Expert Survey on the Viability of Delta Fish Populations
Technical Appendix E

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Description

This document is an appendix to the Public Policy Institute of California report, *Comparing Futures for the Sacramento-San Joaquin Delta*, prepared by a team of researchers from the Center for Watershed Sciences (University of California, Davis) and the Public Policy Institute of California.

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Summary

In current policy efforts to assess and seek solutions to fish population declines in the Sacramento-San Joaquin Delta, there is a strong presumption that water operations have contributed to the problem and that changes in these operations could benefit some key species. There is, at the same time, considerable uncertainty about the response of fish populations to operational changes in the Delta, as well as to a variety of other stressors both now and in the future. Given that management decisions will need to be made in the face of some uncertainty, expert judgment should be useful for informing decision-making.

Here we report the collective views of 39 experts on Delta fish and ecology regarding the likely responses of some key species to water operation alternatives for the Delta. These views were recorded through an anonymous survey, administered at a meeting of the Interagency Ecological Program (IEP) Estuarine Ecology Team, held in Davis, California in early February 2008.

The survey first asked respondents to gauge the likely effects on four key Delta fish species (delta smelt, longfin smelt, young-of-year striped bass, and juvenile Sacramento River Chinook salmon) of significant increases or decreases in seven individual water management factors: volumes of South Delta export pumping, rates of Delta island flooding, levels of western Delta salinity, volumes of cross-Delta flow, levels of San Joaquin River salinity, volumes of Sacramento River flow, and upstream withdrawals on the Sacramento River. The responses suggest that changes in South Delta pumping and in volumes of Sacramento River water available in the Delta are much more important for fish than other factors – with more pumping and lower Sacramento River volumes potentially causing substantial harm.

The survey then asked respondents to estimate the probability of viable populations of these same fish species under four water export management alternatives: (1) continuing the current policy of pumping water through the Delta ("in-Delta" pumping); (2) diverting exports around the Delta through a peripheral canal; (3) combining the first two strategies ("dual" conveyance); or (4) ending exports altogether. Respondents were asked to provide a range of estimates, with the low end corresponding to a scenario where all water operations are done "wrong" from the standpoint of fish health, and the high end corresponding to a scenario where all things are done "right." Estimates were solicited for current Delta conditions and for conditions some decades into the future, for a Delta experiencing significant sea level rise and permanent island flooding.

A majority of respondents thought that all three strategies that allow continued water exports (continued in-Delta pumping, a peripheral canal, and a dual facility) pose higher risks to these key fish species than the alternative of ending exports. However, the details of how export strategies are implemented can greatly improve the prospects for fish – as seen by the substantial spread between the high and low estimates for viability (generally at least 20 percentage points). For delta smelt, longfin smelt, and

striped bass, continued in-Delta pumping is considered the worst of all options by most respondents, with a canal-based solution (alone or as a dual facility) offering a greater likelihood of improvement. For Chinook salmon, there is less difference among in-Delta pumping and the canal-based solutions, although these latter present a somewhat better potential for performance under future conditions.

The experts strongly concur that the prospects for many desirable Delta fish will diminish significantly with climate change and other altered conditions in the Delta under all four export management alternatives, including ending exports. In particular, the delta smelt face significant risks of extinction, especially with continued in-Delta pumping of water exports.

A final section of the survey solicited open-ended suggestions on how to improve conditions for fish in the future Delta through ecosystem investments. The three largest categories of improvements included improvements in aquatic habitat, changes in water operations, and reduction of contaminants in Delta waters.

In the main report and Appendix J, we use the results of this expert survey as information in our assessment of likely fish responses to the four broad Delta export management alternatives examined here. Future work of this nature would provide the opportunity to explore more nuanced implementation of management options (e.g., the role of seasonal sensitivity to management decisions) to provide guidance for developing and implementing Delta ecosystem and water management actions.

Acknowledgments

We are most grateful to the organizers and members of the Interagency Ecological Program's Estuarine Ecology Team for making room in their February 2008 meeting agenda for this expert survey and for their thoughtful and good-natured participation in the survey exercise and associated discussions. We also thank Jed Kolko, Judith Meyer, Kenny Rose, and Anthony Saracino for helpful comments on an earlier draft. We alone are responsible for any errors or omissions.

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Introduction

A central challenge for sustainable management of the Sacramento-San Joaquin Delta is making the Delta a better place for desirable fish species, especially native species currently in severe decline.[1] Five fish species are listed under state and federal Endangered Species Acts, and their population declines have become a growing management and regulatory concern. These concerns have accelerated over the past year. Since September, 2007, the export pumps in the southern Delta have been operating at reduced levels under a federal court order by Judge Oliver Wanger because the two export projects (the Central Valley Project and the State Water Project) were found to be in violation of the federal Endangered Species Act regarding the endemic delta smelt, whose populations are dangerously low.[2]

Following fall 2007 fish surveys, which registered the lowest numbers on record for longfin smelt, another pelagic (or "open water") species that lives in the Delta, this fish was determined to be a "candidate species" for listing under the California Endangered Species Act in February 2008. This action sets a one-year schedule for a final determination regarding listing and it implies additional regulations at the pumps will be needed to accommodate the different seasonal movements of this fish.

Further cutbacks may be ordered as the result of a second decision by Judge Wanger (April 2008) to protect the listed winter- and spring-run Chinook salmon, both in decline. Since 2006, there has also been a rapid decline of fall-run Chinook salmon, forcing closure of the ocean commercial and sport fisheries in California and most of Oregon for 2008. Salmon migrate through the Delta on their way to and from the ocean and upstream spawning sites.

In current policy efforts to assess and seek solutions to the fish declines, there is a strong presumption that water operations have contributed to the problem, and that changes in these operations could benefit key species. There is, at the same time, considerable uncertainty about the response of fish populations to possible operational changes in the Delta, as well as to a variety of other stressors both now and in the future, including biotic stressors such as invasive species, and abiotic stressors such as exposure to toxic chemicals, rising water temperatures, Delta island flooding, and changes in ocean conditions. Although scientific research will continue to advance our knowledge of fish responses to various factors, we are far from having a complete understanding of these complex biological and ecological processes, and will never be able to predict their outcomes with a high degree of certainty. Thus, management decisions will need to be made in the face of large uncertainty. In this context, expert judgment should be useful in informing decisionmaking.

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[1] For a list of these fish species, see Appendix D to the main report.
[2] The final order was issued in December 2007. See Natural Resources Defense Council, et al. v. Kempthorne, Findings of Fact and Conclusions of Law Re Interim Remedies Re: Delta Smelt ESA Remand and Reconsultation, United States District Court, Eastern District of California, 1:05-cv-1207 OWW GSA (2007) .

Here we report the views of a large group of experts on Delta fish and ecology regarding the likely responses of key species to water operation alternatives for the Delta. These views were recorded through an anonymous written survey, administered to members of the Estuarine Ecology Team (EET). The EET is a group of scientific experts on the Delta from California research institutions and government agencies that has been serving as a peer-review forum on Delta ecology issues through bimonthly meetings since the late 1980s. The survey was conducted at the group's February 6, 2008 meeting, held in Davis, California.

This rapid response survey solicited information based on experts' knowledge on the Delta fishes and ecology. As discussed further in the main report and Appendix J, we sought this expert input to aid our analysis of the likely responses of key Delta fishes to the four main alternatives for Delta exports: (1) continued through-Delta export pumping; (2) water conveyance around the Delta (a peripheral canal), (3) a dual conveyance system, combining the first two alternatives, and (4) eliminating the Delta as a source of water for export users. In the remainder of this appendix, we provide a brief overview of the survey and then present results for each part of the survey. A concluding section summarizes main findings.

1. About the Survey

The survey consisted of four sections: respondent characteristics (part I), likely species responses to changes in water management factors (part II), probabilities of fish species viability under different Delta export management alternatives, now and in the future (part III), and suggestions for new ecosystem investments (part IV). The focus for parts II and III was on four key fish species, including three pelagic species that have been in serious decline (delta smelt, longfin smelt, and young-of-year (YOY) striped bass) and juvenile Chinook salmon (labeled "Sacramento River" salmon on the survey instrument).[3] For part IV, respondents could provide more general views about fish and ecosystem response through open-ended answers. The survey instrument is reproduced in an addendum to this appendix.

The survey session began with respondents filling out Parts I and II of the survey, followed by a group discussion. The survey team then presented some hydrodynamic modeling results for different Delta management alternatives under current and future conditions, as described below. Respondents then filled out Parts III and IV, followed, again, by group discussion. Respondents had the option to change their responses to these sections afterwards. Only one person changed the answers to Part III, and the results presented here include these revised answers. Some respondents completed their answers to the open-ended Part IV after the final group discussion.

Of the 45 surveys collected, 39 to 40 are used for the analysis. Four surveys were dropped because of respondent inexperience, defined as less than two years of experience in the Delta or no more than one year of Delta experience and less than three years of general experience in fish and aquatic ecosystems. Incomplete answers led one more survey to be dropped in Part II and two to be dropped in Part III. Unless noted, results are presented for the 39 complete surveys.

[3] Although we did not specify the kind of Chinook salmon in our questionnaire, we assume that most respondents were thinking principally of juvenile fall-run Chinook, which are the most abundant of the four runs present, although the listed winter- and spring-run Chinook were presumably also part of their consideration.

2. Sample Demographics

Table E.1 summarizes respondents' professional characteristics. Two-thirds of the experts are biologists, with academia and the state each accounting for a third of employers. Among biologists, most indicated a broad specialization in fish (20), with a handful in other areas (zooplankton: 5; primary producers: 2).

Table E.1. Professional characteristics of survey respondents (number of respondents)

	Employer							
Profession	**Academic**	**Consultant**	**Local**	**State**	**Federal**	**NGO**	**Other**	**Total**
Biologist	11	1	0	11	3	0	1	27
Hydrodynamicist	0	0	4	1	1	0	1	7
Other	1	3	0	1	0	0	0	5
Total	12	4	4	13	4	0	2	39

Sample excludes 4 biologists (1 academic and 3 state) and 2 respondents from "other" fields dropped for inexperience or missing values. Respondents were dropped for inexperience if <2 years working on the Delta or <1 year working on the Delta and <3 years working on fish.

Respondents had an average of 13 years working on fish or aquatic ecosystems in the Delta, and nearly 19 years of general experience on these topics (Table E.2).

Table 2. Respondent experience in fish and/or aquatic ecosystems (years)

	Delta	**California**	**General**
Mean	13.4	15.4	18.6
(std. deviation)	(10.6)	(11.2)	(11.6)
Minimum	1	1	3
Maximum	35	38	43

n = 39

3. Likely Species Responses to Changes in Delta Water Management Factors

Part II of the survey asked respondents to give their sense of the likely effects on the four fish species of a substantial increase or decrease in a variety of individual Delta water management factors: pumping of exports from the South Delta, rates of Delta island flooding, salinity in the western Delta, cross-Delta flows, salinity of the San Joaquin River, volume of Sacramento River flows into the Delta, and withdrawals from the Sacramento River upstream of the Delta.

Description of the Management Factors

These seven factors are integral parts of current water management in the Delta:

1. *South Delta pumping.* The pumps in the South Delta are the primary tool for moving exports to points south and west of the Delta. They have been the focus of the recent court decision by Judge Wanger regarding delta smelt, given their role in entraining fish and disturbing natural flows within the Delta.

2. *Island flooding rate.* Delta islands have been flooding on a regular basis (166 times in the last 100 years – see Chapter 2 of the main report), and the default policy has been to repair levees and restore islands in the wake of these failures, on the assumption that not only Delta land uses, but also Delta freshwater uses, depend on retaining current land forms. Recently, there has been some debate about whether increased open-water habitat – which results if islands are not repaired when they flood - would help or harm the Delta's native fish species (Chapter 5 of the main report and Appendix D).

3. *Western Delta salinity.* Salinity intrusion from the ocean and bay, on the Delta's western edge, is a concern for agricultural and urban water users and Delta fish species. Current policy uses a combination of reservoir releases and management of export volumes to keep the Delta fresh enough for agricultural and urban uses. In addition, salinity levels in the western Delta are limited during the spring (February to June) to favor conditions for the delta smelt and other pelagic species (the "X2" criterion).

4. *Cross-Delta flow.* To facilitate export pumping through the South Delta pumps, cross-Delta flows are manipulated by channeling some Sacramento River water through an artificial cross-Delta channel at Walnut Grove in the northern Delta. This action increases flows across the Delta and reduces flows remaining in the lower Sacramento River.

5. *San Joaquin River salinity.* The high levels of salinity in the San Joaquin River as it enters the southern Delta pose another management challenge. Extensive upstream diversions limit the natural freshwater flow from this river, and saline agricultural drainage from San Joaquin Valley farms increase the concentration of salts flowing into the southern Delta.

6. *Sacramento River flow.* The Sacramento River is the primary source of freshwater into the Delta. Flows are currently regulated to provide the ability to export water year-round. Upstream diversions (see below) also limit flows.

7. *Sacramento River withdrawals.* Upstream withdrawals on the Sacramento River are an important and potentially growing source of diversions from the Delta watershed (main report, chapter 7). If a peripheral canal were built, it would involve replacing the current through-Delta pumping system with upstream withdrawals.

Survey Responses

In the survey, substantial increases and decreases in the values of each management factor were expressed as a "doubling" or "halving." Respondents were asked to consider these changes as compared with the current policy of Delta water operations since the Wanger decision, which is expected to result in less pumping than in the recent past, but continued large water exports from the pumps in the southern Delta. Other default assumptions included continued reactive responses to levee failures and large areas of the Delta continuing to be dominated by Brazilian waterweed (*Egeria densa)* and other invasive species. The precise nature of doubling or halving (e.g. whether the change would have a precise seasonal pattern) was not specified. As discussed later in this appendix, future surveys could usefully be applied to solicit more detailed information of this type.

Respondents were asked to rank fish population responses on a scale of +3 to -3, where + 3= strongly improves, +2 = somewhat improves, + 1 = slightly improves, 0 = no change, -1 = slightly worsens, -2 = somewhat worsens, and -3 = strongly worsens.

Table E.3 presents the mean responses for a doubling (panel A) and halving (panel B) of each management factor. Most mean values are statistically different from zero, indicating that the respondents on average believed these changes would not be neutral for the fish (significant values are shown in boldface). The exceptions (unbolded) include island flooding for delta smelt and salmon, cross-Delta flows for striped bass and longfin smelt, and decreases in San Joaquin River salinity for Sacramento River salmon.

For five of the seven management factors, respondents generally consider that a doubling would create worse conditions for fish: South Delta pumping, salinity levels in the western Delta and the San Joaquin River, cross-Delta flows, and Sacramento River withdrawals. Conversely, a halving of the other two management factors – island flooding rates and Sacramento River flow, are generally considered bad for fish.

However, the intensity of effects varies across individual management actions, as can be seen in the last rows of panels A and B, which show the average of responses for all four species. Changes in South Delta pumping and Sacramento River flows and withdrawals are anticipated to have significantly greater impacts than the other factors – in the range of 1 to 2 (or "slight" to "somewhat"), versus 0 to 1 (or "none" to "slight"). In other words, respondents consider pumping volumes and actions affecting the volume of Delta flows to be more important for fish than actions affecting western or southern Delta salinity levels, manipulations of cross-Delta flows, or island flooding.[4]

Interestingly, this intensity is not fully symmetrical when one compares a strong increase (doubling) with a strong decrease (halving) of these management actions; lower flows and greater pumping volumes are predicted to cause larger effects than corresponding actions to increase flows and reduce pumping.[5] Doubling the volume of South Delta pumping is considered substantially worse for all four fish than halving pumping volumes is beneficial. Similarly, doubling the volume of Sacramento River withdrawals generates a stronger predicted effect, in absolute terms, than halving withdrawals. For delta smelt, this asymmetry also holds for the volume of Sacramento River flows. These findings suggest that although decreases in water availability will cause serious problems for fish, increases in flows are not likely to be as effective in improving conditions without a range of other actions.

It is also useful to compare the overall sensitivity of individual fish species to various changes in management actions. To this end, the last column in Table E.3 (both panels) reports the average of the absolute values of fish population responses to all seven factors. Delta smelt emerge as the most sensitive of the four species, and young-of-year striped bass the least sensitive.

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[4] The default assumption here is that islands would be repaired after flooding, so levee failures would have only temporary effects.

[5] Roughly half of the respondents answered the "halving" question before the "doubling" question, and vice-versa. Future analysis will consider potential effects of the order in which questions were asked.

Table E3. Effects on fish populations of changes in water management factors

Panel A: Doubling

Species	S. Delta pumping	Island flooding rate	W. Delta salinity	Cross-Delta flow	San Joaquin R. salinity	Sac River flow	Sac River withdrawal	Average for all seven actions*
Delta Smelt	**-2.5**	0.3	**-1.5**	**-0.8**	**-1.1**	**1.5**	**-1.6**	**1.7**
	(0.8)	(1.4)	**(1.4)**	**(1.8)**	**(1.1)**	**(1.3)**	**(1.1)**	**(1.1)**
Striped Bass (YOY)	**-1.7**	**0.5**	**-0.6**	-0.4	**-0.6**	**1.4**	**-1.1**	**1.1**
	(1.1)	**(1.1)**	**(1.1)**	(1.5)	**(0.9)**	**(1.0)**	**(1.2)**	**(0.7)**
Longfin Smelt	**-1.8**	**0.3**	**-0.7**	-0.4	**-0.7**	**1.8**	**-1.4**	**1.2**
	(1.1)	**(1.1)**	**(1.1)**	(1.2)	**(0.9)**	**(1.0)**	**(1.0)**	**(0.6)**
Sacramento R. Salmon	**-1.7**	0.3	**-0.3**	**-1.1**	**-0.6**	**1.9**	**-1.7**	**1.3**
(Juvenile)	**(1.1)**	(1.2)	**(0.8)**	**(1.6)**	**(0.8)**	**(1.3)**	**(1.1)**	**(0.6)**
Average for	**-1.9**	**0.4**	**-0.8**	**-0.6**	**-0.7**	**1.7**	**-1.4**	
all four fish	**(0.8)**	**(0.9)**	**(0.8)**	**(1.4)**	**(0.7)**	**(0.9)**	**(0.9)**	

Panel B: Halving

Species	S. Delta pumping	Island flooding rate	W. Delta salinity	Cross-Delta flow	San Joaquin R. salinity	Sac River flow	Sac River withdrawal	Average for all seven actions*
Delta Smelt	**1.8**	-0.3	**1.1**	**0.5**	**0.8**	**-2.0**	**1.2**	**1.3**
	(1.0)	(1.2)	**(1.1)**	**(1.4)**	**(0.9)**	**(0.9)**	**(1.0)**	**(1.0)**
Striped Bass (YOY)	**1.2**	**-0.3**	**0.7**	0.2	**0.5**	**-1.3**	**0.7**	**0.9**
	(1.0)	**(0.9)**	**(0.7)**	(1.1)	**(0.8)**	**(1.1)**	**(1.3)**	**(0.6)**
Longfin Smelt	**1.3**	**-0.5**	**0.7**	0.3	**0.6**	**-1.8**	**1.0**	**1.1**
	(1.1)	**(0.9)**	**(1.2)**	(1.0)	**(0.8)**	**(1.0)**	**(1.1)**	**(0.6)**
Sacramento R. Salmon	**1.1**	**-0.4**	**0.3**	**0.9**	0.5	**-2.0**	**1.5**	**1.1**
(Juvenile)	**(1.0)**	**(1.0)**	**(0.8)**	**(1.3)**	(1.9)	**(1.2)**	**(1.4)**	**(0.7)**
Average for	**1.4**	**-0.4**	**0.7**	**0.5**	**0.6**	**-1.8**	**1.1**	
all four fish	**(0.9)**	**(0.8)**	**(0.7)**	**(1.1)**	**(0.7)**	**(0.8)**	**(0.9)**	

Table reports sample means with standard deviations in parentheses. Sample size ranges from 37 to 40, as some respondents left some cells blank. Means in bold are significantly different from zero at the 95% level of confidence in a two-tailed test. Overall averages in last columns and rows are calculated from survey responses for individual management factors and fish species, respectively.*Averages for all seven management actions use absolute values of the responses.

4. Probabilities of Fish Species Viability under Different Export Management Alternatives

Respondents were presented an overview of results from hydrodynamic models for some broad management scenarios under current and future conditions. For current conditions, the results compared salinity levels in different parts of the Delta with current through-Delta pumping versus operation of a "dual facility" with through-Delta pumping combined with a small (2500 cubic feet per section (cfs)) or medium-sized (7500 cfs) peripheral canal. For future conditions, these same management alternatives were examined with one and three feet of sea level rise and under conditions where different groups of Delta islands fail permanently (western only, eastern or central only, and 20 islands across the Delta).

The modeling results for current conditions showed increased salinity levels in the western and southern portions of the Delta with higher levels of diversions from a peripheral canal. For future conditions, higher salinity incursions into the Delta occur with sea level rise and the failure of islands in the western Delta under all export management alternatives examined (continued through-Delta pumping and the two variants of a dual facility). By contrast, failures of central and eastern Delta islands do not generate salinity incursions, as long as the western Delta islands remain intact. (For a summary of these modeling results, see Chapter 4 of the main report and Appendix C.) These results on sea level rise and island flooding were presented to illustrate the general trends in future salinity, flow, and accompanying water quality conditions in the Delta, rather than precise scenarios of the future.

Respondents were then asked to gauge probabilities of having viable species populations under four different export management alternatives: (1) continued through-Delta pumping (referred to in the survey as "in-Delta intakes"), (2) moving water around the Delta through a peripheral canal ("peripheral conveyance" in the survey), (3) combining through-Delta pumping and a peripheral canal in a so-called dual facility ("dual intakes" in the survey), and (4) ending exports altogether ("no exports" in the survey). Respondents were asked to provide a high and low estimate for fish population responses to each export alternative, with the low end estimate corresponding to a scenario with "all things done wrong" from the standpoint of fish and the high end estimate to a scenario with "all things done right" for fish.

In distinguishing between these high and low estimates, they were asked to assume that ecosystem management and restoration expenditures were held constant, so that the focus was on water export operations themselves. For instance, the estimate with "all things done right" for a peripheral canal might correspond to a scenario where fish entrainment is minimized at the canal intake and where adequate Sacramento River flows are maintained below the intake, whereas the "all things done wrong" scenario would poorly manage both issues. Similarly, "all things done right" for the no export alternative might correspond to a scenario where upstream diversions are not increased and where toxicants are controlled to provide the most favorable conditions for fish. Respondents were asked to use their own judgment in assessing what constitutes a package of operations done "wrong" or "right" for each alternative.

Population "viability" was defined as achieving similar or higher fish populations relative to the present. This is a potentially narrower definition than that commonly used in conservation biology – wherein viability generally refers to the maintenance of self-sustaining populations over the long term. For instance, for the delta smelt, achieving similar or higher populations to the present might be a lower threshold than achieving long-term sustainability, given this fish's current low population counts. Because this distinction was not raised by survey respondents, we believe that the estimates can be interpreted as corresponding to the maintenance of self-sustaining populations.

Panel A of Table E.4 presents the results for these questions under current conditions, defined as the next 10 years, and Panel B presents the results for projected future conditions (the next 20 to 80 years), described as a Delta with many more permanently failed islands and one to three feet of sea level rise. The results are summarized graphically in Figures E.1a and E.1b for current and future conditions, respectively. In these figures, the low end of the range is the sample mean of the "all things done wrong" estimate and the high end of the range is the mean of the "all things done right" estimate.

Table E.4. Probability of viable fish populations under different export management alternatives (%)

Panel A: Current Conditions

Species	In-Delta Intakes: All things done wrong	In-Delta Intakes: All things done right	Peripheral Conveyance: All things done wrong	Peripheral Conveyance: All things done right	Dual Intakes: All things done wrong	Dual Intakes: All things done right	No Exports: All things done wrong	No Exports: All things done right	Average for four export alternatives
Delta Smelt	10	30	19	46	15	40	29	58	31
	(13)	(25)	(21)	(27)	(20)	(28)	(24)	(28)	(19)
Striped Bass (YOY)	33	56	36	60	34	61	49	75	51
	(25)	(26)	(28)	(27)	(26)	(26)	(27)	(26)	(22)
Longfin Smelt	23	44	31	53	24	50	40	68	42
	(22)	(28)	(25)	(26)	(23)	(24)	(24)	(25)	(19)
Sacramento R. Salmon	33	59	29	56	31	60	51	76	50
	(26)	(29)	(26)	(27)	(27)	(27)	(28)	(23)	(22)
Average for all four fish	25 (17)	47 (21)	28 (20)	54 (22)	26 (20)	53 (21)	42 (20)	69 (20)	

Panel B: Projected Future Conditions

Species	In-Delta Intakes: All things done wrong	In-Delta Intakes: All things done right	Peripheral Conveyance: All things done wrong	Peripheral Conveyance: All things done right	"Dual" Intakes: All things done wrong	"Dual" Intakes: All things done right	No Exports: All things done wrong	No Exports: All things done right	Average for four export alternatives
Delta Smelt	5	21	12	30	9	27	22	42	21
	(7)	(20)	(14)	(25)	(11)	(26)	(20)	(26)	(15)
Striped Bass (YOY)	26	45	33	53	32	53	45	66	44
	(25)	(26)	(23)	(29)	(24)	(29)	(25)	(28)	(22)
Longfin Smelt	17	35	27	46	24	43	35	57	36
	(18)	(25)	(23)	(30)	(22)	(29)	(21)	(23)	(20)
Sacramento R. Salmon	25	45	28	53	30	50	41	61	42
	(23)	(28)	(27)	(29)	(28)	(31)	(27)	(26)	(23)
Average for all four fish	18 (14)	37 (19)	25 (17)	45 (23)	24 (17)	43 (23)	36 (18)	57 (20)	

Notes: Sample size: 39. Table reports sample means with standard deviations in parentheses.

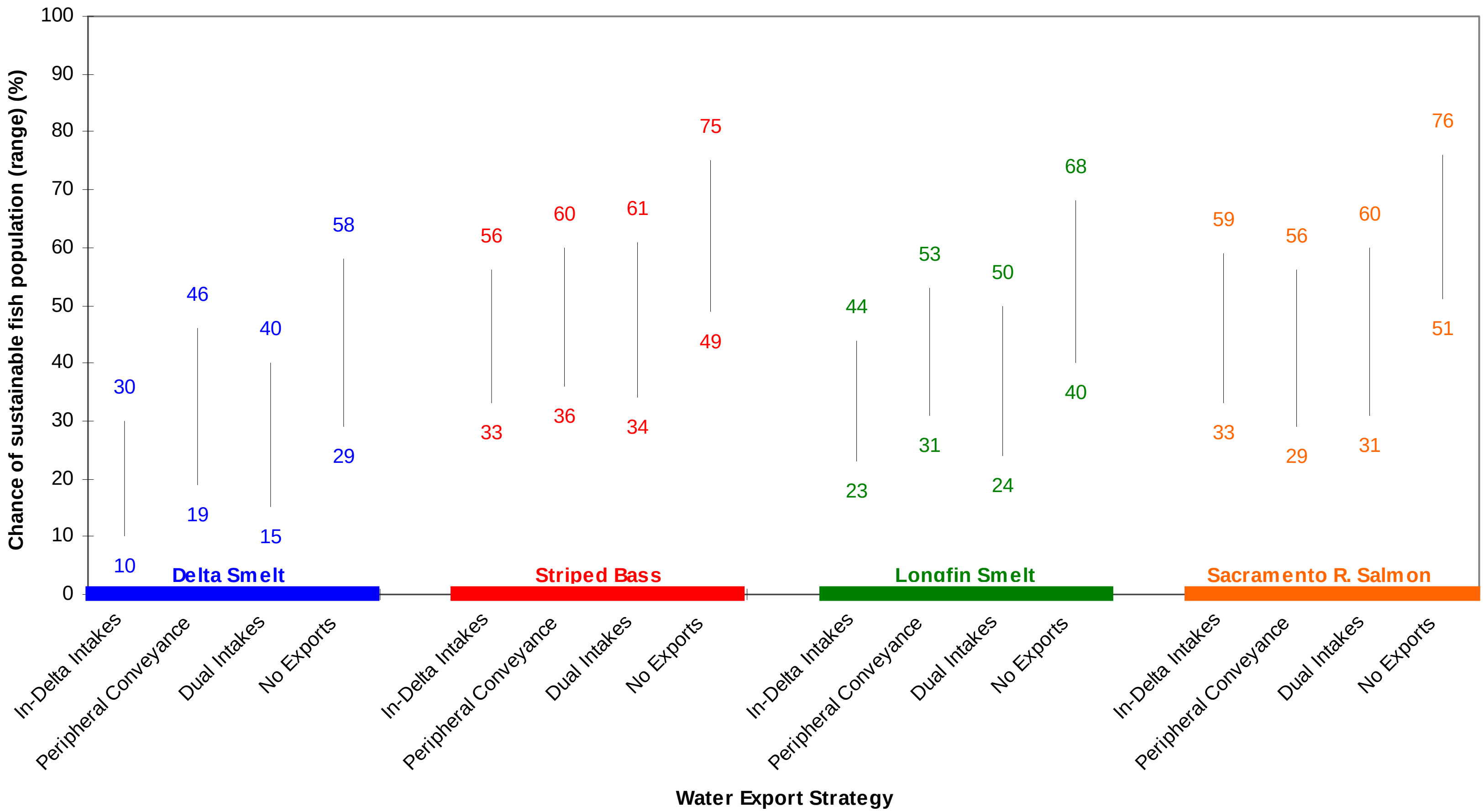

Figure E.1a. Probability of Viable Fish Populations under Different Export Management Alternatives, Current Conditions

Notes: Low and high end of range correspond to sample means for "all things done wrong" and "all things done right," respectively.

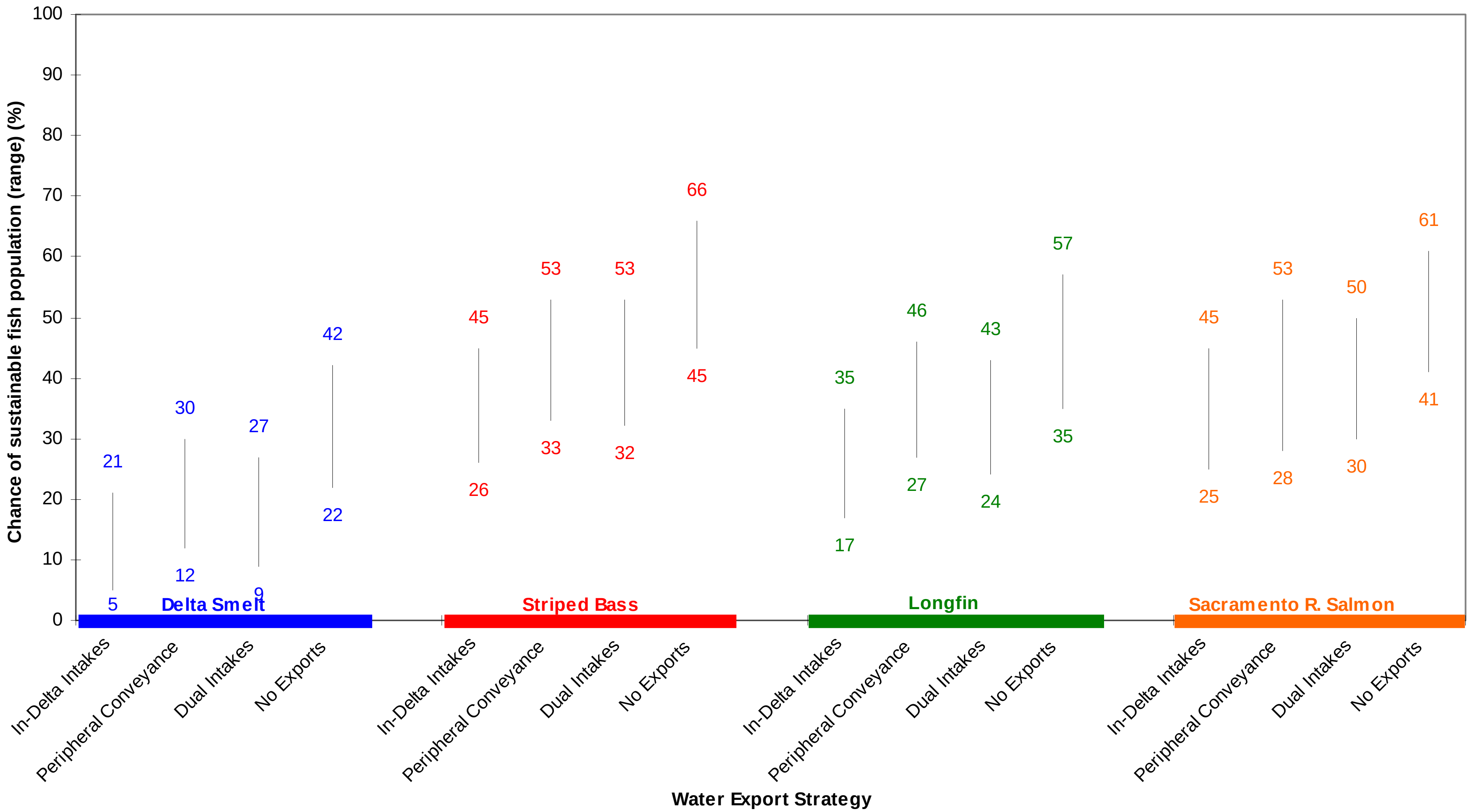

Figure E.1b. Probability of viable fish populations under different export management alternatives, future conditions

Notes: Low and high end of range correspond to sample means for "all things done wrong" and "all things done right," respectively.

Although these are difficult questions, particularly for somewhat non-specific scenarios, the results suggest some strong, consistent patterns. First, delta smelt face the greatest risks under all export management alternatives. Overall viability of delta smelt is consistently, significantly lower than that of the other three species. Under current conditions, averaging across management options and low and high-end estimates, delta smelt are considered to have an average probability of survival of only 31 percent, followed by longfin smelt (42 %), and Sacramento River Chinook salmon and young striped bass, each near 50 percent (Table 5a, last column).

Second, fish prospects look bleaker in the future. Climate change is typically considered to be detrimental to fish species relying on the Delta. Overall survival probabilities decline by 46 percent for the delta smelt (down from 31 to 21 percent) and decline by 15 to 19 percent for the other species, all statistically significant differences.[1]

Third, export management alternatives are very important, particularly for delta smelt. For all species, ending Delta exports significantly improves viability probabilities compared with the current in-Delta pumping system, both now and in the future. For delta smelt and longfin smelt, the second most attractive alternative is a peripheral canal (significantly better than in-Delta exports for both fish). A dual facility also appears marginally better than in-Delta exports for these species, although the difference is only statistically significant for delta smelt. Presumably this is because, in contrast to the pure peripheral canal, a dual facility would continue to entrain fish at the pumps in the South Delta. Although the viability estimates for young striped bass appear slightly higher with these two export management alternatives as compared with in-Delta exports, these differences are not statistically significant. For salmon fisheries, a peripheral canal and a dual facility under current conditions have slightly lower low-end estimates (likely a result of the higher chances of entrainment at upstream intakes in the Sacramento River), but again, this difference is not statistically significant.

Under future conditions, both the peripheral canal and the dual intakes alternatives are somewhat better than continued in-Delta pumping for salmon; this result is presumably because the canal intakes can be managed to reduce direct salmon mortality (by screening, timing of diversion, etc.) while much of the mortality caused by export pumping is indirect (fish pulled to unfavorable places in Delta, increased predation rates, etc.). For other fish, the rankings across alternatives remain consistent under current and future conditions.

Fourth, implementation details matter. There is a substantial gap between the low and high end estimates for each export management alternative, highlighting the importance of management quality. Interestingly, the “all things done right” scenarios for the water export alternatives all result in better predicted outcomes for the fish than the “all things done wrong” scenario for no exports. However, this management quality bonus declines in the future. Under current conditions, it is on the order of 25 percentage points, and it drops by 5 to 7 percentage points in the future, primarily as a result of more pessimistic high end estimates.

[1] Tests for statistical significance are two-tailed t-tests, and the significance cut-off is 95 percent.

Robustness Tests

Although the tests of statistical significance reported above are one way to assess the extent to which there was agreement among survey respondents on estimates of viability reported in Table E.4, it is useful to examine the data in some other ways to assess the robustness of these results. Here, we report the results of two robustness analyses: first, how the respondents rank each export management alternative, and second, how respondents with different professional backgrounds assess the probability of fish population viability.

For the ranking analysis, what matters is not the absolute score respondents predict for fish viability, but how they compare the position of each alternative relative to the others. Table E.5 reports the results of this analysis, by showing the share of respondents who ranked a management alternative best or worst for each fish, either on its own or together with another alternative (a "tie"), and the share who ranked an alternative as neither best nor worst ("intermediate option"). The table also reports the share of respondents who did not think export management alternatives mattered for fish viability (i.e., they ranked all alternatives alike). This last category was only important for striped bass, for which nearly a quarter of all respondents discounted the role of export strategies.[2]

In addition to confirming that export management alternatives matter for fish, the results confirm the strong showing for the "no export" alternative, which was ranked best across the board (only falling below 60 percent for salmon under future conditions). By the same token, continued in-Delta pumping was ranked as the worst option for the three pelagic fish by most respondents (only falling below 50 percent for striped bass under current conditions), although a high share of respondents also score a dual facility in last place for delta smelt and longfin smelt under the low-end, "all things done wrong" scenario. For salmon, by contrast, all three export alternatives fared roughly equally in ranking worst, except in the "all things done right" estimate under future conditions, where the two canal-based alternatives (peripheral conveyance and dual facility) appear better than continued in-Delta pumping.

[2] Overall, 16 respondents (41 % of the sample) reported at least one case for which management alternatives did not matter, out of a possible set of 16 cases – high and low estimates for each fish, under current and future conditions. Only three respondents had strong tendencies to view management alternatives as unimportant, however, ranking all management alternatives as having the same probabilities of viability in at least half of all cases.

Table E.5. Respondent Rankings of Export Management Alternatives (% of respondents)

	Delta Smelt				Striped Bass (YOY)				Longfin Smelt				Sacramento River Salmon			
	In-Delta	PC	Dual	No Exports	In-Delta	PC	Dual	No Exports	In-Delta	PC	Dual	No Exports	In-Delta	PC	Dual	No Exports
Current conditions																
All things done wrong																
Best alone or in ties	3	23	13	**69**	13	21	13	**64**	15	28	15	**72**	8	8	15	**79**
Intermediate option	8	**41**	26	10	21	31	33	8	10	36	18	15	38	26	26	8
Worst alone or in ties	**79**	26	**51**	10	**51**	33	38	13	**64**	26	**56**	3	**46**	**59**	**51**	5
All alternatives alike	10	10	10	10	15	15	15	15	10	10	10	10	8	8	8	8
All things done right																
Best alone or in ties	5	36	21	**74**	8	18	18	**64**	10	21	10	**72**	10	18	23	**72**
Intermediate option	10	31	38	8	23	28	36	8	23	33	**51**	3	33	18	31	8
Worst alone or in ties	**77**	26	33	10	**46**	31	23	5	**51**	31	23	10	**41**	**49**	31	5
All alternatives alike	8	8	8	8	23	23	23	23	15	15	15	15	15	15	15	15
Future conditions																
All things done wrong																
Best alone or in ties	3	21	10	**74**	10	23	21	**74**	5	28	18	**72**	8	18	18	**69**
Intermediate option	13	28	26	10	15	36	33	5	13	31	28	10	28	26	26	13
Worst alone or in ties	**72**	38	**51**	3	**62**	28	33	8	**72**	31	**44**	8	**49**	**41**	**41**	3
All alternatives alike	13	13	13	13	13	13	13	13	10	10	10	10	15	15	15	15
All things done right																
Best alone or in ties	10	23	13	**64**	5	28	23	**67**	13	28	21	**62**	13	28	31	**49**
Intermediate option	13	33	33	15	23	28	31	10	15	31	33	21	15	33	26	28
Worst alone or in ties	**62**	28	38	5	**54**	26	28	5	**62**	31	36	8	**56**	23	28	8
All alternatives alike	15	15	15	15	18	18	18	18	10	10	10	10	15	15	15	15

Notes: Sample size = 39. Categories applying to at least 40 percent of survey respondents are highlighted in bold. PC stands for peripheral conveyance. Totals for each alternative/fish combination may not sum to 100 percent because of rounding.

Turning next to the comparison of viability estimates across different groups within the survey group, Table E.6 reports the sample means for biologists relative to respondents from other professions, along with the results of a test of whether the differences between the two groups are significant. Although on average the biologists appear to give a higher premium to the "no export" alternative and lower scores to the three export alternatives lower, these differences are not statistically significant except in the cases highlighted in bold. Biologists are more pessimistic regarding the viability of salmon with a peripheral or dual conveyance system, and under future conditions this pessimism extends to delta smelt as well. As a result, for the biologists, the peripheral conveyance and dual alternatives do not appear as significantly better than continued in-Delta pumping for these fish.

There are starker contrasts when the sample is split by employer type, as seen in Table E.7, which compares the responses of employees of universities and research institutes with those of employees of state and federal agencies.[8] The academics were considerably more pessimistic about the viability of delta smelt, longfin smelt, and salmon, both under current and future conditions, and these differences are often highly statistically significant. Although the academics are generally more pessimistic about survivability of these species – even with an end to exports and all things done right - their overall rankings of alternatives are similar to the employees of state and federal agencies. It is worth stressing, moreover, that the prospects suggested by the employees of state and federal agencies are hardly cheery, with average high-end estimates of viability in the future never exceeding 70 percent, even with an end to exports. Overall, these estimates of viability suggest that considerably more is wrong with the Delta ecosystem for desirable fishes than water operations.

[8] The other categories (local agency, consulting, and other) are dropped from this comparison because the group sizes are too small.

Table E.6. Comparison of Fish Population Viability Estimates by Professional Background (sample means in %)

	In-Delta Intakes		Peripheral Conveyance		"Dual" Intakes		No Exports	
Current conditions	All things done wrong	All things done right	All things done wrong	All things done right	All things done wrong	All things done right	All things done wrong	All things done right
Delta Smelt								
Biologists	8	27	**15**	44	12	36	31	62
Others	13	36	**28**	48	21	48	26	49
Probability of equal means	0.37	0.32	**0.07**	0.67	0.19	0.24	0.54	0.18
Striped Bass (YOY)								
Biologists	33	58	33	61	32	61	52	**81**
Others	35	51	42	58	40	60	42	**60**
Probability of equal means	0.84	0.44	0.38	0.71	0.38	0.94	0.28	**0.02**
Longfin Smelt								
Biologists	23	42	28	53	21	48	42	70
Others	24	48	36	53	32	55	35	64
Probability of equal means	0.96	0.55	0.35	0.92	0.19	0.40	0.38	0.47
Sacramento R. Salmon								
Biologists	31	58	**24**	**51**	**26**	56	52	76
Others	39	62	**40**	**68**	**43**	67	50	75
Probability of equal means	0.35	0.69	**0.08**	**0.06**	**0.07**	0.27	0.84	0.95
Future conditions								
Delta Smelt								
Biologists	5	19	**8**	26	**6**	**22**	24	44
Others	7	25	**21**	38	**16**	**38**	19	40
Probability of equal means	0.33	0.42	**0.01**	0.16	**0.01**	**0.06**	0.52	0.71
Striped Bass (YOY)								
Biologists	24	47	31	53	29	51	47	69
Others	30	42	37	55	39	58	40	58
Probability of equal means	0.50	0.62	0.47	0.83	0.21	0.54	0.44	0.27
Longfin Smelt								
Biologists	17	34	26	45	21	41	37	59
Others	17	38	29	50	30	47	29	54
Probability of equal means	0.91	0.73	0.72	0.65	0.27	0.61	0.27	0.60
Sacramento R. Salmon								
Biologists	22	41	**22**	**46**	**24**	**43**	39	59
Others	33	53	**41**	**67**	**43**	**66**	45	65
Probability of equal means	0.17	0.22	**0.04**	**0.04**	**0.05**	**0.03**	0.56	0.51

Table reports the mean probability of viability estimates of biologists and respondents with other professions (in percentages) and the probability of equal means between these two groups. Sample sizes: Biologists: 27, other professions: 12. Bolded figures have significantly different means with at least a 90 percent level of confidence in a two-tailed t-test.

Table E.7. Comparison of Fish Population Viability Estimates by Employer Type (samples means in %)

	In-Delta Intakes		Peripheral Conveyance		"Dual" Intakes		No Exports	
Curent conditions	All things done wrong	All things done right	All things done wrong	All things done right	All things done wrong	All things done right	All things done wrong	All things done right
Delta Smelt								
Academics	**2**	**13**	**6**	35	**3**	**26**	**18**	**46**
State/federal employees	**10**	**37**	**16**	49	**15**	**41**	**37**	**68**
Probability of equal means	**0.01**	**0.01**	**0.09**	0.14	**0.06**	**0.10**	**0.06**	**0.02**
Striped Bass (YOY)								
Academics	**23**	50	23	55	24	56	44	75
State/federal employees	**38**	61	36	61	36	61	54	79
Probability of equal means	**0.09**	0.32	0.23	0.52	0.20	0.63	0.33	0.67
Longfin Smelt								
Academics	**10**	**28**	**16**	45	**11**	40	30	61
State/federal employees	**29**	**53**	**36**	55	**25**	51	45	74
Probability of equal means	**0.01**	**0.02**	**0.02**	0.27	**0.08**	0.16	0.11	0.20
Sacramento R. Salmon								
Academics	**11**	**42**	**9**	**35**	**13**	**38**	**28**	**59**
State/federal employees	**39**	**64**	**28**	**60**	**30**	**65**	**61**	**83**
Probability of equal means	**0.00**	**0.06**	**0.01**	**0.01**	**0.03**	**0.01**	**0.00**	**0.01**
Future conditions								
Delta Smelt								
Academics	**0**	**11**	5	**17**	**2**	**12**	**11**	34
State/federal employees	**6**	**24**	9	**33**	**6**	**29**	**30**	50
Probability of equal means	**0.00**	**0.09**	0.16	**0.08**	**0.06**	**0.04**	**0.02**	0.12
Striped Bass (YOY)								
Academics	15	43	25	48	24	48	42	66
State/federal employees	29	46	32	55	30	53	46	68
Probability of equal means	0.11	0.74	0.39	0.50	0.46	0.68	0.63	0.87
Longfin Smelt								
Academics	**8**	25	**14**	**32**	**10**	30	**23**	50
State/federal employees	**21**	41	**31**	**53**	**25**	47	**42**	64
Probability of equal means	**0.05**	0.11	**0.04**	**0.05**	**0.03**	0.11	**0.02**	0.11
Sacramento R. Salmon								
Academics	**6**	30	**8**	**32**	**6**	**25**	**17**	**45**
State/federal employees	**28**	47	**25**	**54**	**29**	**53**	**47**	**65**
Probability of equal means	**0.00**	0.11	**0.03**	**0.04**	**0.00**	**0.01**	**0.00**	**0.06**

Table reports the mean probability of viability estimates of academics and employees of state/federal agencies (in percentages) and the probability of equal means between these two groups. Sample sizes: Academics: 12, state/federal employees: 17. Bolded figures have significantly different means with at least a 90 percent level of confidence in a two-tailed t-test.

5. Targeting New Ecosystem Investments

The final part of the survey provided an opportunity for respondents to suggest new ecosystem management actions that might improve fish populations under future conditions (notably, sea level rise and more permanently flooded islands). Twenty-five respondents provided answers to this section, which allowed for open-ended answers. Figure E.2 summarizes the types of actions mentioned. On average respondents provided suggestions in three distinct categories.

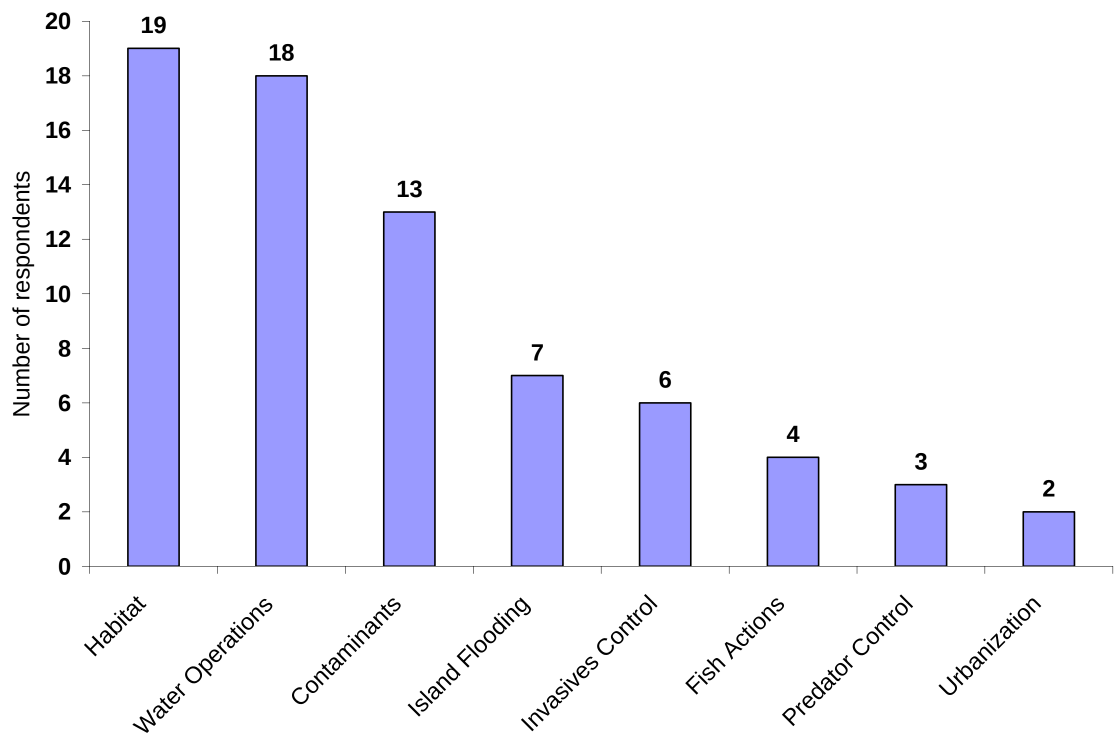

Figure E.2. Ecosystem Investments to Improve Fish Populations

Note: Figure reports number of respondents indicating a type of investment. Figure omits three additional actions that were mentioned by only one respondent: improving food production, decreasing agricultural water use, and stopping sea level rise.

Not surprisingly, the most frequently mentioned actions target investments in habitat (three-fourths of the sample). Common themes include expanding marshlands and tidal and seasonal floodplains, facilitating the migration of wetlands upland as sea level rises, and more generally enhancing the connections between land and water habitat in the Delta and upstream areas such as the Yolo Bypass.

Almost as many respondents highlighted the need to change water operations as part of an ecosystem investment effort. Here again, there were some common themes, although with perhaps less consensus than for habitat. Seven respondents stressed the importance of increasing variability in flows (notably salinity) across years and seasons. A similar number stressed the importance of general reductions in water exports. Several others argued for reducing pumping from the South Delta, but not necessarily a reduction in exports per se, and one suggested reductions in cross-Delta flows. Several suggested introducing a peripheral canal as an alternative to the current through-Delta pumping system, in one case with an initial experiment by isolating the eastern Delta as a partially isolated canal. (One respondent explicitly ruled out a peripheral canal.) Two respondents suggested increased San Joaquin River flows, particularly in the spring and summer.

The third most common theme was contaminant control, highlighted by over half of all respondents. Many respondents did not specify particular actions; when they did, they cited stricter regulation of both urban and agricultural runoff and the outflow from wastewater treatment plants.

A handful of other topics were mentioned by a smaller number of respondents. One theme focused on control of other species harmful to desirable Delta fish: invasive species (6 respondents, generally without reference to any specific actions); predator fish (3 respondents, with one suggestion to allow all ages of striped bass to be fished). Another theme was island flooding. Six respondents considered it beneficial to encourage island flooding to improve open water habitat; one suggested experimentation to gauge the effects. By contrast, one respondent argued for a focus on filling in/restoring islands to prevent flooding in the face of sea level rise. Four respondents focused on direct interventions with desirable fish (e.g. delta smelt, salmon): stocking and marking for tracking purposes. Finally, two respondents argued for controls on urbanization in the Delta to reduce harm to the fish.

6. Interpreting the Survey Results

Expert opinion as synthesized in such a survey is increasingly regarded as a useful form of scientific knowledge (Sullivan et al. 2006). Surveys harnessing the views of multiple experts, especially in the context of peer-review forums such as the EET, can provide reliable information for guiding environmental management and conservation decisions (Martin et al. 2005, Sullivan et al. 2006, Al-Chokhachy et al. 2008). Often, such expert opinion may be one of the only sources of scientific knowledge readily available for addressing tough policy decisions that cannot wait for traditional scientific inquiry. Where appropriate data are also available, survey information is increasingly being sought to formulate prior distributions for examining alternative hypotheses (Martin et al. 2005). Clearly, with regard to the Delta, decisions over the future of water operations and the fates of desired species will far outpace the necessarily slow, deliberate accumulation of formal scientific studies, adding premium to the collective opinions of groups of technical experts.

It is also tempting to dismiss these survey results. The participants consisted of a cross-section of scientists willing and able to attend a regularly scheduled EET meeting who, by-in-large, were unaware they would be solicited for the survey. The participants were also self-selected to a certain degree, however, in that their collective views may not be statistically representative of all those who would consider themselves experts on Delta fish and water operations. Although this may have inflated the potential for a contextual bias, or a certain "faith-based" reasoning (in the sense of Hilborn, 2006) with respect to the influence of water operations on desired Delta fishes, EET members are reputed for expressing and debating divergent viewpoints. Moreover, the questionnaire's descriptions of the four alternatives were deliberately vague, so every participant might have a different idea as to what doing "everything right "or "everything wrong" might be. Nevertheless, the participants were a substantial subset of the real experts on the biology and ecology of the Delta, representing researchers and managers as well as stakeholder consultants. Our assumption is that each expert had enough grasp of both the details and complexity of the Delta to conduct a mental synthesis of what is likely to happen to the best known species if the system is altered in major ways.

What is most remarkable about the survey results, despite the lack of detail in the questionnaire and potential inherent biases of the method, is the general pessimism expressed with regard to the likelihood that desirable fishes can persist into the future, especially if Delta water operations continue in broadly the same way as at present. Most respondents indicated that the probability for species persistence could increase greatly with an alternative to the current water conveyance system. Furthermore, the Delta experts we surveyed, collectively, can envision sets of actions to employ with an alternative water system that are likely to be most effective in precluding the extirpation of desirable fish species. This is an encouraging indication that there are solution sets that might have a good chance of working with refinement and flexibility in their application.

Nevertheless, this survey is clearly a "first cut" at assembling expert opinion on key Delta management issues. Future work of this nature, providing the opportunity to explore more nuanced implementation of management options (e.g., the role of seasonal sensitivity to management decisions) can provide useful guidance on the development and implementation of Delta ecosystem and water management actions.

Conclusion

In the absence of more detailed knowledge, rapid assessments by experts are useful for comparing the likely ecological performance of alternative water management policies. The survey of estuarine experts reported here is not the last word on this subject, but it provides some important insights. Despite the inevitable uncertainties, there appears to be a consensus of scientific opinion on several key points that are relevant for forward-looking policymaking in the Delta. First, substantial changes in South Delta pumping volumes and Sacramento River flows are considered far more important for the health of key Delta fish species (delta smelt, longfin smelt, salmon, and striped bass) than other water management factors, such as salinity levels, island flooding rates, and cross-Delta flows. Second, all three strategies that allow continued water exports (continued in-Delta pumping, a peripheral canal, and a dual facility) increase the risks to these key fish species relative to the alternative of ending exports. Third, the details of how export strategies are implemented can greatly improve the prospects for fish. Fourth, the prospects for many desirable Delta fish will diminish with climate change, under all water export alternatives, including ending exports. Finally, the delta smelt face significant risks of extinction no matter which export alternative is chosen, but particularly with continued in-Delta pumping of water exports.

Addendum E1. The Expert Survey

"Some biologists, engineers, economists, and a geologist walk onto a bar in the Delta, and think about futures for the ecosystem…"

PART I - Respondent characteristics

Employer (circle one): Academic Consulting Local Agency State Agency Federal Agency NGO Other

Background (circle <u>one</u> area of primary expertise): Fish Zooplankton Primary producers Benthos Toxicology Aquatic vegetation Hydrodynamics Other

Years working on Delta fish/ecosystems: _____

Years working on California fish/ecosystems: _____

Years working on fish or aquatic ecosystems: _____

PART II – How are species most likely respond?

You know more about ecosystems in the Delta than any other group. Despite large uncertainties, major decisions will be made about the Delta's future. The current default policy for the Delta is that it will be maintained as it is today, with the added reduction in exports according to the recent Wanger decision, for the foreseeable future (less pumping but continued large exports, reactive responses to levee failures, large expanses dominated by Egeria, etc.). If this basic policy remains in place, what is likely to happen to fish, if despite our best efforts, the following factors a) doubled or b) halved beyond typical conditions in all years? Treat each factor as happening independently, even though you know everything is connected to everything else.

a) **How would a DOUBLING in each factor below affect each fish species' population? Rank fish population effects as follows: +3=strongly improves; +2=somewhat improves; +1=slightly improves; 0=no change;-1=slightly worsens; -2=somewhat worsens; -3=strongly worsens**

	Rank and direction for DOUBLING of:						
Species	S. Delta pumping	Island flooding rate	W. Delta salinity	Cross-Delta flow	San Joaquin R. salinity	Sac River Flow	Sac River withdrawal
Delta Examplefish	-3	+1	0	+2	-2	+3	-3
Delta Smelt							
Striped Bass (YOY)							
Longfin Smelt							
Sac. R. Juvenile Salmon							

b) **How would a HALVING of each factor below affect each fish species' population? (same scale as above)**

	Rank and direction for HALVING of:						
Species	S. Delta pumping	Island flooding rate	W. Delta salinity	Cross-Delta flow	San Joaquin R. salinity	Sac River Flow	Sac River withdrawal
Delta Examplefish	+2	-1	+2	-1	0	-2	+3
Delta Smelt							
Striped Bass (YOY)							
Longfin Smelt							
Sac. R. Juvenile Salmon							

PART III – Probabilities of fish species viability

What is likely to happen to fish, if (1) current conditions and management actions (including Wanger decision) remain the same [In-Delta Intakes], (2) all water exports are halted [No Exports], (3) a peripheral canal becomes the principal export source [Upstream Diversions] or (4) water export is by some combination of a peripheral canal/pipe and in-Delta export pumping [“Dual” intakes].

1) Current conditions In your judgment, what is the probability each species will have similar levels or higher populations in the Delta for the next 10 years (“viable” populations)?

	Probabilities of having viable species populations if:							
	In-Delta intakes		**No Exports**		**Peripheral Conveyance**		**“Dual” intakes**	
Species	All things done wrong	All things done right	All things done wrong	All things done right	All things done wrong	All things done right	All things done wrong	All things done right
Delta examplefish	25	75	50	100	50	100	10	90
Delta Smelt								
Striped Bass (YOY)								
Longfin Smelt								
Sacramento R. Salmon								

2) Projected future conditions Assume the Delta is moving towards many more permanently failed islands over the next 20-80 years, with sea levels 1-3 ft higher. Some of the water quality changes are likely to be those presented from the hydrodynamics model results. Assume for the moment that water exports remain at levels similar to those resulting from the Wanger decision. Under such conditions, with no additional ecosystem management expenditures, if you had to make an assessment today:

In your judgment, what is the probability that each of the following species will have viable populations?

	Probabilities of having viable species populations if:							
	In-Delta intakes		**No Exports**		**Peripheral Conveyance**		**"Dual" intakes**	
Species	All things done wrong	All things done right	All things done wrong	All things done right	All things done wrong	All things done right	All things done wrong	All things done right
Delta Smelt								
Striped Bass (YOY)								
Longfin Smelt								
Sacramento R. Salmon								

PART IV – Targeting new ecosystem investments

The exercise above assumed changes in water operations, with no additional ecosystem management expenditures. However, some ecosystem management activities and investments might improve fish populations in the future, beyond current actions. Given your current understanding, what are the most promising Delta ecosystem improvement actions for future conditions (sea level rise and more permanently flooded islands)? (You may rank these if you'd like.)

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