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MEASUREMENTS AND REGRESSIONS OF OTOLITHS, CEPHALOPOD BEAKS, AND OTHER PREY HARD PARTS USED TO RECONSTRUCT CALIFORNIA CURRENT PREDATOR DIET COMPOSITION

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Measurements and regressions of otoliths, cephalopod beaks, and other prey hard parts used to reconstruct California Current predator diet composition

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Abstract

Prey hard parts are used to reconstruct species composition and prey sizes from analyses of scats or stomachs of many marine predators. Measurements of prey hard parts are often closely related to prey size, allowing estimation of lengths and weights of prey consumed. In addition, otolith morphometrics, such as length, weight, and surface area, are related to otolith survival in predator digestive tracts and may thus help predict recovery rates in scats. Measurements were taken of prey hard part dimensions, additional morphometrics for otoliths, and/or prey size (length and weight) of reference specimens for 158 prey species found in the California Current Large Marine Ecosystem (CCLME), including 137 teleosts, twelve cephalopods, two batoids, one decapod, one myxinid, and one tunicate. Regression relationships of prey size to hard part measurements, among different prey hard part measurements (e.g., otolith length to width), and among different prey size measurements (e.g., weight to length) are provided for most species to facilitate application of these data to reconstruction of predator diets in the CCLME.

Introduction

Digestion-resistant prey structures, such as teleost otoliths and cephalopod beaks, are used to reconstruct diet composition of a wide range of marine predators, from jellyfish to cetaceans (e.g., Scott 1902; Clarke 1962; Purcell 1984). Many prey hard parts can be used not only for taxonomic identification of prey, but also to estimate prey size, based on species-specific regressions of prey hard part size to prey size (e.g., Clarke 1962; Antonelis et al, 1984). Information on species composition and length frequencies of prey in marine predators has a wide range of applications, from informing our basic understanding of marine trophic ecology, to grounding the use of predator population dynamics as ecosystem indicators (e.g., Sydeman et al., 2001; Melin et al., 2012), informing ecosystem models (e.g., Kaplan et al., 2017), and supporting fisheries management (e.g., Field et al., 2007; Velarde et al., 2015). Otoliths have also been used to characterize teleost fauna in middens and sediment deposits (e.g., Fitch 1964; Fitch 1969), including deep-sea sediment cores for paleoecological research (Jones 2016).

Available identification guides for prey hard parts of species occurring in the California Current Large Marine Ecosystem (CCLME) have become increasingly comprehensive over time (Fitch and Brownell, 1968; Pinkas et al., 1971; Wolff 1984; Harvey et al., 2000; Lowry 2011). Some guides also contain regression relationships for prey hard parts to prey size (Wolff 1984; Clarke 1986; Harvey et al., 2000; Kubodera 2005). However, many prey species in the diverse forage assemblage of the CCLME have no data published to support size reconstruction, and sample sizes for many others remain limited, exacerbating the potential for considerable bias in calculating prey sizes from prey hard parts.

Otolith morphometrics may also contain information on resistance to dissolution, and thus probability of surviving passage through a predator’s digestive tract, or through the water column and bioturbated surface sediment layers prior to incorporation into varved sediment layers that can be used for paleoclimate and paleoecological reconstruction. Information on otolith morphometrics may support at least partial correction for biases introduced by differential recovery rates for different fish species and sizes in diet and sediment samples. Several studies have found consistent relationships between otolith morphometrics, such as length and mass-to-length ratio, and their recovery rates in pinniped scats (Harvey 1989; Tollitt et al., 1997; Sweeney and Harvey 2011). However, only one published data source provides such morphometrics for a suite of species, and its focus is primarily on mesopelagic forage species (Jones and Morales, 2014).

We provide extensive additional data on prey length, weight, and hard part measurements and on additional otolith morphometrics for a wide array of forage species and sizes, most of which are consumed by California sea lions (*Zalophus californianus*; M. Lowry, unpublished data, NOAA SWFSC). We also provide regression relationships among prey length, prey weight, prey hard part measurements, and, for teleosts, otolith metrics, to aid in reconstruction of diets for marine predators in the CCLME.

Methods

Reference specimens of teleosts, cephalopods, batoids, decapods, myxinids, and tunicates, with primary focus on known prey of California sea lions, were obtained or measured in situ from a wide range of sources, including preserved whole specimens and prey hard parts from museums, fresh frozen specimens from research vessels, industry samples from commercial fishing operations, and salmon hatcheries. Specimens of halfmoon (*Medialuna californiensis*) were caught with hook and line, spears, dip nets, and as bycatch in gill nets of the Ocean Research Enhancement and Hatchery Program (Boerger 2011; Bredvik et al., 2011). All specimens were collected in the Northeast Pacific, and most more specifically in the Southern California Bight or off the Central Coast of California. For whole museum specimens, length and weight were measured, with specific length measurements depending on taxon (Table 1). For hard part specimens from collections, commonly used prey hard part dimensions for that taxon were measured (Table 1), and any available data on measurements of the original whole specimen recorded. Where specimens were collected purposely for this study, whole prey and dissected hard part dimensions were measured per taxon-specific protocols (Table 1).

For whole prey specimens, measurements were taken with a measuring board (± 1 cm) or a caliper (± 0.1 mm or ± 1 mm). Whole specimens were weighed with a balance (± 0.1 g) or with a microbalance (± 0.0001 g). Sagittal otolith dimensions were measured using digital imaging (more details below; ± 0.001 mm) or a dissecting microscope with an ocular micrometer (± 0.01 mm). Other types of prey hard parts, such as squid beaks, were measured with an ocular micrometer or, where necessary due to size or logistics (e.g., measurement of tooth width in the mouth of a whole batoid specimen), a manual caliper (± 0.1 mm).

Where possible, high resolution digital photographic images of otoliths were taken with a computer connected to a Media Cybernetics Evolution MP color video camera mounted on a Zeiss Stemi 2000-C microscope. Media Cybernetics Image-Pro Plus 5.0 software was used to obtain otolith morphometrics from the resulting images (± 0.001 mm), including (1) otolith length, (2) otolith width, (3) perimeter length (i.e., the distance around the edge of the otolith), and (4) projected area (i.e., area of the otolith in the image). Otoliths for which digital images and morphometrics were obtained were weighed with a microbalance (± 0.001 mg or ± 0.1 mg).

To complement these data for known prey species of California sea lions lacking published regression relationships of prey size to hard part size, and for which we had obtained few or no data, we drew on published and unpublished data from other studies.

No substantive systematic differences were found in any teleost species between left and right sagittal otoliths where both were measured for at least two specimens (M. Lowry, unpublished data, NOAA SWFSC; Appendix A). Therefore, for specimens with measurements for both left and right otoliths, only left-side measurements are included in data summaries and regressions. Likewise, no difference was found between left and right dactylus lengths in tuna crabs (M. Lowry, unpublished data, NOAA SWFSC), so only left-side measurements are included in data summaries and regressions.

We fit regressions for documented prey of California sea lions in the Southern California Bight and for prey species used in captive feeding studies of California sea lions (Orr and Harvey 2001; Sweeney and Harvey 2011), focusing on species for which regression relationships based on higher sample sizes were not already available (e.g., Harvey et al., 2000; Sinclair et al., 2015). Linear regressions were fitted among length dimensions of prey hard parts and for prey length to hard part size. Ln-ln regressions were fitted to weight-to-length (for whole specimens and otoliths) and area-to-length (for otoliths) data. We calculated regressions using *R* 3.6.2 (R Core Team) with the aid of the following packages: *DBI*, *odbc*, *readxl*, *tidyverse*, *magrittr*, and *broom* (Bache and Wickham 2014; R Special Interest Group on Databases et al., 2019; Wickham and Bryan 2019; Wickham et al., 2019; Hester and Wickham 2020; Robinson et al., 2020).

Results

Measurements were taken for a total of 8,142 reference specimens of 137 species of teleosts, twelve cephalopods, two batoids, one decapod, one myxinid, and one tunicate. We also incorporated published data for 21 specimens of football octopus (*Ocythoe tuberculata*; Salman and Akalin, 2012). Data are summarized in Table 2.

Regressions for prey size calculation are summarized in Table 3. Regressions for estimation of otolith morphometrics from otolith length are summarized in Table 4. Where sample sizes for individual species were limited, either regressions were calculated at a higher taxonomic resolution or were not provided if a closely related species was likely to be more reliable.

Discussion

The data and regressions reported here provide the most comprehensive reference available to date for size reconstruction of CCLME forage species from hard parts found in predator diet samples, and represent the first published set of otolith morphometric relationships to otolith length. These regressions fill taxonomic gaps in published prey size to hard part size and weight-to-length information for CCLME forage species, add previously unavailable relationships for converting otolith width – often the only unbroken dimension available to be measured – to prey size, and provide improvements over existing published relationships for numerous species in terms of size range and sample size. The open-access form of these data also will enable future work to build on them.

In many cases, data and regressions reported here include a broader range of size classes than those previously published, often extending coverage to include smaller size classes that often dominate California sea lion diets (unpublished data). Important forage species with data ranges underlying prey-size-to-hard-part regressions extended substantially to smaller size classes include Pacific hake (*Merluccius productus*), shortbelly rockfish (*Sebastes jordani*), and some mesopelagic species (Wyllie Echeverria 1987; Harvey et al., 2000; Sinclair et al., 2015).

Sample sizes were also considerably enhanced for several important forage species, including more than doubling of sample size underlying the prey-size-to-hard-part-size regressions for market squid (*Doryteuthis opalescens*), northern anchovy (*Engraulis mordax*), and *M. productus* (Kashiwada et al., 1979; Harvey et al., 2000). This increase in sample size translates to increased precision in the regression relationships such that uncertainty in population mean relationships is now relatively small in magnitude for most key forage species (Table 3).

Harvey et al. (2000) provide an overview of the key caveats to be considered in applying regressions to calculate animal size from hard part size. These include nonlinearities in otolith size to fish size for some fish species, potential dependence on growth rate of hard part size to animal length, and erosion of otoliths and perhaps other prey hard parts in digestive tracts, sediments, or other environments (e.g., Jobling and Breiby, 1986; Jones 2016), which can lead to underestimation of animal size. This study addresses some of these caveats by extending data ranges to include more size classes. Elsewhere, predator- and prey-specific correction factors for prey length have been estimated from captive feeding experiments (e.g., Harvey 1989; Tollitt et al., 1997; Sweeney and Harvey, 2011). The otolith morphometric data provided in this study may provide a basis for developing a more generalized length correction factor, since length reduction tends to be positively related to otolith size.

This reference data set can be expanded through future work to fill remaining taxonomic gaps, particularly for octopodids and elasmobranchs, and to incorporate more sources of variability in morphometric relationships, such as interannual and geographic, to more accurately reflect population means. Compiling this data set with others will also further improve taxonomic and size coverage and sample sizes. The data and regression parameters published here provide a building block for such further work in addition to improving and facilitating reconstruction of predator diets in the CCLME, among other potential applications.

Data Accessibility

Data and regression summaries are available from SEANOE (Lowry et al., 2020) and from the NOAA Fisheries SWFSC Environmental Research Division ERDDAP deployment (https://oceanview.pfeg.noaa.gov/erddap/search/index.html?searchFor=PreySizeHP).

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Author Contributions

MSL designed and directed the study, collected most of the measurements, conducted preliminary data analysis, and helped draft the manuscript. KAC organized, edited, and analyzed the data, and drafted the manuscript. CMB designed and implemented data collection for halfmoon, and helped edit the manuscript.

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Table 1. Whole-specimen and hard-part dimensions (and abbreviations) that were measured for specimens of each taxon / prey type included in the study. Whole specimens of all taxa were weighed. No whole-specimen length dimension was measured for Decapoda. No hard part dimensions were measured for Myxinidae. For some teleost whole specimens, total length (TL) or fork length (FL) were also measured, but no regressions were fitted to those dimensions. The recoverable digestion resistant "hard part" for tunicates, the test, is also the whole-specimen dimension.

Taxon / Prey type	**Whole specimen dimension**	**Hard part dimension(s)**
Batoidea	Total length (TL)	Tooth width (THW)
Cephalopoda	Dorsal mantle length (ML)	
Doryteuthis opalescens		Upper rostrum width (URW)
Other Decapodiformes		Upper and lower rostrum length (URL, LRL)
Octopodiformes		Upper and lower hood length (UHL, LHL)
Decapoda	–	Dactylus length (DCL)
Myxinidae	Total length (TL)	–
Teleostei	Standard length (SL)	Otolith length and width (OL, OW)
Tunicata	Test length (TSL)	Test length (TSL)

Table 2. Summary of reference specimen measurements. Prey type dictated whole-specimen length dimensions (L1, L2) and prey part dimensions (P1, P2) measured (Table 1), ranges of whole specimens and prey parts measured are provided, and N indicates sample size for each potential regression among prey sizes, prey weight (Wt), and prey parts. Abbreviations for specimen and prey part dimensions are provided in Table 1. Data drawn from external sources for regressions are: most data for *M. californiensis*, which supported Boerger (2008), of which standard length and weight were previously summarized by a regression (Boerger 2008; Bredvik et al., 2011), and some data for *O. mykiss*, *S. goodei*, and *S. jordani*, part of which supported previously published regressions (Sweeney and Harvey, 2011).

Prey type	Species	Family	L1	L2	P1	P2	Range L1 (mm)	Range P1 (mm)	N L1 v P1	N P1 v P2	N Wt v L1	N L1 v L2
batoid	*Beringraja inornata*	Rajidae	TL		THW		150 - 590	0.5 - 1.1	6	0	19	0
batoid	*Beringraja rhina*	Rajidae	TL		THW		160 - 720	0.2 - 1.2	12	0	31	0
cephalopod	*Abraliopsis felis*	Enoploteuthidae	ML		URL	LRL	17 - 59	0.5 - 1.3	67	65	70	0
cephalopod	*Chiroteuthis calyx*	Chiroteuthidae			URL	LRL		1.3 - 1.3	0	1	0	0
cephalopod	*Cranchia scabra*	Cranchiidae	ML		URL	LRL	60 - 114	0.8 - 1.9	7	7	8	0
cephalopod	*Doryteuthis opalescens*	Loliginidae	ML		URW		41 - 163	0.5 - 1.7	128	0	134	0
cephalopod	*Gonatopsis borealis*	Gonatidae	ML		URL	LRL	23 - 133	0.4 - 3.2	53	52	54	0
cephalopod	*Gonatus onyx*	Gonatidae	ML		URL	LRL	39 - 65	1.2 - 2.6	12	12	12	0
cephalopod	*Haliphron atlanticus*	Alloposidae	ML		UHL	LHL	62 - 62	10.3 - 10.3	1	1	1	0
cephalopod	*Leachia dislocata*	Cranchiidae	ML		URL	LRL	11 - 17	0.5 - 0.9	3	4	3	0
cephalopod	*Octopus bimaculatus*	Octopodidae	ML		UHL	LHL	32 - 44	2.2 - 2.5	4	4	4	0
cephalopod	*Octopus rubescens*	Octopodidae	ML		UHL	LHL	75 - 75	4.9 - 4.9	1	1	1	0
cephalopod	*Ocythoe tuberculata*	Ocythoidae	ML		UHL	LHL	20 - 335	7.3 - 23.2	13	13	18	0
cephalopod	*Onychoteuthis borealijaponica*	Onychoteuthidae	ML		URL	LRL	56 - 240	1.6 - 5.7	52	51	55	0
cephalopod	*Onykia robusta*	Onychoteuthidae			URL	LRL		3.3 - 3.3	0	1	0	0
decapod	*Pleuroncodes planipes*[1]	Munididae			DCL			9.5 - 21.4	0	0	0	0
hagfish	*Eptatretus stoutii*	Myxinidae	TL				100 - 480		0	0	29	0
teleost	*Allosmerus elongatus*	Osmeridae	SL				42 - 116		0	0	14	0
teleost	*Ammodytes hexapterus*	Ammodytidae	SL		OL	OW	55 - 187	2.5 - 3.2	4	4	0	0
teleost	*Amphistichus argenteus*	Embiotocidae	SL		OL	OW	71 - 145	2.9 - 5.5	7	7	7	0
teleost	*Anoplopoma fimbria*	Anoplopomatidae			OL	OW		2.4 - 11.8	0	26	0	0
teleost	*Arctozenus risso*	Paralepididae	SL	TL	OL	OW	56 - 252	3.3 - 3.3	0	1	20	14

[1] No prey lengths were measured for *Pleuroncodes planipes*, so sample sizes for regression appear as zero here, but a regression for weight to hard part size is provided in Table 3.

Table 2 (continued).

Prey type	Species	Family	L1	L2	P1	P2	Range L1 (mm)	Range P1 (mm)	N L1 v P1	N P1 v P2	N Wt v L1	N L1 v L2
teleost	*Argentina sialis*	Argentinidae	SL		OL	OW	45 - 175	1.2 - 5.2	3	25	50	0
teleost	*Artedius corallinus*	Cottidae	SL	TL	OL	OW	23 - 107	1.9 - 4	0	11	40	40
teleost	*Artedius notospilotus*	Cottidae	SL	TL	OL	OW	56 - 163	2.9 - 6.2	8	17	34	34
teleost	*Atherinops affinis*	Atherinopsidae	SL		OL	OW	98 - 108	2.1 - 4.9	10	39	10	0
teleost	*Atherinopsis californiensis*	Atherinopsidae	SL		OL	OW	162 - 287	3.5 - 7	11	24	11	0
teleost	*Atractoscion nobilis*	Sciaenidae	SL	TL			38 - 262		0	0	28	27
teleost	*Benthalbella dentata*	Scopelarchidae			OL	OW		3 - 3.6	0	3	0	0
teleost	*Brama japonica*	Bramidae			OL	OW		4.9 - 4.9	0	1	0	0
teleost	*Brosmophycis marginata*	Bythitidae	SL	TL	OL	OW	46 - 245	2.6 - 13.8	0	17	31	31
teleost	*Careproctus melanurus*	Liparidae	SL	TL	OL	OW	82 - 210	2.4 - 3.1	0	5	33	33
teleost	*Ceratoscopelus townsendi*	Myctophidae	SL		OL	OW	49 - 68	1.4 - 3.7	22	65	23	0
teleost	*Cheilopogon pinnatibarbatus*	Exocoetidae	SL	TL	OL	OW	32 - 335	8.4 - 11.6	2	9	18	16
teleost	*Chilara taylori*	Ophidiidae	SL		OL	OW	93 - 215	1.4 - 11.3	7	37	6	0
teleost	*Chitonotus pugetensis*	Cottidae	SL		OL	OW	78 - 107	3.1 - 5.6	12	23	0	0
teleost	*Chromis punctipinnis*	Pomacentridae	SL	FL	OL	OW	39 - 195	2.4 - 7.5	17	31	57	54
teleost	*Citharichthys sordidus*	Paralichthyidae	SL		OL	OW	34 - 335	1.1 - 7.9	27	23	27	0
teleost	*Citharichthys stigmaeus*	Paralichthyidae	SL		OL	OW	45 - 99	0.8 - 3.6	9	29	10	0
teleost	*Citharichthys xanthostigma*	Paralichthyidae			OL	OW		3.1 - 6.5	0	26	0	0
teleost	*Clupea pallasii*	Clupeidae			OL	OW		1.8 - 5.3	0	45	0	0
teleost	*Cololabis saira*	Scomberesocidae	SL	FL	OL	OW	68 - 251	0.8 - 2.4	21	37	77	47
teleost	*Cymatogaster aggregata*	Embiotocidae	SL		OL	OW	90 - 114	2.1 - 7.7	5	96	5	0
teleost	*Diaphus theta*	Myctophidae	SL		OL	OW	31 - 61	1.1 - 3.2	21	49	21	0
teleost	*Embiotoca jacksoni*	Embiotocidae	SL		OL	OW	140 - 177	2.8 - 9.3	0	29	5	0
teleost	*Engraulis mordax*	Engraulidae	SL	FL	OL	OW	50 - 157	1.7 - 5.3	107	106	239	55
teleost	*Eucryphycus californicus*	Zoarcidae	SL	TL			66 - 170		0	0	9	9
teleost	*Genyonemus lineatus*	Sciaenidae	SL		OL	OW	86 - 341	5.3 - 16.8	13	24	12	0
teleost	*Girella nigricans*	Girellidae	SL	FL	OL	OW	46 - 358	3 - 11.5	2	14	31	30
teleost	*Glyptocephalus zachirus*	Pleuronectidae	SL	TL	OL	OW	45 - 340	3.2 - 7.4	2	49	46	46
teleost	*Halichoeres californica*	Labridae	SL	FL	OL	OW	42 - 194	1.1 - 4	14	25	59	15

Table 2 (continued).

Prey type	Species	Family	L1	L2	P1	P2	Range L1 (mm)	Range P1 (mm)	N L1 v P1	N P1 v P2	N Wt v L1	N L1 v L2
teleost	*Halichoeres semicinctus*	Labridae	SL				162 - 207		0	0	2	0
teleost	*Heterostichus rostratus*	Clinidae	SL	FL	OL	OW	82 - 340	1.7 - 3.8	2	10	29	28
teleost	*Hippoglossina stomata*	Paralichthyidae	SL		OL	OW	190 - 190	3 - 5.3	0	22	1	0
teleost	*Hyperprosopon argenteum*	Embiotocidae	SL		OL	OW	125 - 186	5.5 - 8.5	5	5	5	0
teleost	*Hypocritichthys analis*	Embiotocidae	SL	TL	OL	OW	34 - 120	4.4 - 7.6	4	25	39	39
teleost	*Hypomesus pretiosus*	Osmeridae	SL		OL	OW	145 - 145	3.4 - 4.9	1	22	0	0
teleost	*Icelinus filamentosus*	Cottidae	SL	TL	OL	OW	47 - 203	4.2 - 10.4	1	31	36	36
teleost	*Icelinus fimbriatus*	Cottidae	SL	TL	OL	OW	85 - 163	4.6 - 7.9	0	10	9	9
teleost	*Icelinus tenuis*	Cottidae	SL	TL	OL	OW	36 - 110	3.4 - 4.9	0	16	50	50
teleost	*Icichthys lockingtoni*	Centrolophidae	SL		OL	OW	25 - 325	2.3 - 11	9	22	54	0
teleost	*Lampadena urophaos*	Myctophidae	SL	TL			31 - 113		0	0	31	30
teleost	*Lampanyctus ritteri*	Myctophidae	SL		OL	OW	29 - 115	0.7 - 1.6	6	33	54	0
teleost	*Lepidopsetta bilineata*	Pleuronectidae	SL	TL	OL	OW	29 - 205	0.9 - 9	0	9	23	23
teleost	*Leptocottus armatus*	Cottidae	SL		OL	OW	106 - 144	3.7 - 9.4	3	30	0	0
teleost	*Lestidiops ringens*	Paralepididae	SL	TL	OL	OW	52 - 209	1.6 - 2.9	5	17	31	29
teleost	*Leuresthes tenuis*	Atherinopsidae	SL		OL	OW	102 - 168	2.6 - 4.2	8	17	0	0
teleost	*Leuroglossus stilbius*	Bathylagidae	SL		OL	OW	45 - 105	1.7 - 3.7	14	38	38	0
teleost	*Lycodes cortezianus*	Zoarcidae	SL		OL	OW	360 - 420	3.1 - 5.3	3	14	0	0
teleost	*Lycodes pacificus*	Zoarcidae	SL	TL	OL	OW	81 - 222	2.8 - 4.7	0	10	46	46
teleost	*Lyconema barbatum*	Zoarcidae	SL	TL	OL	OW	74 - 139	2 - 2.6	0	7	40	40
teleost	*Lyopsetta exilis*	Pleuronectidae	SL		OL	OW	44 - 49	1.9 - 5.3	2	53	4	0
teleost	*Magnisudis atlantica*	Paralepididae	SL	TL	OL	OW	55 - 310	2.1 - 5.5	0	6	6	5
teleost	*Mallotus villosus*	Osmeridae			OL	OW		2 - 3.4	0	68	0	0
teleost	*Medialuna californiensis*	Scorpididae	SL		OL	OW	153 - 299	4.7 - 9.4	113	124	117	0
teleost	*Melamphaes lugubris*	Melamphaidae	SL	TL	OL	OW	20 - 110	1.6 - 5.4	0	20	49	1
teleost	*Merluccius productus*	Merlucciidae	SL	TL	OL	OW	40 - 650	1.2 - 24.1	205	139	459	68
teleost	*Microgadus proximus*	Gadidae			OL	OW		1.9 - 13.8	0	24	0	0
teleost	*Microstomus pacificus*	Pleuronectidae	SL		OL	OW	50 - 56	1 - 8.1	2	42	0	0
teleost	*Oncorhynchus gorbuscha*	Salmonidae	SL	FL	OL	OW	87 - 552	1.1 - 4.5	201	272	331	71

Table 2 (continued).

Prey type	Species	Family	L1	L2	P1	P2	Range L1 (mm)	Range P1 (mm)	N L1 v P1	N P1 v P2	N Wt v L1	N L1 v L2
teleost	*Oncorhynchus kisutch*	Salmonidae			OL	OW		4 - 5.2	0	4	0	0
teleost	*Oncorhynchus mykiss*	Salmonidae	SL		OL	OW	143 - 460	3 - 6.1	52	64	55	0
teleost	*Ophidion scrippsae*	Ophidiidae			OL	OW		3.7 - 7.9	0	29	0	0
teleost	*Ophiodon elongatus*	Hexagrammidae	SL	TL	OL	OW	67 - 336	2.5 - 12.1	0	21	29	29
teleost	*Orthonopias triacis*	Cottidae	SL	TL	OL	OW	30 - 84	2.3 - 3	0	11	50	50
teleost	*Oxylebius pictus*	Hexagrammidae	SL	TL	OL	OW	37 - 146	1.6 - 4.3	6	20	40	40
teleost	*Paralabrax clathratus*	Serranidae	SL	TL	OL	OW	34 - 385	7.8 - 13.7	13	15	35	34
teleost	*Paralabrax nebulifer*	Serranidae	SL	TL	OL	OW	39 - 223	8.4 - 12.5	0	5	50	50
teleost	*Paralepididae*	Paralepididae	SL				184 - 184		0	0	1	0
teleost	*Paralichthys californicus*	Paralichthyidae	SL		OL	OW	92 - 355	2.8 - 8.2	5	5	5	0
teleost	*Parophrys vetulus*	Pleuronectidae	SL	TL	OL	OW	39 - 285	2.4 - 9.5	0	59	56	55
teleost	*Peprilus simillimus*	Stromateidae	SL		OL	OW	103 - 167	3.6 - 6.2	14	30	16	0
teleost	*Phanerodon furcatus*	Embiotocidae	SL		OL	OW	65 - 189	3.8 - 9.7	6	60	5	0
teleost	*Phanerodon vacca*	Embiotocidae	SL		OL	OW	168 - 219	7.7 - 9.9	7	7	7	0
teleost	*Physiculus rastrelliger*	Moridae	SL	TL	OL	OW	63 - 203	4.5 - 10.2	5	17	58	49
teleost	*Pleuronichthys decurrens*	Pleuronectidae	SL		OL	OW	205 - 205	5.2 - 5.2	1	1	1	0
teleost	*Pleuronichthys ritteri*	Pleuronectidae	SL		OL	OW	47 - 196	1.6 - 4.5	15	15	16	0
teleost	*Pleuronichthys verticalis*	Pleuronectidae	SL		OL	OW	94 - 194	2.5 - 2.5	1	1	4	0
teleost	*Porichthys myriaster*	Batrachoididae			OL	OW		3.5 - 13.8	0	21	0	0
teleost	*Porichthys notatus*	Batrachoididae			OL	OW		1.6 - 11.1	0	48	0	0
teleost	*Prionotus stephanophrys*	Triglidae	SL		OL	OW	57 - 295	2.3 - 10.6	4	11	0	0
teleost	*Protomyctophum crockeri*	Myctophidae	SL	TL	OL	OW	20 - 53	1 - 2.6	6	44	19	18
teleost	*Radulinus asprellus*	Cottidae	SL	TL	OL	OW	45 - 113	2.1 - 4.3	0	37	39	39
teleost	*Rathbunella hypoplecta*	Bathymasteridae	SL	TL	OL	OW	78 - 180	2.2 - 3.5	10	10	11	11
teleost	*Rhinogobiops nicholsii*	Gobiidae	SL	TL	OL	OW	22 - 77	0.9 - 3.3	5	47	48	48
teleost	*Ruscarius creaseri*	Cottidae	SL	TL	OL	OW	24 - 61	2 - 3.3	1	11	30	30
teleost	*Sarda chiliensis*	Scombridae	SL	FL	OL	OW	38 - 256	3.3 - 8.1	0	17	35	35
teleost	*Sardinops sagax*	Clupeidae	SL	FL	OL	OW	45 - 252	1.5 - 4.8	312	261	390	57
teleost	*Scomber japonicus*	Scombridae	SL	FL	OL	OW	52 - 406	1.1 - 6.6	223	242	279	36

Table 2 (continued).

Prey type	Species	Family	L1	L2	P1	P2	Range L1 (mm)	Range P1 (mm)	N L1 v P1	N P1 v P2	N Wt v L1	N L1 v L2
teleost	*Scopelengys tristis*	Neoscopelidae	SL		OL	OW	58 - 172	1.5 - 3.2	4	10	0	0
teleost	*Sebastes aurora*	Sebastidae			OL	OW		10.2 - 15.7	0	8	0	0
teleost	*Sebastes caurinus*	Sebastidae	SL	TL	OL	OW	28 - 265	5 - 17	0	17	41	41
teleost	*Sebastes dallii*	Sebastidae	SL	TL			42 - 160		0	0	53	51
teleost	*Sebastes diploproa*	Sebastidae	SL	TL	OL	OW	40 - 235	3.1 - 16.7	5	25	43	34
teleost	*Sebastes elongatus*	Sebastidae	SL	TL	OL	OW	68 - 246	2.5 - 15	0	16	39	39
teleost	*Sebastes ensifer*	Sebastidae	SL	TL	OL	OW	25 - 182	5.6 - 10.8	0	23	24	24
teleost	*Sebastes entomelas*	Sebastidae	SL	TL	OL	OW	42 - 179	13.6 - 18.7	0	8	22	22
teleost	*Sebastes goodei*	Sebastidae	SL	TL	OL	OW	31 - 280	1.2 - 19	20	41	65	47
teleost	*Sebastes hopkinsi*	Sebastidae	SL	TL	OL	OW	37 - 230	1.2 - 9.9	19	44	58	52
teleost	*Sebastes jordani*	Sebastidae	SL	TL	OL	OW	34 - 212	1.2 - 13.3	59	96	108	73
teleost	*Sebastes lentiginosus*	Sebastidae	SL	TL	OL	OW	79 - 188	8.4 - 9	0	5	11	11
teleost	*Sebastes levis juvenile*	Sebastidae	SL	TL	OL	OW	33 - 59	0.9 - 1.8	4	4	4	4
teleost	*Sebastes miniatus*	Sebastidae	SL	TL	OL	OW	41 - 248	4.9 - 17.7	0	17	45	44
teleost	*Sebastes mystinus*	Sebastidae	SL	TL	OL	OW	43 - 387	5 - 16.9	3	14	40	40
teleost	*Sebastes paucispinis*	Sebastidae	SL	TL	OL	OW	51 - 287	2.4 - 17.5	4	27	46	46
teleost	*Sebastes proriger*	Sebastidae	SL	TL	OL	OW	115 - 346	12.1 - 18.2	0	10	20	20
teleost	*Sebastes rosenblatti*	Sebastidae	SL		OL	OW	91 - 135	5.6 - 7.5	3	3	3	0
teleost	*Sebastes rufus*	Sebastidae	SL	TL	OL	OW	145 - 355	12.7 - 17.7	0	13	8	8
teleost	*Sebastes saxicola*	Sebastidae	SL	TL	OL	OW	43 - 202	4 - 15	0	31	60	59
teleost	*Sebastes semicinctus*	Sebastidae	SL	TL	OL	OW	33 - 157	1.6 - 8.2	6	28	61	57
teleost	*Sebastes serranoides*	Sebastidae	SL		OL	OW	113 - 197	6.2 - 18	3	23	0	0
teleost	*Sebastes simulator*	Sebastidae	SL	TL	OL	OW	122 - 235	8.7 - 8.7	0	1	10	10
teleost	*Sebastes umbrosus*	Sebastidae	SL	TL	OL	OW	82 - 215	5.9 - 12.8	0	11	16	16
teleost	*Sebastes wilsoni*	Sebastidae	SL	TL	OL	OW	75 - 171	4.8 - 9.5	0	12	24	24
teleost	*Sebastolobus alascanus*	Sebastidae			OL	OW		2.5 - 16.2	0	42	0	0
teleost	*Semicossyphus pulcher*	Labridae	SL	TL	OL	OW	93 - 230	6.3 - 9.9	0	8	16	16
teleost	*Seriola dorsalis*	Carangidae	SL		OL	OW	355 - 355	7.9 - 7.9	1	1	0	0
teleost	*Seriphus politus*	Sciaenidae	SL		OL	OW	60 - 260	3.8 - 11.7	22	34	33	0

Table 2 (continued).

Prey type	Species	Family	L1	L2	P1	P2	Range L1 (mm)	Range P1 (mm)	N L1 v P1	N P1 v P2	N Wt v L1	N L1 v L2
teleost	*Sphyraena argentea*	Sphyraenidae	SL		OL	OW	160 - 730	5.6 - 18.3	7	24	5	0
teleost	*Stenobrachius leucopsarus*	Myctophidae	SL		OL	OW	37 - 86	0.7 - 2	44	75	57	0
teleost	*Strongylura exilis*	Belonidae			OL	OW		2.5 - 6	0	8	0	0
teleost	*Symbolophorus californiensis*	Myctophidae	SL		OL	OW	44 - 102	1.3 - 5	56	98	58	0
teleost	*Symphurus atricauda*	Cynoglossidae			OL	OW		2.2 - 2.6	0	8	0	0
teleost	*Synodus lucioceps*	Synodontidae	SL	FL	OL	OW	48 - 465	2.2 - 8.8	2	19	47	47
teleost	*Tarletonbeania crenularis*	Myctophidae	SL		OL	OW	35 - 72	1.1 - 2.1	24	47	30	0
teleost	*Tetragonurus cuvieri*	Tetragonuridae	SL	FL	OL	OW	46 - 300	1.2 - 3.7	4	10	12	9
teleost	*Thaleichthys pacificus*	Osmeridae	SL		OL	OW	80 - 214	2 - 4.7	5	27	0	0
teleost	*Trachurus symmetricus*	Carangidae	SL	FL	OL	OW	30 - 320	1.4 - 11.2	113	142	197	49
teleost	*Triphoturus mexicanus*	Myctophidae	SL		OL	OW	28 - 66	0.9 - 1.5	0	14	51	0
teleost	*Xeneretmus ritteri*	Agonidae	SL	TL	OL	OW	117 - 140	3.6 - 5.1	0	10	9	9
teleost	*Xeneretmus triacanthus*	Agonidae	SL	TL	OL	OW	71 - 200	3.1 - 4.6	0	11	36	36
teleost	*Zalembius rosaceus*	Embiotocidae	SL		OL	OW	113 - 117	2.1 - 7.6	0	32	3	0
teleost	*Zaniolepis frenata*	Zaniolepididae	SL		OL	OW	50 - 212	3.8 - 5.6	2	12	52	0
teleost	*Zaniolepis latipinnis*	Zaniolepididae	SL		OL	OW	52 - 177	1.1 - 5.1	2	21	40	0
tunicate	*Pyrosoma atlanticum*	Pyrosomatidae	TSL		TSL		20 - 230	20 - 230	61	0	61	0

Table 3. Regression summaries for prey size and hard part dimensions, for documented prey of California sea lions in the Southern California Bight and for prey species used in captive feeding studies of California sea lions. Some species for which regression relationships based on higher sample sizes were already available were omitted. Taxonomic level of data aggregation for regression, response (y) and independent (x) variables, with abbreviations defined in Table 1, intercept (b_0), slope (b_1), and respective standard errors (se_{b0}, se_{b1}), coefficient of determination (R^2), and sample size (n). Regressions of weight (Wt) versus length are ln-ln; all others are simple linear regressions. Residual variances for bias-correction in back-transformation of ln-ln regressions are available online (see Data Accessibility). Units are mm (lengths) and g (Wt). Data for *O. tuberculata* regressions were taken from Salman and Akalin (2012). See Table 2 for additional external data sources.

Taxon	**y**	**x**	**b_0**	**b_1**	**se_{b0}**	**se_{b1}**	**R^2**	**n**	**P**
Anoplopoma fimbria	OL	OW	-2.990	3.922	0.50	0.18	0.949	26	< 0.0001
Argentina sialis	OL	OW	-0.070	1.534	0.068	0.034	0.989	25	< 0.0001
	SL	OL	0	36.21	–	0.94	0.999	3	0.0007
	Wt	SL	-12.950	3.244	0.27	0.058	0.985	50	< 0.0001
Artedius notospilotus	OL	OW	0	2.042	–	0.033	0.996	17	< 0.0001
	SL	OL	0	24.73	–	0.48	0.997	8	< 0.0001
	Wt	SL	-11.738	3.236	0.47	0.11	0.966	34	< 0.0001
Atherinopsidae	OL	OW	-0.899	1.767	0.18	0.063	0.910	80	< 0.0001
	SL	OL	-13.197	42.18	4.5	1.1	0.983	29	< 0.0001
	Wt	SL	-10.606	2.849	0.36	0.072	0.988	21	< 0.0001
Batoidea	TL	THW	0	573.1	–	24.	0.971	18	< 0.0001
	Wt	TL	-12.824	3.073	0.37	0.064	0.979	50	< 0.0001
Ceratoscopelus townsendi	OL	OW	-0.246	1.784	0.17	0.11	0.808	65	< 0.0001
	SL	OL	21.955	14.08	8.2	3.1	0.513	22	0.0002
	Wt	SL	-10.552	2.841	1.9	0.48	0.628	23	< 0.0001
Cheilopogon pinnatibarbatus	OL	OW	0	2.467	–	0.091	0.989	9	< 0.0001
	SL	OL	0	32.96	–	0.13	–	2	0.0024
	Wt	SL	-12.911	3.246	0.17	0.033	0.998	18	< 0.0001
Chilara taylori	OL	OW	-0.344	1.650	0.15	0.035	0.985	37	< 0.0001
Chromis punctipinnis	OL	OW	-0.956	2.251	0.42	0.14	0.894	31	< 0.0001
	SL	OL	0	25.07	–	0.41	0.996	17	< 0.0001
	Wt	SL	-11.389	3.204	0.22	0.048	0.988	57	< 0.0001
Citharichthys sordidus	OL	OW	-0.339	1.088	0.19	0.040	0.973	23	< 0.0001
	SL	OL	-32.407	42.04	5.4	1.7	0.959	27	< 0.0001
	Wt	SL	-12.787	3.327	0.23	0.053	0.994	27	< 0.0001
Citharichthys stigmaeus	OL	OW	-0.185	1.174	0.10	0.041	0.969	29	< 0.0001
	SL	OL	0	30.73	–	0.85	0.994	9	< 0.0001
	Wt	SL	-11.372	3.069	0.82	0.19	0.971	10	< 0.0001
Clupea pallasii	OL	OW	-0.438	2.469	0.23	0.13	0.892	45	< 0.0001
Cololabis saira	OL	OW	-0.012	1.588	0.077	0.079	0.921	37	< 0.0001
	SL	OL	-48.783	170.0	27.	19.	0.813	21	< 0.0001
	Wt	SL	-13.379	3.190	0.19	0.038	0.989	77	< 0.0001

Table 3 (continued).

Taxon	y	x	b_0	b_1	se_{b0}	se_{b1}	R^2	n	P
Cranchia scabra	ML	URL	0	61.09	–	1.6	0.996	7	< 0.0001
	ML	LRL	0	61.23	–	1.7	0.995	7	< 0.0001
	Wt	ML	-9.602	2.758	2.3	0.51	0.831	8	0.0016
Cymatogaster aggregata	OL	OW	-0.316	1.610	0.21	0.057	0.894	96	< 0.0001
Diaphus theta	OW	OL	0.123	0.7564	0.041	0.020	0.969	49	< 0.0001
Doryteuthis opalescens	ML	URW	-7.779	93.03	3.4	2.8	0.894	128	< 0.0001
	Wt	ML	-9.053	2.640	0.13	0.028	0.985	134	< 0.0001
Embiotoca jacksoni	OL	OW	-1.982	2.410	0.42	0.11	0.942	29	< 0.0001
Engraulis mordax	OL	OW	-0.162	2.323	0.12	0.074	0.906	106	< 0.0001
	Wt	SL	-12.655	3.240	0.27	0.057	0.931	239	< 0.0001
Genyonemus lineatus	OL	OW	-4.448	2.840	0.60	0.13	0.959	24	< 0.0001
	SL	OL	0	18.66	–	0.39	0.995	13	< 0.0001
	Wt	SL	-11.533	3.151	0.48	0.10	0.990	12	< 0.0001
Girella nigricans	OL	OW	0	1.979	–	0.048	0.992	14	< 0.0001
	SL	OL	0	39.27	–	3.4	–	2	0.0555
Glyptocephalus zachirus	OL	OW	0.904	0.9491	0.45	0.088	0.714	49	< 0.0001
Halichoeres californica	OL	OW	-0.187	1.905	0.24	0.14	0.888	25	< 0.0001
	SL	OL	0	47.54	–	0.85	0.996	14	< 0.0001
	Wt	SL	-12.034	3.147	0.26	0.054	0.984	59	< 0.0001
Haliphron atlanticus	LHL	UHL	0	0.6369	–	–	–	1	–
	ML	UHL	0	6.068	–	–	–	1	–
	ML	LHL	0	9.527	–	–	–	1	–
Heterostichus rostratus	OL	OW	0	2.204	–	0.081	0.988	10	< 0.0001
	SL	OL	0	86.19	–	3.9	–	2	0.0289
	Wt	SL	-13.673	3.378	0.29	0.056	0.993	29	< 0.0001
Hypocritichthys analis	OL	OW	-1.928	2.246	0.62	0.18	0.871	25	< 0.0001
	SL	OL	0	16.50	–	0.18	1.000	4	< 0.0001
	Wt	SL	-10.009	2.844	0.12	0.029	0.996	39	< 0.0001
Icelinus filamentosus	OL	OW	-1.906	2.499	0.58	0.15	0.907	31	< 0.0001
	SL	OL	0	21.28	–	–	–	1	–
	Wt	SL	-11.966	3.210	0.18	0.038	0.995	36	< 0.0001
Icichthys lockingtoni	OL	OW	-0.697	2.921	0.21	0.078	0.986	22	< 0.0001
	SL	OL	0	25.78	–	1.2	0.982	9	< 0.0001
	Wt	SL	-10.751	2.894	0.25	0.058	0.980	54	< 0.0001
Lampanyctus ritteri	OL	OW	-0.059	0.8299	0.11	0.070	0.821	33	< 0.0001
	SL	OL	0	66.86	–	3.3	0.988	6	< 0.0001
	Wt	SL	-11.156	2.862	0.26	0.061	0.977	54	< 0.0001
Leptocottus armatus	OL	OW	-0.432	2.218	0.53	0.17	0.866	30	< 0.0001
Lestidiops ringens	OL	OW	0	1.688	–	0.015	0.999	17	< 0.0001
	SL	OL	0	75.43	–	2.6	0.995	5	< 0.0001
	Wt	SL	-17.020	3.690	0.48	0.10	0.979	31	< 0.0001
Leuroglossus stilbius	OL	OW	-0.666	3.178	0.27	0.27	0.799	38	< 0.0001

Table 3 (continued).

Taxon	y	x	b_0	b_1	se_{b0}	se_{b1}	R^2	n	P
Leuroglossus stilbius	SL	OL	0	28.32	–	0.29	0.999	14	< 0.0001
	Wt	SL	-14.114	3.488	0.61	0.14	0.943	38	< 0.0001
Lycodes cortezianus	OL	OW	0	1.468	–	0.018	0.998	14	< 0.0001
Lycodes pacificus	OL	OW	0	1.657	–	0.033	0.996	10	< 0.0001
	Wt	SL	-12.582	2.999	0.41	0.082	0.968	46	< 0.0001
Lyopsetta exilis	OL	OW	0.013	1.433	0.20	0.072	0.887	53	< 0.0001
Medialuna californiensis	Wt	SL	-9.513	2.811	0.57	0.11	0.857	117	< 0.0001
	OL	OW	-0.110	2.163	0.42	0.13	0.696	124	< 0.0001
	SL	OL	24.480	27.52	11.	1.6	0.738	113	< 0.0001
Merluccius productus	OL	OW	-1.930	2.963	0.27	0.055	0.955	139	< 0.0001
	SL	OL	-37.331	23.82	5.2	0.47	0.927	205	< 0.0001
	Wt	SL	-10.768	2.809	0.10	0.018	0.982	459	< 0.0001
Microstomus pacificus	OL	OW	-0.736	1.919	0.24	0.095	0.910	42	< 0.0001
Octopus spp.	ML	UHL	0	15.96	–	0.66	0.993	5	< 0.0001
	ML	LHL	0	23.48	–	1.2	0.990	5	< 0.0001
	Wt	ML	-11.616	3.916	2.6	0.67	0.918	5	0.0102
Ocythoe tuberculata	ML	UHL	0	12.62	–	0.54	0.979	13	< 0.0001
	ML	LHL	0	16.65	–	0.65	0.979	15	< 0.0001
	Wt	ML	-5.109	2.331	1.1	0.21	0.886	18	< 0.0001
Oncorhynchus gorbuscha	OL	OW	-0.104	1.439	0.057	0.028	0.908	272	< 0.0001
	SL	OL	-63.063	158.1	23.	7.5	0.691	201	< 0.0001
	Wt	SL	-11.225	2.979	0.054	0.0093	0.997	331	< 0.0001
Oncorhynchus mykiss	OL	OW	0.440	1.464	0.13	0.060	0.905	64	< 0.0001
	SL	OL	-157.546	101.0	23.	6.7	0.821	52	< 0.0001
	Wt	SL	-11.283	2.995	0.37	0.070	0.972	55	< 0.0001
Onychoteuthis borealijaponica	ML	URL	10.208	41.00	8.8	2.5	0.845	52	< 0.0001
	ML	LRL	-19.893	50.99	7.1	2.1	0.922	53	< 0.0001
	Wt	ML	-10.005	2.867	0.15	0.029	0.994	55	< 0.0001
Ophiodon elongatus	OL	OW	-1.310	2.910	0.45	0.13	0.961	21	< 0.0001
	Wt	SL	-13.105	3.258	0.21	0.043	0.995	29	< 0.0001
Oxylebius pictus	OL	OW	0.399	1.806	0.31	0.19	0.836	20	< 0.0001
	SL	OL	0	33.85	–	1.7	0.988	6	< 0.0001
	Wt	SL	-11.298	3.097	0.12	0.028	0.997	40	< 0.0001
Paralabrax clathratus	OL	OW	0	2.581	–	0.039	0.997	15	< 0.0001
	SL	OL	0	27.12	–	0.42	0.997	13	< 0.0001
	Wt	SL	-10.623	2.960	0.15	0.032	0.996	35	< 0.0001
Parophrys vetulus	OL	OW	-0.985	2.056	0.30	0.081	0.919	59	< 0.0001
Peprilus simillimus	OL	OW	-0.428	2.212	0.55	0.24	0.758	30	< 0.0001
	SL	OL	0	25.41	–	0.50	0.995	14	< 0.0001
	Wt	SL	-10.844	3.065	0.84	0.17	0.957	16	< 0.0001
Phanerodon spp.	OL	OW	-2.522	2.288	0.43	0.098	0.893	67	< 0.0001
	SL	OL	0	22.19	–	0.40	0.996	13	< 0.0001

Table 3 (continued).

Taxon	y	x	b_0	b_1	se_{b0}	se_{b1}	R^2	n	P
Phanerodon spp.	Wt	SL	-11.444	3.219	1.1	0.21	0.961	12	< 0.0001
Physiculus rastrelliger	OL	OW	0	2.598	–	0.047	0.995	17	< 0.0001
	SL	OL	0	20.23	–	0.33	0.999	5	< 0.0001
	Wt	SL	-12.708	3.207	0.24	0.049	0.987	58	< 0.0001
Pleuroncodes planipes	Wt	DCL	-5.050	2.514	0.32	0.12	0.914	41	< 0.0001
Porichthys notatus	OL	OW	-1.259	1.537	0.22	0.045	0.962	48	< 0.0001
Protomyctophum crockeri	OL	OW	0.170	1.006	0.057	0.032	0.959	44	< 0.0001
	SL	OL	0	17.21	–	0.12	1.000	6	< 0.0001
	Wt	SL	-14.371	3.932	0.91	0.26	0.932	19	< 0.0001
Pyrosoma atlanticum	Wt	TSL	-5.880	1.867	0.21	0.051	0.958	61	< 0.0001
Rathbunella hypoplecta	OL	OW	0	2.527	–	0.050	0.996	10	< 0.0001
	SL	OL	0	38.30	–	0.71	0.997	10	< 0.0001
	Wt	SL	-11.273	2.943	1.2	0.25	0.939	11	< 0.0001
Rhinogobiops nicholsii	OL	OW	-0.626	1.497	0.087	0.041	0.967	47	< 0.0001
	SL	OL	0	24.83	–	0.22	1.000	5	< 0.0001
	Wt	SL	-11.935	3.201	0.17	0.042	0.992	48	< 0.0001
Ruscarius creaseri	OL	OW	0	2.172	–	0.028	0.998	11	< 0.0001
	SL	OL	0	18.19	–	–	–	1	–
	Wt	SL	-10.994	3.096	0.23	0.062	0.989	30	< 0.0001
Sardinops sagax	OL	OW	-0.390	2.689	0.079	0.060	0.886	261	< 0.0001
	SL	OL	-48.932	71.30	3.5	1.2	0.924	312	< 0.0001
	Wt	SL	-12.093	3.126	0.074	0.015	0.991	390	< 0.0001
Scomber japonicus	OL	OW	0.251	2.320	0.086	0.051	0.896	242	< 0.0001
	SL	OL	-54.673	72.45	6.4	1.6	0.908	223	< 0.0001
	Wt	SL	-12.096	3.129	0.11	0.020	0.989	279	< 0.0001
Sebastes diploproa	OL	OW	-0.181	1.576	0.31	0.043	0.983	25	< 0.0001
	SL	OL	0	15.01	–	0.30	0.998	5	< 0.0001
	Wt	SL	-10.842	3.069	0.13	0.029	0.996	43	< 0.0001
Sebastes goodei	OL	OW	-1.544	2.337	0.25	0.052	0.981	41	< 0.0001
	SL	OL	9.098	17.82	3.0	0.45	0.989	20	< 0.0001
	Wt	SL	-11.436	3.098	0.14	0.029	0.994	65	< 0.0001
Sebastes hopkinsi	OL	OW	-0.472	2.184	0.095	0.033	0.990	44	< 0.0001
	SL	OL	0	21.99	–	0.33	0.996	19	< 0.0001
	Wt	SL	-11.388	3.120	0.12	0.027	0.996	58	< 0.0001
Sebastes jordani	OL	OW	-0.233	2.058	0.073	0.020	0.991	96	< 0.0001
	SL	OL	15.993	17.04	1.6	0.26	0.987	59	< 0.0001
	Wt	SL	-11.528	3.064	0.13	0.027	0.992	108	< 0.0001
Sebastes paucispinis	OL	OW	-0.644	2.169	0.26	0.048	0.988	27	< 0.0001
	Wt	SL	-11.142	3.021	0.19	0.041	0.992	46	< 0.0001
Sebastes semicinctus	OL	OW	-0.207	1.893	0.19	0.054	0.980	28	< 0.0001
	SL	OL	0	19.09	–	0.53	0.996	6	< 0.0001
	Wt	SL	-10.874	3.021	0.14	0.031	0.994	61	< 0.0001

Table 3 (continued).

Taxon	y	x	b_0	b_1	se_{b0}	se_{b1}	R^2	n	P
Sebastolobus alascanus	OL	OW	1.777	1.272	0.50	0.076	0.874	42	< 0.0001
Seriphus politus	OL	OW	-2.766	2.231	0.42	0.097	0.942	34	< 0.0001
	SL	OL	-35.671	23.96	4.7	0.70	0.983	22	< 0.0001
	Wt	SL	-11.627	3.101	0.26	0.054	0.991	33	< 0.0001
Sphyraena argentea	OL	OW	-0.975	3.406	0.77	0.19	0.933	24	< 0.0001
	SL	OL	0	36.56	–	2.7	0.967	7	< 0.0001
	Wt	SL	-10.712	2.735	0.93	0.17	0.989	5	0.0005
Stenobrachius leucopsarus	OW	OL	0.105	1.057	0.058	0.041	0.902	75	< 0.0001
Symbolophorus californiensis	OL	OW	-0.204	1.415	0.070	0.025	0.970	98	< 0.0001
	SL	OL	17.452	17.09	3.6	0.92	0.864	56	< 0.0001
	Wt	SL	-11.903	3.121	0.51	0.12	0.929	58	< 0.0001
Symphurus atricauda	OL	OW	0	0.8765	–	0.017	0.997	8	< 0.0001
Synodus lucioceps	OL	OW	0	2.305	–	0.082	0.978	19	< 0.0001
	SL	OL	0	51.87	–	3.3	–	2	0.0398
	Wt	SL	-13.445	3.303	0.14	0.028	0.997	47	< 0.0001
Tarletonbeania crenularis	OL	OW	-0.229	1.445	0.085	0.066	0.915	47	< 0.0001
	SL	OL	4.513	31.61	3.2	2.1	0.912	24	< 0.0001
	Wt	SL	-12.273	3.234	0.36	0.092	0.978	30	< 0.0001
Tetragonurus cuvieri	OL	OW	0	1.707	–	0.061	0.989	10	< 0.0001
	SL	OL	0	88.05	–	2.2	0.998	4	< 0.0001
	Wt	SL	-10.760	2.802	0.24	0.051	0.997	12	< 0.0001
Trachurus symmetricus	OL	OW	-0.291	2.294	0.12	0.043	0.953	142	< 0.0001
	SL	OL	-25.627	39.12	5.1	0.93	0.941	113	< 0.0001
	Wt	SL	-11.490	3.006	0.16	0.031	0.980	197	< 0.0001
Triphoturus mexicanus	OL	OW	0	1.074	–	0.016	0.997	14	< 0.0001
Zalembius rosaceus	OL	OW	-0.946	1.825	0.33	0.095	0.924	32	< 0.0001
Zaniolepis spp.	OL	OW	-0.750	2.638	0.27	0.15	0.908	33	< 0.0001
	SL	OL	0	35.02	–	1.6	0.994	4	0.0002
	Wt	SL	-12.673	3.182	0.18	0.038	0.987	92	< 0.0001

Table 4. Regression summaries for otolith morphometrics as related to otolith length (OL; mm), for documented prey of California sea lions in the Southern California Bight and for prey species used in captive feeding studies of California sea lions. Taxonomic level of data aggregation for regression, response variable (y), intercept (b_0), slope (b_1), and respective standard errors (se_{b0}, se_{b1}), coefficient of determination (R^2), and sample size (n). Regressions of otolith weight (Wt; mg) versus OL are ln-ln; all others are simple linear regressions. Residual variances for bias-correction in back-transformation of ln-ln regressions are available online (see Data Accessibility). Additional abbreviations and units are OW = otolith width (mm), P = otolith perimeter (mm), PA = otolith projected area (mm^2), and Wt = otolith weight (mg). See Methods for description of otolith metrics.

Taxon	**y**	**b_0**	**b_1**	**se_{b0}**	**se_{b1}**	**R^2**	**n**	**p**
Agonidae	OP	-1.084	2.934	0.62	0.14	0.956	21	< 0.0001
	OPA	-0.966	1.997	0.19	0.13	0.926	21	< 0.0001
	OW	-0.215	0.6131	0.27	0.063	0.832	21	< 0.0001
	OWt	-1.347	2.480	0.35	0.24	0.846	21	< 0.0001
Anoplopoma fimbria	OP	1.162	2.317	0.22	0.028	0.996	26	< 0.0001
	OPA	-0.607	1.630	0.053	0.027	0.993	26	< 0.0001
	OW	0.856	0.2421	0.088	0.011	0.949	26	< 0.0001
	OWt	-2.358	2.639	0.13	0.066	0.985	26	< 0.0001
Argentina sialis	OP	-0.086	2.930	0.11	0.036	0.997	25	< 0.0001
	OPA	-0.697	1.893	0.021	0.020	0.997	25	< 0.0001
	OW	0.066	0.6445	0.043	0.014	0.989	25	< 0.0001
	OWt	-1.813	2.404	0.045	0.044	0.992	25	< 0.0001
Artedius notospilotus	OP	0	2.623	–	0.020	0.999	17	< 0.0001
	OPA	-0.859	1.892	0.15	0.090	0.967	17	< 0.0001
	OW	0	0.4876	–	0.0078	0.996	17	< 0.0001
	OWt	-1.625	2.571	0.24	0.15	0.953	17	< 0.0001
Atherinopsidae	OP	0.794	2.822	0.16	0.037	0.990	63	< 0.0001
	OPA	-0.334	1.769	0.035	0.024	0.989	63	< 0.0001
	OW	0.856	0.4912	0.082	0.019	0.919	63	< 0.0001
	OWt	-1.638	2.838	0.098	0.069	0.965	63	< 0.0001
Brosmophycis marginata	OP	0	2.494	–	0.011	1.000	17	< 0.0001
	OPA	-1.036	1.979	0.059	0.029	0.997	17	< 0.0001
	OW	0	0.4448	–	0.0052	0.998	17	< 0.0001
	OWt	-1.819	2.819	0.16	0.079	0.988	17	< 0.0001
Ceratoscopelus townsendi	OP	0.449	2.561	0.16	0.067	0.959	65	< 0.0001
	OPA	-0.543	1.713	0.043	0.048	0.953	65	< 0.0001
	OW	0.399	0.4528	0.069	0.028	0.808	65	< 0.0001
	OWt	-1.249	2.162	0.075	0.084	0.913	65	< 0.0001
Cheilopogon pinnatibarbatus	OP	0	2.655	–	0.038	0.999	7	< 0.0001
	OPA	0.372	1.296	1.2	0.53	0.548	7	0.0569
	OW	0	0.4010	–	0.015	0.989	9	< 0.0001

Table 4 (continued).

Taxon	**y**	b_0	b_1	se_{b0}	se_{b1}	R^2	**n**	**p**
Cheilopogon pinnatibarbatus	OWt	-0.119	1.809	2.7	1.2	0.316	7	0.1894
Chilara taylori	OP	0.387	2.692	0.14	0.020	0.998	37	< 0.0001
	OPA	-0.661	1.953	0.030	0.016	0.998	37	< 0.0001
	OW	0.268	0.5967	0.088	0.013	0.985	37	< 0.0001
	OWt	-1.500	3.026	0.080	0.044	0.993	37	< 0.0001
Chromis punctipinnis	OP	1.003	2.526	0.32	0.056	0.986	31	< 0.0001
	OPA	-0.556	1.732	0.056	0.033	0.990	31	< 0.0001
	OW	0.688	0.3971	0.15	0.025	0.894	31	< 0.0001
	OWt	-1.725	2.567	0.14	0.081	0.972	31	< 0.0001
Citharichthys sordidus	OP	0.577	3.207	0.27	0.056	0.994	23	< 0.0001
	OPA	-0.116	1.866	0.037	0.025	0.996	23	< 0.0001
	OW	0.422	0.8946	0.16	0.033	0.973	23	< 0.0001
	OWt	-0.528	2.388	0.078	0.053	0.990	23	< 0.0001
Citharichthys stigmaeus	OP	0.483	3.010	0.15	0.054	0.991	29	< 0.0001
	OPA	-0.248	1.859	0.028	0.028	0.994	29	< 0.0001
	OW	0.227	0.8253	0.078	0.028	0.969	29	< 0.0001
	OWt	-0.762	2.269	0.060	0.060	0.981	29	< 0.0001
Clupea pallasii	OP	0.618	2.791	0.53	0.13	0.909	45	< 0.0001
	OPA	-0.790	1.747	0.047	0.035	0.983	45	< 0.0001
	OW	0.345	0.3613	0.075	0.019	0.892	45	< 0.0001
	OWt	-2.233	2.540	0.11	0.085	0.954	45	< 0.0001
Cololabis saira	OP	0.045	2.810	0.11	0.070	0.979	37	< 0.0001
	OPA	-0.710	1.891	0.023	0.052	0.974	37	< 0.0001
	OW	0.082	0.5799	0.044	0.029	0.921	37	< 0.0001
	OWt	-2.004	2.386	0.039	0.086	0.957	37	< 0.0001
Cymatogaster aggregata	OP	0.747	2.638	0.21	0.037	0.981	96	< 0.0001
	OPA	-0.464	1.793	0.040	0.023	0.985	96	< 0.0001
	OW	0.570	0.5551	0.11	0.020	0.894	96	< 0.0001
	OWt	-1.160	2.396	0.071	0.041	0.973	96	< 0.0001
Diaphus theta	OP	0.101	3.160	0.10	0.048	0.989	49	< 0.0001
	OPA	-0.476	1.930	0.017	0.024	0.993	49	< 0.0001
	OW	0.123	0.7564	0.041	0.020	0.969	49	< 0.0001
	OWt	-1.307	2.417	0.027	0.037	0.989	49	< 0.0001
Embiotoca jacksoni	OP	0.363	2.816	0.54	0.077	0.980	29	< 0.0001
	OPA	-0.307	1.650	0.054	0.029	0.992	29	< 0.0001
	OW	0.982	0.3911	0.13	0.019	0.942	29	< 0.0001
	OWt	-1.297	2.438	0.12	0.063	0.982	29	< 0.0001
Engraulis mordax	OP	-0.108	2.715	0.21	0.057	0.956	106	< 0.0001
	OPA	-0.838	1.738	0.030	0.023	0.982	106	< 0.0001

Table 4 (continued).

Taxon	y	b_0	b_1	se_{b0}	se_{b1}	R^2	n	p
Engraulis mordax	OW	0.219	0.3899	0.046	0.012	0.906	106	< 0.0001
	OWt	-2.385	2.675	0.083	0.064	0.945	105	< 0.0001
Genyonemus lineatus	OP	2.297	2.366	0.30	0.032	0.996	24	< 0.0001
	OPA	-0.197	1.668	0.051	0.024	0.996	24	< 0.0001
	OW	1.695	0.3377	0.14	0.015	0.959	24	< 0.0001
	OWt	-1.000	2.535	0.14	0.063	0.987	24	< 0.0001
Girella nigricans	OP	0	2.883	–	0.026	0.999	14	< 0.0001
	OPA	-0.880	1.934	0.084	0.046	0.993	14	< 0.0001
	OW	0	0.5015	–	0.012	0.992	14	< 0.0001
	OWt	-2.316	2.997	0.23	0.13	0.980	14	< 0.0001
Glyptocephalus zachirus	OP	1.420	2.995	0.64	0.11	0.940	49	< 0.0001
	OPA	-0.259	1.946	0.11	0.066	0.949	49	< 0.0001
	OW	0.771	0.7521	0.40	0.069	0.714	49	< 0.0001
	OWt	-0.988	2.771	0.22	0.13	0.910	49	< 0.0001
Halichoeres californica	OP	-0.470	3.029	0.44	0.15	0.949	25	< 0.0001
	OPA	-0.638	1.743	0.055	0.051	0.980	25	< 0.0001
	OW	0.271	0.4661	0.10	0.035	0.888	25	< 0.0001
	OWt	-1.425	2.171	0.090	0.083	0.967	25	< 0.0001
Heterostichus rostratus	OP	0	2.795	–	0.043	0.998	10	< 0.0001
	OPA	-0.476	1.305	0.12	0.11	0.949	10	< 0.0001
	OW	0	0.4483	–	0.017	0.988	10	< 0.0001
	OWt	-1.435	1.894	0.18	0.17	0.940	10	< 0.0001
Hypocritichthys analis	OP	1.562	2.455	0.37	0.062	0.985	25	< 0.0001
	OPA	-0.214	1.594	0.10	0.059	0.970	25	< 0.0001
	OW	1.190	0.3878	0.18	0.031	0.871	25	< 0.0001
	OWt	-1.329	2.508	0.17	0.099	0.965	25	< 0.0001
Hypomesus pretiosus	OP	1.629	2.657	1.1	0.26	0.839	22	< 0.0001
	OPA	-0.137	1.542	0.25	0.17	0.796	22	< 0.0001
	OW	1.581	0.2550	0.33	0.079	0.343	22	0.0042
	OWt	-1.629	2.450	0.39	0.27	0.800	22	< 0.0001
Icelinus filamentosus	OP	0.228	2.548	0.45	0.057	0.986	30	< 0.0001
	OPA	-0.529	1.749	0.091	0.045	0.982	30	< 0.0001
	OW	1.053	0.3630	0.17	0.022	0.907	31	< 0.0001
	OWt	-1.207	2.486	0.26	0.13	0.930	30	< 0.0001
Icichthys lockingtoni	OP	3.900	2.046	0.83	0.12	0.940	22	< 0.0001
	OPA	-1.216	1.986	0.062	0.033	0.995	22	< 0.0001
	OW	0.271	0.3376	0.064	0.0090	0.986	22	< 0.0001
	OWt	-2.981	2.692	0.15	0.079	0.983	22	< 0.0001
Lampanyctus ritteri	OP	0.557	3.483	0.22	0.18	0.922	33	< 0.0001

Table 4 (continued).

Taxon	y	b_0	b_1	se_{b0}	se_{b1}	R^2	n	p
Lampanyctus ritteri	OPA	0.082	1.714	0.027	0.089	0.923	33	< 0.0001
	OW	0.322	0.9893	0.10	0.083	0.821	33	< 0.0001
	OWt	-0.325	2.250	0.049	0.16	0.862	33	< 0.0001
Leptocottus armatus	OP	2.004	2.433	0.70	0.11	0.950	30	< 0.0001
	OPA	-0.762	1.839	0.10	0.055	0.976	30	< 0.0001
	OW	0.587	0.3903	0.19	0.029	0.866	30	< 0.0001
	OWt	-1.796	2.599	0.20	0.11	0.955	30	< 0.0001
Lestidiops ringens	OP	0	3.166	–	0.024	0.999	17	< 0.0001
	OPA	-0.633	1.916	0.049	0.066	0.983	17	< 0.0001
	OW	0	0.5918	–	0.0051	0.999	17	< 0.0001
	OWt	-1.789	2.724	0.081	0.11	0.976	17	< 0.0001
Leuroglossus stilbius	OP	0.554	2.278	0.13	0.052	0.982	38	< 0.0001
	OPA	-0.994	1.598	0.049	0.053	0.961	38	< 0.0001
	OW	0.368	0.2515	0.053	0.021	0.799	38	< 0.0001
	OWt	-2.055	1.780	0.086	0.094	0.909	38	< 0.0001
Lycodes cortezianus	OP	0	3.018	–	0.032	0.999	14	< 0.0001
	OPA	-0.468	1.863	0.16	0.10	0.965	14	< 0.0001
	OW	0	0.6797	–	0.0084	0.998	14	< 0.0001
	OWt	-0.489	2.100	0.26	0.17	0.928	14	< 0.0001
Lycodes pacificus	OP	0	2.758	–	0.011	1.000	10	< 0.0001
	OPA	-0.771	1.940	0.17	0.13	0.966	10	< 0.0001
	OW	0	0.6011	–	0.012	0.996	10	< 0.0001
	OWt	-1.256	2.620	0.26	0.20	0.955	10	< 0.0001
Lyopsetta exilis	OP	0.471	2.730	0.23	0.057	0.978	53	< 0.0001
	OPA	-0.442	1.851	0.052	0.039	0.978	53	< 0.0001
	OW	0.298	0.6190	0.12	0.031	0.887	53	< 0.0001
	OWt	-0.879	2.402	0.14	0.11	0.911	53	< 0.0001
Mallotus villosus	OP	0.247	3.020	0.24	0.093	0.941	68	< 0.0001
	OPA	-0.680	1.823	0.052	0.055	0.943	68	< 0.0001
	OW	0.097	0.6448	0.069	0.027	0.896	68	< 0.0001
	OWt	-2.322	2.975	0.14	0.14	0.865	68	< 0.0001
Medialuna californiensis	OP	0	2.783	–	0.030	0.999	11	< 0.0001
	OPA	-0.415	1.685	0.35	0.18	0.911	11	< 0.0001
	OW	1.025	0.3218	0.13	0.019	0.696	124	< 0.0001
	OWt	-1.561	2.421	0.18	0.092	0.849	124	< 0.0001
Melamphaes lugubris	OP	-0.715	2.986	0.25	0.068	0.991	20	< 0.0001
	OPA	-0.811	1.908	0.030	0.024	0.997	20	< 0.0001
	OW	0.068	0.5148	0.039	0.011	0.992	20	< 0.0001
	OWt	-1.880	2.554	0.037	0.029	0.998	20	< 0.0001

Table 4 (continued).

Taxon	**y**	b_0	b_1	se_{b0}	se_{b1}	R^2	**n**	**p**
Merluccius productus	OP	2.731	2.328	0.33	0.026	0.983	139	< 0.0001
	OPA	-0.967	1.865	0.029	0.012	0.994	139	< 0.0001
	OW	0.829	0.3223	0.075	0.0060	0.955	139	< 0.0001
	OWt	-2.448	2.633	0.045	0.019	0.993	139	< 0.0001
Microgadus proximus	OP	1.039	2.422	0.52	0.051	0.990	24	< 0.0001
	OPA	-1.123	1.949	0.030	0.014	0.999	24	< 0.0001
	OW	0.195	0.3632	0.079	0.0078	0.990	24	< 0.0001
	OWt	-2.414	2.853	0.078	0.035	0.997	24	< 0.0001
Microstomus pacificus	OP	0.545	2.643	0.23	0.054	0.983	42	< 0.0001
	OPA	-0.464	1.781	0.039	0.028	0.990	42	< 0.0001
	OW	0.569	0.4745	0.10	0.024	0.910	42	< 0.0001
	OWt	-1.246	2.565	0.10	0.074	0.968	42	< 0.0001
Oncorhynchus mykiss	OP	-1.034	3.051	0.30	0.083	0.956	64	< 0.0001
	OPA	-0.845	1.955	0.081	0.063	0.939	64	< 0.0001
	OW	-0.066	0.6182	0.093	0.025	0.905	64	< 0.0001
	OWt	-1.677	2.419	0.18	0.14	0.828	64	< 0.0001
Ophiodon elongatus	OP	0.640	2.590	0.42	0.049	0.993	21	< 0.0001
	OPA	-0.757	1.763	0.14	0.067	0.973	21	< 0.0001
	OW	0.557	0.3303	0.13	0.015	0.961	21	< 0.0001
	OWt	-2.192	2.696	0.32	0.16	0.940	21	< 0.0001
Oxylebius pictus	OP	-0.371	2.746	0.27	0.080	0.985	20	< 0.0001
	OPA	-0.917	1.872	0.10	0.086	0.963	20	< 0.0001
	OW	0.078	0.4629	0.16	0.048	0.836	20	< 0.0001
	OWt	-1.918	2.577	0.21	0.18	0.923	20	< 0.0001
Paralabrax clathratus	OP	0	2.538	–	0.043	0.996	15	< 0.0001
	OPA	-0.598	1.690	0.19	0.085	0.968	15	< 0.0001
	OW	0	0.3862	–	0.0059	0.997	15	< 0.0001
	OWt	-2.587	2.805	0.42	0.19	0.945	15	< 0.0001
Parophrys vetulus	OP	1.146	2.640	0.37	0.055	0.976	59	< 0.0001
	OPA	-0.429	1.775	0.051	0.028	0.986	59	< 0.0001
	OW	0.731	0.4471	0.12	0.018	0.919	59	< 0.0001
	OWt	-1.515	2.602	0.12	0.063	0.968	59	< 0.0001
Peprilus simillimus	OP	1.421	2.582	0.80	0.17	0.893	30	< 0.0001
	OPA	-0.472	1.620	0.12	0.075	0.944	30	< 0.0001
	OW	0.706	0.3425	0.17	0.037	0.758	30	< 0.0001
	OWt	-2.216	2.481	0.20	0.13	0.929	30	< 0.0001
Phanerodon spp.	OP	0.359	2.736	0.54	0.073	0.955	67	< 0.0001
	OPA	-0.200	1.656	0.056	0.029	0.981	67	< 0.0001
	OW	1.444	0.3903	0.12	0.017	0.893	67	< 0.0001

Table 4 (continued).

Taxon	y	b_0	b_1	se_{b0}	se_{b1}	R^2	n	p
Phanerodon spp.	OWt	-1.031	2.380	0.11	0.058	0.963	67	< 0.0001
Physiculus rastrelliger	OP	0	2.430	–	0.014	1.000	12	< 0.0001
	OPA	-1.355	1.932	0.30	0.15	0.941	12	< 0.0001
	OW	0	0.3829	–	0.0070	0.995	17	< 0.0001
	OWt	-2.212	2.981	0.37	0.19	0.962	12	< 0.0001
Porichthys notatus	OP	1.223	3.107	0.36	0.057	0.985	48	< 0.0001
	OPA	-0.066	1.762	0.030	0.017	0.996	48	< 0.0001
	OW	0.964	0.6262	0.12	0.018	0.962	48	< 0.0001
	OWt	-0.762	2.479	0.057	0.033	0.992	48	< 0.0001
Protomyctophum crockeri	OP	-0.109	3.279	0.095	0.048	0.991	44	< 0.0001
	OPA	-0.393	2.030	0.018	0.026	0.993	44	< 0.0001
	OW	-0.091	0.9533	0.059	0.030	0.959	44	< 0.0001
	OWt	-0.972	2.804	0.035	0.053	0.985	44	< 0.0001
Rathbunella hypoplecta	OP	0	2.412	–	0.011	1.000	10	< 0.0001
	OPA	-0.955	1.683	0.14	0.14	0.951	10	< 0.0001
	OW	0	0.3943	–	0.0078	0.996	10	< 0.0001
	OWt	-1.845	2.296	0.27	0.25	0.914	10	< 0.0001
Rhinogobiops nicholsii	OP	0.782	3.155	0.13	0.053	0.988	47	< 0.0001
	OPA	-0.113	1.740	0.021	0.023	0.992	47	< 0.0001
	OW	0.473	0.6461	0.045	0.018	0.967	47	< 0.0001
	OWt	-0.813	2.375	0.052	0.056	0.975	47	< 0.0001
Ruscarius creaseri	OP	0	2.481	–	0.011	1.000	11	< 0.0001
	OPA	-1.024	1.927	0.068	0.071	0.988	11	< 0.0001
	OW	0	0.4596	–	0.0059	0.998	11	< 0.0001
	OWt	-1.839	2.652	0.13	0.13	0.978	11	< 0.0001
Sardinops sagax	OP	0.166	2.670	0.093	0.033	0.990	66	< 0.0001
	OPA	-0.928	1.684	0.017	0.018	0.993	66	< 0.0001
	OW	0.276	0.3296	0.023	0.0073	0.886	261	< 0.0001
	OWt	-2.476	2.381	0.028	0.029	0.990	66	< 0.0001
Scomber japonicus	OP	0.037	2.673	0.15	0.040	0.977	105	< 0.0001
	OPA	-0.992	1.790	0.031	0.024	0.982	105	< 0.0001
	OW	0.073	0.3863	0.035	0.0085	0.896	242	< 0.0001
	OWt	-2.315	2.455	0.054	0.042	0.971	105	< 0.0001
Sebastes diploproa	OP	-1.975	3.110	0.58	0.052	0.994	25	< 0.0001
	OPA	-0.675	1.933	0.047	0.021	0.997	25	< 0.0001
	OW	0.224	0.6240	0.19	0.017	0.983	25	< 0.0001
	OWt	-1.508	2.759	0.11	0.047	0.993	25	< 0.0001
Sebastes goodei	OP	0.157	2.712	0.41	0.041	0.992	38	< 0.0001
	OPA	-0.649	1.813	0.060	0.027	0.992	38	< 0.0001

Table 4 (continued).

Taxon	y	b_0	b_1	se_{b0}	se_{b1}	R^2	n	p
Sebastes goodei	OW	0.730	0.4200	0.090	0.0093	0.981	41	< 0.0001
	OWt	-1.564	2.538	0.11	0.052	0.985	38	< 0.0001
Sebastes hopkinsi	OP	-1.143	2.837	0.38	0.053	0.991	28	< 0.0001
	OPA	-0.838	1.891	0.071	0.037	0.990	28	< 0.0001
	OW	0.239	0.4534	0.040	0.0069	0.990	44	< 0.0001
	OWt	-1.852	2.629	0.18	0.091	0.970	28	< 0.0001
Sebastes jordani	OP	-0.115	2.678	0.22	0.028	0.992	78	< 0.0001
	OPA	-0.842	1.906	0.037	0.018	0.993	78	< 0.0001
	OW	0.142	0.4816	0.034	0.0047	0.991	96	< 0.0001
	OWt	-1.820	2.606	0.055	0.027	0.992	78	< 0.0001
Sebastes paucispinis	OP	-0.625	2.808	0.67	0.055	0.992	23	< 0.0001
	OPA	-0.814	1.887	0.055	0.023	0.997	23	< 0.0001
	OW	0.353	0.4555	0.11	0.010	0.988	27	< 0.0001
	OWt	-2.105	2.732	0.14	0.060	0.990	23	< 0.0001
Sebastes semicinctus	OP	-0.133	2.647	0.37	0.055	0.990	26	< 0.0001
	OPA	-0.772	1.899	0.070	0.037	0.991	26	< 0.0001
	OW	0.177	0.5174	0.095	0.015	0.980	28	< 0.0001
	OWt	-1.734	2.680	0.16	0.085	0.977	26	< 0.0001
Sebastolobus alascanus	OP	-6.855	3.856	1.7	0.17	0.925	42	< 0.0001
	OPA	-0.789	1.964	0.12	0.056	0.968	42	< 0.0001
	OW	-0.451	0.6869	0.41	0.041	0.874	42	< 0.0001
	OWt	-1.022	2.437	0.19	0.085	0.954	42	< 0.0001
Seriphus politus	OP	1.898	2.463	0.23	0.033	0.994	34	< 0.0001
	OPA	-0.141	1.672	0.046	0.024	0.993	34	< 0.0001
	OW	1.413	0.4225	0.13	0.018	0.942	34	< 0.0001
	OWt	-1.160	2.630	0.10	0.054	0.987	34	< 0.0001
Sphyraena argentea	OP	2.138	2.192	0.36	0.029	0.996	22	< 0.0001
	OPA	-0.950	1.799	0.076	0.031	0.994	22	< 0.0001
	OW	0.520	0.2739	0.20	0.016	0.933	24	< 0.0001
	OWt	-2.319	2.607	0.16	0.065	0.988	22	< 0.0001
Stenobrachius leucopsarus	OP	0.165	3.668	0.16	0.11	0.938	75	< 0.0001
	OPA	-0.050	1.928	0.019	0.050	0.954	75	< 0.0001
	OW	0.105	1.057	0.058	0.041	0.902	75	< 0.0001
	OWt	-0.662	2.613	0.029	0.076	0.941	75	< 0.0001
Symbolophorus californiensis	OP	0.703	2.784	0.12	0.031	0.988	98	< 0.0001
	OPA	-0.444	1.880	0.021	0.017	0.993	98	< 0.0001
	OW	0.221	0.6856	0.046	0.012	0.970	98	< 0.0001
	OWt	-1.084	2.312	0.036	0.028	0.986	98	< 0.0001
Symphurus atricauda	OP	0	3.551	–	0.044	0.999	8	< 0.0001

Table 4 (continued).

Taxon	y	b_0	b_1	se_{b0}	se_{b1}	R^2	n	p
Symphurus atricauda	OPA	-0.338	2.215	0.38	0.43	0.817	8	0.0021
	OW	0	1.138	–	0.022	0.997	8	< 0.0001
	OWt	-3.256	5.948	0.82	0.94	0.870	8	0.0007
Synodus lucioceps	OP	0	2.558	–	0.029	0.998	19	< 0.0001
	OPA	-0.576	1.662	0.058	0.036	0.992	19	< 0.0001
	OW	0	0.4242	–	0.015	0.978	19	< 0.0001
	OWt	-1.673	2.586	0.11	0.068	0.988	19	< 0.0001
Tarletonbeania crenularis	OP	0.612	2.794	0.12	0.072	0.971	47	< 0.0001
	OPA	-0.346	1.784	0.021	0.041	0.977	47	< 0.0001
	OW	0.253	0.6330	0.047	0.029	0.915	47	< 0.0001
	OWt	-1.177	1.896	0.034	0.068	0.945	47	< 0.0001
Tetragonurus cuvieri	OP	0	2.826	–	0.049	0.997	10	< 0.0001
	OPA	-0.564	1.651	0.091	0.090	0.977	10	< 0.0001
	OW	0	0.5793	–	0.021	0.989	10	< 0.0001
	OWt	-1.739	2.417	0.13	0.13	0.977	10	< 0.0001
Thaleichthys pacificus	OP	0.188	3.047	0.29	0.080	0.983	27	< 0.0001
	OPA	-0.564	1.767	0.038	0.030	0.993	27	< 0.0001
	OW	0.327	0.5642	0.063	0.018	0.976	27	< 0.0001
	OWt	-1.845	2.454	0.079	0.063	0.984	27	< 0.0001
Trachurus symmetricus	OP	-1.446	2.901	0.19	0.031	0.985	134	< 0.0001
	OPA	-0.831	1.802	0.027	0.016	0.990	134	< 0.0001
	OW	0.244	0.4157	0.047	0.0078	0.953	142	< 0.0001
	OWt	-2.315	2.643	0.071	0.041	0.970	134	< 0.0001
Triphoturus mexicanus	OP	0	3.306	–	0.027	0.999	14	< 0.0001
	OPA	-0.238	1.709	0.017	0.071	0.980	14	< 0.0001
	OW	0	0.9287	–	0.014	0.997	14	< 0.0001
	OWt	-0.880	2.403	0.037	0.15	0.952	14	< 0.0001
Xeneretmus ritteri	OP	0	2.720	–	0.020	0.999	10	< 0.0001
	OPA	-0.425	1.669	0.19	0.13	0.955	10	< 0.0001
	OW	0	0.5873	–	0.0059	0.999	10	< 0.0001
	OWt	-0.481	1.963	0.52	0.35	0.798	10	0.0005
Xeneretmus triacanthus	OP	0	2.638	–	0.027	0.999	11	< 0.0001
	OPA	-0.848	1.877	0.20	0.14	0.950	11	< 0.0001
	OW	0	0.5357	–	0.0087	0.997	11	< 0.0001
	OWt	-1.068	2.215	0.31	0.22	0.917	11	< 0.0001
Zalembius rosaceus	OP	0.573	2.789	0.42	0.078	0.977	32	< 0.0001
	OPA	-0.510	1.805	0.057	0.034	0.989	32	< 0.0001
	OW	0.737	0.5065	0.14	0.027	0.924	32	< 0.0001
	OWt	-1.540	2.646	0.091	0.056	0.987	32	< 0.0001

Appendix A. Paired Comparisons of Left and Right Sagittal Otoliths

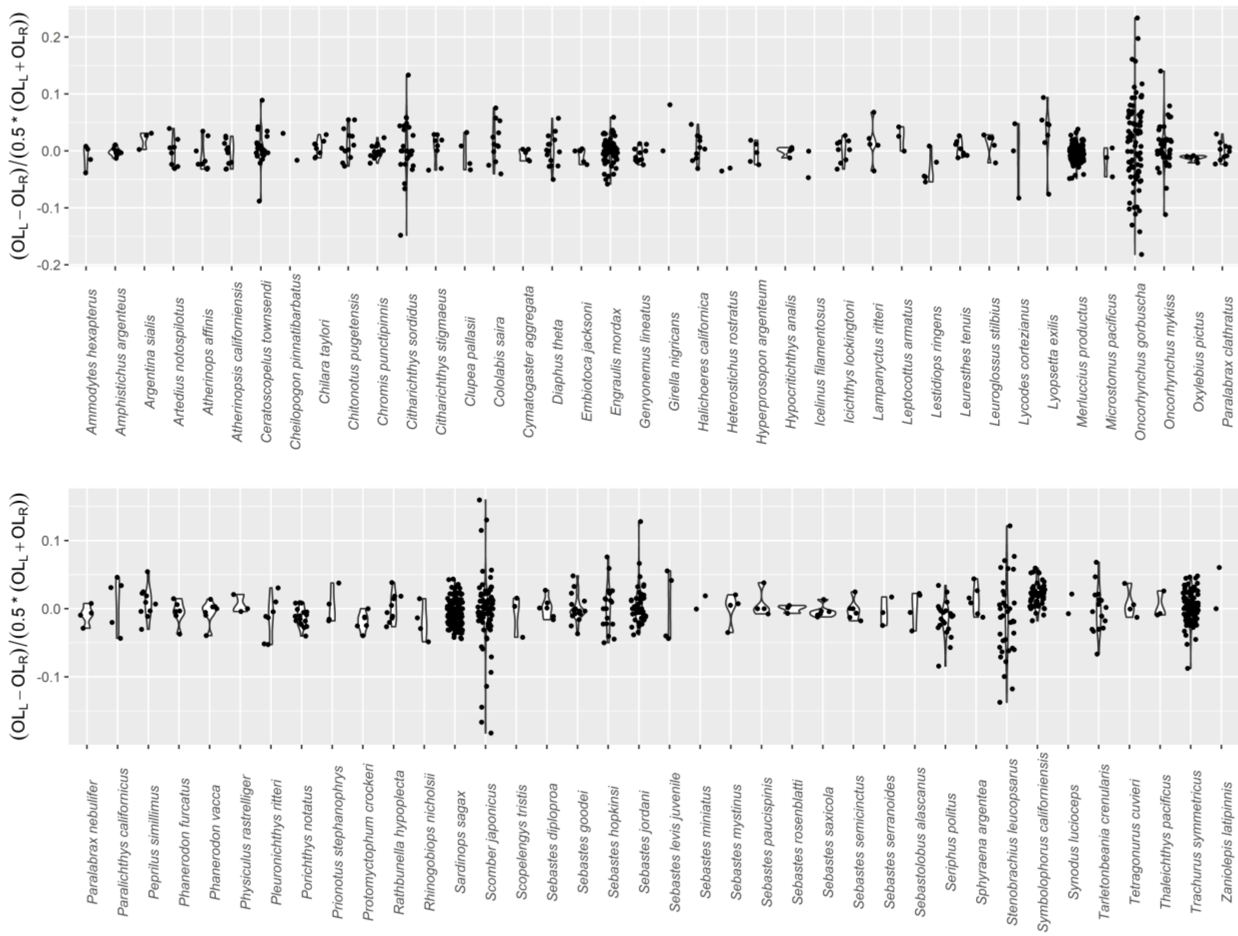

Figure A1. Superimposed violin and one-dimensional scatter plots of normalized differences between left and right sagittal otolith length by species (i.e., $\frac{OL_L - OL_R}{0.5 * (OL_L + OL_R)}$, where OL_L and OL_R are left and right sagittal otolith lengths).

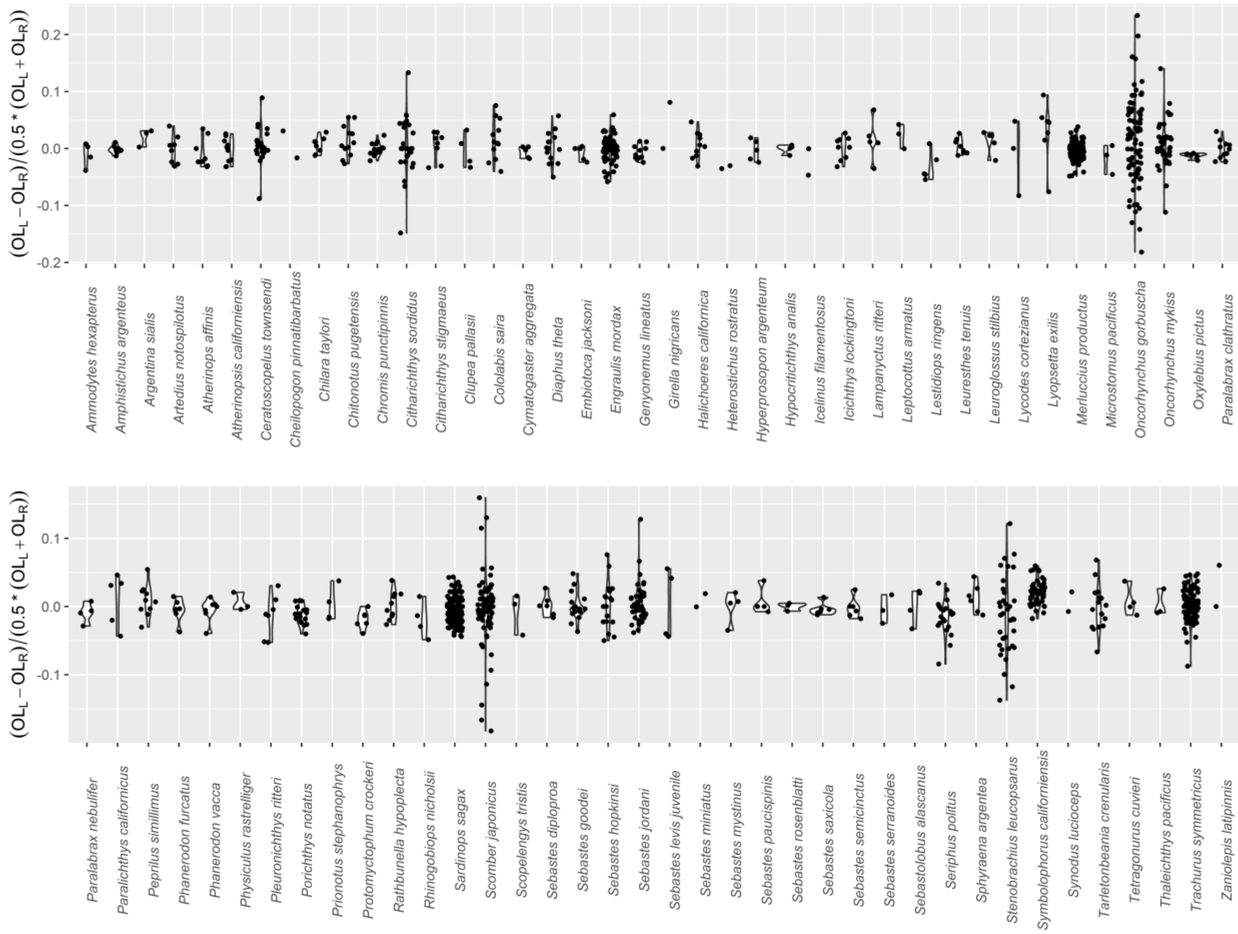

Figure A2. Superimposed violin and one-dimensional scatter plots of normalized differences between left and right sagittal otolith width by species (i.e., $\frac{OW_l - OW_r}{0.5 * (OW_l + OW_r)}$, where OW_l and OW_r are left and right sagittal otolith widths).

Table A1. Paired t-tests of left and right sagittal otolith lengths by species. Sample size (*n*), estimated difference (*d*), p-value (*p*), and scaled difference, calculated as $d_r = 2\,n\,\frac{(0.5\,d)^2}{(2n-1)s_{OL}^2}$, where s^2_{OL} is the variance of all left and right otolith lengths. Using Bonferroni's correction for multiple testing, a p-value of 0.0006 would be equivalent to an alpha-level of 0.05. P-values less than 0.0006 and corresponding scaled differences are highlighted in bold.

Species	*n*	*d*	*p*	d_r
Ammodytes hexapterus	4	-0.028	0.3906	2.97E-03
Amphistichus argenteus	7	-0.013	0.3151	3.97E-05
Argentina sialis	3	0.027	0.1591	5.04E-03
Artedius notospilotus	8	-0.008	0.8752	1.18E-05
Atherinops affinis	8	-0.023	0.4092	9.08E-03
Atherinopsis californiensis	11	-0.013	0.6898	7.49E-05
Ceratoscopelus townsendi	21	0.017	0.3508	1.82E-03
Cheilopogon pinnatibarbatus	2	0.075	0.8033	4.85E-02
Chilara taylori	8	0.027	0.4246	2.01E-04
Chitonotus pugetensis	12	0.051	0.1234	3.35E-03
Chromis punctipinnis	15	-0.004	0.8040	7.43E-06
Citharichthys sordidus	27	0.005	0.8543	2.46E-06
Citharichthys stigmaeus	8	0.013	0.6046	1.36E-03
Clupea pallasii	4	-0.010	0.8201	1.66E-03
Cololabis saira	12	0.021	0.1806	2.29E-03
Cymatogaster aggregata	5	-0.038	0.2390	3.17E-03
Diaphus theta	16	0.004	0.7796	3.69E-05
Embiotoca jacksoni	5	-0.058	0.2387	3.12E-03
Engraulis mordax	89	0.006	0.3737	2.67E-05
Genyonemus lineatus	12	-0.048	0.0779	7.55E-04
Girella nigricans	2	0.331	0.4990	8.96E-02
Halichoeres californica	10	0.015	0.5249	5.13E-04
Heterostichus rostratus	2	-0.106	0.1383	1.29E-02
Hyperprosopon argenteum	5	-0.022	0.7184	9.36E-05
Hypocritichthys analis	4	-0.008	0.7857	6.45E-05
Icelinus filamentosus	2	-0.172	0.4925	1.16E-02
Icichthys lockingtoni	9	-0.011	0.8122	4.25E-06
Lampanyctus ritteri	5	0.020	0.4362	4.93E-03
Leptocottus armatus	3	0.124	0.2172	4.76E-03
Lestidiops ringens	5	-0.073	0.0513	9.83E-03
Leuresthes tenuis	8	0.015	0.4123	2.95E-04
Leuroglossus stilbius	5	0.040	0.2076	2.92E-03
Lycodes cortezianus	3	-0.063	0.7740	3.30E-02
Lyopsetta exilis	7	0.120	0.2234	1.00E-02
Merluccius productus	119	-0.037	0.0384	2.08E-05
Microstomus pacificus	3	-0.067	0.3932	4.05E-03
Oncorhynchus gorbuscha	86	0.026	0.0762	5.79E-04

Table A1 (continued).

Species	***n***	***d***	***p***	d_r
Oncorhynchus mykiss	44	0.029	0.2022	1.04E-03
Oxylebius pictus	5	-0.041	0.0077	5.13E-04
Paralabrax clathratus	12	-0.029	0.5331	5.02E-04
Paralabrax nebulifer	4	-0.105	0.3155	1.06E-03
Paralichthys californicus	5	0.091	0.4107	4.42E-04
Peprilus simillimus	10	0.045	0.2925	1.78E-03
Phanerodon furcatus	6	-0.038	0.5029	1.48E-04
Phanerodon vacca	7	-0.043	0.4511	1.07E-03
Physiculus rastrelliger	3	0.043	0.5389	2.12E-02
Pleuronichthys ritteri	7	-0.021	0.5621	1.47E-04
Porichthys notatus	17	-0.076	0.0019	4.87E-04
Prionotus stephanophrys	4	0.040	0.6751	4.91E-05
Protomyctophum crockeri	6	-0.036	0.0142	1.82E-02
Rathbunella hypoplecta	10	0.003	0.9013	1.24E-05
Rhinogobiops nicholsii	4	-0.043	0.2646	5.07E-03
Sardinops sagax	182	-0.020	**<0.0001**	**3.51E-04**
Scomber japonicus	76	-0.014	0.5634	4.66E-05
Scopelengys tristis	3	-0.006	0.8737	3.60E-05
Sebastes diploproa	6	-0.003	0.9447	6.43E-07
Sebastes goodei	18	0.008	0.7813	1.34E-06
Sebastes hopkinsi	19	-0.006	0.7803	1.35E-06
Sebastes jordani	50	0.009	0.5729	2.28E-06
Sebastes levis juvenile	4	0.006	0.8953	4.59E-05
Sebastes miniatus	2	0.090	0.5206	8.42E-03
Sebastes mystinus	4	0.031	0.8235	3.34E-05
Sebastes paucispinis	4	0.018	0.5285	2.62E-03
Sebastes rosenblatti	3	0.003	0.9118	2.57E-06
Sebastes saxicola	6	-0.032	0.4118	7.40E-04
Sebastes semicinctus	6	-0.019	0.3631	2.11E-05
Sebastes serranoides	3	-0.057	0.6262	3.65E-04
Sebastolobus alascanus	4	0.031	0.8131	5.46E-05
Seriphus politus	21	-0.097	0.0303	7.75E-04
Sphyraena argentea	6	0.155	0.2393	4.94E-04
Stenobrachius leucopsarus	37	-0.026	0.0749	1.55E-03
Symbolophorus californiensis	56	0.074	**<0.0001**	**4.15E-03**
Synodus lucioceps	2	0.000	0.9950	7.22E-09
Tarletonbeania crenularis	17	-0.005	0.6999	5.95E-05
Tetragonurus cuvieri	4	0.010	0.7147	3.86E-05
Thaleichthys pacificus	3	0.002	0.9489	1.21E-06
Trachurus symmetricus	101	0.015	0.1997	4.21E-05
Zaniolepis latipinnis	2	0.033	0.5000	9.50E-05

Table A2. Paired t-tests of left and right sagittal otolith widths by species. Sample size(n), estimated difference (d), p-value (p), and scaled difference, calculated as $d_r = 2\,n\frac{(0.5\,d)^2}{(2n-1)s_{OW}^2}$, where s^2_{OW} is the variance of all left and right otolith widths. Using Bonferroni's correction for multiple testing, a p-value of 0.0006 is equivalent to an alpha-level of 0.05. P-values less than 0.0006 and corresponding scaled differences are highlighted in bold.

Species	***n***	***d***	***p***	***d_r***
Ammodytes hexapterus	4	-0.003	0.7408	3.96E-04
Amphistichus argenteus	7	-0.030	0.0769	1.10E-03
Argentina sialis	3	0.043	0.3363	5.58E-02
Artedius notospilotus	8	-0.002	0.9548	5.05E-06
Atherinops affinis	8	0.020	0.6048	8.05E-03
Atherinopsis californiensis	11	-0.042	0.0852	3.66E-03
Ceratoscopelus townsendi	21	-0.010	0.3663	2.46E-03
Cheilopogon pinnatibarbatus	2	-0.200	0.4485	8.82E-02
Chilara taylori	8	0.146	0.0190	1.88E-02
Chitonotus pugetensis	12	-0.003	0.8074	3.30E-04
Chromis punctipinnis	15	0.024	0.2667	1.27E-03
Citharichthys sordidus	2	-0.079	0.6007	2.04E-04
Citharichthys stigmaeus	8	0.001	0.9825	7.47E-06
Clupea pallasii	4	-0.005	0.5975	1.02E-03
Cololabis saira	12	-0.002	0.8217	4.25E-05
Cymatogaster aggregata	5	-0.030	0.2990	6.21E-03
Diaphus theta	16	0.011	0.2212	4.39E-04
Embiotoca jacksoni	5	-0.050	0.1889	7.00E-03
Engraulis mordax	47	0.017	0.0066	6.92E-03
Genyonemus lineatus	12	-0.022	0.4232	1.17E-03
Girella nigricans	2	0.011	0.9250	7.54E-05
Halichoeres californica	10	0.015	0.3574	6.18E-03
Heterostichus rostratus	2	-0.010	0.5000	1.11E-03
Hyperprosopon argenteum	5	-0.005	0.9275	3.01E-05
Hypocritichthys analis	4	-0.014	0.8608	4.96E-04
Icelinus filamentosus	2	-0.099	0.5032	2.07E-02
Icichthys lockingtoni	9	0.001	0.9505	5.05E-07
Lampanyctus ritteri	5	-0.005	0.7101	8.53E-05
Leptocottus armatus	3	-0.037	0.6731	1.28E-03
Lestidiops ringens	5	-0.005	0.7123	1.27E-04
Leuresthes tenuis	8	-0.010	0.7335	3.53E-04
Leuroglossus stilbius	22	-0.006	0.3563	8.02E-04
Lycodes cortezianus	3	-0.036	0.5187	5.35E-02
Lyopsetta exilis	7	-0.026	0.5396	9.27E-04
Merluccius productus	119	0.023	0.0033	7.26E-05
Microstomus pacificus	3	-0.005	0.8986	2.96E-04
Oncorhynchus gorbuscha	86	-0.016	0.1915	4.03E-04

Table A2 (continued).

Species	***n***	***d***	***p***	***d_r***
Oncorhynchus mykiss	44	0.008	0.6444	2.67E-04
Oxylebius pictus	5	-0.002	0.7413	4.71E-06
Paralabrax clathratus	12	0.023	0.2768	3.41E-03
Paralabrax nebulifer	4	0.053	0.5116	2.96E-03
Paralichthys californicus	5	-0.005	0.9470	3.66E-06
Peprilus simillimus	10	-0.012	0.4787	5.50E-04
Phanerodon furcatus	6	-0.039	0.3394	8.13E-04
Phanerodon vacca	7	-0.017	0.5121	6.17E-04
Physiculus rastrelliger	3	0.067	0.1038	3.29E-02
Pleuronichthys ritteri	7	-0.033	0.0905	1.38E-03
Porichthys notatus	17	-0.017	0.5399	5.80E-05
Prionotus stephanophrys	4	-0.010	0.8028	8.21E-06
Protomyctophum crockeri	6	0.016	0.0283	5.11E-03
Rathbunella hypoplecta	10	-0.004	0.5740	3.32E-04
Rhinogobiops nicholsii	4	-0.025	0.3366	3.27E-03
Sardinops sagax	200	0.010	**0.0001**	**6.80E-04**
Scomber japonicus	104	0.003	0.6157	1.13E-05
Scopelengys tristis	3	-0.015	0.5048	8.29E-04
Sebastes diploproa	6	0.076	0.1828	1.23E-03
Sebastes goodei	18	-0.020	0.1237	4.15E-05
Sebastes hopkinsi	19	0.017	0.0966	5.79E-05
Sebastes jordani	50	-0.007	0.3641	5.81E-06
Sebastes levis juvenile	4	-0.047	0.1939	1.19E-02
Sebastes miniatus	2	0.026	0.5000	3.92E-03
Sebastes mystinus	4	-0.050	0.4573	5.97E-04
Sebastes paucispinis	4	0.003	0.3910	1.83E-04
Sebastes rosenblatti	3	-0.083	0.3925	6.81E-03
Sebastes saxicola	6	-0.058	0.1102	5.99E-03
Sebastes semicinctus	6	0.021	0.1311	8.57E-05
Sebastes serranoides	3	-0.028	0.5747	3.79E-04
Sebastolobus alascanus	4	0.022	0.7772	4.78E-05
Seriphus politus	22	0.030	0.0153	4.14E-04
Sphyraena argentea	7	-0.085	0.3269	2.32E-03
Stenobrachius leucopsarus	37	-0.008	0.3635	1.42E-04
Symbolophorus californiensis	56	0.016	0.0144	3.94E-04
Synodus lucioceps	2	0.058	0.0497	1.78E-03
Tarletonbeania crenularis	17	-0.004	0.4224	9.10E-05
Tetragonurus cuvieri	4	-0.011	0.0784	3.10E-04
Thaleichthys pacificus	3	-0.007	0.8109	3.53E-05
Trachurus symmetricus	105	-0.005	0.4700	3.16E-05
Zaniolepis frenata	2	0.035	0.6855	1.27E-01
Zaniolepis latipinnis	2	-0.048	0.3820	1.69E-03