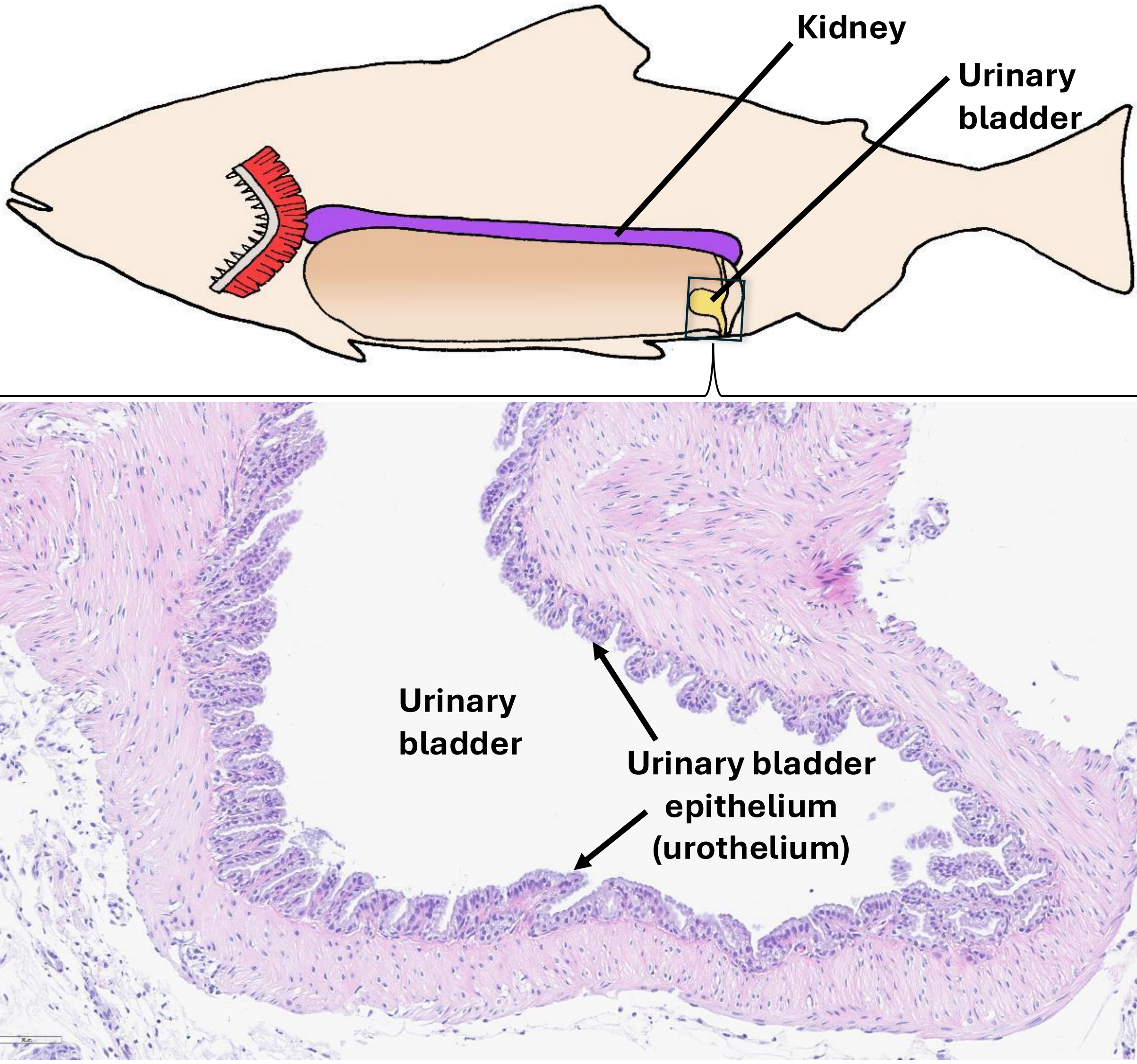
Urinary bladder of fish



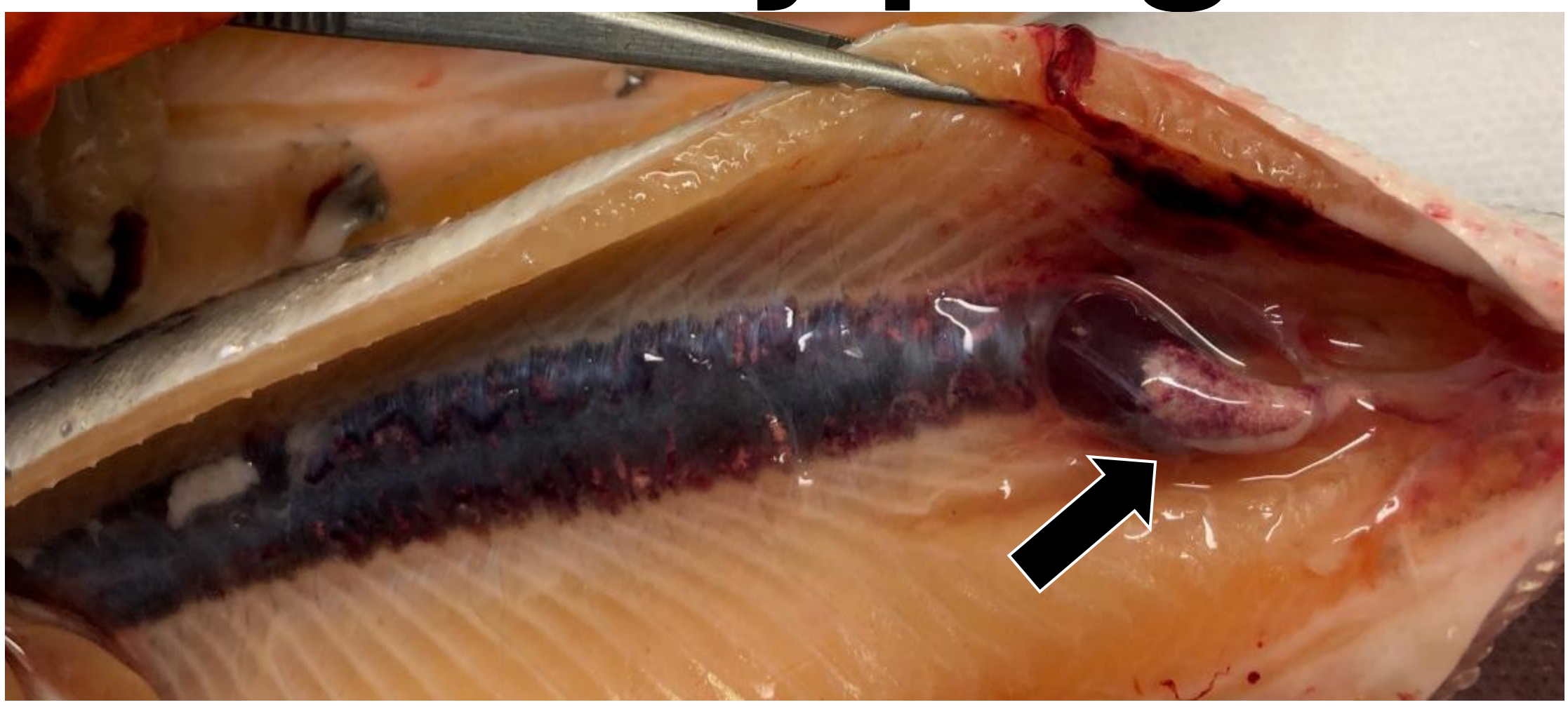
Histology of a normal urinary bladder (haematoxylin eosin, HE)

The urinary bladder of fish does not only serve as a storage organ: it is also substantially involved in the final stage of modification of the urine, like its content of natrium, chloride and water. This is governed by several key mechanisms:

- Regulating glomerular filtration rate (GFR)
- Regulating urinary flow rate (UFR) and frequency of urine discharge
- Specific transporters in the urothelium
- Regulating the permeability of the urothelium

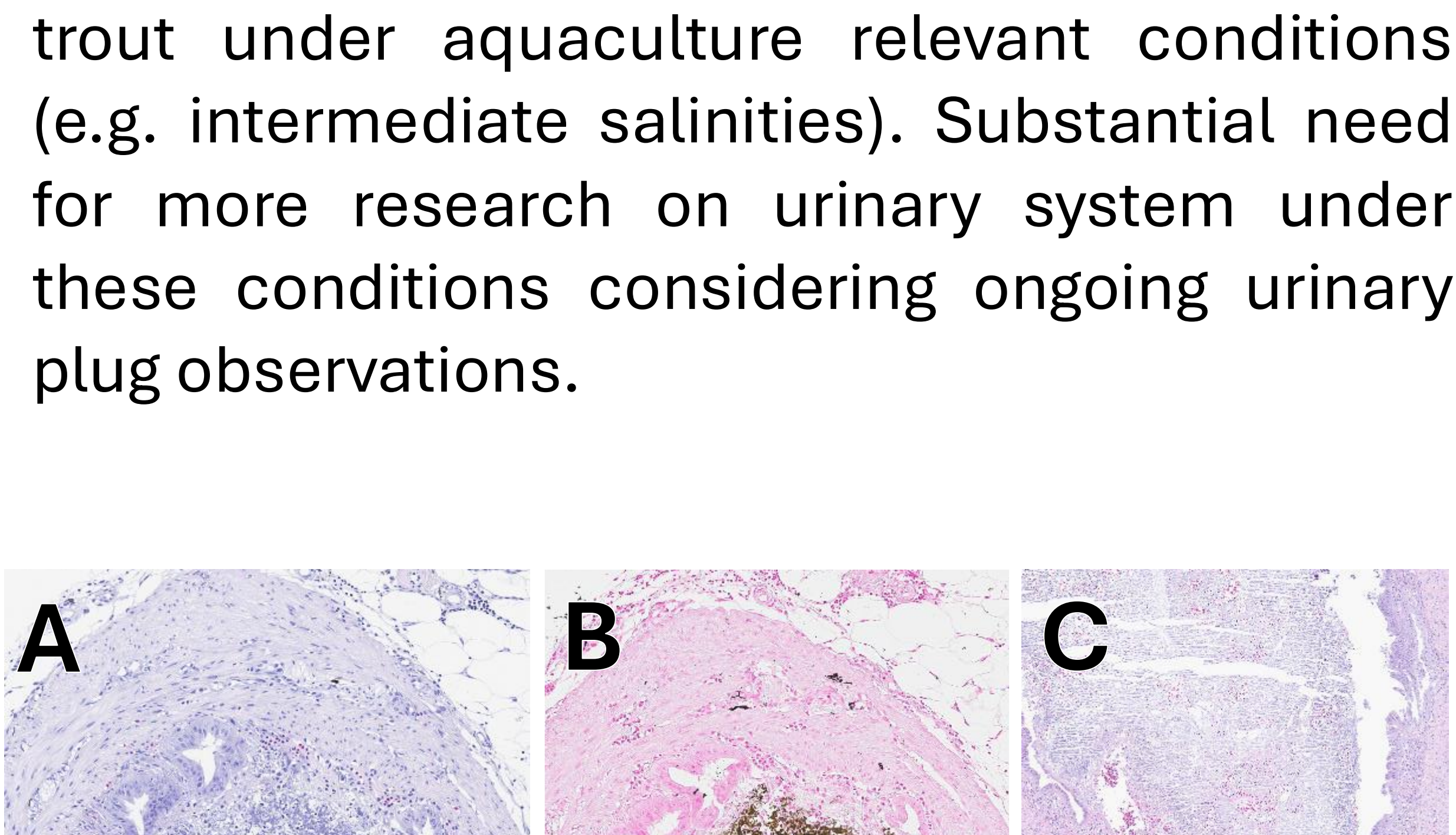
This mechanisms are regulated depending on the environment of the fish particularly salinity

Urinary plugs



Urinary plug (arrow: urocystolithiasis) in Atlantic salmon

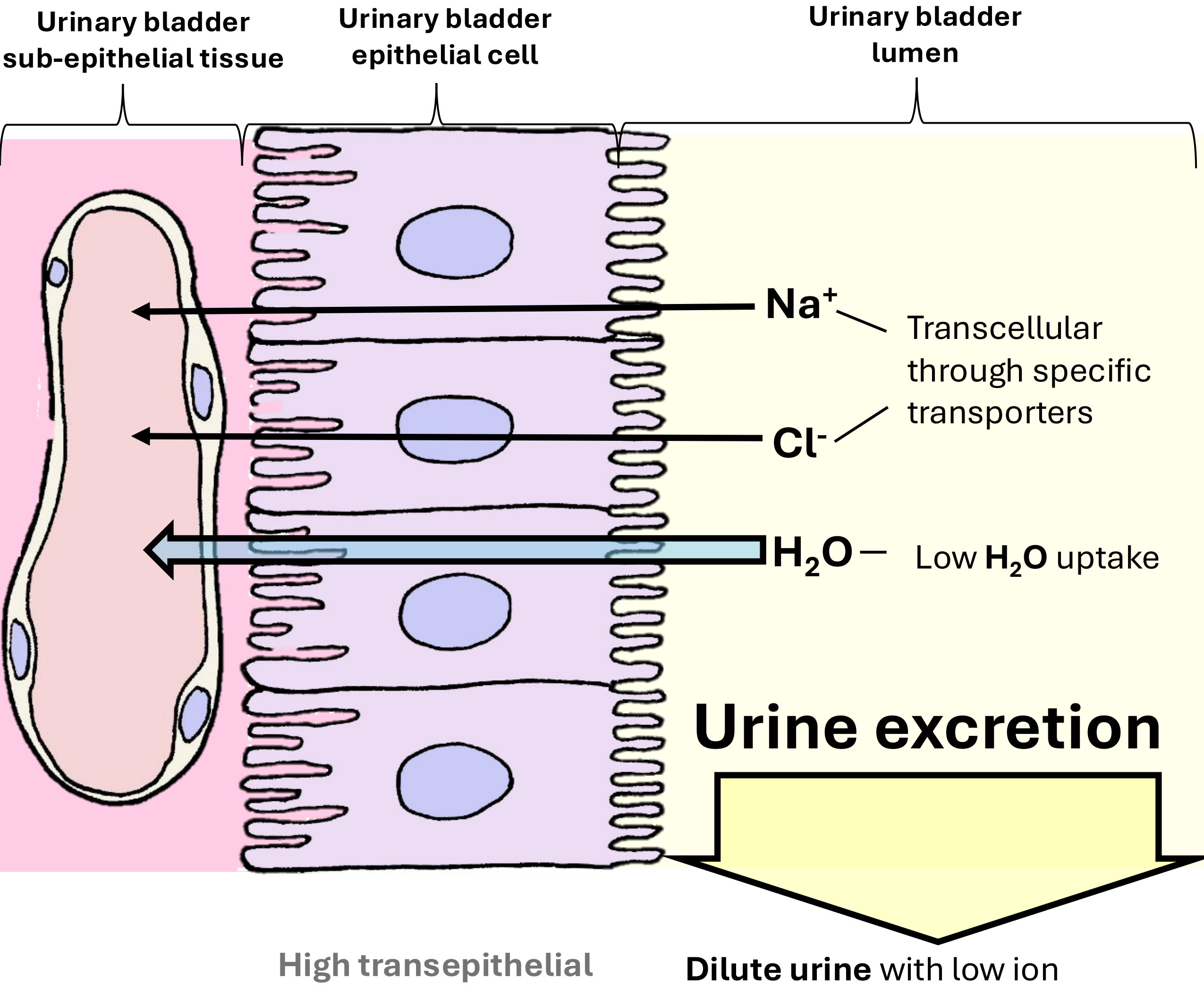
No studies on the urinary system have been performed on either Atlantic salmon or rainbow trout under aquaculture relevant conditions (e.g. intermediate salinities). Substantial need for more research on urinary system under these conditions considering ongoing urinary plug observations.



Histology of urinary plug (urocystolithiasis) in Atlantic salmon, with close to complete occlusion of the urinary bladder (A, HE) consisting of mineralised material (B: von Kossa staining), causing obstruction of urinary flow (C, HE, pattern of normal flow indicated by arrow)

Freshwater (FW)

Salinity: 0-1 ppt



High transepithelial resistance in FW (5-10 Ω·cm^{-2}): low water uptake over the urinary epithelium (“tight”)

Dilute urine with low ion concentrations (20-50 mOsm) and **pH at 7-7,4**

High urine flow rate (UFR):

- 3-4 ml/kg/hour (high volume)

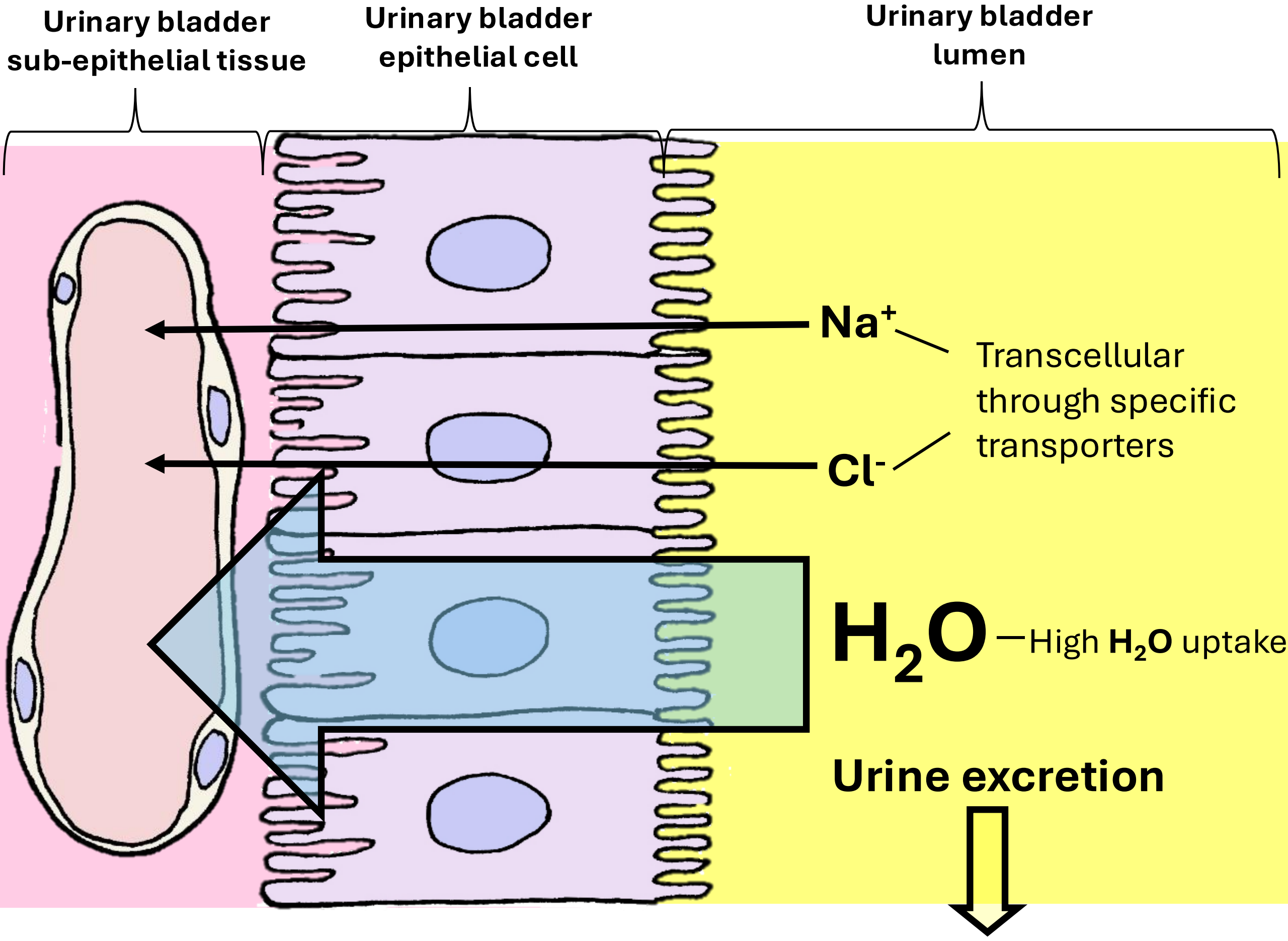
Short residence time:

- 0.5-2 hours

FW conditions: epithelial resistance in the urinary bladder is high to reduce water uptake to remove excess water through the urine while Na^+ and Cl^- is reabsorbed to reduce salt loss. In FW, the urinary flow is high, residence time short, mineral levels low, and urine pH is close to neutral (7.0-7.4) so to **minimize precipitation of crystals under normal conditions**

Sea water (SW)

Salinity: 30-35 ppt



Low transepithelial resistance in SW (0.3–2.3 Ω·cm^{-2}): high water uptake over the urinary epithelium (“leaky”)

Urine excretion

Urine rich in divalent ions (200-400 mOsm) and lower urine **pH 6,3-6,5**

Low urine flow rate (UFR):

- 0.5-1.5 ml/kg/hour (low volume)

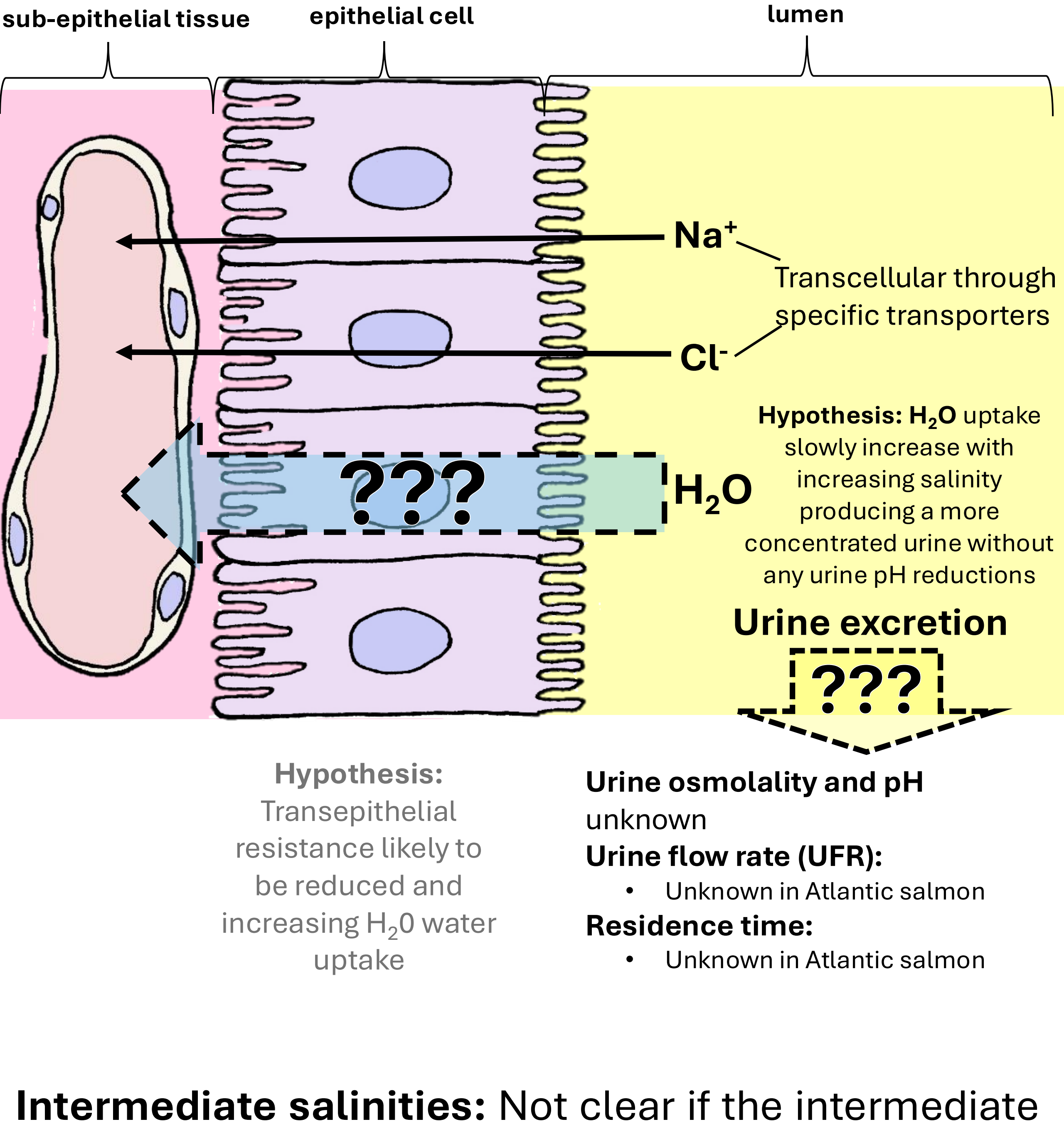
Long residence time:

- 2-3 days

SW conditions: epithelial resistance in urinary bladder is low that allows for NaCl mediated water uptake to minimize water loss. In SW fish the urinary flow is low, with longer residence time and high mineral levels but **urine pH is more acidic, usually 6-6.5, to minimise crystal formation despite lower flow rate, longer residence time and higher mineral levels**

Intermediate salinity

Salinity: 3-20 ppt



Hypothesis:
Transepithelial resistance likely to be reduced and increasing H_20 water uptake

Hypothesis: H_2O uptake slowly increase with increasing salinity producing a more concentrated urine without any urine pH reductions

Urine excretion

???

Urine osmolality and pH
unknown

Urine flow rate (UFR):

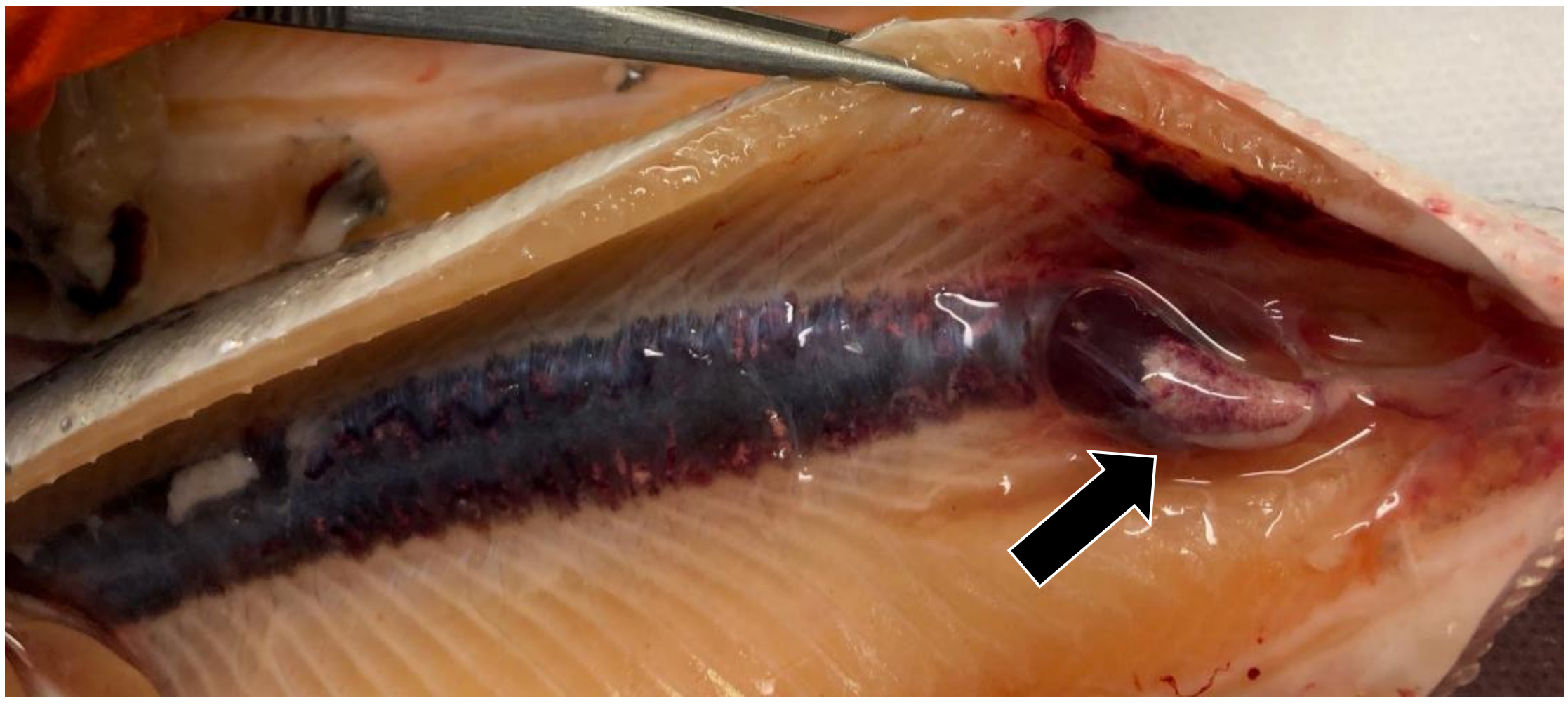
- Unknown in Atlantic salmon

Residence time:

- Unknown in Atlantic salmon

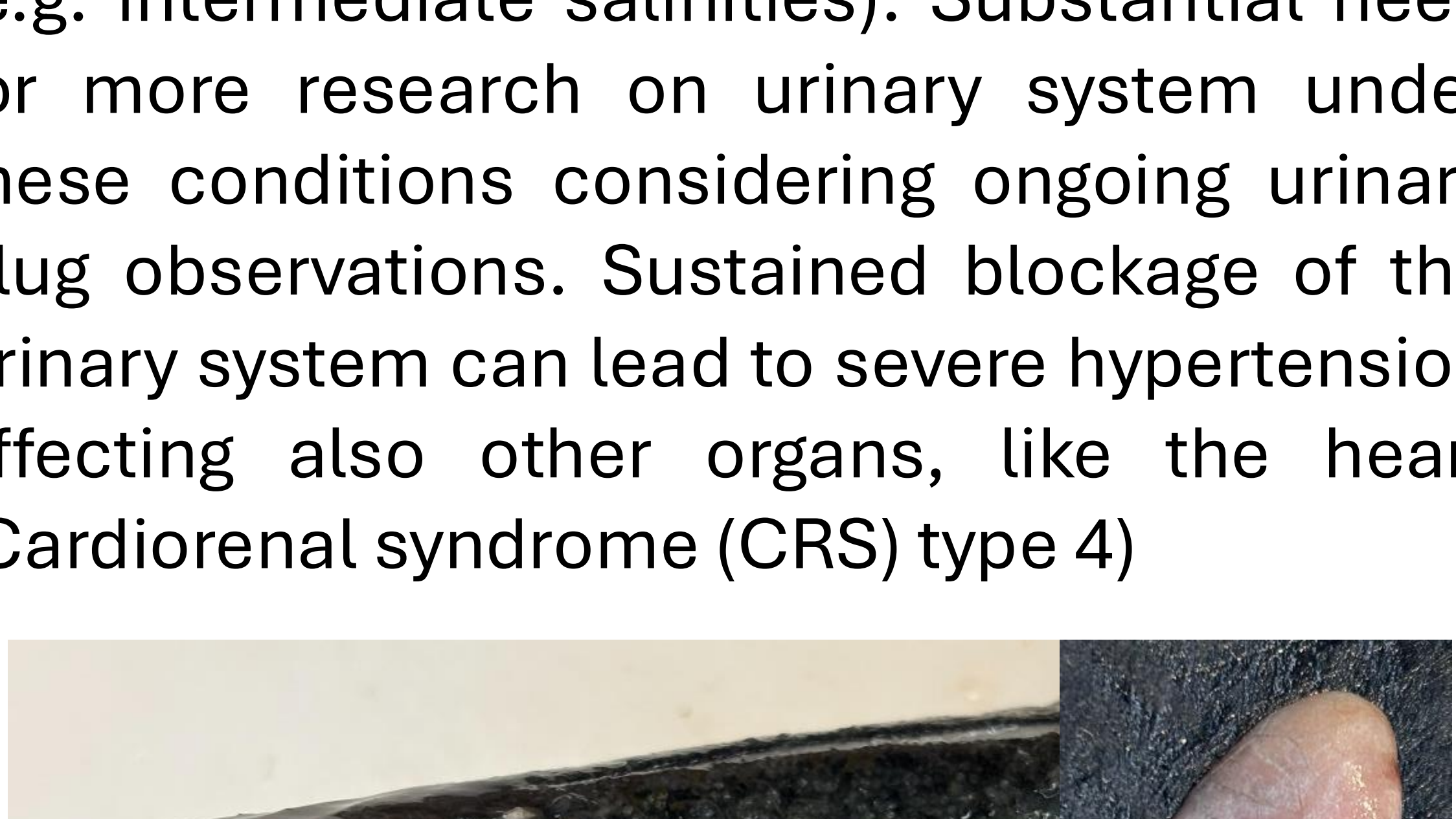
Intermediate salinities: Not clear if the intermediate salinities is a sufficient marine signal to reduce urine pH as that observed for marine fish. The lack of the urine pH reduction together with longer residence time and higher mineral concentrations can significantly increase chances of crystal formation directly in the urinary bladder

Key take-away:



Urinary plug (arrow: urocystolithiasis) in Atlantic salmon.
Image credit: Kari Kaasen McDougall

No studies on the urinary system have been performed on either Atlantic salmon or rainbow trout under aquaculture relevant conditions (e.g. intermediate salinities). Substantial need for more research on urinary system under these conditions considering ongoing urinary plug observations. Sustained blockage of the urinary system can lead to severe hypertension effecting also other organs, like the heart (Cardiorenal syndrome (CRS) type 4)



Severely enlarged (hypertrophic) and pale heart (arrow) in a fish with urinary plug causing complete occlusion of the urinary bladder