Interagency Ecological Program for the San Francisco Estuary

IEP NEWSLETTER

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Fields W and Messer C. 1999. "Life on the bottom: Trends in species composition of the IEP-DWR Benthic Monitoring Program." IEP Newsletter 12: 38-41.

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Estimating Annual Abundance of White Sturgeon 85-116 and ≥ 169 Centimeters Total Length

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Introduction

The annual abundance of San Francisco Estuary White Sturgeon less than 102 centimeters total length (cm TL) has not previously been estimated or indexed, because most research focus has been on harvestable fish and for many decades fishing has been prohibited on fish less than 102 centimeters total length. There is now emphasis on making those abundance estimates, because those are needed to simplify forecasts about reasonable expectations for the fishery (e.g., catch per unit effort; acceptable levels of harvest) and to allow a relatively simple assessment of Age-0 White Sturgeon abundance index accuracy. Although the abundance of White Sturgeon ≥ 169 cm TL — a demographic that has been protected by fishing regulations in full or part since the early 1990s — has been estimated using mark-recapture methods, precision of the estimates has been poor due to a paucity of marked fish and recaptured fish. To begin addressing these shortcomings, here we provide some abundance estimates for White Sturgeon 85-116 cm TL and ≥ 169 cm TL, and describe how we made those estimates using (1) estimated abundance of a third White Sturgeon demographic, (2) White Sturgeon lengths from catch in experimental trammel nets during the California Department of Fish and Wildlife (CDFW) White Sturgeon population study, and (3) White Sturgeon relative retention curves for those trammel nets.

Methods and Results

The primary challenge here is use of *catch length frequency distributions* from experimental trammel nets as proxies for *population length frequency distributions*. The issues are selectivity (i.e., one trammel catches fish better than another) and size-dependent availability of fish (i.e., given migratory and other behaviors, are lengths from the catch representative of the population). To begin addressing that challenge, we developed *modeled length frequency distributions* but we accounted only for selectivity.

The CDFW White Sturgeon population study deployed trammel net gangs composed of panels made from 8" stretched-mesh prior to 1990, but thereafter — laying the groundwork for an investigation into selectivity — the study deployed experimental trammel net gangs composed of panels made from 6", 7", and 8" stretched-mesh. Since 1990, the experimental trammel nets have been deployed weekdays in Suisun Bay and San Pablo Bay during either September-October (1990-1991, 1993-1994, 1997-1998, 2005) or August-October (2001-2002, 2006-2014). Length at recruitment to the experimental trammel nets increased with mesh size (Figure 1), which means information on differences in retention rates of the three mesh sizes would help with interpretation and use of the *catch length frequency distributions*.

We used R statistical and graphics software (R Core Team 2014, R version 3.1.1 2014-07-10) for the creation and assessment of relative retention curves (Figure 2) from CDFW White Sturgeon population study catch during 1990-1991, 1993-1994, 1997-1998, 2001-2002, 2005-2013. Models available to us were (1) "norm.loc," which is a normal curve where mean changes with the gear and standard deviation is constant for all gears, (2) "normal.sca," which is a normal curve where mean and standard deviation change with gear, (3) "lognorm," which is a lognormal curve, (4) "binorm.sca," which is the sum of two normals, and (5) "bilognormal," which is the sum of two lognormals.

We used only 2007-2012 length frequency distributions, because that is the longest uninterrupted time series and the findings speak directly to present harvest-management issues. To model 2007-2012 length frequency distributions that should more-closely approximate the *population length frequency distributions*, we used (1) the best-fitted (i.e., smallest model deviance) and most-plausible of the relative retention curves (Bi-Lognormal), and (2) 2007-2012 annual catch by the CDFW White Sturgeon population study.

As expected from relative retention curve shapes, the *modeled length frequency distributions* include a greater fraction of small fish than the corresponding *catch length frequency distributions* (Figure 3). Though not shown here, the *modeled length frequency distributions* also include many implausibly large variations below about 85 cm TL.

We estimated annual abundance of fish 85-116 cm TL and ≥ 169 cm TL (Figure 4) by using (1) estimates of 117-168 cm TL White Sturgeon abundance (as in DuBois and Gingras 2011) from reported harvest and estimated harvest rate (CDFW's "conventional algorithm") (Gingras and DuBois 2014) and (2) the *modeled length frequency distributions*. We constrained the abundance estimates to a minimum of 85 cm TL, because we believe variations in catch of fish less than 85 cm TL do not reliably reflect variations in abundance of that demographic.

Estimating annual abundance of fish 85-116 cm TL and of fish ≥ 169 cm TL is a multi-step process (Box 1). Catch per length is adjusted using relative retention values from the curve. Adjusted catch is then used to complete the final estimates. The abundance and variance calculations for 117-168 cm TL fish are not shown here, but use data from harvest (as reported on Sturgeon Fishing Report Cards) and harvest rate (as estimated from mark-recapture data). Because the algorithm used to estimate harvest rate is pretty-clearly biased low (Gingras and DuBois 2014), the abundance estimates presented here are all likely biased somewhat high.

Click to View Box 1

Click to view Box 1 Stepwise process for estimating annual abundance of White Sturgeon 85-116 cm TL and ≥ 169 cm TL.

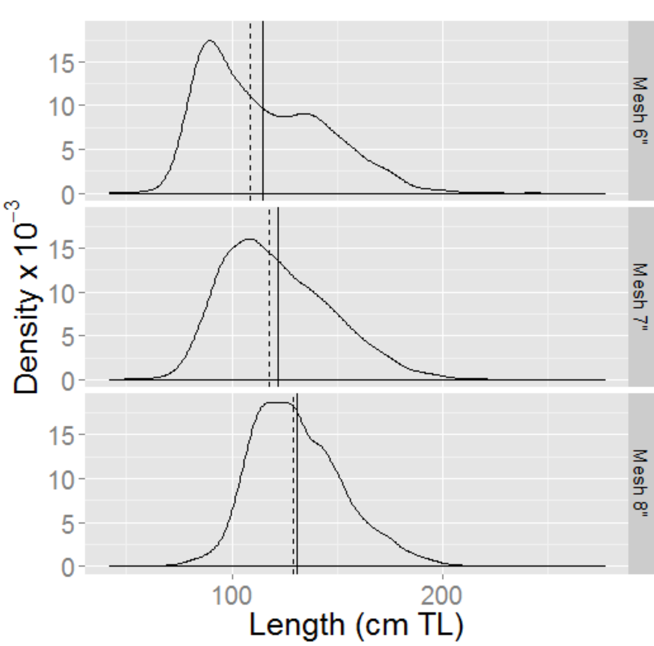

Figure 1 Density plot of White Sturgeon length (centimeters total length [cm TL]) by trammel net mesh size (6", 7", and 8"). Data from 1990-1991, 1993-1994, 1997-1998, 2001-2002, and 2005-2013. The solid vertical line is mean cm TL. The dashed vertical line is median cm TL.

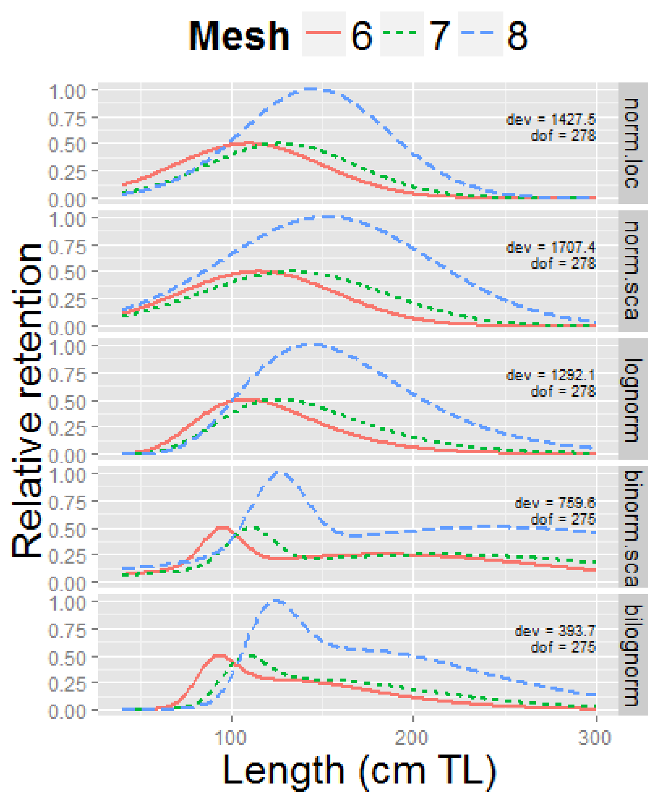

Figure 2 Relative retention curves for White Sturgeon in each trammel net mesh size (6", 7", and 8") for each of the five models over length range of 40-300 centimeters total length (cm TL). Model deviance (dev) and degrees of freedom (dof) displayed in the upper-right corner of each panel.

Discussion

When modeling length frequencies, we did not consider size-dependent availability of fish to the nets because — while recreational and research catch shows that fish in both demographics are ubiquitous in the study area — there are no quantitative distributions or behavior data to work with. Thus, these should be considered estimates of regional abundance that may index and approximate system-wide abundance.

As expected from indices of Age-0 White Sturgeon abundance (California Department of Fish and Wildlife 2014) and presumed growth rates, the trends in estimated 2007-2012 annual abundance of fish 85-116 cm TL reflect growth and protracted recruitment of the modest 2006 cohort to the experimental trammel nets and recruitment of scarcely detectable cohorts for several years prior to 2006. The 2006 cohort is recruiting to legally harvestable size such that catch rate in the fishery has likely begun to increase modestly, but will likely decline rapidly unless harvest is reduced and/or anglers become more efficient.

The estimated 2007-2012 annual abundance of White Sturgeon ≥ 169 cm TL is relatively low and constant, which is expected from the facts that (1) the White Sturgeon fishery has long been popular and is recently highly effective (Gingras and DuBois 2014), (2) these fish are typically from cohorts prior to 1993, (3) a maximum size limit on harvest was first implemented in 1990, and (4) 1984-1994 indices of Age-0 White Sturgeon abundance were negligible. It is particularly important to reliably estimate the abundance of this demographic, because it includes the preponderance of spawning females and — being protected from legal harvest — it is the "insurance policy" (e.g., against drought) for this population. In an effort to improve the rigor of abundance estimates for this demographic, we plan to work with statisticians in an attempt to incorporate adjustments for its migratory behavior.

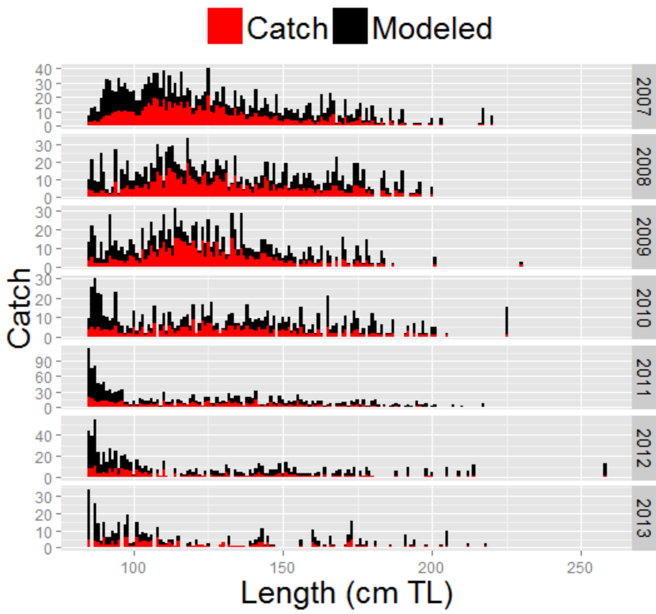

Figure 3 Frequency distributions of White Sturgeon lengths (centimeters total length [cm TL]; ≥ 85) for 2007-2013. Red bars represent catch. Black bars represent modeled (bi-log-normal) catch.

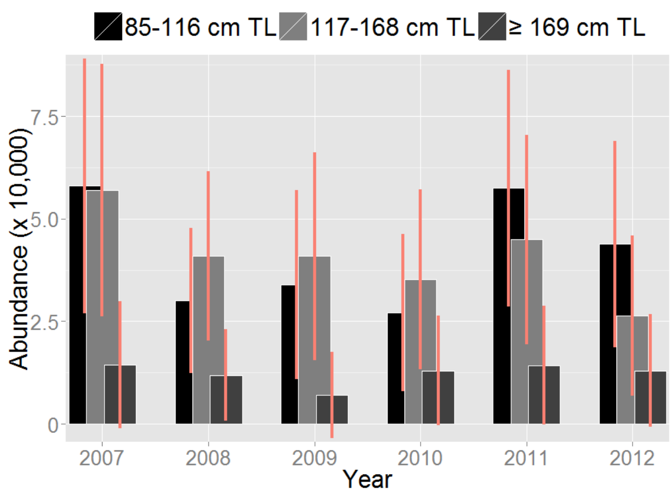

Figure 4 White Sturgeon abundance estimates with 95% confidence intervals for 2007-2012 by size category (85-116 cm TL, 117-168 cm TL, and ≥ 169 cm TL).

Acknowledgments

Russell Millar (https://www.stat.auckland.ac.nz/~millar/selectware/code.html) developed and made available the "R" code we used for the creation and assessment of relative retention curves. U.S. Fish and Wildlife Service statisticians Ken Newman and Lara Mitchell helped us tremendously by pointing us toward Russell Millar's work, coaching us on use of relative retention curves, and developing confidence intervals for these abundance estimates.

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R Core Team (2014). *R: A language and environment for statistical computing.* R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/.

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Issue	Article Submission Deadline
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Issue 3 (Summer)	July 15, 2016
Issue 4 (Fall)	October 15, 2016

Submit articles to Shaun Philippart.

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