COLLATERAL DAMAGE

A citizen's guide to fish kills and habitat degradation at the state and federal water project pumps in the Delta

The Bay Institute

The Bay Institute

The Bay Institute is a 501(c)(3) nonprofit research, education and advocacy organization dedicated to protecting, restoring and inspiring conservation of San Francisco Bay and its watershed, from the Sierra to the sea.

Since 1981, The Bay Institute's policy and scientific experts have worked to secure stronger protections for endangered species and habitats; improve water quality; reform how California manages its water resources; and promote comprehensive ecological restoration of the Bay-Delta estuary and watershed. Since 2009, The Bay Institute has partnered with Aquarium of the Bay to educate Californians about this unique ecosystem. An electronic version of *Collateral Damage* can be downloaded at www.bay.org/publications.

The report was made possible by the support of the Dean Witter Foundation, the Keith Campbell Foundation for the Environment, the Resources Legacy Fund, the Richard and Rhoda Goldman Fund, and the Rose Foundation for Community and the Environment.

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First published March 2012

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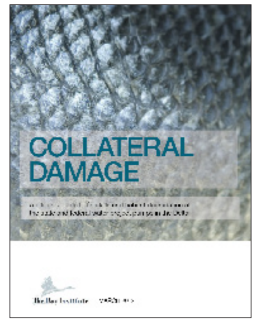


Large-scale fish kills and habitat destruction aren't an unusual occurrence at the giant federal and state pumps that export water from the Sacramento-San Joaquin Delta to agribusinesses and cities in the southern half of the state. These events are business as usual.

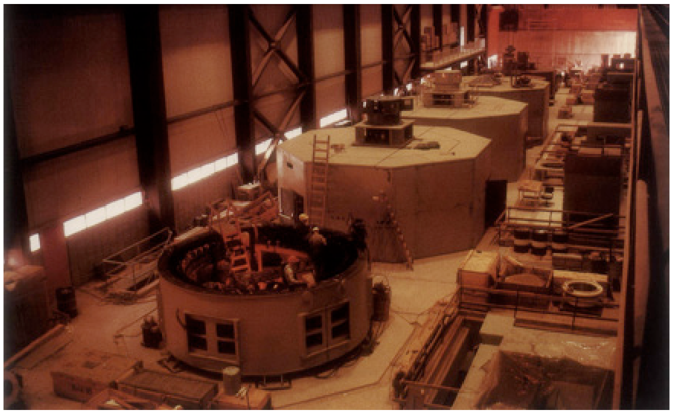
- Every day, between 870 and 61,000 fish – including from 200 to 42,000 native and endangered fishes – are "salvaged" at the pumps. Most die in the process.
- On average, over 9 million fish – representing the twenty fish species considered in this report – are "salvaged" each year at the pumps. As many as 15 million fish of all species encountered are "salvaged" each year.
- Up to 40% of the total population of the endangered delta smelt and 15% of the endangered winter-run population of Chinook salmon are killed at the pumps in some years. In the first half of 2011, over 8.6 million splittail were salvaged.
- Salvage estimates drastically underestimate the problem. The numbers do not factor in the results of "indirect" mortality, as high levels of export pumping disrupt fish migration, shrink the amount of non-lethal habitat available to fish species, and remove vast amounts of biomass, including fish eggs and larvae too small to be screened at the pumps.
- Export pumping causes the lower San Joaquin River to flow backwards most of the year and removes the equivalent of 170 railroad boxcars of water – and the accompanying fish, other organisms, and nutrients – from the Delta ecosystem every minute.
- Large numbers of fish being entrained is a problem even for species that are not currently listed as "endangered." Killing large numbers of fish year after year cuts off population growth in response to favorable conditions and can start the species on a downward path to extinction. As the species declines, the population impacts of entrainment become proportionately larger.
- Entrainment is a real problem. But the same interests in the Delta export community who claim that it isn't also back constructing expensive new conveyance facilities such as a peripheral canal or tunnel to solve the problem that they say doesn't exist.

The problem of “collateral damage” *can be solved using a combination of approaches:*

- **Reduce water exporter reliance on the Delta.** Current federal and state commitments to deliver water from the Delta are unrealistic and unsustainable. Fortunately, the potential for using existing water supplies more efficiently and developing alternative sources from recycling, reuse, groundwater storage, and land use changes is equal to about half the state’s total water demand today.
- **Require more fish-friendly pumping levels.** There is overwhelming scientific evidence that changing pumping regimes to provide more flow into, through, and out of the Delta during much of the year will help rebuild devastated fish populations and restore a functioning, healthy ecosystem.
- **Create alternative fish migration pathways** that permit migrating juvenile fish to avoid areas in the high-impact pumping zone and access to critically imporant rearing habitat using restored floodplains, flood bypasses and other corridors.
- **Improve the water conveyance system.** Proposed physical fixes to the system, such as pumping water from a new facility in the North Delta and conveying it around the Delta, could help reduce some of the worst impacts of the current export scheme and insulate the water supply system from catastrophic failure or sea level rise impacts. But none of these proposed fixes will solve the problem if the state and federal projects continue to withdraw unsustainable amounts of water from the Delta ecosystem.


Federal fish salvage facilities in the south Delta - and a “salvaged” fish. Photo: CA DWR and USBR

ENTRAINMENT:
Killing Machines in the Delta?



State Water Project pumps inside the Banks Pumping Plant. Each machine is capable of extracting nearly one thousand cubic feet of water from the Delta every second – that is nearly one-half million gallons per minute! (Photo: California Water Atlas).

"ENTRAINMENT" and "SALVAGE"

"Entrainment," in this publication, refers to the lethal entrapment of fish and other aquatic animals in the water being pulled towards the pumps, either through direct losses at the pumping facilities or through adverse modification of fish habitat in areas affected by pumping operations.

"Salvage" refers to the interception and capture of fish in the fish screens and facilities in front of the pumps. Not all entrained fish are intercepted, and thus the salvage numbers are always smaller (sometimes much much smaller) than the magnitude of entrainment. Even worse, only a few species survive the salvage process; to many other fish species the salvage itself is, unfortunately, often deadly.

Every so often, you may hear on the news that some endangered fish were sucked into or "salvaged" at the giant federal and state pumps that export water from the southern end of the Sacramento-San Joaquin Delta to the San Joaquin Valley and southern California, and that government officials, environmentalists and water users are battling over what to do about it.

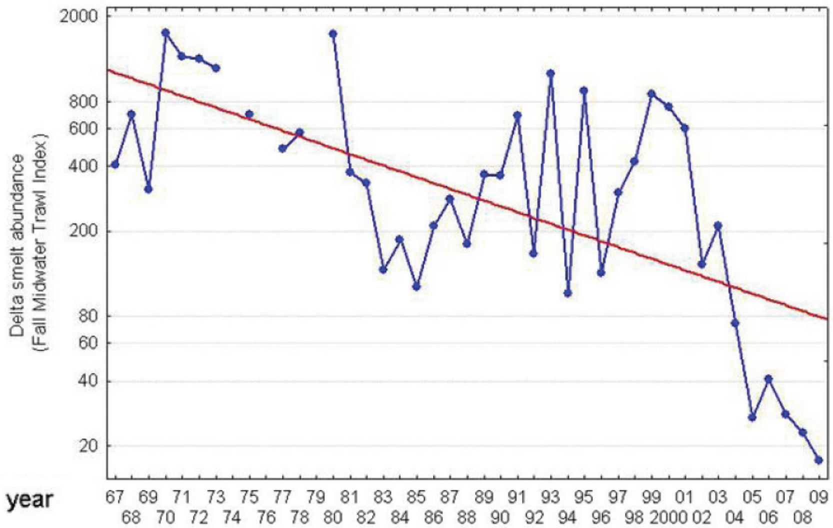
What's not often discussed is that this is business as usual at the pumps.

Of 20 fish species selected to encompass the wide range of species and life history types that are affected by the export pumps, between 870 and 61,000 fish, including between 200 and 42,000 native and endangered fishes, are intercepted every day just before entering the eleven pumps at the State Water Project's Banks facility and the six pumps at the federal Central Valley Project's Tracy plant in the southern Delta. Most of these intercepted fish die during the transport and release ("salvage") process; but countless others perish in the Delta on their way to the pumps as a result of altered water flows or slip though the antiquated fish screens and are killed in the pumps.

The exact number of fish that die before or after the salvage process or that are not counted in the salvage process at all remains unknown, and is not factored into the "salvage" count. The actual numbers of fish "entrained" (impacted by the water pumps) may be an order of magnitude greater than the losses that are counted in salvage.

Between January and July 2011, over 8.6 million Sacramento splittail (a fish found nowhere else in the world) and over 35 thousand Chinook salmon were "salvaged" at the pumps. In some years, up to

DECLINE OF THE DELTA SMELT (*HYPOMESUS TRANSPACIFICUS*) 1967 - 2009



Delta smelt, a native fish that was abundant in the Delta as recently as thirty years ago, has experienced a dramatic population decline - fewer than 10% of the population has survived in recent years. In some years, up to 40% of all smelt are killed at the pumps.

> "In some years, up to 40% of the entire population of the endangered delta smelt may be killed at the pumps."

40% of the entire population of the endangered delta smelt may be killed at the pumps.

And this is only a glimpse of the losses occurring daily at the Delta's lethal pumps.

- How many fish are actually lost or affected by the pumps in the South Delta?
- What's the impact to the sustainability of our commercial and sport fisheries and the survival of a number of endangered species?
- What can be done to stop massive fish kills? Will building a peripheral canal to carry water around or under the Delta solve the problem?

Collateral Damage tells the story of how massive water exports from the Delta kill tens of millions of native fish every year, drastically reduce the Delta's natural productivity, and are an important factor in the decline of endangered species. This guide also describes some potential solutions, both at the pumps and through changes in how we use water in California.

DELTA PUMPING IS NOT THE ONLY IMPORTANT PROBLEM*

Several other factors are also involved in the decline of fish populations in the Delta, including:

- Severely reduced inflows to the Delta from the Central Valley watershed
- Loss and modification of instream, channel, floodplain, and wetland habitats
- Invasive species and related changes to the food web
- Pollutants and toxic substances

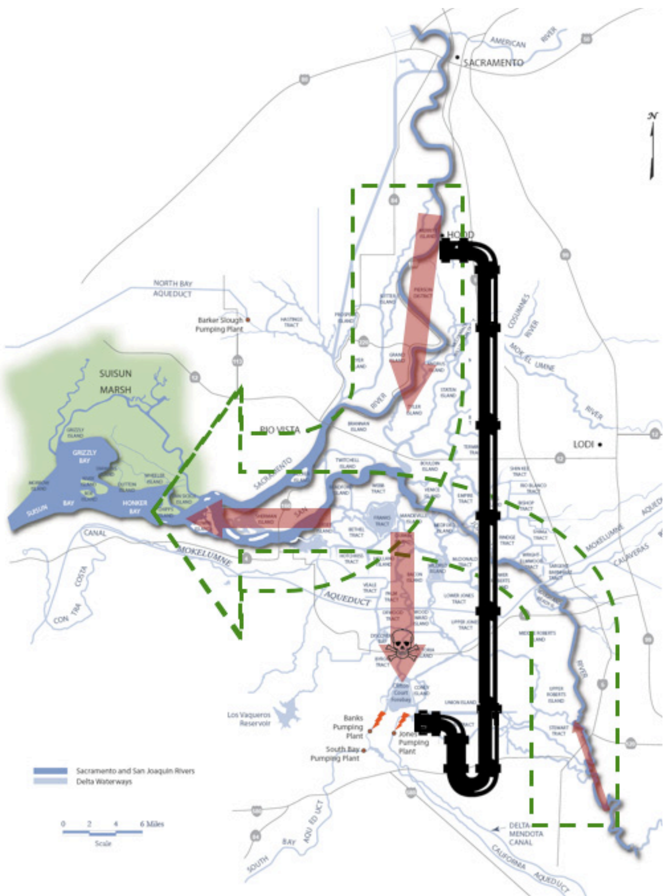
All these factors may play an important role in the decline of some fish species (although the evidence for some, like flow reductions or floodplain loss, is much better than for others). To recover fish populations, it will be necessary to substantively address all credible stressors. However, the lethal effects of high water exports so profoundly damage ecosystem health that addressing these other stressors without reducing or eliminating the large-scale collateral damage at the pumps will be unsuccessful in restoring the fish.

***(but it is one of the most serious)**

END OF THE LINE:

A Giant Sucking Sound

THE DELTA KILLING FIELDS



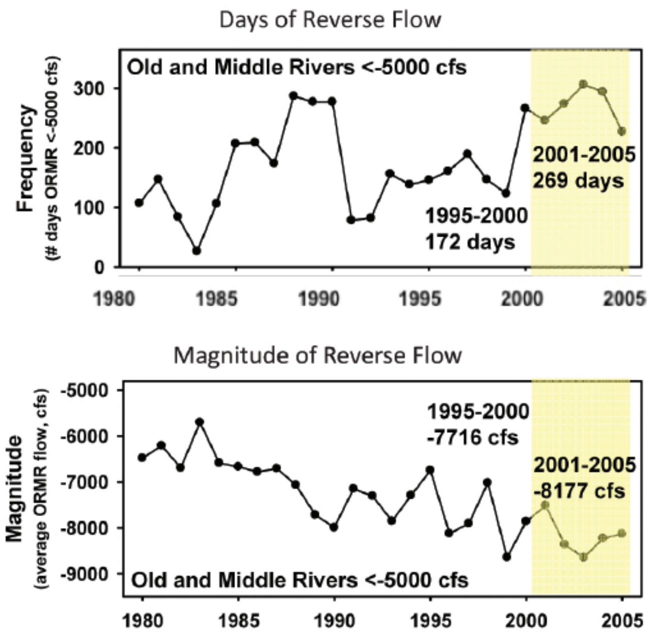
California Delta. Historical water flow is shown in dashed green outline; current water flow in red (schematic – arrows are not to scale). Lightning bolts mark the pumping facilities; crossbones indicate the "reverse flow" in Old and Middle rivers that bring the fish into the deadly vicinity of the pumps. The concept of a "peripheral canal" or "peripheral tunnel" is shown by the black pipes.

The Sacramento and San Joaquin Rivers and all of their tributaries drain water from the Central Valley – over a third of California's land area. These rivers pour into the Sacramento-San Joaquin Delta and, under natural conditions, out to San Francisco Bay and the Pacific Ocean. Dozens of native fish species (including steelhead, Chinook salmon, delta smelt, longfin, and two species of sturgeon) spawn, rear, or migrate through the Delta during their life-cycle. The Delta is, in many ways, the linchpin for much of California's aquatic biodiversity.

The Delta is also home to the largest water diversion facilities in California and some of the largest in the US. The enormous state-owned Harvey O. Banks pumping plant can remove 10,600 cubic feet of water from the Delta every second (cfs) and the federally-owned C.W. Jones pumping plant is able to divert an additional 4,500 cfs. Combined, these two export pumping plants can suck out of the Delta nearly 113 thousand gallons per second, or enough to fill over 170 railroad boxcars each minute! The federal project delivers water mostly to agricultural users in the San Joaquin Valley, while the state project delivers water to both agricultural and urban users in Central and Southern California, including the San Francisco Bay Area. These diversions often cause the water in the lower San Joaquin River to move towards the pumps instead of the ocean – the river actually runs backwards most of the year! The pumps also draw water from the Sacramento River in the north across the Delta to the south, rather than allow water to follow its natural course to the ocean.

As these pumps draw water across the Delta

RIVERS FLOWING BACKWARD



Between 2001 and 2005, high Delta export pumping rates by the State Water Project and federal Central Valley Project caused reverse flows in Delta and lower San Joaquin River channels averaging more than minus 8,000 cubic feet per second for about three-quarters of the year

A badly injured Sacramento splittail, captured at the Tracy Fish Facility. Note: these injuries were likely caused by predators attracted to the screens and water diversion structures, not by the pumps themselves (as this fish was intercepted before reaching the pumps). Photo: USBR

and out of the lower San Joaquin River, fish and other aquatic organisms (including shrimp, plankton, and other fish prey) are drawn towards the pumps as well – they are "entrained". In part, this is just simple physics – suck out the water and what's in the water comes along for the ride. But the continued, day-in/day-out pumping of water may also establish a chemical pathway towards the pumps that misinforms migrating fish about which way to swim. Thus, small migrating fish trying to find the ocean may simply be following the river "downstream" only to find that the ocean has been replaced by the sucking maw of the giant diversion machinery.

The pumping facilities are equipped with rudimentary fish screens that rely on fish swimming behavior to prevent entry into the pumps. This technology may work well at times for juveniles of some fish species (those that respond to the screens by swimming away towards a "salvage" facility); but it does not work for fish that are too small to swim away successfully, for fish eggs, or for most of the zooplankton on which fish feed. Furthermore, before the fish reach these screens, they must survive a journey through the canals that lead to the pumps and Clifton Court Forebay, an artificial lake that regulates water level at the state pumps.

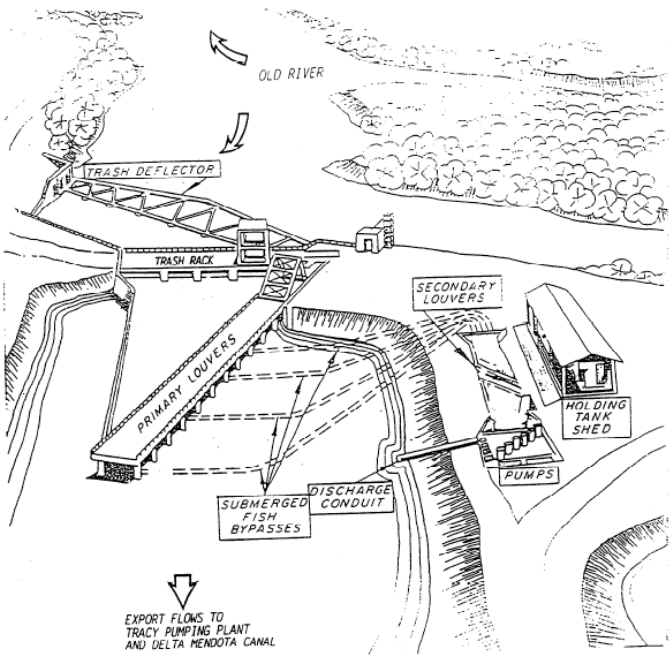
Both the canals and the Forebay are densely packed with predators. Studies indicate that less than one in four individuals of some fish species, to as few as one in one hundred individuals of other species survive the journey from the canals through the Forebay to the "salvage facility." Finally, fish that are successfully screened are processed and then shipped to release locations away from the pumps. Unfortunately, many fish species cannot tolerate such handling and die in the process. And the salvaged fish that do survive are released on a predictable schedule at only a few locations in the Delta. There, predators await a regular feeding of "salvaged" fish. In all, a tremendous screening, counting, and release effort produces little in the way of real protection for our fish. In the end, "salvage," although reassuring-sounding, is largely ineffective in actually saving fish.

> "...the water in the lower San Joaquin River [moves] towards the pumps instead of the ocean - the river actually runs backwards most of the year."

UNDERSTANDING THE PROBLEM PART 1:

Direct & Indirect Mortality

TRACY FACILITY SCHEMATIC



Tracy fish facility schematic. The export pumps (not shown) are located beyond the bottom of the picture. Note that the “primary louvers” are the critical part of the system, designed to “guide” the fish into the bypasses (from which they then reach the fish facility – secondary louvers, tanks, etc.). However, the “primary louvers” are wide enough for the fish to slip through: they rely solely on fish behavior to function effectively, rather than positively excluding the fish from the exported water. Modified from the USBR TFCF Reports, Volume 4.

> “...most organisms...pass right through the screens and are thus removed from the Delta’s food web.”

Understanding the scale of the entrainment problem is challenging. First, let’s distinguish between “direct” and “indirect” mortality.

Many fish die as a result of “direct” mortality at the pumps; that is, only a fraction of the fish drawn into the export facilities are screened out of the man-made river running uphill to export pumps and many of those that are “salvaged” die during the process or soon after they are released back into the Delta. Estimates indicate that up to 40% of the Delta smelt population and 15% of the winter run Chinook salmon may be killed at the export pumps in some years.

However these numbers do not factor in “indirect” mortality, the additional deaths of fish that are displaced from productive to lethal habitats by the altered water currents that result from export pumping. Indirect mortality takes many forms:

- Successful juvenile outmigration to the ocean is reduced, as young salmon, steelhead, sturgeon and other migratory fish are diverted from their natural migration pathway into less suitable habitats, delaying migration and exposing them to a host of new threats, including predators.
- Successful upstream migration of spawning-age adult fish also declines because the chemical signatures of their home streams are muddled when high levels of pumping change patterns of water circulation in the Delta.
- The amount of habitat available for spawning and rearing of Delta-dependent species shrinks as the area affected by export pumping loses its habitat value and becomes a death zone.

The relative importance of direct vs. indirect mortality is a subject of vigorous debate. But one thing is certain: continued loss, year-in and year-out, of millions of fish, eggs and larvae at and on the way to the south Delta pumps makes recovery of endangered species, conservation of other species, and maintenance of a viable food chain much less likely.

SALVAGE TABLE

STATUS KEY:

Endangered - Federal

Endangered - California

Threatened - Federal

Threatened - California

LEGEND:

Native to CA

Recent decline

Important Fishery

Commercial/Sport Fisheries Destroyed

Protection Removed (for political reasons; species has not recovered)

[1] Fish were selected to encompass the wide range of species and life history types that are affected by water pumps.

[2] "Average annual salvage" is mean yearly salvage from 1/1993 through 12/2011; "Maximum salvage" is the value for the calendar year with the highest salvage numbers (years differ among species).

These numbers underestimate the actual fish kills by not counting the fish that slipped through the bypass system and were killed by the pumps, and by not including indirect mortality. "Yearly Total" refers only to the 20 species listed.

Selected Fish Species	1993-2011 Annual Salvage		Status
	Average	Maximum	
American shad	1,022,700	2,510,184	Important Fishery; Recent decline
Bluegill	127,133	394,952	
Channel catfish	45,799	131,484	
Chinook salmon (winter run)	51,955	183,890	Endangered - Federal; Endangered - California; Native to CA; Commercial/Sport Fisheries Destroyed; Recent decline
Chinook salmon (spring run)			Threatened - Federal; Threatened - California; Native to CA; Commercial/Sport Fisheries Destroyed; Recent decline
Chinook salmon (fall run)			Native to CA; Important Fishery; Recent decline
Chinook salmon (late-fall run)			Native to CA; Important Fishery; Recent decline
Delta smelt	29,918	154,820	Threatened - Federal; Endangered - California; Native to CA; Recent decline
Green sturgeon	58	363	Threatened - Federal; Native to CA; Recent decline
Inland silverside	62,838	142,652	
Largemouth bass	54,180	234,198	Important Fishery
Longfin	6,228	97,686	Threatened - California; Native to CA; Recent decline
Prickly sculpin	76,403	274,691	Native to CA
Steelhead (Rainbow trout)	5,278	18,580	Threatened - Federal; Native to CA; Commercial/Sport Fisheries Destroyed; Recent decline
Redear sunfish	1,609	5,611	
Riffle sculpin	155	798	Native to CA
Sacramento sucker	3,443	27,362	Native to CA
Sacramento splittail	1,201,585	8,989,639	Protection Removed; Native to CA; Important Fishery; Recent decline
Striped bass	1,773,079	13,451,203	Important Fishery; Recent decline
Threadfin shad	3,823,099	9,046,050	Recent decline
White catfish	296,543	941,972	
White sturgeon	151	873	Native to CA; Important Fishery; Recent decline
Yellowfin goby	193,399	1,189,962	

Average yearly salvage total: 9,237,444

SPECIES OF FISH COMMONLY COLLECTED AT THE STATE FISH SALVAGE FACILITY

Photo: CA DWR

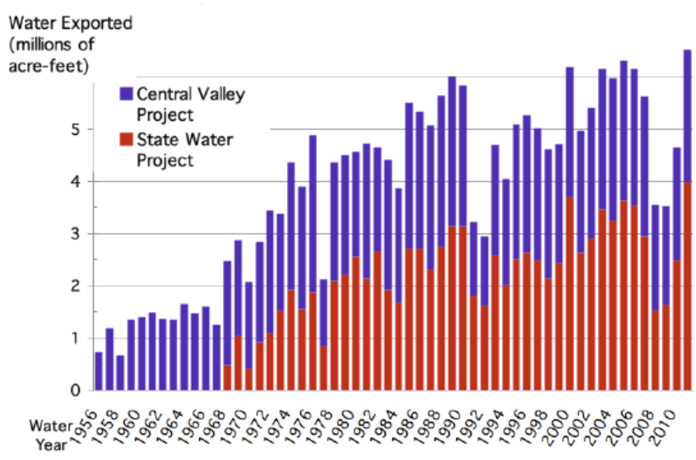
UNDERSTANDING THE PROBLEM PART 2:

The Other Victims

The impact of increasing water withdrawals from the south Delta extends beyond the vast numbers of fish killed directly at the pumps. Massive water exports remove much of the food upon which all species – endangered and non-endangered alike – depend. The millions of fish that are "salvaged" at the pumps represent a loss of potential food for other fish, bird, and mammal species, not to mention the loss of fishing opportunities for anglers and commercial fishermen.

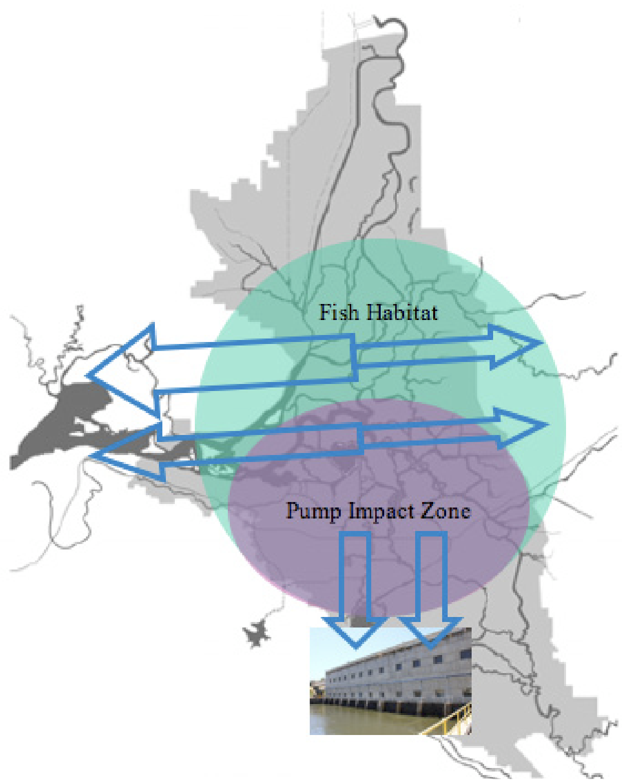
The fact is that most organisms are not screened at all: fish eggs and larvae, as well as zooplankton and algae, pass right through the screens and are thus removed from the Delta's food web. The pumping plants remove billions of gallons of water from the ecosystem every day between January and June (usually a bit less during the summer and fall), and with the water go the tons of fish food, nutrients, and sediments that once made this among the most productive coastal ecosystems in America. The location of the pumps in the once-productive south Delta means that spawning and migratory corridors are lost or blocked. For example, use of the San Joaquin River as spawning habitat by longfin has declined, likely because fish that attempt to spawn in the vicinity of the pumps (and their offspring) are entrained and die. Water exports not only entrain the many unlucky fish, they make it difficult for survivors to migrate towards the habitats that lie beyond the pumps.

WATER EXPORTS FROM THE DELTA HAVE INCREASED



Increasing water withdrawals from the Delta and its watershed have cut outflow in half. The exports from the south Delta pumps, shown here, are especially problematic because they kill large numbers of fish directly, remove vast amounts of biomass from the aquatic ecosystem, and disrupt natural flow patterns in the Delta and downstream habitats.

IMPACTS TO FISH HABITAT



A generalized representation of the interaction of fish habitat (which includes flow) with the water export pumps in the south Delta. The double-headed arrows symbolize natural flows in the Delta, a combination of tidal and river flows; this natural flow pattern is increasingly disrupted in the vicinity of the pumps (the "impact zone"), resulting in both direct mortality and in the degradation of fish habitat.

Photo: Professor P. Moyle, UC Davis

AN IMPERILED NATIVE: SACRAMENTO SPLITTAIL

Sacramento splittail (*Pogonichthys macrolepidotus*) is a fish in the minnow family that is endemic to California (found nowhere else in the world). Once numerous throughout the watersheds of central California, these long-lived (5-7 years), low-oxygen-tolerant, and fertile fish (> 100,000 eggs/female) have been confined to the Delta as a result of habitat alteration and dams. Incredibly, in the first nine months of 2011, nearly nine million splittail were "salvaged" at the pumps. This level of loss is devastating in multiple ways:

- The direct impact on the splittail population
- The removal of a large amount of biomass–food for other fish and birds–from the estuary's food web; and
- Loss of the opportunity to recover the population – while the splittail populations are naturally depressed in low-flow years, during years with better flow conditions (like 2011) the Sacramento splittail population is nevertheless not given a chance to recover (because of the immense mortality at the pumps).

Chinook salmon once represented a major commercial resource for Californians. A number of factors - including the impact of the Delta pumps - have devastated the fishing industry, putting many fishermen out of work. Photo: Barbara Emley, courtesy of Barbara Stickel

A TIME FOR ACTION

The loss of millions of fish, removal of nutrients from the ecosystem, and the degradation of habitats represent huge impacts to the Delta and its public trust resources (i.e., the fish and wildlife resources and habitat values of navigable waterways that the public has a vested right in protecting). At worst, these losses may drive our native species to extinction; at "best," this daily destruction prevents the ecosystem from recovering when conditions improve and denies us all access to our valuable natural resources. Reeling from one crisis to another is neither a responsible nor an effective way to manage natural resources. Our society has greater expectations for managing the Delta ecosystem than this, as expressed in a variety of ways:

- California's Constitution prohibits wasteful and unreasonable use of water, and California case law mandates the protection of public trust resources.
- The state and federal Clean Water Acts require actions to protect the biological, chemical and physical integrity of fishable waters.
- California's taxpayers have spent hundreds of millions of dollars to try to restore the habitats and fish populations that we all value.
- The state and federal Endangered Species Acts promote the recovery of species and ecosystems, not simply actions to avoid extinction.
- State and federal laws mandate doubling of migratory fish populations from late-20th century levels (which were still better than some of today's catastrophic numbers).

None of these mandates can be satisfied – and our investment in recovering natural resources is being wasted – as long as fish continue to die in large numbers at the pumps.

CLAIM #1

"The salvage numbers aren't as bad as they look." **Water users who receive water exported from the pumps claim that entrainment-related mortality is not as big a problem as the vast numbers of salvaged fish would suggest. After all, they claim, the salvaged fish are only a small portion of the total population.**

FACT

Salvage numbers drastically underestimate the actual impact. Although the exact numbers are uncertain, it is clear that tens of millions of fish are killed each year, and only a small fraction of this is reflected in the salvage numbers that are reported.

A conservative estimate (Kimmerer, 2008) is that, for juvenile salmon that have been pulled towards the pumps, only 1 in 5 will survive long enough to be counted in salvage (the rest are lost to predators or other factors). For Delta smelt, which used to live close to the pumps, the impacts are even worse. An experimental study of "pre-screen loss and fish facility efficiency at the State Water Project" found that that for every adult delta smelt counted in salvage at least 37 individuals perished before reaching the fish salvage facility; for delta smelt juveniles the ratio of salvage to "pre-screen loss" was even higher than that found for adults (Castillo, 2010). Overall (Kimmerer, 2008), 15% of adult smelt population is estimated to be killed near the pumps (salvaged or eaten on the way to fish screens) while losses of larval smelt are unknown (because they are too small to be screened and counted). In some years, as much as half the Delta smelt population may be killed at the pumps! The fact is, the salvage numbers look really bad but the real impact of export-related mortality is probably far worse."

Photo: Michael Macor / The Chronicle

Fish intercepted at the pumps being transported to the release point in the lower Delta, often only to be eaten by predators that have learned to expect a "delivery" of dazed and stressed fish. This is the last stage of the salvage process, often referred to as "cheater" (from CHTR - collection, handling, trucking, release), a fitting reference, as, despite all the efforts and expense, this process results in death of many "salvaged" fish.

CLAIMS V

CLAIM #1.5

"Entrainment is not a problem... But a new peripheral canal should be built because it will reduce entrainment..."

FACT

Water exporters also claim that a new diversion facility is necessary because it will reduce harm to endangered species. But if entrainment is "not a big problem," how can reducing entrainment be used to justify a multi-billion dollar new diversion and canal (or tunnel)? Either entrainment-related fish mortality is a big problem, meriting major changes in how we move water through the Delta (as well as major changes in where water exporters get their water and how much water is needed for the Delta ecosystem), or it is not a big problem, and changing the Delta pumping infrastructure will not solve anything. In reality, of course, mortality is a big problem, and improving or changing the Delta pumping infrastructure could be part of a solution (along with other elements discussed below). But it is dishonest to argue in one context (proposed controls on export pumping) that entrainment mortality is not a significant issue and to argue in another context (proposed permitting of a new diversion facility) that moving the pumps is necessary to solve the entrainment mortality problem.

> "...if entrainment is "not a big problem," how can reducing entrainment be used to justify a multi-billion dollar new... canal?"

S.FACTS

CLAIM #2

***"Large salvage numbers mean that the fish populations are doing well"* (and - you guessed it - low salvage numbers mean that "entrainment is not a big problem"). When millions of fish are caught at the pumps in a single week, some people say this indicates that populations are doing well – more fish means more entrainment of fish. Yet, when entrainment and salvage at the pumps is low, these same people say that entrainment is not a problem.**

FACT

Large-scale entrainment-related mortality means, at best that population growth is being negated, and at worst that a large part of the population is being eliminated. The fish species of the Bay-Delta evolved in the highly variable environment characteristic of estuaries in general and California in particular. This means that these fish are adapted to take advantage of those years with favorable conditions, during which they experience high population growth. But the pumps act as a large-scale stressor in good years and bad, driving populations down when conditions are moderate or poor, and preventing population recovery when good conditions return. For instance, Sacramento splittail are entrained in the largest numbers following wetter years when the floodplains where they spawn are inundated for a longer time; the entrainment losses in effect offset the positive gains from wet year conditions. A population can begin to decline if a large part of its growth potential is consistently eliminated in this way in good years.

In contrast, Delta smelt and longfin are entrained in the largest numbers in drier years when Delta outflows are low because they spawn and rear closer to the pumps. Unfortunately, the dry conditions that produce higher entrainment among these species also mean poorer survival and growth of juvenile fish. Thus entrainment often increases just when the natural conditions result in a population decline – a double-whammy! For these reasons, even a few dry years in a row can produce extreme declines in certain sensitive species; entrainment makes a bad situation much worse.

CLAIM #3

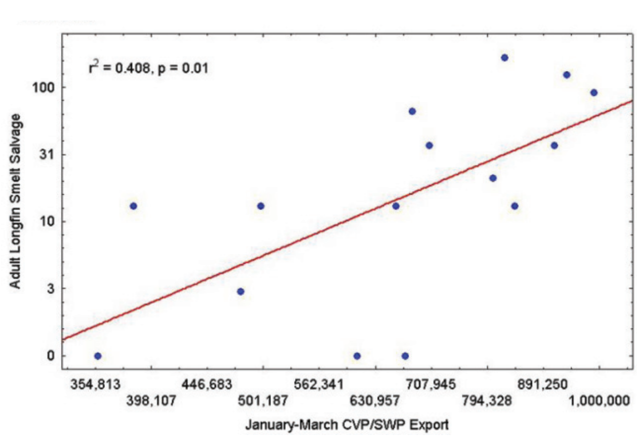
"Pumping rates are not related to entrainment."

FACT

Hmm…we don't know of any cases where entrainment of fish has occurred in the absence of pumping. But some claim that there is no correlation between the level of pumping and the number of fish salvaged. Of course, the logical outcome of this argument is that there is no safe level of export pumping (since all levels are claimed to produce the same impact).

Several interacting factors affect entrainment, complicating a simplistic cause-effect analysis of the relationship between export pumping and entrainment-related mortality at the export pumps. A significant relationship between export rates and entrainment rates exists for some species, such as longfin. The relationship is not a simple correlation (a straight line) between exports and entrainment for all species, however. One important reason is that entrainment rates are related to where the fish are distributed – the closer they are to the pumps, the more likely they are to be entrained (see above). Another important reason is that export rates must be considered in relation to overall flow conditions. Pumping rates in drier years may be lower in absolute terms than in wetter years, but the relative entrainment effects may be equal or greater. When spring flow conditions are poor, even relatively modest increases in pumping can entrain significant numbers of pelagic species like Delta smelt and longfin that spawn closer to the south Delta pumps in drier years. Pumping rates matter – how much they matter depends on how the fish are responding to that particular year's conditions.

SALVAGE OF SPAWNING-AGE LONGFIN SMELT VS. CVP/SWP COMBINED EXPORT RATES, 1993-2007



A clear pumping-entrainment relationship. As the water export rates increase (from left to right), so does the number of longfin intercepted at the pumps (moving up on the vertical axis).

SOLVING THE PROBLEM

At least four major approaches have been identified as ways to end the massive collateral damage at the pumps:

MOVE THE PUMPS

The current system, designed to move water from the Sacramento River across the Delta and up San Joaquin River channels to the pumps, maximizes the negative ecosystem impacts of water export and creates the risk that our water supply will be interrupted in the future. The south Delta export pumps operate in close proximity to important spawning and migration habitats and they are highly vulnerable to salt water intrusion into the Delta; the risk of saltwater reaching the pumps in the future is high because of projected sea level rise and in the event of catastrophic levee failures following an earthquake.

The current design also lacks effective fish screens. Many scientists believe that constructing a new diversion facility directly on the Sacramento River in the north Delta – the latest version of the famous 'Peripheral Canal' – to move water around the Delta instead of through it, and equipped with "positive screens" that reliably exclude fish, could avoid some of the worst impacts of water exports. Others advocate for different physical fixes, such as upgrading the existing screens at the south Delta pumps or relying more on expanded south of Delta storage. But none of these fixes are silver bullets: new pumping and conveyance facilities or improved screening could make a difference, but other factors are even more important than how water is pumped and conveyed from the Delta.

PROVIDE MORE FRESHWATER FLOW FOR FISH

Even more critical than the location of the pumps is how much water is exported and when. The scientific evidence for the primary importance of more natural flow conditions for the health of aquatic species and habitats is overwhelming. An export schedule that more closely resembles natural amounts and patterns of runoff (i.e., provides for increased flows into, through, and out of the Delta during the seasons when freshwater flows would increase under more natural conditions) will benefit imperiled fish and support natural ecosystem functions. Implementing more environmentally friendly pumping regimes is a necessary step in order to comply with laws mandating protection of the Delta ecosystem, its species, and water quality. Doing so becomes easier if at the same time water exporters start shifting to alternative sources of supply (see below).

CREATE NEW FISH MIGRATION PATHWAYS

When water floods the Yolo Bypass (south and west of Sacramento), a portion of the migrating juvenile fish are carried onto the floodplain and move through the western Delta to the ocean. As a result, they avoid much of the area where currents are impacted by pumping in the south Delta. Of course, this only benefits migratory species such as salmon and sturgeon and only in years when the Yolo Bypass floods. There are opportunities to modify the Yolo bypass (and enhance other floodways) in order to maximize the number of years when access to these areas benefits the fish.

FIND WATER SUPPLY ALTERNATIVES TO DELTA EXPORT

Current state and federal commitments to deliver water from the Delta are unrealistic and unsustainable. In most years, limited precipitation prevents delivery of anything near the full amounts of

A floodplain in the Delta. Photo: CA DWR water in the federal and state water project contracts. Less often, and to a much lesser extent, legal, operational, and physical constraints on managing the Central Valley water supply system (e.g. to protect drinking water quality, avoid flood damage) affect availability of supply.

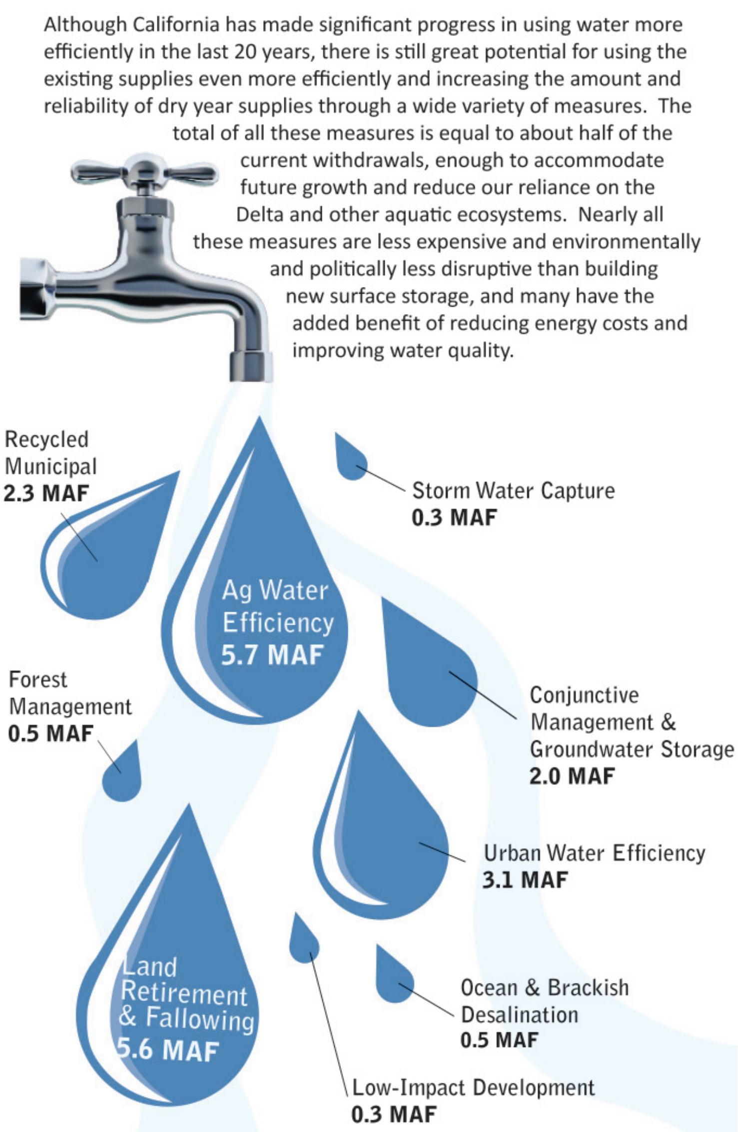
Until these unrealistic water export contracts are changed to match the amount of water that nature actually provides—and are also adjusted to ensure society's minimum requirements for protecting water quality and the environment are met—a completely unnecessary conflict will be perpetuated.

Fortunately, the State has recognized this problem with its policy (adopted in 2009) of reducing human reliance on the Delta's water supplies. There are two main ways to achieve this state policy. First, areas that currently import water from the Delta must become more self-reliant through water conservation, water recycling, groundwater banking, water transfers, and other proven mechanisms. Second, federal and state contracts should be amended to reflect the amount of water that can be sustainably delivered from the Delta without destroying our fisheries and ecosystems, forcing those who use exported water to adopt more sustainable approaches to planning for future water supplies. Making these changes means that any new canal or tunnel can be sized at a capacity and cost that reflect the real export supply needs of water-importing areas and the real flow needs of the Delta ecosystem.

A long-term, durable solution to the problem of collateral damage at the pumps will probably require some mixture of all four of these approaches. Building a peripheral canal (or tunnel) that maintains or even increases export pumping will continue to degrade habitat conditions and drive species declines – just in a different way from the current system. But as long as a significant amount of water continues to be exported from Northern California to other parts of the state, there will continue to be a need to improve the physical infrastructure for doing so in order to minimize its impacts. Together, moving the pumps (and appropriately sizing the new canal or tunnel that moves the water from these pumps), restoring more natural timing and volumes of freshwater flows, requiring more freshwater at the appropriate time for the ecosystem, providing alternative pathways for fish migration, and developing alternative water supply sources, could result in a water transfer system in the Delta that supports a healthier ecosystem and provides more reliable water supplies for all Californians.

IMPORTANCE OF EFFICIENT WATER USE

Making each drop of water do more means a healthy Delta and a healthy economy can coexist



Getting the most out of each drop of water: additional water (in million acre-feet, MAF) that could be made available every year. A suite of water conservation and use-efficiency measures, together with some innovative new supplies, holds great potential to increase reliability of California's water supply while decreasing the reliance on the Delta water exports. The sum of these water efficiency measures is equal to about half of the total water demand in the State today.

TO LEARN MORE:

FRESHWATER FLOWS:

For an introduction to the importance of freshwater flows for fish and aquatic ecosystems in the San Francisco Bay-Delta estuary and its watershed, see The Bay Institute's 2010 report "Gone With The Flow: How the alteration of freshwater flows is killing the Bay-Delta ecosystem" (www.bay.org/publications/gone-with-the-flow).

More detailed technical discussions of the Delta's freshwater flow requirements in the Delta are available in a series of expert reports written by The Bay Institute for the 2010 proceedings by the State Water Resources Control Board to develop public trust flow criteria for the Delta (www.bay.org/publications/flow-criteria-for-the-delta-ecosystem); another critical document is the State Water Board's "Final Report" on flow criteria from those proceedings (www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/index.shtml).

ALTERED FLOWS AND THEIR IMPORTANCE TO FISH ENTRAINMENT:

For a detailed modeling account of what happens to small particles (e.g., plankton or even some larval fish) as they pass through the Delta, see Kimmerer, W.J., and Nobriga, M.L. (2008). Investigating Particle Transport and Fate in the Sacramento-San Joaquin Delta Using a Particle Tracking Model. San Francisco Estuary and Watershed Science, 6(1). Available at http://escholarship.org/uc/item/547917gn.

FISH "SALVAGE":

User-friendly salvage information can be found at Department of Fish and Game's Delta Office website www.dfg.ca.gov/delta/apps/salvage Choose "Salvage/Export Data", and then select a calendar date (prior to the current date) to see a count of "salvaged" fish and export flow information (for SWP, CVP); a longer date range can be set as well, and data can be exported.

FISH MORTALITY:

For a discussion of the levels of mortality at the pumps as a proportion of fish populations, see Kimmerer, W.J. (2008). Losses of Sacramento River Chinook Salmon and Delta Smelt to Entrainment in Water Diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science, 6(2). Available at http://escholarship.org/uc/item/7v92h6fs

PRE-SCREEN MORTALITY:

For another estimate for mortality caused by the altered flow patterns, see Castillo, G. (2010) Initial Evaluation of Entrainment Losses for Delta Smelt in the State Water Project. Available at www.fws.gov/stockton/jfmp/docs/Castillo_2010%20IEP_WORKSHOP%20Initial%20Evaluation%20of%20Entrainment.pdf

HABITAT:

For a discussion of the components of "habitat" in estuaries, see Peterson, M. S. (2003). A Conceptual View of Environment-Habitat-Production Linkages in Tidal River Estuaries. Reviews in Fisheries Science, 11(4). www.usm.edu/gcrl/cv/peterson.mark/docs/Peterson%202003%20Review.pdf

FISH SPECIES:

For a brief, clear overview of California fish, including descriptions and habitat requirements of each species, see the California Fish Website at UC Davis: http://calfish.ucdavis.edu

DELTA BACKGROUND:

For a comprehensive discussion of key Sacramento-San Joaquin Delta issues, with an emphasis on water, see the Delta Vision documents http://deltavision.ca.gov/index.shtml), especially the Final Report: http://deltavision.ca.gov/BlueRibbonTaskForce/FinalVision/Delta_Vision_Final.pdf.
A series of more recent white papers (http://deltacouncil.ca.gov/white-papers) prepared for the Delta Stewardship Council are also informative.

Graph showing the decline of Delta smelt: Figure 1 from The Bay Institute's Exhibit 1 to the SWRCB Flow Criteria Proceedings. Available at: www.bay.org/assets/Bay-Delta%20Flow%20Criteria%20Exhibit%201.pdf

SPECIES OF FISH COMMONLY COLLECTED AT THE SALVAGE FACILITIES

From the California Department of Water Resources brochure "John E. Skinner Delta Fish Protective Facility" decribing the operation of the State fish screens. Available at: www.water.ca.gov/recreation/brochures/pdf/SkinnerFishFacility.pdf

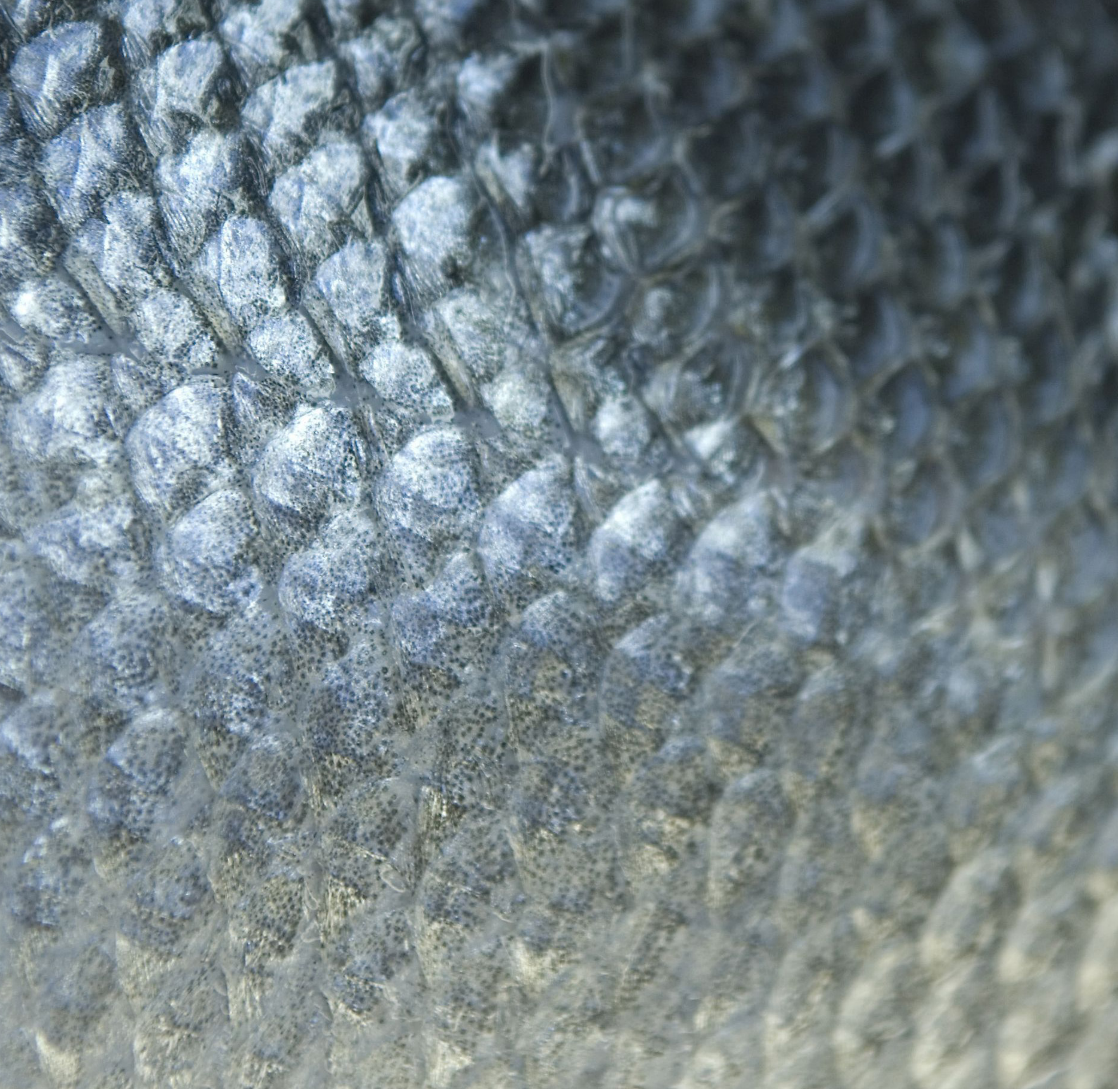
Injured fish: Figure 12, from C. Karp, and J. Lyons. 2008, "Evaluation of Fish Holding at the Tracy Fish Collection Facility, Tracy, California." (TFCF Studies. Volume 39). U.S. Bureau of Reclamation, Mid-Pacific Region and Denver Technical Service Center. 26 pp. Available at www.usbr.gov/pmts/tech_services/tracy_research/tracyreports/TracyReportsVolume39.pdf

SOLVING THE PROBLEM

The Bay Institute uses its scientific and policy expertise to solve the problem of massive fish kills at the pumps by advocating for more stringent regulatory controls on Delta export pumping; more protective flow requirements and more ambitious habitat restoration programs to recover Delta species and habitats; and more aggressive actions to shift Delta exporters to alternative water supply sources. You can help us solve the problem by going to www.bay.org and making a donation to support our work.

California's fish – like this Chinook salmon – were once a great commercial, recreational, and natural resource. With careful water management, including a reduction in collateral damage, they can once again thrive, to the delight of the present and future generations of Californians. Photo: Courtesy of F. Gonzalez

The Bay Institute



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