Scale ageing procedures:

Scales are aged using a microfiche reader (Microfilm ScanPro 300i with 24x and 54x lenses). Scales are typically read, depending on my schedule, Friday afternoon or Monday following the previous week's sampling. Each card is placed into the microfiche reader and scales read beginning with the first scale in the column for the first Chinook salmon. Ageing is done using standard techniques (Johnston 1905, Gilbert 1913, Van Oosten 1929) with differences in growth, thickness, and distance between circuli used to differentiate freshwater and marine growth. I have done all scale ageing (Chinook, sockeye, steelhead) for the Columbia River Inter-Tribal Fish Commission since our scale ageing program began in 1985.

I first examine the scale for checks, which are areas of close circuli growth, which are often annuli formed during winter growth. A series of narrowly spaced circuli in freshwater growth indicates an annuli. There is often a check at the end of freshwater growth but, unless it is a hard check, I consider this an ocean entry check. Saltwater zones are aged similarly, with the harder checks considered annuli. Age data for scales is placed directly into a spreadsheet which also has sampling date, length, adipose clip, and relative maturation indicated. If I consider an age questionable, I note it in a comments field for possible review post-season.

When ageing, I take advantage of much of the data we collect about the fish being aged to come up with what I consider the most likely age. To do this, I lean heavily on a series of guidelines that I have developed over ageing almost 30 years of scales collected at Bonneville Dam.

Freshwater age

1.) Time of migration past Bonneville Dam is a strong predictor of freshwater age.
2.) Clipped spring and summer Chinook are overwhelmingly hatchery fish and hatchery fish are primarily yearling outmigrants. (The main exception is fall Chinook where some wild Hanford Reach fish are clipped as part of a coded wire have some clipped wild fish from the Hanford Reach and are primarily subyearling releases in hatcheries.)
3.) Unclipped summer Chinook last detected in the Snake River are more likely to be yearling outmigrants, while those last detected above Priest Rapids Dam are more likely to be subyearling outmigrants.

Total Age

4.) Length is a strong predictor of age, with some allowance for the time of migration.
5.) Coloration (and sex) can be useful in determining whether the last ocean annulus is resorbed.
6.) Chinook migrating earlier in the year (April) would be expected to have much less plus growth after the last annulus than those later in the year.
7.) Chinook with greater than two ocean annuli tend to have more oval scales and there is much less spacing between annuli than between the first and second annuli.

General Rules

8.) Age x.0 Chinook are tossed out as minijacks
9.) Dark fall Chinook migrating in September and October are referred to in the Columbia Basin as tules and not aged.

10.) Lengths that don't match scale ages or scale sizes are corrected (if an error is found or there is video to verify the length), or discarded.
11.) Do not assign unusual ages (2.x) or ages that strongly disagree with length and scale size unless the evidence presented by the scale appears overwhelming.

Freshwater age

1.) Time of migration past Bonneville Dam is a strong predictor of freshwater age.

In the Columbia Basin, Chinook salmon are divided into spring, summer, and fall runs. The conventional wisdom as follows:

a.) Spring Chinook migrate past Bonneville Dam in April and May, are yearling outmigrants, and wild origin fish spawn higher up in tributaries.
b.) Summer chinook salmon migrate past Bonneville Dam between June 1 and July 31 and spawn lower in Snake and Columbia river tributaries upstream of McNary Dam. Traditionally, summer Chinook from upstream of Priest Rapids Dam have been considered to be subyearling outmigrants while Snake River summer Chinook have been considered yearling outmigrants. With the ability provided by radio tags to track Chinook, many Chinook passing Bonneville Dam in early June have turned out to be Snake River spring Chinook, therefore management agencies have moved the June 1 cutoff for the start of the summer Chinook run to June 15. (We still summarize data using the old June 1 cutoff as this is more commonly used in the Columbia Basin.)
c.) Fall Chinook migrate past Bonneville Dam starting August 1, are generally subyearling outmigrants, and spawn in the mainstem Columbia River (primarily Hanford Reach between Richland, WA and Priest Rapids Dam) and in Hells Canyon on the Snake River.

Even if this run timing is not always true, if spring Chinook are yearlings, summer Chinook a mix, and fall Chinook subyearlings, it would be expected that there would be a relationship between migration timing and the ratio of yearlings and subyearlings which proves to be the case (Figure 1).

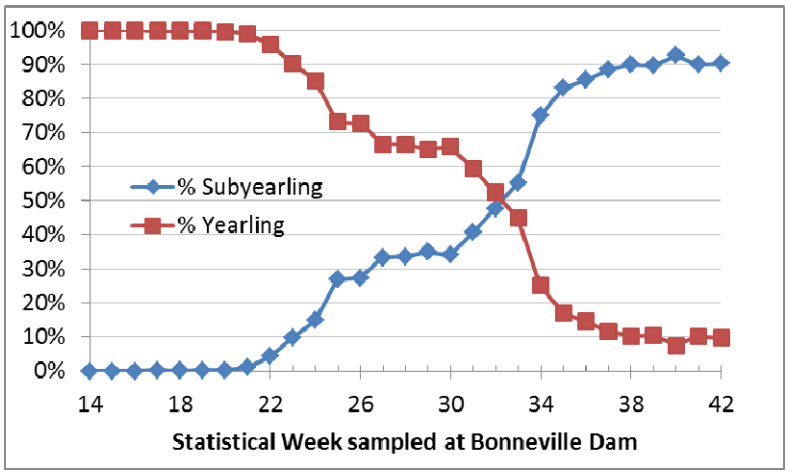


Figure 1 Percentage of the Chinook salmon run sampled at Bonneville Dam which is yearling and subyearling outmigrants 2003-2012.

I use this relationship as an aid in ageing scales. Early in the year I am more inclined to age such as fish as 1.x, later in the year, a 0.x.

2.) Clipped spring and summer Chinook are overwhelmingly hatchery fish and hatchery fish are primarily yearling outmigrants. Most of the Chinook salmon returning to the Columbia Basin are hatchery fish. And almost all spring and summer Chinook hatchery fish are released as yearlings. Even for stocks which may at one time have been predominantly subyearling outmigrants (e.g. summer Chinook above Priest Rapids Dam), yearlings are produced due to their higher survival to returning adults. Virtually all hatchery-origin spring and summer Chinook are fin clipped (generally adipose clipped).

Fall Chinook salmon are different from spring and summer Chinook in several respects:

a.) I run a coded wire tagging program with a goal of tagging and adipose fin clipping 200,000 juvenile fall Chinook. As far as I know, this is the only large scale program fin clipping wild Chinook upstream of Bonneville Dam.

b.) A much higher proportion of hatchery fall Chinook is not clipped than is the case for hatchery spring and summer Chinook.

c.) Most hatchery fall Chinook are released as subyearlings.

I use this relationship in ageing scales for which the freshwater age is uncertain. Unclipped fish I am more inclined to call subyearlings than clipped fish, especially in the June 1-August 1 timeframe.

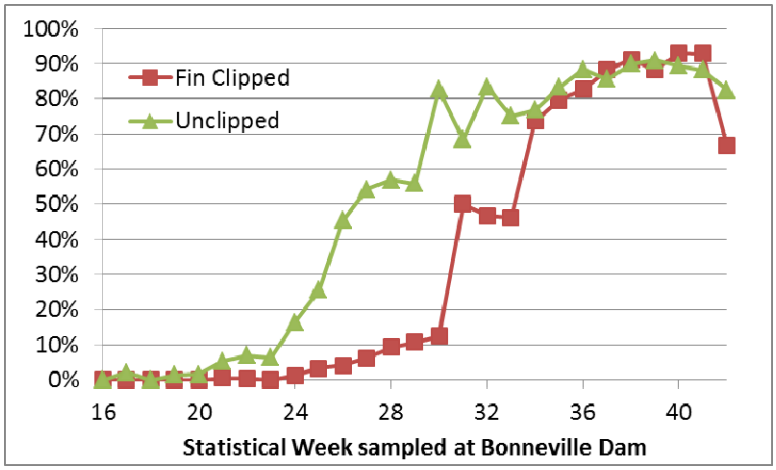


Figure 2. Percentage of fin clipped and unclipped Chinook salmon sampled at Bonneville Dam that are aged as being subyearlings in 2003-2012.

3.) Unclipped summer Chinook last detected in the Snake River are more likely to be a yearling outmigrant, while those last detected above Priest Rapids Dam are more likely to be subyearling outmigrants.

Given that we are PIT tagging almost all Chinook salmon at Bonneville Dam, I can use the final destination as an aid in ageing scales for which I am uncertain. If a summer Chinook is last detected upstream of Ice Harbor Dam, it is likely a yearling, while a summer Chinook last detected upstream of Priest Rapids Dam is more likely to be a subyearling.

Total Age

4.) Length is a strong predictor of age, with some allowance for the time of migration.

Spring Chinook

I have found length to be a key predictor of age, especially for spring Chinook. Spring Chinook can largely be aged by length alone, with those under 60 cm being Age 1.1, fish between about 63 and 80 cm Age 1.2, and over about 80 cm Age 1.3. The primary uncertainty is between about 77 cm and 82 cm where Chinook can be 1.2 or 1.3. Mean length-at-age and confidence intervals correspond with these general rules.

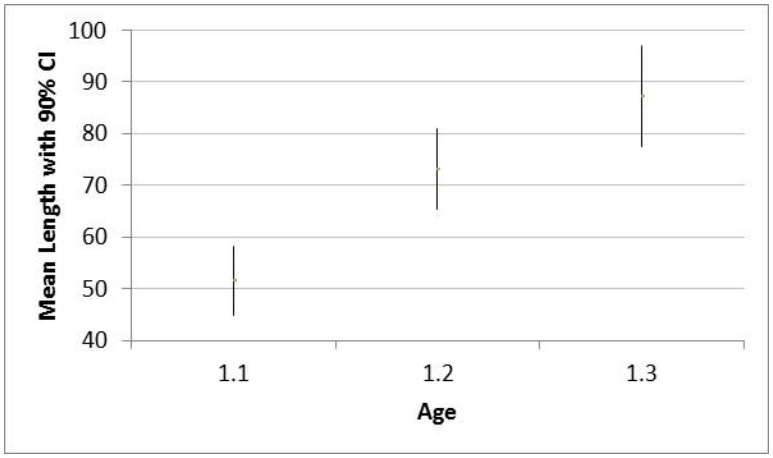


Figure 3. Length at age (with 90% c.i.) for spring Chinook sampled at Bonneville Dam 2001-2012.

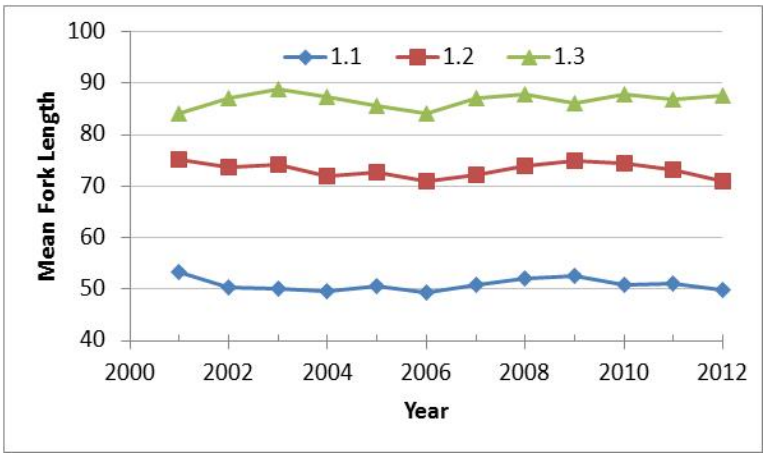


Figure 4. Mean length-at-age for spring Chinook sampled at Bonneville Dam by year 2001-2012.

Summer Chinook

There is not as great a separation in lengths between different age fish, even if they are separated into yearlings and subyearlings. Among subyearlings, there is a great deal of overlap between Age 0.3 and 0.4 Chinook, and a smaller overlap between 0.2 and 0.3. Among yearlings, there is a great deal of overlap between both 1.2s, 1.3s, and 1.4s.

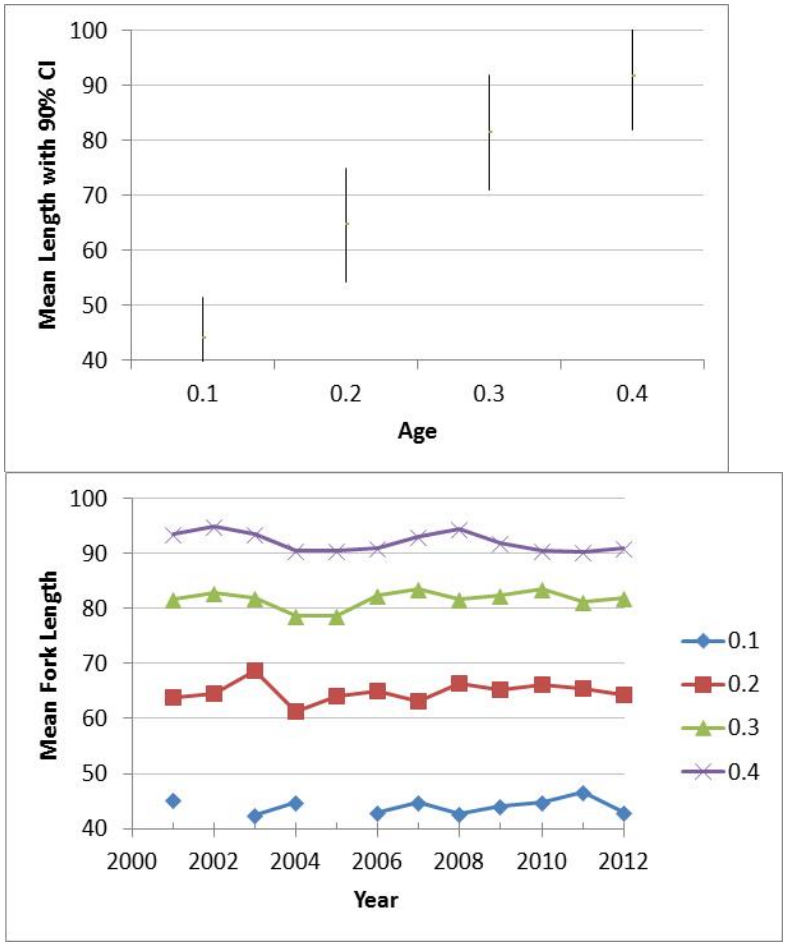


Figure 5 Mean length-at-age subyearling summer Chinook sampled at Bonneville Dam by year 2001-2012.

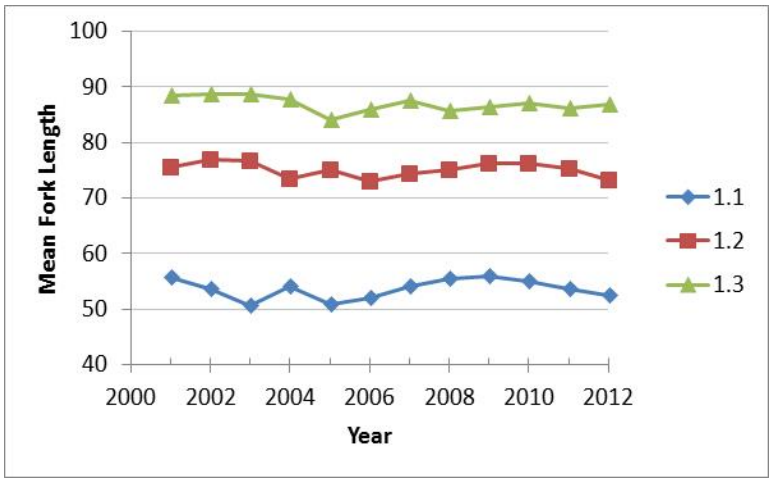


Figure 6. Mean length-at-age yearling summer Chinook sampled at Bonneville Dam by year 2001-2012.

Figure 7. .. Length at age (with 90% c.i.) for subyearling summer Chinook sampled at Bonneville Dam 2003-2012

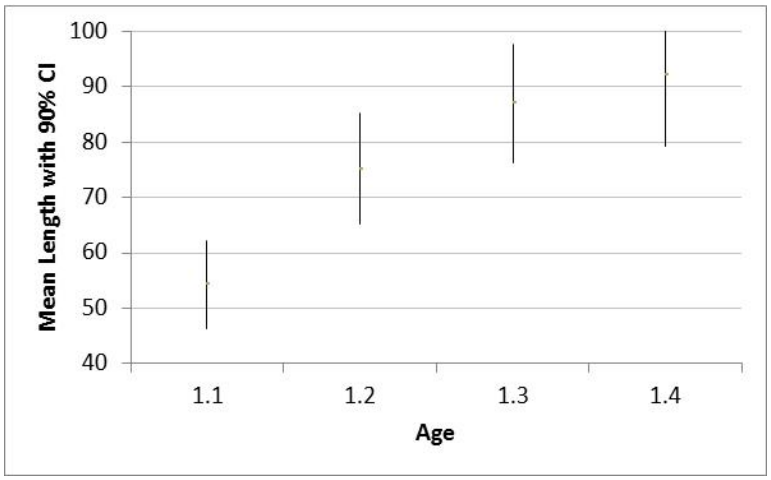


Figure 8. Length at age (with 90% c.i.) for yearling summer Chinook sampled at Bonneville Dam 2003-2012

FALL CHINOOK

Fall Chinook, like summer Chinook show considerable overlap between -0.2s and 0.3s as well as between 0.3s and 0.4s. Among yearlings, there is considerable overlap between 1.2s, 1.3s, and 1.4s.

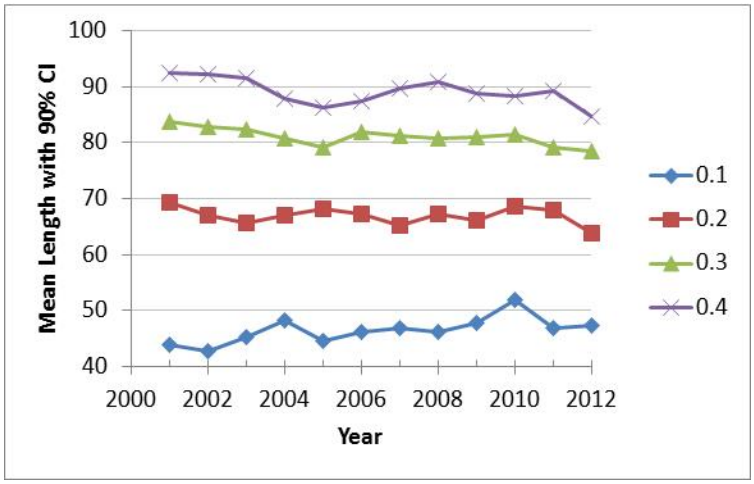


Figure 9. Mean length-at-age subyearling fall Chinook sampled at Bonneville Dam by year 2001-2012.

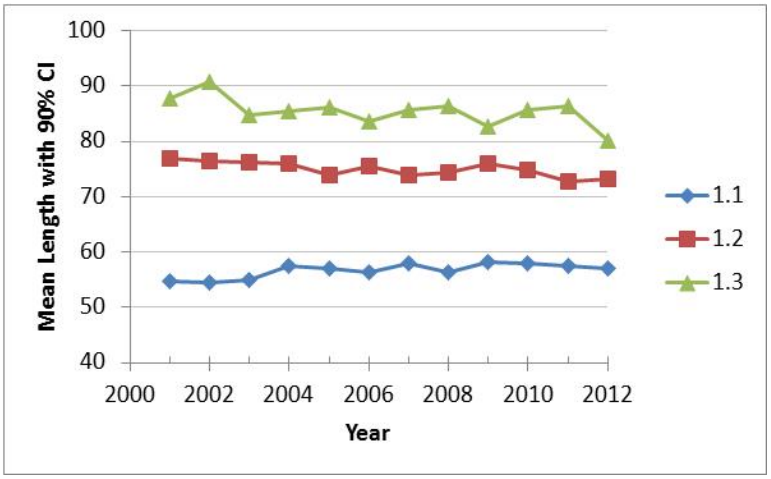
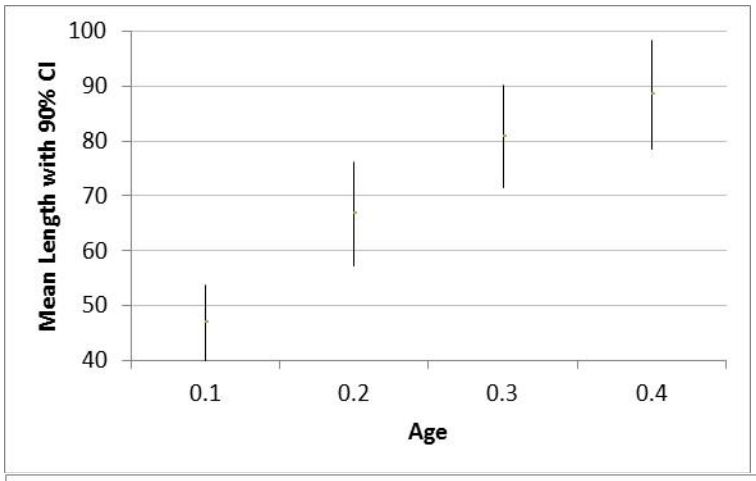
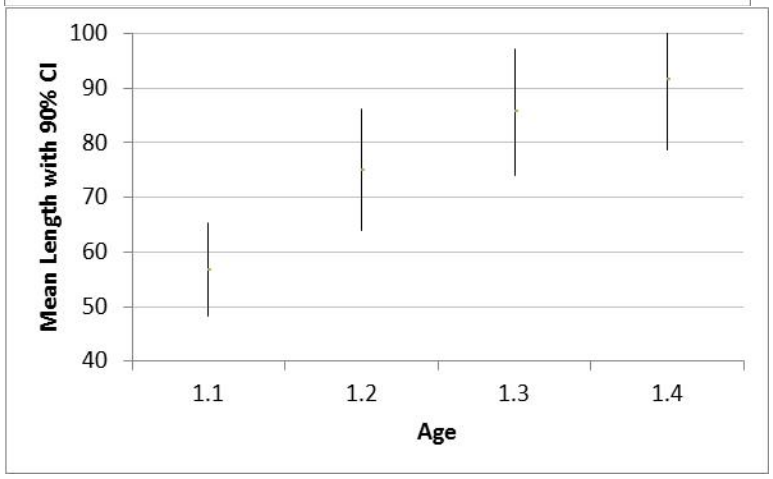


Figure 10. Mean length-at-age yearling fall Chinook sampled at Bonneville Dam by year 2001-2012.





5.) Coloration (and sex) can be useful in determining whether the last ocean annulus is resorbed.

Some Chinook sampled are mature enough that the last annulus is absorbed. I rarely add an annulus to a Chinook sampled at Bonneville Dam unless certain of this resorption. I use length-at-age relationships along with information recorded on the maturity of fish (we designate each Chinook as "Bright", "Intermediate", or "Dark"). At upstream locations, I may also use the sex of Chinook as my experience is males are more likely to resorb annuli than females.

6.) Chinook migrating earlier in the year (April) would be expected to have much less plus growth after the last annulus than those later in the year.

This rule is more appropriate for steelhead ageing, however there may be the occasional early migrating Chinook with a check near the outer edge of the scale which I am more likely to label an annulus due to the expectation of minimal plus growth.

7.) Chinook with greater than two ocean annuli tend to have more oval scales and there is much less spacing between annuli than between the first and second annuli.

General Rules

8.) Age x.0 Chinook are tossed out as minijacks
9.) Extremely dark fall Chinook migrating in September and October (which typically have scales very difficult to remove) are referred to in the Columbia Basin as tules and not aged.
10.) Lengths that don't match scale ages or scale sizes are corrected (if an error is found or there is video to verify the length), are discarded.
11.) I do not assign unusual ages (2.x) or ages that strongly disagree with length and scale size unless the evidence presented by the scale appears overwhelming.

Post Season Review/validation

1.) Outside Review
    a. John Sneva (WDFW)
    b. 2013 technician at CRITFC being trained
2.) Review scales indicated as questionable on first review as well as length-at-age outliers and PIT tag recaps.
3.) Compare scale ages with those of PIT tag recaps
4.) Compare scale ages with those provided by genetics data (parental based analysis).

Post Season Review/validation

In many years I've taken a selection of scale samples up to WDFW to collaborate with John Sneva. In 2013 I began training on two other members of the CRITFC Fish Science Department on scale aging. Weekly, I would sit down and age scales with one or both, depending on their availability. If I was absent in a given week, they would age scales and later we'd go back and review ages. At the end of the year, one technician reviewed all scales, with a particular focus on length-at-age outliers and those listed as questionable, and picked out those that were possibly in error.

After this review, post season I went through the following scales with the technicians looking primarily at:

1.) Those with ages indicated as uncertain.
2.) Length-at-age outliers
3.) PIT tagged fish which could provide age validation. PIT tags are unique and tagging history can be obtained from www.ptagis.org

4.) Fish which had been aged through the use of genetics techniques. These were mostly spring Chinook.

In 2013, accuracies based on comparison with PIT tag ages for 47 Chinook, were 100%:
21 out of 21 for spring Chinook.
18 out of 18 for summer Chinook
8 out of 8 for fall Chinook

A total of 435 out of 445 (97.8%) scale ages agreed with those estimated by genetics analysis (Table 1).

Table 1. Comparison of ages determined by scale samples and genetics samples for Chinook salmon sampled at Bonneville Dam in 2013

	Genetics (Parental Based Analysis) Total Age		
Scale Age	**Age 3**	**Age 4**	**Age 5**
Age 3	250	0	0
Age 4	6	184	0
Age 5	0	4	21
% Scale age agrees with PTA age	97.7%	97.9%	100.0%

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Appendix A

Photographs of Scales used in Determining Age

Comment [MSOffice1]: These images are ones I plan on using but haven't worked into document yet.

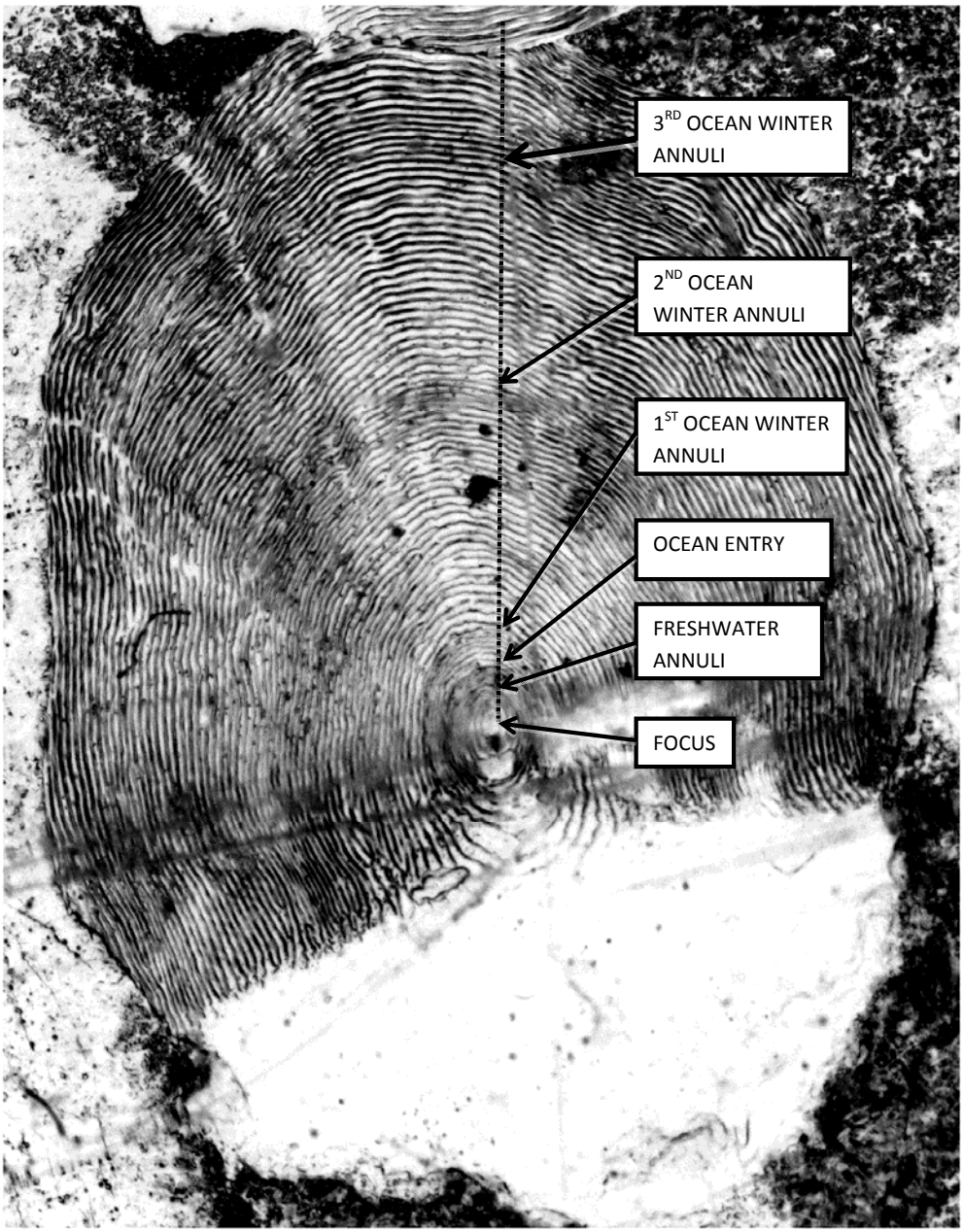

Image 1: This is a scale from a Spring Chinook, aged 1.3, which was released in 2010 from Lostine River. It was recaptured and sampled at Bonneville 05/20/2013. This scale has the focus, ocean water entry and the annuli's marked.

Image 2: Spring Chinook recapture 05/13/2013, aged 0.1. Released in 2012 from Rapid River

Image 3: Spring chinook sampled 04/29/2013 aged 0.2

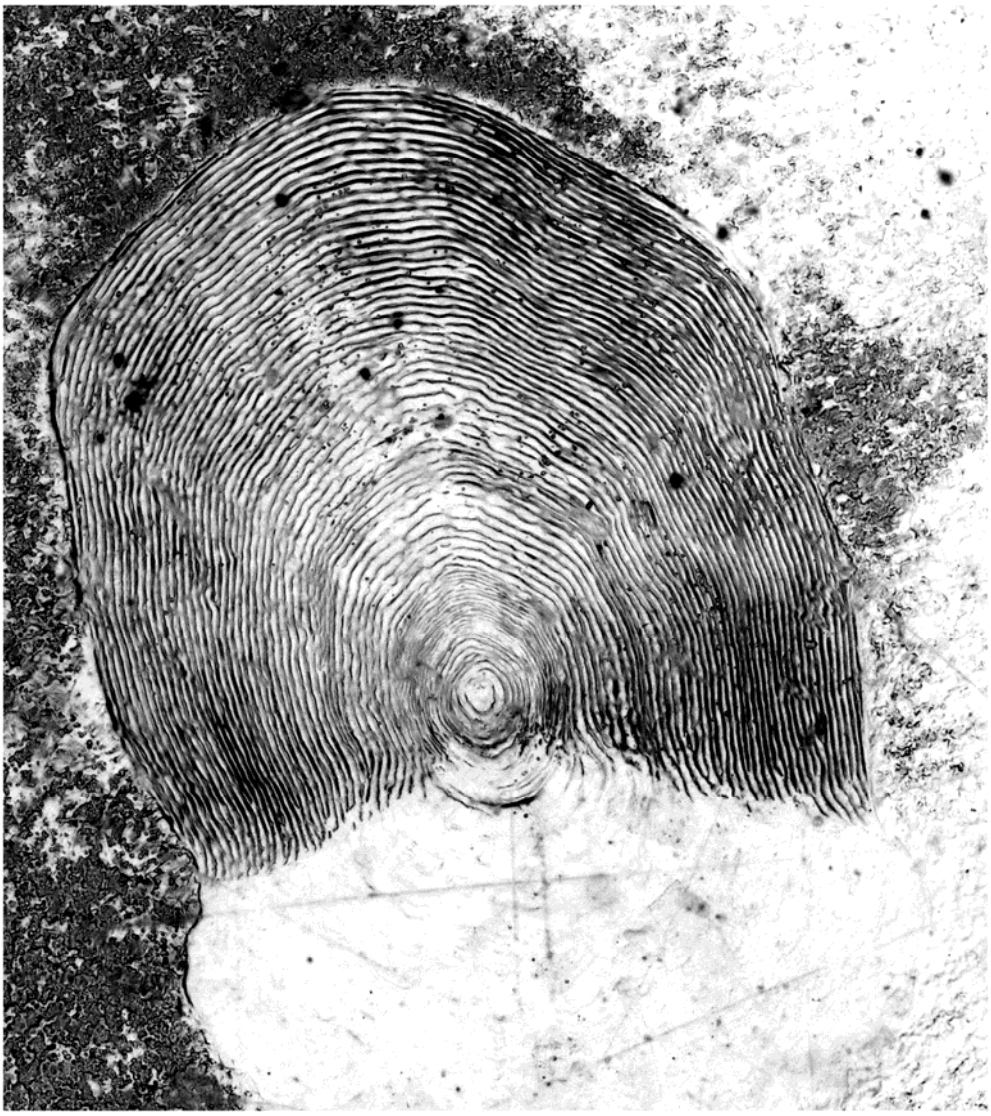

Image 4: Spring Chinook recapture 05/20/2013, aged 1.1. Released 2012 from LWG

Image 5: Spring Chinook recapture 05/08/2013, aged 1.2. Released in 2011 from South Fork

Image 6: Spring Chinook recapture 05/20/2013, aged 1.3. Released in 2010 from Lostine River

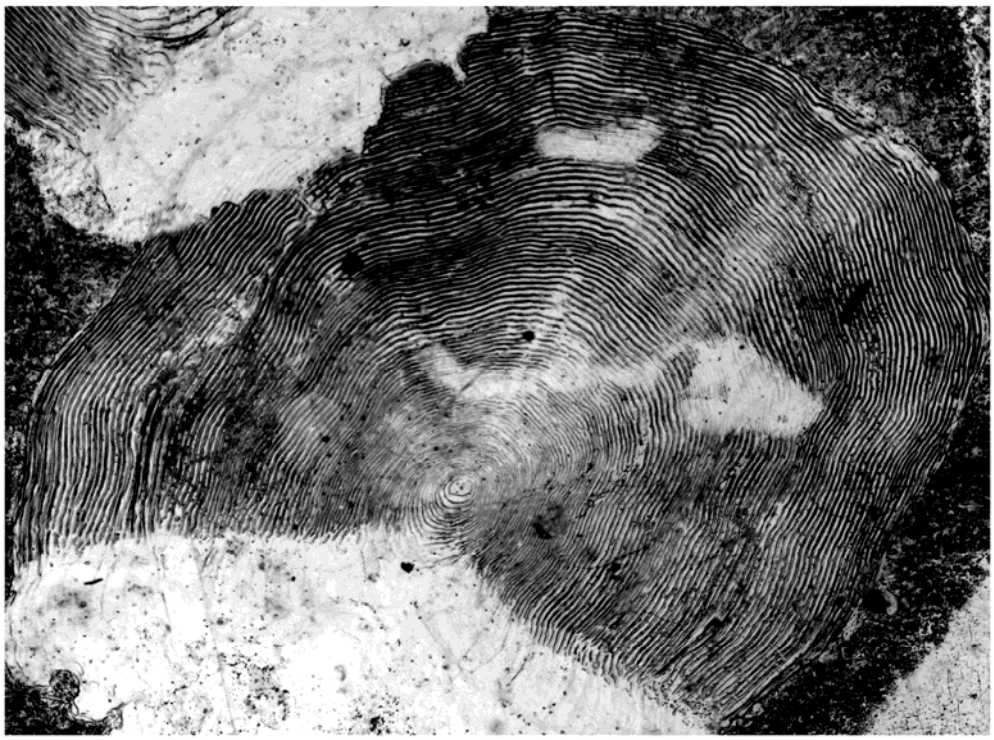

Image 7: Spring Chinook sampled 05/31/2013, aged 1.4.