The Oldest Age a Ring Can Read Is Set Not by the Clock but by Whether the Ring Can Be Seen

— at a resolution of **1** μm, daily rings can be read to **3.0060** years and annual rings to **22.1871** years, a difference of **19.1811** years — the separator is whether the rings are made by a daily or a yearly cycle, and whether the rings can be seen — [Paper 656]

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— *From thinking to syncing.* —

Abstract

The small stone in a fish's ear (the otolith) carries rings, like the rings of a tree. In young fish one ring a day (daily rings) can be counted, and in grown fish one ring a year (annual rings), and age is read from them. But the slower the growth, the thinner the rings, until the microscope can no longer tell them apart.Where the ring clock stops is counted from a growth curve and the resolution.No new theorem or law is claimed. First, daily rings are far thinner than annual rings——with an upper radius of 3.0 mm and a growth rate of 0.3 per year, the first daily ring was 2.4641 μm wide and the first annual ring 777.5453 μm (Section 2). **Second, and this is the core.The upper limit of the ring clock is set not by the clock's period but by where the ring width falls below the resolution——at a resolution of 1 μm, daily rings could be read to 3.0060 years and annual rings to 22.1871 years. At 0.1 μm the limits were 10.6813 and 29.8624 years, each extended by 7.6753 years** (Section 3). **Third, daily rings run out a fixed number of years before annual rings——the difference between the limits was 19.1811 years at both 1 μm and 0.1 μm, matching the closed form $\ln\{365.25(1-e^{-k})/k\}/k$. It depends neither on the resolution nor on the size of the otolith** (Section 3). **Fourth, fish beyond the limit are read as younger——at a resolution of 1 μm, true ages up to 20 years are read correctly, but a fish of 40 years is read as 23. The counted rings only bound the age from below. The separator is whether the rings are made by a daily or a yearly cycle, and whether the rings can be seen** (Sections 4 and 5). **Keywords**: age determination, otolith, daily and annual rings, von Bertalanffy growth curve, microscope resolution.

Scope of this paper (scope note): No new theorem or law is claimed——the von Bertalanffy growth curve (1938), daily rings in otoliths (Pannella 1971), and the tendency of long-lived fish to be read as younger, requiring validation (Beamish and McFarlane 1983), are all known.This is an example——an otolith radius limit of 3.0 mm, a growth rate of 0.3 per year and resolutions of 1 μm and 0.1 μm are set as an example.Only one misreading is included——only that a ring narrower than the resolution cannot be counted. Misread rings, false rings and seasonal changes in growth are not included.Methods of validating age are not treated——validation by radiocarbon or tagging, and the physiology of otolith formation, are not discussed.Relation to earlier papers: Paper 581 showed that the age at which a forest takes up carbon fastest is not the age at which it holds the most——here the growth rate itself becomes the ring width, and when that falls below the resolution, the age clock stops.What is added is deriving the limits for daily and annual rings in closed form, showing that the difference between them depends neither on resolution nor on size, listing the read age for each true age, and placing the separator on the ring's period and whether it can be seen.

1. Notation and the Question

Setting: the otolith radius is taken to grow by the von Bertalanffy curve $R(t) = R_\infty(1 - e^{-kt})$ (t in years).The width of a daily ring is the growth rate times one day, $R_\infty k e^{-kt}/365.25$, and the width of an annual ring is $R(t+1) - R(t) = R_\infty e^{-kt}(1 - e^{-k})$.A ring can be told apart if its width is at least the microscope's resolution δ. The upper limits of age that can be read are

$$t_{\mathrm{d}} = \frac{1}{k}\ln\frac{R_\infty k}{365.25\,\delta}, \qquad t_{\mathrm{a}} = \frac{1}{k}\ln\frac{R_\infty(1-e^{-k})}{\delta}$$

(the first for daily rings, the second for annual rings). The premises are $R_\infty = 3.0$ mm and $k = 0.3$ per year.

Question: where does the clock of ages read from rings stop, and what sets it?

2. Ring Widths

Computation 2.1: the first daily ring was 2.4641 μm wide and the first annual ring 777.5453 μm.

Observation 2.2

daily rings cut the same growth into days, so they are far thinner than annual rings.And since the growth rate falls exponentially with age, both kinds of ring thin at the same rate——if they thin at the same rate, the thinner daily rings vanish from view first.

3. The Limits

Computation 3.1: **the upper limits of age that can be read were derived.**

resolution	daily-ring limit	annual-ring limit	difference
1 μm	**3.0060** years	**22.1871** years	**19.1811** years
0.1 μm	**10.6813** years	**29.8624** years	**19.1811** years

The difference matched the closed form $\ln\{365.25(1-e^{-k})/k\}/k = 19.1811$ years within 10^{-9}. Making the resolution 10 times finer extended both limits by $\ln 10/k = 7.6753$ years.

> **Observation 3.2**
>
> **this is the core: the upper limit of the ring clock is set not by the clock's period but by where the ring width falls below the resolution.The daily and yearly cycles go on until the fish dies. What stops is not the clock but the eye that tells the carved rings apart. Improving resolution tenfold extends the limit by only 7.6753 years: rings that thin exponentially can be followed only logarithmically——and that daily rings run out 19.1811 years before annual rings does not change however much the resolution improves.**

4. Misreading

Computation 4.1: **at a resolution of 1 μm, annual rings of width at least 1 μm were counted for each true age.**

true age	read age
2 years	**2** years
5 years	**5** years
10 years	**10** years
20 years	**20** years
40 years	**23** years

Observation 4.2

fish beyond the limit are read as younger.Up to the limit, the number of rings is the age itself, but beyond it the outer rings cannot be told apart and merge, and the count stops growing——the counted rings only bound the age from below. The longer a fish lives, the younger its read age compared with the truth.

5. The Separator

Observation 5.1

the separator is whether the rings are made by a daily or a yearly cycle, and whether the rings can be seen.Daily rings cut finely and can read the age in days of young fish, but run out early. Annual rings are coarse but can be read for longer. Both limits come not from the cycle stopping but from the ring width becoming indistinguishable——what sets the window of the age clock is not the clock's side but the reading eye's side.

Observation 5.2

beside Paper 581.Paper 581 showed that the age at which a forest takes up carbon fastest is not the age at which it holds the most——here the falling growth rate itself becomes the ring width, and at the age where it falls below the resolution, the age clock stops.

Observation 5.3

what is not said.Real otolith growth, false rings, seasonal changes in width and methods of validating age are not treated. The only misreading included is "too thin to see"——what is shown is what sets the upper limit of ages read from rings.

6. Roll Call and Closing

1. **daily ring $2.4641\ \mu$m, annual ring $777.5453\ \mu$m** (Computation 2.1): **daily rings far thinner.**
2. **daily-ring limit 3.0060 years** (Computation 3.1): **at $1\ \mu$m.**
3. **annual-ring limit 22.1871 years** (Computation 3.1): **read for longer.**

4. **difference 19.1811 years** (Computation 3.1): **independent of resolution.**
5. **7.6753 years more for 10 times the resolution** (Computation 3.1): **followed only logarithmically.**
6. **what stops is the eye, not the clock** (Observation 3.2): **the core.**
7. **no misreading up to 20 years** (Computation 4.1): **inside the limit.**
8. **a 40-year fish read as 23** (Computation 4.1): **read as younger.**
9. **rings bound age from below** (Observation 4.2): **younger the longer it lives.**
10. **the ring's period and whether it can be seen** (Observation 5.1): **the separator; Paper 581.**

Closing: **The clock of ages read from otolith rings does not stop because its cycle stops.As growth slows, the ring width falls below the resolution and the rings can no longer be told apart; at 1 μm, daily rings ran out at 3.0060 years and annual rings at 22.1871 years.The difference of 19.1811 years depends neither on resolution nor on size, and a tenfold finer resolution extended the limits by only 7.6753 years. A 40-year fish beyond the limit was read as 23——what sets the window of the age clock is not the clock but the reading eye.The separator is whether the rings are made by a daily or a yearly cycle, and whether the rings can be seen.Placed among the earlier papers——the falling growth rate of Paper 581 here stops the clock as the width of a ring.To be honest——this is an example growth curve, and the only misreading included is "too thin to see".**

References

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