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Tag-And-Release of Walleye Pollock *Theragra Chalcogramma* in Auke Bay Alaska in 2008

by

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and

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

Symbols and Abbreviations

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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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ABSTRACT

A 2008 capture of 1320 walleye pollock *Theragra chalcogramma* resulted in 999 fish tagged and released in Auke Bay, Alaska. A total of 423 of these tagged fish were also injected prophylactically with the antibiotic oxytetracycline (35 mg/kg). Otoliths were collected from 300 fish for evaluation of age, which ranged from 0 to 4 years old. Based upon a fish length threshold determined from otolith subsample ages, the tagged and released fish were 1 year old and older.

The capture-tag event was stressful for the walleye pollock, so we subsequently developed less stressful techniques that reduced mortality. We recovered one of our tagged fish 65 d post-tagging, and another 74 d post-tagging. Individual specimen growth was 0.65 mm/d 65 d post-tagging, and 0.38 mm/d 74 d post-tagging. One of these specimens was re-released. We will conduct a tag-recovery effort in 2009 and capture, tag, and release more walleye pollock. To prompt tag returns, tags are printed with a contact phone number, and a reward is offered for return of the whole fish with capture information.

Keywords: walleye pollock, Theragra chalcogramma, tag and release, T-bar tag, oxytetracycline, OTC injection, tag recovery, length and weight, otolith, known-age

INTRODUCTION

Little investigation has been conducted on walleye pollock *Theragra chalcogramma* in Southeast Alaska, and few tagging studies of wild pollock have occurred in the eastern North Pacific (Gustafson et al. 2000). Pollock support the largest single-species fishery in the world. Within the U.S. jurisdiction, the vast majority of commercial harvest effort on pollock occurs in waters under federal management. A relatively small commercial fishery occurs in waters under state management (Woodby et al. 2005). This fishery is located on the northern edge of the Gulf of Alaska in state waters, and includes the Alaska Department of Fish and Game's (ADF&G) management areas of Prince William Sound and North Gulf. There are no commercial fisheries targeting pollock in the state waters of Southeast Alaska. However, pollock are noticeably present within the straits, bays (Haldorson et al. 1988), and fjords of Southeast Alaska.

In Southeast Alaska, age-0 y pollock are a dominant nearshore catch in research beach-seining effort between June and August (ADF&G Age Determination Unit beach seining data from 2006 and 2007; Johnson *et al*. 2003 and 2005). Age-1 y pollock are routinely encountered by anglers jigging for herring in shallow (<15 m) water from late May through July. Occasionally, larger pollock are sport caught by anglers bottom fishing, or the pollock are caught in research surface trawls (Orsi *et al*. 2002 and 2004). Pollock are occasionally bycatch in the commercial groundfish fisheries (personal communication, J. Stahl, ADF&G Fishery Biologist, Douglas, Alaska) in the internal waters of Southeast Alaska. A major spawning location south of Dixon Entrance has been documented (Bailey *et al*. 1999; page 182). Yet little is known about the population character, size, or migrations of pollock in Southeast Alaska. Estimating pollock biomass is the target of substantial scientific effort in federal waters (Dorn *et al*. 2000, 2008). Adult pollock have been tagged in the western North Pacific and the Bering Sea, and more recently there has been an effort to trawl-capture and coded-wire-tag adult pollock (Winter *et al*. 2007). Prior to this 2008 pilot effort in Auke Bay, no tagging of wild pollock has ever been conducted in Southeast Alaska.

Our objective is to tag and recapture pollock to document their residence and movement relative to Auke Bay, in Southeast Alaska. Tagging required pollock sufficiently large to carry an external tag—such as a 1-year-old fish. Prior to 2008, we knew where to capture age-1 y pollock. Not known was whether a meaningful volume of age-1 y pollock could be captured to support a tag-release study. We also knew that age-0 y and age-1 y pollock were easily injured—

experiencing up to 100% mortality—when captured with beach-seines, but that nearly 100% survival could be achieved with careful handling. Unknown was whether wild pollock could survive a hook-based capture and the typical handling and tagging conditions generally tolerated by other species. We also knew that pollock could tolerate oxytetracyline (OTC) administered through ingestion. Unknown was whether wild pollock could tolerate prophylactic injection of OTC.

We report results from the first year of tagging and release work conducted in 2008. We also document methods and refinements which resulted in a viable population of tagged pollock. Pollock were captured, tagged and released back to Auke Bay. No targeted recapture effort was made during this initial tagging year; however, incidental tag recoveries were sampled for somatic measurements and otoliths. Focused recapture effort will occur in 2009.

MATERIALS AND METHODS

CAPTURE METHODS

Fishing began May 20, 2008, prior to expected immigration of pollock to relatively shallow (<20 m) nearshore areas in Auke Bay. Fishing occurred at either the Auke Bay Marine Station (ABMS) dock or the Auke Bay Harbor (ABH) float nearest the harbor office (Figure 1).

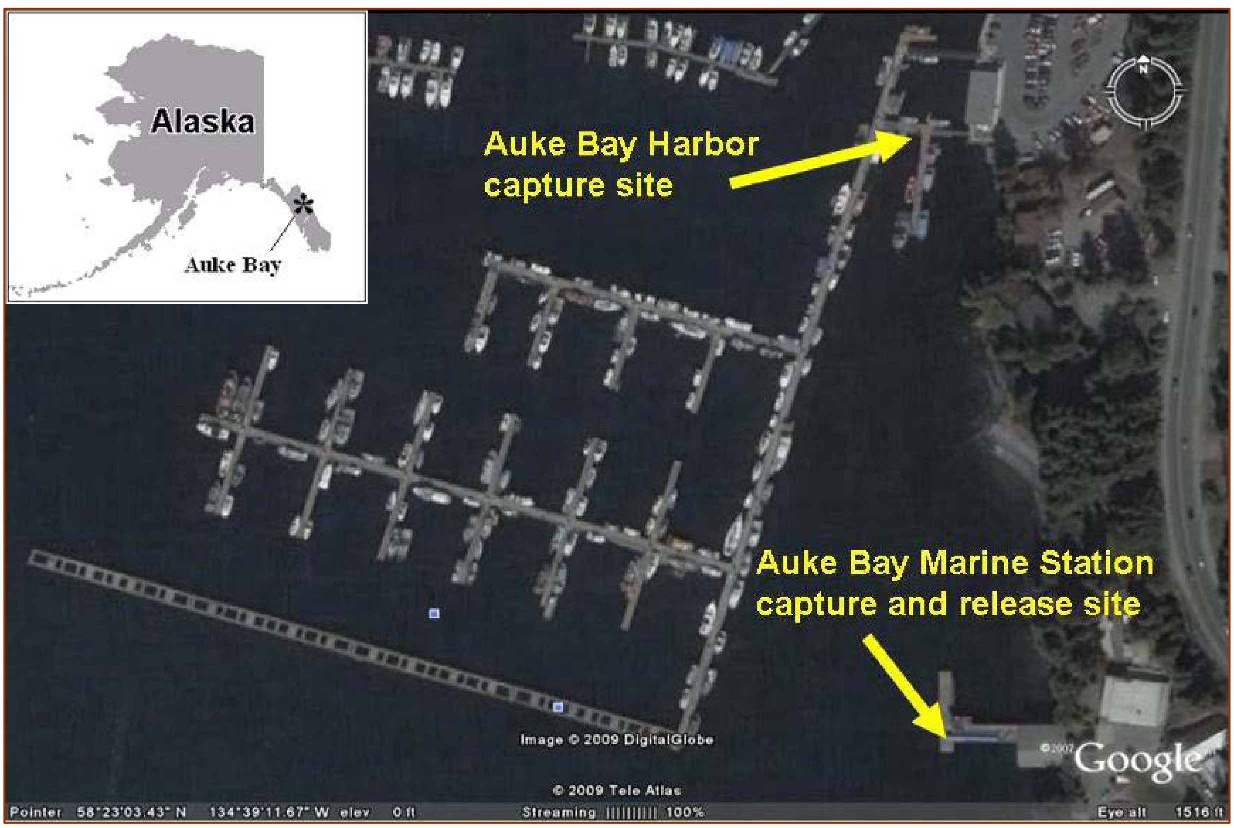

Figure 1.–Capture locations for walleye pollock. Walleye pollock were captured in Auke Bay by jigging off the Auke Bay Marine Station dock (also released) and the Auke Bay Harbor float, between May and September 2008. (Image credit: Image 2008 Digital Globe; Google).

Effort utilized ADF&G anglers, was opportunistic, and commenced at low slack-tide. Anglers fished for at least 20 minutes, and continuation of effort depended on meeting a simple harvest per unit effort (HPUE) goal of 6 pollock angler-hour^{-1} (i.e., HPUE = 6). If a minimum of 2 fish were caught in the first 20 minutes, then the angler continued fishing, if not, fishing ceased. If fish were highly abundant, 1 to 2 additional ADF&G anglers were used. Effort (time spent fishing and number of pollock) was recorded upon completion of each fishing trip.

Fishing gear was lightweight fishing rods and reels with 10- to 15-lb test monofilament line and 6-hook herring jigs. Herring jigs were unbaited gold hooks (10-gage) on line below 1 or 2 colored beads, or a ¼-in fluorescent strip. Fishing action consisted of sinking the weighted herring jigs to the seafloor and retrieving them to just off-bottom, and then a gentle vertical up-and-down (jigging) motion through a range of 6 to 36 in. Hooked fish were brought to the surface rapidly. Pollock were handled delicately to avoid abrading their easily-removed slime-scale coat. Captured specimens were quickly dehooked by grasping the hook and lightly shaking the fish into a 5-gal bucket of seawater, or the lower jaw of the pollock was firmly held while the hook was freed. At times grasping the body of the fish was required to dehook the fish. During the capture period, pollock were held in 5-gal buckets with frequent water changes conducted to minimize fish stress. When pollock were abundant, fish were placed directly in—or 5-gal buckets were decanted into—an on-site 32-gal container. Water changes of 25% of the container volume were frequent. Dead fish were counted and retained for somatic data and otolith collection. Fish were transported to the ABMS and held in aerated water or with water changes, or placed into a larger through-flow tank overnight. Tagging began immediately or within 2 d of capture—samples captured Saturday and Sunday were tagged Monday.

TAGGING AND RELEASE METHODS

Fish were placed into a 2- to 4-L seawater bath of Finquel© anaesthetic (0.1g/L). Fish were measured for fork length (1 mm) and weighed (0.01 g). A tag gun equipped with a 0.07-in (outside diameter) stainless needle was used to insert a discretely numbered, yellow t-anchor Floy Tag©. Tags were 2⅜ in long and the tag information barrel was 1½ in long, imprinted with contact information and the notice "Whole Fish Reward" (Figure 2). The ADF&G Sitka field office phone number was identified on the tag because that office is the focal point of Region I groundfish management operations and because of the potential for these pollock to be intercepted in managed groundfish fisheries for a long time—potentially the 28-y lifespan of pollock (McFarlane and Beamish 1990)—long after the availability of the project researcher. The tag was inserted into the left side of the fish just below the first dorsal fin (Figure 3). We used two tag code series: OTC_001 to OTC_300, and K301 to K1000. Typically, but not exclusively, fish tagged with the OTC-series received an injection of the antibiotic. Some K-series tagged fish also received an injection of antibiotic; however, the majority of K-series fish were simply tagged and not injected with OTC. For all initial captures (and subsequently only a subset of the tagged population) we injected the antibiotic oxytetracycline (OTC; Liquamycin LA-200©) at a rate of 35 mg OTC/kg^{-1} body weight using a 1-cc syringe with a 29-gage needle. Fish were held to observe tag retention and recovery following anaesthesia, injection of OTC, and handling. Fish which were only tagged were held 3–7 d. Fish which were tagged and injected with OTC were held for a 30-d withdrawal period. Mortalities were measured and weighed and otoliths removed.

Fish were held in either an 890-L circular tank or a 651-L rectangular tank which was plumbed for through-flow. The circular tank was also equipped with a custom self-cleaning tube which minimized buildup of waste. The tanks received seawater from the ABMS deepwater (approximately 30 m) intake in Auke Bay. Water parameters of salinity and temperature were monitored.

Figure 2.–A total of 999 walleye pollock were tagged and released with discretely numbered t-anchor Floy-tags© which indicate a reward for return of the whole fish (to enable collection of otoliths). The contact office phone number is for the ADF&G Sitka field office, not the researcher's office.

Figure 3.–Tags were inserted in pollock on the left side and immediately below the first dorsal fin. This example is actually from a larger pollock tagged in a culture study.

On the day of release, fish were herded using a net (without letting the net contact them), and with a 4- to 5-L plastic bin, scooped from the water of the net bag and into 5-gal buckets.

Buckets were hand carried approximately 250 ft where fish were released off the ABMS dock. Fish were first acclimatized by gradually adding surface water to the buckets over a brief period of time. Water parameters (salinity and temperature) for culture and receiving water were measured to gage acclimation progress. The acclimation goal was to at least halve the initial difference between culture and receiving water parameters before releasing fish. Fish were briefly observed upon release for swimming abnormalities or predation.

OTOLITH SUBSAMPLE METHODS

Fish age was determined from otoliths to confirm an age-at-somatic length threshold to confidently establish an age-1 y (known-age fish) versus $\geq$age-1 y fish. This somatic length threshold was applied to the fish which were tagged and released. Otoliths were removed from subsampled specimens and mortalities. Fish tagged and injected with OTC and held for a 30-d withdrawal period were also subsampled to evaluate the incorporation of a chemical signature into the otolith. Sagittae otoliths were excised, cleaned of lymph blood and tissue, and stored dry. After several weeks of air-drying, otoliths were measured for length (0.01 mm), height (0.01 mm), and mass (0.001 g) using digital calipers and an electronic balance. Measurements were recorded electronically into a database, averaged for the left and right sagittae otoliths, and the mean dimensions were used in analyses. Otoliths were first examined for age by placing a "cleared" otolith (cleared with ethanol) into a dish of water with a dark background. The distal surface was viewed using a stereomicroscope set at low magnification and reflected light illumination. Final ages were determined using the "break and burn" method (Christensen 1964). The otolith pattern of a 1-year-old fish was expected to have an annulus, or translucent zone[1] at or near the leading edge of the otolith margin, with an increasingly large opaque zone[2] following the annulus, consistent with the progression of the summer growth season.

Otoliths from fish which received a prophylactic injection of OTC might have incorporated a fluorescing OTC chemical ring within the otolith microstructure. To ensure the integrity of this light-labile chemical, otoliths need to be in darkened conditions throughout handling and storage (this did not happen for our subsampled otoliths, but will occur for tag-recaptures). Otoliths will be examined for the presence or absence of a fluorescing OTC ring by sectioning in the transverse axis. The resulting 1.5-mm section will be mounted onto a glass slide with non-fluorescing cyanoacrylate. The otolith section will be examined using a compound microscope fitted with a filter cube to enable an ultraviolet/violet bandpass excitation wavelength of 355 to 425 nm (per product specification and not *in situ* measurement) with illumination using a 50 W mercury lamp.

TAG RECOVERY METHODS

Recaptured tagged pollock were measured for fork length, weighed, and their otoliths removed, or they were measured for fork length, and their tag number recorded before they were released. Date and location of capture and angler info were recorded.

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[1] Other terms for *annulus* include winter zone, slow growth zone, dark band using reflected light, or D-zone.

[2] Other terms for *opaque zone* include summer zone, fast-growth zone, light band using reflected light, or L-zone.

RESULTS

CAPTURE EFFORT RESULTS

We fished for pollock from May 20 to September 22, 2008. We began fishing in May at the ABMS dock. Later, greater pollock abundance was observed, and subsequent effort concentrated, at the ABH float. Fishing began at the low-slack tide, and continued up to 2.5 h (usually, $\leq$2 h). The first pollock was caught June 13; the last pollock was caught September 8. A total of 4 anglers spent 86.6 h fishing, capturing a total of 1320 pollock with a mean HPUE of 11.23 pollock h^{-1} (range: 0 to 48.0 pollock h^{-1}; Figure 4). Peak pollock harvest occurred between June 19 and July 4, 2008. However, between July 4 and August 31 there were several days to weeks of zero effort.

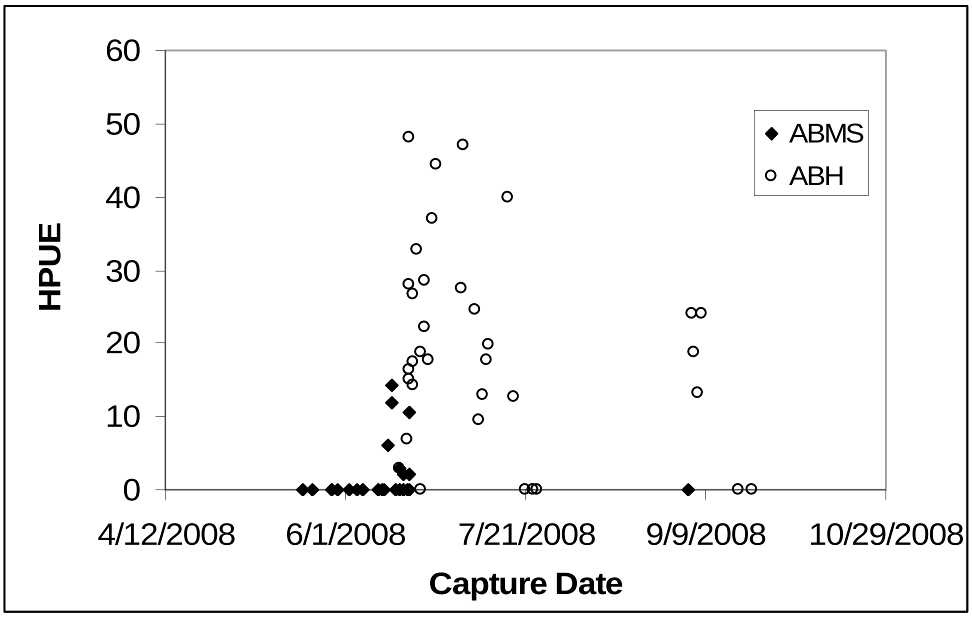

Figure 4.–Harvest per unit effort (HPUE). Fishing began May 20 and ended September 22, 2008. The first pollock was captured in Auke Bay June 13 and the last was captured September 8.

Bycatch was low and seasonal, and we took action to minimize it. For example, herring were caught between June 2 and June 23, 2008. During peak herring presence we relocated away from the herring school and sometimes ceased fishing to limit herring bycatch. Newly smolted Chinook salmon (presumably from the local release of hatchery Chinook from the Ladd Macaulay Hatchery netpen) were caught between June 16 and July 23. These captured juvenile Chinook salmon frequently did not survive hook removal. During peak juvenile Chinook salmon presence we effectively altered fishing methods to avoid these juvenile salmon by adding additional weight to the herring jigs to more rapidly sink them below the mid-water schools of salmon. Flatfish species (rock sole, yellowfin sole, starry flounder) were infrequently caught between June 11 and July 23. Other incidental species caught and released were: Dolly Varden (n = 3), Pacific cod (n = 1; ~ approximately 320 mm), sculpin spp. (n = 1), and greenling spp. (n = 1). During the terminal return of adult hatchery Chinook salmon to Auke Bay, we frequently (approximately 10 times) hooked to what we believed were adult Chinook salmon. This resulted in a brief exciting moment and a straightened hook or broken line; however, we did not land these fish.

The fishing gear was suitable and effective. We preferred the “bead only” style of herring jig; anecdotal experience suggested that the fluorescent strip on the hook resulted in more flatfish being caught. There was some observation of species stratification to the terminal tackle: flatfish were caught on the first hook up from the weight (that is, nearest the sea floor); pollock tended to take the 2^{nd} through 5^{th} hooks (though could be captured on hooks 1 through 6); and herring almost always tended to take the upper hooks. Multiple hook-ups (more than 1 of the 6-hook jig) of pollock were not uncommon. Bottom depth at the preferred fishing locations at both the ABMS dock and ABH float was estimated to range between 5 and 11 m.

We were largely successful in dehooking pollock using the “shake the hook” method (holding the hook and not the fish), or by grasping the lower jaw with one hand and removing the hook with the other. Rarely was grasping the entire fish necessary, and when it was, this action always resulted in massive removal of the scale-slime coat. Approximately 5 times, pollock were hooked in the gills; these fish subsequently died. Injuries, whether loss of the slime-coat or from the hook, later appeared as darkened areas on the body and persisted over several days of observation.

Fish were successfully held in 5-gal buckets or a 32-gal container, with several water changes conducted during the usually ≤2 h fishing cycle. During a period of higher coastal discharge, there was concern that these water changes, which used the warmer and less saline surface water, stressed the fish because they were acclimatized to the likely more saline, colder water at depth. We were not able to mediate this stress throughout the fishing period. Fish captured at the ABH were transported by truck to the ABMS; additional water which had been previously drawn from ABMS’s seawater intake was used. The ABMS intake, which draws water from approximately 30 m deep in Auke Bay, is typically colder and more saline than the surface water. Mixing the ABMS water with the surface water during transport of the captured pollock presumably helped to acclimatize these fish to the eventual holding water from the ABMS seawater intake. No mortality occurred during or immediately following the brief transport. At the ABMS, fish were held in either a through-flow tank (if tagging was to occur at a later date), or in large containers where we conducted water changes. Due to the rapidity of fish processing (measuring, tagging), they were held <2 h in these containers.

TAGGING AND RELEASE RESULTS

Initially, all pollock—and subsequently, only “normal and healthy-looking” pollock—were tagged. Several wild pollock which we captured appeared emaciated and their eye pupils appeared disproportionately larger relative to “normal” wild pollock. All of these specimens tended to be longer (fish length) than a presumed age-1 y length (therefore, ≥age-2 y). Initially, these fish were tagged; however, most (possibly all) did not survive handling. Subsequently, these fish were not tagged, instead they were either immediately released or they were select-sampled for otoliths. Some of these specimens had a coiled parasite *Haemobaphes theragrae* (Moles 2007; Figure 5) attached to the gill; we also noted this same coiled parasite in the gills of some healthy-looking specimens. Sea lice *Lepeophtheirus salmonis* were abundant on all pollock. Based on recorded data, all pollock captured between June 13 and June 17 had sea lice; based on general observations, most pollock after this period had sea lice as well.

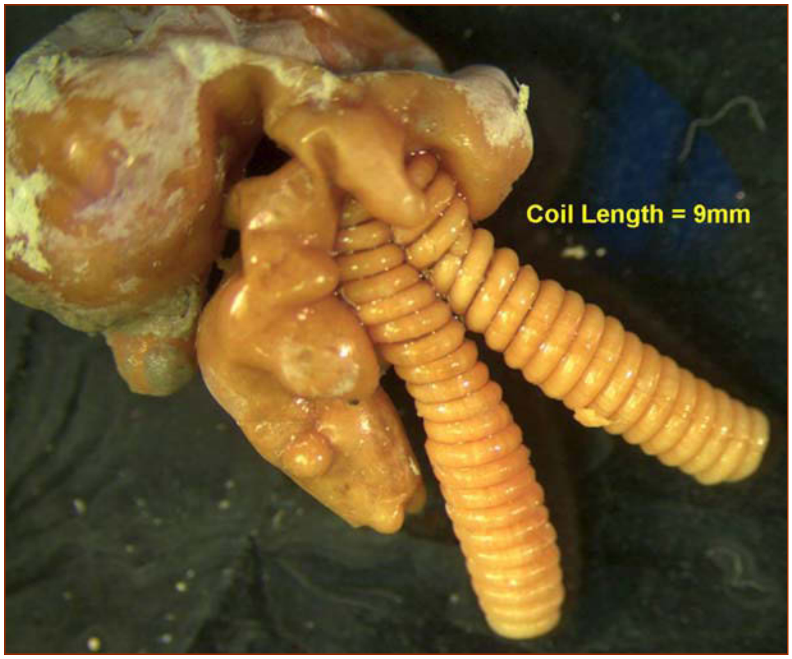

Figure 5.–The parasite *Haemobaphes theragrae* was observed attached to the gills of many wild pollock.

After 1 or 2 min, general body movement and upright swimming ceased in the anaesthetized fish, the gilling action slowed noticeably, and the fish rolled onto their sides. Fish still moving after leaving the anaesthetic bath were returned to the bath, because fish not fully anaesthetized struggled while being restrained during measurement and tagging and this caused removal of their scales and slime coat. Two people conducted the fish tagging. Operator A carefully lifted a fully anaesthetized fish into the weighing bin and called out weight which was recorded by Operator B. The fish was then lifted onto a measuring board and measured, then returned to the table for tagging (and OTC injection for that subset), and then placed into a recovery tank with "fresh" seawater. Fish were carefully handled throughout so as not to disturb the slime-coat.

During the tagging step, we inserted the tag up to ½ inch deep into the muscle with the tag-gun needle held at an approximately 15° angle relative to the body of the fish. This low angle resulted in the inserted tag ultimately laying flat against the fish body. With the needle fully inserted, the tag gun was rotated 180° toward the operator and the needle was then extracted while maintaining the line of insertion. The tag was routinely placed just below the first dorsal fin on the left side of the fish. However, sometimes this resulted in a "right side tag" when the needle scraped along the skin of the fish, under the dorsal fin and punctured the skin surface on the right side of the fish. One fish received a double tag due to malfunction of the tag gun. Fish which received an injection of OTC were immediately injected after insertion of the tag. Operator B used a lookup sheet to determine the correct volume of OTC based upon the fish's weight. The lookup sheet had predetermined volumes for 1-g increments in fish weight for 3 concentrations of OTC (diluted from the original 200 mg ml^{-1}). A higher concentration would offset an otherwise large volume to be injected; all fish effectively received the same dosage. Generally, the largest fish (mean 216 mm; range 118 to 285 mm; n = 45) typically received the higher concentration (10 mg ml^{-1}; least volume), medium size fish (mean 170 mm; range 117 to 226 mm; n = 588) received the median concentration (5 mg ml^{-1}; median volume), and the smallest fish (mean 136 mm; range 119 to179 mm; n = 8) received the lowest concentration (2.5 mg ml^{-1};

greatest volume). This strategy also allowed us to keep a total injection volume to one syringe. The OTC was drawn slowly into the syringe and the air eliminated (OTC tends to foam when drawn rapidly into a syringe). Initially, we injected all OTC interperitoneally. The preferred site for interperitoneal injection was within a 1-in triangle immediately above (dorsal and anterior from) the anus. This preferred site was developed after observing organ placement in the abdominal cavity of a 2-year-old cultured pollock. The day after injection, some of these fish died. A necropsy of the abdomen was inconclusive. In at least one case, the needle punctured an organ; however, for other specimens this was not evident. Even though we were uncertain if interperitoneal injection caused the high mortality, we ceased interperitoneal injection and started intramuscular injection on the left side of the body, just below the dorsal fins. We injected the OTC at 2 injection sites because we saw subcutaneous bulging after injecting all the OTC at one site. Distributing the volume among 2 injection sites prevented skin-bulging or oozing of the antibiotic. We continued to see high mortality over the first few days immediately following intramuscular injection of OTC and insertion of a tag. Cumulative mortality of fish injected with OTC—and believed due to the effects of OTC—was 22.4%. We observed the highest mortality within the first 7 d following injection; this tapered off to low or no mortality following 17 d (Figure 6). Because of this high mortality after tagging and injecting approximately 400 fish with OTC, we reduced OTC-injection and only tagged fish instead. Other low mortality observed in fish held for 30 d was believed to be caused by the effects of culture, not OTC. For example, fish whose fins began to progressively erode during holding generally did not survive. Mortality for fish which were only tagged and held for 2 to 4 d was consistently low, estimated to be <2% for multiple batches of fish tagged.

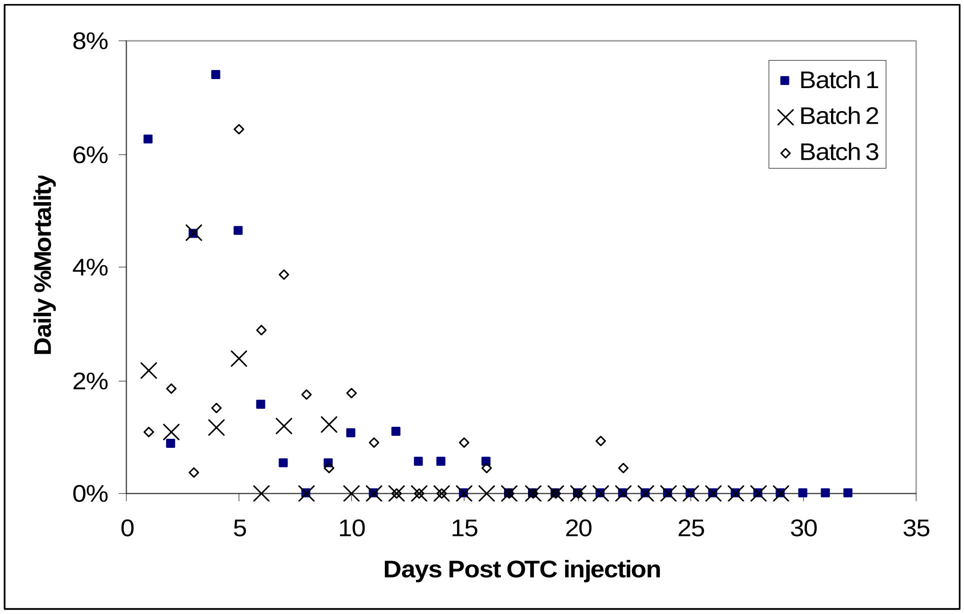

Figure 6.–Daily mortality of OTC-injected, captive pollock in relation to time elapsed since OTC injection. Mortality related to injection of oxytetracycline was high for the first 7 d and then tapered off, for a cumulative mean of 22%. The data set for Batch 3 is abbreviated to Day 22, the day before a tank die-off attributed to insufficient water flow.

During the 30 d holding period, intake seawater ranged from 6.5 to 8°C and salinity ranged from 29.2 to 30.8 ppt. Fish stopped feeding up to 4 d following tagging, injection of OTC, and handling. After this recovery period, we fed these fish a custom pollock chow (a gelatinized blend of herring, commercial fish pellet, squid, and vitamins) prepared weekly at the ADF&G Age Determination Unit. The wild pollock readily ate this food, but clearly we did not always feed enough and some fish resorted to cannibalism (Figure 7). Consequently, we know that the actual number of tagged fish released is <999; although, with only 2 observations of fins in mouths, the number of specimens lost to cannibalism is believed to be <30 (this latter estimate is based upon not noticing a reduction of the population—and assuming that we would have noticed a population of 30 fewer pollock). A subsample of pollock that had been held for 30 d was remeasured immediately prior to release, and an even smaller subset was sacrificed for otolith collection. All healthy specimens increased in somatic length (Figure 8). Across all specimens, there was a mean increase of 7.1 mm (range 17–18 mm), a change of 0.24 mm day^{-1} for the 30 d holding period (fish actually were held 30 to 34 d). Specimens which show a reduction in length were actually missing their tails due to fin erosion, and these tail-less specimens were typically later sacrificed for otolith samples. An adjustment to the size increase was made by excluding tail-less specimens; therefore the adjusted mean increase in size is estimated to be 8.4 mm (range 3–18 mm) for a change of 0.28 mm day^{-1} for 30 d.

Figure 7.–Evidence of cannibalism in captive population of pollock. Some pollock were cannibalistic during the 30 d holding period. Note tail of one pollock protruding from the mouth of another. ©ADF&G.

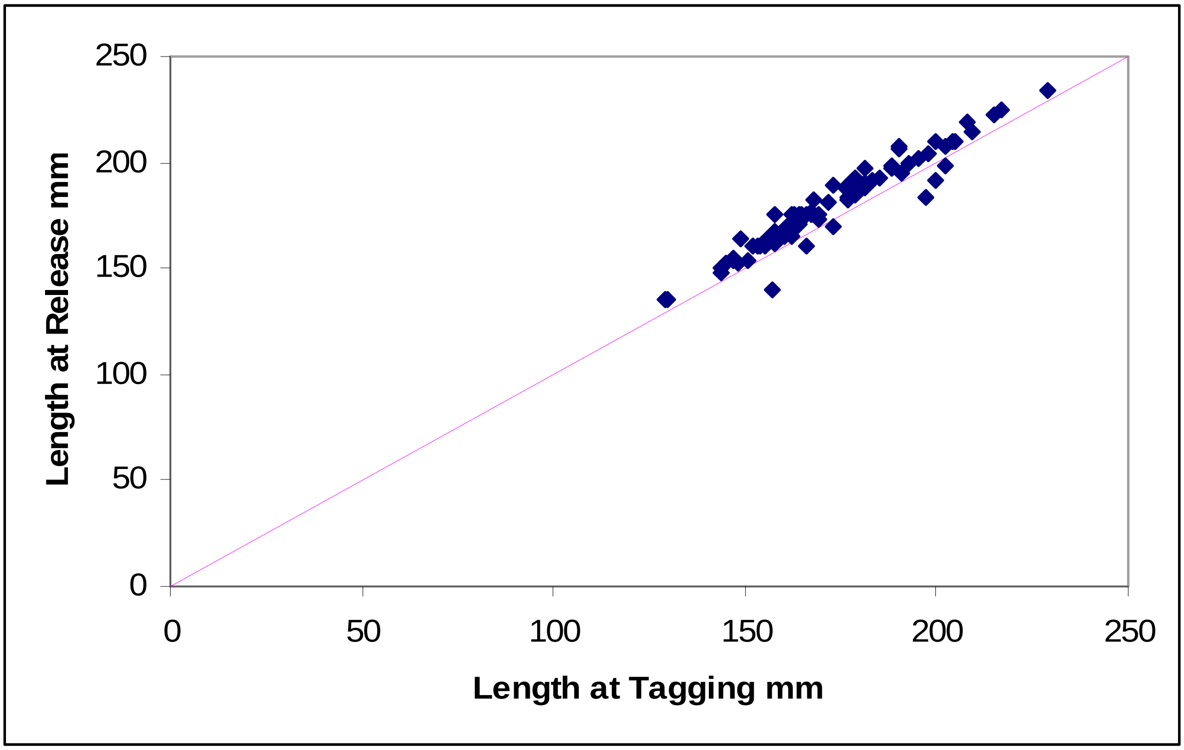

Figure 8.–Length at release vs. length at tagging. Tagged walleye pollock (n = 78) grew during the 30 d holding period. Data points below the line of agreement (zero growth) which suggest a loss in length, actually were specimens which had caudal fins eroded to the caudal peduncle.

During the holding period to observe tag retention and fish health, we found 11 tags at the bottom of the holding tanks. For the first approximately 200 fish tagged we believed that the method of inserting tags was crude and that tag placement was not ideal. Tag loss adjustments to the 999 tagged-released fish do not need to be made because we reused these shed tags. Later modifications to the method resulted in a more deeply placed and secure tag which was not shed during the brief holding period. We also noted a difference in tag-wound character which seemed to be tagging-operator specific. For example, for 25 fish tagged by one tagging operator, 9 of the tag-anchors—the "tee" portion—were erupting several millimeters from the injection site 30 d later.

Approximately 999 (576 tag-only and 423 tag+OTC) tagged pollock were released from the ABMS dock. Containers were filled with seawater from the culture tanks along with a large volume of fish. Fish were not always counted into (nor later out of) the buckets because we presumed that our tagging and mortality counts were sufficient; however, had we counted the fish at this stage we could have assessed the extent of cannibalism. Buckets were hand-carried from the ABMS culture-tank area down to the dock. A few buckets of Auke Bay surface water were mixed into the buckets of fish. Surface water temperature and salinity were recorded for the majority of bulk fish releases; culture water temperature and salinity ranged from 6.7 to 7.7°C and from 29.2 to 30 ppt, and surface water temperature and salinity ranged from 9.8 to 14.4°C and from 9 to 19.4 ppt. The acclimation goal was the approximated mean of these measures achieved over a 15 to 30 min period. For a few later releases, the fish were not acclimatized to this extent; instead, the holding and receiving waters were only briefly (<10 min) mixed, and water parameters were not recorded. Fish were then dumped into the ocean *en masse*. Most of the fish immediately swam to depth and out of sight. A few fish did not descend immediately. On one occasion, 2 tagged pollock joined a school of approximately 15 Dolly Varden (ranging in size from 200 to 350 mm) hanging within 1 m of the surface, and remained within the school for the 5 min observed, with no indication of predatory interest shown by the Dolly Varden. On another occasion, 2 river otters were in the vicinity of the release-site; workers waited for the otters to leave the area prior to releasing the tagged pollock.

The mean fish size (Figure 9) for the tagged fish does not appear to change over time and is likely due to the presence of more than one age class entering the fishable population. These pollock show an allometric and curvilinear relationship of increasing somatic weight at fish length (Figure 10). Based on a somatic length-at-age threshold assignment (see Otolith Subsample Results), a total of 368 fish were thus classified to be "known-age, age-1 y" (therefore, <u><</u>170 mm) and represent the 2007 year class, and, the remaining 631 tagged fish >170 mm were classified as "unknown age"; therefore, <u>></u>age-1 y and represent year classes 2007 and earlier (Figure 11).

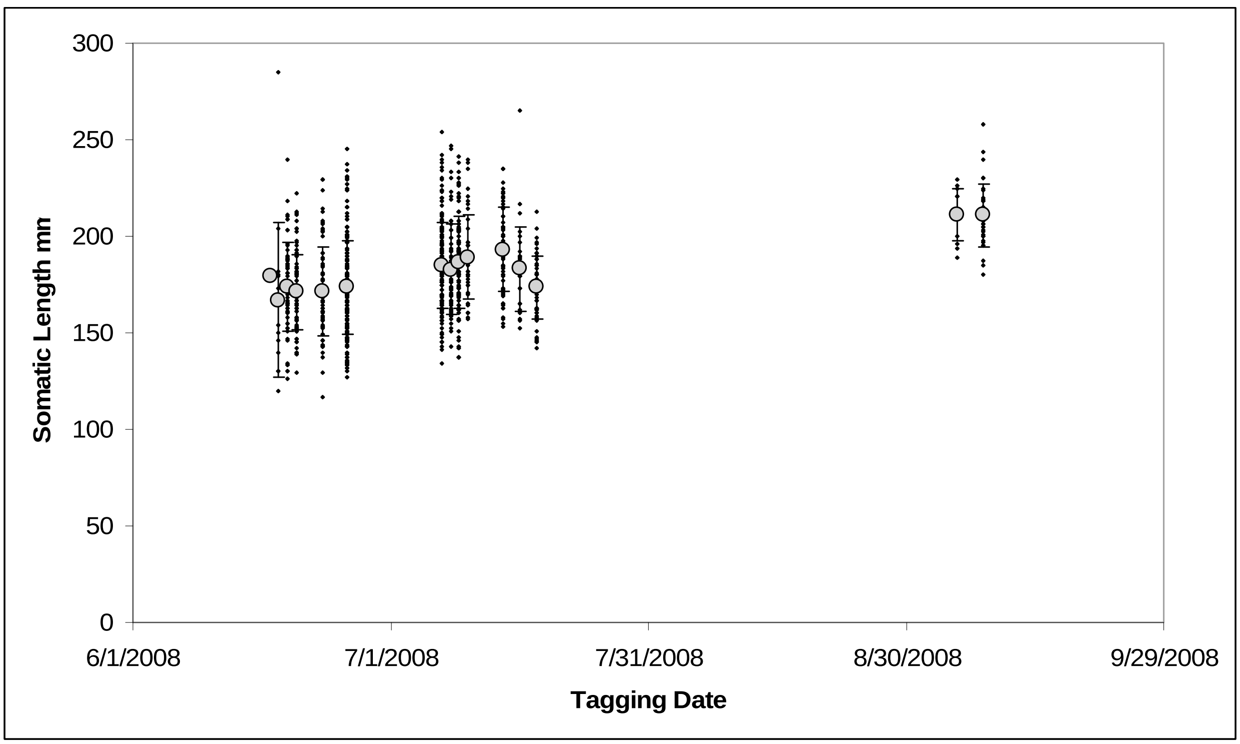

Figure 9.–Somatic length of tagged pollock vs. tagging date. Mean length (grey circles; Y-error bars are 1 SD) distribution over time for tagged walleye pollock seems to suggest no appreciable change; however, this may be due to an abbreviated snapshot for the majority of the data (June–July) and from averaging size across more than one possible age class.

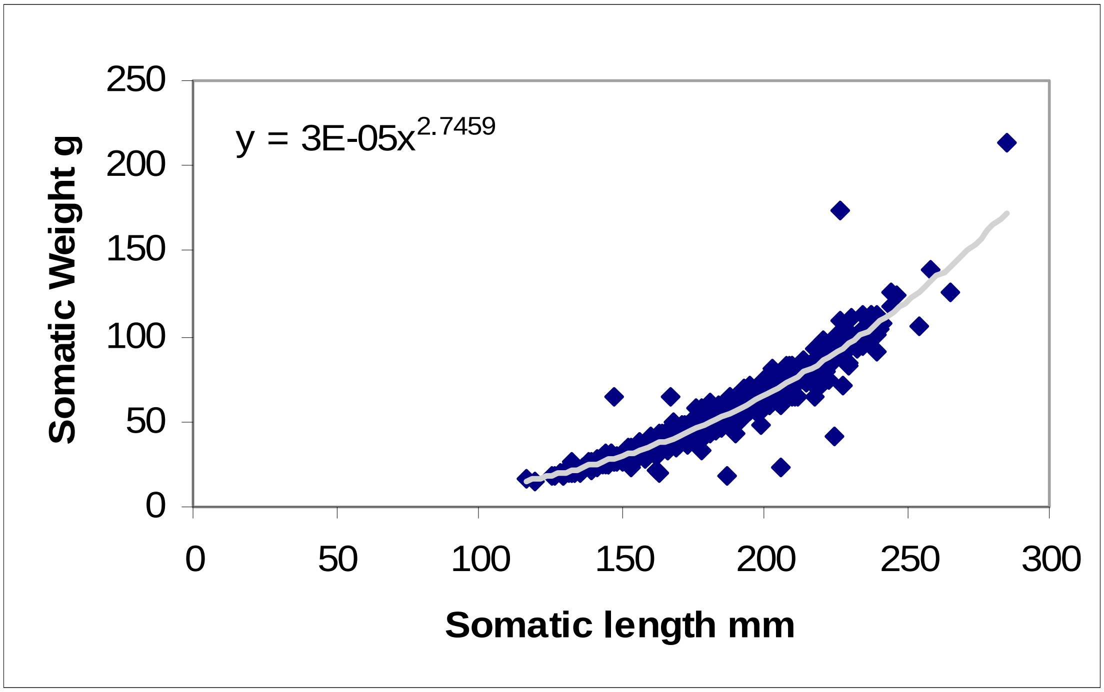

Figure 10.–Somatic weight v. length of tagged pollock. Tagged walleye pollock measurements (n = 999) indicate an allometric somatic weight to somatic length relationship. The power curve and equation were applied using EXCEL.

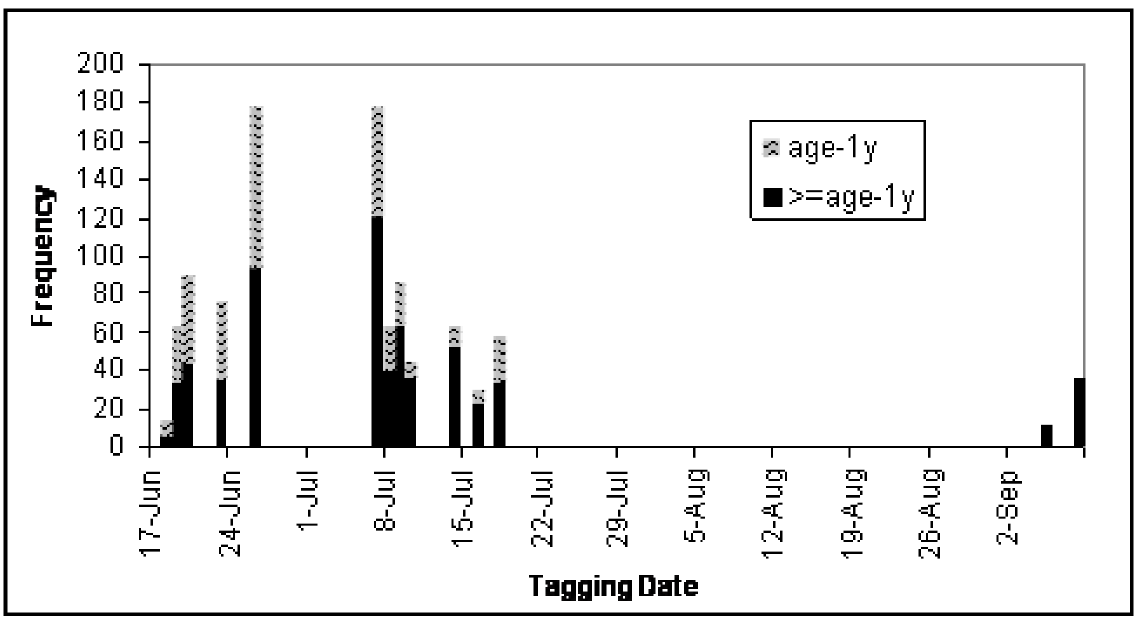

Figure 11.–Frequency of pollock age categories by tagging date. Known-age pollock were assigned by length frequency; fish ≤170 mm were classed as “known-age, age-1 y” (2007 year class), and those >170 mm were classed as “unknown-age” and therefore are ≥age-1 y.

OTOLITH SUBSAMPLES RESULTS

Specimens retained for otoliths arose from random and select sampling of fishing captures, fishing mortalities, tagging or holding mortalities, and subsampling of the held population prior to release. We reduced the original random subsampling goals of our tagged population when it was apparent that mortalities from tagging and culture (presumed generally random) would provide us with our goals. This possibly introduced a bias which we did not attempt to quantify, but which favored the scenario of increasing the number of tagged fish released. We measured otoliths from 302 fish. From these we investigated and removed 2 obvious outlier samples from all analyses where it was believed that field measurement data were in error. We plotted all measurement data for the 6 “skinny, select” fish separately from the remaining samples and did not include these fish in calculation of means or trendlines. For the remaining 294 fish there was a linear relationship between somatic length and otolith length (R^2 = 0.86) and otolith height and otolith length (R^2 = 0.93) and an allometric and curvilinear relationship between otolith weight and otolith length: otolith weight increases with increasing otolith length (Figure 12).

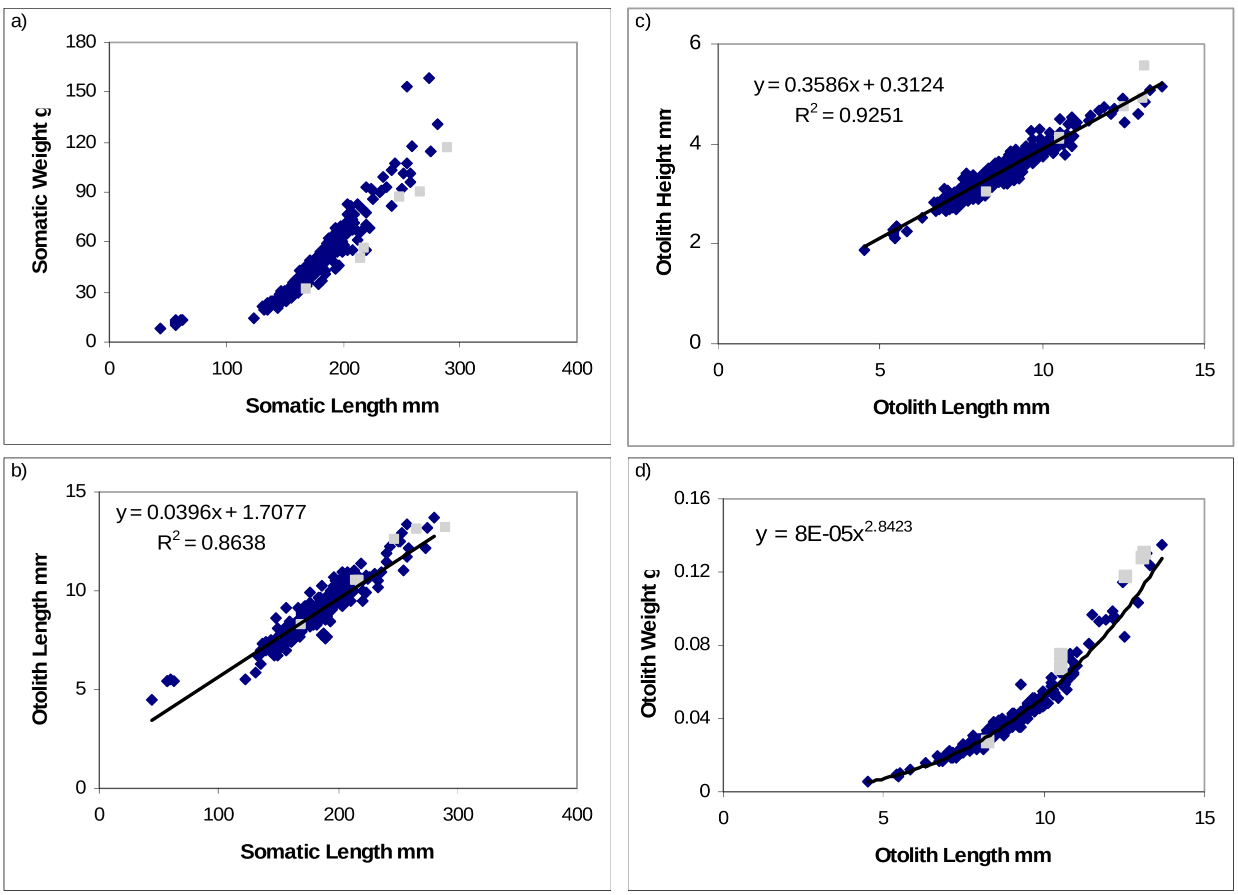

Figure 12.–Somatic and otolith dimensions were compared for 294 fish in the otolith subsample: a) somatic weight at somatic length, b) otolith length at somatic length, c) otolith height at otolith length, and d) otolith weight at otolith length. Data from an additional 6 “skinny select” specimens are plotted (light gray boxes) separately throughout. Trendlines (linear and power curves) and correlations were fitted or calculated by EXCEL software.

Otolith ages were determined from 300 specimens. Ages ranged from 0 to 4 y (Figure 13).

We explored scenarios using these age assignments to develop a temporally progressive length threshold to classify the tagged fish as "known-age, 1-year-old" versus "unknown-age" (therefore, ≥age-1 y). But because we wished to say with certainty whether fish were "known-age, age-1 y," we chose a conservative cutoff length which arose from the "somatic length ranges-at-age" developed from the subjective otolith ages (Table 1). The smallest fish aged to be 2 years old was 171 mm; therefore, all fish ≤170 mm (and not young of the year) were classified as "known-age, age-1 y" (see Figure 11).

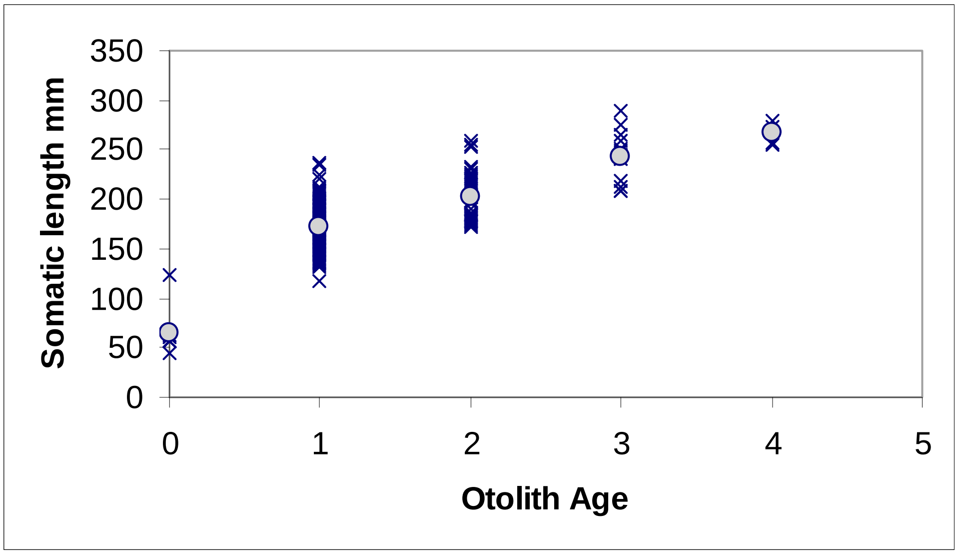

Figure 13.–Somatic length vs. otolith age for pollock. Pollock subsampled in this study ranged in age from 0 to 4 y. Mean values are shown as grey circles.

Table 1.–Otolith ages, sample sizes, and lengths of subsampled pollock. Otolith ages for pollock ranged from 0 to 4 y. This age-at-length range summary indicated that fish age-2 y or greater were as small as 171 mm; therefore a "somatic length threshold" of ≤170 mm was applied to the tagged population and indicated "known-age, age-1 y" fish.

		Length mm		
Age	n=	Mean	Minimum	Maximum
0	8	64.7	43.9	123
1	234	171.8	118	237
2	41	202.4	171	259
3	13	243.2	208	290
4	4	266.3	254	280
Total	300			

We originally intended to evaluate otoliths for possible chemical rings incorporated in the microstructure. However, our otolith specimens were improperly stored so we did not evaluate this potentially valuable time-stamp. Evaluation may be conducted later from otolith samples from tag recoveries.

TAG RECOVERY RESULTS

Two tagged pollock were recaptured from the ABH floats in Auke Bay. The first was captured by a sport angler and submitted by an ADF&G Creel Census Technician. This fish (Tag #OTC_006) was 173 mm when tagged and injected with OTC on June 18; it was held for approximately 30 d and released to the wild on July 21, and recaptured August 22 at 215 mm (Δ42 mm), for a mean growth of 0.65 mm day^{-1} from initial capture to recapture 65 d later (32 d in the wild; Figure 14). The second fish (Tag #K523) was 166 mm (therefore age-1 y by applying our length-threshold) when originally tagged and injected with OTC on June 26; it was held and released to the wild on July 28, and recaptured September 8, 2008 at 194 mm (Δ28 mm), for a mean growth of 0.38 mm day^{-1} from initial capture to recapture 74 d later (42 d in the wild; see Figure 14). The tag wound for #K523 was healed. Because this fish was captured by an ADF&G ADU staff member, it was re-released. In addition, an internet website was launched to heighten public awareness about the importance of return of tagged fish and includes instruction and contact information (Figure 15). The current url for this website is: http://www.taglab.org/ADU/Tagged.asp .

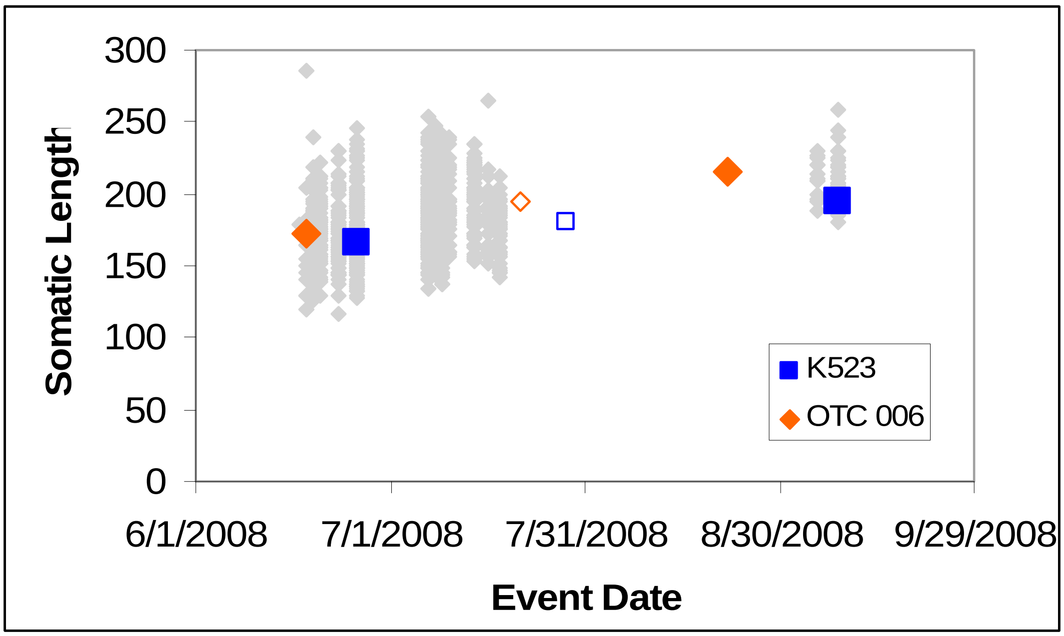

Figure 14.–Somatic length of pollock by event date. Events are capture and recovery. Two tagged walleye pollock were recovered. Somatic lengths of the entire population of tagged pollock (solid gray diamonds) are compared to lengths of 2 recovered specimens. The earlier closed data points indicate capture date, and the later closed data points indicate recovery date. The smaller open data points show the release date and use a calculated mean size between the tagging and recovery date. Fish #K523 was re-released.

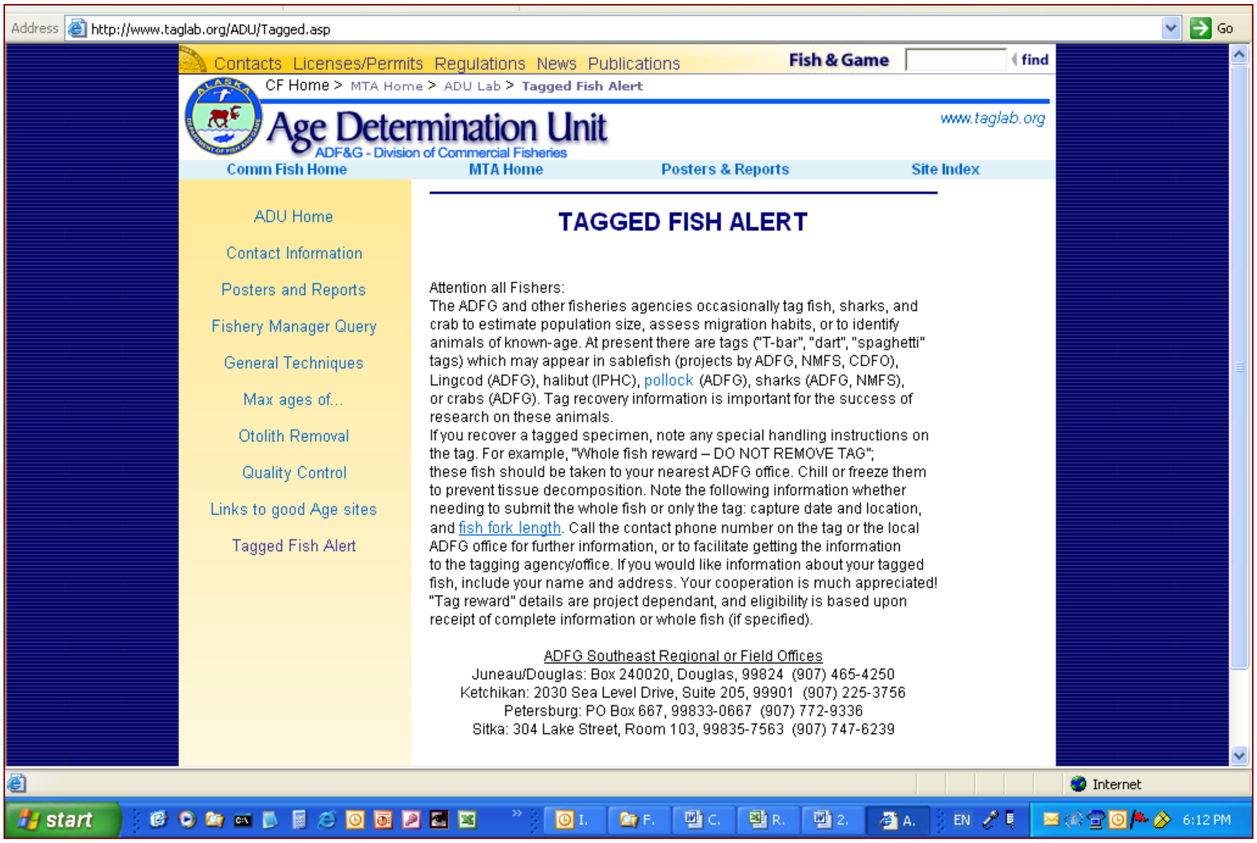

Figure 15.–An informational website was developed to assist the public in turning in a tagged fish. The current url for this website is: http://www.taglab.org/ADU/Tagged.asp . Accessed October 30, 2009.

DISCUSSION

Up to 999 walleye pollock were tagged and released into Auke Bay. This is the first known tagging effort of wild pollock in Southeast Alaska. The pollock were readily available and easily captured. Wild pollock are fragile to handle; however, with considerable attention to careful handling, they tolerated the tagging operation and grew during holding. One of the 2 recaptured fish had been injected with OTC, and this recapture demonstrated that OTC-injected fish can survive and continue to grow in the wild—for at least up to 42 d after release. Somatic to otolith dimensions of the subsample were consistent with data from walleye pollock that represent a broader and more complete range in size and age.

The age classes intercepted for the tagged pollock (therefore not young of the year) are believed to range in age from 1 to 2 y old or older. We believe that the majority of specimens tagged and released were age-1 y; however we assigned a conservative length threshold of <170 mm for specifying "known-age, age-1 y" which resulted in only 37% of the tagged population to be classified as known-age. This threshold undoubtedly resulted in selection for smaller, slower-growing fish, with a bias against larger, faster growing 1-year-olds, and did not adjust for seasonal growth. However, if the threshold to indicate a 1-year-old tagged fish was raised to 237 mm, which is the upper length limit for fish aged 1 year old in the otolith subsample, then this would encompass 98% of all pollock tagged and released. It might also include fish >1 y old. The threshold of $\leq$170 mm is consistent with data from pollock captured in Auke Bay; for example, Salveson (1984) reports that the mean size of 1-year old pollock captured in late June of the year following the year classes of 1977, 1978, and 1979, was 167.80, 131.80, and 162.02 mm,respectively.

Assignment of age-0 y to fish was based upon their small size and recognized young-of-year somatic characters. These fish were not apparent in the fishable population until September, and their recruitment to the small hooks was also likely selective for the largest specimens of their year class. It is notable that the largest of these September-caught age-0 y fish was 123 mm—within the length assignment envelope (range 117–170 mm) for age-1 y fish captured, tagged, and released in June. Comparably, Salveson (1984) reports pollock maximum lengths of 121mm for fish sampled in October of their first year. No age-0 y fish were tagged.

The abundance of age-1 y (2007 year class) pollock in Auke Bay was greater than expected. We knew that age-1 y up to perhaps age-3 y pollock were incidental catches in Auke Bay from sport effort targeting flounder and herring. And Salveson (1984) encountered age-1 y pollock in Auke Bay from 1977 through 1979 while trawling or SCUBA diving. We caught pollock during the majority of our study effort; during the time of peak abundance one project angler could jig up to 45 pollock per hour. From this apparent abundance, we assume that the 2007 pollock year class was, at least locally, above average. Dorn *et al*. (2008) reported that the 2007 pollock year class encountered in Shelikof Strait also appeared to be above average. Future effort is expected to provide further insight into inter-annual abundance of pollock in Auke Bay.

We documented seasonal growth of pollock during a 30 d holding period and from 2 recaptures. During the July 30 d holding period growth averaged 0.28 mm day^{-1}, and for the August and September recaptures growth was 0.38 and 0.65 mm day^{-1}. These growth estimates are much lower than the 0.922 mm day^{-1} previously observed for June growth (Salveson 1984) and possibly reflect handling trauma for the fish we tagged, or seasonal or interannual differences.

Observations made throughout this study will hopefully help us develop more refined tagging methods that will result in a viable population of tagged pollock. The fish seemed to tolerate deep anaesthesia, sometimes taking 15 min to return to normal swimming. Fish seemed to tolerate gentle handling that minimized damage to their slime-coat; however, while we had no specific data for this, we believe that ensuring no disruption of the slime-coat is critical to ensuring health of tagged pollock. While most fish injected with OTC thrived (and 2 recovered OTC-tagged specimens survived and grew 65 d and 74 d post injection), we observed chronic low level mortality of OTC-injected fish during the holding period despite our efforts to reduce this. We have no data to indicate if mortality was primarily due to a toxic reaction to the antibiotic or a possible embolism resulting from the injection (due to inadequate purging of air from the syringe). The fish which were tagged and not injected with OTC survived the handling quite well, with very low mortality for the 1 to 3 d during holding prior to release. We also noticed that tagged, OTC-injected fish required at least 4 d to recover from this trauma. Future studies incorporating unobserved post-tagging impacts on survival should consider and resolve these concerns—or increase sample sizes to include assumptions for post-tagging survival (mortality).

We observed a consistent—though low—presence of malnourished wild pollock. The moribund state of these thus-identified specimens was further apparent when almost all perished within 1 d following tagging (in contrast to excellent survival of fish which were only tagged). Otoliths of malnourished select specimens indicated older fish—all at least 2 y old or older.

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