

## **Sturgeon Movements in the San Francisco Estuary**

### Summary of Current Telemetry Studies and Knowledge

The RMP is currently involved in several studies of selenium concentrations in white sturgeon tissue collected in North San Francisco Bay. However, much is unknown about potential sources of selenium bioaccumulation in these fish over time.

This document summarizes major studies on white and green sturgeon movements within the San Francisco Estuary that are either published or in progress that may provide information helpful to understanding the dynamics of sturgeon movement, behavior, and selenium accumulation over time. A number of key white and green sturgeon telemetry studies are currently in progress by researchers at UC Davis and the US Fish and Wildlife Service (USFWS), for which data are expected to be analyzed beginning this year.

For background, the first section of the document is a short summary of known information about white sturgeon movements in the SF Bay.

This section is followed by a list of current or recent white and green sturgeon telemetry or abundance studies within the San Francisco Bay.. The list is divided into three parts:

- Telemetry Studies in or near the SF Estuary, including White Sturgeon
- Non-Telemetry Studies including the South SF Bay, including white sturgeon
- Telemetry Studies in or near the SF Estuary, Green Sturgeon only

The list is reasonably complete but may not be comprehensive.

### **Background - White Sturgeon Life History**

- Spawning periods in the Sacramento and San Joaquin Rivers are between mid-February to late May, with peak activity during March and April. Upstream migrations are triggered by photoperiod, increases in river flow, and temperature. Fish begin moving upstream in late winter, and may occupy the lower river for a couple months before spawning.
- Spawning periodicity thought to be 2-4 years for females, 1-2 years for males
- Occasionally found in tidal riverine and estuarine habitats of larger tributary streams such as Coyote Creek and Guadalupe River in South Bay, and Napa and Petaluma Rivers and Sonoma Creek in North Bay, which have shallow habitats for benthic feeding
- Foraging movements are presumed to be in response to salinity changes. In dry years, white sturgeon follow brackish waters upstream, and the opposite occurs in wet years.
- Tagging studies suggest that most white sturgeon remain in the estuary year round; however, some have been recaptured out of state (Washington and Oregon)
- White sturgeon appear to show preference for freshwater over brackish. Fish slowly transition to more saline waters during maturation. Juveniles are suggested to be stressed at salinities >15-20 ppt; adults stressed at salinities > 35 ppt.
- Little is known about movements through the Bay; known to be present in the rivers and Delta during fall, winter and spring

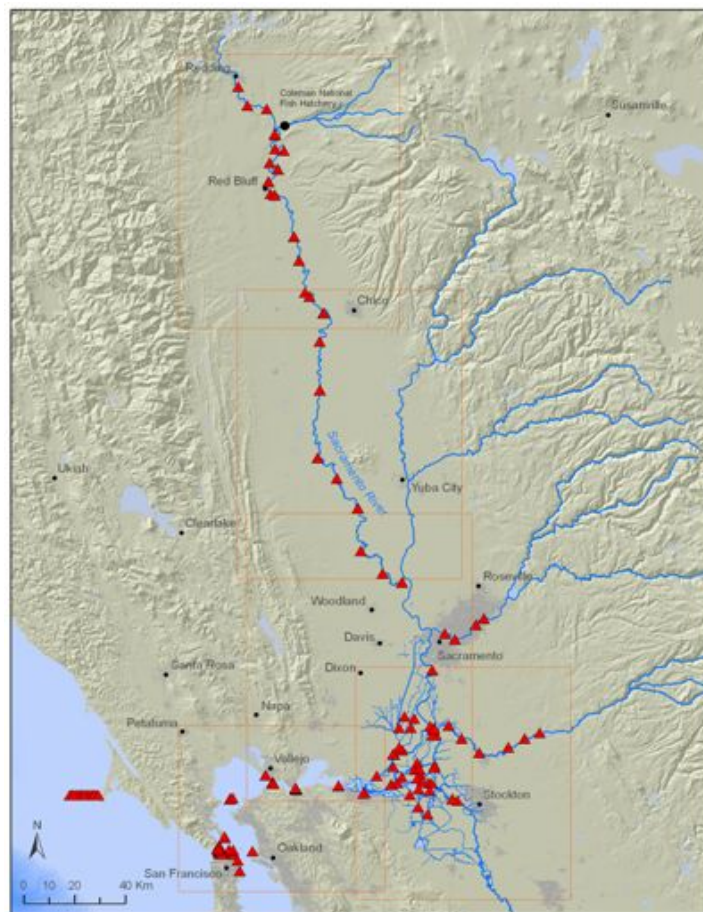
Israel, J., A. Drauch, and M. Gingras. Life History Conceptual Model for White Sturgeon (*Acipenser transmontanus*): Delta Regional Ecosystem Restoration Implementation Plan Conceptual Model. University of California, Davis and California Department of Fish and Game. [http://www.dfg.ca.gov/erp/cm\\_list.asp](http://www.dfg.ca.gov/erp/cm_list.asp)

**Telemetry Studies in or near the SF Estuary, including White Sturgeon (unpublished)**

1. CA Fish Tracking Consortium (<http://californiafishtracking.ucdavis.edu/default.shtml>)

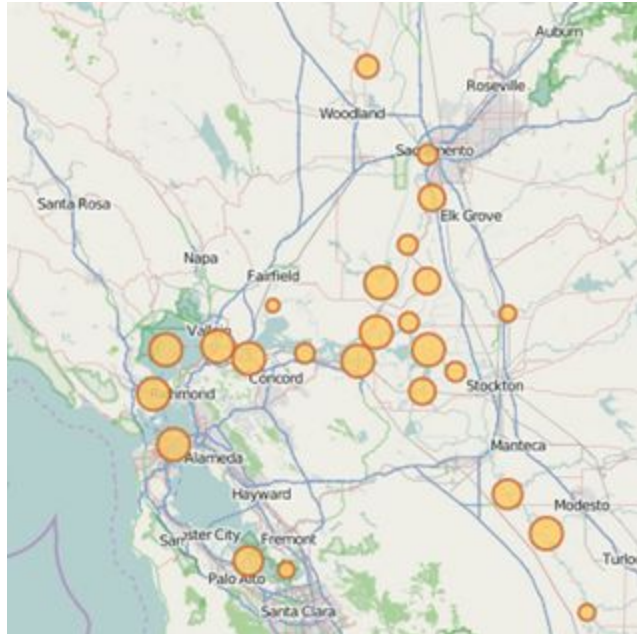
Manages core array and telemetry database among multiple research groups

- Core array: tagged fish are detected at all monitors in the array that they hit, and researchers are able to collect data for their fish from all monitors in the array
  - Major arrays within the SF Bay are located on the San Rafael Bridge (USACE), eastern side of the Bay Bridge (Bay Planning Coalition), and the Golden Gate Bridge (NOAA). Several pairs of monitors are also located in dredged and non-dredged sites within Central and North SF Bay.
  - No monitors are currently located below the Bay Bridge. Some historical data may have been collected.



2. Zachary Jackson, US Fish and Wildlife Service - white sturgeon telemetry throughout SF Bay

- Data collected between South Bay and the Merced River confluence on the San Joaquin River, and the Woodland area on the Sacramento River



Example of a rough detection map

- 34 white sturgeon tagged in 2012-2014, with a 10 year tag life
    - unknown if all fish were sexually mature or not
  - Analysis of movements within the Bay will begin in Summer 2015
  - Analysis of movements within the San Joaquin River have been published:
    - Jackson, Z. J., and J. R. Faulkner. 2014. 2012 San Joaquin River White Sturgeon Telemetry Study. Stockton Fish and Wildlife Office, Anadromous Fish Restoration Program, U. S. Fish and Wildlife Service, Lodi, California.
    - Faulkner, J.R., and Z. J. Jackson. 2014. 2013 San Joaquin River White Sturgeon Telemetry Study. Stockton Fish and Wildlife Office, Anadromous Fish Restoration Program, U. S. Fish and Wildlife Service, Lodi, California.
    - Heironimus, L. B., G. D. Giannetta, and Z. J. Jackson. 2015. 2014 San Joaquin River White Sturgeon telemetry study. Lodi Fish and Wildlife Office, Anadromous Fish Restoration Program, U.S. Fish and Wildlife Service, Lodi, California.
3. Emily Miller, UC Davis, Klimley Group - white and green sturgeon telemetry including Central and North SF Bay, 2010-2014
- Study will focus on analyzing the timing of white and green sturgeon movements throughout the Bay, Delta, and Sacramento River.

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- Focused on adults; some sub-adults may have been included in the study
  - Monitors on the Bay Bridge suggest potential sturgeon use of South Bay, but do not confirm it
  - Data analysis currently in process, with a manuscript in production
4. Myfanwy Johnston, UC Davis, Klimley Group - white sturgeon telemetry focusing on Yolo Bypass, ~2011-2014
- Study will focus on migration to and use of spawning habitat by white sturgeon. Some site fidelity exists; some fish return to their natal tributaries every year.
  - Study area focuses on Yolo Bypass region, but will include movements in the Bay as connected to migrations into the tributaries
  - Data analysis currently in process, with a manuscript in production

## Non-Telemetry Studies including the South SF Bay, including white sturgeon

5. California Department of Fish and Wildlife - sturgeon abundance studies  
<http://www.dfg.ca.gov/delta/data/sturgeon/bibliography.asp>
  - White and green sturgeon tagged with disc-tags in Suisun and San Pablo Bays, August-October annually, returned by anglers
  - Commercial Passenger Fishing Vessel capture data collected year round
    - Good data available 1980-2011; white sturgeon-only after March 2007
    - Captured fish based on legal size limits, which change over time. Length not recorded.
    - Sturgeon not defined by species. White sturgeon only are allowed to be collected after March 2007.
  
6. California Department of Fish and Wildlife - Sturgeon Fishing Report Cards, SF Estuary-wide  
<http://www.dfg.ca.gov/delta/data/sturgeon/bibliography.asp>
  - Annual green and white sturgeon angler card surveys, 2007-present
  - Information collected includes counts by:
    - Location (throughout the Bay, Delta, and tributaries)
    - Season (quarters)
    - Species (green and white sturgeon)
    - Length (incompletely reported)
    - Tag (tagged or untagged fish)
  - Potential error: misidentification, incomplete reporting, incorrect reporting
  
7. Zachary Jackson, US Fish and Wildlife Service - white sturgeon fin ray microchemical analysis (unpublished)
  - Fin rays collected during CDFW tagging events and at the annual Sturgeon Derby
  - Data will not be analyzed and processed for at least another year

### Telemetry Studies in or near the SF Estuary, Green Sturgeon only

8. John T Kelly, formerly UC Davis, Klimley Group - green sturgeon telemetry in Central and North SF Bay, 2001-2002  
(currently at the University of Massachusetts, Amherst)
  - 5 subadult and 1 adult green sturgeon were tagged and tracked by boat between September 2001 and November 2002
  - Four of the five sub-adults remained within San Pablo Bay for the entire period; one sub-adult moved into Suisun Bay; and the adult moved into the ocean
  - Subadult fish typically remained at shallower depths (< 10 m)
  - Movements were believed to be independent of light, temperature, salinity, and dissolved oxygen

Kelly, J.T., A.P. Klimley, and C.E. Crocker. 2007. Movements of green sturgeon, *Acipenser medirostris*, in the San Francisco Bay estuary, California. *Environmental Biology of Fishes*. 79:281-295. [http://www.bio.umass.edu/biology/mccormick/pdf/EBFi\\_2007\\_Kelly\\_etal.pdf](http://www.bio.umass.edu/biology/mccormick/pdf/EBFi_2007_Kelly_etal.pdf)

9. Eric Chapman, UC Davis, Klimley Group - green sturgeon telemetry in Central and Northern SF Bay, 2008-2009
  - Study used detection data from CA Fish Tracking Consortium database and measured exposure time at dredged sites
  - Out of 40 tagged green sturgeon in the Bay Area at the time, 18 were detected from January 2008 to June 2009, and 10 were part of this particular study
  - Fish were found at dredging sites, but exposure on the order of minutes rather than hours or days.
  - Movements were more often random (milling) than directed. Results were for adults only, which transit through this area more quickly for migration.

Chapman, E.D., A.R. Hearn, M. Buckhorn, A.P. Klimley, P.E. LaCivita, W.N. Brostoff, and A.M. Brenner. 2009. Juvenile salmonid outmigration and green sturgeon distribution in the San Francisco Estuary: 2008-2009. University of California Davis and US Army Corp of Engineers. 90p.

10. Mike Thomas, UC Davis, Klimley Group (unpublished) - juvenile green sturgeon modeling
  - Modeling green sturgeon residency in SF Bay, using time spent in the Sacramento River as a predictor of time spent in SF Bay
11. Joseph Heublein, UC Davis, Klimley Group (former) - spawning migrations of green sturgeon in the Sacramento River
  - Green sturgeon tagged 2004-2006; study focuses on migrations within the Sacramento River but includes migratory paths through the Bay

- Of 90 green sturgeon tagged in SF Bay, only 11 moved into the Sacramento River, suggesting that many green sturgeon enter the Bay for purposes other than spawning
- The majority of fish move up the Sacramento River in March and April. Two migration patterns were observed -- one group over-summered and moved out of the River with the first fall flow event, but another group moved out of the Sacramento River before any known flow or temperature cue

12. Lindley et al, 2011, NMFS - large scale green sturgeon movement among estuaries, 2005-2006

- Substantial intrapopulation diversity in migration behavior
- SF Bay green sturgeon populations - frequently detected in Washington and Oregon during the summer, but some populations always remain within SF Bay
- Fish were detected at the Golden Gate Bridge during all months of the year

Lindley ST, Erickson DL, Moser ML, Williams G, Langness OP, et al. 2011. Electronic tagging of green sturgeon reveals population structure and movement among estuaries. *Trans. Am. Fish. Soc.* 140:108–22. [http://www.nmfs.noaa.gov/publications/docs/electronic\\_tagging\\_of\\_green\\_sturgeon\\_reveals\\_population\\_structure\\_and\\_movement.pdf](http://www.nmfs.noaa.gov/publications/docs/electronic_tagging_of_green_sturgeon_reveals_population_structure_and_movement.pdf)