EcoPonics
Ecofood from Aquaponics

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WATER QUALITY

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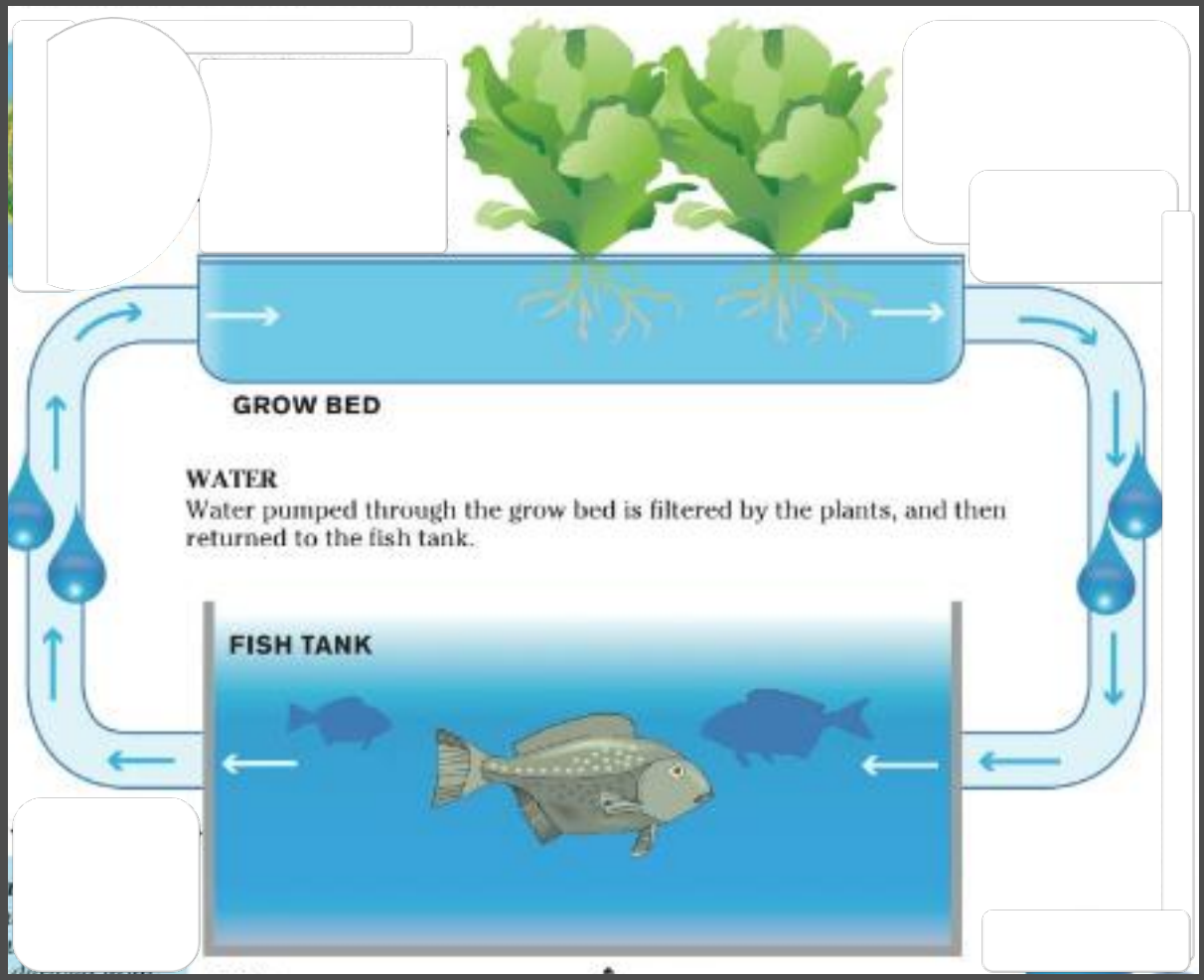
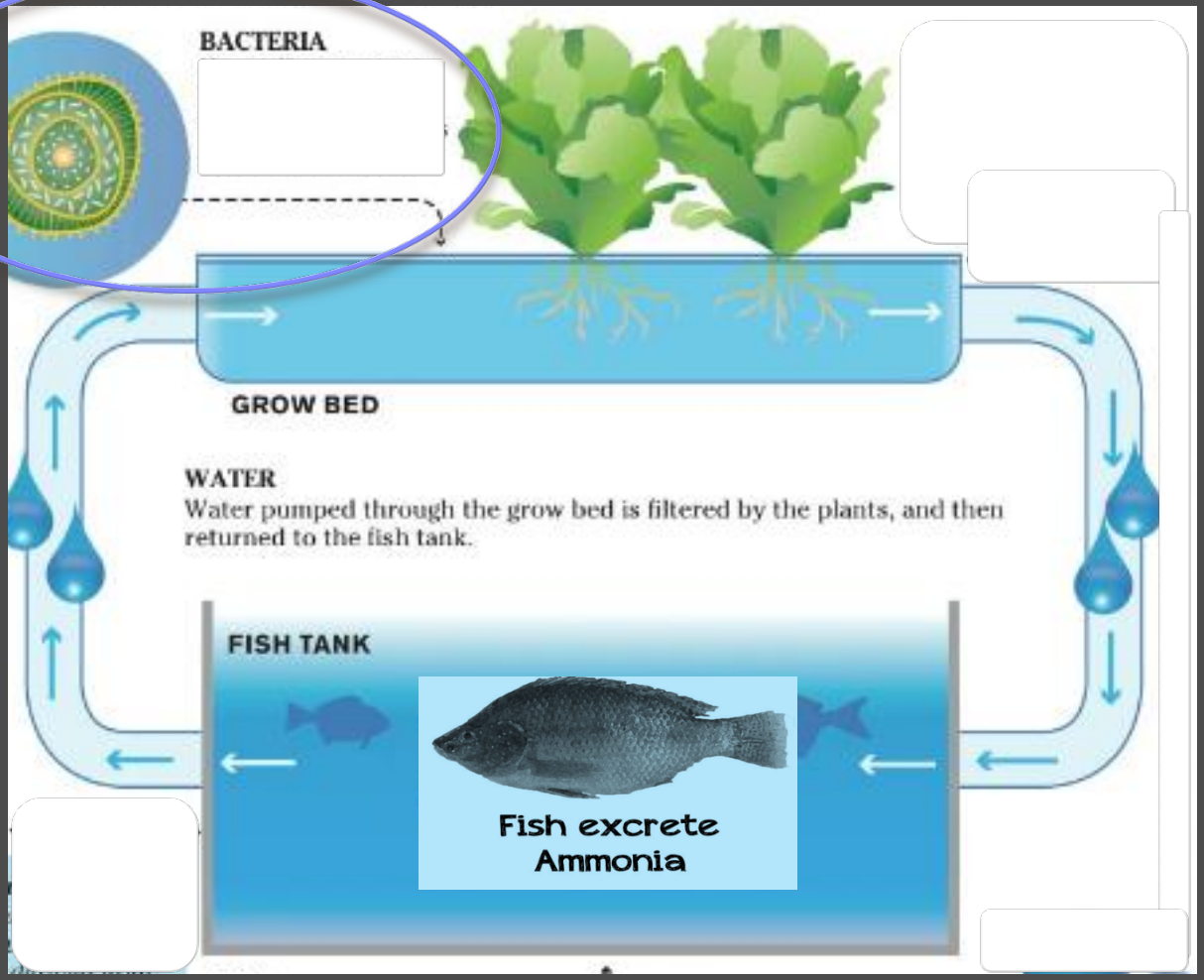
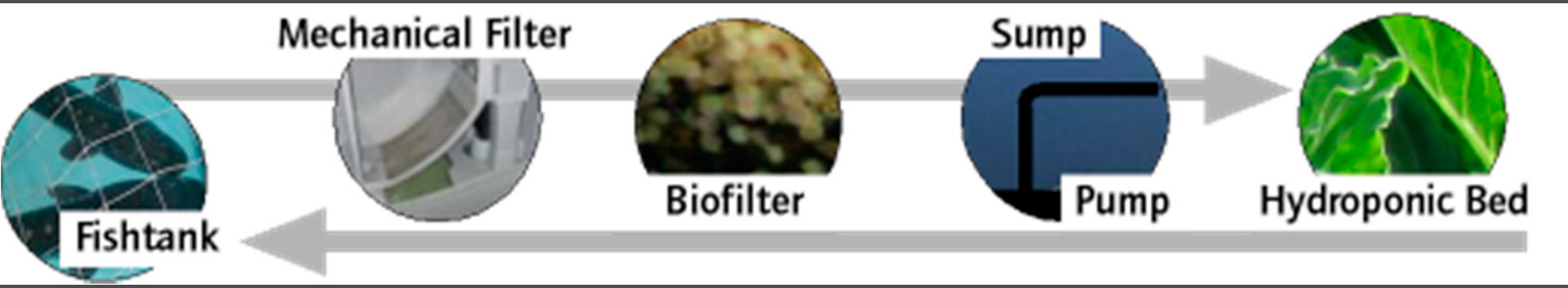
University of Iceland

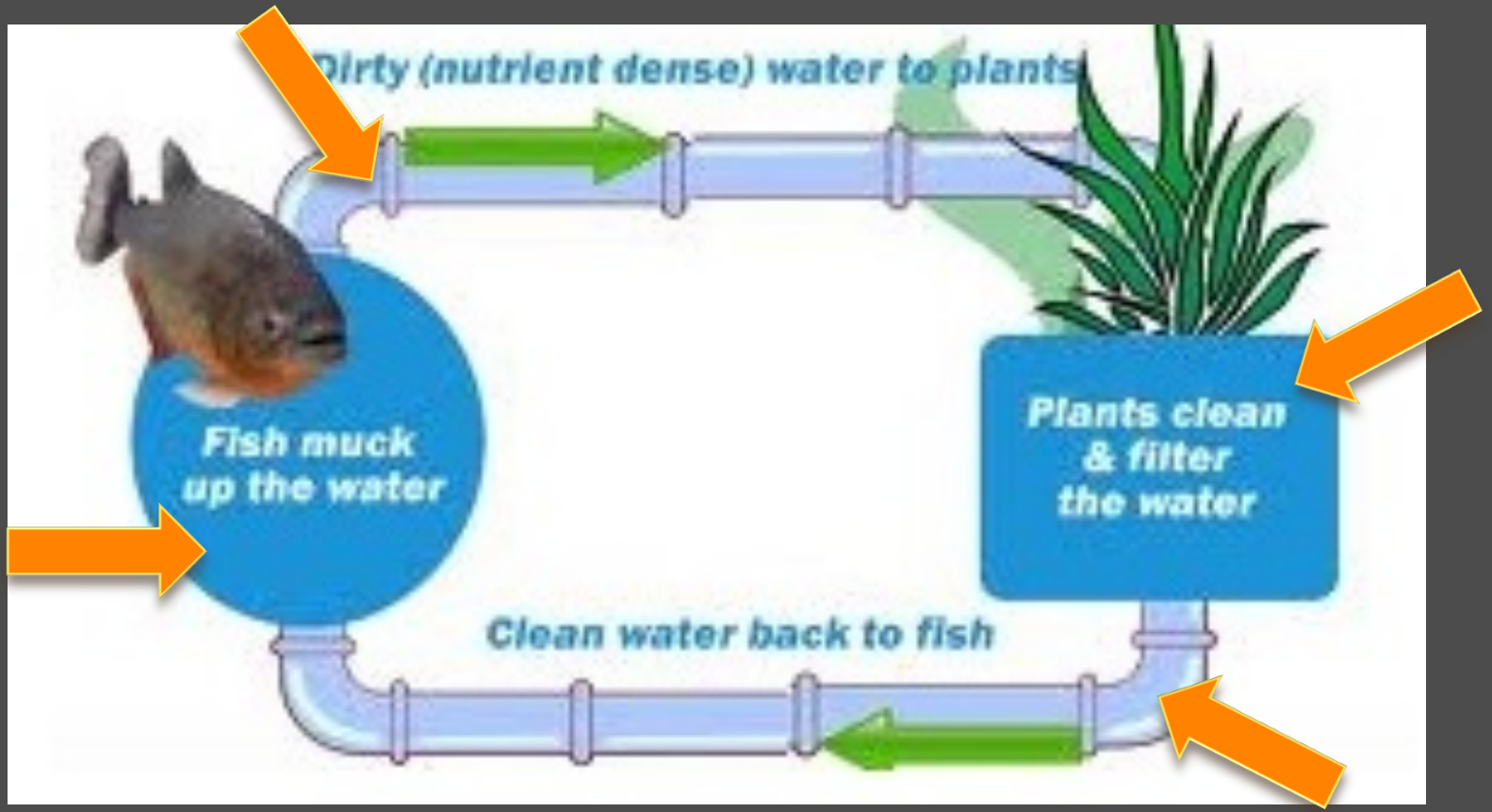
The combination of *aqua*culture and hydro*ponics*, *aquaponics*, is a resource efficient closed loop food production system, mimicking nature itself.




BACTERIA
GROW BED
WATER
Water pumped through the grow bed is filtered by the plants, and then returned to the fish tank.
FISH TANK
Fish excrete Ammonia


Mechanical Filter
Biofilter
Sump
Pump
Hydroponic Bed
Fishtank

Water quality in aquaponics

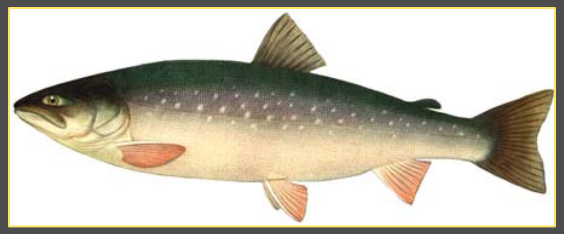


The water quality on each part of the system affects the other

Balance: Needs of the fish balanced with needs of the plant

Water quality could be measured at several points depending on WHY measured

PARAMETERS TO BE MEASURED AND WHY



- pH , Temperature
- alkalinity
- DO
- ammonia/ammonium
- nitrate/nitrite
- BOD/COD
- phosphate

Note: ammonia is pH, temperature and life-stage dependant

- pH
- alkalinity
- DO
- ammonia/ammonium
- nitrate/nitrite
- phosphate
- macronutrients: K, Ca, Mg
- Fe, B
- BOD/COD

MEASUREMENT AND FREQUENCY

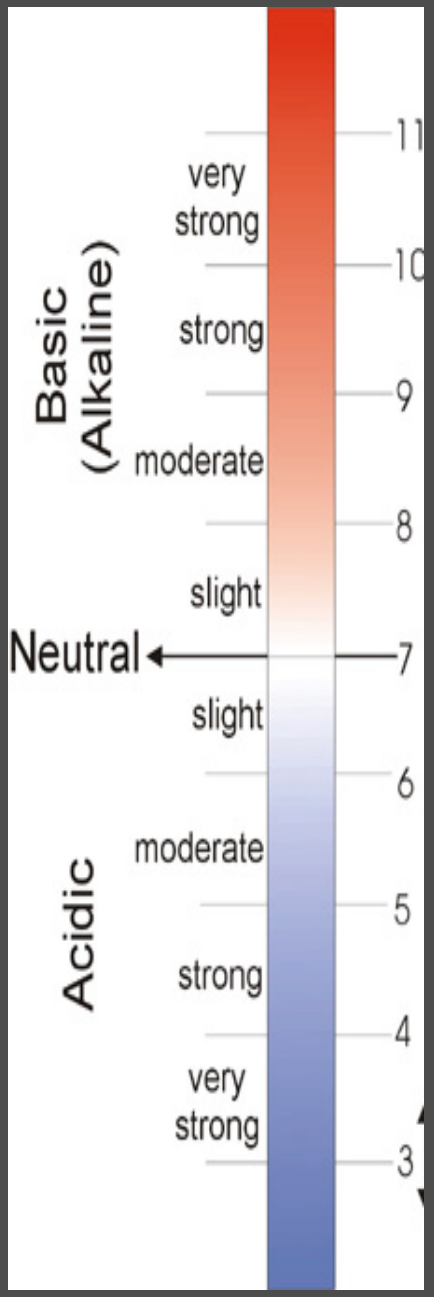
- pH
- temperature
- DO
- ammonia/ammonium
- nitrate/nitrite
- alkalinity
- phosphate
- BOD/COD
- macronutrients: K, Ca, Mg
- micronutrients: Fe, B

essential parameters to be measured :

pH, DO, temperature, ammonia

pH – the master variable

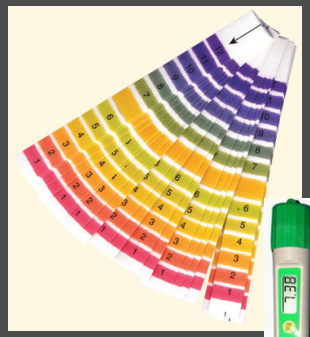
- pH is a measure of acidity
- influences water quality parameters: e.g. % NH_3 vs. NH_4^+
- Acceptable range for fish culture, usually pH 6.5 to pH 9.0
- Guidelines for warm water fish suggest :
  - pH<4.0 acid death point;
  - pH 4.0 – 5.0, no production
  - pH 6.5 - 9.0, desirable range for fish production,
  - pH 9.0 - 11.0, Slow growth,
- Plants prefer slightly acidic environments, pH 5.5 - 6.5
- COMPROMISE: **pH 7**



(PHILMINAQ, ….: Lawson 1995, Tarazona and Munoz, 1995)

pH MEASUREMENT AND FREQUENCY

Hobbyist



daily

Commercial Scale

continuous

DISSOLVED OXYGEN - DO

- Too little oxygen over prolonged periods can cause stress, disease and mortality
- Dissolved oxygen (**DO**) affected by temperature and salinity
- DO decreases as temperature increases
- DO decreases as salinity increases
- chronic problems with DO could be due to too much organic matter/algal growth/turbidity

DO MEASUREMENT AND FREQUENCY

Fish need oxygen to live

Hobbyist

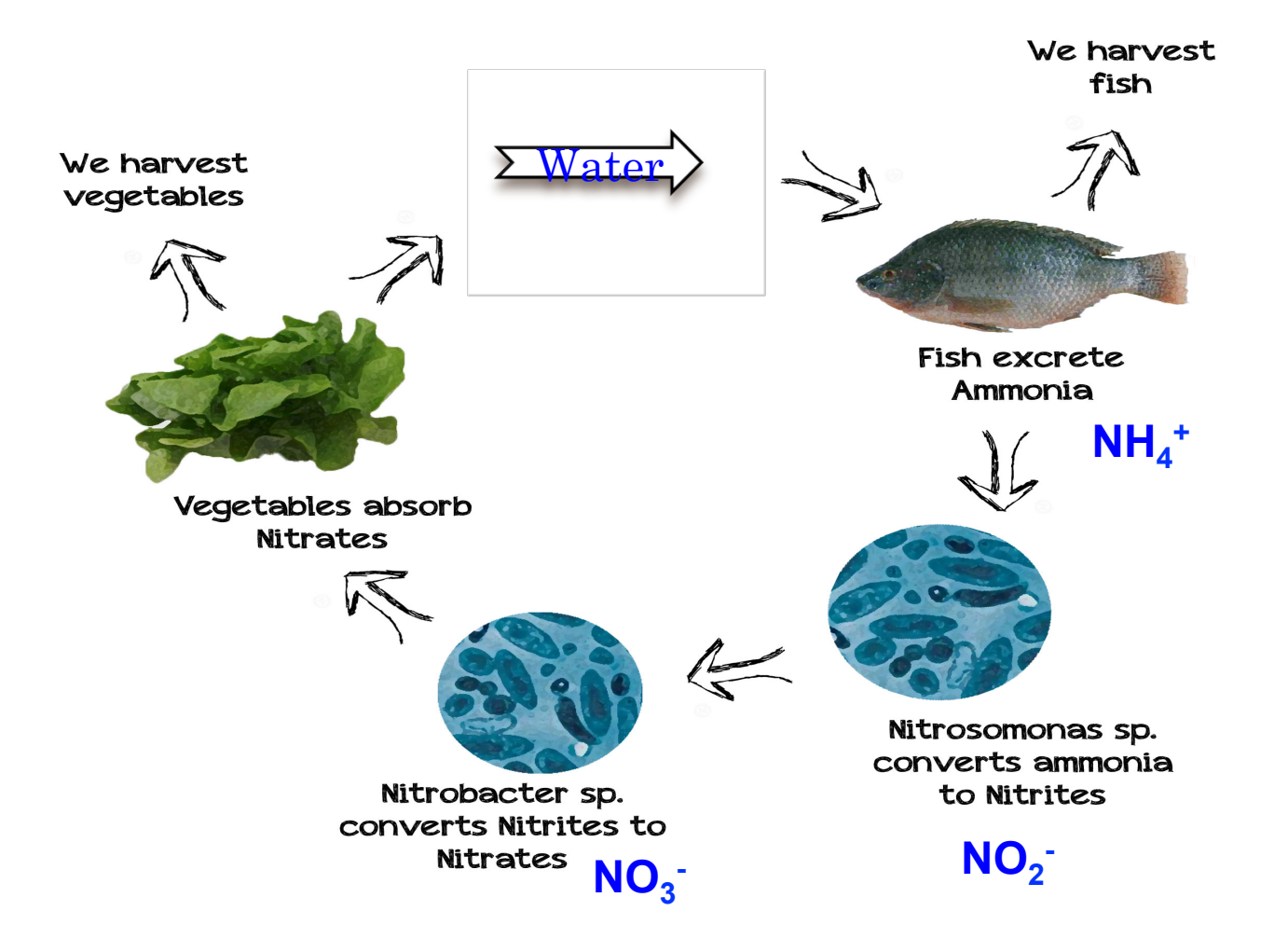
Commercial Scale

°C

DO

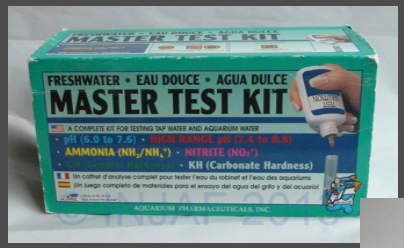
continuous

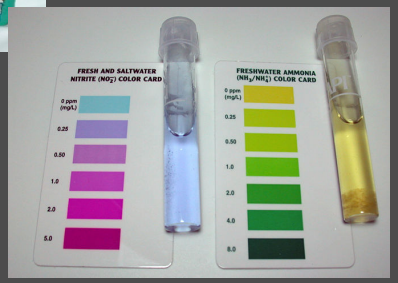
Ammonia, nitrate and nitrite – the N cycle



ammonia MEASUREMENT AND FREQUENCY

Hobbyist

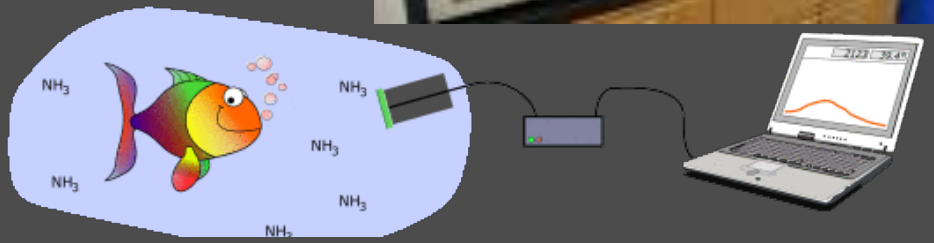




Daily to weekly

Commercial Scale

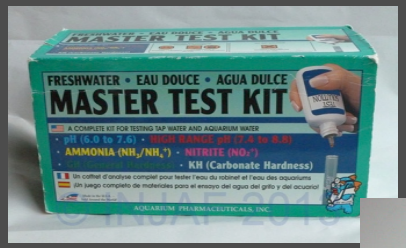
Reporting

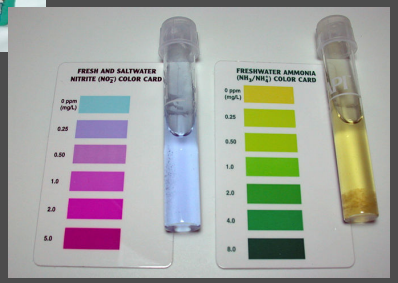


nitrite

MEASUREMENT AND FREQUENCY

Hobbyist





Weekly, to monthly

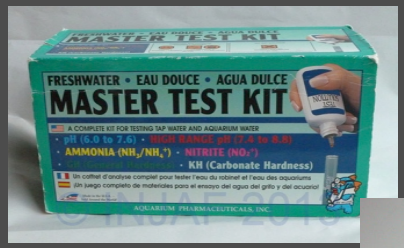
Commercial Scale

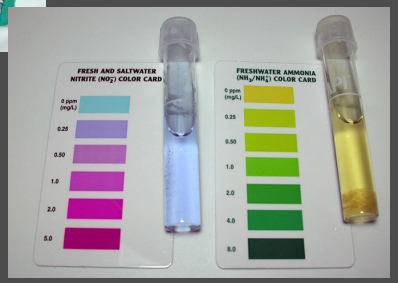
Weekly, to monthly

nitrate
phosphate

MEASUREMENT AND FREQUENCY

Hobbyist



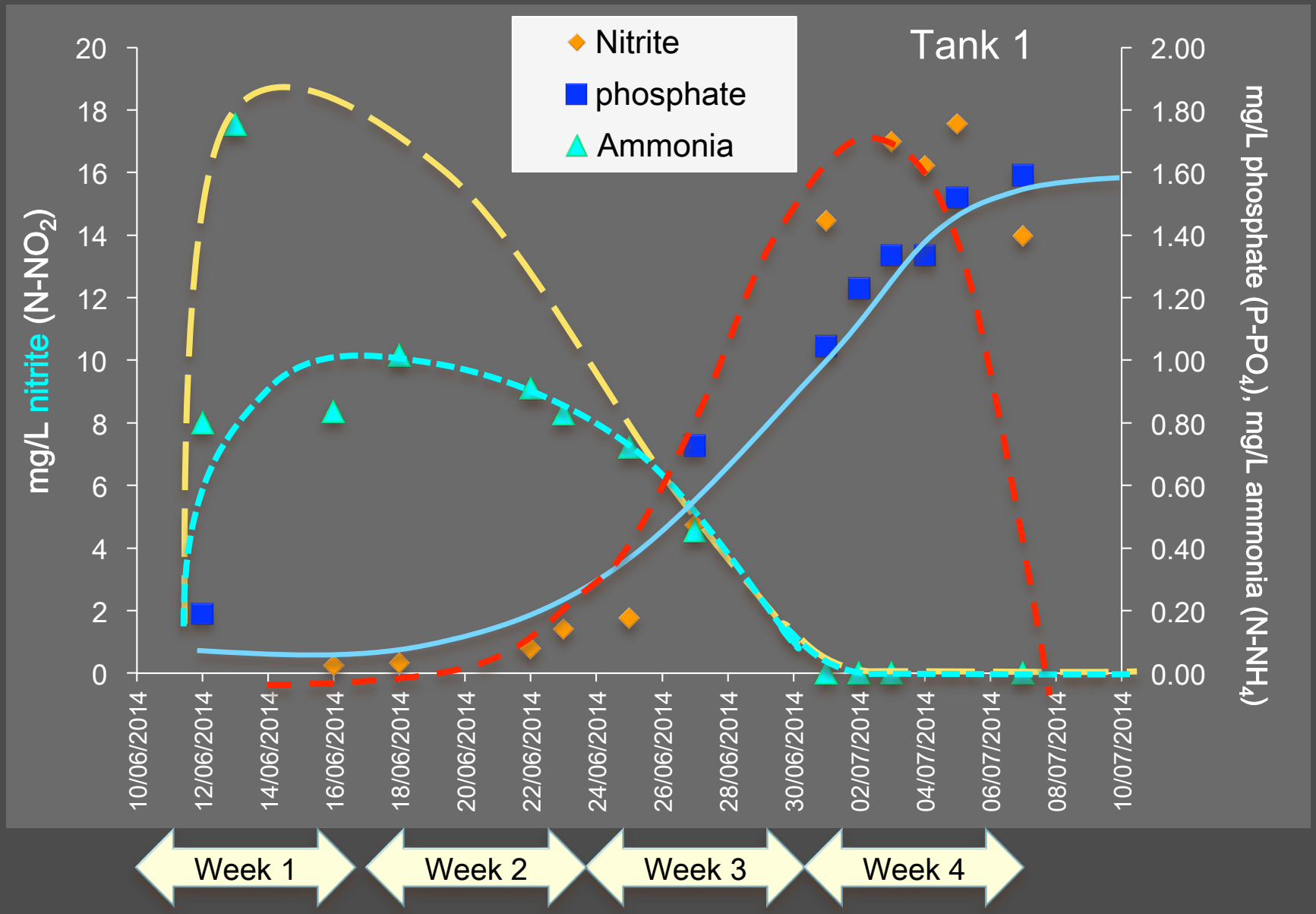


Weekly, to monthly

Commercial Scale

Weekly, to monthly

http://www.cost-es1106.eu/


Tank 1
Nitrite
phosphate
Ammonia
mg/L nitrite (N-NO2)
mg/L phosphate (P-PO4), mg/L ammonia (N-NH4)
0
2
4
6
8
10
12
14
16
18
20
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
10/06/2014
12/06/2014
14/06/2014
16/06/2014
18/06/2014
20/06/2014
22/06/2014
24/06/2014
26/06/2014
28/06/2014
30/06/2014
02/07/2014
04/07/2014
06/07/2014
08/07/2014
10/07/2014
Week 1
Week 2
Week 3
Week 4

Acidity, CO_2 ammonia and pH

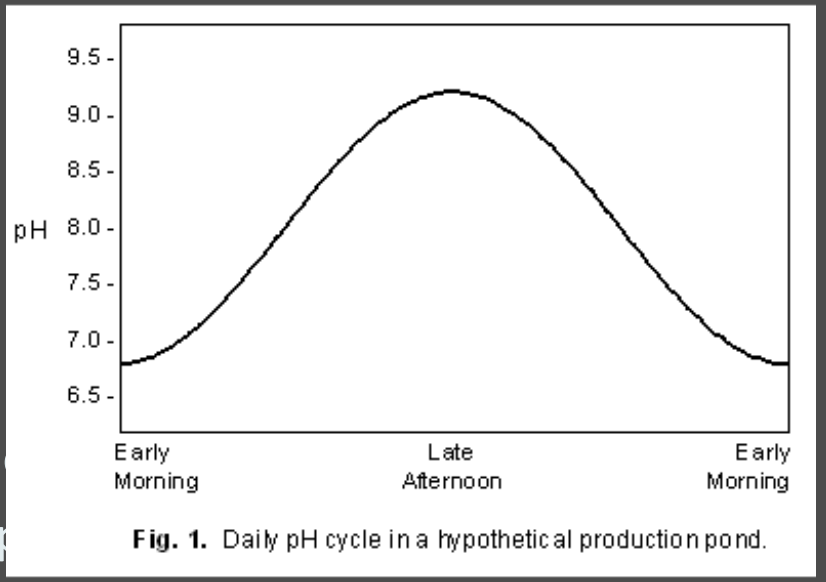


Fig. 1. Daily pH cycle in a hypothetical production pond.

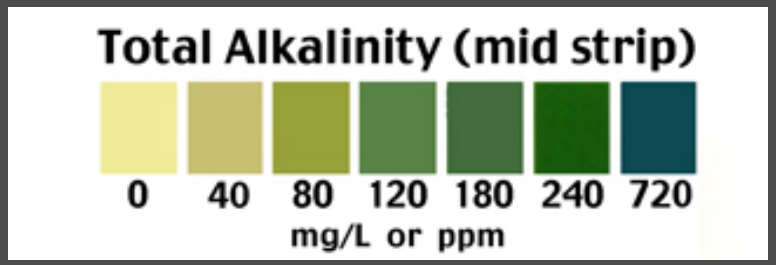
- Tank CO_2 concentrations and pH, are affected by **respiration** and **photosynthesis**.
- As daylight progresses, the rate of photosynth uptake. This removal of CO_2 causes the pond p
- pH is highest late in the afternoon
- High waste nutrient concentrations can promote dense phytoplankton blooms which remove all of the CO_2 during photosynthesis - water to become alkaline pH > 9.0.

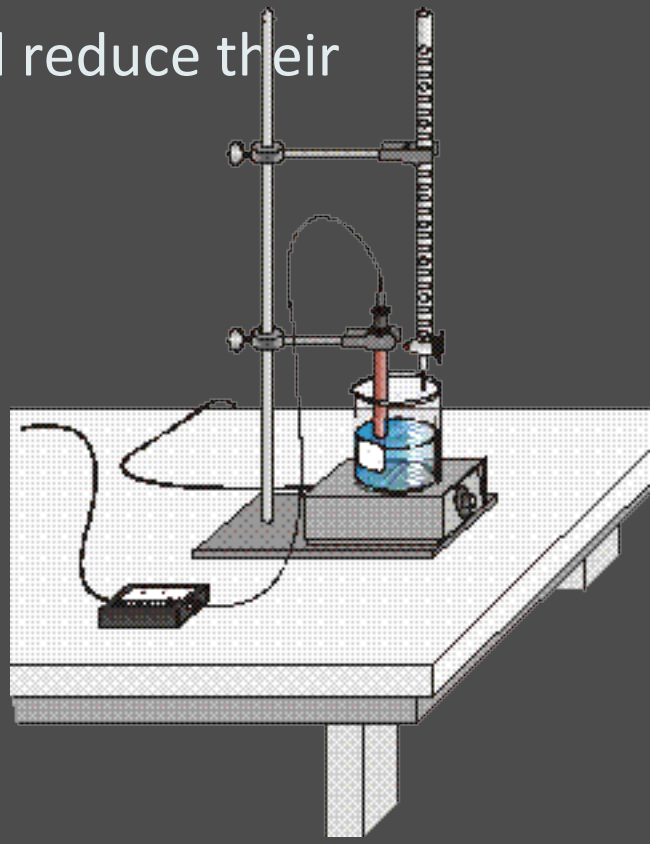
Time	Tot/NH_3-N (mg/L)	Temp °C	pH	UI/NH_3-N (mg/L)
0400 hr	2.7	28	7.0	0.019
1600 hr	2.7	30	9.0	1.2

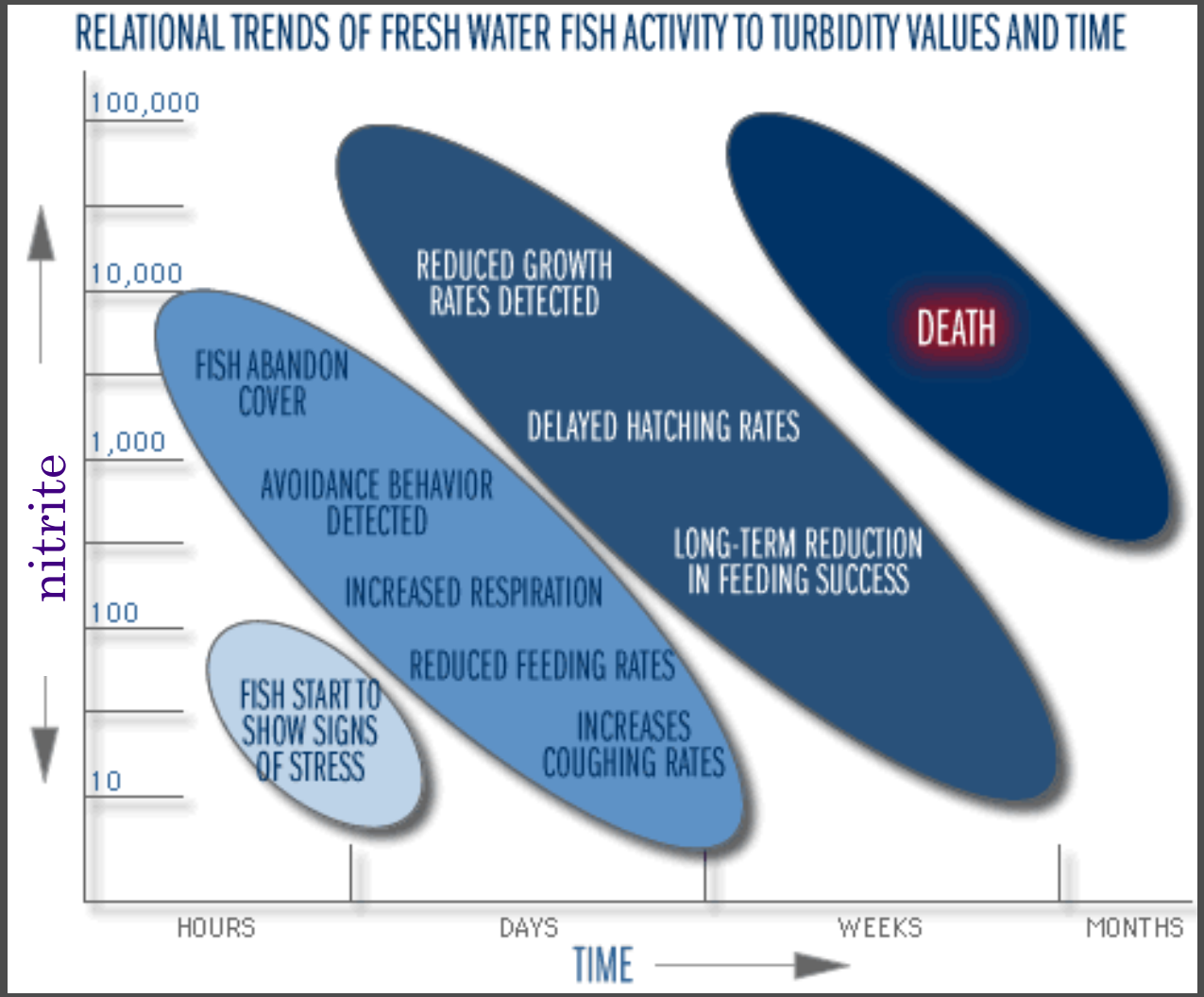
Table 1. pH changes the amount of total ammonia (Tot/NH3-N) present as un-ionized ammonia-nitrogen (UI/NH3-N),

ALKALINITY

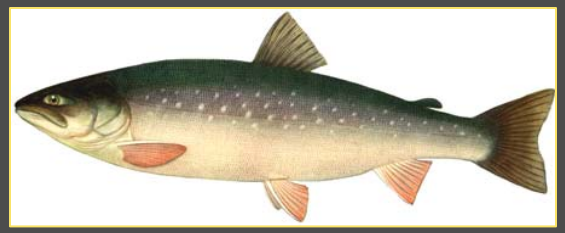
- Alkalinity buffers pH changes that occur naturally as a result of photosynthetic activity of the chlorophyll-bearing vegetation.
- Components of alkalinity such as carbonate and biocarbonate will complex some toxic heavy metals and reduce their toxicity markedly






RELATIONAL TRENDS OF FRESH WATER FISH ACTIVITY TO TURBIDITY VALUES AND TIME
100,000
10,000
1,000
100
10
nitrite
REDUCED GROWTH RATES DETECTED
DEATH
FISH ABANDON COVER
DELAYED HATCHING RATES
AVOIDANCE BEHAVIOR DETECTED
LONG-TERM REDUCTION IN FEEDING SUCCESS
INCREASED RESPIRATION
REDUCED FEEDING RATES
FISH START TO SHOW SIGNS OF STRESS
INCREASES COUGHING RATES
HOURS
DAYS
WEEKS
MONTHS
TIME

MEASUREMENT AND FREQUENCY



- pH ➔ daily to weekly
- DO – continuously/ at least daily – 30 day average for adult, 7 day average for early stage
- alkalinity , weekly unless there is a chronic problem with pH/buffering, should be greater than 20mg/L $CaCO_3$
- ammonia/ammonium – dependant on pH, T ˚C and life-stage
- nitrate/nitrite = none for aquatic life, but high loads can lead to eutrophication which can lead to reduced DO
- BOD/COD, usually… 6-monthly, esp if a chronic problem with DO and turbidity
- phosphate – more than 100µg/L can lead to eutrophicaiton
- macronutrients: K, Ca, Mg
- micronutrients: Fe, B

- Note: ammonia is pH, temperature and life-stage dependant

How often should I measure…?

Parameter	Why measure?
pH	Master variable!!!!!
DO	Fish need oxygen to live!
Temperature	Optimal productivity
Ammonia NH_3 (unionised)/ NH_4^-	Can be toxic to fish
nitrate	Needed for plant growth
nitrite	Can be toxic to fish
phosphate	Needed for plant growth
BOD	Reporting/ certification
COD	Reporting/ certification
Bacterial coliforms	Reporting/ certification

MEASUREMENT AND FREQUENCY

- pH
- DO
- Temperature
- ammonia/ammonium
- nitrate/nitrite
- phosphate
- alkalinity
- BOD/COD
- macronutrients: K, Ca, Mg
- micronutrients: Fe, B

MEASUREMENT AND FREQUENCY

- pH
- DO
- alkalinity
- ammonia/ammonium
- nitrate/nitrite
- BOD/COD → Laboratory
- phosphate
- macronutrients: K, Ca, Mg → Laboratory
- micronutrients: Fe, B → Laboratory

WHAT ARE THE QUESTIONS?

- What are the best conditions for different fish? different plants?
- What are the best combinations?
- conversion ratios? Calculations..
- water quality vs nutrition vs resource reuse
- What are the essential parameters to be measured : pH, DO, temperature, ammonia
- Standards – standards for aquaculture can be used to an extent…
- What is regulated.? How do we get there?