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Reprinted from the  
Alaska Fishery Research Bulletin  
Vol. 8 No. 1, Summer 2001

The Alaska Fishery Research Bulletin can found on the World Wide Web  
at URL: <http://www.state.ak.us/adfg/geninfo/pubs/afrb/afrbhome.htm> .

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## Maximum Ages of Groundfishes in Waters off Alaska and British Columbia and Considerations of Age Determination

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**ABSTRACT:** The longevity in some groundfish species in the eastern North Pacific Ocean and Bering Sea is remarkable. Maximum ages of some species are relatively young: walleye pollock and lingcod are 28 and 25 years, respectively. Some *Sebastes* species are frequently aged to be over 100 years old, with some areas producing more than a few specimens aged 120–160 years old. The oldest fish recorded from Alaska, and possibly for all of the North Pacific, is a rougheye rockfish *Sebastes aleutianus* captured May 2000 in southeastern Alaska, visually aged from a sagittal otolith transverse section to be 205 years old. This paper consolidates and updates the maximum ages achieved by many groundfishes collected primarily during commercial and research harvest operations north of approximately 48°N latitude in the eastern North Pacific Ocean (Aleutians, Gulf of Alaska, nearshore and inshore waters of Alaska and British Columbia) and Bering Sea, and describes typical age-determination process and error which produced these age estimates.

### INTRODUCTION

Fisheries research and management depend upon age data. Age data are critical to characterizing fish populations to produce effective management strategies (Boehlert 1980; Archibald et al. 1981; Hoenig 1983; Boehlert and Yiklavich 1984; Leaman and Beamish 1984; Boehlert 1985; Leaman 1991). Maximum age allows estimation of mortality (Hoenig 1983). A compilation of maximum ages allows comparison of species of functional similarity, with species-assemblage interdependence requiring shared consideration (Adams 1980). Updates of maximum age estimates provide contemporaneous data, which reflect dynamics of fish populations and technology and promote advances in associated theory.

Age structures are widely collected from groundfish stocks for research and management needs. These samples continue to document and occasionally extend the known life span of these fishes. Some of these

life spans range from approximately 20 years old within Gadidae and Hexagrammidae to over 100 years old for many species within the genus *Sebastes*.

Routine age reading (ageing) interprets patterns of annual growth that occur within the chosen age structure. Interpretations are made in accord with criteria standardized by the international Committee of Age-Reading Experts (CARE 2000), a consortium of age readers at several government agencies and academic institutions bordering the eastern North Pacific Ocean. In large part these interpretation criteria are based upon methods documented in Chilton and Beamish (1982), with parallels to age-determination methods by many earlier researchers (Reibisch 1899; Rollefson 1933; Tåning 1938; Chugunova 1963; Christensen 1964). There is broad utilization of age data (e.g., Bechtol and Yuen 1995; Bechtol 1998a, 1998b, 1999, 2000; O'Connell et al. 1998, 1999, 2000; Cartwright 2000) and support of ageing practices (Archibald et al. 1981; Boehlert and Yiklavich 1984; Leaman and Beamish

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**Acknowledgments:** Employees of the Groundfish Program of the Alaska Department of Fish and Game, Commercial Fisheries Division, who provide thousands of otoliths every year to the Age Determination Unit in Juneau — Bill Bechtol, Cleo Brylinsky, Kamala Carroll, Meg Cartwright, Susan Domenowske, Willy Dunne, Deidra Holum, Tory O'Connell, Beverly Richardson, Grace Thornton, Mike Vaughn, and others. Andrea Bowen, Joan Brodie, Willy Dunne, Claudia Echavarría, William A. Foster, Curtis McNeill, Christine Schmale, and Ruby Young — past and present age-readers of the Age Determination Unit. Bill Bechtol, Cleo Brylinsky, Scott Meyer, Mike Vaughn, Cal Blood, Jon Heifetz, Allen Andrews, Craig Kastle, John Butler, Bob Mikus, Tory O'Connell, Paul DeSloover, and Karen Charles — for information included in this document. Shayne MacLellan from the Pacific Biological Station, and Delsa Anderl from the Sand Point Lab — special thanks for numerous updates of maximum ages from samples collected in British Columbia and Alaska waters. Bill Bechtol, Shayne MacLellan, Susan Shirley, and an anonymous reviewer — for critical reviews of this document and helpful comments.



1984) that incorporate the visual inspection of the sagittal-transverse otolith section. Objective validation of the visual interpretation of these growth patterns is incomplete for all species, but extension of this knowledge to similar species is convincing, with application of age data for non-validated species routine. Efforts to validate visual interpretation of growth patterns must continue, and do.

A compilation of maximum ages for 48 groundfishes captured in proximity to British Columbia and Alaska and current to December 2000 are presented. A brief discussion of the conventional age-reading processes and aspects of inherent error is offered to provide perspective to these reported maximum age estimates.

## METHODS

### Sample Collection and Technique

Age structures such as otoliths, fin spines, and fin rays are routinely randomly collected from fish captured in waters in the northern latitudes of the eastern North Pacific Ocean and the Bering Sea and sent to centralized age-reading facilities in British Columbia, Washington, and Alaska. Extracted structures are cleaned of tissue and stored in a variety of containers, dry or immersed in a solution of glycerin or alcohol (depending upon the agency collection standard or reading technique requirements).

For a few species, primarily fin spines or fin rays are collected and examined to produce age estimates. Pigmented zones (early years) and ridges (later years) on the external surface of the dorsal fin spine of *Squalus acanthias* are interpreted and counted as annuli (Ketchen 1975; Chilton and Beamish 1982). Fin rays of *Ophiodon elongatus* and *Gadus macrocephalus* are the preferred age structure at some, but not all, facilities and are sectioned immediately dorsal of the ray's basal ridge, which adjoins the distal pterygiophore.

The sagittal otolith (otolith) has long been utilized for producing estimates of age for many groundfish species (Reibisch 1899; Rollefson 1933; Tåning 1938; Chugunova 1963; Christensen 1964; Williams and Bedford 1974; Beamish and Chilton 1982; Chilton and Beamish 1982; MacLellan 1997; CARE 2000). Otoliths may be cleared (made less opaque through use of a clearing solution) and the surface examined for annuli. Reading the otolith surface may underestimate age (Reibisch 1899; Williams and Bedford 1974; Chilton and Beamish 1982; Boehlert and Yoklavich 1984; Wilson and Boehlert 1990), therefore reading laboratories must thoroughly consider all species or growth charac-

ters before using surface age-reading techniques. Otoliths may be thin-sectioned; however, this technique is not common for "production" age-reading. The most common production reading technique used in revealing all growth events is termed "break and burn." This process utilizes an otolith transverse section prepared by first breaking an otolith on a lateral dorsoventral axis through the core, and passing one half through an alcohol flame until lightly charred (Christensen 1964). Some reading labs may break (or cut) otoliths and bake them to induce similar charring of the proteinaceous winter zone.

### Age-Structure Growth-Pattern Interpretation

The charred half-section is examined using reflected light. The resultant dark zones in a simplified pattern of repeating light and dark zones are enumerated as annuli, based upon periodically reviewed, standardized reading criteria (CARE 2000). These latter criteria are a mixture of both objective measurements of relatively consistent features that are compared to established mean dimensions for a species, and also subjective pronouncement of visual cues. Few, if any, groundfish species across their range of ages may be wholly visually aged utilizing objective criteria. Age reading is described as an art and not a science (Williams and Bedford 1974), and as expected, the inherent terminology describing this recognition process, and used throughout this manuscript, is subjective and without a history of rigorous objective study.

Growth patterns in age structures reflect variation within and between species and populations (Rollefson 1933, 1934; Williams and Bedford 1974) and sexual dimorphisms (unpublished data). Growth patterns are generally described by age readers as "fast-growth type," those fish from generally shallower, more variable waters and tending toward moderate life spans (approximately 25–50 years), and "slow-growth type," generally from deeper, more stable waters and tending toward greater life spans (much greater than 50 years). This simplified explanation compares presumed fast versus slow somatic growth tendencies of a species to the proportional spacing of annular growth zones, which yield quite different patterns within an age structure. Fast growth may confound the reading process by producing "noisy patterns," an accumulation of visually strong growth increments within an annulus that when enumerated exceed the likely age of the fish. Growth rates, and therefore subsequent spacing of annuli, may decrease at different rates after the rapid growth of the early years and necessitate a change in interpretation of succeeding growth increments.

## Verification of Pattern Interpretation

Many processes have been used to corroborate the visual, subjective interpretation of growth patterns. "Marginal increment analysis" examines and measures the progression of new growth at the leading edge of the otolith from samples collected throughout a year. Discrete annular zones within growth patterns have been individually validated for some groundfish species through chemical time-stamping of growth (Cass and Beamish 1983; McFarlane and Beamish 1987). Extreme longevity in some fish has been supported for some species by measuring disequilibria in the radionuclide pair  $^{210}\text{Pb}$ : $^{226}\text{Ra}$  (Bennett et al. 1982; Campana et al. 1990; Fenton et al. 1991; Kestelle et al. 1994; Butler et al. 1995; Fenton and Short 1995; Kestelle et al. 2000). Cailliet et al. (2001) presents a thorough listing of maximum ages of Atlantic and Pacific Ocean species, cross-referenced to species age-validation methods. The measurement of anthropogenic radiocarbon from atmospheric testing of nuclear devices has also been used to corroborate longevity in fish for specimens with birth dates between 1955 and 1985 (Kalish 1995).

## Age-Reading Error

Most age reading facilities reread a portion of age structures to assess the ability to reproduce the age estimate. These precision estimates describe the difficulty inherent to ageing a species (Kimura and Lyons 1991) and can only be considered a proxy for the actual age of the fish if the annular growth pattern has been validated. General or tailored formulations are used to describe and document process error (Shewhart 1931; Abell et al. 1989) or error in age estimates (Beamish and Fournier 1981; Chang 1982; Sharp and Bernard 1988; Kimura and Lyons 1991; Campana et al. 1995). Estimates of precision (error) may indicate (1) consistency of age-reading criteria within or between readers and/or labs, (2) the need for additional reading of the sample if error limits are transgressed, (3) bias within or among samples, and (4) trends in producing age estimates.

Variables that affect reading error may be species-specific or growth-specific (fast versus slow). Examples of variables leading to interpretation errors are

- (1) Misidentification of the first annulus generally results in an error of one year. This can be important to the overall count in young fish and inconsequential in old fish.
- (2) Misinterpretation of the leading edge of growth (otolith margin) may result in an error of one to a few years. This can be important to the overall count in young fish and is of decreasing importance in increasingly older fish.
- (3) Misidentification of a transition zone (the pattern produced during gradual or rapid changes to a slower growth rate). This may result in serious error in generally young to moderately old fish (roughly, age 6–30 years). Ease in consistently detecting transition zones is often species-specific.
- (4) Misidentification of a compressed zone (not identifying a zone of growth as closely-spaced, compressed annuli), an error potentially compounded by the number of compressed zones within the age pattern. This can potentially result in substantial error (overestimating or underestimating age) even in older fish. In contrast, misinterpretation of the number of annuli within a recognized compressed zone will result in a smaller error that predictably will always underestimate the age of the specimen.

## RESULTS AND DISCUSSION

Family, scientific, and common names, along with age validation of species in this study, are presented in Table 1. Many of the species have verified growth patterns that are referenced in CARE (2000). An updated compilation of maximum ages determined for 48 species of groundfish is presented in Table 2. This listing consolidates both new and previously reported maximum age estimates for fish captured north of 48°N latitude, with the inclusion of 3 maximum ages from southerly specimens of species which occur in northern waters but are not extensively sampled, to provide a meaningful indication of maximum age. Five species (including the 3 southerly specimens) for which higher maximum ages are reported for populations south of 48°N latitude are listed in Table 3. All are learned estimates of age and therefore are approximations of the life spans of the species. All maximum age estimates were produced using a broken and burned (for the majority) or thin-sectioned otolith except for *Squalus acanthias*, which utilized a dorsal fin spine. All specimens came from randomly sampled commercial or research harvest operations except those provided from

Table 1. Taxonomic listing of groundfish species and common names, and species age-validation information. OTC = oxytetracycline, MIA = marginal increment analysis, Ra = radionuclide.

Family	Species	Common Name	Age Validation	Source
<b>Anoplopomatidae</b>	<i>Anoplopoma fimbria</i>	Sablefish	OTC	Beamish and Chilton 1982
			Ra	Kastelle et al. 1994
<b>Gadidae</b>	<i>Gadus macrocephalus</i>	Pacific cod	OTC	CARE 2000
	<i>Theragra chalcogramma</i>	Walleye pollock		
<b>Hexagrammidae</b>	<i>Hexagrammos decagrammus</i>	Kelp greenling		
	<i>Ophiodon elongatus</i>	Lingcod	OTC	Cass and Beamish 1983
	<i>Pleurogrammus monopterygius</i>	Atka mackerel	MIA	Anderl et al. 1996
<b>Pleuronectidae</b>	<i>Atheresthes evermanni</i>	Kamtchatka flounder		
	<i>A. stomias</i>	Arrowtooth flounder		
	<i>Eopsetta jordani</i>	Petrale sole		
	<i>Errex zachirus</i>	Rex sole		
	<i>Hippoglossoides elassodon</i>	Flathead sole		
	<i>Hippoglossus stenolepis</i>	Pacific halibut	OTC	IPHC 1998
	<i>Microstomus pacificus</i>	Dover sole		
	<i>Pleuronectes asper</i>	Yellowfin sole		
	<i>P. bilineatus</i>	Rock sole	OTC	CARE 2000
	<i>P. quadrituberculatus</i>	Alaska plaice		
<b>Scorpaenidae</b>	<i>P. vetulus</i>	English sole	OTC	CARE 2000
	<i>Sebastes aleutianus</i>	Rougheye rockfish	Ra	Kastelle et al. 2000
	<i>S. alutus</i>	Pacific ocean perch	Ra	Kastelle et al. 2000
	<i>S. babcocki</i>	Redbanded rockfish		
	<i>S. borealis</i>	Shortraker rockfish	Ra	Kastelle et al. 2000
	<i>S. brevispinis</i>	Silvergray rockfish		
	<i>S. caurinus</i>	Copper rockfish		
	<i>S. ciliatus</i>	Dusky rockfish	Ra	CARE 2000
	<i>S. crameri</i>	Darkblotched rockfish		
	<i>S. diploproa</i>	Splitnose rockfish	Ra	Bennett et al. 1982
	<i>S. elongatus</i>	Greenstriped rockfish		
	<i>S. entomelas</i>	Widow rockfish	MIA	CARE 2000
	<i>S. flavidus</i>	Yellowtail rockfish	OTC	CARE 2000
	<i>S. helvomaculatus</i>	Rosethorn rockfish		
	<i>S. maliger</i>	Quillback rockfish		
	<i>S. melanops</i>	Black rockfish	OTC	CARE 2000
	<i>S. melanostomus</i>	Blackgill rockfish		
	<i>S. miniatus</i>	Vermilion rockfish		
	<i>S. mystinus</i>	Blue rockfish		
	<i>S. nebulosus</i>	China rockfish		
<i>S. nigrocinctus</i>	Tiger rockfish			
<i>S. paucispinus</i>	Boccacio	Ra	A. Andrews, Moss Landing Marine Lab, pers. comm.	
<i>S. pinniger</i>	Canary rockfish	Ra	CARE 2000	
<i>S. polyspinis</i>	Northern rockfish	Ra	Kastelle et al. 2000	
<i>S. proriger</i>	Redstripe rockfish			
<i>S. reedi</i>	Yellowmouth rockfish			
<i>S. ruberrimus</i>	Yelloweye rockfish	Ra	A. Andrews, Moss Landing Marine Lab, pers. comm.	
<i>S. variegatus</i>	Harlequin rockfish			
<i>S. wilsoni</i>	Pygmy rockfish			
<i>S. zacentrus</i>	Sharpchin rockfish			
<i>Sebastolobus alascanus</i>	Shortspine thornyhead	Ra	Butler et al. 1995; Kastelle et al. 2000	
<b>Squalidae</b>	<i>Squalus acanthias</i>	Spiny dogfish	OTC	Chilton and Beamish 1982; Beamish and McFarlane 1985

Table 2. Maximum ages of 48 groundfishes encountered in the eastern North Pacific Ocean and the Bering Sea north of 48°N latitude. Asterisks indicate updated ages. Non-extensive sampling or anecdotal reference to larger fish possibly suggest an understimation of maximum life span for some species (†). Reports reference some specimens as older (‡); however, the age of record is reported here. Higher maximum ages from more southerly populations are given in Table 3.

Species	Maximum		Specimen Capture		Source
	Age (years)	<i>n</i>	Year	Location	
Sablefish	94*‡	>10,000	1989	Aleutian Islands	NMFS <sup>1</sup>
Pacific cod	25*	>1,000	2000	Kachemak Bay	ADF&G <sup>2</sup>
Walleye pollock	28	>10,000	unknown	Bering Sea	McFarlane and Beamish 1990
Kelp greenling	18*†	10	2000	Northern SE Alaska	ADF&G <sup>2</sup>
Lingcod	25*	>10,000	1995	Northern SE Alaska	ADF&G <sup>2</sup>
Atka mackerel	15*	>5,000	2000	Aleutian Islands	NMFS <sup>1</sup>
Kamchatka flounder	33†	>120	1991	Bering Sea	Zimmerman and Goddard 1996
Arrowtooth flounder	23	>1,000	1993	Gulf of Alaska	Turnock et al. 1999
Petrale sole	35*	>6,000	1999	British Columbia	CDFO <sup>3</sup>
Rex sole	27*	>200	1996	Gulf of Alaska	NMFS <sup>1</sup>
Flathead sole	27*	>1,000	1998	Bering Sea	NMFS <sup>1</sup>
Pacific halibut	55	>10,000	1992	Bering Sea	IPHC 1998
Dover sole	53*†	>1,000	1990	Gulf of Alaska	NMFS <sup>1</sup>
Yellowfin sole	34*	>200	1999	Bering Sea	NMFS <sup>1</sup>
Rock sole	26*	>200	1998	Bering Sea	NMFS <sup>1</sup>
Alaska plaice	31*	>500	1998	Bering Sea	NMFS <sup>1</sup>
English sole	22	>1,000	1959	British Columbia	Chilton and Beamish 1982
Rougheye rockfish	205*	>10,000	2000	Southern SE Alaska	ADF&G <sup>2</sup>
Pacific ocean perch	98	>10,000	1990s	Aleutian Islands	Heifetz et al. 2000
Redbanded rockfish	106*	>1,000	1985	Southern SE Alaska	ADF&G <sup>2</sup>
Shortraker rockfish	157*	>10,000	2000	Northern SE Alaska	ADF&G <sup>2</sup>
Silvergray rockfish	81*	>10,000	1981	British Columbia	CDFO <sup>3</sup>
Copper rockfish	50†	>200	1992	Prince William Sound	Meyer 2000
Dusky rockfish	67	>10,000	1992	Kodiak	Meyer 2000
Darkblotched rockfish	48†	198	1977–1979	British Columbia	Archibald et al. 1981
Splitnose rockfish	86	>200	1980	British Columbia, West Coast	Bennett et al. 1982
Greenstriped rockfish	54*†	1	1984	Southern SE Alaska	ADF&G <sup>4</sup>
Widow rockfish	60*	>3,000	1996	British Columbia	CDFO <sup>3</sup>
Yellowtail rockfish	64	>10,000	unknown	British Columbia	Chilton and Beamish 1982
Rosethorn rockfish	87*	>100	1985	Southeastern Alaska	ADF&G <sup>2</sup>
Quillback rockfish	90*	>10,000	1997	Southern SE Alaska	ADF&G <sup>2</sup>
Black rockfish	50	>10,000	1993	Kodiak	Meyer 2000
Blackgill rockfish	87*†	>1,000	1985	West Coast south of 48°N	NMFS <sup>5</sup>
Vermilion rockfish	60*†	1	1996	West Coast south of 48°N	CDFO <sup>3</sup>
Blue rockfish	30*†	>200	1993	West Coast south of 48°N	ODFW <sup>6</sup>
China rockfish	78*	>1,000	1992	Southern SE Alaska	ADF&G <sup>2</sup>
Tiger rockfish	116*	>1,000	1992	Southern SE Alaska	ADF&G <sup>2</sup>
Bocaccio	46*†	>100	1994	Gulf of Alaska	Meyer 2000
Canary rockfish	84*	>5,000	1980	British Columbia	CDFO <sup>3</sup>
Northern rockfish	57	>1,000	1986	Aleutian Islands	Heifetz and Clausen 1991
Redstripe rockfish	55*	>2,000	1999	British Columbia	CDFO <sup>3</sup>
Yellowmouth rockfish	99*	>4,000	1992	British Columbia	CDFO <sup>3</sup>
Yelloweye rockfish	118*	>10,000	1991	Southern SE Alaska	ADF&G <sup>2</sup>
Harlequin rockfish	43†	>300	1980	British Columbia	Chilton and Beamish 1982
Pygmy rockfish	26*†	>100	1991	British Columbia	CDFO <sup>6</sup>
Sharpchin rockfish	58†	>500	1999	Gulf of Alaska	Heifetz et al. 2000
Shortspine thornyhead	89	>1,000	1990s	Prince William Sound	Bechtol 2000
Spiny dogfish	66	>1,000	unknown	British Columbia	Chilton and Beamish 1982

<sup>1</sup> Delsa Anderl, National Marine Fisheries Service (NMFS), Seattle, personal communication.

<sup>2</sup> Alaska Department of Fish and Game (ADF&G) Age Determination Unit, Juneau.

<sup>3</sup> Shayne MacLellan, Canadian Department of Fisheries and Oceans (CDFO), Pacific Biological Station, Nanaimo, personal communication.

<sup>4</sup> Mike Vaughn, ADF&G, Sitka, personal communication.

<sup>5</sup> John Butler, NMFS, La Jolla, personal communication.

<sup>6</sup> Bob Mikus, Oregon Department of Fish and Wildlife (ODFW), Newport, personal communication.



sport harvests (Meyer 2000; Bob Mikus, Oregon Department of Fish and Wildlife, personal communication).

These groundfishes are a mixture of relatively fast, moderately fast, and slow growth types. For the oldest specimens, the progression of growth throughout is generally described as relatively rapid in the early years (large zone width), followed by either a gradual (moderate zone width) or sudden shift (large, then small zone width) to slow growth. These growth types present a mixture of pattern difficulties for reading, which are generally species-specific. Some species are considered generally easy to read, with good likelihood of achieving an estimate closely approximating the actual age of the fish, whereas others may be considered moderately easy to difficult to read. For these specimens, the greater uncertainty results in a concomitant increase in the estimated age range. Generally, older specimens are easier to read because the full range of growth transitions is visible, except for patterns showing extremely slow growth in later years with very closely spaced annuli, which challenge the limits of optical resolution. In other words, an age-reader can easily identify a specimen that is old to very old; however, estimating the actual year of birth is more difficult.

The number of specimens sampled and read to produce these updates of maximum age is important. With very small sample sizes, older specimens likely would be encountered with a modest increase in sample size; Hoenig (1983) speculates that after 200 animals are examined the possibility of extending the maximum age for a species decreases. In Table 2 total sample size was difficult to approximate (amongst all contributing facilities); however, gross approximations of the number of specimens examined are given, which in almost all cases exceed Hoenig's threshold of 200 fish. More effort at resolution of this detail was made for known smaller sample sizes.

Confamilials generally may achieve similarly long life spans. A review of maximum ages of Scorpaenidae further suggests a commonality within species assemblages (Table 4; Figure 1). Shelf (i.e., continental shelf) assemblages of pelagic rockfish are generally considered fast-growth types and had maximum ages of 64 (*Sebastes flavidus*) and 67 (*S. ciliatus*) years. Shelf assemblages of demersal rockfish and assemblages of slope (i.e., continental slope) rockfish are considered slow-growth types. The 2 highest ages for the demersal shelf rockfish were 116 and 118 years for *S. nigrocinctus* and *S. ruberrimus*, respectively. The 2 highest ages for slope rockfish were 157 and 205

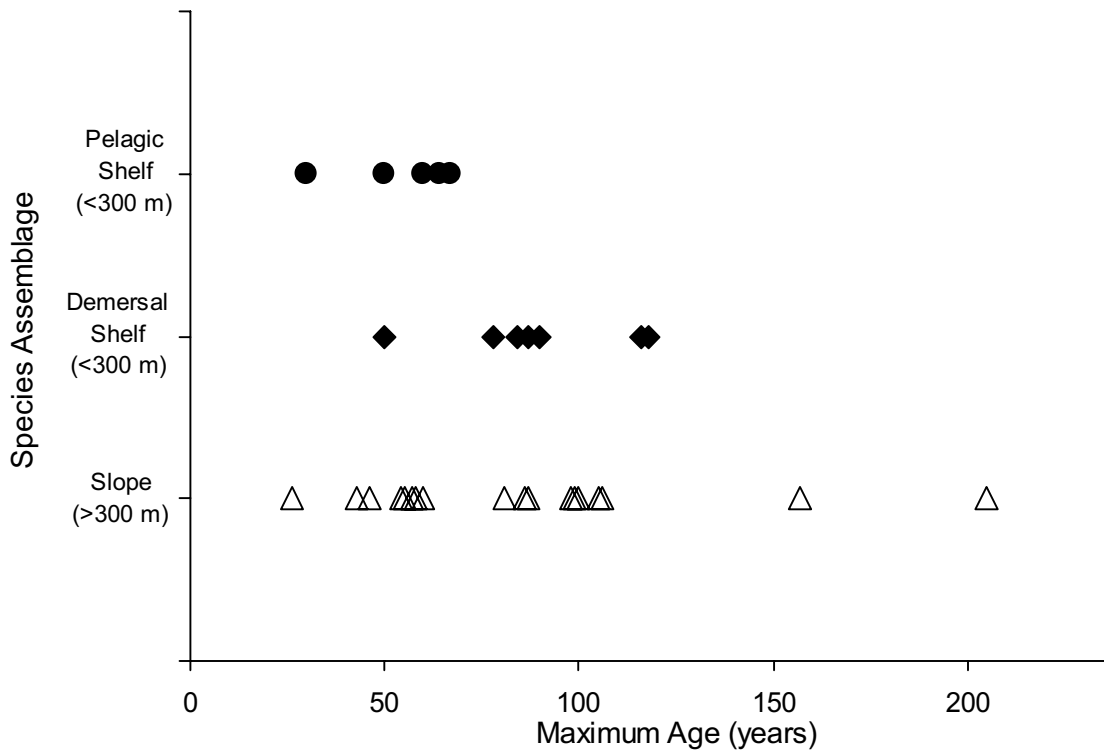


Figure 1. Maximum ages of Scorpaenidae species, grouped by species assemblages. All maximum ages are used, including those from West Coast stocks.

Table 3. Maximum age estimates for specimens collected south of 48°N latitude whose maximum ages exceeded those for the same species collected north of 48°N latitude.

Species	Maximum Age (years)		<i>n</i> (South 48°N)	Specimen Capture			Source
	North of 48°N	South of 48°N		Year	Location	Harvest Type	
Blackgill rockfish		87	>1,000	1985	California	commercial	NMFS <sup>1</sup>
Blue rockfish		30	>200	1993	Oregon	sport	ODFW <sup>2</sup>
Darkblotched rockfish	48	105	>1,000	1990s	Oregon	sport	ODFW <sup>2</sup>
Dover sole	53	60	>10,000	1990	Oregon	sport	ODFW <sup>2</sup>
Vermilion rockfish		60	>100	1996	West Coast	unknown	CDFO <sup>3</sup>
Shortspine thornyhead	89	>100	>1,000	1990	Oregon	unknown	Butler et al. 1995

<sup>1</sup> John Butler, NMFS Southwest Fisheries Science Center, LaJolla, personal communication.

<sup>2</sup> Bob Mikus, Oregon Department of Fish and Wildlife (ODFW), Newport, personal communication.

<sup>3</sup> Shayne MacLellan, Canadian Department of Fisheries and Oceans (CDFO), Pacific Biological Station, Nanaimo, personal communication.

years for *S. borealis* and *S. aleutianus*, respectively. The demarcation of shelf versus slope assemblages of adult rockfish can be approximated by the 300-m depth contour; however, the actual distribution among species within assemblages can vary (Kramer and O'Connell 1988). Gerking (1957) and Pauly (1979) suggested a relationship of increasing longevity in fishes inhabiting stable, cold, deepwater environments. Many of the slope rockfish species reported here were sampled less intensively in waters near Alaska and British Columbia, suggesting that an increase in the maximum ages for the species and a decrease in the mortality rate might be expected with a modest increase in the number of samples examined (Hoenig 1983).

The potential for age-reading error can be a significant factor when utilizing age data (Richards et al. 1992). Generally, most species are aged with relative comfort in final assignments of age. The rougheye rockfish recently aged to be 205 years old was moderately difficult to age and had 2 potential types of error. The otolith had a region approximately one-third of the way through its growth pattern (at about 65 years) where the pattern appeared ambiguous, and the number of annuli in this region could have been overestimated.

The actual age of this fish could be younger than 205 years, but it was determined to be at least 170 years old, which would still be a maximum age for this species. The otolith also had many vague compressed zones. The number of very closely spaced annuli within the compressed zones could have been underestimated. If so, the actual age of the fish may have been underestimated, and the fish is older than 205 years.

This update of maximum ages for many groundfish species in the eastern North Pacific Ocean and Bering Sea is noteworthy not just for the extension of maximum ages of fish, but also because many of these fish were captured within the past 10 years. These increases may reflect changes in population dynamics, perhaps due to management strategies, or changes in the environment, sampling effort, or age-reading conventions. Perhaps more likely it reflects the cumulative effects of increased sampling and reading of age structures, as well as increases in or redistribution of harvests to deeper and previously unexploited waters. Regardless, the extreme longevity, particularly in many scorpaenids, and subsequent harvest of these stocks begs comparison to the mining of nonrenewable resources, which suggests that preservative measures in addition to conservative management practices be effected.

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Table 4. Rockfish assemblage classifications.

<b>“Shelf-pelagic” rockfish assemblage</b>	<b>“Slope” rockfish assemblage</b>
Black rockfish	Blackgill rockfish
Blue rockfish	Bocaccio
Dusky rockfish	Darkblotched rockfish
Widow rockfish	Greenstriped rockfish
Yellowtail rockfish	Harlequin rockfish
	Northern rockfish
<b>“Shelf-demersal” rockfish assemblage</b>	Pacific ocean perch
Canary rockfish	Pygmy rockfish
China rockfish	Redbanded rockfish
Copper rockfish	Redstripe rockfish
Quillback rockfish	Rougheye rockfish
Rosethorn rockfish	Sharpchin rockfish
Tiger rockfish	Shortraker rockfish
Yelloweye rockfish	Shortspine thornyhead
	Silvergray rockfish
	Splitnose rockfish
	Vermilion rockfish
	Yellowmouth rockfish

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## Postnote

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- 01 Jun 11 — The maximum age for rougheye rockfish listed in Table 2 was incorrectly reported in the initial full-issue printing of this article and distributed full-issue copies of this Bulletin still contain the error. The correct maximum age of 205 years appears in this online version and in all reprints of this article.

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