MULTIPLE USE OF MALES IN BROODSTOCK

Snake River Fall Chinook

by

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ACKNOWLEDGEMENTS

Afton Oakerman, WDFW, and Bill Arnsberg, NPT, for summarizing data used in this presentation as well as past and present staff working with WDFW and NPT.

Past Broodstock Focus

- Pre-2010
- Meet program goals
- Sample return to meet run reconstruction needs
- Manage the use of unmarked/untagged brood
  - Reduce the use of out-of-basin strays
  - 2003 - Included unmarked/untagged fish to increase proportion of natural-origin broodstock (pNOB)
- Single-pair mating
  - Maximize N_b

Current Broodstock Focus

- 2010 - present
- Achieve a 30% natural-origin broodstock (pNOB) goal
  - Maximize the use of unmarked/untagged broodstock
- Select for older age-at-return
  - Use large males multiple times
    - Maximize the use of larger, older aged fish
  - Institute a minimum broodstock size of 70 cm
    - Minimize the use of jacks and jills
- Monitor broodstock use to evaluate the impact of using males multiple times
  - Maintain an effective number of breeders (N_b) $\geq$1,000

Why?

- A high proportion of smaller, younger-aged fish could negatively affect the age-at-return of the population
  - Potential for selective harvest to alter the size and age composition of fish available for broodstock
  - Male heritability of age and length is 0.53 and 0.91, respectively (Ford, M. et al 2012)
  - 2009: Identified a high proportion of 1-salt yearling (jacks and jills) in spawning crosses
    - 2000-2009: 62% of matings had at least one 1-salt parent

How?

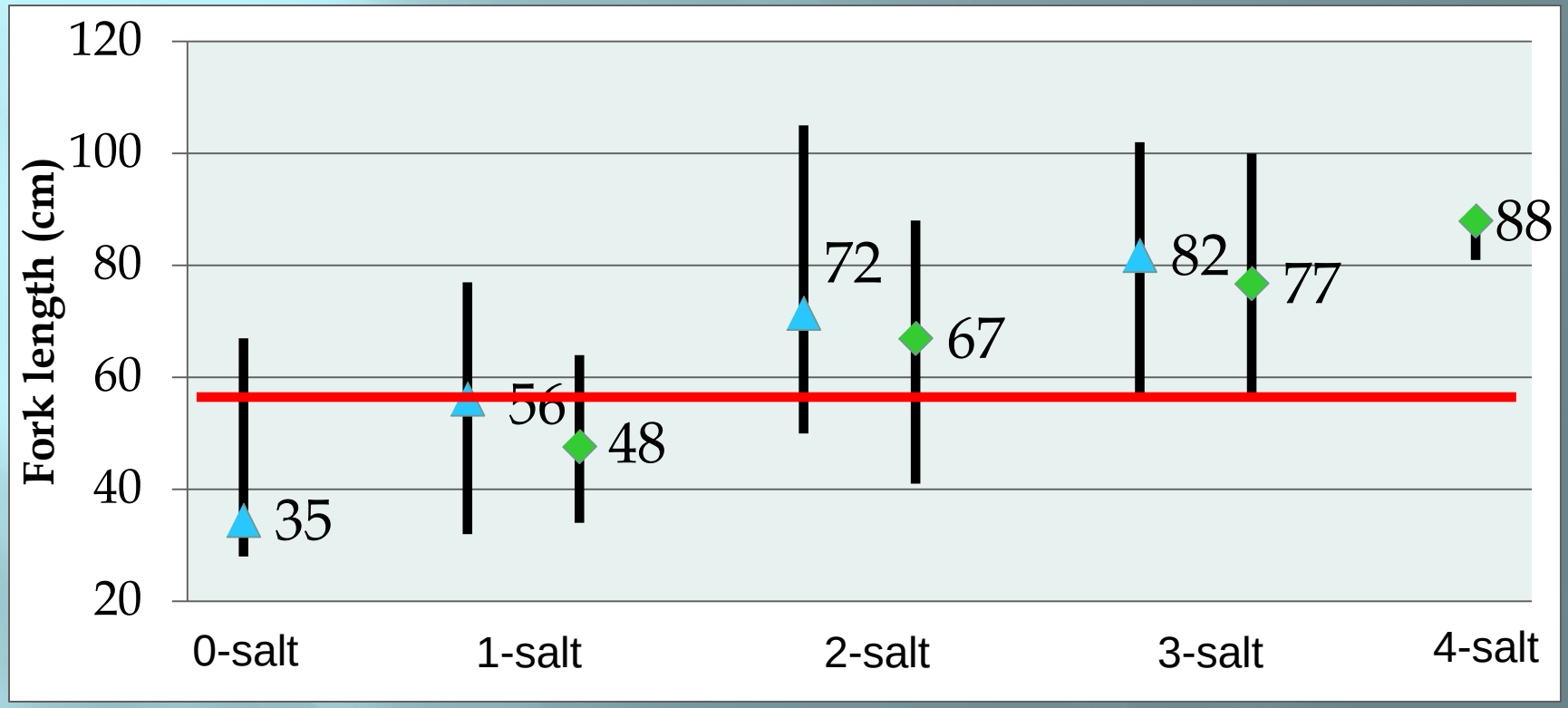
- Hauling protocol
  - Select larger males and females (>70 cm FL)
  - Increase size criteria once run reconstruction needs are met
    - Increase length criteria to >80 or >85 cm FL
    - Increase the proportion of unmarked/untagged females and males shipped to the hatcheries

How?

- Broodstock selection
  - Select larger fish
    - Males and females >70 cm
    - CWT females <70 cm
- Spawning protocols
  - Use larger males multiple times, especially “wild” males
    - Male mated to small female or jill, also use on a larger female
  - Manage the use of jacks and jills
    - Male used on a jill will also be used on a larger female
    - Cull progeny of 1-salts once program goal is met
      - Known-age jacks >70 cm FL determined by CWT and scales

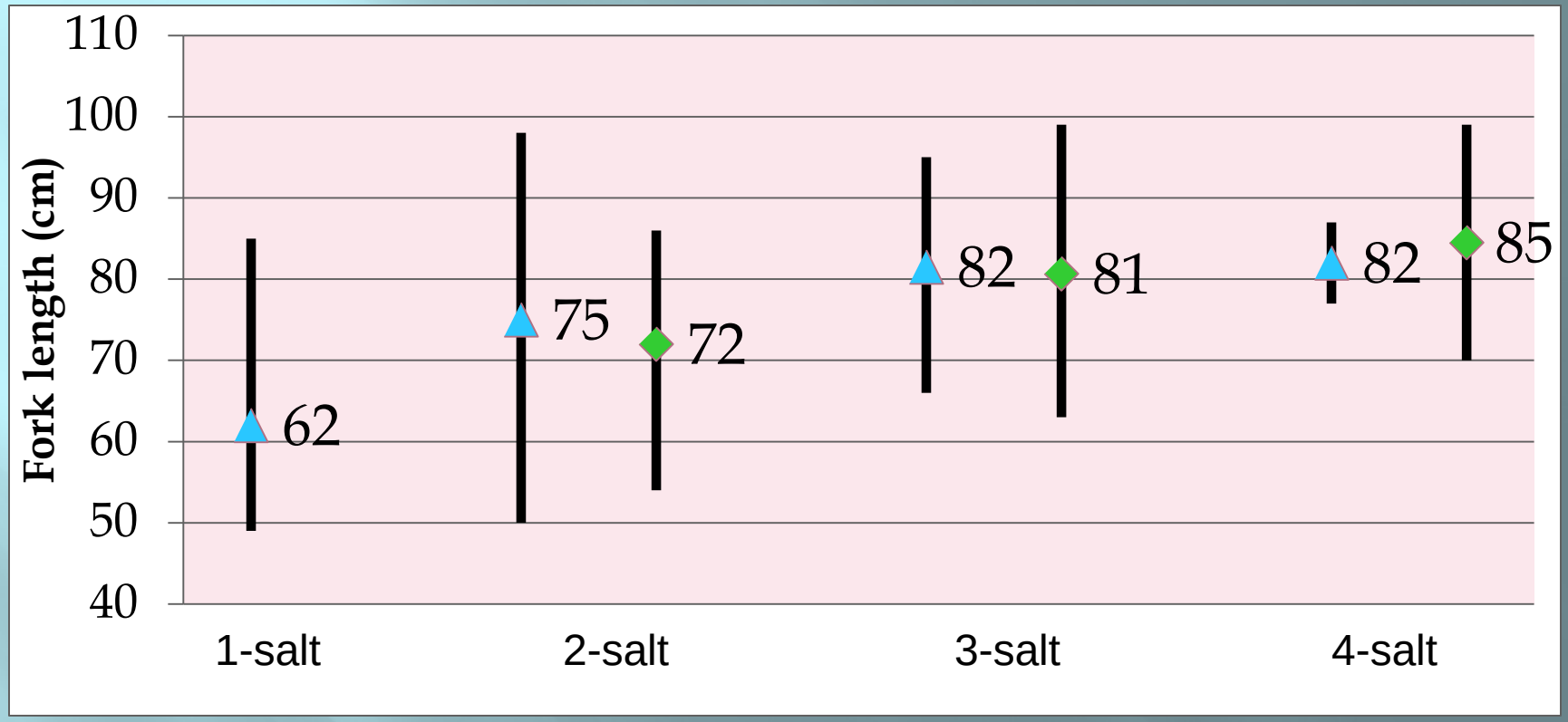
Show me the data!

Male size at age of return 2010–2015



European Age	0.1	0.2	0.3	0.4	1.0	1.1	1.2	1.3
Probability >57 cm	0.02	0.93	1.00	0.99	0.00	0.55	0.99	0.99
Probability >70 cm	0.00	0.29	0.93	0.99	0.00	0.03	0.70	0.91
Proportion of population	0.25	0.37	0.12	0.01	0.07	0.12	0.05	0.00

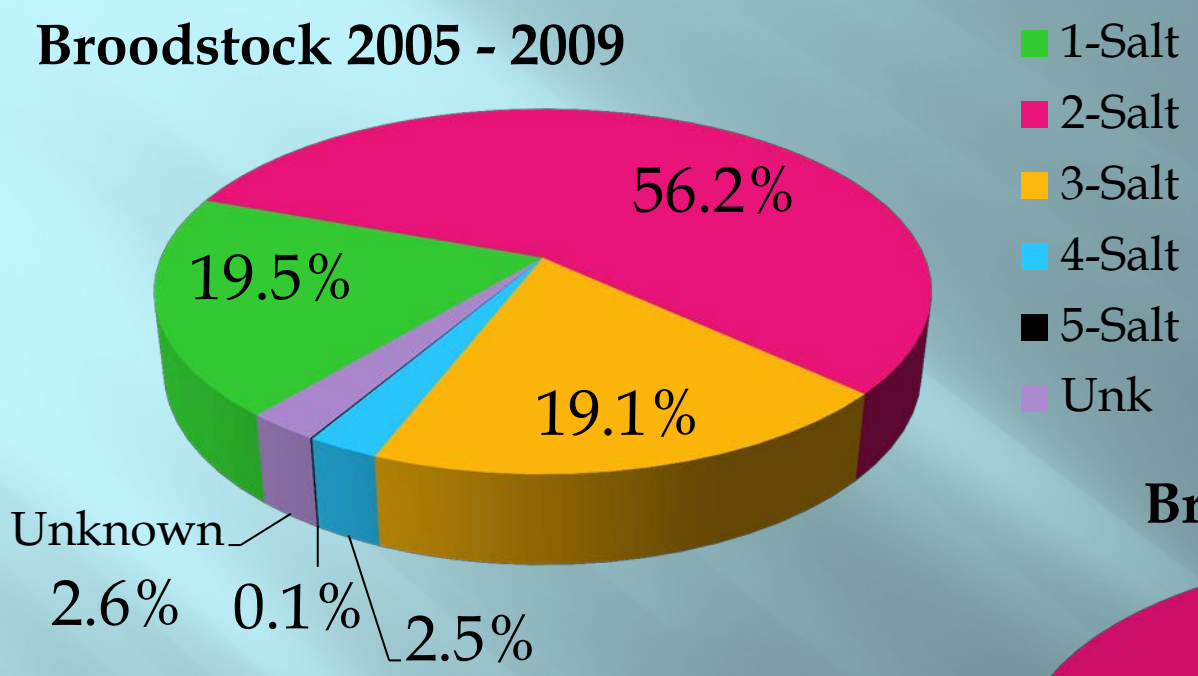
Female size at age of return 2010–2015

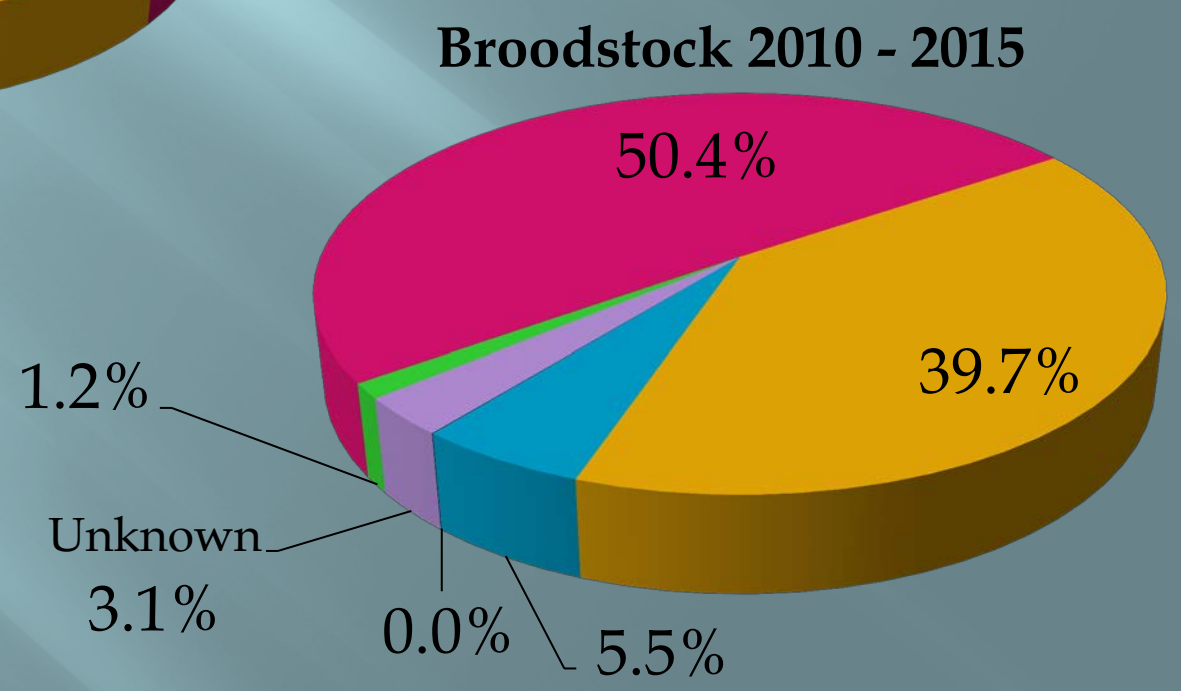


European Age	0.1	0.2	0.3	0.4	1.1	1.2	1.3	1.4
Probability >57 cm	0.27	1.00	1.00	1.00	0.91	1.00	1.00	1.00
Probability >70 cm	0.00	0.63	0.99	1.00	0.10	0.91	0.99	1.00
Proportion of population	0.00	0.20	0.43	0.07	0.03	0.22	0.04	0.00

Salt ages of spawned females

WDFW data

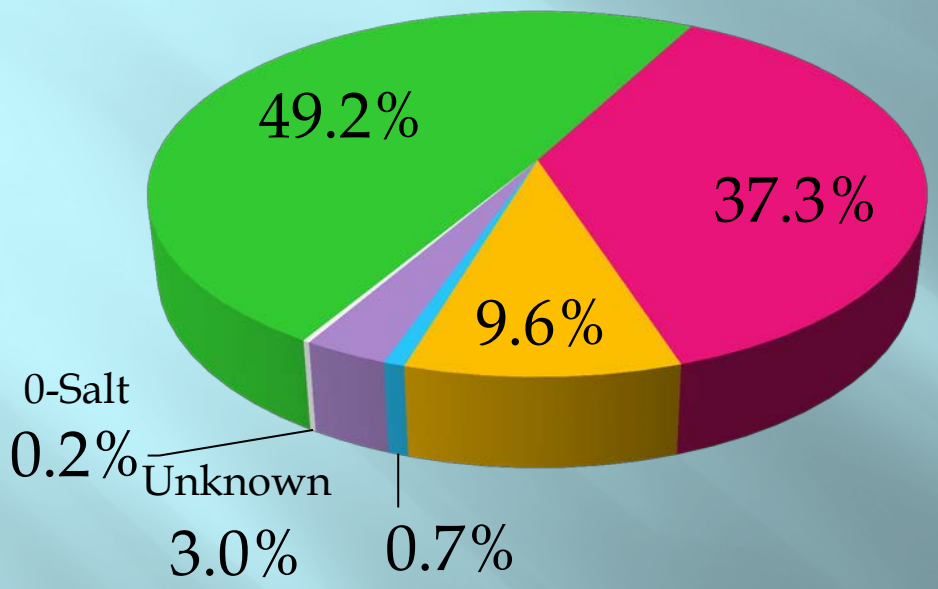




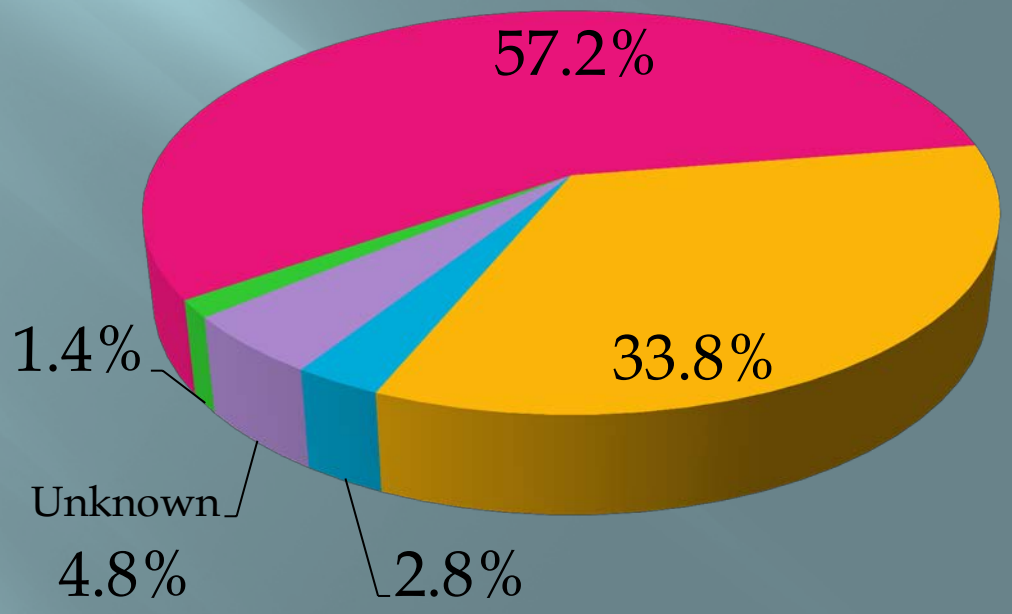
Salt ages of spawned males

WDFW data

Broodstock 2005 - 2009



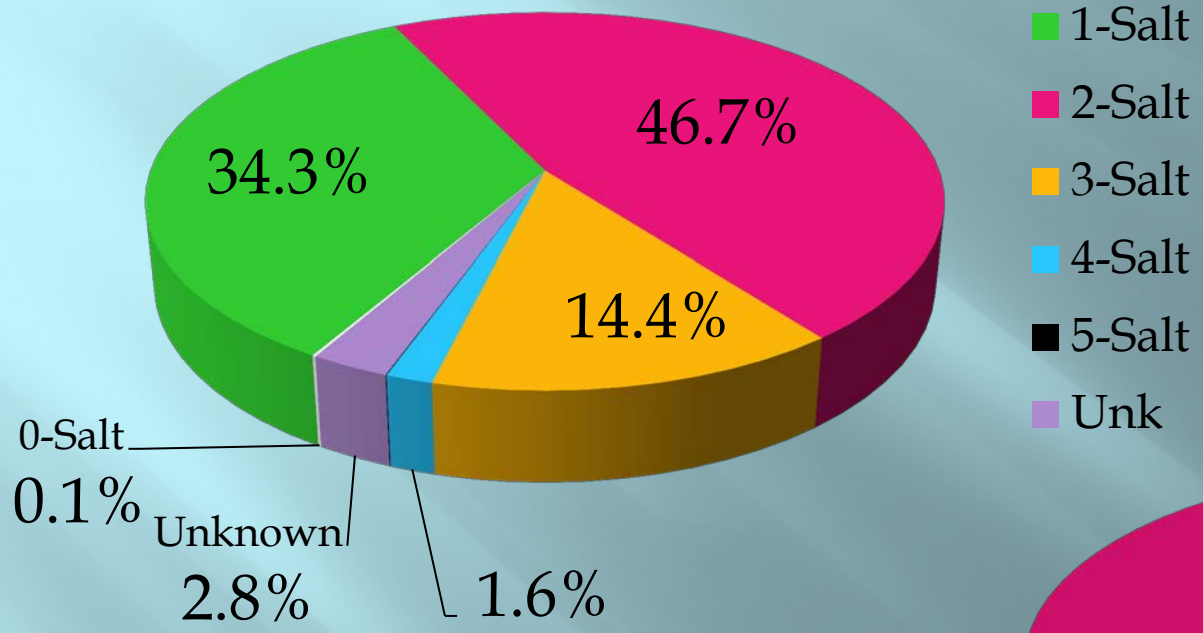
Broodstock 2010 - 2015



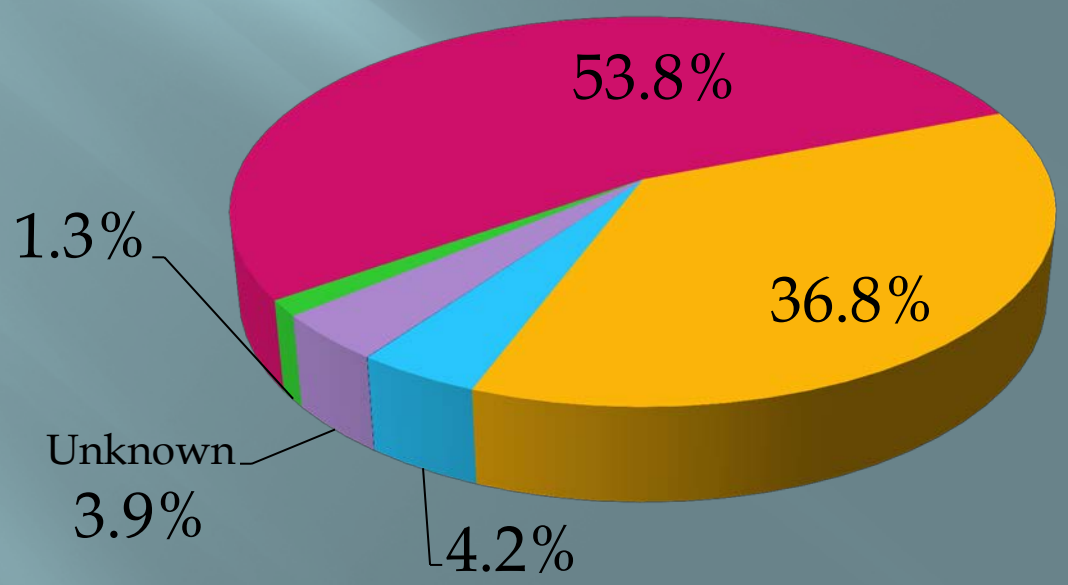
Salt ages of broodstock

WDFW data

Broodstock 2005 - 2009

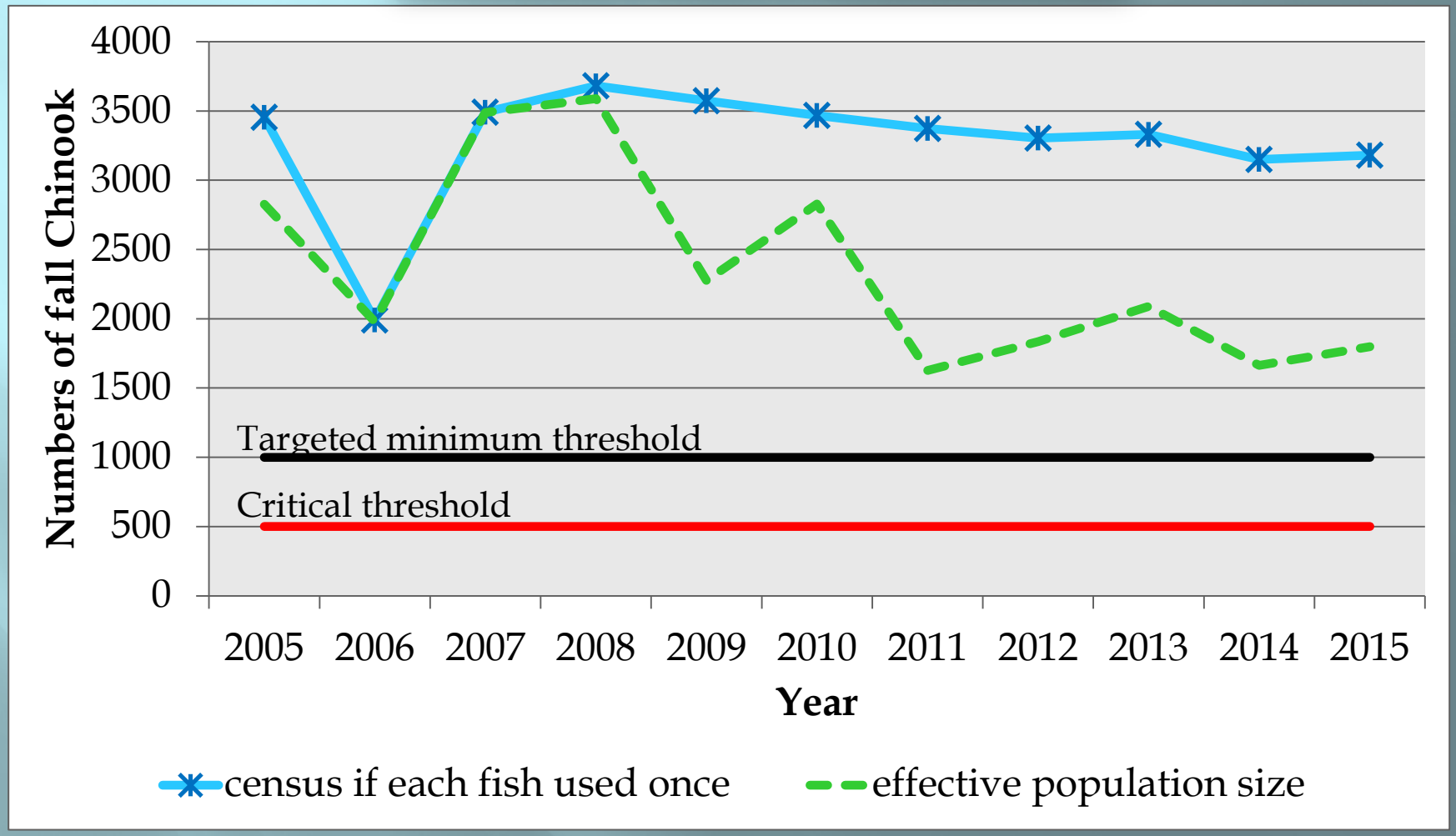


Broodstock 2010 - 2015



Effective spawning population size

LFH and NPTH combined

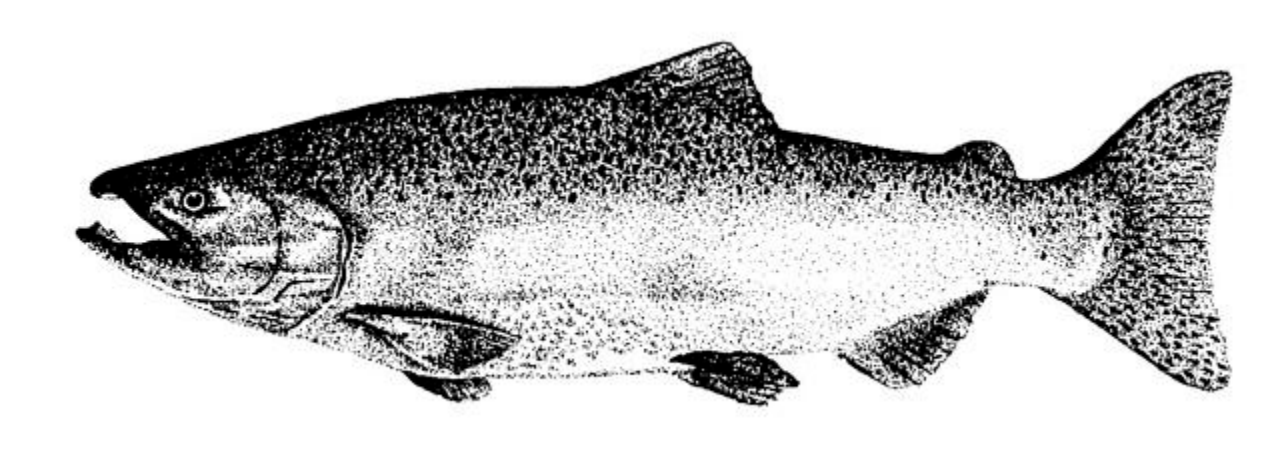


Busack, C. 2007. Aquaculture, doi:10.1016/j.aquaculture.2007.03.027

Results

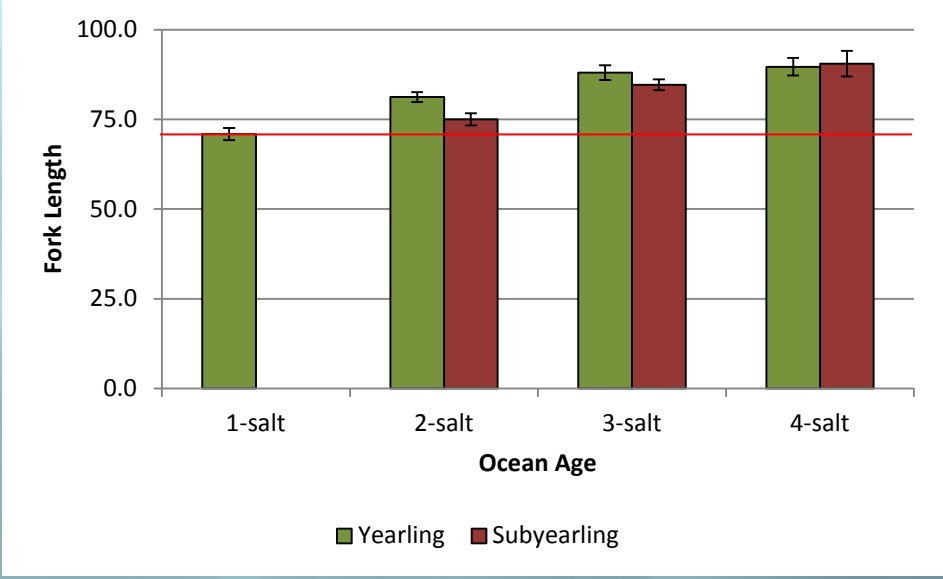
- Since 2010 the contribution of older aged broodstock has increased
  - Jacks and jills (1 salt) reduced from 34% to 1%
  - 3- and 4-salt increased from 16% to 41%
- Effective number of breeders (Nb) was greater than the target level of 1,000
- Future evaluations will assess population changes in age-at-return

Questions?

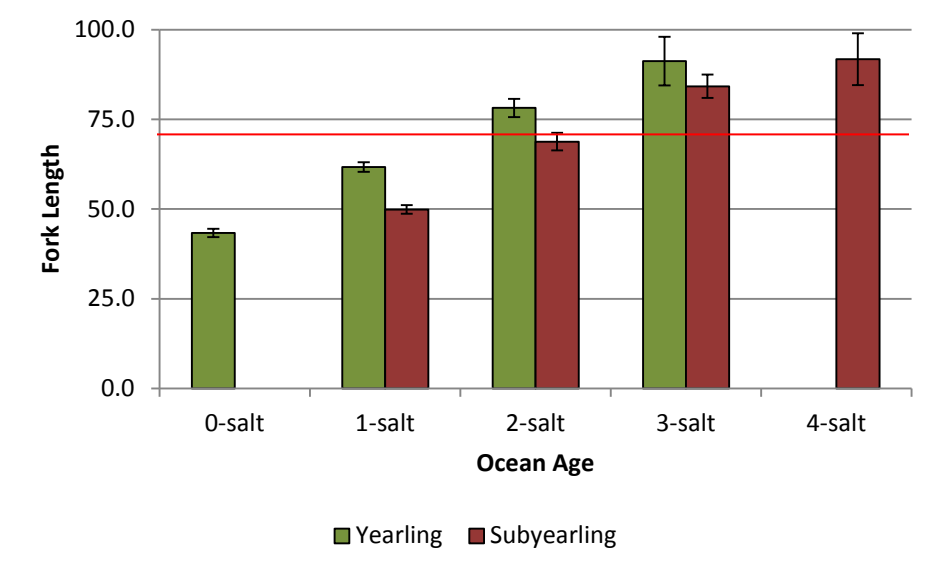


Size at age of return

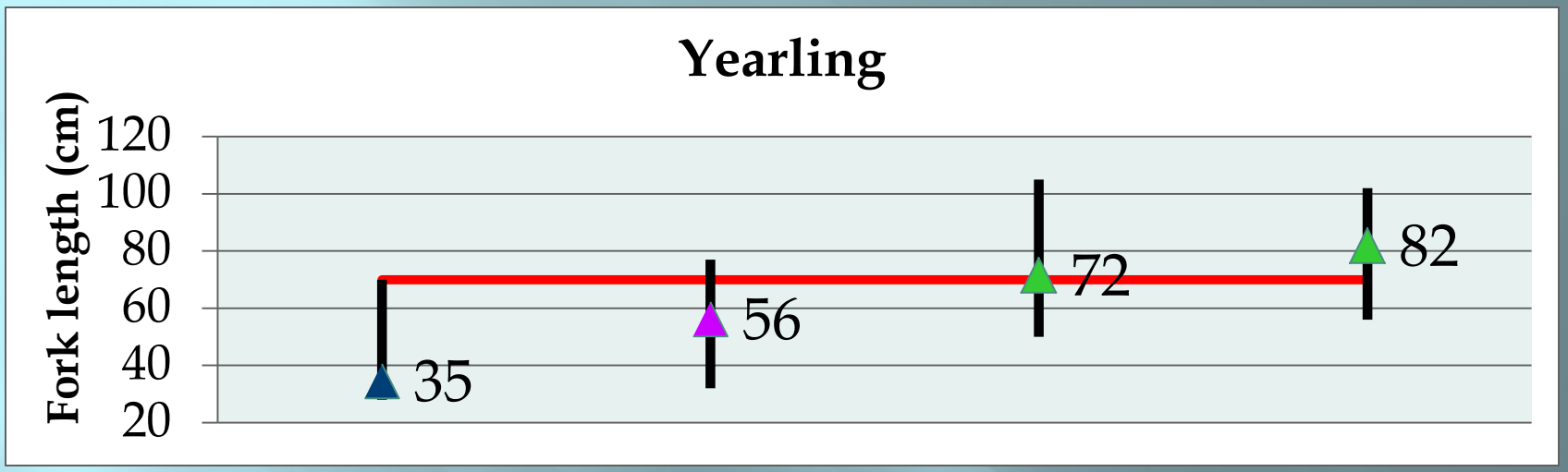
Females

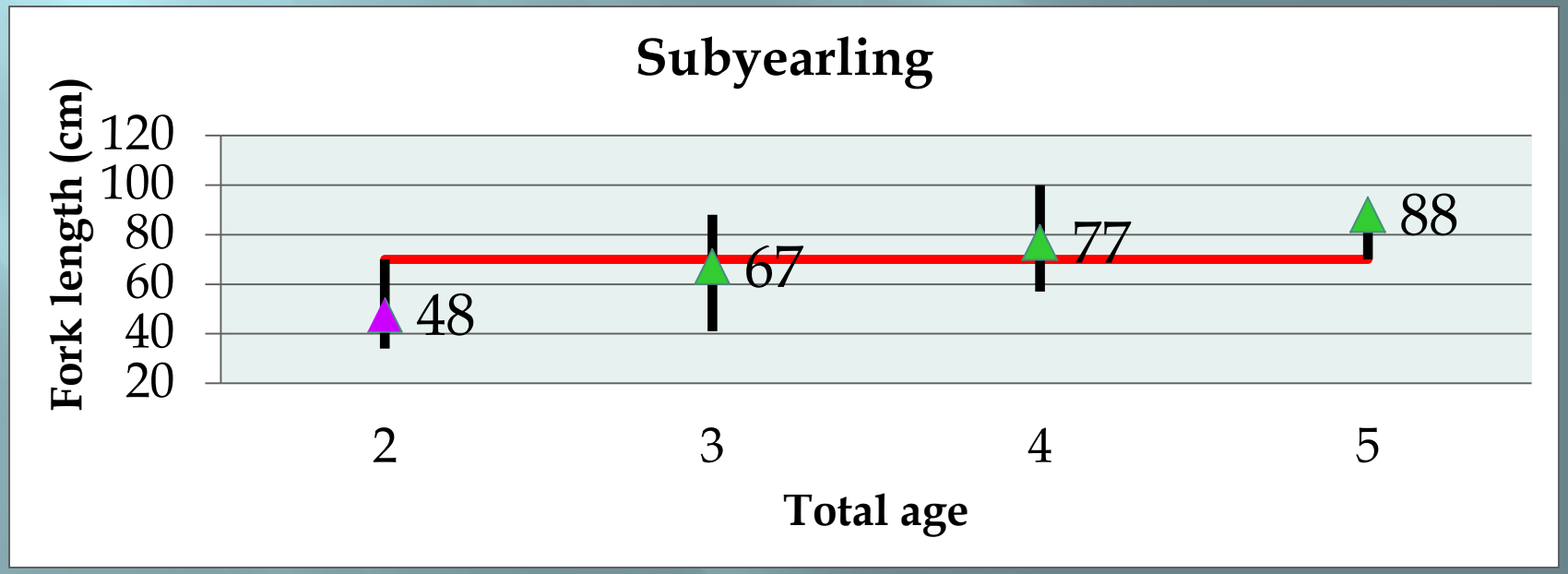


Males

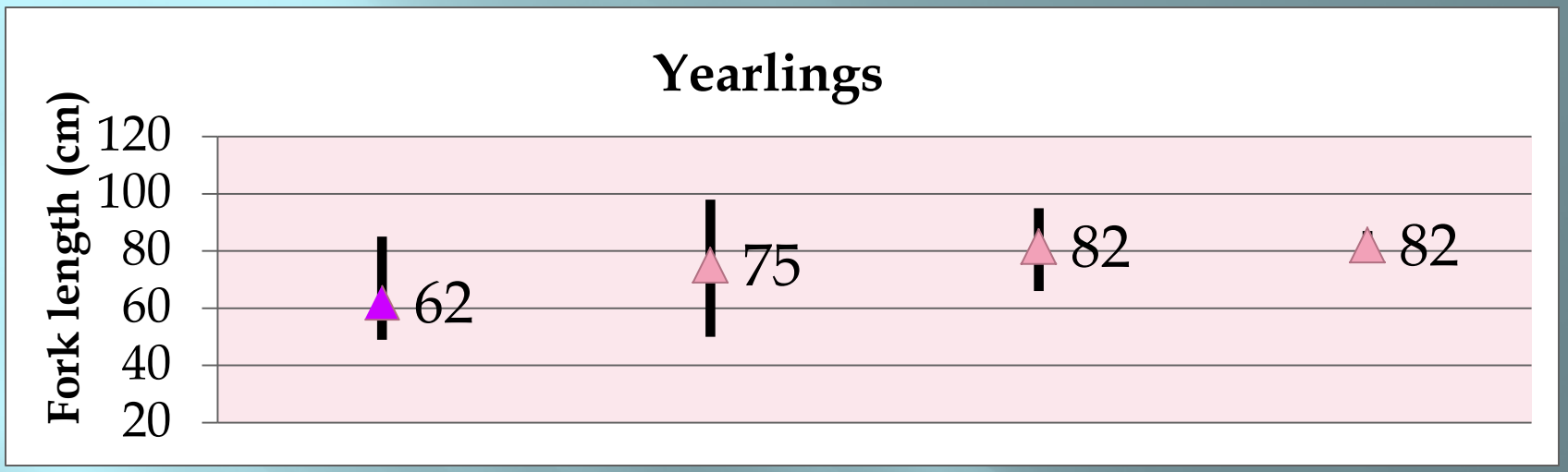


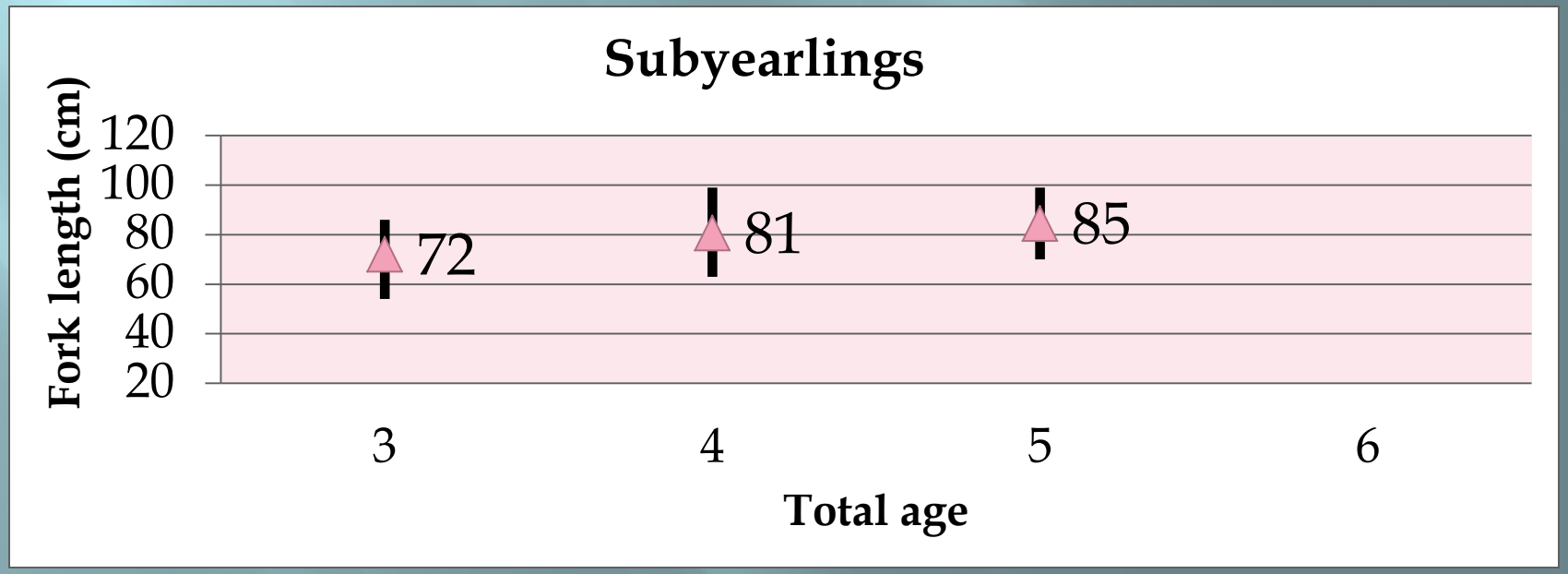
Male size at age of return 2010–2015



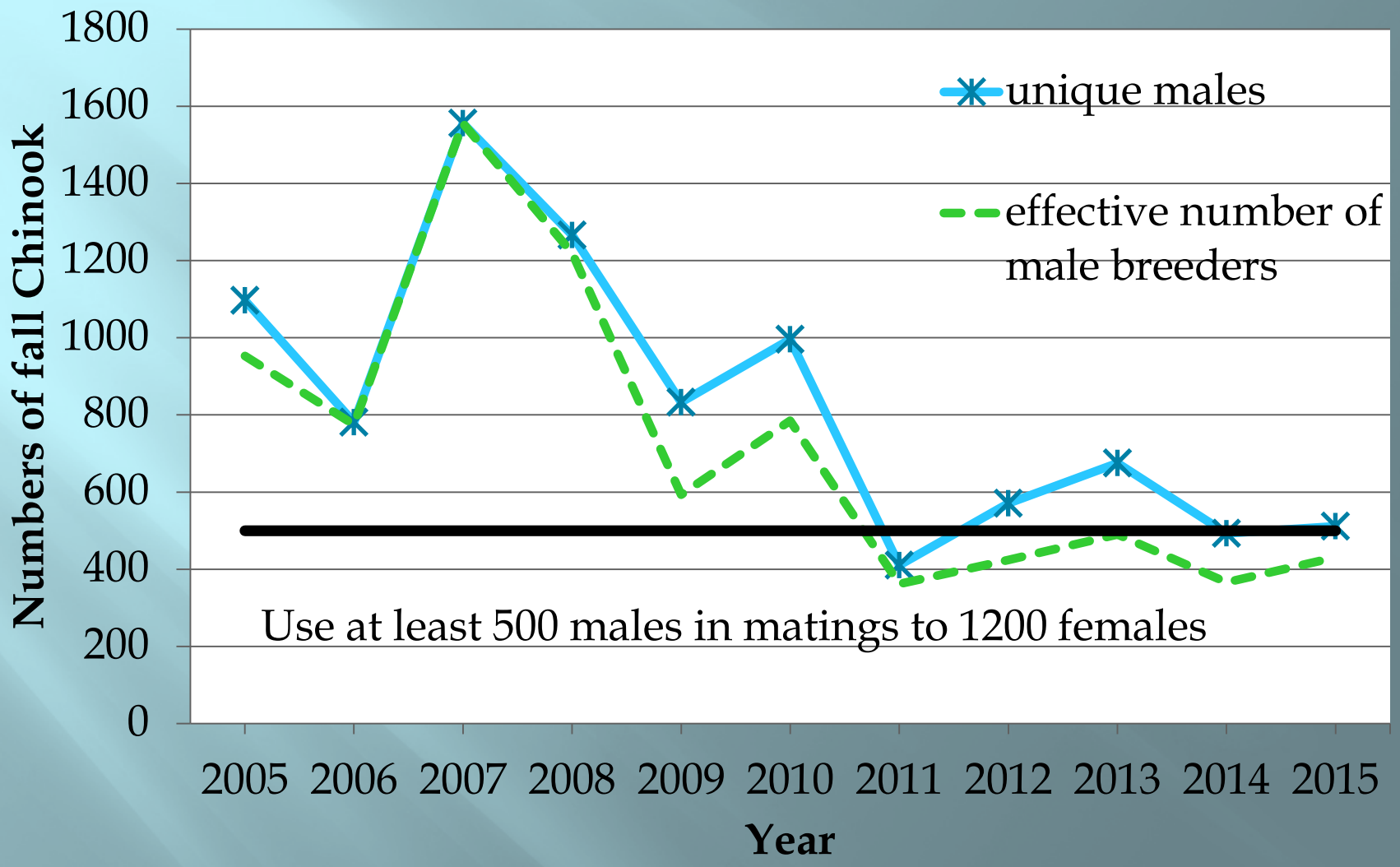


Female size at age of return 2010-2015





Males Spawned at LFH



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Jacks in nature

- Chinook jack male breeding/reproductive success

Study	Breeding groups	Life stage	Jacks in population	% of total offspring produced		Relative success Jack/male	
	n		range	mean	range	mean	range
Berntson et al. unpbl.	5	Rs	10-14%	7%	2-13%	0.61	.22-1.09
Williamson et al 2010	2	Rs	10-61%	27%	8-47%	0.45	.18-.71
Schroder et al 2011	7	Bs	7-13%	3%	1-5%	0.25	.14-.47
Berejikian et al 2010	4	Bs	25-50%	20%	9-33%	0.56	.15-1.0
Overall	**18**		**7-50%**	**14%**	**1-47%**	**0.50**	**0.14-1.09**

Slide provided by Dr. Barry Berejikian NOAA, Seattle.

History

- 2003
  - Began including untagged fish from LGR Dam
- 2005
  - Began multiple use of males and jacks (broodstock shortage, LFH vs LGR maturity timing)
  - Consulted with WDFW geneticist, Craig Busack Ph.D. (determine impact of multiple use)

History

- 2010
  - Data review of jacks in broodstock by age (over utilized through 2009)
- 2011
  - Targeted older aged males for broodstock (Hankin)
  - Mated equal or larger sized males with a female
- 2012
  - Heritability of age and length by sex

Effective Population size

Year	Number of unique males used	Number of males used multiple times	Effective number of male breeders (Nb)	% of census numbers of males	% of Nb if avoided reuse
2005	1097	324	953	86	65
2006	781	5	775	98.6	99.2
2007	1556	0	1556	100	-
2008	1266	39	1220	96.4	93.3
2009	833	213	593	71.2	45.9
2010	996	150	785	78.8	63.4
2011	410	379	362	88.2	28.9
2012	571	348	424	74.2	35.8
2013	675	334	490	72.6	39.5
2014	493	331	366	74.2	31.5
2015	511	413	431	84.4	35.9
Average					

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Why?

- Prior to 2003 natural-origin fish were excluded from broodstock
  - Conserve Snake River fall Chinook genetic diversity by minimize the incorporation of untagged hatchery strays
- Heritability may negatively affect age- and size-at-return
- Male limited during the spawning day
  - "Guessing" numbers of males needed to spawn