are of mixed origin, as judged by the failure of the test for Hardy-Weinberg genotypic proportions in a randomly breeding population.

- On the basis of MSA, the SWP fish are a mixture of the major runs, with winter run comprising about 5% of fish in the sample provided.

We have presented an example of the type of molecular and population genetic analyses that now promise to resolve the run identity of chinook salmon captured at the water projects. Such an analysis may change substantially the conclusions of run identity reached from applying traditional length criteria for identifying winter run. However, to accomplish this MSA with a high degree of statistical confidence and in "real time" (at least weekly), we need:

- Multiple genetic markers to increase the precision with which samples of the mixed take can be allocated to run.
- More and better data on baseline populations, *ie*, larger samples of all chinook spawning populations that potentially contribute to the take of juveniles in the delta.
- Validation of the MSA both by computer simulations and blind tests of mixed samples of known composition.

All these needs are being addressed by current research with the goal of having MSA operational in 1997. Improved methods for run diagnosis will provide a resource for valuable understanding of chinook salmon biology in general. Application of run diagnosis to samples from all stages of the life cycle will enhance perspectives for both freshwater and marine environs.

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Results of 1996 Coded-Wire Tag Smolt Survival Experiment in the San Joaquin River Delta

Pat Brandes

Adult salmon escapement in San Joaquin tributaries has fluctuated dramatically for many years, but since 1989, total annual basin escapement has not exceeded 5,000 fish. There are statistical relationships between escapement and production and flow and CVP/SWP exports 2½ years earlier (DFG 1987; USFWS 1991). As flows increase and exports decrease, adult escapement and production increases. In an attempt to identify management actions that could increase smolt survival (a likely variable responsible for the adult relationships), several smolt survival studies have been conducted. In general, results of survival experiments in the southern delta indicate that:

- Survival to Chipps Island for coded-wire tagged smolts has become increasingly poor over the past 7 years, and recovery of the tagged smolts at the fish facilities has decreased markedly.
- Survival through the San Joaquin side is much lower than in the Sacramento side of the delta.
- Survival down the mainstem San Joaquin River is generally about twofold greater than for smolts emigrating down upper Old River, suggesting that a full barrier at the head of Old River could increase smolt survival and, thus, benefit the adult population.

Survival experiments in 1992 and 1994 focused on evaluating a temporary barrier at the head of Old River as a means to increase smolt survival. In 1992, water temperature increased after barrier installation, preventing unbiased evaluation, and in 1994, all survival indices were too low to differentiate a benefit associated with the barrier. In 1993 and 1995, high flows prevented installation of the barrier.

Based on experience, the 1996 study design included a barrier at the head of Old River for the entire experimental period to get replication with a barrier and determine if survival was higher than in past years without a barrier. However, barrier installation was delayed due to permitting issues and was removed early due to flooding concerns. The barrier was closed fully on May 11 and was partially breached on May 16.

We also increased release numbers in 1996, from 50,000 to 100,000 for the first two sets of releases at Mossdale and Dos Reis, in an attempt to improve precision via greater recoveries at Chipps Island. Because of the limited number of marked fish available, the later releases (May 9 and 16) at Dos Reis were restricted to groups of 50,000. Due to the daily uncertainty of the barrier status in 1996, some changes in release sites and release numbers were necessary, deviating from the study plan.

Smolt survival during 1996 was evaluated under a San Joaquin flow of about 6,000-12,000 cfs and total CVP/SWP exports of about 1,500 cfs during the April 15-May 15 "pulse flow" period, resulting in a 4:1 inflow/export ratio. Exports increased to about 3,000 cfs on May 16 and increased again to 8,300 cfs on May 21. By May 28, combined exports had resumed to pre-pulse-flow levels of 10,300 cfs.

In addition to barrier evaluation, several other concerns with past experiments were addressed in 1996.

Most southern Delta survival experiments have been conducted with smolts from Feather River Hatchery, raising the question of whether using out-of-basin smolts has biased results. The 1996 study was designed to determine if smolts from Merced River Fish Facility released at Dos Reis Park on the San Joaquin River survived to Jersey Point at a higher rate than smolts from Feather River Hatchery released at the same location. Survival to Jersey Point was estimated by comparing differential survival to Chipps Island for the Dos Reis and Jersey Point groups from each facility.

To assess differential temperature tolerance between stocks, a subset of about 200 fish from each paired group released at Dos Reis was held in submerged cages for 48 hours to determine immediate and differential mortality. An additional 33 (Merced) and 34 (Feather) fish were sacrificed for a variety of physiological tests (internal parasites, bacteria, organosomatic analyses, ATPase assay, triglyceride levels, and stress glucose response). Another 12 fish from each facility were used to assess osmoregulatory ability. Additional health monitoring was done at Chipps Island on May 6 to assess change in health status of emigrating smolts.

To identify a potential mechanism for low southern delta survival, the study assessed the percentage of smolts diverted from the mainstem San Joaquin River into Turner Cut. Data from this part of the study have not been completely processed, so results are not included in this article.

The main part of the 1996 study consisted of two sets of CWT releases. The first releases were at Mossdale on April 15, upstream of Turner Cut on April 17, and Jersey

Point on April 18. The second releases were at Mossdale on April 30, Dos Reis on May 1, upstream of Turner Cut on May 2, and Jersey Point on May 3. The barrier was not in place for either set of releases.

Additional groups were released at Dos Reis on May 9 and May 16 to index survival with the barrier installed with low exports and with the partial barrier remaining at higher exports. Although we would have preferred to make these releases at Mossdale so they better represent survival through the delta with the barrier, the barrier was not completely closed on May 9, and a better estimate of survival with the barrier could be obtained by releasing the fish at Dos Reis. For consistency, the May 16 release was also at Dos Reis.

Results

Although significant changes in the data are not expected, this article is based on our initial reading of coded-wire tags, and minor corrections may be necessary. A more detailed analysis and discussion of the experiment will be available next spring from the USFWS Stockton office.

The first set of releases, made under low temperature (60-63°F) and exports (about 1,500 cfs) and medium flow (about 2,500 cfs at Stockton) had survival indices of 0.02 for Mossdale, 0.11 upstream of Turner Cut, and 0.45 for Jersey Point. Survival improved as the fish were released closer to Chipps Island, but indices from both Mossdale and upstream of Turner Cut were low (Table 1).

Similar releases on April 30, May 2, and May 3 resulted in survival indices of 0.01, 0.05 and 0.35. Releases at Dos Reis on May 1 with smolts from Merced River Fish Facility survived at a higher rate than the paired group from Feather River Hatchery. Merced smolts released at Jersey Point also survived at a higher rate than those of Feather River stock. Although the Merced River fish survived at about 2 to 5 times better than those from Feather River, trends are similar and both survival indices from Dos Reis are low. Absolute survival between Dos Reis and Jersey Point for the Merced stock (0.153) was almost 3 times greater than that for the Feather River stock (0.057).

Although, the Dos Reis release using Feather hatchery stock had a greater temperature change between the hatchery truck and river at release, it did not appear to affect the differential mortality of the subset of about 200 fish held in live cages for 48 hours after release. The only mortality observed after the 48 hours was attributed to an injury.

A large temperature differential between the hatchery truck and river water is common in many releases but does not seem to account for the poor mortality. The Mossdale release on April 30 had only a 2.5°F differential, but survival was still extremely low and worse than for the Mossdale release on April 15, when the differential was 10°F.

Reasons for differences in survival between Dos Reis and Jersey Point for the Merced River and Feather River smolts also were not apparent in the health monitoring component of the study. Overall, both stocks appeared healthy, there were no signs of clinical disease, and no significant differences were noted that could have affected survival between stocks. While the PKX agent, a myxosporean parasite, was detected in early infection stage of the Merced River stock, it would not have affected their delta survival. It should be noted, however, that development of this pathogen is progressive and may be a factor in adult survival of this stock. No fish from either facility and released at Dos Reis were recaptured at Chipps Island on May 6, making analyses of health status as they migrated through the river impossible.

There were no recoveries at Chipps Island from either of the Dos Reis releases (May 9 or 16).

As in recent years, relatively few marked fish from the releases were observed at the fish facilities in 1996. Although expanding the recoveries for sampling effort will increase the numbers somewhat, they would still be low (less than 2% per release).

Low southern delta survival in 1996 seems to be confirmed by the low recoveries at Chipps Island from releases in the San Joaquin tributaries using smolts from Merced River Fish Facility. Survival indices to Chipps Island for fish released in the upper and lower Merced and Tuolumne rivers were also extremely low (Table 2).

For comparison purposes, Feather River fish were also released at Sacramento (Miller Park) on April 15 and May 6, 1996. Survival indices were 1.09 and 0.58, respectively. It is unclear why survival was so low for smolts released in the southern delta and in the San Joaquin tributaries in 1996. Based on consistency of results within and between southern delta and tributary releases, it does not appear to be a spurious result.

Comparisons with 1995 results may provide insight. Although water temperatures were similar, flows at Vernalis were much higher in 1995, 20,000-25,000 cubic feet per second in 1995 versus 6,000-12,000 cfs in 1996. Exports were somewhat higher in 1995, with a 5:1 (Vernalis flow to total SWP/CVP export) ratio in 1995 and a 4:1 ratio in 1996.

Table 1
CHIPPS ISLAND TAG SUMMARY AND SURVIVAL CALCULATIONS AND UNEXPANDED FISH FACILITY RECOVERIES FOR CODED-WIRE-TAGGED CHINOOK SALMON RELEASED IN 1996
Preliminary Data 9/26/96

Tag Code	Release Site	Release Date	Truck Temp	River Temp	Number Recovered	Survival Index	Group Survival Index	SWP Unexpanded Salvage	CVP Unexpanded Salvage
San Joaquin Releases									
6-01-06-01-14	Mossdale				0	0.00		9	40
6-01-06-01-15	Mossdale				2	0.04		2	48
	Total	15-Apr-96	49.5	59.5	2		0.02		
6-01-14-05-05	Turner Cut	17-Apr-96	52	63	6		0.11	0	1
6-01-06-01-13	Jersey Point	18-Apr-96	50	62	24		0.45	0	0
6-01-06-02-01	Mossdale				1	0.02		15	46
6-01-06-02-05	Mossdale				0	0.00		9	64
	Total	30-Apr-96	61.5	64	1		0.01		
6-01-06-02-03	Dos Reis (FRH)				2	0.04		0	0
6-01-06-01-10	Dos Reis (FRH)				0	0.00		0	0
	Total	01-May-96	52	63	2		0.02		
6-01-11-04-12	Dos Reis (MRH)				2	0.07		0	0
6-01-11-04-13	Dos Reis (MRH)				3	0.10		0	0
6-01-11-04-14	Dos Reis (MRH)				1	0.05		0	0
6-01-11-04-15	Dos Reis (MRH)				5	0.13		0	0
	Total	01-May-96	57	63	11		0.10		
6-01-06-01-11	Turner Cut		56	70*	4	0.08		0	1
6-01-06-01-12	Turner Cut		62	70*	1	0.02		0	1
	Total	02-May-96			5		0.05		
6-01-06-01-09	Jersey Point (FRH)	03-May-96	50.5	64	24		0.35	0	1
6-01-11-05-01	Jersey Point (MRH)	03-May-96	50	65.5	39		0.72	0	0
6-01-06-02-06	Dos Reis	09-May-96	54	60	0		0.00	1	0
6-01-06-02-04	Dos Reis	16-May-96	51	62	0		0.00	4	0
Sacramento River Releases									
6-01-06-01-08	Miller Park	25-Apr-96	48	57	57		1.09	0	0
6-01-06-02-02	Miller Park	06-May-96	58	65	30		0.58	0	1

* It is unclear why Turner Cut temperature is so much higher than Dos Reis or Mossdale only days earlier.

Table 2
CHIPPS ISLAND TAG SUMMARY AND SURVIVAL CALCULATIONS AND UNEXPANDED FISH FACILITY RECOVERIES FOR CODED-WIRE-TAGGED SMOLTS RELEASED IN SAN JOAQUIN TRIBUTARIES IN 1996
Updated 9/26/96

Tag Code	Release Site	Release Date	Number Recovered	Tag Survival	Group* Survival	SWP Unexpanded Salvage	CVP Unexpanded Salvage
6-01-11-04-08	Upper Merced		0	0.00		1	3
6-01-11-04-09	Upper Merced		0	0.00		2	1
6-01-11-04-10	Upper Merced		1	0.04			10
6-01-11-04-11	Upper Merced		0	0.00		1	8
	Total	25-Apr-96	1		0.01		
6-01-11-05-03	Lower Merced		1	0.04		0	4
6-01-11-05-04	Lower Merced		1	0.04		1	5
6-01-11-05-05	Lower Merced		0	0.00		1	12
	Total	26-Apr-96	2	0.03			
6-01-11-05-06	Upper Tuolumne		0	0.00		2	14
6-01-11-05-07	Upper Tuolumne		2	0.08		2	7
6-01-11-05-08	Upper Tuolumne		1	0.04		4	11
	Total	26-Apr-96	3		0.04		
6-01-11-05-09	Lower Tuolumne		1	0.04		2	13
6-01-11-05-10	Lower Tuolumne		1	0.03		2	17
	Total	27-Apr-96	2		0.04		

Table 3
CHIPPS ISLAND TAG SUMMARY AND SURVIVAL CALCULATIONS AND EXPANDED FISH FACILITY RECOVERIES FOR CODED-WIRE-TAGGED SMOLTS RELEASED IN 1995

Tag Code	Release Site	Release Date	Truck Temp.	Release Temp.	Number Recovered	Survival Index	Group Survival Index	SWP Expanded Salvage	CVP Expanded Salvage
6-1-14-5-1	Mossdale				11	0.21		12	1245
6-1-14-4-14	Mossdale				12	0.23		24	1487
	Total	17-Apr-95	50.5	57	23		0.22		
6-1-14-4-12	Dos Reis	17-Apr-95	51	57	8		0.15	0	1
6-1-14-4-13	Jersey Point	19-Apr-95	51	60	25		0.46	0	0
6-31-47	Dos Reis	05-May-95	50	63	21		0.39	0	0
6-31-50	Mossdale				10	0.19		20	1019
6-31-51	Mossdale				3	0.06		54	840
	Total	05-May-95	49	62	13		0.12		
6-31-49	Dos Reis	17-May-95	56	65	9		0.16	0	24
6-1-14-5-4	Mossdale				1	0.02		66	720
6-31-48	Mossdale				7	0.13		62	732
	Total	17-May-95	49.5	63	8		0.07		
6-1-11-4-1	Upper Merced				5	0.17		102*	313
6-1-11-4-2	Upper Merced				3	0.10		148	255
6-1-11-4-3	Upper Merced				4	0.14		229	423
6-1-11-4-4	Upper Merced				6	0.20		139	351
	Total	03-May-95	51	51	18		0.15		
6-1-11-4-5	Lower Merced				7	0.24		137	341
6-1-11-4-6	Lower Merced				4	0.13		123	475
6-1-11-4-7	Lower Merced				7	0.23		154	418
	Total	04-May-95	51	59	18		0.20		
6-1-11-3-11	Upper Tuolumne				8	0.26		474	510
6-1-11-3-12	Upper Tuolumne				5	0.18		177	461
6-1-11-3-13	Upper Tuolumne				8	0.26		277	572
	Total	04-May-95	51	48	21		0.25		
6-1-11-3-14	Lower Tuolumne				5	0.18		236	607
6-1-11-3-15	Lower Tuolumne				7	0.25		203	707
	Total	05-May-95	48	51	12		0.22		

* This SWP expanded value is preliminary.

Survival indices for Mossdale and Dos Reis releases with Feather River stock (Table 3) were higher in 1995 than for similar releases in 1996. Similarly, smolts released in the tributaries (Merced River stock) survived at higher levels in 1995 than in 1996. The similar indices for all four tributary groups within a year indicates that mortality of the marked fish in the delta is overpowering mortality in the tributaries.

Survival in 1995 between Mossdale and Chipps Island was higher (by about 9 times) than in 1996. The difference could be partly associated with the somewhat different ratios (5:1 versus 4:1) but more likely reflects the higher flow or the greater difference between flow and export in 1995. The barrier was not in place for either group. Comparison of groups released at Dos Reis with those released at Mossdale in 1995 and 1996 indicated a 30-70% increase associated with the barrier, assuming that the Dos Reis release group survival would represent survival of a Mossdale group released with a barrier in place.

Further studies in 1997 will address the relative importance of flow and export to smolt survival in the southern delta. An draft proposal is under review.

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Science, Policy, and the Interagency Program

Wim Kimmerer and Bill Bennett

Misunderstandings have arisen in discussions of bay/delta environmental issues about what constitutes science, how ecosystems (and ecology) function, and in particular, how to deal with uncertainty in scientific findings. This essay describes our views of the nature of science, particularly ecological science, and how it can support effective management and policy-making. We then evaluate the ability of the Interagency Ecological Program to provide valid scientific input to policy-makers, drawing on our experiences as members of the Estuarine Ecology Team. We conclude that Interagency Program is doing a creditable job of providing scientific input for policy decisions, although there will always be room for improvement.

The Nature of Science

Science is often portrayed as a deliberative gathering of facts. Missing from this picture are the creative, anarchic, and consensual aspects of science. Science is creative in the development of new ideas, theories, or methods; anarchic in the way that the entire process lurches toward understanding; and ultimately consensual in the way that new ideas are either accepted or rejected. Science is imperfect and scientists are often wrong; we discuss this further below.

Science is not simply the accumulation of facts, but a way of knowing about the natural world (Gould 1979; Futuyma 1983). In the scientific process facts (*ie*, data) are gathered through observation and experiment. Creativity enters science in the way that new ideas are incorporated into the existing body of knowledge and in the development of new theories.

Darwin pointed out that facts are not very interesting unless they contribute to the development or testing of a theory. A scientific theory is a system of ideas that accounts for or explains a group of observations in a complete and self-consistent way. It may be revised, or even replaced, as new information becomes available. This differs vastly from the general definition of "theory", which includes such ideas as "conjecture", "speculation", and "unproved assumption". A scientific theory is an idealized description of a part of the real world. It is the best description the scientists can devise that is consistent with current information.

A theory is only the first step in the scientific process. Theories arise out of the attempts of scientists to explain observations. For a theory to be useful, it must not only explain previous observations but also predict observations not yet made. To accomplish this, the theory, or parts of it, must be framed as hypotheses, which are statements arising from the theory that lend themselves to testing. For example, from Einstein's general theory of relativity arises the prediction that light is bent by strong gravitational fields, from which could be developed a hypothesis about gravitational lenses. Many theories, including Einstein's, have been subjected to numerous tests through this cycle of prediction, hypothesis, and testing through controlled observations. Some have weathered these tests without the need for modification; indeed, as far as we are aware, all of the predictions of Einstein's theory have been borne out (except of course the one about dice).

Sometimes theories collapse under the weight of newly discovered observations. For example, data inconsistent with immovable continents stimulated development of the plate tectonic theory, which completely revolutionized geology and provided an internally consistent framework to explain the new observations. More commonly, though, theories are modified to accommodate new observations. Darwin's theory of evolution has passed the test of time in general terms, but many of the specific features of that theory (*eg*, the idea that evolution is necessarily gradual) have been modified as new observations have been made.

The anarchic aspect of science arises because any scientist is free in principle to test the theories of other scientists. Indeed, there is tremendous incentive for young scientists in particular to make a name for themselves by refuting or modifying some widely-held theory. This means that flawed theories sooner or later show their weaknesses to the probing community of scientists, and theories that provide an accurate and useful depiction of the natural world are more likely to survive than those that do not.

The chaotic tendency in science is roughly balanced by a process of consensus. This process operates in an informal way to resolve disputes arising from conflicting theories and differing sets of observations. The consensus process operates through two complementary pathways: publication of results in peer-reviewed journals, and a general insistence that results obtained in one location be replicated by other scientists in other locations. Peer-review is an imperfect process, and some papers are published that in retrospect ought not to have survived. When other