CHAPTER 10

OTHER FLATFISH

by

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EXECUTIVE SUMMARY

The following changes have been made to this assessment relative to the November 2005 SAFE:

Changes in the input data

1) The 2006 catch (total and discarded) was updated, and catch through 6 September, 2006 were included in the assessment.

2) 2006 Eastern Bering Sea and Aleutian Islands trawl survey biomass estimates and standard errors of other flatfish species were included in the assessment. A linear regression between the EBS shelf biomass estimates and the AI survey estimates was used to predict the AI biomass in years where an AI survey did not occur.

Changes in assessment results

1) Species specific values of natural mortality were used for Dover sole and rex sole to calculate the 2007 harvest recommendations. A summary of the 2006 assessment harvest recommendations relative to the 2005 assessment harvest recommendations are as follows:

	2006 Assessment recommendations	2005 Assessment recommendations
Exploitable biomass	149,292 t	120,900 t
ABC	21,396 t	18,135 t
Overfishing	28,528 t	24,180 t
F_{ABC} for rex sole	0.13	--
$F_{overfishing}$ for rex sole	0.17	--
F_{ABC} for Dover sole	0 .64	--.
$F_{overfishing}$ for Dover sole	0.085	--
F_{ABC} for the remaining species	0.20	0.20
$F_{overfishing}$ for the remaining species	0.15	0.15

Response to SSC comments

The SSC requests an evaluation of species-specific natural mortality rates for the species in this complex.

Species-specific natural mortality rates are presented and used for Dover sole and rex sole using Gulf of Alaska stock assessment values. Starry flounder natural mortality was considered from a west coast stock assessment, but not used.

The SSC appreciates the exploration of bottom water temperature effects on Sakhalin sole biomass estimates and encourage similar explorations of other species in the other flatfish complex. It would be useful to be able to identify indicator species that are particularly sensitive to changes in environmental conditions.

No further explorations of this type were tried this year.

The SSC notes that the exploitation rate on butter sole, implied by fishery catches relative to survey biomass, is very high and the cause of this warrants further investigation.

Our discussion in the text is our best appraisal of this phenomena. Butter sole are seemingly at the periphery of their distribution in the Bering Sea and Aleutian Islands and are sometimes caught in large quantities in a few trawl hauls when the fishery is targeting other species. The survey CV's in both the Aleutian Islands and on the EBS shelf are large.

Introduction

The Bering Sea/Aleutian Islands "other flatfish" group have typically included those flatfish besides rock sole, yellowfin sole, arrowtooth flounder, and Greenland turbot. Flathead sole (*Hippoglossoides elassodon*) were part of the other flatfish complex until they were removed in 1995, and Alaska plaice was removed from the complex in 2002, as sufficient biological data exists for these species to construct age-structured population models. In contrast, survey biomass estimates are the principal data source used to assess the remaining other flatfish. Although over a dozen species (Table 10.1) of flatfish are found in the BSAI area, the other flatfish biomass consists primarily of starry flounder, rex sole, longhead dab, and butter sole.

Catch History

The miscellaneous species of the other flatfish species category are listed in Table 10.1, and their catches from 1995-2005 are shown in Table 10.2. These species are not pursued as fishery targets but are captured in fisheries for other species. Catch from 1995-2003 were obtained from the NMFS Regional Office "blend" data, and the catch for some species are reported by species and in an aggregate flatfish group. The catch estimates for these years were produced by applying the proportional catch, by species, from fishery observer data to the estimated total catch for the aggregate other flatfish group, and adding this total to the catch that was reported by species. In the newer catch accounting system (in use since 2003), catches of other flatfish are reported only in an aggregate group, and the catch estimates for these years were produced by applying the proportional catch, by species, from fishery observer data to the estimated total catch of the aggregate group. In recent years, starry flounder (*Platichthys stellatus*) and rex sole (*Glyptocephalus zachirus*) account for most of the harvest of other flatfish, and contributed 91% of the harvest of other flatfish in 2006.

Other flatfish are grouped with Alaska plaice, rock sole, and flathead sole and other flatfish fisheries in a single prohibited species class (PSC) classification, with seasonal and total annual allowances of prohibited bycatch applied to the classification. In recent years, this group of fisheries has been closed prior to attainment of the TAC due to the bycatch of halibut (Table 10.3). In 2006, after closures in the first and second quarters due to halibut bycatch, 1,400 t of TAC reserve was apportioned to the "other flatfish" complex on June 30 to supplement the TAC. The retention of these species was prohibited after August 7 to prevent exceeding the 2006 TAC. The total catch of other flatfish, as September 6, 2006, was 3,233 t, 92% of the TAC level of 3,500 t.

DATA

Absolute Abundance and Exploitation Rates

The biomass of the other flatfish complex on the eastern Bering Sea shelf has been relatively stable from 1983-1995, averaging 50,200 t, and has slightly increased from 1996 to 2005, averaging 84,500 t (Table 10.4). The 2006 biomass estimate of 132,852 t of other flatfish on the EBS shelf is the highest estimate since surveys began in 1982 and the Aleutian Islands trawl survey biomass estimate of 16,440 is the highest observed there as well. The increases are

primarily due to the higher estimate of starry flounder on the Eastern Bering Sea shelf. An estimate of total BSAI biomass for the years in which an AI survey was not conducted was calculated by regressing the AI survey biomass against the EBS survey biomass and adding the predicted AI biomass estimate to the observed EBS estimate. Individual species biomass estimates for the EBS and AI areas from 1997-2006 are shown in Table 10.5. Estimates of species biomass for starry flounder, rex sole, and butter sole in the Aleutian Islands were computed by fitting a linear trend to the observed survey data from 1991-2004, and using this trend to estimate biomass in years without an Aleutian Island survey. Estimate of total BSAI biomass (Table 10.6) were then used to compute species-specific exploitation rates.

Exploitation rates for starry flounder and rex sole have been low, not exceeding 0.10 from 1997 to 2006 (Table 10.6). The exploitation rates for butter sole have been higher, exceeding 0.14 in 1997, 2000, 2001, and 2003-2006, but the biomass estimates for butter sole have large sampling variances, with coefficients of variation ranging from 0.5 to 0.86 in recent EBS trawl surveys dating back to 1999.

The 2003 biomass estimate of butter sole of 429 t is less than one-fourth the 2002 estimate of 2382, and results in an estimated exploitation rate of nearly 70%. However, butter sole were only captured in four hauls in the 2003 EBS trawl survey, leading to the large coefficient of variation of 0.61 for the estimated biomass. In addition, the bulk of the 2003 fishery catch came primarily from waters less than 50 m in January and February, a depth and time not covered by the trawl survey. Thus, it is likely that the population of butter sole is larger than that indicated from the survey, and the comparison of survey biomass to harvest should be interpreted accordingly. The 2006 biomass estimate of butter sole was 1104 t, more than twice the 2003 estimate, with a high CV in both the shelf survey (0.53) and in the Aleutian Islands (0.98).

Several species of other flatfish are relatively rare on the EBS shelf, including Dover sole, Sakhalin sole, and English sole, and it is useful to identify whether the EBS represents the edge of the distribution for these species. The distribution of English sole has been identified as Baja California to Unimak Island, and the distribution of Dover sole has been identified as from Baja California to the Bering Sea (Hart 1973). Thus, the eastern Bering Sea can be considered the periphery of the range for these species. They are much more abundant in the Gulf of Alaska. For example, the abundance of Dover sole in the 1984-2001 GOA surveys has fluctuated between 63,000 t and 96,000 t, the abundance of butter sole has fluctuated between 17,000 t and 30,000 t, and the abundance of English sole has fluctuated between 3,000 t and 14,000 t (Turnock et al. 2001). Dover sole and English sole were most common in the eastern portion of the GOA, consistent with their reported distribution along the west coast of North America. In the case of Sakhalin sole, which prefer colder water and are caught at the northern extent of the survey, their perceived abundance from survey biomass estimates may be related to annual mean bottom water temperature (Fig 10.1).

PROJECTIONS AND HARVEST ALTERNATIVES

Reference Fishing Mortality Rates and Yields

Other flatfish are assessed under Tier 5 of Amendment 56 to the BSAI groundfish management plan, and thus have harvest recommendations which are directly calculated from estimates of biomass and natural mortality. The natural mortality rates used in age-structured BSAI flatfish assessments can be used as guidance and are presented below:

Species	Natural mortality rate used for stock assessment
BSAI Yellowfin sole	0.12
BSAI Rock sole	0.16
BSAI Flathead sole	0.20
BSAI Alaska plaice	0.25
GOA Rex sole	0.17
GOA Dover sole	0.085

Natural mortlity values for rex and Dover sole are available from age-structured assessments in the Gulf of Alaska SAFE document (Turnock and A'mar 2005 and Stockhausen et al. 2005) and those published values are used for rex and Dover sole in this stock assessment. For the remaining flatfish species, where less information is available, an assumption of M = 0.2 appears reasonable given the range of values shown above. For the case of starry flounder where estimates are available from a west coast stock assessment (Ralston 2005), the high estimates of M (male = 0.45, female = 0.3) are not used here due to the uncertainty of the estimates and the large spatial difference between the two management areas.

The estimates of F_{abc} and F_{ofl} under tier 5 are 0.75M and M, respectively, and the ABC and OFL levels are the product of the fishing mortality rate and the biomass estimate. Given the F_{abc} and F_{ofl} levels of 0.15 and 0.20, and the biomass estimate of 149,292 t, the resulting ABC and OFL levels are 21,396 and 28,528 t.

	F_{ABC}	**F_{OFL}**	**ABC**	**OFL**
Rex sole	0.17	0.13	4,557	6,077
Dover sole	0.064	0.085	143	191
Others	0.15	0.20	16,695	22,260
Total Other flatfish			**21,396**	**28,528**

Summary

In summary, several quantities pertinent to the management of the other flatfish are listed below.

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Quantity	Value
Tier	5
Year 2006 Total Biomass	149,292 t
OFL	28,528 t
Maximum allowable ABC	21,396 t
Recommended ABC	21,396 t

REFERENCES

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Research Board of Canada, Bulletin 180, Ottawa. 740 pp.

Ralston, S. 2005. Starry flounder. An assessment of starry flounder off California, Oregon and Washington. In Status of the Pacific coast groundfish fisheries through 2005. Stock assessment and fishery evaluation. Pacific Fishery Management Council, Portland Oregon.

Spencer, P.D., T.K. Wilderbuer, and C.I. Zhang. 2002. A mixed-species yield per recruit model for eastern Bering Sea flatfish fisheries. Can J. Fish. Aquat. Sci. 59:291-302.

Stockhausen, W.T., B. J. Turnock, A. T. A'mar, M. E. Wilkins and M. H. Martin. 2005. Gulf of Alaska Dover Sole. In Stock Assessment and Fishery Evaluation Document for Groundfish Resources in the Gulf of Alaska Region as Projected for 2002. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage Alaska 99510.

Turnock, B.J., T.K. Wilderbuer, and E.S. Brown. 2001. Gulf of Alaska flatfish. In Stock Assessment and Fishery Evaluation Document for Groundfish Resources in the Gulf of Alaska Region as Projected for 2006. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage Alaska 99510.

Turnock, B.J. and Z. T. A'mar. 2005. Gulf of Alaska rex sole stock assessment. In Stock Assessment and Fishery Evaluation Document for Groundfish Resources in the Gulf of Alaska Region as Projected for 2006. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage Alaska 99510.

Table 10.1. Flatfish species of the Bering Sea/Aleutian Islands "other flatfish" management complex.

Common Name	Scientific Name
Arctic flounder	*Liopsetta glacialis*
butter sole	*Isopsetta isolepis*
curlfin sole	*Pleuronectes decurrens*
deepsea sole	*Embassichths bathybus*
Dover sole	*Microstomus pacificus*
English sole	*Parophrys vetulus*
longhead dab	*Limanda proboscidea*
Pacific sanddab	*Citharichthys sordidus*
petrale sole	*Eopsetta jordani*
rex sole	*Glyptocephalus zachirus*
roughscale sole	*Clidodoerma asperrimum*
sand sole	*Psettichthys melanostictus*
slender sole	*Lyopsetta exilis*
starry flounder	*Platichthys stellatus*
Sakhalin sole	*Pleuronectes sakhalinensis*

Table 10.2. Harvest (t) of other flatfish from 1995-2006. 2006 catch is through September 6, 2006.

Year	Starry Flounder	Rex Sole	Butter Sole	Remaining Species	Total	ABC	TAC
1995	398	673	157	97	1324	117,000	19,540
1996	1171	1148	218	211	2748	102,000	35,000
1997	1043	687	448	312	2490	97,500	50,750
1998	402	998	229	136	1765	164,000	89,434
1999	725	998	230	164	2117	154,000	154,000
2000	1151	1069	458	349	3027	117,000	83,813
2001	755	869	244	160	2028	122,000	28,000
2002	1075	1192	222	142	2631	18,100	3,000
2003	887	1399	296	166	2749	16,000	3,000
2004	2062	1858	514	235	4669	13,500	3,000
2005	2069	2001	487	42	4599	21,400	3,500
2006	1663	1266	261	43	3233	18,100	3,500

Table10.3. Restrictions on the "other flatfish" fishery from 1995 to 2006 in the Bering Sea – Aleutian Islands management area. Note that in 1994, the other flatfish category included flathead sole. Unless otherwise indicated, the closures were applied to the entire BSAI management area. Zone 1 consists of areas 508, 509, 512, and 516, whereas zone 2 consists of areas 513, 517, and 521.

Year	Dates	Bycatch Closure
1995	2/21 – 3/30	First Seasonal halibut cap
	4/17 – 7/1	Second seasonal halibut cap
	8/1 – 12/31	Annual halibut allowance
1996	2/26 – 4/1	First Seasonal halibut cap
	4/13 – 7/1	Second seasonal halibut cap
	7/31 – 12/31	Annual halibut allowance
1997	2/20 – 4/1	First Seasonal halibut cap
	4/12 – 7/1	Second seasonal halibut cap
	7/25 – 12/31	Annual halibut allowance
1998	3/5 – 3/30	First Seasonal halibut cap
	4/21 – 7/1	Second seasonal halibut cap
	8/16 – 12/31	Annual halibut allowance
1999	2/26 – 3/30	First Seasonal halibut cap
	4/27 – 7/04	Second seasonal halibut cap
	8/31 – 12/31	Annual halibut allowance
2000	¾ – 3/31	First Seasonal halibut cap
	4/30 – 7/03	Second seasonal halibut cap
	8/25 – 12/31	Annual halibut allowance
2001	3/20 – 3/31	First Seasonal halibut cap
	4/27 – 7/01	Second seasonal halibut cap
	8/24 – 12/31	Annual halibut allowance
2002	2/22 – 12/31	Red King crab cap (Zone 1 closed)
	3/1 – 3/31	First Seasonal halibut cap
	4/20 – 6/29	Second seasonal halibut cap
	7/29 – 12/31	Annual halibut allowance
2003	2/18 – 3/31	First Seasonal halibut cap
	4/1 – 6/21	Second seasonal halibut cap
	7/31 – 12/31	Annual halibut allowance
2004	2/24 – 3/31	First Seasonal halibut cap
	4/10 – 12/31	Bycatch status
2005	3/1 - 3/31	First Seasonal halibut cap
	4/22-6/30	Second Seasonal halibut cap
	5/9-12/31	Bycatch status, TAC attained
2006	2/21 - 3/31	First Seasonal halibut cap
	4/5 – 12/31	Red King crab cap (Zone 1 closed)
	4/12 – 5/31	Second seasonal halibut cap
	5/26	TAC attained, 7,000 t reserve released
	8/7 – 12/31	Annual halibut allowance

Table 10.4. Estimated biomass (t) of other flatfish from the eastern Bering Sea and Aleutian Islands trawl surveys. Species included are Dover sole, longhead dab, rex sole, Sakhalin sole, starry flounder, and butter sole. A linear regression between EBS and AI survey abundance was used to predict AI abundance in years in which an AI survey did not occur.

	Area		
Year	EBS	AI	Total
1982	117763		129518
1983	66131	2700	68831
1984	59647		64956
1985	34572		37101
1986	39517	6100	45617
1987	49764		53977
1988	43751		47298
1989	49592		53786
1990	46649		50517
1991	72399	2144	74543
1992	53817		58480
1993	44399		48017
1994	54045	5464	59509
1995	37786		40671
1996	60225		65599
1997	70225	7580	77805
1998	73936		80830
1999	67713		73917
2000	70538	8149	78687
2001	78844		86282
2002	98052	8801	106853
2003	90327		99039
2004	127630	14980	142610
2005	107538		120900
2006	132852	16440	149292

Table 10.5 --Estimated biomass (t) and coefficient of variation (in parentheses) for the miscellaneous species of the "other flatfish" management complex in the Bering Sea trawl and Aleutian Islands surveys.

Eastern Bering Sea Shelf survey

Year	Dover Sole	Rex Sole	Species longhead dab	Sakhalin sole	starry flounder	butter sole	English sole
1982	--	5994 (0.16)	103806 (0.16)	--	7781 (0.32)	182 (0.82)	--
1983	--	7272 (0.18)	51386 (0.38)	--	7436 (0.25)	37 (0.45)	--
1984	--	13058 (0.28)	35308 (0.16)	137 (0.43)	8913 (0.36)	2231 (0.64)	--
1985	10 (1.04)	10751 (0.20)	9107 (0.13)	102 (0.37)	12181 (0.24)	2421 (0.83)	--
1986	15 (1.00)	12886 (0.22)	10889 (0.14)	274 (0.48)	9112 (0.33)	6341 (0.58)	--
1987	81 (0.91)	12931 (0.19)	11897 (0.19)	110 (0.59)	22702 (0.63)	2043 (0.38)	--
1988	38 (0.59)	15445 (0.15)	16710 (0.19)	253 (0.63)	9222 (0.30)	2083 (0.47)	--
1989	--	12939 (0.15)	13086 (0.16)	58 (0.57)	22205 (0.35)	1304 (0.54)	--
1990	47 (0.58)	11857 (0.21)	18601 (0.15)	110 (0.51)	15048 (0.26)	986 (0.60)	--
1991	55 (0.70)	16014 (0.28)	18680 (0.14)	291 (0.79)	34303 (0.23)	3056 (0.50)	--
1992	137 (0.58)	14001 (0.24)	10827 (0.17)	75 (0.48)	27544 (0.22)	1233 (0.70)	--
1993	37 (0.75)	14567 (0.32)	11690 (0.21)	78 (0.34)	16510 (0.22)	1517 (0.75)	--
1994	73 (0.72)	15943 (0.38)	18533 (0.26)	183 (0.41)	18218 (0.22)	1095 (0.97)	--
1995	--	10420 (0.28)	8402 (0.15)	109 (0.32)	17652 (0.29)	1203 (0.54)	--
1996	--	10532 (0.40)	8567 (0.20)	34 (0.34)	40409 (0.45)	683 (0.53)	--
1997	--	8233 (0.27)	18003 (0.21)	87 (0.49)	41018 (0.21)	2884 (0.43)	--
1998	41 (0.44)	7588 (0.22)	14737 (0.19)	34 (0.49)	49605 (0.30)	1942 (0.38)	--
1999	16 (0.65)	8020 (0.28)	12087 (0.21)	63 (0.29)	43375 (0.25)	4152 (0.62)	--
2000	11 (1.02)	9348 (0.19)	13511 (0.30)	145 (0.88)	45810 (0.19)	1713 (0.56)	--
2001	16 (0.84)	21660 (0.23)	12764 (0.26)	31 (0.43)	43026 (0.25)	796 (0.50)	--
2002	7 (0.80)	26053 (0.20)	9740 (0.22)	7 (0.69)	59877 (0.23)	2254 (0.64)	--
2003	350 (0.66)	28023 (0.15)	8827(0.22)	55 (0.40)	52893 (0.17)	179 (0.61)	
2004	31(0.51)	28762 (0.19)	11290 (0.23)	8 (0.64)	86698 (0.38)	841 (0.86)	--
2005	157(0.19)	23171 (0.19)	11556 (0.21)	23(0.90)	71673(0.26)	958(0.81)	--
2006	90(0.53)	21515(0.28)	13204 (0.25)	52(0.41)	96900(0.37)	1091(0.53)	--

Aleutian Islands Surveys

Year	Dover Sole	Rex Sole	Species longhead dab	Sakhalin sole	starry flounder	butter sole	English sole
1991	174 (0.45)	1694 (0.18)	--	--	142 (0.85)	86 (0.73)	47 (0.80)
1994	438 (0.41)	4306 (0.15)	--	--	134 (0.69)	505 (0.98)	83 (0.81)
1997	386 (0.34)	6378 (0.16)	--	--	459 (0.90)	346 (0.98)	12 (0.72)
2000	630 (0.38)	6526 (0.18)	--	--	590 (0.71)	310 (0.99)	95 (0.97)
2002	575 (0.28)	7381 (0.15)	--	--	671 (0.72)	127 (0.83)	47 (0.94)
2004	870 (0.28)	13717 (0.18)	--	--	123 (0.72)	235 (0.93)	35(1.00)
2005	2155 (0.57)	14230 (0.19)	--	--	17 (0.97)	13(0.98)	25(0.84)

Table 10.6. Estimated exploitation rates of rex sole, starry flounder and butter sole from 1997 to 2006.

	Rex sole			Starry Flounder			Butter sole		
Year	Biomass (t)	Harvest (t)	Exp. Rate	Biomass (t)	Harvest (t)	Exp. Rate	Biomass (t)	Harvest (t)	Exp. Rate
1997	14611	401	0.03	41477	814	0.02	3230	336	0.10
1998	14250	569	0.04	49950	242	0.00	2210	157	0.07
1999	15415	516	0.03	43750	597	0.01	4416	167	0.04
2000	15874	569	0.04	46400	770	0.02	2023	266	0.13
2001	30524	507	0.02	43829	479	0.01	1059	147	0.14
2002	33411	1227	0.04	60633	1023	0.02	2382	187	0.08
2003	38349	1399	0.04	53353	887	0.02	429	296	0.69
2004	42479	1858	0.04	86821	2062	0.02	1076	514	0.48
2005	34963	1830	0.05	72176	1892	0.03	1201	445	0.37
2006	35745	1266	0.04	96917	1663	0.02	1104	261	0.24

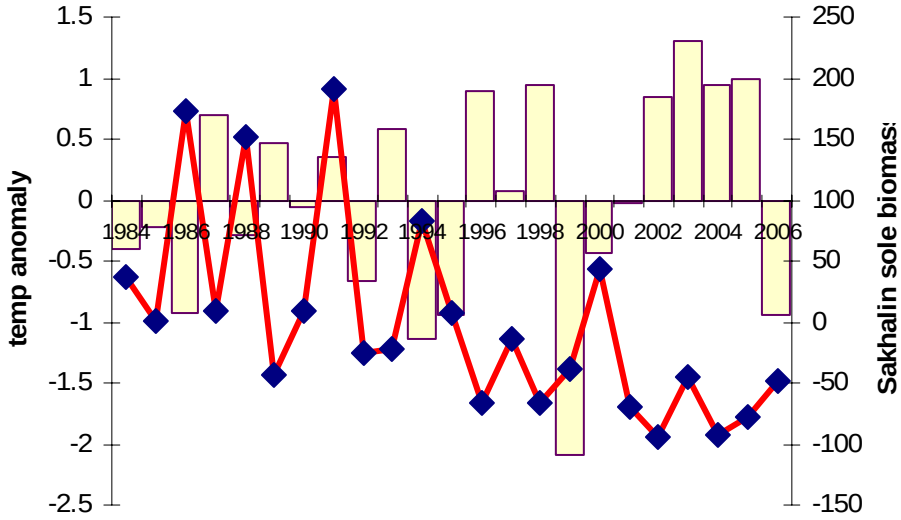

Figure 10.1—Relationship between annual survey bottom water temperature anomalies (yellow bars) and Sakhalin sole biomass estimates (red line).