Mechanisms of Tilapia salinity tolerance at the limits of osmoregulation

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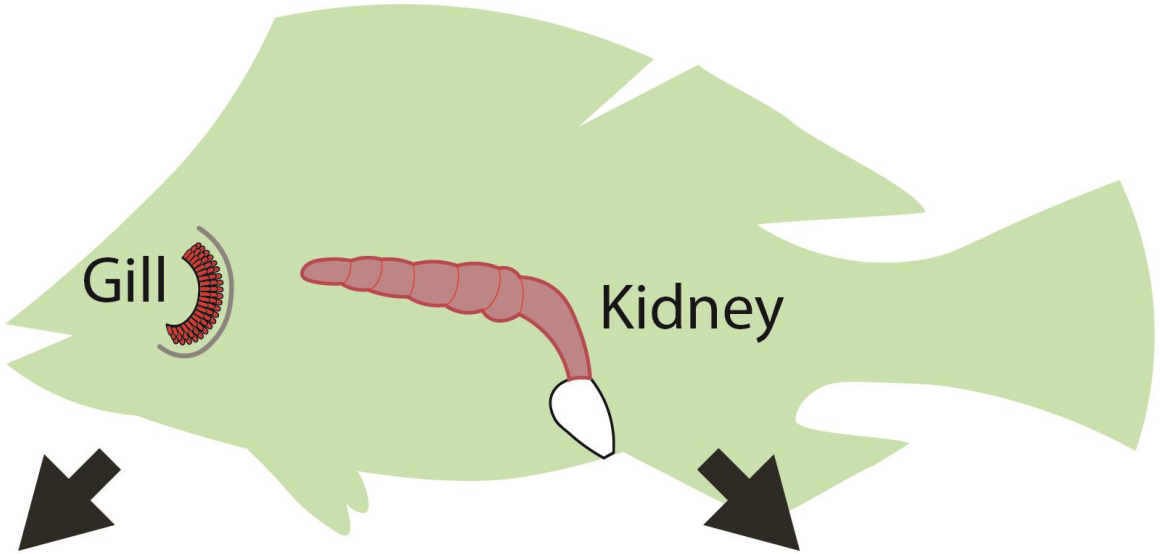
Tilapia species

Nile Tilapia
Oreochromis niloticus

Mozambique Tilapia
O. mossambicus

Image credits: O. niloticus photo by Germano Roberto Schüür, O. mossambicus photo by Greg Hume

Osmoregulation



salinity (ppt)	Active Ion Transport		Urine volume	Ion concentration	
25					
20					
15	Out	Hyperosmotic	↓	↑	Divalent ion secretion to intestine
10					
5	In	Hypoosmotic	↑	↓	
0					

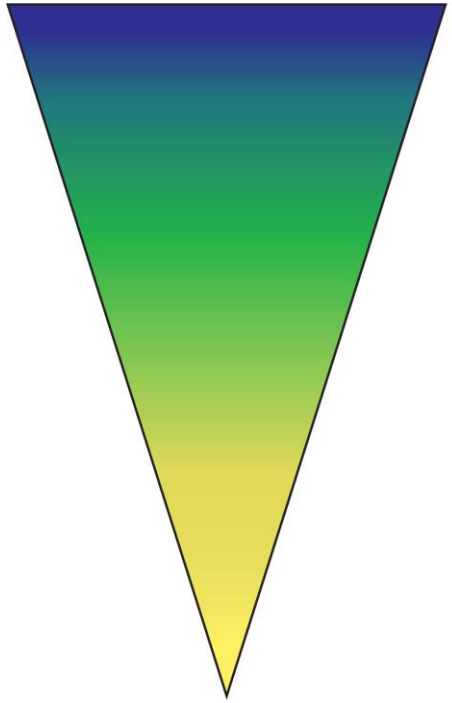
Salinity tolerance in aquaculture

Growing fish in saline waters allows for minimizing reliance on scarce freshwater resources

Understanding stress is also important in many aspects of aquaculture for improved animal welfare and production

Image credit: photo by Janine Mary Pierce from “Mangrove Conservation in Australia: Involving all People”

Proteomics



Ecosystem

Population

Organism

Tissue

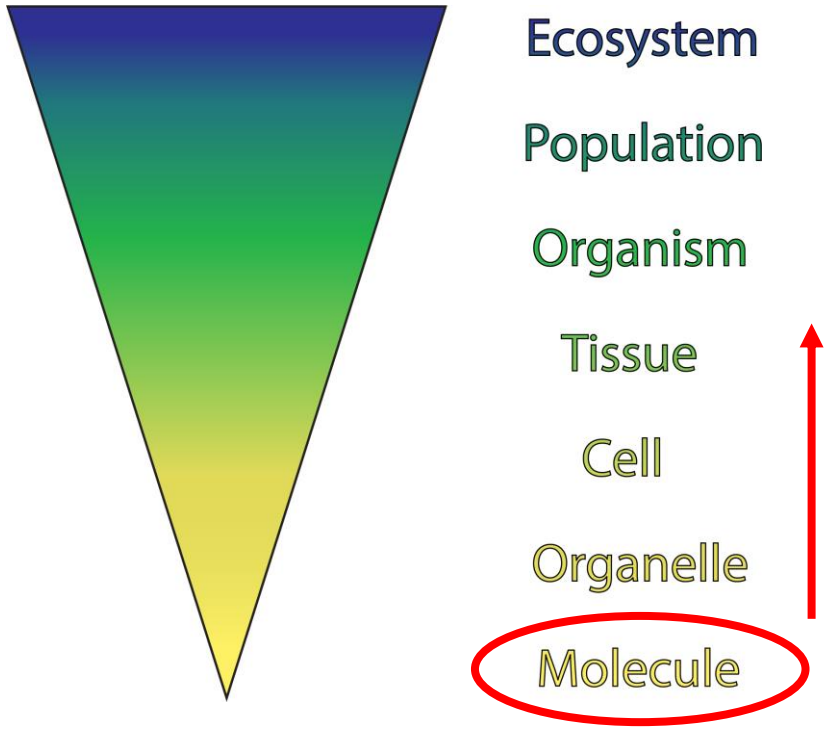
Cell

Organelle

Molecule

Proteins are one of the essential biological molecules

Proteomics



Proteins are one of the essential biological molecules

Proteomics connects molecules to higher orders of organization

Data Independent Acquisition Proteomics

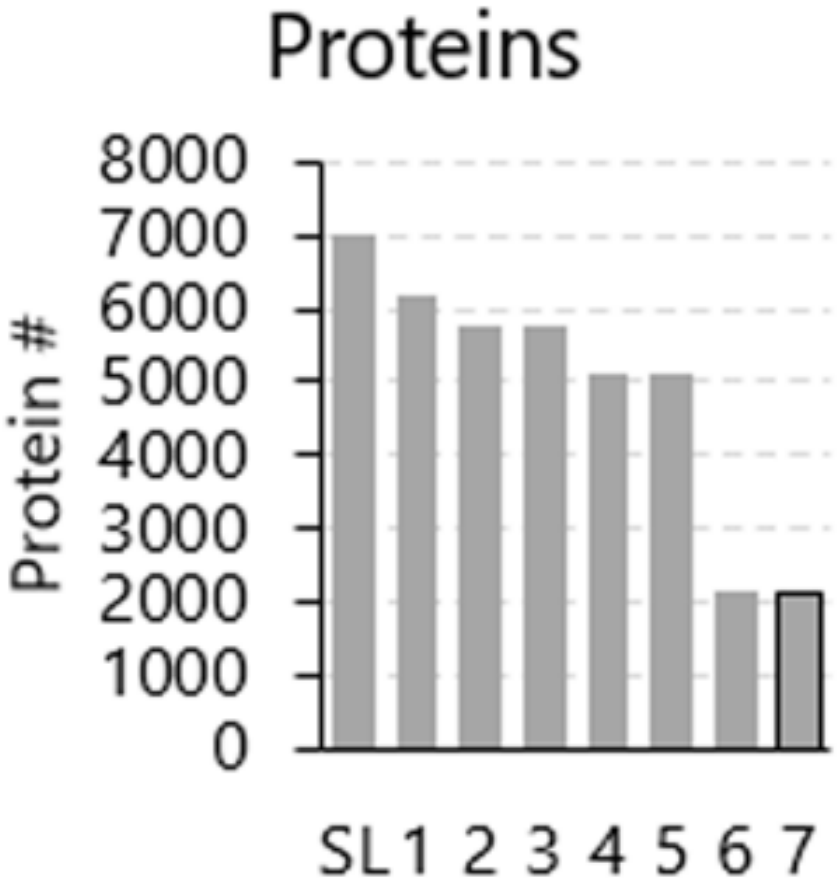
Proteins isolated and cut into short **peptide** chains

Peptides sequenced by determining mass and charge(m/z) using Mass Spectrometry with and without fragmentation

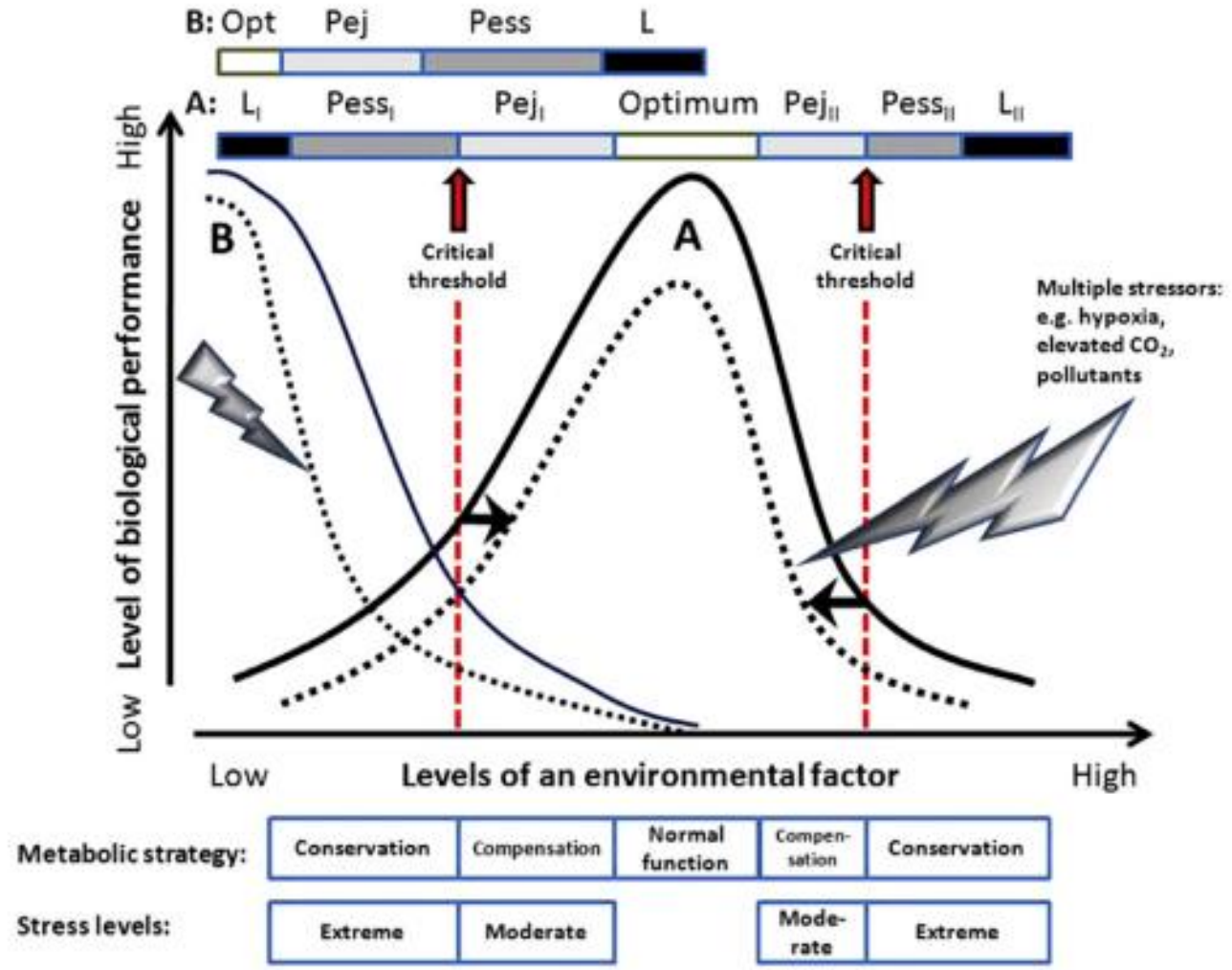
Proteins identified using an annotated genome

Spectral library created, which is refined through step-wise process to create a DIA assay library

Reanalyze using a sliding window of m/z acquisition (SWATH-MS), and resulting data used to quantify all matching peptides in the window.



Environmental stressors and tolerance limits

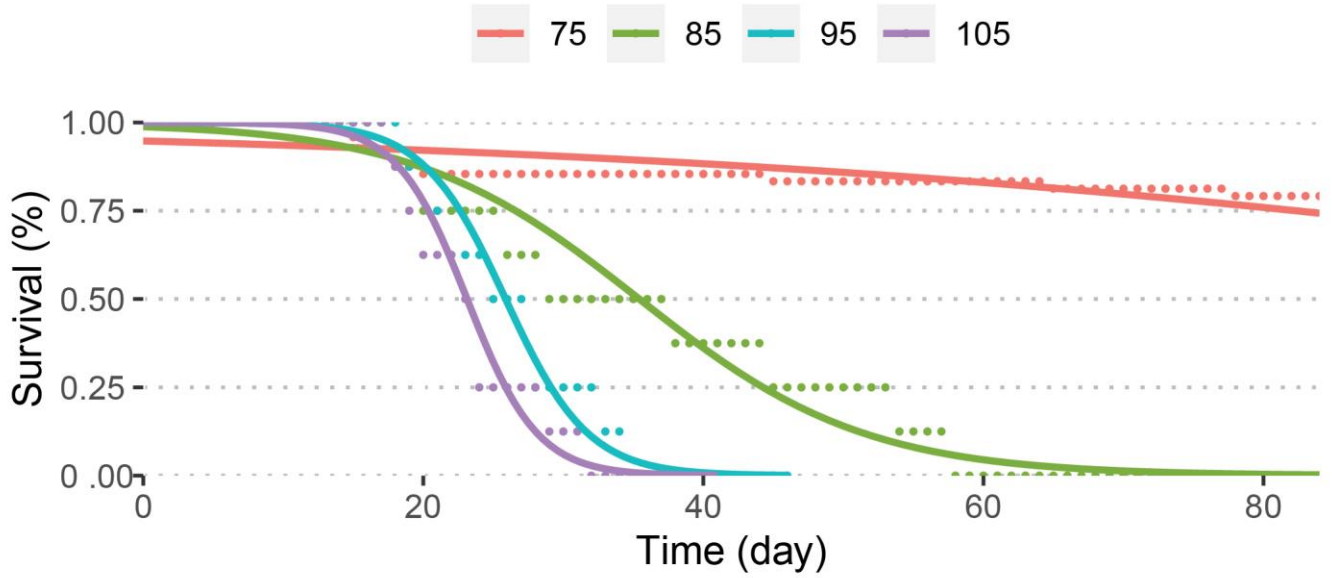


Sokolova et al. *Marine Environmental Research* 79 (2012) 1-15

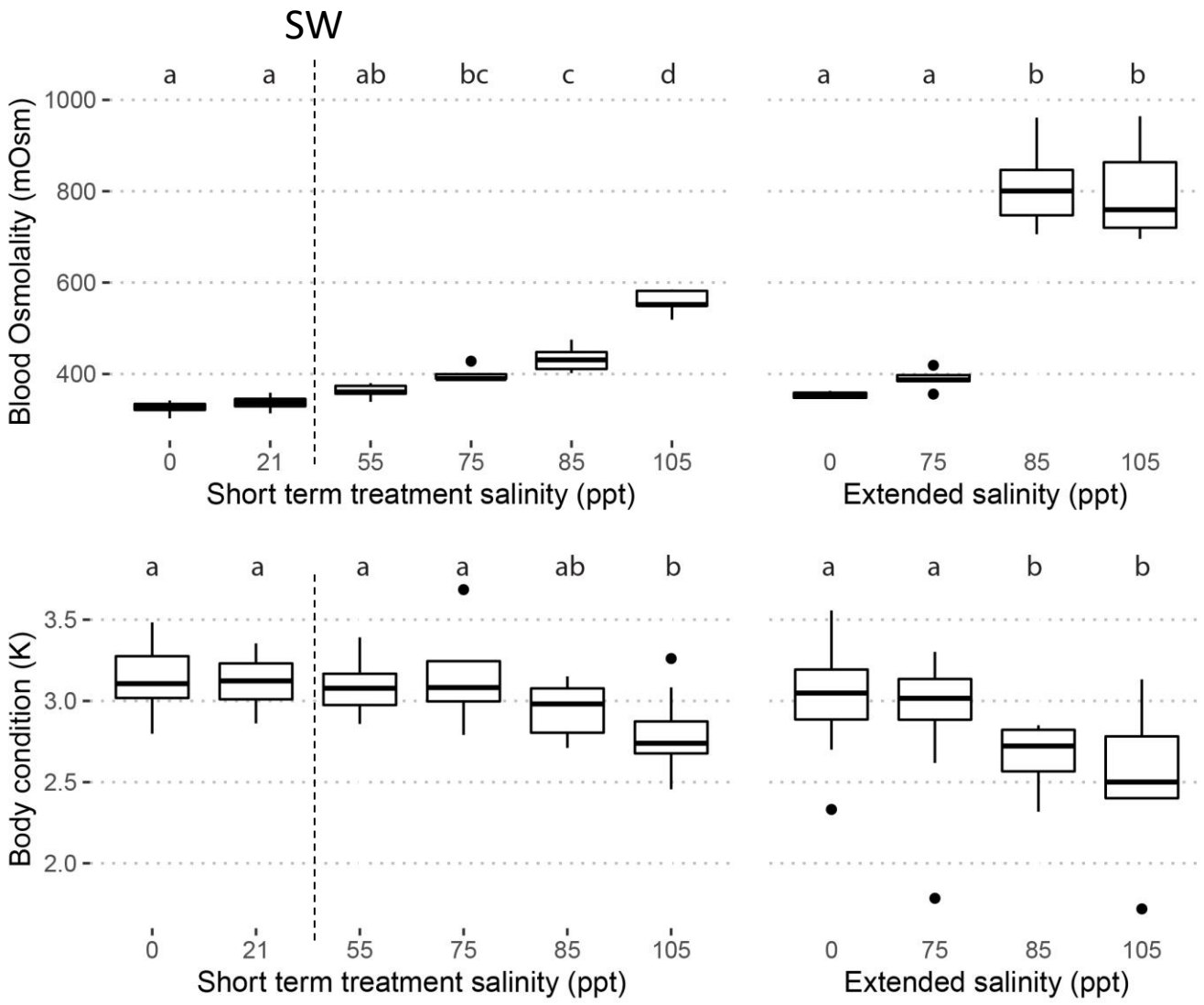
Tilapia salinity tolerance limits

A series of acclimations showed that Mozambique Tilapia can acclimate to salt levels around 120 ppt, which is approximately four times higher than seawater

At high salinity, they can still survive for weeks to months



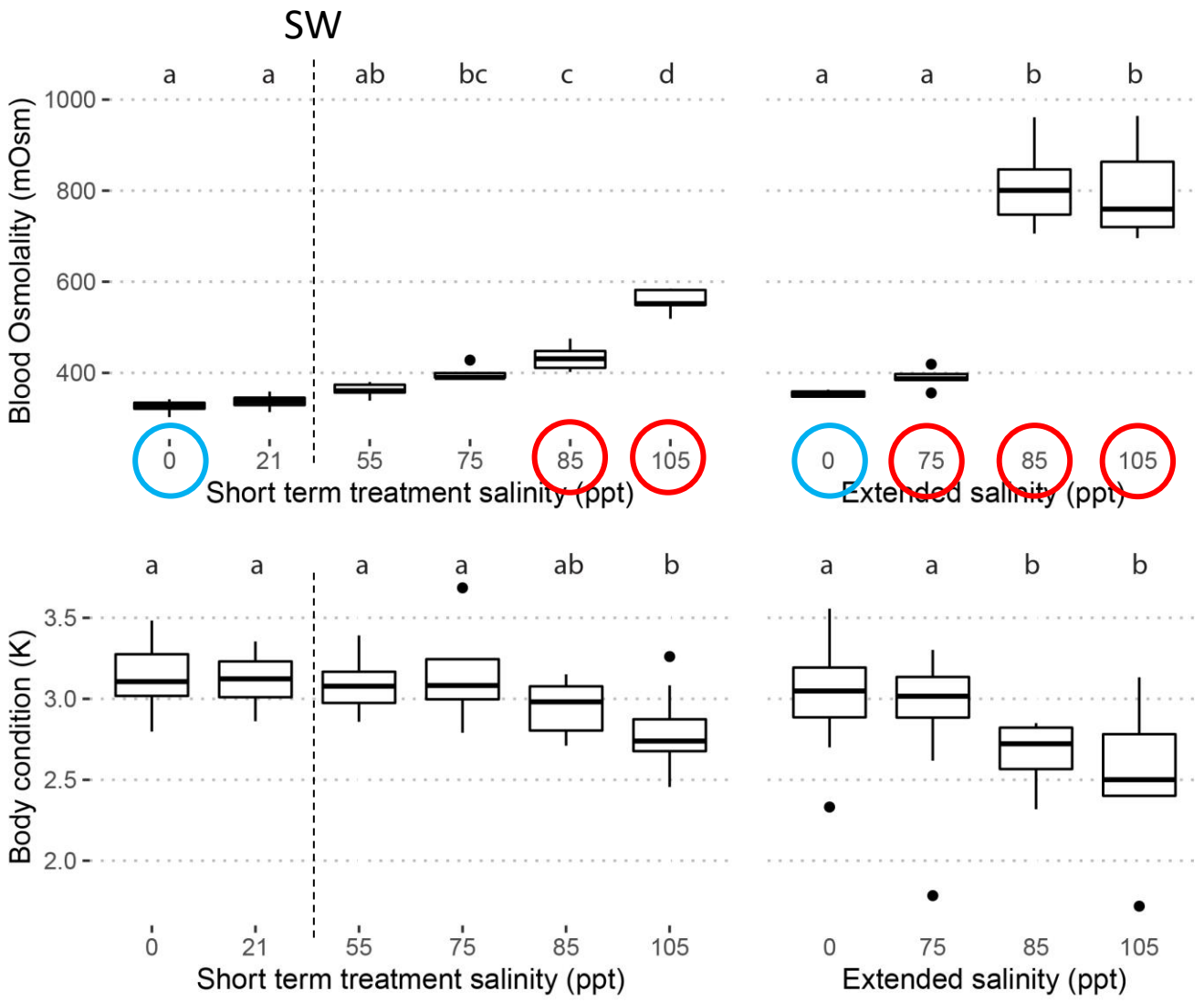
Physiological response to high salinity



Blood osmolality increased slightly and body condition was unaffected up to 75 ppt

Above 75 ppt, blood osmolality began to increase and body condition to decrease. Over long time periods, the differences in these parameters becomes quite large versus fish in freshwater

Physiological response to high salinity



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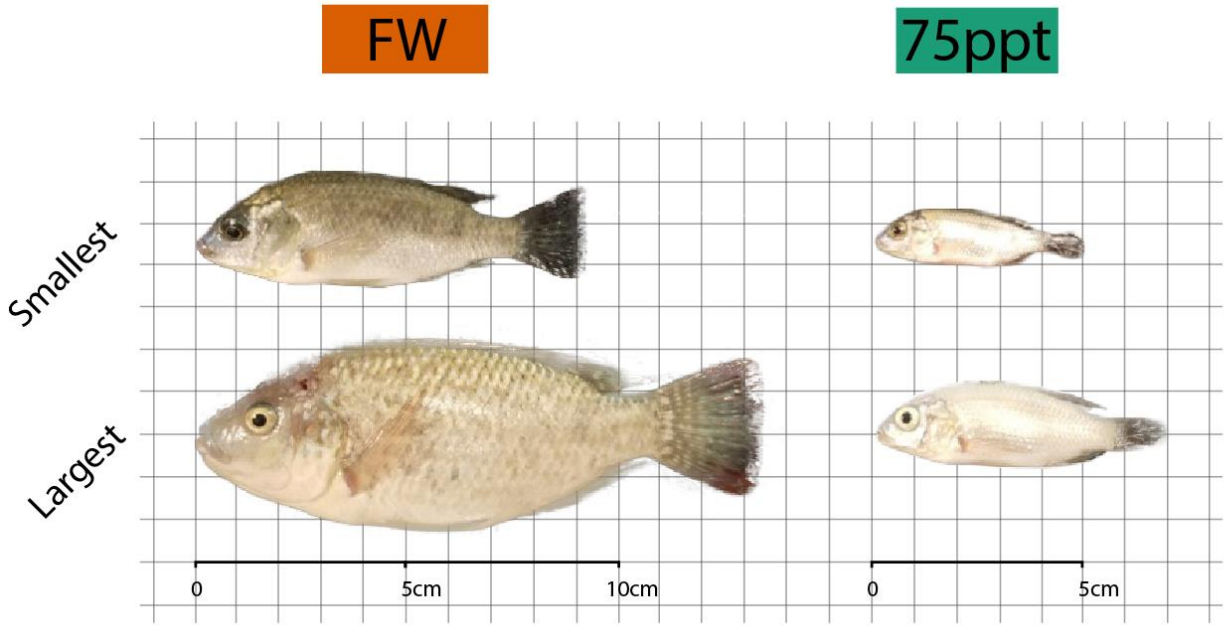
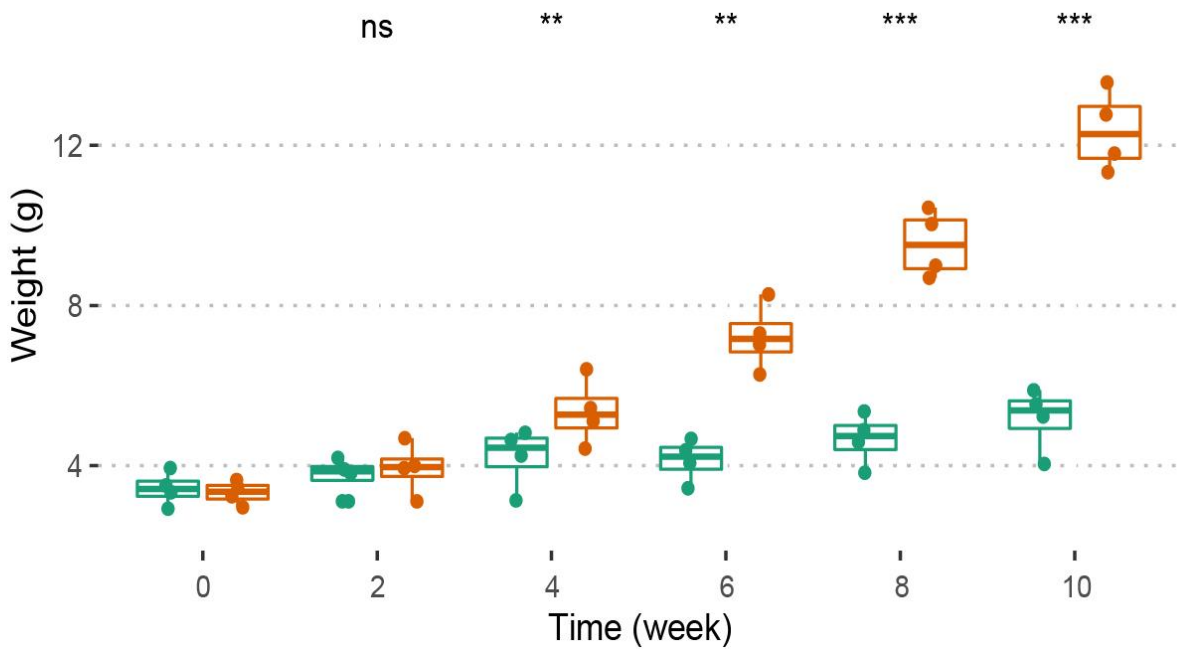
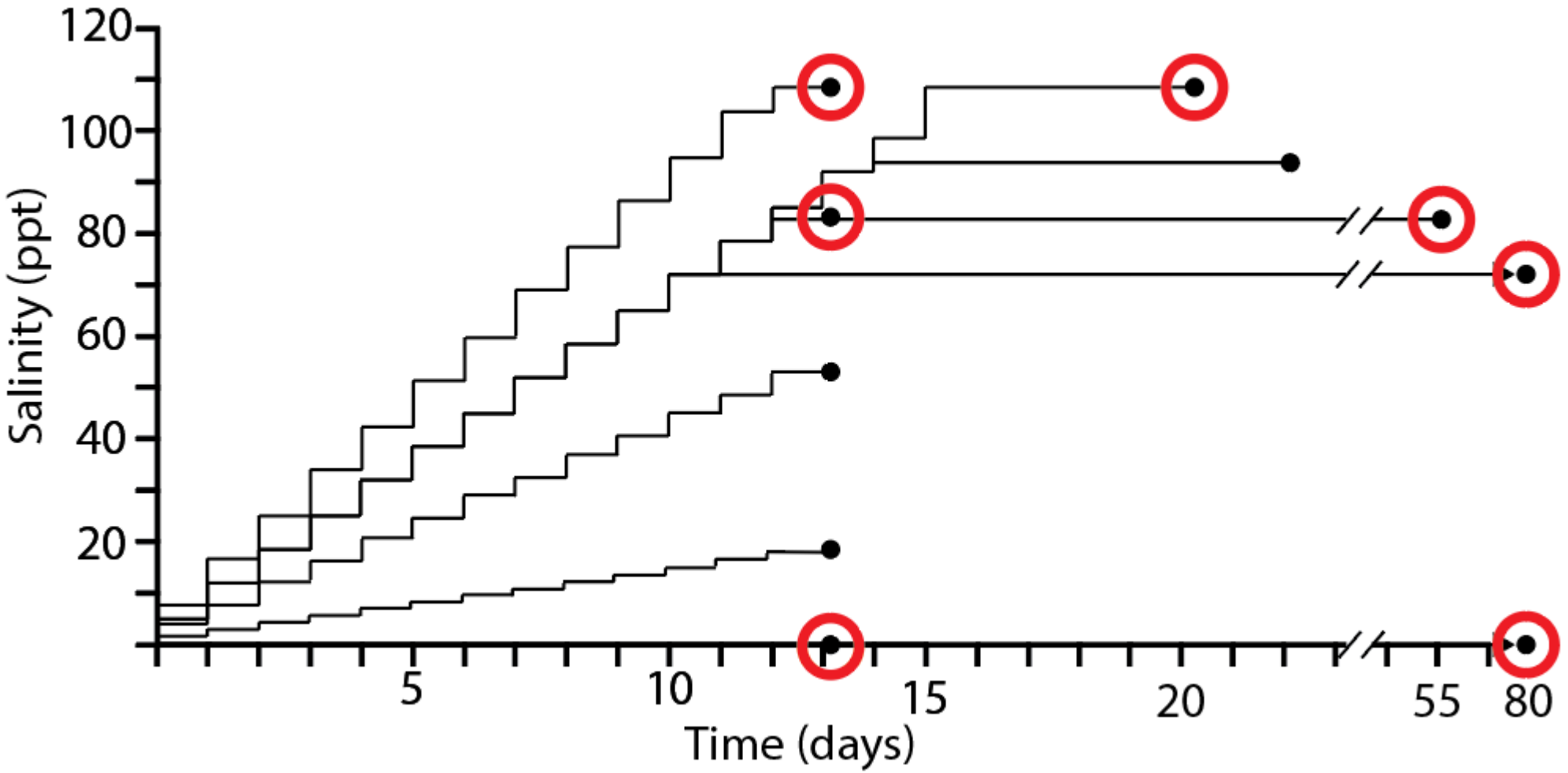
Growth response to high salinity

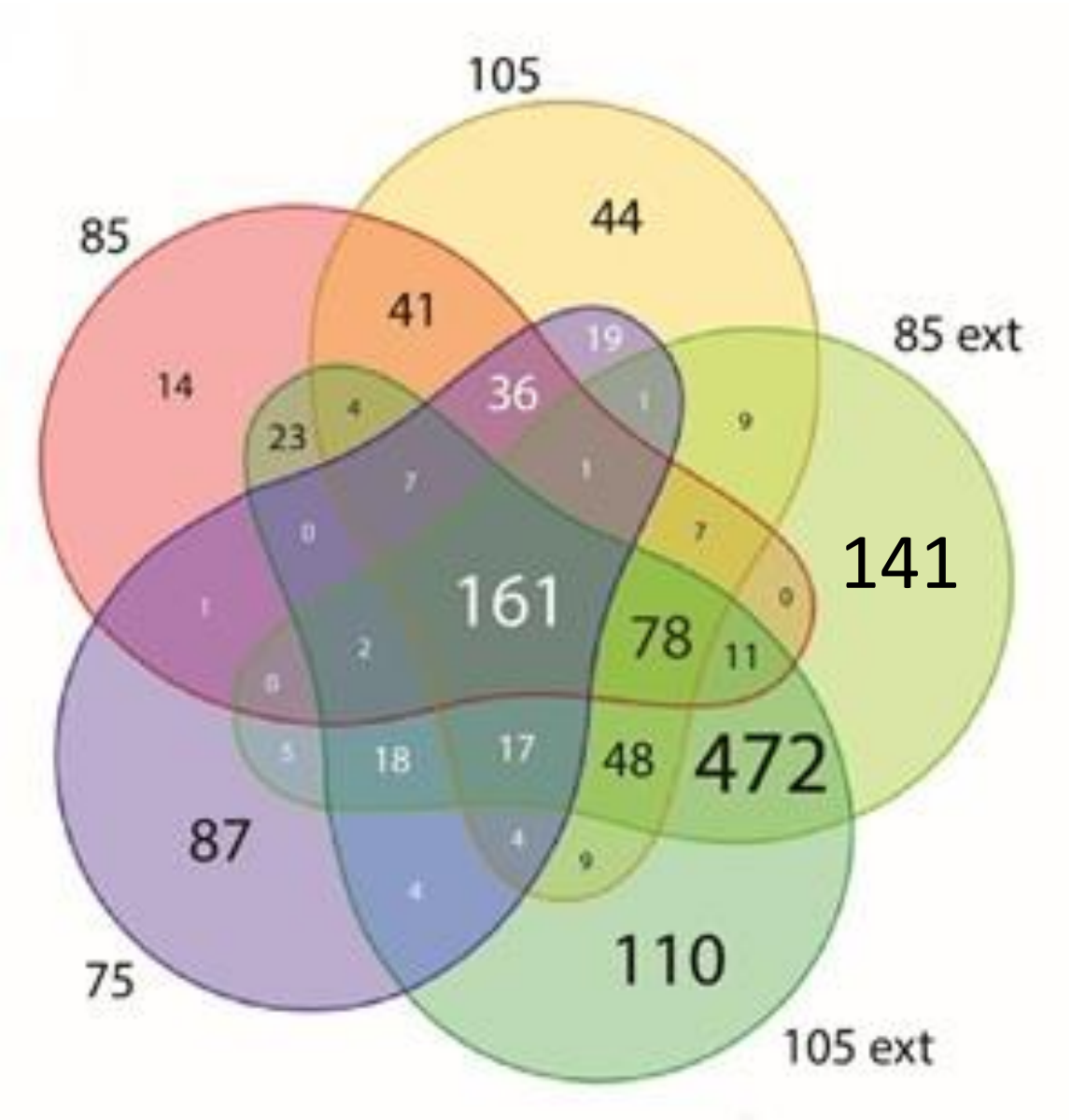




Protein expression- samples

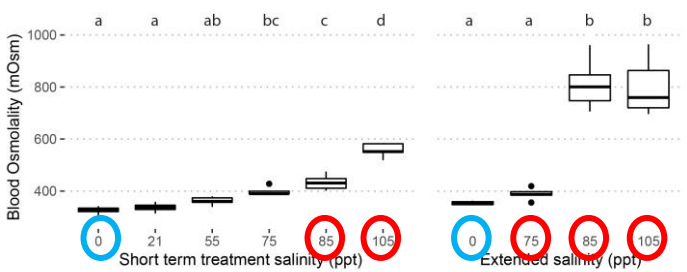


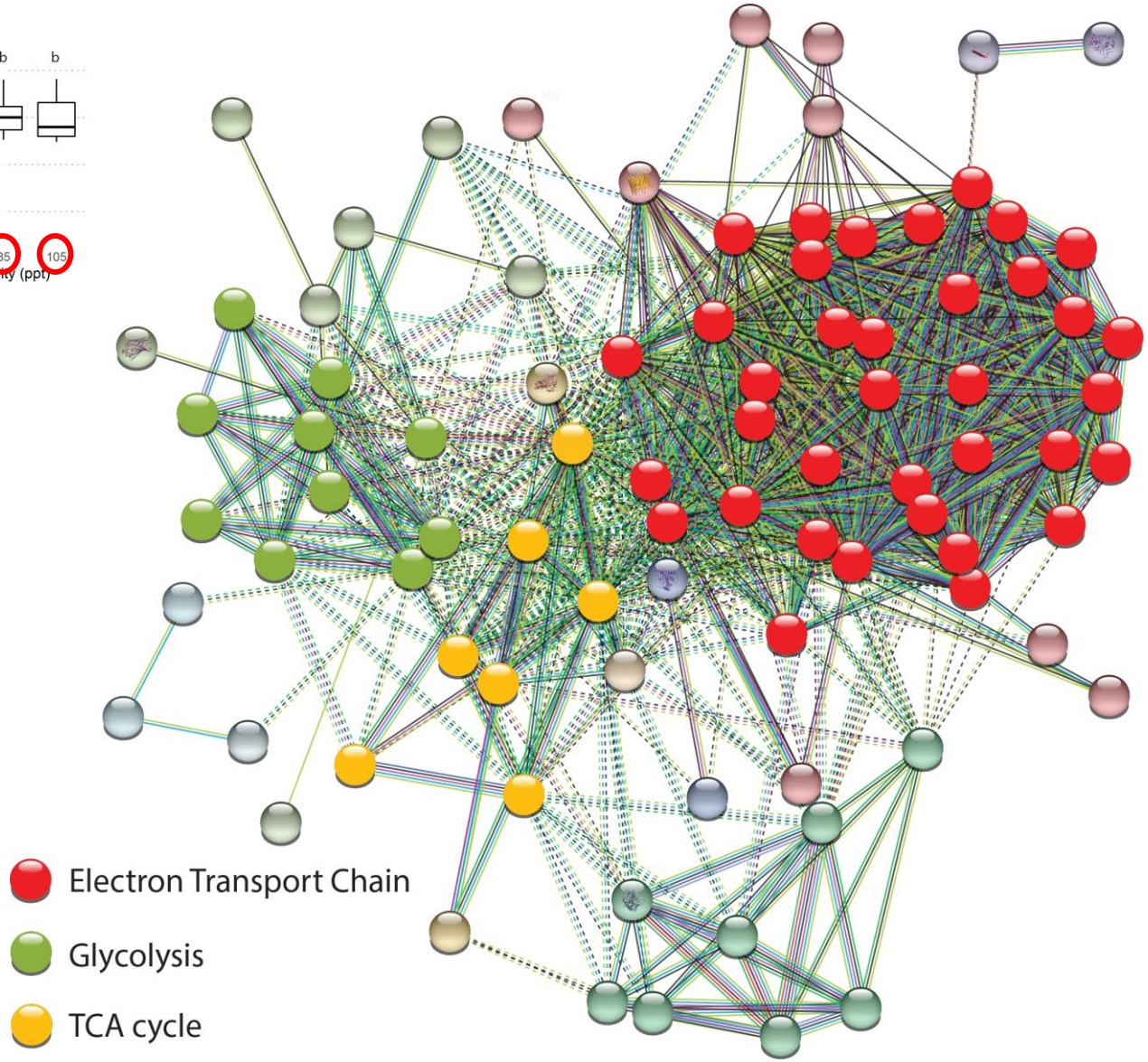
Protein expression



Greatest overlap was between all treatments and between the two extended treatments over the critical threshold

Cellular processes: energy production





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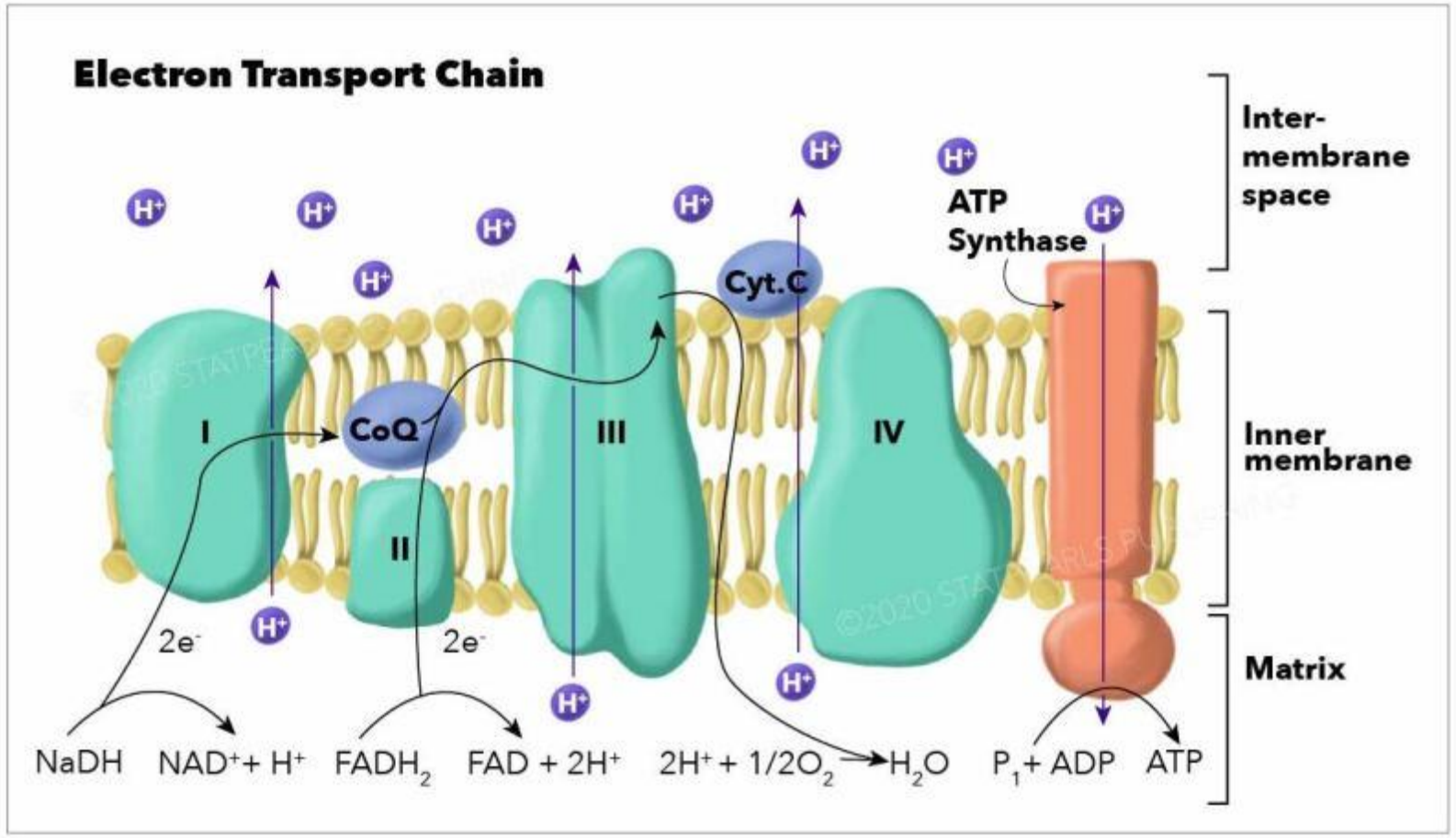
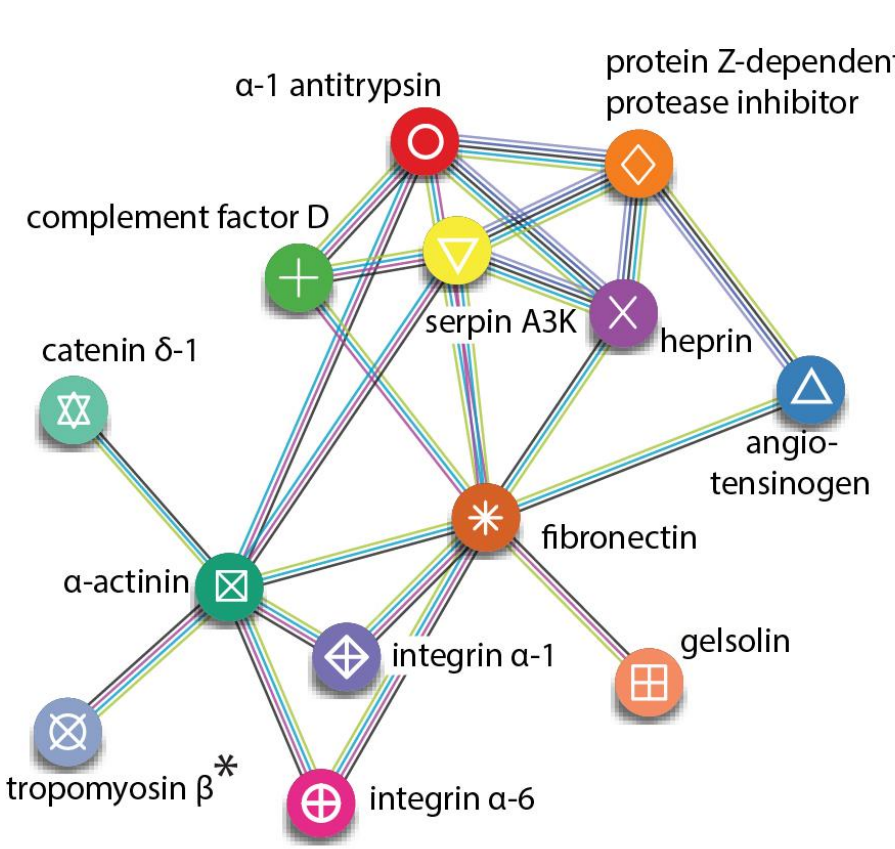
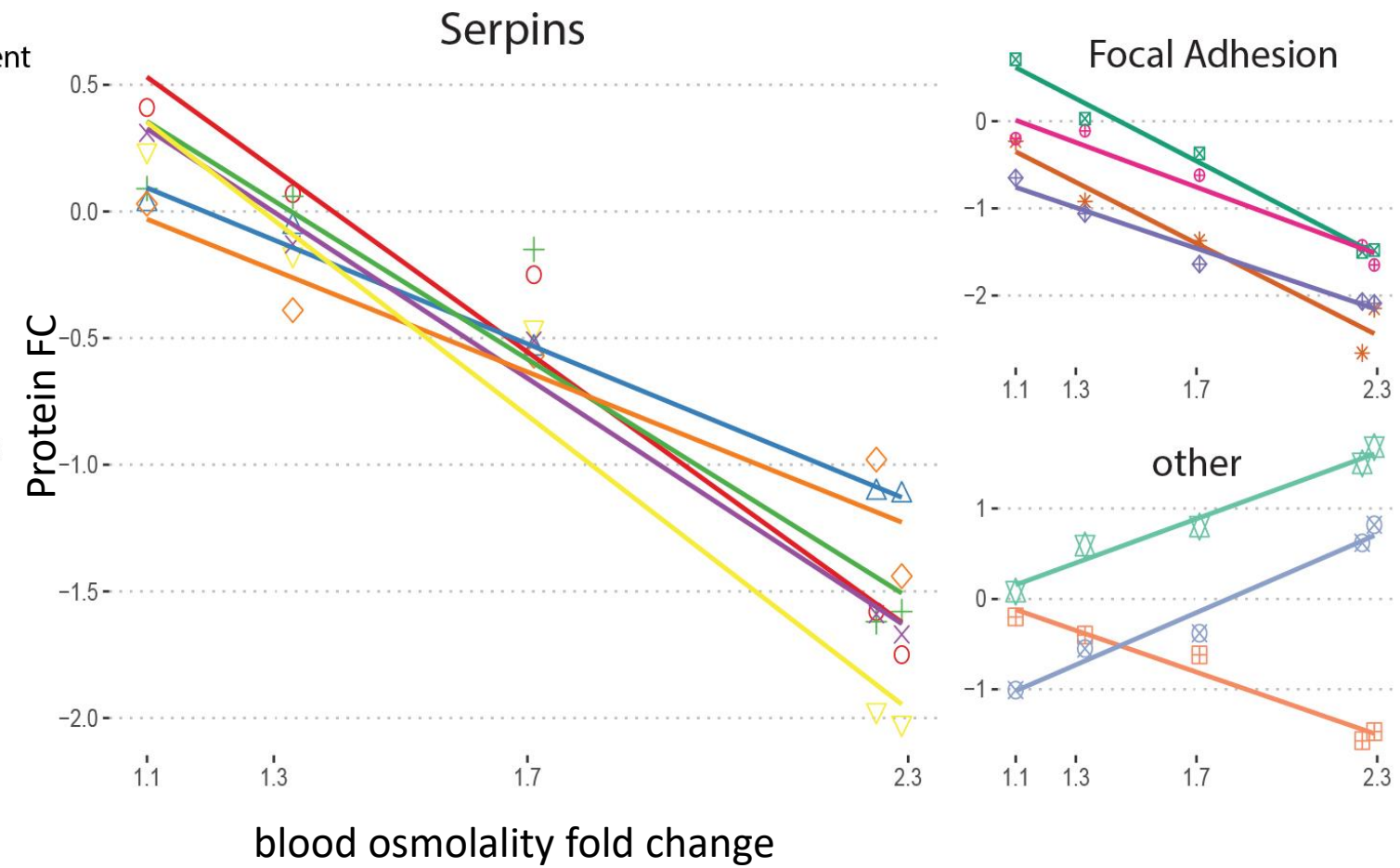


Illustration by Emma Gregory, from: [Biochemistry, Electron Transport Chain]

Electron transport chain proteins are highly upregulated in both species

Cytoskeleton and extracellular matrix





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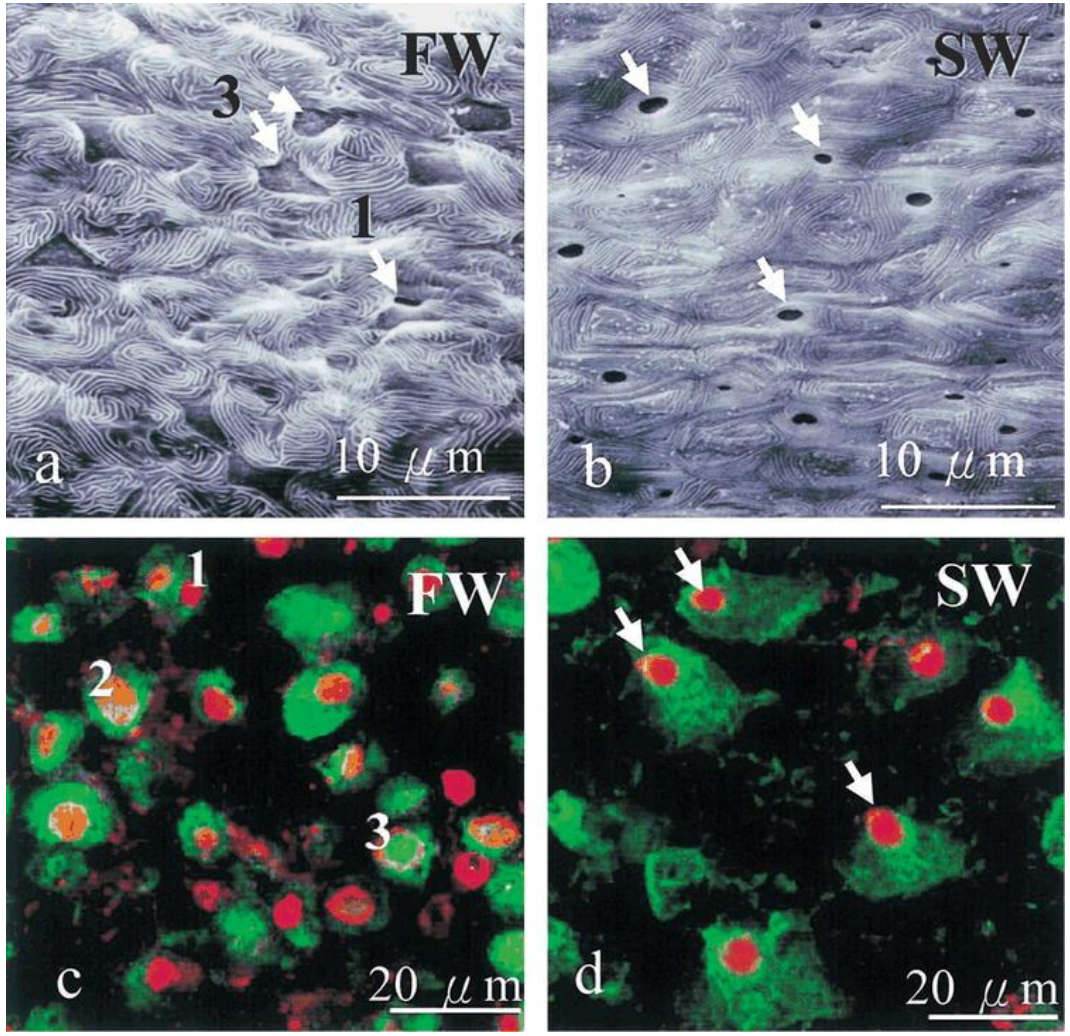


Image credit: Lee, Tsung-Han, et al. *Zoological science* 20.1 (2003): 29-36.

Specific cellular processes are affected by high salinity

Increased energy production is highly reliant on upregulation in the electron transport chain at high salinity regardless of organism's level of stress

Cellular structure and interaction with the ECM is highly regulated, but protein regulation changes between different high salinity levels

Conclusions

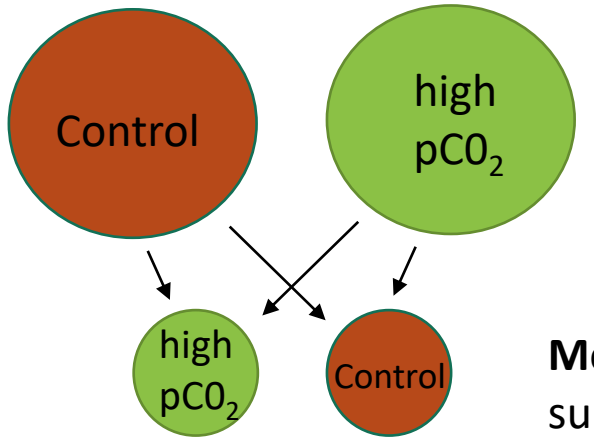
Supporting the energy demands of fish during salinity stress can be very important

Looking for the transcription promoters of important genes for proteins identified, and ways to signal these promoters during salinity stress

Using specific proteins to develop breeds of fish with greater tolerance either as indicators of improvement or through targeted selection

Current work

Transgenerational impacts of OA on native Pacific littleneck (*Leukoma staminea*) and naturalized Manila clams (*Ruditapes philippinarum*)



Measure: growth, survival, maturation and molecular profile of sperm and eggs

Measure: larval growth and survival