Water Chemistry

- Objective 1: exposure to the physical, chemical and biological parameters which control the composition of "natural" waters
- Objective 2: become familiar with practical methodologies used by today's aquaculturists

Lecture 1: Introduction, Water Sources

Readings:

Tomasso, J.R. and Brune, D.E., 1991. Aquaculture and Water Quality, The World Aquaculture Society, Baton Rouge, LA. Pages 11-20.

Lawson,T.B., 1995. Fundamental of Aquaculture Engineering, Chapman & Hall. Pages 52-56.

Why Study Water Quality?

- Aquaculture produces a commodity and therefore production must be standardized.
  - **What are the environmental requirements for a species?**
  - **How do we meet and maintain these during production?**
  - **Does it influence the environment?**
- Interdisciplinary approaches are often needed to solve the problem!

Expectations/Limitations

- Conventional agriculture ≠ aquaculture:
- Data base on aquatic organisms is small.
- Much data derived from native populations: aquaculture production isn't "natural."

Expectations/Limitations

- Aquatic environment vs. gaseous environment
- Water = “universal solvent”
- Aquatic organisms are exposed to much more material (potential toxins).

Expectations/Limitations

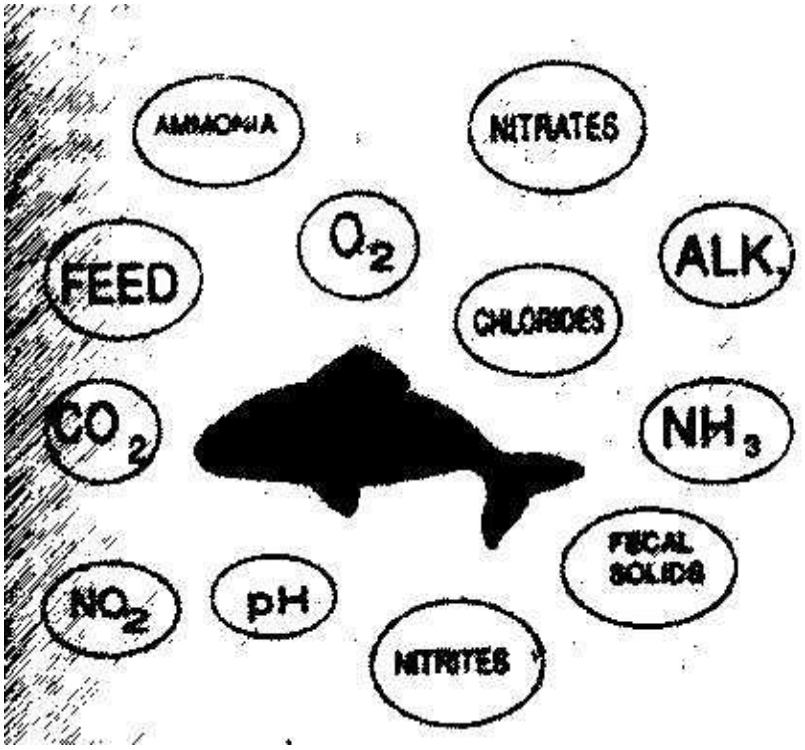
- Another problem: water is heavy (8.3 lbs., or 3.7 kg/ gallon)!
- Makes it difficult to change environment.
- Must streamline energy efficiency in production systems
- Hydrosphere is also very non-dynamic compared to atmosphere: poor nutrient movement towards and metabolite movement away from aquatics

Environmental Criteria

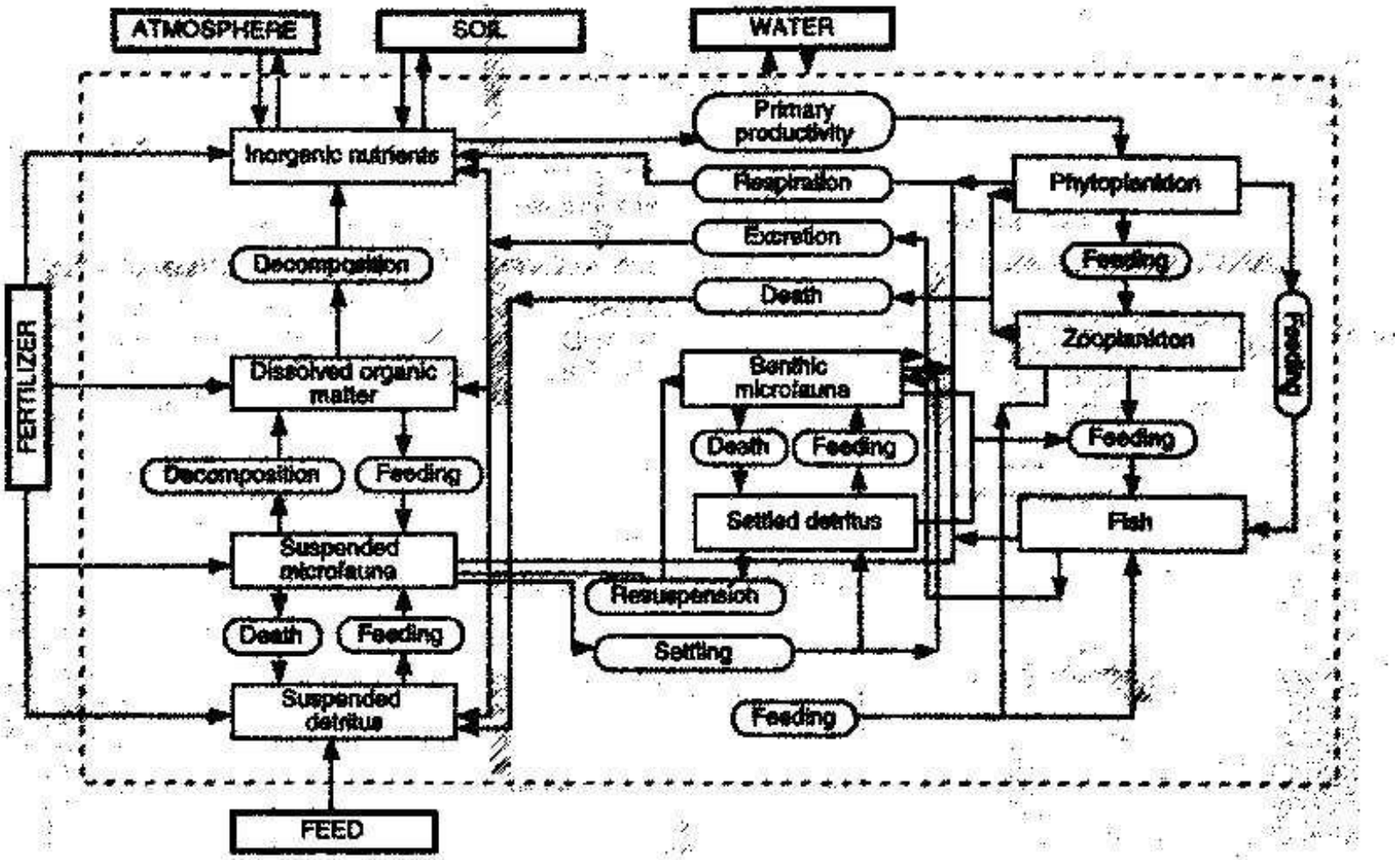
- Production, survival, growth, and reproduction of aquatic animals is directly influenced by chemistry of water, microbes and toxins.
- Physical, chemical and biological factors are interrelated
- Aquaculture can also have a ***reverse*** effect on environment (i.e., the environment is made suitable for aquaculture)

Environmental Criteria

- Aquacutlured animals consume O_2 and produce metabolic byproducts.
- Therefore, water chemistry is constantly changing with respect to “quality.”



That's enough Soup!



What is Water Quality???

- Chemicals dissolved in the water + physical attributes affecting them = water quality
- When we talk about good water quality we imply that all attributes are present at an appropriate level for whatever stocking density required
- Often aquaculture water quality ≠ environmental water quality
- “Good” water quality criteria differ from species to species

Non-natural Factors

- water filtration
- stocking density
- fertilization
- supplemental feeding
- aeration
- liming
- water exchange rate
- species cultured (bivalves vs. fish vs. macroalgae)
- chemical amendments

Part 2: Water Sources

- Supplies of quality water are decreasing.
- What is “good” for one species may be bad for another.
- Degree to which water quality can be allowed to degrade is highly dependent upon waste generated

Water Sources

- Waste generated = intensity of culture amount (type) of feed added to the system
- Key: highest stocking density possible without degrading water quality
- Much depends upon the water source

TABLE 19.2 The World's Water Supply (Selected Examples)

Location	*Surface Area (km^2)*	*Water Volume (km^3)*	*Percentage of Total Water*	*Estimated Average Residence Time of Water*
Oceans	361,000,000	1,230,000,000	97.2	Thousands of years
Atmosphere	510,000,000	12,700	0.001	9 days
Rivers and streams	—	1,200	0.0001	2 weeks
Groundwater (shallow to depth of 0.8 km)	130,000,000	4,000,000	0.31	Hundreds to many thousands of years
Lakes (fresh water)	855,000	123,000	0.009	Tens of years
Ice caps and glaciers	28,200,000	28,600,000	2.15	Tens of thousands of years and longer

Source: U.S. Geological Survey.

- Seawater: plentiful
- Freshwater:
- two options: **groundwater** (wells) or **surface water** (lakes, rivers)
- other sources not considered: rain, city water

Groundwater: advantages

- Groundwater is preferred: **Why**?
- More dependable, uniform over time, free from competitors, competitors' eggs, no predatory insects.
- Temperature nearly constant.
- Susceptibility to contaminants reduced.

Groundwater: disadvantages

- Pollution: septic fields, chemical and radioactive dumps, landfills, agricultural chemicals
- Toxic gases: NH_3, hydrogen sulfide, methane, CO_2
- Major disadvantage: low oxygen, must be recharged (injected), excessive iron, or metal ions.

Aquaculture Groundwater

- Two major sources: springs and wells
- **springs**: exposure of an aquifer at the ground surface or via a crack or fault in an upper area
- **wells**: human-built, accessing aquifer
- **advantages**: usually clean, no pumping
- **disadvantages**: yield varies, recharge requires evaluation, ownership, permits, competition

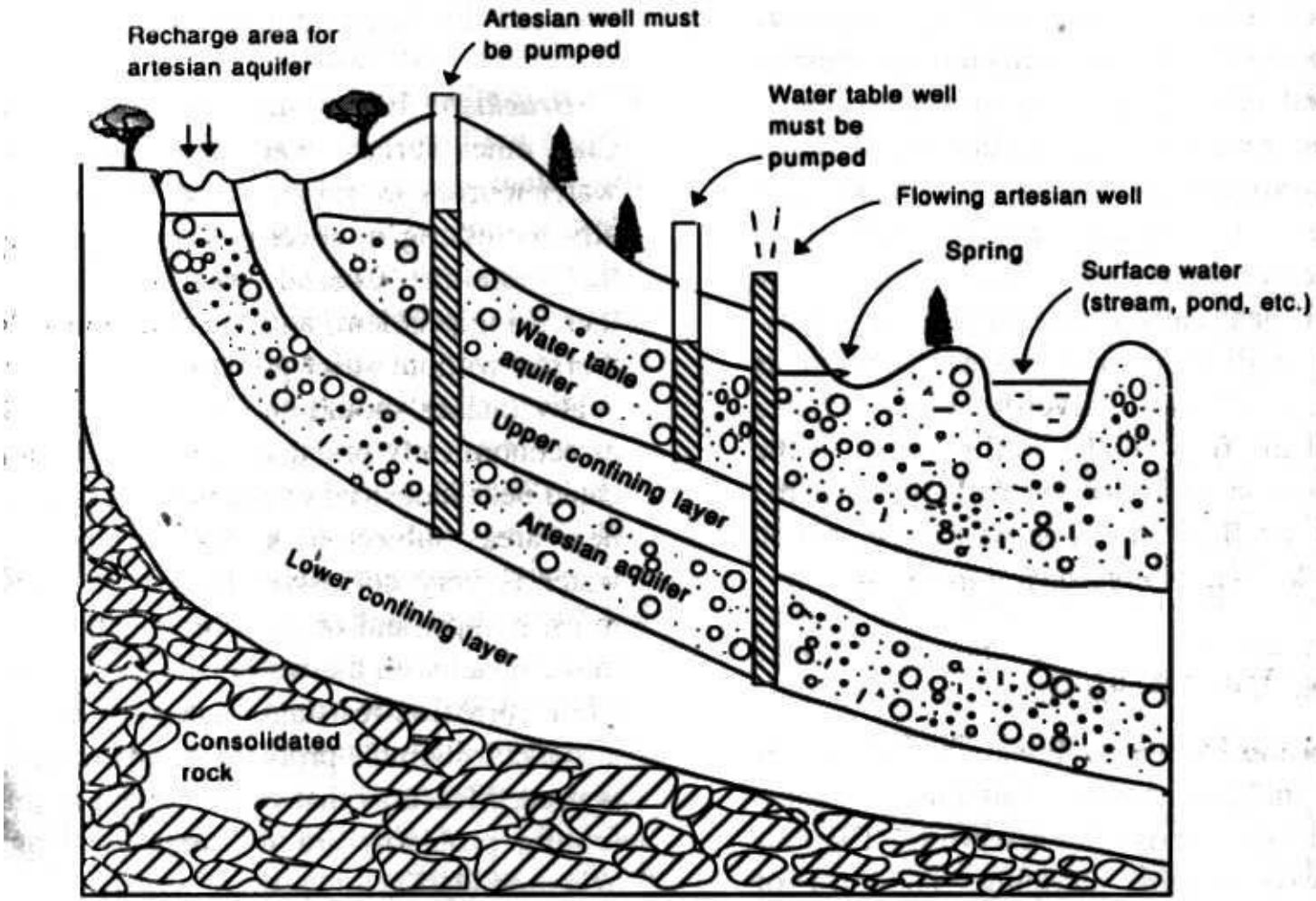
Aquaculture Groundwater

- Well water is usually a good source for aquaculture (freshwater) purposes
- usually better than surface water, but must also be pumped
- cost of construction and pumping is high
- types of wells: water table, flowing artesian, and non-flowing artesian
- water table wells are simply holes dug into the water table of an aquifer

Aquaculture Groundwater

- shallow or water table wells are influenced by rainfall
- **flowing artesian wells** are those abstracting water from two impermeable layers
- the well outlet is of lower elevation than the recharge zone, thus, flow by gravity
- **nonflowing artesian wells** are those where the outlet is above the recharge zone

Various Types of Groundwater



Lawson (1995, page 53)

Groundwater Sources:

Comal Springs

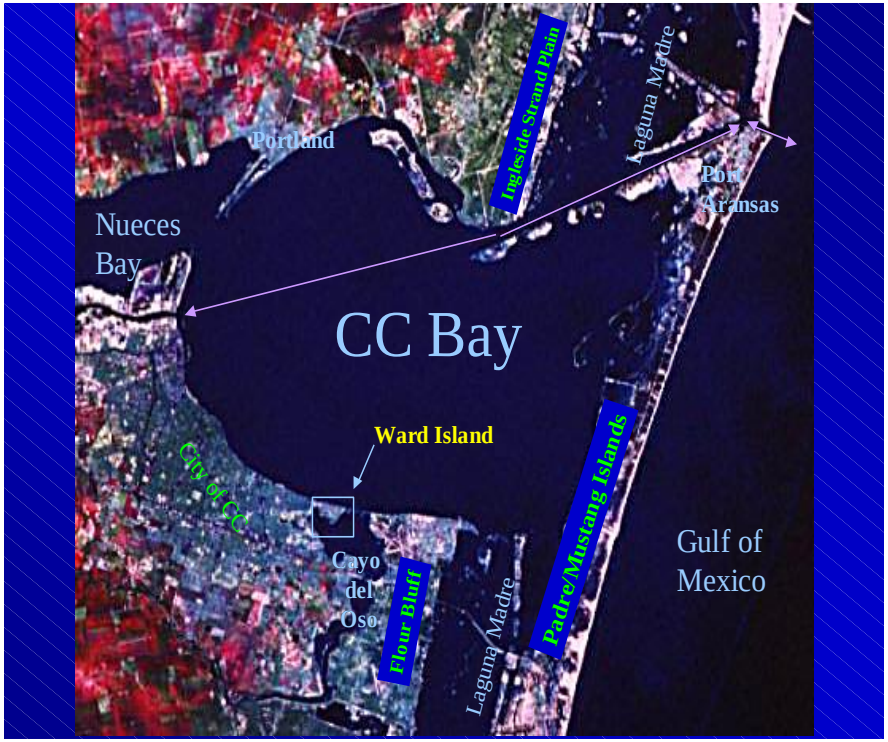
Surface Water: freshwater

- Fresh surface water sources include rivers, streams, bayous, sloughs, lakes, ponds and reservoirs
- Require pumping, but cheaper than wells
- High levels of silt, predators, disease, pesticides make them undesireable.
- Subject to seasonality, permitting process

Surface Water: brackishwater, seawater

- Same potential for contamination as fresh-water sources
- However, potential increases closer to shore
- Main concern is intake location, biofouling of intakes and salinity fluctuations
- Often, seawater sources have increased potential for hydrocarbon contamination, especially if intake is in navigation lanes
- Estuaries usually have high tidal amplitude and, thus, entrainment of sediment

Water Sources: surface



Alternative Water Sources

- **rainwater**: free, unpredictable, only a supplement, often acidic, poorly buffered
- **city water**: limited potential due to cost, also contains disinfectants (e.g., chlorine)
- **saltwater wells**: via saltwater intrusion, ancient seabeds, mineral variation, high cost
- **recycled water**: availability depends upon prior use, conserves pumping, keeps you within permitting guidelines, sedimentation, biofiltration required