4. Assessment of the Shallow-water Flatfish Stock Complex in the Gulf of Alaska

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Executive Summary

Summary of Changes in Assessment Inputs

Changes in the input data

The random effects model was fit to the 1984 to 2017 NMFS summer bottom-trawl survey biomass for shallow-water flatfish (minus rock sole) to estimate current biomass which was used to estimate ABC and OFL for 2018 and 2019. Tables of catch data were updated with catch extracted from the AKFIN database by year (1991 to October 1, 2017), species, area and fishery.

Changes in assessment methodology

The random effects model was used to estimate the fraction of biomass by area to use for apportionment of the ABC. The random effects model was also used to estimate the percent of each species in the total biomass (determined using the random effects model summed over species) to estimate ABC by species.

Summary of Results

Survey abundance estimates for the shallow-water complex were higher in 2017 compared to 2015 for all species except Yellowfin sole and Butter sole. The random effects model was used to estimate current biomass for estimating the OFL and ABC values.

The total 2018 biomass estimate is 339,152 t an increase from the 2016 assessment estimate of 301,047 t. The survey biomass estimate for the shallow-water complex increased from 265,116 t in 2015 to 285,047 t in 2017. Butter sole, English sole and southern rock sole survey biomass declined, while all other species increased. The random effects model estimates for current biomass of shallow-water flatfish without rock sole were higher than estimated in the 2015 assessment. The model estimates of current biomass for both Southern and Northern rock sole were higher than last year as well (Bryan, et al. 2017).

OFL and ABC values for 2018 and 2019 are higher in this assessment than the 2016 assessment mainly due to increases in survey and model estimated biomass. The current assessments recommended OFL and ABC values for 2018 are 67,240 t and 54,688 t compared to last year's assessment of 54,893 t and 44,770 t.

The recommended 2018 and 2019 shallow-water flatfish ABC and OFL levels with tier 3a estimates from projections run with the 2017 model for northern and southern rock sole (see Bryan, et al. 2017):

Stock/		**2017**				**2018**		**2019**	
Assemblage	**Area**	**OFL[1]**	**ABC[1]**	**TAC[1]**	**Catch[2]**	**OFL**	**ABC**	**OFL**	**ABC**
Shallow water flatfish	W	--	20,921	13,250	259	--	25,206	--	25,544
	C	--	19,306	19,306	2,109	--	25,315	--	25,655
	WYAK	--	3,188	3,188	<1	--	2,242	--	2,272
	SEO	--	1,099	1,099	<1	--	1,925	--	1,951
	Total	54,583	44,514	36,843	2,369	67,240	54,688	68,114	55,422

[1]As published in the Federal Register. [2]As of Oct. 1, 2017.

Note: Tables of ABCs, OFLs, and TACs published in the Federal Register are available for: 2017: https://alaskafisheries.noaa.gov/sites/default/files/17_18goatable1.pdf

The recommended shallow-water flatfish ABC and OFL levels are:

Quantity	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
	2017	2018	2018	2019
M (natural mortality rate)[1]	0.2	0.2	0.2	0.2
Tier	3a and 5	3a and 5	3a and 5	3a and 5
Biomass (t)	299,858	301,047	339,152	343,018
F_{OFL}	*	*	*	*
$maxF_{ABC}$	*	*	*	*
F_{ABC}	*	*	*	*
OFL (t)	54,583	54,893	67,240	68,114
maxABC (t)	44,514	44,770	54,688	55,422
ABC (t)	44,514	44,770	54,688	55,422
Status	As determined *this* year for:			
	2015	2016	2016	2017
Overfishing	No	NA	No	NA

* See Table 4.15 and Bryan, et al. 2017 for values by species. [1] Northern rock sole male M=0.253, southern rock sole male M= 0.262, all other M=0.2.

Area Apportionment

The recommended apportionments for the 2018 ABC are estimated using the random effects model estimates of biomass for the shallow water flatfish complex by management areas.

	Western	Central	Yakutat	Southeast
Proportions this assessment	0.46	0.46	0.04	0.04
2018 ABC[1]	25,206	25,315	2,242	1,925
2019 ABC[1]	25,544	25,655	2,272	1,951

[1]The sum over areas may not equal the total ABC due to rounding

The history of biomass, OFL, ABC, TAC and catch for shallow-water flatfish is:

Species/Assemblage	Year	Biomass	OFL[1]	ABC[1]	TAC[1]	Catch[2]
Shallow water flatfish	2007	365,766	62,418	51,450	19,972	8,692
	2008	436,591	74,364	60,989	22,256	9,721
	2009	436,591	74,364	60,989	22,256	8,485
	2010	398,961	67,768	56,242	20,062	5,534
	2011	398,961	67,768	56,242	20,062	3,998
	2012	329,217	55,943	45,802	37,029	4,015
	2013	433,869	55,680	45,484	37,077	5,523
	2014	384,134	50,007	40,805	33,679	4,750
	2015	287,534	54,207	44,205	35,381	3,358
	2016	303,299	54,520	44,364	36,763	3,807
	2017	299,858	54,583	44,512	36,843	2,369

[1]As published in the Federal Register. [2]As of Oct. 1, 2017.

Responses to SSC and Plan Team Comments on Assessments in General

SSC (Oct 2016): "The SSC reminds groundfish and crab stock assessment authors to follow their respective guidelines for SAFE preparation."

Authors' response: SAFE guidelines were followed.

Responses to SSC and Plan Team Comments Specific to this Assessment

There were no specific comments for this assessment from 2015 or 2016.

Introduction

The "flatfish" species complex previous to 1990 was managed as a group in the Gulf of Alaska and included the major flatfish species inhabiting the region with the exception of Pacific halibut (*Hippoglossus stenolepis*). The North Pacific Fishery Management Council divided the flatfish assemblage into four categories for management in 1990; "shallow flatfish" and "deep flatfish" (Table 4.1), flathead sole (*Hippoglossoides elassodon*) and arrowtooth flounder (*Atheresthes stomias*). This classification was made because of the significant difference in halibut bycatch rates in directed fisheries targeting on shallow-water and deep-water flatfish species. Arrowtooth flounder, because of its present high abundance and low commercial value, was separated from the group and managed under a separate acceptable biological catch (ABC). Flathead sole were likewise assigned a separate ABC since they overlap the depth distributions of the shallow-water and deep-water groups. In 1993 rex sole (*Glyptocephalus zachirus*) was split out of the deep-water management category because of concerns regarding the Pacific ocean perch bycatch in the rex sole target fishery.

The major species, which account for the majority of the current biomass for shallow-water flatfish are: northern rock sole (*Lepidopsetta polyxystra*), southern rock sole (*Pleuronectes bilineata*), butter sole (*Pleuronectes isolepis*), yellowfin sole (*Pleuronectes asper*), and starry flounder (*Platichthys stellatus*). For this assessment, biomass, fishing mortality rates, and ABC estimates are presented for each species and management category.

Beginning with the 1996 triennial trawl survey, rock sole was split into two species, a northern rock sole and a southern rock sole. Due to overlapping distributions, differential harvesting of the two species may occur, requiring separate management in the future.

This report describes flatfish catches taken from 1978 through October 1, 2017 and presents information on the status of flatfish stocks and their potential yield based a random effects model fit to Gulf of Alaska demersal trawl survey data through 2017 and population dynamics model estimates for Northern and Southern rock sole (Bryan, at al. 2017).

Fishery

Since the passage of the MFMCA in 1977, the fishery for flatfish in the Gulf of Alaska has undergone changes. Until 1981 flatfish catch was primarily taken by foreign vessels targeting other species. With the cessation of foreign fishing in 1986, joint venture fishing began to account for the majority of the catch. In 1987, the gulf-wide flatfish catch increased with the joint venture fisheries accounting for nearly all of the increase. After 1988, only domestic fleets harvested flatfish.

The North Pacific Fishery Management Council (NPFMC) Central Gulf management area has produced the majority of the flatfish catch from the Gulf of Alaska (Table 4.2). Since 1988 the majority of the harvest has occurred on the continental shelf and slope east of Kodiak Island. Although arrowtooth flounder comprised about half the catch, the fishery primarily targeted on rock, rex and Dover sole.

Data

Fishery:

Shallow-water flatfish catch since 1991 has varied between 2,578 t (1999) and 9,721 t (2008) (Table 4.2 and Figure 4.1). Catch has declined since 2013 from 5,523 t to 3,807 t in 2016. Catch was 2,369 t in 2017 through October 1.

Flatfish catch is currently reported for deep-water flatfish, shallow-water flatfish, arrowtooth flounder, flathead sole and rex sole by management area. This assessment includes shallow-water flatfish only.

The catch by species in each year and area was extracted from the AKFIN database (Table 4.3). Flatfish not identified to species range between 1% and 11% of the shallow-water flatfish catch since 2000 (Table 4.3). Most of the shallow-water flatfish catch (other than assigned to shallow-water flatfish fishery) comes from the Pacific cod fishery, followed by arrowtooth flounder and pollock bottom trawl and then flathead sole and rex sole fisheries (Tables 4.4 and 4.5 and Figure 4.20). Table 4.6 documents annual research catches (1977 to 2009) from NMFS longline, trawl, and echo integration trawl surveys. Table 4.7 contains research catch for 2010 by survey for shallow-water flatfish complex. Prohibited species catch and non-target species catch in the shallow water flatfish fishery are contained in Tables 4.8 and 4.9.

The shallow-water flatfish catch in 2017 through October 1, was about 5.3% of the ABC (44,514 t) and about 6.4% of the TAC (36,843 t). In 2016 (the most recent full year of data), total catch was 8.6% of the ABC and 10.4% of the TAC. Retention of shallow water flatfish has been greater than 87% since 2000, although declined from 93.8% in 2016 to 80% in 2017.

Survey:

The principal source of information for evaluating the condition of flatfish stocks in the Gulf of Alaska is the bottom trawl survey conducted from 1984 to 2017 (Table 4.11 and 4.12 and Figure 4.2). Flatfish biomass estimates from the 2001 to 2017 surveys by International North Pacific Fishery Council (INPFC) area are given in Tables 4.14a through 4.14m. Sampling for the 2001 survey was conducted in the western and central portions of the Gulf of Alaska only. 2001 survey biomass for the eastern Gulf of Alaska was approximated using the average of the 1999 to 2003 eastern Gulf of Alaska biomass estimates for all flatfish species (Table 4.12j).

Survey abundance estimates for the shallow-water complex were higher in 2017 compared to 2015 for all species except Southern rock sole, English sole and butter sole.

Length composition data from the triennial surveys are shown in Figures 4.3 to 4.7. Aging of Gulf of Alaska flatfish species has been sporadic since the inception of the triennial surveys.

The apportionment of survey sampling stations on the shelf and slope followed the methods developed for the shelf portion of the 1984 survey (Brown 1986). There was no sampling deeper than 500 meters during 1990 to 1996, and 2001 because of limited vessel time. The 500- 1,000 m depths sampled in 1984 and 1987, 1999, 2007, 2009 and 2011 are generally outside the depth range of most shallow-water flatfish species. The 2003 and 2005 survey covered depths to 700 m.

Experimental evidence suggests that flatfish biomass estimates derived from the Noreastern trawl used in the survey may underestimate true biomass because the escapement occurs under the net (e.g., Weinberg et al., 2002).

Analytic Approach

The random effects model was used to estimate current biomass for species other than northern and southern rock sole (for details see Spencer, et al. 2013). The random effects model was fit to survey biomass for 1984 to 2017, leaving out 2001 where the Eastern area was not surveyed (Figure 4.8). The survey biomass for each year was summed over species (not including rock sole). The apportionment by area was estimated by fitting the random effects model to the survey biomass summed for all species (including rock sole) by area and then estimating the percent biomass in the ending year by area. The percent biomass by species (excluding rock sole) was estimated using the random effects model fit to survey biomass by species and dividing by the total from the fit by species. The current biomass by

species uses the estimation of the percent by species (using the random effects model fit by species) and the total biomass estimated using the random effects model fit to total biomass (excluding Rock sole).

The likelihood equation for the random effects model is,

$$\sum_{i=1}^{yrs}\left\{0.5\left(\log(2\pi\sigma_i^2)+\left(\frac{(\hat{B}_i-B_i)^2}{\sigma_i^2}\right)\right)\right\}+\sum_{t=2}^{yrs}\left\{0.5\left(\log(2\pi\sigma_p^2)+\left(\frac{(\hat{B}_t-\hat{B}_{t-1})^2}{\sigma_p^2}\right)\right)\right\}$$

Where,

B_i is the log of observed biomass in year i,

$\hat{B}_t$ is the model estimated log biomass in year t,

σ_i^2 is the variance of observed log biomass in year i,

σ_p^2 is the variance of the deviations in log survey biomass between years (i.e. process error variance), σ_p^2 was estimated as $e^{(2\lambda)}$, where λ is a parameter estimated in the random effects model and,

Yrs is the number of years of survey biomass values.

Parameters Estimated Outside the Assessment Model

Natural mortality

Natural mortality rates for Gulf of Alaska flatfish species were estimated using the methods of Alverson and Carney (1975), Pauly (1980), and Hoenig (1983) in the 1988 assessment (Wilderbuer and Brown 1989). The estimates were different for each method and were not inconsistent with the value of 0.2, used in previous assessments (Wilderbuer and Brown 1989). A natural mortality value of 0.2 was used for all flatfish. Table 15 contains growth estimates for Gulf of Alaska yellowfin sole.

Parameters Estimated Inside the Assessment Model

Random Effects Model

There were 11 parameters estimated, one for each random effects model fitted. One parameter for the summed biomass (Table 4.13a), six parameters for the fit to biomass by species (Table 4.13b), and four parameters for the fit to the four areas summed over species (including rock sole) (Table 4.13a).

Results

The total current biomass estimate is 339,152 t an increase from the value of 301,047 t used in last year's assessment for 2018 biomass (Table 4.17). There was an increase in estimated biomass for all species except English sole which had about the same biomass.

The fits to total biomass (excluding rock sole) from the random effects model smooth the data fitting higher than the 2013 and 2015 survey biomass and lower than the 2017 biomass (Figure 4.8). The fits to biomass by area were used to apportion the ABC (Figures 4.9 to 4.12). Apportionment by area was estimated at 46.09% Western, 46.29% Central, 4.10% Yakutat and 3.52% Southeast (Table 4.13a and Figures 4.9 to 4.12). The trends in biomass over time in the western and central areas that contain most of the biomass are similar (Figure 4.13). Figures 4.14 to 4.19 and show the random effects model fits to individual species for estimation of biomass, OFL and ABC by species (Table 4.17).

Parameter estimates from the random effects model fit are shown in Tables 4.13a and 4.13b. The process variance for the fit to total biomass (excluding rock sole, 109,738 t) was relatively low (0.0045) which

results in a smoother fit to the data than higher process variances. The parameter estimated in the random effects model (λ) was -2.7013 with a standard error of 0.6217 (Table 4.13a). Process variances for the other random model fits varied between 0.0055 and 0.28.

Harvest Recommendations

ABCs for all shallow-water flatfish species other than northern and southern rock sole were calculated using F_{ABC}= 0.75 M and F_{OFL} = M (tier 5), since maturity information was not available. Natural mortality was assumed to be 0.2 for yellowfin sole, butter sole, starry flounder, English sole, Alaska plaice, and sand sole.

The flatfish complex ABCs for the 2018 and 2019 fishing seasons were calculated using the F_{ABC} fishing mortality rate, and the random effects model estimate of current biomass for each species over all areas except Rock sole which are estimated from an assessment model (Bryan et al. 2017).

The 2018 ABC for shallow-water flatfish increased to 54,688 t from the 2017 ABC of 44,514 t. The estimated 2019 ABC was estimated at 55,422 t an increase from the 2018 ABC of 54,688 t.

Due to the overlapping distributions of flatfish species, especially in the shallow-water group, it may be difficult to target a species within an arbitrary management group without impacting other flatfish species in that group or other species which were "split-out" and managed separately. Given the present management strategy used by the North Pacific Fishery Management Council for Gulf of Alaska flatfish, some species may be subjected to higher fishing mortalities than that resulting from the recommended ABCs. The ongoing efforts by the observer program to improve species identification will help monitor these fisheries in the event that species compositions change.

Under tiers 4 through 6 projections of harvest scenarios equivalent to tier 1 through 3 stocks are not possible. No projections were done for the shallow-water flatfish complex.

Ecosystem Considerations

Ecosystem Effects on the Stock

Flatfish consume a variety of benthic organisms (Table 4.16; Livingston and Goiney 1983, Yang 1990). Fish prey make up a large part of the diet of rock sole adults and possibly sand sole (although the sample size was small for sand sole). Other flatfishes consume mostly polychaetes, crustaceans and mollusks.

Fishery Effects on the Ecosystem

Non-target and prohibited species catch in the directed GOA shallow-water flatfish fishery are shown in Tables 4.8 and 4.9. In recent years the 3 highest Non-target catch was from state managed rockfish, sea stars and miscellaneous fish. Prohibited species catch is mostly Bairdi Tanner crab, followed by Halibut, with a few Chinook salmon.

Data Gaps and Research Priorities

More aging data is needed to improve estimates of natural mortality for Tier 5 species.

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Tables

Table 4.1. Flatfish constituents of the NPFMC Gulf of Alaska shallow-water management category.

Common name	**Genus and Species**
Northern rock sole	*Lepidopsetta polyxystra*
Southern rock sole	*Pleuronectes bilineata*
Yellowfin sole	*Pleuronectes asper*
Starry flounder	*Platichthys stellatus*
Butter sole	*Pleuronectes isolepis*
English sole	*Pleuronectes vetulus*
Alaska plaice	*Pleuronectes quadrituberculatus*
Sand sole	*Psettichthys melanostictus*

Table 4.2. Composition of the 1978 to October 1, 2017 Gulf of Alaska shallow water flatfish catch. Catch by North Pacific Fishery Management Council regulatory area available from 1991 to present.

	Area						
Year	Western	Central	Eastern	Total	ABC	OFL	TAC
1978				5,455			
1979				5,625			
1980				5,301			
1981				5,890			
1982				1,802			
1983				4,146			
1984				2,392			
1985				1,020			
1986				957			
1987				3,561			
1988				2,082			
1989				6,160			
1990				5,214			
1991	2,174	3,050	1	5,224			
1992	2,287	6,046	2	8,334			
1993	378	8,729	6	9,114			
1994	189	3,643	11	3,843			
1995	373	5,057	7	5,437			
1996	443	8,899	30	9,372			
1997	401	7,332	48	7,780			
1998	271	3,204	91	3,567			
1999	268	2,299	12	2,578			
2000	560	6,320	49	6,929			
2001	207	5,956	1	6,163			
2002	260	6,914	3	7,177			
2003	202	4,443	4	4,649			
2004	118	2,975	1	3,094			
2005	122	4,676	7	4,805			
2006	240	7,411	1	7,652			
2007	191	8,501	1	8,692	51,450	62,418	22,256
2008	762	8,958	1	9,721	60,989	74,364	22,256
2009	97	8,386	3	8,485	60,989	74,364	22,256
2010	84	5,448	1	5,534	56,242	67,768	20,062
2011	124	3,870	5	3,998	56,242	67,768	20,062
2012	153	3,861	1	4,015	45,802	55,943	37,029
2013	155	5,362	6	5,523	45,484	55,680	37,077
2014	246	4,499	6	4,750	40,805	50,007	33,679
2015	274	3,082	1	3,358	44,205	54,207	35,381
2016	148	3,658	1	3,807	44,364	54,520	36,763
2017	259	2,109	1	2,369	44,514	54,583	36,843

Table 4.3. Estimated catch (t) of species in the shallow-water flatfish group by area for 1991 to October 1, 2017.

	Year	Western	Central	Yakutat	Southeast	Total
Unidentified Species						
	1991	2173.60	3049.61	0.79	0.59	5224.59
	1992	2286.55	6045.62	1.51	0.12	8333.80
	1993	293.45	866.04	0.27	6.17	1165.93
	1994	138.83	316.28	8.73	0.00	463.84
	1995	318.27	753.46	3.33	0.99	1076.05
	1996	338.22	1030.20	12.90	0.12	1381.44
	1997	344.79	926.54	9.98	1.50	1282.81
	1998	220.61	344.11	33.99	1.25	599.96
	1999	170.80	364.02	5.37	3.66	543.85
	2000	170.61	341.45	3.00	1.85	516.91
	2001	128.36	556.13	0.34	0.42	685.25
	2002	154.36	537.48	0.35	0.43	692.62
	2003	70.45	250.63	0.04	3.92	325.04
	2004	16.89	180.07	0.04	0.17	197.17
	2005	38.80	121.77	0.04	6.53	167.14
	2006	139.55	333.11	0.19	1.20	474.04
	2007	127.90	204.33	0.16	0.73	333.12
	2008	700.85	167.74	0.27	0.59	869.45
	2009	19.46	72.22	1.01	1.63	94.32
	2010	34.01	196.54	0.16	0.76	231.47
	2011	10.09	158.78	0.28	4.01	173.17
	2012	45.24	143.18	0.21	1.05	189.69
	2013	124.70	72.91	1.15	4.59	203.36
	2014	206.07	134.84	1.30	3.52	345.74
	2015	214.35	120.88	0.93	0.00	337.15
	2016	128.34	69.34	0.81	0.00	198.49
	2017	234.20	192.87	1.00	0.00	428.07

	Year	Western	Central	Yakutat	Southeast	Total
Rock sole sp.						
	1993	83.02	7455.68	0.00	0.00	7538.70
	1994	44.07	2962.02	2.02	0.00	3008.11
	1995	47.11	3874.68	1.32	0.80	3923.91
	1996	71.71	6523.09	0.00	0.52	6595.32
	1997	26.49	5406.06	34.23	0.00	5466.78
	1998	40.33	2440.23	1.14	50.64	2532.34
	1999	64.24	1698.60	0.41	2.10	1765.35
	2000	341.44	5001.40	43.85	0.00	5386.69
	2001	75.75	4695.85	0.13	0.00	4771.73
	2002	101.87	5460.38	2.04	0.00	5564.29
	2003	128.46	3426.13	0.00	0.06	3554.64
	2004	82.78	2133.39	0.58	0.00	2216.75
	2005	81.61	4048.90	0.00	0.00	4130.50
	2006	51.50	5711.77	0.01	0.00	5763.28
	2007	59.23	6668.16	0.00	0.00	6727.39
	2008	57.65	7211.43	0.00	0.00	7269.09
	2009	74.74	6463.95	0.01	0.00	6538.69
	2010	47.90	3237.15	0.22	0.01	3285.28
	2011	111.84	2982.58	0.00	0.01	3094.43
	2012	97.26	2731.20	0.00	0.11	2828.57
	2013	28.71	4029.52	0.02	0.00	4058.26
	2014	36.13	3403.30	0.02	0.89	3440.34
	2015	59.15	2562.98	0.07	0.00	2622.20
	2016	19.08	2989.39	0.00	0.00	3008.46
	2017	24.72	1664.40	0.00	0.00	1689.12

	Year	Western	Central	Yakutat	Southeast	Total
Yellowfin sole						
	1993	0.47	69.08	0.00	0.00	69.55
	1994	3.59	57.74	0.00	0.00	61.33
	1995	6.89	58.66	0.00	0.00	65.55
	1996	1.40	77.14	0.00	0.00	78.54
	1997	0.02	41.96	0.00	0.00	41.98
	1998	0.31	15.06	0.00	0.00	15.37
	1999	23.85	1.92	0.00	0.00	25.77
	2000	17.67	0.55	0.00	0.00	18.22
	2001	0.52	1.93	0.00	0.00	2.45
	2002	0.14	0.04	0.00	0.00	0.18
	2003	7.61	0.00	0.00	0.00	7.61
	2004	1.32	9.09	0.00	0.00	10.41
	2005	0.30	0.25	0.00	0.00	0.55
	2006	0.19	11.29	0.00	0.00	11.48
	2007	1.14	0.00	0.00	0.00	1.15
	2008	1.07	0.00	0.00	0.00	1.07
	2009	0.18	0.20	0.00	0.00	0.38
	2010	0.15	0.00	0.00	0.00	0.15
	2011	0.06	0.00	0.00	0.00	0.06
	2012	0.04	0.18	0.00	0.00	0.22
	2013	0.40	0.08	0.00	0.00	0.48
	2014	0.25	0.45	0.00	0.00	0.70
	2015	0.35	0.93	0.00	0.00	1.27
	2016	0.05	0.13	0.00	0.00	0.17
	2017	0.00	0.32	0.00	0.00	0.32

	Year	Western	Central	Yakutat	Southeast	Total
Butter sole						
	1993	0.00	250.47	0.00	0.00	250.47
	1994	2.15	227.23	0.00	0.00	229.38
	1995	0.01	177.02	0.00	0.00	177.03
	1996	29.79	379.77	0.00	0.00	409.56
	1997	26.76	424.81	0.00	0.05	451.62
	1998	9.79	167.81	0.00	0.00	177.60
	1999	2.24	145.60	0.00	0.00	147.84
	2000	21.39	694.78	0.00	0.00	716.17
	2001	1.05	597.85	0.00	0.00	598.90
	2002	2.13	778.54	0.14	0.00	780.81
	2003	1.37	606.57	0.00	0.00	607.94
	2004	7.09	532.34	0.00	0.00	539.43
	2005	0.38	378.17	0.00	0.00	378.55
	2006	0.01	1084.03	0.00	0.00	1084.04
	2007	0.00	1431.44	0.00	0.00	1431.44
	2008	0.02	1419.12	0.00	0.00	1419.14
	2009	0.00	1698.07	0.00	0.00	1698.07
	2010	0.00	1835.18	0.32	0.00	1835.50
	2011	0.04	591.31	0.00	0.00	591.35
	2012	0.10	796.72	0.00	0.00	796.81
	2013	0.00	1076.05	0.00	0.00	1076.05
	2014	0.00	826.70	0.00	0.00	826.70
	2015	0.02	284.14	0.00	0.00	284.15
	2016	0.00	500.14	0.00	0.00	500.14
	2017	0.01	139.39	0.00	0.00	139.40

	Year	Western	Central	Yakutat	Southeast	Total
Starry flounder						
	1993	0.00	80.09	0.00	0.00	80.09
	1994	0.00	52.22	0.12	0.00	52.34
	1995	0.33	134.37	0.00	0.02	134.72
	1996	0.02	805.86	0.22	0.00	806.10
	1997	0.00	401.17	0.43	0.29	401.89
	1998	0.03	148.32	0.00	3.94	152.29
	1999	0.66	85.84	0.00	0.00	86.50
	2000	2.67	265.17	0.00	0.00	267.84
	2001	0.46	86.02	0.00	0.00	86.48
	2002	0.00	109.84	0.00	0.00	109.84
	2003	0.29	138.94	0.00	0.00	139.23
	2004	0.27	114.17	0.01	0.00	114.44
	2005	0.00	110.96	0.00	0.00	110.96
	2006	0.00	265.26	0.00	0.00	265.26
	2007	0.04	154.02	0.00	0.00	154.07
	2008	0.01	130.32	0.00	0.00	130.33
	2009	0.08	114.99	0.00	0.00	115.06
	2010	0.15	123.99	0.00	0.00	124.14
	2011	0.03	99.69	0.00	0.00	99.72
	2012	0.05	166.31	0.00	0.00	166.36
	2013	0.04	119.05	0.00	0.00	119.09
	2014	0.60	73.00	0.00	0.00	73.59
	2015	0.04	77.34	0.00	0.00	77.38
	2016	0.05	62.02	0.00	0.00	62.07
	2017	0.01	67.62	0.00	0.00	67.62

	Year	Western	Central	Yakutat	Southeast	Total
English sole						
	1993	0.23	6.18	0.00	0.00	6.41
	1994	0.07	7.64	0.41	0.00	8.12
	1995	0.18	16.08	0.16	0.13	16.55
	1996	0.28	12.38	16.67	0.12	29.45
	1997	0.61	20.73	1.05	0.00	22.39
	1998	0.38	10.36	0.09	0.00	10.83
	1999	5.55	1.34	0.05	0.00	6.94
	2000	2.20	10.99	0.00	0.00	13.19
	2001	0.16	5.75	0.00	0.00	5.91
	2002	0.00	12.73	0.00	0.00	12.73
	2003	0.07	2.22	0.00	0.00	2.29
	2004	0.49	5.56	0.30	0.00	6.36
	2005	0.24	1.73	0.00	0.00	1.97
	2006	48.23	10.18	0.00	0.00	58.41
	2007	3.16	22.38	0.00	0.00	25.54
	2008	2.37	23.28	0.00	0.00	25.65
	2009	0.88	26.75	0.00	0.00	27.63
	2010	1.71	33.49	0.00	0.00	35.20
	2011	1.49	26.87	0.00	0.39	28.75
	2012	10.26	18.28	0.00	0.00	28.54
	2013	1.62	50.32	0.00	0.00	51.94
	2014	2.27	54.67	0.25	0.00	57.20
	2015	0.09	32.27	0.01	0.00	32.36
	2016	0.49	34.06	0.19	0.00	34.74
	2017	0.06	41.11	0.00	0.00	41.17

	Year	Western	Central	Yakutat	Southeast	Total
Sand sole						
	1993	0.50	0.00	0.00	0.00	0.50
	1994	0.00	15.03	0.01	0.00	15.04
	1995	0.08	10.23	0.00	0.00	10.31
	1996	1.65	4.70	0.00	0.00	6.35
	1997	1.84	41.05	0.00	0.00	42.89
	1998	0.00	0.78	0.00	0.00	0.78
	1999	0.00	1.26	0.00	0.00	1.26
	2000	0.99	4.88	0.00	0.00	5.87
	2001	0.00	12.79	0.00	0.00	12.79
	2002	1.51	11.97	0.00	0.00	13.48
	2003	0.00	3.27	0.00	0.00	3.27
	2004	0.00	3.94	0.00	0.00	3.94
	2005	0.00	2.77	0.00	0.00	2.77
	2006	0.00	5.13	0.00	0.00	5.13
	2007	0.00	3.23	0.00	0.00	3.23
	2008	0.00	3.34	0.00	0.00	3.34
	2009	0.00	2.35	0.00	0.00	2.35
	2010	0.00	0.84	0.00	0.00	0.84
	2011	0.00	0.74	0.00	0.00	0.74
	2012	0.00	0.75	0.00	0.00	0.75
	2013	0.00	1.85	0.00	0.00	1.85
	2014	0.00	2.15	0.00	0.00	2.15
	2015	0.02	2.07	0.00	0.00	2.09
	2016	0.00	0.27	0.00	0.00	0.27
	2017	0.00	0.11	0.00	0.00	0.11

	Year	Western	Central	Yakutat	Southeast	Total
Alaska plaice						
	1993	0.04	1.44	0.00	0.00	1.48
	1994	0.00	4.75	0.00	0.00	4.75
	1995	0.06	26.08	0.00	0.00	26.14
	1996	0.01	65.61	0.00	0.00	65.62
	1997	0.00	69.23	0.00	0.00	69.23
	1998	0.03	9.78	0.00	0.00	9.81
	1999	0.83	0.03	0.00	0.00	0.86
	2000	3.37	0.39	0.00	0.00	3.76
	2001	0.99	0.89	0.00	0.00	1.88
	2002	0.00	1.10	0.00	0.00	1.10
	2003	1.23	14.77	0.00	0.00	15.99
	2004	3.08	5.39	0.00	0.00	8.47
	2005	0.00	2.76	0.00	0.00	2.76
	2006	0.00	0.92	0.00	0.00	0.92
	2007	0.15	5.91	0.00	0.00	6.06
	2008	0.01	2.63	0.00	0.00	2.65
	2009	0.41	7.80	0.00	0.00	8.21
	2010	0.11	20.86	0.00	0.00	20.96
	2011	0.55	9.42	0.00	0.00	9.98
	2012	0.06	4.63	0.00	0.00	4.69
	2013	0.00	12.33	0.00	0.00	12.33
	2014	0.04	4.09	0.00	0.00	4.13
	2015	0.00	1.39	0.00	0.00	1.39
	2016	0.01	2.66	0.00	0.00	2.66
	2017	0.00	3.19	0.00	0.00	3.19

Table 4.4. Shallow-water flatfish catch (t) by year and fishery from 1991 to October 1, 2017. See table 4.5 for full fishery names abbreviated in column headings.

Year	AF	AM	DWF	FS	Ha	OS	PC	PB	PM	RS	RF	SF	SWF	Unid	Total
1991			460.0			39.1	685.0	54.4	1.8		69.5	0.0	76.2	3838.7	5224.6
1992	4.0		484.9			85.3	3273.1	377.5	60.2		36.7	1.5	4010.6	0	8333.8
1993	100.0		387.5			68.1	1182.9	935.4	103.0		18.1	3.1	6315.7	0	9113.7
1994	92.7	22.2	257.0	159.4		0.5	837.3	150.3	22.2	58.4	29.1	1.2	2212.7	0	3843.0
1995	275.7		159.4	48.1			1792.5	37.6	5.6	46.9	321.0	11.4	2738.7	0	5436.9
1996	275.7	26.2	227.5	145.6		0.6	1406.5	155.9	18.6	42.6	368.0	11.0	6694.3	0	9372.4
1997	180.2		334.1	133.2		49.0	2998.7	62.8	128.0	66.5	108.6	3.8	3714.7	0	7779.6
1998	6.6		97.3	133.0		10.1	1653.2	28.3	5.1	20.3	109.3	1.6	1502.6	0	3567.3
1999	18.3		53.1			54.7	1402.6	21.4	41.2	15.8	72.6	24.1	874.7	0	2578.4
2000	611.3		83.2	5.8		0.7	987.4	74.4	6.5	54.1	366.1	7.4	4732.0	0	6928.7
2001	65.6		17.6	135.9			1946.3	170.0	1.3	7.3	416.9	4.2	3398.1	0	6163.3
2002	183.8		27.2	193.0			627.6	18.3	4.4	45.2	142.3	2.9	5932.6	0	7177.3
2003	95.0		11.2	145.8	1.2	189.5	661.0	20.2	5.3	31.5	126.1	4.5	3357.4	0	4648.6
2004	270.5		46.8	40.2	0.2	23.4	807.7	6.1	3.6	10.8	110.7	0.6	1773.5	0	3094.1
2005	106.2		2.1	2.5	0.2	0.4	370.6	3.4	1.2	8.4	64.4	7.3	4238.3	0	4805.1
2006	539.3		1.7	28.7	0.4		396.4	437.8	0.9	40.2	45.1	6.8	6154.2	0	7651.6
2007	350.6			26.2	1.3		1032.6	155.5	1.5	9.6	21.6	32.0	7061.6	0	8692.3
2008	407.4			41.0	0.4		1670.6	228.3	1.7	12.1	70.9	10.5	7278.0	0	9720.8
2009	228.5			94.9	0.9	0.1	248.7	15.3	1.6	46.5	52.6	1.1	7795.2	0	8485.4
2010	470.5		3.8	121.6	0.0		678.8	75.5	3.0	39.8	46.7	1.5	4092.6	0	5533.8
2011	779.2	0.0	4.0	78.4	0.0	10.0	944.1	252.2	37.2	11.4	48.3	4.2	1829.2	0	3998.4
2012	361.0			150.2	0.0	1.1	811.5	148.0	23.2	100.9	64.7	2.4	2352.5	0	4015.5
2013	301.8	1.4	17.9	48.2	7.5	0.0	965.7	178.6	4.8	14.2	27.0	9.6	3946.3	0	5523.1
2014	722.9		0.0	116.1	3.1		918.1	244.1	4.7	28.0	28.4	3.3	2681.6	0	4750.4
2015	156.3			0.2	4.8		1,012.5	324.0	33.6	4.2	27.3	2.1	1,792.8	0	3,357.7
2016	448.4	1.2		27.1	2.7		746.0	250.2	15.5	1.7	14.8	4.3	2,294.9	0	3,806.8
2017	289.3	0.6		0.0	2.4	0.3	829.8	367.1	3.3	24.4	10.9	6.7	834.5	0	2,369.2

Table 4.5. Code values for fishery names used in Table 4.4.

Code	Fishery Name
AF	Arrowtooth Flounder
AM	Atka Mackerel
DWF	Deep Water Flatfish - GOA
FS	Flathead Sole
Ha	Halibut
OS	Other Species
PC	Pacific Cod
PB	Pollock - bottom
PM	Pollock - midwater
RS	Rex Sole - GOA
RF	Rockfish
SF	Sablefish
SWF	Shallow Water Flatfish - GOA
Unid	Blank - Unidentified fishery

Table 4.6. Catch (t) from longline and trawl research cruises from 1977 to 2009. From 1999 to 2009 catches are from bottom trawl survey only.

Year	Rock sole sp.	North Rock	South Rock	Yellowfin sole	Butter sole	Starry flounder	English sole	Sand sole	Alaska plaice
1977	4.26			1.17	0.22	0.12	0.04	0.00	0.01
1978	44.72			3.76	2.61	1.85	1.74	3.69	0.39
1979	0.96			0.00	0.06	0.00	0.02	0.00	0.00
1980	15.83			8.98	2.70	0.98	0.31	0.31	0.48
1981	30.84			10.91	5.05	1.86	0.53	0.24	0.75
1982	26.15			2.48	3.45	1.07	0.64	0.16	0.19
1983	3.32			1.67	0.30	0.02	0.02	0.00	0.03
1984	19.10			9.08	1.88	0.97	0.39	0.09	0.17
1985	3.22			0.05	0.23	0.02	0.14	0.00	0.03
1986	4.18			4.09	0.08	0.03	0.13	0.00	0.03
1987	24.56			6.85	1.43	1.52	0.87	0.00	0.53
1988	0.37			2.56	0.00	0.01	0.00	0.00	0.03
1989	1.12			1.78	0.07	0.13	0.00	0.00	0.25
1990	11.13			2.84	0.94	0.44	0.31	0.01	0.30
1991	0.00			0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00			0.00	0.00	0.00	0.00	0.00	0.00
1993	16.53			7.26	2.17	3.19	0.59	0.04	0.26
1994	0.00			0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00			0.00	0.00	0.00	0.00	0.00	0.00
1996	0.44	5.08	7.06	3.67	0.96	0.94	0.37	0.05	0.35
1997		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998		0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
1999		3.60	5.78	2.83	0.75	2.69	0.72	0.01	0.52
2000		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001		3.72	7.48	4.23	0.50	2.74	0.19	0.03	0.24
2002		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003		6.73	9.76	5.20	1.57	3.06	0.74	0.07	0.72
2004		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005		6.62	9.64	4.02	1.55	1.65	0.68	0.21	0.55
2006		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007		7.95	12.10	3.61	1.49	3.93	0.52	0.22	0.88
2008		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2009		7.92	13.78	2.68	1.23	1.91	1.05	0.22	0.65

Table 4.7. Catch (kg) from research cruises for GOA shallow-water flatfish in 2010 by survey.

Year	2010 Shelikof Acoustic Survey	2010 Shumigans Acoustic Survey	IPHC	large-mesh trawl	NMFS_LL	Scallop dredge	small-mesh trawl	GOAIERP*	Grand Total
2010	1	6	2	145	1	2	58	1	216

*Structure of Gulf of Alaska Forage Fish Communities -- GOA IERP

Table 4.8. Prohibited species catch (t) from 2015 to 2017 in the shallow water flatfish fishery.

	2017	2017	2016	2016	2015	2015
Species Group Name	PSCNQ Estimate (numbers)	Halibut Mortality (t)	PSCNQ Estimate (numbers)	Halibut Mortality (t)	PSCNQ Estimate (numbers)	Halibut Mortality (t)
Bairdi Tanner Crab	9,149.84		9,992.24		62,250.06	
Blue King Crab	0		0		0	
Chinook Salmon	0.11		145.58		0	
Golden (Brown) King Crab	0.02		0.70		0	
Halibut	72.93	47.71	90.83	59.95	160.53	107.56
Herring	0.07		0.53		1.38	
Non-Chinook Salmon	0.10		2.02		0	
Opilio Tanner (Snow) Crab	0		0.12		0	
Red King Crab	0		0		0	

Table 4.9. Nontarget species caught (t) in the shallow water flatfish fishery from 2003 to 2017.

Species Group Name	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
"Benthic urochordata"	0.15	0.02	1.67		0.56			0.41	0.64	2.15	0.74	7.48	0.53	0.29	0.90
"Bivalves"	0.00	0.20		0.00	0.22	0.64	0.58	0.33	0.52	0.60	5.96	2.25	2.71	0.49	0.27
"Brittle star unidentified"	0.00	0.00		0.02				0.00	4.71	0.00	0.08	0.00	0.01		0.00
"Corals Bryozoans - Corals Bryozoans Unidentified"								0.00	0.00		0.01				
"Dark Rockfish"						0.22				0.62					
"Eelpouts"	0.04	0.13	0.23	0.17	0.15			0.08	0.49	0.01		0.03	0.03		0.13
"Eulachon"	0.04	0.06		0.19				0.10	1.64	0.04	0.11			0.03	
"Giant Grenadier"								16.05	13.59			3.98			
"Greenlings"	0.02	0.07		0.06	0.41	0.12	0.75	0.28	1.63	1.14	1.93	0.98	0.93	0.42	0.06
"Grenadier - Ratail Grenadier Unidentified"												0.00	1.41	1.82	
"Hermit crab unidentified"	0.00	0.01	0.01	0.09	0.09	0.00	0.02	0.00	0.16	0.13	0.31	0.16	0.03	0.31	0.42
"Invertebrate unidentified"	0.05					4.11		0.01	0.23	2.43	0.30	6.25	0.01	0.66	12.95
"Large Sculpins - Bigmouth Sculpin"						1.28			18.00	12.58					
"Large Sculpins - Great Sculpin"						25.49			55.27	147.10					
"Large Sculpins - Hemilepidotus Unidentified"									0.82	0.26					
"Large Sculpins - Myoxocephalus Unidentified"						0.26			15.51	0.41					
"Large Sculpins - Plain Sculpin"						0.06				1.77					
"Large Sculpins - Red Irish Lord"						0.03			5.44	0.22					
"Large Sculpins - Warty Sculpin"									8.38	0.02					
"Large Sculpins - Yellow Irish Lord"						208.00			241.77	780.58					
"Large Sculpins"											328.25	119.68	195.80	114.80	14.55
"Misc crabs"	0.01	0.00		1.01	0.31		0.59	0.04	0.89	0.70	0.99	0.11	0.04	0.17	0.35

Table 4.9 cont. Nontarget species caught in the shallow water flatfish fishery from 2003 to 2017.

Species Group Name	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
"Misc crustaceans"	0.00							0.00							
"Misc fish"	4.08	1.74	10.96	11.99	15.20	1.67	29.32	10.51	44.71	49.27	129.42	24.41	6.59	7.85	32.70
"Misc inverts (worms etc)"				0.00						0.02	0.05				
"Other Sculpins"						0.08			170.60	13.69	52.05	5.50	3.92	14.42	98.50
"Other osmerids"				0.03	0.03						0.01			0.00	0.05
"Pacific Sand lance"		0.00			0.00					0.00			0.00		
"Pacific Sandfish"					0.11	0.00									
"Pandalid shrimp"	0.02	0.03		0.09	0.06		0.00	0.16	0.08	0.00	0.01		0.05	0.00	0.03
"Polychaete unidentified"	0.05		0.06							0.02	0.11		0.00		
"Scypho jellies"	0.10	3.97	11.82	1.50	0.13	0.97	0.23	5.43	1.58	0.96	0.00	0.48	0.14	0.23	6.34
"Sea anemone unidentified"	0.71	0.79	0.58	5.58	10.16	3.31	2.73	2.86	19.98	8.64	24.08	2.20	21.46	3.20	5.04
"Sea pens whips"		0.00							0.01	0.17	0.26	0.04	0.02		
"Sea star"	2.09	10.91	22.84	19.63	20.70	13.90	8.76	15.29	22.40	35.24	56.29	39.40	49.05	28.72	32.81
"Snails"	0.04	0.26	0.73	0.45	0.13	0.03	0.05	0.12	0.38	0.15	1.71	0.28	0.15	0.06	0.68
"Sponge unidentified"	0.01	0.11		0.01		0.00	0.09		1.07	1.75	0.01	0.08	0.12	1.82	0.58
"State-managed Rockfish"	0.61	12.18		3.65	0.53		1.24	0.45							
"Stichaeidae"	0.04	0.00		0.00	0.00			0.00	0.01	0.01	0.01	0.18			
"urchins dollars cucumbers"	0.00	0.04	0.20	0.14	0.09	0.24	0.12	0.01	0.97	1.30	0.41	0.29	0.05	0.66	1.30

Table 4.10. Percent (by weight) of catch for shallow-water flatfish that is retained for the Gulf of Alaska fisheries.

Year	shallow-water flatfish
1991	58.5
1992	69.1
1993	69.0
1994	72.6
1995	70.5
1996	86.1
1997	76.0
1998	83.0
1999	77.1
2000	88.7
2001	90.7
2002	91.2
2003	90.5
2004	87.0
2005	92.3
2006	93.7
2007	93.1
2008	87.9
2009	98.3
2010	95.0
2011	94.6
2012	94.4
2013	95.6
2014	90.7
2015	88.5
2016	93.8
2017	80.0

Table 4.11. Biomass estimates from the NMFS bottom-trawl surveys from 1984 to 2017. In 1984, 1987, 1999, 2007, to 2015 depths surveyed were to 1000 meters. In 1990, 1993 and 1996 depths were surveyed to 500 meters. In 2003 and 2005 the survey extended to 700 meters.

	1984	1987	1990	1993	1996	1999	2001	2003	2005	2007	2009	2011	2013	2015	2017
Rock sole total	137,472	123,221	156,032	173,361	206,343	166,603	190,297	207,265	239,218	263,919	287,611	193,448	206,027	177,303	163,032
Northern rock sole	-	-	-	-	78,845	61,081	64,240	79,998	91,525	102,303	95,846	72,875	74,586	52,069	55,047
Southern rock sole	-	-	-	-	127,390	105,522	126,057	127,267	147,693	161,617	191,765	120,573	131,441	125,234	107,985
Yellowfin sole	91,341	56,135	57,524	81,329	47,789	48,309	55,303	54,738	48,823	41,824	33,414	46,576	23,016	24,789	51,547
Butter sole	22,504	19,273	17,339	29,809	20,916	14,188	9,812	31,148	26,226	30,174	15,405	19,695	8,122	16,331	13,862
Starry flounder	14,293	14,141	10,218	40,288	27,309	46,652	76,418	58,530	26,586	73,039	33,264	39,757	30,028	23,446	28,013
English sole	3,202	7,243	7,597	8,403	7,946	14,432	14,166	17,832	14,595	12,287	18,671	16,720	18,121	17,498	12,789
Sand sole	1,216	82	129	479	940	234	357	1,359	2,379	3,168	2,808	755	703	301	2,020
Alaska plaice	1,912	4,830	5,977	2,583	4,870	8,680	3,639	5,078	7,939	12,179	7,788	12,266	8,044	5,448	13,784
Total	134,468	101,704	98,784	162,891	316,005	299,098	349,992	375,950	365,766	436,591	398,961	329,217	294,061	265,116	285,047

Table 4.12. CV of biomass estimates from the NMFS bottom-trawl surveys from 1984 to 2017.

	1984	1987	1990	1993	1996	1999	2001	2003	2005	2007	2009	2011	2013	2015	2017
Northern rock sole	N/A	N/A	N/A	N/A	0.13	0.25	0.14	0.12	0.11	0.12	0.17	0.17	0.18	0.15	0.15
Southern rock sole	N/A	N/A	N/A	N/A	0.10	0.10	0.11	0.10	0.10	0.07	0.12	0.09	0.11	0.08	0.09
Yellowfin sole	0.25	0.23	0.43	0.25	0.19	0.31	0.43	0.22	0.23	0.28	0.24	0.29	0.32	0.35	0.27
Butter sole	0.33	0.44	0.39	0.30	0.28	0.19	0.31	0.22	0.27	0.31	0.24	0.25	0.39	0.25	0.27
Starry flounder	0.32	0.27	0.42	0.33	0.54	0.25	0.63	0.28	0.28	0.28	0.22	0.28	0.41	0.23	0.30
English sole	0.42	0.35	0.46	0.49	0.28	0.29	0.53	0.29	0.31	0.30	0.26	0.26	0.41	0.26	0.28
Sand sole	0.72	0.98	0.79	0.46	0.59	0.45	0.85	0.64	0.41	0.41	0.77	0.46	0.68	0.73	0.54
Alaska plaice	0.27	0.25	0.35	0.33	0.22	0.33	0.24	0.19	0.23	0.41	0.23	0.37	0.29	0.37	0.32

Table 4.13a. Percent shallow water flatfish biomass by area estimated from random effects model fit to combined species (including rock sole).

Survey Year	Western	Central	Yakutat	Southeast
Survey 2017	47.32	45.05	4.11	3.52
Survey 2015	46.7	43.3	7.3	2.7
Survey 2013	49.9	43.7	5.0	1.4
average Survey 2013-2017	47.97	44.02	5.47	2.54
Random Effects model 2015 assessment percentage	47.00	43.37	7.16	2.47
Random effects Model 2017 Biomass estimates	130,042	130,592	11,570	9,932
Random Effects model 2017 percentage	46.09	46.29	4.10	3.52
λ	-2.6010	-2.3130	-0.8549	-0.9423
s.e. λ	0.3660	0.3166	0.3163	0.2822
σ_p^2	0.0055	0.0098	0.1809	0.1519

Table 4.13b. 2017 biomass and parameter estimates by species estimated using the random effects model. Percent biomass by species was used to adjust 2017 biomass so that the sum of species is equal to the random effects model estimated 2017 biomass fit to all species combined (excluding rock sole).

	Random effects biomass 2017	Percent	Adjusted 2017 biomass	λ	s.e. λ	σ_p^2
butter	15,111	14.9	16,368	-2.2427	0.6830	0.0113
english	14,965	14.8	16,210	-2.0842	0.4060	0.0155
plaice	10,054	9.9	10,890	-1.8016	0.5043	0.0272
sand	1,395	1.4	1,511	-0.6365	0.3445	0.2800
starry	27,210	26.9	29,474	-1.6748	0.3901	0.0351
yellowfin	32,574	32.2	35,284	-2.4638	0.4959	0.0072
Sum from species fits	101,310					
Random effects 2017 biomass from fit to sum of species			109,738	-2.7013	0.6217	0.0045

Table 4.14a. Biomass estimates (t) for Gulf of Alaska flatfish, based on the 2017 bottom trawl survey, by North Pacific Fishery Management Council regulatory area and species.

Species	Western	Area Central	Yakutat	Southeast	Total
Shallow-water flatfish					
Rock sole total	69,308	85,562	567	7,596	163,032
Northern rock sole	28,820	26,227	0	0	55,047
Southern rock sole	40,487	59,335	567	7,596	107,985
Yellowfin sole	39,554	11,993	0	0	51,547
Butter sole	2,119	8,478	3,266	0	13,862
Starry flounder	10,196	14,151	3,665	0	28,013
English sole	2,439	3,716	2,511	4,123	12,789
Sand sole	23	1,980	17	0	2,020
Alaska plaice	4,785	8,998	0	0	13,784

Table 4.14b. Biomass estimates (t) for Gulf of Alaska flatfish, based on the 2015 bottom trawl survey, by North Pacific Fishery Management Council regulatory area and species.

Species	Western	Area Central	Yakutat	Southeast	Total
Shallow-water flatfish					
Rock sole total	90,405	81,957	89	4,851	177,303
Northern rock sole	26,958	25,108	0	4	52,069
Southern rock sole	63,448	56,850	89	4,847	125,234
Yellowfin sole	16,238	8,552	0	0	24,789
Butter sole	5,202	7,866	3,263	0	16,331
Starry flounder	6,777	11,123	5,546	0	23,446
English sole	505	4,236	10,467	2,290	17,498
Sand sole	0	283	18	0	301
Alaska plaice	4,692	756	0	0	5,448

Table 4.14c. Biomass estimates (t) for Gulf of Alaska flatfish, based on the 2013 bottom trawl survey, by North Pacific Fishery Management Council regulatory area and species.

Species	Western	Area Central	Yakutat	Southeast	Total
Shallow-water flatfish					
Rock sole total	105,548	95,898	885	3,697	206,027
Northern rock sole	47,447	27,139	0	0	74,586
Southern rock sole	58,101	68,759	885	3,697	131,441
Yellowfin sole	15,405	7,612	0	0	23,016
Butter sole	880	5,524	1,717	0	8,122
Starry flounder	18,049	11,617	362	0	30,028
English sole	1,666	4,263	11,734	459	18,121
Sand sole	0	703	0	0	703
Alaska plaice	5,297	2,747	0	0	8,044

Table 4.14d. Biomass estimates (t) for Gulf of Alaska flatfish, based on the 2011 bottom trawl survey, by North Pacific Fishery Management Council regulatory area and species.

Species	Western	Area Central	Yakutat	Southeast	Total
Shallow-water flatfish					
Rock sole total	96,382	89,873	808	6,386	193,448
Northern rock sole	45,063	27,717	0	96	72,875
Southern rock sole	51,319	62,156	808	6,290	120,573
Yellowfin sole	26,057	20,139	0	380	46,576
Butter sole	6,687	7,541	5,462	4	19,695
Starry flounder	5,670	14,774	19,218	96	39,757
English sole	961	5,932	8,145	1,682	16,720
Sand sole	33	722	0	0	755
Alaska plaice	5,271	6,995	0	0	12,266

Table 4.14e. Biomass estimates (t) for Gulf of Alaska flatfish, based on the 2009 bottom trawl survey, by North Pacific Fishery Management Council regulatory area and species.

	Area				
Species	Western	Central	Yakutat	Southeast	Total
Shallow-water flatfish					
Rock sole total	138,906	144,282	384	4,038	287,611
Northern rock sole	56,186	39,635	0	25	95,846
Southern rock sole	82,720	104,647	384	4,013	191,765
Yellowfin sole	11,695	21,627	29	62	33,414
Butter sole	902	12,964	1,539	0	15,405
Starry flounder	10,154	19,960	2,717	433	33,264
English sole	903	8,797	4,042	4,928	18,671
Sand sole	36	2,772	0	0	2,808
Alaska plaice	5,387	2,401	0	0	7,788

Table 4.14f. Biomass estimates (t) for Gulf of Alaska flatfish, based on the 2007 bottom trawl survey, by North Pacific Fishery Management Council regulatory area and species.

	Area			
Species	Western	Central	Eastern	Total
Shallow-water flatfish				
Rock sole total	143,768	111,328	8,823	263,919
Northern rock sole	65,563	36,739	0	102,303
Southern rock sole	78,205	74,589	8,823	161,617
Yellowfin sole	21,437	20,387	0	41,824
Butter sole	7,068	21,097	2,010	30,174
Starry flounder	12,043	44,585	16,411	73,039
English sole	620	5,042	6,624	12,287
Sand sole	348	2,643	177	3,168
Alaska plaice	3,415	8,764	0	12,179

Table 4.14g. Biomass estimates (t) for Gulf of Alaska flatfish, based on the 2005 bottom trawl survey, by North Pacific Fishery Management Council regulatory area and species.

	Area			
Species	Western	Central	Eastern	Total
Shallow-water flatfish				
Rock sole total	122,628	107,495	9,095	239,218
Northern rock sole	58,648	32,877	0	91,525
Southern rock sole	63,980	74,618	9,095	147,693
Yellowfin sole	23,405	25,418	0	48,823
Butter sole	5,952	20,242	31	26,226
Starry flounder	16,122	10,106	358	26,586
English sole	825	4,396	9,374	14,595
Sand sole	61	2,318	0	2,379
Alaska plaice	2,480	5,459	0	7,939

Table 4.14h. Biomass estimates (t) for Gulf of Alaska flatfish, based on the 2003 bottom trawl survey, by North Pacific Fishery Management Council regulatory area and species.

Species	Area Western	Central	Eastern	Total
Shallow-water flatfish				
Rock sole total				
Northern rock sole	43,127	36,871	0	79,998
Southern rock sole	55,116	65,251	6,900	127,267
Yellowfin sole	42,178	12,560	0	54,738
Butter sole	3,370	25,123	2,655	31,148
Starry flounder	5,355	49,793	3,382	58,530
English sole	334	5,363	12,135	17,832
Sand sole	0	1,331	28	1,359
Alaska plaice	2925.8	2152.2	0	5078

Table 4.14i. Biomass estimates (t) for Gulf of Alaska flatfish, based on the 2001 bottom trawl survey, by North Pacific Fishery Management Council regulatory area and species.

Species	Area Western	Central	Eastern	Total
Shallow-water flatfish				
Rock sole total	96,178	89,264	6,644	192,086
Northern rock sole	36,987	27,237	16	64,240
Southern rock sole	59,191	62,027	6,628	127,846
Yellowfin sole	49,586	5,612	43	55,241
Butter sole	3,338	5,578	1,965	10,881
Starry flounder	14,291	57,469	5,322	77,082
English sole	89	3,274	11,469	14,832
Sand sole	43	232	42	317
Alaska plaice	2,116	1,523	0	3,639

Table 4.14j. Survey biomass in the Eastern Gulf of Alaska for 1993, 1996, 1999 and 2003. The biomass estimated for the Eastern Gulf in 2001 is the average of the 1999 and 2003 eastern gulf biomass.

Species	1993	1996	1999	2003	Average 1999 and 2003
Shallow-water flatfish					
Northern rock sole		0	31	0	16
Southern rock sole		3,323	6,355	6,900	6,628
Yellowfin sole	0	229	85	0	43
Butter sole	2,906	104	1,274	2,655	1,965
Starry flounder	5,193	1,518	7,262	3,382	5,322
English sole	5,341	5,713	10,803	12,135	11,469
Sand sole	8	183	56	28	42
Alaska plaice	0	0	0	0	0

Table 4.14k. Biomass estimates (t) for Gulf of Alaska flatfish, based on the 1999 bottom trawl survey, by North Pacific Fishery Management Council regulatory area and species.

	Area			
Species	Western	Central	Eastern	Total
Shallow-water flatfish				
Rock sole total	89,487	70,730	6386	166,603
Northern rock sole	44,731	16,319	31	61,081
Southern rock sole	44,756	54,411	6,355	105,522
Yellowfin sole	36,368	11,856	85	48,309
Butter sole	4,985	7,929	1,274	14,188
Starry flounder	10,627	28,763	7,262	46,652
English sole	563	3,066	10,803	14,432
Sand sole	61	117	56	234
Alaska plaice	5,647	3,033	0	8,680

Table 4.14l. Biomass estimates (t) for Gulf of Alaska flatfish, based on the 1996 bottom trawl survey, by North Pacific Fishery Management Council regulatory area and species.

	Area			
Species	Western	Central	Eastern	Total
Shallow-water flatfish				
Rock sole total	110,303	92,718	3,323	206,343
Northern rock sole	62,883	15,962	0	78,845
Southern rock sole	47,420	76,647	3,323	127,390
Yellowfin sole	29,857	17,704	229	47,789
Butter sole	6,265	14,547	104	20,916
Starry flounder	16,181	9,610	1,518	27,309
English sole	297	1,936	5,713	7,946
Sand sole	0	757	183	940
Alaska plaice	2,295	2,575	0	4,870

Table 4.14m. Biomass estimates (t) for Gulf of Alaska flatfish, based on the 1993 bottom trawl survey, by North Pacific Fishery Management Council regulatory area and species.

	Area			
Species	Western	Central	Eastern	Total
Shallow-water flatfish				
Rock sole total	88,644	83,163	1,554	173,361
Yellowfin sole	70,669	10,660	0	81,329
Butter sole	3,626	23,277	2,906	29,809
Starry flounder	3,778	31,318	5,193	40,288
English sole	1,189	1,874	5,341	8,403
Sand sole	81	390	8	479
Alaska plaice	1,667	917	0	2,583

Table 4.15. Von Bertalanffy parameter estimates for Yellowfin sole in the Gulf of Alaska.

Species	Linf	K	t0
Yellowfin sole 1987 survey			
males	32.8	0.19	-2.24
females	38.2	0.14	-2.18
combined	34	0.18	-1.82

Table 4.16. Food habits of flatfish. Percent observed stomach contents in parentheses where available (Livingston and Goiney, 1983).

Fish species	Observed stomach contents
Rex sole	Polychaetes, euphausiids, pandalus sp.
Flathead sole	various fishes(38%), mysids(36%), shrimp(15%), clams(6%), polychaetes(3%)
rock sole-adults	fish(40%) polychaetes(27%), clam siphons(10%)
rock sole-juveniles	fish(10%), polychaetes(45%), clam siphons(15%), gammarids(8%)
yellowfin sole	Polychaetes, shrimp, fish, tanner crab, clam siphons
Dover sole	Polychaetes(64%),crustaceans(11%),mollusks(18%), echinoderms(3%), coelenterates(3%)
English sole	Polychaetes, ophiuroidea, ophiura sarsi, amphipoda, bivalves
sand sole	fish with a high frequency of arrowtooth flounder(only 4 stomachs out of 10 with food)
starry flounder	Echiuroidea(starfish), ophiuroidea(brittle star), fish, shrimp, crabs
butter sole	Polychaetes, ophiuroidea, crustacea, shrimp, tanner crab, fish

Table 4.17. Calculations of the 2018 and 2019 shallow-water flatfish ABC and OFL levels by species including values for Tier 3a for northern and southern rock sole (See Bryan, et al. 2017). Species splits were estimated using the random effects model.

Species						As *specified last* year for:				As *recommended this* year for:			
						2017		2018		2018		2019	
Shallow-water flatfish	Tier	FABC	FOFL	2018 Biomass[1]	2019 Biomass[1]	ABC	OFL	ABC	OFL	ABC	OFL	ABC	OFL
Northern rock sole	3a	0.242	0.287	90,794	93,374	12,283	14,548	12,788	15,146	16,802	19,960	17,243	20,477
Southern rock sole	3a	0.271	0.326	138,620	139,907	18,865	22,215	18,618	21,927	21,424	25,333	21,717	25,689
Yellowfin sole	5	0.15	0.2	35,284	35,284	4,150	5,533	4,150	5,533	5,293	7,057	5,293	7,057
Butter sole	5	0.15	0.2	16,368	16,368	2,133	2,844	2,133	2,844	2,455	3,274	2,455	3,274
Starry flounder	5	0.15	0.2	29,474	29,474	3,597	4,796	3,597	4,796	4,421	5,895	4,421	5,895
English sole	5	0.15	0.2	16,210	16,210	2,438	3,251	2,438	3,251	2,432	3,242	2,432	3,242
Sand sole	5	0.15	0.2	1,511	1,511	96	129	96	129	227	302	227	302
Alaska plaice	5	0.15	0.2	10,890	10,890	950	1,267	950	1,267	1,634	2,178	1,634	2,178
Total2				339,152	343,018	44,514	54,583	44,770	54,893	54,688	67,240	55,422	68,114

[1] 2017 estimate from random effects model fit to survey biomass estimates except northern and southern rock sole age 0+ 2017 model estimates from Bryan, et al., 2017.

[2] Sum of columns may not equal Totals due to rounding.

Table 4.18. Catch of shallow-water flatfish by species from 1991 to October 1, 2017 from AKFIN data.

	Unid. Flatfish[1]	Rock sole	Yellowfin sole	Butter sole	Starry flounder	English sole	Sand sole	Alaska plaice
1991	5,224.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	8,333.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	1,165.9	7,538.7	69.6	250.5	80.1	6.4	0.5	1.5
1994	463.8	3,008.1	61.3	229.4	52.3	8.1	15.0	4.8
1995	1,076.1	3,923.9	65.6	177.0	134.7	16.6	10.3	26.1
1996	1,381.4	6,595.3	78.5	409.6	806.1	29.5	6.4	65.6
1997	1,282.8	5,466.8	42.0	451.6	401.9	22.4	42.9	69.2
1998	600.0	2,532.3	15.4	177.6	152.3	10.8	0.8	9.8
1999	543.8	1,765.4	25.8	147.8	86.5	6.9	1.3	0.9
2000	516.9	5,386.7	18.2	716.2	267.8	13.2	5.9	3.8
2001	685.2	4,771.7	0.0	598.9	86.5	5.9	12.8	1.9
2002	692.6	5,564.3	2.5	780.8	109.8	12.7	13.5	1.1
2003	325.0	3,554.6	0.2	607.9	139.2	2.3	3.3	16.0
2004	197.2	2,216.7	7.6	539.4	114.4	6.4	3.9	8.5
2005	167.1	4,130.5	10.4	378.5	111.0	2.0	2.8	2.8
2006	474.0	5,763.3	0.6	1,084.0	265.3	58.4	5.1	0.9
2007	333.1	6,727.4	11.5	1,431.4	154.1	25.5	3.2	6.1
2008	869.5	7,269.1	1.1	1,419.1	130.3	25.7	3.3	2.6
2009	94.3	6,538.7	1.1	1,698.1	115.1	27.6	2.4	8.2
2010	231.5	3,285.3	0.4	1,835.5	124.1	35.2	0.8	21.0
2011	173.2	3,094.4	0.1	591.3	99.7	28.7	0.7	10.0
2012	189.7	2,828.6	0.1	796.8	166.4	28.5	0.8	4.7
2013	203.4	4,058.3	0.2	1,076.1	119.1	51.9	1.8	12.3
2014	345.7	3,440.3	0.5	826.7	73.6	57.2	2.1	4.1
2015	337.2	2,622.2	1.3	284.2	77.4	32.4	2.1	1.4
2016	198.5	3,008.5	0.2	500.1	62.1	34.7	0.3	2.7
2017	428.1	1,689.1	0.3	139.4	67.6	41.2	0.1	3.2

[1] Unidentified flatfish were assigned based on the difference between the total shallow water flatfish catch and the sum of the species catch.

Figures

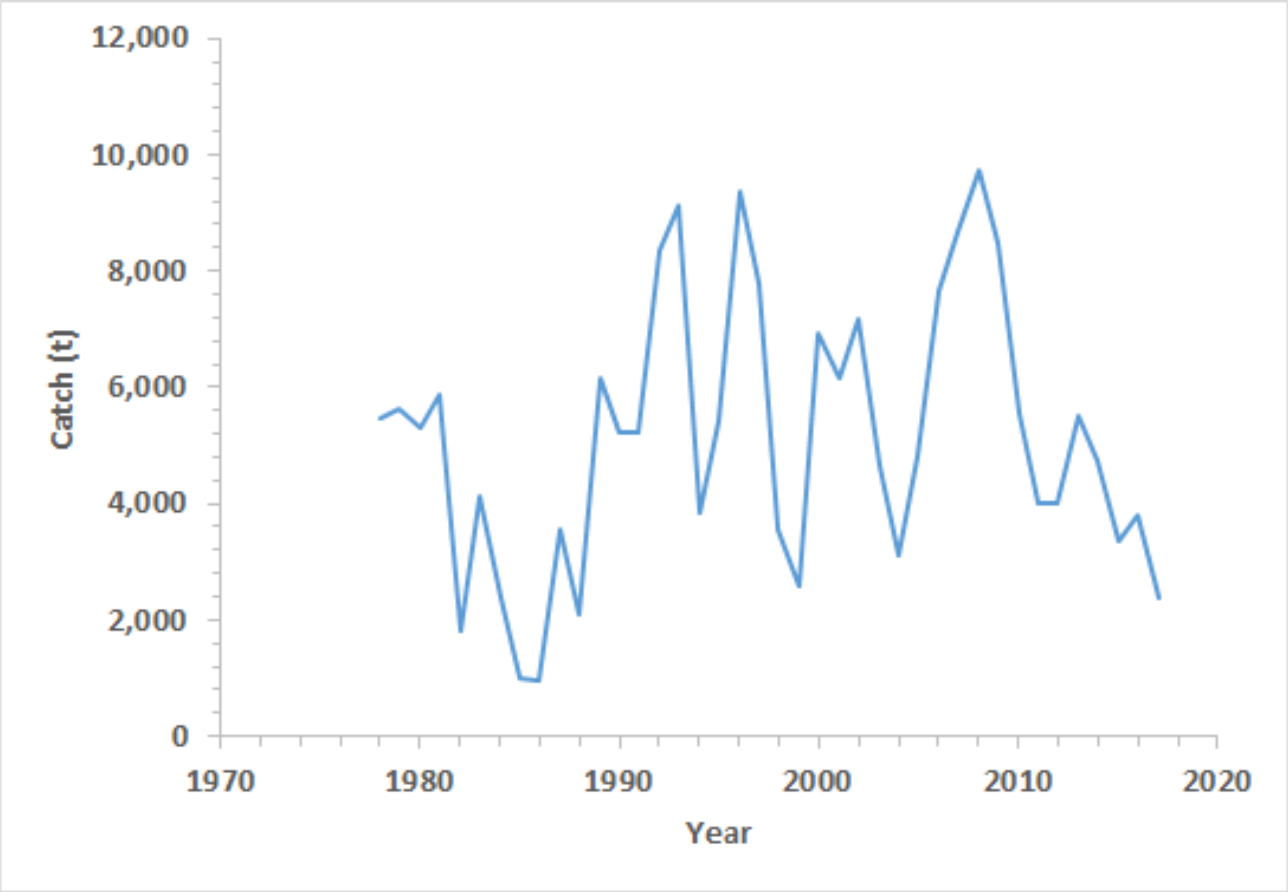

Figure 4.1. Catch (t) of shallow-water flatfish from 1978 to October 1, 2017.

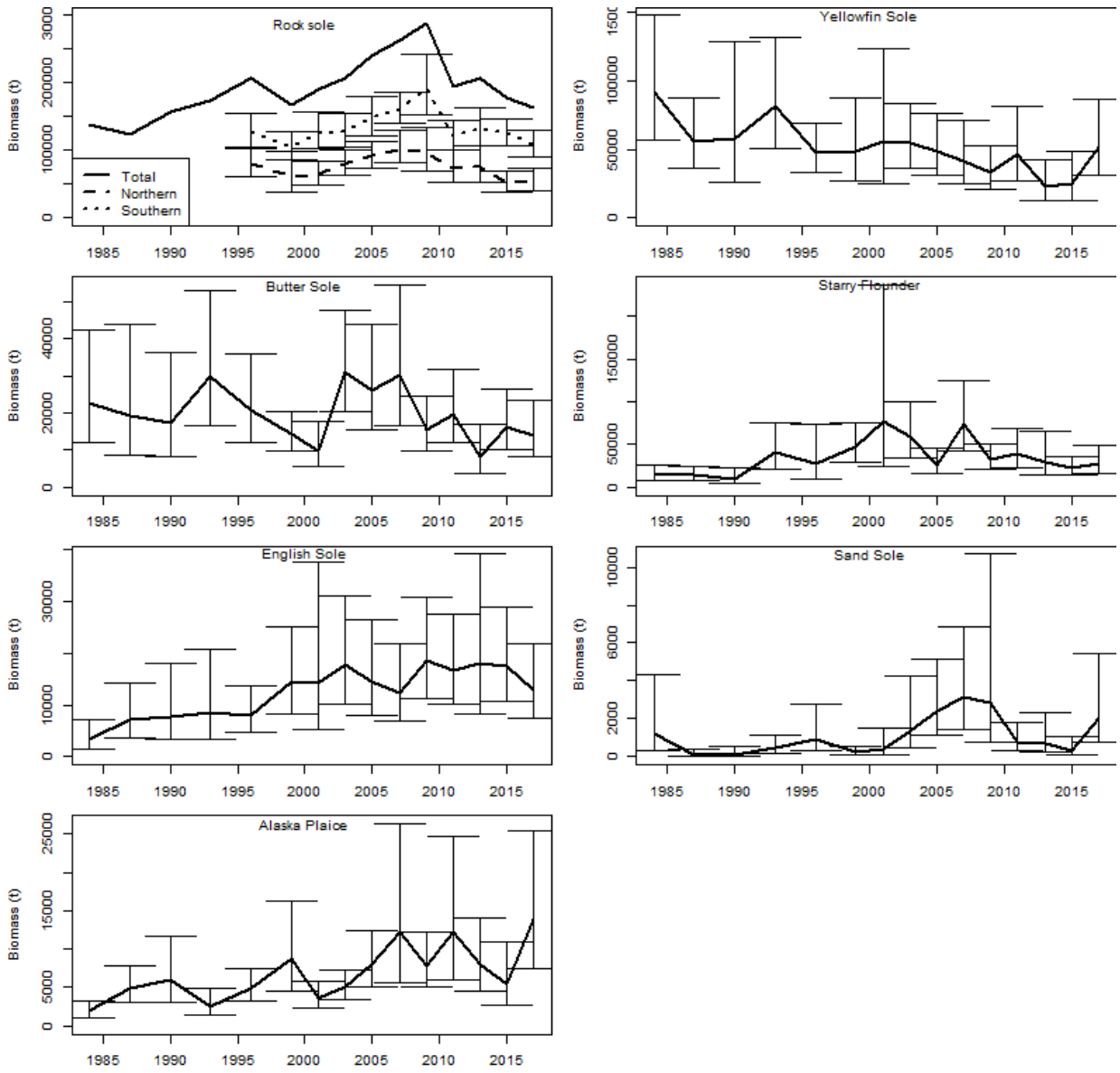

Figure 4.2. NMFS survey biomass estimates by shallow water flatfish species for 1984 to 2017.

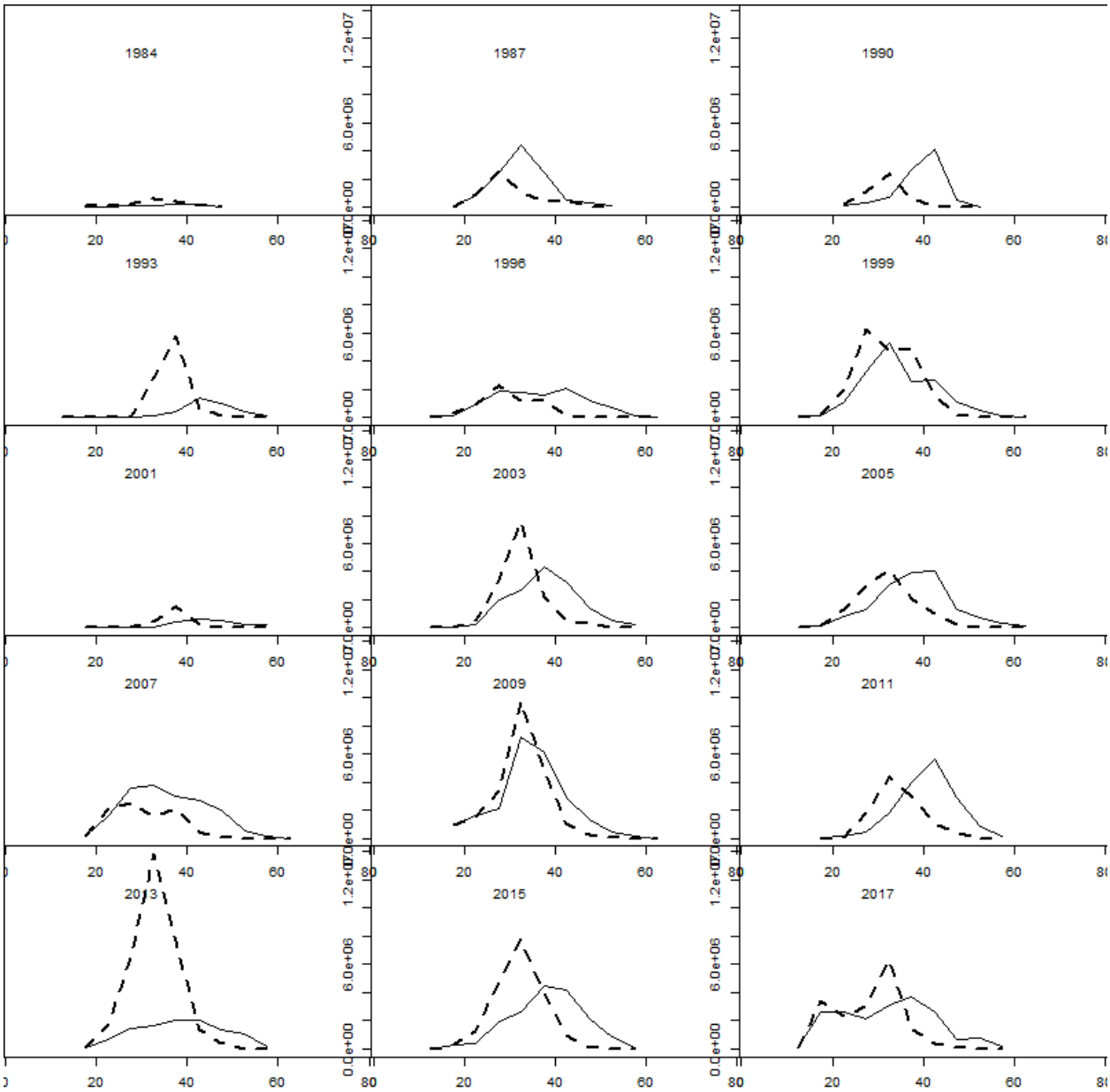

Figure 4.3. Population size composition (females solid line, males dashed line) of English sole as estimated from the NMFS bottom trawl surveys, 1984-2017.

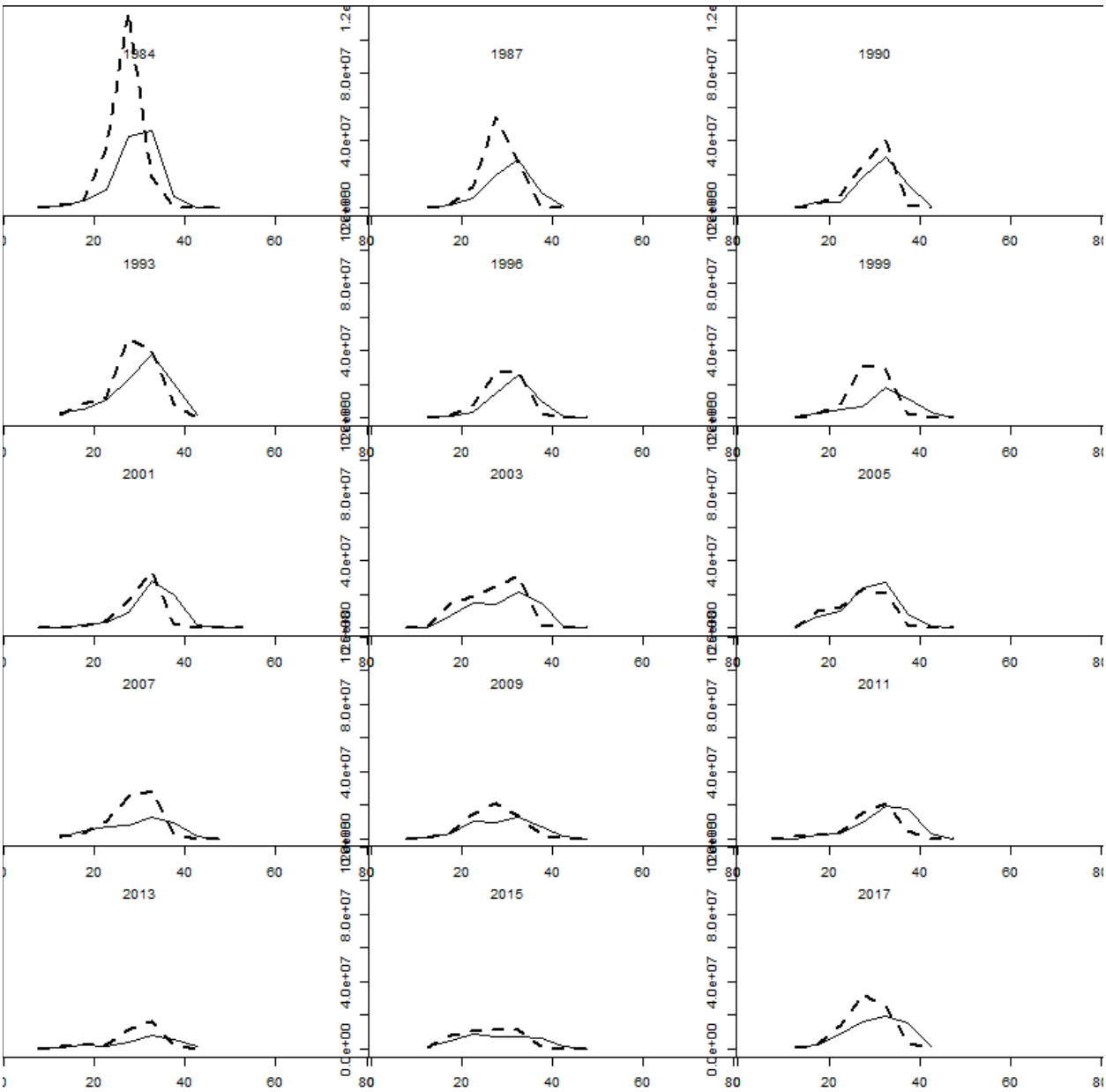

Figure 4.4. Population size composition (females solid line, males dashed line) of yellowfin sole as estimated from the NMFS bottom trawl surveys, 1984-2017.

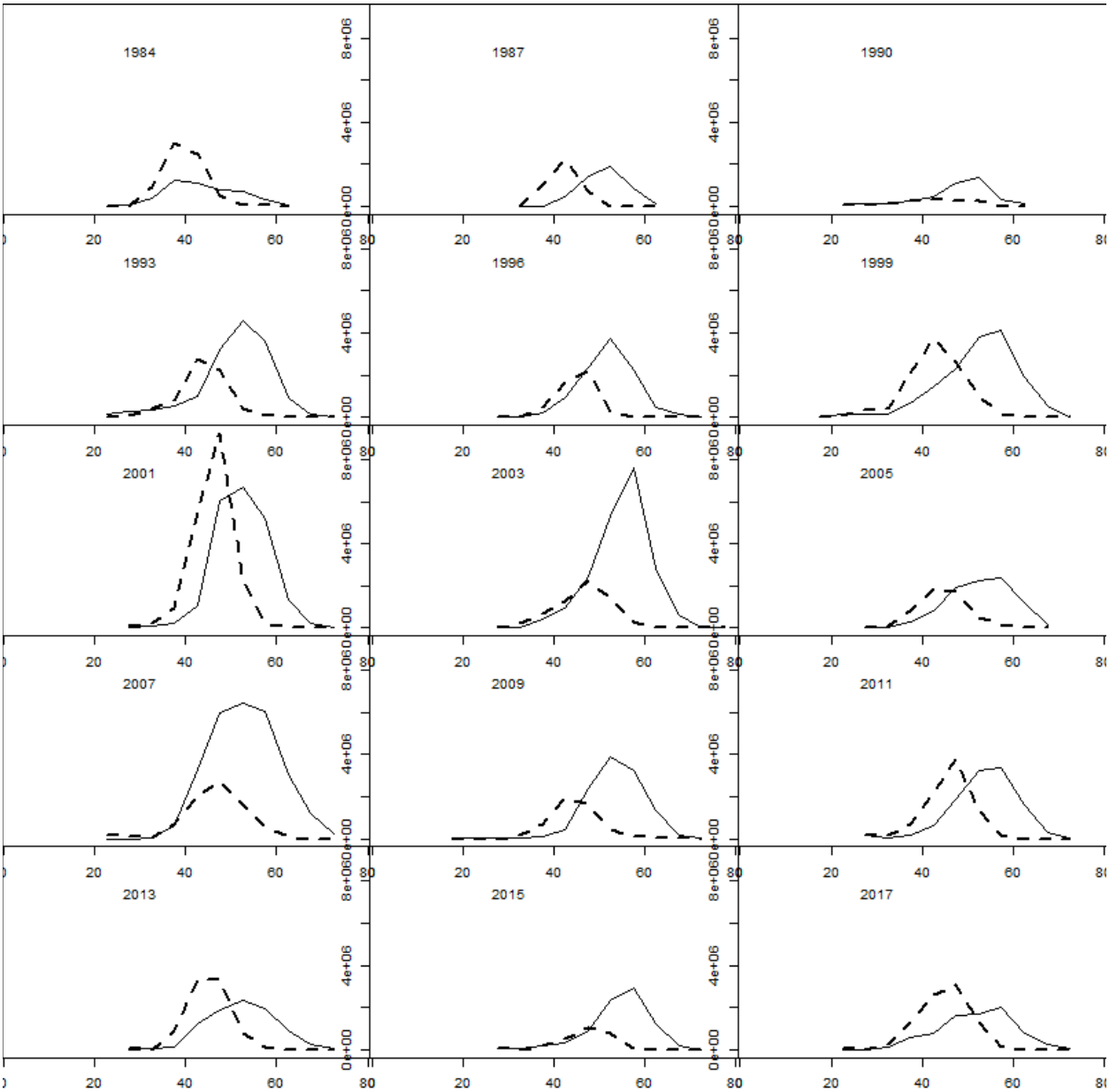

Figure 4.5. Population size composition (females solid line, males dashed line) of starry flounder as estimated from the NMFS bottom trawl surveys, 1984-2017.

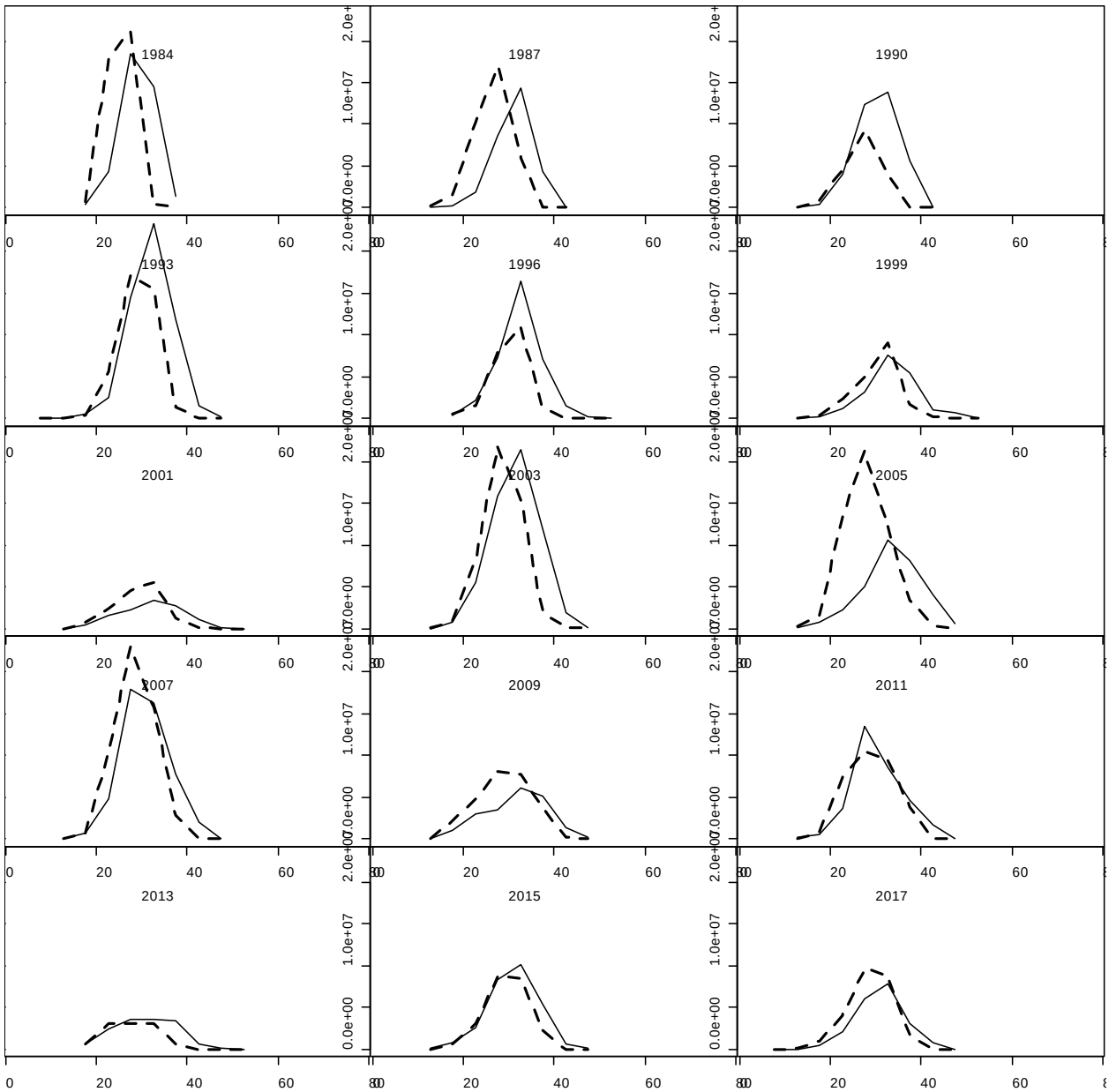

Figure 4.6. Population size composition (females solid line, males dashed line) of butter sole as estimated from the NMFS bottom trawl surveys, 1984-2017.

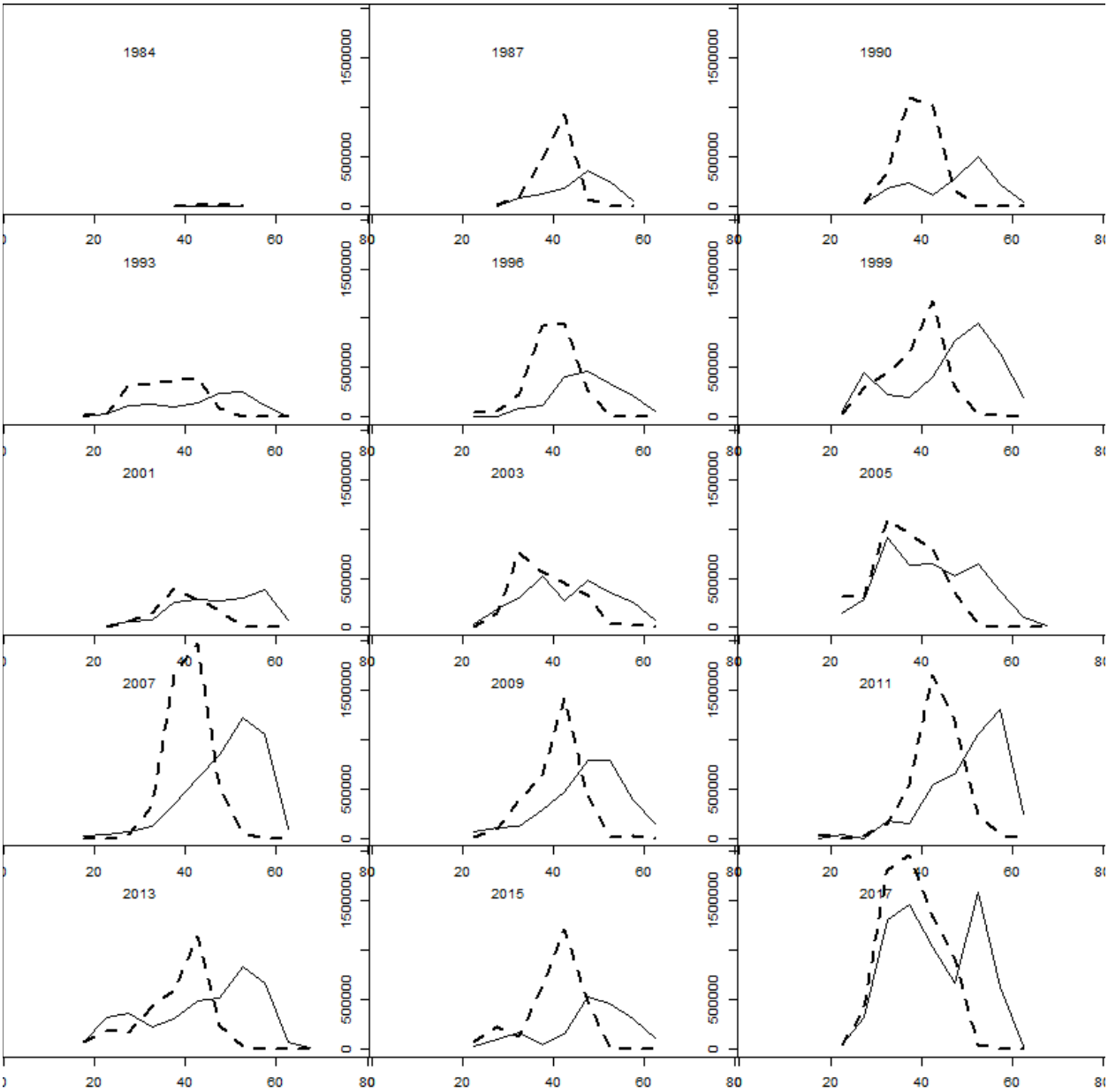

Figure 4.7. Population size composition (females solid line, males dashed line) of Alaska plaice as estimated from the NMFS bottom trawl surveys, 1984-2017.

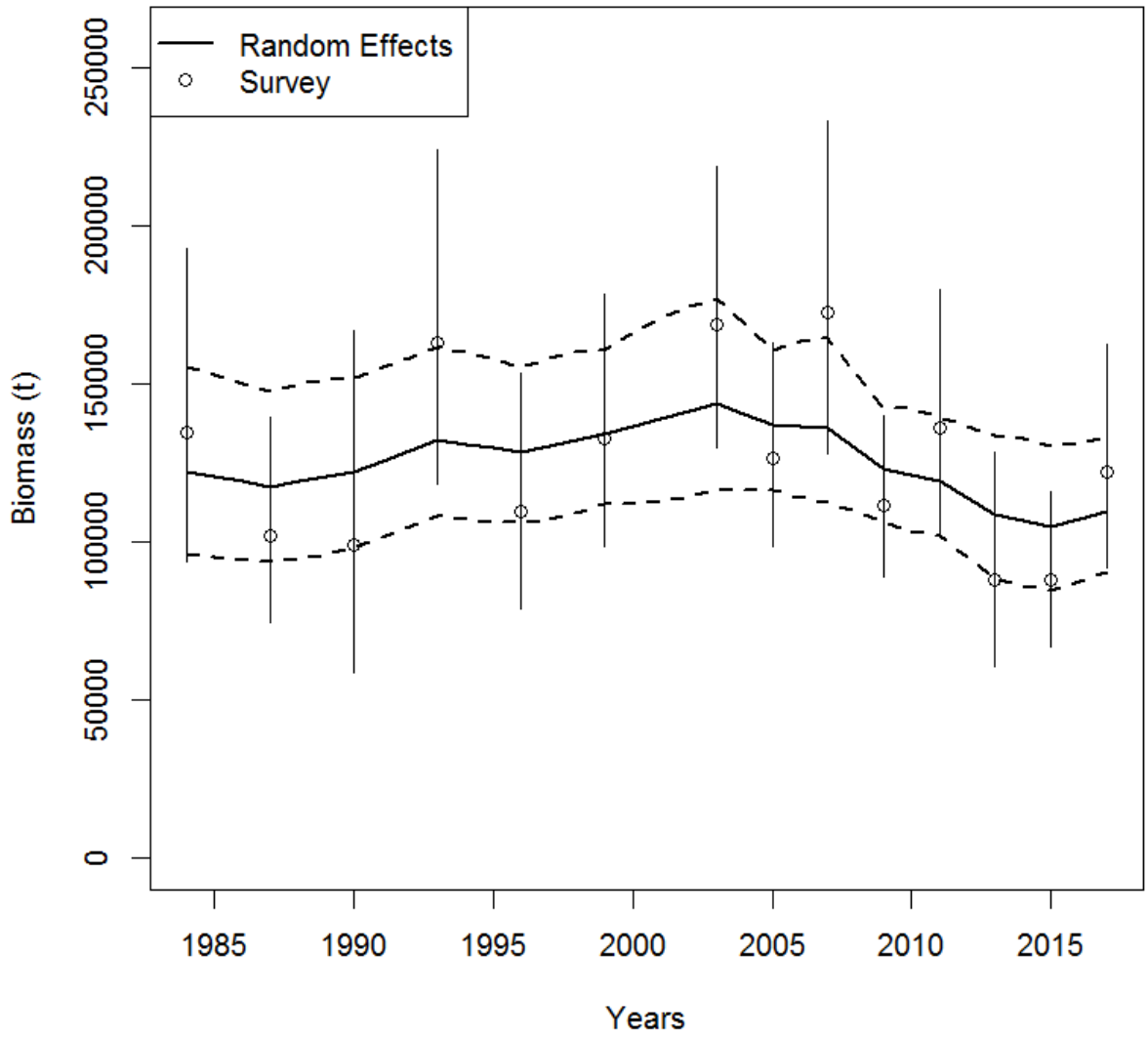

Figure 4.8. Fit of random effects model to shallow-water flatfish survey biomass 1984 to 2017 (excluding Rock sole). Dashed lines are 95% CI.

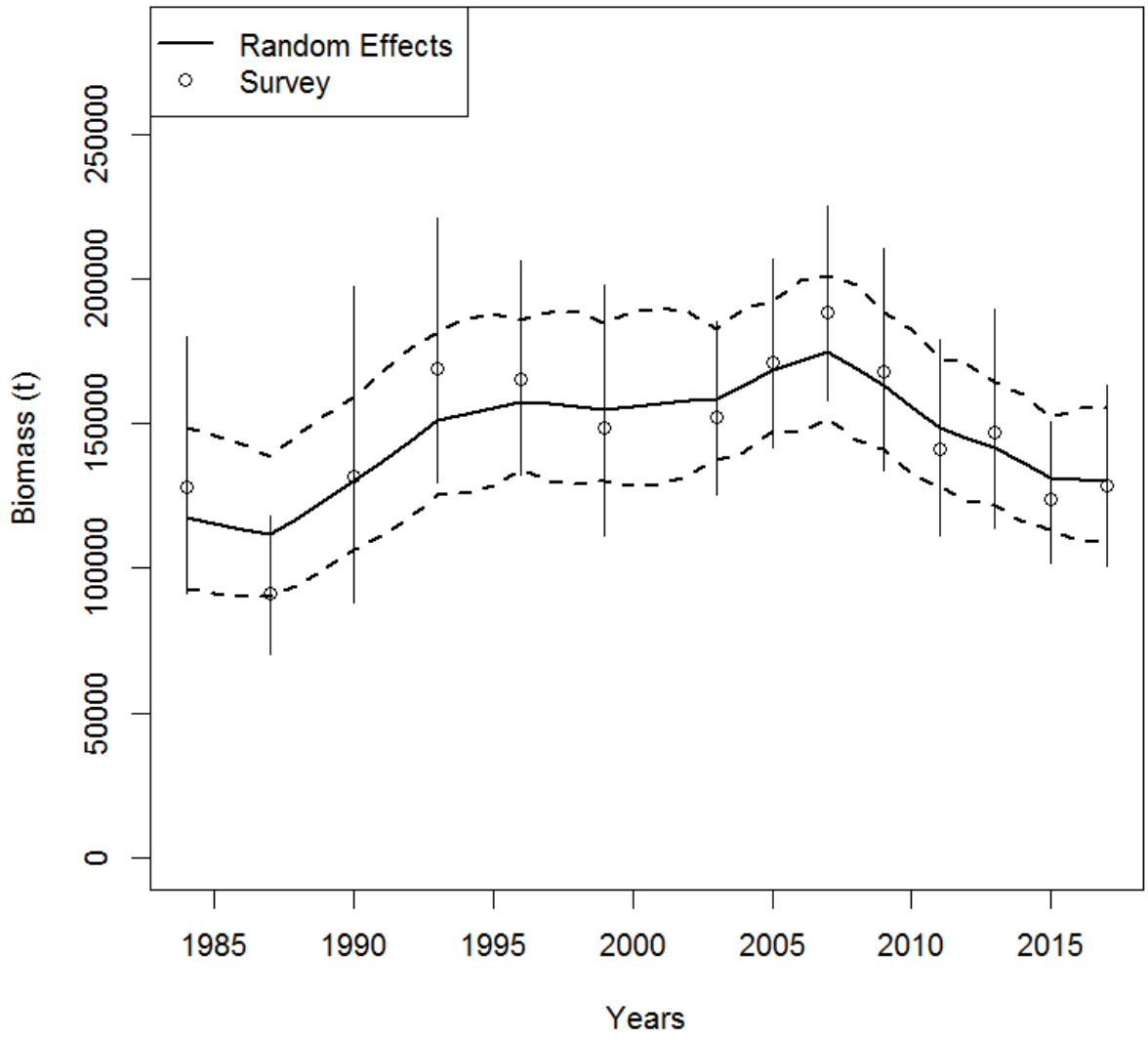

Figure 4.9. Fit of random effects model to Western area shallow-water flatfish survey biomass 1984 to 2017 (including Rock sole). Dashed lines are 95% CI.

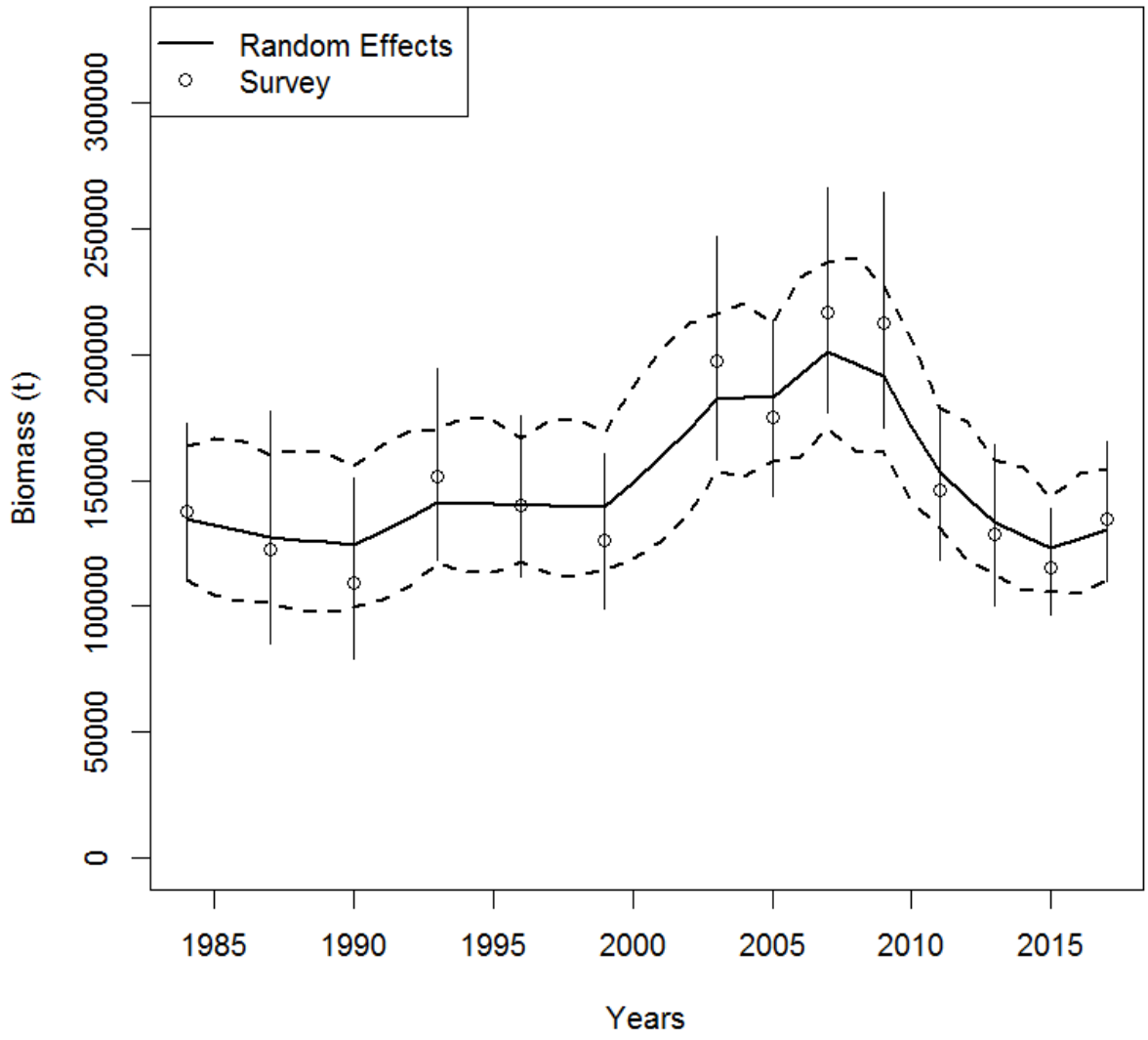

Figure 4.10. Fit of random effects model to Central area shallow-water flatfish survey biomass 1984 to 2017 (including Rock sole). Dashed lines are 95% CI.

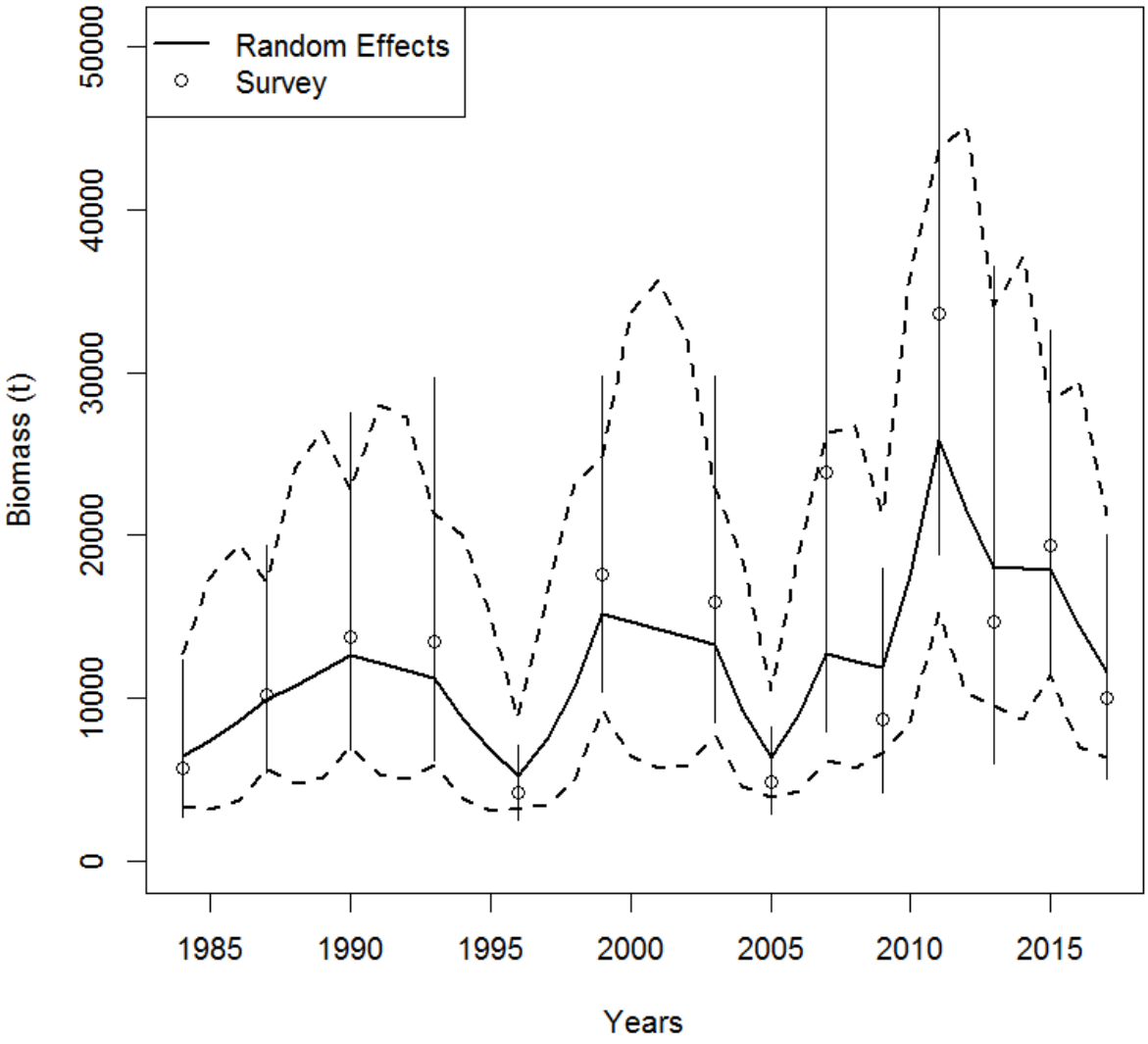

Figure 4.11. Fit of random effects model to Yakutat area shallow-water flatfish survey biomass 1984 to 2017 (including Rock sole). Dashed lines are 95% CI.

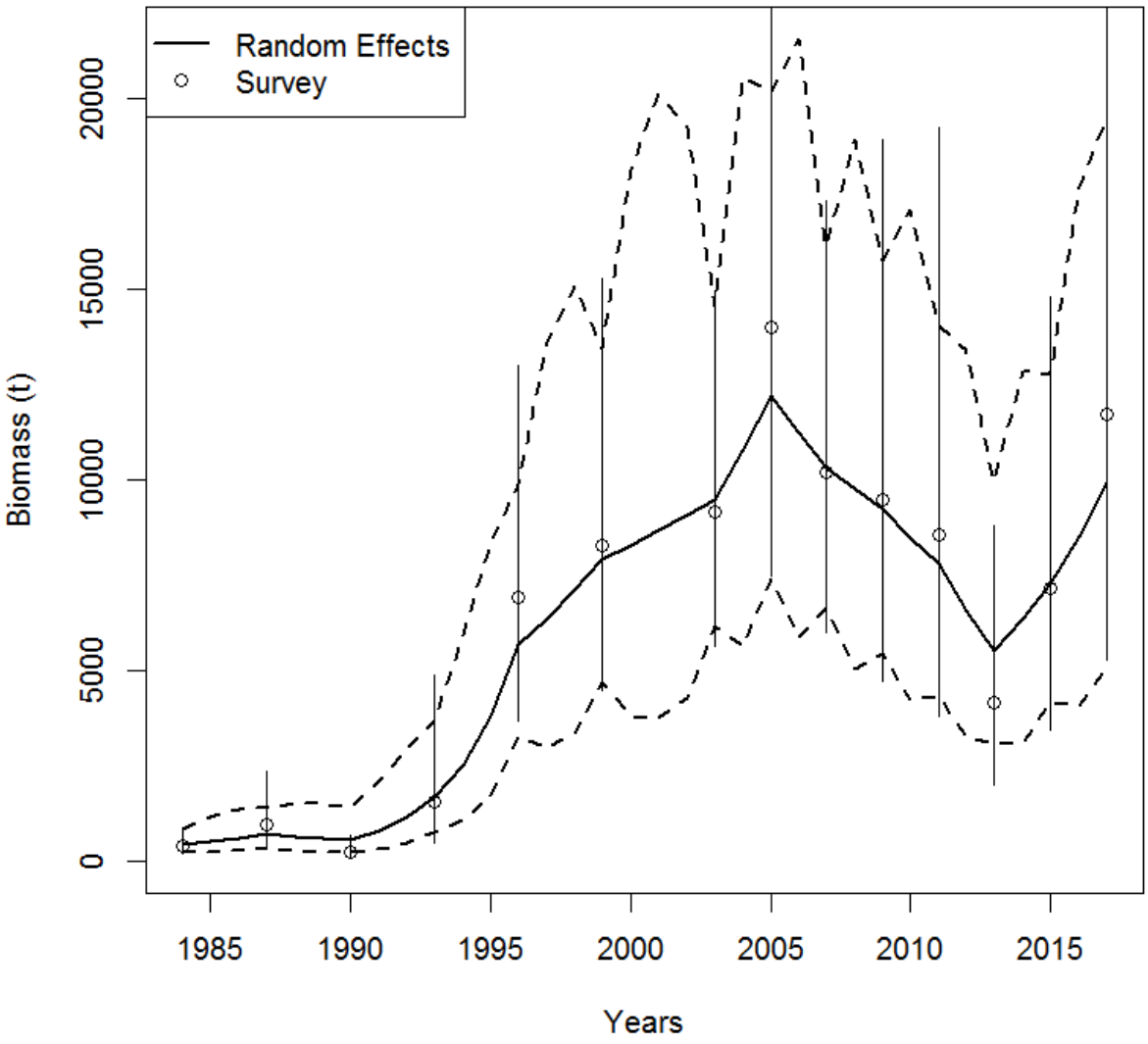

Figure 4.12. Fit of random effects model to Southeast area shallow-water flatfish survey biomass 1984 to 2017 (including Rock sole). Dashed lines are 95% CI.

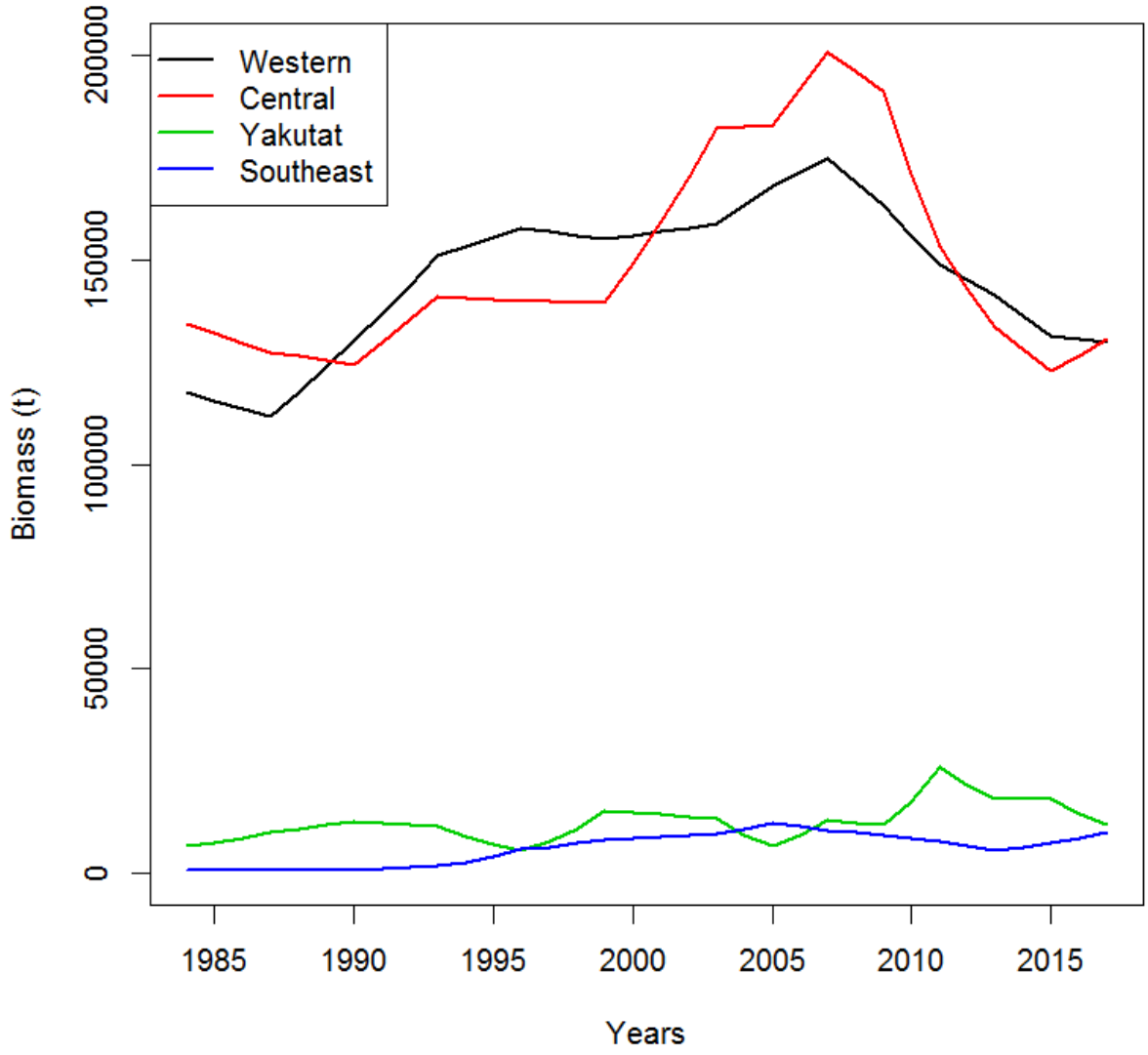

Figure 4.13. Random effects model estimates of biomass by area for shallow-water flatfish 1984 to 2017 (including Rock sole).

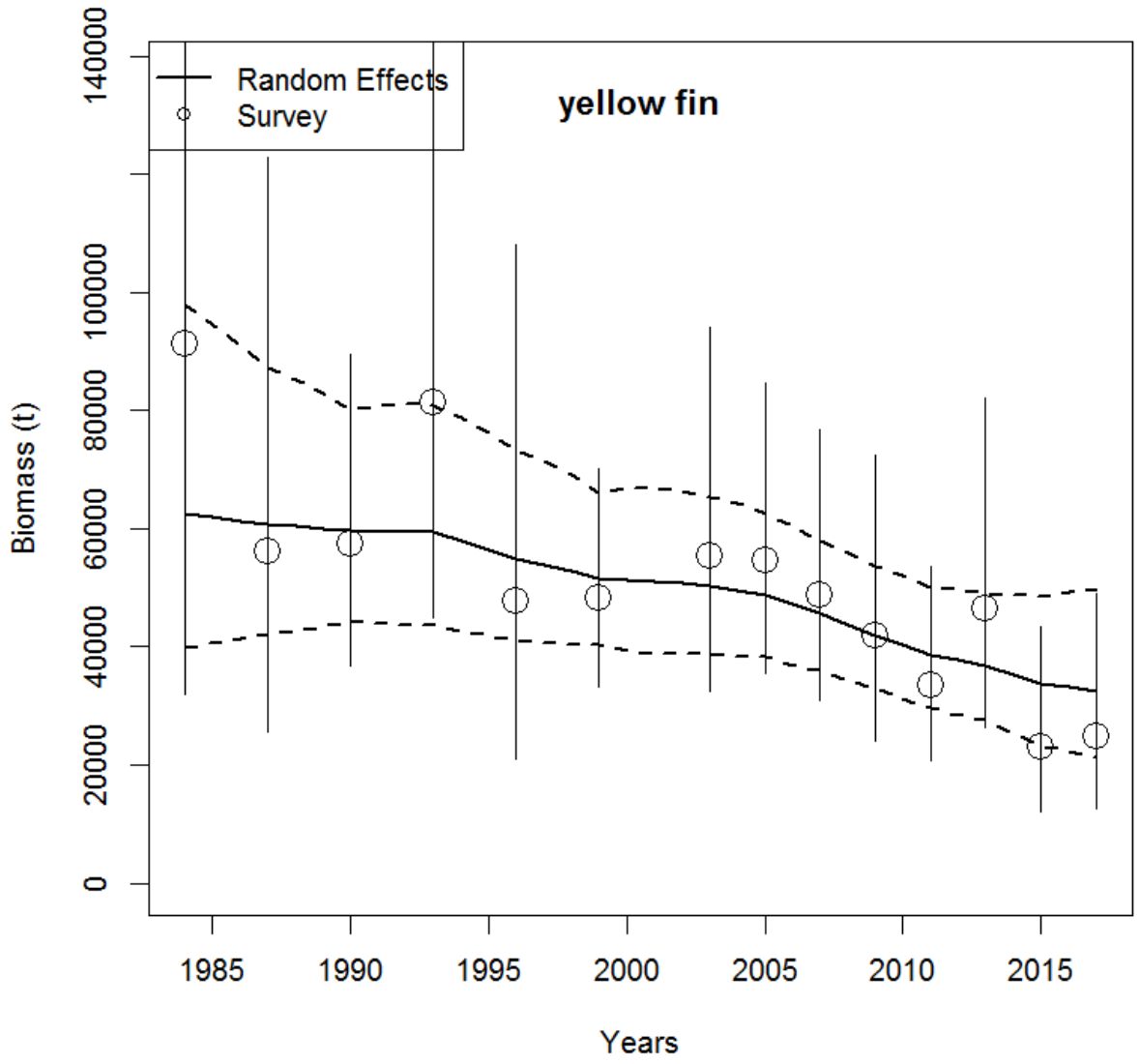

Figure 4.14. Fit of random effects model to yellowfin sole survey biomass 1984 to 2017. Dashed lines are 95% CI.

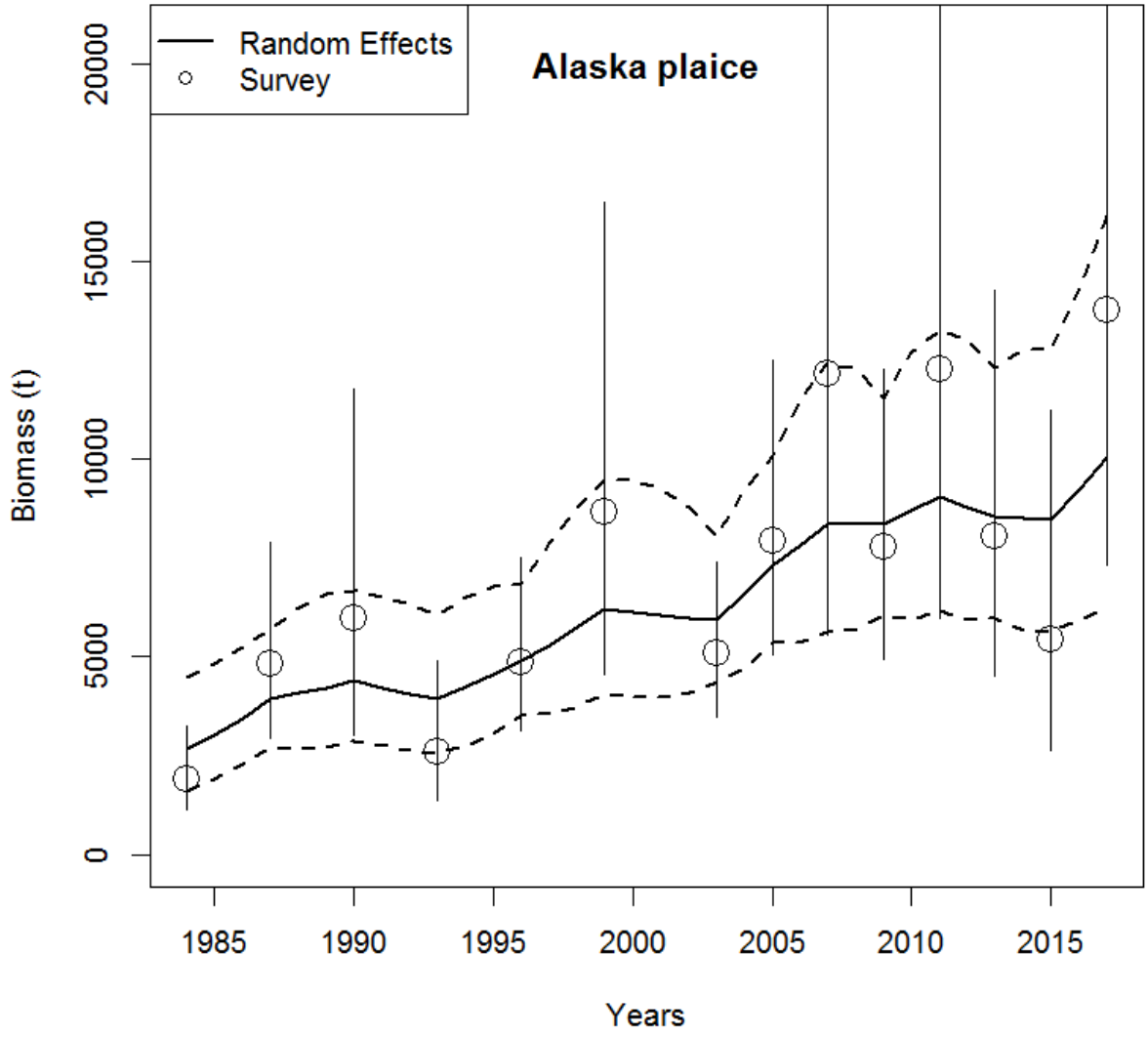

Figure 4.15. Fit of random effects model to Alaska plaice survey biomass 1984 to 2017. Dashed lines are 95% CI.

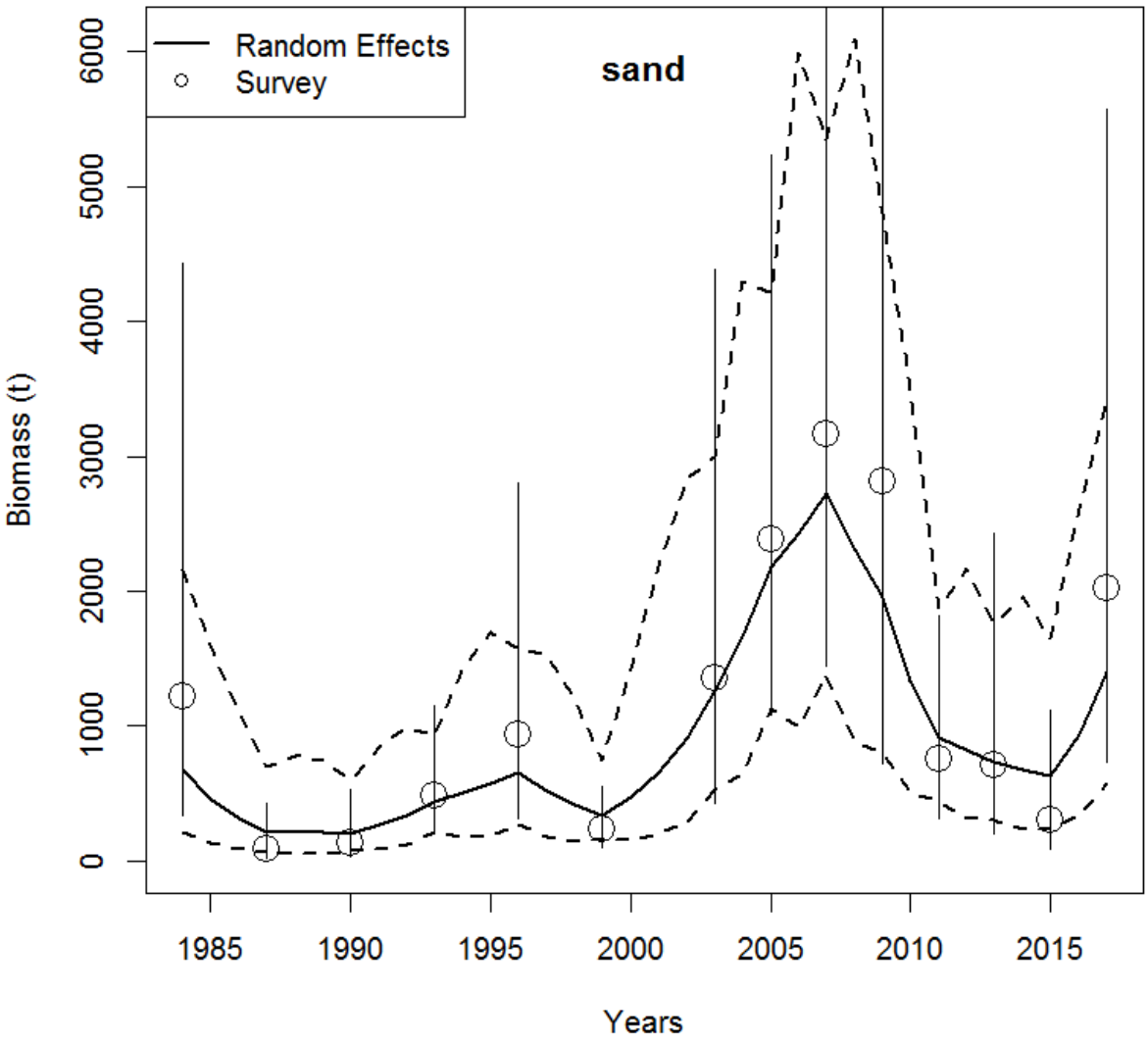

Figure 4.16. Fit of random effects model to sand sole survey biomass 1984 to 2017. Dashed lines are 95% CI.

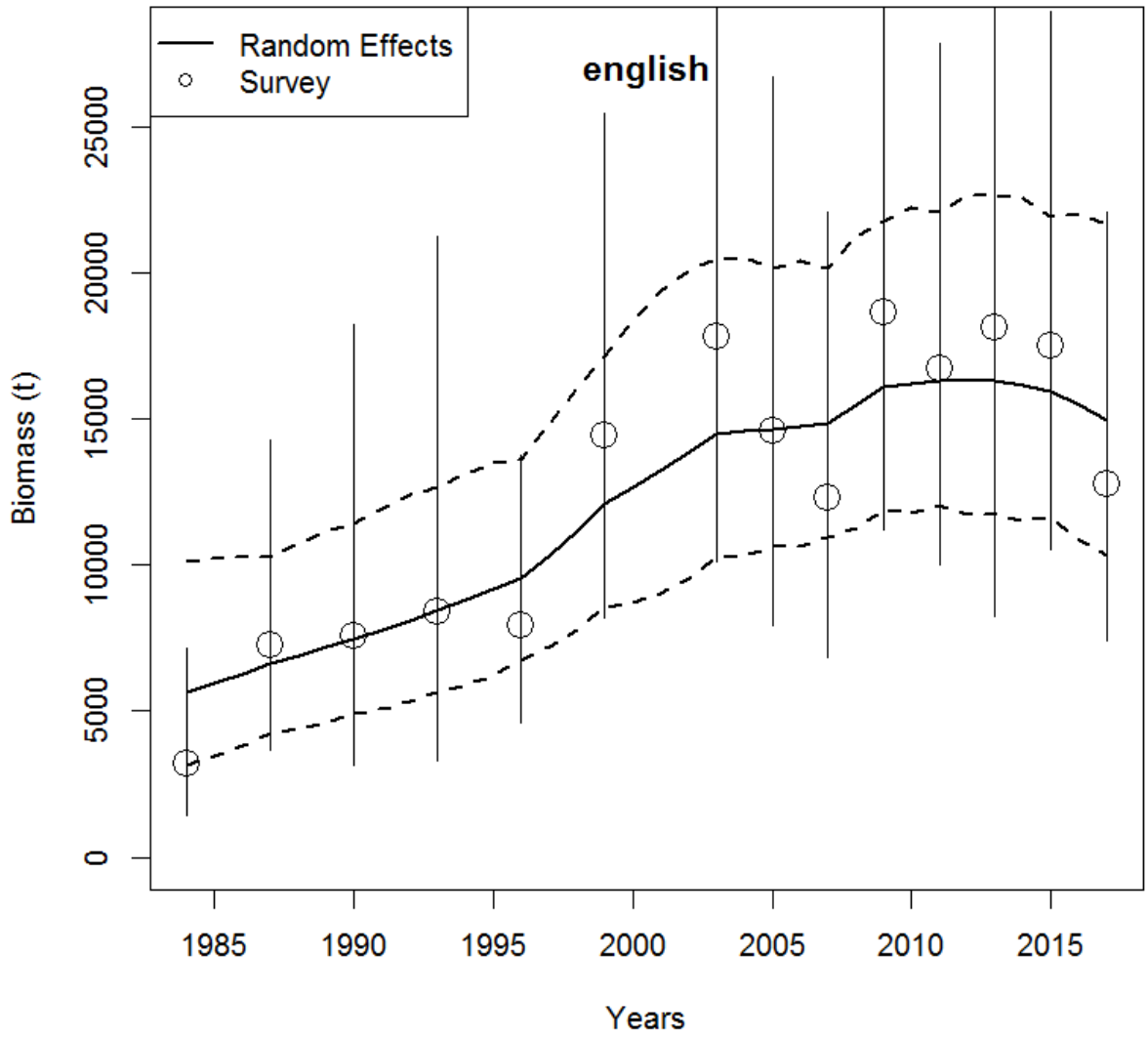

Figure 4.17. Fit of random effects model to English sole survey biomass 1984 to 2017. Dashed lines are 95% CI.

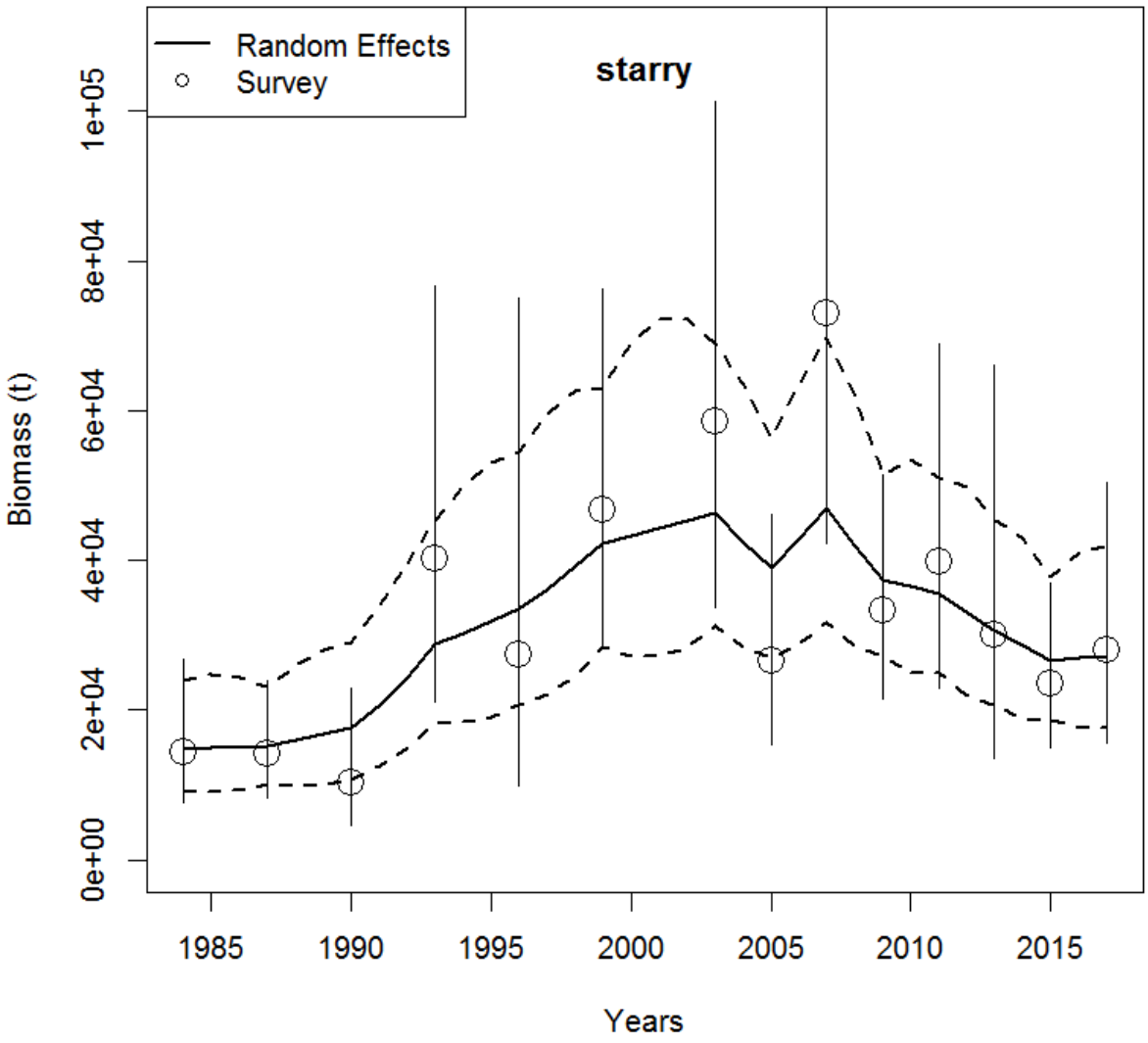

Figure 4.18. Fit of random effects model to starry flounder survey biomass 1984 to 2017. Dashed lines are 95% CI.

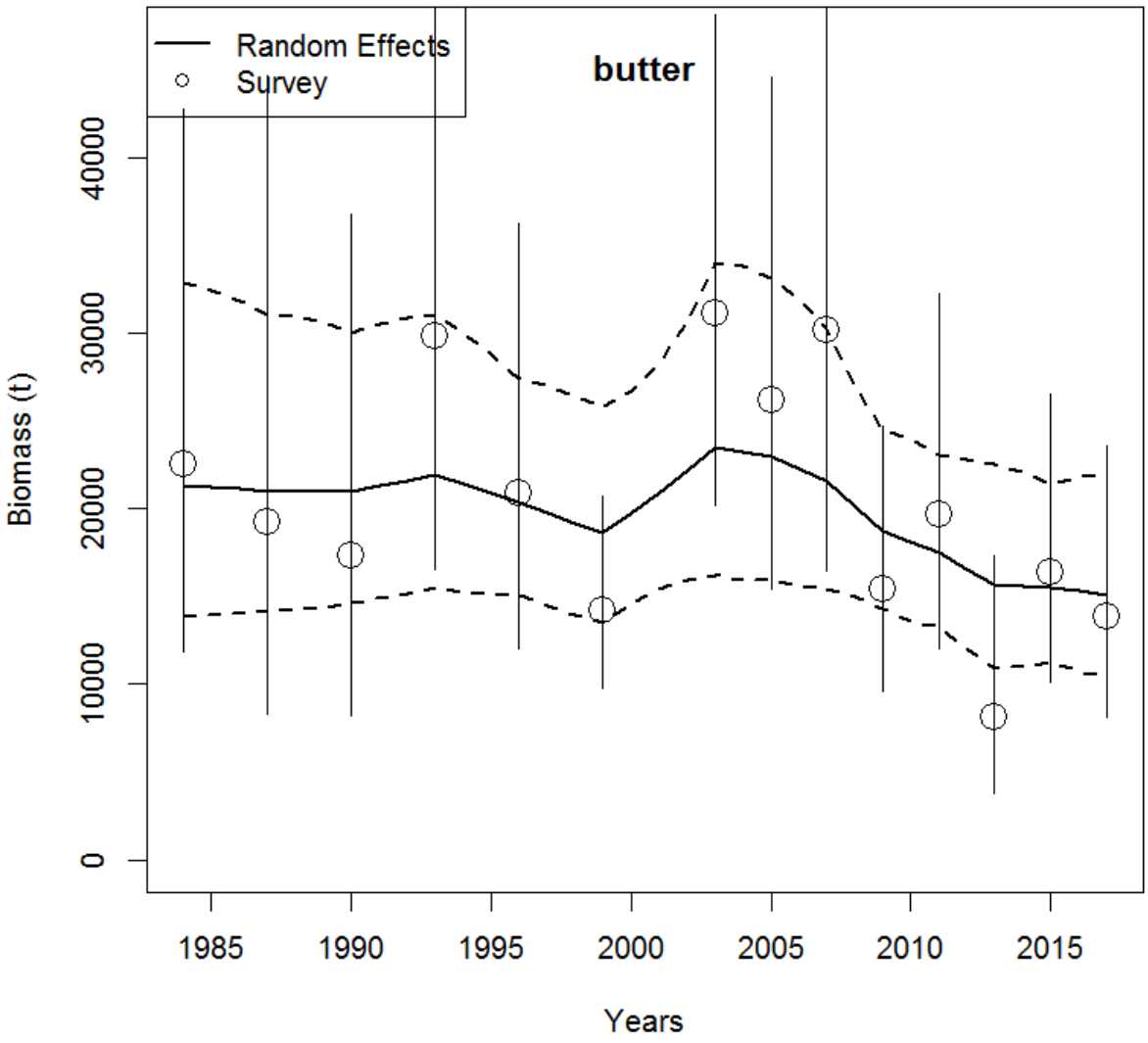

Figure 4.19. Fit of random effects model to butter sole survey biomass 1984 to 2017. Dashed lines are 95% CI.

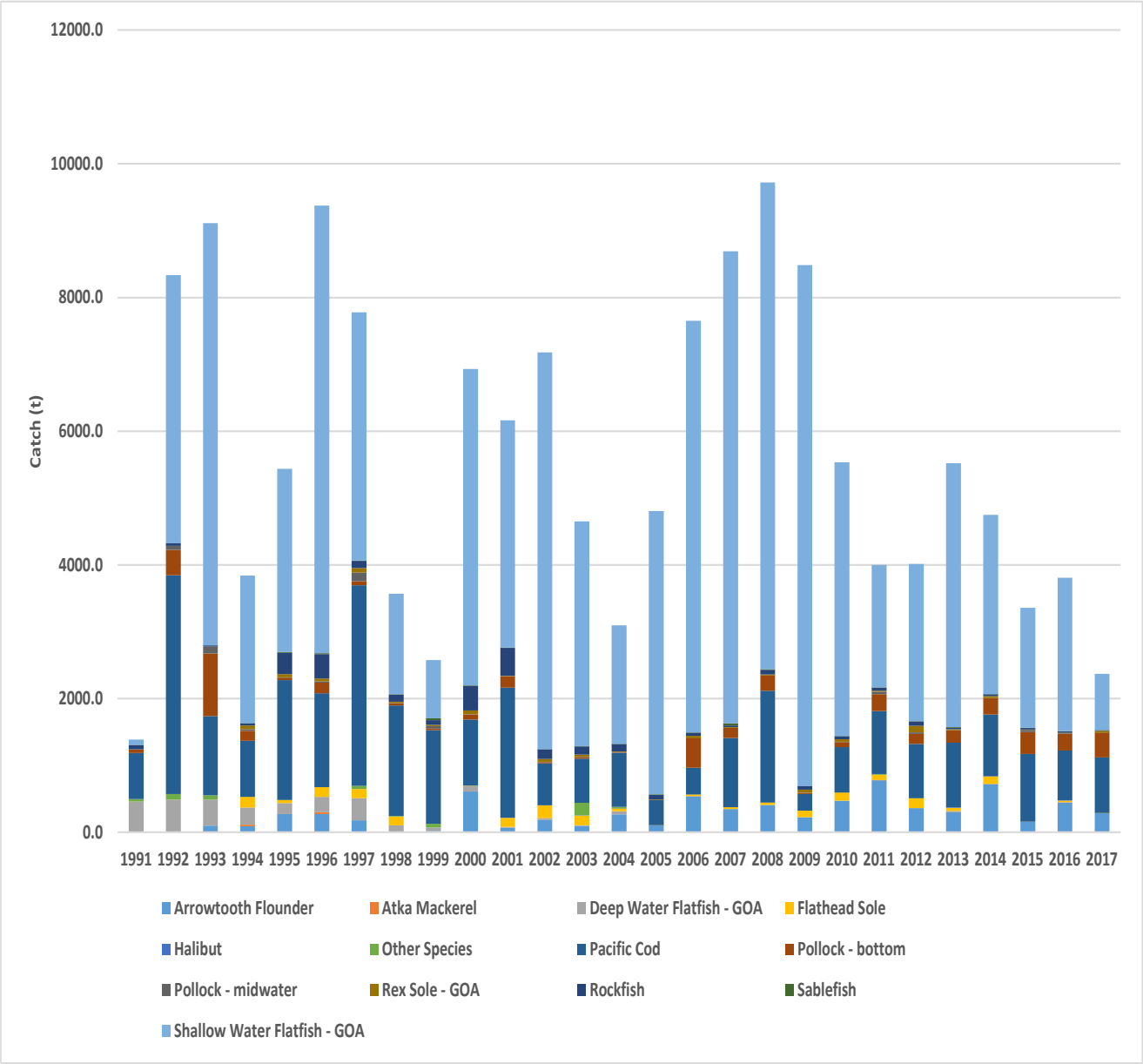

Figure 4.20. Catch of shallow-water flatfish by fishery and year from AKFIN database for 1991 to October 1, 2017.