

Numeric recommendations for flows to protect estuarine resources

This letter combines the functional flow relationships summarized and described in Fleenor et al. and presented to the Board at their March 22, 2010 workshop with a consideration of the historical hydrology of the Central Valley. Flow functionality is useful because it highlights the appropriate performance measure and the science needed to improve the standard. A functional approach also allows for easier adaptation of flow needs as the physical habitat changes either through restoration actions or the catastrophic loss of levees.

Table 3 in Fleenor et al. 2010 lists flows associated with various ecological functions, describing their rates, seasonality and frequency within a ten year period. Consideration of the historic hydrology of the Central Valley shows clearly that there is tremendous variability in frequency of the various hydrologic year types in different decades. Therefore, to implement a function-based suite of flows, as described in Table 3 of Fleenor et al. 2010, it is better to associate flow requirements with some measure of upstream hydrology. This approach rather than a percent frequency of occurrence is likely more effective ecologically and more implementable because it links higher delta flow requirements to years when more water is available.

These comments address only delta outflow, not internal delta flow conditions such as Yolo Bypass flows, Old and Middle River flows, flow needs of eastside streams, or instream flows on mainstem rivers. However, linking delta outflow needs to water availability upstream promotes a watershed approach that is likely to best meet the needs of the desired ecosystem.

Linking upstream conditions with delta flow conditions already is in use for the Estuarine habitat standard which uses the 8-river index of one month to set outflow/X2 requirements for the subsequent month (SWRCB 2006).

Targeted Beneficial Uses

Two beneficial uses identified by the board (SWRCB 2006) encompass the valuable biological resources of the estuary that were the subject of most discussion at the Board's workshop in March:

Migration of aquatic organisms (especially salmon, steelhead and sturgeon) and

Estuarine habitat (especially for delta smelt, longfin smelt, Sacramento splittail, striped bass and the food web associated with these species).

These two beneficial uses include the state and federally listed fish (and other valued species) so they also would seem to encompass the fish associated with the beneficial use of Rare, Threatened or Endangered Species. However, flows adequate to protect the listed species may not encompass all the needs of the species associated with these beneficial uses. In addition, measures in the biological opinions for listed species are aimed at avoiding jeopardy as posed by particular projects. Such measures may not be adequate to meet the Board's broader challenge.

Functional flow measures to protect migratory species

San Joaquin Valley migratory species include fall-run salmon and steelhead; they do not include winter-run salmon, spring-run salmon or sturgeon. This allows a narrower focus on fewer taxa than for the Sacramento Valley. A migratory corridor for anadromous fish consists of two parts; 1) a physical channel that provides adequate feeding and resting habitat for the migratory species and 2) a hydrodynamic connection that connects the freshwater spawning habitat with the oceanic maturation habitat. In the lower San Joaquin River the physical nature of the channel offers little refuge from predation on juveniles and amplifies the effects of other stressors such as contaminants, toxics and low dissolved oxygen levels. The hydrodynamic connection of the waters of the San Joaquin Basin with the waters of San Francisco Bay has been absent for 40 km of the river channel through the delta under all year types in all seasons of recent years (Fleenor presentation to the Board March 22, 2010).

Two factors affect the formation of a hydrodynamic bridge from the San Joaquin River to the Bay: the level of San Joaquin River inflows and the amount of water removed from south delta channels. As noted in the Delta Science Program/SWRCB review of the Vernalis Adaptive Management Program earlier in March, all of the San Joaquin inflow at Vernalis goes to the south delta diversions if those diverters are taking more than the San Joaquin River inflow.

The 2009 NMFS Biological Opinion for the Operations Criteria and Plan of the State and Federal water projects requires that inflows at Vernalis significantly exceed expected diversion rates for two months of the juvenile outmigration period. In addition, a range of San Joaquin River flows are required that change with upstream hydrology and through time. These flow and export regimes are probably adequate to ensure some level of hydrodynamic connectivity between the river and the bay. As such they provide an excellent experimental matrix for VAMP type studies to measure the degree to which different hydrodynamic conditions control salmon passage. Steelhead may not benefit to the same degree as salmon by the use of flow criteria, but by focusing on a functional approach for migratory corridors, species specific differences play a smaller role.

The use of natal stream chemistry to guide adult salmon back to their spawning grounds is a basic feature of salmon management world-wide. It is therefore surprising that no effort to ensure a migratory corridor exists for adult salmonids of the San Joaquin River. During the adult salmon upmigration season, south delta diversions are frequently almost an order of magnitude greater than San Joaquin River inflows (As evidenced by almost all years in the DAYFLOW database). Under such combinations of diversion and inflow, there is effectively no hydrodynamic connection between the Bay and the San Joaquin River.

The very large adults of chinook salmon and steelhead trout can transit the delta much more quickly than their juveniles. Therefore, although they are thought to be entering the delta for several months in the fall (Moyle 2002; NMFS 2009), protection of their migratory corridor through the delta could be a much briefer and/or sporadic event. A suitable condition would be hydrodynamic conditions like those stipulated for the fall (i.e. total south delta diversions of about San Joaquin River inflow) but because of the much greater swimming ability of adults, the migratory corridor for adults might be needed for as

little as 3 or 4 days, but would be needed several times through the fall months. To ensure genetic diversity amongst the returning adults so the migratory window could be opened at different times in different years and for multiple times in years when San Joaquin Valley reservoirs have been filled by wetter springtime conditions.

Functional flow measures to protect estuarine habitat

Springtime estuarine habitat needs of resident fishes were the basis for the Board's adoption of flow/X2 requirements in the 1994/2006 Water Quality Control Plans. As described in the Delta Smelt Biological Opinion for OCAP (USFWS 2008), total annual diversions increased by about one million acre-feet decreasing fall outflows to the bay by a like amount, since delta inflows did not change. In addition, it appears that the projects were able to manipulate springtime conditions in order to avoid some of the higher outflow requirements (Bay Institute testimony to the Board's 2006 WQCP).

Resident species like the smelts, striped bass and their foodweb require adequate habitat year-round. An essential element of the habitat needs of species that have formerly thrived in the estuary appears to be variability in habitat conditions. Variability in the extent and distribution of various seasonal conditions of salinity, turbidity, temperature and other features of the open-water environment appears to give a competitive edge to these species (Moyle and Bennett 2010). Flow conditions affect salinity and other aspects of the open water environment. Since 2000, outflows in the fall have become much lower and less variable than they were historically (CCWD 2006). More constant conditions promote the spread of aquatic weeds, toxic algae, jellyfish, invasive clams and the invasive freshwater fishes of eastern North America (Moyle and Bennett 2009).

Variability in February-June flow conditions is already assured somewhat by the current estuarine habitat standard. The widely described shift toward more rainfall and less snow in the spring months suggests that variability in this season is likely to remain fairly large. However, the use of a trigger for the Roe Island X2 requirement limits variability under moderately wet conditions. Variability of springtime flows during more normal years could be assured simply by removal of footnote [d] in Table 4 of the 2006 WQCP.

Estuarine habitat in the summer months (July and August) is most affected by the spread of aquatic weeds and the effects on turbidity and fish communities that accompany them (Feyrer et al 2009). Drinking water and agricultural standards may continue to serve as adequate protection of the flow associated aspects of summertime habitats. As guidance for future planning of the delta, the value of outflows during the summer must be recognized. As per Table 3 in Fleenor et al. 2010 it may be valuable to use variability in flows in these months in experimental approaches to the control of invasive clams, weeds and mussels that are intolerant of brackish water. However, the current delta configuration and beneficial uses would make such experiments difficult to pursue.

Fall (September-November) open-water habitat conditions have changed substantially in the last 10 years. In the 1990s fall monthly outflows varied substantially (3000 cfs-20,000cfs) but since 2001 delta

outflows in these months have varied little from a minimum of 3500 cfs (DAYFLOW and USFWS 2008). The delta smelt Biological Opinion for OCAP requires some restoration of this former variability. The level of variability is enough to restore some measure of smelt habitat but may not be enough to interfere with the growth and survival of the overbite clam or other invasive freshwater species.

A substantial first step toward providing adequate Fall outflow variability would be to take the 1990s as a reference conditions. Since September - November crosses two water years, it is important to link September-November outflows with the upstream conditions that occurred in the preceding spring, rather than trying to forecast conditions of the spring of the water year that begins in October.

An alternative approach to restoring fall outflow variability would be to ensure that all flood control releases in these months were not available for export.

Functional flow measure integration

Water flows unite watersheds. Anadromous species tie together the various reaches of the watershed with their needs for cool, constant spawning flows below the dams and adequate migratory conditions to and from the ocean. However, resident delta species not only benefit from direct habitat improvement via flow, such as wetland inundation and greater volumes of suitable salinity habitat but flows transport nutrients and food downstream. Thus, delta outflows are most likely to achieve ecosystem benefits when managed on a watershed level and when flow needs are put in the context of water quality and the bathymetry the water will pass over.

The two ecosystem aspects addressed here lend themselves to watershed considerations and multiple beneficial effects of flow. Springtime conditions that promote an adequate migratory corridor for San Joaquin salmonid juveniles overlap with the sensitive time for smelt juveniles which were spawned in the delta and are moving downstream to Suisun Bay. Fall outflow requirements to increase variability of smelt and striped bass habitat coincide in time with the need to establish a migratory corridor from the bay to the natal streams of the all salmonids. The higher flows needed to support estuarine habitat are likely to serve as guidance for adult salmon, steelhead, sturgeon and American shad back to their native streams. Since these delta outflows would be derived from required flood protection releases, they could not conflict with the management of reservoirs for cold water pools or other uses.

A migratory corridor for adults is particularly important for the San Joaquin populations which have declined most precipitously and for which no meaningful fall hydrodynamic connection currently exists. Especially in the case of the San Joaquin River, ensuring that some part of all flood control releases in the fall are at least partially allowed to transit the delta could serve as an important migratory cue all the way from the bay to the salmon and steelhead spawning habitats.