Informational Proceeding
To Develop Flow Criteria for the Delta Ecosystem
Necessary to Protect Public Trust Resources

California Department of Fish and Game

WRITTEN SUMMARY

This written summary provides the Department of Fish and Game's (DFG's) description of how exhibits supports responses to key issues identified in the notice of informational proceeding.

1. *What key information, in particular scientific information or portions of scientific information, should the State Water Board rely upon when determining the volume, quantity, and timing of water needed for the Delta ecosystem pursuant to the board's public trust obligations? What does this scientific information indicate regarding the minimum and maximum volume, quality, and timing of flows needed under the existing physical conditions, various hydrologic conditions, and biological conditions? With respect to biological conditions, what does the scientific information indicate regarding appropriateness of flow to control non-native species?*

   DFG has provided data and information that links the abundance, habitat, etc. of key species that live in, move through or otherwise depend for survival upon the Delta and its ecosystem. Exhibits 1 through 4 are provided on the relationship between water flow quantity, quality and timing for the following species: (1) Chinook salmon, (2) Pacific herring, (3) longfin smelt, (4) prickly sculpin, (5) splittail, (6) delta smelt, (7) starry flounder, (8) white sturgeon, (9) green sturgeon, (10) Pacific lamprey, (11) river lamprey, (12) bay shrimp, (13) mysid shrimp and a copepod, *Eurytemora affinis*, (14) American shad, and (15) striped bass. In general, the available data and information indicates: (1) Many species abundance is related to water flow timing and quantity (or the placement of X_2); (2) For many species, more water flow translates into greater species production or abundance; (3) Species are adapted to use the water resources of the Delta during all seasons of the year, yet for many important life history stages or processes consistently coincide with increased winter-spring flows; and (4) The source, quality, and timing of water flows influences the production of Chinook salmon in both the San Joaquin River and Sacramento River basins.

   DFG's current science-based conceptual model is that placement of X_2 in Suisun Bay (65 km to 74 km from February to June) represents the best interaction of water quality and landscape for fisheries production given the current estuary geometry. However, it is expected that major changes to the estuary landscape will occur over the next several decades. Sea level rise and human water demand will likely lessen the ability of resource managers to keep X_2 as far downstream as currently required. The current placement of X_2 is less than it was prior to 1977. Further, other components of estuarine habitat are changing independent of X_2 variation that evidence suggests are also lowering estuarine habitat suitability. For some of the estuary's animals (e.g., longfin smelt, starry flounder, striped bass) this has meant lower productivity per unit of outflow or X_2. These findings (DFG Exhibit 2) demonstrate that X_2 (or Delta outflow) is necessary, but not sufficient to sustain and recover the estuary's low-salinity zone ecosystem.

In DFG Exhibits 1 through 4, DFG scientists have updated much of the testimony provided since the late 1980s and early 1990s. The flow needs or relationships to flow are provided for many species as follows:

A. Chinook salmon: Delta inflow and outflow affects migration patterns of Chinook salmon through the estuary. Freshwater flow is an important cue for upstream migration of adult salmon and directly affects survival of juveniles moving downstream through the Delta. Decreased flows through the Delta may decrease the migration rate of juveniles moving downstream, increasing their exposure time to unsuitable water temperatures, cause entrainment into the interior Delta or in water diversions, and cause greater exposure to contaminants and predation. Increasing salmon survival rates through the Delta will be a critical step toward restoring natural salmon production in the Central Valley. Flows needed in the Sacramento River during fall through March have been estimated at 20,000 cfs or greater (DFG Exhibit 1). Fall-run Chinook salmon needs continue through May and into June. For the San Joaquin River at Vernalis estimates of spring flows needed for outmigrating smolts to meet the Bay-Delta Plan's salmon doubling objective ranges from 7,000 cfs (for 31 days) in critically dry years to 15,000 cfs (for 70 days) in wet years (DFG Exhibit 3).
B. Pacific herring: Recent analysis of X_2 location and juvenile Pacific herring abundance shows no relationship between Pacific herring abundance and X_2, suggesting additional factors other than habitat are involved, because both measures of herring habitat improved (one significantly) as X_2 shifted downstream. Thus, outflow is an important component and not the sole driver of Pacific herring juvenile survival or abundance.
C. Longfin smelt: Freshwater outflow during the incubation and early rearing periods (December through May) has a strong positive effect on longfin smelt recruitment to the juvenile stage. Outflow during the December through May period continues to have a significant positive relationship to longfin smelt abundance even though the relationship changed after the introduction of the over-bite clam (*Corbula amurensis)*.
D. Prickly sculpin: Available data and information to link this species to outflow are limited. No indices of abundance are calculated and no relationship can be investigated between outflow and species abundance. Nonetheless, larval dispersal appears to be a function of winter-spring outflow and such dispersal can benefit the populations by facilitating genetic transfer between streams that might otherwise be isolated from one another by high salinities.
E. Sacramento splittail: Large scale spawning and juvenile recruitment occurs only in years with significant protracted (≥30 days) flood plain inundation, particularly in the Sutter and Yolo bypasses. Some spawning also occurs in perennial

marshes and along the vegetated edges of the Sacramento and San Joaquin Rivers. During periods of low outflow, splittail appear to migrate farther upstream to find suitable spawning and rearing habitats. Splittail age-0 abundance has been significantly correlated to mean February through May Delta outflow and to days of Yolo Bypass flood plain inundation, representing flow/inundation during the incubation and early rearing periods. Splittail abundance was highest when the Yolo Bypass remained flooded for 50 days or more.

F. Delta smelt: This species' abundance does not respond to springtime freshwater flow in a predictable manner as does abundance of other estuary fishes. However, recent research shows that fall abundance is correlated with fall outflow. At all life stages, delta smelt distribution is influenced by outflow and its influence on the location of X_2. Flow has positive effects on several measures of delta smelt habitat. Moreover, the spring abundance of a copepod (*Eurytemora affinis*) that is an important prey for delta smelt does have a positive relationship with spring outflow.

G. Starry flounder: This species' abundance in the estuary is significantly and positively correlated to March through June outflow, when larvae and juveniles are located in the estuary, immigrating and beginning to rear. High river flows strongly correlate with the abundance of the bay shrimp (*Crangon franciscorum*), an important food source for starry flounder.

H. White sturgeon: This species likely responds to winter flows into and out of the Delta that stimulate adult migration (attraction flows) and spring flows in the rivers that cue spawning. Larvae benefit from spring river flows and Delta flows that transport them downstream to estuarine nursery areas. Juvenile white sturgeon may also benefit from spring river and Delta outflow that aid their downstream dispersal and spring Delta outflow enhances nursery habitat quantity and quality. The high winter and spring delta and river flows needed to attract migrating adults, cue spawning, transport larvae, and enhance nursery habitat happen only periodically in the estuary. Historical flow patterns combined with the unique life history of white sturgeon (long-lived, late maturing, long intervals between spawning, high fecundity) result in infrequent strong recruitment in the San Francisco Estuary.

I. Green sturgeon: Increased early-spring Delta and river flows would likely increase attraction and successful migration of adult green sturgeon to the upstream spawning areas. Increased late-spring river flows would likely increase hatching success and survival of larval and young juvenile green sturgeon.

J. Pacific lamprey: Based on its life history, increased flows in the spring would likely support upstream migration of Pacific lamprey adults, and possibly downstream migration of newly transformed sub-adults. Summer and fall flows should be maintained such that stream temperatures remain below lethal levels and stranding of ammocoete colonies on streambed margins is avoided.

K. River lamprey: Since river lamprey spawn in small tributaries, flows in larger rivers or the Delta will not likely have a large impact on spawning or hatching. Maintaining sufficient fall flows to support upstream migration and maintaining summer flows so that lethal temperatures and stranding of ammocoete colonies are avoided are likely the most important manageable actions. Increased spring flows would likely support downstream migration of newly transformed sub-adults.

L. Bay shrimp: Freshwater outflow from the Delta affects bay shrimp at every life stage. With higher outflows, mature shrimp move further downstream and early stage larvae are transported to Central Bay and the nearshore coastal area. Freshwater outflow from March to May is most critical in the establishment of a strong year class of bay shrimp in the Estuary. Most late-stage larval and small juvenile bay shrimp migrate into the estuary and upstream to the nursery area between April and June and then begin a period of rapid growth. In years with high freshwater outflow, the chemical cues used to locate the estuary and the bottom currents that aid the young shrimp's upstream migration are stronger and the area of shallow, brackish-water nursery habitat is larger than in low outflow years.

M. Zooplankton: Historically the mysid shrimp *Neomysis mercedis* responded positively to increased summer and fall outflow, but since the introduction of the overbite clam, *Corbula amurensis* it no longer does. After 1987, copepod (*E. affinis)* spring abundance (March-May) has significantly increased as spring X_2 has moved downstream. Relative abundance in recent years is highest in spring and persistence of abundance is related to spring outflow. As flows decrease in late spring, abundance decreases to extremely low levels throughout the Estuary.

N. American shad: Year class strength correlates positively with freshwater outflow during spawning and nursery periods of April through August, with the highest correlations observed in April-June. Although the outflow abundance relationship is based on Delta outflow, and transport to and through the Delta comprise important components of the relationship, actual flows in spawning tributaries are also important for both attraction flow and for proper incubation and early rearing conditions.

O. Striped bass: The abundance of young striped bass in summer has been positively correlated to delta outflows during the early rearing period (June-July) and survival from egg to 38mm has been significantly correlated to April through July X_2 position and fall abundance to July through November X_2 position. These relationships suggest both flow and habitat (derived from flow) influenced striped bass juvenile abundance. Recent analyses indicated that survival from egg to 38mm significantly increased as X_2 shifted downstream in the Estuary, however subsequent to the establishment of the over-bite clam (*C. amurensis)* the relationship between April through July outflow and the Fall Midwater Trawl age-0 striped bass abundance was no longer significant. As X_2 location moves downstream several measures of striped bass survival and abundance significantly increase, as do several measures of striped bass habitat. These results indicate that April though July flows still positively affect striped bass survival and summer abundance, and are positively related to some measures of age-0 striped bass abundance. X_2 position downstream later in the year is significantly related to important measures for age-0 striped bass habitat (May-December and September-December time periods).

2. *What is the level of scientific certainty regarding the foregoing information? How should the State Water Board address scientific uncertainty when developing the Delta outflow criteria?*

   The level of certainty and uncertainty in the available data and information is summarized in Exhibit 1. While the assessment of uncertainty is important, it should be acknowledged that uncertainty is inherent in all scientific endeavors and is usually managed by focusing on the degree of acceptance of the available scientific data and information among scientific experts. This degree of acceptance is quite high as evidenced by the numerous published papers that have described relationships between flow (or X_2) and the population-level responses of many estuarine species.

3. *What methodology should the State Water Board use to develop flow criteria for the Delta?*

   The Water Board should use a methodology that acknowledges that uncertainty is inherent in all environmental decision making, that incorporates available scientific understanding, and that explicitly presents, to the extent possible, all assumptions and judgments made in the development of flow criteria. The methodology should depend on the weight of the scientific information. A suggestion for a weight of evidence approach is presented in DFG Exhibit 5. The weight of evidence approach should be a narrative process where "confluences" in the individual lines of evidence (scientific understanding of water flow quantity, quality, and timing on fish and wildlife resources) are demonstrable. While not always available for all important species or processes, emphasis should be placed on studies where causal mechanisms have been identified, but it should be recognized that long-term, consistent species responses to flows during important life history stages are evidence of an important mechanism at work regardless of whether it can be identified.

4. *What does that methodology indicate are the needed minimum and maximum volume, quality, and timing of flows for different hydrologic conditions under the current physical conditions of the Delta?*

   Before minimum and maximum flows are identified, the Water Board should assemble all data and information provided in this proceeding to identify the range of flow criteria that should be considered. A range of flow criteria, rather than specific values at specific times and places, should be adopted because it is not known presently what is needed to support the yet-to-be-initiated or completed proceedings (e.g., the scope of the Delta Plan has yet to be developed and the Bay Delta Conservation Plan processes is still evaluating many options in and around the Delta). Notwithstanding the previous statement, DFG has provided flow recommendations for enhancing populations of fall run Chinook salmon in the San Joaquin River basin (DFG Exhibit 3) and for placement of X_2 (DFG Exhibit 2).

5. *When determining Delta outflows necessary to protect public trust resources, how important is the source of those flows? How should the State Water Board address this issue when developing Delta outflow criteria?*

   The challenge is to make sure that as solutions to problems are implemented within the Delta we do not create new problems or ignore existing problems upstream and overlook opportunities for remedies. In most cases it seems certain that addressing water quantity and quality issues in the Sacramento River and San Joaquin River watersheds can also generate ecological benefits in the Delta. For example, increased flow from the San Joaquin River into the Delta will likely have positive effects on other anadromous fish besides Chinook salmon (e.g., steelhead, sturgeon, American shad and striped bass) and other Delta and/or estuarine-dependent fish (longfin smelt and starry flounder). Entrainment in the winter and spring of delta smelt and longfin smelt at the State Water Project and Central Valley Project diversions in the south Delta is related to the magnitude of upstream flow in Old and Middle rivers. These flows are mainly a function of San Joaquin River inflow to the Delta and diversion rate from south Delta channels. Minimizing entrainment of adult smelt and facilitating rearing and transport of larval and juvenile smelt would be an added benefit of improving San Joaquin flows for Chinook salmon. Such flows would also provide somewhat more balance among sources of Delta inflow, improving hydrodynamics in Delta channels and potentially favoring the recovery and conservation of imperiled Delta species. Care should be taken to also meet the upstream needs of salmon. Water temperature in the rivers can have a large effect on salmon egg production, rearing, smoltification, and migration (DFG Exhibit 4).

   Another example is the need to preserve low water temperature in the upper Sacramento River. Given the recent low storage levels in Shasta, Oroville and Folsom reservoirs, providing suitable water temperature through the summer and early fall for spawning and rearing salmon and steelhead is very challenging. If the cold water pool in these reservoirs is not managed carefully, the river miles of stream habitat below these dams with water temperature suitable for salmonid reproduction and rearing will be diminished. At worst, running out of cold water before the end of the summer could result in extensive temperature-related mortality. Finding a balance between retaining water in several project reservoirs or releasing it to meet outflow objectives in late winter through spring is essential. If properly managed, cold water storage could help extend the frequency and durations of periods during summer when water temperature remains below harmful levels.