# Lewis River Hydroelectric Projects Settlement Agreement
# Aquatic Coordination Committee (ACC)
# Meeting Agenda

**Date & Time:** **Thursday, April 10, 2014**
**9:00 a.m. – 11:45 a.m.**

**Place:** **Merwin Hydro Control Center**
**105 Merwin Village Court**
**Ariel, WA 98603**

**Contacts:** **Frank Shrier: (503) 320-7423**

| Time | Discussion Item |
|---|---|
| 9:00 a.m. | Welcome<br>➢ Review Agenda & 3/13/14 Meeting Notes<br>➢ Comment & accept Agenda & 3/13/14 Meeting Notes |
| 9:15 a.m. | Woodland Release Ponds; explore other options/alternatives for release pond or direct release strategy |
| 10:00 a.m. | Review Ocean Recruit Calculation and Results |
| **10:45 a.m.** | **Break** |
| 11:00 a.m. | 2012/2013 Aquatic Fund Project - BT Habitat Restoration Project ID Assessment<br>➢ Request for contract extension and add'l insurance expense |
| 11:15 a.m. | Study/Work Product Updates<br>o Eulachon Consultation - Status<br>o Woodland Release Ponds - Status<br>o Hatchery Upgrades - Status<br>o Hatchery and Supplementation Plan – Status<br>o Crab Creek Acclimation Pond Screen - Status<br>o Merwin Upstream Construction - Status<br>o Swift Downstream Collector – Status<br>o Future Fish Passage Facilities New Information – Status |
| 11:30 a.m. | ➢ Next Meeting's Agenda<br>➢ Public Comment Opportunity<br>Note: all meeting notes and the meeting schedule can be located at: http://www.pacificorp.com/es/hydro/hl/lr.html# |
| **11:45 a.m.** | ***Adjourn*** |

Join by Phone
+1 (503) 813-5252 [Portland, Ore.]
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Conference ID: 5709805

**FINAL Meeting Notes**
**Lewis River License Implementation**
**Aquatic Coordination Committee (ACC) Meeting**
**April 10, 2014**
**Ariel, WA**

**ACC Participants Present (13)**

Kimberly McCune, PacifiCorp Energy
Frank Shrier, PacifiCorp Energy
Erik Lesko, PacifiCorp Energy (via conference)
Peggy Miller, WDFW (via conference)
Aaron Roberts, WDFW
Eric Kinne, WDFW (via conference)
Jim Malinowski, Fish First (via conference)
Pat Frazier, LCFRB
Adam Haspiel, USDA Forest Service
Shannon Wills, Cowlitz Indian Tribe
Diana Gritten-MacDonald, Cowlitz PUD (via conference)

Mara Zimmerman, WDFW (via conference)
Pete McHugh, WDFW (via conference)

**Calendar:**

| | | |
|---|---|---|
| May 8, 2014 | ACC Meeting | Merwin Hydro |
| June 12, 2014 | ACC Meeting | Merwin Hydro |

| **Assignments from April 10, 2014 meeting** | |
|---|---|
| Eric Kinne (WDFW): Look at old conceptual hand drawings of Pond 15 alteration to act as a release pond and provide a copy to the ACC for its review. | **N/A – pursued another option than Pond 15.** |

| **Assignments from March 13, 2014 meeting** | |
|---|---|
| Shrier: Send copy of email sent to Bryan Nordlund (NMFS) regarding the Crab Creek 60% design drawings to McCune and Michelle Day (NMFS). | **Complete – 3/13/14** |
| Haspiel: Email Michelle Day (NMFS) when he receives the draft BA for Crab Creek. | **Complete** |
| ACC: Explore other options/alternatives for Woodland release pond or direct release strategy. Bring ideas to the April ACC meeting. | **Complete – 4/9/14** |

| **Assignments from February 13, 2014 meeting** | |
|---|---|
| Wills: Contact Cowlitz Indian Tribe Council and Yakama Nation Council to encourage them contacting NMFS regarding concern over lack of response regarding the Eulachon consultation. | **Pending** |
| Eric Kinne: Work on securing the 2012/2013 lower river coho abundance survey data and provide this information to Erik Lesko (PacifiCorp) for | **Pending – as of 5/8/14 data has** |

| | |
|---|---|
| the 2013 H&S Annual Report. Lesko requires this data by February 28, 2014. | **not been received and will not be provided in the 2014 report** |

**Opening, Review of Agenda and Meeting Notes**

Frank Shrier (PacifiCorp) called the meeting to order at 9:07 a.m. The ACC reviewed the agenda and agreed to review the Ocean Recruit results first for the benefit of certain attendees. The March 13, 2014 meeting notes were reviewed and approved without change at 9:15 a.m. Kimberly McCune (PacifiCorp) will finalize the March 13, 2014 meeting notes for posting to the Lewis River website.

**Review Ocean Recruit Calculation and Results**

Shrier informed the ACC attendees that preliminary results were provided via email, which has been attached to these meeting notes, **Attachment A**.

Shrier expressed that he had hoped more would have been completed at this point but PacifiCorp has taken the necessary steps to extend the contract with Fish Metrics and provide the funds needed to finish the model and populate it so it can be used as an effective tool. The contract was extended to May 31, 2014 to finish the calculation project.

Shrier explained Ocean Recruit to be escapement plus harvest which is defined the Lewis River Settlement Agreement. The calculations in the M&E Plan included incidental mortalities. The ACC, Mara Zimmerman (WDFW) and Pete McHugh (WDFW) discussed the example cohort model as detailed in Fish Metric's report, computing incidental mortalities, cohort reconstruction, comparing Lewis River numbers to other stocks/watersheds, sensitivity analysis and spatial complexity. McHugh offered his availability to speak with Brian Pyper (Fish Metrics) to lend his knowledge and expertise. Shrier will provide McHugh's contact information to Pyper.

Jim Malinowski (Fish First) expressed concern that targets are already low in his opinion; he expressed caution to not let the model over estimate what is available for harvest by including incidental mortalities.

In response to Malinowski's questions Shrier informed the ACC that he is counting on peer review and other expert entity(s) to review the model annually. The ACC will have a 30-day review and comment period.

**Woodland Release Ponds: explore other options/alternatives for release pond or direct release strategy**

In order to address the delayed construction schedule to Spring 2015 the ACC discussed options as alternatives to direct release to evaluate mortality. Options included using Pond 15 at Lewis River hatchery, using a circular pond and potentially using the Echo Bay net pens. There was also discussion of using a small net pen in Pond 15 to more easily assess mortality and move fish. Erik Lesko expressed potential concerns with disease transmission from adults in the center channel; however, WDFW did not view this potential as significant. Pond 15 has been used in the past, but there is concern that release from the pond may cause injury. There was discussion about creating a plunge pool during the release periods so mitigate this concern; Pond 15 also lends itself to keep the fish and they can leave overnight; monetary investment will be needed for any option selected. Eric Kinne (WDFW) will look at previous hand drawings that WDFW developed in the past looking at various release configurations for the pond and, if available, provide a copy to the ACC for its review.

Aaron Roberts (WDFW) suggested arranging a meeting as quickly as possible with interested parties to discuss the options in more detail and view the Pond 15 alternatives.

A meeting was scheduled at Lewis River Hatchery on April 17, 2014 at 11:30am. Attendees include, Erik Lesko, Aaron Roberts, Shannon Wills and Erik Kinne.

*<Break 10:05am>*
*<Reconvene 10:15am>*

**2012/2013 Aquatic fund Project – BT Restoration Project ID Assessment: Request for contract extension and add'l insurance expense**
McCune informed the ACC attendees that Mt. Saint Helens Institute (MSHI) requested a contract extension to 12/31/2016 and payment of the 2015/2016 insurance expense from ACC funds for an amount not-to-exceed (NTE) $3,400 for the Bull Trout Restoration ID Assessment project.

MSHI reported via email on March 21, 2014 that all project partners of the above-referenced project decided that the project needs to be extended for an additional year. The extension request is due to incomplete surveying as a result of the government shutdown in October 2013 and to high stream flows in late September. MSHI also reported on April 8, 2014 that the following work has been completed thus far:

1. **Bull trout bibliography and collection of existing data (in-kind, MSHI)**

2. **Temperature hobo's deployed (in-kind, MSHI and USFS)**
   - Pine Creek, P-8, and below their confluence (3 units)
   - Little Creek (2)
   - Crab Creek (2)
   - Drift Creek (2)
   - Bean Creek (2)
   - Rush Creek (3)
   - Spencer Creek (1)
   - Upper Muddy River (1)
   - Clearwater Creek (1)
   - Swift Creek (1)
   - Clear Creek (1)
   - Elk Creek (1)

3. **USFS Level III Stream Surveys (in-kind, USFS)**
   - 20 miles of stream surveyed

4. **Snorkel survey design (WDFW)**

5. **Snorkel surveys started (MSHI)**
   - 12 days of surveying
   - Just over 1 rotation of approximately 25 miles
   - Weather conditions and government shutdown. Too much time elapsed to continue surveying.
   - No redds found, adults found including in Big Creek

6. **Habitat and snorkel survey design planning (WDFW) (to be completed and implemented in 2014)**

The ACC decision is outlined in the table below. ACC representatives not in attendance have seven (7) days to provide a response/decision.

After the 7-day comment period the ACC decisions will be considered final and McCune will proceed with notifying MSHI.

| **ACC Representative** | **Decision to use Aquatic Fund for 2015/2016 MSHI additional insurance expense for the above-referenced 2013 Aquatic Fund Projects and to extend the agreement to 12/31/2016 (NTE $3,400): Yes or No** |
|---|---|
| Frank Shrier, PacifiCorp Energy | Yes |
| Adam Haspiel, USFS | Yes |
| Aaron Roberts, WDFW | Yes |
| Pat Frazier, LCFRB | Yes |
| Diana Gritten-MacDonald, Cowlitz PUD | No – but will not block the decision to move forward |
| Jim Malinowski, Fish First | No – but will not block the decision to move forward |
| Shannon Wills, Cowlitz Indian Tribe | Yes |

**Study/Work Product Updates**

**Eulachon Consultation**
Michelle Day (NMFS) has committed to providing the biological assessment to her supervisor for internal review by April 30, 2014.

**Hatchery and Supplementation (H&S) Program**

- Wild winter steelhead collection is ongoing at both the Merwin trap and through in-river netting. We have increased our in-river netting effort the past two weeks in an effort to capture and meet targets for females. Currently we have 7 females and 7 males assigned to the Lewis River. 5 males and 4 females are also being held pending assignment. PacifiCorp is again netting the river today.

- As in 2013, PacifiCorp PIT tagged a portion of the late winter steelhead production and put those fish in circular tanks as opposed to raceways. This year we tagged 800 smolts (last year was 1,000). We expect our first returns from the 2013 group in spring of 2015. This program is intended to generally document return rates between raceway and circular pond reared late winter steelhead smolts.

- Erik Lesko will be working on a new draft of the HS plan this year. Consultants will also provide expertise during the rewrite. Target date for a draft plan is July 1. Meetings will be scheduled to review the plan and finalize by December 2014. In addition, the HS subgroup will be working on the 2015 Annual Plan concurrently.

- Screw traps are both in place and fishing. Catch results are not yet available. PacifiCorp is still waiting on permit approval for a tandem trap in the lower Lewis River (currently there is only a single trap).

- Aerial surveys for released steelhead started last week and will continue every other week through May. In addition, fixed stations have been placed at the Swift collector, Swift boat ramp and at Eagle Cliff.

**Hatchery Upgrades**
Two projects remain as part of Schedule 8.7 of the Settlement Agreement.

**Speelyai Hatchery Intake Modifications:** On Schedule for completion in 2014.

**Merwin Hatchery PLC Ozone Upgrades:** This project is ongoing and scheduled for completion by the end of November

**Acclimation Pond/Crab Creek Screen**
Adam Haspiel (USFS) informed the ACC attendees that the Forest Service (FS) does not need to go back out for comment with the Instream/Crab Creek environmental assessment. The FS will submit its decision approximately mid to the end of April to begin the initial 45-day objection period. If objection is received then there is another 45-day review period.

**Muddy and Clear Creek Acclimation Ponds**
PacifiCorp tagged 10% (3,800) fish per pond; completed last week. Placing fish on April 16, 2014. Experienced some vandalism already; The ponds were flushed and made ready to receive fish by next week. The Muddy River intake was back-flushed and there was virtually no sediment in the instream intake.

**Merwin Upstream and Swift Downstream Collector Status**
PacifiCorp provided the Lewis River Fish Passage Report to the ACC via email on April 7, 2014 (**Attachment B**).

**Development of New Information to Inform Fish Passage**
Bringing annual report to PacifiCorp in May that summarizes the 2013 efforts and identifies the 2014 work; thanks to WDFW we provided additional 5,000 coho smolts for release into Yale Lake for hydroacoustic tracking; leading to where we might position the Yale surface collector; the crew is working day and night to gather the necessary information.

*<11:00 a.m. meeting adjourned >*

**Agenda items for May 8, 2014**

- ➢ Review April 10, 2014 Meeting Notes
- ➢ Study/Work Product Updates

**Public Comment**
None

**Next Scheduled Meetings**

| | |
|---|---|
| May 8, 2014 | June 12, 2014 |
| Merwin Hydro Control Center | Merwin Hydro Control Center |
| Ariel, WA | Ariel, WA |
| 9:00 a.m. –11:00am | 9:00 a.m. – 3:00pm |

**Meeting Handouts & Attachments**

- ➢ Notes from 3/13/14
- ➢ Agenda from 4/10/14
- ➢ **Attachment A** – Preliminary assessment of methods and steps required to compute ocean recruits of salmon for the Lewis River, as provide by Fish Metrics - March 31, 2014
- ➢ **Attachment B** – Lewis River Fish Passage Report, March 2014

## Preliminary assessment of methods and steps required to compute ocean recruits of salmon for the Lewis River

Brian Pyper, Fish Metrics

March 31, 2014

## Summary

For this contract, I was tasked to provide assistance with the interpretation and implementation of methods for computing ocean recruits for components of Lewis River salmon production. It is my opinion that considerable effort is required to produce a (reasonably) defensible framework for computing the desired metrics. While considerable progress was made, there is still much work to do to (1) complete the general statistical framework; (2) integrate ocean-wide CWT recovery data (RMIS) with specific sampling programs for fisheries and escapements within the Lewis River basin; and (3) develop robust procedures for annually computing ocean recruits. In this report, I provide a rough outline of the various methods, data, and tools required to compute ocean recruits, and conclude with recommendations for steps needed to complete these tasks.

## Background

The Lewis River Hatchery and Supplementation Plan (H&S Plan) identified three indices that could be used to measure ocean recruits (PacifiCorp Energy and Cowlitz PUD 2006). These were reiterated in the Aquatic Monitoring and Evaluation Plan ("AM&E Plan") for the Lewis River (PacifiCorp Energy and Cowlitz PUD 2010). In both reports, it is noted that "ocean recruits" is defined in the Settlement Agreement as "… *the total escapement (fish that naturally spawned above Merwin and hatchery fish) plus harvest (including ocean, Columbia River, and Lewis River Harvest)*." Furthermore, in both reports it is noted that jacks are not to be included or counted as part of the ocean recruits analysis (May 11, 2006 ACC Meeting).

The three measures discussed are:

1. **Age 2 Recruits (Age 2)**: Number of fish alive at the time of first recruitment into a fishery (typically at age 2). Represents the maximum number of fish available to be managed.

2. **Adult Equivalent Run (AER)**: The total number of fish that would have returned to the spawning grounds at all ages in the absence of fisheries. In other words, AER is the best estimate of adult run-size absent human harvest.

3. **Catch Plus Escapement (C+E)**: Total catch of all ages plus total escapement of all ages. This method is in reality the outcome of harvest management activities affecting the species.

Further details in the H&S Plan indicate that: (1) all three methodologies will be used to calculate spring Chinook and coho ocean recruit numbers, while only the third method (catch plus escapement) will be used for the steelhead calculation (due to limited harvest); and (2) program success for Chinook and coho should likely be based on the AER method because it defines total production absent fisheries.

Formulas for computing the above recruitment metrics were provided in the H&S plan and duplicated in Appendix D of the AM&E Plan. However, the computations for AER are not correct. The flow chart presented in Figure D-1 (PacifiCorp Energy and Cowlitz PUD 2010) depicts a simple cohort model, while the "AER equations" are actually cohort-reconstruction equations (with additional errors) used to estimate age-specific ocean recruits. I recommend that these formulas be disregarded.

In the following sections, I outline methods required to compute the three measures of ocean recruits. Computations of catch plus escapement (C+E) are relatively trivial, although considerable effort may be required to tabulate catch and escapement data. Estimates of age-2 recruits and AER require cohort modeling (or some suitable proxy thereof). Thus, I begin with a simple cohort model and then discuss addition complexities in later sections.

## Example cohort model

The following model provides a very simple depiction of age-specific processes and fisheries for a typical brood-year cohort of Chinook salmon. For initial consistency, the model structure is very similar to that presented in Appendix D of the AM&E Plan, which included possible straying and pre-spawn mortality. A model schematic is provided in Figure 1; variables and parameters are defined in Table 1.

In this example, it is assumed that ocean recruitment starts at age $a = 2$ and ends at age $a = 5$. Catch ($C$) and incidental fishing mortalities ($I$) are defined for three sequential fisheries: ocean (subscript "1"); Columbia River (subscript "2"); and terminal (subscript "3"). Abundances ($N$) are depicted at four stages: $N_0$, the starting ocean abundance of a given age before applying the natural survival rate ($s$); $N_1$, the abundance just prior to ocean fishing; $N_2$, the abundance of mature recruits entering the Columbia River; and $N_3$, the abundance of mature recruits entering the Lewis River and terminal fishery.

For illustrative purposes, the sequential equations for propagating a cohort forward through time are as follows (e.g., starting with an assumed age-2 abundance, $N_{0,a=2}$):

$$N_{1,a} = s_a N_{0,a}$$ Abundance before ocean fisheries

$$N_{2,a} = m_a (N_{1,a} - C_{1,a} - I_{1,a})$$ Abundance to Columbia River

(1) $$N_{3,a} = (1 - r_a)(N_{2,a} - C_{2,a} - I_{2,a})$$ Abundance to terminal fisheries

$$E_a = (1 - p_a)(N_{3,a} - C_{3,a} - I_{3,a})$$ Escapement

$$N_{0,a+1} = (1 - m_a)(N_{1,a} - C_{1,a} - I_{1,a})$$ Abundance next year

The computations end with the final age group for which the maturity rate, $m_a$, is 1.0 (100%).

Our interest lies in cohort reconstruction. For a given brood-year cohort, it is assumed that age-specific values of catch ($C$) and escapement ($E$) are known, and estimates of incidental mortalities ($I$) are available. The reconstruction equations run backwards starting with age-5 data, providing the following age-specific estimates of abundance and maturity rate:

$$\hat{N}_{3,a} = E_a/(1-p_a) + C_{3,a} + \hat{I}_{3,a}$$ Abundance to terminal fisheries

$$\hat{N}_{2,a} = \hat{N}_{3,a}/(1-r_a) + C_{2,a} + \hat{I}_{2,a}$$ Abundance to Columbia River

(2) $$\hat{N}_{1,a} = \hat{N}_{0,a+1} + \hat{N}_{2,a} + C_{1,a} + \hat{I}_{1,a}$$ Abundance before ocean fisheries

$$\hat{N}_{0,a} = \hat{N}_{1,a}/s_a$$ Starting abundance

$$\hat{m}_a = \hat{N}_{2,a}/(\hat{N}_{2,a} + \hat{N}_{0,a+1})$$ Estimate of maturity rate

where $\hat{N}_{0,a=6} = 0$. Incidental mortalities and parameter assumptions are discussed further below.

**Table 1.** Variables and parameters in the cohort model.

| Symbol | Description |
|---|---|
| *t* | Subscript denoting brood year |
| *a* | Subscript denoting age |
| *N* | Abundance (number of fish) |
| *C* | Catch (number of fish) |
| *I* | Incidental fishing mortality (number of fish) |
| *E* | Escapement (number of fish) |
| *s* | Natural survival rate |
| *m* | Maturity rate |
| *r* | Stray rate |
| *p* | Pre-spawn mortality rate |

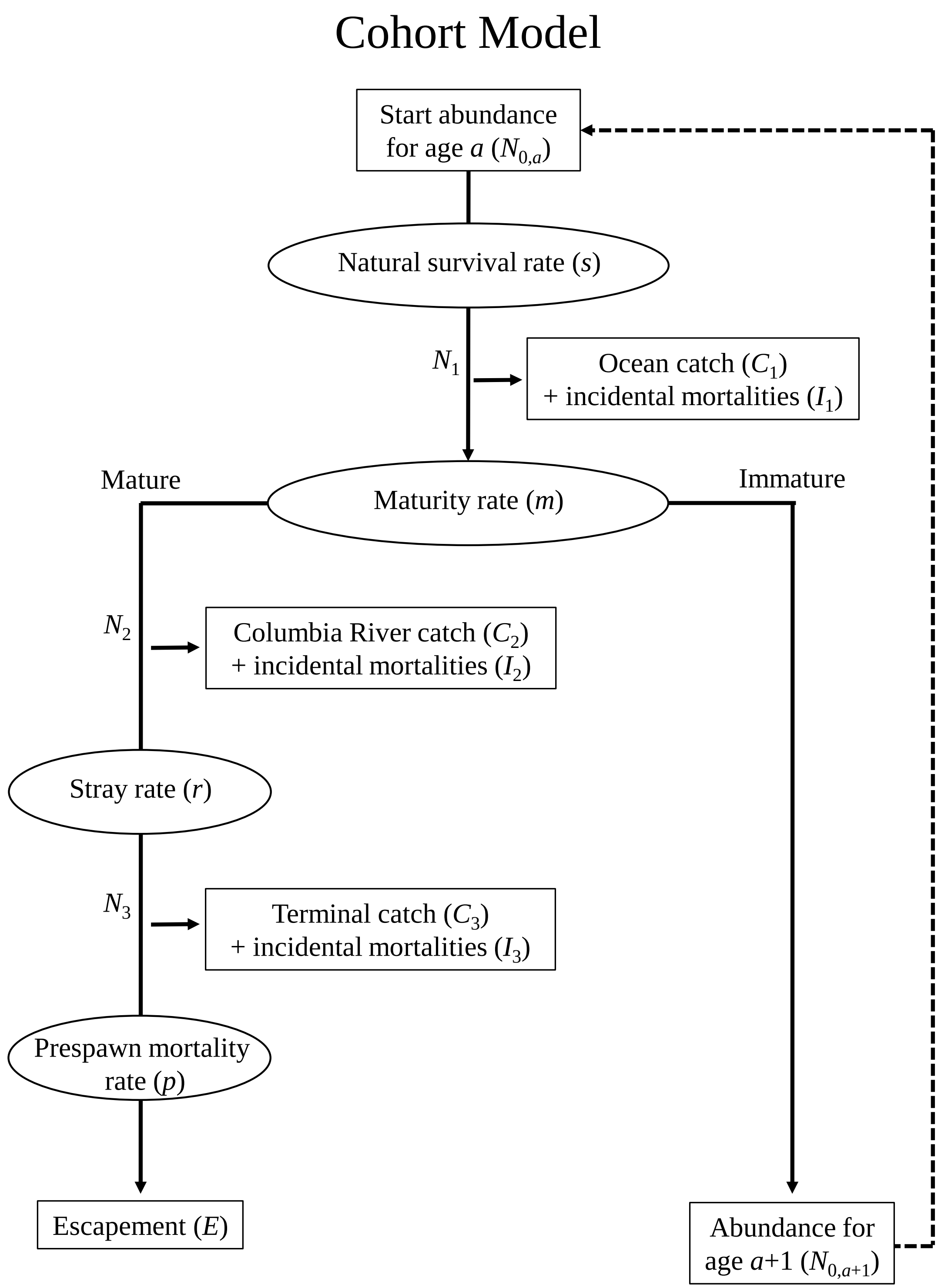


**Figure 1.** Cohort model depicting processes and fisheries for a given age (subscript "*a*" omitted for clarity). See text for details.

## Measures of ocean recruits

The following provides simple formulas for computing measures of ocean recruits, predicated on the above cohort model and symbol definitions. Additional details are provided in later sections.

Catch plus escapement

Catch plus escapement, $(C+E)_t$, for brood year $t$ is computed as the sum of age-specific escapement ($E$) and catch (based on expanded CWT recoveries) in ocean fisheries ($C_1$), Columbia River mainstem fisheries ($C_2$), and terminal fisheries ($C_3$):

$$(3) \qquad (C+E)_t = \sum_{a=2}^{5} \left( E_{a,t} + C_{1,a,t} + C_{2,a,t} + C_{3,a,t} \right).$$

Age-2 recruits

A cohort reconstruction is required to estimate age-2 recruitment (e.g., see equation 2). To reiterate, the definition provided in the AM&E Plan for age-2 recruits is the "[n]umber of fish alive at the time of first recruitment into a fishery." This value is given by $\hat{N}_{1,a=2}$ in equation (2). Additional data requirements and computational details are discussed below.

Adult equivalent run (AER)

As noted above, the AER measure was defined as:

> "The total number of fish that would have returned to the spawning grounds at all ages in the absence of fisheries. In other words, AER is the best estimate of adult run-size absent human harvest."

This is somewhat ambiguous in terms of the final destination; on one hand it's the "spawning grounds" whereas "adult run-size" could be interpreted as, for example, "entering the Columbia River" or "entering the Lewis River." However, as outlined below, this distinction only matters if straying rates ($r$) and/or pre-spawn mortality rates ($p$) are greater than zero.

A general formula for adult equivalent returns (AER) is given by:

$$(4) \qquad AER_t = \sum_{a=2}^{5} \left( f_{E,a} E_{a,t} + f_{1,a}[C_{1,a,t} + \hat{I}_{1,a,t}] + f_{2,a}[C_{2,a,t} + \hat{I}_{2,a,t}] + f_{3,a}[C_{3,a,t} + \hat{I}_{3,a,t}] \right)$$

where $f$ denotes an adult equivalent factor (AEF). Two sets of AEFs are considered: (1) AEFs that exclude strays and pre-spawn mortalities as adult equivalents (i.e., only recruits that would have reached the spawning grounds); and (2) AEFs that include strays and pre-spawn mortalities as adult equivalents (i.e., all recruits that would have entered the Columbia River). Note that when all stray rates ($r_a$) and pre-spawn mortality rates ($p_a$) are equal to zero, both sets of AEFs will be the same.

For AER estimates that exclude strays and pre-spawn mortalities, the AEF factors are defined as (for ages 2 through 5):

$$f_{E,a} = 1 \quad \text{AEF for escapement}$$

$$f_{1,a=5} = (1 - p_5)(1 - r_5) \quad \text{AEF for age-5 ocean impacts}$$

$$f_{1,a=4} = m_4(1 - p_4)(1 - r_4) + (1 - m_4)s_5 f_{1,a=5} \quad \text{AEF for age-4 ocean impacts}$$

(5) $$f_{1,a=3} = m_3(1 - p_3)(1 - r_3) + (1 - m_3)s_4 f_{1,a=4} \quad \text{AEF for age-3 ocean impacts}$$

$$f_{1,a=2} = m_2(1 - p_2)(1 - r_2) + (1 - m_2)s_3 f_{1,a=3} \quad \text{AEF for age-2 ocean impacts}$$

$$f_{2,a} = (1 - p_a)(1 - r_a) \quad \text{AEF for Columbia River impacts}$$

$$f_{3,a} = (1 - p_a) \quad \text{AEF for terminal impacts}$$

Here, ocean impacts and Columbia River impacts are reduced by straying rates and pre-spawn mortality rates, while terminal impacts are reduced by pre-spawn mortality rates.

For AER estimates that include strays and pre-spawn mortalities, the AEF factors are defined as:

$$f_{E,a} = 1/[(1 - p_a)(1 - r_a)] \quad \text{AEF for escapement}$$

$$f_{1,a=5} = 1 \quad \text{AEF for age-5 ocean impacts}$$

$$f_{1,a=4} = m_4 + (1 - m_4)s_5 f_{1,a=5} \quad \text{AEF for age-4 ocean impacts}$$

(6) $$f_{1,a=3} = m_3 + (1 - m_3)s_4 f_{1,a=4} \quad \text{AEF for age-3 ocean impacts}$$

$$f_{1,a=2} = m_2 + (1 - m_2)s_3 f_{1,a=3} \quad \text{AEF for age-2 ocean impacts}$$

$$f_{2,a} = 1 \quad \text{AEF for Columbia R. impacts}$$

$$f_{3,a} = 1/(1 - r_a) \quad \text{AEF for terminal impacts}$$

Here, escapements are expanded by straying rates and pre-spawn mortality rates, while terminal impacts are expanded by straying rates.

For either set of AEFs, the ocean-fishery AEFs ($f_{1,a}$) are computed recursively beginning with $f_{1,a=5}$, and require values for age-specific maturity rates ($m_a$), which can be estimated from reconstructed abundances (e.g., see $\hat{m}_a$ in equation 2). Additional data requirements and computational details are discussed below. It is worth noting that a cohort model can provide an equivalent but simpler approach to estimating AER. Specifically, if a cohort reconstruction is conducted (equation 2), then a parallel forward cohort model (equation 1) can be implemented using the reconstructed estimates for age-2 recruits ($N_{1,a=2}$) and maturity rates ($m_a$). After setting all fishery impacts (*C* and *I*) to zero, the model values of $E_a$ and $N_{2,a}$ represent adult equivalents excluding ($E_a$) and including ($N_{2,a}$) strays and pre-spawn mortalities.

Comments

As noted in the Background, it was indicated in the H&S Plan that jacks (i.e., age-2 fish) would not be included in measures of ocean recruits. As such, a more appropriate measure may be "age-3 recruits" rather than age-2 recruits. Note that if all coho salmon are assumed to recruit and mature at age 3, estimates of age-3 recruits and AER will only differ if either (1) stray rates and/or pre-spawn mortality rates are greater than zero and the AER measure of interest excludes these adult equivalents (equation 5); or (2) natural survival rates are applied at time steps after recruitment to ocean fisheries. For Chinook salmon, the age-2 (or age-3) recruits measure will be much greater than $C+E$ and AER, depending on maturity schedules and natural survival rates (i.e., these early measures of recruits contain a high proportion of fish that would be expected to perish naturally, in contrast to AER, which accounts for natural survival rates). In short, the AER measures for Chinook or coho salmon will be of primary interest, as suggested in the H&S Plan.

## Cohort model details

As described above, a cohort-model framework (e.g., Prager and Mohr 2001; Palmer-Zwahlen et al. 2006) will be required to estimate the age-2 and AER measures of ocean recruitment. However, it is currently unclear what level of spatial and temporal complexity is appropriate. The example cohort model (Figure 1) defines only three fisheries (ocean, Columbia River, and terminal) and an annual time step. While this might be sufficient for the Columbia River and terminal fisheries, greater complexity will be required to model incidental mortalities in ocean fisheries. Before addressing options for spatial complexity of fisheries, it is useful to review sources of incidental mortality.

Computing incidental mortalities

A key challenge of a cohort reconstruction is estimating incidental fishing mortalities (*I*). In general, three types of fisheries are applicable here (e.g., MEW 2008): (1) retention fisheries (in which all retrieved fish of legal size are retained); (2) non-retention fisheries (all retrieved fish are released); and (3) mark-selective fisheries (only landed ad-clip fish of legal size are retained). In conventional assessments, two types of incidental mortalities are computed, referred to here as "release mortalities" (fish that are retrieved and released but later die of injury) and "drop-off mortalities" (in hook and line fisheries, these are fish assumed to have been hooked but that were lost before retrieval and died due to gear-inflicted injury or predation).

All sources of fishing mortality depend on the number of fish "encountered" (or "contacted") by the ocean fishery, that is, the number of fish caught and successfully retrieved. For the *j*th fishery (at a given time step), example calculations of the various age-specific mortalities are as follows (e.g., Prager and Mohr, 2001; Pyper et al. 2012):

$$V_{j,a} = N_a v_{j,a}$$ Encounters (contacts)

$$C_{j,a} = V_{j,a} q_{j,a}$$ Catch

(7) $$R_{j,a} = V_{j,a}(1-q_{j,a}) r_{j,a}$$ Release mortalities

$$D_{j,a} = V_{j,a} d_{j,a}$$ Drop-off mortalities

$$I_{j,a} = R_{j,a} + D_{j,a} = V_{j,a}[r_{j,a}(1-q_{j,a}) + d_{j,a}]$$ Incidental mortalities

where

$V$ = number of encounters
$v$ = proportion of age-specific abundance ($N$) encountered (contact rate)
$q$ = proportion of encounters retained
$R$ = number of release mortalities
$r$ = catch-and-release mortality rate
$D$ = number of drop-off mortalities
$d$ = additional fraction of the total encounters assumed as drop-off mortalities

As observed in equation (7), incidental mortalities are the sum of release mortalities ($R$) and drop-off mortalities ($D$). In a retention fishery, catch by age ($C_a$) can be estimated via CWT expansions, and $q_a$ represents the proportion of fish that are of legal size (assuming size limits). In this case, the number of total encounters is given by $V_a = C_a / q_a$ , and hence, incidental mortalities can be computed as

(8) $$I_{j,a} = \frac{C_{j,a}}{q_{j,a}}[r_{j,a}(1-q_{j,a}) + d_{j,a}].$$

If virtually all fish (e.g., at age 2) are below the size limit, $q_a$ is effectively zero, and an alternative estimate of encounters is required (as for non-retention fisheries below). Size limits may only be applicable for Chinook, in which case, incidental mortalities for coho would be simply $I_{j,a} = C_{j,a}[1 + d_{j,a}]$, where $j$ represents all retention fisheries.

A non-retention fishery is more problematic. There are no CWT recoveries to estimate encounter rates, so an estimate of $v_a$ (the proportion of age-specific abundance $N_a$ encountered) is required. In non-retention fisheries, $q_a = 0$ (all retrieved fish are released), and hence, incidental mortalities are given by

(9) $$I_{j,a} = N_a v_{j,a}[r_{j,a} + d_{j,a}].$$

A mark-selective fishery is essentially the same as a retention fishery for marked fish (e.g., ad-clipped hatchery fish), or the same as a non-retention fishery for unmarked fish (e.g., natural production).

Spatial complexity for ocean fisheries

The most broadly applied (conventional) uses of cohort modelling for Chinook and coho salmon are contained within the assessment models used by technical committees of the Pacific Marine Fisheries Council (PFMC) and Pacific Salmon Commission (PSC). These include the coho and Chinook versions of FRAM (MEW 2008) and the PSC Chinook Model (CTC 2014a). I also searched relevant agency literature and contacted several WDFW staff to see if other cohort reconstructions had been specifically developed for Lewis River (or similar) salmon stocks. The only examples I found with specific relevance were by Cramer (1996, 1997), in which reconstructions were completed for several Cowlitz River and Lewis River runs.

My thoughts on model complexity have evolved. Initially, I pursued an approach in which cohort models for Lewis River runs would mimic (to the extent possible) the fishery structures and methods used in the coho/Chinook FRAMs and/or PSC Chinook Model. My reasoning was that:

(a) These model frameworks provide the most defensible methods and structures available;
(b) The present complexity of ocean fisheries and regulations is extensive (e.g., Figure 2);
(c) The PFMC and PSC assessments are updated annually, documenting changes in fishery regulations and relevant parameter values; and
(d) I thought it would be relatively easy to obtain the essential "data tables" (e.g., within FRAM) that translate RMIS recovery locations (for CWTs) to modelled fisheries, as well as those tables that link fisheries with their specific annual regulations (e.g., size limits, periods of non-retention, mark-selective status, etc.).

However, I had recent discussions with Gary Morishima and Larry Lavoy (who collectively have decades of experience with these assessment models), which discouraged this idea. My impression is that it would be a challenge to obtain the essential "data tables" in (d) above, and that the entire approach would be overly complex. As noted by Larry Lavoy, the accuracy of cohort reconstructions usually depends, to a much greater extent, on having solid estimates of age-specific escapement and terminal fishing harvests, rather than having precise estimates of incidental mortalities.

I therefore recommend use of a relatively simple structure for ocean fisheries in Lewis River cohort reconstructions (focused on marked fish). I have not flushed out all of the details yet, but it will likely involve omitting incidental mortalities for certain fisheries (e.g., non-retention fisheries for Chinook, low impact net and seine fisheries, etc.). For validation, reconstructed estimates of incidental mortalities could be compared with (or supplemented by) those estimated for specific indicator stocks that are modelled in PFMC and PSC annual analyses (e.g., Willamette River spring Chinook). Total fishing mortalities for unmarked fish (i.e., accounting for mark-selective fisheries) will be derived using escapement recoveries of DIT releases.

As discussed below, I developed a preliminary model and conducted reconstructions for Lewis River spring Chinook for numerous brood years. These analyses provide an initial indication of maturity rates, incidental mortalities, and relative differences among the three measures of ocean recruits.

*Table 4.1 Mark-selective fisheries occurring 2003–2011 (√).*

| Fishery | Location | Period | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sport | B.C. Strait of Juan de Fuca, selected subareas | Mar–Apr | | | | | | √ | √ | √ | √ |
| Sport | WA/OR Ocean Area 1-4 | June | | | | | | | | √ | √ |
| Sport | WA PS Area 5 | Summer | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Sport | WA PS Area 6 | Summer | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Sport | WA PS Area 7 | Winter | | | | | | √ | √ | √ | √ |
| Sport | WA PS Area 8.1 | Winter | | | √ | √ | √ | √ | √ | √ | √ |
| Sport | WA PS Area 8.2 | Winter | | | √ | √ | √ | √ | √ | √ | √ |
| Sport | WA PS Area 9 | Summer | | | | | √ | √ | √ | √ | √ |
| Sport | WA PS Area 9 | Winter | | | | | | √ | √ | √ | √ |
| Sport | WA PS Area 10 | Summer | | | | | √ | √ | √ | √ | √ |
| Sport | WA PS Area 10 | Winter | | | | | | √ | √ | √ | √ |
| Sport | WA PS Area 11 | Summer | | | | | √ | √ | √ | √ | √ |
| Sport | WA PS Area 11 | Winter | | | | | | | √ | √ | √ |
| Sport | WA PS Area 12 | Winter | | | | | | | | √ | √ |
| Sport | WA PS Area 13 | Summer | | | | | √ | √ | √ | √ | √ |
| Sport | Nooksack | Sep–Dec | | √ | √ | √ | √ | √ | √ | √ | √ |
| Sport | Skykomish | Jun–July | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Sport | Carbon and Puyallup | Aug–Dec | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Sport | Upper Skagit | Jun–July | | | √ | √ | √ | √ | √ | √ | √ |
| Sport | Nisqually | Jul–Jan | | | | √ | √ | √ | √ | √ | √ |
| Sport | Skokomish | Aug–Dec | | | | | | | | √ | √ |
| Sport | Quillayute | Feb–Dec | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Sport | Hoh | May–Aug | | | | | | √ | √ | √ | √ |
| Sport | Willapa Bay and tributaries | Jul–Jan | | | | | | | | √ | √ |
| Commercial | Willapa Bay | Aug–Nov | | | | | | | | √ | √ |
| Sport | Columbia | Summer | √ | √ | | √ | | √ | | √ | √ |
| Sport | Lower Columbia | Spring | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Sport | Lower Columbia tributaries | Fall | | | | | | | | | √ |
| Commercial (tangle net) | Lower Columbia | Spring | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Commercial, (large net) | Lower Columbia | Spring | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Sport | Willamette | Spring | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Sport | Yakima | Spring | | √ | | | | √ | | √ | √ |
| Sport | Lower Snake | Fall | | | | | | √ | √ | √ | √ |
| Sport | Lower Snake | Spring | | | | | | | | √ | √ |
| Sport | Oregon terminal | Spring | | | | | | √ | √ | √ | √ |

*Note*: See SFEC (2013) for more detailed information on MSF proposals and fisheries.

**Figure 2.** Summary of mark-selective fisheries for Chinook salmon (Table 4.1 in CTC 2014a).

Parameter values

Some of the required parameter values used in the cohort reconstructions can be obtained from FRAM (or PSC Chinook model) documentation (e.g., MEW 2008; CTC 2014a, 2014b). These include age-specific survival rates (*s*; equation 2) and incidental mortality rates (*r* and *d*; equation 7). For spring Chinook, we will need to derive age-specific estimates for *q* (proportions of legal-sized fish), and perhaps *v* (contact rate), or obtain surrogate estimates for a suitable stock (e.g., Cowlitz or Willamette spring Chinook, both of which appear to have been modelled within FRAM over the years). These latter parameters will most influential for age-3 fish (assuming age-2 fish or "jacks" can be omitted); age-4 fish and older are predominantly of legal size.

Example parameter values, as well as straying rates, are discussed below in the context of the preliminary model and reconstructions.

## Preliminary analyses

To get an initial understanding of the data, I used the RMIS database to obtain all CWT releases and corresponding recovery data for Lewis River hatcheries (Lewis River, Merwin, and Speelyai). Initially, I found the "report" formats for RMIS output to be either cumbersome or limiting, so I extracted all of the data in raw format (csv files) for use in Excel and R (a statistical programming package). I then developed "key tables" that allowed me to filter and process the raw data as needed (in R). This overall approach provided an efficient and flexible platform for analysis.

The following data summaries and analysis are exploratory only. It was not my intention to examine only certain release types (e.g., production versus experimental releases) or address other nuances. Rather, I was interested in developing analytical procedures (for later use with refined datasets) and characterizing general patterns of age-specific CWT recoveries across years (i.e., to get a "sense" for the data and runs).

Data summaries

Hatchery releases were filtered to include only those for spring Chinook and coho (type N and S) released in the Lewis River basin. Releases began in brood year 1972 for spring Chinook, 1976 for coho (type S), and 1986 for coho (type N). I further limited releases to brood years 1988-2008 (a period when releases were made for all runs in each year, with almost ages of spring Chinook recovered). This provided a total of 115 releases (by specific tag code), which are summarized in Table 2. The total number of CWTs released were roughly 5.1, 2.4, and 2.7 million for spring Chinook, coho (N), and coho (S), respectively.

**Table 2.** Total hatchery releases (by tag code) across brood years 1988-2008.

| | LEWIS | SPEELYAI |
|---|---|---|
| Chinook (spr) | 43 | 1 |
| Coho (type N) | 35 | 0 |
| Coho (type S) | 34 | 2 |

A key step for simplifying cohort models is to define a limited set of fisheries for computing incidental mortalities. Recovery locations in RMIS are defined via a “fishery code” and a “location code” (among other variables). Across the 115 releases, CWTs recoveries were associated with 36 unique fishery codes (Table 3) and over 400 location codes. Note that fishery codes (Table 3) include recoveries at hatcheries (code 50) and spawning grounds (code 54). To simplify the recovery structure, I pooled fishery codes into ten categories (“pooled groups”), which were then further pooled into four “lumped groups” for summaries (Table 3). Again, these are tentative and for exploratory purposes only.

Recoveries (across years) are summarized by pooed group in Table 4. These data correspond to “estimated” recoveries (i.e., expanded estimates provided by RMIS that account for sampling fractions), with the exception of “Spawning Ground” recoveries for coho (these were reported almost exclusively as observed recoveries without expansions). Note that the miscellaneous fishery codes assigned to the “Other Ocean” and “Other Freshwater” pooled groups (Table 3) account for very low proportions of the total recoveries (Table 4).

Other interesting summaries included age-specific recoveries by lumped group (Table 5) and by group and month (not shown).

<u>Strays</u>

To provide a rough indication of potential straying rates, I tabulated recoveries by specific location (RMIS field “location name”) within the four fishery codes corresponding to hatchery (Table 6), spawning ground (Table 7), freshwater sport (Table 8), and Columbia River sport recoveries (Table 9).

For example, across brood years, 3.4% of the estimated recoveries of spring Chinook occurred at hatchery facilities outside of the Lewis River basin (Table 6). (Assuming I identified in-basin facilities correctly). Only 0.1% of coho were recovered at out-of-basin facilities. Roughly 1% to 2% of observed spawning-ground recoveries appear to be outside the Lewis River basin (e.g., Kalama River; Table 7). Similar inferences can be drawn using freshwater sport (Table 8) and Columbia River sport recoveries (Table 9), recognizing that these are much more ambiguous in nature (i.e., fish captured in other tributaries or upstream in the Columbia River may have returned to the Lewis River basin).

**Table 3.** Recovery locations for Lewis River hatchery releases by RMIS fishery code and name. Fishery codes were pooled (Pooled group) and then further combined (Lumped group).

| Fishery code | Fishery name | Pooled group | Lumped group |
|---|---|---|---|
| 10 | Ocean Troll (non-treaty) | Ocean Troll | Ocean Catch |
| 11 | Ocean Troll - Day Boat | Ocean Troll | Ocean Catch |
| 12 | Ocean Troll - Trip Boat | Ocean Troll | Ocean Catch |
| 15 | Treaty Troll | Ocean Troll | Ocean Catch |
| 20 | Ocean Gillnet non-treaty | Other Ocean | Ocean Catch |
| 21 | Columbia River Gillnet | Columbia River Gillnet | Freshwater Catch |
| 22 | Coastal Gillnet | Other Ocean | Ocean Catch |
| 23 | Mixed Net and Seine | Other Ocean | Ocean Catch |
| 24 | Freshwater Net | Other Freshwater | Freshwater Catch |
| 25 | Commercial Seine | Other Ocean | Ocean Catch |
| 26 | Terminal Seine | Other Freshwater | Freshwater Catch |
| 27 | Freshwater Seine | Other Freshwater | Freshwater Catch |
| 40 | Ocean Sport | Ocean Sport | Ocean Catch |
| 41 | Sport (charter) | Ocean Sport | Ocean Catch |
| 42 | Sport (private) | Ocean Sport | Ocean Catch |
| 43 | Sport (jetty) | Ocean Sport | Ocean Catch |
| 44 | Columbia River Sport | Columbia River Sport | Freshwater Catch |
| 45 | Estuary Sport | Estuary Sport | Ocean Catch |
| 46 | Freshwater Sport | Freshwater Sport | Freshwater Catch |
| 50 | Hatchery | Hatchery | Hatchery |
| 52 | Fish Trap (freshwater) | Other Freshwater | Freshwater Catch |
| 54 | Spawning Ground | Spawning Ground | Spawning Ground |
| 61 | Test Fishery Net | Other Ocean | Ocean Catch |
| 64 | Test Fishery Unkn Mult Gr | Other Ocean | Ocean Catch |
| 70 | Juv Sampling - Troll(Mar) | Other Ocean | Ocean Catch |
| 72 | Juv Sampling - Seine(Mar) | Other Ocean | Ocean Catch |
| 74 | Juv Sampling - trawl(mar) | Other Ocean | Ocean Catch |
| 80 | Hake Trawl, At-Sea | Other Ocean | Ocean Catch |
| 81 | Groundfish Obs (Gulf AK) | Other Ocean | Ocean Catch |
| 82 | Grdfish Obs (Ber/Aleuts) | Other Ocean | Ocean Catch |
| 83 | Foreign Research Vessels | Other Ocean | Ocean Catch |
| 85 | Ocean Trawl By-Catch | Other Ocean | Ocean Catch |
| 88 | Juvenile Sampling - trawl | Other Ocean | Ocean Catch |
| 90 | Multiple Gear | Other Ocean | Ocean Catch |
| 95 | Confiscated | Other Ocean | Ocean Catch |
| 800 | Hake Trawl, Shoreside | Other Ocean | Ocean Catch |

**Table 4.** Recoveries by pooled group for Lewis River hatchery releases of spring Chinook and coho (all years combined).

| | Estimated | | | Percent | | |
|---|---|---|---|---|---|---|
| Pooled group | Chinook | Coho (N) | Coho (S) | Chinook | Coho (N) | Coho (S) |
| Ocean Troll | 2273 | 2140 | 974 | 12.4% | 2.7% | 1.4% |
| Ocean Sport | 331 | 12052 | 7799 | 1.8% | 15.2% | 11.1% |
| Other Ocean | 101 | 261 | 77 | 0.5% | 0.3% | 0.1% |
| Estuary Sport | 50 | 682 | 1580 | 0.3% | 0.9% | 2.2% |
| Columbia River Gillnet | 348 | 15242 | 1578 | 1.9% | 19.2% | 2.2% |
| Columbia River Sport | 342 | 37 | 190 | 1.9% | 0.0% | 0.3% |
| Freshwater Sport | 3971 | 2171 | 1568 | 21.7% | 2.7% | 2.2% |
| Other Freshwater | 4 | 1 | 15 | 0.0% | 0.0% | 0.0% |
| Hatchery | 9404 | 45923 | 55494 | 51.3% | 57.9% | 78.7% |
| Spawning Ground | 1492 | 815 | 1212 | 8.1% | 1.0% | 1.7% |
| Total | 18315 | 79322 | 70487 | 100.0% | 100.0% | 100.0% |

**Table 5.** Recoveries by lumped group and age for Lewis River hatchery releases of spring Chinook and coho (all years combined).

| Run | Group | age=2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Chinook | Ocean Catch | 41 | 474 | 1852 | 357 | 30 | 0 |
| | Freshwater Catch | 289 | 292 | 1661 | 2279 | 142 | 2 |
| | Hatchery | 169 | 407 | 3651 | 4837 | 332 | 7 |
| | Spawning Ground | 8 | 41 | 469 | 919 | 55 | 0 |
| Coho (N) | Ocean Catch | 22 | 15101 | 6 | 4 | 0 | 0 |
| | Freshwater Catch | 747 | 16704 | 0 | 0 | 0 | 0 |
| | Hatchery | 5846 | 40076 | 0 | 0 | 0 | 0 |
| | Spawning Ground | 27 | 788 | 0 | 0 | 0 | 0 |
| Coho (S) | Ocean Catch | 34 | 10395 | 0 | 0 | 0 | 0 |
| | Freshwater Catch | 352 | 2996 | 4 | 0 | 0 | 0 |
| | Hatchery | 7589 | 47905 | 0 | 0 | 0 | 0 |
| | Spawning Ground | 28 | 1184 | 0 | 0 | 0 | 0 |

**Table 6.** Estimated recoveries at hatchery facilities by location (all years combined).

| Location | Chinook (Spr) | Coho (N) | Coho (S) |
|---|---|---|---|
| ALSEA HATCHERY | 0 | 1 | 0 |
| BIG CR (LWR COL R) | 0 | 1 | 1 |
| BONNEVILLE HATCHERY | 0 | 2 | 5 |
| COLE RIVERS HATCHERY | 0 | 5 | 2 |
| COWLITZ SALMON HATCH | 99 | 0 | 3 |
| EAGLE CR NFH | 0 | 0 | 1 |
| ELK R HATCHERY | 0 | 2 | 0 |
| ENTIAT NFH | 1 | 0 | 0 |
| FALLERT CR HATCHERY | 0 | 0 | 25 |
| GEORGE ADAMS HATCHRY | 0 | 1 | 0 |
| KALAMA FALLS HATCHRY | 249 | 18 | 17 |
| LEWIS RIVER HATCHERY | 1544 | 37848 | 45152 |
| LTL WHITE SALMON NFH | 0 | 0 | 1 |
| MERWIN DAM FCF | 7512 | 8034 | 10276 |
| MINTER CR HATCHERY | 0 | 1 | 1 |
| ROCK CR HATCHERY | 0 | 0 | 1 |
| SALMON R HATCHERY | 0 | 2 | 0 |
| SANDY HATCHERY | 0 | 2 | 1 |
| WASHOUGAL HATCHERY | 0 | 5 | 7 |
| | | | |
| **Total** | 9404 | 45923 | 55494 |
| Lewis total | 9056 | 45882 | 55428 |
| Other total | 348 | 41 | 66 |
| Percent other | 3.7% | 0.1% | 0.1% |

**Table 7.** Observed spawning-ground recoveries by location (all years combined).

| Location | Chinook (Spr) | Coho (N) | Coho (S) |
|---|---|---|---|
| ABERNATHY CR 25.0297 | 0 | 0 | 1 |
| BITTER CR 27.0367 | 0 | 1 | 0 |
| CEDAR CR 27.0339 | 26 | 22 | 554 |
| COLVIN CR 27.0392 | 0 | 21 | 119 |
| ELK VALLEY CR | 0 | 1 | 0 |
| FIDDLE CR (SILTCOOS) | 0 | 1 | 0 |
| GNAT CR (LWR COL R | 0 | 1 | 0 |
| JOHNSON CR 27.0327 | 0 | 7 | 6 |
| KALAMA R 27.0002 | 3 | 2 | 15 |
| LEWIS R -EF 27.0173 | 1 | 3 | 29 |
| LEWIS R -NF 27.0168 | 39 | 388 | 162 |
| LEWIS R 27.0168 | 35 | 41 | 26 |
| LEWIS R & CEDAR CR | 122 | 0 | 0 |
| LEWIS R + LEWIS R-NF | 45 | 320 | 288 |
| LITTL WHITE SALMON R | 0 | 1 | 0 |
| MILL CR 25.0284 | 0 | 1 | 2 |
| MOON CR TRIB A (N FK COQU | 0 | 1 | 0 |
| NETTLE CR (ALSEA R) | 0 | 1 | 0 |
| NEWTON CR | 0 | 0 | 1 |
| PARADISE CR SEC #2 | 0 | 0 | 1 |
| PUP CR 27.0345 | 0 | 0 | 2 |
| ROSS CR 27.0305 | 0 | 3 | 0 |
| SCHOLFIELD CR (UMPQU | 0 | 0 | 1 |
| SILVER CR (ROGUE R) | 0 | 0 | 1 |
| UMPQUA R SPAWN 43 | 0 | 0 | 3 |
| WIND R 29.0023 | 0 | 0 | 1 |
| **Total** | 271 | 815 | 1212 |

**Table 8.** Estimated recoveries in "freshwater sport" fisheries by location (all years combined).

| Location | Chinook (Spr) | Coho (N) | Coho (S) |
|---|---|---|---|
| CASCADE R -LOWER 3.1411 | 0 | 0 | 9 |
| CHEHALIS R 22.0190 | 0 | 4 | 0 |
| COWLITZ R 26.0002 | 14 | 0 | 0 |
| KALAMA R 27.0002 | 109 | 0 | 0 |
| LEWIS R -NF 27.0168 | 561 | 1175 | 870 |
| LEWIS R 27.0168 | 2635 | 630 | 644 |
| LEWIS R & CEDAR CR | 227 | 0 | 0 |
| LEWIS R + LEWIS R-NF | 365 | 362 | 31 |
| TOUTLE R-NF 26.0314 | 0 | 0 | 14 |
| WILLAMETTE R LWR BTS | 51 | 0 | 0 |
| WIND R 29.0023 | 8 | 0 | 0 |
| **Total** | 3971 | 2171 | 1568 |

**Table 9.** Estimated recoveries in Columbia River sport fisheries by location (all years combined).

| Estimated | Chinook (Spr) | Coho (N) | Coho (S) |
|---|---|---|---|
| COL R OR SPORT SEC 2 | 0 | 6 | 0 |
| COL R OR SPORT SEC 3 | 20 | 0 | 0 |
| COL R OR SPORT SEC 4 | 46 | 0 | 0 |
| COL R OR SPORT SEC 5 | 18 | 7 | 16 |
| COL R OR SPORT SEC 6 | 8 | 0 | 0 |
| COL R OR SPORT SEC 7 | 18 | 7 | 70 |
| COL R OR SPORT SEC 9 | 9 | 0 | 0 |
| COL R OR SPT SEC 10 | 16 | 0 | 38 |
| COL R WA SEC 10 | 55 | 0 | 0 |
| COL R WA SEC 4 | 24 | 0 | 6 |
| COL R WA SEC 6 | 9 | 0 | 13 |
| COL R WA SEC 7 | 0 | 0 | 26 |
| COL R WA SPORT SEC 3 | 22 | 0 | 0 |
| COL R WA SPORT SEC 5 | 65 | 0 | 6 |
| COL R WA SPORT SEC 8 | 27 | 18 | 15 |
| COL R WA SPORT SEC 9 | 9 | 0 | 0 |
| **Total** | 342 | 37 | 190 |

Example cohort reconstructions and measures of ocean recruits

To develop initial methods, I conducted reconstructions for spring Chinook using pooled releases by brood year. (These analyses were coded in R to quickly produce results across brood years). The cohort model included:

(a) Ages 3 to 6;
(b) Annual time steps;
(c) Survival rates (applied at year end) of 0.7 for age 3, 0.8 for age 4, and 0.9 for age 5 (consistent with CTC 2014a);
(d) Fisheries defined by the "pooled groups" in Table 3; and
(e) Incidental mortality rate parameters (*r* and *d*) used in CTC (2014a), as summarized below in Table 10.

The model did not include straying rates or pre-spawning mortality, and all hatchery and spawning ground recoveries were included regardless of location. Crude estimates of the proportion of legal-sized fish (*q*) were derived using fork length distributions of hatchery recoveries and an assumed size limit of 24 inches (Figure 3). The estimates of *q* were 0.07 for age 3, 0.95 for age 4, and 1.0 for ages 5 and 6.

*Results*: Estimates of maturity rates are presented in Table 11, while Table 12 summarizes estimated recoveries and measures of ocean recruits by brood year. Obviously, recoveries were limited for some brood years (e.g., 1991 and 1995), yielding unreliable estimates, but again this is just exploratory. Across years, median estimates of maturity rate were 0.02 for age 3, 0.33 for age 4, and 0.95 for age 5. As expected, reconstructed estimates of age-3 "ocean recruits" were much greater than C+E measures (about 65% higher on average). Estimates of adult equivalent returns (AER) tended to be slightly higher than C+E measures (about 4% higher on average).

Conclusions

I have developed procedures to rapidly extract and process RMIS data, and conduct the necessary cohort reconstructions to generate measures of ocean recruitment. Additional refinements to the cohort model are needed, but the framework is in place. The preliminary results for spring Chinook suggest that differences between measures of C+E and AER will be relatively minor (due in large part to low harvest rates), reducing the practical importance of simplified structures and assumptions in the cohort model (i.e., keep it reasonably simple). Reconstructions for marked coho will be even simpler with one age class and no size limits. The current framework allows for rapid assessment of historic data, which may be important if comparisons with other stocks (e.g., FRAM index stocks) are needed or requested.

**Table 10.** Incidental mortality rate parameters used in the cohort model (values from Appendix F of CTC 2014b).

| Pooled group | Catch-and-release (*r*) Sublegal | Catch-and-release (*r*) Legal | Dropoff (*d*) |
|---|---|---|---|
| Ocean Troll | 0.220 | 0.185 | 0.016 |
| Ocean Sport | 0.123 | 0.123 | 0.069 |
| Other Ocean | 0 | 0 | 0 |
| Estuary Sport | 0.123 | 0.123 | 0.069 |
| Columbia River Gillnet | 0.9 | 0.9 | 0 |
| Columbia River Sport | 0.123 | 0.123 | 0.069 |
| Freshwater Sport | 0.123 | 0.123 | 0.069 |
| Other Freshwater | 0 | 0 | 0 |

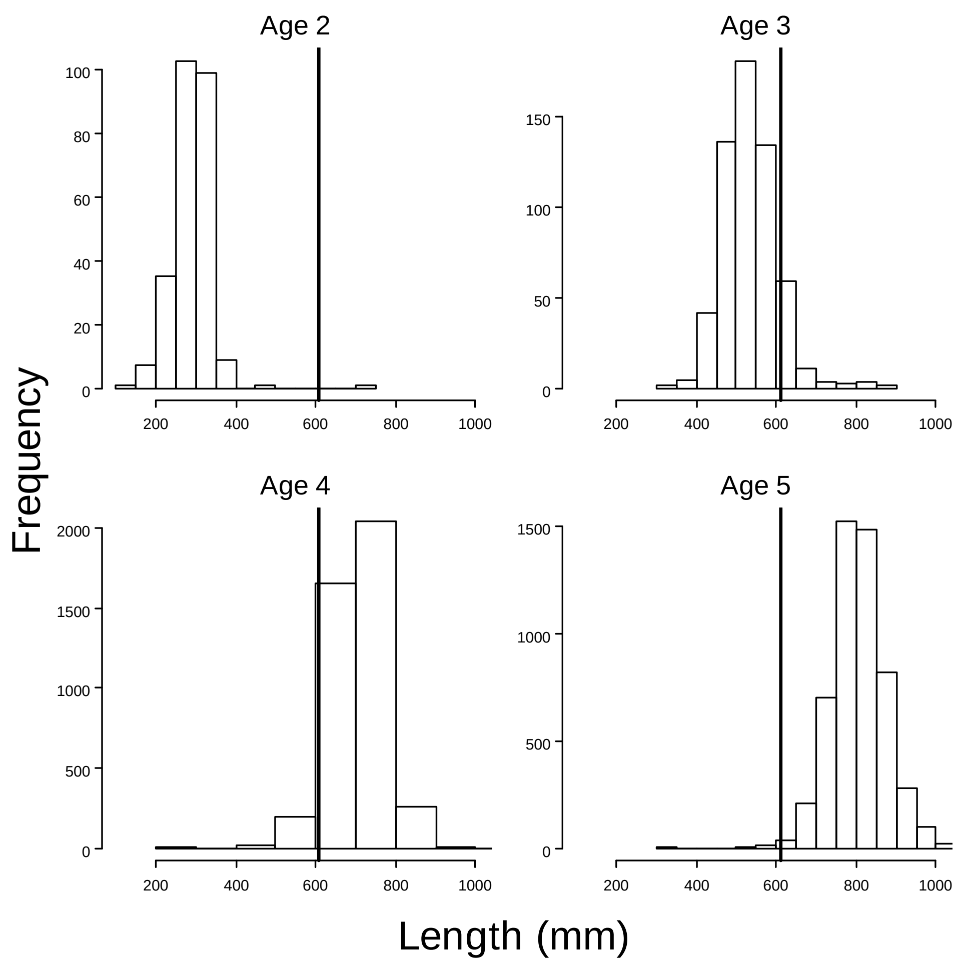


**Figure 3**. Fork length distributions of spring Chinook recoveries at hatchery facilities by age (all years). Solid vertical line depicts an example size limit of 24 inches.

**Table 11.** Estimates of maturity rates by brood year derived from cohort reconstructions of hatchery releases of spring Chinook.

| BroodYr | Age 3 | Age 4 | Age 5 |
|---|---|---|---|
| 1988 | 0.040 | 0.322 | 0.968 |
| 1989 | 0.041 | 0.332 | 0.790 |
| 1990 | 0.043 | 0.199 | 0.966 |
| 1991 | 0.000 | 0.330 | 0.796 |
| 1992 | 0.020 | 0.337 | 0.913 |
| 1993 | 0.004 | 0.274 | 0.925 |
| 1994 | 0.004 | 0.219 | 0.988 |
| 1995 | 0.000 | 0.398 | 1.000 |
| 1996 | 0.026 | 0.438 | 0.965 |
| 1997 | 0.021 | 0.397 | 0.951 |
| 1998 | 0.018 | 0.239 | 0.922 |
| 1999 | 0.004 | 0.118 | 0.832 |
| 2000 | 0.070 | 0.645 | 0.975 |
| 2001 | 0.034 | 0.310 | 0.907 |
| 2002 | 0.015 | 0.315 | 0.956 |
| 2003 | 0.020 | 0.295 | 0.927 |
| 2004 | 0.057 | 0.327 | 0.950 |
| 2005 | 0.045 | 0.596 | 0.935 |
| 2006 | 0.118 | 0.732 | 0.992 |
| 2007 | 0.021 | 0.411 | 0.942 |
| 2008 | 0.107 | 0.909 | 1.000 |

**Table 12.** Estimated recoveries and measures of ocean recruitment (by brood year) for hatchery releases of spring Chinook.

| | Estimated recoveries | | | | Ocean recruits | | |
|---|---|---|---|---|---|---|---|
| Brood Year | Ocean Catch | Freshwater Catch | Hatchery | Spawning Ground | C+E | Age 3 | AER |
| 1988 | 501 | 1264 | 246 | 286 | 2297 | 3890 | 2410 |
| 1989 | 176 | 269 | 72 | 100 | 618 | 1118 | 687 |
| 1990 | 58 | 352 | 205 | 31 | 646 | 1147 | 693 |
| 1991 | 2 | 6 | 21 | 0 | 29 | 50 | 30 |
| 1992 | 15 | 107 | 231 | 40 | 393 | 651 | 398 |
| 1993 | 36 | 19 | 95 | 15 | 166 | 287 | 171 |
| 1994 | 34 | 29 | 170 | 46 | 278 | 466 | 276 |
| 1995 | 3 | 24 | 50 | 8 | 85 | 140 | 86 |
| 1996 | 10 | 301 | 194 | 60 | 565 | 927 | 584 |
| 1997 | 330 | 614 | 754 | 261 | 1959 | 3476 | 2162 |
| 1998 | 345 | 301 | 1028 | 358 | 2031 | 3457 | 2066 |
| 1999 | 414 | 167 | 1003 | 149 | 1734 | 3097 | 1766 |
| 2000 | 49 | 159 | 707 | 0 | 915 | 1370 | 924 |
| 2001 | 110 | 98 | 490 | 12 | 711 | 1195 | 733 |
| 2002 | 320 | 396 | 1909 | 62 | 2687 | 4471 | 2719 |
| 2003 | 89 | 101 | 535 | 2 | 727 | 1230 | 746 |
| 2004 | 16 | 23 | 223 | 0 | 262 | 422 | 264 |
| 2005 | 36 | 41 | 218 | 55 | 349 | 582 | 383 |
| 2006 | 69 | 71 | 676 | 0 | 816 | 1243 | 873 |
| 2007 | 20 | 16 | 144 | 0 | 181 | 289 | 180 |
| 2008 | 79 | 17 | 256 | 0 | 352 | 494 | 356 |
| **Total** | 2713 | 4374 | 9228 | 1484 | 17799 | 30002 | 18508 |

## Next steps

Remaining tasks include:

(1) Finalize the cohort models for marked spring Chinook and coho runs. I recommend that the time steps, equation structures, and assumed parameter values mimic those of the Chinook and coho versions of FRAM, which are most applicable to Lewis River runs (I currently have used PSC Chinook Model structures/assumptions). This will be a relatively easy task and would provide a clearly defensible framework. For spring Chinook, it is critical that a defensible age-3 estimate of *q* (proportion of vulnerable fish) be developed. For all runs, we need to account for, or defensibly dismiss, straying rates and pre-spawn mortality rates (review methods in Cramer 1996 & 1997 for strays).

(2) Develop ocean recruit measures for unmarked runs based on DIT releases. It is not practical to model mark-selective fisheries and incidental mortalities within a cohort reconstruction. Fishery-specific computations within FRAM are complex and evolving (Conrad et al. 2013). It is much more reasonable to develop metrics using either DIT releases or exploitation-rate estimates for regional index stocks modelled in FRAM.

(3) Review the Lewis River sampling programs and data sources that determine age-specific terminal harvests and escapements. These data are crucial for measuring brood-year ocean recruits. It is unlikely that the terminal harvest and escapement data pulled from RMIS will be complete or sufficient. The process will begin with in-river harvest/escapement data, followed by CWT releases and RMIS data, and finalized by appropriately expanding results to obtain complete production of hatchery and natural runs.

(4) Outline annual procedures for (a) integrating the terminal harvest and escapement data with RMIS recoveries (ocean and Columbia River), and (b) computing measure of ocean recruits for Chinook, coho, and steelhead runs.

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# Lewis River Fish Passage Report

## March 2014

**Merwin Sorting Facility Fish Collection and General Operations**

The Merwin Sorting Facility continued to operate daily through March 2014. During that period, a total 344 fish were captured; the majority (91%) of these fish were winter steelhead (n = 314). Other species collected included resident rainbow trout (n = 15), cutthroat trout (n = 11), sockeye salmon (n = 2), whitefish (n=1), and largescale sucker (n = 1). The two sockeye salmon were collected immediately following the spill event that occurred mid-March and were suspected to be kokanee.

River flow at Merwin Dam fluctuated approximately 5,020 cubic feet per second (cfs) to 26,400 cfs throughout the month of March. Heavy rainfall earlier in the month attributed to opening spill gates 2-4 at Merwin Dam; spill at Merwin Dam occurred from March 4$^{th}$ through March 10$^{th}$ , 2014.

Only the 30 cfs Ladder Water Supply (LWS) was used during the month of March. The Auxiliary Water Supply (AWS) system, which boosts attraction flow to 400 cfs, was still being tested. Full operation of the AWS system is anticipated in early April 2014.

**Upstream Transport**

A total 291 (111 m: 180 f) winter steelhead having a Blank Wire Tag (BWT) were collected and transported upstream during March 2014. Including these fish, a total 348 (132 m: 216 f) BWT steelhead have been transported and released into the headwaters of Swift Reservoir late 2013. In addition to winter steelhead, 8 cutthroat trout greater than 13 inches in length were also transported and released upstream. All other fish collected at the Merwin Sorting Facility were returned the river downstream of Merwin Dam.

**Swift Floating Surface Collector**

The Swift Floating Surface Collector (FSC) did not operate during March in consideration of the fish net repair project. Based on the project schedule, the FSC did go back into operation on March 31, 2014.

# Fish Facility Report
# Merwin Adult Trap
# March 2014

| Reporting Date | Spring Chinook | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AD-Clip | | | AD+CWT | | | CWT Only | | | Wild | | | TOTAL | | |
| | M | F | JK | M | F | JK | M | F | JK | M | F | JK | M | F | JK |
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| **Annual** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Reporting Date | Early Coho | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AD-Clip | | | AD+CWT | | | CWT Only | | | Wild | | | TOTAL | | |
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| **Annual** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Reporting Date | Late Coho | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AD-Clip | | | AD+CWT | | | CWT Only | | | Wild | | | TOTAL | | |
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| **Monthly** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Annual** | 10 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 12 | 4 | 3 |

| Reporting Date | S. Steelhead | | | | W. Steelhead | | | | | | Fall Chinook | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | | Recap | | AD-Clip | | BWT | | Wild | | AD-Clip | | | Wild | | |
| | M | F | M | F | M | F | M | F | M | F | M | F | JK | M | F | JK |
| 01-Mar | | | | | | | | 2 | | | | | | | | |
| 02-Mar | | | | | | | 1 | 1 | | | | | | | | |
| 03-Mar | | | | | | 1 | | 3 | | | | | | | | |
| 04-Mar | | | | | | | | 2 | | | | | | | | |
| 05-Mar | | | | | 1 | | | 2 | | | | | | | | |
| 06-Mar | | | | | | | 5 | 1 | | | | | | | | |
| 07-Mar | | | | | 1 | | | | | | | | | | | |
| 08-Mar | | | | | 1 | | 2 | 5 | | | | | | | | |
| 09-Mar | | | | | | | | | | | | | | | | |
| 10-Mar | | | | | 1 | 1 | 6 | 5 | | | | | | | | |
| 11-Mar | | | | | | | | 1 | | | | | | | | |
| 12-Mar | | | | | 1 | 1 | 6 | 15 | | | | | | | | |
| 13-Mar | | | | | | | 2 | 2 | | | | | | | | |
| 14-Mar | | | | | | 1 | 12 | 7 | | | | | | | | |
| 15-Mar | | | | | | | 3 | 3 | | | | | | | | |
| 16-Mar | | | | | | | 8 | 9 | | | | | | | | |
| 17-Mar | | | | | 1 | | 10 | 16 | | | | | | | | |
| 18-Mar | | | | | | | 0 | 3 | | | | | | | | |
| 19-Mar | | | | | | | 1 | 3 | | | | | | | | |
| 20-Mar | | | | | | | 7 | 11 | | | | | | | | |
| 21-Mar | | | | | 1 | | 3 | 4 | | | | | | | | |
| 22-Mar | | | | | 2 | 2 | 1 | 1 | | | | | | | | |
| 23-Mar | | | | | | | 2 | 5 | | 1 | | | | | | |
| 24-Mar | | | | | | | 4 | 5 | | | | | | | | |
| 25-Mar | | | | | | | | | | | | | | | | |
| 26-Mar | | | | | 2 | | 8 | 18 | | 1 | | | | | | |
| 27-Mar | | | | | | 1 | 9 | 15 | 1 | | | | | | | |
| 28-Mar | | | | | | | 2 | 7 | | | | | | | | |
| 29-Mar | | | | | 1 | | 9 | 12 | | | | | | | | |
| 30-Mar | | | | | | | 4 | 14 | | | | | | | | |
| 31-Mar | | | | | 1 | | 6 | 8 | | | | | | | | |
| **Monthly** | 0 | 0 | 0 | 0 | 13 | 7 | 111 | 180 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Annual** | 0 | 0 | 0 | 0 | 72 | 75 | 132 | 216 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |

| Reporting Date | Sockeye | | Chum | | Cutthroat (>13 inches) | Cutthroat (< 13 inches) | Rainbow (< 20 inches) | Bull Trout (> 13 inches) | Bull Trout (< 13 inches) | Whitefish | Sucker | Daily Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | | | | | | | | |
| 01-Mar | | | | | | | 1 | | | | | **3** |
| 02-Mar | | | | | | | | | | | | **2** |
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| 04-Mar | | | | | 1 | | | | | | | **3** |
| 05-Mar | | | | | | 1 | | | | | | **4** |
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| 15-Mar | | | | | | | | | | | | **6** |
| 16-Mar | 1 | | | | | | 1 | | | | | **19** |
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| 29-Mar | | | | | | | | | | | | **22** |
| 30-Mar | | | | | | | 1 | | | | | **19** |
| 31-Mar | | | | | | | | | | | | **15** |
| **Monthly** | 2 | 0 | 0 | 0 | 8 | 3 | 15 | 0 | 0 | 1 | 1 | **344** |
| **Annual** | 2 | 0 | 0 | 0 | 9 | 3 | 16 | 0 | 0 | 1 | 1 | **549** |

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A PACIFICORP COMPANY

**Thursday, April 3rd, 2014**