FISH EFFECTS ANALYSIS

Methods Overview, 10/30/2019

Sites

Agenda items

- Overview of effects analysis
  - Construction effects
  - Operations effects
    - Sacramento River - near field
    - Sacramento River - far field
    - Feather River
    - American River
    - Delta
    - Life cycle models
  - Cross-walk NMFS-provided model matrix and methods used to date

Construction Effects

- (Geotechnical Explorations)
- Turbidity and suspended sediment
- Release and exposure of contaminants
- Underwater noise
  - NMFS spreadsheet model
- Fish stranding
- Direct physical injury
- Loss and alteration of habitat

Near-Field Effects (Sacramento River) - Salmonids

- Spatial distribution (screen exposure)
  - Horizontal/vertical: literature review, with specific info. for water surface elevations of screens, etc., % flow split at GCID
- Entrainment through screens
  - Consideration of size distribution (RBDD) vs. mesh size
- Impingement, screen contact, and screen passage
  - Literature review & Swanson et al. equations
- Predation
  - Literature review, including Vogel GCID studies
- Stranding behind screens during high flow
  - High flow, based on water surface elevation
- Attraction to screens during reservoir discharge

Near-Field Effects (Sacramento River) – Green Sturgeon

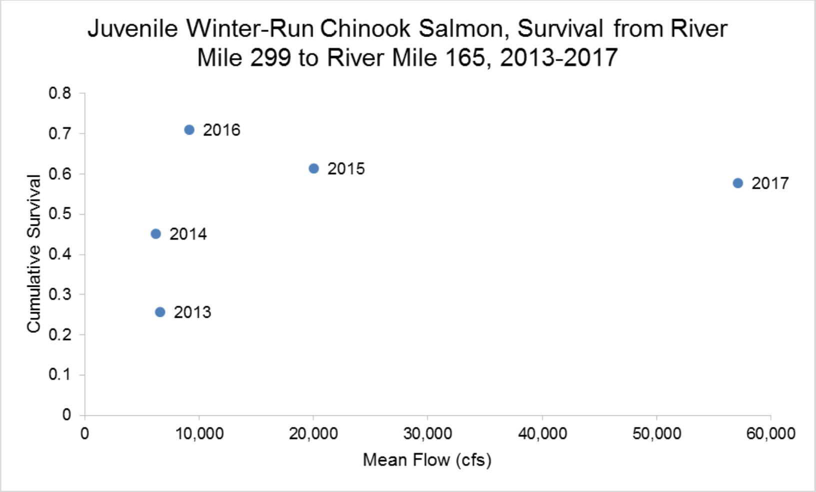
- Review of protective velocity criteria
  - Verhille et al. (2014)
- Entrainment through screens
  - Size distribution

Far-Field Effects (Sacramento River) - Salmonids

- Temperature effects
  - HEC-5Q/USRWQM, incl. 7DADM, etc.; Anderson/Martin models (Winter-Run)
- Redd scour/entombment
  - USRDOM, >40,000 cfs
- Redd dewatering
  - USRDOM, USFWS relationships
- Habitat capacity
  - Spawning WUA w/ CalSim
  - Rearing WUA w/ CalSim
- Juvenile stranding
  - USRDOM, USFWS relationships
- SALMOD
- Floodplain inundation and access
  - Yolo Bypass: daily downscaled CalSim; habitat inundation area (DWR 2016); mean number of days flooded (considering Takata et al. 2017)

Far-Field Effects (Sacramento River) - Salmonids

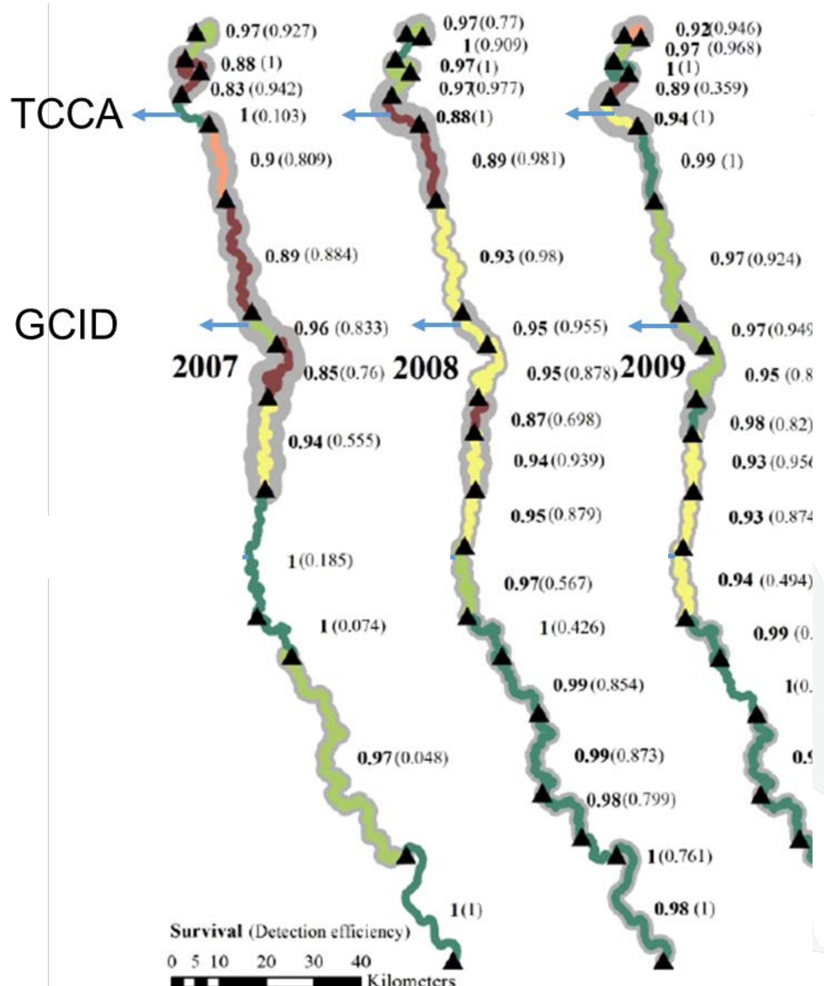
- Migration flow-survival
  - Quantitative analysis based on Henderson et al. (2018) – see next slides
  - Qualitative discussion considering Michel (2018) and Hassrick et al. in prep.



- Sites reservoir releases effects
  - Temperature
  - Water quality (mercury, salinity, false attraction)

Far-Field Flow-Survival Analysis

- Henderson et al. (2018) paper for quantitative analysis
    - Multiple reaches from above Red Bluff down to Knights Landing
    - Focus on Sites withdrawal period (winter/spring), daily timescale
    - Incorporates flow and temperature effects
    - Also includes other (non-operations) covariates
    - Results will allow adjustment of other models, e.g., OBAN



NRC Research Press

ARTICLE

Estimating spatial–temporal differences in Chinook salmon outmigration survival with habitat- and predation-related covariates

Mark J. Henderson, Ilysa S. Iglesias, Cyril J. Michel, Arnold J. Ammann, and David D. Huff

Far-Field Flow-Survival Analysis

Table 1: A description of the covariates included in the mark recapture model.

Category	Covariate	Range	Definition	Hypothesized relationship with survival
Individual	Fish Length[1]	135 - 204 mm	Fork length	Larger fish may exceed gape width of predators
	Fish Condition[1]	0.59 - 1.32	Fulton's K	Increased condition improves predator escape capability
	Transit speed[2]	0.02 - 8.25 km h^{-1}	Reach specific transit speed	Faster moving fish have less exposure to predators
Release group	Batch release[2]	Binary	Tagged fish released concurrently with large hatchery releases.	Predator swamping
	Release reach[1]	Binary	Difference in survival between newly released fish and those released upstream.	Newly released hatchery fish are naïve and susceptible to predation
	Annual flow[3]	179 - 499 cms	Mean flow measured at Bend Bridge throughout outmigration (December-March).	Increased flows produce more habitat and predator refugia throughout the river
Reach specific	Sinuosity[4]	1.04 - 2.74	River distance divided by Euclidean distance.	More natural habitats have more predator refugia
	Diversion density[5]	0 - 1.05 num km^{-1}	Number of diversions per reach length.	Increased predator densities near diversions
	Adjacent cover density[6]	0.2 - 0.76 %	Percent of non-armored river bank with adjacent natural woody vegetation.	Increased cover produces more predator refugia
	Off-channel habitat density[6]	0 - 1.62 %	Off-channel habitat within 50 m of river expressed as percentage of river area	Increased off-channel habitat produces more predator refugia
Time varying	Temperature[7]	6.2 - 12.9 °C	Mean water temperature per reach	Increased temperatures results in increased predation due to higher metabolic demands of predators
	Inter-annual Reach flow[7]	215 – 447 cms	Mean water flow per reach	Higher flows within a reach will produce more habitat and predator refugia within that reach
	Intra-annual Reach flow[7]	129 – 902 cms	Mean water flow per reach and year	Higher intra-annual flows (e.g., precipitation or dam releases) decreases predation due to increased turbidity and increased predator refugia.

[1]Measured during tagging and release; [2]Observed travel times and mixed effects model estimates; [3]California Water Data Library; [4]National Hydrography Dataset; [5]Passage Assessment Database - verified by field survey; [6]Department of Water Resources; [7]River Assessment for Forecasting Temperature (RAFT) model

Far-field effects: Henderson et al.

Category	Covariate	Range	Definition	Hypothesized relationship with survival	Notes/source	Source/assumption for analysis of proposed action
Individual	Transit speed	0.02–8.25 km/h	Reach-specific transit speed	Faster fish have less exposure to predators	Observed travel times and mixed effects model estimates	Assumed mean value from Henderson et al.
Release group	Batch release	Binary	Tagged fish released concurrently with large hatchery releases	Predator swamping	Observed travel times and mixed effects model estimates	Assumed fish not released with large hatchery releases
	Annual flow	179–499 cumecs (6,321–17,622 cfs)	Mean flow measured at Bend Bridge throughout outmigration (December–March)	Increased flows produce more habitat and predator refugia throughout the river	California Water Data Library	USRDOM
Reach-specific	Sinuosity	1.04–2.74	River distance divided by Euclidean distance	More natural habitats have more predator refugia	National Hydrography Dataset	Assumed same values as Henderson et al.
	Diversion density	0–1.05 diversions/km	No. of diversions per reach length	Increased predator densities near diversions	Passage Assessment Database—verified by field survey	Added one to reach 13 to account for Delevan intake; otherwise assumed same values as Henderson et al.
Time-varying	Temperature	6.2–12.9°C (42–55°F)	Mean water temperature per reach	Increased temperatures results in increased predation due to higher metabolic demands of predators	River Assessment for Forecasting Temperature (RAFT) model	USRWQM
	Intra-annual reach flow	129–902 cumecs (4,556–31,853 cfs)	Mean water flow per reach and year	Higher intra-annual flows (e.g., precipitation or dam releases) decrease predation due to increased turbidity and increased predator refugia	RAFT model	USRDOM

Far-field effects: Henderson et al.

- Focused on Dec-Mar
  - Bend Bridge mean flow covariate period
- Scenario 1
  - Equal numbers of fish beginning migrating on each day, Dec-Mar
  - All fish begin migration at Jellys Ferry (upstream of Red Bluff and all project intakes)

Far-field effects: Henderson et al.

- Scenario 2
  - Equal numbers of fish beginning migrating on each day, Dec-Mar
  - Equal numbers of fish beginning migration at the upstream end of each Henderson et al. reach
- Scenario 3
  - Equal numbers of fish beginning migration at the upstream end of each Henderson et al. reach
  - Fish moving in proportion to daily proportion of flow

Far-Field Effects (Feather River) - Salmonids

- Temperature effects
  - Reclamation temperature model
- Redd scour/entombment
- Redd dewatering
- Habitat capacity
  - Spawning WUA
  - Rearing WUA

Far-Field Effects (American River) - Salmonids

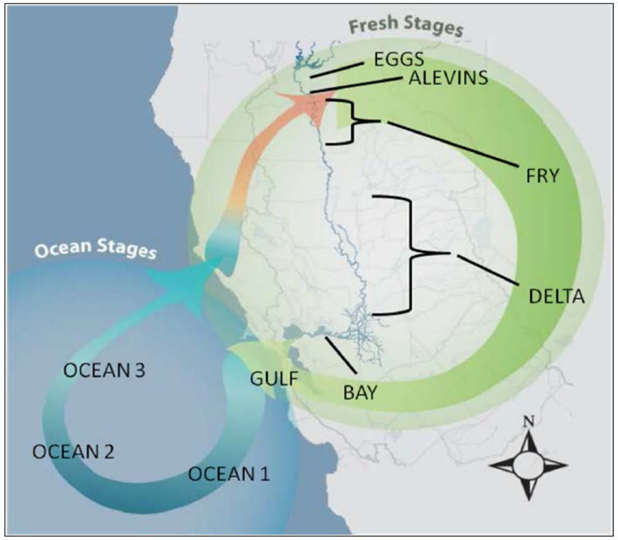
- Temperature effects
  - HEC-5Q, e.g., for 7DADM
- Redd scour
  - CalSim
- Redd dewatering
  - CalSim/Bratovich et al. (2017)
- Habitat capacity
  - Spawning WUA (USFWS)
  - Rearing WUA (USFWS)

Delta - Salmonids

- South Delta Entrainment
  - Qualitative consideration of CalSim OMR, etc.
- Juvenile through-Delta survival
  - DSM2-HYDRO Velocity Summary
  - Analysis based on Perry et al. (2018) - STARS
  - Delta Passage Model

Sites

Life Cycle Modeling: OBAN



General Details:

- Winter-Run Chinook Salmon
- Egg/alevin temperature effects
- Fry rearing flow effects
- Juvenile Yolo flow effects
- Juvenile south Delta export effects
- Juvenile DCC effects
- Ocean conditions not affected by project but included in model (productivity and harvest)
- Incorporate flow-survival adjustment based on Henderson et al. (2018) model

Sites

Life cycle modeling: IOS

Application of a Life Cycle Simulation Model to Evaluate Impacts of Water Management and Conservation Actions on an Endangered Population of Chinook Salmon

(1) spawning, models the number and temporal distribution of eggs deposited in the gravel at the spawning grounds

(2) Early development, models the impact of temperature on maturation timing and mortality of eggs at the spawning grounds

(3) fry rearing, models the relationship between temperature and mortality of salmon fry during the river rearing period

(4) river migration, estimates mortality of migrating salmon smolts in the Sacramento River between the spawning and rearing grounds and the Delta

(5) Delta passage, models the impact of flow, route selection, and water exports on the survival of salmon smolts migrating through the Delta to San Francisco Bay

(6) ocean survival, that estimates the impact of natural mortality and ocean harvest to predict survival and spawning returns (escapement) by age

Zeug et al. Environ Model Assess (2012) 17:455–467

Critical Habitat

Salmonids:

- Adult migration corridors
- Spawning habitat
- Adequate river flows
- Water temperatures
- Habitat and adequate prey free of contaminants
- Riparian and floodplain habitat
- Juvenile emigration corridors
- Estuarine areas

Green Sturgeon

- Sacramento and Feather River far-field effects
  - Temperature effects (Sac-USRWQM, Feather-Reclamation temp. model)
    - Spawning and egg incubation
    - Non-spawning adult presence
    - Pre- and post-spawn adult holding, immigration, and post-spawn emigration
    - Larval and juvenile rearing and emigration
  - Flow effects (CalSim)
- Flow effects Delta
  - South Delta entrainment – salvage-density method (CalSim)
  - Delta outflow – White Sturgeon year-class strength regression (CalSim)
- Critical Habitat
  - Food resources
  - Substrate type / size
  - Water flow and quality
  - Migration corridor
  - Water depth
  - Sediment quality

Sites

Delta Smelt

- North Delta food subsidy from Colusa Basin Drain
  - Qualitative discussion based on pilot study years
- South Delta entrainment
  - Adults & Larvae/early juveniles – consideration of OMR flows
- Flow effects
  - Spring – *Eurytemora affinis* – X2 regression
  - Summer – *Pseudodiaptomus forbesi* subsidy to LSZ (QWEST)
  - Fall – consideration of Delta outflow/X2 in relation to habitat attributes
- Upstream sediment entrainment
  - Modeling of sediment concentration in river flow in relation to diversions
- Critical habitat
  - Physical habitat, water, river flow, salinity

Longfin Smelt Outflow-Abundance

Transactions of the American Fisheries Society 145:44–58, 2016

ISSN: 0002-8487 print / 1548-8659 online
DOI: 10.1080/00028487.2015.1100136

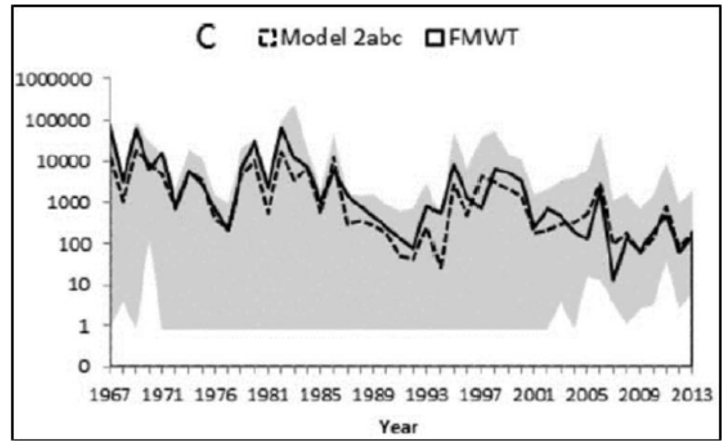
ARTICLE

Population Dynamics of an Estuarine Forage Fish: Disaggregating Forces Driving Long-Term Decline of Longfin Smelt in California's San Francisco Estuary

Matthew L. Nobriga*
U.S. Fish and Wildlife Service, Bay Delta Fish and Wildlife Office, 650 Capitol Mall, Suite 8-300, Sacramento, California 95831, USA

Jonathan A. Rosenfield
The Bay Institute, Pier 39, Box Number 200, San Francisco, California 94133, USA

(b) Original



(a) Reproduction

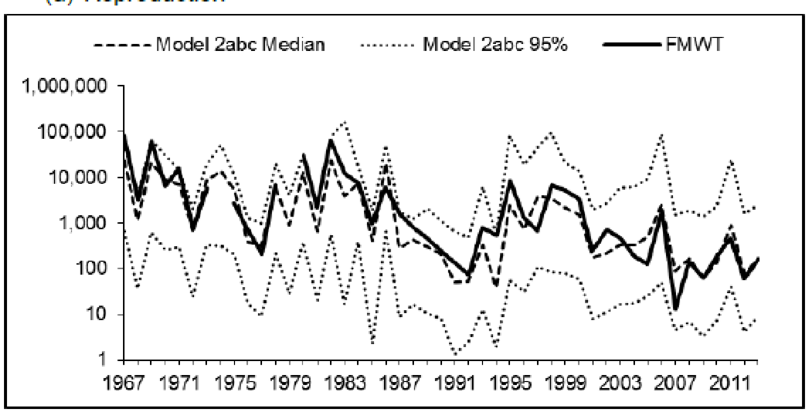


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Exhibit DWR-1352

Technical Memorandum

To: California Department of Water Resources (DWR)

From: Marin Greenwood, Ph.D. (Aquatic Ecologist, ICF) and Corey Phillis, Ph.D. (Resource Specialist, Metropolitan Water District of Southern California)

Date: 7/2/2018

Re: Comparison of Predicted Longfin Smelt Fall Midwater Trawl Index for Existing Conditions, No Action Alternative, and California WaterFix CWF H3+ Operational Scenarios Using the Nobriga and Rosenfield (2016) Population Dynamics Model