THE UNIVERSITY OF QUEENSLAND AUSTRALIA

UQBR AQUATICS

Managing Water Quality

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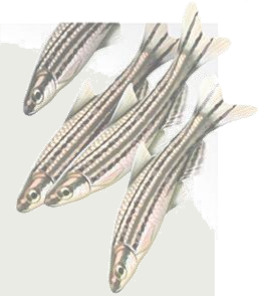
UQ Biological Resources

Monitoring Water Quality

- *Acute impact (daily / continual monitoring)*
  - *water temperature*
  - *pH*
  - *Conductivity (salinity)*
  - *Dissolved Oxygen / TGP (design dependent)*
  - *Ammonia (stock movement dependent)*
  - *Chlorine (source water dependent)*

Monitoring Water Quality

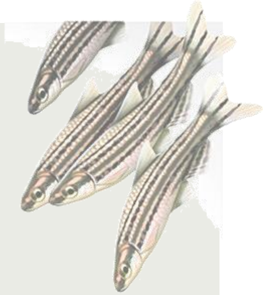


- *Chronic impact (weekly monitoring)*
  - *Nitrate*
  - *Nitrite*
  - *Hardness*
  - *Alkalinity*
  - *CO_2*

Monitoring Water Quality

- Different methods for monitoring water quality
  - Integrated monitoring systems and probes
  - Handheld devices
  - Chemical test kits
  - Test strips

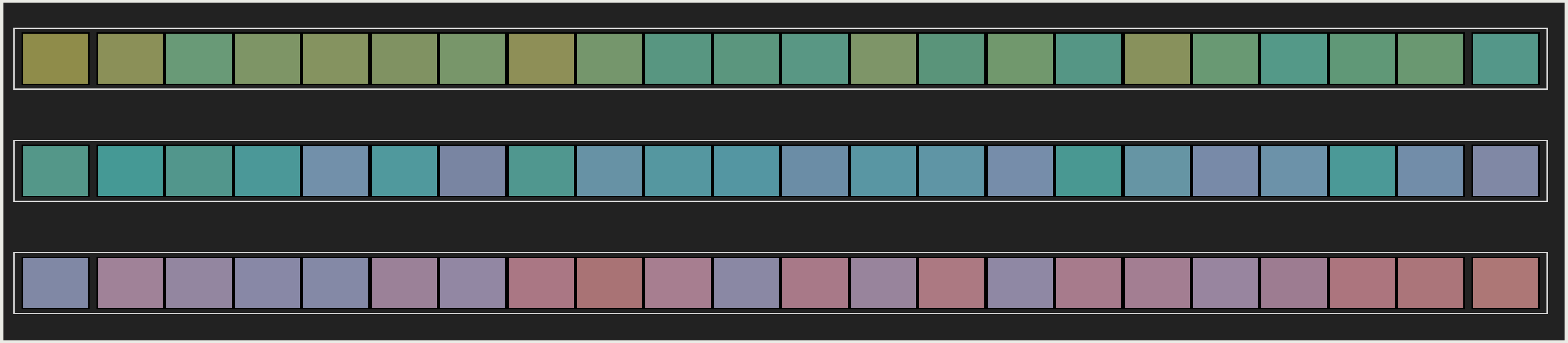
Colorimetric Test Kits



- *Reagents should be in date*
- *Tester must be able to determine color change*

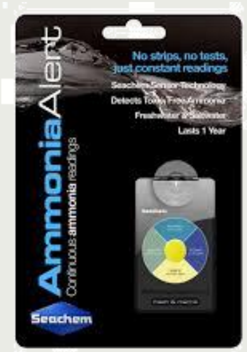
- *Test your team's hue differentiation abilities:*

http://www.xrite.com/custom_page.aspx?pageid=77&lang=en



Colorimetric Test Kits

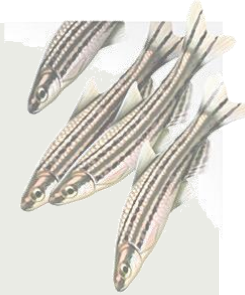
Hach™ "Fish Farming" Test Kit (FF-1A)



Free Ammonia indicator

API® – Ammonia test kit most reliable
– Wide range pH test kit

Test Strips for:
ammonia, chlorine nitrate, nitrite, general hardness (GH), alkalinity (KH) and pH



Electronic meters & probes

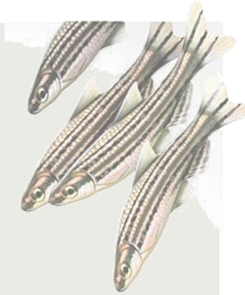
- *Fast test with high degree of accuracy*
- *Probes must be properly maintained and calibrated*

YSI 556 MPS – portable multiprobe

YSI 556 System Specifications (Instrument with Cable & Probe)

	Sensor Type	Range	Accuracy	Resolution
Dissolved Oxygen (%)	Polarographic	0 to 500% air saturation	0 to 200% air saturation, ± 2% of the reading or ± 2% air saturation, whichever is greater; 200 to 500% air saturation, ± 6% of the reading	0.1% air saturation
Dissolved Oxygen (mg/L)	Polarographic	0 to 50 mg/L	0 to 20 mg/L, ± 0.2 mg/L or ± 2% of reading, whichever is greater; 20 to 50 mg/L, ± 6% of the reading	0.01 mg/L
Temperature	Thermistor	-5 to 45°C	±0.15°C	0.1°C
Conductivity	Four electrode cell	0 to 200 mS/cm (auto range)	±0.5% of reading or 0.001 mS/cm, whichever is greater (4-m cable) ±1% of reading or 0.001 mS/cm, whichever is greater (20-m cable)	0.001 mS/cm to 0.1 mS/cm (range dependent)
Salinity	Calculated from conductivity and temperature	0 to 70 ppt	±1.0% of reading or 0.1 ppt, whichever is greater	0.01 ppt
pH (optional)	Glass Combination Electrode	0 to 14 units	±0.2 units	0.01 units
ORP (optional)	Platinum button	-1999 to +1999 mV	±20 mV	0.1 mV
Total Dissolved Solids (TDS)	Calculated from conductivity and temperature	0 too 100 g/L		4 digits
Barometer (optional)		500 to 800 mmHg	±3 mmHg within ±10°C temperature range from calibration point	0.1 mmHg

Spectrophotometry



- *More precise readings*
- *Slower tests*

Industrial Test Systems eXact Micro 7+

Hach DR 3900 Benchtop Spectrophotometer

Guided Procedures
The DR 3900 guides you step-by-step through the testing procedure like a GPS, so you can get the accurate results you need every time.

Elimination of False Readings
Scratched, flawed, or dirty glassware becomes a non-issue when your machine takes 10 readings and eliminates outliers.

Hands Free Updates*
RFID technology automatically updates the program calibration factors when you place a TNTplus box near the machine.
*RFID technology currently available in US, Canada, Puerto Rico, Australia, New Zealand, and Colombia only.

Flexible Connectivity
Built with 1 ethernet and 3 USB ports, the DR 3900 easily connects to your computer and is programmed to easily interface with Hach WIMS™ or any LIMS system.

Sample Tracking*
Sample bottles with smart tags can easily be tracked with the optional Hach RFID sample-ID system, eliminating sample mix-ups and providing better sample traceability.

Integrated monitoring

- *Increased automation*
- *Independent control and alarming*
- *Remote monitoring*
- *Graphical User Interface*

Integrated monitoring

Automated System control

- Touch screen interface

Monitor various parameters in real time

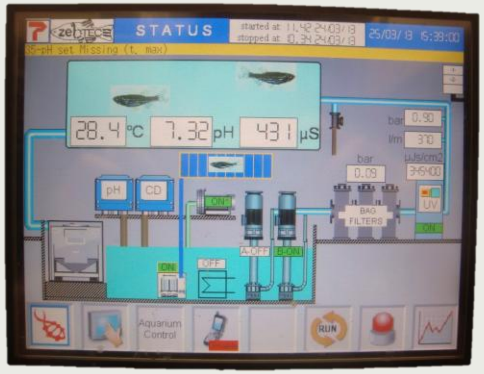
- Temperature
- pH
- Conductivity
- Water level
- Flow
- Total gas pressure (TGP)
- dissolved oxygen

Automatic control of environment

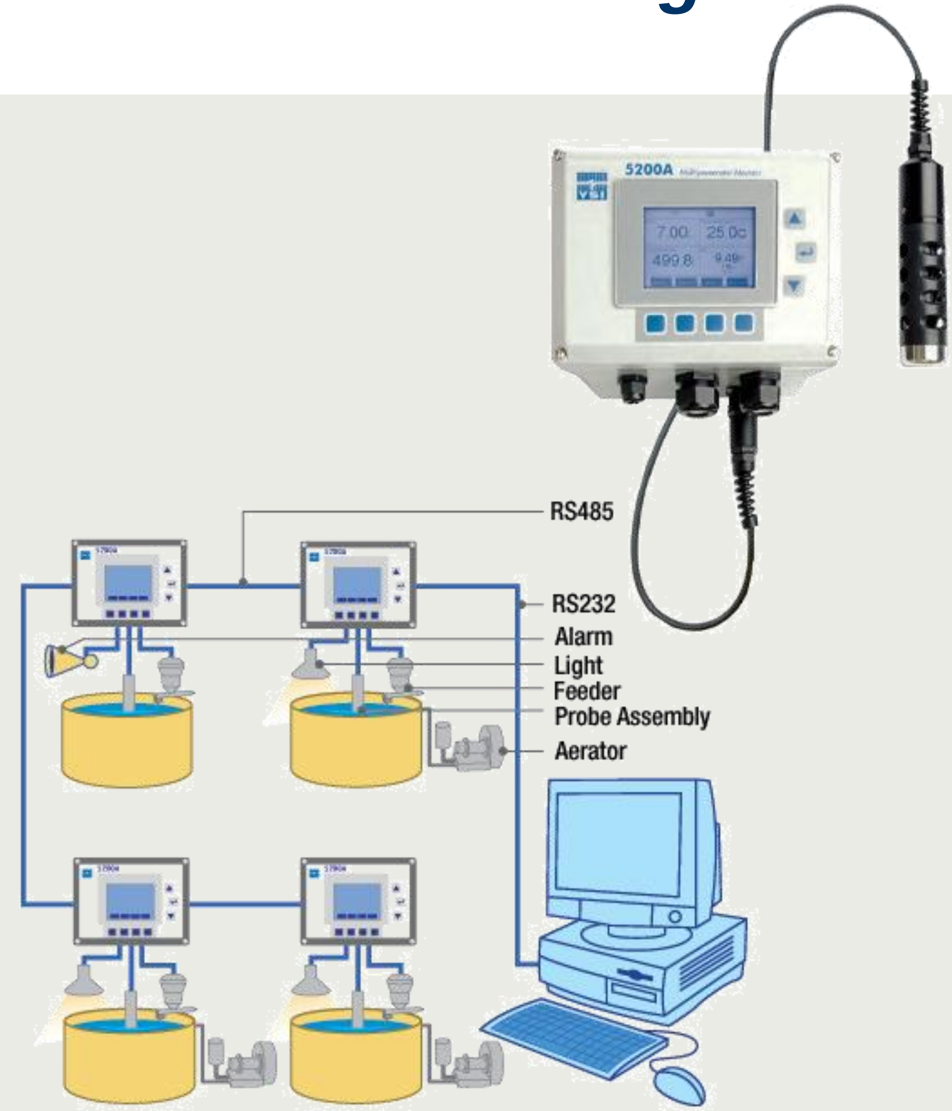
- Flow rates
- UV dosage
- Heater/chiller
- pH dosing
- Conductivity dosing
- Water exchange

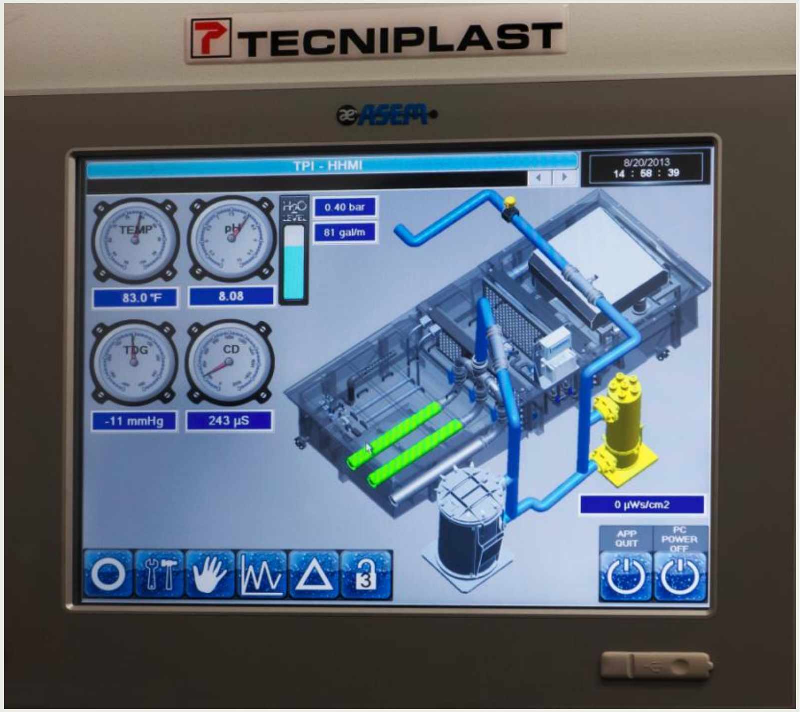
Remote alarm

- BMS integration
- phone/email alarms



Remote monitoring





Remote monitoring

Managing Off Target Culture Conditions

- Water temperature
- pH
- Conductivity (salinity)
- Dissolved Oxygen / TGP (design dependent)
- Ammonia (stock movement dependent)
- Chlorine (source water dependent)

Conductivity (salinity)

- Natural habitat salinity as 0.6ppt (1,200µS)
  Spence et al (2006)
- Dechlorinated municipal supply often suitable as is
  - ~1,000-1,500µS
- Reverse osmosis water requires conditioning to use
  - ~20µS or less
  - Manipulate with conductivity salts

Salt is salt, right?

- Options to consider
  - Synthetic marine salt
  - Rift lake salt
  - Pool salt
  - Table salt

Table Salt

- Constituents
  - Sodium chloride - NaCl

Epsom Salt

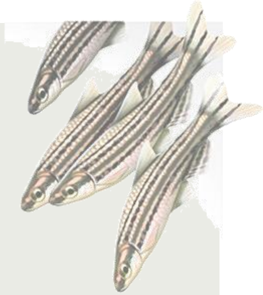
- Constituents
  - Magnesium chloride - $MgCl_2$

Rift Lake Salt

Constituents

Chemical Compound	Lake Victoria	Lake Malawi	Lake Tanganyika
Sum of cations (meq/L)	1.04-1.21	2.45	7.30-7.46
Sum of anions (meq/L)	1.08-1.77	1.08-1.77	7.25-7.71
Na (sodium) (mg/L)	10.4-13.5	21.0	57-63.6
K (potassium) (mg/L)	3.7-4.2	6.4	18.0-35.5
Ca (calcium) (mg/L)	5-15	16.4-19.8	9.2-17.6
Mg (magnesium) (mg/L)	1.59-8	4.7-8.8	39.2-43.3
HCO3 + CO3 (bicarbonate,carbonate) (meq/L)	0.25-1.53	2.36-2.58	6.02-6.81
Cl (chloride) (mg/L)	3.9-7.0	3.57-4.3	20.9-36.6
SO4 (sulfate) (mg/L)	2.3	5.5	7.2-15.3
SiO2 (dissolved silica) (mg/L)	3-20	1.1-4	0.3-6.6
NO3 · N (nitrate-nitrogen) (μg/L)	11-29	—	—
PO4 · P (phosphate) (μg/L)	3-13	<7-30	7
Total P (phosphorus) (μg/L)	47-67	—	—
pH	8.0-8.8	7.5-8.6	8.66-9.06

Synthetic Marine Salt



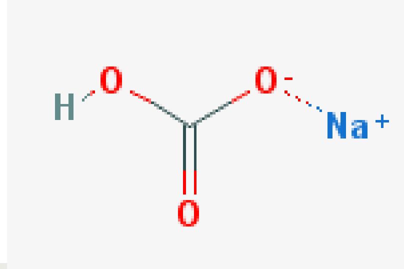
Constituents

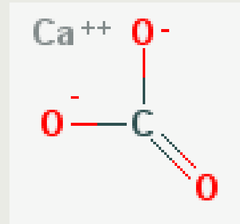
Chloride,	Cl2	19,500	Molybdenium,	Mo	0.01	Zirconium,	Zr	0.00003	Cerium,	Ce	1x10-6
Sodium,	Na	10,770	Arsenic,	As	0.0037	Bismuth,	Bi	0.00002	Dysprosium,	Dy	9x10-7
Magnesium,	Mg	1,290	Uranium,	U	0.0032	Niobium,	Nb	0.00001	Erbium,	Er	8x10-7
Sulfur,	S	905	Vanadium,	V	0.0025	Thallium,	Tl	0.00001	Ytterbium,	Yb	8x10-7
Calcium,	Ca	412	Titanium,	Ti	0.001	Thorium,	Th	0.00001	Gadolinium,	Gd	7x10-7
Potassium,	K	380	Zinc,	Zn	0.0005	Hafnium,	Hf	7x10-6	Praseodymium,	Pr	6x10-7
Bromide,	Br	67	Nickel,	Ni	0.00048	Helium,	He	6.8x10-6	Scandium,	Sc	6x10-7
Carbon,	C	28	Aluminium,	Al	0.0004	Beryllium,	Be	5.6x10-6	Tin,	Sn	6x10-7
Nitrogen,	N	11.5	Cesium,	Cs	0.0004	Germanium,	Ge	5x10-6	Holmium,	Ho	2x10-7
Strontium,	Sr	8	Chromium,	Cr	0.0003	Gold,	Au	4x10-6	Lutetium,	Lu	2x10-7
Oxygen,	O	6	Antimony,	Sb	0.00024	Rhenium,	Re	4x10-6	Thulium,	Tm	2x10-7
Boron,	B	4.4	Krypton,	Kr	0.0002	Cobalt,	Co	3x10-6	Indium,	In	1x10-7
Silicon,	Si	2	Selenium,	Se	0.0002	Lanthanum,	La	3x10-6	Trebium,	Tb	1x10-7
Fluoride,	F	1.3	Neon,	Ne	0.00012	Neodymium,	Nd	3x10-6	Palladium,	Pd	5x10-8
Argon,	Ar	0.43	Manganese,	Mn	0.0001	Lead,	Pb	2x10-6	Samarium,	Sm	5x10-8
Lithium,	Li	0.18	Cadmium,	Cd	0.0001	Silver,	Ag	2x10-6	Tellurium,	Te	1x10-8
Rubidium,	Rb	0.12	Copper,	Cu	0.0001	Tantalum,	Ta	2x10-6	Europium,	Eu	1x10-8
Phosphorus,	P	0.06	Tungsten,	W	0.0001	Gallium,	Ga	2x10-6	Radium,	Ra	7x10-11
Iodine,	I	0.06	Iron,	Fe	0.000055	Yttrium,	Y	1.3x10-6	Protactinium,	Pa	5x10-11
Barium,	Ba	0.02	Xenon,	Xe	0.00005	Mercury,	Hg	1x10-6	Radon,	Rn	6x10-16

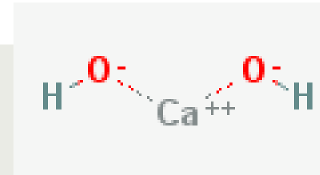
Managing pH

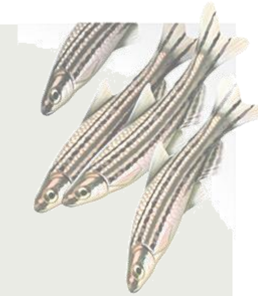
- Target = 7.5
- Options for manipulating pH?

Increasing pH





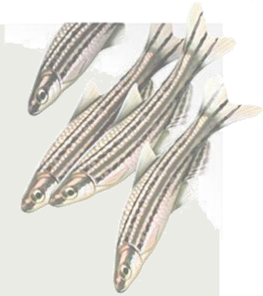




Options to consider

Base	Formula	Normality	pH	Soulbility
Sodium bicarbonate	NaHCO3	0.1 N	8.4	9 g/100 mL (20ºC)
Calcium carbonate	CaCO3	saturated	9.4	0.001 g/100ml (20ºC)
Calcium hydrate	Ca(OH)2 (lime water - CaO:H2O)	saturated	12.4	0.16 g/100ml (20ºC)

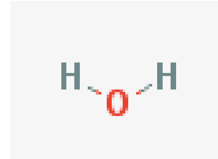
Kalkwasser (pH = 12.4)



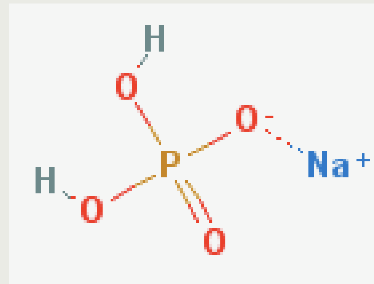
Natural White Vinegar (5%)	250ml
Hydrated Lime - $Ca(OH)_2$	85g
RO Water	20L

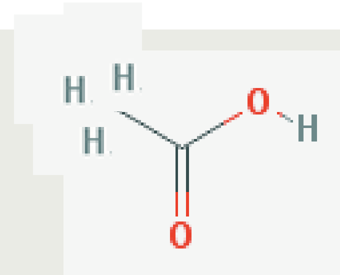
- Gently stir lime into the vinegar
- When milky, slowly add water avoiding bubbles
- Cover container to minimise air exchange

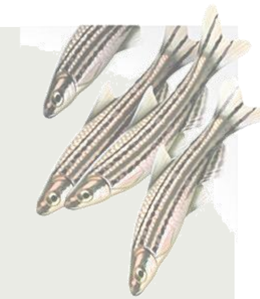
Decreasing pH



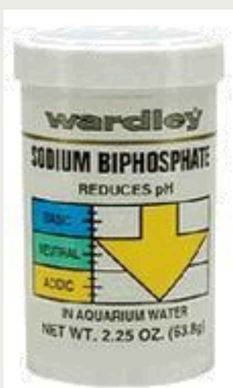
Options to consider



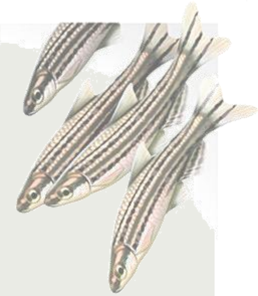




Acid	Formula	Normality	pH	Solubility
RO Water	H20	-	~5-6.5	-
Sodium biphosphate	H2NaO4P	1%	4.5	85 g/100ml (20ºC)
Acetic acid	CH3COOH	5%	2.4	100 g/100ml (25ºC)



Acetic acid in the aquarium

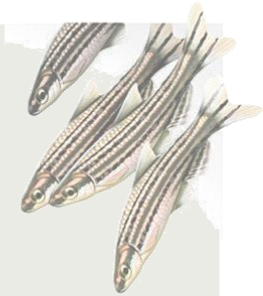


- On addition
  - $CH_3COOH \rightarrow CH_3COO^- + H^+$
- Acetate stimulates heterotrophic bacterial growth
  - $CH_3COO^- + 2O_2 \rightarrow 2CO_2 + H_2O + OH^-$
- net addition is simply carbon dioxide
  - $H^+ + OH^- \rightarrow H_2O$
  - $CH_3COOH + 2O_2 \rightarrow 2CO_2 + 2\,H_2O$

pH effect on Ammonia

- Total Ammonia Nitrogen (TAN) = $NH_4^+ + NH_3$
- TAN species ratio influenced by pH
  - pH 7.5, 28.5°C, 1000µS
    - TAN = 1.0ppm, NH_3 = 0.0234ppm
  - pH 8.0, 28.5°C, 1000µS
    - TAN = 1.0ppm, NH_3 = 0.0677ppm

High Ammonia



- Options to consider:
  - Reduce pH to shift species ratio
  - Increase biofilter bacteria
  - Add water conditioner
  - Increase water exchange

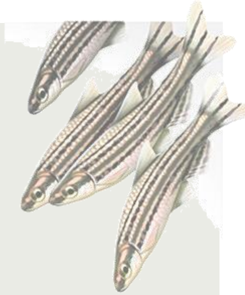
High Ammonia

- Reducing pH:
  - Nitrifying bacteria have reduced growth and activity at pH levels below 6.4
  - Heavy metal toxicity increases as pH drops below 7
    - Not recommended for municipal water source systems

High Ammonia

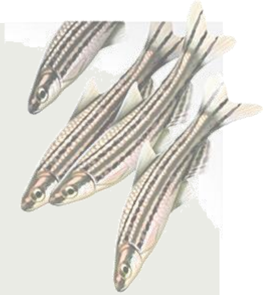
- Increase biofilter bacteria
  - Concentrated lag-phase bacterial cultures
  - Effectiveness hotly debated

High Ammonia



- Water conditioner
  - Binds free ammonia, detoxifying it until biofilter responds
  - Many also bind chlorine & chloromines, and other nitrogen species
  - Cannot be used with some ammonia tests

High Nitrates



- NO_3^- >50ppm not toxic until 400ppm (learmonth & carvalho, 2015)
- Options to consider:
  - Increased water exchange
    - Impact on other water parameters
  - Water conditioner
  - Emerging technology - Nitrate filter

High Nitrates

- Nitrate Filter
  - Autotrophic sulfur denitrification
  - Run in parallel to filtration system
  - Require anaerobic conditions
    - Bacteria utilise O_2 from NO_3
    - CO_2 & N_2 are produced
    - CO_2 is passed through $CaCO_3$ source

Questions?