Delta Outflows and Related Stressors

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Process

- Late 2013
  - Background and key material provided
  - Conference call, reading assignments
- February 10-11, 2014 – workshop
- Panel discussion of issues and conclusions
- Writing assignments
- Editor-in-Chief Peebles collated and edited
- Circulated among members multiple times

Workshop

- Presentations
  - Science program
  - Public water agencies
  - Dischargers
  - In-Delta water users
  - Scientists/managers

- Extensive Q&A and discussion

Charge Question 1

- *What are the key studies and synthesis reports that the State Water Board should rely on in making their decisions on Delta outflow requirements?*

- Response embedded within report including commentary on several studies

Measuring X2

- Several approaches to measurement
- Some confusion regarding equations
- Importance of the stratification assumption
- Errors can be high, especially during periods of variability in outflow or when X2 is at 'extremes'

Key Findings and Observations

- In general, there should be no expectation that the species responses to X2 indicated by the existing regressions, which involve correlations with multi-year collections of seasonal field sampling across multiple stations, would be manifest at the fine time scales that salinity distributions can now be estimated within the estuary.

Key Findings and Observations

- Give careful consideration to the time and space scales of responses to outflow management.
- If a reasonable biological rationale for fine-scale management of X2 can be clearly expressed and agreed upon, then it may be implemented in an adaptive management experiment where field data regarding both the physical character of the system and the biological response are also collected to test the rationale.
- Until this has been accomplished, it is important to remember that the existing X2-abundance relationships do not provide the rationale for fine-scale management of X2.

Charge Question 2

- *The existing Delta outflow objectives are based largely on documented relationships between a suite of estuarine organisms and the 2 ppt isohaline (X2).*
  - *Should these flow relationships still be used as the basis for protecting estuarine fish, estuarine fish habitat, and other important ecosystem attributes?*
  - *Are there other methods or indicators available to serve as the basis for protecting estuarine fish, estuarine fish habitat, and other important ecosystem attributes? If so, what are they and how could they be applied?*

Key Findings and Observations

Use a suite of indicators in setting Delta outflow objectives, including X2, to ensure ecosystem (beyond individual species) health and to better understand and anticipate how outflow changes will affect not only target species but also other aspects of the ecosystem.

Key Findings and Observations

Clarify interpretation of X2 relationships by:

- Standardize X2 abundance relationships and include estimates of uncertainty
- Use linear scales (in addition to log or other transformations)
- Consistently use X2 or outflow

Key Findings and Observations

Consider additional factors in the development of indicators, e.g.:

- changes in X2 between seasons and water-year types,
- habitat suitability, spatial and temporal dynamics of the area and volume of habitat,
- water age,
- benthos community structure and function,
- patterns of gross energy flows in the system, and
- flowpath-related metrics such as the split between Sacramento and San Joaquin flows.

Important for species-specific indices to include vital rates in addition to indices for standing stock abundance.

Charge Question 3

- *What scales (magnitude and duration) of outflow change are needed to produce measurable changes in native species population viability and/or ecosystem function over what time frame? Are there thresholds for achieving specific responses? How could adaptive management experiments be conducted on these scales to inform manipulation of Delta outflow to better protect estuarine fish, estuarine fish habitat, and other important ecosystem attributes?*

Key Findings and Observations

- It seems unlikely that the predicted increase in the abundance index under any proposed regime would result in a substantive improvement in abundance of Delta Smelt in the short-term due to stock size limitations.
- Little evidence that the relatively modest changes in fall Delta outflows being proposed are going to result in substantive increases in abundance of key pelagic fish species based on their X2-abundance relationships

Key Findings and Observations

- Substantive increases in Longfin Smelt abundance index may be realized under the proposed 75% winter-spring unimpaired flow standard. Even in that case, population changes may be very difficult to detect given the variance of the regression, potentially high observation error in the sampling programs, and the infrequent implementation of high flows, even under the unimpaired flow strategy.

Key Findings and Observations

- The data are extensive but there are key limitations
- Models are useful but complexity can surpass the information available
- Panel encourages continued, but thoughtful, use of multistage life-cycle modeling in the analysis of Bay-Delta data
- Critical that quantitative analyses communicate uncertainty in recommended flow criteria to decision makers

Key Findings and Observations

- Decision makers are hesitant to adopt costly policies in the absence of relatively convincing model predictions that indicate they will achieve the desired objectives. However, it is very difficult to improve model predictions without implementing these policies in the first place. Thus, the rate of learning about the efficacy of alternate flow policies in the Delta will likely be very slow
- Explicit AM plans and realistic experimental designs should be a fundamental part of setting outflow objectives

Charge Question 4

- *How are other factors that affect estuarine fish, estuarine fish habitat, and other ecosystem attributes likely to interact with Delta outflow requirements?*
  - *Are there tools or methods available that could help the State Water Board to better assess the interactions between flow and other factors that affect the estuarine fish, estuarine fish habitat, and other important ecosystem attributes?*
  - *Can we reasonably expect that addressing other stressors without addressing flow will lead to specific improvements in the status of estuarine fish, estuarine fish habitat, and other important ecosystem attributes?*
  - *Conversely, can we reasonably expect that addressing flow without addressing other stressors will lead to specific improvements in the status of estuarine fish, estuarine fish habitat, and other important ecosystem attributes?*

Key Findings and Observations

- A number of important ecological factors "co-vary" with outflow and X2 and are more proximal influences on organism distribution, condition, and abundance
- The distribution, condition, and abundance of some estuarine organisms are statistically associated with outflow and X2 because these two indicators are tied to underlying physical and ecological processes that more directly affect the estuarine organisms

Key Findings and Observations

- Ecosystem change in the San Francisco Bay estuary has been continuous on a decadal scale.
- This slow continual change has been punctuated by events such as the sudden increase in *Potamocorbula* clam biomass and the decline in chlorophyll and pelagic organisms that followed.
- While such punctuating events are dramatic, it should be kept in mind that continuous ecosystem change had been taking place at all trophic levels before such conspicuous events occurred

Key Findings and Observations

- Ammonium concentrations greater than some threshold inhibit the uptake of nitrate by phytoplankton.
- Thus high ammonium concentrations and growth on ammonium will always correlate with low phytoplankton biomass, while growth on nitrate will always correlate with high biomass accumulation, i.e., blooms.
- If phytoplankton growth is truncated for reasons other than nitrogen limitation (e.g., light, grazing) prior to reaching “bloom” conditions, then no nitrate will be consumed and some ammonium will remain
- This does not necessarily provide evidence that ammonium had inhibited bloom formation

Key Findings and Observations

- Ammonium inhibition of nitrate uptake has been interpreted as ammonium inhibition of phytoplankton growth. A critical question that has not been adequately addressed is whether or not phytoplankton grow “better” (faster, more efficiently) on nitrate than on ammonium
- Is the growth rate of phytoplankton lower on ammonium or nitrate at the concentrations typically encountered in San Francisco Bay?
- Blooms in LSZ maybe due to advection of phytoplankton from Delta

Key Findings and Observations

- Build on improved hydrodynamic models toward a ‘Delta ecosystem model’
- Increased assessment of fish ‘condition’ including routine sampling
- Identify dominant biomass pathways that support fish at different life history stages

Charge Question 5

- How should Delta outflow be measured and managed to better reflect the flows necessary to protect estuarine fish, estuarine fish habitat, and other important ecosystem attributes?
  - To what extent does managing winter-spring outflow by X2 reflect the flows necessary to protect estuarine fish? Are there other approaches to managing winter-spring outflow that could improve our ability to protect estuarine fish, estuarine fish habitat, and other important ecosystem attributes?
  - How should summer-fall outflow be measured and managed to better reflect the flows necessary to protect estuarine fish, estuarine fish habitat, and other important ecosystem attributes? Are there other approaches to managing summer-fall outflow that could improve our ability to protect estuarine fish, estuarine fish habitat, and other important ecosystem attributes?

Key Findings and Observations

- There is solid evidence that high outflows during various combinations of winter-spring months benefit a variety of species
- Summer-fall outflow objectives should be developed with an AM approach
- Managing outflows, whether directly or via X2, can provide a coarse level of protection to estuarine fish and ecosystem health

Key Findings and Observations

- Use of outflow objectives on a monthly to seasonal basis does not capture all of the desired dynamics that ensure protection of species and ecosystem health

Concluding Remarks

- Two decades have passed since the Schubel report was published; using X2 as the sole indicator (at least during spring) has not resulted in the intended protective effect
- The use of X2 as a management tool should be continued, at least in the near term, but there should also be a concerted effort to explore and document the utility of viable alternatives

Concluding Remarks

- Inferences based on correlation analyses have been the main tool applied to understanding the relationships between resources and processes
- These are limited because they do not inherently show cause and effect.
- This is especially true in a system where so many changes have occurred, and responses to change have covaried over the same, relatively short period