

Bay Delta Conservation Plan
Adaptive Management Comments
Areas of Concern to Reclamation District 999

Draft Comments 11/13/08

Reclamation District 999
38563 Netherlands Road
Clarksburg, California 95612

Bay Delta Conservation Plan
Adaptive Management Comments
Areas of Concern to Reclamation District 999
Draft Comments 11/13/08

INTRODUCTION

Reclamation District RD 999 (district or RD 999) has been a Delta land steward for almost a century, and supports adaptive management as a tool to manage the Bay-Delta system for ecological sustainability and water supply, and to guide specific habitat restoration actions. However, it is not a substitute for detailed understanding of ecosystem functions and processes, and it does not relieve managers for responsibility for inherently risky actions.

RD 999 and the Clarksburg community are likely to be impacted through the proposed altered hydrology of the Sacramento river system or/and the Yolo Bypass; the proposed flooding of the islands south of the district; infrastructure modifications along (or of) its levees, and the associated changes in the types of nearby habitats; and, the proposed new governance entity for the Delta, regardless of the final scope of the Bay Delta Conservation Plan (BDCP). *However, properly developed adaptive management can help reduce the impacts from BDCP to our community, if the community is allowed to participate in a meaningful way.*

RD 999 puts forth these comments on the BDCP premise that flooding of the District and the Clarksburg community is an adaptive management action, and that flooding will provide the specific benefits that have been stated by the BDCP. Prior to planning, prioritizing, and funding actions in the district, the BDCP needs to demonstrate that the scientific basis for its premises for action, the desired cause and effect are demonstrable, and that adaptive management (according to the framework described later) can be accomplished.

Just as ecological restoration means many different things to many people, and for each species of concern, adaptive management means different things in different contexts and viewpoints. The BDCP proposes to use what it calls adaptive management to overcome uncertainty in the nature of and extent of project impacts, *and* uncertainty regarding the effectiveness of its proposed mitigation measures.

This *dual-use* of adaptive management, and the ambiguity of what adaptive management under the BDCP really means on this landscape and in this context, has resulted in significant

confusion among the people who live in the proposed impact zone. This analysis and commentary is intended to provide a primer, and address specific concerns regarding its use in the BDCP.

ADAPTIVE MANAGEMENT

All natural resource management of species, habitats, and ecosystems requires an adaptive approach. Natural variation at each scale can be substantial and difficult to understand and manage for, even before changing anthropogenic system drivers at the same time. Most natural resource scientists understand this dynamic environment all too well, and resource managers have started to accept this philosophy. However, it is critical to distinguish that attempting to manage natural resources, managing resources to particular metrics, and managing to diverse metrics under changing conditions, are three very different things.

By any definition, adaptive management is not intended to replace careful planning and a foundation of science. It is intended to supplement the best available information, in a framework that tests (testable) competing hypotheses to inform future management decisions, in a continuous feedback loop. The management framework (testable hypotheses, metrics, statistical tests) must be developed a priori, and not to support essentially pre-determined outcomes.

“It is not a “trial and error” process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits.” (NAS, 2004)

“There are multiple views and definitions regarding adaptive management, but elements that have been identified in theory and in practice are: management objectives that are regularly revisited and accordingly revised, a model(s) of the system being managed, a range of management options, monitoring and evaluating outcomes of management actions, mechanisms for incorporating learning into future decisions, and a collaborative structure for stakeholder participation and learning.” (NAS, 2004)

Adaptive management is not a trivial process when done effectively. It requires at the minimum:

I. A management structure-

Who is assessing the effectiveness of the management structure and system?

What are the qualifications of the people in the management structure?

Who is included and who is excluded?



Is there effective stakeholder participation, as identified in the Department of the Interior's (DOI) adaptive management process (Williams *et al.*, 2007)?

II. A management process-

Where is the feedback loop in the decision making?

How does the management team identify the appropriateness of tools, effectiveness of decisions, applicability of methods, outcome metrics?

How is funding associated with management metrics or success criteria?

How is funding (and projects) adjusted to meet evolving conditions?

What types of questions/uncertainties require new science?

III. Within the structure and process, the appropriate management tools-

What is the spatial resolution (granularity) of the monitoring tools vs. the scale of effect for the management tools?

What is the temporal scale for monitoring vs. management vs. outcome?

What statistics are they using to define states or outcomes?

What statistical significance is appropriate for decision making?

These structural and functional issues, and associated questions, are by no means all-inclusive or in a particular order of importance, but are provided to illustrate the challenges of establishing adaptive management at an ecosystem scale.

Adaptive management has progressed in the many years of its theoretical development and application. While there are entire journals devoted to land and wildlife management, there is a local application of one of the more advanced versions of adaptive management, the Point Reyes Bird Observatory (PRBO) Conservation Science program, Adaptive Conservation Planning (2008).

PRBO's application uses birds as the biological integrator of habitat structure and complexity, certainly useful for the BDCP's riparian, seasonal wetland, and channel (riparian to emergent aquatic) habitats. More importantly, they have taken the approach that adaptive management is not the only tool in an adaptive management strategy, but is instead the initial step in a coherent multi-project, multi-habitat learning process:

An adaptive conservation strategy has two components:

1. Adaptive management is a decades-old method of natural resource management that integrates design, management, and monitoring to systematically test assumptions in order to adapt and learn.



2. **Adaptive Conservation Planning** is the process of synthesizing monitoring and assessment data from many projects to develop science-based conservation recommendations that can be shared across projects. (PRBO, 2008, emphasis in original)

It would do the BDCP process well to adopt the DOI's adaptive management process in its entirety to supplement the proposed Natural Community Conservation Planning (NCCP/Habitat Conservation Plan (HCP), and add the PRBO adaptive conservation planning element. This would bring the BDCP adaptive management process and structure up to the current state of the field, a critical foundation for a process with a 50-year permit. A final note on this discussion of the mechanics of adaptive management, external scientific peer review should not be discretionary. *External scientific peer review is a critical element in ensuring that the process is scientifically valid and that the iterative process is actually followed.*

The preceding sections identified some of the key areas where the BDCP's general approach to adaptive management might be strengthened. The following sections identify the specific failure of the BDCP to integrate a specific, crucial, adaptive management element of effective public participation, and continues with a "drill down" of how the BDCP's process does not address some of the critical scientific issues inherent in its proposed management.

Public Participation and Stakeholders

One of the key elements in successful adaptive management and natural resource management in general is participation. The desire by Federal Agencies to keep their decision making process secret was one of the reasons that lead to the National Environmental Policy Act (NEPA 1970, [42 U.S.C. 4321 et seq.]). This is why there is mandatory opportunity for public participation and for comment as the central core of the NEPA process.

In terms of public participation, NEPA itself is considered flawed because the public is typically not involved in the *actual* decision making process, which can artificially narrow the decision space and engender conflict (Cheek and Ringelberg, 1999). This has lead to a movement by academics and Federal Agencies to use a pre-NEPA, collaborative process (Shindler and Cheek, 1999; Wondolleck and Yaffee, 2000; Ringelberg, 2002).

"Despite challenges that attend meaningful stakeholder collaboration, it is an important part of adaptive management. Stakeholder and agency involvement should begin in the initial stages of adaptive management efforts and should include participation in periodic review of monitoring results and management models." (NAS, 2004)



“Stakeholder collaboration should be an integral component in the adaptive management of Corps projects and systems. ...Furthermore, as illustrated in reviews of adaptive management science programs in the Comprehensive Everglades Restoration Plan, independent expert review can point out inadequacies in modeling, monitoring, and assessment.” (NAS, 2004)

There is significant disagreement about the form and effectiveness of the BDCP’s outreach efforts. It is fair to say that individuals within the BDCP process have attempted to engage local stakeholders. The difference between those positive engagements and the larger process have created difficulties in the pre-NEPA stage, ranging from denial to engage active local stakeholders in the process¹, refusal to provide meeting documents from the various teams², refusing to provide email updates³, and refusing to provide countervailing scientific references to advisory groups⁴, the BDCP must significantly change its outreach and process to follow the DOI’s guidance (Williams *et al.* 2007) and NAS recommendations for meaningful stakeholder involvement, an explicit component of adaptive management. Adaptive management is not just a check box to be completed some time in the future, it is a process that has to begin with the formulation of the management needs.

“Adaptive management requires the participation of stakeholders. Stakeholders include people and organizations who use, influence, and have an interest, or “stake,” in a given resource (25). Stakeholders should be involved early in the adaptive management cycle, to help assess the problem and design activities to solve it. Stakeholders also can help to implement and monitor those activities, and participate in the evaluation of results. Involvement of stakeholders from the beginning increases management effectiveness and the likelihood of achieving agreed-upon outcomes (25).” (Williams *et al.*, 2007, emphasis in original)

For the BDCP to substantively engage the directly affected communities, it must make substantive changes in its polices and outreach, required to implement adaptive management.

¹ 2008. BDCP Steering Committee membership denied for North Delta Cares, 2008.

² 2008. Mark Wilson correspondence, The Resource Agency Public Records Act requests.

³ 2008. Holly Wilson, SAIC; 6/30/08 Email: Regarding your request to be added to the distribution list for BDCP Working Groups and Technical Teams, per BDCP Steering Committee policy, we only provide emailed notices and materials for technical teams and working groups to representatives of Steering Committee member agencies, so we cannot put you on the mailing list.

⁴ 2008. RD 999 Comments to BDCP Terrestrial Experts.



ADAPTIVE MANAGEMENT IMPLICATIONS

It is important to illustrate the implications of adaptive management on the smallest scale, with just one species, in terms of a couple of variables. For example, adult Delta smelt (*Hypomesus transpacificus*) require plankton to feed on. The species of zoophytoplankton that makes up most of the smelt's diet have changed over time as new plankton and bivalve species invade its habitat; and, the overall plankton numbers has been observed to decline over time (Orsi and Mecum, 1996). The overbite clam (*Corbula amurensis*) has been associated with the decline of plankton (Kimmerer, 2002), as has the Asian clam (*Corbicula fluminea*), to a lesser degree (Phelps, 1994). Freshwater clams are also apparently food limited in the Delta (Foe and Knight, 1986). This precipitous plankton decline parallels other bi-valve invasions in the US (Pace *et al.*, 2002).

Therefore, simply looking at smelt population dynamics, Delta trophic level interactions, Delta nutrient cycling, or water management operations alone is not going to provide a basis for effective management for this species. An adaptive management team for smelt-associated actions then needs to have experts in conservation biology, aquatic ecology, fish biology, fish ecology, aquatic toxicology, Delta water management, local stakeholders, Regional water supply and delivery agencies, and State and Federal Agency managers with the authority to authorize immediate implementation of control strategies, and control over water management facilities.

This team has only a limited set of controls over the smelt and its ecosystem based on current conditions and BDCP-proposed future projects (assuming a Delta-wide real-time water quality monitoring system and SCADA control system, and the decision making system described above):

Short-Term

Water management (mainly reservoir control) and the existing cross-channel, and diversion intake control.

Long-Term

Proposed in-Delta flow control structures, diversion intake control (proposed upstream and in-Delta), and proposed hatchery system.

Indirect Benefits

Improved structural habitat condition, arguably improved water quality, reduced rate of predation, and reduced rate of invasives.



Clearly, the key structures and potential control over the ecological functions are related to the control of the quantity and quality of the water. *It does not appear that there are sufficient control mechanisms in either the short- or long-term to achieve the necessary adaptive management of this species.* Adaptive management is a useful process to manage these direct control systems and guide the specific needs for the long-term control systems. Adaptive management is still useful for the indirect benefits, but as the management metrics are secondary and tertiary effects, spread over long time scales for both implementation and for effects measures, the management process becomes more traditional and takes the form of best guess.

It is this area of purported indirect benefits, specifically the BDCP FLOO2.1 Clarksburg Bypass, flooding portions of RD 999 and the community of Clarksburg that requires much greater scientific analysis than has happened to this point in the BDCP process. The following section describes how and why the purported ecological reasons for flooding Clarksburg are largely speculative and not well grounded in science.

Eutrophication and Diet

The 2007, Independent Science Advisors Report (BDCP) specifically identified that, under current ecological conditions, aquatic invasive species which dominate the Delta may respond more favorably than the covered species, and potentially that other species' interactions may be changed in unpredictable ways: "Rather, considering how these species [non-native striped bass and threadfin shad] may respond to actions that are designed to benefit the Covered Species may provide information on the potential effects of plan implementation on a more diverse set of components of the Delta Ecosystem." This is an accurate analysis for essentially any ecosystem, which has apparently gone unnoticed by the BDCP.

The BDCP technical documents (Habitat Restoration Program documents August 8, 2008, define one of the key benefits of seasonal flooding and shallow water restoration activities is the increased export of materials out of the terrestrial system into the aquatic system and eventually to the Delta. These nutrients are couched in the language of "increased primary and secondary activity," and DOC (dissolved organic carbon), so there is no need to go into the actual chemistry and biochemical cycling here, but to simply identify that deliberately introducing nutrients into a system and increasing productivity is a form of eutrophication.

The deliberate eutrophication of the Delta as a proposed seasonally flooding regime, "conservation measure" is at best an indirect means of increasing plankton, which may increase smelt numbers or body condition. *A much likelier* condition, given the ecological history of the Delta, is that increased eutrophication will result in more and healthier clams, and not translate to



detectible smelt improvements. This supposition needs to be tested through adaptive management.

Given that the adult smelt feeds almost exclusively on zooplankton, and that plankton is declining, we can hypothesize that some portion of the smelt decline is correlated to the decline in food. In order to manage the food resources to maximize smelt, we might want to attempt to improve not just “nutrients” or a coarse metric such as TOC, but the specific suite of plankton that are the actual prey for the smelt.

Keep in mind that there are many illustrations of “management” that attempted to maximize food productivity through eutrophication or new “better” diets. Mysis shrimp introduction in Flathead Lake Montana, (Chess and Stanford, 1998; Spencer *et al.* 1999), is a classic example of apparently well-intentioned management actions that lacked a scientific understanding and resulted in the collapse of the native fishery.

Indeed, locally, the related non-native wakasagi, *H. nipponensis*, was first introduced into California in 1959 as a forage fish for salmonids in warm-water reservoirs (Wales, 1962). The ecological implications of this fish for Delta smelt food competition and genetics are not well understood, but given the overlap in range in the Sacramento River system, certainly can be considered a threat. Trenham *et al.*, (1995) found an F1 hybrid (wakasagi x Delta smelt), and delta and longfin smelt hybrids have also been found (May, 1996).

There is also a historic parallel in Europe that demonstrates that the theoretical benefits of limited eutrophication, increased productivity, can be easily overwhelmed leading to ecological collapse (de Nie, 1987). The now historic analysis demonstrates the relationship between suitable prey size, dietary shifts, eutrophication, loss of native species fish diversity and eventual collapse. Ironically, the striped bass cohort disappeared with the simplification of the ecosystem from eutrophication, the wrong lesson to be learned from this study.

Also it is critical that any attempt to increase the available food resources for the smelt succeed in providing not just more plankton (or worse still maximizing a secondary metric associated indirectly with plankton), but more of the specific plankton size and food quality that the smelt requires. Plankton of the right size, but lower quality can lead to worsening fish body condition and make them more susceptible to other stressors (Allen *et al.* 2006; Mitra and Flynn, 2006). Plankton of the right quality, but smaller size can lead to the same problem because of the greater effort required to consume the same relative diet (loss of feeding efficiency). Rolke, 2000, gives an indication of how adaptive management might achieve the proposed combination of nutrients and ideal prey size.



RESTORATION IMPLICATIONS

The proceeding discussions have examined the potential risks, benefits, and challenges of applying adaptive management for a single species. Taken more broadly, the implications of attempting adaptive management on a basin scale, without adequate science for the basic premise that underlies the *need* for a specific type of restoration (such as seasonal floodplain and shallow tidal habitat), and without management tools to reverse the effects, is a recipe for disaster.

Management action as simple as creating preferential flows for Delta smelt spawning, can potentially induce hybridization with longfin smelt. A management action that intends to improve habitat can readily have an opposite from intended effect for a target species: “However, if restored habitats are dominated by exotic fishes such as inland silversides, improvements in spawning could be offset by increased predation on delta smelt larvae(.)” (Bennett, 2005).

Other researchers have provided the same warning for competition issues: “With respect to these factors, the native delta smelt may be at a physiological disadvantage, particularly in habitats with suboptimal environmental conditions, and may be excluded from shallow-water habitat restoration sites, which are characterized by poor circulation, low flows, and more environmentally extreme conditions.” (Swanson *et al.*, 2000)

Swanson, *et al.*, (2000) also provide the following warning: “Further habitat modifications, particularly those that exacerbate extreme environmental conditions, such as seasonal high temperatures in poorly circulated shallow waters, could inadvertently favor non-native species like the wakasagi and trigger an ecological time bomb that results in abiotic and/or biotic conditions that exceed the capacity of the delta smelt to persist within this system. (Swanson, *et al.*, 2000). When cautious scientists identify ecological “time bombs” and extinction in regards to a proposed action, politicians and resource managers should do everything in their power to ensure that the proposal is scientifically based, and approached as diligently as possible.

Even the fundamental ecological concepts used by the BDCP as the basis for restoration, and the proposed flooding of RD 999 and the Clarksburg community, go beyond the significant risk and uncertainty identified by the previously cited researchers, and enter the realm of speculation:

“There are few quantitative data to suggest that restoration of tidal wetlands will substantially increase populations of native fishes. On a qualitative basis, there is some support for the idea that tidal wetland restoration will increase populations of some native



fishes; however, the species deriving the most benefit from restoration might not be of great management concern at present.” (Brown, 2003)

Brown, (2003^b), further identifies in his seminal series of analyses:

“Ecologically, DOC and POC that are derived from decomposing plant material appear to be of fairly low importance in supporting higher trophic levels. In contrast, DOC is very important for drinking water quality. Conceptually, minimizing DOC export from restored tidal wetlands would be beneficial; however, it is unclear how such reductions could be accomplished for large areas of tidal wetlands.”

Brown is not alone in his analysis that seasonal flooding and shallow wetlands do not have a strong foundation of science to support its use for improving food availability for Delta fish, indeed the scientific data shows that Upper Delta nutrients are of low importance (Jassby *et al.*, 2002):

“Second, although nutrient concentrations have increased over the past decades, they were already far above levels saturating phytoplankton growth in 1975.

Why is Delta annual production low compared with other systems, given that nutrients are plentiful and the water column light utilization efficiency is high? Low biomass therefore probably plays a role in low production.

Relatively high TSS is an additional reason underlying relatively low annual production.”

Nutrients in the Delta are usually far in excess of needs and unlikely to be a driving force.”

Nutrients already saturate the system, and TSS, total suspended sediments are already very high and in fact play a part in suppressing internal Delta productivity. Why then would the BDCP promote even more nutrients in the Upper Delta? (Jassby *et al.*, 2002 continued)

“It appears that the dissolved and detrital particulate organic carbon delivered to the Delta does not enter the planktonic food web to a significant degree even though it may support net microbial ecosystem metabolism.



The combination of metabolic losses, recalcitrance of detrital POC, and short residence time combine to minimize the importance of riverine sources of particulate and dissolved organic carbon to Delta consumers...()

These results suggest that incidental export of phytoplankton associated with water export from the Delta may be more important than originally thought. In the Delta, significant amounts of primary production are exported at the state and federal pumping facilities.”

Given these data, simply providing in-river export, instead of taking the water from lower in the Delta could by itself significantly improve high-quality zooplankton resources for the smelt. Although, it could move X2 up gradient, and increase the influence of San Joaquin toxins. (Jassby *et al.*, 2002 continued)

“The resulting primary producer biomass is consumed by higher trophic levels within tidal wetlands, exported to open water systems for consumption, or decomposes, possibly to the detriment of drinking water quality.”

This citation is intended to provide a caution that an action may indeed benefit the main Delta’s productivity, but lead to unintended water quality impacts to communities that draw their water from the Delta.

Finally the BDCP’s own Independent Science Advisors Report (2007) identifies:

“While habitat enhancement or restoration can theoretically benefit populations, these effects are difficult to quantify compared to direct mortality. Consequently, the measurable impact of habitat improvement on fish populations may be small, and the scale of restoration needed to achieve conservation goals through mitigation is likely very large. Moreover, the potential for success of large-scale restoration efforts is often uncertain.”

When your own scientists warn that your “conservation measure” may be a small improvement, hard to measure, on a vast scale, with uncertain effect, why would you flood a vibrant community with productive farms and valuable intact terrestrial and riparian habitat?

Summary

The existing science either provides cautionary notes or does not support the BDCP premises that flooding will benefit the Covered species’ food needs. This uncertainty requires adaptive



management and a solid scientific foundation to ensure the success of the actions or mitigate impacts to the residents and other water users of the Delta. The science does provide evidence that the BDCP's various proposals to flood RD 999 and Clarksburg can make ecological conditions worse, at high risk, and low certainty.

CONCLUSIONS

RD 999 has significant concerns that the BDCP process has failed to adequately: assess the current ecological conditions, base its proposal on the available science, develop realistic alternatives, assess likely project impacts, and avoid before it mitigates for foreseeable impacts, or identify cumulative impacts.

A thorough scientific analysis is required to understand site specific, watershed and cumulative impacts of the BDCP and its various alternatives before those actions take place, not after.

It is our hope that the BDCP rely more on its technical advisors and its consultants, and specifically that the BDCP legitimize its efforts by following a developed framework, such as the DOI's Adaptive Management (2007), including the public participation component; and, learn from existing, mature processes including PRBO's Adaptive Conservation Planning.

REFERENCES

- Allen, L. G., D.J. Pondella, M.H. Horn. 2006. The Ecology of Marine Fishes: California and Adjacent Waters. University of California Press.
- Anderson, J. L., R. W. Hilborn, R. T. Lackey, and D. Ludwig. 2003. Watershed restoration: Adaptive decision making in the face of uncertainty. In: Wissmar, R. C., and P. A. Bisson (eds.) Strategies for Restoring River Ecosystems: Sources of Variability and Uncertainty in Natural and Managed Systems. Bethesda, MD: American Fisheries Society.
- Bennett, B. 2005. Conceptual Model - Delta Smelt -A Contribution for the CBDA Ecosystem Restoration Program. Available online at:
http://www.delta.dfg.ca.gov/GIS/erip/Con_ds1_default.asp
- Bennett, W.A. and P.B. Moyle. 1996. Where have all the fishes gone? Interactive factors producing fish declines in the Sacramento-San Joaquin estuary. J. T. Hollibaugh (ed.) San Francisco Bay: The Ecosystem, Further Investigations into the Natural History of San Francisco Bay and Delta With Reference to the Influence of Man. Pacific Division, American Association for the Advancement of Science, Pacific Division. 519-542.



- Brown, L.R. 2003. Will Tidal Wetland Restoration Enhance Populations of Native Fishes? In: L. R. Brown, (ed.) Issues in San Francisco Estuary Tidal Wetlands Restoration. San Francisco Estuary and Watershed Science. Vol. 1, Issue 1 (October 2003), Article 2. Available online at <http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art2>
- Brown, L.R. 2003^b. Potential Effects of Organic Carbon Production on Ecosystems and Drinking Water Quality. In: L. R. Brown, ed. Issues in San Francisco Estuary Tidal Wetlands Restoration. San Francisco Estuary and Watershed Science. Vol. 1, Issue 1 (October 2003), Article 3. Available online at <http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art2>
- Cheek, K., and E. Ringelberg. 1999. Rural Community Collaborations in Natural Resource Management, a Case Study in Western Montana. The University of Montana. (Manuscript)
- Chess, D.W. and J.A.Stanford. 1998. Comparative energetics and life cycle of the opossum shrimp (*Mysis relicta*) in native and non-native environments Freshwater Biology, Blackwell Publishing. Volume 40, Number 4, December 1998, pp. 783-794
- Crowfoot, J. E., J. M. Wondolleck (and eds.) 1990 Environmental Disputes: Community Involvement in Conflict Resolution. Island Press. 295 pp
- de Nie, H. W. 1987. The decrease in aquatic vegetation in Europe and its consequences for fish populations (1987) EIFAC Occasional Papers EIFAC/OP19 1987 52 pp
- Elliott, G., M. Chase, G. Geupel, and E. Cohen. 2008. Developing and Implementing an Adaptive Conservation Strategy: A guide for improving adaptive management and sharing the learning among conservation practitioners. PRBO Conservation Science. 72 pp. Available online at <http://www.prbo.org/cms/docs/consplans/ACSGUIDEweb.pdf>
- Foe C and A. Knight. 1985. The effect of phytoplankton and suspended sediment on the growth of *Corbicula fluminea* (Bivalvia). Hydrobiologia 127: 105-115.
- Gunderson, L. 1999. Resilience, flexibility and adaptive management—Antidotes for spurious certitude? Conservation Ecology 3(1):7. Available online at <http://www.consecol.org/vol3/iss1/art7>,
- Jassby, A.D., J.E. Cloern, and B.E. Cole. 2002. Annual primary production: Patterns and mechanisms of change in a nutrient-rich tidal ecosystem by the American Society of Limnology and Oceanography, Inc. Limnol. Oceanogr., 47(3), 698–712.
- Johnson, B.L. 1999. The Role of Adaptive Management as an Operational Approach for Resource Management Agencies. Conservation Ecology 3(2):8. Available online at <http://www.consecol.org/vol3/iss2/art8>,
- Kimmerer, W. J. 2002. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages. Marine Ecology Progress Series 243:39-55.
- Lee, K.N. 1999. Appraising Adaptive Management. Conservation Ecology 3(2):3. Available online at <http://www.consecol.org/vol3/iss2/art3>,
- May, B. 1996. Identification of Smelt Species and Their Interspecific Hybrids in the Sacramento-San Joaquin Estuary by Allozyme Analysis. Interagency Ecological Program. Available online at <http://iep.water.ca.gov/report/newsletter/1996summer/96sum06.html>



- McLain, R.J. and R.G. Lee. 1996. Adaptive management: Promises and pitfalls. *Environmental Management* 20: 437-438.
- Mitra A. and K.J. Flynn Accounting for variation in prey selectivity by zooplankton. *Ecological Modelling*. Volume 199, Issue 1, 1, Pages 82-92.
- National Research Council (NRC). 2004. Adaptive Management for Water Resources Project Planning. Panel on Adaptive Management for Resource Stewardship, Committee to Assess the U.S. Army Corps of Engineers Methods of Analysis and Peer Review for Water Resources Project Planning, National Research Council. National Academies Press. 138pp.
- Orsi, J.J. and W.L. Mecum. 1996. Food limitation as the probable cause of a long-term decline in the abundance of *Neomysis mercedis* the opossum shrimp in the Sacramento-San Joaquin Estuary. In: JT. Hollibaugh (ed.) *San Francisco Bay: The Ecosystem*. San Francisco: Pacific Division, AAAS, California Academy of Sciences. Pg 375–401.
- Pace, M.L., S.E.G. Findlay, and D. Fischer. 2002. Effects of an invasive bivalve on the zooplankton community of the Hudson River Freshwater Biology Volume 39 Issue 1, Blackwell Publishing Ltd. Pg 103 – 116.
- Phelps H. 1994. The Asiatic Clam (*Corbicula fluminea*) invasion and system-level ecological change in the Potomac River estuary Washington, DC. *Estuaries* 17: 614-621.
- Regan, H.M., M. Colyvan, and M.A. Burgman. 2002. A taxonomy and treatment of uncertainty for ecology and conservation biology. *Ecological Applications* 12: 618-628.
- Ringelberg, E. 2002. Stakeholder Involvement in Department of Energy Decision Making: A Stakeholder's Perspective, Spectrum, International Conference on Nuclear and Hazardous Waste Management. American Nuclear Society.
- Rolke, D.L. 2000. Copepod food-quality threshold as a mechanism influencing phytoplankton succession and accumulation of biomass, and secondary productivity: a modeling study with management implications. *Ecological Modelling*. Volume 134, Issue 2, 3, Pg 245-274.
- Shindler, B. and K.A. Cheek. 1999. Integrating Citizens in Adaptive Management: A Propositional Analysis. *Conservation Ecology* 3(1): 9. Available online at <http://www.consecol.org/vol3/iss1/art9>,
- Spencer, C.D. Potter, R. Bukantis, and J. Stanford. 1999. Impact of predation by *Mysis relicta* on zooplankton in Flathead Lake, Montana, USA. *Oxford University Press Journal of Plankton Research*, Vol 21, 51-64.
- Swanson, C., T. Reid, P.S. Young, and J.J. Cech Jr. 2000. Comparative environmental tolerances of threatened delta smelt (*Hypomesus transpacificus*) and introduced wakasagi (*H. nipponensis*) in an altered California estuary. *Oecologia*, Springer Berlin / Heidelberg. 123:384-390.
- United States General Accounting Office (GAO). 2003. South Florida Ecosystem Restoration: Task Force Needs to Improve Science Coordination to Increase the Likelihood for Success. GAO-03-345. Washington, DC: Government Printing Office.



Wales, J.H. 1962. Introduction of pond smelt from Japan into California. California Fish and Game. 48(2):141-142.

Walters, C.J. 1997. Challenges in Adaptive Management of Riparian and Coastal Ecosystems. Conservation Ecology 1(2):1. Available online at <http://www.consecol.org/vol1/iss2/art1>,

Williams, B.K., R.C. Szaro, and C.D. Shapiro. 2007. Adaptive Management, The US Department of the Interior Technical Guide. Adaptive Management Working Group (AMWG). U.S. Department of the Interior, Washington, DC.

Wondolleck, J.M. and S.L. Yaffee, 2000. Making Collaboration Work: Lessons from Innovation in Natural Resource Management. University of Chicago Press 280 pp.

