Stock Assessment of Pacific Hake (Whiting) in U.S. and Canadian Waters in 2007

Report of the U.S.-Canada Pacific Hake Joint Technical Committee (JTC)

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Executive Summary

Stock

This assessment reports the status of the coastal Pacific hake (*Merluccius productus*) resource off the west coast of the United States and Canada. The coastal stock of Pacific hake is currently the most abundant groundfish population in the California Current system. Smaller populations of hake occur in the major inlets of the north Pacific Ocean, including the Strait of Georgia, Puget Sound, and the Gulf of California. However, the coastal stock is distinguished from the inshore populations by larger body size, seasonal migratory behavior, and a pattern of low median recruitment punctuated by extremely large year classes. The population is modeled as a single stock, but the United States and Canadian fishing fleets are treated separately in order to capture some of the spatial variability in Pacific hake distribution.

Catches

Fishery landings from 1966 to 2006 have averaged 162 thousand mt, with a low of 90 thousand mt in 1980 and a peak harvest of 360 thousand mt in 2006. Recent landings have been above the long term average, at approximately 360 thousand mt in 2005 and 2006. Catches in both of these years were predominately comprised by the large 1999 year class. The United States has averaged 159 thousand mt, or 74.6% of the total landings over the time series, with Canadian catch averaging 54 thousand mt. The 2004 and 2005 landings had similar distributions, with 62.9 and 72.1%, respectively, harvested by the United States fishery. The current model assumes no discarding mortality of pacific hake.

Table a. Recent commercial fishery landings (1000s mt).

Year	US at-sea	US shore based	US Tribal	US total	Canadian foreign and JV	Canadian shore based	Canadian total	Total
1996	113	85	15	213	67	26	93	306
1997	121	87	25	233	43	49	92	325
1998	120	88	25	233	40	48	88	321
1999	115	83	26	225	17	70	87	312
2000	116	86	7	208	16	6	22	231
2001	102	73	7	182	22	32	54	236
2002	63	46	23	132	0	51	51	183
2003	67	55	21	143	0	62	62	206
2004	90	96	24	210	59	65	124	335
2005	150	86	24	260	15	85	100	360
2006	134	97	35	266	14	80	94	360

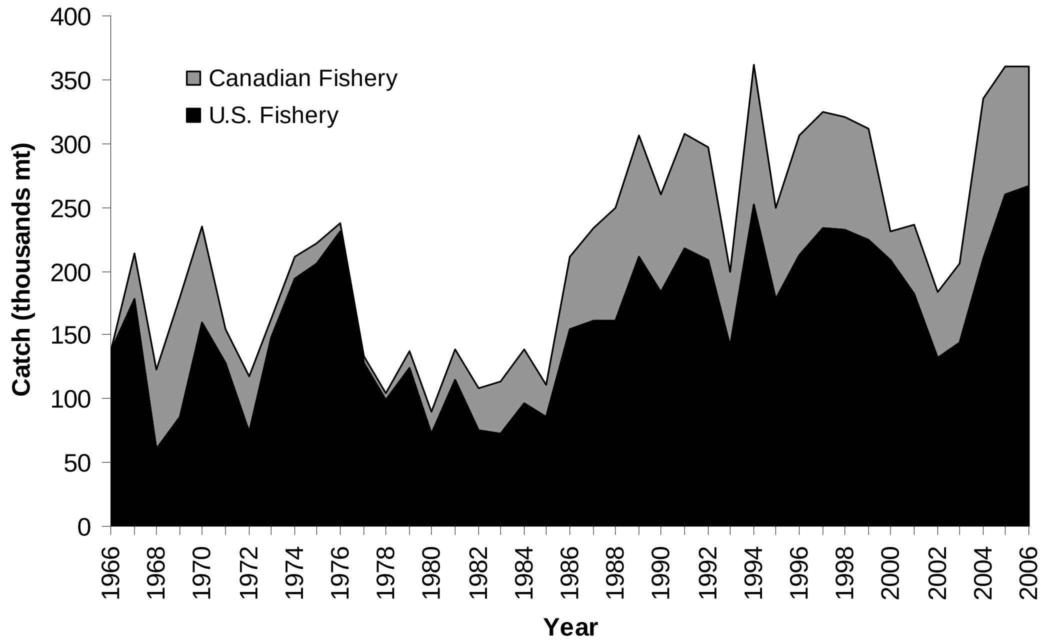


Figure a. Pacific whiting landings (1000s mt) by nation, 1966-2006.

Data and assessment

Age-structured assessment models of various forms have been used to assess Pacific hake since the early 1980's, using total fishery catches, fishery age compositions and abundance indices. In 1989, the hake population was modeled using a statistical catch-at-age model (Stock Synthesis) that utilizes fishery catch-at-age data and survey estimates of population biomass and age-composition data (Dorn and Methot, 1991). The model was then converted to AD Model Builder (ADMB) in 1999 by Dorn (1999), using the same basic population dynamics equations. This allowed the assessment to take advantage of ADMB's post-convergence routines to calculate standard errors (or likelihood profiles) for any quantity of interest. Since 2001, Helser et al. (2001, 2003, 2004) have used the same ADMB modeling platform to assess the hake stock and examine important assessment modifications and assumptions, including the time varying nature of the acoustic survey selectivity and catchability. The acoustic survey catchability coefficient (q) has been, and continues to be, one of the major sources of uncertainty in the model. Due to the lengthened acoustic survey biomass trends the assessment model was able to freely estimate the acoustic survey q. These estimates were substantially below the assumed value of q=1.0 from earlier assessments. The 2003 and 2004 assessment presented uncertainty in the final model result as a range of biomass. The lower end of the biomass range was based upon the conventional assumption that the acoustic survey q was equal to 1.0, while the higher end of the range represented a q=0.6 assumption. In 2005, the coastal hake stock was modeled using the Stock Synthesis modeling framework (SS2 Version 1.21, December, 2006) which was written by Dr. Richard Methot (Northwest Fisheries Science Center) in AD Model Builder. Conversion of the previous hake model into SS2 was guided by three principles: 1) the incorporation of less derived data, 2) explicitly model the underlying hake growth dynamics, and 3) achieve parsimony[1] in terms on model complexity. "Incorporating less derived data" entailed

[1] Parsimony is defined as a balance between the number of parameters needed to represent a complex state of nature and data quality/quantity to support accurate and precise estimation of those parameters.

fitting observed data in their most elemental form. For instance, no pre-processing to convert length data to age compositional data was performed. Also, incorporating conditional age-at-length data, through age-length keys for each fishery and survey, allowed explicit estimation of expected growth, dispersion about that expectation, and its temporal variability, all conditioned on selectivity.

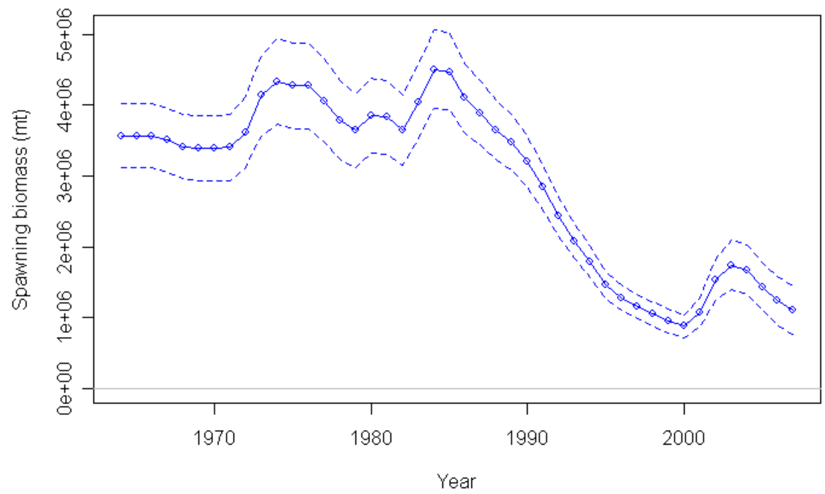
This year's assessment builds on the same SS2 (Ver 1.23E) approach and incorporates a new coast-wide recruitment index that draws upon data from the expanded SWFSC Santa Cruz and PWCC/NMFS mid-water trawl surveys. As in the previous year's assessment, two models are presented to bracket the range of uncertainty in the acoustic survey catchability coefficient, q. The base model with steepness fixed at h=0.75 and q=1.0 represents the endpoint of the lower range while the alternative model which places a prior on q (effective q=0.7) represents the upper endpoint of the range. As such, model estimates presented below report a range of values representing these endpoints.

Stock biomass

Pacific hake spawning biomass declined rapidly after 1984 (4.6-5.1million mt) to the lowest point in the time series in 2000 (0.92-1.15 million mt). This long period of decline was followed by a brief increase to 1.80-2.36 million mt in 2003 as the 1999 year class matured. In 2007 (beginning of year), spawning biomass is estimated to be 1.15 – 1.65 million mt and approximately 32.1%-39.80% of the unfished level. Estimates of uncertainty in level of depletion range from 24.3%-39.7% and 30.7%-48.8% of unfished biomass for the base and alternative models, respectively, based on asymptotic confidence intervals. It should be pointed out that the 2007 estimates of spawning biomass and depletion are not too dissimilar from last year's assessment result for 2006. The reason for this is that removal of the early SWFSC Santa Cruz pre-recruit time series and inclusion of the new coast-wide pre-recruit index has resulted is a slightly higher 1999, as well as 2003-2004, recruitment strengths. As such, spawning biomass in the most recent years is slightly greater than predicted from the 2006 assessment.

Table b. Recent trend in Pacific hake spawning biomass and depletion level from the base and alternative SS2 models.

	Base Model					***Alternative Model***				
Year	Spawning biomass millions mt	~ 95% Interval		Relative Depletion	~ 95% Interval	Spawning biomass millions mt	~ 95% Interval		Relative Depletion	~ 95% Interval
1998	1.088	0.952	1.224	30.4%	-	1.299	1.113	1.486	31.3%	-
1999	0.986	0.850	1.122	27.6%	-	1.203	1.013	1.394	29.0%	-
2000	0.916	0.774	1.057	25.6%	-	1.149	0.946	1.351	27.7%	-
2001	1.111	0.925	1.297	31.1%	-	1.424	1.147	1.701	34.3%	-
2002	1.587	1.298	1.875	44.4%	-	2.058	1.624	2.491	49.6%	-
2003	1.807	1.460	2.154	50.6%	-	2.360	1.839	2.880	56.9%	-
2004	1.738	1.384	2.093	48.6%	-	2.295	1.764	2.827	55.3%	-
2005	1.496	1.156	1.837	41.9%		2.024	1.514	2.533	48.8%	
2006	1.295	0.954	1.637	36.2%	28.9% - 43.5%	1.806	1.299	2.314	43.6%	34.9% - 52.1%
2007	1.146	0.790	1.502	32.1%	24.3% - 39.7%	1.651	1.126	2.175	39.8%	30.7% - 48.8%



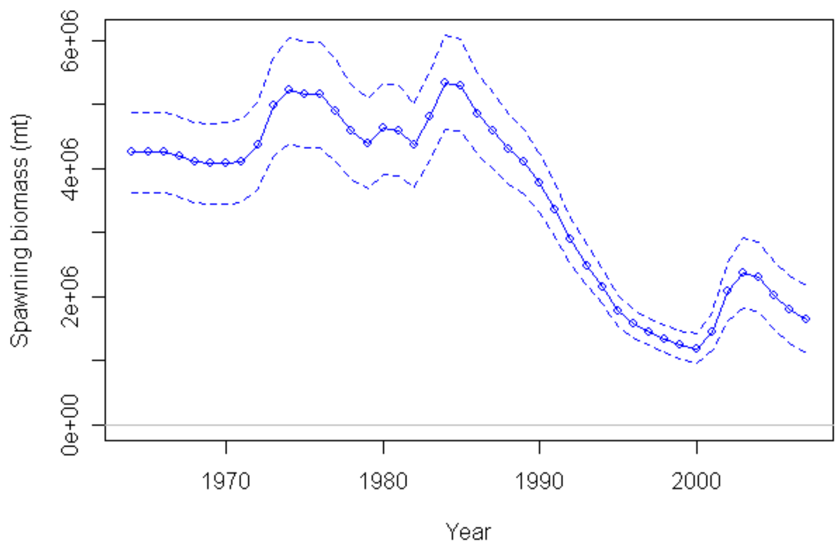


Figure b. Estimated spawning biomass time-series with approximate asymptotic 95% confidence intervals for the base (upper plot) and alternative (lower plot) models.

Recruitment

Estimates of Pacific hake recruitment indicate very large year classes in 1980 and 1984, with secondary recruitment events in 1970, 1973 and 1977, earlier in the time series. The recent 1999 year class was the single most dominate cohort since the late 1980s and has in large part support fishery catches during the last few years. Uncertainty in recruitment can be substantial as shown by asymptotic 95% confidence intervals. Recruitment to age 0 before 1967 is assumed to be equal to the long-term mean recruitment. Age-0 recruitment in 2003 is very uncertain, but predicted to be below the mean, despite some evidence to the contrary in the 2005 acoustic survey.

Table c. Recent estimated trend in Pacific hake recruitment.

	Base Model				Alternative Model			
	Recruitment	~ 95%			Recruitment	~ 95%		
Year	(billions)	Interval			(billions)	Interval		
1998	2.887	2.435	-	3.423	3.641	2.977	-	4.453
1999	14.975	12.384	-	18.108	19.124	15.346	-	23.832
2000	1.044	0.823	-	1.323	1.355	1.042	-	1.761
2001	1.423	1.106	-	1.831	1.878	1.426	-	2.474
2002	0.243	0.168	-	0.352	0.320	0.217	-	0.471
2003	2.251	1.602	-	3.164	3.051	2.140	-	4.348
2004	3.030	1.795	-	5.115	4.099	2.413	-	6.964
2005	1.249	0.271	-	5.750	1.479	0.328	-	6.663
2006	0.366	0.113	-	1.187	0.462	0.142	-	1.503
2007	2.094	0.353	-	12.425	2.539	0.428	-	15.072

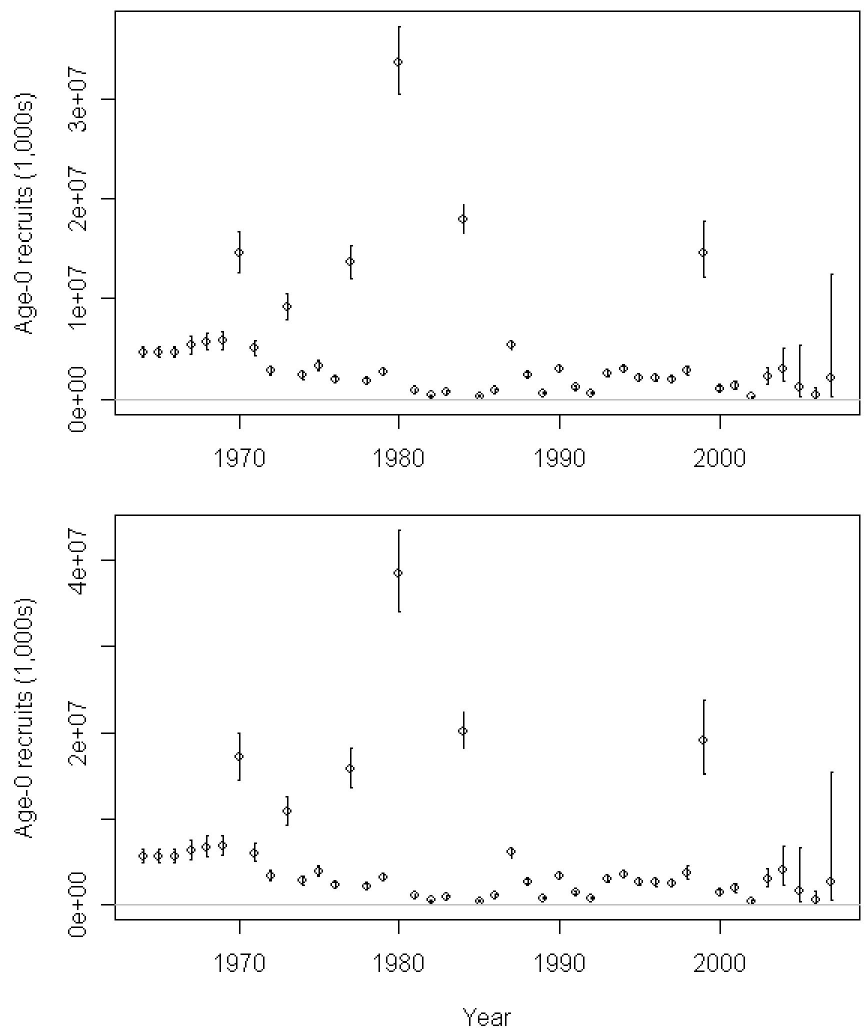
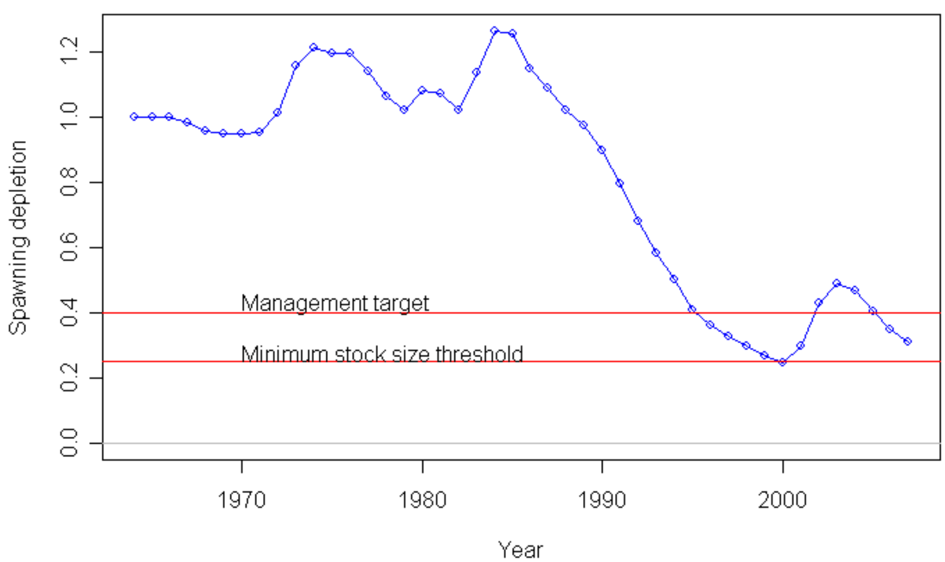


Figure c. Estimated recruitment time-series with approximate asymptotic 95% confidence intervals for the base (upper plot) and alternative (lower plot) models.

Reference points

Two types of reference points are reported in this assessment: those based on the assumed population 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. This distinction is important since temporal variability in growth and other parameters can result in different biological reference point calculations across alternative chronological periods. 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 Pacific hake spawning biomass (B_{zero}) from the base model was estimated to be 3.57 million mt (~ 95% confidence interval: 3.14 – 4.0 million mt), with a mean expected recruitment of 4.66 billion age-0 hake. Under the alternative model, spawning biomass (B_{zero}) from the base model was estimated to be 4.15 million mt (~ 95% confidence interval: 3.57 – 4.73 million mt), with a mean expected recruitment of 5.53 billion age-0 hake. Associated management reference points for target and critical biomass levels for the base model are 1.43 million mt (B40%) and 0.89 million mt (B25%), respectively. Under the alternative model, B40% and B25% are estimated to be 1.66 and 1.04 million mt, respectively. The MSY-proxy harvest amount (F40%) under the base model was estimated to be 531,565* mt (~ 95% confidence interval: 469,581-585,020), and 621,810* mt (~ 95% confidence interval: 535,186-696,527) under the alternative model. The spawning stock biomass that produces the MSY-proxy catch amount under the base model was estimated to be 0.98 million* mt (confidence interval is 0.74-1.20* million mt), and 1.15 million* mt (confidence interval is 0.82 -1.47* million mt) under the alternative model, given current life history parameters.



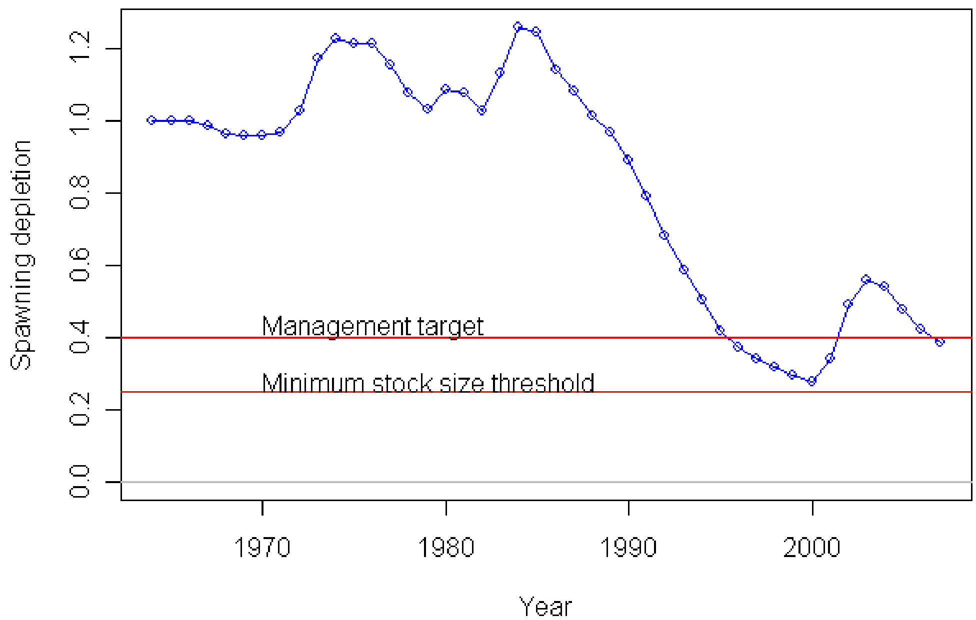


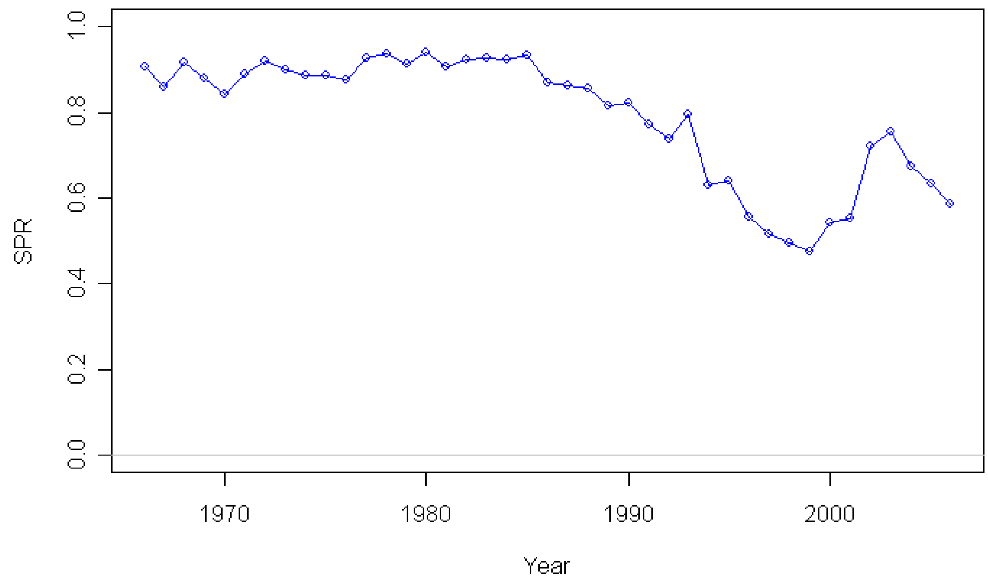
Figure d. Time series of estimated depletion, 1966-2006, for the base (upper plot) and alternative (lower plot) models.

Exploitation status

The estimated spawning potential ratio (SPR) for Pacific hake has been above the proxy target of 40% for the history of this fishery. In terms of its exploitation status, Pacific hake are presently below the target biomass level (40% unfished biomass) and above the target SPR rate (40%). The full exploitation history is portrayed graphically below, plotting for each year the calculated SPR and spawning biomass level (B) relative to their corresponding targets, F40% and B40%, respectively.

Table d. Recent trend in spawning potential ratio (SPR).

	Base Model		alternative Model	
Year	Estimated SPR	~ 95% Interval	Estimated SPR	~ 95% Interval
1997	0.519	-	0.569	-
1998	0.498	-	0.556	-
1999	0.482	-	0.548	-
2000	0.550	-	0.624	-
2001	0.562	-	0.646	-
2002	0.730	-	0.796	-
2003	0.761	-	0.823	-
2004	0.683	-	0.756	-
2005	0.642	-	0.721	-
2006	0.579		0.668	



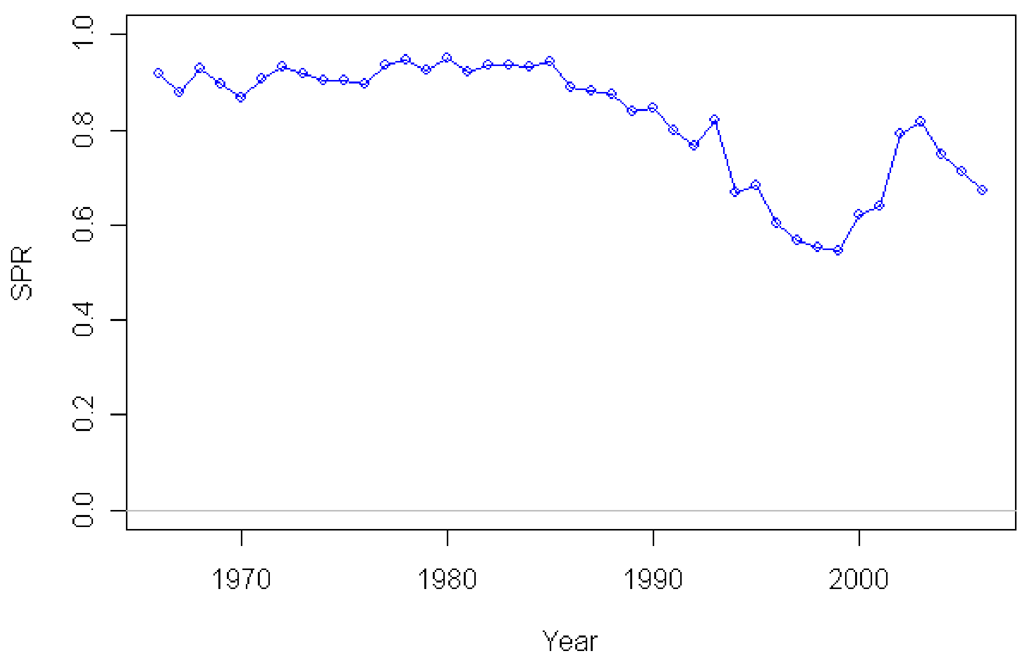
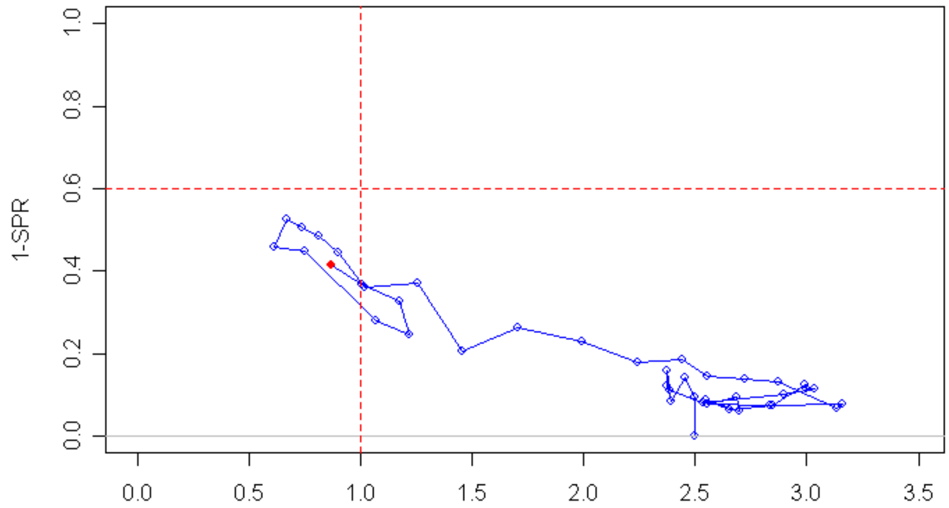


Figure e. Time series of estimated spawning potential ratio from base (upper plot) and alternative (lower plot) models.



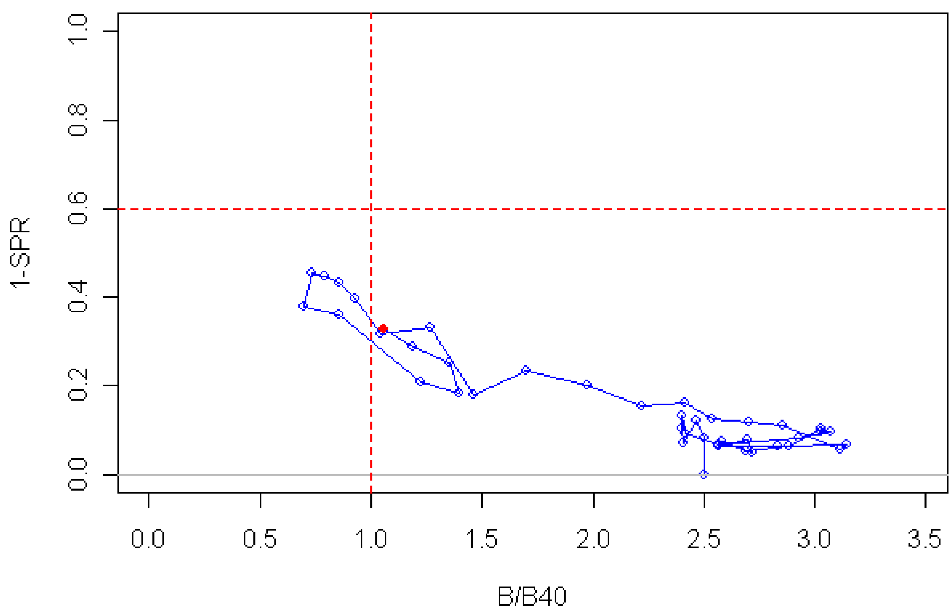


Figure f. Temporal pattern of estimated spawning potential ratio relative to the proxy target of 40% vs estimated spawning biomass relative to the proxy 40% level for base (upper plot) and alternative (lower plot) models.

Management performance

Since implementation of the Magnuson Fisheries Conservation and Management Act in the U.S. and the declaration of a 200 mile fishery conservation zone in Canada in the late 1970's, annual quotas have been the primary management tool used to limit the catch of Pacific hake in both zones by foreign and domestic fisheries. The scientists from both countries have collaborated through the Technical Subcommittee of the Canada-US Groundfish Committee (TSC), and there has been informal agreement on the adoption of an annual fishing policy. During the 1990s, however, disagreement between the U.S. and Canada on the division of the acceptable biological catch (ABC) between the two countries led to quota overruns; 1991-1992 quotas summed to 128% of the ABC and quota overruns have averaged 114% from 1991-1999. Since 2000, total catches have been below coastwide ABCs. A recent treaty between the United States and Canada (2003), which awaits final signature, establishes U.S. and Canadian shares of the coastwide allowable biological catch at 73.88% and 26.12%, respectively.

Table e. Recent trend in Pacific hake management performance.

Year	Total landings (mt)	ABC
1996	306,100	265,000
1997	325,215	290,000
1998	320,619	290,000
1999	311,855	290,000
2000	230,819	290,000
2001	235,962	238,000
2002	182,883	208,000
2003	205,582	235,000
2004	334,721	514,441
2005	360,306	531,124
2006	359,901	661,681

Unresolved problems and major uncertainties

The acoustic survey catchability, *q*, remains uncertain. This is largely driven by an inconsistency in the acoustic survey biomass time series and age compositions; age composition data suggest a large build up of stock biomass in the mid 1980s while the acoustic survey biomass time series is relatively flat since 1977.

Forecasts

Forecasts were generated assuming the maximum potential catch would be removed under 40:10 control rule for both the base and alternative models. Projections were based on the relative F contribution of 73.88% and 26.12% coast wide national allocation to the U.S. and Canada, respectively. For the base case model, the 2007 coastwide ABC is estimated to be 612,068 mt with an OY of 575,090 mt. Under the alternative model, the 2007 coastwide ABC is estimated to be 879,000 mt with an OY of 878,670 mt. Spawning stock biomass is projected to decline with a corresponding relative depletion of 24.5% and 29.3% for the base and alternative models, respectively in 2008.

Table f. Three year projection of potential Pacific hake landings, spawning biomass and depletion for the base and alternative models under the 40:10 rule.

	Expected coastwide	Spawning biomass millions mt			Depletion percent unfished biomass		
Year	catch (mt)	Mean	5%	95%	Mean	5%	95%
Base model, h=0.75, q=1.0							
2007	575,090	1.146	0.790	1.502	32.1%	24.3%	39.8%
2008	377,360	0.876	0.617	1.136	24.5%	19.5%	29.5%
2009	232,040	0.690	0.472	0.909	19.3%	15.0%	23.6%
2010	191,600	0.657	0.334	0.979	18.4%	10.2%	26.6%
Alt. model, h=0.75, q prior							
2007	878,670	1.651	1.126	2.175	39.8%	30.8%	48.8%
2008	560,070	1.215	0.844	1.585	29.3%	23.6%	35.0%
2009	334,990	0.921	0.629	1.214	22.2%	17.6%	26.8%
2010	258,650	0.842	0.439	1.244	20.3%	11.7%	28.9%

Decision table

A decision table was constructed to represent the uncertainty on the acoustic survey catchability coefficient, q. The base model with a q=1.0 represents the lower range while the alternative model which places a prior on q (effective q=0.7) represents the upper range. Below the decision table shows the consequences of management action given a state of nature. States of nature include the base model (h=0.75, q=1.0) and the alternative model (h=0.75, q prior). The management actions include the OY from each state of nature and four constant coastwide catch scenarios.

Table g. Decision table for two states of nature (base and alternative models) and four different harvest strategies given the state of nature.

			State of Nature	
Relative probability			**0.5**	**0.5**
Model			**h = 0.75, q = 1.0**	**h = 0.75, q prior**
Management action	Total coast-wide Catch (mt)	Year	Relative depletion (2.5%-97.5% interval)	
OY Model h=0.75, q=1.0	575,090	2007	0.321 (0.243-0.397)	0.398 (0.308-0.488)
	377,360	2008	0.245 (0.195-0.295)	0.326 (0.236-0.417)
	232,040	2009	0.193 (0.150-0.236)	0.271 (0.180-0.363)
	191,600	2010	0.184 (0.102-0.266)	0.257 (0.138-0.376)
OY Model h=0.75, q prior	878,670	2007	0.321 (0.243-0.397)	0.398 (0.308-0.488)
	560,070	2008	0.208 (0.126-0.290)	0.293 (0.236-0.350)
	334,990	2009	0.139 (0.052-0.226)	0.222 (0.176-0.268)
	258,650	2010	0.124 (0.008-0.240)	0.203 (0.117-0.289)
Total coast-wide catch = 100,000 mt	100,000	2007	0.321 (0.243-0.397)	0.398 (0.308-0.488)
	100,000	2008	0.305 (0.230-0.379)	0.377 (0.290-0.463)
	100,000	2009	0.279 (0204-0.354)	0.344 (0.259-0.428)
	100,000	2010	0.274 (0.167-0.381)	0.333 (0.218-0.447)
Total coast-wide catch = 200,000 mt	200,000	2007	0.321 (0.243-0.397)	0.398 (0.308-0.488)
	200,000	2008	0.291 (0.216-0.367)	0.365 (0.277-0.452)
	200,000	2009	0.254 (0.177-0.332)	0.323 (0.233-0.409)
	200,000	2010	0.239 (0.131-0.348)	0.303 (0.186-0.419)
Total coast-wide catch = 300,000 mt	300,000	2007	0.321 (0.243-0.397)	0.398 (0.308-0.488)
	300,000	2008	0.278 (0.201-0.355)	0.354 (0.266-0.442)
	300,000	2009	0.230 (0.150-0.309)	0.302 (0.213-0.389)
	300,000	2010	0.205 (0.094-0.316)	0.273 (0.155-0.392)
Total coast-wide catch = 400,000 mt	400,000	2007	0.321 (0.243-0.397)	0.398 (0.308-0.488)
	400,000	2008	0.265 (0.187-0.342)	0.343 (0.253-0.432)
	400,000	2009	0.205 (0.124-0.286)	0.280 (0.190-0.371)
	400,000	2010	0.170 (0.057-0.283)	0.244 (0.123-0.364)

Research and data needs

1) The quantity and quality of biological data prior to 1988 from the Canadian fishery should be evaluated for use in developing length and conditional age at length compositions.
2) Evaluate whether modeling the distinct at-sea and shore based fisheries in the U.S. and Canada explain some lack of fit in the compositional data.
3) Compare spatial distributions of hake across all years and between bottom trawl and acoustic surveys to estimate changes in catchability/availability across years. The two primary issues are related to the changing spatial distribution of the survey as well as the environmental factors that may be responsible for changes in the spatial distribution of hake and their influences on survey catchability and selectivity.

4) Initiate analysis of the acoustic survey data to determine variance estimates for application in the assessment model. The analysis would provide a first cut to define the appropriate CV for the weighting of the acoustic data.
5) Develop an informed prior for the acoustic q. This could be done either with empirical experiments (particularly in off-years for the survey) or in a workshop format with technical experts. There is also the potential to explore putting the target strength estimation in the model directly. This prior should be used in the model when estimating the q parameter.
6) Review the acoustic data to assess whether there are spatial trends in the acoustic survey indices that are not being captured by the model. The analysis should include investigation of the migration (expansion/contraction) of the stock in relation to variation in environmental factors. This would account for potential lack of availability of older animals and how it affects the selectivity function.
7) Investigate aspects of the life history characteristics for Pacific hake and their possible effects on the interrelationship of growth rates and maturity at age. This should include additional data collection of maturity states and fecundity, as current information is limited.
8) Examine the potential use of the CalCOFI data as an index for hake spawning biomass.

Table h. Summary of recent trends in Pacific hake exploitation and stock levels; all values reported at the beginning of the year.

Base Model	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Landings (1000s mt)	325.2	320.6	311.9	230.8	236.0	182.9	205.6	334.7	360.3	359.9	NA
ABC (1000s mt)	290	290	290	290	238	208	235	514	265	661	612
OY (1000s mt)											
SPR*	0.520	0.500	0.483	0.551	0.562	0.729	0.760	0.679	0.637	0.588	NA
Total biomass (millions mt)	2.566	2.317	2.097	1.902	1.967	4.106	3.985	3.706	3.022	2.667	2.496
Spawning biomass (millions mt)	1.197	1.088	0.986	0.916	1.111	1.587	1.807	1.738	1.496	1.295	1.146
~95% interval	1.333-1.651	0.952-1.224	0.850-1.122	0.774-1.057	0.925-1.297	1.298-1.875	1.460-2.154	1.384-1.093	1.156-1.837	0.954-1.637	0.790-1.502
Recruitment (billions)	1.980	2.887	14.975	1.044	1.423	0.243	2.251	3.030	1.249	0.366	2.094
~95% interval	1.617-2.245	2.435-3.423	12.384-18.108	0.823-1.323	1.106-1.832	0.168-0.352	1.602-3.164	1.795-5.115	0.271-5.750	0.113-1.187	0.353-12.425
Depletion	33.8%	30.4%	27.6%	25.6%	31.1%	44.4%	50.6%	48.6%	41.9%	36.2%	32.1%
~95% interval	NA	NA	NA	NA	NA	NA	NA	NA	NAS	28.9%-43.5%	24.3%-39.7%

Alternative Model	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Landings (1000s mt)	325.2	320.6	311.9	230.8	236.0	182.9	205.6	334.7	360.3	359.9	NA
ABC (1000s mt)	290	290	290	290	238	208	235	514	265	901	879
OY (1000s mt)											
SPR*	0.567	0.553	0.544	0.620	0.640	0.791	0.818	0.750	0.713	0.673	NA
Total biomass (millions mt)	3.126	2.879	2.671	2.494	2.633	5.498	5.377	4.054	4.227	3.838	3.698
Spawning biomass (millions mt)	1.406	1.299	1.203	1.149	1.424	2.058	2.360	2.295	2.024	1.806	1.651
~95% interval	1.150-1.936	1.113-1.486	1.013-1.394	0.946-1.351	0.147-1.701	1.624-2.491	1.839-2.880	1.764-2.827	1.514-2.533	1.299-2.314	1.126-2.175
Recruitment (billions)	2.501	3.641	19.124	1.355	1.878	0.320	3.051	4.099	1.479	0.462	2.539
~95% interval	2.171-2.884	2.877-4.453	15.346-23.832	1.042-1.761	1.426-2.474	0.217-0.471	2.140-4.348	2.413-6.964	0.328-6.663	0.142-1.503	0.428-15.072
Depletion	33.9%	31.3%	29.0%	27.7%	34.3%	49.6%	56.9%	55.3%	48.8%	43.6%	39.8%
~95% interval	NA	NA	NA	NA	NA	NA	NA	NA	NA	34.9%-52.1%	30.7%-48.8%

Table i. Summary of Pacific hake reference points.

Base Model

Quantity	Estimate	~95% Confidence interval
Unfished spawning stock biomass (SB_0, millions mt)	3.567	3.14 - 4.0
Unfished total biomass (B_0, millions mt)	8.511	NA
Unfished age 3+ biomass (millions mt)	7.336	NA
Unfished recruitment (R_0, billions)	4.665	4.098 – 5.288
Spawning stock biomass at MSY (SB_{msy})*	0.981	0.776 – 1.203
Basis for SB_{msy}	$F_{40\%}$ proxy	NA
SPR_{msy}*	40.0%	33.2%-46.7%
Basis for SPR_{msy}	$F_{40\%}$ proxy	NA
Exploitation rate corresponding to SPR_{msy}*	24.6%	NA
MSY* (mt)	531,565	468,853 – 595,015

Alternative Model

Quantity	Estimate	~95% Confidence interval
Unfished spawning stock biomass (SB_0, millions mt)	4.148	3.57 – 4.73
Unfished total biomass (B_0, millions mt)	10.220	NA
Unfished age 3+ biomass (millions mt)	8.869	NA
Unfished recruitment (R_0, billions)	5.534	4.796 - 6.420
Spawning stock biomass at MSY (SB_{msy})*	1.151	0.821 - 1.472
Basis for SB_{msy}	$F_{40\%}$ proxy	NA
SPR_{msy}*	40.0%	33.2%-46.7%
Basis for SPR_{msy}	$F_{40\%}$ proxy	NA
Exploitation rate corresponding to SPR_{msy}*	24.6%	NA
MSY* (mt)	621,810	535,186 – 696,527