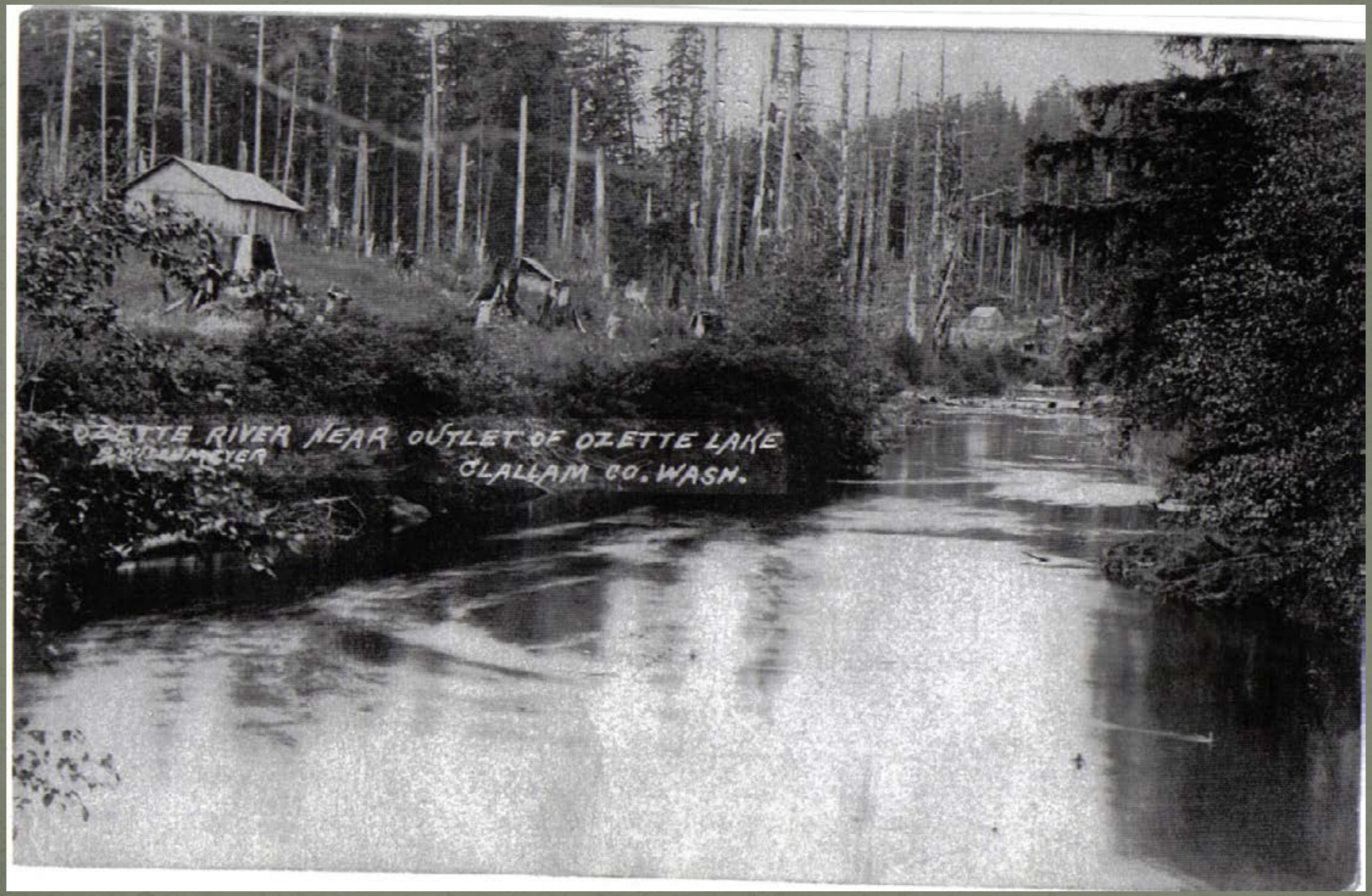
Lake Ozette Sockeye Salmon:
limiting factors and recovery planning

April 28, 2016

Presentation Overview

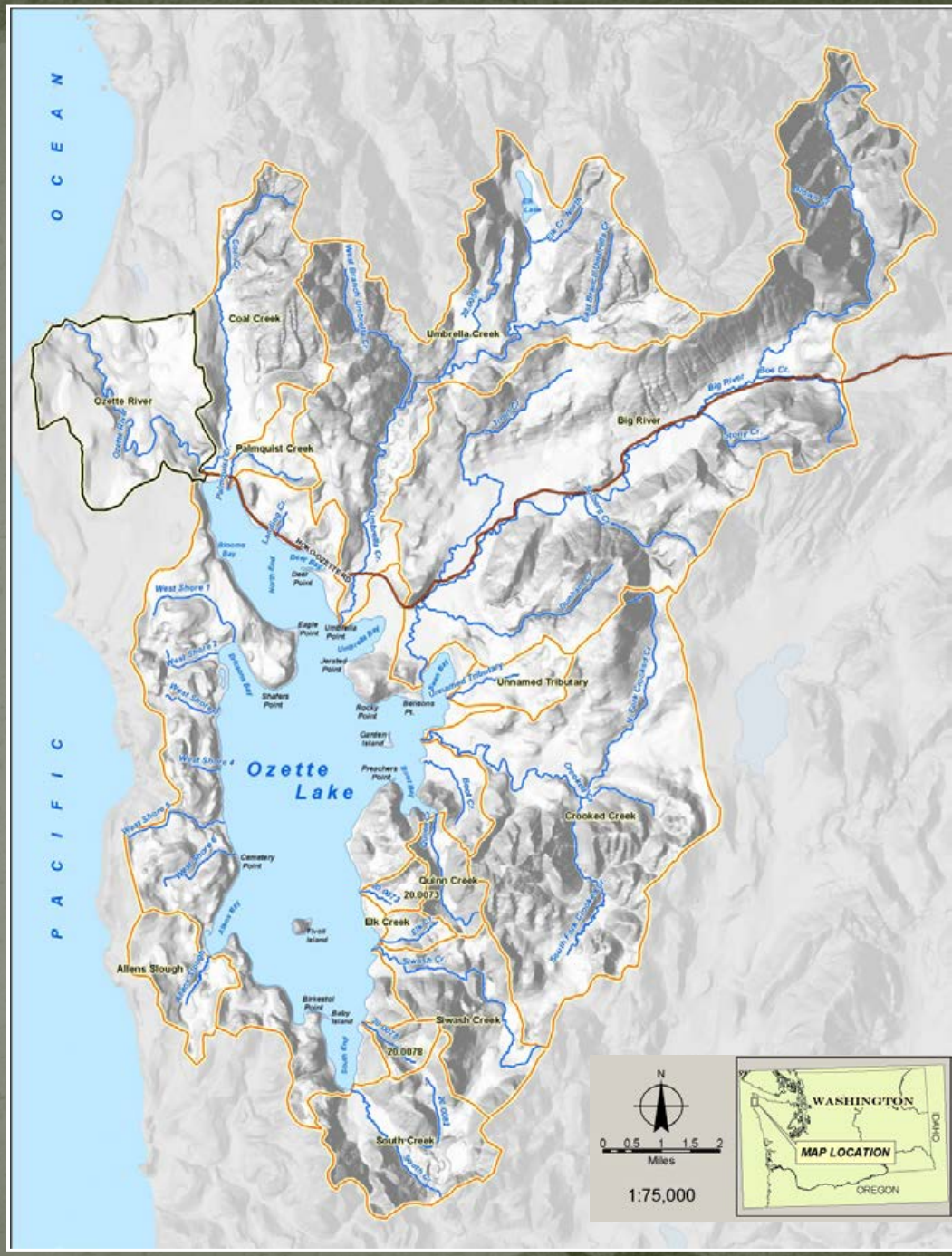
- Watershed Overview
- Sockeye salmon population abundance and trends
- Sockeye Salmon factors for decline and limiting factors
- Sockeye salmon recovery planning
- Development of a new limiting factors/survival model

Watershed Overview



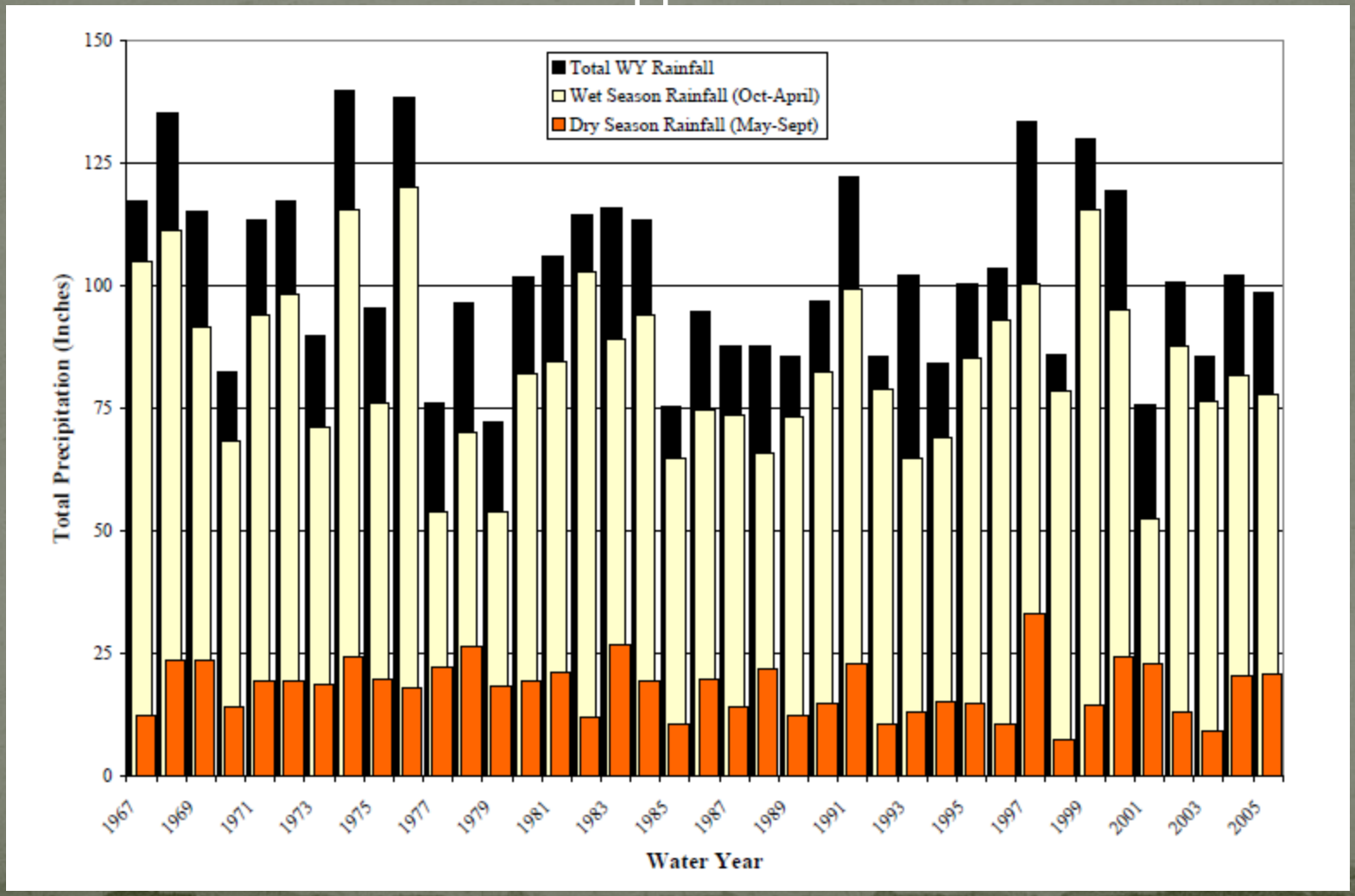
The Lake Ozette Watershed

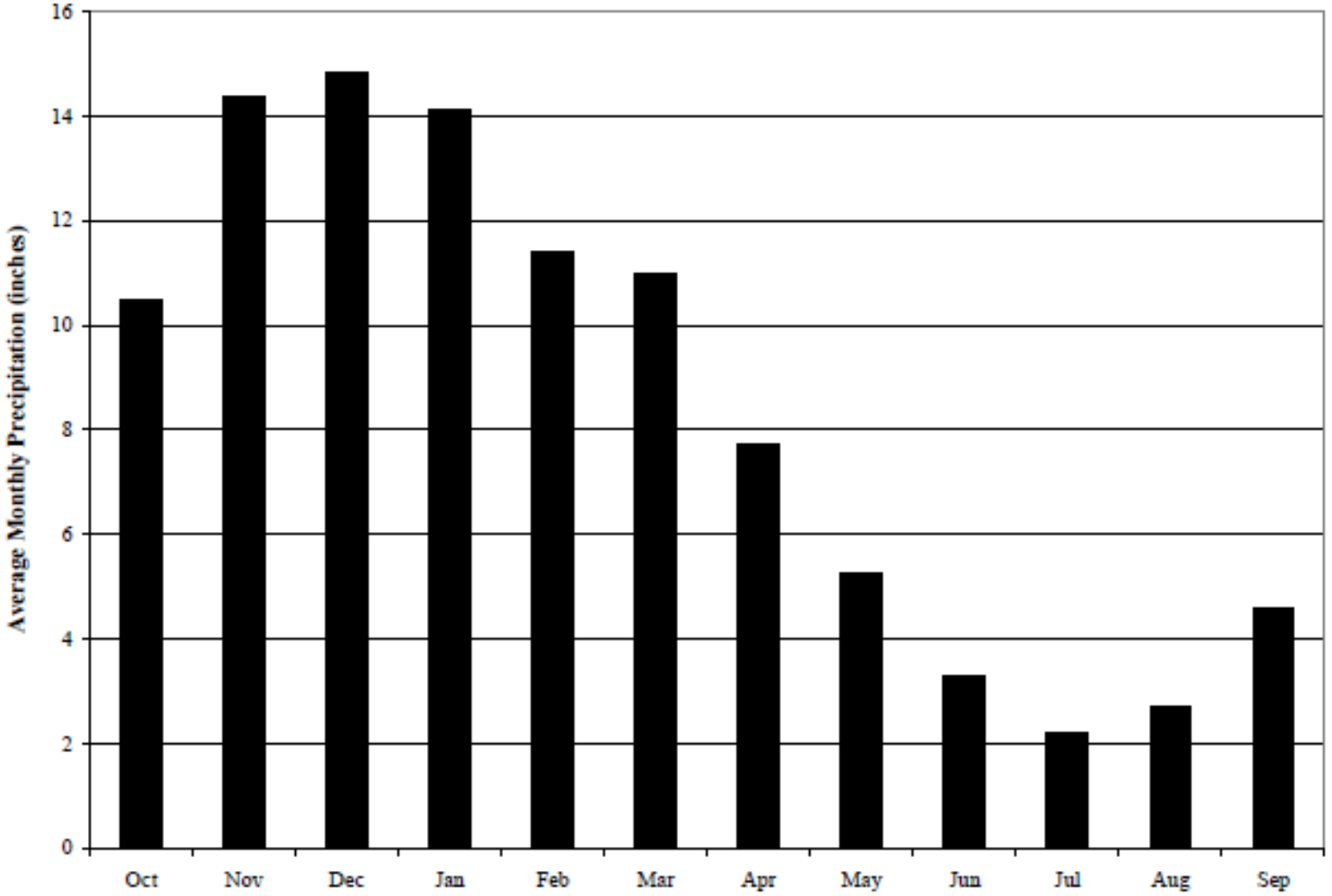
- Located along the northwest tip of the Olympic Peninsula.
- Coastal temperate rainforest.
- Drainage area = 88.4 sq mi (229 sq km).
- Terrain ranges from slightly rolling to steep; elevation ranges from zero to 1,940 ft; averaging 304 ft.
- Geology is composed of a mix of glacial deposits situated between resistant small hills composed of sedimentary rock units.

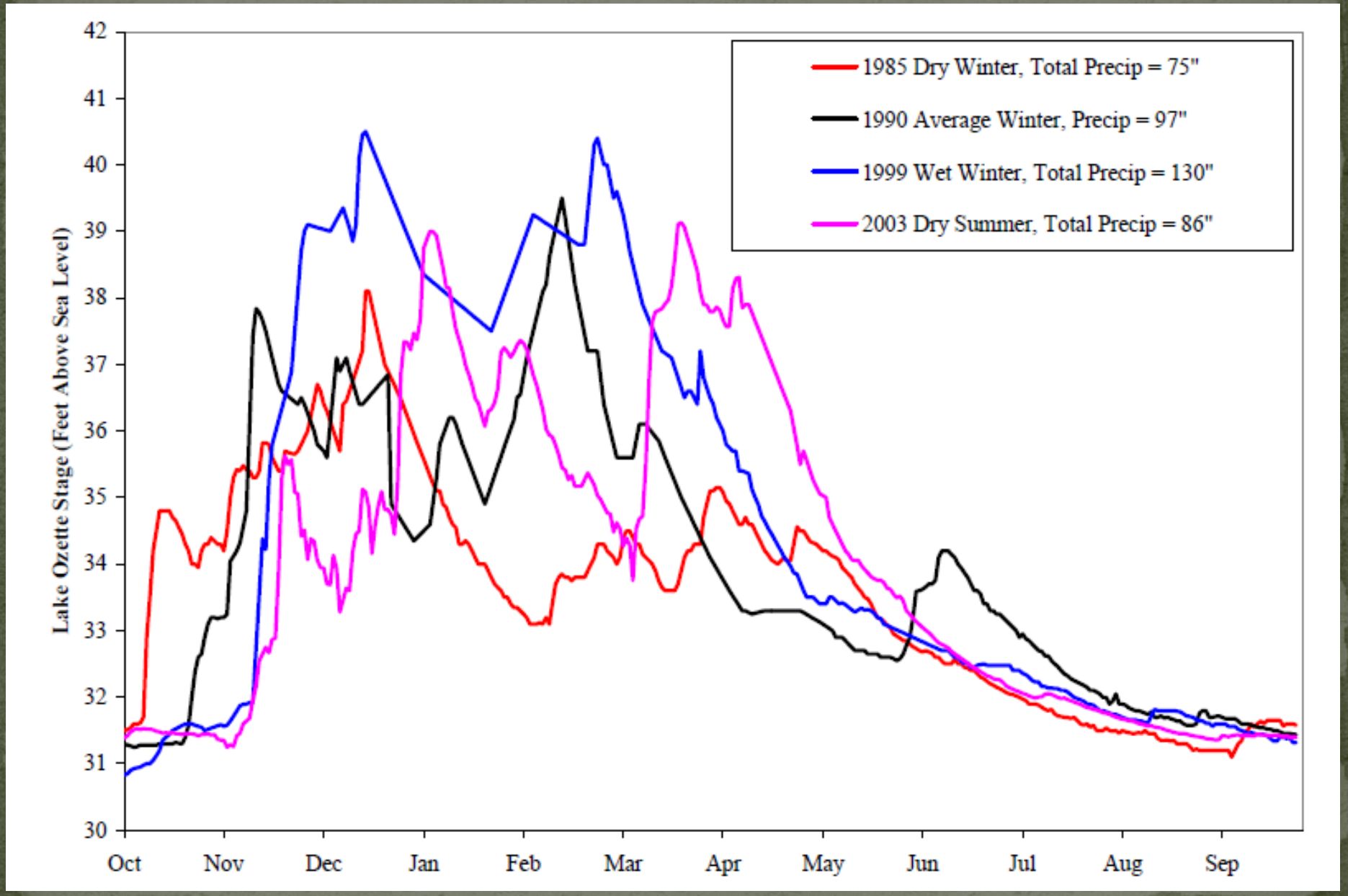


Climate

- Temperate coastal-marine climate with mild winters and cool summers
- Precipitation ranges from 90 inches per year near the coast to in excess of 120 inches in the upper elevations.

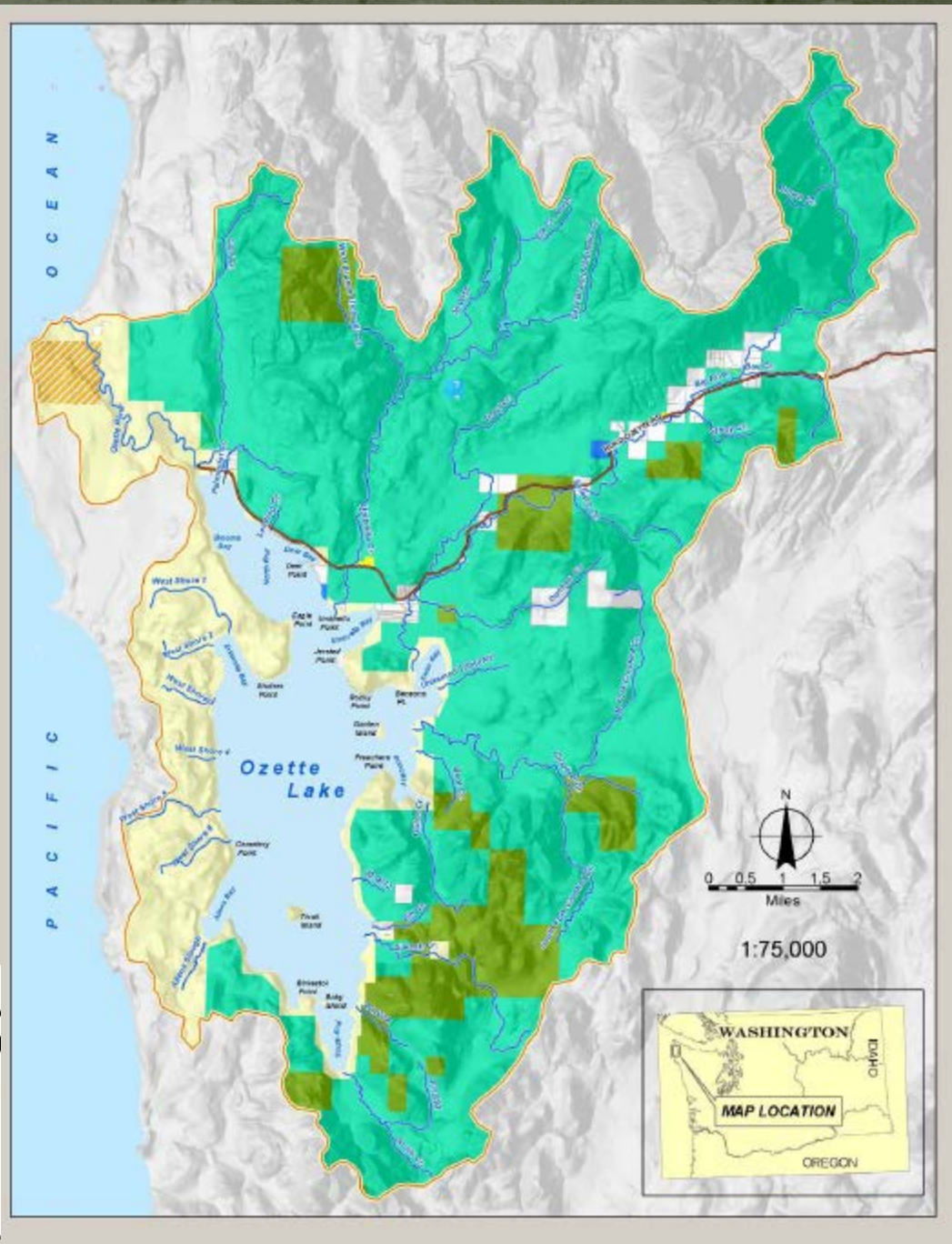



Average Monthly Precipitation (inches)
16
14
12
10
8
6
4
2
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep


1985 Dry Winter, Total Precip = 75"
1990 Average Winter, Precip = 97"
1999 Wet Winter, Total Precip = 130"
2003 Dry Summer, Total Precip = 86"
Lake Ozette Stage (Feet Above Sea Level)
42
41
40
39
38
37
36
35
34
33
32
31
30
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

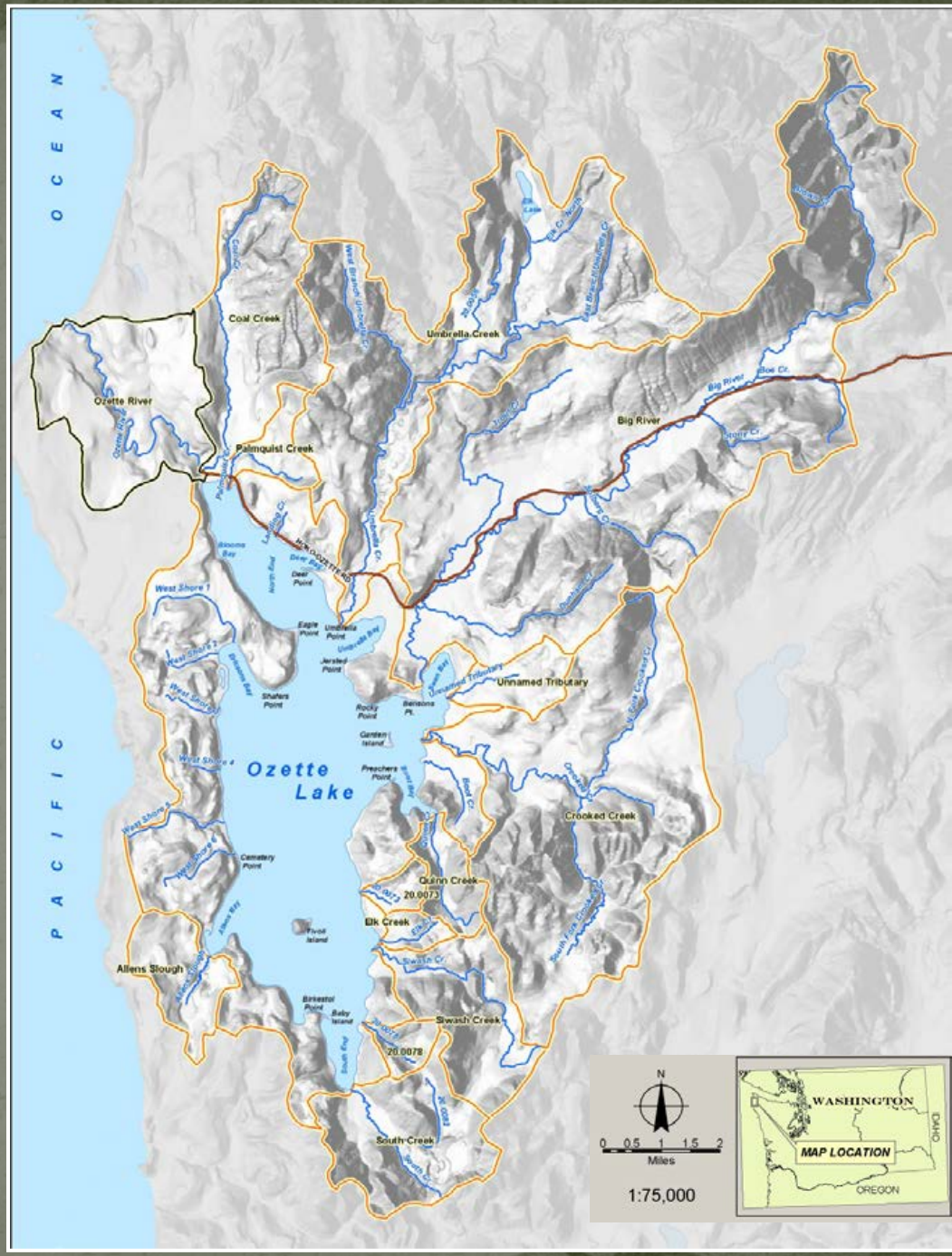
Ozette Landownership

- Private landownership 74%
- The NPS 15%
- DNR 10%
- Makah Tribe 1%.
- Over 81% of the watershed's land surface is zoned as commercial forest land.



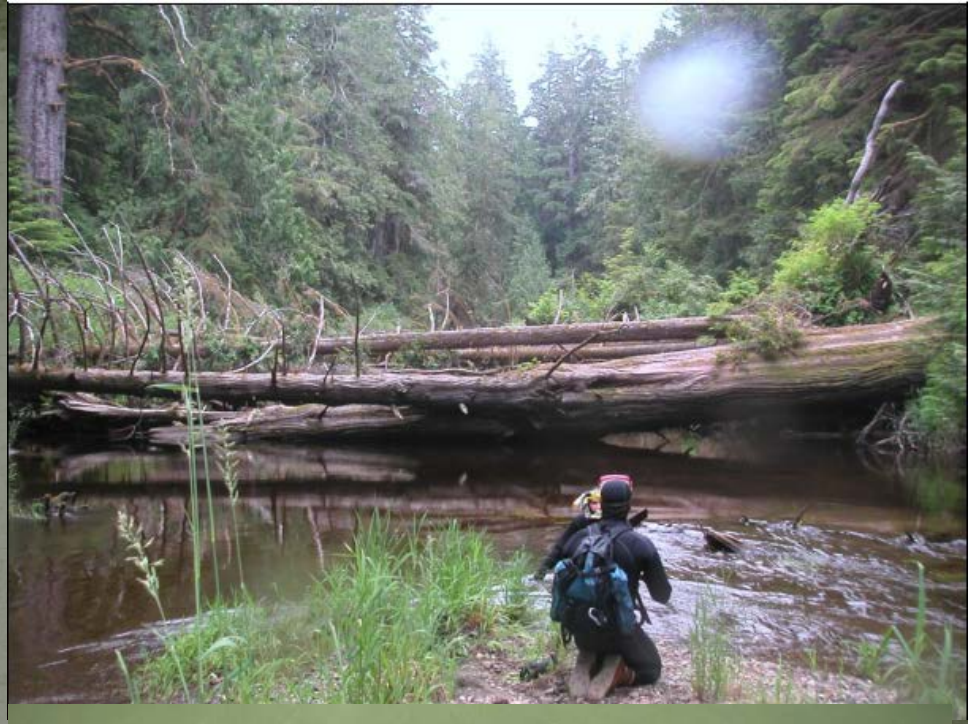
Lake Ozette Subbasins

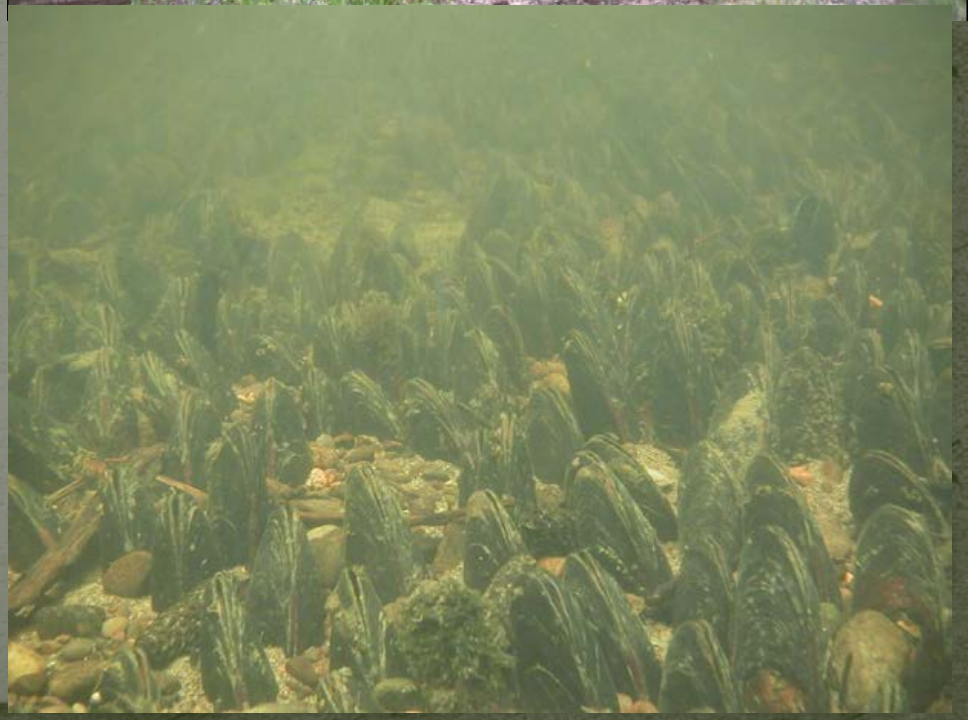
- Three main subbasins within the watershed: Ozette River, Lake Ozette, and lake tributaries.
- Ozette River not including the lake 9.8 sq. mi.
- Lake Ozette not including tributaries 11.8 sq. mi.
- Lake Ozette tributaries 66.8 sq. mi.



Ozette River

- Exits the lake at the north end.
- Drops ~33 feet over its sinuous 5.3 mile coarse to the Pacific Ocean
- Largest tributary is Coal Creek (4.6 sq. mi.)
- Habitat units dominated by pools and sluggish glides
- Substrate varies by location but is dominated sand and fines, with gravel and cobbles present is some of the riffles
- Unique large fresh water mussel beds present in some locations



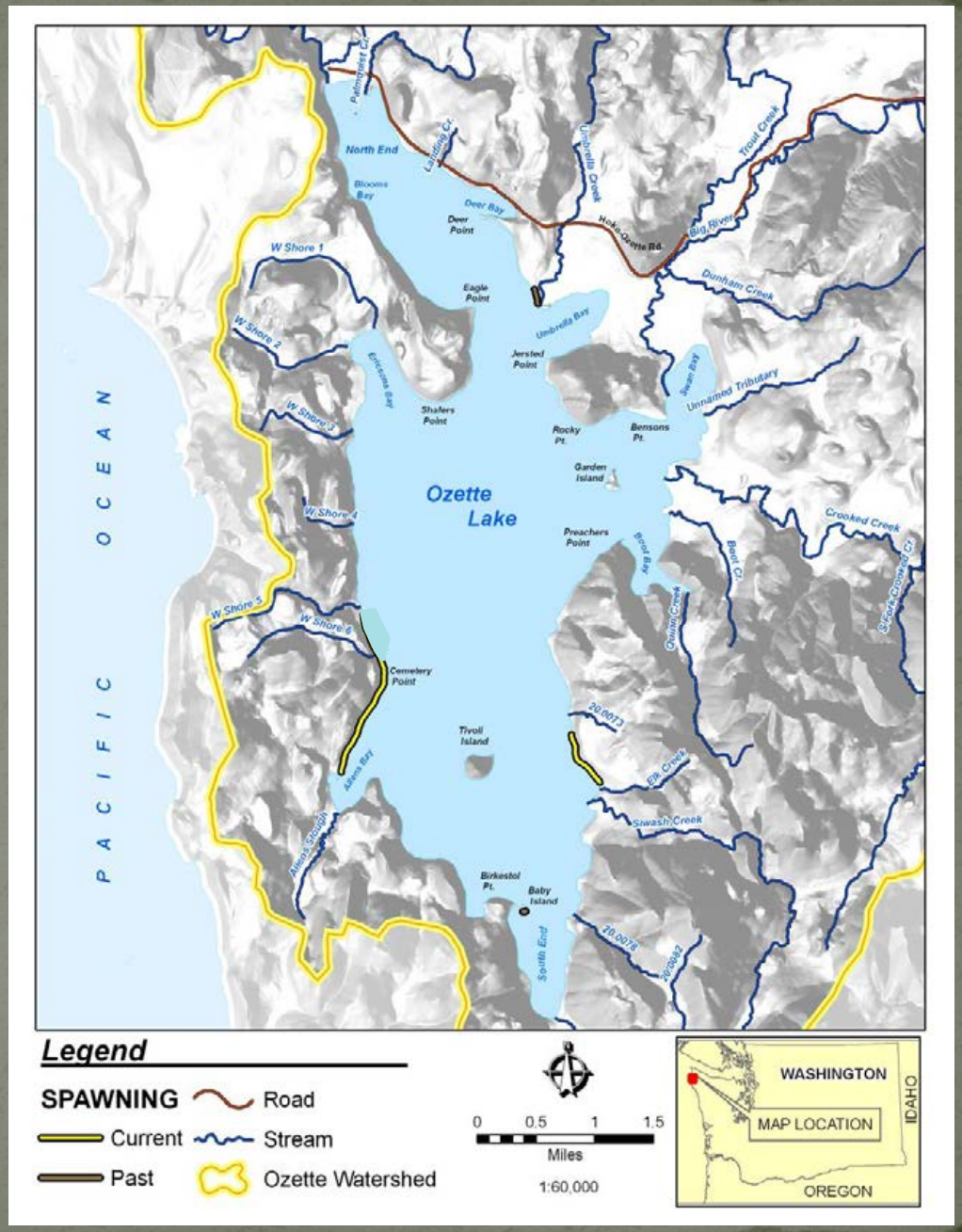


Lake Ozette

- Lake Ozette is the third largest natural lake in Washington (11.8 sq. mi.; 7,550 acres).
- 8 miles long and approximately 2 miles wide, with 36.5 miles of shoreline
- It is irregularly shaped and contains several bays and distinct points.
- Average depth is 120 ft with a maximum depth of 320 ft
- Average water surface elevation 34 ft; min 30.8 ft and max 41.5

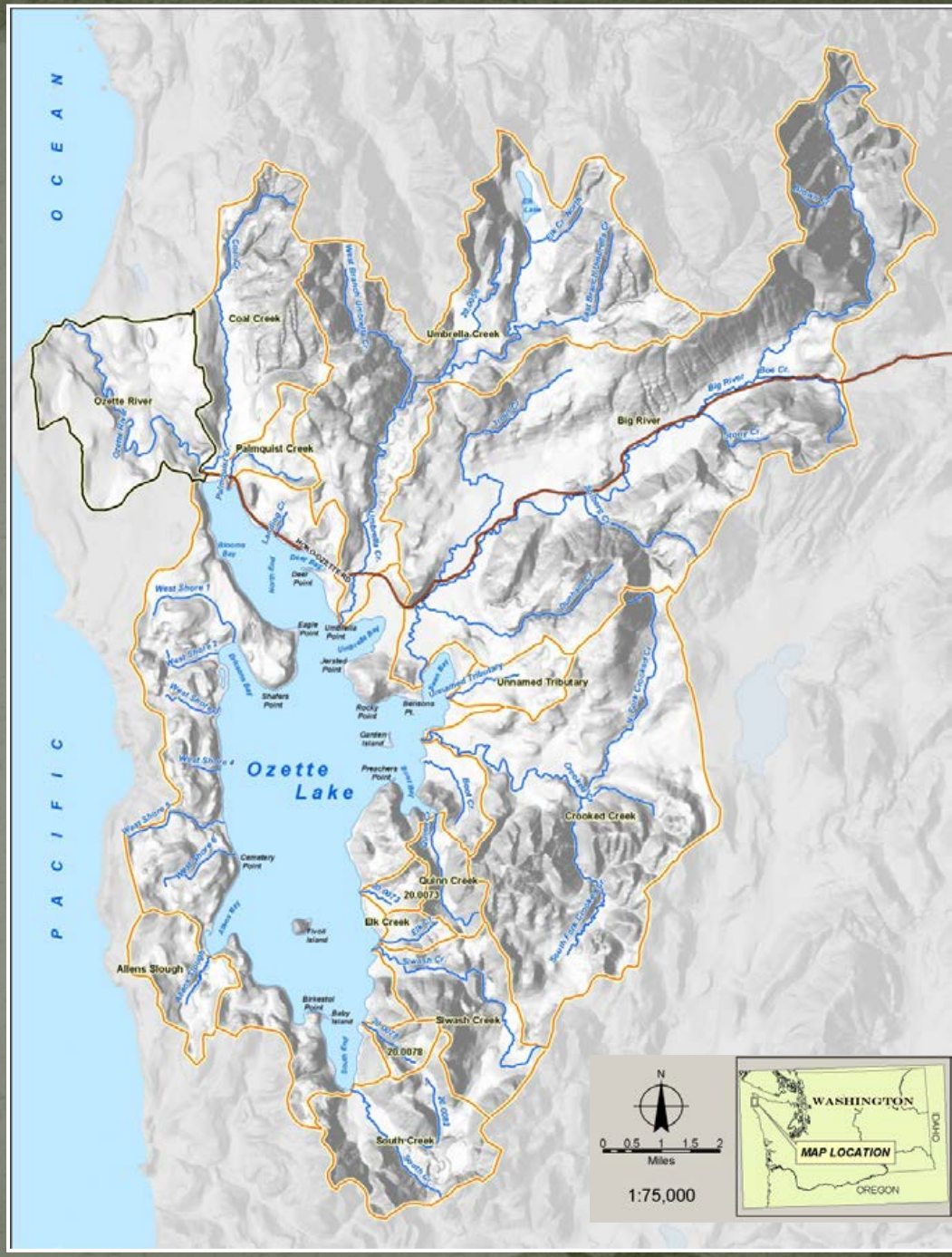
Lake Ozette Beach Spawning Sites

- Olsen's Beach
  - Olsen's Beach Core
  - North Olsen's
- Allen's Beach
  - Allen's Primary 1
  - Allen's Primary 2
  - Cemetery Point
- Umbrella Beach (no longer used)



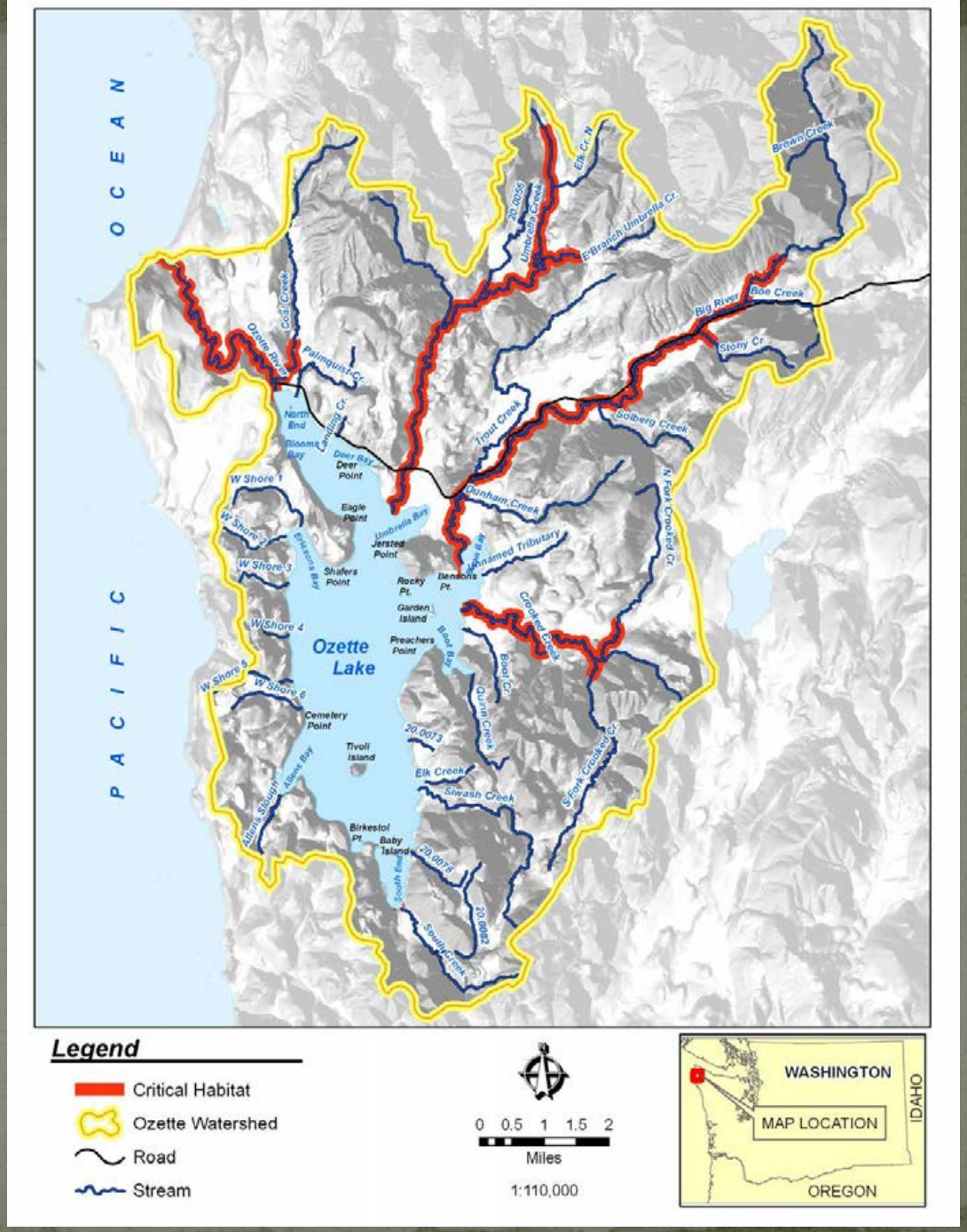
Lake Ozette Tributaries

- Drainage area = 66.8 sq mi
- Big River = 22.8 sq. mi.
- Crooked Creek = 12.2 sq. mi.
- Umbrella Creek = 10.6 sq. mi.
- South Creek = 3.3 sq. mi.
- Siwash Creek = 2.9 sq. mi.



Lake Ozette Tributaries

- Critical habitat in red
- Hatchery sockeye salmon releases:
  - Up to 100 pairs
  - Juveniles from 40 pairs into Umbrella Creek and 60 pairs into Big River



Fish Populations within the Ozette Basin

- Salmonid Populations (7 “species”)
  - Kokanee Salmon
  - Coho Salmon
  - Chum Salmon
  - Chinook Salmon
  - Steelhead
  - Coastal Cutthroat
  - Sockeye Salmon

Fish Populations within the Ozette Basin

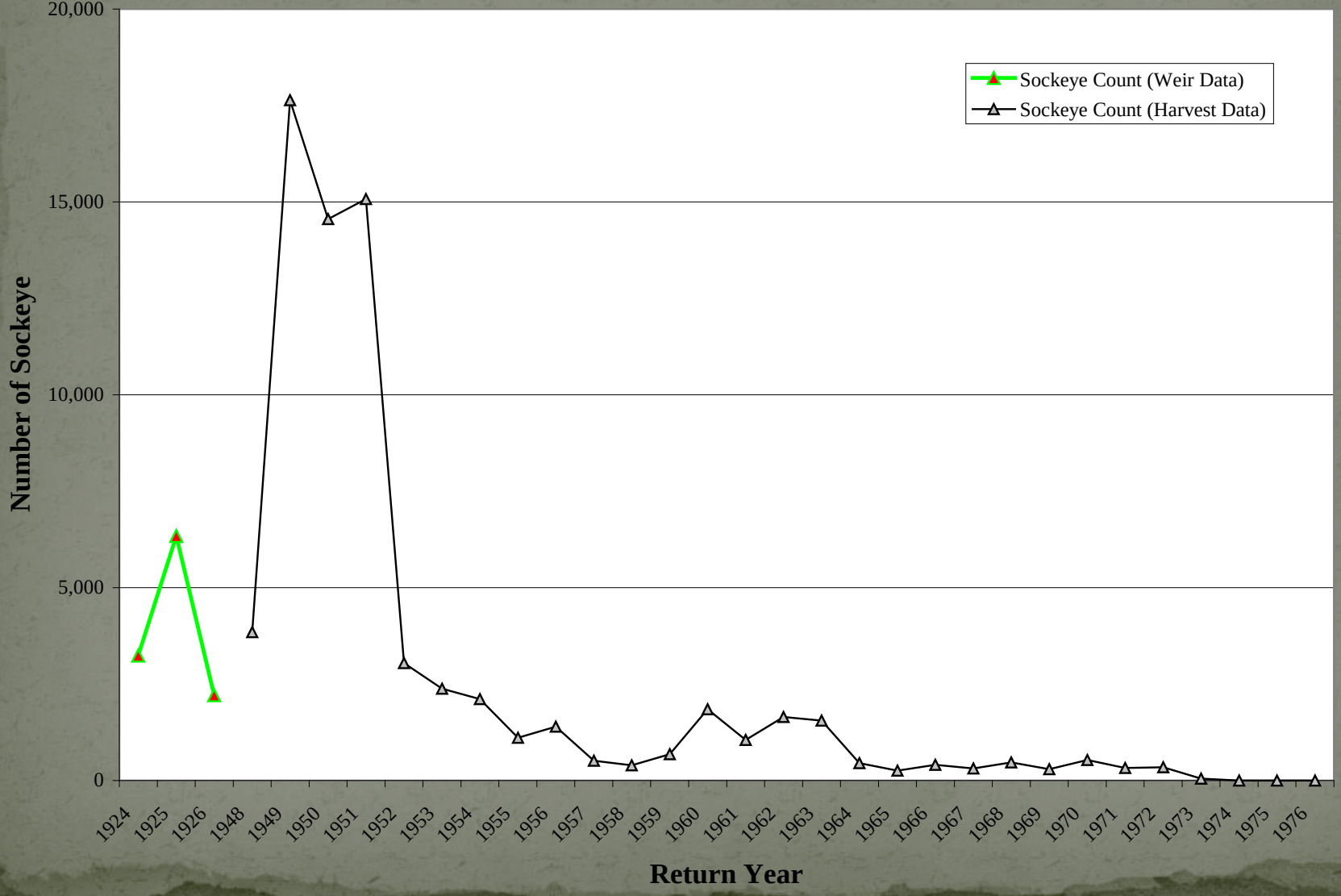
- Native Non-Salmonid Populations (12 "species")
  - Speckled Dace
  - Prickly Sculpin
  - Reticulate and Riffle Sculpins
  - Coast Range Sculpin
  - Torrent Sculpin
  - Western Brook Lamprey
  - Pacific Lamprey
  - Olympic Mudminnow
  - Peamouth Chub
  - Northern Pikeminnow
  - Redside Shiner

Fish Populations within the Ozette Basin

- Introduced Non-Salmonid Populations (6 “species”)
  - Tui Chub
  - American Shad
  - Yellow Perch
  - Largemouth Bass
  - Brown Bullhead
  - Yellow Bullhead

Lake Ozette Sockeye Salmon Abundance and Trends

Lake Ozette Sockeye Salmon Historical Abundance

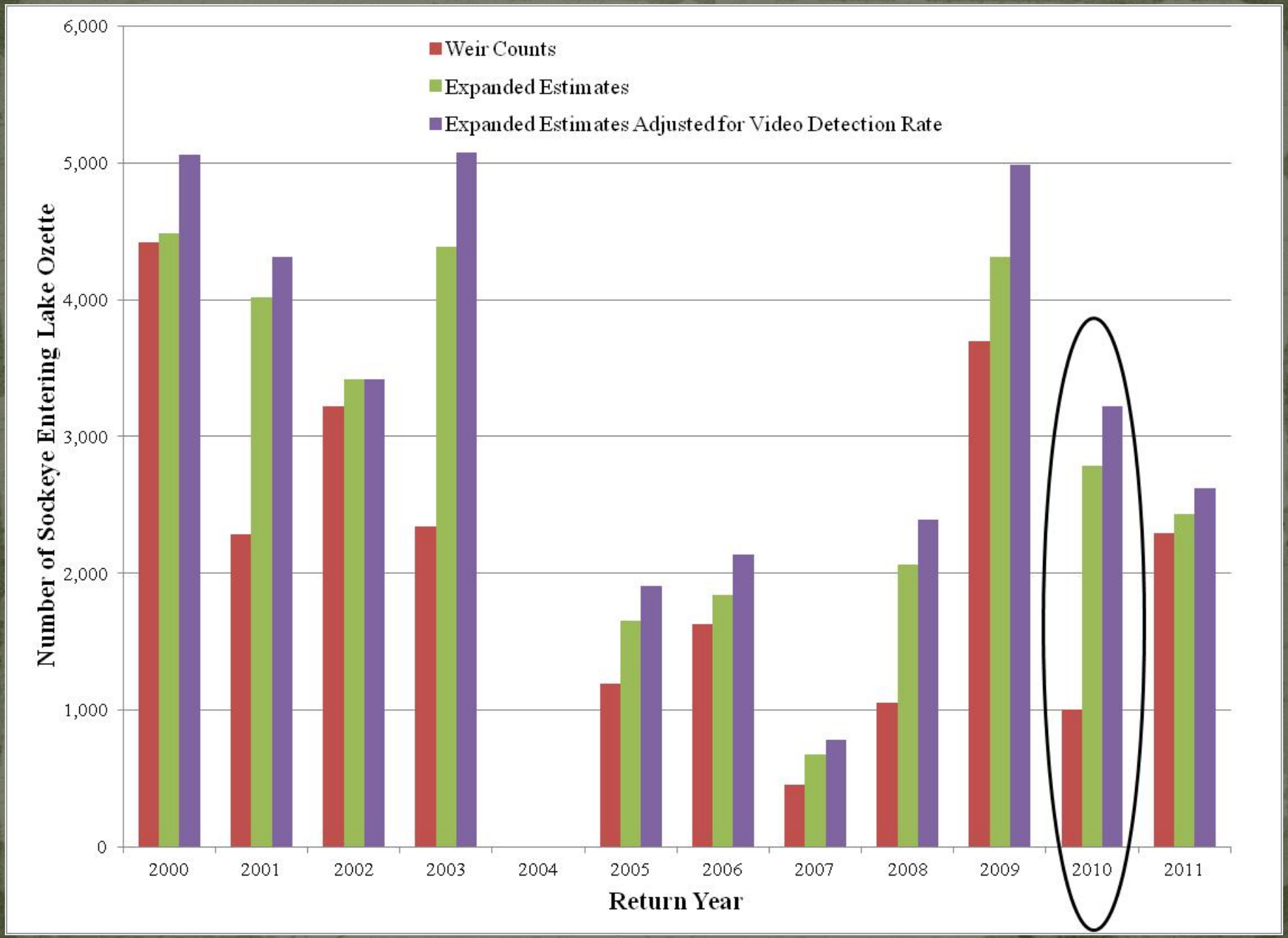


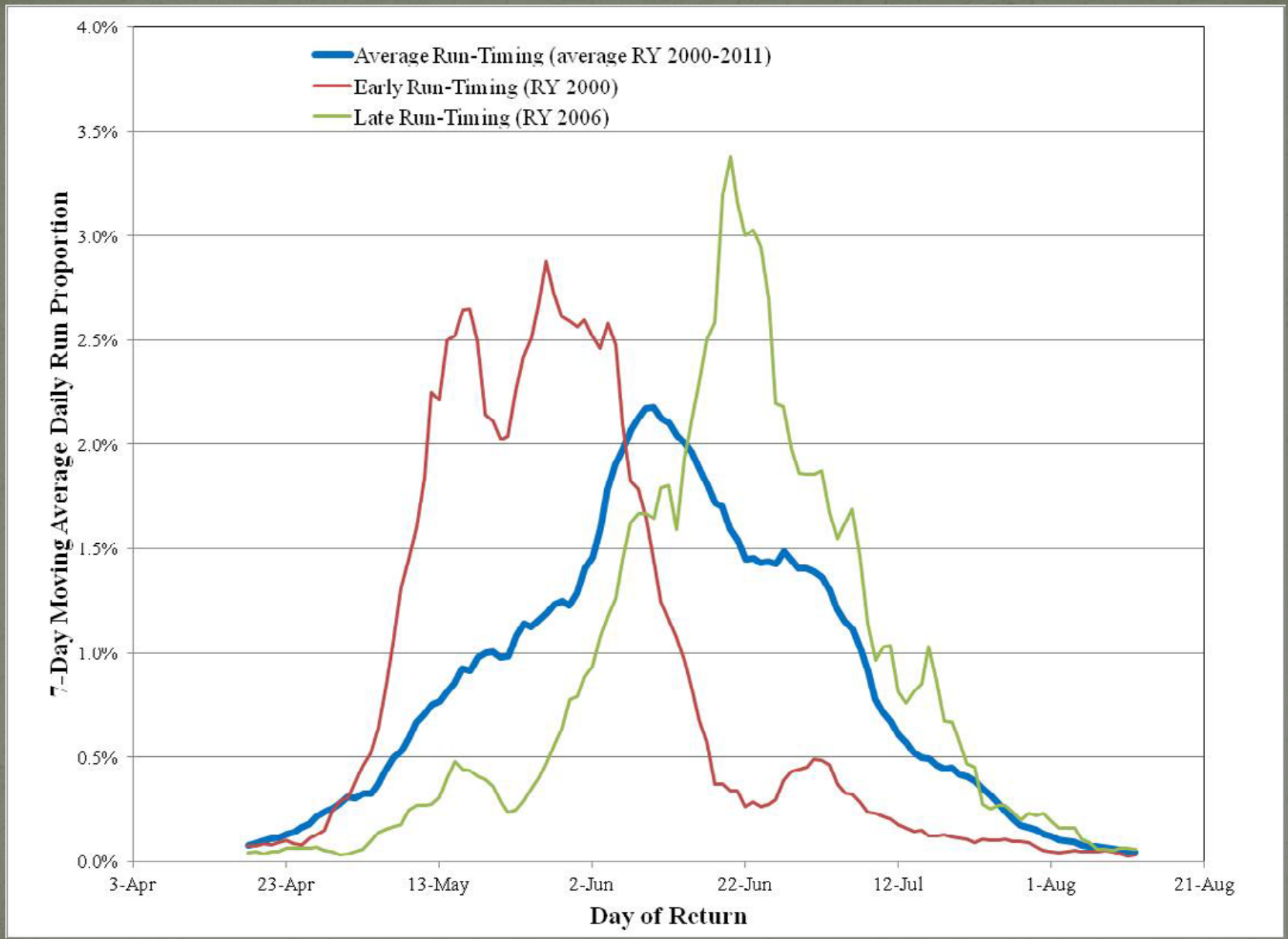
Recent Sockeye Salmon Abundance Estimates

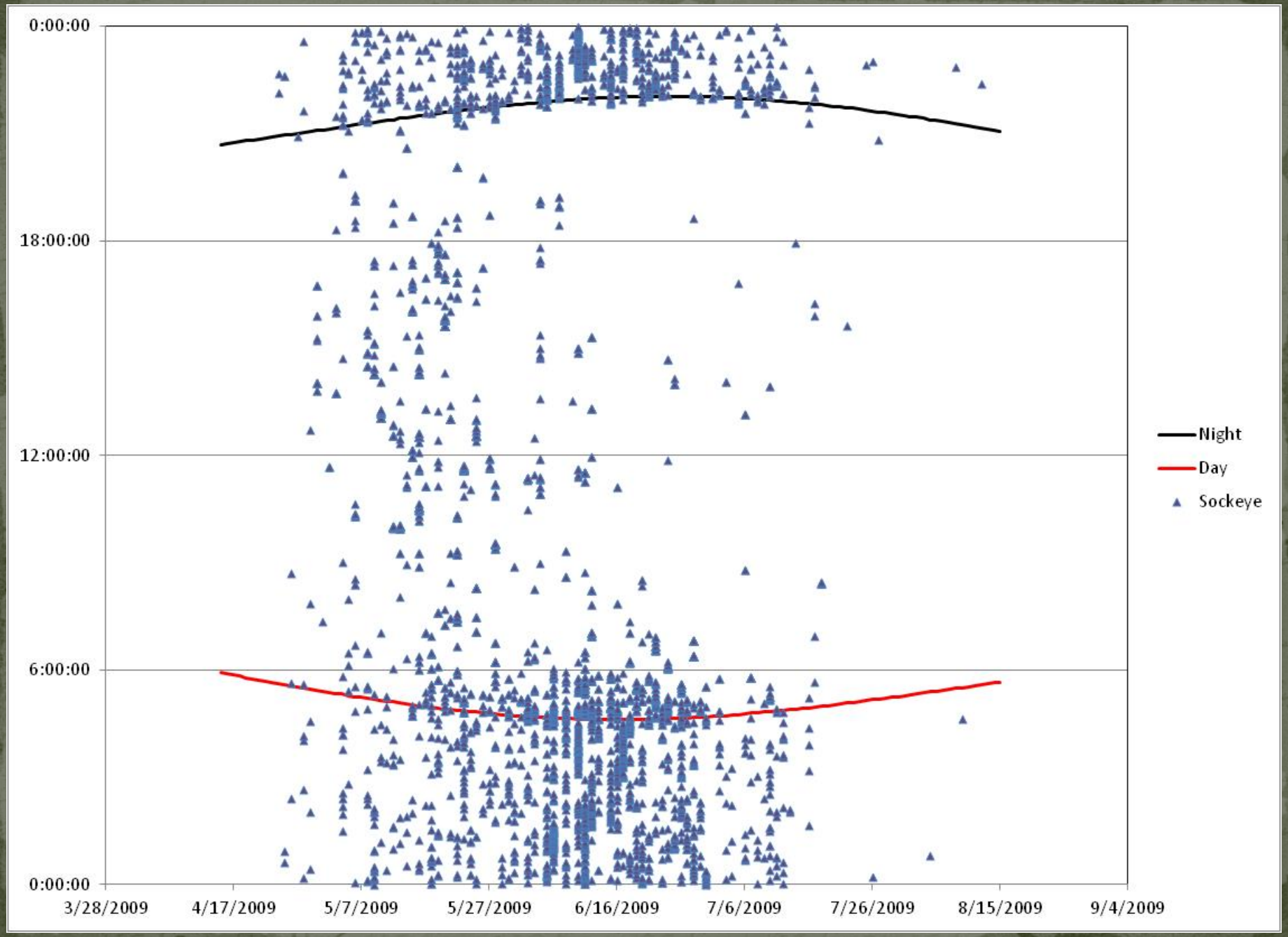
- Run is monitored from April 15 through August 15 using a channel spanning weir, viewing chamber, and video recording system (123 days; 2,952 hours)
- Run-sizes from 2000-2011 averaged 3,348 sockeye salmon
- During the most recent 4 years the run-size have averaged 3,532

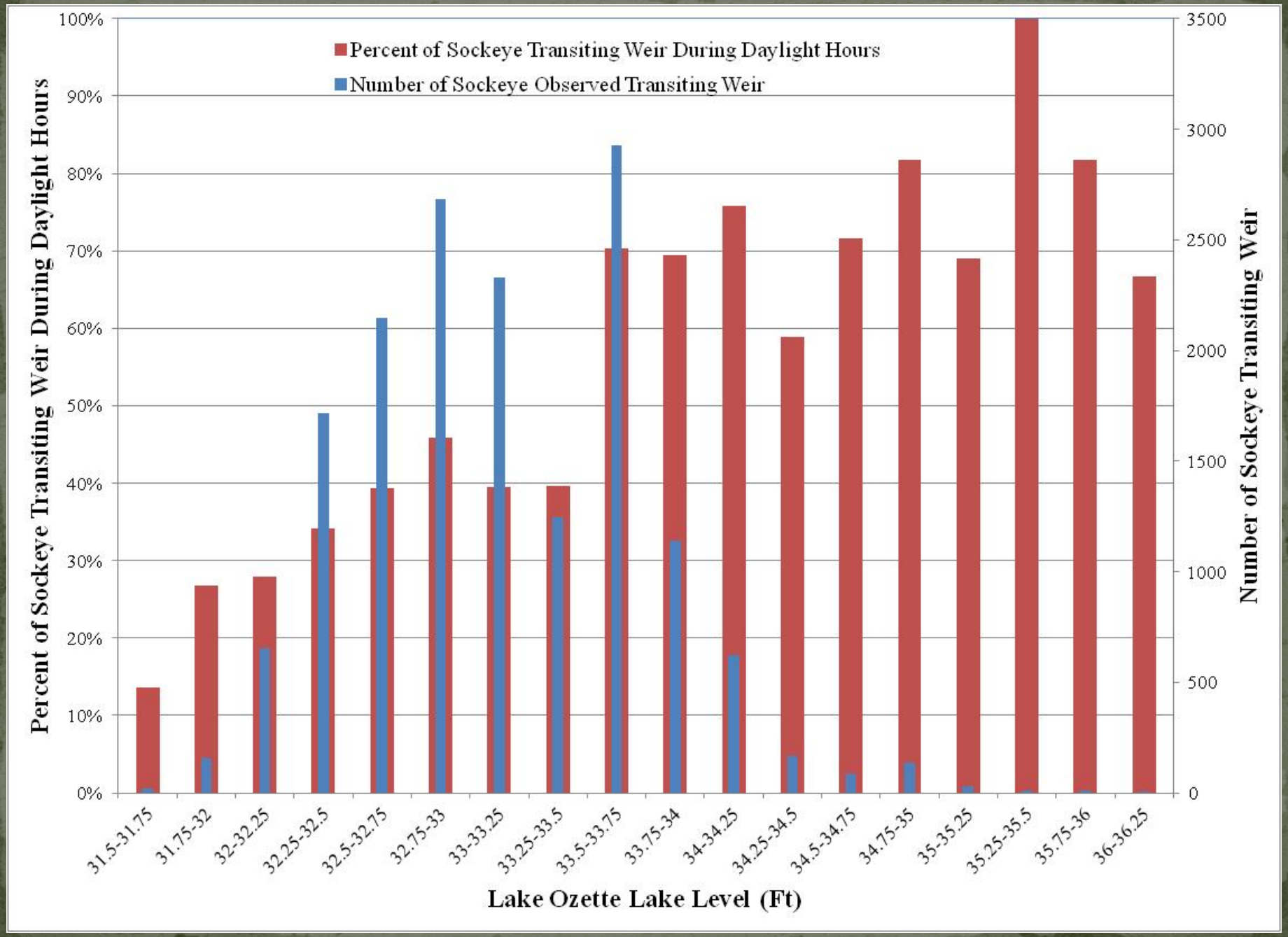
Future Sockeye Salmon Abundance Estimates

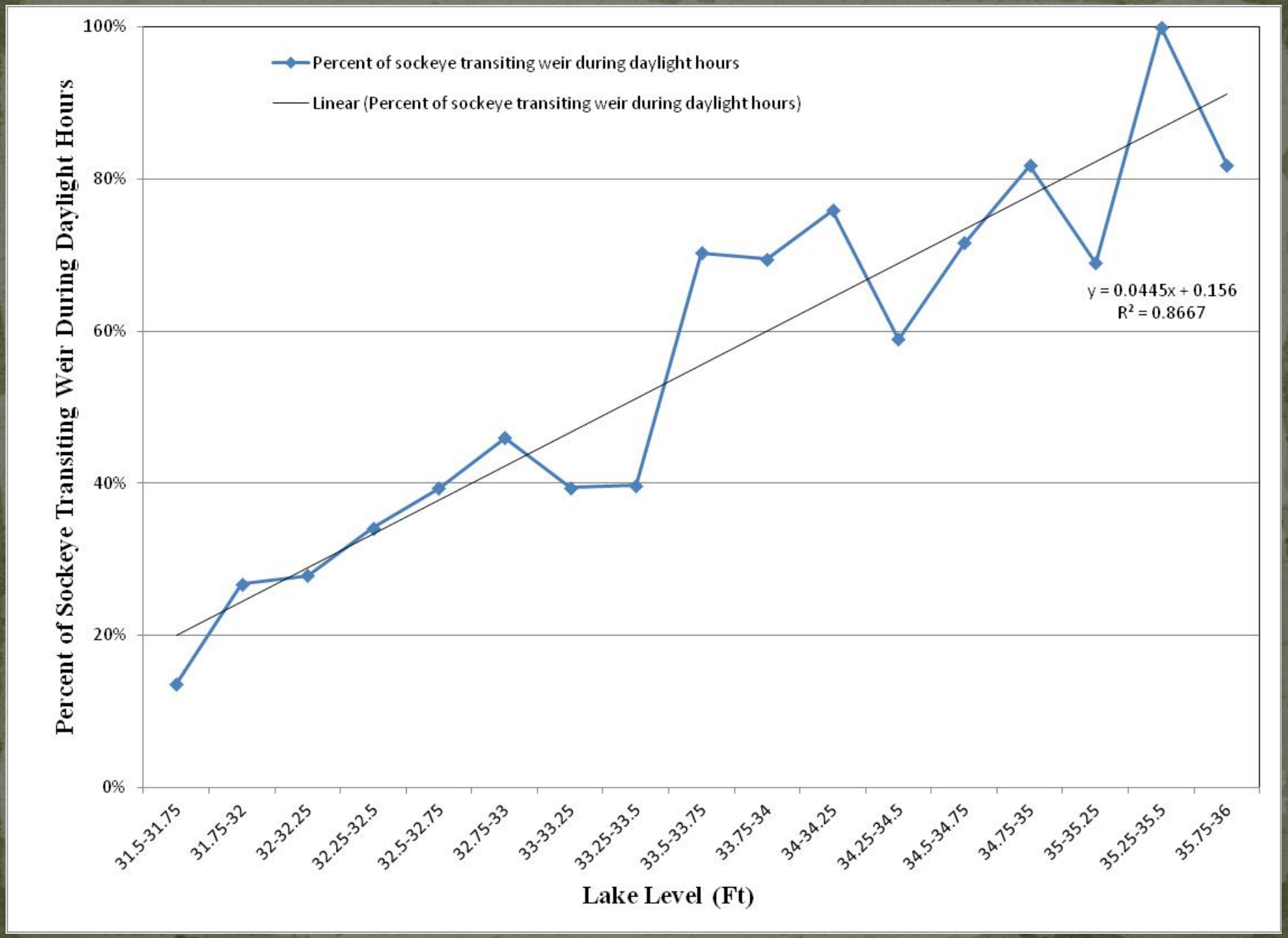
- Transitioning from full spanning weir to partial weir and ARIS imaging sonar.
- Currently testing new system and correlating with “traditional” monitoring equipment


Weir Counts
Expanded Estimates
Expanded Estimates Adjusted for Video Detection Rate
Number of Sockeye Entering Lake Ozette
6,000
5,000
4,000
3,000
2,000
1,000
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Return Year


Average Run-Timing (average RY 2000-2011)
Early Run-Timing (RY 2000)
Late Run-Timing (RY 2006)
7-Day Moving Average Daily Run Proportion
4.0%
3.5%
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
3-Apr
23-Apr
13-May
2-Jun
22-Jun
12-Jul
1-Aug
21-Aug
Day of Return

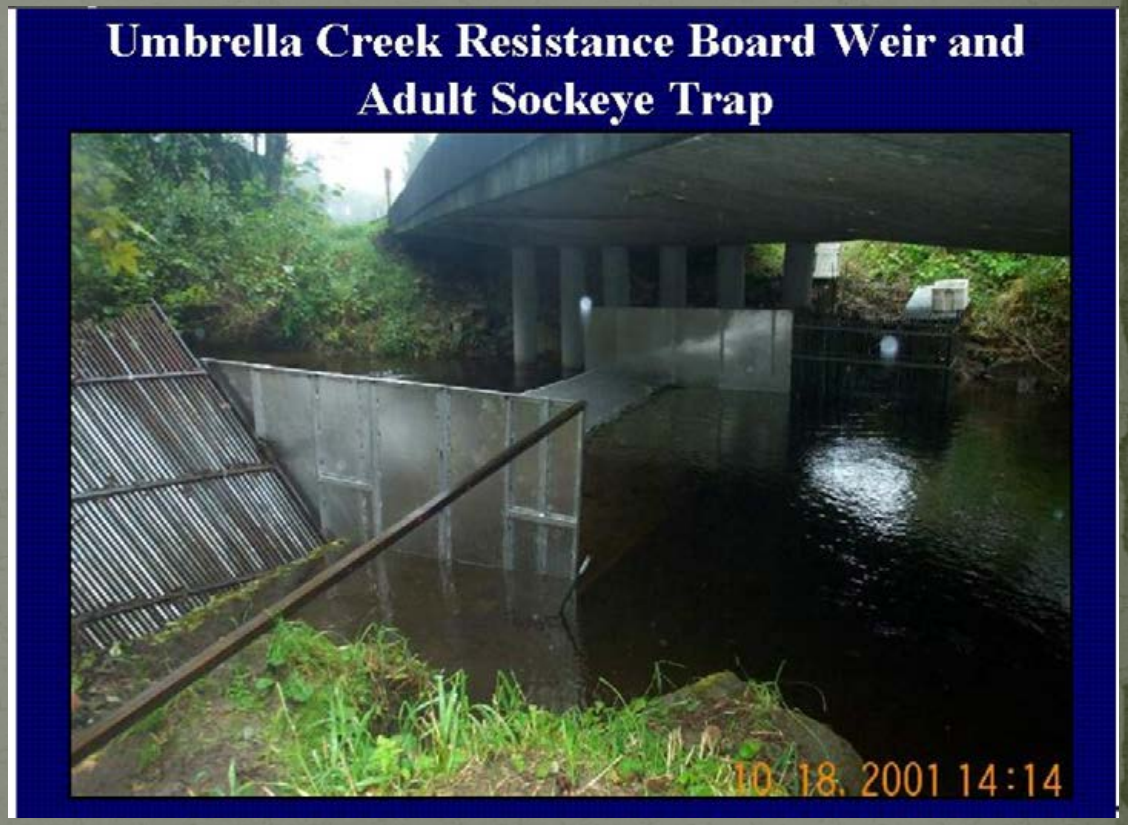

0:00:00
18:00:00
12:00:00
6:00:00
0:00:00
3/28/2009
4/17/2009
5/7/2009
5/27/2009
6/16/2009
7/6/2009
7/26/2009
8/15/2009
9/4/2009
Night
Day
Sockeye

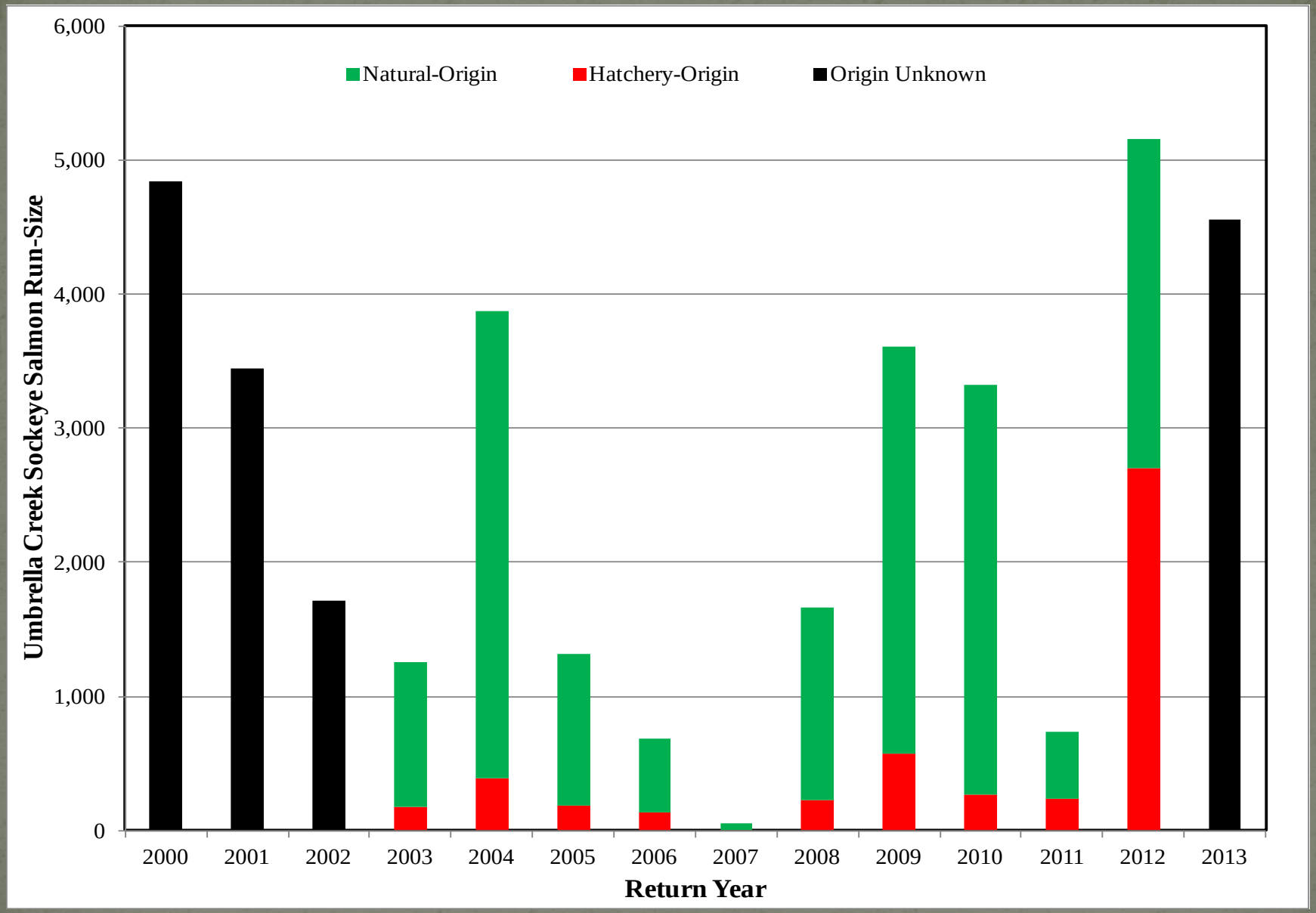

Percent of Sockeye Transiting Weir During Daylight Hours
Number of Sockeye Observed Transiting Weir
Percent of Sockeye Transiting Weir During Daylight Hours
Number of Sockeye Transiting Weir
Lake Ozette Lake Level (Ft)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
3500
3000
2500
2000
1500
1000
500
0
31.5-31.75
31.75-32
32-32.25
32.25-32.5
32.5-32.75
32.75-33
33-33.25
33.25-33.5
33.5-33.75
33.75-34
34-34.25
34.25-34.5
34.5-34.75
34.75-35
35-35.25
35.25-35.5
35.75-36
36-36.25

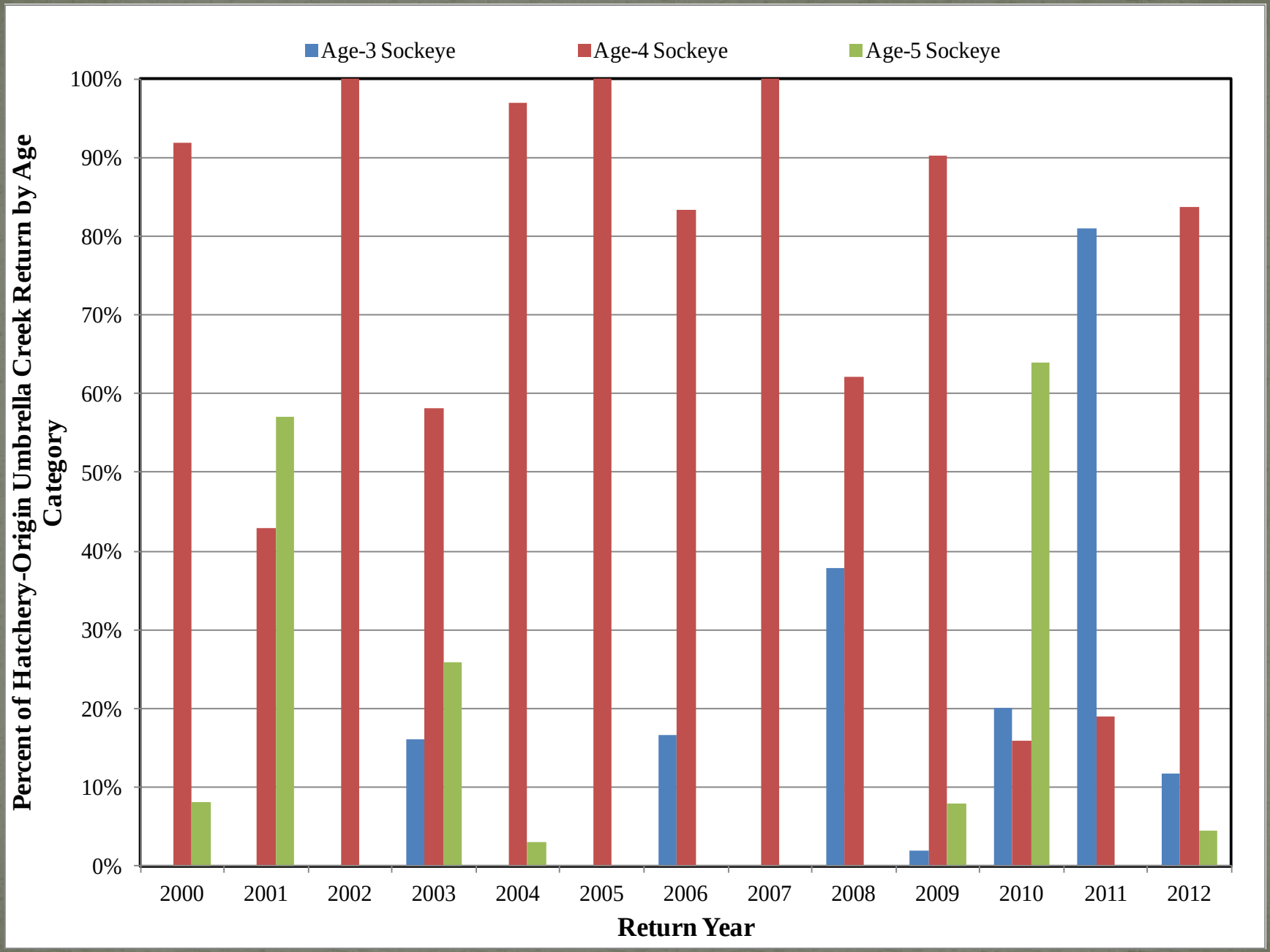

Percent of Sockeye Transiting Weir During Daylight Hours
100%
80%
60%
40%
20%
0%
Percent of sockeye transiting weir during daylight hours
Linear (Percent of sockeye transiting weir during daylight hours)
y = 0.0445x + 0.156
R² = 0.8667
31.5-31.75
31.75-32
32-32.25
32.25-32.5
32.5-32.75
32.75-33
33-33.25
33.25-33.5
33.5-33.75
33.75-34
34-34.25
34.25-34.5
34.5-34.75
34.75-35
35-35.25
35.25-35.5
35.75-36
Lake Level (Ft)

Recent Sockeye Salmon Abundance Estimates – Umbrella Creek

- Run is monitored from late-September through December
- Estimates made using Schnabel mark and recapture model
- Run-sizes from 2000-2013 averaged 2,558 fish
- pHOS averages about 19%

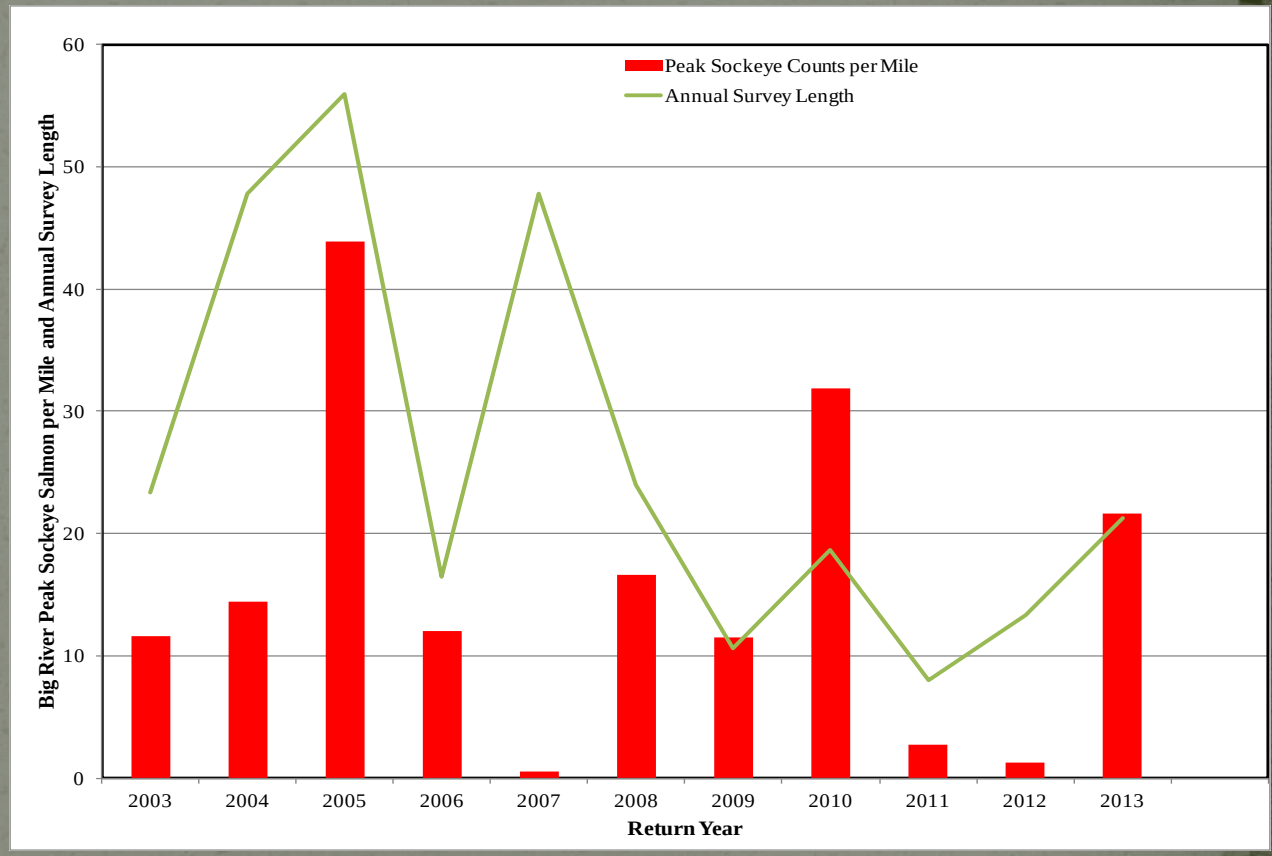



Natural-Origin
Hatchery-Origin
Origin Unknown
Umbrella Creek Sockeye Salmon Run-Size
6,000
5,000
4,000
3,000
2,000
1,000
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Return Year


Age-3 Sockeye
Age-4 Sockeye
Age-5 Sockeye
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Hatchery-Origin Umbrella Creek Return by Age Category
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Return Year

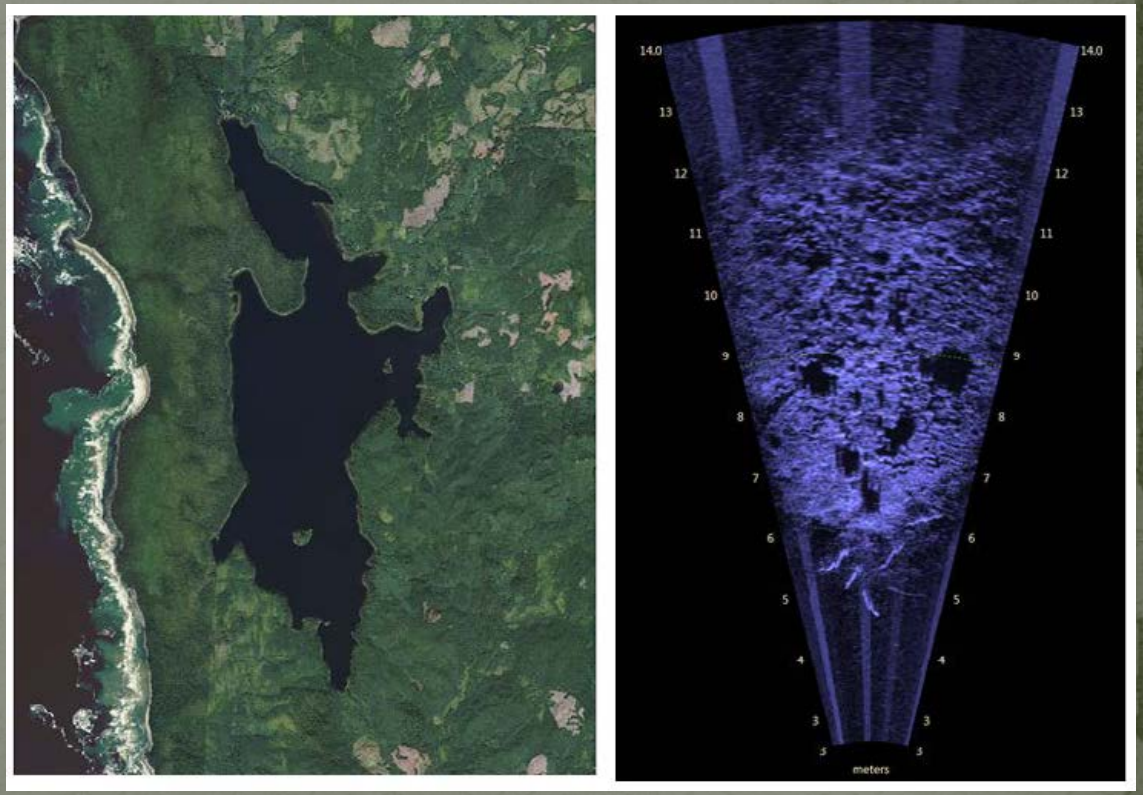
Recent Sockeye Salmon Abundance Estimates – Big River

- Run is monitored from October through December
- No estimates are made: only peak counts are used as an index of abundance

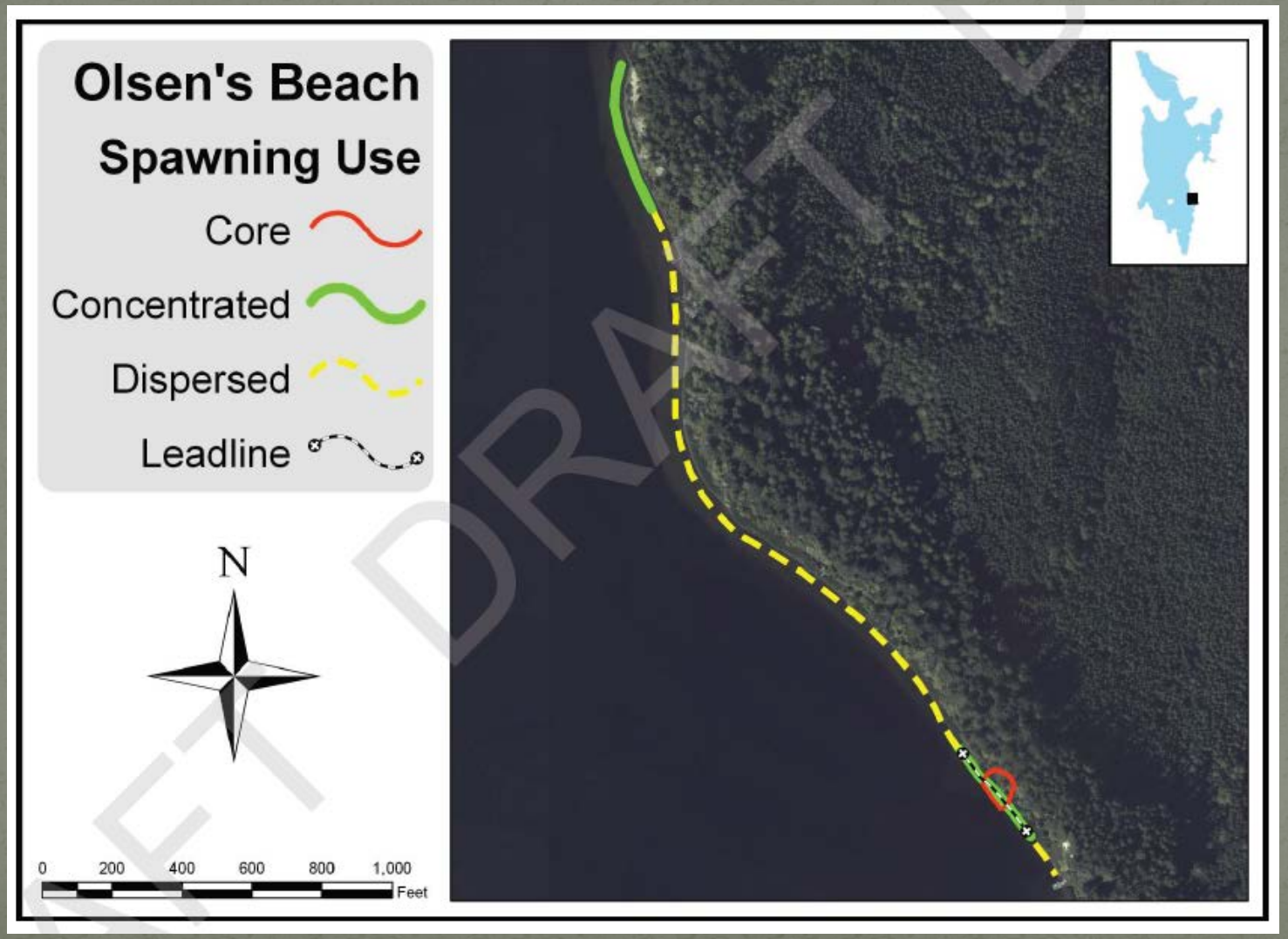


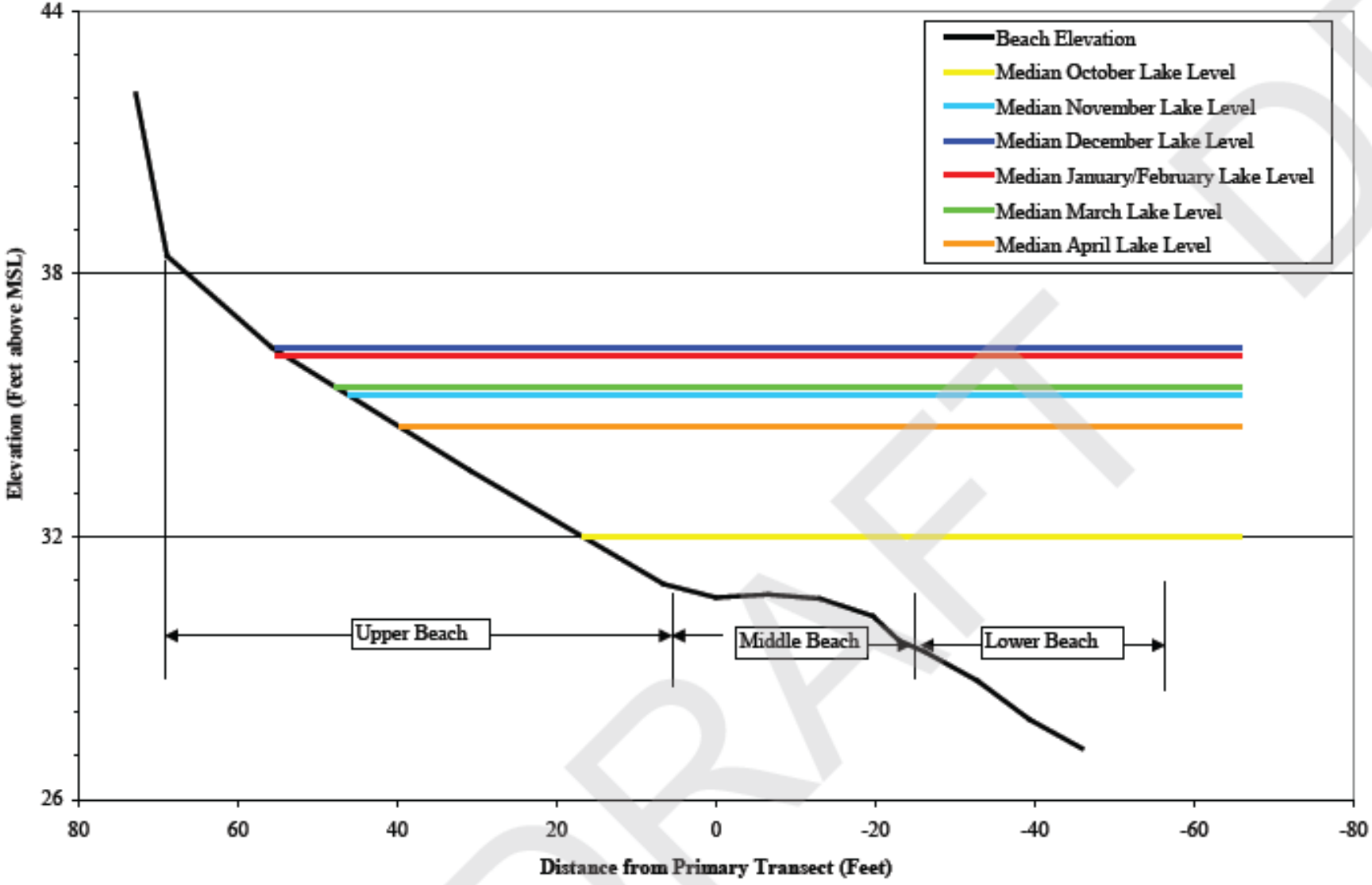
Recent Sockeye Salmon Abundance Estimates – Lake Ozette Beaches

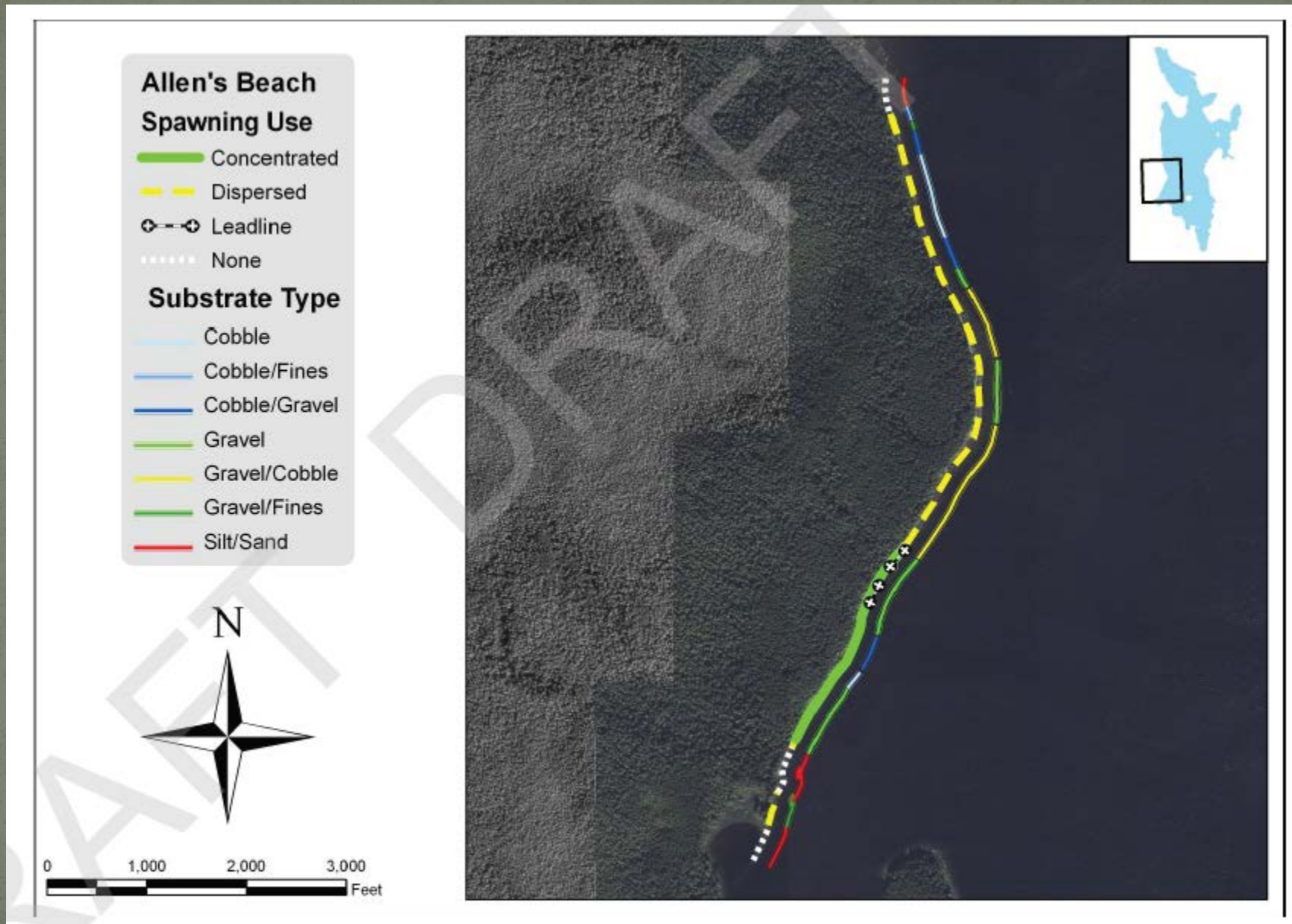
- Escapement is monitored from October through January
- Methods have varied over the years from seining, netting, scuba, and snorkel surveys
- Recently developed imaging sonar methods are now being implemented



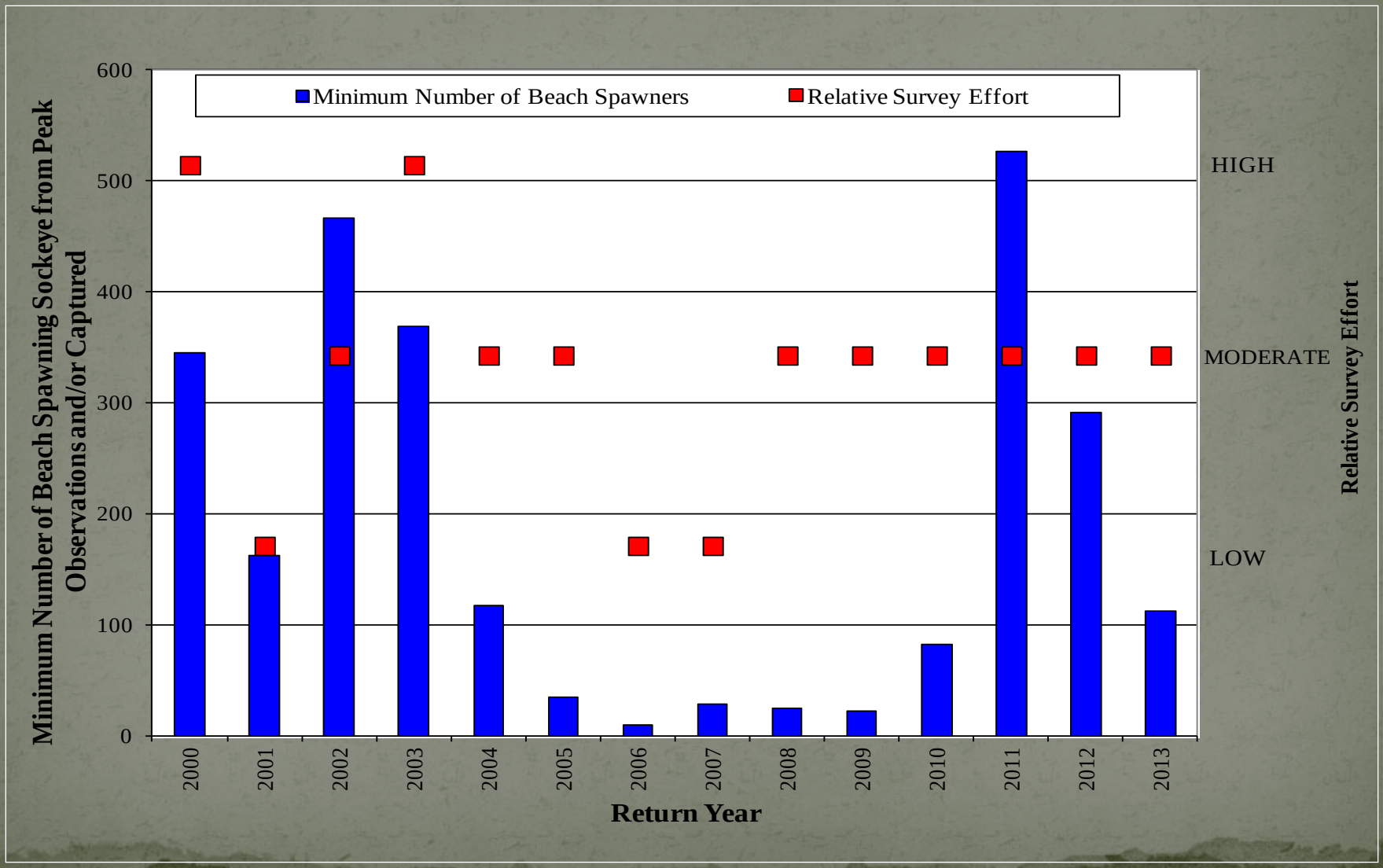
Olsen's Beach Spawning Area




Beach Elevation
Median October Lake Level
Median November Lake Level
Median December Lake Level
Median January/February Lake Level
Median March Lake Level
Median April Lake Level
Elevation (Feet above MSL)
44
38
32
26
Upper Beach
Middle Beach
Lower Beach
80
60
40
20
0
-20
-40
-60
-80
Distance from Primary Transect (Feet)


Allen's Beach
Spawning Use
Concentrated
Dispersed
Leadline
None
Substrate Type
Cobble
Cobble/Fines
Cobble/Gravel
Gravel
Gravel/Cobble
Gravel/Fines
Silt/Sand
N
0
1,000
2,000
3,000
Feet

Lake Ozette Sockeye Salmon Beach Spawners



Lake Ozette Sockeye Factors for Decline and Limiting Factors

Factors for Decline (from MFM 2000)

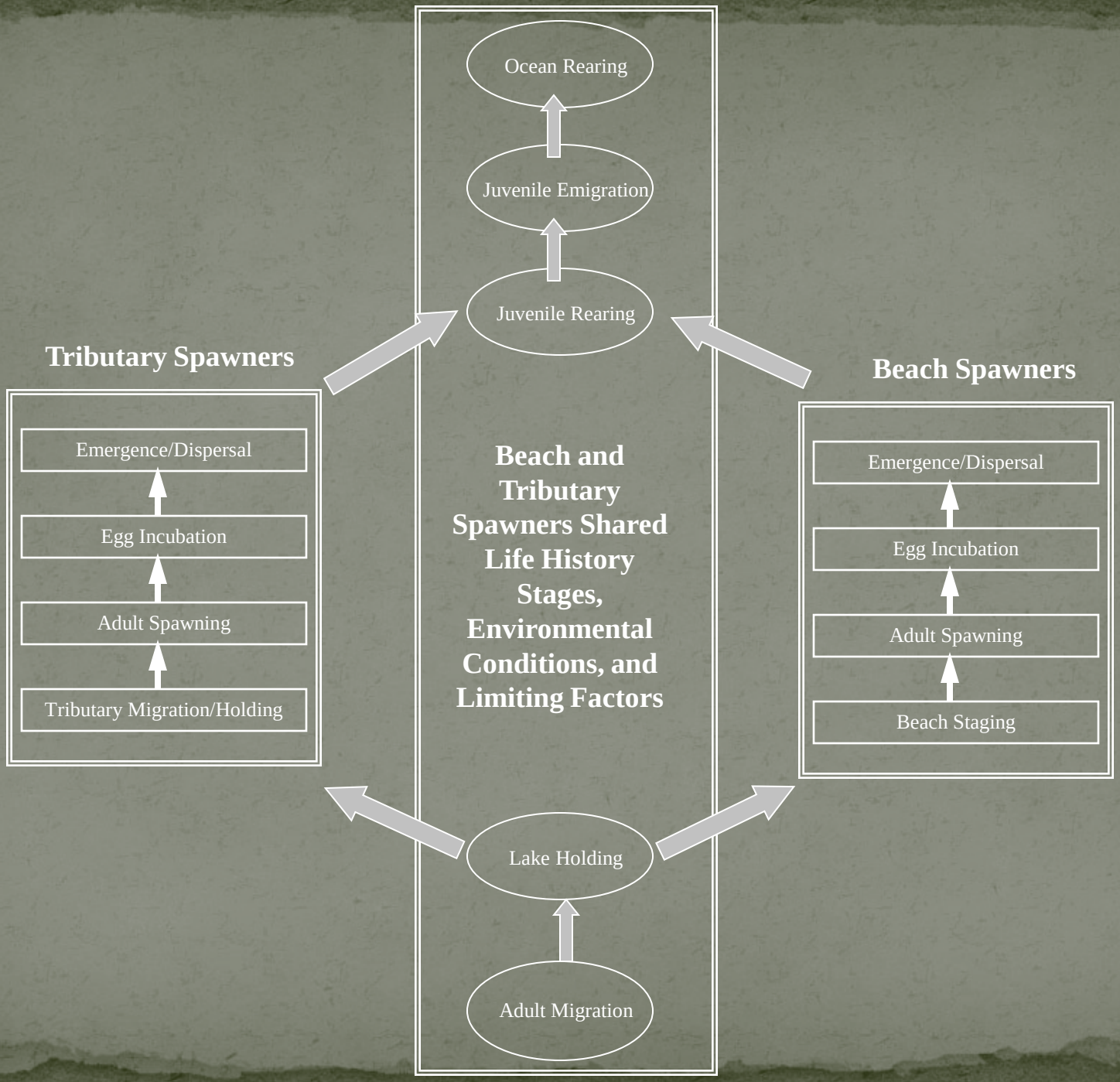
- Loss of adequate quality and quantity of beach spawning habitat,
- Loss of tributary spawning sockeye populations,
- Past over-exploitation,
- Predation and disruption of natural predator-prey relationships,
- Introduction of nonnative fish and plant species,
- Temporarily poor ocean conditions, and
- Interactions of these factors.

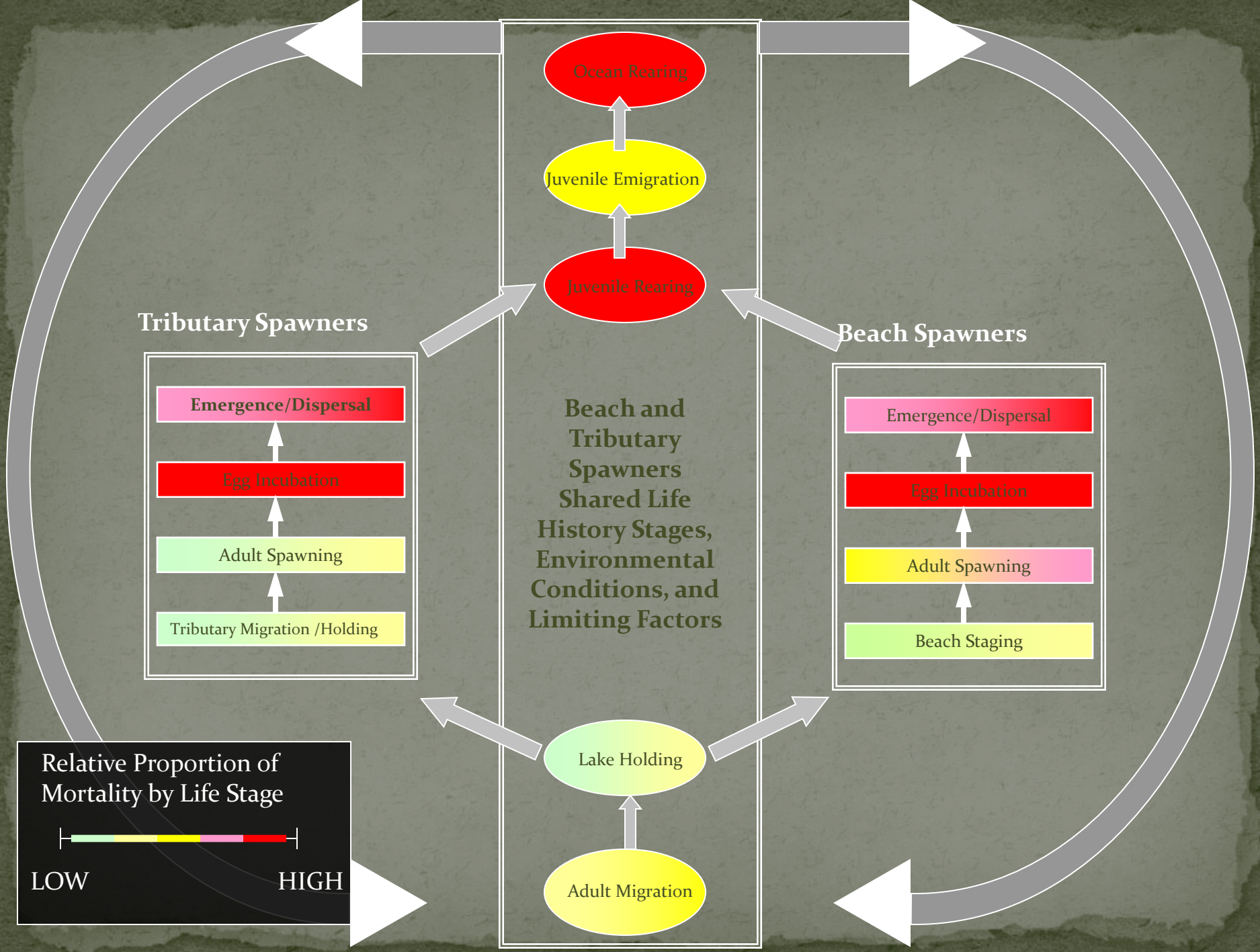
Limiting Factors Approach

- The hypothesized limiting factors affecting Lake Ozette sockeye salmon were delineated by geographic area, areas included:
  - Estuary and Nearshore
  - Ozette River
  - Lake Ozette
  - Lake Ozette Tributaries
  - Off-Shore Marine Environment

Limiting Factors Approach

- The hypothesized limiting factors affecting Lake Ozette sockeye salmon were further delineated by life history phase:
  - Adult sockeye salmon entering the system
  - Adult sockeye salmon holding in the Lake Ozette
  - Adult sockeye salmon staging at spawning beaches
  - Adult sockeye salmon spawning on lake beaches
  - Sockeye salmon egg incubation on beaches
  - Lake beach fry emergence and dispersal
  - Adult sockeye entering, migrating, and holding in tribs
  - Adult sockeye spawning in tributaries
  - Sockeye egg incubation in tributaries
  - Tributary fry emergence and dispersal
  - Juvenile sockeye freshwater rearing
  - Seaward migration
  - Marine ocean phase


Ocean Rearing
Juvenile Emigration
Juvenile Rearing
Tributary Spawners
Emergence/Dispersal
Egg Incubation
Adult Spawning
Tributary Migration/Holding
Beach and Tributary Spawners Shared Life History Stages, Environmental Conditions, and Limiting Factors
Beach Spawners
Emergence/Dispersal
Egg Incubation
Adult Spawning
Beach Staging
Lake Holding
Adult Migration


Ocean Rearing
Juvenile Emigration
Juvenile Rearing
Tributary Spawners
Emergence/Dispersal
Egg Incubation
Adult Spawning
Tributary Migration /Holding
Beach and Tributary Spawners Shared Life History Stages, Environmental Conditions, and Limiting Factors
Beach Spawners
Emergence/Dispersal
Egg Incubation
Adult Spawning
Beach Staging
Lake Holding
Adult Migration
Relative Proportion of Mortality by Life Stage
LOW
HIGH

Limiting Factors Hypotheses

- Hypothesized limiting factors affecting adult Lake Ozette sockeye salmon entering the system:
  - Aquatic mammal predation (moderate)
  - Ozette River habitat conditions (low)
  - Water quality (temperature and low frequency high intensity turbidity and suspended sediment events [moderate])
  - Streamflow (unknown)
  - Fisheries impact (none)
  - Disease (unknown)
  - Research and monitoring (low)

Limiting Factors Hypotheses

- Example for water quality
- **Hypothesis 3:** High stream temperatures and low frequency, high intensity turbidity events reduce the fitness of sockeye salmon entering Lake Ozette, and result in increased egg retention and pre-spawning mortality; in some cases, high stream temperatures exceeding 20°C result in direct en route mortality.
- **Rationale:** High stream temperatures and low frequency, high intensity turbidity events occur during the sockeye migration period. Temperatures approaching 24°C have been recorded during the adult migration period. Sockeye covered in silt and bleeding from the gills have been observed following high turbidity and suspended sediment concentrations events. Cumulatively, approximately 12% of the population on average would be exposed to high SSC events based upon the frequency and duration of these events during the migration period. These events would result in moderate physiological stress (Newcombe and Jansen 1996) based on the expected sockeye exposure times, which are a function of average measured migration times (Gearin et al. 2002).

Table 5.1. Proportion of Lake Ozette sockeye runs exposed to different temperature ranges during upstream migration and the potential biological effects (source: Haggerty 2004a, 2005a, and MFM unpublished data).

Average Daily Temperature Exposure	Percent of Sockeye Run Exposed to Specified Temperature Range			Potential Effects
	RY 2002	RY 2003	RY 2004	
<18°C	83.7%	78.7%	44.1%	No Direct Effect
18-19°C	6.6%	8.0%	5.0%	Decreased swimming performance, increased energy use
19-20°C	7.3%	8.6%	29.2%	Increased physiological stress, slow or delayed migration
20-21°C	1.3%	4.4%	4.8%	Increased risk of pre-spawning mortality and disease
>21°C	1.1%	0.3%	16.2%	Chronic exposure can lead to severe stress, direct en-route mortality, and delayed pre-spawning mortality

Limiting Factors Hypotheses

- Hypothesized limiting factors affecting adult Lake Ozette sockeye salmon holding in Lake Ozette:
  - Predation, disease, and water quality (unknown)
  - Fisheries impacts (negligible)

Limiting Factors Hypotheses

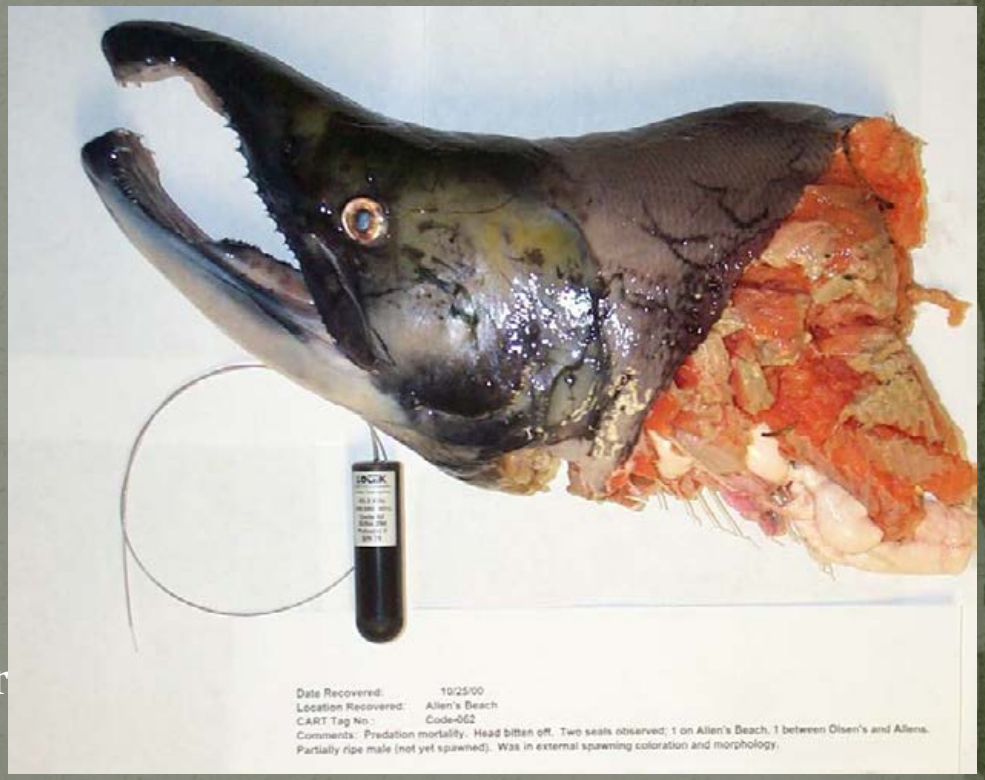
- Hypothesized limiting factors affecting adult sockeye staging at spawning beaches:
  - Aquatic mammal predation (low)
  - Water quality (low)

Limiting Factors Hypotheses

- Hypothesized limiting factors affecting adult sockeye spawning on lake beaches:
  - Aquatic mammal predation (high)
  - Water quality (low)
  - Tributary hatchery program impacts (negligible)
    - pHOS has averaged between 0.4 and 0.8% between the two beaches since HGMP was approved by NMFS.

Limiting Factors Hypotheses

- Example for predation
- **Hypothesis 11:** Predation of adult sockeye salmon primarily by harbor seals and river otters reduces the number of effective spawners and therefore reduces the size of the sockeye population.
- **Rationale:** Data collected during the spawning season in 2000 suggest that 40% or more of the sockeye at Allen's Beach were killed by harbor seals and river otters prior to completion of spawning….



Limiting Factors Hypotheses

- Hypothesized limiting factors affecting sockeye salmon egg incubation on lake beaches:
  - Reduced spawning habitat quality and quantity (high)
    - Complete loss of Umbrella Beach due to several acres of sediment accumulation on historical spawning beach.
    - Vegetation colonization along the shoreline of the lake between 1953 and 2003 resulted in a 56% net decrease in the quantity of unvegetated shoreline.
  - Egg predation (unknown)
  - Seasonal lake level changes (low to moderate)
  - Competition (redd superimposition) (low to moderate)
  - Small population size (Unknown)

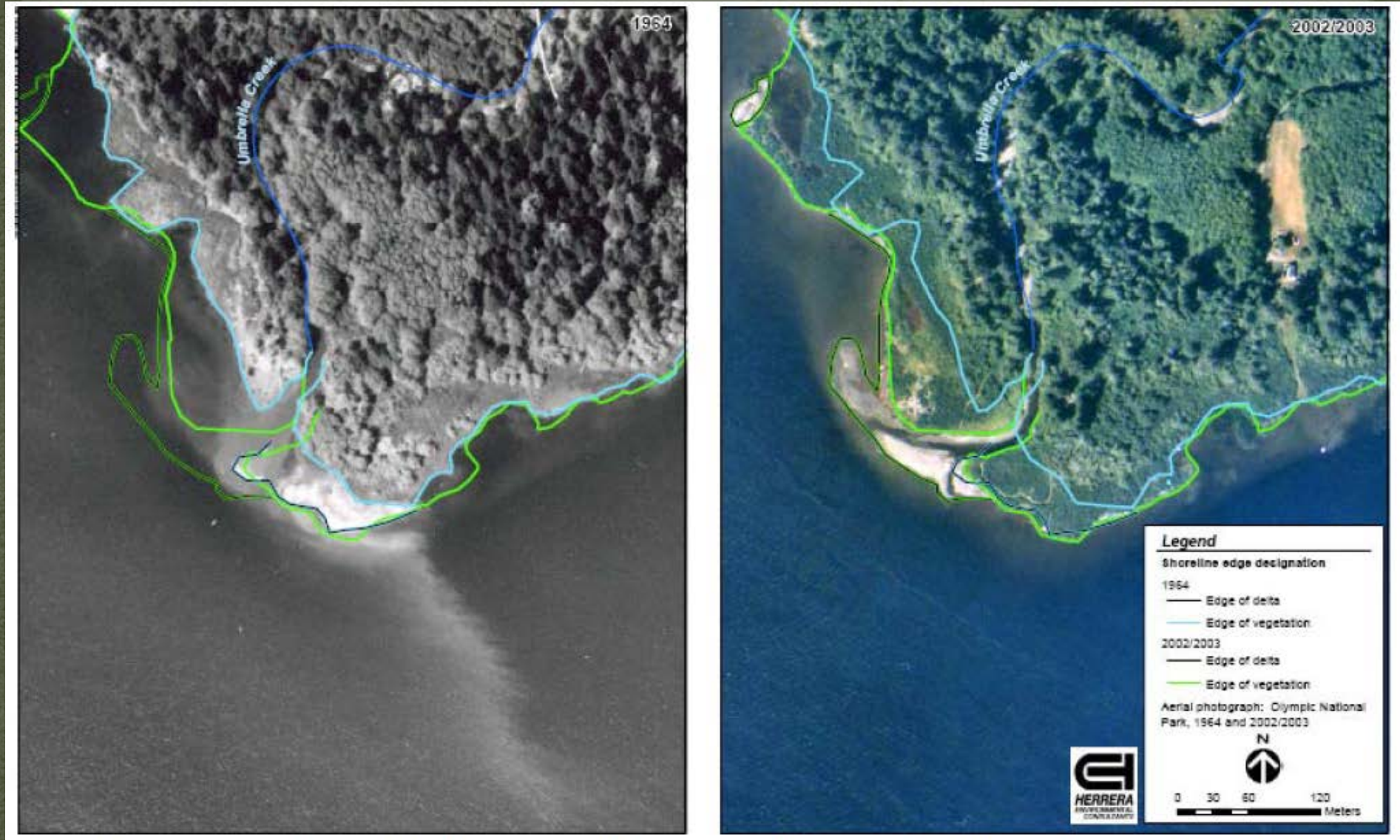


Figure 4.7. Comparison of 1964 and 2002 shoreline and delta conditions at the mouth of Umbrella Creek (source: Herrera 2005)

Limiting Factors Hypotheses

- Hypothesized limiting factors affecting sockeye salmon fry emergence and dispersal on lake beaches:
  - Fine sediment (moderate)
  - Predation (unknown)
  - Seasonal lake level changes (low to moderate)

Limiting Factors Hypotheses

- Hypothesized limiting factors affecting sockeye salmon adults entering, migrating, and holding in tributaries:
  - Predation (low)
  - Holding pool quantity and quality (low)
  - Streamflow (low)
  - Water quality (low)
  - Research and monitoring (negligible)

Limiting Factors Hypotheses

- Hypothesized limiting factors affecting sockeye salmon spawning in tributaries:
  - Predation (low)
  - Holding pool quantity and quality (negligible)
  - Quantity of suitable spawning habitat (low)
  - Streamflow (low)
  - Kokanee-sockeye interactions (negligible to low)
  - Water quality (low)
  - Research and monitoring (negligible)

Limiting Factors Hypotheses

- Hypothesized limiting factors affecting sockeye salmon egg incubation in tributaries:
  - Fine sediment (high)
  - Channel stability and floodplain alterations (moderate)
  - Streamflow (unknown)
  - Water quality (high)
  - Competition- redd superimposition (negligible to moderate)
  - Predation (low)
  - Research and monitoring (low)

Limiting Factors Hypotheses

- Hypothesized limiting factors affecting sockeye salmon fry emergence and dispersal in tributaries:
  - Predation (moderate)
  - Streamflow (low)
  - Water quality (low)

Limiting Factors Hypotheses

- Hypothesized limiting factors affecting sockeye salmon freshwater rearing in Lake Ozette:
  - Predation (high)
  - Fisheries impacts (negligible)
  - Disease (unknown)
  - Food availability/competition (negligible)

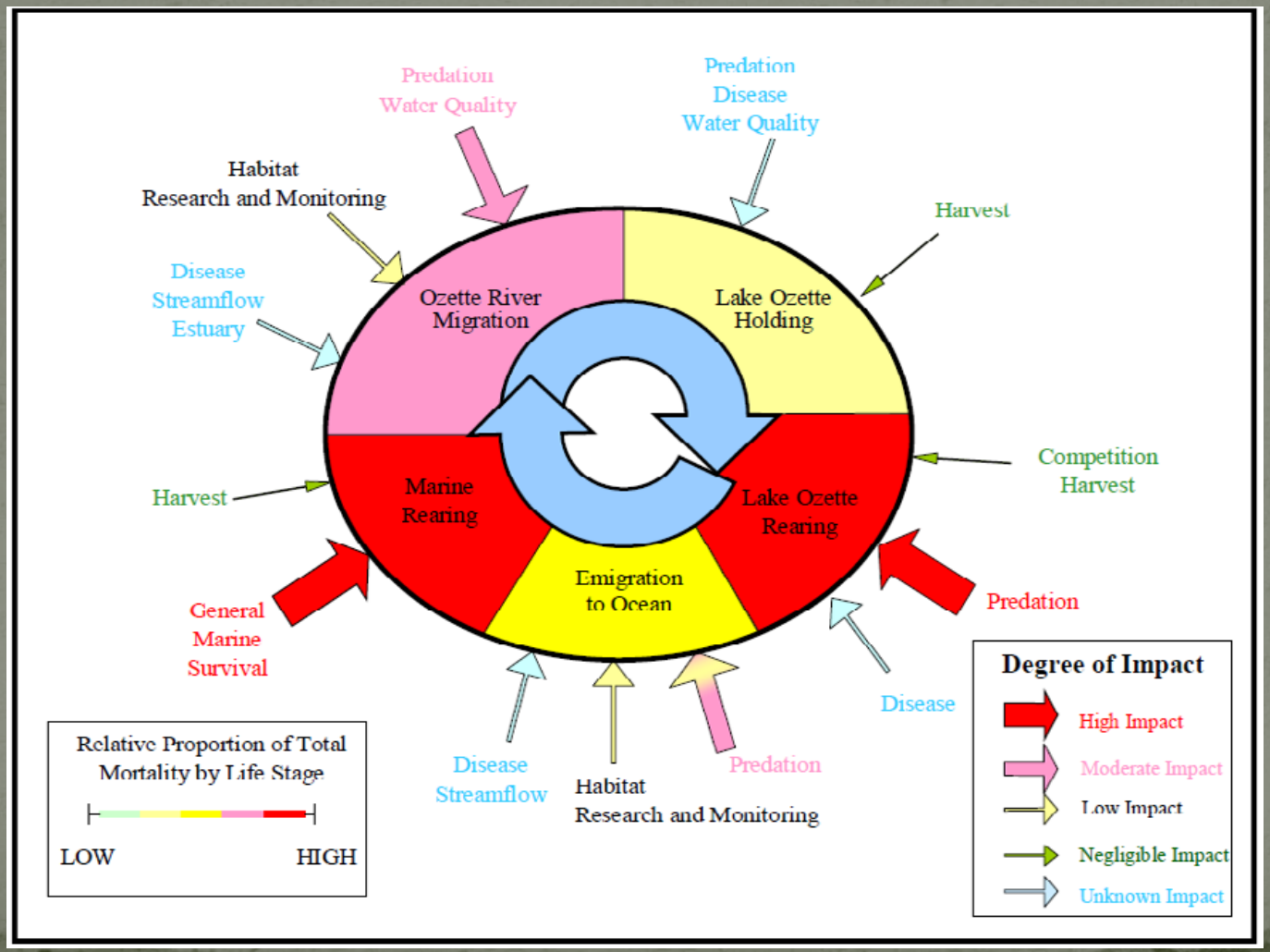
Limiting Factors Hypotheses

- Hypothesized limiting factors affecting sockeye salmon freshwater rearing in Lake Ozette:
  - Predation (moderate)
  - Ozette River habitat conditions (low)
  - Water quality (low)
  - Streamflow (unknown)
  - Tidal prism and physical estuarine habitat conditions (unknown)
  - Fisheries impacts (none)
  - Disease (unknown)
  - Research and monitoring (low)

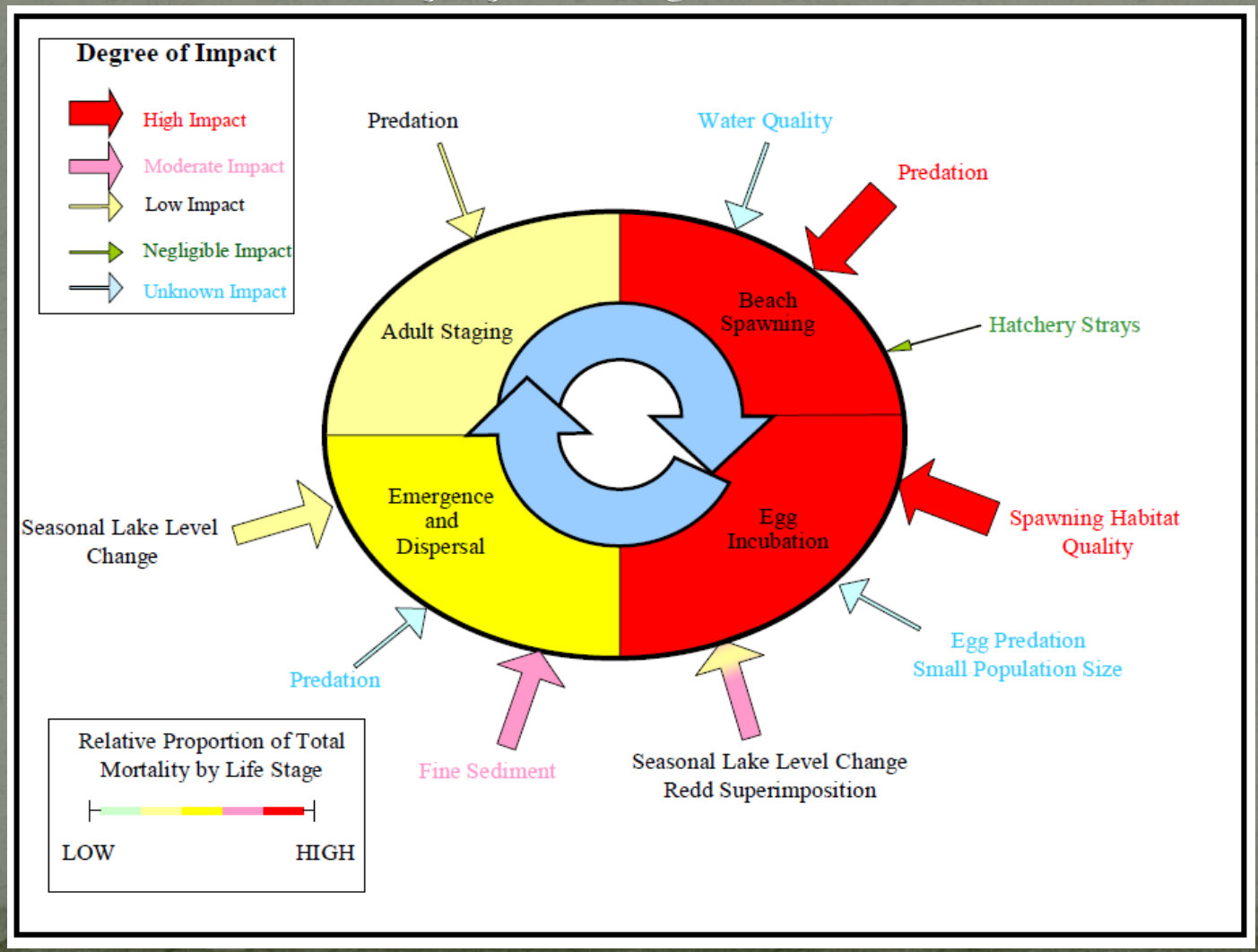
Limiting Factors Hypotheses

- Hypothesized limiting factors affecting sockeye salmon marine ocean phase:
  - Fisheries impacts (none/negligible)
  - General marine survival (high)

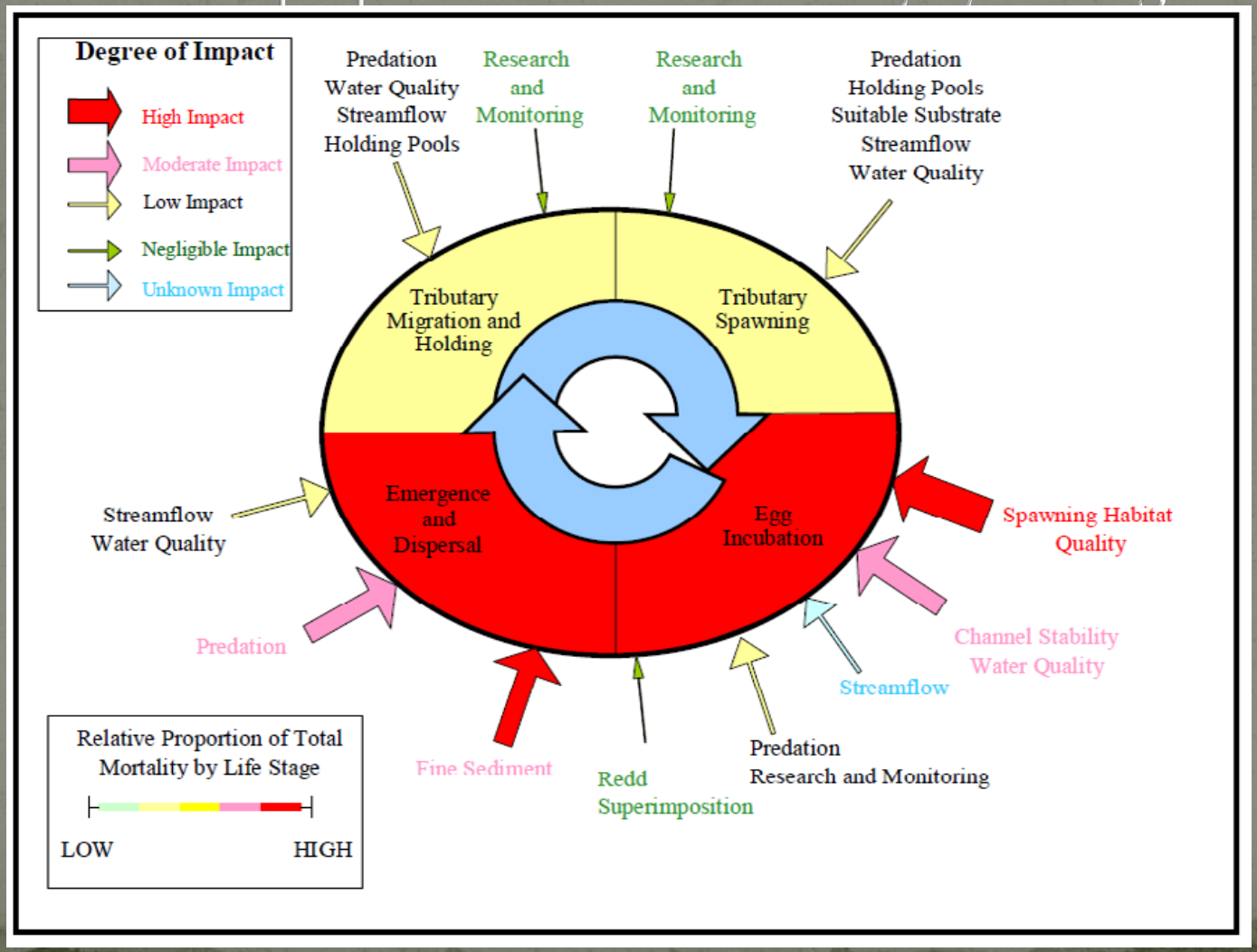
Conceptualization of hypothesized limiting factors affecting all Lake Ozette sockeye population segments. Arrows depict the degree of impact for each limiting factor and colored polygons depict the relative proportion of total mortality by life stage.



Conceptualization of hypothesized limiting factors affecting beach spawning Lake Ozette sockeye subpopulations. Arrows depict the degree of impact for each limiting factor and colored polygons depict the relative proportion of total mortality by life stage.



Conceptualization of hypothesized limiting factors affecting tributary spawning sockeye subpopulation segments. Arrows depict the degree of impact for each limiting factor and colored polygons depict the relative proportion of total mortality by life stage.



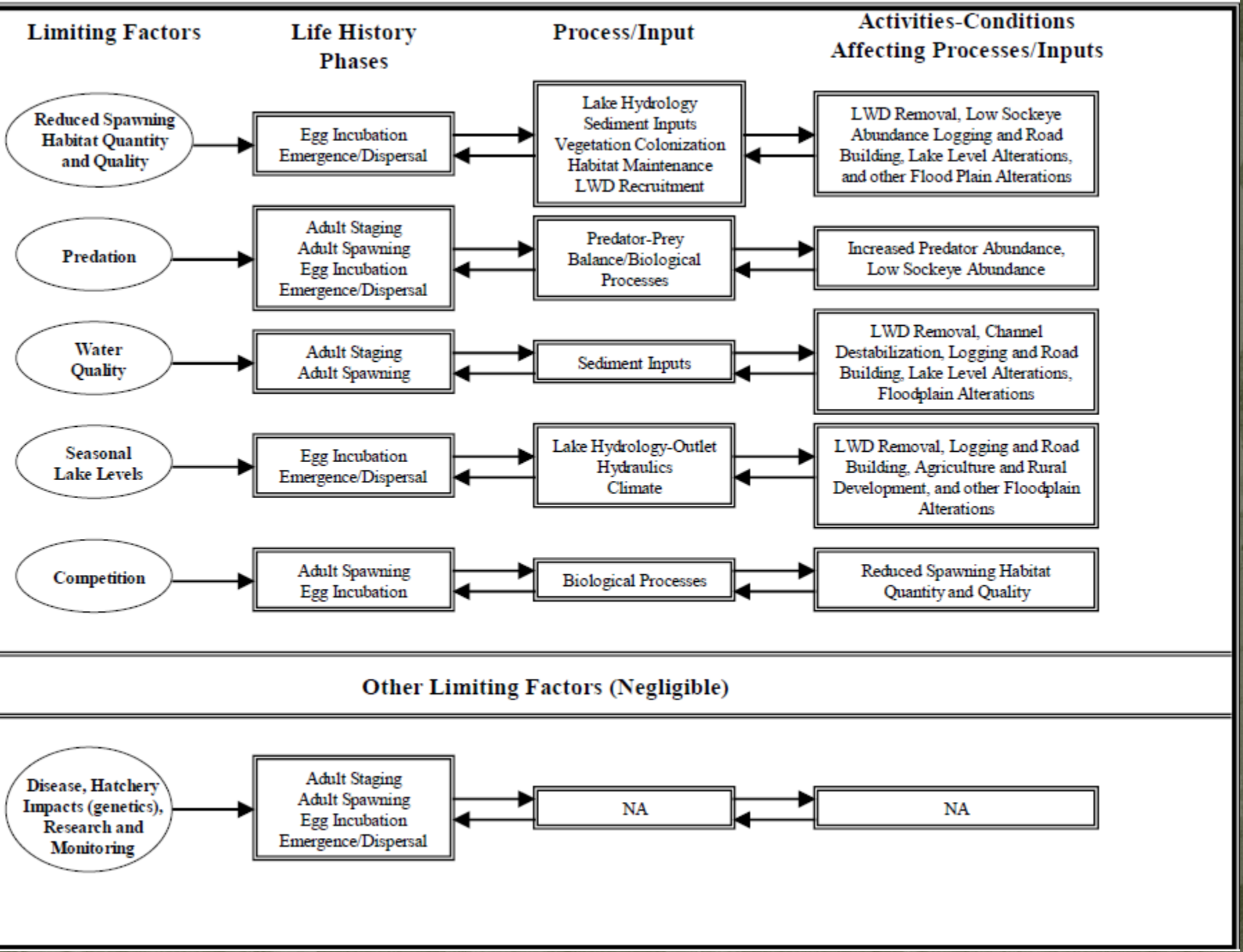
Lake Ozette Sockeye Salmon: recovery planning

Lake Ozette Sockeye Salmon Recovery Planning

- The 53 primary (+sub-hypotheses) hypotheses from the limiting factors analysis were simplified into much broader limiting factors hypotheses and classified as: Key, Contributing, or Not Likely Limiting:
  - **Key** limiting factors are those with the greatest impact on the population's ability to reach the status desired for it.
  - Contributing limiting factors influence survival and/or directly result in the mortality of sockeye salmon (but to a lesser degree than Key LFs).
  - Factors not likely limiting.

- Four Key Limiting Factors Identified:

Limiting Factor Hypothesis # Used in Plan	Limiting Factor Hypothesis # in LFA	Limiting Factor Hypothesis Category	Population Segment(s) Affected	Limiting Factor	NARRATIVE
Hypothesis 1 (Predation)	1, 7, 41, 45	Key	ALL	Predation	Changes in relative predator-prey abundances in the Ozette River and Lake Ozette have increased the proportion of juvenile and adult sockeye consumed by predators and resulted in decreased freshwater survival, as well as an overall decrease in the number of sockeye returning to spawn.
Hyporthsis 6 (Beach Spawning Habitat)	13, 17	Key	Beach Spawners	Beach Spawning Habitat	Reduced quality and quantity of beach spawning habitat in Lake Ozette has decreased egg to emergence survival, resulting in reduced fry production from the beach spawning aggregations.
Hypothesis 7 (Predation)	11, 18	Key	Beach Spawners	Predation	Changes in relative predator-prey abundances on Ozette spawning beaches have increased the proportion of adult sockeye, eggs, and newly emerged fry consumed by predators, resulting in decreased freshwater survival.
Hypothesis 11 (Tributary Spawning Habitat)	26, 31	Key	Tributary Spawners	Tributary Spawning Habitat	Channel simplification and increased sediment production and delivery to streams have decreased the quantity of suitable spawning habitat (i.e., gravel) available to tributary spawning sockeye. Increased levels of fine sediment (<0.85mm) in spawning gravels reduces intra-gravel flow and oxygenation of redds, resulting in decreased egg-to-fry survival.


Limiting Factors
Life History Phases
Process/Input
Activities-Conditions Affecting Processes/Inputs
Reduced Spawning Habitat Quantity and Quality
Egg Incubation
Emergence/Dispersal
Lake Hydrology
Sediment Inputs
Vegetation Colonization
Habitat Maintenance
LWD Recruitment
LWD Removal, Low Sockeye Abundance Logging and Road Building, Lake Level Alterations, and other Flood Plain Alterations
Predation
Adult Staging
Adult Spawning
Egg Incubation
Emergence/Dispersal
Predator-Prey Balance/Biological Processes
Increased Predator Abundance, Low Sockeye Abundance
Water Quality
Adult Staging
Adult Spawning
Sediment Inputs
LWD Removal, Channel Destabilization, Logging and Road Building, Lake Level Alterations, Floodplain Alterations
Seasonal Lake Levels
Egg Incubation
Emergence/Dispersal
Lake Hydrology-Outlet Hydraulics
Climate
LWD Removal, Logging and Road Building, Agriculture and Rural Development, and other Floodplain Alterations
Competition
Adult Spawning
Egg Incubation
Biological Processes
Reduced Spawning Habitat Quantity and Quality
Other Limiting Factors (Negligible)
Disease, Hatchery Impacts (genetics), Research and Monitoring
Adult Staging
Adult Spawning
Egg Incubation
Emergence/Dispersal
NA
NA

Lake Ozette Sockeye Salmon Recovery Framework

- Strategies are based upon protection, restoration, and/or rehabilitation of critical processes, inputs, and habitat conditions associated with limiting factors affecting LOS.
- Recovery strategies are based upon hierarchical recovery flow charts that integrate geography, life history, and sockeye salmon spawning aggregations…all recovery strategies and actions fall within our sockeye recovery pyramid.
- Recovery strategies across the watershed can be categorized by importance based upon subbasin, spatial extent, spawning distribution goals, inter-species competition and hybridization concerns….

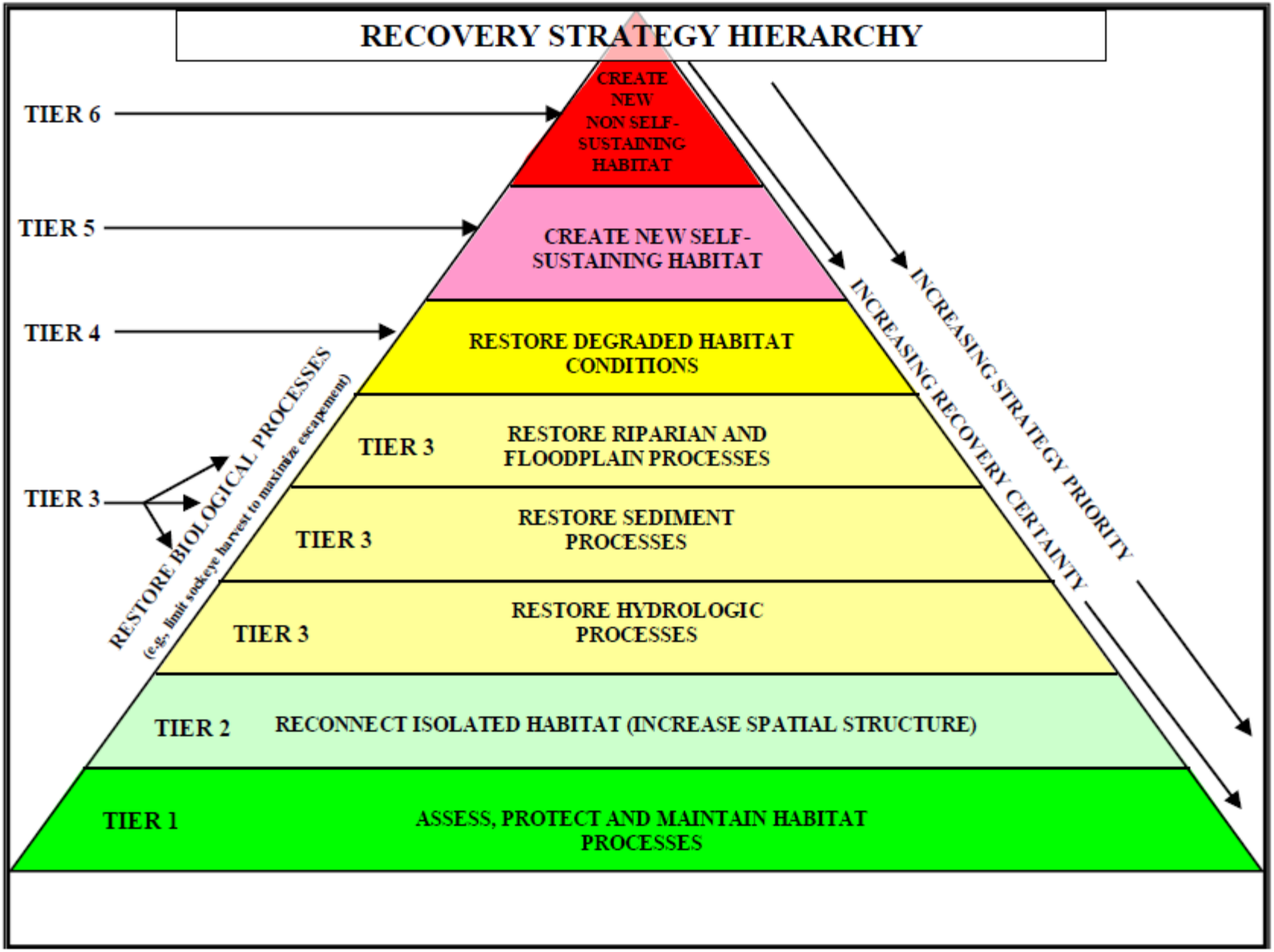
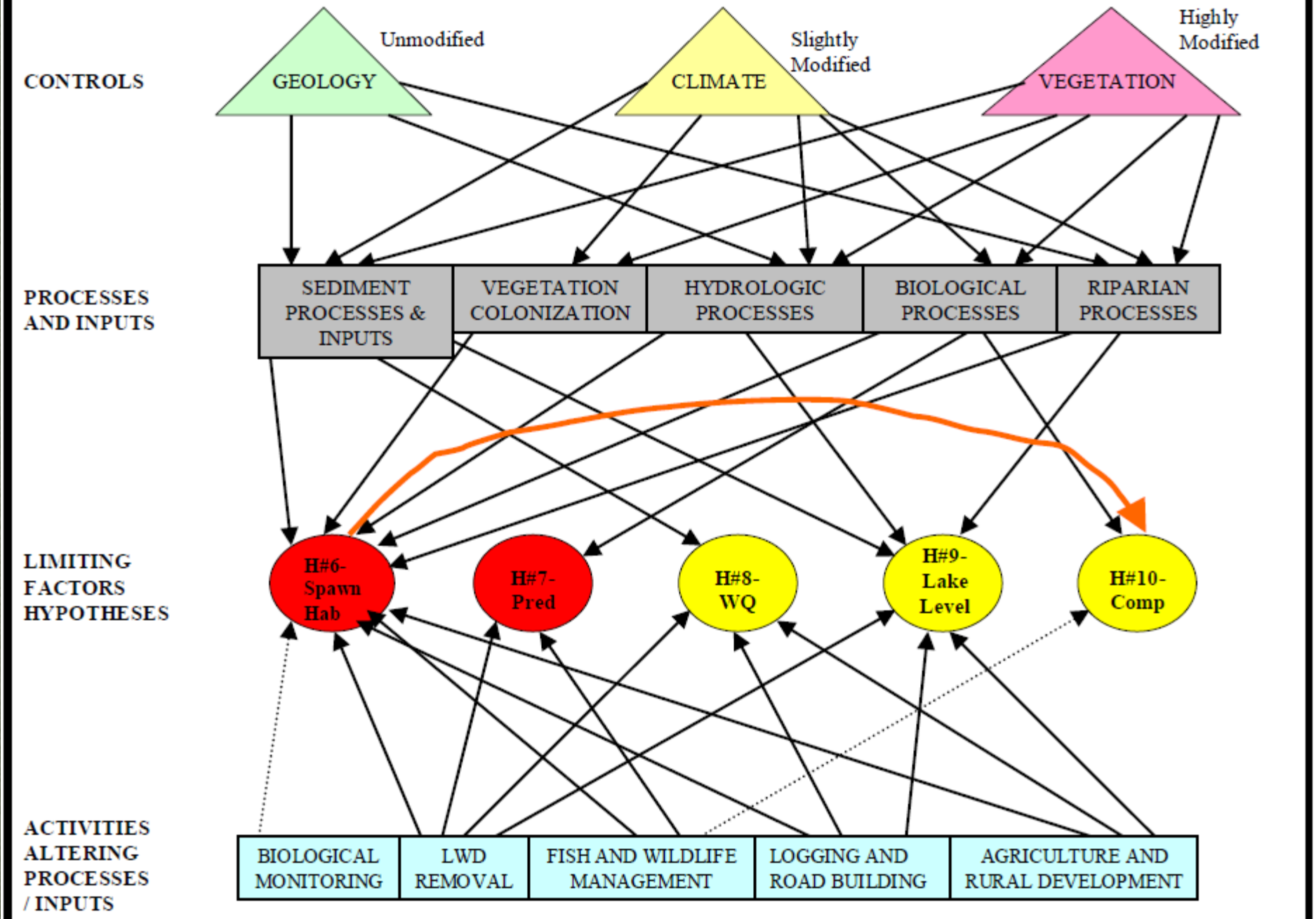
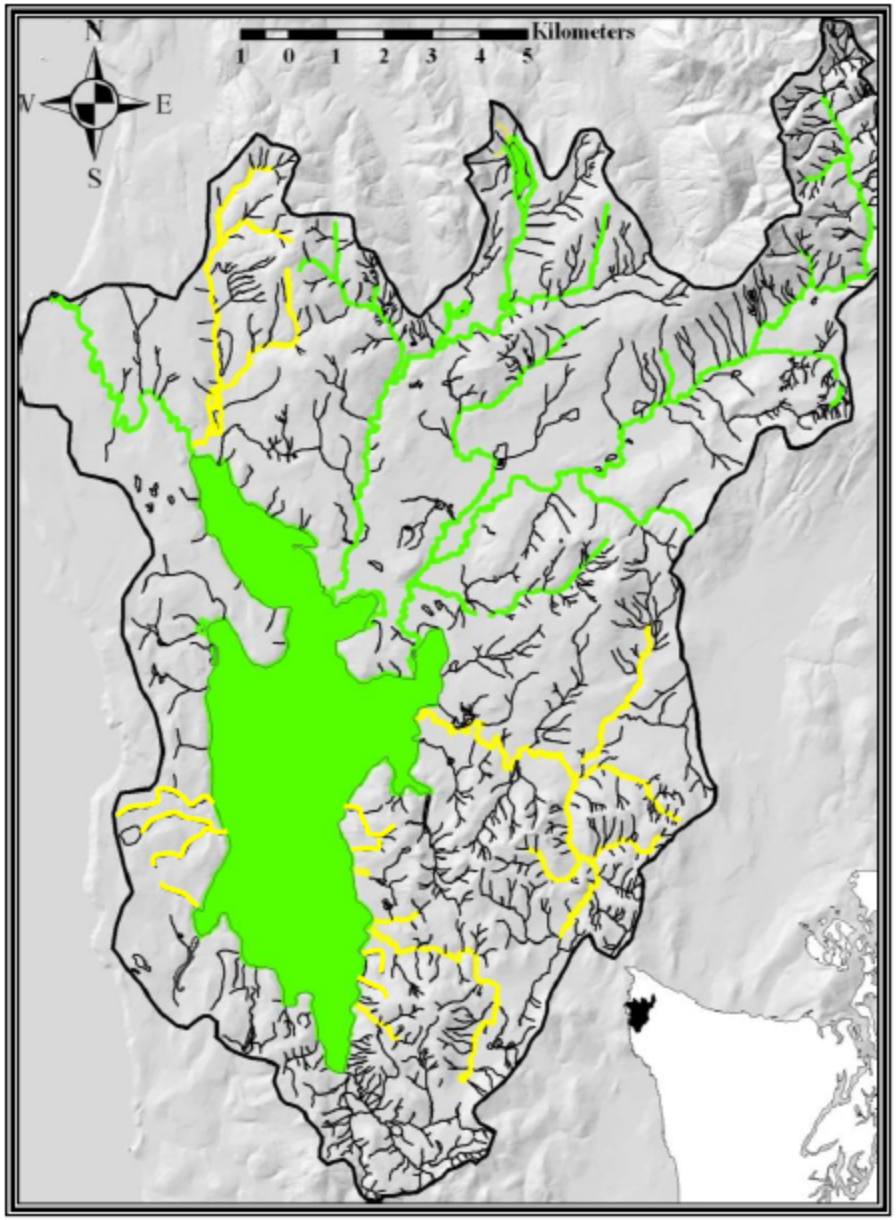


Figure 6.4. Ozette sockeye-specific recovery strategy and action hierarchy.

LIMITING FACTORS AFFECTING BEACH SPAWNERS





SUB-BASIN PRIORITIZATION

PRIORITY I
- Lake Ozette
- Ozette River
- Umbrella Creek
- Big River

PRIORITY II
- Coal Creek
- Crooked Creek
- Siwash Creek
- Elk Creek
- 20.0073 and 20.0078
- Unnamed West- and East-side Tributaries

PRIORITY III
- Palmquist Creek
- Quinn Creek
- South Creek
- Allen Slough
- 20.0079
- All other Unnamed Tributaries

Figure 6.6. Lake Ozette subbasin prioritization. Green lines depict priority I subbasins, yellow lines depict priority II subbasins, and black lines entering Lake Ozette and the Ozette river depict priority III subbasins.

Beach Spawners-

Summary of biologic process condition, linkage to limiting factors hypotheses, and activities affecting biological processes.

Process/input condition status:	Impaired
Primary limiting factor hypothesis associated with process/input:	Hypothesis 7 (Pred)
Geographic location of limiting factor:	Lake Ozette
Life history stages affected:	Egg incubation and emergence and dispersal; adult staging and spawning
Degree of impact of primary limiting factor hypothesis:	High Key limiting factor
Secondary limiting factors hypotheses associated with process/input:	Hypotheses 6 (BSH) and 10 (Comp)
Activities and/or conditions affecting predation:	Past LWD removal, current habitat conditions at spawning beaches, biological monitoring, fish and wildlife management

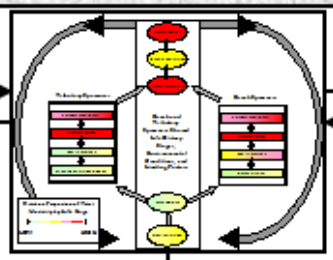
Recovery goal: Restore and protect biological processes so that freshwater predation, habitat maintenance, and competition are no longer limiting Lake Ozette sockeye viability.

Recovery strategy 22: Implement strategies and actions to increase egg-to-fry survival of beach and tributary spawners so that the habitat can produce abundant sockeye salmon, reducing the overall percent impact of predation on the population.
Recovery strategy hierarchy: Tier 3-4.
Priority subbasin rating: Priority I.

Recovery strategy 23: Increase the spatial distribution of Lake Ozette beach spawning sockeye.
Recovery strategy hierarchy: Tier 2.
Priority subbasin rating: Priority I.

Recovery strategy 24: Restore natural predator-prey balance by reducing pre-spawn predation mortalities.
Recovery strategy hierarchy: Tier 3.
Priority subbasin rating: Priority I.

LAKE OZETTE SOCKEYE RECOVERY STRATEGY



RECOVERY MODEL I (ALL POPULATION SEGMENTS)	RECOVERY MODEL II (BEACH SPAWNERS)	RECOVERY MODEL III (BIG RIVER SPAWNERS)	RECOVERY MODEL IV (UMBRELLA CREEK SPAWNERS)
SYNTHESIS •Watershed Controls •Processes •Hypotheses •Activities (Threats)	**SYNTHESIS** •Watershed Controls •Processes •Hypotheses •Activities (Threats)	**SYNTHESIS** •Watershed Controls •Processes •Hypotheses •Activities (Threats)	**SYNTHESIS** •Watershed Controls •Processes •Hypotheses •Activities (Threats)
Hierarchal Recovery Strategy 1) Assess & Protect Processes 2) Reconnect Habitats 3) Restore Processes 4) Enhance Habitat 5) Create New Self-Sustaining Habitats 6) Create New Non Self-Sustaining Habitats	**Hierarchal Recovery Strategy** 1) Assess & Protect Processes 2) Reconnect Habitats 3) Restore Processes 4) Enhance Habitat 5) Create New Self-Sustaining Habitats 6) Create New Non Self-Sustaining Habitats	**Hierarchal Recovery Strategy** 1) Assess & Protect Processes 2) Reconnect Habitats 3) Restore Processes 4) Enhance Habitat 5) Create New Self-Sustaining Habitats 6) Create New Non Self-Sustaining Habitats	**Hierarchal Recovery Strategy** 1) Assess & Protect Processes 2) Reconnect Habitats 3) Restore Processes 4) Enhance Habitat 5) Create New Self-Sustaining Habitats 6) Create New Non Self-Sustaining Habitats
ACTION PLAN	**ACTION PLAN**	**ACTION PLAN**	**ACTION PLAN**

Challenges?

Questions?