FISH BENEFITS WORKBOOK

Current applications and future development

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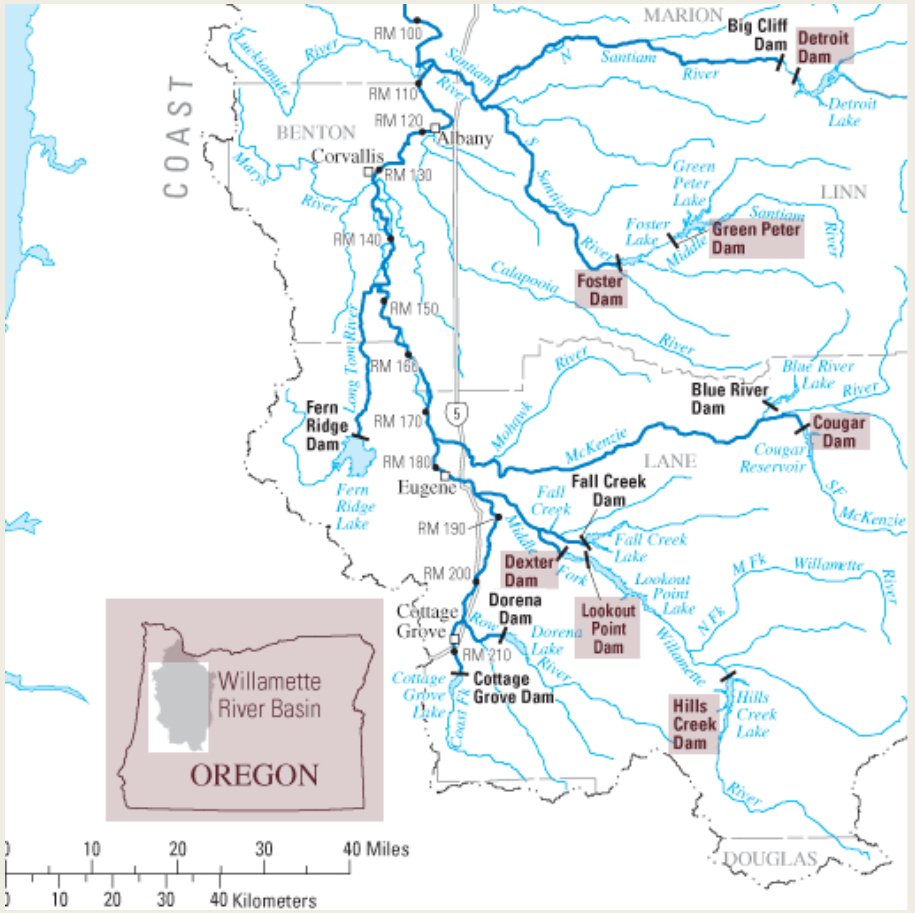
INTEGRATED FISH PASSAGE PROJECT

Aims of the talk

1. Origins and purpose of the Fish Benefits Workbook (FBW)
2. Overview of the FBW model, including main inputs and outputs
3. Limits of the current FBW model and ongoing improvements to modelling dam passage

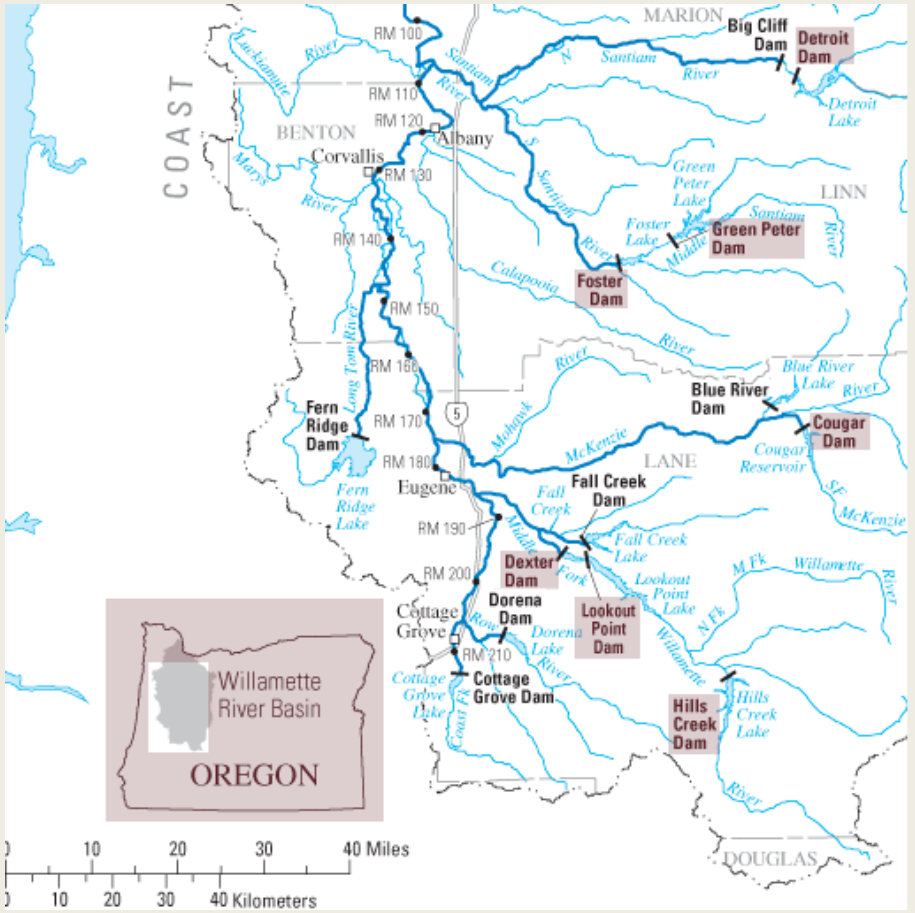
Origins of the Fish Benefits Workbook (FBW)

- 1999: ESA listing of Willamette Basin spring Chinook and winter Steelhead



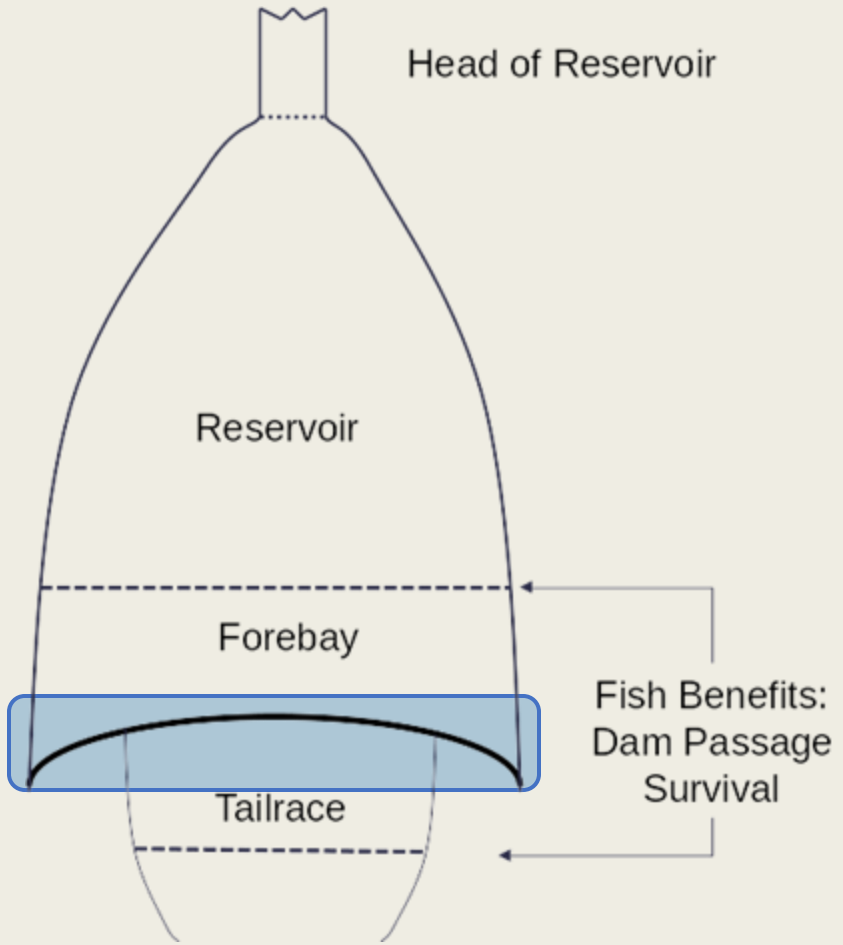
Origins of the Fish Benefits Workbook (FBW)

- 1999: ESA listing of Willamette Basin spring Chinook and winter Steelhead
- 2008: NOAA Fisheries Biological Opinion identified project changes, including **dam passage improvements**
  - 13 high-head, in-river, and regulating projects in the system, 7 assessed for passage improvements



Origins of the Fish Benefits Workbook (FBW)

- 1999: ESA listing of Willamette Basin spring Chinook and winter Steelhead
- 2008: NOAA Fisheries Biological Opinion identified project changes, including **dam passage improvements**
- 2014: FBW Excel+VBA workbook designed by the U.S. Army Corps with inputs from NOAA, ODWF, others
  - Purpose: to rank possible operational (flow regime, temperature controls) and structural (passage structures) improvements to juvenile downstream **dam passage** and survival

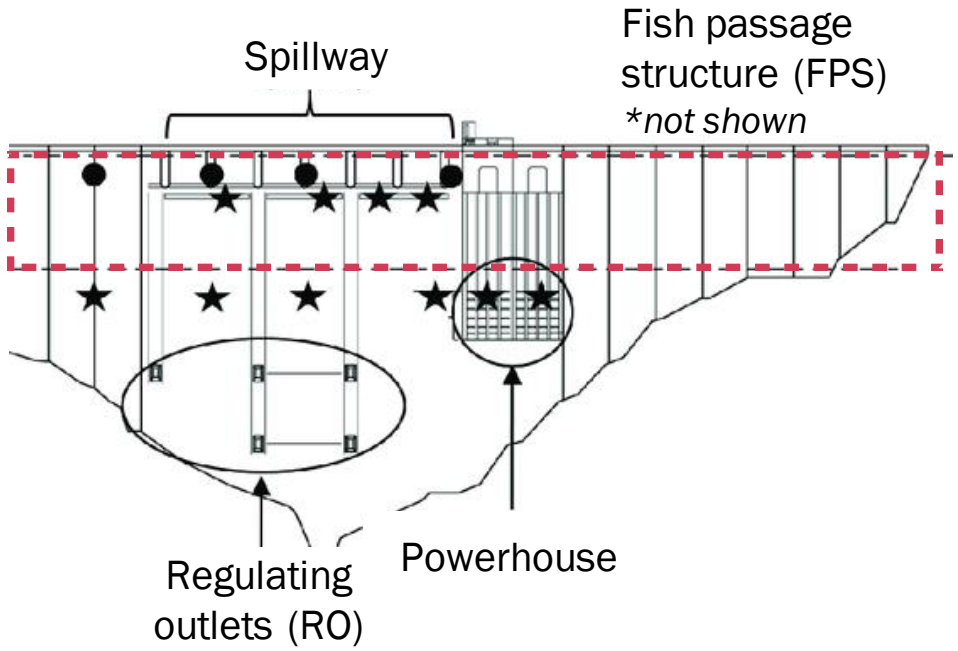


USACE Portland (2012)

Backbone of FBW: ResSim

Corps'-developed hydrological model of daily:

- Pool elevation,

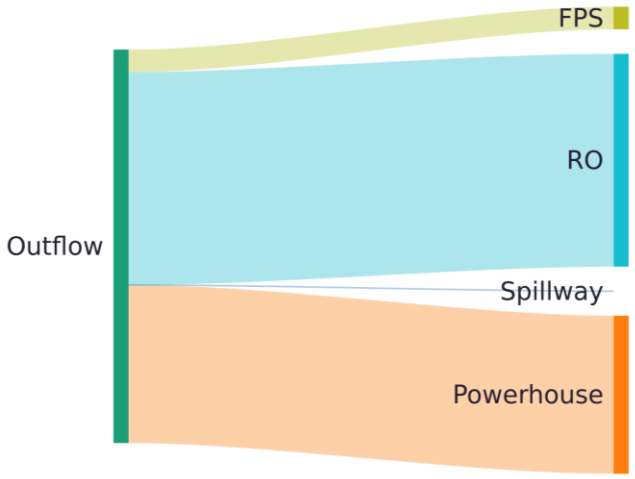


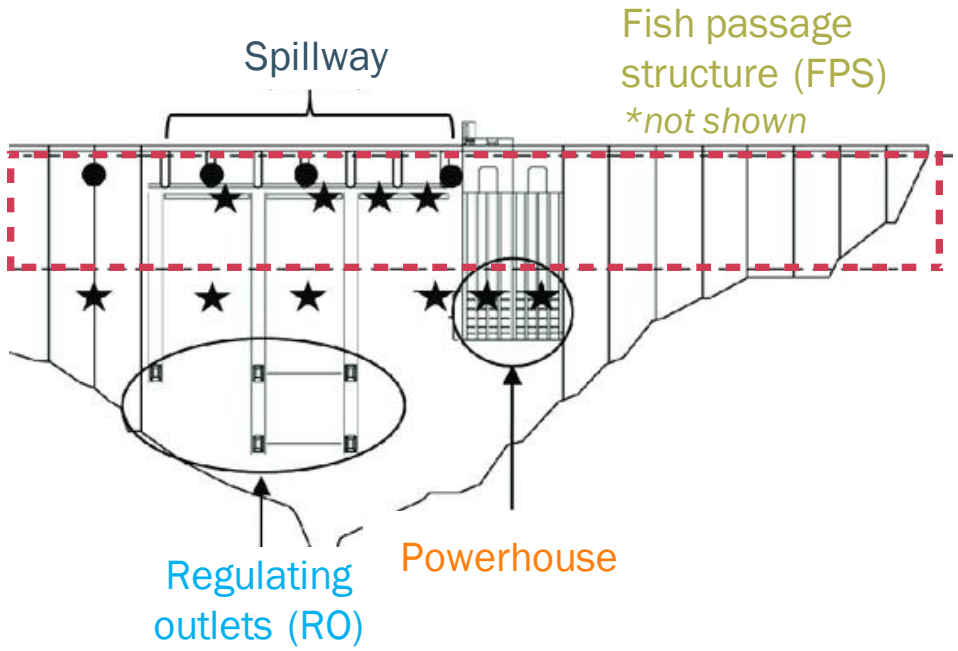
Kock et al. (2015; USGS Report 2015-1220)

Backbone of FBW: ResSim

Corps'-developed hydrological model of daily:

- Pool elevation,
- Total outflow,
- Distribution of flow through available outlets





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Backbone of FBW: ResSim

Corps'-developed hydrological model of daily:

- Pool elevation,
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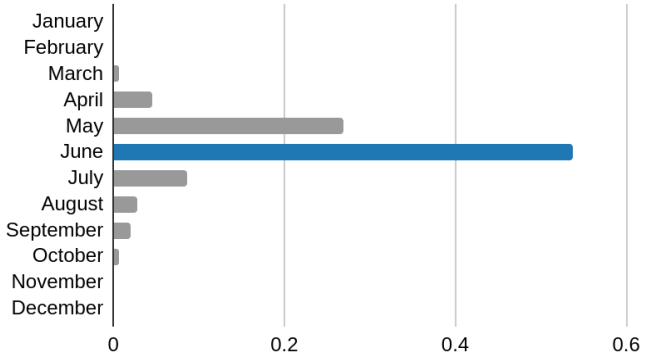
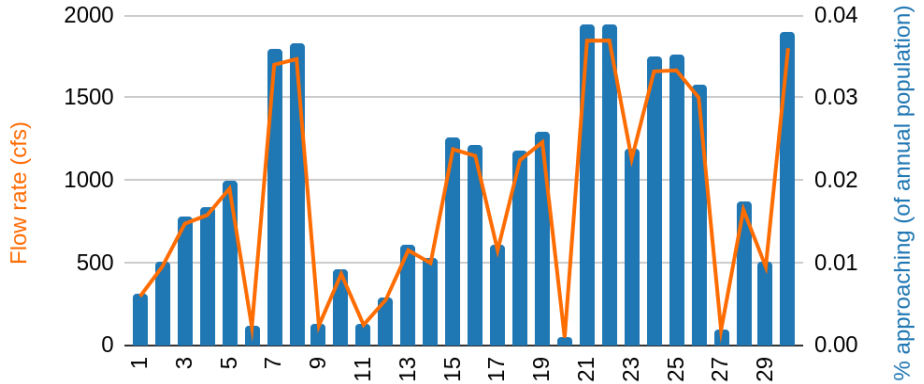
*Which, **within FBW**, inform each species' and life stages':*

1. Daily run timing - *f*(Flow)

Monthly run timing (%)



Daily run timing (%)



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*Which, **within FBW,** inform each species' and life stages':*

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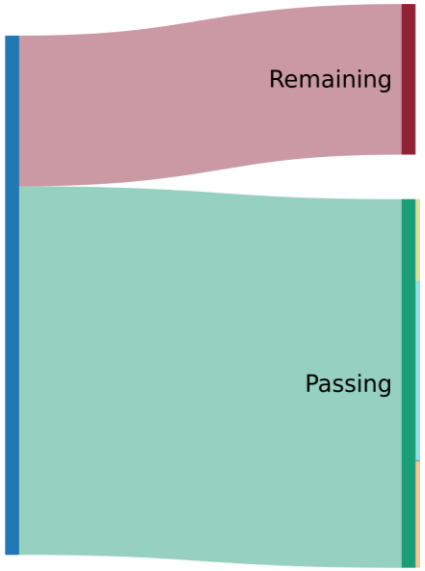
2. Daily dam passage efficiency - *f*(Elevation)



Fish distribution

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*Which, **within FBW**, inform each species' and life stages':*

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2. Daily dam passage efficiency - *f*(Elevation)
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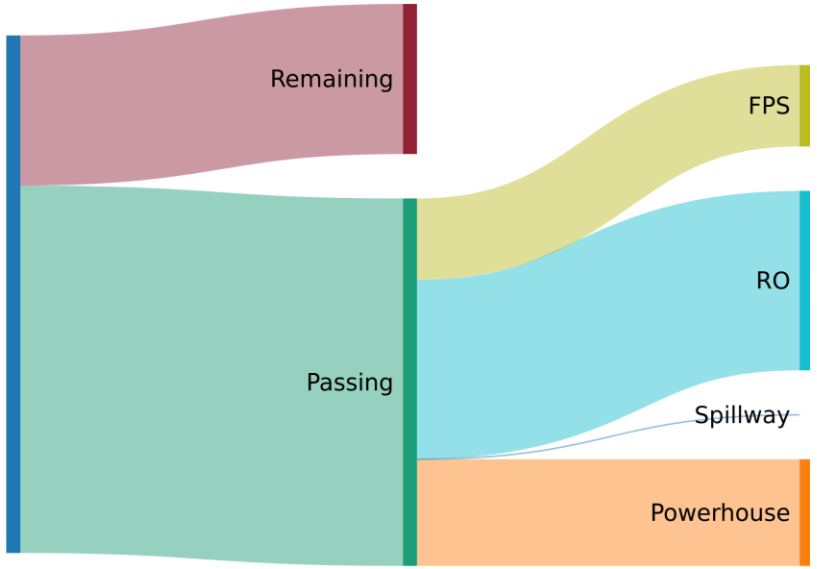

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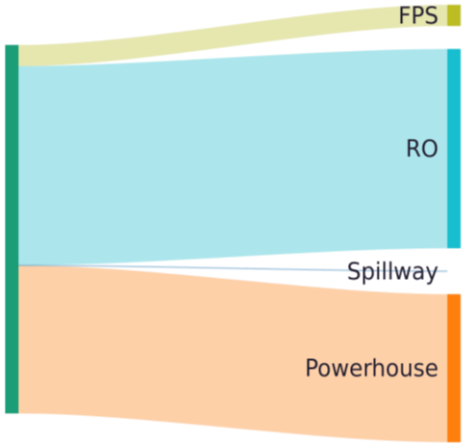

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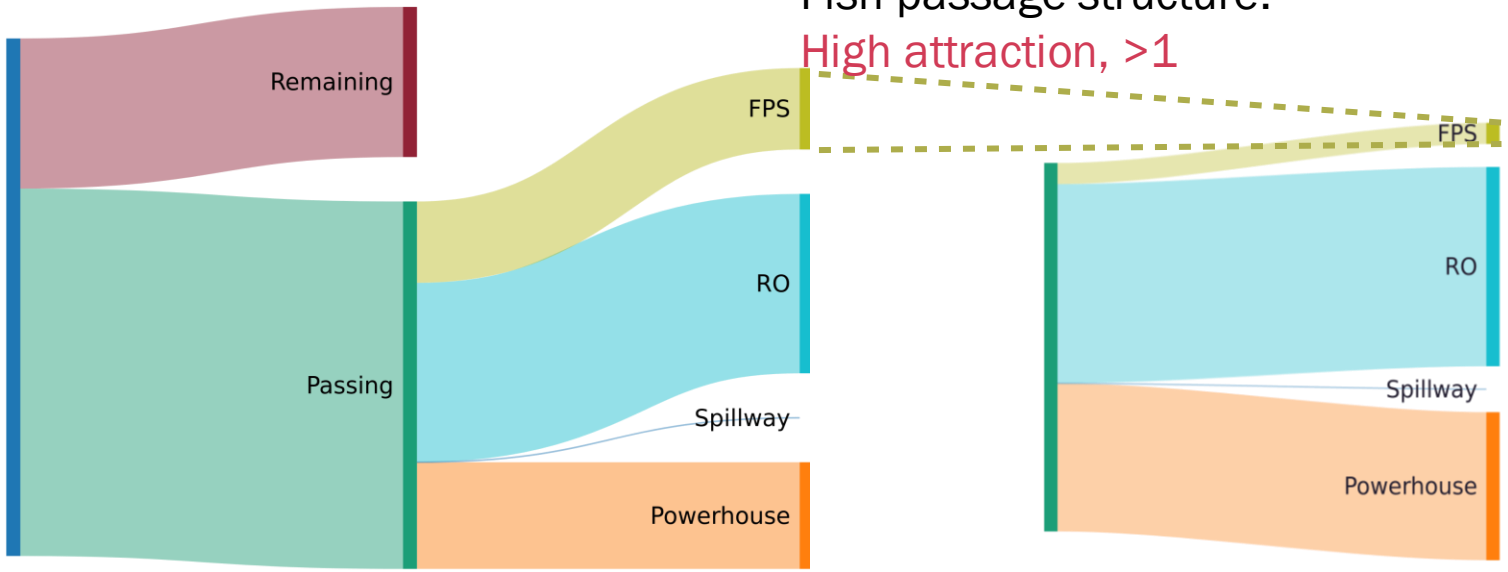
Fish passage structure:
High attraction, >1



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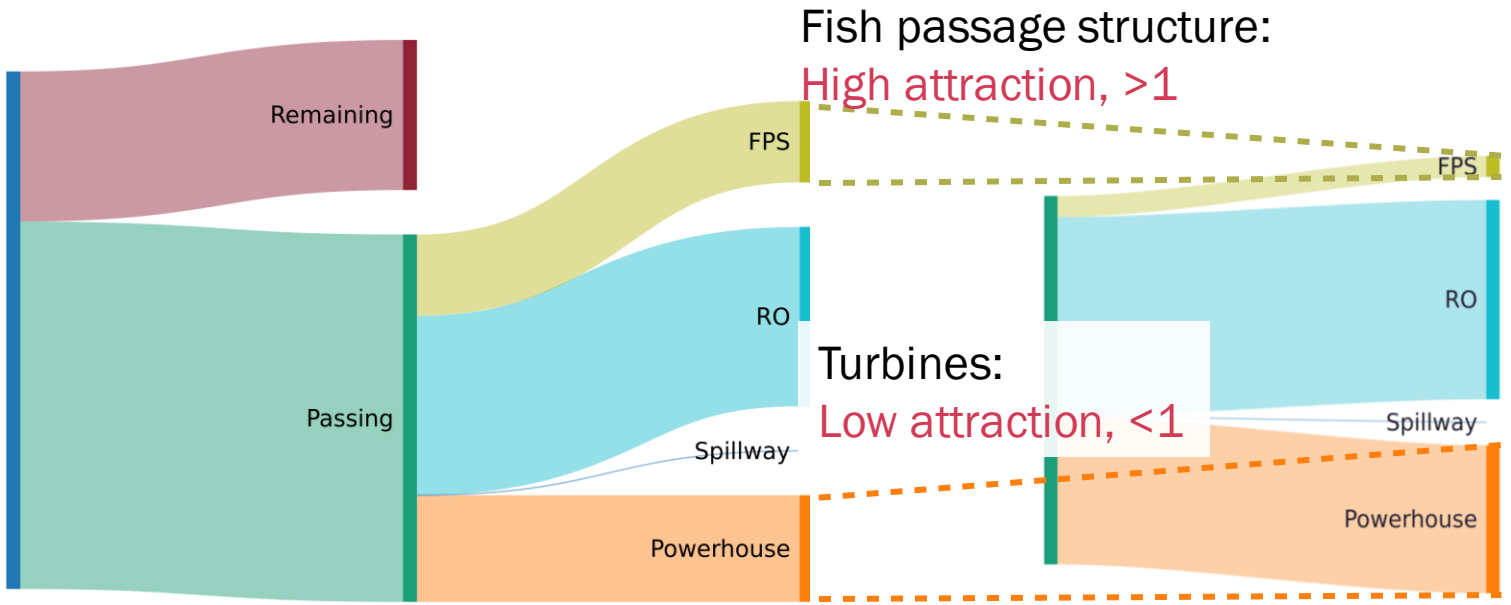

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Corps'-developed hydrological model of daily:

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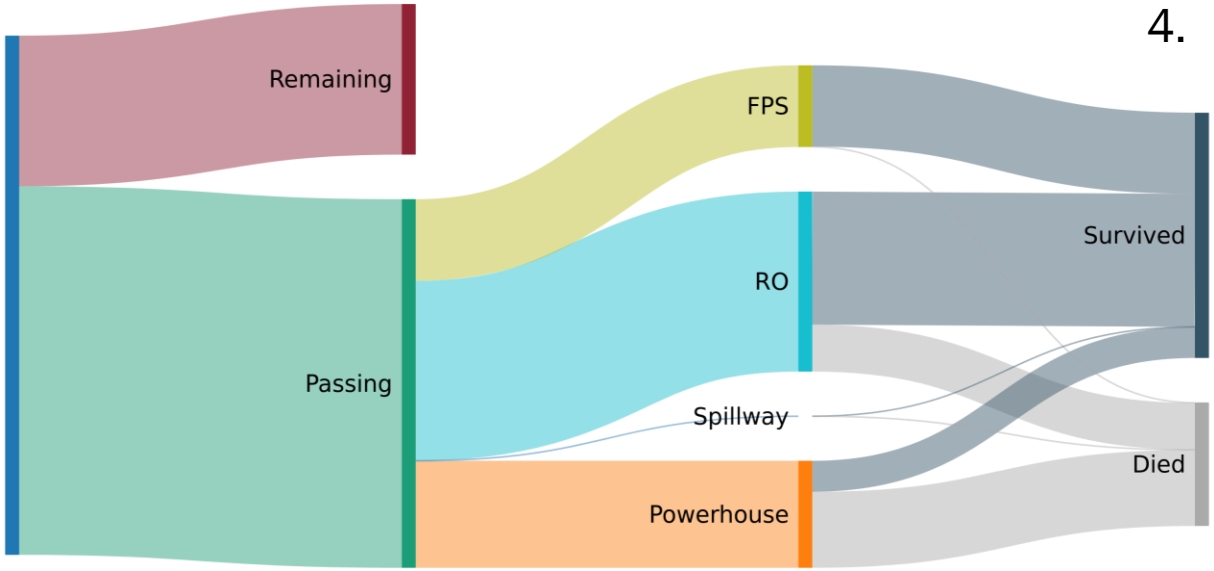
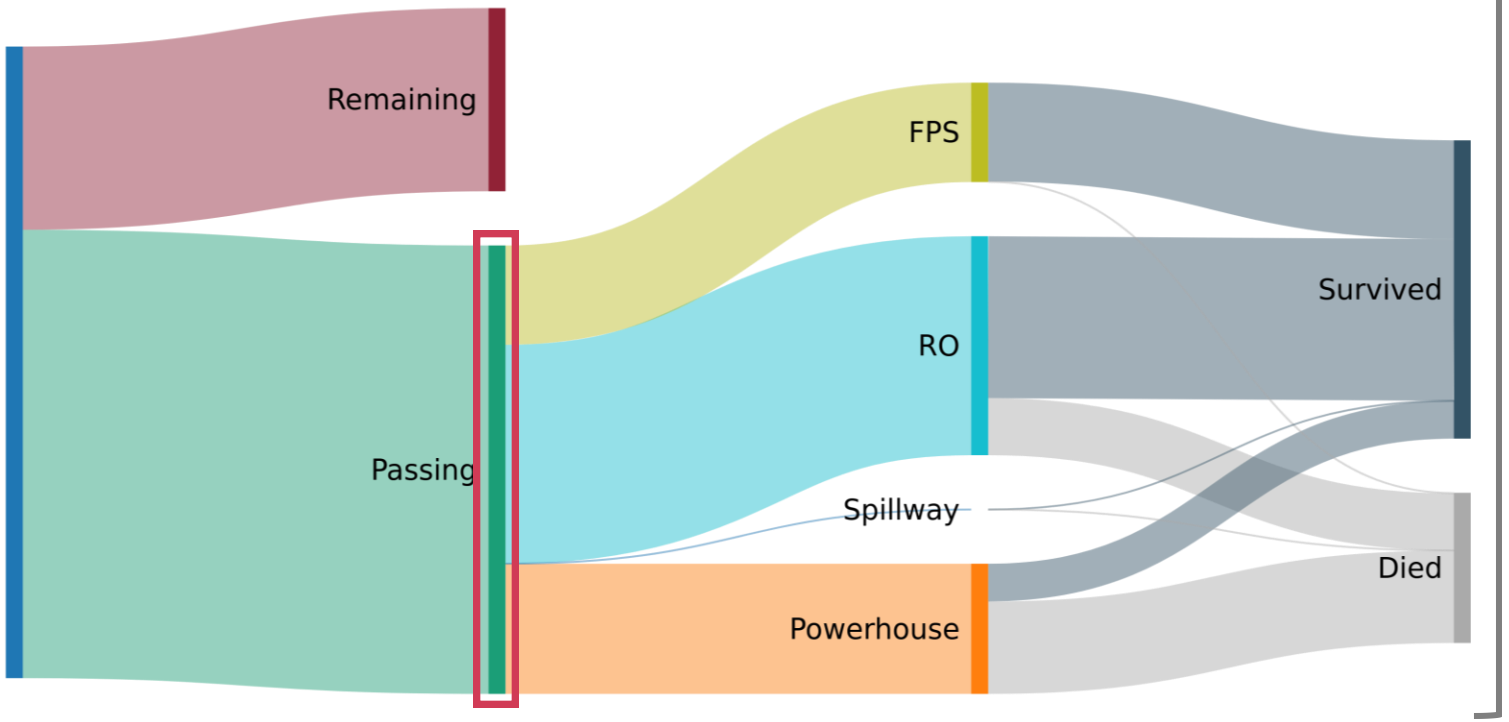
*Which, **within FBW**, inform each species' and life stages':*

1. Daily run timing - *f*(Flow)
2. Daily dam passage efficiency - *f*(Elevation)
3. Distribution in outlets – *f*(Flow + Attractiveness)
4. Outlet-based survival – *f*(Flow)



Fish distribution

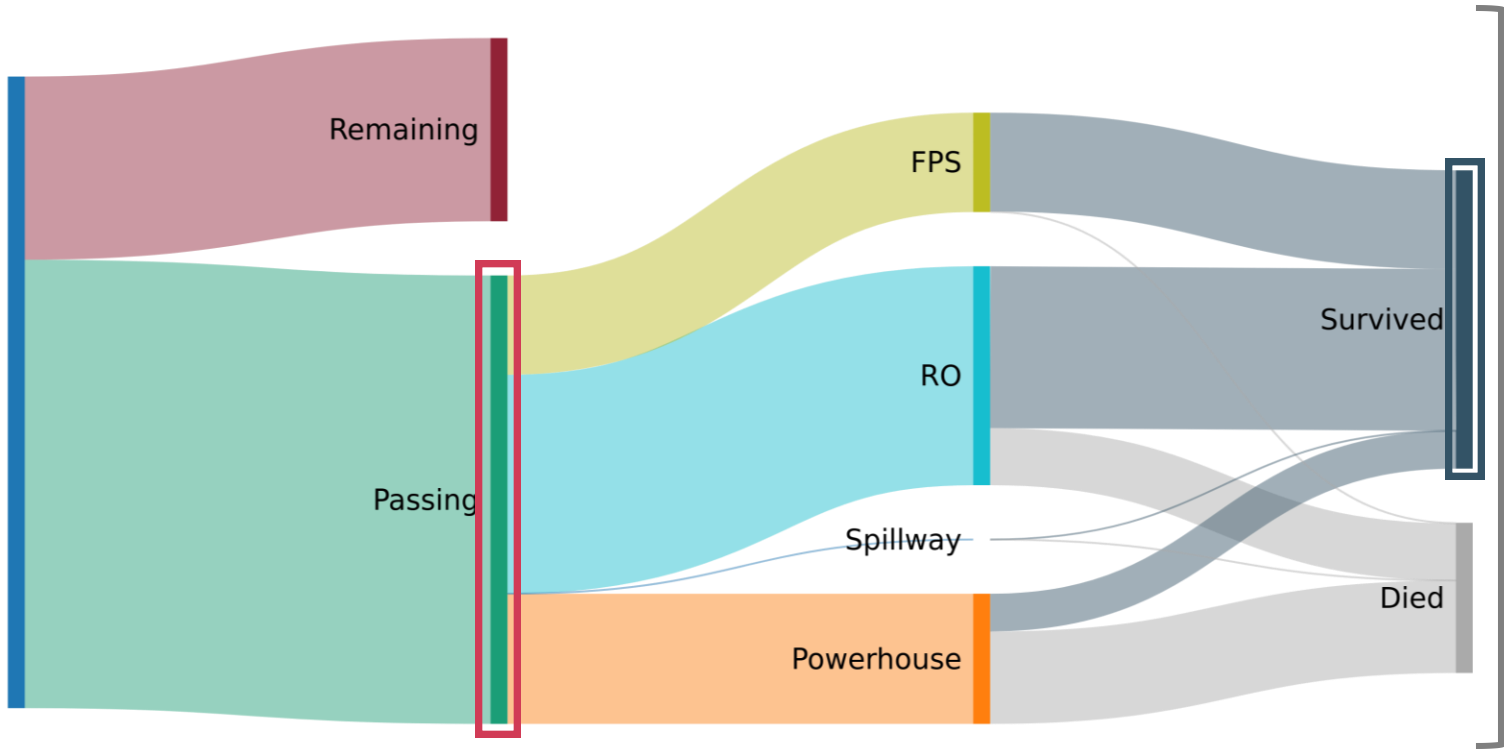
FBW's key outputs



Repeat for each day in the period of record (1936-2019), then **summarize into annual estimates** of:

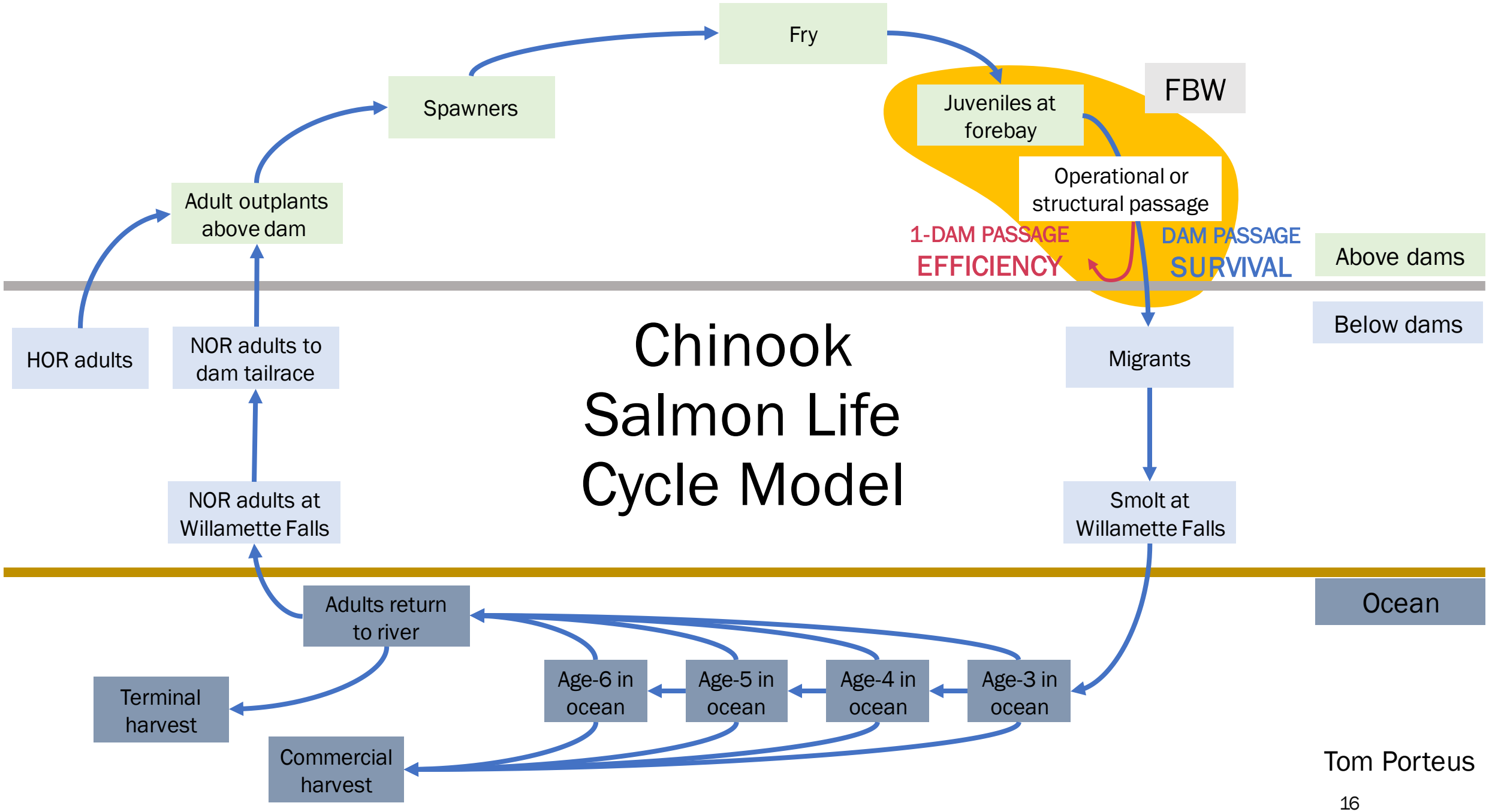
- Dam passage efficiency (DPE)

FBW's key outputs



Repeat for each day in the period of record (1936-2019), then **summarize into annual estimates** of:

- Dam passage efficiency (DPE)
- Dam passage survival (DPS)


Fry
Spawners
Juveniles at forebay
FBW
Operational or structural passage
1-DAM PASSAGE EFFICIENCY
DAM PASSAGE SURVIVAL
Above dams
Below dams
Adult outplants above dam
HOR adults
NOR adults to dam tailrace
Migrants
Chinook Salmon Life Cycle Model
NOR adults at Willamette Falls
Smolt at Willamette Falls
Ocean
Adults return to river
Terminal harvest
Age-6 in ocean
Age-5 in ocean
Age-4 in ocean
Age-3 in ocean
Commercial harvest

Tom Porteus

FBW'S LIMITATIONS

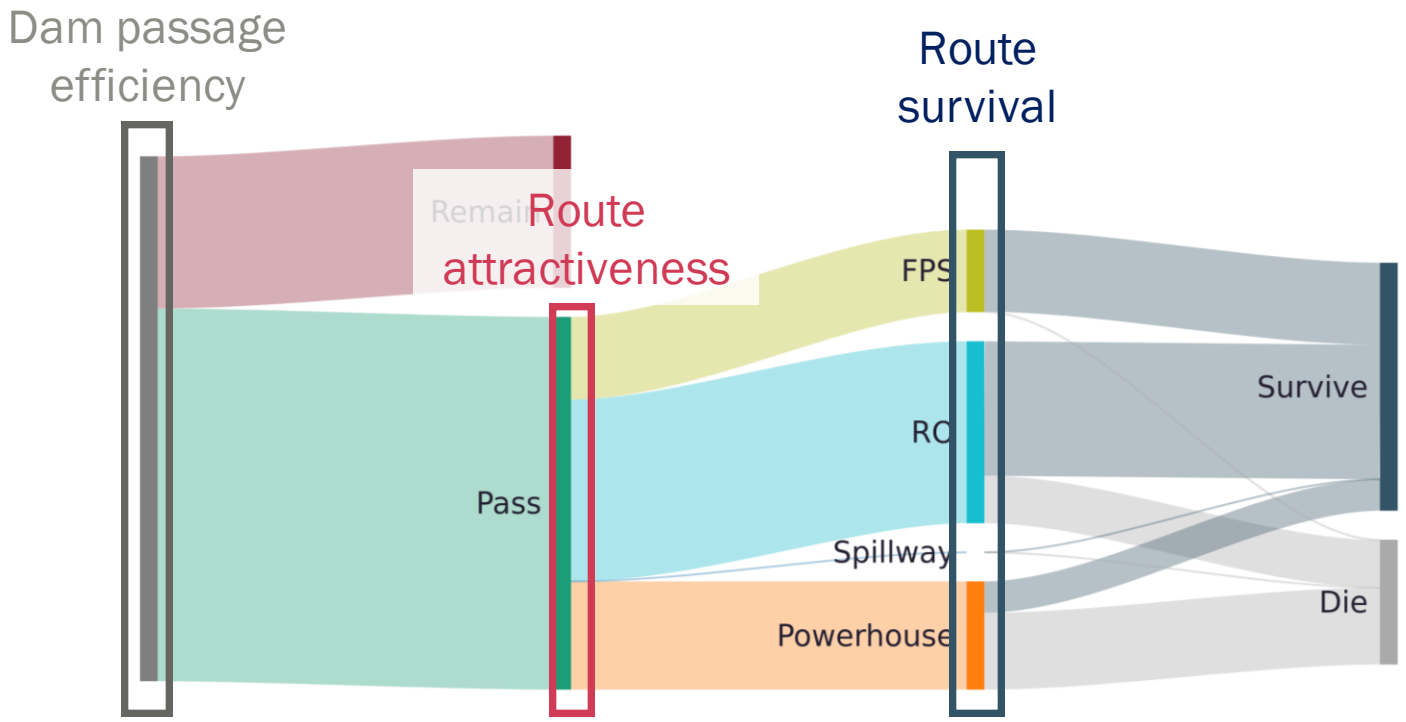
FBW's limitations

- FBW parameterized, reviewed in 2014 by Alden Research Laboratory and BioAnalysts, then by Independent Scientific Advisory Board
- Two major shortcomings to FBW:
  - Limited data available to inform inputs
  - Limited model flexibility

Limitations: input parameters

Biological parameters

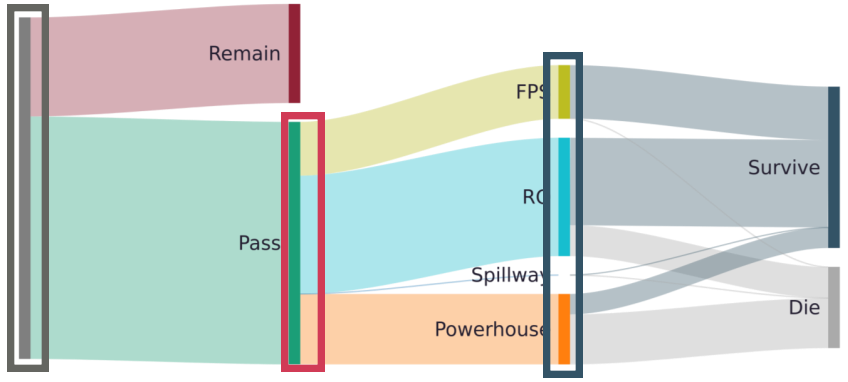
- Initial parameterization by Tetra Tech, Bioanalysts and Alden Research Laboratory



Limitations: input parameters

Biological parameters

- Initial parameterization by Tetra Tech, Bioanalysts and Alden Research Laboratory
  - Literature review, primarily tagging studies (PIT, balloon, radio-tagged, etc.)
  - Data generally from studies at Cougar and Detroit dams, supplemented with additional studies and expert opinion



Project	Dam Passage Efficiency	Route attractive-ness	Turbine Survival	RO Survival	Spillway Survival
Cougar	Cougar	Cougar	Cougar	Cougar	NA
Detroit	Detroit	Detroit	Detroit	Detroit	Detroit
Foster	Foster	Foster	Foster	NA	Foster
Green Peter	Green Peter	Detroit	Cougar	Cougar	Detroit
Hills Creek	Cougar	Cougar	Cougar	Cougar	Opinion
Lookout Point/Dexter	Detroit	Detroit	Cougar	Cougar	Detroit

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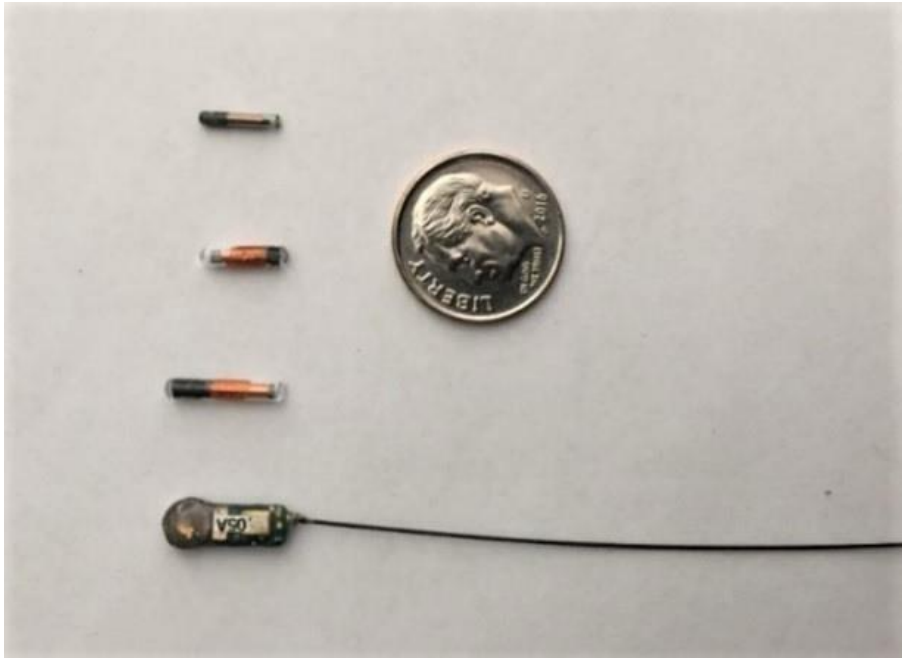
- Tagging studies = no survival estimates for fry (<60mm)



PIT and radio tags
Biomark Applied Biological Services

Limitations: input parameters

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ResSim

- Based on a historical period of record (1936-2019) - ignores full range of future outcomes
  - e.g., regime changes
- Describes untested structural and operational options at some locations

Limitations: input parameters

Problems:

- Poor understanding of fish passage at dams other than Cougar and Detroit, which may not be representative

- Uncertain future conditions = greater risk during decision-making

Limitations: input parameters

Solutions:

- Ongoing project-specific fish passage research – parameters have been informed by new studies

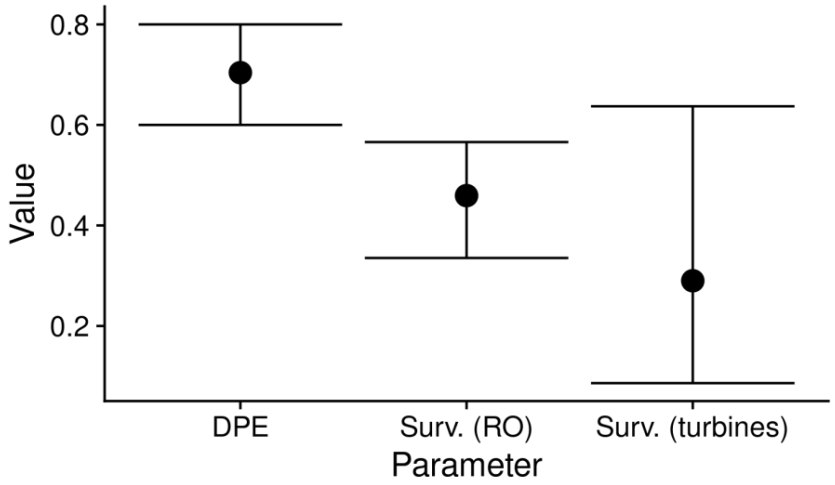
- Continued updating of parameters and model configuration*

** to the extent possible with VBA and Excel*

Limitations to the model

Biological parameters

- FBW requires point estimates, but inputs are uncertain



Range of DPE and route survival estimates at Cougar Dam, from Beeman *et al.* (2012, 2014)

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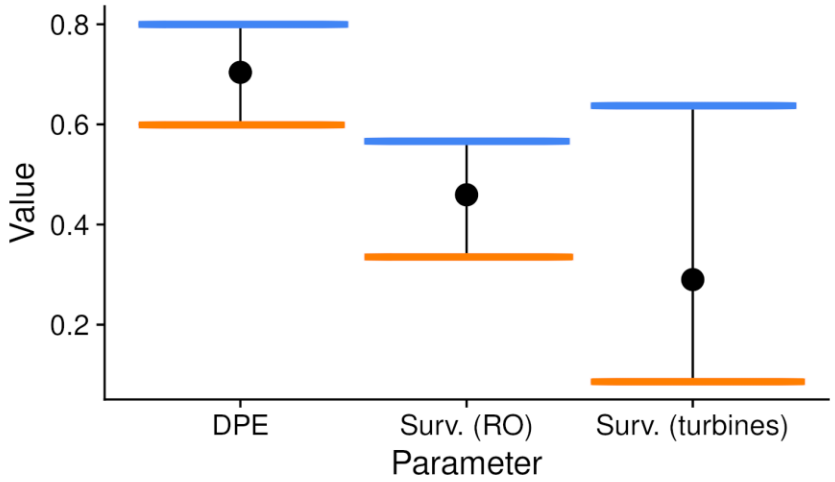

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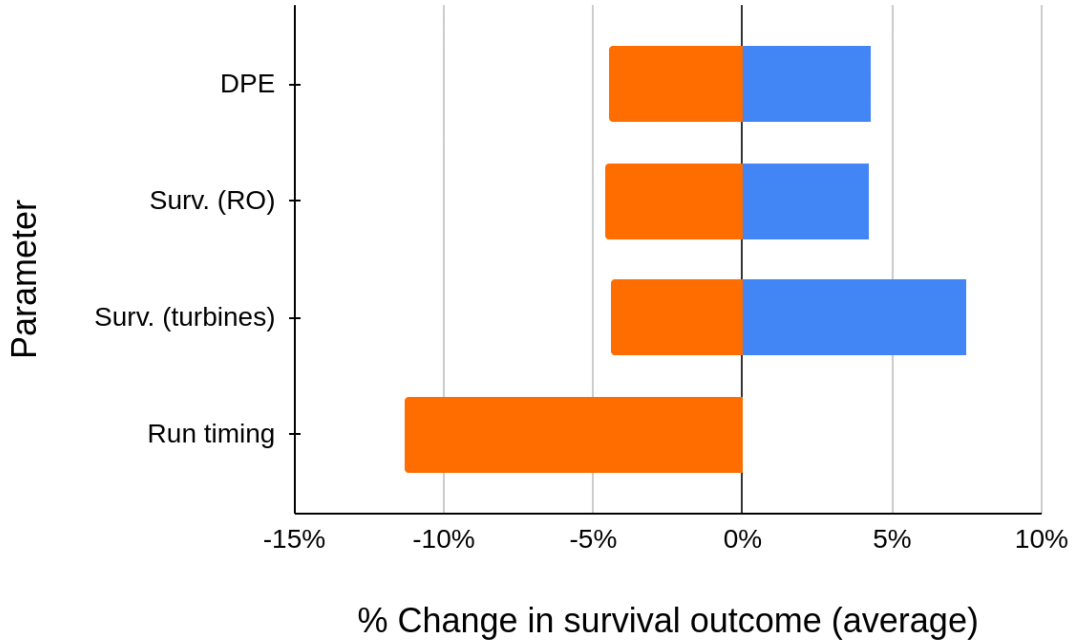


Sensitivity test results from Cougar Dam (Alden memo, 2014)

Limitations to the model

Biological parameters

- FBW requires point estimates, but inputs are uncertain

- Cannot align with most up-to-date knowledge of dam passage
  (e.g.,
  - *route attractiveness = function of pool elevation and passage alternatives,*
  - *passage efficiency a function of time at the forebay and forebay area,*
  - *fish that do not pass may return next month*

  etc.)

Development limited by structure of FBW, lack of capacity to access and modify code

Limitations to the model

Problems:

- VBA = barrier to development, dissemination

- Unable to propagate uncertainties, ignores range of possible parameter values
- Limited ability to update even as new information becomes available

Limitations to the model

Solution:

→ Adapt into software capable of easy modification and expression of uncertainty

ONGOING FBW DEVELOPMENT

FBW-R

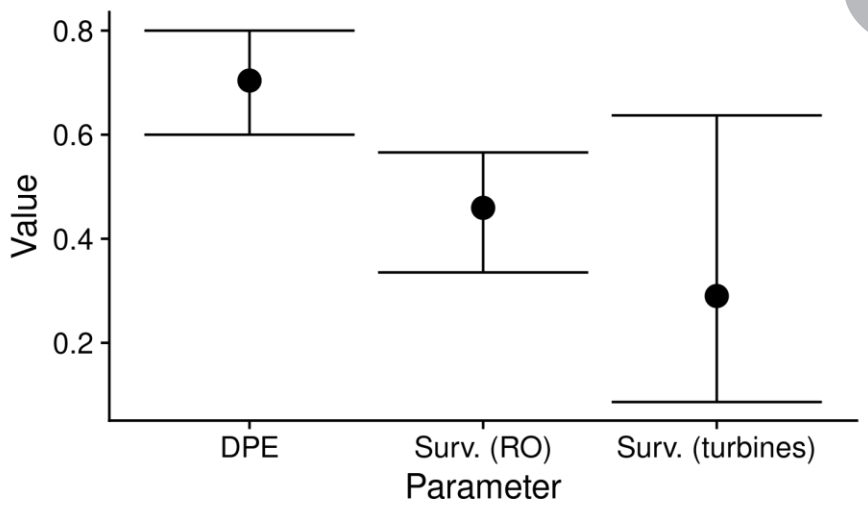
- Developed in 2021 to recreate FBW workbook model

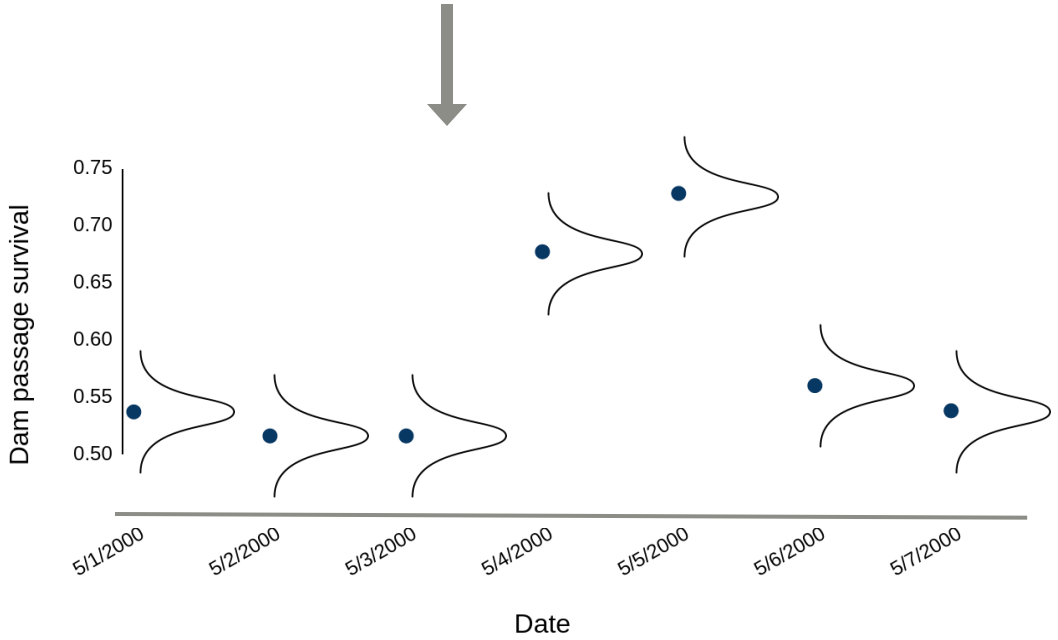
www.r-project.org

FBW-R

- Developed in 2021 to recreate FBW workbook model
- Benefits of R:
  - **Propagation of uncertainty**: parameters can be probabilistic, sampled from within R
  - **Ease of modification**: commonly used, free and open-source software

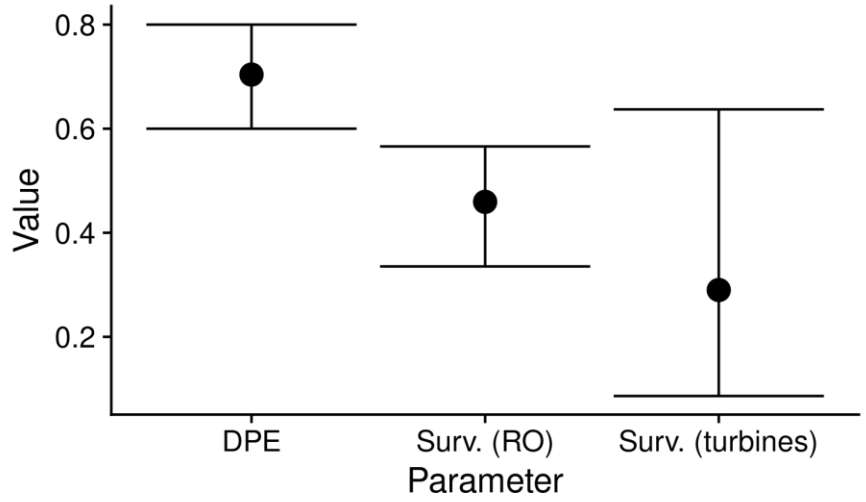
    = **Integration** in life cycle models

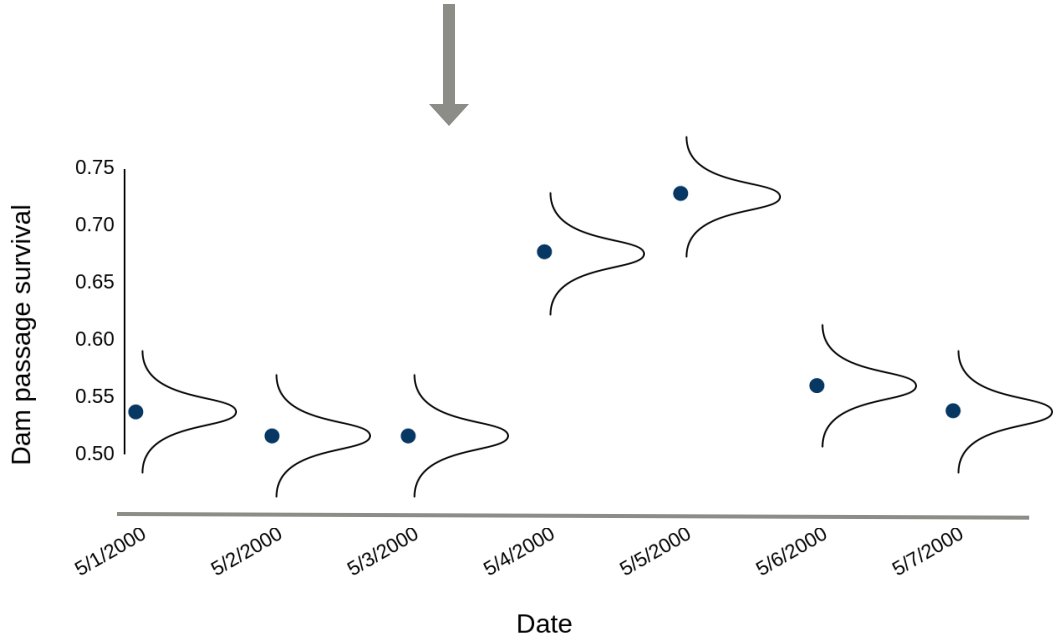




FBW-R: Next steps

- State of the model:
  - Recreates FBW Excel outputs, undergoing final testing
- **Future development:**
  - Conversion of point values to probabilistic parameters with uncertainty

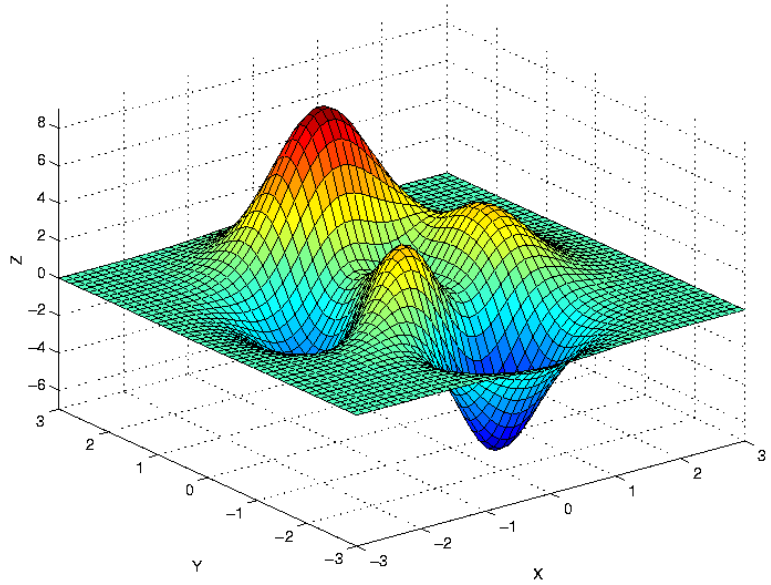




FBW-R: Next steps

- State of the model:
  - Recreates FBW Excel outputs, undergoing final testing

- **Future development:**
  - Conversion of point values to probabilistic parameters with uncertainty
  - Multi-variate sensitivity analysis – combinations of parameters?
  - Potentially: wrap into a graphical interface (e.g., Shiny app)



Chang *et al.* (2021)

Acknowledgements

- US Army Corps of Engineers
  - Ryan Woolbright
  - Rachel Laird
  - Richard Piaskowski

- Alden Research Laboratory, BioAnalysts, and TetraTech for documentation, parameterization
- Independent Scientific Advisory Board for comments and review in 2014

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Literature cited

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