<u>Selected Delta-related references (2008 or later) potentially relevant to ROC on LTO effort</u>

Prepared by Barb Byrne, NMFS California Central Valley Office

July 2018

NOTES

- Citations in red text are particularly relevant to evaluation of the actions proposed in the June 19, 2018, outline of a draft Environmental Assessment for "Initial Actions" (June 2018 Draft EA Outline).
- Citations with an asterisk are not included in the references of the June 2018 Draft EA Outline (some may not be relevant for that document, but rather are provided here for the overall ROC on LTO effort).
- A few of the references already cited in the June 2018 Draft EA Outline (and therefore in red text without an asterisk) are included here in order to highlight some key excerpts.
- Abstracts are included only if already available in my digital reference library.
- Key conclusions or caveats are excerpted from some references.
- URLs provided for all listed references; contact barbara.byrne@noaa.gov if you have any trouble downloading the full-text reference.

REFERENCES

***California Department of Water Resources (2015). An Evaluation of Juvenile Salmonid Routing and Barrier Effectiveness, Predation, and Predatory Fishes at the Head of Old River, 2009-2012. February 2015.**

California Department of Water Resources (2014). Stipulation Study: Steelhead Movement and Survival in the South Delta with Adaptive Management of Old and Middle River Flows. Prepared by David Delaney, Paul Bergman, Brad Cavallo, and Jenny Melgo (Cramer Fish Sciences) under the direction of Kevin Clark (DWR). February 2014.

http://baydeltaoffice.water.ca.gov/announcement/Final_Stipulation_Study_Report_7Feb2014.pdf

> *Byrne comment:* Limitations in the range of OMR conditions tested, changes to OMR within treatment periods, and relatively low power tests should be taken into consideration when interpreting the results of the stipulation study. The report reflects the outcomes of the statistical analysis of selected hypotheses at a few locations in the south Delta and, in my opinion, does not support broad conclusions about fish movement in the interior Delta in relation to OMR flows.

***Cavallo, B., J. Merz and J. Setka (2013). "Effects of predator and flow manipulation on Chinook salmon (*Oncorhynchus tshawytscha*) survival in an imperiled estuary." <u>Environmental Biology of Fishes</u> 96(2): 393-403.**

https://link.springer.com/article/10.1007/s10641-012-9993-5

> *Abstract:* We evaluated the effects of non-native, piscivorous fish removal and artificial flow manipulation on survival and migration speed of juvenile Chinook salmon, *Oncorhynchus tshawytscha*, emigrating through the eastern Sacramento-San Joaquin

Delta of California (Delta) using a Before-After-Control-Impact study design. Acoustically-tagged salmon survival increased significantly after the first predator reduction in the impact reach. However, survival estimates returned to pre-impact levels after the second predator removal. When an upstream control gate opened (increasing flow and decreasing tidal effect) juvenile salmon emigration time decreased and survival increased significantly through the impact reach. Though a short-term, single season experiment, our results demonstrate that predator control and habitat manipulation in the Delta tidal transition zone can be effective management strategies to enhance salmon survival in this highly altered system.

***del Rosario, R. B., Y. J. Redler, K. Newman, P. L. Brandes, T. Sommer, K. Reece and R. Vincik (2013). "Migration Patterns of Juvenile Winter-run-sized Chinook Salmon (*Oncorhynchus tshawytscha*) through the Sacramento–San Joaquin Delta." San Francisco Estuary and Watershed Science 11(1).** *Cited in text of June 2018 Draft EA Outline but not in list of references.*

https://escholarship.org/uc/item/36d88128

Abstract: The decline of Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) remains one of the major water management issues in the Sacramento River. Few field studies have been published on winter-run, leaving gaps in our knowledge about their life history. This is especially true in the Sacramento–San Joaquin Delta, which provides essential rearing and migratory habitats for winter-run, and serves as the center of water operations for California. Using long-term monitoring data that identified winter-run-sized fish ("winter-run") using length-at-date criteria, we examined patterns of juvenile migration in terms of geographic distribution, timing, numbers, and residence times. We analyzed the role of flow, turbidity, temperature, and adult escapement on the downstream movement ("migration") of winter-run. Winter-run passed Knights Landing (rkm 144 or 51 rkm upstream of the Delta) between October and April, with substantial variation in peak time of entry that was strongly associated with the first high flows of the migration season. Specifically, the first day of flows of at least 400 m3 s-1 at Wilkins Slough (rkm 190) coincided with the first day that at least 5% of the annual total catch was observed at Knights Landing. While the period during which winter-run left the Delta spanned several months based on Chipps Island (rkm 29) catch data, the median catch typically occurred over a narrow window in March. Differences in timing of cumulative catch at Knights Landing and Chipps Island indicate that apparent residence time in the Delta ranges from 41 to 117 days, with longer apparent residence times for juveniles arriving earlier at Knights Landing. We discuss the potential importance of the Yolo Bypass floodplain as an alternative rearing and migratory corridor, contingent on the timing, duration, and magnitude of floodplain inundation. These results carry implications for habitat restoration and management of Sacramento River flows.

***Delta Independent Science Board (2015). Flows and Fishes in the Sacramento-San Joaquin Delta: Research Needs in Support of Adaptive Management. August 2015.**

http://deltacouncil.ca.gov/sites/default/files/2015/09/2015-9-29-15-0929-Final-Fishes-and-Flows-in-the-Delta.pdf

***DiGennaro, B., D. Reed, C. Swanson, L. Hastings, Z. Hymanson, M. Healey, S. Siegel, S. Cantrell and B. Herbold (2012). "Using Conceptual Models in Ecosystem Restoration Decision Making: An Example from the Sacramento-San Joaquin River Delta, California." San Francisco Estuary and Watershed Science 10(3).**

https://escholarship.org/uc/item/3j95x7vt

Abstract: The Sacramento–San Joaquin Delta (the Delta) is located on the western edge of California's Central Valley and is of critical ecological and economic importance. However, ecosystem alterations for human uses changed many of the Delta's natural processes, and it is now considered in need of restoration. An approach was developed to evaluate and rank restoration actions in the Delta under the Ecosystem Restoration Program's Delta Regional Ecosystem Restoration Implementation Plan (DRERIP). The DRERIP approach provides an explicit framework for evaluating restoration actions, using linked conceptual models, an action evaluation procedure, and a decision-support tool. Conceptual models allow scientists and managers to synthesize scientific information and make qualitative predictions about ecosystem function and restoration outcomes to guide and focus restoration efforts. The action evaluation procedure is a structured assessment of restoration actions. The procedure clearly describes actions to be evaluated, assesses the magnitude (importance and scale) and certainty of anticipated ecological outcomes, estimates degrees of worth (achieving intended outcomes) and risk (causing adverse consequences), evaluates the reversibility of the action, and identifies opportunities for learning. The values for worthiness, risk, reversibility, and learning opportunity are used in the decision- support tool to determine the fate of a proposed action. The decision-support tool is a structured decision tree that determines the disposition of an action: whether a restoration project should be discarded, revised with a different approach and re-evaluated, or implemented; and, if implemented, at what scale (targeted research, pilot project, or full implementation). The DRERIP approach provides managers with a valuable tool for restoration planning, and a foundation for integration with quantitative methods for a comprehensive ecosystem restoration plan.

***Foley, M. M., R. G. Martone, M. D. Fox, C. V. Kappel, L. A. Mease, A. L. Erickson, B. S. Halpern, K. A. Selkoe, P. Taylor and C. Scarborough (2015). "Using ecological thresholds to inform resource management: current options and future possibilities." Frontiers in Marine Science 2.**

https://www.frontiersin.org/articles/10.3389/fmars.2015.00095/full

Abstract: In the face of growing human impacts on ecosystems, scientists and managers recognize the need to better understand thresholds and non-linear dynamics in ecological systems to help set management targets. However, our understanding of the factors that drive threshold dynamics, and when and how rapidly thresholds will be crossed is currently limited in many systems. In spite of these limitations, there are approaches available to practitioners today—including ecosystem monitoring, statistical methods to identify thresholds and indicators, and threshold-based adaptive management—that can be used to help avoid reaching ecological thresholds or restore systems that have crossed them. We briefly review the current state of knowledge and then use real-world examples to demonstrate how resource managers can use available approaches to avoid crossing ecological thresholds. We also highlight new tools and indicators being developed that have the potential to enhance our ability to detect change, predict when a system is approaching an ecological threshold, or restore systems that have already crossed a tipping point.

***Grossman, G. D. (2016). "Predation on Fishes in the Sacramento–San Joaquin Delta: Current Knowledge and Future Directions." San Francisco Estuary and Watershed Science 14(2).**

https://escholarship.org/uc/item/9rw9b5tj

Abstract: The Sacramento–San Joaquin Delta (Delta) is a heterogeneous, highly modified aquatic system. I reviewed relevant predator–prey theory, and described extant data on predator–prey relationships of Delta fishes. I ranked predator consumption rates as occasional, moderate, and common, based on frequency-of-occurrence data, and evaluated the frequency, and hypothesized the effects of predation on native and invasive species. I identified 32different predator categories and 41 different prey categories. Most predators were occasional consumers of individual prey species, although I also observed moderate and common consumption of some prey types. My analysis yielded few generalizations regarding predator–prey interactions for Delta fishes; most predators consumed a variety of both native and invasive fishes. The only evidence for predator specialization on either native or invasive fishes occurred in Prickly Sculpin which, when it consumed fishes, ate mostly native species. Both Striped and Largemouth Bass exhibited wide dietary breadth, preying upon 32 and 28 categories of fish prey respectively. Sacramento Pikeminnow, a native predator, also displayed wide dietary breadth of piscine prey, with 14 different prey categories consumed. Data for reptilian, avian, and mammalian predators were sparse; however, these predators may be significant fish predators in altered habitats or when hatchery salmonids are released. The database for predators and their fish prey was not strong, and I recommend long-term dietary studies combined with prey availability and behavioral and experimental studies to establish predator preferences and antipredator behaviors, rather than just consumption. The behavioral effects of contaminants on prey species also warrant further examination. Although it has been suggested that a reduction in the Striped Bass population be implemented to reduce predation mortality of Chinook Salmon, the large number of salmon predators in the Delta make it unlikely that this effort will significantly affect salmon mortality.

***Hankin, D., D. Dauble, J. Pizzimenti, and P. Smith (2010). The Vernalis Adaptive Management Program (VAMP): Report of the 2010 Review Panel. Prepared for the Delta Science Program. May 13, 2010.**

http://www.sjrg.org/peerreview/review_vamp_panel_report_final_051110.pdf

> *Excerpt (p. 5):* "We believe the information obtained from VAMP studies regarding export effects on juvenile salmon survival has been useful, but inconclusive. Both standard regression analyses (summarized in SRJTC, 2008) and Bayesian hierarchical modeling (BHM) analyses (Newman, 2008) were unable to detect any statistical associations between exports and smolt survival through the Delta using the VAMP CWT study data. For a number of reasons, however, we do not believe these findings should be interpreted as meaning that exports, especially at high levels, have no effect on survival rates. CWT study data were not collected over an adequate range of export levels to achieve enough statistical power to identify an export effect. More recent acoustic-tagging studies done under the VAMP have not yet generated enough data to conclude much about export effects and these studies have also been carried out under tightly restricted levels of exports."

> *Excerpt (p. 9):* "Regarding export objectives, our feeling is that it makes sense during VAMP to continue limiting exports to some fraction of San Joaquin River flow at Vernalis so that the entire flow of the San Joaquin River is not diverted and so that reverse flows, if they occur, are not large. We cannot, however, offer any guidance as to what the Vernalis flow/export ratio should be…However, we do not believe that migration through Old River and subsequent salvage trucking and release is a desirable route for downstream migrating smolts. To the maximum extent possible, migration through the mainstem San Joaquin channel should be encouraged."

***Harvey, B. N., D. P. Jacobson and M. A. Banks (2014). "Quantifying the Uncertainty of a Juvenile Chinook Salmon Race Identification Method for a Mixed-Race Stock." North American Journal of Fisheries Management 34(6): 1177-1186.**

https://www.tandfonline.com/doi/abs/10.1080/02755947.2014.951804

> *Abstract:* Expected daily FL ranges (length at date) of juvenile Chinook Salmon *Oncorhynchus tshawytscha* have been used throughout California's Central Valley to identify federally listed winter-run and spring-run juveniles in a mixed four-race stock. Accurate race identification is critical both to species recovery and to management of the water supply for 25 million people and a multibillion-dollar agricultural industry. We used genetic race assignment of 11,609 juveniles sampled over 6 years to characterize the accuracy of the length-at-date approach, specifically by testing two of its central assumptions: (1) juvenile FL distributions do not overlap between races on a daily basis; and (2) the growth rates that are used to project FL at date are accurate. We found that 49% of FLs for genetically identified juveniles occurred outside the expected length-at-date ranges for their respective races, and we observed a high degree of overlap in FL ranges among the four races. In addition, empirical growth rates were well below those

from which length-at-date criteria were derived. Given the high degree of FL overlap between races, we conclude that modification of the length-at-date method will not substantially reduce identification error. Thus, we recommend that genetic assignment be used at least as a supplemental approach to improve Central Valley Chinook Salmon race identification, research, and management. Received January 7, 2014; accepted July 22, 2014

***Healey, M., M. Dettinger and R. Norgaard (2016). "Perspectives on Bay–Delta Science and Policy." San Francisco Estuary and Watershed Science 14(4).**

https://doi.org/10.15447/sfews.2016v14iss4art6

Abstract: The State of Bay–Delta Science 2008 highlighted seven emerging perspectives on science and management of the Delta. These perspectives had important effects on policy and legislation concerning management of the Delta ecosystem and water exports. From the collection of papers that make up the State of Bay–Delta Science 2016, we derive another seven perspectives that augment those published in 2008. The new perspectives address nutrient and contaminant concentrations in Delta waters, the failure of the Delta food web to support native species, the role of multiple stressors in driving species toward extinction, and the emerging importance of extreme events in driving change in the ecosystem and the water supply. The scientific advances that underpin these new perspectives were made possible by new measurement and analytic tools. We briefly discuss some of these, including miniaturized acoustic fish tags, sensors for monitoring of water quality, analytic techniques for disaggregating complex contaminant mixtures, remote sensing to assess levee vulnerability, and multidimensional hydrodynamic modeling. Despite these new tools and scientific insights, species conservation objectives for the Delta are not being met. We believe that this lack of progress stems in part from the fact that science and policy do not incorporate sufficiently long-term perspectives. Looking forward half a century was central to the Delta Visioning process, but science and policy have not embraced this conceptual breadth. We are also concerned that protection and enhancement of the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place, as required by the Delta Reform Act, has received no critical study and analysis. Adopting wider and longer science and policy perspectives immediately encourages recognition of the need for evaluation, analysis, and public discourse on novel conservation approaches. These longer and wider perspectives also encourage more attention to the opportunities provided by heavily invaded ecosystems. It is past time to turn scientific and policy attention to these issues.

***Healey, M., P. Goodwin, M. Dettinger and R. Norgaard (2016). "The State of Bay–Delta Science 2016: An Introduction." San Francisco Estuary and Watershed Science 14(2).**

http://dx.doi.org/10.15447/sfews.2016v14iss2art5

Abstract: The State of Bay–Delta Science 2016 (SBDS) is a collection of papers that summarizes the scientific understanding of the Sacramento–San Joaquin Delta,

emphasizing progress made during the past decade. It builds on the first SBDS edition (Healey et al. 2008). Paper topics for this edition address the most relevant scientific issues in the Delta identified by senior scientists and managers. The topical papers cover issues ranging from contaminants in the Delta to levee stability, and from Delta food webs to recent discoveries about salmon migration. These papers are written for a scientific audience. Two additional papers, one describing the challenges of managing water and ecosystems in the Delta and another that discusses policy implications of the recent scientific findings, are written for a general audience. The papers will be published in at least two issues of San Francisco Estuary and Watershed Science and will be available as a set electronically.

***Johnson, R. C., S. Windell, P. L. Brandes, J. L. Conrad, J. Ferguson, P. A. L. Goertler, B. N. Harvey, J. Heublein, J. A. Israel, D. W. Kratville, J. E. Kirsch, R. W. Perry, J. Pisciotto, W. R. Poytress, K. Reece and B. G. Swart (2017). "Science Advancements Key to Increasing Management Value of Life Stage Monitoring Networks for Endangered Sacramento River Winter-Run Chinook Salmon in California." San Francisco Estuary and Watershed Science 15(3).**

https://doi.org/10.15447/sfews.2017v15iss3art1

Abstract: A robust monitoring network that provides quantitative information about the status of imperiled species at key life stages and geographic locations over time is fundamental for sustainable management of fisheries resources. For anadromous species, management actions in one geographic domain can substantially affect abundance of subsequent life stages that span broad geographic regions. Quantitative metrics (e.g., abundance, movement, survival, life history diversity, and condition) at multiple life stages are needed to inform how management actions (e.g., hatcheries, harvest, hydrology, and habitat restoration) influence salmon population dynamics. The existing monitoring network for endangered Sacramento River winter-run Chinook salmon (SRWRC, *Oncorhynchus tshawytscha*) in California's Central Valley was compared to conceptual models developed for each life stage and geographic region of the life cycle to identify relevant SRWRC metrics. We concluded that the current monitoring network was insufficient to diagnose when (life stage) and where (geographic domain) chronic or episodic reductions in SRWRC cohorts occur, precluding within- and among-year comparisons. The strongest quantitative data exist in the Upper Sacramento River, where abundance estimates are generated for adult spawners and emigrating juveniles. However, once SRWRC leave the upper river, our knowledge of their identity, abundance, and condition diminishes, despite the juvenile monitoring enterprise. We identified six system-wide recommended actions to strengthen the value of data generated from the existing monitoring network to assess resource management actions: (1) incorporate genetic run identification; (2) develop juvenile abundance estimates; (3) collect data for life history diversity metrics at multiple life stages; (4) expand and enhance real-time fish survival and movement monitoring; (5) collect fish condition data; and (6) provide timely public access to monitoring data in open data formats. To illustrate how updated technologies can enhance the existing monitoring to provide quantitative

data on SRWRC, we provide examples of how each recommendation can address specific management issues

***Marston, D., C. Mesick, A. Hubbard, D. Stanton, S. Fortmann-Roe, S. Tsao and T. Heyne (2012). "Delta Flow Factors Influencing Stray Rate of Escaping Adult San Joaquin River Fall-Run Chinook Salmon (*Oncorhynchus tshawytscha*)." San Francisco Estuary and Watershed Science 10(4).**

https://escholarship.org/uc/item/6f88q6pf

Abstract: Adult salmon that stray when they escape into non-natal streams to spawn is a natural phenomenon that promotes population growth and genetic diversity, but excessive stray rates impede adult abundance restoration efforts. Adult San Joaquin River (SJR) Basin fall-run Chinook salmon (*Oncorhynchus tshawytscha*) that return to freshwater to spawn migrate through the San Francisco Bay and Sacramento–San Joaquin River Delta (Delta). The Delta has been heavily affected by land development and water diversion. During the fall time-period for the years 1979 to 2007 Delta pumping facilities diverted on average 340% of the total inflow volume that entered the Delta from the SJR. The hypothesis tested in this paper is that river flow and Delta exports are not significantly correlated with SJR salmon stray rates. Adult coded-wire-tagged salmon recoveries from Central Valley rivers were used to estimate the percentage of SJR Basin salmon that strayed to the Sacramento River Basin. SJR salmon stray rates were negatively correlated ($P = 0.05$) with the average magnitude of pulse flows (e.g., 10 d) in mid- to late-October and positively correlated ($P = 0.10$) with mean Delta export rates. It was not possible to differentiate between the effects of pulse flows in October and mean flows in October and November on stray rates because of the co-linearity between these two variables. Whether SJR-reduced pulse flow or elevated exports causes increased stray rates is unclear. Statistically speaking the results indicate that flow is the primary factor. However empirical data indicates that little if any pulse flow leaves the Delta when south Delta exports are elevated, so exports in combination with pulse flows may explain the elevated stray rates. For management purposes, we developed two statistical models that predict SJR salmon stray rate: (1) flow and export as co-independent variables; and (2) south Delta Export (E) and SJR inflow (I) in the form of an E:I ratio.

***Michel, C. J., A. J. Ammann, E. D. Chapman, P. T. Sandstrom, H. E. Fish, M. J. Thomas, G. P. Singer, S. T. Lindley, A. P. Klimley and R. B. MacFarlane (2013). "The effects of environmental factors on the migratory movement patterns of Sacramento River yearling late-fall run Chinook salmon (*Oncorhynchus tshawytscha*)." Environmental Biology of Fishes 96(2-3): 257-271.**

https://link.springer.com/article/10.1007/s10641-012-9990-8

Abstract: Understanding smolt migration dynamics is a critical step in the preservation and conservation of imperiled salmonids in California's Sacramento River system. Late-fall run Chinook salmon yearling smolts were acoustically tagged and tracked during

their outmigration through California's Sacramento River and San Francisco Estuary during 2007-2009. Migration rates were 14.3 km day^{-1} (+/- 1.3 S.E.) to 23.5 km day^{-1} (+/- 3.6 S.E.), similar to rates published for other West Coast yearling Chinook salmon smolt emigrations. Region-specific movement rates were fastest through the upper river regions, and slowest in the Sacramento/San Joaquin River Delta. River travel times were recorded for smolts travelling through a series of ten monitor-delimited reaches. Using these, a smolt travel time model determined by two parameters (movement rate and rate of population spreading) was then used to determine the influence of different factors on the model's fit, using model selection with Akaike's Information Criterion. The model that allowed for both year and reach to be expressed additively for both travel time and population spreading rate estimates, while accounting for a "release" effect, was the best supported model. Finally, several models incorporated environmental data as a linear predictor of movement rates. The addition of the environmental variables, in order of importance, river width to depth ratio, river flow, water turbidity, river flow to mean river flow ratio, and water velocity all resulted in improved model fit. Water temperature did not improve model fit. These environmental associations are discussed and potential improvements on the travel time model are suggested.

***Monismith, S., M. Fabrizio, M. Healey, J. Nestler, K. Rose and J. Van Sickle (2014). Workshop on the Interior Delta Flows and Related Stressors: Panel Summary Report. Prepared for the Delta Science Program. July 2014.**

http://deltacouncil.ca.gov/sites/default/files/documents/files/Int-Flows-and-Related-Stressors-Report.pdf

Excerpt (p. 37): “Chinook salmon fry are not strong swimmers and typically hold in shallow embayments or use structures to keep from being carried along by the prevailing current. Kjelson et al. (1982) noted that beach seine catches of Chinook salmon fry in the Delta dropped significantly at night, suggesting fry were moving away from shallow nearshore areas at night. Larger fry were captured further offshore, near the surface during the day but broadly distributed in the water column at night. If the fry move away from shore at night they would lose visual and tactile clues to their position and would likely simply be carried by the currents. This is characteristic of salmon fry (and smolt) behavior during downstream migration, which occurs primarily at night due to passive drift, but may be less functional in the tidal Delta. In the historic Delta, with its extensive marshes and many blind ending dendritic channels, simply drifting at night might not take the fry very far. In the modern Delta, however, with open trapezoidal channels and high-velocity tidal currents, fry might be carried a considerable distance in the Delta and find themselves in unfavorable habitats when light returns.”

Excerpt (p. 39-40): “Although Chinook salmon smolts do not go with the flow strictly in proportion to discharge they do make use of flow during migration. This raises the possibility that they could be confused by reverse flows in OMR. Because of the reverse flows in OMR when exports are large, the smolts are likely to receive mixed signals from tidal flux as water could be moving toward the pumps on both flood and ebb tides depending on the operation of the gates to Clifton Court Forebay (CCF). In this case, smolts may find themselves virtually trapped within OMR over several tidal cycles and potentially attracted into CCF because of inappropriate signals from water chemistry and flow. Since conveyance through the Delta is designed to ensure high quality of export waters (i.e., low salinity) it may be that near the pumps there is insufficient salinity signal on the tidal flow to direct the smolts and they simply go with the flow toward the pumps expecting that it is carrying them downstream. Salmon also make use of compass orientation during their migrations although the extent to which they might use this ability in the Delta is uncertain. It is possible that they might recognize that moving southward in OMR was inappropriate but whether they would be motivated to make some kind of corrective action is unknown."

Excerpt (p. 44): "It appears that steelhead, which are larger than Chinook salmon smolts, are less affected by interior Delta flow fields, move through the Delta more quickly than Chinook salmon and experience greater survival. Nevertheless, steelhead are entrained into CCF and into the export pumps suggesting that some of the cues and clues they receive during their migration through the Delta lead them in the wrong direction."

***Moyle, P. B., J. Durand and C. Jeffres (2018). Making the Delta a Better Place for Native Fishes, Orange County Coastkeeper.**

https://www.coastkeeper.org/wp-content/uploads/2018/03/Delta-White-Paper_completed-3.6.pdf

***Mussen T.D., D. Cocherell, J.B. Poletto, J.S. Reardon, Z. Hockett, A. Ercan, H. Bandeh, M. L. Kavvas, J. Cech Jr. and N. Fangue. (2014) Unscreened Water-Diversion Pipes Pose an Entrainment Risk to the Threatened Green Sturgeon, *Acipenser medirostris*. PLoS ONE 9(1): e86321.**

https://doi.org/10.1371/journal.pone.0086321

Abstract: Over 3,300 unscreened agricultural water diversion pipes line the levees and riverbanks of the Sacramento River (California) watershed, where the threatened Southern Distinct Population Segment of green sturgeon, *Acipenser medirostris*, spawn. The number of sturgeon drawn into (entrained) and killed by these pipes is greatly unknown. We examined avoidance behaviors and entrainment susceptibility of juvenile green sturgeon (35±0.6 cm mean fork length) to entrainment in a large (>500-kl) outdoor flume with a 0.46-m-diameter water-diversion pipe. Fish entrainment was generally high (range: 26–61%), likely due to a lack of avoidance behavior prior to entering inescapable inflow conditions. We estimated that up to 52% of green sturgeon could be entrained after passing within 1.5 m of an active water-diversion pipe three times. These data suggest that green sturgeon are vulnerable to unscreened water-diversion pipes, and that additional research is needed to determine the potential impacts of entrainment mortality on declining sturgeon populations. Data under various hydraulic conditions also suggest that entrainment-related mortality could be decreased by extracting water at lower diversion rates over longer periods of time, balancing agricultural needs with green sturgeon conservation.

***Perry, R. W., R. A. Buchanan, P. L. Brandes, J. R. Burau and J. A. Israel (2016). "Anadromous Salmonids in the Delta: New Science 2006–2016." San Francisco Estuary and Watershed Science 14(2).**

http://dx.doi.org/10.15447/sfews.2016v14iss2art7

> *Abstract:* As juvenile salmon enter the Sacramento–San Joaquin River Delta ("the Delta") they disperse among its complex channel network where they are subject to channel-specific processes that affect their rate of migration, vulnerability to predation, feeding success, growth rates, and ultimately, survival. In the decades before 2006, tools available to quantify growth, dispersal, and survival of juvenile salmon in this complex channel network were limited. Fortunately, thanks to technological advances such as acoustic telemetry and chemical and structural otolith analysis, much has been learned over the past decade about the role of the Delta in the life cycle of juvenile salmon. Here, we review new science between 2006and 2016 that sheds light on how different life stages and runs of juvenile salmon grow, move, and survive in the complex channel network of the Delta. One of the most important advances during the past decade has been the widespread adoption of acoustic telemetry techniques. Use of telemetry has shed light on how survival varies among alternative migration routes and the proportion of fish that use each migration route. Chemical and structural analysis of otoliths has provided insights about when juveniles left their natal river and provided evidence of extended rearing in the brackish or saltwater regions of the Delta. New advancements in genetics now allow individuals captured by trawls to be assigned to specific runs. Detailed information about movement and survival in the Delta has spurred development of agent-based models of juvenile salmon that are coupled to hydrodynamic models. Although much has been learned, knowledge gaps remain about how very small juvenile salmon (fry and parr) use the Delta. Understanding how all life stages of juvenile salmon grow, rear, and survive in the Delta is critical for devising management strategies that support a diversity of life history strategies.

Salmonid Scoping Team (2017). Effects of Water Project Operations on Juvenile Salmonid Migration and Survival in the South Delta. Volume 1: Findings and Recommendations. January 2017.

http://www.westcoast.fisheries.noaa.gov/central_valley/water_operations/OCAPreports.html

> *Excerpt (p. ES-6):* "Water export operations contribute to salmonid mortality in the Delta via direct mortality at the facilities, but direct mortality does not account for the majority of the mortality experienced in the Delta; the mechanism and magnitude of indirect effects of water project operations on Delta mortality outside the facilities is uncertain."

> *Excerpt (p. ES-6):* "The evidence of a relationship between exports and through-Delta survival is inconclusive; the key findings presented in this table are supported by medium or high basis of knowledge, but our basis of knowledge on the relationship between exports and through-Delta survival is low (Appendix E, Section E.6.2.1)."

> *Excerpt (p. ES-7):* "It is unknown whether equivocal findings regarding the existence and nature of a relationship between exports and through-Delta survival is due to the lack of a

relationship, the concurrent and confounding influence of other variables, or the effect of low overall survival in recent years. These data gaps support a recommendation for further analysis of available data, as well as additional investigations to test hypotheses regarding export effects on migration and survival of Sacramento and San Joaquin River origin salmonids migrating through the Delta."

Excerpt (p. ES-10): "Uncertainty in the relationships between I:E, E:I, and OMR reverse flows and through-Delta survival may be caused by the concurrent and confounding influence of correlated variables, overall low survival, and low power to detect differences (Appendix E, Section E.2.3)."

Excerpt (p. ES-10):

"• I:E: The relationship between Delta survival of San Joaquin River Chinook salmon and I:E is variable but generally positive for lower I:E values (e.g., I:E less than 3) (Appendix E, Section E.11, Figure E.11-1). Results of these studies are confounded by the use of flow ratios since the same I:E ratio can represent different absolute flow and export rates. These results are further confounded by installation and operations of various South Delta barriers. Data are available from only two years of AT studies using steelhead (Appendix E, Section E.11-4).

• Exports: There was a weak positive association between the through-Delta survival of San Joaquin Chinook salmon and combined exports using the CWT data set, but comparisons are complicated by the correlation between exports and San Joaquin River inflow (Appendix E, Section E.6.2.1)."

Excerpt (p. ES-12): "Current understanding of juvenile salmon and steelhead survival in the Delta is constrained by a variety of factors…" [See the list of "Constraints on Understanding" on pages ES-12 to ES-13]

***Salmonid Scoping Team (2017). Effects of Water Project Operations on Juvenile Salmonid Migration and Survival in the South Delta. Volume 2: Responses to Management Questions. January 2017.**

http://www.westcoast.fisheries.noaa.gov/central_valley/water_operations/OCAPreports.html

Excerpt (p. ES-2): "Although not capturing the seasonal variation in juvenile movement, the January 1 onset of Old and Middle rivers (OMR) reverse flow management coincides with the presence of winter-run Chinook salmon in most years, spring-run Chinook salmon in many years, and steelhead in some years (Figures 4-1, 4-2, 4-3, and 4-4 in Section 4). If OMR reverse flow management were initiated based on first detection in the Delta rather than a fixed date, OMR reverse flow management would often begin earlier than January 1 for the protection of winter-run or spring-run Chinook salmon, and later than January 1 for the protection of steelhead. The January 1 trigger date provides a general approximation of a date by which juvenile winter-run Chinook have likely entered the Delta and, based on its simplicity for triggering management actions, has utility." [See also some technical disagreements described on pages ES-2 to ES-3]

***Windell, Sean, Patricia L. Brandes, J. Louise Conrad, John W. Ferguson, Pascale A.L. Goertler, Brett N. Harvey, Joseph Heublein, Joshua A. Israel, Daniel W. Kratville, Joseph E. Kirsch, Russell W. Perry, Joseph Pisciotto, William R. Poytress, Kevin Reece, Brycen G. Swart, and Rachel C. Johnson (2017). Scientific framework for assessing factors influencing endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) across the life cycle. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-586. 49 p.**
Cited in text of June 2018 Draft EA Outline but not in list of references.

http://doi.org/10.7289/V5/TM-SWFSC-586