Columbia Basin White Sturgeon Workshop

Our Shared Legacy & Opportunities

November 15-16, 2017 ♦ Coeur d'Alene, Idaho

WORKSHOP REPORT

Overview

The Columbia Basin 2017 White Sturgeon Workshop was convened on November 15-16, 2017, by the Northwest Power and Conservation Council, with additional support from the Kootenai Tribe of Idaho and Ziji Creative Resources.

Purpose

Bring together regional White Sturgeon managers and experts to share information and ideas, identify priorities, and support efforts to restore and conserve White Sturgeon populations.

The meeting was designed to be interactive, facilitate dialog, and lead to a better understanding of what research and management actions the region should concentrate on moving forward. Workshop presentations and activities focused on early life survival and recruitment failure, stock assessment, conservation aquaculture, and emerging issues.

Planning and outreach

A 14-person steering committee including representatives from sturgeon programs throughout the Columbia Basin (US and Canada), met multiple times to identify themes, topics, desired outcomes, and the workshop structure.

Invitations to participate were extended to over 145 individuals who study and manage White Sturgeon throughout the Columbia River Basin, the Fraser River in British Columbia, and the San Joaquin and Sacramento rivers in California.

WHO CAME?

✓ 67 INDIVIDUALS
✓ 6 STATES AND 2 PROVINCES
✓ 27 UNIQUE ENTITIES

- BC Hydro
- BC Ministry of Environment (BCMOE)
- BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (BCMFLNRORD)
- Bonneville Power Administration (BPA)
- Columbia Power Company (CPC)
- Colville Confederated Tribes (CCT)
- Columbia River Inter-Tribal Fish Commission (CRITFC)
- Department of Fisheries and Oceans Canada (DFO)
- Fraser River Sturgeon Conservation Society (FRSCS)
- Idaho Senator Crapo's Office
- Idaho Power
- Idaho Department of Fish and Game (IDFG)
- Independent consultants (11 entities)
- Independent Science Advisory Board (ISAB)
- Kootenai Tribe of Idaho (KTOI)
- Mid-Columbia Public Utility Districts (PUDs)
- Chelan PUD
- Douglas PUD
- Grant PUD
- Montana Fish Wildlife & Parks (MFWP)
- Northwest Power and Conservation Council (NWPCC)
- Oregon Department of Fish and Wildlife (ODFW)
- Okanagan Nation Alliance (ONA)
- Pacific Northwest National Laboratory (PNNL)
- Spokane Tribe of Indians (STOI)
- University of California Davis (UC Davis)
- US Fish and Wildlife Service (USFWS)
- US Geological Survey (USGS)

DAY 1

Columbia Basin and Beyond: White Sturgeon Programs Ignited

The workshop kicked off with a virtual tour of White Sturgeon programs throughout the Columbia Basin including the mainstem Columbia River, Snake, Kootenai/ay, Fraser and Nechako. Programs from the Sacramento and San Joaquin rivers were also highlighted. Five-minute “ignite” presentations provided concise snapshots of each program. Presentations included information on the status of White Sturgeon populations, conservation aquaculture, habitat restoration, monitoring and evaluation, research, outreach, and education.

Failure is Always (Not?) and Option: Early Life Survival & Recruitment Failure

Workshop participants engaged in an extended series of small group discussions about early life survival and recruitment failure. Participants discussed the following:1) what do, or don’t we know about recruitment failure; 2) what assumptions do we need to test or challenge; and 3) what can we begin today that would create new possibilities for the future of White Sturgeon conservation?

Evening Social

The first day concluded with an optional evening social to continue discussions and foster existing and new connections.

DAY 2

Stock Assessments, Survival Estimates, and Maturation Rates in Hatchery-Reared White Sturgeon

This session included five presentations illustrating different approaches to stock assessments and survival estimates, and a presentation on maturation rates in hatchery-reared White Sturgeon. The presentations were followed by a panel discussion on the differences and implications of different gear types, methodologies. and frequency of data collection.

Conservation Aquaculture

This session looked at genetic diversity in conservation aquaculture programs, spontaneous autopolyploidy, and the use of larval collection and rearing. Participants also engaged in a large group discussion focused on where the Columbia Basin is going with the various aquaculture programs.

Research Highlights

Research presentations included: the effects of mercury in White Sturgeon, a unique approach to determining sex in White Sturgeon, and results of modeling of White Sturgeon habitat in the Columbia and Snake rivers for the Columbia River Treaty.

Emerging Issues

Participants identified and ranked emerging issues that require additional exploration. The top three issues were: carrying capacity, recruitment failure, and climate change effects. Other high-ranking topics included the need for a basin-wide sturgeon meta-analysis, increased and improved information sharing between entities, and better integration of science with policy.

What’s Next?

Attendees identified a number of near-term actions to build on the workshop discussions. There was also broad agreement in the value of continuing to meet as a region in order to learn from and with each other. Participants recommended having another workshop within a year to two and identified a list of potential topics and desired outcomes for a future workshop.

Workshop Summary

DAY 1: NOVEMBER 15, 2017

Columbia Basin and Beyond: White Sturgeon Programs Ignited

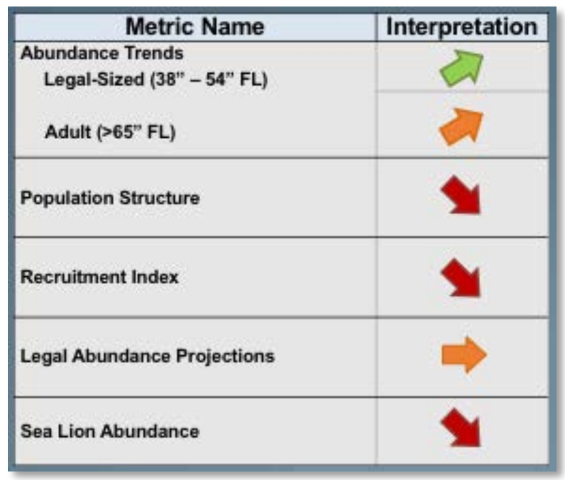
The workshop kicked off with 12 five-minute "ignite" presentations providing an overview of White Sturgeon programs throughout the Columbia Basin and beyond. The Columbia Basin presentations started in the lower Columbia River and progressed upstream to the upper Columbia and its major tributaries including the Snake, Kootenai (Kootenay in Canada) and Nechako rivers. Additional presentations highlighted work in the Fraser River in BC, and the Sacramento and San Joaquin rivers in California. Presenters were invited to focus on an overview of the status of their White Sturgeon population, their programs, research, or specific successes and challenges.

Lower Columbia

Sending Mixed Signals: Lower Columbia River White Sturgeon Populations

Peter Stevens (ODFW), used a dashboard format to talk about five top metrics: abundance trends, population structure, recruitment index, legal abundance projections, and Sea Lion abundance.

- Adult abundance trends are positive. A large increase in adult (broodstock) abundance in 2017, although there's some skepticism about the magnitude of the trend.
- Population structure is trending in the wrong direction. Recruitment is a perennial concern above and below Bonneville Dam.
- The recruitment index is declining on the mainstem but increasing on the Willamette. Population predictions over the last three years are flat.
- Sea Lion abundance has consistently increased at Bonneville. This year there also substantial numbers below Willamette falls. But predation rates are low relative to long-term averages. Concerns about sub-lethal effects of harassment especially during the spring spawn.
- Hope to see improvement in current trends and possibly a strong year class from the 2016 high-water year.



Metric Name	Interpretation
Abundance Trends	
Legal-Sized (38" – 54" FL)	
Adult (>65" FL)	
Population Structure	
Recruitment Index	
Legal Abundance Projections	
Sea Lion Abundance	

Lower Columbia dashboard (Peter Stevens)

McNary to Bonneville

Zone 6 Sturgeon Populations: A Decade+ of Change

Blaine Parker (CRITFC) gave an overview of Zone 6 work including: population assessment, fishery monitoring, recruitment monitoring, and individual reservoir assessments (Bonneville 2006-2015, The Dalles 2005-2014, John Day 2007-2016).

- Reservoir populations are assessed every three years through collaborative effort with Yakima Nation staff, ODFW, and WDFW.
- Winter tagging in December and January and a summer recapture period. Annual recruitment monitoring in the three Zone 6 reservoirs.
- Zone 6 includes tribal commercial fisheries, state recreational fisheries, and tribal subsistence fisheries.
- Bonneville: best recruitment of the three reservoirs possibly due to spawning location downstream of John Day Dam. "Overabundance" of slow growing juvenile fish. Slowest growth rates. Dramatic shifts in abundance over the past decade.

- Dalles: most consistent sturgeon production and smallest of the three reservoirs. Recruitment less consistent than Bonneville, but better than John Day. Summer 2015 broodstock losses, likely due to elevated water temperatures.
- John Day: largest reservoir, with the smallest sturgeon population. Substantial number of broodstock-sized fish. Sturgeon growth is best of the three reservoirs, but the population is declining due to lack of consistent recruitment. Location for future production stockings efforts.

Photo from Blaine Parker's ignite presentation.

Hanford Reach and Lower Snake

2018/2019 Lower Snake River Stock Assessments

Olaf Langness (WDFW), outlined the assessment history and planned work in the Lower Snake to determine the stock status of small isolated populations in Ice Harbor, Lower Monumental, and Little Goose reservoirs.

- Ice Harbor: only two population assessments of juvenile and adult sturgeon conducted over three decades (1996 and 2014). Age-0 index surveys completed in 1997 and 1999 through 2005. Assessment work is planned for 2018.
- Lower Monumental: stock assessments of juvenile and adult sturgeon were completed in 1997 and 2012. No Age-0 index surveys completed. Assessment work planned for 2019.
- Little Goose: population assessments of juvenile and adult sturgeon conducted in 1997 and 2012. Seven Age-0 surveys conducted in 1998 through 2005. Little Goose assessment stock tentatively planned for 2020.
- Substantial population declines occurred between the initial assessments in 1996-1997 and follow-ups in 2012-14.
- Monitoring of natural production from 1995-2005 showed infrequent and low success, likely from poor spawning and early rearing conditions.
- Pool-specific population abundance is in the low 1,000s. The stock decline triggered fisheries managers to close all three pools to retention effective in 2015.
- Future actions include assessing each of the three impounded populations every third year on a rotating basis with more days of sampling than in past. Interest in developing a different approach to doing stock assessments that might be more efficient and suitable for sparse data situations (e.g., sequential Bayesian algorithms).
- Will be looking at trends in growth patterns using pectoral fin ray sections from White Sturgeon marked with oxytetracycline (OTC) in 1996 and 1997.

Mid-Columbia

Sturgeon Management in the Mid-Columbia

Paul Anders (Cramer Fish Sciences), presenting for Donella Miller and Bob Rose (YN), summarized the Yakama Sturgeon Management Project. Program goals are: 1) restoring healthy, harvestable White Sturgeon populations and fisheries in the mid-Columbia River and Lower Snake reservoirs, and 2) providing tribal and non-tribal recreational and harvest fishery opportunities to mitigate losses from hydropower.

- Construction of the Yakama Nation sturgeon hatchery began in 2009 with support from BPA, BIA, the PUDs and Yakama Nation.
- Yakama program uses a "conventional" White Sturgeon hatchery approach (vs. repatriation).
- Program components include: a centralized brood holding facility, cooperative spawning, distribution of fertilized eggs (Chelan PUD, Douglas PUD), juvenile rearing and tagging (Grant PUD), wild larvae collection and rearing (Chelan PUD, Grant PUD), and ploidy level testing.

- Supplementation from 2011 through 2017 totaled 83,441 from all four programs (Priest Rapids – 9,314, Wanapum – 23,351, Rocky Reach – 30,404, Wells – 20,372).
- The program is currently in Step 2 of the NPCC's 3-Step Process.
- Scientific information and knowledge is growing annually through a strong commitment among collaborators.
- Long-term challenges include: broodstock collection, adaptive genetic, stocking and demographic management; accurately estimating population size and inter-species relationships (lamprey), and program responses; and understanding food web and trophic effects and program responses.

Mid-Columbia

Mid-C PUD's Sturgeon

Andrew Gingerich (Douglas PUD), presented on behalf of all three mid-Columbia technical sturgeon leads (Lance Keller, Chelan PUD; and Chris Mott, Grant PUD). Andrew took a different approach to the ignite session. In lieu of a presentation he narrated a five-minute video illustrating the different components of the mid-Columbia PUD White Sturgeon efforts. Video highlights included:

- Locations of Wells, Rocky Reach, and Priest Rapids dams
- An overview of the hatchery facility including footage of fish rearing operations, scute marking and tagging, and fish releases from both trucks and nets.
- Outreach activities, including hatchery tours and kids releases.
- Monitoring and evaluation activities, with video footage including placement of acoustic tags and receivers.

Still photo from the Mid-C ignite video.

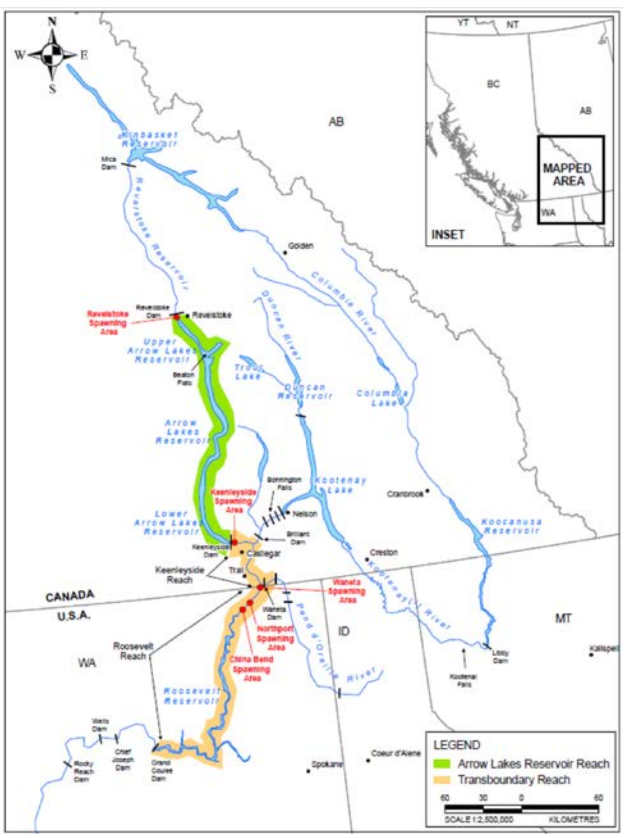
Upper Columbia

Upper Columbia White Sturgeon Recovery Initiative

Jason McLellan (CCT) delivered a presentation for the Upper Columbia White Sturgeon Recovery Initiative (UCWSRI). The UCWSRI is an international organization formed in 2000 in response to the lack of recruitment. The goal of the UCWSRI is to ensure the persistence and viability of naturally-reproducing populations and to restore beneficial uses where feasible.

- White sturgeon in the upper Columbia suffer from persistent recruitment failure. There are two "sub-populations," one in the Transboundary Reach and one in Arrow Lakes.
- White Sturgeon in Canada are listed as endangered under the Canadian Species at Risk Act; not listed in the US.
- Spawning is detected, thousands of first-feeding larvae are captured annually but captures of age-0 juveniles are extremely rare. Age-1 hatchery survival indicates recruitment bottleneck occurs between first-feeding larval and fall sub-yearling juvenile stages.
- Many recruitment failure hypotheses e.g., related to flow alterations, habitat changes, non-native fish, food availability, and contaminants.
- Larval transport hypothesis currently being tested by capturing drifting larvae, marking them with calcein, translocating them further downstream than currently detected, and then sampling for marked juveniles.
- Conservation aquaculture begun in 2001 in BC and 2004 in WA to restore population demographics and preserve genetic diversity.
- Approximately 150,000 juveniles released in Transboundary Reach; 61,000 to Arrow Lakes.
- In 2011 and 2014, the WA and BC programs transitioned to use of wild caught eggs and larvae to increase genetic diversity, allow for natural mate selection, and eliminate broodstock handling.
- Coordinated stock assessment (US and Canada) began in 2013 to support adaptive management of the aquaculture releases and evaluation of the wild population status.
- Hatchery fish have higher than anticipated survival with some year classes estimated to be in higher abundance than the wild population.

- Despite family equalization at release, differential survival resulted in unequal abundance of maternal families, which reduces genetic diversity.
- Sex and stage of maturity research of hatchery fish began in 2015. Indicated larger males (primarily in the US) capable of reproducing. Thus, need for urgent management actions to address over-represented family groups.
- Harvest fisheries implemented in the US in 2017 to address over-represented families; about 3,500 hatchery-sturgeon were harvested. Future harvest is under consideration.
- In Canada due to listed status, fish are being selectively removed from over-represented families as a precautionary approach while a longer-term strategy is developed.
- The UCWSRI is currently evaluating stocking targets based on stock assessment data.
- Habitat restoration (i.e., spawning substrate restoration) is currently under consideration in Canada.



UCWSRI area from Jason McLellan's Upper Columbia ignite presentation.

Snake River

Snake River White Sturgeon 2017 Program Highlights

Ken Lepla (Idaho Power) provided an overview of the 2017 Snake River program activities. The program is guided by FERC licenses, a White Sturgeon Technical Advisory Committee, and the Snake River White Sturgeon Conservation Plan. Ken's presentation included: population monitoring, recruitment assessment, conservation aquaculture, dam entrainment, and translocation.

- Lower Granite to Shoshone Falls study area includes the Bliss and Hells Canyon core conservation populations.
- Approximately 4,000 fish in each population supported by natural production. The remaining reaches contain small numbers of wild sturgeon.
- Sampling in 2017 included YoY sampling in the fall in C.J. Strike Reservoir. YoY sturgeon (28-32 cm) found feeding on larval catfish.
- Larval sampling in the Hells Canyon Reach (lower Granite Reservoir) in June. Nine fish tagged with acoustic transmitters to monitor over-wintering habitat.
- Snake River White Sturgeon Conservation Plan partners include: IDFG, Idaho Power, College of Southern Idaho, and Blind Canyon AquaRanch. FERC license includes wild broodstock spawning and in-river egg/larvae collection.
- Goals are to support the mid Snake population by 1) increasing abundance, demography and persistence in a recruitment-limited population; 2) conserving patterns of population structure and genetic diversity; and 3) support resource management objectives for recreational fisheries.
- Aquaculture program includes: factorial spawning (6 adults) and genetic evaluations (parent relatedness, ploidy status of offspring, diversity of release groups).
- Conservation populations are stocked below Shoshone Falls, C.J. Strike and Swan Falls dams. Release numbers, location and timing are determined by IDFG.
- Sturgeon are stocked at approximately 1+ year old (35-45 cm). Approximately 1,800 stocked from 2014-2017.

- Monitoring and evaluation activities include: abundance, growth, movement and habitat use, survival, and genetic diversity.
- In-river egg/larvae collection takes place in the Bliss Reach. Field collections are genetically diverse with over 100 breeders represented in samples. The number of alleles (Na) is similar to the wild population.
- Other activities include early life habitat investigation including: habitat mapping, substrate evaluation, flow and temperature, and instream incubators.

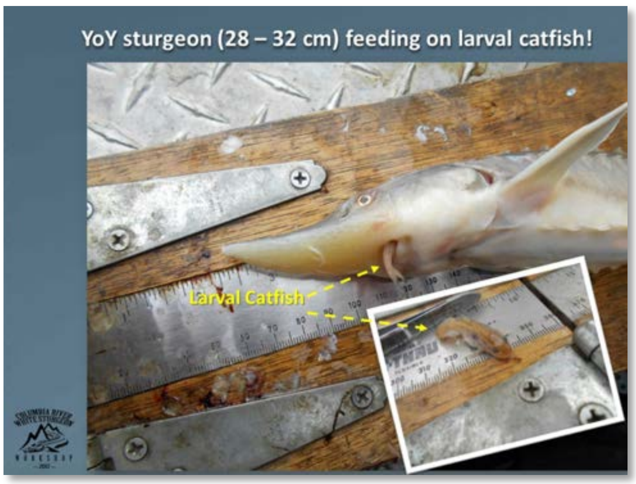


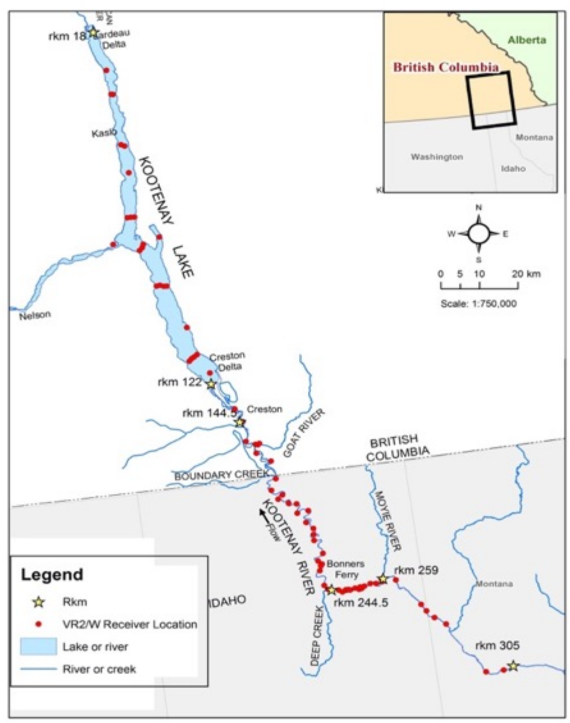
Photo from Ken Lepla's ignite presentation.

Kootenai/Kootenay

Kootenai/ay River White Sturgeon Research and Recovery Efforts

Ryan Hardy (IDFG) presented information on the collaborative research and recovery efforts in the Kootenai River (Kootenay in Canada).

- Construction and operations of Libby Dam, extensive diking, resulting losses of floodplains negatively impacted ecosystem functions.
- Adult abundance of Kootenai River White Sturgeon declined from approximately 8,000 in 1970 to approximately 1,000 in 2010.
- Kootenai sturgeon are listed as endangered under the ESA.
- Actions to restore Kootenai sturgeon include: conservation aquaculture, mitigation activities (e.g., flow management, habitat restoration), and research and evaluation.
- Kootenai recovery actions are highly collaborative including participation of: IDFG, KTOI, USFWS, BCMFLNRORD, MFWP, USACE, BPA, USGS.
- Goal is a self-sustaining population and fisheries.
- KTOI habitat restoration includes: substrate enhancement; construction of a "ladder" of pools to support holding, spawning and upstream movement; islands on gravel bars to support native vegetation and enhance nutrients and food web; and floodplain and side channel reconnection.
- IDFG evaluates wild adult sturgeon population trends (general catch rates), adult spawning movements (VPS), early life history (egg mats, larval sampling), juvenile population trends, and juvenile survival. Much of this work is done in coordination with BCMFLNRORD and MFWP.
- IDFG data analysis supports habitat restoration evaluation and design, identification of conservation harvest stocking targets, release strategies, and recruitment failure hypotheses testing.
- IDFG adult movement modeling (river segments to river segment upstream/downstream, and river to lake) is helping to answer questions about the effect of mitigation strategies (e.g. flows and habitat restoration).



Kootenai/ay telemetry array from Ryan Hardy's ignite presentation.

Kootenai River White Sturgeon Conservation Aquaculture

Shawn Young (KTOI) gave an overview of the Kootenai Tribe's conservation aquaculture program, which has been rearing Kootenai River White Sturgeon for 27 years (since 1990).

- The historical abundance estimate, and current target is 8,000 adults.
- Conservation aquaculture program goals: 1) prevent extinction, 2) balance aquaculture production with genetic management and ecosystem carrying capacity, 3) restore a viable and self-sustaining sturgeon population in the Lower Kootenai River, and 4) restore a fishery.
- The program is guided through annual planning and adaptive management. Formal coordination includes: Kootenai White Sturgeon Recovery Team Meetings, Sturgeon Annual Program Review, Burbot Annual Program Review, International Kootenai Ecosystem Restoration Team, Habitat Restoration Team Meetings, and Sturgeon Spawning Flows Technical Team.
- Monitoring and evaluation results drive adaptive management. Data used include post-release survival, dispersal, population abundance, population structure, growth, spawning/recruitment, and genetics.
- Program uses wild broodstock (no alternative at this time). A new group of spawning adults each year (8-10 females to create 3-4 families per) female, 30 males per year.
- Approximately 400 wild adults have been spawned in the program.
- Annual spawning plan includes 30 unique families, about 6,000 eggs per family. About 50% of fish from each family reared at 14°C for accelerated growth and 50% of fish from each family reared at ambient river temperatures.
- Annual release is about 18,000 1-year old juveniles. From 1990 through 2016, released 284,000 sturgeon from 23 year classes.
- Current hatchery-reared juvenile abundance estimate is 12,000-15,000. About 56% of families created are represented in the river.
- To date, no hatchery-reared sturgeon have been confirmed as sexually mature.
- KTOI has examined year classes for spontaneous autopolyploidy since 2011. In those years the total percent per year class was 10%, except for 2016, which was >50%.
- Currently using a Coulter Counter to test fish.
- Spontaneous autopolyploidy percent per family is highly variable; but appears mainly dependent on the female.
- Have confirmed that some wild adults are spontaneous autopolyploidy.

Kootenai sturgeon and burbot release locations from Shawn Young's ignite presentation.

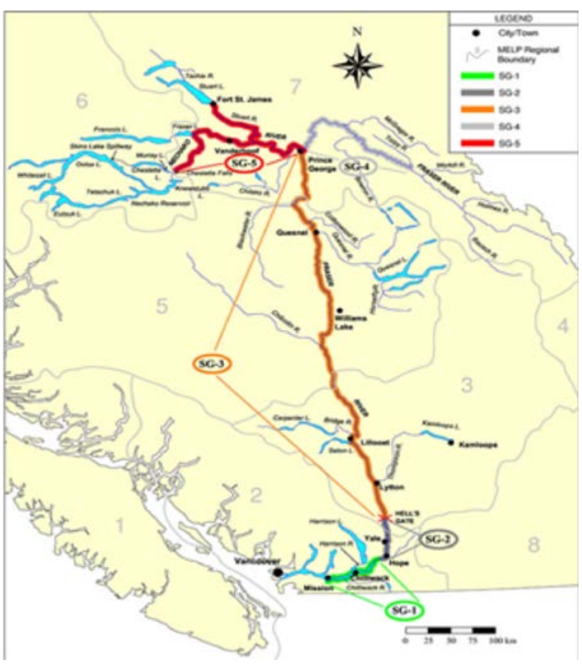
Nechako

Nechako River White Sturgeon: Six Steps to Recovery

Steve McAdam (BCMOE) gave an overview of recovery efforts on the Nechako, a tributary of the Fraser River. The Nechako White Sturgeon population is the most northerly of four distinct population is the Fraser watershed. There are no physical barriers in the watershed.

- Step 1: Diagnosis. Recruitment failure coincided with an influx of fine sediment. Substrate impacts have been verified by field and lab studies.
- Step 2: Analysis. Spawning has been detected throughout the braided reach; but is concentrated downstream.

- Early life stage influences include: egg suffocation and predation; yolk sac drift and predation, growth; and feeding larvae, food supply.
- Step 5: Experimental restoration. Lab studies (2005-2007), small scale field work (2008), large scale field work (2011). Followed by “un-restoration” via sand influx. Experimental re-restoration (2016). Gravel cleaning just prior to spawning.
- Step 6: Monitoring. Potential recruitment: 1) 2006-09 – pilot hatchery, 2007 high flow, 2011 habitat restoration, 2016 “re-restoration”, and 2014 to present hatchery inputs.
- Concerns: 1) 2007 ‘missing’ in 2013 sampling, 2) decline in catch of 2011 cohort, 3) previous ‘cohorts’ (2006-2009 pilot hatchery, 2007 cohort) not evident from 2017 sampling. Juveniles are ‘disappearing,’ is it due to movement, mortality, or vulnerability?
- Emerging issue is juvenile predation. There is 80% mortality of radio tagged hatchery juveniles. Radio and PIT tags retrieved on shore.
- In 2014 constructed full scale hatchery for conservation-based fish culture. Sited in known spawning reach.
- Considering substrate rearing of yolk sac larvae.

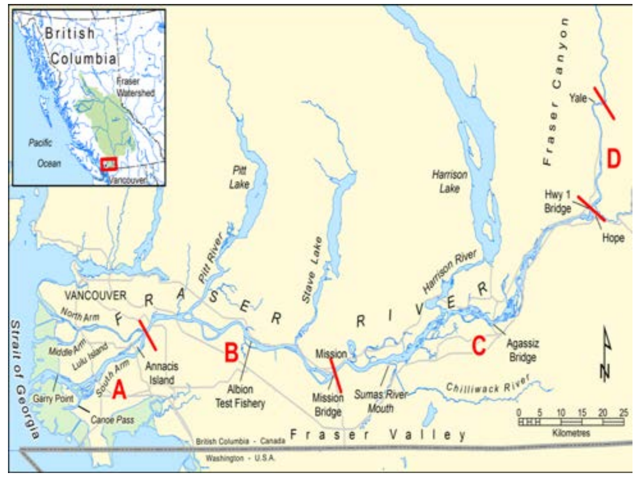


Nechako map from Steve McAdams ignite presentation.

Fraser River

Keeping the Legend Alive

Sarah Schreier (FRSCS), spoke about the Fraser River Sturgeon Conservation Society. It is a not-for-profit organization founded in 1997 dedicated to the conservation and restoration of wild Fraser River White Sturgeon.



Fraser River map from Sarah Schreier’s ignite presentation.

- The FRSCS works to identify and address issues that affect the recovery of White Sturgeon in the Fraser River watershed using critical data.
- Data collected through volunteer-driven monitoring and assessment program.
- The FRSCS brings together a diverse community of stakeholders – leaders, all areas of government and First Nations, commercial and recreational fishing sectors, research and education
- Activities include: sturgeon conservation challenge program using tag and release fishing, a curriculum-based education program, public awareness initiatives to promote community understanding of White Sturgeon, and urban sturgeon week.
- The FRSCS has also launched a ghost net removal initiative.
- Priority focuses include: mortality, habitat erosion, technology and recruitment of juvenile stocks.

Sacramento and San Joaquin

Status of the Sacramento-San Joaquin White Sturgeon population

Andrea Schreier (UC Davis), presented an overview of California White Sturgeon status. The population is thought to be harvest and recruitment limited.

- Popular recreational fishery since 1954.
- Recruitment is irregular and dependent on spring flows.
- California Department of Fish and Wildlife (CDFW) conducts White Sturgeon monitoring in California.
- Subadult/adult tagging study in Suisun and San Pablo Bays (CDFW).
- Trammel net capture and tagging of subadult and adult White Sturgeon in the Suisun and San Pablo Bays (CDFW)
- Abundance estimates are derived from recaps angler reports. Peterson tags offer rewards of $20, $50, $100, $150 for return. Sturgeon report cards implemented in the mid 2000s.
- Information collected includes location, number anglers, season, and length.
- Harvest estimates are based on return of tags with different awards.
- CDFW 20 mm survey – 10 min oblique tows with small mesh net

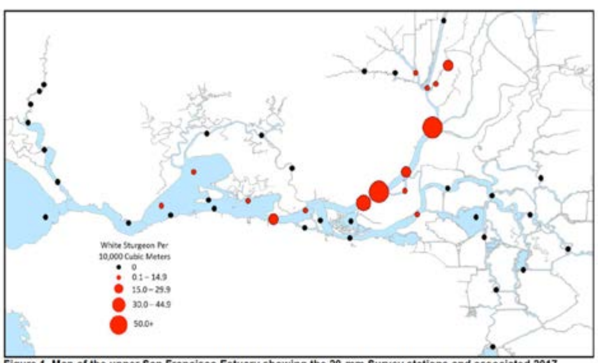


Figure 1. Map of the upper San Francisco Estuary showing the 20-mm Survey stations and associated 2017 cumulative age-0 White Sturgeon catch per unit effort

Upper San Francisco estuary showing 20-mm survey stations and associated 2017 cumulative age-0 White Sturgeon CPUE from Andrea Schreier's ignite presentation.

Map of Sacramento and San Joaquin rivers from Andrea Schreier's ignite presentation.

- Recent management efforts to protect White Sturgeon include a fishing closure in the Upper Sacramento River.
- CDFW is collaborating on a modeling study to examine the effects of management actions on the abundance trajectory
- Other California White Sturgeon work includes:
    - Discovery and monitoring of White Sturgeon spawning on the San Joaquin River by USFWS
    - Acoustic tagging adults and setting egg mats
    - Recent efforts to locate spawning sites on Sacramento River

Sturgeon Café

Failure is Always (Not?) an Option: Early Life Survival & Recruitment Failure

For the "sturgeon café," workshop participants split into groups of four or five people to discuss the following questions:

1. What do/don't we know about early life survival/recruitment failure?
2. What assumptions do we need to test or challenge in thinking about early life survival/recruitment failure?
3. What conversation, if begun today, could ripple out in a way that creates new possibilities for the future of White Sturgeon conservation?

Each small group engaged in discussion for 15 to 20 minutes and then individuals moved to a new group. This process was repeated multiple times so that each participant had an opportunity to talk in small groups with the majority of workshop attendees.

After the discussions the large group was asked to respond verbally and in writing to the following prompts: what was the most interesting thing you talked about? The most exciting? The most surprising? The most disappointing?

Following is a summary of participant responses, organized by overall question and category of response.

What do/don't we know?

Recruitment Failure

- The definition of recruitment failure is not universal. There are many interpretations of recruitment criteria, and that is causing inconsistency.
- The mechanisms driving recruitment failure likely differ among systems and populations. However, recruitment failure is occurring at the same suite of early life stages.
- There does appear to be a similarity of recruitment responses to high water years across populations and rivers.
- Unknown natural rate of recruitment.
- Are there recruitment differences between run of river reservoirs versus storage reservoirs?
- Certain flows are conducive to spawning success across river reaches.
- Is egg production limiting or is a/the bottleneck between summer and fall of first year.

Early Life Stage Survival

- Survival bottleneck may be between summer/fall of first year of life.
- What factors influence larvae to age-0 survival? Flow? Habitat? Food? Shelter? Temperature? What can we do to influence increased survival?

- Everyone (almost) has problems capturing larval stages which also makes it hard to answer some of our questions.

Flow and Recruitment

- Flow appears to be important to recruitment, but the mechanism remains elusive. Is it related only to spawning cues? Or to larval dispersal? Or nutrients and food for larvae? Or habitat conditions? Or something else? Or all of the above?

What assumptions do we need to test or challenge?

Episodic Recruitment

- There is a disconnect between episodic natural recruitment and annual hatchery production. Maybe we're putting too much weight on annual recruitment? Would 5-year or 10-year targets provide greater management flexibility?
- What does "natural" recruitment periodicity look like for a White Sturgeon population?

Flow and Management

- Can sturgeon recovery be effectuated in a system largely devoted to salmon and steelhead? Can we prioritize sturgeon in the fight for water?
- What about managing for overall ecosystem function instead of one or two species?
- Consider white sturgeon management through the Columbia system rather than in small segments defined by dams. Are there some segments we should prioritize over others? Historically, there was much more connection.

Habitat

- Don't overlook the importance of habitat conditions.
- Are White Sturgeon adapted to spawn in side channels not the mainstem, and spawn where larvae drift into overbank (flooded) habitats?
- Assumption that quality/quantity of spawning habitat is limiting. Do White Sturgeon eggs need deep interstitial habitats for hiding?
- Early larval feeding likely occurred in very productive habitat, warmth may improve that productivity.
- Increasing diversity of juvenile habitat may not be addressed as much as it should be.

Spontaneous Autopolyploidy

- Don't know the rate of autopolyploidy in the wild.

What could we begin today that would create new possibilities for the future?

Learn from Other Systems

- Compare Fraser River (un-impounded) to Columbia River (impounded). What can we learn about recruitment, population metrics, movements, habitat, food availability, etc.
- Compare Lake Roosevelt to Lower Columbia. Recruitment failure is happening at different times of year.
- Compare areas where recruitment occurs in most years (Fraser, below Bonneville) versus other areas where recruitment is intermittent or very limited (Upper Columbia, Kootenai).
- Where is recruitment correlated with flow/freshet (in spawning years)?
- Compare stages of recruitment failure in different systems (egg, early life stage, juveniles).
- Compare how family diversity (number of parents reproducing) relates to flow, stages of recruitment failure, etc.

Learn from Other Species

- Sturgeon are not salmon, but does the history and legacy of salmon conservation hold lessons to guide the future of White Sturgeon conservation and management in the Columbia Basin?
- More integration of lessons from other species of sturgeon would be beneficial because sturgeon have similar ontogeny.

Share Information from Multiple Disciplines

- Include multiple disciplines to better understand physical processes and impacts on White Sturgeon (e.g., ecologists, biologists, hydraulic modelers, geomorphologists, etc.). This is also critical for designing habitat restoration treatments and flow management.
- Develop a non-profit to assist with collaboration between managers, researchers, anglers, harvesters, and funding groups.

Data Collection, Research and Analysis

- How can we limit impacts of sampling (do we need to sample so much) but still collect the necessary data?
- Develop a better understanding of gear efficiency (e.g., larval capture) so we can better understand recruitment rates, etc.
- Share information about studies in different regions to we can learn from study design, implementation and conclusions.

Climate Change and Energy Markets

- Will new technologies make hydropower obsolete? In 100 years? Sooner? What are impacts of resulting funding losses and how do we continue sturgeon work? What are possible long-term benefits? How to we plan for the transition?

DAY 2: NOVEMBER 16, 2017

Day 2 started with a series of presentations and a panel discussion on stock assessments, survival estimates, and maturation rates in hatchery-reared white sturgeon.

This was followed by updaters on conservation aquaculture including genetic diversity, spontaneous autopolyploidy, and the use of larval collection and rearing.

Following the conservation aquaculture presentations, workshop participants engaged in a large-group “fish bowl” discussion reflecting on where the Columbia Basin is going with the various aquaculture programs.

The final presentations of the day highlight three different research efforts including: the effects of mercury in White Sturgeon, an approach to determining sex in White Sturgeon, and results of modeling of White Sturgeon habitat in the Columbia and Snake rivers for the Columbia River Treaty.

Throughout the workshop participants posted emerging issues on a wall banner illustrating the Columbia River, its tributaries, and the Fraser, San Joaquin, and Sacramento rivers. At the end of the workshop attendees discussed and ranked the emerging issues.

Participants also posted questions and responses to various presentations throughout the two-day workshop.

Finally, attendees identified a number of near-term and longer-term actions to build on the workshop discussions.

There was also broad agreement in the value of continuing to meet as a region in order to learn from and with each other. Participants recommended having another workshop within a year to two and identified a list of potential topics and desired outcomes for a future workshop.

Stock Assessments, Survival Estimates, and Maturation Rates in Hatchery-Reared White Sturgeon

This portion of the workshop consisted of five presentations illustrating different approaches to stock assessments and survival estimates.

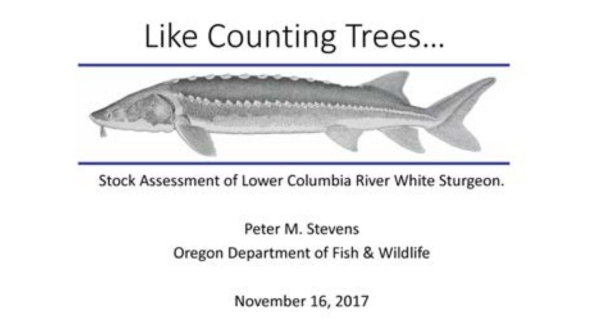
- Peter Stevens (ODFW), gave a presentation on stock assessment work in the lower Columbia River.
- Dave Robichaud (LGL), gave a presentation on stock assessment and survival estimates of hatchery-reared White Sturgeon in the mid-Columbia.
- Brandon Bentz (Idaho Power), gave the following presentation on population sampling methods in the Snake River.
- James Crossman (BC Hydro), gave a presentation on survival and population abundance estimates in the Upper Columbia River.
- Kevin McDonnell (IDFG), gave the following presentation on stock assessment and survival estimates in the Kootenai River system.

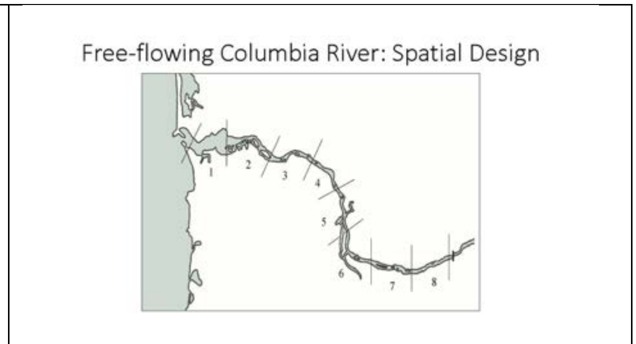
In addition, James Crossman also presented information on work to assign sex and stage of maturity in hatchery-origin white sturgeon.

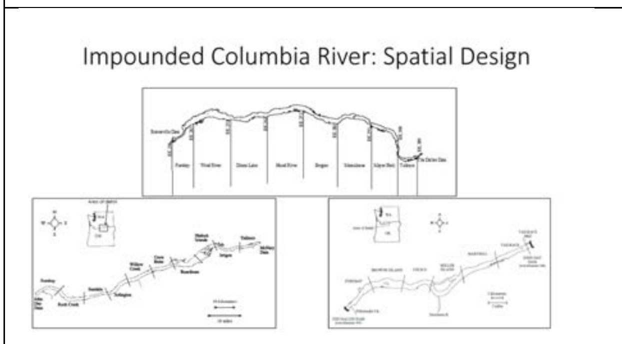
Thumbnail sketches of each presentation are provided below. The full presentations are available for download on the NWPPC site.

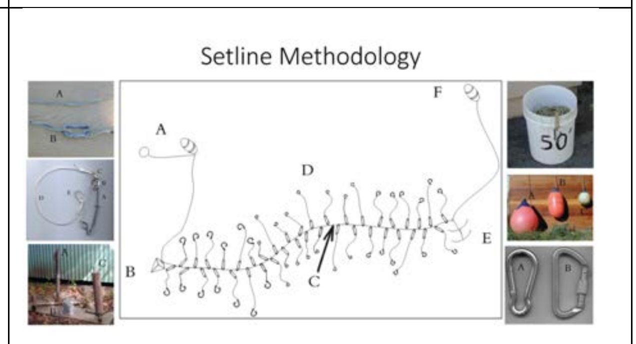
Like Counting Trees: Stock Assessment of Lower Columbia River White Sturgeon

Peter Stevens (ODFW), gave the following presentation on stock assessment work in the lower Columbia River.



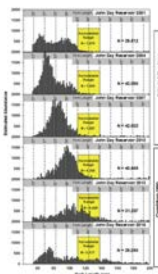


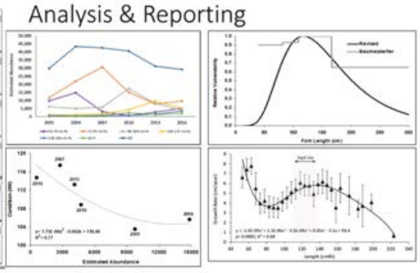




Workin' hard or hardly workin'…

Analysis & Reporting





Challenges

- Methodological
  - Peterson or Schnabel Estimator

$$P = \frac{MC}{R} \qquad \hat{N} = \frac{\sum_{i=1}^{t}(C_i M_i)}{\left(\sum_{i=1}^{t} R_i\right)+1}$$

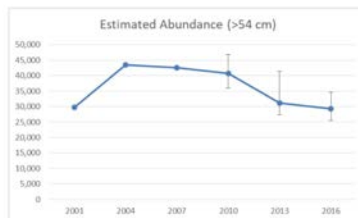
Challenges

- Methodological
  - Peterson or Schnabel Estimator

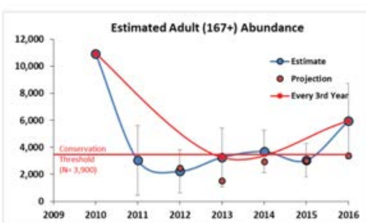
$$P = \frac{MC}{R} \qquad \hat{N} = \frac{\sum_{i=1}^{t}(C_i M_i)}{\left(\sum_{i=1}^{t} R_i\right)+1}$$

- Logistical
  - More fish marked; more recapture passes
  - Sample pools more often

Challenges



Challenges



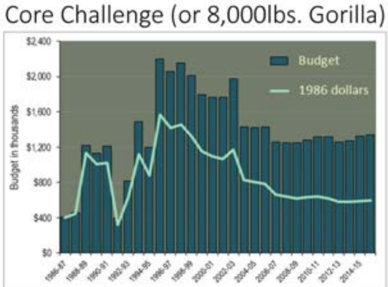
Challenges

- Methodological
  - Peterson or Schnabel Estimator

$$P = \frac{MC}{R} \qquad \hat{N} = \frac{\sum_{i=1}^{t}(C_i M_i)}{\left(\sum_{i=1}^{t} R_i\right)+1}$$

- Logistical
  - More fish marked; more recapture passes
  - Sample pools more often
- Equipment
  - Old vessels reaching the end of effective life-span

Core Challenge (or 8,000lbs. Gorilla)



Stock Assessment and Survival Estimation of Hatchery-Reared White Sturgeon in the Mid-Columbia

Dave Robichaud (LGL), gave the following presentation on stock assessment and survival estimates of hatchery-reared White Sturgeon in the mid-Columbia.

Stock Assessment & Survival Estimation of Hatchery-Reared White Sturgeon in the Mid-Columbia

David Robichaud, LGL Limited
Andrew Gingerich, Douglas PUD
Lance Keller, Chelan PUD
Chris Mott, Grant PUD

LGL Limited environmental research associates

P.U.D. CHELAN COUNTY

DOUGLAS COUNTY P.U.D.

Grant PUD

Geographic Scope

White Sturgeon Management Plans

All three PUDs have White Sturgeon management plans that include:

- The promotion of White Sturgeon population growth to carrying capacity (with some future harvest) via supplementation (i.e., release of hatchery-reared juveniles); and
- Post-release monitoring of the hatchery fish (survival, growth, distribution)

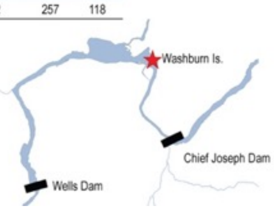
Supplementation

- 83,467 hatchery-reared PIT-tagged sturgeon have been released in four reservoirs to end of 2017
- The three PUD's programs vary in:
  - Number of active years
  - Release timing (spring / fall releases)
  - Number of release locations
  - Release quantities & fish sizes
  - Fish source (wild-caught larvae, wild-caught adult broodstock, captive broodstock)
  - Hatcheries

Supplementation - Douglas

Year	Broodstock Crosses	Wild-caught Larvae	Release Date	Mean Length	Mean Weight
2014	2,912	0	April 10	265	143
2014	0	2,132	Jun 12	305	198
2015	0	5,009	June 1-2	234	98
2016	0	5,289	June 1	276	147
2017	0	5,030	June 2	257	118
Total	**20,372**				

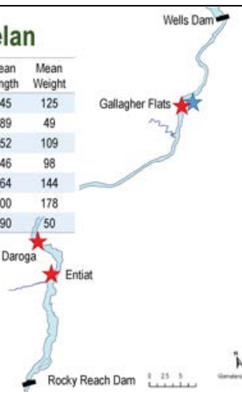
- Four years
- One release site
- Two origins: wild-caught larvae vs. broodstock parents
- Wells Hatchery



Supplementation - Chelan

Year	Captive Parents	Wild-caught Parents	Release Date	Mean Length	Mean Weight
2011	2,530	3,846	April 20-21	245	125
2012	0	137	May 16	189	49
2013	0	7,975	May 20-23	252	109
2014	0	4,962	May 8,14-15	246	98
2015	0	6,487	April 27-30, May 8	264	144
2016	0	2,273	May 10-12	300	178
2017	0	2,185	May 24-25	190	50
Total	**30,395**				

- Seven years
- Three release sites
- Two origins: wild-caught parents vs. broodstock parents
- Three Hatcheries (Chelan Falls, Marion Drain, Columbia Basin)



Supplementation - Grant

Year	Captive Parents	Wild-caught Parents	Release Date	Mean Length	Mean Weight
2011	2600	6517	April 26-29	292	174-187
2013	0	3981	May 14-15	291	149-156
2014	0	4328	May 5-6	267	129-133
2014	0	2266	Sept 17-18	289	129-133
2015	0	6502	April 30 – 1 May	312	194-199
2016	0	3258	April 28	303	171
2017	0	3248	May 2	272	127
Total		32,700			

- Six years
- Three release locations
- Fall releases in 2014
- Three origins: wild-caught parents (upper vs. mid Columbia) vs. broodstock parents
- Marion Drain Hatchery

Telemetry Monitoring

- Vemco VR2W receivers, deployed at regular intervals and key locations throughout reservoirs
- Limited mobile tracking
- Similar tags (models, sizes, battery strengths)
- Standard surgical methods:
  - At hatchery before release (small fish)
  - *In situ* upon recapture (larger fish)
- Measure emigration, movement, and distribution

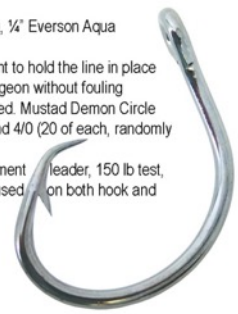
Indexing Studies

The three PUD's programs are consistent in terms of:
- Use of stratified random sampling locations
- Use of overnight setlines
- Scanning catch for PIT tags, length, weight

But vary in terms of:
- Number of lines per year, timing of surveys
- Hook number/type, hook size, bait (now standardized)
- Setline length (now standardized)
- Allowance for targeted sets or incidental capture

Indexing Studies

Standardized gear:
- Setlines are 400 ft (122m) long, ¼" Everson Aqua tarred line (3 strand nylon)
- Anchors on either end, sufficient to hold the line in place while capturing large adult sturgeon without fouling
- 40 hooks per line, evenly spaced. Mustad Demon Circle Perfect 2X Strong, sizes 2/0 and 4/0 (20 of each, randomly distributed)
- 12' Jinkai (or similar) monofilament leader, 150 lb test, with 1-2 'size I' crimp sleeves used on both hook and snap end
- Bait: Gilmore pickled squid



Survival Estimation

The three PUD's programs are consistent in terms of:
- Survival estimates derived from indexing data
- Use of Cormack-Joly-Seber model to estimate capture probability and survival
- AIC used to select or average among models

But vary in terms of model complexity:
- Grant PUD modelled survival in terms of fish age and release reservoir; capture probability in terms of year and release reservoir
- Douglas PUD modelled survival in terms of release year, allowing survival to vary over time; capture probability in terms of release year and survey event
- Chelan PUD has complex model

Chelan Sturgeon Capture Probability

Model Terms:
- M_t Sampling method (incidental, random, targeted)
- H_t Gear (treble-cricket vs. circle-squid)
- E_t Effort (number of setlines deployed)
- $A_{i,t}$ Sturgeon age (cohort effects)
- $year_t$ Annual differences

Final Detection Model (33 parameters):

$$\text{logit}(p_{i,t}) = M_t + H_t + year_t : M_t : H_t : log(E_t) + M_t : H_t : log(A_{i,t}) + M_t : H_t : log(E_t) : log(A_{i,t})$$

Method Gear Effort Effects Age Effects

Chelan Sturgeon Survival

Model Terms:
- β 'Long-term survival' (intercept)
- $R_{i,t}$ 'Short-term survival' (first few months)
- $Y_{i,t}$ 'Medium-term survival' (rest of first year)

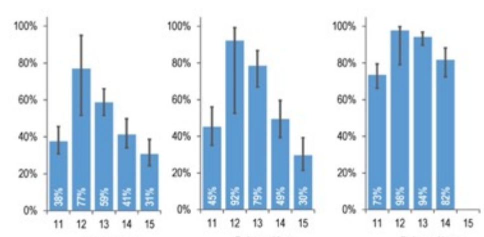
- G_i Release group (cohort effects)
- L_i Sturgeon length
- H_i Hatchery effects
- O_i Parental origin (progeny of wild vs. captive parents)
- RL_i Release location (3 locations to compare)

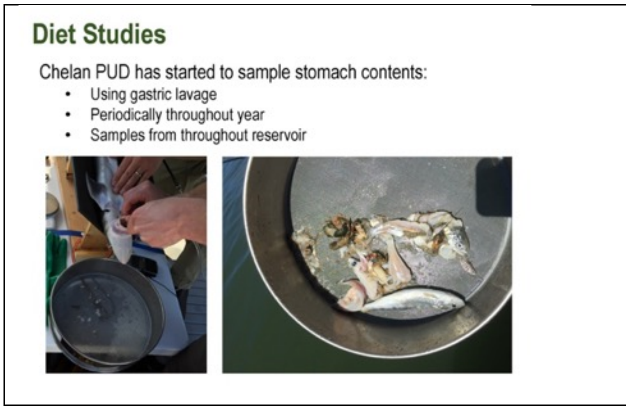
Final Cohort Survival Model (34 parameters):

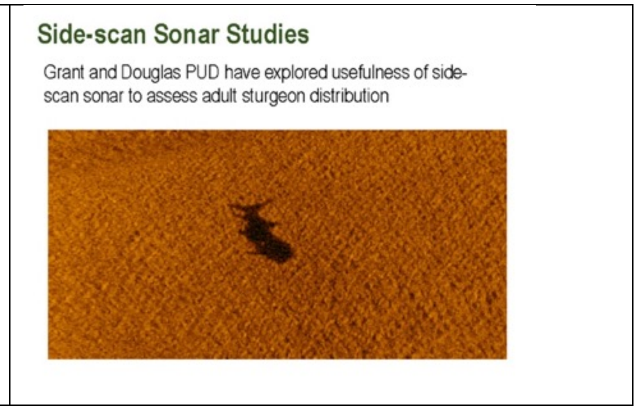
$$\text{logit}(\Phi_{i,t}) = G_i + R_{i,t} + R_{i,t} : G_i : log(L_i) + Y_{i,t}$$

Chelan Sturgeon Survival

Cohort Effects

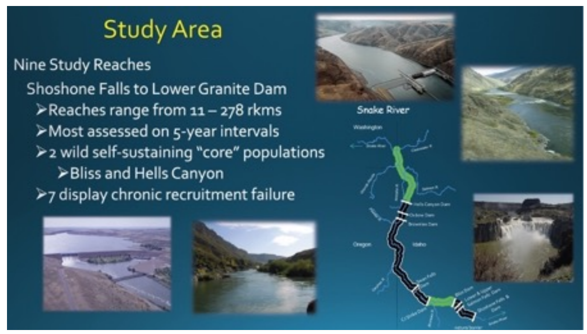


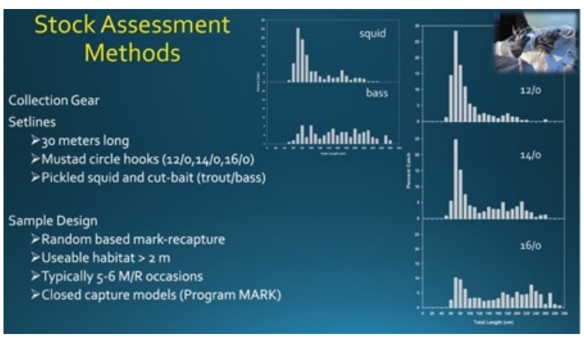


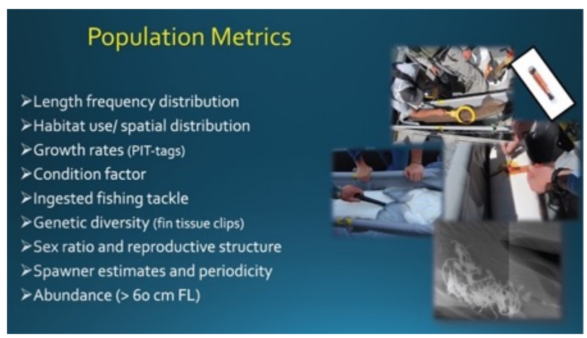


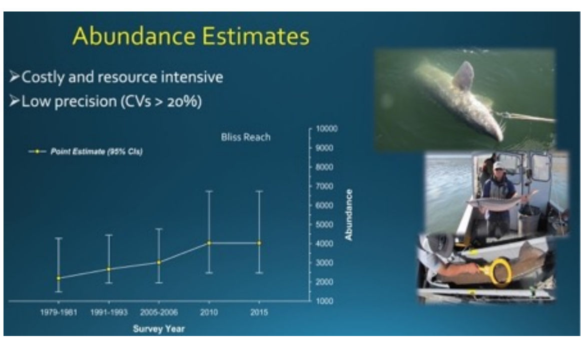
Snake River White Sturgeon Population Sampling Methods

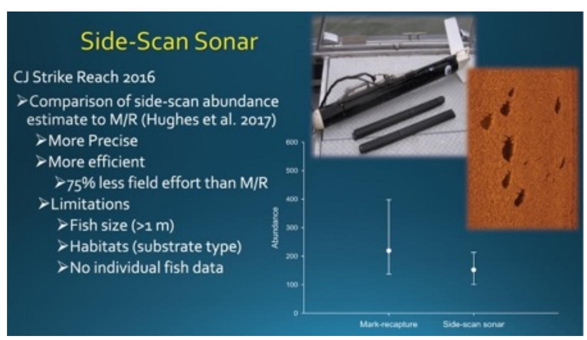
Brandon Bentz (Idaho Power), gave the following presentation on population sampling methods in the Snake River.

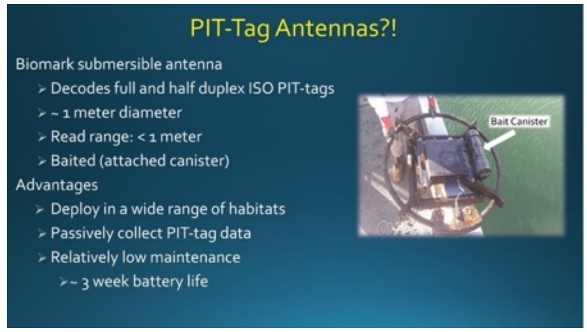






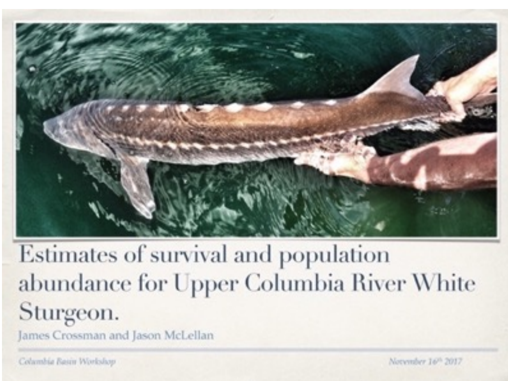


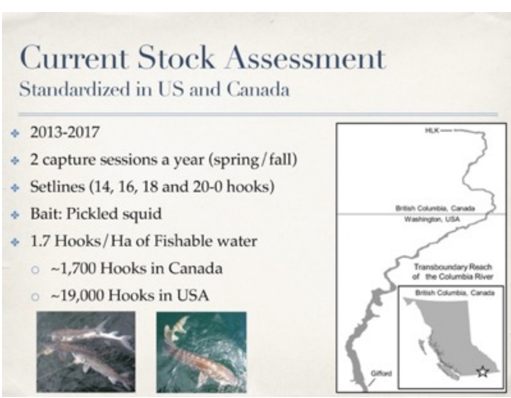


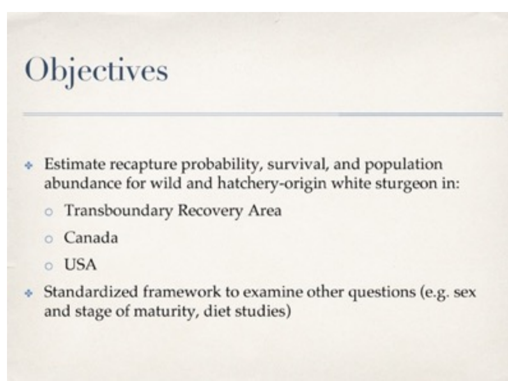


Estimates of Survival and Population Abundance for Upper Columbia River White Sturgeon

James Crossman (BC Hydro), gave the following presentation on survival and population abundance estimates in the Upper Columbia River.



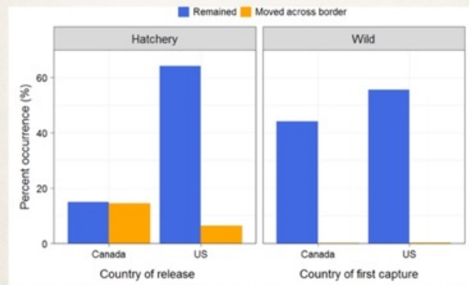




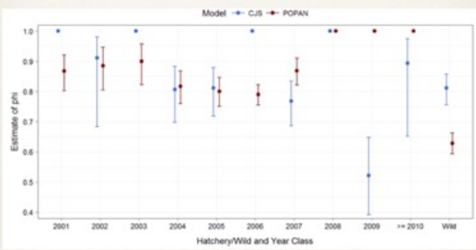
Fish capture

Origin	Sampling event	N individuals		N Recaptured							
		Total	New[1]	2013 Spring	2013 Fall	2014 Spring	2014 Fall	2015 Spring	2015 Fall	2016 Spring	2016 Fall
Hatchery	2013 spring	474	474	0	56	11	76	23	46	31	37
	2013 fall	1,204	1,147	0	0	18	130	47	77	61	58
	2014 spring	352	322	0	0	0	36	10	27	20	30
	2014 fall	1,789	1,541	0	0	0	0	64	117	53	90
	2015 spring	658	510	0	0	0	0	0	43	20	32
	2015 fall	1,408	1,092	0	0	0	0	0	0	41	62
	2016 spring	818	587	0	0	0	0	0	0	0	9
	2016 fall	1,135	807	0	0	0	0	0	0	0	0
Wild	2013 spring	262	262	0	19	15	40	13	12	11	14
	2013 fall	278	259	0	0	12	20	8	7	6	14
	2014 spring	173	146	0	0	0	15	8	6	10	3
	2014 fall	326	251	0	0	0	0	8	9	7	6
	2015 spring	119	82	0	0	0	0	0	2	4	7
	2015 fall	123	87	0	0	0	0	0	0	4	6
	2016 spring	123	81	0	0	0	0	0	0	0	6
	2016 fall	156	100	0	0	0	0	0	0	0	0

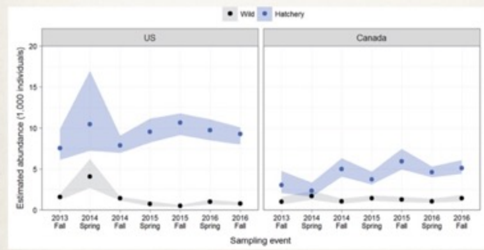
Movement between countries



Survival



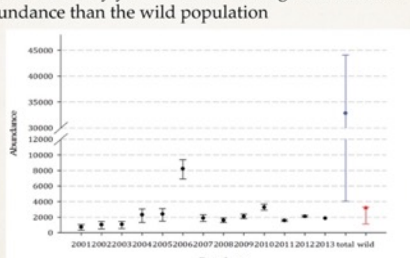
Population abundance - CJS



- Conservation aquaculture has been very successful.

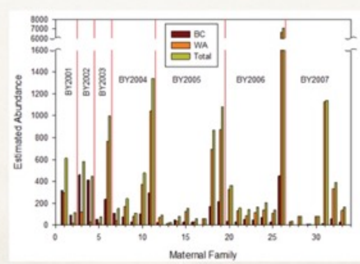
Learnings from standardized population assessment

- Certain hatchery year classes are in higher estimated abundance than the wild population



Learnings from standardized population assessment

- Concerns not only with high year class abundance but with apparent unequal family contributions

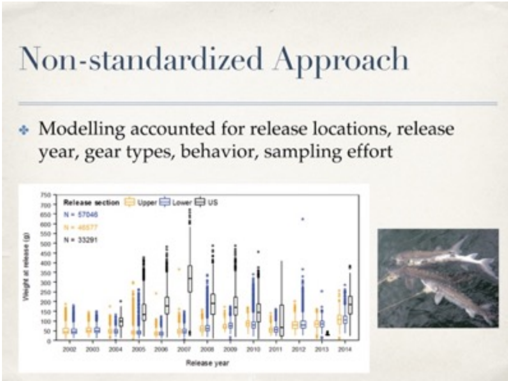


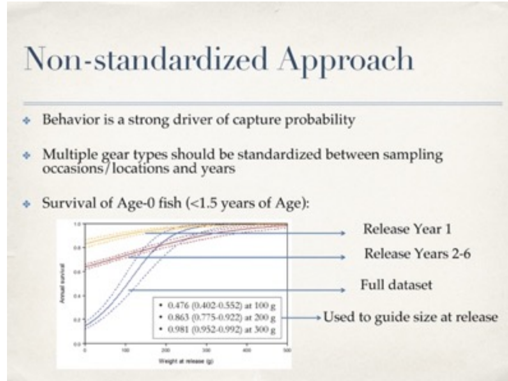
Learnings from standardized population assessment

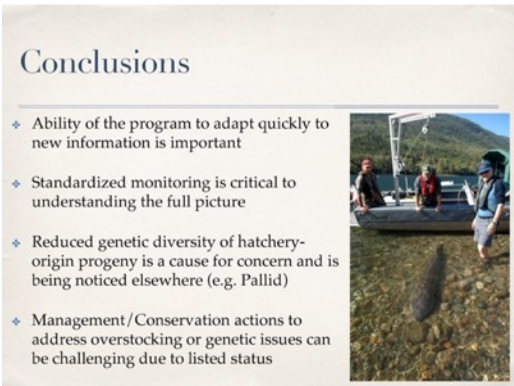
- Better survival of hatchery progeny than originally predicted for many populations
- Over-representation of certain family groups
  - Lower genetic diversity than expected.
  - Poses a risk to the wild population (e.g. inbreeding)
- Evaluation of progeny sources used for stocking
  - Adoption of completely wild-origin progeny approach

Non-standardized Approach

- Post-release monitoring results for hatchery-origin White Sturgeon in the Columbia River (Canada/USA)
- Coordinated by a recovery team
- Monitoring capture dataset spanning 13 years (n=7,024)

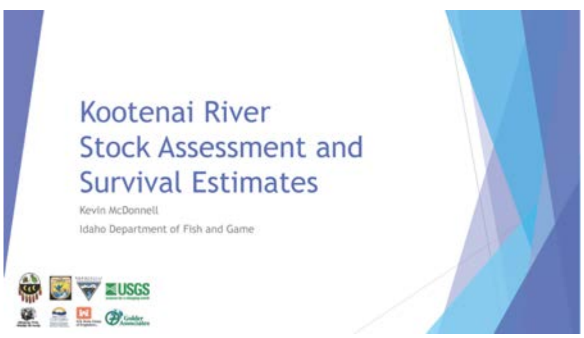


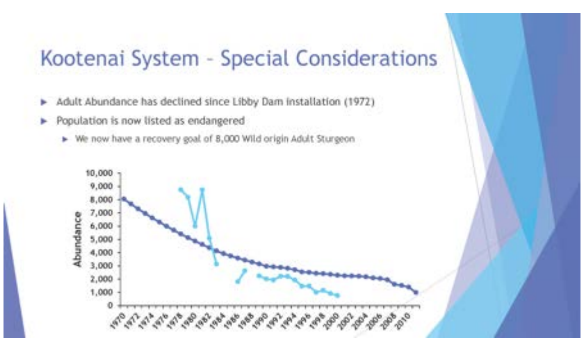




Kootenai River Stock Assessment and Survival Estimates

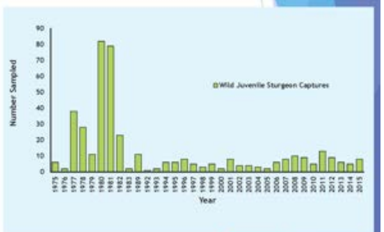
Kevin McDonnell (IDFG), gave the following presentation on stock assessment and survival estimates in the Kootenai River system.





Kootenai System – Special Considerations

- Natural recruitment has been low for recovery goals
  - Almost all juveniles we encounter are of hatchery origin - known age.
  - Spawning and juvenile survival are being evaluated
- Almost all fish are uniquely tagged (PIT)
- Supported by conservation aqua culture



Kootenai System – Special Considerations

- High variation in growth rates - May influence age specific survival rates

River - 1995 Brood year

Lake - 1995 Brood year

Biggest Questions Related to Abundance and Vital Rate Estimation

- Total population size
  - Adults vs. Juveniles?
- Age/Stage specific survival rates
  - What covariates influence those survival rates?

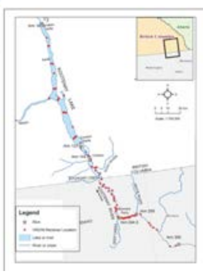
?????

Data Collection

- Adults
  - Set lines
  - Angling
  - All wild adults are scutted and PIT tagged when first encountered.
- Juveniles
  - Most juvenile captures is done via gill netting
    - 2-6" mesh currently
    - Going to introduce 1" mesh this spring
  - Set lines to a smaller degree
    - Don't recruit until ~1m

Data Collection

- Acoustic Array
  - ~100 individuals tagged
  - Mostly Adults tagged
- 85 Total recievers



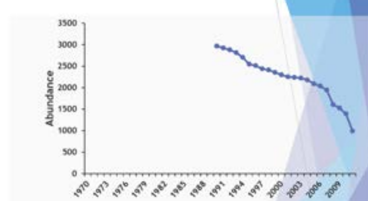
Description	Param	Data Used	Model Used	Management Informed	Notes
Wild Adult Survival	φ_{WA}				
Wild Adult Detection	p_{WA}				
Wild Adult Abundance	N_A				
Hatchery Juv. Survival	φ_{HJ}				
Hatchery Juv. Detection	p_{HJ}				
Hatchery Juv. Abundance	N_{HJ}				
Wild Juv. Survival, Detection, Abundance	$\varphi_{WJ}, p_{WJ}, N_{WJ}$				

Adults – Survival and Abundance Estimation

- Currently all adults are of wild origin
- Open Jolly-Seber Approach (Royle and Dorazio 2008)
  - State-space formulation
    - Two models - process model ("truth") and observation model
  - Allows for inclusion of individual covariates, including detection probability.
  - Individual heterogeneity included on p
  - $\hat{N}_t$ can be estimated
- Why JS and not CJS?
  - CJS has no assumption of how individuals are initially marked, unable to make inference on total number of individuals
  - Allows us to estimate recruitment and thus population size

$$\begin{array}{ccccccccccc} t_1 & \xrightarrow{\varphi_1} & t_2 & \xrightarrow{\varphi_2} & t_3 & \xrightarrow{\varphi_3} & t_4 & \xrightarrow{\varphi_4} & t_5 & \cdots \\ \uparrow & & \uparrow & & \uparrow & & \uparrow & & \uparrow & \\ p_1 & & p_2 & & p_3 & & p_4 & & p_5 & \\ M_1 & & M_2 & & M_3 & & M_4 & & M_5 & \\ U_1 & & U_2 & & U_3 & & U_4 & & U_5 & \end{array}$$

- Mean φ_{LWA} ~0.97
- Mean p_{LWA} ~0.07
- Mean b_t ~13 individuals

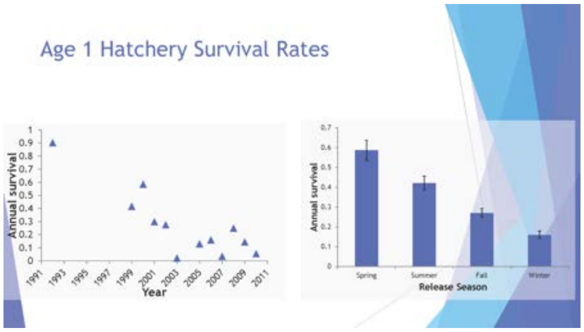


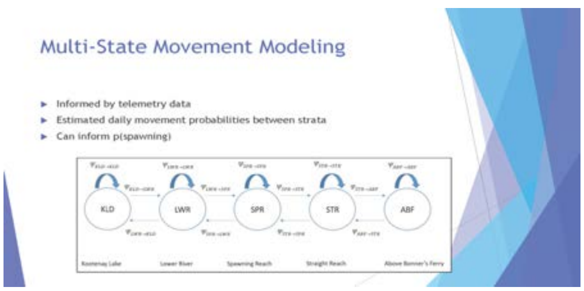
Description	Param	Data Used	Model Used	Management Informed	Notes
Wild Adult Survival	φ_{WA}	Mark/Recap from Angling, Set lines, in-river & lake	Open JS (State-Space Formulation)	-	Time varying survival
Wild Adult Detection	p_{WA}	Mark/Recap from Angling, Set lines, in-river & lake	Open JS (State-Space Formulation)	-	Time varying, Individual heterogeneity (mixing rates)
Wild Adult Abundance	N_A	Mark/Recap from Angling, Set lines, in-river & lake	Open JS (State-Space Formulation)	Recovery Goals	-
Hatchery Juv. Survival	φ_{HJ}				
Hatchery Juv. Detection	p_{HJ}				
Hatchery Juv. Abundance	N_{HJ}				
Wild Juv. Survival, Detection, Abundance	$\varphi_{WJ}, p_{WJ}, N_{WJ}$				

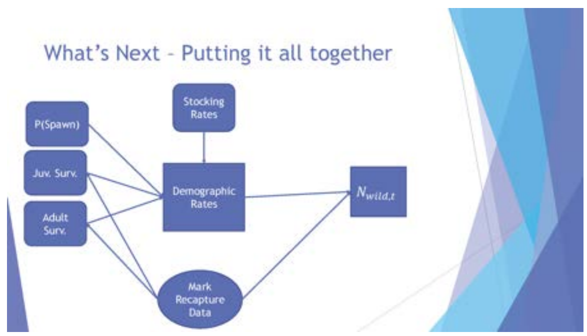
Hatchery Juveniles – Survival Estimates

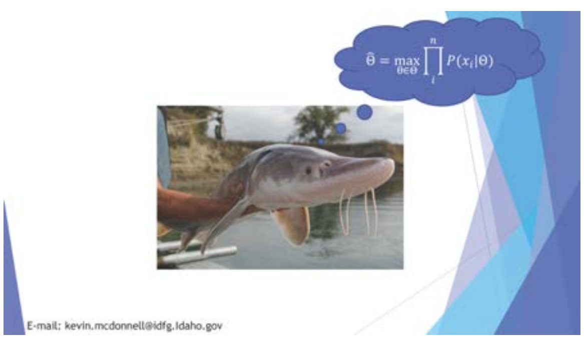
- Standard CJS model
  - All hatchery juveniles are marked prior to release
  - Because of initial marking can't use other JS models to estimate abundance (N)
  - Closure assumptions couldn't be met to use robust models to estimate N
- Covariates - Determined used AICc model selection
  - φ = f(age @ release, season of release, FL)
  - p = f(Year, FL)

$$\begin{array}{ccccccccccccc} 1 & \xrightarrow{\phi_1} & 2 & \xrightarrow{\phi_2} & 3 & \xrightarrow{\phi_3} & 4 & \xrightarrow{\phi_4} & 5 & \xrightarrow{\phi_5} & 6 & \xrightarrow{\phi_6} & 7 \\ & & p_2 & & p_3 & & p_4 & & p_5 & & p_6 & & p_7 \end{array}$$



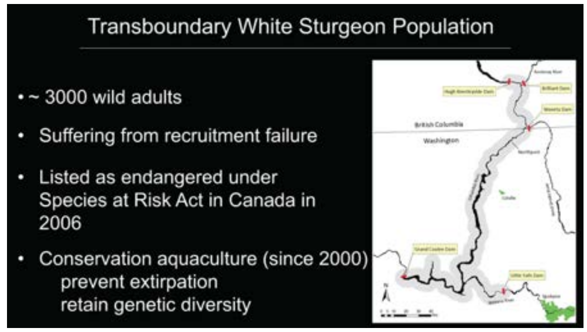


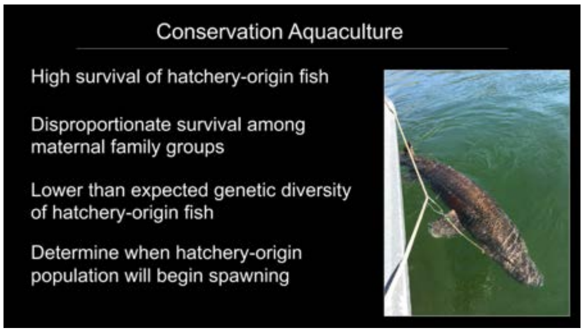


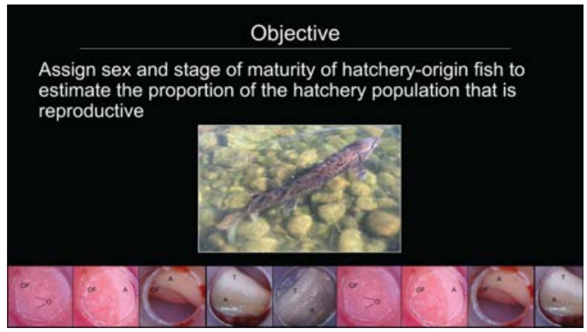


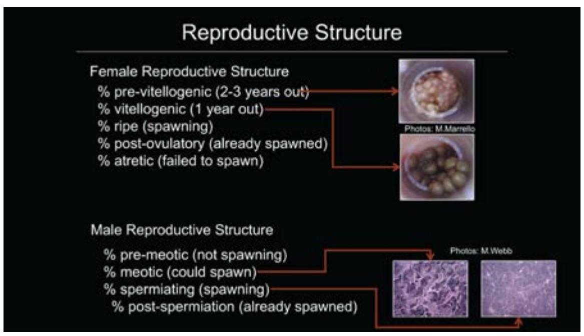
Assessing Sex and Stage of Maturity of Hatchery-origin White Sturgeon in the Transboundary Reach of the Columbia River

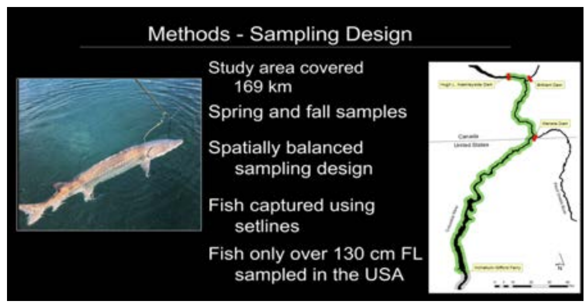
James Crossman (BC Hydro), gave the following presentation addressing the importance of assigning sex and stage of maturity in hatchery-origin white sturgeon.

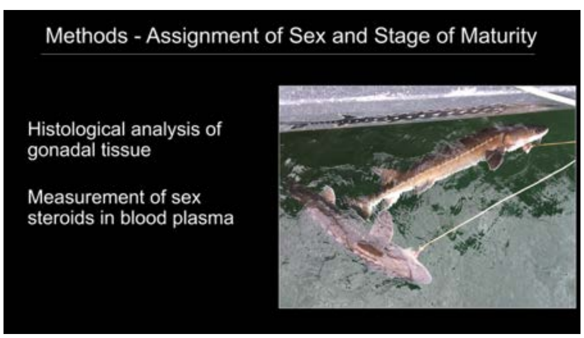


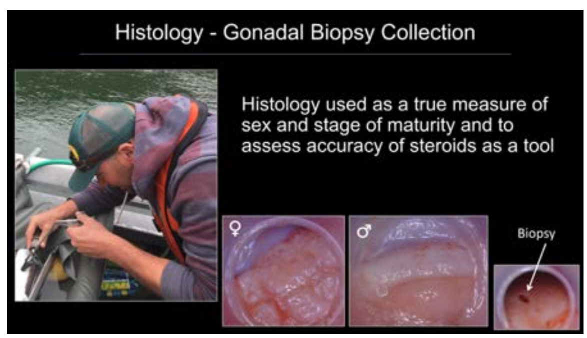


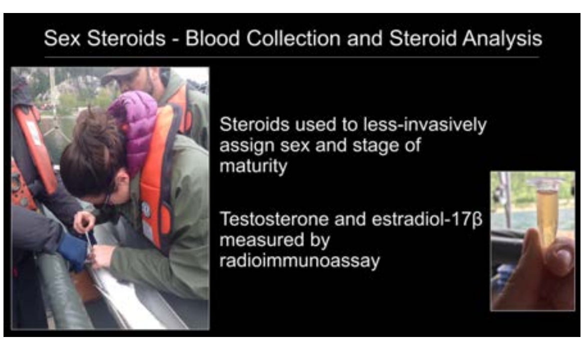


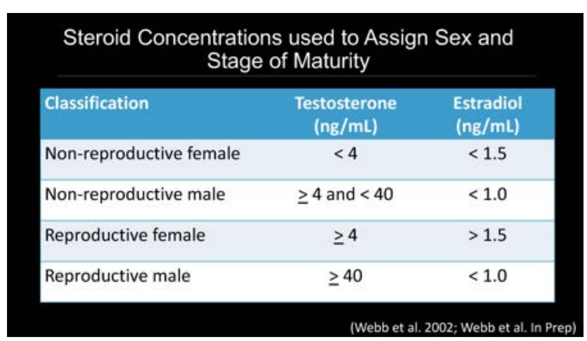






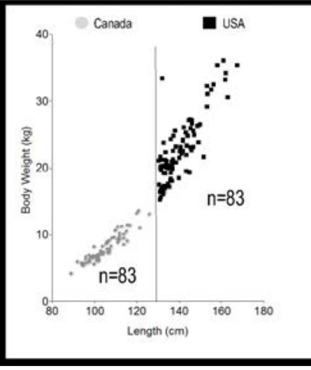






Classification	Testosterone (ng/mL)	Estradiol (ng/mL)
Non-reproductive female	< 4	< 1.5
Non-reproductive male	≥ 4 and < 40	< 1.0
Reproductive female	≥ 4	> 1.5
Reproductive male	≥ 40	< 1.0

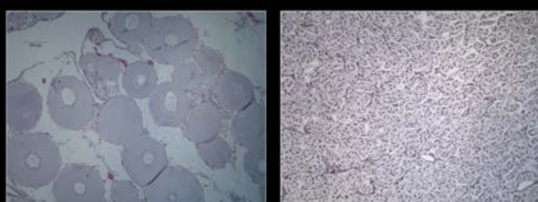
Results – Fish Capture



Results - Range of Ages Sampled

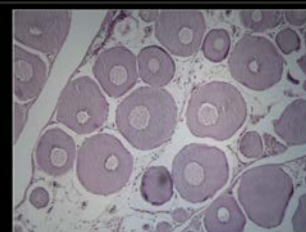
Sex	Canada	USA
Females	7-15	9-15
Males	9-15	9-15

Histological Analysis of Gonadal Tissue in Canada



Females Males

Histological Analysis of Gonadal Tissue in USA

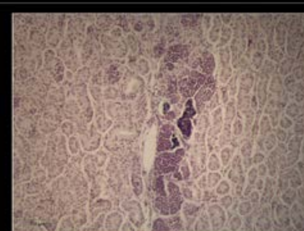


Female

Histological Analysis of Gonadal Tissue in USA

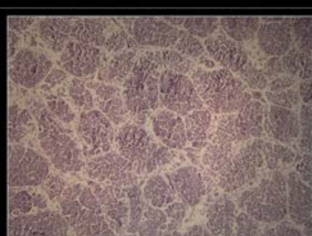
Male

Histological Analysis of Gonadal Tissue in USA



Male

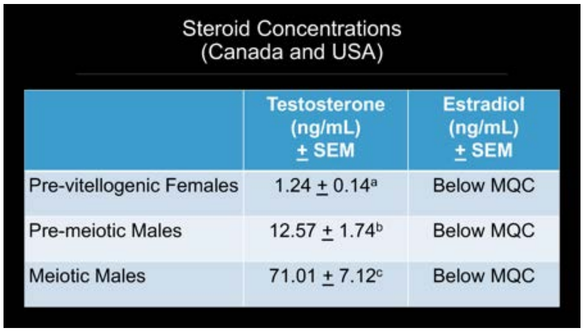
Histological Analysis of Gonadal Tissue in USA



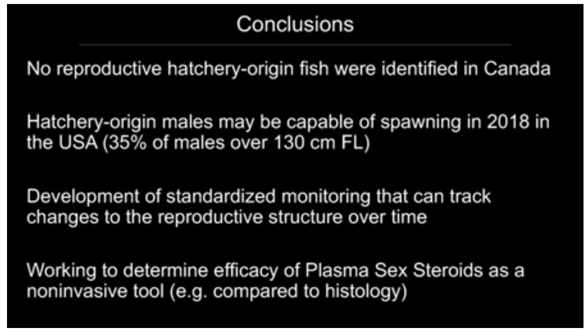
Male

Percentage of Males in Different Stages of Maturity

Stage of Testicular Development	Canada	USA
Pre-meiotic (Spermatogonia)	100%	65%
Meiotic (Spermatogonia and Spermatocytes)	0	33%
Meiotic (Spermatocytes only)	0	2%


Steroid Concentrations (Canada and USA)

	Testosterone (ng/mL) ± SEM	Estradiol (ng/mL) ± SEM
Pre-vitellogenic Females	1.24 ± 0.14[a]	Below MQC
Pre-meiotic Males	12.57 ± 1.74[b]	Below MQC
Meiotic Males	71.01 ± 7.12[c]	Below MQC



Panel Discussion and Take Homes from Stock Assessment Session

After the presentations the presenters from the Lower Columbia, Mid-Columbia, Snake, Upper Columbia, and Kootenai lead a panel discussion and question and answer session. Some of the questions discussed included:

- How does the use of specific gear or methodologies influence results? What are the implications of those differences at a regional or basin-wide scale?
- How are stock assessments and survival estimates being used to inform regional White Sturgeon programs? What level of confidence is there in regional population/survival estimates?
- What challenges and/or opportunities exist to standardize gear and/or methodologies?
- What are the challenges and opportunities for data sharing?

Workshop participants were asked to summarize major "take homes" and questions that stood out for them. Following is a summary of those responses.

Survival estimates and stocking targets

- How to reconcile survival rates and abundance models that do not agree (i.e., do not provide similar results).
- Is abundance the right target?
- Do we know power and sensitivity of our estimates?
- How does everyone meet their closure assumptions?
- Are we under-estimating large adults (>8 feet), and does it matter?

Maturation estimates

- How does age affect the impact of in vivo aging?

Carrying capacity

- How to determine carrying capacity of reservoirs. Can it be done without stocking to levels that exhibit density dependence?
- Is carrying capacity important to measure if we're adaptively managing our programs?
- Has carrying capacity been reached in some river reaches with historical/current hatchery releases?
- Is seeing downstream migrants indicative of systems being saturated?

Information sharing

- Important to clearly identify reasons for models/analysis when we share them so we can all learn from choices and lessons learned.
- Better ways to share methods such as aquaculture larval collection, stock assessment.

Photo from IDFG ignite presentation.

Conservation Aquaculture

This session looked at genetic diversity in conservation aquaculture programs, spontaneous autopolyploidy, and the use of larval collection and rearing. Presentations included:

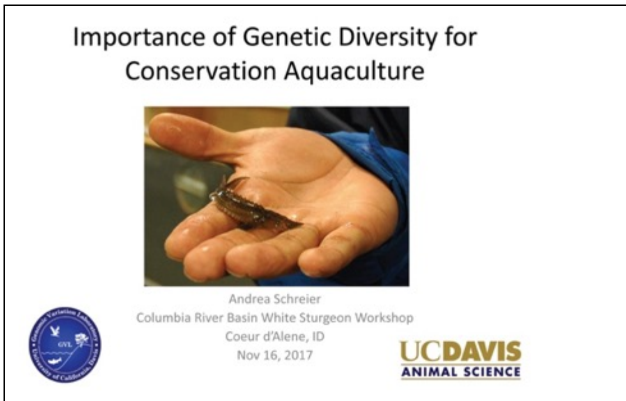
- Andrea Schreier (UC Davis), on genetic diversity in conservation aquaculture programs.
- Andrea Schreier on spontaneous autopolyploidy in White Sturgeon.
- Jason McLellan (CCT), on larvae collection and rearing as a conservation aquaculture tool.

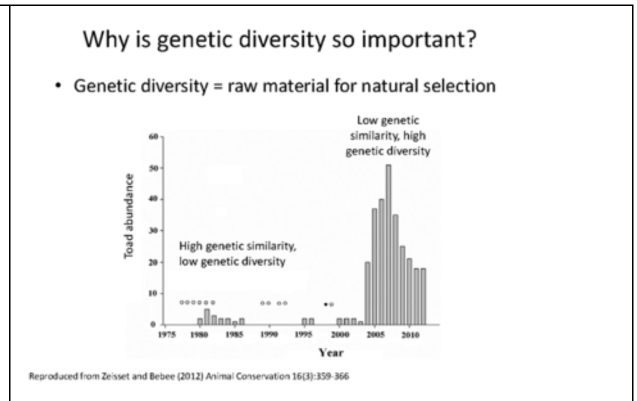
After the presentations participants engaged in a brief question and answer session followed by a large group discussion (fish bowl format) focused on questions about where the Columbia Basin is going with the various aquaculture programs.

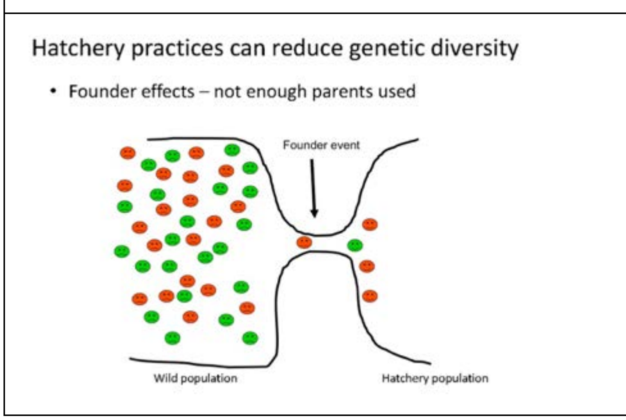
Thumbnail sketches of the three presentations follow.

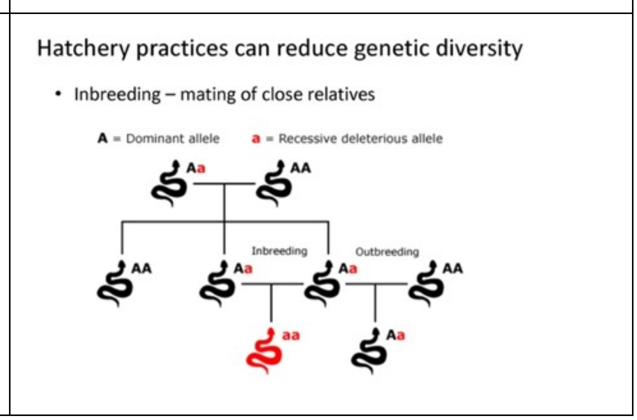
Importance of Genetic Diversity for Conservation Aquaculture

Andrea Schreier (UC Davis), gave the following presentation on genetic diversity in conservation aquaculture programs.



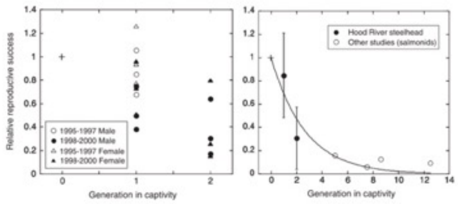






Hatchery practices can reduce genetic diversity

- Domestication – relaxed selection pressure or artificial selection for hatchery conditions

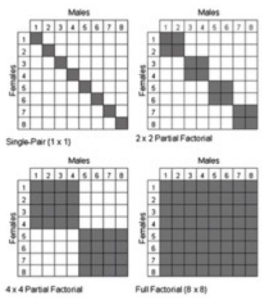


Reproduced from Ariaki et al. (2007) Science 318:100-103

How to maximize genetic diversity?

- Consider larval collection/repatriation
- If broodstock must be used, incorporate as many parents as possible
- Consider factorial or partial factorial spawning matrix

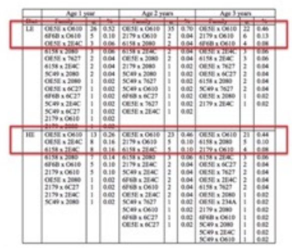
Full vs. partial factorial designs



Reproduced from Busack and Knudsen (2007) Aquaculture 273(1):24-32

Equalizing family sizes

- Sturgeon naturally exhibit high variability in reproductive success



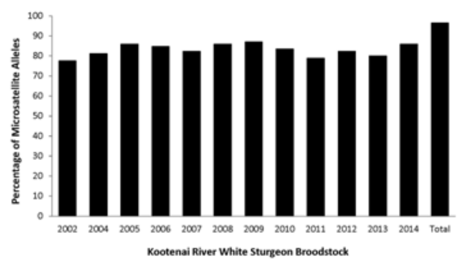
	Age 1 year			Age 2 years			Age 3 years		
Diet	Family	N	%	Family	N	%	Family	N	%
LE	OE5E x O610	26	0.52	OE5E x O610	35	0.70	OE5E x O610	22	0.46
	6F6B x O610	5	0.10	2179 x O610	2	0.04	2179 x O610	6	0.13
	OE5E x 2E4C	3	0.06	6158 x 2080	2	0.04	6F6B x O610	4	0.08
	6158 x 2080	3	0.06	6158 x 2E4C	2	0.04	OE5E x 2E4C	3	0.06
	OE5E x 7627	2	0.04	OE5E x 2080	2	0.04	6158 x 2E4C	3	0.06
	6158 x 2E4C	2	0.04	2179 x 2080	1	0.02	OE5E x 7627	2	0.04
	5C49 x 2080	2	0.04	5C49 x 2080	1	0.02	OE5E x 6C27	2	0.04
	OE5E x 2080	1	0.02	5C49 x 7627	1	0.02	6158 x 2080	2	0.04
	OE5E x 6C27	1	0.02	5C49 x O610	1	0.02	5C49 x 7627	2	0.04
	6F6B x 6C27	1	0.02	6F6B x 6C27	1	0.02	OE5E x 2080	1	0.02
	5C49 x 2E4C	1	0.02	OE5E x 7627	1	0.02	2179 x 2E4C	1	0.02
	5C49 x 6C27	1	0.02	OE5E x 2E4C	1	0.02			
	2179 x O610	1	0.02						
	2179 x 2080	1	0.02						
HE	OE5E x O610	13	0.26	OE5E x O610	23	0.46	OE5E x O610	21	0.44
	OE5E x 2E4C	8	0.16	2179 x O610	5	0.10	6158 x 2080	5	0.10
	6158 x 2E4C	8	0.16	6158 x 2E4C	5	0.10	2179 x O610	4	0.08
	6158 x 2080	7	0.14	6158 x 2080	3	0.06	6158 x 2E4C	3	0.06
	6F6B x O610	5	0.10	2179 x 2E4C	2	0.04	OE5E x 6C27	2	0.04
	2179 x O610	5	0.10	5C49 x 2E4C	2	0.04	OE5E x 7627	2	0.04
	OE5E x 2080	1	0.02	6F6B x 2E4C	2	0.04	OE5E x 2E4C	2	0.04
	2179 x 6C27	1	0.02	6F6B x O610	2	0.04	6158 x 7627	2	0.04
	2179 x 2E4C	1	0.02	OE5E x 2E4C	2	0.04	OE5E x 2080	1	0.02
	5C49 x 2080	1	0.02	5C49 x 7627	1	0.02	OE5E x 234A	1	0.02
				5C49 x O610	1	0.02	2179 x 2080	1	0.02
				6F6B x 6C27	1	0.02	6F6B x O610	1	0.02
				OE5E x 6C27	1	0.02	5C49 x 2080	1	0.02
							5C49 x 2E4C	1	0.02
							5C49 x O610	1	0.02

Van Eenennaam et al. 2015 WRAC Annual Termination Report

Equalizing family sizes also boosts N_e

- N_e determines manner in which genetic diversity is maintained
- High N_e = greater retention of diversity (low drift)
- Low N_e = greater genetic diversity loss (high drift)

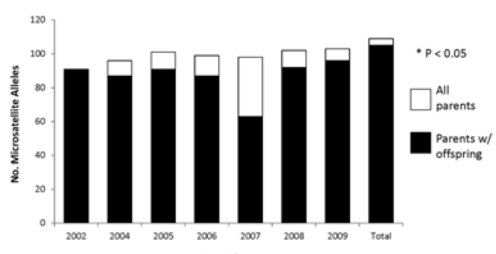
Stocking multiple year classes maximizes genetic diversity



Target levels of genetic diversity?

- Preserve as much as possible
- Important to consider not only alleles but combinations of alleles
- Also, remember that not all released fish survive

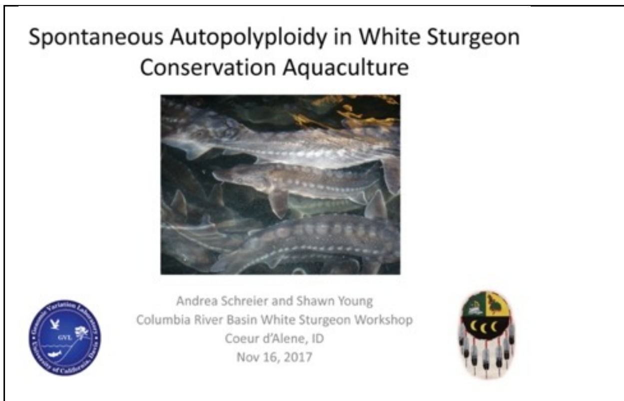
Remember that post-release mortality reduces genetic diversity preservation

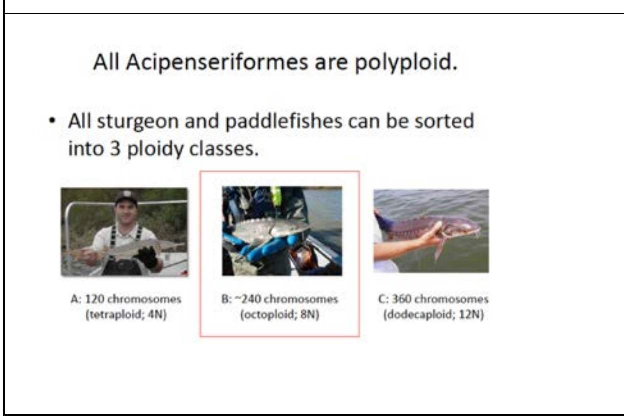


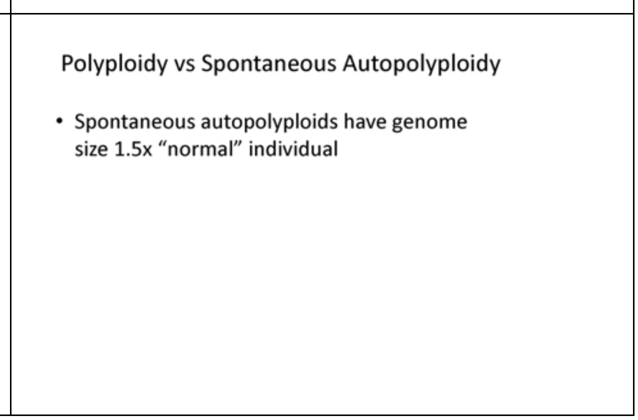
Schreier et al (2015) Biological Conservation

Spontaneous Autopolyploidy in White Sturgeon Conservation Aquaculture

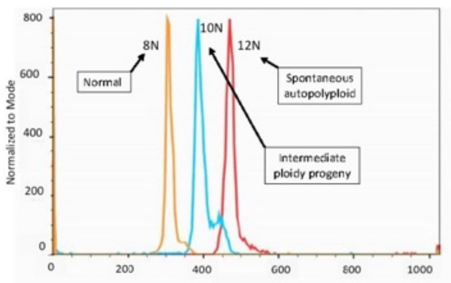
Andrea Schreier (UC Davis), gave the following presentation on spontaneous autopolyploidy in White Sturgeon.

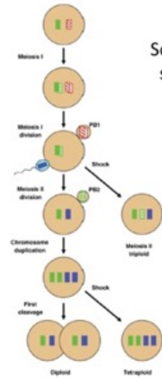






Spontaneous autopolyploidy in white sturgeon





So what is the ultimate cause of spontaneous autopolyploidy?

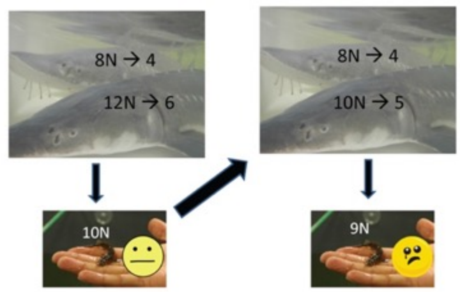
Something happens during meiosis II to prevent ejection of the 2nd polar body

Figure 2 from Piferrer et al. (2009) Aquaculture

Prevalence of spontaneous autopolyploidy in white sturgeon culture

- Specific to maternal family
- Range: 0% - 90% 12Ns per family

Problems with spontaneous autopolyploidy in culture



Bottom Line

- White sturgeon conservation hatcheries…
  - Do not want spontaneous autopolyploids or their offspring in broodstock or production fish
  - Do not want to release high number of spontaneous autopolyploids into the wild
- Must determine cause of spontaneous autopolyploidy so it can be managed in aquaculture.

Several causes of spontaneous autopolyploidy in culture.

- Poor quality eggs more likely to experience meiotic problems
- *In vivo* post-ovulatory ageing
- Mechanical shock during de-adhesion
- Genetic predisposition

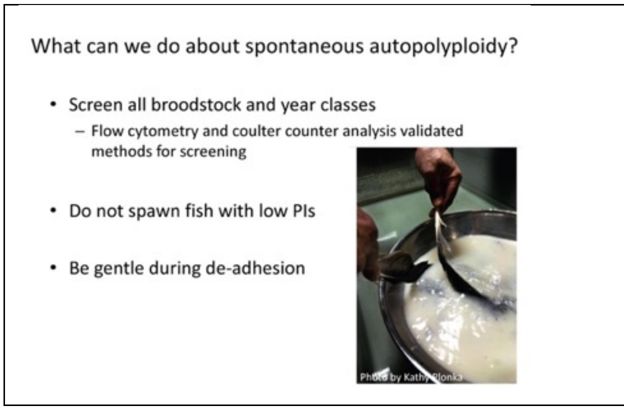
Mechanical Shock Experiment Results (Yr 2)

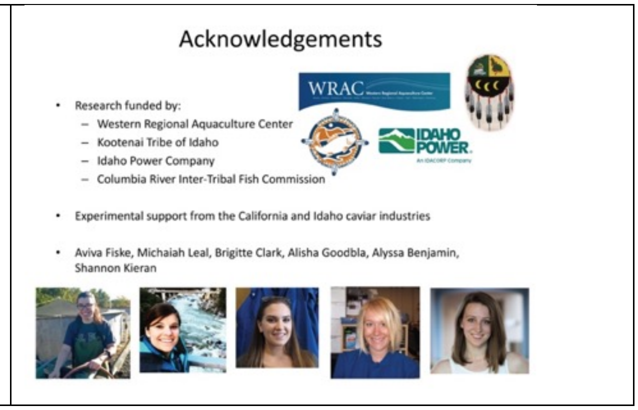
Female	Pop/Year	Last PI and # days to Injection	Treatment	% Fertility	% Neur	% 12N (N=150-200)
7A54*	ID/2016	0.084 11	Gentle Vigorous	89 ± 1 90 ± 1	86 ± 4 88 ± 2	0.00 1.30
2062*	ID/2016	0.069 46	Gentle Vigorous	95 ± 2 96 ± 2	90 ± 1 90 ± 2	0.70 43.3
F8	CA/2017	0.080 13	Gentle Vigorous	80 ± 2 82 ± 3	64 ± 5 65 ± 5	1.50 45.0
R1	CA/2017	0.044 15	Gentle Vigorous	50 ± 1 50 ± 1	37 ± 2 36 ± 1	0.00 21.0
R14	CA/2017	0.073 15	Gentle Vigorous	90 ± 2 90 ± 2	75 ± 2 75 ± 3	57.5 77.5

*At first egg check, 100s of eggs found so post-ovulatory ageing may have occurred

Can spontaneous autopolyploidy occur in wild fish?

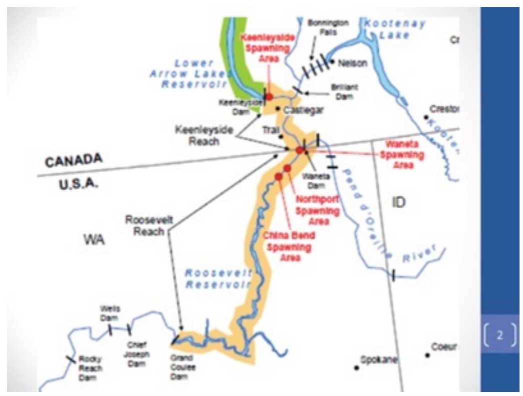
- Yes. Several wild 12N wild fish detected in the Columbia Basin
- Three 10N half-sib families inadvertently produced in KTOI 2016 year class

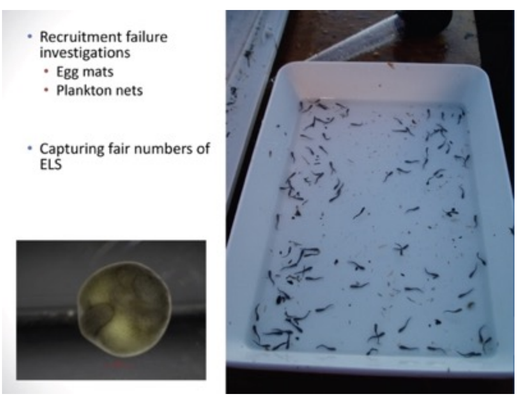


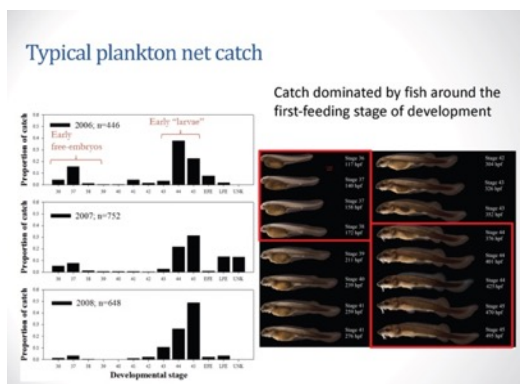


Use of Wild Caught White Sturgeon Early Life Stages for Aquaculture

Jason McLellan (CCT), gave the following presentation on larvae collection and rearing as a conservation aquaculture tool.







Are wild caught early life stages a viable alternative for aquaculture?

- Lake Sturgeon
  - Holtgren et al. (2007); Smith and Hobden (2011)
  - Greater genetic diversity with eggs/larvae v. adult broodstock (Crossman et al. 2011)
- Wanted to test it for white sturgeon
  - How many can we catch?
  - Will they survive?
  - Genetic benefits?

5

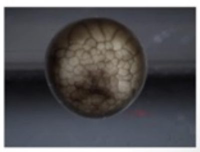
How many larvae can we catch in US?

Collection Year	Number Captured				Goal	
	WDFW	STI	CCT	Total	Roosevelt	Wells
2010 (pilot)	3,235	-	-	3,235	N/A	-
2011	10,355	-	-	10,355	10,000	-
2012	-	1,580	-	1,580	10,000	-
2013	-	2,072	3,752	5,824	10,000	5,000
2014	-	9,037	21,931	30,968	10,000	10,000
2015	-	7,205	20,914	28,119	5,000	10,000
2016	-	7,202	21,680	28,882	5,000	10,000
2017	-	see total	see total	40,123	5,000	2,500
Total	**13,590**	**27,096**	**68,277**	**149,086**	-	-

6

How many early life stages can we catch Canada?

- Primarily focused on eggs
- Long-term egg mat program
- Variable catch - 100's to a few thousand



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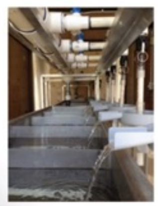
Will they survive in the hatchery?

- Survival has ranged from approximately 20 – 50%
- Varies by facility and year



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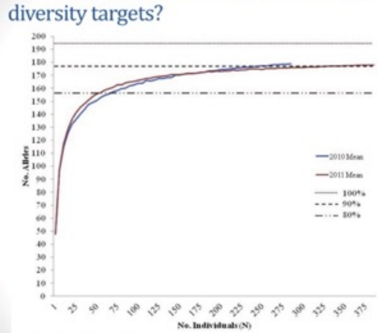
Are they more diverse genetically?

Program	N_T	N_G	No. Alleles
BC_{01}	3	3	78
BC_{02}*	NA	NA	NA
BC_{03}	6	6	96
BC_{04}	6	6	99
BC_{05}	8	5	95
BC_{06}	16	14	114
BC_{07}	11	11	120
BC_{08}	14	14	118
BC_{09}	21	21	132
BC_{10}	15	15	121
Rp_{10}	522	285	180
Rp_{11}	500	383	179
$BC_{10}+Rp_{10}$	537	300	180

Schreier and May, unpublished data

How many larvae are needed to meet genetic diversity targets?



Schreier and May 2012

10

How many parents are represented?

- ≈80 adults represented in 2010 Lake Roosevelt collections (Schreier and May, unpublished data)
- 118 and 97 adults represented in 2011 and 2012 upper Columbia BC egg/larvae collections (Jay et al. 2014)

11

Why you should consider wild caught early life stages for your program?

- Greater genetic diversity
- Artificial selection is reduced - natural mate selection, incubation, and early rearing
- No impacts to broodstock
- Parents of larvae used in aquaculture programs can also produce offspring that contribute to natural recruitment

12

Questions and Take Homes from Conservation Aquaculture Session

Following is a summary of the major take homes and questions raised in a brief session after the presentation. Note the discussion from the "fish bowl" exercise is not included in this summary.

Goals and tradeoffs

- What is the end game with conservation aquaculture? Will we ever shut down a hatchery program?
- What are the impacts of supplementation on ecosystem populations of other species?
- If hatchery fish behave differently from wild fish, how do we make comparison to wild juveniles that don't exist (in some systems)? Is it based on assumptions?

Larval collection and rearing

- A cautionary note on the risk of reliance on early life history repatriation versus restoring natural recruitment
- Recommend holding a workshop on best practices, methods of egg/larvae collection.

Genetics

- Need to keep in mind and explore genetic diversity implications of downstream drift.

Spontaneous Autopolyploidy

- Need for Coulter Counter workshop and clear protocols so testing is consistent in basin. How to interpret results.
- Risk analysis talk and discussion to develop approach.

Information sharing

- Need for coordination of supplementation programs in the Columbia River to efficiently use available larvae and reduce potential genetic effects of conventional broodstock.

Research Highlights

The workshop included three research presentations. The first, given by Collin Eagles-Smith (USGS), addressed mercury bioaccumulation and toxicological effects in White Sturgeon; the second from Andrew Matala (CRITFC), presented a quick approach to determining White Sturgeon sex; and the third presented by Jim Hatten (USGS), dealt with modeling of White Sturgeon spawning habitat in the Columbia and Snake rivers.

Mercury Bioaccumulation and Toxicological Effects in White Sturgeon

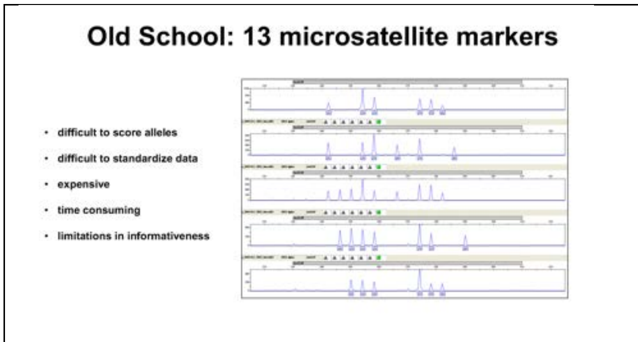
Collin Eagles-Smith (USGS), requested that the presentation not be posted or included in the notes until the work is published. Following are highlights:

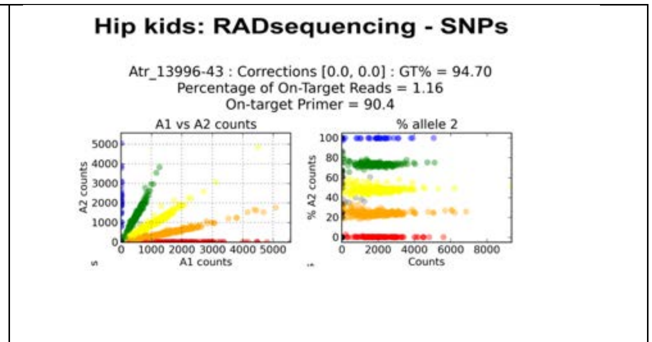
- Mercury is responsible for 80% of all fish consumption advisories. Mercury is an endocrine disruptor that reduces the body's ability to regulate hormones.
- There are high concentrations in mercury in south east Idaho (below American Falls down to Hells Canyon) in Smallmouth Bass, the concentrations get higher.

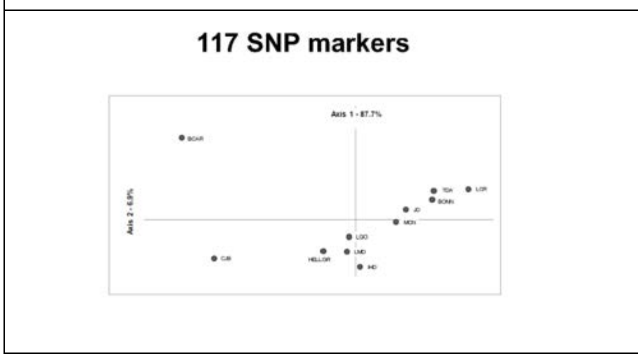
- Mercury is the only element with its own international treaty.
- Study objectives are:
    - Compare Hg concentrations in Hells Canyon population of White Sturgeon with elsewhere in the Snake and Columbia rivers.
    - Assess the biological significance of Hg concentrations to White Sturgeon reproductive and endocrine markers.
    - Evaluate Hg concentrations in potential prey items of White Sturgeon, and the influence of ontogenetic diet shifts on sturgeon Hg concentrations.

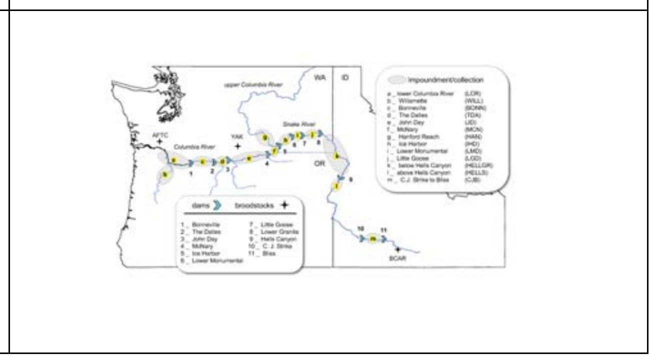
A Quick Way to Determine White Sturgeon Sex

Andrew Matala (CRITFC), gave the following presentation on a new approach to determining White Sturgeon sex. Andrew asked participants for known parent samples to contribute to the SNP research.









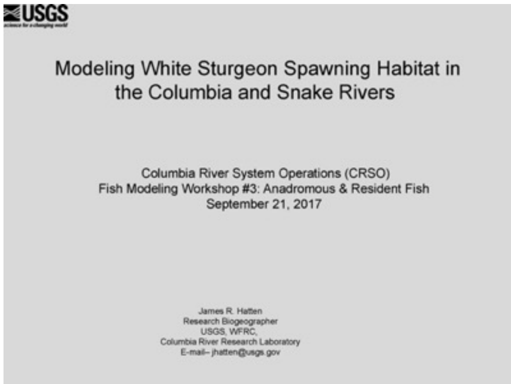
The polyploid genome is a challenge for genome assembly. We plan to outsource the genome assembly and some of the more difficult library preparation to a company specializing in the assembly of complex genomes (NRGene). The approach for generating sequence data involves the creation of several types of sequencing libraries including PCR free paired-end shotgun libraries, mate-pair libraries, and 10X genomics phased libraries (Details in supplemental documents). The sequence data is assembled using a proprietary assembly pipeline called "DeNovoMAGIC" (http://nrgene.com/products-technology/denovomagic/) which has gained notoriety in the genomics community for producing a high quality genome assembly of bread wheat (a hexaploid species with a genome size of 17GB). Once the genome assembly has been completed, we plan to create pooled sequencing libraries of male and female sturgeon samples for the sex determination study. DNA extracts from roughly 50 known sex males and 50 known sex females will be quantified and combined into sex specific pools that will then be made into shotgun libraries for in-house sequencing using our Illumina NextSeq platform. The sequence data will be aligned to the genome assembly and areas of the genome that are missing sequence alignments in a sex specific manner will be identified. When an obvious sex specific gap is identified, we can validate it as a sex determination locus by PCR amplification in individual samples of known sex.

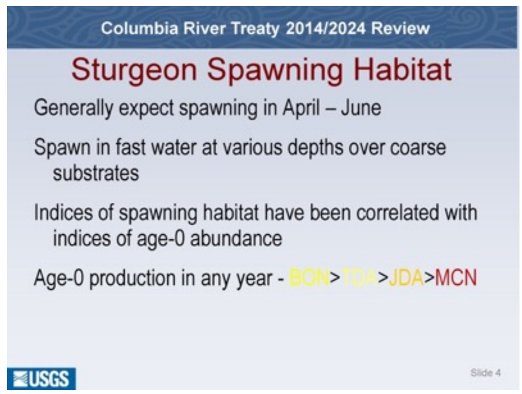
Table 1. White sturgeon genetic tissue samples (2008-2016) identified by primary location (see figure 1) and age class; UNK is unknown. The sample numbers (n) are the total number prepped for analyses and assembled into three GT-seq libraries. Progress as of the submission of this report includes genotypic data from one completed library ("2016 report").

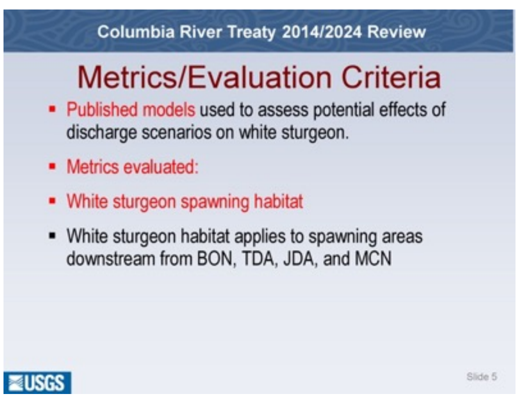
Location / impoundment	code	YOY (n)	Jsub (n)	adult (n)	UNK (n)	total (n)	2016 report
Yakama broodstock	YAK	0	0	49	0	49	**0**
Abernathy broodstock	AFTC	0	0	66	0	66	**0**
Lower Columbia	LCR	235	1	88	0	324	**19**
Willamette River	WILL	0	0	14	0	14	**0**
Bonneville	BONN	272	0	51	198	521	**204**
The Dalles	TDA	429	0	28	0	457	**84**
John Day	JD	91	359	98	0	548	**164**
McNary	MCN	15	119	112	199	445	**153**
Hanford Reach	HAN	0	0	93	0	93	**3**
Ice Harbor	IHD	1	97	29	0	127	**103**
Lower Monumental	LMD	0	73	66	0	139	**135**
Little Goose	LGO	0	54	64	0	118	**22**
Hells Canyon - downstream	HELLGR	0	0	29	0	29	**5**
Hells Canyon - upstream	HELLS	1	0	25	0	26	**0**
C. J. Strike to Bliss	CJB	0	0	85	0	85	**64**
Blind Canyon Aqua-ranch	BCAR	0	0	94	0	94	**62**
Sacramento-San Joaquin	SAC	0	0	5	0	5	**0**
Middle Fraser	FR	0	0	5	0	5	**0**
Lower Fraser	FR	0	0	5	0	5	**0**
Nechako River	NR	0	0	5	0	5	**0**
total		**1044**	**703**	**1011**	**397**	**3155**	**1018**

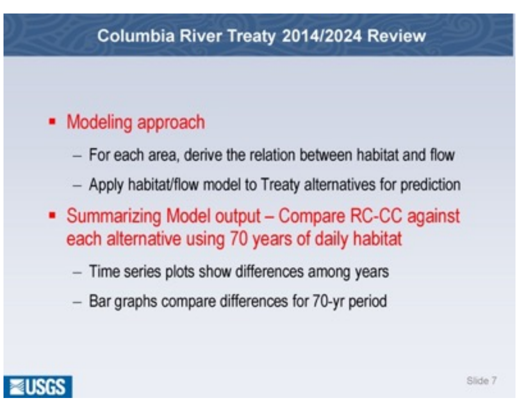
Modeling White Sturgeon Spawning Habitat in the Columbia and Snake Rivers

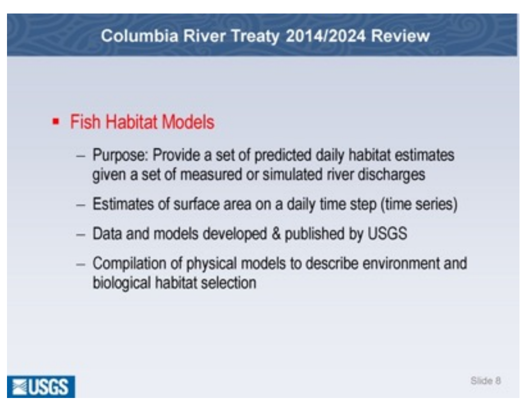
Jim Hatten (USGS), gave the following presentation on modeling of White Sturgeon spawning habitat in the Columbia and Snake rivers.











Columbia River Treaty 2014/2024 Review

- Physical Attributes of River Reaches
  - Flow – taken as input at dams
  - Velocity – calculated from flow and river geometry
  - Depth – calculated from flow and river geometry
  - Riverbed substrate – mapped
  - Lateral slope – derived from river geometry
- Biological Habitat Selection
  - White sturgeon spawning – Habitat suitability criteria derived from locations where newly-spawned eggs found.

USGS Slide 9

Columbia River Treaty 2014/2024 Review

- Important considerations
  - E components are bookends to identify and better understand potential improvements
  - Only sturgeon spawning habitat modeled – other life stages were not
  - Daily water temperature defines the spawning period for sturgeon and was not included in this analysis
  - Inter & intra specific reach and species conflicts require careful consideration (e.g. JDA sturgeon spawning & fall chinook rearing; Hanford & JDA fall chinook rearing)

USGS Slide 10

Columbia River Treaty 2014/2024 Review

- Key attributes of the model/analysis
  - Habitat has direct linkages to fish
  - Input daily flow from HYDSIM model
  - Outputs used to calculate differences between RC-CC and alternatives for 70-yr period
  - Model outputs have spatial and temporal components
  - Provide practical quantification of habitat useful to decision makers

USGS Slide 11

Columbia River Treaty 2014/2024 Review

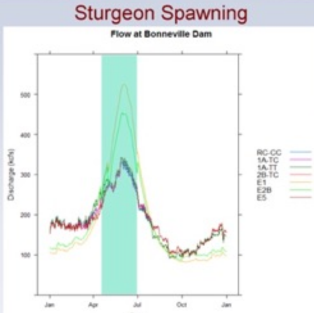
Modeling Results

White Sturgeon Spawning Habitat

USGS Slide 12

Columbia River Treaty 2014/2024 Review

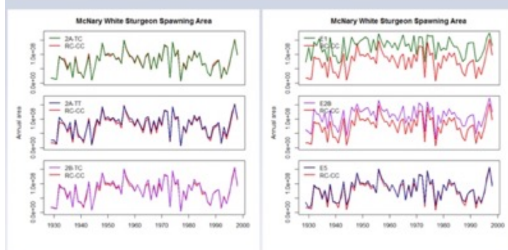
Sturgeon Spawning



USGS Slide 13

Columbia River Treaty 2014/2024 Review

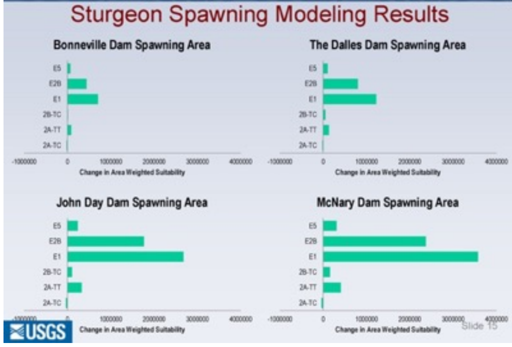
Sturgeon Spawning Modeling Results



USGS Slide 14

Columbia River Treaty 2014/2024 Review

Sturgeon Spawning Modeling Results



USGS Slide 15

Columbia River Treaty 2014/2024 Review

Summary

- Sturgeon Spawning
  - All but one alternative resulted in more habitat than the reference condition over the 70-yr period
  - Relative changes were greater for spawning areas with backwater effects from downstream dams
  - E1 & E2B show greatest increases in habitat

USGS Slide 16

Emerging Issues

Throughout the workshop participants posted emerging issues on a wall banner illustrating the Columbia River, its tributaries, and the Fraser, San Joaquin, and Sacramento rivers.

Photo of wall banner with emerging issues.

At the end of the workshop participants were asked to vote for the “top” emerging issue (from their individual perspective). The top emerging issues identified through that exercise were:

1. Carrying capacity
2. Recruitment failure
3. Climate change effects
4. Tied for fourth place:
    a. More information and data sharing between entities.
    b. Applying current science to management decisions.
    c. Need for a commitment from BPA to fund basin-wide sturgeon meta-analysis.

Following is a summary of the emerging issues identified by workshop participants organized by general theme.

General and/or Basinwide Issues

Climate Change

- Climate change and variable weather patterns will reduce the frequency of already rare high-water events that drive recruitment in an altered ecosystem.
- How will white sturgeon conservation strategies address a rapidly changing climate?

Larval Transport

- Larval transport downstream through dams is largely unknown e.g., how much does spawning in John Day tailrace contribute to Bonneville reservoir population?
- How far will larval sturgeon drift in a free-flowing system?

Flow Management

- What mechanism explain the positive relationship between higher water years and sturgeon year class production?
- Are they mechanisms managers or regulators can control, manage or regulate? Snake Columbia and Sacramento populations all show this trend.

Spawning and Aging Wild Populations

- Reservoir ageing is lowering productivity.
- Wild populations are aging.

Recruitment Failure and Early Life History

- Ongoing uncertainty about causes of recruitment failure in different populations.
- Unknowns about bottlenecks in early life history. Food web, habitat needs, predation, other factors?
- Understanding recruitment versus growth and how it pertains to population stability.
- Can we synthesize information on recruitment years (good and bad) from around the regions to begin seeing patters and testing hypotheses?

Conservation Aquaculture, Hatcheries and Genetics

- Options to expand repatriation efforts to broader river or basin scales. The case for using larvae and eggs collected from the wild for artificial production appears strong.
- Unintended consequences of hatchery rearing.
- What about using fish reared from larval and egg collections in segment of the Columbia River basin reservoir system where they weren't collected?
- Reliance on "hatchery" fish at the expense of natural recruitment may lead to ESA listing.

Spontaneous Autopolyploidy

- What is the incidence of spontaneous autopolyploidy in wild fish?
- What is cause in hatchery populations? What is risk?

Abundance Estimates, Juvenile Survival and Growth

- Best practices to determine juvenile survival.
- Juvenile white sturgeon growth bottleneck
- Large confidence interval around abundance estimates, challenges to improve.

Carrying Capacity

- How to determine?

Funding

- Need for permanent endowment. BPA funding challenges. How to engage other potential funders?

Big Picture Questions

- How to move sturgeon conservation forward by introducing new ideas and acknowledging what we know and don't know.
- Realization that the original issues have not been solved yet.
- How do you apply the current science to management? How do you include decision-makers?

Lower Columbia to McNary

- How do we know magnitude of sea lion predation in the Lower Columbia?
- How can we engage with our fishing community to help gather data?
- Increasing recreation (kiting, windsurfing) at Hood River and Big White Salmon River deltas may preclude fish from accessing productive shallow habitat to forage.
- Commercial navigation stretch: prop wash/shear stress from commercial navigation in spawning, incubation and dispersal areas could be lowering recruitment success.
- Are we loosing spawning habitat in the lower river due to substrate embeddedness? No "recruitment" of new spawning gravels due to dams.

McNary through Mid-Columbia

- Trap and haul from below Bonneville to John Day. Cheaper and more effective than building a hatchery.
- Long-term habitat change – loss of islands in John Day and below Bonneville over past decade has reduced habitat complexity.
- Reconsider building a lower Columbia sturgeon hatchery; switch to larval repatriation.
- What can we learn from our fish and game enforcement officers on public sturgeon interactions?
- What role are introduced species playing?

Upper Columbia (US and Canada)

- How will salmon reintroduction and salmon passage at Canadian dams influence White Sturgeon recovery?
- Need to ensure compatibility of policy objectives across US/Canada border (listed versus not-listed, conservation versus harvest).

Snake River

- Predation on non-native catfish may harm white sturgeon.
- Plan to introduce hatchery fish to lower Snake reservoirs.

- Lack of stock assessment age-0 and habitat information.
- No data in Lower Monumental, Little Goose, Ice Harbor.
- Upper reaches Hells Canyon, Bliss are in the best shape of any reach.
- Effects of mercury on white sturgeon reproduction? Bio-accumulation of contaminants.

Kootenai/Kootenay

- In dealing with autopolyploidy, proceed with caution! Research in 2013 suggests paternal effect, in 2014 suggests maternal effect, in 2017 suggests egg stirring effect. Nothing conclusive so far.
- Habitat and food web are important.

Lower Fraser

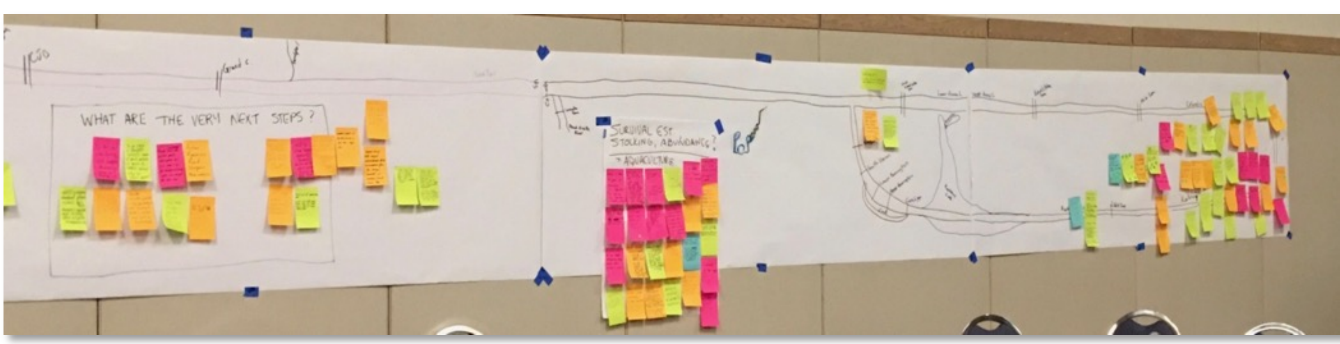
- Is there sufficient data to craft sturgeon-centric guidelines for dredging operations in the Lower Fraser River?
- Does dredging impact sturgeon in that region?

Nechako

- Need better understanding of exactly what flow related mechanisms affect recruitment.
- Cormorant mortality?

Sacramento and San Joaquin

- Fish in California get to 300 mm in 1 year?
- Need to improve abundance estimates for Sacramento-San Joaquin population.



What's Next?

The Very Next Thing…

Participants identified the following list of potential follow-up actions from the November 2017 Workshop. "*The very next things we should do is…*"

Coordination

- Is this our new White Sturgeon community? Should we formalize it as the Columbia River Sturgeon Conservation Society (CRSCS)?
- Develop and distribute a contact list that includes contact information, each individuals role and expertise (e.g., population assessment, aging, habitat work, etc.)
- Use the contact list to keep lines of communication open year-round, not just at workshops and meetings.
- There is no lead entity for White Sturgeon throughout their range, is that something we need to develop?

NWPCC Program Amendment Process

- The NWPCC program amendment process launches April 2017. Managers and regulators should begin thinking about mitigation recommendations.
- Compare the focus of NWPCC sturgeon amendments with recommendations from the "sturgeon community" for consistency/priority items.

Autopolyploidy

- Hold a Coulter Counter hands-on workshop ASAP.

Funding

- Should a "White Sturgeon community" foundation be formed to access grant funding and help guide science?
- Action Agencies commit to fund sturgeon meta-analysis.

Information and Data Sharing

- Develop and distribute a standardized basin-wide population-specific status update form to be filled in by population managers and researchers.
- Gather/distribute information on common methodologies for obtaining and analyzing data (e.g., stock assessments, survival estimates, etc.)
- Compile a table of survival estimates and vital rates. Publish these results so all can have.
- Compare and update White Sturgeon population status/trends with 2013 basin management plan.

Analysis and Research

- Expand recruitment failure experiments and share information basinwide.
- Plot the perceived bottlenecks for each reach/subpopulation. Then look at conditions of areas not exhibiting those specific bottlenecks. Then explore opportunities to replicate those non-bottleneck conditions.
- Do we need a sturgeon carcass team or point person in basin to collect carcass information for a central database?

> ***"Learning from each other is great. Appreciated the willingness of everyone to have deep, thought provoking conversation. Excited to have the synergy of all the people in the room thinking/caring about sturgeon."***
>
> ***- Workshop Participant***

Another Workshop

Workshop participants expressed enthusiasm for having another workshop in the next year or two. Attendees were asked to provide input on the following two prompts:

1. The number one thing that should be included in the next workshop.
2. The number one desired outcome from the next workshop.

Future Workshop Topics

Early Life History

- A focused forum on early life history investigations (e.g., larval behavior, larval survival, capture techniques).
- Studies of areas where recruitment is being detected (what are conditions that support recruitment).
- What habitat, flow, food web, actions can be taken to address bottlenecks in early life stage?

Hatcheries/Conservation Aquaculture

- What works, what doesn't
- Hatchery overviews (total number of fish by size released each year)
- Presentations and discussions on wild source repatriation.
- Transport of wild caught larvae for use in other areas (pros, cons, genetic impacts)

Analysis and Research

- Sampling design, data collection/storage and analysis, standardization
- Alternative stock assessment models.
- An attempt to structure data/results from multiple populations to address an important question/hypothesis

Habitat Restoration and Food Web

- Information on habitat or ecosystem restoration efforts (e.g., KTOI program).
- How and/or if to measure fish response to habitat restoration.
- Consideration of larval and juvenile habitat needs, off-channel and floodplain functions.
- Diet analysis and food web considerations.

Climate Change

- Forecast of effects of climate change/climate variability on White Sturgeon and their habitat.
- Impacts on program viability.

Progress Assessment

- Review basinwide progress against the early 1980s BPA workshop on sturgeon research needs.

Coordination and Information Sharing

- Keep meeting to learn from each other and share information
- How can we increase coordination and data and information exchanges (both formally and informally)?

Other Recommendations

Participants identified the following recommendations for future workshop structure and participation:

- Forums guided by key questions like the 2017 workshop are good. A goal could be a tangible outcome with associated funding (e.g., cross population evaluation of recruitment failure, or case study on bias in population estimates.
- Would like to see participation from ISRP, US Army Corps of Engineers (Seattle District and others), and Bureau of Reclamation (Grand Coulee).
- Would like to see more participation from decision-makers, policy, and management people.
- Include field trips and site visits.
- Liked the small group discussions, would like more of those.
- Everyone always wants more time: for questions after talks, for more networking, for socializing.

Desired Outcomes

Workshop participants highlighted the following items as outcomes they would like to see resulting from future workshops:

- An increase in, and support for, information and data sharing between entities.
- Identification of key uncertainties that need to be addressed for White Sturgeon throughout the basin (based on data/results from all).
- Support for prioritizing larvae or fertilized eggs over conventional brood crosses (where possible), even in harvest-oriented programs.
- Development of a consensus on design, collection, and analysis best practices (i.e., stock assessment, survival estimates, etc.)
- Consideration of how the Columbia River Power System can be operated toward normative conditions for multiple species of fish including White Sturgeon.
- Framework in place for meta-analysis of sturgeon populations.
- A commitment from BPA to fund basinwide sturgeon meta-analysis.
- Development of mechanisms to fund additional projects and research (outside of traditional funding avenues).
- Greater consideration of science in policy decisions.
- A compiled list of White Sturgeon research, monitoring and evaluation throughout the basin (reports, data, contacts).

Thank you!

Thanks to all of you for all you do! Without the efforts of each and every one of you we would know so much less and we would do so much less on behalf of White Sturgeon conservation.

Let's continue to work together for those amazing and iconic White Sturgeon.