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TECHNICAL MEMORANDUM

Date: March 19, 2015

To: Steve Centerwall, ICF International; Adam Smith, ICF International; Cassandra Enos, DWR

From: Robertson-Bryan, Inc.

Project: Bay Delta Conservation Plan EIR/EIS Water Quality Chapter

Re: San Joaquin River Salinity Objective at and between Jersey Point and Prisoners Point

Introduction

The most recent version of the Bay-Delta Water Quality Control Plan (Bay-Delta Plan), adopted in 2006, contains a salinity objective for the San Joaquin River for the protection of striped bass spawning. The objective is 0.44 millimhos per centimeter electroconductivity (mmhos/cm EC) on the San Joaquin River at and between Jersey Point and Prisoners Point from April 1 through May 31 during all water year types except critical years, measured as a maximum 14-day running average of mean daily EC.

The purpose of this technical memorandum (TM) is to provide background information on the San Joaquin River salinity objective, as a means to provide context for Bay-Delta Conservation Plan (BDCP) modeling results that show a greater number of exceedances of the San Joaquin River salinity objective occurring under Alternatives 2, and 4-8 than under the baseline conditions.

Modeled Exceedances

Alternative BDCP modeling for the period of water year 1976 through 1991 determined that a greater number of exceedances of the San Joaquin River salinity objective occurred under Alternatives 2, and 4-8 than under the baseline conditions. Depending on the Alternative, exceedances generally occurred in six out of the 16 years (1976, 1978, 1981, 1985, 1987, and 1989), all of which were categorized as dry years at the late long term except for 1978, which was an above normal water year type. EC values during the exceedances ranged from 0.44 mmhos/cm (the standard) to 0.60 mmhos/cm. Exceedances occurred in April in all six years and in May all six years except 1978, the above normal water year type. The cause of the exceedances appears related to an increase in San Joaquin River flow due to Head of Old River barrier operations and/or less south Delta diversions – Alternatives 1 and 3 have more south Delta exports due to I/E ratio differences.

History and Background of the San Joaquin River Salinity Objective

The origin of the San Joaquin River salinity objective, as shown above, goes back to the late 1960's when the State Water Resources Control Board (SWRCB) began to recognize that the State and federal water projects were likely impacting biological resources in the Sacramento-San Joaquin Delta (Delta). To mitigate these impacts the SWRCB adopted various water quality objectives and standards, including the San Joaquin River

salinity objective, which were intended to ensure the continued viability of aquatic resources in the Delta. The San Joaquin River salinity objective was specifically adopted to protect striped bass and was modified several times from its initial adoption in 1967 through 1995.

On June 14, 1967 the SWRCB adopted Supplemental Water Quality Control Policy 68-17 (Policy 68-17). Policy 68-17 contained the following water quality objective, which used chloride as the indicator of salinity and was primarily for the protection of neomysis, an important prey species for striped bass: At Jersey Point in the San Joaquin River and at Emmaton in the Sacramento River, an average mean daily chloride content of 200 parts per million or less for a period of at least 10 consecutive days each year during the period April 1 through May 31, except in dry and critical years.

On July 28, 1971 the SWRCB adopted Water Right Decision 1379, which included the first standard specifically for the protection of striped bass spawning. The standard was: for five weeks after the water temperature at Antioch reaches 60° F the mean daily salinities in the San Joaquin River at the Antioch Water Works Intake and at Prisoners Point shall not exceed 1.5 mmhos/cm EC and 0.55 mmhos/cm EC, (approximately 1,000 and 350 mg/l TDS, respectively).

On August 16, 1978 the SWRCB adopted both the 1978 Delta Plan and Water Rights Decision 1485 (D-1485). The 1978 Delta Plan included water quality objectives intended to protect municipal and industrial, agricultural, and fish and wildlife beneficial uses in the Delta, and fish and wildlife beneficial uses in Suisun Marsh. D-1485 was adopted as the primary means to implement the 1978 Delta Plan. Both the 1978 Delta Plan and D-1485 were specifically intended to provide water quality standards in the Delta that resulted in water quality as good as the levels which would have been available had the State and federal water projects not been constructed. The San Joaquin River salinity objective included in D-1485 was designed to maintain the Striped Bass Index (CDFW's monitoring based index which was and continues to be the primary means of evaluating the overall condition of striped bass over time) at a long-term average equivalent to the so-called "without project condition." Specifically for the protection of striped bass spawning, D-1485 established a salinity objective of 0.55 mmhos/cm EC at Prisoners Point on the San Joaquin River. The objective was measured as the average of mean daily EC for the period April 1 through May 5, and was applicable in all water year types.

On May 1, 1991 the SWRCB adopted the 1991 Bay-Delta Plan. In recognition that striped bass populations were continuing to decline and previous salinity objectives were not achieving their intended and expected results the 1991 Bay-Delta Plan revised the San Joaquin River salinity objective to 0.44 mmhos/cm EC at Prisoners Point from April 1 through May 31 (or until spawning has ended) during all water year types, measured as a maximum 14-day running average of mean daily EC. This revision reduced the salinity concentration and extended the compliance period as compared to the 1978 plan.

On May 20, 1995 the SWRCB adopted the 1995 Bay-Delta Plan, which again altered the San Joaquin River salinity objective. Revisions included alteration of: 1) the compliance location, which was expanded from the San Joaquin River at Prisoners Point to the San Joaquin River at and between Jersey Point and Prisoners Point, 2) the water year types, which eliminated compliance of the objective during critical water year types, and 3) the compliance period, which eliminated the "or until spawning has ended" language.

The 2006 Bay-Delta Plan did not include any revisions to the San Joaquin River salinity objective. The SWRCB is currently working towards a substantial update and modification of the Bay-Delta Plan; however, there does not appear to be any discussion of altering the San Joaquin River salinity objective. Therefore, the current version of the San Joaquin River salinity objective has remained unchanged since 1995 and there appears to be low probability that the SWRCB will alter it in the near future.

Striped Bass in the Delta

Striped bass (*Morone saxatilis)* is an introduced (i.e., non-native) species in California that was first planted in the Delta in 1879 (Moyle 2002). Shelby (1917) called the successful introduction of striped bass on the West Coast of California "one of the greatest feats of acclimation of new species of fish in the history of fishculture..." Striped bass populations were strong from their introduction into the Delta in the late 1800s through the early and mid 1900s, as evidenced by the species supporting important commercial (late 1800s and early 1900s) and recreational fisheries (mid 1900s) (Chadwick 1968). However, by the end of the 1970's the Bay-Delta striped bass population began a period of steep decline, which has continued despite increased scrutiny and evolving protection measures aimed at striped bass.

Current striped bass population estimates continue to be at historically low levels. The 2014 striped bass total index was 0.3 (combined Delta and Suisun Marsh indexes), which is equal to the lowest on record, dating back to 1959 when the index was first compiled. As a point of reference, the water quality objectives of D-1485 were designed to maintain the striped bass index at a long-term average of 79.

Striped Bass Spawning in the Delta

Striped bass are an anadromous fish that spends the majority of its life in saltwater, returning to freshwater to spawn. While in saltwater, the Bay-Delta striped bass population is concentrated in San Pablo Bay, San Francisco Bay, and the Pacific Ocean (Moyle 2002). Spawning occurs in the spring, peaking between May and early June but can begin as early as April (Moyle 2002). Historically, the majority of spawning occurred in two main areas, the Sacramento River between Isleton and Butte City and the San Joaquin River between Antioch and Venice Island (Farley 1966); however, specific locations are dictated on an annual basis dependant on water temperature, river flow, and salinity (Moyle 2002). Approximately one-half to two-thirds of striped bass spawning occurs in the Sacramento River system, while the remainder spawn in the Delta and the lower San Joaquin River below Vernalis (BDOC 1993). Important spawning areas in the San Joaquin River include the area between Antioch Bridge and the mouth of Middle River (BDOC 1993). Successful spawning in the San Joaquin River upstream of the Delta occurs mainly during years of high flow, when runoff dilutes the irrigation water that makes up most of the river's flow (Moyle 2002).

Striped bass spawn in freshwater; consequently, salinity is an important factor in where they spawn. Therefore, the reach of the San Joaquin River between the Prisoners Point (i.e., Venice Island) and Jersey Island (near the Antioch Bridge) is considered an important spawning area for striped bass. The area downstream of the Prisoners Point has reduced salinity due to fresh water from the Sacramento and Mokelumne rivers diluting the saltier San Joaquin River and the area upstream of the Antioch Bridge is typically less impacted by salt water intrusion.

Several research studies have evaluated the impacts of salinity on striped bass spawning in the Delta. Radke and Turner (1967) determined that in 1966 striped bass did not migrate through salinities in the eastern Delta when EC exceeded 0.55 mmhos/cm (likely the basis for the standard included in Water Right 1379). The IEP (1987), using historical striped bass spawning surveys, determined that the majority of spawning occurred where EC was less than 0.30 mmhos/cm. In several of the drier years (i.e., 1968, 1972, 1976, and 1977), when salinity intruded into the Delta, striped bass spawning shifted upstream, but not necessarily high enough to avoid higher salinities, as evidenced by the fact that about 25% of spawning occurred in salinities between 1.5 and 1.8 mmhos/cm in 1972 and between 3.0 and 6.0 mmhos/cm in 1977 (IEP 1987). Because there are likely dry year impacts to striped bass other than those attributable to increased salinity (e.g., altered hydrology, increased entrainment, impacts to food web productivity), the extent to which

age 0+ striped bass were affected by the increased salinity is not known, however, it is worth noting that the results of the striped bass index in 1972 and 1977 were the lowest recorded at the time of each survey, respectively. Turner (1976) assessed striped bass spawning in the Sacramento and San Joaquin rivers from 1963 to 1973 and concluded that in the Delta, striped bass generally spawn where the water is very fresh (<200 mg/l TDS (approximately 0.31 mmhos/cm EC)). Turner went on to state that "at least in the short run though, water that fresh is not that essential, as spawning occurred in approximately the same location in 1968 and 1972, despite ocean derived salinities reaching 1,500 mg/l TDS" (approximately 2.3 mmhos/cm EC). Turner concluded that "while salinity within the ranges discussed above (i.e., 0.31 to 2.3 mmhos/cm EC) apparently does not increase egg mortality and has at most a limited short term effect on the location of spawning, the longer term effect of such salinities is uncertain. Striped bass have a pronounced tendency to return to the same spawning area each year, and thus might respond little to occasional less than optimum salinity conditions. Yet, regular occurrence of the same salinity could reduce spawning in the area gradually, due to accumulative effects of either small differences in survival or migratory preferences."

In addition to the field studies discussed above, laboratory studies have been conducted to determine potential impacts of increased salinity on striped bass egg and larvae survival. Turner and Farley (1971) indicated that ECs up to 1.5 mmhos/cm do not adversely affect egg survival. Fay et al. (1983) in a literature review of tolerance and optimal values on striped bass concluded that striped bass eggs tolerate salinity ranging from 0 to 15.6 mmhos/cm EC with optimal salinity ranging from 2.3 to 4.7 mmhos/cm EC. Fay et al. (1983) also concluded that striped bass larval stages tolerate salinity ranging from 0 to 23.4 mmhos/cm EC with optimum salinity ranging from 5.3 to 52.7 mmhos/cm EC.

Conclusions

Based on the conclusions of Turner (1976) and IEP (1987), higher salinities in the San Joaquin River at and between Jersey Point and Prisoners Point, as modeled for Alternatives 2 and 4-8, have the potential to affect the location of where striped bass spawn. However, the significance of a shift in the location of where striped bass spawn is difficult to evaluate and further research on potential impacts may be necessary to fully understand how exceedances of the San Joaquin River salinity objective could affect striped bass populations.

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