Striped Bass

Striped bass are one of the most popular gamefish in California because of their large size, abundance, eating quality, wariness, fighting ability and voracity in taking lures and bait. Like the salmon and steelhead, striped bass numbers in California have declined sharply over the past 50 years. Despite these parallel declines, the striped bass have become the red herring of California's water wars.

The decline of striped bass is generally associated with the startup of the State Water Project in the mid-1970s in concert with the 1976-77 drought and a subsequent general acceleration of drought frequency. Adult striped bass population numbers fell from several million in the 1960s and 1970s to several hundred thousand in the 1980s; they eventually received protection and enhancement under the Central Valley Project Improvement Act (CVPIA) in 1992 and State Water Board water quality standards issued in 1978 (D-1485) and 1999 (D-1641).

> ***D-1641****, which was adopted by the SWRCB December 29, 1999 and revised on March 15, 2000, is the implementation plan for the 1995 Bay-Delta Plan, with respect to the operation of water projects within the Delta watershed. D-1641 includes water right permit terms and conditions to implement water quality objectives to protect Municipal and Industrial (M&I) beneficial uses in the Delta, as well as water quality objectives to protect Fish and Wildlife beneficial uses. D-1641 contains flow and water quality objectives that must be measured at various compliance monitoring stations throughout the Delta.* (Mavens Notebook)

Striped bass became the "canary in the coal mine" for the Bay-Delta ecosystem, a harbinger of general decline driven by the exploitation of Bay-Delta water resources over the course of 70 years. The real problems started when the Central Valley Project's Tracy Pumping Plant (TPP) began operating in the South Delta. South Delta exports were expanded (tripled from the 4,000 cfs transported by the TPP) in the 1970s when the State Water Project's Byron Pumping Plant came online. Millions of juvenile striped bass were salvaged at the pumping plants each year through the mid-1970s; that continued until the State Water Board's restrictions on exports began in 1978. The U.S. Army Corps of Engineer's restrictions to minimize the pumping effect on Delta levees also helped to limit the SWP pumping capacity from 12,000 cfs to 8,000 cfs. Due to these restrictions, summer-fall exports were generally limited to 11,400 cfs from a capacity of almost 15,000 cfs. Winter-spring exports were increasingly restricted to protect listed salmon and steelhead, developments that also benefitted striped bass. Restrictions on exports and releases of millions of hatchery-raised striped bass helped to restore the striped bass population to approximately one million adults around the turn of the century. However, over the past two decades the population has again declined (additional details follow in this chapter).

Striped bass have also been blamed for the declines in salmon and steelhead populations[1]. Because of their popularity – and reputation for voracity – striped bass remain a key factor in Central Valley water politics.

[1] https://www.c-win.org/cwin-water-blog/2022/1/26/striped-bass-the-red-herring-in-californias-water-wars, https://californiawaterblog.com/2011/01/31/striped-bass-control-the-cure-worse-than-the-disease/

"The California Department of Fish and Wildlife is working to monitor and manage the striped bass fishery for vitality, consistent with The California Fish and Game Commission policy that the Department emphasize programs that ensure, enhance, and prevent loss of sport fishing opportunities."[2]

Early History in San Francisco Bay

"There were originally no striped bass in California. They were introduced from the East Coast, where they are found from the Gulf of St. Lawrence to Alabama. The initial introduction took place in 1879, when 132 small bass were brought successfully to California by rail from the Navesink River in New Jersey and released near Martinez. Fish from this lot were caught within a year near Sausalito, Alameda, and Monterey, and others were caught occasionally at scattered places for several years afterwards. There was much concern by the Fish and Game Commission that such a small number of bass might fail to establish the species, so a second introduction of about 300 stripers was made in lower Suisun Bay in 1882.

In a few years, striped bass were being caught in California in large numbers. By 1889, a decade after the first lot of eastern fish had been released, bass were being sold in San Francisco markets. In another 10 years, the commercial net catch alone was averaging well over a million pounds a year. In 1935, however, all commercial fishing for striped bass was stopped in the belief that this would enhance the sport fishery." (CDFW)

Modern History

The modern history of striped bass began in the 1960s and 1970s with the onset of Delta water exports and the beginning of intensive State and federal monitoring of the species and its Bay-Delta Estuary habitat. Indices of age-0 (young - under one year of age) striped bass abundance were first obtained in 1959 (Figure 1). Drought periods (1976-1977, 1987-1992, 2007-2009, 2013-2015, 2021-2022) are key features of the modern period and have caused major striped bass declines, while post-drought recoveries have gradually weakened. In response, the state began releasing hatchery-bred young stripers in the early 1990s, which helped increase the population (see Appendix I). Stocking of pen-reared salvaged age-0 striped bass occurred near the end of the century, again providing some population increase. After 2001 the population generally declined although there were small increases in the trawl index in wet years (2006, 2011, 2017, and 2019). The record low trawl index occurred in 2018.

During the recent drought years, 2021 and 2022, the index again fell to near record lows. With a very wet 2023, nominally reasonable indices in the wet years 2017 and 2019 that provided some adult recruits, and the fact that stripers s typically reach maturity between four to six years of age, we can expect a small level of recovery in the fall trawl 2023 index.

South Delta export salvage of age-0 striped bass was very low in the summers of the drought years 2021 and 2022 (Figure 2). This is a continuing trend (Figure 3). But it is a trend that reversed dramatically when the CVP pumps were activated in late June of 2023 (Figure 4), even when compared to 2017 (Figure 5). With the state pumps beginning operation in early July and exports increasing to a maximum 10,000+ cfs (20,000 AF/day), relatively high striped bass age-0 salvage numbers continued in summer

[2] https://marinespecies.wildlife.ca.gov/striped-bass/false/#:~:text=According%20to%20California%20Department%20of,about%201.3%20million%20in%201998

2023. The fall striped bass trawl index should indicate at least a modest recovery, although maybe not to 2017 and 2019 levels. After the 2017 and 2019 brood years work through the system, we can again expect a downturn in striped bass until the 2023 brood year reaches maturity. The proposed slot limit restrictions on harvest may increase the adult abundance, especially if the rules minimize the harvest on the 2017 and 2019 brood years over the next few years. Regardless, brood years 2020-2022 will provide minimal adult recruitment. More information on the slot limit and its potential effects will follow in this chapter.

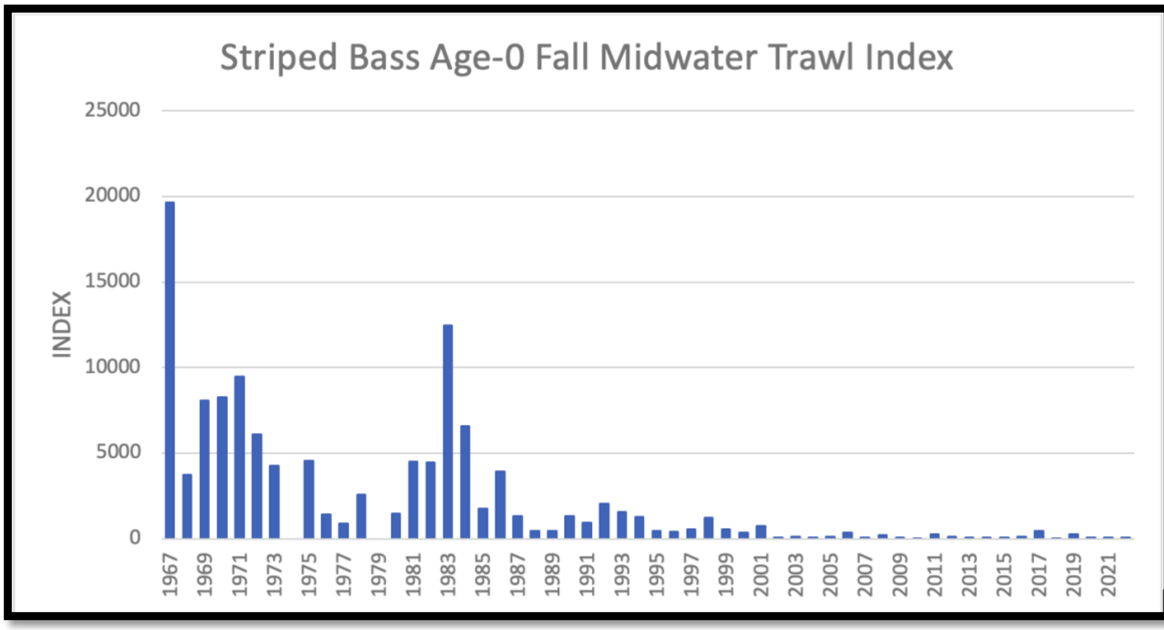

Figure 1. Striped bass age-0 annual abundance indices from [the Bay-Delta Fall-Midwater Trawl Survey](#).

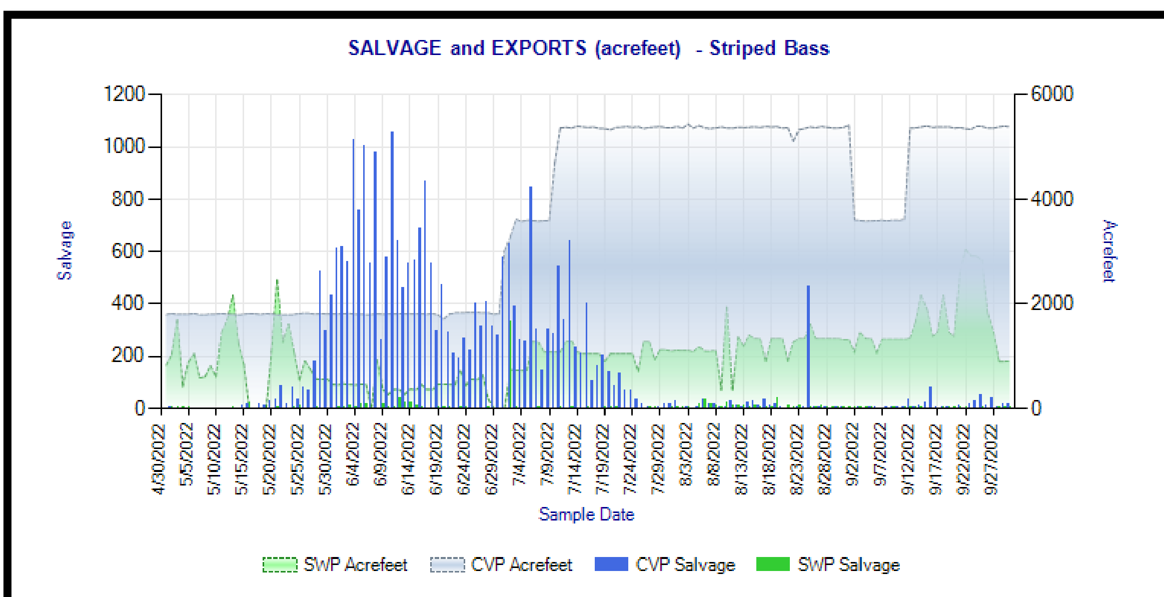

Figure 2. Striped bass salvage and export rates at SWP and CVP in spring-summer 2022.

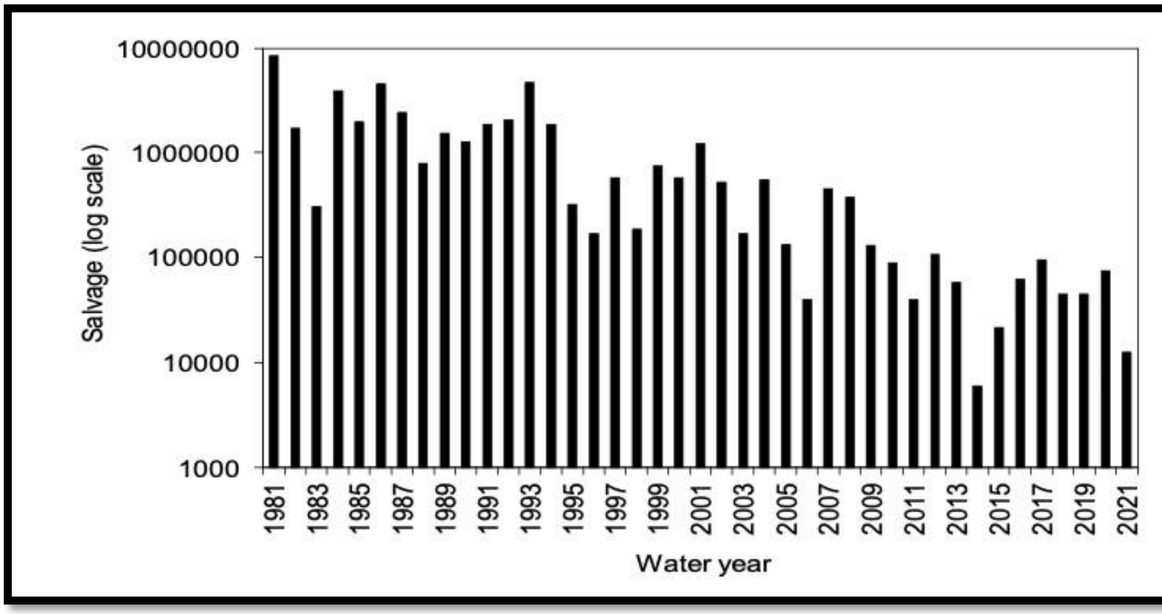

Figure 3. Annual striped bass salvage at the CVP Tracy Fish Collection Facility (TFCF,) water years 1981-2021. Source: CDFW.

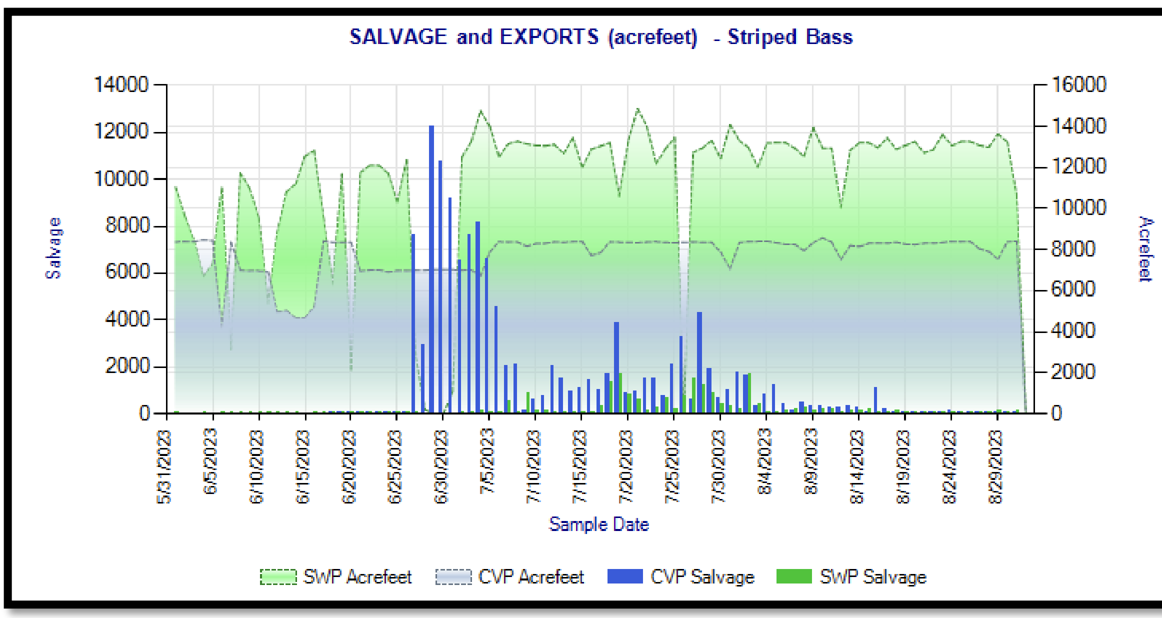

Figure 4. Striped bass salvage and export rates at the SWP and CVP in spring-summer 2023.

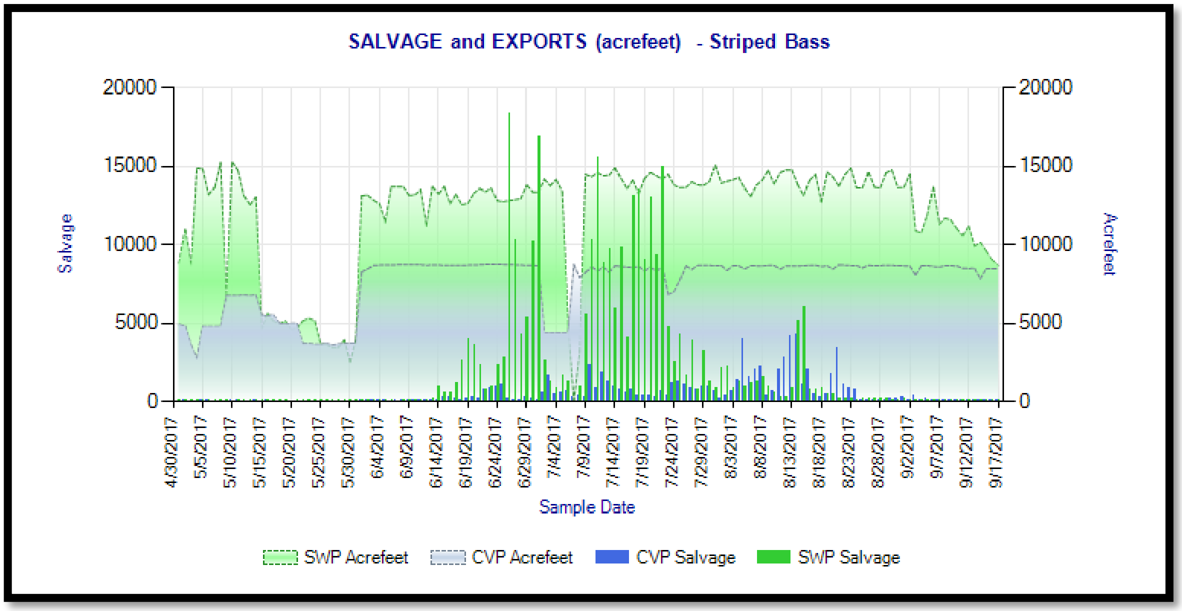

Figure 5. Striped bass salvage and export rates at SWP and CVP in spring-summer 2017.

Population Dynamics

Recruitment and Reproductive Success

The population dynamics of striped bass are best observed in the long-term indices of the fall-midwater-trawl (Figure 1), the summer-townet surveys (Figure 6), and the strong correlation between the two indices (Figure 7). The strong relationship between the indices[3] indicates that brood year success is mainly a function of the number of eggs spawned and spring water year conditions. At the present low level of adults (eggs spawned), the number of fall age-0 striped produced from summer numbers is approximately an order of magnitude higher in wet years compared to dry years (Figure 7). The numbers of age-0 striped bass produced each year is a function of the number of adults (i.e., eggs that adults produce) and water year conditions. The population is down because the spawning stock is down; it remains depressed because of poor recruitment of age-0 striped bass in dry years. Slow recovery is possible with a series of wet years or improvement in dry year survival over the summer and fall. The population is low, but still at a state where the capacity to recover is substantial. There are sufficient age 4-8 year-old spawners to produce brood year 2011, 2017, and 2019 levels of fall age-0 recruitment. Brood years 2017 and 2019 are sufficiently abundant to sustain recruitment over the next several years, at which time brood year 2023 and future brood years will become important. If the

[3] The fact that these two independent survey data sources are so closely related is an indication of a strong relationship and provides confidence that the patterns are real. While they do not provide direct evidence of adult population size, they certainly support the hypothesis that the adult stock is low when indices are low.

population – especially brood years 2017 and 2019 – are not reasonably protected (or enhanced by other means), then the stock could collapse, and recovery potential would be very limited.

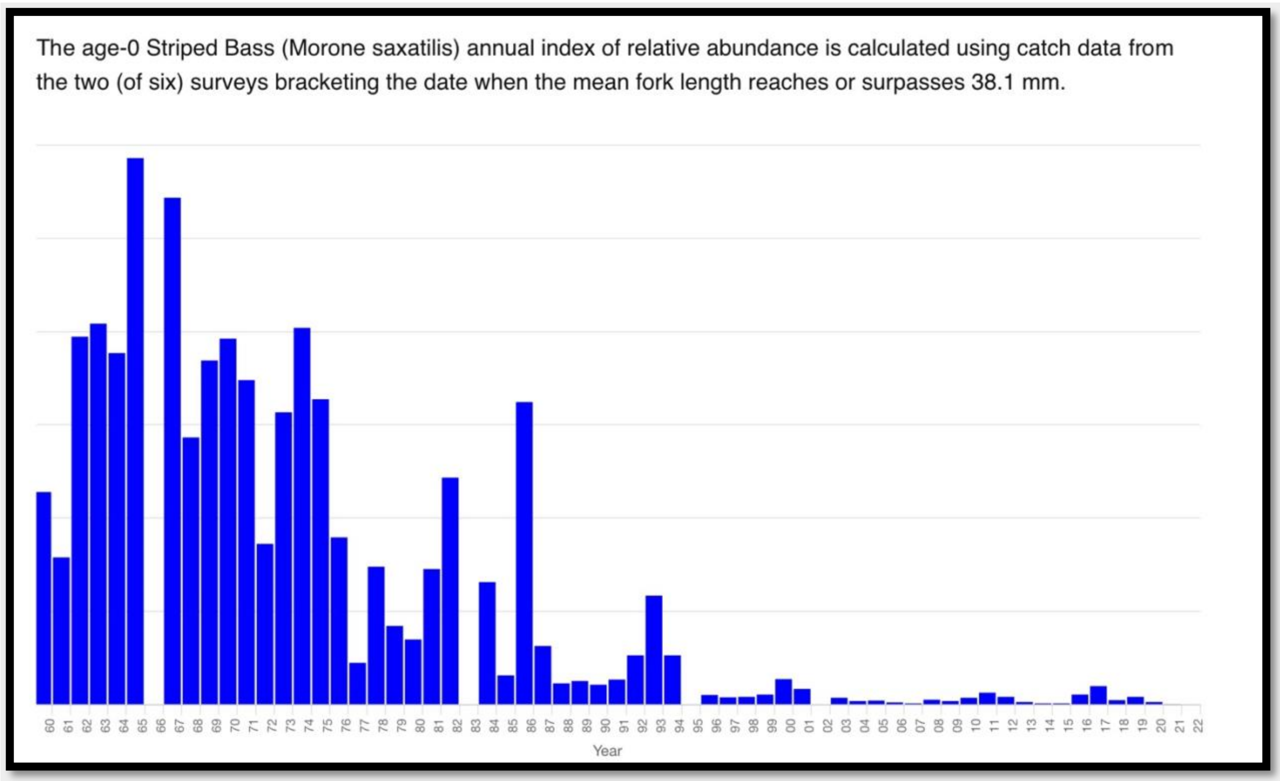

Figure 6. Striped bass age-0 annual abundance indices from the [Summer Townet Survey.]

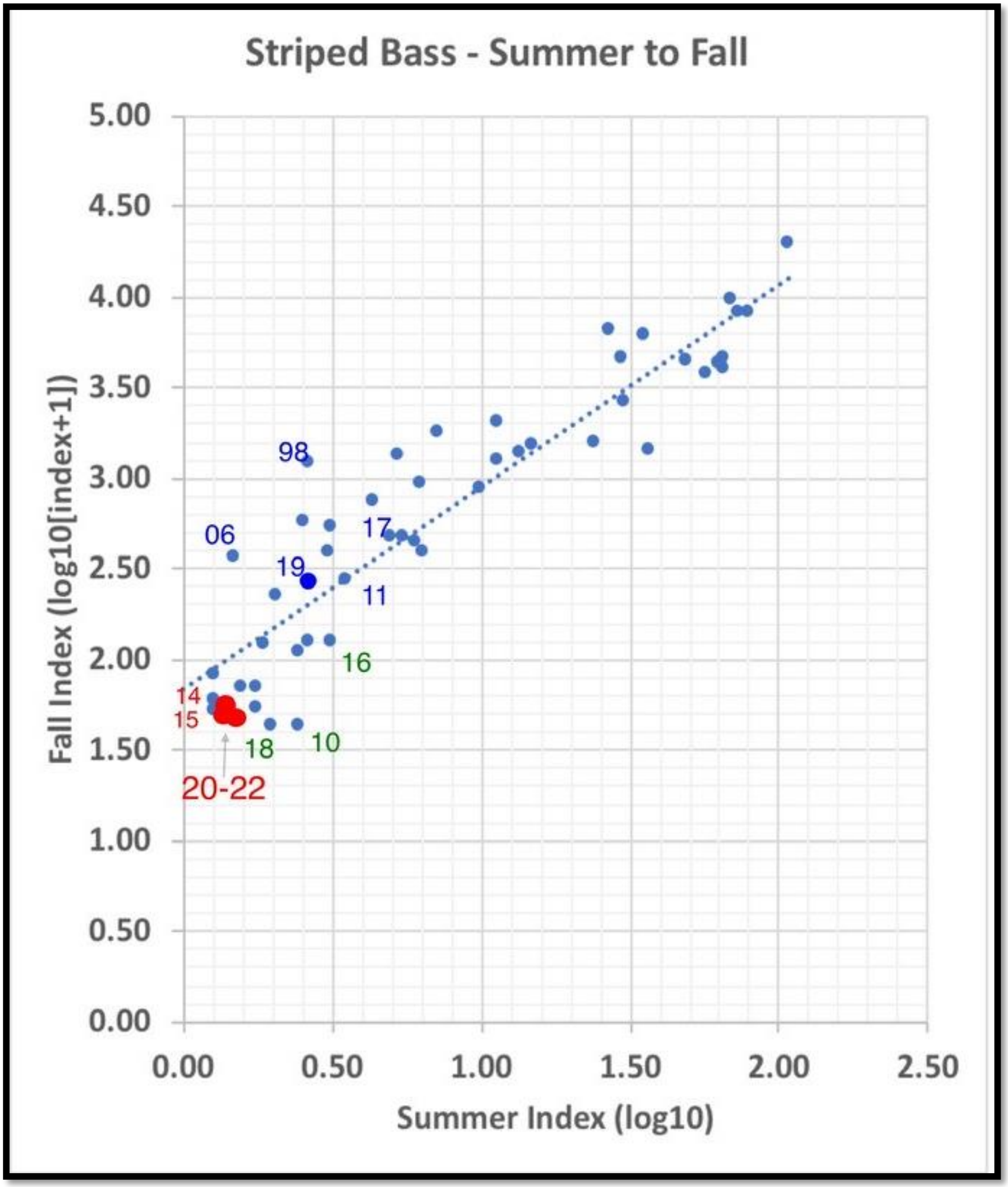

Figure 7. Striped bass Fall Midwater Trawl Survey Index (log10[index+1]) versus prior Summer Townet Index (log10). Select years labeled, with color of number showing water year type: blue=wet, green=normal, and red=dry.

Adult Population

Normally population dynamics of a fish population like striped bass would be assessed through an analysis of adult population numbers over time using spawner-recruit relationships. This is a very difficult and cumbersome process with striped bass because a brood year's production of young can involve many parent brood years a consequence of the long life cycle and the contributions of many age groups in a spawning population. This type of striped bass population information has not been available over the past decade. The most recent assessment of the adult population of striped bass in the Central Valley and Bay-Delta by CDFW (CDFG 2011) involved some earlier tagged-based annual multi-aged assessments (Figure 8) and relative measures of adult population abundance from fishery catch statistics (Figure 9).

In Figure 8, the trends reflect the abrupt decline in adult striped bass numbers from the 1976-77 drought[4] and a 1990-1994 decline that was attributed to poor recruitment and survival in the 1987-1992 drought. A recovery period from 1996-2005 was attributed to better recruitment in this wet period and supplementation of the population by hatchery stocking and pen rearing of millions of age-0 striped bass salvaged at the south Delta export pumping plants.

> *"Efforts to manage and recover striped bass became controversial with the listing of Chinook salmon and delta smelt under the state and federal Endangered Species Acts and have remained controversial since. To address concerns about Winter-run Chinook salmon, the Department temporarily stopped stocking striped bass in 1990. The Department worked for several years to receive federal permits from the United States Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NOAA Fisheries) to resume stocking striped bass but again stopped stocking striped bass in 2000 to address concerns about several listed species in the Central Valley.*
>
> *Whereas the decline and year-to-year variation in striped bass abundance through the mid-1990s has been attributed primarily to environmental conditions (including operation of the State Water Project (SWP) and Central Valley Project (CVP)) affecting young striped bass (Stevens et al. 1985), the most-recent increasing trend (1994-2000), though still the subject of active investigation, is likely attributable in large part to augmentation with hatchery-reared fish (Kohlhorst 1999)."* (CDFG 2011)

Being striped bass are non-native predators of native fish, CDFW was unable to obtain permits at the turn of the century to continue supplementing non-native striped bass numbers. CDFW was also unable to sustain prior protections provided under D-1485 (1978) in the new D-1641 (1999) water quality control plans (spring-summer export restrictions designed to protect striped bass).

[4] When I first arrived in the Central Valley 1977 to work on PG&E licensing I noticed a large number of adult striped bass were collected from power plant intake trash racks. CDFG staff at the time were studying an adult die-off they associated with drought stress.

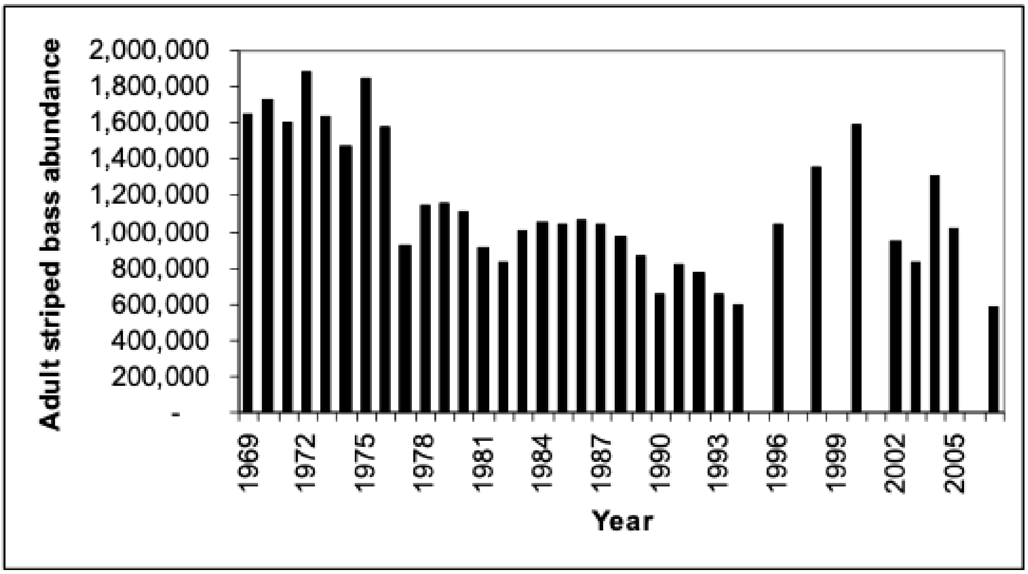

Figure 4. The annual abundance of adult striped bass in California's anadromous waters.

Figure 8. Tag mark-recovery estimates of striped bass. (CDFG 2011).

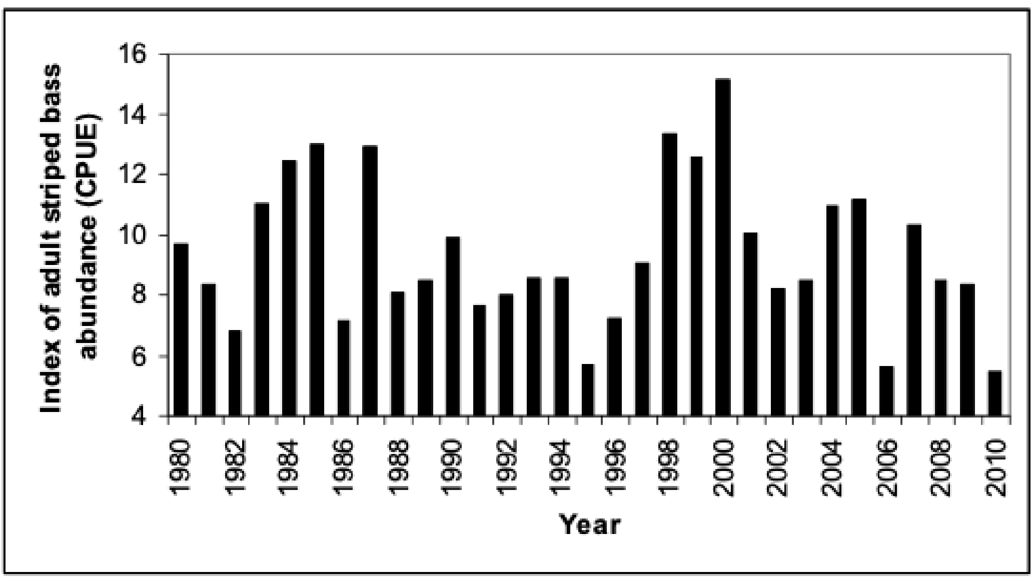

Figure 5. Trends in annual abundance of adult striped bass in California's anadromous waters, expressed in terms of catch-per-unit-effort (fish kept/100 hours) from Commercial Passenger Fishing Vessels inside the San Francisco Estuary.

Figure 9. Annual catch trends (1980-2010) in the Bay-Delta commercial party-boat fishery (CDFG 2011)

Causes of the Long-Term Decline in Striped Bass

So, what is driving the decline in striped bass production and what is sustaining the adult population at its present low level (several hundred thousand)? Why have striped bass not returned to their recent historical levels one to two million adults?

The decline is caused in large part by poor age-0 recruitment in dry and below-normal water years and the high frequency of such years over the recent five decades. The decline is accelerated by the continuing decline in the numbers of spawners (and their eggs) from poor age-0 recruitment, as well as reduced survival of older age groups from fishery harvest and unknown factors (predators, pollution, etc). From 2007-2022, only three water years were wet or above normal. Poor recruitment occurred in 83% of the years in that period. In the three decades before that (1976-2006), drier years (13) only occurred in 42% of the years. In the 25 years prior to that (1951-1975), drier years only occurred in 32% of the years. The increasing frequency of drought and a declining adult striped bass population (and associated reduced egg production) has driven recruitment and the adult spawning stock down.

The ultimate villain is poor recruitment in drier years – especially over the recent two decades. At low population levels, the difference in recruitment of age-0 striped bass between wetter and drier years is an order of magnitude. This is especially the case over the past 20 years. Some say this was caused by the pelagic organism decline (or POD) in the Bay-Delta estuary at the beginning of the century[5]. Regardless, given that the potential for higher recruitment remains reasonable in wetter years at present adult spawner levels (several hundred thousand), poor Bay-Delta habitat conditions in drier years and the high frequency of such years are the prime factors hindering a striped bass population recovery. Based on the strong relationship as illustrated in Figure 7, poor early age-0 survival is the obvious culprit in hindering recovery of the population to pre-early-2000s levels.

A major cause of poor striped bass age-0 recruitment in dry years after water year 2000 was the change in the D-1641 water quality control plan (1999) from D-1485 (1978). D-1485 restricted Delta exports to 6,000 cfs[6] in June and 9,000 cfs in July. Those restrictions were dropped in D-1641 in favor of a 65% export-to-inflow restriction. The change is apparent in striped bass salvage in spring-summer 2000 (Figure 10). Exports reached 10,000 cfs in late June and July, resulting in the salvage of over 1 million juvenile striped bass in one week. Many juvenile fish do not survive the salvage process. Salvage is also an indicator of overall exposure to poor Delta conditions as well as striped bass egg and larval loss as they pass directly through the export facility fish-salvage screens and louvers.

Any semblance of export restrictions in late spring and early summer has disappeared in recent years of Delta operations (e.g., 2017, Figure 5); exports commonly are at maximum (11,400 cfs). One only must look back at 1993 (Figure 11) to see the difference with D-1485 regulations. Because summer salvage is only indicative of part of the problem – the total spring entrainment losses (and subsequent population effects) of undocumented loss of eggs and larvae are likely significant. Higher South Delta project

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[5] Another theory is that a very concerted effort to recover striped bass with hatchery production and salvaged fish net pen rearing in the Napa estuary in the 1990s and early 2000s contributed to the POD. Millions of hatchery striped bass present in a compromised/stressed estuary could have had a large impact on the pelagic fish species, including wild striped bass young production.

[6] A daily average rate of 6,000 cubic feet per second is the equivalent of 12,000 acre-feet per day exported.

export rates in spring and early summer are the likely cause of many declines of Bay-Delta fishes, striped bass being just one.

There is also evidence that age-0 to age-3 striped bass survival and recruitment have suffered from the effects of changes in habitat and prey availability (Nobriga and Feyrer 2008). These other factors could have affected age-0 survival as well as age-1 and age-2 survival. (See Appendix P for more details.) Any factor affecting recruitment into the adult population would affect the number of eggs available for age-0 production. Changes in factors such as habitat and prey availability were also caused by the same water management changes that led to the declines in age-0 striped bass production.

In summary, despite recruitment of age-0 striped bass being very near zero or at a minimum record low after the 2020-2022 drought, adults from brood years 2017 and 2019 remained sufficiently abundant to provide eggs for a modest brood year 2023. Available adult mark-recapture survey data in 2004 (Figure 12) shows that an adult stock in the range of 300,000 to 500,000 is at the lower end of the stock-recruitment relationship. At this lower end of the "curve" it is difficult to forecast future population stability.

In the meantime, we can expect (or hope) the FMWT index to stay above the 250,000-500,000 range after what can be expected as a small bump of the Summer-Townet Index into the single digits. We shall see.

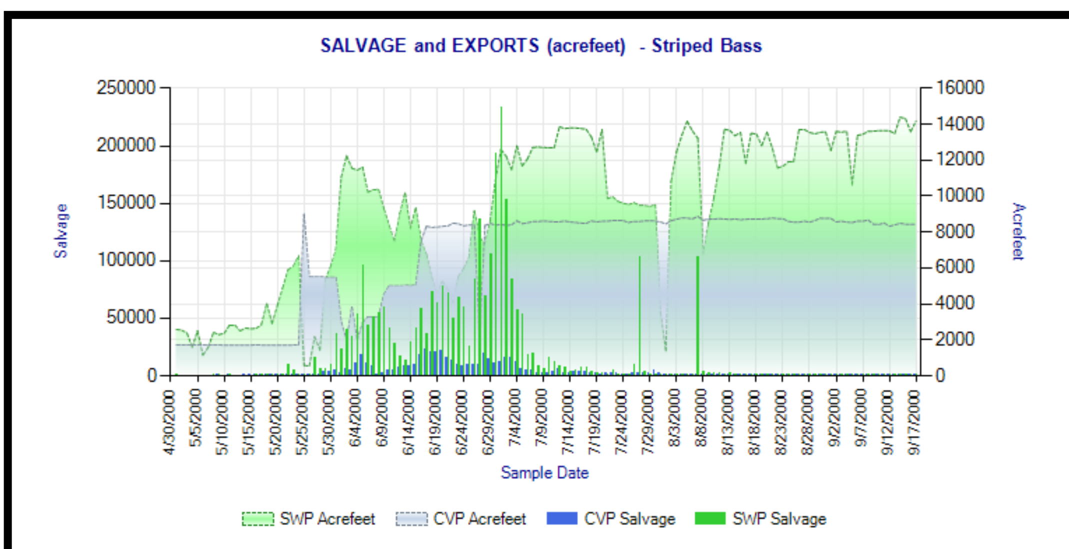

Figure 10. Delta pumping plant striped bass salvage, spring-summer 2000. Source.

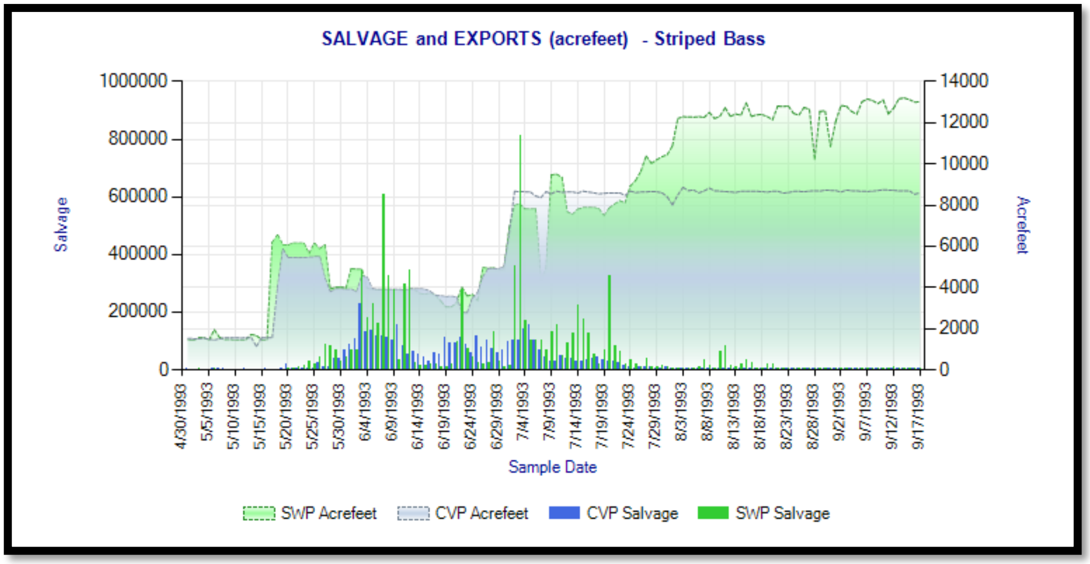

Figure 11. Delta pumping plant striped bass salvag,e spring-summer 1993. [Source](#).

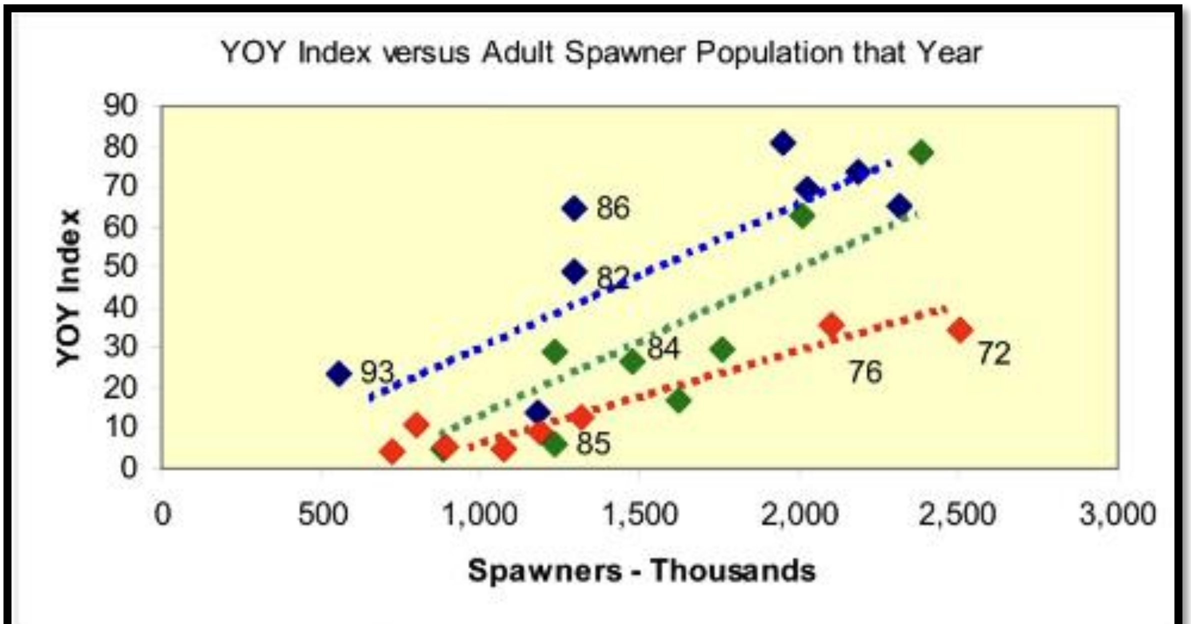

Figure 54. Version of Figure 31 showing spawner to first-summer recruit relationship for different water year types (blue = wet year; green = moderate year; and red = dry year).

Figure 12. The stock-recruitment relationship for the Bay-Delta striped bass population. (from Cannon (2004[7]).

Potential for Recovery

The many actions we have prescribed for salmon and steelhead in this recovery plan also will benefit striped bass. Better drier year habitat will benefit striped bass recruitment. More drought or worse drought conditions will minimize the recovery potential, or drive adult striped bass population numbers even lower. Under the recent climate trajectory (a higher frequency of drier years), the population will likely remain at or near the present low level with sporadic modest recruitment success in wet years like 2023.

Actions to Improve Recruitment and Population Abundance

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[7] Cannon, T.C. 2004. Status and Protection of the San Francisco Bay – Sacramento-San Joaquin Delta Striped Bass Population. Prepared for California Striped Bass Association. October 2004.

There are many possible actions that may be taken to improve striped bass recruitment (age-0 survival), juvenile to adult survival, and the number of adult spawners. Adoption of these actions as a whole would likely measurably increase striped bass abundance or help maintain the existing population level.

- **Improve Age-0 Survival and Production**

  - **Improve spawning and rearing habitat conditions.**
    1. Most striped bass spawning occurs in the Sacramento River and some of its lower tributaries in spring when water temperatures are 60-65^{o}F. Maintaining the water temperatures standard (<68^{o}F) in the Lower Sacramento River through the Delta would generally benefit spawning and early rearing (egg/embryo development and larval survival). Maintaining early spring water temperatures in the rivers below 60^{o}F (with higher flows) would delay or inhibit spawning. It may also encourage spawning and spawner distribution to the warmer, lower velocity lower mainstem and estuary, potentially benefitting striped bass (placing eggs and larvae closer to the tidal lower salinity zone and reducing predation on juvenile salmonids.) Higher flows and cooler water will serve to keep striped bass further downstream from proposed salmon sanctuaries and downstream nursery areas.
    2. Provide adequate spring flow rates (positive Delta Qwest channel net tidal flows) in the North, Central, and West Delta to transport larvae to Suisun Bay (East Bay) to maximize larval survival in optimal tidal LSZ rearing habitat.
  - **Reduce River and Delta entrainment losses at water diversions.**
    3. Reduce river and Delta water diversions when egg and larval striped bass concentrations are high in spring.
    4. Maintain closure of the Delta Cross Channel in late spring when striped bass egg/larval concentrations are high.
    5. Reduce South Delta exports when striped bass juvenile salvage numbers rise in late spring and early summer. (Note: there were provisions in D-1485 to limit exports in June (maximum of 6,000 cfs) and July (maximum of 9,000 cfs) to specifically protect young striped bass.
    6. Screen unscreened Delta diversions.
    7. Upgrade south Delta export fish salvage systems to improve salvage of smaller juvenile striped bass (>15mm).
    8. Transport salvaged juvenile striped bass in late spring and early summer to the LSZ in the East Bay or further west if smelt are a concern.

  - **Improve over-summer juvenile striped bass survival and production in the Bay-Delta, especially in drier years.**

9. Improve summer Delta habitat conditions for striped bass, including higher Delta outflow to maintain the low salinity zone (LSZ) in the eastern Bay rather than the western Delta. Maintain the LSZ in Suisun Marsh and Montezuma Slough, where juvenile striped bass production was once high[8]. The Suisun Marsh Salinity Control Gates can be employed to help maintain low salinities in the Marsh and Montezuma Slough.
10. Reduce the negative flows toward the South Delta export pumps with more inflow and lower exports. (The 65% export-to-inflow ratio should be reduced to 35-50% depending on water year type and demands.)

- **Enhance summer juvenile production**

11. Young striped bass salvaged at South Delta export facilities in late spring and early summer can be reared in a hatchery or Bay pens for later release into the Bay[9] downstream of smelt concentrations. At present, salvaged striped bass are released in the West Delta, where smelt concentrate in early summer. Salvaged striped bass numbers are much higher in wet years, reflecting both their higher production in wet years and their vulnerability to higher exports in wet years (see Figure 5).

- **Improve fall survival of age-0 striped bass in the Bay-Delta**

12. Maintain the LSZ in the East Bay in fall with higher Delta outflow than presently provided.
13. Limit the South Delta pumping plants exports. (The 65% export-to-inflow ratio should be reduced to 35-50%, depending on water year type and demands.)

- **Improve Yearling and Older Striped Bass Survival and Production**
  - **Fall X2 Action**

14. Provide higher Delta outflows in the fall to move age-0 striped bass downstream to Suisun Bay and Suisun Marsh (Montezuma Slough).

- **Late Fall Export Reductions**

15. Limit the South Delta pumping plants exports. (The 65% export-to-inflow ratio should be reduced to 35-50%, depending on water year type and demands.)

- **Transport Striped Bass to the Bay**

Transporting striped bass to the Bay should provide better survival in brackish water with lower water temperatures than Delta release sites.

16. Transport salvaged age-0+ striped bass to eastern San Francisco Bay.

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[8] https://californiawaterblog.com/2019/08/25/remarkable-suisun-marsh-a-bright-spot-for-fish-in-the-san-francisco-estuary/

[9] In years around the turn of the century, in addition to hatchery production, millions of south Delta export salvaged striped bass young were reared in Napa River estuary net pens for a year or more and then released to the North Bay.

17. Transport striped bass captured in the Clifton Court Forebay in the Predator Removal Program and at segregation weirs to the Bay instead of Bethany Reservoir.

- **Modify sportfishing regulations**

18. Employing a slot limit on striped bass sportfishing harvest[10] would increase the spawning stock. Any reduction in harvest would increase the spawning stock. The slot limit would reduce the harvest (and targeted catch) of certain sizes. Returning the largest oldest spawners would theoretically provide more eggs per fish, plus more genetically fit and larger fish. Reducing the harvest of smaller premature individuals would increase the numbers reaching spawning age (age 4-6). Encouraging the harvest of slot-size adults may reduce the abundance of strong brood years that are important in sustaining the population. East Coast regulation reforms focus on reducing harvest by employing a maximum size limit of 31 inches to preserve adult female spawners[11].

- **Juvenile Index and Adult Population Targets**

19. Recent-historic population estimates of the number of adult striped bass were one to several million[12]. In the past decade, a consensus estimate was a half-million adult striped bass in the Bay/Delta/Central Valley population. A consensus doubling goal for the CVPIA was three million that was later reduced to one to two million. A comprehensive mark-recapture tagging program is no longer conducted (or not reported) by CDFW, but should be reinstated to fulfill regulatory requirements. We recommend the adult population should be maintained in the range of 200,000 to 500,000 adults age-4 and above (the present population level), and the development of specific goals (and management) for age-3 pre-adult recruitment.
20. A target index for the Fall Midwater Trawl Survey should post a running average index of 100-200 (with an annual range of 50-500).

- **Reduce SB predation on native anadromous salmonids.**
  There are many potential actions that could reduce striped bass predation on native salmon. Many are actions we recommend in other chapters to improve salmon production. These recommended actions will help reduce predation on native salmonid populations while maintaining the striped bass population near present levels. If such actions prove ineffective, other more drastic population controls may prove necessary.

[10] https://ncgasa.org/2022/04/07/update-on-striped-bass-slot-limit-from-the-smith-policy-group/
[11] https://www.cbf.org/blogs/save-the-bay/2023/05/how-worried-should-you-be-about-striped-bass.html, http://www.asmfc.org/files/AtlSrripedBass/StripedBassFMPReview_FY2021_BoardApproved.pdf , https://www.fisheries.noaa.gov/species/atlantic-striped-bass
[12] https://swfsc-publications.fisheries.noaa.gov/publications/CR/1982/1982Striped.pdf (p12)

21. Our recommendation to transport all hatchery salmonid smolts to the Bay-Delta or coast may very well reduce striped bass growth and production, but it would reduce striped bass predation on hatchery and wild salmonids. (Striped bass would feed somewhere else on something different.) This action may reduce the harvest on striped bass and force them to reside more in the Bay, where they likely would be better off. Spawning, feeding, and over-summering by striped bass in the rivers forces adult striped bass into unsuitable habitat niches also frequented by native salmonids. Like the salmonids, striped bass adults do not do well at water temperatures above 70°F. Like juvenile salmonids, striped bass become trapped upstream of warm water in late spring and cannot get back to the Bay. Some may take up permanent residence in the rivers. Striped bass adults are relatively abundant in the main rivers and tributaries, especially in summer in cooler tailwaters below rim dams. There is anecdotal evidence and personal testimony from fishermen that striped bass are now more common in the mainstem river and lower tributaries above the location of the former Red Bluff Diversion Dam (which was removed in 2010).
22. We also recommend employing segregation weirs on all the major salmon rivers to keep striped bass out of spawning/rearing areas (our proposed sanctuaries); we recognize, though, that striped bass predation could become a problem below some segregation weirs. We have prescribed actions to minimize this potential problem on a case-by-case basis. We consider the state's plan to provide a bypass at the Daguerre Dam on the Yuba River (our recommended segregation weir location) inadequate because it may allow passage of striped bass and/or a predation hot spot below the bypass.
23. We recommend trap-and-haul programs for striped bass captured at or below segregation weirs or other locations (i.e., the lowermost tributaries) for transport to the Bay. Such a program is underway on the Mokelumne River by EBMUD. The study showed a reduction in predation rate after striped bass removal[13].
24. Another recommendation is to capture and transport natural-born salmonids at the segregation weirs and transport them to the Bay-Delta, lower floodplains, or conservation hatcheries for grow-out to avoid predators, including striped bass. This recommendation is necessary in drier years when good emigration conditions cannot be achieved in winter or spring. It would also help reduce attraction of striped bass and

[13] https://afspubs.onlinelibrary.wiley.com/doi/abs/10.1080/02755947.2015.1121938

other predators to the primary migration routes of native natural-born salmonids.

25. We recommend dealing with localized river predation hotspots, i.e., areas with conditions that favor striped bass predation. They should be modified and/or the striped bass captured and relocated. Some notable locations include diversion dams, culverts, irrigation diversions and returns, flood bypass infrastructure, deep pools, and slough connections. Examples of specialized locations include the Sacramento Deepwater Shipping Channel and Lower Yolo Bypass (favored by both Delta smelt and striped bass), and flood bypass overflow weirs (e.g., Fremont Weir).
26. We recommend against restoring smelt and salmonid habitat in areas that would lead to higher spring water temperatures that would attract striped bass.

- **Monitor population abundance, population-controlling factors, and assess long-term trends and changes.**

Each of the above prescribed population parameters should be monitored in a comprehensive manner and include appropriate adaptive management. All actions taken related to striped bass should be monitored to determine the effectiveness of the action(s). Comprehensive review, analyses, and reporting of the obtained information should be an integral part of overall program objectives. Predation by striped bass should be monitored through all available means[14].

27. The Interagency Ecological Program (IEP) should continue to monitor striped bass in the larval surveys, 20-mm survey, Townet Survey, salvage surveys, and Fall Midwater Trawl Survey.
28. The IEP should continue to conduct an Adult Striped Bass Survey to monitor the population dynamics of striped bass. The survey should be comprehensive and provide accurate population estimates of the striped bass brood years through their adult age-groups.
29. CDFW should continue to monitor striped bass party boat catch and provide long-term trends in catch-per-unit-effort.
30. We recommend that the Fish and Game Commission update their policy regarding striped bass and the striped bass fishery.

[14] https://afspubs.onlinelibrary.wiley.com/doi/full/10.1002/nafm.10582 , *https://doi.org/10.15447/sfews.2016v18iss1art4* , *https://californiawaterblog.com/2016/05/22/6206/* , *https://afspubs.onlinelibrary.wiley.com/doi/full/10.1002/nafm.10391* , *https://www.noaa.gov/sites/default/files/legacy/document/2020/Oct/07354626541.pdf* , *https://esassoc.com/projects/predatory-fish-relocation-study/*

Appendix – Selected Relevant Scientific Literature

A. THE SAN FRANCISCO BAY-DELTA STRIPED BASS FISHERY: ANATOMY OF A DECLINE

a. Callahan et al. 1989[15]

1) *"The striped bass population in the San Francisco Bay/Delta estuary has been declining over the past two decades."* (p1)

   Comment: The decline has continued over the next three decades. In 2021, the Summer Townet Index was at its lowest point in 62 years (see Figure 6).

2) *"Striped bass are voracious predatory fish that, as Raney (1952) summarizes, will eat "practically every marine form found in the San Francisco Bay area." That includes crabs and clams and every kind of fish of a suitable size. The State Water Contractors (1987) report that the important prey species are northern anchovy in the summer and pacific herring in the winter, though most recent reports (Hedgepeth and Mortensen, 1987) mention that the most common prey of adult bass are shad and young striped bass."* (p4).

   Comment: One of the compensatory (density dependent) population-control mechanisms of striped bass is that production is controlled by adult cannibalism of younger age groups when either juveniles or adults are at high abundance. We also recognize that striped bass exert predation control on predators and competitors of salmonids to the benefit of salmonids. Studies over the decades show no clear preference by striped bass for salmonids, although there are locations and times when striped bass certainly focus on salmonids, especially winter-spring hatchery smolt releases.

[15] WORKING PAPER NO. 499 THE SAN FRANCISCO BAY-DELTA STRIPED BASS FISHERY: ANATOMY OF A DECLINE Joseph Callahan, Anthony Fisher, and Scott Templeton. California Agricultural Experiment Station Giannini Foundation of Agricultural Economics February 1989.

3) Life History

Males are mature at two to three years and about 10 inches in length while females mature later at 4 or 5 years and around 16 to 18 inches (Raney, page 34). They can grow to be more than 4 feet long and over 40 pounds. The adult bass follow an annual cycle of migration (Chadwick, 1967). They spend the summer feeding in San Francisco Bay and the nearby areas of the Pacific Ocean. Apparently the cold California Current keeps these bass from undertaking the extensive ocean migrations that have been seen in Atlantic Coast striped bass. In the fall they begin to migrate into fresh water, with many of the adults passing through the San Pablo Bay-Carquinez Strait areas and then spending the winter in the Delta (but not all--adult bass does not necessarily spawn every year). In the winter they are relatively inactive, present in the Delta as shown by net surveys, but seldom caught by fishermen in that season. In spring, as water in the inflowing Sacramento and San Joaquin Rivers warms up, the bass swim upstream to spawn. In the Sacramento River the peak of spawning occurs around 100 miles up river. The spawning run up the San Joaquin is blocked by salinity in the river from agricultural return flows, so the spawning is limited to the lower reaches that receive fresh water due to cross-Delta flows of Sacramento River water drawn toward the export pumps at Tracy (Radtke and Turner, 1967). Most spawning in the San Joaquin occurs in the broad channels between Antioch and Venice Island (see Figures 3 and 4 for a depiction of the Delta and spawning migration). After spawning, the adults return to the salt waters of San Francisco Bay and the ocean.

Comment: Many adult striped bass spend the summers in Central Valley rivers, especially in cooler tailwaters below the rim dams (e.g., American River below Folsom/Nimbus dams). They are attracted by the millions of salmonid hatchery smolts released from federal and state hatcheries.

The fecundity of female striped bass ranges from around 250,000 eggs per newly mature female to over 1 million eggs from an eight-year or older bass (Wang, 1986). Estimated annual production in the San Francisco Bay system is in the order of several hundred billion eggs. The eggs are nonadhesive and slightly more dense than water so the eggs and newly hatched larvae drift downstream with the bottom currents. Where they reach the entrapment zone they accumulate. The eggs generally hatch in two days, and the infant bass are about 3 millimeters long. After hatching, the larvae depend on yolk sac absorption until they reach about 6 millimeters in length. They then begin feeding on the smaller zooplankton. Their mobility is limited at this stage, so survival is dependent on the presence of adequate food nearby. Later on, as the larvae

Comment: Plankton food supply from Bay-Delta blooms have become infrequent compared to historical levels, with the higher exports beginning in the 1970s when the SWP began high exports. Annual exports increasingly take larger portions of the LSZ. This is especially the case in drier years when low Delta inflow/outflow keeps the LSZ in the western Delta: in the zone of influence of the South Delta pumping plants. The striped bass population elements in the Central and South Delta that are associated with the San Joaquin Channel were the first to be eliminated following the State pumping plant coming online in the 1970s. Elimination of D-1485, CVPIA, and VAMP export-limiting protections in spring and summer in the decades of the 2000s all contributed to reducing the striped bass population to its present record low reproduction level.

D. Ecology of Suisun Bay

Now that we have presented an overview of the striped bass life cycle and food web, we discuss the separate geographical habitats, starting with Suisun Bay. To understand the ecology of Suisun Bay, particularly in the spring, one must understand the impact of the entrapment zone. The entrapment zone is an area of increased turbidity that is caused by the pattern of mixing of fresh and salt water. At the upstream end of the estuary, the water is completely fresh, but at the ocean end it is salty. In between, there is a region of partial mixing where the lighter, partly fresh water overlies the more dense salty water. The salinity gradient creates a density driven current that moves salt water landward along the bottom while the partly mixed brackish water moves seaward in the surface layer (see Figure 6). Any material that tends to sink would be moved landward in the bottom current to its upper end. That upper end of the salinity gradient is thus known as the entrapment zone because certain materials tend to accumulate there.

The entrapment zone moves up and down the estuary depending on tidal flows and changes in inflow. High inflows push the zone downstream toward the ocean, and lower inflows allow it to move inland (see Figure 7). At low flow rates, the stratification of fresh water over salt water becomes less pronounced and the zone shrinks and becomes weaker. Increased turbulence from tides or winds also tends to weaken the zone. The zone does not trap all suspended material, only material with a certain rate of sinking. Light material does not sink and so is swept downstream. Heavy particles sink to the bottom. Only intermediate particles which are dense enough to sink out of the upper layer of water but light enough to remain suspended are trapped.

Comment: The Suisun Bay/Marsh ecosystem is shallow and characterized by wind mixing of the LSZ: the "mixing zone" where plankton and organic matter accumulate, forming an area of high productivity. However, when the LSZ is upstream in the narrow, deep Delta shipping channels during drier years, the process is less complete and driven by local mixing and circulation. In the North Delta Sacramento River Channel above the LSZ, there is a zone of continuous downstream freshwater flow. The LSZ can also develop in the West Delta near Rio Vista close to the confluence of the two river channels, and within the zone of influence of the SWP's South Delta exports. Off-channel habitats like the Cache Slough complex and the Sacramento Deepwater Shipping Channel have less inflow and stronger tidal circulation; they warm early and produce stronger plankton blooms. Estuarine species like striped bass and Delta smelt seek out such warmer, more productive water in late winter and early spring. The goal should be to keep the LSZ in Suisun Bay and Suisun Marsh, not in the Delta. This is the cause of the major production difference between the red and blue groups brood years in Figure 7.

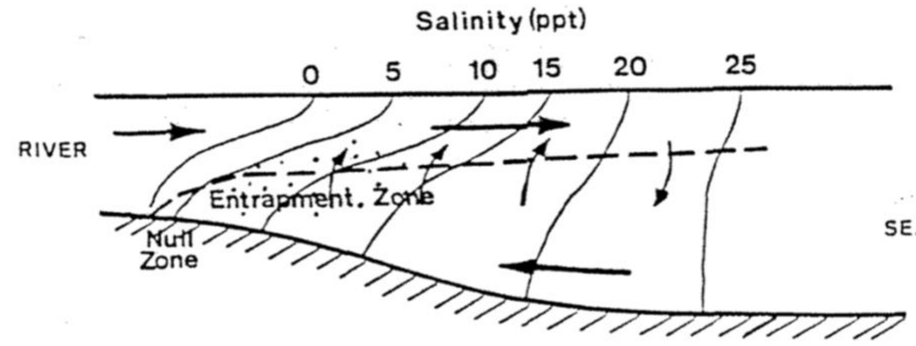


Figure 6. Entrapment zone schematic, from Williams and Hollibaugh (1987) (their figure 12). In the zone of mixing, the fresher water flowing into the estuary forms a layer above the more dense saline water. Tidal currents move both layers in and out twice a day. But in addition, there is a net seaward movement of the upper fresh water layer. As mixing occurs, this upper layer increase in volume due to the incorporation of more saline water into the partly fresh water, and thus has a volume greater than the total freshwater inflow. So to keep the flows in balance as the fresh layer moves seaward, there must be a compensating landward flow of the lower saline layer. This compensating flow runs from the seaward end of the mixing zone to the fresh-water end. The upper end of the return flow, where the landward flowing saline bottom current meets the seaward flowing fresh water bottom current, is thus an area with zero net flow. This is the area known as the null zone, and it marks the upstream end of the entrapment zone.

Comment: When the entrapment zone or LSZ is in the Delta, it tends to be a narrower and smaller zone that is vulnerable to South Delta export entrainment or elimination of most freshwater inputs and nutrient sources.

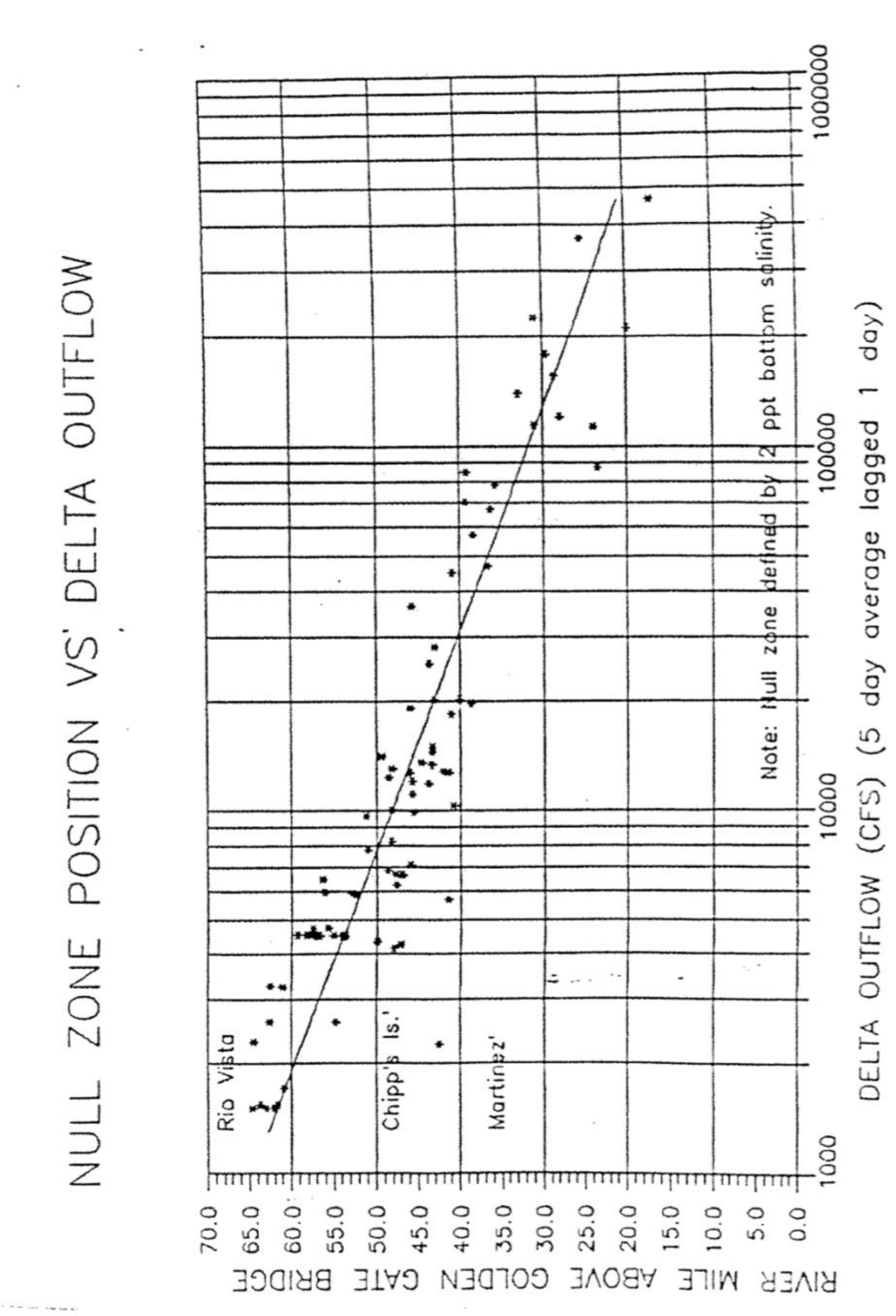


Figure 7. Taken from Williams and Hollibaugh (1987) (their figure 23).

Comment: This relationship is characterized by a specific low salinity and different periods of the spring-neap seasonal tidal cycle; it is not a null zone. The goal should be maintaining the LSZ in Suisun Bay (Chipps Is.), which takes 6,000-10,000 cfs of outflow – an occurance that has become rare in recent decades due to an increased number of drier years (see Figure A-1 below).

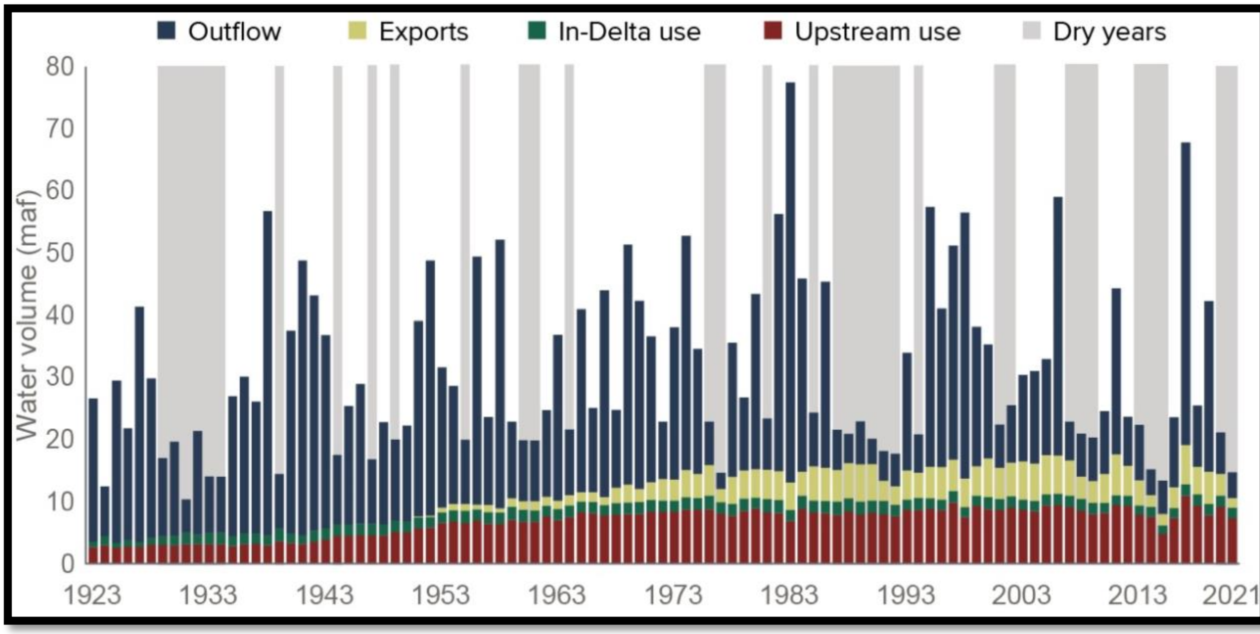


Figure A-1. Bay-Delta key water statistics. The dry year Delta outflows are generally <5,000 cfs in late spring and summer. Source: CDEC.

Comment: Dry, low outflow water years (grey outlined in Figure A-1) limit production of pelagic organisms, including Delta smelt, striped bass, and their food supplies. While total exports may be lower in dry years, their relative effect can be much greater.

affect the size of the standing crop. In addition, in moving water the residence time becomes important. In order for a large standing crop to develop, the growth rate of the phytoplankton must be greater than the rate at which the flow carries away the stock.

The concentration of nutrients in the estuary is generally high enough not to be limiting. The estuary is turbid and the turbidity is caused by river inflow, so light availability can be limiting. Residence time is also important. Cloern *et al.* (1985) describe the different regimes in three areas: South Bay, San Pablo Bay, and Suisun Bay. All three areas have deep channels flanked by broad shallow areas. South Bay is far removed from river inflow so that it has low turbidity and a long residence time and growth rates are high. But benthic grazing keeps the standing crop low. By contrast, Suisun Bay is close to the river inflow and, so, is turbid. This limits the growth rate of the phytoplankton, particularly in the channels. But the shallow areas have enough light penetration to sustain a modest rate of growth. The problem here is the residence time. The growth rate is not high enough to compensate for the loss of stock from the flats out to the channels. But when when the entrapment zone is located in that region, diatoms are caught and cycled back onto the flats so that a standing crop can develop (see Figure 8). It is possible that the dominant diatom species in this area is determined by the sinking rates, with production being dominated by those diatoms whose sinking rate is most appropriate for being caught in the entrapment zone.

The hypothesis of Cloern *et al.* (1983) is that the dynamics of river discharge exert a controlling influence on the phytoplankton population of Suisun Bay. When outflow is in a range that positions the entrapment zone adjacent to the shallows of Suisun Bay, then the standing crop of diatoms increases. If the entrapment zone is not in that area, then the standing crop is low.

Orsi and Knutson (1979) note that the opossum shrimp, *Neomysis mercedis*, is most abundant in the entrapment zone; but they are not sure whether this is because they are concentrated there by hydrological forces or because that area is somehow optimal for them. They found that *Neomysis* populations were positively correlated with chlorophyll-a and outflow. Knutson and Orsi (1983) found in a 14-year study (1968-1981) that the highest *Neomysis* densities occurred in

-14-

Comment: Phytoplankton are carried "upstream" by the strong negative draw resulting from the SWP's Clifton Court Forebay filling on flood tides twice a day (functioning like a tide gate). Nutrient levels are often limited. Blooms are often fleeting. Tides also carry nutrients, sediment, and plankton into marshes that subsequently do not return to the bays, especially with the high abundance of invasive non-native aquatic macrophytes. Residence time of water and plankton is limited in the LSZ when it is in the West Delta. With the demise of the LSZ blooms, plankton communities have dwindled, as did opossum shrimp (Neomysis) and calanoid copepod (Eurytemora), the principle prey of young striped bass and smelt.

B. California Fish and Game Commission Proposed Changes to the Striped Bass Policy: Stakeholder Draft 2 Version date: December 3, 2019

Proposed changes to the policy are shown in strike-out (deletion) and underscore (addition).

It is the policy of the Commission that:

I. The Department of Fish and ~~Game~~ Wildlife shall ~~work toward stabilizing and then restoring the presently declining~~ monitor and manage striped bass ~~fishery of~~ in the Sacramento-San Joaquin Estuary. This goal is consistent with Commission policy that the Department shall emphasize programs that ensure, enhance, and prevent loss of ~~sport fishing~~ recreational angling opportunities.

II. The Department shall ensure that actions to increase striped bass abundance are consistent with the Department's long-term mission and public trust responsibilities including those related to threatened and endangered species and other species of ~~special concern~~ greatest conservation need. ~~Recognizing issues associated with potential incidental take of these species, an appropriate interim objective is to restore the striped bass population to the 1980 population level of 1.1 million adults within the next 5-10 years.~~ In light of the foregoing, the Department will seek to achieve a sustainable striped bass population in order to maintain or increase recreational angling opportunities, taking into account the availability of habitat to support the species as well as the need to avoid taking any action that would result in incidental take of listed species.

~~III. The long-term striped bass restoration goal, as identified in the Department's 1989 Striped Bass Restoration Plan, is 3 million adults.~~

~~IV.~~ III. The Department shall work toward these goals through any appropriate means. Such means may include actions to help maintain, restore, and improve habitat~~;~~ beneficial to striped bass, reduce impacts of invasive aquatic vegetation, improve water quality, reduce loss of striped bass ~~pen-rearing of fish salvaged~~ from water projects and diversions, ~~fish screens; and artificial propagation~~ and assess the status and population of striped bass in the Delta.

Comment: These are vague, likely unachievable, and contradictory guidelines. We have recommended reasonable goals, objectives, and actions. These prescribed actions were included in our proposed plan.

I must admit that in the past, my attitude towards striped bass has been ambiguous because they are a non-native species and much of my research has focused on conservation of native species. However, striped bass are also one of the best studied species, whose population fluctuations, with a mostly downward trend, are a good indicator of the 'health' of the estuary, including its ability to support native fishes. The importance of striped bass for monitoring started when regular fish sampling programs were established to determine the impacts of the State Water Project and the Central Valley Project on fisheries (e.g. Fall Midwater Trawl Survey, Summer Tow Net Survey). These surveys were focused on striped bass and are still ongoing; they have been the principal source of status information on other species such as delta smelt, as well as striped bass. In fact, the trends in juvenile striped bass numbers closely follow those of delta and longfin smelt, indicating all have a similar response to the major changes that have taken place in the Delta in the past couple of decades. I recognized this in my 2002 book *Inland Fishes of California* where I conclude the striped bass account with:

> "The striped bass is a very resilient species and is now a permanent part of the California fish fauna….The best thing that can be done for striped bass is to restore the estuary to a condition that allows it to support more fish of all kinds, but especially native species (p 362)."

Attached letter section from Peter Moyle.

Comment: We agree.

Next Steps

FGC staff agrees with the stakeholders that striped bass is an economically significant and recreationally important fishery in the Delta, and also understands and supports the desire to identify a numeric target and specific strategies that will be used to ensure a robust recreational fishery. Where staff does not agree is that having a numeric target in a public policy will lead to anything different from what has ocurred over the last 25 years with the existing numeric targets.

Policies provide guidelines for how FGC and DFW operate, and their eventual success or failure is contingent upon the relationship between the two organizations, the management processes that convert such policies into action, and the relationships with other organizations and stakeholders that help create success or failure. To be successful, policies must be realistic and attainable, standards not met by the current striped bass policy. DFW has indicated a willingness to work with stakeholders to discuss those actions that will benefit striped bass, such as specific goals, objectives and projects, understanding that activities may be targeted to listed species where DFW has resources available (DFW does not currently receive funding for work specific to striped bass). However, many projects DFW implements or funds to help restore the Delta ecosystem is of benefit to striped bass.

Today, FGC is being asked to adopt the draft FGC Delta Fisheries Management Policy as amended by staff and to adopt revisions to the FGC Striped Bass Policy. Staff also recognizes that FGC may not be prepared to adopt the new policy and/or make revisions to the striped bass policy, and stands ready to implement any direction or actions.

Comment: We disagree: a numerical goal is needed to guide actions undertaken per the target objective. Success should be determined by progress toward a numerical goal that is "…*realistic and attainable*" and limited given the negative consequences of a large striped bass population. CDFW should receive funding to monitor striped bass because of their potential role in affecting native fishes and their role as a popular gamefish that requires control.

C. California Fish and Game Commission Draft Delta Fisheries Management Policy Version date: February 14, 2020

This version of the draft policy reflects the December 3, 2019 version with additional minor clean-up proposed by staff; proposed changes are shown in strike-out (deletion) and underscore (addition).

The Sacramento-San Joaquin Delta has faced, and continues to experience, declines in pelagic fishes and anadromous salmonids. This policy is intended to guide management decisions that could affect fish species and other aquatic resources. ~~The Delta, for~~For the purposes of this policy, the Delta means the Sacramento-San Joaquin Delta as defined in Section 12220 of the California Water Code. "Delta fisheries" includes listed species, species of greatest conservation need, native species, and game fish.

It is the policy of the California Fish and Game Commission (Commission) that:

I. The Commission and California Department of Fish and Wildlife (Department) shall seek to collaborate and coordinate with other agencies whose actions may affect species and other resources in the Delta and its tributaries as the Department manages Delta fisheries and other aquatic resources. The Commission and Department will provide feedback to other agencies on any actions in the Delta that could have significant, adverse impacts to California's fisheries.

II. The Commission and Department shall strive to manage ~~these~~ fisheries and aquatic resources holistically, sustainably, and consistent with the direction of the legislature to protect, restore, and enhance the Delta ecosystem.

III. The Department shall rely on credible science (as defined by Section 33 of the California Fish and Game Code) to develop strategies and recommendations for managing Delta fisheries; using this information, the Department shall strive to improve habitat conditions (such as water temperature and flows, water quality, and food) and manage other stressors (such as disease, predation and prey availability, and competition) to promote recovery of Delta fisheries, ~~(~~where applicable~~)~~.

IV. Recognizing that listed species have highest priority, the Department shall manage Delta fisheries to protect and enhance each species' abundance, distribution, and genetic integrity to support ~~their~~ resiliency and, ~~(~~where applicable~~)~~, recovery.

V. The Department shall manage Delta fisheries in a manner that provides for maximizing sustainable recreational angling opportunities while avoiding or minimizing adverse effects to native and listed species, species of greatest conservation need, and recovery activities.

VI. To the extent feasible, the Commission and the Department shall support scientific research on habitat or species improvement projects and investments to help the policy goals set forth herein. The Department ~~should~~ shall ~~determine and~~ identify clear, objective-based research needs when developing research and recovery project plans, making research investments, making research and recovery funding decisions, and when reviewing and/or authorizing research projects. Where feasible, the Department should encourage and permit recreational anglers to contribute to

Comment: The FGC should adopt clear statements of goals and objectives regarding striped bass and support a comprehensive monitoring and assessment program for the species that addresses their role as a top predator in the Bay/Delta/River fish communities.

D. DELTA PROTECTION COMMISSION – Letter to FGC January 16, 2020 - RE: Comments on proposed Striped Bass Policy

> The Delta Protection Commission serves as a forum for Delta residents and fosters communication between public agencies and private entities to encourage increased recreation and tourism in the Delta. The Delta Protection Commission supports efforts to maintain the striped bass population as important to Delta recreational and economic values, and approved this letter at its January 16, 2020 meeting by a unanimous vote.
>
> At the December 2019 California Fish and Game Commission (CFGC) meeting, your Commission heard public comment on the proposed amended Delta Fisheries Management Policy and Striped Bass Policy. Many of the speakers at the meeting were concerned the Delta striped bass fishery will no longer be supported because of concerns over bass predation of listed fish species. Fish researchers also commented that striped bass were unlikely to be the primary cause of listed species declines. We ask that you consider the following comments as you work with stakeholders to revise the Striped Bass Policy:
>
> - Include the language from Stakeholder Draft Version 1: "...the department's goal is to restore the striped bass population to a healthy, self-sustaining growing population and robust recreation fishery...reduce impacts of invasive aquatic vegetation, improve water quality, reduce loss of striped bass...and assess the status and population of striped bass in the Delta." Further, incorporate the 1.1 million striped bass fish population numeric target as a replacement for the existing numeric target, as supported by many members of the stakeholder group.

Comment: CDFW actions at the turn of the century included stocking millions of hatchery-reared striped bass and Bay pen-reared salvaged juvenile striped bass; these practices expanded the striped bass population close to the agency's goal of two million adult fish. That population level was inadequately addressed in discussions on the concomitant Pelagic Organism Decline (POD), probably because striped bass young production also declined due to cannibalism and habitat impacts. Regardless, the population was artificially enhanced, leading to the widespread belief in subsequent years that the striped bass population was in a healthy state.

- Include language supportive of interagency research efforts to identify steps to manage a successful striped bass fishery and what the striped bass population needs to be self-sustaining.

- In order to address the questions about predation, the CFGC should promote additional studies on the relationship between striped bass and listed species, including predation, habitat needs, and how to manage game fish and species of conservation need.

Comment: We agree.

- **Letter from LONG ISLAND PROPERTY OWNER'S ASSOCIATION LONG ISLAND – ON THE SACRAMENTO RIVER WALNUT GROVE, CALIFORNIA**

  The Long Island Property Owner's Association strongly urges you to reject the proposed modification of the Striped Bass Policy. Our Delta and the local business will be significantly adversely impacted by modification of the policy.

  TWO SPECIFIC THOUGHTS

  We urge you to include language that requires an objective and measurable target for Striped Bass (our observation is that the population has significantly declined)

  We urge you to have language in the policy that provides for "Restore and Enhance" this fishery, NOT "monitor and manage."

- **Letter from recreational fishing organizations (Coalition)**

  Striped bass were introduced in California back in 1879. Since that time, striped bass has been an economically significant and recreationally important fishery in the Delta. Recreational striped bass fishing is an economic driver creating revenue and jobs, supporting industry and local businesses, and draws tourism and competitive events. A numeric striped bass population target is necessary to ensure proper fisheries management of this important fishery.

E. Petition aimed at protecting non-native Striped Bass will only worsen the plight of California's imperiled native fishes – Center for California Water Resources Policy & Management 2022.

The number of striped bass caught by anglers has increased over the last 30 years, while the hours devoted to angling have remained steady.

Acknowledging the trend of more striped bass being caught per unit time by anglers, an alternative justification for the petition could be that too many striped bass are being harvested. Not so — striped bass harvest has held steady since 1990 at about 50,000 fish per year.

Moreover, the number of striped bass caught and released by anglers increased dramatically from 150,000 per year in 1990 to more than 250,000 per year in 2016, the last year for which data are available. DFW's data suggest no immediate threat to the conservation of striped bass and no decline in angling success.

Comment: The fishery catch data may or may not show the population trend. It may also show resiliency in the fishery and improved efficiency and interest. However, the fact is that such data have not been collected since 2016. The survey data that have been collected shows a definitive decline in striped bass juvenile production with an order of magnitude higher production in wet years.

F. Enumerating Predation on Chinook Salmon, Delta Smelt, and Other San Francisco Estuary Fishes Using Genetics, First published: 07 February 2021 https://doi.org/10.1002/nafm.10582

- *The establishment of nonnative predatory fish species is a worldwide phenomenon often having adverse effects on native species. Trophic interactions are complex, and uncertainty is a common theme in discussions of nonnative predator management. Several fishes of the San Francisco Estuary have experienced significant declines in recent decades due to multiple factors, including habitat alteration and predation. The role of predation as a direct cause of mortality remains an open question, as does whether habitat conditions play a role in promoting predation on species of concern.*

  Comment: Is predation by striped bass a problem, or is the problem habitat changes (e.g., higher water temperatures) that make salmon more vulnerable to striped bass predation? Or is the problem releasing millions of hatchery salmon smolts into the mouths of striped bass, encouraging them to feed on wild salmon as well? No doubt the answer is "yes" to all these questions. We recommend addressing all aspects of the problem and see what the responses might be. Keeping striped bass in the Bay where there are other abundant prey sources may be one solution.

- *Unlike previous studies in the region, the proportion of predators with no prey detected in their gut contents was high (47–81%). The study detected Delta Smelt in 1.3% of Striped Bass—considerably higher than other contemporary predation studies in the Sacramento–San Joaquin Delta. In April 2014, 6.6% of Striped Bass were positive for Chinook Salmon—substantially higher than observed in recent visual diet studies. Interestingly, native species comprised a relatively high proportion of Striped Bass prey (60%). Water temperature and conductivity were identified as significant predictors of Chinook Salmon presence in Striped Bass gut contents. This research also suggests that predation on soft-bodied prey may be an overlooked segment of the diets of piscivores.*

  Comment: While the results of the study were surprising, they are certainly believable. Previous studies had already shown salmon and smelt were minor components of striped bass diet before and after the population decline. Salmon and smelt are generally a very minor component of the fish prey community because they are such a small part of the overall prey base, excepting certain times and locations. It really is a matter of time and place: striped bass feeding in the Lower Sacramento River shortly after a million hatchery smolts are released upstream feed on a lot of salmon. Striped bass are keen predators and learn quickly where the food is. One example: the Bay net pens release locations have to be moved often because striped bass and other predators (e.g., birds) quickly catch on. The point about water temperature and salinity is obvious, but also complicated. Mainly it relates to large releases of hatchery smolts having to migrate through stressful warm water and encountering many striped bass on their way to the Bay/Delta.

*The effects of these introduced species are complex and highly variable (Best and Arcese **2009**), and how to manage them remains the subject of continuous debate (Gozlan **2008**; Cucherousset and Olden **2011**). The effects of introduced predators are not limited to their prey; they may alter multiple trophic levels through cascading effects with unpredictable results due to indirect, nonadditive, and interactive effects (Bruno and Cardinale **2008**)…. In California, the Sacramento–San Joaquin Delta (Delta) has also undergone significant changes in its fish assemblages, yet the role of introduced predators remains murky. This study aims to expand the knowledge of predation by nonnative predators as part of a conservation strategy for native fishes…. Thus, a description of piscivore diets, spatial distributions of predation detections, and the habitats associated with the detection of predation are critical to shaping resource management strategies aimed at diminishing predation on protected fishes.*

Comment: When asked a decade ago whether striped bass fishing regulations should be dropped in favor of all-out slaughter, Peter Moyle suggested that if you take away a top predator like striped bass, you may unleash the far bigger problem of enhancing populations of smaller predators that really prefer salmon or smelt. (Striped bass eat many of the other predators and competitors of salmon and smelt.)

*Striped Bass consumption of Chinook Salmon was not evenly distributed across our sampling regions (Figure **3A**). Striped Bass captured in the three northern Delta migratory routes (upper Sacramento River, Miner Slough, and Steamboat Slough) had significantly more Chinook Salmon DNA detected in their stomach contents compared to other regions (Figure **3A**; $\chi^2 = 7.64$, P = 0.006).*

Comment: Again, this was to be expected because the striped bass are in the river on the annual spring spawning run and come across a veritable wall of Coleman salmon smolts – and many wise sportfishermen as well, i.e.,   "The *Coleman bite is on!*"   Note the study did not differentiate between predation on hatchery vs wild salmon smolts.

While predator and prey abundances and distribution were not estimated, this study's broad sampling of the northern Delta and sensitive detection methods highlight important temporal and spatial variation in predation. Future study designs would benefit from more specific study questions and a focus on how to best utilize presence–absence data produced using this method.

Comment: Well said.

*Catch patterns: Predator sampling was marked by a large catch of Striped Bass in April 2014. It is likely that this catch pattern for Striped Bass was due to our sampling overlapping with the Striped Bass spawning migration period in the Delta, which typically begins in April (Moyle **2002**). The diets of Striped Bass showed a large variety of species; all 13 assayed prey taxa were detected in Striped Bass except for Green Sturgeon. The breadth of prey observed is consistent with the hypothesis that Striped Bass are not highly selective in their prey choice, and they have been shown to exhibit considerable trophic adaptability (Nobriga and Feyrer **2008**).*

Comment: See above comments.

Empty guts: This study contrasts with other diet studies that used visual analyses to identify fish and invertebrate prey. A previous diet study (Zeug et al. 2017) showed that only 18% of Striped Bass guts were empty, whereas this study showed 62% of Striped Bass had no prey detected genetically or visually. The disparity may be due to sampling location differences between the studies. Zeug et al. (2017) focused their sampling in the confluence region of the Sacramento and San Joaquin rivers, downstream of our sampling sites in November and December of 2010 and 2011. When pared down to the overlapping site, the Lower Sacramento sampling station in December, our study observed a similar rate of empty guts to the Zeug study (18%), indicating that Striped Bass did not consume prey as frequently in the upstream sampling locations and/or during the months of spawning migration.

Comment: This pattern would further indicate that feeding on the Coleman smolts is an opportunistic event that was interrupting the annual striped bass spawning run.

Piscivores as prey: Another notable finding was the degree to which predatory fish comprised relatively high proportions of the diets of other predatory fish. Striped Bass consumed other predators at rates comparable to their more traditional prey items like Threadfin Shad and Chinook Salmon. Additionally, 27% of Sacramento Pikeminnow were found to have Striped Bass in their gut contents. This finding may provide insight into the debate surrounding the effectiveness of predator removal as a means of improving survival rates of native species. If there is a high proportion of predators consuming other predators, would predator removal release predation pressure on nontarget predators, thereby increasing their populations and reducing the long-term effectiveness of predator control efforts?

Comment: It is interesting that the authors took on this subject. Striped bass are large predators and are known to consume prey larger than that favored by the typical fish predator. Otherwise, this goes to Peter Moyle's point mentioned earlier about who preys on whom.

*Native species comprised a relatively high proportion of Striped Bass prey detections overall (60%), which corresponds to natives being detected in 15% of all Striped Bass sampled. The percentage of native fish detected varied by month, with 29, 82, and 20% of prey detections composed of native species in December, April, and June, respectively. These proportions are representative of the reproductive phenology of the fish of the Delta (Moyle **2002**; Nobriga and Feyrer **2007**) but are interesting when considering the relative abundance of native species found in monitoring surveys. In the Yolo Bypass (part of the northern Delta) during our study period, surveys showed less than 10% of total catch was comprised of native species (Mahardja **2016**), a proportion matched by other monitoring surveys in the northern Delta (Castillo et al. **2018**).*

Comment: Again, the "April 82" is simply the great abundance of juvenile hatchery and wild salmon coming down the Sacramento River into the North Delta (probably under stressful conditions) into the mouths of these voracious predators. The authors fail to mention the relative large size of migrating salmon smolts compared to larvae and small juvenile native and non-native salmon.

General patterns observed in the nonmetric multidimensional scaling were confirmed through the analyses of similarity. Prey detections did not differ substantively across locations within a given month, but they were distinct across sampling months, with more native prey observed in April and more nonnative prey in June.

Comment: Yes, the salmon and splittail would be gone sometime in June and abundant non-natives like threadfin and silversides would dominate the prey of striped bass.

G. Phantom Predator – Striped Bass?

In a recent 2020 essay in SAN FRANCISCO ESTUARY & WATERSHED SCIENCE, authors Nobriga and Smith describe striped bass as a "phantom predator" that for a century has been secretly driving down their "naïve prey" the Delta smelt. The authors hypothesize that Delta smelt were much more abundant that the earliest regular monitoring data would indicate, and that striped bass did most of this damage to the Delta smelt population before there was widespread monitoring of either Delta smelt or striped bass.

Comment: Smelt were much more abundant in early monitoring years (see Figure G-1 below). They have declined in much the same pattern as striped bass (see Figure 1). The three orders of magnitude decline in Delta smelt was not caused by striped bass because striped bass production fell as well. However, the concerted effort by CDFW near the turn of the century to improve adult striped bass numbers by stocking millions of hatchery striped bass and pen rearing salvaged juvenile striped bass cannot be ruled out as a contributor to the POD, including the declines in Delta smelt, striped bass age-0, salmon, and other POD species. At high adult population levels, striped bass are known to prey on their own young to limit competition and control their numbers. If the numbers of pre-adult and adult striped bass were too high for the habitat capacity of the Bay-Delta around the turn-of-the-century because of high rates of supplementation, a reaction like the POD in the early years of the 2000 decade was possible. The resource agency reaction at that time to stop striped bass supplementation and lower the adult striped bass target from three million to one million probably was in response to this same conclusion (especially having been warned of the consequences of this program a decade earlier – Figure G-2). The concern was also expressed in references to a program considering striped bass removal at specific locations[16]. Stopping supplementation and the low reproductive success of striped bass at that point in time appears to have brought down striped bass recruitment levels (Figure G-3 and see Figure 3).

[16] https://filelib.wildlife.ca.gov/Public/Adult_Sturgeon_and_Striped_Bass/Gingras%20and%20McGee%201997.pdf , https://filelib.wildlife.ca.gov/Public/Adult_Sturgeon_and_Striped_Bass/Kano.pdf

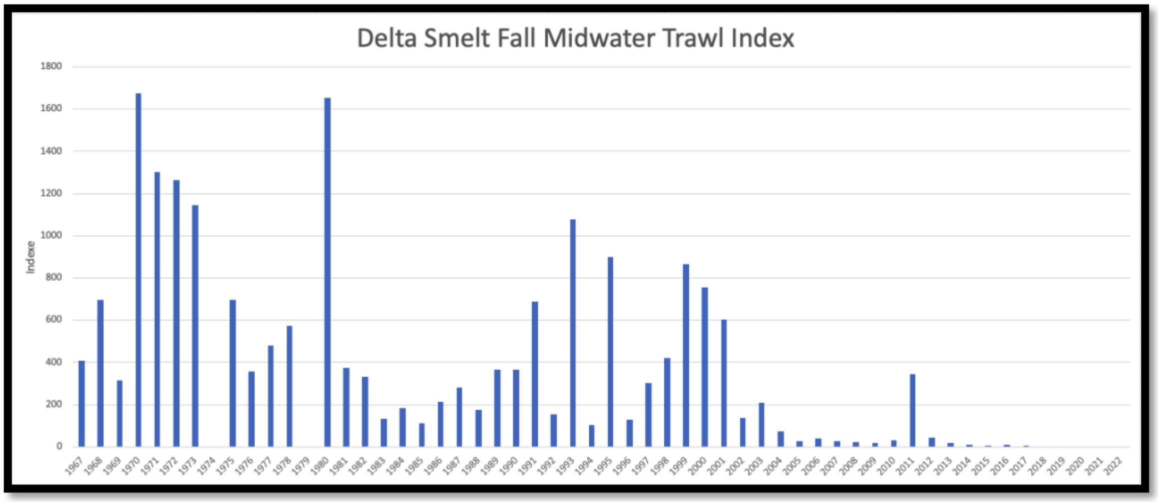


Figure G-1. Chart of Delta smelt fall midwater trawl index. Data source: CDFW.

In essence, there just has not been a consistent increase in the abundance of any potential predator or competitor that could account for the decline of delta smelt.

Drs. Moyle and Herbold (1989) suggest that the Department's effort to enhance the Sacramento-San Joaquin striped bass population through the stocking of hatchery-reared fish could cause excessive predation on delta smelt. Striped bass are highly pisciverous (eat other fish); however, comprehensive striped bass food habit studies (Stevens 1966, Thomas 1967)

81

Figure G-2. Source

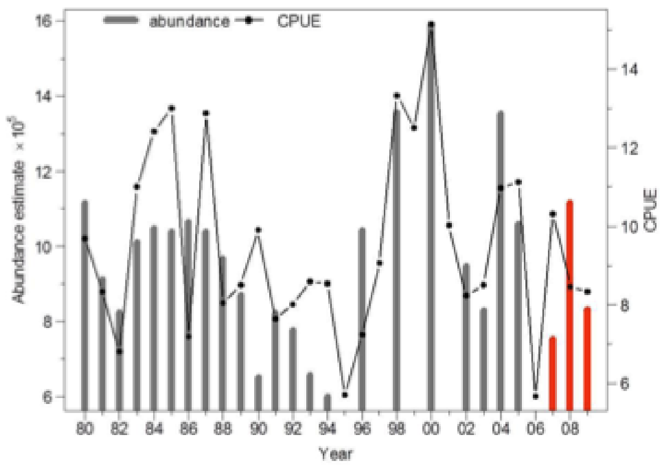


Figure 3 Estimated annual striped bass abundance and partyboat CPUE (success (Table 1); effort as 100 angler-hours); no abundance estimates were made for 1995, 1997, 1999, 2001, and 2006; effort was substantial every year (min: 13,174 hours; max: 117,715 hours; avg: 51,470 hours); red bars indicate preliminary abundance estimates

Figure G-3. Source.

The authors' analyses, interpretations, and conclusions have a major omission. They fail to include the potential role of other native and non-native predatory fish in driving down the population of Delta smelt, regardless of the actual abundance of Delta smelt in the eighty years after stripers were introduced to the Bay-Delta in 1879 and 1882. Dozens of other predatory species also proliferated in the Delta over that past century, especially over the past several decades. Today, those other predatory species are far more abundant than the striped bass, and many are equal if not greater potential predators on young smelt than striped bass. In fact, striped bass are more likely to prey on juveniles and adults of other predator species than on smelt

The authors are from the US Fish and Wildlife Service, the federal agency bound to protect the Delta smelt under the Endangered Species Act. The authors used "California Department of Fish and Wildlife fish monitoring data to provide evidence for a 'phantom predator' hypothesis: that ephemeral but persistent predation by Striped Bass helped to marginalize Delta Smelt before the estuary was routinely biologically monitored." The authors argue against "…a misinterpretation that Striped Bass had little contemporary effect on Delta Smelt," and contend that " …the Delta Smelt population has declined steadily since Striped Bass were introduced to the estuary, and that has masked a substantial predatory effect of Striped Bass on Delta Smelt." The article describes and supports a hypothesis that striped bass remain a problem for Delta smelt, despite the precipitous decline in the production of juvenile striped bass over the past century or so.

To partially address the hypothesis myself, I analyzed some Interagency Environment Program (IEP) data[1] collected over the decade of 2009-2018 from one of the remaining Delta smelt strongholds – the Lower Yolo Bypass portion of the Cache Slough Complex of the North Delta

(Figure 1). Delta smelt were a common seasonal resident of the area (Figure 2). Striped bass, as expected, were very abundant in all age groups over much of the survey periods (Figure 3). But so were many species of invasive non-native predatory catfish, sunfish, crappie, gobies, minnows, tule perch (native)*, black bass, and shad, most of which have been present in the Delta as long as striped bass.*

Black crappie alone made up an equivalent or greater predator force on Delta smelt (Figure 4). In addition, black crappie as well as many of the other abundant predators compete with Delta smelt for their common zooplankton food supply. Not one of these other potential sources of predation or competition is mentioned in the essay.

Nobriga and Smith did acknowledge: "A generalist predator like Striped Bass, however, could suppress Delta Smelt competitors in addition to Delta Smelt, leading to non-linear and counter-intuitive community dynamics." This supports the theory that once-abundant striped bass have been suppressing other non-native predators and competitors of Delta smelt. So how long has that dynamic been functioning? Was it functioning in the hypothesized epoch of "phantom" predation? Did striped bass accelerate the decline of Delta smelt or, by eating and consuming other predators, slow it down? And assuming that Delta smelt really were much more abundant than previously believed prior to widespread monitoring in the Delta, to what degree was predation a factor in that decline?

Figure 1. Map of the Yolo Bypass and the surrounding region, with all locations for all sampling and monitoring locations indicated.

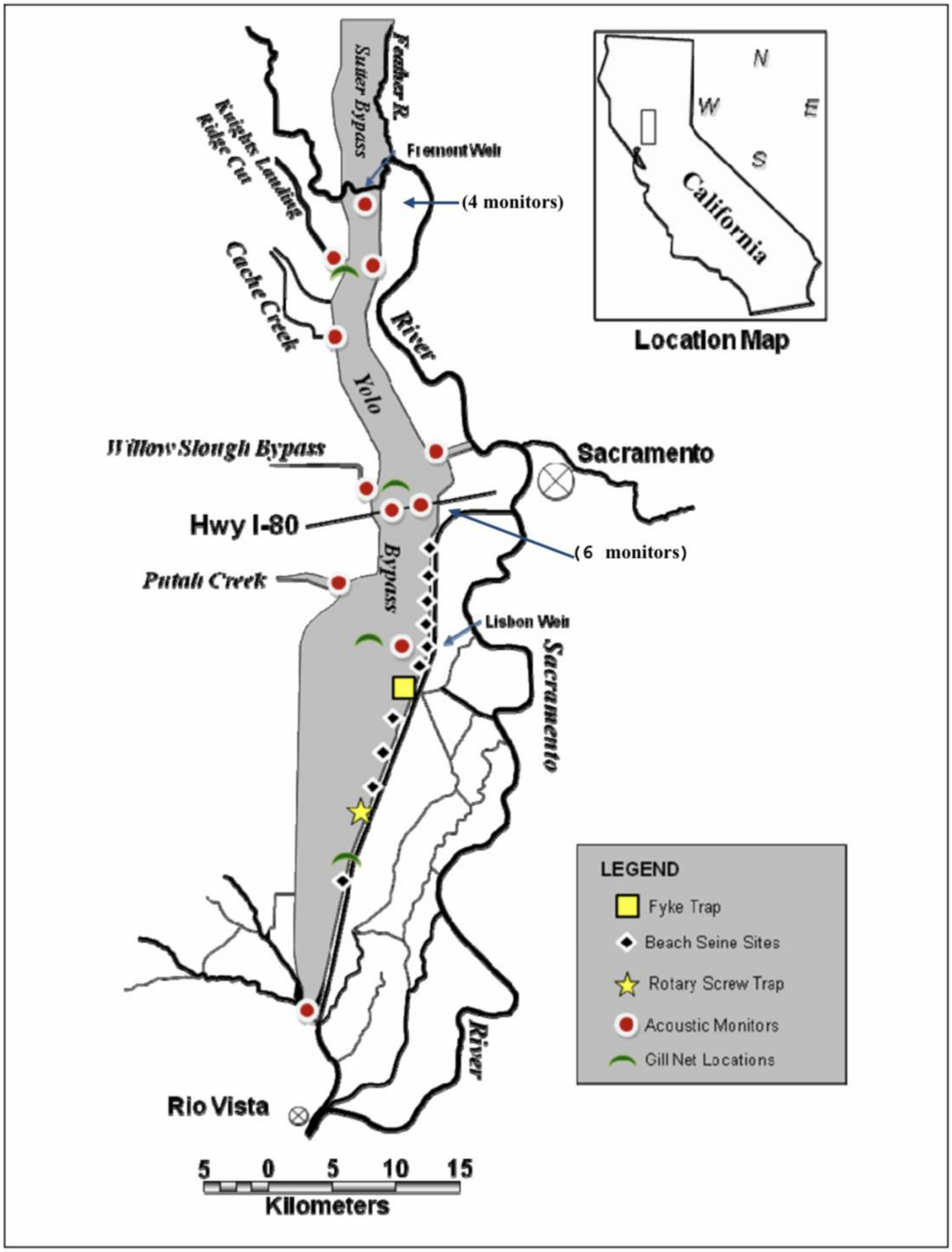


Figure G-4.

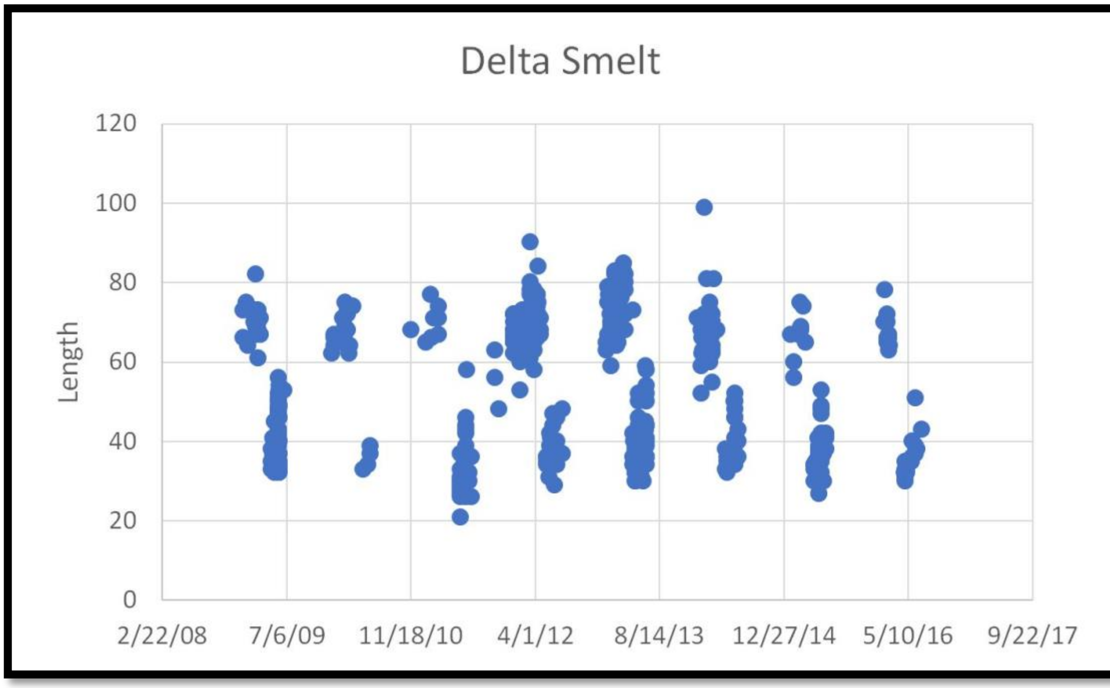


Figure G-5. Lengths of Delta smelt collected in fish surveys in the Lower Yolo Bypass, 2009-2018. Note that up to 70% of the smaller young 20-60 mm smelt were later genetically identified as Wakasagi.

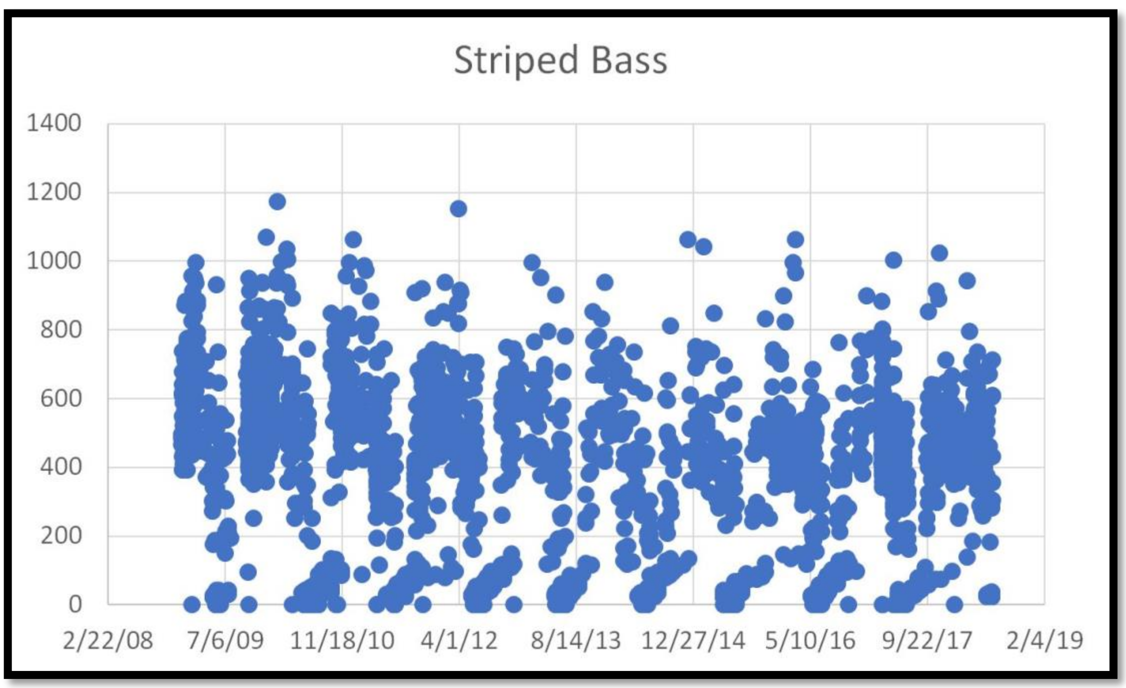


Figure G-6. Lengths of striped bass collected in fish surveys in the Lower Yolo Bypass 2009-2018.

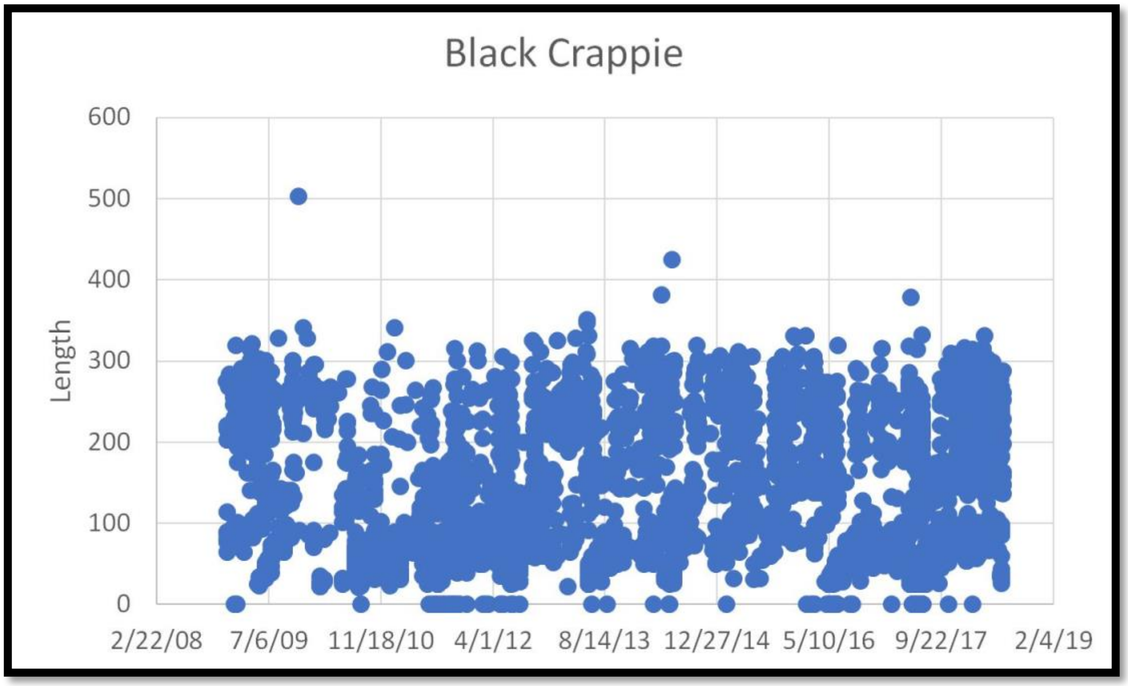


Figure G-7. Lengths of black crappie collected in fish surveys in lower Yolo Bypass 2009-2018.

1. https://www.fws.gov/lodi/juvenile_fish_monitoring_program/edsm/?dir=Enhanced%20Delta%20Smelt%20Monitoring%20Daily%20Report↩

H. DRAFT SCIENTIFIC BASIS REPORT SUPPLEMENT IN SUPPORT OF PROPOSED VOLUNTARY AGREEMENTS FOR THE SACRAMENTO RIVER, DELTA, AND TRIBUTARIES UPDATE TO THE SAN FRANCISCO BAY/SACRAMENTO-SAN JOAQUIN DELTA WATER QUALITY CONTROL PLAN – Prepared by State Water Resources Control Board California Department of Water Resources California Department of Fish and Wildlife January 2023

- *It is currently unknown if or to what extent predation by native (chiefly Sacramento pikeminnow) and nonnative (chiefly striped bass, catfishes, and black bass) fishes is a limiting factor in the flood bypasses. Sommer et al. (2001b) hypothesized that predator encounters may be lower in the Yolo Bypass. Unpublished data suggest that as flow decreases and temperature increases, survival of juvenile Chinook salmon decreases. Predation may be situational and dependent on environmental conditions (Ward and McReynolds 2004; DWR 2019). This limiting factor warrants further investigation.* (p2-18).

  Comment: Predators like silversides, pikeminnows, crappie, black bass, and catfish are generally abundant and ubiquitous throughout the Central Valley floodplain, bypasses, and Delta tidal channels. Falling river flows coincident with spring reservoir storage recovery create a period of habitat overlap between salmon juvenile emigrants (wild and hatchery) and these many potential predators. In drier years, the overlap is a regular occurrence and a likely factor in poor numbers of salmon smolts reaching the ocean. Even in the four most recent wetter years – 2011, 2017, 2019, and 2023 – there was usually a spring overlap (Figure H-1 and H-2). The spring target for the Lower Sacramento River in wet years should be 65°F with a maximum of 68°F; river and Delta net flows should be maintained near 15,000 cfs through May and near 10,000 cfs in June. The same pattern should occur about a month earlier in drier years.

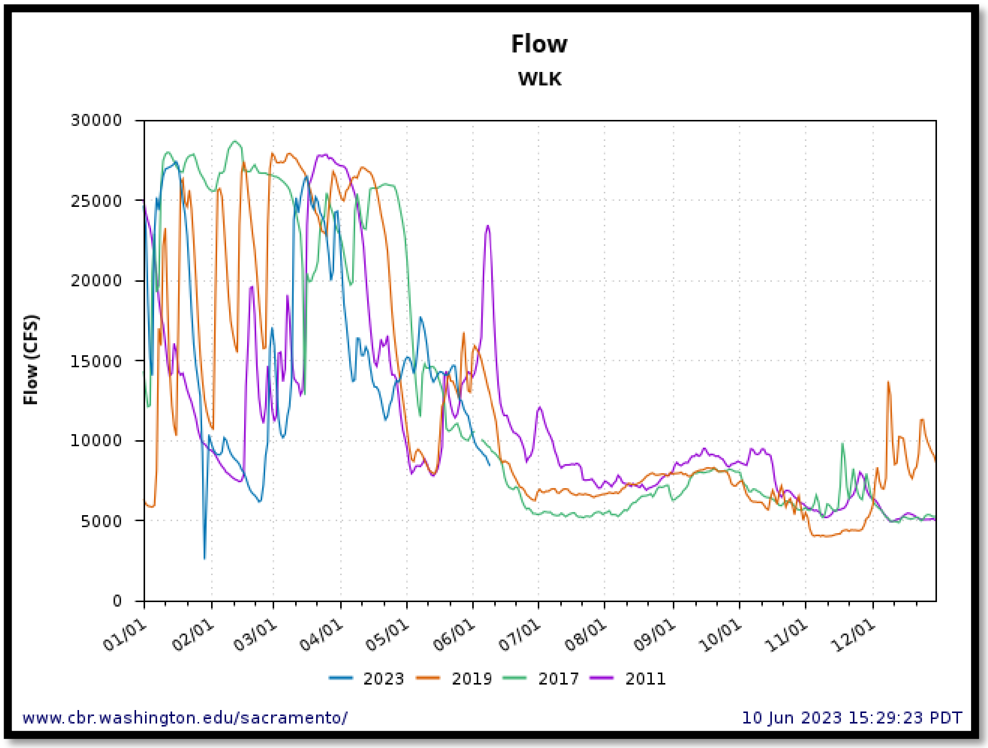


Figure H-1. Streamflow at Wilkins Slough gage on lower Sacramento River in four recent wet years.

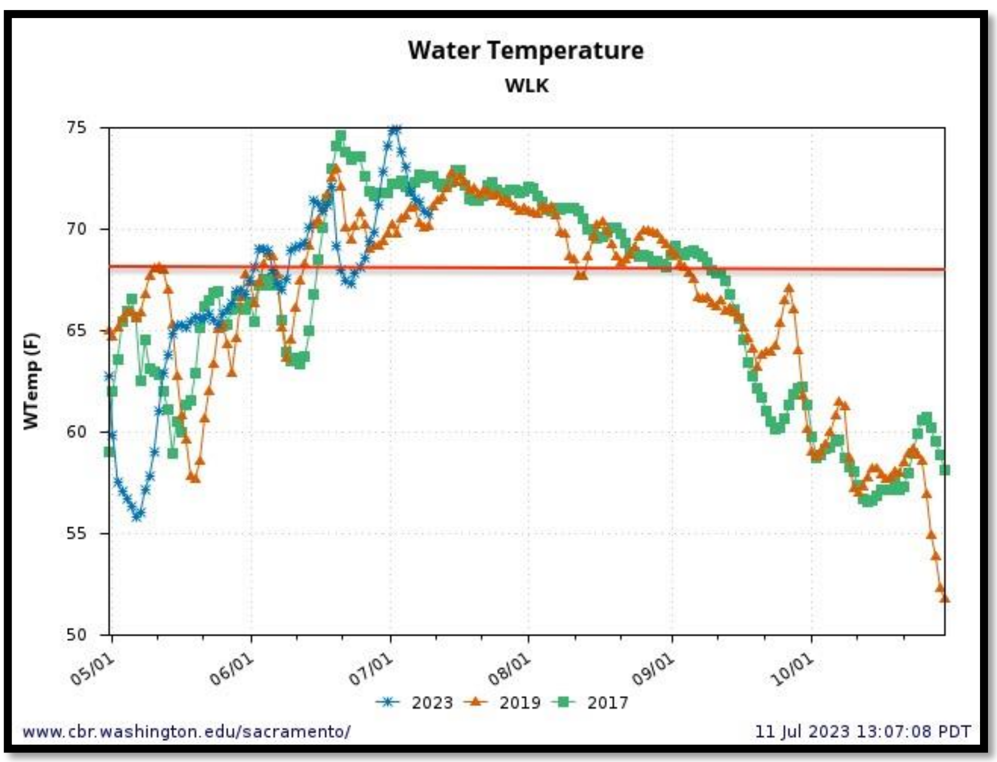


Figure H-2. Water temperature in three recent wet years at Wilkins Slough gage in lower Sacramento River. Red line is water quality standard.

I. Should the striped bass be a suspect in the decline of the Delta smelt?[17]

Comment: This article is a follow up to an earlier article (Appendix G). The author begins by describing the speculative nature by the original paper's authors about the role played by striped bass in the decline of native fishes. It should be noted that there is no biologist, resource manager, recreational fisherman, or government official who would consider stocking striped bass into a virgin San Francisco Bay Estuary today. Almost everyone clearly understands the risk and potential harm of introduced fishes – it was only a decade or so ago that the threat of Northern Pike invading the Sacramento River watershed was real. All three authors simply want to express their fear of reconsidering the striped bass's pecking order in the Central Valley. Though we sincerely agree with the fear and risks, it seems unfair to overstate the role of striped bass in the decline of estuarine and riparian native species, including salmonids. Like it or not striped bass are here to stay; their role or population level, however, remains an open question. There is no doubt that both striped bass and Delta smelt were several orders of magnitude more abundant just five decades ago. Now, with both hanging on the verge of irrelevance, a reconsideration of their roles and importance is needed.

"…The smelt's baseline might have shifted long before anyone was paying attention, and striped bass predation may have constrained its numbers before recent water diversions and food web changes added their effects."

Comment: Though this is possible, it is also possible that swamp reclamation and placer gold mining in the watershed exerted effects a century ago. The important point is the authors' understanding of the cause of the recent decline that they monitored.

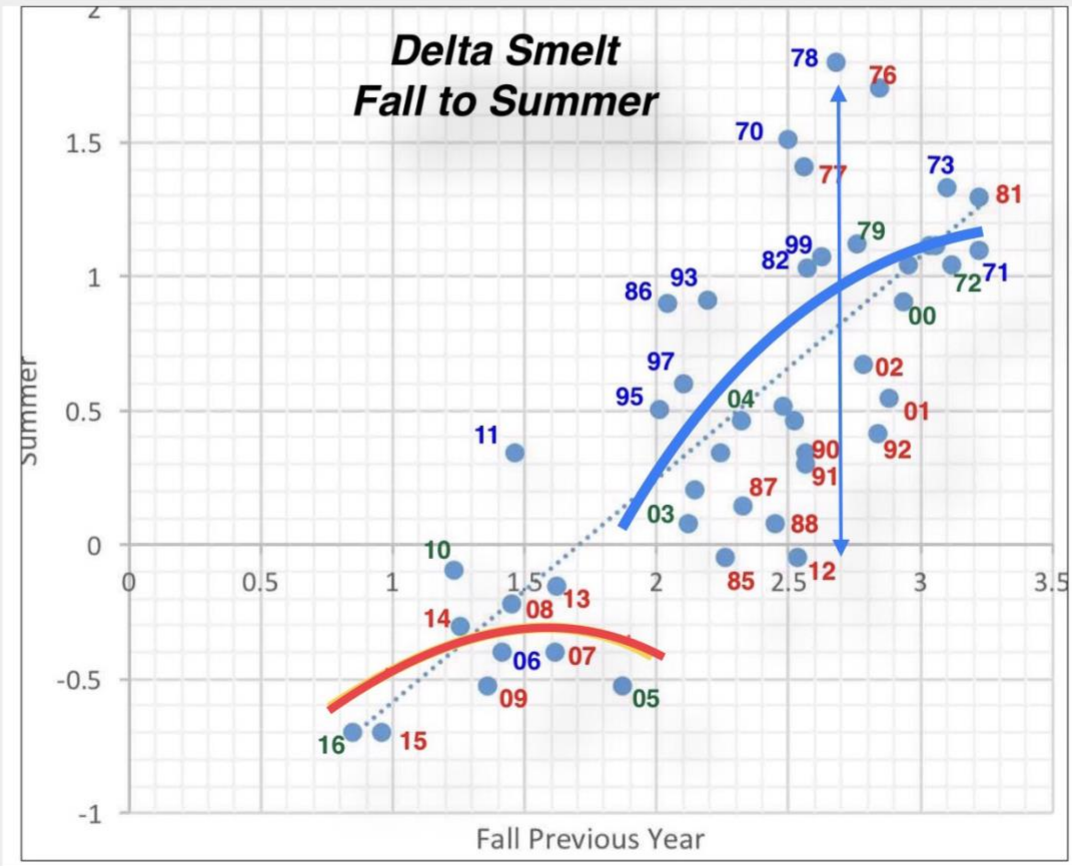
"Nobriga notes that Delta smelt don't respond predictably to changing flows: "From what we know about its basic biology, it should have good responses in wet years and poor responses in dry years, like longfin smelt and young striped bass. The data haven't shown that. Something is getting in the way of its response."

Comment: Contrary to this theory, the data do show the Delta smelt production *does* respond to wet-dry conditions (see Figure 11, year 2011; and Figure I-1). The authors imply striped bass are getting in the way, despite providing no evidence of that occurring. The real problem in recent decades for both smelt and striped bass is the POD, with the shift in reproduction in the mid-2000s (Figure I-1). Before the POD, smelt production was ten times higher on average in wetter years. There is more on this topic in the Smelt Chapter.

"A tiny change in the fraction of Delta smelt in its diet would account for a big change in the abundance of Delta smelt." This effect could account for apparently chaotic patterns of smelt abundance.

Comment: This argument degenerates into pure biased speculation. The odds of a striped bass finding a Delta smelt are now infinitesimally small. Other predators far outnumber the striped bass. Few small striped bass persist. The multi-aged adult striped bass population has far better prey options than small smelt. Hungry striped bass are following the hatchery trucks and net pens full of fat salmon – most of which are released in the Napa River estuary smelt sanctuary. Yes, hatchery salmon smolts eat young smelt.

[17] https://archive.estuarynews.org/striped-bass-suspect-decline-delta-smelt/



— The relationship (log-log) between the fall midwater trawl index and the subsequent summer townet survey index (year noted) is remarkably significant, especially when water-year type is taken into account. Red years are dry/critical. Green years are below/above normal. Blue years are wet.

Figure I-1. Delta smelt spawner-recruit relationship. Source.

"Nobriga and Smith don't advocate bass suppression as a smelt management tool (which would be controversial; like the eucalyptus, the bass is an exotic with a strong fan base). Such an effort might have unanticipated consequences, such as increased competition for the smelt from other bass prey species, like Mississippi silversides."

Comment: No, it's because it wouldn't do any good – other smelt predators are far more abundant**.**

"But they suggest any attempt to supplement the dwindling smelt population with captive-reared fish should consider the bass factor. "There's nowhere Delta smelt can go to get away from striped bass,"

Nobriga observes. A smelt can dive to evade birds or swim out of a pikeminnow's salinity comfort zone, but that wouldn't deter a bass. "What seems to help is turbid water." Smelt tolerate turbidity, but striped bass have trouble locating prey in turbid conditions."

Comment: Couldn't be further from the truth. Striped bass experts are "rolling on the floor" at this point.

In conclusion: Striped bass were certainly among the many human-induced villains entering the picture a century ago, but they are a minor factor in the forces of Delta smelt population recovery today. There are so many better fish to fry, so to speak**.**

J. STATUS OF STRIPED BASS IN THE SACRAMENTO-SAN JOAQUIN ESTUARY (Kohlhorst CDFG 1999)[18]

Adult striped bass abundance and mortality rates have been monitored since 1969 with mark-recapture techniques (Stevens 1977b). Reward and nonreward disk-dangler tags (Chadwick 1963) are applied to legal-sized striped bass captured during their spring spawning migration in the Sacramento-San Joaquin Delta and the Sacramento River. Recaptures during tagging in subsequent years and during a creel census are used to estimate abundance; tags returned from anglers through the mail and during the creel census are used to estimate mortality rates. From 1969 to 1976, estimates of the legal-sized striped bass population were relatively stable, ranging from 1.5 to 1.9 million fish (Fig. 1a). Since then, estimated abundance has declined, first to 800,000–1.2 million fish in the late 1970s and 1980s, followed by a further decrease to only 579,000 legal-sized fish in 1994.

The adult striped bass population decline primarily reflects reduced recruitment. Estimates of the abundance of 3-year-old fish, which are the youngest and most numerous component of the adult population, have also declined and were at a record low in 1996 (Fig. 1b).

[18] Kohlhorst: California Fish and Game 85(1):31-36 1999

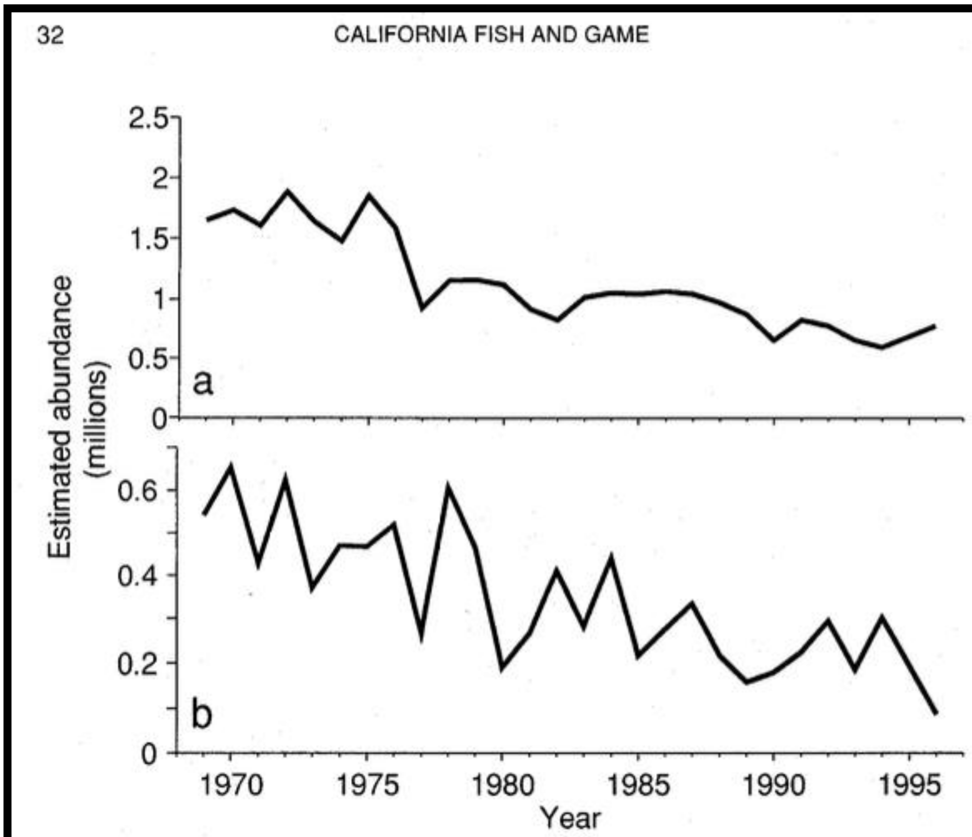


Figure 1. Estimated abundance of a) legal-sized and b) age-3 striped bass in the Sacramento-San Joaquin Estuary, 1969–1996.

Comment: The CDFG striped bass population survey used mark-recapture on a large scale to estimate the population of striped bass in the Bay-Delta estuary. The survey enabled CDFG to observe the significant population declines following the 1976-77 and 1987-92 droughts. The information led to a recovery effort involving hatchery production and pen-rearing of salvaged striped bass that brought the population back to near pre-1976 levels of over one million striped bass. An updated survey effort is included in our recommended recovery/maintenance action for striped bass to track our recommended 200,000-500,000 adult population range target.

"The adult striped bass population decline primarily reflects reduced recruitment. Estimates of the abundance of 3-year-old fish, which are the youngest and most numerous component of the adult population, have also declined and were at a record low in 1996 (Fig. 1b)." (p31)

Comment: The management program for striped bass should include adequate monitoring of three-year-old recruits, allowing managers to control population abundance when controls and monitoring are most effective and when applied at the earliest opportunity**.**

"Evaluations of potential causes of the post-1976 YOY striped bass decline concluded that it probably was caused by some combination of 1) the reduced adult stock producing fewer eggs, 2) reduced food production in the nursery area, (3) increased, losses of young fish entrained in water diversions, and (4) toxicity (Stevens et al. 1985)." (p32)

Comment: Potential causes remain the same after more than 40 years of subsequent study.

"In addition to the effect on recruitment of decreased young striped bass production, estimated mortality rates of adults also have changed. Estimated total annual mortality rate has shown a significantly increasing trend since 1969 (F = 7.35; df = 1, 24; P <0.05) and reached its highest level (0.67) in 1993 (Fig. 3). This change in total mortality is the result of a significant increase in estimated "natural" (due to factors other than legal fishing) mortality rate (F = 14.1; df = 1, 24; P <0.01), whereas estimated harvest rate exhibited a significant downward trend (F = 9.89; df = ,1 25; P <0.01) (Fig. 3). The cause(s) of the increase in estimated natural mortality is unknown." (p33)

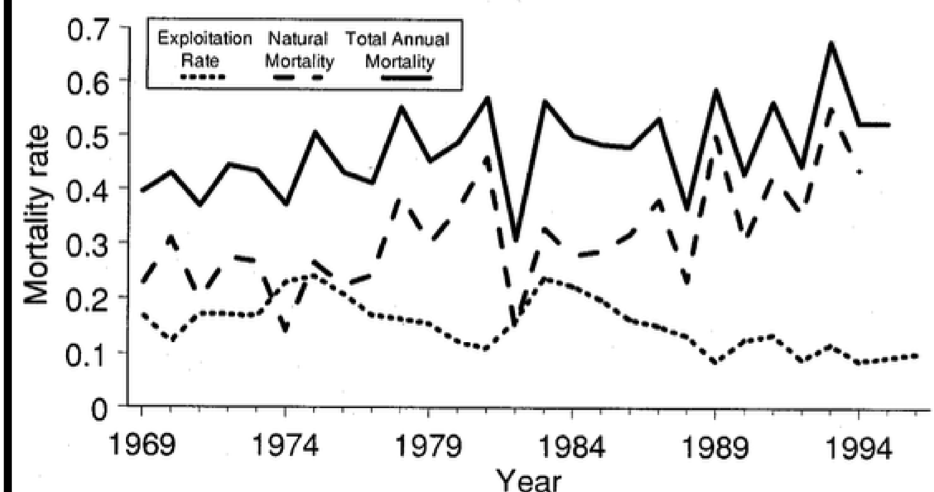


Figure 3. Estimated mortality rates of legal-sized striped bass in the Sacramento-San Joaquin Estuary, 1969-1996.

Comment: The increase in the natural mortality rate in the adult striped bass population observed by CDFG coincides with the reduction in Delta outflow that began in the 1970s with the higher South Delta exports of the SWP Delta Pumping Plan (see Figure A-1). Climate change, water management, river and Delta water temperatures, poaching, and disease all likely contributed. Such natural mortality estimates are derived from adult population estimates that should again be monitored. Striped bass have been and remain one of the *canaries in the coal mine*.

"As a result of the initial decline in estimated legal-sized striped bass abundance in the late 1970s, and also in response to public pressure for supplementation stocking, the California Department of Fish and Game began a hatchery program starting with the 1980 year class, stocked as yearlings in 1981. The number of fish stocked increased from about 63,000 for the 1980 year class to almost 3.4 million for the 1990 year class (Fig. 4a)." (p34)

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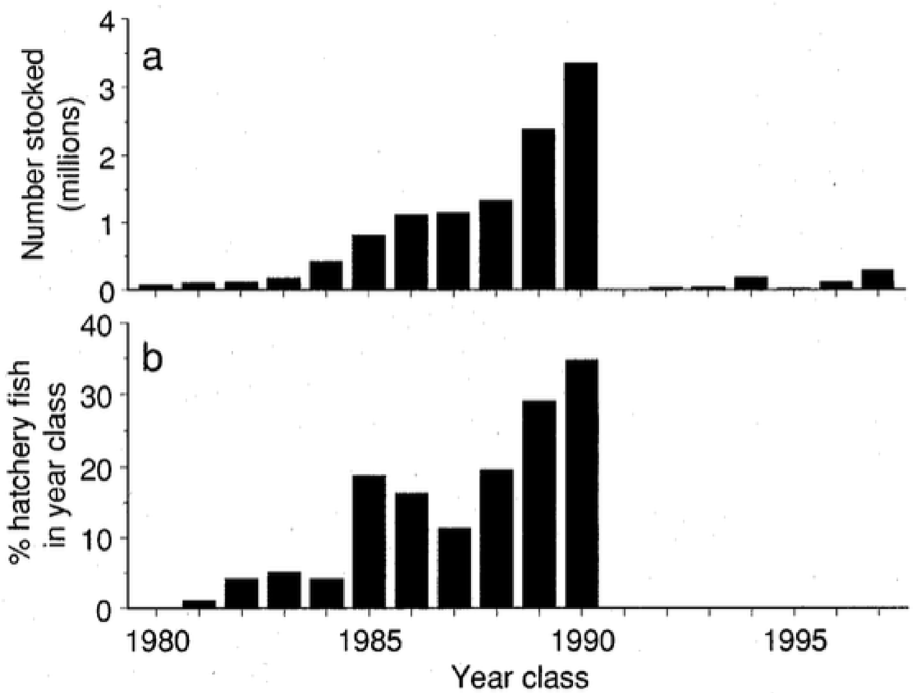

Figure 4. a) Number of hatchery-reared striped bass stocked in the Sacramento-San Joaquin Estuary, 1980–1997 year classes. b) Percent contribution of hatchery-reared fish to each striped bass year class in the Sacramento-San Joaquin Estuary from the 1981 to the 1990 year class. No hatchery fish were marked in 1980 and data have not been summarized for net-pen-reared year classes from 1992 to 1997.

"The hatchery program changed substantially in 1992 as a result of concern over potential predation by striped bass on threatened and endangered species, such as Sacramento River winter-run chinook salmon, Oncorhynchus tshawytscha, and delta smelt, Hypomesus transpacificus, and all stocking of hatchery-reared striped bass was suspended (Age-1 fish from the 1991 year class were not stocked in the estuary). Instead, 22,000-284,000 fish obtained from fish screens in the southern Sacramento-San Joaquin Delta and reared in floating pens have been stocked annually, beginning with the 1992 yearclass released as yearlings in 1993 (Fig. 4a). In most years, a fraction of the stocked fish have been externally marked or coded-wire tagged to allow estimation of their contribution to the population."

"Hatchery fish have contributed measurably to the population of each year class in the estuary, especially at the higher stocking levels. Estimated percentage of hatchery-reared striped bass in each year class increased from about 1% for the 1981 yearclass to almost 35% for the 1990 yearclass (Fig. 4b) (Harris and Kohlhorst', in review). The contribution of hatchery-reared striped bass to each year class is linearly related to stocking rate (12 = 0.88, P <0.001)." (p34)

Comment: The use of salvaged "wild" young striped bass for pen rearing continued for a decade before the practice ceased because of concerns over predation of endangered salmonids. We do not propose reinstating such a practice (or stocking hatchery-raised striped bass), but we do recommend transporting salvaged striped bass (normally a late spring or early summer peak) to an appropriate location in the Bay rather than to the western Delta.

"Greater stocking of age-1 and age-2 striped bass (up to 1.275 million age-1 equivalents) reared in hatcheries and pens is planned to begin in summer 2000. This stocking is the focus of the Striped Bass Management Conservation Plan being prepared according to federal Endangered Species Act requirements."

Comment: The Conservation Plan was not approved. Some of the last striped bass releases involved hundreds of thousands of age 3-4 striped bass (2-4 lbs each), which likely contributed measurably to the population recovery that occurred at that time (see Figure 4). We hypothesize that the large releases of pre-adult pen-reared striped bass may have contributed to the POD and declines in striped bass age-0 recruitment in the early 2000s, while increasing sportfishing success (see Figure G-3).

K. Fish predation on a landscape scale in the delta – NMFS/University of California Santa Cruz presentation 2020[19]

"Predation is a challenge in the Sacramento–San Joaquin River Delta where non-native predators are known to have substantial impacts on salmonid and other native fish populations; however, resource managers lack the knowledge of the landscape-scale predator–prey information to mitigate these impacts."

Comment: Resource managers, fishermen, and most Central Valley residents are aware that striped bass and other non-native and native predatory fish are a *landscape wide* problem in the Central Valley. Throughout the various chapters in our proposed recovery plan, we describe the order of magnitude lower survival of salmon and steelhead smolts to the ocean during drier years. Much of that lower survival is a consequence of predation on wild and hatchery salmon and steelhead smolts on their way to the ocean. Our recommended recovery program focuses on reducing that problem through the multiple actions outlined in this chapter. To maintain 10% of the historical number of striped bass, we should provide additional protections to minimize their impact on salmon and steelhead.

"These studies have shown that we see about 5% survival to the ocean on average, which is much lower than other large West Coast rivers and does not allow for sustainable fisheries."

Comment: From the Klamath River north to Alaska there are many predators that prey on salmon and steelhead, including seals, sea lions, orcas, beluga whales, and sea birds. What makes the Central Valley so different? Five things: Most of our hatcheries are hundreds of miles from the ocean. We have huge storage reservoirs that capture much of the storm runoff in drier years. We have huge diversions that capture millions of acre feet of runoff (over half in dry years), two of which take water directly from the salmon Delta migration route. The Central Valley and Bay-Delta have striped bass – the ultimate fish

[19] https://mavensnotebook.com/2020/10/14/fish-predation-on-a-landscape-scale-in-the-delta/, https://afspubs.onlinelibrary.wiley.com/doi/full/10.1002/nafm.10391

predator in what is often ideal habitat for this non-native species. And finally, the Central Valley's rivers and the Bay-Delta are warmer than the rivers to the north, putting the California salmon at the southern end of their natural geographic distribution**.**

"The researchers wanted to help resource managers answer the questions, how can we reduce predation on juvenile salmon? Can we just simply remove some of these predators? So they took those two questions, and formulated a research question for their first study, which was, are localized predator removals feasible and effective at reducing predation and ultimately increasing salmon survival?"

"The predator manipulation experiment was a Before After Control Impact (or BACI) design that was done in the Lower San Joaquin River in the Delta which is tidally influenced."

"The first thing we learned is that localized predator removals don't appear to work in this system, or at a minimum, that there's more powerful drivers of predation risk and salmon survival and the signal of the predator removals is being swamped out by these more power drivers. So this was an important realization for us that we really need to better understand these other drivers of predation risk in salmon survival."

Comment: The results of this and similar studies in the Central Valley and on the Columbia River also focused us on approaches other than direct predator control.

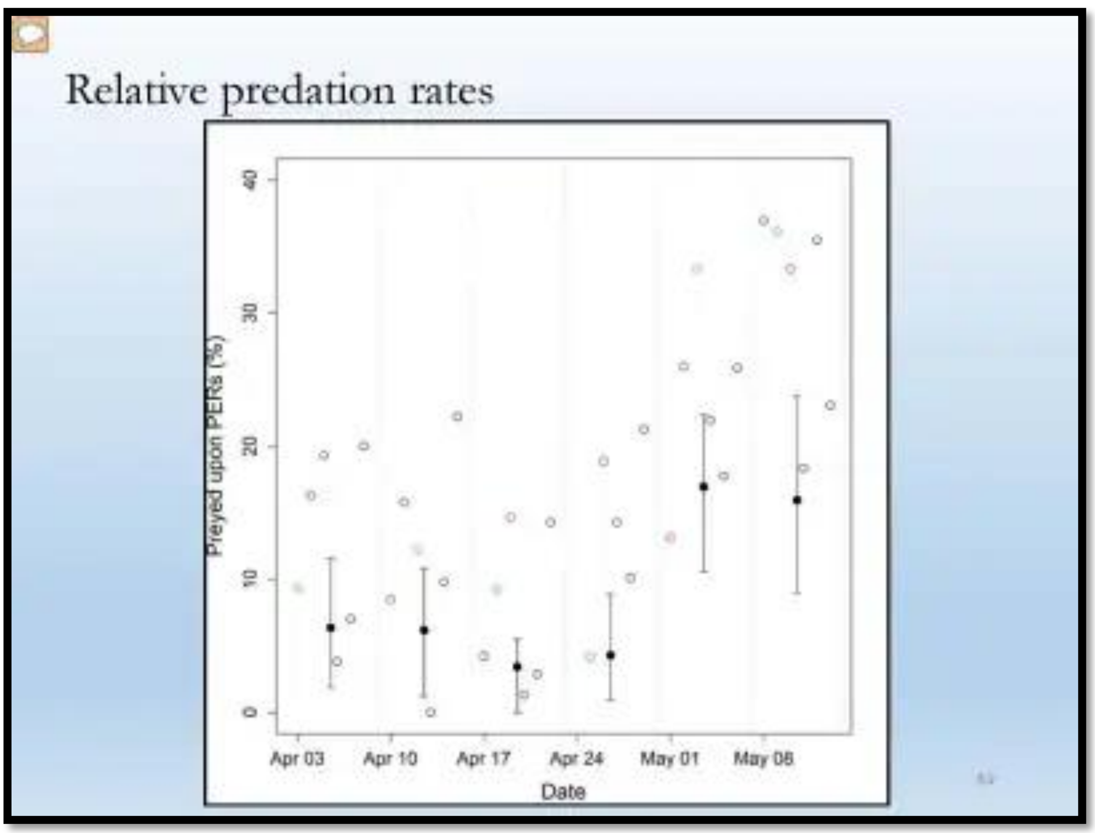

Figure K-1. Study results showing rate of predation on tag release salmon smolts in 2017.

Comment: The study results showed higher predation rates later in spring as waters warmed. Long-standing scientific literature shows that striped bass and other non-native fish predators are more active and effective at higher temperatures and juvenile salmonids are more vulnerable at higher temperatures.

"*We used every possible combination of those habitat and environmental variables to build multiple different models as we wanted to see which model had the most ability to explain the dynamics in predation risk*," Mr. Michel said. "*Of all those models that we tested, the top model had four covariates in it. And so I'm going to walk you through the response plots for those four different variables*."

Comment: The take home here is that predator density does matter for predation risk.

- Bottom roughness is an important factor as well. When the bathymetry is more complex, there's a higher predation risk.
- Time to sunset is very important, as was predicted.
- The most important predictor of predation risk was temperature. At the higher end of the measured temperatures 20C/68F – the predation risk was four times greater than during mean conditions.

"One thing they found was that predation risk changes depending upon the time of year. Early in the season, predation risk was fairly low across the system due to cold water temperatures, but as the spring progressed and water temperatures become warmer, there were increases in predation risk to the point where by late May, predation risk skyrockets."

Comment: The empirical evidence cited here supports our recommendations on maintaining spring water temperatures below 68^{o}F in the Central Valley migration corridors to sustain salmon and steelhead recovery. But while lower temperatures might help minimize predation and enhance the ability of juvenile salmonids to avoid predators, it really does not help with striped bass predation because 65-68^{o}F is their preferred feeding temperature. Striped bass (like salmonids) do not like warm water (>70^{o}F). This why we recommend 60-65^{0}F in sanctuaries and migration routes as well as early spring flow pulses to move smolt salmonids to the Bay. Segregation weirs are also important to keep striped bass out of sanctuaries. Dry year capture and transport of wild salmonid smolts (and striped bass) at segregation weirs and transport to the Bay in spring is also an important action in our plan. Note: we see the irony of taking the striped bass to the Bay as well, however, the prey base is far more diverse and abundant in the Bay than in the rivers where the salmonids dominate the prey base.

"There is the lower portion of the south Delta, there's a lot of different areas that have differing predation risk, and near the upper portion of the south Delta, we see that predation risk seems mostly homogenous except for one particular site that has very high predation risk which happens to be the Head of Old River site."

Comment: Like the Delta Cross Channel, the Head of Old River and head of Georgianna Slough should be closed or screened in the spring. These are predation hotspots that warrant immediate correction**.**

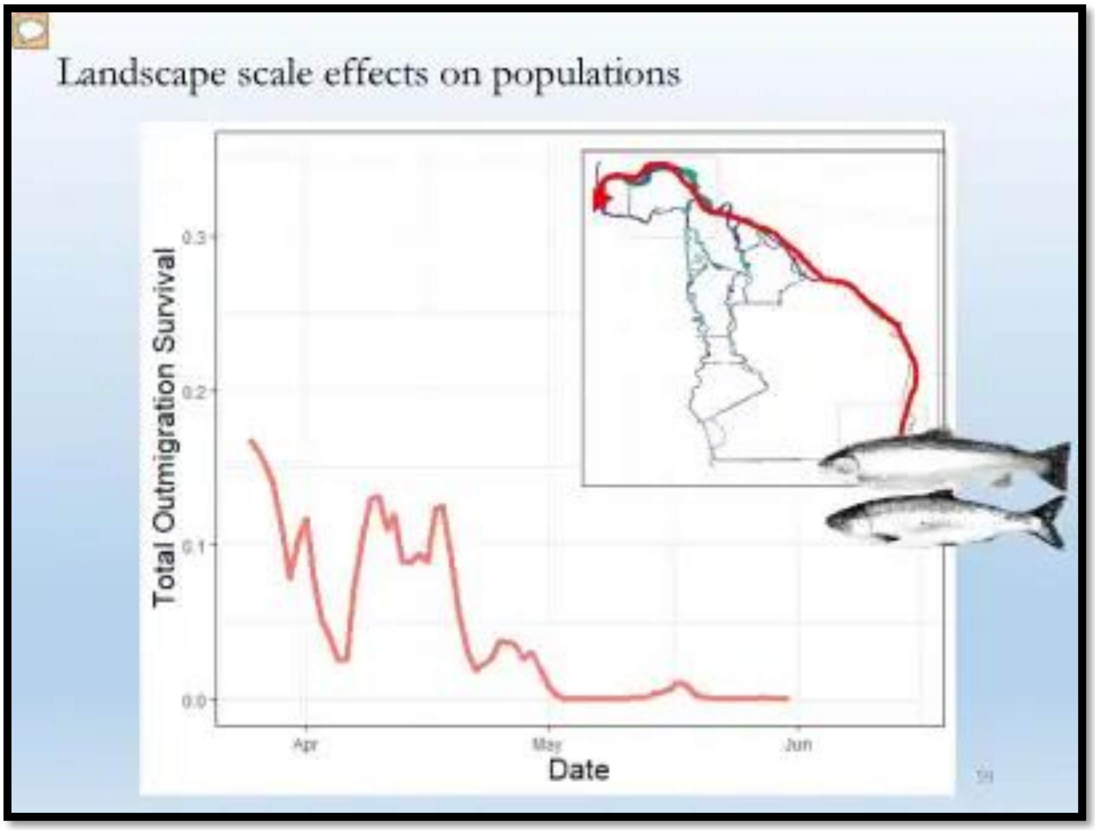

Figure K-2. Model prediction of survival through the Lower San Joaquin River Channel during the Delta in wet year 2017.

"What we see for this spring of 2017, was that through Delta survival was relatively good during the late March early April period, but then as temperatures increase, especially into early and late May, survival really goes to zero."

Comment: This result supports our recommendation for an early spring pulse streamflow throughout the Central Valley. In some wet years and in all dry years, it may be necessary to trap all emigrating wild juvenile salmonids at segregation weirs beginning in early spring for transport to the Bay. The chart below (Fig K-3) shows the catch per unit effort from the trawl and represents salmon entering the Delta.

"*What we see is in the spring of 2017, the majority of the salmon were entering the Delta during the worst time, when our model was predicting total outmigration survival of near zero*,".

"Another scenario is imagining if temperature can be managed in the Delta. Mr. Michel noted that while we might have control over when hatchery fish move through the Delta, we don't really have control over when the wild fish are going to move through and they are the fish we're most concerned about, so if we could increase survivorship of salmon through this May period when a lot of fish seem to be moving through, it could be great for wild fish."

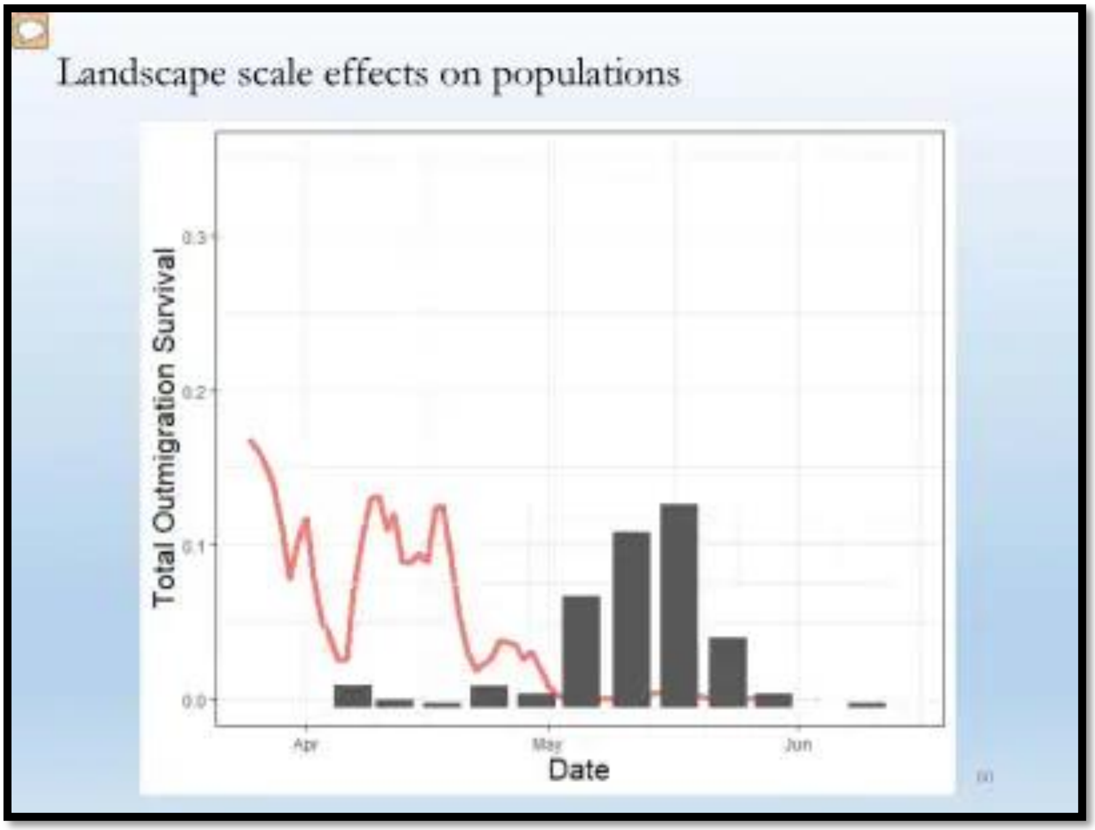

Figure K-3. Timing of Lower San Joaquin salmon smolt migration into the Delta in 2017.

Comment: While many of the smolts in Figure K-3 were likely Mokelumne and Merced hatchery fall-run salmon smolts released near these hatcheries, they also likely included wild smolts. We recommend trucking all hatchery smolts to the Bay or Coast. Wild smolts can only be protected through flow pulses and water temperature standards (<65-68^{o}F) in spring, or by capture and transport from segregation weirs to the Bay.

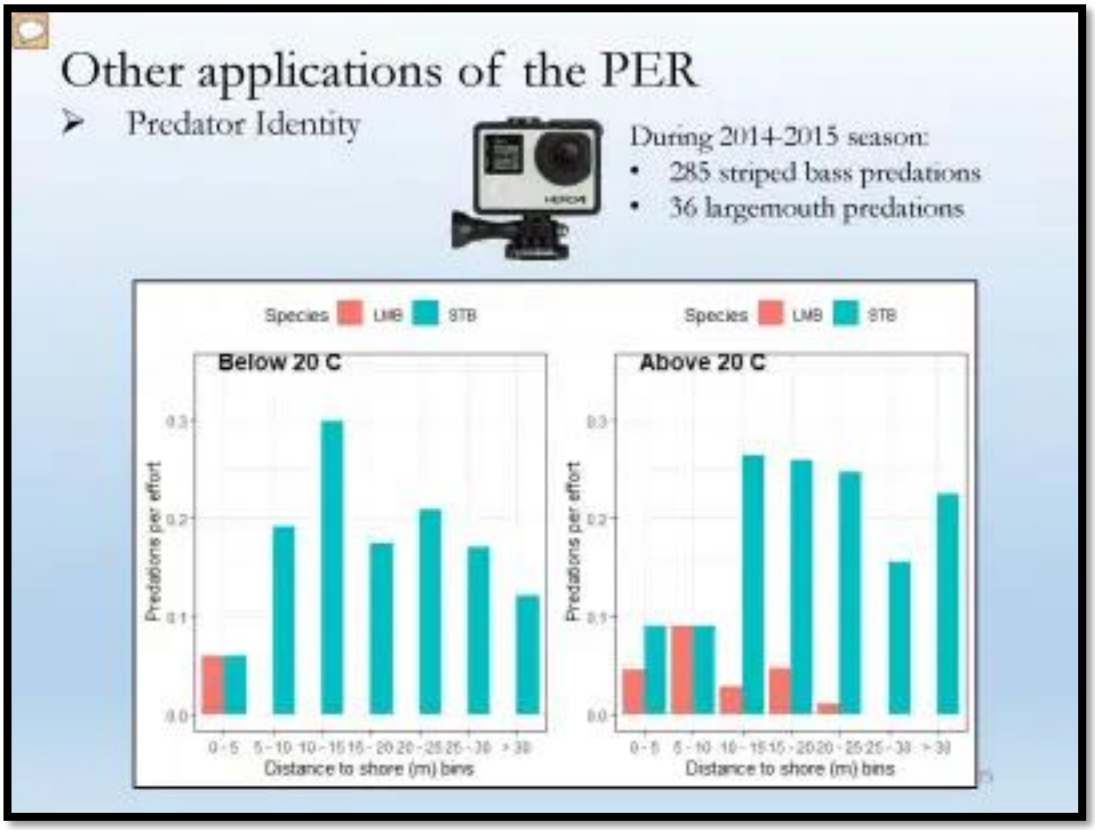

Figure K-4. Effects of prey species and water temperature in study.

"What we see is the largemouth bass predation events tend to occur nearshore while the striped bass predation events tend to occur further offshore, which is not a big surprise to people familiar with the system," said Mr. Michel. "*What's interesting too is you can parse this out by predation events occurring below 20 degrees Celsius versus above 20 degrees Celsius; there's also an important dynamic there where these largemouth bass are fairly inactive at these lower temperatures but they tend to wake up above 20 degrees Celsius and there's a lot more predations in this nearshore littoral zone*."

Comment: As noted earlier, striped bass predation remains a problem at temperatures down to 65°F. When water temperatures in spring reach 60°F, striped bass start moving into Central Valley rivers and lower tributaries. Water management should delay this event as long as possible. After water temperatures reach 60°F below segregation weirs, wild juvenile emigrants should be captured and transported to the Bay. We also recommend capturing striped bass in lower tributaries in spring and transporting them to the Bay where water temperatures are below 60°F.

Question: Can you speak a little bit about the significance of these results relative to the low flow conditions in 2014 and 2015, that is, during the drought? Mr. Michel: "In 2014-2015 when we attempted those predator removals, that was right in the middle of a historic drought here in California and I think that played a large role in the fact that we did not measure a response to our predator removals. That's what I insinuated earlier, which was that the noise created by this drastically changing environment swamped out the signal of the predator removals, and what I mean by a drastically changing environment is, due to this drought, water temperatures in the Lower San Joaquin River were *abnormally high for the springtime to the point where we actually had to end one of our study seasons early because the salmon were not surviving when they were attached to our PERs just due to poor water conditions… So that's an important point, and perhaps studying predator removals should be done again during more normal conditions, and I know there's some work going on in a major tributary here in California in the Stanislaus where they are looking into predator removals again, so more research to come on that, I'm sure*."

Comment: We recommend capturing striped bass in lower Central Valley salmon tributaries such as the Stanislaus River in spring and transporting them to the Bay, especially in dry years, and where and when possible.

Question: What do we do with all the removed fish? Since relocation within the same general area is not a solution, as demonstrated by your removal translocation work. Mr. Michel: "Removing predators, in this system at least, is controversial, and a lot of large, powerful fishing advocacy groups really enjoy fishing for striped bass and largemouth bass. So when you talk about removing these predators, it can really cause problems, and that's part of why we designed the study as we did, because we saw value in having a supersaturated predator site for one, but also realized that it would be less controversial to just relocate predators than to remove them completely."

Comment: While we do recommend relocation of striped bass, we do not recommend relocating other predators, including black bass. Relocation of other predators to other freshwater habitats not in the direct Bay-Delta watershed is a reasonable option. If the target goals for striped bass are exceeded, then limiting striped bass relocation to the Bay could be reasonably reconsidered by resource managers. Relocated striped bass should be tagged and if their rate of return to Valley tributaries is high, the relocation program should be reevaluated.

Michel et al 2020 p14: ***Management Implications***

"We believe that there are four major approaches to be considered for mitigating the effects of predators on salmonid smolts in the Sacramento–San Joaquin Delta.

> *First, resource managers may attempt to reduce the risks associated with the predator population, whether by way of topdown controls, such as targeted removals and increased fishing limits, or bottom-up controls, such as managing the populations of nonnative forage species (crayfish, Threadfin Shad Dorosoma petenense, etc.) that sustain the large predator populations.*
>
> **Comment:** We do not recommend these measures, except for using regulations to reduce the harvest of striped bass if the population falls dramatically and the population target is not sustained.
>
> *Second and more promising, resource managers may attempt to reduce the predator exposure and minimize the spatial and temporal overlap of predators and smolts by using actions such as pulse flows that may help smolts to move through the Sacramento–San Joaquin Delta faster or control of the nonnative submerged aquatic vegetation that provides habitat for Largemouth Bass along the migration corridor (Conrad et al. 2016).*
>
> **Comment:** We recommend and generally support such actions.

Third, resource managers may attempt to manipulate water quality to reduce the foraging success and energetic demands of predators (e.g., increased turbidity and reduced temperature) and increase the juvenile salmonids' ability to evade predators.

Comment: We recommend and generally support such actions.

Fourth and more generally, managers may also consider ways to restore habitats to promote the return of native fish communities and reduce the presence of nonnatives; some limited areas of the Sacramento–San Joaquin Delta are dominated by native fishes, and the habitat attributes of these areas may help to guide restoration elsewhere (Young etal. 2018). The present study attempted to determine the feasibility and effectiveness of the top-down controls only; in reality, utilizing multiple approaches in concert is necessary to improve the likelihood of success for migrating smolts and to reduce population-level out-migration mortality."

Comment: We recommend and generally support such actions.

"Looking beyond the immediate impacts of predator manipulations, this study and others suggest that managers should not be overly optimistic regarding the long-term effects of predator reductions in localized reaches with the intention of improving salmonid survival, even if such areas are deemed predation "hot spots." Although beyond the scope of this study, there is also uncertainty as to how the continuous removal of predators at the top of the food chain may affect the ecological order of the fish communities in the area. Invasive or not, apex predators may be important for ecosystem function and resilience (Estes et al. 2011) and predator removals may lead to unintended trophic cascades that could negatively affect salmonid populations in the long run. This is in part because food chains are rarely linear and tend to be complex and dynamic (Polis and Strong 1996). Further investigation of predator removal efforts may benefit from careful planning and study of the apex predators and the food web they occupy."

Comment: We agree.

L. CLIFTON COURT FOREBAY PREDATORY FISH RELOCATION STUDY - Biological Assessment 2018[20]

The Clifton Court Forebay (CCF) Predatory Fish Relocation Study (PFRS) and Clifton Court Forebay Predator Reduction Electrofishing Study (PRES) were developed in response to the 2009 National Marine Fisheries Service (NMFS) Biological Opinion (BiOp) and Conference Opinion on the Long-Term Operations of the Central Valley Project (CVP) and State Water Project (SWP). Reasonable and Prudent Alternative Action IV.4.2 of this BiOp directs the California Department of Water Resources (DWR) and U.S. Bureau of Reclamation (Reclamation) to commence studies to develop predator control methods for the CCF.

The PFRS augments efforts of the PRES, an on-going study that commenced in 2016 that involves electroshocking and removing predators from CCF and transporting them to Bethany Reservoir with the goal of decreasing predation of ESA listed fish species in CCF. The PFRS study expands on PRES methods, utilizing a wider array of fish removal methods with the intention of maximizing predator removal.

[20] https://www.noaa.gov/sites/default/files/legacy/document/2020/Oct/07354626541.pdf

Comment: We recommend removing striped bass from the Clifton Court Forebay, tagging them, and transporting them to the Bay. Any tagged fish subsequently recovered may be removed to Bethany Reservoir.

M. Understanding predation impacts on Delta native fishes

Posted on May 22, 2016 by UC Davis Center for Watershed Sciences

"In this blog we express our skepticism of large-scale predator control as a conservation tool, based on eight principles."

Comment: We agree with all the points made in this blog post, including those on the role of striped bass in the estuary.

1) *Predation 'problems' do not have simple solutions.*
2) *The best long-term strategy for increasing populations of small fish (prey) is to improve the ability of the ecosystem to support them.*
3) *Bypassing problem areas can reduce predation impacts.*
4) *Changing release strategies of captive fish can reduce predation mortality.*
5) *The solution to reducing the effects of predation 'hot spots' is to move prey around them (see #3) or to reduce their attractiveness to predators.*
6) *Striped bass are not the problem.*
   - *Striped bass get blamed for declines of native fishes because they are an abundant, voracious, non-native predator. Yet striped bass have been part of the Delta ecosystem for nearly 150 years: plenty of time for co-adaptation of predator and prey. In past periods when delta smelt, longfin smelt, and salmon were abundant, striped bass were likewise much more abundant than they are today, suggesting that the factors that drive native fish declines are also driving striped bass populations.*
   - *If striped bass regulate populations of any other fishes, their effects will be mostly on small, consistently abundant prey fishes such as Mississippi silverside and threadfin shad: fishes that may compete with or prey on smelt and juvenile salmon.*
7) *If striped bass regulate populations of any other fishes, their effects will be mostly on small, consistently abundant prey fishes such as Mississippi silverside and threadfin shad, fishes that may compete with or prey on smelt and juvenile salmon.*
8) *Hatchery-reared salmon are exceptionally vulnerable to predation.*

N. DELTA FISHERIES MANAGEMENT POLICY AND STRIPED BASS POLICY – California Fish and Game Commission (FGC 2020)

"An effort to review existing policy and potentially adopt a new policy concerning fisheries management in the Sacramento San-Joaquin Delta (Delta) has been underway since 2017. Throughout 2019, effort focused on WRC vetting and FGC discussion of a draft Delta Fisheries Management Policy."

"Three options for a revised FGC Striped Bass Policy were presented (two stakeholder options and one staff option). FGC did not take any action; commissioners expressed a desire to act on both policies in

tandem and directed staff to continue to work with stakeholders on revisions to the FGC Striped Bass Policy"

Where There is Agreement

1. *In section II, all drafts add language about a robust recreational fishery or maintaining/increasing striped bass recreational angling opportunities. Staff believes the language is sufficiently similar.*
2. *Remove section III, the three million striped bass long-term goal. DFW's estimate of striped bass before declines started in the 1970s was between 1.5 and 1.9 million fish. Under the prior regime with striped bass stocking activities, the 1994 estimate was only 600,000 fish. A three million fish goal is likely not achievable by DFW in any realistic time frame nor under the current conditions in the Delta.*

   Comment: Our recommended goal is to maintain the existing population (200,000-500,000) and the existing fishery.

3. *In section IV, remove pen rearing and artificial propagation of striped bass as recommended practices; past efforts using these methods were not successful in reversing declines, and conditions in the Delta have worsened since. Pen rearing is not a current DFW practice in inland waters.*

   Comment: We disagree. Supplementation was highly successful for nearly two decades (1985-2005), reaching reproductive recovery in the early 90s and at the turn of the century (see Figures G-1 and G-3). We do not believe supplementation is necessary to maintain the population at the recommended goal level.

4. *In section IV, add activities that DFW is encouraged to undergo to support striped bass, including habitat improvement, controlling invasive aquatic vegetation, improving water quality, reducing striped bass loss, and monitoring the status/population of striped bass.*

   Comment: We concur**.**

Where There are Differences

1. *In section I, the language "stabilizing and restoring" striped bass is revised to "monitor and manage" in the staff draft and stakeholder draft 2. The language is retained in stakeholder draft 1; further, in that version, DFW is charged with restoring the striped bass population to a "growing" population, which imparts to DFW a responsibility to undertake active enhancement efforts. Staff believes that the State's limited resources, and DFW's in particular, should be focused primarily on species that are native, threatened, endangered or of greatest conservation need, without forclosing options to stabilize and ultimately restore the striped bass fishery where compatible with these goals; many efforts can benefit both.*

   Comment: We concur.

2. *In section II, the short-term goal of 1.1 million striped bass is removed in the staff draft and stakeholder draft 2, and retained in stakeholder draft 1. Consistent with the proposed Delta fisheries policy, which is focused on balancing the needs of native, listed, and game species, staff believes a more appropriate policy for the Department's management of striped bass is "a healthy, self-sustaining striped bass population" and "a robust recreational fishery." The proposed language reflects the stated aims of recreational fishing interests in the Delta, with one part common to stakeholder draft 1 and the other stakeholder draft 2.*

   Comment: We concur.

3. *In section II, the staff draft adds the last sentence, which includes "to develop appropriate goals and objectives to achieve these broad aims," consistent with FGC's Cooperation Policy. The sentence is intended to help ensure that applicable management goals and objectives, tiered to the guidance in the policy, will be developed in consultation with affected interests.*

   Comment: We concur.

Next Steps

FGC staff agrees with the stakeholders that striped bass is an economically significant and recreationally important fishery in the Delta, and also understands and supports the desire to identify a numeric target and specific strategies that will be used to ensure a robust recreational fishery. Where staff does not agree is that having a numeric target in a public policy will lead to anything different from what has occurred over the last 25 years with the existing numeric targets.

Comment: We concur, although we believe a target goal is needed for adult stock (age-specific population estimates) and recruitment (maintaining Townet and Fall Trawl indices). Otherwise, the minimal target population might expand or contract, jeopardizing the overall goals.

Policies provide guidelines for how FGC and DFW operate, and their eventual success or failure is contingent upon the relationship between the two organizations, the management processes that convert such policies into action, and the relationships with other organizations and stakeholders that help create success or failure. To be successful, policies must be realistic and attainable, standards not met by the current striped bass policy. DFW has indicated a willingness to work with stakeholders to discuss those actions that will benefit striped bass, such as specific goals, objectives and projects, understanding that activities may be targeted to listed species where DFW has resources available (DFW does not currently receive funding for work specific to striped bass). However, many projects DFW implements or funds to help restore the Delta ecosystem is of benefit to striped bass.

Comment: We concur.

Significant Public Comments

1. *Dr. Peter Moyle states that striped bass can be a surrogate for the overall health of the Delta and that regulations should not be aimed at reducing its population (Exhibit 7).*

   Comment: We concur.

2. *The Delta Protection Commission supports language from stakeholder draft 1 , a goal of 1.1 million striped bass, the inclusion of support for interagency research efforts, and studies on the relationship between striped bass and listed species. It urges adoption of the Delta Fisheries Management Policy (Exhibit 8).*

   Comment: We do not concur with the suggested numerical goal because it would likely require supplementation and would conflict with other goals.

3. *A property owner's association supports a measurable target and the "restore and enhance" language; it asks FGC to support local businesses in the Delta (Exhibit 9).*

4. *A coalition of angling associations, sporting groups, and scientists express their view that a numeric target is important for the policy. They also urge retention of "restore and enhance" instead of "monitor and manage" (Exhibit 10).*

   Comment: We agree that a numerical target is important. We do not support "restore and enhance".

5. *A fishing association supports a numeric target of 1 million and notes that other policies which do not have numeric goals have management plans; it requests an assessment of striped bass before making changes to the policy. It questions statements made by FGC staff (Exhibit 11).*

   Comment: See response to Item #2 above.

6. *An individual supports a numeric goal of 1 million striped bass, urges population assessments, questions "credible science" of the policy, and asks that FGC consider the economic impacts of its decisions (Exhibit 12).*
7. *Over 50 emails in support of striped bass; the various concerns and criticisms from the public are generally identified in exhibits 7-12.*

California Fish and Game Commission Striped Bass Policy (Existing Policy)
Adopted April 5, 1996

It is the policy of the Commission that:

I. *The Department of Fish and Game shall work toward stabilizing and then restoring the presently declining striped bass fishery of the Sacramento-San Joaquin Estuary. This goal is consistent with Commission policy that the Department shall emphasize programs that ensure, enhance, and prevent loss of sport fishing opportunities.*

Comment: We concur. The actions we recommend should stabilize the striped bass population declining trend and include measures to adjust the population in either direction as necessary.

II. *The Department shall ensure that actions to increase striped bass abundance are consistent with the Department's long-term mission and public trust responsibilities including those related to threatened and endangered species and other species of special concern. Recognizing issues associated with potential incidental take of these species, an appropriate interim objective is to restore the striped bass population to the 1980 population level of 1.1 million adults within the next 5-10 years.*

Comment: We do not concur because the target level would likely require supplementation and is too high; it would likely hinder endangered Delta native fish recovery.

III. *The long-term striped bass restoration goal, as identified in the Department's 1989 Striped Bass Restoration Plan, is 3 million adults.*

Comment: This goal should no longer be supported.

IV. *The Department shall work toward these goals through any appropriate means. Such means may include actions to help maintain, restore, and improve habitat; pen-rearing of fish salvaged from water project fish screens; and artificial propagation.*

Comment: We do not concur. Supplementation should only be considered if the population falls below our recommended target goal of 200,000 to 500,000 adult fish; further, only pen acclimation of salvage age-0 fish should be employed, with releases confined to the Bay. We concur with Staff Draft dated February 14, 2020.

O. Incidental Take Permit (ITP) for Long-Term Operation of the State Water Project in the Sacramento-San Joaquin Delta (2081-2019-066-00) CDFW 2020

Although the ITP was prescribed mainly to protect smelt and salmon, its actions affect striped bass as well. When the Delta smelt need protection, striped bass presence may be an effective surrogate.

- *Clifton Court Forebay (p6)*

"The CCF is located near the city of Byron in the South Delta. The Banks Pumping Plant pumps water diverted from the CCF via the intake channel past Skinner Fish Facility. A set of five radial gates are located at the CCF inlet near the co9ffuence of the Grant Line and West Canal. They are operated so that they can be closed during critical periods of the ebb/flood tidal cycle to protect water levels experienced by local agricultural water users in the South Delta. The gates are operated on the tidal cycle to reduce approach velocities, prevent scour in adjacent channels, and minimize fluctuations in water elevation in the South Delta by taking water in through the gates at times other than low tide.

Banks Pumping Plant pumping rates are constrained operationally by limits on CCF diversions from the Delta. The maximum daily diversion limit from the Delta into the CCF is 13,870 AF per day (6,990 cfs/day) and the maximum averaged diversion limit over any 3 days is 13,250 AF per day (6,680cfs/day). In addition to these requirements, Permittee may increase diversions from the Delta into the CCF by one-third of the San Joaquin River flow at Vernalis from mid-December through mid-March when flows at Vernalis exceed 1,000 cfs. These limits are listed in USAGE Public Notice 5820AAmended (Oct. 13, 1981).

From July through/September, the maximum daily diversion limit from the Delta into the CCF may be increased from 13,870 AF per day (6,990 cfs/day) to 14,860 AF per day (7,490 cfs/day), and the maximum averaged diversion limit over any 3 days is increased from 13,250 AF per day (6,680 cfs/day) to 14,240 AF per day (7,180 cfs/day). These increases are for the purpose of recovering water supply losses incurred earlier in the same year to protect fish species listed under the Endangered Species Act.

Comment: Under D-1485 (1978-1995), June exports were limited to a maximum of 6,000 cfs and July exports were limited to a maximum of 9,000 cfs. June-July limits under D-1641 have been about 11,400 cfs including 7,180 cfs from the Banks Pumping Plant (SWP). The D-1641 limits do not protect striped bass even in wet years (see Figure 5 discussion, Figure O-1). The D-1485 limits in wet years such as 1993 (see Figure 11 discussion, Figure O-2) were also not protective, which likely led to the collapse of the striped bass population in the early 1990s after the 1987-1992 drought. The same can be said for Delta smelt (Figure O-3), especially given most Delta smelt were too small to be salvaged in late spring and early summer (and were thus entrained into the pumping plants).

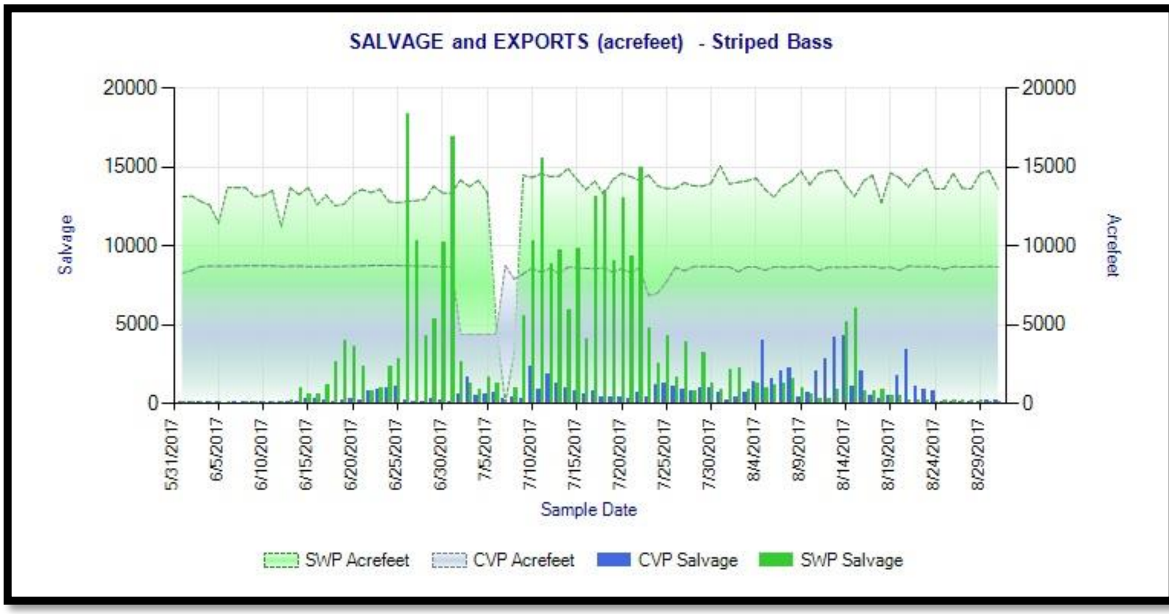

Figure O-1. Striped bass salvage in June-August of wet year 2017 under D-1641 limits of approximately 11,000 cfs (no limits). Source: CDFW.

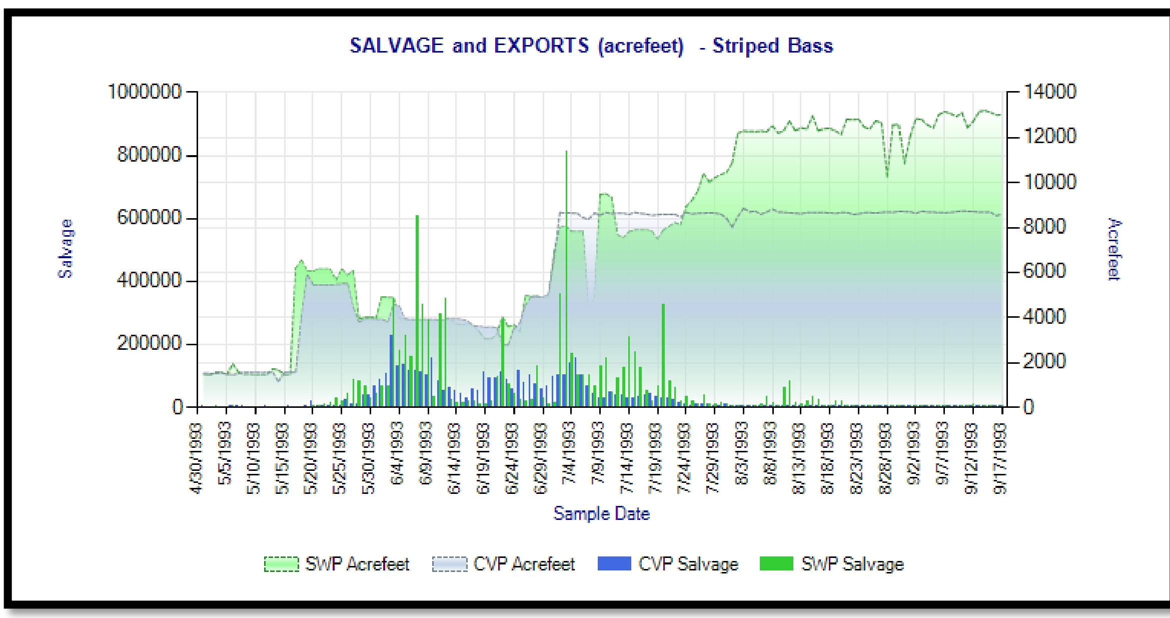

Figure O-2. Striped bass salvage in May-July of wet year 1993 under D-1485 limits of approximately 6,000 cfs in June. Source: CDFW.

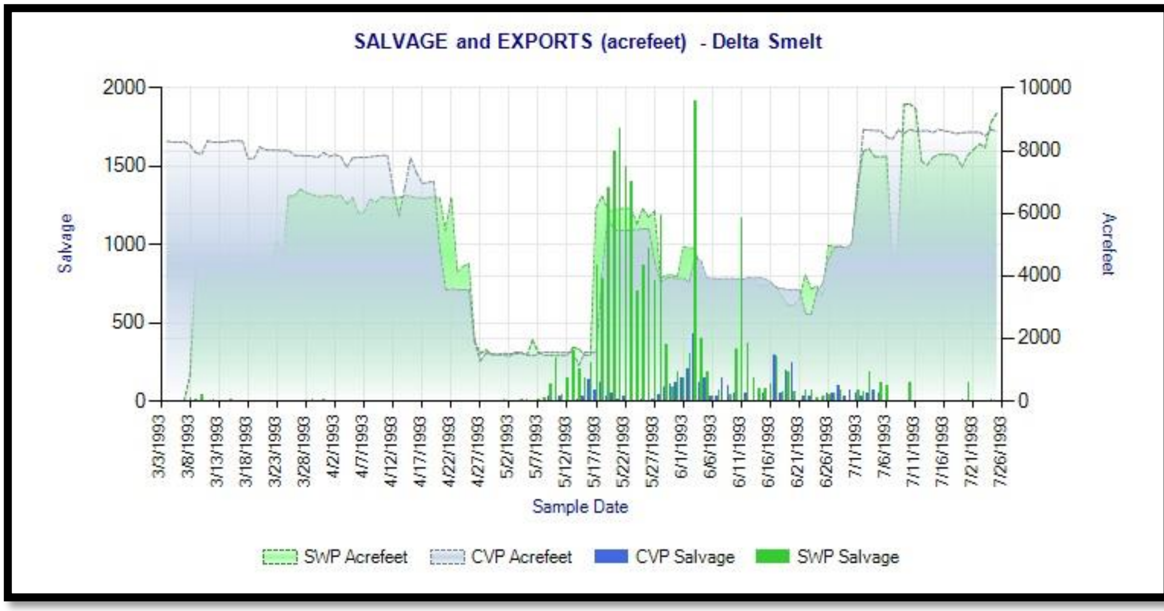

Figure O-3. Delta smelt salvage in March-July of wet year 1993 under D-1485 limits of approximately 6,000 cfs in June. Source: CDFW.

- *OMR Management (p22)*

Old and Middle River (OMR) flow is a surrogate indicator of the influence of export pumping at Banks and Jones Pumping Plants, as well as other south Delta diversions, on hydrodynamics in the South Delta. The management of OMR flow, in combination with other environmental variables, can minimize or avoid entrainment offish into the South Delta, the Banks Pumping Plant and the Skinner Fish Facility. Permittee will manage OMR flow by changing exports at the Banks Pumping Plant in response to real time operating criteria described below. Some of these real-time operating criteria require Permittee, in collaboration with CDFW and multi-agency/Delta-focused technical teams, to evaluate results from real-time fish distribution monitoring, turbidity, temperature, hydrodynamic models, and entrainment models arid make informed recommendations regarding changes in OMR flow management.' ·

From the onset of OMR management to the end, Permittee, in coordination with Reclamation, will operate to an OMR index that is no more negative than a 14-day moving average of -5,000 cfs unless Delta excess conditions occur (described below). OMR flow could be more positive than -5,000 cfs if additional real-time OMR restrictions are triggered (described below) or constraints other than OMR flow control exports. OMR flows will be estimated using an OMR flow index published by Hutton in 2008. 11 Permittee, in coordination with Reclamation, will make a change to exports to achieve the new OMR limit within three days of a trigger or decision to restrict Banks Pumping Plant operations to allow for efficient power scheduling.

OMR flow criteria may control operations until June 30 each year.

Comment: The OMR is not a reasonable surrogate for the influence of the export pumps on Delta smelt or striped bass. Its application can be seen in Figure O-4 and compared with exports in Figure O-1. Maximum exports in June 2017 created devastating conditions for striped bass and Delta smelt – OMR limit levels of -5,000 cfs not only did nothing to constrain exports, the limits also did nothing to protect smelt of striped bass. Further, a lack of OMR criteria after June 30 did nothing to protect the fish. The minus-10,000 cfs in July was certainly not protective of Delta smelt. The fact that none were salvaged simply reflected their extreme scarcity (Figure O-3 shows their temporal vulnerability at a low abundance level). We recommend restricting spring-summer exports in all year types to protect striped bass and Delta smelt. With adequate outflow in late summer (when Delta outflow is sufficient to maintain the LSZ west of the Delta), export restrictions could be lifted in favor of other restrictions (e.g., Delta water temperature).

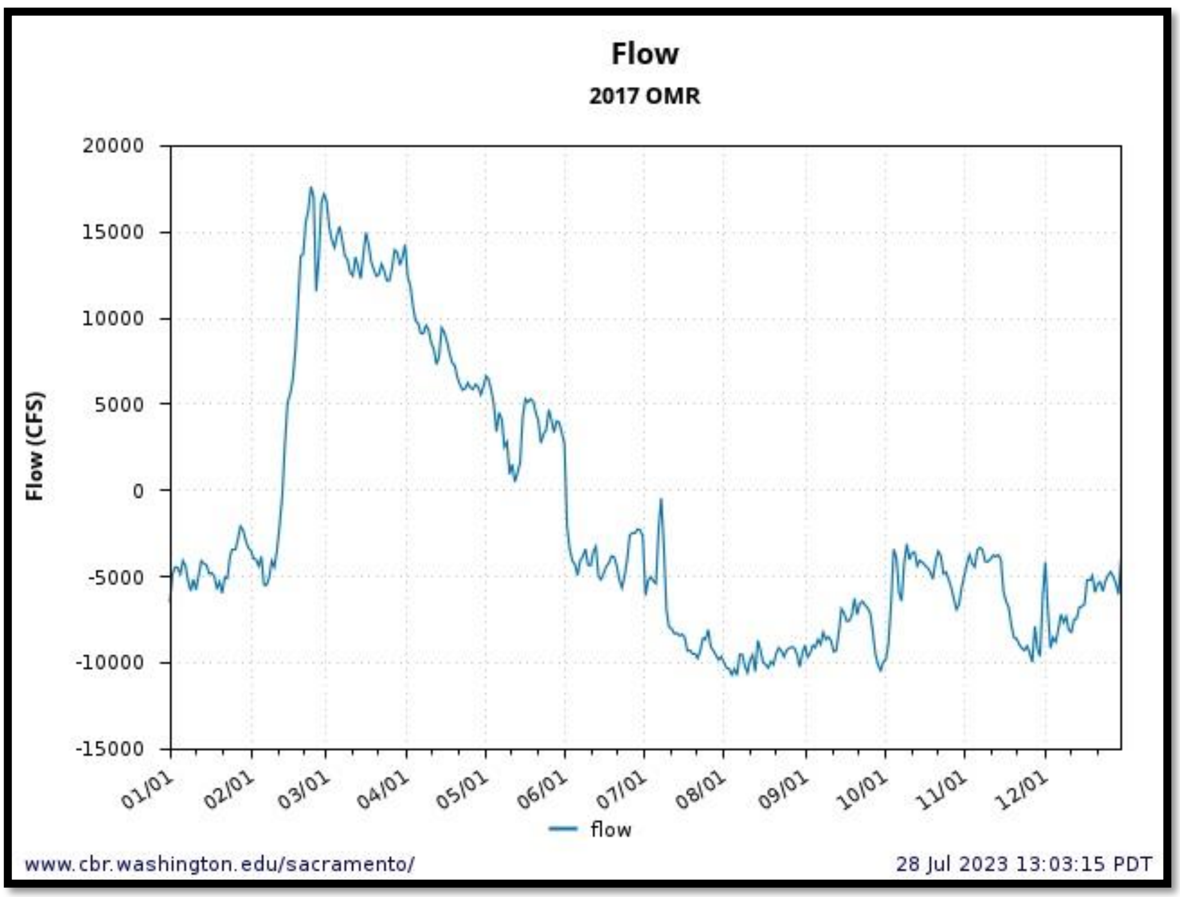

Figure O-4. OMR in 2017.

- *3.9 Delta smelt summer-fall habitat action (p26)*

North Delta Food Subsidies and Colusa Basin Drain Project: While the Cache Slough Complex and the lower Yolo Bypass are known to have relatively high levels of food resources, local water diversions *create net negative flows during summer and fall that may inhibit downstream food transport. By enhancing summer and fall flows through the Yolo Bypass, downstream transport of food could be improved.*

Comment: The Lower Yolo Bypass, the adjoining Deepwater Shipping Channel, and Cache Slough are tidal nursery sanctuaries for striped bass and Delta smelt. We recommend more freshwater flow through both areas from their upstream entrances as prescribed in the ITP; however, we recommend caution and careful management to ensure that Bypass and downstream North Delta waters do not become excessively warm (see Figure O-5) and harm smelt and striped bass. This would require water temperature management from Knights Landing downstream to and through the mouths of the Feather and American Rivers, and on to Freeport and Rio Vista in the tidal Sacramento River Channel. These summer conditions also affect immigrating adult spring-run, winter-run, and fall-run Chinook salmon bound for the Upper Sacramento River and its tributaries.

As part of the Voluntary Agreement Review (Section 3.13.9) and Four-Year Review (3.13.8), Permittee and CDFW will evaluate whether increased summer outflows provided through the Voluntary Agreements, without SMSCG operations, achieve an X2 of 80 km from June through August.

Comment: This action -maintaining the LSZ west of the Delta - is a necessary condition to the above-described actions.

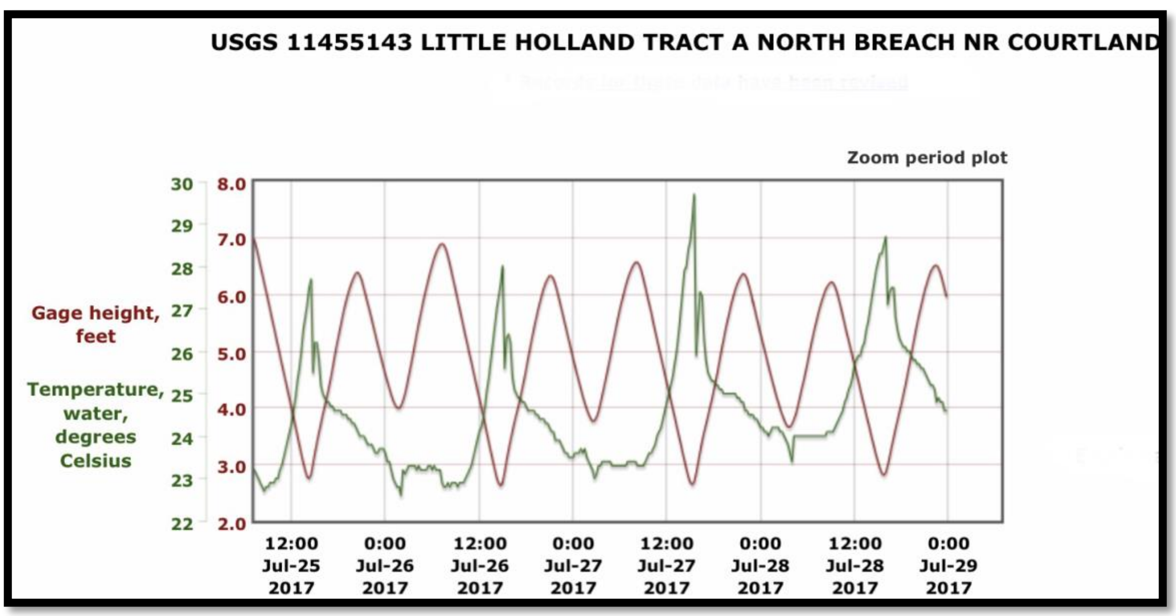

Figure O-5. Water temperature and tide heights in the Lower Yolo Bypass in July 2017. Note the extremely high water temperatures on ebbing tides.

- *8.17 Export Curtailments for Spring Outflow.*

Each year, following the finalization of the March forecast, Permittee will confer with CDFW regarding export reductions from April 1 to May 31. During the term of this ITP, Permittee and its SWP Contractors identify in a written operations plan, submitted to CDFW following the March forecast, and throughout April and May condition SWP export reductions pursuant to the Voluntary Agreements that are consistent with the SWP export reductions required by this Condition, then the Voluntary Agreement implementation may satisfy the reductions required to meet this Condition.

Permittee shall not be required to restrict operations as described above under either of the following circumstances-If the three-day average Delta outflow is greater than 44,500 cfs, then Project operations shall not be controlled by this Condition until the flows drop below 44,500 cfs--··on a three-day average.

Comment: Striped bass spawn primarily in the Lower and Middle Sacramento River in and above the Delta. Their eggs and larvae are pelagic and free-floating, and wash into the Delta from late April to mid-June, where larvae disperse into tidal LSZ shoal waters. By mid-June most have reached the juvenile stage above 10-mm in length (Figure O-6). We recommend reducing exports during the peak occurrence of eggs and larval striped bass in spring; we also recommend closure of the Delta Cross Channel to reduce the movement of pelagic striped bass eggs and larvae into the interior Delta from the Lower Sacramento River (except during high natural flows as prescribed).

- *8.20 Delta Outflow Operations Plan and Report.*

Conditions of Approval 8.18 and 8.19 describe blocks of water that shall be made available to supplement spring, summer or fall Delta outflow at the discretion of CDFW.

Comment: We recommend a spring pulse river flow, and a Delta inflow/outflow pulse through coordinated spring pulse flows in the Central Valley for all target fish species including smelt, salmon, and steelhead. We recommend inclusion of striped bass in this target group.

- *9 Compensatory mitigation:*

CDFW has determined that permanent protection and perpetual management of compensatory habitat is necessary and required pursuant to CESA to fully mitigate Project-related impacts of the taking on the Covered Species that will result with implementation of the Covered Activities (see CDFW Effects Analysis). This determination is based on factors including an assessment of the importance of the habitat in the Project Area, the extent to which the Covered Activities will impact the habitat, and CDFW's estimate of the acreage required to provide for adequate compensation.

Comment: We are not recommending compensatory habitat mitigation other than that proposed for the target listed species. However, if striped bass population targets are not met, we propose mitigation in the form of salvaged juvenile striped bass Bay pen-rearing on a scale consistent with losses and target population level deficits. If these proposed changes in salvage striped bass relocation methods provide the necessary mitigation benefits, pen-rearing may be removed from the process.

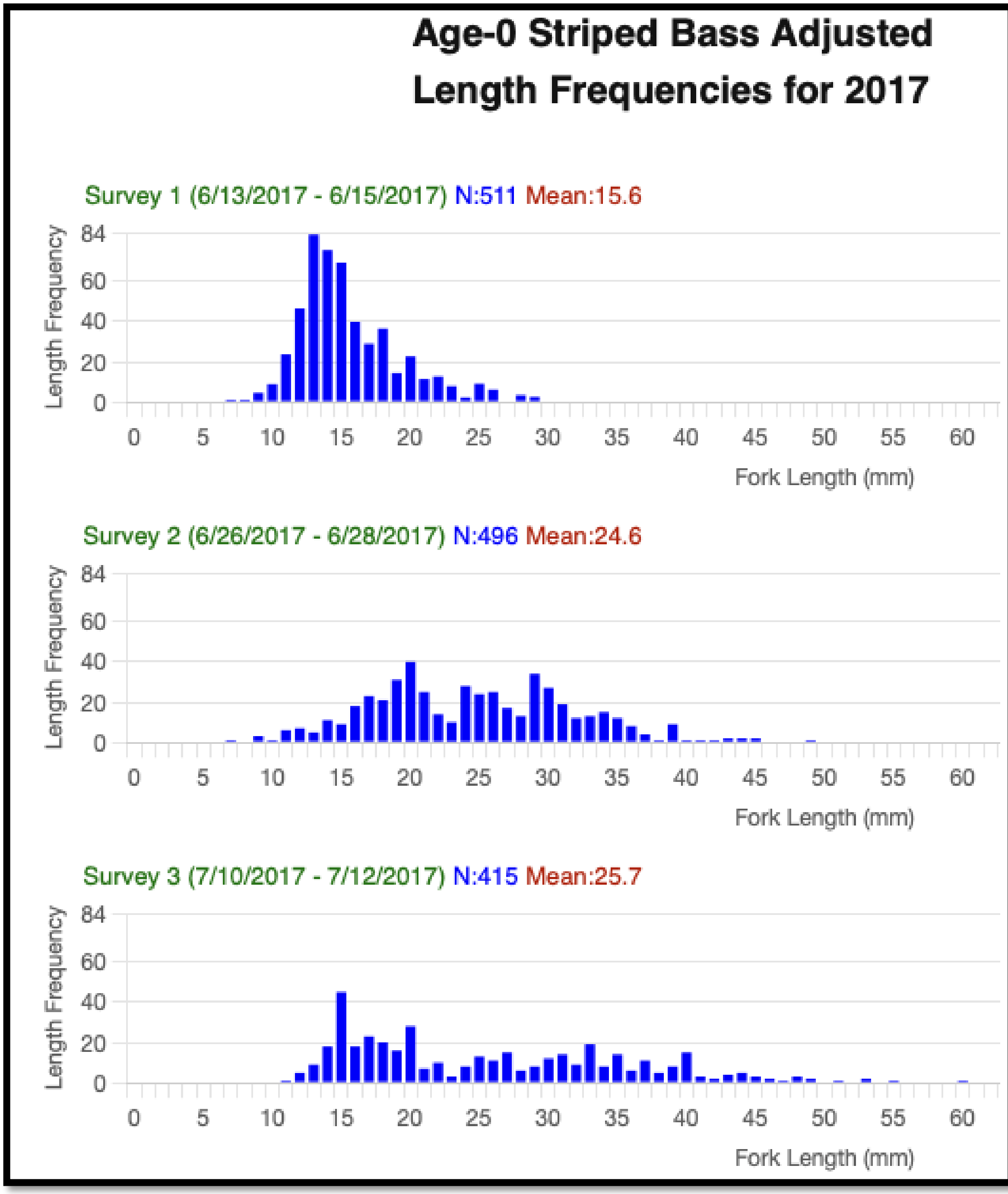

Figure O-6. Striped bass length-frequency charts from the 2017 Summer Townet Survey. .

P. Nobriga and Feyrer 2008). Diet composition in San Francisco Estuary striped bass: does trophic adaptability have its limits?

"It is possible the changed SFE food web supporting juvenile striped bass production may have little to do with their decline; other factors such as excessive entrainment in water diversions (Stevens et al. 1985), exposure to toxic chemicals (Bennett et al. 1995), or declining abiotic habitat suitability (Feyrer et al. 2007) may have collectively had greater impacts."

Comment: The causes of the striped bass and other POD species declines remain debated. These authors support the theory that a shift in the striped bass prey base was a potential cause of the striped bass decline (Figure P-1).

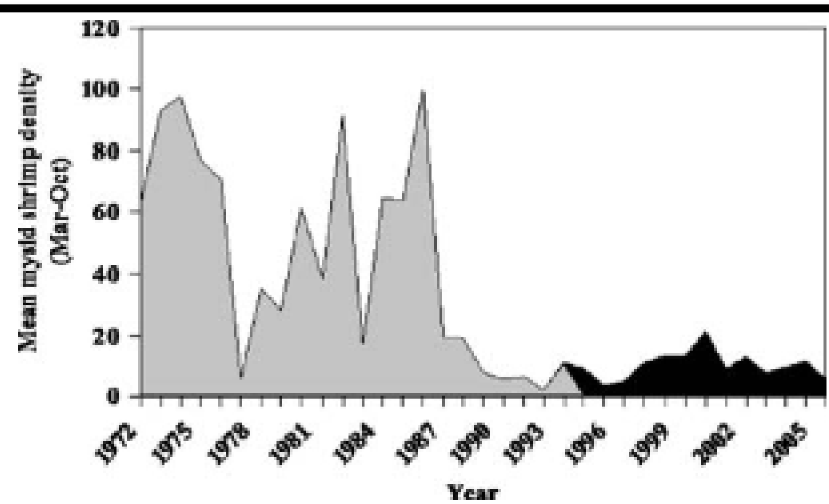

Fig. 2 Time series of mysid shrimp relative abundance in the northern San Francisco Estuary, USA. The data are mean March–October densities (number/cubic meter) of *Neomysis mercedis* (*gray*) and *Acanthomysis bowmani* (*black*) based on plankton trawling, 1972–2006. The former is a native species, the latter was first reported from the estuary in 1992. The interested reader is referred to Orsi and Mecum (1996) for a description of the sampling methods

Figure P-1. Authors' Figure 2.

"Alternatively, the extreme alteration of the SFE food web may have strongly impacted juvenile striped bass production despite an inherent and demonstrated ability of juvenile striped bass to switch prey."

Comment: If this were the case, the turn-of-the-century recoveries illustrated in Figures 8 and 9 would seem unlikely. However, those recoveries may have been the result of the supplementation actions discussed elsewhere in this chapter. Figure 1, 6, and 7 patterns could have been caused at least in part by the theory espoused by these authors. In fact, the prey community change may be one of the direct mechanisms resulting from changes in water management under D-1641 – mysids and eurytemora zooplankton were likely affected by changes in water management.

"there is evidence to suggest that SFE striped bass productivity has declined in part because mysid productivity has declined (Fig. 2). Kimmerer et al. (2000) found evidence that the carrying capacity for SFE striped bass has declined. This imparts density-dependence on the population sometime between the first summer of life and age-3, a period when mysids were the primary historical prey (Stevens 1966; Feyrer et al. 2003)."

Comment: Most likely such an effect would be density independent – simply reducing survival based on lower production under a compromised food supply. If this were the case, then the blue dots (wet years) indicating higher age-0 production would also be related to higher mysis/eurytemora production and would result in higher age-3 pre-adult recruitment – a possibility for which there are no available data. A permanent shift in the prey base caused by water management (allowing a one-time invasion of non-native prey to dominate) would be more ominous and less likely mitigable. For now, we support the inferences derived from Figure 7 – that is, the decline is caused by early age-0 factors (egg/larval stage likely) with possible concomitant factors related to age-3 or older recruitment limiting the egg supply.

"The decline in carrying capacity is correlated with the declining abundance of mysids (Kimmerer et al. 2000). Similarly, Sommer et al. (2007) showed that the relative abundance of age-0 SFE striped bass by their first autumn of life was uniformly low, and stopped responding to variation in estuarine inflows, following the overbite clam invasion, which affected many organisms including mysids (Orsi and Mecum 1996). Feyrer et al. (2003) also showed that the striped bass decline matched the decline of mysids in their diet. Thus, it is likely that suppressed prey production has contributed to the lower striped bass carrying capacity."

Comment: As seen in Figure 7, the relative abundance in age-0 striped bass is not "*uniformly low,*" *nor* has it "*…stopped responding to variation in inflows*".

Q. REPORT AND RECOMMENDATION TO THE FISH AND GAME COMMISSION IN SUPPORT OF A PROPOSAL TO REVISE SPORTFISHING REGULATIONS FOR STRIPED BASS. DEPARTMENT OF FISH AND GAME 2011. Plus Review of and Comments provided by Thomas Cannon, Peter Moyle, Donald Stevens, and David Kohlhorst. Review prepared for Allied Fishing Groups January 11, 2012

The following are excerpts from the review of the recommendations to revise sportfishing regulations to the FGC by CDFG in 2011. Red text are comments of the four reviewers. The arguments are much the same, although regulatory efforts today are less supportive of expanded harvests of striped bass. We generally agree with the reviewers and provide no additional comments.

Upon review of comments, the FGC made no determination to change regulations to increase the harvest of striped bass in 2012. Of note is the FGC's interest now on proposals to reduce the harvest on striped bass based on sport angler pressures (a slot limit is proposed and the subject of FGC review in late 2023). Upon our recent review in July 2023, we recommend no changes in regulations, but support monitoring the striped bass population per specific targets and implementing other actions to increase or reduce population levels within the purview of water management and agency authority.

Comments on Presentation:

- *While predation by striped bass is only one of numerous stressors on the listed species, by previously stocking striped bass and by enacting the striped bass sport fishing regulations currently in effect, the Department of Fish and Game (Department) and the Fish and Game Commission (Commission) may have inadvertently contributed to this stressor by helping establish and maintain the current population of predatory striped bass. More importantly, this particular stressor not only has roots in the actions of the Department and the Commission, but standard fisheries management practices indicate it may be alleviated, at least in part, by further action on the part of the Department and Commission.*

  Comment: DFG actions were not inadvertent but mandated by laws and agreements to protect and enhance striped bass populations. First, project operators (DFG/DWR/USBR) salvaged striped bass at the export pumping plants[4] and trucked them to the western Delta. Salvage facilities and procedures were also improved to increase the survival of salvaged fish. Second, DFG fed and reared large numbers of salvaged young bass in pens in the 1990s to improve their survival to subadult stage. Third, eggs were taken from wild fish that were hatched in hatcheries; the young were reared to yearlings in hatcheries and estuary pens, and stocked in the Bay- Delta until 2000. Large numbers were reared in pens until the subadult stage (two-year-olds) prior to stocking. DFG fought hard against the stocking program concerns expressed by NMFS and the USFWS, because risks to native fishes were minimal. DFG also mandated screening and funded many screen projects of Bay-Delta diversions to reduce striped bass and native fish entrainment losses. Over the past several decades, DFG has reduced the harvest of striped bass by instituting restrictive catch and size limits (1982). DFG has also warned anglers about the health hazards of eating striped bass and other Delta fishes because the fish tissue contains toxins. DFG went to extraordinary efforts to “rescue” thousands of striped bass trapped in flooded islands after levee breaks in the past decade. DFG has provided technical and logistic support to angler tournaments to allow striped bass and other non-native game fish to be returned uninjured to the Bay-Delta. All these actions were aimed at fulfilling DFG’s and the Commission’s mission to provide sportfishing opportunities to California citizens.

  DFG has completed CEQA and ESA requirements for many of these programs and has documented known potential effects of striped bass predation on native fishes. In these assessments and in their testimony for this case, DFG concluded that the effects of predation by striped bass are minimal.

  In conclusion, this staff report fails to point out that all the actions related to striped bass in the last 20 years were guided by the F&G Commission policy to increase striped bass abundance to three million adult fish, with an intermediate goal of 1.1 million fish, and by the federal CVPIA mandate to double anadromous fish populations (specifically including striped bass). Despite major striped bass rearing programs of the 1990s, salmon and smelt made substantial recoveries in the same period and splittail were delisted, because there were many actions taken under CVPIA and CALFED that targeted native fish and their habitats, leading to substantial native fish recovery. Some of the new improvements were specifically designed to improve conditions for native fish at the expense of striped bass[5]. Subsequent native fish and striped bass declines in the past decade can be attributed to a lack of funding and follow-up on these programs and the steady expansion of Delta exports to record levels with few added protections.

[4] During the past twenty years DFG/DWR and BOR have salvaged up to 20,000-50,000 striped bass young per day on average in the month of July, transporting the fish via truck to the western Delta and away from the influence of the pumps.

[5] Delta Standards (D-1485) prior to 1995 included provisions to protect striped bass specifically (e.g., restricted summer export pumping rates); they were removed to "pay for" new restrictions in winter and spring pumping to protect salmon and smelt. Because striped bass "salvage" and vulnerability to Delta export pumps are concentrated in summer, these changes – although likely beneficial to smelt and salmon – have devastated striped bass young production. Young recruitment has plummeted to record low levels and the adult population is at its lowest measured level.

- *The populations of the listed species have long been in decline. Striped bass are known and/or expected to prey on each of the listed species, sometimes very extensively. While the precise impact of striped bass predation on the listed species is unknown, the best available science indicates that the impact on listed species populations is substantial.*

Comment: The "best available science" indicates that total predation by striped bass has greatly declined and that native fishes represent a small part of the diet of striped bass. What was once a problem was addressed by trucking hatchery salmon to the Bay. Smelt are no longer available to striped bass in the Lower Sacramento River. When they were an item in the striped bass diet, they were one of the more abundant fish in the estuary. Furthermore, given the extensive review and assessment of factors controlling salmon and smelt, "science experts" unanimously agree that of all the factors, predation is one of the least important. As striped bass declined so did salmon and smelt. As striped bass recovered in the 1990s from active management, so did salmon and smelt. Juvenile striped bass are one of the POD species that exhibited drastic reproductive failure beginning in 2002, and adult striped bass have not been identified by the POD scientists as a cause of the POD problem. When examining the general ecological literature, predation is represented as a complex phenomenon; it is often emphasized that a predator eating a particular species does not mean it is controlling the abundance of that species. The much-cited cases of predators controlling prey (e.g., lampreys in the Great Lakes) are usually noted because they are so exceptional; plus 'top-down' control usually occurs in relatively simple ecological systems. The San Francisco Bay/Delta Estuary is a complex system with multiple predators feeding on diverse prey, greatly reducing the probability that one predator is controlling the population of one prey species. In conclusion, the 'best available science' indicates that the impact of striped bass predation on listed species populations is minimal.

The removal of all non-native fishes and several native fishes (e.g., pikeminnow) would also likely benefit listed fish. In managing native fishes (including several dozen listed species) in the Columbia River system, the states of Oregon, Washington, and Idaho (with funding from the federal government) have addressed only the predation problem posed by native pikeminnow (with a longstanding bounty program), while continuing to protect substantial fisheries for non-native predatory black bass, catfish, crappie, and walleye, whose diets include native fishes. The Columbia programs now focus on native bird predation on listed species, which has been found to be a major factor in the declines of listed species. The Lower American River, for example, witnesses tremendous early spring predation of wild young salmon emerging from their spawning beds by many thousands of predatory birds on. Likewise, birds are probably major predators of salmon released from hatcheries.

Finally, the largest predators in the Bay-Delta remain the Delta pumping plants of the CVP and SWP. Despite mandates and agreements, little has been done to reduce entrainment and salvage losses on listed species at these facilities.

- *By virtue of their abundance, habits, and size, predation by striped bass has been implicated as a substantial contributor to the poor survival of young salmon used in experiments to estimate reach- and site-specific survival rates through the Delta and in the Sacramento River (Bowen et al. 2009; Gingras 1997; MacFarlane et al. 2008; Michel 2010; Newman and Brandes 2010; Perry and Skalski 2008; Perry and Skalski 2009; Tucker et al. 1998; Vogel 2010; Vogel 2011). By plausible extension, listed salmon (and steelhead) also suffer poor survival rates due to predation, including predation by striped bass.*
-
- Comment: The referenced experiments involve hatchery smolts large enough to be tagged and are not relevant to wild salmon. These fish are poorly adapted for survival because they were reared in hatchery troughs with no reinforcement of predator avoidance behavior. In fact, it is likely that most salmon eaten by striped bass are poorly adapted fish fresh from hatchery release. This suggests that a change in hatchery rearing practices is needed to increase survival rates of hatchery fish in the wild. Wild salmon use the Delta for rearing and migrating in winter and are gone by late spring when non-native predators begin to feed. Specifically, winter-run smolts pass through the Delta from December to February on their way to ocean and are thus subject to limited predation. Many, perhaps most salmon enter the Delta as fry in early winter and reach smolt size by early spring and proceed to the ocean. There may be times during early spring of warmer dry years when predation by striped bass may be a concern. Poor escapement in the late 1980s and early `990s (see Figure 1) is likely attributable to the mid-1980s drought. Poor escapement in recent years is likely attributable to the early to mid–2000s drought, which was characterized by record exports.

1. Development of the Striped Bass Fishery

- *Striped bass in California are an abundant, broadly-distributed, resilient, piscivorous (fish-eating), non-native sport species. Striped bass are anadromous and occur in coastal rivers and lagoons, the ocean, the San Francisco Estuary and Sacramento-San Joaquin Delta, the Sacramento River watershed, and the San Joaquin River watershed. Striped bass spawn during spring in rivers (predominantly the Sacramento River), and rear and forage year-round in bays, estuaries, and the ocean. The Sacramento-San Joaquin river system is likely the southern-most extent of striped bass spawning and is clearly where most spawning occurs. Striped bass in California mature at 2-4 years old, can reach a maximum size of greater than 3 feet, and can live more than 20 years. Striped bass life- history characteristics (e.g., frequent spawning after maturity and high fecundity) make striped bass very resilient in the face of environmental and other stressors.*

- Comment: When striped bass were more abundant in the 1960s and early 1970s, a large spawning population segment developed in the Delta. This population declined sharply with the construction of the SWP and its diversion at Clifton Court Forebay. Many features of the population that provide resilience no longer exist, including many spawning and older age classes. Adults older than eight years that provided the backbone of reproduction no longer occur because of high adult mortality rates. Adult die–offs are common during drought (Stevens et. al. 1985; Kohlhorst 1999).
- *Commercial and recreational fisheries on a booming striped bass population extended from southern California to Washington shortly after striped bass were introduced into California in 1879 from New Jersey. After development in the Central Valley caused a substantial decline in the number of adult striped bass, striped bass recovery — through restrictions on the fishery, augmentation with fish produced in hatcheries, and protective approaches to water management — became a focus in the 1970s. Although striped bass recovery has not been achieved, the fishery remains substantial, and in 2000 the population experienced a spike in adult abundance not seen since the mid-1970s.*
-
- Comment: Many near adult striped bass were stocked until 2000 by DFG programs, when target adult population goals were reached. But protections for striped bass instituted in Delta Standards D-1485 in 1978 were removed in 1995. The new 1995 Standards allowed much higher summer exports, leading to a 2002 striped bass recruitment crash (as confirmed in both summer and fall young index surveys); this development resulted in a record low adult striped bass population in 2007. The 2002 recruitment failure is one of the effects under analysis in the POD program; also under investigation is the crash of other pelagic organisms including threadfin shad, longfin smelt, and delta smelt.

2. Striped Bass Status and Trends

- *Although the population of striped bass has declined in recent decades, it remains substantial, and there have likely been millions of striped bass in California every year for more than a century. The abundance (Figure 4) and relative abundance (Figure 5) of adult striped bass has varied substantially over the decades. The present abundance of adult striped bass may be as low as roughly 500,000 after a recent peak of approximately 1,500,000 in the year 2000.*

  Comment: Funding and program design for striped bass adult abundance estimation remain limited. Estimates of adult abundance made every other year have wide confidence limits and are likely biased to the high end because of experimental design flaws. The population is at a size not previously observed, meaning it is difficult to evaluate the stock / recruitment relationship or predict the consequences of recruitment failure, let alone estimating the impacts of the additional prescribed harvest guidelines proposed in the Settlement. Recruitment failure appears to be a consequence of the low adult population, poor young production in dry years, and elimination of the summer protections of D-1485 Delta Standards in 1995.

- *Whereas the decline and year-to-year variation in striped bass abundance through the mid-1990s has been attributed primarily to environmental conditions (including operation of the State Water Project (SWP) and Central Valley Project (CVP)) affecting young striped bass (Stevens et al. 1985), the most-recent increasing trend (1994-2000), though still the subject of active* *investigation, is likely attributable in large part to augmentation with hatchery-reared fish (Kohlhorst 1999).*

-
- Comment: We agree with this conclusion. Without further augmentation and continued high summer exports (and poor production of young) we can only expect further population decline with or without increased harvest rates. Any increase in harvest rates could impose drastic consequences on the population, especially in combination with dry years; that seems to to have happened in 2012.
- *The abundance of young striped bass is also known to vary substantially, declining from very-high levels in the 1960s to moderate levels in the 1980s, then declining further during the last decade to record-low levels (Figure 6). Although the Department rarely estimates the abundance of young striped bass, they are generally vastly more abundant than adult striped bass. The continued high abundance of adult striped bass after decades of low juvenile abundance is a sign of striped bass resilience, as is the shift of young striped bass from mid-water habitat towards shallow-water habitat (Sommer et al. 2011).*
- Comment: As stated above, the abundance of adult striped bass is likely at record lows and will continue to decline. The production of young is also at record lows. Resilience could easily be depleted if it exists at all. (See previous discussion of adult striped bass estimates). Sommer et. al. imply that the fall young striped bass index may be biased to the low end because of a shift in young fish distribution; however, the young fish index is also at a record low for the summer shoal survey (see companion to Figure 6). Our review of all survey data and types clearly indicates a substantial decline in the abundance of Bay-Delta striped bass young since the 1970s.

3. Striped Bass Predation on Listed Species

Due to striped bass abundance and listed species rarity, accurate and comprehensive assessments of predation are difficult, if not impossible, to obtain. Listed species are, in this respect, a needle in the haystack of striped bass. Notwithstanding the difficulty in assessing the precise level of striped bass predation, however, studies of striped bass feeding habits indicate they consume an enormous volume of fish, overlap in their geographic range with the listed species, and have historically consumed listed species, at times in very substantial quantities.

Comment: The young of listed species numbers in the millions – much like striped bass. We know how many listed species are stocked or salvaged and released. DFG has data from many food habitat studies of striped bass, so reasonable estimates of predation are possible. Based on our review, we expect that the numbers and rates will be small except for certain places and times, such as those documented in the Red Bluff Diversion Dam Predation Study. Generally, high rates as documented in earlier studies were a consequence of releasing hatchery smolts into the Sacramento River in spring. Otherwise, rates are very low – especially in the Delta and Bay where alternative prey for striped bass is very abundant.

As fish in their first year of life, striped bass eat mostly zooplankton. Some first-year fish and most second-year fish eat other fish (i.e., they are piscivorous). As striped bass age, their diet includes increasing fractions of fish but they also eat invertebrates (e.g., crabs, crayfish, etc).

Consumption of Chinook salmon, coho salmon, steelhead, and tidewater goby (each presently a listed species) by striped bass in California was first documented in collections from Waddell Creek Lagoon (Santa Cruz County) in the year 1935 (Shapovalov 1936). When Chinook salmon and delta smelt were common they were often observed to be common in the diet of striped bass from the San Francisco Estuary (e.g., Figure 7; Stevens 1963; Stevens 1966; Thomas 1967). Because the listed species are rare and quickly digested and because striped bass were abundant, the listed species have rarely been found in *the striped bass diet (Nobriga and Feyrer 2007; Boyd 2007; CDFG unpublished) since the listed species declined.*

Comment: Stevens (1966) reported that subadult bass fed 10% on salmon and 4% on smelt in spring, whereas young striped bass and shad made up more than 50% of prey. Predation rates on smelt and salmon were <1% in other seasons. Adult striped bass fed predominantly on shad and small striped bass, while only 1-3 % fed on salmon (primarily fall-run hatchery smolts) and <1% on smelt, again predominantly in the spring. Striped bass were far more numerous in the 1960s, as were salmon and smelt. Again, hatchery smolts were more available in rivers and the Delta than today, as most are trucked to the Bay. Though salmon and smelt have been found in the stomachs of striped bass in rivers, striped bass generally key on larger and far more abundant and vulnerable prey such as American shad, pikeminnow, tule perch, and suckers.

Striped bass may be more prevalent today in tributary streams upstream of the Delta because of poor Delta conditions, including poor water quality and lack of prey. In summer, striped bass likely seek out cool water refuges in the rivers, which now are more prevalent because of management efforts to keep the rivers cooler for salmon and steelhead. Cheek et al (1985)[12] and Coutant (1985)[13] documented striped bass seeking summer cool-water refuge habitat. Though no specific studies other than the Red Bluff Diversion Dam Predation Study have assessed the potential predation by striped bass, we do know they feed on crayfish, suckers, pikeminnow, American shad, as well as salmon and steelhead in tributaries. More study on the role of striped bass in rivers in summer is needed.

The tolerable temperature range for striped bass is thought to be between 50 and 75 degrees, with their thermal optimum from 55 to 65 degrees. Striped bass feed most often when the ambient water temperature is to their liking, that is, between 57° and 68°F. When it is colder, they become lethargic and don’t feed for days, remaining in a semi-dormant state. In summer, when water temperatures rise above 70°F, striped bass may stop feeding and search out cooler waters. Water temperatures that exceed 70°F for anything but a short period are considered stressful for adults, resulting in poor growth and a reduction in fecundity and condition. The Delta and lower rivers are generally warmer than 70°F in summer, so striped bass head for the Bay or upper rivers.

In coastal waters, it is the warmer discharges of the rivers and tidal lagoons that attract striped bass from the too-cold ocean waters along the coast. Here again is the potential overlap of striped bass and salmonid young.

[12] Cheek, T.E., M.J. Van Den Avyle, and C.C. Coutant. 1985. Influences of water quality on distributions of striped bass in a Tennessee River impoundment. Transactions of the American Fisheries Society 114:67–76.

[13] Coutant, C.C. 1985. Striped bass, temperature, and dissolved oxygen: a speculative hypothesis for environmental risk. Transactions of the American Fisheries Society 114:31–61.

Comment: Delta smelt, salmon, and steelhead have similar cool water habitat needs, so their distribution tends to overlap with striped bass, causing similar concerns. In the Bay there are many pelagic prey options other than smelt or salmon. However, striped bass are known to congregate around North Bay hatchery salmon stocking locations to feed on salmon smolts. Striped bass are also abundant below the Red Bluff Diversion Dam on the Sacramento River, Daguerre Diversion Dam on the Yuba River, and

Woodbridge Diversion Dam on the Mokelumne River, where they feed on young salmonids that become disoriented when passing over or through the dams. Striped bass are also very abundant in Clifton Court Forebay, where prey become disoriented in front of the large fish salvage facilities of the State Pumping Plant.

Other abundant predators in the Bay-Delta include pikeminnow, largemouth and smallmouth bass, crappie, and channel catfish. Stevens (1966) reported that black crappie adults generally fed less than 1% on smelt and salmon, more than 70% on juvenile striped bass and shad, and only 2% on salmon during spring. Largemouth bass fed mostly on shad and bluegill, but fall-run hatchery salmon were a small portion of their diet (4%). He reported "*…Few striped bass stomachs contained small king salmon.... Hatton (1940) analyzed stomach contents of 224 adult striped bass from the Delta during the salmon migration primarily to determine the extent of this predation. He found no salmon in the stomachs and concluded that they were not an important food source. Adult bass are spawning during the salmon migration, therefore, they would not be serious predators because they do not feed on them."*

4. *The Recreational Fishery for Striped Bass*

Because anglers have released many striped bass, the preponderance of which were likely not of legally harvestable size, lowering the minimum size of striped bass that may be taken would encourage and likely lead to increased harvest of striped bass.

Comment: With a total harvest of around 60,000 fish or 10 percent of the population, a reasonable estimate is a 40% increase, or about 25,000 fish. We would expect the number of anglers to remain steady or increase if angling regulations are liberalized – at least initially. As 12-to-18-inch fish are cropped off and success on this size fish declines, angler behavior would be unpredictable. Whereas now the "average" angler probably catches and retains fewer than one legal-sized fish per trip – even with a reduced abundance of juvenile fish – the average catch may eventually be three or four fish per trip – fewer than the proposed limit of six, but substantially more (and smaller) than the present harvest. Thus, the reduction in size limit to 12 inches from 18 inches could result in a major change in the character of the fishery. Fewer fish would be allowed to grow to a larger size, creating a major impact on the segments of the fishery that depend on larger fish (i.e., ocean surf, ocean party boat, San Francisco Bay, fall and winter Suisun Bay, Delta spring troll, and spring Sacramento River fisheries).

5. *Regulatory Proposal*

The attached regulatory proposal was developed by the Department, with technical support from the USFWS and NOAA Fisheries. Within the Department, input was received from Bay Delta Region, Fisheries Branch, Marine Region, the Law Enforcement Division, and the Office of General Counsel. Prior to developing the regulatory proposal, Department representatives met separately with and received input from representatives of the Coalition for a Sustainable Delta, the lead plaintiff in the litigation over the striped bass sport fishing regulations, and representatives of the California Sportfishing Protection Alliance, the California Striped Bass Association, the Northern California Council of the Federation of Fly fishers, the Central Delta Water Agency, and the South Delta Water Agency, all of which were intervenors in the litigation. While the regulatory proposal is rooted in part in the litigation, this proposal represents the shared and reasoned views of the Department and is based on the best available science. This proposal has been reviewed by the USFWS and NOAA Fisheries and found consistent with the federal agencies' goals for endangered species protection and ecosystem restoration in the Delta.

Comment: Striped bass have been the top predator in the Bay-Delta for more than a century, and this has helped shape the fish community to what it is today. Though resilient in the face of much depredation, the striped bass population is now at its lowest recorded level; with ongoing pressures and habitat loss, their population viability may be unsustainable. For evidence and support for this hypothesis, refer to the late 1990s, when listed winter-run and spring-run Chinook salmon, Delta smelt, splittail, and striped bass had significant recoveries during an aggressive, decade-long striped bass enhancement program by the CFGC, CDFG, CVPIA, FOUR PUMPS, and CALFED.

A major threat to striped bass – harvest by humans – has been contained so far by the efforts of the CFGC and CDFG through careful management of the hugely popular striped bass fishery and strict regulation and enforcement of legal and illegal harvest. Sportsmen of the CSBA, CSPA, FFF, and other groups have helped by supporting strict regulation and enforcement, and by further adopting a catch-and-release ethic promoted by CDFG and many sportsmen groups.

The proposed new regulations would undermine all these efforts, potentially accelerating the decline in salmon and smelt, and risking the collapse of the striped bass population and its recreational fishery. Small improvements in the salmon, smelt, and striped bass populations due to the abundant rains of winter- spring 2011 will be negated if these regulations are adopted and successful in their purpose.

Because striped bass are resilient and fishing effort for striped bass appears to be a simple function of striped bass abundance (DuBois 2009), the Department expects the striped bass population and the associated fishery would not collapse if managed according to the proposed regulations. Furthermore, the fundamental character of California's striped bass fishery would be preserved under the proposed regulations. We strongly disagree that the fundamental character of the fishery would be preserved.

Comment: There is no scientific support for this statement. First, striped bass "resilience" at this record low stock level and current period of record summer exports likely would not exist without the benefit of a decade of enhancement and the protection of existing regulations; there is no science to support the conjecture that their resilience would continue. Second, the size distribution changes alone would impact important components of the fishery and population egg production. A good population model would likely support the theory that the population and fishery could collapse.

The proposed bag, possession, and size limits are intended and expected to encourage more fishing effort for and greater harvest of striped bass. These expectations are due to the facts that to date: (1) fishing effort and the abundance of legally harvestable striped bass have been correlated; and (2) anglers have released many striped bass, the preponderance of which were likely not legally-harvestable size.

Comment: First, Dubois (2009) found little change in fishing effort with the regulation change in 1982. Second, if the regulations are successful in reducing striped bass abundance, then the fishing effort will ultimately decline, reducing the level of harvest below the original level. Many anglers release fish because of the catch-and-release ethic or because smaller fish are not worth the trouble of keeping and processing. Allowing smaller fish to be harvested may reduce the harvest of larger fish that are more effective predators and superior reproductive contributors to the population.

Conceptual Alternatives;

Because adverse impacts to the listed species by striped bass predation are likely and protection for the listed species is of overriding importance, the Department and Commission must err on the side of caution. That said, the primary scientific arguments are these:

o *Striped bass could precipitously decline with additional harvest and (if so) other predators (e.g., Sacramento pikeminnow, largemouth bass, and the egg-eating Mississippi silverside) could expand such that the listed species would not benefit. While this scenario is possible, available data — limited in some regards (e.g., striped bass stock-recruit curve; Botsford 2009) but very robust in many others — suggests neither is likely. The Department fully expects that ongoing monitoring of the impacted fisheries and fish populations would signal the need for adaptive management in a timely manner.*

Comment: Botsford also notes that the population is operating in an area of the S/R (stock-recruitment curve), for which we know little; a response is quite unpredictable as a result. With no "signals" in several decades on striped bass, what indications would show the effect on striped bass and the listed species? Collapse of fisheries are commonly observed only after they have happened and are hard to reverse. Is the Department prepared to stock striped bass again if it proves necessary to preserve some semblance of the fishery? Smelt crashed to a record level in the 2000s, yet the Department and DOI allowed exports to reach record levels many times, including during the summer of 2011. Winter-run and spring-run Chinook are again declining sharply, while NMFS and the Department do little to improve survival.

Comment: The DFG analysis is disingenuous because it essentially says that a reduction in the striped bass population will have no impact on other fishes while simultaneously benefitting salmon and smelt. If the striped bass is indeed the top predator in the system, then responses of other species to changes in the striped bass population should also be expected. Increases in the numbers of threadfin shad and inland silverside would seem possible, given they are major prey species for striped bass. Silversides are likely predators on smelt eggs and larvae. There could also be an increase in pikeminnow in the Central Valley if striped bass predation is reduced – or even an increase in the survival rates of juvenile bass, a prey of adult bass. The fact is that the system the striped bass inhabits is complex, and the bass have been part of it for a long time, presumably replacing the original predators in the system, such as Sacramento perch and thicktail chub. So predicting the impacts of their removal or reduction in the system is not easy, nor is detecting the response of other fish populations. For example, a small increase in predation by silversides on Delta smelt eggs and larvae could be catastrophic to the smelt but very hard to separate from other causes of decline. Likewise, silversides are abundant in the same edge habitats that support juvenile salmon, where they may compete for food, increasing stresses on wild salmon fry-rearing in the Delta. These are the kinds of unexpected results of the striped bass 'experiment' that would be very hard to detect yet could prove significant.

It is interesting that the CDFG analysis of predation impacts totally ignores largemouth bass, which are presumably now as abundant as striped bass and certainly an important predator on fish. Largemouth bass are widespread in the Delta and are known for eating juvenile salmon and smelt. Are there plans to evaluate their predation impacts similar to the plans for striped bass – and to take action to reduce their population if they are shown to prey on salmon and smelt?

o *Striped bass predation on the listed species may not adversely impact the listed species, because the listed species are so rare that striped bass may not pursue them to any notable extent. This is a question of the 'functional response' of striped bass to varying densities of prey. Although the functional responses of striped bass to varying densities of the listed species is not known, the responses can range from linear responses with devastating consequences to complicated responses that involve abandoning listed species as prey.*

Comment: Like most predators, striped bass "key in" on prey; they do not just sit around waiting for the random meal. They follow schools of prey such as threadfin shad or large concentrations of hatchery-released salmon smolts. The chances are small under the existing population levels of smelt that striped bass ever feed on them, as is evident in the lack of smelt in the stomachs of striped bass in all recent studies. In the Lower Sacramento River during the 1960s, Delta smelt were present in striped bass stomachs; that's because smelt were sufficiently abundant in their spawning runs to attract the attention of striped bass once the horde of hatchery salmon had passed through in spring. In summer and fall during that period, striped bass also fed heavily on schools of their own young. With the decline of their summer forage (threadfin shad) over the past decade, research indicates striped bass shifted to more abundant inshore prey, particularly inland silverside (Sommer et. al. 2011); this may have relieved what little predation pressure existed on the more pelagic Delta smelt.

Habitat (Including Water) Restoration and Mitigation

The decline of listed species occurred only after striped bass had been established in California for many decades and the SWP and CVP were substantially implemented, which, given the timing and rate of development (e.g., water, timber, agriculture, roads, industry, etc.) in California, suggests the species could co-exist in a future where the impact of development was effectively mitigated. Although some have argued that habitat restoration and mitigation is being implemented to the fullest extent of the law, the status of the listed species has not improved. Recovering the listed species is an extremely urgent matter that must be attempted using all feasible means.

Comment: Even following the wet-winter spring of 2011, striped bass were hard hit by high salvage levels from record level Delta exports. In contrast, salmon and smelt had largely succeeded in escaping the Delta in spring before the high export levels.

Catch-and-Kill Regulations

Requiring anglers to kill the striped bass they catch is feasible and would likely quickly provide greater benefit to the listed species than the proposed regulations, but would: (1) be a 'nuclear option' that could be effectively implemented only with extensive education and outreach; and (2) likely have significant longer-term impacts on the fishery and damage the sport fishing industry.

Comment: The proposed regulations could potentially increase the kill to levels comparable to those resulting from very liberal size and creel limits. Such "kill" regulations have been adopted in Yellowstone Park to reduce the populations of non- native trout, with only limited success. Using anglers to control fish populations usually has limited success and is usually unpopular (e.g., Yellowstone, Columbia River).

Site-Specific Eradication Programs

Agency staff could authorize and/or conduct eradications of striped bass at sites where predation is a particular problem or where striped bass can be efficiently captured. Translocating striped bass (e.g., to a reservoir) would be very expensive and killing striped bass would deprive anglers of fishing opportunity.

Comment: Agency-managed and staff- conducted eradication programs are generally far more effective than anglers at removing problem fish. Study plans for such efforts have been developed over the past two decades to remove predatory fish from Clifton Court Forebay but have not been implemented. On a site-by-site basis, this may be the most cost-effective approach. However, even in the case of the Forebay, efforts would have to be continuous because of the constant recruitment of new predators into the problem areas. Relocation efforts from problem areas to distant non-problem areas would be a reasonable approach. The proposed regulations seem to be based on the idea that CDFG can have it both ways: supporting a popular fishery and greatly reducing the population of the fish. If it is important to reduce the population, then the best way is a focused gill and trap net fishery on the spawning adults. There is a long history in the fishery literature that demonstrates that the best way to overfish a population (and to eliminate the fishery) is to focus harvest on the largest and oldest females. If the proposed fishery regulations work, then the fishery will gradually disappear. If they don't work, then the alleged predation problem will continue to exist. CDFG should choose a single goal and focus on it.

Impact of the Proposed Regulation on the Striped Bass Population and Fishery

Due primarily to lack of information about angler preference and on the striped bass stock-recruitment relationship (Botsford 2009), the Department cannot forecast specifically how the proposed regulation would impact the striped bass population or fishery. Because striped bass are resilient and fishing effort for striped bass appears to be a function of striped bass abundance (DuBois 2009), however, the Department expects striped bass would become somewhat less abundant, the average size of striped bass would decline, and both fishing effort and fishing success would increase for a period of at least several years. Given the lack of certainty as to the ultimate effectiveness of the proposed regulation change, the Department recommends an adaptive management plan designed, in part, to assess the efficacy of the new regulations as a means of increasing fishing effort and harvest of striped bass.

Comment: There are many years of creel census and angler preference records, plus records of salmon, steelhead, and Bay-Delta stamps. There are many years of records from Bay-Delta charter (party) boats. The expected increase in effort and harvest (predicted by CDFW) would likely be short term, and the program (benefits) would decline with the striped bass population; in sum, the regulations would have limited long-term benefit.

CONCLUSION

Having studied striped bass for nearly a century and listed species for many decades, the Department recognizes that the consequences of management actions — past, present and future — are rarely certain. Although the impact of striped bass predation on the listed species is not certain, the Department has evaluated the large body of information and has determined that striped bass predation is an adverse impact, albeit one of unknown magnitude, that can likely be mitigated in part by promulgating a set of regulations that would authorize additional harvest by recreational anglers. The regulations would allow for the harvest of smaller and more striped bass in anadromous waters only. The Department expects that striped bass would become somewhat less abundant, the average size of striped bass would decline, and both fishing effort and fishing success would increase for a period of at least several years — resulting in a measure of protection for the listed species that would not cause the collapse of the striped bass fishery. For the foregoing reasons, the Department recommends that the Commission adopt the attached regulatory proposal. As a first step in that process, the Department recommends that the Commission direct the Department and Commission staff to prepare a regulatory packet for the attached regulatory proposal in accordance with the California Administrative Procedure Act and commence appropriate environmental review under CEQA for the proposed regulation change.

Comment: Such efforts are generally resource intensive and costly. Where will the funding originate, and what will be the ramifications to the State Budget?

Literature Review:

- John L. Thomas (1967) — "*At times striped bass feed heavily on their own young and on young king salmon. The effects of this predation on these populations can not be determined from the available data*."
- Comment: Thomas concluded that 62% of the diet in the Upper Sacramento River in spring was young salmon. In the Lower Sacramento River above the Delta, the figure was 22% *in spring*. Smelt made up 7% of *the spring* diet in the Lower Sacramento River. *In summer*, the rate was 30% for salmon and 8% for smelt in the Lower Sacramento River. Other than the Sacramento River above the Delta, rates were 0-3% in other areas of the Bay-Delta. *In summer*, salmon remained an important element of the diet of striped bass in the Upper Sacramento River above the Delta (60%). It is worthy to note that approximately 10 million hatchery salmon smolts were stocked each spring in the Upper Sacramento River above the Delta during these years. The high predation rates on salmon led to many of these hatchery-produced smolts trucked to the Bay in later years. In winter, smelt and salmon made up little of the striped bass diet, but smelt accounted for 26% of the diet of 28 striped bass sampled in the Crockett to Pittsburg area of the Upper Bay. Conclusions: (1) striped bass predation on salmon was and remains predominantly on hatchery salmon; (2) striped bass predation on smelt was significant in the Lower Sacramento River where smelt are now rarely found because of water project operation; (3) predation in the Bay-Delta on smelt and salmon is minimal.
- Loboschefsky et al. (2011) — *"As expected, long-term trends in population consumption (total and prey fish) by all striped bass cohorts (ages 1 though 6) closely followed their respective population abundance trends. Population total consumption and prey fish-specific consumption by sub-adult striped bass was found to be similar to the population consumption by adult striped bass, due largely to the high abundance of sub-adults. Unlike adult striped bass that may emigrate and forage in the Pacific Ocean, the majority of sub-adult striped bass reside permanently within the [San Francisco Estuary]; hence, consumption by the relatively abundant sub-adult population may have significant impacts upon their estuarine prey species."*
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- Comment: Note that the reference from Leo Shapovalov and Alan C. Taft (1954) above and more recent data from Carmel Lagoon (this report) indicate the presence of sub-adult striped bass. Also, note that in all the studies referenced, predation rates on salmon and smelt in the estuary were generally very low (also noted above). Also note the statement by the authors: "*The present study is focused on broad categorical prey types (e.g., fish, decapods, isopods, mysids) and not specific prey species (e.g., delta smelt, longfin smelt, threadfin shad) due to the coarse resolution of the available empirical data."* The authors observe that effects on the native species are likely very low and that reductions in striped bass numbers could lead to increased numbers of silversides (predators and competitors) and largemouth bass (predators). They also note the subject is worthy of further study. Conclusion: based on this study, the predation rate of striped bass on salmon and smelt must now be much lower than in the past, given the record low levels of striped bass. With salmon and smelt at lower levels and other prey more abundant, a logical conclusion is that predation by striped bass on salmon and smelt is even lower than this study indicates.

  COMMENT: In the opinion of the reviewers, the selected quotes at the beginning of this report from the striped bass literature are distinctly biased to support the conclusions of the staff report.

- Loboschefsky et al. (Submitted for publication 2011): Population-level consumption of fish by striped bass has been a linear function of striped bass abundance (Figure 8; Loboschefsky et al. 2009). By virtue of their growth rate, striped bass *individuals* aged 2-6 have consumed (on average) approximately 5-25 kilograms of fish per year. Given their individual consumption of prey and striped bass abundance, (a) the *population* of striped bass aged 3-6 has consumed approximately 8-30 million kilograms (18-66 million pounds) of fish per year while (b) the *population* of striped bass aged 1-2 has consumed approximately 2-25 million kilograms (4-55 million pounds) of fish per year.

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- Comment: The authors of this study did not speculate on the degree of predation that can be attributed to listed species. This was primarily a modeling exercise, meaning the results are only as good as the limited data used. Strictly based on numbers, 99.9% of the fish consumed would be non-listed native and non-native prey species. Little of the consumption would occur in winter when salmon are prevalent because waters are well below the preferred feeding temperatures for striped bass. Again, overlap may occur in April of drier years; plus, striped bass would likely prey heavily on hatchery salmon smolts released above the Delta in spring. DFG is considering stopping the practice of trucking hatchery smolts to the Bay to reduce adult straying and program costs, which may result in increased loss from predation.
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- *CDFG 1999: The great abundance of striped bass suggests that even a small predation rate results in the loss of many individuals of the listed species. For example, CDFG (1999) wrote that, "Based on the 1994 abundance of delta smelt (4,803,000), annual consumption of delta smelt by the present (mean 1992-94) striped bass population in the Estuary is estimated to be 5.3% of the population...." The "(mean 1992-1994) striped bass population" used by CDFG (1999) was 6,760,385 and included estimated abundance of piscivorous age-1 and older striped bass (CDFG, unpublished analysis). The striped bass population characterized by CDFG (1999) would have consumed 254,559 delta smelt annually, even though delta smelt were very rarely observed in the stomachs of striped bass.*
- Comment: The DFG Conservation Plan for the striped bass enhancement program estimated the take of smelt in a very conservative manner, befitting such an approach. This analysis stretches the data to an inappropriate degree, essentially ignoring confidence limits, which must be huge. The number "5.3%" sounds precise, but it is not; also, it uses a conservative estimate of predation from historic feeding studies. Total mortality was more than 95%, thus estimated predation mortality was a very small portion of an estimated overall effect. It is an educated guess without confidence limits. The actual feeding rate of nearly 7 million stripers on a population of nearly 5 million Delta smelt cannot be determined with any accuracy. A rate of 0.001 or 0.1 percent would have been 7,000 smelt. One percent would be 70,000. For contrast, actual SWP salvage of smelt in spring of 2000 was more than 1,000 smelt per day for 20 days, with a total of more than 60,000 fish over that entire period.
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- Johnson et al. 1992: A decline of Chinook salmon in Coos Bay coincided with large populations of striped bass and loss of spawning habitat, and a period of Chinook recovery coincided with reduced striped bass populations and improved habitat. When considering a striped bass enhancement program, Oregon Department of Fish and Wildlife wrote that it is plausible for striped bass in the Coos Bay watershed to consume many thousands of young Chinook salmon annually and that large striped bass populations may limit enhancement options for salmonids. Note: In an independent review of the Central Valley Project Improvement Act fisheries program organized by the US Fish and Wildlife Service, Cummins et al.(2008) expressed a similar notion by writing that "The stated goal to increase the production of both native salmonids and exotic predators/competitors (e.g., striped bass and shad) is internally inconsistent."
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- Comment: The large populations of winter-run Chinook and striped bass in the 1970s would seem "internally inconsistent" to Cummins. The situation in Coos Bay is far different than in the Bay-Delta and Central Valley.

- Lindley and Mohr (2003): In a modeling effort limited by available data (e.g., striped bass functional response to prey abundance), the authors predicted that if the striped bass population declines to 512,000 adults, Winter-run Chinook salmon will have about a 28% chance of quasi-extinction (i.e., three consecutive spawning runs of fewer than 200 adults) within 50 years whereas a population of 3 million adult striped bass would increase the predicted quasi-extinction probability to 55%.[14]

[14] The Commission's Striped Bass Policy, adopted in April 1996, sets forth a restoration goal of 3 million adult striped bass.

Comment: This modeling assessment was entirely hypothetical. It only shows what *could* happen if all the assumptions of the model were real.

- NMFS on Striped Bass Predation (NMFS 2005, 2011a, 2011b):

Comment: These documents address concerns about striped bass predation at specific structures including RBDD, Daguerre Dam (Yuba River), the Suisun Salinity Structure, and others. NMFS (2005) states: "…*Although the two species coexisted at high population levels within the past several decades, efforts to artificially increase the striped bass population at this time may adversely affect the ability of winter-run chinook to recover. Environmental conditions within the aquatic habitats of the Central Valley have undergone profound changes in recent decades, such that the environment that the two species now share no longer has the variety of microhabitats that existed previously. Progress is needed in recovering the winter-run chinook population before efforts are implemented to enhance the striped bass population."* NMFS (2011a) states*: "...Predation is an ongoing threat to this ESU, especially in the lower Sacramento River and Delta where there are high densities of non-native (i.e., striped bass, smallmouth bass, and largemouth bass) and native species (e.g., pikeminnow) that prey on out- migrating juvenile salmon. The presence of man-made structures in the freshwater habitat likely contribute to increased predation levels by altering the predator-prey dynamics that often favor predatory species. In the Sacramento River, removal of the gates at the RBDD minimizes predation impacts on this ESU at that location. In the ocean, and even the Delta environment, salmon are also common prey for harbor seals, sea lions, and killer whales."*

These assessments recognize that striped bass predation – and predation from pikeminnow and other predators are largely a function of unnatural prey availability and vulnerability. In none of these documents did NMFS suggest added harvest or controls on striped bass; they only supported refraining from the enhancement programs of the past.

"Recent acoustic tag studies indicate that freshwater survival may be much lower than previously thought (<10% instead of 50%) indicating that juvenile production at least to the Delta could be overestimated. Potential causes of higher mortality rates include increased predation from introduced species (e.g., striped bass, largemouth bass, smallmouth bass), poor water quality from pesticide and herbicide runoff, lack of food from loss of riparian community (due to rip-rap and levee protection), and diversion of juveniles into less productive areas of the Delta."

Comment: Again, these tag studies were carried out on hatchery smolts that are exceptionally vulnerable to predation in the Delta; this is the driving rationale for trucking these fish in May and June to the Bay. Winter-run Chinook salmon and steelhead move through the Delta in winter when predation is low because of cold and generally turbid water from storm runoff. Spring-run and fall-run salmon young enter the Delta in winter as fry or sub-yearlings, and usually move on to the Bay by April or early May.

R. DISTRIBUTION, HABITAT USE, AND MOVEMENT PATTERNS OF SUB-ADULT STRIPED BASS MORONE SAXATILIS IN THE SAN FRANCISCO ESTUARY WATERSHED, CALIFORNIA 2012. By CYNTHIA M. LE DOUX-BLOOM. PhD DISSERTATION. UNIVERSITY OF CALIFORNIA DAVIS.

Abstract: we investigate movement patterns of transmittered sub-adult striped bass using statistics and Esri's GIS Tracker Analyst and Time Slider to conduct Visual Analysis. Movement patterns differed between fish and groups of fish. During our study, sub-adult striped bass exhibited three distinct patterns of residence: 1) Riverine, 2) Estuarine, and 3) Bay. Riverine residents remained within freshwater habitat across all seasons. Estuarine residents exhibited movement patterns dominated within mesohaline habitats, seldom visiting riverine or marine habitats. Bay residents moved within polyhaline and euhaline habitats across all seasons. In summary, our findings represent the first behavior studies on sub-adult striped bass in the SFEW and describe their distribution, habitat use, and movement patterns.

Dissertation Scope

The overall objective of this dissertation was to improve our understanding of sub-adult striped bass behavior inhabiting the SFEW. Using acoustic biotelemetry, we investigated their distribution, habitat use, and movement patterns over 17 months.

Abstract (p36): Sub-adult striped bass distribution and habitat use differed by season and region. In fall, fish were widely distributed from the bays to rivers. Between fall and winter, the distribution shifted toward the ocean, likely in response to decreasing water temperatures in the rivers. In winter, detections decreased and fish were typically found in or near the bays while some fish emigrated to the ocean. In spring, detections increased and fish were distributed from the bay to 325 km upstream in the Sacramento River. In summer 2010, most fish were distributed in the Sacramento River, while in 2011, most fish were distributed in the bays. Differences in distribution may have been associated with the higher flow in 2011. Although the SFEW has been transformed from wetlands to channelized river systems, the current and historic distribution appears very similar. In fall, sub-adult striped bass inhabited diverse pelagic habitats from limnetic to euhaline (0- 31‰) coupled with temperate (15-20ºC) water temperatures. In winter, fish were found in limnetic, mesohaline, and polyhaline habitats mixed with cool (10-15ºC) temperatures. In spring, fish were found in a wide range of habitats from limnetic to euhaline (0-31‰) coupled with cool (10-15ºC) and temperate (15-20ºC) temperatures. Habitat use differed between the summers. In 2010, fish inhabited mostly limnetic and mesohaline habitat with warm (20-25ºC) or temperate temperatures. In summer 2011, fish inhabited higher salinities mixed with temperate temperatures. Sub-adult striped bass were detected most often on shoals (<4m) except in winter when channels (>4m) *were inhabited equally. Water temperature likely plays a more important role on distribution and habitat use than salinity or depth in winter and spring. Fish forage density likely influences summer and fall distribution and habitat use. Differences in habitat use between individual fish or subgroups may help explain the seeming erratic distribution and the population fluxes observed in sub-adult striped bass inhabiting the SFEW.*

Distribution (p53):

In 2010, an average precipitation year, sub-adult striped bass were mainly distributed from Carquinez Strait to the Sacramento River near 192 RKm (rm 120 120 near Wilkins Slough). *In 2011, an above average precipitation year, the distribution shifted toward the ocean, with most fish observed between the Central Bay and Carquinez Strait. The difference in distribution between the two summers may be related to increased flow (Stevens 1977), which forced usually estuarine fish to lower flow, higher salinity habitat.*

We suspect the large increase in spatial distribution in spring may be related to increased temperature in the SFEW. The timing of the upstream migration may be temperature mediated as reported in other striped bass populations (Van Den Avyle and Evans 1990; Carmichael et al. 1998; Bjorgo et al. 2000; Ng 2007) as it occurred when temperatures increased from cold to cool. When temperatures in the SFEW became warmer than the Pacific Ocean, the sub-adult striped bass returned to the watershed (Radovich 1963; PSMFC 2012). Finally, the increase in range in the spring may reflect that some of our study fish matured and engaged in their first spawning migration similar to fish recorded by Chadwick (1967).

Comment: This shift in sub-adult distribution is important because these fish constitute the most abundant life stage and are highly capable of feeding on smelt and salmonid juveniles. Dry year spring flows and water temperatures likely increase the predation rate of subadult striped bass on juvenile hatchery and wild salmonids as they migrate through the confines of the Lower Sacramento River, where water temperatures are nearer optimal for subadult striped bass and above optimal for salmonids seeking to avoid predation (65-70^{o}F).

Habitat Use (p53):

Restoration planning should consider the effects of developing shoal habitat with increased seasonal temperature if the projects are intended to provide refugia for native fishes. Sub-adult striped bass may also be attracted to these areas, thus potentially increasing predation by striped bass on native fishes.

Comment: This is the basis of our recommendation #26.

Movement Patterns (p79):

Movements differed between some fish and showed three distinct residence patterns: riverine, estuarine, and bay residence. Riverine residents remained within freshwater habitat across all seasons. Estuarine residents exhibited movement primarily within *mesohaline habitats, seldom visiting the riverine or marine habitat. The bay residents moved within polyhaline and euhaline habitats across all seasons. There are two notable deviations from these patterns. In fall, an upstream foray was undertaken by a few bay and estuarine residents into freshwater habitat averaging 14 days, with fish returning to their departure location. In late spring 2011, an upstream migration occurred which included fish from all groups. This may indicate that some male fish had matured and engaged in their first spawning run.*

Our findings represent the first studies on the movement patterns of sub-adult striped bass and concur with recent otolith microchemistry studies in the SFEW. The distinct movement patterns of sub-adult striped bass could have important consequences to the management of the recreational fishery, ESA-listed species recovery plans, and future restoration planning.

Three movement patterns of sub-adult striped bass were identified by visualization analysis and were defined by the habitat where the movement occurred most or exclusively: riverine, estuarine, and bay. Fish remaining in freshwater during the study period were defined as "riverine residents." Fish displaying movements that included fresh water to mesohaline habitats were termed "estuarine residents." Fish detected in predominately polyhaline to euhaline habitats were categorized as "bay residents."

Riverine residents (n=10) spent summer 2010 moving within or between locations in the Sacramento or American rivers (Figure 3.4). In fall, riverine resident moved downstream into the San Joaquin River and were last detected in the South Delta. Over winter, these fish were not detected by any of the receivers in the SFEW. In spring, riverine residents were again detected by receivers in the Central and East Delta regions. These fish moved upstream through the Central Delta and into the Sacramento River, typically following their fall downstream route in reverse. In summer 2011, riverine residents moved farther upstream into the Sacramento and Feather rivers. In late summer and early fall, riverine residents again moved downstream into the Central Delta and San Joaquin River following the same or similar route as the previous year.

In late spring, water temperatures begin to increase and riverine residents reversed their movement patterns, returning to more eastern locations located higher in the watershed.

It appears water temperature of both the ocean and rivers may trigger sub-adult striped bass movement by bay and riverine resident groups. Analyzing recreational catch and bycatch records during El Nino Southern Oscillation and La Nina ocean-atmosphere phenomena may assist in determining movement of sub-adult striped bass from the SFEW into the Pacific Ocean. Warming water temperatures predicted with climate change may be beneficial to the striped bass population in the SFEW.

Sub-adult striped bass movement has been shown to be influenced by prey availability. Scofield (1928) concluded that sub-adult striped bass movement patterns were largely dependent upon seeking prey. He noted that over summer, sub-adult striped bass moved onto the mudflats of San Pablo Bay feeding on small fishes. However, crabs and shrimp *are the mainstay of their diet. Turner and Heubach (1966) found that sub- adult females remained or moved into lower salinity habitat in late spring and summer, likely in response to increased prey concentration. Scofield and Bryant (1926) described an early fall upstream movement by "immature females fresh from the ocean for feeding purposes." A few bay and estuarine residents showed similar patterns by moving upstream for a few weeks in early fall into the Sacramento River and Cache Complex.*

Summary (p95):

Movement of diadromous sub-adult striped bass necessitates large physiological osmotic changes across salinities and water temperatures and is likely influenced by seasonal fish forage density.

Comment: This study shows the distribution and movement patterns of subadult (age-1 to age-3) striped bass and the reasons for such patterns. Water temperature, flow, and prey availability influence the major movement patterns. Sub-adult striped bass sought the warmest water – especially in spring, with movements into lower rivers where juvenile salmonid prey was most abundant. Our most important recommendation in this chapter is maintaining spring water temperatures in lower Central Valley rivers below 65ºF by using higher stream flows to minimize striped bass predation on out-migrating smolt salmonids. This temperature is at the lower end of striped bass feeding preference and at the upper end of salmonid temperature tolerance – the range where predator avoidance is most optimal.

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