

University of Washington

School of Aquatic & Fishery Sciences

Columbia Basin Research

Salmon Insider

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Columbia Basin Research Newsletter

University of Washington
School of Aquatic & Fishery
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Columbia Basin Research (CBR) is a scientific research group at the University of Washington, School of Aquatic & Fishery Sciences. We investigate salmon biology and survival in the Columbia and Snake river basins. We provide user-friendly data analysis and modeling tools, and maintain DART, an interactive secondary database, for the fisheries community and the public.

Inside . . .

This issue of the newsletter is intended as an introduction to the website, database, and programs of Columbia Basin Research.

Please visit the Columbia Basin Research website for further information about our products and services. Email your questions, comments or requests to web@cbr.washington.edu.

Thank you for your interest.

About the Columbia River Basin

The Columbia River Basin is renowned for its salmon and steelhead fish populations. These salmonid stocks are a living symbol of the Pacific Northwest. The anadromous fish hatch in the basin, migrate to the ocean as juveniles and subyearlings, and return to the basin as adults one to four years later. A number of these fish species are listed as threatened or endangered under the Endangered Species Act (ESA).

Industrial, agricultural, and urban development in the region have contributed to a near century-long decline in these fish. The area's hydro projects have contributed to these declines by impeding juvenile and adult migration, by direct mortality to juveniles passing through turbines on their way to the ocean, and by changes in the river environment due to impounded river waters and altered flow regimes.

In 1980, the U.S. Congress passed the Pacific Northwest Electric Power Planning and Conservation Act, which charges federal agencies to ensure both hydro production and the restoration and protection of fish populations. Fourteen federal hydro projects in the Columbia River Basin are coordinated under the act. The Bonneville Power Administration, which markets and distributes the power from these projects, and the U.S. Department of the Interior's Bureau of Reclamation and the U.S. Army Corps of Engineers, which own and operate the dams, are responsible for implementing mitigation activities to help restore the salmonid populations.

Since the Power Planning Act of 1984, more fish have been tagged and released in the Columbia Basin than anywhere else in the world. Currently, on an annual basis, more than 20 million coded wire tags, 2 million passive integrated transponder (PIT) tags, and 30,000 to 40,000 radio and acoustic tags are used to mark juvenile salmonids for research. Results from this cumulative research are used to evaluate mitigation efforts at hydro projects, manage fishery harvests, and monitor stock recoveries.

Columbia Basin Research is a research group at the University of Washington, School of Aquatic & Fishery Sciences, that investigates salmon biology and survival in the Columbia River Basin. We manage *Columbia River DART (Data Access in Real Time)*, a second-tier database with current

and historical information on salmon populations and river environment in the Columbia River Basin. We provide *Status and Trends* information to analyze, online, the status of salmon populations with respect to specific performance measures, e.g., survival and travel time estimates and smolt-to-adult return ratios. We provide *Inseason Forecasts* on the run timing of juvenile and adult salmon migration in real time throughout migration seasons. We develop and provide online *Tools and Models* for fish growth and vitality, harvest, and parameter estimation, i.e., programs to help with the design and analysis of fisheries tagging data.

Adapted from: Skalski, J.R. 2008. Using PIT tags to study effects of hydro projects on fish. *Hydro Review* 27(5): 48-55.

Study Design & Analysis Tools

Program SampleSize – Calculates optimal sample sizes to obtain a desired study precision for fish and wildlife studies using release-recapture methods. This program can be used to construct multiple “what if” scenarios and observe the subsequent precision levels.

Program SampleSize offers scenarios for single release-recapture studies, paired release-recapture studies, and radiotelemetry studies based on paired release-recapture models.

Two models are designed specifically for salmonid studies on the Columbia River. The Transport in River Ratio model is specifically designed to assess the effects on survival of transporting juvenile salmon on the Columbia River. The Virtual with Paired Release (VWPR) is the newest model and a special application to determine the sample sizes necessary to estimate survival through the dams of the Columbia River to meet precision requirements of the Biological Opinion (BiOp). The program and user’s manual are available online at our website.

www.cbr.washington.edu/paramest/samplesize/

Program PitPro – Translates raw PTAGIS PIT-tag data into usable capture histories for programs SURPH and ROSTER. PitPro also provides a variety of reports, including an error

report, Cormack-Jolly-Seber estimates, a travel-time table, and program diagnostics for further analysis. The logic of the program is updated continuously, based on the latest PTAGIS site configuration, ensuring accuracy.

www.cbr.washington.edu/paramest/pitpro/

Program ROSTER (River-Ocean Survival and Transportation Effects Routine) – Analyzes the migratory life cycle of Pacific salmon, from seaward migration as a juvenile to return to the river as a spawning adult. Program ROSTER analyzes juvenile and adult salmonid PIT-tag detection data, and accounts for juvenile transportation, adult age structure, and known removals at detection sites. It provides maximum likelihood estimates and standard errors of juvenile survival, ocean survival, adult inriver survival, smolt-to-adult ratios (SARs) (**Figure 1**), transportation effects, and the adult age distribution. Several types of transportation effect measures are estimated, including dam-specific and system-wide measures, measures for untagged fish, and differential mortality (“D”).

Through the Status & Trends Overview web-base tool, results from the application of Program ROSTER to Snake River Basin PIT-tag data can be accessed by measures, e.g., ocean survival, smolt-to-adult-return ratio, transport-inriver ratio, and

delayed mortality. The program and a user's manual are available at our website.

www.cbr.washington.edu/paramest/roster/

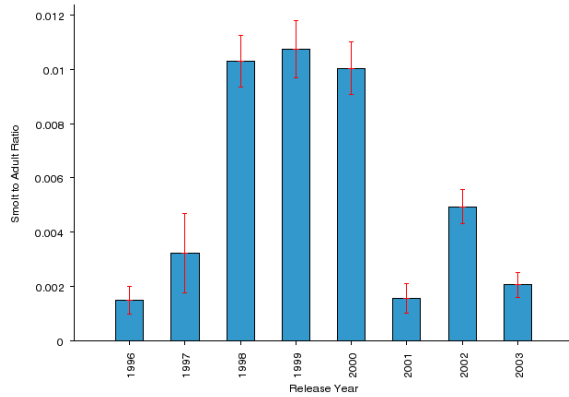


Figure 1 Smolt-to-adult return ratio of Clearwater River hatchery spring Chinook salmon from Lower Granite Dam to Lower Granite Dam, including transported and non-transported fish.

Program SURPH (SURvival under Proportional Hazards) – Estimates survival using release-recapture data as a function of environmental and experimental effects (**Figure 3**). SURPH can test for homogeneity within a release group or between release groups. It provides a flexible modeling capability to analyze data, select the most parsimonious models, and generate diagnostic reports and graphs. Hypothesis tests include Likelihood Ratio Test, AIC, or Analysis of Deviance. Applications include estimating survival of juvenile salmon in the

Columbia River Basin from PIT-tag data and survival of game animals from radiotelemetry data.

www.cbr.washington.edu/paramest/surph/

Program USER (User Specified Estimation Routine) – Develops customized statistical likelihood models for analyzing tagging and counts data. Program USER has been applied to both fish and wildlife data. One application includes analyzing route-specific survival of juvenile salmon through Columbia River hydroelectric projects, i.e., through fish bypasses, powerhouse, sluiceway, turbines. Another example includes analyzing age-at-harvest data of game animals.

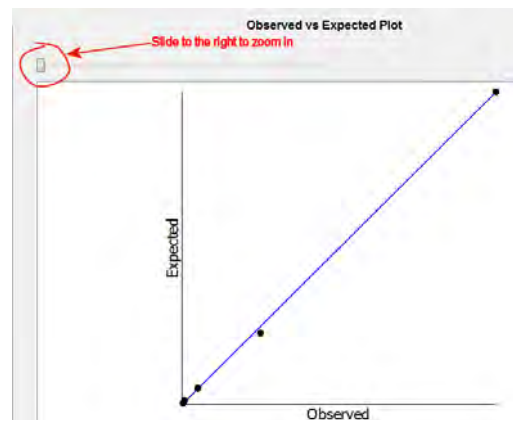


Figure 2 Plot of observed vs. expected for abundance estimation.

The program and the user's manual are available at our website.

www.cbr.washington.edu/paramest/user/

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Cormack/Jolly-Seber Estimates
(Cormack 1964, Jolly 1965, Seber 1965)

Data: Dworshak Hatchery 4/8/93, 4/22/93, and 5/6/93 Releases
File: C:\code\var\surph\dworshak.srh

Survival Probabilities
    
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Population	Period		Overall
	1	2	
1	0.64 (0.05)	0.71 (0.08)	0.46 (0.04)
2	0.66 (0.04)	0.80 (0.08)	0.53 (0.04)
3	0.66 (0.05)	0.75 (0.09)	0.49 (0.05)
4	0.85 (0.06)	0.64 (0.09)	0.55 (0.06)

Figure 3 Program SURPH provides Cormack-Jolly-Seber (CJS) estimates for Dworshak hatchery salmon.

Data Integration & Analysis Services: Columbia River DART

Columbia River DART (Data Access in Real Time) provides direct and timely public access to integrated Columbia Basin environmental, operational, fishery, riverine, ocean and climactic data resources for sound management of the Columbia Basin resources and hydrosystem by federal, state, tribal, public and private entities. DART has been providing web services since 1994.

Through regional cooperation with numerous federal, state, tribal, and private entities, DART provides support for monitoring and evaluation of scientific research efforts; access to spatially and temporally integrated biological and environmental data; and integration and exchange of information.

www.cbr.washington.edu/dart/

Data Integration

DART currently addresses specific data integration needs in the region by presenting an integrated, web-accessible system for tracking and analyzing Columbia River fish passage. DART data integration and online services allows the public, fish managers and researchers to explore and analyze historical passage seasons, track in real-time the status of current adult and juvenile fish passage through the Columbia River system, evaluate hydrosystem operations on anadromous and resident fish, and explore future and forecasted passage scenarios. Various tools provide sub-basin specific monitoring and evaluation analyses of salmonid passage, survival and adult returns.

DART interacts with regional data managers to increase collections of historic datasets not yet available via the Internet and adds datasets as directed by BPA and regional needs. DART current datasets include:

- Adult Passage counts from Chelan PUD, Douglas PUD, Grant PUD, USACE, WDFW, YKFP, Colville Tribes, ODFW
- Hydroelectric project data from USACE, Chelan PUD, Douglas PUD, Grant PUD, USBR, ODFW
- Water Quality Monitor data from USACE
- Surface Water data from USGS
- PIT Tag release, observation, recapture, and mortality data from PTAGIS, PSMFC
- Smolt Indices & Collection Counts from FPC
- Transportation data from FPC
- Hatchery Release data from FPC

- Trap Collected Counts from WDFW, Chelan PUD, Colville Tribes Fish & Wildlife (OBMEP), Douglas PUD, USFWS, Yakama Nation
- Ocean Conditions from NOAA and PFEL
- CWT data from RMPC, PSMFC.

Routine reporting and analysis by DART provides information on the impacts of the hydrosystem on fish passage. Historical, real time, and predictive passage statistics provide resources for managing the hydrosystem in relation to migrating and resident stocks. The real time analysis and modeling tools facilitate adaptive management for fish passage.

Analysis Services

Beyond routine reporting of data, DART identifies, develops and implements value-added aggregate data and analyses services for the region served to the public in real time.

Aggregate data provided by DART include:

- PIT-tagged migrants segregated into explicit adult or juvenile categories based on complex release and observation protocols developed by DART. We continually refine these protocols.
- PIT-tagged migrants segregated into distinct Columbia Basin ESU stocks as defined by NOAA ESA listings and complex protocols developed by DART.
- Ten year averages for adult passage and river condition datasets by location and date for comparison with single year observations and conditions (**Figure 4**).

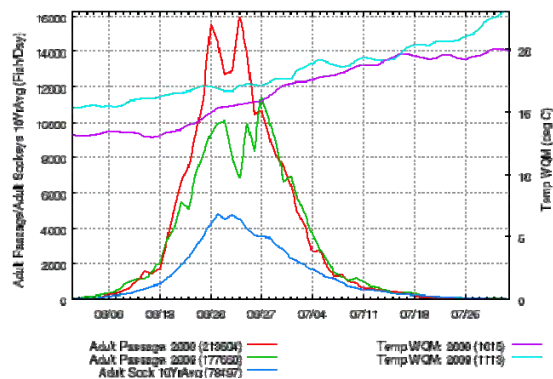


Figure 4 DART Adult Sockeye Passage graphed with Adult Sockeye Passage 10 Year Average and Temperature graph.

Hydrosystem and fish passage analyses provided by DART include:

- Detail and summary statistics and analysis of PTAGIS data for juveniles and adults.
- Monitoring and reporting detailed status of ESA listed stock migrations in real-time.
- Adult and juvenile migration status within the hydrosystem providing reach- and system-level information for ESA-listed and non-ESA species.
- Reports of migrant exposure to environmental and hydrosystem conditions.
- Extensive online analytical processing of PIT Tag data for estimates of passage travel time, survival, historical run-timing, plus release and observation summaries for user-selected stocks.
- Summary statistics and analyses of user-selected juvenile and adult stocks.

In addition, DART services include by request survival analyses and covariate preparation, vitality work, turbine mortality, and COMPASS calibration data preparation. The following sections highlight some of the complex data services developed by DART in response to specific regional needs and requests; these services are available to public through the DART website.

Columbia Basin ESU (Evolutionarily Significant Unit)

DART is the only project directly reporting the status of PIT-tagged ESU stocks. PIT tag data specific to populations listed as ESU are analyzed and provided on the website. As part of the ESU data services, we aggregate PIT Tag release and detection information in order to provide summary and detailed observation information on the ESU populations. Analyses are updated daily with the most recent information and statistics calculated including juvenile and adult mean travel time estimates. We provide analyses for 9 distinct ESU populations from the Snake, Columbia and Willamette rivers.

www.cbr.washington.edu/dart/esu.html

Conversion Rates

DART provides summary and detail Conversion Rate analysis of PIT Tag adult returns based on user selections. Conversion rates provide a measure of adult, upstream migration success

through a designated reach. In addition to PIT Tag observations, users can chose to include mortality recoveries and recaptures when calculating the conversion rates. Special conditions for overwintering and multiple migrations are tracked in all the conversion rate reports.

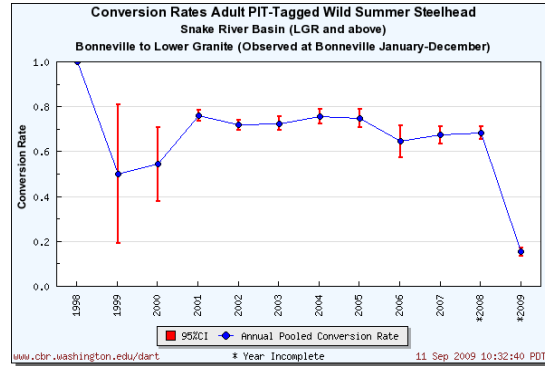


Figure 5 Conversion Rate for Bonneville to Lower Granite for Adult PIT-Tagged Wild Summer Steelhead Released above Lower Granite, by observation year.

www.cbr.washington.edu/dart/pit_obs_adult_conrate.html

Spring and Fall Transition Dates

Ocean conditions are crucial to the success of anadromous salmonids. We report the spring and fall transitions of upwelling patterns off the coast of the Pacific Northwest. Transition dates can be indexed in several ways; we present 5 various methods of determining Spring Transition Date and Fall Transition Date (**Figure 6**). Updated annually by DART.

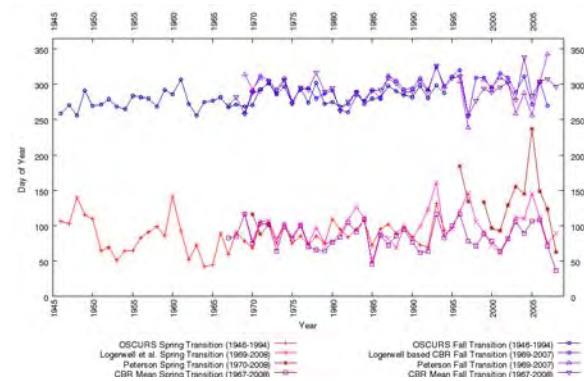


Figure 6 Spring Transition Date and Fall Transition Date for all years for all methods.

www.cbr.washington.edu/data/trans.htm

10 Year Historical Run Timing

The 10 Year Historical Run Timing reports are available for Adult Passage Visual Counts, Smolt Index, juvenile and adult PIT Tag stocks, and Columbia Basin ESU populations with run timing

and migration timing characteristics--including first, 1%, 5%, 10%, 50%, 90%, 95%, and last passage dates as well as the number of days for the middle 80% of the run--at the user-selected project for the last 10 years.

Inseason Forecasts: Juvenile and Adult Passage and Water Quality

Inseason Forecasts use real time data, i.e., PIT-tag detections, passage indices, visual counts and river conditions, to provide current information on the status and passage predictions of Columbia River juvenile and adult salmon migrations.

We forecast the run timing and arrival distributions of 52 salmonid and steelhead stocks from 29 release sites at 10 monitoring sites in the Columbia River Basin. These forecasts are updated daily from data provided by the Pacific States Marine Fisheries Commission, Fish Passage Center, US Army Corps of Engineers, Chelan PUD, Tribes and First Nations, and state agencies. Juvenile passage forecasts include ESU passage forecasts – arrival distributions, historical timing, and survival – for specific Snake River and Upper Columbia River ESU. Forecasts are based on selected PIT Tag detections at McNary Dam, as identified by DART.

www.cbr.washington.edu/crisprt/

Juvenile Passage Forecasts

The juvenile passage forecasts use two separate programs to generate downstream passage distributions: Program RealTime and COMPASS (COMprehensive PASSage) model.

Program RealTime uses statistical algorithms, updated annually, to smooth patterns of historical PIT-tag data and passage indices to forecast percent daily passage for salmonid stocks at index locations, e.g., Lower Granite Dam, using weighted generalized least squares for decision criteria (**Figure 7**).

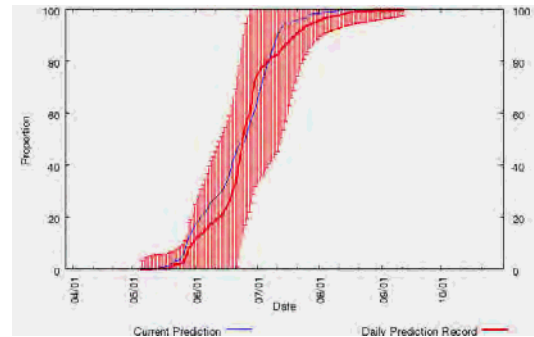


Figure 7 Percent daily passage of PIT-tagged wild subyearling Chinook salmon at Lower Granite Dam.

COMPASS (COMprehensive PASSage)—a juvenile fish passage model developed by NOAA Fisheries in collaboration with federal, state and tribal agencies and CBR—uses Program RealTime arrival distributions at Lower Granite and McNary dams, hydrological, fish behavioral and dam geometry information to simulate the movement and inriver reach survival (**Figure 8**) of juvenile salmonids through the remainder of the Columbia River system.

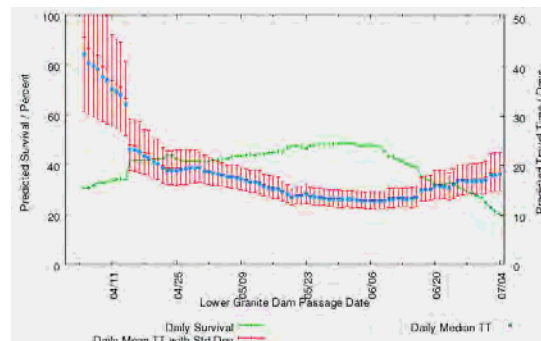


Figure 8 Reach survival and travel time predicted for wild yearling Chinook salmon passing Lower Granite Dam to Bonneville Dam.

Adult Passage Forecasts

The Adult Passage Inseason Forecasts predict the arrival distributions of adult Chinook migrating upstream at several monitoring sites along the Snake and Columbia Rivers. The tool uses "real time" information about the current observed counts at Bonneville Dam along with current hydrographic information to predict the future progress of the migrating fish.

The Adult Passage Inseason Forecasts utilize three separate programs: Escapement Projector, Adult Upstream Migration and Adult Peak Predictor. The **Escapement Projector** is pattern matching algorithm that compares the current year's data to historical years of adult passage counts to predict arrival distributions at Bonneville Dam. The **Adult Upstream Migration** model takes the predictions from the Escapement Projector and reservoir and dam passage, fallback, straying and energy consumption with a physical river description and environmental data to simulate the movement and survival of adult salmonids from Bonneville through the Columbia River system.

Adult Peak Predictor generates predictions for spring Chinook at Bonneville Dam (**Figure 9**) that begins with a preseason prediction of run timing from a Genetics and Environment Timing model and a preseason run-size prediction based on the previous year's Jack returns. The daily, inseason methods to simultaneously estimate distribution parameters from the observations-to-date include use of real time environmental conditions, historical bounds on parameters, and the mathematical properties of the Gaussian distribution.

Anderson, JJ, and WN Beer. 2009 *Ecological Applications*. "Distal, Proximal, and Genetic Influences on spring Chinook salmon migratory timing."

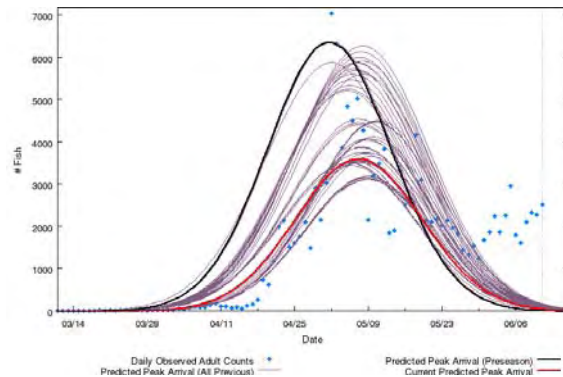


Figure 9 2009 daily Adult Peak Arrival Timing & Run Size Prediction: black line = preseason, gray line = daily predictions, red line = current prediction, and blue points = daily observations.

Water Quality Forecasts

Water quality forecasts include water temperature and total dissolved gas percent at various dams in the Columbia and Snake rivers.

Temperature Forecasts use the Temperature Algorithm – a multi-method algorithm that uses historical mean data, year-to-date observed data, and a forecast of flow – to predict temperature values at locations throughout the Columbia and Snake rivers. Temperature forecasts are used as input to the **Total Dissolved Gas** forecasts as well as the COMPASS juvenile passage and adult passage forecasts.

Total Dissolved Gas Forecasts are produced by the COMPASS. The equations predict tailwater gas production as a function of spill. Temperature forecasts, flow and spill forecasts, and year-to-date observed data are inputs to the gas modeling forecasts.

Post-Season Analyses

Post-Season Analyses provide interactive displays of important metrics after the completion of the migration seasons. These population measures contribute to the rigorous monitoring and evaluation of salmonid populations.

Status & Trends Overview provides access, through interactive map or forms interface, to post-season analyses of historical and current salmonid data and environmental data with compliance targets for wild and hatchery adult and smolt salmon. The goal of these summaries is to assist in the monitoring and evaluation of compliance pursuant to Biological Opinions. Users can assess compliance with decadal means and trends as well as graphs on Adult Escapement, Adult Counts at the major Columbia River dams, Coded Wire Tag (CWT) Smolt to Adult Ratios, Passive Integrated Transponder (PIT) Tag Survival and Travel Time analyses, Harvest Estimates, and hydrosystem conditions (Temperature, Dissolved Gas Percent, Outflow).

www.cbr.washington.edu/trends/

Adult escapement is one measure represented with two bar graphs; one indicating adult escapement by natural fish by brood year (**Figure 10**) and another distinguishing natural (wild) and hatchery spawners. In addition, the source, explanatory notes, and CBR declared status are provided with the graphs.

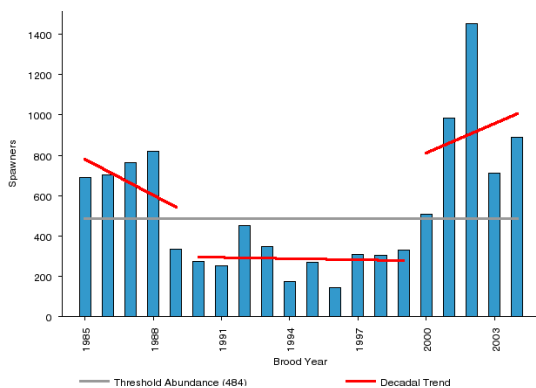


Figure 10 Adult escapement for natural summer steelhead in Naches River with threshold abundance (gray line) and decadal trends (red lines).

Columbia Basin Performance Measures

online data analysis tool calculates observed fish exposure – adult passage counts, smolt indices, adult and juvenile PIT Tag stocks, and ESU populations – to river conditions at the major hydroelectric projects on the Columbia and Snake Rivers based on user selections.

Exposure graphs and summary tables are based on observed data retrieved from the Columbia River DART database. Fish exposure is based on the total number of fish passing a selected project under user-specified hydrological conditions (**Figure 11**). This online analysis tool allows the user to specify the criteria to which the fish are exposed: location, river parameter and the critical value of the river parameter to use in the exposure calculations (e.g., Lower Granite, Temperature, 15°C). Summary tables include statistics for the total run period and the middle 80% of the run period.

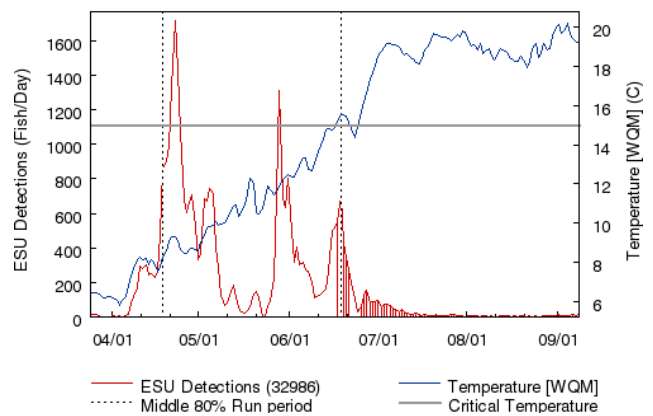


Figure 11 2009 Snake River Fall Chinook ESU exposure to temperatures at Lower Granite Dam above 15°C.

www.cbr.washington.edu/perform/