**Mathematical Programming Model Description**

**for**

**Analysis of the Cost-Effectiveness of Fish Tagging Technologies and Programs**

**Developed by IEAB/NPCC**

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1. General Overview

This LP fish tagging model is a linear programming/integer programming model of the Columbia River system, fish populations, and fish tagging objectives. The model a representative set of fish life cycles, normalized to a one-year scale for number of smolts, detections, harvests, etc. The model simulates juvenile and adult migrations, ocean survival and fishery harvests. Tagging options include PIT, CWT, PBT and CSI.

1. Network

The model “network” is the set of river segments, dams and other nodes that represent a simplified version of the Columbia River system. The LP model represents 64 distinct locations within the basin and four coastal/ocean locations. The network includes the Columbia and Snake Rivers, as well as numerous smaller tributaries. See Appendix tables for details. Nearly all dams are represented, as are nearly all release sites for hatchery anadromous salmon and steelhead.

1. Fish populations, migration, survival

The model replicates the life cycle of fish, their migration, survival rates and harvest pressure. The model is intended to represent a typical year in a steady state setting for populations and tagging. The fish populations begin as hatchery and wild smolts for spring Chinook, fall Chinook, Coho, Steelhead, and Sockeye. The number of smolts occurring/released in each subbasin is calibrated based on ten-year averages of the total estimated releases from CWT databases, plus total PIT tagged fish. Wild fish populations are based on estimates of adult escapement from Columbia Basin Research ([www.cbr.washington.edu/trends](http://www.cbr.washington.edu/trends)) and some estimates from Doug Marsh. In the cases where the estimates available are for adult escapement or number of spawners, 200 smolts per adult is assumed to calculate the number of smolts (this would be consistent with a stable population and a 0.5% SAR).

Survival rates are assumed as follow: juvenile survival per 100 km (95%), juvenile survival per major dam (92%), adult survival across each major dam (98%), adult survival other than dam passage (100%). Ocean survival is assumed to be 1.5% for

Chinook and 2% for steelhead. The ocean survival rates will likely be adjusted to achieve an overall calibration of the model with escapement levels similar to those observed.

1. Tagging technologies

Four tag technologies are included in the model: coded-wire tags (CWT), PIT tags, genetic tagging using PBT, and genetic tagging using GSI. Cost assumptions are still be developed. Preliminary figures for “marginal cost” are:

Tagging Interrogation Recovery

CWT 0.18 12.00 (per sample)

PIT 4.00 0.00 ?

PBT 0.03 ?

CSI 0.03 ?

More information is being collected. See tables for cost data needs. Fixed costs (capital costs) have not yet been included.

1. Detection

For CWT, with fishery harvests it is assumed that at current tagging levels only 15% of sampled fish will have tags that are collected for the target species. The model will be able to adjust tagging levels and thus alter the ratio of snouts to sampled fish. This will influence the costs. This relationship will also apply to other tag technologies. Given the observed 15% snout/sample ratio, the collection cost per collected tag is $80. With PBT or CSI, all sampled fish can be assumed to be “tagged” if the hatchery parents or wild population has been genotyped. This means that sampling with PBT or CIS can be reduced by 85% compared to CWT to collect the same number of tags (given current CWT tagging rates and if genetic tagging is 100%). For example, to collect 20 tags from a given strata, 133 fish samples might be necessary with CWT versus 20 with PBT or CSI.

For PIT tags, a 30% detection probability is assumed for juvenile fish on the main dams; 100% for adults. The possibility of fishery detections for PIT have not yet been introduced in the model.

Detection costs for estuary troll, spawners, carcasses, have not been specified yet, nor have the costs for tagging and detections at weirs, remote locations.

1. Indicators and metrics

The initial focus is on metrics tied to juvenile survival, SARs, and fishery catches. However, detection requirements are being set to reflect average detections over a ten-year period by species, subbasin, and detection point.

1. Tagging activities not included

Studies aimed at surveillance of fish movements like those requiring acoustic or radio tags are not included in the model.