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Known Otolith Accretion in Cultured Walleye Pollock with Comparison to Prince William Sound and Radiometric Age Validation Pollock

by

Kristen M. Munk

December 2011

Alaska Department of Fish and Game **Division of Commercial Fisheries**

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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KNOWN OTOLITH ACCRETION IN CULTURED WALLEYE POLLOCK WITH COMPARISON TO PRINCE WILLIAM SOUND AND RADIOMETRIC AGE VALIDATION POLLOCK

by

Kristen M. Munk,
Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau

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Division of Commercial Fisheries, Juneau

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The Regional Information Report Series was established in 1987 and was redefined in 2006 to meet the Division of Commercial Fisheries' regional need for publishing and archiving information such as project operational plans, area management plans, budgetary information, staff comments and opinions to Board of Fisheries proposals, interim or preliminary data and grant agency reports, special meeting or minor workshop results and other regional information not generally reported elsewhere. Reports in this series may contain raw data and preliminary results. Reports in this series receive varying degrees of regional, biometric and editorial review; information in this series may be subsequently finalized and published in a different department reporting series or in the formal literature. Please contact the author or the Division of Commercial Fisheries if in doubt of the level of review or preliminary nature of the data reported. Regional Information Reports are available through the Alaska State Library and on the Internet at: http://www.sf.adfg.ak.us/statewide/divreprots/htlm/intersearch.cfm.

Kristen M. Munk
Department of Commercial Fisheries, Mark/Tag & Age Laboratory – Age Determination Unit
P.O. Box 115526 Juneau, AK 99811-5526, USA

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ABSTRACT

Routine age estimation of walleye pollock has been disputed since the year 2000. Two ways to interpret the growth pattern in otoliths describe pollock as *generally young* or *generally old*(*er*). Kastelle and Kimura (2006) conducted a radiometric age validation study that concluded that walleye pollock were generally young. This report presents annual otolith accretion (the amount of change in otolith mass per year) values measured from walleye pollock that were cultured between 2006 and 2011, and compares these known otolith accretion values to calculated otolith accretion based upon subjectively produced ages in three data sets: matched data from the Kastelle and Kimura (2006) radiometric study Method A, Method B age reading criteria, and Prince William Sound (aged consistent with Method B). Culture resulted in walleye pollock that were somatically larger at age than wild pollock. Because otolith accretion is correlated to somatic length, the mean annual otolith accretion values from known-age cultured fish are presumed to establish an upper boundary to annual otolith accretion in wild pollock. Otolith accretion in cultured pollock nearly doubled during the second year, decreased 33.8% in the third year, and then commenced a gradual declining trend between the third through fifth years of culture. For pooled age classes 4 and 5, the averaged mean annual accretion for the cultured pollock is 0.0582 g; while for the Radiometric Method A it is 0.081 g, for Method B it is 0.019 g, and for Prince William Sound it is 0.036 g. For combined age classes 4 and 5, hypotheses tests failed to reject the null hypothesis that Radiometric Method A and the Prince William Sound data were less than or equal to the known otolith accretion; however, the null hypothesis was rejected for Radiometric Method B data. This report documents results through year 5 of a 6-year study.

Key Words: Walleye pollock, *Theragra chalcogramma*, culture of pollock, radiometric age validation, otolith, known-age, otolith accretion, age reading inaccuracy

INTRODUCTION

Walleye pollock *Theragra chalcogramma* (pollock) is a dominant species in the North Pacific. Pollock range from central California to the Bering Sea and Japan (Eschmeyer et al. 1983), although Bailey et al. (1999) limit the southern range in the eastern North Pacific to Washington state. Pollock are ubiquitous in food webs of fishes (Livingston 1993), seabirds (Hatch and Sanger 1992; Springer 1996; Piatt 2002; Romano et al. 2006), and marine mammals (Rosen and Trites 2000; Merrick and Calkins 1996). Humans consume pollock primarily as surimi (fish paste), fillets, and roe[a]. Pollock support the second largest biomass fishery in the world and the species is considered fully exploited (FAO 2010). From 1998 to 2002 the pollock harvest averaged almost 2.9 billion pounds (Woodby et al. 2005). In 2004 the wholesale value of the Alaska pollock fishery was (USD) $1.1 billion dollars[b]. From 1998 to 2002 over 99% of harvested pollock came from waters under management by the National Marine Fisheries Service (NMFS), and the remaining amount was under management by the Alaska Department of Fish and Game (ADF&G; Woodby et al. 2005).

Age data are routinely used by fishery managers for characterizing populations and for guiding harvest allocations. Pollock otoliths are aged at the NMFS Alaska Fisheries Science Center. These age data are used in age-structured models that guide harvest of pollock populations in the Bering Sea (Ianelli et al. 2000; Ianelli et al. 2010), Aleutian Islands (Barbeaux et al. 2003; Barbeaux et al. 2010), and Gulf of Alaska (Dorn et al. 1999; Dorn et al. 2010). Since 2003, pollock otoliths from state fisheries are aged at the ADF&G Region II Homer office, and these age data are available to NMFS to use in their age structured models.

The age reading method for walleye pollock otoliths has been disputed since the year 2000 (Munk 2001, 2004). The NMFS Alaska Fisheries Science Center ages pollock generally young (termed Method A by Kastelle and Kimura 2006), while another age reading method (termed

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[a] Knapp, G. 2006. An Overview of Alaska Pollock Markets. http://doc.nprb.org/web/symposium/2006/tuesday/session_3/Knapp_Pollock_Markets_MSS_060124.ppt; Access date 9/20/2011.

[b] Ibid.

Method B by Kastelle and Kimura 2006) developed at the ADF&G Age Determination Unit in Juneau, Alaska produces ages up to three times older or greater (Kastelle and Kimura 2006). Kastelle and Kimura (2006) concluded that "… ages from method A were more accurate than those from method B."

It is valuable to retest validations of age through other means to ensure that a false validation has not occurred. A false validation can have serious ramifications. For example (1) true age could be chronically misrepresented; and (2) managers and researchers using these data could misestimate natural mortality, which could result in unsustainable harvest goals and inaccurate ecosystem-based models.

In 2006 we initiated a study to culture walleye pollock from young-of-year pollock in order to measure their otolith mass at known age and determine mean yearly accretion. Otolith mass (that is, the overall accretion of primarily calcium carbonate) is the quantity focused on in this study because it is easy to measure and is presumed to continue to increase over time in a manner proportional to the laying down of increments that are typically used in visual assessments of age. This project has completed 5 years of a potentially 6-year project in producing yearly accretion values and trends that allow initial comparison. This report documents the known yearly accretion values and trends and compares them to three sets of subjectively produced age data and calculated mean yearly accretion: matched data from the Kastelle and Kimura (2006) radiometric study (aged using Method A and Method B), and Prince William Sound (aged consistent with Method B) data.

MATERIALS AND METHODS

OVERVIEWS OF WALLEYE POLLOCK STUDIES AND DATA SETS

Culture and Known Otolith Accretion

Pollock were beach seined from Bridget and Echo Coves (Lynn Canal, Southeast Alaska; Figure 1) from June to August 2006. We beach seined during minus tide series, within 2 h of the low. Three ADF&G personnel aboard a 5.2 m skiff deployed one of two nets: either (1) 37 m long, 5 m deep at the center and tapering to 1 m at the end, with 3 panels of differing mesh size (10 m long outer panels were comprised of 32 mm stretch mesh; 4 m long intermediate panels, 6 mm square mesh; and the 9 m long inner panel used 3.2 mm square mesh); or (2) 37 m long with no taper, 1.2 m deep, and square 3.2 mm mesh (Figure 2). Captured pollock were subsampled for somatic measurements and otoliths and transported to culture tanks; pollock were cultured at the Auke Bay Marine Station from 2006 to 2011 (Figure 3). Fish were fed to satiation daily during the first year of culture, and 1 to 3 times weekly after the first year. The food was a custom and blended chow with core ingredients of herring, commercial fish food pellet, vitamins (B, C, multi), and krill, with occasional inclusion of squid or other fish protein. The percentage of food remaining on the bottom was estimated after 5 minutes. Excess food and fish waste were removed from the tank through self-cleaning outflow tubes, or vacuumed weekly as needed. Water for the culture tanks came from 33 m deep in Auke Bay and demonstrated seasonal temperature fluctuation (Figure 4). Growth was monitored with quarterly live sampling from 2006 through 2010. Some fish were individually externally tagged as early as 2007; all fish were individually tagged in October 2008 (Note: later somatic measurements were identified with these tag numbers however discrete fish growth data are not part of this report). From 2007 to 2011, a sample of fish was sacrificed each year between late March and early April, the designated birth anniversary. Fish were measured for somatic length and weight, and gender and maturity were noted. Otoliths were extracted, cleaned of lymph and blood, air dried, and stored for later measuring.

Kastelle and Kimura (2006): Radiometric Study

The Kastelle and Kimura (2006) study used the age validation method known as lead-radium radiometric. Features (Table 1) of their radiometric study which produced matched age data (the same specimens aged using Method A and Method B) for 618 pollock are as follows:

1. Method A – the age reading method applied by NMFS, e.g., young profile age estimates.
2. Method B – the age reading method applied by K. Munk, e.g., old profile age estimates.
3. Method A readers had access to fish length data, while Method B reader did not.
4. Method A readers used break and burn on 33.7% of otoliths, while Method B reader used break and burn on 100% of otoliths.
5. Sample design was structured to develop radiometric sample pools based upon Method A ages with a study assumption of no age-reading error using Method A; age ranges of radiometric sample pools using Method B differed markedly from the ranges produced using Method A.
6. Radiometric sample pools had 40 to 45 like-aged specimens comprising each tested age class, for five age classes (3, 4, 6, 7, 8) developed using Method A ages.
7. Kastelle and Kimura's Figure 1 (Figure 5).
8. Methods A and B had 45% agreement at age 3 and begin strong divergence after age 3.

An age bias plot and age-at-length graph (Figure 6) characterize the different outcomes using Method A versus Method B. The radiometric study specimen otoliths were measured for length, height, and weight by ADF&G in 2005 (Appendix 1; Kristen Munk, Age Determination Unit program manager. Walleye pollock otolith accretion study proposal, 2006).

Prince William Sound Catch Sampling

Pollock were sampled from commercial and research harvests conducted in Prince William Sound from 1996 through 2003. Capture months were from January through October. Somatic length and weight were recorded. Sagittal otoliths (otoliths) were removed and placed in a sampling tray numbered to coordinate with somatic data. Otoliths were sent to the ADF&G Age Determination Unit in Juneau, Alaska. Otoliths were stored dry for months to years before measuring. All otoliths were aged without access to fish length, and using the break and burn preparation technique and pattern interpretation consistent with age reading criteria of Method B.

MEASURING OTOLITH DIMENSIONS

All otoliths were dry before measuring. Measurements were made consistent with Munk and Smikrud (2002); the longest (length = anterior-posterior axis) and shortest (height = dorso-ventral) otolith axes were measured using digital calipers, and mass was weighed using an analytical balance with resolution to 0.001 g or 0.0001 g. Data were manually entered into an EXCEL template, or were electronically captured through instrument software. For the cultured and PWS otoliths, these were measured whole or with broken halves rejoined to make whole. For the radiometric study otoliths, which had previously been cut and burned, the halves were first wiped of debris (clay, oil, etc) and then rejoined and observed for missing chips (if missing chips, these otoliths were not included in the measurement data set). Appendix I lists otolith measurement data for each study specimen number. Rejoined and essentially whole otoliths were then measured for length and height. Individual halves were weighed separately and these component weights were combined. An adjustment[c] was made for lost otolith length (+0.39 mm) and mass (+5.29%) attributed to the blade kerf. No adjustment was made for change in mass attributed to oiling (oiling effect is presumed to cause increase in mass) or charring (charring effect is presumed to cause loss of mass); therefore, these respective increases or decreases in mass were presumed to be coarsely offsetting.

AGE READING METHODS: METHOD A AND METHOD B

Kastelle and Kimura (2006) generally describe the Method A and Method B age reading approach as follows: "One method, hereafter called method A, usually interprets prominent, evenly spaced, and continuous zones as annual, and disregards other less prominent zones.", and, "…The other method, hereafter called method B, often interprets zones as annual that are finer, less prominent, but still visible, and often not as continuous."

Method A differs from Method B largely through two mechanisms:

1. Method A does not require that all otoliths be half sectioned (cut or broken and burned) and the majority of otoliths are surface aged; while the Method B requires half sections and burns for 100% of all otoliths (in the break and burn manner), and never a surface age.
2. Method A groups visible increments in the growth pattern into single swaths representing annual increments, while Method B claims that transitional growth stages exist and asserts that there are multiple annual increments within the swaths or groups (Figure 7).

The radiometric study otoliths produced matched data for Method A and Method B. The Prince William Sound data set presents only Method B age data.

DATA AND STATISTICAL ANALYSES

Calculation of descriptive statistics, and generation of trendlines and error bars within the charts utilized Microsoft EXCEL[d] (2003). All other statistical analyses were conducted using SYSTAT[e] (2011).

Mean yearly accretion (*MYA*) was calculated (Equation 1) for all data sets as follows:

$$MYA = \frac{\sum w_{i(y)}}{n_y} - \frac{\sum w_{i(y-1)}}{n_{(y-1)}} \qquad (1)$$

Where:
MYA = mean yearly accretion
$w_{i(y)}$ = weight of the otolith from the i^{th} age y fish sampled
$n_{(y)}$ = the number of otoliths from age y fish sampled
$w_{i(y-1)}$ = weight of the otolith from the i^{th} age y–1 fish sampled
$n_{(y-1)}$= the number of otoliths from age y–1 fish sampled

The known otolith accretion (KOA) data from cultured fish and the estimated accretion data based upon subjective age were evaluated, in part, using hypothesis testing. KOA data are assumed to be the standard to which other data are compared due to known time (age; annual) and because otolith accretion-at-known-time is directly measured for each fish. The hypothesis

[c] We measured and weighed n = 24 whole otoliths, and then cut and remeasured/reweighed otoliths and calculated adjustment factors for mean differences between uncut and cut length and weight. Note that measurement of blade thickness is not appropriate because potential blade oscillation (wobble) increases the kerf width.
[d] Product names used in this publication are included for completeness but do not constitute product endorsement.
[e] Ibid.

test is directional because the culture of fish, and therefore their somatic otolith accretion data (values and trend) are presumed to achieve levels greater than that of wild fish; therefore, KOA values presumably set an upper boundary to the calculated yearly accretion values for all tested data sets. The null hypothesis was rejected when the *p*-value was less than the critical value. We utilized a two-sample *t*-test to compare sample means. The null hypothesis was developed with the assumptions that (1) the cultured fish likely achieved higher growth (somatic growth and otolith accretion) than what subjective ages from Method A and Method B describe for wild fish; (2) otolith length is a linear function of somatic length; (3) while otolith weight is highly correlated with somatic length, otolith weight continues to increase over time while somatic length increases at decreasing rates; and (4) culture (accretion) time is known (not estimated). Therefore, the null hypothesis ($\alpha = 0.05$) states that the mean (μ_i) of combined age-4 and age-5[f] known mean yearly accretion (eg. KOA *MYA*) for the cultured fish (μ_1) is less than or equal to the estimated accretion relative to subjective age interpretation (μ_2), and can be written as $H_{0,1:}$ $\mu_1 \leq \mu_2$. The alternate hypothesis is that $\mu_1 > \mu_2$.

RESULTS

CULTURE AND KNOWN OTOLITH ACCRETION

Captured pollock were determined to be young-of-year (age 0) at time of capture based upon somatic length (mean fork length = 68.9 mm [range 40–97 mm]; SD = 10.19; *n* = 578; Müter and Norcross 1993; Wilson et al. 2005). Pollock grew well under culture (Figure 8); by age 2 they surpassed growth measures for wild pollock by achieving a somatic length of at least a 3-year-old wild pollock for Gulf of Alaska (DiCosimo 1998) or Bering Sea Aleutian Islands stock (Witherell 2000). Mortality outside of predation or operational incidents during culture was <12% between age 0 and age 4 and increased to 25% at age 5 (Figure 9); mortality increased presumably due to an increase in human activity near the culture tanks after their relocation in May 2010.

Seventy four percent (*n* = 35) of cultured pollock were mature by year 2, and 86% (*n* = 22) were mature by year 5. Somatic and otolith dimensions were measured and mean values and standard deviations calculated (Table 2). Somatic and otolith dimensions are highly correlated (Figure 10 a–d). Mean whole otolith weight-at-known-age are charted with their *MYA*s (Figure 11). *MYA* reached a maximum value in year 2 (0.0974 g), and dropped 33.8% in year 3 (0.0645 g), and continued a declining trend through year 5 (0.054 g). The averaged KOA *MYA* for years 4 and 5 (the *MYA* for age 4 and age 5 for KOA were combined to compare to data sets from subjectively aged fish for which sample size at year 5 was too low to test individually) is 0.0582 g and the mean rate of change between years 3 through 5 is -0.0147.

COMPARISON BETWEEN KNOWN OTOLITH ACCRETION AND CALCULATED ACCRETION USING SUBJECTIVE AGE METHODS A AND B

Somatic and otolith measurements at age are identified for the three subjective-aged data series (Table 3): Radiometric Methods A (R:A) and B (R:B), and Prince William Sound (PWS). Somatic length and otolith weight are highly correlated within each of the three datasets; Pearson's correlation coefficients were calculated to be 0.907 for the cultured pollock, 0.961 for the Radiometric specimens, and 0.931 for the PWS data sets. The otolith weight-at-otolith-length are plotted for four data series: KOA; R:A and R:B; and PWS (Figure 12). The R:A mean otolith

[f] Only age 4 and age 5 were testable because *a*) age 3 would require estimation (not calculation) for the tested data sets, and/or, *b*) sample size for age 5 was too low to test individually.

weight-at-otolith-length for age 5 is greater than the mean otolith weight-at-otolith length for known age 4 (Figure 12a). The KOA otolith weights-at-ages (n = 154; ages 1–5) are plotted against calculated otolith weights-at-ages for R:A and R:B (n = 533 each data series) and PWS (n = 1709; Figure 13); the R:A mean otolith weight-at-ages are initially less than the KOA mean otolith weight at ages 3 and 4, and then R:A accretion increases to the level of known accretion at age 5. *MYA* values were calculated for subjective age as follows: R:A and R:B for age 1 used Kastelle and Kimura's (2006) reported mean otolith weight at age 1 (0.014 g); and R:A, R:B, and PWS age-4 and age-5 *MYA* values were estimated using Equation 1 (Figure 14; R:A and R:B *MYA* values at age 2 and age 3 are not indicated because they would require greater estimation and not direct calculation, and, while PWS data exist through this range, the sample sizes are too small to support hypothesis testing). From age 4 through age 8, the averaged *MYA* is 0.0739 g for R:A, 0.0214 g for R:B, and 0.0253 g for PWS. The difference in *MYA*s between years 4 and 5 is 0.0186 g for R:A and 0.0091 g for R:B, and for PWS, between years 3 through 5 is -0.0089 g. Negative *MYA* values presumably do not indicate negative accretion, but rather interannual differences in accretion owing to year class-specific growth and/or age reading error.

Due to absent data for age 2 (R:A, R:B), and low sample sizes from ages 3 through 5 (R:A, R:B, PWS), *MYA* for age 4 and age 5 were combined to evaluate for equality of variance and conduct hypotheses tests. Equality of variances for ages 4 and 5 (combined) were tested between KOA and R:A, R:B, and PWS. Variation of *MYA* within R:A ($p < 0.001$) and R:B ($p < 0.001$) samples are not equal to KOA. Variation of *MYA* within the PWS sample is not different from KOA (p = 0.849). We therefore used hypothesis test p-values for separate variance for KOA, R:A, and R:B hypothesis tests, and used pooled variance p-values for KOA and PWS hypothesis tests.

Tests to evaluate KOA relative to calculated accretion for R:A, R:B, and PWS failed to reject the null hypotheses that KOA was less than or equal to accretion for R:A (p = 0.972; Table 4) and PWS (p = 0.130; Table 4). However, tests rejected the hypothesis that KOA was less than or equal to R:B (p = 0.001; Table 4). All hypotheses test results are shown in Table 4.

DISCUSSION

It is a tenet of aquaculture that fish which are cultured often achieve rates of growth typically higher than rates of growth in wild fish. Achieving a high rate of growth was a goal in this study in order to establish an upper boundary for mean otolith dimensions at somatic size and age. Somatic and otolith dimensions for 13 groundfish species of wild origin are known to be well correlated (range of r^2 = 0.663 to 0.967, mean r^2 = 0.83, n > 67000; wild pollock r^2 = 0.9148, n = 4669; in-house data). I assume that the physiological mechanism of accretion of calcium carbonate to the otolith as a function of somatic growth would be the same for wild fish as for cultured fish. The high rates of somatic growth observed in these cultured fish would theoretically result in the highest possible mean somatic and otolith dimensions at age. Given that somatic size of the cultured pollock exceeded that reported for wild pollock, this implies that otoliths from the cultured fish would also be larger in comparison to the wild pollock in the radiometric study and the PWS sample. These known-age, objectively measured somatic and otolith dimensions attest to achievement of two goals critical to this study: (1) somatic length-at-age in these cultured pollock was greater than that suggested by either Method A or B in Kastelle and Kimura (2006); and (2) somatic to otolith dimensions in the cultured pollock are well correlated, consistent with wild pollock.

The culture–accretion data objectively document the otolith dimensions over known time and provide upper boundaries (thus the choice of one-tailed hypothesis tests) for values and trendlines, for comparison to data based on subjective age determinations. Due to this high rate of growth, the Method A or Method B otolith dimensions at subjective-age should not exceed the values established by the cultured pollock. However, the Method A *MYA* values exceed those for the known accretion data, which suggests that Method A does not produce reasonable age estimates following age 3. The relationship of otolith weight-at-otolith-length would need to uncouple for maintaining Method A for further consideration. Method B (R:B, PWS) remains plausible because these data do not exceed the maximum values for otolith dimensions set by the known accretion data. Method B implies a slower growth rate for wild fish; this does not exclude the possibility that Method B overages pollock.

Using the known accretion data to prove accuracy of R:B ages is not staightforward. This is because the Kastelle and Kimura study was biased in its selection of specimens[g]; specimens were selected based upon Method A ages and presuming correctness of Method A. If Method A age estimates were incorrect, then the true age composition of the fish in the radiometric sample is not known. However, the PWS ages, which were produced consistent with Method B, were randomly sampled specimens and not biased in age estimation because fish length was not available to the age reader. The PWS weight-at-otolith-age do not exceed the known accretion values, their *MYA*s are within the boundary set by KOA, changes in *MYA*s are low and negative after age 2, and are consistent with KOA for years 4 and 5.

Pollock KOA through age 5 in comparison to tested data sets (R:A, R:B, and PWS) does not prove conclusively that one otolith age reading methodology over the other produces more accurate ages. However, the KOA data begin to describe an upper boundary to overall otolith weight-at-age and *MYA* through age 5: an early peak in accretion at age 2; a lower rate of change; and a consistent, slightly declining trend after the peak year in accretion. This description of KOA currently suggests that the Method A ages produce calculated *MYA* values that are higher than observed, and that the Method B ages produce calculated *MYA* values which are lower than observed.

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[g] Other biases reported in the Kastelle and Kimura (2006) study are Method A age readers had access to fish length during aging; and study specimens were selected for a reported strong 1994 year class.

REFERENCES CITED

Bailey, K. M., T. J. Quinn II, P. Bentzen, and W. S. Grant. 1999. Population structure and dynamics of walleye pollock, *Theragra chalcogramma*. Advances in Marine Biology 37:179–255.

Barbeaux, S., J. Ianelli, E. Brown. 2003. Aleutian Islands walleye pollock SAFE [*In*] Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pacific Fishery Management Council, Anchorage, AK.

Barbeaux, S., J. Ianelli, S. Gaichas, and M. Wilkins. 2010. Assessment of the pollock stock in the Aleutian Islands [*In*] Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pacific Fishery Management Council, Anchorage, AK.

DiCosimo, J. 1998. Groundfish of the Gulf of Alaska: A species profile. North Pacific Fishery Management Council. Anchorage, AK..

Dorn, M.W., A. B. Hollowed., E. Brown, B. A. Megrey, C. Wilson and J. Blackburn. 1999. Walleye pollock [*In*] Stock assessment and fishery evaluation report for groundfish resources of the Gulf of Alaska. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, Anchorage, AK.

Dorn, M., K. Aydin, S. Barbeaux, M. Guttormsen, K. Spalinger, and M. Wilkins. 2010. Assessment of the walleye pollock stock in the Gulf of Alaska [*In*] Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pacific Fishery Management Council, Anchorage, AK.

Eschmeyer W. N., E. Herald, and H. Hammann. 1983. A field guide to Pacific Coast fishes of North America. Boston, Houghton Mifflin Company.

FAO. 2010. The State of World Fisheries and Aquaculture. Rome, FAO. 2010.

Hatch, S. A. and G. A. Sanger. 1992. Puffins as samplers of juvenile pollock and other forage fish in the Gulf of Alaska. Marine Ecology Progress Series 80:1–14.

Ianelli, J. N., L. Fritz, T. Honkalehto, N. Williamson and G. Walters. 2000. Bering Sea-Aleutian Islands walleye pollock assessment for 2001 [*In*] Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pacific Fisheries Management Council, Anchorage, AK.

Ianelli, J. N., S. Barbeaux, T. Honkalehto, S. Kotwicki, K. Aydin and N. Williamson. 2010. Assessment of the Walleye Pollock Stock in the Eastern Bering Sea. [*In*] Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea and Aleutian Islands. North Pacific Fishery Management Council, Anchorage, AK.

Kastelle, C. R., and D. K. Kimura. 2006. Age validation of walleye pollock (*Theragra chalcogramma*) from the Gulf of Alaska using the disequilibrium of Pb-210 and Ra-226. ICES Journal of Marine Science 63:1520–1529.

Livingston, P. A. (1993). The importance of predation by groundfish, marine mammals, and birds on walleye pollock, *Theragra* chalcogramma, and Pacific herring, *Clupea pallasi*, in the eastern Bering Sea. Marine Ecology Progress Series 102:205–215.

Merrick, R .L., and D. G. Calkins. 1996. Importance of juvenile walleye pollock, *Theragra chalcogramma*, in the diet of Gulf of Alaska Steller sea lions, *Eumetopias jubatus* [*In*] Ecology of juvenile walleye pollock, *Theragra chalcogramma*. NOAA Technical Report NMFS 126.

Munk, K. M. 2001. Walleye pollock otolith aging: comparison of the techniques used by two agencies. Regional Information Report No. 5J01-06, Juneau, AK.

Munk, K. M., and K. M. Smikrud. 2002. Relationships of otolith size to fish size and otolith ages for yelloweye Sebastes ruberrimus and Quillback S. maliger rockfishes. Regional Information Report Number 5J02-05, Juneau, AK.

Munk, K. M. 2004. Otolith diagnostic characters used to reveal older age range in walleye pollock. Poster presented at the Third International Symposium on Fish Otolith Research and Application, 11-16 July 2004, Townsville, Australia (available from K. M. Munk, Alaska Department of Fish and Game, Box 115526, Juneau, AK 99811).

Muter, F-J., B. L. Norcross. 1993. Distribution, abundance and growth of larval walleye pollock, *Theragra chalcogramma*, in an Alaskan fjord. Fishery Bulletin 92:579–590.

REFERENCES CITED (Continued)

Piatt, J. F., editor. 2002. Response of seabirds to fluctuations in forage fish density. Final Report to *Exxon Valdez* Oil Spill Trustee Council (Restoration Project 00163M) and Minerals Management Service (Alaska OCS Region). Alaska Science Center, U.S. Geological Survey, Anchorage, AK.

Romano, M. D., J. F. Piatt, and D. D. Roby. 2006. Testing the junk-food hypothesis on marine birds: Effects of prey type on growth and development. Waterbirds 29(4):407–414.

Rosen, D. A. S. and A. W. Trites. 2000. Pollock and the decline of Steller sea lions: Testing the junk-food hypothesis. Canadian Journal of Zoology 78:1243–1250.

Springer. A. M. 1996. Prerecruit walleye pollock, *Theragra chalcogramma*, in seabird food webs of the Bering Sea (abstract) 198–201 [*In*] Ecology of juvenile walleye pollock, *Theragra chalcogramma*. NOAA Technical Report NMFS 126.

Wilson, M. T., A. L. Brown, K. L. Mier. 2005. Geographic variation among age-0 walleye pollock (Theragra chalcogramma): evidence of mesoscale variation in nursery quality? Fisheries Bulletin 103:207–218.

Witherell, D. 2000. Groundfish of the Bering Sea and Aleutian Islands Area: Species profiles 2001. North Pacific Fishery Management Council, Anchorage, AK.

Woodby D. W., D. Carlile, S. Siddeek, F. Funk, J. H. Clark, L. Hulbert. 2005. Commercial fisheries of Alaska. Alaska Department of Fish and Game, Special Publication No. 05-09.

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Table 1.–Overview of Kastelle and Kimura (2006) walleye pollock study samples and age interpretation using Method A and Method B.

Description	Sample	Method A	Method B
selection of study specimens	biased (used Method A)		
surface predetermination of age		yes	no
use of otolith cross section		33.7%	100%
fish length available to reader		yes	no
age profile		young	old
5 radiometric sample groups	40–45 specimens each		

Table 2.–Walleye pollock were cultured and sampled yearly to collect otoliths and to document otolith and somatic dimensions at known age.

Sample Date	*n*=	Known Age	Mean Somatic Length	Somatic Length Standard Deviation	Mean Somatic Weight	Somatic Weight Standard Deviation	Mean Otolith Length	Otolith Length Standard Deviation	Mean Otolith Height	Otolith Height Standard Deviation	Mean Otolith Weight	Otolith Weight Standard Deviation
6/29/2006	2	0.25	41.1	0.721249	0.421	0.043841	1.8	0.141421	0.8	0.240416	0.0008	0.000035
8/10/2006	198	0.375	63.0	7.615948	1.83574	0.838099	2.9	0.454804	1.3	0.184548	0.0020	0.000853
8/11/2006	226	0.375	72.8	9.920478	2.947888	1.335876	3.5	0.580752	1.5	0.250555	0.0034	0.001479
8/12/2006	123	0.375	68.9	9.152364	2.319951	1.096475	3.3	0.533845	1.4	0.227312	0.0027	0.001340
8/14/2006	30	0.375	78.4	10.20782	3.763167	1.492553	3.9	0.610847	1.7	0.263029	0.0044	0.001762
1/2/2007	8	0.75	132.0	8.213766	16.075	3.603074	6.4	0.362321	2.5	0.097043	0.0158	0.001518
4/2/2007	*38*	*1*	*176.6*	*16.95071*	*46.73947*	*13.85552*	*8.2*	*0.697093*	*3.2*	*0.288279*	*0.0317*	*0.020894*
6/8/2007	65	1.25	197.4	23.08911	59.11234	21.67827	9.0	0.882974	3.6	0.400651	0.0403	0.009935
4/8/2008	*35*	*2*	*329.3*	*25.07257*	*326.6029*	*98.23477*	*13.4*	*0.841881*	*5.3*	*0.412755*	*0.1292*	*0.021658*
4/1/2009	*32*	*3*	*379.0*	*34.64563*	*533.2727*	*188.9233*	*15.3*	*1.096241*	*5.8*	*0.53194*	*0.1937*	*0.036536*
4/1/2010	*27*	*4*	*419.0*	*34.948*	*677.4074*	*209.1566*	*16.7*	*1.110692*	*6.5*	*0.657899*	*0.2561*	*0.047623*
3/25/2011	*22*	*5*	*443.9*	*41.97*	*772.2*	*327.93*	*17.4*	*2.6123*	*6.6*	*1.0453*	*0.3096*	*0.111*
Grand Total	725											
Full Years	***154***											

Note: Italics indicate full years of growth.
Note: Sample dates from 6/29/2006 through 8/14/2006 represent subsamples from wild fish entering the cultured population.

Table 3.–Walleye pollock somatic and otolith data for subjective aged methodologies. R:A used Method A, while R:B and PWS used Method B. R:A and R:B are matched data.

	R:A (Method A)							
AGE	Somatic n	Mean Somatic Length	Somatic Length Standard Deviation	Otolith n	Mean Otolith Length	Otolith Length Standard Deviation	Mean Otolith Weight	Otolith Weight Standard Deviation
1								
2								
3	184	284	21.96022	145	13.2	0.839188	0.129245	0.020083
4	142	354	30.9033	128	15.4	1.019697	0.210071	0.034967
5	2	445	25	2	17.6	1.31	0.309553	0.069491
6	159	457	41.01777	136	18.3	1.117857	0.366674	0.050479
7	55	514	51.22822	49	19.5	1.748496	0.466327	0.081693
8	75	530	29.02872	72	19.9	1.113719	0.499078	0.065507
9	1	460		1	20.0		0.44643	
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
Total	618			533				

-continued-

Table 3. Page 2 of 3.

	R:B (Method B)							
AGE	Somatic n	Mean Somatic Length	Somatic Length Standard Deviation	Otolith n	Mean Otolith Length	Otolith Length Standard Deviation	Mean Otolith Weight	Otolith Weight Standard Deviation
1								
2								
3	82	279	16.58537	66	13.0	0.772814	0.124832	0.01465
4	67	294	29.96694	52	13.4	1.007492	0.14036	0.030737
5	45	312	36.14511	38	14.0	1.413808	0.165028	0.047229
6	48	340	37.47221	40	14.9	1.067461	0.190893	0.037462
7	34	348	34.62228	31	15.2	0.913457	0.204534	0.030434
8	23	373	60.23269	20	15.8	1.289303	0.232059	0.078551
9	31	385	43.39399	27	16.3	1.492398	0.260359	0.066459
10	30	441	44.93947	24	18.1	1.194416	0.355441	0.076553
11	31	466	53.32054	28	18.0	1.817376	0.379758	0.080604
12	39	461	59.19913	37	18.4	1.605246	0.38724	0.099739
13	42	466	50.70702	37	18.3	1.475654	0.379975	0.076171
14	29	499	46.85597	26	19.4	0.943709	0.452059	0.084003
15	38	503	36.03246	35	19.2	1.714325	0.43551	0.085302
16	31	505	54.64482	26	19.6	1.216054	0.458254	0.083516
17	22	511	70.1489	20	19.5	1.534591	0.461539	0.115986
18	11	535	29.03404	11	20.2	0.967418	0.493044	0.061971
19	5	536	55.35341	5	20.4	1.464426	0.498696	0.115824
20	4	468	14.7902	4	18.4	1.431422	0.37957	0.054495
21	2	550	20	2	20.7	0.415	0.497495	0.001579
22	1	500		1	20.0	0	0.449588	
23	1	570		1	19.6	0	0.42853	
24	1	530		1	19.6	0	0.435901	
25								
26								
27								
28	1	550		1	18.3	0	0.4538	
29								
30								
31								
Total	618			533				

-continued-

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	PWS (Method B)						
AGE	Somatic Otolith n	Mean Somatic Length	Somatic Length Standard Deviation	Mean Otolith Length	Otolith Length Standard Deviation	Mean Otolith Weight	Otolith Weight Standard Deviation
1	8	204	26.77285	9.5	1.056392	0.048188	0.013074
2	7	280	23.85971	12.7	0.761886	0.110214	0.017583
3	4	333	55.72178	14.1	1.450812	0.164625	0.04956
4	11	369	38.18186	15.7	1.185664	0.212636	0.043821
5	31	391	74.8603	16.3	1.676851	0.247871	0.092737
6	59	375	56.49436	16.1	1.46676	0.231992	0.072393
7	92	402	66.28947	16.7	1.777498	0.268625	0.089673
8	81	429	63.31551	17.2	1.67137	0.29129	0.093029
9	86	455	61.75501	17.9	1.483428	0.334128	0.102909
10	80	489	64.69554	19.0	1.878216	0.403575	0.126783
11	76	503	64.97494	19.0	1.667917	0.419868	0.11954
12	80	500	64.27475	19.3	1.679355	0.418994	0.123458
13	109	521	61.67347	19.6	1.576256	0.451619	0.113125
14	122	523	53.17451	19.9	1.613412	0.472787	0.110145
15	111	531	54.27837	20.2	1.406909	0.494495	0.103387
16	142	541	46.49852	20.2	1.39205	0.502687	0.109448
17	167	546	46.64909	20.3	1.328916	0.516213	0.101109
18	112	552	45.97624	20.6	1.288658	0.525362	0.092535
19	94	553	48.81592	20.5	1.272918	0.540043	0.110384
20	68	558	45.93475	20.7	1.44543	0.5475	0.113046
21	54	559	51.34552	20.7	1.184976	0.568741	0.115593
22	40	556	50.57171	20.4	1.178693	0.543963	0.10097
23	27	563	41.62038	21.1	1.316763	0.564685	0.09256
24	15	553	45.25936	20.6	0.903969	0.507767	0.076279
25	16	563	38.5914	21.0	1.50694	0.584531	0.125601
26	8	561	47.48665	21.2	1.760835	0.567813	0.136743
27	3	574	34.70351	21.6	0.347707	0.6535	0.061524
28	3	641	66.19919	22.0	1.256198	0.659667	0.058774
29	2	565	78.48885	21.3	2.064752	0.627	0.250316
30							
31	1	584		19.8		0.615	
Total	1709						

Table 4.–One-tailed two-sample hypotheses tests (alpha = 0.05) compared KOA to calculated otolith accretion for data sets Radiometric Methods A (R:A) and B (R:B) and PWS, and assuming that KOA established an upper boundary (e.g. the H_A). Significant *p*-values are underlined and in bold font.

Age Class(es)	Test	Known	N	Mean	SD	sign	Tested	N	Mean	SD	*p*-value	Outcome
4 & 5	H_0	KOA	49	0.06	0.08	$\leq$	R:A	130	0.081	0.036	0.972	fail to reject null
4 & 5	H_0	KOA	49	0.06	0.08	$\leq$	R:B	90	0.019	0.039	**0.001**	reject null
4 & 5	H_0	KOA	49	0.06	0.08	$\leq$	PWS	42	0.036	0.082	0.130	fail to reject null

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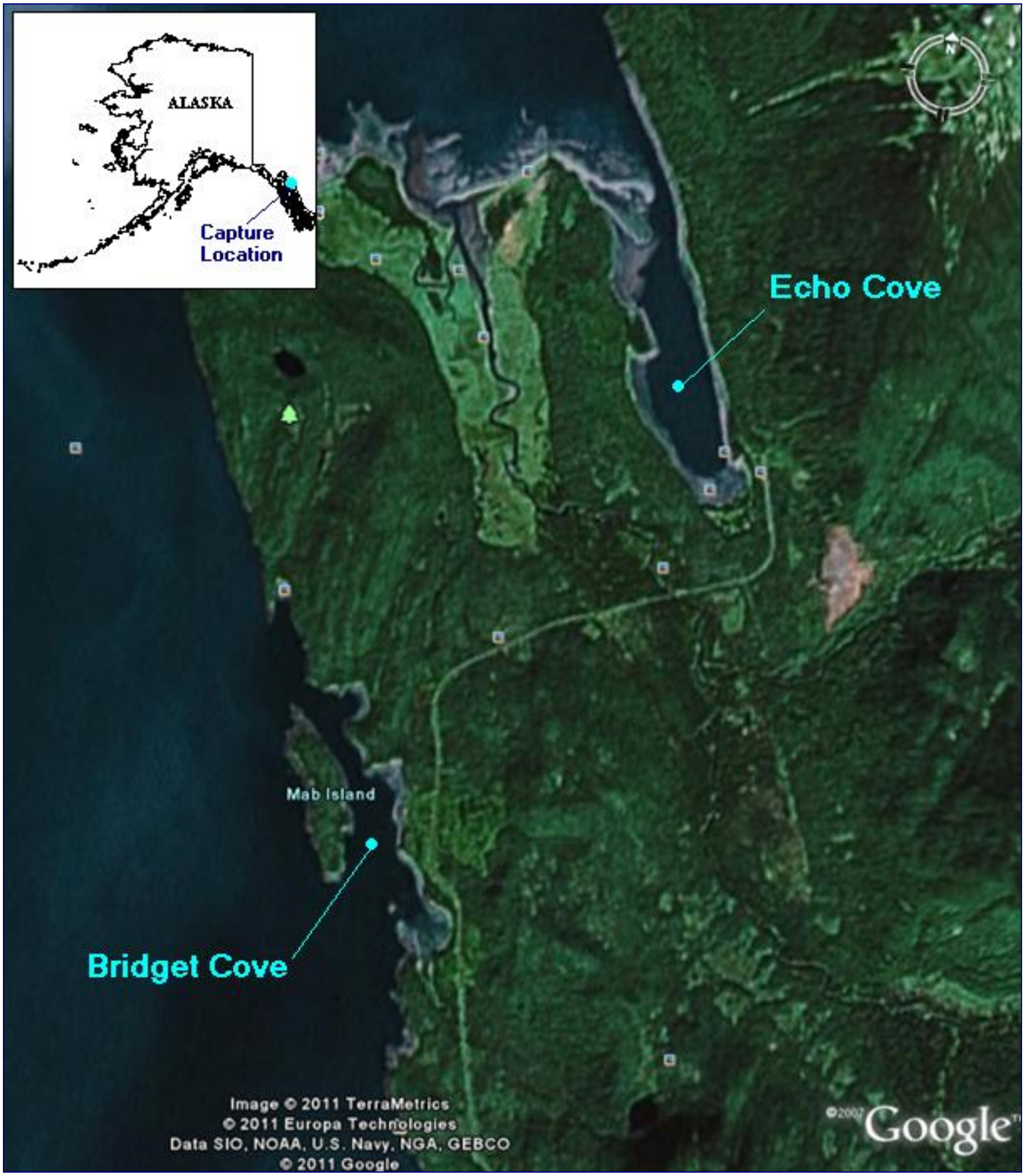


Figure 1.–From June through August 2006, young-of-year walleye pollock were beach seined in Echo and Bridget Coves in Lynn Canal, Southeast Alaska, and then transported to culture tanks.

Figure 2.–Beach seining was conducted during minus tide series by three ADF&G personnel deploying either a 37 m × 5 m or a 37 m × 1.2 m net from a 5.2 m skiff, at both Echo (in photo) and Bridget Coves.

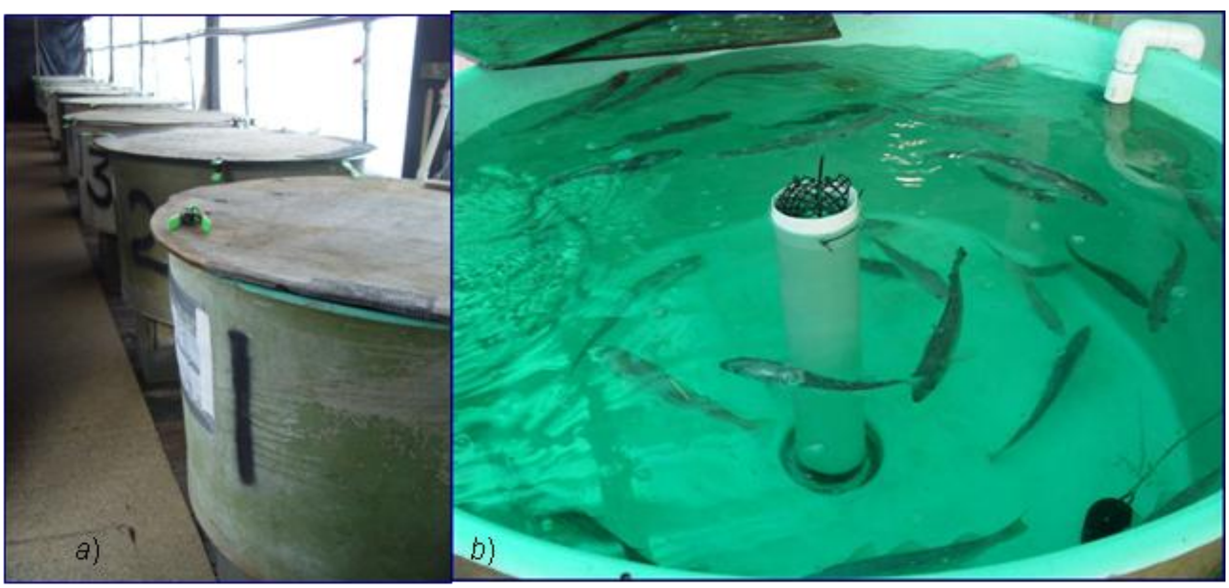


Figure 3.–The age-0 walleye pollock from the 2006 year class were cultured at the Auke Bay Marine Station from 2006 to March 2011 (ongoing) in *a*) 10 circular tanks *b*) 48′′ diameter and 30′′ deep. Age-1+ pollock are seen in the open tank.

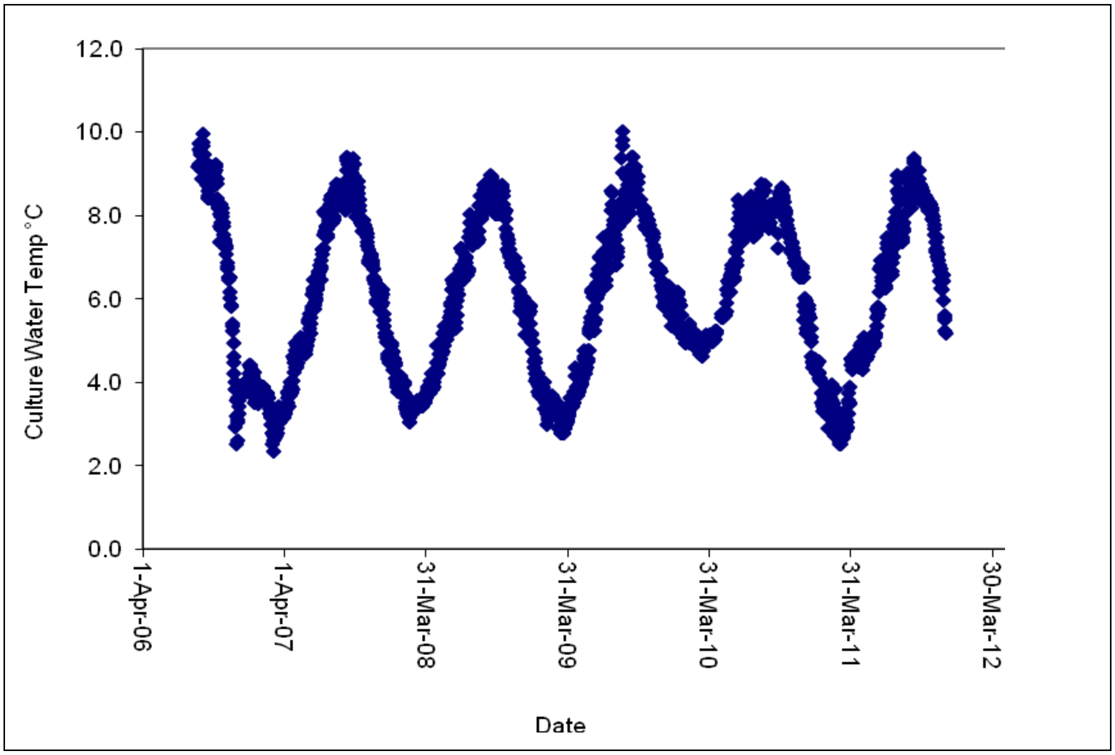


Figure 4.–Water source for the culture tanks came from 33 m deep in Auke Bay and demonstrated seasonal temperature fluctuation.

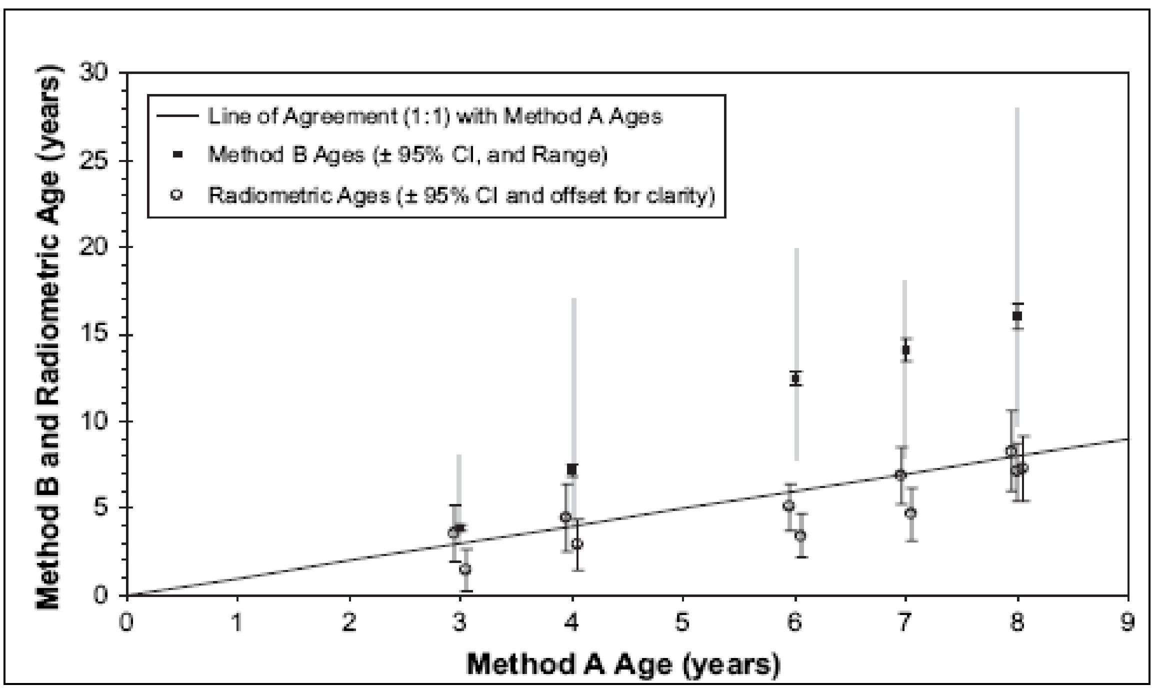


Figure 5.–Reproduced from Kastelle and Kimura (2006) radiometric study: "Figure 1. Comparison of method B average ages and radiometric ages with method A ages. Error bars are ±95% CI, and shaded bars on method B are the range showing the maximum and minimum age."

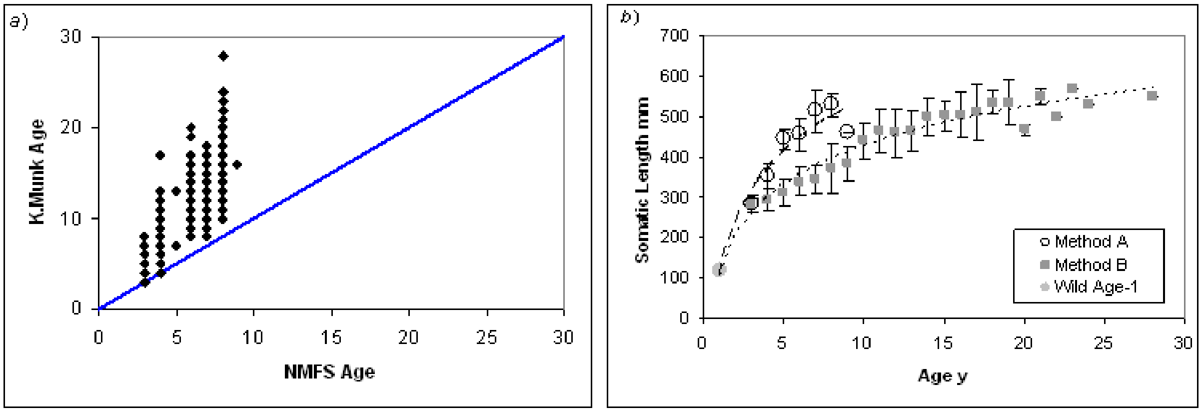


Figure 6.–Matched data from specimens used in the radiometric age validation reveal the degree of difference in the Method A versus Method B age reading strategies: *a*) With 45% agreement at age 3, an age bias plot indicates divergence after age 3 (the diagonal line indicates agreement); and *b*) Somatic length-at-age (n = 618) indicate very different rates of growth and overall age in pollock. A mean somatic length at age 1 from wild pollock reported in Kastelle and Kimura (2006) is used in common for Method A and B data sets to anchor their respective trendlines. *Y*-error bars are standard deviation for somatic length at estimated age.

Note: These graphics were not presented in Kastelle and Kimura 2006.

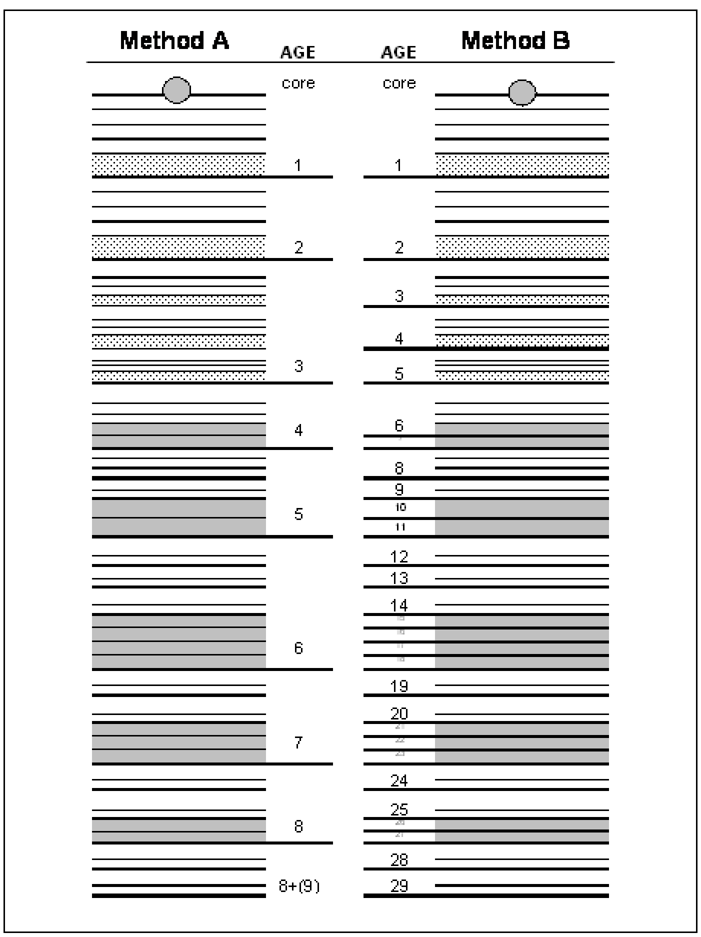


Figure 7.–A representation of parsing differences of the pollock growth pattern. The younger age profile for pollock (Method A) groups growth increments according to visually dominant swaths, while the older age profile for pollock (Method B) tends to split later swaths, which results in more annuli. The methods have 45% agreement through age 3.

Note: This graphic was not presented in Kastelle and Kimura 2006.

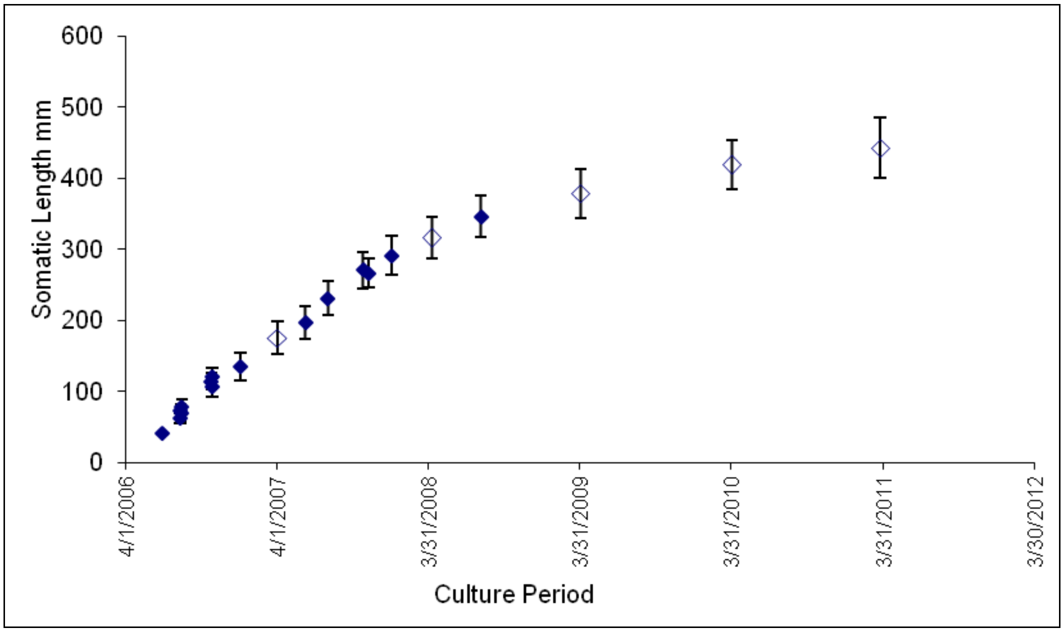


Figure 8.–Pollock grew well under culture and achieved a high rate of growth. Dates from 6/12/2006 through 8/14/2006 represent wild fish growth entering the population; dates after 8/15/2006 represent growth under culture. Cultured pollock were live sampled quarterly (2006–2009) with a yearly subsample for otoliths; this data series includes all sampling (n = 1751). *Y*-error bars are standard deviation for somatic length-at-age. Open points indicate full years of growth, and are inclusive of the annual otolith sample.

Figure 9.–Annual mortality was <12%, through age 4; however, mortality increased to 25% after culture tanks were relocated.

Note: These mortality estimates represent fish which were discovered dead or moribund in the culture tanks; they exclude fish deaths resulting from operational incidents, fish jumping from tanks, predation, and annual sampling.

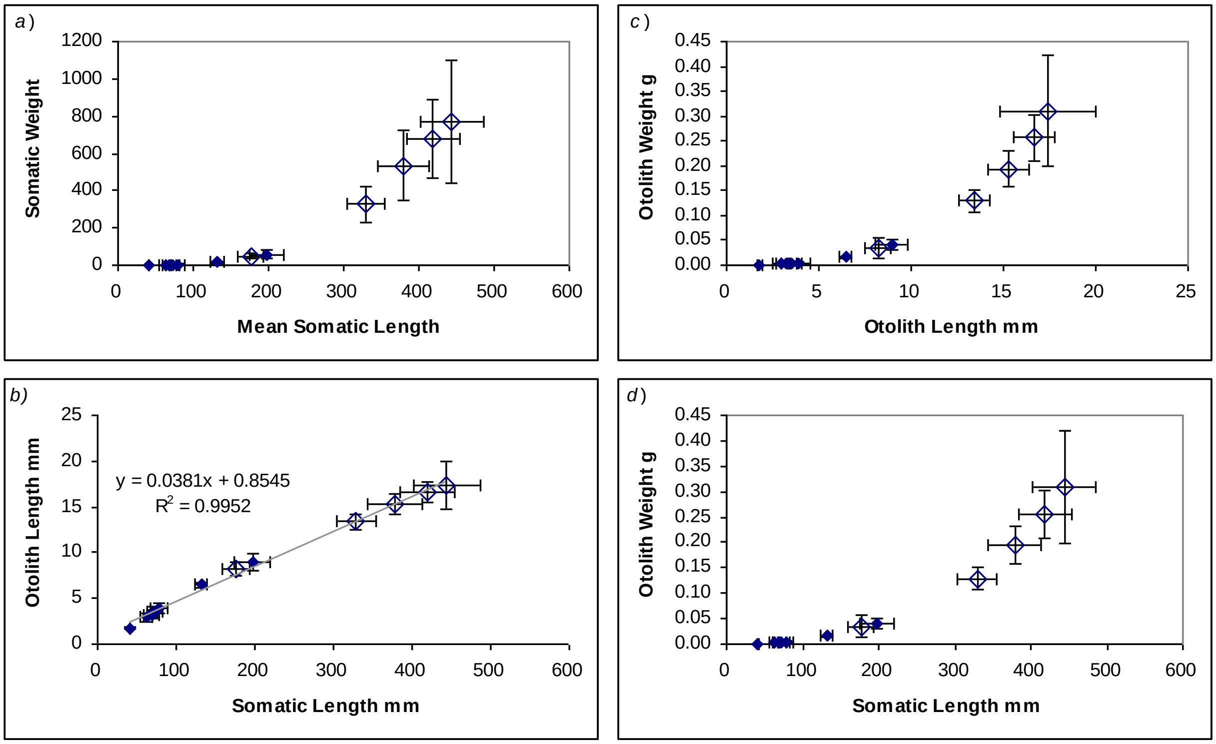


Figure 10.–Cultured walleye pollock somatic and otolith dimensions (n = 725) are well correlated: *a*) somatic length to somatic weight; *b*) somatic length to otolith length; *c*) otolith length to otolith weight; and *d*) somatic length to otolith weight. The *X*- and *Y*-error bars are standard deviation for their respective dimensions. The data in these charts include subsamples from wild fish entering the cultured population (ending 8/14/2006), tank mortalities resulting from water failure, and annual otolith samples (open points).

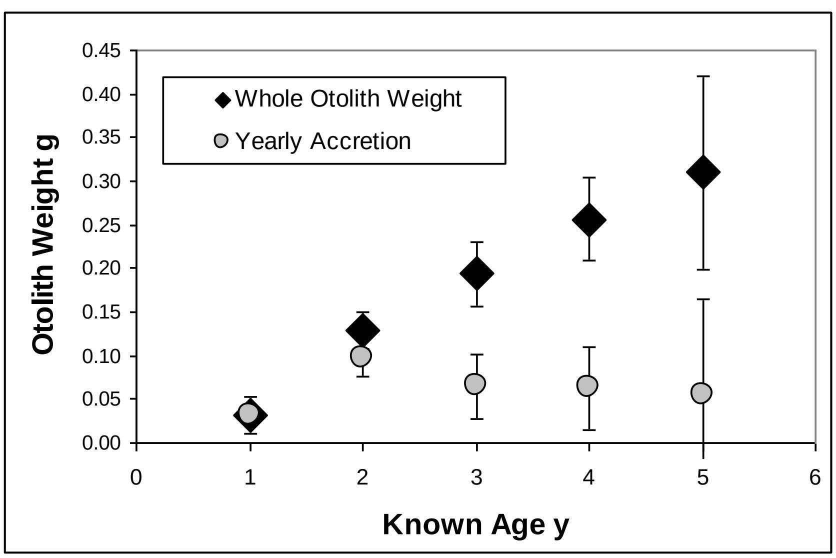
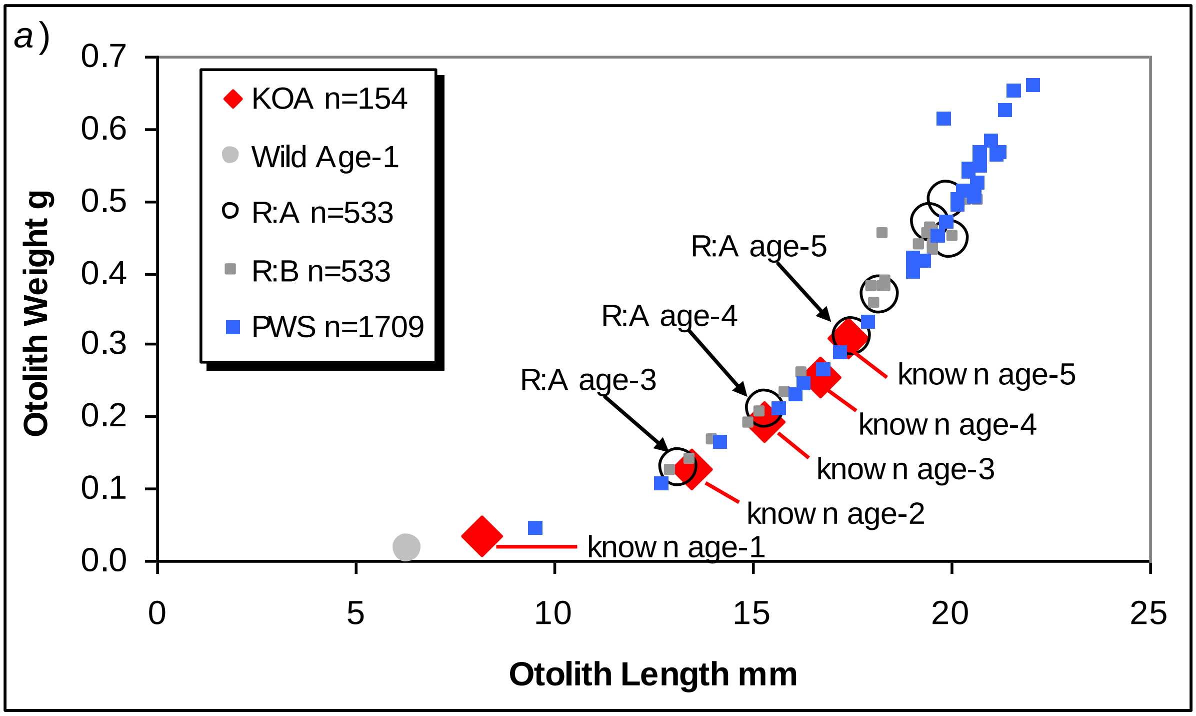


Figure 11.–Known whole otolith weight-at-age (n = 154) and yearly accretion in cultured walleye pollock. Yearly accretion is the amount of calcium carbonate accreted to the otolith for any single year. *MYA* peaked during the second year (also when mean somatic length doubled) and dropped in the third year and commenced slight decline. *Y*-error bars are +/- one standard deviation in whole otolith weight or yearly accretion.



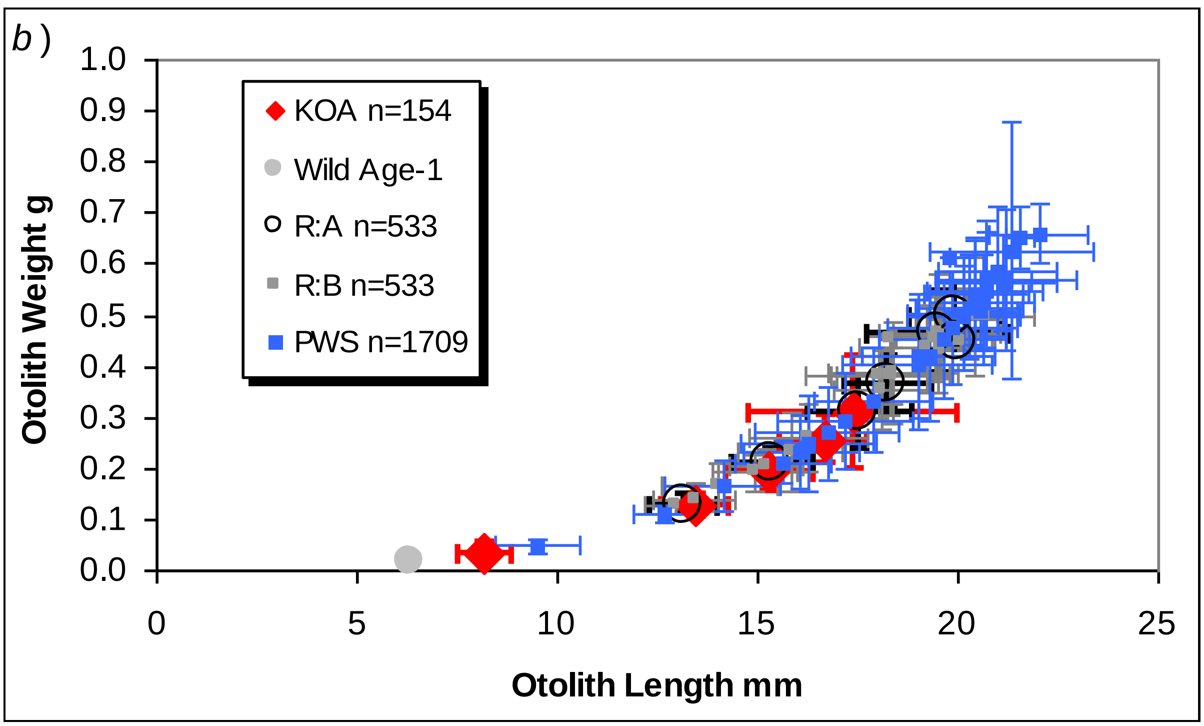


Figure 12.– *a*) The relationship between mean otolith weight and mean otolith length for the cultured walleye pollock KOA data is consistent with the radiometric and PWS otolith specimen data. Ages are annotated for the KOA data below the curve (age 1 through age 5), and above the curve for estimated ages for R:A data. Note that the otolith weight-at-length datum for R:A age 5 inordinately increased from R:A age 4, leap-frogging a known accretion year data point and after the known yearly accretion was in decline. *b*) Same data as in *a*) but with error bars (+/- one standard deviation).

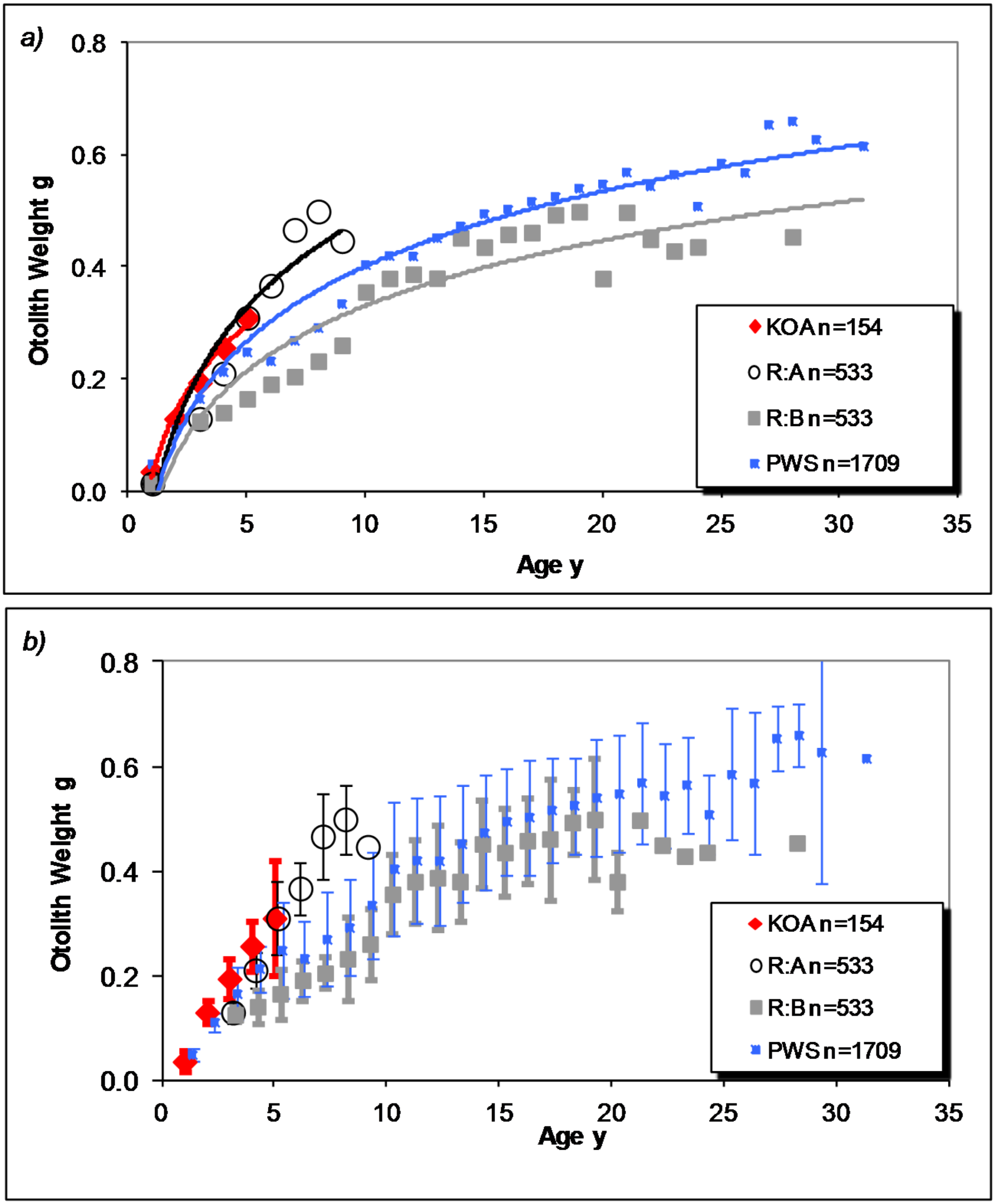


Figure 13.–*a*) Known mean otolith weight-at-age (n = 154) for walleye pollock chart an upper boundary for tested data: R:A (n = 533), R:B (n = 533), PWS (n = 1709). The accretion boundary (red line) represents an expected change of rate given known accretion through age 5. A mean otolith weight at age 1 (black circle) from wild pollock reported in Kastelle and Kimura (2006) is used to anchor trendlines for R:A and R:B. *b*) Same data as in *a*) but with error bars (+/- one standard deviation).

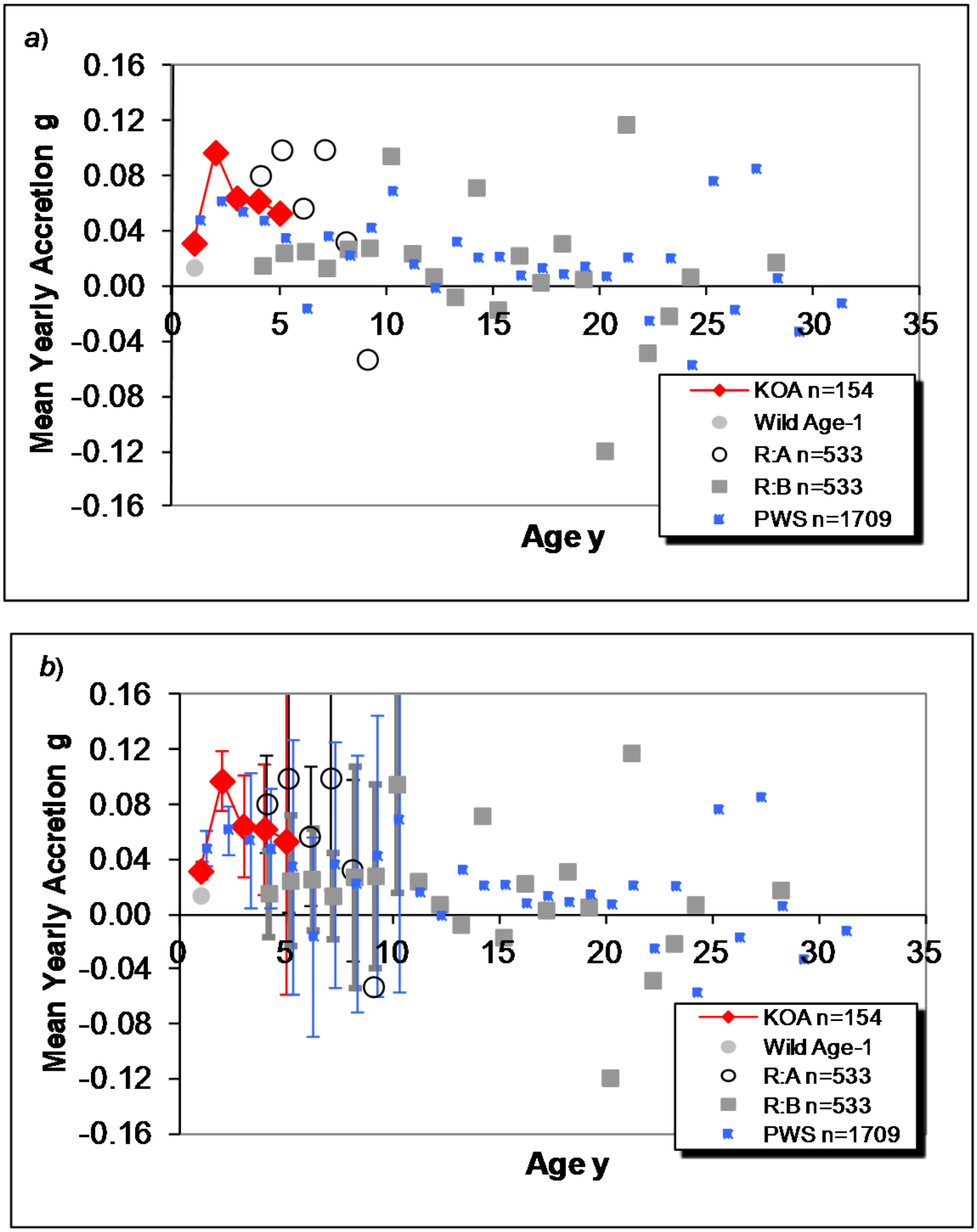


Figure 14.– *a*) *MYA* is the averaged amount of calcium carbonate accreted to the otolith for one year. The high rate of growth in cultured pollock (solid diamonds, red error bars) establishes the upper boundary for expected *MYA* values: R:A (open circles, black error bars), R:B (solid squares, green error bars), and PWS (blue squares with x, blue error bars). *b*) Same data as in *a*), but with *Y*-error bars (+/- one standard deviation) noted through age 10 only. Ages are offset slightly to facilitate viewing of error bars.

Note: See Equation 1 for description of calculation of *MYA* values.

Note: *MYA* values for successive known-age age classes are expected always to be positive; however, calculated *MYA*s based on subjective ages might not always be positive because they could represent differences in growth between multiple year classes or include age reading error.

APPENDIX

Appendix 1.– Otolith age and otolith weight data for the Kastelle and Kimura (2006) radiometric data set.

NMFS ID No.	Fish Length mm	ADF&G Age [a]	NMFS Age	Otolith Length mm	Otolith Height mm	Otolith Weight g
2	440	13	6	18.3	6.92	0.305
4	340	11	4	14.52	5.9	0.199
5	510	16	8	19.36	7.49	0.425
6	530	15	8	18.45	7.75	0.438
7	340	6	3	13.49	5.61	0.143
10	330	7	4	15.07	5.36	0.179
15	420	13	6	18.08	7.07	0.367
18	270	6	3	13.42	4.89	0.121
19	510	18	8	18.75	7.56	0.404
20	470	15	7	17.64	6.89	0.340
21	420	10	6	17.91	6.64	0.335
22	280	5	3	12.49	5.15	0.093
24	420	12	6	17.43	7.17	0.371
26	510	16	8	20.02	7.81	0.501
28	430	10	4	18.09	6.23	0.263
29	390	13	4	15.16	6.43	0.245
31	380	8	4	16.19	6.39	0.260
32	500	15	8	17.18	6.96	0.288
33	480	15	6	18.64	7.42	0.383
34	510	16	7	19.86	6.96	0.499
35	510	16	8	19.21	7.57	0.490
36	280	5	3	12.58	4.84	0.122
37	300	6	3	13.29	5.59	0.161
38	530	13	6	18.64	7.29	0.377
39	390	10	4	15.79	6.05	0.243
40	500	15	6	20.39	8.37	0.447
41	340	8	4	14.56	5.79	0.174
42	270	5	3	12.19	5.06	0.135
45	460	14	7	17.59	7.46	0.414
47	350	6	4	16.08	6.06	0.235
48	500	12	8	20.58	7.63	0.568
49	290	5	3	13.03	4.95	0.125
50	560	18	7	19.26	7.81	0.465
53	520	17	6	19.82	6.98	0.344
54	640	17	7	20.9	7.92	0.682
55	270	6	3	13.16	4.59	0.116
56	260	4	3	11.78	4.71	0.110
60	290	3	3	12.79	5.23	0.122
62	540	17	8	19.97	8.63	0.588
63	360	9	4	16.53	6.36	0.220
64	320	9	4	15.21	5.47	0.182
67	340	8	4	15.52	6.27	0.230
68	430	13	6	17.33	7.31	0.342
71	280	4	3	13	4.79	0.124
72	340	7	4	14.53	5.66	0.181
73	500	13	7	20.83	7.96	0.502
74	260	6	3	12.71	4.65	0.116
76	470	13	5	18.87	7.27	0.379
77	560	15	8	20.19	8.69	0.530
78	340	7	4	15.3	6	0.215
79	430	10	6	18.29	6.67	0.353
80	520	14	8	20.28	8.32	0.678
81	540	13	6	21.17	8.35	0.406
82	330	7	4	15.16	5.38	0.184
84	450	20	6	18.06	7.8	0.386
85	500	18	8	19.41	8.29	0.492
87	490	20	8	19.62	7.13	0.433
89	480	15	7	19.81	7.38	0.464
90	410	17	6	18.01	6.72	0.311
92	300	5	3	12.3	5.24	0.115
94	270	3	3	12.69	4.96	0.126
96	320	9	4	13.76	5.5	0.147
97	500	14	6	18.93	7.21	0.417
99	470	20	6	19.69	7.55	0.410
102	340	6	4	13.83	5.69	0.181
103	420	9	6	17.57	6.88	0.326
104	560	16	7	20.24	7.88	0.502
106	360	6	4	15.47	6.1	0.211
107	500	10	8	21.99	8.16	0.555
109	410	12	6	17.02	6.73	0.318
111	470	17	6	17.45	6.79	0.340
113	490	10	6	18.44	7.3	0.412
116	340	5	4	15.85	6.02	0.213
117	500	11	6	19.22	7.58	0.426
118	510	15	8	18.97	8.25	0.499
126	360	6	4	15.82	6.38	0.237
127	350	7	4	14.21	6.14	0.202
131	540	17	8	18.32	7.97	0.416
132	560	12	7	20.58	8.01	0.489
137	340	7	4	14.62	6.03	0.213
139	410	12	6	17.72	6.51	0.321
140	400	17	6	16.59	6.59	0.281
142	370	7	4	14.69	6.23	0.208
144	490	12	7	20.64	8.18	0.526
145	480	11	6	17.75	7.29	0.344
146	480	12	6	18.46	7.41	0.417
148	520	14	8	19.63	8.48	0.573
149	430	12	6	18.27	5.99	0.343
150	460	12	6	18.72	7.35	0.364
152	270	3	3	12.71	5.06	0.121
153	350	6	4	15.6	5.28	0.171
156	520	15	6	19.24	7.98	0.438
157	270	4	3	12.83	5.1	0.125
160	550	13	8	20.47	8.25	0.524
161	430	13	6	16.88	7.49	0.350
164	320	6	4	13.83	5.68	0.188
166	260	4	3	12.11	4.87	0.110
167	370	7	4	14.89	6.14	0.193
169	400	10	6	17.36	6.94	0.338
170	610	16	7	22.26	8.35	0.654
173	460	13	6	16.9	7.61	0.354
174	470	12	6	17.22	6.51	0.367
176	460	20	6	16.18	6.89	0.290
177	370	8	4	15.85	6.13	0.208
179	580	14	8	20.89	8.44	0.511
181	470	16	7	19.33	8.13	0.436
183	450	13	7	19.63	7.85	0.402
184	400	11	4	16.14	6.52	0.236
187	360	7	4	15.9	6.02	0.220
188	460	8	6	17.51	7.2	0.384
190	520	16	8	18.94	7.92	0.538
191	320	5	4	13.69	5.73	0.162
193	480	13	6	19.21	7.03	0.366
194	510	11	6	17.48	8.03	0.390
195	350	6	4	14.85	5.97	0.201
197	400	6	4	16.06	6.5	0.233
198	290	3	3	12.21	4.96	0.113
199	520	11	6	17.31	7.24	0.377

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Source: Kristen Munk, Age Determination Unit program manager. Walleye pollock otolith accretion study proposal, 2006.

[a] ADF&G Age actually represents an experimental methodology developed by K. Munk and is not the age estimage supported by ADF&G.

NMFS ID No.	Fish Length mm	ADF&G Age [a]	NMFS Age	Otolith Length mm	Otolith Height mm	Otolith Weight g
200	510	15	8	20.9	8.04	0.553
201	420	11	6	17.95	7.08	0.363
202	340	7	4	15.5	5.73	0.211
204	510	15	8	18.53	7.55	0.460
205	320	4	3	13.85	5.47	0.148
207	440	9	6	17.57	6.79	0.340
211	360	10	4	16.02	5.72	0.213
213	310	4	3	13.12	5.75	0.157
215	540	17	8	17.7	7.81	0.432
216	290	4	3	12.93	5.22	0.123
217	440	9	6	18.05	7.01	0.321
219	430	13	6	17.29	7.08	0.341
223	280	4	3	12.44	4.99	0.118
224	500	17	7	19.16	7.72	0.479
225	520	13	8	19.2	8.33	0.520
226	290	3	3	12.71	5.05	0.125
227	440	13	6	17.98	6.81	0.336
228	500	14	6	18.87	7.58	0.461
229	460	11	6	17.54	7.07	0.371
232	300	4	3	13.92	5.15	0.135
233	290	7	3	13.16	5.28	0.141
235	330	9	4	14.43	6.23	0.221
236	270	4	3	12.13	4.73	0.116
237	270	3	3	12.26	4.84	0.113
238	350	6	4	15.19	6.15	0.212
241	340	6	4	15.08	5.86	0.203
243	570	10	7	19.14	8.13	0.484
244	340	8	4	13.75	6.33	0.211
246	550	16	8	18.95	8.21	0.517
247	320	8	4	15.07	5.69	0.206
248	340	6	4	15.62	5.9	0.214
250	360	9	4	16.97	6.06	0.234
252	310	5	3	12.12	5.06	0.125
255	290	3	3	13.41	5.19	0.140
256	340	9	4	14.31	6.2	0.195
257	340	5	4	15.16	6.1	0.214
258	320	5	3	13.49	5.1	0.135
259	510	10	6	18.6	7.8	0.397
261	350	6	4	14.59	6.27	0.222
262	410	9	4	15.42	6.78	0.278
263	530	16	8	19.13	7.45	0.473
264	440	6	4	14.5	6.99	0.223
265	330	4	3	13.72	6.07	0.172
266	320	3	3	14.73	5.4	0.164
267	520	16	8	19.76	7.79	0.475
268	510	10	8	19.1	8.07	0.491
269	260	4	3	11.79	4.79	0.113
270	320	5	4	15.79	5.46	0.208
271	260	3	3	12.01	5.23	0.114
272	530	16	8	20.96	7.26	0.537
274	270	3	3	13.26	5.24	0.144
275	340	4	4	13.82	5.67	0.181
278	520	15	7	19.18	7.25	0.373
279	300	3	3	12.53	5.15	0.130
280	280	4	3	12.97	4.96	0.120
281	310	4	3	14.14	5.36	0.162
282	540	16	7	19.95	7.29	0.426
284	460	11	4	15.72	7.2	0.320
289	350	9	4	14.42	5.37	0.165
290	270	3	3	12.61	4.94	0.119
291	620	17	8	21.85	7.9	0.538
292	290	3	3	13.13	5.18	0.125
293	290	3	3	12.8	5.2	0.126

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NMFS ID No.	Fish Length mm	ADF&G Age [a]	NMFS Age	Otolith Length mm	Otolith Height mm	Otolith Weight g
295	320	6	4	14.09	5.45	0.170
300	440	11	6	15.37	6.88	0.306
301	290	4	3	13.28	5.42	0.134
302	480	17	4	19.74	7.33	0.421
306	320	11	4	15.82	6.07	0.206
307	440	12	6	17.96	7.06	0.360
308	300	4	3	13.07	5.44	0.143
309	270	5	3	13.74	5.11	0.121
311	520	15	8	19.11	7.84	0.504
312	520	19	8	20.54	8.02	0.432
313	360	7	4	16.17	5.77	0.224
314	300	4	3	13.53	5.03	0.125
315	300	4	3	13.69	5.12	0.133
316	450	11	6	17.69	7.35	0.331
317	260	4	3	12.87	4.94	0.123
318	460	11	7	18.4	7.42	0.419
319	300	4	3	13.03	5.46	0.146
320	320	12	4	14.28	5.67	0.165
321	300	3	3	14.23	5.56	0.138
322	490	12	6	17.31	7.01	0.350
324	420	7	4	15.86	6.51	0.237
325	300	3	3	14.08	5.74	0.150
326	450	15	6	18.55	6.61	0.335
329	290	3	3	12.25	5.19	0.121
330	560	14	7	19.19	8.55	0.504
332	290	5	3	14.11	5.72	0.140
333	420	14	7	19.66	8.11	0.455
339	350	8	4	16.15	6.12	0.173
342	530	16	8	22.07	8.43	0.618
346	490	13	6	14.4	8	0.500
347	530	19	8	20.05	8.3	0.530
348	510	13	7	19.24	7.93	0.442
349	480	13	7	19.18	7.29	0.430
350	380	13	4	16.37	6.52	0.216
352	290	5	3	13.36	5.01	0.136
355	450	19	6	18.43	6.72	0.322
356	370	9	4	14.98	6.51	0.219
359	500	13	6	19.33	7.56	0.415
361	340	8	4	16.29	5.81	0.185
364	530	24	8	19.6	8.03	0.436
365	340	12	4	15.39	5.65	0.170
366	330	13	4	15.96	5.66	0.171
370	320	4	3	15.11	5.31	0.161
372	380	16	6	17.32	6.65	0.285
373	340	5	4	10.88	6.27	0.235
374	480	17	8	20.36	7.04	0.442
375	370	7	4	16.37	6.49	0.216
376	570	21	8	21.1	8.04	0.499
378	530	15	8	21.01	7.88	0.549
380	270	7	3	12.94	5.19	0.124
381	460	13	6	18.03	7.05	0.325
382	540	18	8	20.35	8.11	0.520
383	430	15	7	19.06	7.98	0.398
384	270	3	3	12.66	4.87	0.121
385	560	18	8	21.81	9.34	0.616
386	510	11	7	21	8.18	0.480
387	420	10	6	18.42	7.07	0.352
390	440	9	6	18.55	6.94	0.350
392	460	12	6	18.72	7.66	0.347
393	450	13	6	18.86	7.18	0.379
394	440	14	6	18.73	7.17	0.351
396	290	4	3	13.08	5.48	0.143
397	290	3	3	13.62	5.45	0.137

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Source: Kristen Munk, Age Determination Unit program manager. Walleye pollock otolith accretion study proposal, 2006.
[a] ADF&G Age actually represents an experimental methodology developed by K. Munk and is not the age estimage supported by ADF&G.

NMFS ID No.	Fish Length mm	ADF&G Age [a]	NMFS Age	Otolith Length mm	Otolith Height mm	Otolith Weight g
401	370	9	4	15.92	5.96	0.204
404	480	11	6	19.55	7.61	0.409
405	520	11	8	20.68	8.15	0.540
406	400	10	6	17.81	6.83	0.287
407	530	15	8	21.8	8.92	0.525
408	300	3	3	13.23	5.54	0.134
409	490	11	7	19.97	7.74	0.466
410	390	5	4	15.84	6.55	0.220
412	550	11	7	19.95	7.59	0.498
415	400	6	4	16.93	6.75	0.271
417	420	9	6	17.9	7.13	0.338
419	340	5	4	14.63	5.93	0.198
420	270	5	3	12.8	4.73	0.112
421	260	3	3	13.13	4.64	0.114
423	510	12	7	15.54	7.76	0.544
426	280	3	3	13.34	5.21	0.131
427	480	11	7	13.75	7.62	0.372
428	260	3	3	14.02	4.54	0.121
430	300	7	3	14.58	5.9	0.180
431	410	10	6	17.69	6.6	0.341
432	370	9	4	15.6	6.45	0.245
435	330	9	4	14.93	5.83	0.225
437	280	5	3	14.31	5.27	0.131
438	280	3	3	12.93	4.58	0.113
439	480	10	6	18.98	7.55	0.421
441	430	10	6	18.97	6.8	0.355
442	580	12	8	20.87	8.01	0.529
444	330	6	4	15.18	5.82	0.177
445	340	9	4	15.79	6.16	0.230
450	450	15	6	16.89	7.1	0.324
451	470	13	6	18.84	7.32	0.362
452	480	12	6	19.29	7.99	0.412
454	290	4	3	14.75	5.81	0.174
455	450	17	6	20.03	7.39	0.353
456	330	4	4	14.61	5.39	0.180
458	300	5	3	13.67	5.33	0.140
460	270	4	3	12.17	5.13	0.116
461	270	3	3	13.48	5.05	0.119
462	340	6	4	15.41	5.78	0.177
463	530	18	8	20.63	7.95	0.456
464	260	3	3	12.82	5.08	0.123
465	270	8	3	13.57	5.16	0.125
467	330	6	4	17.03	5.6	0.225
470	330	12	4	15.27	5.44	0.190
471	420	12	6	19.02	6.68	0.371
472	430	11	6	18.43	7.16	0.347
473	290	5	3	14.45	5.13	0.147
474	250	4	3	12.72	4.77	0.104
475	270	3	3	12.57	5.08	0.124
476	460	14	6	19.22	7.2	0.366
477	320	8	4	14.15	5.89	0.182
479	530	21	8	20.27	7.77	0.496
482	320	6	4	13.83	5.35	0.153
483	330	7	4	14.43	5.52	0.162
484	570	15	7	21.62	7.84	0.494
489	290	3	3	13.79	5.1	0.132
490	340	9	4	15.54	5.94	0.200
491	340	4	3	15.32	5.5	0.179
492	330	6	4	15.3	5.9	0.187
495	330	4	3	14.02	5.71	0.164
496	360	5	3	15.59	6.23	0.200
498	520	14	6	19.07	7.39	0.377

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NMFS ID No.	Fish Length mm	ADF&G Age [a]	NMFS Age	Otolith Length mm	Otolith Height mm	Otolith Weight g
499	500	14	8	20.34	8.11	0.568
500	350	9	4	13.75	6.08	0.183
501	280	4	3	13.17	5.28	0.126
502	530	15	7	21.15	8.04	0.496
505	460	11	6	19.29	7.09	0.447
506	370	6	4	15.72	6.28	0.228
511	340	8	4	15.42	5.4	0.171
514	560	18	8	21.7	8.32	0.542
515	280	5	3	13.08	5.03	0.117
516	270	3	3	11.68	5.03	0.111
517	280	3	3	13.65	5.01	0.131
518	430	9	6	17.15	7.18	0.365
519	280	4	3	13.26	4.76	0.121
520	260	5	3	12.93	4.71	0.105
521	320	7	4	14.43	5.71	0.190
523	250	4	3	12.43	4.4	0.107
525	400	5	4	16.68	6.2	0.266
526	520	12	7	19.45	8.23	0.535
531	500	16	7	19.46	7.41	0.429
532	300	3	3	13.82	5.2	0.139
533	440	15	6	15.82	6.68	0.270
536	430	14	6	18.37	7.4	0.365
537	520	18	8	20.31	8.29	0.509
538	370	7	4	16.31	6.25	0.230
539	460	16	9	20.01	6.83	0.446
540	350	6	4	16.42	5.77	0.213
542	520	12	6	18.74	7.94	0.425
545	430	16	6	17.04	6.96	0.283
547	460	17	6	18.84	6.83	0.373
548	260	3	3	12.06	4.48	0.111
549	500	11	6	18.59	7.95	0.409
550	260	3	3	12.33	4.59	0.110
551	540	16	6	20.14	8.14	0.447
552	380	7	4	15.92	6.61	0.253
553	270	4	3	13.03	4.89	0.117
554	270	3	3	13.27	4.89	0.117
556	370	6	4	16.02	6.29	0.223
557	330	7	4	15.04	5.63	0.181
558	250	3	3	13.11	4.69	0.118
559	350	6	4	15.12	5.72	0.203
561	400	8	6	16.56	6.08	0.255
562	350	6	4	14.36	5.78	0.176
565	270	3	3	11.51	4.56	0.101
566	410	8	4	17.39	6.37	0.258
567	250	3	3	12.22	4.55	0.106
569	540	14	8	19.6	8.1	0.503
570	460	15	7	15.13	7.43	0.246
571	260	4	3	11.89	4.56	0.095
573	350	6	4	16.06	6.26	0.247
574	520	14	6	19.63	7.77	0.439
575	390	16	6	17.47	6.22	0.298
576	300	5	3	12.9	5.34	0.137
577	280	4	3	13.07	4.88	0.127
578	470	14	6	18.84	7.31	0.393
579	270	4	3	12.76	4.81	0.118
580	340	7	4	15.19	5.83	0.190
581	300	6	4	14.45	5.46	0.141
582	260	3	3	12.07	4.42	0.101
583	350	7	4	16.47	5.95	0.230
585	460	11	6	19.01	6.99	0.378
587	270	3	3	11.96	4.93	0.117
588	440	12	6	17.77	6.43	0.308

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Source: Kristen Munk, Age Determination Unit program manager. Walleye pollock otolith accretion study proposal, 2006..
[a] ADF&G Age actually represents an experimental methodology developed by K. Munk and is not the age estimage supported by ADF&G.

Appendix 1. Page 4 of 5.

NMFS ID No.	Fish Length mm	ADF&G Age [a]	NMFS Age	Otolith Length mm	Otolith Height mm	Otolith Weight g
591	480	14	6	21.11	7.2	0.400
593	350	6	4	14.93	5.96	0.199
595	280	4	3	13.33	5.09	0.135
597	560	14	7	20.9	8.29	0.516
598	430	15	6	17.45	6.82	0.303
599	480	16	6	20.37	7.85	0.434
600	350	8	4	15.49	5.58	0.190
605	530	15	8	19.89	8.31	0.510
606	440	12	6	18.31	7.6	0.369
610	480	18	7	20.32	8.31	0.403
612	480	13	6	16.99	7.89	0.366
613	470	16	7	17.89	7.54	0.409
615	510	16	7	19.87	7.71	0.462
616	430	10	6	16.97	6.54	0.287
618	450	10	6	17.62	7.31	0.317
619	510	15	7	15.39	8.32	0.365
620	380	7	4	15.89	6.11	0.234
621	290	5	3	13.69	5.31	0.137
622	430	11	6	17.2	7.23	0.320
623	500	11	7	19.57	7.96	0.431
625	470	12	6	19.75	7.29	0.404
626	500	15	8	20.05	8.02	0.478
628	580	13	6	19.65	7.83	0.482
629	450	11	6	17.36	7.31	0.391
631	270	4	3	13.03	4.76	0.115
633	370	5	4	15.64	6.09	0.220
634	530	15	7	22.21	8.67	0.516
638	520	12	6	19.8	8.47	0.489
642	510	12	6	19.1	8.61	0.452
645	280	3	3	12.87	5.28	0.130
646	450	10	6	18.74	6.67	0.367
647	560	17	8	21.66	8.67	0.553
648	520	17	8	18.47	8.04	0.463
649	510	13	6	19.05	7.4	0.403
650	420	9	4	17.12	6.51	0.253
651	580	18	8	20.69	8.65	0.559
653	570	15	8	19.22	8	0.536
654	250	3	3	12.47	4.64	0.108
655	450	13	6	18.67	6.71	0.361
656	470	13	6	19.62	6.86	0.417
658	560	19	8	20.09	7.8	0.542
659	280	3	3	12.34	4.86	0.123
661	410	14	6	16.79	6.9	0.343
664	270	5	3	12.59	5.11	0.125
666	500	15	7	20.23	6.77	0.427
667	500	22	8	20.04	7.53	0.450
669	420	12	6	16.99	6.82	0.327
670	380	12	6	16.42	6.28	0.285
671	280	3	3	13.53	5.22	0.135
672	630	17	7	20.77	8.89	0.600
673	350	4	3	14.61	5.75	0.168
678	420	7	5	16.25	6.3	0.240
679	370	5	4	14.89	6.15	0.219
680	570	23	8	19.55	7.58	0.429
684	520	14	8	19.53	8.57	0.398
686	390	7	4	17.13	6.47	0.244
687	480	12	7	20.56	7.41	0.505
688	240	4	3	12.65	4.51	0.094
691	360	8	4	15.7	5.81	0.198
692	370	8	4	16.5	6.18	0.221
694	430	13	6	16.91	6.46	0.292
696	490	14	6	19.84	7.68	0.372

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NMFS ID No.	Fish Length mm	ADF&G Age [a]	NMFS Age	Otolith Length mm	Otolith Height mm	Otolith Weight g
702	370	6	4	15.88	6.4	0.218
705	500	13	8	18.35	7.49	0.386
707	420	9	6	17.34	6.91	0.337
715	360	5	4	15.41	6.45	0.258
716	510	13	6	20.31	8.08	0.476
717	320	6	4	15.06	5.67	0.176
718	500	14	8	19.97	7.92	0.572
720	460	8	6	18	7.4	0.444
722	370	6	4	15.86	6.28	0.218
726	270	5	3	12.56	4.99	0.125
727	470	13	8	17.34	8.44	0.358
728	500	15	8	19.91	7.72	0.459
729	470	12	7	18.51	7.02	0.377
733	370	9	4	15.86	6.28	0.241
735	510	15	8	20.22	7.33	0.499
736	490	13	6	18.66	7.74	0.407
738	300	3	3	14.2	5.31	0.154
739	420	12	6	19.8	7.31	0.423
741	510	17	7	18.98	7.14	0.394
743	270	3	3	11.97	4.83	0.118
744	360	8	4	14.59	6.15	0.193
751	290	3	3	13.08	5.16	0.142
752	290	3	3	14.21	5.31	0.138
755	290	4	3	13.26	4.86	0.124
756	550	18	8	19.03	8.13	0.457
757	550	17	8	19.45	8.25	0.530
758	470	13	6	17.99	7.42	0.386
759	280	3	3	14.44	4.94	0.139
766	360	7	4	15.39	5.66	0.216
767	300	6	4	14.66	5.56	0.176
769	350	5	4	16	5.98	0.200
770	360	4	4	15.05	6.08	0.224
772	260	3	3	11.75	4.74	0.099
774	350	4	4	15.48	5.93	0.207
782	270	3	3	12.61	4.86	0.105
783	290	3	3	12.31	5.2	0.131
784	360	5	4	16.35	6.35	0.222
789	290	3	3	13.21	5.16	0.128
791	400	10	6	18.12	6.52	0.340
792	570	11	6	20.44	8.5	0.483
798	260	4	3	11.81	4.64	0.097
800	420	9	6	17.2	6.79	0.351
804	330	3	3	14.79	5.44	0.170
805	310	5	3	14.04	5.67	0.136
806	480	16	8	20.49	7.08	0.439
807	470	10	6	17.39	7.47	0.378
809	410	12	6	17.72	6.89	0.281
811	280	3	3	13.4	5.39	0.131
813	290	3	3	14.1	4.94	0.135
819	260	3	3	12.72	4.69	0.106
820	330	4	4	14.54	5.52	0.184
822	410	7	4	15.61	6.52	0.254
823	260	4	3	13.37	4.53	0.110
824	520	12	8	20.09	7.93	0.528
825	280	3	3	12.63	5.23	0.131
826	300	4	3	12.51	5.07	0.126
827	530	14	8	19.76	7.48	0.490
828	450	12	6	19.02	6.61	0.337
831	290	3	3	13.56	5.02	0.131
834	350	7	4	15.39	6.05	0.222
836	390	9	6	18.81	6.66	0.365
837	330	5	4	14.83	5.89	0.203

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Source: Kristen Munk, Age Determination Unit program manager. Walleye pollock otolith accretion study proposal, 2006.

[a] ADF&G Age actually represents an experimental methodology developed by K. Munk and is not the age estimage supported by ADF&G.

Appendix 1. Page 5 of 5.

NMFS ID No.	Fish Length mm	ADF&G Age [a]	NMFS Age	Otolith Length mm	Otolith Height mm	Otolith Weight g
841	460	12	6	18.48	7.39	0.367
842	470	10	6	18.27	7.08	0.363
844	360	4	3	15.81	6.13	0.200
841	460	12	6	18.48	7.39	0.367
846	350	7	4	15.22	5.93	0.192
847	420	9	6	18.53	5.86	0.293
848	270	3	3	12.34	4.44	0.107
852	450	15	6	19.28	6.7	0.364
853	470	13	6	17.58	7.02	0.365
854	510	12	7	19.44	7.43	0.394
858	530	15	7	21.28	8.03	0.467
861	550	28	8	18.33	8.19	0.454
864	500	15	6	18.46	6.73	0.418
865	300	5	3	14.07	5.94	0.157
866	510	14	8	19.27	7.49	0.454
867	620	19	8	22.97	8.68	0.668
870	300	6	3	13.24	5.24	0.142
872	480	8	6	18.17	7.76	0.374
873	310	6	3	13.85	5.13	0.131
874	540	14	6	19.89	8.25	0.496
875	300	4	4	14.58	5.32	0.164
876	600	17	7	22.75	8.65	0.692
877	490	16	6	19.9	7.44	0.424
878	440	10	6	16.94	7.29	0.321
879	530	16	8	19.74	7.94	0.466
881	250	3	3	12.4	4.91	0.114
883	440	11	6	18.51	7.11	0.374
884	350	4	3	15.01	5.66	0.190
888	420	14	6	18.79	6.79	0.339
890	360	6	4	15.65	6.16	0.198
892	290	3	3	13.27	5.95	0.125
893	540	15	7	19.93	9.12	0.544
894	400	10	6	17.26	6.34	0.317
895	350	5	4	16.04	5.87	0.217
898	320	7	4	14.4	5.53	0.177
900	260	3	3	12	4.43	0.100
901	310	3	3	14.28	5.53	0.155
902	260	3	3	12.61	4.88	0.123
904	280	3	3	13.23	5.05	0.123
905	340	4	4	13.74	5.57	0.172
906	320	4	3	14.05	4.93	0.138
907	280	3	3	13.35	5.2	0.120

Source: Kristen Munk, Age Determination Unit program manager. Walleye pollock otolith accretion study proposal, 2006.
[a] ADF&G Age actually represents an experimental methodology developed by K. Munk and is not the age estimage supported by ADF&G.