Public Comment
Bay-Delta Fact Finding Issues
Deadline: 9/29/08 by 5:00 p.m.

SRCSD

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September 29, 2008

Ms. Jeanine Townsend
Clerk to the Board
State Water Resources Control Board
1001 I Street, 24th Floor
Sacramento, CA 95814

Sent via e-mail to: commentletters@waterboards,ca.gov

Subject: **Bay-Delta Fact Finding Issues**
(Request for Written Input on Factual Issues regarding the Bay-Delta)

Ms. Townsend:

This letter is written to provide recommendations developed by Sacramento Regional County Sanitation District (District) regarding factual issues that the SWRCB should consider during upcoming evidentiary hearings. The information provided has been developed in response to the request for written input dated August 29, 2008.

The District owns and operates the Sacramento Regional Wastewater Treatment Plant, which provides treatment for municipal wastewater produced in the cities of Sacramento, West Sacramento, Folsom, Elk Grove, Rancho Cordova, Citrus Heights, and surrounding communities in the metropolitan area. The District has participated in the series of hearings held by the SWRCB in the development of the July 2008 Bay-Delta Strategic Plan work plan. The District appreciates the opportunity to provide factual, science-based information into the process to enable the development of sound policy determinations for the management of the Bay-Delta system.

Information provided herein is divided into three sections: (1) New topical categories that the SWRCB should consider in its evidentiary hearing process, (2) the order that the SWRCB should consider the topical categories and (3) factual information regarding studies (completed or underway) that the SWRCB should review and consider in its strategic planning effort for the Bay-Delta.

New Topics that the SWRCB should consider in evidentiary hearings

The August 29 notice lists six topical areas for the evidentiary hearings.

- Sources of salt to the Bay-Delta estuary
- Biological impacts of constant or variable salinity on fisheries

- Biological benefits (if any) of fish screens in the legally defined Delta
- Biological impacts of ammonia discharges
- Biological impacts of toxic substances (other than ammonia)
- Biological impacts of net outflow objectives

The District requests that the following three topical areas be added to the evidentiary hearing process by the SWRCB.

- ***Export pump fish screen entrainment and impacts***

The entrainment of fish on existing fish screens serving the export pumps in the South Delta is a recognized stressor that is likely impacting the health of Delta fish populations. It is important that the SWRCB develop and document the facts surrounding this factor, including the significance of fish losses at these screens on specific fish populations.

- ***Invasive species impacts***

Invasive species have caused significant, well documented disruption of the aquatic food web in the Bay-Delta system over the past 20 years. It is important that the SWRCB develop and document the facts surrounding this factor to better understand the significance of this stressor and its role in the Pelagic Organism Decline. This understanding may lead to extraordinary efforts by the SWRCB to address the adverse effects of invasive species on the Bay-Delta.

- ***Impact of nutrients in the Delta***

Nutrients are an essential component of the Bay-Delta ecosystem, vital to the productivity of the system. Information presented to date would encourage the SWRCB to limit nutrient sources to the Delta to address water supply taste and odor concerns and nuisance growths of plants and algae through nutrient source control. Information is available to indicate that control of nutrient concentrations in the Delta would not be an effective approach to dealing with either of these concerns. In fact, nutrient control in the Delta could have an overriding adverse impact on the system. The need exists to examine the nutrient question holistically to understand the complexities of the nutrient management question prior to setting policies or taking action that could produce significant unintended consequences.

Recommended order that topics should be considered in the SWRCB hearing process

The following order is recommended for use by the SWRCB in its hearing process.

1. Export pump fish screen entrainment
2. Net outflows
3. Invasive species
4. Salt loadings

5. Salt biological impacts

6. Ammonia

7. Toxic substances (other than ammonia)

8. Fish screens in the Delta

9. Nutrients

Studies that should be reviewed and considered by SWRCB

The August 29 notice requests that commenters inventory and summarize the results of well-documented data-based scientific analysis. The District has assembled information on the following topics in response to this request. That information is contained in the attached table.

1. Export pump fish screen entrainment

2. Invasive species

3. Ammonia

4. Nutrients

The District anticipates participating in the evidentiary hearing process and is hopeful that the SWRCB can design a process that provides adequate opportunity for stakeholder input and yet avoids unnecessary and time-consuming legal or quasi-legal processes. We encourage the SWRCB to develop a streamlined process that achieves the goal of developing an essential assemblage of facts that will guide future policy determinations by the SWRCB, Regional Water Boards and other agencies.

Sincerely,

Terrie L. Mitchell for

Wendell H. Kido
District Manager

cc: Mary Snyder – SRCSD
Stan Dean – SRCSD
Terrie Mitchell – SRCSD
Debbie Webster – CVCWA

Attachments

State Water Resources Control Board Request for Factual Issues Regarding the Bay-Delta
September 29, 2008

Priority/ Issue	Citation/Reference	Author(s). Year	Links	Key Findings
1/Entrainment*				
	Untested assumptions: effectiveness of screening diversions for conservation of fish populations. *Fisheries* 30:20-28.	P.B. Moyle and J.A. Israel. 2005	www.fisheries.org	An evaluation of literature on entrainment and fish screens, focusing on the Central Valley. Main conclusions from the literature review were that published information is limited and widely variable, but that diversions can be significant sources of fish mortality and that the impacts on fish populations are highly variable.
	An evaluation of the effectiveness of fish salvage operations at the intake to the California aqueduct, 1979-1993. Pp. 497-518 *in* J. T. Hollibaugh, ed. San Francisco Bay: The ecosystem. Pacific Division of the American Association for the Advancement of Science, San Francisco, CA. 1996.	R. Brown, S. Green, P. Coulston, and S. Barrow. 1996	This reference was cited by Sommer *et al.* in The Collapse of Pelagic Fishes in the Upper San Francisco Estuary. *Fisheries* 32:270-277. 2007.	Diversions are known to entrain most species of fish in the upper estuary. Approximately 110 million fish were salvaged at the SWP screens and returned to the delta over the 15-year study period (1979-1993).
	Resilience of splittail in the Sacramento-San Joaquin estuary. *Transactions of the American Fisheries Society*. 126:961-976. 1997.	T. Sommer, R. Baxter and B. Herbold. 1997	afs.allenpress.com	Entrainment in diversions is of particular concern in dry years, when distributions of young striped bass, delta smelt, and longfin smelt shift closer to the SWP and CVP water diversion facilities.

*Issues not identified in the Strategic Workplan

State Water Resources Control Board Request for Factual Issues Regarding the Bay-Delta
September 29, 2008

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1/Entrainment*				
	2006 Fish Salvage at the State Water Project and Central Valley Project Fish Facilities. IEP Newsletter, Volume 20, No. 2, Spring 2007.	R. Gartz. 2007	http://www.iep.ca.gov/report/newsletter/	2006 salvage data and historical salvage data (1982 onward) are presented for Chinook salmon (Oncorhynchus tshawytscha), steelhead (O. mykiss), striped bass (Morone saxatilis), American shad (Alosa sapidissima), longfin smelt1 (Spirinchus thaleichthys), delta smelt (Hypomesus transpacificus), inland silversides (Menidia beryllina), threadfin shad (Dorosoma petenense), splittail (Pogonichthys macrolepidotus), green sturgeon (Acipenser medirostris), white sturgeon (A. transmontanus), common carp (Cyprinus carpio), and Chinese mitten crab (Eriocheir sinensis).
	Losses of Sacramento River Chinook Salmon and Delta Smelt to Entrainment in Water Diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary & Watershed. June. 27 pages.	W. Kimmerer. 2008	http://repositories.cdlib.org/jmie/sfews/	Pumping at the water export facilities in the southern Sacramento-San Joaquin Delta kills fish at and near the associated fish-salvage facilities. The proportion of fish salvaged increased with export flow. Losses of delta smelt adult, and juveniles are estimated.
	Pelagic Organism Decline Progress Report: 2007 Synthesis of Results. Interagency Ecological Program for the San Fransisco Estuary, January 2008.	Baxter, R, R. Breuer, L. Brown, M. Chotkowski, F. Feyrer, M. Gingras, B. Herbold, Anke Mueller-Solger, M. Nobriga, T. Sommer and K. Souza. 2008.	http://www.science.calwater.ca.gov/pdf/workshops/POD/IEP_POD_2007_synthesis_report_031408.pdf	Substantial increases in winter CVP and SWP salvage of Delta smelt and Threadfin shad occurred during the POD years.

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State Water Resources Control Board Request for Factual Issues Regarding the Bay-Delta
September 29, 2008

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2/Flow				
	Physical, Biological, and Management Responses to Variable Freshwater Flow in the San Francisco Estuary. *Estuaries*. 25:1275-1290.	W.J. Kimmerer. 2002	http://springerlink.metapress.com/content/120846/-	Fish survival increases with greater freshwater flow. Fish losses by entrainment increase as freshwater exports increase. This paper discusses the issues, management, and recommendations for experimental manipulations to better understand flow dynamics.
	Investigating the Mechanisms Underlying the Relationships between Abundance of Estuarine Species and Freshwater Flow. IEP Newsletter, Vol. 18, No. 2, Spring 2005	Kimmerer, W.J. and B. Bennett2005	http://www.iep.ca.gov/report/newsletter/	Flow determines salinity gradients (e.g., X2), food and nutrient imports and delivery of organisms from upstream to downstream. Mechanisms of interaction between flow and other factors affecting delta fish species are summarized.
	Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages? *Marine Ecology Progress Series* 243:39-55.	Kimmerer, W.J. 2002	http://www.int-res.com/journals/meps/meps-home/-	Flow is more important than food (trophic transfer) in determining fish populations, and acts through changes in habitat. The food web appears strongly coupled between benthos and plankton, and weakly coupled between zooplankton and fish.
	Investigating the Mechanisms Underlying the Relationships between Abundance of Estuarine Species and Freshwater Flow. (Source?)	Kimmerer, W.J (year?).		Flow determines salinity gradients (e.g., X2), food and nutrient imports and fish delivery from upstream to downstream. Mechanisms of interaction between flow and other factors affecting delta fish species are summarized.
	Multidecadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA. *Can. J. Fish. Aquat. Sci.* 64:723-73 4	Feyrer, F., M.L. Nobriga, and T.R. Sommer. 2007	http://pubs.nrc-cnrc.gc.ca/rp-ps/journalDetail.jsp?lang=eng&jcode=cjfas	Sechi depth (water clarity) and conductivity were important predictors of delta smelt and striped bass occurrence and recruitment over the past 36 years . Long-term changes in flow patterns affected these important water quality measures.

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State Water Resources Control Board Request for Factual Issues Regarding the Bay-Delta
September 29, 2008

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2/Flow				
	Isohaline Position as a Habitat Indicator for Estuarine Populations. *Ecological Applications*, 5(1):272-289.	Jassby, A.D., W.J. Kimmerer, S.G. Monismith, C.Armor, J. E. Cloern, T.M. Powell, J.R. Schubel, and T.J. Vendlinski. 1995.	http://www.jstor.org/journals/10510761.html	The 2% salinity position (X2) is directly dependent on river flows and freshwater exports. The need to consider diversions, in addition to X2 for managing some delta fish populations is reviewed and illustrated with the example of striped bass survival.
	Investigating Particle Transport and Fate in the Sacramento-San Joaquin Delta Using a Particle Tracking Model. San Francisco Estuary & Watershed. February. 26 pages.	Kimmerer, W.J. and M.L. Nobriga. 2008	http://repositories.cdlib.org/jmie/sfews/-	Pelagic fish movement is influenced greatly by flows. Model shows that larval Delta smelt entrainment is dependent on diversion flows relative to outflows.
3/Invasive Species*				
	Predation by an introduced clam as the likely cause of substantial declines in zooplankton of San Francisco Bay. *Marine Ecology Progress Series* 113:81-93.	Kimmerer, W.J., E. Gartside and J.J. Orsi. 1994.	http://www.int-res.com/journals/meps/meps-home/-	The invasive clam (P. amurensis) reduced phytoplankton (chlorophyll) and three common estuarine copepod species by 53-91% in the late 1980's in only a few years.
	Fish community ecology in an altered river delta: Spatial patterns in species composition, life history strategies, and biomass. Estuaries 28:776-785.	Nobriga, M.L., F Feyrer, RD Baxter, and M. Chotkowski. 2005	http://springerlink.metapress.com/content/120846/-	Striped bass and special-status native fishes such as delta smelt, Chinook salmon, and splittail, were most abundant in turbid, open water habitats, as opposed to habitats high in submerged aquatic vegetation (SAV) with greater water clarity. The low abundance of special-status fishes in the comparatively productive SAV-dominated habitats suggests these species would benefit more from large-scale restoration actions that result in abiotic variability that mirrors natural river-estuary habitat than from actions that emphasize local (site-specific) productivity.

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3/Invasive Species*				
	Trophic interactions and direct physical effects control phytoplankton biomass and production in an estuary. Limnology and Oceanography 37:946-955.	Alpine A.E. and J.E. Cloern. 1992.	http://aslo.org/lo/toc/index.html	In the northern and eastern SFE, years when the introduced clam *Potamocorbula [Corbula] amurensis* was abundant had mean summer primary productivity of 39 g C/m2/y compared to a value of 106 g C/m2/y for years when they were rare or absent.
	Dietary shifts in a stressed fish assemblage: Consequences of a bivalve invasion in the San Fransisco Estuary. Environmental Biology of Fishes 67:277-288.	Feyrer F., B. Herbold, S.A. Matern, P.B. Moyle. 2003	http://springerlink.metapress.com.proxy.library.ucsb.edu:2048/content/102877/	Mysid shrimp sharply declined after the invasion of the clam *Corbula amurensis* in SFE. Eight of 13 fish species which were previously highly dependent on mysid shrimp for food declined after the clam invaded the estuary, including 3 of the 4 POD species.
	Ecological Value of Shallow-Water Habitats: Implications for the Restoration of Disturbed Ecosystems. *Ecosystems*. 9:422-440.	Lopez, C. B., J. E. Cloern, T. S. Schraga, A.J. Little, L. V. Lucas, J. K. Thompson and J. R. Burau. 2006.	http://springerlink.metapress.com/content/101552/	Phytoplankton in the delta is primarily produced in marshes and exported to open water where its abundance is controlled by invasive clams.
	Accelerating invasion rate in a highly invaded estuary. *Science* 279: 555-558.	A. Cohen and J. Carleton. 1998	www.sciencemag.org	The authors assembled data on introduced species to the Bay/Delta ecosystem, and identified 234 invasive species. They concluded that "the large number of exotic species, their dominance in many habitats, and the rapid and accelerating rate of invasion suggest that the San Francisco Bay and Delta may be the most invaded aquatic ecosystem in the world."
	The effects of introduced water hyacinth on habitat structure, invertebrate assemblages, and fish diets. *Estuaries* 26: 746-758.	Jason Toft, Charles Simenstad, Jeffery Condelli, and Lenny Grimaldo. 2003	www.erf.org/journal/	Introduction of water hyacinth has caused significant ecological impacts, since it is functionally different from native pennywort vegetative species. Water hyacinth could have a pervasive effect on the fish-invertebrate food web.

*Issues not identified in the Strategic Workplan

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3/Invasive Species*				
	Will Tidal Wetland Restoration Enhance Populations of Native Fishes? *San Francisco Estuary and Watershed Science* 1, 2003.	L. Brown. 2003	http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art2/	The most common invasive macrophyte species, Brazilian waterweed Egeria densa has significantly impacted the Delta ecosystem. Egregia impacts water clarity by allowing suspended solids to settle out in the dense vegetative growth, and provides habitat for invasive predatory fish. Invasive species predominate in Egregia patches. When Egeria is abundant, open-water habitat is reduced and alien fish and invertebrates are more likely to dominate.
	Phytoplankton in the Upper San Francisco Estuary: Recent Biomass Trends, Their Causes and Their Trophic Significance. *San Francisco Estuary and Watershed Science* Vol. 6, Issue 1, Article 2.	Jassby, A.D. 2008	http://repositories.cdlib.org/jmie/sfews/	This study focused on food availability as a factor in fish abundance, exploring the hypothesis that changes in phytoplankton populations could be a factor in the decline of zooplankton and fish species in the San Francisco Estuary. Jassby investigated productivity by assessing chlorophyll levels, Phytoplankton population levels in Suisun Bay have been maintained at low levels due to filter feeding by the invasive clam *Corbula amurensis* (introduced in 1986).

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State Water Resources Control Board Request for Factual Issues Regarding the Bay-Delta
September 29, 2008

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3/Invasive Species*				
	Functional variability of habitats within the Sacramento-San Joaquin Delta: restoration implications. *Ecological Applications* 12:1528-1547. 2002.	L. Lucas, J. Cloern, J. Thompson, and N. Monsen. 2002	http://www.jstor.org/stable/3099989	The researchers explored declining productivity in the Delta as a factor in declining fish abundance. They considered grazing losses due to the Asiatic freshwater clam *Corbicula fluminea*, finding that *Corbicula* colonization had a negative impact on phytoplankton productivity.
4/Salt Loadings				
	Metadata Guide for Salinity Data Sources for the Central Valley of California Final Report Submitted to State Water Resources Control Board Central Valley Regional Water Quality Control Board for Agreement No. 05-416-150-0 ("Central Valley Salinity Data Study" component) California Water Institute, California State University, Fresno CWI-GEOL-08SAL002	C. John Suen, Sc.D., P.G. 2008	http://www.swrcb.ca.gov/centralvalley/water_issues/salinity/programs_policies_reports/cwi_metaguide_toc.pdf	Summarizes and describes databases and other sources of data on salinity in the Central Valley.
	Hilmar Supplemental Environmental Project Submitted to the California Regional Water Quality Control Board Central Valley Region In Compliance With Order No. R5-2006-0025 November 16, 2007	Yoram Rubin David Sunding Mark Berkman 2007	http://www.hilmarsep.com/files/Report_11-19-07.pdf	The physical modeling undertaken for this study shows that there is not a single inventory of salt in the San Joaquin Valley. The problem of salt management is a local one, particularly for point sources. The tools identified and demonstrated in this study allow the Regional Board to undertake accurate and effective, site-specific analysis of salt management alternatives. There is no single salt concentration of discharge that is appropriate or reasonable in every instance.

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State Water Resources Control Board Request for Factual Issues Regarding the Bay-Delta
September 29, 2008

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4/Salt Loadings				
	Delta Simulation Model II (DSM2) modeling scenarios, City of Tracy and the Mountain House Community Services District (MHCSD), Waste Discharge Requirements for City of Tracy Wastewater Treatment Plant, Order No. R5-2007-0036 at pp. F-46 – F-47, Attachment H; Waste Discharge Requirements for Mountain House Community Services District, Order No. R5-2007-0039 at pp. F-49.	Dept. of Water Resources September 2006	http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/san_joaquin/r5-2007-0036.pdf http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/san_joaquin/r5-2007-0039.pdf	The DSM2 modeling demonstrated that even under reasonable worst-case conditions, discharges from Tracy and Mountain House, collectively and individually, had limited impacts on the salinity problem in the southern Delta. Salt loadings from Tracy and Mountain House are fairly typical of salt loads from other wastewater discharges into the Delta.
5/Salt Biological Impacts				
	Multidecadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA. *Canadian Journal of Fisheries and Aquatic Sciences* J19439, 64: 723-734. May 11, 2007	Feyrer, F.;Nobriga, M.L., Sommer, T.R. 2007	www.cjfas.nrc.ca	Delta smelt are low salinity zone specialists, so it is reasonable to expect specific conductance to affect their occurrence.
	Physical, Biological, and Management Responses to variable Freshwater Flow into the SF Estuary, *Estuaries*, Vol 25 No.6B, p 1275-1290, December 2002.	Kimmerer, WJ 2002		Several flow-based management actions were established in the mid-1990s, including a salinity standard based on these flow effects, known as "X2". Concludes further investigation is needed to understand the underlying mechanisms, and to make the salinity standard more effective and more applicable to future estuarine conditions.

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6a/Ammonia (re. food web)				
	Phytoplankton in the Upper San Francisco Estuary: Recent Biomass Trends, Their Causes and Their Trophic Significance. *San Francisco Estuary & Watershed Science.* Vol. 6, Issue 1, Article 2.	Jassby, A.D. 2008	http://repositories.cdlib.org/jmie/sfews/	Despite an environment of higher ammonium, there was an overall trend of increasing spring–summer chlorophyll in the Delta during the last decade. Ammonium may very well play a role in the dynamics of specific phytoplankton events. But it is one factor among many, and its ecological impact relative to other sources of variability underlying long-term phytoplankton patterns is not clear. Changes in phytoplankton biomass and production during the last decade are therefore unlikely to be the cause of recent metazoan declines. More likely these declines are due to invasive clams. In the past, flows into Suisun Bay generally diluted the higher phytoplankton concentrations within the bay; now they bring in higher phytoplankton concentrations from upstream.

Priority/ Issue	Citation/Reference	Author(s). Year	Links	Key Findings
6a/Ammonia (re. food web)				
	Response of summer chlorophyll concentration to reduced total phosphorous concentration in the Rhine River (Netherlands) and the Sacramento – San Joaquin Delta (California, USA) Can. J. Fish. Aquat. Sci. 64:1529-1542.	Van Nieuwenhuyse, E. E. 2007.	http://pubs.nrc-cnrc.gc.ca/rp-ps/journalDetail.jsp?lang=eng&jcode=cjfas	The author used data from 1975-2005 as the evidence for a step decline (starting about 1994) in ambient *mean summertime* (May-Sept.) [TP], [SRP], and [chl.a] in the water column at 3 monitoring sites in the Delta. Because the halving of phosphorus concentrations in the Sacramento Regional WWTP effluent that occurred between 1992-1994 was temporally coincident with the step decrease in TP, SRP, and chla at the delta sites the author concluded that P was controlling chla concentrations and that the decrease in WWTP-P loading led to a decrease in May-Sept. phytoplankton biomass at the Delta stations. (Note: the chl.a data utilized may have been biased by exclusion of March and April data, which have shown trends of increasing chl.a in the Delta since 1996; Jassby 2008).
	Annual primary production: Patterns and mechanisms of change in a nutrient-rich tidal ecosystem. Limnology and Oceanography 47(3):698-712	Jassby, A.D., J.E. Cloern and B.E. Cole. 2002.	http://aslo.org/lo/toc/index.html	From 1975-1995 annual primary productivity was controlled by (1) invasive clam (P. amurensis), (2) a long-term decline in TSS (related to flow management), (3) river inflow, and (4) another undetermined factor.

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6a/Ammonia (re. food web)				
	The influence of environmental conditions on the seasonal variation of Microcystis cell density and microcystins concentration in the San Francisco Estuary. Hydrobiologia. 600:187-204.	Lehman, P.W., G. Boyer, M. Satchwell, S. Waller. 2008.	http://springerlink.metapress.com/content/100271/	Stream-flow, Contra Costa Canal pumping, and water temperature were the primary factors explaining the abundance and toxin (microcystin) content of *Microcystis aeruginosa in the brackish and freshwater reaches of the Delta*. Total dissolved solids and nutrient concentrations were of secondary importantce. Ammonia concentration was negatively correlated with Microcystis abundance , meaning that higher ammonia was associated with fewer Microcystis.

State Water Resources Control Board Request for Factual Issues Regarding the Bay-Delta
September 29, 2008

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6a/Ammonia (re. food web)				
	Interactions between NH4 and NO3 uptake and assimilation: comparison of diatoms and dinoflagellates at several growth temperatures. Marine Biology 1233: 541-551	Lomas M.W. and P.M. Glibert. 1999.	http://springerlink.metapress.com/content/100441/	Although ammonium concentrations of ~1 µM are commonly cited as thresholds for inhibition of nitrate uptake by phytoplankton, little is known about how ammonium/nitrate interactions – and thresholds for interactions - differ among taxonomic classes of phytoplankton. In this study, rates of uptake and assimilation of nitrate and ammonium were compared for two different classes of estuarine phytoplankton: diatoms and dinoflagellates. Also, the role of temperature as an environmental factor influencing the magnitude and nature of ammonium/nitrate interactions was investigated. Key findings were that nitrate uptake and assimilation were not completely inhibited even at elevated ammonium concentrations of 200 µM. Also (based on half-inhibition concentrations) twice as much ammonium was needed to produce the same effect on nitrate uptake and assimilation for diatoms, compared to dinoflagellates. This is of significance given that a much-cited hypothesis concerning bottom-up effects in the Delta ("good Suisun-bad Suisun", R. Dugdale and colleagues) posits that diatom growth is disproportionately hindered by ammonium concentrations, compared to other phytoplankton taxa. The authors cite other experimental results indicating that diatoms appear to be less susceptible to NH4+ inhibition than other taxa. Finally, the study showed that ammonium/nitrate interactions were more pronounced at higher growth temperatures. This means that water temperature is one of the environmental factors (along with turbidity and light) moderating the potential for ammonium/nitrate interactions to influence primary production.

*Issues not identified in the Strategic Workplan

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6a/Ammonia (re. food web)				
	The interaction between ammonium and nitrate uptake in phytoplankton. Mar. Ecol. Prog. Ser. 61:183-201.	Dortch Q. 1990.	http://www.int-res.com/journals/meps/meps-home/	This well-cited, thorough review reveals that species differences in interactions between ammonium and nitrate uptake make it impossible to make valid generalizations across taxa and systems regarding N uptake behavior. Significantly, the author explains that many reports of ammonium inhibition (of nitrate uptake and/or assimilation) in the literature result from experiments which are **not** designed to separate ammonium preference from ammonium inhibition. Specifically, true ammonium inhibition can only be demonstrated by comparing rates of nitrate uptake and assimilation in the presence AND absence of ammonium, which is not possible when experiments are conducted using water from the field. Also, inhibition generally varies inversely with the degree of N deficiency. In other words, phytoplankton that are not N-limited are less likely to exhibit ammonium inhibition of nitrate uptake. This is potentially an important factor influencing ammonium/nitrate interactions in the Delta, which is not considered a nutrient limited environment.

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6a/Ammonia (re. food web)				
	Short-term interaction between nitrate and ammonium uptake in *Thalassiosira pseudonana*: effect of preconditioning nitrogen source and growth rate. Marine Biology 110:183-193.	Dortch Q., P. A. Thompson and P.J. Harrison. 1991.	http://springerlink.metapress.com/content/100441/	An experimental method was employed that allowed genuine distinction between ammonium preference and ammonium inhibition of nitrate uptake for the marine diatom *Thalassiosira pseudonana*. Key findings were (1) that short term N-uptake behavior results from a combination of genuine ammonium preference and inhibition of nitrate uptake by ammonium, (2) that **prior nitrogen conditioning** (i.e, whether the algal cells were exposed to ammonium and/or nitrate prior to experimental additions of nitrate or ammonium) can determine the degree to which ammonium inhibition is observed. The study, and references cited therein, indicate that extrapolation of laboratory experimental results to the field is not appropriate when prior N availability and species composition are not addressed.
	Mesozooplankton omnivory in the upper San Fransisco Estuary. Mar. Ecol. Prog. Ser. 348:33-46.	Gifford, S.M., G. Rollwagen-Bollens, and S.M. Bollens. 2007.	http://www.int-res.com/journals/meps/meps-home/	In feeding experiments using natural plankton assemblages from the SFE, a cladoceran (*Daphnia*), a calanoid copepod *Acartia*, and two cyclopoid copepods (*Oithona davisae* and *Limnoithona tetraspina*), all grazed heterotrophic ciliates at higher rates than diatoms. These results lend support to the idea that detrital pathways for energy transfer may contribute more to pelagic secondary production in the SFE than previously acknowledged.

*Issues not identified in the Strategic Workplan

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6a/Ammonia (re. food web)				
	Ecology of a highly abundant, introduced cyclopoid copepod in a temperate estuary. Mar. Ecol. Prog. Ser. 324:219-228	Bouley, P. and W.J. Kimmerer. 2006.	are	The raptorial-feeding cyclopoid copepod *Limnoithoina tetraspina*, which has accounted for a large proportion of copepod biomass in the low salinity zone of the estuary since its introduction in 1993, was observed to feed on mixotrophic and heterotrophic ciliates, but rarely on diatoms. Significant grazing on heterotrophic ciliates was also observed for both filter-feeding calanoid copepods *Pseudodiaptomus forbesi* (a common smelt prey item) and *Eurytemora affinis*. These results are significant because they show that non-diatom organisms occupy an important position at the base of the pelagic food web in the SFE. *L. tetraspina* accounted for about 20% of July prey abundance for Delta smelt between 1993-1996, although its contribution to smelt diet in other months was lower.

*Issues not identified in the Strategic Workplan

Priority/ Issue	Citation/Reference	Author(s). Year	Links	Key Findings
6a/Ammonia (re. food web)				
	Feeding dynamics of Acartia spp. copepods in a large, temperate estuary (San Fransisco Bay, CA) Marine Ecology Progress Series 257: 139-158.	Rollwager Bollens G.C. and D.L. Penry. 2003.	http://www.int-res.com/journals/meps/meps-home/	There are less than a handful of published studies of the feeding habits of zooplankton in the San Fransisco Estuary. This study found that the diet of *Acartia* (an important calanoid copepod genus in the estuary) in San Pablo Bay was dominated by heterotrophic prey (especially protozoans such as cilliates and non-pigmented flagellates). This means that the detrital food web (dead organic matter →bacteria →heterotrophic protozoans/rotifers/others →higher consumers) contributes to secondary productivity (zooplankton, fish) in the estuary. *This study, as well as the two studies above, suggests that the pelagic food web in the San Fransisco Estuary is may be less dependent on phytoplankton biomass (e.g., diatoms), than is commonly asserted.*
	Apparent growth rates of pelagic fishes and relationship to abundance. Supporting document for the IEP Synthesis of 2005 Work to Evaluate the Pelagic Organism Decline (POD) in the Upper San Francisco Estuary.	Souza K, K Hieb, K Fleming, M Bryant and R Baxter. 2005.	http://www.science.calwater.ca.gov/pdf/workshops/POD/CDFG_POD_Status_report_pelagic_fish_apparent_growth_rates.pdf	Apparent growth rates for striped bass, delta smelt and longfin smelt did not show a decline during 2002-2004, compared to previous years. There was no apparent decline in length attained by the end of the first year for years 2002-2004 to indicate growth of survivors has been impacted recently.

Priority/ Issue	Citation/Reference	Author(s). Year	Links	Key Findings
6a/Ammonia (re. food web)				
	Fish otolith and condition study. Progress Report #1. Supporting document for the IEP Synthesis of 2005 Work to Evaluate the Pelagic Organism Decline (POD) in the Upper San Francisco Estuary.	Bennett B. 2005.	http://www.science.calwater.ca.gov/pdf/workshops/POD/CDFG_POD_Fish_growth_and_otoliths.pdf	2004 data for delta smelt growth rates and natal habitat location (determined via otolith microstructure and microchemistry) indicated fish reared in the upper Sacramento River grew faster than smelt reared in other Delta locations.
	Pelagic Organism Decline Progress Report: 2007 Synthesis of Results. Interagency Ecological Program for the San Fransisco Estuary, January 2008.	Baxter, R, R. Breuer, L. Brown, M. Chotkowski, F. Feyrer, M. Gingras, B. Herbold, Anke Mueller-Solger, M. Nobriga, T. Sommer and K. Souza. 2008.	http://www.science.calwater.ca.gov/pdf/workshops/POD/IEP_POD_2007_synthesis_report_031408.pdf	The calanoid copepod *Pseudodiaptomus forbesi* was the dominant summer prey item of smelt caught in the Sacramento River in both 2005 and 2006. In 2006, calanoid copepod abundance, especially those of P. forbesi, rebounded in the Delta – as evidenced both by net tow data and the composition of gut contents of delta smelt. Despite the rebound in P. forbesi in 2006, smelt abundance indices remained low. This finding weakens a hypothesis that shortages of quality zooplankton prey (i.e., *P. forbesi*) are responsible for continuing decline in smelt . In turn, it weakens the hypothesis that poor production of diatoms is driving down the abundance of quality zooplankton prey in smelt habitat

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Priority/ Issue	Citation/Reference	Author(s). Year	Links	Key Findings
6b/Ammonia – (re. toxicity)				
	Study to Evaluate Potential Effects of Ammonia on Delta Smelt. Status Update. 30 July.	CVRWQCB & Inge Werner (UCD-ATL).	http://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/index.shtml	Ammonia concentrations 4x the average concentration in the Sacramento River at Hood were not acutely toxic to delta smelt. Definitive ammonia toxicity tests showed that ambient ammonia concentrations are not acutely toxic to delta smelt, and that current EPA water quality criteria for ammonia are protective of delta smelt.
	The effects of wastewater treatment effluent associated contaminants on delta smelt. Ammonia Toxicity sampling and analysis plan. Final, 28 July.	I. Werner, C. Irvine, C. Foe. 2008.	-	Summary of the 2006 and 2007 delta smelt toxicity studies by Inge Werner. Description of the 2008 delta smelt effluent-ammonia toxicity study.
	Pelagic Organism Decline (POD): Acute and Chronic Invertebrate and Fish Toxicity Testing in the Sacramento-San Joaquin Delta *2006-2007*. Final Report. 30 April.	Werner, I., L.Deanovic, D. Markiewicz, M. Stillway, N. Offer, R. Connon, and S. Brander. 2008.	-	Report summarizes findings from delta smelt and *Hyalella azteca* toxicity bioassays in samples collected throughout the delta in 2006 and 2007. These initial findings showed a weak correlation with ammonia in field samples in 2006 but not in 2007. This led to a hypothesis that ambient ammonia might be adversely affecting delta smelt.
	1999 *Update of Ambient Water Quality Criteria for Ammonia* (EPA-822-R-99-014).	USEPA. 1999	http://www.epa.gov/waterscience/criteria/ammonia/index.html	National Recommended Water Quality Criteria for ammonia is presented.
	Final Report -Toxic effects of surface water in the upper San Francisco Estuary on Eurytemora affinis. Submitted to San Luis and Delta-Mendota Water Authority. 24 pages.	Teh, S.J., M. Lu, F. Teh, S. Lesmeister, I. Werner, J. Krause, and L. Deanovic. 2008.	-	The author found ammonia concentrations were below the EPA chronic criterion, and that E. affinis survival was not correlated with ammonia concentrations.

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6b/Ammonia – (re. toxicity)				
	Phytoplankton biomass and production in the Delta and Suisun Bay: Current conditions and trends. IEP Newsletter Vol. 19, No. 2, Spring 2006.	Jassby A. 2006	http://www.iep.ca.gov/report/newsletter/	Phytoplankton declines may underly long-term declines in higher organisms in the SFE over the past 35 years. But phytoplankton biomass trends for the last decade are either neutral or positive and cannot account for more recent declines in zooplankton or fish. If phytoplankton is playing a role, it is through changes in taxonomic composition rather than through total biomass and production.
	Evidence of Food Limitation in Larval Delta Smelt. IEP Newsletter, Winter 1998.	Nobriga, M. 1998	http://www.iep.ca.gov/report/newsletter/	In a 1993-1994 study of the gut contents of 1552 delta smelt, first feeding delta smelt larvae (5-6 mm in length) preferred cyclopoid copepodids (copepodids are immature copepods) over calanoid copepodids. *Eurytemora affinis* (a calanoid) was the most elected prey of larger smelt larvae (12-20 mm in length). These results are noteworthy because it is commonly hypothesized that cyclopoid copepods (especially the introduced *Limnoithona tetraspina)* are an inferior food resource for POD fishes (although no studies have compared the energetic value of calanoid and cyclopoids)– but success at first feeding is a crucial element of larval survival, and the data indicate that newly hatched smelt may preferentially consume cyclopoid copepodids.

Priority/ Issue	Citation/Reference	Author(s). Year	Links	Key Findings
6b/Ammonia – (re. toxicity)				
	Feeding habits of juvenile and adult delta smelt form the Sacramento-San Joaquin River Estuary. IEP Newsletter, Winter 1998.	Lott J. 1998.	http://www.iep.ca.gov /report/newsletter/	Gut content data from 1993-1996, showed that although *Pseudodiaptomus forbesi* (a calanoid copepod) was the most abundant taxa consumed by smelt between 20-50+ mm in length, *Limnoithona* and other cyclopoids comprised 13% and 22% of the diet (by abundance) of the diet of juvenile smelt 25-49 mm long, in May and July, respectively. The study shows that *Limnoithona* (an omnivore), contributes to smelt nutrition, along with more herbivorous (phytoplankton eating) zooplankton. *Gammarus* (a benthic amphipod) was an important June prey item for smelt 25-49mm in length.
	Update on delta smelt culture with an emphasis on larval feeding behavior. IEP Newsletter, Winter 2000.	Lindberg J. and S. Doroshov. 2000.	http://www.iep.ca.gov /report/newsletter/	The effect of turbidity on first-feeding behavior of delta smelt larvae was investigated in a laboratory experiment. The majority of larvae fed when turbidity was at least 25 NTU, but none of the larvae fed in clear water. The cause of the turbidity was not important (clay vs. phytoplankton) – supporting the hypothesis that turbid water produces better contrast between the prey and background – enabling smelt larvae to locate their prey. ***This study is important because it illustrates how an abiotic factor (turbidity) can be as crucial as food web parameters (e.g., zooplankton biomass) in determining the survival of larval smelt.***

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6b/Ammonia – (re. toxicity)				
	Growth of larval striped bass in the San Fransisco Estuary. IEP Newsletter, Fall 2001.	Foss S. and L. Miller. 2001	http://www.iep.ca.gov /report/newsletter/	Age-0 striped bass declined sharply in abundance during 1983-2005. Otolith-based growth rates of larval striped bass did not decline during the decade 1984-1993. In many estuaries, growth of striped bass larvae is strongly influenced by temperature and zooplankton prey density. This study suggests that zooplankton prey were not in short supply for striped bass larvae during the decade examined, and that food limitation does not explain poor survival of young-of-year striped bass.
	Culturing delta copepods. IEP Newsletter, Vol. 18, No. 3, Summer 2005.	Hall C. and A. Mueller-Solger. 2005.	http://www.iep.ca.gov /report/newsletter/	*Eurytemoris affinis* and *Pseudodiaptomus forbesi* were more successfully cultured in the lab when fed the motile cryptophyte alga *Cryptomonas* than when fed the diatom *Skeletonema* or the green alga *Scenedesmus*. Author suggests that these calanoid copepods might prefer motile prey. The study raises the possibility that the nutritional status of these two important calanoid copepods is less tightly linked to diatoms than commonly asserted.

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Priority/ Issue	Citation/Reference	Author(s). Year	Links	Key Findings
7/Other Toxics				
	Are steroids really the cause for fish feminization? A mini-review of in vitro and in vivo guided TIEs. *Marine Pollution Bulletin* 57: 250-254. 2008.	D. Schlenk, 2008	www.sciencedirect.com	Fish feminization is likely a very complex issue, and that a combination of factors contributes to the problem. The current consensus from scientific studies is inconclusive whether endocrine disrupting chemicals are the primary cause of fish feminization, or whether complex physiological interactions and mechanisms are responsible.
8/In Delta Fish Screens				
	Close Encounters with a Fish Screen II: Delta Smelt Behavior Before and During Screen Contact. *Transactions of the American Fisheries Society* 136: 528-338. 2007	White, David; Swanson, Christina; Young, Paciencia; Cech, Joseph; Chen, ZhiQiang; Kavvas, Levent	http://afs.allenpress.com/	Studied the likelihood, consequences, and mechanics of involuntary contact of fish with fish screens, and found that contact with screens was more harmful to delta smelt than other small fishes tested. Impact velocity affected injury, and the researchers stressed the need for fish screen criteria designed to limit fish contact with screens.
	Close Encounters with a Fish Screen: Integrating Physiological and Behavioral Results to Protect Endangered Species in Exploited Ecosystems. *Transactions of the American Fisheries Society* 134: 1111-1123. 2005.	C. Swanson, P. Young, J. Cech, Jr. 2005	http://afs.allenpress.com/	Researchers conducted Fish Treadmill experiments, and found that delta smelt experienced injury or mortality after contact with fish screens in the laboratory. Injuries included scale loss, fin damage, abrasions, and hemorrhaging.

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Priority/ Issue	Citation/Reference	Author(s). Year	Links	Key Findings
9/Nutrients*				
	Taste and Odor Problems in Southern Water Supplies. Presentation given at the California Water and Environmental Modeling Forum (CWEMF) Technical Workshop of Overview of Delta Nutrient Water Quality Problems: Nutrient Load-Water Quality Impact Modeling, March 25, 2008.	Losee RW. 2008	Workshop agenda with embedded links to presentations: http://www.cwemf.org/workshops/NutrientLoadWrkshp.pdf	Taste & Odor (TO) events in the California Aqueduct and SWP reservoirs are not predicted by water quality parameters, including nutrient concentrations. So far, direct monitoring for TO-producing algae, or their byproducts (e.g., via scuba and solid phase microextraction [SPME]) is the only reliable means for predicting TO events in drinking water supplies. Longitudinal surveys of TO compounds (such as MIB and geosmin) down the California Aqueduct (at check stations) show that the concentration of TO compounds can be inversely related to proximity to the Clifton Court Forebay – i.e., that conditions improve for TO-producing algae with distance from the Delta. This pattern does not support a direct relationship between nutrients in SWP water and TO-algal biomass. Also, biomass of TO-producing algae attached to the surfaces of the aqueduct is affected by turbulence; middle reaches of pools with smooth flow support less attached algae than reaches with siphons and check structures. It was determined that TO events in Castaic Lake largely resulted from an engineering design flaw, in which an air boil caused by a siphon entrained TO-producing algal cells from a narrow surface water stratum to water outtakes at depth. Improvements in reservoir design employed for Diamond Valley Lake – including avoidance of air entrainment, outtakes at multiple depths, and steeper reservoir sides, are expected to help avoid TO issues in Diamond Valley Lake.

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9/Nutrients*				
	Phytoplankton Regulation in a Eutrophic Tidal River (San Joaquin River, California). San Fransisco Estuary & Watershed Science, Vol. 3, Issue 1 (March 2005), Article 3.	Jassby A. 2005	http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1024&context=jmie/sfews	Factors other than nutrient concentrations prevent phytoplankton from reaching the N- or P-determined carrying capacity of the tidal San Joaquin River. Growth rate is light limited owing to mineral turbidity. In most years, maximum phytoplankton biomass depends on river discharge, which controls the cumulative light exposure of algal cells in transport (less flow, more light exposure). Annual peak chl.a in the tidal San Joaquin River (=downstream of Vernalis) reaches only a small percentage of the river's carrying capacity; 13% on the basis of total phosphorus. Only in extreme dry years might phytoplankton in the tidal river become limited by nutrients. For this reason, reductions in chl.a levels to the boundary between mesotrophy and eutrophy (~25 µg/L) would entail reductions (at Mossdale) of 61-95% for N, and 72-95% for P. Maintaining river discharge above 50 m3/s during late spring/early summer could eliminate nuisance algal blooms at Vernalis.

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9/Nutrients*				
	Nutrient Sources for Growth of Exotic Aquatic Plants in the Sacramento-San Joaquin Delta. Presentation given at the California Water and Environmental Modeling Forum (CWEMF) Technical Workshop of Overview of Delta Nutrient Water Quality Problems: Nutrient Load-Water Quality Impact Modeling, March 25, 2008.	Anderson L, and M Carlock. 2008	Workshop agenda with embedded links to presentations: http://www.cwemf.org/workshops/NutrientLoadWrkshp.pdf	The abundance and distribution of invasive vascular (non-algae) aquatic plants is a function of water depth, channel morphology, current speed, and other physical habitat variables, as opposed to nutrient supply or other water quality variables. Controlling dissolved nutrient levels is unlikely to affect the success of rooted aquatic vascular plants (emergent or submersed), because they have access to large reserves of sediment-N and P. Submersed, rooted aquatic plants probably obtain about 80-95% of their N, P and K supplies from the sediment. Experimental fertilization of the invasive, free-floating aquatic plant *Eichhornia crassipes* did not result in changes in the nitrogen content or the biomass of plant tissue. This implies that dissolved nitrogen supplies in the water column are not controlling the biomass of this particular invasive plant.
	Delta and Aqueduct -Tastes and Odors and Algal Cyanotoxins. Presentation given at the California Water and Environmental Modeling Forum (CWEMF) Technical Workshop of Overview of Delta Nutrient Water Quality Problems: Nutrient Load-Water Quality Impact Modeling, March 25, 2008.	Janik, J. 2008	Workshop agenda with embedded links to presentations: http://www.cwemf.org/workshops/NutrientLoadWrkshp.pdf	While summer (July) peaks in the TO compound MIB are detected in most years at the Banks Pumping Plant (BPP), one of the recent large MIB events (July 2004) was related to a bloom of *Planktothrix perornata* in the newly flooded Jones Tract (rather than a bloom in Delta waterways). MIB and geosmin concentrations were not well correlated to overall phytoplankton biomass at BPP between 2001-2007.

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State Water Resources Control Board Request for Factual Issues Regarding the Bay-Delta
September 29, 2008

Priority/ Issue	Citation/Reference	Author(s). Year	Links	Key Findings
9/Nutrients*				
	The influence of environmental conditions on the seasonal variation of *Microcystis* cell density and microcystins concentration in the San Francisco Estuary. Hydrobiologia. 600:187-204.	Lehman, P.W., G. Boyer, M. Satchwell, S. Waller. 2008	http://springerlink.metapress.com/content/100271/	Stream-flow, Contra Costa Canal pumping, and water temperature were the primary factors explaining the abundance and toxin (microcystin) content of *Microcystis aeruginosa* in the brackish and freshwater reaches of the Delta. Total dissolved solids and nutrient concentrations were of secondary importance. Ammonia and nitrate concentrations were weakly negatively correlated with *Microcystis* abundance, meaning that higher nitrogen concentrations were associated with fewer *Microcystis*. Sacramento and San Joaquin River flows were strongly negatively correlated to *Microcystis* abundance, while East Side stream flow was strongly positively correlated with *Microcystis abundance*.

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