Ionic changes during the production of *Litopenaeus vannamei* fed two feeds of differing protein content in a zero-exchange, biofloc-dominated system

David Prangnell[1], Leandro Castro[1], Abdulmehdi S. Ali[2], Thomas Zeigler[3], Craig Browdy[3], Tim Markey[3], Darrin Honious[4], and Tzachi Samocha[1]

[1]Texas A&M AgriLife Research Mariculture Lab at Flour Bluff, Corpus Christi, Texas
[2]Earth and Planetary Sciences Dept., University of New Mexico, Albuquerque, New Mexico
[3]Zeigler Bros., Gardners, Pennsylvania
[4]YSI, Yellow Springs, Ohio

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Introduction

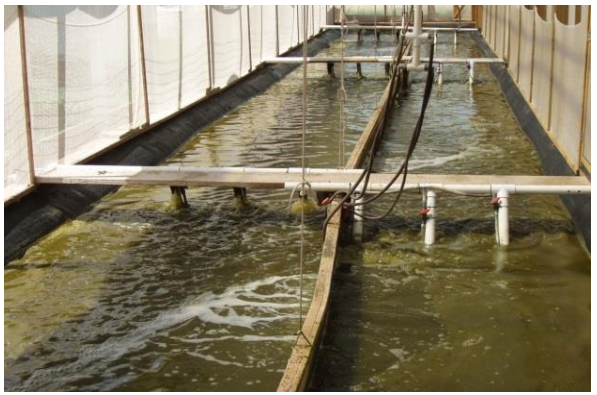
- Water composition in RAS will change over time without remediation: NO_3, PO_4, alkalinity, solids, phytoplankton and microbial density, trace elements
- Heavy metals may also accumulate in culture water, biofloc, and shrimp tissue
- These changes may reduce shrimp and bacterial performance and compromise marketability
- Ionic changes and their interactions with feed and water in limited exchange, biofloc dominated shrimp culture systems need to be established

Objectives

- To evaluate the use of a commercial (HI-35) and an experimental (EXP-14) feed formulated for super-intensive biofloc-dominated shrimp production systems for *Litopenaeus vannamei* under no water exchange
- To study the changes in selected water quality indicators throughout the trial
- To monitor changes in the ionic profile of shrimp and culture water throughout the trial

Materials & Methods

- Four 40 m^3 EPDM-lined RWs were filled with biofloc-rich water (35 m^3) from an earlier nursery trial, and chlorinated natural seawater (5 m^3)
- Salinity was adjusted to 30 ppt
- RWs stocked at 457/m^3 with Taura Resistant/Fast-Growth juveniles (5.3 g) raised at the lab from PL (*Shrimp Improvement Systems, Islamorada, FL*)
- No water exchange*
- Study duration: 48 d



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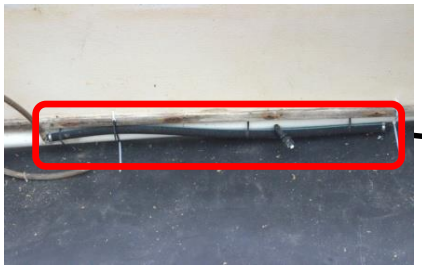
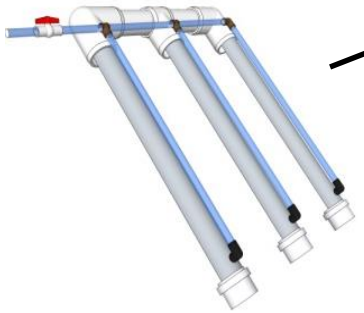
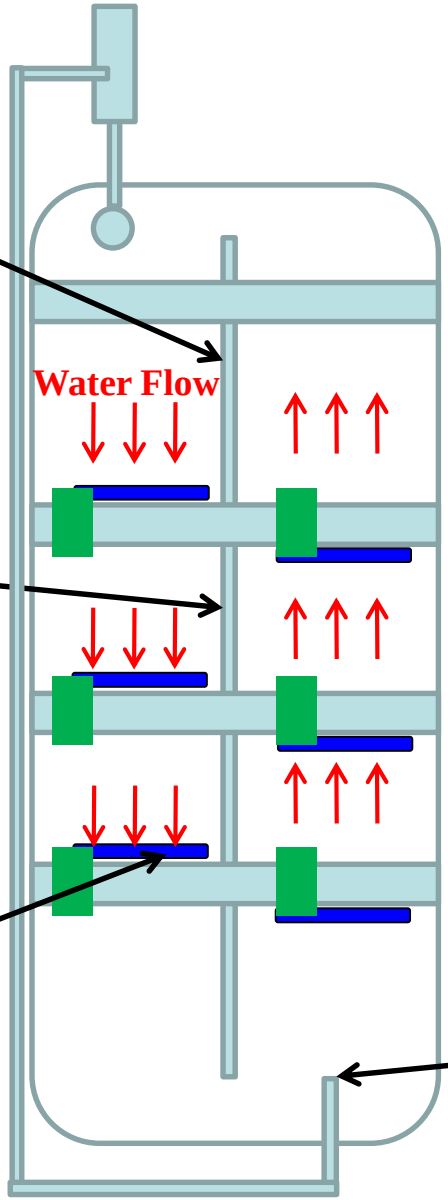
Materials & Methods

Raceways







Each RW has:

- 18 air-lifts
- 6 air-diffusers
- 1 x 2 hp pump to circulate water through a Venturi and nozzles

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Materials & Methods

Feeds

Two RWs were fed Shrimp GR Hyper-Intensive (HI-35) feed while the other two received Shrimp EXP-14 (EXP) feed (*Zeigler Bros., Gardners, PA*)

Component	HI-35	EXP
Crude Protein (%)	35	40
Lipid (%)	7	9
Fiber (%)	2	2
Phosphorus (%)	-	1
VPak™	✓	✓

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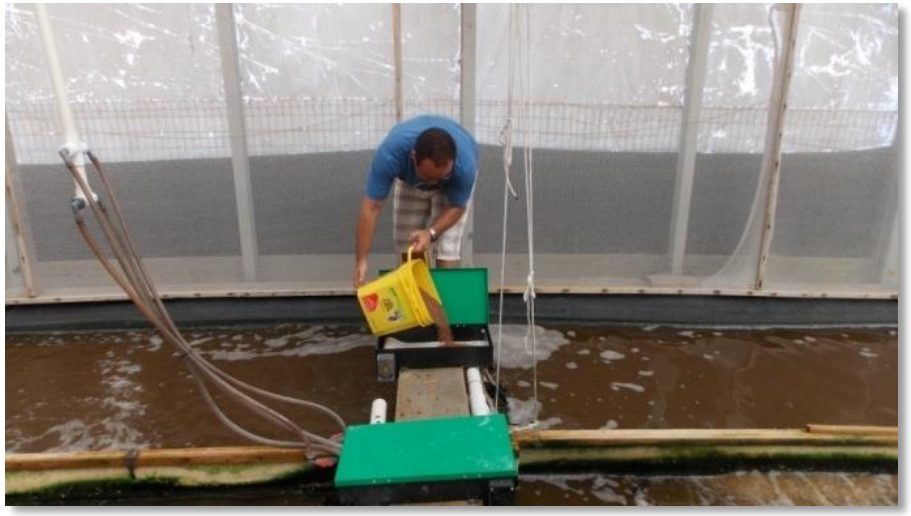
Materials & Methods

Feeds

- Feed was distributed 24/7 using belt feeders
- Rations adjusted according to twice weekly growth samples and observations of mortality



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Materials & Methods

Water Quality

- Every RW had an optical DO monitoring probe and YSI 5500D monitoring system (*YSI Inc., Yellow Springs, OH*)

- Alkalinity adjusted to 160 mg L^{-1} (as $CaCO_3$) using $NaHCO_3$ every 2nd day
- pH adjusted to >7 using NaOH on days 33 – 40
- O_2 supplemented from day 14 onwards
- A probiotic was added every 1-3 days: Ecopro® (*EcoMicrobials, LLC, Miami, FL*)

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Materials & Methods

Solids Control

- One Foam Fractionator (*VL 65 Aquatic Eco Systems, Apopka, FL*) and 450 L Settling Tank per RW to control particulate matter and dissolved organics
- Target TSS: 200-300 mg L^{-1}
- Target SS: 10-14 mL L^{-1}

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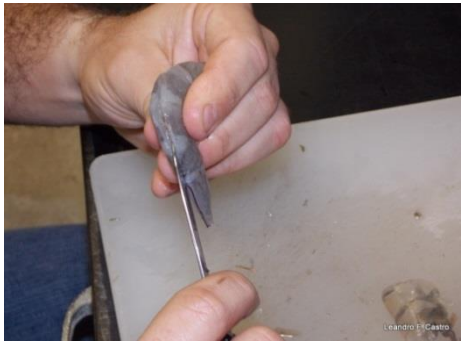
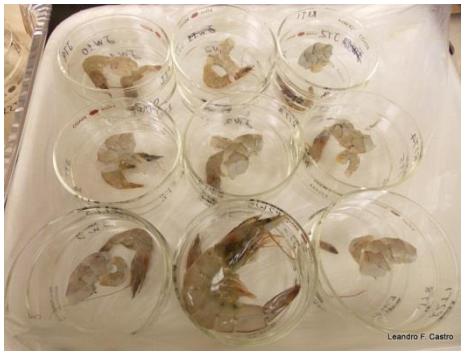
Materials & Methods

Ionic Composition

- 500 mL water samples collected on days 0, 5, 29 & 48
- Shrimp sampled on days 0, 29 & 48 (10 shrimp/RW) & frozen
- Shrimp were later weighed, dissected, dried & ground
- Acid digestion & ICP-OES





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Results

Shrimp Performance

- No significant differences were found in shrimp performance between feed types
- Mortality increased towards the end of the trial due to confirmed *Vibrio* infections

Harvested shrimp with no signs of chitinoclastic bacteria infection

Results

Shrimp Performance

	HI-35	EXP-14
Final Weight (g)	19.82±0.38	21.46±1.69
Growth (g/wk)	2.10±0.02	2.33±0.21
Total Biomass (kg)	289.5±22.9	294.4±27.9
Yield (kg/m^3)	7.24±0.57	7.36±0.70
FCR	1.68±0.22	1.63±0.22
Survival (%)	79.86±4.78	75.57±13.07

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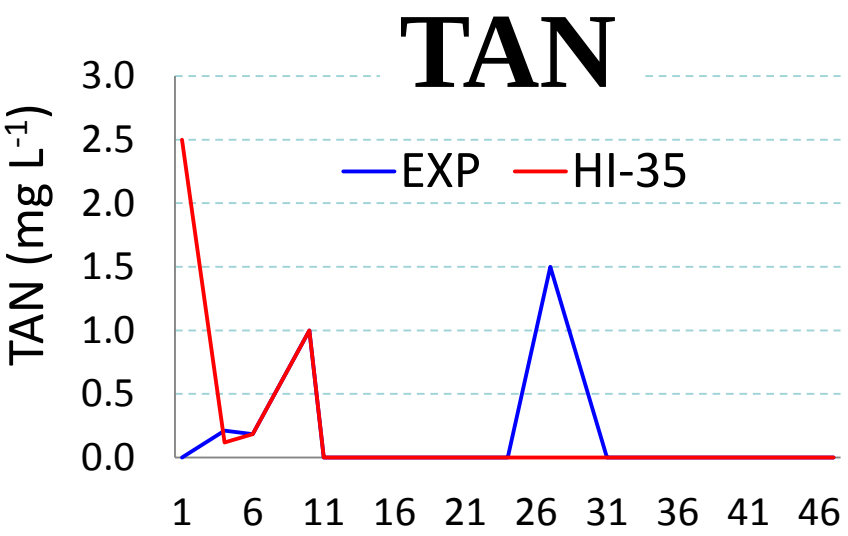
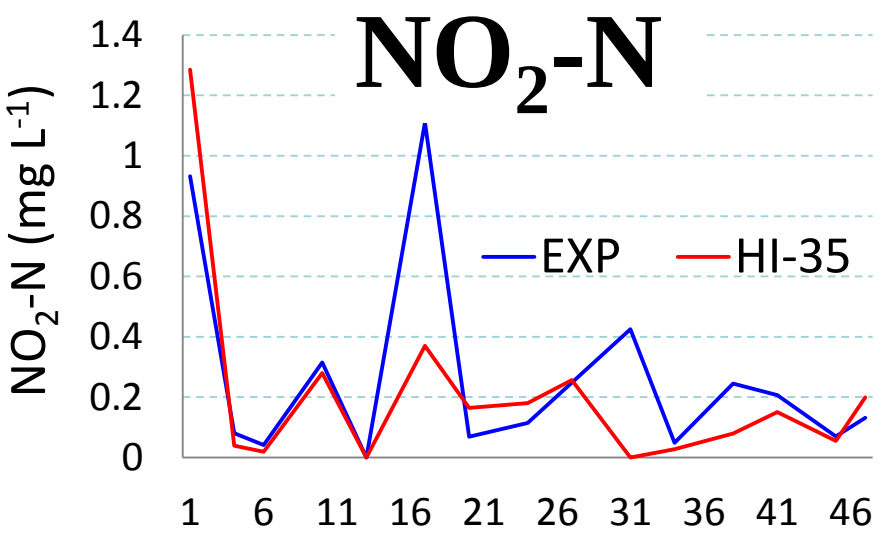
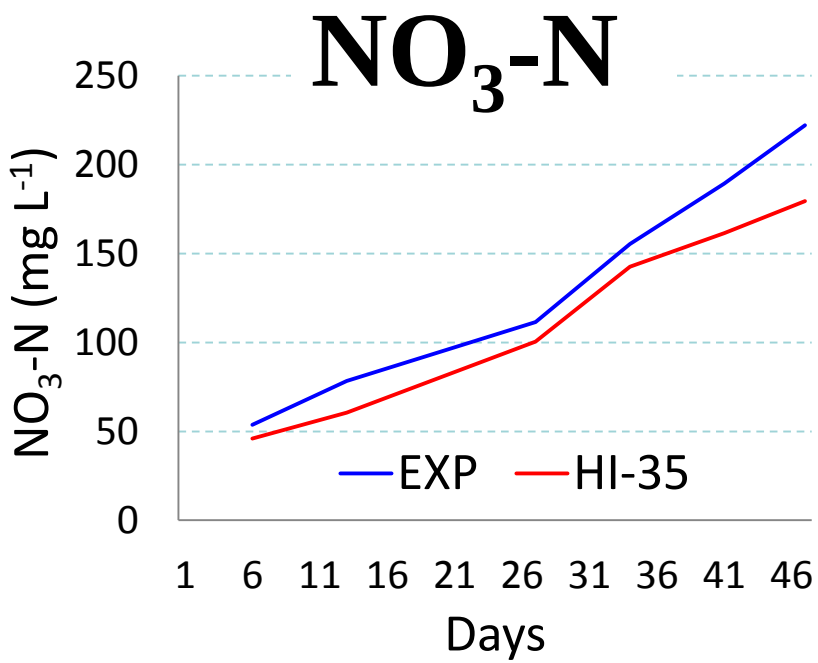
Results

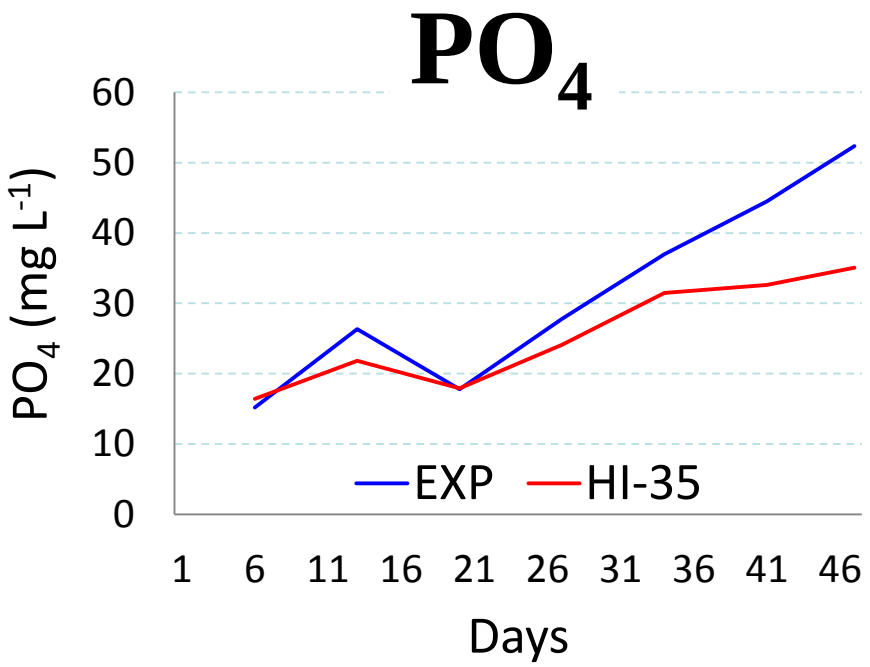
Daily Water Quality

	HI-35		EXP-14	
	Mean	Min - Max	Mean	Min - Max
Temperature (°C)	30.0	27.8 - 31.8	29.9	27.8 - 31.9
DO (mg L^{-1})	5.3	3.5 - 6.9	5.3	3.8 - 6.8
pH	7.5	6.8 - 8.0	7.5	6.7 - 8.0
Salinity (ppt)	30.3	29.6 - 31.2	30.4	29.7 - 31.3


TAN
TAN (mg L-1)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
EXP
HI-35
1
6
11
16
21
26
31
36
41
46


NO2-N
NO2-N (mg L-1)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
EXP
HI-35
1
6
11
16
21
26
31
36
41
46


NO3-N
NO3-N (mg L-1)
250
200
150
100
50
0
EXP
HI-35
1
6
11
16
21
26
31
36
41
46
Days


PO4
PO4 (mg L-1)
60
50
40
30
20
10
0
EXP
HI-35
1
6
11
16
21
26
31
36
41
46
Days

Results

Water Quality

	HI-35		EXP-14	
	Mean	Min-Max	Mean	Min-Max
Alkalinity (mg L^{-1})	158	102-199	143	109-189
TSS (mg L^{-1})	348	150-533	364	175-550
VSS (mg L^{-1})	253	142-367	221	117-288
SS (mL L^{-1})	26.7	8-90	11.2	3.5-31
Turbidity (NTU)	147	94-202	161	102-241

$NaHCO_3$ added/RW- HI-35: 27.5 kg (0.69 kg/m^3); EXP: 40.8 kg (1.02 kg/m^3)

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Results

Ionic profile: Feeds

Content (mg kg^{-1})	HI-35	EXP-14
Al	83.3	128.5
B	46.8	53.5
Ba	4.6	8.9
Ca	2,199.6	23,482.9
Cu	18.9	38.4
Fe	377.0	359.3
K	15,055.6	10,508.2
Mg	8,299.0	2,471.9
Mn	51.1	78.8
Na	2,004.2	1,596.5
Si	44.7	66.9
Sr	15.4	24.9
Zn	193.4	177.7

As, Be, Cd, Co, Cr, Li, Mo, Ni, Pb, Se, and V were not detected or <method detection limits.

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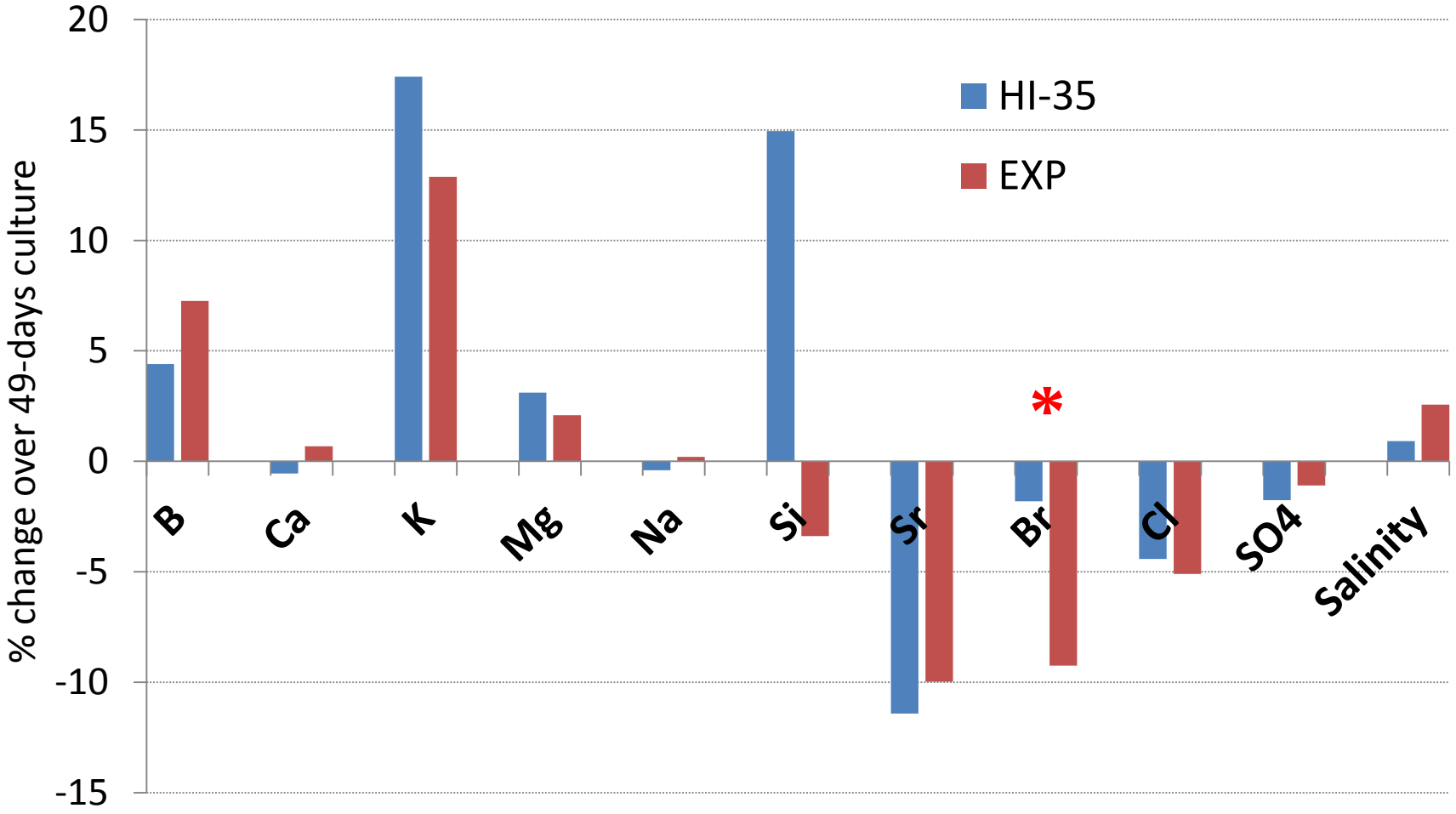
Results

Ionic profile: Culture water



Al, As, Ba, Be, Cd, Co, Cr, Cu, Fe, Li, Mn, Mo, Ni, Pb, Se, V, and Zn were not detected or <method detection limits.

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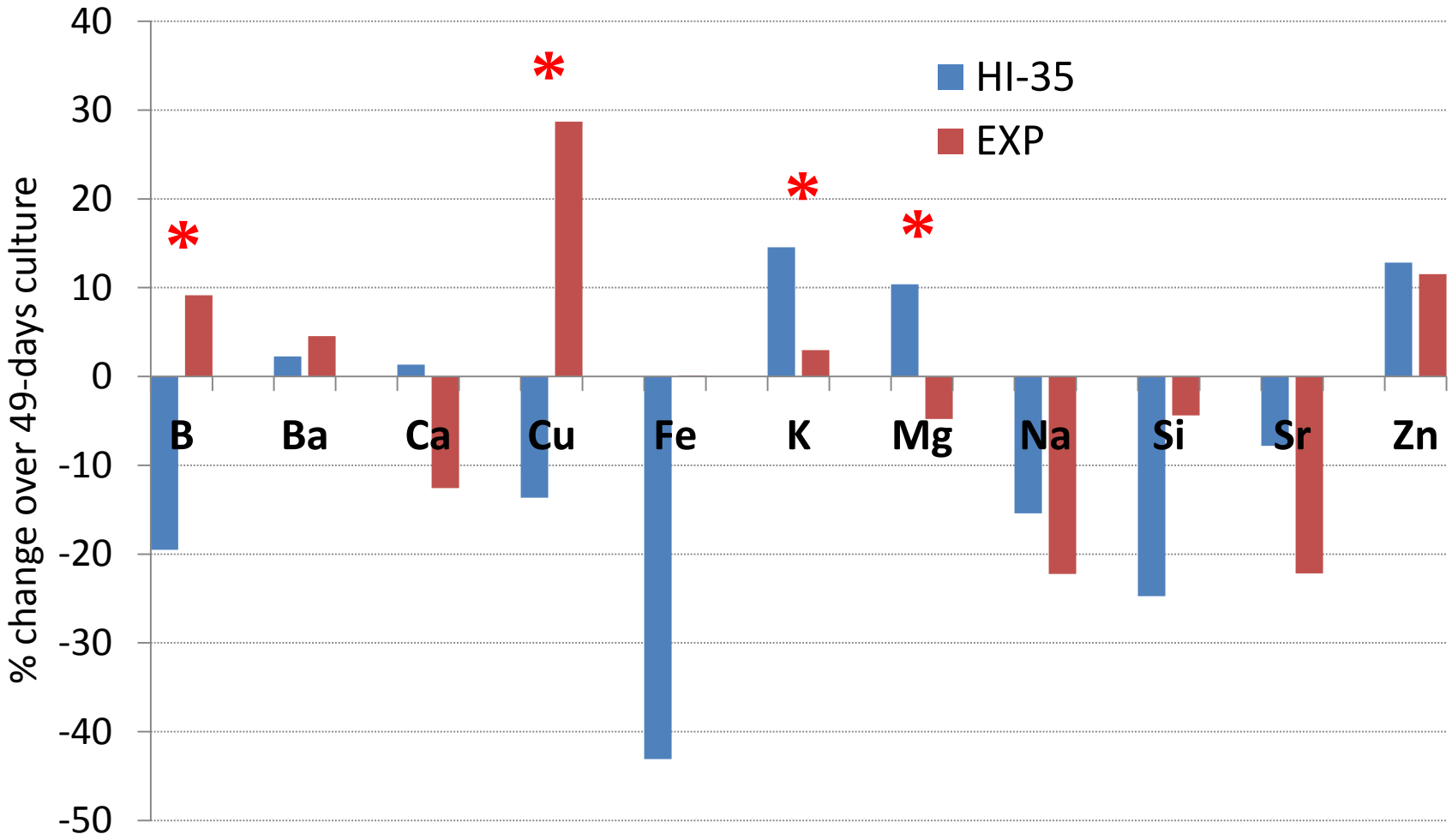
Results

Ionic profile: Whole shrimp



Al, As, Be, Cd, Co, Cr, Li, Mn, Mo, Ni, Pb, Se, and V were not detected or <method detection limits.

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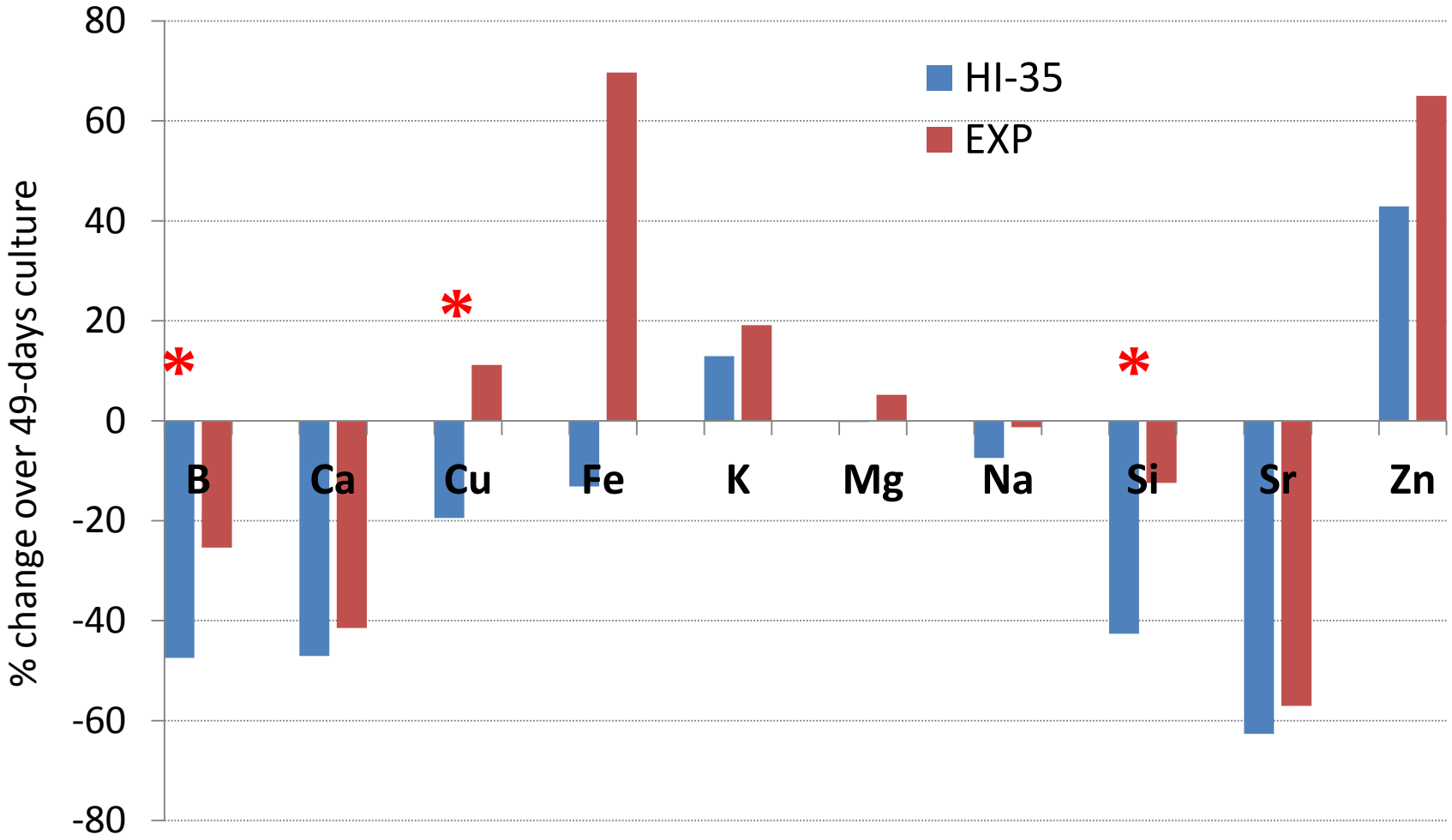
Results

Ionic profile: Tail muscle



Al, As, Ba, Be, Cd, Co, Cr, Li, Mn, Mo, Ni, Pb, Se, and V were not detected or <method detection limits.

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Results

Ionic profile

- The differences in shrimp composition between feed types all reflected differences in the two feeds
- Shrimp ionic profile changes (↓ B, Ca, Na, Si, & Sr; ↑ Cu, K, & Zn) may be due to normal changes in physiology and metabolic needs as shrimp grew
- Similar ionic changes were also observed in three other AgriLife studies (49-77 days; in 40 & 100 m^3 systems)
- Some metals (Al, Cu, Fe, Mn, Sr, V, Zn) accumulated in settled solids in a denitrification tank during a later study

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Conclusion

- Under these study conditions, marketable sized shrimp were produced at a biomass of 7.3 kg/m^3
- No heavy metals accumulated to problematic levels in culture water or shrimp tissue
- Feed ionic composition and normal physiological changes appeared to be the main factors associated with changes in shrimp ionic composition
- Sr may need to be supplemented if water is to be re-used for successive culture cycles

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Acknowledgements

- *The National Sea Grant, Texas A&M AgriLife Research* for funding
- *Zeigler Bros.* for the feed & funding
- *YSI* for the DO monitoring systems
- *Keeton Industries* for the nitrifying bacteria
- *Aquatic Eco-Systems* for the foam fractionators
- *Colorite Plastics* for the air diffusers
- *Firestone Specialty Products* for the EPDM liner
- *Florida Organic Aquaculture* for funding