Aquatic Organisms and Stream Crossings




Ecological Connectivity

- A watershed is a network of channels that drain a common boundary.
- Channel characteristics formed by interaction of precipitation, geology, topography, and riparian vegetation.
- Inter-connected channels transport watershed products downstream and function as migration corridors for aquatic and riparian species.

Fish Passage Design Workshop

Ecological Connectivity

- Stream channels and road networks are linear systems.
- Perpendicular orientation of stream channels and roads = many intersections.
- Both systems are at risk of disruption from each other.

Fish Passage Design Workshop

Importance of Ecological Connectivity

- Disruption watershed processes.
- Disruption of migration patterns of numerous species.
- Loss of tributary habitat for spawning and rearing.
- Multiple stream crossings within single watershed = fragmentation.

Fish Passage Design Workshop

Anadromous Salmonids in CA.

- Coho Salmon
- Chinook Salmon
- Coastal Rainbow Trout - resident and anadromous (steelhead)
- Coastal Cutthroat trout - resident and anadromous

Fish Passage Design Workshop

General Salmonid Life History

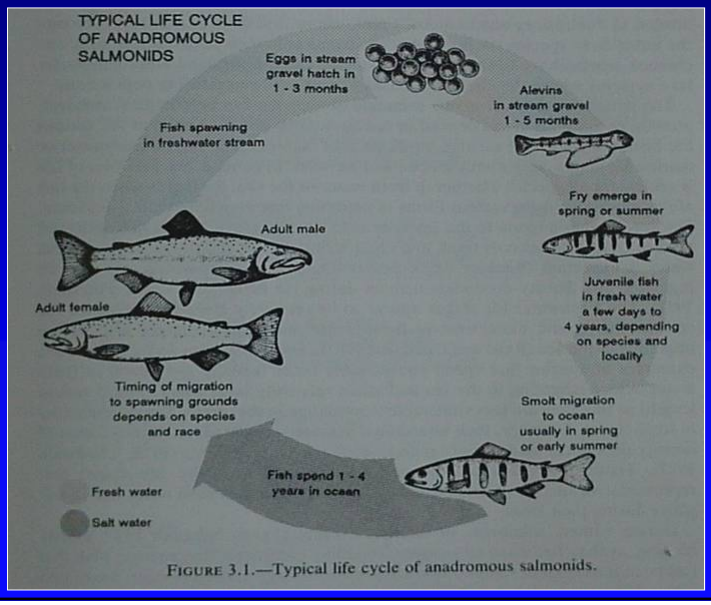


FIGURE 3.1.—Typical life cycle of anadromous salmonids.

Fish Passage Design Workshop

Coho Salmon in CA.

- Oregon border to Santa Cruz County.
- Mostly three-year life cycle.
- Juveniles spend approximately 18 months in freshwater.
- Cool water temperatures and LWD.
- All Pacific salmon die post-spawn.

Fish Passage Design Workshop

Coho Salmon

Fish Passage Design Workshop

Chinook Salmon in CA.

- Oregon border to Sacramento River.
- Largest of the Pacific salmon.
- Two to seven-year life cycle. Three to five years most common in CA.
- Fall-run and spring-runs have distinctly different life history strategies.

Fish Passage Design Workshop

Chinook Salmon

Fish Passage Design Workshop

Steelhead in CA.

- Oregon border to San Diego County.
- Resident and anadromous inter-changeable.
- One to four-year freshwater. One to two years most common in CA.
- Fall/winter-run and summer-runs have distinctly different life history strategies

Fish Passage Design Workshop

Coastal Rainbow-Steelhead

Fish Passage Design Workshop

Coastal Cutthroat Trout in CA.

- Oregon border to lower Eel River.
- Resident and anadromous inter-changeable.
- One to six-year as juveniles in freshwater.
- Brief saltwater forays – never over-winters in ocean.

Fish Passage Design Workshop

Coastal Cutthroat Trout

Fish Passage Design Workshop


Coho Salmon
Coastal Rainbow Trout
Chinook Salmon
Coastal Cutthroat Trout


Other Species of Concern
Fish Passage Design
Workshop

Native Fish Species

Tidewater Goby

Photo: Greg Goldsmith - USFWS

Fish Passage Design Workshop

Native Fish Species

Prickly Sculpin

Fish Passage Design Workshop

Native Fish Species

Klamath Small Scale Sucker

Fish Passage Design Workshop

Native Fish Species

Santa Ana Sucker

Fish Passage Design Workshop

Native Fish Species

Pacific Lamprey

Fish Passage Design Workshop

Other Aquatic Species

Pacific Giant Salamander

Fish Passage Design Workshop

Other Aquatic Species

Red Legged Frog

Fish Passage Design Workshop

Other Aquatic Species

Tailed Frog

Fish Passage Design Workshop

Passage of Terrestrial Species

Fish Passage Design Workshop

Why Fish Need to Move - Migratory Patterns of Salmonids

Fish Passage Design Workshop

Reasons for Migration

Adults

- Migration to spawning habitat.
- Spatially separate from competing species.
- Spatially separate throughout a basin.
- Reduce mortality from redd superimposition.

Reasons for Migration

Juveniles

- Migration to favorable over-wintering habitat.
- In CA., coho, steelhead, and coastal cutthroat trout.
- Following potential food source upstream.
- Summer migration to thermal refugia.

Migration Timing

Adults and Juveniles

- Triggered by winter storms and stream discharge.
- Behavior dependant on storm magnitude and frequency.
- Falling limb of storm hydrograph.

Fish Passage Design Workshop

Stream Crossing Characteristics that Create Migration Barriers

Fish Passage Design Workshop

Types of Passage Problems

- Excessive velocity through crossing.
- Lack of depth w/in crossing.
- Perched crossing outlet.
- Lack of depth in outlet pool.
- Obstructions within crossing.
- Turbulence.

Types of Passage Problems

Velocity Barriers

- Crossing set at too steep of slope.
- Roughness reduced through crossing - varies with construction materials.
- Reduction of channel cross-sectional area - inlet drops.
- Length of crossing x velocity > fish swimming abilities.

Velocity Barrier - Steep Slope

Fish Passage Design Workshop

Velocity Barrier - Concrete Floor

Fish Passage Design Workshop

Velocity Barrier - Concrete Apron

Fish Passage Design Workshop

Velocity Barrier - Inlet Drop

Fish Passage Design Workshop

Types of Passage Problems

Perched Outlets

- Local scour of outlet pool by high-velocity flows exiting culvert/crossing.
- Crossings set in a static location within a dynamic system.
- Disrupts migration at heights less than observed maximum leaping abilities.
- Physical injury of migrating fish.

Fish Passage Design Workshop

Perched Outlet - Freefall to Pool

Fish Passage Design Workshop

Perched Outlet - Cascade over Boulder

Fish Passage Design Workshop

Perched Outlet – Over Remnant Dam

Fish Passage Design Workshop

Perched Outlet – Over Hardened Ford

Fish Passage Design Workshop

Perched Outlet – Water Line Encasement

Fish Passage Design Workshop

Just when you think you've seen it all!

Fish Passage Design Workshop

Types of Passage Problems

Lack of Depth within Crossing

- Wide, flat-bottomed structures.
- Concrete aprons.
- Reduces swimming abilities of partially submerged fish.
- Increases likelihood of injury or predation.

Fish Passage Design Workshop

Lack of Depth - Concrete Bottom

Fish Passage Design Workshop

Lack of Depth - Concrete Apron

Fish Passage Design Workshop

Lack of Depth – Hardened Ford

Fish Passage Design Workshop

Lack of Depth – Flood Control Channel

Fish Passage Design Workshop

Types of Passage Problems

Lack of Depth in Outlet Pool

- Jump height to pool-depth ratio = 1:1.25-1.5
- Rip rap placed at outlet to dissipate stream flow.

Fish Passage Design Workshop

Lack of Depth in Outlet Pool

Fish Passage Design Workshop

Types of Passage Problems

Obstructions within Crossing

- Storm debris.
- Create turbulence.
- Damage to crossing.
- Additional consequences.

Fish Passage Design Workshop

Obstructions within Crossing

Fish Passage Design Workshop

Turbulence within Crossing

Fish Passage Design Workshop

Effects of Migration Barriers at Stream Xings

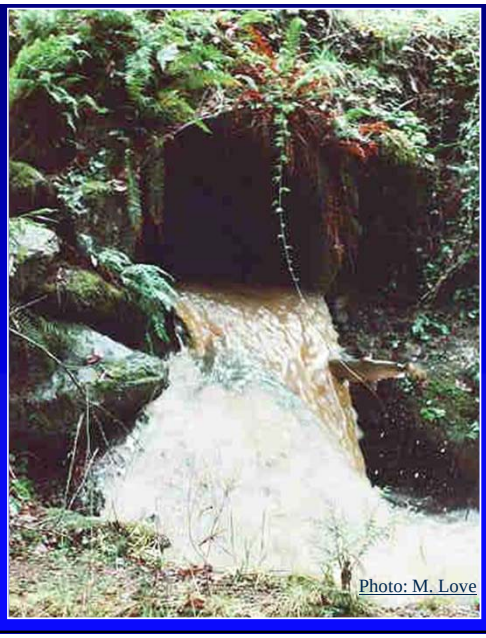


Photo: M. Love

Fish Passage Design Workshop

Effects on Salmonids

Barrier Types:

Temporal - impassable to one or more species or lifestages at certain flows.

Potential Impact: delays movement beyond barrier.

Partial - impassable to some species and/or lifestages at all flows.

Potential Impact: exclusion of certain species or lifestages from sections of a watershed.

Total - impassable to all fish at all times.

Potential Impact: exclusion of certain species or lifestages from sections of a watershed.

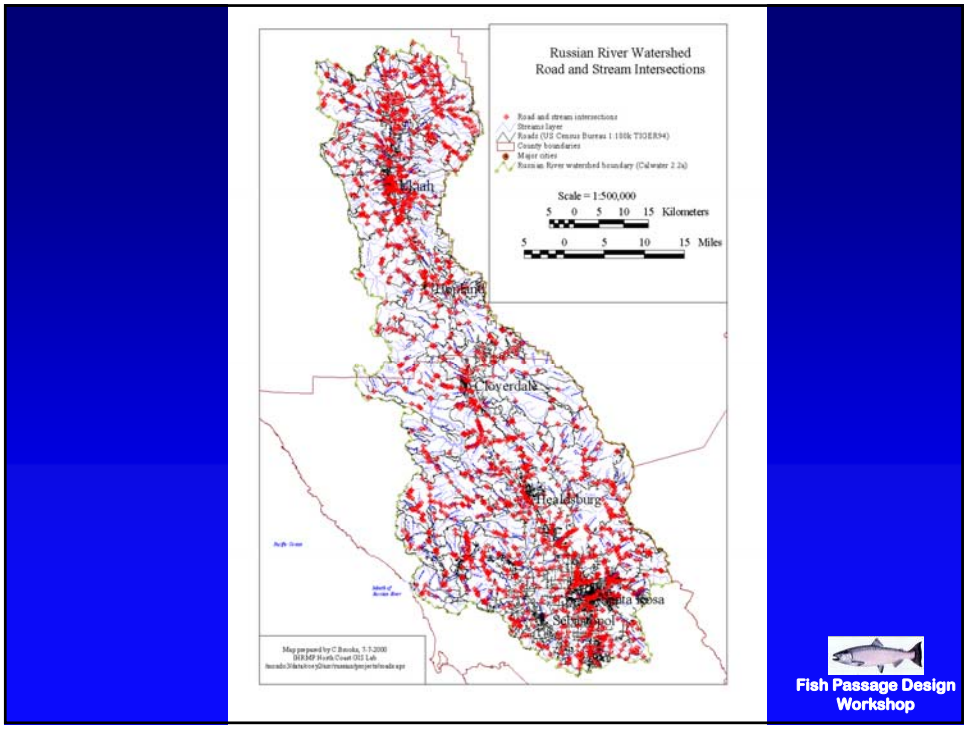
Fish Passage Design Workshop

Effects on Salmonids

Cumulative Effects:

- Multiple crossings within a fishes migration corridor.
- Delays at lower crossings may prevent passage at other crossings.
- Effects of delays more apparent in years or areas of CA with sporadic rainfall.

Fish Passage Design Workshop



Effects on Salmonids

Adults:

- Disrupts spawning migrations.
- Under-utilization of tributary habitat.
- Over-crowding of available spawning habitat.
- Increased likelihood of stress, injury, or predation/poaching.
- Limits spatial separation of competing species.

Effects on Salmonids

Juveniles:

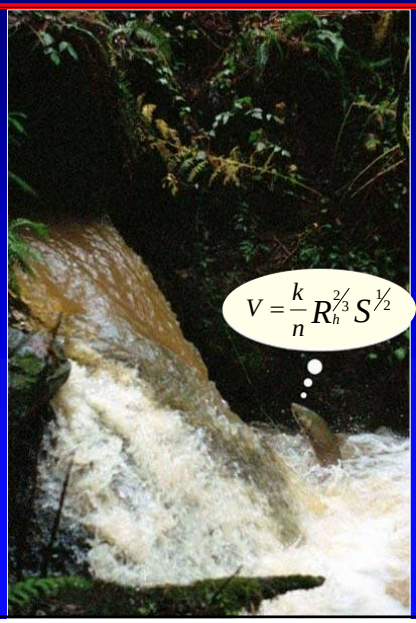
- Limits or prevents use of over-wintering habitat in tributaries.
- Increases predation in outlet pools.
- Limits or prevents summer migration from thermally-stressed main-stems to cool-water refugia.

Culvert Hydraulics vs Fish Abilities

Leaping and Swimming Abilities:

- Size of fish.
- Condition of fish.
- Level of exertion required - cruising, sustained, or burst speed.
- Other: water temperature, water quality, leap conditions.

The "Design" Fish



Fish Passage Design Workshop

The "Design" Fish

Factors to Consider:

- Selection of an appropriate species or age-class.
- Is designing for a single species or age-class a valid approach?
- Timing, behavior, and variations of individual abilities lead to uncertainties.

Fish Passage Design Workshop

Swimming Abilities and Requirements

Types of Swimming Modes:

- Sustained – maintained indefinitely.
- Prolonged – maintained for 20 seconds to 200 minutes.
- Burst – highest velocity mode, maintained for < 20 seconds.

Fish Passage Design Workshop

Swimming Abilities and Requirements

Adult Anadromous Assessment Criteria:

Minimum Depth	0.8 ft
Prolonged swim speed	6 ft/s for 30 minutes
Burst (maximum) swim speed	10 ft/s for 5 sec
Maximum leap speed	15 ft/s (Leap heights less than 2 ft with good jump pool conditions)

Part IX California Salmonid Stream Habitat Restoration Manual (Taylor and Love, 2003)

Fish Passage Design Workshop

CDFG Stream Crossing Ranking

Ranking Objectives:

- A first-cut, sorting of evaluated sites using "scored" criteria.
- Division of sites into groups of: high, medium, and low priority.
- Consideration of other factors prior to selection of sites for remediation.
- Identification of restoration sites vs. maintenance sites.

Fish Passage Design Workshop

CDFG Stream Crossing Ranking

Ranking Criteria:

- Species diversity and listing status.
- Extent of barrier for three groups of salmonid age classes.
- Quantity and quality of potential upstream habitat.
- Sizing and condition of current crossing.

Fish Passage Design Workshop

CDFG Stream Crossing Ranking

Other Factors to Consider:

- Additional stream crossings or migration barriers.
- Current diversity of species versus historic diversity.
- Presence of fish at stream crossing during migration periods.
- Costs of treatment options.
- Opportunity.
- Scheduling of other road maintenance projects.
- Amount of road fill at undersized and/or poor condition stream crossings.

Fish Passage Design Workshop

Why is Fish Passage Important???

- Improve transportation network.
- Safety.
- Comply with ESA regulations.
- Restore fish populations.

Fish Passage Design Workshop

Why is Fish Passage Important???

Fish Passage Design Workshop

Why is Fish Passage Important???

Fish Passage Design Workshop

Why is Fish Passage Important???

FIGURE 11. Fishing for salmon with drift gill nets at the mouth of the Klamath River. *Photograph by Hazeltine, 1913.*

Fish Passage Design Workshop