Summary of SWFSC report to USBR on analysis on subset of Steelhead "6-year Study" acoustic telemetry data

Background: The SWFSC (Dr. Andrew Hein) used a subset of six-year study steelhead acoustic telemetry data at five hydrophone arrays in the Delta to understand the relationship between the instantaneous migration rate and environmental variables using a novel point process statistical model framework. The instantaneous migration rate refers to the minute-by-minute fish movements into the zone within range of detection by a hydrophone array, rather than the long-term movements of fish throughout the system.

Methods (refer to Fig. 1): Acoustically tagged fish were released at Durham Ferry (release location) and subset for analysis purposes to include mostly 2011 data. The environmental variables of interest were turbidity, conductivity, temperature, diel phase, discharge, and the rate of discharge over time. These data were subjected to a symbolic regression (point process model) aimed at generating a variety of models to predict the instantaneous movement behavior in response to different environmental variables, specifically the expected arrival of fish at location x and time t.

Results (refer to Fig. 2): Discharge, conductivity and turbidity were the variables that most often had the strongest relationship with the arrival rate of steelhead at the subset of hydrophone arrays investigated. The conditional effects of each environmental variable (varying one variable at a time while holding all others at their mean value) for each hydrophone array location are described below:

- At **BCA** (near release site), arrivals of fish were negatively related to discharge, and positively related with warmer and more turbid water conditions.
- At **SJL,** turbidity and temperature exerted dominant effects on arrival rates with a slightly less pronounced effect of water conductivity, however discharge did not have a strong influence. The conductivity effect was stronger than at other arrays higher in the river.
- At **Turner Cut (C18/16),** a more tidally influenced region, the fish moved most with high conductivity, discharge, temperature and turbidity – with discharge and conductivity having the strongest positive relationship with arrivals. (More tidal region)
- At **Jersey Point (JPT)** arrival rates were positively correlated with conductivity with less influence to no relationship with other variables. (More tidal region)
- At the **Old River (ORN)** hydrophone array, there was a different pattern in arrivals in relation to environmental variables than at other arrays investigated here. Specifically, predicted fish arrival rates increased with strong negative flows and with positive flows (a non-linear relationship) with also a small net positive effect of turbidity.

Caveats: The analysis in this report was done as a proof of concept for the modelling framework, not to answer specific management related questions. Only one full year of data was used (2011) and as such results only provide a partial understanding of conditions that might affect steelhead movement during dry years. Further, models assume that detection probability for a given hydrophone array are constant but there is likely different detection probabilities through time for each array. The models also do not necessarily use the most representative

(closest) gauge data for environmental data to model with arrival detections. Other gauges or hydrological models might be appropriate to use here to couple environmental conditions with arrival detections at hydrophone locations.

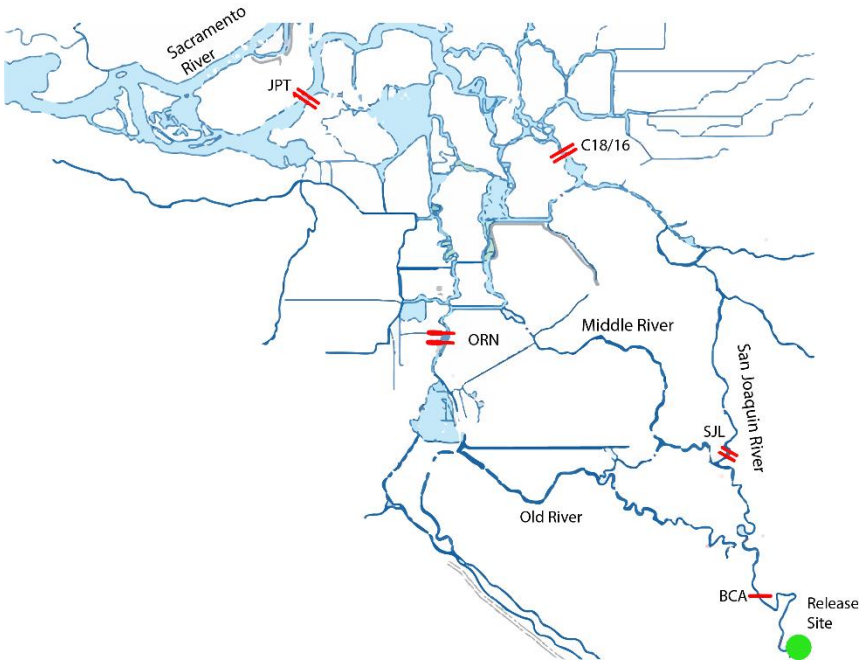

Fig. 1) Map of the Sacramento/San-Joaquin Delta with locations of single or dual hydrophone arrays (represented by one and two red bars, respectively) used in the analysis.

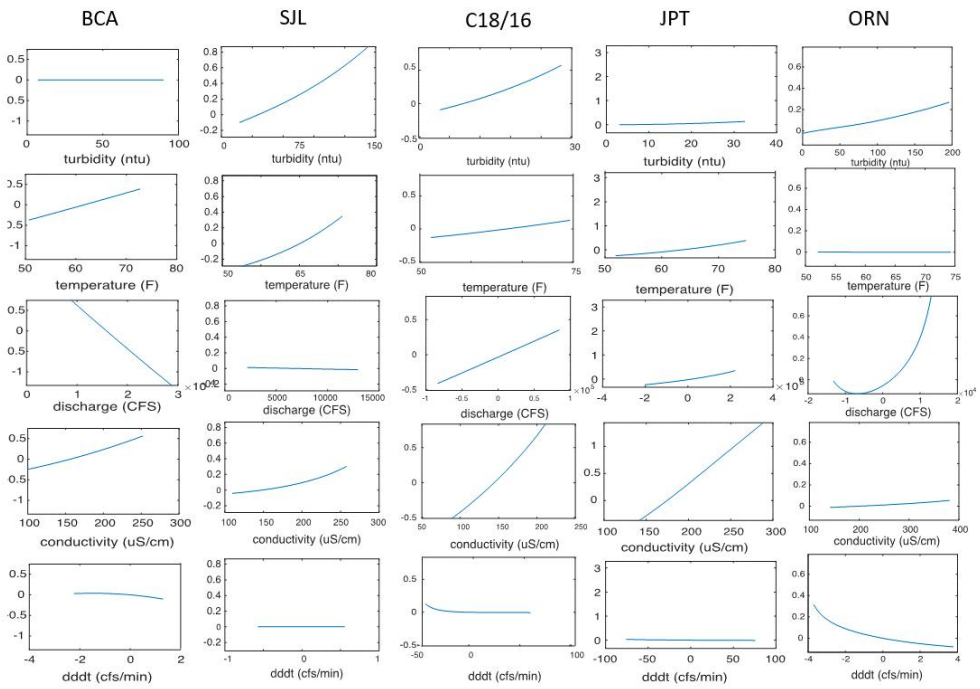

Fig. 2) Model averaged conditional effect of each environmental variable (holding others constant at mean values) on arrival rates for each hydrophone array within the Delta. Column names (BCA, SJL, C18/16, JPT, ORN) refer to individual hydrophone arrays within the Delta identified in Fig 1.