Lecture 16: Fishes in Lakes and Reservoirs

I. Introduction

Lentic = standing water: lakes, ponds, reservoirs, bogs

A. Objectives
1. Summarize key processes/features of lentic habitats and ecosystems
2. Summarize consequences for lentic fishes
3. Summarize key patterns for lentic fish assemblages
4. Summarize major human impacts on lentic fish assemblages

B. Lentic vs lotic environments
1. Lakes, rivers differ generally in 3-D shape, sediment dynamics, hydrology, habitat zonation
   a. lakes are rounder, deeper, less interactive w/ shoreline, retain water for longer
   b. rivers vary more horizontally, lakes vary more vertically

C. Ponds, lakes, and reservoirs
1. Lakes (not ponds) are large enough to be influenced strongly by wind

2. Lakes vary greatly in size; some are huge, like small oceans

3. Lakes formed by natural processes; reservoirs built by humans via dams
   - reservoirs are artificial hybrids between rivers and lakes

II. Types of lakes

A. Formation processes
- lakes come and go over geological time

1. Process of origin affects lake morphology, physical characteristics, longevity, species pool
   a. plate tectonics – Lake Okeechobee in FL formed by uplift of seafloor, African rift lakes
   b. volcanic
   c. landslide
   d. flooding – floodplain lakes ("oxbows")
   e. glaciation – North American Great Lakes
   f. human engineering

2. Fish colonization
   a. generally from connecting streams, lakes
   b. rate: c,d,f > a,e > b

B. Productivity; trophic status
1. Source and fate of production very important characteristic
2. Function of dissolved oxygen, geography, nutrients, transparency

3. Extremes are eutrophy and oligotrophy (but MANY intermediates)
   a. oligotrophic lake – low in nutrients, primary productivity, biomass, temperature; clear, large oxygenated hypolimnion, high altitude or latitude; coldwater fishes like salmonids, whitefishes, and sculpins

   b. eutrophic lake – high in nutrients, primary productivity, biomass, temperature; low in transparency, hypolimnetic oxygen, altitude or latitude; warmwater fishes like shads, herrings, sunfishes

4. Effects on fishes
   a. food availability via production
   b. oxygen availability (summer and winter)

C. Lake morphology
1. Typically deepest in middle, shallower near inflow/outflow (if present), ~round

2. Shoreline development = actual length of SL / length of SL of circular lake of same surface area
   a. good indicator of lake depth, productivity, vegetation, and fish assemblage
   b. complex shorelines → shallow, warm habitats with littoral vegetation, fishes

3. Morpho-edaphic index (MEI) = [total dissolved solids] / mean depth
   - good predictor of a lake's total fish biomass (within a geographic region)

D. Features of reservoirs
1. Morphology
   a. deepest near dam, elongate (hi shoreline development)
      - shorelines may be steep-sided (flooded valleys), unproductive, little littoral vegetation

2. Hydrology
   a. more variable water level, lower retention time than lakes
   b. variable patterns in water flux depending on management objectives
      - flood control, power generation, water supply

C. Sediment dynamics
1.Tend to be sediment, pollution traps; fill in over time

III. Zonation in lakes & reservoirs
A. Oxygen availability
1. <3.5 ppm oxygen is lethal to most fishes, but >5 ppm is OK
2. Fish can move to find suitable spots

3. Seasonal variation in oxygen availability
   a. high respiration (decomposition) in hypolimnion of eutrophic lakes may deplete oxygen
   b. DO depletion in summer <u>or</u> winter (if ice/snow cover prohibits photosynthesis – winterkill)

B. Temperature stratification (vertical)
1. Main types
   a. dimictic – stratify, then turn over, in summer and winter (temperate)
   b. monomictic -- stratify, then turn over only in winter (tropical)
   c. meromictic – never mix completely (very deep anoxic and/or saline layer)

2. Productivity determines if temperature stratification coincides with oxygen depletion
   a. coincidence applies only to eutrophic lakes
   b. eutrophic hypolimnion unsuitable for fish because of low oxygen,
      as well as toxins from anaerobic bacteria (H sulfide, ammonia, methane, acetic acid)

   c. fish may be sandwiched in summer between hot surface and O_2-depleted hypolimnion

C. Wind and water movement
1. Most water movement is in epilimnion

2. Wind can cause surface and subsurface waves
   a. most small fishes avoid strong wave action
   b. waves can cause thermocline to "rock", forming a seiche, – can cause fish kills
   c. subsurface Langmuir currents (spirals) can concentrate plankton

D. Major trophic zones in a lake
1. Littoral zone
   a. associated with shoreline, shallow, extends to depth of rooted vegetation
   b. most production from rooted vegetation
      - emergent (cattails), submerged (pondweed), or floating (water lilies)

   c. a few fishes (eg, grass carp) eat macrophytes
   d. many juvenile fishes, invertivores (small sunfishes, minnows), piscivores (basses, pikes)

2. Limnetic zone
   a. open-water, defined by depth of light penetration, P>R; not = thermocline
   b. most production from phytoplankton
      - diatoms, green algae, blue-green algae

   c. a few fishes (eg, gizzard shad) eat phytoplankton
   d. planktivores (herrings, minnows, sunfishes, others), piscivores (trouts, basses, walleye)

3. Profundal zone
   a. deep benthic, R>P, suitability for life dependent on location of thermocline in eutrophic lake
   b. most production from decomposers, often anaerobic
      - bacteria, clams, bloodworms
   c. few fishes well adapted
   d. if oxygen permits, benthic omnivores (catfishes, sturgeons), piscivores (trouts)

E. Littoral habitats (horizontal)
1. Fish sizes, species segregate by shoreline habitat-types
   - substrate size (sorted by waves, tributary streams), woody debris, vegetation configuration

2. Macrophyte beds
   a. more common in lakes than streams, but may be precluded from widely fluctuating reservoirs
   b. key form of cover/structure, especially for young fishes
   c. mediate biotic processes among fishes

F. Hierarchical choices by fishes (synthesis)
   - balance among temperature, oxygen, food availability, predation risk

IV. Community regulation in lakes
A. Interactions between abiotic and biotic fators
1. eg, small Northern lakes in WI
   a. 4 assemblage types reflect interactions between winter anoxia, pH, piscivory
      - dominants: sunfishes, pikes, minnows, mudminnow/perch

   b. sunfishes voracious predators on minnows, mudminnows but sensitive to low DO
   c. pikes voracious predators but sensitive to low pH
   d. minnows tolerate low DO but sensitive to low pH, predation
   e. mudminnows tolerate low pH, DO but sensitive to predation, competition

2. Reservoir communities
   a. stocked with hodge-podge of species, often no co-evolved community-regulating mechanisms
   b. determined by general environmental tolerances of fishes, desired uses of reservoir
   c. often see dramatic changes in biotic composition relative to prior lotic community
   d. biotic responses reflect wholesale changes in abiotic and biotic conditions
   e. typically, ↓ in obligate lotic species; ↑ in lentic and exotic species
   f. piscivores often prominent to serve mgmt objectives (recreational fishing)
   g. fish populations may be limited by hydrologic consequences of other mgmt objectives

B. Bottom-up versus top-down trophic control
   - interest in if lake communities are regulated by nutrients/productivity or top predators

1. "Bottom-up" control
   a. if nutrients (N, P) are limiting, top predators may not be able to persist
   b. only 10-20% of energy/biomass gets passed from one trophic level to the next
   c. base of food chain may determine what can be supported at higher levels

2. "Top-down" control
   a. predators can quickly change composition/abundance of prey, with cascading effects
   b. piscivorous fish are at the top of most lake food webs
   c. most planktivorous fish select the largest plankters they can find
   d. abundance of planktivorous fish strongly affects size distribution of zooplankton
   e. small zooplankton less capable of controlling large phytoplankton
   f. large phytoplankton (certain diatoms, blue-green algae) strongly affect water clarity
   g. piscivorous fish can diminish abundance of (smaller) planktivorous fish
   h. potential end result: high piscivore, low phytoplankton community