
Patterns and trends in age composition and
size-at-maturity for hatchery- and natural-origi
Imnaha River Chinook salmon
LOWER SNAKE RIVER COMPENSATION PLAN
Hatchery Program
State of OREGON
Fish & Wildlife
NEZ PERCE TRIBE
TREATY OF 1855

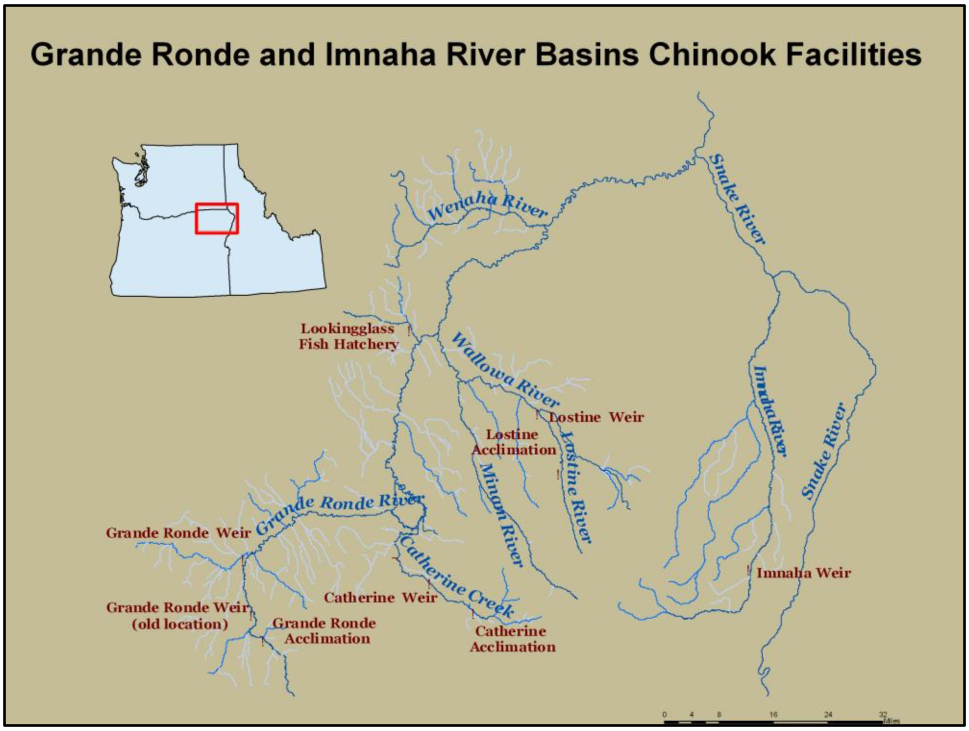
Imnaha River Chinook

- Between 1962 and 1976 four dams were built on the Snake River, resulting in Imnaha River Chinook salmon being listed as threatened under the ESA.
- In 1984, ODFW began releasing hatchery smolts to augment natural Imnaha River Chinook salmon.
- Some objectives of the program:
  - Establish a self-sustaining population of natural Imnaha River Chinook.
  - Maintain genetic and life history characteristics of the natural population.
  - Re-establish historic tribal and recreational fisheries.

Presentation Outline

- Trends in mean ages and age composition of Imnaha Chinook
- Mean length (size-at-age) and changes
- Spawner and recruit age relationships, and some surprises; quick look at age composition and SARs
- Jacks Gone Bad – age composition and run predictions
- Relationships with ocean conditions; new adult return prediction models
- Conclusions and future challenges

I’m going to cover a number of things the other presenters have today, as well as spawner/recruit relationships, age composition and what happens to run predictions when age comp is skewed, and relationships with ocean conditions .

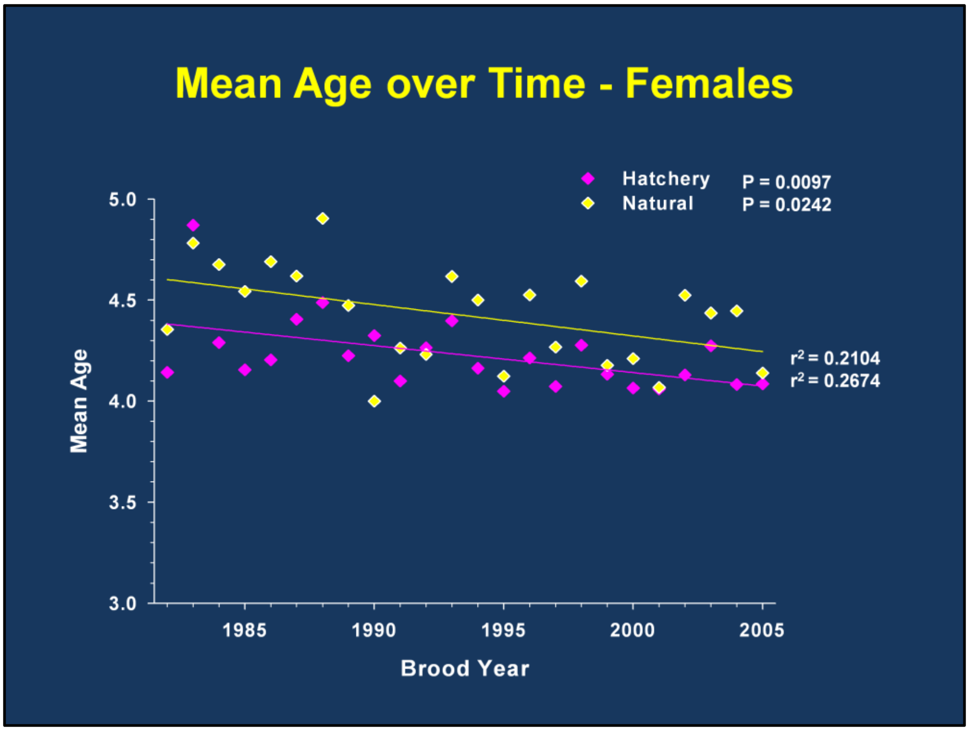


The obligatory map – the Imnaha River is a tributary of the Snake.

Trends in Mean Age Imnaha Chinook
Brood Years 1982 - 2005

Origin	Direction of Change	P value	r^2
<u>Total</u>			
Hatchery		0.6685	0.0085
Natural		0.1851	0.0784
<u>Males</u>			
Hatchery		0.3171	0.0455
Natural		0.5299	0.0182
<u>Females</u>			
Hatchery	↓	0.0097	0.2674
Natural	↓	0.0242	0.2104

On my slides, the salmon color illustrates a significant result.

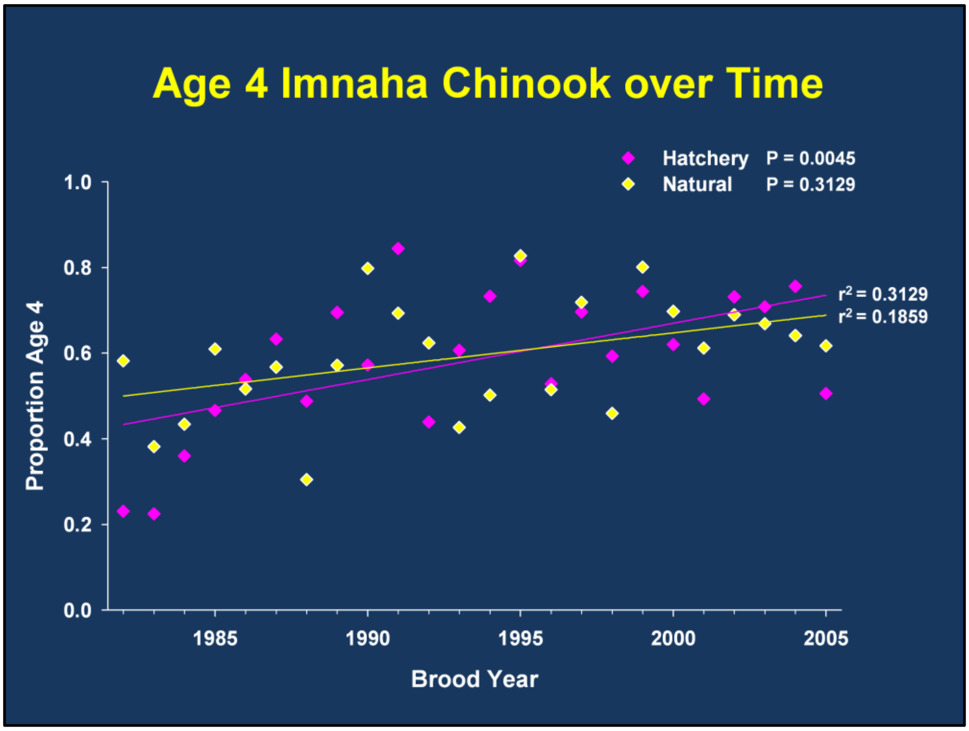


Females are getting steadily younger.

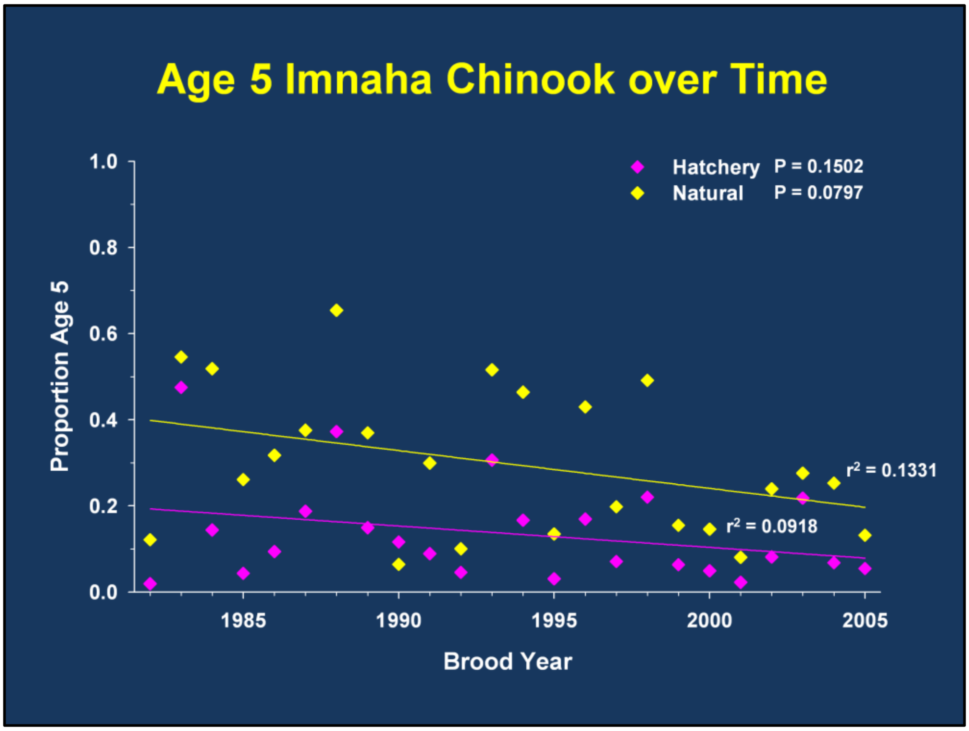
Trends in Age Composition
Brood Years 1982 - 2005

Origin/Age Class	Change in Proportion	P value	r^2
Hatchery 3		0.1151	0.1090
Natural 3		0.8330	0.0021
Hatchery 4	↑	0.0045	0.3129
Natural 4	↑	0.0419	0.1859
Hatchery 5		0.1502	0.0918
Natural 5	↓	0.0797	0.1331

The proportion of age 4s is increasing in both hatchery and natural fish; we are losing our age 5 natural fish.



Here are our age 4s over time; like the tortoise, slow but steady.

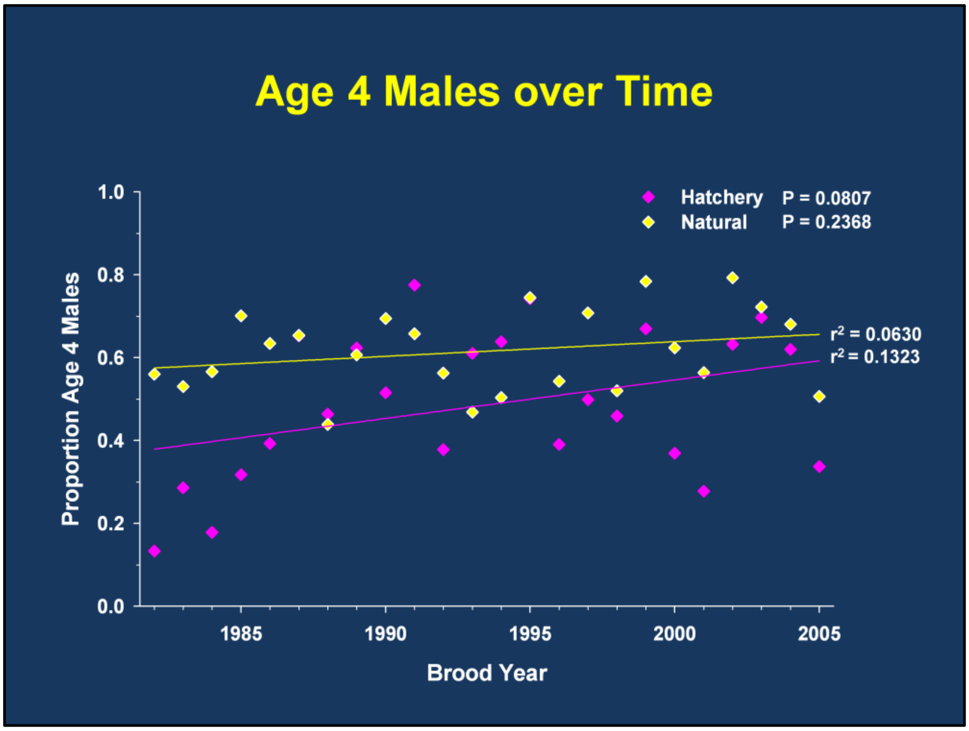


Here is our decline in age 5s.

Trends in Age Composition – Males
Brood Years 1982 - 2005

Origin/Age Class	Change in Proportion	P value	r^2
Hatchery 3		0.1708	0.0835
Natural 3		0.8858	0.0010
Hatchery 4	↑	0.0807	0.1323
Natural 4		0.2368	0.0630
Hatchery 5		0.7749	0.0038
Natural 5		0.3390	0.0416

Seeing more age 4 hatchery males.

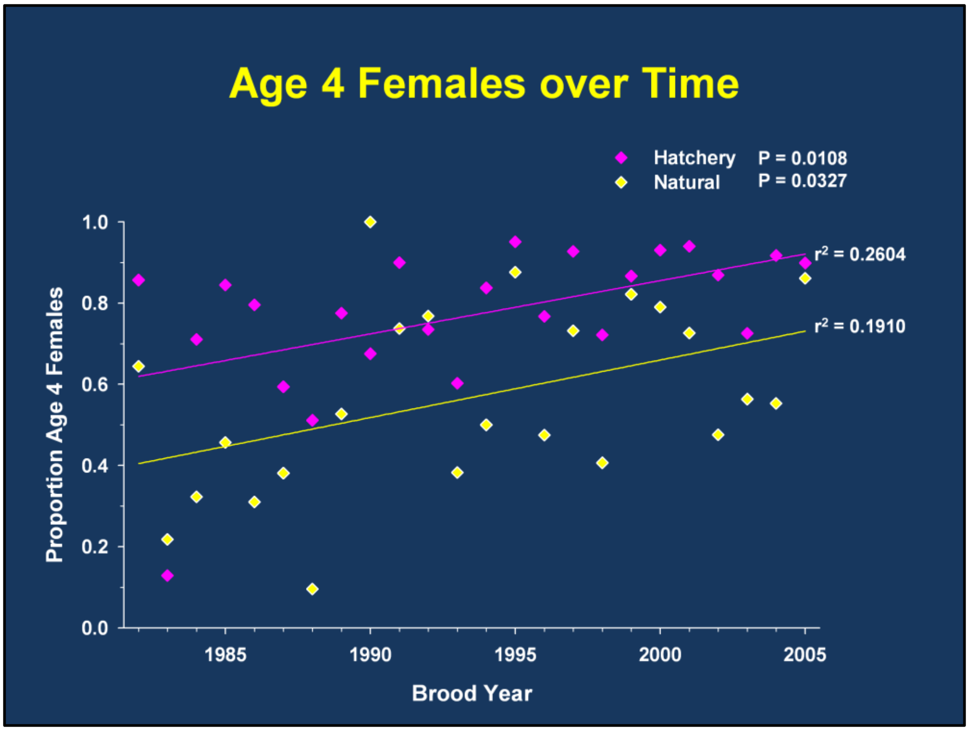


We are seeing more age 4 hatchery males, but not natural males.

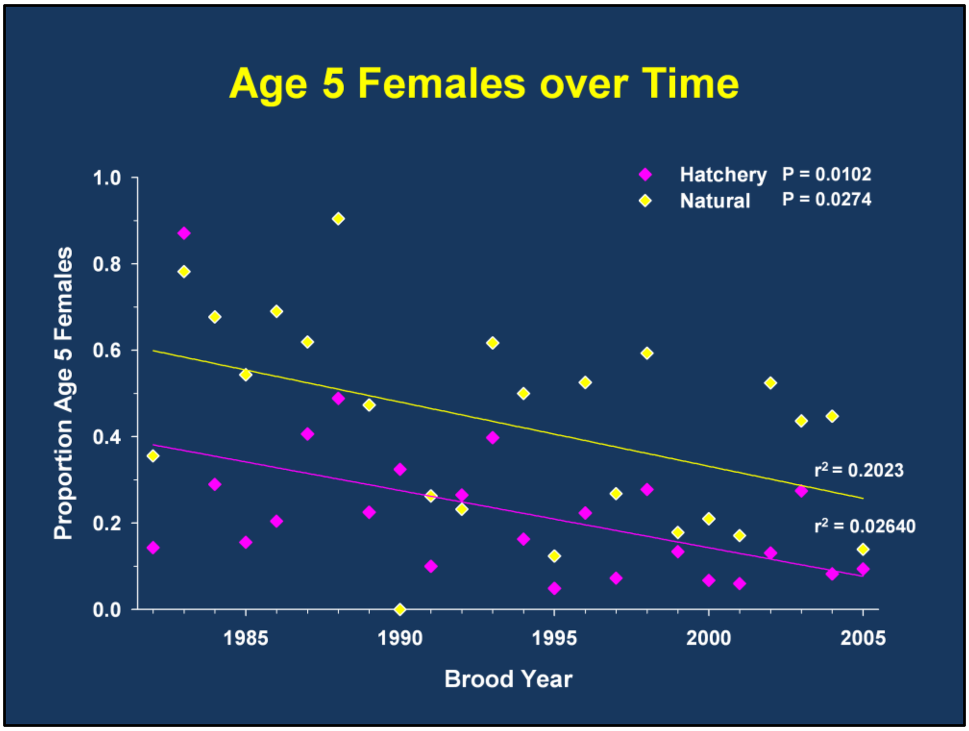
Trends in Age Composition – Females Brood Years 1982 - 2005

Origin/Age Class	Change in Proportion	P value	r^2
Hatchery 4	↑	0.0108	0.2604
Natural 4	↑	0.0327	0.1910
Hatchery 5	↓	0.0102	0.2640
Natural 5	↓	0.0274	0.2023

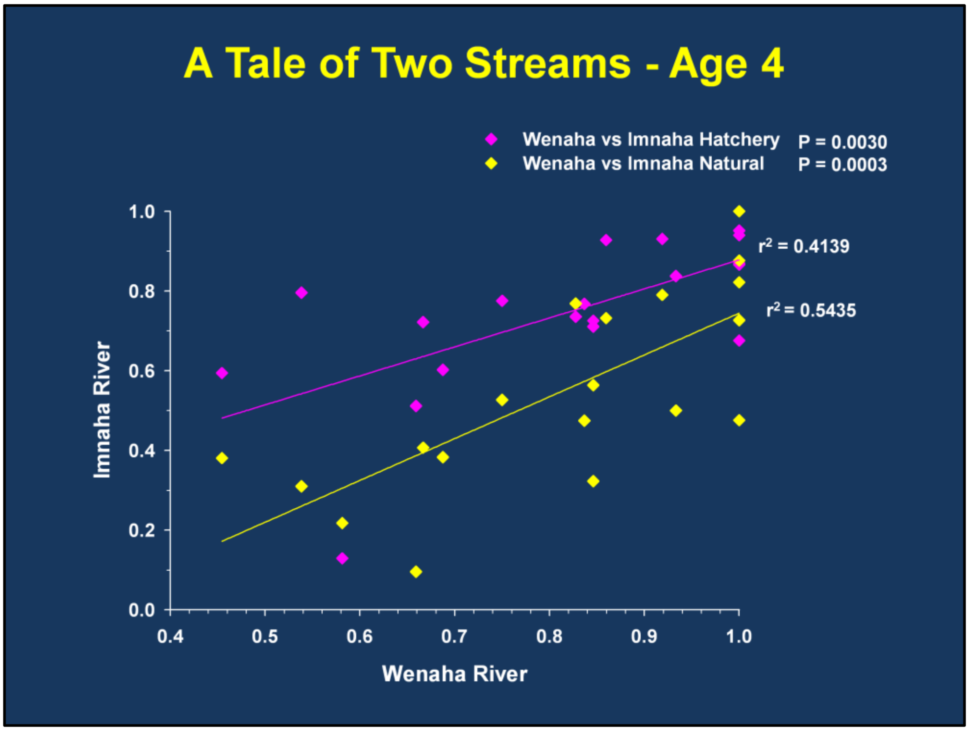
. there is a lot going on with females.



We have gained about 20% more age 4s over the brood years shown.



Here is the corresponding decline in age 5s – alsom over 20%.



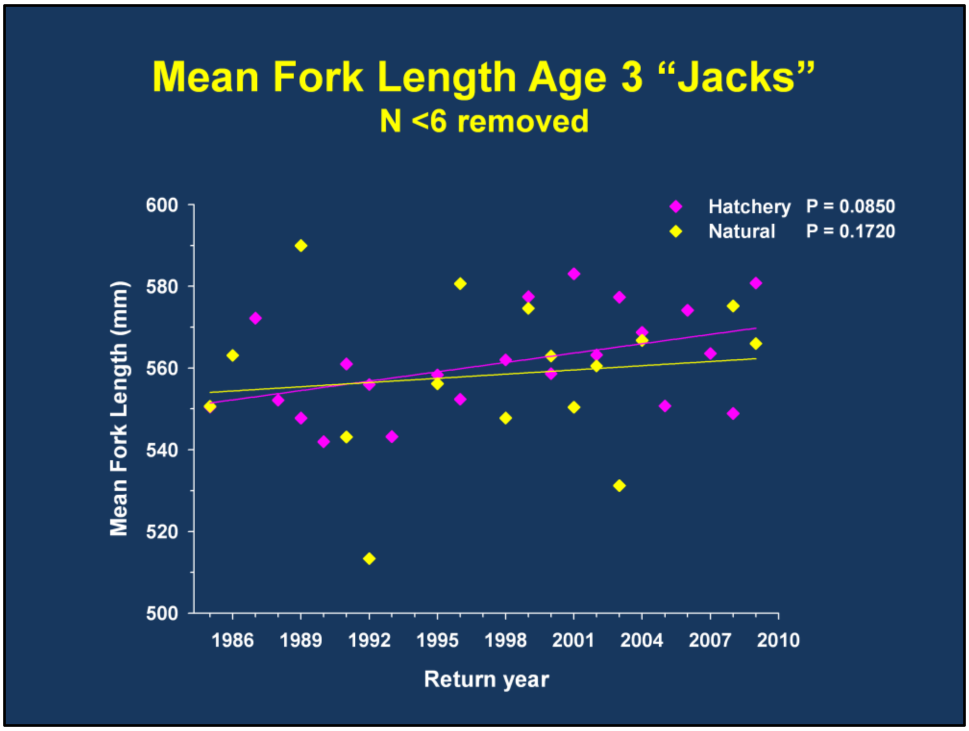
Looked at the Wenaha and Minam, two of our most pristine streams. They have never had a hatchery program, and generally have lower levels of hatchery straying. Yet we saw the same thing – proportion of age 4s is increasing. Can't say it's not a hatchery effect, but we can't say that it is..

Mean Length
Return Years 1985-2009

	Hatchery P-value	Natural P-value
Age 3	**0.085↑**	0.172
Age 4	**0.012↑**	0.813
Age 5	0.995	0.735

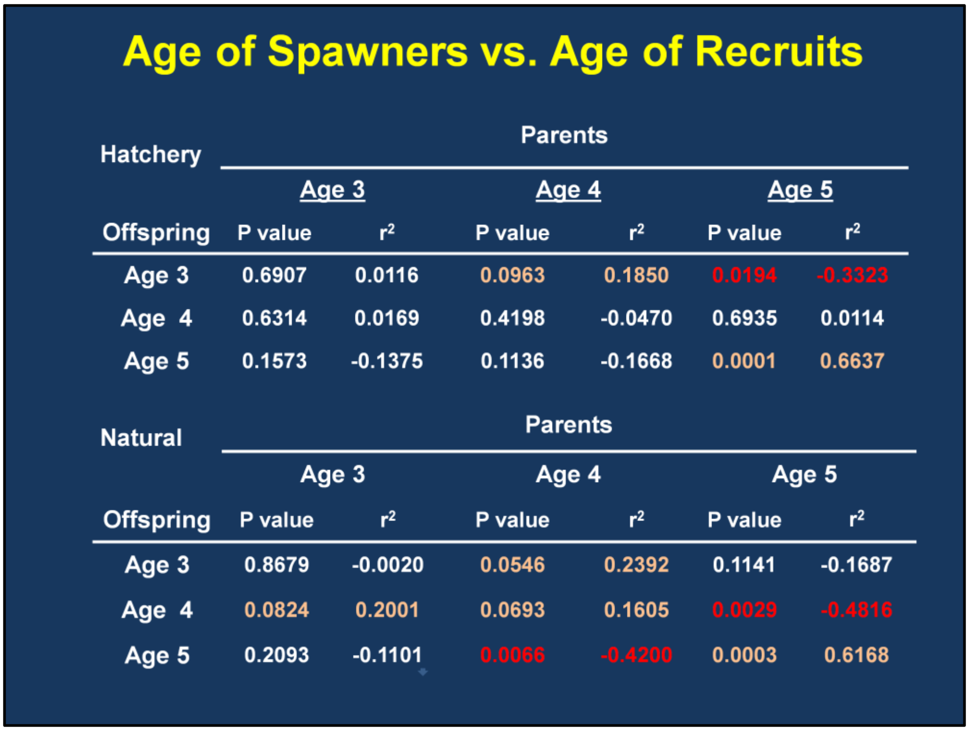
	Hatchery		Natural	
	Male P-value	Female P-value	Male P-value	Female P-value
Age 4	**0.101↑**	**0.097↑**	0.751	0.403
Age 5	0.468	0.84	0.245	0.471

Return years – not brood years. Jacks are getting bigger, as are our age 4 hatchery fish of both sexes. We see no corresponding change in mean length of natural fish.



Rate of change is approximately 20 mm over these return years. Age 4 males and females are growing at a similar rate; their mean length has increased by approximately 25 mm over the same period .

Here is the problem in a nutshell. This is what we want, and this is sometimes what we get.



Age of Spawners vs. Age of Recruits

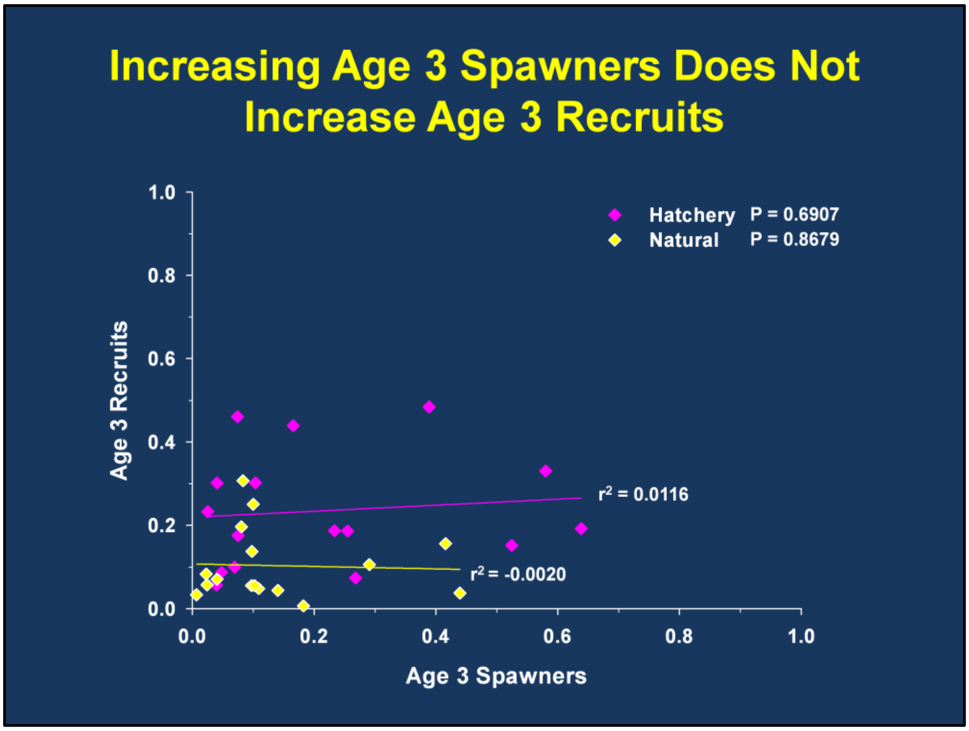
Hatchery

Offspring	Parents: Age 3 P value	Age 3 r^2	Age 4 P value	Age 4 r^2	Age 5 P value	Age 5 r^2
Age 3	0.6907	0.0116	0.0963	0.1850	0.0194	-0.3323
Age 4	0.6314	0.0169	0.4198	-0.0470	0.6935	0.0114
Age 5	0.1573	-0.1375	0.1136	-0.1668	0.0001	0.6637

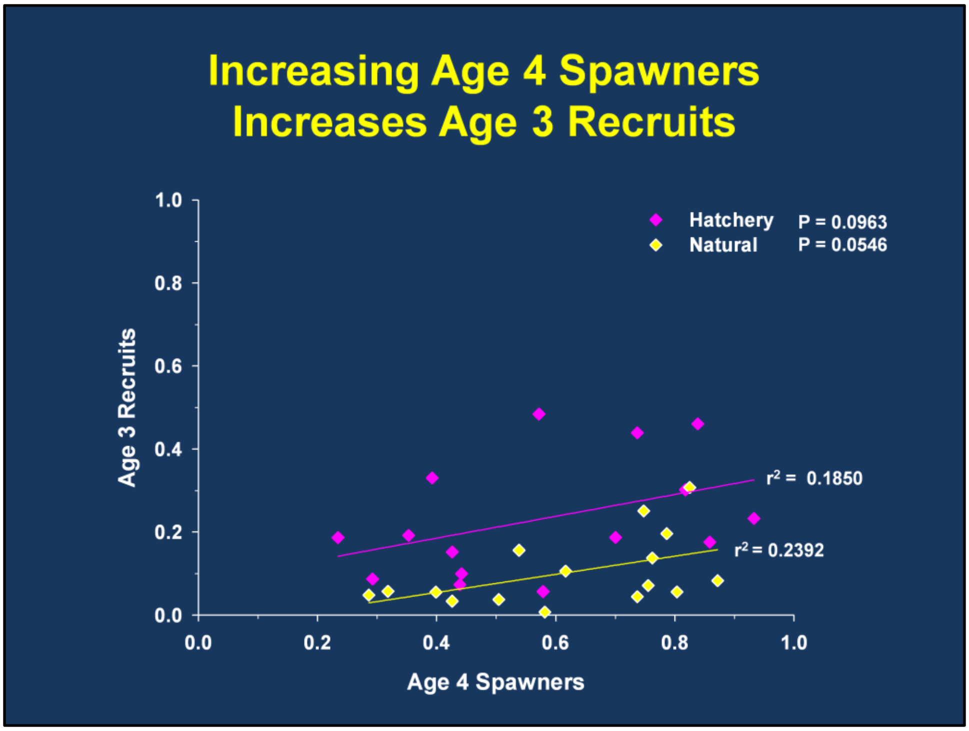
Natural

Offspring	Parents: Age 3 P value	Age 3 r^2	Age 4 P value	Age 4 r^2	Age 5 P value	Age 5 r^2
Age 3	0.8679	-0.0020	0.0546	0.2392	0.1141	-0.1687
Age 4	0.0824	0.2001	0.0693	0.1605	0.0029	-0.4816
Age 5	0.2093	-0.1101	0.0066	-0.4200	0.0003	0.6168

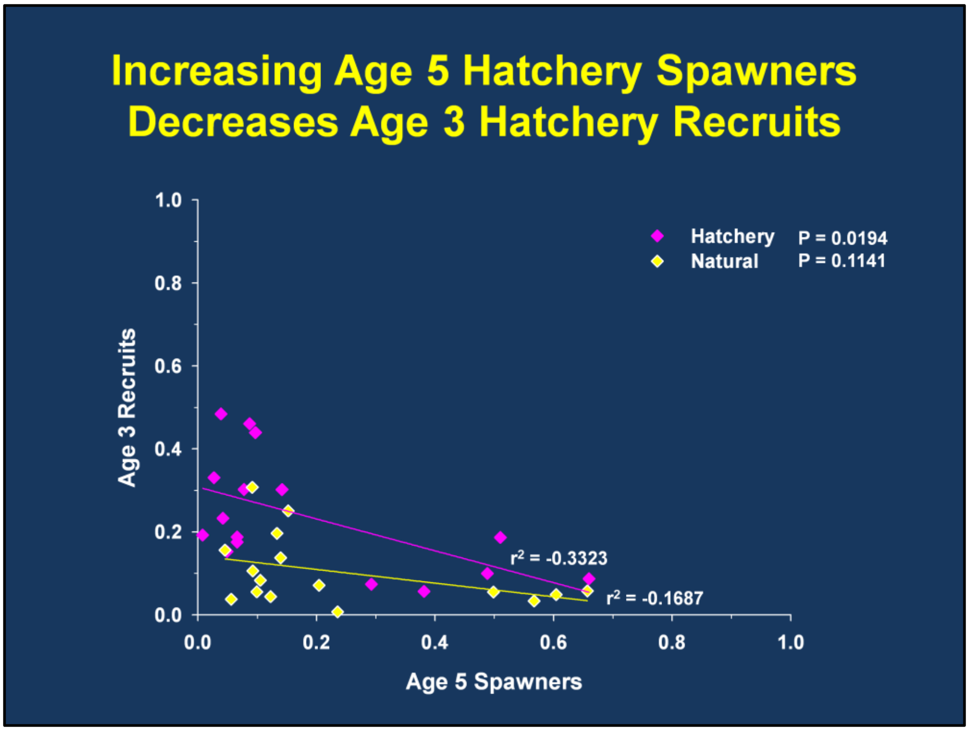
Pool of all spawners for one year – have age 3, 4 and 5. Pool all the offspring from the same spawn year – also have age 3, 4 and 5. All this slide does is show the relationship between the pool of spawners and the pool of their recruits. Significant negative relationships are in red.



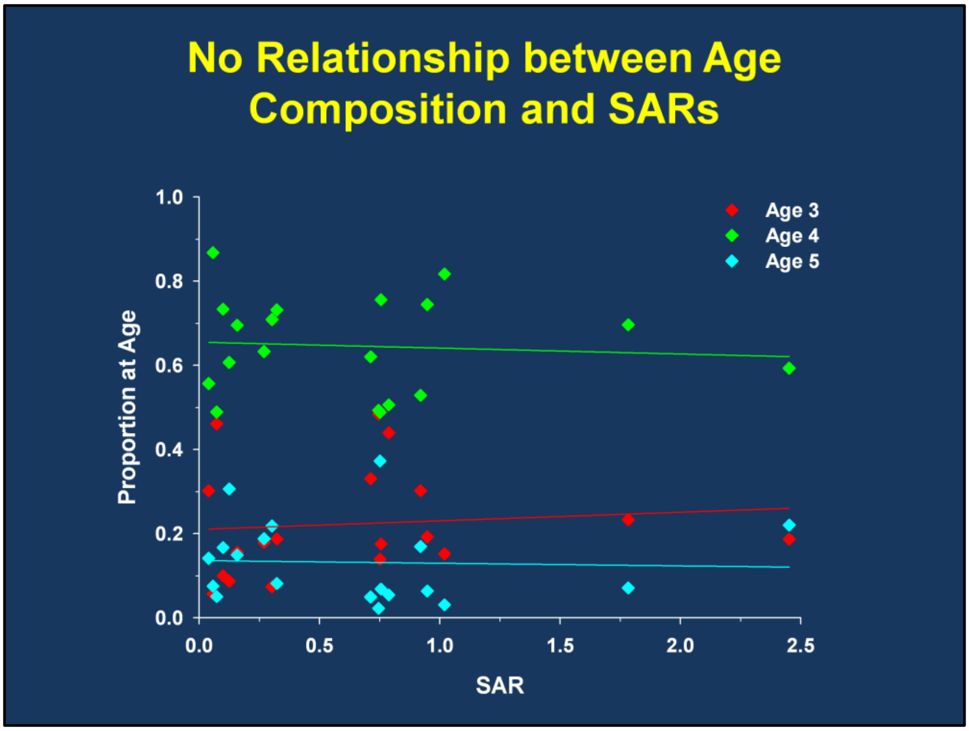
These are not raw numbers, but proportions. **No relationship between proportion of proportion of jacks spawned and proportion of jacks produced!!** This was a surprise. In the Imnaha hatchery program, we have often pooled jacks (spawn several jacks together as one male) to decrease their contribution. However, that may not be necessary.



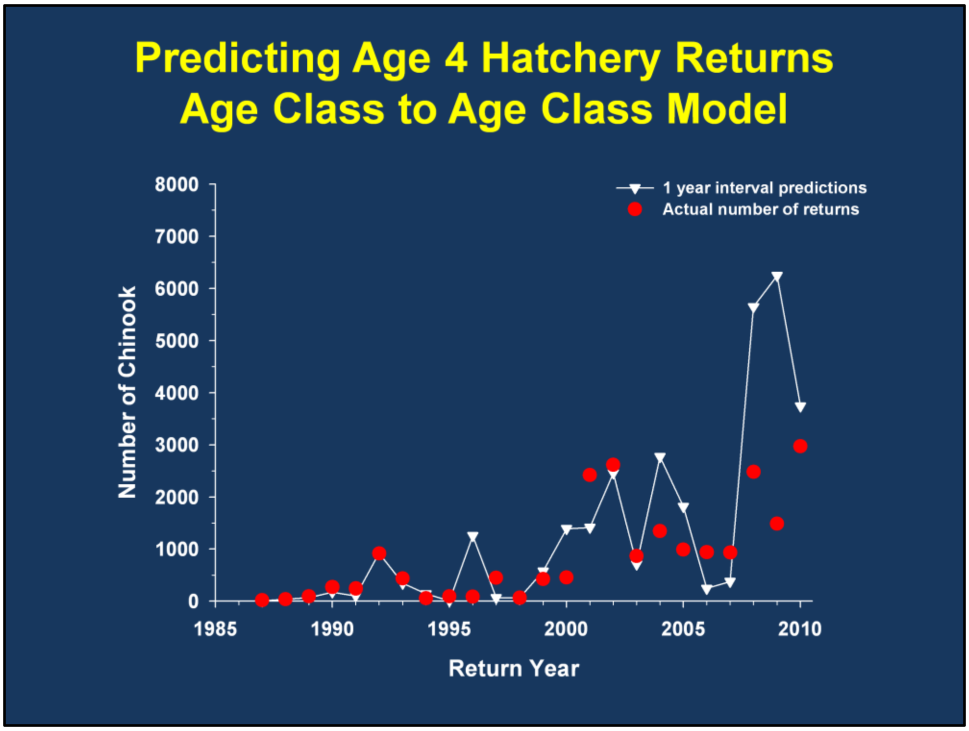
More surprising. More age 4 spawners produce more age 3 recruits. Keep in mind that proportion of age 4 Chinook is increasing in both our hatchery and natural populations. So if this holds true, we would expect to see more jacks.



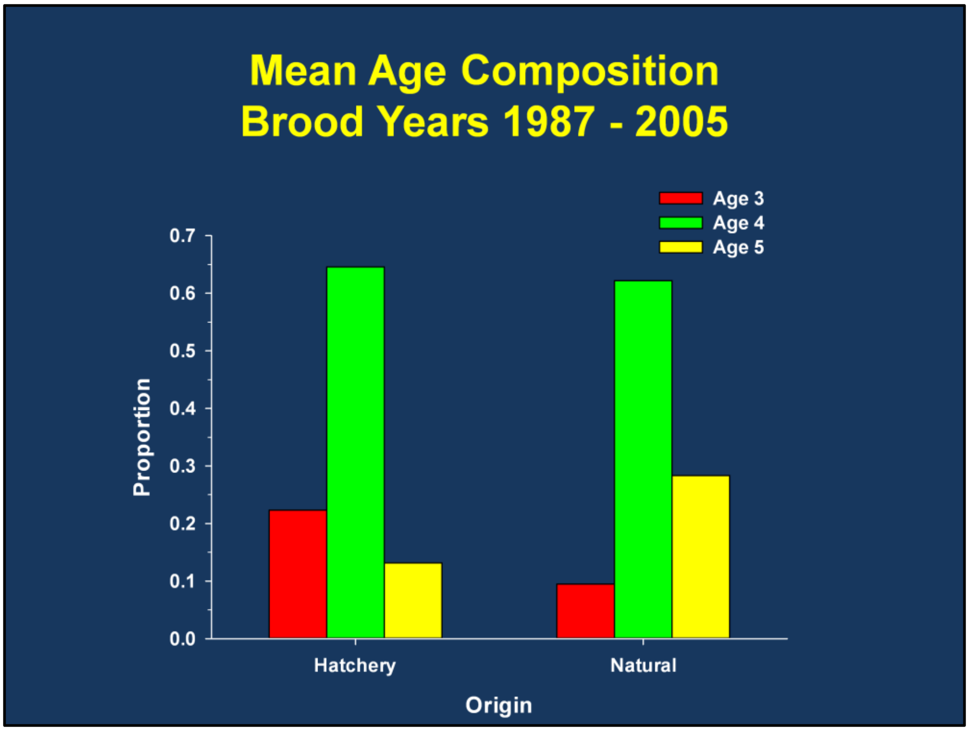
And then, finally, increasing the proportion of age 5 hatchery spawners decreases the proportion of hatchery jacks; if we want to produce fewer jacks, we should be spawning more age 5s



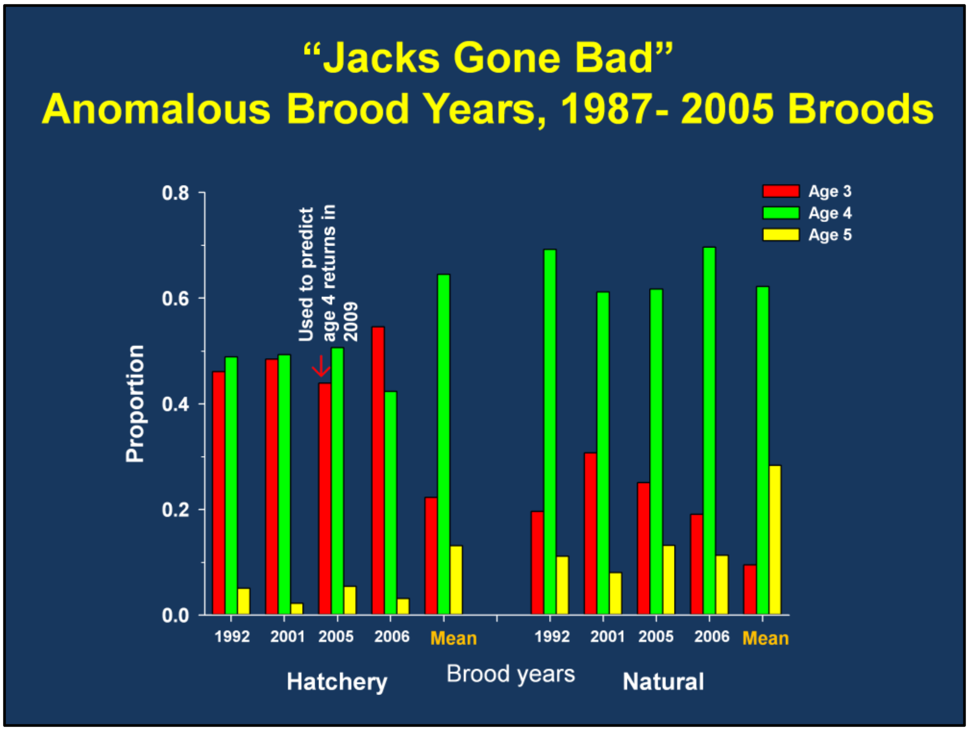
Absolutely no relationship between age comp and smolt to adult returns.



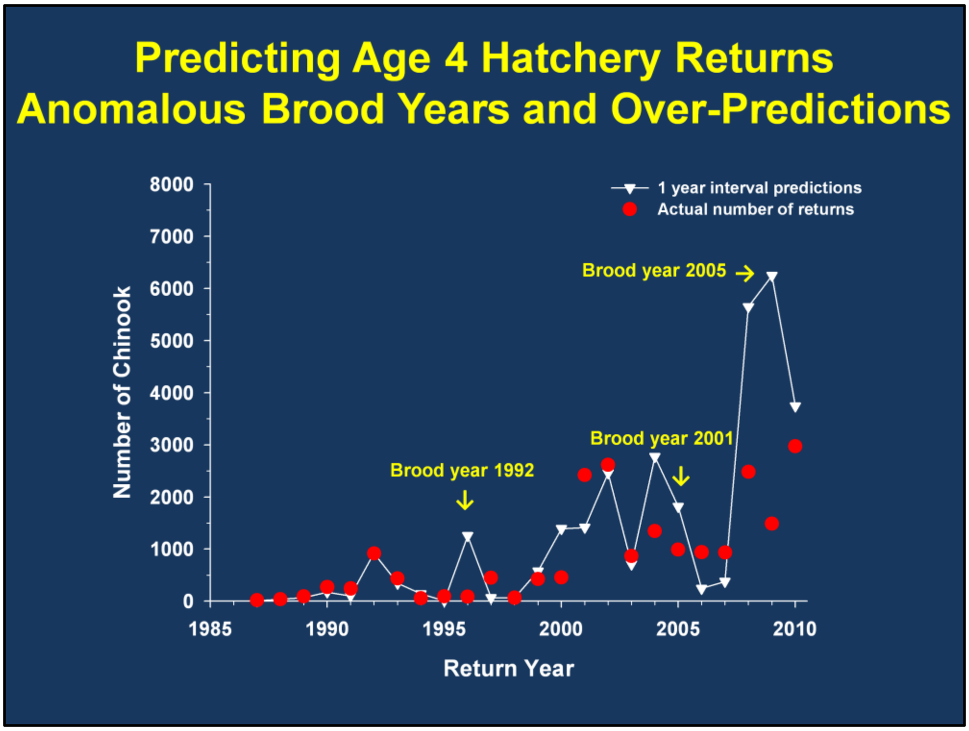
Our run predictions affect a whole host of management activities and decisions, so it is important that they are accurate. Jacks are important because we base our predictions on conversions from one age class to another, and age 3 fish are the base of the pyramid.. This age-to-age model has been refined and honed a bit, but it has worked well for years. Things fell apart in 2008 and 2009, when we substantially over-predicted returns. This understandably created a lot of chaos….so we asked, “what happened?”



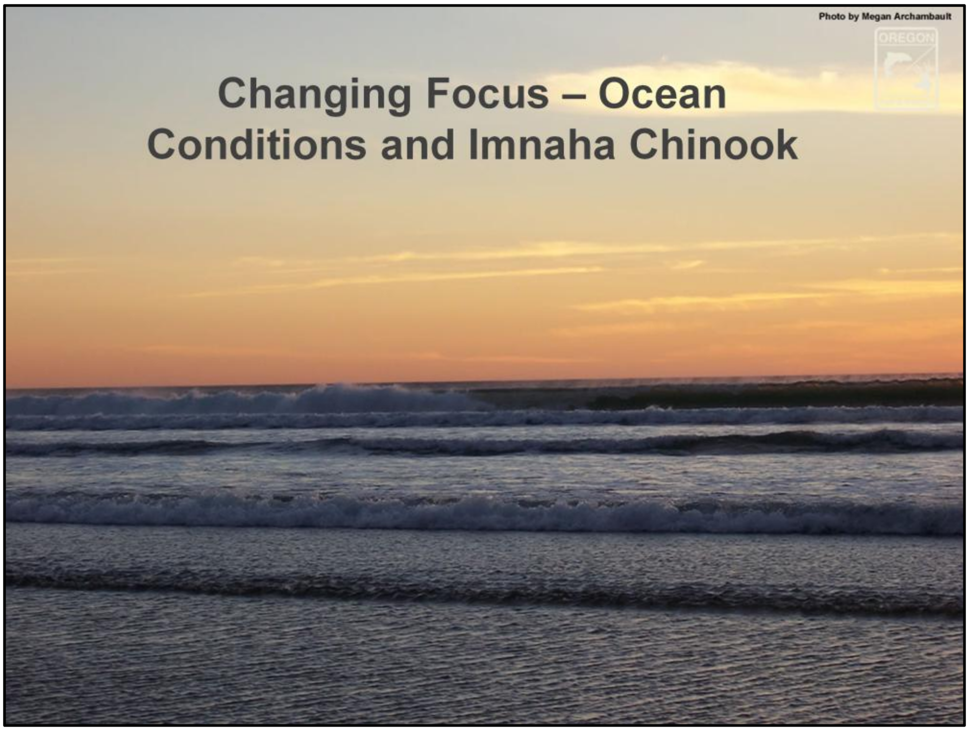
Hatchery jack component is usually about 22%; natural jacks closer to 11%.



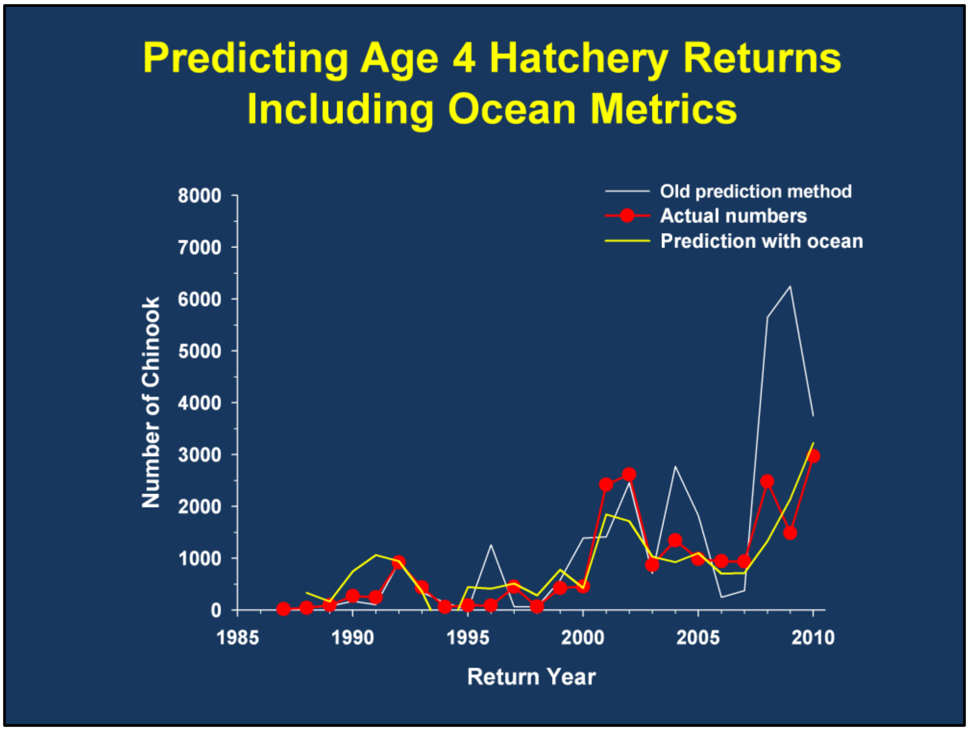
These are 4 brood years in which the proportion of jacks was much higher than average. How can fluctuations in age composition affect our predictions? Our worst prediction is for 2009. Broody ear 2005 age 3s were jacks in 2008.. These fish were used to estimate the age 4 returns in 2009. Look at the difference between the mean (22%) and proportion of jacks in brood year 2005 (47%).



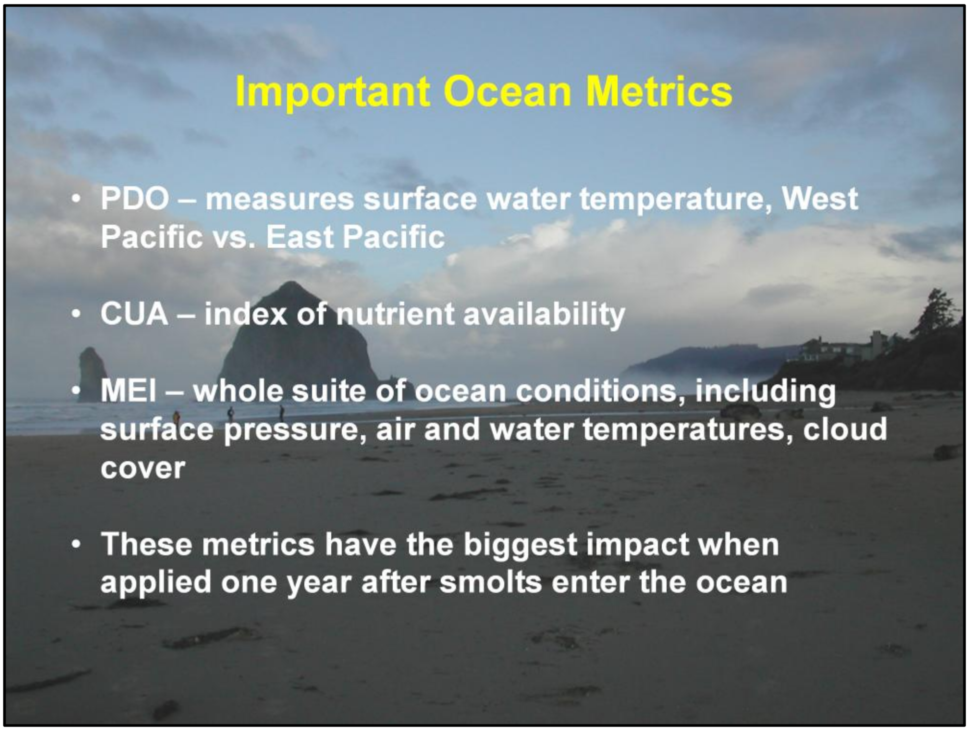
We plot our anomalous brood years against their age 4 returns." The yellow are brood years with a higher-than-normal proportion of jacks. However, this does not explain our over-prediction in return year 2004 , or the huge overprediction in 2008. Age composition is not the only part of the story..



we are going to talk about ocean conditions.   NOAA , in particular, has been doing a lot of work looking at ocean metrics. Joseph has been incorporating these metrics into our prediction model.



Voila! White is original prediction, red is actual, yellow is new prediction method including ocean metrics. Follows along nicely amd we lose all this nonsense in 2008 and 2009.

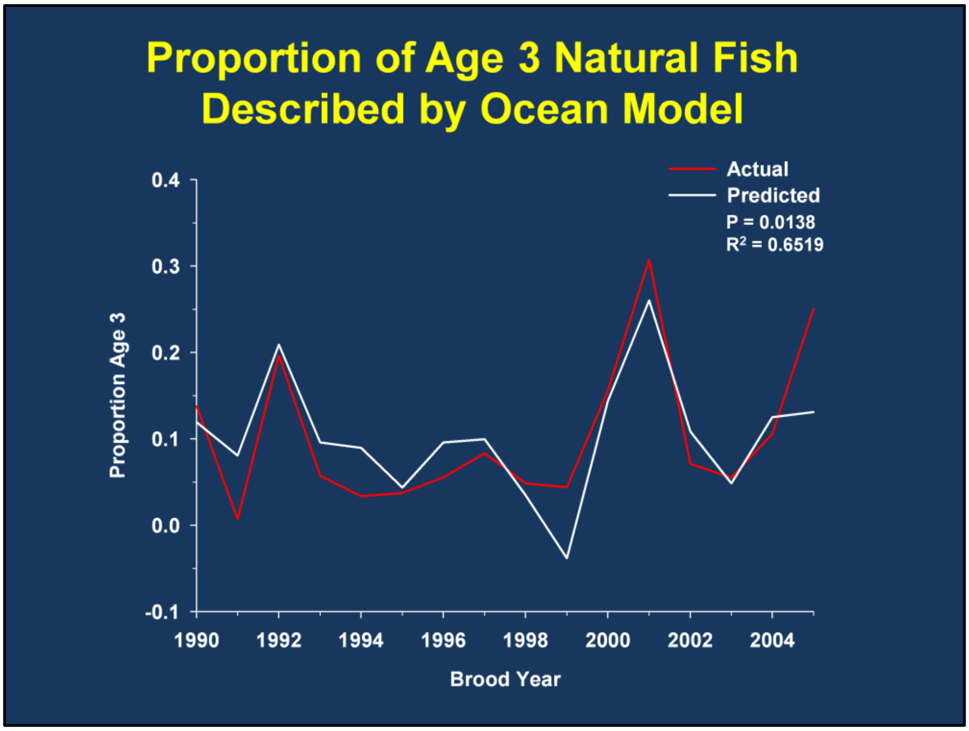


What are we looking at?
We use 3 metrics:

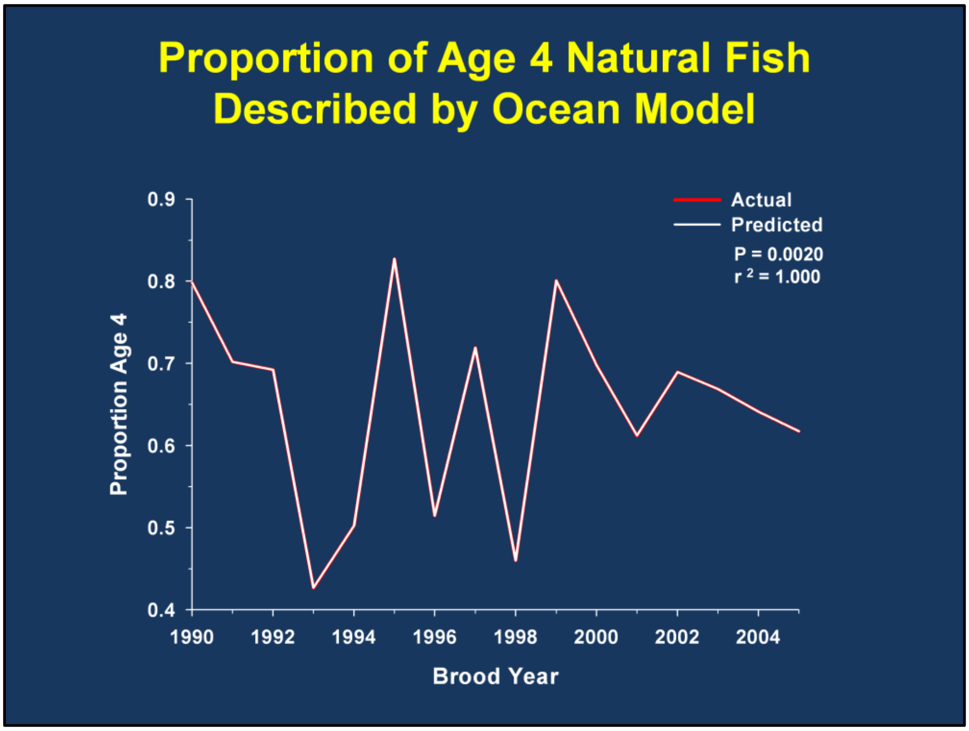
Origin and Age Class Proportions/Brood Year Described by Ocean Conditions Model

Hatchery			Natural		
Age 3	Age 4	Age 5	Age 3	Age 4	Age 5
$P=0.0025$	$P<0.0001$	$P=0.0013$	$P=0.0138$	$P=0.0020$	$P<0.0001$
$r^2=0.8056$	$r^2=0.9936$	$r^2=0.7809$	$r^2=0.6519$	$r^2=1$	$r^2=0.8703$
Variables	Variables	Variables	Variables	Variables	Variables
CUA JAN	PDO DEC-MAR	CUA MAR-JUL	CUA JAN	PDO DEC-MAR	CUA JAN
CUA NOV	PDO MAY-SEP	CUA MAY	CUA AUG	PDO MAY-SEP	CUA JUL
MEI MAR	CUA APR-MAY	CUA JUL	CUA NOV	CUA MAR	CUA NOV
MEI APR	CUA MAR	CUA12	CUA12	CUA APR	% NAT Age 4
MEI OCT	CUA APR			CUA AUG	
	CUA SEP			CUA SEP	
	CUA NOV			CUA OCT	
	MEI JAN			CUA NOV	
	% HAT Age 3			CUA DEC	
				MEI JAN	
				MEI FEB	
				MEI OCT	
				MEI DEC	
				% NAT Age 3	

Don't let variables overwhelm you – these are the ocean metrics I just described. Tim has taken these variables and used them to describe the proportions of each origin/age class in our brood years, over time. I want you to focus on the P values and r squared – all relationships are all relatively strong. Relationships are between the model and actual proportion of each age class.



This is the weakest relationship of all the ocean models; there is a little slop, but it still follows reasonably well. We do lose a bit of our fit in recent broodyears.



One of the variables used to construct this model is the percent age 3s, which you won't know if we are going to use this model as a predictor. Even if we remove the % Age 3 variable, the model still has an r squared of .99, which means it will be an excellent predictor of the proportion of natural age 4 Chinook in a brood year. So Joseph is developing a model for numbers of fish returning, and Tim is developing a model for proportion of origins and age classes we expect in a brood year. We now have two very good complementary tools to use for run predictions.

Conclusions

- **The proportion of age 4 Chinook is increasing, and we are losing age 5s.**
- **Mean length of age 3 fish and age 4 hatchery fish is *increasing*.**
- **Increased size of age 4 hatchery females may help balance loss of productivity resulting from the higher proportion of younger females.**
- **Relationships between age of spawners and age of recruits are complicated.**
- **Ocean metrics can explain much variation in adult returns, and can also help predict them accurately.**

This is a concern because older, bigger fish have greater fecundity; don’t want to lose that productivity.

Challenges

- The proportion of age 4 Chinook is increasing, and this may or may not be a hatchery effect.
- Increasing size of age 3 fish and age 4 hatchery fish makes it difficult to know which age fish we are collecting for broodstock/spawning.
- Increased proportion of age 4 spawners is expected to produce more age 3 recruits.
- Fewer age 5 spawners will continue to produce fewer age 5 recruits – how to break cycle?
- We have gained much recent knowledge of how ocean conditions affect Imnaha Chinook, but we need to keep building on this knowledge.

As we gain age 4s, we will have an increased proportion of age 4 spawners, which are expected to produce more jacks. And the flip side of that is, as we lose our age 5s, we will be spawning a decreasing proportion of age 5 spawners, which in turn will produce a decreasing proportion of age 5 recruits. How do we break the cycle? GOOD NEWS/BAD NEWS on ocean conditions.


Fish drive us crazy!!!
Cabela's