

Proceedings of the Chum Salmon Stock Identification and Assessment Workshop

Prepared by the

**CHUM TECHNICAL
COMMITTEE**

for the

**PACIFIC SALMON
COMMISSION**

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Pacific Salmon Commission Chum Technical Committee

Proceedings of the Chum Salmon Stock Identification and Assessment Workshop

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Chairs: Bill Patton and Brittany Jenewein

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FOREWORD

The purpose of these Proceedings is to document the activities, key discussions, research recommendations, and uncertainties noted at the workshop. Consequently, interpretations or opinions presented individually in this report may not always be accurate or fully representative but are included to faithfully document discussions held during the workshop. No statements should be considered representative of the workshop's conclusions unless explicitly identified as such. Furthermore, conclusions presented herein may change upon additional review if relevant information, unavailable at the time of the workshop, becomes accessible later.

SUMMARY

This Proceedings Report summarizes key discussions and outcomes from the Fisheries and Oceans Canada (DFO) Chum Salmon Stock Identification and Assessment Workshop held on January 17, 2025, in Vancouver, British Columbia (BC), and online. Participants included representatives from Tribes, First Nations, academia, fisheries, and agencies, emphasizing collaborative, interdisciplinary dialogue.

Central discussions revolved around the Chum Genetic, Environmental, and Management Model (ChumGEM). Phase I, nearing completion, integrates catch data, genetic stock composition, and escapement data to estimate run sizes, timings, and exploitation rates for southern BC and Puget Sound Chum Salmon. Phase II will introduce age composition and environmental covariates into a user-friendly interface, and Phase III aims to develop a fisheries planning module for evaluation of management strategies.

Southern Endowment Fund (SEF) project updates highlighted advancements since 2013 in genetic stock identification (GSI), Chum Salmon migration studies, single nucleotide polymorphisms (SNPs) baseline enhancements, escapement methods, and juvenile Chum Salmon assessments. Continued genetic sampling, particularly on Vancouver Island's northern and west coast, remains crucial.

A Puget Sound case study demonstrated GSI's effectiveness in refining fisheries management through better forecasting, real-time stock monitoring, and improved run reconstruction accuracy. Scale-aging validation studies confirmed reliability but noted potential biases. Otolith thermal marking was validated as an effective method for age verification.

Hydroacoustic surveys at Apple Cove Point (ACP) showed promise for non-invasive Chum Salmon assessments but require further refinement. The ASSESSOR stock-recruit model highlighted significant environmental impacts, notably sea lion predation and scouring flows, recommending escapement goals aligned with these realities.

Juvenile Chum thermal tolerance (CT_{max}) studies revealed lower thermal resilience compared to Chinook Salmon, stressing the potential impacts of elevated river temperatures on survival and smolt productivity. Future research was recommended for understanding temperature effects on growth and smoltification.

Participants were encouraged to provide additional feedback through a post-workshop survey. The workshop concluded by acknowledging collective efforts toward improving science-based management of Chum Salmon.

WORKSHOP

WELCOME

*Presenters: Co-Chair Brittany Jenewein, Fisheries and Oceans Canada
Co-Chair Bill Patton, Northwest Indian Fisheries Commission*

Reference: “Chum Salmon Stock Identification and Assessment Workshop – Meeting Agenda”; and presentation titled “Chum Salmon Stock ID and Assessment Workshop”, dated January 17, 2025

In 2012, the Chum Technical Committee (ChumTC) finalized a Strategic Plan to address significant knowledge gaps affecting Chum Salmon management effectiveness, notably in stock composition identification and understanding stock contributions to fisheries. To address these gaps, the ChumTC organized workshops aimed at improving genetic baseline data collection and promoting collaboration among various groups, including Tribes, First Nations, commercial fishers, academia, and other agencies.

The initial workshops, held in Vancouver and Portland, facilitated detailed discussions on genetic sampling techniques, sampling objectives, best practices, and enhancing cross-border and cross-disciplinary communication. Emphasis was placed on improving Chum Salmon genetic baselines through the use of microsatellites and SNPs, laying foundational knowledge critical for future research and application in fisheries management.

The ChumTC, comprised of 12 members equally representing Canada and the United States, manages fisheries under the Pacific Salmon Treaty (PST), focusing primarily on areas from the Strait of Georgia to Johnstone Strait and southern Vancouver Island in Canada, and Puget Sound (Areas 7 and 7A) and other fisheries in Hood Canal and South Puget Sound in the United States (U.S.). The ChumTC’s responsibilities under the PST include maintaining and exchanging catch and escapement data, estimating stock composition, documenting exploitation rates, and guiding research priorities.

Central to ChumTC’s Strategic Plan is the ChumGEM. Phase I of ChumGEM focused on developing a run-reconstruction module incorporating catch stock composition and escapement data from southern BC and Puget Sound to estimate run sizes, timing, and escapement, enabling calculation of stock-specific exploitation rates. Phase II involves creating a user-friendly graphical interface and integrating age composition data to conduct brood-year analysis and assess environmental impacts on Chum Salmon productivity. Phase III aims to develop a fisheries planning module to simulate various management scenarios to support strategic evaluations and informed decision-making.

Throughout the process, the ChumTC actively solicits stakeholder input to refine data collection methods, address data gaps, and enhance model effectiveness, facilitating a collaborative approach to sustainable Chum Salmon management.

PROJECT UPDATES

Chum Technical Committee Southern Endowment Fund Projects

Presenters: Co-Chair Brittany Jenewein, Fisheries and Oceans Canada

Co-Chair Bill Patton, Northwest Indian Fisheries Commission

Reference: Presentations titled “ChumTC Southern Endowment Fund Projects – 2013-2024” and “ChumTC Research Priorities as of 2024”

Presentation Summary

Since the last workshop in 2013, the ChumTC has participated in 42 projects funded through the Southern Endowment Fund (SEF). Among these projects, 24 focused on GSI for mixed-stock Chum Salmon fisheries, involving both commercial fisheries and targeted research collections across Johnstone Strait, U.S. Areas San Juan 7/7A, and the Puget Sound region. Another significant project investigated Chum Salmon migration patterns and stock composition within the Strait of Juan de Fuca, examining their relation to fish movements through Johnstone Strait.

Eight SEF-funded projects enhanced the Chum GSI baseline, initially using microsatellites until 2015, followed by SNPs starting in 2018. Additionally, six projects directly supported development of the ChumGEM model, while five improved stock assessment and escapement survey methodologies. Two additional SEF projects focused on juvenile Chum Salmon distribution and stock composition in early marine environments and outreach activities, including workshops.

Each year, the ChumTC identifies research priorities to guide SEF funding decisions, maintaining consistent priorities with varying rankings from year to year. The development of the ChumGEM model remains the highest priority, with supporting projects focused on genetic baseline development and related methodologies.

The ChumTC encouraged workshop participants to provide feedback on research directions, unaddressed knowledge gaps, relevant external research, and potential contributions by their organizations. The following guiding questions were posed with feedback invited from participants by January 25, 2025:

- What do you think about the direction the ChumTC is taking in terms of Chum-related research?
- Are there any knowledge gaps that have not been addressed in today’s presentations?
- Is there other research going on that we should be aware of?
- How do you see your organization contributing to these research gaps or applying methods you have learned about today?

A comprehensive workshop report and presentation materials will be shared with participants by April 2025.

GSI OVERVIEW

Genetic Stock ID (GSI) Overview and Update on Bilateral Genetic Baseline Development

Presenters: Claire Rycroft, Fisheries and Oceans Canada

Rebecca Cheek, Washington Department of Fish and Wildlife

Reference: Presentation titled "Chum Technical Committee Genetics 101 – February Meeting 2024"

Presentation Summary

The presentation provided an overview of deoxyribonucleic acid (DNA) structure, genetic assessment techniques, sample processing methods, and baseline development practices relevant to Chum Salmon management. DNA, structured as a double helix with nucleotide bases (A, T, G, C), forms the basis of genetic identification through SNPs, a method widely used in genetic assessments.

Samples submitted for genetic analysis undergo rigorous processing by the Molecular Genetics Section (MGS), starting with biodata confirmation and subsample digestion to extract DNA. Extracted DNA is amplified using polymerase chain reactions (PCRs), tagged with unique barcodes, and sequenced for SNP loci. Quality-filtered genetic data are then statistically analyzed for assignment probabilities, enabling the estimation of stock composition in mixed fisheries.

Baseline collections are critical to effective GSI analyses, ideally requiring over 100 individual samples per collection site to accurately represent genetic variability. Regular updates to baseline collections are essential, given potential population shifts over time. High-quality biodata – detailing collection location, date, and methodology – is essential to maintaining confidence in genetic assignments.

Baseline resolution, tested via principal components analysis (PCA) and "leave-one-out" methods, evaluates the accuracy of genetic assignments to reporting groups. Although U.S. baselines show distinct groupings in certain areas (e.g., Puget Sound), challenges persist, notably in differentiating stocks originating from Strait of Juan de Fuca systems. The Canadian baseline, with 162 collection sites, also demonstrates distinct genetic clusters but requires additional sampling in specific regions (Howe Sound, Fraser Canyon, near Sooke, and north of Campbell River) to improve resolution.

The presentation emphasized proper sample preservation techniques and reviewed options including freezing, ethanol preservation, and Whatman paper drying, each with distinct benefits and logistical considerations. The goal remains to develop a robust, bilateral genetic baseline between Canada and the U.S., ensuring optimal management and conservation outcomes for Chum Salmon populations.

Discussion

- Participants discussed optimal life stages for baseline sample analysis. It was clarified that spawning adults captured on their spawning grounds are preferred, as their natal locations are easily identifiable.
- Regarding the analysis of sperm and eggs separately from area to area, it was explained that sperm and eggs individually carry only half of the genome (haploid); as such, analyzing sperm or eggs individually is typically insufficient. For complete genetic information, analysis requires offspring (diploid), enabling parental-based tagging. Identifying juveniles to a specific hatchery is possible if both parents' genetic backgrounds are known.
- Participants suggested including information about complete fish migration routes in future presentations.

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- A question was raised about whether mortality rates were included in the findings, and interest in examining the Chum Salmon's complete life cycle was noted.
 - Discussion occurred on whether coded wire tags (CWTs) or fin clipping negatively impact fish by altering their weight and consequently affecting their movement. It was noted that CWTs, being small, generally do not significantly affect fish movement after an initial adjustment period. In contrast, larger tags, like radio tags, are more likely to impact movement.
 - In response to a query about genetic comparisons between saltwater and freshwater salmon, it was clarified that the genome itself does not change between these environments. Instead, different genome sections become active to help the fish adapt to freshwater or saltwater conditions. Consequently, genetic data obtained from a fish caught in the ocean will be identical to data from the same fish caught in freshwater.
 - The West Coast of Vancouver Island was identified as an area requiring further genetic sampling, particularly Vancouver Island's northern end, which is difficult to access. There is good representation for Southwest Vancouver Island.
 - The usability of older samples stored at -4°C was discussed. Although older samples can still yield viable DNA, difficulties arise in analyzing samples that have gone through repeated freeze-thaw cycles and/or were subject to improper preservation methods (e.g., frozen in tap water, which can cause degradation). However, methods exist to evaluate the integrity of extracted DNA to determine sample viability.
 - A query regarding the availability of blood-type analyses was raised, and a commitment was noted to provide additional information on the feasibility of these types of analyses.
 - Participants asked about using commercially available RNA products for sample preservation. It was clarified that while RNA-based preservation methods (high-salt content) allow DNA extraction, these methods are typically more expensive.
 - Regarding methods for analyzing poorly resolved genetic groupings, it was noted that PCA is illustrative but not the sole method used. Additional techniques, such as structure analyses, are employed to ensure accurate assessments of genetic collections.

GSI AND MANAGEMENT

Case Study: Using GSI Data to Improve Management of Chum Fisheries

Presenter: Co-Chair Bill Patton, Northwest Indian Fisheries Commission

Reference: Presentation titled "Case Study: Using GSI data to improve management of Chum fisheries"

Presentation Summary

The presentation discussed the application of GSI to effectively manage mixed-stock Chum Salmon fisheries in Washington State's South Puget Sound. Key fisheries identified were San Juan Islands (Area 7/7A), Hood Canal (Area 12/12B/12C), and South Sound (Area 10/11), noting significant non-local fish contributions, particularly from Hood Canal hatchery programs.

Several test fisheries, notably at Apple Cove Point (ACP) since 1981 and newly established West and East Pass fisheries, have generated substantial GSI data used to refine fisheries management. GSI collections have been consistently gathered from ACP since 2005, providing robust time-series data primarily used in post-season assessments, enhancing run reconstructions, improving forecasts, and refining pre-season fisheries planning. Additionally, real-time GSI analyses have supported in-season management, specifically for managing stocks of concern such as the declining Nisqually winter Chum Salmon.

Traditional run reconstructions, reliant on freshwater escapement, spawning migration assumptions, and estimated catch compositions, have significantly improved through integrating actual GSI-derived stock composition data. To address data gaps, the run reconstruction employs infilling methods, using historical weekly means adjusted by fishery catch-per-unit-effort (CPUE) and relative commercial catch composition.

A GSI-informed management tool was developed, enabling fisheries managers to evaluate potential impacts of varying pre-terminal fishery scenarios on Chum Salmon stocks, assisting in finding a balance between pre-terminal and terminal fishery interests. This approach has allowed real-time in-season predictions of impacts on sensitive stocks, facilitating adaptive fishery management to adhere to agreed-upon exploitation limits.

Key lessons highlighted include the versatility and importance of GSI at multiple stages – forecasting, post-season stock assessments, and real-time monitoring – and the need for standardized methodologies to enhance the consistency and effectiveness of applying GSI data in fisheries management.

SCALES FOR AGEING CHUM

Validation of Age Estimates for Chum Derived from Scales

Presenter: Andrew Claiborne, Washington Department of Fish and Wildlife

Reference: Washington Department of Fish and Wildlife presentation titled “Validation of Chum Salmon Scale Ages”

Presentation Summary

The presentation addressed methods and findings from validation studies of Chum Salmon age estimates using scales, a process critical to fisheries management. Fish ageing involves visually examining growth patterns on structures such as otoliths or scales, which tend to vary seasonally. Typically, wider spacing indicates growth periods, while narrower spacing indicates slower growth associated with winter periods, forming visible “annuli.” An essential assumption in fish ageing is that one annulus equates to one year. However, the identification of annuli is inherently subjective, relying on the age reader's interpretation.

Fish age data significantly contribute to fishery management, primarily through run reconstruction and forecasting. Age structure from spawning ground samples informs estimates of recruits per spawner, often analyzed at watershed or population-specific scales. These estimates, combined with covariates such as sea surface temperature and run size, aid in forecasting future stock abundance.

Validation studies, as outlined by Kimura et al. (2006), assess the accuracy and precision of age estimates. The current study utilized otolith thermal marking – a barcode-like symbology applied via controlled temperature changes in hatcheries – as the reference age for validation. The study populations included

Hood Canal Summer Chum Salmon and Lower Columbia Fall Chum Salmon, both *Endangered Species Act*-listed populations with extensive paired scale and otolith data from carcass surveys.

Three main methods compared scale ages against known thermal mark ages:

- Percent Agreement (with accuracy above 90% considered good)
- Average Percent Error (APE) (precision less than 5% considered acceptable)
- Bias plots and symmetry tests (Evans-Hoenig Test).

For Hood Canal Summer-run Chum Salmon, scale ages were highly accurate (95.7%) with excellent precision (APE = 1.29%). Similarly, Lower Columbia Fall-run Chum Salmon showed an accuracy of 93.0% with an APE of 2.23%. However, bias analysis indicated a consistent trend of over-ageing younger individuals and under-ageing older individuals.

Scale interpretation presents challenges, particularly with rare age classes and variability in ocean growth patterns. Readers often default to familiar age classes, particularly when faced with ambiguous growth patterns, potentially influencing accuracy.

This study was funded by the PSC (project SF-2020-SP-31) with contributions from the Washington Department of Fish and Wildlife (WDFW) and Tribal staff in collecting scales, otoliths, and biological data essential for the validation process.

Discussion

- Participants asked if similar age validation studies were available for Fall Chum Salmon. It was noted that such work exists for Lower Columbia runs but not yet for Hood Canal Fall Chum Salmon. However, considerable otolith marking occurs in parts of Hood Canal, and it is anticipated these otoliths will be analyzed in future. Additionally, there is ongoing work on Nooksack Chum Salmon, including reading thermal marks, which will contribute valuable age data. Further integration of these findings is expected.
- It was questioned whether otolith reading involved traditional human examination via microscopes or if computer-assisted methods were being used. It was clarified that current practices remain largely traditional, relying on human interpretation of otoliths under microscopes. Although images are analyzed onscreen using specialized software, the final age determination is human-based. However, there are ongoing efforts, spearheaded by the Pacific States, aimed at automating otolith reading using models and image-based technologies, starting from Alaska and progressively moving south along the West Coast.
- Participants noted historical observations of older salmon age classes and questioned whether shifts in age structure might result from changes in analytical methods over time or be due to variations among staff members. While direct comparisons with known-age fish from the 1980s and 1990s are limited, re-analysis of available scale samples from those periods has shown no significant age discrepancies, suggesting minimal methodological impacts on age determination.
- The potential impact of climatic and environmental changes on the accuracy of otolith age determination was questioned. It was acknowledged that previous studies have demonstrated correlations between annual growth measurements on Chum Salmon scales and environmental variables, including climatic indices in the North Pacific and abundance of Pink Salmon. Specifically, Chum Salmon tend to exhibit reduced growth during years of high Pink Salmon abundance, though it remains uncertain exactly how these environmental factors directly influence age reading accuracy.

JDF TEST FISHERY

Juan de Fuca Test Fishery Meta-Analysis (2014-2023)

Presenter: Pieter Van Will, Fisheries and Oceans Canada

Reference: Presentation titled “Juan de Fuca Chum Sampling Program Meta-Analysis (2016-2023)”, PSC Chum Workshop – January 17, 2025

Presentation Summary

The Juan de Fuca Chum Sampling Program Meta-Analysis (2016-2023) was established to address critical gaps identified at the workshop in 2013 regarding the understanding of stock-specific Chum Salmon migration patterns and timing through the Juan de Fuca Strait, a key input for ChumGEM. Supported by the SEF, this initiative conducted approximately 1,075 fishing sets, encountering an estimated 29,000 Chum Salmon and sampling approximately 10,000 individuals. This effort resulted in an extensive dataset providing spatial and temporal details, stock-specific CPUEs, and biological information, including age, sex composition, and fish length.

The program significantly enhanced the understanding of migration timing, revealing a clear pattern of stock segregation by national origin, which was previously unknown. Canadian stocks typically appeared earlier in the sampling season, predominantly in late September, while U.S. stocks became more prevalent later in October. This pattern was consistently held across the study period, offering important insights for managing fisheries and understanding Chum Salmon movements through this migratory corridor.

Technological advancements and improvements in genetic baselines, transitioning from microsatellites to SNPs, allowed for better resolution of stock assignments and genetic units (GUs), facilitating more precise run reconstruction models. Additionally, analysis of CPUE data across spatial and temporal dimensions provided reliable indicators reflective of abundance variations.

The program also identified trends in biological data, notably, sex-specific declines in fish size over the years. Although size generally decreased within each sampling year, this was not universally consistent, highlighting the need for further examination by age and stock grouping to better inform brood-year run reconstructions.

Objectives of ongoing meta-analysis include evaluating the interannual variability of stock composition and timing, developing diversion rate estimates for key GUs, improving in-season assessment capabilities by combining data from other fisheries such as Johnstone Strait, and recommending directions for future research.

Dr. Trevor Davies is currently leading the analysis, focusing on data compilation and coding for comprehensive analysis. Upcoming efforts will assess interannual variability, analyze diversion rates, particularly for Fraser River stocks, and determine how CPUE data can enhance both in-season and post-season assessments, directly supporting ChumGEM model improvements.

Discussion

- A participant asked how the weekly GSI sample size goal for the test fishery was determined. It was clarified that the target was set at 200 samples per area per week for both Canadian and U.S. waters, resulting in a combined weekly total of 400 samples. It was acknowledged that achieving this goal posed challenges in some years. The sampling target was established based on consultations and expert recommendations provided by the Molecular Genetics Laboratory.

DISCUSSION

Questions and Answers from the Morning's Presentations

The guiding questions were reposted for participants' consideration:

- What do you think about the direction the ChumTC is taking in terms of Chum-related research?
- Are there any knowledge gaps that have not been addressed in today's presentations?
- Is there other research going on that we should be aware of?
- How do you see your organization contributing to these research gaps or applying methods you have learned about today?

Discussion

- A question was raised about contributing genetic baseline data. It was noted that external groups can share collected information directly with Claire Rycroft, Rebecca Cheek, and/or Andrew Claiborne.
- It was suggested that historical development along the Strait of Juan de Fuca over the past 13-20 years might be impacting fish numbers. Although the Strait primarily serves as a migration corridor rather than spawning habitat, development in nearby spawning regions (North and South Puget Sound near Seattle) likely influences stock abundances and conditions.
- Participants proposed examining the impacts of environmental and infrastructural changes to the Fraser River over the last two decades, both within and below the riverbed.
- It was recommended to further investigate hatchery contributions versus wild Chum Salmon stocks. The ChumTC has already prioritized understanding the interactions between hatchery fish, wild stocks, and mixed-stock fisheries. Several proposals addressing this issue, including one focused on the Fraser River, have been submitted for the SEF's consideration.
- A knowledge gap discussed was the integration of environmental and climate covariates into the ChumGEM model, particularly related to Chum Salmon survival. It was noted that ChumGEM Phase 1, nearly completed, will soon provide run size outputs that can be correlated with environmental variables. Collaborative work through PSC workshops (facilitated by Environmental Science Services Administration) is ongoing to better incorporate environmental data into assessment models. Contributions of existing research or suggested covariates from participants are encouraged, though integrating environmental data remains a secondary priority until the ChumGEM model is fully operational.
- Regarding the ChumGEM model's phases, Phase I is nearly complete, and initial work on Phase II (graphic user interface development and exploration of environmental covariates) has begun. Phase III (fishery planning module) remains largely untouched.

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- Interest in making ChumGEM modeling results accessible to non-modelers via interactive applications ("Shiny apps") was noted. Although ChumGEM has been rebuilt in Shiny for internal testing, broader public availability and data-sharing strategies remain under consideration. The ChumTC is also collaborating with PSC to enhance the online accessibility of the ChumTC Annual Report data and tables.

SURVEY LIFE

Fraser River Survey Life Results and How to Apply Work to Other Areas

Presenters: Matthew Townsend, Department of Fisheries and Oceans

Reference: Presentation titled "Chum Survey Life"

Presentation Summary

The Area Under-the-Curve (AUC) method is commonly used for estimating escapement in Interior Chum Salmon populations, largely due to its affordability and effectiveness in detecting changes greater than 25% in fish abundance year-to-year. This approach depends on regular visual surveys conducted throughout the spawning season to generate a comprehensive spawning escapement curve. A critical component of AUC estimates is Survey Life (SL), defined as the number of days that salmon remain alive and observable within the surveyed stream. Historically, a 10-day SL value from Perrin & Irvine (1990) was widely applied; however, recent studies indicate this duration may be overestimated, particularly in Fraser River tributaries, potentially leading to underestimations in Chum Salmon escapement.

Using actual survey data from Hunter Creek near Hope, BC, researchers demonstrated the sensitivity of escapement estimates to changes in SL. Applying the conventional 10-day SL yielded an estimate of 37 spawning fish. When the SL was reduced to seven days, the escapement estimate rose substantially to 53 fish, emphasizing the need for accurate SL values.

To refine these estimates, researchers tested three methods over a three-year period. The first method, Petersen Disc Tagging, involved applying coloured tags to individual fish entering the stream, followed by daily observations of live and dead tagged salmon. While this approach offered precise individual SL estimates, it required significant resources, including intensive labour, equipment, and personnel, resulting in relatively small sample sizes (approximately 40-50 fish per tagging event).

The second method, Peak Live Count versus Peak Dead Count, required minimal staffing, relying solely on daily surveys comparing the timing of peak live and carcass counts to estimate SL. However, this method proved challenging, offering low-resolution results due to difficulties in accurately identifying peak spawning events.

The third and preferred method involved comparing Cumulative Live Counts with Cumulative Dead Counts. By measuring the timing differences at various cumulative percentiles (e.g., 25th, 50th, and 70th percentiles), this approach produced multiple reliable SL estimates per stream each year. It required minimal resources and was resilient to unusual spawning patterns and environmental disturbances, although it did not yield fish-specific SL estimates.

Over three years at Kanaka Creek, the Petersen tagging method produced an average SL of 7.5 days, the peak live vs. dead method averaged 8.0 days but was less reliable, and the cumulative count method consistently provided robust results, averaging an SL of 6.5 days. Across multiple Fraser River tributaries,

SL varied among streams and across years. For example, Railroad Creek showed consistently shorter SL due to beaver activity delaying salmon migration, Squawkum Creek exhibited shorter SL likely due to higher water temperatures, and Chilqua Creek had significantly reduced SL in 2019 resulting from pollution-induced low dissolved oxygen levels.

Future work includes considering the adoption of a standardized seven-day SL for AUC estimates within Fraser River tributaries. Researchers also plan to investigate physical and biological stream characteristics that influence Chum SL, with the goal of applying these insights more broadly to other salmon-bearing systems. Appreciation was expressed to the PSC for funding this study, to the Sts'ailes First Nation for their partnership, and to DFO staff for their support.

Discussion

- In response to a question regarding whether SL estimates derived from Petersen Disc tagging differed significantly from those obtained through cumulative counts, it was noted that cumulative methods typically yielded slightly longer SL estimates compared to tagging. Participants interested in the precise values were invited to contact Matthew Townsend at Matthew.Townsend@dfo-mpo.gc.ca or refer to the detailed reports on the SEF website.
- With regard to whether recent survey work indicates significant annual variations in SL and if surveys must be conducted every year, it was clarified that SL does fluctuate year-to-year. Regular annual surveys are ideal for capturing accurate SL trends, but daily surveys necessary for precise SL calculations require substantial effort. While the AUC method is appealing because it generally uses weekly data, adapting cumulative methods to weekly counts could still provide improved resolution. Although such an approach has not yet been implemented, participants agreed it would be a valuable future project.
- Participants appreciated that the current distribution of SL estimates could be integrated into the AUC methodology, providing greater certainty to escapement assessments. It was also suggested that incorporating multiple observers to assess variation and observer error could further refine the accuracy of SL measurements.
- A participant questioned why recent SL estimates consistently appeared lower than the traditional 10-day estimate from Perrin & Irvine (1990). It was suggested that environmental changes over the past 30 years might contribute to the observed discrepancy. It was acknowledged that a few individual estimates reached up to 19 days, indicating the potential range is broader, and variability might exist depending on specific tributaries. Differences in environmental conditions or migration characteristics might also influence observed SLs.
- The potential influence of geographical location was highlighted. Streams on Vancouver Island, typically closer to the ocean, might exhibit different SL patterns compared to streams higher up the Fraser River system, where lower SLs could be expected due to longer migration routes.
- Regarding whether variations in age composition could influence SL estimates, it was recognized as a valid question; however, the current study did not specifically examine fish age. This was identified as a potential future research direction.

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- It was confirmed that proposals are in place to expand SL and AUC studies into additional Fraser River tributaries, including those nearer the estuary and further upstream, as well as into Howe Sound. These studies aim to investigate physical and biological stream characteristics, such as temperature gradients, canopy coverage, and substrate composition. Participants outside these specific study areas were encouraged to coordinate with Matthew Townsend if interested in conducting their own surveys.
 - It was noted that fish behavior, particularly pre-spawning holding patterns, could affect SL calculations. Fish observed holding in streams before actively spawning could artificially lengthen SL estimates. While current methods do not formally incorporate this behavioral factor, participants acknowledged its potential importance, emphasizing the need for considering the functional definition of SL as the time fish spend actively spawning and observable by surveyors, which varies considerably among tributaries.

HYDROACOUSTICS

Investigating the Relationship Between Hydroacoustic Transect Signals and Test Fishery Catches

Presenter: Kirsten Simonsen, Washington Department of Fish and Wildlife

Reference: WDFW presentation titled "Using hydroacoustics to develop new in-season abundance monitoring strategies for Puget Sound Chum fisheries"

Presentation Summary

Chum Salmon stocks, particularly in South Puget Sound, are managed collaboratively by WDFW and tribal co-managers and have faced significant declines over the past two decades. These declines are likely climate-driven, causing shifts in the spatial and temporal distribution of stocks returning to spawn. Due to uncertainty in assessing these stocks, alternative methods like hydroacoustics have been considered.

Hydroacoustics provides high-resolution spatial and temporal coverage of the traditional ACP test fishing area, offering a less invasive approach during low-abundance years compared to traditional net sampling. It is a globally standardized method widely employed in fisheries management.

The ACP survey area covers approximately 0.5 km south of the ACP channel marker, extending 2.5 km north and out to the southbound shipping lane. Surveys include 11 parallel transects spaced 250 meters apart, completed weekly alongside ACP test fisheries. A dual-frequency split-beam system by BioSonics Inc. (38 kHz and 120 kHz) is utilized, mounted on a pivoted boom below the surface to avoid bubbles and interference, and calibrated using standard methods.

Surveys typically run from weeks 40-49 annually (October to November). Transect data is analyzed using Echoview® software, breaking data into 10m depth by 25m spatial bins. Environmental conditions, such as temperature and salinity, are recorded for accurate calibration.

Analysis involves identifying individual fish targets acoustically, specifically potential Chum Salmon identified by target strength at 38 kHz frequency. Groundtruthing is conducted by comparing acoustic detections to weekly ACP fishery catch data, validating acoustic estimates.

Preliminary data indicates variability in Chum Salmon detections across depth and weeks. Discrepancies between acoustic detections and test fishery catches suggest possible shifts in spatial distributions or

depth preferences. Future analyses will use spatial techniques, like kriging, to generate heat maps highlighting Chum Salmon hotspots.

Challenges in acoustic data analysis include distinguishing single acoustic detections from individual Chum Salmon due to variables like target position in the beam, swimming angle, and target strength. Fish tracking algorithms in Echoview® address these challenges by aggregating single detections into individual fish tracks, though Chum-specific target strength data remains sparse. Recent *in-situ* tests have started establishing a more accurate relationship between Chum Salmon size and acoustic target strength, essential for precise analyses.

Initial findings confirm the utility of hydroacoustics for quickly surveying ACP's entire historic fishing area, improving understanding of Chum Salmon migratory behaviors under changing population conditions. Next steps include continuous data collection, refining detection algorithms, enhancing target strength estimations, and strengthening the linkage between acoustic data, fishery catches, and overall run sizes.

Acknowledgements were extended to Northwest Indian Fisheries Commission, tribal co-managers, WDFW staff, survey teams, and the ACP test fishery crew for their contributions.

Discussion

- There was support expressed for applying the hydroacoustic survey method in other geographic areas. Given its effectiveness in providing high-resolution spatial and temporal coverage, the method could significantly enhance salmon abundance assessments elsewhere.
- Regarding acoustic blind spots, specifically related to Chum Salmon moving vertically in the water column, clarification was provided that while no true blind spot exists, the survey typically excludes the uppermost three meters to avoid interference from entrained bubbles, particularly in rough weather conditions. Generally, data collection occurs effectively from approximately four meters down to 50 meters depth, though adjustments can be made depending on environmental conditions and boat traffic.
- It was noted that similar acoustic studies have been conducted for other salmon species and in freshwater environments more frequently than in marine areas. For example, the Fraser River has a significant stationary ARIS acoustic camera multi-beam system near Mission, and similar systems have been employed in Skagit River and Lake Washington. Although hydroacoustic approaches have been successfully employed for species like pollock, large-scale salmon assessments in marine waters remain less common, highlighting the unique value of the ACP hydroacoustic study, particularly due to its alignment with existing ACP test fishery data.
- There was ChumTC interest in the ability of hydroacoustics to observe fish "milling around." It was clarified that while mobile acoustic surveys like the ACP method are limited in tracking directional movement, stationary acoustic surveys provide better capabilities to monitor milling behavior due to their continuous coverage of a single area. This could potentially support analyses of directional movement and biomass accumulation, although such stationary surveys would require specific planning and design to complement broader abundance assessments.
- Despite 2024 being generally recognized as a good year for Chum Salmon returns – based on test fisheries, commercial harvest, and spawning ground surveys – the acoustic spatial analysis presented seemed to show fewer fish detections than expected. This led to discussion about the possible reasons for lower acoustic detections, including potentially early migration that occurred before the survey began. The survey recorded the highest detections early in the season (week 41), followed by a steady

decline, indicating that the peak migration may have occurred earlier. Alternative explanations considered included spatial shifts in migration routes further offshore or deeper in the water column or impacts from active fisheries occurring concurrently. Further analysis, incorporating comprehensive run reconstruction data and fisheries catch data, will be essential to fully understand this discrepancy.

ASSESSOR MODEL

Novel Stock – Recruit Method for Estimating Escapement Targets

Presenter: Jillian Howard, Muckleshoot Indian Tribe

Reference: Presentation titled “The ASSESSOR Stock-Recruit Model for Escapement Goal Estimation”

Presentation Summary

Stock-recruit models explore the relationship between spawning stock size and the number of returning recruits, reflecting a stock’s productivity and the carrying capacity of the environment. Recruitment tends to be highly variable and influenced by both spawning stock size and environmental factors. Identifying the most influential environmental factors among numerous potential variables is challenging.

Two common models used in stock-recruit analysis include:

- Beverton-Holt model, which defines the maximum potential recruits (asymptote 'a') and the number of spawners needed for half-maximum recruitment ('b').
- Ricker model, which highlights recruits per spawner at low population levels ('a') and the rate of decrease in recruits as spawners increase ('b'). The intersection represents the carrying capacity, with maximum sustainable yield (MSY) slightly to the left of this peak.

To set escapement goals, managers consider estimates of spawners at MSY as a minimum, and carrying capacity as a maximum, creating a bracketed target range.

The ASSESSOR model, developed by Scheuerell et al. (2021), is a Bayesian age-structured state-space model that includes Beverton-Holt, Ricker, and density-independent models. It uses a leave-one-out cross-validation method for model selection. The model was applied to Nisqually River winter Chum Salmon, historically spawning primarily in Muck Creek. The run period has shifted earlier, with significantly low recent returns. GSI-run reconstruction was used to estimate escapement and catch values.

For Nisqually Chum Salmon, the Ricker model was selected, incorporating environmental covariates individually. Sea lion presence and scouring flows emerged as significant predictors. Multivariate modeling confirmed these covariates' importance, indicating that sea lions negatively impact Chum Salmon populations more severely than scouring flows.

Model results revealed distinct stock-recruit dynamics after sea lion arrival. Escapement targets were suggested based on these findings: setting an escapement goal near the upper limit of MSY (approximately 27,000-29,000 fish) and defining a critical low-run-size trigger around the median MSY (approximately 13,000 fish). These targets acknowledge the environmental variability and increased uncertainty faced by this Chum Salmon population.

Discussion

- A participant questioned how "scouring flows" were defined. It was noted that Craig Smith from Nisqually set the threshold at flows of 8,000 cubic feet per second (CFS), based on levels likely to impact spawning conditions.
- There was discussion about the influence of sea lions on stock-recruit curves and their subsequent impact on escapement goals. Sea lions primarily consume returning adults rather than juveniles, complicating interpretations of carrying capacity. A concern arose about potentially setting escapement goals lower based on MSY estimates influenced by sea lion predation, which might inadvertently undervalue the system's true spawning habitat capacity. While data provides important insights, it was suggested that decisions on escapement goals involve policy considerations and should reflect broader conservation objectives.
- Participants noted that sea lions introduced a "new normal" since their arrival in 2002, significantly affecting adult Chum Salmon populations. It was suggested that if the model omitted sea lion and scouring flow covariates, MSY and capacity estimates would likely be higher. However, the current model aims to realistically characterize spawning ground conditions, given the contemporary presence of these factors, rather than depicting an idealized scenario unlikely to recur.
- Concern was raised about the broader ecological context, recognizing numerous natural oceanic factors affecting Chum Salmon populations beyond measured covariates. The discussion acknowledged potential correlation without direct causation, noting that other ecosystem changes in Puget Sound – such as shifts in forage fish populations – might simultaneously affect Chum Salmon abundance alongside sea lion predation.
- Participants emphasized the importance of identifying thresholds for initiating recovery or special management actions, particularly given the declining escapement goals suggested by the model. Establishing clear criteria for conservation concern was recognized as an essential next step for decision-makers.
- A participant raised the possibility of correlation without causation, questioning if other factors in Puget Sound, such as increased populations of herring or anchovy, could be influencing Chum Salmon abundance through competition rather than direct predation by sea lions. Although this alternative mechanism has not been specifically documented, it remains a plausible hypothesis. However, the arrival of sea lions in the early 2000s coincided clearly and immediately with significant declines in Chum Salmon stocks.
- Another point discussed was the timing of the late-returning Chum Salmon runs, making these salmon the final substantial food source available to sea lions in Puget Sound before winter. This seasonal timing likely contributes to concentrated predation by sea lions, particularly around the Nisqually estuary, potentially exacerbating impacts on the chum population.
- The ecological behavior of California sea lions was highlighted, noting their intense predation behavior at the mouth and well into the Nisqually river system, significantly impacting Chum Salmon. This observation further underscores the complexity of setting realistic, actionable escapement goals amidst shifting ecological conditions.

ENVIRONMENTAL DATA

Determining Lethal Temperatures (CTmax) for Juvenile Chum Salmon

Presenter: Leah Mellinger, Port Gamble S’Klallam Tribe

Reference: Presentation “Juvenile Chum Thermal Tolerance – Critical Thermal Maximum and Management Implications”

Presentation Summary

The Juvenile Chum Salmon Critical Thermal Maximum (CTmax) pilot study is part of the Chum Comprehensive Management Plan, aimed at establishing thermal tolerance thresholds for juvenile Chum Salmon populations across Puget Sound. Understanding upper thermal limits is vital because elevated river temperatures can significantly impact pre-spawn mortality and smolt productivity, factors that are currently underrepresented in fishery forecasting models.

Elevated temperatures impose substantial physiological stress on fish, doubling their metabolic rate with every 10°C increase. This leads to elevated heart rate, respiration, enzyme rates, protein damage, disruption in osmoregulation, and potentially severe cell damage through apoptosis or necrosis. Smoltification, the critical physiological transition from freshwater parr to saltwater smolt, further exacerbates these stresses, demanding significant gill remodeling and changes in osmoregulatory function.

In this study, hatchery juvenile Chum Salmon were randomly selected, placed individually in controlled water baths, and subjected to temperature increases at a rate of 1°C per five minutes. Researchers noted two critical thresholds: the Point of Fatigue, characterized by signs of distress like gulping, erratic swimming, and slight loss of equilibrium, and the Point of Ecological Mortality, marked by complete loss of equilibrium (though fish were recovered immediately post-experiment, no mortalities occurred).

Preliminary results for hatchery fall Chum Salmon from Little Boston showed fatigue at approximately 24.67°C (76.43°F) and ecological mortality at about 25.83°C (78.54°F). These temperatures were notably lower compared to Chinook Salmon juveniles, whose CTmax ranges from 27-29°C. Such differences underscore the sensitivity of Chum Salmon, possibly due to shorter parr stages and limited fat reserves.

Future research steps include repeating this pilot with larger sample sizes from the Port Gamble S’Klallam Tribe hatchery, partnering with Long Live the Kings Lilliwaup Hatchery to examine wild summer and fall Chum Salmon juveniles, and collaborating with other Puget Sound Chum Salmon managers to expand the study's geographic scope. Ultimately, the aim is to integrate these juvenile thermal tolerance thresholds into the ChumGEM model, enhancing forecast precision and informing management practices.

Discussion

- There was a discussion around typical Chum Salmon outmigration timing, highlighting variation based on run type. Generally, fall run outmigrations occur around March to April, whereas summer run outmigrations are typically earlier, from late January into February. With regard to whether recorded temperatures approach critical thermal thresholds during these outmigration periods, it was noted that although typical temperatures are not usually extreme, consecutive El Niño seasons combined with low water conditions can result in warmer water temperatures. This highlights the importance of monitoring temperature closely to ensure comprehensive coverage of potential thermal stress conditions.

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- Participants discussed potential impacts of persistent elevated temperatures on juvenile Chum Salmon. Specifically, there was interest in understanding how prolonged exposure (days or weeks) to elevated temperatures around 18°C might influence mortality or fatigue. It was noted that a temperature increase of approximately 10°C could double fish metabolism, significantly elevating respiration, heart rate, and enzyme activity. Such metabolic increases could be manageable only if ample food resources and no additional stressors are present; however, in natural river systems, increased metabolism typically results in decreased growth due to limited food availability. Smaller body size reduces the capacity of juvenile Chum Salmon to successfully manage the substantial physiological changes involved in smoltification, negatively impacting their survival.
 - It was recognized that any exposure to temperatures outside normal evolutionary ranges triggers stress responses in fish. While juvenile Chum Salmon can temporarily tolerate increased cortisol levels associated with thermal stress, sustained exposure eventually leads to physiological breakdown and mortality. Even sub-lethal thermal stressors, such as short-term exposure to temperatures of around 14°C, can significantly compromise juvenile fitness by diverting energy toward thermal regulation rather than growth, ultimately affecting survival. It was suggested that future studies incorporating multiple stressors could further clarify how sustained versus transient thermal events at varying temperatures (e.g., 14°C and 18°C) affect metabolism, growth, smoltification capability, and overall fitness of juvenile Chum Salmon. Such studies were identified as important considerations for future research funding.

CHUMGEM

Chum Genetic and Environmental Management Model – Bringing It All Together

Presenter: Brittany Jenewein, Department of Fisheries and Oceans

Reference: Presentation “Chum Genetic, Environmental, and Management Model (ChumGEM)”, dated January 17, 2025

Presentation Summary

The ChumGEM project is central to the strategic planning efforts of the ChumTC. Currently, the project is focused on developing a comprehensive run-reconstruction model that integrates catch data, genetic stock composition, escapement information, and environmental variables. This model generates critical management metrics including total catch, run size, run timing, escapement, and exploitation rates by stock aggregate. Future development includes incorporating age data for cohort abundance estimation and productivity analysis and developing a dedicated fishery planning module to evaluate various management strategies and facilitate proactive fishery management decisions.

ChumGEM serves as both a database and a robust analytical tool, consolidating genetic samples, catch records, and escapement data specifically for southern BC and Puget Sound, Washington. The model operates on a detailed spatial-temporal framework, spanning all oceanic and terminal fisheries from Calvert Island in northern BC down through southern Puget Sound. Its temporal scale encompasses a 250-day fishing season (July 1 to March 7), modeled on a daily timestep, ensuring high-resolution insights into Chum Salmon movements and management scenarios.

The model currently incorporates 10 stock aggregates, including Canadian aggregates (Fraser River, Johnston Strait, Strait of Georgia West, West Coast Vancouver Island, and Strait of Georgia East) and U.S.

aggregates (Strait of Juan de Fuca, Hood Canal, Puget Sound South, Central, and North). Migration pathways are visualized through "hotels," rough representations of fishery management areas and assumed routes of Chum Salmon around Vancouver Island and through Puget Sound, informed by historical data and expert judgment. The proportion of Chum Salmon populations that migrate along each pathway around Vancouver Island and on either side of the Strait of Juan de Fuca remains partially uncertain, and assumptions are applied where empirical data is sparse.

ChumGEM's analytical approach involves three primary parameters: stock-specific run size upon entering Pacific Fisheries Management Area (PFMA) 10, mean arrival date at PFMA 10, and variability around this arrival timing. To constrain and stabilize estimates, migration pathways and population proportions for each route are predefined, guided by prior research such as tagging studies from Johnstone Strait. The model inputs include comprehensive catch data by area and time, GSI samples, test fishery CPUE, and escapement data rolled up to the stock aggregates.

Dynamic equations within ChumGEM follow a Bayesian framework, incorporating assumptions such as uniform harvest rates within specific management areas and a normal distribution for migration rates (mean of 37.7 km/day, standard deviation of 6 km/day). The model iteratively simulates fish movements through the network of management areas, removing fish from populations based on observed catches and escapement records.

ChumGEM relies on a sophisticated likelihood minimization approach, which integrates multiple data sources into an overall likelihood value. Key likelihood components include comparisons between model-predicted and observed area-specific catches, escapements, daily test fishery CPUE, and GSI stock composition proportions. Each likelihood component can be weighted differently, enabling greater flexibility in emphasizing the most reliable data.

Through iterative adjustments to parameters, the model identifies parameter combinations that minimize discrepancies between observed and predicted values, thereby ensuring realistic and data-driven estimates. The final outputs provide comprehensive estimates of run sizes, arrival timings, exploitation rates, and escapements, critical for assessing the health and productivity of Chum Salmon stocks.

ChumGEM's development has been significantly advanced through SEF funding and technical input from LGL Ltd. Key outcomes include the current user-friendly graphical interface built using the R-based Shiny application, which enables broad accessibility to model outputs and eases interpretation for non-specialists.

Currently, ChumGEM Phase I, focused on database construction and the run-reconstruction model, is nearing completion. Immediate next steps involve fine-tuning the model for enhanced reliability and producing full reconstruction outputs from 2008 through 2024. Subsequent phases will incorporate environmental covariates, juvenile data, age-structured analysis, and eventually, a comprehensive fishery planning module designed to support strategic management evaluations and improve forecasting capabilities in response to environmental variability.

Discussion

- A participant questioned whether death and migration were incorporated in the ChumGEM model and if assumptions existed around natural mortality. Currently, ChumGEM does not include explicit instances of natural mortality. However, there is potential for integrating mortality estimates, especially as the exploration of environmental covariates progresses and provides better insights into factors influencing natural mortality.

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- Participants asked about available documentation detailing the ChumGEM model equations. Although some documentation from earlier model versions exists through SEF links, comprehensive and finalized documentation for the current version is still in development and not yet available.
 - Regarding the temporal scope of the run reconstruction data (2008-2024), question arose as to whether there were plans to revisit data prior to 2008. Presently, there is limited genetic data prior to 2008, mainly due to fewer fishery samples and less robust analytical tools available at the time. The year 2008 marks significant improvements in fishery sampling and analysis methodologies initiated by ChumTC, resulting in higher confidence in data from that point forward. Some historical data from Johnstone Strait and U.S. fisheries has been incorporated into the model where applicable. Although incorporating earlier data is technically feasible, it would represent a weaker and less reliable component of the model.
 - A participant questioned the possibility of integrating the impacts of earthquakes as environmental covariates in the context of climate challenges. This specific factor has not yet been explored, but there was openness to investigating potential variables associated with seismic activities and their possible impacts on Chum Salmon populations.

CONCLUSION

Participants were thanked for attending the workshop. A survey link was available for one week following the workshop, providing participants the opportunity to share feedback on the guiding questions or offer general comments. The workshop concluded at 3:54 p.m.

THREATS

Several threats impacting Chum Salmon stocks were highlighted during the Chum Salmon Stock Identification and Assessment Workshop. Significant knowledge and data gaps remain, particularly regarding genetic baseline information on Vancouver Island's remote west coast and northern areas, which restrict accurate GSI and long-term analysis capabilities. Additionally, insufficient data on juvenile Chum Salmon distribution and marine survival rates limit effective forecasting and management decisions.

Environmental pressures, including rising river and ocean temperatures linked to climate variability, impose substantial physiological stress and potential mortality risks to juvenile Chum Salmon. Increased occurrence of extreme river flow events, such as scouring floods, further disrupt spawning success and threaten overall survival rates. Ecosystem interactions also pose notable risks, particularly predation by sea lions in areas like South Puget Sound and the Nisqually River estuary, significantly reducing adult escapement and altering the stock-recruit dynamics. Moreover, competition from other salmon species and forage fish populations potentially impacts chum salmon growth and survival rates.

Methodological limitations continue to challenge fisheries management efforts. Hydroacoustic surveys, though promising, face difficulties accurately correlating acoustic data to fishery catches, resulting in uncertainties regarding abundance assessments. While scale-based age determination methods generally yield accurate results, biases persist, complicating productivity analyses. Additionally, logistical challenges related to accessing remote regions impede essential genetic baseline sampling.

Additionally, infrastructure development and environmental changes near key migratory corridors such as the Strait of Juan de Fuca and Fraser River, may disrupt Chum Salmon migration patterns and degrade habitat quality. Historical and ongoing regional development activities are likely influencing current stock abundance and overall habitat conditions. Addressing these combined threats requires ongoing interdisciplinary research, improved data integration, and strategic cooperation to ensure the sustainable and effective management of Chum Salmon populations.

CONCLUSIONS

The Chum Salmon Stock Identification and Assessment Workshop successfully advanced discussions aimed at improving Chum Salmon management across southern BC and Puget Sound. Participants recognized progress through the ongoing development and refinement of the ChumGEM model, particularly emphasizing achievements in GSI, run reconstruction modeling, and juvenile salmon research. ChumGEM Phase I is nearing completion, providing enhanced capabilities for accurately estimating run sizes, escapements, run timings, and exploitation rates.

Several knowledge gaps and threats persist, including environmental stressors, predation pressures, limited genetic sampling coverage in remote regions, and methodological challenges in fisheries assessment. Participants affirmed the importance of continued interdisciplinary collaboration and the necessity of regularly updating genetic baselines, integrating environmental variables into management models, and broadening sampling efforts to strengthen decision-making tools.

Discussions also highlighted innovative methods, such as hydroacoustic surveys, scale-age validation techniques, and thermal tolerance studies as valuable complements to traditional management approaches. It was recommended to prioritize research that addresses climate-induced environmental impacts, predator interactions, and anthropogenic effects on critical migratory corridors.

Participants emphasized maintaining the collaborative framework established through ChumTC's initiatives, acknowledging that effective Chum Salmon conservation and fisheries management will require ongoing engagement with Tribes, First Nations, and stakeholders, robust scientific analysis, and adaptive strategies informed by comprehensive, integrated data systems.

RESEARCH RECOMMENDATIONS

Participants identified several research priorities to enhance the effectiveness of Chum Salmon stock assessment and management. Continued refinement and expansion of ChumGEM emerged as a priority, particularly the integration of environmental covariates and improved age composition data. Specific recommendations included:

- **Genetic Baseline Enhancement:** Expand genetic sampling coverage, especially on the west and northern coasts of Vancouver Island, remote regions of BC, and underrepresented stock aggregates in Puget Sound. Regular updates and expansions of genetic baselines using SNP markers are crucial to accurately estimate stock composition in mixed-stock fisheries.
- **Hydroacoustic Method Refinement:** Further develop and standardize hydroacoustic survey techniques, particularly at ACP and other strategic locations. Priority actions include enhancing methods to reliably link acoustic data with fisheries catches, refining target strength estimations

specifically for Chum Salmon, and expanding spatial-temporal coverage to detect shifts in migration routes.

- **Age Validation Studies:** Expand age-validation research to additional Chum Salmon populations, incorporating otolith thermal marking and other validation techniques. Future research should focus on automating scale and otolith analysis to reduce subjective bias, enhance precision, and improve historical comparability.
- **Environmental Impact Integration:** Prioritize incorporating environmental and ecological variables into ChumGEM and stock-recruit models, emphasizing climate-driven changes, predator-prey interactions (particularly sea lion predation), and riverine environmental stressors such as temperature fluctuations and scouring flows.
- **Thermal Tolerance Thresholds:** Conduct broader, geographically diverse studies on juvenile Chum Salmon thermal tolerances to better understand the physiological impacts of elevated river temperatures on smolt productivity and survival. Emphasis should be placed on prolonged exposure studies and interactions with additional environmental stressors.
- **Escapement Survey Life Validation:** Continue refining SL estimates used in AUC methodologies by applying cumulative count methods across more tributaries. Further research should investigate how stream-specific physical and biological characteristics influence Chum Salmon survey life durations and the accuracy of escapement estimates.
- **Stock-Specific Migration and Timing Studies:** Further develop analyses of migration timing, stock segregation, and migration pathways through test fisheries and meta-analyses, particularly in migration corridors like the Strait of Juan de Fuca. Enhanced understanding of interannual variability and stock-specific run timing is essential for improved run reconstruction accuracy.
- **Interactive Model Applications:** Explore broader public and stakeholder accessibility of ChumGEM model outputs through interactive online platforms ("Shiny" applications), enabling non-specialists to utilize management scenario simulations effectively.

Participants strongly supported continued interdisciplinary collaboration and recommended these research initiatives be pursued through coordinated efforts among Tribes, First Nations, academia, commercial fisheries, and government agencies, fostering robust scientific data essential for sustainable management of Chum Salmon populations.

APPENDIX 1: AGENDA

CHUM SALMON STOCK IDENTIFICATION AND ASSESSMENT WORKSHOP



Georgia B, 2nd floor

Virtual link: [Join Here](#)

MEETING AGENDA

PURPOSE: What have we learned since the 2013 workshop, and where do we go from here?

8:30 AM	SIGN-IN	Please sign-in so we know who joined us today!
9:00 AM	WELCOME	ChumTC Co-chairs - Brittany Jenewein, DFO & Bill Patton, NWIFC
9:15 AM	PROJECT UPDATES	ChumTC Southern Endowment Fund projects Brittany Jenewein, DFO & Bill Patton, NWIFC
9:30 AM	GSI OVERVIEW	Genetic Stock ID (GSI) overview and update on bilateral genetic baseline development. Todd Seamons, WDFW, Claire Rycroft, DFO, & Rebecca Cheek, WDFW
10:15 AM	BREAK	
10:30 AM	GSI AND MANAGEMENT	Case Study: Using GSI data improve management of Chum fisheries. Bill Patton, NWIFC
10:50 AM	SCALES FOR AGEING CHUM	Validation of age estimates for Chum derived from scales. Andrew Claiborne, WDFW
11:10 AM	JDF TEST FISHERY	Juan de Fuca Test Fishery meta-analysis (2014-2023). Pieter Van Will, DFO
11:30 AM	DISCUSSION	Q&A from the morning's presentations. See guiding questions p.2.
12:00 PM	LUNCH	
1:00 PM	SURVEY LIFE	Fraser River survey life results and how to apply work to other areas. Joe Tadey & Matt Townsend, DFO
1:30 PM	HYDRO-ACOUSTICS	Investigating the relationship between hydroacoustic transect signals and test fishery catches. Kirsten Simonsen, WDFW
2:00 PM	ASSESSOR MODEL	Novel Stock-Recruit method for estimating escapement targets. Jillian Howard, Muckleshoot Indian Tribe
2:30 PM	BREAK	
2:45 PM	ENVIRONMENTAL DATA	Determining lethal temperatures (CT _{max}) for juvenile Chum Salmon. Leah Mellinger, Port Gamble S'Klallam Tribe
3:15 PM	CHUMGEM	Chum Genetic and Environmental Management Model - Bringing it all together Brittany Jenewein, DFO
3:45 PM	DISCUSSION	Q&A from the day's presentations. See guiding questions p.2.
4:30 PM	ADJOURN	Thank you for joining us and contributing to these programs!

APPENDIX 2: PRESENTER LIST

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