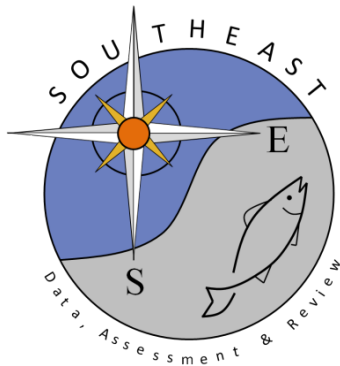


Updated growth parameters for sandbar shark *Carcharhinus plumbeus* based on mark recapture data from the Western North Atlantic

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SEDAR 101 DATA WORKSHOP DOCUMENT

Updated growth parameters for sandbar shark *Carcharhinus plumbeus* based on mark recapture data from the Western North Atlantic

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Summary

Growth parameter estimates for sandbar sharks *Carcharhinus plumbeus* were produced using mark-recapture data collected from 1964-2024. Five models were fit for males and females separately and for sexes combined: Gulland & Holt (1959), Fabens (1965), Francis (1988), and Bayesian versions of the Fabens (1965) and Francis (1988) models. Separate GROTAG models (Francis 1988) were also fit following the parameterizations used in Natanson & Deacy (2019) for comparison to previous work. Models varied widely, but all models produced biologically realistic results: L_{∞} = 164.9-188.4 cm FL and k = 0.099-0.125 yr⁻¹. von Bertalanffy growth parameters derived from the Bayesian Fabens and the Bayesian Francis models produced nearly identical results, and varied relative to the other models. GROTAG models following Natanson & Deacy (2019) resulted in lower L_{∞} but higher k estimates for all models, and Dureil et al. (2022) implementations of GROTAG varied from the Natanson & Deacy (2019) models. These results are the first sex-specific growth models produced from tag-recapture data for sandbar sharks, and may provide insights for age and growth estimation when used in conjunction with traditional length-age data.

Methods

Mark-recapture data were sourced from the NOAA Fisheries NEFSC Cooperative Shark Tagging Program (CSTP) and the SEFSC Elasmobranch Tagging Management System. Data used in this study consisted of sharks that were measured reliably for length (cm) at both tagging and recapture events. Fish at liberty for less than 90 days and recaptures that resulted in negative growth between tagging and recapture events were excluded. Analyses were conducted for males and females separately and for all fish combined, including unsexed fish. Analyses were conducted using fork length (FL, cm) and lengths reported for other measurements were converted to FL before analysis.

Growth models were estimated following the Gulland & Holt (1959), Fabens (1965), and Francis (GROTAG, 1988) model frameworks based on the von Bertalanffy growth equation. Bayesian implementations of the Francis and Fabens models are based on Dureuil et al. (2022). Priors used to inform the Bayesian models were based on Driggers et al. (2017). A lognormal prior distribution was generated for asymptotic fork length, L_{∞} (cm), with median $L_{\infty} = L_{\max}/0.99$, using the given mean and standard deviation on the log scale for narrow and wide priors. A uniform prior distribution was used for the von Bertalanffy growth constant, $k(\text{year}^{-1})$, with minimum and maximum bounds. The wide priors for k were set between $10^{-10} \text{ year}^{-1}$ and 100 year^{-1} (Dureuil et al. 2022). Gulland & Holt, Francis, and Fabens models were also estimated within the framework provided by Dureuil et al. (2022). In addition, the Natanson & Deacy (2019) implementation of the GROTAG model (using the “fishmethods” package) was also estimated to allow direct comparisons to previous work. Values supplied by Natanson & Deacy (2019) for G_a and G_b were used in this model for comparison purposes, while the Dureuil et al. (2022) implementation allowed the G_a and G_b values to vary based on the size distribution of the sample. AIC values were calculated and used to determine the model with best fit, where applicable. All analyses were performed in R (version 4.5.2).

Results

A total of 315 sharks captured and recaptured in the western north Atlantic Ocean and Gulf of America between 1964 to 2024 were analyzed ($n=121$ male, $n=190$ female, $n=4$ unknown sex). Four recaptures were sourced from the SEFSC and 311 from the NEFSC. Males ranged 46-162 cm FL at tagging and 50-184 cm FL at recapture, and females ranged 47-183 cm FL at tagging and 51-189.3 cm FL at recapture (Figure 1). Time at liberty ranged 0.25-26.7 years. Raw tag-recapture data are included in table S1.

Growth models produced biologically relevant von Bertalanffy growth parameters, with L_{∞} ranging 164.9-188.4 cm FL and k values ranging $0.099\text{-}0.125 \text{ yr}^{-1}$ (Tables 1-3). The Dureuil implementation of the Francis (1988) model consistently produced the lowest L_{∞} estimates, while the Gulland & Holt (1959) model consistently produced the highest. The lowest k values were produced by Gulland & Holt and Bayesian Fabens/Francis models, while the Fabens (1965) model consistently produced the highest k values. Standard error estimates for von Bertalanffy growth parameters, where estimated, were relatively low with the exception of those produced for Dureuil implementations of the Francis (1988) model, especially for estimates of k ($\text{SE} = 5.0\text{-}9.5$), and the L_{∞} estimates in the Gulland and Holt models ($\text{SE} = 8.09\text{-}13.1$). This indicates greater variability and relatively reduced predictive capabilities for these parameters.

Our results indicate sandbar sharks exhibit overall smaller L_{∞} and faster growth rates (k) relative to previously published tag-recapture growth models (Table 4). The Bayesian Fabens and Francis models provide the most consistent results across sample groups, and closely mirror the GROTAG results from Natanson & Deacy (2019). However, our tag-recapture models suggest slower growth and smaller L_{∞} in comparison with vertebral growth models calculated for SEDAR 101 (Driggers et al. 2026), SEDAR 54 (Driggers et al. 2017) and SEDAR 21 (Hale & Baremore 2010; Table 4, Figure 2). This may be due to differences in representative samples comprising tagging data relative to vertebral age data, the latter of which have much larger sample sizes and spatial distributions and have varying temporal scales for sample inclusion within each data set. When plotted relative to validated length-age data from mark-recaptured

and radiocarbon validated vertebral samples, both vertebral and tag-recapture derived curves approximated the point data fairly well, with the tag-recapture curves tending to slightly underestimate size at age while vertebral-based curves tended to slightly overestimate size at age (Figure 4).

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Model	n	L_{inf} (SE)	k (SE)	AIC	-Log likelihood	Other parameters
Gulland & Holt (1959)	315	186.3(8.09)	0.101(0.009)	—	—	—
Fabens (1965)	315	170.4(2.2)	0.119(0.006)	—	—	—
Grotag - Francis (1988) a=60 b=160 *Natanson & Deacy parameterization, best model=(4) no seasonal variation	315	173.4	0.103	2202.5	1095.2	s = 5.74 nu = 0.132 m = 1.08 p = 0.045 G60=11.1 G160=1.31
Francis (1988) a=52.0 b=149.5 *Dureil parameterization, best model=full	315	170.2(0.87)	0.106(5.0)	2191.7	—	s = 4.69 nu = 0.101 m = 1.60 p = 0.044 G52=11.8 G149.5=2.07
Bayesian_Fabens (Dureil 2022)	315	175.8(1.1)	0.107(0.003)	2269.3	—	—
Bayesian_Francis (Dureil 2022)	315	175.7(1.1)	0.107(0.003)	2269.3	—	—

Table 1. Growth model outputs for sandbar sharks, sexes combined.

Model	n	L_{inf} (SE)	k (SE)	AIC	-Log likelihood	Other parameters
Gulland & Holt (1959)	121	182.2(13.1)	0.100(0.015)	—	—	—
Fabens (1965)	121	165.0(3.5)	0.125(0.011)	—	—	—
Grotag - Francis (1988) a=60 b=160 *Natanson & Deacy parameterization, best model=(4) ,no seasonal variation	121	172.2	0.108	866.5	427.2	s = 5.70 nu = 0.163 m = 0.380 p = 0.060 G60=11.5 G160=1.25
Francis (1988) a=52.0 b=134.6 *Dureil parameterization, best model: (ga,gb,s) + (nu,p)	121	164.9(2.6)	0.122(9.5)	856.7	—	s = 3.33 nu = 0.232 p = 0.029 G52=12.9 G134.6=3.47
Bayesian_Fabens (Dureil 2022)	121	177.2(1.3)	0.099(0.004)	911.5	—	—
Bayesian_Francis (Dureil 2022)	121	177.2(1.2)	0.099(0.004)	911.5	—	—

Table 2. Growth model outputs for male sandbar sharks.

Model	n	L_{inf} (SE)	k (SE)	AIC	-Log likelihood	Other parameters
Gulland & Holt (1959)	190	188.4(10.2)	0.099(0.012)	—	—	—
Fabens (1965)	190	173.2(2.7)	0.115(0.008)	—	—	—
Grotag - Francis (1988) a=60 b=160 *Natanson & Deacy parameterization Best model=full	190	173.6	0.102	1308.6	646.3	s = 5.26 nu = 0.130 m = 1.35 p = 0.043 G60=11.0 G160=1.32
Francis (1988) a=52.9 b=155.2 *Dureil parameterization Best model=full	190	172.2(0.9)	0.102(6.1)	1301.7	—	s = 4.63 nu = 0.086 m = 1.66 p = 0.038 G52.9=11.6 G155.2=1.65
Bayesian_Fabens (Dureil 2022)	190	177.7(1.2)	0.105(0.004)	1357.9	—	—
Bayesian_Francis (Dureil 2022)	190	177.7(1.2)	0.105(0.004)	1357.9	—	—

Table 3. Growth model outputs for female sandbar sharks.

Study	Model	L _{inf}	k	t ₀	n
Natanson & Deacy (2019)	Gulland & Holt (1959)	188.4	0.079	-3.678	149
Natanson & Deacy (2019)	GROTAG-Francis (1988)	178.6	0.094	-3.300	149
Casey & Natanson (1992)	Fabens (1965)	186.0	0.046	-6.450	33
Driggers et al. (2026)	SEDAR 101 (sexes combined)	177.0	0.14	-2.224	315

Table 4. Growth parameters from previously produced tag-recapture models for sandbar sharks. Vertebral-based von Bertalanffy growth parameters from SEDAR 101 (Driggers et al. 2026) are also provided for comparison.

Figure 1. Length at tagging of sandbar sharks tagged and recaptured by NOAA Fisheries tagging programs between 1964-2024.

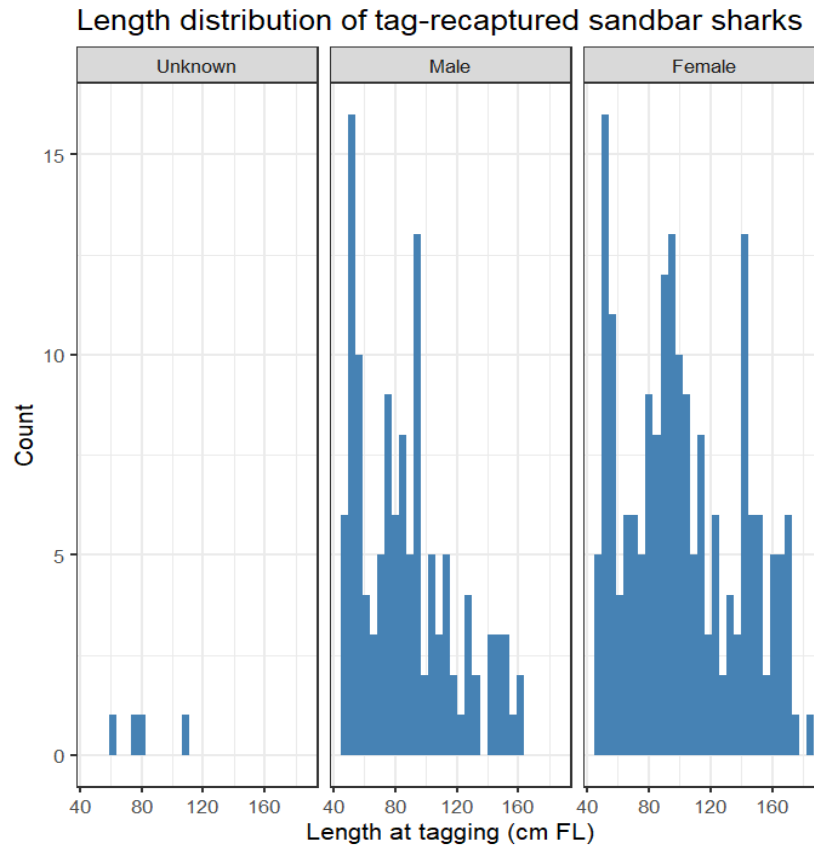


Figure 2. Comparison of combined-sex growth curves for sandbar sharks *Carcharhinus plumbeus* in relation to OTC and bomb radiocarbon validated length at age data from Natanson & Deacy 2019 (black circles). von Bertalanffy growth parameters are also plotted for SEDAR 21, 54, and 101 (current), for comparison. Bayesian Francis and Fabens model parameters were nearly identical and are represented by a single curve.

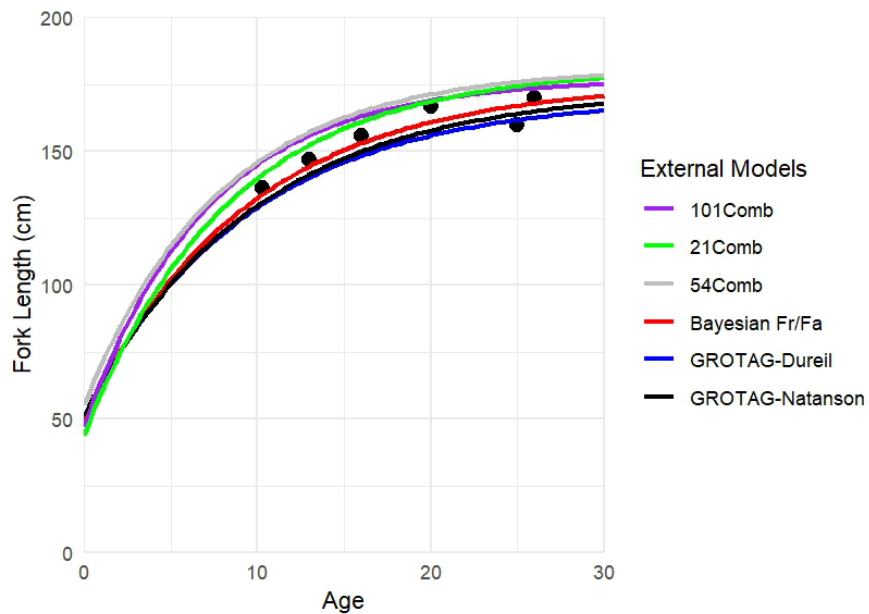


Table S1. Raw data for all tag recaptured sandbar sharks (n=315) used in this analysis. TAL = time at liberty.

<u>Tag</u>	<u>Program</u>	<u>Sex</u>	<u>FL Tag (cm)</u>	<u>FL Recap (cm)</u>	<u>Growth (cm)</u>	<u>Tag Date</u>	<u>Recapture Date</u>	<u>TAL (yrs)</u>
125	NEFSC	M	49	50	1	8/27/1997	11/26/1997	0.25
128	NEFSC	M	63	75	12	7/16/1965	8/17/1967	2.09
136	NEFSC	M	76	145	69	7/16/1965	3/27/1986	20.70
145	NEFSC	F	52	55	3	8/28/1997	4/30/1998	0.67
164	NEFSC	F	48	51	3	8/28/1997	6/16/1998	0.80
176	NEFSC	M	92	94	2	7/22/1964	6/1/1965	0.86
189	NEFSC	M	52	98	46	8/28/1997	3/17/1999	1.55
196	NEFSC	F	53	61	8	8/28/1997	8/8/1998	0.95
199	NEFSC	M	88	109	21	7/28/1964	7/11/1965	0.95
219	NEFSC	M	86	89	3	7/29/1964	5/28/1968	3.83
330	NEFSC	F	92	95	3	6/17/1966	6/20/1967	1.01
359	NEFSC	M	80	141	61	6/17/1966	5/14/1991	24.91
369	NEFSC	F	104	114	10	6/19/1965	8/25/1968	3.18
375	NEFSC	F	101	105	4	6/17/1966	6/26/1967	1.02
408	NEFSC	F	83	105.35	22.35	6/18/1966	3/29/1967	0.78
410	NEFSC	F	81	106	25	6/19/1965	6/22/1970	5.01
435	NEFSC	F	101	111	10	6/20/1965	8/31/1966	1.20
471	NEFSC	F	86	98	12	6/18/1966	6/16/1969	3.00
691	NEFSC	M	96	157	61	6/20/1965	10/7/1986	21.30
714	NEFSC	M	94	102	8	6/22/1965	9/12/1966	1.22
722	NEFSC	F	94	101	7	6/26/1967	6/3/1968	0.94
736	NEFSC	F	94	157	63	6/22/1965	7/6/1990	25.04
747	NEFSC	F	80	99	19	6/22/1965	6/18/1970	4.99
758	NEFSC	M	102	118	16	6/22/1965	10/4/1966	1.28
769	NEFSC	M	81	92	11	6/23/1965	6/17/1966	0.98
798	NEFSC	M	88	98	10	6/23/1965	8/8/1967	2.13
837	NEFSC	U	60	88	28	11/12/1998	8/13/1999	0.75
839	NEFSC	M	56	59	3	11/3/1998	4/20/1999	0.46
847	NEFSC	M	52	104	52	11/3/1998	7/4/2004	5.67
862	NEFSC	F	55	57	2	11/3/1998	5/17/1999	0.53
884	NEFSC	M	95	101	6	8/1/1967	8/28/1968	1.08
894	NEFSC	F	95	112	17	6/24/1965	8/5/1968	3.12
930	NEFSC	F	89	115	26	6/25/1965	8/25/1968	3.17
948	NEFSC	M	54	79	25	11/12/1998	8/24/2001	2.78
951	NEFSC	F	69	78	9	6/15/1966	5/8/1968	1.90
955	NEFSC	F	58	94	36	11/12/1998	1/3/2003	4.14
962	NEFSC	M	93	138	45	6/15/1966	8/8/1973	7.15
995	NEFSC	M	74	83	9	6/16/1966	8/25/1967	1.19
1219	NEFSC	F	91	102	11	8/10/1968	7/5/1970	1.90
1373	NEFSC	M	83	103	20	6/9/1969	6/21/1971	2.03
1541	NEFSC	F	51	52	1	7/25/2000	10/25/2000	0.25
1610	NEFSC	F	47	178.7	131.7	8/21/2000	4/21/2024	23.66

2079	NEFSC	M	54	86	32	8/25/1995	6/22/1997	1.83
2102	NEFSC	M	58	68	10	8/25/1995	6/30/1996	0.85
2135	NEFSC	M	54	102	48	8/25/1995	3/9/2001	5.54
2388	NEFSC	M	53	121	68	9/4/1996	3/19/2000	3.54
2490	NEFSC	M	93	102	9	9/12/2000	5/8/2001	0.65
2844	NEFSC	F	94	99	5	11/7/2001	8/10/2002	0.76
2901	NEFSC	M	56	81	25	1/2/1996	3/25/1998	2.23
3054	NEFSC	M	59	63	4	11/13/1998	7/4/1999	0.64
3135	NEFSC	M	54	76	22	11/14/1998	6/15/2000	1.58
3196	NEFSC	F	56	63	7	10/25/2000	8/3/2001	0.77
3232	NEFSC	F	52	106	54	7/26/1997	6/12/2002	4.88
3303	NEFSC	M	51	57	6	11/1/2000	5/26/2001	0.56
3522	NEFSC	F	58	63	5	10/24/1996	2/24/1997	0.34
3555	NEFSC	M	50	52	2	11/19/2000	5/14/2001	0.48
3576	NEFSC	M	57	71	14	10/24/1996	7/12/1998	1.71
4024	NEFSC	M	48	52	4	6/27/1998	7/25/1999	1.08
4035	NEFSC	F	59	60	1	10/29/1996	7/23/1997	0.73
4152	NEFSC	F	50	80	30	7/29/1998	5/28/2000	1.83
4228	NEFSC	M	48	57	9	8/1/1998	7/6/1999	0.93
4293	NEFSC	F	51	55	4	7/27/1997	7/1/1998	0.93
4361	NEFSC	F	50	55	5	8/17/1998	6/26/1999	0.86
4406	NEFSC	F	57	60	3	9/15/1998	2/15/1999	0.42
4469	NEFSC	F	61	71	10	9/21/1998	7/25/1999	0.84
4492	NEFSC	M	57	69	12	9/21/1998	5/31/2000	1.69
4613	NEFSC	F	52	62	10	7/24/1999	7/25/2000	1.00
4695	NEFSC	M	51	56	5	7/28/1999	3/25/2000	0.66
4730	NEFSC	F	103	140	37	8/3/1999	10/29/2005	6.24
4732	NEFSC	F	52	64	12	8/3/1999	7/16/2000	0.95
4739	NEFSC	M	51	60	9	8/3/1999	6/17/2000	0.87
4748	NEFSC	F	109	118	9	8/18/1999	7/14/2000	0.90
4764	NEFSC	F	55	72	17	8/19/1999	11/18/2000	1.25
4765	NEFSC	M	56	113	57	8/19/1999	7/23/2005	5.93
4857	NEFSC	M	57	69	12	8/24/1999	5/22/2000	0.74
4903	NEFSC	F	67	112	45	6/3/2000	9/3/2005	5.25
6299	NEFSC	M	85	105.67	20.67	8/17/2003	5/14/2008	4.74
6689	NEFSC	M	84	112.4	28.4	10/30/2004	8/6/2009	4.77
6763	NEFSC	M	69	97.3	28.3	9/29/2008	9/29/2010	2.00
7464	NEFSC	F	47	55	8	7/17/2003	4/10/2004	0.73
8335	NEFSC	F	100	100	0	8/24/1983	8/17/1984	0.98
9065	NEFSC	F	78	100	22	8/31/1993	8/26/1994	0.99
9670	NEFSC	M	75	110	35	8/18/1992	3/29/1998	5.61
9695	NEFSC	F	70	161	91	9/14/1992	6/14/2019	26.75
9888	NEFSC	F	81	115	34	9/23/2003	6/11/2005	1.72
10155	NEFSC	F	61	71	10	6/23/2005	7/1/2006	1.02

10853	NEFSC	F	108	125	17	7/3/2004	6/28/2007	2.98
11002	NEFSC	F	71	110.5	39.5	5/26/2004	7/30/2007	3.18
11130	NEFSC	M	76	96	20	7/3/2004	7/4/2005	1.00
11278	NEFSC	F	66.5	123	56.5	9/9/2004	5/14/2011	6.67
11312	NEFSC	M	81	90	9	9/24/2004	6/27/2005	0.76
11568	NEFSC	F	50	65	15	6/28/2005	6/21/2006	0.98
11973	NEFSC	M	56	74	18	8/16/2005	6/16/2006	0.83
12103	NEFSC	F	77	104	27	7/23/2005	9/8/2007	2.13
12262	NEFSC	F	88	132.08	44.08	7/24/2007	6/16/2014	6.90
13357	NEFSC	M	53.5	125.08	71.58	7/12/2006	7/4/2012	5.98
13523	NEFSC	F	78.6	105.5	26.9	8/11/2006	10/9/2008	2.16
13942	NEFSC	M	59.5	72.9	13.4	5/30/2007	5/29/2008	1.00
16637	NEFSC	F	80	158.3	78.3	7/8/2009	4/2/2021	11.74
18905	NEFSC	F	95	147.5	52.5	7/10/2008	5/11/2018	9.83
19234	NEFSC	F	93	116	23	9/20/2012	3/27/2017	4.51
19300	NEFSC	F	101	124.46	23.46	7/15/2009	10/10/2015	6.24
19399	NEFSC	F	164	168	4	3/13/1973	3/27/1976	3.04
20214	NEFSC	F	91	121.92	30.92	8/7/2009	6/9/2013	3.84
20515	NEFSC	F	64	79.4	15.4	6/20/2012	5/26/2014	1.93
20562	NEFSC	F	98.5	118	19.5	7/16/2012	3/10/2015	2.65
21610	NEFSC	F	105	114.7	9.7	8/24/2018	5/18/2019	0.73
21784	NEFSC	M	81	101.6	20.6	6/26/2016	9/3/2018	2.19
22064	NEFSC	F	101	137.16	36.16	3/9/2015	7/4/2016	1.32
23026	NEFSC	F	95.9	96.52	0.62	6/18/2013	10/12/2013	0.32
23232	NEFSC	F	82	104.31	22.31	7/10/2014	6/27/2015	0.96
23639	NEFSC	M	85	98	13	6/19/2015	4/23/2016	0.84
23692	NEFSC	M	94	123	29	7/14/2015	7/15/2021	6.00
25431	NEFSC	F	103.7	111	7.3	10/9/2017	5/31/2018	0.64
25450	NEFSC	F	124.5	134	9.5	10/16/2017	6/29/2018	0.70
25467	NEFSC	M	106	110	4	11/15/2017	7/2/2018	0.63
25481	NEFSC	M	81.2	84	2.8	11/2/2017	7/5/2018	0.67
25787	NEFSC	M	84	96.01	12.01	10/23/2018	7/21/2019	0.74
25880	NEFSC	M	66	70.05	4.05	6/28/2019	10/13/2019	0.29
28338	NEFSC	M	95	98	3	9/7/2023	5/24/2024	0.71
30137	NEFSC	M	75	81.28	6.28	8/13/2020	5/20/2021	0.77
30206	NEFSC	F	91.6	100.16	8.56	10/20/2020	7/17/2021	0.74
30263	NEFSC	F	93.5	96.52	3.02	11/11/2020	6/27/2022	1.62
30286	NEFSC	F	94	96.52	2.52	4/5/2021	7/14/2021	0.27
30338	NEFSC	F	76.5	101.6	25.1	6/21/2021	7/2/2023	2.03
30410	NEFSC	M	69.9	77.32	7.42	8/19/2021	6/20/2022	0.84
39393	NEFSC	F	140	154	14	9/25/1982	2/14/1988	5.39
42420	NEFSC	F	86	157	71	6/27/1978	7/20/1990	12.06
50701	NEFSC	M	49.5	64.14	14.64	9/15/2011	3/27/2012	0.53
51939	NEFSC	M	72.5	83.55	11.05	9/20/2012	5/25/2013	0.68

52016	NEFSC	M	97	169	72	11/3/1979	4/27/1989	9.48
52110	NEFSC	F	52	75.24	23.24	7/17/2012	6/7/2014	1.89
52116	NEFSC	M	52	77.47	25.47	7/17/2012	2/4/2015	2.55
52291	NEFSC	M	62	71	9	7/13/2012	12/8/2012	0.40
52801	NEFSC	M	46	51.36	5.36	6/30/2014	11/12/2014	0.37
54679	NEFSC	M	53	58.42	5.42	8/28/2012	2/10/2013	0.45
54698	NEFSC	F	54.5	62.78	8.28	8/28/2012	5/27/2013	0.75
57036	NEFSC	F	75	102.24	27.24	8/29/2013	10/9/2015	2.11
57191	NEFSC	M	68	115.6	47.6	5/21/2015	9/10/2019	4.31
60109	NEFSC	F	79	92.8	13.8	6/22/2016	5/16/2018	1.90
60229	NEFSC	F	50	58.63	8.63	8/18/2015	6/21/2016	0.84
60556	NEFSC	F	50	59.67	9.67	6/21/2018	11/1/2018	0.36
60575	NEFSC	M	47	53.34	6.34	6/21/2018	11/3/2018	0.37
60721	NEFSC	M	53	57.15	4.15	8/19/2014	1/1/2015	0.37
61802	NEFSC	M	112	139.61	27.61	10/4/2016	6/1/2019	2.66
61976	NEFSC	F	78.1	81.28	3.18	6/20/2018	3/24/2019	0.76
63759	NEFSC	F	49	85.63	36.63	7/24/2018	4/19/2020	1.74
63833	NEFSC	M	51	56.56	5.56	7/26/2017	3/18/2018	0.64
63848	NEFSC	F	51	58.11	7.11	7/26/2017	3/9/2018	0.62
64429	NEFSC	F	62	110.54	48.54	8/4/2017	6/30/2021	3.90
64628	NEFSC	F	86	106.68	20.68	6/15/2017	6/18/2018	1.01
65683	NEFSC	M	63.5	66.04	2.54	10/18/2018	7/27/2019	0.77
65729	NEFSC	F	49	58.42	9.42	6/21/2019	10/13/2019	0.31
66024	NEFSC	F	70	83.55	13.55	7/10/2019	8/29/2020	1.14
66313	NEFSC	M	77.8	101	23.2	9/11/2019	7/26/2021	1.87
66477	NEFSC	F	75.6	88.22	12.62	10/23/2019	4/30/2020	0.52
66494	NEFSC	M	75.2	81.28	6.08	10/24/2019	6/10/2020	0.63
66803	NEFSC	F	52	60.71	8.71	7/14/2020	11/7/2020	0.32
67002	NEFSC	F	56	61	5	3/25/2022	8/12/2022	0.38
67254	NEFSC	F	54	57	3	3/25/2022	7/1/2022	0.27
67354	NEFSC	F	92	118.11	26.11	9/18/2020	6/13/2023	2.73
67514	NEFSC	F	57	76.28	19.28	6/18/2018	6/29/2019	1.03
67645	NEFSC	F	66	76.28	10.28	6/29/2021	10/15/2021	0.30
71042	NEFSC	F	71.5	87.7	16.2	6/21/2021	7/4/2022	1.04
73454	NEFSC	M	73.1	77.32	4.22	8/15/2024	11/30/2024	0.29
76677	NEFSC	M	73.1	89.79	16.69	8/7/2023	6/10/2024	0.84
86153	NEFSC	M	112	147	35	5/7/1983	6/23/1991	8.13
88949	NEFSC	F	90	118	28	7/8/1988	2/23/1995	6.63
92092	NEFSC	M	130	158	28	10/17/1986	5/18/1991	4.58
99882	NEFSC	M	112	115	3	5/13/1984	7/5/1987	3.14
100011	NEFSC	M	97	137	40	5/16/1984	4/11/1991	6.90
100027	NEFSC	M	99	135	36	5/16/1984	1/25/1993	8.69
103464	NEFSC	M	157	184	27	10/14/1986	8/13/1991	4.83
108340	NEFSC	F	152	170	18	8/20/1988	4/5/1996	7.62

111582	NEFSC	M	147	167	20	11/16/1985	5/17/1989	3.50
114657	NEFSC	F	143	176	33	10/15/1986	3/10/1990	3.40
114666	NEFSC	M	120	127	7	10/16/1986	1/24/1990	3.27
115001	NEFSC	M	152	157	5	8/30/1987	8/18/1989	1.97
121230	NEFSC	F	114	132	18	8/6/1986	7/29/1993	6.98
121264	NEFSC	F	141	151	10	8/10/1986	8/24/1990	4.04
130438	NEFSC	F	132	139	7	7/22/1989	1/30/1996	6.52
131151	NEFSC	U	77	116	39	9/26/1988	10/1/1992	4.01
132653	NEFSC	F	108	114	6	3/9/1988	5/3/1990	2.15
140691	NEFSC	M	94	94	0	5/16/1989	4/14/1993	3.91
142419	NEFSC	M	115	134	19	5/19/1989	2/22/1993	3.77
142793	NEFSC	F	91	102	11	5/25/1989	4/17/1991	1.90
143890	NEFSC	F	91	102	11	7/14/1990	7/23/1991	1.02
150528	NEFSC	U	110	157	47	3/11/1990	2/1/2000	9.89
166397	NEFSC	F	107	112	5	8/6/1991	1/14/1993	1.44
170020	NEFSC	F	120	150	30	5/13/1991	5/6/1994	2.98
178214	NEFSC	M	74	110	36	8/11/1996	3/9/2001	4.57
188605	NEFSC	F	99	152	53	3/15/1993	3/22/2003	10.02
191379	NEFSC	M	91	110	19	7/30/1994	1/6/1996	1.44
192319	NEFSC	M	111	152	41	1/11/1994	3/16/2000	6.18
200715	NEFSC	F	61	67	6	2/9/2004	7/2/2004	0.39
207134	NEFSC	M	95	100	5	5/13/1995	1/1/1996	0.64
210499	NEFSC	F	92.49	164.53	72.04	5/24/1995	6/6/2009	14.04
211448	NEFSC	M	104	130	26	7/10/1995	3/11/2001	5.67
216987	NEFSC	F	109	110	1	7/20/1995	3/17/1996	0.66
217006	NEFSC	M	94	154	60	7/13/1995	6/2/2009	13.89
217017	NEFSC	M	130	155	25	7/18/1995	10/11/1999	4.23
217033	NEFSC	F	85	147	62	8/3/1996	7/29/2006	9.98
217033	NEFSC	F	85	147	62	8/3/1996	7/27/2006	9.98
217129	NEFSC	M	99	123	24	6/30/1996	3/11/2001	4.69
222066	NEFSC	F	68	150.4	82.4	10/25/1996	8/2/2008	11.77
223576	NEFSC	M	68	81	13	10/21/1996	7/14/1997	0.73
232183	NEFSC	F	115	122	7	10/25/1996	7/16/1998	1.72
242493	NEFSC	M	78	120	42	2/2/1998	3/8/2003	5.09
245919	NEFSC	F	142	155	13	5/7/1998	8/16/2002	4.28
246079	NEFSC	F	117	147	30	5/17/1998	1/31/2005	6.71
246351	NEFSC	M	107	150	43	5/19/1998	7/22/2006	8.18
246351	NEFSC	M	107	150	43	5/19/1998	7/19/2006	8.17
246389	NEFSC	M	83	154	71	5/20/1998	7/2/2011	13.12
253835	NEFSC	F	87	164	77	4/23/2000	4/20/2023	22.99
268301	NEFSC	F	143	166	23	11/14/2000	5/20/2010	9.51
268309	NEFSC	F	136	156	20	11/14/2000	5/26/2010	9.53
269661	NEFSC	M	143	149	6	5/9/2001	5/16/2003	2.02
269859	NEFSC	F	119	159	40	5/16/2001	6/28/2017	16.12

280121	NEFSC	M	152	155	3	10/20/2006	11/11/2015	9.06
281271	NEFSC	F	112	137	25	8/17/2003	6/8/2007	3.81
282261	NEFSC	M	127	144	17	1/14/2003	4/12/2005	2.24
286056	NEFSC	F	151	157	6	4/26/2007	4/18/2009	1.98
294346	NEFSC	M	90	158	68	6/23/2005	6/21/2018	13.00
296039	NEFSC	F	95	138	43	3/6/2010	6/15/2016	6.28
296720	NEFSC	F	98	110	12	7/17/2017	5/30/2019	1.87
296720	NEFSC	F	98	110	12	7/17/2017	5/30/2019	1.87
299733	NEFSC	F	168.68	172.84	4.16	3/9/2007	12/7/2008	1.75
299734	NEFSC	F	183.22	185.3	2.08	3/9/2007	2/9/2008	0.92
299775	NEFSC	F	161.42	167.13	5.71	1/14/2006	4/9/2010	4.23
304302	NEFSC	M	151	152	1	8/5/1993	1/7/1999	5.43
304436	NEFSC	F	140	148	8	8/12/1993	8/17/1995	2.01
308677	NEFSC	F	139	157	18	7/21/2007	3/31/2017	9.69
308677	NEFSC	F	139	157	18	7/21/2007	3/30/2017	9.69
310352	NEFSC	M	162	165	3	5/23/2006	4/5/2022	15.87
315688	NEFSC	F	148	151	3	2/20/2007	8/28/2010	3.52
315753	NEFSC	M	148	157	9	2/20/2007	2/26/2011	4.02
318133	NEFSC	M	120	154.94	34.94	6/20/2007	6/23/2015	8.01
318519	NEFSC	F	155	163	8	4/24/2007	5/12/2015	8.05
318612	NEFSC	F	114	137	23	4/26/2007	2/23/2011	3.83
320539	NEFSC	F	124	156	32	8/19/2007	7/18/2020	12.91
324140	NEFSC	F	144.78	176.99	32.21	6/19/2008	2/27/2018	9.69
325402	NEFSC	F	104	150	46	6/20/2009	10/16/2018	9.32
325403	NEFSC	F	103.8	157	53.2	8/12/2008	7/11/2021	12.91
325610	NEFSC	F	85.09	111.7	26.61	6/28/2011	8/27/2013	2.17
331362	NEFSC	F	130.4	132.08	1.68	4/29/2009	7/11/2010	1.20
331513	NEFSC	M	142.8	160.2	17.4	4/22/2009	8/7/2015	6.29
331711	NEFSC	M	129	154	25	5/2/2009	5/29/2017	8.07
332307	NEFSC	F	129.6	156.22	26.62	5/12/2009	5/2/2015	5.97
332322	NEFSC	F	121.4	158	36.6	5/12/2009	8/11/2021	12.25
333000	NEFSC	F	82.5	152	69.5	5/16/2009	5/15/2022	13.00
333480	NEFSC	F	96.52	162.79	66.27	7/15/2010	6/15/2015	4.92
333855	NEFSC	F	115	149	34	7/12/2009	6/16/2022	12.93
336667	NEFSC	M	134.62	158	23.38	6/4/2010	4/3/2024	13.83
339027	NEFSC	F	139.7	158	18.3	8/30/2010	1/13/2014	3.37
340065	NEFSC	F	69.85	106.68	36.83	4/18/2013	4/22/2017	4.01
340984	NEFSC	F	128	129.5	1.5	10/3/2011	5/12/2012	0.61
340985	NEFSC	M	103.8	106.68	2.88	10/4/2011	8/4/2013	1.83
342639	NEFSC	F	149.86	156	6.14	8/26/2010	3/6/2018	7.53
345896	NEFSC	M	97	148	51	8/11/2011	10/25/2020	9.21
349290	NEFSC	F	146.5	168	21.5	5/8/2012	6/23/2021	9.12
349451	NEFSC	F	134.5	149	14.5	5/9/2012	7/20/2016	4.20
349471	NEFSC	F	141	157	16	5/9/2012	8/5/2018	6.24

349708	NEFSC	F	140.5	154.15	13.65	5/12/2012	3/19/2022	9.85
350654	NEFSC	F	149	151	2	6/21/2013	10/28/2014	1.35
350941	NEFSC	F	64.86	106.68	41.82	8/8/2012	9/10/2013	1.09
351560	NEFSC	F	121.92	153	31.08	6/9/2013	12/13/2020	7.51
352701	NEFSC	F	170.18	171	0.82	3/30/2013	6/15/2019	6.21
352787	NEFSC	F	170.18	170.18	0	4/5/2013	4/2/2016	2.99
354815	NEFSC	F	164.43	170.18	5.75	6/24/2013	9/29/2016	3.27
355067	NEFSC	F	142.24	168.68	26.44	5/5/2013	10/24/2019	6.47
360162	NEFSC	M	147.32	150	2.68	6/1/2014	6/13/2025	11.03
360931	NEFSC	F	160.02	160.02	0	7/6/2014	7/30/2015	1.07
363240	NEFSC	F	139.7	153.81	14.11	8/25/2014	6/23/2016	1.83
363751	NEFSC	U	78.74	91	12.26	8/5/2014	1/9/2016	1.43
364017	NEFSC	F	113	126	13	6/21/2015	4/12/2017	1.81
364017	NEFSC	F	113	126	13	6/21/2015	4/12/2017	1.81
365285	NEFSC	F	152.4	162.8	10.4	12/29/2015	1/10/2020	4.03
369824	NEFSC	F	144.78	157.26	12.48	5/28/2015	10/17/2015	0.39
369983	NEFSC	F	160	160.2	0.2	6/18/2015	8/8/2016	1.14
370041	NEFSC	F	164	165	1	4/29/2016	4/9/2018	1.94
371489	NEFSC	F	160.02	162.56	2.54	7/30/2015	6/30/2018	2.92
378750	NEFSC	M	102	109	7	8/7/2016	5/15/2018	1.77
381658	NEFSC	F	157.48	164.53	7.05	4/22/2018	6/9/2021	3.13
382719	NEFSC	F	104	139	35	7/14/2017	6/25/2021	3.95
382924	NEFSC	F	114.3	137.16	22.86	7/7/2017	6/14/2021	3.94
383453	NEFSC	F	99.06	137.54	38.48	7/22/2017	7/16/2022	4.98
383579	NEFSC	F	122.92	124	1.08	7/28/2017	5/30/2019	1.84
385082	NEFSC	M	123	137.54	14.54	7/20/2018	10/21/2020	2.26
385889	NEFSC	M	160.02	161	0.98	4/21/2018	4/21/2022	4.00
388358	NEFSC	F	95.1	106.39	11.29	5/15/2018	6/28/2019	1.12
388889	NEFSC	F	106	127	21	8/6/2018	6/13/2024	5.85
390057	NEFSC	M	113	137.16	24.16	6/13/2018	8/27/2020	2.21
391283	NEFSC	F	160.02	169	8.98	7/28/2018	8/22/2020	2.07
391511	NEFSC	F	165.1	174	8.9	1/12/2019	4/20/2021	2.27
394278	NEFSC	M	134.2	135.38	1.18	10/21/2019	5/21/2022	2.58
394301	NEFSC	F	148	164	16	11/3/2020	3/24/2025	4.39
394364	NEFSC	M	81.28	102.24	20.96	6/8/2019	5/25/2020	0.96
395799	NEFSC	F	170.18	180.34	10.16	12/11/2019	1/30/2023	3.14
397479	NEFSC	M	83.82	96.52	12.7	4/14/2020	7/10/2021	1.24
397573	NEFSC	F	152.4	157	4.6	1/7/2020	9/8/2022	2.67
399776	NEFSC	F	167.64	172	4.36	4/8/2021	5/6/2022	1.08
403859	NEFSC	F	172.72	180.34	7.62	8/1/2020	8/13/2022	2.03
405066	NEFSC	F	170.18	170.18	0	3/18/2021	8/5/2021	0.38
405129	NEFSC	F	132.08	150	17.92	8/13/2021	8/12/2024	3.00
498623	NEFSC	F	142.34	161	18.66	8/17/2016	4/19/2023	6.67
498623	NEFSC	M	142.34	161	18.66	8/17/2016	4/19/2023	6.67

A09047	NEFSC	F	88	152	64	4/14/1999	7/10/2013	14.24
B11173	NEFSC	F	88	160	72	7/20/2004	4/17/2022	17.74
B3521	NEFSC	F	55	154	99	11/19/2000	5/25/2014	13.51
B4484	NEFSC	M	56	156	100	9/21/1998	6/4/2014	15.70
B8640	NEFSC	F	102	156	54	9/19/2002	4/22/2014	11.59
P004556	SEFSC	F	144	157	13	8/7/2013	7/11/2021	7.93
P006525	SEFSC	F	151	189.3	38.3	4/10/2018	10/28/2022	4.55
P01757	SEFSC	F	122.3	135	12.7	4/7/2015	5/7/2018	3.08
P02790	SEFSC	F	170	172	2	9/8/2012	4/3/2015	2.57