Estimating Escapement Using GSI and CWT

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Escapement Data Applications

- Stock-recruitment analysis
  - Escapement goals
  - MSY (Exploitation Rate constraints)
- Pre-season fisheries impact modeling
- Post-season monitoring harvest impacts
- Stock status and trends analysis
  - Viability analysis
  - Recovery monitoring

Wild Escapement Estimation Problems

- Uncertainty in estimates based on direct measurement methods
  - Numerous methods and assumptions
  - Expansion factors
- Mark-recapture method is expensive
- Unknown hatchery stray component on spawning grounds

Proposed Alternative Method

- Indirectly estimate wild escapement using GSI-based stock composition with CWT-based exploitation (harvest) rates

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$$\text{Escapement} = \text{Catch} \times \frac{1 - \text{Harvest Rate}}{\text{Harvest Rate}}$$

Terminal Fishery Example

$$\text{Escapement} = \text{Catch} \times \frac{1 - \text{Harvest Rate}}{\text{Harvest Rate}}$$

Catch = 100
Harvest Rate = 0.1 (10%)
Escapement = 900

Assumptions

- Terminal fishery on mature fish
- No incidental or natural mortality
- Harvest rate equal for all ages

Additional Pre-terminal Considerations

- Incidental fishery mortality
- Natural mortality
- Maturation Rate
- Age-specific harvest impacts
- Catch estimate is reflective of escapement estimate

Pre-Terminal Algorithm using Maturation Rates

$$Esc_a = Catch_{a,f} * \frac{[1 - \sum_f (ER_{a,f} + IM_{a,f})] * MR_a * [1 - (HR_{term} - IM_{term} - NM_{term})]}{ER_{a,f}}$$

- Esc_a — Escapement Estimate (Stock/Age)
- $Catch_{a,f}$ — Catch estimated by GSI (Stock/Age/Fishery)
- $ER_{a,f}$ — Exploitation Rate CWT (Stock/Age/Fishery)
- IM_f — Fishery Incidental Mortality (Fishery)
- NM_{term} — Natural Mortality Rate (Stock/Age)
- MR_a — Maturation Rate (Stock/Age)
- HR_{term} — Terminal CWT Harvest Rate (Fishery)

Pre-Terminal Example

North Oregon Coast Chinook using SE Alaska Troll (PSC Expert Panel)

Age	Age Comp	GSI Catch	Maturation Rate	GSI Mature Catch	Ratio SEAK to Terminal	Terminal Estimate
6	0.018	467	1.000	467	0.727	642
5	0.118	3,033	0.988	2,995	0.192	15,571
4	0.766	19653	0.394	7,737	0.045	170,289
3	0.098	2,508	0.113	284	0.005	57,677
2	0.000	0	0.068	0	0.000	0

244,178

Revised Pre-Terminal Algorithm

$$\hat{M}_{term\ (W)} = \sum_{a} \sum_{f} \hat{\pi}_{a(I)} \hat{C}_{fa(W)}$$

$$\hat{\pi}_{a(I)} = \frac{n_{term,\ a(I)}}{\sum_{f} n_{fa(I)}}$$

C = Catch by fishery, stock, and age from GSI

n = CWT recoveries for stock and brood year

M = Mature Run (terminal)

π = CWT multiplier for terminal run

Revised Pre-Terminal Example

Brood Year	CWT SEAK	CWT Term	$\pi_{\alpha(1)}$ SEAK/ Term	GSI SEAK Catch	Mature Term Wild
1995	8	11	1.375	467	642
1996	52	267	5.135	3,033	15,571
1997	337	2,920	8.665	19,653	170,289
1998	43	989	23.000	2,508	57,677
1999	0	337	-	-	-

244,178

Advantages of Revised Algorithm

- Maturation Rates not needed for calculations
- Variance can be estimated
- Age Composition not needed if estimates are the same for GSI estimate (Wild Stock) and indicator stock (CWT)

Major Assumptions for Expansion of GSI – CWT Method

- Natural stock vulnerability and distribution in the ocean fishery is the same as that of the associated hatchery indicator stock. (“gorilla assumption”)
- Both stocks have the same growth and maturation rates.
- GSI stock catch estimates by age can be made without error.

Variance Estimate of NOC Terminal Run using multiple fishery recoveries

Brood Year	CWT SEAK	CWT Other	CWT Term	$\pi_{\alpha(I)}$	Variance $\pi_{\alpha(I)}$	CV $\pi_{\alpha(I)}$
1995	8	6	11	0.786	0.287	68%
1996	52	26	267	3.423	0.803	26%
1997	337	204	2,920	5.397	0.281	10%
1998	43	60	989	9.602	4.585	22%
1999	0	0	337	-	-	-
Totals	440	296	4187	5.689	0.223	8%

Comparison of Estimates

- ODFW Terminal Run Estimate ~ 150,000
- GSI + CWT Estimate 244,178
- Difference ~ 60%

- High Level of uncertainty in escapement estimate and terminal fishery numbers