Endangered Fishes and the Delta

Peter B. Moyle

Remarks to NRC Committee of Sustainable Water and Environmental Management in the California Bay-Delta.
January 26, 2010

Thank you for inviting me to present my views on water and fish in the Delta, in relation to the Biological Opinions for smelt and salmon. In deference to the post-lunch timing of this talk and the fact you have already seen more Power Point presentations than you can possibly absorb, I will try to keep my comments to a minimum. I would like to put the smelt and salmon BiOps in context of what is going on statewide and in the Delta. So I have three basic points to make, none of which will really be new to you at this point:

1. Endangered fishes and aquatic ecosystems are a statewide problem. What is going on in the Delta is really a subset of a much bigger problem. Most of this is tied to competition between humans and fish for water.
2. The root cause of recent fish declines in the Delta is diversions from all sources. The removal of water from the system has fundamentally changed the physical and biological processes of the Delta. I will focus on the big pumps in the South Delta because that is what you have to focus on and because they *do* have a major impact on the system on their own.
3. The Delta is one of the best studied ecosystems in the world. We know a huge amount about this system and the abundance of data can lead to many confusing analyses. The debate seems to be over how to use the information we have available. Analysis of huge data sets by itself does not necessarily lead to greater understanding of the problems, especially when you need to separate proximate from ultimate causes of change,

Endangered fishes and aquatic ecosystems are a statewide problem.

I want to give you a quick summary of some recent work I have been doing on the overall status of the fish fauna of California. First, it is important to remember that this is a big state (slide 3, S3), with an amazing diversity of aquatic habitats. However, the center of native fish diversity is the Central Valley, including the Delta.

Second, because of the complex topography of the state, 60% of the 131 kinds of fish are found ONLY in California, while another 19% are shared with just one other state, mostly Oregon (S4). Arguably, then, almost 80% of the fish are endemic to this region. Most of the native fish in the Delta are endemic to the Central Valley, including the four distinctive runs of Chinook salmon, but some are largely endemic to the Delta, such as delta smelt and splittail.

Most of these fish are in trouble or worse: 7% are extinct, 21% are listed, and 21% qualify for listing (by my analysis). This indicates that 49% of the fishes are either extinct or headed in that direction (S5). If you count other fishes that are in decline but not in danger of extinction in the next 50 years, the number climbs to

75%. The native fish of the Delta include two species that are extinct, six species that are listed, at least five that probably qualify for listing, a pretty dismal record. This is why determining causes of just delta smelt and salmon declines is not sufficient to figure out how to make the Delta ecosystem work better.

In California, extinction is not an abstraction (S6). We know it happens. The thicktail chub was once of the most abundant fish in Delta and the last one was seen in 1957. The Sacramento perch disappeared about the same time, but survives in some habitats outside its native range. The cause of the disappearance of these two species is not known for sure, but it was likely the result of massive habitat change that occurred when the Delta was converted from marsh to farmland. This was coupled with interactions with alien fishes.

The root cause of RECENT fish declines in Delta is water diversions.

As Jeff Mount indicated in his introductory presentation, massive amounts of water are removed from the Delta and the rivers that feed it every year. Some of the biggest dams in the world capture the flows of the Sacramento River and dole out the water for human use, changing both amount and pattern of inflow. The San Joaquin River is allowed to dry up completely, its water sent elsewhere. But at the heart of the diversion problems are the Jones and Banks pumping plants in the South Delta. Since the 1960s, the amount of water being diverted from these pumps has steadily increased, with temporary declines due to droughts: the water was simply not available for diversion (S8). This pattern can be seen in the reduction in the amount of water diverted from the Delta in the past two years, as the result of drought. Note that only about 10% of the decline in water available for export can be attributed to the Wanger decision to provide more water for smelt. The crisis that created this NRC panel therefore seems to me to be based on unrealistic expectations that water for farms and cities will always be available in increasing amounts.

A central problem the NRC panel has wrestle with, therefore, is the relationship of fish declines to South Delta diversions. At one level, the relationship seems pretty simple, diversions go up, smelt and salmon populations go down. In the case of Delta smelt, good arguments can be made that direct mortality from the pumps is a major cause of decline. Bill Bennett's research, for example, suggests that the pumps behave like a size-selective fishery, removing the biggest and most fecund females (and their young) from the population.

But explanations based on direct take are always suspect because there is a confusing array of other factors that are least contributing to the fish declines such invasive species, pollution, and habitat loss, as numerous analyses indicate. But when you look at the big picture, these factors can be regarded in good part as a secondary or indirect consequence of the ever-increasing diversion of water.

Bill Bennett and I argue that the increase in pumping from the Delta has resulted in a regime shift, turning the Delta into a very different ecosystem than what it was 20-30 years ago. Here is a series of graphs (S9) which show some of the trends. I realize there is way more information here than can be easily absorbed but even these graphs are an oversimplification of a complex change.

One thing to notice on these graphs is that green lines represent data from Suisun Marsh, which is downstream from the Delta (S16) and so less affected directly by the diversions, so it makes for an interesting comparison. The top two graphs show the much talked about Pelagic Organism Decline (POD) relationship: diversions go up, POD species go down. I want you to notice one thing here, though, which is that the decline in juvenile striped bass is not apparent in Suisun Marsh. They seem to have found the conditions there that they need for persistence (among other things, abundant food, variable salinity).

The other four graphs (S9) provide additional suggestions of a regime shift in recent decades: salinity decreasing, water clarity increasing with increases in invasive freshwater species, such as inland silverside, sunfishes, and catfish.

This shift in water quality and the fish fauna has been accompanied by shifts in the hydrodynamics of the Delta (S10). The system now behaves less like an estuary and more like a lake, as Jeff Mount pointed out. The pull of the pumps is strong enough disrupt the basic upstream-downstream gradients that exist in estuaries. This can also be seen in the distribution of submerged aquatic vegetation, especially Brazilian waterweed (S11). This freshwater plant forms dense beds in the channels creating habitat which favors species such as largemouth bass. The abundance of freshwater aquatic plants is just one of the more obvious indicators of the regime shift that has taken place in the Delta (S12). This regime shift has resulted in a less variable, more freshwater environment and appears to be largely driven by the massive amounts of water taken by the pumps in the South Delta (S13).

This leads to the need to mention ultimate vs proximate causes of the fish declines that are the subject of discussion today. The real ultimate cause of the fish declines, not just here but statewide, is ever increasing human demand for water. For the Delta, this is reflected in the increased export of water from the system. The changed ecosystem has created lots of secondary effects that also impact the native fishes, effects may or may not be reversible. I actually think that most of them are reversible, but that requires creating another regime shift, to a more variable Delta, which is beyond the scope of this talk (but see Lund et al. 2010). Instead I want to shift gears and emphasize the huge amount of information we have on this system.

Delta is part one of best studied estuaries in world.

As members of the NRC committee, you have heard this mantra many times. It is true, but it does not necessarily mean this is the best understood estuary in the world. Huge data sets can be used to obfuscate problems as well as to clarify them. This is why it is especially important to look at the ecosystem as a whole and not just the species of most concern.

I want to use this as an excuse to talk briefly about my own long-term research program in Suisun Marsh, as an example of the kinds of long-term studies being done (S13,14). This is a study that has been focused from its inception as a study of the entire assemblage of fish and macroinvertebrates in the Marsh. As I indicated, the Marsh presents some interesting contrasts to the Delta. It is a large tidal marsh downstream of the Delta that is strongly influenced by flows of the

Sacramento River, which flows past the entrance to the Marsh. It is also strongly influenced by the tides pushing in salt water, which makes it more variable in water quality than the Delta. It is also less influenced by changed hydrology created by the pumps.

The heart of my research program is sampling of fish at locations throughout the marsh. I have had a crew doing this monthly since 1980, which gives some impressive statistics about numbers of fish caught. This program, funded by the Department of Water Resources, is one of six major fish monitoring programs in the San Francisco estuary, some which have been in place since the late1950s. My crew does lots of focused studies on the fish as well as on the invertebrates, especially on the impacts of invasive species. For example, we have ongoing studies on three species of invasive jellyfish, to see if they may have contributed to the POD (S18). Our results so far suggest jellyfish have not had much of an impact on the POD species, despite being present in huge numbers at times.

This graph (S19) is a grand overview of the results of the Suisun Marsh study which shows how fish numbers have fluctuated over the years. There are several things I want you to notice. First, there was a decline in fish numbers in the early 1980s, reflecting a similar decline in the Delta, especially of native species. But thereafter the fish community remained fairly abundant, although non-native species showed wider fluctuations in abundance than did native species. Much of this was due to variable recruitment of striped bass. The second thing I would like you to notice is the repeated invasion of major new species that became abundant in the Marsh. We have had a very hard time discerning effects of these invasions on populations of Marsh fishes, including effects of the overbite clam. This suggests to me that the more variable and more saline conditions in Marsh sloughs convey a certain amount of resistance to the effects of the invasive species. Changes in flow patterns and habitats in the Delta may likewise reduce the impacts of invasive species.

Conclusions

Let me now conclude my talk by providing you with some rather broad generalizations. The Delta has undergone at least two major regime shifts since the 19th century. The first was the result of major diking and draining that created the physical delta with which we are all familiar. The second was the result of the dams and diversions that shifted the ecosystem to its present rather undesirable state, with lots of endangered species.

The secondary (indirect) effects of these regime shifts contributed to declines and extinctions of native fishes but are probably not the ultimate causes. The Reasonable and Prudent Alternative (RPA) of the BiOp for delta smelt and to a less extent for Chinook salmon therefore rightfully attempt to deal some of with the major changes associated with the regime shift which probably has created the declines. These RPA measures are long overdue, but they are not enough. The Delta needs to become more an estuary, with more environmental variability than it probably experienced in the past (another regime shift!) Unfortunately, smelt numbers are so small, there are unlikely to be detectable increases in numbers in

response to actions taken under the RPA, unless conditions throughout the Delta change.

The RPAs are a step in the right direction but the best we can hope for them is to prevent extinction while we wait for grander solutions to the problems to appear.

Suggested reading

Lund, J., E. Hanak, W. Fleenor, W. Bennett, R. Howitt, J. Mount, and P. B. Moyle. 2010. Comparing Futures for the Sacramento-San Joaquin Delta. Berkeley, University of California Press.

Lund, J., E. Hanak., W. Fleenor, W., R. Howitt, J. Mount, and P. Moyle. 2007. Envisioning futures for the Sacramento-San Joaquin Delta. San Francisco: Public Policy Institute of California. 284 pp. (Available at *ppic.org*)

Moyle, P.B. 2008. The future of fish in response to large-scale change in the San Francisco Estuary, California. Pages 357-374 *In* K.D. McLaughlin, editor. Mitigating Impacts of Natural Hazards on Fishery Ecosystems. American Fishery Society, Symposium 64, Bethesda, Maryland.

Moyle, P. B. and W. A. Bennett. 2008. The future of the Delta ecosystem and its fish. Technical Appendix D, Comparing Futures for the Sacramento-San Joaquin Delta. San Francisco: Public Policy Institute of California. 38 pp. (Available at *ppic.org*)

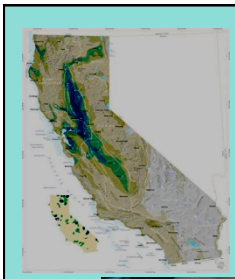
Endangered Fishes and the Delta

Peter Moyle
UC Davis
January 2010

MESSAGES

- Endangered fishes and ecosystems a statewide problem
- Root cause of RECENT fish declines in Delta is water diversions
- Delta is part one of best studied estuaries in world

California

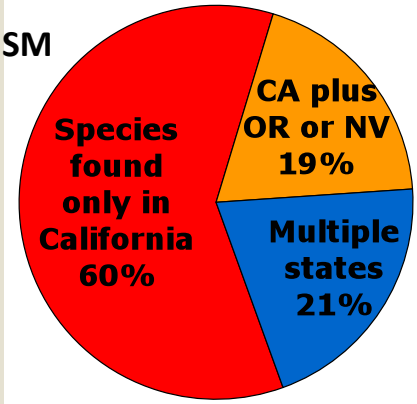


Spans 10 degrees, latitude
411,000 sq km area
2100 km coastline

ENDEMISM

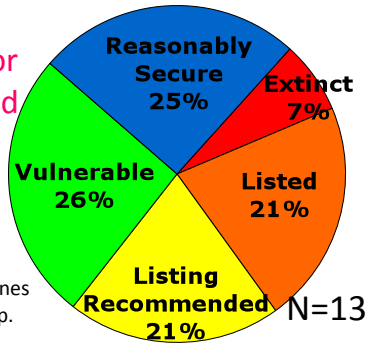
N = 131

79% are state or regional endemics



CA FISHES: STATUS, 2009

49% extinct or imperiled



Moyle, Quinones & Katz, in prep.

N=131

Globally extinct

EXTINCTION HAPPENS!

Global extinction pending

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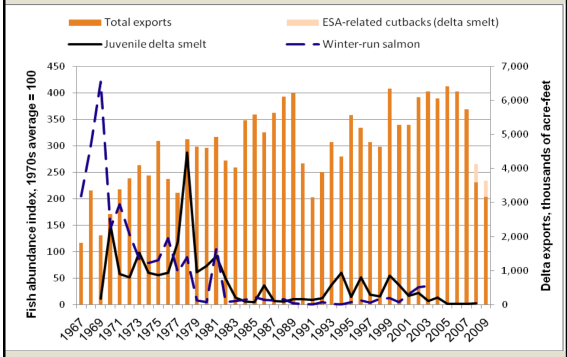
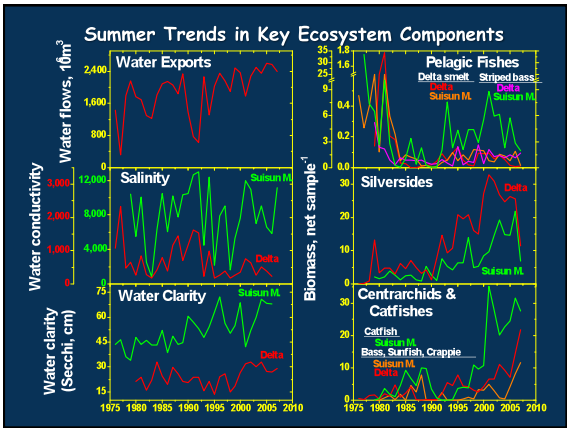
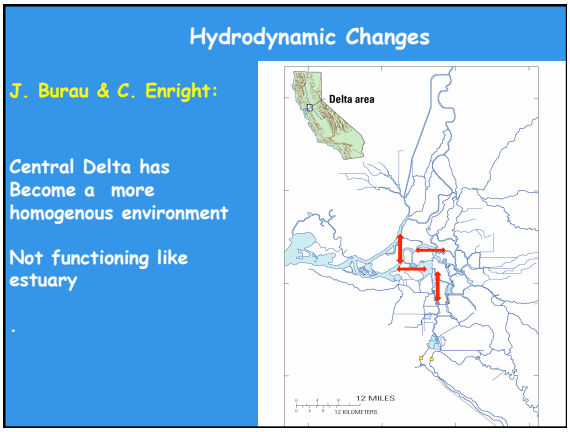
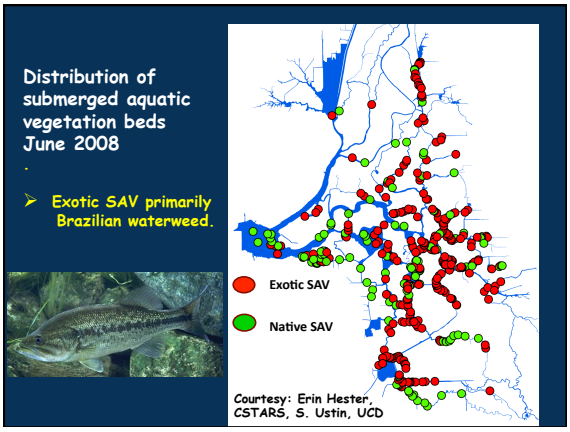
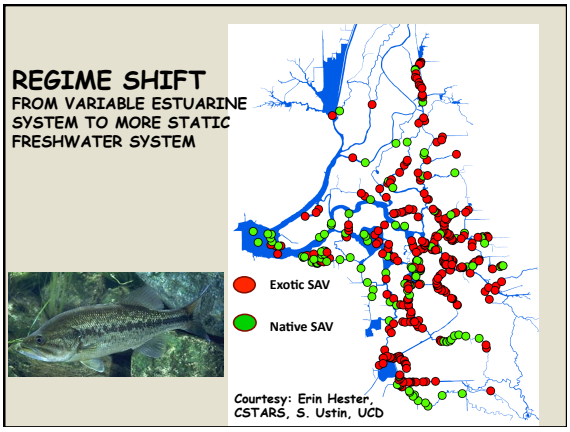


Lund et al. 2010



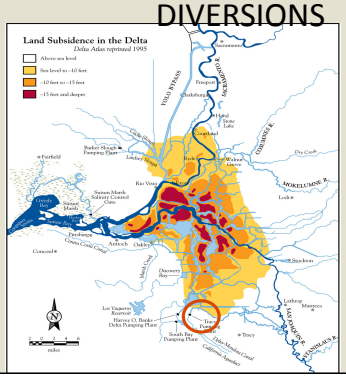






Why a freshwater, less variable Delta?

DIVERSIONS



SECONDARY EFFECTS

- ENHANCED ALIEN INVASIONS
- REDUCED FOOD SUPPLIES
- WATER QUALITY CHANGES
- INCREASED POLLUTION EFFECTS
- PREDATION
- ETC.

ULTIMATE VS PROXIMATE CAUSES of FISH DECLINES

Messages

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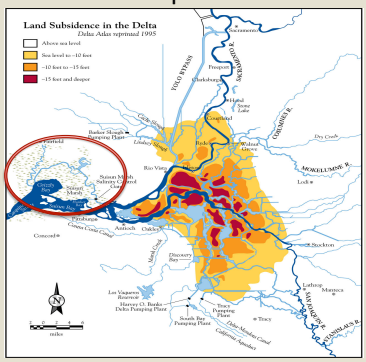
Suisun Marsh: Delta Comparisons

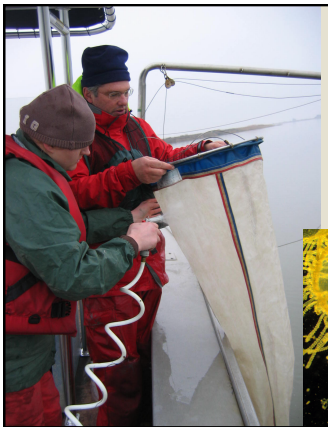


SAMPLING monthly since 1980

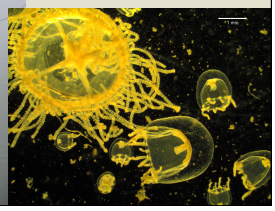
7075 trawls, 210,254 fish,

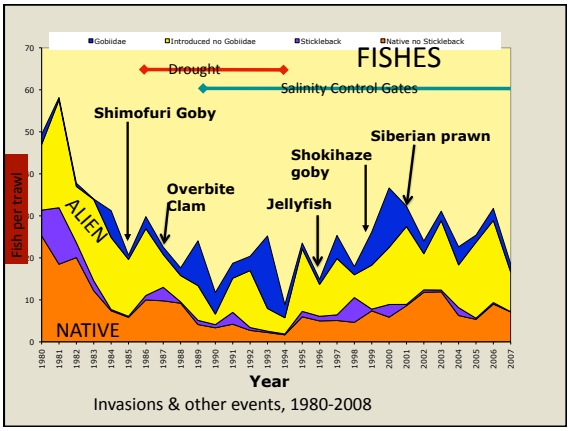
1756 seine hauls, 116,911 fish,

UCD program one of six regular fish monitoring programs



Invertebrate Sampling





Invasions & other events, 1980-2008

WHAT DOES THE SCIENCE TELL US?

PAST PHYSICAL HABITAT CHANGE

+

DIVERSIONS

+

SECONDARY EFFECTS

↓

NATIVE FISH DECLINES

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THANK YOU!