Science, Service, Stewardship

Comparison of methods for Chinook abundances using CWT Run Reconstruction, PSC Chinook Model, and FRAM

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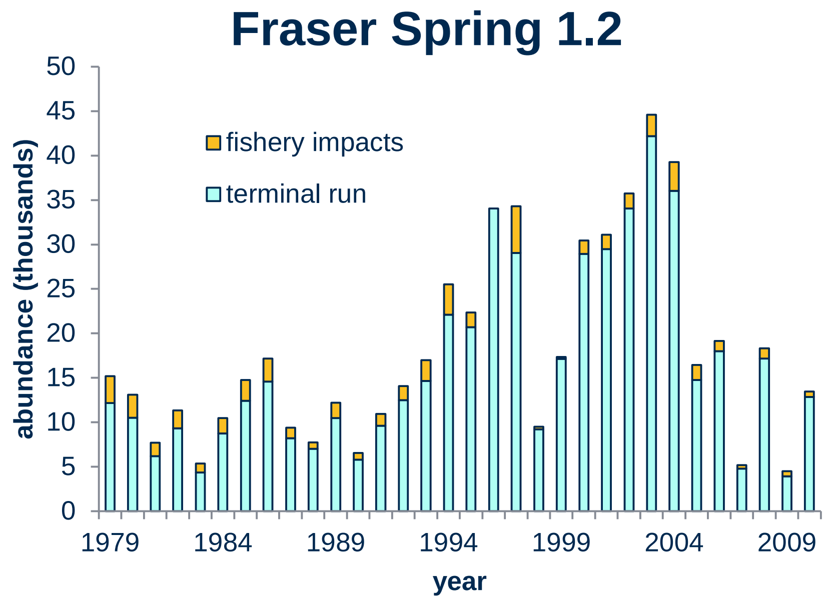
CWT based Run Reconstruction

- Rely on CWT recoveries in fisheries and escapement to reconstruct the population; starts with oldest age works to youngest age; applying natural mort. constant between ages.
- Fishery exploitation rates calculated from reconstructed cohort.
- CWT based exploitation and escapement relationship from representative hatchery groups used to derive total run size of stock/basin production.
- Usually, terminal run (ie mature run to river) used as anchor point to calculate number of fish taken in preterminal (mixed stock) ocean fisheries to produce total run size estimate.
- Run size estimates usually cover preterminal salmon fishery impacts and terminal run; does not include fish that do not mature, but survive and remain in the ocean (Parken-Kope, Workshop I).
- May be finer scale than run reconstruction using fishery model estimates for preterminal fishery expansions of terminal run.


Fraser Spring 1.2
fishery impacts
terminal run
abundance (thousands)
year
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1979
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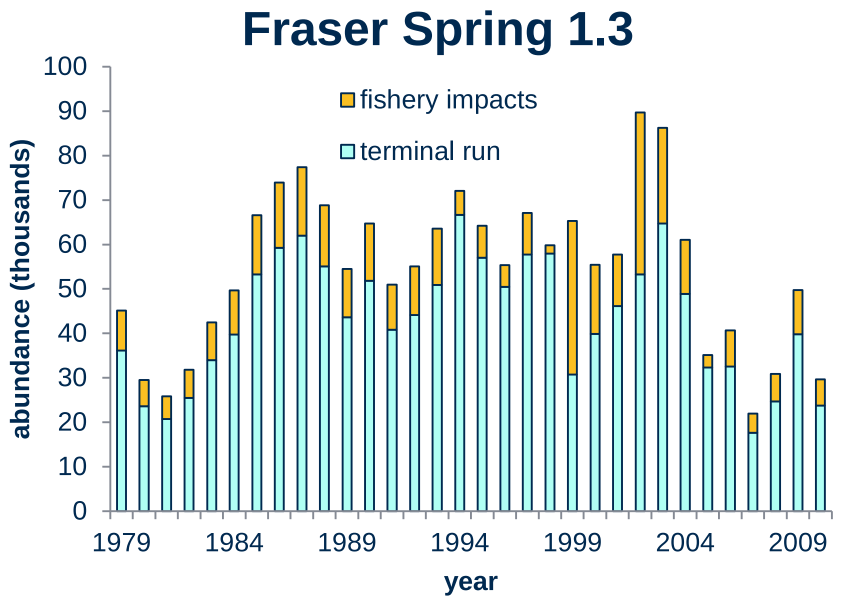
Fraser Spring 1.3
fishery impacts
terminal run
abundance (thousands)
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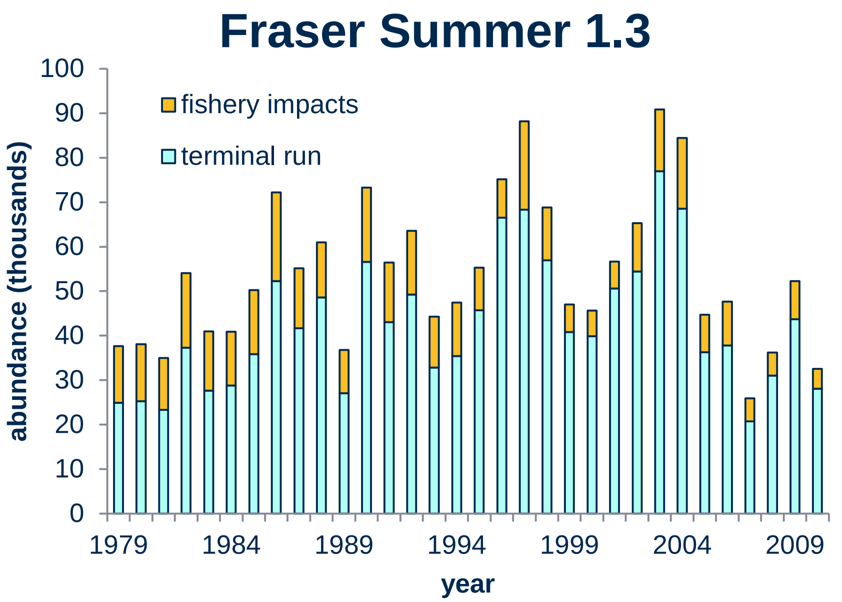
Fraser Summer 1.3
fishery impacts
terminal run
abundance (thousands)
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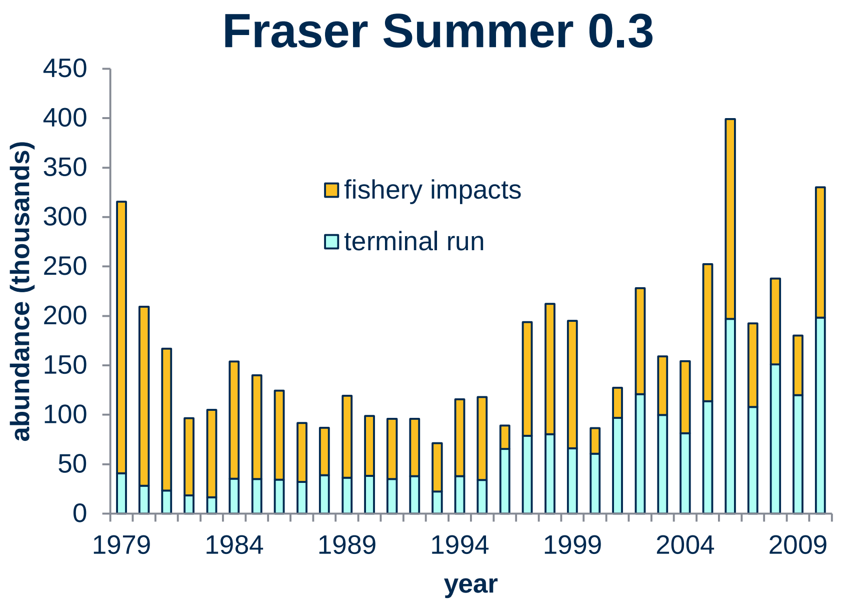
Fraser Summer 0.3
fishery impacts
terminal run
abundance (thousands)
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2009

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Chinook Fishery Models--commonality

- Rely on stock cohort reconstruction from CWT recoveries.
- Have different levels of stock, fishery, area, and time strata depending on salmon fishery management need.
- Use constant natural mortality rates across stocks, run years and within age classes.
- Exploitation rates derived from CWT recoveries applied to single-pool cohorts (“all fish in the sea”).
- Local-area total abundance not available; “catch” as an index

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PSC-CTC Chinook Model
(Abundance Indices (AI))

- Originally designed to assess rebuilding of Chinook stocks under the Pacific Salmon Treaty, can project stock abundances/escapement in future under different fishery regimes.
- Primary purpose now to calculate Abundance Indices(AIs) to identify catch ceilings in the “AABM” fisheries (Southeast Alaska troll, sport, net; northern BC troll and sport; WCVI troll and sport) under the PST.

Stocks and Fisheries in the Chinook Model

STOCK #	STOCK
1	**Southeast Alaska**
2	North/Central BC
3	Fraser Early
4	Fraser Late
5	West Coast Vancouver Island Hatchery
6	West Coast Vancouver Island Natural
7	Georgia Strait Upper
8	Georgia Strait Lower Natural
9	Georgia Strait Lower Hatchery
10	Nooksack Fall
11	Puget Sound Hatchery Fingerling
12	Puget Sound Natural Fingerling
13	Puget Sound Hatchery Yearling
14	Nooksack Spring
15	Skagit Wild
16	Stillaguamish Wild
17	Snohomish Wild
18	Washington Coastal Hatchery
19	Columbia UpRiver Brights
20	Spring Creek Hatchery
21	Lower Bonneville Hatchery
22	Fall Cowlitz Hatchery
23	Lewis River Wild
24	Willamette River
25	Spring Cowlitz Hatchery
26	Columbia River Summer
27	Oregon Coastal
28	Washington Coastal Wild
29	Lyons Ferry (Snake River Fall)
30	Mid-Columbia River Brights

FISHERY #	FISHERY
1	**Alaska Troll**
2	North BC Troll
3	Central BC Troll
4	WCVI Troll
5	WA/OR Troll
6	Georgia Strait Troll
7	**Alaska Net**
8	North BC Net
9	Central BC Net
10	WCVI Net
11	Juan De Fuca Net
12	Puget North Net
13	Puget South Net
14	Washington Coastal Net
15	Columbia River Net
16	Johnstone Strait Net
17	Fraser Net
18	**Alaska Sport**
19	North/Central BC Sport
20	WCVI Sport
21	WA Ocean Sport
22	Puget North Sport
23	Puget South Sport
24	Georgia Strait Sport
25	Terminal (Col Riv) Sport

Courtesy of John Carlile, ADFG-CTC

PSC-CTC Chinook Model Input Data

- Base Period (1979-82 catch year) CWT Data
- Fishery Catch Data
- Chinook Nonretention Release (CNR) Data
- Past Escapement and/or Terminal Run Data
- Terminal Run Forecasts
- Fishery Policy (FP) Data— harvest rates by fishery
- Maturation Rate and Adult Equivalent Data
- Hatchery Enhancement Data
- Spawner-Recruit Parameters
- Proportion Non-Vulnerable (PNV) Changes
- Inter-Dam Loss Factors

Complete Calibration Procedure (required for annual AI calculation)

CoShaker

Summarizes Base Period CWT Data by Stock.

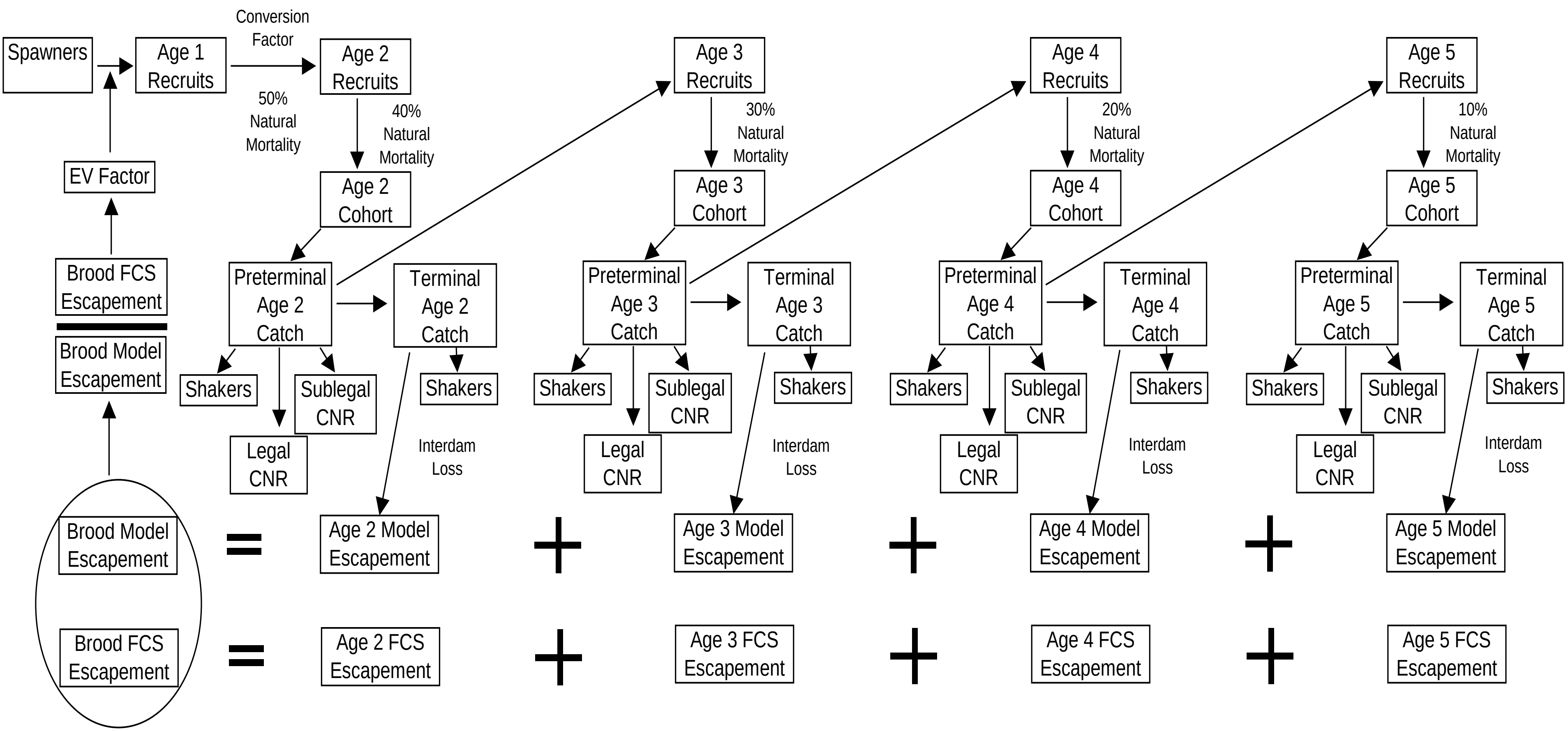
Calib

Computes Base Period Exploitation Rates, Initial Cohort Abundances and Spawner-Recruit Parameters.

Chinook Model

Fits to Catches, FPs, Escapement, Terminal Runs, Forecast Data, etc.

Chinook Model Calibration Procedure



Calculation of the Abundance Index

$$AI_{fy} = \frac{\sum_{s}\sum_{a}\left[C_{sa(b=y-a)} * SR_{a} * ER_{fsa} * (1 - PNV_{fa})\right]}{\sum_{y=1979}^{1982}\left\{\sum_{s}\sum_{a}\left[C_{sa(b=y-a)} * SR_{a} * ER_{fsa} * (1 - PNV_{fa})\right]\right\} / 4}$$

Where

AI = Abundance Index

C = Cohort Size

SR = Survival Rate (ie. 1- natural mortality)

ER = Base Period Exploitation Rate

PNV = Proportion Non-Vulnerable (ie legal size dependent)

f = fishery

s = stock

a = age

b = brood year

y = calendar year

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AI is catch-in-year divided by average annual catch in 1979-82. Catch-in-year is calculated as abundance-in-year times 1979-82 average exploitation rates. AIs are calculated for each stock in the fishery, then summed.

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Example AI

Fishing Year	Stock 1-O	Stock 2-I	Stock 3-I	Stock 4-C	Total All
1979-82 Ave Catch	**25,000**	**5,000**	**40,000**	**30,000**	**100,000**
2005	18,000	10,000	25,000	20,000	73,000
2006	5,000	4,000	20,000	10,000	39,000
2007	28,000	18,000	40,000	14,000	100,000
2008	20,000	2,000	30,000	34,000	86,000

AIs by stock and year

Fishing Year	Stock 1-O	Stock 2-I	Stock 3-I	Stock 4-C	Total All
1979-82 Ave Catch	0.25	0.05	0.40	0.30	1.00
2005	0.18	0.10	0.25	0.20	0.73
2006	0.05	0.04	0.20	0.10	0.39
2007	0.28	0.18	0.40	0.14	1.00
2008	0.20	0.02	0.30	0.34	0.86

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PSC Chinook Model—Key Points

- AI’s are index of abundance using catch in fishery, subject to size regs and season structure in each.
- AI’s for different fisheries have the same stocks measured—AI’s across fisheries are not additive.
- Stocks contributing to the AIs don’t all have the same preference/importance as prey for killer whales.
- AI for WCVI may have more relevance to SRKW than AI for SEAK because of SRKW range; any of the AIs may simply reflect general productivity of the ocean in a string of years.

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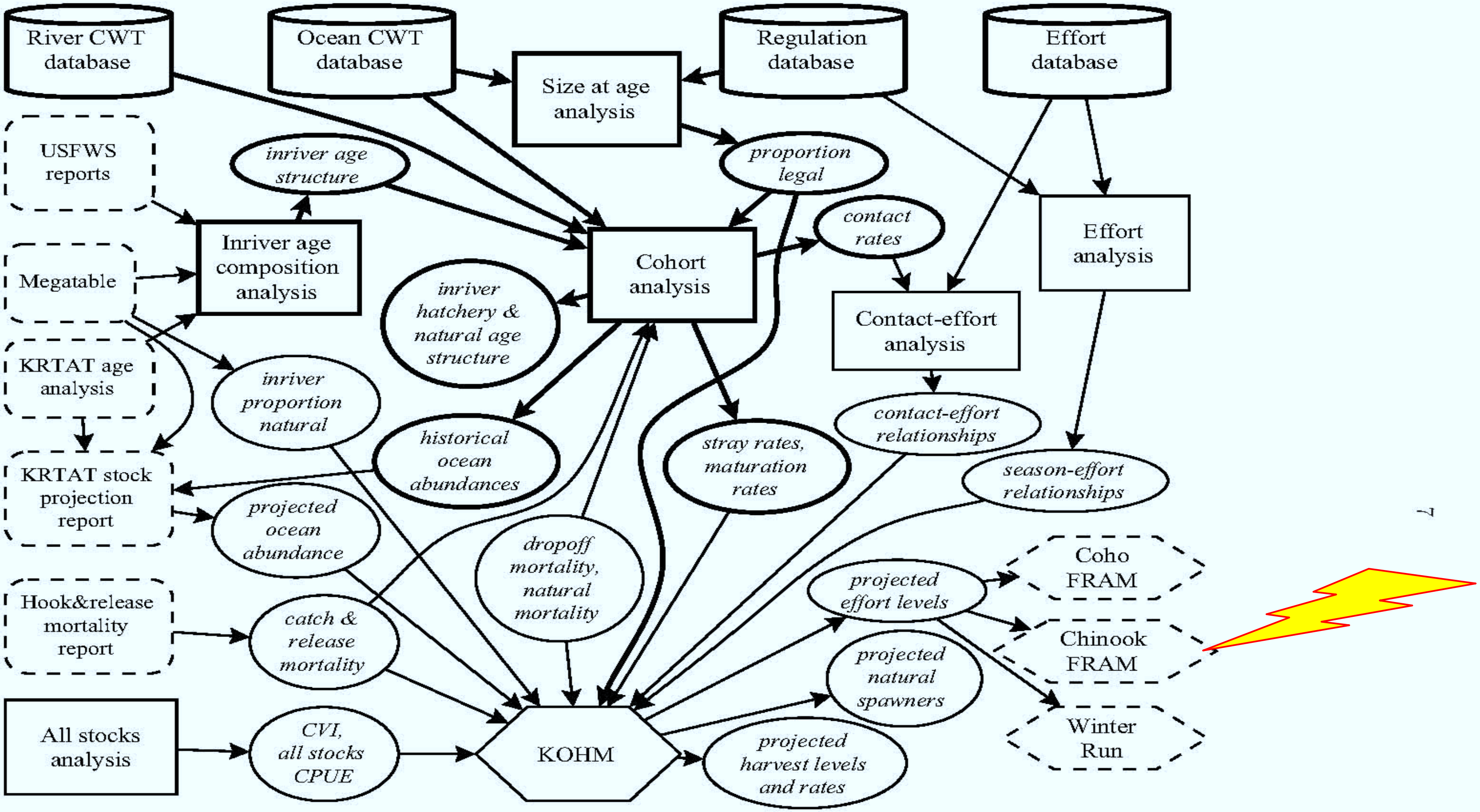
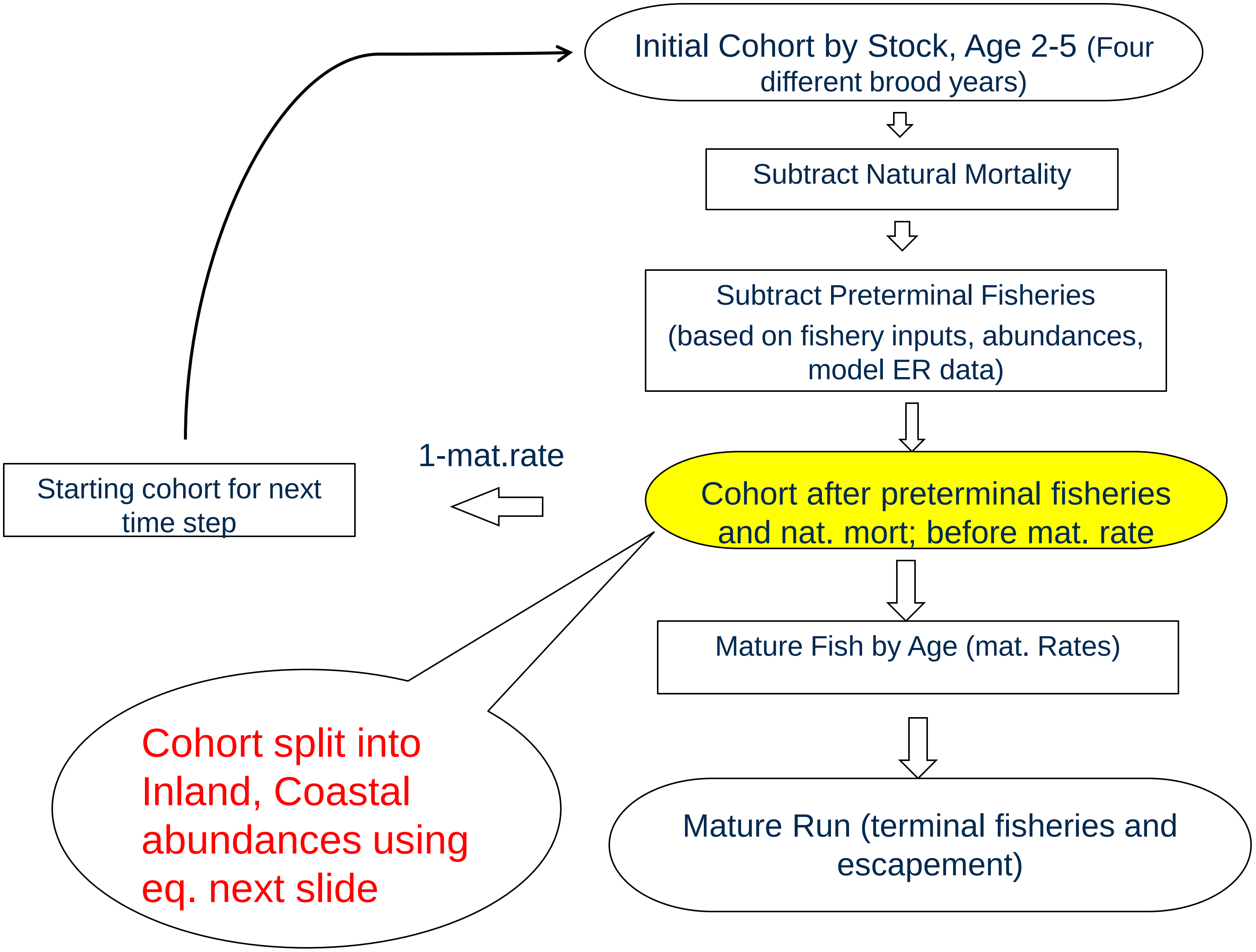
FRAM (“oh no, not this again”)


River CWT database
Ocean CWT database
Size at age analysis
Regulation database
Effort database
USFWS reports
inriver age structure
proportion legal
Inriver age composition analysis
Cohort analysis
contact rates
Effort analysis
Megatable
inriver hatchery & natural age structure
Contact-effort analysis
KRTAT age analysis
inriver proportion natural
contact-effort relationships
historical ocean abundances
stray rates, maturation rates
season-effort relationships
KRTAT stock projection report
projected ocean abundance
dropoff mortality, natural mortality
Coho FRAM
projected effort levels
Hook&release mortality report
catch & release mortality
Chinook FRAM
projected natural spawners
Winter Run
All stocks analysis
CVI, all stocks CPUE
KOHM
projected harvest levels and rates


Initial Cohort by Stock, Age 2-5 (Four different brood years)
Subtract Natural Mortality
Subtract Preterminal Fisheries
(based on fishery inputs, abundances, model ER data)
1-mat.rate
Starting cohort for next time step
Cohort after preterminal fisheries and nat. mort; before mat. rate
Mature Fish by Age (mat. Rates)
Cohort split into Inland, Coastal abundances using eq. next slide
Mature Run (terminal fisheries and escapement)

Abundance Distribution to SRKW Range Type

$$BP\_PPN_{s,l} = \%Esc_{s,l} + \sum_{f} \%Mort_{s,f,l}$$

Where BP_PPN = base period proportion for Inland, Coastal or Outside SRKW range

%ESC = percent of escapement across all ages

%Mort = percent of adult equivalent fisheries mortality; across all time steps and ages

S = FRAM stock

f = FRAM fishery

l = Inland (Salish Sea), Coastal within range of SRKW, or Outside range of SRKW

Apply $BP\_PPN_{s,l}$ to this

Cohort after preterminal fisheries and natural mortality removed (previous slide). Includes fish that will later die from natural mortality, or caught in fisheries or mature

Abundance of Age 3-5 Chinook in inland waters SRKW range per time step

→ **Abundance of Age 3-5 Chinook after preterminal fishing and natural mortality of all stocks projected to be available in inland SRKW waters (based on base period catch and escapement distribution).**

Biops and Workshop I FRAM based abundances used these for Jul-Sep time period in Chinook to SRKW pop. relationship (Eric Ward)

Abundance of Age 3-5 Chinook in coastal waters SRKW range per time step

→ **Abundance of Age 3-5 Chinook after preterminal fishing and natural mortality of all stocks projected to be available in coastal SRKW waters (based on base period catch and escapement distribution).**

Abundance of Chinook outside SRKW range

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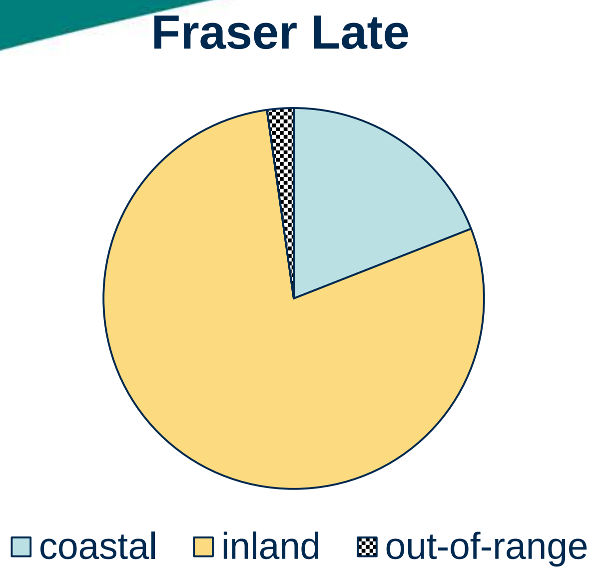
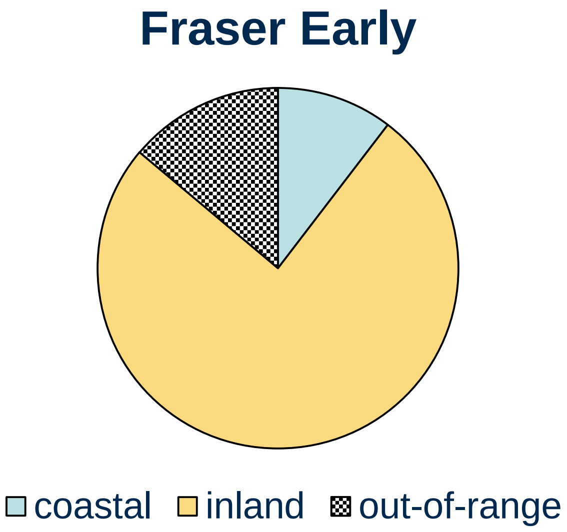
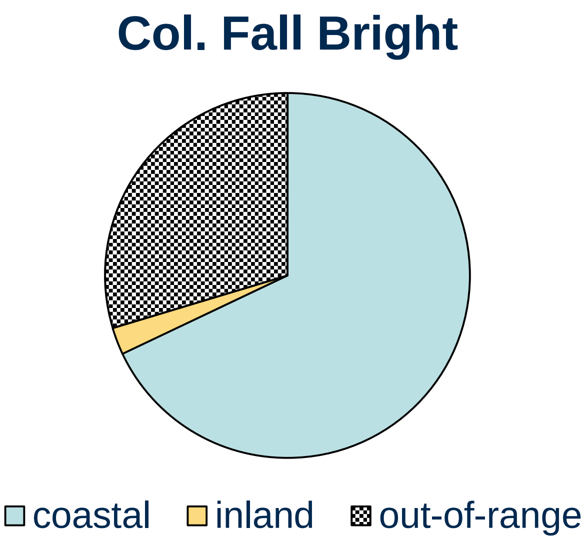
Contribution of stock cohort to Chinook prey in SRKW range







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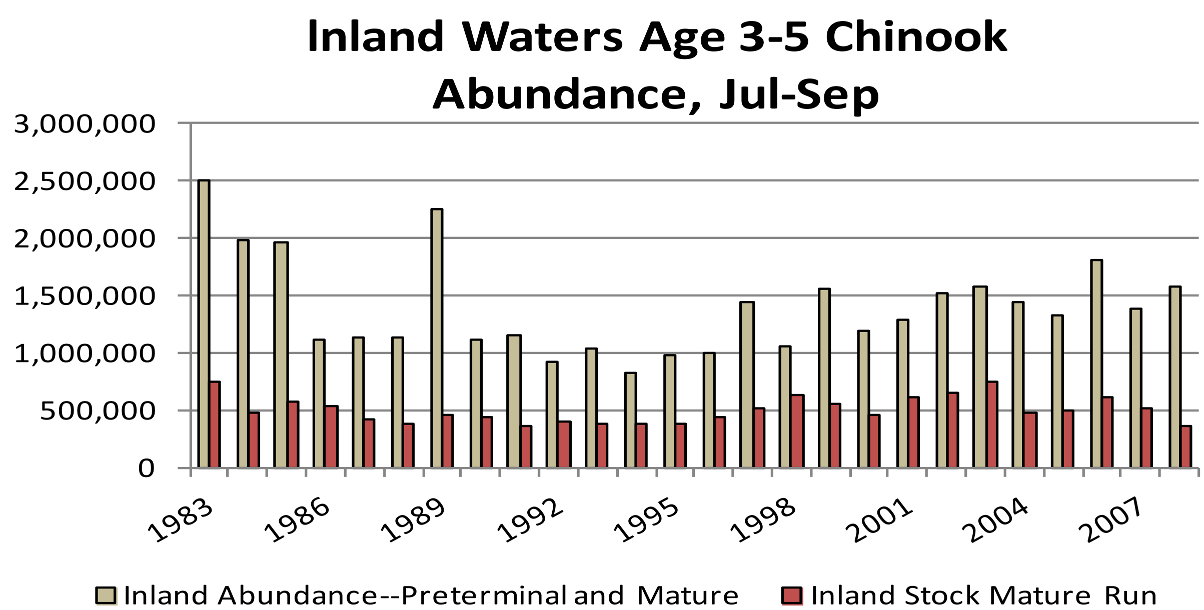
Workshop I follow up

- Calculated age 3-5 Chinook abundance for mature run of inland stocks.
- Calculated size selectivity curve using inland mature run(Eric Ward).



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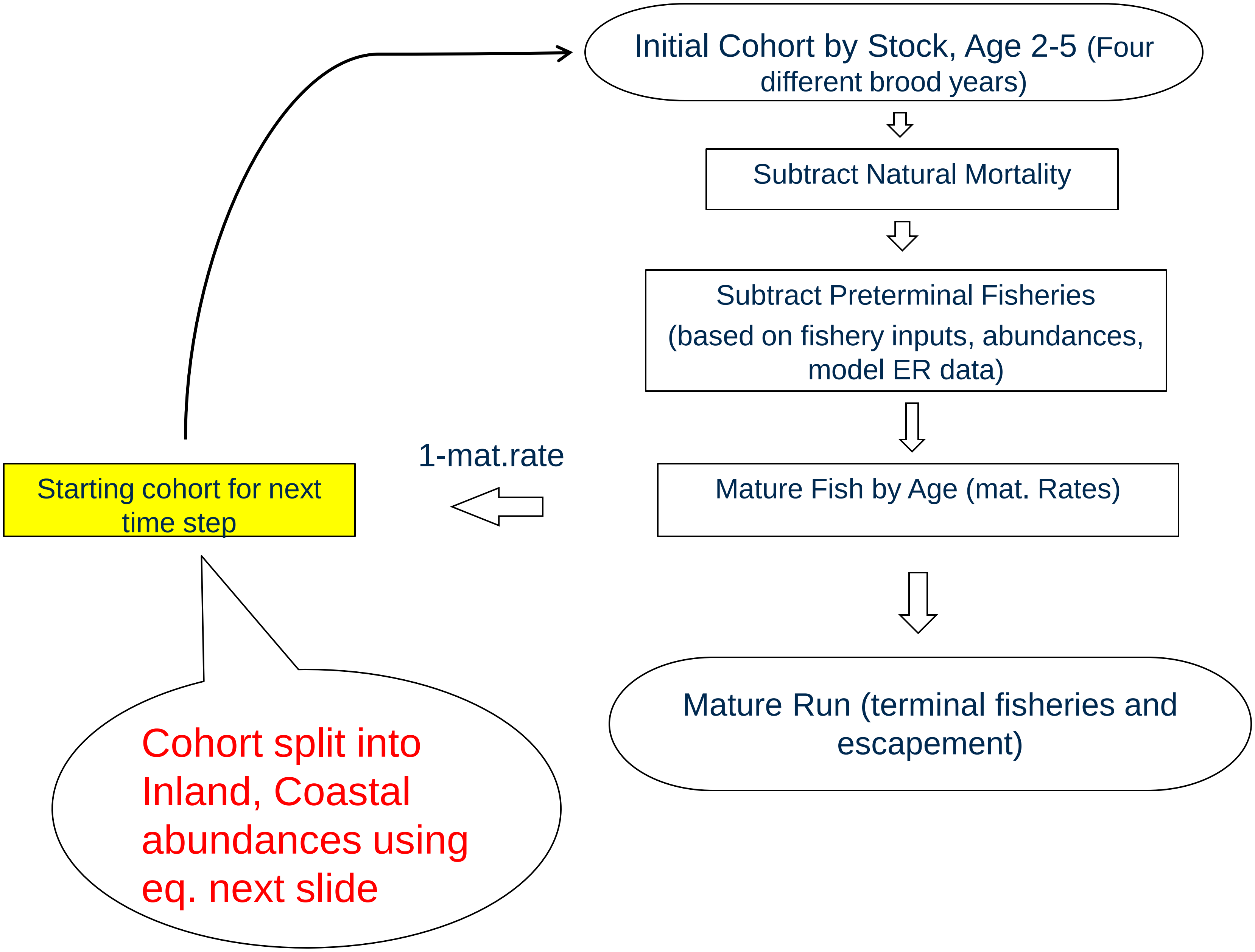
Attribute	CWT/Run Reconst.	PSC CTC Chinook Model	FRAM
Availability of data, reports	Yes and No	Yes, as in AIs	Yes and No
Abundance by fishery region	Yes (to fisheries)	Yes (to fisheries)	Yes (to fisheries)
Local area abundance	No	No	No
Fishery mortality by region	Yes	Yes	Yes
Exploitation rate by major fishery	Yes, (best CWTs)	Yes, (model est.)	Yes, (model est.)
Predation/natural mortality	No	as static rates	as static rates
Time strata	annual	annual	seasonal
Stock, Age, and Size of Chinook	Yes, stock, age, size	Yes, stock and age	Yes, stock, age, size
Mature Run	Yes	Yes	Yes
Ability to manipulate fisheries	Not easy	somewhat easy	"easy"
Chinook abundance w/I SRKW range	good coverage	No, for Calif, so. Oregon	good coverage, not all

IMHO

- CWT reconstructions, FRAM abundances, and AIs all forms of indices in sense that not all fish accounted for and not all available as prey at any one time/place.
- CWTs and fishery models not very good at estimating Chinook actually available as prey to SKRWs present in area.
- Inland and coastal origin stocks of different ocean distribution and mature run timing will have different importance as prey; Chinook abundance measure should try to capture this if possible.
- Some stocks shown as key in diet samples are not well represented in Chinook Model or FRAM; and not all stocks covered in these models either.
- Exploitation rate analysis of annual CWT recoveries provides best estimates of time series of past salmon fishery reductions to specific stocks in specific fisheries.
- Fishery models (FRAM, PSC-CTC) provide the best tools to make projections of the relative impacts on Chinook abundance from fishing season options.
- Distinguishing causation vs. correlation for Chinook “Abundance” and SRKW population parameters is way over my head.


FRAM
259125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1-mat.rate
Starting cohort for next time step
Mature Run (terminal fisheries and escapement)
Cohort split into Inland, Coastal abundances using eq. next slide

Canadian stock estimates (Parken-Kope Workshop I)

- For Canadian stocks actual terminal run data were used.
- Stocks were disaggregated to a finer scale than CTC model stocks.
- Pre-terminal fishery impacts were estimated from CWT recoveries of exploitation rate indicator stocks.
- Missing values in CWT fishery impact rates were filled in with CWT average rates, or relationships with either CWT or CTC model stocks.
- Expansions were made by calendar year.
- Incidental fishing mortality is not included.

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FRAM Model Processes

- From starting FRAM cohort abundance for each stock and age:
  - Compute natural mortality
  - Split cohort into mature & immature components
  - For each fishery compute:
    - Legal and Sublegal Populations using Von Bertalanffy growth functions
    - Landed Catch
    - Release and Other Mortality
  - Compute escapement by subtracting terminal area fishing mortality from mature run

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Major Model Input Data

Historical Data

- Stock specific exploitation rates derived from recoveries of coded-wire tags during the base period (1974-1979 brood years); modified to account for stocks not tagged in the base period
- Non-landed mortality rates on fish released
- Natural mortality rates; constant by age (0.4; 0.3; 0.2;0.1 for ages 2-5 respectively)
- Maturation rates; % that matures each age
- Von Bertalanffy growth functions by stock and maturity type.