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

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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; Rollefsen 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 Yoklavich 1984; Leaman and Beamish

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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; Rollefsen 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 characters 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 (Rollefsen 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 $^{210}Pb$:$^{226}Ra$ (Bennett et al. 1982; Campana et al. 1990; Fenton et al. 1991; Kastelle et al. 1994; Butler et al. 1995; Fenton and Short 1995; Kastelle 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 |
|---|---|---|---|---|
| **Anoplopomatidae** | *Anoplopoma fimbria* | Sablefish | OTC<br>Ra | Beamish and Chilton 1982<br>Kastelle et al. 1994 |
| **Gadidae** | *Gadus macrocephalus* | Pacific cod | OTC | CARE 2000 |
| | *Theragra chalcogramma* | Walleye pollock | | |
| **Hexagrammidae** | *Hexagrammos decagrammus* | Kelp greenling | | |
| | *Ophiodon elongatus* | Lingcod | OTC | Cass and Beamish 1983 |
| | *Pleurogrammus monopterygius* | Atka mackerel | MIA | Anderl et al. 1996 |
| **Pleuronectidae** | *Atheresthes evermanni* | Kamtchatka flounder | | |
| | *A. stomias* | Arrowtooth flounder | | |
| | *Eopsetta jordani* | Petrale sole | | |
| | *Errex zachirus* | Rex sole | | |
| | *Hippoglossoides elassodon* | Flathead sole | | |
| | *Hippoglossus stenolepis* | Pacific halibut | OTC | IPHC 1998 |
| | *Microstomus pacificus* | Dover sole | | |
| | *Pleuronectes asper* | Yellowfin sole | | |
| | *P. bilineatus* | Rock sole | OTC | CARE 2000 |
| | *P. quadrituberculatus* | Alaska plaice | | |
| | *P. vetulus* | English sole | OTC | CARE 2000 |
| **Scorpaenidae** | *Sebastes aleutianus* | Rougheye rockfish | Ra | Kastelle et al. 2000 |
| | *S. alutus* | Pacific ocean perch | Ra | Kastelle et al. 2000 |
| | *S. babcocki* | Redbanded rockfish | | |
| | *S. borealis* | Shortraker rockfish | Ra | Kastelle et al. 2000 |
| | *S. brevispinis* | Silvergray rockfish | | |
| | *S. caurinus* | Copper rockfish | | |
| | *S. ciliatus* | Dusky rockfish | Ra | CARE 2000 |
| | *S. crameri* | Darkblotched rockfish | | |
| | *S. diploproa* | Splitnose rockfish | Ra | Bennett et al. 1982 |
| | *S. elongatus* | Greenstriped rockfish | | |
| | *S. entomelas* | Widow rockfish | MIA | CARE 2000 |
| | *S. flavidus* | Yellowtail rockfish | OTC | CARE 2000 |
| | *S. helvomaculatus* | Rosethorn rockfish | | |
| | *S. maliger* | Quillback rockfish | | |
| | *S. melanops* | Black rockfish | OTC | CARE 2000 |
| | *S. melanostomus* | Blackgill rockfish | | |
| | *S. miniatus* | Vermilion rockfish | | |
| | *S. mystinus* | Blue rockfish | | |
| | *S. nebulosus* | China rockfish | | |
| | *S. nigrocinctus* | Tiger rockfish | | |
| | *S. paucispinus* | Boccacio | Ra | A. Andrews, Moss Landing Marine Lab, pers. comm. |
| | *S. pinniger* | Canary rockfish | Ra | CARE 2000 |
| | *S. polyspinis* | Northern rockfish | Ra | Kastelle et al. 2000 |
| | *S. proriger* | Redstripe rockfish | | |
| | *S. reedi* | Yellowmouth rockfish | | |
| | *S. ruberrimus* | Yelloweye rockfish | Ra | A. Andrews, Moss Landing Marine Lab, pers. comm. |
| | *S. variegatus* | Harlequin rockfish | | |
| | *S. wilsoni* | Pygmy rockfish | | |
| | *S. zacentrus* | Sharpchin rockfish | | |
| | *Sebastolobus alascanus* | Shortspine thornyhead | Ra | Butler et al. 1995; Kastelle et al. 2000 |
| **Squalidae** | *Squalus acanthias* | 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 Age (years) | *n* | Specimen Capture Year | Specimen Capture Location | Source |
|---|---|---|---|---|---|
| Sablefish | 94*‡ | >10,000 | 1989 | Aleutian Islands | NMFS[1] |
| Pacific cod | 25* | >1,000 | 2000 | Kachemak Bay | ADF&G[2] |
| Walleye pollock | 28 | >10,000 | unknown | Bering Sea | McFarlane and Beamish 1990 |
| Kelp greenling | 18*† | 10 | 2000 | Northern SE Alaska | ADF&G[2] |
| Lingcod | 25* | >10,000 | 1995 | Northern SE Alaska | ADF&G[2] |
| Atka mackerel | 15* | >5,000 | 2000 | Aleutian Islands | NMFS[1] |
| 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[3] |
| Rex sole | 27* | >200 | 1996 | Gulf of Alaska | NMFS[1] |
| Flathead sole | 27* | >1,000 | 1998 | Bering Sea | NMFS[1] |
| Pacific halibut | 55 | >10,000 | 1992 | Bering Sea | IPHC 1998 |
| Dover sole | 53*† | >1,000 | 1990 | Gulf of Alaska | NMFS[1] |
| Yellowfin sole | 34* | >200 | 1999 | Bering Sea | NMFS[1] |
| Rock sole | 26* | >200 | 1998 | Bering Sea | NMFS[1] |
| Alaska plaice | 31* | >500 | 1998 | Bering Sea | NMFS[1] |
| English sole | 22 | >1,000 | 1959 | British Columbia | Chilton and Beamish 1982 |
| Rougheye rockfish | 205* | >10,000 | 2000 | Southern SE Alaska | ADF&G[2] |
| Pacific ocean perch | 98 | >10,000 | 1990s | Aleutian Islands | Heifetz et al. 2000 |
| Redbanded rockfish | 106* | >1,000 | 1985 | Southern SE Alaska | ADF&G[2] |
| Shortraker rockfish | 157* | >10,000 | 2000 | Northern SE Alaska | ADF&G[2] |
| Silvergray rockfish | 81* | >10,000 | 1981 | British Columbia | CDFO[3] |
| 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[4] |
| Widow rockfish | 60* | >3,000 | 1996 | British Columbia | CDFO[3] |
| Yellowtail rockfish | 64 | >10,000 | unknown | British Columbia | Chilton and Beamish 1982 |
| Rosethorn rockfish | 87* | >100 | 1985 | Southeastern Alaska | ADF&G[2] |
| Quillback rockfish | 90* | >10,000 | 1997 | Southern SE Alaska | ADF&G[2] |
| Black rockfish | 50 | >10,000 | 1993 | Kodiak | Meyer 2000 |
| Blackgill rockfish | 87*† | >1,000 | 1985 | West Coast south of 48°N | NMFS[5] |
| Vermilion rockfish | 60*† | 1 | 1996 | West Coast south of 48°N | CDFO[3] |
| Blue rockfish | 30*† | >200 | 1993 | West Coast south of 48°N | ODFW[6] |
| China rockfish | 78* | >1,000 | 1992 | Southern SE Alaska | ADF&G[2] |
| Tiger rockfish | 116* | >1,000 | 1992 | Southern SE Alaska | ADF&G[2] |
| Bocaccio | 46*† | >100 | 1994 | Gulf of Alaska | Meyer 2000 |
| Canary rockfish | 84* | >5,000 | 1980 | British Columbia | CDFO[3] |
| Northern rockfish | 57 | >1,000 | 1986 | Aleutian Islands | Heifetz and Clausen 1991 |
| Redstripe rockfish | 55* | >2,000 | 1999 | British Columbia | CDFO[3] |
| Yellowmouth rockfish | 99* | >4,000 | 1992 | British Columbia | CDFO[3] |
| Yelloweye rockfish | 118* | >10,000 | 1991 | Southern SE Alaska | ADF&G[2] |
| Harlequin rockfish | 43† | >300 | 1980 | British Columbia | Chilton and Beamish 1982 |
| Pygmy rockfish | 26*† | >100 | 1991 | British Columbia | CDFO[6] |
| 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 |

[1] Delsa Anderl, National Marine Fisheries Service (NMFS), Seattle, personal communication.
[2] Alaska Department of Fish and Game (ADF&G) Age Determination Unit, Juneau.
[3] Shayne MacLellan, Canadian Department of Fisheries and Oceans (CDFO), Pacific Biological Station, Nanaimo, personal communication.
[4] Mike Vaughn, ADF&G, Sitka, personal communication.
[5] John Butler, NMFS, La Jolla, personal communication.
[6] 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

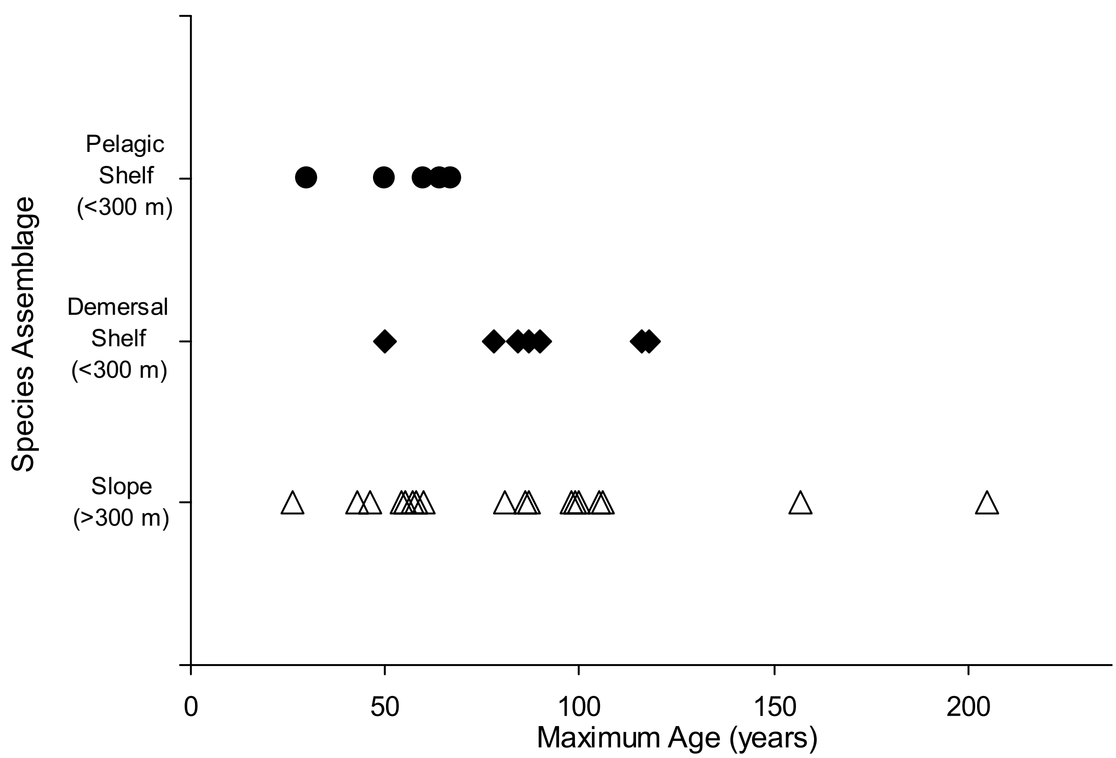


Figure 1. Maximum ages of Scorpaenidae species, grouped by species assemblages. All maximum ages are used, including those from West Coast stocks.

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

[1] John Butler, NMFS Southwest Fisheries Science Center, LaJolla, personal communication.
[2] Bob Mikus, Oregon Department of Fish and Wildlife (ODFW), Newport, personal communication.
[3] Shayne MacLellan, Canadian Department of Fisheries and Oceans (CDFO), Pacific Biological Station, Nanaimo, personal communication.

Table 4. Rockfish assemblage classifications.

| "Shelf-pelagic" / "Shelf-demersal" rockfish assemblages | "Slope" rockfish assemblage |
|---|---|
| **"Shelf-pelagic" rockfish assemblage** | **"Slope" rockfish assemblage** |
| Black rockfish | Blackgill rockfish |
| Blue rockfish | Bocaccio |
| Dusky rockfish | Darkblotched rockfish |
| Widow rockfish | Greenstriped rockfish |
| Yellowtail rockfish | Harlequin rockfish |
| | Northern rockfish |
| **"Shelf-demersal" rockfish assemblage** | 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 |

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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# Postnote

01 Jun 11 — The maximum age for rougheye rockfish listed in Table 2 was incorrectly reported in the intial 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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