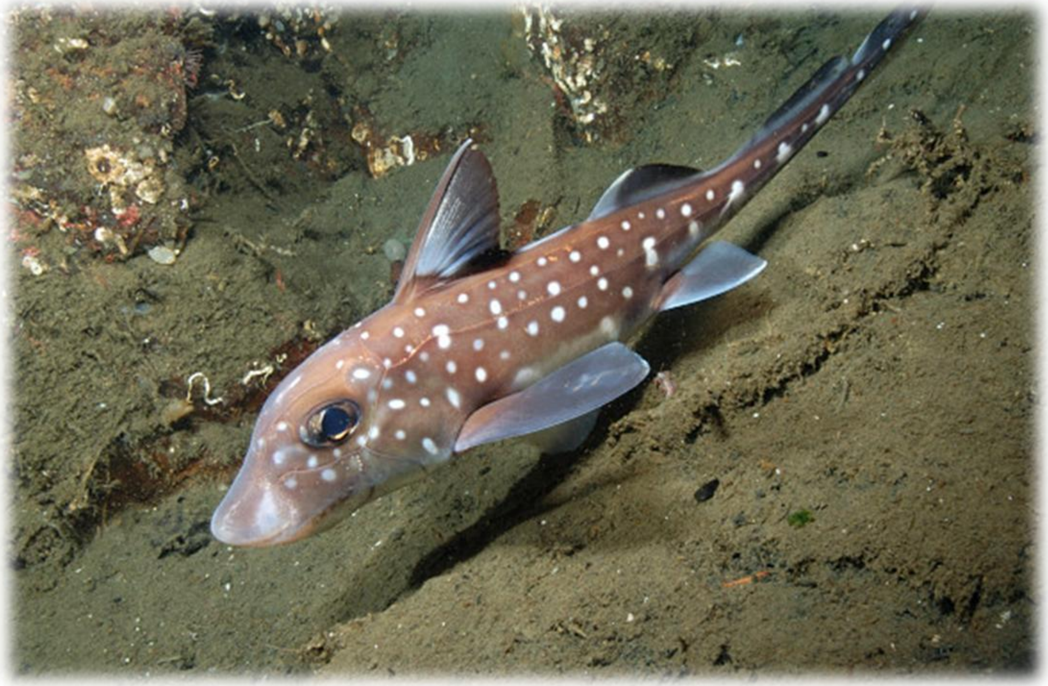
Effect of ocean acidification on deep sea spotted ratfish *Hydrolagus colliei*: physiological consequences on acid-base balance, ion-regulation and nitrogenous waste dynamics

Jyotsna Shrivastava (Jo)

University of Antwerp
Belgium, Europe

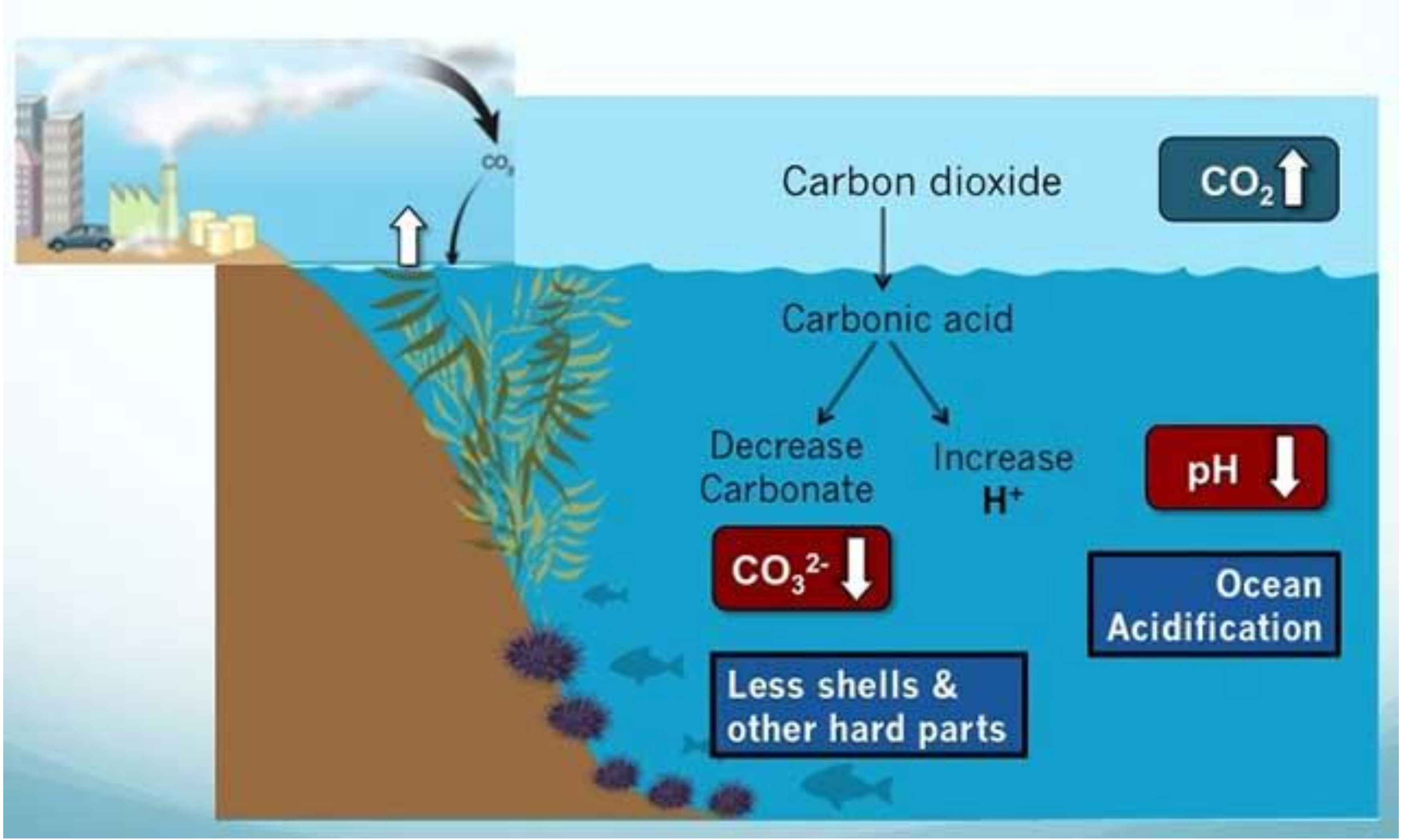
Overview

- Introduction
- Methodology
- Results
- Discussion
- Conclusion

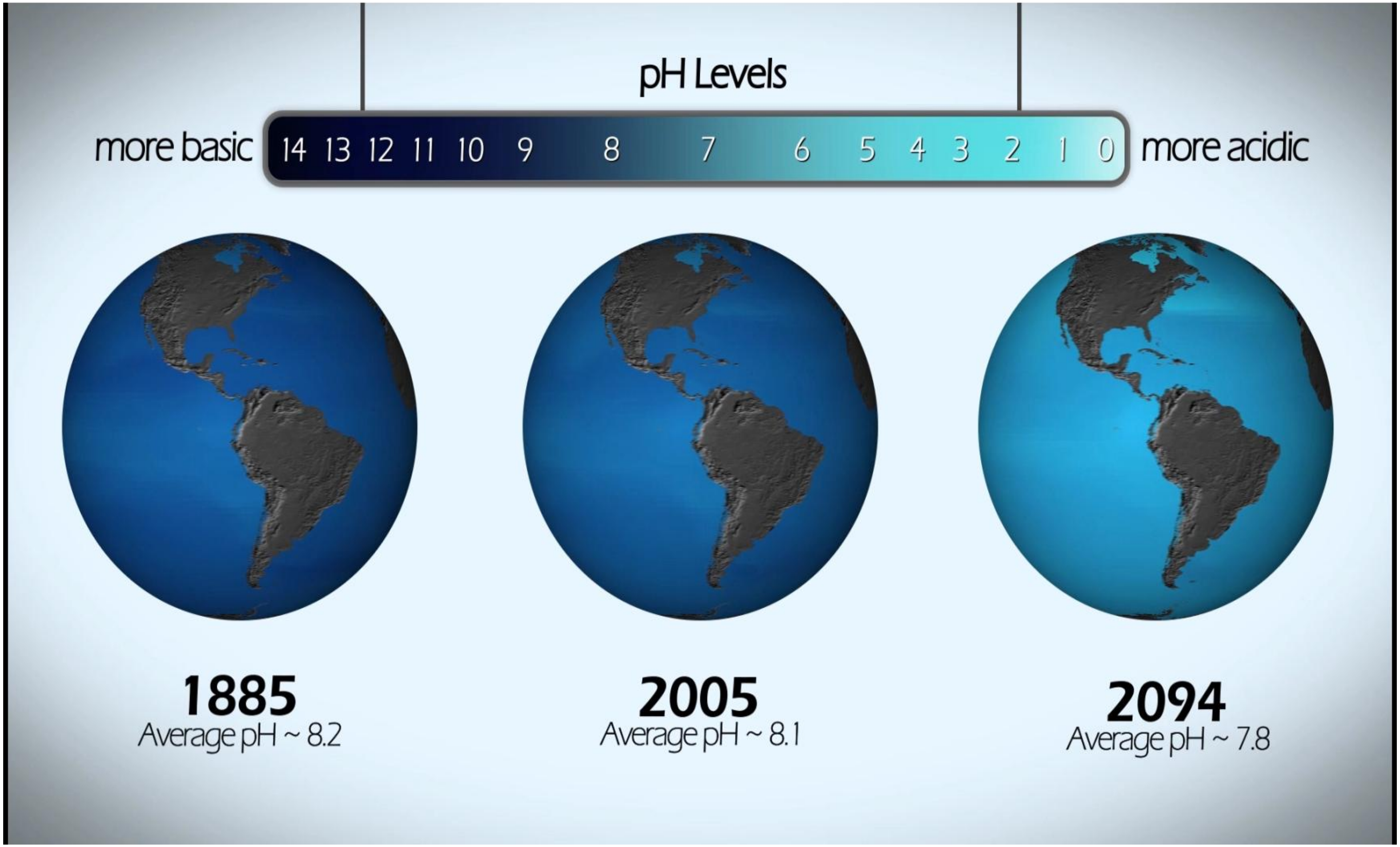


Ocean acidification

The decrease in the pH of earth's oceans caused by the uptake of CO_2 from atmosphere.



Ocean acidification



The pH Scale

Concentration of Hydrogen ions compared to distilled water		Examples
10,000,000	pH 0	Battery acid
1,000,000	pH 1	Hydrochloric acid
100,000	pH 2	Lemon juice, vinegar
10,000	pH 3	Grapefruit, soft drink
1,000	pH 4	Tomato juice, acid rain
100	pH 5	Black coffee
10	pH 6	Urine, saliva
1	pH 7	"Pure" water
1/10	pH 8	Sea water
1/100	pH 9	Baking soda,
1/1,000	pH 10	Great Salt Lake
1/10,000	pH 11	Ammonia solution
1/100,000	pH 12	Soapy water
1/1,000,000	pH 13	Bleach
1/10,000,000	pH 14	Liquid drain cleaner

pH scale is logarithmic

meaning a difference of one pH unit is equal to a ten-fold change in acidity.

A small change in pH is equal to a LARGE change in acidity.

Experimental fish species

Taxonomical classification

Chondrichthyes
(cartilaginous fish)

Elasmobranchii

Sharks, rays and skates



Holocephali (primitive fish)

Chimeras

Ratfish, Rabbitfish and elephant fish



→ Ratfish are non-elasmobranchs cartilaginous fish

Introduction

Morphological Characteristic of Ratfish

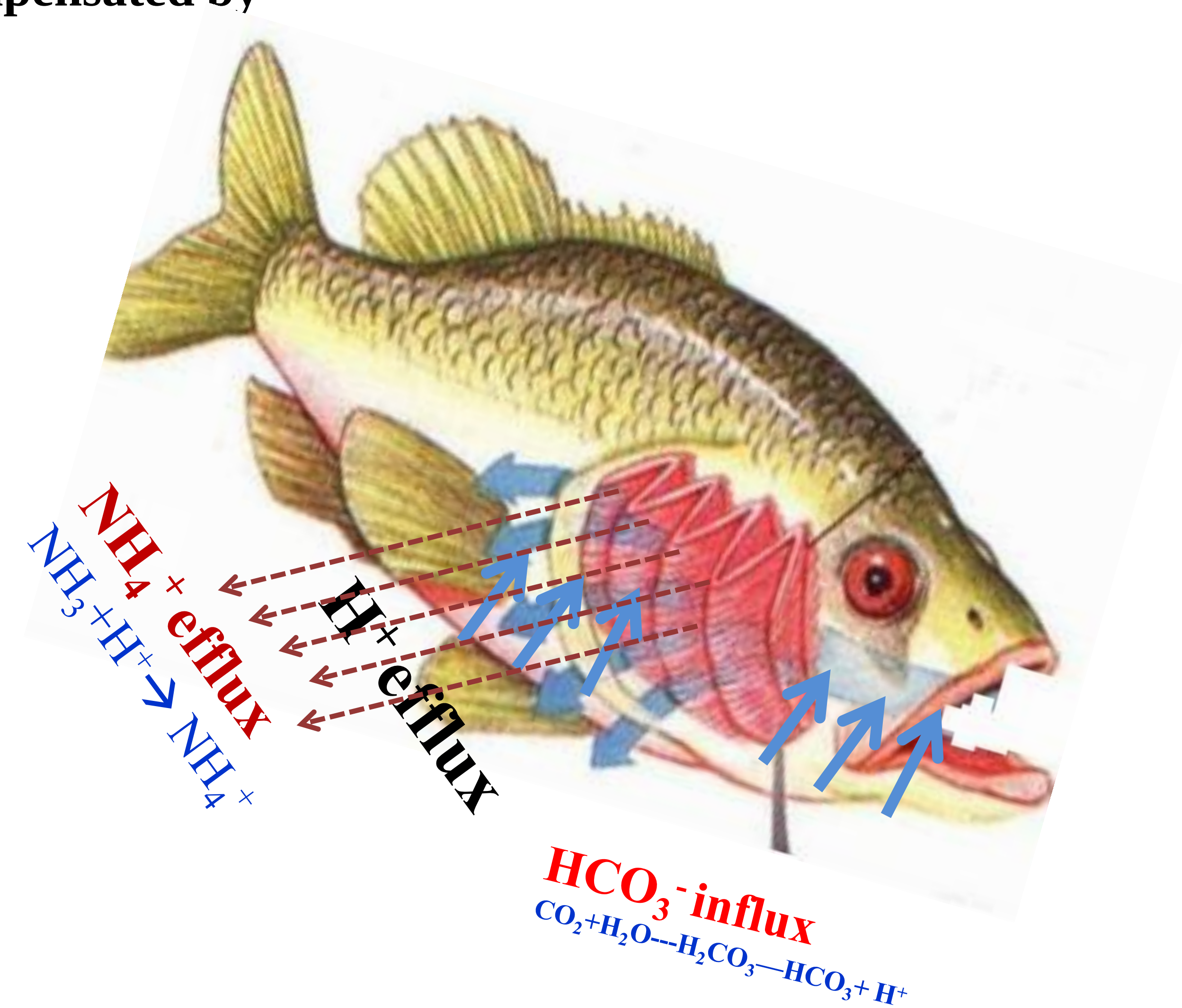
- It is a chimaera found in the north-eastern Pacific Ocean.
- It is most common between 200 and 400 m below sea level.
- This cartilaginous fish gets its characteristic name from a pointed rat- like tail.
- They have a venomous spine located at their dorsal fin which is used in defense.

Introduction…

Ocean acidification / Hypercapnia (increase in CO_2 level)

-ambient CO_2 levels induce a respiratory acidosis in a number of fish species-

Blood pH is compensated by



Background

- **Among Cartilaginous fish**, the most extensive studies on acid-base regulation during ocean acidification (hypercapnia) are done in elasmobranch

  -typically the spotted dogfish (Randall et al., 1976; Heisler et al. 1976).

- Dogfish are able to compensate ocean acidification induced acidosis very quickly by
  - by extracting HCO_3^- from the surrounding water
  - Increasing the rate of H^+ excretion and/or
  - elevating NH_4^+ excretion

→ **Overall, suggesting dogfish and also teleosts are efficiently regulator of acid/base balance during hypercapnic events.**

→ **Till date, no study has been done in non-elasmobranch cartilaginous fish (e.g. ratfish)**

Objectives

Extracellular pH

Blood pH
Plasma TCO_2

Intracellular pH

RBC
Hepatic cells

Excretion rate

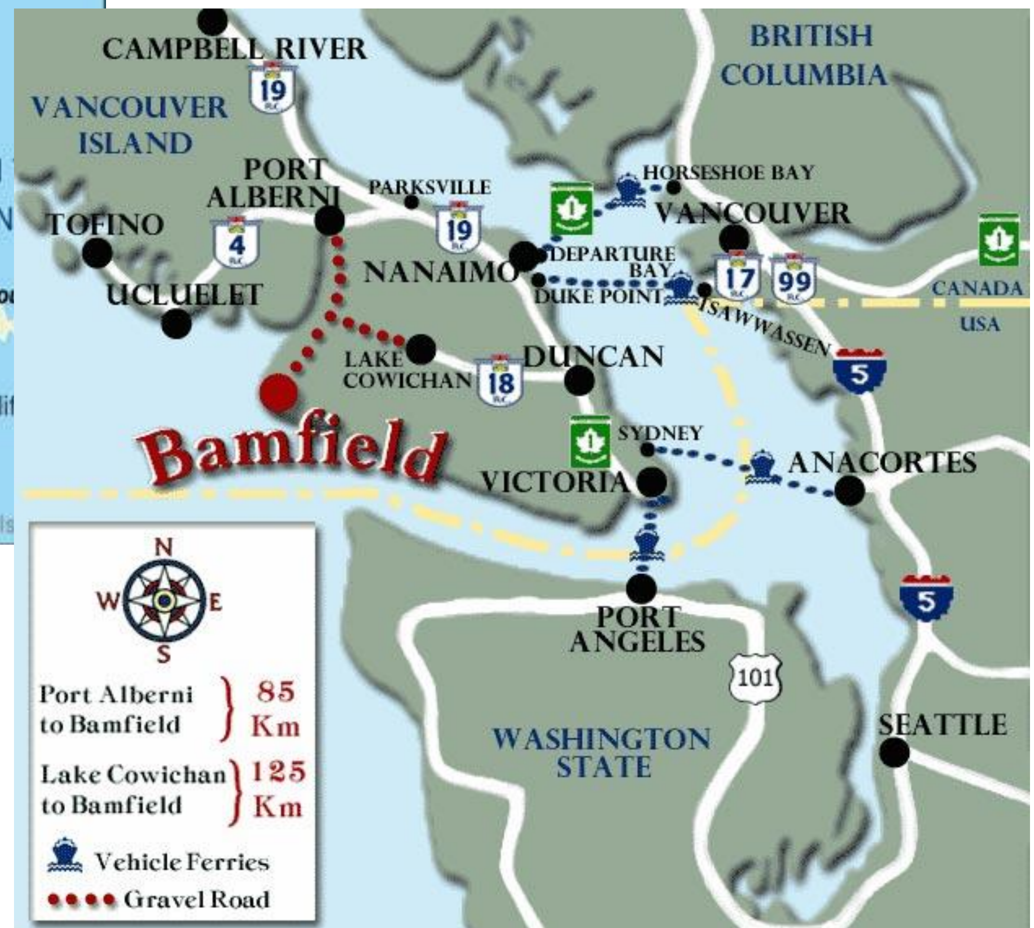
H^+
Ammonia

Ion-regulation

Na^+
Cl^-
Osmolality

Experimental Site:

Bamfield Marine Science Research Centre, Canada




BMSC


bmsc

Experimental design

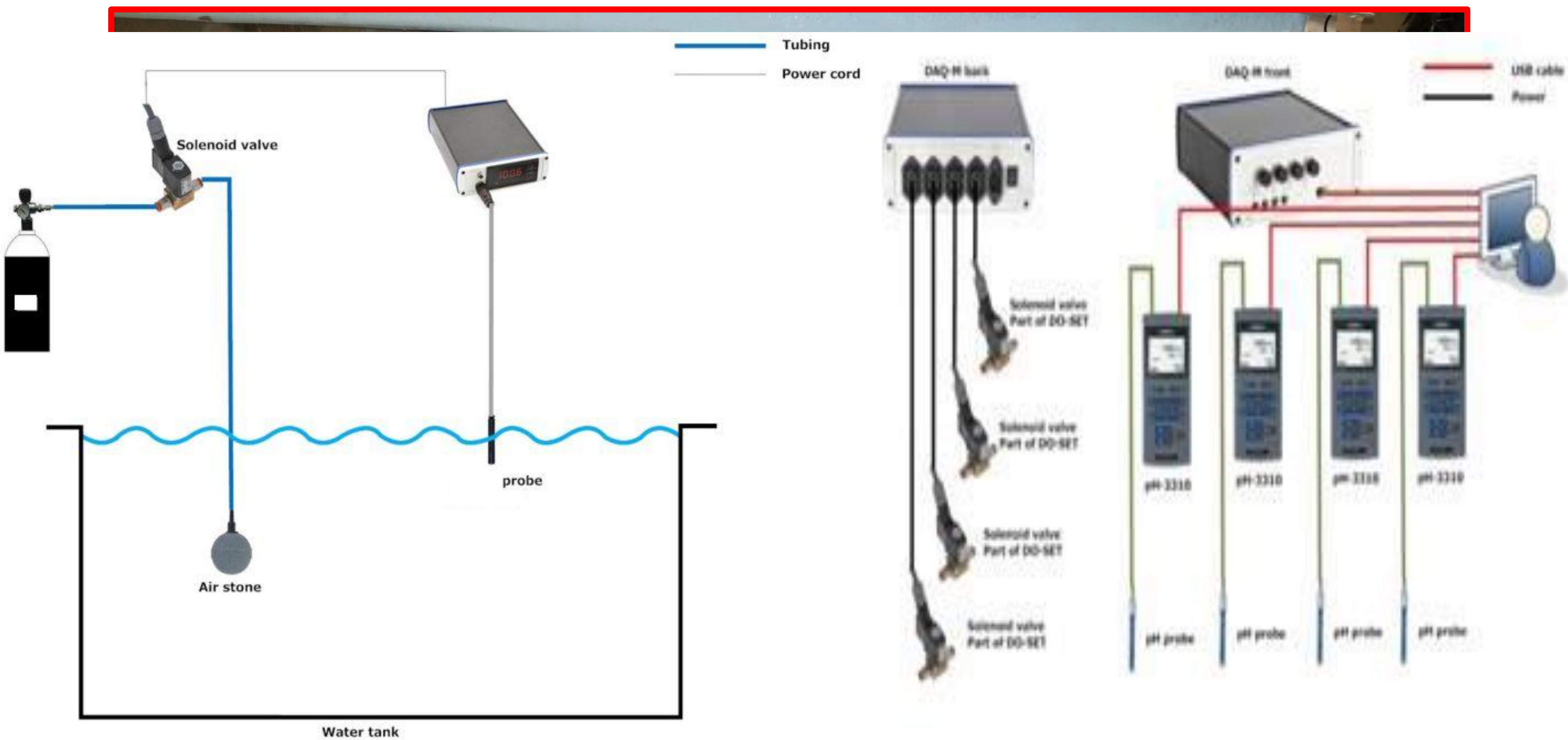
- Test species: Ratfish
- Exposure to 1.5% PCO_2 (15,000 ppm)
- Exposure period: Pre-exposure (0 h), 4 h, 12h, 24 h and 48 h
- At the end of each exposure period fish (n= 6) were sacrificed.
- Water samples were taken at each time point (and some intermediate points) at an interval of 4 hrs.

-Cannulation!!!!!!

the arterial/venous tension is too low

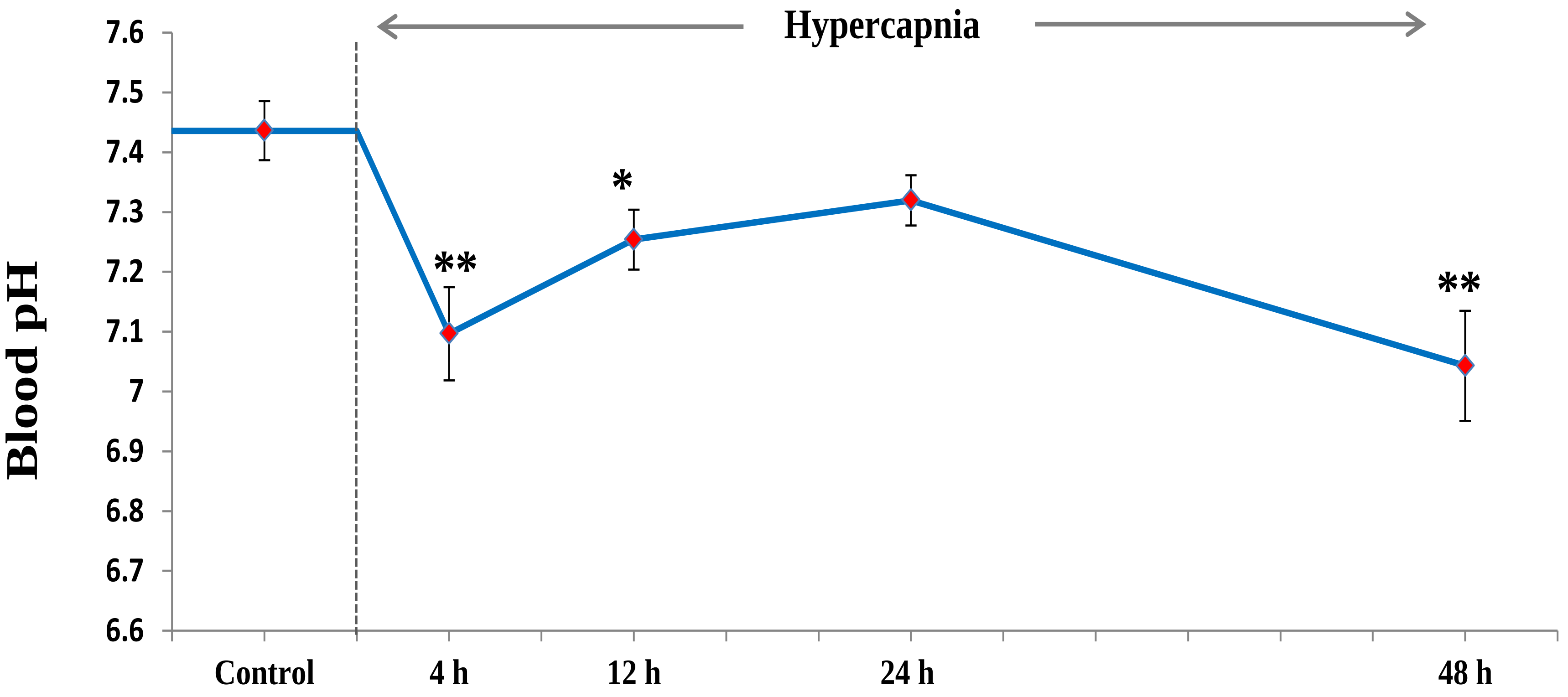
Experimental set up

- Flux box of 20 L (flux vol. 16L)
- Fish were acclimated overnight in the box.
- CO_2 level was controlled by an automated **Loligo CO_2 system** via CapCTRL software.



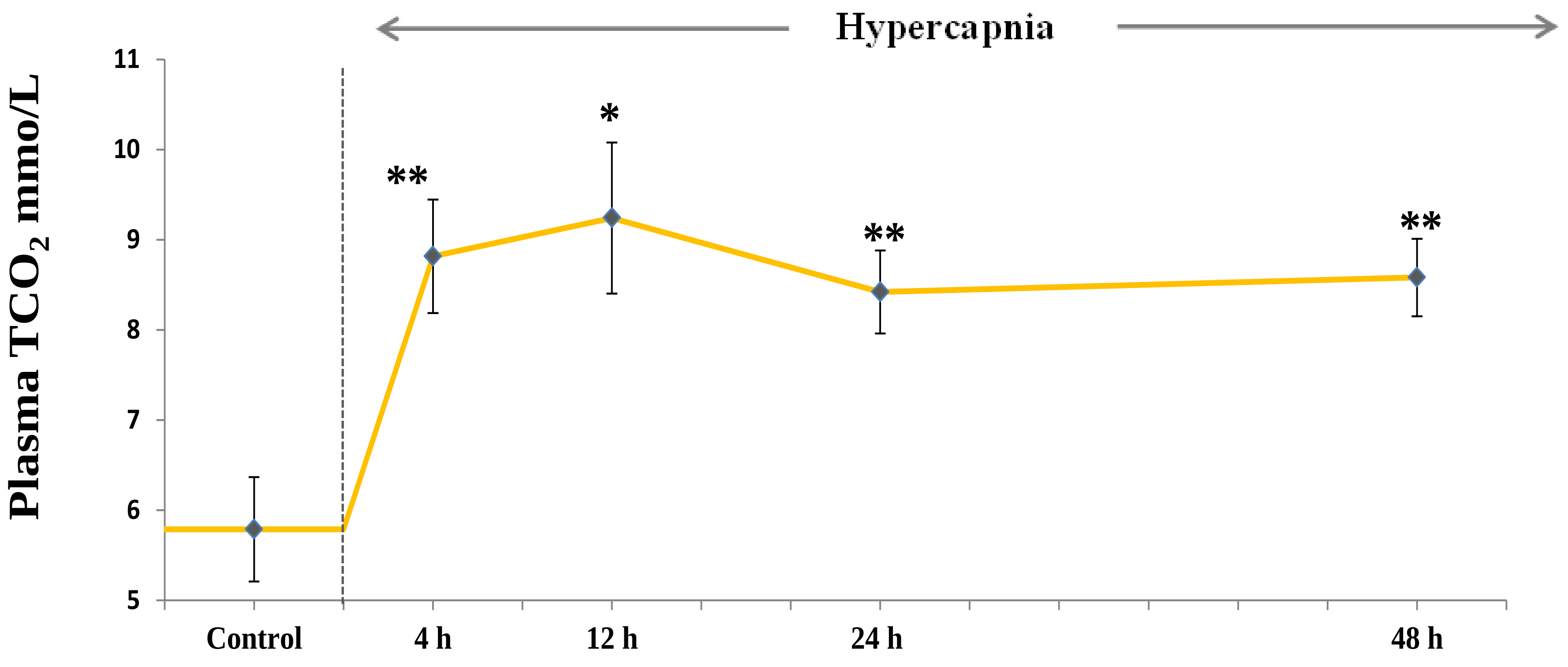
Results

Blood pH



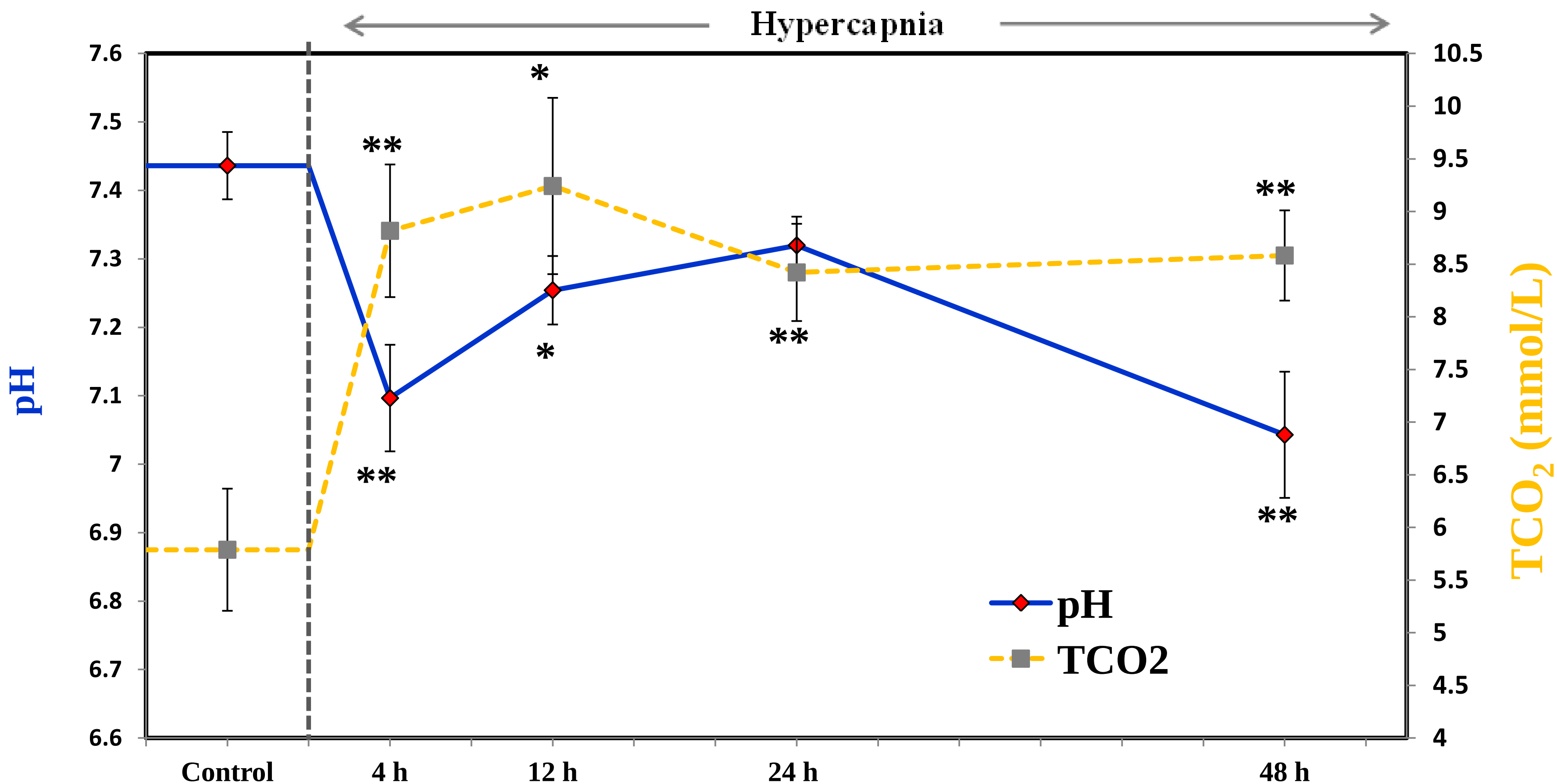
Results

Plasma TCO_2



Results

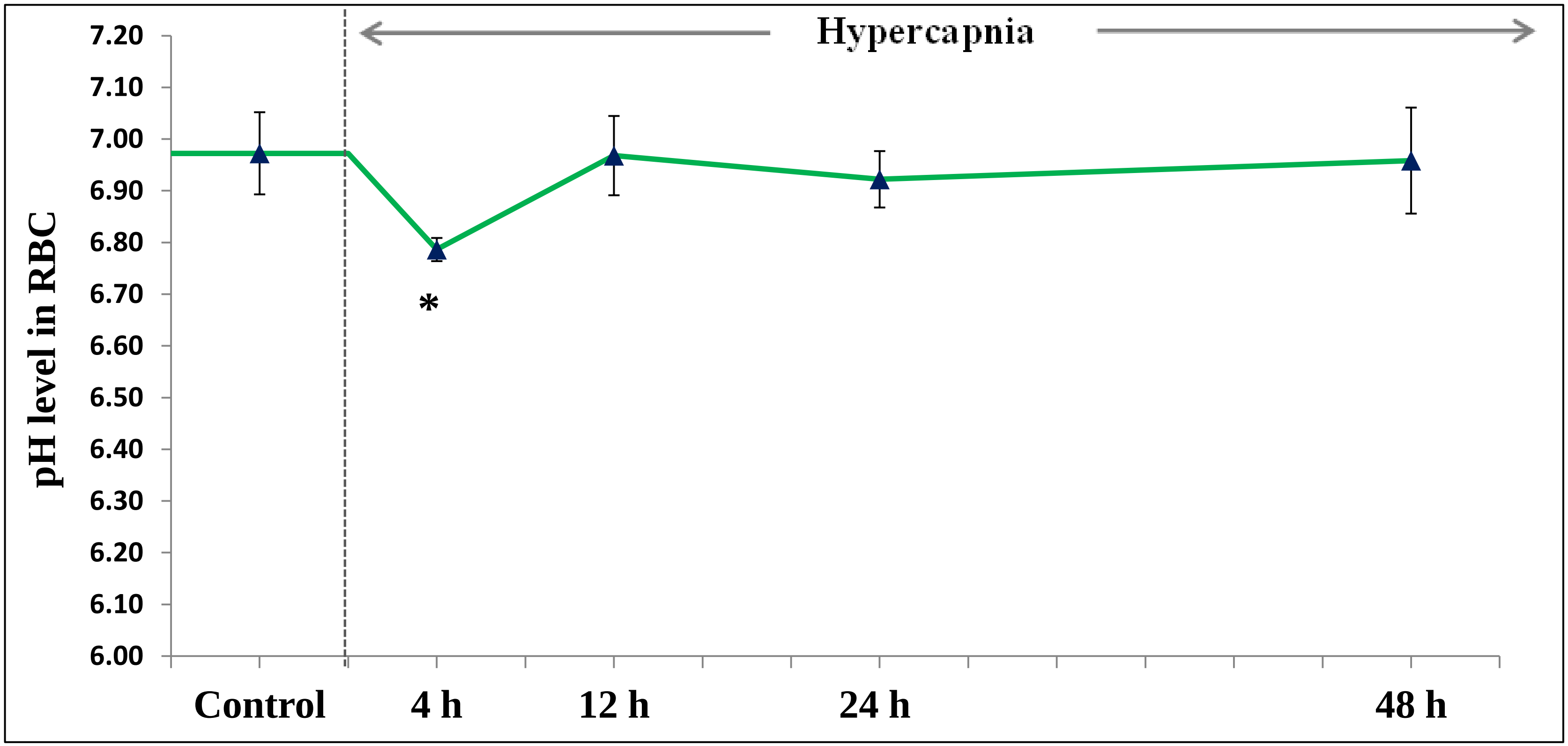
Blood pH and Plasma TCO_2



→Extracellular pH was not restored to control level

Results

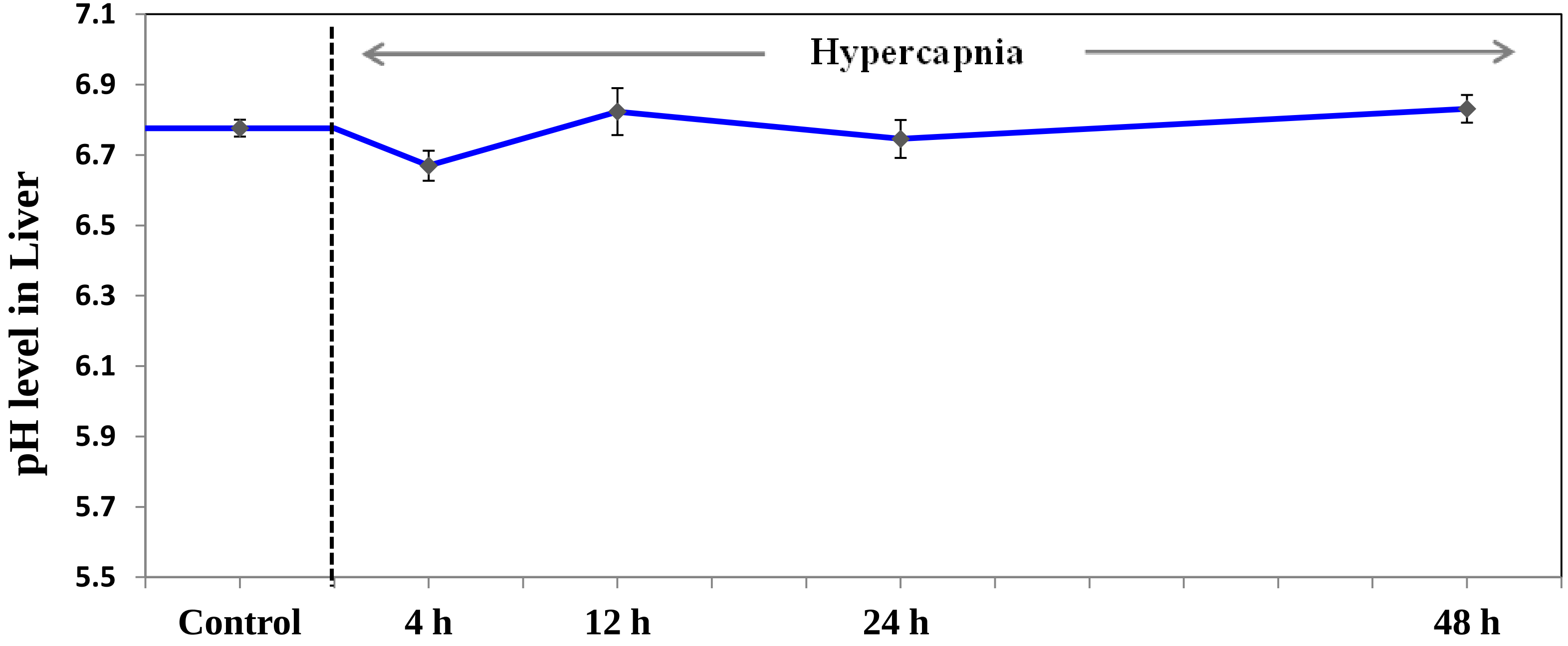
Intracellular pH: **RBC**



→ pH level in RBC was strictly maintained with in control level

Results

Intracellular pH: **Hepatic tissue**

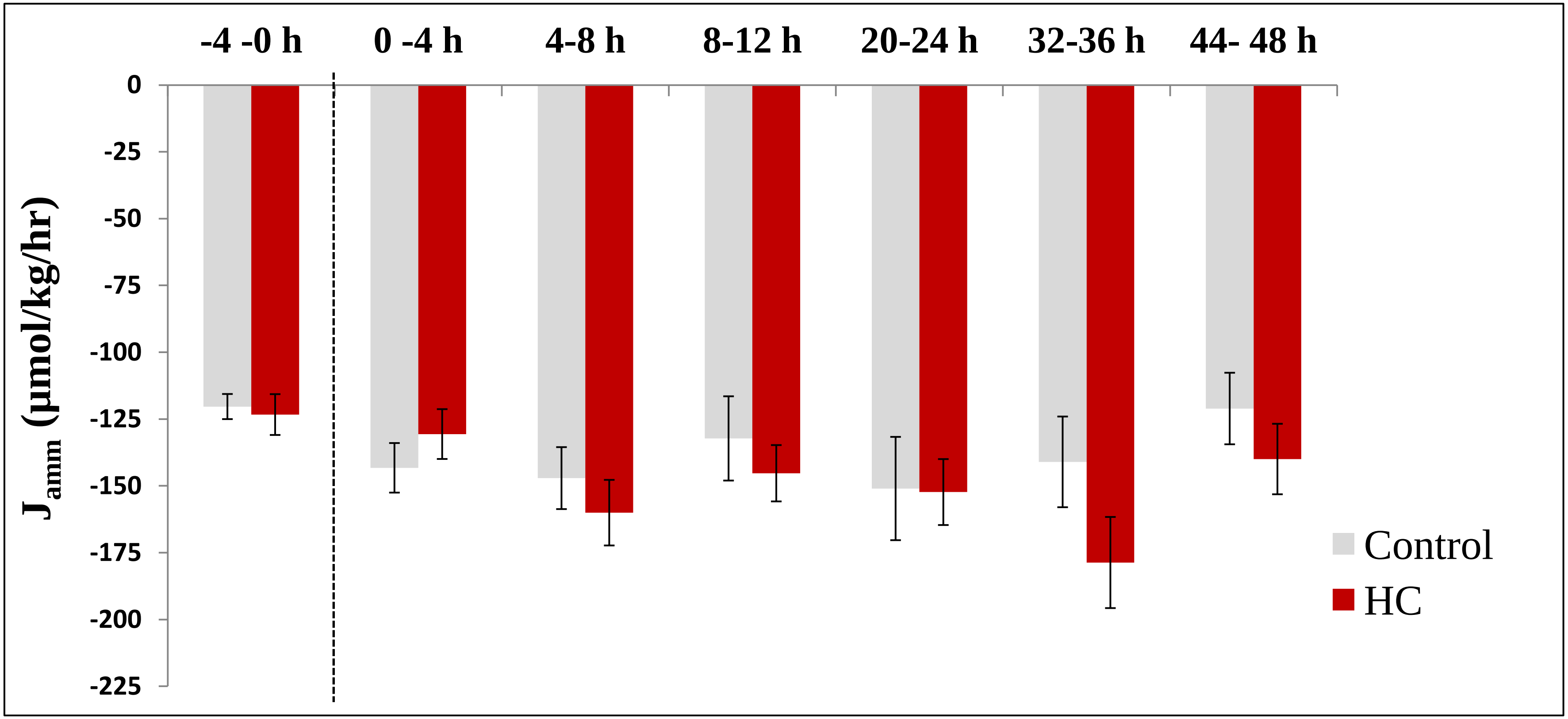


→ Similar to RBC, pH in liver cells were strictly maintained with in control level

Suggesting that intracellular pH was maintained quite well (contrast to extracellular pH)

Results

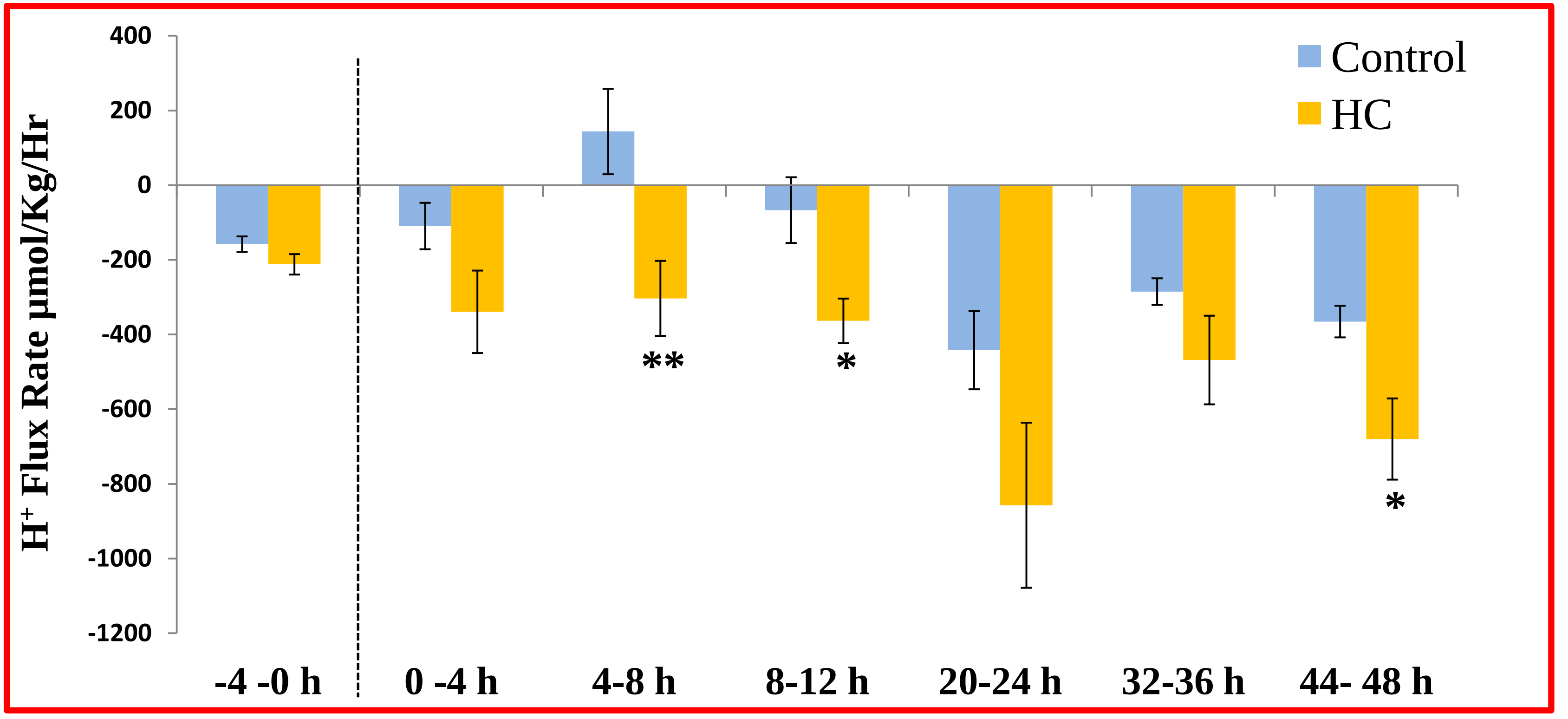
Ammonia excretion rate



→ **Ammonia excretion rate did not contribute to reduce extracellular acidosis**

Results

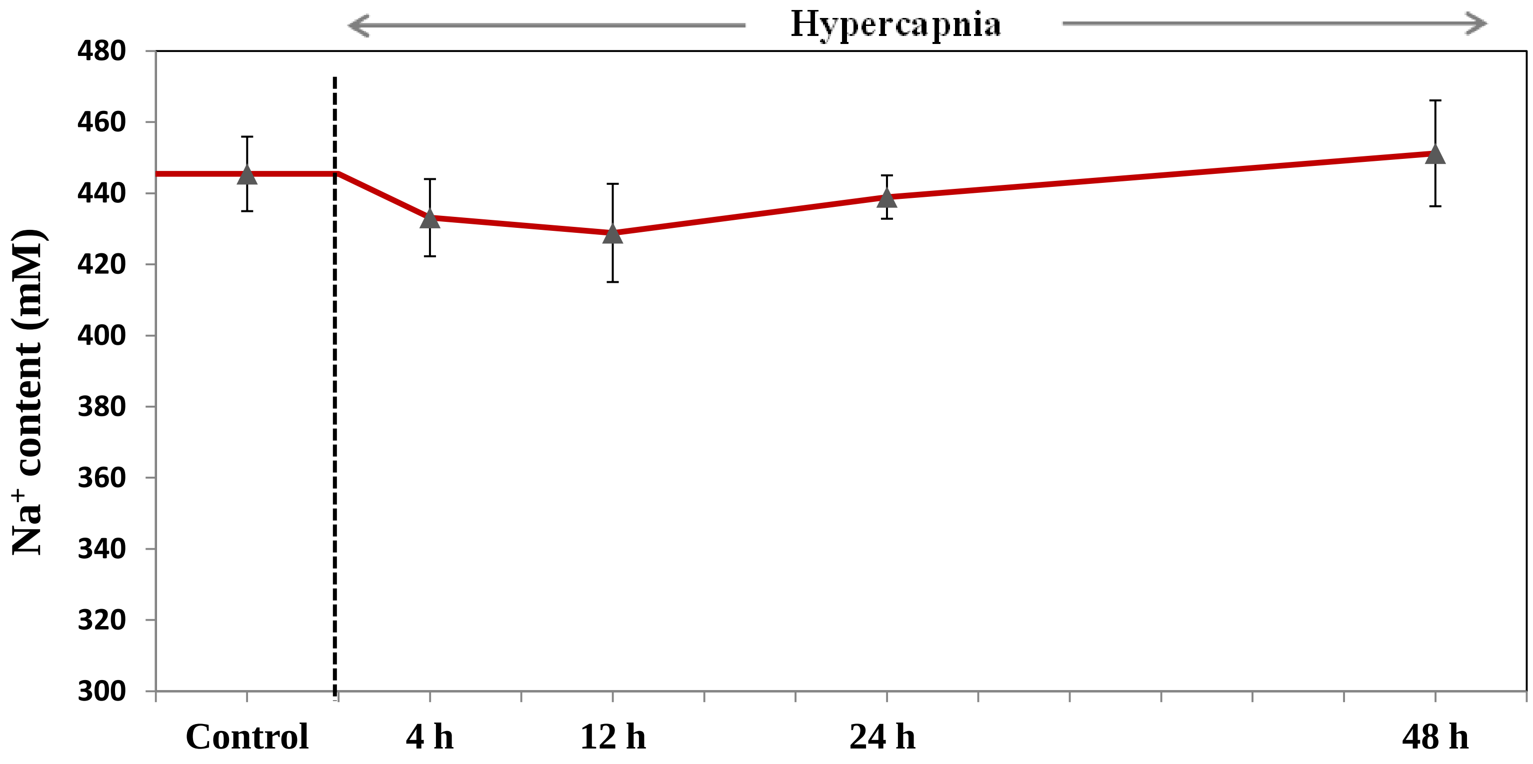
H^+ excretion rate



→A slight (and temporary) increment was revealed

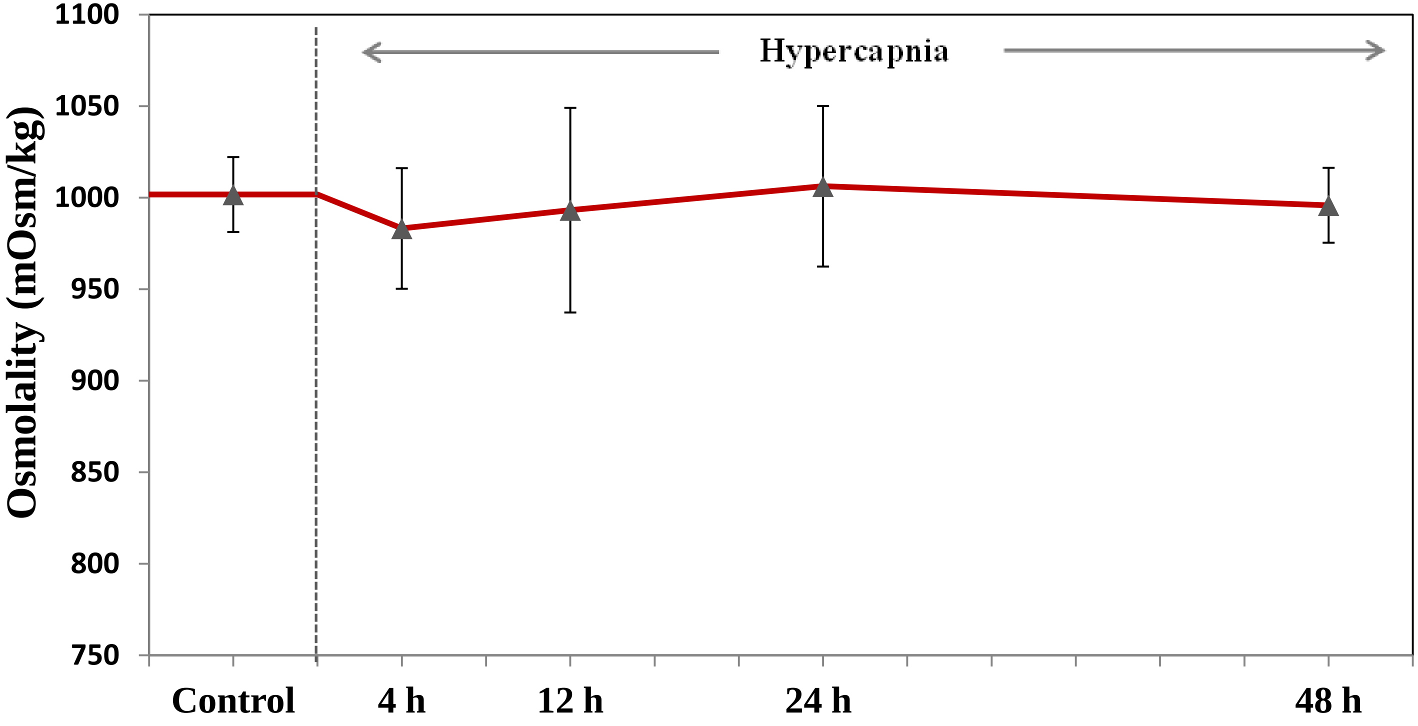
Results

Na^+ level



Results

Osmolality



→ Similar to Na^+ concentration, osmolality remained unchanged

Discussion

- **Extracellular pH (blood pH) was not compensated**

    -Level remained below control level

    - Fish seems to suffer acidosis in extracellular fluid.

- **Intracellular pH (RBC and liver cell) was regulated efficiently**

    -suggesting that ratfish prioritize intracellular pH over extracellular pH

- **Ratfish does not seem to utilize ammonia excretion pathway to cope with acidosis.**

- **Plasma sodium concentration (and H^+ excretion) remains constant throughout the experiment**

    -does not favor the Na^+/H^+ exchange as the operative mechanism in ratfish

Conclusion

Ratfish seems to be a poor acid-base regulator during ocean acidification (hypercapnia).

- Net bicarbonate uptake from the environment might be the compensation of the intracellular acidosis.
- Additional bicarbonate is gained by active HCO_3^-/$C1^-$ ion exchange.

Thanks to

Prof. Gudrun De Boeck, Prof. Ronny Blust and others………