The Bay Institute

by email
(Federal Rulemaking Portal, www.regulations.gov, Docket # EPA-R09-OW-2010-0976)
and hardcopy

April 25, 2011

Erin Foresman
U.S. Environmental Protection Agency
75 Hawthorne Street, WTR-3
San Francisco, CA 94105

RE: ADVANCED NOTICE OF PROPOSED RULEMAKING

Dear Ms. Foresman,

This letter is submitted as the comments of The Bay Institute regarding the Unabridged Advanced Notice of Proposed Rulemaking (ANPR) for Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, published by the U.S. Environmental Protection Agency (USEPA) in February 2011.

For the most part, the ANPR provides a good overview of water quality challenges in the estuary and poses important questions regarding future management. We too are concerned about the potential individual and synergistic effects of the broad spectrum of contaminants introduced into estuarine waters and strongly support actions to better understand these effects and to reduce overall loadings of these contaminants. However, we are most concerned about the well-documented, large-scale effects of modifying aquatic habitat (including estuarine habitat, fish migration corridors, and wetlands), probably the primary stressor in the Bay-Delta estuary, and the well-understood effects of selenium on Bay-Delta fish and wildlife resources. There is more than sufficient scientific information available to conclude that current levels of aquatic habitat modification and selenium contamination are extremely serious problems and that current water quality regulations are not adequate to address these problems, and to develop and promulgate new rules that will fully protect beneficial uses of the estuary's waters.

ESTUARINE HABITAT

The ANPR correctly identifies the maintenance of low salinity (and therefore higher outflow) conditions as essential to the protection of estuarine habitat, finding that:

1) ñé X2 is an effective indicator of ecosystem conditions from year to yearò (pp. 51-52);

2) ñA number of factors are apparently important for the health of estuarine species, but the location of the low salinity zone (X2) plays a large role,ò which continues to be as important as it has been in the past (p. 52); and,

3) the position of the low-salinity zone (or a close correlate such as outflows or the strength of gravitational circulation currents) appears to have a strong influence on populations of pelagic fish and invertebrates in both the fall and spring months (pp. 52-53).

These findings are not only consistent with recent findings of the State Water Resources Control Board (SWRCB 2010), California Department of Fish and Game (CDFG 2010), and US Fish and Wildlife Service (USDOI 2010), but are, in fact, unavoidable given the overwhelming evidence documented in an extensive series of scientific studies and reviews over the past three decades that reveal high magnitude, statistically significant, long-term positive relationships between the abundance of numerous fish or invertebrate prey species and the flow of fresh water out of the Delta. The ANPR errs, however, in focusing on admittedly critical fall X2 conditions while overlooking the even larger degradation of habitat values that are indexed by winter-spring X2 values.

What, if any, information is available to determine if an increase in low salinity habitat would affect the fate, concentration and distribution of nutrients and toxics that are potentially negatively affecting the estuarine food web?

<u>Current conditions of higher X2 values (lower Delta outflows) prevent estuarine habitat from providing natural dilution and flushing services.</u>

Implicit in this question is the central role that fresh water flow plays in modulating all impacts to aquatic habitat quantity and quality in the Delta. USEPA should explicitly recognize Delta fresh water outflows as a primary driver of ecosystem processes, and severe modifications to the unimpaired Delta hydrograph as the primary stressor on the Delta ecosystem. Low salinity zone habitat results from the interaction of marine influence and fresh water outflows from the Delta to San Francisco Bay. As fresh water outflow from the Delta increases, the volume of low salinity habitat increases and shifts to the west (Kimmerer et al. 2009). The long-term trend of decreased fresh water outflow relative to unimpaired outflow, and recent extremes of this trend, have served to concentrate nutrients and suspected toxins within the low salinity zone of the

Delta. For example, Dugdale et al. (2007) indicate that increasing Delta outflow in the spring may alleviate levels of ammonium that potentially impair foodweb productivity. Recognizing this fact is not at all the same as arguing that ñdilution as the solution to pollution.ò Rather, it is to acknowledge that Delta outflows play a critical role in supporting natural dilution and flushing processes in the Delta, and that USEPA can restore this ecosystem process by requiring more natural volumes and temporal patterns of Delta outflow (i.e., a more natural Delta hydrograph).

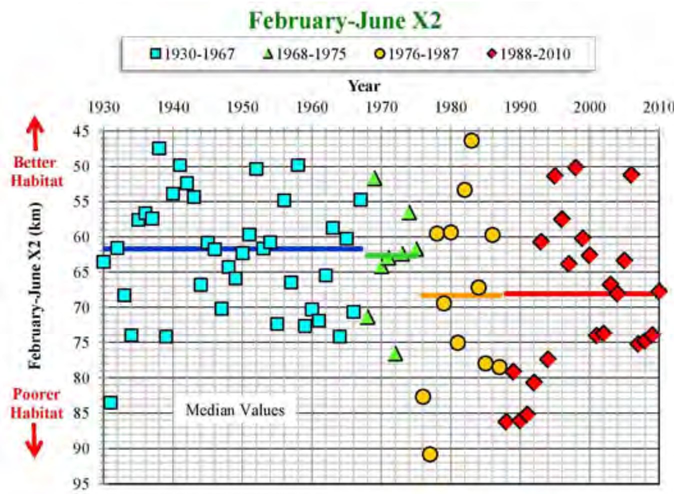
Could the frequency, area, and/or duration of low salinity habitat be changed so as to achieve ecosystem benefits for the suite of species that use the low salinity zone? If so, how? Is historical data on inter-or intra-annual frequency of variability the best basis for setting goals or are there other bases that could be used?

<u>There is an overwhelming need for improved winter-spring and fall X2 conditions ï and an extensive body of scientific evidence for adopting new regulations to protect estuarine habitat and numerous pelagic species dependent on that habitat.</u>

Winter-spring and fall X2 (or outflow) effects should be treated separately by USEPA because the effects of outflow (or X2) in the winter-spring and fall periods have different histories, patterns, and probable origins. The ANPR correctly identifies recent sustained increases in fall X2 (decreased fresh water outflow in the fall) as a negative impact to pelagic fish populations ï a finding with which we agree. However, although the ANPR references many of the numerous studies that document strong correlations between winter-spring X2 and the abundance and distribution of pelagic organisms, it does not identify long-term increases in winter-spring X2 (decreased winter-spring fresh water Delta outflow) as a large-scale negative impact to a wide variety of pelagic species and ecosystem processes. The X2:abundance relationships in winter-spring are strong, durable, and demonstrate the incremental benefits of flow to populations of numerous pelagic species. The bases for adopting new regulations to improve winter-spring estuarine habitat conditions in the Delta are even stronger than those for improving fall habitat conditions.

The degradation of winter-spring estuarine habitat conditions over time has been dramatic, and clearly linked to declines in abundance and distribution of estuarine species. With respect to baseline hydrological conditions (i.e. the ñ8-River indexò), winter-spring X2 has increased substantially over time (Figure 1a). Not surprisingly, most of the pelagic species that respond to winter-spring X2 have declined precipitously in recent decades (Kimmerer 2002a; Sommer et al. 2007; Kimmerer et al. 2009) while net Delta outflow (NDO) has remained less than 50% of unimpaired Delta outflow in a majority of years (Figure 1b). Clearly, the existing water quality objectives related to winter-spring X2 have proven to be insufficient to protect, much less restore, the pelagic fish species and important prey species of the Bay-Delta estuary.

a)



b)

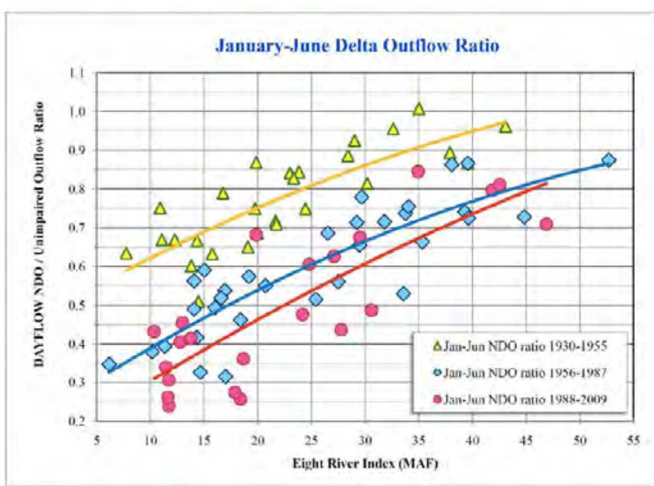


Figure 1: (a) Trends over time in X2 position (indicating the position, extent, and qualities of low-salinity habitat) and (b) the ratio of net Delta outflow (NDO) to unimpaired outflow (indicating the amount of unimpaired winter-spring outflow that makes it out of the Delta to the rest of the Estuary). These indicators reveal extreme impacts to natural processes and low salinity habitats in the Bay-Delta estuary over recent decades. (note: X2 is typically calculated for Feb-Jun time period, whereas the outflow calculations typically use a slightly longer Jan-Jun season).

The ANPR mingles evidence supporting the benefits of low winter-spring and fall X2 values. Whereas there is strong evidence that outflows are important to pelagic species in both seasons, the impacts of Delta outflow in fall and spring are different with regard to species affected (or at least those with high magnitude, statistically significant relationships) and the nature of the flow:abundance relationships. For example, winter-spring outflows (or X2) have been statistically correlated with the abundance indices of numerous pelagic species on a log-log (log-linear, for X2) basis in multiple data sets for the entire time period that abundance indices have been recorded (e.g. Jassby et al. 1995; Kimmerer 2002a; Rosenfield and Baxter 2007; Kimmerer et al. 2009; Thomson et al. 2010). The relationships are consistent with our understanding of the behavior and ecology of estuarine pelagic species and appear to reflect natural processes that operated historically in the Delta. The flows involved are far less than unimpaired spring outflows (Figure 1b); thus, flow standards can be attained with available water.

Winter-spring X2 -- In our 2010 testimony to the State Board (TBI 2010b, *attached*), we analyzed the historical relationship between abundance, population growth, and spatial distribution of several pelagic fish species and winter-spring Delta outflow (the controllable causal factor in determining X2). In a retrospective analysis, we studied Delta outflow in the period 1967-1987, a time when most native pelagic species populations displayed acceptable levels of these attributes of viability. We also analyzed population growth metrics for several pelagic species and compared those with Delta outflow values since 1987 (following introduction of the invasive clam *Corbula amurensis*); we found a very strong relationship between levels of Delta outflow and the recent historical frequency of inter-generation growth of longfin smelt and *Crangon* shrimp (the two populations we studied). Specifically, a logit analysis of longfin smelt productivity indicated that the likelihood of positive productivity was 50% in years with March ï May Delta outflows of ~6.3 MAF (TBI 2010b; Figure 15); flows above that level corresponded to an increasing incidence of population growth. Our analysis also suggested that outflows during March ï May that were likely to produce population growth for longfin smelt were even more likely to produce a positive population response for *Crangon* shrimp, an important food item for fish in the pelagic zone of the estuary (TBI 2010b; Figure 16). A logit analysis of the relationship between Delta outflow in the January-March period indicated that Delta outflows of ~9.1 MAF corresponded to a 50% likelihood of inter-generational growth in the longfin smelt population (TBI 2010b). Results from our analyses of flows that corresponded to population growth in the recent past matched remarkably well with our analysis of flows that corresponded to desirable population abundance levels from an earlier period of sampling (1967-1987).

Based on these findings, we recommended a continuous distribution of winter and spring outflows. The continuous nature of the frequency distribution is an important departure from the incremental, discrete regulation of outflows that exist now because a continuous outflow relationship more accurately mimics natural hydrological patterns in terms of inter-annual variability and timing of flows. Also, the incremental flow targets that are currently in place can be ñgamedò by manipulation of reservoir releases and exports to avoid the highest outflow requirements (most critically in the case of the ñPort Chicago triggerò). Specific points along these continuous relationships are described below for reference.

January through March: Delta outflows should exceed 6.3MAF in at least 60% of years, and exceed 10MAF in 40% of years. Flows should always exceed 2.5MAF in 95% of years during this season.

March through May: Delta outflows should exceed 6.3MAF in half of years, and exceed 10.0MAF in at least one quarter of years. Outflows less than 2.5MAF should occur in no more than 1 of 8 years.

June: Delta outflows should exceed 508 TAF in at least 50% of years, and exceed 1.2MAF in at least 25% of years. Outflows less than 250 TAF should occur in no more than 25% of years.

January-June: In total, outflows in the January through June period should exceed 6.3MAF in at least 8 of 10 years; exceed 13.5MAF in half of years; exceed 20MAF in at least one-third of years. Outflows less than ~3.2 MAF should occur in no more than 1 out of 20 years.

Below, we present actual exceedance curves developed from our targeted analysis of the population responses of pelagic species to Delta outflows (Figure 2).

In adopting new non-binding flow criteria necessary to protect public trust resources in the Delta, the State Water Resources Control Board (SWRCB 2010) agreed with our findings and translated them into a set of criteria requiring that 75% of unimpaired runoff be dedicated to Delta outflow during the January ï June period. We concur with the Boardôs approach as it best simulates the characteristics of a natural hydrograph and provides a clear and simple method for implementing our recommendations. However, these new criteria are informational only, and the existing, insufficiently protective Bay-Delta Water Quality Control Plan estuarine habitat objectives continue to be in effect. USEPA should develop and promulgate new water quality objectives for winter-spring X2 values that will fully protect the estuarine habitat beneficial use and support viable populations of a suite of pelagic species.

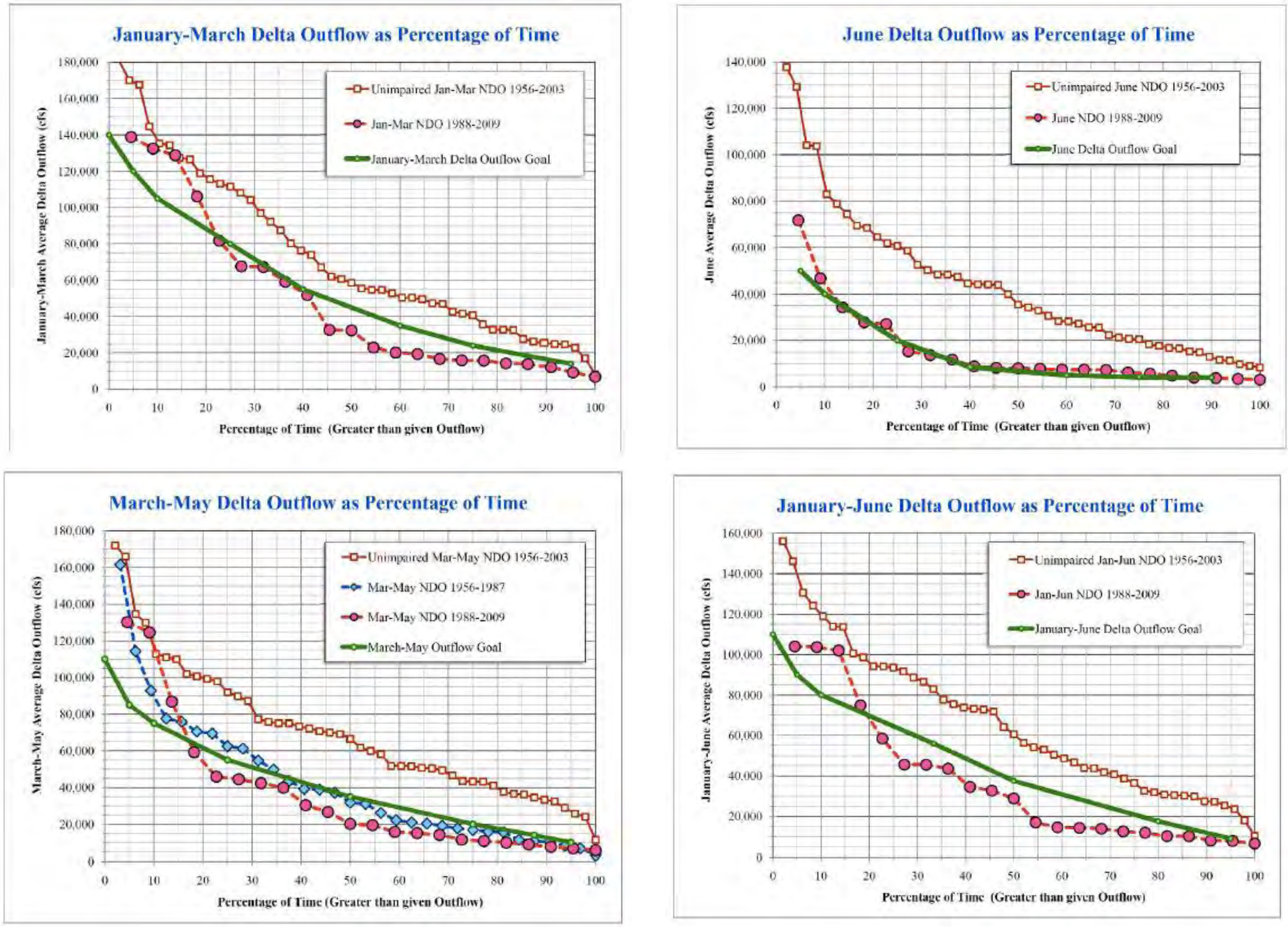


Figure 2: Frequency distribution of Delta outflows as a percentage of time. Relationship of outflows criteria compared to both the 1) actual distributions over the past 22 years and 2) unimpaired flows. Seasonal periods (identified in panel headers) are linked to biologically relevant periods for public trust resources. Criteria call for higher magnitudes among intermediate and low outflows (to the right on each graph).

Fall X2 -- Fall Delta outflows appear to benefit Delta smelt and striped bass in a non-linear fashion (Feyrer et al. 2010). High fall X2 values (low outflow) produce low areal extent of physically suitable habitat for Delta smelt; these conditions have corresponded to a relatively wide range of Delta smelt abundances including the lowest population abundance levels on record (as measured by CDFGôs Fall Mid-water trawl abundance index; Feyrer et al. 2010). Low fall X2 values (high outflow) produce a greater areal extent of physically suitable habitat for Delta smelt and correspond consistently to higher Delta smelt populations (i.e. the variance in the abundance index decreases as habitat area and outflow increases), including some of the highest recorded recently. This non-linear phenomenon seems to have manifested relatively recently and involves freshwater flow volumes greater than the (usually low) unimpaired Delta outflows in the fall months. Thus, the ecosystem response to fall X2 is different than to spring X2, is of more recent origin, and probably does not reflect processes that operated in the Delta historically.

The special nature of the fall X2:abundance relationships notwithstanding, the Delta smelt is in dire jeopardy of extinction and both the Delta smelt and striped bass populations appear to receive substantial protections from supplemental flows in the fall that increase the habitat available during this period (Feyrer et al. 2010). Given this situation, USEPA should develop and promulgate new regulations for fall outflows that will allow Delta fish populations to recover. The Delta smelt, in particular, cannot be exposed to the risks associated with high fall X2 values, even in dry and critically dry years; minimum thresholds for fall outflow/X2 should be established for all year types. Simultaneously, EPA should encourage research into the mechanisms that drive the fall X2:abundance relationship and implement an adaptive management program for fall X2. Such an adaptive management approach would specify a pathway for potential modifications of fall X2 regulations if more effective means of protecting fall habitat are identified or the need diminishes for this supplemental fall habitat as a result of other water quality or ecological restoration actions. When population levels of at-risk species have recovered and if research reveals that other aspects of water quality can be regulated to protect estuarine habitat during the fall months, regulatory requirements established by EPA for fall X2 may be reconsidered.

In our testimony to the State Water Resources Control Board (TBI 2010b), we identified criteria for the frequency of fall Delta outflow (X2) that would protect the abundance and spatial distribution attributes of viability for Delta smelt. These same outflow objectives would likely be protective of striped bass and other organisms that require supplemental fall habitat as well.

Table 1. Recommended average monthly X2 values and fall outflows (cfs) for September, October and November necessary to protect abundance and spatial extent of public trust resources, under five hydrological conditions.

Frequency	X2	Delta outflow
100% of years (all years)	<83 km	~5750 cfs
80% (dry years)	<80 km	~7500 cfs
60% (below normal years)	<77 km	~9700 cfs
40% (above normal years)	<74 km	~12,400 cfs
20% (wet years)	<71 km	~16,100 cfs

Are methods available for more systematically addressing ecological or biological connections between springtime X2 and subsequent fall X2 conditions? If so, what are they and what are their strengths and weaknesses?

We suggest that USEPA investigate historical data to determine what, if any, relationship exists between spring X2 conditions and the success of Delta smelt population between the previous fall (e.g. the FMWT abundance index) and the subsequent summer (e.g. the Summer Townet Survey). For such an analysis, it will be important to remove the effect of the stock population size on subsequent results (i.e. determine the effect, if any, of outflow conditions on population growth after accounting for abundance of spawners in the previous generation). In addition, USEPA should investigate the effect of winter and spring X2 values on the geographical distribution of Delta smelt spawning (as measured by the spring Kodiak Trawl).

Would changes in water system operations to move X2 seaward in the fall adversely affect the reservoir storage needed to conserve salmonid fish spawning and other designated uses in the watershed? If so, under what conditions?

The current Biological Opinions for delta smelt, Chinook salmon and steelhead call for supplementation of fall habitat by moving X2 to the west only following ñwetò and ñabove normalò years (USFWS 2008; RPA Action 4). Such years are characterized by higher end-of-year storage than drier years; this is especially true under the 2009 NMFS Biological Opinion (NMFS 2009; RPA Actions I.2.1 to I.2.4), which regulates end-of-year carryover storage. Thus, we anticipate little impact to reservoir storage or reservoir cold-water pool in the subsequent year from water releases needed to attain a fall X2 target following wet and above normal years.

Indeed, it may be that provision of fall X2 in wet and above normal years solves numerous ecosystem problems with negligible or low impacts to other water uses. In its modeling of hypothetical operations, which did not include provision of the fall X2 described in the USFWS Biological Opinion RPA (USFWS 2008; RPA Action 4), the BDCP found that potentially major impacts to covered species occurred in the fall of wet and above normal years (BDCP 2010, pp. 5-47 thru 5-48). These included impacts of high temperatures for spring run Chinook salmon spawning below Shasta/Keswick and low flows below the proposed intakes of a new North Delta diversion. Both of these effects were believed to result from low release of water from reservoirs in the Sacramento River system; modeled releases were low because of *lack of demand* from water users in the fall of wet and above normal years (A. Munevar, CH2M-Hill, *personal communication*). Thus, releases from storage needed to move X2 to the west in the fall following Wet and Above Normal years may also benefit the spring run Chinook salmon population of the Sacramento River and migrating adult fall run Chinook salmon returning to the Sacramento River.

The water storage and supply impacts of our proposed fall X2 requirements (Table 1, above) should be modeled. We believe that if these fall X2 requirements are implemented along with the

NMFS Biological Opinion RPA (NMFS 2009; RPA Actions I.2.1 to I.2.4), then any impacts to carryover storage and coldwater pool will be minimal.

Does the geographic location of low-salinity habitat have an effect on the quality of the habitat or its availability to species of concern? If so, what is the nature and extent of such effect? Is the distribution pattern of low salinity habitat important in determining its quality?

<u>Water quality regulations to improve X2 values should not depend on speculative or simplistic assumptions about underlying mechanisms.</u>

It is often assumed that the position of the low salinity zone, with respect to shallow shoals or tidal wetlands, is responsible for the winter-spring X2:abundance relationships that are so well-documented in the literature. In fact, this is only one of several potential explanations for the winter-spring X2(outflow):abundance relationships (Kimmerer 2002b). Most of the winter-spring X2:abundance relationships are log-linear over the entire range of X2 values studied; the population responds positively, and in a consistent manner, to each incremental decrease in X2 (increase in outflow). If the position of the 2ppt isohaline relative to other habitat features was responsible for the improved performance of pelagic species when winter-spring X2 moves west, then one would expect to detect a threshold value for X2 that was consistent across species. No such threshold X2 value has been detected for any population studied in the Bay-Delta. Among the species that show a significant, persistent relationship between winter-spring X2 and abundance, abundance continues to improve as X2 declines (moves to the west)[1].

The location of the low salinity zone (as indexed by X2) does have an effect on the quality of estuarine habitat in at least one respect. Several authors have observed that, as fresh water flow through and out of the Delta increases and the low salinity zone moves to the west (lower values of X2), entrainment of pelagic species is reduced (e.g. USDOI 2008; Grimaldo et al. 2009; Rosenfield 2010). This is likely because the some of the pelagic species spawn in areas near (or just upstream of) the low salinity zone (Dege and Brown 2004; Rosenfield 2010) ï as X2 decreases, spawning adults and their offspring move further away from the zone of influence of the South Delta export facilities.

It is also likely that numerous X2-related mechanisms affect certain species and that individual species may be affected by more than one X2-related mechanism. For example, winter-spring X2 is negatively associated with abundance of longfin smelt prey items (positively associated with

[1]Although we concur with CDFGôs findings regarding the need for improved outflows to benefit public trust resources in the Delta (CDFG 2010), we disagree with their recommendation for placing winter-spring X2 in a range between 64km and 75km. This recommendation implicitly relies on the hypothesis that it is the position of X2 relative to other habitat features that produces the beneficial population level effect. As noted above, populations of many pelagic species continue to improve as X2 drops below 75km and even as it moves beyond 64km (e.g. Kimmerer 2002b; Rosenfield and Baxter 2007; Kimmerer et al. 2009; Rosenfield 2010). For example, for each 10km shift in X2, longfin smelt abundance has historically experienced a 3-fold change.

winter-spring Delta outflow; e.g. Jassby et al. 1995; Kimmerer 2002a; Rosenfield and Baxter 2007; Kimmerer et al. 2009; Rosenfield 2010) and X2 is negatively correlated with transport and retention dynamics (caused by gravitational circulation) that benefit longfin smelt. The former mechanism could potentially have something to do with the position of X2 relative to other ecosystem features; the latter mechanism is not likely to be affected by geography in a similar manner (i.e. greater fresh water outflow in this Estuary will produces stronger gravitational circulation currents, regardless of the positioning of ñhabitatò features). Similarly, the X2:abundance relationship for Sacramento splittail is often attributed to splittail spawning success on inundated floodplains that correspond with periods of low X2 (Sommer et al. 1997); however, this mechanism would not preclude other winter-spring outflow-related effects that benefit juvenile or sub-adult Sacramento splittail in the estuarine zone.

How can performance measures for species population and/or habitat condition be used to evaluate restoration of Bay Delta Estuary water quality?

Attributes of population viability and ecosystem viability should be used to develop performance targets to guide both promulgation of new regulations and post-promulgation adaptive management efforts.

Performance measures are not only desirable complements to water quality regulations that can help monitor progress toward achievement of regulatory goals and guide future implementation; they can and should be integral elements in developing such regulations. In developing and promulgating new water quality regulations, USEPA should articulate specific goals and quantifiable objectives for desired conditions in the Bay-Delta (i.e. what does a functioning, ñhealthyò ecosystem look like, as defined using attributes of population viability and ecosystem health) and then identify which of these goals will be served by specific improvements in water quality and to what extent. Developing the units and magnitude of performance measures will be aided by explicit descriptions of objectives that are S.M.A.R.T. (specific, measureable, achievable, relevant-to-a-goal, and time-bound) and enunciation of the amount that specific water quality enhancements can contribute to these S.M.A.R.T. objectives

In addition, USEPA should be aware that more than one goal may be established for each species or the ecosystem as a whole and that some, but not all, water quality improvements may serve more than one goal. For example, whereas EPA may seek to reverse severe population declines of many of the native fish species in the Delta (an ñabundanceò goal), several species also suffer from impacts that restrict their already limited spatial range or the timing of certain life history stages. Successful delta smelt reproduction, for instance, is constrained to a very small area (even under the best of circumstances) and successful spawning is increasingly limited to a specific small time-window (Bennett 2005) -- water quality targets should be aimed at increasing the spatial and temporal extent of potential Delta smelt reproduction. Performance measures for the Delta smelt ñabundanceò objective and the Delta smelt ñspatial distributionò objective may differ.

In general, improvements in four attributes of viability (McElhany et al. 2000) are critical for populations of each of the native species in the Delta:

- Abundance
- Spatial distribution (usually of spawning habitat)
- Life history diversity (usually represented by the timing of life history events)
- Productivity (or population growth rate/frequency)

Many (if not all) of these goals may be addressed (at least in part) by improving water quality characteristics in the Bay-Delta in order to support achievement of appropriate objectives and performance targets (*for further description, see* TBI 2010a, *attached*).

Furthermore, there are a number of ecosystem attributes that both support population viability and enhance overall ecosystem function, including:

- Natural hydrograph patterns
- Foodweb structure and food production
- Habitat diversity
- Habitat connectivity (particularly between upstream and pelagic environments)

Unlike species viability criteria, an idea commonly used in such contexts as the federal Endangered Species and National Forest Management Acts, the ecosystem viability concept remains less well known, occasionally appearing in the ecosystem management literature (Brussard et al. 1998; Vogt et al. 1997). Ecosystem viability nevertheless represents a framework for considering the landscape-scale implications of water quality protection and regulation ï the implications of which are not necessarily adequately included in the species-by-species approach to viability analysis. We strongly recommend that USEPA develop water quality regulations that not only support attributes of population viability, but are specifically intended to advance appropriate objectives and performance targets for each ecosystem health attribute.

Once attributes are defined and goals and objectives are developed for priority, indicator species and ecosystem processes, USEPA can better identify the desired improvements in water quality intended to contribute toward achieving the desired ecosystem state. These performance targets form the basis both for promulgating new water quality regulations and for adaptively managing water quality stressors and other ecosystem restoration activities throughout the Bay-Delta. Because this system is (and ecological systems, in general, are) so complex and the outcome of certain actions are likely to be somewhat uncertain, USEPA should describe in its final water quality regulations, an adaptive management program that integrates monitoring/research with the larger goals and objectives that are served by reducing water quality-related stressors. USEPAôs guidance on adaptive management should go beyond the basic-textbook descriptions of the process to describe actual decision-trees, decision-making thresholds, and decision timelines that will be employed to manage water quality criteria in a way that adapts to a changing knowledge base.

FISH MIGRATION CORRIDORS

The ANPR correctly notes the severe degradation of water quality conditions in the San Joaquin River basin and the associated adverse impacts on salmonid migration through the Delta to and from the lower San Joaquin River. In addition to the highly degraded San Joaquin, USEPA should recognize that there are other compelling cases where water quality in the Bay-Delta compromises the ability of both salmonids and other species to migrate to and from their historic spawning grounds. There is sufficient scientific information to develop and promulgate new water quality regulations to protect fish migration corridors in the Bay-Delta estuary in a variety of ways, as detailed below.

What role, if any, do gradients in physical and chemical constituents of water play in the suitability of the Bay Delta Estuary and San Joaquin River Basin migratory corridor for salmon?

<u>Osmotic gradients are extremely important for adult salmonid migration</u>

In constructing regulations for fresh water flow that protect both upstream adult and downstream smolt migrations, USEPA should use the best available conceptual models of salmon migration and orientation. A reasonable conceptual model of salmonid migration and orientation in the Bay-Delta would recognize that migratory cues (or combination of cues):

- must have historically allowed migrating salmon to minimize activities that did not maximize survival and reproduction.
- had to be reliable under most climatic and hydrological conditions that fish in the San Francisco Estuary experienced through evolutionary time.

That migrating adult salmon follow osmotic gradients (a ñsense of smellò) to discriminate between their natal stream and other waterways they pass on their migrations is well established (e.g Donaldson and Allen 1957; Scholz et al. 1976). Experiments show that if chemicals are added to the water where juvenile salmon rear, these salmon can be made to return to a different spawning stream as adults, simply by adding that same chemical to another waterway. Thus, USEPAòs focus on and concern with providing an adequate chemical connection between the Pacific Ocean, San Francisco Bay-Delta, and its tributaries (the San Joaquin River, in particular) is well justified. It is not at all clear that the needed migratory corridor between the San Joaquin River, lower bays of the estuary, and Pacific ocean can be maintained by permitting exports from the south Delta to exceed San Joaquin inflows by a 3:1 ratio. USEPA could use particle-tracking methodology to determine both the magnitude and duration of water export rates that serve to break the osmotic connection between salmon spawning streams, the Bay and the ocean. USEPA could then determine both maximum export rates and also minimum recovery periods (when exports are reduced) to allow re-establishment of a continuous, strong osmotic gradient between natal spawning areas, the Bay, and the ocean.

It is important that the ANPR recognizes the need to provide protection for both the fall run Chinook salmon populations on the San Joaquin tributaries and for the spring run Chinook salmon populations that will be reintroduced above the Merced confluence starting in late 2012. One of the major impediments to restoring spring run Chinook salmon to the San Joaquin Basin is the need to provide migratory corridors used by adult fish ï many of the same impairments to adult migration that impact fall run Chinook salmon in the San Joaquin River (lack of chemical and physical migration cues, low dissolved oxygen) must also be addressed in the spring, for the benefit of adult spring run Chinook salmon.

<u>USEPA must also address water quality challenges to juvenile salmonid migration</u>

The ANPR does not focus adequately on the effect of water quality conditions in the Delta on outgoing migrant salmonids. Both TBI (2010c, *attached*) and CDFG (2010) provided analyses that found a strong connection between flow conditions in the Delta and subsequent returns of salmon to the San Joaquin River 2.5 years later. These results indicate that migratory success of juvenile Chinook salmon is affected by water quality conditions in the lower San Joaquin River.

The migratory behavior demonstrated by adults must be learned because the fish can be manipulated to return to a different stream by switching osmotic cues (e.g. Scholz et al. 1976) and Chinook salmon from the Sacramento River appear to have little problem orienting towards their ñhomeò stream in environments where they have been successfully introduced (e.g. New Zealand, the Laurentian Great Lakes). In order for adults to follow the ñsmellò of their home river, they must smell the habitats as they perform their juvenile migration ï many papers demonstrate higher rates of straying among hatchery-reared and trucked fishes, among whom this learning process would be disrupted (see, e.g. Groot and Margolis 1991; Quinn 2005).

Thus, it is very likely that juvenile salmon use chemical and physio-chemical gradients for orientation through the Delta. The historically natural flow of fresh water to the Estuary and its mixing in the tidal zone would be expected to establish relatively stable gradients in the Delta (e.g., the general orientation of the gradient would be unlikely to change). The chemical landscape in the Delta at any one moment would normally be an interaction of the recent history of fresh water flow (volume and source) and tidal activity. Incoming tides would bring an increasingly strong chemical signal from environments downstream and a decreasing signal from upstream. The reverse is true on an outgoing tide; the chemical signature of ñhomeò would increase over time in such a flow. Chemical gradients (or physico-chemical gradients such as temperature or turbidity) were likely available and reliable historically in the tidal environments of the Delta.

Increased water exports, relative to flow, alter the chemical gradients in a way that would confuse, or at least delay emigration of juvenile salmon from the Delta into Suisun Bay. Particle tracking models reveal that export pumping can alter the chemical landscape of the Delta in the weeks and days before migrating fish arrive. When/if chemical gradients that migrating fish rely on become oriented toward the export facilities, one would expect increased migration of juvenile salmonids towards those water diversions; this is true regardless of the intensity of export pumping on the day the fish encountered the gradient or the day the fish was subsequently entrained. In addition, the export pumping may interact with the tides in such a way that there is not a clear signal towards the south Delta export facilities, but there is not a clear signal towards the ocean either. In this environment, migrating salmon smolt would be expected to migrate in a variety of directions ï in the Delta, such a scattered migration would lead to a large number of negative outcomes (the pumps, predators, etc.).

Particle tracking could be employed to reveal the chemical landscape that migrating salmon would encounter when they reached the Delta. USEPA should use particle tracking studies to understand what levels of pumping are likely to reorient chemical gradients from the Sacramento and/or San Joaquin Rivers such that migrating fish relying on a freshwater-to-saltwater osmotic gradient would become confused or, worse, begin to orient towards the export facilities. The ñparticlesò in these particle tracking studies would represent water molecules themselves, a chemical constituent of the water or, perhaps, turbidity.

Migrating juvenile salmonids are not aware of the entire chemical ñlandscapeò of the Delta nor do they have a hard-wired map; they can respond only to conditions in their immediate, sensible surroundings. When those conditions are radically altered, the migration route of juvenile salmon may be seriously impaired and those juvenile salmon that do survive their journey through the Delta and ocean may have a confused sense of how to find their natal streams when they return as adults. The strength of the relationships between Delta flows and hydrodynamics during the San Joaquin River fall run Chinook salmon juvenile migration period and the subsequent return of adult salmon 2.5 years later (CDFG 2010; TBI 2010c, d, *attached*) are surprising because one would expect the signal established during a migration season to dissipate over the intervening period of ocean residence. That this relationship is detectable at all demonstrates the potentially large-scale impact of Delta flows and hydrodynamics on the suitability of juvenile salmonid migratory corridors through the Delta. USEPA should regulate conditions in the Delta so as to ensure adequate migration corridors for juvenile salmonids.

Barriers to fish migration strongly affect other native Delta fishes

The ANPR does not address impairment of migratory corridors for fish species other than the salmonids. Clearly, the water quality modifications that impair migratory behavior of adult and juvenile salmonids also impact migration for adults and juveniles of other anadromous species. In some cases, providing for adequate salmonid migration corridors may provide ancillary benefits to these other anadromous species. However, there are cases where conditions tolerated by salmonids may not be acceptable to other species. For instance, sturgeon may require higher levels of dissolved oxygen than many other species (Cech et al. 1984; Cech and Doroshov 2004) and therefore may not be well-served by regulations designed only to protect migrating salmon.

Weakly anadromous species (those that migrate to brackish or marine environments but whose populations never completely leave the Estuary) are not mentioned at all in the ANPRôs review of impairments to migratory corridors, yet these species do migrate to and through the Delta. For example, Delta smelt, longfin smelt, and Sacramento splittail may all be impacted by Delta flow and hydrodynamic conditions that prevent them from reaching or successfully utilizing their spawning grounds. It is highly likely that the south Delta and lower San Joaquin River provided spawning habitat or access to spawning habitats for each of these species historically. Consistently abysmal flows on the San Joaquin River and high exports from the south Delta pumps would be expected to impair migration to and from these spawning habitats. Entrainment rates for adult and juvenile pelagic migratory species increase dramatically as export rates increase (Grimaldo et al. 2009) and it is likely (though unmeasured) that larvae of these fish are also severely impacted by exports activities in the South Delta. Thus, access to spawning grounds and the connection between spawning and rearing grounds may be heavily impacted by export operations in the south Delta for a wide variety of species. This problem is identified as a potentially critical impairment of spawning habitat spatial distribution for longfin smelt (Rosenfield 2010), which are believed to spawn further to the east (closer to or even beyond the export facilities) as Delta outflow decreases (Dege and Brown 2004; Grimaldo et al. 2009; Rosenfield 2010).

What are the best measures of success for restoration of a migratory corridor? Could these measures be incorporated into new or revised biological criteria protecting the fish migration designated use?

The ñbest measuresò of success for restoration of a migratory corridor are:

- the proportion of migrants (adults and juveniles) that make it through the corridor successfully;

- the fraction of the migration season that the corridor remains open (so as to avoid impacts to alternate life history types, which may have differential success in later life stages); and,

- the frequency (in terms of years) that the migration corridor is open for the full migration season.

How success is measured will depend in part on which organisms are of interest. As discussed above, salmonid use of the Delta as a migratory corridor has two components: emigration of smolts to the ocean and successful navigation of the Delta (return to their natal stream) of adults on their spawning migration. The ñsuccessò of the migratory corridor must account for both components of this migration. Traditional methods of measuring success of salmonid migration through the Delta include coarse comparisons of escapement from one generation to the next and directed sampling upstream, downstream, and perhaps within the migration corridor of interest.

Cohort Replacement Rate (CRR; the ratio of adult escapement in one generation to escapement in its preceding generation) is one valuable metric of emigration that integrates impacts to both salmonid life stages that pass through the Delta. TBI (2010c) used CRR San Joaquin River fall run Chinook salmon to demonstrate an effect of Delta flows on productivity of this run. Cohort Replacement Rate is, however, a very coarse measure as it reflects impacts to salmon throughout their life cycle, including those that occur upstream of the Delta and in the ocean. This measure should be supplemented (not replaced) by a direct measure of juvenile migration success through the Delta. Preferably, this would involve the capture, tagging and release of wild salmon and steelhead juveniles upstream, release at the entrance to the Delta, and recapture at the western terminus of the Delta[2]. USEPA can and should set criteria for both emigration success and timing (duration of migration) through the Delta. Survival through the Delta may vary naturally with changes in hydrological conditions and it may be possible to develop emigration survival sub-targets for these different hydrological regimes. Emigration targets may be achieved through any combination of restoration activities that improve natural transport of salmonids through the Delta (i.e. not trucking or shipping to bypass the Delta); adaptive management should be employed to determine the best mix of restoration solutions.

As with anadromous fish such as the salmonids, the best measuress of success of a migratory corridor for pelagic fish (e.g. Sacramento Splittail, Delta smelt, longfin smelt) relate to the magnitude, duration, and frequency of (1) successful spawning in habitats upstream of the corridor and (2) successful emigration of larvae/juveniles from those upstream locations to the open waters of Suisun Bay. Use of spawning habitats upstream of a South Delta corridor (for instance) can be determined by direct surveys for spawning adults and or very early stage larvae. Surveys of this kind are already conducted for Delta smelt by CDFGôs Spring Kodiak Trawl (http://www.dfg.ca.gov/delta/data/skt/DisplayMaps.asp) and Smelt Larva Survey (http://www.dfg.ca.gov/delta/projects.asp?ProjectID=SLS) -- the latter survey samples longfin smelt as well. By adding additional survey locations, adapting the approach of the Kodiak Trawl to a gear that would be useful for longfin smelt (i.e. a bottom trawl), and by increasing the frequency of surveys, CDFG could identify frequency of successful spawning in different areas of the Delta and locations immediately upstream of the Delta for the two smelt species of interest. Adult Sacramento splittail are relatively large fish that spawn primarily in inundated shallow habitats (Moyle 2002); successful spawning can be detected by sampling for gravid or spent adults and larvae near inundated habitats upstream.

In addition to traditional survey and mark-recapture techniques, we strongly suggest that USEPA

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2 Previous studies of salmon migration success through the Delta (e.g. Perry and Skalski 2008) have, understandably, relied on hatchery-produced salmon. This may be the most practicable option for mark-recapture studies but the hatchery surrogates must represent the wild fish of interest in terms of species, run, and mean/min-max size. Even then, results of the mark-recapture of tagged hatchery fish must be interpreted with the understanding that hatchery fish and wild fish are known to display potentially important behavioral and ecological differences (*for review, see* Quinn 2005).

collaborate with other agencies to develop a sampling program that integrates genetic techniques and microchemical analyses (e.g. isotopic analysis of fish otoliths) into monitoring migration success. Genetic techniques are available to distinguish between the different runs of Central Valley Chinook salmon (and in at least one case, sub-populations of salmon; Banks et al. 2000; Hedgecock 2002). Application of these techniques to accurately discriminate among salmon smolt migrants will be particularly valuable for clearly identifying the typical migration season of these different populations and for measuring their migration success. Application of these genetic techniques will enable the fisheries agencies to study the success of wild fish (which, as noted above, behave differently from marked hatchery fish) and reduce reliance on current size-at-age run identification methods that are clearly inadequate (Williams 2006).

Furthermore, microchemical analysis of bony structures (e.g. fish otoliths) can been used to help identify natal spawning region and spawning time for numerous fishes in this Estuary, including pelagic species (Hobbs et al. 2005; Feyrer et al. 2007) and anadromous salmon (e.g., Weber et al. 2002). These microchemical analyses can help determine the proportion of fish emanating from different natal waterways and therefore can be used as part of an integrated program to measure migration success through the Delta. Among other things, by analyzing the microchemistry of bony structures of fish caught in existing sampling programs, one can determine whether fish in the lower estuary emanated from the Sacramento drainage or San Joaquin drainage and when they migrated from freshwater to brackish water; comparing these proportions to that expected from survey programs upstream of the Delta can provide information about the relative success of migrants through the North Delta vs. the South Delta. Also, these microchemical techniques combined with traditional otolith analyses (e.g. age determination), if applied to post-spawning fish, would enable managers to study the age-structure of a population (rather than assuming it is static, as is common now) and the life history of fish that actually survived to reproduce. These analyses could be used to address important management questions like inter-annual (or even intra-annual) migration success through the Delta, residence periods in the Delta, size and growth upon entry to the ocean/Bay, etc. In short, by integrating traditional survey methods with microchemical analyses of fish bones and genetic analysis, management agencies can vastly increase the precision and scope of their monitoring related to fish migration through the Delta.

Should temporal characteristics be included in the definition of the physical and/or chemical properties of a migration corridor based on a reference condition? If so, how? What frequency and duration of such a corridor is required for salmonids? How might these characteristics change with the impacts of climate change?

There is no question that temporal characteristics must be included in the definition of the physical/physio-chemical properties of a migration corridor. As described above, part of the measure of success for a migration corridor is the fraction of the population that can access the corridor, as distinct from the fraction of the population that navigates the corridor successfully. Maintaining a usable corridor throughout the migration season of different fishes is essential to maintain the phenotypic diversity that allows for later life-stages to succeed in the face of unpredictable environmental conditions ï this is critical for maintaining the population productivity and resilience of salmonids (Miller et al. 2010) and other species (e.g. Rosenfield 2010). For example, the success of Chinook salmon smolts entering the ocean is likely related to the abundance of appropriately sized food resources that these fish encounter. The protracted migration period of Central Valley Chinook salmon runs, combined with life histories that produce different sizes at migration, has probably been maintained through evolutionary time because, every year, some salmon arrive at the ocean at the right time and at the right size to capitalize on the highly variable ocean food-resources. Continuous truncation of the migration period through the Delta limits life history diversity of emigrating salmon and may jeopardize the entire run in years when the migration corridor is not open during the period that would allow for success in the ocean environment.

Similarly, Bennett (2005) suggested that hydrodynamic conditions in the Delta regularly truncate the period of successful Delta smelt spawning/larval incubation. This consistently selects against a life-history variant (Bennettös ñBig Mommasò) that may be critical to maintaining abundance and productivity of this population. In our submission to the State Board (TBI 2010d), we identified the critical need to maintain an adequate duration of suitable through-Delta migration conditions for both anadromous and Delta pelagic fishes.

The baseline for determining the migration period for different fishes in the Delta must be based on our knowledge of seasonality and variability in the life cycle of the species of interest. Conceptual models for numerous species of interest (e.g. longfin smelt, Delta smelt, Sacramento splittail) have been developed as part of the CALFED Ecosystem Restoration Programös DRERIP process (e.g. Rosenfield 2010) and these models identify the expected range of timing for each speciesô various life history stages. Because the life histories of native fishes are very often cued to flow patterns in the Delta and these life histories probably evolved to capitalize on these flow patterns, the knowledge assembled in the DRERIP (or other) conceptual models must be combined with estimates of unimpaired flow patterns to form a baseline for a USEPA water quality performance metric. This baseline may be modified to better protect fish in the face of direct and indirect changes to the Deltaös watershed. For example, global climate change may produce higher water temperatures in the late spring (e.g. late June) than have been experienced historically. Such temperatures may exceed the tolerances of many native pelagic or anadromous fish species (Williams 2006) ï thus, USEPA may want to consider regulations that allow for a higher degree of migration success earlier in the season rather than provide sub-par protection for emigrating fish throughout their historical migration period. USEPA should evaluate localized temperature impacts in order to identify the risks and potential rewards of targeted, intentional truncation of the historical migration period for certain fishes. Such decisions should be well-justified by available data and be undertaken in service of providing excellent protection for the remaining phenotypic temporal diversity exhibited among the species of interest.

Would establishing a migratory corridor for upmigrating adult chinook salmon succeed in improving adult migration success if temperatures in the river channels upstream of Vernalis are unchanged? If so, how? How might actions to establish a migratory corridor in the south Delta also moderate temperature and/or dissolved oxygen problems in the San Joaquin River?

Based on the results of Cain et al. (2003) we concluded in testimony to the SWRCB that:

> *Inflow from the lower San Joaquin basin is essential to maintain suitable water temperature conditions in the lower San Joaquin and southern Delta for salmonids, particular during the spring outmigration period. Temperature is determined by a number of factors including reservoir releases, channel geometry, and ambient air temperatures, however, water temperature data from the Vernalis gauge shows that flows over 5,000 cfs in the late spring are necessary to provide water temperatures suitable for juvenile salmon and smolts.* [TBI 2010c: p13]

This recommendation is based on the relationship between temperature and spring flow at Vernalis (Cain et al. 2003) matches remarkably well with the level of Vernalis flow which corresponds to positive CRR for San Joaquin salmon (TBI 2010c). Increased flows in the lower San Joaquin River are necessary to combat a series of barriers to effective Chinook salmon emigration and the spawning run of adult spring-run Chinook salmon, including: temperature impairment, dissolved oxygen impairment (e.g. Van Nieuwenhuyse, 2002; Jassby and Van Nieuwenhuyse 2005), predation, and entrainment at the South Delta export facilities. USEPA should also be aware that other fishes may suffer from high temperatures and low dissolved oxygen levels in the lower San Joaquin River. The requirements of each of these species do not always overlap with those of salmonids; thus, focusing solely on conditions suitable for salmonid migrations may not provide adequate protection for the habitat of other fishes. For example, sturgeon are likely to avoid or be negatively impacted by areas with dissolved oxygen levels that are tolerable for Chinook salmon (Cech et al. 1984; Cech and Doroshov 2004). USEPA should articulate the physical and physio-chemical criteria of suitable migration corridors for species in addition to Chinook salmon.

Are additional efforts to improve dissolved oxygen regimes in the Delta necessary to provide an adequate migratory corridor for San Joaquin salmonids? If so, what should those efforts include?

Additional efforts to eliminate dissolved oxygen impairment on the lower San Joaquin River are essential to restoring salmonids and other migratory fish (anadromous and pelagic) to the San Joaquin watershed. Low dissolved oxygen conditions most frequently occur during the spring and summer when flows are less than 2000cfs and water temperatures are elevated. Although management of other variables in addition to flow will be necessary to completely alleviate this problem, Jassby and Van Nieuwenhuyse (2005) found that: ñ[r]iver discharge has had the biggest impact é on hypoxiaò; their modeling demonstrated that increased management of other important factors would be far less effective without improvement of freshwater flows in this area.

Existing flow requirements for the lower San Joaquin River allow flow levels substantially less than 2,000cfs for nearly all months in the year in every water year type (SWRCB 2006). USEPA should develop and promulgate new regulations for San Joaquin inflows throughout the year in order to protect spatial distribution (e.g. spawning in the San Joaquin River and its tributaries) of public trust resources that use the Delta as a migratory corridor. San Joaquin River flows at Vernalis should exceed 2000 cfs in all months of all years. These flows will alleviate the potential for low dissolved oxygen conditions and are expected to have synergistic positive effects with other management responses to this problem (e.g., reduction in nutrient pollution and biological oxygen demand; Jassby and Van Nieuwenhuyse 2005).

What other information is available on barriers to salmon migration in the Bay Delta Estuary and San Joaquin River watershed?

Known barriers to migration in the Bay Delta Estuary that are not covered in the ANPR include impediments to migrating through:

- the Yolo Bypass, because of the configuration of the Fremont Weir. This problem affects adult Chinook salmon and both sturgeon species and likely impacts steelhead as well.

- Suisun Marsh, because of the operation of the salinity control gates. This problem likely affects all salmonids as these species use osmotic cues to find home and the Suisun Marsh salinity control gates are likely to produce a relatively stronger osmotic signal of the Sacramento River at the west end of the Marsh than would be present if the tidal gates were not operated.

USEPA should also consider regulation of the frequency, duration, and flow of Yolo Bypass inundation as the Bypass can provide an alternative migration pathway for emigrating juvenile fish. Migration down the Yolo Bypass may circumvent certain stressors associated with emigration through the Delta via the lower Sacramento system (e.g. increased predation, water quality impairment, and disorienting patterns of flow and osmotic gradients created by South Delta export pumping).

Finally, USEPA should anticipate the potential for additional diversions from a proposed new North Delta diversion facility and clearly articulate the flows necessary to ensure adequate passage of <u>all</u> lifestages of the native migratory fish species that use the lower Sacramento River as a migration corridor. A clear articulation of such requirements will provide much-needed guidance to efforts such as the Bay Delta Conservation Plan process that are developing operational plans for the proposed new export facility.

SELENIUM

The ANPRôs inclusion of selenium (Se) as a concern is timely and justified. While it is prudent to be concerned about the potential effects of a number of insufficiently studied contaminants, it is imperative to address the known effects of one of the best understood contaminants. A persistent pollutant that bioaccumulates in the food chain, selenium has been termed a ñtime bombò for its characteristic ability to rapidly and severely affect fish populations while giving little indication of the problem until profound impacts have occurred (Lemly 1999).

Complicating the evaluation of selenium impacts is the fact that this toxin exhibits a biphasic dose-response relationship (Beckon et al. 2008), acting as an essential nutrient at low doses (i.e., increasing survival) and as a toxin and teratogen at only slightly higher doses (i.e., decreasing survival rates); that is, the difference between a beneficial effect and a disaster is vanishingly small (Hilton et al. 1980). In addition, the primary exposure comes from dietary sources (rather than direct exposure in water), and the strong biomagnification effect complicates toxicity testing to such an extent that ñ*the concentration at which occurs the effect of Se on the ability of a species to produce viable young cannot be determined by acute or dissolved toxicity testing*ò (Luoma and Presser 2009, SI p2-3).

Nevertheless, a sizeable body of knowledge has been assembled in the past thirty years indicating that the current standard is insufficiently protective, but also demonstrating a way forward through the use of ecosystem scale models that link trophic levels and Se biodynamics. These new approaches will allow us to enter ña new era in management of environmental contamination in which ecology finally becomes as important as toxicity testing in deciphering environmental risks of contaminantsò (Luoma and Presser 2009; p.8487), and enable us to more effectively reduce Se risks.

TABLE III

Toxic effects thresholds for selenium in water, food-chain organisms, and fish and aquatic bird tissues.

Selenium source	Selenium concentration[1]	Effect
Water		
Inorganic selenium	2 μg/l	Food-chain bioaccumulation and reproductive failure in fish and wildlife
Organic selenium	< 1 μg/l	Food-chain bioaccumulation and reproductive failure in fish and wildlife
Food-chain organisms	3 μg/g	Reproductive failure in fish and wildlife
Fish tissues		
Whole-body	4 μg/g	Mortality of juveniles and reproductive failure
Skeletal muscle (skinless fillets)	8 μg/g	Reproductive failure
Liver	12 μg/g	Reproductive failure
Ovary and eggs	10 μg/g	Reproductive failure
Aquatic bird tissues		
Liver	10 μg/g	Reproductive failure
Eggs	3 μg/g	Reproductive failure

[1] Selenium concentrations in parts per billion for water; parts per million on a dry weight basis for food-chain organisms and fish and bird tissues.

Table III (p. 92) from Lemly, 1993.
Note that the water concentration thresholds are well below the 5 ppb standard

What, if any, additional information is available to better characterize selenium sources, loadings and impacts within the watershed of the Bay Delta Estuary?

<u>The current water quality standard (5 ppb) is insufficiently protective for sensitive fish and birds.</u>

The main mode of selenium toxicity is through dietary exposure (e.g., Luoma and Presser 2009): ñ*Biogeochemical processes convert Se to concentrations at the base of the food web orders of magnitude greater than in water and passage of that Se through the food web is the source of Se exposure. Therefore, ecosystems will be badly damaged by dietary exposure before dissolved Se concentrations reach levels that themselves are dangerous to animals*.ò (SI, p. 2) Existing studies indicate that the bio-concentration of selenium ranges widely, with bioaccumulation factors from 500 to 200 000 times shown in field and laboratory studies involving only moderate water concentrations of Se (< 16 ppb) (Lemly 1993 and the references therein).

Bio-accumulation is sufficient to produce toxic levels of Se in the food chain even where the waterborne concentrations are in the 0.5 to 3 ppb range (Lemly 1993 and the references therein), well below the current 5 ppb water quality standard. The ANPR correctly points out that the ñcurrent selenium standards lack criteria specific to water-dependent wildlifeò (p.32), and it is known that, unfortunately, Chinook salmon are especially sensitive to selenium (Beckon and Maurer 2008), with significant mortality (LC10) at Se tissue levels as low as 1.8 ppm (Beckon 2008). As a rough ï albeit optimistic ï estimate (W. Beckon, *personal communication*), we should expect a minimum of 1000-fold increase in Se concentration from water to tissue (i.e., a 1 ppb Se water concentration will result on the order of 1 ppm Se concentration in fish tissue) in the Bay-Delta estuary.

Worse yet, there is evidence that the more biologically reactive forms of selenium (selenite and organo-selenide) increase as the water moves downstream, so that they are uncommon in smaller streams and irrigation water, but more prevalent in the San Joaquin-Sacramento River Delta and the San Francisco Bay. As noted by Luoma and Presser (2009): ñ*This unidirectional build-up of potentially reactive forms, especially in environments where water residence times are extended (e.g., wetlands, estuaries) is a key factor in the ecological risks posed by Se*ò (p. 8485).

For these reasons, we suggest that the current 5 ppb standard is inappropriate, and as a first approximation, Lemlyôs (1993) Table III can be used as a indication of what a more protective water quality standard should look like (but see below for the our recommended approach to actually calculating a site-specific, biologically meaningful standard)

<u>New information is available to guide development of a local protective standard</u>

The ANPR appropriately notes that a deficiency of the current selenium standards is their ñ*use of a measure (water column concentration, determined through dose-response tests) that is not a consistent indicator of exposure and environmental risk, because it fails to account for variables such as food web characteristics*ò (p. 32). However, new approaches have become available to both evaluate the effects of Se and develop protective standards, as outlined in recent articles (e.g., Luoma and Presser 2009; Presser and Luoma 2010) . These approaches involve quantifying the factors that control how Se is processed in the trophic web, from water through producers and consumers, to top-level predators (i.e., fish and water birds) through kinetic bioaccumulation models.

A critical feature of these models are the trophic transfer factors (TTFs), a measure of linkage between trophic levels which represent the ratio of the Se concentration in each animal to the Se concentration in its food; TTFs explicitly recognize the fact that selenium concentrations in animal tissues are at least ñconservedò, and usually magnified at each step up the food web (e.g., from plankton to invertebrates to fish) (Presser and Luoma 2010). Models based on TTFs are an improvement over the current approach because when ñ*biogeochemical transformation of Se is considered, and linked to trophic transfer through the food web via TTFs, the uncertainties about toxicity and site-specificity can be greatly reduced*ò (Luoma and Presser 2009, p. 8486).

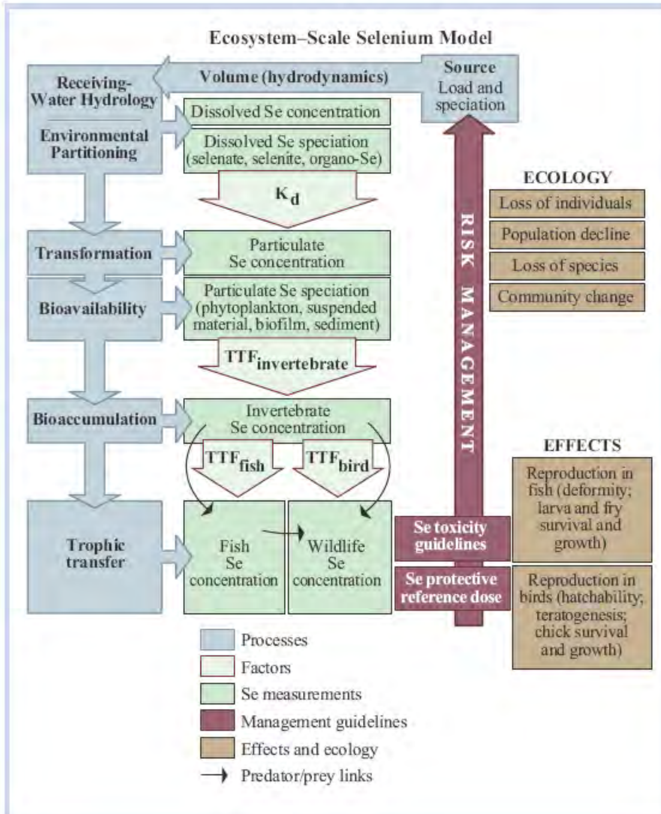


Fig. 1 in Presser and Luoma 2010. (Kd - empirically determined environmental partitioning factor between water and particulate material; TTF - biodynamic food web transfer factor between an animal and its food.)

Although such models are complex, they can be constructed using existing information, which should include ñ*the biogeochemical partitioning ratio within the system, rudimentary knowledge of feeding relationships in the local foodwebs, TTFs from the base of the food web to the most common consumer organisms ,and TTFs from consumers to predators.*ò (Luoma and Presser 2009: 8486). The crucial advantage of this approach is that the ñ*guidelines based upon bioaccumulated Se… …can be used to derive allowable Se concentrations in water with much less ambiguity than presently exists. The allowable water values would change from environment to environment, but the bioaccumulated Se guidelines would not.*ò (Luoma and Presser, 2009: 8487). We urge the use of ecosystem-scale Se models, with the modeled food webs chosen so as to include sensitive fish (salmonids) and birds.

What data are needed to track selenium impacts in the Bay Delta ecosystem as currently configured, and to evaluate potential impacts of selenium under changed flow and transport conditions into and within the Delta?

<u>Special focus is needed to monitor and address potential impacts on salmonids migrating through the San Joaquin River upstream of the Merced River confluence.</u>

Beckon and Maurer (2008) clearly state the danger that Se poses to salmon: ñ*California Central Valley Chinook salmon evidently are among the most sensitive of fish and wildlife to selenium. They are especially vulnerable during juvenile life stages when they migrate and rear in selenium-contaminated Central Valley rivers and the San Francisco Bay/Delta estuary*ò (p.18). We are concerned that Chinook salmon and other salmonids ï which will begin to migrate through the reaches of the San Joaquin River upstream of the confluence with the Merced as flows begin to be released from Friant Dam pursuant to the river restoration settlement agreement ï may be exposed to increased Se-induced mortality as a result of the extension of the Grasslands Bypass Project (GBP) to 2019.

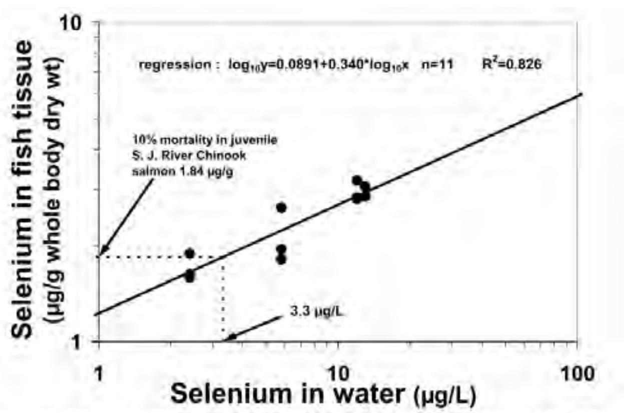


Figure 10. Relationship between selenium in juvenile Chinook salmon (Saiki *et al.* 1991, Saiki pers. com.) and water (Central Valley Regional Water Quality Control Board "Flat File") in the San Joaquin River and its tributaries.

Specifically, the information in Beckon and Maurer (2008, and references therein) and the GBP Report (see, e.g. ñLemly Indexò tables, p.122-123; SFEI 2010) indicates that the project is likely to result in water Se-concentrations (3.3 ppb) that exceed the LC10 level. Furthermore, such selenium concentrations were measured at a location (Crows Landing) where they have already been diluted (by Merced River inflows). Selenium concentrations in the water column upstream of the Merced River (where the water column is almost entirely composed of the GBP discharges and other agricultural

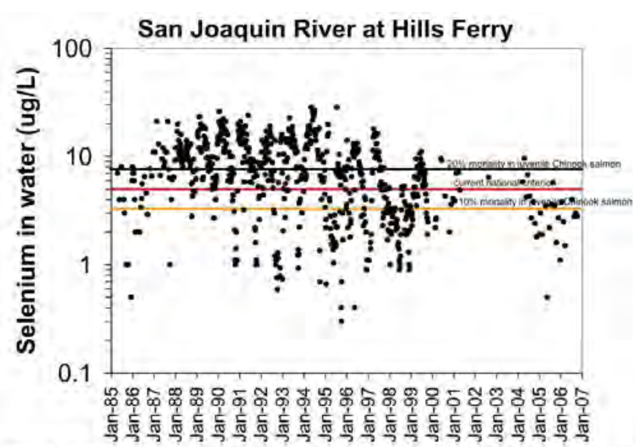


Figure 11. Selenium concentrations measured in the San Joaquin River at Hills Ferry, just upstream of the confluence of the Merced River. The data are from the Central Valley Regional Water Quality Control Board.

Figures 10 and 11 from Beckon and Maurer (2008). While the Se concentrations in water have declined over time (Fig. 11), they remain well above LC10 level for juvenile Chinook salmon (3.3 ppb; Fig 10).

return flows), although declining dramatically after the implementation of GBP, still present a ñsubstantial ongoing risk to migrating juvenile Chinook salmon ñ (Beckon and Maurer 2008). In addition, there are indications (W. Beckon, *personal communication*.) that green sturgeon could be as Se-sensitive as salmonids, and the data on related white sturgeon indicate potentially harmful Se-concentrations in the diets and tissues of that species as well (Beckon and Maurer 2008, and references therein). While we continue to support the GBPôs load reduction approach, and think it likely that over time the combination of decreasing Se loading under the GBP and increasing restoration flows under the San Joaquin River restoration settlement will be sufficient to lower the Se concentration below a threshold of significance, we have serious concerns about the near-term impacts to migrating salmon.

For these reasons, we strongly urge the development of a comprehensive monitoring program in the San Joaquin River, focusing on the reach between Mud Slough (GBP discharge) and the confluence with the Merced River (which dilutes the GBP-discharged selenium). Importantly, this monitoring program should be implemented immediately, because the greatest risk to migrating salmonids is in the near term (next 2-3 years) before the next major increment of Se load reduction is required under the GBP and compliance with the full restoration flow requirements is achieved on the San Joaquin (in 2014), which together will likely lower the Se concentration in water below levels of concern. Because Se impacts are dependent in large part on the salmon residence time in the reach of concern, we urge identification of action triggers for review of the current protections and potential actions to remedy the impacts (e.g., temporary halt to GBP discharges; additional water releases from Friant Dam, etc).

Are there additional selenium control methods or programs that should be considered for reducing selenium inputs and impacts?

<u>Land retirement in the Central Valley Project South of Delta export areas should be considered as an additional approach for reducing selenium inputs and impacts, at the same time contributing to improved estuarine habitat in the Delta.</u>

As indicated above, there is a compelling need to reduce fish and wildlife exposure to selenium in the estuary and a compelling need to improve estuarine habitat conditions for pelagic species. Fortunately, a potential program exists that can assist the federal and state governments in meeting both of these objectives: increased retirement of drainage-impaired lands on the west side of the San Joaquin Valley.

It is very significant that the agricultural districts of the west side include some of the most junior CVP contractors, some of the export areas most frequently subject to shortages, and some of the most problematic lands for generating irrigation-induced water quality problems. The problem of drainage-impaired lands contributing to selenium pollution of the environment is well known to USEPA as well as other federal and state agencies (including SWRCB and USGS). These environmental risks including not only local groundwater but also receiving surface waters and the downstream estuarine environment. Also, the problems posed by insufficient CVP export capacity to safely meet the demands on the west side of the SJ Valley are equally well known to these agencies. Rather than pursuing expensive, potentially unreliable, and potentially risky drainage ñfixesò in order to keep these impaired lands in production (only to keep facing recurring water supply shortages), there is a growing consensus that the more cost-effective, environmentally responsible and expeditious solution is to retire these problematic lands from irrigated agriculture, reduce the associated water contracts accordingly, and pursue where possible other ñgreenò economic alternatives on these lands such as renewable energy production, especially solar development.

If properly overseen by federal and state agencies, such a program could simultaneously improve X2 values in the Delta, prevent downstream transfer of selenium and other contaminants, reduce federal costs and increase the prospects for environmental restoration. Accordingly, we urge USEPA to consider such an approach as an additional ñcontrol methodò whether or not USEPA itself would be able to pursue all elements of such a program independently.

WETLANDS

What different approaches under the Clean Water Act Section 404 program should EPA consider, in consultation with the U.S. Army Corps of Engineers, to improve the protection of aquatic resource functions in the Bay Delta Estuary?

<u>USEPA should explicitly consider the landscape level values of wetlands when permitting wetland activities, and develop ecosystem viability criteria for use in the permitting process.</u>

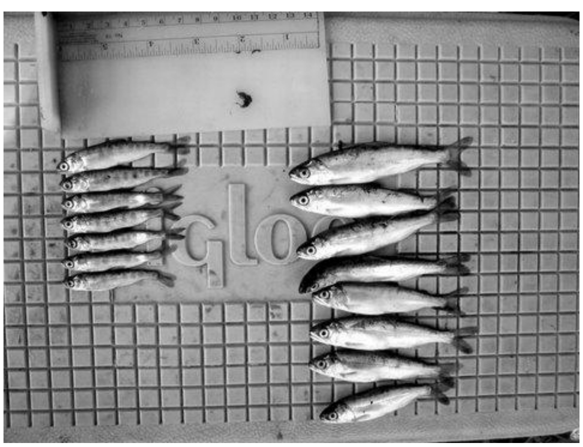
Wetlands ï like the present-day remnants in the Bay-Delta of a once much larger tidal-, brackish- and freshwater-marsh system ï serve vital ecosystem functions, and the ANPR appropriately includes a section evaluating the wetlands condition in the Bay-Delta. Although heavily degraded and greatly reduced in extent, as noted in the ANPR, the Bay-Deltaōs wetlands nevertheless continue to provide important ecosystem services, in several categories.

First, wetlands regulate movement of water within watersheds as well as in the regional and global hydrological cycle (Mitsch and Gosselink 1993; Richardson 1994). By storing precipitation (and infiltrating surface runoff) and then releasing it into other surface waters and groundwater, wetlands control water flow, and regulate discharge from watersheds. In addition, wetlands retard high river flows and mitigate flood damage, and protect the soil from erosion. They also play a critical role in connecting groundwater with surface waters, helping maintain water table levels and influencing hydraulic pressure, thus both recharging the aquifer and regulating its discharge to other waterbodies.

Second, wetlands are critical to biogeochemical cycling, retention, and export of nutrients and organic matter. Uniquely in wetlands, water-level fluctuations optimize coupled geochemical reactions (oxidation and reduction; Johnston 1991) that serve to transform nutrients, organic compounds and metals into biologically useful forms, or remove them from the aquatic ecosystem (e.g., heavy metals: through adsorption, and burial (e.g., in peat); ammonia: through nitrification-denitrification and atmospheric release; etc.).

Third, wetlands act both as carbon sinks, and as energy sources for the resident and migrant biota. Organic matter decomposition, coupled with slow water movement, allows the carbon to be deposited and stored within peat and wetlands soils. On the other hand, the inputs of terrestrial carbon into the detrital food chain, as well as the high rates of primary production in the wetlands, provide a large amount of biomass which represents an important source of carbon for the aquatic organisms, allowing exchange of nutrients, facilitating passage of aquatic organisms among systems (the ñflood pulse hypothesisò by Junk et al. 1989), and providing a critical life-support function required for spawning, migration, maintenance of species richness both in the wetland and in aquatic ecosystems up- and downstream. Thus, floodplain wetlands provide higher biotic diversity (Junk et al. 1989) and increased production of fish (Bayley 1991; Halyk and Balon 1983) and macroinvertebrates (Gladden and Smock 1990).

Finally, wetlands provide an irreplaceable habitat for plants, invertebrates, resident and migrating fish (including the endangered species of salmonids), birds, and mammals. Some of these are restricted to wetlands for their entire lives while others require wetlands for migration, rearing, or feeding (Mitsch and Gosselink 1993); endangered species are found in both of these categories (e.g., saltmarsh harvest mouse, winter-run Chinook salmon). The effect of wetlands on biological productivity, especially fish production, is well known: for example, riverine fish with access to wetlands have been shown to grow faster and/or larger than those restricted to the river channel (Junk et al. 1989; Bayley 1995). A analogous outcome has been demonstrated in the Bay-Delta (Sommer et al. 2001), showing increased survival and growth rates for juvenile Chinook salmon in the Yolo Bypass (seasonal wetland) than in the Sacramento River.



The importance of wetlands: juvenile salmon from the floodplain (right) growing faster and larger than those (left) from the Cosumnes River channel (Photo by J. Operman, from study by C. Jeffres)

The degree to which these critical ecosystem services are provided is determined by the quantity and quality of total wetland habitat, not by the status of a single wetland considered in isolation from the larger ecological landscape. For this reason, USEPA should consider the importance of Bay-Delta wetlands at the regional level when exercising its authority to regulate wetland activities, and develop and adopt ecosystem viability criteria to assist in doing so.

Unlike species viability criteria, an idea commonly used in such contexts as the federal Endangered Species and National Forest Management Acts, the ecosystem viability concept remains less well known, occasionally appearing in the ecosystem management literature (Brussard et al. 1998; Vogt et al. 1997). Ecosystem viability nevertheless represents a useful framework for considering the landscape-scale implications of wetlands management and regulation ï the implications of which are not necessarily adequately included in the species-by-species approach to viability analysis. Thus, although current planning efforts in the Bay-Delta (such as the BDCP process) include species-specific viability analysis measures, we would urge the USEPA to specifically consider the *desired mosaic of habitat types*, their *connectivity*, habitat-patch *size*, and habitat *distribution* in future permitting of wetlands activities in the Bay-Delta. These well-established concepts of landscape ecology (Forman 1995) appropriately form the basis for ecosystem viability analysis, as a necessary complement to (not a substitute for) population viability analysis.

While USEPA will need to develop regionally specific indicators of ecosystem viability, the framework described by Brussard and colleagues (1998) provides a useful starting point, listing the four overarching criteria that need to be met for ñimpacted ecosystemsò (such as the Bay-Delta) to be considered viable:

(1) *current utility* (does the ecosystem provide services expected from it)
(2) *future potential* (do present uses not disrupt the processes that generate and maintain the desired ecosystem structure and function)
(3) *containment* (do current conditions not degrade areas beyond the ecosystem/region), and
(4) *resilience* (does the ecosystem maintain the capacity for self-maintenance and regeneration).

A regionally-developed set of indicators for assessing ecosystem viability would thus allow a new approach to permitting decisions regarding wetland activities, one that would should consider not just site-specific impacts but the role of Bay-Delta wetlands at the landscape level.

CONTAMINANTS

We offer brief additional comments in response to USEPAôs questions regarding contaminants.

Are there contaminants, other than those named above, causing adverse impacts to aquatic resource designated uses in the Bay Delta Estuary and that should receive more focused review?

The ANPR does not appear to identify methylmercury or other nitrogenous compounds (e.g. urea based fertilizers contributing to total nitrogen loads); we believe these contaminants merit further attention.

How can pollutant-specific water quality criteria effectively address or incorporate interactive effects between multiple contaminants and other physical, chemical, and biological stressors?

Contaminant threshold levels below the lethal level (LC50s) should be considered (e.g. EC50s, or EC25s). Studies that document synergistic effects for two compounds found in the Bay-Delta system should be used to set contaminant thresholds. Where information on the direct or synergistic effects a particular compound is not available, thresholds should be set based on the lowest limit applicable to a member of the same class of chemical compounds (e.g. pyrethroids, organophosphates, etc.). Higher thresholds can be established when data specific to this compound is published in reputable (peer-reviewed) studies. Also, adequate freshwater flows will tend to reduce concentrations of all interacting contaminant compounds and thereby reduce their individual and synergistic effects. A specific example is the known interaction between low DO and several contaminant metals.

What information exists about how climate change impacts will affect contaminant pollution (generally or for individual contaminants)?

See research by Denise Breitberg (and associates) at Smithsonian Environmental Research Center.
http://www.serc.si.edu/people/resumes/breitburg_cv.htm
See research by Paul Klerks (and associates) at Louisiana State University
http://biology.louisiana.edu/klerks.html
See research by Inge Werner (and associates) at UC Davis
http://ecology.ucdavis.edu/people/PersonalInfo.aspx?fld_ID=173
and other faculty of the graduate group of ecotoxicology at UC Davis.

Thank you for the opportunity to comment on the ANPR. We look forward to working with USEPA to meet the serious water quality challenges faced by the San Francisco Bay-Delta Estuary.

Sincerely,

Gary Bobker
Program Director

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