

Special Study Proposal: Sturgeon Derby - Correlation of Selenium in Sturgeon Tissues

Summary: In March 2016, the State Water Resources Control Board approved a Selenium TMDL for North San Francisco Bay, which established a white sturgeon muscle tissue target of 11.3 ug/g dry weight as the basis for evaluating impairment. In 2015 and 2016, the RMP funded a study in collaboration with USFWS and Stantec, Inc. to collect tissue samples from angler-harvested female sturgeon collected as part of the annual Sturgeon Derby held out of Bay Point. The objective of this study was to establish relationships between selenium concentrations measured in non-lethally collected tissues (muscle plugs, fin rays) and those that are more closely tied to, or predictive of, adverse impacts in white sturgeon due to selenium (ovaries, otoliths). This study proposes a continuation of this sampling in 2017.

Estimated Cost: \$42,000

Oversight Group: RMP Selenium Workgroup

Proposed by: Jennifer Sun and Jay Davis

Background

Since 1998, San Francisco Bay has been identified as impaired by selenium under the Clean Water Act. In April 2014, the RMP formed a Selenium Workgroup to evaluate information needs that can be addressed by the Program in the next several years. The charge given to the workgroup by the RMP Steering Committee was to focus on low-cost, near-term monitoring elements that can provide information that provides high value in support of policy development and decision-making.

In 2016, the State Water Resources Control Board approved a selenium TMDL for North San Francisco Bay. The TMDL established a target concentration of 11.3 ug/g dw in white sturgeon muscle tissue as the basis for evaluating impairment (Baginska 2015). In order to help implement this regulation, the Selenium Workgroup has recently focused on developing non-lethal monitoring methods that will allow for the routine collection of large numbers of white sturgeon muscle tissue samples.

Sampling sturgeon ovaries, although logistically more challenging than sampling using non-lethal methods, would provide a more direct metric of the risk to sturgeon reproduction. USEPA recently published draft selenium criteria for freshwater that highlight egg or ovary data as the preferred endpoint most directly tied to adverse effects (USEPA 2015). Data that would allow evaluation of the correlation between concentrations measured in non-lethally collected tissues and ovary concentrations would enhance the application of muscle plugs as an impairment indicator.

The RMP is currently working to establish two non-lethal sampling methods for measuring selenium concentrations in sturgeon tissues. During the 2009 and 2014 RMP sport fish sampling events, paired muscle plug and muscle fillet samples were analyzed for selenium to determine if muscle plugs could be used as surrogates for the more common measurement of muscle tissue – muscle fillets. Selenium concentrations in muscle plugs were found to correlate well with concentrations in muscle fillets for the 24 fish sampled. In 2016, paired muscle plug and muscle fillets were analyzed from nine female sturgeon collected during the Sturgeon Derby, and were also found to be significantly and positively correlated. The RMP has also further developed the muscle plug collection technique on live sturgeon in collaboration with the California Department of Fish and Wildlife (CDFW), during the 2014 and 2015 Selenium in White Sturgeon Muscle Plugs special studies (Sun et al. 2016, DuBois & Harris 2015).

As part of the 2015 and 2016 Sturgeon Derby studies, the RMP also collaborated with Dr. Vince Palace, currently with the International Institute of Sustainable Development (IISD) (formerly with Stantec, Inc.), and Dr. Norman Halden with the University of Manitoba, Department of Geological Sciences, to test a second non-lethal sampling method using fin rays using data collected at the annual Sturgeon Derby. In this Sturgeon Derby, held on Super Bowl weekend, anglers attempt to catch sturgeon that come closest to a selected size. Fish that are close to the target size are brought to a central location and sacrificed. For the past several years, the USFWS has collected tissues from these sturgeon and analyzed them for a suite of metals and organics, including selenium, in gonads (including ovaries), liver, and plasma. These data have not yet been published. During the 2015 and 2016 Sturgeon Derbies, the RMP successfully collaborated with USFWS and Dr. Palace to collect fin ray and otolith samples for selenium analysis, for comparison with concentrations measured in muscle plugs, ovaries, and other tissues.

Fin rays are taken as a clip and are easy to collect by non-specialists, and fin clips have been shown to be non-harmful to sturgeon (Collins and Smith 1996). Because fin rays have a regular growth pattern similar to growth rings of a tree, a laser ablation MS technique (laser ablation inductively coupled plasma mass spectrometry [LA-ICP-MS]) can be used to allow for the analysis of concentrations of selenium and other elements in each annual ring (i.e., concentrations in the fish tissue over the time). Data showing trends in selenium concentrations in North San Francisco Bay white sturgeon tissue over time will help elucidate the dynamic selenium bioaccumulation patterns in sturgeon, and begin to answer the question of whether or not changes in selenium water chemistry and prey over time relates to changes in tissue concentrations in sturgeon.

A recent study found that fish otolith selenium measurements are the best predictors of ovary selenium, enhancing data collected from tissues alone (Reash, Friedrich, and Halden 2014). However, otoliths can only be collected from sacrificed fish. Thus, fin ray analysis is being developed as a potential alternative to both muscle plug and otolith sampling. The research team is currently using otolith microchemistry analyses to establish the chemical stability of fin ray samples. Fin ray data will also be compared with muscle and ovary data to develop a model that establishes the relationship between selenium concentrations in these tissues.

During the 2016 Derby, endolymph samples were also collected for selenium analysis by Dr. Fei Wang at the University of Manitoba. Understanding selenium concentrations in the endolymph, or the fluid in which otoliths are suspended, will contribute to a more complete model of selenium partitioning from the blood plasma to the endolymph to the otoliths, which will then be compared to selenium in the fin rays.

The annual sturgeon fishing tournament in the Delta again provides an opportunity to obtain tissue samples from a small number of female sturgeon in 2017. These samples will be used to test the relationships between selenium concentrations measured in tissues collected using lethal (ie. ovaries) and non-lethal (ie. muscle plugs, fin rays) methods, and contribute the development of the fin ray microchemistry analysis technique.

In both 2015 and 2016, just under 30 fish were sacrificed during the Derby, including 8 females in 2015 and 9 females in 2016. Because sampling conditions and sex ratios may be unpredictable, the proposed target number of female fish sampled during the 2017 Sturgeon Derby will remain at 15.

This proposal is requesting funds for a third year of sampling at the sturgeon Derby in 2017, which will include measuring selenium in muscle plugs, ovaries, fin rays, otoliths, and endolymph. The continuation of endolymph selenium analysis in 2017 will be reviewed by the Selenium Workgroup following the analysis of data from the 2016 Derby samples.

Study Objectives and Applicable RMP Management Questions

The primary objectives of this monitoring element are to:

1. Develop methods for non-lethal white sturgeon tissue sample collection and selenium analysis, including muscle plug and fin ray sampling techniques; and
2. Evaluate the relationship between tissues that can be monitored non-lethally (muscle plug or fin rays) and tissues that are more directly tied to adverse reproductive effects (ovary and eggs); and
3. Track temporal trends in selenium impairment over time

This study addresses key questions identified by the Selenium Strategy and RMP (Table 1).

Selenium Strategy questions addressed:

2. Are the beneficial uses of San Francisco Bay impaired by selenium?
4. How do selenium concentrations and loadings change over time?

Table 1. Study objectives and questions relevant to RMP management questions.

| Management Question | Study Objective | Example Information Application |
|--|---|--|
| <p>1) Are chemical concentrations in the Estuary at levels of potential concern and are associated impacts likely? 1B. What potential for impacts on humans and aquatic life exists due to contaminants in the Estuary ecosystem?</p> | <p>Compare measured concentrations to toxicity and regulatory thresholds (North Bay Selenium TMDL, USEPA site-specific criteria).</p> | <p>Do the data indicate a need for management actions? What factors are influencing the observed selenium concentrations? How should the TMDL muscle tissue target be assessed?</p> |
| <p>2) What are the concentrations and masses of contaminants in the Estuary and its segments? 2.1 Are there particular regions of concern?</p> | | |
| <p>3) What are the sources, pathways, loadings, and processes leading to contaminant-related impacts in the Estuary? 3.1. Which sources, pathways, etc. contribute most to impacts?</p> | | |
| <p>4) Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased? 4.B. What are the effects of management actions on the potential for adverse impacts on humans and aquatic life due to Bay contamination?</p> | <p>Compare measured concentrations to plug and fillet concentrations measured during past studies, including past iterations of this study.</p> | <p>Are selenium concentrations increasing or decreasing? What factors may be influencing these trends?</p> |
| <p>5) What are the projected concentrations, masses, and associated impacts of contaminants in the Estuary?</p> | | |

Approach

This study would be performed in collaboration with IISD. IISD would perform the collection of tissue samples from female fish caught at the Derby, and conduct selenium microchemistry analyses on the fin rays and otoliths. Analyses of selenium in endolymph will be conducted by the University of Manitoba. RMP staff would plan the study, assist with tissue sample collection, manage the data, and write a brief

technical report. The Moss Landing Marine Laboratory, Marine Pollutions Studies Lab (MLML-MPSL) or a comparable laboratory would perform selenium analyses on ovaries and muscle plugs, and subsequently prepare and ship these samples to UC Davis to perform C, N, and S stable isotope analyses. The stable isotopes will provide information on diet and habitat use by the sturgeon.

Tissues would be collected and analyzed from up to 15 female white sturgeon. If fewer than 15 females are euthanized during the Derby, tissues would be collected from all females. If samples are collected from fewer than 15 females, the remaining analytical budget will be used to analyze selenium in the muscle fillets of female fish. The sampling would occur on Super Bowl weekend in 2017.

Budget

The proposed budget for this Special Study is \$42,000.

Table 2. Budget for the 2017 Sturgeon Derby Proposal

| Task | Estimated Cost |
|--|-----------------------|
| <i>Labor*</i> | |
| Project Planning & Coordination | \$4,000 |
| Field Work | \$3,800 |
| Data Management | \$7,800 |
| Reporting | \$7,000 |
| <i>Subtotal</i> | \$22,600 |
| <i>Subcontracts</i> | |
| MLML-MPSL – 15 Se analyses (muscle plugs) @ \$222/sample | \$3,330 |
| MLML-MPSL – 15 Se analyses and sample homogenization (ovaries) @ \$327/sample | \$4,905 |
| UCD - 15 C, N, S analyses (muscle plugs) @ \$25/sample | \$375 |
| IISD- Travel (\$3,000), instrument set-up (\$2,500), 15 fin ray and 15 otolith selenium microchemistry analyses @ 115/sample | \$8,950 |
| University of Manitoba – 15 Se analyses (endolymph) @ \$60/sample | \$900 |
| <i>Subtotal</i> | \$18,460 |
| <i>Direct Costs</i> | |
| Equipment - biopsy plugs, sample containers, etc. | \$390 |
| Shipping | \$200 |
| Travel - 2 days of travel for 2 RMP staff | \$350 |
| <i>Subtotal</i> | \$940 |
| <i>Grand Total</i> | \$42,000 |

*Project management, contract management, and archiving costs will be included in the RMP base funding

Reporting

A draft technical report describing the results of the study will be prepared by September 30, 2017. The technical report will be reviewed by the Selenium Workgroup and the TRC and will be finalized by December 31, 2017.

References

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