Fish Committee Meeting
Willapa Bay Policy C-3622

June 10, 2022

Kenneth Warheit
Marlene Wagner
Fish Program

Washington Department of FISH and WILDLIFE

Meeting Outline

1. Fall Chinook natural spawning escapement goal and spawner – recruit analysis
2. Comparative analysis of alternatives
3. Policy language questions
4. Next steps

The Anatomy of a Spawner-Recruit Curve

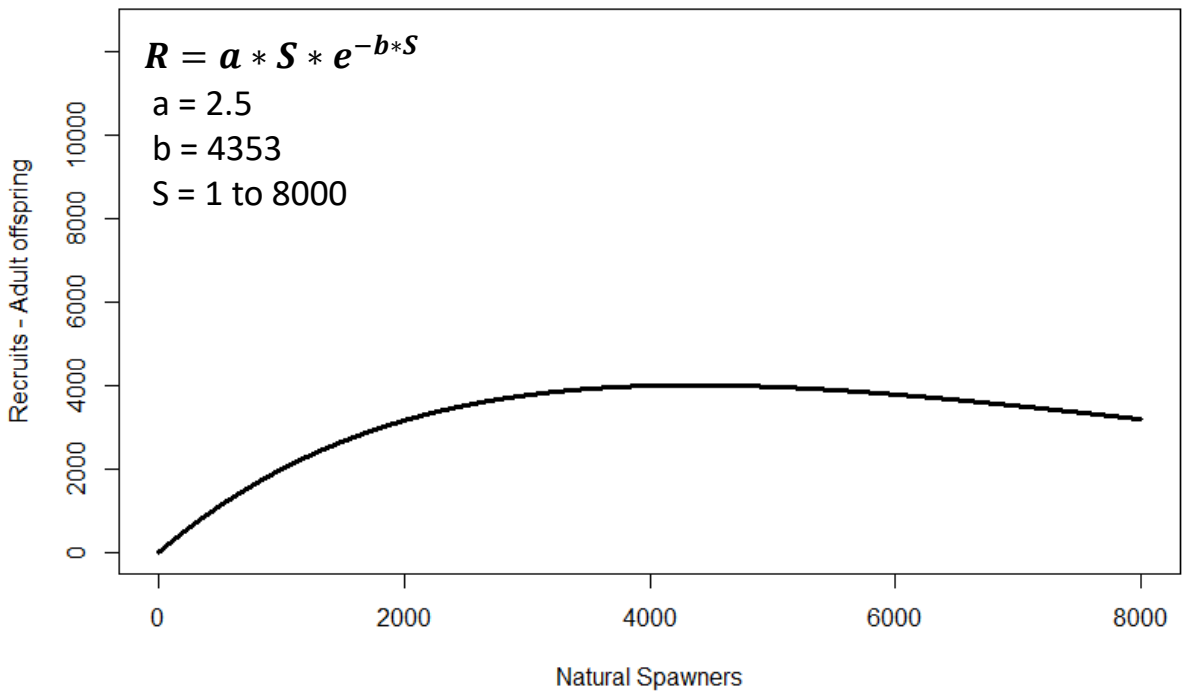
Ricker Curve: $R = a * S * e^{-b*S}$

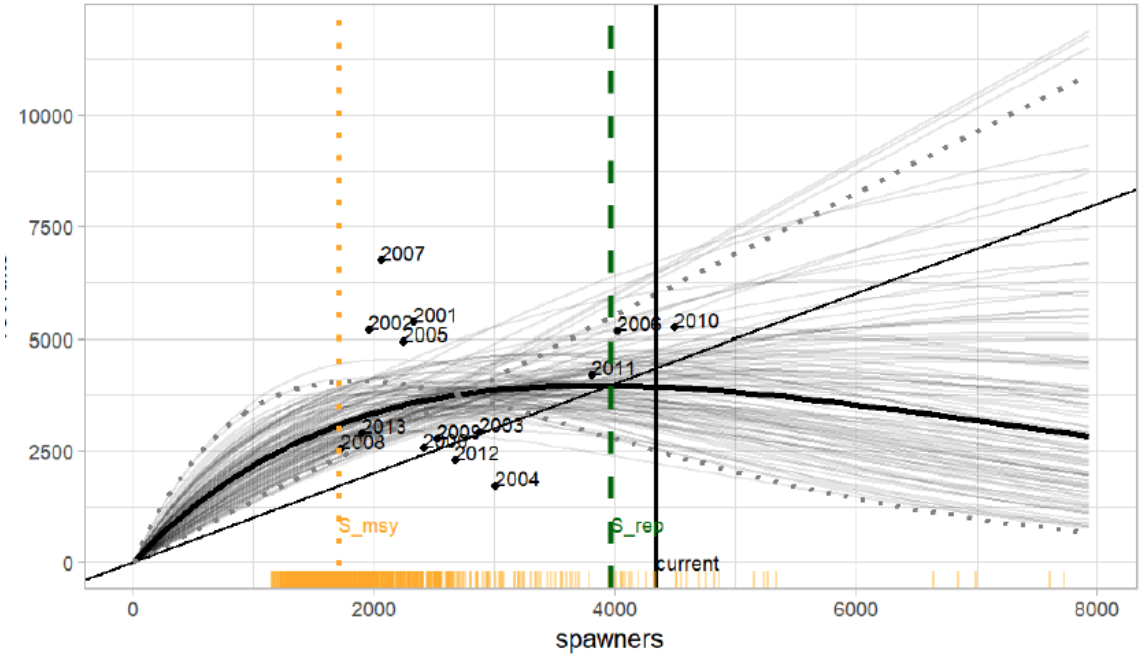
- R = Recruits
- S = Spawners
- b = carrying capacity
- a = recruits per spawner at low spawner density

We do not know empirically either a or b.

We've estimated b imperfectly using a survey of habitat several decades ago

The Anatomy of a Spawner-Recruit Curve

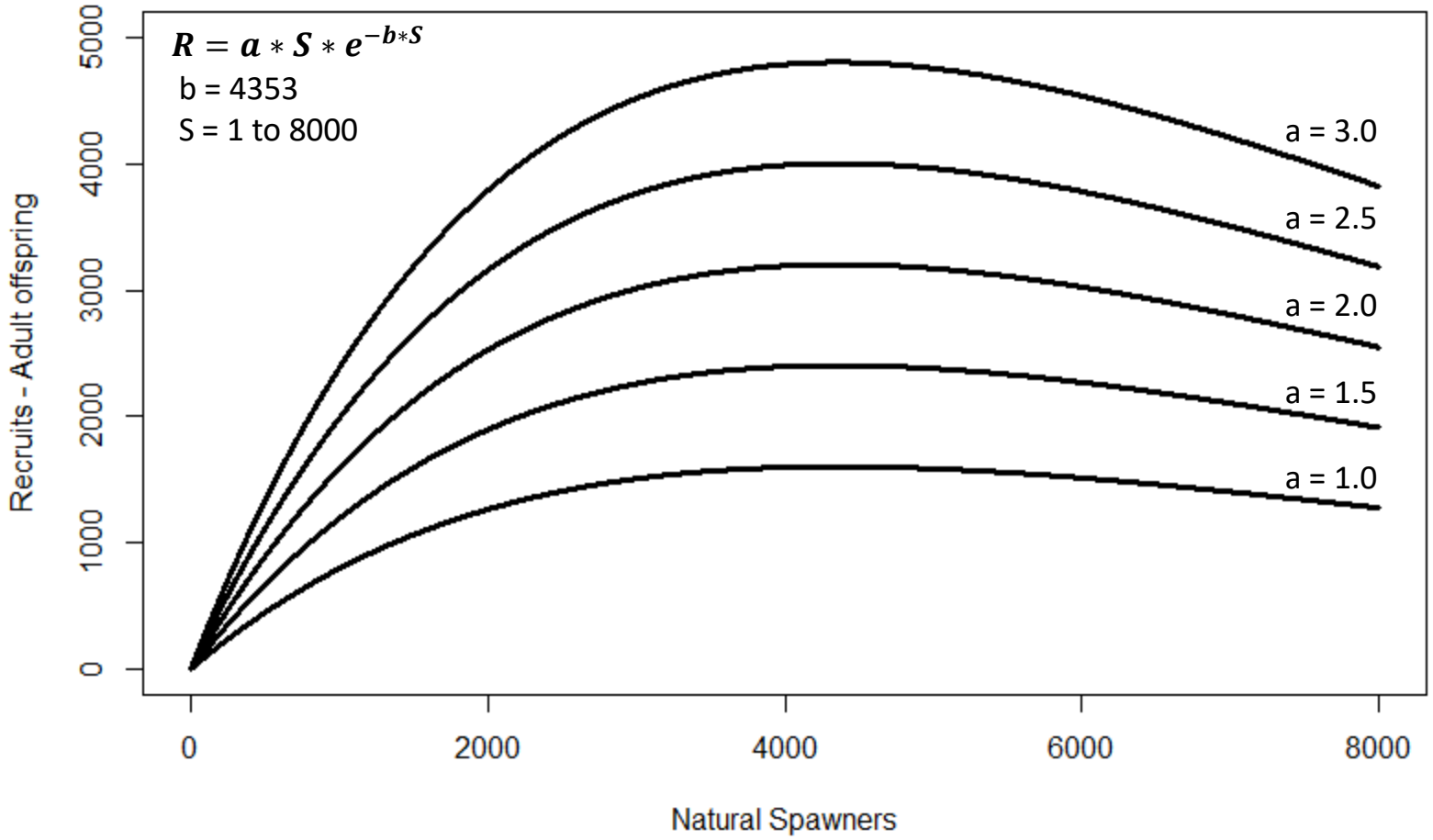




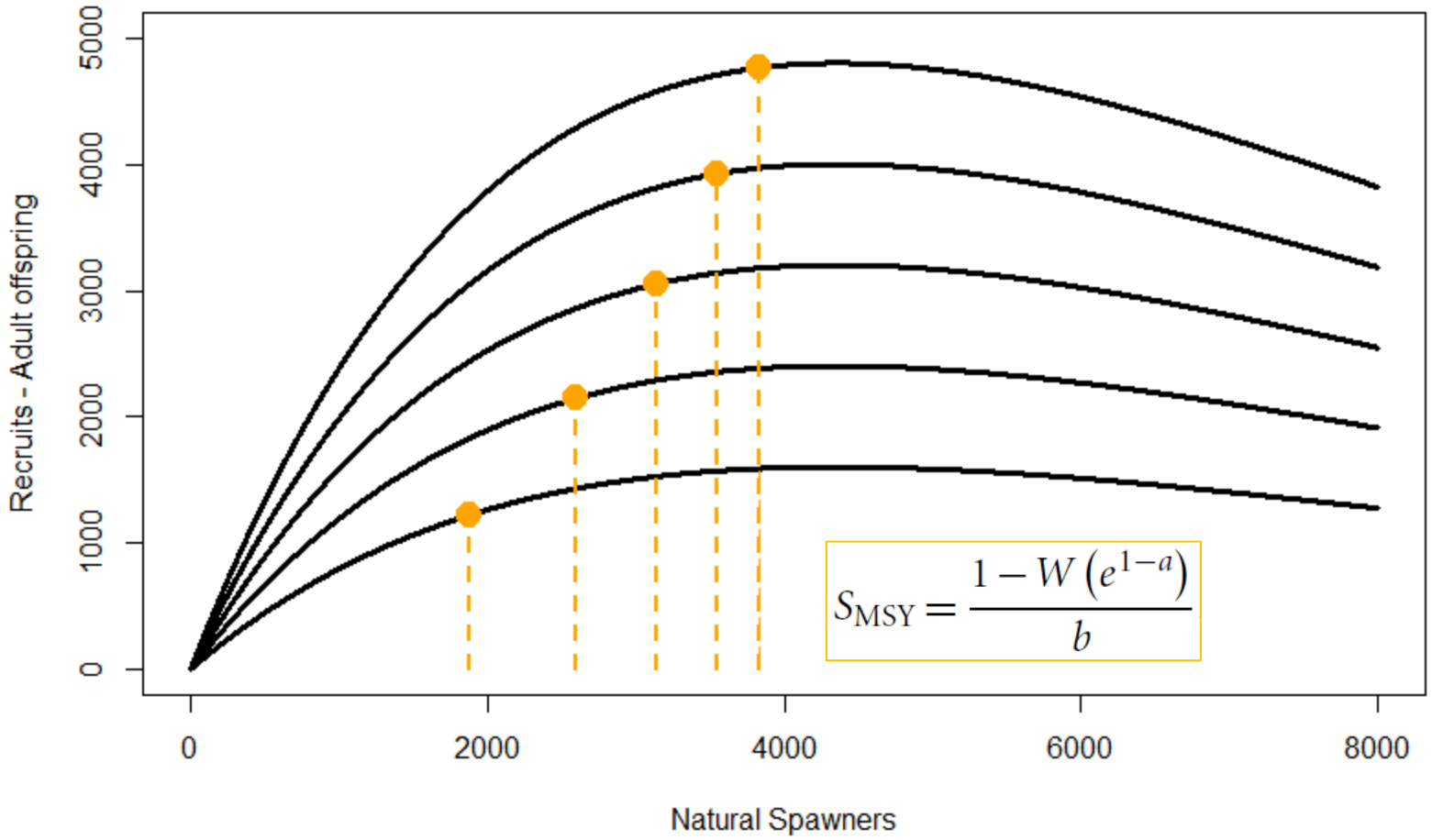
$$S_{MSY} = \frac{1 - W\left(e^{1-a}\right)}{b}$$

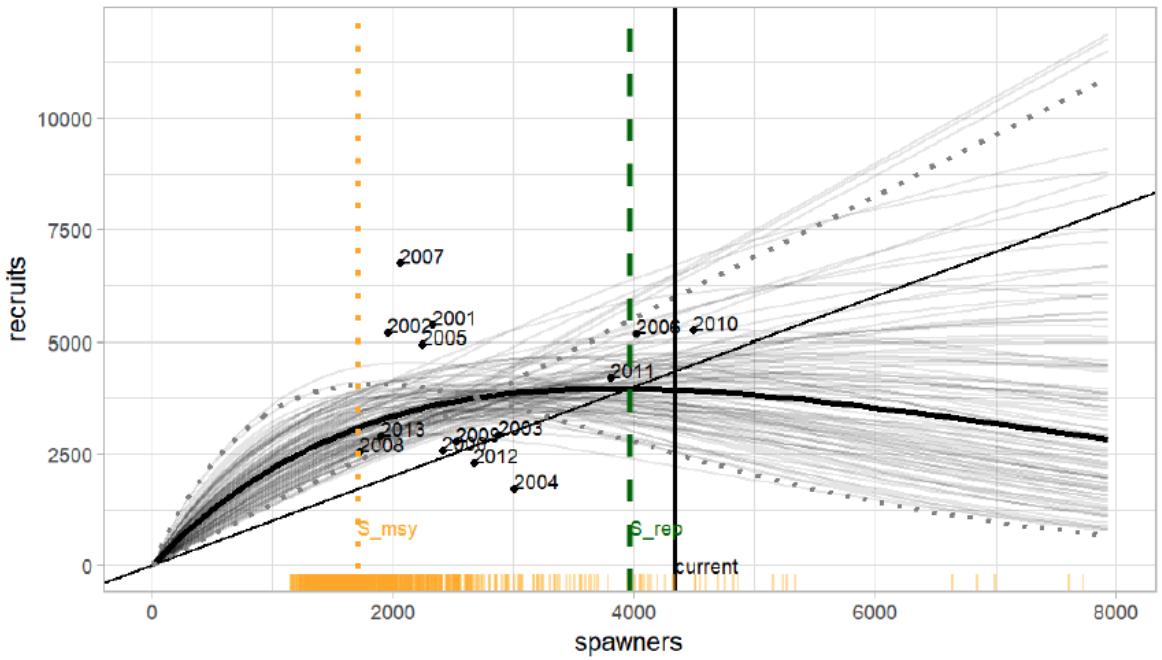
(from Scheuerell et al. 2016)

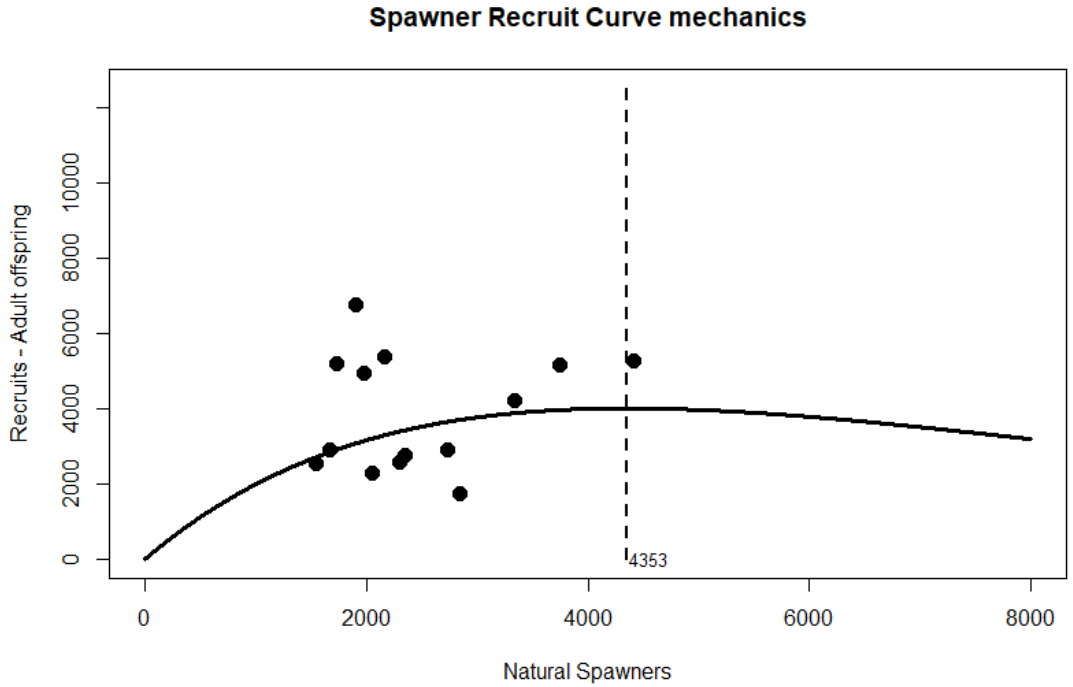
Spawner Recruit Curve mechanics



Spawner Recruit Curve mechanics

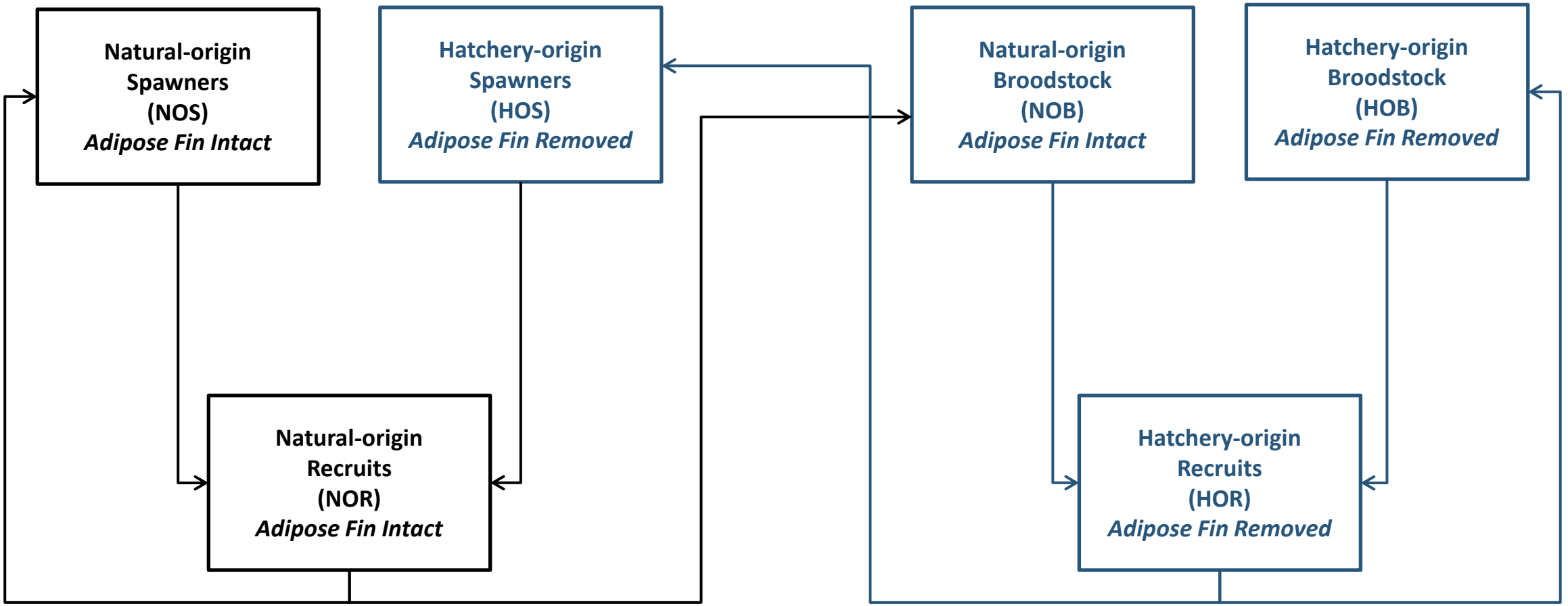


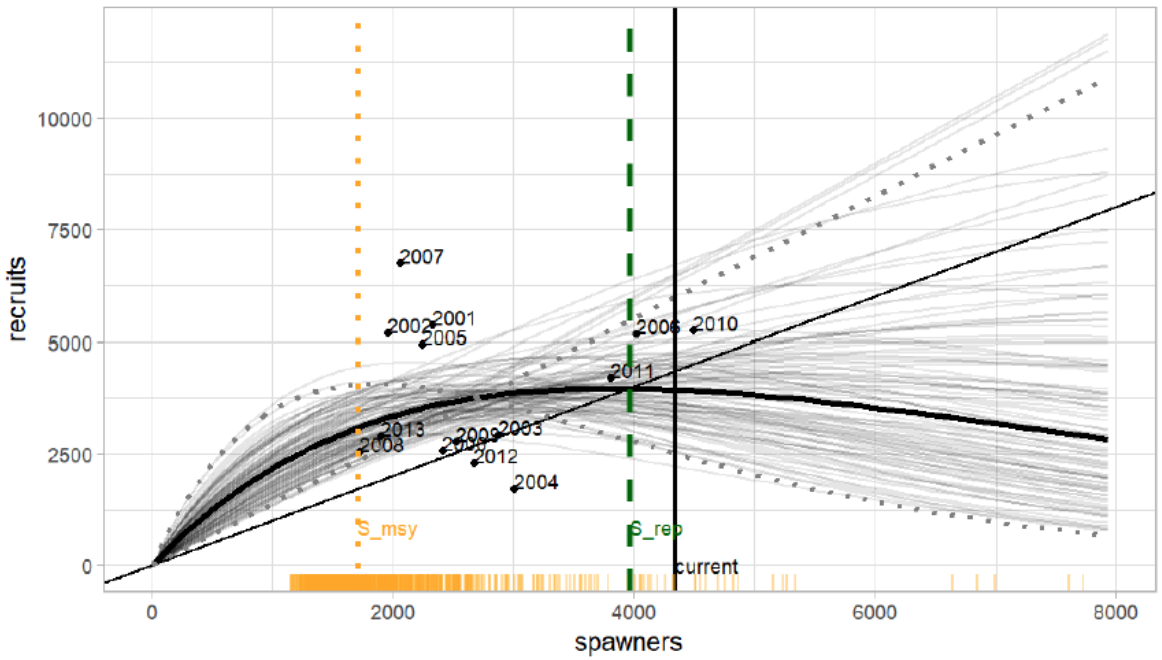

recruits
spawners
10000
7500
5000
2500
0
0
2000
4000
6000
8000
2007
2002
2001
2005
2006
2010
2011
2013
2008
2009
2003
2012
2004
S_msy
S_rep
current

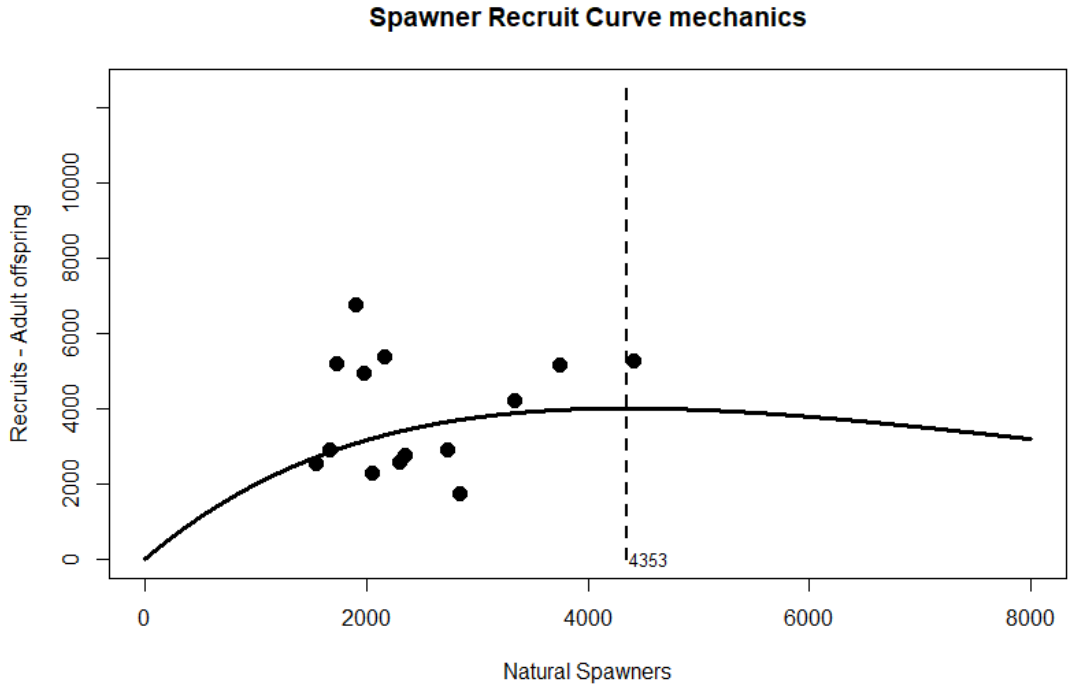

Spawner Recruit Curve mechanics
Recruits - Adult offspring
Natural Spawners
0
2000
4000
6000
8000
10000
4353

NATURAL ENVIRONMENT

HATCHERY ENVIRONMENT

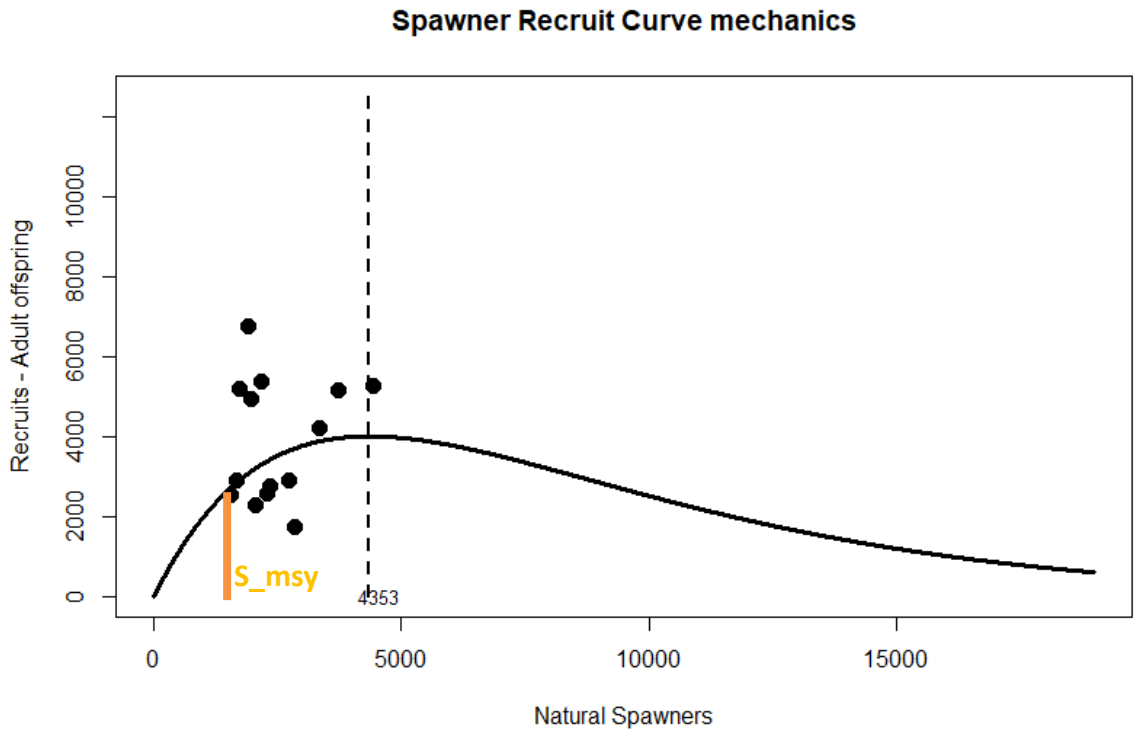


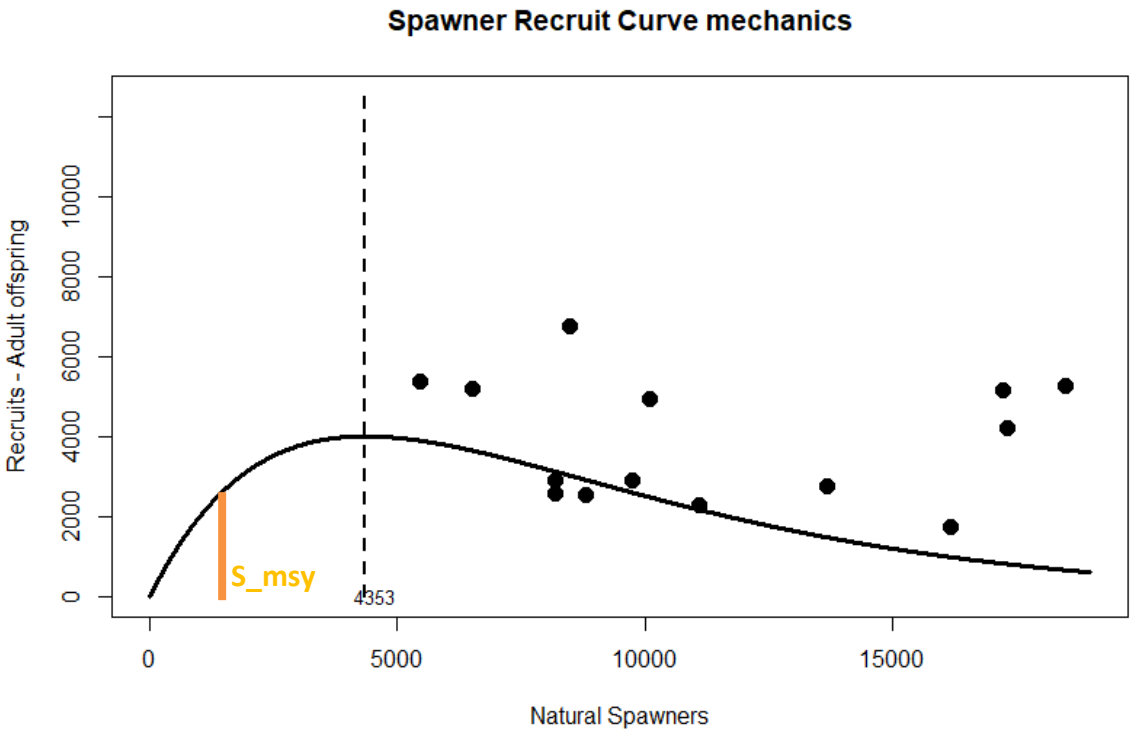


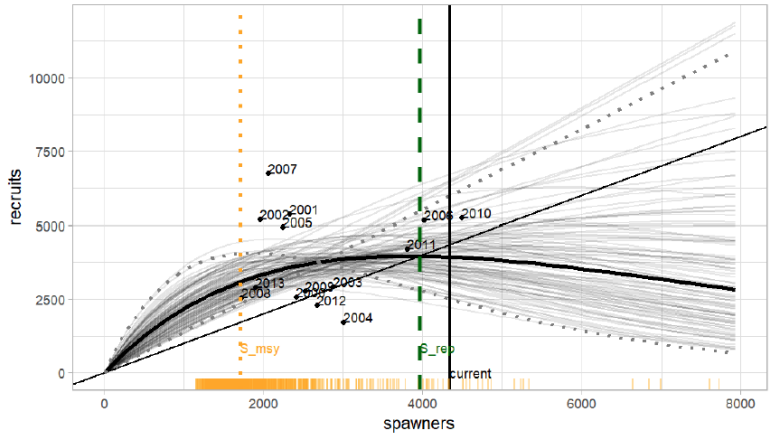


PROBLEM:

- Spawner – recruit data are <u>incorrect</u>
- Spawners should be the population from which recruits were derived
- But, here:
  - Spawners = natural-origin natural-spawners (NOS)
  - Recruits are derived from NOS + HOS (Total Spawners)


Spawner Recruit Curve mechanics
Recruits - Adult offspring
0
2000
4000
6000
8000
10000
S_msy
4353
0
5000
10000
15000
Natural Spawners


Spawner Recruit Curve mechanics
Recruits - Adult offspring
0
2000
4000
6000
8000
10000
S_msy
4353
0
5000
10000
15000
Natural Spawners


recruits
0
2500
5000
7500
10000
2007
2002
2001
2005
2006
2010
2011
2013
2008
2009
2003
2012
2004
S_msy
S_rep
current
0
2000
4000
6000
8000
spawners

Spawner-recruit Curves and Spawner-Escapement Goals

- Two parameters (a & b) are unknown and need to be estimated.
- The purpose of the SRC in the Comprehensive Evaluation document was to explore the effects of different parameters and not to derive meaningful S_msy or spawner-escapement goals.
- The SRC used incorrect data to determine the most-likely a & b parameters, and therefore,
- S_msy derived from the analysis is also incorrect.
- Interpretation of a SRC can be difficult when most of the recruits are immigrants from another population (e.g., a hatchery).

Model to compare the three alternatives

Willapa Bay Policy Objectives

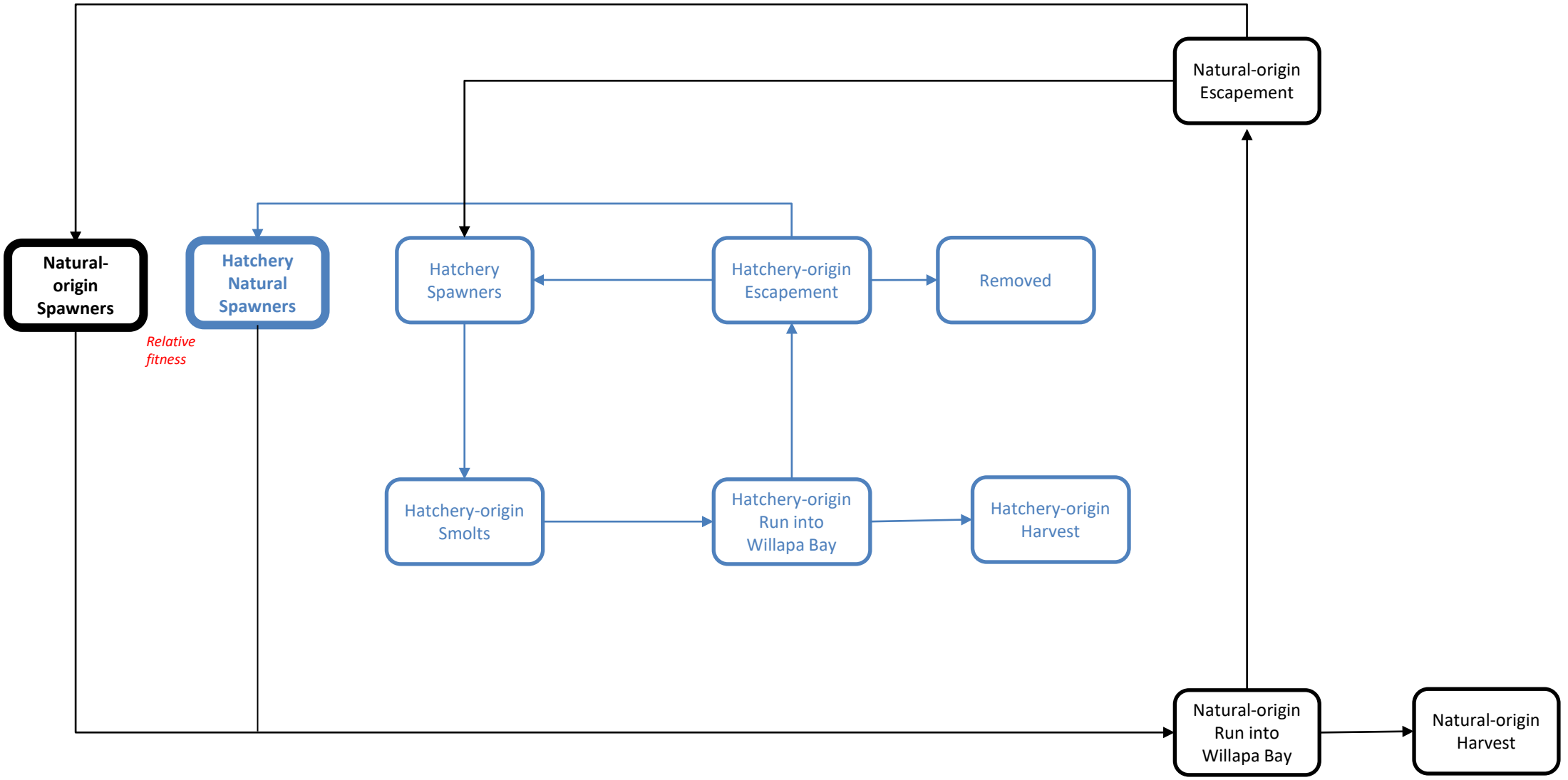
(concise statements of desired future states)

- Increased both commercial and recreational fishing opportunities in Willapa Bay and tributaries
  - compared with current (2015) policy (Alternative 1)
- Wild populations are restored and conserved, and are adapted to the basin tributaries

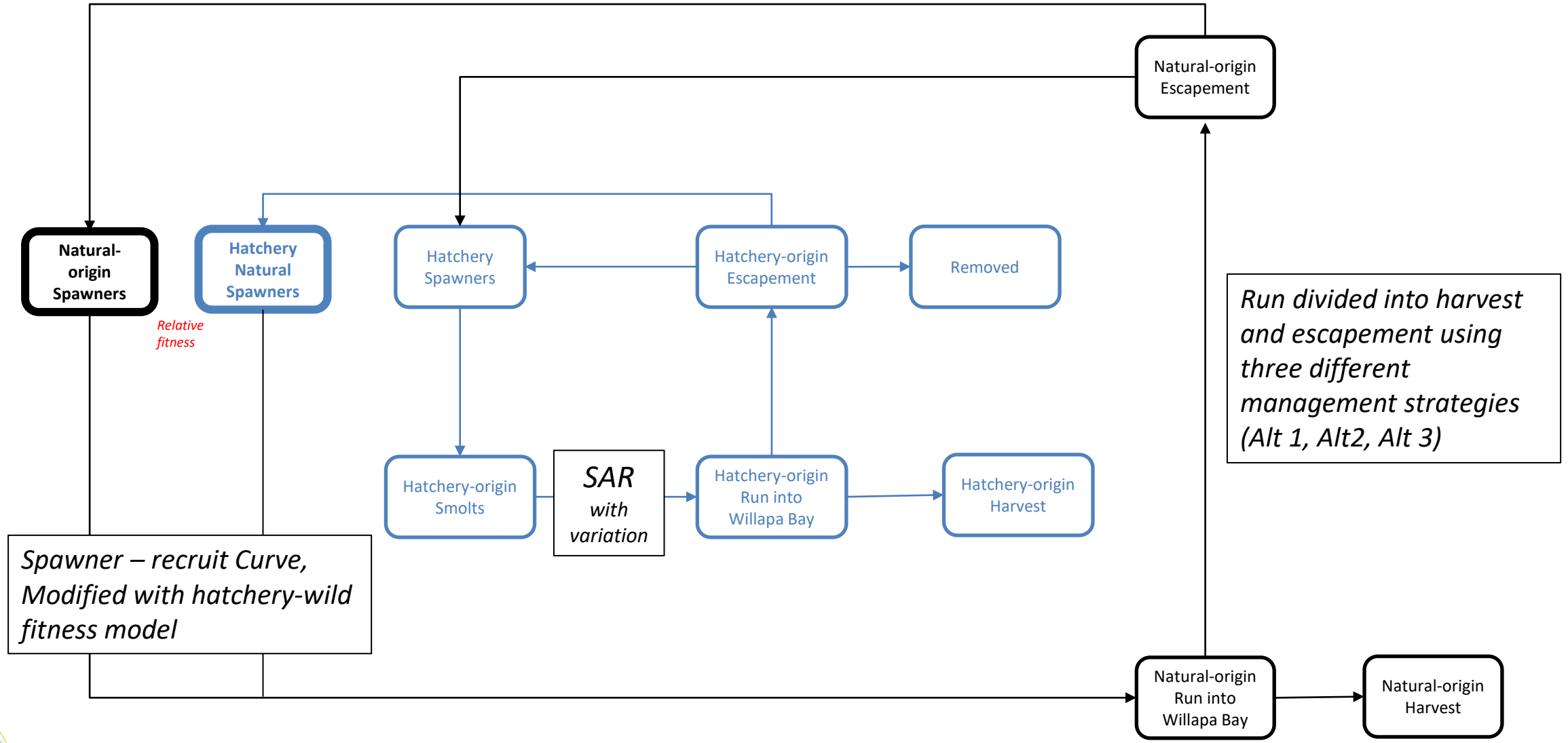
Activities designed to achieve the objectives

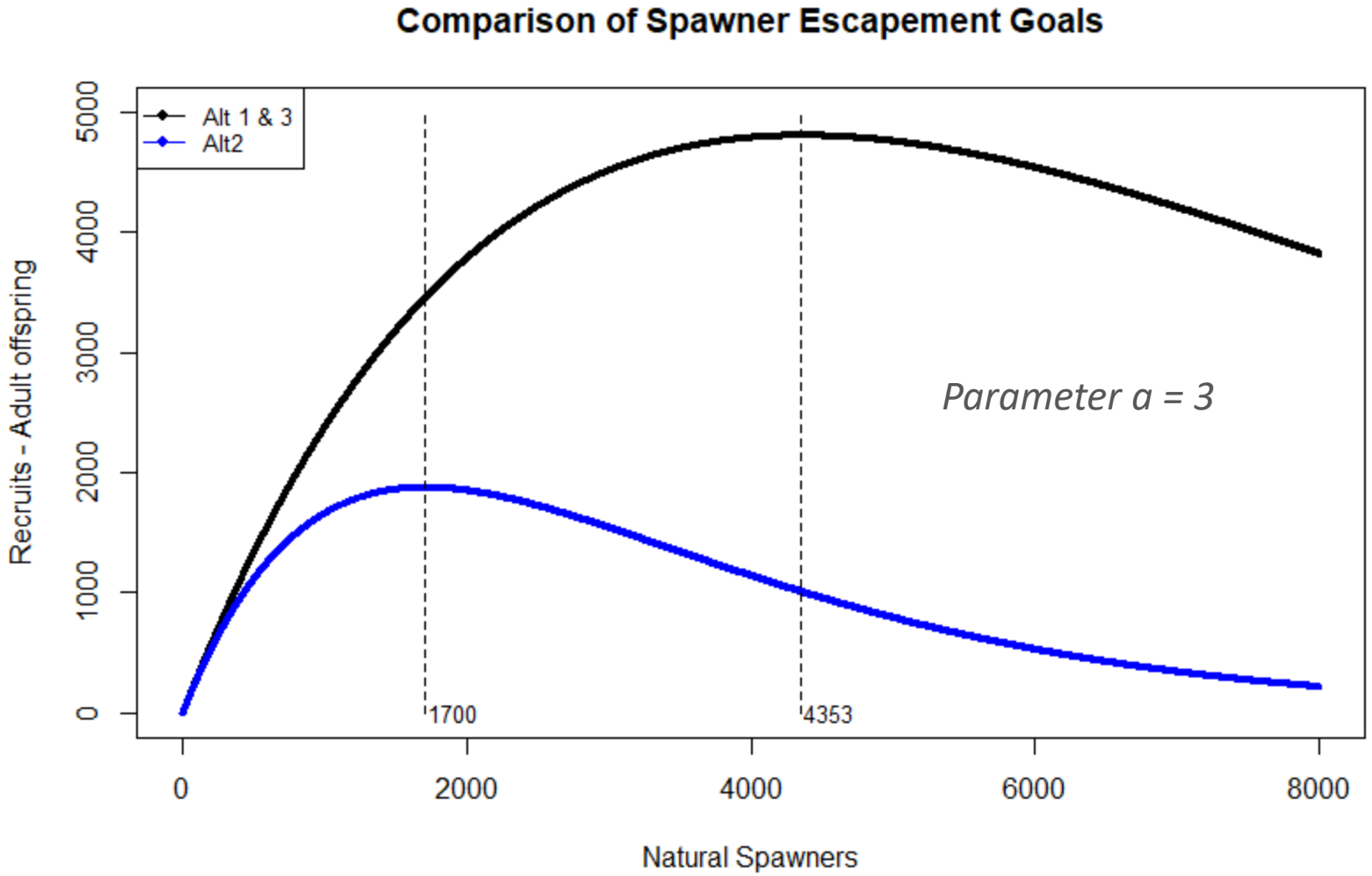
- Increase hatchery production
- Establishing specific spawner escapement goals
- Using specific methods to determine appropriate spawner escapement goals (e.g., spawner-recruit curves) and size of hatchery programs (e.g., Hatchery Management Plans, HMPs, and Commission Policy C-3624)

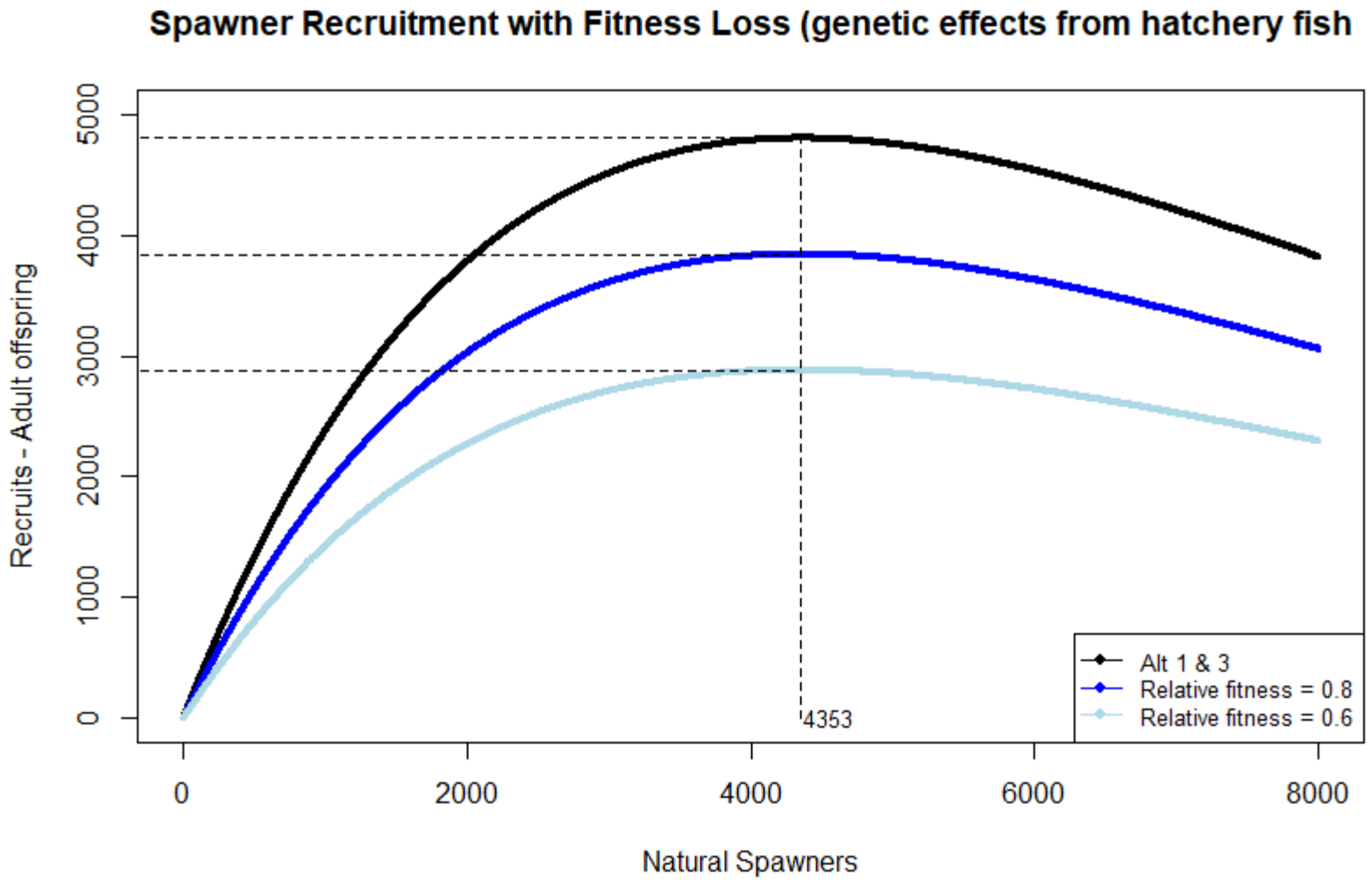
MULTI-STATE MODEL FOR WILLAPA BAY

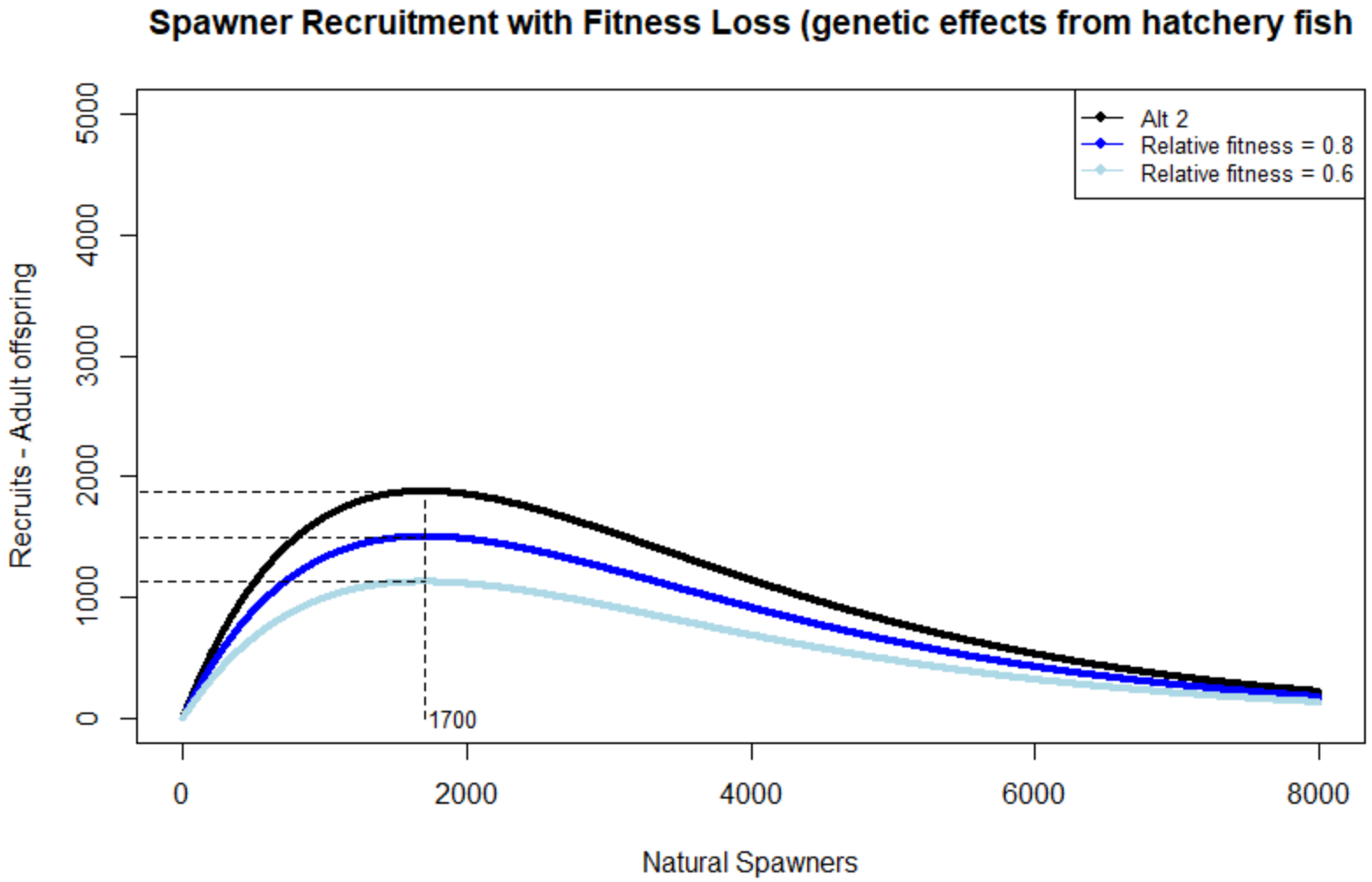


MULTI-STATE MODEL FOR WILLAPA BAY

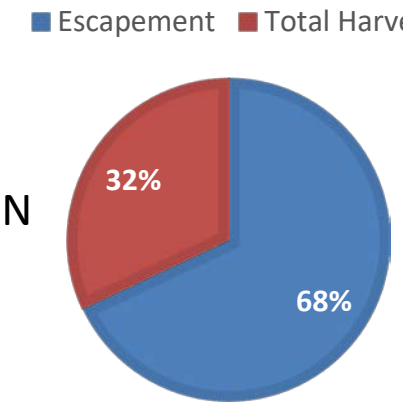
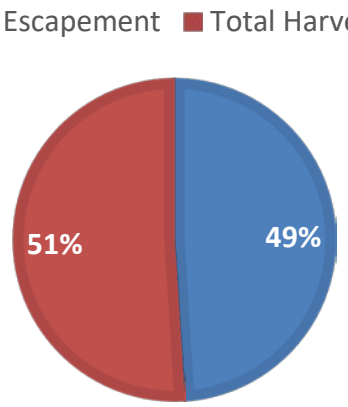
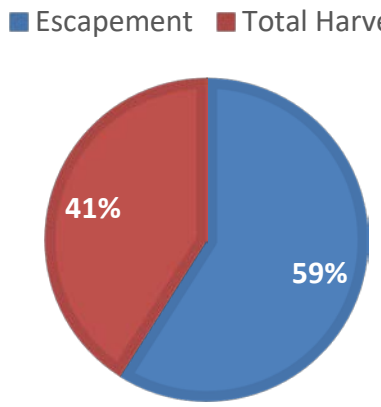
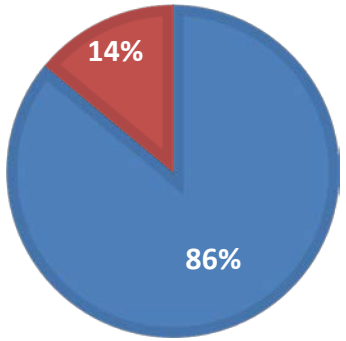
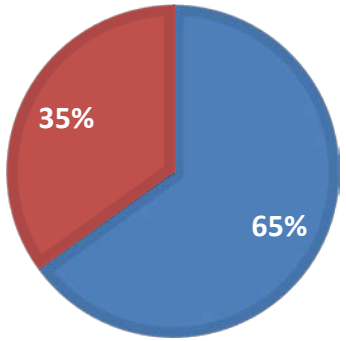
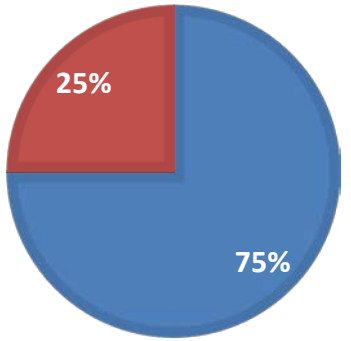



Comparison of Spawner Escapement Goals
Alt 1 & 3
Alt2
Recruits - Adult offspring
0
1000
2000
3000
4000
5000
1700
4353
Parameter a = 3
0
2000
4000
6000
8000
Natural Spawners


Spawner Recruitment with Fitness Loss (genetic effects from hatchery fish
Recruits - Adult offspring
0
1000
2000
3000
4000
5000
0
2000
4000
6000
8000
Natural Spawners
4353
Alt 1 & 3
Relative fitness = 0.8
Relative fitness = 0.6


Spawner Recruitment with Fitness Loss (genetic effects from hatchery fish
Alt 2
Relative fitness = 0.8
Relative fitness = 0.6
Recruits - Adult offspring
0
1000
2000
3000
4000
5000
1700
0
2000
4000
6000
8000
Natural Spawners

Harvest Strategies

	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
HATCHERY-ORIGIN RUN			
NATURAL-ORIGIN RUN			
	2015 – 2020 Escapement Data	2010 – 2014 Escapement Data	Mid-way between Alt 1 and Alt 2

*Hatchery Harvest = Harvest proportion * Hatchery-origin run*

*Natural Harvest = Natural proportion * Natural-origin run*

Assignment from Fish Committee

When comparing three Alternatives:

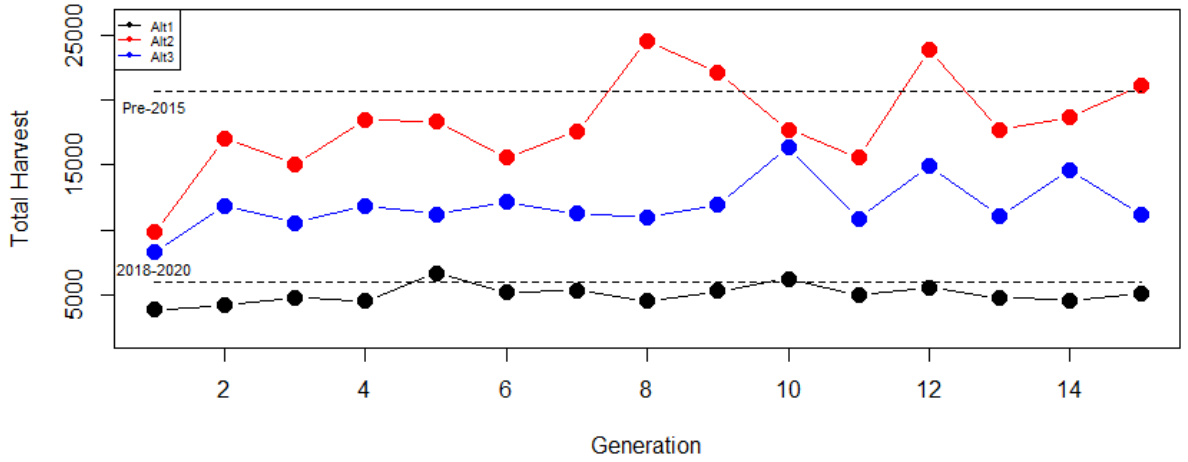
1. Show average take in fisheries (harvest) after policy implementation

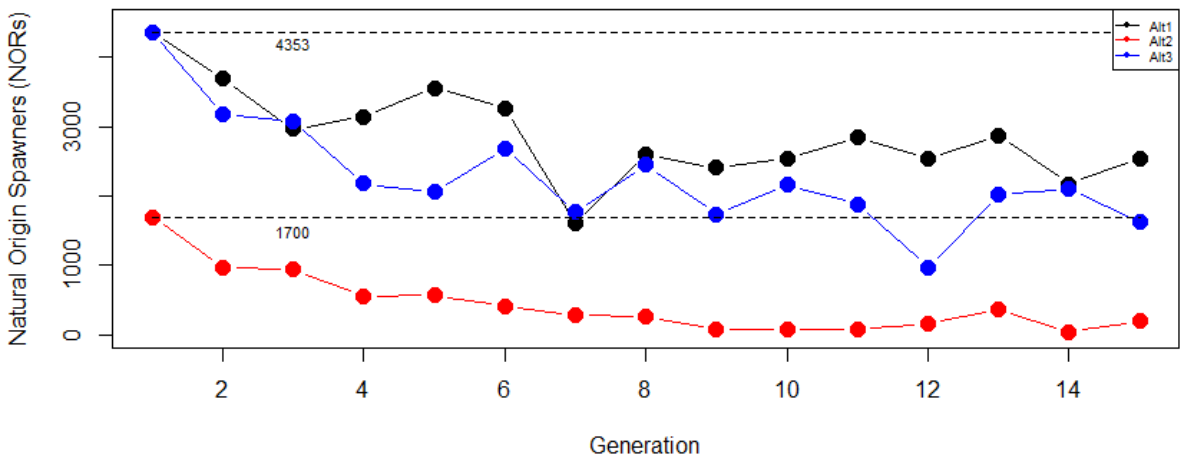
2. Status of wild populations at point 2015 rebuilding plan target date (2033)

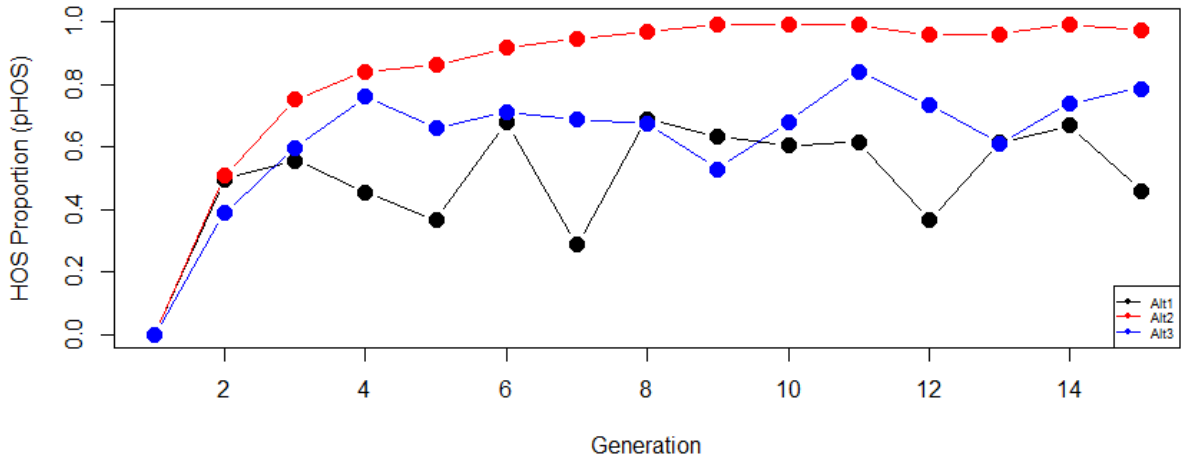
Model Implementation

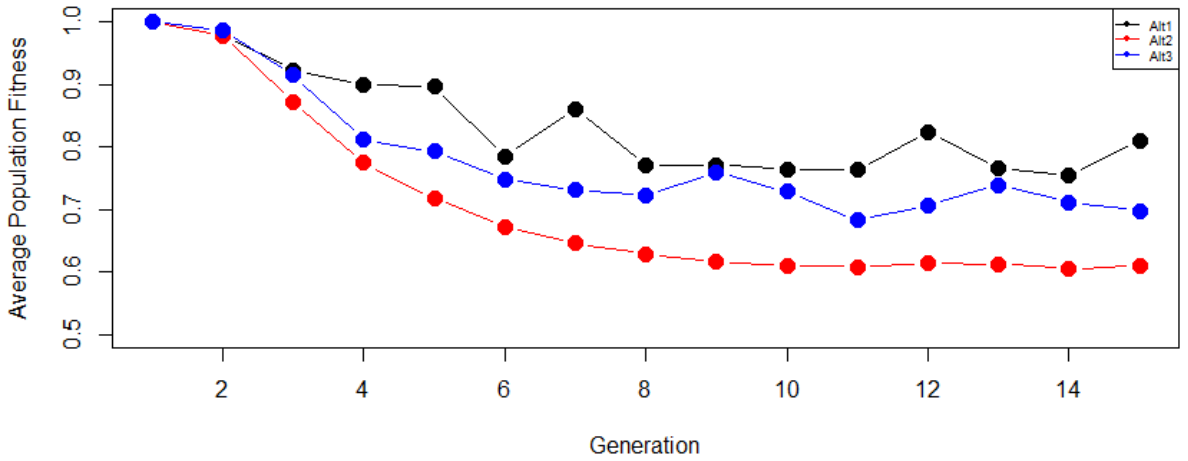
- Each Alternative is run separately as shown below
- Model starts with 100% NOS and 100% NOB
- Model runs for 15 generations
- Repeat 1000 times
- Parameter "a" fixed at 3
- Report after 15th Gen.

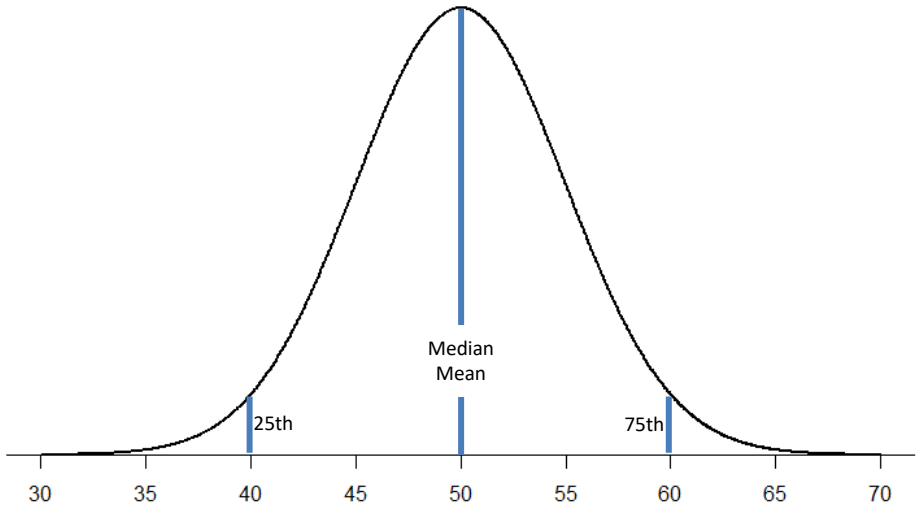
	Alt 1	Alt2	Alt3
Production	4,450,000	11,800,000	8,700,000
Escapement Goal (Capacity "b")	4353	1700	4353
Harvest Strategy	2015 – 2020 Escapement Data	2010 – 2014 Escapement Data	Mid-way between Alt 1 and Alt 2
pHOS control	None **Current** Complete	None **Current** Complete	None **Current** Complete

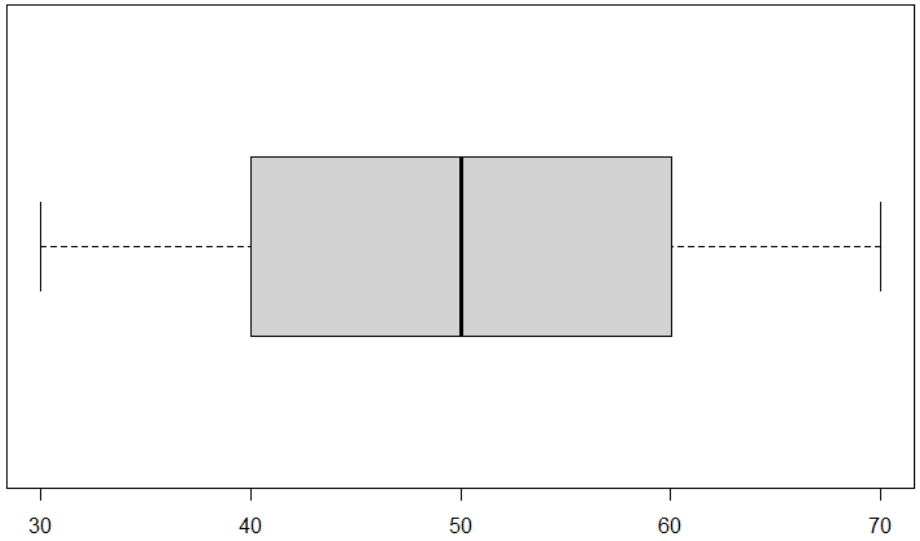

Total Harvest
Alt1
Alt2
Alt3
Pre-2015
2018-2020
Generation

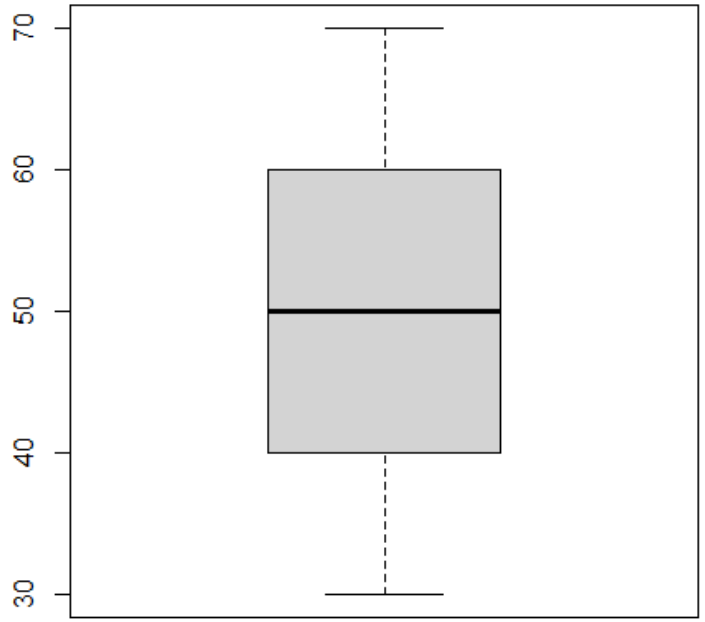

Natural Origin Spawners (NORs)
4353
1700
Alt1
Alt2
Alt3
Generation

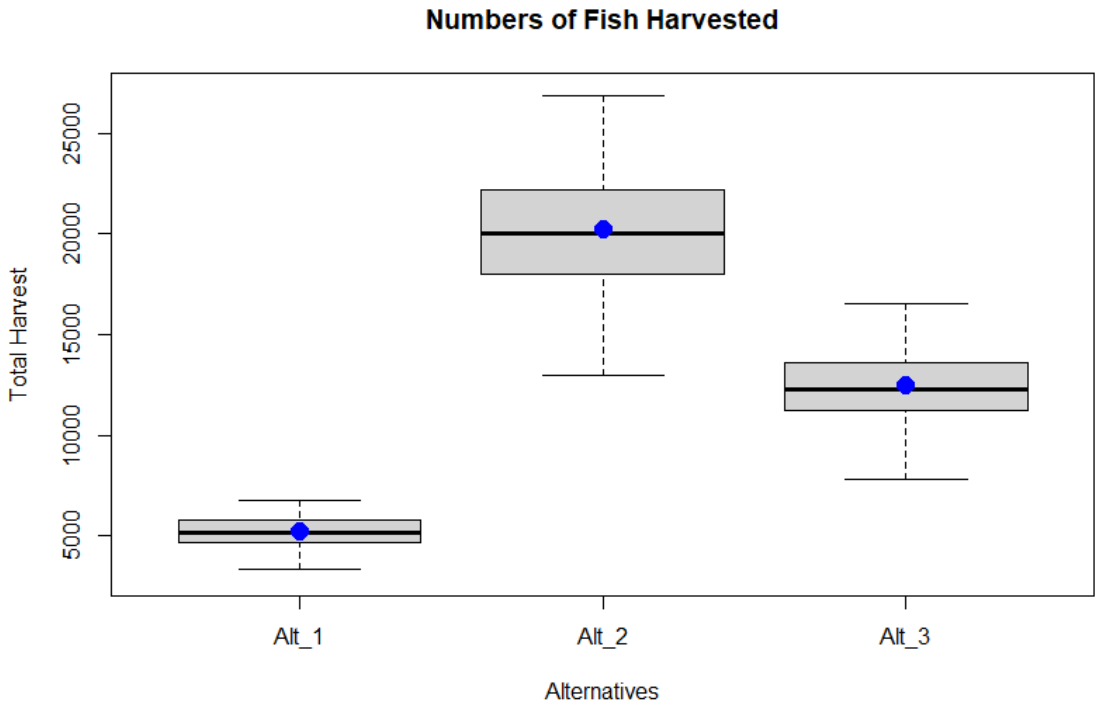

HOS Proportion (pHOS)
Alt1
Alt2
Alt3
Generation

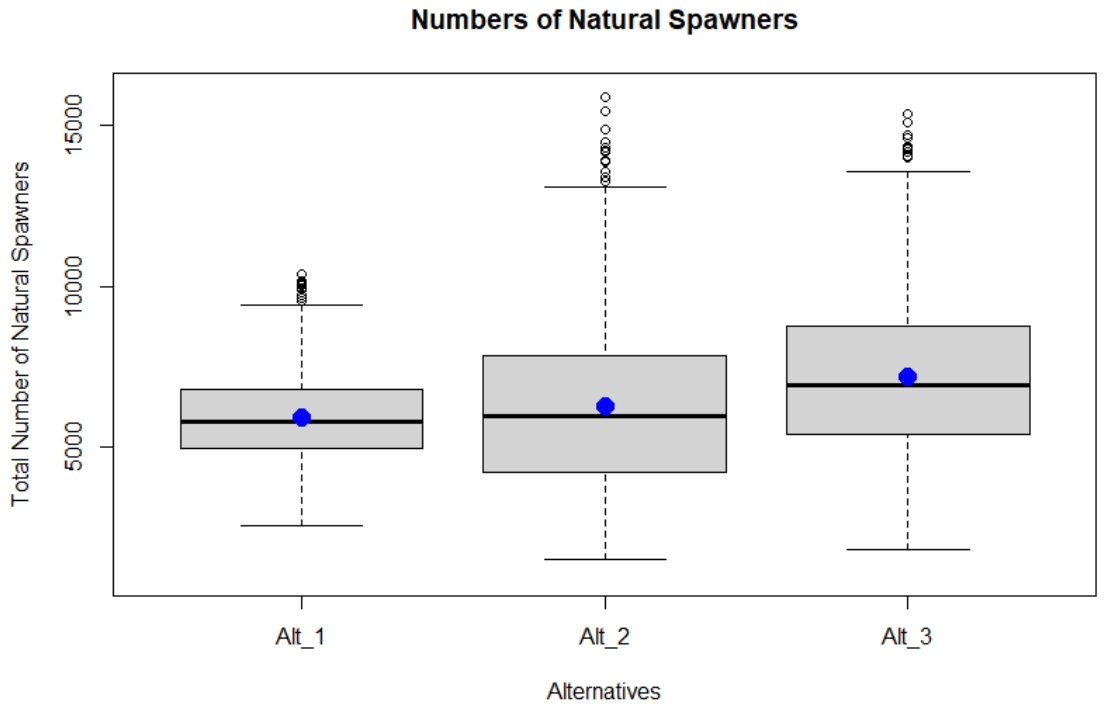

Average Population Fitness
Alt1
Alt2
Alt3
Generation

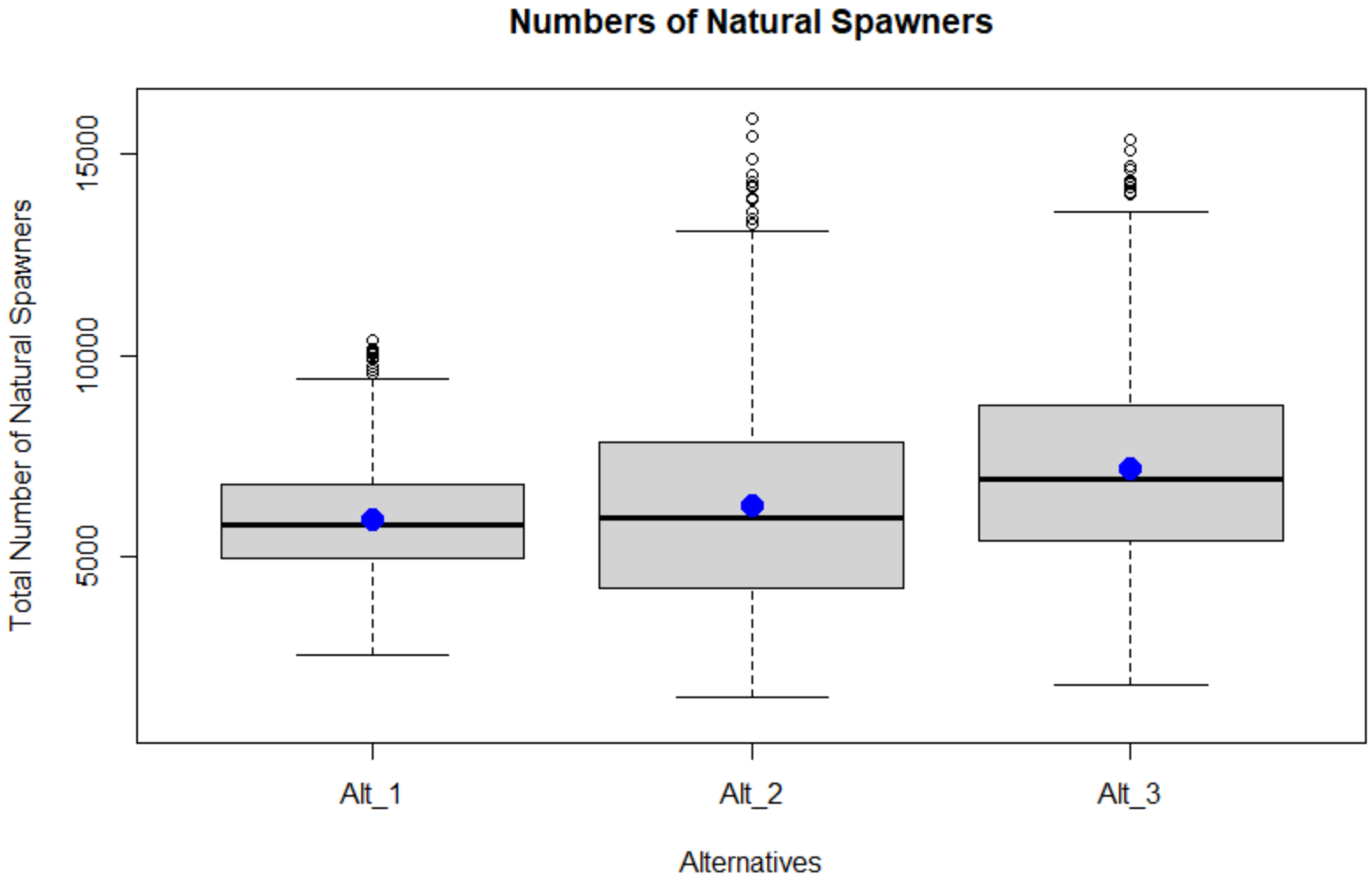

Median
Mean
25th
75th
30
35
40
45
50
55
60
65
70


30
40
50
60
70


30
40
50
60
70

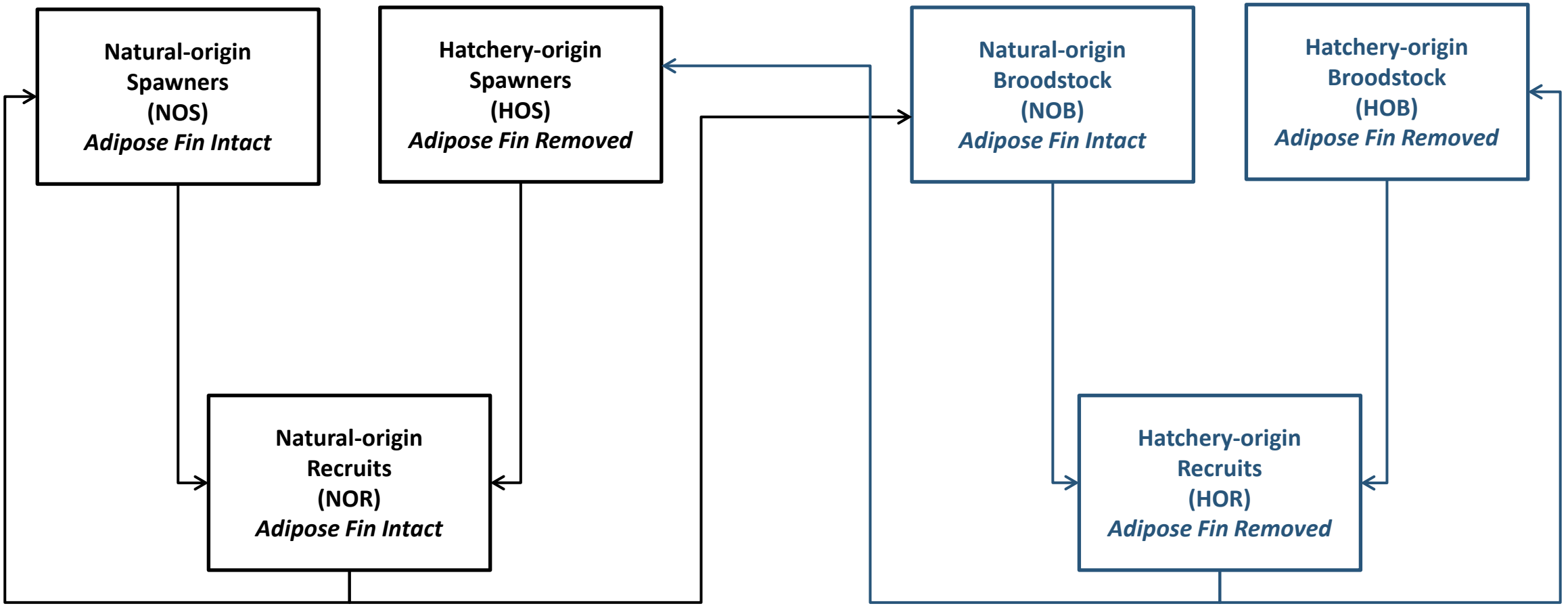

Numbers of Fish Harvested
Total Harvest
5000
10000
15000
20000
25000
Alt_1
Alt_2
Alt_3
Alternatives

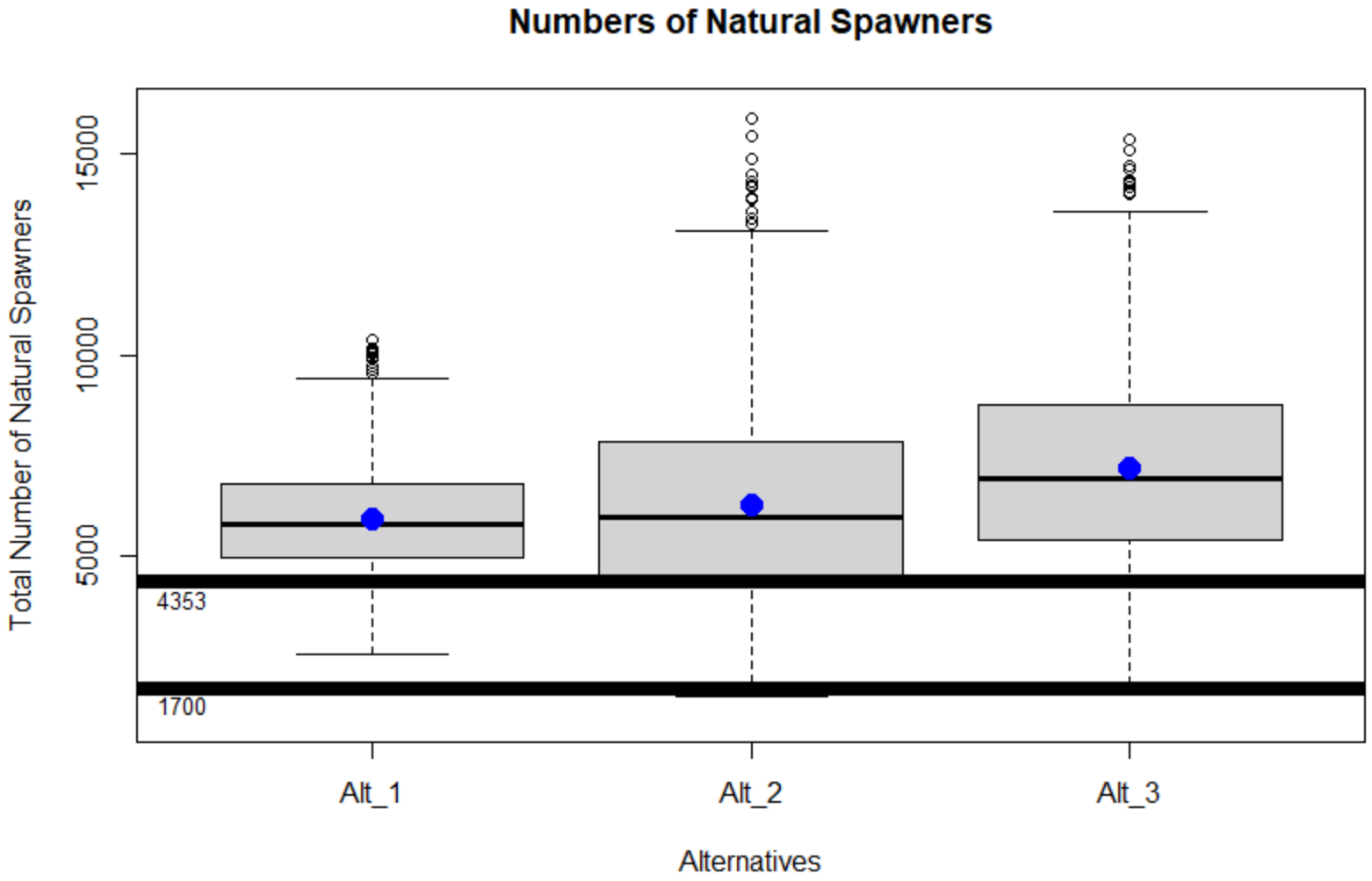

Numbers of Natural Spawners
Total Number of Natural Spawners
5000
10000
15000
Alt_1
Alt_2
Alt_3
Alternatives

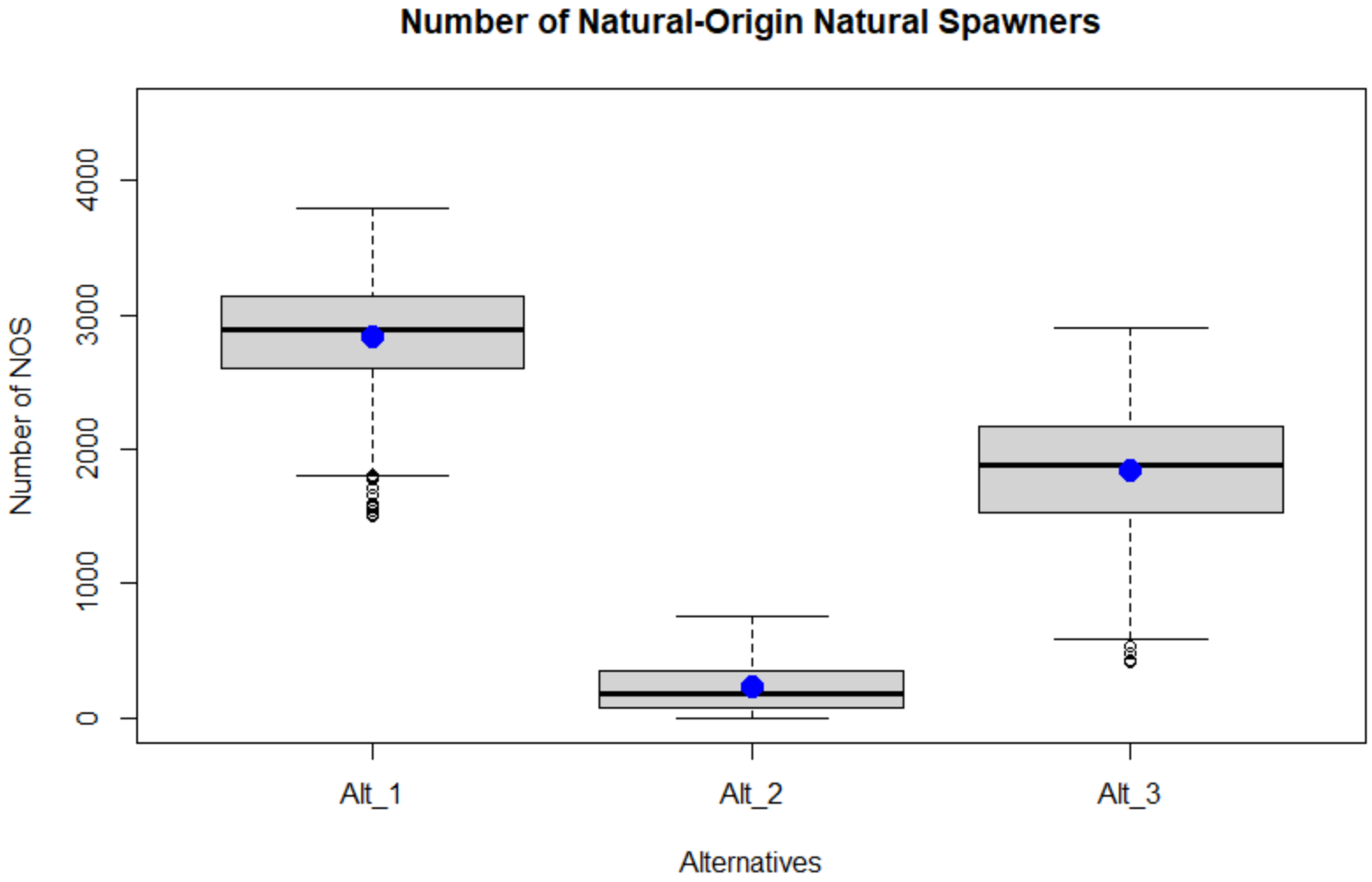

Numbers of Natural Spawners
Total Number of Natural Spawners
5000
10000
15000
Alt_1
Alt_2
Alt_3
Alternatives

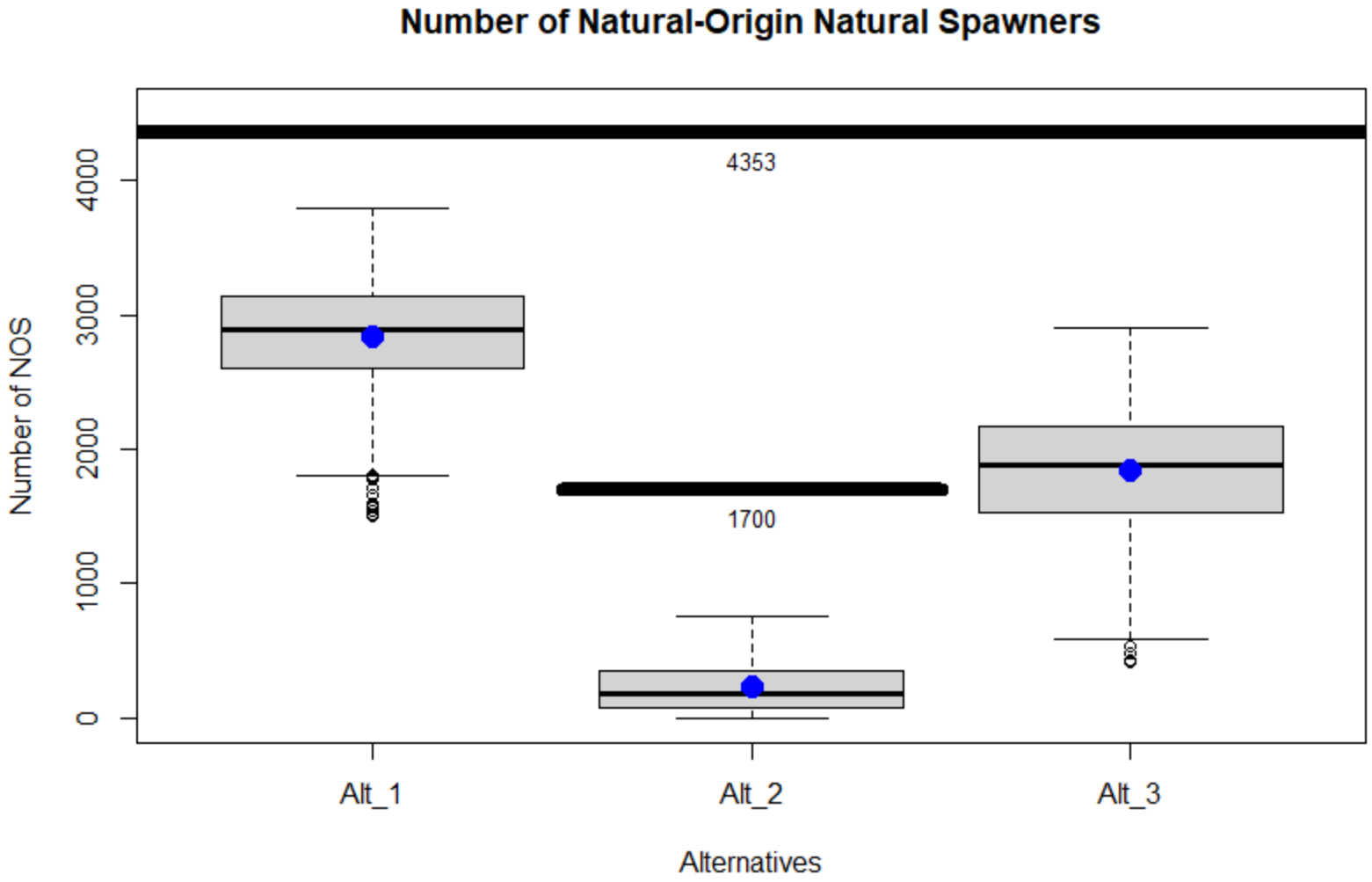
NATURAL ENVIRONMENT

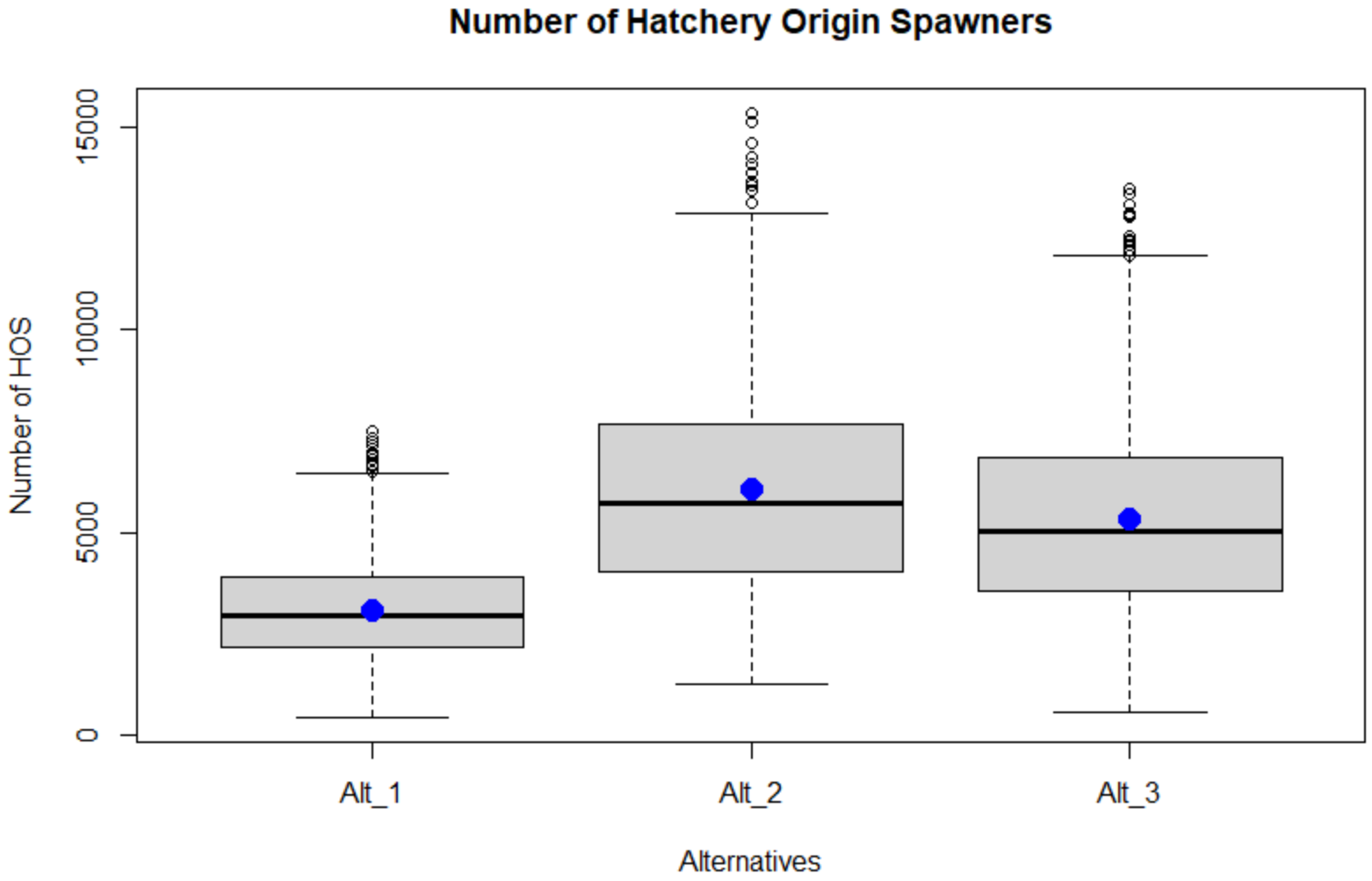
HATCHERY ENVIRONMENT



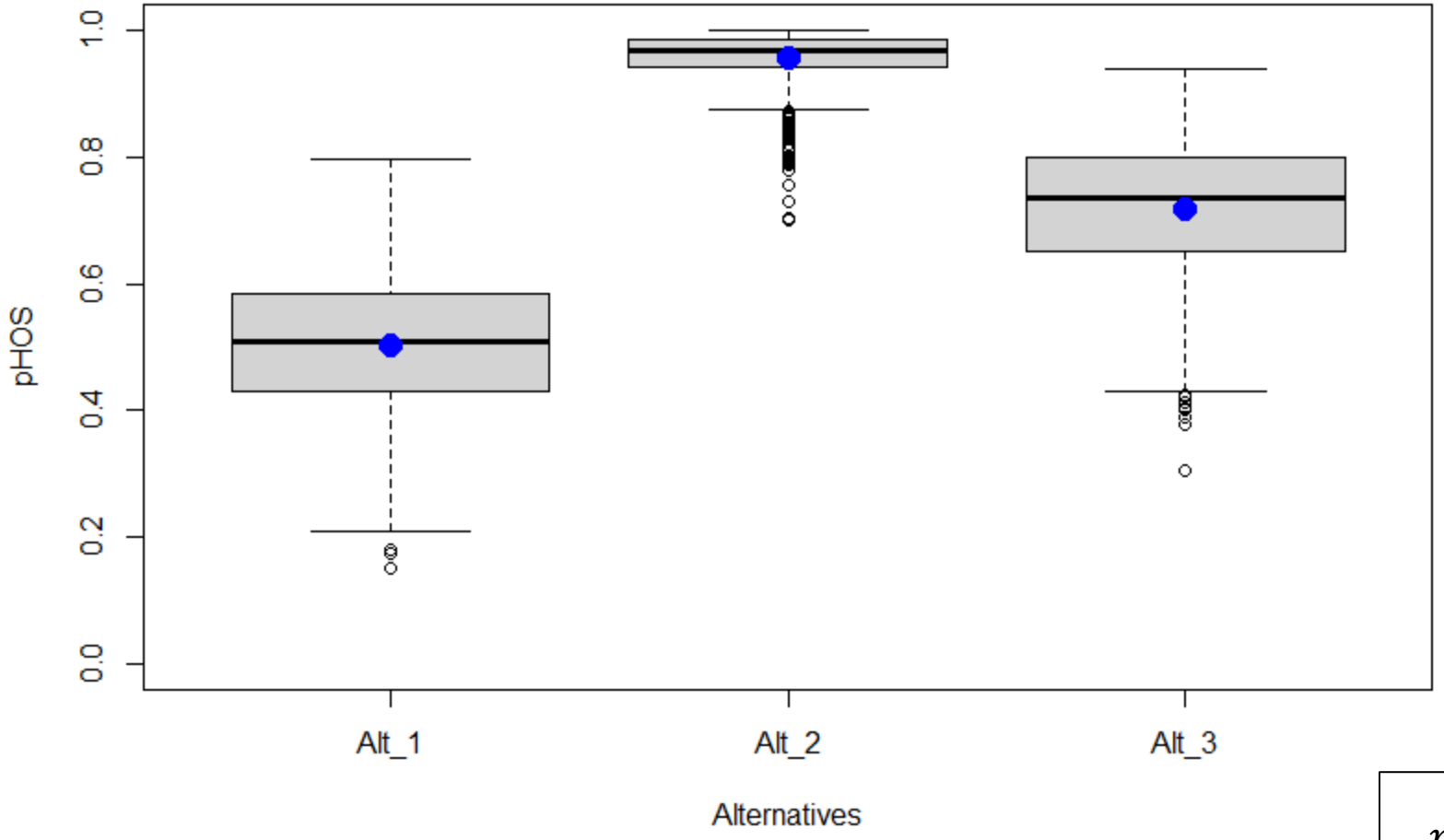

Numbers of Natural Spawners
Total Number of Natural Spawners
15000
10000
5000
4353
1700
Alt_1
Alt_2
Alt_3
Alternatives


Number of Natural-Origin Natural Spawners
Number of NOS
0
1000
2000
3000
4000
Alt_1
Alt_2
Alt_3
Alternatives

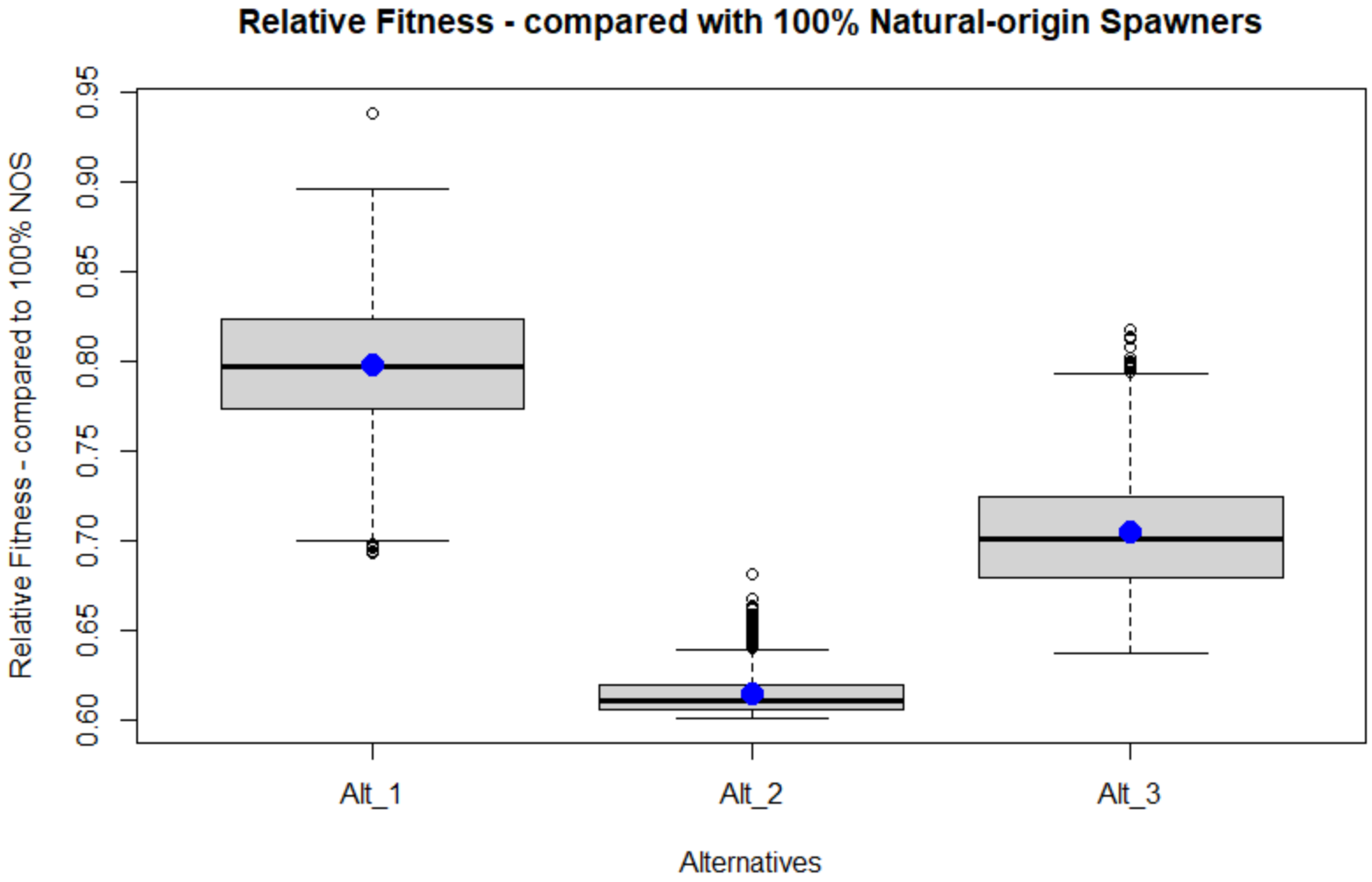

Number of Natural-Origin Natural Spawners
4353
1700
Number of NOS
0
1000
2000
3000
4000
Alt_1
Alt_2
Alt_3
Alternatives


Number of Hatchery Origin Spawners
Number of HOS
0
5000
10000
15000
Alt_1
Alt_2
Alt_3
Alternatives

Hatchery-origin Spawners compared with Total Number of Natural Spawners (pHOS)



$$pHOS = \frac{HOS}{HOS + NOS}$$


Relative Fitness - compared with 100% Natural-origin Spawners
Relative Fitness - compared to 100% NOS
0.60
0.65
0.70
0.75
0.80
0.85
0.90
0.95
Alt_1
Alt_2
Alt_3
Alternatives

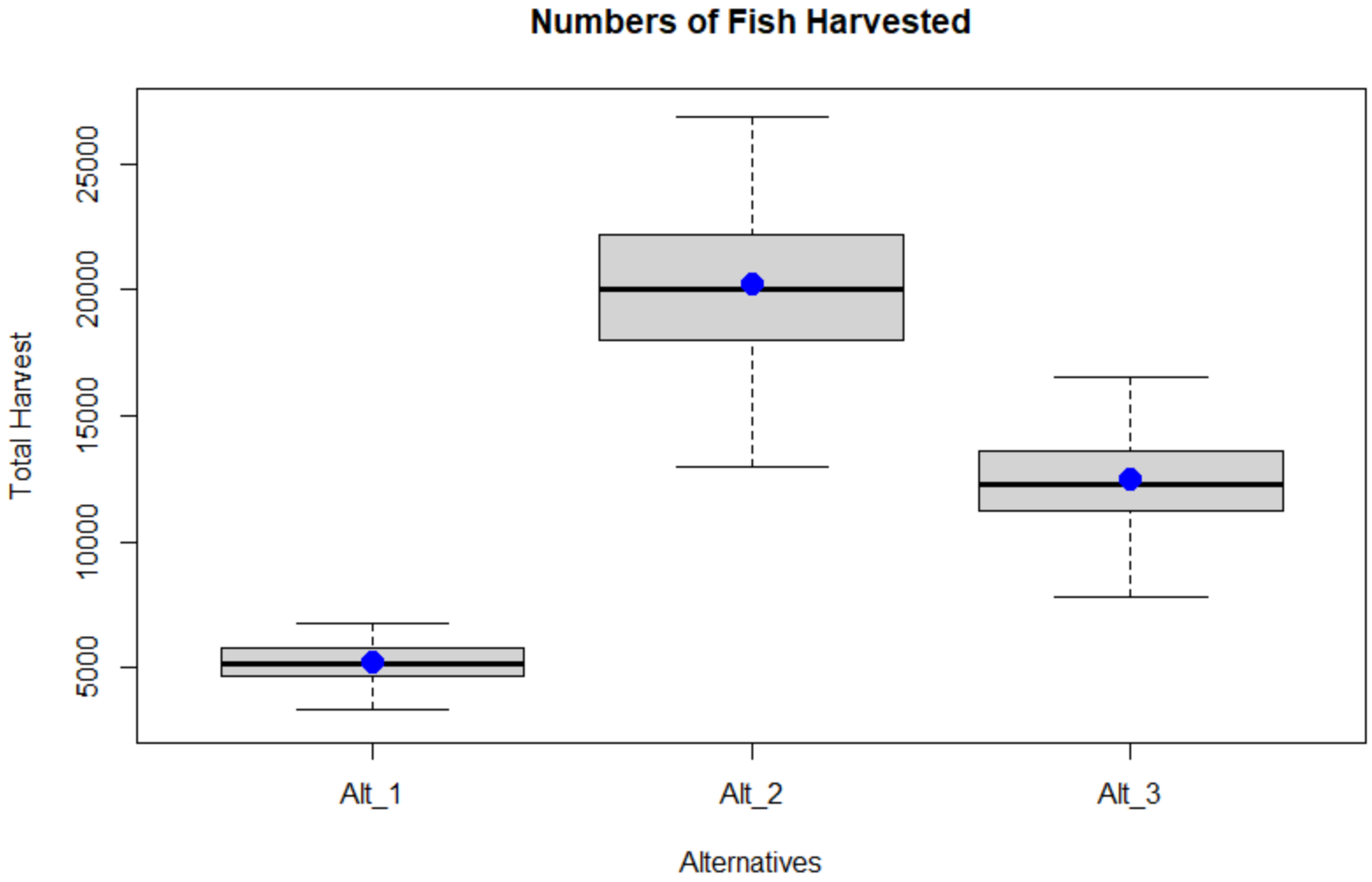
Willapa Bay Policy Objectives

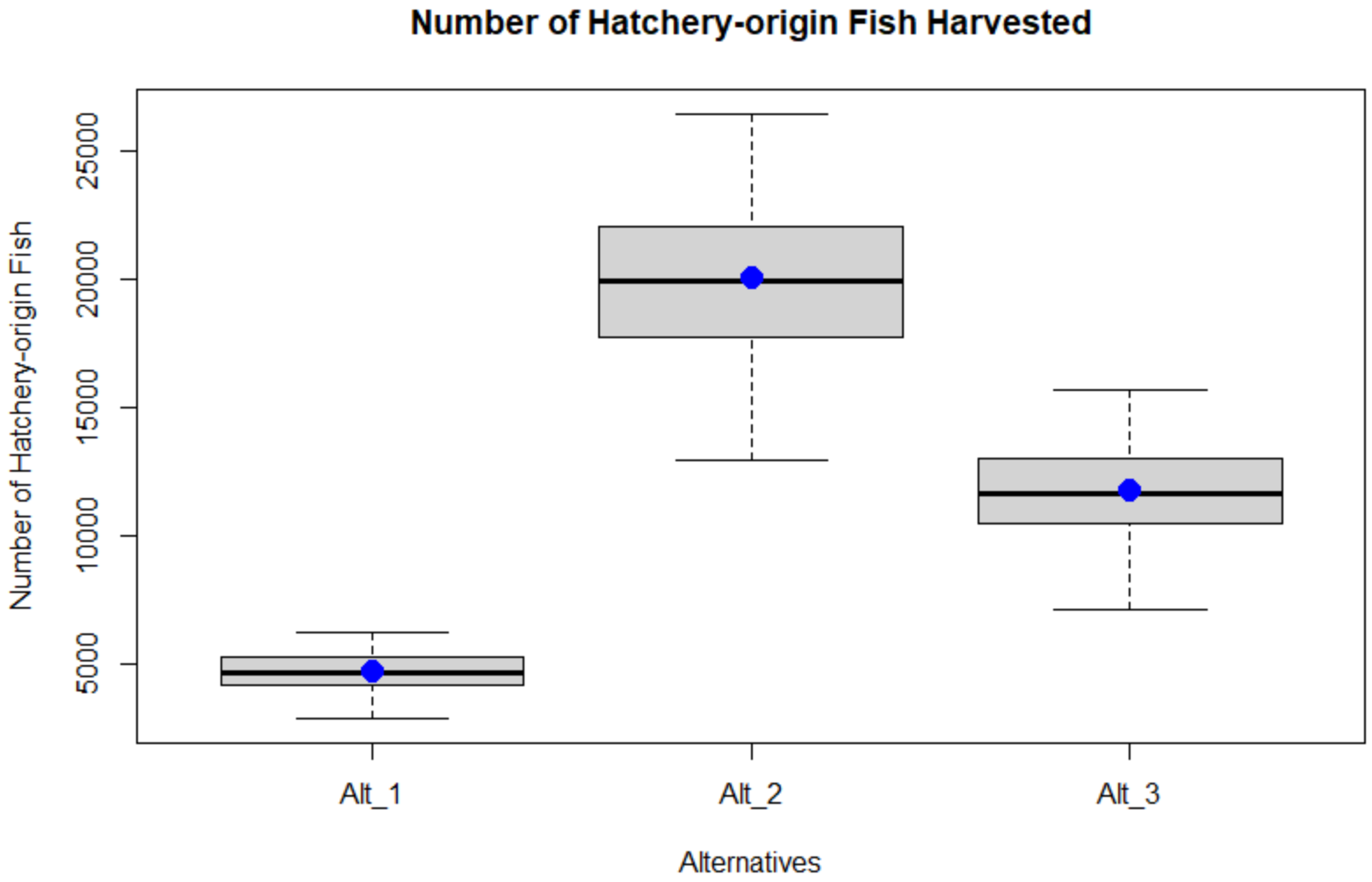
(concise statements of desired future states)

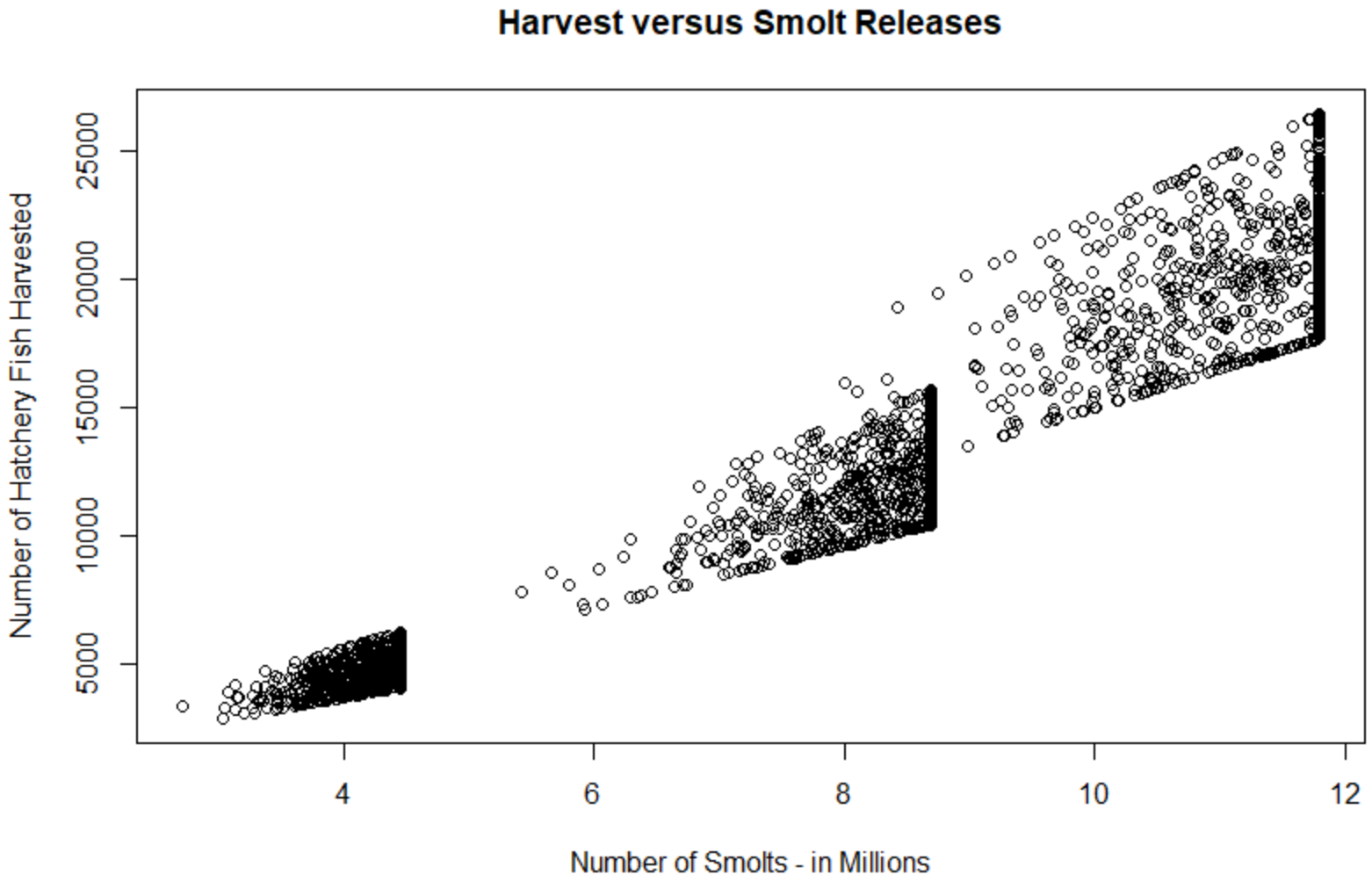
- Increased both commercial and recreational fishing opportunities in Willapa Bay and tributaries
  - compared with current (2015) policy (Alternative 1)
- Wild populations are restored and conserved, and are adapted to the basin tributaries

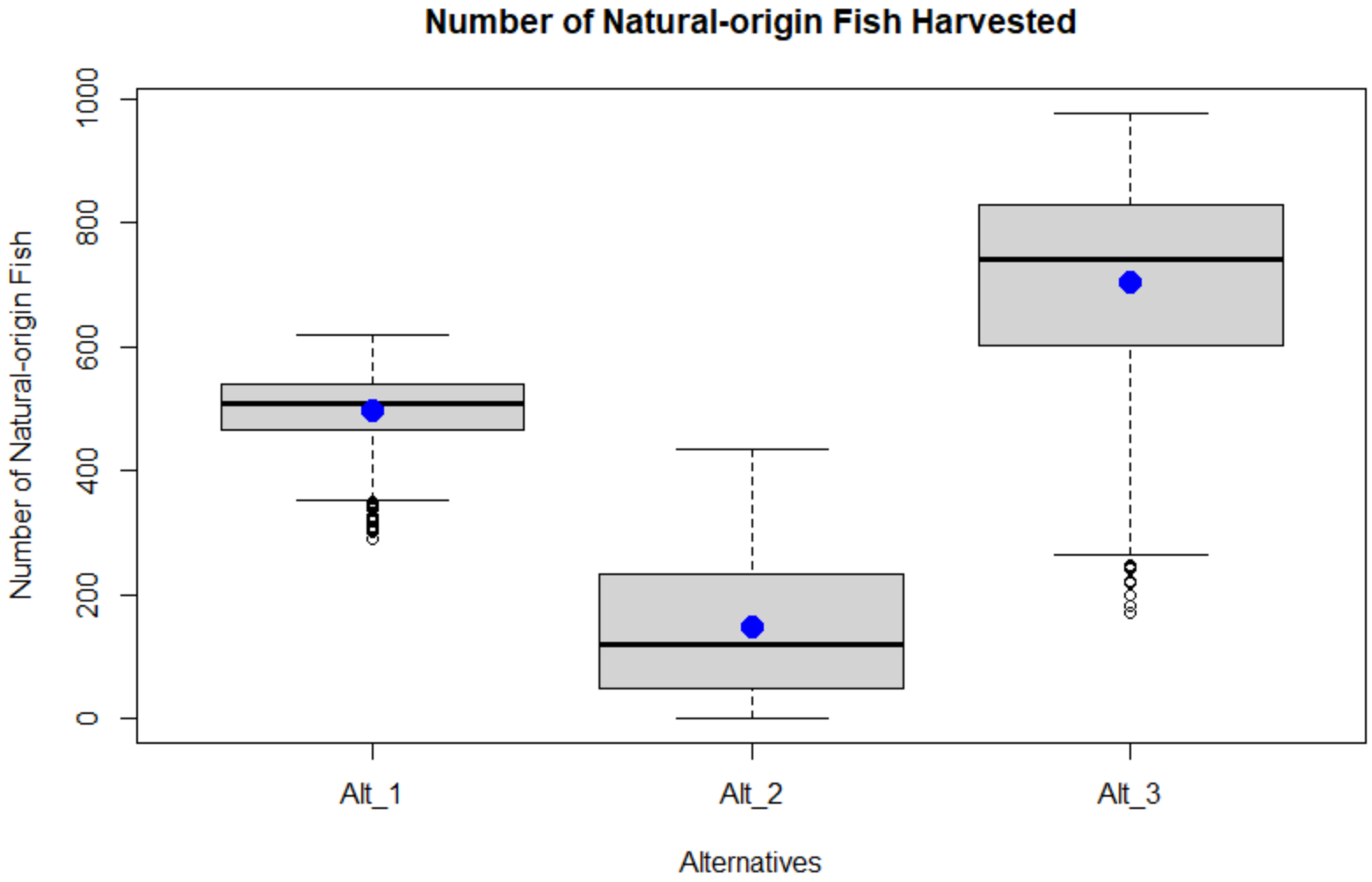
Alternative performances:

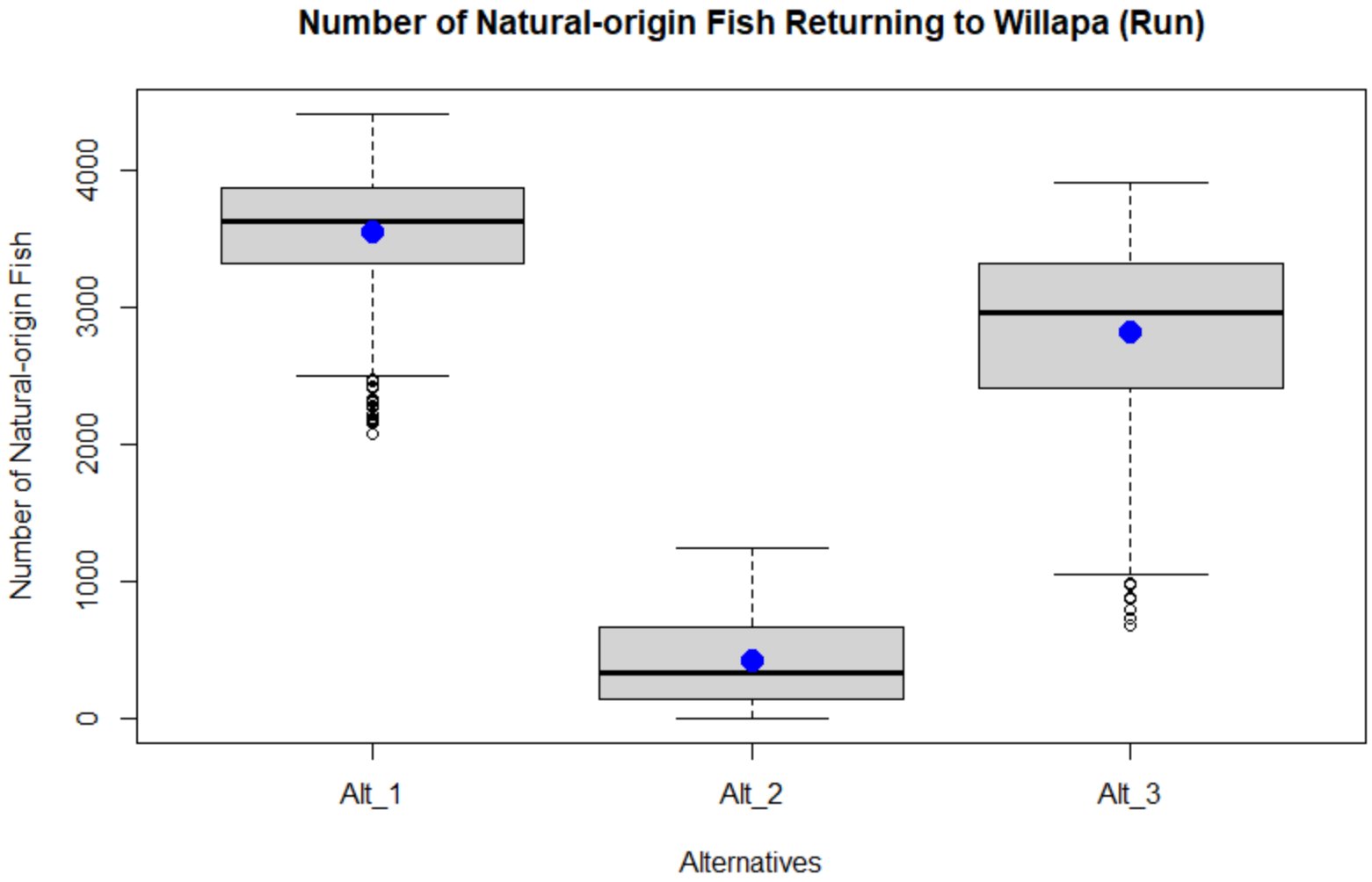
1. Alt 1 > Alt 2 > Alt 3
2. Too many HOR spawning naturally

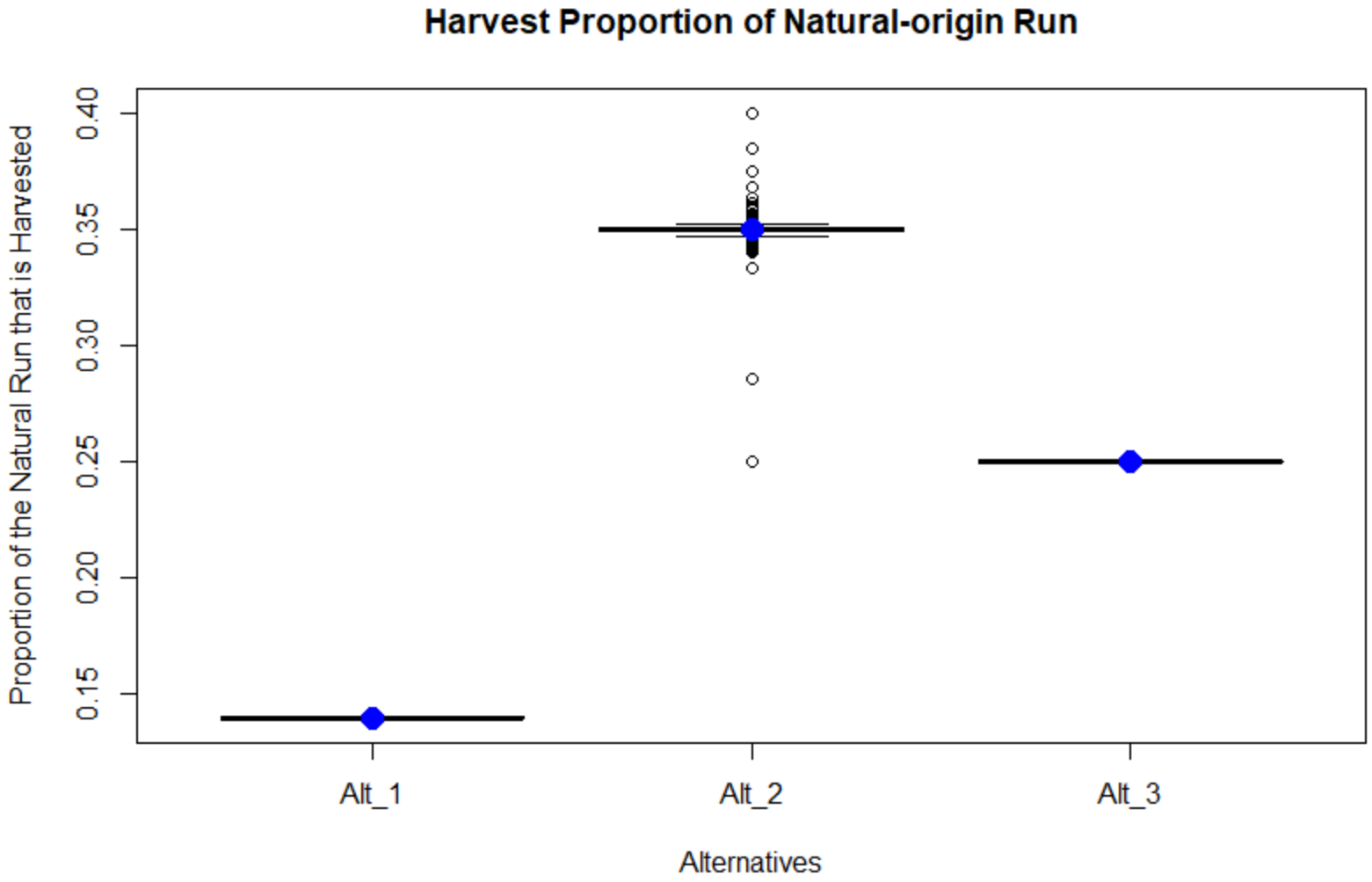

Numbers of Fish Harvested
Total Harvest
5000
10000
15000
20000
25000
Alt_1
Alt_2
Alt_3
Alternatives


Number of Hatchery-origin Fish Harvested
Number of Hatchery-origin Fish
5000
10000
15000
20000
25000
Alt_1
Alt_2
Alt_3
Alternatives


Harvest versus Smolt Releases
Number of Hatchery Fish Harvested
5000
10000
15000
20000
25000
4
6
8
10
12
Number of Smolts - in Millions


Number of Natural-origin Fish Harvested
Number of Natural-origin Fish
0
200
400
600
800
1000
Alt_1
Alt_2
Alt_3
Alternatives


Number of Natural-origin Fish Returning to Willapa (Run)
Number of Natural-origin Fish
0
1000
2000
3000
4000
Alt_1
Alt_2
Alt_3
Alternatives


Harvest Proportion of Natural-origin Run
Proportion of the Natural Run that is Harvested
0.15
0.20
0.25
0.30
0.35
0.40
Alt_1
Alt_2
Alt_3
Alternatives

Willapa Bay Policy Objectives

(concise statements of desired future states)

- Increased both commercial and recreational fishing opportunities in Willapa Bay and tributaries
  - compared with current (2015) policy (Alternative 1)
- Wild populations are restored and conserved, and are adapted to the basin tributaries

<u>Alternative performances</u>:

1. Alt 2 > Alt 3 > Alt 1
2. Reflects size of hatchery releases
3. And model's conversion of smolts to hatchery run
   - Using SARs

Questions and Discussion

Willapa Bay Policy Objectives

(concise statements of desired future states)

- Increased both commercial and recreational fishing opportunities in Willapa Bay and tributaries
  - compared with current (2015) policy (Alternative 1)
- Wild populations are restored and conserved, and are adapted to the basin tributaries

One last comment:

- This process:
  1. Establishing a single set of objectives
  2. Establishing a set of Alternatives
  3. Seeing tradeoffs among alternatives
- Is exactly the intent of Technical Procedures Document in C-3624
- Only one alternative includes this process: Alt 3