

Lecture 21: Habitat and hydrologic changes

I. Introduction

A. Objectives

1. Summarize human impacts on habitat quality for fishes
2. Summarize human impacts on hydrologic conditions for fishes
3. Illustrate how these impacts affect fish distribution, abundance, and status
4. Relate impacts on fishes to efforts to manage aquatic ecosystems

B. Habitat as a multi-dimensional place

1. Key dimensions
 - Local conditions, connectedness
2. Narrow ranges of dimensions are suitable
 - Habitat suitability curves

Shifts in available conditions → shifts in fitness → shifts in species composition

C. Habitat as a spatially hierarchical place

1. Key hierarchical levels
2. Species- and stage-specific perceptions of habitat quality

D. Natural versus anthropogenic variation in habitat

1. Anthropogenic conditions often exceed natural range
 - Key details usually unknown
2. Ecological relevance of habitat changes
 - Major causes of fish endangerment

Specialists more sensitive than generalists

II. Hydrologic influences on lotic habitat

(recall) hydrologic vs hydraulic

- hydraulic: force of flowing water (velocity, turbulence)
- hydrologic: source, amount, temporal variation of flow; more relevant to flow regime

A. Key aspects of flow regime

Relevant to rivers' capacity to create productive habitat, flush out sediment, support life, etc.

1. Magnitude – how much water
 2. Frequency – how often do certain conditions occur
 3. Duration – how long do certain conditions persist
 4. Timing – during what season do certain conditions occur
 5. Rate of change – how quickly does one set of conditions supplant another set
- B. What dams (and their impoundments) do
- Main purposes: flood control, power generation, water supply
 Extent: ~45,000 large (>15m high) dams globally; ~5,500 in US
1. Trap sediment
 - “Sediment-hungry” water from dam scours river
 little gravel left for spawning, food production
 - Causes downstream bank erosion and bed armoring
 2. Reduce flood magnitude
 - Reduced flushing of fine sediment
 - Channel narrowing, less meandering
 - Reduced channel complexity, floodplain connection
 3. Alter flow cues for fish migration, spawning
 4. Alter temperature regime downstream
 - Especially when water is released from hypolimnion
 - Fish may suffer negative effects from “cold shock”
 5. Subtract natural habitat
 - Lotic habitat converted to lentic
 - Impaired access to upstream habitat
 - Population fragmentation
 inhibits recolonization after local extinction
 6. Add artificial habitat for non-native species
 - In impoundment (sunfishes, catfishes)
 - In cold tailwater downstream (trout)
 7. Vulnerable fish species
 - Migratory (diadromous, potadromous)
 - Small obligate riverine
 - Flood-dependent

C. Mitigation for dams' effects on migratory fishes

1. Native-fish breeding, stocking
2. Non-native introductions
3. Fish passage structures (ladders)
4. Ineffectiveness of mitigation due to
 - strong species selectivity of ladders
 - high predation near ladders
 - genetic impoverishment
 - genetic dilution from hatchery fish

D. Groundwater removal

1. Common for drinking water and especially for irrigation
2. Greater stream drying, more extreme water temperatures
3. Water withdrawal from Aral Sea basin (Uzbekistan-Kazakhstan)
 - reduced 4th largest lake in world to 1/3 of its area
 - caused salinity to nearly triple (now essentially seawater)
 - former fish fauna of 24 species reduced to 4
 - annual lost fisheries revenue = \$3.2 billion

E. Changes in land cover (indirect effects of de-vegetating)

1. Agriculture
 - Drainage tiling or ditching, unvegetated fields
2. Urbanization
 - Paved surfaces, rooftops (impervious surfaces)

Both → flashier flow regimes, lower base-flows, wider channels, more fine sediment
harsher, more variable conditions for fishes
favor hardy generalists
typically fewer total species

F. Channelization

1. Direct modification of physical structure (lateral and vertical) of waterbodies
 - eg, straightening, deepening; often to enhance navigation or water conveyance
 - generally reduces spatial complexity of channel
2. Levees often constructed to prevent flooding
 - disconnect rivers from floodplains (used by fishes for breeding, feeding, refuge)
 - impair formation of lateral, secondary channels

channelization in lower Mississippi R. has led to 90% reduction in fish biomass
3. Riprap and revetments
 - installed at key points along bank to keep river from meandering
 - increases erosion potential downstream

G. Management approaches for fish-flow-habitat relations

1. Individual-based Instream Flow Incremental Methodology

Main steps:

Characterize fish preferences/suitabilities along key habitat parameters

Map available habitat for a given life-stage at a given flow

Project how available habitat varies with flow magnitude

Predict fish responses to selected flow regimes

2. Ecosystem-based Environmental Flow Components

Main steps:

Divide natural hydrograph into major types of flow (flow components)

Develop list of key ecological functions dependent on each flow component

Develop ranges of hydrologic parameters needed to make components functional

Predict fish responses to selected flow regimes

III. Anthropogenic effects on lentic habitat

A. Siltation

1. Fine-sediment inputs reduce substrate complexity, ability to support benthic insects and fishes
More acute in oligotrophic lakes with oxygenated hypolimnion

B. Shoreline development

1. Piers and docks can reduce prevalence of rooted vegetation, associated fishes
2. Armored shoreline may reduce very shallow areas

IV. Anthropogenic effects on marine habitat

Focus on near-shore areas

A. Coral reef communities

Intimately tied to coral, which (when alive) provides spatial complexity

1. Some shallow coral reefs mined for use in road- and home-building
2. Some traditional reef-fishers use poisons or explosives, which kill corals along with fishes
3. Modern bottom-trawls damage reefs
4. Boat groundings and anchoring, diver traffic can damage reefs
5. Coral bleaching (occurs when ocean becomes too warm, corals die) destroys reefs

B. Bottom-trawling in neritic zone (over continental shelf)

1. Can seriously reduce habitat complexity, availability of benthic invertebrates
presumed effects on benthic fishes, juvenile stages of many fishes