Agenda Item E.6.a
Attachment 5
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Updated U.S. English sole stock assessment: Status of the resource in 2007

Ian J. Stewart
National Marine Fisheries Service
Northwest Fisheries Science Center
2725 Montlake Blvd. E.
Seattle WA, 98112
206-302-2447 (phone)
206-860-6792 (fax)
Ian.Stewart@noaa.gov

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Executive Summary

Stock

This assessment updates the status of the English sole (*Parophrys vetulus*) resource off the coast of the United States from the Mexican Border to the Canadian border. As in the 2005 assessment, data sources are treated separately for a southern (INPFC Conception and Monterey) and a northern (INPFC Eureka, Columbia and U.S. Vancouver) area, however the English sole population is modeled as a single stock.

The biggest obstacle to modeling the English sole population in the southern and northern areas separately is a lack of data; specifically the length frequency of discarded fish (to reliably estimate selectivity separately for each fleet), current maturity observations and sufficient age data (mainly from the south) to allow estimation of the growth curve for each area as well as model changes in growth over time. Without these data and more spatially complex models, it is difficult to speculate on whether regional management is appropriate for English sole, as relatively large historical catches of similar magnitude have been removed from both areas, albeit over different portions of the historical record.

Catches

This updated assessment uses historical landings reconstructed from a variety of sources for the 2005 assessment describing the fishery removals over the period 1876 to 1980. Landings from 1981 to 2006 have been updated to reflect the best available estimates as of May, 2007. Peak landings from the southern area occurred in the 1920s with a maximum of 3,976 metric tons (mt) of English sole landed in 1929. Peak landings from the northern area occurred from the 1940s to the 1960s with a maximum of 4,008 mt landed in 1948. Landings in both areas have generally declined since the mid 1960s and are at historical lows in recent years. Model estimates of discarding average 24% by weight over the time-series since 1940, with higher discards corresponding to periods of large recruitment and due to the associated increase in catch of smaller unmarketable English sole due to modeled changes in selectivity and growth.

Table a. Recent commercial fishery landings by INPFC area and fleet.

Year	Conception	Monterey	South total	Eureka	Columbia	US Vancouver	North total
1997	12	453	466	185	454	301	941
1998	5	224	229	198	330	264	792
1999	9	219	227	158	296	172	626
2000	9	173	182	125	227	200	552
2001	29	170	199	223	340	180	742
2002	6	95	102	271	342	439	1,052
2003	3	114	117	68	171	432	670
2004	31	66	97	205	242	372	819
2005	15	55	70	183	290	345	818
2006	1	56	57	238	338	254	829

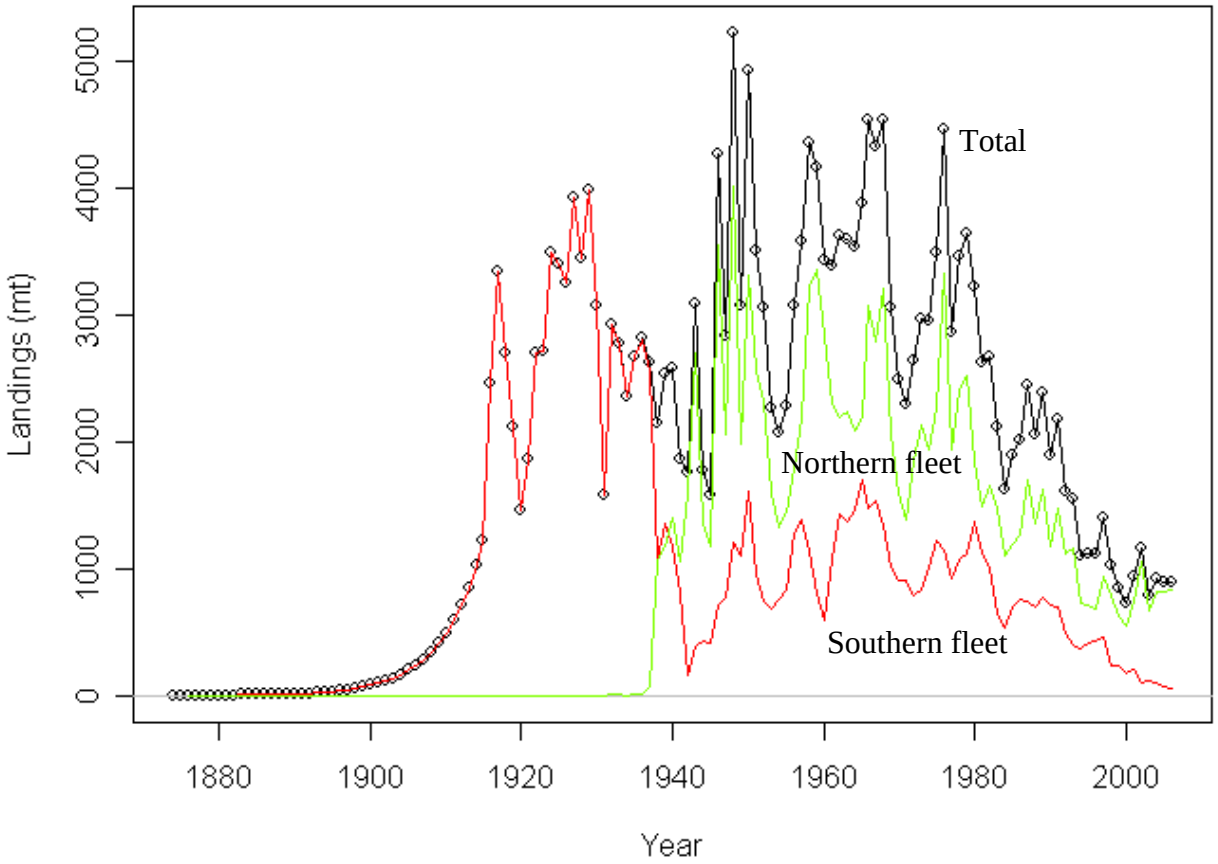

Figure a. Reconstructed historical landings (mt) by year and fleet, 1876-2006.

Data and assessment

The most recent assessment for English sole was performed in 2005. The 2005 assessment used an early version (1.19) of the Stock Synthesis 2 modeling framework to estimate model parameters and management quantities. That assessment modeled the coast-wide English sole population (U.S. only), including both males and females. Fishery independent data included the NMFS triennial groundfish survey index of abundance (1980-2004), maturity observations, length-weight relationships as well as survey length-frequency and age-frequency data. Length and age data from commercial fishery landings are included from 1948-2004, as well as fishery discard information from three separate observer programs, 1950-1961, 1985-1987 and 2001-2004.

This document updates the 2005 assessment using the newest version of SS2 available, 2.00e (Methot 2007). The methods for summarizing the raw data and the modeling approach are maintained. The recent landings series have been updated for 1981-2006, and a large quantity of fishery length and age data (primarily from Washington) that was previously unavailable is now included. These new data provide substantially improved information regarding recent year class strengths and current stock status.

Stock biomass

As in 2005, English sole spawning biomass was found to be increasing rapidly over the last 15 years after a period of poor recruitments from the mid 1970s to the early

1990s, which left the stock at nearly historically low levels. The spawning biomass at the beginning of 2007 was estimated to be 41,906 mt (~ 95% confidence interval: 31,046-52,766), which corresponds to 116% (83-149%) of the unexploited equilibrium level. This value reflects the accelerated maturity schedule estimated from the 1990's relative to historical conditions and therefore does not necessarily correspond to the same age structure in the population as implied by unexploited conditions. Historical depletion levels were estimated to have reached minima as low as 20% in 1953 and, more recently, 23% in 1992. Current (2006) total catches were estimated to be 1,078 mt, of which 886 mt were landed. These results are very similar to the 2005 assessment, although the recent trend shows a slightly larger increase in stock size.

Table b. Recent trend in English sole spawning biomass and depletion level.

Year	Estimated spawning biomass (mt)	~95% confidence interval	Estimated depletion	~95% confidence interval
1998	11,022	7,920-14,124	31%	NA
1999	13,290	9,756-16,824	37%	NA
2000	16,006	11,924-20,088	44%	NA
2001	20,120	15,201-25,039	56%	NA
2002	26,545	20,167-32,923	74%	NA
2003	33,548	25,386-41,710	93%	NA
2004	38,534	29,057-48,011	107%	NA
2005	41,029	30,767-51,289	114%	NA
2006	42,193	31,445-52,939	117%	83-151%
2007	41,907	31,046-52,766	116%	83-149%

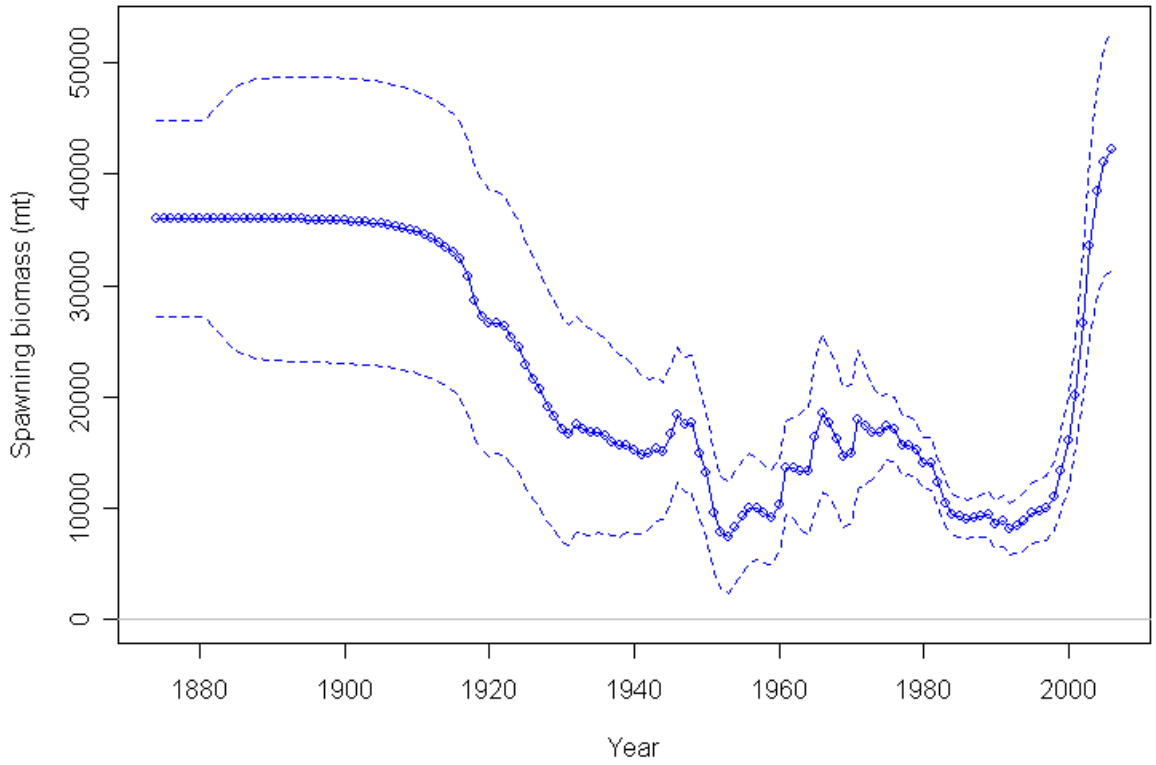

Figure b. Estimated spawning biomass time-series with approximate asymptotic 95% confidence interval.

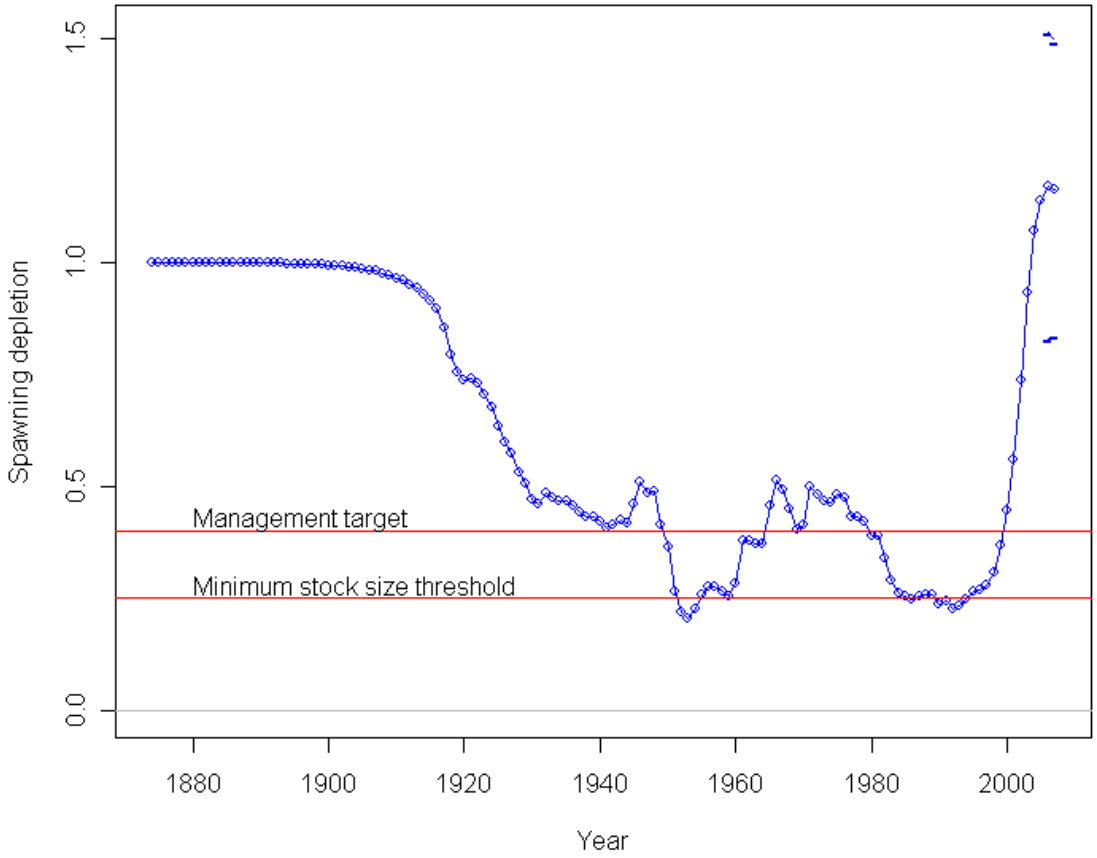

Figure c. Time-series of estimated depletion level, 1876-2007 with approximate asymptotic 95% confidence interval for 2006 and 2007.

Recruitment

Following two decades of low recruitments, strong year classes were estimated for 1995, 1998-2000, and 2002. The data indicate that the 1999 year class is the largest in the time-series, and the magnitude of this event is now much more certain than in the 2005 assessment; the coefficient of variation (CV) of this estimate has dropped from 25% (in 2005) to 19%. This change is mainly due to the large quantity of age data now available through 2006. These large recent recruitment estimates are larger than those from the 2005 assessment, resulting in the estimate of relatively higher current stock size. The recruitment deviations for 2004 and later years are informed primarily by the stock-recruitment function and this is reflected in the increased relative uncertainty of these estimates.

Table c. Recent estimated trend in English sole recruitment.

Year	Estimated recruitment (1000s)	~95% confidence interval
1998	284,960	195,739-414,849
1999	403,290	279,399-582,116
2000	274,080	172,836-434,631
2001	111,850	57,834-216,315
2002	209,360	109,931-398,721
2003	140,690	58,711-337,140
2004	118,760	50,558-278,965
2005	115,140	49,545-267,577
2006	114,440	49,350-265,380
2007	124,990	54,067-288,949

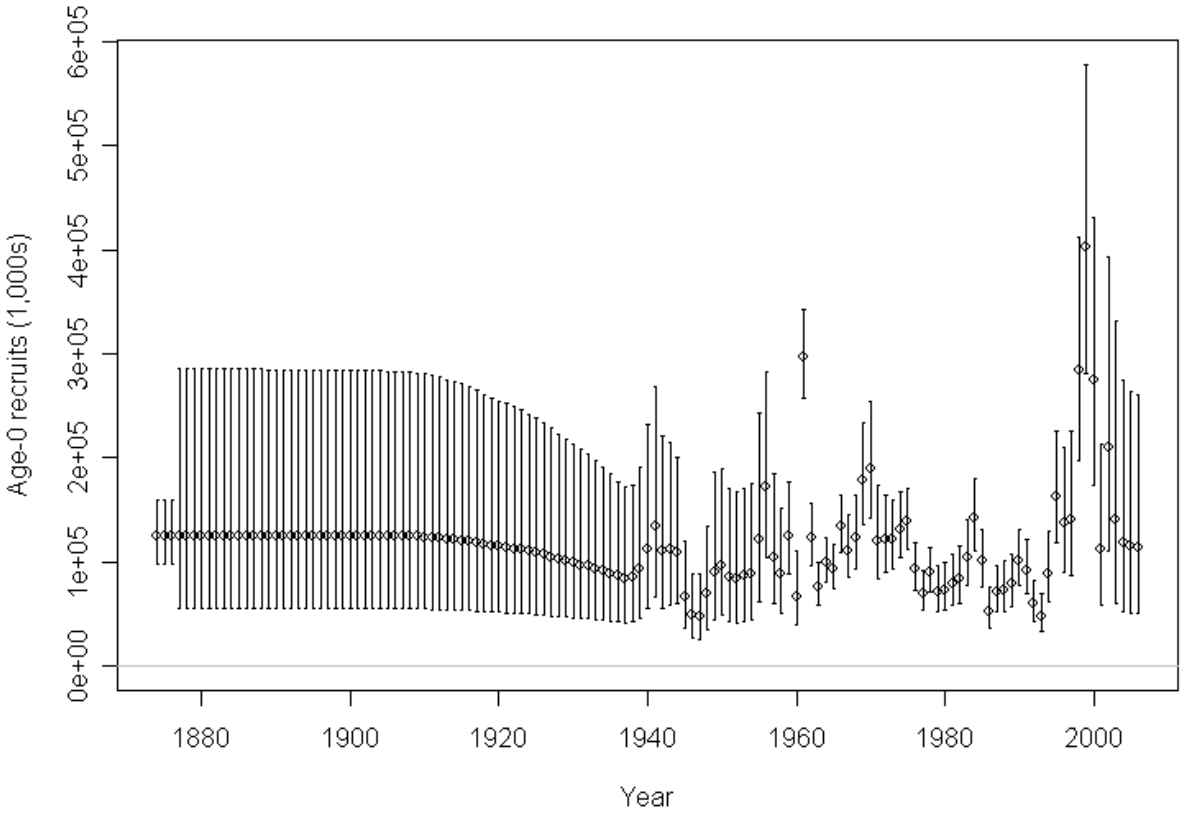

Figure d. Time-series of estimated English sole recruitments with approximate asymptotic 95% confidence interval.

Reference points

As was the case in the 2005 assessment, there are two types of reference points reported in this assessment: those based on the growth and maturity parameters at the beginning of the modeled time period and those based on the most recent time period in a 'forward projection' mode of calculation. All strictly biological reference points (e.g.,

unexploited spawning biomass) are calculated based on the unexploited conditions at the start of the model, whereas management quantities (*MSY*, SB_{msy}, etc.) are based on the current growth and maturity schedules and are marked throughout this document with an asterisk (*).

Unexploited equilibrium English sole spawning biomass (SB_0) was estimated to be 36,012 mt (~ 95% confidence interval: 27,219-44,805), with a mean expected recruitment of 124,990 thousand age-0 English sole. The $SB_{40\%}$ management proxy for target spawning biomass was estimated to be 14,405 mt (10,888-17,922), producing a landed catch of 2,523 and a total yield of 3,452 mt (2,986-3,918). The model-based estimate of retained *MSY* was 2,487* mt, which corresponds to a total mortality of 4,252 mt (~ 95% confidence interval: 2,687-5,816). The apparent increased discard rate at *MSY* is due to the interaction of size-based retention and the truncation of the size structure of the modeled population. The estimate of *MSY* is only slightly larger than the average estimated total catch from the period 1916-1991 of 3,701 mt, indicating the stock has been exploited at near optimal levels for most of the time-series, but levels have been much lower in recent years. The spawning stock biomass expected to produce *MSY* catch levels was 6,526* mt (*1*-13,654, the symmetric approximation of the 95% confidence interval included zero and was therefore rounded up), or 18.1% of SB_0. This level of exploitation was estimated to result in a spawning potential ratio (SPR) of 25.9%*. The overfished threshold for English sole was estimated to be 9,003 mt. These reference point estimates are very close to the values reported in the 2005 assessment.

Exploitation status

The estimated spawning potential ratio (SPR) for English sole fluctuated above and below the proxy target of 40% for flatfish from the late 1940s to the early 1990s. Since 1992 the intensity of exploitation has been less than that of the target, resulting in higher SPR levels. This corresponds to a relative exploitation rate (catch/biomass of age 3 and older fish) history that is high from the late 1940s to the early 1990s, and steadily declining to very low levels over the last 15 years. The stock appears to have never been exploited at the rate (0.27) that would reduce the stock to SPR levels estimated to produce *MSY*, 0.259, during the time-series. The fishery has exceeded the relative exploitation rate that results in fishing at the SPR target of 40% of 0.17 in only a few years of the historical series.

Table d. Recent trend in spawning potential ratio (SPR) and relative exploitation rate (catch/biomass of age 3 and older fish).

Year	Estimated SPR	Relative exploitation rate
1997	0.55	0.11
1998	0.63	0.07
1999	0.69	0.05
2000	0.76	0.04
2001	0.76	0.04
2002	0.76	0.03
2003	0.86	0.02
2004	0.87	0.02
2005	0.89	0.02
2006	0.90	0.02

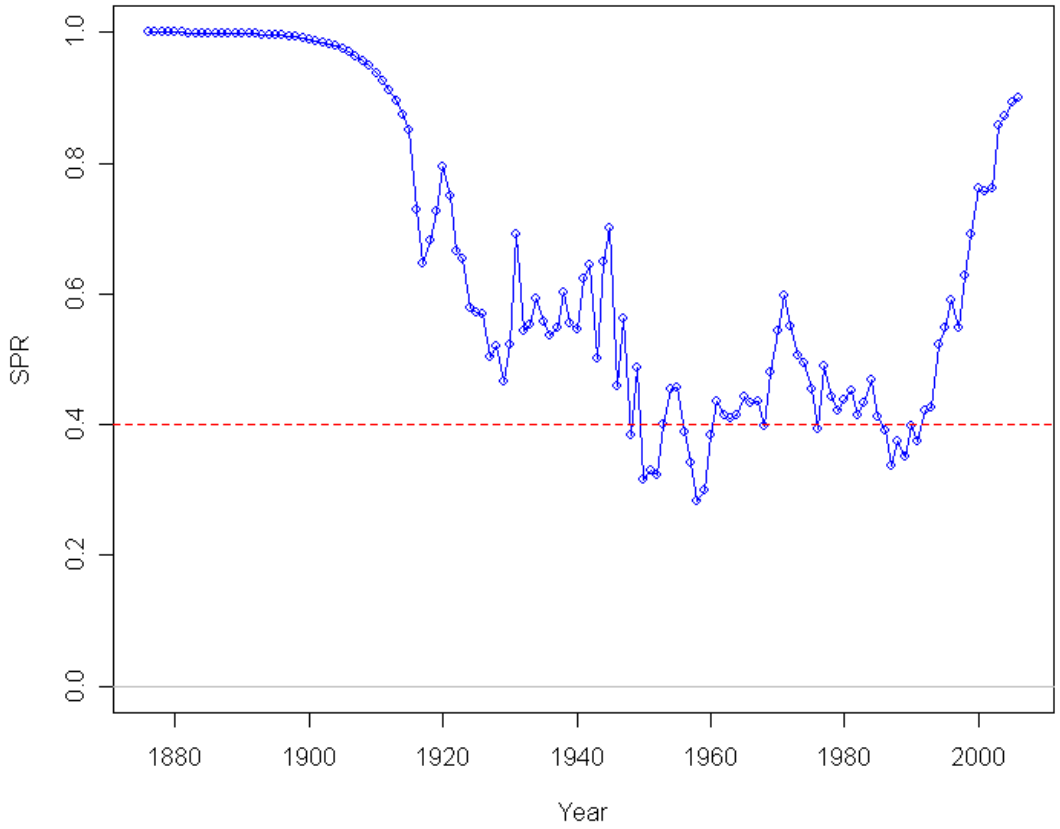

Figure e. Time-series of estimated spawning potential ratio 1876-2006.

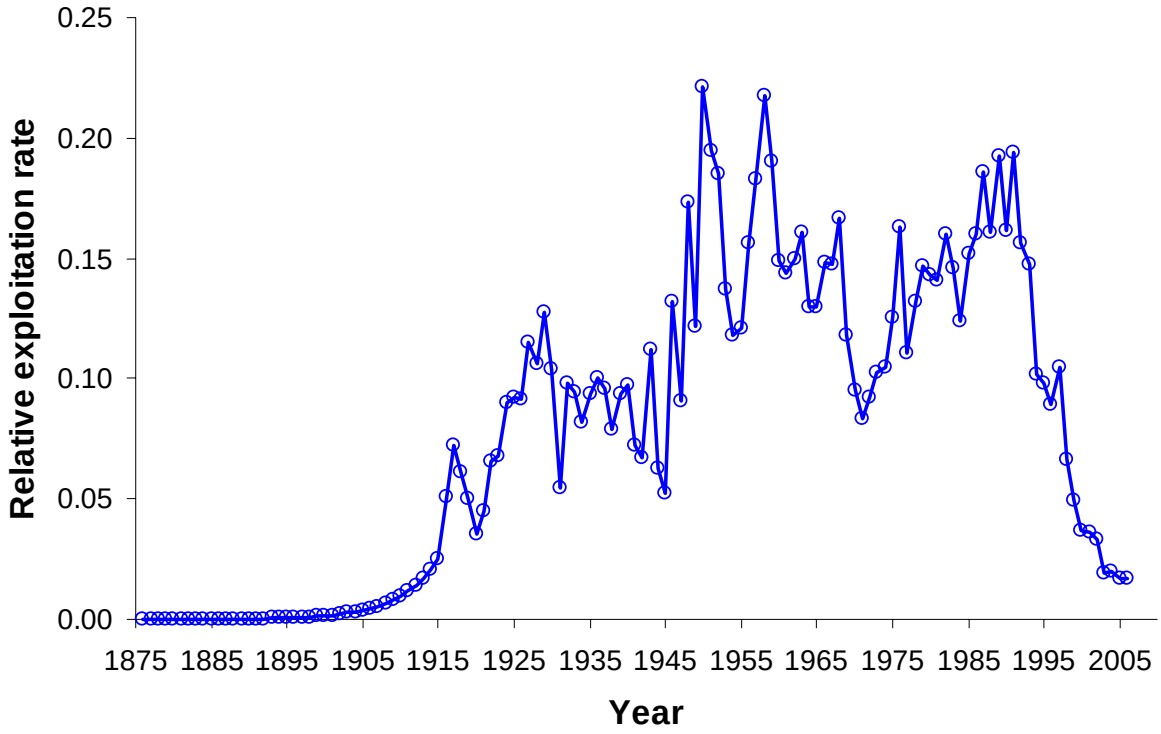

Figure f. Time-series of relative exploitation rate (catch/biomass of age 3 and older fish) 1876-2006.

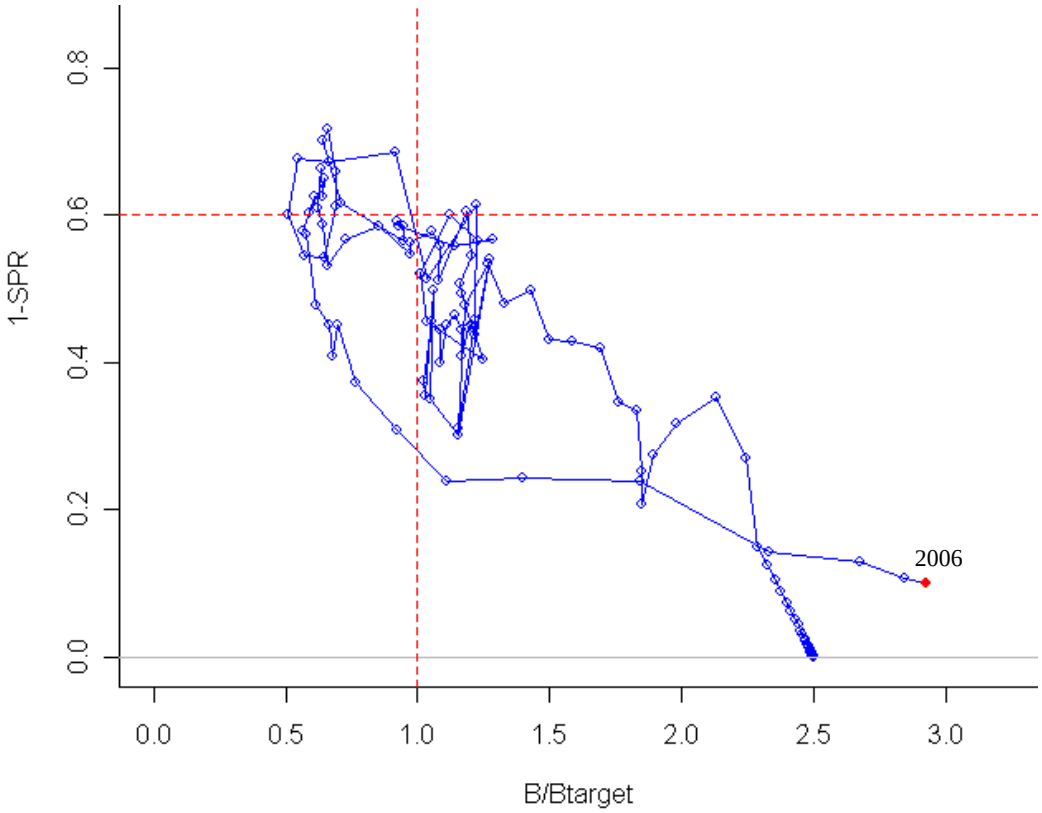

Figure g. Estimated spawning potential ratio relative to the proxy target of 40% vs. estimated spawning biomass relative to the proxy 40% level. Higher biomass occurs on the left side of the x-axis, higher exploitation rates occur on the upper side of the y-axis.

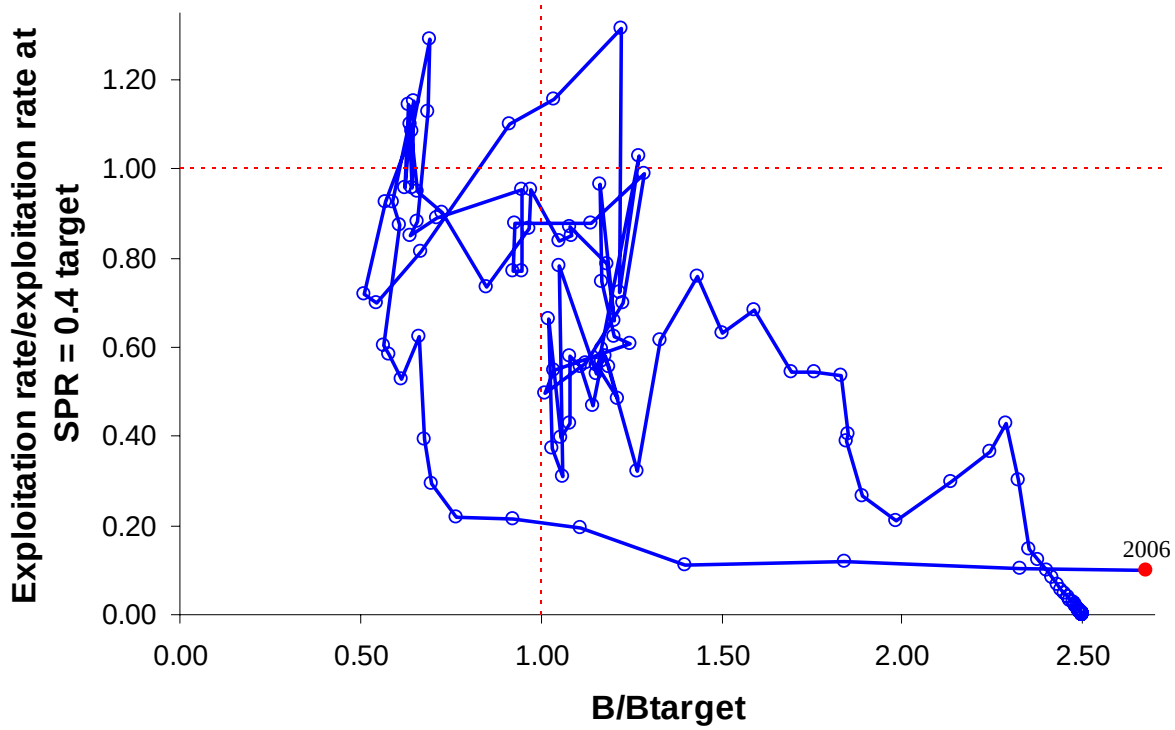

Figure h. Relative exploitation rate/exploitation rate at SPR = 0.4 target vs. estimated spawning biomass relative to the proxy 40% level.

Management performance

Recent English sole landings and estimated discards have been below both the coast-wide ABC of 3,100 mt and the estimated *MSY* harvest level of 4,080 mt.

Table e. Recent trend in estimated total English sole catch and landings (mt)

Year	Landings (mt)	Estimated total catch (mt)	Coast-wide ABC
1997	1,406	1,911	3,100
1998	1,021	1,441	3,100
1999	853	1,245	3,100
2000	734	1,061	3,100
2001	942	1,363	3,100
2002	1,154	1,683	3,100
2003	787	1,125	3,100
2004	916	1,218	3,100
2005	888	1,115	3,100
2006	886	1,078	3,100

Unresolved problems and major uncertainties

This update uses the same approach to address uncertainty as the 2005 assessment: asymptotic variance estimates, sensitivity testing and retrospective analysis of the maximum likelihood estimates for parameters and predictions of stock status. Confidence intervals for population parameters were generally wide, indicating substantial uncertainty in the time-series of spawning biomass, recruitment and relative depletion level for English sole. Three specific areas of uncertainty were selected to

reflect new sensitivity testing for this update using all available data in 2007, while maintaining those areas still relevant from the 2005 assessment:

1) This assessment allows the maturity schedule to change over time to match the large reduction in the length at 50% maturity observed between samples from the 1950s and 1995. Although it is likely that maturity does change over time, it is not clear whether these two values represent endpoints of a relatively smooth decline (as modeled), stochastic, or environmentally driven variability. With only two observations, there is little ability to explore these hypotheses in detail, so two sensitivities were performed using only the 1950s maturity curve and only the 1995 curve.
2) Because this is an update assessment, the NWFSC survey data, including indices of abundance, length- and age-frequency data for both the north and the south could not be included in the base case. A sensitivity analysis of the effect of adding these data was performed.
3) Changes in fishery selectivity and retention appear to have occurred over time and between fleets. Selectivity was allowed to change over time in the base case model (as in the 2005 assessment), however, sparse data on the discarded fraction of the catch and for the landed catch over certain time periods results in the need for the modeled patterns of fishery selectivity and retention to be very simple, likely underestimating the uncertainty in population dynamics. An effort was made to explore these simple assumptions through sensitivity testing, but further analysis should be done during the next full assessment.

As was concluded in the 2005 assessment, current spawning biomass is estimated to exceed the target level ($B_{40\%}$) throughout exploration of these major sources of uncertainty, as well as other sensitivity analyses included.

Forecasts

Forecasts were generated assuming the average landings over the period 2004-2006 would be removed in 2007 and 2008 before the results of this updated assessment would be used for management. This value was 897 metric tons, of which 79 mt would be landed in the south (Conception and Monterey areas) and 818 mt in the north (Eureka, Columbia and Vancouver areas). Beginning in 2009, the maximum potential catch would be removed under the 40:10 harvest control rule. A 10-year average of the relative F contribution from the southern and northern fleets was used for this projection. This ratio was 8.8% for the southern fleet to 91.2% for the northern fleet. An extremely large potential catch (>13 times recent average values) is predicted to be possible in 2009 based on the ABC from the $F_{40\%}$ harvest rate proxy because the stock is projected to be above unexploited spawning biomass level. Subsequent landings remain very high relative to those observed in the historical time-series for the duration of the 10-year projection. Due to the implausibility of the removals in this forecast scenario, alternates are used for the decision table analysis presented below.

Table f. Projection of potential English sole catch, landings, spawning biomass and depletion for the base case model under the 40:10 harvest control rule.

Year	Total catch (mt)	~95% interval	Total landings (mt)	Age 3+ biomass (mt)	Spawning biomass (mt)	~95% interval	Depletion	~95% interval
2007	1,069	NA	897	62,172	41,907	31,046-52,766	116%	83-149%
2008	1,053	NA	897	59,444	40,559	29,827-51,291	113%	82-143%
2009	14,326	10,473-18,179	12,303	56,494	38,711	28,203-49,219	107%	79-136%
2010	9,745	7,049-12,441	8,057	42,894	26,321	28,203-49,219	73%	54-92%
2011	7,158	5,042-9,275	5,616	35,259	19,585	18,839-33,803	54%	39-70%
2012	5,790	3,913-7,667	4,315	31,137	16,136	13,474-25,696	45%	31-59%
2013	5,095	3,307-6,882	3,660	28,843	14,420	10,528-21,742	40%	26-54%
2014	4,630	2,516-6,743	3,263	27,429	13,523	9,016-19,822	38%	24-52%
2015	4,388	2,484-6,293	3,072	26,517	13,053	8,307-18,739	36%	23-49%
2016	4,235	2,476-5,994	2,960	25,850	12,749	8,319-17,787	35%	23-48%
2017	4,122	2,461-5,784	2,880	25,335	12,527	8,364-17,134	35%	22-48%
2018	4,036	2,435-5,637	2,819	24940	12,362	8,387-16,668	34%	21-47%

Decision table

In the 2005 assessment, the strength of recent year classes was identified the primary "axis of uncertainty" was therefore selected for inclusion in the decision table. This choice reflected the lack of age data from fishery or survey sources with which to reliably estimate the strength of those year classes. Because there is now much more data informing large recruitment estimates from 1998-2000, sensitivity analysis was performed to update the dominant sources of uncertainty for inclusion in the decision table. Those sensitivity runs that appeared to show the greatest uncertainty in current stock status and recent trend included: 1) modeling the stock as if the maturity schedule had not changed since the 1950s, and 2) for comparative purposes only (because this is an update assessment) including the NWFSC trawl survey index, length and age information (2003-2006). As in 2005, given the large current stock size, the focus of the decision table is on an alternate model with a lower stock size than the base case. The spawning biomass estimated from the base case model was 41,907 mt at the beginning of 2007, with an approximate 95% confidence interval including the range of 31,046-52,766 mt. Constraining the maturity schedule to the values observed in the 1950s resulted in an estimate of current spawning biomass reduced to 28,610 mt. Including the NWFSC trawl

survey data resulted in an estimated 2007 spawning biomass of 46,140 mt. Together, these two alternate models represent "much less likely" and "less likely" scenarios bracketing the 2007 base case results. The relative probability is also described via the location in the approximate probability distribution (via the asymptotic approximation) for the base case model result. In this context, the estimate of current spawning biomass from the 1950s maturity schedule sensitivity was smaller than all but 1% of the density from the base case, while the sensitivity with NWFSC survey data resulted in a spawning biomass larger than all but 22% of the density from the base case. The English sole stock is predicted to remain above the 40% spawning biomass target for all states of nature and management options presented for the next 5 years and close to it as far into the future as 2018.

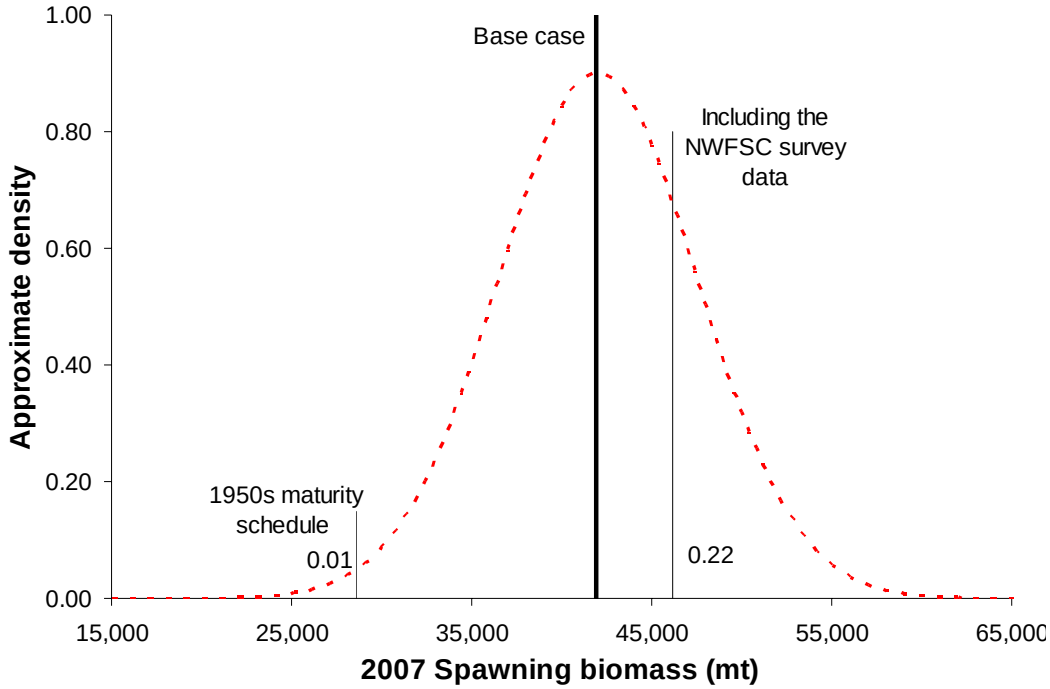

Figure i. Approximate distribution of uncertainty in estimated 2007 spawning biomass from the base case model (dashed line) density function based on the normal approximation. Bold vertical line indicates the maximum likelihood estimate from the base case, light lines the less likely alternate model including the 1950s maturity and, for comparative purposes, the alternate including NWFSC survey data.

Table g. Decision table of 10-year projections (years 1-5, 10 shown) for alternate models (columns) and management options (rows) beginning in 2009. Landings for 2007-2008 are the average in 2004-2006. The alternate model including the NWFSC survey data is presented for comparative purposes only.

			State of nature		**Comparison only**
			1950s maturity	Base case	With NWFSC survey data
Relative probability			Less likely	Most likely	Less likely
~ probability state of nature is > base case			0.01	0.5	0.78
Management decision	**Quantity**	**Year**			
3-year average landings (2004-2006) South = 79 mt, North = 818 mt	Depletion	2009	85%	107%	117%
		2010	81%	102%	111%
		2011	76%	98%	105%
		2012	71%	94%	101%
		2013	67%	90%	97%
		2014	64%	88%	94%
		2018	56%	81%	85%
	Spawning biomass (1000s mt)	2009	27,696	38,711	43,165
		2010	26,220	36,822	41,001
		2011	24,585	35,147	39,009
		2012	23,067	33,724	37,270
		2013	21,776	32,541	35,800
		2014	20,717	31,571	34,583
		2018	18,191	29,183	31,607
200% of 3-year average landings (2004-2006) South = 158 mt, North = 1,636 mt	Depletion	2009	85%	107%	117%
		2010	78%	100%	109%
		2011	72%	93%	101%
		2012	65%	88%	95%
		2013	60%	83%	90%
		2014	55%	79%	86%
		2018	45%	70%	75%
	Spawning biomass (1000s mt)	2009	27,696	38,711	43,165
		2010	25,506	35,997	40,183
		2011	23,239	33,618	37,494
		2012	21,185	31,607	35,177
		2013	19,449	29,936	33,231
		2014	18,024	28,560	31,625
		2018	14,562	25,062	27,580
3,100 mt total catch (current ABC; requested by GMT in 2005) South = 273 mt, North = 2,827 mt	Depletion	2009	85%	107%	117%
		2010	76%	98%	106%
		2011	67%	89%	97%
		2012	60%	82%	90%
		2013	53%	76%	83%
		2014	48%	72%	78%
		2018	36%	60%	65%
	Spawning biomass (1000s mt)	2009	27,696	38,711	43,165
		2010	24,806	35,197	39,382
		2011	21,929	32,146	36,011
		2012	19,379	29,593	33,142
		2013	17,260	27,498	30,763
		2014	15,549	25,792	28,822
		2018	11,539	21,522	23,980
	Landings (mt)	2009	2,674	2,662	2,672
		2010	2,664	2,653	2,673
		2011	2,638	2,628	2,655
		2012	2,603	2,597	2,628
		2013	2,568	2,566	2,600
		2014	2,534	2,538	2,573
		2018	2,429	2,457	2,497

Research and data needs

The following research would substantially improve the ability of this assessment to reliably and precisely model English sole population dynamics in the future. In order of priority (author's personal opinion):

1) Collection of maturity data on an ongoing basis from survey or fishery sources that could be used to track future changes affecting modeled spawning stock biomass.
2) This assessment contains little data on the length frequency of the discarded portion of the commercial catch of English sole. This would be valuable data to add to the discard fractions and average individual weights currently being collected. Based on changes to sampling protocols beginning with 2006, observer data will soon be available in much greater quantities and should be used in the next full assessment.
3) Because the U.S.-Canada border does not appear to be a meaningful biological boundary for the English sole population, extension of this assessment to include Canadian waters may be necessary to better capture population trends. Further, the use of explicitly spatial models for English sole (e.g., Stewart 2006) should be explored to better account for regional differences in recruitment and exploitation intensity.
4) The next full assessment can make use of the recently completed cross-method study of ageing comparing interopercular bones and otoliths that will allow revision of the ageing error matrix. This will be necessary, as otoliths are now being collected on a routine basis by the NWFSC survey and Oregon port samplers.
5) Despite much effort in the 2005 assessment, there is still uncertainty in some parts of the historical landings series. Specifically needed are: 1) a method for reconstructing landings in Washington prior to 1956 from U.S. waters, 2) landings data from Oregon from 1954-1955 and 3) a thorough study of the mink food fishery in Oregon and California including estimates of the total volume and length- or age-structure of catches associated with this fishery.
6) As part of the next full assessment, a re-evaluation of the weighting of data sources should be performed, perhaps weighting by a function of the number of fish and samples instead of just the un-tuned number of samples following the method of Stewart and Miller presented at the 2006 Data and Modeling workshop (NWFSC 2007).
7) Based on the relatively poor and biased fit to the age-at-length data from the 1995 triennial survey, the next full assessment should either find a way to fit these data better or remove them from the assessment.
8) The evaluation of uncertainty performed for the 2005 assessment and maintained in this update relies heavily on asymptotic variance estimates and sensitivity testing. A more thorough Bayesian approach to parameter and model uncertainty could be completed.
9) As recommended by the 2005 STAR panel, sex-specific natural mortality rates and selectivity curves should be explored in the next full assessment.

Rebuilding projections

The stock of English sole off the United States was not found to be currently overfished, and therefore does not require rebuilding projections.

Table h. Summary of recent trends in English sole exploitation and stock levels; all values reported at the beginning of the year. Quantities based on the current growth and maturity schedules and are marked with an asterisk (*) and are not comparable to those based on unfished conditions.

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Landings (mt)	1,021	853	734	942	1,154	787	916	888	886	NA
Estimated discards (mt)	420	392	327	421	529	338	302	227	192	NA
Estimated total catch (mt)	1,441	1,245	1,061	1,363	1,683	1,125	1,218	1,115	1,078	NA
ABC (mt)	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100
OY	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SPR*	0.63	0.69	0.76	0.76	0.76	0.86	0.87	0.89	0.90	NA
Exploitation rate (catch/age 3+ biomass)	0.07	0.05	0.04	0.04	0.03	0.02	0.02	0.02	0.02	NA
Age 3+ biomass (mt)	21,727	25,113	28,627	37,538	51,026	59,605	61,226	64,401	64,165	62,172
Spawning biomass (mt)	11,022	13,290	16,006	20,120	26,545	33,548	38,534	41,029	42,193	41,907
~95% interval	7,920-14,124	9,756-16,824	11,924-20,088	15,201-25,039	20,167-32,923	25,386-41,710	29,057-48,011	30,767-51,289	31,445-52,939	31,046-52,766
Recruitment (1000s)	284,960	403,290	274,080	111,850	209,360	140,690	118,760	115,140	114,440	124,990
~95% interval	195,739-414,849	279,399-582,116	172,836-434,631	57,834-216,315	109,931-398,721	58,711-337,140	50,558-278,965	49,545-267,577	49,350-265,380	54,067-288,949
Depletion	31%	37%	44%	56%	74%	93%	107%	114%	117%	116%
~95% interval	NA	NA	NA	NA	NA	NA	NA	NA	83-151%	83-149%

Table i. Summary of English sole reference points. Quantities based on the current growth and maturity schedules and are marked with an asterisk (*) and are not comparable to those based on unfished conditions. The symmetric approximation of the 95% confidence interval included zero for some quantities, the lower limit is therefore rounded up and in italics.

Quantity	Estimate	~95% Confidence interval
Unfished spawning stock biomass (SB_0, mt)	36,012	27,219-44,805
Unfished 3+ biomass (mt)	59,944	NA
Unfished recruitment (R_0, thousands)	124,990	97,519-160,199
Reference points based on $SB_{40\%}$		
MSY Proxy Spawning Stock Biomass ($SB_{40\%}$)	14,405	10,888-17,922
SPR resulting in $SB_{40\%}$ ($SPR_{SB40\%}$)	0.49	0.38-0.60
Exploitation rate resulting in $SB_{40\%}$	0.13	NA
Yield with $SPR_{SB40\%}$ at $SB_{40\%}$ (mt)	3,452	2,986-3,918
Reference points based on SPR proxy for MSY		
Spawning Stock Biomass at SPR (SB_{SPR})(mt)	11,411	10,157-12,665
$SPR_{MSY\text{-}proxy}$	0.40	NA
Exploitation rate corresponding to SPR	0.17	NA
Yield with $SPR_{MSY\text{-}proxy}$ at SB_{SPR} (mt)	3,877	3,443-4,311
Reference points based on estimated MSY values		
Spawning Stock Biomass at *MSY* (SB_{MSY}) (mt)	6,526	*1*-13,654
SPR_{MSY}	0.26	*0.01*-0.54
Exploitation Rate corresponding to SPR_{MSY}	0.27	NA
MSY (mt)	4,252	2,687-5,816