5. Assessment of the Deepwater Flatfish Stock in the Gulf of Alaska

By
William T. Stockhausen, Mark E. Wilkins and Michael H. Martin

Executive Summary

Changes in the Input Data

1) The last full assessment was performed in 2009. Fishery catches for 2010 and 2011 (through Sept. 24, 2011) were incorporated in the age-structured assessment model for Dover sole. The fishery catch for 2009 was updated to reflect final information for that year.
2) The 2010 and 2011 fishery size compositions for Dover sole were added to the assessment model. Fishery size compositions for 2009 were updated to reflect final information for that year.
3) Survey biomass and size compositions for Dover sole from the 2011 GOA groundfish survey were added to the model. Survey biomass for Dover sole increased marginally from 76,277 t in 2009 to 77,531 t in 2011.
4) Survey age compositions for Dover sole from the 2009 survey was added to the model. The corresponding size compositions were substantially de-weighted to avoid "double counting".

Changes in the Assessment Model

No changes were made to the underlying mathematical structure of the Tier 3 assessment model for Dover sole. The preferred model from the 2009 assessment (the "base case" model) was used to perform the assessment this year. However, the model code was improved to provide a number of outputs for Markov Chain Monte Carlo (MCMC) analysis and a suite of plotting routines to visualize the MCMC results was developed in the R software package. As a result of the new MCMC analyses, it is clear the 2009 assessment was based on a model that had converged to a local maximum on the model's likelihood surface, not to the global maximum. Model results from the newly-identified maximum suggest that only the oldest Dover sole are well-selected by the GOA groundfish survey, which resulted in much higher estimates of species biomass than were obtained in the past—with similar consequences for harvest reference points. Given these dramatic changes, and a compressed time frame to validate them, we currently have reduced confidence in the Tier 3 model. Consequently, we recommend setting harvest reference points using a Tier 5, rather than Tier 3, framework for this year. Because this is a rather unexpected outcome, we provide information in both this Executive Summary and in the chapter itself for both the recommended Tier 5 and non-recommended Tier 3 approaches for Dover sole.

Based on Tier 5 Approach for Dover Sole (__recommended__ by authors)

Changes in the Assessment Results

1. Using Tier 5 considerations for the Dover sole component of the deepwater flatfish complex, F_{OFL} for this component is equal to M, its natural mortality rate (0.085), and max F_{ABC} = 0.75*M (0.064). Our recommended F_{ABC} is max F_{ABC}.
2. Based on the 2011 GOA groundfish survey estimate of abundance for Dover sole (77,531 t), OFL for Dover sole in 2012 is 6,590 t while both the max and recommended ABC are 4,943 t. Recommended ABC is equal to max ABC.
3. OFL, max ABC and recommended ABC for 2013 are identical to there corresponding values for 2012.

The area apportionments corresponding to the recommended ABCs for the deepwater flatfish are:

Quantity	Species	Western	Central	West Yakutat	Southeast Outside	Total
Area Apportionment	Dover sole	1.1%	45.8%	31.8%	21.3%	100.0%
	Greenland turbot	68.2%	22.3%	5.0%	4.5%	100.0%
	Deepsea sole	0.0%	100.0%	0.0%	0.0%	100.0%
2012 ABC (t)	Dover sole	54	2,264	1,572	1,053	4,943
	Greenland turbot	122	40	9	8	179
	Deepsea sole	0	4	0	0	4
	Deepwater flatfish	176	2,308	1,581	1,061	5,126
2013 ABC (t)	Dover sole	54	2,264	1,572	1,053	4,943
	Greenland turbot	122	40	9	8	179
	Deepsea sole	0	4	0	0	4
	Deepwater flatfish	176	2,308	1,581	1,061	5,126

A summary of the recommended ABCs from the2011 assessment, relative to the 2010 SAFE projections, is as follows:

Species	Quantity	As estimated or specified last year (2010)		As estimated or specified this year (2011)	
		2011	2012	**2012**	**2013**
Dover sole	M (natural mortality)	0.085	0.085	**0.085**	**0.085**
	Specified/recommended tier	3a	3a	**5**	**5**
	Total biomass (Age 3+; t)	89,691	89,728	--	--
	Female Spawning Biomass (t)	32,577	32,910	--	--
	$B_{100\%}$	35,622	35,622	--	--
	$B_{40\%}$	14,249	14,249	--	--
	$B_{35\%}$	12,468	12,468	--	--
	Tier 5 biomass (Survey biomass,t)	--	--	**77,531**	77,531
	F_{OFL}	0.149	0.149	**0.085**	0.085
	max F_{ABC}	0.119	0.119	**0.064**	0.064
	recommended F_{ABC}	0.119	0.119	**0.064**	0.064
	OFL (t)	7,579	7,802	**6,590**	6,590
	max ABC (t)	6,122	6,303	**4,943**	4,943
	ABC (t)	6,122	6,303	**4,943**	4,943
Greemnland Turbot	Specified/recommended tier	6	6	**6**	**6**
	OFL (t)	238	238	**238**	238
	max ABC (t)	179	179	**179**	179
	ABC (t)	179	179	**179**	179
Deepsea sole	Specified/recommended tier	6	6	**6**	**6**
	OFL (t)	6	6	**6**	6
	max ABC (t)	4	4	**4**	4
	ABC (t)	4	4	**4**	4
Deepwater flatfish complex	OFL (t)	7,823	8,046	**6,834**	**6,834**
	max ABC (t)	6,305	6,486	**5,126**	**5,126**
	ABC (t)	6,305	6,486	**5,126**	**5,126**
	Status	As determined last year (2010) for:		As determined this year (2011) for:	
		2009	2010	**2010**	**2011**
	Overfishing	no	n/a	**no**	n/a
	Overfished	n/a	no	n/a	n/a
	Approaching overfished	n/a	no	n/a	n/a

Plan Team Summary Tables

Species	Year	Biomass[1]	OFL[2,3]	ABC[2,3]	TAC[2,3]	Catch[4]
Deepwater flatfish	2010	89,682	7,680	6,190	6,190	544
	2011	77,531	7,823	6,305	6,305	403
	2012	--	6,834	5,126		
	2013	--	6,834	5,126		

[1] Age 3+ Dover sole biomass from the assessment model (2010) or survey biomass (2011).
[2] http://www.fakr.noaa.gov/sustainablefisheries/specs10_11/goa_table1.pdf
[3] http://www.fakr.noaa.gov/sustainablefisheries/specs11_12/goa_table1.pdf
[4] As of Sept. 24, 2011.

Stock/ Assemblage	Area	2011				2012		2013	
		OFL[1]	ABC[1]	TAC[1]	Catch[2]	OFL[3]	ABC[3]	OFL[3]	ABC[3]
Deepwater flatfish	W	--	529	529	10	--	176	--	176
	C	--	2,919	2,919	386	--	2,308	--	2,308
	WYAK	--	2,083	2,083	6	--	1,581	--	1,581
	SEO	--	774	774	1	--	1,061	--	1,061
	Total	7,823	6,305	6,305	403	6,834	5,126	6,834	5,126

[1]http://www.fakr.noaa.gov/sustainablefisheries/specs11_12/goa_table1.pdf
[2]As of Sept. 24, 2011.
[3]Based on the Tier 5 calculations for Dover sole and Tier 6 calculations for Greenland turbot and deepsea sole.

Based on Tier 3 Approach for Dover Sole (not recommended by authors)

Changes in the Assessment Results

1. Results from the Dover sole assessment model this year differ substantially from those of the 2009 model: this year's model estimates for recent total (age 3+) biomass and spawning biomass are over 2*x* the 2009 model estimates, while estimated recruitments are quite different, as well. Analysis using the new MCMC diagnostics indicates that the 2009 model solution was probably at a local maximum of the likelihood function, not the global maximum and thus yielded spurious results.
2. Based on an $F_{40\%}$ harvest level of 0.142 for Dover sole (Tier 3a calculations) and 0.75 *x* mean historic catch for Greenland turbot and deepsea sole (Tier 6 calculations), the ABCs for the deepwater flatfish complex would be 17,736 t for 2012 and 18,893 t for 2013.
3. The OFLs, based on an $F_{35\%}$ harvest level of 0.184 for Dover sole and mean historic catch for Greenland turbot and deepsea sole, would be 22,515 t for 2012 and 23,983 t for 2013.
4. Projected female spawning biomass for Dover sole was estimated at 82,809 t for 2012.
5. Projected total biomass (age 3+) for Dover sole was estimated at 228,820 t for 2012.

The area apportionments corresponding to these ABCs are:

Quantity	Species	Western	Central	West Yakutat	Southeast Outside	Total
Area Apportionment	Dover sole	1.1%	45.8%	31.8%	21.3%	100.0%
	Greenland turbot	68.2%	22.3%	5.0%	4.5%	100.0%
	Deepsea sole	0.0%	100.0%	0.0%	0.0%	100.0%
2012 ABC (t)	Dover sole	193	8,039	5,582	3,739	17,553
	Greenland turbot	122	40	9	8	179
	Deepsea sole	0	4	0	0	4
	Deepwater flatfish	315	8,083	5,591	3,747	17,736
2013 ABC (t)	Dover sole	206	8,569	5,950	3,985	18,710
	Greenland turbot	122	40	9	8	179
	Deepsea sole	0	4	0	0	4
	Deepwater flatfish	328	8,613	5,959	3,993	18,893

A summary of these ABCs, relative to the 2010 SAFE projections, is as follows:

Species	Quantity	As estimated or specified last year (2010)		As estimated or specified this year (2011)	
		2011	2012	**2012**	**2013**
Dover sole	M (natural mortality)	0.085	0.085	**0.085**	**0.085**
	Specified/recommended tier	3a	3a	**3a**	**3a**
	Total biomass (Age 3+; t)	89,691	89,728	**228,820**	227,986
	Female Spawning Biomass (t)	32,577	32,910	**82,809**	85,570
	$B_{100\%}$	35,622	35,622	**90,443**	90,443
	$B_{40\%}$	14,249	14,249	**36,177**	36,177
	$B_{35\%}$	12,468	12,468	**31,655**	31,655
	$F_{OFL} = F_{35\%}$	0.149	0.149	**0.184**	0.184
	$max\ F_{ABC} = F_{40\%}$	0.119	0.119	**0.142**	0.142
	$recommended\ F_{ABC}$	0.119	0.119	**0.142**	0.142
	OFL (t)	7,579	7,802	**22,271**	23,739
	max ABC (t)	6,122	6,303	**17,553**	18,710
	ABC (t)	6,122	6,303	**17,553**	18,710
Greemnland Turbot	Specified/recommended tier	6	6	**6**	**6**
	OFL (t)	238	238	**238**	238
	max ABC (t)	179	179	**179**	179
	ABC (t)	179	179	**179**	179
Deepsea sole	Specified/recommended tier	6	6	**6**	**6**
	OFL (t)	6	6	**6**	6
	max ABC (t)	4	4	**4**	4
	ABC (t)	4	4	**4**	4
Deepwater flatfish complex	OFL (t)	7,823	8,046	**22,515**	**23,983**
	max ABC (t)	6,305	6,486	**17,736**	**18,893**
	ABC (t)	6,305	6,486	**17,736**	**18,893**
	Status	As determined last year (2010) for:		As determined this year (2011) for:	
		2009	2010	**2010**	**2011**
	Overfishing	no	n/a	**no**	n/a
	Overfished	n/a	no	n/a	**no**
	Approaching overfished	n/a	no	n/a	**no**

Note that the OFL and ABC values above for 2012 and 2013 **are not those recommended by the authors** but are provided for completeness.

Plan Team Summary Tables

Species	Year	Biomass[1]	OFL[2,3]	ABC[2,3]	TAC[2,3]	Catch[4]
Deepwater flatfish	2010	89,682	7,680	6,190	6,190	544
	2011	229,580	7,823	6,305	6,305	403
	2012	228,820	22,515	17,736		
	2013	227,986	23,983	18,893		

[1] Age 3+ Dover sole biomass from the Tier 3 assessment model.
[2] http://www.fakr.noaa.gov/sustainablefisheries/specs10_11/goa_table1.pdf
[3] http://www.fakr.noaa.gov/sustainablefisheries/specs11_12/goa_table1.pdf
[4] As of Sept. 24, 2011.
Note that the OFL and ABC values above for 2012 and 2013 **are not those recommended by the authors** but are provided for completeness.

Stock/ Assemblage	Area	2011				2012		2013	
		OFL[1]	ABC[1]	TAC[1]	Catch[2]	OFL[3]	ABC[3]	OFL[3]	ABC[3]
Deepwater flatfish	W	--	529	529	10	--	315	--	328
	C	--	2,919	2,919	386	--	8,083	--	8,613
	WYAK	--	2,083	2,083	6	--	5,591	--	5,959
	SEO	--	774	774	1	--	3,747	--	3,993
	Total	7,823	6,305	6,305	403	22,515	17,736	23,983	18,893

[1]http://www.fakr.noaa.gov/sustainablefisheries/specs11_12/goa_table1.pdf
[2]As of Sept. 24, 2011.
[3]Based on the Dover sole Tier 3a assessment model and Tier 6 calculations for Greenland turbot and deepsea sole.
Note that the OFL and ABC values above for 2012 and 2013 **are not those recommended by the authors** but are provided for completeness.

SSC Comments Specific to the Deepwater Flatfish Assessments

SSC comment: "*Because adjacent age-classes are likely to overlap in size and spatial distribution, the fishery selectivity curves estimated by the model seem implausibly steep, possibly indicating mis-specification of the age-length conversion matrices. The SSC requests that the growth model and age-length conversion matrices be re-evaluated in the next assessment.*"

Author response: The principal author regrets that this analysis was not completed for this assessment and will make it a top priority for completion by next year.

SSC comment: "*The SSC also requests that the next assessment provide likelihood profiles or similar analyses that illustrate the consistency of the model fits to the various input data sources.*"

Author response: In 2009, we addressed this request using AD Model Builder's built-in likelihood profile variables. Subsequently, we decided that using an MCMC approach would be much more flexible than the likelihood profile approach. Consequently, we modified the assessment model to provide MCMC output and developed a suite of plotting routines in R to visualize the results.

SSC Comments on Assessments in General

SSC request: *The SSC requested that the next round of assessments consider the possible use of ADF&G bottom trawl survey data to expand the spatial and depth coverage.*

Author response: The current assessment model can not accommodate surveys from multiple sources. We continue to develop a new assessment model that will incorporate surveys from multiple sources as one of its new features. When completed, this new model will allow us to explore the utility of using the ADF&G bottom trawl survey data in future assessments.

Introduction

The "flatfish" species complex previous to 1990 was managed as a unit in the Gulf of Alaska (GOA). It included the major flatfish species inhabiting the region, with the exception of Pacific halibut. The North Pacific Fishery Management Council divided the flatfish assemblage into four categories for management in 1990; "shallow flatfish" and "deep flatfish", flathead sole and arrowtooth flounder. This classification was made because of significant differences in halibut bycatch rates in directed fisheries targeting the shallow-water and deepwater 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 deepwater groups. In 1993, rex sole was split out of the deepwater management category because of concerns regarding the bycatch of Pacific ocean perch in the rex sole target fishery.

The deepwater complex, the subject of this chapter, is composed of three species: Dover sole (*Microstomus pacificus*), Greenland turbot (*Reinhardtius hippoglossoides*) and deepsea sole (*Embassichthys bathybius*). Dover sole is by far the biomass-dominant in research trawl surveys and constitutes the majority of the fishery catch in the deepwater complex (typically over 98%). Little biological information exists for Greenland turbot or deepsea sole in the GOA. Better information exists for Dover sole, which allowed the construction of an age-structured assessment model in 2003 (Turnock et al., 2003).

Greenland turbot have a circumpolar distribution and occur in both the Atlantic and Pacific Oceans. In the eastern Pacific, Greenland turbot are found from the Chukchi Sea through the Eastern Bering Sea and Aleutian Islands, in the Gulf of Alaska and south to northern Baja California. Greenland turbot are typically distributed from 200-1600 m in water temperatures from 1-4^{o} C, but have been taken at depths up to 2200 m.

Dover sole occur from Northern Baja California to the Bering Sea and the western Aleutian Islands; they exhibit a widespread distribution throughout the GOA (Miller and Lea, 1972; Hart, 1973). Adults are demersal and are mostly found at depths from 300 m to 1500 m.

Dover sole are batch spawners; spawning in the Gulf of Alaska has been observed from January through August, peaking in May (Hirschberger and Smith, 1983). The average 1 kg female may spawn it 83,000 advanced yolked oocytes in about 9 batches (Hunter et al., 1992). Although the duration of the incubation period is unknown, eggs have been collected in plankton nets east of Kodiak Island in the summer (Kendall and Dunn, 1985). Larvae are large and have an extended pelagic phase that averages about 21 months (Markle et al., 1992). They have been collected in bongo nets only in summer over mid-shelf and slope areas in the Gulf. The age or size at metamorphosis is unknown, but pelagic postlarvae as large as 48 mm have been reported and juveniles may still be pelagic at 10 cm (Hart, 1973). Juveniles less than 25 cm are rarely caught with the adult population in bottom trawl surveys (Martin and Claussen, 1995).

Dover sole move to deeper water as they age and older females may have seasonal migrations from deep water on the outer continental shelf and upper slope where spawning occurs to shallower water mid-shelf in summer time to feed (tagging data from California to British Columbia; Demory et al., 1984; Westrheim et al., 1992). Older male Dover sole may also migrate seasonally but to a lesser extent than females. The maximum observed age for Dover sole in the GOA is 57 years.

Fishery

Since passage of the MFMCA in 1977, the flatfish fishery in the GOA has undergone substantial changes. Until 1981, annual harvests of flatfish were around 15,000 t, taken primarily as bycatch by foreign vessels targeting other species. Foreign fishing ceased in 1986 and joint venture fishing began to account for the majority of the catch. In 1987, the gulf-wide flatfish catch increased nearly four-fold , with joint venture fisheries accounting for all of the increase. Since 1988, only domestic fishing fleets are allowed to harvest flatfish. As foreign fishing ended, catches decreased to a low of 2,441 t in 1986. Catches subsequently increased under the joint venture and then domestic fleets to a high of 43,107 t in 1996. Catches then declined to 23,237 t in 1998 and were 22,700 t in 2004.

Focusing more specifically now on the deepwater flatfish complex, in the GOA this trio of species is caught in a directed fishery primarily using bottom trawls. Fewer than 20 shore-based catcher-type vessels participate in this fishery, together with about 6 catcher-processor vessels. Fishing seasons are driven by seasonal halibut PSC apportionments, with fishing occurring primarily in April and May because of higher catch rates and better prices. Annual catch in the deepwater flatfish fishery was estimated by partitioning the flatfish catch into its component species groups based on historical species composition of observed catch. The deepwater flatfish complex catch is dominated by Dover sole (over 98%, typically; Table 5.1, Figure 5.1). Dover sole have been taken primarily in the Central Gulf in recent years, as well on the continental slope off Yakutat Bay in the eastern Gulf (based on fishery observer data; Figures 5.2-3). Dover sole recruit to the fishery starting at about age 10.

Deepwater flatfish are also caught in pursuit of other bottom-dwelling species as bycatch. They are taken as bycatch in Pacific cod, bottom pollock and other flatfish fisheries, and are caught along with these species in the deepwater flatfish-directed fishery. The gross discard rates for deepwater flatfish across all fisheries are relatively high, with 39% discarded in 2010 and 49% in 2011 (Table 5.2).

Historically, catch of Dover sole increased dramatically from a low of 23 t in 1986 to a high of almost 10,000 t in 1991 (Table 5.1, Figure 5.1). Following that maximum, annual catch has declined rather steadily, with perhaps a 6-year cycle imposed on the overall trend. The catch in 2011 (403 t as of Sept. 24) was the second lowest since 1987, although it will probably exceed catches in 2005-2006 by year end. Catch of Greenland turbot has been sporadic and has been over than 100 t only 5 times since 1978. The highest catch of Greenland turbot (3,012 t) occurred in 1992, coinciding with the second highest catch of Dover sole (8,364 t) since 1978. This was followed by a catch of 16 t for Greenland turbot the next year. Annual catch has been less than 25 t since 1995. Deepsea sole is the least caught of the three deepwater flatfish species. It has been taken only intermittently, with less than a ton of annual catch occurring 11 times since 1978. The highest annual catch occurred in 1998 (38 t), but since then annual catch has been less than 2 t for 9 out of the past 11 years. Less than 1 t of Greenland turbot and deepsea sole were taken in each of the past two years.

The spatial distributions of fishery catches in 2009-2011 (through Sept. 11), based on observer reports, are illustrated in Figures 5.2 (annually) and 5.3 (by quarter for 2010-2011). Most catches in 2010-2011 were made along the edge of the continental shelf east of Kodiak Island, but were off the Shumagin Islands in 2009. More Dover sole were caught in the 2^{nd} quarter of 2011 than the 1^{st} quarter, while the opposite was true in 2010.

Annual catches of deepwater flatfish have been well below the TACs in recent years (Table 5.2a, Figure 5.1). Annual TACs, in turn, have been set equal to their associated ABCs. Limits on catch in the deepwater flatfish complex are driven by within-season closures of the directed fishery due to restrictions on halibut PSC, not attainment of the TAC (Table 5.2b). Currently, ABCs for the entire complex are based on summing ABCs for the individual species. Because population biomass estimates based on research trawl surveys are considered unreliable for Greenland turbot and deepsea sole, as well as there being an absence of basic biological information from the GOA for these two species, Tier 6 calculations are used to obtain species-specific contributions to the complex-level ABC and OFL for each year. As such, ABCs for Greenland turbot and deepsea sole (179 t and 4 t, respectively) are based on average historic catch levels and do not vary from year to year. Since 2003, the ABC for Dover sole has been based on an age-structured assessment mode (Turnock et al., 2003).

Data

Fishery Data

This assessment used fishery catches from 1978 through 24 September, 2011 (Table 5.1; Figure 5.1). ABC and OFL calculations for Greenland turbot and deepsea sole were based on Tier 6 considerations using the mean historical catch from 1978-1995. The age-structured model for Dover sole incorporated catch data from 1984-2011, as well as estimates of the proportion of individuals caught by length group and sex for the years 1985-2004 and 2009-2011 (Table 5.3). Size composition data from 2005-2008 was not included in the model due to the low number of samples collected by fishery observers. Sample sizes for the size compositions are shown in Table 5.4. Fishery age composition data is not incorporated in the current model structure.

Survey Data

Because deepwater flatfish are lightly exploited by the target fishery and are (relatively speaking) often taken incidentally in target fisheries for other species, CPUE data from commercial fisheries probably do not reflect trends in abundance for these species. The Alaska Fishery Science Center's Gulf of Alaska Groundfish Trawl Survey is the principal source of fishery-independent data available to assess the deepwater flatfish complex. The gulf-wide survey includes shelf and slope depth strata and has been conducted with standardized gear and a randomized design since 1984 on a triennial (1984-1999) or biennial (2001-2011) basis. The survey typically samples depth strata up to 1000 m, although the deepest strata (> 500 m) have not been sampled consistently (see Table 5.5a.1). While depth coverage to 1000 m is adequate to assess the GOA Dover sole population, it is appears to be inadequate to obtain reliable estimates of biomass for the Greenland turbot and deep-sea sole populations (Table 5.5a, Figure 5.4). In addition to inconsistent depth coverage, the 2001 GOA survey did not include the eastern portion of the Gulf. As noted below, these inconsistencies complicate the interpretation of estimates of biomass from the groundfish survey.

The age-structured model for Dover sole used in this assessment incorporates estimates of total biomass for Dover sole to provide indices of population abundance (Table 5.5a; Figure 5.4). As noted above, survey coverage in both depth range and geographical area has varied among years and requires careful consideration of the survey results. Survey coverage was limited to less than 500 m depths in 1990, 1993, 1996 and 2001 but extended to 1000 m in 1984, 1987, 1999, 2005 and 2007. The survey extended to 700 m in 2003 and 2011. In 2001, the survey was not conducted in the eastern portion of the Gulf of Alaska. Turnock et al. (2003) developed correction factors to scale "raw" survey results for differences in availability caused by differences in survey coverage; "corrected" survey biomass estimates are obtained by dividing the observed biomass by assumed availability (Table 5.5a.1). On average, about 18% of Dover sole biomass occurs at depths greater than 500 m, while the eastern portion of the Gulf accounts for nearly 50% of the biomass (Turnock et al., 2003; Table 5.5a.1).

Since 1984, survey estimates of total biomass for Dover sole have fluctuated about a mean of ~75,000 t. After starting relatively low at 68,521 t in 1984, the survey-estimated biomass jumped to a maximum of 117,000 t (corrected for availability) in 1990, followed by declining estimates through the rest of the decade. Survey biomass increased to 99,297 t in 2003, then decreased to 71,624 t in 2007, followed by slight increases in 2009 (76,277 t) and 2011 (77,531 t). Survey data indicates concentrations of Dover sole that do not appear to be targeted by the fishery, e.g. near Cape St. Elias in the northern Gulf(Figure 5.5), as well as near Cape Spencer and Cape Ommaney in the southeast, which is closed to trawl gear.

However, the areas of highest fishery catch (near the Shumagins in 2009, east of northern Kodiak in 2011) are also evident in the survey data (compare Figure 5.2 with Figure 5.5).

Estimates of age and size compositions from the GOA groundfish surveys were also incorporated in the age-structured model. Estimates of numbers-at-age by sex were available for surveys conducted in 1987 and from 1993 to 2009 (Table 5.6). Estimates of the numbers-at-size by sex were available for every survey year and also included in the model (Table 5.7), although size compositions from years with corresponding age compositions were substantially de-weighted in the model to avoid “double counting” but were included to better assess model fits. Sample sizes for the survey age and size compositions are shown in Table 5.4b.

Data on individual growth was incorporated in the age-structured model using sex-specific age-length conversion matrices (Table 5.8; Stockhausen et al., 2005). Sex-specific weight-at-age and maturity-at-age schedules developed using survey data were also incorporated in the model (Table 5.9; Stockhausen et al. 2005).

To summarize, the following data were incorporated in the assessment:

Source	type	years
Fishery	catch	1984-2011
	length compositions	1991-2004, 2009-2011
Survey	biomass	1984-1999 (triennial); 2001-2011 (biennial)
	length compositions	1984-1999 (triennial); 2001-2011 (biennial)
	age compositions	1987, 1993, 1996, 1999; 2001-2009 (biennial)

Analytic Approach

Model structure

The assessment for Dover sole was conducted using a split-sex, age-structured model with parameters evaluated in a maximum likelihood context. The model structure (Appendix A) was developed following Fournier and Archibald’s (1982) methods, with many similarities to Methot (1990). We implemented the model using automatic differentiation software developed as a set of libraries under C++ (ADModel Builder). ADModel Builder can estimate a large number of parameters in a non-linear model using automatic differentiation software extended from Greiwank and Corliss (1991) and developed into C++ class libraries. This software provides the derivative calculations needed for finding the minimum of an objective function via a quasi-Newton function minimization routine (e.g., Press et al. 1992). It also gives simple and rapid access to these routines and provides the ability to estimate the variance-covariance matrix for all parameters of interest.

In 2009, we evaluated a number of alternative models primarily using different functions to describe age- and sex-specific fishery and survey selectivities within the model (Stockhausen et al., 2009). This year, due to time constraints, we simply fit the available data using the preferred model from the 2009 assessment

Age classes included in the model ran from age 3 to 40. Age at recruitment was set at 3 years in the model due to the small number of fish caught at younger ages. The oldest age class in the model, age 40, serves as a plus group in the model. This year, the Age and Growth Program at the AFSC estimated an age of 57 years for one individual sampled in the 2009 GOA groundfish survey. Previously, the maximum age of Dover sole based on otolith age determinations was estimated at 54 years (Turnock et al., 2003). Details of the population dynamics and estimation equations, description of variables and likelihood components are presented in Appendix A (Tables A.1, A.2, and A.3). Model parameters that are typically fixed are presented in Table A.4. A total of 107 parameters were estimated in the model (Table A.5).

Parameters estimated independently

Model parameters related to natural mortality, growth, weight, maturity and survey catchability (Table A.4) were fixed in all models.

Natural mortality

As in previous assessments, natural mortality (M) was fixed at 0.085 yr^{-1} for both sexes in all age classes. This estimate was based on Hoenig's (1983) method and a maximum observed age of 54 years. Although an older fish (57 years) was aged this year, as noted above, we did not update the estimate of natural mortality used in the model to account for this new observation. Using the new maximum age, the revised estimate natural mortality would be about 6% smaller than that used here. This was done primarily to maintain consistency with the previous assessment and will be updated in the next assessment.

Growth

Mean size-at-age, L_t, was modeled using the von Bertalanffy growth equation as:

$$L_t = L_{\inf}\left(1 - e^{-k(t-t_0)}\right)$$

Survey age and length data from 1984, 1993, 1996, 1999 and 2001 were used to estimate the parameters (Turnock et al., 2003). The parameter values used in this assessment are:

Sex	L_∞	k	t_0
Males	42.42	0.195	-1.97
Females	51.51	0.127	-2.66

The estimated size-at-age relationships (Table 5.9; Figure 5.6a) was used to convert model age compositions to estimated size compositions, based on sex-specific age-length conversion matrices (Table 5.8). The conversion matrices used were identical to those used in assessments since 2003.

Weight-at-length

The weight-length relationship used for Dover sole was identical to that used in assessments since 2003: $W = 0.0029\,L^{3.3369}$ for both sexes (weight in grams and length in centimeters; Abookire and Macewicz, 2003). Weight-at-age (Table 5.9; Figure 5.6b) was estimated using mean length-at-age and the weight-length relationship.

Maturity

The maturity schedule for Gulf of Alaska Dover sole was estimated using histological analysis of ovaries collected in 2000 and 2001 (Abookire and Macewicz, 2003; Table 5.9; Figure 5.6c). A total of 273 samples were analyzed for estimation of age at maturity. Size at 50% mature was estimated to be 43.9 cm with a slope of 0.62 cm^{-1} from a sample of 108 fish. Age at 50% mature was 6.7 years with a slope of 0.880 yr^{-1}. Minimum-age at-maturity was 5 years.

Survey catchability

For this assessment, survey catchability (*Q* in Table A.1) was fixed at 1. Alternative models with *Q* allowed to vary have been explored in previous assessments (Stockhausen et al., 2005), but estimability was poor.

Parameters estimated conditionally

A total of 107 parameters were estimated in the preferred model (Table A.5). These consisted primarily of parameters on the recruitment of Dover sole to the population (66 parameters total, including ones determining the initial age composition) and values related to annual fishing mortality (29 parameters total).

The separable age component of fishing mortality was modeled using a two parameter ascending logistic function estimated separately for males and females (4 parameters total). The same form of curve was also used to estimate sex/age-specific survey selectivity. However, two sets of curves were estimated: one set corresponding to surveys with full depth coverage (> 500 m; "full coverage" surveys) and the second set corresponding to surveys that only sampled shallow (1-500 m) areas ("shallow" surveys). Thus, 8 parameters were used to estimate survey selectivity. Selectivities were normalized such that the maximum female selectivity was 1.

Annual recruitment to age 3 was parameterized in the models using one parameter for the log-scale mean recruitment and 65 parameters for the annual log-scale deviation from the mean. Recruitments were estimated back to 1947 to provide an initial age distribution for the model in its starting year (1984). In an analogous fashion, fully-recruited fishing mortality was parameterized in the models using one parameter for the log-scale mean and 28 parameters for the annual log-scale deviation from the mean.

Final parameter estimates were obtained based on minimizing an objective function equivalent to the negative log-likelihood for the model, hence the parameter estimates are maximum likelihood estimates (when the model converges to the global minimum of the objective function). Components that contributed to the overall (-log) likelihood included those related to observed fishery catches, fishery size compositions, survey biomass estimates, survey size compositions, survey age composition, and recruitment deviations (Table A.3). The observed fishery catch was assumed to have a lognormal error structure, as was estimated survey biomass. The size and age compositions were assumed to be drawn from different sex-specific multinomial distributions. The recruitment deviation parameters were incorporated directly into the overall likelihood via three temporal components: "early" recruitment, "ordinary" recruitment and "late" recruitment (Table A.3). This allowed different weights to be applied in the likelihood function to recruitment estimates that were not well observed in the data (i.e., recruitments prior to the model period or the most recent ones). The "early" recruitment component incorporated deviations from 1947 to 1983 (i.e., prior to the modeled age structure), "ordinary" recruitment incorporated deviations from 1984-2008 and "late" recruitment incorporated deviations from 2009-2011. All three components were formulated assuming a lognormal error structure.

Different weights were assigned to each likelihood component in the model to increase or decrease the relative degree of model fit to the data underlying the respective component (Table 5.10). Identical values for the weights were used in the 2009 assessment. A larger weight induces a closer fit to a given likelihood component. A relatively large weight (30) was applied to the catch component, reflecting a belief that total catch is relatively well known, while smaller weights (e.g., 1) were applied to the survey biomass, recruitment, and size and age composition components. We assigned weights of 1 to the survey biomass, survey age composition and "normal" recruitment components. Model-predicted size compositions are not expected to fit the data as well as age compositions should because the model uses time-invariant sex-specific age-length conversion matrices to convert from numbers-at-age to numbers-at-size, which generally introduces a "smearing" of numbers-at-age across too many length bins for any given year. The size composition-associated components (fishery and survey) were thus assigned weights of 0.5, down-weighting their importance relative to the survey biomass and age composition fits. For the recruitment components, larger weights applied to a component force the deviations contributing to that component closer to zero (and thus force recruitment closer to the geometric mean over the years that contribute to the component). We assigned higher weights (2 and 3, respectively) to the "early" and "late" recruitment components to keep the associated recruitments close to the long-term median.

Initial values for the estimable parameters were set as listed in Table 5.11. We made multiple model runs with slightly different ("perturbed") initial parameter values to test that convergence to the final solution was truly a global minimum, rather than a local minimum, of the model objective function. Most of these runs resulted in the model converging to the same minimum objective function value, indicating that the model had indeed reached the global minimum. Estimates for most parameters were very similar to those obtained in the 2009 assessment, as well.

We also, however, used the model's new Markov Chain Monte Carlo (MCMC; Gelman et al., 1995) capability to assess posterior uncertainties associated with the estimated parameters and various other model quantities. Ten million MCMC simulations were conducted using ADMB's MCMC functionality for the converged model, dropping the first million simulations and saving every 2000th subsequently, to sample the joint posterior distribution. Marginal posterior density functions were estimated from the sampled joint posterior for all parameters and many other model quantities of interest. Comparison of these densities with the estimated values for the model parameters indicated that the model had not, indeed, converged to the global minimum but rather to a local minimum.

In previous assessments, we had found it useful to "turn on" estimation of the model parameters in an iterative sequence of phases to achieve model convergence to a solution. In the first phase, all parameters started at their initial values but only a few of them were freely estimated, while the remainder were fixed at their initial values. In subsequent phases, more parameters were "turned on" and estimated, using their final values from the previous phase as initial values in the current phase. In the final phase, all parameters were "turned on" and estimated. In many applications, this type of approach can speed up model convergence and appeared to do so in the 2009 assessment. However, when we re-ran the model by estimating the parameters all at once (i.e., without turning parameter estimation "on" in a phased sequence), we obtained a substantially lower objective function value (> 20 log-likelihood units) at convergence than the (local) minimum we had previously obtained. Again, we re-ran the model using a series of perturbed initial values for the model parameters but did not obtain a smaller final value for the objective function, once again suggesting that this time we had found the global minimum and not just a local minimum. Re-running the MCMC analysis for the new candidate minimum value solution yielded much better diagnostics in terms of posterior densities, as well.

Final parameter estimates

Final parameter values, corresponding to (presumed) maximum likelihood estimates, are given in Table 5.12.

Model evaluation

Because we fit only one model this year, evaluation of model performance was limited to assessing the adequacy of the fit to the data and the internal consistency of model parameter estimates. Model selection based on information criteria (e.g., AIC) is not possible because these techniques evaluate the relative suitability between models, not the absolute suitability of any particular model.

Contributions to the final objective function value from the various components of the (-log) likelihood for the converged model are listed in Table 5.13. These indicate that the fishery size compositions were not fit terribly well, but this was expected (see below). On the plus side, the calculation of the model Hessian was successful, indicating that the model had converged to a multidimensional (local or global) minimum, not a saddle point, on the objective function surface and allowing simple estimates of standard errors associated with the parameter estimates. However, we also noted that estimates for several of the "slope" parameters involved in the model selectivity functions ended up at one of the limits set for a slope parameter. This is discussed further below.

The model fit the observed catch history quite well (Table 5.14, Figure 5.7), as expected given the large weight placed on this component in the overall objective function. Only the two highest catches (in 1991 and 1992) were somewhat underestimated.

The model also fit the observed survey biomass history quite well (Table 5.14, Figure 5.8a), and much better than it had in the 2009 assessment (Figure 5.8b). The 2009 assessment severely overestimated survey biomass in 1984 and 1987, but the fit this year was able to match those data points well. In contrast, the model overestimated survey biomass in 2001 while the 2009 assessment was "dead on". However, it is worth noting that the eastern portion of the GOA was not surveyed during the 2001 GOA Groundfish Survey and that the observed value was "inflated" to account for this, but its associated uncertainty seems to be much smaller than is likely.

Model fits to survey age compositions appear to improve with time, such that the fits are pretty good for recent surveys (2003-2009) and poorer for early surveys (1987; Figures 5.9a and b). The poor fits to the early surveys may indicate poor performance in estimating initial numbers-at-age in the model: the assumption in the model is that "early" recruitment (i.e., to model year classes earlier than 1981) is in stochastic equilibrium and that no fishing has occurred. The 2009 assessment yielded similar results.

Model fits to survey size compositions generally follow the same trend as with survey age compositions, such that fits are pretty good for recent surveys and poorer for early surveys (Figures 5.10a and b). In particular, size compositions in the early surveys display a much more pronounced peak in both the male and female size compositions up through 1996 (and is possibly seen in 2001, as well) than is estimated in the model.

Model fits to fishery size compositions are moderately poor (Figures 5.11a and b). The model size compositions exhibit very little variability between years, while the observed compositions exhibit quite a lot of temporal variability. In recent years, this may be due primarily to sampling variability (given the small numbers of fish that have been measured in recent years). In earlier years this may be indicative of variable fishing patterns that are inconsistent with the assumption of time-invariant catchability used in the model.

Slope parameter values for four of the six logistic selectivity functions (two fishery selectivities, four survey selectivities) ended up at bounds placed on the parameter search algorithm: the slope for fishery selectivity for females reached the maximum allowed slope (25, essentially indicating knife-edge selection) while the three of the four survey selectivities reached the minimum (0.1)—survey selectivity for females in the "shallow" surveys being the exception. The resulting selectivity functions are illustrated in Figure 5.12a. The fishery selectivity curves are very similar, however, to those obtained in the 2009 assessment (Figure 5.12b)—in which the slopes were also estimated to be extremely large. The SSC has suggested that this behavior may indicate that the age-length conversion matrices used in the model are poorly specified. It may also, however, indicate that fishery selectivity does not conform to a logistic function or that selectivity is time-varying. Examination of the marginal posterior distributions, based on MCMC sampling, for quantities related to fishery selectivity (Figure 5.13) indicates that the

$a_{50\%}$ parameters (age at 50% selection), as well as the derived quantities $a_{05\%}$ and $a_{95\%}$ have, on the whole, reasonable distributions that are consistent with the maximum likelihood estimates. This is not true for the slope parameters, for which the posterior distributions are highly skewed and the maximum likelihood estimates are inconsistent with the distributions. This, of course, is a consequence of the estimates occurring at the upper limit set on the slopes. The observation that the results for the derived quantities $a_{05\%}$ and $a_{95\%}$ are reasonable suggests that it might be wise to re-parameterize the logistic selectivity functions to eliminate estimating the slope (e.g., parameterizing in terms of $a_{05\%}$ and $a_{95\%}$). Comparison with equivalent results for the 2009 assessment model (we re-ran the model with the 2009 data and the new MCMC diagnostics) reveals that this year's model, while not perfect, has much better estimation performance than in the 2009 model. These results further suggest that the 2009 model did not converge to the global maximum, rather to a local maximum.

The survey selectivity curves for females are also fairly similar between this year's model and the 2009 assessment (Figure 5.12), although the parameter values that give rise to these curves are different, whereas the estimated survey selectivity curves for males are quite different. In this year's model, the selectivity curves for males and females were quite similar, whereas they were quite different in the 2009 assessment: males were fully selected by age 10 whereas females were fully selected only by age 20, if not older (depending on the survey type). Examination of the marginal posterior distributions for the estimated survey selectivity parameters and derived quantities ($a_{05\%}$ and $a_{95\%}$, again) yields observations similar to those for the fishery selectivity parameters: quantities related to age at *xx*% selection ($a_{50\%}$, $a_{05\%}$ and $a_{95\%}$) have reasonable distributions and consistent maximum likelihood estimates while the slopes do not (Figures 5.14a and 5.15a)—once again indicating that the logistic selectivity functions should be re-parameterized. Also, as with the fishery selectivity parameters, comparison with equivalent distributions from the 2009 assessment lends additional evidence to the conclusion that the 2009 model convergence was inadequate.

Marginal posterior distributions based on MCMC sampling are presented in Figures 5.16-5.18 for additional model parameters and derived quantities, along with equivalent results from the (re-run) 2009 assessment. The conclusion from examining these graphs is the same as that obtained from examining the graphs for the selectivity curves: the 2009 assessment model were based on a model that did not converge to the global minimum of the model's objective function

Results

Model results suggest that total biomass, defined as age 3+ biomass, has undergone moderate decadal-scale fluctuations imposed on a slight longterm increasing trend (Table 5.15, Figures 5.18a and 5.19a). Total biomass rose from 203,000 t in 1984 to a peak of 227,000 t in 1989, declined to 180,000 t in 1999, rose again to a maximum in 232,000 t in 2009 and remains near that high level in 2011 (229,600 t). This differs both in overall magnitude and pattern from the two most recent assessments (Figure 5.19a). Total biomass in the current model is estimated at more than twice that of the 2009 assessment for comparable recent years. The current model also suggests that the longterm trend in total biomass has been slightly upward and that the current total biomass is at a maximum for the time series, while the 2009 assessment model suggested the longterm trend was downward and that it was at a minimum.

Similar decadal-scale fluctuations imposed on a very gradual upward trend are also suggested by model results for spawning biomass (Table 5.16, Figures 5.18a and 5.19b), although the phase of the fluctuations differ such that in 2011 spawning biomass appears to still be rising following a minimum in 2005 while total biomass had reached a plateau. In contrast, spawning biomass in the 2009 assessment was estimated be on a longterm decline and to be at a minimum.

Model results further suggest that (age 3) recruitment was above the longterm average in the late 1990s through 2007, following a period of below-average recruitment in the late 1980s through mid-1990 (Figure 5.20). Recruitment since 2007 has been lower than normal, according to the model. Interestingly, the current estimates of recruitment agree with those from the 2009 and 2007 assessments in terms of overall pattern, if not magnitude (Figure 5.21). In each assessment, recruitment is high in the mid 1980s, declines in the late 1980s and remains low until the mid 1990s, then increases and achieves the highest recruitment in 2002, followed immediately by sharp declines in 2003 and 2004. Mean recruitment in the current model (28.5 million individuals) is almost 3 times that of the 2009 assessment model (11.2 million).

Marginal posterior distributions based on MCMC integration are shown in Figure 5.22 for the Tier 3 quantities $F_{35\%}$ and $F_{40\%}$, $B_{35\%}$ and $B_{40\%}$, and max ABC and OFL for 2012 as calculated using Tier 3a rules. The distributions indicate that these quantities are well-estimated from the current model. A control rule plot of the time evolution of estimated fishing mortality against spawning biomass indicates that Dover sole is at high spawning biomass and no overfishing has occurred (Figure 5.23).

Because several of the estimates for slope parameters for the survey selectivities converged to the lower bound set for these parameters, and because model estimates of total biomass, spawning biomass and recruitment are consequently much higher than have been obtained in previous assessments, our confidence in the overall suitability of the current assessment model for Dover sole has been substantially reduced. Therefore, **we do not recommend using the Tier 3 model results for Dover sole to set harvest limits**. Instead, **we recommend using a Tier 5 approach for Dover sole until issues with the Tier 3 model can be resolved**. However, for completeness, we present harvest limit calculations based on both approaches for Dover sole.

Projections and Harvest Alternatives

The reference fishing mortality rate for Dover sole is determined by the amount of reliable population information available (Amendment 56 of the Fishery Management Plan for the groundfish fishery of the Bering Sea/Aleutian Islands).

Recommended Tier 5 approach for Dover sole

The GOA groundfish survey appears to provide reliable estimates of species abundance for Dover sole based on a swept-area approach. Because we currently have little confidence in estimates from the Tier 3 assessment model for Dover sole, we recommend using a Tier 5 approach to setting harvest limits for Dover sole. Under this approach, F_{OFL} is equal to M, the natural mortality (0.085 yr^{-1}) and max F_{ABC} = 0.75*M (0.064 yr^{-1}). Because recent harvests of Dover sole have been extremely small relative to survey biomass levels, we see no reason to reduce F_{ABC} beyond the maximum allowed.

Tier 3 approach for Dover sole (not recommended)

If estimates of $F_{40\%}$, $F_{35\%}$, and $SPR_{40\%}$ obtained from a spawner-per-recruit analysis were considered reliable, an estimate of $B_{40\%}$ could be calculated as the product of $SPR_{40\%}$ times the equilibrium number of recruits. Assuming that the average recruitment from the 1981-2008 year classes (1984-2011 age 3 recruits) estimated in the Tier 3 model represented a reliable estimate of equilibrium recruitment, then $B_{40\%}$ would be 36,177 t. The estimated 2011 spawning stock biomass from the model was 79,487 t. If reliable estimates of the 2011 spawning biomass (B), $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ existed, and because B>$B_{40\%}$, the Dover sole reference fishing mortality would be defined in Tier 3a. For this tier, F_{ABC} is constrained to be ≤ $F_{40\%}$, and F_{OFL} is defined to ≤be $F_{35\%}$. The values of these quantities are:

estimated 2011 SSB	=	79,487	t
$B_{40\%}$	=	36,177	t
$F_{40\%}$	=	0.142	
F_{ABC} (max)	=	0.142	
$B_{35\%}$	=	31,655	t
$F_{35\%}$	=	0.184	
F_{OFL}	=	0.184	

Because the Dover sole stock has not been overfished in recent years and the stock biomass is relatively high, we would not recommend adjusting F_{ABC} downward from its upper bound.

A standard set of projections is required for each stock managed under Tiers 1, 2, or 3 of Amendment 56. This set of projections encompasses seven harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Policy Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

For each scenario, the projections begin with the vector of 2011 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2012 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2011. In each subsequent year, the fishing mortality rate is prescribed on the basis of the spawning biomass in that year and the respective harvest scenario. In each year, recruitment is drawn from an inverse Gaussian distribution whose parameters consist of maximum likelihood estimates determined from recruitments estimated in the assessment. Spawning biomass is computed in each year based on the time of peak spawning and the maturity and weight schedules described in the assessment. Total catch is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1000 times to obtain distributions of possible future stock sizes, fishing mortality rates, and catches.

Five of the seven standard scenarios will be used in an Environmental Assessment prepared in conjunction with the final SAFE. These five scenarios, which are designed to provide a range of harvest alternatives that are likely to bracket the final TAC for 2012, are as follow ("*max* F_{ABC}" refers to the maximum permissible value of F_{ABC} under Amendment 56):

Scenario 1: In all future years, *F* is set equal to *max* F_{ABC}. (Rationale: Historically, TAC has been constrained by ABC, so this scenario provides a likely upper limit on future TACs.)

Scenario 2: In all future years, *F* is set equal to a constant fraction of *max* F_{ABC}, where this fraction is equal to the ratio of the F_{ABC} value for 2011 recommended in the assessment to the *max* F_{ABC} for 2011. (Rationale: When F_{ABC} is set at a value below *max* F_{ABC}, it is often set at the value recommended in the stock assessment.)

Scenario 3: In all future years, *F* is set equal to 50% of max F_{ABC}. (Rationale: This scenario provides a likely lower bound on F_{ABC} that still allows future harvest rates to be adjusted downward when stocks fall below reference levels.)

Scenario 4: In all future years, *F* is set equal to the 2007-2011 average *F*. (Rationale: For some stocks, TAC can be well below ABC, and recent average *F* may provide a better indicator of F_{TAC} than F_{ABC}.)

Scenario 5: In all future years, F is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

The recommended F_{ABC} and the maximum F_{ABC} are equivalent in this assessment, so scenarios 1 and 2 yield identical results. The 14-year projections of the mean harvest, spawning stock biomass and fishing mortality using the base model results for the five scenarios are shown in Table 5.18-20.

Two other scenarios are needed to satisfy the MSFCMA's requirement to determine whether the Dover sole stock is currently in an overfished condition or is approaching an overfished condition. These two scenarios are as follows (for Tier 3 stocks, the MSY level is defined as $B_{35\%}$):

Scenario 6: In all future years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be above its MSY level in 2012, then the stock is not overfished.)

Scenario 7: In 2012 and 2013, F is set equal to *max* F_{ABC}, and in all subsequent years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is expected to be above its MSY level in 2024 under this scenario, then the stock is not approaching an overfished condition.)

The results of these two scenarios indicate that the Dover sole stock is not overfished and is not approaching an overfished condition (Tables 5.18-20). With regard to assessing the current stock level, the expected stock size in the year 2012 of scenario 6 (82,809) is over twice its $B_{35\%}$ value of 31,655 t, thus the stock is not currently overfished. With regard to whether the stock is approaching an overfished condition, the expected spawning stock size in the year 2024 of scenario 7 (33,163 t) is greater than $B_{35\%}$; thus the stock is not approaching an overfished condition.

Acceptable Biological Catch and Overfishing Level

Because little biological information exists for Greenland turbot and deepsea sole, and because survey biomass estimates are not considered reliable indicators of population status, these two species fall under Tier 6 for ABC and OFL determination. For species in Tier 6, ABC is $0.75 x \overline{C}$ and OFL is $\overline{C}$, where $\overline{C}$ is the average historical catch from 1978-1995. Thus, ABC and OFL for Greenland turbot and deepsea sole are

Tier 6 Species	Mean catch (t)	2012 ABC (t)	2012 OFL (t)	2013 ABC (t)	2013 OFL (t)
Greenland turbot	238	179	238	179	238
Deepsea sole	6	4	6	4	6

Recommended Tier 5 approach for Dover sole

The GOA groundfish survey appears to provide reliable estimates of population status for Dover sole using a swept-area approach, so a Tier 5 approach is appropriate for setting harvest limits for Dover sole. Under this approach, OFL= F_{OFL} *B, max ABC = max F_{ABC} *B, and recommended ABC = recommended F_{ABC} *B, where B is the biomass of Dover sole estimated from the most recent GOA groundfish survey. Using the 2011 GOA groundfish survey estimate for Dover sole abundance (77,531 t), the resulting OFL and max ABC for 2012 are 6,590 t and 4,943 t respectively. The recommended ABC is also 4,943 t.

Tier 3 approach for Dover sole (not recommended)

Assuming Dover sole were in Tier 3a, the maximum value for F_{ABC} would be equal to $F_{40\%}$ while F_{OFL} would be equal to $F_{35\%}$. If one accepts the results of the assessment model, there do not seem to be compelling reasons to recommend a lower value for F_{ABC}, so we recommend using $F_{40\%}$ as F_{ABC}. As such, ABC in 2012 for Dover sole would be 17,553 t and OFL would be 22,271 t. For 2012, female spawning biomass was projected to be 82,809 t while total biomass (i.e., age 3+ biomass) was projected to be 228,820 t.

Estimating an ABC and OFL for Dover sole for 2013 is somewhat problematic using a Tier 3 approach because these values depend on the catch that will be taken in 2012. The actual catch taken in the GOA deepwater flatfish fishery has been substantially smaller than the TAC for the past several years. We assumed that a reasonable estimate of the catch to be taken in 2012 was the five-year average of recent catches apportioned to Dover sole (461 t). Using this value and the estimated population size at the start of 2012, we projected the Dover sole population ahead through 2012 and calculated a species-specific ABC and OFL for 2013. ABC for 2013 was 18,710 t and OFL was 23,739 t. For 2013, female spawning biomass was projected to be 85,570 t while total biomass (i.e., age 3+ biomass) was projected to be 227,986 t.

ABC allocation by management area

TACs for deepwater flatfish in the Gulf of Alaska are divided among four smaller management areas (Eastern, Central, West Yakutat and Southeast Outside). As in previous assessments, the proportion of historical catch among the management areas is used to apportion the total ABCs for Greenland turbot and deepsea sole. Area-specific ABCs for Dover sole are divided up over the four management areas by applying the fraction of 2011 survey biomass estimated for each area (relative to the total over all areas) to the 2012 and 2013 ABCs. The area-specific allocations for 2012 and 2013 are:

Based on Tier 5 approach for Dover sole (Recommended)

Quantity	Species	Western	Central	West Yakutat	Southeast Outside	Total
Area Apportionment	Dover sole	1.1%	45.8%	31.8%	21.3%	100.0%
	Greenland turbot	68.2%	22.3%	5.0%	4.5%	100.0%
	Deepsea sole	0.0%	100.0%	0.0%	0.0%	100.0%
2012 ABC (t)	Dover sole	54	2,264	1,572	1,053	4,943
	Greenland turbot	122	40	9	8	179
	Deepsea sole	0	4	0	0	4
	Deepwater flatfish	176	2,308	1,581	1,061	5,126
2013 ABC (t)	Dover sole	54	2,264	1,572	1,053	4,943
	Greenland turbot	122	40	9	8	179
	Deepsea sole	0	4	0	0	4
	Deepwater flatfish	176	2,308	1,581	1,061	5,126

Based on Tier 5 approach for Dover sole (<u>Not Recommended</u>)

Quantity	Species	Western	Central	West Yakutat	Southeast Outside	Total
Area Apportionment	Dover sole	1.1%	45.8%	31.8%	21.3%	100.0%
	Greenland turbot	68.2%	22.3%	5.0%	4.5%	100.0%
	Deepsea sole	0.0%	100.0%	0.0%	0.0%	100.0%
2012 ABC (t)	Dover sole	193	8,039	5,582	3,739	17,553
	Greenland turbot	122	40	9	8	179
	Deepsea sole	0	4	0	0	4
	Deepwater flatfish	315	8,083	5,591	3,747	17,736
2013 ABC (t)	Dover sole	206	8,569	5,950	3,985	18,710
	Greenland turbot	122	40	9	8	179
	Deepsea sole	0	4	0	0	4
	Deepwater flatfish	328	8,613	5,959	3,993	18,893

Ecosystem Considerations

Ecosystem effects on the stock

Based on results from an ecosystem model for the Gulf of Alaska (Aydin et al., 2007), Dover sole adults occupy an intermediate trophic level (Figure 5.24). Dover sole commonly feed on brittle stars, polychaetes and other miscellaneous worms (Figure 5.25; Buckley et al., 1999). Trends in prey abundance for Dover sole are unknown.

Important predators identified in the GOA ecosystem model include walleye pollock and Pacific halibut; however, the major source of Dover sole mortality is from the flatfish fishery (Figure 5.26). The ecosystem model was developed using food habits data from the early 1990s when GOA pollock biomass was much larger than it is currently and fishing mortality on Dover sole was much higher than it is now. Biomass of GOA pollock has been declining and is at historically low levels, thus the ecosystem model results may not reflect the current impact of pollock on Dover sole.

Little is known regarding the roles of Greenland turbot or deepsea sole in the Gulf of Alaska ecosystem. Within the 200-mile limits of the Exclusive Economic Zone of the United States, Greenland turbot are mainly found in the Bering Sea and the Aleutian Islands (Ianelli et al., 2006). Although the Gulf of Alaska component of Greenland turbot may represent a marginal stock, the species range in the eastern Pacific extends to northern Baja California. It thus seems somewhat unlikely that stock size in the Gulf is limited by simple environmental factors such as temperature, rather it seems more likely that substantial biomass exists beyond the depth range of the fishery and the surveys. Greenland turbot are epibenthic feeders and prey on crustaceans and fishes. Walleye pollock are important predators on turbot in the Bering Sea, but it is unknown whether this holds true in the Gulf as well.

Fishery effects on ecosystem

Only small amounts of protected species (crab, halibut, and salmon) are typically taken in the deepwater flatfish directed fishery (Table 5.21a, b, and c). In 2010 and thus far in 2011, essentially no halibut, crab, or salmon were caught in this fishery.

Catches of Dover sole have been concentrated along the shelf edge east and southeast of Kodiak Island in the Gulf of Alaska over the past few years (Figures 5.2 and 5.3). It is unknown whether this level of spatial concentration by the fishery will have any effects on the stocks making up this complex, but it seems unlikely.

Bycatch of non-target species in the deepwater flatfish fishery is almost non-existent (Table 5.22).

In addition to deepwater flatfish, the directed fishery has also caught small amounts of arrowtooth flounder, Pacific cod and rex sole as bycatch in recent years (Table 5.23).

Effects of discards and offal production on the ecosystem are unknown for the deepwater flatfish fishery.

Data gaps and research priorities

We are obviously concerned about the suitability of the current Tier 3 model for Dover sole. The model and data will undergo a thorough and comprehensive internal review prior to the next assessment cycle and results will be presented to the GOA Plan Team at the annual September meeting for additional review. Natural mortality rates and growth rates will be re-assessed. Age and size classes used in the model will be re-evaluated. Assumptions regarding selectivities will be re-visited and alternative selectivity functions will be tested.

We remain concerned that fishery size compositions for Dover sole are under-sampled in the Observer Program, as they were in 2005-2008, although more recent sampling efforts have sampled somewhat more fish (Table 5.4a). Fishery size compositions were not included in the Dover sole assessment model for 2005-2008 because so few length samples were reported during this time period. This may, however, simply have been a consequence of the overall low total catches in the deepwater flatfish fishery.

Thanks to the industrious work of the AFSC's Age and Growth Program, the amount of age data for Dover sole in the Gulf of Alaska that is available from the groundfish survey has improved remarkably in the past few years. However, complementary data from the fishery is does not exist. Although the current assessment model can not incorporate fishery age compositions, we anticipate adding this capability in the future. We also need to use the existing data to update estimates of individual growth and age-length conversion matrices currently used in the assessment. Existing age/length data will be used in the upcoming year to re-evaluate current growth models and the associated age-length conversion matrices used in the model. We continue to develop a new assessment model that will be able, among other things, to estimate growth rates directly within the model rather than using conversion matrices estimated outside the model. The new model will also allow us to incorporate ageing error into the estimates of growth and size compositions.

Finally, given the dearth of biological knowledge regarding Greenland turbot and deepsea sole in the Gulf of Alaska, a concerted effort should be made to obtain more samples from the GOA survey. This would probably entail expanding the survey into deeper strata than currently sampled, however, and thus may not be feasible.

Summary

Based on Tier 5 approach for Dover sole (Recommended)

Dover sole

Tier	5	
Reference mortality rate		
M	0.085	
Reference biomass		
2011 GOA survey biomass (t)	77,531 t	
Fishing rates		
F_{OFL}	0.085	
F_{ABC} (maximum permissible)	0.064	
F_{ABC} (recommended)	0.064	
Harvest limits	**2012**	**2013**
OFL (t)	6,590	6,590
ABC (maximum permissible; t)	4,943	4,943
ABC (recommended; t)	4,943	4,943

Greenland turbot

Tier	6	
Reference catch (t)	238	
Harvest limits	**2012**	**2013**
OFL (t)	238	238
ABC (maximum permissible; t)	179	179
ABC (recommended; t)	179	179

Deepsea sole

Tier	6	
Reference catch (t)	6	
Harvest limits	**2012**	**2013**
OFL (t)	6	6
ABC (maximum permissible; t)	4	4
ABC (recommended; t)	4	4

Based on Tier 5 approach for Dover sole (Not Recommended)

Dover sole

Tier	3a	
Reference mortality rates		
M	0.085	
$F_{35\%}$	0.184	
$F_{40\%}$	0.142	
Equilibrium female spawning biomass		
$B_{100\%}$	90,443 t	
$B_{40\%}$	36,177 t	
$B_{35\%}$	31,655 t	
Fishing rates		
F_{OFL}	0.184	
F_{ABC} (maximum permissible)	0.142	
F_{ABC} (recommended)	0.142	
Projected biomass	**2012**	**2013**
Age 3+ biomass (t)	228,820	227,986
Female spawning biomass (t)	82,809	85,570
Harvest limits	**2012**	**2013**
OFL (t)	22,271	23,739
ABC (maximum permissible; t)	17,553	18,710
ABC (recommended; t)	17,553	18,710

Greenland turbot

Tier	6	
Reference catch (t)	238	
Harvest limits	**2012**	**2013**
OFL (t)	238	238
ABC (maximum permissible; t)	179	179
ABC (recommended; t)	179	179

Deepsea sole

Tier	6	
Reference catch (t)	6	
Harvest limits	**2012**	**2013**
OFL (t)	6	6
ABC (maximum permissible; t)	4	4
ABC (recommended; t)	4	4

Literature Cited

Abookire, A. A. and B. J. Macewicz. 2003. Latitudinal variation in reproductive biology and growth of female Dover sole (Microstomus pacificus) in the Nort Pacific, with emphasis on the Gulf of Alaska stock. J. Sea Res. 50: 187-197.

Aydin, K., S. Gaichas, I. Ortiz, D. Kinzey, and N. Friday. 2007. A comparison of the Bering Sea, Gulf of Alaska, and Aleutian Islands large marine ecosystems through food web modeling. NOAA Tech Memo. NMFS-AFSC-178. 298 p.

Buckley, T.W., G.E. Tyler, D.M. Smith and P.A. Livingston. Food habits of some commercially important groundfish off the costs of California, Oregon, Washington, and British Columbia. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-102, 173 p.

Demory, R.L., J.T. Golden and E.K. Pikitch. 1984. Status of Dover sole (*Microstomus pacificus*) in INPFC Columbia and Vancouver areas in 1984. Status f Pacific Coast Groundfish Fishery and Recommendations for Management in 1985. Pacific Fishery Management Council. Portland, Oregon 97201.

Fournier, D.A. and C.P. Archibald. 1982. A general theory for analyzing catch-at-age data. Can. J. Fish. Aquat. Sci. 39:1195-1207.

Gelman, A., J.B. Carlin, H.S. Stern and D.A. Rubin. 1995. Bayesian Data Analysis. Chapman and Hall, New York. 522 pp.

Greiwank, A. and G.F. Corliss (ed.s). 1991. Automatic differentiation of algorithms: theory, implementation and application. Proceedings of the SIAM Workshop on the Automatic Differentiation of Algorithms, held Jan 6-8, Breckenridge, CO. Soc., Induust. and Applied Mathematics, Philadelphia.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Canada, Bull. No. 180. 740 p.

Hirschberger, W.A. and G.B. Smith. 1983. Spawning of twelve groundfish species in the Alaska and Pacific coast regions. 50 p. NOAA Tech. Mem. NMFS F/NWC-44. U.S> Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Hoenig, J. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. 82:898-903.

Hunter, J.R., B.J. Macewicz, N.C.-H. Lo and C.A. Kimbrell. 1992. Fecundity, spawning, and maturity of female Dover sole, *Microstomus pacificus*, with an evaluation of assumptions and precision. Fish. Bull. 90:101-128.

Ianelli, J.N. T.K. Wilderbuer and D. Nichol. 2006. 5. Assessment of Greenland Turbot in the Eastern Bering Sea and Aleutian Islands. In Stock Assessment and Fishery Evaluation Document for Groundfish Resources in the Gulf of Alaska as Projected for 2007. pp. 492-540. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage AK 99510.

Kendall, A.W. Jr. and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. NOAA Tech. Rep. NMFS 20, U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Markle, D.F., P.M. Harris and C.L. Toole. 1992. Metamorphosis and an overview of early life-history stages in Dover sole *Microstomus pacificus*. Fish. Bull. 90:285-301.

Martin, M.H. and D.M. Clausen. 1995. Data report: 1993 Gulf of Alaska Bottom Trawl Survey. U.S. Dept. Commer., NOAA, Natl. Mar. Fish. Serv., NOAA Tech. Mem. NMFS-AFSC-59, 217p.

Methot, R.D. 1990. Synthesis model: An adaptable framework for analysis of diverse stock assessment data. Intl. N. Pac. Fish. Comm. Bull. 50:259-277.

Miller, D.J. and R.N. Lea. 1972.Guide to the coastal marine fishes pf California. Calif. Dept. Fish. Game, Fish. Bull. 157, 235 p.

Press, W.H., A.A. Teukolsky, W.T. Vetterling and B.P. Flannery. 1992. Numerical Recipes in C. Second Ed. Cambrige Univ. Press. 994 p.

Stockhausen, W.T., B.J. Turnock, Z.T. A'mar, M.E. Wilkins and M.H. Martin. 2005. 4a. Gulf of Alaska Dover Sole. In Stock Assessment and Fishery Evaluation Document for Groundfish Resources in the Gulf of Alaska as Projected for 2006. pp. 351-397. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage AK 99510.

Stockhausen, W.T., B.J. Turnock, M.E. Wilkins and M.H. Martin. 2007. 5. Gulf of Alaska Deepwater Flatfish. In Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. pp. 339-397. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage AK 99510.

Stockhausen, W.T., M.E. Wilkins and M.H. Martin. 2009. 5. Gulf of Alaska Deepwater Flatfish. In Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. pp. 495-563. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage AK 99510.

Turnock, B.J., T.K. Wilderbuer and E. S. Brown. 2003. Gulf of Alaska Dover sole. In Stock Assessment and Fishery Evaluation Document for Groundfish Resources in the Gulf of Alaska as Projected for 2004. pp. 341-368. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage AK 99510.

Westrheim, S.J., W.H. Barss, E.K. Pikitch, and L.F. Quirollo. 1992. Stock Delineation of Dover Sole in the California-British Columbia Region, Based on Tagging Studies Conducted during 1948-1979. North American Journal of Fisheries Management 12:172-181.

Tables

Table 5.1. Annual catch of deepwater flatfish species (Greenland turbot, Dover sole and deep-sea sole) in the Gulf of Alaska from 1978. 2011 catch is through Sept. 24.

Year	Greenland turbot	Dover sole	Deepsea sole	Total
1978	51	827	5	883
1979	24	530	5	559
1980	57	570	2	629
1981	8	457	8	473
1982	23	457	31	511
1983	145	354	11	510
1984	18	132	1	151
1985	0	43	3	47
1986	0	23	0	23
1987	44	56	0	100
1988	256	1,087	0	1,343
1989	56	1,521	0	1,577
1990	0	2,348	30	2,378
1991	446	9,741	2	10,189
1992	3,012	8,364	3	11,379
1993	16	3,804	3	3,823
1994	17	3,108	4	3,129
1995	116	2,096	1	2,213
1996	15	2,177	0	2,193
1997	11	3,652	1	3,664
1998	18	2,230	38	2,286
1999	14	2,270	0	2,285
2000	23	961	1	985
2001	4	800	0	804
2002	5	554	0	559
2003	10	936	0	946
2004	1	679	1	680
2005	5	407	0	412
2006	12	390	3	405
2007	1	286	0	287
2008	1	561	1	563
2009	3	457	6	466
2010	0	544	0	544
2011	0	403	0	403

Table 5.2a. Time series of recent reference points (ABC, OFL), TACs, total catch and retention rates for the deepwater flatfish complex. All values are in metric tons.

Year	ABC	TAC	OFL	Total Catch	Retained	Discarded	Percent Retained
1995	14,590	11,080	17,040	2,213	1,746	467	79%
1996	14,590	11,080	17,040	2,193	1,584	609	72%
1997	7,170	7,170	9,440	3,664	3,006	658	82%
1998	7,170	7,170	9,440	2,286	2,064	222	90%
1999	6,050	6,050	8,070	2,285	1,824	461	80%
2000	5,300	5,300	6,980	985	701	284	71%
2001	5,300	5,300	6,980	804	607	197	75%
2002	4,880	4,880	6,430	559	357	202	64%
2003	4,880	4,880	6,430	946	470	476	50%
2004	6,070	6,070	8,010	680	549	131	81%
2005	6,820	6,820	8,490	412	171	241	42%
2006	8,665	8,665	11,008	405	162	243	40%
2007	8,707	8,707	10,431	287	116	171	41%
2008	8,903	8,903	11,343	563	210	353	37%
2009	9,168	9,168	11,578	466	99	367	21%
2010	6,190	6,190	7,680	544	333	211	61%
2011	6,305	6,305	7,823	403	205	198	51%

Table 5.2b. Status of the deepwater flatfish fishery in recent years.

Year	Dates	Status
2005	Jan 20	open
	Mar 23	halibut bycatch status
	Apr 1	open
	Apr 8	halibut bycatch status
	Apr 24	open
	May 3	halibut bycatch status
	Jul 5	open
	Jul 24	halibut bycatch status
	Sep 1	open
	Sep 4	halibut bycatch status
	Sep 8	open
	Sep 10	halibut bycatch status
	Oct 1	open
	Oct 1	halibut bycatch status
2006	Jan 20	open
	Apr 27	halibut bycatch status
	Jul 1	open
	Sep 5	halibut bycatch status
	Oct 1	open
	Oct. 8	halibut bycatch status
2007	Jan 20	open
	May 17	halibut bycatch status
	Jul 1	open
	Aug 10	halibut bycatch status
	Sep 1	open
	Oct 8	halibut bycatch status
	Oct 10	open
	Oct 15	halibut bycatch status
	Oct 22	open
2008	Jan 20	open
	Apr 21	halibut bycatch status
	Jul 1	open
	Sep 9	A80 vessels subject to sideboard limits
	Sep 11	halibut bycatch status
	Oct 1	open
	Nov 6	halibut bycatch status
	Nov 16	open
2009	Jan 20	open
	Mar 3	halibut bycatch status
	Apr 1	open
	Apr 23	halibut bycatch status
	Jul 1	open
2010	Jan 20	open
	Apr 28	halibut bycatch status
	Jul 1	open
2011	Jan 20	open
	Apr 22	halibut bycatch status
	Jul 1	open
	Jul 1	halibut bycatch status (RP, CV Coop.s and LA)
	Aug 1	open

Table 5.3a. Annual normalized fishery size compositions for female Dover sole (only) from the domestic fishery. The 2011 composition is based on observer reports through Sept. 24. Normalization is over both sexes. Size compositions for 2005-2008 were excluded from the model fitting because sample sizes in these years were extremely low.

	Length cutpoints (cm)																							
year	**19**	**21**	**23**	**25**	**27**	**29**	**31**	**33**	**35**	**37**	**39**	**41**	**43**	**45**	**47**	**49**	**51**	**53**	**55**	**57**	**59**	**61**	**63**	**65**
1991	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0001	0.0016	0.0229	0.0698	0.1511	0.0905	0.1043	0.0366	0.0203	0.0015	0.0010	0.0001	0.0000	0.0000	0.0000	0.0000
1992	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0055	0.0171	0.0144	0.0460	0.0549	0.0901	0.0919	0.0580	0.0609	0.0189	0.0125	0.0130	0.0168	0.0000	0.0000
1993	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0024	0.0213	0.0595	0.0384	0.0637	0.0434	0.0638	0.0671	0.0418	0.0224	0.0282	0.0160	0.0109	0.0134	0.0029	0.0047	0.0000
1994	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0032	0.0095	0.0409	0.0721	0.0904	0.1145	0.0903	0.0363	0.0275	0.0029	0.0049	0.0052	0.0010	0.0010	0.0000
1995	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0013	0.0028	0.0061	0.0248	0.0620	0.0919	0.0885	0.0846	0.0350	0.0519	0.0079	0.0274	0.0093	0.0000	0.0064	0.0000	0.0000
1996	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0032	0.0137	0.0321	0.0454	0.0485	0.1013	0.0938	0.0752	0.0441	0.0261	0.0127	0.0032	0.0000	0.0000	0.0006	0.0000
1997	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0029	0.0048	0.0225	0.0280	0.0470	0.0560	0.0826	0.0817	0.0382	0.0539	0.0326	0.0281	0.0105	0.0082	0.0019	0.0006
1998	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020	0.0028	0.0050	0.0103	0.0228	0.0444	0.0807	0.1262	0.0933	0.0546	0.0350	0.0129	0.0080	0.0007	0.0014	0.0000
1999	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0070	0.0136	0.0181	0.0481	0.0562	0.0598	0.0778	0.0590	0.0521	0.0504	0.0284	0.0090	0.0066	0.0052	0.0026	0.0030	0.0010
2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0009	0.0032	0.0019	0.0053	0.0108	0.0171	0.0251	0.0452	0.0753	0.1015	0.0691	0.0484	0.0676	0.0144	0.0106	0.0015	0.0021	0.0000
2001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0164	0.0441	0.0419	0.0147	0.0327	0.0695	0.0691	0.0655	0.0668	0.0373	0.0113	0.0191	0.0011	0.0103	0.0000
2002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0009	0.0000	0.0000	0.0081	0.0000	0.0084	0.0145	0.0506	0.0088	0.1227	0.1146	0.0707	0.0475	0.0411	0.0000	0.0000	0.0120	0.0000
2003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0051	0.0000	0.0112	0.0018	0.0029	0.0178	0.0078	0.0085	0.0252	0.0880	0.1067	0.0969	0.0428	0.0337	0.0354	0.0154	0.0010	0.0000
2004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0090	0.0077	0.0255	0.0575	0.0772	0.0597	0.0504	0.0824	0.0357	0.0230	0.0126	0.0496	0.0044	0.0042
2005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0213	0.0213	0.0000	0.1382	0.1169	0.0213	0.1169	0.0427	0.0000	0.0213	0.0000	0.0000	0.0000
2006	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1147	0.1146	0.0003	0.0175	0.0034	0.0002	0.1146	0.1146	0.0139	0.0000	0.0000	0.0000	0.0000	0.0000	0.0060
2007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0371	0.0371	0.0397	0.0026	0.0371	0.0371	0.0741	0.0397	0.0397	0.1138	0.0397	0.0000	0.0026	0.0000
2008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0084	0.0360	0.0360	0.1159	0.0175	0.1519	0.0984	0.0360	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2009	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0465	0.0049	0.0025	0.0442	0.0313	0.1226	0.1314	0.0590	0.0136	0.0000	0.0000	0.0441	0.0000
2010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0038	0.0054	0.0086	0.0091	0.0097	0.0136	0.0194	0.0266	0.0443	0.1161	0.0752	0.0801	0.0623	0.0181	0.0078	0.0000	0.0000
2011	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0040	0.0000	0.0190	0.0000	0.0660	0.0710	0.0389	0.1033	0.0569	0.0464	0.0204	0.0174	0.0425	0.0000	0.0141	0.0000

Table 5.3b. Annual normalized fishery size compositions for male Dover sole (only) from the domestic fishery. The 2011 composition is based on observer reports through Sept. 24. Normalization is over both sexes. Size compositions for 2005-2008 were excluded from the model fitting because sample sizes in these years were extremely low.

year	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
1991	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0001	0.0016	0.0229	0.0698	0.1511	0.0905	0.1043	0.0366	0.0203	0.0015	0.0010	0.0001	0.0000	0.0000	0.0000	0.0000
1992	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0055	0.0171	0.0144	0.0460	0.0549	0.0901	0.0919	0.0580	0.0609	0.0189	0.0125	0.0130	0.0168	0.0000	0.0000
1993	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0024	0.0213	0.0595	0.0384	0.0637	0.0434	0.0638	0.0671	0.0418	0.0224	0.0282	0.0160	0.0109	0.0134	0.0029	0.0047	0.0000
1994	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0032	0.0095	0.0409	0.0721	0.0904	0.1145	0.0903	0.0363	0.0275	0.0029	0.0049	0.0052	0.0010	0.0010	0.0000
1995	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0013	0.0028	0.0061	0.0248	0.0620	0.0919	0.0885	0.0846	0.0350	0.0519	0.0079	0.0274	0.0093	0.0000	0.0064	0.0000	0.0000
1996	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0032	0.0137	0.0321	0.0454	0.0485	0.1013	0.0938	0.0752	0.0441	0.0261	0.0127	0.0032	0.0000	0.0000	0.0006	0.0000
1997	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0029	0.0048	0.0225	0.0280	0.0470	0.0560	0.0826	0.0817	0.0382	0.0539	0.0326	0.0281	0.0105	0.0082	0.0019	0.0006
1998	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020	0.0028	0.0050	0.0103	0.0228	0.0444	0.0807	0.1262	0.0933	0.0546	0.0350	0.0129	0.0080	0.0007	0.0014	0.0000
1999	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0070	0.0136	0.0181	0.0481	0.0562	0.0598	0.0778	0.0590	0.0521	0.0504	0.0284	0.0090	0.0066	0.0052	0.0026	0.0030	0.0010
2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0009	0.0032	0.0019	0.0053	0.0108	0.0171	0.0251	0.0452	0.0753	0.1015	0.0691	0.0484	0.0676	0.0144	0.0106	0.0015	0.0021	0.0000
2001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0164	0.0441	0.0419	0.0147	0.0327	0.0695	0.0691	0.0655	0.0668	0.0373	0.0113	0.0191	0.0011	0.0103	0.0000
2002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0009	0.0000	0.0000	0.0081	0.0000	0.0084	0.0145	0.0506	0.0088	0.1227	0.1146	0.0707	0.0475	0.0411	0.0000	0.0000	0.0120	0.0000
2003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0051	0.0000	0.0112	0.0018	0.0029	0.0178	0.0078	0.0085	0.0252	0.0880	0.1067	0.0969	0.0428	0.0337	0.0354	0.0154	0.0010	0.0000
2004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0090	0.0077	0.0255	0.0575	0.0772	0.0597	0.0504	0.0824	0.0357	0.0230	0.0126	0.0496	0.0044	0.0042
2005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0213	0.0213	0.0000	0.1382	0.1169	0.0213	0.1169	0.0427	0.0000	0.0213	0.0000	0.0000	0.0000
2006	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1147	0.1146	0.0003	0.0175	0.0034	0.0002	0.1146	0.1146	0.0139	0.0000	0.0000	0.0000	0.0000	0.0000	0.0060
2007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0371	0.0371	0.0397	0.0026	0.0371	0.0371	0.0741	0.0397	0.0397	0.1138	0.0397	0.0000	0.0026	0.0000
2008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0084	0.0360	0.0360	0.1159	0.0175	0.1519	0.0984	0.0360	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2009	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0465	0.0049	0.0025	0.0442	0.0313	0.1226	0.1314	0.0590	0.0136	0.0000	0.0000	0.0441	0.0000
2010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0038	0.0054	0.0086	0.0091	0.0097	0.0136	0.0194	0.0266	0.0443	0.1161	0.0752	0.0801	0.0623	0.0181	0.0078	0.0000	0.0000
2011	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0040	0.0000	0.0190	0.0000	0.0660	0.0710	0.0389	0.1033	0.0569	0.0464	0.0204	0.0174	0.0425	0.0000	0.0141	0.0000

Table 5.4. Sample sizes for Dover sole (only): a) sample sizes for size compositions and otolith collections from the domestic fishery and b) sample sizes for estimated biomass, age and size compositions from the GOA groundfish survey.

a). Fishery size compositions and otolith collections.

year	Size compositions				Age compositions				
	hauls	total indiv.s	females	males	hauls	total indiv.s	females	males	otoliths collected
1990	35	3041	24	225					--
1991	36	2539	443	636					295
1992	53	3071	197	171					280
1993	44	2045	631	823					40
1994	64	3027	433	1353					50
1995	116	4069	561	904					40
1996	40	2678	730	693					79
1997	47	2524	866	1460					--
1998	72	2483	863	1193					320
1999	62	1225	625	595					159
2000	52	964	347	556					125
2001	44	811	280	433					65
2002	15	277	69	208					47
2003	27	415	140	275					54
2004	33	625	230	395					56
2005	2	12	10	2					13
2006	5	48	18	30					20
2007	2	40	20	20					11
2008	5	44	11	33					16
2009	6	80	29	51					26
2010	17	284	89	195					31
2011	10	135	36	99					24

b). GOA groundfish surveys.

year	biomass	Size compositions				Age compositions				
	total hauls	hauls	total indiv.s	females	males	hauls	total indiv.s	females	males	otoliths collected
1984	929	284	11298	3828	6271	13	464	209	255	464
1987	783	80	5180	2308	2872	16	359	212	147	637
1990	708	195	7435	4034	3401					213
1993	775	321	10491	4866	5316	35	252	147	105	257
1996	807	406	7125	3239	3886	66	383	213	170	400
1999	764	363	6580	2573	3961	55	310	162	148	365
2001	489	183	1940	965	975	129	535	296	239	553
2003	809	387	6729	2893	3785	99	504	266	238	510
2005	839	440	7272	3003	4269	103	514	273	241	530
2007	820	426	5929	2466	3461	64	371	188	183	385
2009	823	415	6356	2633	3718	97	466	238	228	470
2011	670	308	4629	1988	2615					473

Table 5.5a. Biomass estimates (t) for GOA deepwater flatfish by NPFMC regulatory area from the NMFS groundfish trawl surveys. Note that the Eastern Gulf (West Yakutat + Southeast) was not surveyed in 2001. Maximum survey depth coverage and the assumed availability of Dover sole to each survey are given in the first table, as well.

1) Dover sole.

Year	Western Gulf	Central Gulf	West Yakutat	Southeast	Total	Std. Dev	Max Depth (m)	Assumed availability
1984	4,460	52,469	7,516	4,076	68,521	6,136	1000	1
1987	2,623	34,577	21,067	5,127	63,394	7,388	1000	1
1990	1,649	71,109	18,699	5,140	96,597	12,375	500	0.82
1993	2,371	43,515	26,877	12,787	85,549	6,441	500	0.82
1996	1,458	37,144	29,766	11,162	79,531	5,624	500	0.82
1999	1,442	34,155	25,647	13,001	74,245	5,236	1000	1
2001	895	31,529	--	--	32,424	3,758	500	0.42
2003	3,149	49,283	31,609	15,256	99,297	10,544	700	1
2005	2,832	38,881	25,177	13,647	80,538	6,794	1000	1
2007	2,325	43,490	13,690	12,120	71,624	7,112	1000	1
2009	5,067	35,820	25,838	9,551	76,277	6,437	1000	1
2011	833	35,548	24,678	16,473	77,531	7,398	700	1

2) Greenland turbot

Year	Western Gulf	Central Gulf	West Yakutat	Southeast	Total	Std. Dev
1984	108	184	0	0	292	87
1987	76	67	0	0	143	61
1990	0	0	0	0	0	0
1993	0	0	0	0	0	0
1996	0	0	0	0	0	0
1999	0	0	--	--	0	0
2001	0	0	0	0	0	0
2003	109	0	0	0	109	108
2005	0	0	0	0	0	0
2007	122	0	0	0	122	122
2009	0	0	0	0	0	0
2011	0	0	0	0	0	0

3) Deepsea sole.

Year	Western Gulf	Central Gulf	West Yakutat	Southeast	Total	Std. Dev
1984	0	28	0	190	218	15
1987	0	5	8	147	160	45
1990	0	0	0	0	0	0
1993	0	0	0	0	0	0
1996	0	0	0	0	0	0
1999	0	97	0	0	97	34
2001	0	52	0	0	52	52
2003	12	117	32	19	180	122
2005	0	140	102	20	262	133
2007	0	208	35	30	274	88
2009	0	188	0	60	249	112
2011	0	0	0	41	41	26

Table 5.5b. Biomass estimates (t) for GOA deepwater flatfish by depth strata from the NMFS groundfish trawl surveys. Note that the Eastern Gulf (West Yakutat + Southeast) was not surveyed in 2001.

1) Dover sole.

year	Depth strata (m)				
	1-100	100-200	200-300	300-500	>500
1984	2,829	30,220	7,928	6,822	20,723
1987	4,401	25,831	12,039	8,934	12,189
1990	12,290	57,774	19,985	6,549	--
1993	4,760	43,999	19,930	16,861	--
1996	6,561	37,856	18,101	17,013	--
1999	6,431	28,549	19,576	12,317	7,372
2001	3,803	16,294	7,491	4,836	--
2003	10,154	45,181	17,832	13,593	12,537
2005	6,654	32,613	17,675	17,774	5,823
2007	2,814	29,709	19,598	11,335	8,168
2009	6,534	26,486	23,685	9,300	10,271
2011	4,422	24,739	26,241	19,416	2,714

2) Greenland turbot

year	Depth strata (m)				
	1-100	100-200	200-300	300-500	>500
1984	0	0	1	204	87
1987	0	25	0	19	99
1990	0	0	0	0	--
1993	0	0	0	0	--
1996	0	0	0	0	--
1999	0	0	0	0	0
2001	0	0	0	0	--
2003	0	0	0	109	0
2005	0	0	0	0	0
2007	0	0	0	0	122
2009	0	0	0	0	0
2011	0	0	0	0	0

3) Deepsea sole.

year	Depth strata (m)				
	1-100	100-200	200-300	300-500	>500
1984	0	0	0	0	218
1987	0	0	0	0	160
1990	0	0	0	0	--
1993	0	0	0	0	--
1996	0	0	0	0	--
1999	0	0	0	0	97
2001	0	0	0	52	--
2003	0	0	0	0	180
2005	0	0	0	0	262
2007	0	0	0	8	265
2009	0	0	0	0	249
2011	0	0	0	0	41

Table 5.6a. Survey age compositions for Dover sole: females. Age 40 is a plus group.

Age bin	Year 1984	1987	1993	1996	1999	2001	2003	2005	2007	2009
3	0	0	175	307	115	153	2,009	1,586	198	0
4	0	232	590	501	1,053	602	5,285	992	1,397	727
5	3,027	2,627	1,973	2,117	3,131	969	4,851	3,370	1,083	2,466
6	6,099	590	1,332	507	1,612	1,166	4,606	5,721	1,789	2,513
7	2,296	2,151	1,500	544	751	692	2,516	2,695	1,988	2,283
8	1,267	5,095	886	1,224	1,085	680	3,176	3,718	2,905	2,141
9	331	5,014	1,869	2,313	1,386	249	1,385	839	2,586	3,058
10	967	3,728	2,525	643	524	505	2,121	1,642	1,070	3,525
11	340	2,193	2,439	1,854	1,594	180	1,849	1,928	879	2,652
12	212	1,162	2,356	2,664	762	0	1,624	367	1,451	1,381
13	1,204	1,326	2,691	2,178	1,820	189	1,063	811	875	1,410
14	1,050	930	3,036	751	994	168	1,359	1,030	853	1,381
15	2,078	1,578	2,262	2,756	2,732	304	1,180	462	950	459
16	627	708	64	1,695	2,765	38	1,083	686	199	1,461
17	1,429	383	1,190	1,228	1,184	616	250	356	964	787
18	1,147	2,230	1,292	1,092	854	553	973	922	867	404
19	852	1,102	140	1,665	854	188	1,219	1,296	594	507
20	2,601	927	718	3,328	879	319	583	716	708	890
21	1,203	866	2,842	2,371	214	335	2,057	2,054	679	426
22	1,858	452	68	1,032	2,100	238	1,719	1,707	791	1,103
23	2,657	1,140	338	590	1,505	188	1,287	1,176	455	294
24	1,403	1,310	1,915	1,235	662	721	1,023	806	487	1,479
25	2,698	770	1,630	1,120	973	456	807	602	1,065	219
26	1,450	691	1,432	360	616	351	747	684	450	634
27	478	1,078	2,025	1,136	1,140	334	1,347	823	425	609
28	740	578	462	1,114	327	89	1,112	276	383	553
29	1,460	212	1,457	496	319	177	680	418	794	606
30	298	104	1,765	1,333	514	480	582	254	732	503
31	728	0	162	0	297	626	968	168	590	385
32	526	264	2,558	1,710	347	172	128	677	548	261
33	254	0	1,312	654	1,246	397	558	359	244	798
34	169	492	1,064	471	756	429	306	554	54	635
35	0	78	436	0	536	205	394	452	403	108
36	807	59	268	155	0	348	462	332	260	584
37	212	223	451	986	359	237	624	671	1,220	707
38	0	0	1,258	937	604	632	774	673	355	135
39	0	0	547	386	0	418	232	261	1,231	542
40	174	0	415	1,967	4,465	1,872	5,979	5,201	5,825	3,835

Table 5.6b. Survey age compositions for Dover sole: males. Age 40 is a plus group.

Age bin	Year 1984	1987	1993	1996	1999	2001	2003	2005	2007	2009
3	367	68	1,538	275	551	300	1,746	1,236	803	0
4	304	371	2,408	1,125	2,910	989	7,903	1,000	648	1,090
5	2,937	1,676	4,084	3,362	3,415	1,710	5,282	6,882	2,571	6,188
6	8,572	3,717	2,699	2,317	2,456	1,529	7,926	8,562	1,502	3,199
7	5,069	2,261	4,722	2,126	804	1,311	4,847	3,913	2,809	2,566
8	2,611	6,598	5,201	2,167	2,017	680	4,343	1,676	3,000	2,710
9	788	7,440	2,811	2,813	880	521	1,027	2,898	3,915	3,616
10	776	2,213	3,355	1,523	750	448	2,933	1,667	1,574	1,556
11	924	975	1,102	1,381	1,025	187	1,663	1,847	2,076	3,288
12	1,055	929	2,306	4,437	1,235	57	1,470	584	1,969	2,057
13	525	286	1,311	5,056	531	0	2,487	1,878	2,842	2,363
14	812	1,187	1,144	3,900	1,452	210	1,763	947	1,145	829
15	2,288	321	2,185	2,832	76	449	1,502	1,141	852	1,146
16	2,340	810	1,168	2,450	1,392	311	0	1,389	880	1,035
17	2,221	816	963	629	624	396	2,298	976	876	490
18	2,105	1,202	663	1,552	2,541	122	640	702	945	689
19	1,817	1,212	595	1,792	76	436	1,666	305	476	831
20	1,912	2,747	141	1,252	491	426	832	1,623	955	656
21	2,463	850	1,508	1,571	2,451	62	1,678	1,055	818	516
22	1,849	642	769	580	1,447	103	1,518	1,742	0	511
23	3,244	1,357	965	652	2,114	233	999	2,291	221	812
24	1,634	1,565	2,820	0	2,935	333	1,448	411	490	606
25	3,629	365	323	343	921	434	1,902	728	1,266	1,170
26	2,209	304	721	0	2,185	97	4,783	1,163	843	1,559
27	1,571	1,472	516	499	833	266	460	1,411	701	762
28	883	522	0	118	458	282	134	370	1,239	964
29	441	0	135	1,641	1,136	0	713	386	326	1,281
30	778	284	516	0	1,393	117	517	343	570	1,148
31	682	0	721	0	837	69	664	39	0	247
32	849	0	626	0	1,141	236	794	401	856	555
33	934	591	0	0	1,024	212	1,407	504	426	436
34	250	0	0	0	524	662	644	786	725	680
35	157	0	769	0	1,531	348	1,046	1,097	469	537
36	0	0	287	631	1,503	736	664	316	836	247
37	0	0	287	55	1,317	381	435	159	519	2,107
38	0	0	287	0	255	448	301	1,427	797	1,054
39	0	0	0	66	1,675	441	651	473	692	78
40	811	0	0	325	6,045	1,439	9,062	6,776	6,721	6,850

Table 5.7. Survey length compositions for Dover sole (only). Survey length compositions from all years except 1984 and 2011 were de-weighted in fitting the assessment model because age compositions were available for these years.

a) Females.

year	Length bin cutpoints (cm)																			
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56
1984	0	0	0	57	103	770	1,380	2,521	3,523	4,472	5,530	6,600	5,515	4,126	3,205	2,297	1,616	918	697	184
1987	0	45	236	69	148	307	495	1,027	1,907	2,767	4,772	6,098	6,139	6,028	4,393	3,058	1,740	1,376	524	279
1990	23	23	23	14	41	173	500	808	1,178	2,347	3,233	5,507	7,595	10,100	8,525	7,074	6,798	2,907	1,250	846
1993	0	0	11	73	183	247	650	968	1,387	1,677	2,257	3,460	5,314	6,987	8,764	6,453	5,151	3,307	1,562	1,000
1996	93	113	185	300	324	399	521	989	1,621	1,731	2,234	2,358	3,288	4,435	5,755	6,347	5,787	4,286	2,546	1,484
1999	53	133	154	390	614	1,362	1,878	1,437	1,804	2,044	2,297	2,771	3,316	3,514	4,080	4,118	4,775	3,327	2,139	1,284
2001	102	73	59	47	236	416	340	381	603	757	653	501	505	785	1,117	1,589	1,584	1,870	1,717	954
2003	2,262	1,401	1,702	1,416	1,552	2,242	2,756	2,283	2,536	4,031	3,668	3,983	4,002	4,705	4,302	3,893	4,461	3,478	2,885	1,806
2005	133	162	578	724	908	1,856	2,413	2,592	3,676	3,828	3,338	3,709	3,238	3,032	3,193	2,885	2,682	2,824	2,295	1,748
2007	71	139	442	681	920	1,025	1,128	1,220	1,873	2,364	2,240	2,910	3,582	3,475	3,225	2,820	2,648	3,198	2,277	1,589
2009	252	292	555	504	622	843	1,554	2,507	2,694	3,111	2,642	3,114	3,256	4,019	4,020	3,268	3,462	1,992	1,950	1,084
2011	108	158	208	260	318	702	722	1,267	1,630	2,239	2,906	3,925	3,335	3,891	3,712	3,622	3,073	3,039	1,891	1,399

b) Males.

year	Length bin cutpoints (cm)																			
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56
1984	0	0	42	300	815	1,977	3,424	7,462	13,140	13,923	9,558	5,446	2,543	1,310	429	120	71	143	10	102
1987	0	0	84	73	303	940	1,354	2,592	6,251	8,146	9,794	7,360	4,083	1,997	876	430	222	0	14	0
1990	0	37	20	42	80	619	917	2,264	3,832	6,828	10,361	11,752	9,519	3,741	1,410	787	695	326	49	0
1993	13	36	50	141	200	605	994	1,822	4,317	6,813	9,588	10,428	7,949	4,589	1,884	921	334	97	67	0
1996	25	140	132	326	452	514	1,286	2,239	3,871	6,314	8,310	9,526	7,493	4,119	1,842	674	309	91	23	5
1999	90	18	504	841	1,266	1,965	2,608	3,365	3,774	5,707	8,411	9,447	7,077	5,435	3,223	1,217	560	205	26	24
2001	49	26	71	111	232	564	879	924	1,424	896	1,721	2,705	2,833	2,084	1,382	531	353	183	67	0
2003	1,659	1,431	2,126	2,008	2,682	3,400	3,540	3,973	4,961	5,980	9,086	10,931	10,660	8,671	5,369	2,966	1,569	417	65	65
2005	91	276	656	937	1,407	2,017	2,876	4,358	5,636	6,546	8,029	8,128	7,493	6,184	3,406	1,967	1,023	218	105	12
2007	38	383	474	686	712	1,577	1,998	2,541	3,065	4,620	6,611	7,745	6,507	5,331	3,837	1,834	791	326	108	5
2009	211	211	533	614	1,045	1,367	2,892	3,780	4,372	4,874	6,286	8,740	7,793	6,723	4,169	1,851	896	402	91	0
2011	0	151	67	229	557	1,013	1,744	2,899	4,091	4,826	6,520	7,805	7,100	7,408	4,342	2,918	911	399	141	71

Table 5.8a. Age-length transition matrix for female Dover sole. Values at a row/column combination correspond to the fraction of individuals at the age indicated by the row that fall into the length group indicated by the column.

	Length cutpoints (cm)																								
age	**18**	**20**	**22**	**24**	**26**	**28**	**30**	**32**	**34**	**36**	**38**	**40**	**42**	**44**	**46**	**48**	**50**	**52**	**54**	**56**	**58**	**60**	**62**	**64**	**66**
3	0.0265	0.0654	0.1430	0.2188	0.2343	0.1756	0.0922	0.0338	0.0087	0.0016	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0053	0.0170	0.0493	0.1074	0.1750	0.2135	0.1951	0.1335	0.0683	0.0262	0.0075	0.0016	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0013	0.0048	0.0165	0.0439	0.0915	0.1495	0.1913	0.1915	0.1502	0.0922	0.0443	0.0167	0.0049	0.0011	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0004	0.0016	0.0060	0.0181	0.0439	0.0863	0.1370	0.1757	0.1821	0.1524	0.1031	0.0563	0.0249	0.0089	0.0026	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0002	0.0006	0.0025	0.0080	0.0215	0.0477	0.0874	0.1327	0.1664	0.1725	0.1478	0.1047	0.0613	0.0297	0.0119	0.0039	0.0011	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0001	0.0003	0.0011	0.0039	0.0111	0.0268	0.0544	0.0929	0.1334	0.1610	0.1636	0.1397	0.1004	0.0607	0.0308	0.0132	0.0047	0.0014	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0001	0.0006	0.0020	0.0062	0.0158	0.0344	0.0639	0.1013	0.1368	0.1576	0.1547	0.1294	0.0923	0.0561	0.0291	0.0128	0.0048	0.0016	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0001	0.0003	0.0012	0.0037	0.0098	0.0224	0.0444	0.0758	0.1115	0.1412	0.1540	0.1447	0.1171	0.0817	0.0491	0.0254	0.0113	0.0043	0.0014	0.0004	0.0001	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0002	0.0007	0.0023	0.0064	0.0152	0.0317	0.0572	0.0896	0.1222	0.1446	0.1487	0.1329	0.1031	0.0695	0.0407	0.0207	0.0092	0.0035	0.0012	0.0003	0.0001	0.0000	0.0000
12	0.0000	0.0000	0.0001	0.0005	0.0015	0.0044	0.0108	0.0232	0.0438	0.0723	0.1043	0.1317	0.1454	0.1405	0.1187	0.0877	0.0567	0.0321	0.0159	0.0069	0.0026	0.0009	0.0002	0.0001	0.0000
13	0.0000	0.0000	0.0001	0.0003	0.0011	0.0031	0.0079	0.0175	0.0343	0.0588	0.0889	0.1182	0.1382	0.1421	0.1286	0.1023	0.0716	0.0441	0.0239	0.0114	0.0048	0.0018	0.0006	0.0002	0.0001
14	0.0000	0.0000	0.0001	0.0002	0.0008	0.0023	0.0060	0.0137	0.0274	0.0486	0.0763	0.1057	0.1294	0.1401	0.1340	0.1133	0.0846	0.0559	0.0326	0.0168	0.0077	0.0031	0.0011	0.0003	0.0001
15	0.0000	0.0000	0.0000	0.0002	0.0006	0.0018	0.0047	0.0109	0.0224	0.0408	0.0660	0.0946	0.1204	0.1359	0.1360	0.1209	0.0953	0.0666	0.0413	0.0228	0.0111	0.0048	0.0019	0.0006	0.0003
16	0.0000	0.0000	0.0000	0.0001	0.0005	0.0014	0.0038	0.0090	0.0187	0.0349	0.0578	0.0852	0.1118	0.1306	0.1359	0.1258	0.1037	0.0761	0.0497	0.0289	0.0149	0.0069	0.0028	0.0010	0.0005
17	0.0000	0.0000	0.0000	0.0001	0.0004	0.0012	0.0032	0.0075	0.0160	0.0302	0.0511	0.0772	0.1040	0.1251	0.1343	0.1287	0.1101	0.0841	0.0573	0.0349	0.0189	0.0092	0.0040	0.0015	0.0008
18	0.0000	0.0000	0.0000	0.0001	0.0003	0.0010	0.0027	0.0064	0.0138	0.0266	0.0458	0.0705	0.0971	0.1197	0.1320	0.1302	0.1150	0.0908	0.0642	0.0406	0.0230	0.0116	0.0053	0.0021	0.0011
19	0.0000	0.0000	0.0000	0.0001	0.0003	0.0009	0.0023	0.0056	0.0122	0.0238	0.0415	0.0649	0.0911	0.1146	0.1292	0.1307	0.1185	0.0963	0.0702	0.0459	0.0269	0.0141	0.0066	0.0028	0.0016
20	0.0000	0.0000	0.0000	0.0001	0.0002	0.0008	0.0020	0.0050	0.0109	0.0215	0.0379	0.0602	0.0858	0.1099	0.1263	0.1305	0.1210	0.1008	0.0754	0.0507	0.0306	0.0166	0.0081	0.0035	0.0021
21	0.0000	0.0000	0.0000	0.0001	0.0002	0.0007	0.0018	0.0045	0.0099	0.0196	0.0351	0.0563	0.0813	0.1057	0.1235	0.1298	0.1228	0.1044	0.0799	0.0550	0.0340	0.0190	0.0095	0.0043	0.0027
22	0.0000	0.0000	0.0000	0.0001	0.0002	0.0006	0.0017	0.0041	0.0091	0.0181	0.0327	0.0530	0.0774	0.1019	0.1208	0.1289	0.1240	0.1074	0.0837	0.0588	0.0372	0.0212	0.0109	0.0050	0.0033
23	0.0000	0.0000	0.0000	0.0001	0.0002	0.0006	0.0015	0.0038	0.0084	0.0169	0.0307	0.0502	0.0741	0.0985	0.1182	0.1279	0.1248	0.1097	0.0870	0.0622	0.0401	0.0233	0.0122	0.0058	0.0039
24	0.0000	0.0000	0.0000	0.0000	0.0002	0.0005	0.0014	0.0035	0.0078	0.0159	0.0290	0.0478	0.0712	0.0956	0.1159	0.1268	0.1252	0.1116	0.0898	0.0652	0.0427	0.0253	0.0135	0.0065	0.0045
25	0.0000	0.0000	0.0000	0.0000	0.0002	0.0005	0.0013	0.0033	0.0074	0.0150	0.0276	0.0458	0.0687	0.0930	0.1138	0.1257	0.1255	0.1132	0.0922	0.0678	0.0451	0.0271	0.0147	0.0072	0.0051
26	0.0000	0.0000	0.0000	0.0000	0.0001	0.0004	0.0012	0.0031	0.0070	0.0143	0.0264	0.0441	0.0665	0.0907	0.1118	0.1247	0.1256	0.1144	0.0942	0.0701	0.0472	0.0287	0.0158	0.0078	0.0057
27	0.0000	0.0000	0.0000	0.0000	0.0001	0.0004	0.0012	0.0030	0.0067	0.0137	0.0254	0.0426	0.0646	0.0887	0.1101	0.1236	0.1256	0.1154	0.0959	0.0721	0.0490	0.0302	0.0168	0.0084	0.0063
28	0.0000	0.0000	0.0000	0.0000	0.0001	0.0004	0.0011	0.0028	0.0064	0.0132	0.0246	0.0413	0.0630	0.0870	0.1086	0.1227	0.1255	0.1162	0.0974	0.0738	0.0507	0.0315	0.0177	0.0090	0.0069
29	0.0000	0.0000	0.0000	0.0000	0.0001	0.0004	0.0011	0.0027	0.0062	0.0128	0.0238	0.0403	0.0616	0.0854	0.1072	0.1218	0.1254	0.1169	0.0986	0.0754	0.0522	0.0327	0.0185	0.0095	0.0074
30	0.0000	0.0000	0.0000	0.0000	0.0001	0.0004	0.0010	0.0026	0.0060	0.0124	0.0232	0.0393	0.0604	0.0841	0.1060	0.1211	0.1253	0.1174	0.0997	0.0767	0.0534	0.0337	0.0193	0.0100	0.0078
31	0.0000	0.0000	0.0000	0.0000	0.0001	0.0004	0.0010	0.0026	0.0058	0.0121	0.0226	0.0385	0.0593	0.0829	0.1049	0.1203	0.1251	0.1178	0.1006	0.0779	0.0546	0.0347	0.0200	0.0104	0.0083
32	0.0000	0.0000	0.0000	0.0000	0.0001	0.0004	0.0010	0.0025	0.0057	0.0118	0.0222	0.0378	0.0584	0.0818	0.1040	0.1197	0.1249	0.1182	0.1014	0.0789	0.0556	0.0355	0.0206	0.0108	0.0087
33	0.0000	0.0000	0.0000	0.0000	0.0001	0.0003	0.0010	0.0024	0.0056	0.0116	0.0218	0.0372	0.0576	0.0809	0.1031	0.1191	0.1248	0.1185	0.1021	0.0797	0.0565	0.0363	0.0211	0.0112	0.0091
34	0.0000	0.0000	0.0000	0.0000	0.0001	0.0003	0.0009	0.0024	0.0055	0.0114	0.0214	0.0367	0.0569	0.0801	0.1024	0.1186	0.1246	0.1188	0.1027	0.0805	0.0573	0.0370	0.0216	0.0115	0.0094
35	0.0000	0.0000	0.0000	0.0000	0.0001	0.0003	0.0009	0.0023	0.0054	0.0112	0.0211	0.0362	0.0563	0.0794	0.1017	0.1181	0.1245	0.1190	0.1032	0.0812	0.0580	0.0375	0.0221	0.0118	0.0097
36	0.0000	0.0000	0.0000	0.0000	0.0001	0.0003	0.0009	0.0023	0.0053	0.0110	0.0208	0.0358	0.0558	0.0788	0.1011	0.1177	0.1243	0.1192	0.1036	0.0818	0.0586	0.0381	0.0224	0.0120	0.0100
37	0.0000	0.0000	0.0000	0.0000	0.0001	0.0003	0.0009	0.0023	0.0052	0.0109	0.0206	0.0354	0.0553	0.0783	0.1006	0.1173	0.1242	0.1193	0.1040	0.0823	0.0591	0.0385	0.0228	0.0122	0.0102
38	0.0000	0.0000	0.0000	0.0000	0.0001	0.0003	0.0009	0.0022	0.0052	0.0108	0.0204	0.0351	0.0549	0.0778	0.1001	0.1170	0.1241	0.1194	0.1044	0.0828	0.0596	0.0389	0.0231	0.0124	0.0104
39	0.0000	0.0000	0.0000	0.0000	0.0001	0.0003	0.0009	0.0022	0.0051	0.0107	0.0202	0.0349	0.0545	0.0774	0.0997	0.1167	0.1240	0.1195	0.1046	0.0832	0.0600	0.0393	0.0234	0.0126	0.0106
40	0.0000	0.0000	0.0000	0.0000	0.0001	0.0003	0.0009	0.0022	0.0051	0.0106	0.0201	0.0346	0.0542	0.0770	0.0994	0.1164	0.1239	0.1196	0.1049	0.0835	0.0604	0.0396	0.0236	0.0128	0.0108

Table 5.8b. Age-length transition matrix for male Dover sole. Values at a row/column combination correspond to the fraction of individuals at the age indicated by the row that fall into the length group indicated by the column.

	Length cutpoints (cm)																								
age	**18**	**20**	**22**	**24**	**26**	**28**	**30**	**32**	**34**	**36**	**38**	**40**	**42**	**44**	**46**	**48**	**50**	**52**	**54**	**56**	**58**	**60**	**62**	**64**	**66**
3	0.0296	0.0688	0.1453	0.2171	0.2298	0.1723	0.0915	0.0344	0.0092	0.0017	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0063	0.0192	0.0541	0.1141	0.1804	0.2139	0.1900	0.1266	0.0632	0.0237	0.0066	0.0014	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0017	0.0061	0.0202	0.0523	0.1050	0.1639	0.1988	0.1872	0.1370	0.0778	0.0343	0.0118	0.0031	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0006	0.0022	0.0083	0.0246	0.0578	0.1081	0.1608	0.1900	0.1785	0.1333	0.0791	0.0373	0.0140	0.0042	0.0010	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0002	0.0009	0.0038	0.0124	0.0327	0.0695	0.1192	0.1650	0.1845	0.1665	0.1214	0.0715	0.0340	0.0130	0.0040	0.0010	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0001	0.0005	0.0019	0.0068	0.0195	0.0456	0.0869	0.1352	0.1717	0.1779	0.1505	0.1038	0.0585	0.0269	0.0101	0.0031	0.0008	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0001	0.0002	0.0011	0.0040	0.0123	0.0310	0.0642	0.1093	0.1529	0.1758	0.1662	0.1291	0.0825	0.0433	0.0187	0.0066	0.0019	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0001	0.0006	0.0025	0.0082	0.0220	0.0487	0.0889	0.1342	0.1674	0.1724	0.1467	0.1031	0.0599	0.0287	0.0114	0.0037	0.0010	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0001	0.0004	0.0017	0.0057	0.0162	0.0379	0.0734	0.1179	0.1569	0.1730	0.1581	0.1196	0.0750	0.0390	0.0168	0.0060	0.0018	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
12	0.0000	0.0001	0.0003	0.0012	0.0042	0.0123	0.0302	0.0617	0.1044	0.1465	0.1707	0.1650	0.1324	0.0881	0.0487	0.0223	0.0085	0.0027	0.0007	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
13	0.0000	0.0000	0.0002	0.0008	0.0031	0.0096	0.0247	0.0527	0.0933	0.1370	0.1671	0.1691	0.1421	0.0991	0.0574	0.0276	0.0110	0.0036	0.0010	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
14	0.0000	0.0000	0.0001	0.0006	0.0024	0.0077	0.0207	0.0458	0.0843	0.1287	0.1631	0.1715	0.1496	0.1083	0.0650	0.0324	0.0134	0.0046	0.0013	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000
15	0.0000	0.0000	0.0001	0.0005	0.0019	0.0063	0.0176	0.0404	0.0770	0.1216	0.1592	0.1728	0.1554	0.1158	0.0716	0.0366	0.0156	0.0055	0.0016	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0001	0.0004	0.0015	0.0053	0.0152	0.0361	0.0710	0.1156	0.1557	0.1736	0.1601	0.1221	0.0771	0.0403	0.0174	0.0062	0.0018	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0001	0.0003	0.0012	0.0045	0.0133	0.0326	0.0660	0.1105	0.1527	0.1742	0.1640	0.1274	0.0817	0.0433	0.0189	0.0068	0.0020	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000	0.0002	0.0010	0.0038	0.0117	0.0296	0.0619	0.1062	0.1501	0.1747	0.1673	0.1319	0.0856	0.0457	0.0201	0.0073	0.0022	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000	0.0002	0.0008	0.0033	0.0104	0.0272	0.0583	0.1025	0.1480	0.1752	0.1703	0.1358	0.0888	0.0477	0.0210	0.0076	0.0022	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0001	0.0007	0.0028	0.0093	0.0251	0.0552	0.0994	0.1462	0.1759	0.1730	0.1391	0.0915	0.0492	0.0216	0.0078	0.0023	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000
21	0.0000	0.0000	0.0000	0.0001	0.0006	0.0025	0.0084	0.0233	0.0526	0.0967	0.1448	0.1767	0.1756	0.1421	0.0937	0.0503	0.0220	0.0078	0.0023	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0001	0.0005	0.0021	0.0076	0.0217	0.0502	0.0943	0.1437	0.1776	0.1781	0.1448	0.0955	0.0511	0.0222	0.0078	0.0022	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000
23	0.0000	0.0000	0.0000	0.0001	0.0004	0.0019	0.0069	0.0202	0.0480	0.0922	0.1428	0.1787	0.1805	0.1472	0.0970	0.0515	0.0221	0.0077	0.0021	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000
24	0.0000	0.0000	0.0000	0.0001	0.0003	0.0016	0.0062	0.0189	0.0461	0.0903	0.1422	0.1799	0.1830	0.1495	0.0981	0.0518	0.0219	0.0075	0.0020	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000	0.0003	0.0014	0.0056	0.0177	0.0443	0.0886	0.1417	0.1813	0.1854	0.1516	0.0991	0.0518	0.0216	0.0072	0.0019	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000
26	0.0000	0.0000	0.0000	0.0000	0.0002	0.0013	0.0051	0.0166	0.0426	0.0870	0.1414	0.1828	0.1878	0.1535	0.0998	0.0516	0.0212	0.0069	0.0018	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000
27	0.0000	0.0000	0.0000	0.0000	0.0002	0.0011	0.0046	0.0155	0.0410	0.0855	0.1412	0.1844	0.1903	0.1554	0.1003	0.0512	0.0206	0.0066	0.0017	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000
28	0.0000	0.0000	0.0000	0.0000	0.0002	0.0010	0.0042	0.0145	0.0394	0.0841	0.1411	0.1861	0.1929	0.1571	0.1006	0.0506	0.0200	0.0062	0.0015	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000
29	0.0000	0.0000	0.0000	0.0000	0.0001	0.0008	0.0038	0.0136	0.0379	0.0828	0.1411	0.1879	0.1955	0.1588	0.1008	0.0500	0.0194	0.0059	0.0014	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000
30	0.0000	0.0000	0.0000	0.0000	0.0001	0.0007	0.0034	0.0127	0.0365	0.0815	0.1411	0.1898	0.1981	0.1604	0.1009	0.0492	0.0186	0.0055	0.0012	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
31	0.0000	0.0000	0.0000	0.0000	0.0001	0.0006	0.0031	0.0118	0.0351	0.0802	0.1412	0.1918	0.2008	0.1620	0.1008	0.0483	0.0178	0.0051	0.0011	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
32	0.0000	0.0000	0.0000	0.0000	0.0001	0.0005	0.0027	0.0110	0.0337	0.0788	0.1413	0.1939	0.2035	0.1636	0.1006	0.0473	0.0170	0.0047	0.0010	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
33	0.0000	0.0000	0.0000	0.0000	0.0001	0.0004	0.0025	0.0102	0.0323	0.0775	0.1415	0.1960	0.2064	0.1650	0.1003	0.0463	0.0162	0.0043	0.0009	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
34	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0022	0.0094	0.0309	0.0762	0.1416	0.1983	0.2093	0.1665	0.0998	0.0451	0.0154	0.0039	0.0008	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
35	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0019	0.0087	0.0296	0.0749	0.1417	0.2006	0.2123	0.1679	0.0993	0.0439	0.0145	0.0036	0.0007	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
36	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0017	0.0080	0.0282	0.0735	0.1418	0.2030	0.2153	0.1693	0.0987	0.0426	0.0137	0.0032	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
37	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0015	0.0074	0.0269	0.0720	0.1419	0.2054	0.2185	0.1707	0.0980	0.0413	0.0128	0.0029	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
38	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0013	0.0067	0.0255	0.0706	0.1420	0.2079	0.2217	0.1720	0.0972	0.0399	0.0119	0.0026	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
39	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0011	0.0061	0.0242	0.0690	0.1420	0.2105	0.2250	0.1733	0.0962	0.0385	0.0111	0.0023	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
40	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0010	0.0055	0.0229	0.0674	0.1420	0.2132	0.2284	0.1746	0.0952	0.0370	0.0103	0.0020	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 5.9. Age-specific schedules for Dover sole in the Gulf of Alaska. Maturity ogive is based on Abookire and Macewicz (2003).

	Length (cm)		Weight (kg)		Maturity
Age	Males	Females	Males	Females	ogive
3	26.3	26.4	0.16	0.16	0
4	29.2	29.4	0.22	0.21	0.0001
5	31.5	32.0	0.31	0.32	0.0006
6	33.5	34.4	0.38	0.42	0.0027
7	35.0	36.4	0.44	0.51	0.0094
8	36.3	38.2	0.49	0.60	0.0281
9	37.4	39.8	0.53	0.68	0.0719
10	38.3	41.2	0.57	0.75	0.1556
11	39.0	42.4	0.61	0.82	0.2834
12	39.6	43.5	0.63	0.88	0.4366
13	40.1	44.5	0.66	0.94	0.5836
14	40.5	45.3	0.68	0.99	0.7026
15	40.9	46.0	0.70	1.04	0.7891
16	41.1	46.7	0.71	1.08	0.8487
17	41.4	47.3	0.72	1.12	0.8891
18	41.6	47.8	0.74	1.16	0.9165
19	41.7	48.2	0.74	1.19	0.9354
20	41.8	48.6	0.75	1.23	0.9487
21	41.9	49.0	0.76	1.25	0.9582
22	42.0	49.3	0.77	1.28	0.9652
23	42.1	49.5	0.77	1.31	0.9703
24	42.2	49.8	0.78	1.33	0.9743
25	42.2	50.0	0.78	1.35	0.9773
26	42.2	50.2	0.78	1.37	0.9797
27	42.3	50.3	0.79	1.39	0.9816
28	42.3	50.5	0.79	1.40	0.9832
29	42.3	50.6	0.79	1.42	0.9844
30	42.3	50.7	0.79	1.43	0.9854
31	42.4	50.8	0.79	1.44	0.9863
32	42.4	50.9	0.79	1.46	0.987
33	42.4	51.0	0.80	1.47	0.9876
34	42.4	51.0	0.80	1.48	0.9881
35	42.4	51.1	0.80	1.49	0.9885
36	42.4	51.1	0.80	1.49	0.9888
37	42.4	51.2	0.80	1.50	0.9892
38	42.4	51.2	0.80	1.51	0.9894
39	42.4	51.3	0.80	1.51	0.9896
40	42.4	51.3	0.80	1.52	0.9898

Table 5.10. Likelihood component multipliers for the Dover sole age-structured assessment model.

Fishery		Survey			Recruitment		
catch	size compositions	biomass	size compositions	age compositions	early	ordinary	late
30	0.5	1	0.5	1	2	1	3

Table 5.11. Initial parameter values for the Dover sole age-structured assessment model.
a) Recruitment and fishing mortality parameters.

$\overline{\ln R_0}$			recruitment deviations			$\overline{\ln F}$			fishing mortality deviations		
value	min	max	value	min	max	value	min	max	value	min	max
17	10	20	0	-15	15	-4	-5	5	0	-5	5

b) Logistic parameters for fishery sex-specific age selectivities.

slope			A_{50}		
value	min	max	value	min	max
0.5	0.1	25	5	-40	40

b) Logistic parameters for survey sex-specific age selectivities.

slope			A_{50}		
value	min	max	value	min	max
2	0.1	25	5	1	40

Table 5.12. Final parameter estimates for the Dover sole assessment model.

Recruitment										
$\overline{\ln R_0}$	16.2475									
$\boldsymbol{\tau_t}$	1947-2011:						-1.35594	-0.35693	-0.37642	-0.39672
	-0.394337	-0.410831	-0.42743	-0.44419	-0.461503	-0.36842	-0.19487	-0.2974	-0.38129	-0.23159
	-0.282471	-0.09205	0.154527	0.141033	-0.154211	0.357331	0.253108	-0.37629	0.183129	0.300376
	-0.056438	0.2472485	-0.20537	-0.22847	0.063435	-0.10575	-0.16433	0.2534	0.445536	0.688121
	0.71246	0.559106	0.133751	0.67566	0.816675	0.449124	0.028685	-0.13595	-0.45265	-0.47984
	-0.3597	-0.5480	-0.4306	-0.0546	-0.3377	-0.2020	0.2799	0.3719	0.2823	0.5315
	0.6548	1.0960	0.7832	0.2243	0.3316	0.3470	0.5426	-0.3171	-0.5700	-0.1209
	-0.1355									
Fishing mortality										
$\overline{\ln F}$	-4.963555									
$\boldsymbol{\varepsilon_t}$	1984-2009:			-1.63647	-2.718785	-3.34596	-2.50718	0.32476	0.608353	0.99239
	2.3185	2.1925	1.4237	1.2341	0.8514	0.8707	1.3877	0.9471	0.9977	0.2011
	0.0505	-0.2907	0.2451	-0.0453	-0.5527	-0.6008	-0.9089	-0.2930	-0.5364	-0.4337
	-0.775751									
Fishery Selectivity										
	females	**males**								
slope	24.9980	13.5205								
A_{50}	13.5	10.5								
Survey Selectivity										
	"Full Coverage" Surveys			**"Shallow" Surveys**						
	females	**males**		**females**	**males**					
slope	0.1000	0.1000		0.1424	0.1000					
A_{50}	28.1	24.6		17.4	15.8					

Table 5.13. Values for (-log) likelihood components for the converged model and other observations on convergence.

Model	**# of parameters**	**Likelihood components: Fishery Size Comps**	**Survey Biomass**	**Survey Size Comps**	**Survey Age Comps**	**Recruitment: Early**	**Normal**	**Late**	**Hessian OK?**	**Parameters at Bounds**
Base	107	3244.91	9.14621	94.6798	390.241	6.03163	12.0821	0.357896	yes	logistic slopes

Table 5.14. Model-estimated catch and survey biomass, with observed values for comparison.

year	catch (t)			survey biomass (t)		
	estimated	std dev	observed	estimated	std dev	observed
1984	139	18	132	69,400	3,775	68,521
1985	47	6	43	71,868	3,788	
1986	26	3	23	74,236	3,792	
1987	61	8	56	76,440	3,783	63,394
1988	1,062	134	1,087	78,436	3,757	
1989	1,463	184	1,521	79,606	3,688	
1990	2,215	278	2,348	87,550	3,984	96,597
1991	8,328	1,019	9,741	80,474	3,474	
1992	7,367	912	8,364	77,273	3,227	
1993	3,491	435	3,804	81,096	3,433	85,549
1994	2,882	360	3,108	73,734	2,865	
1995	2,000	252	2,096	73,047	2,740	
1996	2,091	264	2,177	78,724	3,176	79,531
1997	3,462	438	3,652	72,547	2,547	
1998	2,158	274	2,230	71,700	2,453	
1999	2,203	280	2,270	71,526	2,397	74,245
2000	957	122	961	71,539	2,368	
2001	799	102	800	39,708	1,703	32,424
2002	560	71	554	73,918	2,405	
2003	931	118	936	75,576	2,459	99,297
2004	682	87	679	76,914	2,530	
2005	415	53	407	78,473	2,623	80,538
2006	398	51	390	80,134	2,734	
2007	295	38	286	81,886	2,866	71,624
2008	567	72	561	83,274	3,003	
2009	466	59	457	84,330	3,153	76,277
2010	552	70	544	85,330	3,305	
2011	413	53	403	86,092	3,459	77,531

Table 5.15. Estimated age 3+ population biomass.

year	Age 3+ Biomass (1000's t)					
	2011 Assessment		2009 Assessment		2007 Assessment	
	estimate	std dev	estimate	std dev	estimate	std dev
1984	202.6	8.8	156.7	4.7	171.6	6.9
1985	211.3	9.4	156.9	4.6	171.9	6.8
1986	218.3	10.0	156.8	4.5	172.9	6.7
1987	223.3	10.4	156.0	4.4	172.7	6.7
1988	226.6	10.8	154.1	4.4	171.6	6.6
1989	226.4	11.1	150.8	4.3	168.8	6.5
1990	224.3	11.3	146.3	4.2	164.8	6.5
1991	220.5	11.4	140.9	4.1	159.7	6.4
1992	209.5	11.4	129.8	3.8	148.3	6.2
1993	199.4	11.3	119.8	3.7	138.2	6.0
1994	194.1	11.4	113.5	3.5	132.5	5.9
1995	188.7	11.5	107.6	3.4	127.2	5.8
1996	184.7	11.6	102.9	3.3	123.3	5.8
1997	182.6	12.0	98.8	3.3	120.3	5.8
1998	180.2	12.4	94.1	3.2	116.9	5.9
1999	179.8	12.9	90.8	3.2	114.9	6.1
2000	181.6	13.7	88.2	3.2	115.1	6.5
2001	186.2	14.7	87.4	3.3	116.6	6.9
2002	195.8	16.3	88.5	3.5	122.4	7.6
2003	204.6	17.7	89.3	3.7	125.9	8.3
2004	211.1	19.0	89.1	4.0	127.7	8.8
2005	217.7	20.3	89.4	4.2	129.4	9.3
2006	223.5	21.4	89.2	4.5	130.8	9.7
2007	229.5	22.6	89.0	4.7	131.7	10.0
2008	231.5	23.2	89.4	5.0		
2009	231.6	23.7	89.5	5.2		
2010	231.3	23.9				
2011	229.6	23.9				

Table 5.16. Estimated spawning biomass.

year	Female Spawning Stock Biomass (1000's t)					
	2011 Assessment		2009 Assessment		2007 Assessment	
	estimate	std dev	estimate	std dev	estimate	std dev
1984	62.8	2.8	57.8	2.3	60.3	3.1
1985	63.6	2.8	57.7	2.2	60.9	3.0
1986	64.9	2.8	57.7	2.1	61.7	2.9
1987	66.6	2.9	57.9	2.1	62.6	2.9
1988	68.9	2.9	58.3	2.0	63.5	2.8
1989	71.1	3.1	58.4	1.9	64.0	2.8
1990	73.4	3.2	58.2	1.9	64.1	2.7
1991	75.5	3.4	57.7	1.8	63.6	2.7
1992	74.5	3.5	54.1	1.7	59.8	2.6
1993	73.9	3.7	50.8	1.6	56.5	2.5
1994	75.1	3.9	49.2	1.6	55.2	2.5
1995	76.1	4.1	47.8	1.6	54.0	2.5
1996	76.6	4.3	46.5	1.5	53.1	2.4
1997	76.2	4.4	45.0	1.5	51.8	2.4
1998	74.3	4.4	42.6	1.5	49.6	2.4
1999	72.7	4.4	40.7	1.4	47.9	2.4
2000	70.7	4.5	38.6	1.4	46.1	2.3
2001	69.3	4.5	37.2	1.3	44.8	2.3
2002	68.1	4.5	35.9	1.3	43.9	2.3
2003	67.2	4.5	34.7	1.3	43.0	2.3
2004	66.4	4.6	33.5	1.2	42.2	2.3
2005	66.2	4.8	32.6	1.2	41.7	2.3
2006	66.8	5.0	32.1	1.2	41.8	2.4
2007	68.1	5.3	31.8	1.2	42.3	2.5
2008	70.1	5.7	31.7	1.2		
2009	72.7	6.1	31.8	1.3		
2010	76.0	6.7				
2011	79.5	7.3				

Table 5.17. Estimated age 3 recruitment (millions of individuals).

Year	2011 Assessment		2009 Assessment		2007 Assessment	
	estimate	std dev	estimate	std dev	estimate	std dev
1984	44.7	6.0	17.3	2.4	22.7	4.0
1985	51.5	6.6	17.4	2.4	17.4	3.3
1986	35.7	4.9	16.1	2.2	22.8	3.5
1987	23.4	3.5	13.1	1.9	17.3	2.7
1988	19.9	3.3	9.4	1.5	12.2	2.2
1989	14.5	2.4	9.0	1.4	11.5	2.0
1990	14.1	2.4	7.6	1.3	9.9	1.8
1991	15.9	2.8	7.5	1.2	10.6	1.9
1992	13.2	2.5	5.8	1.1	8.3	1.7
1993	14.8	2.8	6.4	1.1	9.1	1.8
1994	21.6	4.0	7.9	1.3	13.2	2.5
1995	16.2	3.3	6.1	1.1	9.5	2.0
1996	18.6	3.5	7.3	1.3	11.8	2.3
1997	30.1	5.3	10.8	1.7	17.3	3.1
1998	33.0	5.6	11.8	1.7	19.0	3.3
1999	30.2	5.3	10.1	1.6	16.2	3.1
2000	38.7	6.8	12.4	2.0	26.8	5.1
2001	43.8	7.6	14.3	2.4	24.0	4.9
2002	68.1	11.3	22.8	3.5	43.6	7.8
2003	49.8	9.2	15.2	2.8	22.6	5.0
2004	28.5	6.9	7.7	2.1	9.0	3.4
2005	31.7	7.4	10.4	2.7	12.3	3.5
2006	32.2	8.6	8.6	3.1	15.7	5.9
2007	39.2	9.9	9.4	2.8	16.1	5.8
2008	16.6	6.9	13.7	5.1		
2009	12.9	4.4	14.0	5.2		
2010	20.2	7.9				
2011	19.9	7.6				

Table 5.18. Projected catch (t) for the seven harvest scenarios.

	Catch (t)						
year	scenario 1	scenario 2	scenario 3	scenario 4	scenario 5	scenario 6	scenario 7
2011	455	455	455	455	455	455	455
2012	17,553	17,553	9,083	526	0	22,271	17,553
2013	16,590	16,590	9,128	560	0	20,307	16,590
2014	15,381	15,381	8,947	580	0	18,236	19,515
2015	14,011	14,011	8,588	586	0	16,130	17,127
2016	12,534	12,534	8,085	581	0	14,027	14,802
2017	11,263	11,263	7,609	574	0	12,302	12,902
2018	10,538	10,538	7,350	576	0	11,349	11,814
2019	9,393	9,393	6,835	561	0	9,902	10,261
2020	8,538	8,538	6,424	549	0	8,809	9,144
2021	8,025	8,025	6,158	543	0	7,875	8,201
2022	7,602	7,602	5,923	538	0	7,295	7,512
2023	7,432	7,432	5,833	539	0	7,239	7,383
2024	7,286	7,286	5,755	540	0	7,243	7,340

Table 5.19. Female spawning biomass (t) for the seven harvest scenarios. The values of $B_{40\%}$ and $B_{35\%}$ are 36,177 t and 31,655 t, respectively.

	Female spawning biomass (t)						
year	scenario 1	scenario 2	scenario 3	scenario 4	scenario 5	scenario 6	scenario 7
2011	79,487	79,487	79,487	79,487	79,487	79,487	79,487
2012	82,809	82,809	82,809	82,809	82,809	82,809	82,809
2013	77,264	77,264	81,378	85,538	85,794	74,975	77,264
2014	71,563	71,563	79,265	87,563	88,090	67,493	71,563
2015	65,938	65,938	76,623	88,861	89,663	60,568	63,801
2016	60,706	60,706	73,654	89,416	90,481	54,515	57,064
2017	55,735	55,735	70,368	89,266	90,581	49,067	51,066
2018	51,070	51,070	66,925	88,597	90,149	44,168	45,730
2019	46,735	46,735	63,512	87,692	89,471	39,728	40,943
2020	43,328	43,328	60,587	86,828	88,810	36,415	37,359
2021	40,964	40,964	58,317	86,163	88,325	34,336	35,037
2022	39,402	39,402	56,619	85,728	88,047	33,309	33,788
2023	38,489	38,489	55,406	85,483	87,941	33,003	33,333
2024	37,912	37,912	54,482	85,365	87,949	32,936	33,163

Table 5.20. Fishing mortality for the seven harvest scenarios.

	Fishing mortality						
year	scenario 1	scenario 2	scenario 3	scenario 4	scenario 5	scenario 6	scenario 7
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.14	0.14	0.07	0.00	0.00	0.18	0.14
2013	0.14	0.14	0.07	0.00	0.00	0.18	0.14
2014	0.14	0.14	0.07	0.00	0.00	0.18	0.18
2015	0.14	0.14	0.07	0.00	0.00	0.18	0.18
2016	0.14	0.14	0.07	0.00	0.00	0.18	0.18
2017	0.14	0.14	0.07	0.00	0.00	0.18	0.18
2018	0.14	0.14	0.07	0.00	0.00	0.18	0.18
2019	0.14	0.14	0.07	0.00	0.00	0.18	0.18
2020	0.14	0.14	0.07	0.00	0.00	0.18	0.18
2021	0.14	0.14	0.07	0.00	0.00	0.17	0.18
2022	0.14	0.14	0.07	0.00	0.00	0.17	0.17
2023	0.14	0.14	0.07	0.00	0.00	0.17	0.17
2024	0.14	0.14	0.07	0.00	0.00	0.16	0.17

Table 5.21. Prohibited species catch (PSC) in the deep-water flatfish target fishery.

a) Crab PSC:

year	PSC in target fishery (#)					fraction of total PSC				
		King Crab		Tanner Crab			King Crab		Tanner Crab	
	Blue	Golden	Red	Bairdi	Opilio	Blue	Golden	Red	Bairdi	Opilio
2003	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	0.0%
2004	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	0.0%
2005	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	0.0%
2006	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	0.0%
2007	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	0.0%
2008	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	0.0%
2009	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	0.0%
2010	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	0.0%
2011	0	0	0	0	0	0.0%	0.0%	0.0%	0.0%	0.0%

b) Halibut PSC:

Year	directed fishery halibut PSC (kg)	% total halibut PSC
2003	34,519	0.6%
2004	101,460	1.7%
2005	0	0.0%
2006	0	0.0%
2007	593	0.0%
2008	0	0.0%
2009	0	0.0%
2010	1	0.0%
2011	0	0.0%

c) Salmon PSC (2011 data unavailable at time of document preparation).:

Year	Chinook		Non-Chinook	
	PSC (#)	fraction of total	PSC (#)	fraction of total
2003	0	0.0%	0	0.0%
2004	0	0.0%	2	0.0%
2005	0	0.0%	0	0.0%
2006	0	0.0%	0	0.0%
2007	0	0.0%	0	0.0%
2008	0	0.0%	0	0.0%
2009	0	0.0%	0	0.0%
2010	0	0.0%	0	0.0%

Table 5.22. Catch of nontarget species in the deepwater flatfish target fishery, expressed as the fraction of species catch by all fisheries in the FMP.

Nontarget Species	Year								
Group	2011	2010	2009	2008	2007	2006	2005	2004	2003
Benthic urochordata	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Birds	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bivalves	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Brittle star unidentified	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Capelin	0.0%	0.0%	0.0%	0.0%	--	0.0%	0.0%	0.0%	0.0%
Corals Bryozoans	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Dark Rockfish	0.0%	0.0%	0.0%	0.0%	--	--	--	--	--
Eelpouts	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Eulachon	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Giant Grenadier	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Greenlings	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Grenadier	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	1.2%
Gunnels	--	--	--	0.0%	--	0.0%	--	--	0.0%
Hermit crab unidentified	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Invertebrate unidentified	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Lanternfishes (myctophidae)	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Large Sculpins	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	1.4%
Misc crabs	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Misc crustaceans	0.0%	0.0%	0.0%	--	--	--	0.0%	0.0%	0.0%
Misc deep fish	--	--	--	0.0%	--	--	--	--	--
Misc fish	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%
Misc inverts (worms etc)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	--	--
Octopus	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	0.7%
Other osmerids	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Other Sculpins	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Pacific Sand lance	0.0%	--	0.0%	0.0%	--	0.0%	0.0%	0.0%	0.0%
Pandalid shrimp	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Polychaete unidentified	0.0%	0.0%	0.0%	0.0%	0.0%	--	0.0%	--	0.0%
Scypho jellies	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sea anemone unidentified	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%
Sea pens whips	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sea star	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.0%
Shark, Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Shark, Pacific sleeper	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Shark, salmon	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Shark, spiny dogfish	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%
Skate, Alaska	0.0%	0.0%	--	--	--	--	--	--	--
Skate, Aleutian	0.0%	--	--	--	--	--	--	--	--
Skate, Big	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	1.6%	--
Skate, Longnose	0.3%	0.1%	0.0%	0.1%	0.0%	0.0%	0.1%	1.0%	0.0%
Skate, Other	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.3%
Skate, Whiteblotched	0.0%	--	--	--	--	--	--	--	--
Snails	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sponge unidentified	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Squid	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	1.4%	0.5%
Stichaeidae	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Surf smelt	--	--	--	0.0%	--	--	0.0%	0.0%	--
urchins dollars cucumbers	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 5.23. Catch of non-prohibited species in the deepwater flatfish target fishery. The two species constituting the largest fraction of the catch are highlighted.

	2011		2010	
Species	total (t)	% retained	total (t)	% retained
Atka mackerel	0	--	0	--
arrowtooth flounder	35	100%	4	100%
big skate	1	100%	0	--
deep water flatfish	81	100%	18	100%
flathead sole	6	100%	0	--
longnose skate	0	100%	0	--
northern rockfish	0	100%	0	--
all sharks, squid, sculpin, octopus	0	--	0	--
Pacific cod	16	100%	0	--
pelagic rockfish complex	0	--	0	--
pollock	6	100%	0	--
POP	0	--	0	--
rex sole	13	100%	0	100%
rougheye	0	100%	0	100%
other rockfish	0	--	0	--
sablefish	7	100%	1	100%
shallow water flatfish	4	100%	0	--
shortraker	1	100%	0	100%
thornyheads	4	100%	2	100%
unidentified skates	0	--	0	--
octopus	0	--	0	--
sculpin	1	100%	0	--
unidentified sharks	0	--	0	--

Figures

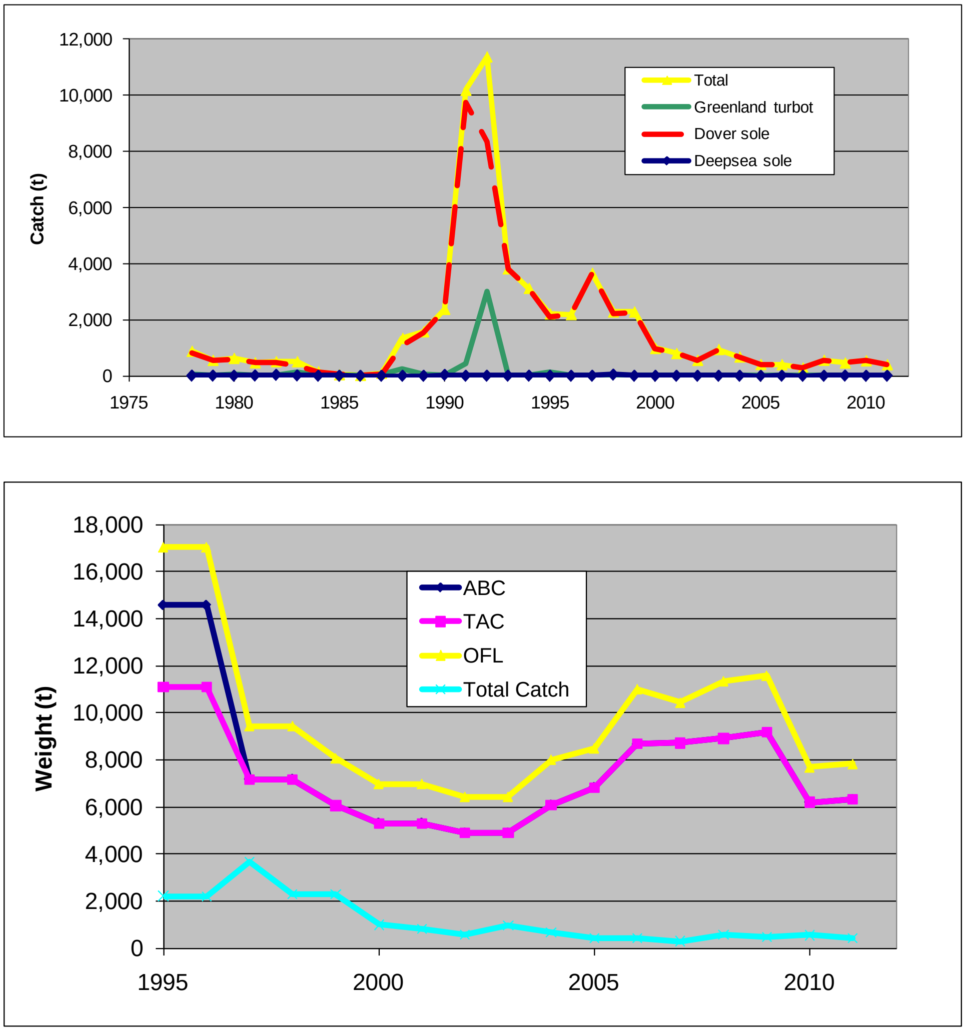


Figure 5.1. Fishery catches for GOA deepwater flatfish (Dover sole, Greenland turbot and deepsea sole), 1978-2011. Upper figure: total catch and catch by species; lower figure: total fishery catch plotted with corresponding ABCs, OFLs and TACs.

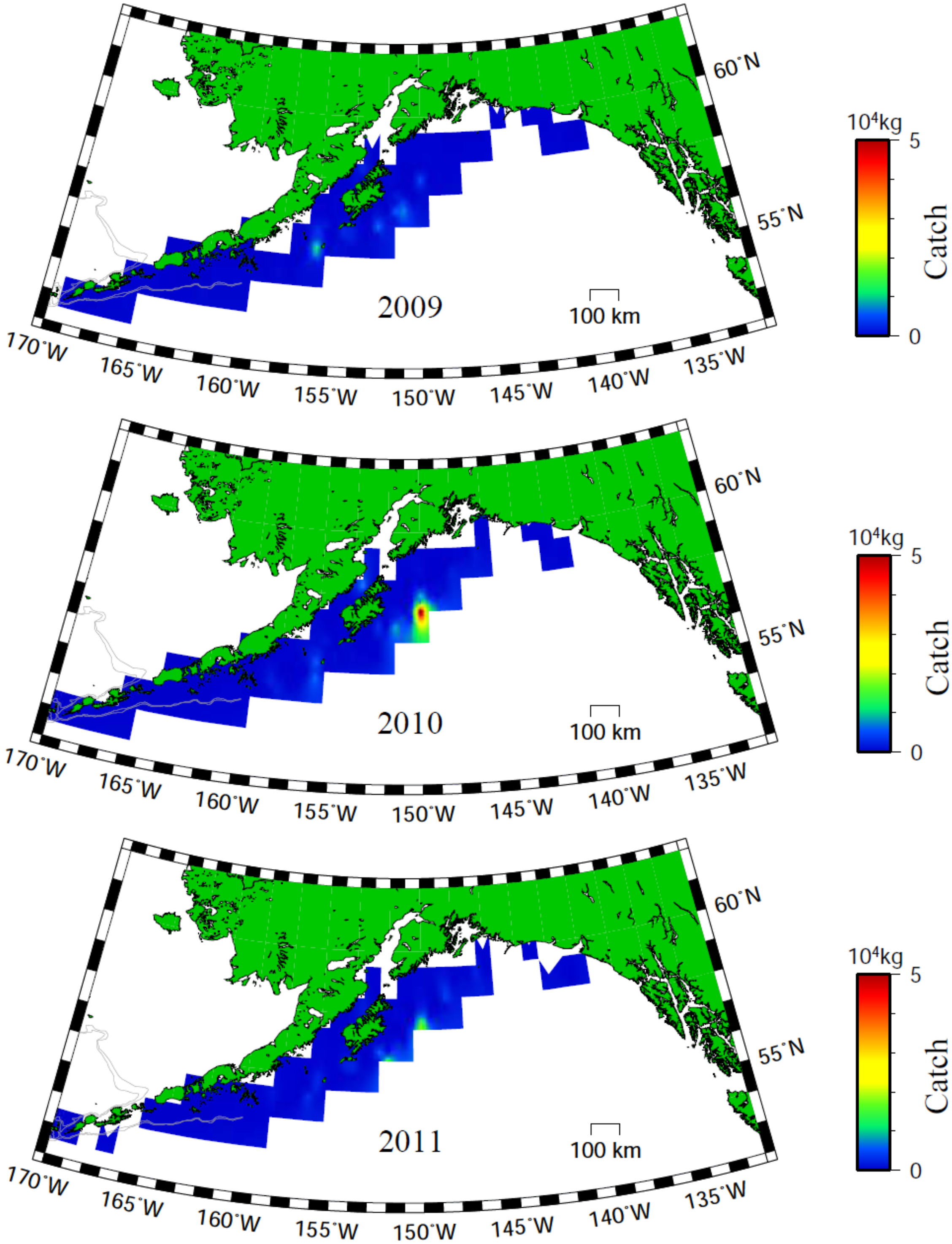


Figure 5.2. Spatial patterns of fishery catches for Dover sole, 2009-2011.

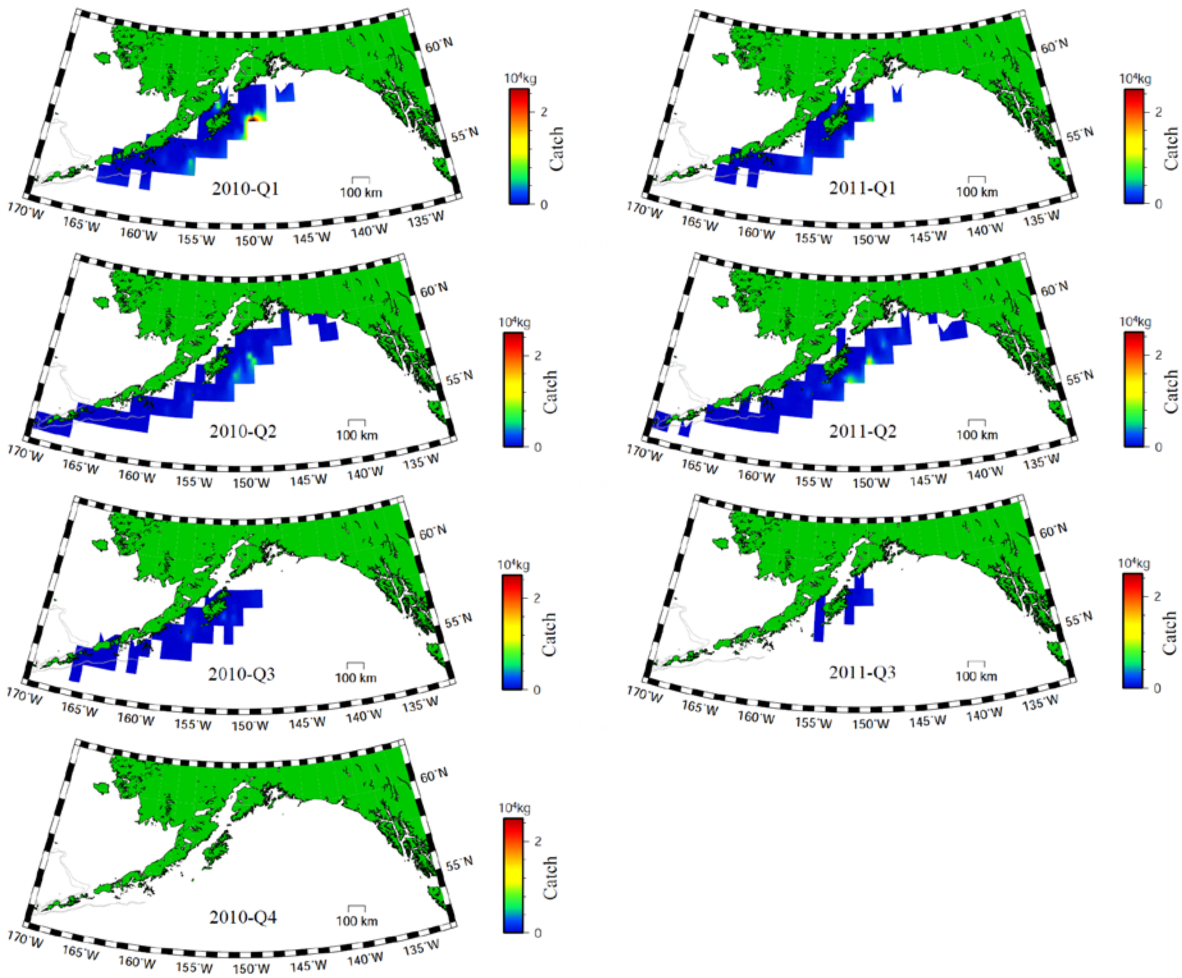


Figure 5.3. Spatial patterns of fishery catches for Dover sole from the first three quarters of 2010 and 2011. Little to no Dover sole is caught in the fourth quarter.

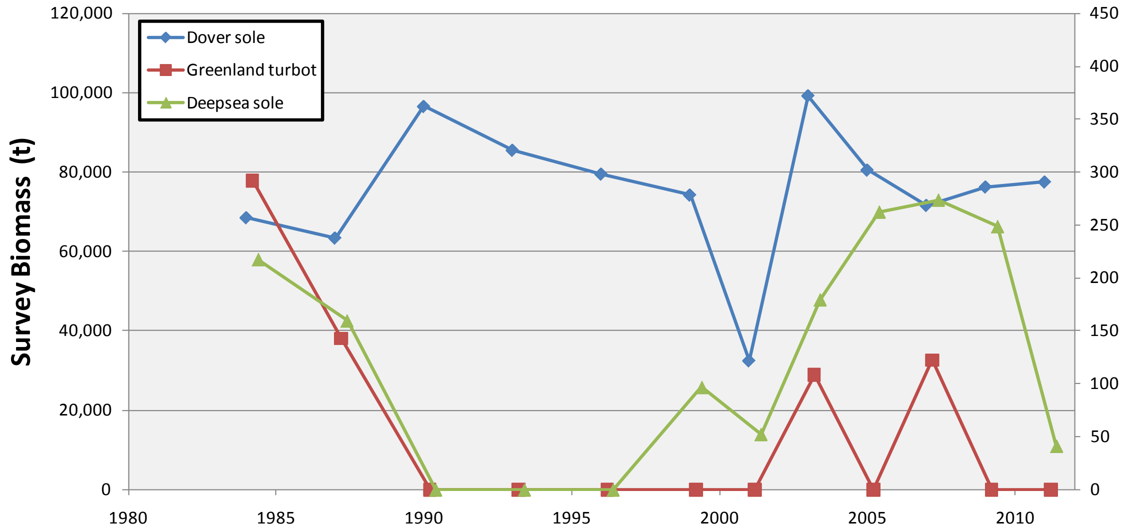


Figure 5.4. Observed GOA survey biomass for the deepwater flatfish. Dover sole is plotted against the left-hand y-axis, while Greenland turbot and deepsea sole are plotted against the righthand y-axis. Error bars are ± 1 standard deviation. The 2001 GOA survey did not survey the Eastern Gulf. Survey coverage was limited to < 500 m in 1990, 1993, 1996, and 2001.

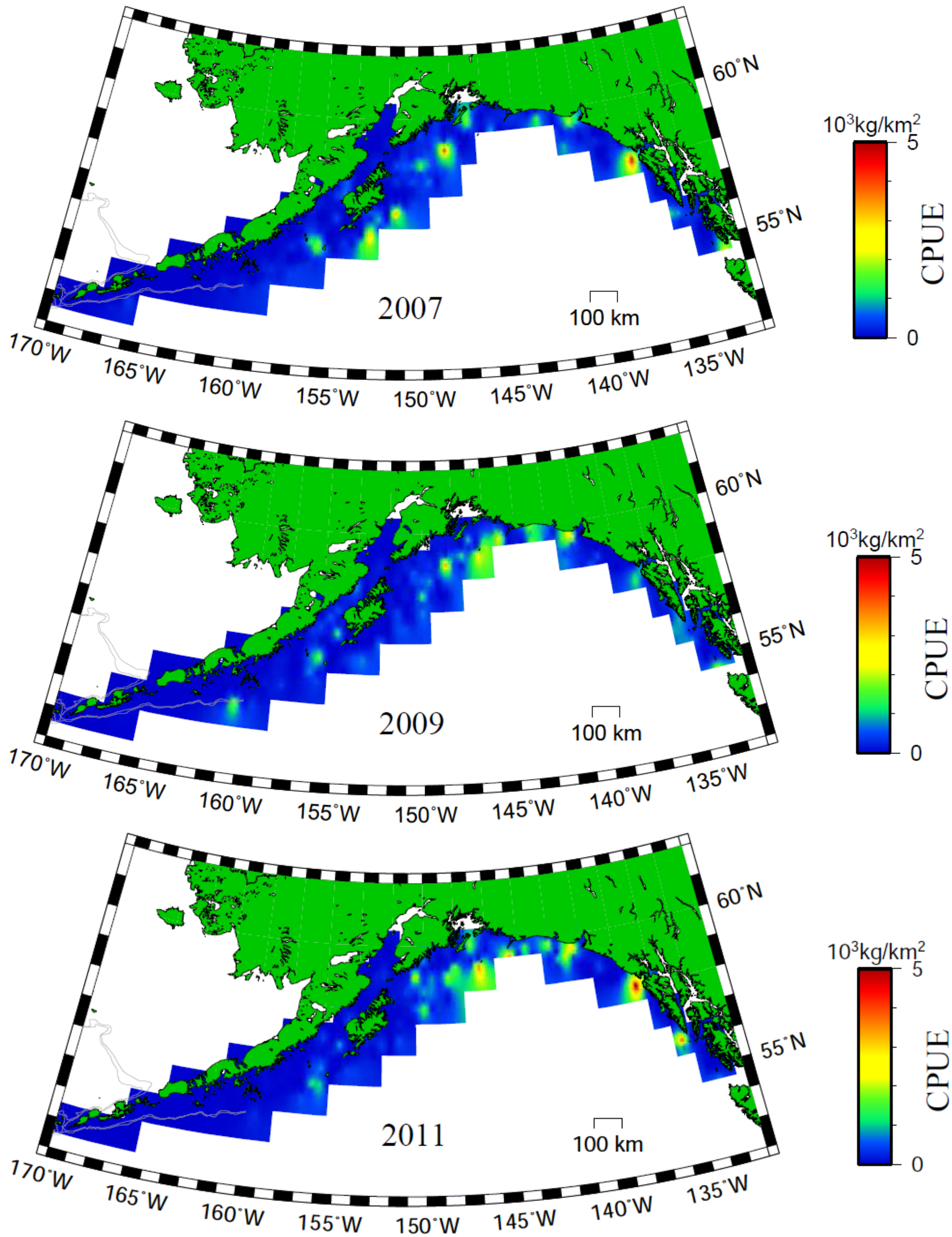
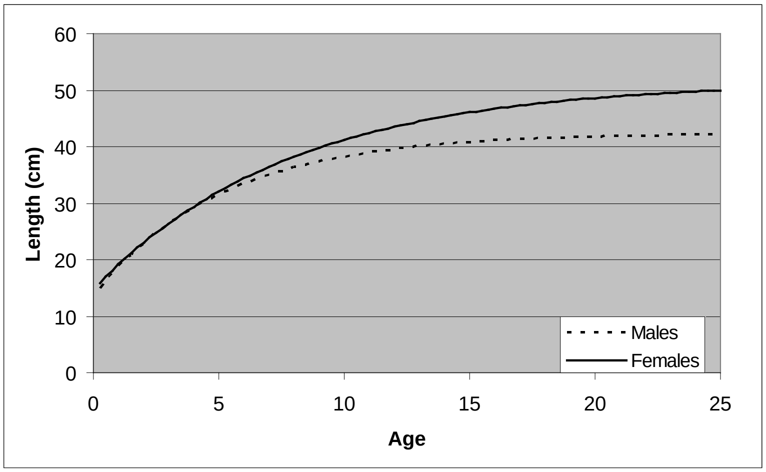
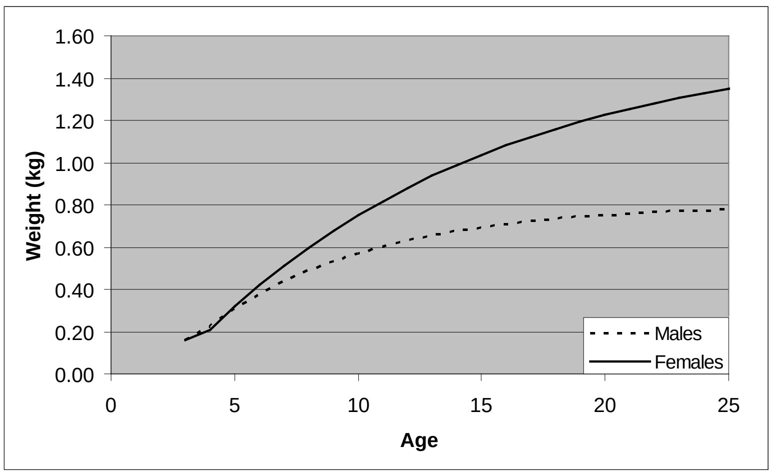


Figure 5.5. Spatial patterns of CPUE for Dover sole in the biennial GOA groundfish surveys for 2007-2011.

a) Length-at-age.



b) Weight-at-age.



c) Maturity-at-age (females).

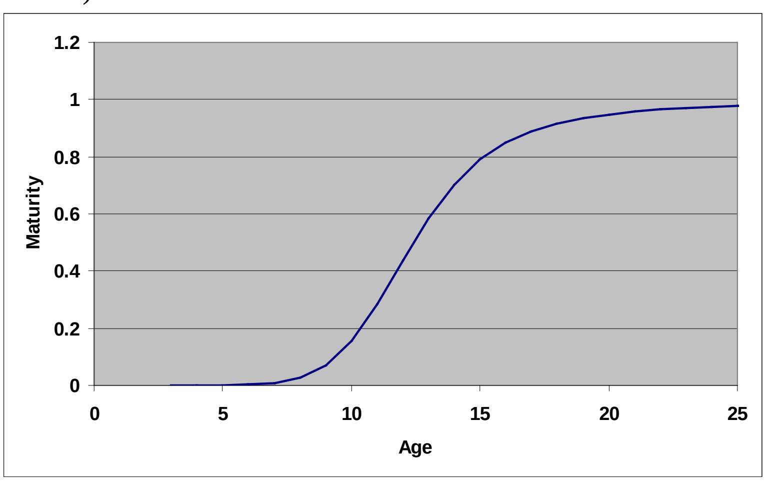


Figure 5.6. Age-specific schedules for GOA Dover sole: females solid line, males dotted line.

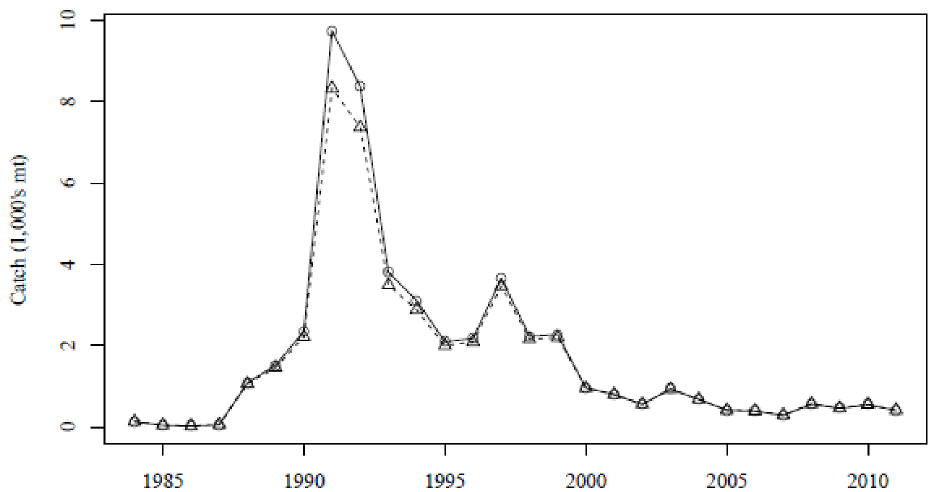
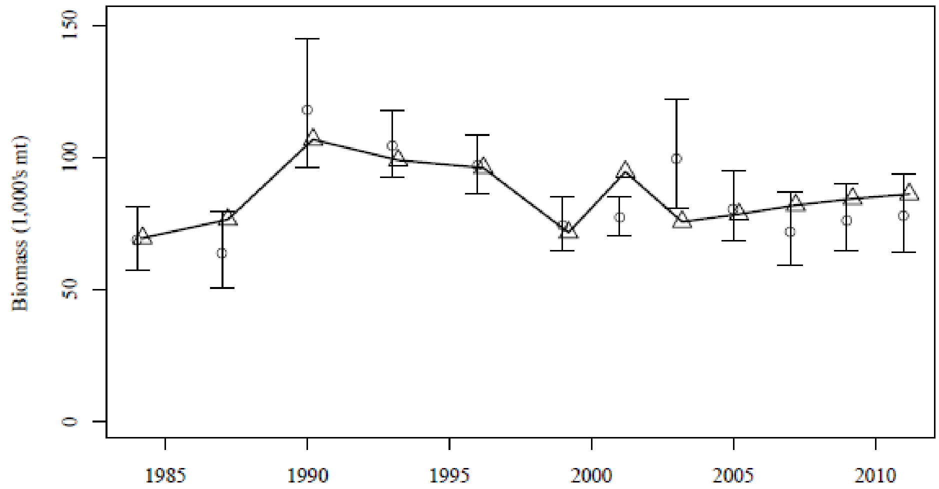


Figure 5.7. Comparison of observed fishery catch of Dover sole (only) with model estimates. Estimated catch = dotted line with triangles, observed catch = solid line with circles.

a) This year's assessment:



b) 2009 assessment:

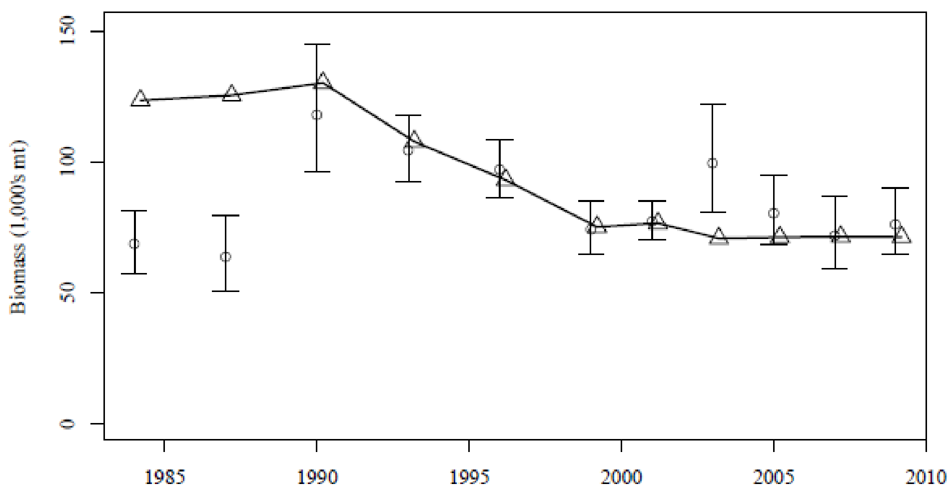


Figure 5.8. Comparison of observed survey biomass with model estimates. Observations have been corrected for incomplete survey coverage using assumed availability. Estimated survey biomass = solid line with triangles, observed survey biomass = circles with error bars (approximate lognormal 95% confidence intervals).

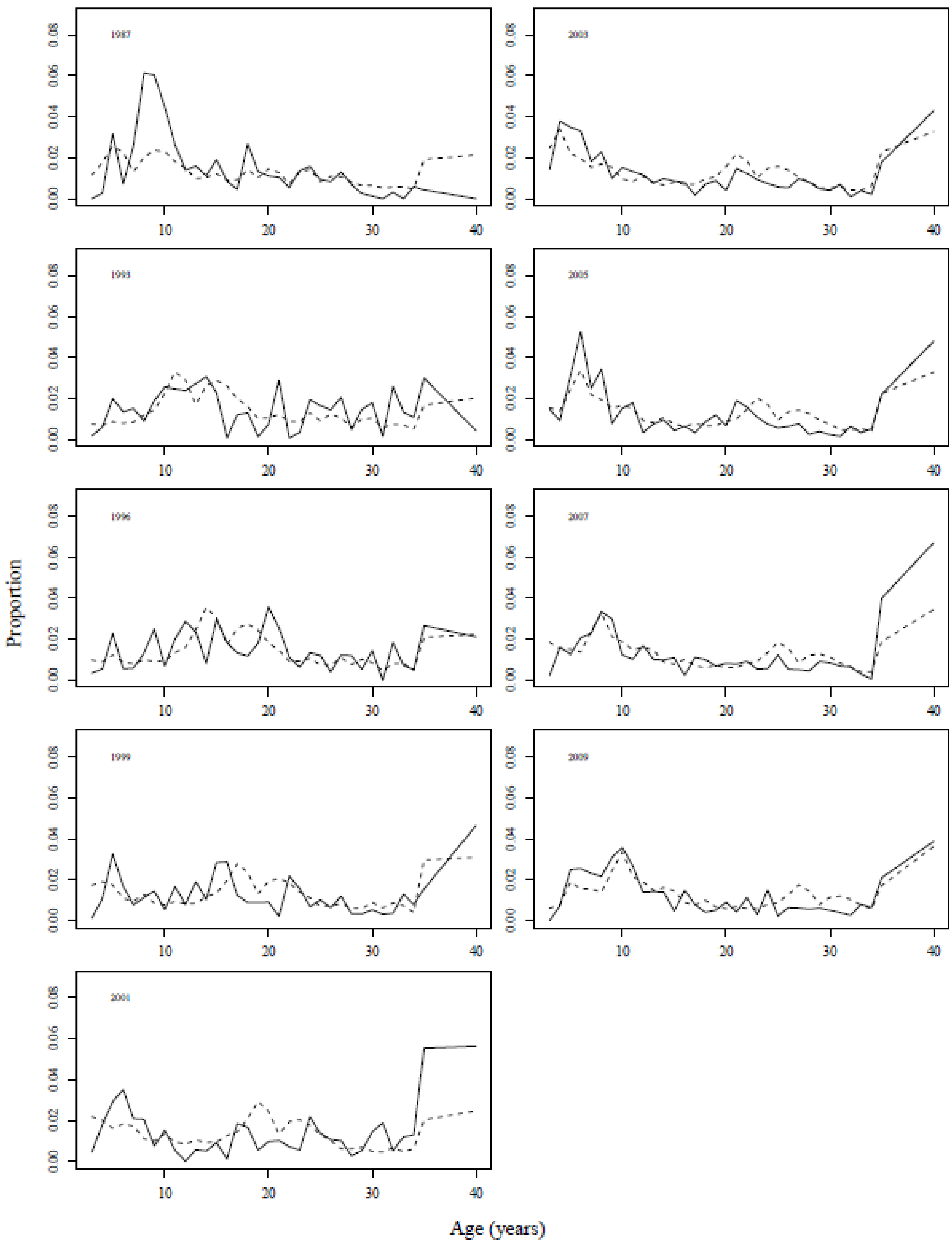


Figure 5.9a. This year's model fits to the female survey age composition data for Dover sole. Dashed lines represent the model estimates, solid lines represent the data. Age 40 is a plus group and ages 35-39 are collapsed into one age bin (age 35).

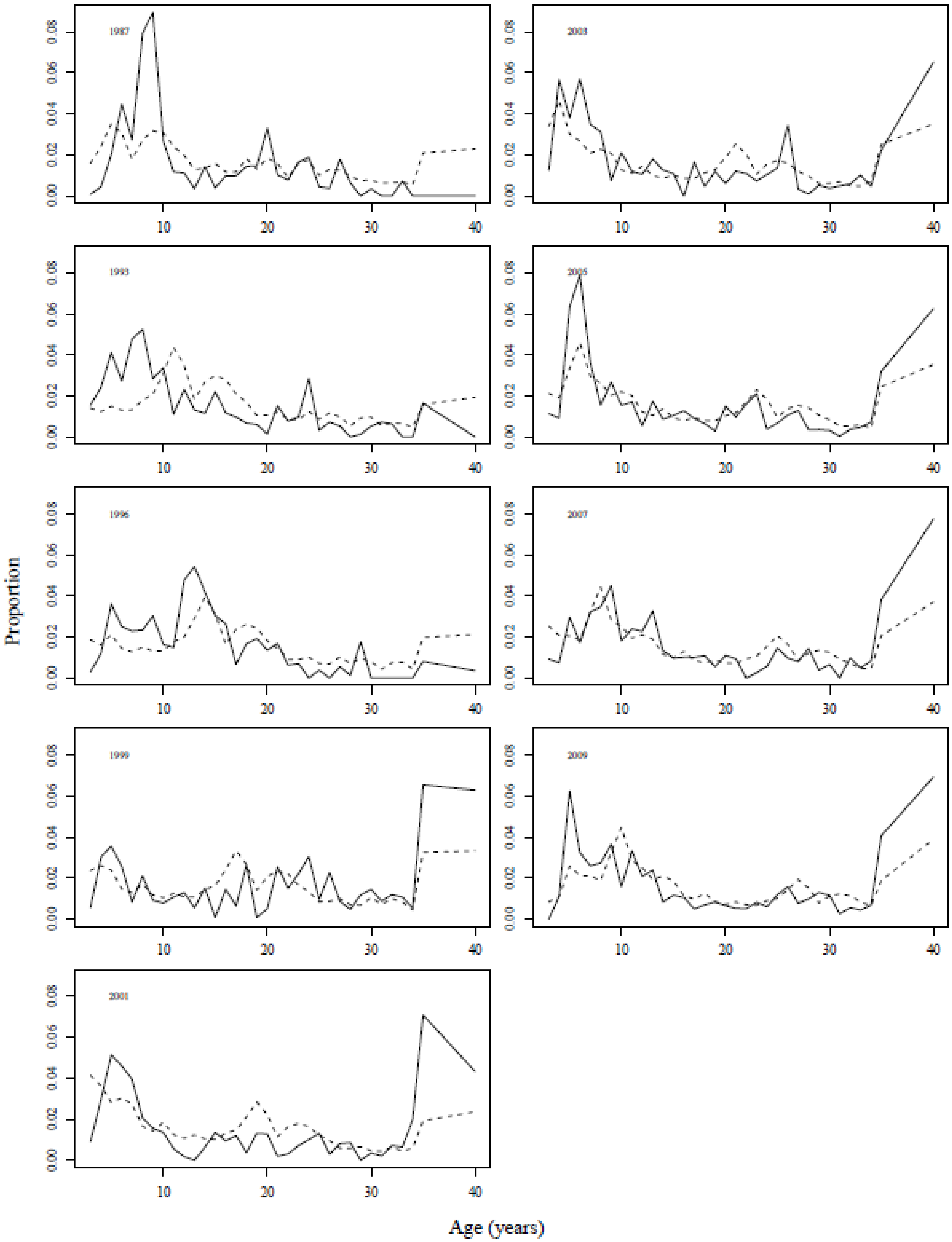


Figure 5.9b. This year's model fits to the male survey age composition data for Dover sole. Dashed lines represent the model estimates, solid lines represent the data. Age 40 is a plus group and ages 35-39 are collapsed into one age bin (age 35).

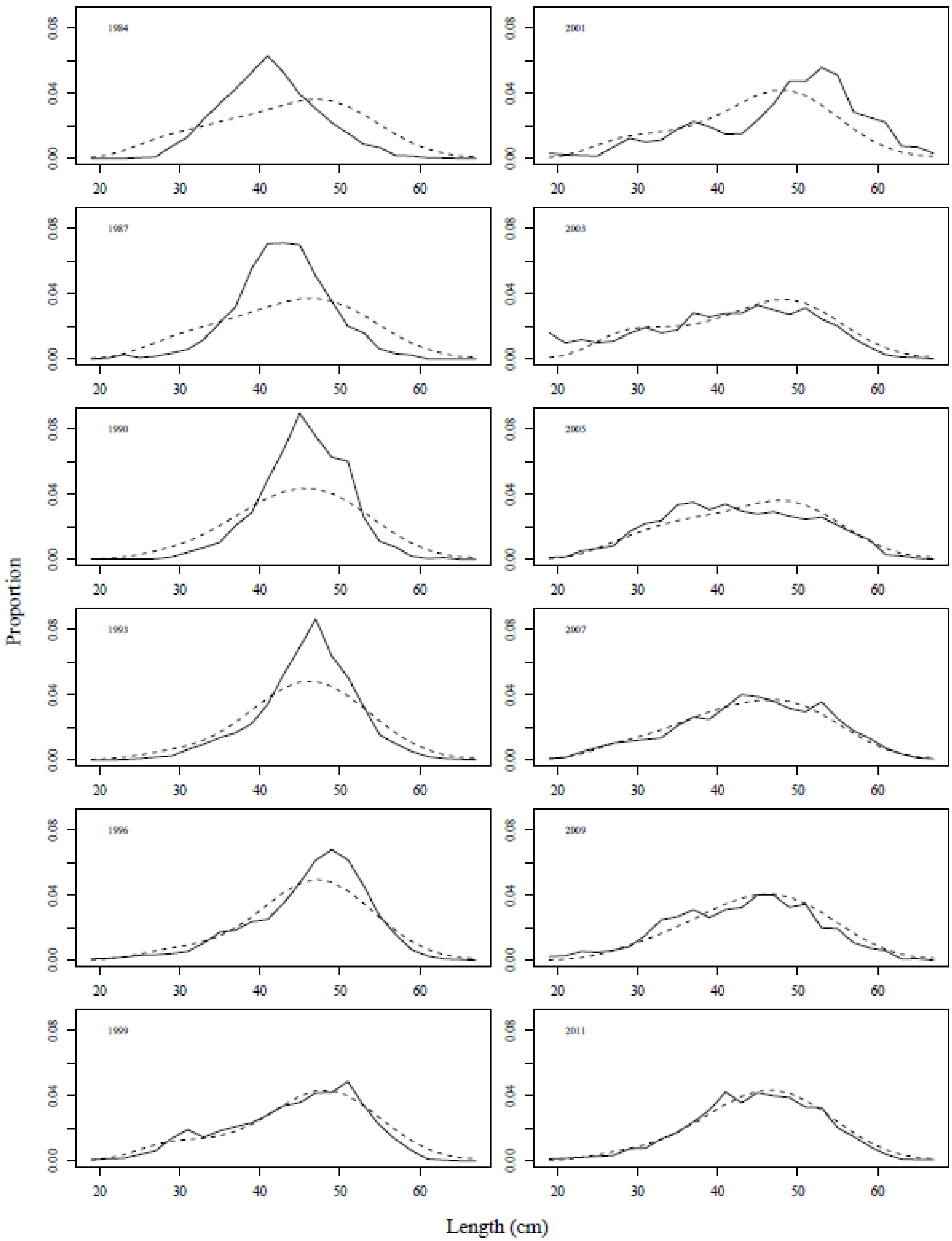


Figure 5.10a. This year's model fits to the female GOA Dover sole survey size composition data. Dashed lines represent the model estimates, solid lines represent the data.

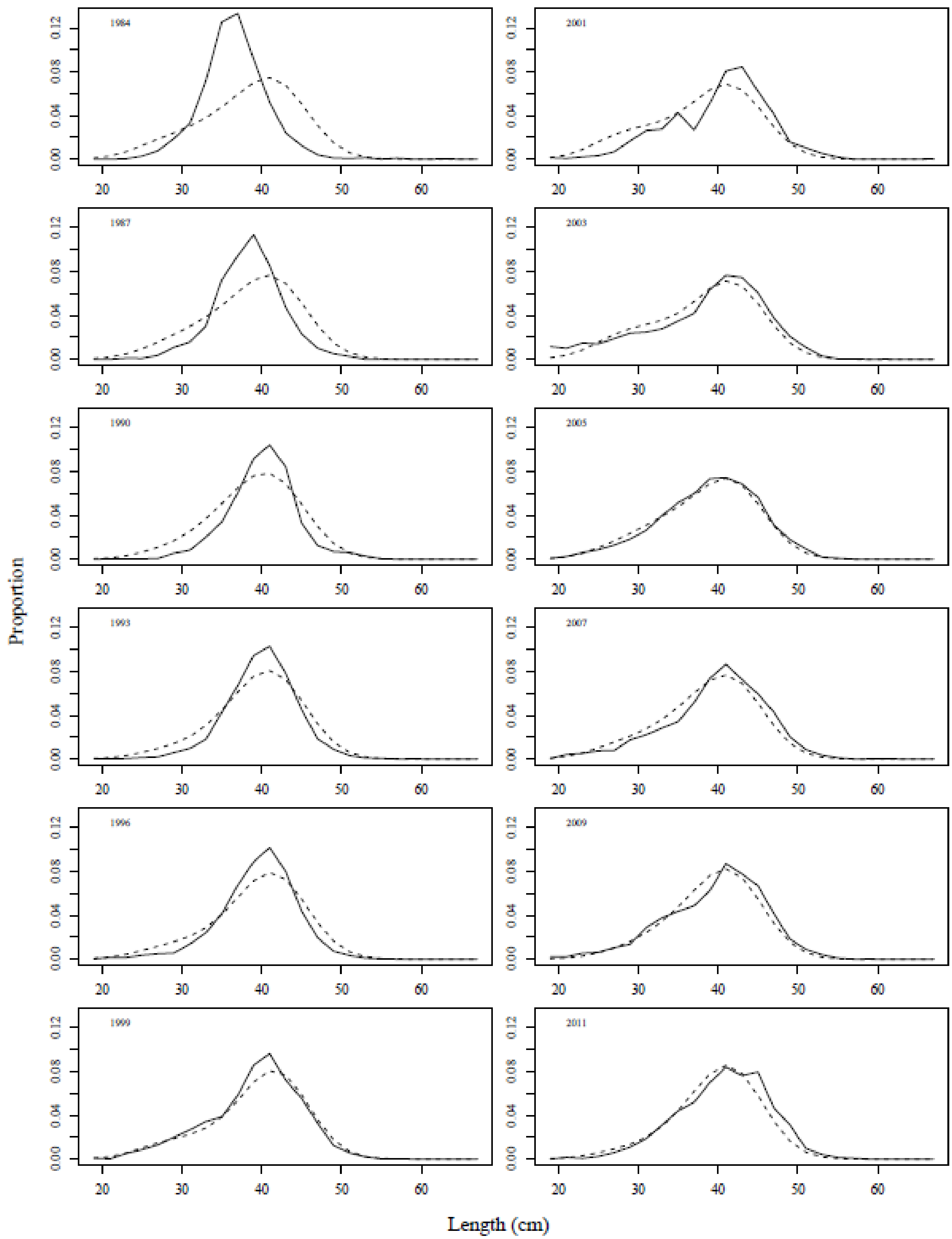


Figure 5.10b. This year's model fits to the male GOA Dover sole survey size composition data. Dashed lines represent the model estimates, solid lines represent the data.

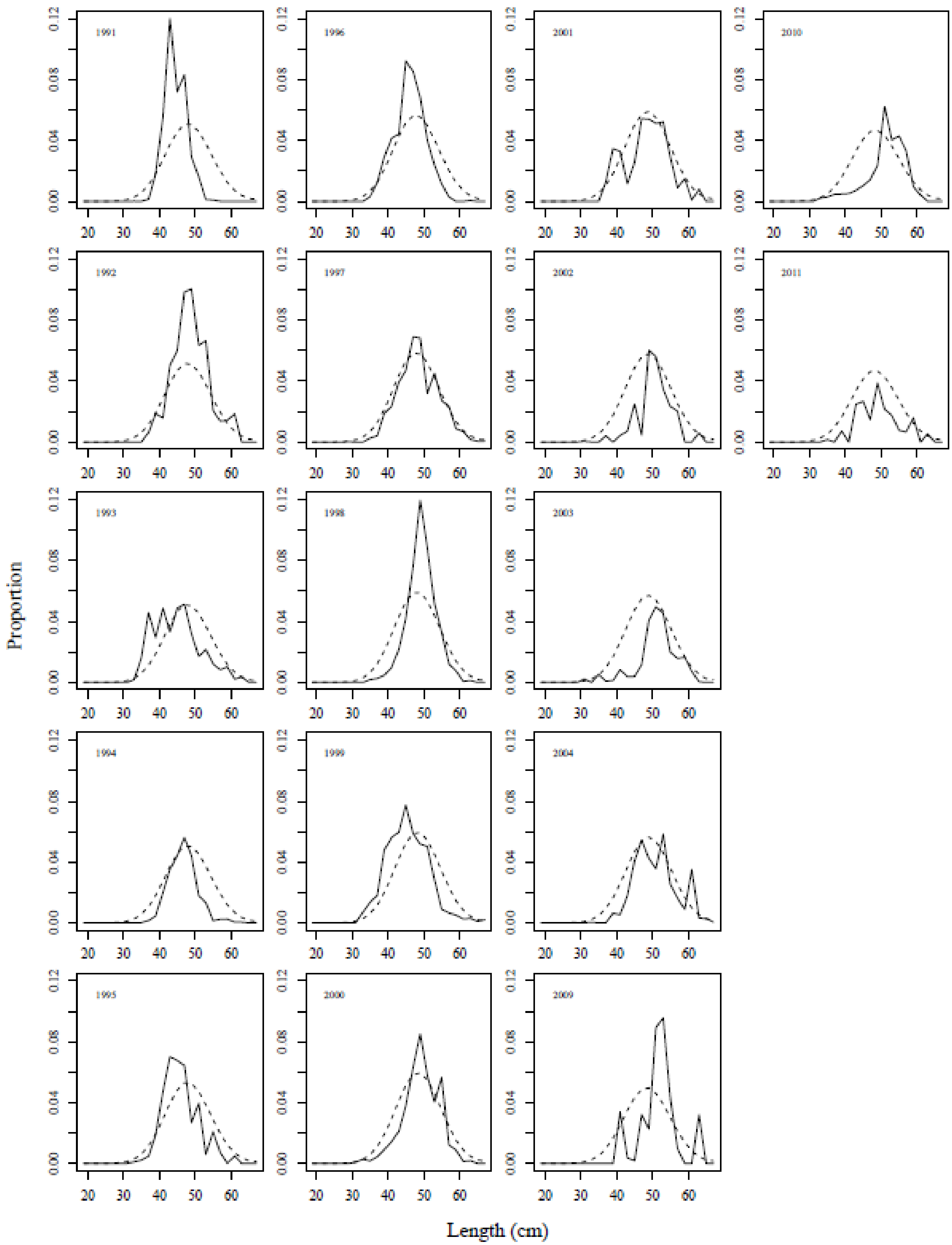


Figure 5.11a.This year's model fits to female GOA Dover sole fishery size composition data. Dashed lines represent the model estimate, solid lines represent the data.

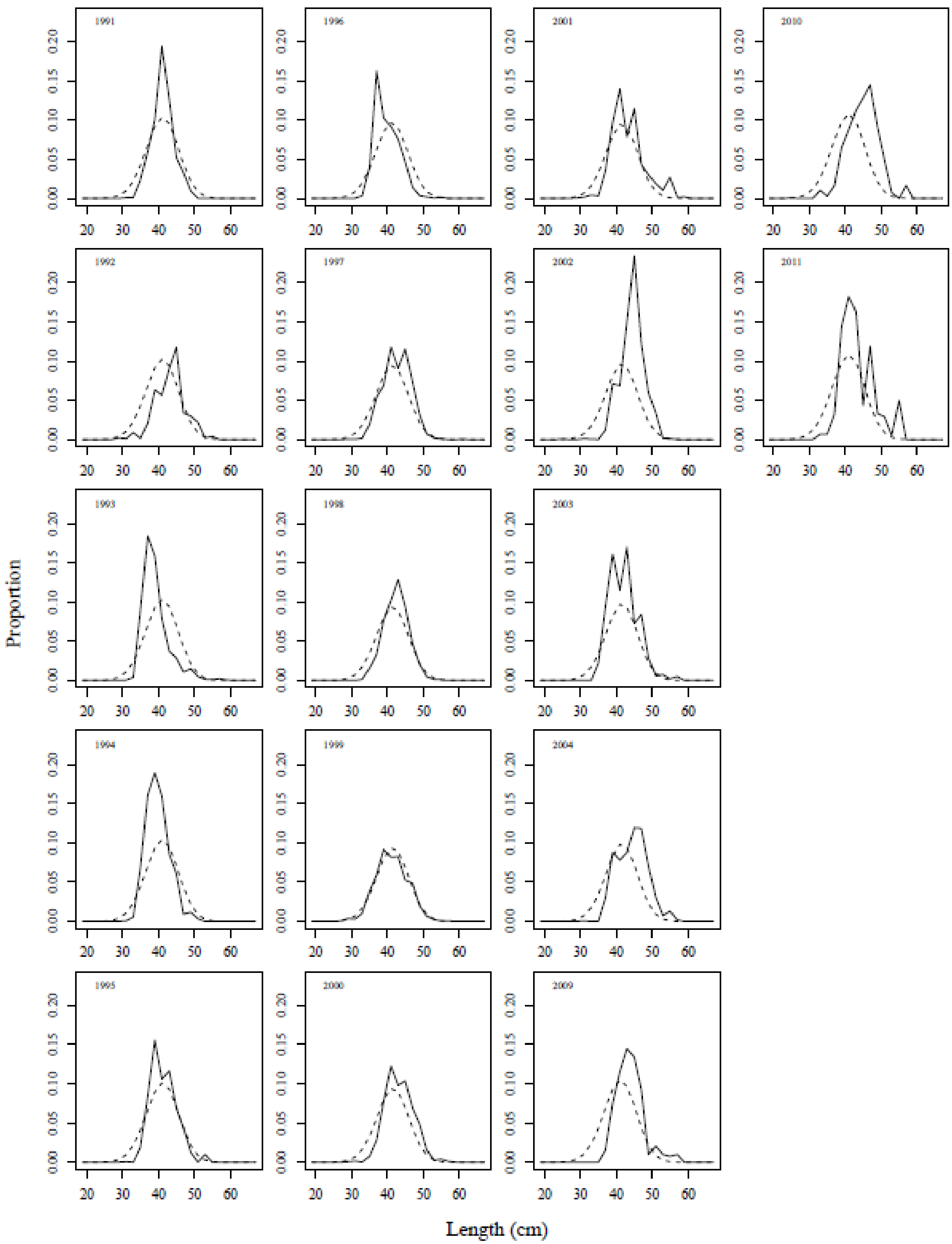
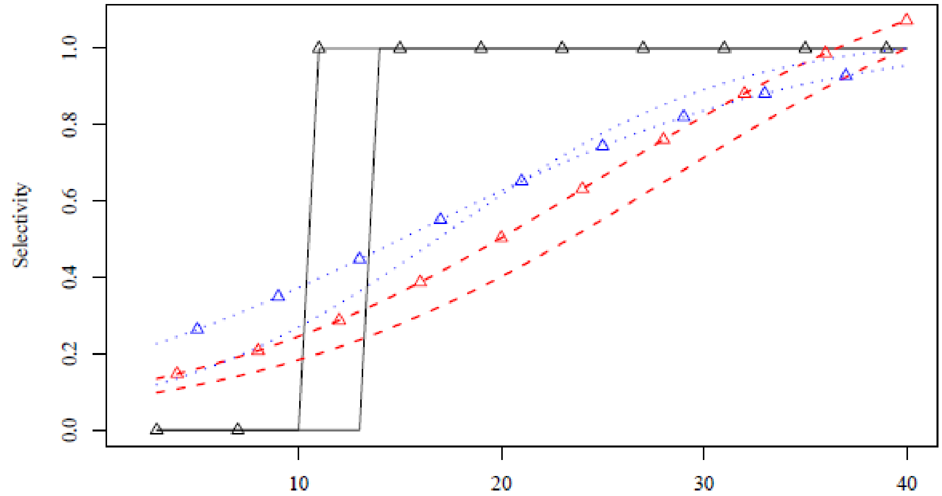


Figure 5.11b. This year's model fits to male GOA Dover sole fishery size composition data. Dashed lines represent the model estimate, solid lines represent the data.

a) This year's assessment:



b) 2009 assessment:

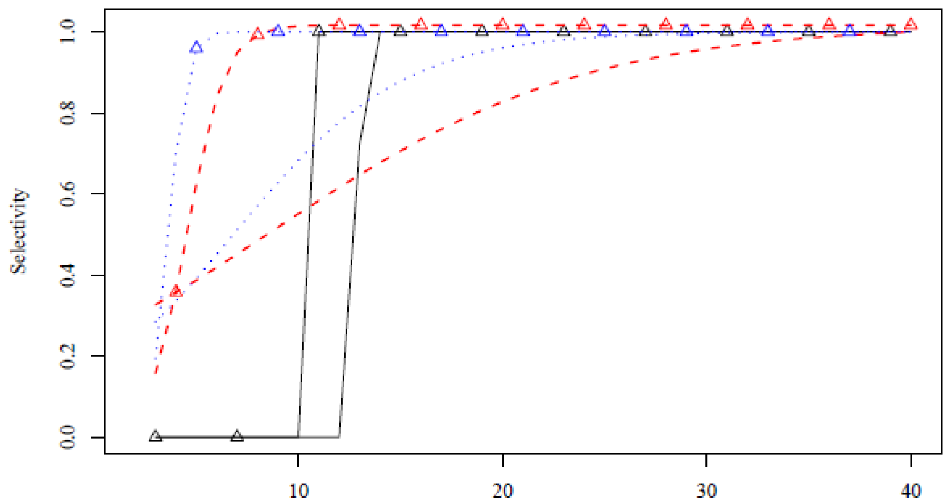
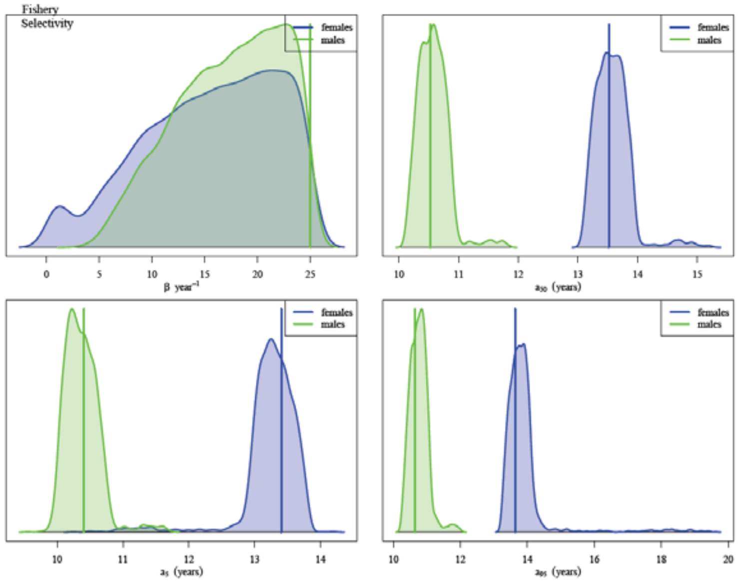


Figure 5.12. Estimated survey and fishery logistic selectivity functions. Red dashed line: "full coverage" surveys; blue dotted lines: "shallow" surveys; solid black line: fishery. Triangle symbol: males; no symbol: females.

a) This year's assessment:



b) 2009 assessment:

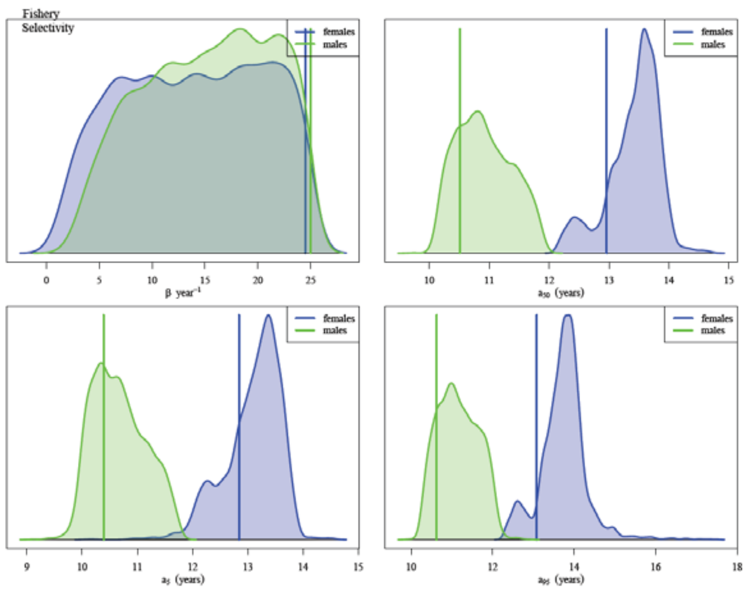
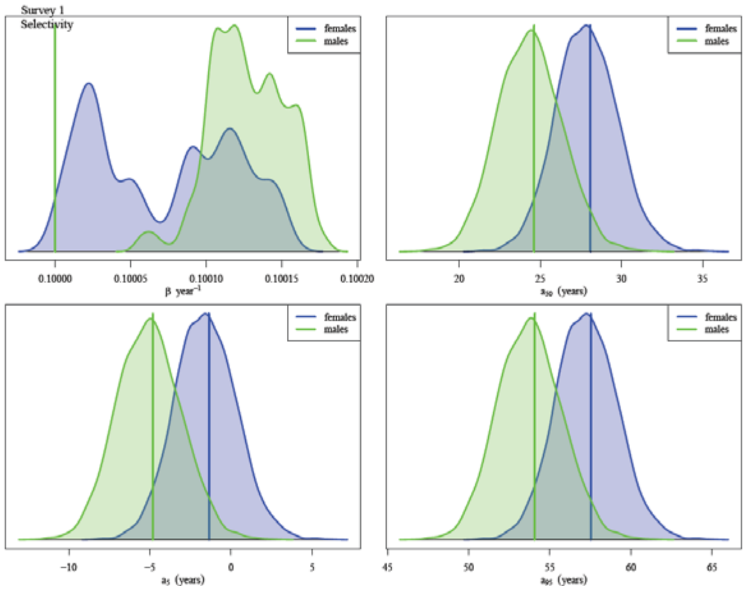


Figure 5.13. Marginal posterior distributions based on MCMC integration for the fishery logistic selectivity functions' parameters (β, i.e. slope, and age at 50% selection) and derived quantities (ages at 5% and 95% selection). Vertical lines indicate model estimates.

a) This year's assessment:



b) 2009 assessment:

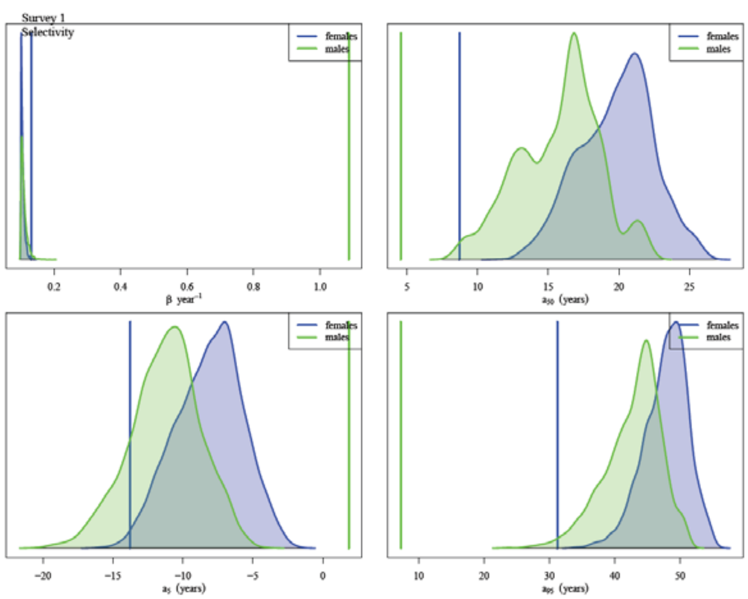
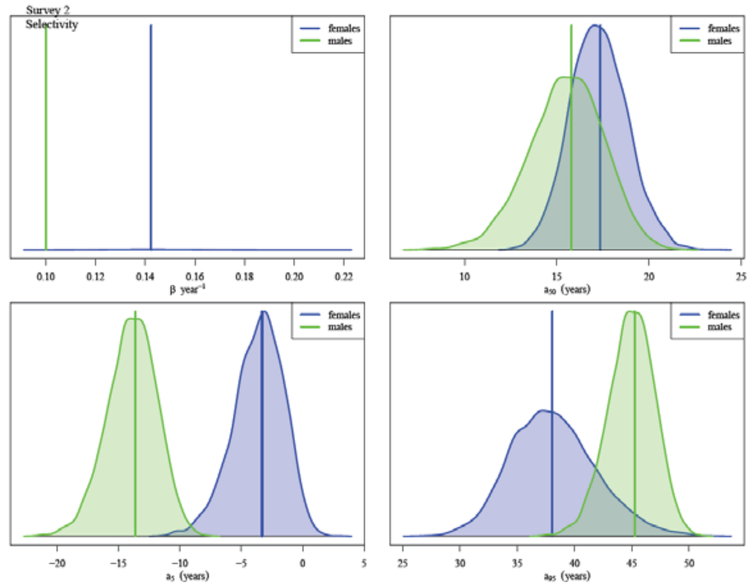


Figure 5.14. Marginal posterior distributions based on MCMC integration for the "full coverage" survey logistic selectivity functions' parameters (β, i.e. slope, and age at 50% selection) and derived quantities (ages at 5% and 95% selection). Vertical lines indicate model estimates.

a) This year's assessment:



b) 2009 assessment:

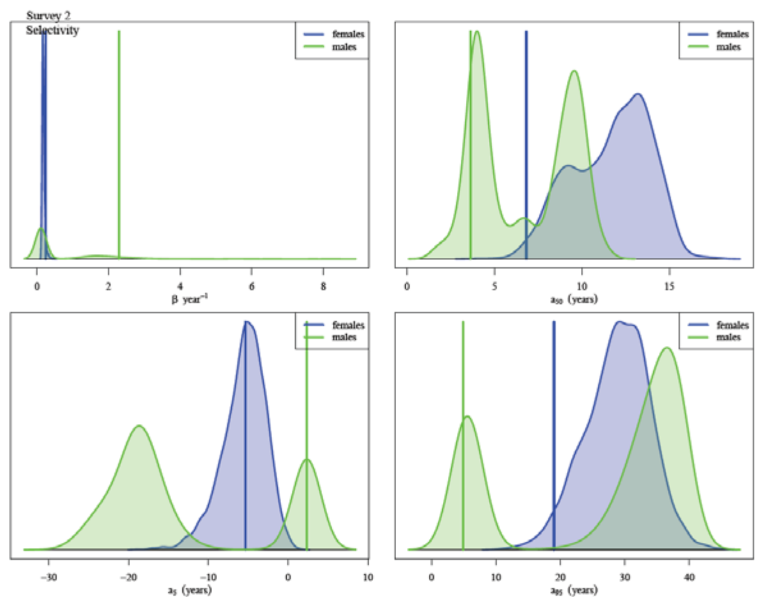
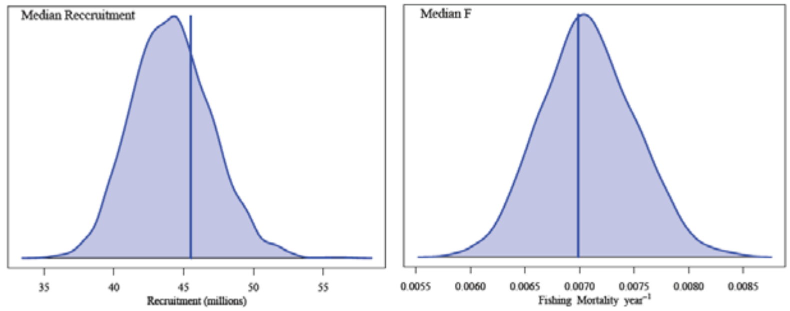


Figure 5.15. Marginal posterior distributions based on MCMC integration for the "shallow" survey logistic selectivity functions' parameters (β, i.e. slope, and age at 50% selection) and derived quantities (ages at 5% and 95% selection). Vertical lines indicate model estimates.

a) This year's assessment:



b) 2009 assessment:

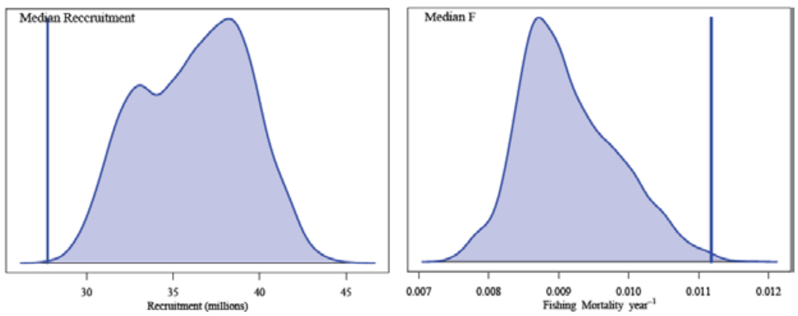
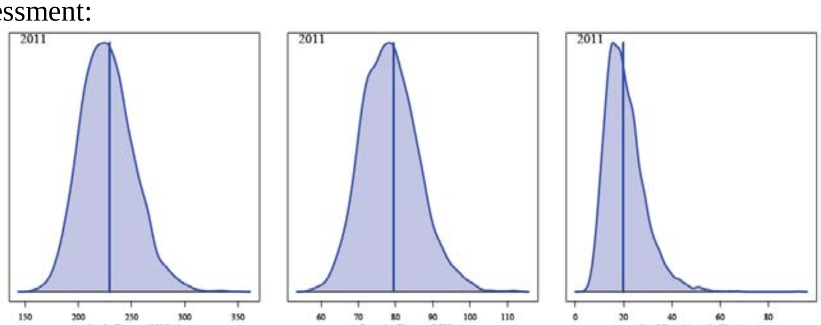


Figure 5.16. Marginal posterior distributions based on MCMC integration for median recruitment and median fishing mortality Vertical lines indicate model estimates.

a) This year's assessment:



b) 2009 assessment:

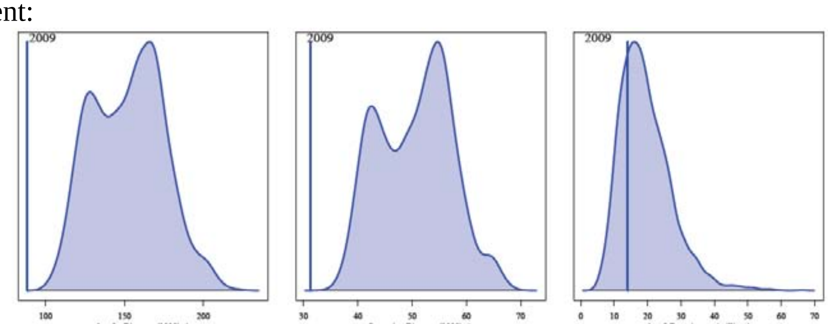
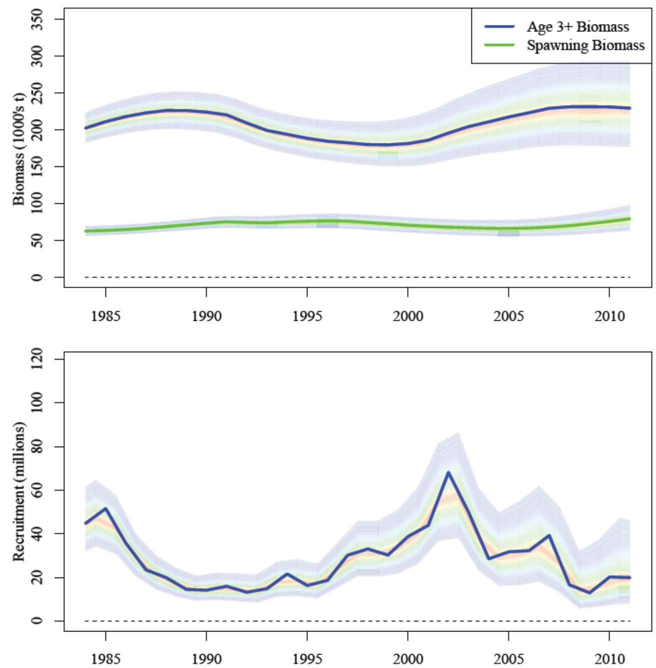


Figure 5.17. Marginal posterior distributions based on MCMC integration for total (age 3+) biomass, spawning biomass, and recruitment in the assessment year. Vertical lines indicate model estimates.

a) This year's assessment:



b) 2009 assessment:

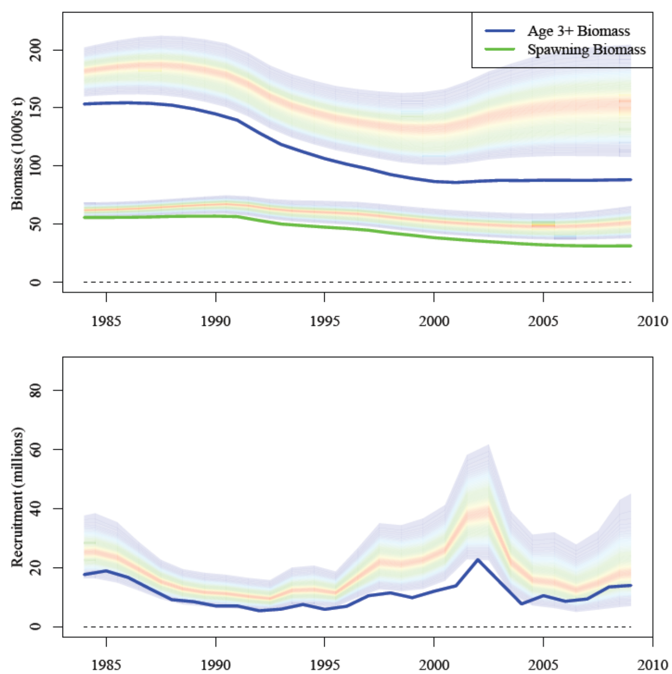
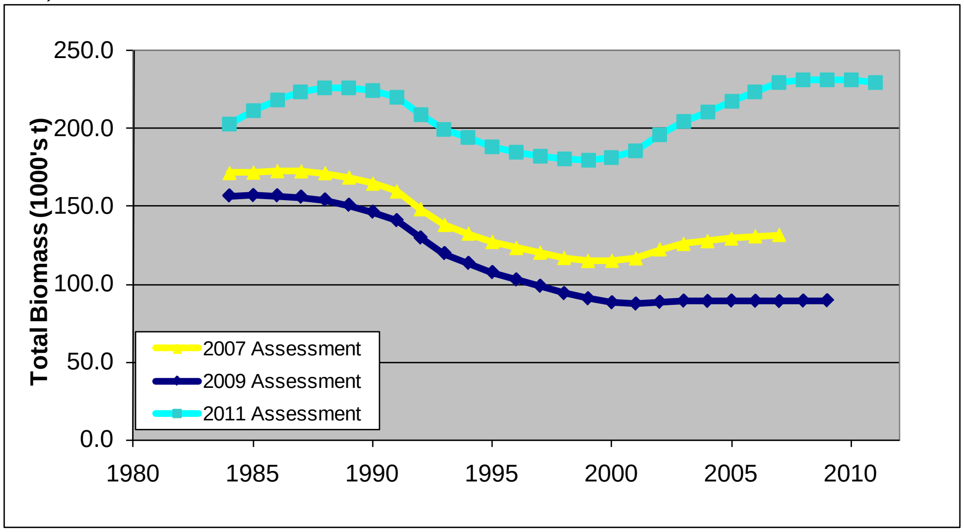


Figure 5.18. Comparison of time series estimates (solid line) and 99% credibility intervals based on MCMC integration (shaded area) for total (age 3+) biomass and spawning biomass (upper graph) and recruitment (lower graph) for: a) this year's assessment model and b) the 2009 assessment model.

a) Total (age 3+) biomass:



b) Spawning biomass :

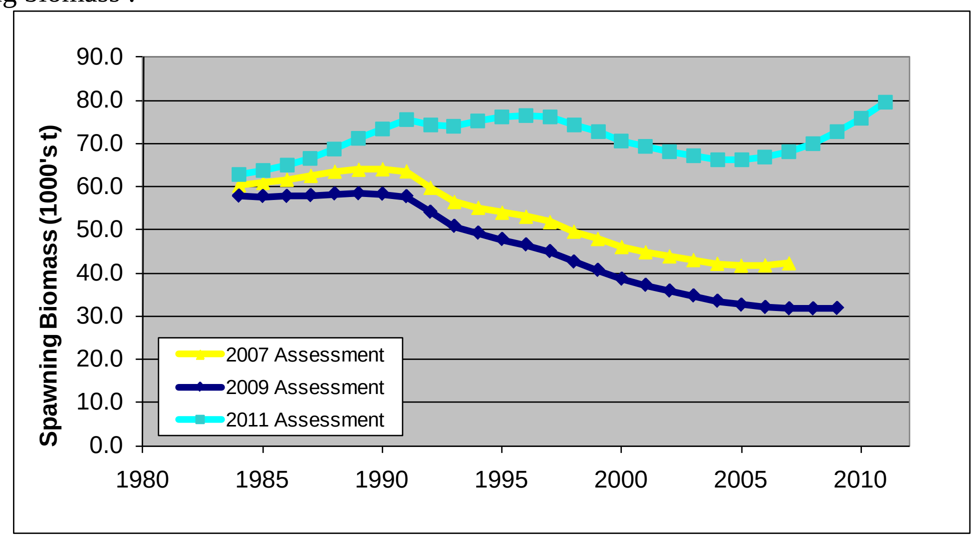


Figure 5.19. Comparison of model estimates from the 2011 (this year), 2009 and 2007 assessments for: a) total (age 3+) biomass and b) female spawning biomass.

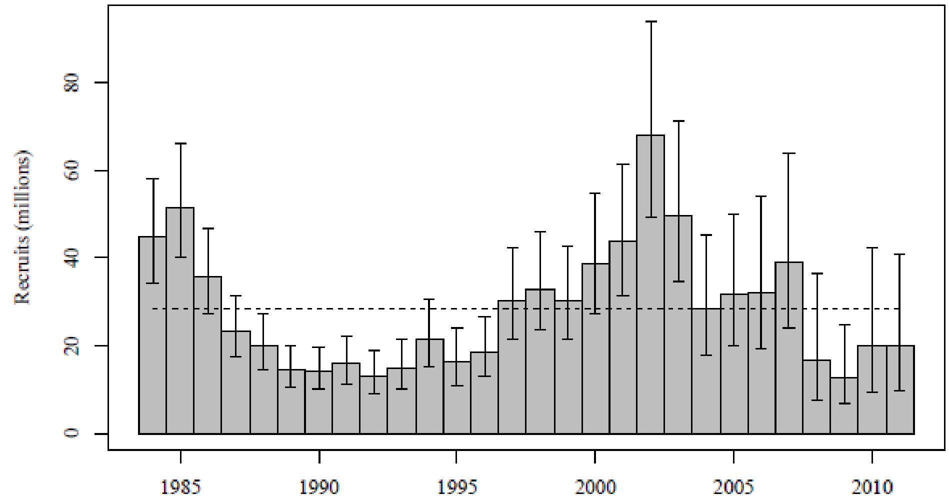


Figure 5.20. Estimated age 3 recruitments of GOA Dover sole from the preferred (base) model, with approximate 95% lognormal confidence intervals bassed on the model Hessian. The horizontal line is mean recruitment (28.5 million individuals).

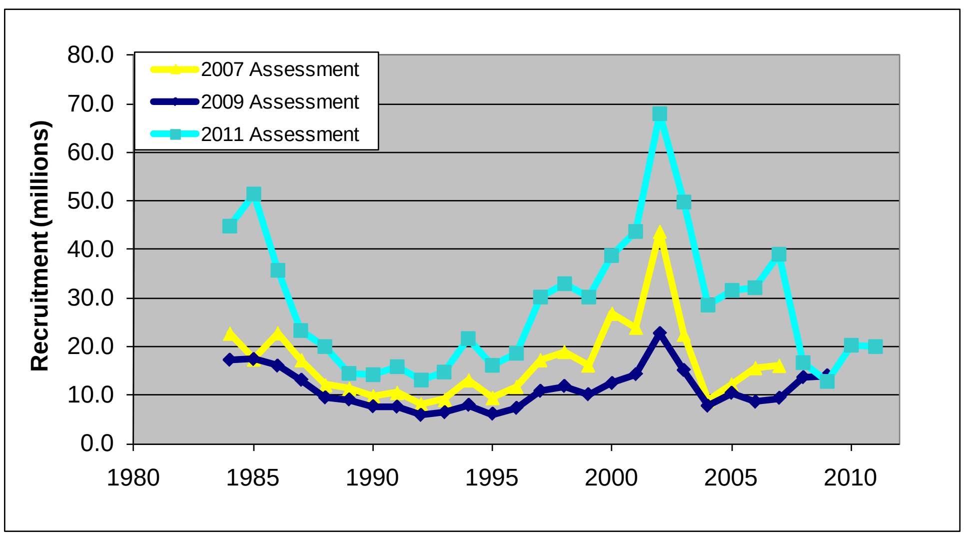


Figure 5.21. Comparison of recruitment estimates from the 2011 (this year), 2009 and 2007 assessments.

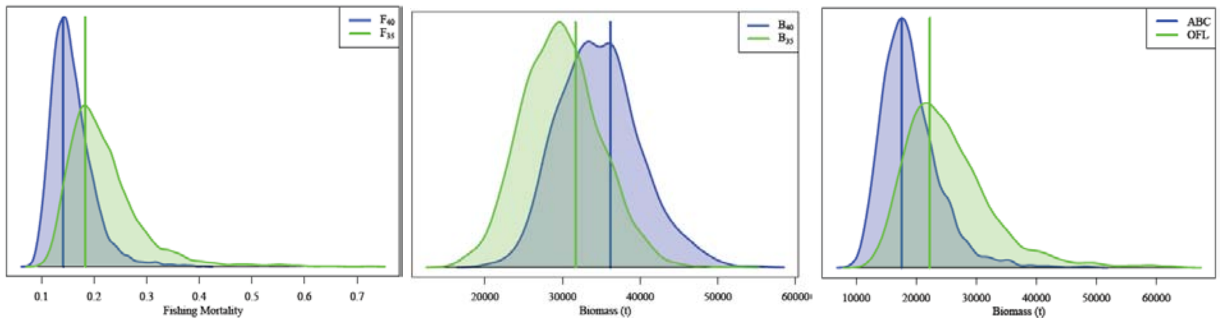


Figure 5.22. Marginal posterior distributions based on MCMC integration for several management – related quantities estimated in the 2011 model: $F_{40\%}$ and $F_{35\%}$ (left), $B_{40\%}$ and $B_{35\%}$ (center), and Tier 3-based estimates of ABC and OFL for 2012. Vertical lines indicate the estimated value.

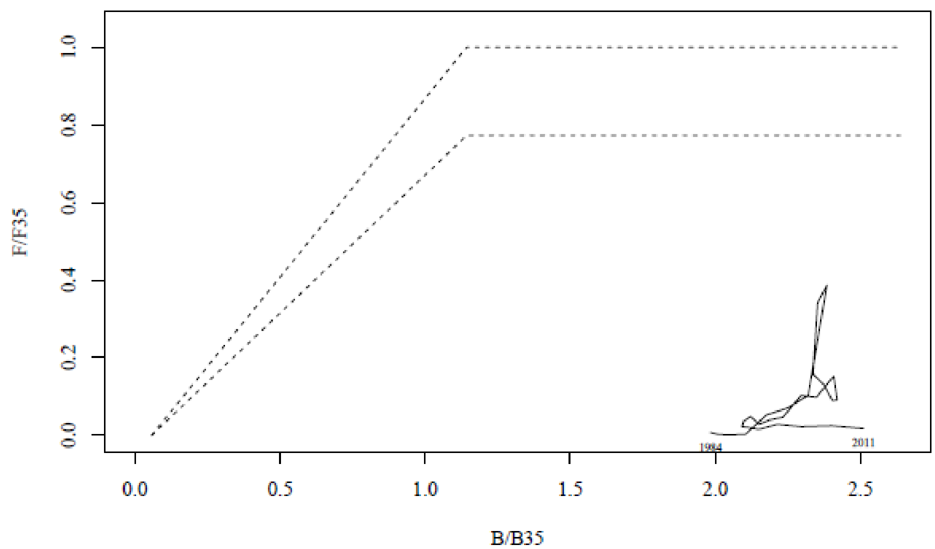


Figure 5.23. Control rule plot of estimated fishing mortality versus estimated female spawning biomass for GOA Dover sole as estimated by the model. The upper dotted line represents the prescribed OFL rule, the lower dotted line represents the prescribed ABC rule.

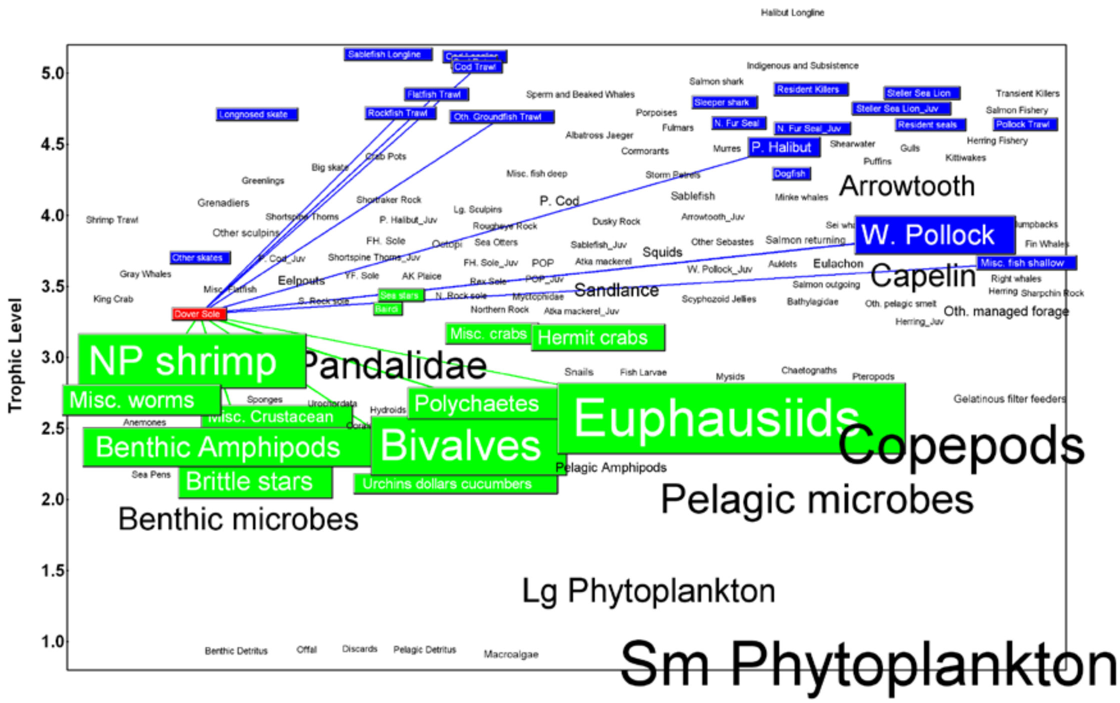


Figure 5.24. The food web from the GOA ecosystem model (Aydin et al., 2007) highlighting Dover sole links to predators (blue boxes and lines) and prey (green boxes and lines). Box size reflects relative standing stock biomass.

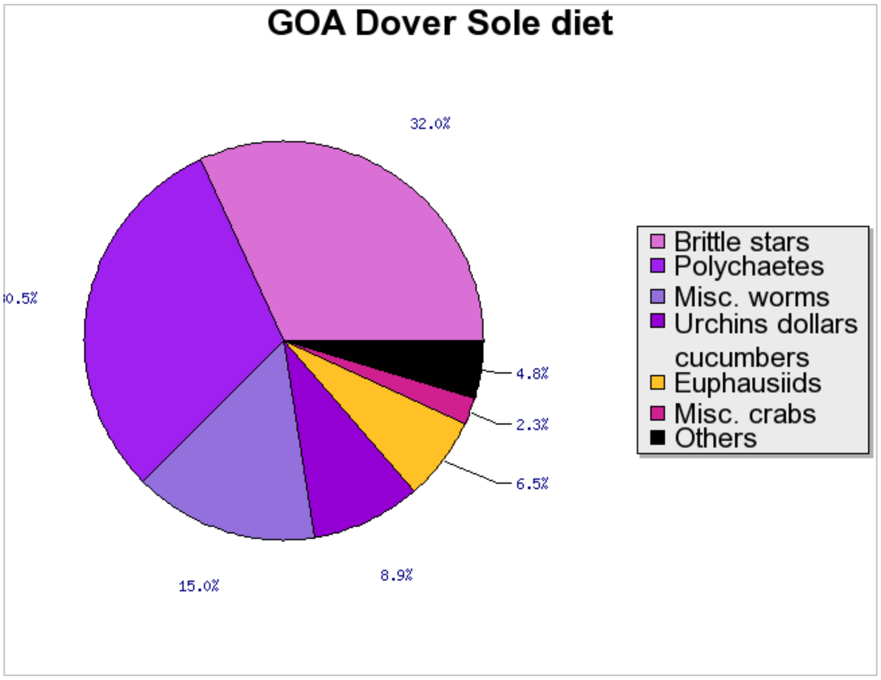


Figure 5.25. Diet composition for Dover sole from the GOA ecosystem model (Aydin et al., 2007).

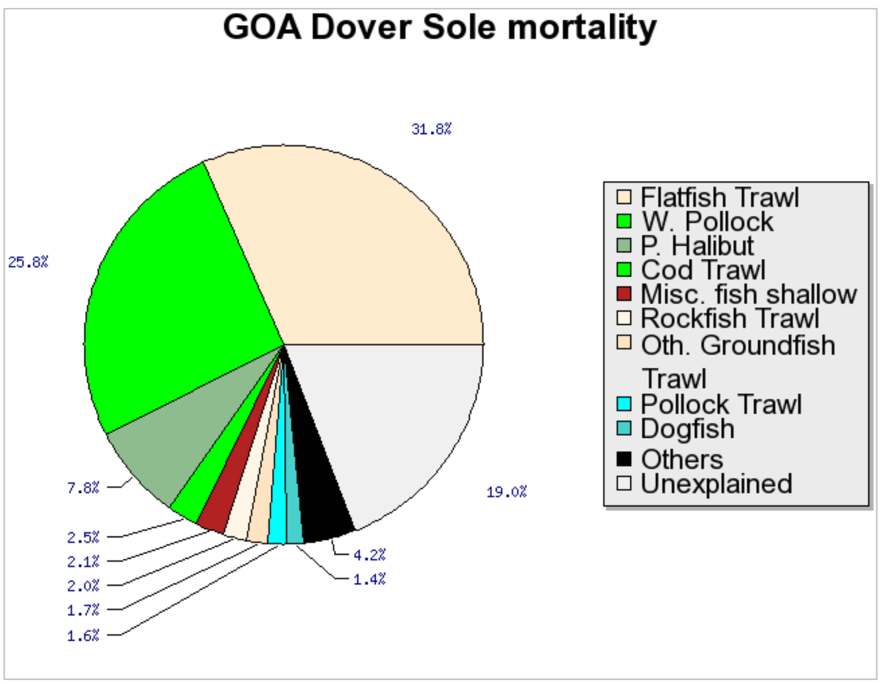


Figure 5.26. Decomposition of natural mortality for Dover sole from the GOA ecosystem model (Aydin et al., 2007).

Chapter 5 Appendix A: Model Equations

Table A.1. List of quantities and their definitions as used in the model.

Quantity	Definition
T	number of years in the model.
A	number of age classes (38).
L	number of length classes (28).
T_{min}	model start year (1984).
T_{max}	assessment year (2011).
t	time index.
a	age index ($1 \le a \le A$; a=1 corresponds to age at recruitment).
x	sex index ($1 \le x \le 2$; 1=female, 2=male).
l	length index ($1 \le l \le L$; l=1 corresponds to minimum length class).
$\{t^S\}$	set of years for which survey biomass data is available.
$\{t^{F,A}\}$	set of years for which fishery age composition data is available.
$\{t^{F,L}\}$	set of years for which fishery length composition data is available.
$\{t^{S,A}\}$	set of years for which survey age composition data is available.
$\{t^{S,L}\}$	set of years for which survey length composition data is available.
$L^x_{l,a}$	elements of length-age conversion matrix (proportion of sex x fish in age class a that are in length class l). (fixed)
$w_{x,a}$	mean body weight (kg) of sex x fish in age group a. (fixed)
ϕ_a	proportion of females mature at age a. (fixed)
$\overline{\ln R_0}$	mean value of log-transformed recruitment. (estimable)
τ_t	recruitment deviation in year t. (estimable)
M_x	instantaneous natural mortality rate. (fixed)
$\overline{\ln F}$	mean value of log-transformed fishing mortality. (estimable)
ε_t	deviations in fishing mortality rate in year t. (estimable)
R_t	recruitment in year t.
$N_{t,x,a}$	number of fish of sex x and age class a in year t.
$C_{t,x,a}$	catch (number) of fish of sex x and age class a in year t.
$p^{F,A}_{t,x,a}$	proportion of the total catch in year t that is sex x and in age class a.
$p^{F,L}_{t,x,l}$	proportion of the total catch in year t that is sex x and in length class l.
$p^{S,A}_{t,x,a}$	proportion of the survey biomass in year t that is sex x and in age group a.
$p^{S,L}_{t,x,l}$	proportion of the survey biomass in year t that is sex x and in age group a.
C_t	total catch (yield) in tons in year t.
$F_{t,x,a}$	instantaneous fishing mortality rate for sex x and age group a in year t.
$Z_{t,x,a}$	instantaneous total mortality for sex x and age group a in year t.
$s^{FU}_{x,a}$	unnormalized fishery selectivity for sex x and age group a.
$s^{SU}_{x,a}$	unnormalized survey selectivity for sex x and age group a.
$s^{FN}_{x,a}$	normalized fishery selectivity for sex x and age group a.
$s^{SN}_{x,a}$	normalized survey selectivity for sex x and age group a.

Table A.2. Model equations describing the model populations dynamics.

Equation	Description
$\tau_t \sim N(0,\sigma_R^2)$	Random deviate associated with recruitment.
$N_{t,x,1} = R_t = \exp\left(\overline{\ln R_0} + \tau_t\right)$	Recruitment (assumed equal for males and females).
$N_{t+1,x,a+1} = N_{t,x,a} e^{-Z_{t,x,a}}$	Numbers at age.
$N_{t+1,x,A} = N_{t,x,A-1} e^{-Z_{t,x,A-1}} + N_{t,x,A} e^{-Z_{t,x,A}}$	Numbers in "plus" group.
$C_{t,x,a} = \frac{F_{t,x,a}}{Z_{t,x,a}}(1-e^{-Z_{t,x,a}})N_{t,x,a}$	Catch at age (in numbers caught).
$C_t = \sum_{x=1}^{2}\sum_{a=1}^{A} w_{x,a} C_{t,x,a}$	Total catch in tons (i.e., yield).
$FSB_t = \sum_{a=1}^{A} w_{1,a}\phi_a N_{t,1,a}$	Female spawning biomass.
$Z_{t,x,a} = F_{t,x,a} + M$	Total mortality.
$F_{t,x,a} = s_{x,a}^F \cdot \exp\left(\overline{\ln F} + \varepsilon_t\right)$	Fishing mortality.
$\varepsilon_t \sim N(0,\sigma_F^2)$	Random deviate associated with fishing mortality.
$s_{x,a}^{FU} = \frac{1}{1+e^{(-b_x^F(age-{}_{50}A_x^F))}}$	Unnormalized fishery selectivity- 2 parameter ascending logistic - separate for males and females.
$s_{x,a}^{SU} = \frac{1}{1+e^{(-b_x^S(age-{}_{50}A_x^S))}}$	Unnormalized survey selectivity- 2 parameter ascending logistic - separate for males and females.
$s_{x,a}^{FN} = \exp(r_x^F)\frac{s_{x,a}^{FU}}{\max\{s_{1,a}^{FU}\}}$	Normalized fishery selectivity. $r^F_1 \equiv 0$.
$s_{x,a}^{SN} = \exp(r_x^S)\frac{s_{x,a}^{SU}}{\max\{s_{1,a}^{SU}\}}$	Normalized survey selectivity. $r^S_1 \equiv 0$.
$N^S{}_{t,x,a} = Q\ s^S_{x,a} N_{t,x,a}$	Survey numbers for sex *x*, age *a* at time *t*.
$SB_t = \sum_{x=1}^{2}\sum_{a=1}^{A} w_{x,a}\ N^S{}_{t,x,a}$	Total survey biomass.
$p_{t,x,a}^{F,A} = C_{t,x,a} / \sum_{x=1}^{2}\sum_{a=1}^{A} C_{t,x,a}$	Proportion at age in the catch.
$p_{t,x,l}^{F,L} = \sum_{a=1}^{A} L_{l,a}^x \cdot p_{t,x,a}^{F,A}$	Proportion at length in the catch.
$p_{t,x,a}^{S,A} = N^S{}_{t,x,a} / \sum_{x=1}^{2}\sum_{a=1}^{A} N^S{}_{t,x,a}$	Proportion at age in the survey.
$p_{t,x,l}^{S,L} = \sum_{a=1}^{A} L_{l,a}^x \cdot p_{t,x,a}^{S,A}$	Proportion at length in the survey.

Table A.3. Likelihood components.

Component	**Description**
$\sum_{t=1}^{T}\left[\log(C_t^{obs})-\log(C_t)\right]^2$	Catch; assumes a lognormal distribution.
$\sum_{t\in\{t^{F,A}\}}\sum_{x=1}^{2}\sum_{a=1}^{A} n_t^{samp}\cdot p_{t,x,a}^{F,A,obs}\cdot\log(p_{t,x,a}^{F,A})$ - offset	Fishery age composition; assumes a multinomial distribution. Observed sample size is n_t^{samp}.
$\sum_{t\in\{t^{F,L}\}}\sum_{x=1}^{2}\sum_{l=1}^{L} n_t^{samp}\cdot p_{t,x,l}^{F,L,obs}\cdot\log(p_{t,x,l}^{F,L})$ - offset	Fishery length composition; assumes a multinomial distribution. Observed sample size is n_t^{samp}.
$\sum_{t\in\{t^{F,A}\}}\sum_{x=1}^{2}\sum_{a=1}^{A} n_t^{samp}\cdot p_{t,x,a}^{S,A,obs}\cdot\log(p_{t,x,a}^{S,A})$ - offset	Survey age composition; assumes a multinomial distribution. Observed sample size is n_t^{samp}.
$\sum_{t\in\{t^{F,L}\}}\sum_{x=1}^{2}\sum_{l=1}^{L} n_t^{samp}\cdot p_{t,x,l}^{S,L,obs}\cdot\log(p_{t,x,l}^{S,L})$ - offset	Survey length composition; uses a multinomial distribution. Observed sample size is n_t^{samp}.
offset $=\sum_{t}\sum_{x=1}^{2}\sum_{a=1}^{A} n_t^{samp}\cdot p_{t,x,a}^{obs}\cdot\log(p_{t,x,a}^{obs}))$	The offset constants for age composition components are calculated from the observed proportions and the sample sizes. A similar formula is used for length composition component offsets.
$\sum_{t\in\{t^{S}\}}\left[\frac{\log\left[\frac{SB_t^{obs}}{SB_t}\right]}{\sqrt{2}\cdot s.d.(\log(SB_t^{obs}))}\right]^2$	Survey biomass; assumes a lognormal distribution.
$\sum_{t=T_{\min}}^{T_{\max}-3}(\tau_t)^2$	Recruitment; assumes a lognormal distribution, since τ_t is on a log scale.
$\sum_{t=T_{\max}-2}^{T_{\max}}(\tau_t)^2$	"Late" recruitment; assumes a lognormal distribution, since τ_t is on a log scale.
$\sum_{t=T_{\min}-A+1}^{T_{\min}-1}(\tau_t)^2$	"Early" recruitment; assumes a lognormal distribution, since τ_t is on a log scale. Determines age composition at starting year of model.

Table A.4. Parameters fixed in the model.

Parameter	Description
$M_x = 0.085$	sex-specific natural mortality rate.
$Q = 1.0$	survey catchability.
$L^x_{l,a}$	sex-specific length-at-age conversion matrix.
$w_{x,a}$	sex-specific weight-at-age.
ϕ_a	proportion of females mature at age a.

Table A.5. Parameters estimated in the model. A total of 103 parameters were estimated in the preferred model.

Parameter	Subscript range	Total no. of Parameters	Description
$\ln(R_0)$	NA	1	natural log of the geometric mean value of age 3 recruitment.
τ_t	$T_{\min} - A + 1 \le t \le T_{\max}$	63	log-scale recruitment deviation in year t.
$\ln(f_0)$	NA	1	natural log of the geometric mean value of fishing mortality.
ε_t	$T_{\min} \le t \le T_{\max}$	26	log-scale deviations in fishing mortality rate in year t.
r^F_2	NA	not estimated	scaling from female to male fishery selectivity (log-scale).
b^F_x , ${}_{50}A^F_x$	$1 \le x \le 2$	4	sex-specific selectivity parameters (slope and age at 50% selected) for the fishery.
r^S_2	S=1	not estimated	scaling from female to male survey selectivity (log-scale).
b^S_x , ${}_{50}A^S_x$	$1 \le x \le 2$ S=1	4	sex-specific selectivity parameters (slope and age at 50% selected) for the survey.

Chapter 5 Appendix B: Supplemental Catch Data

In order to comply with the Annual Catch Limit (ACL) requirements, two new datasets have been generated to help estimate total catch and removals from NMFS stocks in Alaska.

The first dataset, non-commercial removals, estimates total removals that do not occur during directed groundfish fishing activities (Table 5B.1). This includes removals incurred during research, subsistence, personal use, recreational, and exempted fishing permit activities, but does not include removals taken in fisheries other than those managed under the groundfish FMP. These estimates represent additional sources of removals to the existing Catch Accounting System estimates. For the GOA Dover sole stock, these estimates (currently available only for 2010) can be compared to research removals that have occurred in conjunction with the Gulf of Alaska Groundfish Surveys (Table 5B.2). Compared with the 2010 ABC (6,190 t), these non-commercial catches are miniscule (< 0.3% ABC) and do not present a risk to the GOA Dover sole stock.

The second dataset, the Halibut Fishery Incidental Catch Estimation (HFICE), is an estimate of the incidental catch of groundfish in the halibut IFQ fishery in Alaska, which is currently unobserved. To estimate removals in the halibut fishery, methods were developed by the HFICE working group and approved by the Gulf of Alaska and Bering Sea/Aleutian Islands Plan Teams and the Scientific and Statistical Committee of the North Pacific Fishery Management Council. A detailed description of the methods is available in Tribuzio et al. (2011).

These estimates are for total catch of groundfish species in the halibut IFQ fishery and do not distinguish between “retained” or “discarded” catch. These estimates should be considered a separate time series from the current CAS estimates of total catch. Because of potential overlaps HFICE removals should not be added to the CAS produced catch estimates. The overlap will apply when groundfish are retained or discarded during an IFQ halibut trip. IFQ halibut landings that also include landed groundfish are recorded as retained in eLandings and a discard amount for all groundfish is estimated for such landings in CAS. Discard amounts for groundfish are not currently estimated for IFQ halibut landings that do not also include landed groundfish. For example, catch information for a trip that includes both landed IFQ halibut and sablefish would contain the total amount of sablefish landed (reported in eLandings) and an estimate of discard based on at-sea observer information. Further, because a groundfish species was landed during the trip, catch accounting would also estimate discard for all groundfish species based on available observer information and following methods described in Cahalan et al. (2010). The HFICE method estimates all groundfish caught during a halibut IFQ trip and thus is an estimate of groundfish caught whether landed or discarded. This prevents simply adding the CAS total with the HFICE estimate because it would be analogous to counting both retained and discarded groundfish species twice. Further, there are situations where the HFICE estimate includes groundfish caught in State waters and this would need to be considered with respect to ACLs (e.g. Chatham Strait sablefish fisheries), although the extent to which this occurs for Dover sole is unknown. Therefore, the HFICE estimates should be considered preliminary estimates for what is caught in the IFQ halibut fishery. Improved estimates of groundfish catch in the halibut fishery may become available following restructuring of the Observer Program in 2013.

The HFICE estimates of Dover sole catch by the halibut fishery in the Gulf of Alaska are miniscule compared with recent ABC’s for the GOA stock (Table 5B.3). Based on these values, the risk to the stock from the halibut IFQ fishery is nil.

References:

Cahalan J., J. Mondragon., and J. Gasper. 2010. Catch Sampling and Estimation in the Federal Groundfish Fisheries off Alaska. NOAA Technical Memorandum NMFS-AFSC-205. 42 p.

Tribuzio, CA, S Gaichas, J Gasper, H Gilroy, T Kong, O Ormseth, J Cahalan, J DiCosimo, M Furuness, H Shen, K Green. 2011. Methods for the estimation of non-target species catch in the unobserved halibut IFQ fleet. August Plan Team document. Presented to the Joint Plan Teams of the North Pacific Fishery Management Council.

Tables

Table 5B.1. Non-commercial use catches of Dover sole in the Gulf of Alaska for 2010. Non-commercial use includes catches for research, recreation, subsistence, personal use and exempted fishing permits. The ABC for 2010 was 6,190 t.

Source	Dover Sole (t)
2010 Shumigans Acoustic Survey	0.0
IPHC	0.0
large-mesh trawl	2.5
NMFS_LL	1.1
Scallop dredge	0.0
small-mesh trawl	0.1
Structure of Gulf of Alaska Forage Fish Communities	0.0
Grand Total	**3.7**

Table 5B.2. Research catches from the Gulf of Alaska Groundfish Surveys. The ABC for 2011 was 6,305 t.

year	Research Catch (t)
1984	14.15
1987	12.80
1990	11.65
1993	14.77
1996	6.28
1999	5.49
2001	1.97
2003	5.80
2005	6.31
2007	5.75
2009	5.24
2011	4.55

Table 5B.3. HFICE estimated catches of Dover sole in the Gulf of Alaska by the halibut fishery. The ABC for the GOA Dover sole fishery is also listed for each year. The ABC for 2011 was 6,305 t.

	Dover sole (t)					
Year	Western Gulf	Central Gulf	West Yakutat	Southeast	Total	ABC
2001	0.0	0.0	0.0	0.0	0.0	
2002	0.0	0.0	0.0	0.0	0.0	
2003	0.0	0.0	0.0	0.0	0.0	
2004	0.0	0.3	0.0	0.0	0.3	
2005	0.0	0.0	0.0	0.0	0.0	
2006	0.0	0.0	0.0	0.0	0.0	
2007	0.0	0.0	0.0	0.7	0.7	
2008	0.2	0.0	0.0	0.1	0.2	
2009	0.0	0.0	0.0	0.0	0.0	
2010	0.0	1.4	0.0	0.0	1.4	