Fish Passage: What is it and Why is it Necessary?




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.

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.

Importance of Ecological Connectivity

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

Anadromous Salmonids in CA.

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

General Salmonid Life History

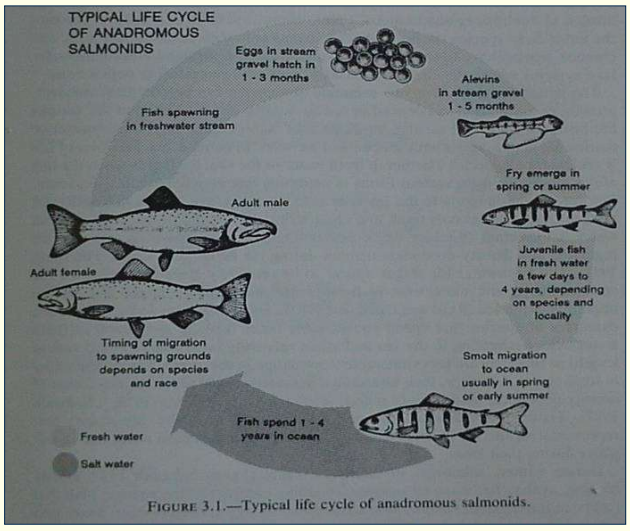


FIGURE 3.1.—Typical life cycle of anadromous salmonids.

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.

Coho Salmon

Chinook Salmon in CA.

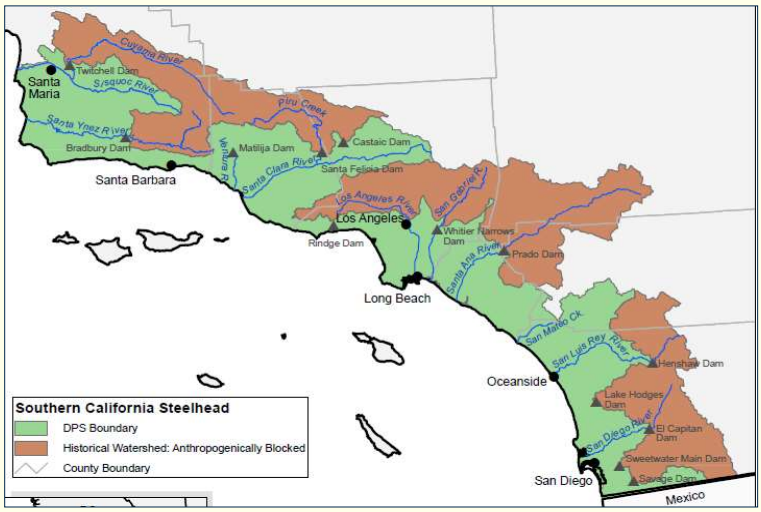
- Oregon border to Sacramento River.
- Largest of the Pacific salmon.
- Two to seven-year life cycle. Three to five years most common in CA.
- Fall-run and spring-run have distinctly different life history strategies.

Chinook Salmon

Steelhead in CA.

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

Southern CA. Steelhead - Distribution



Southern CA. Steelhead - Adaptations

- Adapted to extreme conditions in marginal habitats.
- Lower smolt age and older ocean age.
- Use of non-natal streams for spawning.
- Complete life-cycle in freshwater.
- Delay adult return from ocean for years during severe drought conditions.

Southern CA. Steelhead - Declines

- Severe (>90%) population declines since 1950's.
- 55,000 to less than 500 returning adults.
- Extirpated from approximately 14 larger drainages.

Southern CA. Steelhead - Impacts

- Dams and road crossings block more than 85% of historic spawning and rearing habitat.
- Loss/degradation of estuaries.
- Channelization and dewatering of mainstem migration corridors.
- Water pollution.

Coastal Rainbow-Steelhead

Coastal Rainbow-Steelhead Interactions

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.

Coastal Cutthroat Trout

Other Species of Concern

Native Fish Species

Tidewater Goby

Native Fish Species

Prickly Sculpin

Native Fish Species

Klamath Largescale Sucker

Native Fish Species

Klamath Smallscale Sucker

Native Fish Species

Santa Ana Sucker

Native Fish Species

Pacific Lamprey

Other Aquatic Species

Pacific Giant Salamander

Other Aquatic Species

Rough-skinned Newt

Other Aquatic Species

Red Legged Frog

Other Aquatic Species

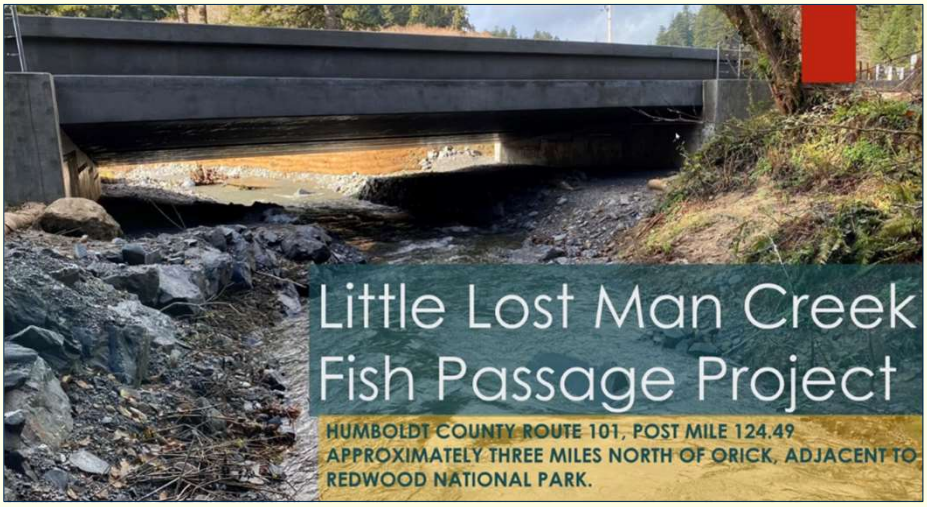
Foothill Yellow Legged Frog

Other Aquatic Species

Tailed Frog

Passage of Terrestrial Species

Passage of Terrestrial Species



Passage of Terrestrial Species

Passage of Terrestrial Species

Why Fish Need to Move - Migratory Patterns of Salmonids

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

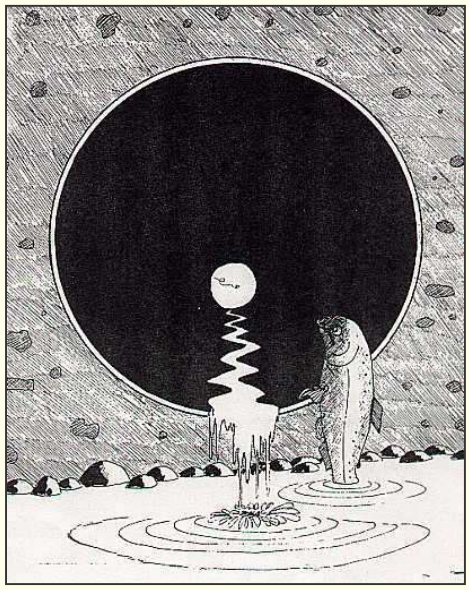
- Migration to favorable over-wintering habitat.
- In CA. coho, steelhead, and coastal cutthroat trout.
- Following potential food source upstream.
- Summer migration to thermal refugia.

Migration Timing

Adults and Juveniles

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

Stream Crossing Characteristics that Create Migration Barriers



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

Velocity Barrier - Concrete Floor

Velocity Barrier - Concrete Apron

Velocity Barrier - Inlet Drop

Types of Passage Problems

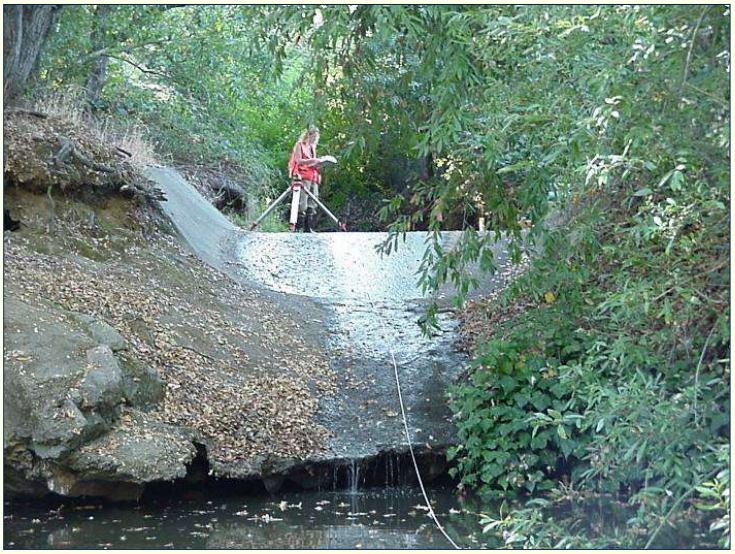
Perched Outlets

- 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.

Perched Outlet - Freefall to Pool

Perched Outlet - Cascade over Boulder

Perched Outlet – Over Remnant Dam



Perched Outlet – Over Hardened Ford

Perched Outlet – Water Line Encasement

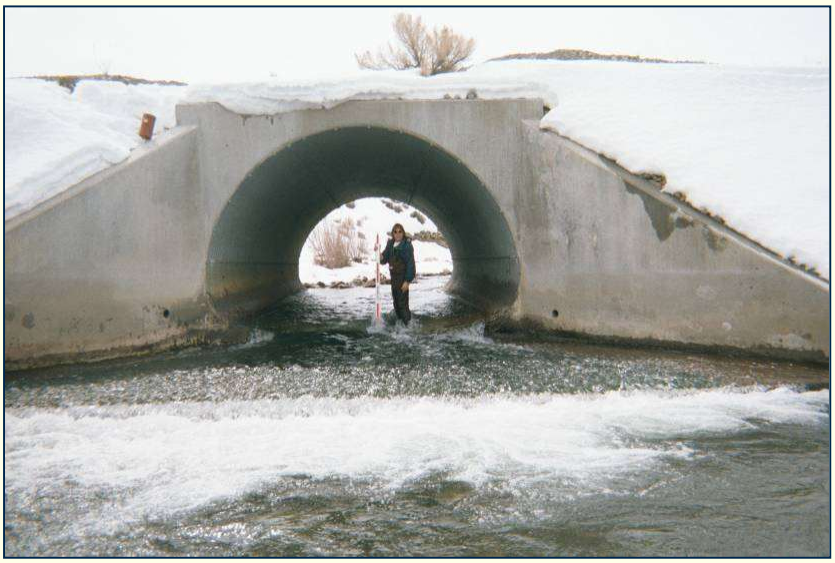
Types of Passage Problems

Lack of Depth within Crossing

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

Lack of Depth - Concrete Bottom

Lack of Depth - Concrete Apron



Lack of Depth – Hardened Ford

Lack of Depth – Flood Control Channel

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.

Lack of Depth in Outlet Pool

Types of Passage Problems

Obstructions within Crossing

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

Obstructions within Crossing

Turbulence within Crossing

Biological Effects of Migration Barriers

Effects on Salmonids

Barrier Types:

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

Potential Impact: delays movement beyond barrier.

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

Potential Impact: exclusion of certain species or life-stages from sections of a watershed.

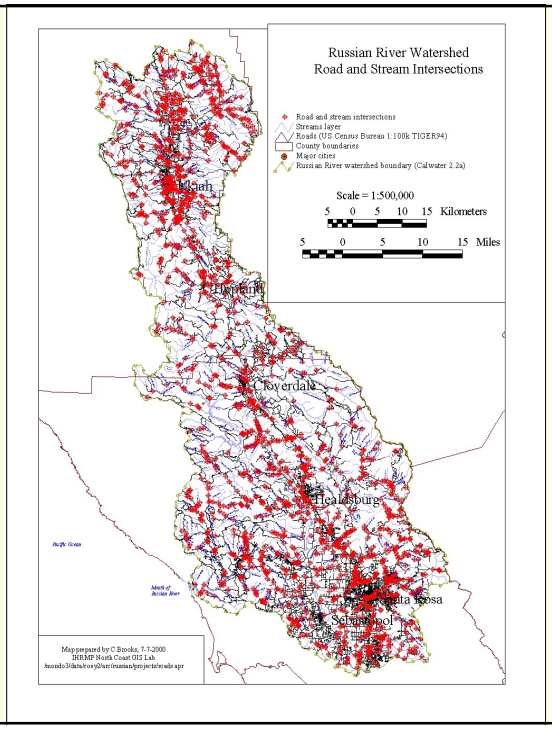
Total - impassable to all fish at all times.

Potential Impact: exclusion of certain species or life-stages from sections of a watershed.

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.



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:

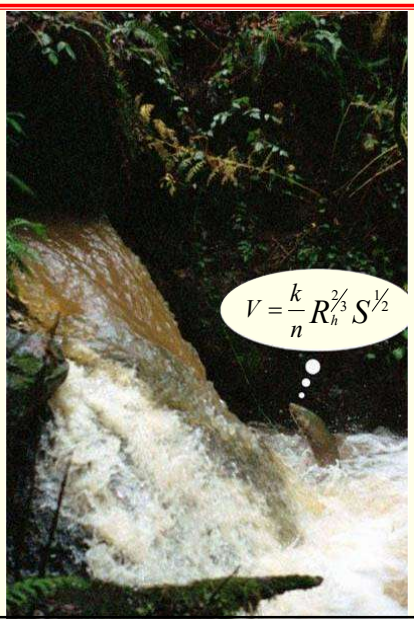
- Limits or prevents use of over-wintering habitat in tributaries.
- Increases predation in outlet pools.
- Limits or prevents summer migration from thermally-stressed main-stems to cool-water refugia.

Culvert Hydraulics vs Fish Abilities

Leaping and Swimming Abilities:

- Size and condition of fish.
- Level of exertion required – sustained, prolonged or burst.
- Other – water temperature, water quality, leap conditions.

The "Design" Fish



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.

Swimming Abilities and Requirements

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

Salmonid Performance Criteria

CDFW : Assessment Criteria

Species or Lifestage	Minimum Water Depth	Prolonged Swimming Mode		Burst Swimming Mode		
		Maximum Swim Speed	Time to Exhaustion	Maximum Swim Speed	Time to Exhaustion	Maximum Leap Speed
Adult anadromous salmonids	0.8 feet	6.0 ft/sec	30 minutes	10.0 ft/sec	5.0 sec	15.0 ft/sec
Resident trout and juvenile steelhead trout >6"	0.5 feet	4.0 ft/sec	30 minutes	5.0 ft/sec	5.0 sec	6.0 ft/sec
Juvenile salmonids <6"	0.3 feet	1.5 ft/sec	30 minutes	3.0 ft/sec	5.0 sec	4.0 ft/sec

Salmonid Performance Criteria

CDFW : Hydraulic Design Criteria

Species/Lifestage	Maximum Average Water Velocity (fps)	Minimum Flow Depth (ft)
Adult Anadromous Salmonids	See Table 6	1.0
Adult Non-Anadromous Salmonids	See Table 6	0.67
Juvenile Salmonids	1	0.5
Native Non-Salmonids	Species specific swimming performance data is required for the use of the hydraulic design option for non-salmonids. Hydraulic design is not allowed for these species without this data.	
Non-Native Species		

Table IX-A- 5. Maximum average water velocity and minimum depth of flow.

Culvert Length (ft)	Adult Non-Anadromous Salmonids (fps)	Adult Anadromous Salmonids (fps)
<60	4	6
60-100	4	5
100-200	3	4
200-300	2	3
>300	2	2

Table IX-A- 6. Culvert length vs. maximum average water velocity for adult salmonids.

Salmonid Performance Criteria

CDFW : Hydraulic Design Criteria

Maximum Outlet Drop - Hydraulic drops between the water surface in the culvert to the pool below the culvert should be avoided for all cases. Where fish passage is required and a hydraulic drop is unavoidable, its magnitude should be evaluated for both high design flow and low design flow and shall not exceed the values shown in Table IX-A-7. If a hydraulic drop occurs at the culvert outlet, a jump pool of at least 2 feet in depth shall be provided.

Species/Lifestage	Maximum Drop (ft)
Adult Anadromous Salmonids	1
Adult Non-Anadromous Salmonids	1
Juvenile Salmonids	0.5
Native Non-Salmonids	Where fish passage is required for native non-salmonids, no hydraulic drop shall be allowed at the culvert outlet unless data is presented which will establish the leaping ability and leaping behavior of the target species of fish.
Non-Native Species	

Table IX-A- 7. Maximum drop at culvert outlet.

CDFW Stream Crossing Ranking

- 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.

CDFW Stream Crossing Ranking

- 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.

CDFW Stream Crossing Ranking

- 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.

California Fish Passage Forum

FISH*Pass* is a web-based decision-support tool designed to help users identify fish passage barriers for remediation. FISH*Pass* is an optimization model that uses barrier information from the California Passage Assessment Database (PAD), accounts for spatial layout of the barriers in the network, cumulative barrier passability, potential upstream habitat, and optionally, estimated costs.

Why is Fish Passage Important?

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

Why is Fish Passage Important?

Why is Fish Passage Important?

Why is Fish Passage Important?

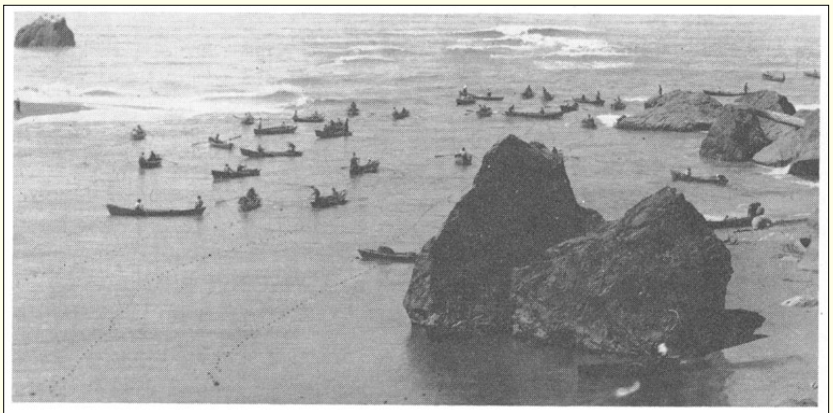


FIGURE 11. Fishing for salmon with drift gill nets at the mouth of the Klamath River. *Photograph by Hazeltine, 1913.*

Why is Fish Passage Important?

Fish Passage Resources

CA Fish Passage Forum:

The mission of the Fish Passage Forum is to protect and restore listed anadromous salmonid species, and other aquatic organisms, in California by promoting collaboration among public and private sectors for fish passage improvement projects and programs.

http://www.cafishpassageforum.org/

Fish Passage Resources

Passage Assessment Database: (PAD)

The Passage Assessment Database (PAD) is an ongoing map-based inventory of known and potential barriers to anadromous fish in California, compiled and maintained through a cooperative interagency agreement. The PAD compiles currently available fish passage information from many different sources, allows past and future barrier assessments to be standardized and stored in one place, and enables the analysis of cumulative effects of passage barriers in the context of overall watershed health.

http://www.calfish.org/tabid/420/Default.aspx

CalFish A California Cooperative Anadromous Fish and Habitat Data Program

Fish Passage Resources

CDFW – Restoration Manual

Part IX – Fish Passage Evaluation at Stream Crossings.

Part XII – Fish Passage Design and Implementation.

http://www.dfg.ca.gov/fish/

California Department of Fish and Wildlife

Fish Passage Resources

NOAA FISHERIES | West Coast Region
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Construction and development activities affect aquatic habitats. They impact the hydraulic conditions of a natural waterway and can block fish from migrating to and from the ocean. We work to minimize these impacts by implementing innovative engineering designs that facilitate safe, timely, and effective fish passage in estuaries and inland watersheds.

http://www.westcoast.fisheries.noaa.gov/fish_passage/solutions/

Fish Passage Resources

FishXing Download:
www.fs.fed.us/biology/nsaec/products-tools.html