■ Interagency Ecological Program for the San Francisco Estuary ■

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Threadfin Shad

Annual salvage at the SDFPF (720,945) was lower than at the TFCF (811,164) (Figure 15). Salvage at the SDFPF was higher than in 2009 (387,940). Similarly, TFCF salvage was higher than in 2009 (401,911). Similar to splittail, annual salvage of threadfin shad has varied greatly through time.

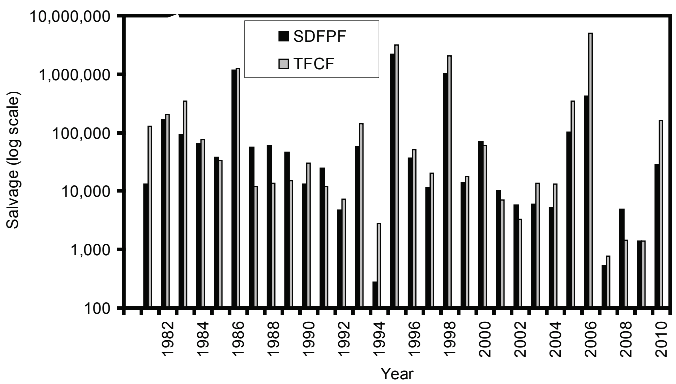

Figure 14 Annual salvage of splittail at the SDFPF and the TFCF, 1981 to 2010

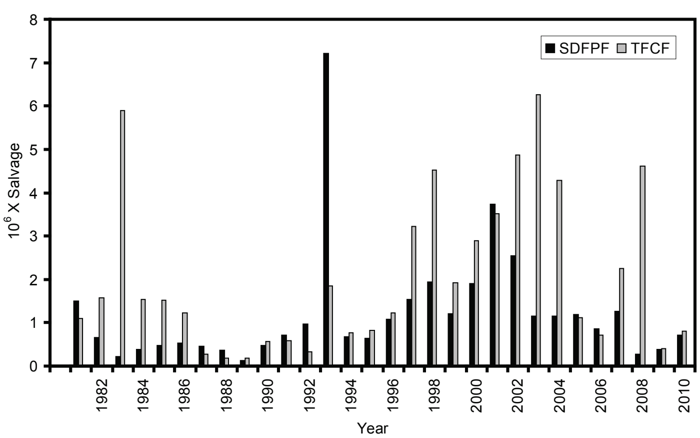

Figure 15 Annual salvage of threadfin shad at the SDFPF and the TFCF, 1981 to 2010

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Status and Trends of San Francisco Estuary White Sturgeon

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Introduction

The California Department of Fish and Game's (CDFG) sturgeon population study (study) develops data and collects information to assess the suitability of fishing regulations, to determine progress towards management objectives, and to contribute to the understanding of how sturgeon populations respond to changes in environmental conditions.

The study uses mark-recapture methods to develop information on the absolute abundance, harvest rate, and survival rate of white sturgeon (*Acipenser transmontanus*) and — to a much lesser extent due to scarcity of individuals — of green sturgeon (*A. medirostris*). The metrics require a minimum of 1-3 years to develop and broad confidence intervals around most of the estimates are attributable in large part to relatively small sampling effort. We do not know the degree to which these estimates violate pertinent assumptions for mark-recapture studies (Ricker 1975), but the metrics have critical management utility.

The study also uses the reported catch and catch per unit effort (CPUE) of sturgeon by the Commercial Passenger Fishing Vessel (CPFV) fleet, an index of age-0 white sturgeon year class strength from the San Francisco Bay Study, length data from Sturgeon Fishing Report Cards and during tagging, and CPUE during tagging. Taking just 1-2 years to develop and speaking to a large fraction of the sturgeon age distribution, these are important and complementary metrics.

With green sturgeon listed under the federal Endangered Species Act and San Francisco Estuary white sturgeon the object of an important sport fishery while classified as *conservation dependent* by the American Fisheries Society (Musick et al. 2000), we are striving to improve some aspects of the sturgeon population study. We are (accordingly) in the midst of an in-depth exploration of extant and alternative methods, but we avoid much discussion about analytical methods here. Instead, we include citations to a number of memo reports for those who are interested in details.

Status and Trends

Year-class Strength

The years 1998 and 2006 were the two most-recent 'notably strong' year classes as indexed by catch from the San Francisco Bay Study (Figure 1). See Fish (2010) for methods and the relationship between year-class indices and Delta outflow.

Length Frequencies

The length-frequency distribution from catch during tagging — using trammel nets that select for fish between roughly 102 centimeters total length (cm TL) and 183 cm TL — shows modes at around 110 cm TL and around 180 cm TL (Figure 2) corresponding to the relatively-strong late-1990s year classes and the record-strong early-1980s year classes that have been depleted through three decades of mortality (Schaffter and Kohlhorst 1999; Fish 2010).

The length-frequency distribution from Sturgeon Fishing Report Cards (which is negatively biased for fish between 117 cm TL and 168 cm TL) shows modes around 60, 110, and 180 cm TL (Figure 3) that correspond to the relatively strong 2006, late-1990s, and record-strong early-1980s year classes. See DuBois et al. (2011, 2010a, and 2009) and Gleason et al. (2008) for more information on data from Sturgeon Fishing Report Cards.

Relative Abundance

Although not designed as a catch per unit effort (CPUE) study *per se*, we consider CPUE during tagging to be an index of abundance and it is positively correlated with estimated abundance via mark-recapture when years 1984, 1985, and 1994 are excluded (all years: r=0.1805, p=0.49; less years 1984, 1985, and 1994: r=0.6445, p=0.013). The period 2000-2009 included a near-record low value (the year 2005; Figure 4) and all values fell below the historical average. See DuBois et al. (2010b), DuBois and Mayfield (2009a; 2009b), Schreier and Donnellan (2007), and Donnellan and Gingras (2007) for more information on tagging CPUE.

The CPFV fleet is not obligated to speciate or to record the lengths of captured sturgeon, but we believe most are legally-harvested white sturgeon. Sturgeon CPUE during tagging and from the CPFV fleet are positively correlated (r=0.5793, p=0.019). The period 2000-2008 included a near-record low value for CPFV CPUE (the year 2005; Figure 5) and an increasing trend. See DuBois (2011a) for more information about CPFV CPUE.

Harvest and Survival Rates

Annual harvest rate is calculated from the number of tagged sturgeon reported caught by the public within one year of application and the number of tags applied during field sampling initiating the annual time period. Due to variations in the lengths of fish tagged during the course of the study and of fish legally harvested, we can only calculate harvest rate for certain population segments. The harvest rates of fish 117-168 cm TL (i.e., the legally-harvestable size as of March 2007 and a subset of all prior legal sizes) during 2000-2008 were generally lower than rates during the 1980s (Figure 6). See DuBois (2011b) for more information about harvest rate.

Annual survival rate is calculated from catch curves through the use of lengths of fish captured during tagging (DuBois et al. 2010) and/or from tags returned to us by the public (Ricker 1975). The period 2000-2008 included annual rates near the average (Figure 7). The survival rates from tag returns are for fish legal to harvest at tagging and are sometimes impossibly high due to small sample sizes and/or recruitment. Survival rates from catch curves include error attributable to variations in recruitment. See DuBois (2011b) for more information about survival rate.

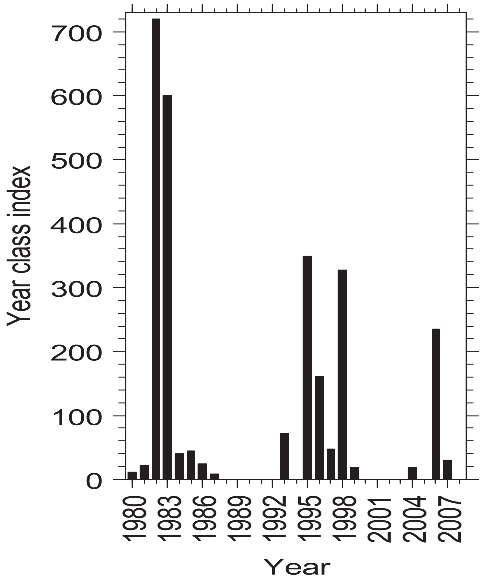

Figure 1 Time series (1980-2008) of San Francisco Bay Study white sturgeon year-class indices (Fish 2010); index is zero in years for which no bar appears (N=12)

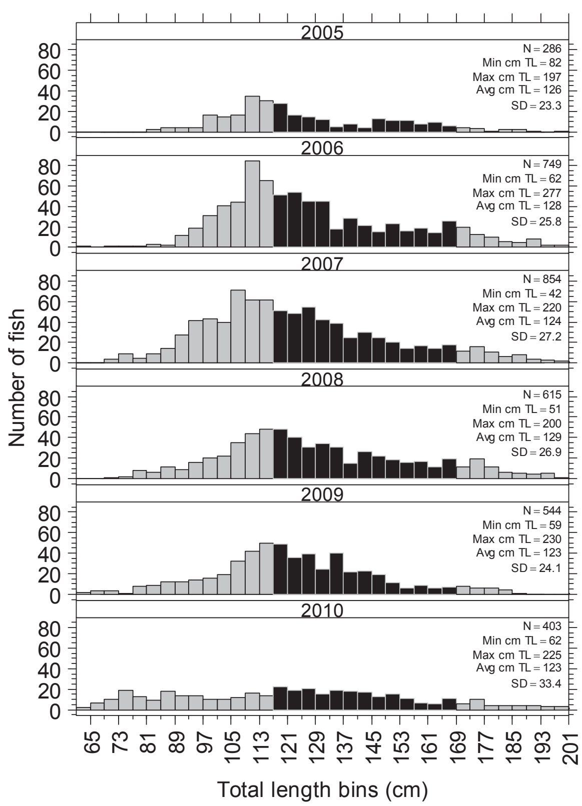

Figure 2 Length frequency distributions from the six most recent years of tagging (2005-2010); dark bars denote the current legally-harvestable size range (117-168 cm TL); fish less than 61 cm TL (N=12) and fish greater than 200 cm TL (N=12) are not included in graphics.

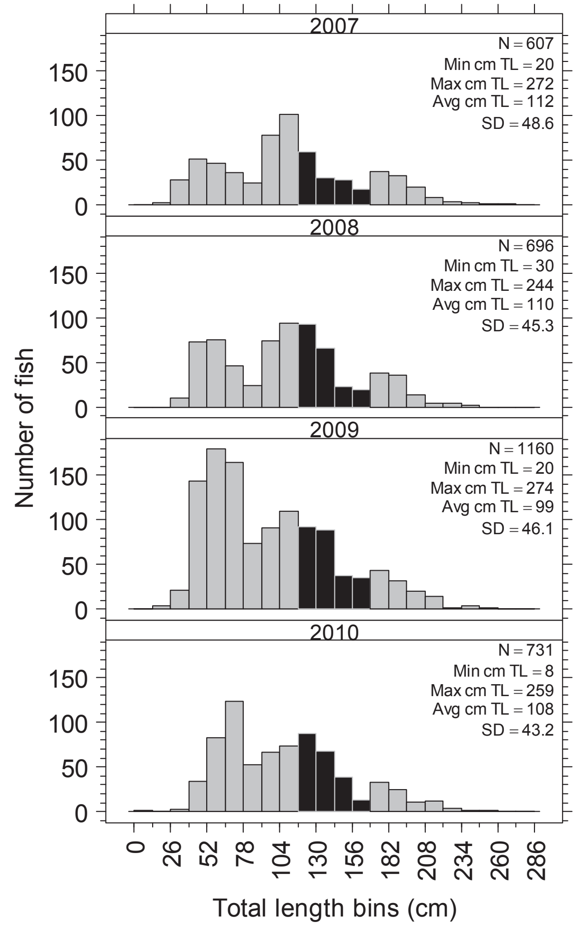

Figure 3 Length frequency distributions from the four years of California Sturgeon Fishing Report Card data (2007-2010); dark bars denote the current legally-harvestable size range (117-168 cm TL)

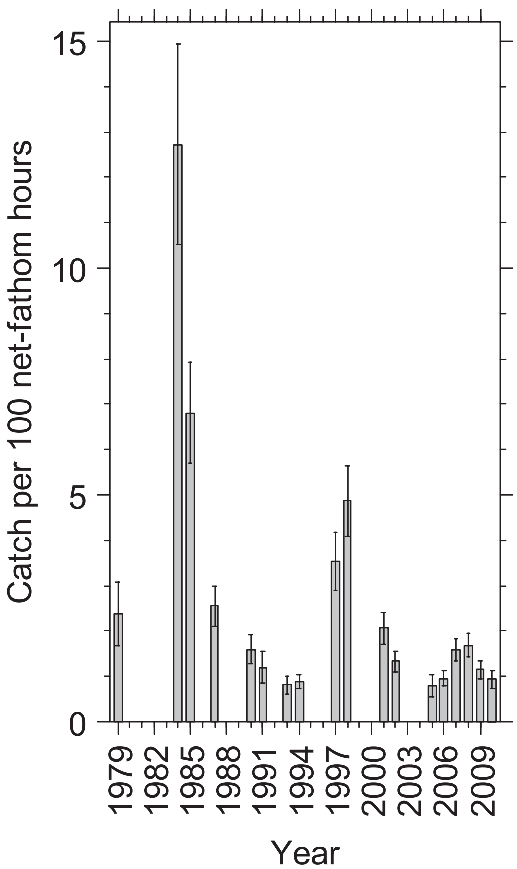

Figure 4 Time series (1979-2010) of catch per 100 net-fathom hours from tagging with 95% Confidence Intervals for fish within the current legally-harvestable size range (117-168 cm TL) and years in which tagging occurred.

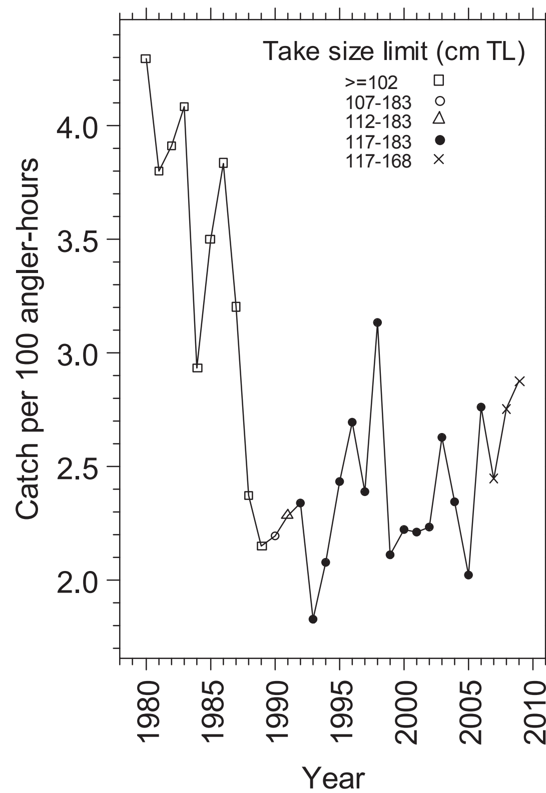

Figure 5 Time series (1980-2009) of Commercial Passenger Fishing Vessel fish kept (catch) per 100 angler-hours within the San Francisco Estuary (successful trips only); symbols denote change in legal size limit over the years

Abundance

Using Petersen mark-recapture methods we directly estimate the annual abundance of some population segments (i.e., based on a length range or lower length limit). We indirectly estimate abundance for other population segments by considering the length-frequency distribution of catch during tagging, the relationship between length and age, and the direct estimates.

The period 2000-2009 included near-record low abundance of white sturgeon ≥ 102 cm TL (Figure 8) and 3,252-6,539 age-15 fish as estimated (in full or part) using the indirect approach. The abundance of age-15 fish is the metric by which progress toward Central Valley Project Improvement Act (CVPIA) recovery goal (11,000 fish) is assessed. See DuBois (2011c) for more information about abundance.

Discussion

It is important to consider all available data (both dependent on and independent of the fishery) when evaluating the status of white sturgeon and management actions, because all of it is subject to uncertainty, some of it is subject to high uncertainty, and much of it (e.g., survival rate and abundance) is crucial for effective conservation and management.

We (and the sturgeon biologists who predated us) used a complicated mark-recapture algorithm to estimate abundance. The algorithm includes periodic updates using recapture data collected up to several years after tagging, assumptions about growth rate and about mortality attributable to tagging, and more professional judgment than we'd like. Although trends in mark-recapture abundance and in measures of relative abundance are generally harmonious, the mark-recapture abundance estimates are imprecise, and we have little ability to evaluate the accuracy of historical estimates. However, we have developed a new algorithm to estimate abundance — one that uses harvest rate from tagging and harvest from Sturgeon Fishing Report Cards — that is precise, with which we can evaluate the accuracy of corresponding estimates from the mark-recapture algorithm, and about which we will report in the near future.

Central Valley Project Improvement Act 's objective of a sustained increase in the number of age-15 fish (an index of adult fish productivity) to 11,000 is the only quantitative management objective for white sturgeon in California. It has not been achieved nearly 2 decades after being established. Given the apparent size of recent year classes as well as recent survival rates, harvest rates, indices of abundance, and length-frequency distributions, it is plausible (we plan to model this) that the number of age-15 fish will not increase to 11,000 for many years. That said, qualitative and intuitive management objectives — such as avoiding a petition to list under ESA, the presence of several relatively strong year classes, and harvest broadly allocated amongst user groups (Gleason et a. 2008; DuBois et al. 2009; DuBois et al. 2010a; DuBois et al. 2011) — have been achieved and appear sustainable for the foreseeable future.

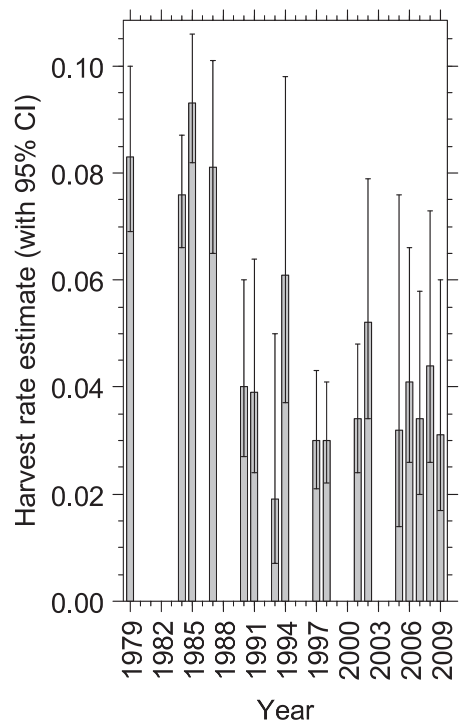

Figure 6 Time series (1979-2009) of harvest rate estimates with 95% Confidence Intervals for fish within current legally-harvestable size range (117-168 cm TL)

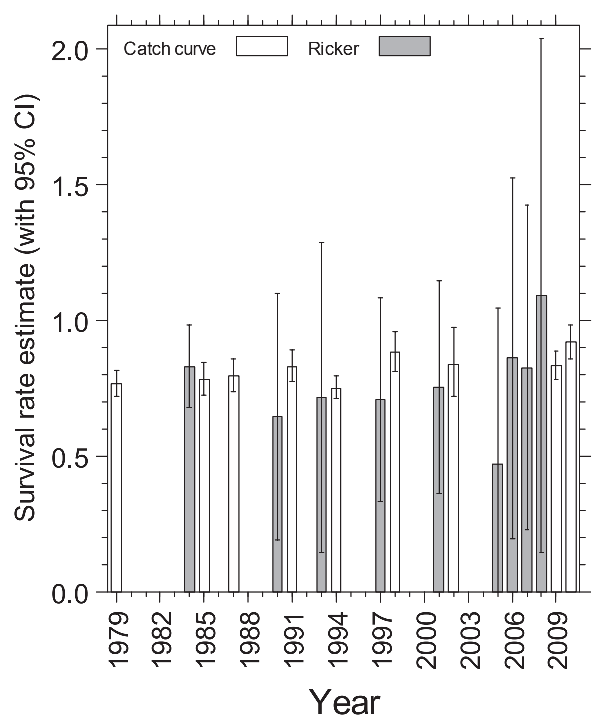

Figure 7 Time series (1979-2010) of survival rate estimates with 95% Confidence Intervals; note the two methods used to estimate rates; lower 95% CI for 2005 = -0.101, upper 95% Confidence Intervals for 2008 = 2.038

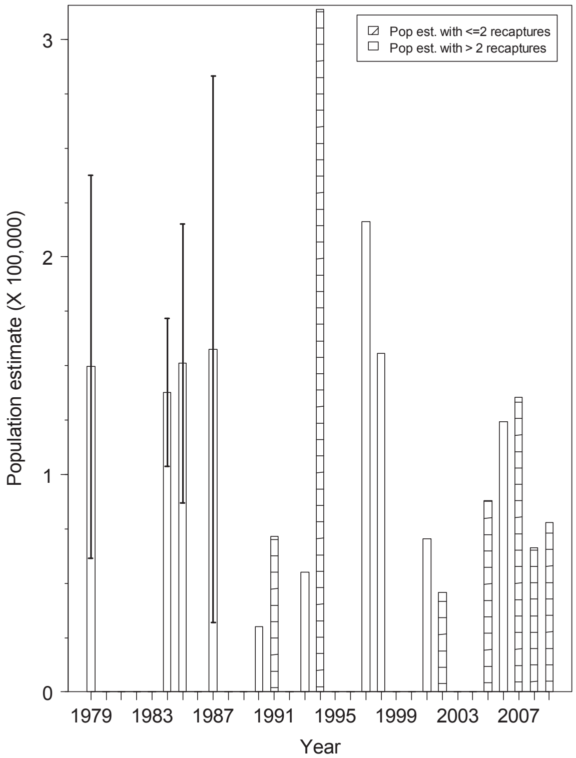

Figure 8 Time series (1979-2009) of population estimates fish≥ 102 cm TL; 95% Confidence Intervals are not shown for estimates made using the indirect approach

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The Interagency Ecological Program for the San Francisco Estuary
is a cooperative effort of the following agencies:

California Department of Water Resources
State Water Resources Control Board
U.S. Bureau of Reclamation
U.S. Army Corps of Engineers

California Department of Fish and Game
U.S. Fish and Wildlife Service
U.S. Geological Survey
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