A Review of Golden Tilefish (*Lopholatilus chamaeleonticeps*) Length and Age Data Collected from the Gulf of America from 1985 to 2024

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SEFSC01-WP-06

July 2026

Please cite this document as:

Garner, Steve, Laura Thornton, and Naeem Willett. 2026. A Review of Golden Tilefish (*Lopholatilus chamaeleonticeps*) Length and Age Data Collected from the Gulf of America from 1985 to 2024. SEFSC01-WP-06. National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center (SEFSC). Miami, FL. 42 pp.

A review of golden tilefish (*Lopholatilus chamaeleonticeps*) length and age data collected from the Gulf of America from 1985 to 2024.

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Introduction

Tilefishes (Latilidae) are meso- to bathybenthic demersal fishes found throughout the northern Gulf of America (Gulf) and U.S. South Atlantic (Dooley, 1978). The Gulf stock boundary for the federally managed tilefish complex is defined by the south Texas border through the Gulf waters of the Florida Keys. The tilefish complex is comprised primarily by three species: 1) golden tilefish (*Lopholatilus chamaeleonticeps*), blueline tilefish (*Caulolatilus microps*), and goldface tilefish (*Caulolatilus chrysops*). However, golden tilefish comprise the overwhelming majority of the annual landed catch (NMFS SERO, 2024) and are primarily harvested by the commercial fishery with very little recreational catch. The National Marine Fisheries Service Lab in Panama City, FL (PCLab) has blueline and goldface tilefish otolith samples inventoried. However, there are extremely few in comparison to golden tilefish, and no ageing techniques have been collectively established for either species. Therefore, results of this report will hereafter refer only to golden tilefish (tilefish).

Tilefish are a long-lived species with maximum observed age up to 40, slow growth rate, and late maturity (Turner et al. 1983, Harris and Grossman 1985, Palmer et al. 2004). They construct burrows (Able et al., 1982) in soft sediments of the continental shelf, preferably at depths between 80 and 400 m (Freeman and Turner, 1977) at temperatures between ~9-14 °C (Grimes et al., 1986). Annual deposition has been assumed when estimating ages from sagittal otoliths but has not been fully validated for this species. Furthermore, annuli deposition in otolith sections appears complex and variable, presumably due to constant environmental conditions below the permanent thermocline, making age estimation difficult (Cailliet et al., 2001).

This report is prepared for SEFSC-Gulf-01 (Southeast Fisheries Science Center, Gulf of America, Assessment 01) for the assessment of the Gulf tilefish complex. The complex was previously assessed in SEDAR 22 (2011) with a terminal year of 2009. The objectives of this report are to 1) provide updated meristic conversion factors given the addition of new data collected from 2010-2024; 2) summarize the age-at-length data by year, fishery, mode, and gear; 3) describe ageing protocols and provide ageing error estimates; and 4) provide updated growth model parameters.

Methods

Sample Collection and Subsampling

Tilefish otoliths have been collected since 1985 from commercial and recreational sources with collections from fishery-independent surveys starting in 2001. Samples were provided by federal and state agencies including Alabama Marine Resources Division (ALMR), Cooperative Research Program (CO-OP), Florida Fish and Wildlife Research Institute (FWRI-OBS), Galveston Observer Program (GOP), Beaufort Lab Headboat Survey (HB), PCLab, Recreational Fisheries Information Network (RECFIN), Representative Biological Sampling Program (REPBIO), Shark Bottom Longline Observer Program (SBLOP), State Reef Fish Survey (SRFS), and the Trip Interview Program (TIP). Fishery-dependent samples were collected from fish caught with hand-lines (HL), bottom longlines (LL), traps (TR), or vertical longlines (VL). Fishery-independent samples were provided by the Expanded Stock Assessment Survey (EASA), FWRI fishery-independent monitoring program (FWRI-FIM), Louisiana Department of Wildlife and Fisheries (LADWF), and NMFS - Pascagoula Laboratory, MS (MSLAB). Fishery-independent samples were collected from fish caught with HL, LL, TR, or VL.

Corresponding length and weight data collected with each otolith sample was used to update the morphometric conversion equations shown in Table 1A. Unspecified total length was used as the final length metric in SEDAR 22 (2011). However, we recommend using fork length (FL) as the final length type as nearly all tilefish in the dataset have an observed FL. This would reduce unnecessary noise in the length data versus using two different total length (TL) metrics (maximum or natural) to comprise unspecified TL. Therefore, we created conversion equations for other length types to FL as well as equations for converting FL to weight (Table 1B). All results presented in this document are in FL (mm). We did not estimate parameters for converting standard length to FL because all samples had an observed length for at least one of the three other length types. The equation for converting gutted weight to whole weight was not updated due to lack of data (Table 1C).

All tilefish otoliths collected prior to 2010 were processed and aged. Tilefish otolith processing for SEFSC-Gulf-01 began in early 2025, but dramatic staff reductions in August of that year necessitated subsampling of the remaining otoliths. Therefore, subsampling methods were applied to samples from the commercial fleet with a target of at least 300 otoliths processed for ageing per year. Specifically, if at least 300 otoliths had already been processed from a single year when staff reductions occurred, no more otoliths were processed from that year. For years, with <300 samples processed as of August 2025, otoliths were randomly selected from among all remaining available within a given year such that at least 300 otoliths would be processed and aged. This approach also applied to fishery-independent samples collected only in 2011, due to the large number received in that year. Samples from the recreational sector were not subsampled.

Otolith Processing and Age Estimation

Sagittal otoliths were the primary ageing structures for tilefish (Turner et al. 1983). Otoliths were cut into thin sections with a Hillquist, high-speed saw and adhered to glass microscope slides for viewing with transmitted light (GSMFC, 2003; NMFS, 2008). Tilefish otolith sections are considered difficult to interpret due to varied and inconsistent patterns in deposition. Andrews (2009) conducted a validation study for golden tilefish (GTL) but results were inconclusive. Lombardi and Andrews (2015) reported good agreement between radiometric and traditional age estimates for female and unknown age groups of GTL, but there were inconsistencies between radiometric and male age estimates. Patterson and Chamberlin (2023) did not validate annual deposition for tilefish, but did provide a method to validate deep-water fish age as well as a mechanism to explain discrepancies between $\Delta^{14}C$-based and traditional age estimates observed in previous studies. They found that bomb radiocarbon-based age estimates from eye lens cores agreed with traditional age estimates assuming annual deposition. They attributed agreement between eye lens core radiocarbon and traditional age estimates to the incorporation of enriched pelagic organic carbon (i.e., via food) into eye lens material and disagreement between otolith core radiocarbon and traditional age estimates to the incorporation of depleted inorganic carbon into otoliths. Although sample sizes in Patterson and Chamberlin (2023) were insufficient to fully validate GTL deposition rates, we maintained the previous assumption of annual deposition (i.e., a single translucent and opaque region comprised one year of growth) in tilefish otolith sections. Edge types were not assigned due to the difficulty in discerning otolith section margins and final ages were set equal to the annuli count.

A validated age reference set is not available for any Gulf tilefish species. Therefore, error in age estimates for the new data period was estimated using the set of (golden) tilefish otoliths (n=200) compiled by Lombardi and Andrews (2015). Despite their inconclusive validation results, extreme care and attention were given to that set of otoliths (i.e., double reads and consensus ages developed by two experts on tilefish age and growth) and are presumed to be the most accurately aged tilefish samples available. Preliminary estimates of ageing error were compared using indices of precision (Campana 2001) including percent agreement (PA), average percent error (APE), and average coefficient of variation (ACV), as well as Bland-Altman plots produced with the "*FSA*" package (Ogle et al., 2025) in R (R Core Team, 2025).

Both primary readers contributed approximately equal numbers of unique age estimates for the new data period. Therefore, bias (mean expected age-at-age) and precision (SD-at-age) were estimated for both readers with a single parameter set (i.e., mirrored) in the "*AgeingError*" package (Punt et al., 2008; Thorson et al. 2008) in R. Age estimates were converted to counts of each age-age combination and mode-predicted age estimated for the data. Candidate models included: 1) constant CV; 2) curvilinear SD; 3) curvilinear CV; 4) SD as a linear function of age; or 5) CV as a linear function of age. Akaike's information criterion (AIC), Bayesian information criterion (BIC), and diagnostic plots were used to identify the best-fit model to describe ageing error.

<u>Growth</u>

Gulf tilefish growth was modeled with the von Bertalanffy growth equation in AD Model Builder (Fournier et al., 2012). Models were built under four scenarios: 1) Gulf-wide, sexes combined; 2) Gulf-wide, sex-specific; 3) region-specific, sexes combined; or 4) region- and sex-specific. For region-specific models, samples were assigned to western or eastern Gulf regions demarcated by -89 degrees Longitude (the outflow of the Mississippi River at the Bird's Foot Delta) according to their fishing location coordinates (Lat/Long); headboat area, NMFS statistical grid, or state landed. Growth models were fit without specifying a truncated normal distribution because no minimum length limits have been imposed as management regulations for tilefish. Model variance was estimated with several different parameterization options including: 1) constant SD; 2) constant CV; 3) CV as a linear function of age; or 4) CV as a linear function of length-at-age. Due to the lack of small, young fish in the data (<5 yr), all models interpolated growth linearly until an initial specified age (A_{init}), after which growth followed the von Bertalanffy growth function. Model types 3 and 4 estimated two variance parameters where CV_1 described variance in growth from A_{init} to an initial age (A_{min}), and CV_2 described growth after A_{max} where growth was asymptotic. Variance in growth changed as a linear function of age or length-at-age between A_{min} and A_{max} following the equation:

$$CV_{linear} = CV_1 + (CV_1 - CV_2) * \frac{(A_{init} - A_{min})}{(A_{max} - A_{min})}$$

For model type 4, predicted lengths were converted to ages and input for A_{init}, A_{min}, and A_{max} and followed the same equation. Model types 1 and 2 estimated only a single variance parameter (σ_1 or CV_1). Fork length (mm) was used as the final length type in all growth models. Age-at-length data were not weighted.

Results and Discussion

Samples Collected

A total of n = 19,700 tilefish samples were collected since 1985, with n = 14,783 samples collected since 2010. A total of n = 12,469 age estimates were produced for tilefish, with n = 7,779 age estimates available since 2010. Nearly all (99.3%) of the samples collected since 2009 were received by the PC Lab and all otoliths were processed and aged by PC Lab personnel (Table 2). Nearly all age estimates were from commercial sector samples (92.1%) with fishery-independent and recreational samples comprising 7.6% and 0.4%, respectively (Table 3). Age samples were collected from among several Gulf states with 43.0% collected from FL, 34.1% from LA, and 20.5% from TX. Prior to 2008, most age samples (67.0%) were taken from fish captured off of Florida, but commercial samples from LA and TX increased in the late 2000s and have remained high throughout the time series (Table 4). The overwhelming majority of age samples were collected with COM LL gear (88.1%) and a small portion collected from fish caught with COM HL (3.8%) or FI LL (7.2%) gear (Table 5). Nearly all age samples from the commercial fleet and fishery independent surveys were captured with LL gear and all REC samples were collected from handline catches.

<u>Age Data</u>

Fish from the new data period were comprised of older (age-12+) individuals than in the previous data period, predominantly 6-12 yrs (Figure 1). Boxplots of age by year indicated that the shift to older individuals occurred rapidly from 2008 to 2010 and largely persisted through 2024 (Figure 2). A modest shift to larger sized individuals also was observed (Figure 3). Larger individuals were collected from 2008 through 2016 but length declined through 2020, then again increased through 2024 (Figure 4). Males comprised slightly larger percentage of the age samples than females overall (Figure 5), but females comprised more of the older individuals in most years (Figure 6). Females were much smaller than males (Figures 7 and 8). Samples from the West region comprised a slightly greater percentage of the age samples, with fish from the West region being slightly larger (Figures 9 and 10) and moderately older (Figures 11 and 12) than fish from the East. Proportions-at-age (Figure 13) and length (Figure 14) indicated relatively minor differences across fleets with COM HL gear collecting slightly more younger individuals (ages 5-10) than bottom longline gear.

An examination of the location data (i.e., NMFS statistical grid) for age samples from the commercial fleets indicated a strong shift in the predominant fishing grids where catch was taken (Figure 15). During the early 2000s, most age samples were collected from fish captured off of the west-Florida shelf and panhandle region (grids 1-10). Then, the percentage of age samples taken from fish captured from western grids off Texas and Louisiana rapidly increased from 2007 to 2010 and remained high (60-90%) through the terminal data year. This shift coincides with the adoption of Amendment 29 to the reef fish management plan, which implemented the individual fishing quota program for groupers and tilefish (GT-IFQ, GMFMC, 2008). We do not attribute the observed shift to changes in port sampler distribution as both state and federal port samplers were present along the western Gulf coast since 2000. Fish from the western Gulf were older than fish from the eastern Gulf overall (Figure 11) in most years (Figure 12). Therefore, the observed shift in age data to larger, older individuals during the new data period was likely due to the redistribution of fishing effort or quota allocation to the western Gulf resulting from the implementation of the GT-IFQ program (NMFS SERO, 2024). The percentage of age samples from the West-Florida shelf and panhandle region was variable over time comprising between ~15 and 40% across years. The variability in numbers of age samples from grids 1-10 was likely due to shifts in the spatial distribution of fishing vessels and/or allocation changes in response to red grouper quotas, which consistently comprise the majority of the landed catch since the start of the GT-IFQ program (NMFS SERO, 2024).

Ageing Error

Age estimates provided by each primary reader for the reference set were surprisingly low considering the relative difficulty of interpreting tilefish banding patterns. There was a consistent but small bias (+1 yr) for fish aged 4 and 5 by both readers compared to their "true" age, but negligible bias with high precision across the remainder of the age classes (Figure 16). Compared to the expert readers' "true" age estimates, average percent error (APE) was 5.6 and 8.6 for readers 1 and 2, respectively. The ages included in the reference set were slightly younger than the majority of the age classes observed in the production age data, but did include ages 15 to 32 yrs.

The best-fit model of ageing error (SD-at-age) assumed curvilinear bias for both primary readers and curvilinear SD for all three readers. This model better-fit the small bias in expected age for the youngest age classes included in the reference set but resulted in non-sensical SD-at-age estimates where expected age did not change after ~age 10. The full suite of candidate models allowing for non-linear bias resulted in similar non-sensical fits and were therefore not recommended for use in the assessment. With curvilinear bias excluded, the best-fit model assumed no bias in reader age estimates and linear SD-at-age for all readers (Table 6; Figure 17).

Growth

Age-at-length data indicated very high variability in size-at-age across all observed age classes. Growth models fit to all data estimated variance in size-at-age to span most of the size range across all ages (Figure 18). After ~age-7, Gulf tilefish of any age could be approximately any length. For example, one individual estimated to be 26 years old was measured at just over 400 mm FL, while another individual estimated to be 26 years old was measured at over 1000 mm FL. In contrast, other individuals at similar lengths (i.e., ~400 and ~1000 mm FL) were both estimated to be only 7 years of age. Several candidate models had statistically similar fits to the data (based on AICc values) but had a very narrow range of estimates for the L_∞ (770.8 to 773.6) and k (0.0970 to 0.0985) parameters (Table 7). Models were sensitive to the input values for the A_{init} parameter because very few small (≤400 mm FL) and young (≤4 yr) fish were available in the age data to estimate growth during the first few years of life. All four models with the lowest AICc values linearly interpolated growth through age-4. The model with the lowest AICc value and most parsimonious had constant CV and parameter estimates of L_∞ = 773.3 mm FL, k = 0.0970, and t_0 = -5.99 (Table 7). Residual plots indicated the model displayed no residual patterns with relatively evenly distributed data about the mean expected age.

Regional heterogeneity was described by Lombardi et al. (2010) for SEDAR 22 (2011), but we found little evidence to support region-specific growth models given data through 2024 (Figure 19). Both growth curves (constant CV) had very similar asymptotic length estimates (West = 779.3 mm; East = 774.6 mm), and the difference in the k parameter estimate was likely due to the lack of any young (<5 yrs old) fish from the western Gulf. Both best-fit models were linearly interpolated through age-3 yr.

We did find evidence to support sex-specific growth for tilefish (Table 8, Figure 20). Multiple models with different A_{init} values had statistically similar fits within each sex, and male growth fit with variance as constant sigma and CV was similar in some scenarios (Table 8). Therefore, we selected the best-fit sex-specific models as those with variance as having constant CV and interpolated growth through age-3 because 1) growth for females was significantly better fit with variance fit having constant CV; and 2) both sexes had a best-fit candidate model with A_{init} = 3. Mean asymptotic length among the selected sex-specific models was approximately 50 mm larger and growth coefficient 1.5 times larger for males than females. Both L_∞ and k parameter ranges were narrow among other statistically similar models. Parameter estimates for

L_∞ ranged from 802.7-826.0 mm for males and 735.6 to 751.2 mm for females. The estimated *k* parameter ranged from 0.1015 to 0.1186 for males and 0.0699 to 0.0774 for females. It is unclear how *k* was affected by the low number of small, young fish in the age data, but both sexes had similar numbers of observations ≤ age-5 yr in sex-specific models.

Ageing error is likely not the primary driver of variable growth-at-age or the shift to older ages in data from 2010-2024. "Reference set" age estimates provided by the two primary readers for SEFSC-Gulf-01 had very high precision (APEs of 5.6 and 8.6) for such a difficult to age species and very little bias that only was observed in the youngest two age classes. Alternatively, Gulf tilefish growth variability may be primarily influenced by their life history and the shift to older ages attributable to spatial shifts in fishing effort or primary target species. Living in deep-water burrows (>300 m), Gulf tilefish likely have very limited home ranges with variable access to food (Vecchio et al. 2021), which influences their growth rate and the corresponding thickness of the otolith deposition layers comprising annuli.

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TABLES

Table 1. Meristic regressions for the tilefish complex (golden tilefish only) from the Gulf of America updated with data through 2024.

Table 1A. Previous conversion equations updated with data through 2025.

Conversion and Units	n	Equation	Data Ranges	
FL (mm) to $TL_{unspecified}$ (mm)	1577	$TL_{unspecified} = -9.31 + 1.07 * FL$	FL (mm): 261-1153	$TL_{unspecified}$ (mm): 262-1109
$TL_{unspecified}$ (mm) to WWt (g)	1837	$WW = 5.31 \times 10^{-06} * (TL_{unspecified}{}^{3.11})$	$TL_{unspecified}$ (mm): 262-1109	WWt (g): 230-18000
FL (mm) to WWt (g)	1800	$WW = 3.43 \times 10^{-06} * (FL^{3.20})$	FL (mm): 275.2-1045	WWt (g): 200-16330
FL (mm) to GWt (g)	6288	$GW = 2.27 \times 10^{-06} * (FL^{3.25})$	FL (mm): 290-1153	GWt (g): 230-21591
FL (mm) to WWt (g)	1800	$WW = \ln(-12.03) + 3.11 * \ln(FL)$	FL (mm): 275.2-1045	WWt (g): 200-16330
FL (mm) to MaxTL (mm)	502	$MaxTL = -9.48 + 1.07 * FL$	FL (mm): 269-1023	Max TL (mm): 262-1103
MaxTL (mm) to WWt (g)	659	$WW = 4.95 \times 10^{-06} * MaxTL^{(3.11)}$	Max TL (mm): 262-1103	WWt (g): 230-16330

Table 1B. Newly created conversion equations.

Conversion and Units	n	Equation	Data Ranges	
FL (mm) to NatTL (mm)	1089	$NatTL = -8.42 + 1.07 * FL$	FL (mm): 326-1045	Nat TL (mm): 371-1109
$TL_{unspecified}$ (mm) to FL (mm)	1577	$FL = 16.66 + 0.92 * TL_{unspecified}$	TL unspecified (mm): 262-1109	FL (mm): 269-1045
MaxTL (mm) to FL (mm)	502	$FL = 10.48 + 0.93 * MaxTL$	Max TL (mm): 262-1103	FL (mm): 269-1023
NatTL (mm) to FL (mm)	1089	$FL = 20.58 + 0.91 * NatTL$	Nat TL (mm): 371-1109	FL (mm): 326-1045
NatTL (mm) to WWt (g)	1191	$WW = 5.50 \times 10^{-06} * NatTL^{(3.10)}$	Nat TL (mm): 371-1109	WWt (g): 300-18000

Table 1C. Conversion equations not updated.

Conversion and Units	n	Equation	Data Ranges	
GWt (g) to WWt (g)	75	$WW = 1.065 * GW$	GWt (g): NA	WWt (g): NA

Table 2. Number of golden tilefish age samples (n =12,469) from the Gulf of America from 1985 to 2024 by data provider. The black line indicates the terminal data year in SEDAR 22 (i.e., 2009). Total Collected indicates the number of samples received by PC Lab originally available for processing for SEFSC-Gulf-01. No age samples were collected in 1986-1996 or 1999.

Year	FWRI	PCLab-AGR	PCLab-BSD	Total Aged	Total Collected
1985	0	43	0	43	43
1997	0	43	0	43	43
1998	0	4	0	4	4
2000	0	22	0	22	23
2001	0	91	0	91	91
2002	0	143	0	143	146
2003	0	307	0	307	353
2004	0	546	0	546	576
2005	0	614	0	614	649
2006	0	271	0	271	289
2007	0	405	0	405	432
2008	0	775	0	775	795
2009	0	1426	0	1426	1473
2010	0	46	326	372	965
2011	0	246	287	533	2213
2012	0	76	454	530	1706
2013	0	64	323	387	1388
2014	0	23	281	304	955
2015	37	40	289	366	858
2016	7	121	603	731	788
2017	3	9	395	407	1016
2018	14	22	495	531	1090
2019	8	39	760	807	844
2020	0	39	446	485	497
2021	0	24	378	402	420
2022	15	16	567	598	666
2023	0	50	695	745	790
2024	0	11	570	581	587
Total aged	84	5516	6869	12469	19700
% Total aged	0.7	44.2	55.1	--	--

Table 3. Number of golden tilefish age samples collected from the Gulf of America from 1985 to 2024 by fishery (commercial, COM; fishery independent, FI; or recreational, REC). No age samples were collected in 1986-1996 or 1999.

Year	COM	FI	REC	Total
1985	0	43	0	43
1997	43	0	0	43
1998	4	0	0	4
2000	16	6	0	22
2001	44	47	0	91
2002	98	45	0	143
2003	307	0	0	307
2004	509	37	0	546
2005	594	20	0	614
2006	240	31	0	271
2007	347	58	0	405
2008	747	28	0	775
2009	1382	44	0	1426
2010	326	46	0	372
2011	287	246	0	533
2012	488	39	3	530
2013	387	0	0	387
2014	281	23	0	304
2015	287	72	7	366
2016	697	23	11	731
2017	395	12	0	407
2018	495	36	0	531
2019	770	28	9	807
2020	485	0	0	485
2021	388	14	0	402
2022	572	11	15	598
2023	721	24	0	745
2024	570	11	0	581
Total	11480	944	45	12469
% Total	92.1	7.6	0.4	--

Table 4. Number of tilefish age samples collected from the Gulf of America from 1985 to 2024 by state landed (Alabama, AL; Florida, FL; Louisiana, LA; Texas, TX; Not Landed, NL; or Unknown, UNK). All samples labeled as NL were collected in FL waters. No age samples were collected in 1986-1996 or 1999.

Year	AL	FL	LA	TX	NL	Unk	Total
1985	5	38	0	0	0	0	43
1997	0	43	0	0	0	0	43
1998	0	4	0	0	0	0	4
2000	0	16	6	0	0	0	22
2001	2	65	12	12	0	0	91
2002	0	106	17	20	0	0	143
2003	0	277	19	11	0	0	307
2004	2	518	22	4	0	0	546
2005	0	576	38	0	0	0	614
2006	30	202	11	28	0	0	271
2007	9	278	24	94	0	0	405
2008	43	259	155	318	0	0	775
2009	94	765	142	425	0	0	1,426
2010	0	83	226	63	0	0	372
2011	11	140	269	113	0	0	533
2012	6	252	153	119	0	0	530
2013	0	194	125	68	0	0	387
2014	12	129	69	94	0	0	304
2015	1	147	125	61	32	0	366
2016	0	258	234	238	1	0	731
2017	0	59	209	136	3	0	407
2018	0	139	337	41	14	0	531
2019	1	190	523	93	0	0	807
2020	0	87	354	44	0	0	485
2021	0	84	246	72	0	0	402
2022	1	191	214	192	0	0	598
2023	0	224	228	269	0	24	745
2024	0	42	500	39	0	0	581
Total	217	5,366	4,258	2,554	50	24	12,469
% Total	1.7	43.0	34.1	20.5	0.4	0.2	100.0

Table 5. Number of tilefish age samples collected from the Gulf of America from 1985 to 2024 by fishery (commercial, COM; fishery independent, FI; or recreational, REC) and by gear (handline, HL; bottom longline, LL; trap, TR; unknown, UA; or vertical longline, VL). No age samples were collected in 1986-1996 or 1999.

	COM			FI				REC	
Year	**HL**	**LL**	**UA**	**HL**	**LL**	**TR**	**VL**	**HL**	**Total**
1985	0	0	0	0	43	0	0	0	43
1997	0	43	0	0	0	0	0	0	43
1998	0	4	0	0	0	0	0	0	4
2000	5	11	0	0	6	0	0	0	22
2001	0	44	0	0	47	0	0	0	91
2002	24	74	0	0	45	0	0	0	143
2003	34	273	0	0	0	0	0	0	307
2004	2	507	0	0	37	0	0	0	546
2005	44	550	0	0	20	0	0	0	614
2006	3	237	0	0	31	0	0	0	271
2007	10	337	0	0	58	0	0	0	405
2008	55	692	0	0	28	0	0	0	775
2009	59	1323	0	0	44	0	0	0	1426
2010	6	320	0	0	46	0	0	0	372
2011	4	283	0	2	244	0	0	0	533
2012	46	442	0	0	39	0	0	3	530
2013	52	335	0	0	0	0	0	0	387
2014	8	273	0	0	23	0	0	0	304
2015	13	271	3	2	40	29	1	7	366
2016	15	682	0	1	22	0	0	11	731
2017	7	388	0	3	9	0	0	0	407
2018	40	455	0	11	22	2	1	0	531
2019	27	743	0	0	28	0	0	9	807
2020	1	484	0	0	0	0	0	0	485
2021	0	372	16	0	14	0	0	0	402
2022	21	551	0	0	11	0	0	15	598
2023	0	721	0	0	24	0	0	0	745
2024	3	567	0	0	11	0	0	0	581
Total	479	10982	19	19	892	31	2	45	12469
% Fleet	4.2	95.7	0.2	2.0	94.5	3.3	0.2	100.0	--
% Total	3.8	88.1	0.2	0.2	7.2	0.2	0.0	0.4	--

Table 6. Standard deviation (SD)-at-age of Gulf tilefish production age estimates. Age estimates were assumed to be unbiased with linear SD in precision. Bias and precision parameter estimates for reader 2 were mirrored to those for reader 1.

True Age	Expected Age	SD-at-age
0	0.5	0.10
1	1.5	0.10
2	2.5	0.20
3	3.5	0.30
4	4.5	0.40
5	5.5	0.50
6	6.5	0.60
7	7.5	0.70
8	8.5	0.81
9	9.5	0.91
10	10.5	1.01
11	11.5	1.11
12	12.5	1.21
13	13.5	1.31
14	14.5	1.41
15	15.5	1.51
16	16.5	1.61
17	17.5	1.71
18	18.5	1.81
19	19.5	1.91
20	20.5	2.01
21	21.5	2.11
22	22.5	2.21
23	23.5	2.32
24	24.5	2.42
25	25.5	2.52
26	26.5	2.62
27	27.5	2.72
28	28.5	2.82
29	29.5	2.92
30	30.5	3.02
31	31.5	3.12
32	32.5	3.22

Table 7. Model number, type, inputs, fit statistics, and parameter estimates from the von Bertalanffy growth function fit to length-at-age data (sexes combined) for Gulf tilefish sampled from 1985-2024. Parameter estimates from SEDAR22 are indicated in models a-j. The best-fit model (ΔAICc) is indicated with gray shading.

Source	Number	Model	Sex	Region	n	VB_{min}	A_{min}	A_{max}	Obj Fxn	AICc	ΔAICc	L_∞	k	t_0	σ_1/CV_1	σ_2/CV_2
SEDAR22-DW-01	a	Constant sigma (external)	Both	Gulf	4,841	--	--	--	--	--	--	830.0	0.1300	-2.14	--	--
SEDAR22-DW	b	Constant sigma (external)	M	Gulf	534	--	--	--	--	--	--	767.0	0.1500	-1.46	--	--
SEDAR22-DW	c	Constant sigma (external)	F	Gulf	341	--	--	--	--	--	--	613.0	0.1300	-4.56	--	--
SEDAR22 SS	d	Linear fxn age (age-1) (internal)	Both	Gulf	4,841	--	--	--	--	--	--	830.0	0.1400	--	0.08	--
SEDAR22 SS	e	Linear fxn age (age-1) (internal)	Both	East	3220	--	--	--	--	--	--	878.0	0.1090	-2.86	--	--
SEDAR22 SS	f	Linear fxn age (age-1) (internal)	Both	West	1427	--	--	--	--	--	--	773.0	0.1721	-2.36	--	--
SEDAR22 SS	g	Linear fxn age (age-1) (internal)	M	East	?	--	--	--	--	--	--	866.0	0.1603	--	--	--
SEDAR22 SS	h	Linear fxn age (age-1) (internal)	M	West	?	--	--	--	--	--	--	924.0	0.1334	--	--	--
SEDAR22 SS	i	Linear fxn age (age-1) (internal)	F	East	?	--	--	--	--	--	--	656.0	0.1882	--	--	--
SEDAR22 SS	j	Linear fxn age (age-1) (internal)	F	West	?	--	--	--	--	--	--	821.0	0.1082	--	--	--
Source	**Number**	**Model**	**Sex**	**Region**	**n**	**VB_{min}**	**A_{min}**	**A_{max}**	**Obj Fxn**	**AICc**	**ΔAICc**	**L_∞**	**k**	**t_0**	**σ_1/CV_1**	**σ_2/CV_2**
SEFSC-Gulf-01	1	Constant sigma	Both	Gulf	12,465	0.1	--	--	77662.6	155333.0	316.0	827.7	0.0935	-6.20	122.92	--
SEFSC-Gulf-01	2	Constant sigma	Both	Gulf	12,465	1	--	--	77662.6	155333.0	316.0	827.7	0.0935	-6.20	122.92	--
SEFSC-Gulf-01	3	Constant sigma	Both	Gulf	12,465	2	--	--	77662.4	155333.0	316.0	828.0	0.0933	-6.22	122.92	--
SEFSC-Gulf-01	4	Constant sigma	Both	Gulf	12,465	3	--	--	77660.2	155328.0	311.0	830.2	0.0916	-6.41	122.90	--
SEFSC-Gulf-01	5	Constant sigma	Both	Gulf	12,465	4	--	--	77655.2	155318.0	301.0	838.9	0.0854	-7.18	122.85	--
SEFSC-Gulf-01	6	Constant sigma	Both	Gulf	12,465	5	--	--	77650.7	155309.0	292.0	864.1	0.0709	-9.40	122.81	--
SEFSC-Gulf-01	7	Constant CV	Both	Gulf	12,465	0.1	--	--	77557.1	155122.0	105.0	807.1	0.1107	-4.63	0.18	--
SEFSC-Gulf-01	8	Constant CV	Both	Gulf	12,465	1	--	--	77513.9	155036.0	19.0	801.8	0.1191	-4.03	0.18	--
SEFSC-Gulf-01	9	Constant CV	Both	Gulf	12,465	2	--	--	77513.9	155036.0	19.0	801.8	0.1191	-4.03	0.18	--
SEFSC-Gulf-01	10	Constant CV	Both	Gulf	12,465	3	--	--	77508.1	155024.0	7.0	806.6	0.1139	-4.43	0.18	--
SEFSC-Gulf-01	11	Constant CV	Both	Gulf	12,465	4	--	--	77504.7	155017.0	0.0	816.1	0.1044	-5.24	0.18	--
SEFSC-Gulf-01	12	Constant CV	Both	Gulf	12,465	5	--	--	77510.8	155030.0	13.0	831.1	0.0898	-7.00	0.18	--
SEFSC-Gulf-01	13	Linear fxn age	Both	Gulf	12,465	0.1	1	20	77556.9	155124.0	107.0	806.0	0.1115	-4.58	0.18	0.18
SEFSC-Gulf-01	14	Linear fxn age	Both	Gulf	12,465	1	1	20	77556.9	155124.0	107.0	806.0	0.1115	-4.58	0.18	0.18
SEFSC-Gulf-01	15	Linear fxn age	Both	Gulf	12,465	2	2	20	77556.5	155123.0	106.0	806.2	0.1113	-4.60	0.18	0.18
SEFSC-Gulf-01	16	Linear fxn age	Both	Gulf	12,465	3	3	20	77552.3	155115.0	98.0	808.4	0.1091	-4.79	0.18	0.18
SEFSC-Gulf-01	17	Linear fxn age	Both	Gulf	12,465	4	4	20	77547.6	155105.0	88.0	820.2	0.0981	-5.82	0.18	0.18
SEFSC-Gulf-01	18	Linear fxn age	Both	Gulf	12,465	5	5	20	77555.0	155120.0	103.0	859.8	0.0724	-9.24	0.18	0.18
SEFSC-Gulf-01	19	Linear fxn age	Both	Gulf	12,465	0.1	5	20	77556.9	155124.0	107.0	805.9	0.1115	-4.58	0.18	0.18
SEFSC-Gulf-01	20	Linear fxn age	Both	Gulf	12,465	0.1	5	30	77556.7	155123.0	106.0	804.9	0.1123	-4.53	0.18	0.18
SEFSC-Gulf-01	21	Linear fxn size-at-age	Both	Gulf	12,465	0.1	1	20	77557.0	155124.0	107.0	806.5	0.1111	-4.61	0.18	0.18

Table 8. Model number, type, inputs, fit statistics, and parameter estimates from the von Bertalanffy growth function fit to sex-specific length-at-age data for Gulf tilefish sampled from 1985-2024. Best-fit models (ΔAICc) are indicated with gray shading.

Source	Number	Model	Sex	Region	n	A_{init}	A_{min}	A_{max}	Obj Fxn	AICc	ΔAICc	L_∞	k	t_0	σ_1/CV_1	σ_2/CV_2
SEFSC-Gulf-01	22	Constant sigma	M	Gulf	965	0.1	--	--	5882.2	11772.5	0.60	826.0	0.1019	-4.70	107.41	--
SEFSC-Gulf-01	23	Constant sigma	M	Gulf	965	1	--	--	5882.2	11772.5	0.60	826.0	0.1019	-4.70	107.41	--
SEFSC-Gulf-01	24	Constant sigma	M	Gulf	965	2	--	--	5882.2	11772.5	0.60	826.0	0.1019	-4.70	107.41	--
SEFSC-Gulf-01	25	Constant sigma	M	Gulf	965	3	--	--	5882.4	11772.8	0.90	826.4	0.1015	-4.73	107.42	--
SEFSC-Gulf-01	26	Constant sigma	M	Gulf	965	4	--	--	5883.0	11774.1	2.20	831.2	0.0977	-5.10	107.50	--
SEFSC-Gulf-01	27	Constant sigma	M	Gulf	965	5	--	--	5883.2	11774.3	2.40	847.0	0.0867	-6.31	107.51	--
SEFSC-Gulf-01	28	Constant CV	M	Gulf	965	0.1	--	--	5881.9	11771.9	0.00	802.7	0.1186	-3.63	0.16	--
SEFSC-Gulf-01	29	Constant CV	M	Gulf	965	1	--	--	5881.9	11771.9	0.00	802.7	0.1186	-3.63	0.16	--
SEFSC-Gulf-01	30	Constant CV	M	Gulf	965	2	--	--	5881.9	11771.9	0.00	802.7	0.1186	-3.63	0.16	--
SEFSC-Gulf-01	31	Constant CV	M	Gulf	965	3	--	--	5882.2	11772.5	0.60	804.3	0.1169	-3.75	0.16	--
SEFSC-Gulf-01	32	Constant CV	M	Gulf	965	4	--	--	5885.2	11778.5	6.60	818.0	0.1036	-4.86	0.16	--
SEFSC-Gulf-01	33	Constant CV	M	Gulf	965	5	--	--	5889.0	11786.1	14.20	845.6	0.0833	-7.10	0.16	--
SEFSC-Gulf-01	34	Constant sigma	F	Gulf	940	0.01	--	--	5698.2	11404.4	55.50	716.0	0.0838	-6.03	103.86	--
SEFSC-Gulf-01	35	Constant sigma	F	Gulf	940	1	--	--	5698.2	11404.4	55.50	716.0	0.0838	-6.03	103.86	--
SEFSC-Gulf-01	36	Constant sigma	F	Gulf	940	2	--	--	5698.2	11404.4	55.50	716.0	0.0838	-6.03	103.86	--
SEFSC-Gulf-01	37	Constant sigma	F	Gulf	940	3	--	--	5697.8	11403.7	54.80	720.1	0.0812	-6.34	103.82	--
SEFSC-Gulf-01	38	Constant sigma	F	Gulf	940	4	--	--	5697.8	11403.6	54.70	727.1	0.0768	-6.93	103.81	--
SEFSC-Gulf-01	39	Constant sigma	F	Gulf	940	5	--	--	5700.2	11408.4	59.50	754.8	0.0627	-9.32	104.09	--
SEFSC-Gulf-01	40	Constant CV	F	Gulf	940	0.01	--	--	5671.8	11351.6	2.70	730.0	0.0804	-5.97	0.18	--
SEFSC-Gulf-01	41	Constant CV	F	Gulf	940	1	--	--	5671.8	11351.6	2.70	730.0	0.0804	-5.97	0.18	--
SEFSC-Gulf-01	42	Constant CV	F	Gulf	940	2	--	--	5671.8	11351.6	2.70	730.0	0.0804	-5.97	0.18	--
SEFSC-Gulf-01	43	Constant CV	F	Gulf	940	3	--	--	5670.7	11349.5	0.60	735.6	0.0774	-6.31	0.18	--
SEFSC-Gulf-01	44	Constant CV	F	Gulf	940	4	--	--	5670.4	11348.9	0.00	751.2	0.0699	-7.33	0.18	--
SEFSC-Gulf-01	45	Constant CV	F	Gulf	940	5	--	--	5677.1	11362.3	13.40	777.5	0.0572	-10.00	0.18	--

FIGURES

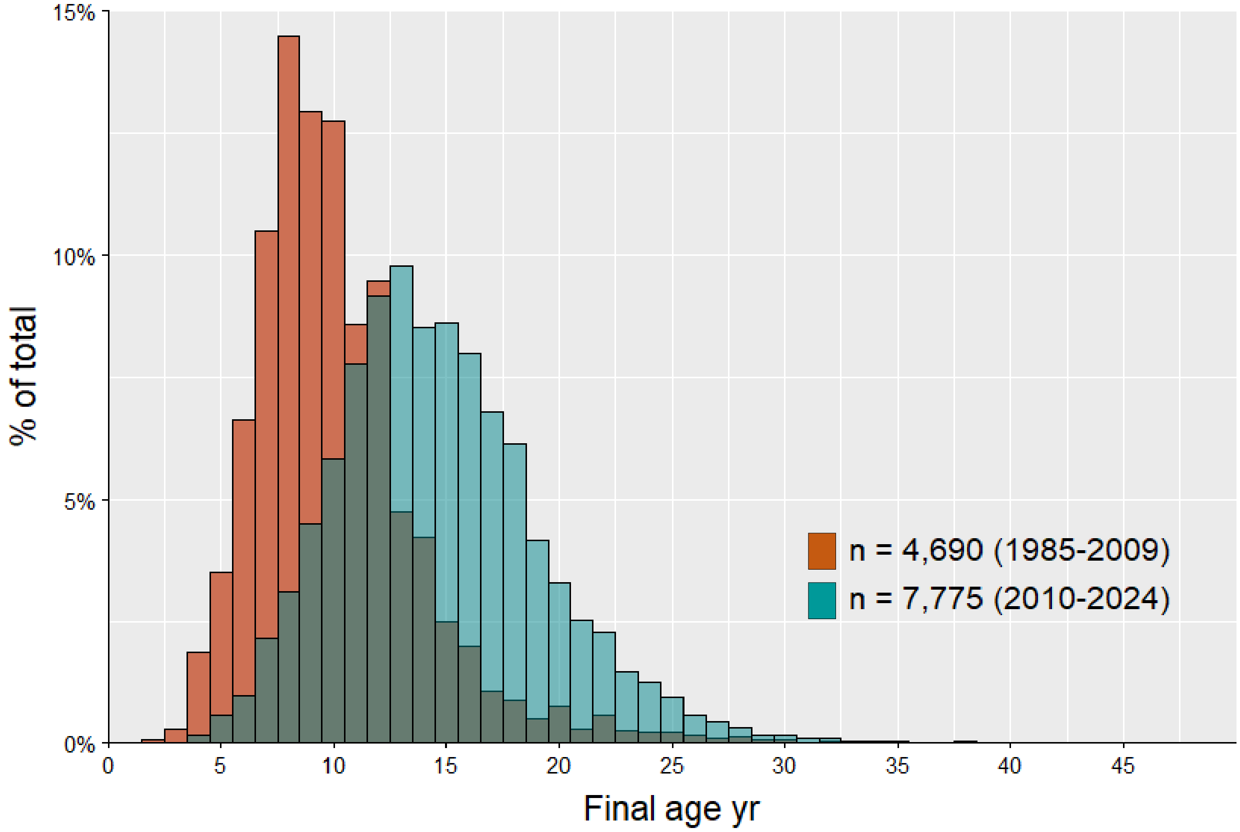

Figure 1. Frequency (% of total) histogram of age samples from new (red bars) versus previously submitted (turquoise bars) data (SEDAR 22).

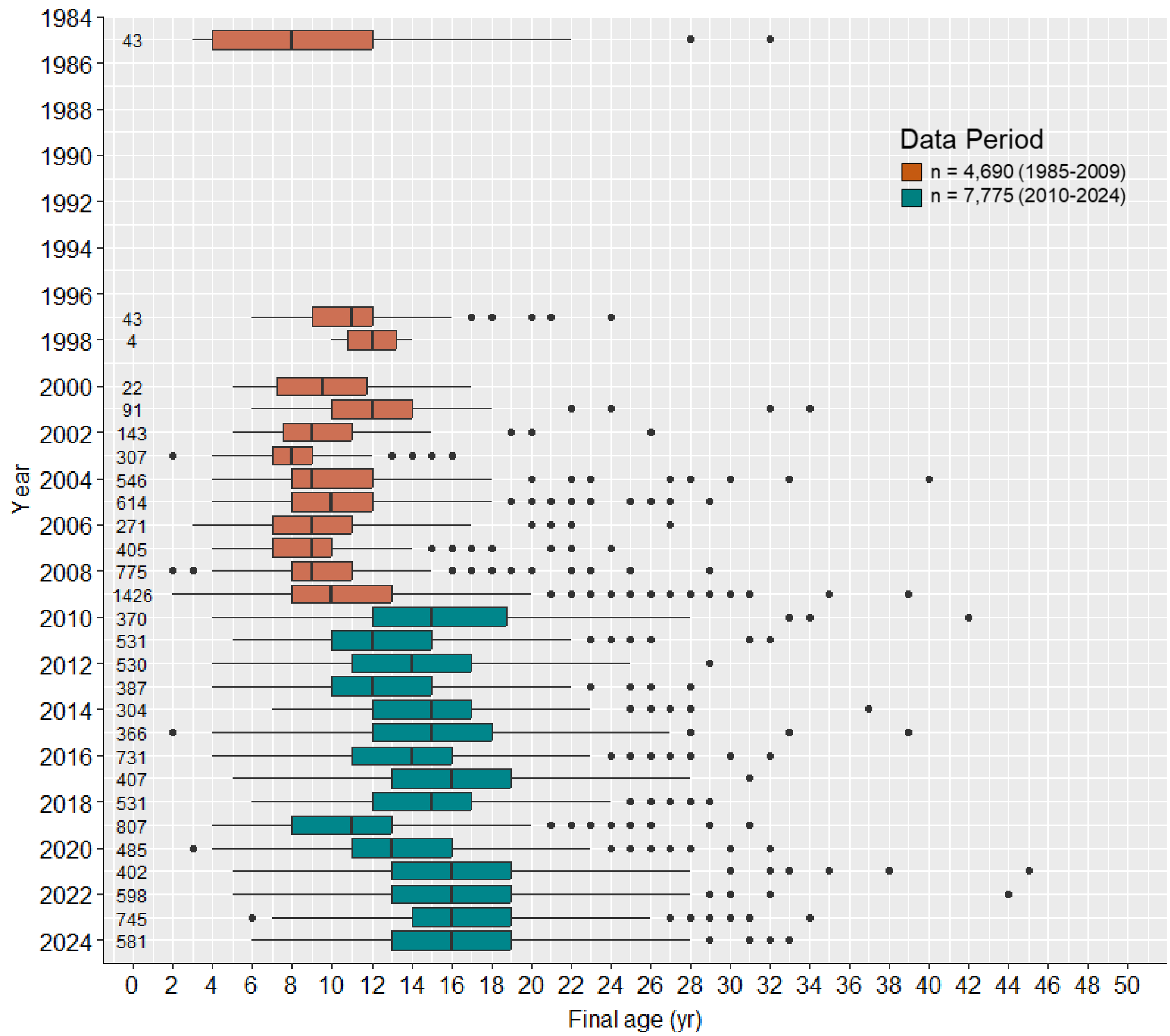

Figure 2. Boxplot of final (calendar) age (yr) by year for tilefish age samples collected from the Gulf of America from 1985 to 2024 for new (2010-2024, red bars) versus previously submitted (1985-2009, turquoise bars) data (SEDAR 22). No age samples were collected from 1986-1996 or 1999. Sample numbers are shown along the right side of the figure. Boxes indicate the 25th and 75th percentiles, vertical lines indicate median values, horizontal lines indicate the min and max values of the IQR*1.5, and points indicate values outside that range.

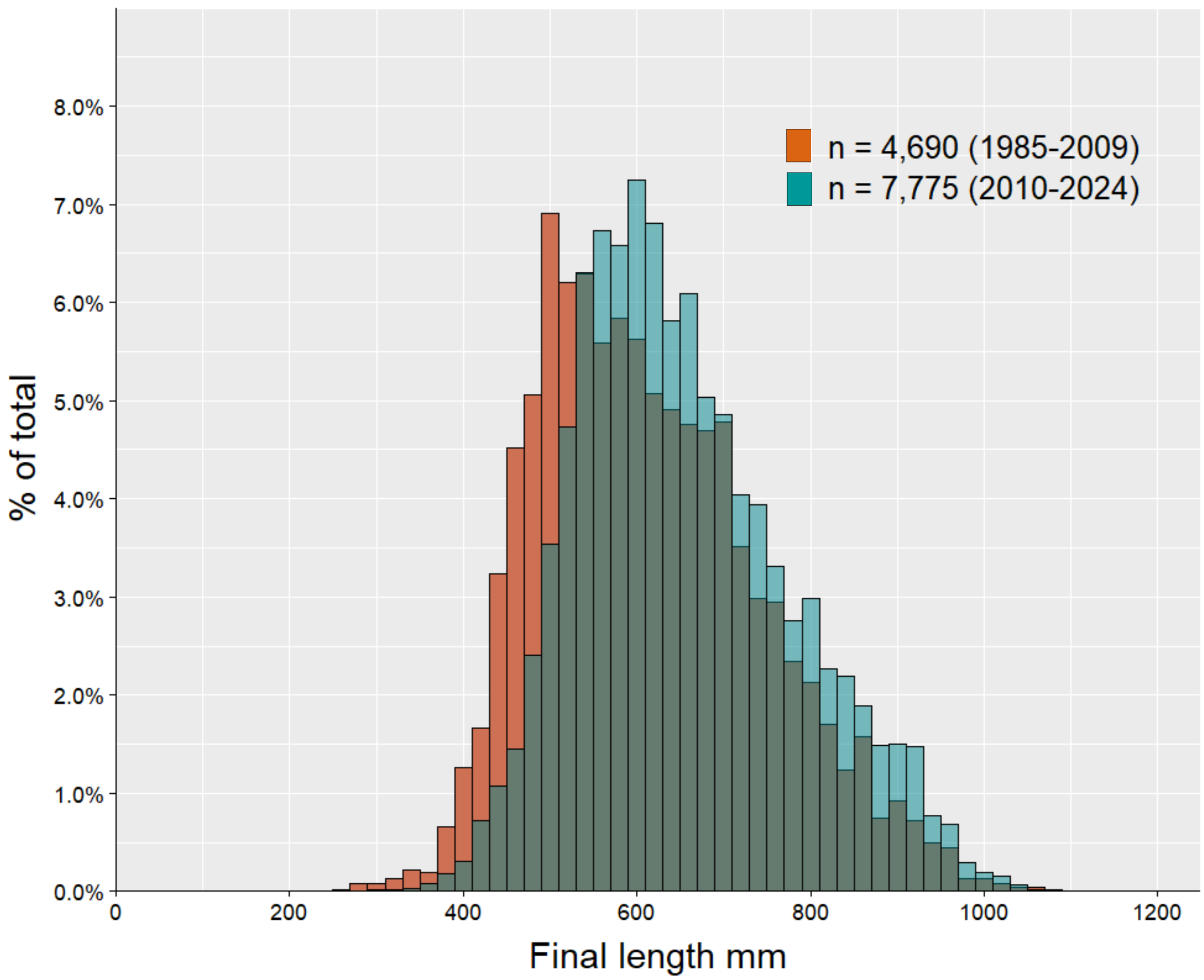

Figure 3. Frequency (% of total) histogram of final (fork) length data (mm) for new (red bars) versus previously submitted (turquoise bars) data (SEDAR 22).

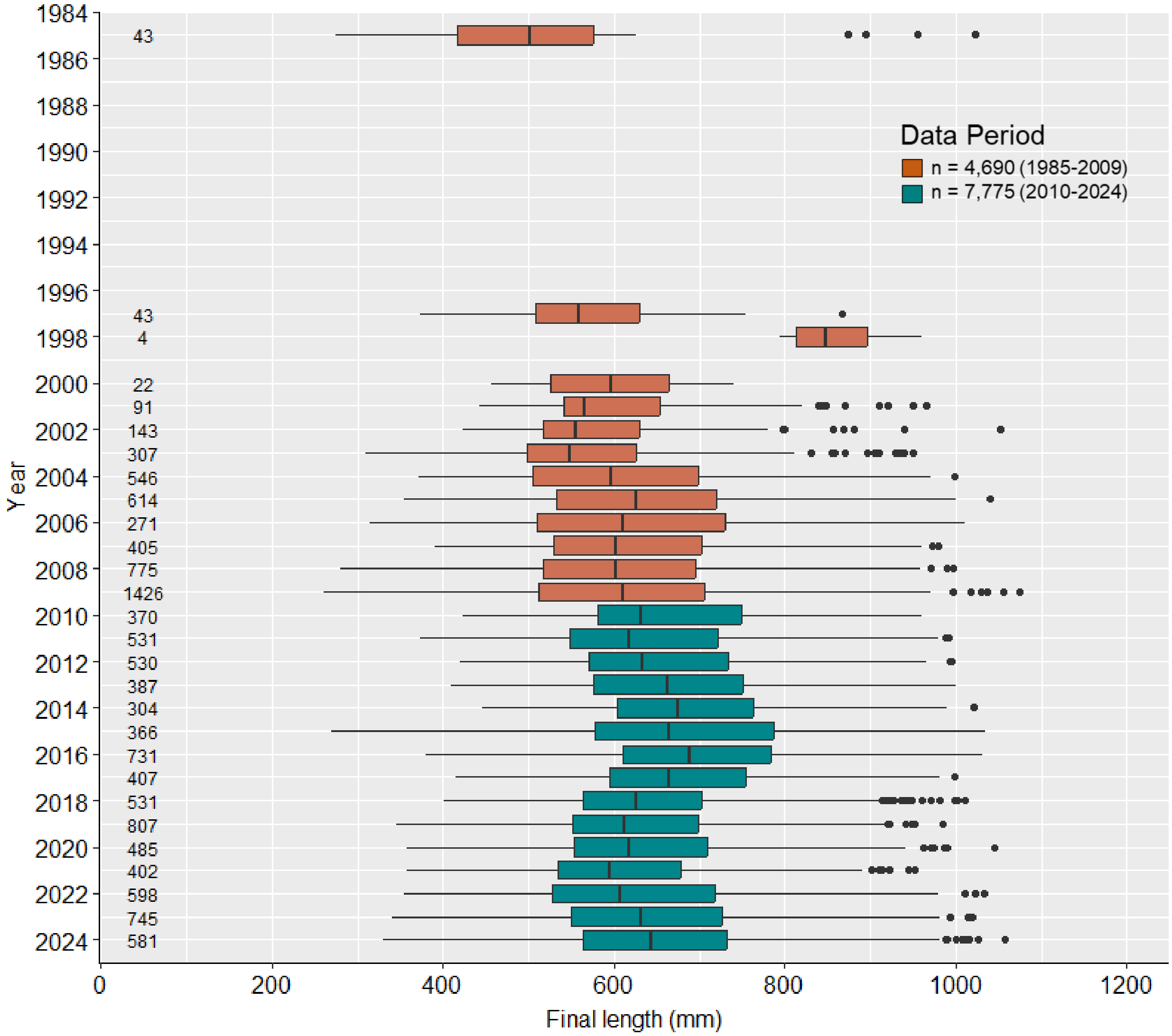

Figure 4. Boxplot of final (fork) length (mm) by year for tilefish age samples collected from the Gulf of America from 1985 to 2024 for new (red) versus previously submitted (turquoise) data (SEDAR 22). No age samples were collected from 1986-1996 or 1999. Sample numbers are shown along the right side of the figure. Boxes indicate the 25th and 75th percentiles, vertical lines indicate median values, horizontal lines indicate the min and max values of the IQR*1.5, and points indicate values outside that range. Sample sizes are shown at the inner left of the panel.

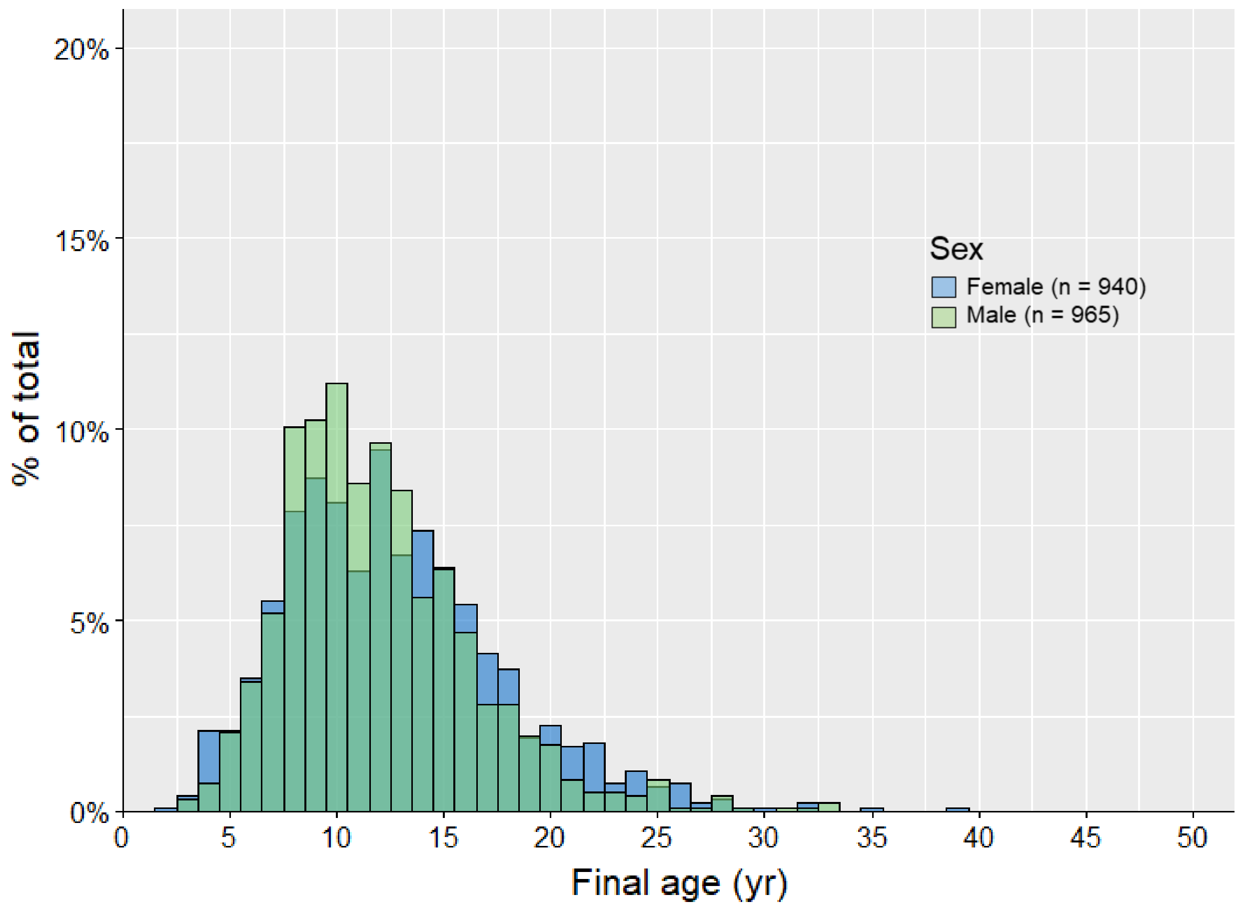

Figure 5. Frequency histogram (% total) of final age (yr) for female (light blue bars) vs male (light green bars) tilefish collected from the Gulf of America from 1985-2024.

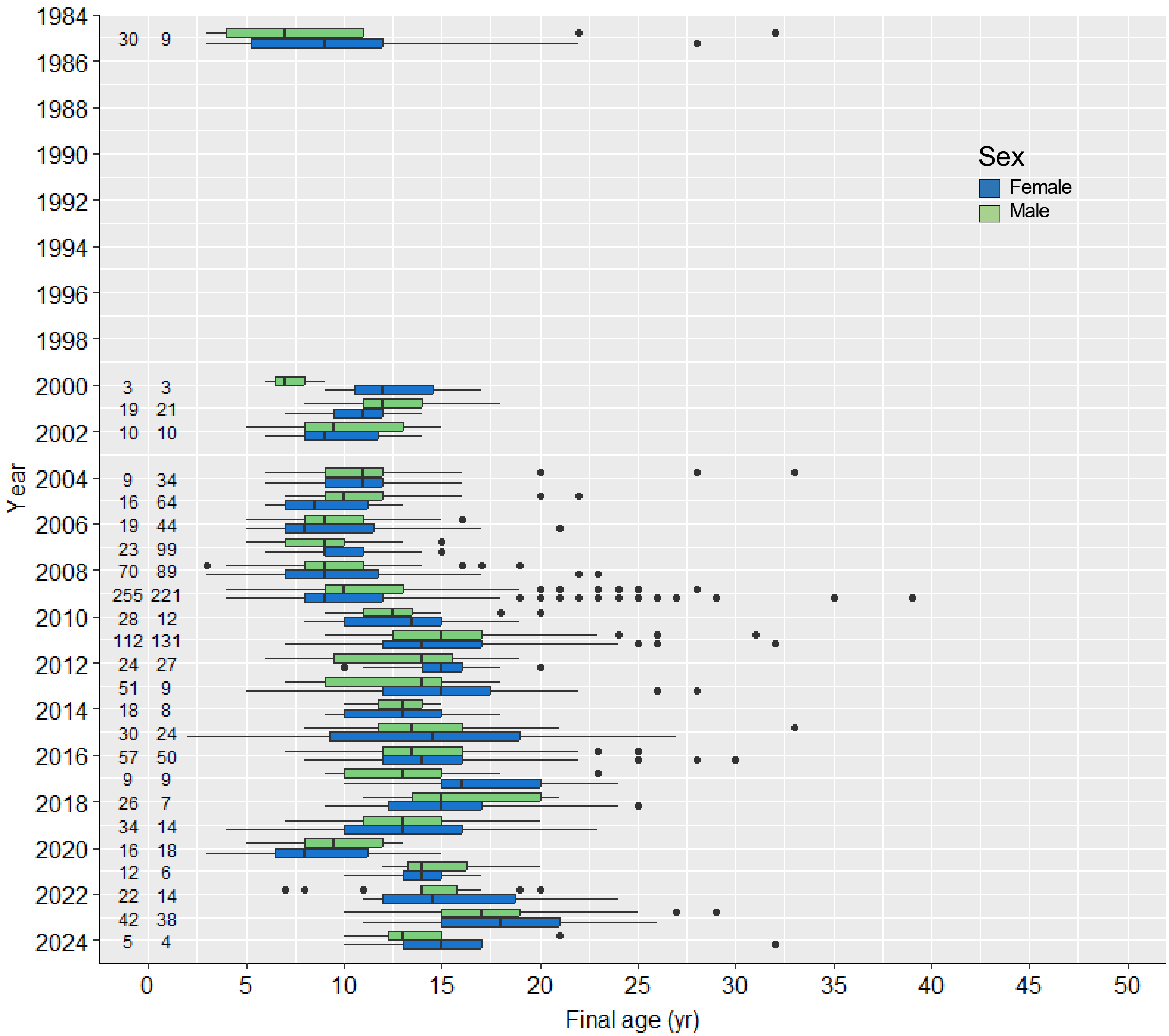

Figure 6. Boxplot of final (calendar) age (yr) by year for tilefish age samples collected from the Gulf of America from 1985 to 2024 for females (light blue) versus males (light green). No age samples were collected from 1986-1996 or 1999. Sample numbers are shown along the right side of the figure. Boxes indicate the 25th and 75th percentiles, vertical lines indicate median values, horizontal lines indicate the min and max values of the IQR*1.5, and points indicate values outside that range. Sample sizes (female left, male right) are shown at the inner left of the figure.

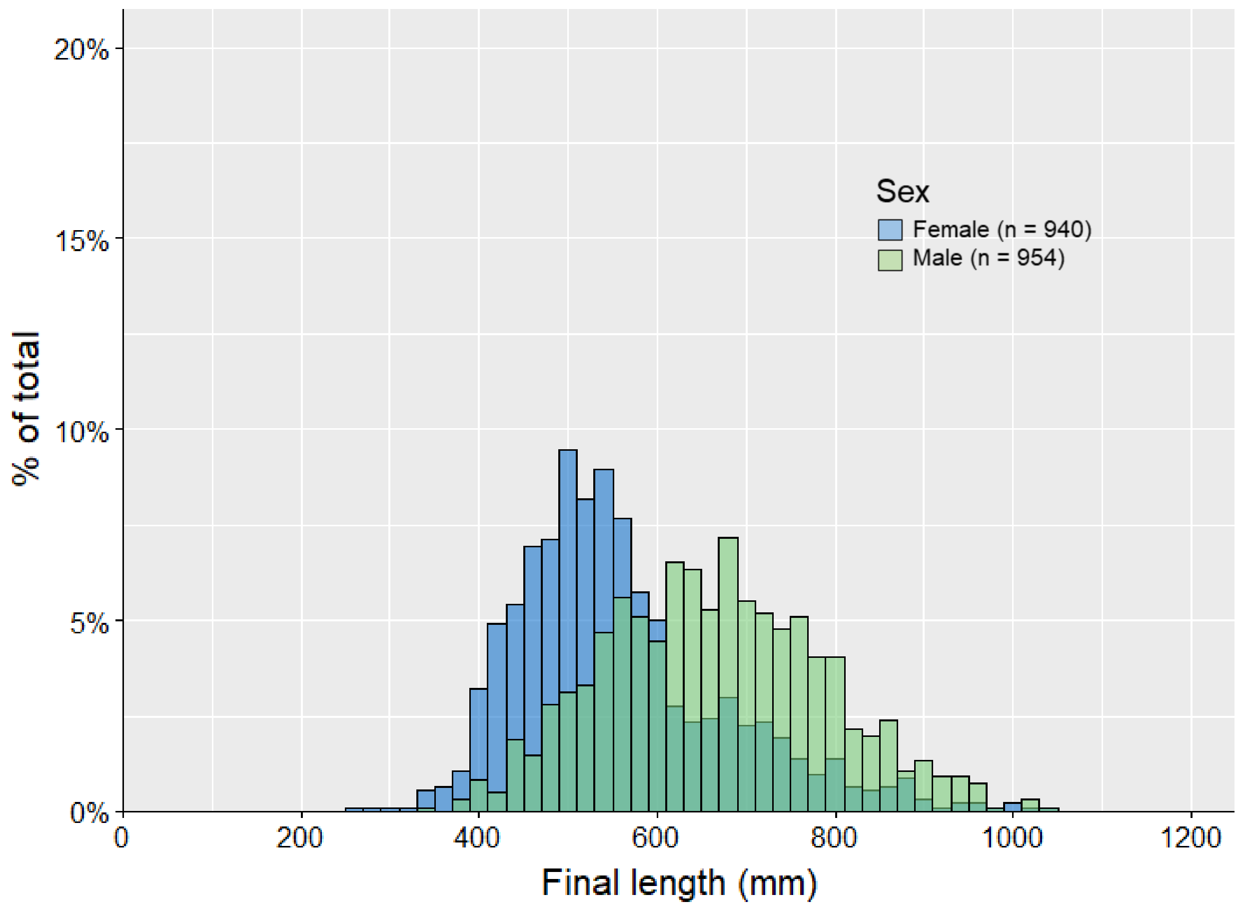

Figure 7. Frequency histogram (% of total) of final (fork) length (binwidth = 20 mm) for female (light blue bars) vs male (light green bars) tilefish collected from the Gulf of America from 1985-2024.

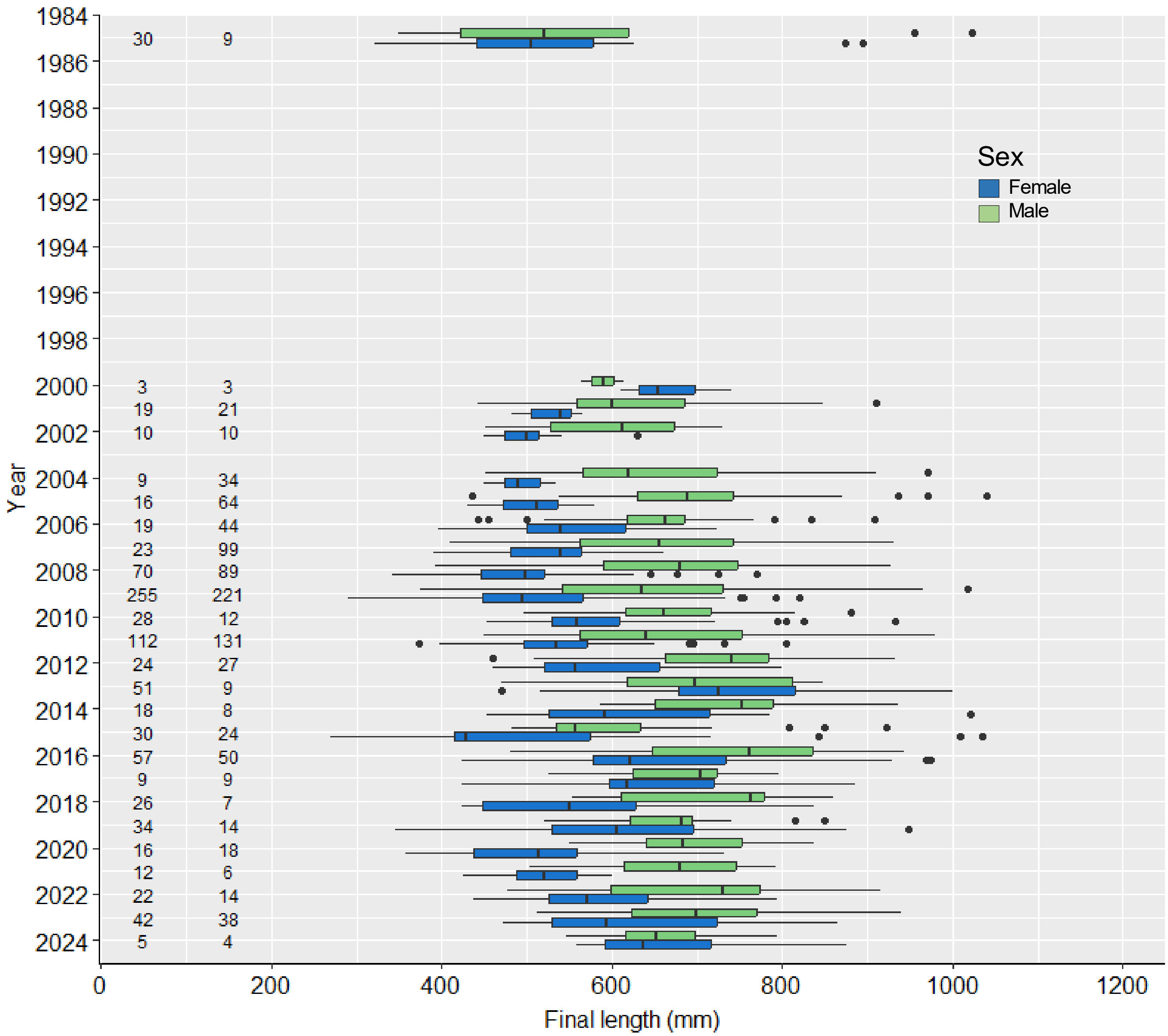

Figure 8. Boxplot of final (fork) length (mm) by year for tilefish age samples collected from the Gulf of America from 1985 to 2024 for females (light blue) versus males (light green). No age samples were collected from 1986-1996 or 1999. Sample numbers are shown along the right side of the figure. Boxes indicate the 25th and 75th percentiles, vertical lines indicate median values, horizontal lines indicate the min and max values of the IQR*1.5, and points indicate values outside that range. Sample sizes (female left, male right) are shown on the left side of the figure.

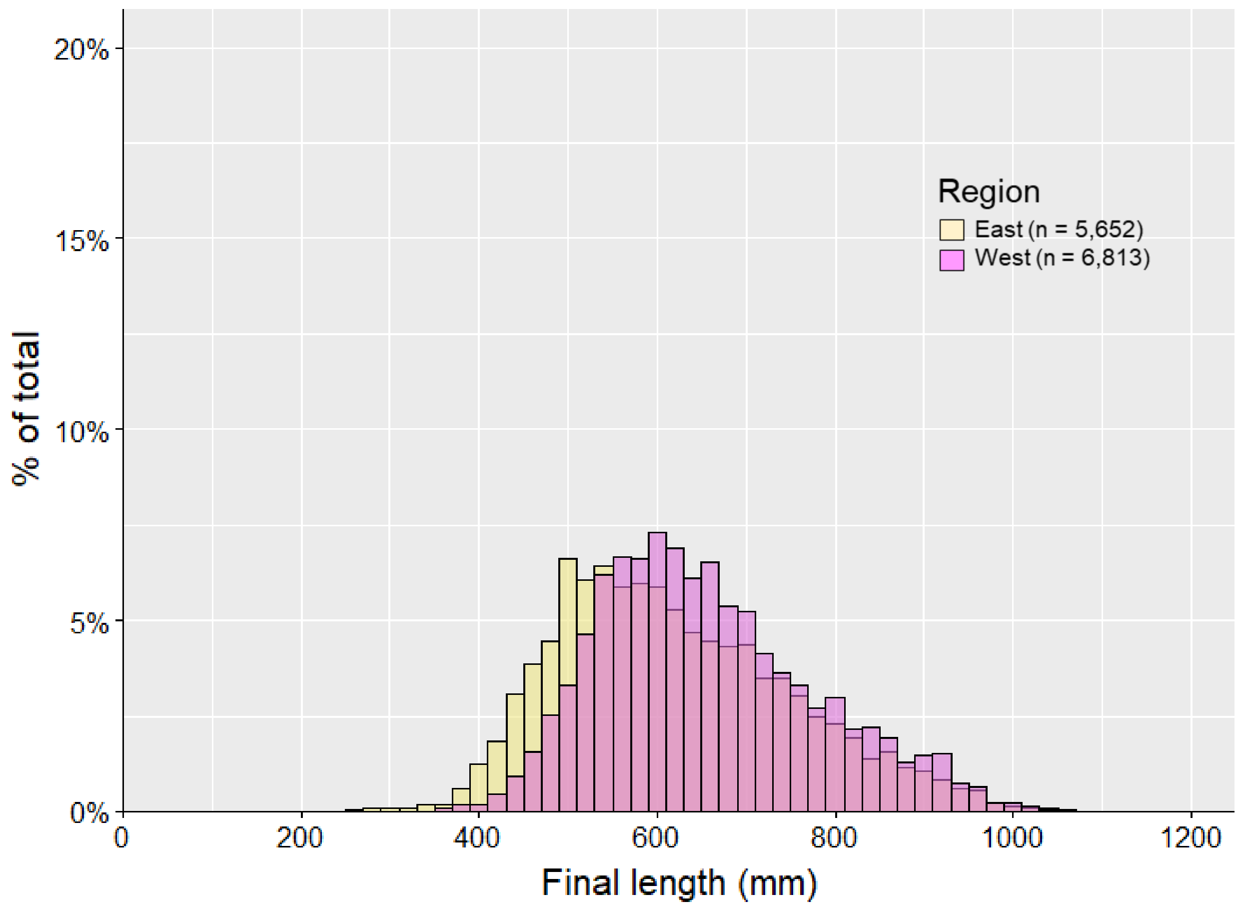

Figure 9. Frequency histogram (% of total) of final (fork) length (binwidth = 20 mm) for tilefish collected from the eastern vs western Gulf of America from 1985-2024. Regions are demarcated by the Mississippi river outflow at the Bird's Foot Delta (-89.0 Longitude).

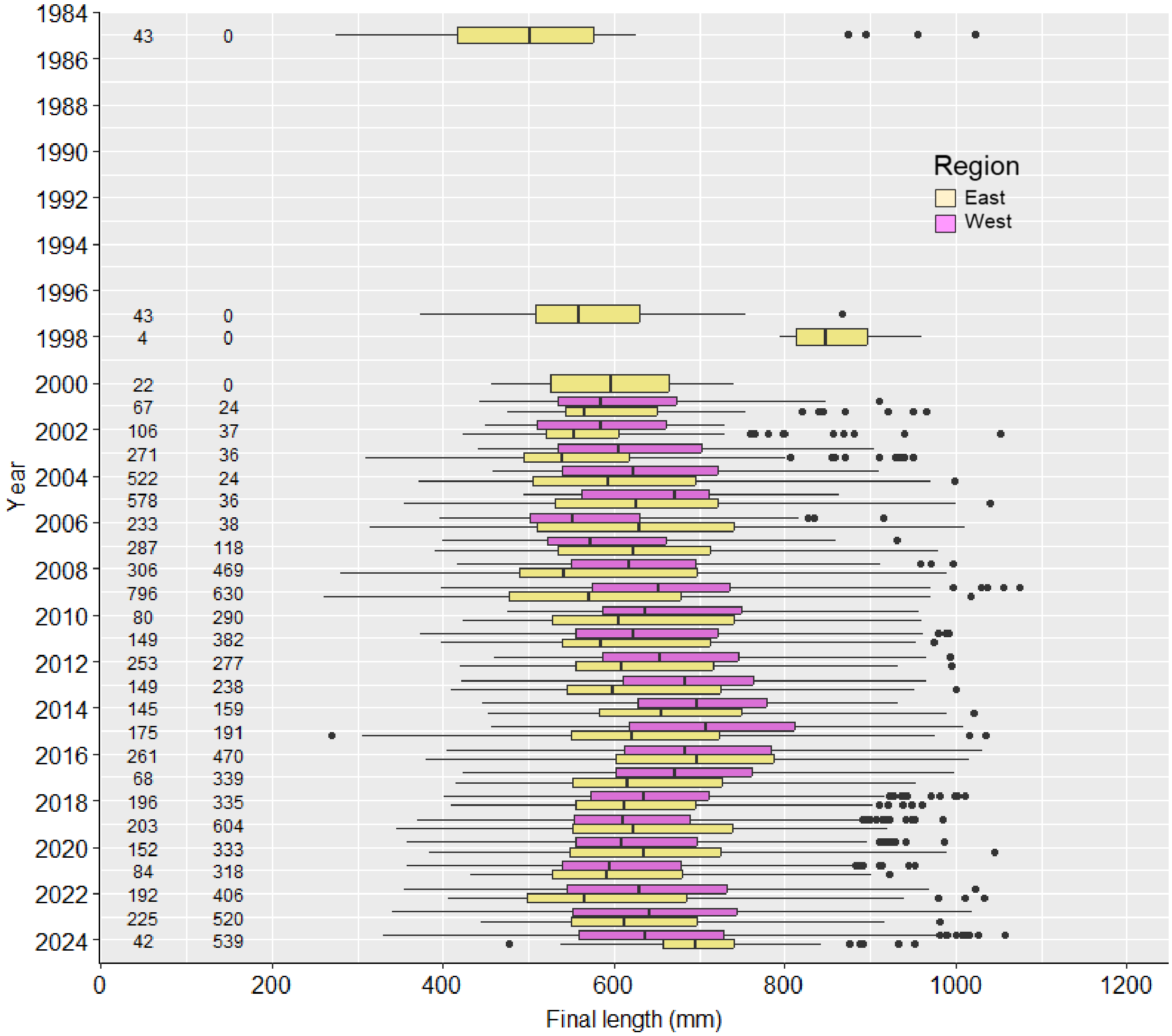

Figure 10. Boxplot of final (fork) length (mm) by year for tilefish age samples collected from the Gulf of America from 1985 to 2024 for each region (East, yellow bars vs West, pink bars). No age samples were collected from 1986-1996 or 1999. Sample numbers are shown along the right side of the figure. Boxes indicate the 25th and 75th percentiles, vertical lines indicate median values, horizontal lines indicate the min and max values of the IQR*1.5, and points indicate values outside that range. Sample sizes (female left, male right) are shown on the left side of the figure.

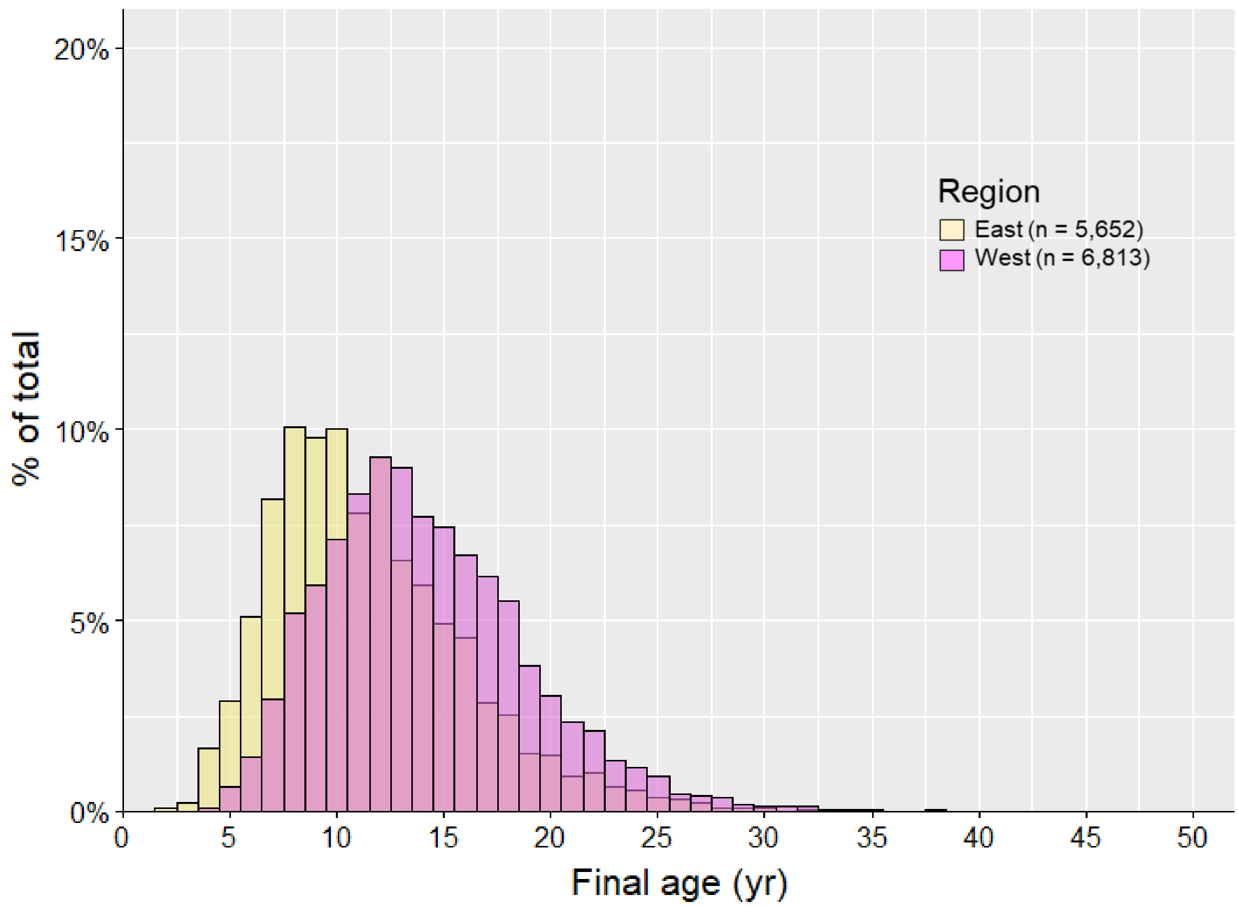

Figure 11. Frequency histogram (% of total) of final age (yr) for tilefish collected from the eastern vs western Gulf of America from 1985-2024. Regions are demarcated by the Mississippi river outflow at the Bird's Foot Delta (-89.0 Longitude).

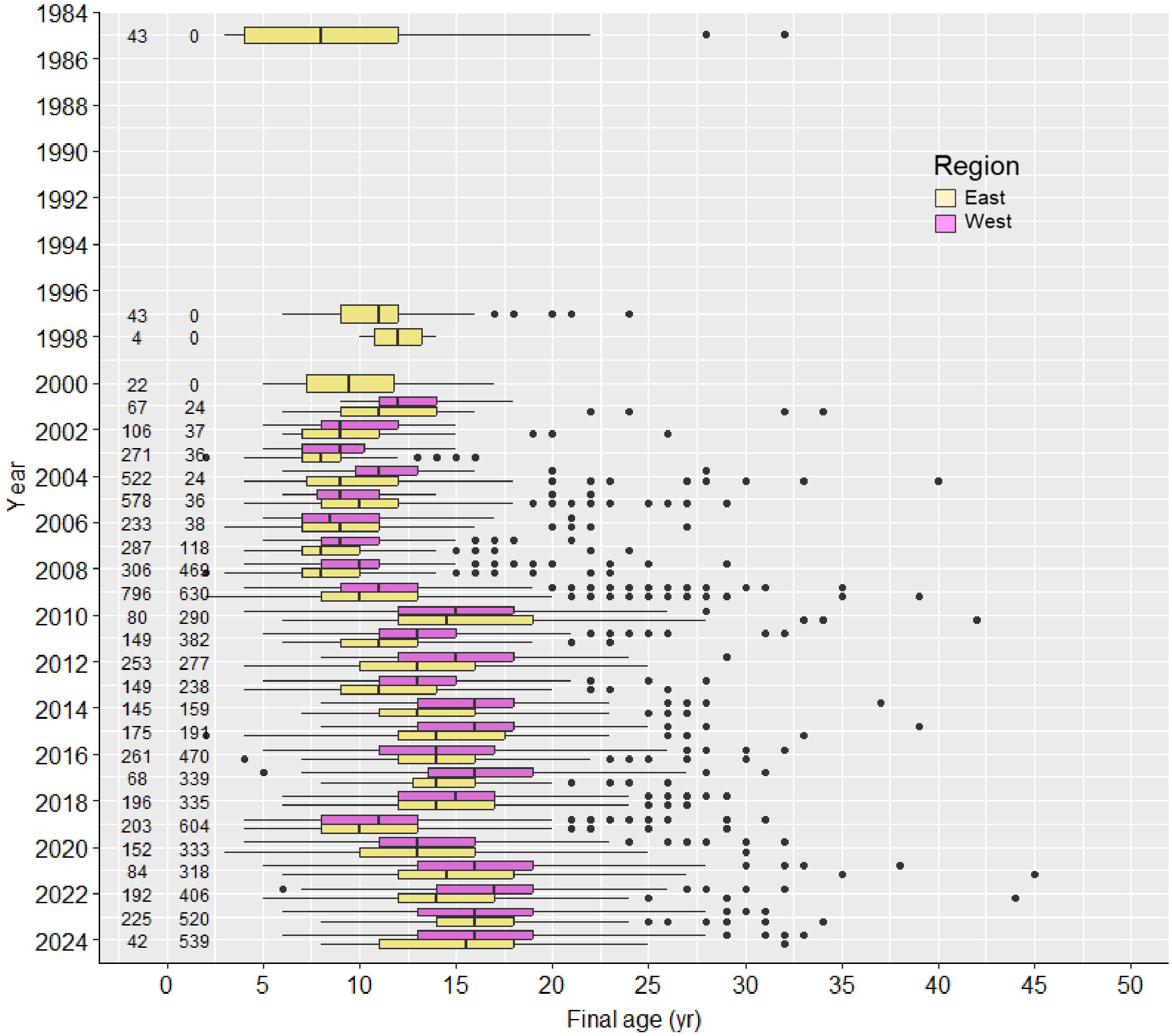

Figure 12. Boxplot of final (calendar) age (yr) by year for tilefish age samples collected from the Gulf of America from 1985 to 2024 for each region (East, yellow bars vs West, pink bars). No age samples were collected from 1986-1996 or 1999. Sample numbers are shown along the right side of the figure. Boxes indicate the 25th and 75th percentiles, vertical lines indicate median values, horizontal lines indicate the min and max values of the IQR*1.5, and points indicate values outside that range. Sample sizes (female left, male right) are shown on the left side of the figure.

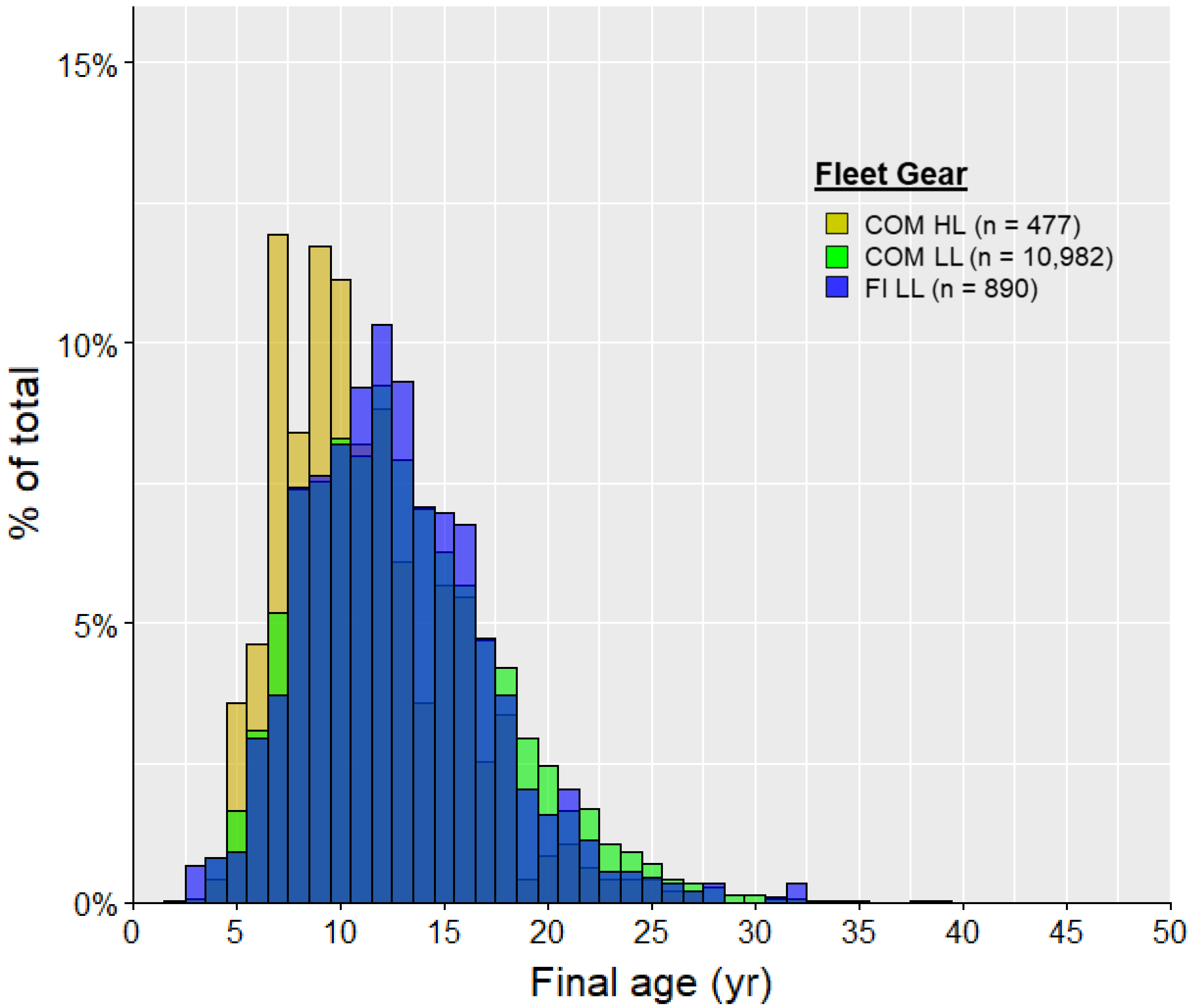

Figure 13. Frequency histograms of final age (yr) by fishing mode and gear (commercial handline, COM HL; commercial longline, COM LL, scientific survey longline, SS LL, and unknown, NA) for golden tilefish age samples collected from the Gulf of America from 1985 to 2024. No age samples were collected from 1986-1996 and 1999. The number of observations is shown at the right of each panel.

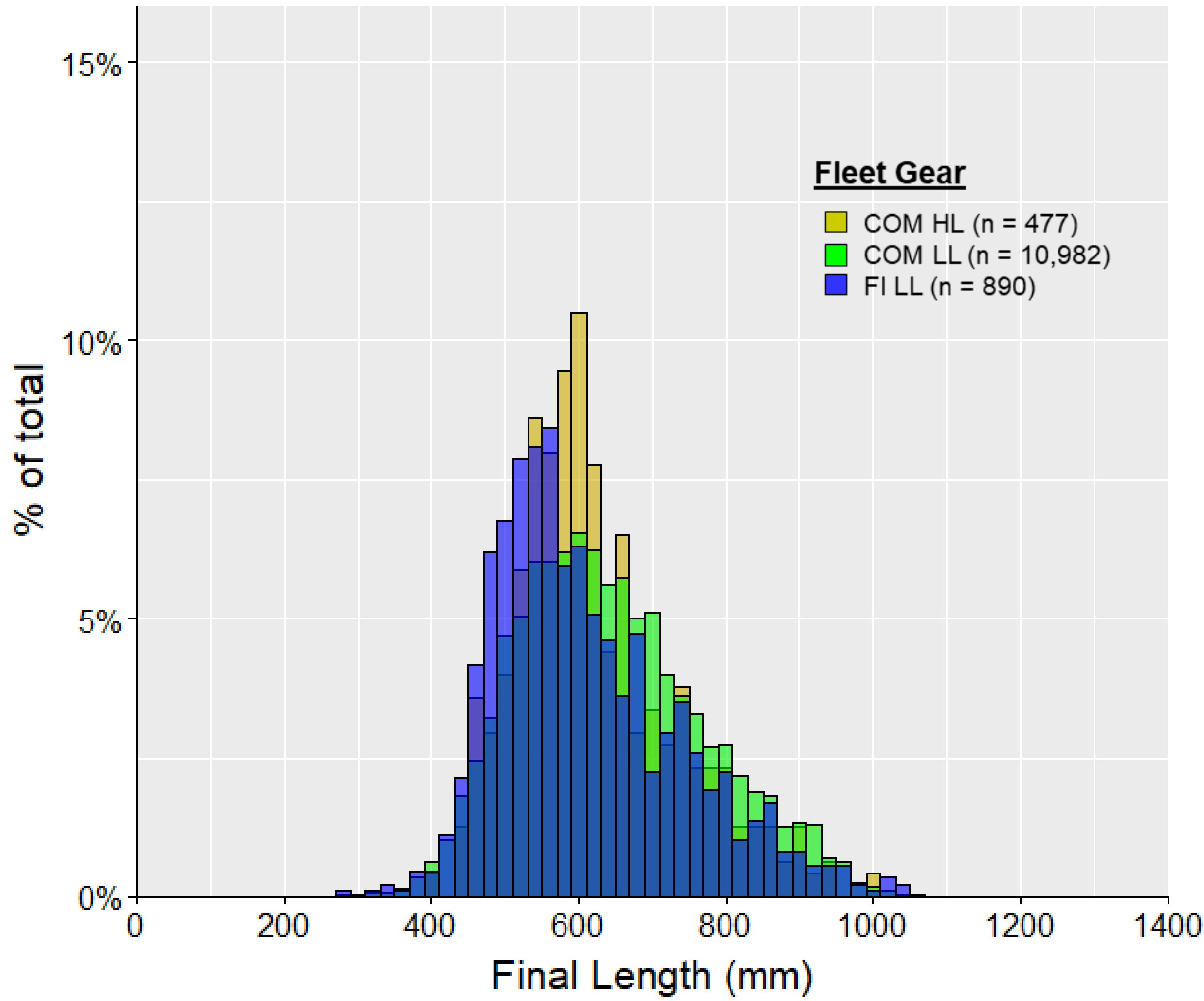

Figure 14. Frequency histograms of final (fork) length (binwidth = 20 mm) by fishing mode and gear (commercial handline, COM HL; commercial longline, COM LL, scientific survey longline, SS LL, and unknown, NA) for golden tilefish age samples collected from the Gulf of America from 1985 to 2024. No age samples were collected from 1986-1996 and 1999. The number of observations is shown at the right of each panel.

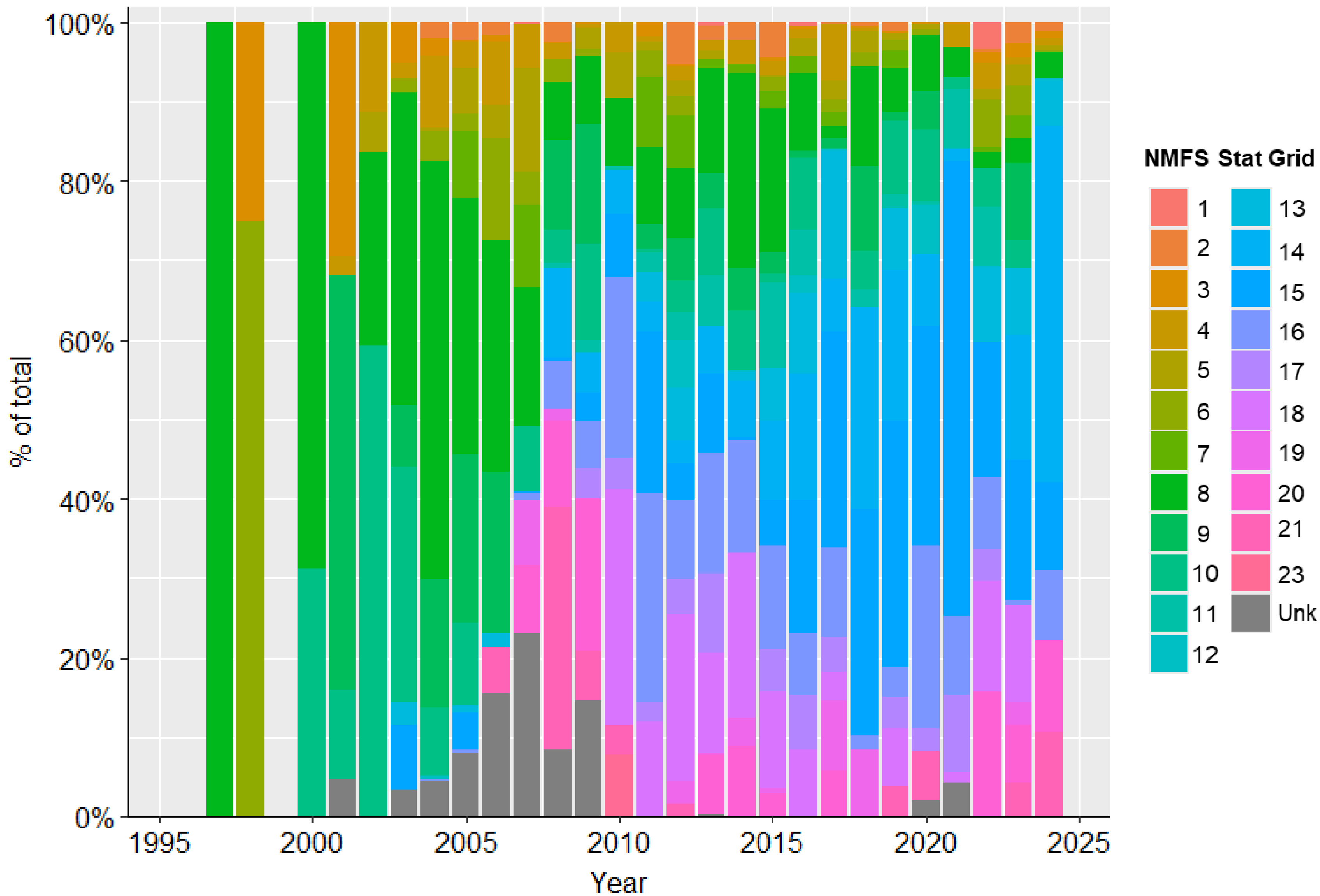

Figure 15. Stacked bar chart of age samples (% of total) by year and NMFS statistical Grid. No age samples were taken from grid 22.

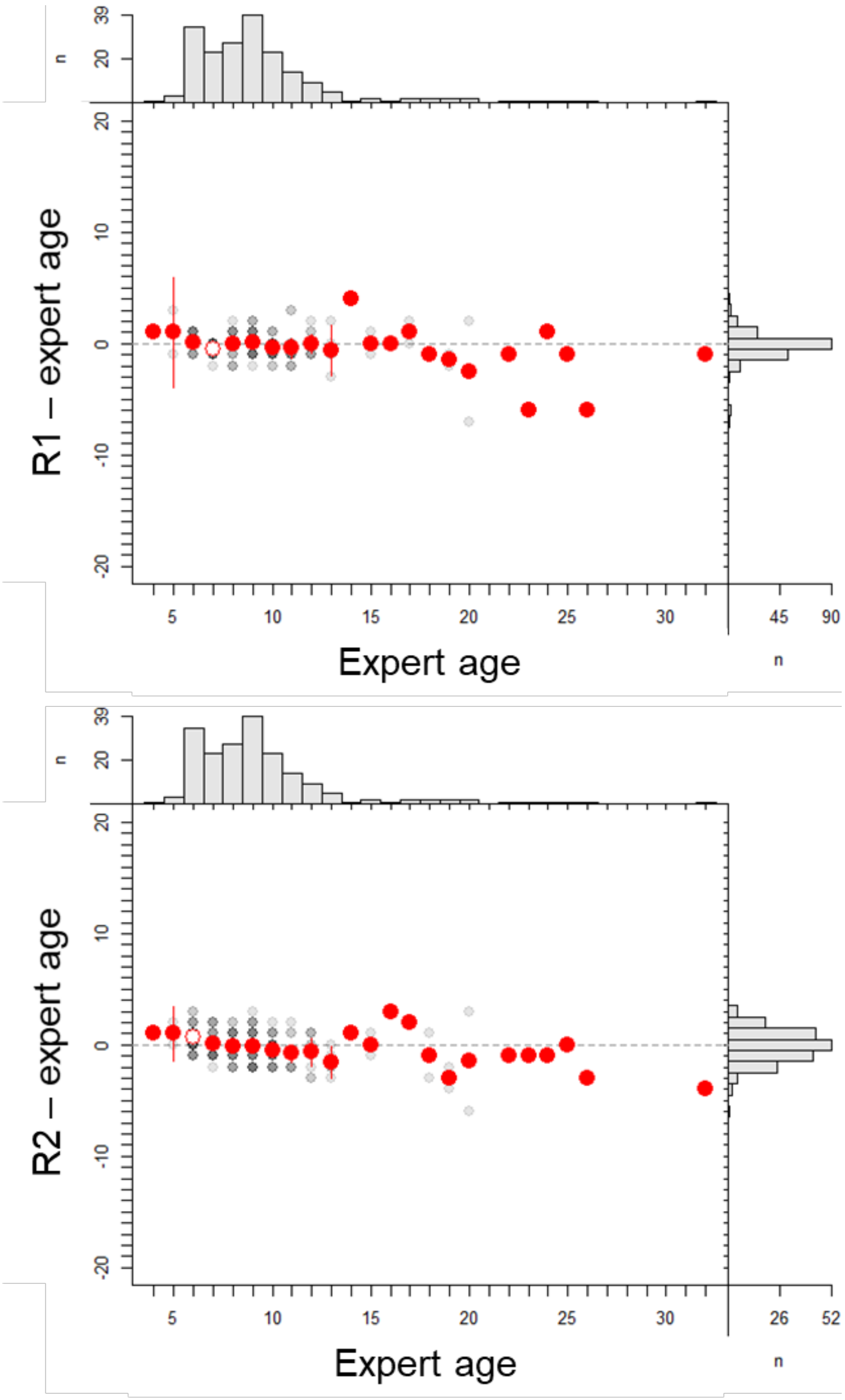

Figure 16. Bland-Altman plots of expert vs primary (reader 1 or reader 2) reader age estimates for the set of tilefish otoliths provided by Lombardi and Andrews (2015). Gray dots indicate observed data (scaled to 1/10th color intensity per sample), red circles indicate mean values with 99% CIs (vertical red lines), and white dots indicate means significantly different from 0 (paired t-test; ∞ = 0.05). Sample sizes are indicated by gray bars along the top and right of each panel.

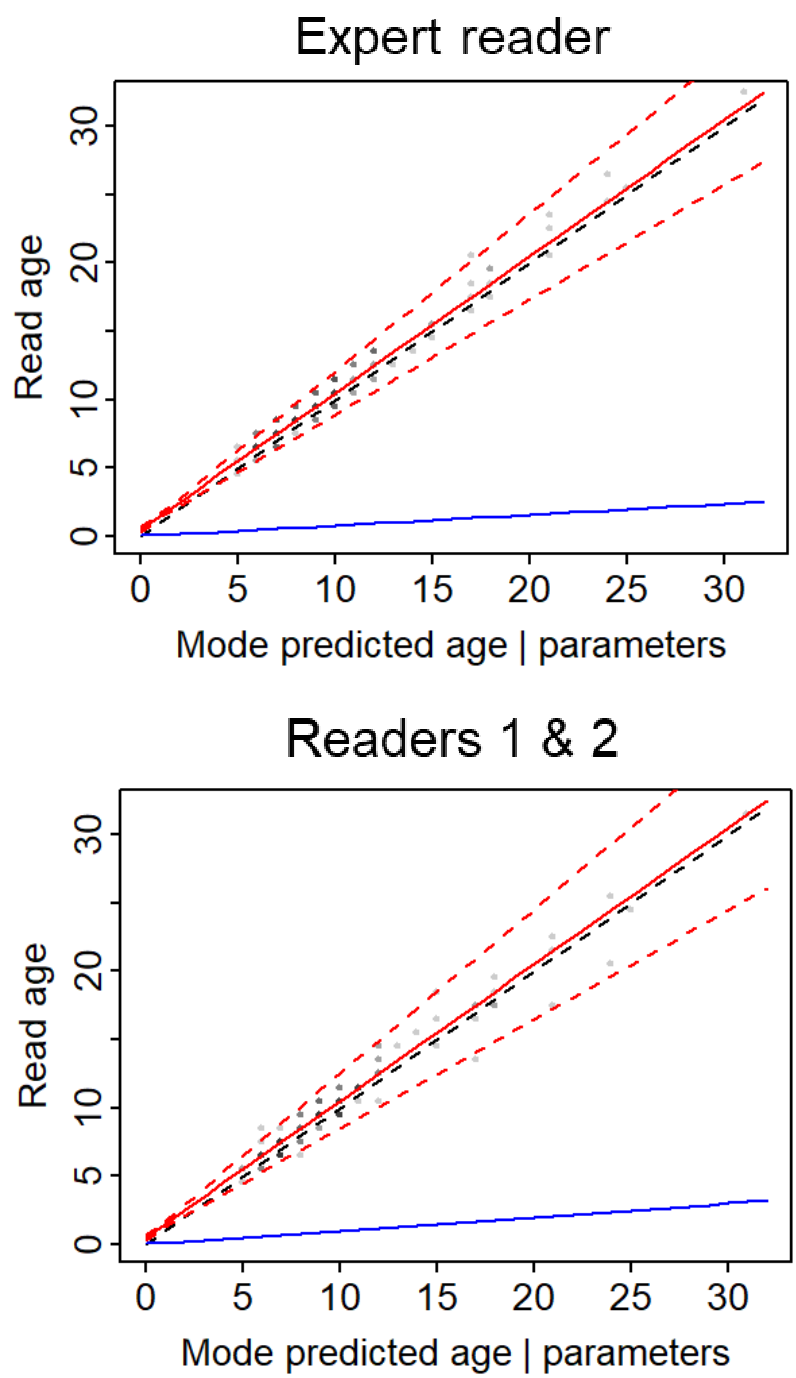

Figure 17. Reader precision plots for expert reader age estimates vs age estimates from primary readers 1 and 2 given the variance parameters estimated in the ageing error. Gray points indicate observed ages, the black dashed line indicates the 1:1 line of agreement, the red solid line indicates the expected age, red dashed lines indicate the 95% CI for expected ages, and the blue line indicates the SD-at-age. Age estimates of all three readers were assumed to be unbiased with linear error with age. Error parameters for the two primary readers were mirrored to produce a single SD-at-age matrix for use in the assessment model.

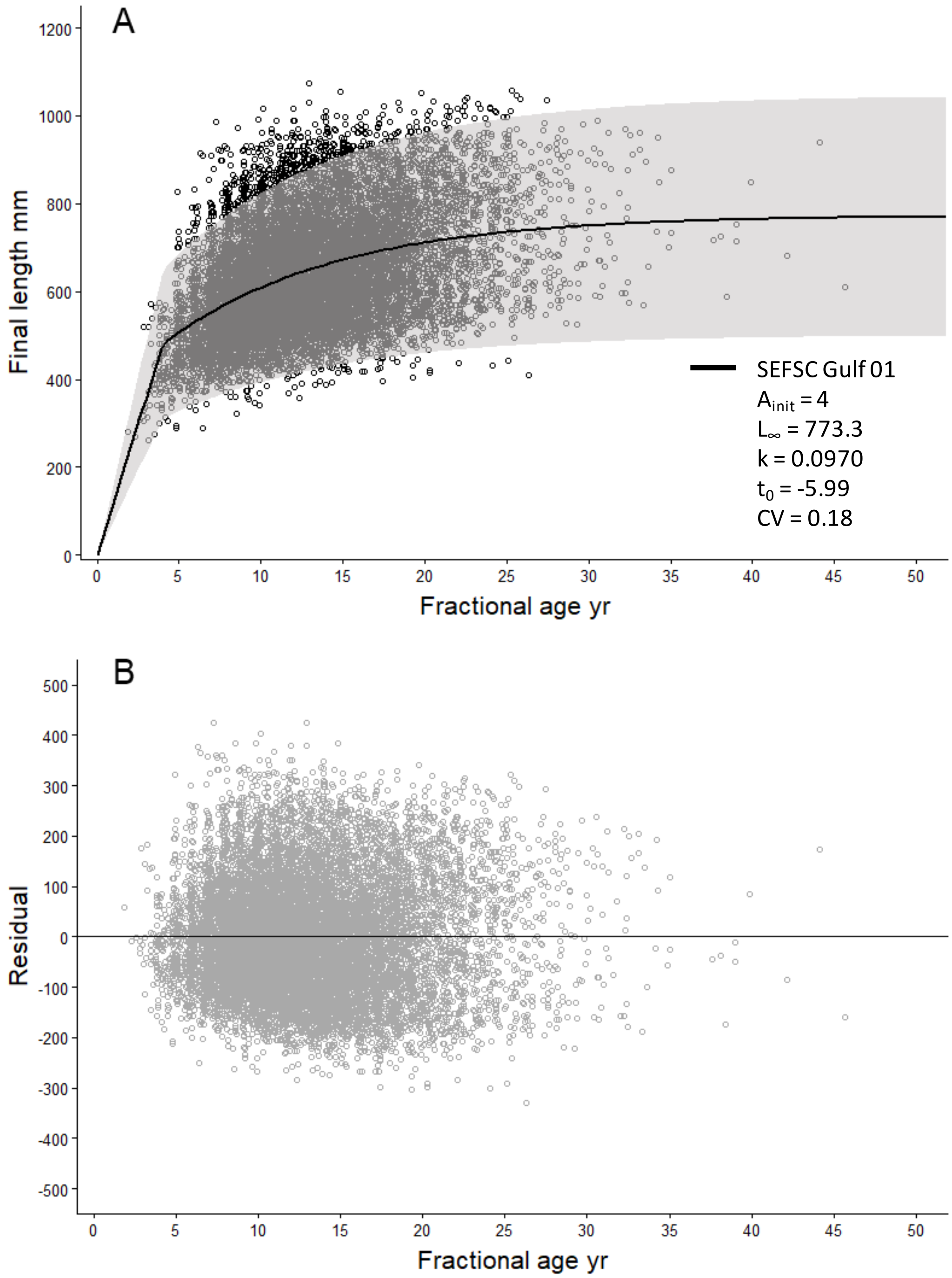

Figure 18. von Bertalanffy growth function fit to Gulf tilefish final (fork) length-at-age data (A) and model residuals (B) with variance estimated as constant CV (gray shaded region) with growth linearly interpolated from the origin to age-4 yrs (A_{init}).

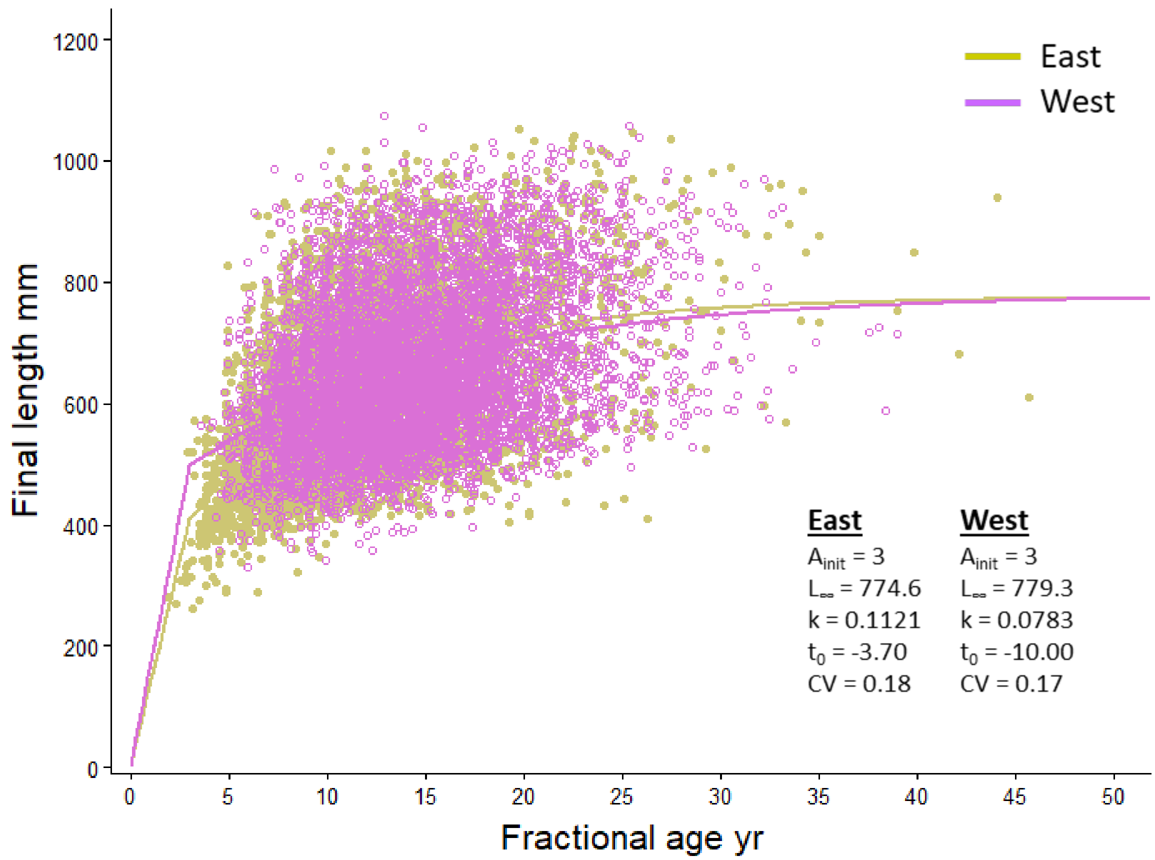

Figure 19. von Bertalanffy growth functions fit to Gulf tilefish length-at-age data by region (western vs eastern). Variance was estimated as constant CV and growth linearly interpolated from the origin to age-3 (yrs).

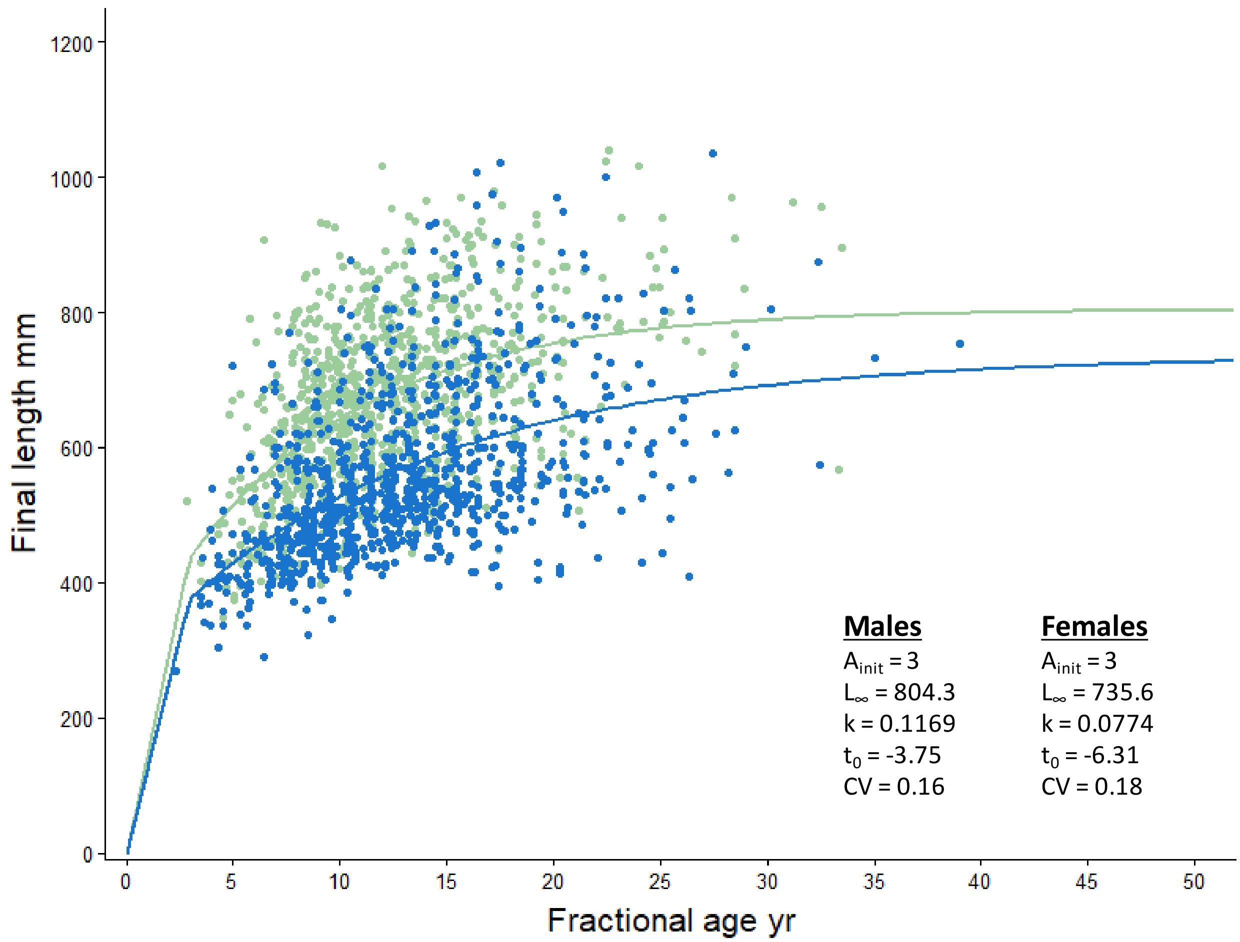

Figure 20. von Bertalanffy growth functions fit to Gulf tilefish length-at-age data by sex (male vs female). Variance was estimated as constant CV and growth linearly interpolated from the origin to age-2 (yrs).