■ Interagency Ecological Program for the San Francisco Estuary ■

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Spawning of Wakasagi *Hypomesus nipponensis* at Los Vaqueros Reservoir

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Eggs from the introduced osmerid wakasagi were collected from Los Vaqueros Reservoir on February 11, 2010. Eggs were collected from the northeast cove of the reservoir where the Adobe Creek, an intermittent stream, empties. Temperature at the collection site was 11.2 °C, dissolved oxygen level of 10 mg/L, and salinity of 0.2 ppt. There was light precipitation the day before collection and the water was slightly turbid. Eggs were collected from shallow water (15-45 cm deep) with little to no water movement, and were attached to submerged, horizontally-positioned dead vegetation. Other substrates available were silt and mud; however, as expected, no eggs were observed since silt and mud are not good substrate for egg attachment. Egg concentrations were heaviest in vegetation that was decomposing into thin threadlike strands of fiber. Eggs were translucent, had a diameter between 0.85–1.0 mm, and had an adhesive anchor made from the chorion, a characteristic found in osmerids (Wang 1986). The eggs were of different embryonic stages even within the same strand of fiber substrate, ranging from newly fertilized to advanced eyed embryo. The newly fertilized eggs were in the high blastomere stage meaning that the eggs were probably only a few hours old. The advanced eyed embryos were likely several days or weeks old (incubation period for wakasagi in the laboratory can reach 3 weeks at 14 °C). This age diversity means that there were several spawning events before our collection. To verify the species, the eggs were incubated and the larvae raised to juvenile stage.

These naturally spawned eggs collected from an adjacent reservoir of the Sacramento-San Joaquin Delta may be the first documented wakasagi egg collection from the system. Wakasagi eggs were collected from the Portuguese Cove in San Luis Reservoir (J. Wang, personal communication 2010) by Hess et al. (1995); however, only collection of wakasagi prejuveniles and juveniles were mentioned by Hess et al. Locating osmerid eggs and spawning microhabitat in the system, especially for delta smelt *Hypomesus transpacificus*, is difficult. Since wakasagi and delta smelt share several ecological traits, spawning information of wakasagi may provide clues to finding delta smelt eggs.

Reference

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Using Harvest Rate and Harvest to Estimate White Sturgeon Abundance

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Introduction

The California Department of Fish and Game (CDFG) has estimated abundance of white sturgeon (*Acipenser transmontanus*) in the San Francisco Estuary many times for several decades using a complicated algorithm. The algorithm (and application thereof) includes (1) periodic updates with recapture data collected up to several years after tagging, (2) assumptions about growth rate and about mortality attributable to tagging, and (3) more professional judgment than we'd like. Aside from their infrequent use when considering regulation of the fishery and the impact of development, abundance estimates are used each year to monitor progress toward the CVPIA 'Doubling Goal' for both white sturgeon and green sturgeon. Because the estimates are imprecise and take years to develop, their use in any near-real time sense is very limited. Here we describe and briefly explore an alternative method of estimating white sturgeon abundance that is precise and can be finalized relatively quickly. The alternative method uses estimates of harvest rate and uses harvest data from Sturgeon Fishing Report Cards.

Methods and Results

Abundance Estimates

We estimated the abundance of white sturgeon 117-168 centimeters total length (cm TL) by dividing harvest by harvest rate (Table 1). The size range is dictated by — and identical to — the legal limits on harvest of white sturgeon in California since March 2007.

Anglers are required to document the date and location of harvested fish on Sturgeon Fishing Report Cards (Cards) and are required to submit Cards by January 31 of the following year. Harvest is simply the number of fish that anglers reported harvesting.

Harvest rates are estimated by dividing the number of tags returned (by anglers) by the number of tagged fish released by the CDFG (DuBois 2011a) and can be (but was not in this instance) adjusted to address factors that may bias the estimate (e.g., tagging-induced mortality). Because the CDFG releases tagged fish only during August-October, harvest rate estimates — though reported per calendar year — are actually for the period of August-October in Year-X to August-October in Year-X+1.

To assure that the estimates of abundance are calculated using values for harvest and harvest rate that are reasonably synoptic and as an exploratory analysis, we considered harvest for 3 periods: (1) 365 days from beginning of tagging (1-beg); (2) 365 days from midpoint of tagging (2-mid); and (3) 365 days from the end of tagging (3-end). The period over which harvest was summarized made little difference in the estimate (Table 1).

Confidence Intervals

Asymptotic normally-distributed (Wald-type) upper and lower 95% confidence intervals (CI) were estimated per methodology developed by Ken Newman (pers. comm.). This type of interval assumes a normal distribution of the data (i.e., abundance estimates in this case) and was calculated using the equations below, where $SE(\hat{A})$ = standard error of the abundance estimate. Lower and upper confidence intervals (at 95%) were calculated as $\hat{A} \pm CI$.

$$SE(\hat{A}) = \frac{\text{Harvest}}{\sqrt{\text{Harvest Rate}^3 \times \text{Number of tags released}}}$$

$$CI = 1.96 \times SE(\hat{A})$$

Despite a skewed distribution of abundance estimates simulated via Poisson distribution (N=5,000) using 2007 1-beg data (Figure 1), the Wald-type intervals provide good coverage of the abundance estimate (Figure 2). Poisson distribution simulations (N=5,000) using 2008 and 2009 data produce similar distributions and thus yield the same conclusion.

Table 1 Estimated abundance of white sturgeon 117-168 cm TL using harvest and harvest rate (see DuBois 2011a for harvest rate estimates).

Year	Estimate Period	Period From	Period To	Harvest	Tags Released	Tags Returned	Harvest Rate	Estimated Abundance	Lower 95% CL	Upper 95% CL
2007	1-beg	08/03/07	08/01/08	1,931	388	13	0.034	56,794	26,146	87,442
	2-mid	09/14/07	09/12/08	1,918				56,412	25,970	86,854
	3-end	10/25/07	10/23/08	1,829				53,794	24,765	82,823
2008	1-beg	08/11/08	08/10/09	1,902	320	14	0.044	43,227	20,648	65,807
	2-mid	09/20/08	09/19/09	1,914				43,500	20,778	66,222
	3-end	10/29/08	10/28/09	1,931				43,886	20,963	66,810
2009	1-beg	08/10/09	08/09/10	1,397	286	9	0.031	45,065	15,401	74,728
	2-mid	09/18/09	09/17/10	1,397				45,065	15,401	74,728
	3-end	10/27/09	10/26/10	1,361				43,903	15,004	72,803

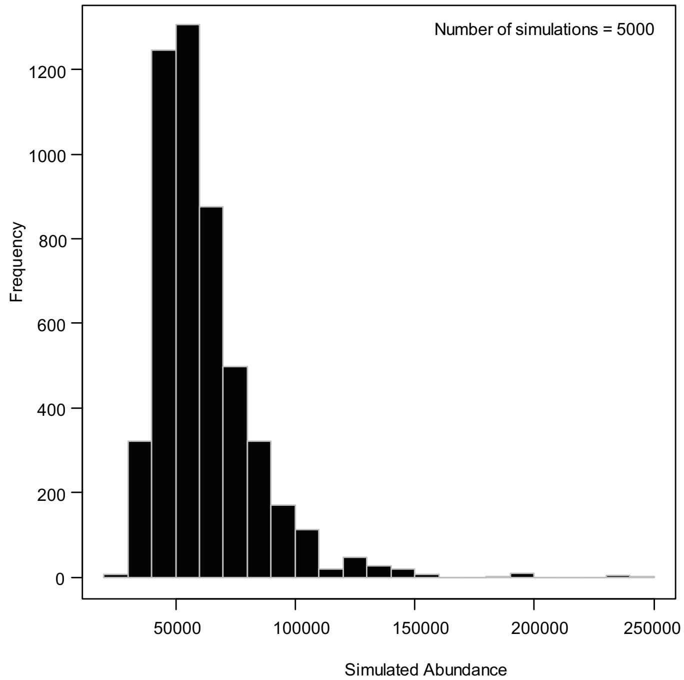

Figure 1 The distribution of simulated estimates of white sturgeon abundance (117-168 cm TL) in 2007 using harvest and harvest rate

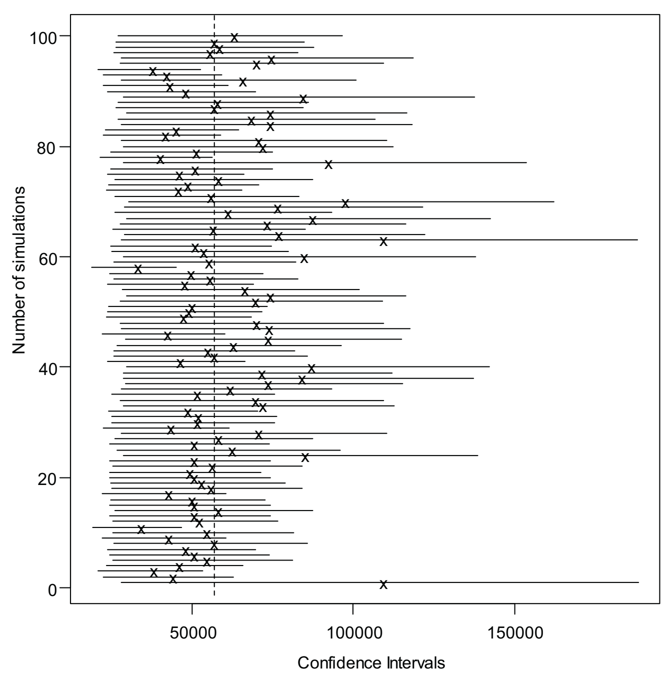

Figure 2 Confidence intervals for simulated estimates of white sturgeon abundance (117-168 cm TL) in 2007 using harvest and harvest rate. X = simulated abundance estimates (N=100); dashed vertical line = 2007 abundance estimate (56,794)

Discussion

The degree to which estimates made using the alternative algorithm have management utility depends in large part on their cost, timeliness, and precision. The annual cost (excluding postage paid by anglers) of Sturgeon Fishing Report Cards data has been approximately $25,000 and should decrease with full implementation of the Automated License Data System. Estimates using the alternative algorithm can be finalized within about a year, which is several years sooner than estimates have been finalized using the conventional algorithm. Because estimates made using the alternative algorithm do not require updating, their precision — unlike the precision for estimates made using the conventional algorithm (Miller 1972; DuBois 2011b) — is not an issue.

Cost, timeliness, and precision of these abundance estimates are moot if accuracy (trend-wise and/or absolute) of the estimates is not good enough. Accuracy is notoriously hard to evaluate and is beyond the scope of this article, but we will approach it here through a brief exploration of biases for the alternative algorithm and a brief review of estimates made using both algorithms.

Accuracy of estimates using the alternative algorithm is impacted by the net effect of several likely biases. Because none of those biases have been quantified recently (if ever), the following speaks mostly to their likely directions and suggests that the biases tend to offset:

(1) If harvest rate is underestimated, then estimates made using the alternative algorithm are biased high. We believe harvest rate is likely under-estimated due to under-reporting by anglers, mortality attributable to tagging, and tag shedding (Ricker 1975). With new research (e.g., a double-tagging study), additional outreach (e.g., posters alerting anglers about tagged sturgeon), and the inclusion of a tagged-fish section of 2010 and later Cards, we hope to reduce and quantify the impact of these issues.

(2) If harvest is underestimated, then estimates made using the alternative algorithm are biased low. While both under- and over-reporting of catch by anglers is possible, we have heard from anglers and law enforcement that under-reporting is the more-common of the two. We are in the “shall-we-do-this” stage of planning a study with law enforcement to quantify the degree of under-reporting.

Abundance estimates from the two algorithms vary no more than about ± 5,000 for 2008 and 2009 and no more than about ± 20,000 for 2007, suggesting that the alternative and routine algorithms generally track the same trends in abundance. Although several more estimates made using both approaches will be required before we can reasonably describe their statistical relationship (e.g., through regression), these initial signs of accuracy are promising.

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Notes

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Length-at-Date Criteria to Classify Juvenile Chinook Salmon in the California Central Valley: Development and Implementation History

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Introduction

California is unique in having four different spawning runs of Chinook salmon in the Sacramento River, resulting in a mixed population of juveniles in the river and downstream habitat. Identifying the offspring of these four runs (fall, late-fall, winter and spring) is particularly challenging as the runs are distinguished by the timing of adult spawning migrations, rather than juvenile behavior or appearance. The current solution is to classify the run origin of juveniles in this mixed population using length-at-date size criteria. Length-at-date criteria are the expected fork-length ranges of each run at each calendar date. Length-at-date criteria are organized into tables such that the fork-length of any Chinook salmon juvenile encountered in the Central Valley can be compared to the expected length ranges for the encounter date, and classified to run accordingly. Length-at-date classification is the accepted approach for designating run origin of juvenile Chinook salmon in the Sacramento and San Joaquin rivers and the Delta, and is central to loss and take estimates of threatened and endangered Chinook salmon runs at state and federal water pumping facilities. Since take estimations can affect the operations of the California State Water Project (SWP) and the federal Central Valley Project (CVP), the accuracy or inaccuracy of run classifications has enormous implications both for the persistence of Chinook salmon runs and for water use in California. Considering the importance of salmon and water to the California economy, it is surprising that the development of length-at-date size criteria is so poorly documented that few people are aware of the theory, assumptions and supporting data upon which the criteria are based. Following is an account of the development and implementation history of length-at-date size criteria for juvenile Chinook salmon in the California Central Valley. As the details of this account were pieced together from memoranda, meeting minutes and unpublished draft reports, those who par-

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