Identification and Prioritization of Gaps in the Current Understanding of Water Project-Linked Effects on Juvenile Salmonid Survival in the South Delta (Salmonid Scoping Team Work Plan Element 1)

CAMT Salmonid Scoping Team

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Introduction and Purpose

The purpose of this project is to collaboratively identify and evaluate driver-linkage-outcomes regarding water project–linked effects on factors affecting salmonid survival in the south Delta. The water project-linked effects on salmonid survival are defined in the scope of the CAMT Salmonid Scoping Team (SST). The objectives are to document scientifically well supported linkages in the conceptual models, highlight key scientific uncertainties, and prioritize selected linkages for future research. The starting point for the analyses will be the South Delta Salmonid Research Collaborative (SDSRC) conceptual model that depicts a broad overview of drivers and outcomes, a subset of which are within the CAMT SST scope. The conceptual model will be expanded into one or more specific sub-models to more explicitly depict cause and effect linkages linked to export operations at a finer scale of resolution for use as part of the framework for conducting the analyses. One example is the effect of water exports on water velocity and flows in the south Delta channels and subsequent effects on juvenile salmonids, including migration route, residence time and predation risk. Conclusions of the Gap Analysis regarding the scientific rationale, effect size and effect variability of conceptual model linkages will be based on the best available information. Specifically, we will review existing analyses (published and unpublished) and document how each provides evidence related to how, when and where stressors linked to export operations (identified in conceptual model linkages) can affect different species, life stages, and populations of juvenile salmonids during their migration through the south Delta. The review and synthesis of available information on water project-linked effects on salmonid survival, referred to as a Gap Analysis, is identified as Work Plan Element 1 in the CAMT Salmon Scoping Team Work Plan.

In other contexts, a gap analysis is a planning tool used to assess existing information and identify where future research and analysis should be focused. Here a "gap" is defined as a hypothesized or putative linkage between a specific driver and an outcome where the existence or strength of the linkage requires further evaluation. As such, the SST will conduct a gap analysis on water project-linked effects on factors affecting survival of juvenile salmonids in the South Delta. The objectives of this process are two-fold:

1. Identify linkages characterized by a clearly defined and supported mechanism consistent with best available physical and biological information, as well linkages that represent "gaps" in our current understanding, either because of poorly defined mechanisms, conflicting

mechanisms, and/or data which provides equivocal evidence for importance or certainty; and

2. Prioritize a subset of linkages for further investigation.

The identified information gaps will be used to prioritize research questions that can be addressed via new analyses and/or new investigations. Although this latter step is not explicitly identified in the CAMT SST Work Plan Element 1, it is the logical extension of the Gap Analysis and sets up CAMT SST Work Plan Element 3. This document briefly outlines an approach for the Gap Analysis. Appendix A to this document is an example of the application this approach to three test DLOs that were used as a proof of concept. The Gap Analysis will be conducted collaboratively by the SST, which is composed of technical staff from the National Marine Fisheries Service, the US Fish and Wildlife Service, Bureau of Reclamation, California Department of Water Resources, Delta Science Program, federal and state water contractors, and academic institutions. As the Gap Analysis proceeds the SST anticipates that refinements will occur to the initial conceptual model and the analytical process.

Process Overview

The SST intends to initially use an approach modeled after the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) using conceptual models as a framework for identifying and evaluating driver-linkage-outcomes (DiGennaro *et al*., 2012), with possible modifications based on other published "weight of evidence" approaches (e.g., Burkhardt-Holm and Scheurer, 2007, Suter II and Cormier, 2011), to identify attributes of each of the linkages. Best available data and scientific literature will be compiled to evaluate these linkages. Based on the compiled evidence, attributes of each linkage will be defined according to:

- Direction of the effect—positive, negative, or threshold response,
- Understanding that underlies the effect (i.e. clarity of mechanism),
- Relative magnitude of the effect, and
- Independence of the effect.

The Gap Analysis consists of the following sequential steps:

(1) An initial identification of ecological pathways and linkages in the SDSRC Conceptual Model (Figure 1) based primarily on relevance to the SST scope. This will be accomplished via review and discussion of potential linkages and pathways within the SST and refinement and revision of the conceptual model(s). This step is to ensure relevance to the CAMT mission. Based on this initial prioritization, linkages not relevant to the SST's scope will be removed from further evaluation steps at this time.

(2) The relevant ecological linkages will be subject to detailed evaluation of best available scientific information including data, published reports, unpublished reports,

science panel reports, and presentations. Where necessary, sub-models of the conceptual model will be developed to expand and elucidate the more complex linkages. Ultimately, selected linkages will be described, all relevant information will be synthesized and finally, linkages will be categorized and ranked based upon the considerations described in the Approach section below.

(3) The SST will develop a collaborative report describing ecological linkages that are (a) generally well understood with a strong scientific foundation; (b) less understood because of conflicting or inconclusive evidence; or (c) largely unknown because of the paucity of information. Most importantly, the report will summarize the scientific support for each linkage using consistent criteria and terminology. It is expected that linkages with strong scientific support regarding a large effect on survival of Central Valley salmonids in the Delta will support either short-term or long-term management actions to predictably alter that effect and therefore will not require additional analysis or investigation. The SST will evaluate and prioritize for future investigation the ecological linkages that are less understood or studied but are deemed relevant to improved understanding of water project-linked effects on factors affecting salmonid survival. The SST working conceptual model will be refined and updated upon completion of these analyses.

Approach

Phase 1: Gap Analysis

1.1 Prioritize linkages in the revised SDSRC conceptual model and more detailed conceptual sub-models for evaluation based on their relevance to the SST scope. The SST scope is as follows:

> *The scope of the CAMT Salmonid Scoping Team is to review existing information and develop new information on salmonid survival as affected by factors linked to State Water Project and Central Valley Project-linked operations, including San Joaquin River inflow, delta exports, and south delta hydrodynamics. The primary focus of this work is the Sacramento-San Joaquin Delta south of the San Joaquin River (including Old and Middle River, the State and Federal Export Facilities, and the Head of Old River Barrier). The geographic scope also includes those pathways and export-related facilities that provide access for Sacramento River salmonids into the central and south Delta, such as the Delta Cross Channel (DCC). The water project-linked effects considered within this scope may include entrainment, hydrodynamics, barriers, predator-prey interactions, food supply, aquatic macrophytes, habitat suitability, and water quality as part of the "driver-linkage-outcome" cascade. The results are intended to contribute information relevant to the ESA consultation on the Long Term Operation of the CVP and SWP.*

1.2 Compile and review scientific information relevant to conceptual model linkages selected for evaluation (data, reports, publications, agency studies, dissertations, expert panel reports, presentations, etc.).

> (NOTE: For each of the following linkage attributes evaluation steps, the SST working group of scientists will apply the same ranking system to mitigate bias. Narratives will be prepared documenting the evidence supporting the ranking (e.g., high, medium, etc.) of each of the conceptual model linkages included in the evaluation.)

1.3 Evaluate relevant linkages in the conceptual model based on the compiled scientific information for *direction of effect*. The evaluation will consider how location, time or other circumstances may alter the direction of the effect.

a. Positive - The driver elicits a positive outcome.
b. Negative - The driver elicits a negative outcome.
c. Variable effect - The driver elicits a variable outcome.
d. No effect - Evidence indicates that the driver has no effect on the outcome.
e. Insufficient information available to evaluate driver effect.

1.4 Evaluate relevant linkages in the conceptual model based on the scientific information for *understanding of mechanism.* The DRERIP criteria for scientific understanding (Table 3 in DiGennaro *et al*., 2012), summarized with some preliminary modifications below, will be used initially to rank the evidence available for each linkage in the conceptual model, with modifications as needed:

e. High - based on peer-reviewed studies from within the system and scientific reasoning supported by most experts within the system,
f. Medium - based on peer-reviewed studies from outside the system and corroborated by non-peer-reviewed studies within the system,
g. Low - based on non-peer-reviewed research within system or elsewhere, and
h. Minimal - scientific evidence lacking
i. Conflicting – conflicting scientific evidence

1.5 Evaluate linkages in the conceptual model based on scientific information for *magnitude of the effect* on the outcome. The evaluation will include consideration of how location, time or other factors may alter magnitude both at the proximate scale and ultimate scale regarding through-Delta survival. The general approach outlined in DRERIP for establishing evaluation criteria for ranking importance (Table 2 in DiGennaro *et al*., 2012), modified below, will be used initially to rank the potential importance for each linkage evaluated:

a. High - Evidence indicates potential sustained major effect; the outcome addresses a key limiting factor affecting south Delta-wide survival (e.g., contributes substantially not only to the immediate outcome under consideration, but also the broader outcome of south Delta survival rate).
b. Medium - Evidence indicates potential sustained minor effect; the outcome addresses a limiting factor affecting immediate outcome under consideration, but outcome of south Delta-wide survival rate is limited to minor effect on large areas (regions) or multiple patches of habitat
c. Low - Evidence indicates potential limited effect, influences the outcome in a minor way, or limited spatial (local) or temporal habitat effects.
d. Insufficient information to evaluate relative magnitude of linkage.

Score	Proximate	Ultimate
High	Evidence indicates potential sustained major effect to the immediate outcome under consideration	Evidence indicates potential sustained major effect; the outcome addresses a key limiting factor the broader outcome of south Delta survival rate).
Medium	Evidence indicated potential effect addresses a limiting factor affecting immediate outcome under consideration	Evidence indicates potential sustained minor effect on south Delta-wide survival rate limited to large areas (regions) or multiple patches of habitat
Low	Evidence indicates potential limited effect, influences the outcome in a minor way, or limited spatial (local) or temporal habitat effects.	
Insufficient	Insufficient information to evaluate relative magnitude of linkage.	Insufficient information to evaluate relative magnitude of linkage.

1.6 Evaluate linkages in the conceptual model based on *independence of interactions* with drivers other than the focal driver:

a. High - The linkage is largely independent of interaction with other drivers.
b. Low - The linkage is greatly dependent upon interactions with other drivers.

1.7 *Revise* conceptual model as necessary when linkage suggested by evidence is not accounted for in current conceptual model.

1.8 If evidence suggests different linkage outcomes for salmonid species, Chinook salmon life histories, or perhaps even more defined populations (e.g., San Joaquin River fall-run), consider separate rankings based on relevance to that defined population. This may lead to separate versions of the conceptual model.

Phase 2: Research Prioritization

2.1 Initially, evaluated linkages identified as high/medium *magnitude of effect* and medium/low/conflicting *understanding of mechanism* is considered among priority candidates for further research. This approach to prioritizing linkages is likely to evolve as the Gap Analysis proceeds, and additional criteria may be developed. As part of finalizing the evaluation, CAMT will be briefed regarding relevance of the high priority research topics identified through the SST evaluation and their importance in resolving key scientific issues and informing management decisions in the future.

Products

The results of the Gap Analysis will be summarized in a collaboratively produced final report to CAMT (see Schedule below). This report will include (a) a summary of linkages evaluated and their scientific support, and (b) the revised version of the conceptual model(s). Together, the refined conceptual model(s) and linkage rankings will highlight linkages with varying levels of support based on scientific evidence, and certainty. If completed, the results of ranked research priorities (Phase 2) will also be included in the final report. However, if workload and schedule preclude completing the research prioritization phase, it will be completed and reported by the SST in an addendum at a later date. The final rankings, categorizations, and conclusions will be reviewed, revised, and agreed upon by the SST with any differences in opinion included. It is expected that the Gap Analysis and associated set of research priorities will be used to guide future research. The final report will be peer reviewed under the guidance of the Delta Science Program, and revised by the SST as appropriate.

Schedule

A draft report on CAMT SST Work Plan Element 1, Gap Analysis, will be completed by September 2014, and provided to the Delta Science Program for peer review. A final report will be submitted to CAMT in November 2014.

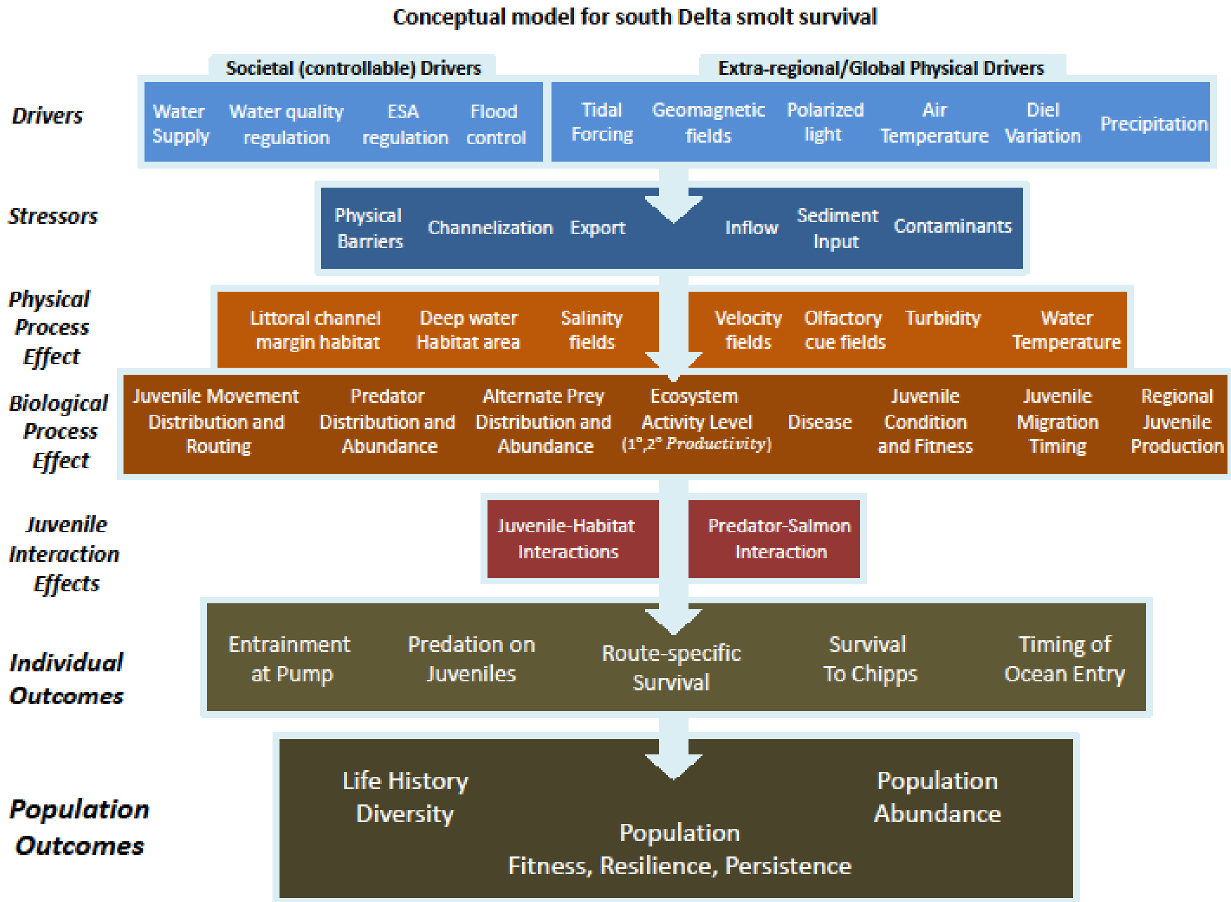

Figure 1. Conceptual Model from the South Delta Salmonid Research Collaborative report to CAMT, February 2014, describing factors affecting survival of juvenile salmonids in the south Delta.

References

Burkhardt-Holm, P., and K. Scheurer. 2007. Application of the weight-of-evidence approach to assess the decline of brown trout (*Salmon trutta*) in Swiss rivers. Aquatic Science 69:51-70.

DiGennaro, Bruce; Reed, Denise; Swanson, Christina; Hastings, Lauren; Hymanson, Zachary; Healey, Michael; Siegel, Stuart; Cantrell, Scott; and Herbold, Bruce. 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). jmie_sfews_11181. Retrieved from: http://escholarship.org/uc/item/3j95x7vt

Suter II, G. W., and S. M. Cormier. 2011. Why and how to combine evidence in environmental assessments: weighing evidence and building cases. Science of the Total Environment 409:1406-1417.

Appendix A: Gap Analysis Approach Proof of Concept

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Upon completion of the "Identification and Prioritization of Gaps in the Current Understanding of Water Project-Linked Effects on Juvenile Salmonid Survival in the South Delta" approach, a subteam was tasked with attempting to use the described method to evaluate Driver-Linkage-Outcome pathways (hereafter referred to as DLOs). For this purpose, three DLOs were selected from an initial list developed by the SST regarding export facility operations and entrainment of Chinook salmon. A preliminary proof of concept exercise was undertaken by subteam members during the week of June 30 and presented to the SST on July 7. This appendix is a final iteration of this preliminary exercise, subject to further analysis and refinement of the analysis process and outcomes of the gap analysis, and contains information presented to the SST and revisions based on their input. While the DLO pathways completed in this document are reasonably representative of what is anticipated to result from the gap analysis, there are numerous other DLO pathways regarding export facility operations and entrainment of Chinook salmon which the subteam did not address. This appendix is provided for illustrative purposes only.

Our first step was to review the South Delta Salmonid Research Collaborative conceptual model and identify what processes and measures may constitute drivers, linkages, and outcomes for a sub-model on this topic (Table 1).

Table 1. Possible Drivers, Linkages, and Outcomes for a Gap analysis submodel of export facility operations and entrainment of Chinook salmon.

Driver	• Tides • Combined operations (e.g., Radial Gate, Louver Cleaning) • Day/Night • Exports • Temperatures • Juvenile proximity (distribution/abundance)
Linkage	• Efficiency • Predator distribution and abundance • Vegetation/Debris • Facility entrance • Fish behavior • Alternate prey distribution and abundance
Outcome	• Direct mortality (includes prescreen and entrainment loss) • Salvage • Collection, handling, transport, and release (CHTR) mortality

The next step was clarifying the previous hypotheses described by SST members into pathways (Table 2). It was estimated that these well documented DLOs could be reasonably examined within a limited timeframe (~8 hours per pathway) and were thus tractable for the proof-of-concept. Submodels of the conceptual model were developed to elucidate the linkages in each DLO pathway (Figures 1-3).

Table 2. Original statement regarding export facility operation and entrainment of Chinook salmon and modified Driver-Linkage-Outcome pathway.

Original	Modified
Volume of exports influences the CVP salvage efficiency. The greater the volume, the higher the facility velocities and the higher the survival to Chipps Island through the facility.	Export velocity affects louver efficiency which affects salvage.
Predation mortality is higher adjacent to the SWP and CVP (i.e., Grant Line Canal and Old River) than in other freshwater reaches of the South Delta and San Joaquin River salmonid migration corridors.	Juvenile proximity (distribution/abundance) affects predator distribution and abundance which affects salvage.
Salmon entrainment into Clifton Court Forebay is not affected by diel cycles.	Diel cycles affect fish behavior affect entrance into facility.

Figure 1. DLO submodel for export efficiency - affects louver efficiency - affects salvage.

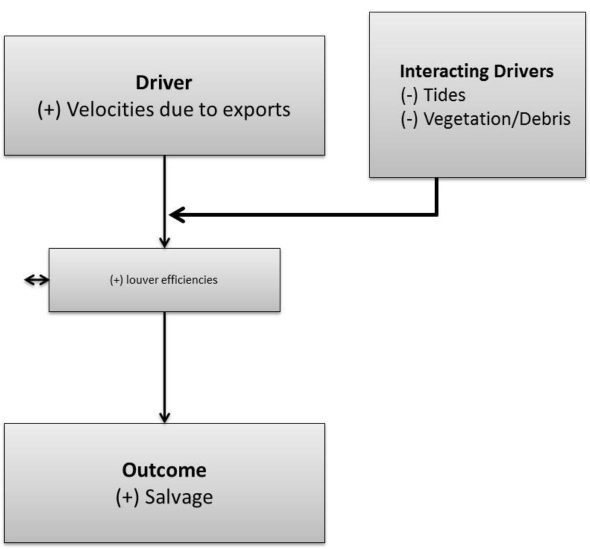


Figure 2. DLO submodel for juvenile proximity (distribution/abundance) - affects predator distribution and abundance - affects salvage.

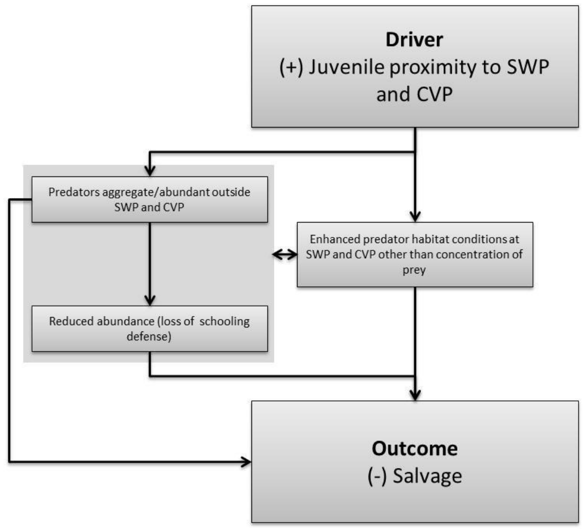
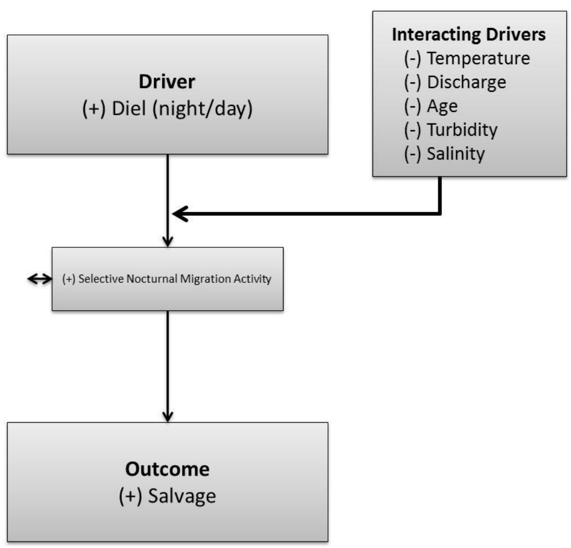


Figure 3. DLO submodel for diel cycle affects - fish behavior - affects entrance into facility.



Using literature sources and other information available to the subteam, standardized narrative forms were completed to document the best available scientific information including data, published reports, unpublished reports, science panel reports, and presentations (Tables 3-5). Upon completion of the tables, the criteria values were placed into a matrix (Table 6). This matrix demonstrates that the criteria used are objective enough to score independent DLO pathways that influence the same outcome differently. These differences will be useful for assessing DLO pathways that require additional analysis and experimentation to evaluate their utility in managing salmonid survival through the south Delta. Further work to develop narratives for additional DLO pathways is necessary to develop a complete score matrix for this topic to consider in identifying specific DLO pathways for data assessment synthesis and adaptive management.

Table 3. Narrative table for export efficiency affects louver efficiency affects Chinook salvage.

Direction	**Variable Outcome:** Numerous lab and field studies have evaluated velocities influence on louver efficiency and noted that efficiencies at the same velocities have decreased through time (Bates and Vinsonhaler, 1961; Haefner and Bowen, 2002; Bowen *et al*., 2004). While the current equation (CDFW, 1986) used to describe the relationship between velocities and louver efficiency is positive, many studies demonstrate more variable empirical estimates of efficiency possibly due to other drivers influencing the mechanism (Bates and Logan, 1960; Bates and Vinsonhaler, 1961; Karp *et al*., 1995; Bowen *et al*., 1998; Haefner and Bowen, 2002; Bowen *et al*., 2004).
Understanding of mechanism	**High Understanding:** Migratory juvenile Chinook behavior, louver efficiencies, and export velocity is well understood. These principles underlie the design, construction, and operations of the fish collection facilities. There is likely some interaction between louver efficiency and fish size. Many publications have recognized that the louver efficiency-velocity relationship is complex and not linear. Karp *et al*. (1995) stated; “The relationship between louver efficiency, flows, velocities, tides, and debris loads is complex and we cannot clearly state which factor more strongly influences performance of the primary system. However, efficiencies were lowest when conducted during low flow/low velocity conditions, and when the louver screens were clogged or out of the water for cleaning. “ Bowen *et al*. (2002) stated “conflicting results leave us without a consistent relationship between approach velocity and Chinook salmon secondary louver efficiency.”
Proximate magnitude of the effect on the outcome	**Medium Magnitude:** The potential effect of louver efficiencies in salvage addresses a limiting factor in the fish protection facilities. It affects the immediate outcome under consideration (salvage).
Ultimate magnitude of the effect on the outcome	**Medium Magnitude:** Only a small fraction of the salmonid populations in the Central Valley enter the facility and are exposed to the louvers. Due to the local scale of the effect of velocity and the interaction of other drivers in the outcome, evidence indicates the potential effect on the outcome is sustained (exports are pretty continuous) but minor spatially.
Independence of interactions with other drivers	**High**, but other drivers interact. **Tides**: Tides are a very influential modulator of this independence given that they happen half the time. Tidal effects are more influential when exports are lower. **Louver cleaning**: Only likely an issue when louvers are packed with plants or pulled up for cleaning. This occurs approx. 60% of the time up to 480 min., but averaging less than 120 min. per day (CFS 2013).

Table 4. Narrative table for juvenile proximity (distribution/abundance) affects - predator distribution and abundance - affects salvage DLO pathway.

Direction	**Negative:** Increase in proximity (i.e., spatially closer) to SWP or CVP increases predation risk mortality (decrease salvage).
Understanding of Mechanism	**General evidence of lower survival for migrations routes near export stations:** For Sacramento origin fish, route-specific survival is lower through the interior Delta (south Delta) where export facilities are located compared to routes through Sacramento River and Sutter and Steamboat Sloughs (Perry, 2010). **General evidence supporting the existence of a dynamic predation environment that could set up a "hot spot" near the CVP or SWP facilities:** -At CCFB, a meaningful number of predator-sized striped bass flux through the radial gates on very short timescales (Gingras and McGee, 1997). -Shallow water piscivores are widespread in the Delta and generally respond in a density-dependent manner to seasonal changes in prey availability (Nobriga and Feyrer, 2007). -Predators can consume large numbers of juvenile salmon in a short period of time (e.g., Shively *et al*., 1996) **Mechanism 1 Aggregated predators at SWP and CVP (High Understanding):** Predators aggregate in areas where flow modulation and prey are present: at CCFB/SWP (Clark *et al*. 2009). Striped bass congregate near screens and louvers (Brown *et al*., 1996); WIDD (Sabal, 2014); out of basin (Rieman *et al*., 1991; Ward *et al*., 1995). More predators = more predation. **Mechanism 1.a Reduction in patch size (Minimal Understanding):** Increased duration of migration period, mortality among cohorts, and overall low abundance leads to disruption of defensive mechanisms such as ability to school contributing to increases in vulnerability to predators at potential hotspots (e.g., CCFB; Petersen and DeAngelis, 2000). Interacts with aggregation of predators.

	Mechanism 2. Enhanced Local Predation Conditions: The SWP and CVP export facilities increase habitat modifications that enhance sensory capabilities of predators (i.e., reduced turbidity increases risk of predation (Gregory and Levings, 1998), velocity and turbulence associated with CCFB radial gate operation (Clark *et al*. 2009), and habitat for predators (SAV, FAV)).
Proximate Magnitude	**Mechanism 1 Aggregated predators at SWP and CVP:** Predators abundant in the vicinity of export facilities (Brown *et al*., 1996)- support significant predation potential (Rieman *et al*., 1991; Ward *et al*., 1995). The current Sacramento River striped bass population of roughly $1{\times}10^6$ adults is estimated to consume about 9% of winter-run Chinook salmon outmigrants (Lindley and Mohr, 2003). **High**-San Joaquin River: close to 50% of all SJR fish pass export facilities. **Medium**-Sacramento River: route specific passage limits exposure to predation for Sacramento origin fish at SWP and CVP facilities. For a December release group, 64.8% of fish took migration routes largely consisting of the Sacramento River and 35.2% migrated into the interior Delta via the Delta Cross Channel and Georgiana Slough. In contrast, only 8.8% percent of fish migrated into the interior Delta through Georgiana Slough in January when the Delta Cross Channel was closed, with the remaining 91.2% migrating mostly within the Sacramento River (Perry, 2010) **Mechanism 1.a Reduction in patch size:** **Insufficient** No local examples. Available information is limited to application of a theoretical model (Petersen and DeAngelis, 2000). **Mechanism 2. Enhanced local predation conditions:** **Medium** Evidence of high rates of tag loss in channels approaching export facilities (VAMP 2011). Many of the SJR fish were observed in the vicinity of export facilities. In the Sacramento River the current striped bass population of roughly $1{\times}10^6$ adults is estimated to consume about 9% of winter-run Chinook salmon outmigrants (Lindley and Mohr, 2003). At Woodbridge Irrigation District dam (WIDD), 10-29% of the juvenile salmon population migrating downstream in the Mokelumne River was estimated to be consumed by striped bass (Sabal, 2014)

Ultimate Magnitude	**Mechanism 1 Aggregated predators at SWP and CVP:** **Insufficient.** Stock/race- specific exposure remains unclear to make expansion to Delta scale. **Mechanism 1.a Reduction in patch size:** **Insufficient** to make Delta scale assessment. Limited to theoretical predation loss estimates. **Mechanism 2. Enhanced Local Predation conditions:** **Insufficient** to make Delta scale assessment. Indirect support for proximate relationship.
Independence of Interactions with Other Drivers	For all Mechanisms: **Low** Minimal independence Interacts with: Tides Combined Operations (Radial Gate, Louver Cleaning) Day/Night Exports Temperatures

Table 5. Narrative table for diel cycle affects - fish behavior affects - entrance into export facility.

Direction	**Positive Outcome (night positively affects entrainment risk):** Acoustic telemetry data for age-1+ late fall-run Chinook salmon showed predominantly nocturnal migration in the upper Sacramento River, which diminished with distance downstream (Chapman *et al*., 2012). While no distinct diel pattern was detected by the time the fish reached San Pablo/San Francisco Bay, a statistically significant tendency toward nocturnal migration was still discernible in the tidal Delta (69% of juvenile detections were at night). Unpublished salvage data (1993-2010), which is an indicator of entrainment, also demonstrates greater salvage density (expanded salvage/thousand acre feet) during night hours. Studies of sea run Atlantic salmon have also found that more juveniles migrate at night than during the day (Ibbotson *et al*., 2006 and other studies cited therein).
Understanding of Mechanism	**High Understanding:** Although the underlying physical mechanisms controlling nocturnal migration are not well understood, the positive influence of night on the tendency of juvenile Chinook salmon, and related salmonid species in other systems, to actively migrate in the Sacramento River is well understood.
Proximate Magnitude of the Effect on the Outcome	**Medium Magnitude:** Chapman *et al*. (2012) and Ibbotson *et al*. (2006) both indicate that diel migration activity is affected by a number of other drivers, and salvage data indicates a sizable portion of Chinook salmon are still participating in salvage during the day; therefore the proximate effect is medium.
Ultimate Magnitude of the Effect on the Outcome	**Low Magnitude:** While evidence indicates the effect of the driver is sustained, only a small fraction of the population of salmonids in the Central Valley is exposed to the export facilities. This local scale effect, coupled with the large influence of other drivers on migration activity, suggest the ultimate magnitude of the diel cycle on salvage is low.
Independence of Interactions with Other Drivers	**Minimal Independence**: Nighttime-specific migration activity diminishes at higher water temperatures (Chapman *et al*. 2012, Ibbotson *et al*. 2006), and is muted by the influence of river discharge, turbidity and possibly age and progression through the migration season (Chapman *et al*. 2012).

Table 6. Combined scores for DLO pathways evaluated in preliminary proof of concept.

Driver	Linkage	Outcome	Direction	Understanding	Proximate Magnitude	Ultimate Magnitude	Independence
Export Velocity	Louver Efficiency	Salvage	Variable	High	Medium	Medium	High
Proximity	Predator Abundance	Salvage	Negative	High	High (SJR) Medium (SAC)	Insufficient	Minimal
Proximity	Reduction in Prey Abundance/ Schooling Defense	Salvage	Negative	Minimal	Insufficient	Insufficient	Minimal
Proximity	Predation Opportunity due to Favorable Habitat Conditions	Salvage	Negative	Medium	Medium	Insufficient	Minimal
Diel Cycle	Fish Behavior	Participation	Positive	High	Medium	Low	Minimal