Briefing Paper on Limiting Factors

For North Olympic Peninsula Lead Entity for Salmon

WH Pearson, Peapod Research

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Introduction

Criterion 2 in the North Olympic Peninsula Lead Entity for Salmon's criteria for scoring and ranking proposals for capital projects speaks to how well a project proposal addresses limiting factors relevant to the watershed and stock of interest. Also, Criterion 2 is the most heavily weighted (4.04) of all 13 criteria. The next most heavily weighted criterion (3.88) is Criterion 7 about how well a proposal restores formerly productive habitat.

The aim of this briefing paper is to provide an overview of the concept of limiting factors and information on the limiting factors pertinent to the watersheds and fish stocks in the Lead Entity's geographical area. A call for a concise summary of limiting factors made at the fall NOPLE retreat prompted this effort. This paper is not based on new field work and is not a critical analysis of previous studies and publications. Rather, this paper is a summary of the information on limiting factors available in spring and summer 2017. This briefing paper and more detailed information to which it links is intended to be used by the Lead Entity's proposal scorers in their assessments of proposals under Criterion 2.

Concept and Definitions of Limiting Factor

The concept of a limiting factor was first articulated in Liebig's Law of the Minimum, which refers to the condition in which plant growth is limited by the nutrient in least supply relative to need (Odum 1993). An example would be nitrate in a field plot at a concentration of 10 mg/g of soil when 20 mg/g of soil is needed for the plant to grow and all the other nutrients are above the threshold for growth. The law of the minimum has evolved into the concept of a limiting factor, which Odum (1993) defines as the situation where

> "The success of an organism, population, or community depends on a complex of conditions; any condition that approaches or exceeds the limits of tolerance for the organism or group in question may be said to be a limiting factor."

For fish, a classic example is water temperature, which may become lethal to fish if water temperature exceeds the upper thermal tolerance (too hot) or the lower tolerance (too cold). Many biologists would consider any factor that is limiting reproduction, growth, or distribution of a population as limiting. Thus, high temperature in stream reaches that are avoided by fish is a limiting factor on fish distribution.

NOAA has developed a limiting factor definition that is tied to viable population parameters (http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/recovery_glossary.html). This definition is:

> "Limiting Factor: Physical, biological, or chemical features (e.g., inadequate spawning habitat, high water temperature, insufficient prey resources) experienced by the fish that results in reductions in viable salmonid population parameters (abundance, productivity, spatial structure, and diversity). Key limiting factors are those with the greatest impacts on a population's ability to reach a desired status."

Abundance refers to the numbers of fish returning to spawn; Productivity, to the extent or rate at which the salmonid population replaces itself; Spatial structure, to the extent to which a population's distribution is clumped versus dispersed; Diversity, to the extent to which a population exhibits a variety of genetic and behavioral traits, such as, run-timing, age at maturity.

General Limiting Factors for Salmon

Salmon have a complex life history in which different limiting factors affect survival, growth, and distribution at different life history stages. Ocean conditions can decrease the prey field that, in turn, reduces ocean survival and growth. Harvest at sea and along the adult migration pathways affects survival and distribution and can reduce the abundance of spawning adults. Because nearshore and stream habitats are so critical to salmon reproduction and rearing, the availability of such habitat in sufficient quality and quantity and the ability of salmon to gain access, are the focus of many salmon recovery projects. In developing salmon recovery projects, fisheries biologists have assessed deficiencies in habitat through limiting factors analyses (NAS 1996). Types of habitat deficiencies have included:

- High water temperatures,
- Lack of stream pools and large woody debris (LWD),
- Erosion and sedimentation (especially, in spawning areas),
- Stream flow and other hydrodynamics.

Also, dams, culverts, weirs, and other physical barriers can impair passage of adult and rearing juvenile fish and prevent access to critical habitat such as spawning grounds and overwintering areas.

Limiting Factors in Salmon Recovery Plan and Other Documents

The Salmon Recovery Planning Act required Limiting Factors Analyses (LFA), which were conducted from 1998 to 2003 by the Washington State Conservation Commission in association with the Tribes and Washington State Department of Fish and Wildlife (WDFW) for 45 Watershed Resource Inventory Areas (WRIA) (Smith 2005). Results for 45 WRIAs were tabulated for 15 limiting factors:

1. Access
2. Floodplain to side channel connectivity
3. Sediment quantity
4. Sediment quality
5. Road density
6. Stability of stream bank, bed and channel
7. In-stream Large Woody Debris (LWD)
8. Pool habitat
9. Riparian zone
10. Water Quality: Water temperature

11. Water Quality: Dissolved Oxygen
12. Water Quality: Nutrients, toxins, pH
13. Hydrodynamics: High flows
14. Hydrodynamics: Impervious surfaces
15. Hydrodynamics: Low flows

The Puget Sound Recovery Plan (Shared Strategy Development Committee 2007) discusses the limiting factors relevant to the region's stocks. Shared Strategy (2007) concluded that habitat deficiencies are limiting recovery. The habitat limiting factors for Puget Sound salmon listed in Shared Strategy (2007) appear in the Appendix Table.

The recovery plan document includes chapters that have discussions of limiting factors pertinent to the Dungeness and Elwha Rivers, but more detailed information on limiting factors specific to other Lead Entity watersheds and stocks is available through the Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP), a cooperative program between the Northwest Indian Fisheries Commission and the Washington State Depart of Fish and Wildlife. SSHIAP provides data on salmon distribution and habitat conditions summarized in publically available interactive maps and other digitalized formats (http://www.nwifc.org/about-us/habitat/sshiap/). The narratives accessed through the interactive maps include discussion of limiting factors (http://geo.nwifc.org/swifd/). The limiting factors compiled from SSHIAP 2016 narratives for North Olympic Watersheds by WRIA appear in the Appendix Table. Progress between 2012 and 2016 addressing the limiting factors and other concerns have been assessed in the SSHIAP narratives.

The Restoration Plan for WRIA 19 (NOPLE 2016) describe the limiting factors for 9 major rivers of the WRIA as well for compilation of independent streams and the nearshore areas of the WRIA (Appendix Table).

The 2016 Five-Year Review (NOAA 2017) for Puget Sound salmon and steelhead notes improvements in water quality and removal of passage barriers but degradation has occurred in water quantity, marine shoreline habitat conditions, and impervious surfaces. The factors that remain of dominant concern include:

- "impaired water quality in both fresh and marine waters;
- continued lack of access to functional floodplains and marine shorelines;
- impaired passage" for the Puget Sound Chinook salmon ESU.

For chum salmon, the limiting factors of concern are "degraded water quality, estuarine habitat, degraded in-stream habitat features (such as channel structure and complexity), degraded riparian areas and LWD recruitment, degraded stream substrate and flow, and degraded floodplain connectivity and function."

Limiting Factors in Decision Making by the North Olympic LE for Salmon

The information and Appendix Table here are intended to be used by those scoring capital project proposals to the North Olympic Peninsula Lead Entity under Criterion 2, addresses limiting factor. The two main questions are:

- Does the proposal address a limiting factor pertinent to the watershed and stock of interest, and, secondly,
- How well does the proposal address the limiting factor?

During spring and summer 2017, a set of rubrics have been developed for all the criteria and are intended to be used to aid scorers in distinguishing the relative merits of the proposal under each criterion.

REFERENCES

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Appendix Table: Limiting Factors Compiled from (a) Shared Strategy (2007), (b) SSHIAP (2016), and (c) NOPLE (2015).

Limiting Factor (a)	Examples (a)	WRIA 18 Morse Creek East to Dungeness River (b)	WRIA 18 Morse Creek West to Elwha River (b)	WRIA 19 NW Olympic Peninsula (b, c)
Altered hydrology (a)	Low base flows; higher peak flows following storms; increased "flashiness" (more frequent and rapid responses when it rains)	Low in-stream flows; Water withdrawals for irrigation reduced but summer flows still inadequate; Flashiness from impervious surfaces	Low in-stream flows from water withdrawals from wells; Flashiness from impervious surfaces	Peak flows becoming higher; Low in-stream flows from water withdrawals
Loss of floodplain connectivity (a)	Reduced access to side-channels or off-channel areas due to bank armoring and development close to shorelines	Floodplain modifications; Stream channelization	Floodplain modifications; Stream channelization	Floodplain modifications; Stream channelization; Stream destabilization and incision; Bank armoring
Lack of riparian vegetation (a)	Loss of riparian vegetation due to clearing and development	Land use conversion; Loss of forest cover and riparian vegetation	Land use conversion in lower reaches	Land use conversion
Disrupted sediment processes (a)	Sediment instability; Too much fine sediment deposited in streams, or sources of spawning gravel disconnected from the river channel	Sediment instability; Sediment aggradations (sedimentation in lower reaches causes the streambed to rise)	Sediment instability; Aggradations	Sediment instability; Excessive sedimentation in spawning areas (can be associated with high densities of logging roads); Lack of spawning gravel; Poor gravel quality
Loss of channel and shoreline complexity (a)	Lack of woody debris (LWD) and stream pools	Impaired LWD recruitment	Impaired LWD recruitment	Impaired LWD recruitment
Fish passage barriers (a)	Road crossings (culverts), weirs, and dams block access to spawning and rearing habitat	Culverts	Elwha Dams Removal in 2014 eliminated major limiting factor	Culverts (53% fixed)
Degraded water and sediment quality (a)	Pollutants and high water temperatures	?? Not mentioned in (b)	Pollutants (Port Angeles Harbor)	High water temperatures in 32 water bodies
Degraded nearshore habitat (b, c)	Nearshore is a migration pathway for listed stocks. Loss of estuarine habitat through dikes, culverts, tide gates, and filling; Loss of estuarine and shoreline riparian vegetation	Loss of estuarine and shoreline habitat; Loss of littoral drift and other habitat forming processes; Loss of forage fish habitat	Loss of estuarine and shoreline habitat; Loss of littoral drift and other habitat forming processes; Loss of forage fish habitat	Loss of estuarine and shoreline habitat; Loss of littoral drift and other habitat forming processes; Loss of forage fish habitat