APPENDIX E.
APPLICATION OF THE EDT MODEL

This chapter was drafted in 2004 and has not been revised for 2010.

APPENDIX E. APPLICATION OF THE EDT MODEL

Tables

Figures

E.1. Introduction

Ecosystem Diagnosis & Treatment (EDT) is an approach to developing and implementing watershed plans (MBI 1999). EDT includes three primary components; a conceptual framework, analytical model, and a step-by-step procedure. For Lower Columbia River recovery and subbasin planning, we have limited our use of EDT to the analytical model itself, and have integrated it into a broader conceptual framework. For our purposes, the EDT model is used as one of several tools to assess fish population performance and fish / habitat interactions. Specifically, the model allows us to estimate fish population performance based on characteristics of physical habitat. Included in the EDT analyses are comparisons of model scenarios, which highlight geographic areas and reach-specific habitat attributes that are believed to be the most limiting for salmonid populations.

A strength of the model is its applicability to population viability criteria (McElhany et al. 2000). EDT addresses most of the Viable Salmonid Population (VSP) parameters, which include productivity, abundance, diversity, and spatial structure. Another major strength of the model is its comprehensiveness. In accounting for the important link between aquatic habitat and fish performance, EDT considers 46 different reach level habitat attributes, integrates all potential life history trajectories, and calculates 4 population performance parameters. Furthermore, the EDT Reach Analysis identifies potential restoration and preservation benefits and the specific habitat attributes that need to be restored. This level of comprehensiveness is not possible with other fish / habitat assessment techniques. Application of EDT across the planning area also allows for a high level of consistency. Consistency of results is especially important in the large and diverse Lower Columbia region, which consists of over 80 salmonid populations across nearly 20 basins. Conducting EDT across the entire planning area allows for a reasonable comparison of results among populations.

Despite the benefits and utility of using EDT, the model also has potential drawbacks. A commonly cited weakness of EDT is its complexity. The complexity can obscure transparency in underlying assumptions, which has led to its characterization as a *black box*. We have attempted to address this by describing the EDT model in sufficient detail, however, an in-depth description of model functions is beyond the scope of this document. Interested readers can learn more by visiting the EDT website (www.edthome.org), which contains links to supporting documentation. Another criticism of EDT is that it allows for the use of expert opinion for input variables where empirical data is unavailable. While this increases flexibility in areas where data is scarce, it can possibly result in erroneous outputs that are difficult to assess for accuracy. We have attempted to address this concern by comparing EDT inputs to the outputs of a watershed process model and by comparing EDT results to empirical fish abundance data. These comparisons are presented in other appendices to this document. The other major criticism of EDT is that it is not explicit with respect to uncertainty in model functions and sensitivity to inputs or errors. Model uncertainty is difficult to assess due to its complexity, breadth, and the use of expert opinion. The evaluations presented here provide insight into the degree of prediction and parameter uncertainty. An analysis to investigate the sensitivity of outputs to errors in input parameters is currently underway by NMFS and Mobrand Biometrics Inc.

This document consists of two primary sections. First, we give a brief description of how the EDT model works in general and how it was specifically applied to the lower Columbia region. Second, we present an evaluation of the lower Columbia EDT runs by comparing model outputs with empirical fish abundance data and by comparing model inputs with outputs of a watershed process model that has been applied in the lower Columbia region. These evaluations are intended to provide information on the appropriate utility of EDT for lower Columbia recovery planning.

E.2. EDT Overview

E.2.1. Baseline Runs

EDT can be classified as a mechanistic model that is based on the relationships between aquatic habitat characteristics and fish performance. Model inputs include descriptions of the physical stream environment, at a reach level, which are then related through a set of rules to life-stage specific survival. These survival characteristics are then integrated across the entire life history of the population. Results include estimates of population productivity, capacity, equilibrium abundance, and diversity. EDT is typically used to model conditions for the current (patient), historical (template), and Properly Functioning Condition (PFC) scenarios.

Descriptions of physical habitat are made for individual reaches, and take the form of scores (0-4) for each of 46 habitat attributes, known as Level 2 attributes (Table E6-1). Guidelines have been developed that specify appropriate scores according to available coarse scale data (Level 1 data) and the scenario being considered. If no data exists, scores may be inferred from similar areas where there is data or can be estimated using expert opinion. Model inputs also include a description of stream size and the relative quantity of habitat unit types (e.g. backwater pools). Level 2 habitat attribute scores are then combined through a set of rules into relative survivals for 16 Level 3 attributes (Table E6-1). For instance, the level 2 attributes of turbidity, embeddedness, and fine sediment are combined to create a relative survival for the level 3 attribute Sediment Load. The rules used to combine level 2 attributes into level 3 relative survivals depend on the life stage being considered. For instance, for the egg incubation stage, fine sediment receives more 'weight' than embeddedness, and turbidity has no effect. These rules are based on empirical data or assumed relationships based on the current state of the knowledge of fish / habitat relationships. For each life stage in each reach, Level 3 relative survivals are applied to a theoretical optimum survival to obtain a realized survival (productivity) estimate. This value is then applied to a density dependent Beverton-Holt survival function which uses a theoretical optimum capacity based on the spatial extent of available habitat unit types in the reach. The extent of biologically possible life history trajectories is another model input and typically involves assigning percentage use of several different life history patterns that are offered as options in the model. In order to correctly estimate life history trajectories, model users must have knowledge of which life stages are carried out in which stream reaches. This information may also be inferred from physical stream channel characteristics such as gradient and channel width. Reach and life-stage specific survival functions are integrated across all life history stages in all life history trajectories in order to arrive at population performance parameters. A conceptual diagram of the EDT model is presented in Figure E6-1.

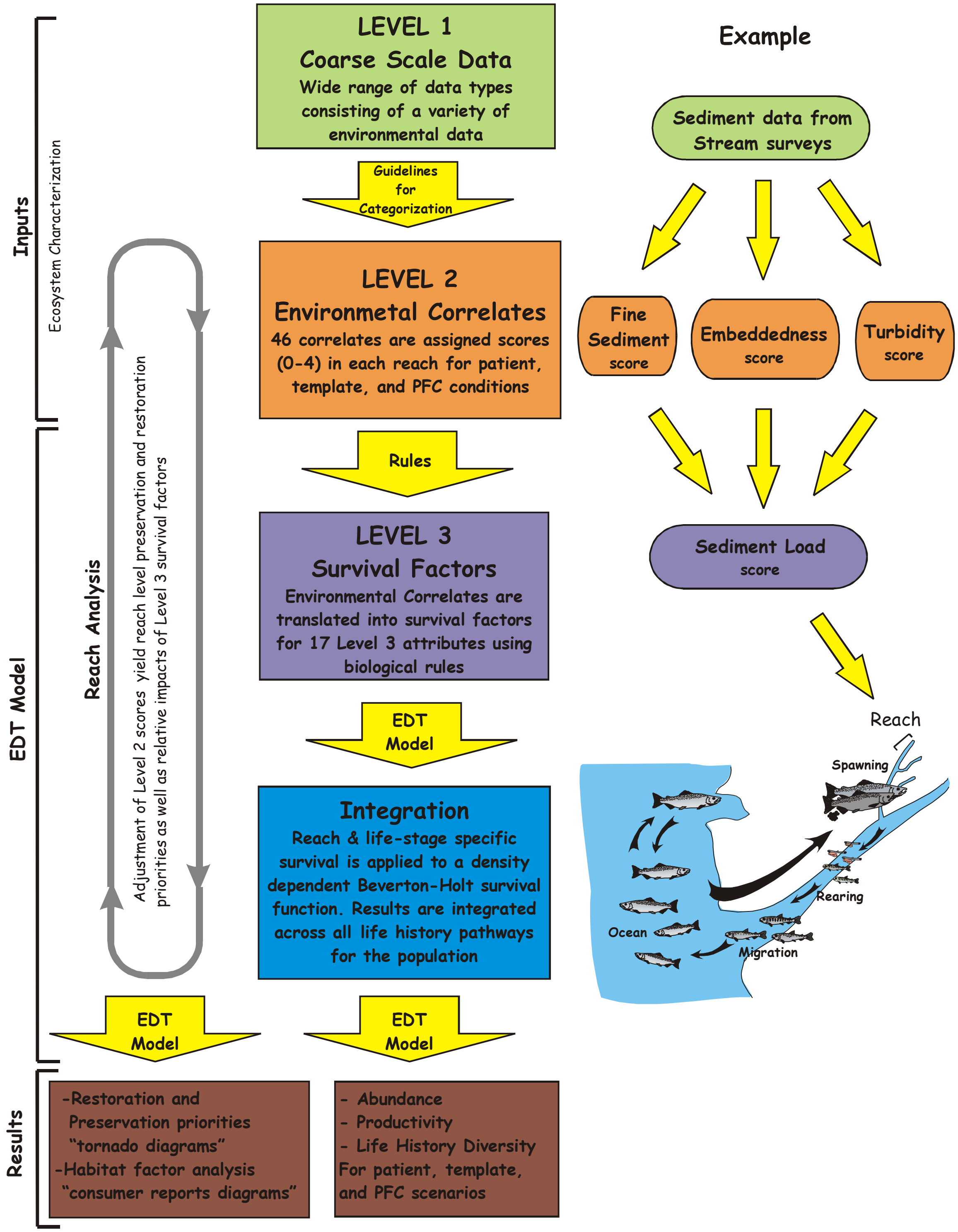

Figure E6-1. Conceptual diagram of the EDT model.

Final model results include smolt and adult productivity, equilibrium abundance, capacity, and diversity estimates. Adult productivity is the measure of density independent survival, and can be thought of as a population's capacity to replace itself. It is represented in EDT as the number of adults produced in the next generation per spawner. Smolt productivity is expressed as the number of smolts per spawner. Adult and smolt capacity are the theoretical maximum capacities that the habitat can support, but that it cannot sustain over multiple generations due to density dependent effects (i.e. superimposition).

Adult abundance (equilibrium abundance or Neq) is the density dependent abundance at the point where the population is just replacing itself. It can generally be thought of as the average abundance of the population. Mathematically, it is the intersection of the stock recruit (Beverton-Holt) curve with the 1:1 replacement line (Figure E6-2). Smolt abundance is calculated similarly but is concerned with the equilibrium abundance of smolts leaving the system. Diversity in EDT is expressed as the percentage of theoretically possible life history trajectories that are viable under the specified habitat conditions. Estimates of smolt productivity and abundance are useful for describing effects of subbasin spawning and rearing habitats independent of out-of-basin fishery, mainstem, estuary, and ocean concerns.

EDT estimates have been generated for historical (template), current (patient), and “Properly Functioning Conditions” (PFC). The historical/template condition is defined as pre-non-Native American European influence and represents a hypothetical optimum. The current/patient condition represents the immediate past few years. PFC represents favorable habitat conditions for salmonids throughout the basin based on criteria identified by NMFS (1996). PFC conditions are less optimum than the pristine historical template but are assumed to ensure population persistence (i.e. avoid extinction).

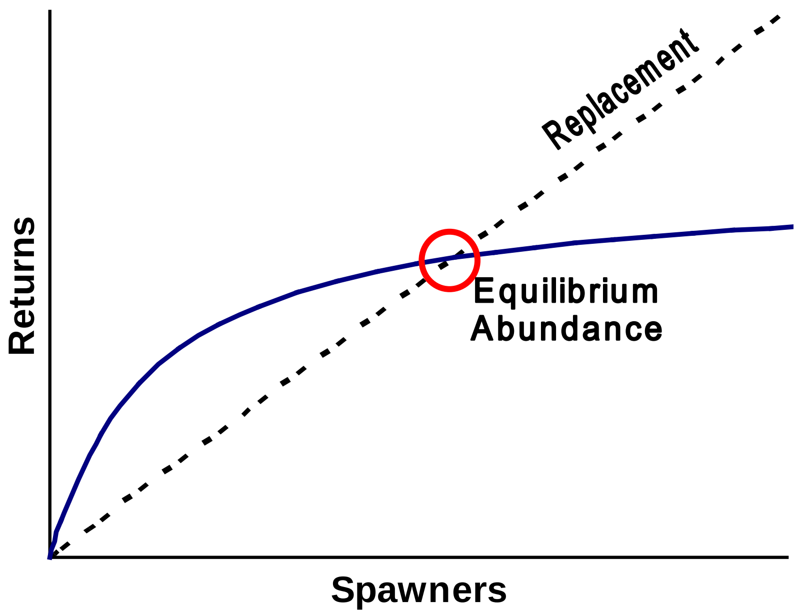

Figure E6-2. Example of a stock recruitment curve generated using a density dependent survival function. The equilibrium abundance (Neq) is the intersection of the spawner-recruit curve with the 1:1 replacement line and represents a theoretically sustainable abundance.

Table E6-1. Definition of EDT Level 3 attributes and their associated level 2 correlates. The primary effects and secondary effects are generalizations of the primary and modifying level 2 environmental correlates used by the EDT model. Specific primary and modifying effects depend on species and life stage.

Level 3 Attribute	Definition	Modifying Level 2 Attributes Primary effects	Secondary effects
Channel stability	The effect of stream channel stability (within reach) on the relative survival or performance of the focus species; the extent of channel stability is with respect to its streambed, banks, and its channel shape and location.	Bed scour	Icing Riparian function Wood Confinement -natural Confinement -artificial Flow – change in interannual high flow variation Flow – intraannual flow pattern
Chemicals	The effect of toxic substances or toxic conditions on the relative survival or performance of the focus species. Substances include chemicals and heavy metals. Toxic conditions include low pH.	Miscellaneous toxic pollutants – water column	Metals – in water column Metals / Pollutants – in sediment / soils Nutrient enrichment
Competition (with hatchery fish)	The effect of competition with hatchery produced animals on the relative survival or performance of the focus species; competition might be for food or space within the stream reach.	Hatchery Fish Outplants	Alkalinity Benthos Diversity and Production Riparian Function Salmon Carcasses
Competition (with other species)	The effect of competition with other species on the relative survival or performance of the focus species; competition might be for food or space.	Fish Community Richness	Alkalinity Benthos Diversity and Production Riparian Function Salmon Carcasses
Flow	The effect of the amount of stream flow, or the pattern and extent of flow fluctuations, within the stream reach on the relative survival or performance of the focus species. Effects of flow reductions or dewatering due to water withdrawals are to be included as part of this correlate.	Flow – change in daily variation Flow – change in interannual high flow variation Flow – change in interannual low flow variation	Confinement -natural Confimement -artificial Gradient Riparian function Wood Embeddedness Habitat type
Food	The effect of the amount, diversity, and availability of food that can support the focus species	Benthos diversity and production	Alkalinity Riparian function Salmon carcasses

Level 3 Attribute	Definition	Modifying Level 2 Attributes Primary effects	Secondary effects
Habitat diversity	The effect of the extent of habitat complexity within a stream reach on the relative survival or performance of the focus species.	Gradient	Confinement –natural Confinement -artificial Riparian function Wood Icing
Harassment (harvest)	The effect of harassment, poaching, or non-directed harvest (i.e., as can occur through hook and release) on the relative survival or performance of the focus species.	Harassment	Habitat type – primary pools Riparian function Turbidity Wood
Key habitat	The relative quantity of the primary habitat type(s) utilized by the focus species during a life stage; quantity is expressed as percent of wetted surface area of the stream channel.	Habitat type - backwater pools Habitat type - beaver ponds Habitat type - Glides Habitat type - large cobble/boulder riffles Habitat type - off-channel habitat factor Habitat type - primary pools Habitat type - pool tailouts Habitat type - small cobble/gravel riffles	
Obstructions	The effect of physical structures impeding movement of the focus species on its relative survival or performance within a stream reach; structures include dams and waterfalls.	Obstructions to fish migration	
Oxygen	The effect of the concentration of dissolved oxygen within the stream reach on the relative survival or performance of the focus species.	Dissolved Oxygen	
Pathogens	The effect of pathogens within the stream reach on the relative survival or performance of the focus species. The life stage when infection occurs is when this effect is accounted for.	Fish Pathogens	Fish species introductions Temperature – daily maximum (by month) Nutrient enrichment
Predation	The effect of the relative abundance of predator species on the relative survival or performance of the focus species, apart from the influence of the amount of cover habitat used by the focus species.	Predation risk	Fish community richness Fish species introductions Hatchery fish outplants Temperature – daily maximum (by month) Flow – change in interannual low flow variation

Level 3 Attribute	Definition	Modifying Level 2 Attributes Primary effects	Secondary effects
Sediment	The effect of the amount of fine sediment present in, or passing through, the stream reach on the relative survival or performance of the focus species.	Turbidity Fine sediment Embeddedness	Temperature – daily maximum (by month) Flow – change in interannual high flow variation Flow – change in interannual low flow variation
Temperature	The effect of water temperature in the stream reach on the relative survival or performance of the focus species.	Temperature – daily maximum (by month)	Temperature – spatial variation
Withdrawals (entrainment)	The effect of entrainment (or injury by screens) at water withdrawal structures within the stream reach on the relative survival or performance of the focus species. This effect does not include dewatering due to water withdrawals, which is covered by the flow correlate.	Water withdrawals	

E.2.2. Reach Analysis

EDT reach analyses have been conducted for all populations assessed with EDT in the lower Columbia. The reach analysis function in EDT adjusts the level 2 input scores up or down for individual reaches and then ranks the reaches according the effect that the adjustment has on total population performance parameters. Reach analysis considers the same population performance parameters as the baseline run analysis though it provides a greater level of detail as it identifies reaches based on their relative preservation and restoration value. Reach analysis results are specific to each fish species because of the different fish habitat requirements of each.

The assessment of restoration value in a particular reach is conducted by hypothetically *restoring* all of the level 2 scores for that reach from patient to template conditions, with the assumption that template conditions represent habitat conditions that would result from full reach restoration. The model is then re-run in order to capture the percent change in fish performance due to this hypothetical restoration in the reach. This is conducted for all reaches independently and the reaches are ranked accordingly. A higher ranked reach for restoration would therefore become high priority for habitat restoration measures because of the greater potential benefit to the population than from restoration of lower ranked reaches. A similar exercise is conducted to identify preservation value, except that level 2 scores in a particular reach are artificially *degraded* and the reaches are ranked according to how great of a negative impact they have on total population performance. If degradation of habitat scores has a large negative effect on population performance, then that reach has high preservation value. Reaches with a high preservation value should be protected because of the disproportionately high negative impact on the population that would result from degradation. In order to reduce the influence of reach length on reach importance, the population change that results from hypothetical restoration or preservation was normalized by reach length. This results in percentage change in population values that are expressed per 1000 meters of reach length. Results are typically displayed in a graphical format that is often referred to as a ladder or tornado diagram (Figure E6-3).

Many reaches have both high preservation and high restoration value. These tend to be highly productive or potentially highly productive reaches, where relatively modest changes in habitat quality can have a significant effect on population performance. In these reaches, management strategies should work to both preserve existing functional attributes and restore degraded attributes.

Reach Group (H, M, L) and Recovery Emphasis (P, R, PR) are designations developed for recovery planning purposes and are not generated by the EDT model. A description of these designations is presented below.

A limitation of the reach analysis is that it analyzes reach restoration and degradation independently for each reach. An example of this limitation is that a reach that may actually hold a lot of promise for restoration may show no positive effect to the population if a severely degraded or impassable reach (bottleneck) exists downstream. It is therefore important to be aware of where such bottlenecks are located, and if necessary eliminate them from the reach analysis to prevent misleading results.

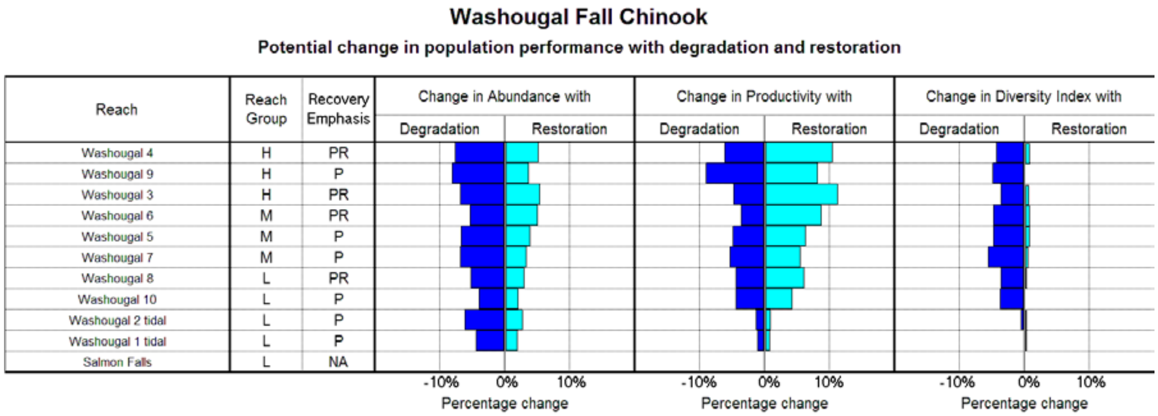

Figure E6-3. Example of ladder diagram for Washougal Fall Chinook. The longer the bars, the greater the change in the population performance parameters (abundance, productivity, and life history diversity) when reach scores are changed to Template conditions (restoration analysis) or set to a degraded condition (preservation analysis). The percentage change values are expressed as the percentage change in population performance per 1000 meters of channel length within the reach.

Another assessment conducted as part of the EDT reach analysis evaluates the effect of the Level 3 survival factors on reach and life-stage productivity. The results are displayed on “consumer report diagrams” (Figure E6-4). While this level of detail is useful for local restoration practitioners, it is generally too specific for comparisons across populations or even across reaches. For this reason, we chose to summarize the effect of survival factors across all life history stages in a reach. We termed this assessment a Habitat Attribute Impact Analysis. It is described in the following section.

Species/Component:	Fall Chinook	***Washougal Watershed - Reach Analysis - Fall Chinook***
Restoration Potential:	Current Conditions versus Historic Potential	
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories	

Geographic Area:	Washougal 6		**Stream:**		
Reach:		0	**Reach Length (mi):**	2.40	
			Reach Code:	Washougal 6	

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	3	**Potential % change in productivity:2/**	16.2%
Overall Restoration Potential Rank:1/	2	**Average Abundance (Neq) Rank:1/**	2	**Potential % change in Neq:2/**	9.9%
(lowest rank possible - with ties)1/	11	**Life History Diversity Rank:1/**	1	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	4	**loss in productivity with degradation:2/**	-13.8%
Overall Preservation Rank:1/	4	**Average Abundance (Neq) Rank:1/**	4	**% loss in Neq with degradation:2/**	-15.9%
(lowest rank possible - with ties)1/	12	**Life History Diversity Rank:1/**	4	**% loss in diversity with degradation:2/**	-9.3%

					Change in attribute impact on survival															
Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Nov	11.2%	-10.8%	4							Moderate	Moderate					Small	Moderate		
Egg incubation	Nov-May	11.2%	-25.4%	6	High							Small					Moderate	Small		
Fry colonization	Apr-May	31.9%	-17.1%	7	Moderate			Small	High	Moderate	High					Moderate	Moderate			Small
0-age active rearing	Mar-Oct	48.4%	-1.0%	3	Small		Small			Small	Moderate					Small				Moderate
0-age migrant																				
0-age inactive																				
1-age active rearing																				
1-age migrant																				
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Oct	67.9%	-0.2%	2							Small	Small						Small		
Prespawning holding	Oct-Nov	11.2%	-10.8%	5					Moderate		High	Moderate					Small	Moderate		Small
All Stages Combined		67.9%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	●	○
Moderate	●	○
High	●	○
Extreme	●	○

Figure E6-4. Example of "Consumer Report Diagram" for Washougal Fall Chinook. Top rows give information on preservation and restoration benefit. Note that "Benefit category" does not apply for our analysis. Dots represent the relative impact of the level 3 habitat attributes (survival factors) on life-stage specific productivity in the reach. One of these reports is created for each reach utilized by the population.

E.2.3. Specific applicability to Lower Columbia Recovery Planning

Spatial Extent

A total of 83 Lower Columbia anadromous fish populations have been assessed through the EDT Model. These runs represent all of the major basins with significant anadromous fish use on the Washington side of the Lower Columbia, extending from the Columbia River mouth east to the Wind River. Populations include native runs of winter and summer steelhead, chum, fall and spring Chinook, and coho. EDT has not been fully developed for Bull Trout, cutthroat, and the many other resident fish species present in the study area. However, model results for species that inhabit the same stream reaches can provide insight into habitat effects for non-modeled species.

EDT model runs have been conducted by various agencies and organizations depending on the river system. A map of EDT progress in the region and the organization(s) that have been most involved with the model runs are presented in Figure E6-5. Table E6-2 provides a list of all the populations that have been assessed using EDT.

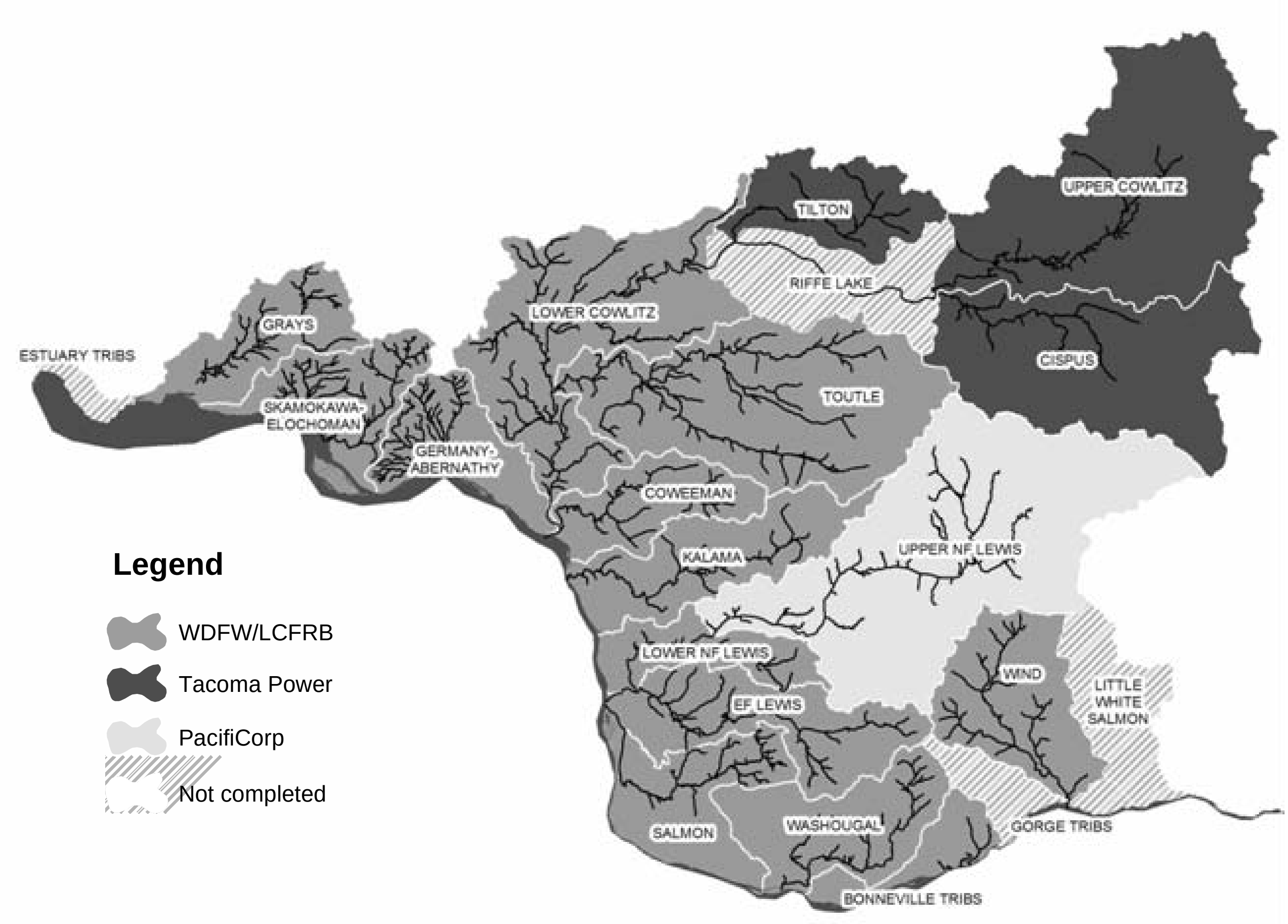

Figure E6-5. **Map of lower Columbia region showing EDT modeling status.**

Table E6-2. Status of EDT modeling for populations on the Washington side of the lower Columbia River.

Organization	River basin	Species					
		chum	fall chinook	spring chinook	summer steelhead	winter steelhead	coho
--WA Dept. of Fish & Wildlife --Lower Columbia Fish Recovery Board (2003/2004)	Grays	✓	✓			✓	✓
	Skamokawa	✓	✓			✓	✓
	Elochoman	✓	✓			✓	✓
	Mill	✓	✓			✓	✓
	Abernathy	✓	✓			✓	✓
	Germany	✓	✓			✓	✓
	Lower Cowlitz	✓	✓			✓	✓
	Coweeman	✓	✓			✓	✓
	Toutle	✓	✓	✓		✓	✓
	Kalama	✓	✓	✓	✓	✓	✓
	Lower NF Lewis	✓	✓			✓	✓
	EF Lewis	✓	✓		✓	✓	✓
	Salmon Creek	✓	✓			✓	✓
	Washougal	✓	✓		✓	✓	✓
	Bonneville Tributaries	✓	✓			✓	✓
	Wind	✓	✓		✓	✓	✓
Tacoma Power (2003)	Tilton		✓	✓		✓	✓
	Upper Cowlitz/Cispus		✓	✓		✓	✓
PacifiCorp (2003)	Upper Lewis			✓		✓	✓

Additional Analyses

Additional analyses have been applied to EDT results for the purposes of recovery planning. The two primary additional analyses include the identification of reach priority rankings and the assessment of the relative effects of Level 3 Habitat Attributes (Survival Factors).

Reach ranking

In order to narrow the focus of habitat recovery planning such that the most important reaches are targeted for restoration or preservation, reaches were ranked according to where recovery actions would yield the greatest benefits to a particular population. Based on reach rank, the reaches were then binned into high, medium, and low priority categories.

Reach rankings were determined by summing the potential change values for preservation and restoration across the 3 performance measures (i.e. summing the values for all bars of the ladder diagram for each reach). Reach rankings therefore reflect the contribution of the reach to current AND potential population performance. In the ladder diagrams (Figure E6-3) reaches are ordered according to their prioritized rank.

The binning of reaches into high, medium, and low categories was conducted using the following methodology. Beginning with the top ranked reach and working down in ranked order, the running sum of performance values (using population change values not normalized for reach length in this case) was calculated until at least one-third of the cumulative sum of all reach performance values was reached. These reaches were placed into the high category. The process was continued until two-thirds of the cumulative sum was reached and these reaches were designated as medium priority. The remainder were designated low priority. This process results in approximately one-third (or slightly less on average) of the channel lengths allocated to the high category, one-third to the medium category, and one-third to the low category.

Reaches were also given a recovery emphasis designation. A designation of P indicates that preservation measures should be emphasized within the reach. A designation of R indicates that restoration measures should be emphasized. A designation of PR means that both preservation and restoration are equally important. Reaches were designated P or R if greater than 60% of total population change (the summing of the bars in the ladder diagram) resulted from preservation or restoration, respectively. Reach priority groups (H, M, L) and reach recovery emphasis (P, R, PR) are displayed in the ladder diagrams (Figure E6-3).

Habitat Attribute Impact Analysis

An assessment of the effect of degraded habitat attributes in specific reaches is necessary to evaluate causes of population decline and to identify recovery measures. In the EDT reach analysis, the relative impact of the various level 3 habitat attributes (see discussion in section above) is evaluated. The model accomplishes this by artificially restoring each of the habitat attributes in a reach to template conditions one at a time and evaluating the change to reach productivity. This is done for individual life stages within individual reaches. These results are displayed in what are commonly termed “consumer report diagrams” (Figure E6-4). While this level of detail is useful for practitioners who are implementing specific recovery measures in specific reaches, it is too detailed for an effective comparison of habitat impairments across reaches in a basin. In order to expand the analysis to the population-scale, we combined all life stages within a reach and weighted the reach values according to the relative contribution of the reach to overall population abundance. Similar to consumer report diagrams, the result is a chart with sized dots representing the level of impact of the 16 level 3 attributes, only there is just one dot per reach and all the reaches for a population are combined in one chart (Figure E6-6). These are referred to as Habitat Attribute Impact charts. A similar analysis can be conducted using the EDT model itself and is termed an “attribute splice”, but it has the disadvantage of requiring additional model runs.

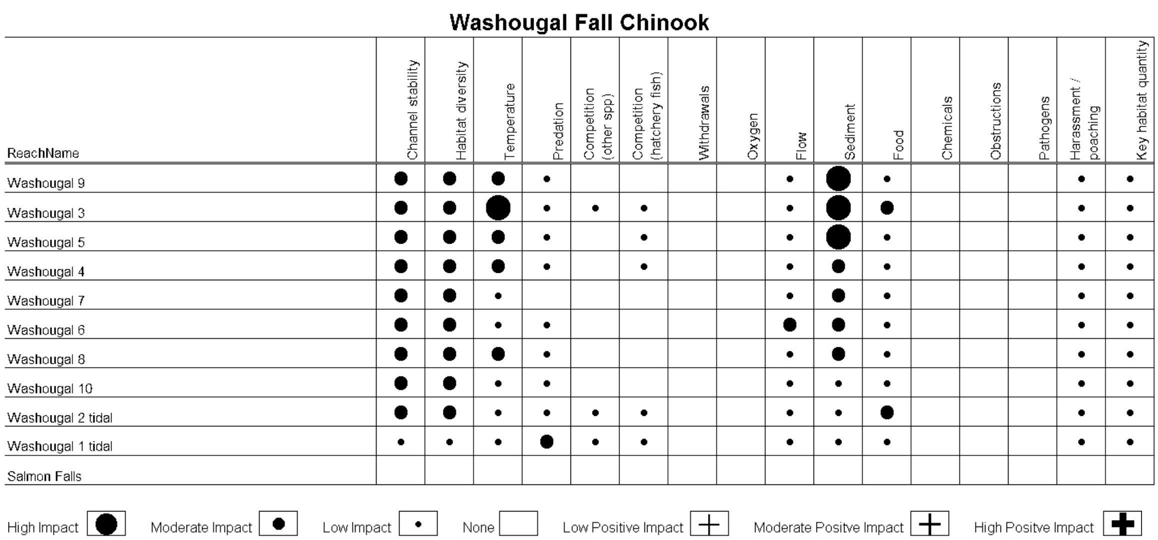

Figure E6-6. Example of Habitat Factor Analysis diagram for Washougal Fall Chinook. The dots represent the relative impact of level 3 habitat attributes (survival factors) within all reaches utilized by the population.

E.3. Evaluation of EDT

E.3.1. Introduction

The EDT model has several potential sources of error and uncertainty due to the many inputs, functions, and their associated assumptions. These include input parameters, which include reach delineation, level 2 scores, level 2 scoring guidelines, and life history pathways / trajectories; benchmarks, which are productivity and capacity estimates under optimal conditions; and biological rules, which translate level 2 scores to level 3 survival factors. Due to the large number of calculations involved with integrating all life stages across life history trajectories, the potential for compounded error and uncertainty is a concern. There are several approaches to evaluating the aforementioned sources of error and uncertainty. In this document, we focus on two primary approaches; comparison of results (performance parameters) to empirical data, and comparison of input scores to watershed process modeling results. An analysis of model sensitivity to error and uncertainty in inputs, biological benchmarks, rules, and trajectory selection is beyond the scope of this evaluation; however, analyses that have been conducted to date by others are briefly summarized.

Once again, an exhaustive technical evaluation of EDT is beyond the scope of this project, but is being conducted in pieces by other entities. Relevant references are provided for those wishing to obtain additional information. The primary objective of this analysis is to shed some light on the adequacy of the model as a tool for recovery planning and thus better inform the interpretation of results.

E.3.2. Evaluations

Comparison of EDT with empirical observations[1]

In this analysis, the smolt production (abundance) estimates of lower Columbia EDT runs are compared to actual smolt outmigration estimates from trap data throughout the Northwest. A comparison of modeled and empirical smolt data was chosen for two reasons: 1) reliable smolt data from trapping studies is readily available for many regional streams, and 2) compared to adult return data, smolt abundance is less affected by the potentially confounding variability of out-of-basin (i.e. ocean) conditions. It should be noted that this assessment provides a “first glance” evaluation of EDT reasonableness. A more thorough evaluation is underway by WDFW that will compare the suite of EDT performance parameters (capacity, Neq, initial productivity) to estimates derived from empirical data. Results will be incorporated into the technical foundation as this effort moves forward.

Methods

Data Description

EDT smolt production estimates were made for salmonid populations including chum, spring and fall Chinook, summer and winter steelhead and coho for basins on the Washington side of the Columbia River from the Grays River to the Wind River (Figure E6-5). Estimates reflect equilibrium abundance (Neq or realized capacity) for the entire basin upstream of the mouth of each river. Only patient (current) estimates of smolt equilibrium abundance were considered in this analysis. Equilibrium abundance reflects the average expected performance of a population given average environmental conditions. The EDT data used in this analysis are presented in Table E6-3.

[1] The EDT smolt abundance data used in this analysis are from year 2003 model runs. Subsequent runs have been conducted using updated model inputs.

Table E6-3. EDT data used in analysis. Data are Patient (current) smolt equilibrium abundance (Neq).

Basin	Basin Size (mi²)	Patient Neq Fall Chinook	Patient Neq Steelhead[4]	Patient Neq Coho	Patient Neq Smolts/mi² of watershed Fall Chinook	Patient Neq Smolts/mi² of watershed Steelhead[4]	Patient Neq Smolts/mi² of watershed Coho
Coastal Region							
Grays River	61	57,260	8,941	--	945	148	--
Skamokawa Creek	17	95,719	2,513	19,736	5,501	144	1,134
Elochoman River	66	182,410	6,265	27,015	2,772	95	411
Germany Creek	23	120,843	5,846	11,040	5,277	255	482
Abernathy Creek	20	101,917	5,254	13,575	5,021	259	669
Mill Creek	28	82,379	2,623	4,287	2,911	93	151
Cascade Region							
Cowlitz River[1]	445	1,976,934	5,739	--	4,443	13	--
Toutle River	511	758,300	16,388	--	1,484	32	--
Coweeman River	119	192,384	10,221	--	1,617	86	--
Kalama River	205	80,908	24,700	--	395	120	--
Lewis River							
E.Fk. Lewis River	235	221,799	10,160	--	942	43	--
N.Fk. Lewis River[2]	101	1,172,483	3,223	--	11,666	32	--
Upper Lewis[3]	731	114,154	32,330	254,912	156	44	349
Washougal River	108	366,647	13,076	--	3,395	121	--
Gorge Region							
Duncan/Hardy/ Hamilton Creeks	52	--	1,053	--	--	20	--
Wind River	225	129,563	29,312	--	576	130	--
Little White Salmon R.	134	--	--	--	--	--	--
White Salmon River	294	--	--	--	--	--	--

[1] Cowlitz below Mayfield Dam
[2] Lewis below Merwin Dam; not including E. Fk. Lewis
[3] Lewis River above Swift Reservoir - hypothetical population
[4] Includes summer and winter steelhead

Estimates of smolt outmigration from field trapping were gathered from throughout the Pacific Northwest for steelhead, coho, and fall Chinook. Data were used from traps located in the Cascades, the Gorge, the Coast, and the Umpqua Basin because these regions were the same as or similar to those in the lower Columbia Basin where EDT estimates were made. No spring Chinook trap data were found in these regions, and thus no comparisons are made to EDT spring Chinook results. For each trapping location, data were obtained for all years where estimates were made. Only spring smolt outmigrants were included in the analysis except with fall Chinook where all outmigrants were used. Trap location, years data were available, and range of values across years are presented in Table E6-4. A complete list of trap locations where data were obtained and the source of the data can be found in the Supplemental Information section at the end of this document.

Table E6-4. Information on smolt traps and trap data used for comparison with EDT.

Basin	Subbasin	Est. Drainage Area (mi^2) Above Trap	Years of Estimates	Outmigration Estimates (outmigrants/mi^2) (min-max) Steelhead	Coho	Fall Chinook
Coastal Region						
Alsea	Cascade Cr.	5.6	1998-2002	13 - 25	2 - 314	206 - 206
Alsea	E.Fk. Lobster	6	1998-2002	--	152 - 633	--
Alsea	Upper Lobster	5	1998-2002	--	75 - 900	--
Coos	Bottom Cr.	17.8	1999	9 - 9	144 - 144	--
Coos	Fall Cr.	15	1999-2001	--	22 - 234	288 - 848
Coos	Winchester Cr.	10	1999-2002	--	100 - 460	--
Coquille	N. Fk. Coquille R.	291	1998	15 - 15	9 - 9	--
Kilchis	Little S. Fk. Kilchis R.	12	1998-2002	118 - 300	3 - 191	380 - 12,874
Lower Columbia	Abernathy Cr.	28.7	2001-2002	188 - 369	216 - 244	--
Lower Columbia	Germany Cr.	22.5	2001-2002	333 - 338	311 - 363	--
Lower Columbia	Mill Cr.	29.1	2001-2002	43 - 59	217 - 326	--
Nehalem	N. Fk. Nehalem R.	24.4	1998-2002	140 - 715	777 - 1901	6,593 - 79,391
Nestucca	Little Nestucca R.	45.3	1998	176 - 176	278 - 278	--
Oregon Coast	Cummins Cr.	10	1998-2002	142 - 321	1 - 222	--
Oregon Coast	Tenmile Cr.	23	1998-2002	262 - 864	73 - 403	210 - 1,515
Siletz	Mill Cr.	13	1998-2002	18 - 87	332 - 1328	27 1,303
Wilson	Little N. Fk. Wilson	20	1998-2002	176 - 1034	112 - 722	11,306 - 61,197
Yaquina	Bales Cr.	3.5	1998-2002	--	118 - 464	633 - 71,231
Yaquina	Mill Cr.	8	1999-2002	35 - 109	--	4 - 919
Yaquina	Mill Cr.	8	1998-2002	--	278 - 878	--
Cascade Region						
Clackamas	Big Bottom	139	1994 & 1998	21 - 23	34 - 314	--
Clackamas	Fish Cr.	47	1989-2000	22 - 198	1 - 176	--
Clackamas	Mainstem Above N. Fk. Dam	681	1994-1996	18 - 37	41 - 180	--
Clackamas	N. Fk. Clackamas	32	1998	63 - 63	--	--
Clackamas	N. Fk. Eagle Cr.	28	1999	134 - 134	--	--
Clackamas	Oak Grove Fk.	142	1998-1999	8 - 11	0 - 30	--
Kalama	Kalama R.	179	1978-84,92-94,98-02	48 - 254	--	--
Lewis	Cedar Cr.	30	2001-2001	90 - 119	805 - 1167	--
Gorge Region						
Hood	Hood R.	352	1994-2001	8 - 70	--	--
Wind	Wind R.	225	1995-1999	36 - 109	--	--
Umpqua Region						
Umpqua	W. Fk. Smith R.	26	1998-2002	103 - 295	418 - 862	36 - 4,913
Umpqua	Smith R.	202	1998-2002	1 - 144	535 - 7197	--
Umpqua	Big Tom Folley Cr.	22.2	1998-2002	7 - 113	19 - 302	--
Umpqua	Brush Cr.	21	1998-2002	12 - 66	39 - 319	--
Umpqua	Elk Cr.	104	2002	14 - 14	--	--
Umpqua	Rock Cr.	98	2001	376 - 376	65 - 65	--
Umpqua	Cow Cr.	499	1999-2002	6 - 30	15 - 79	--

Data Analysis

To compare EDT and actual outmigrant estimates, estimates were standardized by watershed area, resulting in a smolt density value (i.e. number of fish per watershed area). For EDT estimates, watershed area for the entire basin was used, and for migrant traps, the watershed area above the trap was used. Watershed areas were derived from published reports, GIS analysis, or from published watershed areas above nearby USGS gauges.

Maximum, as opposed to average, annual outmigrant estimates from trapping data in recent years were used for comparison to EDT. The maximum outmigrant estimate was chosen because recent trapping studies have taken place during years of low adult returns that resulted in underseeded habitat. We therefore believe that the maximum value best represents long-term average capacities.

For each species, the distribution of EDT estimates and maximum observed outmigrations at migrant traps (by watershed area) were plotted via box plots. All available EDT estimates in the lower Columbia were used, and data from all migrant traps were used.

To facilitate more specific comparisons, basins were grouped into regions including: Coastal, Cascade, and Gorge. Data from different basins were pooled with others within their region for analysis. Data from the Umpqua Basin were not used in this comparison because that basin represents somewhat of an overlap in coastal and cascade habitats. Estimated EDT and observed outmigration densities by watershed area were compared between like regions and species.

Basin specific comparisons were made in situations where both migrant trap and EDT estimates were available for lower Columbia Basins. These comparisons were made by examining the EDT/trap ratio. There were no recent and reliable fall Chinook outmigrant estimates in the lower Columbia tributaries, thus no comparison for fall Chinook was made.

Results

Broad-scale Comparisons

The distribution of EDT and trap estimates indicated that medians of each group were similar to each other, but that the distributions were somewhat dissimilar (Figure E6-7). For each species, medians were within 30%. The range of migrant trap estimates was greater than EDT estimates for each species and the migrant trap distributions tended to be right-skewed, indicating the presence of some very high values; a condition not seen with EDT results. Most notably, the greatest fall Chinook trap estimate was near 80,000 smolts/mi^2 as compared to 12,000 smolts/mi^2 for the greatest EDT estimate (Figure E6-7).

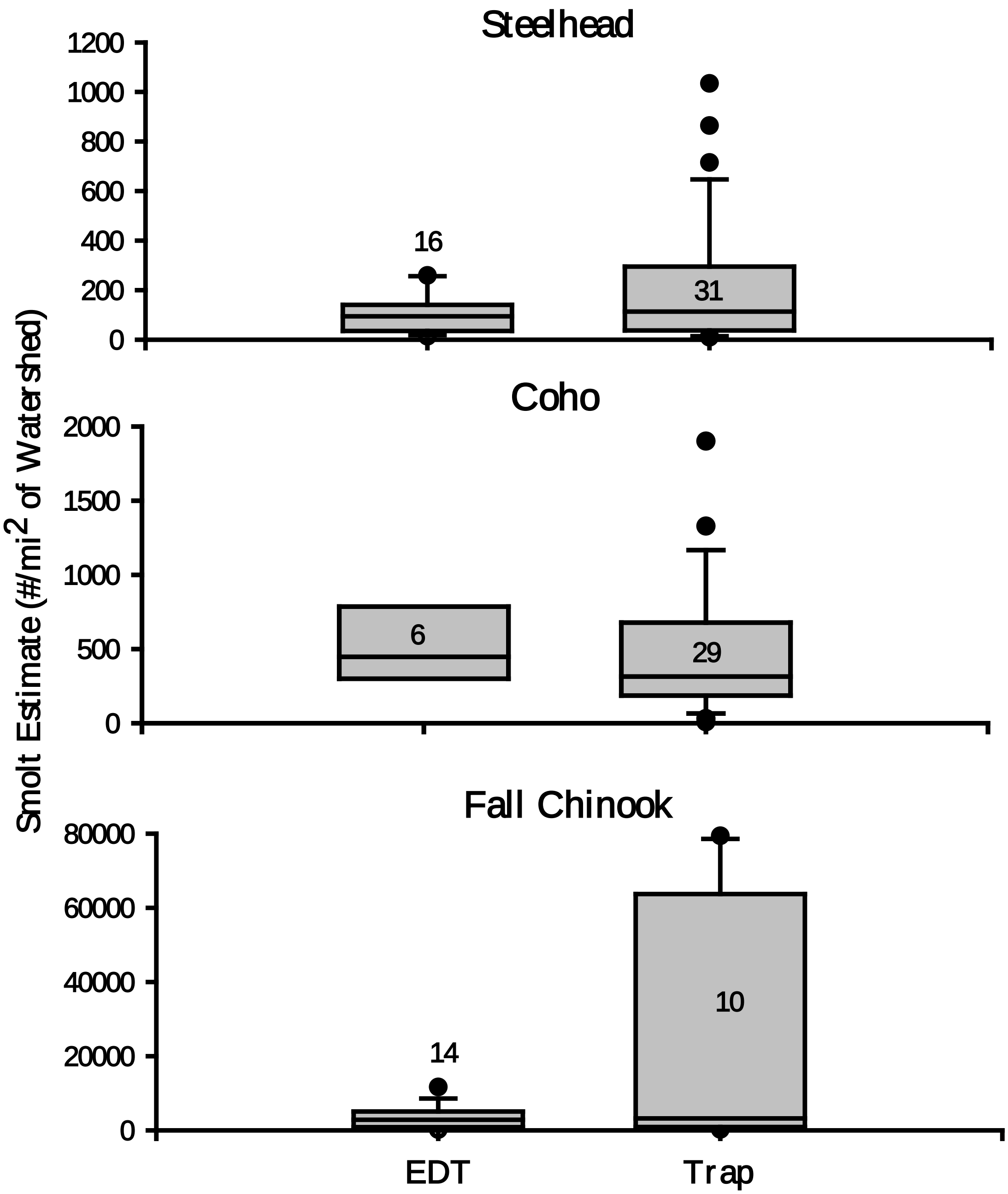

Figure E6-7. **Box plots of EDT smolt Neq (lower Columbia Washington populations) and maximum trap estimates (Western Washington and Oregon) per watershed area. Bars represent 10th, 25th, 50th, 75th, and 90th percentiles. Points indicate outliers. Sample sizes are indicated.**

Regional Comparisons

Comparisons by region showed that median estimates were reasonably similar between EDT and migrant traps for all three species in each region where comparisons were possible (Figure E6-8). The largest differences were in fall Chinook in coastal streams and in steelhead in Cascade streams. As with the broad-scale comparison, the range of values observed at migrant traps is greater than that for EDT (Table E6-5).

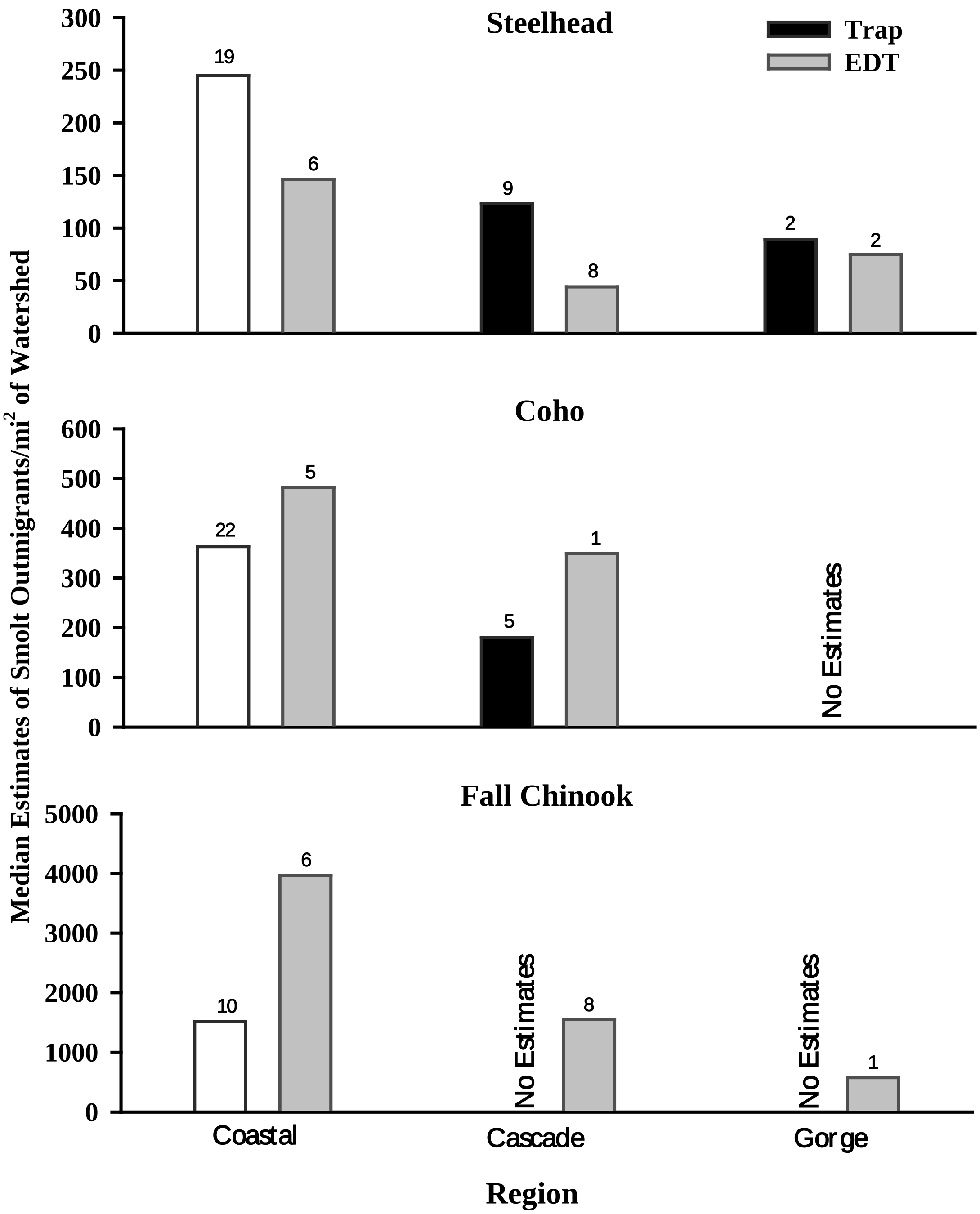

Figure E6-8. **Comparison of median EDT and migrant trap estimates of steelhead, coho, and Chinook for three different regions. Migrant trap data is the median of maximum observations at several traps. Sample sizes are indicated above bars.**

Table E6-5. Median, minimum and maximum EDT and migrant trap smolt density estimates by species for three different regions. Trap Count values are based on the maximum value recorded for the period of record.

		Smolts/watershed mi^2					
		Trap Counts			EDT* Patient		
Species	**Region**	**Med.**	**Min.**	**Max.**	**Med.**	**Min.**	**Max.**
Steelhead	Coastal	245	9	1,034	146	93	259
	Cascade	123	11	254	44	13	121
	Gorge	89	70	109	75	20	130
Coho	Coastal	363	9	1,901	482	151	1134
	Cascade	180	30	1,167	349	349	349
	Gorge	--	--	--	--	--	--
Fall Chinook	Coastal	1,515	206	71,231	3,966	945	5,501
	Cascade	--	--	--	1,551	156	11,666
	Gorge	--	--	--	576	576	576

* Lower Columbia Basins only

Lower Columbia Specific Comparisons

In the lower Columbia, paired (within the same basin) comparisons were possible for five steelhead populations and three coho populations. Paired comparisons have a few advantages over grouped comparisons. First, watershed area is held constant, allowing absolute estimates of smolt abundance can be compared instead of smolt densities, allow for the comparison of absolute values instead of smolt densities Ratios closer to 1:1 indicate better correlation between EDT and trap data. For both species at all traps, ratios ranged from 0.4:1 to 3:1 (Figure E6-9). Coho EDT tended to be greater than trap estimates and steelhead EDT tended to be less than trap estimates. Mill Creek is an exception to this pattern.

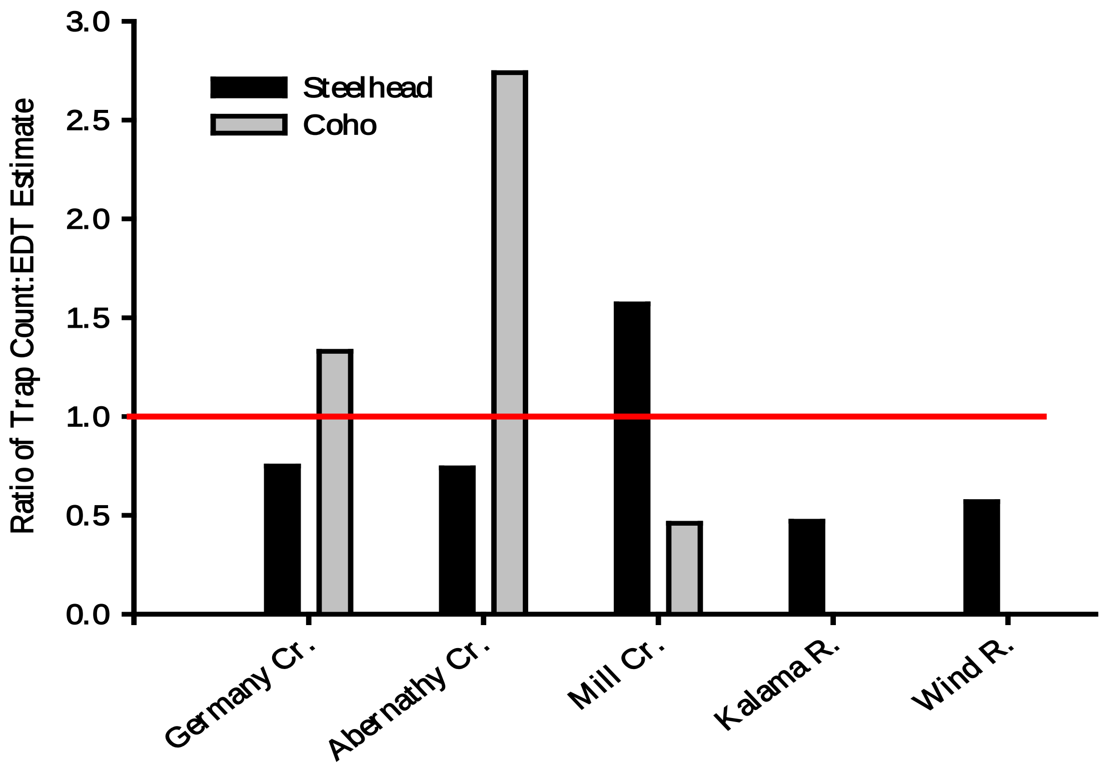

Figure E6-9. Lower Columbia basin-specific (paired) evaluations of EDT Neq and trap estimates. Data are expressed as the EDT / trap ratio.

Discussion

In the broad- and regional-scale comparisons, the similarity between median trap and median EDT values were within reason for most cases, although trap values had a considerably greater range. The smaller range of EDT values may be partly due to the use in EDT of 'equilibrium abundance', which does not reflect the potentially high variability in productivity between years. Moreover, use of maximum trap values may have skewed trap distributions unreasonably. In some basins, the use of average trap values may be more appropriate. The greatest differences between trap data and EDT at the regional scale are observed for Cascade steelhead and coastal fall Chinook. In general, the data show that within regions, steelhead EDT runs tend to estimate lower values than trap data, whereas fall Chinook and coho EDT runs potentially over-estimate actual smolt abundance. This same trend is seen at the river basin scale (Figure E6-9), with the exception of Mill Creek, which shows the inverse pattern.

This assessment suggests that EDT results are within the range of empirical observations throughout the region. Differences between EDT and trap data are related to natural variability, measurement error, model error, and model uncertainty, though the specific contribution of each is difficult to assess. In general, we can be relatively confident, albeit cautious, in our use of EDT population performance results for recovery planning. The inherent uncertainty in EDT suggests that results be used primarily in a relative sense, with less weight on absolute numbers and instead an emphasis on the relative magnitude of values between populations and between scenarios (i.e. historic versus current). The greatest use of EDT for recovery planning is not in specifying exact numbers of fish abundance and productivity for a population, but rather in determining how impacts to a population are distributed throughout the fishes' life cycle and the degree to which recovery measures at particular life stages will improve the potential for population persistence.

Comparison of EDT and the Integrated Watershed Assessment (IWA)[2]

In the Recovery Planning Technical Foundation, the EDT model is linked with the IWA in order to identify the spatial extent of impaired and functional watershed processes that most affect the habitat of focal fish species. The two assessments are used together to pinpoint the location and type of salmon restoration and/or preservation measures that will yield the greatest benefit to populations. This linking of EDT and IWA thus warrants an examination of the level of consistency between the two approaches.

The IWA is a GIS-based watershed process model that uses remotely sensed and spatially referenced data in order to rate subwatersheds (7th field Hydrologic Unit Codes, HUCs) according to their hydrology, sediment, and riparian impairment. IWA looks at the effect of land use and land cover on watershed processes, whereas EDT looks at the effect of instream habitat on fish performance. Considering that watershed processes are driving factors of fish habitat condition, then EDT picks up where IWA leaves off. Thus, while EDT and IWA look at different pieces of the fish and habitat puzzle, IWA *outputs* have direct relevance to certain EDT *inputs*. Since these two processes will be used collectively to identify recovery measures, it is important to know the level of consistency between EDT inputs and IWA outputs. Ideally, IWA outputs and EDT inputs would be compared to empirical data, however, applicable empirical data is scarce, especially in regards to land-use induced changes to watershed hydrology and sediment regime. With a lack of suitable benchmarks to compare to EDT and IWA, we have conducted this comparison simply to determine the level of correlation between the two.

Comparing EDT and IWA will help identify potential deficiencies in each approach, which will aid in our interpretation of model results. Furthermore, the comparison will determine where future updates to EDT inputs would benefit most from the use of IWA results. Specifically, the comparison presented here will:

1. Identify limitations in using a linkage of IWA and EDT for recovery planning.
2. Identify strengths and potential limitations with both EDT and IWA.
3. Identify where future updates to EDT would benefit most from applying IWA outputs.
4. Identify the error associated with using expert opinion versus remotely sensed data to populate EDT level 2 scores.

EDT level 2 input scores have been developed by the WDFW through a combination of available direct data, proxy measures, and expert opinion. IWA, on the other hand, is based on remotely sensed and spatially referenced GIS data that was derived in a similar fashion for all areas of the lower Columbia. In some cases, EDT scores have been developed using the same data sources as used in the IWA model (i.e. road densities), but in many cases, different data or approaches have been used. We therefore expect good consistency between the two models in some cases and less consistency in other cases.

Caution is necessary when comparing IWA outputs and EDT inputs. For instance, it may seem logical that IWA sediment impairment rating should correspond to EDT fine sediment scores. However, further investigation into these parameters indicates that important differences exist in how they are determined. While both rely heavily on road densities as an indicator of increased sediment levels, EDT inputs, which are concerned with *accumulation* of sediment, have been developed by factoring in stream gradient and the presence of tidal influence. In contrast, IWA, which is interested in the *delivery* of sediment from hillslopes, factors in watershed slope and natural soil erodability. Since the techniques differ according to their different application in the models, it makes a valid comparison very difficult.

[2] The EDT input scores used in this analysis are from year 2003 model runs. Subsequent runs include updated input scores.

Table E6-6 summarizes the relationship of IWA ratings to the most relevant EDT level 2 attributes.

EDT / IWA comparisons were conducted for each of the three IWA categories; hydrology, sediment, and riparian. In each case, one or two EDT scores were selected for comparison to IWA based on Table E6-6 and the discussions below. Two river basins from the region were chosen for the evaluation; the Washougal and the Elochoman. The Washougal was selected because 1) it represents an older run (spring 2003) that relied more on expert opinion than newer runs (summer/fall 2003), 2) it is not affected by hydro-regulation (IWA does not specifically evaluate the effect of hydro-regulation) or other potentially confounding factors, and 3) unlike some basins, it has a complete data set to run all IWA assessments. The Elochoman was selected because 1) it is a newer run representing improved scoring techniques and 2) it encompasses a greater number of IWA subwatersheds than other newer runs, thus increasing the sample size.

In the comparisons discussed below, EDT reach scores were compared to the impairment category of the IWA subwatershed that encompasses them. For the hydrology and sediment comparisons, IWA watershed-level impairment, which considers the effect of the entire contributing watershed, was used as opposed to subwatershed-level ("local") impairment (see Appendix E Chapter 4- IWA Methods). The riparian IWA rating, on the other hand, only considers local conditions. The identification of appropriate reach/subwatershed pairings for the comparisons was conducted using a GIS overlay of IWA subwatersheds (polygons) on EDT reaches. In a few cases, there was overlap between reaches and subwatershed polygon boundaries. In these instances, reaches with 50% or more of their length within a polygon (subwatershed) are compared to that polygon. It is helpful here to have an understanding of the difference in scale of subwatersheds versus EDT reaches. With rare exceptions, EDT reaches are at a finer scale than subwatersheds. An example is presented in Figure E6-10. The scale difference is mostly a concern for the riparian comparison, where reach-level riparian conditions may have been used to determine EDT scores as opposed to conditions at the subwatershed level used in IWA.

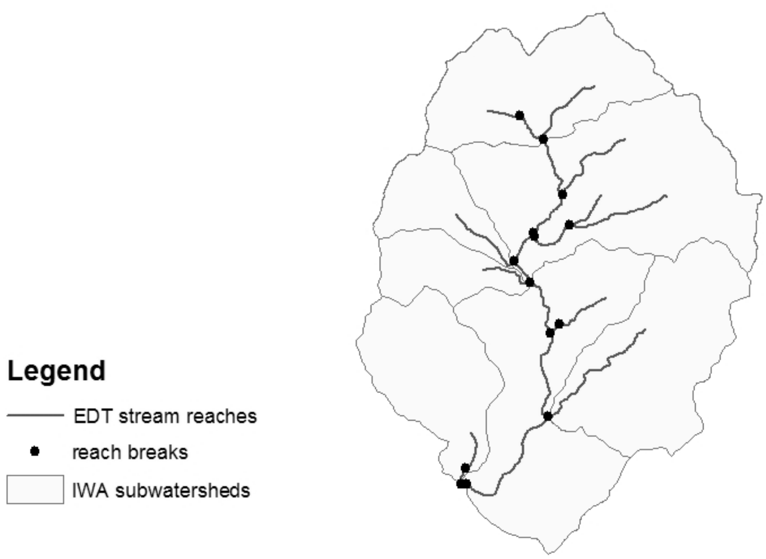

Figure E6-10. Example of typical difference in scale between EDT stream reaches and IWA subwatershed polygons (Upper Washougal River).

Table E6-6. Relationship of IWA to EDT level 2 attributes

IWA		EDT			
Process	**Data used / attributes considered**	**EDT level 2**	**Data used / attributes considered (WDFW older runs)**	**Data used / attributes considered (WDFW newer runs)**	**Valid Comparison?**
Sediment	Road densities, watershed slope, soil erodability	Turbidity	Expert opinion (except Toutle and coastal basins)	Determined by estimating Scale of Severity using existing turbidity data.	Yes- With caution. Different data sources used. However, correlation expected in some cases
		Embeddedness	Expert opinion	Based on road densities, stream gradient, tidal influence	Yes- With caution. EDT looks at additional factors
		Fine sediment	Expert opinion	Based on road densities, stream gradient, tidal influence	Yes- With caution. EDT looks at additional factors
Hydrology	Forested areas - Vegetation, road densities Urban areas - impervious surfaces	Flow – inter annual variability in high flows (FlowHigh)	USFS watershed analysis data used. For forested basins not analyzed by USFS but with roads, assumed a 10% increase in high flow.	USFS watershed analysis data used. For forested basins not analyzed by USFS but with roads, assumed a 10% increase in high flow.	Yes
		Flow – inter annual variability in low flows	Assumed a slight decrease in summer low flows for most basins due to land use. No consideration of water withdrawals.	WDFW rated no change in this parameter due to land use b/c of inconclusive relationships. Water withdrawal data was used in some cases.	Partial- Not for newer runs b/c WDFW assumed no relation with land use and they factored in withdrawals.
		Flow – intra daily (diel) variation	Assumed no change in coastal basins and moderate change (1 score) in other basins due to roads and vegetation impacts.	Rated same as pristine b/c of no metro areas or hydro development in any of the basins.	No- no significant urbanization
		Flow – intra annual flow pattern	WDFW rated same as FlowHigh	WDFW rated same as FlowHigh	Yes
Riparian	(vegetation, buffer size)	Riparian function	Based on vegetation, development, and hydro confinement (artificial). Inferences made to reference sites where data unavailable.	Based on vegetation, development, and hydro confinement (artificial). Inferences made to reference sites where data unavailable.	Yes- With caution. EDT factors in additional conditions not used in IWA.

Hydrology Comparison

EDT has four level 2 flow attributes, however, the IWA hydrology rating is most directly comparable to only two of them: "Flow – inter annual variability in high flows" (FlowHigh) and "Flow – intra annual flow pattern" (FlowPattern). IWA does not consider the processes affecting "Flow – intra daily (diel) variation", which is primarily a measure of ramping rates due to hydro-regulation, or "Flow – inter annual variability in low flows", which is mostly related to hydro regulation or water withdrawals. FlowHigh scores range from 0 to 4, with 2 representing pristine conditions and values greater than 2 representing the impaired condition of increased variability in peak flows due to land-use changes.

The two comparable parameters, FlowHigh and FlowPattern, were ranked identically in EDT, therefore only FlowHigh is used in the comparison. EDT reaches were compared to the IWA subwatershed encompassing them. The EDT value used in the comparison was the Patient score minus the Template score (P – T), or the Patient score minus 2, since all Template conditions were given a 2 for the FlowHigh attribute. This value represents the level of impairment compared to pristine conditions. The frequency distributions of EDT scores (P – T) within IWA impairment categories were compared to assess consistency between the values (see Figure E6-11).

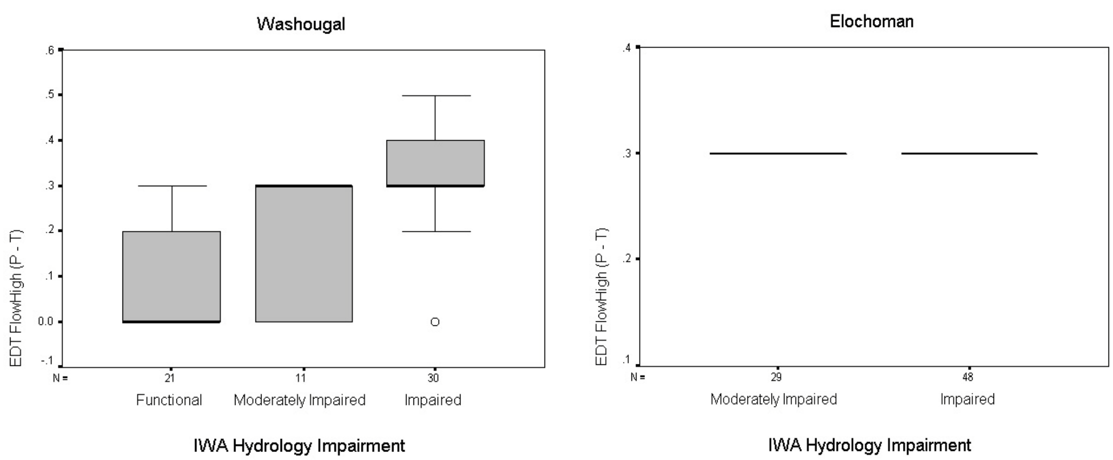

Figure E6-11. Frequency distribution of EDT FlowHigh scores (P – T) within IWA Hydrology impairment categories for the Washougal and Elochoman Rivers. The box represents the interquartile range which contains the 50% of values. The whiskers are lines that extend from the box to the highest and lowest values, excluding outliers. The bold line across the box indicates the median.

In the Washougal, the EDT inputs follow the general trend of increasing impairment as one moves from IWA Functional to IWA Impaired, though there is significant overlap (Figure E6-11). In the Elochoman, however, all EDT reaches were scored the same and there were no IWA Functional subwatersheds (Figure E6-11). EDT FlowHigh scoring in the Washougal relied partly on USFS watershed analysis results (where available) and partly on the assumption that forested basins with road systems had a 10% increase in peak flows. General correlation between EDT and IWA in the Washougal is likely because of the use of the USFS watershed analysis peak flow rating, which considers similar landscape conditions as those used in IWA (e.g. vegetation and roads). In the Elochoman, however, no previous hydrology assessment had been conducted and therefore WDFW's 10% assumption was applied to the entire basin. In this instance, EDT scoring could benefit from the use of IWA modeling. In general, IWA, which has been applied uniformly to all areas in the region, could assist in the development of EDT flow scores.

Recommendation:

Use IWA hydrology rating to score FlowHigh and FlowPattern, the later of which is a measure of a stream's "flashiness" due to watershed development or hydro-development. Data on subwatershed imperviousness gathered as part of the IWA analysis could be used to further modify FlowPattern in cases of intense urbanization.

Sediment Comparison

The three EDT level 2 attributes that relate to sediment are fine sediment, embeddedness, and turbidity. Fine sediment and embeddedness are evaluated similarly in EDT and therefore, of these two, fine sediment was used in the IWA comparison. EDT turbidity scores were developed using a different approach and therefore were compared to IWA separately.

The development of IWA sediment scores involves the calculation of a natural sediment delivery index (GSSD) and a managed condition sediment delivery index (MCSD), with road density as the primary change variable. Subwatersheds are considered 'moderately impaired' if they have a MCSD that equals or exceeds 1.5 times the GSSD and are considered 'impaired' if the MCSD equals or exceeds 3 times the GSSD. For comparison to EDT, the EDT fine sediment and turbidity scores are also expressed in terms of change from natural conditions, using the Patient scores minus the Template scores (P – T).

EDT fine sediment scores for the Washougal (older run) were determined primarily through expert opinion, whereas scores for the Elochoman (newer run) were inferred from landscape conditions. The newer EDT runs used a two-step process to derive fine sediment scores. First, road density was used to determine percent fines based on a relationship established by Rittmueller (1986), using sample sites consisting primarily of low to moderate gradient reaches. Higher gradient streams do not retain sediment to the same degree as low or moderate gradient streams and therefore, WDFW adjusted the percent fines value downward in higher gradient reaches. Additionally, scores were adjusted upward if tidal influence was present in the reach. The final percent fines value was applied to the EDT guidelines to obtain the EDT score. Fine sediment scores range from 0 to 4, with 0 representing pristine conditions. EDT reaches were compared to the IWA subwatershed encompassing them. The distributions of EDT values (P – T) are compared within IWA sediment impairment categories to assess consistency between the two.

EDT turbidity scores were developed primarily by expert opinion for the Washougal. Scores for the Elochoman used a combination of empirical data and expert opinion, generally following the guidelines set forth in the EDT manual. Scores were extrapolated to other reaches without data. EDT turbidity scores range from 0 to 4, with 0 representing pristine conditions. EDT reach level turbidity scores (P – T) were compared to the IWA subwatershed encompassing them, in the same fashion as described above for fine sediment.

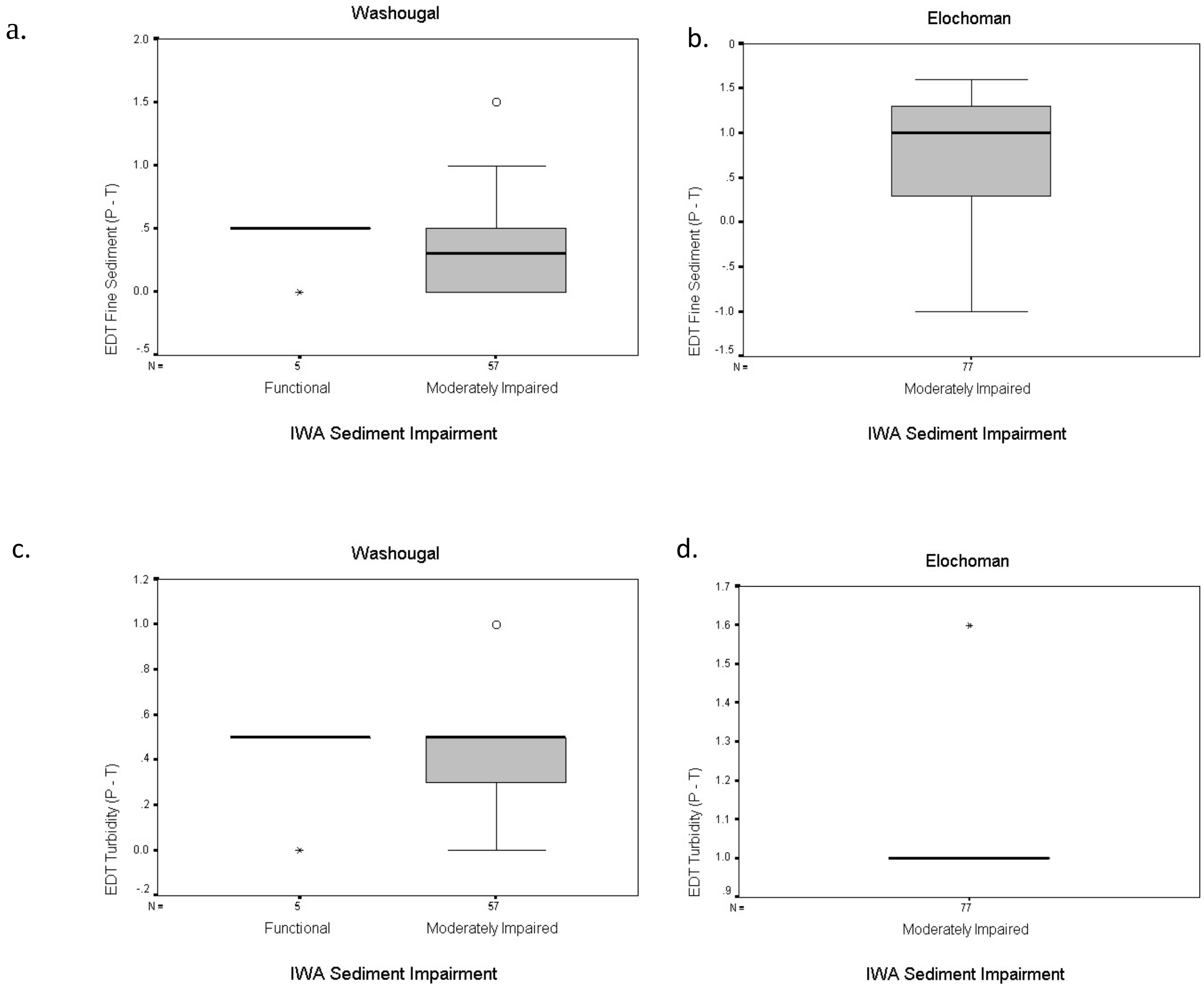

Figure E6-12. Frequency distribution of EDT Fine Sediment scores (P – T) in IWA Sediment impairment categories for the Washougal (a) and the Elochoman (b). Frequency distribution of EDT Turbidity scores (P – T) in IWA Sediment impairment categories for the Washougal (c) and the Elochoman (d). The box represents the interquartile range which contains the 50% of values. The whiskers are lines that extend from the box to the highest and lowest values, excluding outliers. A line across the box indicates the median.

For the Elochoman and the Washougal, all or nearly all of the subwatersheds are ranked Moderately Impaired in IWA, whereas the fine sediment and turbidity EDT values exhibit more variability, except for Elochoman turbidity (Figure E6-12). This pattern is similar for all of the subwatersheds throughout the region. This suggests that the IWA sediment rating may not be fine enough to segregate out modest changes in road densities. EDT, on the other hand, does break out sediment impacts to a finer scale, although it is impossible to assess the suitability of the values using this analysis. In the Washougal, where we have two IWA categories, the correlation is poor between EDT and IWA (Figure E6-12a and Figure E6-12c). The reason for this discrepancy is not entirely clear, but may be related to the use of expert opinion in EDT and/or the different attributes considered in EDT versus IWA. A comparison of expert opinion derived scores (Washougal) versus scores derived using newer techniques (Elochoman) was not possible due to the low variability in IWA categories.

Recommendations:

Use IWA to assist in the development of EDT fine sediment scores. IWA has an advantage over the Rittmueler (1986) relationship in that it considers soil erodability and watershed slope, in addition to road density. Thus, a watershed with high soil stability and low slope would not be as affected by high road density as would a steep, unstable basin. A disadvantage of using IWA to derive EDT scores is that a relationship between IWA values and percent fines would need to be established. In addition, IWA would essentially predict sediment delivery rates, and would need to be adjusted for accumulation as WDFW has done for the values derived using the Rittmueler (1986) relationship.

Where turbidity data is scarce or absent, IWA sediment impairment could be used to generate EDT turbidity scores, however, where data exists, using the Scale of Severity index as outlined in the EDT guidelines (MBI 2003) would provide a more direct representation of turbidity.

Riparian Comparison

A number of EDT level 2 attributes are related to riparian condition in some fashion (i.e. confinement, bed scour, wood); however, the 'riparian function' attribute is most related to the IWA riparian rating. The EDT riparian function score is based on vegetation conditions, hydro-confinement, and the presence of road or development impacts. The score ranges from 0 to 4, with 0 representing pristine conditions and 4 representing fully degraded conditions. The IWA riparian rating uses only the percent of the riparian area within a particular vegetation class. The EDT and IWA values are expected to generally conform, though inconsistencies are expected in some cases due to the different rating techniques. EDT reaches were compared to the IWA subwatershed encompassing them. The EDT and IWA values are compared by looking at the frequency distribution of EDT scores within IWA riparian impairment categories.

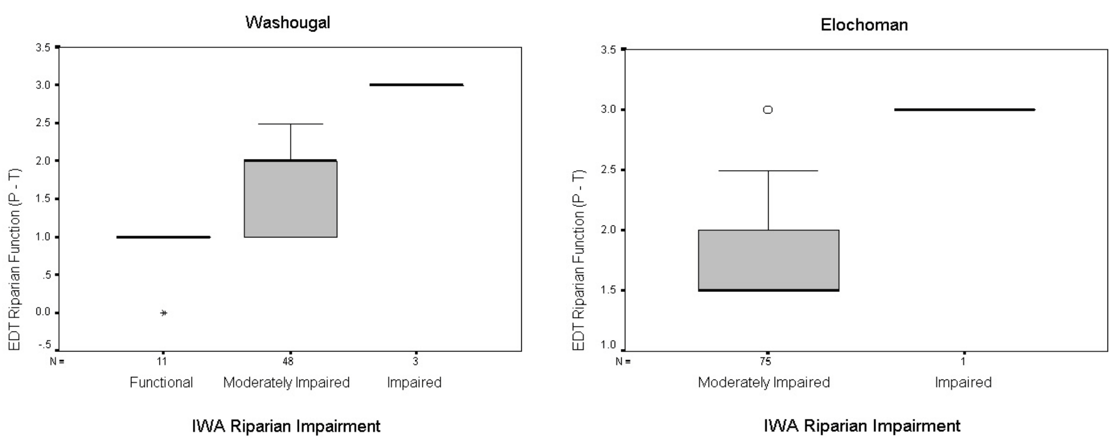

Figure E6-13. Frequency distribution of EDT Riparian Function scores (P – T) in IWA Riparian impairment categories. The box represents the interquartile range which contains the 50% of values. The whiskers are lines that extend from the box to the highest and lowest values, excluding outliers. A line across the box indicates the median.

For the Washougal basin, EDT riparian scores generally conform to IWA riparian impairments, with only minor overlap (Figure E6-13). The similarity is because of the use of vegetation conditions in both models. Most of the subwatersheds were rated Moderately Impaired in IWA, which corresponds to a range of 1.0 to 2.5 for EDT P – T. There is also conformity in the Elochoman, although true conformity is difficult to assess because there is only one impaired subwatershed in the basin and that subwatershed contains only one EDT reach. Nevertheless, the EDT P – T scores in the Moderately Impaired category exhibit a similar range (1.5 – 2.5, excluding outliers) as in the Washougal. These results demonstrate that IWA and EDT are generally consistent with regards to riparian function.

Recommendations:
EDT inputs could benefit from using the same data sources used in IWA but not the IWA ratings themselves because of the shorter length of EDT reaches compared to IWA subwatersheds

(Figure E6-10). EDT scoring could be accomplished using a simple GIS overlay of vegetation class polygons (the same info used in IWA) on EDT reach riparian buffers. This information could be further adjusted based on artificial confinement and the presence of roads / development. Incorporating artificial confinement and the presence of roads / development into IWA could serve to bolster IWA and allow for a direct link with EDT inputs.

Discussion

EDT and IWA correlate fairly well for the hydrology and riparian attributes. Sediment shows the weakest correlation. It is difficult, however, to determine the source of the discrepancy. Comparison of EDT sediment scores and IWA ratings to empirical data could assist with determining potential error; however, a severe lack of empirical sediment data throughout the region complicates such an evaluation. Poor correlation in the case of sediment may also be due to the fact that IWA is concerned with sediment delivery and EDT is concerned with sediment accumulation, so it is not entirely an 'apples to apples' comparison.

IWA could be used to derive EDT scores for fine sediment, embeddedness, FlowHigh, and FlowPattern, and could possibly assist with rating other EDT attributes. Linking watershed process modeling to EDT scoring in this fashion could decrease the reliance on expert opinion. Such a link could also benefit EDT scenario-building and other techniques using IWA and EDT to identify land-use changes that yield fish benefits.

E.4. References

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E.5. Supplemental Information

Table E6-7. Trap locations where outmigrant data were obtained and the source of those data.

Basin	Trap Location	Source
Alsea	Cascade Cr.	Solazzi et al. 2003
Alsea	E. Fk. Lobster Cr.	Solazzi et al. 2003
Clackamas	Fish Cr.	Shibahara and Taylor 2001
Clackamas	Big Bottom (mainstem)	Shibahara and Taylor 2001
Clackamas	Oak Grove Fk.	Shibahara and Taylor 2001
Clackamas	N. Fk. Clackamas	Shibahara and Taylor 2001
Clackamas	N. Fk. Eagle Cr.	Shibahara and Taylor 2001
Clackamas	Above N. Fk. Dam (mainstem)	Shibahara and Taylor 2001
Coos	Fall Cr.	Solazzi et al. 2002
Coos	Bottom Cr.	Mario Solazzi, ODFW, personal comm. 2003
Coos	N. Fk. Coquille R.	Mario Solazzi, ODFW, personal comm. 2003
Coos	Winchester Cr.	Solazzi et al. 2003
Hood	Hood R. (mainstem)	Olsen draft 2003
Kalama	Gobar Cr.	Loch et al. 1985
Kalama	Kalama R. (trap near Kalama Falls Hatchery)	Loch et al. 1985; Cameron Sharpe, WDFW, personal comm. 2003
Kilchis	Little S. Fk. Kilchis R.	Solazzi et al. 2003
L. Columbia	N. Fk. Scappoose Cr.	Solazzi et al. 2003
L. Columbia	Germany Cr.*	Patrick Hanratty, WDFW, personal comm. 2003
L. Columbia	Mill Cr.*	Patrick Hanratty, WDFW, personal comm. 2003
L. Columbia	Abernathy Cr.*	Patrick Hanratty, WDFW, personal comm. 2003
Lewis	Cedar Cr.	Dan Rawding, WDFW, personal comm. 2003
Nehalem	N. Fk. Nehalem R.	Solazzi et al. 2003
Nehalem	Upper N. Fk. Nehalem R.	Solazzi et al. 2002
Nehalem	Upper Nehalem R.	Mario Solazzi, ODFW, personal comm. 2003
Nestucca	Little Nestucca R.	Mario Solazzi, ODFW, personal comm. 2003
Oregon Coast	Tenmile Cr.	Solazzi et al. 2003
Oregon Coast	Cummins Cr.	Solazzi et al. 2003
Oregon Coast	Euchre Cr.	Tom Satterthwaite, ODFW, personal comm. 2003
Oregon Coast	Hunter Cr.	Tom Satterthwaite, ODFW, personal comm. 2003
Oregon Coast	Hinkle Cr.	Dave Harris, ODFW, personal comm. 2003
Siletz	Mill Cr.	Solazzi et al. 2003
Umpqua	W. Fk. Smith R.	Solazzi et al. 2003
Umpqua	Smith R.	Dave Harris, ODFW, personal comm. 2003
Umpqua	Big Tom Folley Cr.	Dave Harris, ODFW, personal comm. 2003
Umpqua	Brush Cr.	Dave Harris, ODFW, personal comm. 2003
Umpqua	Elk Cr.	Dave Harris, ODFW, personal comm. 2003
Umpqua	Rock Cr.	Dave Harris, ODFW, personal comm. 2003
Umpqua	Cow Cr.	Dave Harris, ODFW, personal comm. 2003
Wilson	Little N. Fk. Wilson R.	Solazzi et al. 2003
Wind	Wind R. (mainstem)**	Rawding 2000
Yaquina	Mill Cr.	Solazzi et al. 2003
Yaquina	Bales Cr.	Solazzi et al. 2003