Relationship between Fish Size and Otolith Length for 63 Species of Fishes from the Eastern North Pacific Ocean

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National Marine Mammal Laboratory
Alaska Fisheries Science Center
National Marine Fisheries Service, NOAA
7600 Sand Point Way N.E.
Seattle, Washington 98115-0070

ABSTRACT

Otoliths commonly are used to determine the taxon, age, and size of fishes. This information is useful for population management, predator-prey studies, and archaeological research. The relationship between the length of a fish and the length of its otoliths remains unknown for many species of marine fishes in the Pacific Ocean. Therefore, the relationships between fish length and fish weight, and between otolith length and fish length, were developed for 63 species of fishes caught in the eastern North Pacific Ocean. We also summarized similar relationships for 46 eastern North Pacific fish species reported in the literature. The relationship between fish length and otolith length was linear, and most of the variability was explained by a simple least-squares regression ($r^2 > 0.700$ for 45 of 63 species). The relationship between otolith length and fish length was not significantly different between left and right otoliths for all but one fish species. Images of otoliths from 77 taxa are included to assist in the identification of species.

Introduction

All bony fishes (Osteichthyes) have three pairs of otoliths (earbones or earstones): the sagittae, asteriscus, and lapillus. These otoliths are composed of calcium carbonate in the form of aragonite, in a protein matrix. They are contained within membranous labyrinths in paired otic capsules on either side of the skull. The sagittae are the largest pair of otoliths in most bony fishes; however, in minnows (Cypriniformes) and catfish (Siluriformes) the asterici are the largest (Hecht, 1977). Fisheries biologists have used sagittae to determine age and growth of fishes because of the large size and distinct growth rings of sagittae (Chilton and Beamish, 1982; Boehlert, 1985; Summerfelt and Hall, 1987).

Because otoliths are dense they can withstand some degree of dissolution, and often species can be recognized by the distinctive morphology of the sagittae (Morrow, 1979; Smale et al., 1995). Paleontologists have identified otoliths in middens (Fitch, 1969), oceanographers have determined species of fishes from otoliths in sediments (Fitch, 1964, 1968), and prey have been identified using otoliths collected from stomachs of piscivorous fishes (Trippel and Beamish, 1987), marine birds (Ainley et al., 1981), and marine mammals (Fitch and Brownell, 1968; Treacy and Crawford, 1981). Fishes eaten by pinnipeds also were identified using otoliths found in feces (Bailey and Ainley, 1982; Brown and Mate, 1983; Antonelis et al., 1984; Harvey, 1987).

Trout (1954) and Templemann and Squires (1956) were among the first to demonstrate a significant positive relationship between otolith size and fish size of Barents Sea cod (Boreogadus saida) and haddock (Melanogrammus aeglefinus). Otolith length also has been correlated with fish weight (Casteel, 1976). Since these early studies, relationships between otolith length and fish length have been determined for some species, including North Pacific gadids (Frost and Lowry, 1981), rockfishes (Sebastes spp.; Wylie Echeverria, 1987), and several fishes off Baja California, Mexico (Gamboa, 1991).

For most species, the relationship between otolith length and fish length can be described by a simple linear regression. For North Pacific gadids, this relation-
ship has been best described by two linear regressions with an inflection point (Frost and Lowry, 1981). Left and right sagittae also may differ in size within a rockfish species (Wyllie Echeverria, 1987), and sometimes otolith size is different among stocks of fishes, such as Atlantic herring (Clupea harengus; Messieh, 1972).

The objective of this study was to compile information regarding the relationship between otolith length and fish length for fish species of the eastern North Pacific Ocean using original collections and published and unpublished literature. These data may be used by researchers studying archaeology and food habits of piscivores to determine the size of fishes from the length of recovered otoliths. We also wanted to provide images of most fish otoliths, for which we had regressions, to be used as an aid for identifying species of fish.

Methods

Fishes were collected throughout the eastern North Pacific Ocean (e.g., Bering Sea, Gulf of Alaska, and off Washington, Oregon, and California) using bottom and midwater trawls, beach seines, gill nets, and hook-and-line gear. Fish were weighed to the nearest 0.1 g on a Mettler balance (<600 g) and spring or pan scale (>600 g). Standard length (SL; most anterior point to the base of hypural plate at caudal fin flexion) or fork length (FL; most anterior point to the base of the fork in the caudal fin) was measured to the nearest millimeter.

Sagittae were removed, cleaned, and stored dry in vials. Lengths of sagittae were determined using handheld vernier calipers under a dissecting microscope. Sagittal otolith length was recorded as the greatest distance measured from the anterior rostrum to the posterior edge, parallel to the sulcus.

The relationship between otolith length and fish length (SL or FL) was determined using a least-squares linear regression. The appropriateness of the linear model was determined by plotting the residuals against the independent variable. Differences between regression coefficients for the relationship of fish length and the lengths of left and right otoliths were tested using t tests. When the equations for left and right otoliths did not differ statistically, one right or left otolith was selected randomly from each individual and a single linear regression reported for each fish species. The significance of the linear regression was tested using an analysis of variance (ANOVA). Relationships between otolith length and fish length for additional species were obtained from published and unpublished sources. Relationships between fish length and fish weight were determined using a least-squares regression of the log of fish weight and length (Ricker, 1975). Although transformation back to arithmetic units may result in underestimating weight, these errors are usually small (Saila et al., 1988).

Results

Forty-six relationships between fish and otolith size previously reported in the literature involved various measures of fish length—fork length, total length (defined as the distance from the most anterior point to the most posterior point), and standard length measured in millimeters or centimeters—and otolith length (Table 1). Many of the published regressions of fish length to otolith length were developed for species common in food habit studies of marine mammals (Frost and Lowry, 1981; Brown and Mate, 1983) or species that were commercially important (Spratt, 1975; Boehlert and Yoklavich, 1984; Wyllie Echeverria, 1987).

Sixty-three species of fishes were collected in connection with the current study (Table 2). Most relationships between weight and length were described by a traditional allometric equation, where weight of a fish is approximately equal to length to the third power (Table 2). Linearized forms of this power relationship explained >90% of the variability in 43 of 60 cases. For three species, no weight data were collected. For 17 additional species, the sample size was less than 20; therefore, these weight/length relationships should be used with caution.

Generally the relationship between fish length and otolith length was linear, and most of the variability was explained by the regression (r^2>0.700 in 45 of 63 cases; Table 2). All relationships except one were significant (P<0.05). There was no significant relationship between otolith length and fish length for Trachurus symmetricus (Table 2). Regression coefficients of otolith length to fish length were not significantly different for left and right otoliths, except for the wattled eelpout (Lycopectes palaearis; P<0.05), however, the analysis was probably influenced by the small sample size (n=12). Size of fish should not be predicted from otolith size or fish weight for measurements outside the range used for the regressions.

To assist in the identification of recovered otoliths, we provide images of fish otoliths (Fig. 1) for most species sampled. These otoliths are listed according to taxonomic relationships (Robins et al., 1991). We chose otoliths that were representative of the species, and presented multiple images of otoliths from species where the otolith morphology changed with size.

Discussion

Otoliths have been used to identify fish species eaten by marine predators (Fitch and Brownell, 1968; Pitcher, 1980;
Table 1
Published relationships of fish otolith length (or mass) and fish length (or mass) for fishes in the eastern North Pacific. NA indicates data not available, and the codes for the variables (x and y) are defined at the bottom of the table.

<table>
<thead>
<tr>
<th>Species</th>
<th>Regression</th>
<th>Variables</th>
<th>$r^2$</th>
<th>n</th>
<th>Location</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boreogadus saida (Arctic cod)</td>
<td>$y = 2.20x + 1.59$</td>
<td></td>
<td>0.98</td>
<td>202</td>
<td>Beaufort &amp; Chukchi Seas</td>
<td>Frost and Lowry (1981)</td>
</tr>
<tr>
<td>Citharichthys sordidus (Pacific sanddab)</td>
<td>$y = 0.02x + 1.92$</td>
<td>a</td>
<td>0.93</td>
<td>46</td>
<td>Oregon</td>
<td>Brown and Mate (1983)</td>
</tr>
<tr>
<td>Eleginus gracilis (saffron cod)</td>
<td>$y = 2.32x - 4.84$</td>
<td>b, c</td>
<td>0.96</td>
<td>110</td>
<td>Bering &amp; Chukchi Seas</td>
<td>Frost and Lowry (1981)</td>
</tr>
<tr>
<td></td>
<td>$y = 1.74x - 0.99$</td>
<td></td>
<td>0.99</td>
<td>36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engraulis mordax (northern anchovy)</td>
<td>$y = 0.02x + 1.02$</td>
<td>a</td>
<td>0.98</td>
<td>78</td>
<td>Oregon</td>
<td>Brown and Mate (1983)</td>
</tr>
<tr>
<td>Engraulis mordax (northern anchovy)</td>
<td>$ln(y) = 1.31 ln(x) - 1.32$</td>
<td></td>
<td></td>
<td></td>
<td>North Pacific</td>
<td>Southward (1962)</td>
</tr>
<tr>
<td>Engraulis mordax (northern anchovy)</td>
<td>$ln(y) = 1.97 ln(x) + 6.00$</td>
<td></td>
<td></td>
<td></td>
<td>North Pacific</td>
<td>Southward and Chapman (1965)</td>
</tr>
<tr>
<td>Errex zachirus (rex sole)</td>
<td>$y = 0.02x + 1.02$</td>
<td>a</td>
<td>0.98</td>
<td>78</td>
<td>Oregon</td>
<td>Brown and Mate (1983)</td>
</tr>
<tr>
<td>Hippoglossus stenolepis (Pacific halibut)</td>
<td>$y = 0.02x + 1.92$</td>
<td>a</td>
<td>0.98</td>
<td>78</td>
<td>Oregon</td>
<td>Brown &amp; Mate (1983)</td>
</tr>
<tr>
<td>Hippoglossus stenolepis (Pacific halibut)</td>
<td>$ln(y) = 1.31 ln(x) - 1.32$</td>
<td></td>
<td></td>
<td></td>
<td>North Pacific</td>
<td>Southward (1962)</td>
</tr>
<tr>
<td>Hippoglossus stenolepis (Pacific halibut)</td>
<td>$ln(y) = 1.97 ln(x) + 6.00$</td>
<td></td>
<td></td>
<td></td>
<td>North Pacific</td>
<td>Southward and Chapman (1965)</td>
</tr>
<tr>
<td>Leptocottus armatus (staghorn sculpin)</td>
<td>$y = 0.03x + 1.31$</td>
<td>a</td>
<td>0.98</td>
<td>14</td>
<td>Oregon</td>
<td>Brown and Mate (1983)</td>
</tr>
<tr>
<td>Lyophis euxis (slender sole)</td>
<td>$y = 0.02x + 0.30$</td>
<td>a</td>
<td>0.98</td>
<td>45</td>
<td>Oregon</td>
<td>Brown and Mate (1983)</td>
</tr>
<tr>
<td>Microstomus pacificus (dover sole)</td>
<td>$y = 0.02x + 0.62$</td>
<td>a</td>
<td>0.97</td>
<td>45</td>
<td>Oregon</td>
<td>Brown and Mate (1983)</td>
</tr>
<tr>
<td>Oncorhynchus keta (chum salmon)</td>
<td>$log_{10}y = 1.23 + 3.21 log_{10}x$</td>
<td></td>
<td></td>
<td></td>
<td>North Pacific</td>
<td>Casteel (1974)</td>
</tr>
<tr>
<td>Oncorhynchus kisutch (coho salmon)</td>
<td>$log_{10}y = 0.89 + 5.93 log_{10}x$</td>
<td></td>
<td></td>
<td></td>
<td>North Pacific</td>
<td>Casteel (1974)</td>
</tr>
<tr>
<td>Oncorhynchus mykiss (rainbow trout)</td>
<td>$y = 0.06x + 2.16$</td>
<td>a</td>
<td>0.97</td>
<td>128</td>
<td>Oregon, California, Washington, Oregon</td>
<td>McKern et al. (1974)</td>
</tr>
<tr>
<td>Oncorhynchus nerka (sockeye salmon)</td>
<td>$log_{10}y = 0.29 + 4.13 log_{10}x$</td>
<td></td>
<td></td>
<td></td>
<td>North Pacific</td>
<td>Casteel (1974)</td>
</tr>
<tr>
<td>Oncorhynchus tshawytscha (chinook salmon)</td>
<td>$log_{10}y = 0.59 + 4.15 log_{10}x$</td>
<td></td>
<td></td>
<td></td>
<td>North Pacific</td>
<td>Casteel (1974)</td>
</tr>
<tr>
<td>Pleuronectes sexilis (English sole)</td>
<td>$y = 0.05x + 0.53$</td>
<td>a</td>
<td>0.99</td>
<td>81</td>
<td>Oregon</td>
<td>Brown and Mate (1983)</td>
</tr>
<tr>
<td>Sebastes auriculatus (brown rockfish)</td>
<td>$y = 3.31x - 53.03$</td>
<td></td>
<td>0.94</td>
<td>78</td>
<td>California</td>
<td>Wyllie Echeverria (1987)</td>
</tr>
<tr>
<td>Sebastes aurora (aurora rockfish)</td>
<td>$y = 19.91x + 15.12$</td>
<td></td>
<td>0.97</td>
<td>71</td>
<td>California</td>
<td>Wyllie Echeverria (1987)</td>
</tr>
<tr>
<td>Sebastes carnatus (gopher rockfish)</td>
<td>$y = 30.57x - 39.37$</td>
<td></td>
<td>0.97</td>
<td>203</td>
<td>California</td>
<td>Wyllie Echeverria (1987)</td>
</tr>
<tr>
<td>Sebastes chrysomelas (black-and-yellow rockfish)</td>
<td>$y = 28.61x - 21.98$</td>
<td></td>
<td>0.97</td>
<td>166</td>
<td>California</td>
<td>Wyllie Echeverria (1987)</td>
</tr>
<tr>
<td>Sebastes constellatus (starry rockfish)</td>
<td>$y = 25.27x - 37.48$</td>
<td></td>
<td>0.97</td>
<td>59</td>
<td>California</td>
<td>Wyllie Echeverria (1987)</td>
</tr>
<tr>
<td>Sebastes crameri (darkblotched rockfish)</td>
<td>$y = 28.10x - 27.10$</td>
<td></td>
<td>0.97</td>
<td>89</td>
<td>California</td>
<td>Wyllie Echeverria (1987)</td>
</tr>
<tr>
<td>Sebastes diploproa (splitnose rockfish)</td>
<td>$y = 22.64x - 12.85$</td>
<td></td>
<td>0.97</td>
<td>78</td>
<td>California</td>
<td>Wyllie Echeverria (1987)</td>
</tr>
<tr>
<td>Sebastes elongatus (greenstriped rockfish)</td>
<td>$y = 24.02x - 13.56$</td>
<td></td>
<td>0.97</td>
<td>98</td>
<td>California</td>
<td>Wyllie Echeverria (1987)</td>
</tr>
<tr>
<td>Sebastes entomelas (widow rockfish)</td>
<td>$y = 33.16x - 53.03$</td>
<td></td>
<td>0.94</td>
<td>78</td>
<td>California</td>
<td>Wyllie Echeverria (1987)</td>
</tr>
<tr>
<td>Sebastes flavidus (yellowtail rockfish)</td>
<td>$y = 25.27x - 37.48$</td>
<td></td>
<td>0.97</td>
<td>71</td>
<td>California</td>
<td>Wyllie Echeverria (1987)</td>
</tr>
<tr>
<td>Sebastes goodei (chilipepper)</td>
<td>$y = 28.61x - 21.98$</td>
<td></td>
<td>0.97</td>
<td>166</td>
<td>California</td>
<td>Wyllie Echeverria (1987)</td>
</tr>
<tr>
<td>Sebastes hopkinsi (squarespot rockfish)</td>
<td>$y = 28.10x - 27.10$</td>
<td></td>
<td>0.97</td>
<td>89</td>
<td>California</td>
<td>Wyllie Echeverria (1987)</td>
</tr>
<tr>
<td>Sebastes jordani (shortbelly rockfish)</td>
<td>$y = 22.0x - 2.31$</td>
<td>g</td>
<td>0.97</td>
<td>183</td>
<td>California</td>
<td>Wyllie Echeverria (1987)</td>
</tr>
</tbody>
</table>

Continued
Table 1 (continued)

<table>
<thead>
<tr>
<th>Species</th>
<th>Regression</th>
<th>Variables</th>
<th>$r^2$</th>
<th>$n$</th>
<th>Location</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Sebastes levis</em> (cowcod)</td>
<td>$y = 47.46x - 170.11$</td>
<td>$g$</td>
<td>0.95</td>
<td>29</td>
<td>California</td>
<td>Willie Echeverría (1987)</td>
</tr>
<tr>
<td><em>Sebastes maliger</em> (quillback rockfish)</td>
<td>$y = 29.97x - 53.11$</td>
<td>$g$</td>
<td>0.86</td>
<td>34</td>
<td>California</td>
<td>Willie Echeverría (1987)</td>
</tr>
<tr>
<td><em>Sebastes melanops</em> (black rockfish)</td>
<td>$y = 30.56x - 48.22$</td>
<td>$g$</td>
<td>0.86</td>
<td>209</td>
<td>California</td>
<td>Willie Echeverría (1987)</td>
</tr>
<tr>
<td><em>Sebastes melanostomus</em> (blackgill rockfish)</td>
<td>$y = 30.56x - 47.07$</td>
<td>$g$</td>
<td>0.86</td>
<td>80</td>
<td>California</td>
<td>Willie Echeverría (1987)</td>
</tr>
<tr>
<td><em>Sebastes miniatus</em> (vermillion rockfish)</td>
<td>$y = 29.36x - 56.74$</td>
<td>$g$</td>
<td>0.93</td>
<td>99</td>
<td>California</td>
<td>Willie Echeverría (1987)</td>
</tr>
<tr>
<td><em>Sebastes mystinus</em> (blue rockfish)</td>
<td>$y = 29.77x - 18.18$</td>
<td>$g$</td>
<td>0.83</td>
<td>204</td>
<td>California</td>
<td>Willie Echeverría (1987)</td>
</tr>
<tr>
<td><em>Sebastes nebulosus</em> (China rockfish)</td>
<td>$y = 25.18x + 32.97$</td>
<td>$g$</td>
<td>0.79</td>
<td>48</td>
<td>California</td>
<td>Willie Echeverría (1987)</td>
</tr>
<tr>
<td><em>Sebastes ovalis</em> (speckled rockfish)</td>
<td>$y = 33.56x - 53.47$</td>
<td>$g$</td>
<td>0.91</td>
<td>84</td>
<td>California</td>
<td>Willie Echeverría (1987)</td>
</tr>
<tr>
<td><em>Sebastes paucispinis</em> (bocaccio)</td>
<td>$y = 41.09x - 77.09$</td>
<td>$g$</td>
<td>0.82</td>
<td>86</td>
<td>California</td>
<td>Willie Echeverría (1987)</td>
</tr>
<tr>
<td><em>Sebastes piniger</em> (canary rockfish)</td>
<td>$y = 29.41x - 85.11$</td>
<td>$g$</td>
<td>0.92</td>
<td>173</td>
<td>California</td>
<td>Willie Echeverría (1987)</td>
</tr>
<tr>
<td><em>Sebastes rasaurus</em> (rosy rockfish)</td>
<td>$y = 22.53x - 83.48$</td>
<td>$g$</td>
<td>0.81</td>
<td>147</td>
<td>California</td>
<td>Willie Echeverría (1987)</td>
</tr>
<tr>
<td><em>Sebastes ruberrimus</em> (yelloweye rockfish)</td>
<td>$y = 31.33x - 76.23$</td>
<td>$g$</td>
<td>0.92</td>
<td>102</td>
<td>California</td>
<td>Willie Echeverría (1987)</td>
</tr>
<tr>
<td><em>Sebastes saxicola</em> (stripetail rockfish)</td>
<td>$y = 23.40x - 32.77$</td>
<td>$g$</td>
<td>0.95</td>
<td>102</td>
<td>California</td>
<td>Willie Echeverría (1987)</td>
</tr>
<tr>
<td><em>Sebastes semicinctus</em> (halfbanded rockfish)</td>
<td>$y = 25.27x - 19.18$</td>
<td>$g$</td>
<td>0.85</td>
<td>31</td>
<td>California</td>
<td>Willie Echeverría (1987)</td>
</tr>
<tr>
<td><em>Sebastes serranoides</em> (olive rockfish)</td>
<td>$y = 29.35x - 51.01$</td>
<td>$g$</td>
<td>0.93</td>
<td>130</td>
<td>California</td>
<td>Willie Echeverría (1987)</td>
</tr>
<tr>
<td><em>Theragra chalcogramma</em> (walleye pollock)</td>
<td>$y = 3.18x - 9.77$</td>
<td>$b, h$</td>
<td>0.97</td>
<td>98</td>
<td>Bering Sea</td>
<td>Frost and Lowry (1981)</td>
</tr>
<tr>
<td></td>
<td>$y = 2.25x - 0.51$</td>
<td>$b, i$</td>
<td>0.98</td>
<td>158</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a* x = fish standard length (mm), *y* = otolith length (mm)
*b* x = otolith length (mm), fish fork length (cm)
*c* otolith length > 8.5 mm
*d* otolith length < 8.5 mm
*e* x = otolith length (mm), fish standard length (mm)
*f* x = otolith length (mm), x = fish weight (g)
*g* x = otolith length (mm), x = fish total length (mm)
*h* otolith length > 10.0 mm
*i* otolith length < 10.0 mm
### Table 2

Relationships of fish weight (WT) in grams to fish standard length (SL) in centimeters, and standard length to length of otolith (OL) in millimeters. For each equation, the number of fish or otoliths measured (N), coefficient of determination ($r^2$), standard error of the regression coefficient (SE), and range of fish lengths is given. Species and common names from Robins et al. (1991).

<table>
<thead>
<tr>
<th>Species (common name)</th>
<th>Location</th>
<th>Fish weight/fish length</th>
<th>Equation</th>
<th>N</th>
<th>$r^2$</th>
<th>Fish length/otolith length</th>
<th>Equation</th>
<th>N</th>
<th>$r^2$</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Allosmerus elongatus</em> (whitebait smelt)</td>
<td>OR</td>
<td>WT = 0.0063 SL$^3$$^{2.23}$</td>
<td>25</td>
<td>0.893</td>
<td>SL = 2.11 (OL) + 3.02</td>
<td>23</td>
<td>0.838</td>
<td>7.9–9.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Alosa sapidissima</em> (American shad)</td>
<td>OR</td>
<td>WT = 0.0135 SL$^3$$^{3.46}$</td>
<td>7</td>
<td>0.997</td>
<td>SL = 11.46 (OL) – 11.08</td>
<td>14</td>
<td>0.960</td>
<td>8.1–37.1</td>
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<tr>
<td><em>Ammodites hecatopus</em> (Pacific sand lance)</td>
<td>CA</td>
<td>WT = 0.0063 SL$^2$</td>
<td>10</td>
<td>0.915</td>
<td>SL = 4.06 (OL) + 2.01</td>
<td>10</td>
<td>0.433</td>
<td>9.5–13.6</td>
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<tr>
<td><em>Anoplopoma fimbria</em> (sablefish)</td>
<td>OR</td>
<td>WT = 0.0163 SL$^2$</td>
<td>74</td>
<td>0.995</td>
<td>SL = 5.28 (OL) + 1.62</td>
<td>94</td>
<td>0.955</td>
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<tr>
<td><em>Atheresthes stomias</em> (arrowtooth flounder)</td>
<td>OR</td>
<td>WT = 0.0093 FL$^2$</td>
<td>101</td>
<td>0.961</td>
<td>FL = 4.75 (OL) – 2.96</td>
<td>84</td>
<td>0.925</td>
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<tr>
<td><em>Atherinops affinis</em> (topsmelt)</td>
<td>CA</td>
<td>WT = 0.1698 SL$^1$</td>
<td>14</td>
<td>0.429</td>
<td>SL = 3.72 (OL) + 0.55</td>
<td>18</td>
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<td><em>Atherinopsis californiensis</em> (jacksmelt)</td>
<td>CA</td>
<td>WT = 0.0217 SL$^2$</td>
<td>11</td>
<td>0.960</td>
<td>SL = 3.37 (OL) – 4.52</td>
<td>11</td>
<td>0.857</td>
<td>5.5–11.8</td>
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<td><em>Bathymaster signatus</em> (searcher)</td>
<td>CA</td>
<td>WT = 0.0049 SL$^2$</td>
<td>12</td>
<td>0.968</td>
<td>SL = 3.48 (OL) + 1.90</td>
<td>43</td>
<td>0.883</td>
<td>11.8–31.5</td>
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<tr>
<td><em>Bathygaster signatus</em> (shiner perch)</td>
<td>WA</td>
<td>WT = 0.0058 SL$^3$</td>
<td>44</td>
<td>0.991</td>
<td>SL = 2.51 (OL) + 2.15</td>
<td>29</td>
<td>0.730</td>
<td>11.4–25.2</td>
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<tr>
<td><em>Chitonotus pugetensis</em> (roughback sculpin)</td>
<td>WA</td>
<td>WT = 0.0917 SL$^2$</td>
<td>11</td>
<td>0.960</td>
<td>SL = 3.37 (OL) + 1.62</td>
<td>94</td>
<td>0.955</td>
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<tr>
<td><em>Citharichthys sordidus</em> (Pacific sanddab)</td>
<td>WA, OR</td>
<td>WT = 0.0322 SL$^3$</td>
<td>60</td>
<td>0.851</td>
<td>SL = 2.87 (OL) + 3.29</td>
<td>61</td>
<td>0.727</td>
<td>3.3–25.5</td>
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<tr>
<td><em>Clupea pallasi</em> (Pacific herring)</td>
<td>WA, OR</td>
<td>WT = 0.0044 SL$^3$</td>
<td>83</td>
<td>0.976</td>
<td>SL = 5.24 (OL) – 1.85</td>
<td>82</td>
<td>0.934</td>
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<tr>
<td><em>Coryphaenoides acrolepis</em> (Pacific rattail)</td>
<td>OR</td>
<td>WT = 0.0016 SL$^3$</td>
<td>10</td>
<td>0.921</td>
<td>SL = 3.44 (OL) – 3.25</td>
<td>10</td>
<td>0.926</td>
<td>19.0–36.0</td>
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<tr>
<td><em>Cymatogaster aggregata</em> (spotted cusk-eel)</td>
<td>OR, CA</td>
<td>WT = 0.0100 SL$^3$</td>
<td>85</td>
<td>0.979</td>
<td>SL = 1.74 (OL) – 0.52</td>
<td>90</td>
<td>0.925</td>
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<td><em>Dasyopterus setiger</em> (spinyhead sculpin)</td>
<td>GA</td>
<td>No data available</td>
<td>FL = 3.11 (OL) – 7.03</td>
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<td><em>Eleginus gracilis</em> (saffron cod)</td>
<td>GA</td>
<td>WT = 0.0059 SL$^3$</td>
<td>13</td>
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<td>SL = 1.89 (OL) – 2.76</td>
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<td>0.960</td>
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<tr>
<td><em>Embiotoca jacksoni</em> (black perch)</td>
<td>CA</td>
<td>WT = 0.0282 SL$^3$</td>
<td>19</td>
<td>0.992</td>
<td>SL = 2.45 (OL) – 2.61</td>
<td>52</td>
<td>0.947</td>
<td>5.2–18.4</td>
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<tr>
<td><em>Embiotoca lateralis</em> (striped seaperch)</td>
<td>OR, CA</td>
<td>WT = 0.0329 SL$^3$</td>
<td>25</td>
<td>0.998</td>
<td>SL = 2.90 (OL) – 5.68</td>
<td>25</td>
<td>0.990</td>
<td>6.6–26.4</td>
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<tr>
<td><em>Engraulis mordax</em> (northern anchovy)</td>
<td>CA</td>
<td>WT = 0.0485 SL$^3$</td>
<td>34</td>
<td>0.807</td>
<td>SL = 2.28 (OL) + 0.85</td>
<td>56</td>
<td>0.694</td>
<td>3.6–14.4</td>
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<tr>
<td><em>Eospilus exilis</em> (slender sole)</td>
<td>GA</td>
<td>WT = 0.0058 SL$^2$</td>
<td>50</td>
<td>0.974</td>
<td>SL = 3.37 (OL) + 1.08</td>
<td>50</td>
<td>0.771</td>
<td>8.0–29.5</td>
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Table 2 (continued)

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<tr>
<td><em>Eopsetta jordani</em> (petrale sole)</td>
<td>OR, CA</td>
<td>$WT = 0.0086 \text{SL}^{3.23}$</td>
<td>17</td>
<td>0.986</td>
<td>$SL = 4.85 \text{(OL)} - 4.81$</td>
<td>20</td>
<td>0.857</td>
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<td><em>Eriphias zachirus</em> (rex sole)</td>
<td>WA, OR</td>
<td>$WT = 0.0238 \text{SL}^{2.69}$</td>
<td>67</td>
<td>0.932</td>
<td>$SL = 4.80 \text{(OL)} - 2.50$</td>
<td>70</td>
<td>0.869</td>
<td>12.0–29.7</td>
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<td><em>Gadus macrocephalus</em> (Pacific cod)</td>
<td>BS</td>
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<td>$FL = 4.51 \text{(OL)} - 22.97$</td>
<td>110</td>
<td>0.883</td>
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<tr>
<td><em>Genyonemus lineatus</em> (white croaker)</td>
<td>CA</td>
<td>$WT = 0.0530 \text{SL}^{2.70}$</td>
<td>40</td>
<td>0.767</td>
<td>$SL = 1.52 \text{(OL)} + 4.66$</td>
<td>48</td>
<td>0.534</td>
<td>9.1–28.0</td>
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<tr>
<td><em>Gymnothorax galenius</em> (armorhead sculpin)</td>
<td>BS</td>
<td>$WT = 0.0100 \text{SL}^{3.19}$</td>
<td>29</td>
<td>0.939</td>
<td>$SL = 1.75 \text{(OL)} + 0.82$</td>
<td>28</td>
<td>0.476</td>
<td>7.3–15.0</td>
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<tr>
<td><em>Hippoglossa claussoni</em> (flathead sole)</td>
<td>WA</td>
<td>$WT = 0.0078 \text{FL}^{3.54}$</td>
<td>99</td>
<td>0.984</td>
<td>$SL = 2.57 \text{(OL)} - 2.83$</td>
<td>24</td>
<td>0.987</td>
<td>5.6–20.7</td>
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<tr>
<td><em>Hypomesus pretiosus</em> (surf smelt)</td>
<td>OR</td>
<td>$WT = 0.0044 \text{SL}^{3.45}$</td>
<td>42</td>
<td>0.986</td>
<td>$SL = 3.61 \text{(OL)} - 0.63$</td>
<td>25</td>
<td>0.932</td>
<td>6.9–15.4</td>
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<tr>
<td><em>Hypopsammus guttatus</em> (diamond turbot)</td>
<td>CA</td>
<td>$WT = 0.0111 \text{SL}^{2.72}$</td>
<td>51</td>
<td>0.990</td>
<td>$SL = 2.58 \text{(OL)} - 2.26$</td>
<td>32</td>
<td>0.928</td>
<td>3.7–22.5</td>
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<tr>
<td><em>Leptocottus armatus</em> (Pacific staghorn sculpin)</td>
<td>WA, OR, CA</td>
<td>$WT = 0.0094 \text{SL}^{3.10}$</td>
<td>75</td>
<td>0.993</td>
<td>$SL = 2.94 \text{(OL)} + 0.96$</td>
<td>86</td>
<td>0.891</td>
<td>26.3–54.4</td>
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<tr>
<td><em>Lycodes breviceps</em> (shortfin eelpout)</td>
<td>BS</td>
<td>$WT = 0.0195 \text{FL}^{2.52}$</td>
<td>56</td>
<td>0.826</td>
<td>$FL = 3.47 \text{(OL)} + 4.83$</td>
<td>62</td>
<td>0.520</td>
<td>18.5–27.6</td>
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<tr>
<td><em>Lycodes crosii</em> (bigfin eelpout)</td>
<td>WA, CA</td>
<td>$WT = 0.0018 \text{FL}^{3.24}$</td>
<td>40</td>
<td>0.993</td>
<td>$SL = 10.96 \text{(OL)} - 21.82$</td>
<td>41</td>
<td>0.742</td>
<td>11.5–44.7</td>
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<tr>
<td><em>Lycodes philaeus</em> (wattled eelpout)</td>
<td>BS</td>
<td>$WT = 0.0007 \text{FL}^{3.48}$</td>
<td>25</td>
<td>0.913</td>
<td>$FL = 5.22 \text{(OL)} + 12.42$</td>
<td>24</td>
<td>0.283</td>
<td>32.0–47.0</td>
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<tr>
<td><em>Lycodias pacifica</em> (blackbelly eelpout)</td>
<td>GA</td>
<td>$WT = 0.0018 \text{SL}^{3.50}$</td>
<td>22</td>
<td>0.954</td>
<td>$SL = 3.82 \text{(OL)} + 4.69$</td>
<td>38</td>
<td>0.610</td>
<td>14.4–25.3</td>
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<tr>
<td><em>Mallotus villosus</em> (capelin)</td>
<td>BS</td>
<td>$WT = 0.0054 \text{SL}^{3.10}$</td>
<td>39</td>
<td>0.717</td>
<td>$SL = 3.45 \text{(OL)} + 3.62$</td>
<td>39</td>
<td>0.649</td>
<td>10.0–15.7</td>
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<tr>
<td><em>Merluccius productus</em> (Pacific hake)</td>
<td>OR</td>
<td>$WT = 0.0081 \text{SL}^{2.90}$</td>
<td>75</td>
<td>0.933</td>
<td>$SL = 2.04 \text{(OL)} + 0.96$</td>
<td>86</td>
<td>0.891</td>
<td>26.3–54.4</td>
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<tr>
<td><em>Micropogonias proximus</em> (Pacific tomcod)</td>
<td>WA, OR</td>
<td>$WT = 0.0064 \text{SL}^{3.19}$</td>
<td>80</td>
<td>0.988</td>
<td>$SL = 1.77 \text{(OL)} + 3.51$</td>
<td>106</td>
<td>0.932</td>
<td>6.1–28.3</td>
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<tr>
<td><em>Microstomus pacificus</em> (Dover sole)</td>
<td>OR</td>
<td>$WT = 0.0094 \text{SL}^{3.92}$</td>
<td>101</td>
<td>0.854</td>
<td>$SL = 3.72 \text{(OL)} + 6.97$</td>
<td>117</td>
<td>0.587</td>
<td>7.6–37.8</td>
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<tr>
<td><em>Oncorhynchus kisutch</em> (coho salmon)</td>
<td>OR</td>
<td>$WT = 0.0103 \text{SL}^{3.92}$</td>
<td>43</td>
<td>0.898</td>
<td>$SL = 16.31 \text{(OL)} - 40.74$</td>
<td>46</td>
<td>0.569</td>
<td>12.5–58.4</td>
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<td><em>Oncorhynchus mykiss</em> (rainbow trout)</td>
<td>OR</td>
<td>$WT = 0.0275 \text{SL}^{2.89}$</td>
<td>18</td>
<td>0.905</td>
<td>$SL = 16.28 \text{(OL)} - 38.14$</td>
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<td>0.790</td>
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<td><em>Ophiodon elongatus</em> (lingcod)</td>
<td>OR, CA</td>
<td>$WT = 0.0023 \text{SL}^{3.56}$</td>
<td>10</td>
<td>0.620</td>
<td>$SL = 8.23 \text{(OL)} - 8.20$</td>
<td>55</td>
<td>0.722</td>
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<td><em>Osmerus mordax</em> (rainbow smelt)</td>
<td>BS</td>
<td>$WT = 0.0038 \text{SL}^{3.78}$</td>
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<td>$SL = 2.69 \text{(OL)} + 0.32$</td>
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<tr>
<td>Phanerodon furcatus (white seaperch)</td>
<td>OR, CA</td>
<td>WT = 0.0213 SL^{3.086}</td>
<td>17</td>
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<td>SL = 2.33 (OL) − 2.15</td>
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<td>4.5−23.5</td>
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<tr>
<td>Platriothys stellatus (starry flounder)</td>
<td>OR, CA</td>
<td>WT = 0.0107 SL^{3.208}</td>
<td>25</td>
<td>0.985</td>
<td>SL = 3.35 (OL) + 0.23</td>
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<td>8.2−37.3</td>
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<tr>
<td>Pleuragrammus monopterygius (Atka mackerel)</td>
<td>BS</td>
<td>WT = 0.0054 FL^{3.401}</td>
<td>16</td>
<td>0.987</td>
<td>FL = 8.40 (OL) − 4.99</td>
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<td>19.0−35.0</td>
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<td>Pleuronectes asper (yellowfin sole)</td>
<td>BS</td>
<td>WT = 0.0024 SL^{3.605}</td>
<td>7</td>
<td>0.859</td>
<td>SL = 2.17 (OL) + 10.65</td>
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<td>Pleuronectes bilineatus (rock sole)</td>
<td>BS</td>
<td>WT = 0.0112 FL^{2.397}</td>
<td>83</td>
<td>0.931</td>
<td>FL = 6.16 (OL) − 6.97</td>
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<td>7.5−32.0</td>
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<td>Pleuronectes vetulus (English sole)</td>
<td>WA, OR, CA</td>
<td>WT = 0.0163 SL^{2.939}</td>
<td>98</td>
<td>0.995</td>
<td>SL = 3.82 (OL) − 2.76</td>
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<td>Podothecus acipenserinus (sturgeon poacher)</td>
<td>BS, WA, OR</td>
<td>WT = 0.0050 SL^{3.235}</td>
<td>93</td>
<td>0.956</td>
<td>SL = 6.58 (OL) − 6.21</td>
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<td>7.3−25.7</td>
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<td>Pomichthys notatus (plainfin midshipman)</td>
<td>WA, OR, CA</td>
<td>WT = 0.0207 SL^{2.936}</td>
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<td>Psettichthys melanostictus (sand sole)</td>
<td>WA, OR, CA</td>
<td>WT = 0.0052 SL^{3.441}</td>
<td>25</td>
<td>0.985</td>
<td>SL = 5.06 (OL) − 3.18</td>
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<td>Rhacochilus vacca (pile perch)</td>
<td>WA, OR</td>
<td>WT = 0.0182 SL^{3.218}</td>
<td>46</td>
<td>0.997</td>
<td>SL = 3.35 (OL) − 8.19</td>
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<td>Sebastes melanops (black rockfish)</td>
<td>OR</td>
<td>WT = 0.1225 SL^{2.499}</td>
<td>21</td>
<td>0.585</td>
<td>SL = 2.23 (OL) − 1.48</td>
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<td>Sebastes paucispinis (bocaccio)</td>
<td>OR</td>
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<td>SL = 2.41 (OL) + 0.14</td>
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<td>8.4−41.8</td>
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<tr>
<td>Sebastolobus alascanus (shortspine thornyhead)</td>
<td>OR</td>
<td>WT = 0.0102 SL^{3.230}</td>
<td>69</td>
<td>0.988</td>
<td>SL = 2.31 (OL) − 3.71</td>
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<tr>
<td>Sebastolobus altivelis (longspine thornyhead)</td>
<td>OR</td>
<td>WT = 0.0155 SL^{3.113}</td>
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<td>0.997</td>
<td>SL = 4.94 (OL) − 27.50</td>
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<td>Spirinchus thaleichthys (longfin smelt)</td>
<td>OR</td>
<td>WT = 0.0288 SL^{2.531}</td>
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<td>SL = 2.64 (OL) + 0.20</td>
<td></td>
<td></td>
<td></td>
<td>7.3−11.6</td>
</tr>
<tr>
<td>Symphurus atricauda (California tonguefish)</td>
<td>CA</td>
<td>WT = 0.0074 SL^{3.136}</td>
<td>32</td>
<td>0.789</td>
<td>SL = 3.56 (OL) + 4.64</td>
<td></td>
<td></td>
<td></td>
<td>6.5−15.2</td>
</tr>
<tr>
<td>Thaleichthys pacificus (eulachon)</td>
<td>OR</td>
<td>WT = 0.0077 SL^{3.075}</td>
<td>129</td>
<td>0.884</td>
<td>SL = 4.71 (OL) − 2.70</td>
<td></td>
<td></td>
<td></td>
<td>10.5−19.8</td>
</tr>
<tr>
<td>Theragra chalcogramma (valleye pollock)</td>
<td>WA</td>
<td>WT = 0.0043 SL^{3.255}</td>
<td>46</td>
<td>0.985</td>
<td>SL = 2.24 (OL) − 2.35</td>
<td></td>
<td></td>
<td></td>
<td>12.6−14.2</td>
</tr>
<tr>
<td>Trachurus symmetricus (jack mackerel)</td>
<td>OR, CA</td>
<td>WT = 0.0635 SL^{2.536}</td>
<td>18</td>
<td>0.761</td>
<td>Not significant</td>
<td></td>
<td></td>
<td></td>
<td>14.5−33.5</td>
</tr>
<tr>
<td>Trichodon trichodon (Pacific sandfish)</td>
<td>BS</td>
<td>WT = 0.0170 FL^{3.993}</td>
<td>19</td>
<td>0.971</td>
<td>FL = 0.06 (OL) − 4.57</td>
<td></td>
<td></td>
<td></td>
<td>15.0−25.0</td>
</tr>
<tr>
<td>Zalembius rosaceus (pink seaperch)</td>
<td>CA</td>
<td>WT = 0.0199 SL^{3.102}</td>
<td>48</td>
<td>0.841</td>
<td>SL = 1.88 (OL) − 0.97</td>
<td></td>
<td></td>
<td></td>
<td>7.0−12.8</td>
</tr>
</tbody>
</table>

1 Location of capture: BS = Bering Sea, CA = California, GA = Gulf of Alaska, OR = Oregon, WA = Washington.
Brown and Mate, 1983; Harvey, 1987). Specific guides or keys to fish otoliths also have been published (Morrow, 1979; Harkonen, 1986; Hecht, 1987; Smale et al., 1995).

Generally, standard length of fishes is linearly related to otolith length. Predicting size of fishes (length and weight) can be accomplished with fair reliability on the basis of otolith length. This relationship, however, is not always reliable. Otolith length typically is linearly related to length of the fish until the fish reaches maximum size; thereafter, the otolith increases only in thickness (Blacker, 1974; Williams and Bedford, 1974). Otolith lengths of larval and juvenile fishes may increase in a curvilinear fashion relative to fish length for some species, such as sockeye salmon (Oncorhynchus nerka; West and Larkin, 1987) and walleye pollock (Theragra chalcogramma; Nishimura and Yamada, 1988). The relationship between otolith length and fish length may be dependent on the growth rate of the fish, as was reported for striped bass (Morone saxatilis; Secor and Dean, 1989). Additionally, the relationship between otolith length and fish length may be described by multiple linear lines with inflection points (e.g. gadids; Frost and Lowry, 1981). Multiple linear relationships may result from different growth stanzas (Laidig et al., 1991). These results indicate that size of fish should only be estimated over the size distribution sampled, and that all length intervals should be sampled properly with the appropriate statistical model.

Estimating size of consumed fishes from measurements of otoliths recovered in stomachs or feces may be biased because of partial or complete digestion of otoliths (Jobling and Breiby, 1986; Jobling, 1987). For instance, size of fish eaten by the harbor seal (Phoca vitulina) may be underestimated by 16–44% (Harvey, 1989). Similar results have been reported for many pinnipeds (Hawes, 1983; da Silva and Neilson, 1985; Murie and Lavigne, 1986). Although a rough estimate of these errors may be obtained from controlled experiments, the amount of digestion may be species-specific, requiring numerous tests to document all forms of bias. There also may be differences between the sexes in the relationship between fish size and otolith size, something we did not test. Researchers using otoliths to determine number and size of fish eaten, therefore, should realize the limitations of this technique.

Fish size-otolith size relationships will be useful for researchers examining food habits of piscivores and size of fish in archaeological samples. Many more species and sizes of fish should be sampled to cover the full range of fishes involved in these studies.

Acknowledgments

We thank students and coworkers at Oregon State University, Moss Landing Marine Laboratories, and the National Marine Mammal Laboratory for their assistance in removing and measuring fish otoliths. In particular, Mary Yoklavich helped enter data, checked data for accuracy, and reviewed the manuscript. Daniel Kimura, Mark Lowry, Beth Sinclair, and Jay Orr also provided thoughtful comments on the manuscript. This work was funded, in part, by the National Marine Mammal Laboratory, National Marine Fisheries Service, Seattle, Washington.

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Figure 1
Otolith images of 76 species of fishes from the eastern North Pacific, listed in taxonomic order (Robins et al., 1991). For species with extreme variability in otolith morphology, multiple images are provided. For each species, the scientific and common names, position and size of the otolith pictured, and length and mass of the fish from which the otolith was removed are given. The regression relationships between (1) weight (WT in grams) and fish length (SL in cm) and (2) fish length (SL or FL in cm) and otolith length (OL in mm) are provided for each species. The coefficient of determination is $r^2$. 
CLUPEIDAE

*Alosa sapidissima*  
(American shad)

Left otolith; length (mm): 3.6  
Fish length (cm): 27.3  
Fish weight (g): 320.5

Regression equations:
- Length: $SL = 11.46 \times OL - 11.08 \quad r^2 = 0.960$
- Weight: $WT = 0.0135 \times SL^{3.046} \quad r^2 = 0.997$

*Clupea pallasi*  
(Pacific herring)

Right otolith; length (mm): 3.3  
Fish length (cm): 17.7  
Fish weight (g): 71.6

Regression equations:
- Length: $SL = 5.24 \times OL - 1.85 \quad r^2 = 0.934$
- Weight: $WT = 0.0044 \times SL^{3.398} \quad r^2 = 0.976$

ENGRAULIDAE

*Engraulis mordax*  
(northern anchovy)

Right otolith; length (mm): 3.5  
Fish length (cm): 8.0  
Fish weight (g): 7.8

Regression equations:
- Length: $SL = 2.28 \times OL + 0.85 \quad r^2 = 0.694$
- Weight: $WT = 0.0485 \times SL^{2.413} \quad r^2 = 0.807$

*Engraulis mordax*  
(northern anchovy)

Left otolith; length (mm): 3.4  
Fish length (cm): 11.9  
Fish weight (g): 12.8

Regression equations:
- Length: $SL = 2.28 \times OL + 0.85 \quad r^2 = 0.694$
- Weight: $WT = 0.0485 \times SL^{2.413} \quad r^2 = 0.807$
OSMERIDAE

*Allosmerus elongatus*  
*(whitebait smelt)*  
Right otolith; length (mm): 3.0  
Fish length (cm): 9.3  
Fish weight (g): 5.9  
Regression equations:  
Length: \( SL = 2.11 \ (OL) + 3.02 \) \( r^2 = 0.838 \)  
Weight: \( WT = 0.0063 \ SL^{3.233} \) \( r^2 = 0.893 \)

*Hypomesus pretiosus*  
*(surf smelt)*  
Left otolith; length (mm): 3.8  
Fish length (cm): 12.6  
Fish weight (g): 20.1  
Regression equations:  
Length: \( SL = 3.61 \ (OL) - 0.63 \) \( r^2 = 0.932 \)  
Weight: \( WT = 0.0044 \ SL^{3.345} \) \( r^2 = 0.986 \)

*Mallotus villosus*  
*(capelin)*  
Right otolith; length (mm): 2.5  
Fish length (cm): 11.6  
Fish weight (g): 12.0  
Regression equations:  
Length: \( SL = 3.45 \ (OL) + 3.62 \) \( r^2 = 0.649 \)  
Weight: \( WT = 0.0054 \ SL^{3.160} \) \( r^2 = 0.717 \)

*Osmerus mordax*  
*(rainbow smelt)*  
Left otolith; length (mm): 5.1  
Fish length (cm): 13.0  
Fish weight (g): 17.9  
Regression equations:  
Length: \( SL = 2.69 \ (OL) + 0.32 \) \( r^2 = 0.759 \)  
Weight: \( WT = 0.0038 \ SL^{3.278} \) \( r^2 = 0.819 \)
OSMERIDAE (cont.)

*Spirinchus thaleichthys*  
(longfin smelt)

Left otolith; length (mm): 3.8  
Fish length (cm): 9.9  
Fish weight (g): 8.8  
Regression equations:  
Length: \( SL = 2.64 \, (OL) - 0.20 \quad r^2 = 0.878 \)  
Weight: \( WT = 0.0288 \, SL^{2.531} \quad r^2 = 0.854 \)

*Thaleichthys pacificus*  
(eulachon)

Left otolith; length (mm): 4.1  
Fish length (cm): 16.5  
Fish weight (g): 32.7  
Regression equations:  
Length: \( SL = 4.71 \, (OL) - 2.70 \quad r^2 = 0.871 \)  
Weight: \( WT = 0.0077 \, SL^{3.075} \quad r^2 = 0.884 \)

SALMONIDAE

*Oncorhynchus kisutch*  
(coho salmon)

Right otolith; length (mm): 3.7  
Fish length (cm): 18.0  
Fish weight (g): 98.9  
Regression equations:  
Length: \( SL = 16.31 \, (OL) - 40.74 \quad r^2 = 0.569 \)  
Weight: \( WT = 0.0103 \, SL^{3.092} \quad r^2 = 0.989 \)

*Oncorhynchus kisutch*  
(coho salmon)

Right otolith; length (mm): 3.3  
Fish length (cm): 17.7  
Fish weight (g): 66.6  
Regression equations:  
Length: \( SL = 16.31 \, (OL) - 40.74 \quad r^2 = 0.569 \)  
Weight: \( WT = 0.0103 \, SL^{3.092} \quad r^2 = 0.989 \)
SALMONIDAE (cont.)

**Oncorhynchus mykiss**
(rainbow trout)

Left otolith; length (mm): 5.0  
Fish length (cm): 24.3  
Fish weight (g): 320.9  

Regression equations:  
Length: $SL = 16.28 \times OL - 38.14 \quad r^2 = 0.790$
Weight: $WT = 0.0275 \times SL^{2.895} \quad r^2 = 0.905$

**Oncorhynchus mykiss**
(rainbow trout)

Right otolith; length (mm): 4.8  
Fish length (cm): 25.3  
Fish weight (g): 315.6  

Regression equations:  
Length: $SL = 16.28 \times OL - 38.14 \quad r^2 = 0.790$
Weight: $WT = 0.0275 \times SL^{2.895} \quad r^2 = 0.905$

**Oncorhynchus nerka**
(sockeye salmon)

Left otolith; length (mm): 3.0  
Fish length (cm): 20  
Fish weight (g): N/A  

Regression equations:  
Length: No data available  
Weight: No data available

**Oncorhynchus tshawytscha**
(chinook salmon)

Left otolith; length (mm): 2.4  
Fish length (cm): 7.6  
Fish weight (g): N/A  

Regression equations:  
Length: No data available  
Weight: No data available
GADIDAE

**Eleginus gracilis**  
(Saffron cod; ventral view)

Left otolith; length (mm): 6.8  
Fish length (cm): 9.2  
Fish weight (g): 6.2  

Regression equations:

\[
\text{Length: } SL = 1.89 \text{ (OL)} - 2.76 \quad r^2 = 0.960 \\
\text{Weight: } WT = 0.0039 \text{ SL}^{3.292} \quad r^2 = 0.990 
\]

**Eleginus gracilis**  
(saffron cod)

Left otolith; length (mm): 6.8  
Fish length (cm): 9.2  
Fish weight (g): 6.2  

Regression equations:

\[
\text{Length: } SL = 1.89 \text{ (OL)} - 2.76 \quad r^2 = 0.960 \\
\text{Weight: } WT = 0.0039 \text{ SL}^{3.292} \quad r^2 = 0.990 
\]

**Gadus macrocephalus**  
(Pacific cod)

Right otolith; length (mm): 12.0  
Fish length (cm): 29.5  
Fish weight (g): 373.8  

Regression equations:

\[
\text{Length: } FL = 4.51 \text{ (OL)} - 22.97 \quad r^2 = 0.883 \\
\text{Weight: } \text{No data available} 
\]

**Merluccius productus**  
(Pacific hake)

Right otolith; length (mm): 22.0  
Fish length (cm): 42.0  
Fish weight (g): 659.0  

Regression equations:

\[
\text{Length: } SL = 2.04 \text{ (OL)} + 0.96 \quad r^2 = 0.891 \\
\text{Weight: } WT = 0.0081 \text{ SL}^{2.966} \quad r^2 = 0.933 
\]
GADIDAE (cont.)

**Microgadus proximus**  
(Pacific tomcod)

Right otolith; length (mm): 12.3
Fish length (cm): 18.2
Fish weight (g): 59.8

Regression equations:
- **Length:** \( SL = 1.77 \times OL - 3.51 \)  \( r^2 = 0.932 \)
- **Weight:** \( WT = 0.0064 \times SL^{3.191} \)  \( r^2 = 0.988 \)

---

**Theragra chalcogramma**  
(walleye pollock)

Left otolith; length (mm): 16.0
Fish length (cm): 33.5
Fish weight (g): 394.0

Regression equations:
- **Length:** \( SL = 2.24 \times OL - 2.35 \)  \( r^2 = 0.948 \)
- **Weight:** \( WT = 0.0043 \times SL^{3.255} \)  \( r^2 = 0.985 \)

---

MACROURIDAE

**Coryphaenoides acrolepis**  
(Pacific rattail)

Right otolith; length (mm): 10.0
Fish length (cm): 36.0
Fish weight (g): 148.8

Regression equations:
- **Length:** \( SL = 3.44 \times OL - 3.23 \)  \( r^2 = 0.926 \)
- **Weight:** \( WT = 0.0016 \times SL^{3.209} \)  \( r^2 = 0.921 \)

---

OPHIDIIDAE

**Chilara taylori**  
(spotted cusk-eel)

Left otolith; length (mm): 7.6
Fish length (cm): 21.8
Fish weight (g): 46.6

Regression equations:
- **Length:** \( SL = 2.51 \times OL + 2.15 \)  \( r^2 = 0.730 \)
- **Weight:** \( WT = 0.0004 \times SL^{3.761} \)  \( r^2 = 0.964 \)
BATRACHOIDIDAE

*Porichthys notatus*  
*(plainfin midshipman)*

Left otolith; length (mm): 9.1  
Fish length (cm): 22.5  
Fish weight (g): 215.1

Regression equations:
Length:  \( SL = 2.80 \, (OL) - 2.59 \)  
\( r^2 = 0.926 \)

Weight:  \( WT = 0.0207 \, SL^{2.916} \)  
\( r^2 = 0.967 \)

ATHERINIDAE

*Atherinops affinis*  
*(topsmelt)*

Right otolith; length (mm): 2.4  
Fish length (cm): 9.9  
Fish weight (g): 10.2

Regression equations:
Length:  \( SL = 3.72 \, (OL) + 0.55 \)  
\( r^2 = 0.891 \)

Weight:  \( WT = 0.1698 \, SL^{1.733} \)  
\( r^2 = 0.429 \)

*Atherinops affinis*  
*(topsmelt)*

Left otolith; length (mm): 3.2  
Fish length (cm): 11.8  
Fish weight (g): 13.2

Regression equations:
Length:  \( SL = 3.72 \, (OL) + 0.55 \)  
\( r^2 = 0.891 \)

Weight:  \( WT = 0.1698 \, SL^{1.733} \)  
\( r^2 = 0.429 \)

*Atherinopsis californiensis*  
*(jacksmelt)*

Right otolith; length (mm): 6.1  
Fish length (cm): 28.7  
Fish weight (g): 260.0

Regression equations:
Length:  \( SL = 4.85 \, (OL) - 2.46 \)  
\( r^2 = 0.950 \)

Weight:  \( WT = 0.0049 \, SL^{3.228} \)  
\( r^2 = 0.968 \)
SCORPAENIDAE

**Sebastes auriculatus**  
(brown rockfish)

Left otolith; length (mm): 3.2  
Fish length (cm): 6.7  
Fish weight (g): 6.9  

Regression equations:  
Length: \( SL = 3.32 \text{ (OL)} - 5.30 \)  
\( r^2 = 0.940 \)  
Weight: No data available

**Sebastes constellatus**  
(starry rockfish)

Right otolith; length (mm): 12.3  
Fish length (cm): N/A  
Fish weight (g): N/A  

Regression equations:  
Length: \( SL = 2.53 \text{ (OL)} - 3.75 \)  
\( r^2 = 0.960 \)  
Weight: No data available

**Sebastes crameri**  
(darkblotched rockfish)

Left otolith; length (mm): 13.9  
Fish length (cm): 31.0  
Fish weight (g): 1121.5  

Regression equations:  
Length: \( SL = 2.81 \text{ (OL)} - 2.71 \)  
\( r^2 = 0.940 \)  
Weight: No data available

**Sebastes diploproa**  
(splitnose rockfish)

Right otolith; length (mm): 15.1  
Fish length (cm): N/A  
Fish weight (g): N/A  

Regression equations:  
Length: \( SL = 2.26 \text{ (OL)} - 1.29 \)  
\( r^2 = 0.960 \)  
Weight: No data available
SCORPAENIDAE (cont.)

**Sebastes flavidus**  
(yellowtail rockfish)

Right otolith; length (mm): 12.2  
Fish length (cm): 24.5  
Fish weight (g): N/A

Regression equations:
- **Length:** $SL = 2.65 \times OL - 1.09$  
  $r^2 = 0.880$
- **Weight:** No data available

**Sebastes maliger**  
(quillback rockfish)

Left otolith; length (mm): 13.0  
Fish length (cm): 32.5  
Fish weight (g): N/A

Regression equations:
- **Length:** $SL = 2.99 \times OL - 5.31$  
  $r^2 = 0.860$
- **Weight:** No data available

**Sebastes melanops**  
(black rockfish)

Right otolith; length (mm): 12.4  
Fish length (cm): 29.0  
Fish weight (g): N/A

Regression equations:
- **Length:** $SL = 2.23 \times OL - 1.48$  
  $r^2 = 0.749$
- **Weight:** $WT = 0.1225 \times SL^{2.499}$  
  $r^2 = 0.585$

**Sebastes miniatus**  
(vermillion rockfish)

Right otolith; length (mm): 15.1  
Fish length (cm): 35.5  
Fish weight (g): N/A

Regression equations:
- **Length:** $SL = 2.94 \times OL - 5.67$  
  $r^2 = 0.930$
- **Weight:** No data available
SCORPAENIDAE (cont.)

*Sebastes mystinus*  
(blue rockfish)

Right otolith; length (mm): 12.8  
Fish length (cm): 29.0  
Fish weight (g): N/A

Regression equations:  
Length: $SL = 2.98 \times (OL) - 1.82 \quad r^2 = 0.830$  
Weight: No data available

*Sebastes nebulosus*  
(China rockfish)

Right otolith; length (mm): 10.7  
Fish length (cm): N/A  
Fish weight (g): N/A

Regression equations:  
Length: $SL = 2.52 \times (OL) + 3.30 \quad r^2 = 0.790$  
Weight: No data available

*Sebastes paucispinis*  
(boccacio)

Left otolith; length (mm): 14.0  
Fish length (cm): 39.8  
Fish weight (g): 1191.8

Regression equations:  
Length: $SL = 2.41 \times (OL) + 0.14 \quad r^2 = 0.769$  
Weight: No data available

*Sebastes pinniger*  
(canary rockfish)

Right otolith; length (mm): 16.3  
Fish length (cm): 31.8  
Fish weight (g): N/A

Regression equations:  
Length: $SL = 2.94 \times (OL) - 8.51 \quad r^2 = 0.920$  
Weight: No data available
SCORPAENIDAE (cont.)

**Sebastes ruberrimus**
(yellow eye rockfish)

Left otolith; length (mm): 14.4
Fish length (cm): 34.0
Fish weight (g): N/A

Regression equations:
- **Length:** $SL = 3.13 \ (OL) - 7.62 \quad r^2 = 0.920$
- **Weight:** No data available

**Sebastolobus alascanus**
(shortspine thornyhead)

Right otolith; length (mm): 14.1
Fish length (cm): 27.7
Fish weight (g): 515.6

Regression equations:
- **Length:** $SL = 2.31 \ (OL) - 3.71 \quad r^2 = 0.828$
- **Weight:** $WT = 0.0102 \ SL^{3.239} \quad r^2 = 0.988$

**Sebastolobus altivelis**
(longspine thornyhead)

Right otolith; length (mm): 10.9
Fish length (cm): 24.5
Fish weight (g): 328.8

Regression equations:
- **Length:** $SL = 4.94 \ (OL) - 27.50 \quad r^2 = 0.839$
- **Weight:** $WT = 0.0155 \ SL^{3.113} \quad r^2 = 0.997$
ANOPLOPOMATIDAE

Anoplopoma fimbria
(sablefish)
Left otolith; length (mm): 6.2
Fish length (cm): 36.4
Fish weight (g): 541.7
Regression equations:
Length: \( SL = 5.28 \times (OL) + 1.62 \) \( r^2 = 0.955 \)
Weight: \( WT = 0.0163 \times SL^{2.902} \) \( r^2 = 0.993 \)

Anoplopoma fimbria
(sablefish)
Right otolith; length (mm): 7.7
Fish length (cm): 41.6
Fish weight (g): 868.1
Regression equations:
Length: \( SL = 5.28 \times (OL) + 1.62 \) \( r^2 = 0.955 \)
Weight: \( WT = 0.0163 \times SL^{2.902} \) \( r^2 = 0.993 \)

HEXAGRAMMIDAE

Ophiodon elongatus
(lingcod)
Right otolith; length (mm): 9.1
Fish length (cm): 62.0
Fish weight (g): N/A
Regression equations:
Length: \( SL = 8.23 \times (OL) - 8.20 \) \( r^2 = 0.722 \)
Weight: \( WT = 0.0023 \times SL^{3.567} \) \( r^2 = 0.620 \)

Ophiodon elongatus
(lingcod)
Left otolith; length (mm): 5.3
Fish length (cm): 38.2
Fish weight (g): N/A
Regression equations:
Length: \( SL = 8.23 \times (OL) - 8.20 \) \( r^2 = 0.722 \)
Weight: \( WT = 0.0023 \times SL^{3.567} \) \( r^2 = 0.620 \)
HEXAGRAMMIDAE (cont.)

*Ophiodon elongatus* (lingcod)

Left otolith; length (mm): 9.0
Fish length (cm): 62.0
Fish weight (g): N/A

Regression equations:

- **Length**: \( SL = 8.23 \times (OL) - 8.20 \)  \( r^2 = 0.722 \)
- **Weight**: \( WT = 0.0023 \times SL^{3.567} \)  \( r^2 = 0.620 \)

*Pleurogrammus monopterygius* (Atka mackerel)

Right otolith; length (mm): 3.5
Fish length (cm): 21.2
Fish weight (g): 108.8

Regression equations:

- **Length**: \( FL = 8.40 \times (OL) - 4.99 \)  \( r^2 = 0.864 \)
- **Weight**: \( WT = 0.0034 \times FL^{3.401} \)  \( r^2 = 0.987 \)

COTTIDAE

*Chitonotus pugetensis* (roughback sculpin)

Right otolith; length (mm): 2.9
Fish length (cm): 6.0
Fish weight (g): 3.3

Regression equations:

- **Length**: \( SL = 3.37 \times (OL) - 4.52 \)  \( r^2 = 0.857 \)
- **Weight**: \( WT = 0.0217 \times SL^{2.871} \)  \( r^2 = 0.960 \)

*Dasycottus setiger* (spinyhead sculpin)

Left otolith; length (mm): 8.5
Fish length (cm): N/A
Fish weight (g): N/A

Regression equations:

- **Length**: \( FL = 3.11 \times (OL) - 7.03 \)  \( r^2 = 0.655 \)
- **Weight**: No data available
COTTIDAE (cont.)

*Dasycottus setiger*  
(spinyhead sculpin)

Right otolith; length (mm): 8.3  
Fish length (cm): N/A  
Fish weight (g): N/A

Regression equations:
Length: \( FL = 3.11 \times (OL) - 7.03 \)
\( r^2 = 0.655 \)

Weight: No data available

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*Gymnocanthus galeatus*  
(armorhead sculpin)

Right otolith; length (mm): 6.6  
Fish length (cm): 13.4  
Fish weight (g): 43.5

Regression equations:
Length: \( SL = 1.75 \times (OL) + 0.82 \)
\( r^2 = 0.476 \)

Weight: \( WT = 0.0100 \times SL^{3.196} \)
\( r^2 = 0.939 \)

---

*Gymnocanthus galeatus*  
(armorhead sculpin)

Right otolith; length (mm): 6.5  
Fish length (cm): 11.3  
Fish weight (g): 22.4

Regression equations:
Length: \( SL = 1.75 \times (OL) + 0.82 \)
\( r^2 = 0.476 \)

Weight: \( WT = 0.0100 \times SL^{3.196} \)
\( r^2 = 0.939 \)

---

*Leptocottus armatus*  
(Pacific staghorn sculpin)

Right otolith; length (mm): 5.2  
Fish length (cm): 11.5  
Fish weight (g): 30.5

Regression equations:
Length: \( SL = 2.58 \times (OL) - 2.26 \)
\( r^2 = 0.928 \)

Weight: \( WT = 0.0111 \times SL^{3.229} \)
\( r^2 = 0.990 \)
COTTIDAE (cont.)

**Leptocottus armatus**
*(Pacific staghorn sculpin)*

- Left otolith; length (mm): 5.8
- Fish length (cm): 13.6
- Fish weight (g): 46.5

Regression equations:
- **Length:** SL = 2.58 (OL) – 2.26 \( r^2 = 0.928 \)
- **Weight:** WT = 0.0111 SL^{3.229} \( r^2 = 0.990 \)

**Leptocottus armatus**
*(Pacific staghorn sculpin)*

- Left otolith; length (mm): 6.1
- Fish length (cm): 13.5
- Fish weight (g): 47.8

Regression equations:
- **Length:** SL = 2.58 (OL) – 2.26 \( r^2 = 0.928 \)
- **Weight:** WT = 0.0111 SL^{3.229} \( r^2 = 0.990 \)

AGONIDAE

**Podothecus acipenserinus**
*(sturgeon poacher)*

- Right otolith; length (mm): 4.2
- Fish length (cm): 19.1
- Fish weight (g): 54.0

Regression equations:
- **Length:** SL = 6.58 (OL) – 6.21 \( r^2 = 0.840 \)
- **Weight:** WT = 0.0030 SL^{3.233} \( r^2 = 0.956 \)

CARANGIDAE

**Trachurus symmetricus**
*(Jack mackerel)*

- Right otolith; length (mm): 7.6
- Fish length (cm): 26.8
- Fish weight (g): 266.0

Regression equations:
- **Length:** Not significant \( r^2 = 0.141 \)
- **Weight:** WT = 0.0635 SL^{2.556} \( r^2 = 0.761 \)
SCIAENIDAE

*Genyonemus lineatus*  
*(white croaker)*

Left otolith; length (mm): 10.2  
Fish length (cm): 20.5  
Fish weight (g): 171.8

Regression equations:

\[
\text{Length: } SL = 1.52 \times OL + 4.66 \quad r^2 = 0.534
\]

\[
\text{Weight: } WT = 0.0550 \times SL^{2.700} \quad r^2 = 0.767
\]

---

*Genyonemus lineatus* (lateral view)  
*(white croaker)*

Left otolith; length (mm): 10.2  
Fish length (cm): 20.5  
Fish weight (g): 171.8

Regression equations:

\[
\text{Length: } SL = 1.52 \times OL + 4.66 \quad r^2 = 0.534
\]

\[
\text{Weight: } WT = 0.0550 \times SL^{2.700} \quad r^2 = 0.767
\]

---

EMBIOTOCIDAE

*Cymatogaster aggregata*  
*(shiner perch)*

Right otolith; length (mm): 6.3  
Fish length (cm): 10.1  
Fish weight (g): 35.7

Regression equations:

\[
\text{Length: } SL = 1.74 \times OL - 0.52 \quad r^2 = 0.925
\]

\[
\text{Weight: } WT = 0.0100 \times SL^{3.515} \quad r^2 = 0.979
\]

---

*Cymatogaster aggregata* (shiner perch)

Left otolith; length (mm): 6.3  
Fish length (cm): 10.7  
Fish weight (g): 38.6

Regression equations:

\[
\text{Length: } SL = 1.74 \times OL - 0.52 \quad r^2 = 0.925
\]

\[
\text{Weight: } WT = 0.0100 \times SL^{3.515} \quad r^2 = 0.979
\]
EMBIOTOCIDAE (cont.)

**Embiotoca jacksoni**  
*(black perch)*

Right otolith; length (mm): 7.4  
Fish length (cm): 15.6  
Fish weight (g): 169.0

Regression equations:  
**Length:**  \( SL = 2.45 \, (OL) - 2.61 \)  
\( r^2 = 0.947 \)  
**Weight:**  \( WT = 0.0282 \, SL^{3.148} \)  
\( r^2 = 0.992 \)

**Embiotoca lateralis**  
*(striped seaperch)*

Right otolith; length (mm): 10.5  
Fish length (cm): 24.2  
Fish weight (g): 540.2

Regression equations:  
**Length:**  \( SL = 2.90 \, (OL) - 5.68 \)  
\( r^2 = 0.990 \)  
**Weight:**  \( WT = 0.0329 \, SL^{3.043} \)  
\( r^2 = 0.998 \)

**Hyperprosopon argenteum**  
*(walleye surfperch)*

Right otolith; length (mm): 7.9  
Fish length (cm): 18.7  
Fish weight (g): 213.0

Regression equations:  
**Length:**  \( SL = 2.57 \, (OL) - 2.83 \)  
\( r^2 = 0.987 \)  
**Weight:**  \( WT = 0.0116 \, SL^{3.361} \)  
\( r^2 = 0.996 \)

**Phanerodon furcatus**  
*(white seaperch)*

Right otolith; length (mm): 8.7  
Fish length (cm): 23.5  
Fish weight (g): 402.2

Regression equations:  
**Length:**  \( SL = 2.33 \, (OL) - 2.15 \)  
\( r^2 = 0.912 \)  
**Weight:**  \( WT = 0.0213 \, SL^{3.086} \)  
\( r^2 = 0.997 \)
EMBIOTOCIDAE (cont.)

**Rhacochilus vacca**  
(pile perch)

Right otolith; length (mm): 11.8  
Fish length (cm): 31.2  
Fish weight (g): 1326.40  

Regression equations:  
**Length**: \( SL = 3.35 \times (OL) - 8.19 \)  
\( r^2 = 0.965 \)  
**Weight**: \( WT = 0.0182 \times SL^{3.218} \)  
\( r^2 = 0.997 \)

**Zalembius rosaceus**  
(pink seaperch)

Left otolith; length (mm): 4.7  
Fish length (cm): 8.9  
Fish weight (g): 19.0  

Regression equations:  
**Length**: \( SL = 1.88 \times (OL) - 0.07 \)  
\( r^2 = 0.912 \)  
**Weight**: \( WT = 0.0199 \times SL^{3.102} \)  
\( r^2 = 0.841 \)

BATHYMASTERIDAE

**Bathymaster signatus**  
(searcher)

Left otolith; length (mm): 6.3  
Fish length (cm): 21.0  
Fish weight (g): 150.3  

Regression equations:  
**Length**: \( SL = 3.48 \times (OL) + 1.90 \)  
\( r^2 = 0.883 \)  
**Weight**: \( WT = 0.0038 \times SL^{3.256} \)  
\( r^2 = 0.991 \)

**Bathymaster signatus**  
(searcher)

Left otolith; length (mm): 6.9  
Fish length (cm): 23.3  
Fish weight (g): 212.9  

Regression equations:  
**Length**: \( SL = 3.48 \times (OL) + 1.90 \)  
\( r^2 = 0.883 \)  
**Weight**: \( WT = 0.0038 \times SL^{3.256} \)  
\( r^2 = 0.991 \)
ZOARCIDAE

*Lycodes brevipes* *(shortfin eelpout)*

Left otolith; length (mm): 5.1  
Fish length (cm): 24.0  
Fish weight (g): 61.3  

Regression equations:

Length: \( FL = 3.47 \times (OL) + 4.83 \)  
\( r^2 = 0.520 \)  
Weight: \( WT = 0.0195 \times FL^{2.522} \)  
\( r^2 = 0.826 \)

*Lycodes cortezianus* *(bigfin eelpout)*

Left otolith; length (mm): 4.9  
Fish length (cm): 38.5  
Fish weight (g): 286.8  

Regression equations:

Length: \( SL = 10.96 \times (OL) - 21.82 \)  
\( r^2 = 0.742 \)  
Weight: \( WT = 0.0018 \times SL^{3.245} \)  
\( r^2 = 0.993 \)

*Lycodopsis pacifica* *(blackbelly eelpout)*

Right otolith; length (mm): 3.6  
Fish length (cm): 19.5  
Fish weight (g): 30.6  

Regression equations:

Length: \( SL = 3.82 \times (OL) + 4.89 \)  
\( r^2 = 0.610 \)  
Weight: \( WT = 0.0018 \times SL^{3.302} \)  
\( r^2 = 0.954 \)
TRICHODONTIDAE

*Trichodon trichodon*  
(Pacific sandfish)

Right otolith; length (mm): 4.0  
Fish length (cm): N/A  
Fish weight (g): N/A

Regression equations:

**Length:** FL = 6.06 (OL) – 4.57 \( r^2 = 0.684 \)  
**Weight:** WT = 0.0170 FL^{2.953} \( r^2 = 0.971 \)

AMMODYTIDAE

*Ammodytes hexapterus*  
(Pacific sand lance)

Right otolith; length (mm): 2.4  
Fish length (cm): 11.7  
Fish weight (g): 6.4

Regression equations:

**Length:** SL = 4.06 (OL) + 2.01 \( r^2 = 0.433 \)  
**Weight:** WT = 0.0063 SL^{2.790} \( r^2 = 0.913 \)

BOTHIDAE

*Citharichthys sordidus*  
(Pacific sanddab)

Left otolith; length (mm): 6.3  
Fish length (cm): 23.0  
Fish weight (g): 175.8

Regression equations:

**Length:** SL = 2.87 (OL) + 3.29 \( r^2 = 0.727 \)  
**Weight:** WT = 0.0352 SL^{2.710} \( r^2 = 0.851 \)

*Citharichthys sordidus*  
(Pacific sanddab)

Right otolith; length (mm): 5.8  
Fish length (cm): 20.6  
Fish weight (g): 119.5

Regression equations:

**Length:** SL = 2.87 (OL) + 3.29 \( r^2 = 0.727 \)  
**Weight:** WT = 0.0352 SL^{2.710} \( r^2 = 0.851 \)
PLEURONECTIDAE

Atheresthes stomias
(arrowtooth flounder)
Right otolith; length (mm): 9.0
Fish length (cm): 37.5
Fish weight (g): 662.6
Regression equations:
\[
\text{Length: } \text{FL} = 4.75 (\text{OL}) - 2.96 \quad r^2 = 0.925
\]
\[
\text{Weight: } \text{WT} = 0.0093 \text{FL}^{2.999} \quad r^2 = 0.961
\]

Eopsetta exilis
(slender sole)
Left otolith; length (mm): 4.6
Fish length (cm): 19.6
Fish weight (g): 95.4
Regression equations:
\[
\text{Length: } \text{SL} = 3.37 (\text{OL}) + 1.08 \quad r^2 = 0.771
\]
\[
\text{Weight: } \text{WT} = 0.0058 \text{SL}^{3.293} \quad r^2 = 0.974
\]

Eopsetta exilis
(slender sole)
Right otolith; length (mm): 4.6
Fish length (cm): 18.5
Fish weight (g): 61.0
Regression equations:
\[
\text{Length: } \text{SL} = 3.37 (\text{OL}) + 1.08 \quad r^2 = 0.771
\]
\[
\text{Weight: } \text{WT} = 0.0058 \text{SL}^{3.293} \quad r^2 = 0.974
\]

Eopsetta jordani
(petrale sole)
Right otolith; length (mm): 7.3
Fish length (cm): 29.0
Fish weight (g): 502.7
Regression equations:
\[
\text{Length: } \text{SL} = 4.85 (\text{OL}) - 4.81 \quad r^2 = 0.857
\]
\[
\text{Weight: } \text{WT} = 0.0086 \text{SL}^{3.231} \quad r^2 = 0.986
\]
PLEURONECTIDAE (cont.)

*Errex zachirus*
(rex sole)
Right otolith; length (mm): 6.6  
Fish length (cm): 27.2  
Fish weight (g): 171.0  
Regression equations:  
Length: \( SL = 4.80 \text{ (OL)} - 2.50 \) \( r^2 = 0.869 \)  
Weight: \( WT = 0.0238 SL^{2.692} \) \( r^2 = 0.932 \)

*Hippoglossoides elassodon*
(flathead sole)
Left otolith; length (mm): 5.5  
Fish length (cm): 19.1  
Fish weight (g): 117.3  
Regression equations:  
Length: \( FL = 4.63 \text{ (OL)} - 0.71 \) \( r^2 = 0.947 \)  
Weight: \( WT = 0.0078 FL^{3.041} \) \( r^2 = 0.984 \)

*Hippoglossus stenolepis*
(Pacific halibut)
Left otolith; length (mm): 12.8  
Fish length (cm): 80.0  
Fish weight (g): 6,600.0  
Regression equations:  
Length: No data available  
Weight: No data available

*Hypsopsetta guttulata*
(diamond turbot)
Left otolith; length (mm): 4.8  
Fish length (cm): 21.3  
Fish weight (g): 345.0  
Regression equations:  
Length: \( SL = 4.89 \text{ (OL)} - 0.29 \) \( r^2 = 0.835 \)  
Weight: \( WT = 0.0853 SL^{2.664} \) \( r^2 = 0.967 \)
PLEURONECTIDAE (cont.)

**Hypsopsetta guttulata**
*(diamond turbot)*

Right otolith; length (mm): 4.7
Fish length (cm): 21.3
Fish weight (g): 345.0

Regression equations:
- **Length:** \( SL = 4.89 \times (OL) - 0.29 \) \( r^2 = 0.835 \)
- **Weight:** \( WT = 0.0853 \times SL^{2.664} \) \( r^2 = 0.967 \)

**Microstomus pacificus**
*(Dover sole)*

Left otolith; length (mm): 5.3
Fish length (cm): 26.9
Fish weight (g): 268.1

Regression equations:
- **Length:** \( SL = 3.72 \times (OL) + 6.97 \) \( r^2 = 0.587 \)
- **Weight:** \( WT = 0.0094 \times SL^{3.092} \) \( r^2 = 0.854 \)

**Microstomus pacificus**
*(Dover sole)*

Right otolith; length (mm): 5.4
Fish length (cm): 26.9
Fish weight (g): 268.1

Regression equations:
- **Length:** \( SL = 3.72 \times (OL) + 6.97 \) \( r^2 = 0.587 \)
- **Weight:** \( WT = 0.0094 \times SL^{3.092} \) \( r^2 = 0.854 \)

**Microstomus pacificus**
*(Dover sole)*

Right otolith; length (mm): 4.6
Fish length (cm): 26.2
Fish weight (g): 239.5

Regression equations:
- **Length:** \( SL = 3.72 \times (OL) + 6.97 \) \( r^2 = 0.587 \)
- **Weight:** \( WT = 0.0094 \times SL^{3.092} \) \( r^2 = 0.854 \)
PLEURONECTIDAE (cont.)

Microstomus pacificus
(Dover sole)
Left otolith; length (mm): 4.8
Fish length (cm): 26.7
Fish weight (g): 289.0
Regression equations:
Length: $SL = 3.72 \ (OL) + 6.97 \quad r^2 = 0.587$
Weight: $WT = 0.0094 \ SL^{3.092} \quad r^2 = 0.854$

Platichthys stellatus
(starry flounder)
Left otolith; length (mm): 7.0
Fish length (cm): 27.6
Fish weight (g): 547.4
Regression equations:
Length: $SL = 3.35 \ (OL) + 0.23 \quad r^2 = 0.814$
Weight: $WT = 0.0107 \ SL^{3.268} \quad r^2 = 0.985$

Pleuronectes asper
(yellowfin sole)
Left otolith; length (mm): 6.6
Fish length (cm): 25.3
Fish weight (g): 294.4
Regression equations:
Length: $SL = 2.17 \ (OL) + 10.65 \quad r^2 = 0.638$
Weight: $WT = 0.0024 \ SL^{3.605} \quad r^2 = 0.859$

Pleuronectes bilineatus
(rock sole)
Left otolith; length (mm): 6.8
Fish length (cm): 23.5
Fish weight (g): 287.2
Regression equations:
Length: $FL = 6.16 \ (OL) - 6.97 \quad r^2 = 0.841$
Weight: $WT = 0.0112 \ FL^{2.997} \quad r^2 = 0.931$
PLEURONECTIDAE (cont.)

**Pleuronectes vetulus**  
(English sole)

Right otolith; length (mm): 6.6  
Fish length (cm): 21.2  
Fish weight (g): 104.0

Regression equations:
- **Length**: $SL = 3.82 \times OL - 2.76$  
  $r^2 = 0.965$
- **Weight**: $WT = 0.0163 \times SL^{2.939}$  
  $r^2 = 0.995$

**Pleuronectes vetulus**  
(English sole)

Left otolith; length (mm): 9.0  
Fish length (cm): 32.3  
Fish weight (g): 439.2

Regression equations:
- **Length**: $SL = 3.82 \times OL - 2.76$  
  $r^2 = 0.965$
- **Weight**: $WT = 0.0163 \times SL^{2.939}$  
  $r^2 = 0.995$

**Psetticthys melanostictus**  
(sand sole)

Right otolith; length (mm): 5.2  
Fish length (cm): 23.0  
Fish weight (g): 288.0

Regression equations:
- **Length**: $SL = 5.06 \times OL - 3.18$  
  $r^2 = 0.942$
- **Weight**: $WT = 0.0052 \times SL^{3.441}$  
  $r^2 = 0.983$

**Psetticthys melanostictus**  
(sand sole)

Left otolith; length (mm): 4.5  
Fish length (cm): 21.7  
Fish weight (g): 231.3

Regression equations:
- **Length**: $SL = 5.06 \times OL - 3.18$  
  $r^2 = 0.942$
- **Weight**: $WT = 0.0052 \times SL^{3.441}$  
  $r^2 = 0.983$
SOLEIDAE

*Symphurus atricauda*
(California tonguefish)

Left otolith; length (mm): 2.3
Fish length (cm): 14.5
Fish weight (g): 33.2

Regression equations:

**Length:** \( SL = 3.56 \times OL + 4.64 \) \( r^2 = 0.464 \)

**Weight:** \( WT = 0.0074SL^{3.136} \) \( r^2 = 0.789 \)