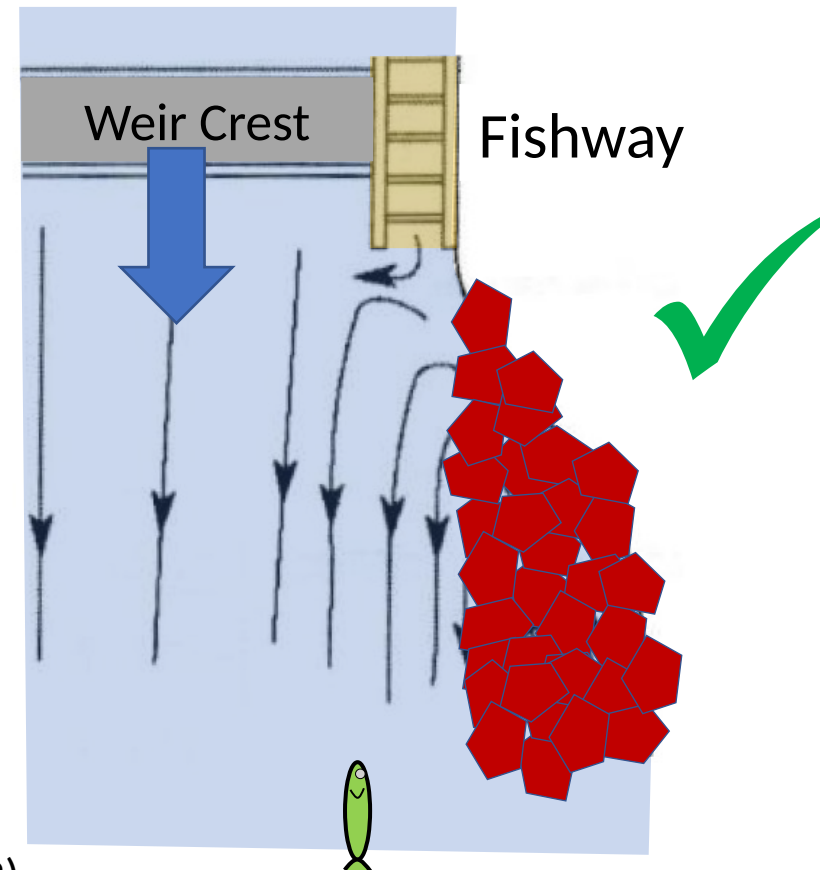
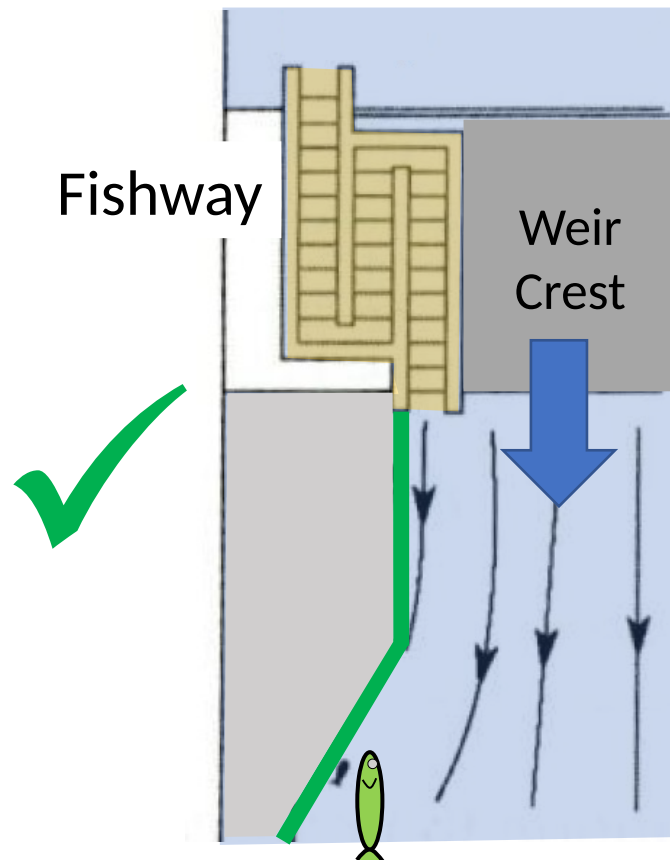
- Use physical models
 - Avoid recirculating flows or eddies



(Larinier 2002)

3: Design for **attraction** (fishway entrance)

- Use physical models
 - Solutions

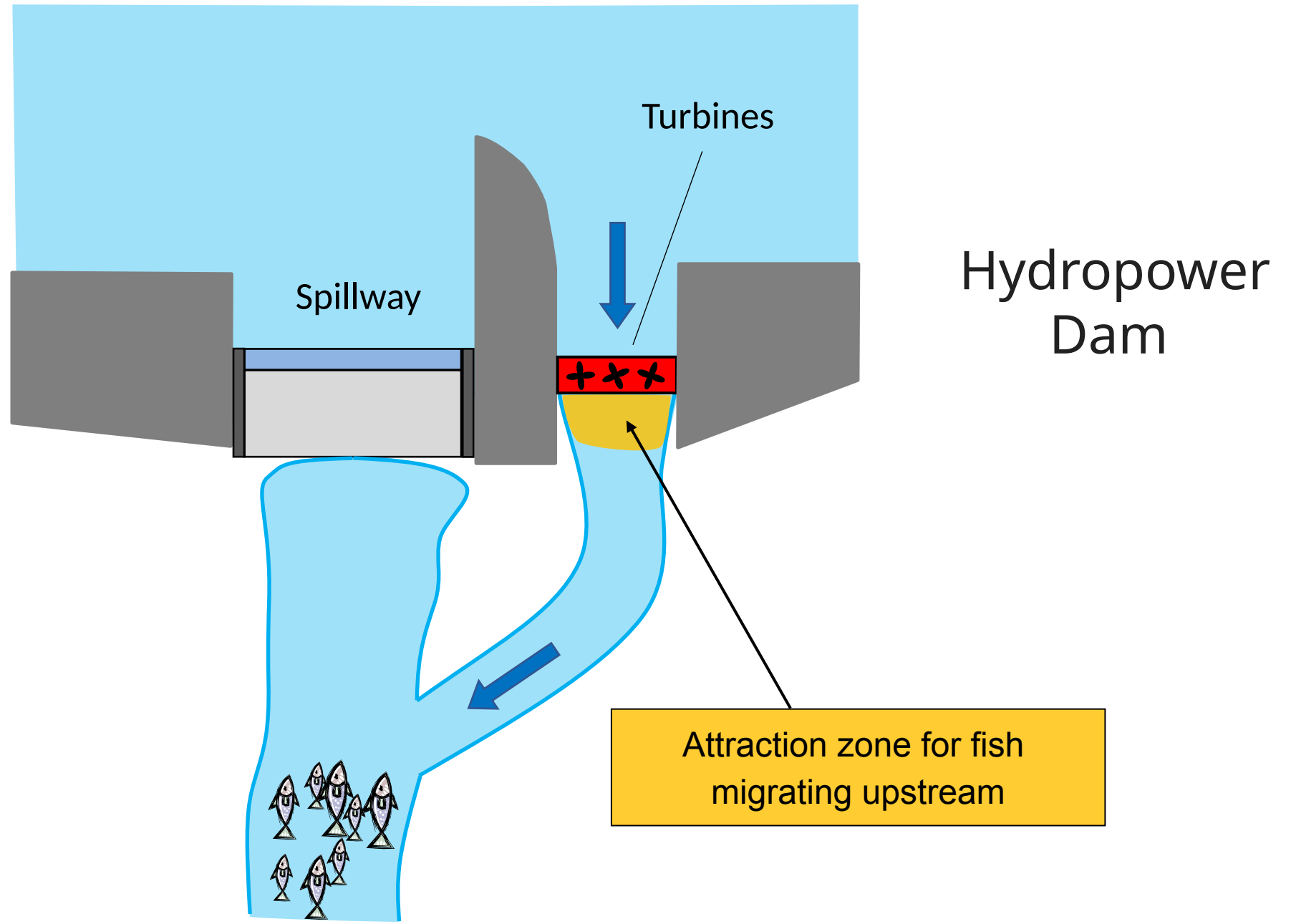


(Larinier 2002)

3: Design for **attraction** (fishway entrance)

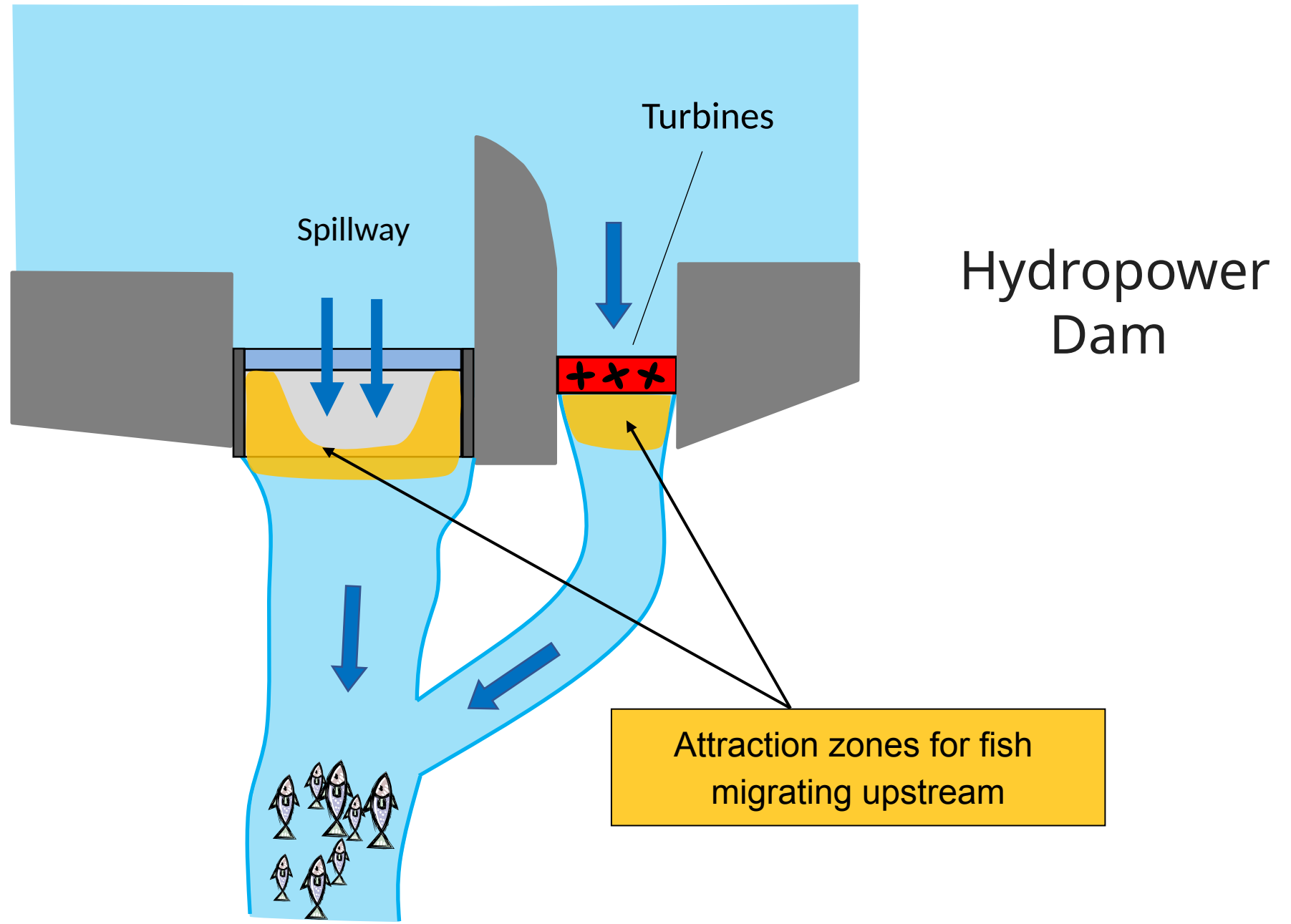
Different flows

- Dry Season



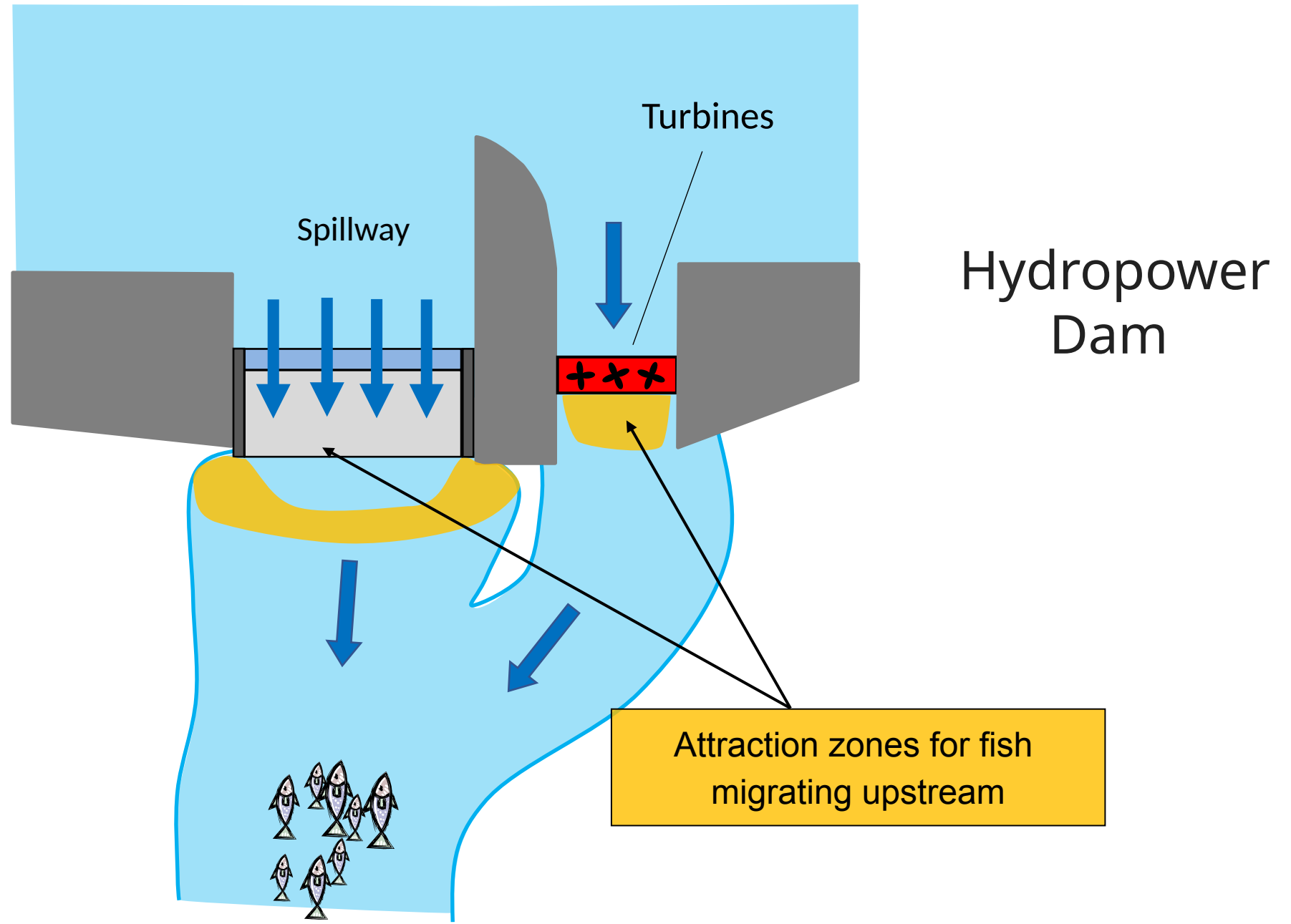
3: Design for **attraction** (fishway entrance)

Early wet season

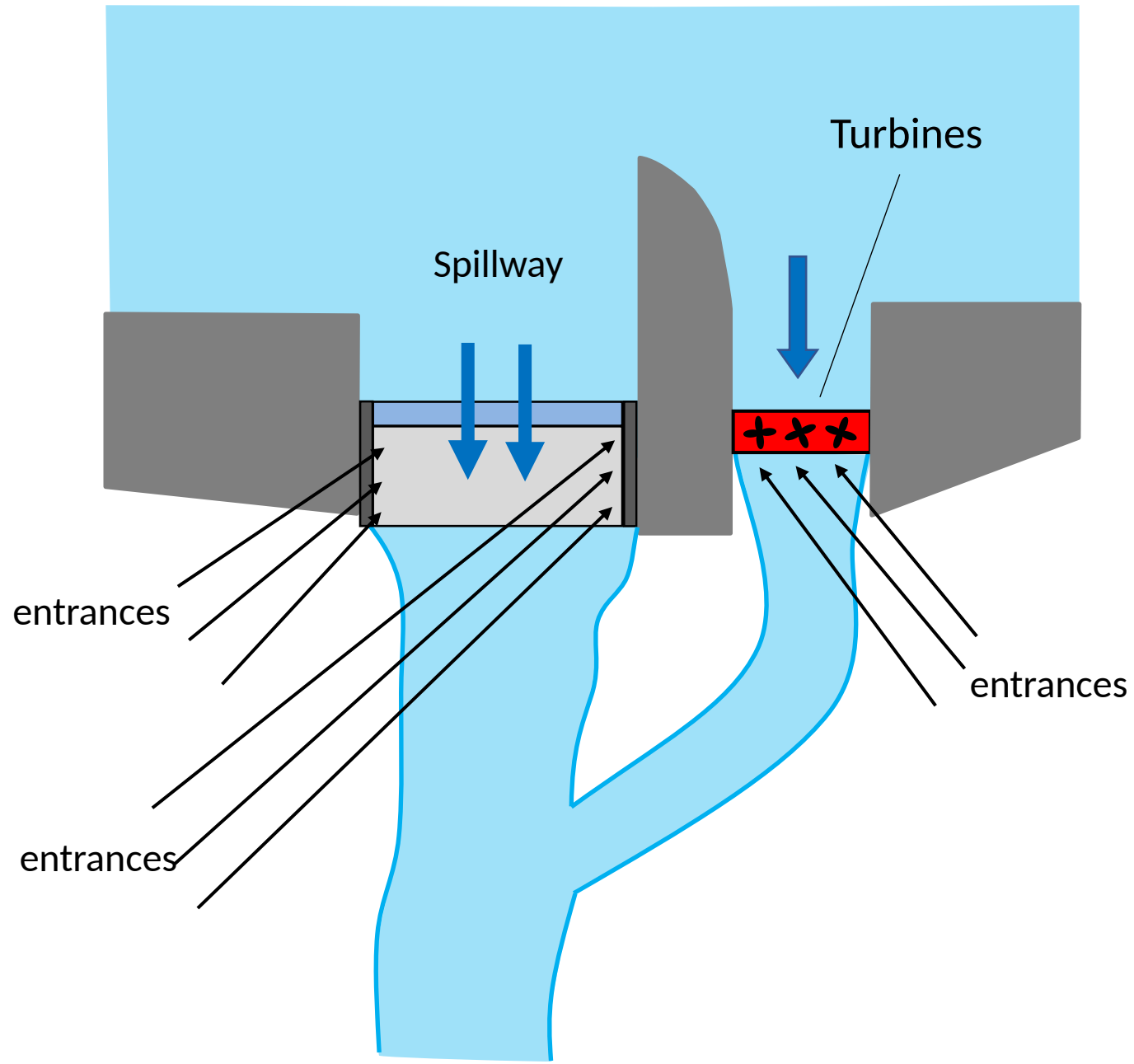


3: Design for **attraction** (fishway entrance)

Peak wet season



3: Design for **attraction** (fishway entrance)



3: Design for **attraction** (fishway entrance)

Location of fishway entrances

Discharge in fishway to attract fish

- Use 10% of low flows (Q_{95})
- Use 2% of high flows (1-in-1year flow)

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4: Design for **passage** (fishway channel)



4: Design for **passage** (fishway channel)

Biology

Smallest fish

Largest fish

Migration Season and Flows

Biomass

Fishway Hydraulics & Design Criteria

- Water velocity
- Turbulence
- Pool / channel size
- Channel depth
- Fishway discharge

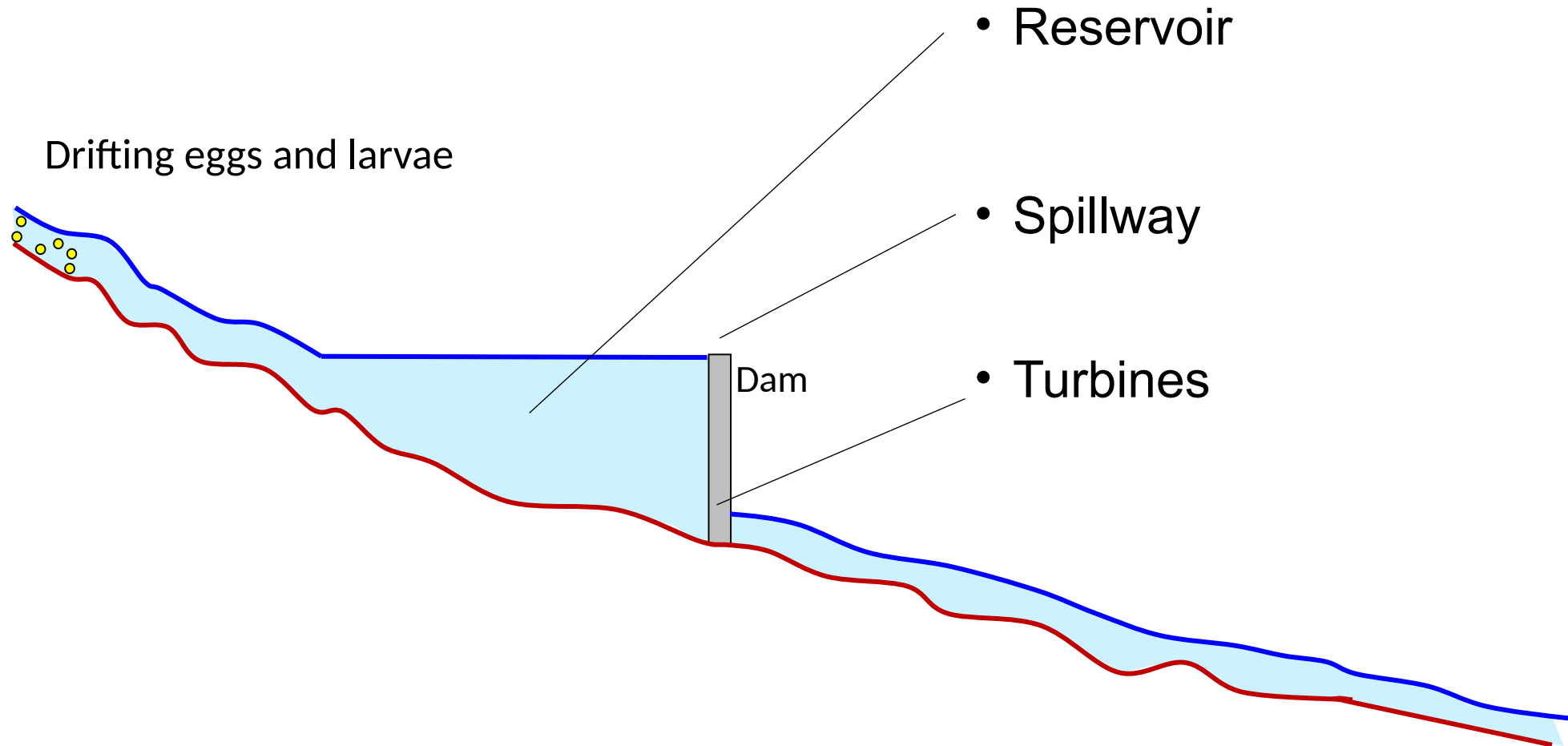
Downstream Fish Passage at Hydropower

3. Design for **attraction**
4. Design for **passage**

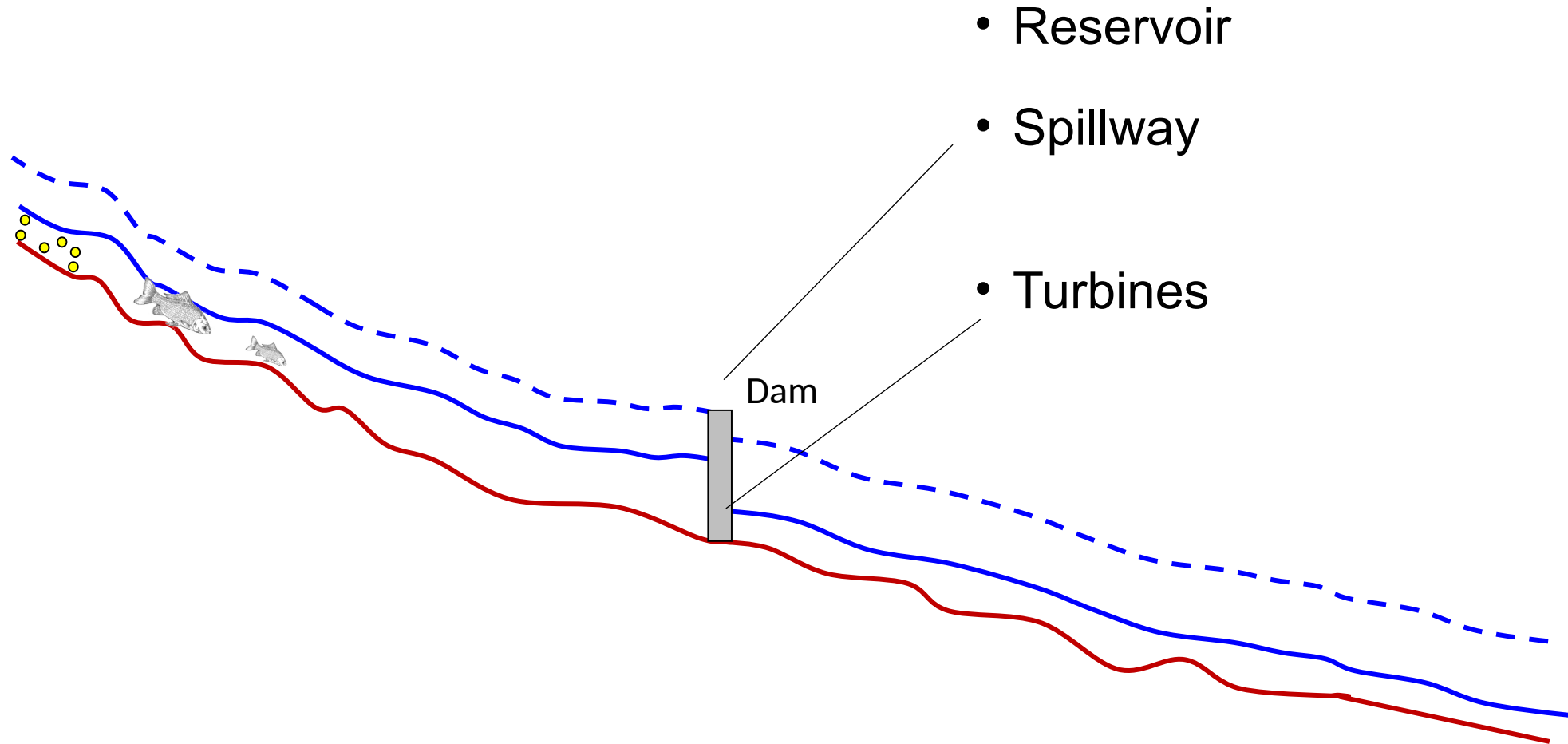
Downstream Fish Passage at Hydropower

3. Design for **attraction**

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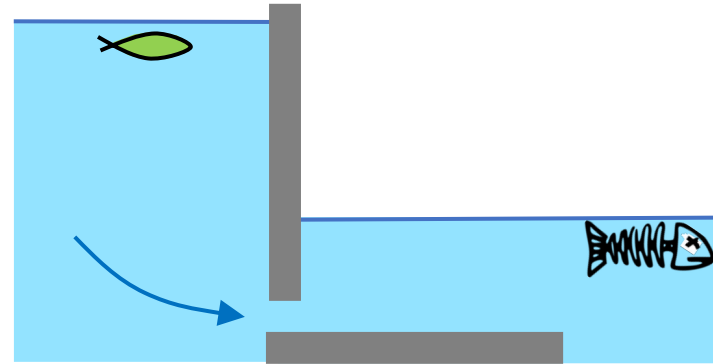
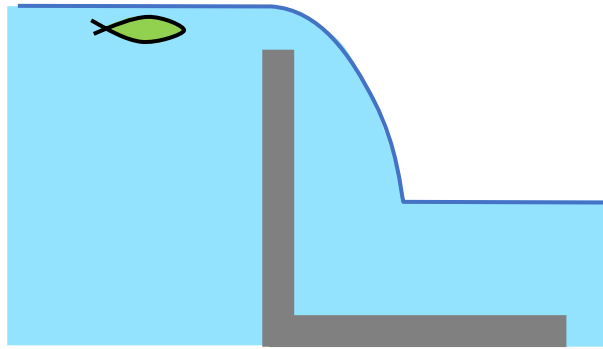
Downstream Fish Passage at Hydropower



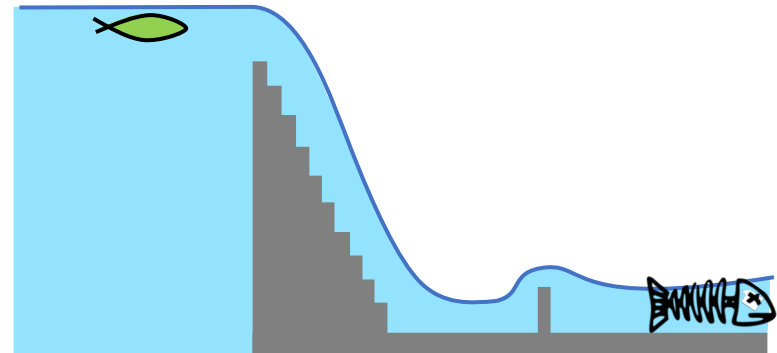
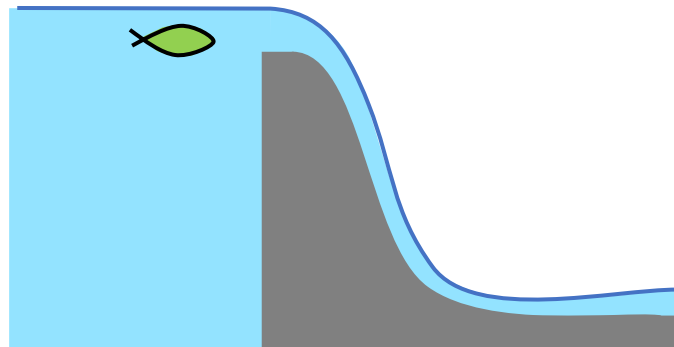
Downstream Fish Passage

Spillway impacts

Overshot gates better than undershot



Smooth spillways better



Downstream Fish Passage - turbines

Option 1) Screen and divert fish before turbines

Option 2) Design turbine to pass fish

Or both: screen large fish, and pass small fish safely through turbines

Downstream Fish Passage - turbines

“Fish-friendly turbines”

- No industry standard, or criteria
 - might reduce fish mortality,
 - but no published data on Mekong fish species
-
- If you are a developer, ask the turbine manufacturer for the data
 - If you are a reviewer, ask the developer for the data
-
- The developer is responsible for fish survival (60-95%, depending on species, as per PDG)

Downstream Fish Passage - turbines

Turbine impacts:

- Pressure
- Shear
- Blade Strike

Downstream Fish Passage - turbines

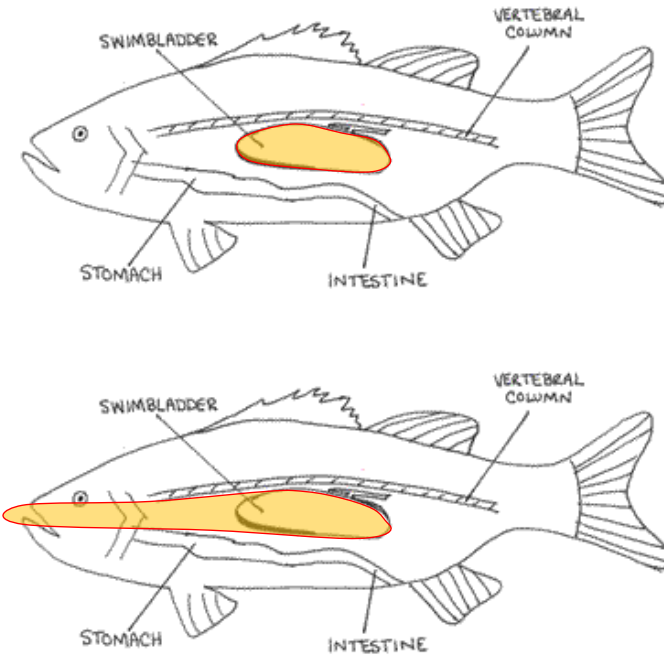
Impacts of pressure change (barotrauma)

e.g. 20 m dam

Upstream



In turbine



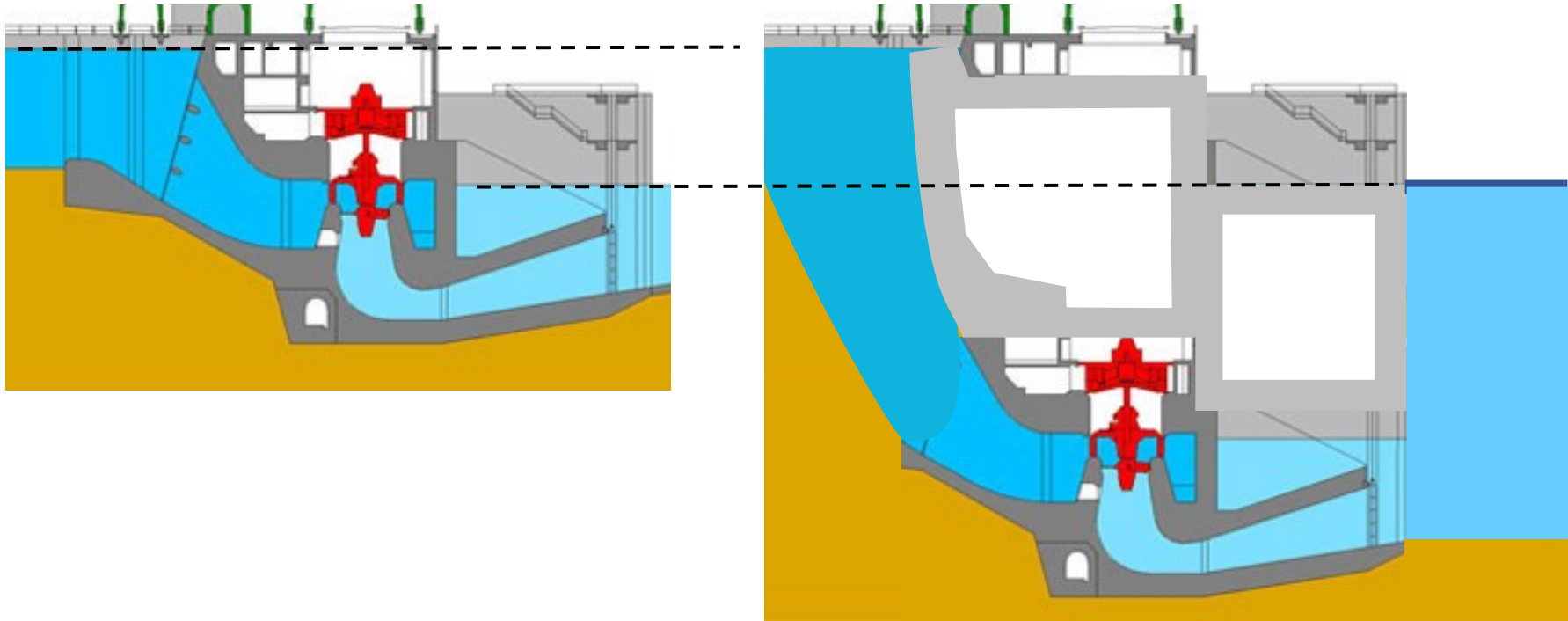
Swim bladder
approx. 3X volume



Photograph courtesy of Luiz Silva

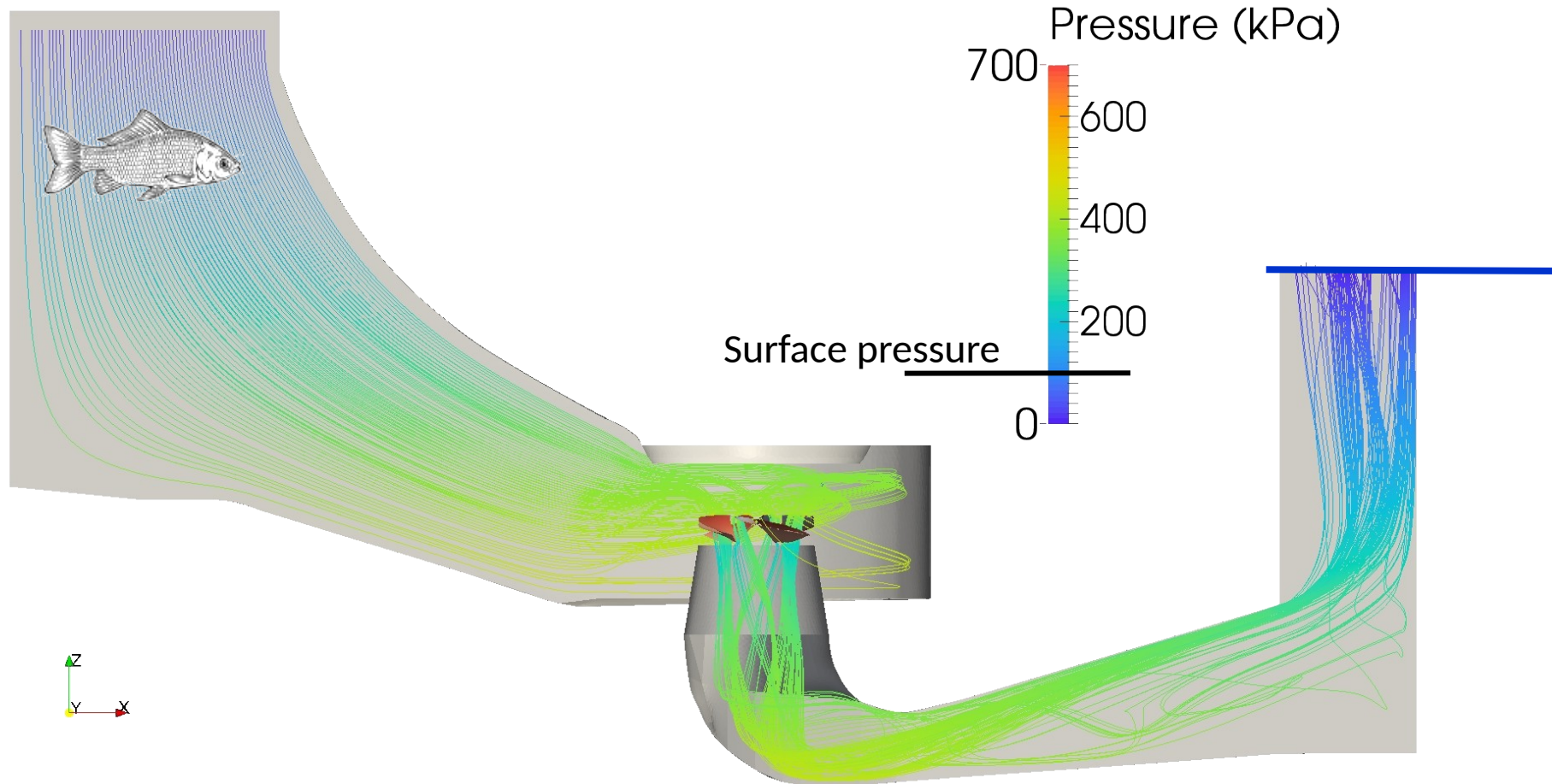
Downstream Fish Passage - turbines

Deep turbines – minimise pressure impacts



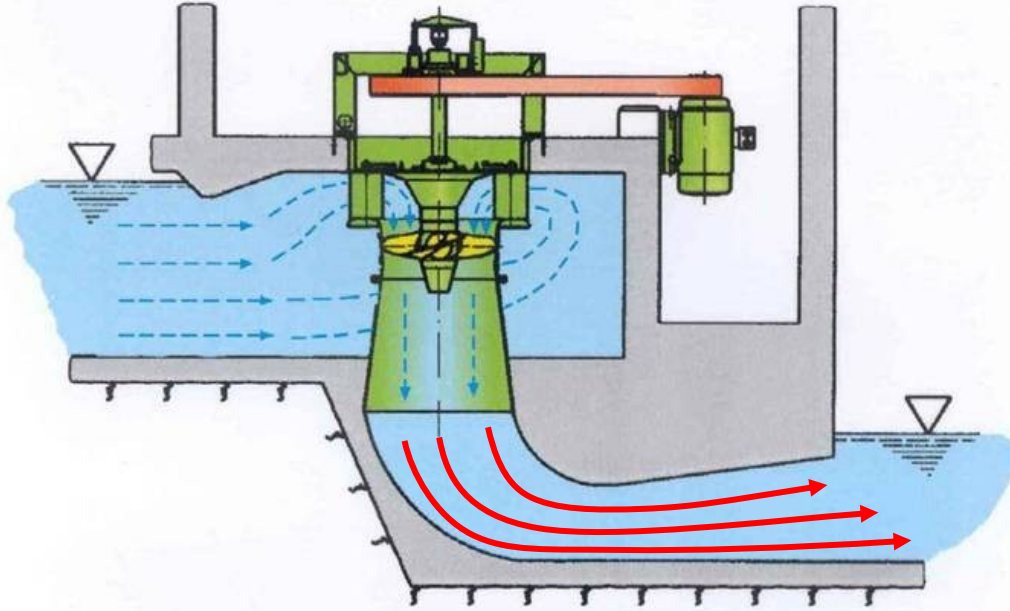
Downstream Fish Passage - turbines

Use Computer Modelling (CFD) to assess pressure impacts

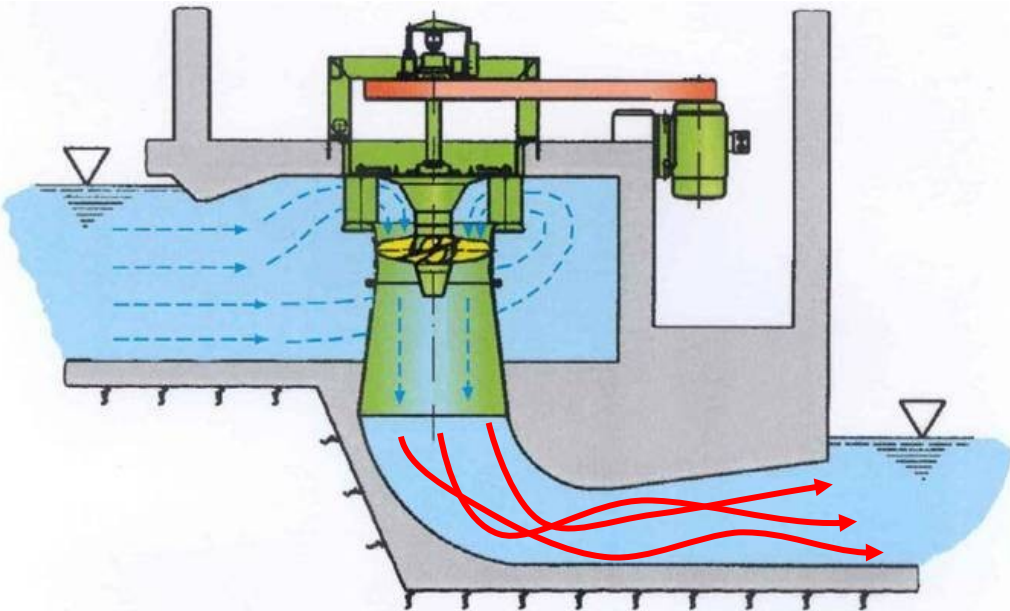


Downstream Fish Passage – turbines - shear

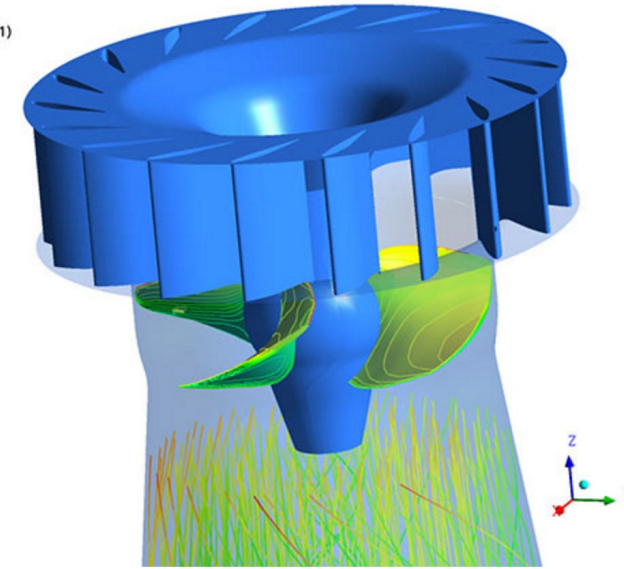
Low shear



High shear



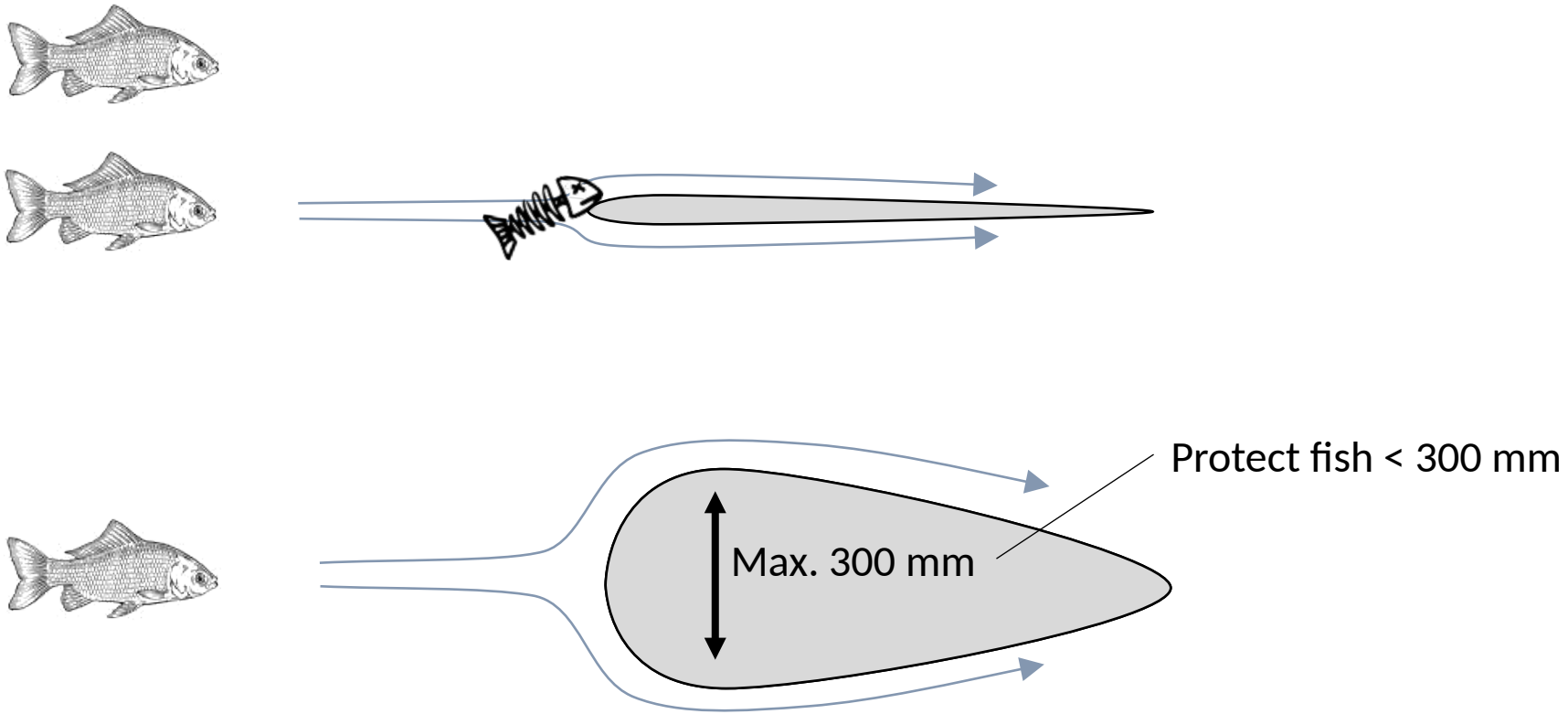
Velocity
(Streamline 1)
5.32
4.01
2.71
1.40
0.09
[m s⁻¹]



Use Computer Modelling (CFD) to reduce risk

Downstream Fish Passage – turbines – blade strike

- Thicker blade is better



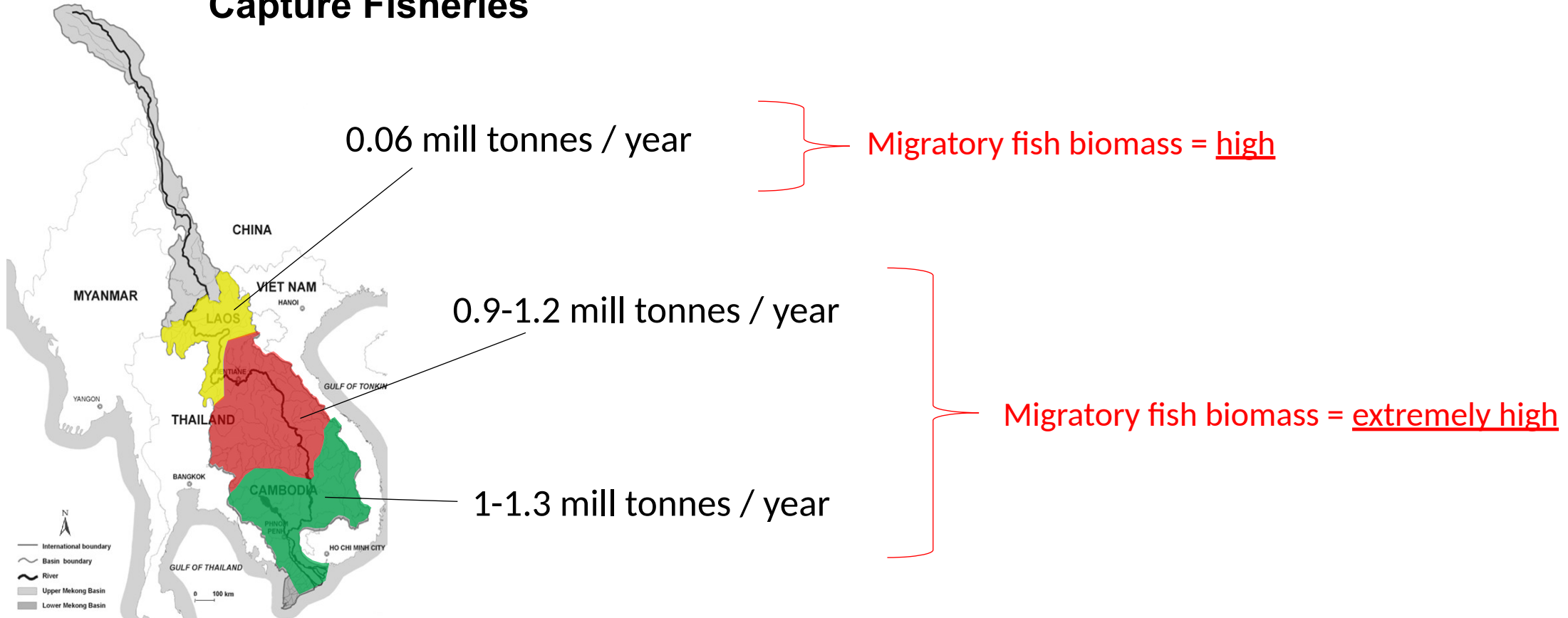
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5: Size the fishway to meet the flows and biomass of the river system

- Large tropical rivers have large migratory fish biomass (kg of fish)

Mekong Freshwater Capture Fisheries



5: Size the fishway to meet the flows and biomass of the river system

How to design for high biomass:

- Large fishways
- Use 10% of river flow in fishway

Six Design Principles of Fish Passage

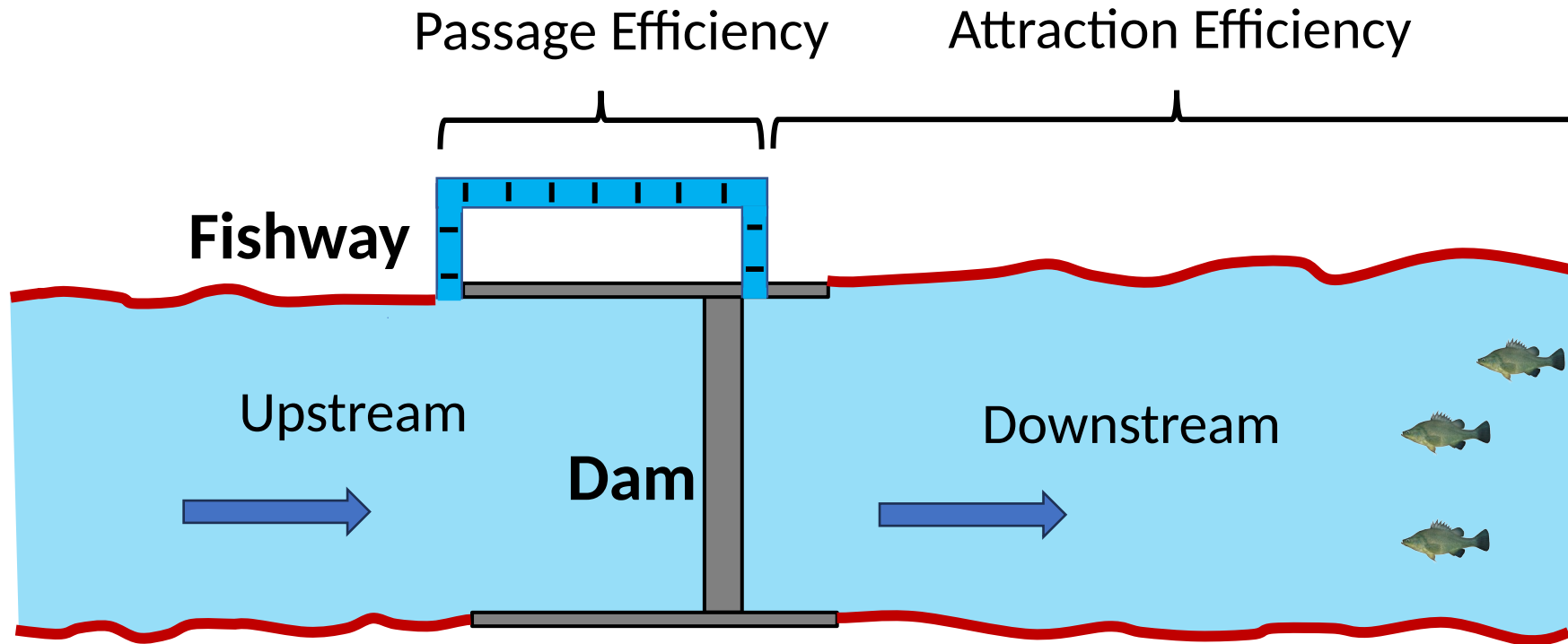
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Monitoring & Assessment

- Upstream & Downstream fish passage
- Attraction & Passage

6: Apply adaptive management (monitoring)



- Budget for monitoring and modifications

Summary

- Hydrology, biology
- Attraction zones
- Fishway channel design
- Downstream migration (reservoir, turbines, screens, spillway)
- Adaptive management

Thank you!

