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Status and Future Prospects for the Pacific Ocean Perch Resource in Waters off Washington and Oregon as Assessed in 2009

by

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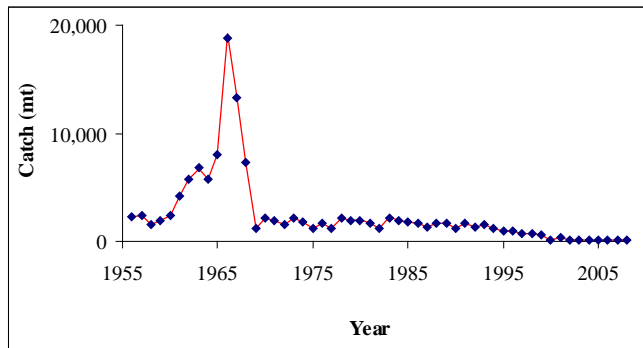
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This assessment update applies to the Pacific ocean perch (*Sebastes alutus*) (POP) species of rockfish for the combined US Vancouver and Columbia INPFC areas. Catches are characterized by large removals of between 5,000 and 20,000 mt during the mid-1960's, primarily by foreign vessels. The fishery proceeded with more moderate removals of between 1,100 and 2,200 metric tons per year from 1969 through 1994, with the foreign fishery ending in 1977. Management measures further reduced landings to below 900 metric tons by 1995, with subsequent landings falling steadily until reaching between 60 and 150 metric tons per year from 2002 through 2008. Total catch, including discard, has been estimated to be between 80 and 180 metric tons since 2002.

Catch history from 1956-2006



Catch estimates for past 10 years including discard

<i>Year</i>	<i>Catch</i>
<i>1999</i>	<i>593</i>
<i>2000</i>	<i>171</i>
<i>2001</i>	<i>307</i>
<i>2002</i>	<i>178</i>
<i>2003</i>	<i>145</i>
<i>2004</i>	<i>150</i>
<i>2005</i>	<i>81</i>
<i>2006</i>	<i>82</i>
<i>2007</i>	<i>156</i>
<i>2008</i>	<i>106</i>

This assessment is an update and uses the same model as in the 2003, 2005 and 2007 assessments, a forward projection age-structured model (Hamel 2007, Hamel 2005, Hamel et al. 2003).

New data and changes to the data used in the previous assessment are as follows. Catch data for 2002-2006 were updated using total mortality estimates from the observer program. New catch data were added for 2007 and 2008. The 2007 and 2008 NWFSC slope survey indices were added. Fishery age compositions from 2004-2006 were updated, with new 2008 age compositions added. 2007 length compositions were used in place of age compositions on account of substantial issues with the quality of age assignments for that year of data. The 2001-2006 NWFSC slope survey age compositions were recalculated, and the 2008 compositions added. Due to the ageing issues mentioned above, the 2007 NWFSC slope survey length compositions were used in place of age compositions.

A number of sources of uncertainty are explicitly included in this assessment. For example, allowance is made for uncertainty in natural mortality, the parameters of the stock-recruitment relationship, and the survey catchability coefficients. However, sensitivity analyses based upon alternative model structures / data set choices in the 2003 and 2005 assessments suggest that the overall uncertainty may be greater than that predicted by a single model specification. There are also other sources of uncertainty that are not included in the current model. These include the degree of connection between the stocks of Pacific ocean perch off British Columbia and those in PFMC waters; the effect of the PDO, ENSO and other climatic

variables on recruitment, growth and survival of Pacific ocean perch; gender differences in growth and survival; a possible non-linear relationship between individual spawner biomass and effective spawning output and a more complicated relationship between age and maturity.

A reference case was selected which adequately captures the range for those sources of uncertainty considered in the model. Bayesian posterior distributions based on the reference case were estimated for key management and rebuilding variables. These distributions best reflect the uncertainty in this analysis, and are suitable for probabilistic decision making.

Retrospective of past 10 years

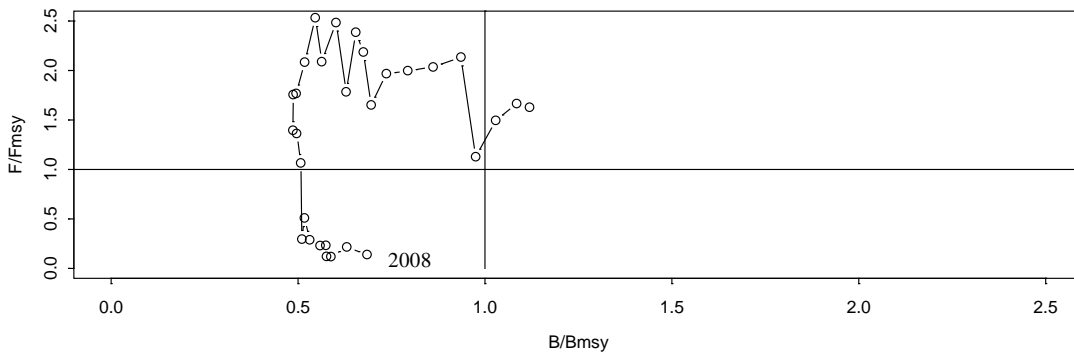
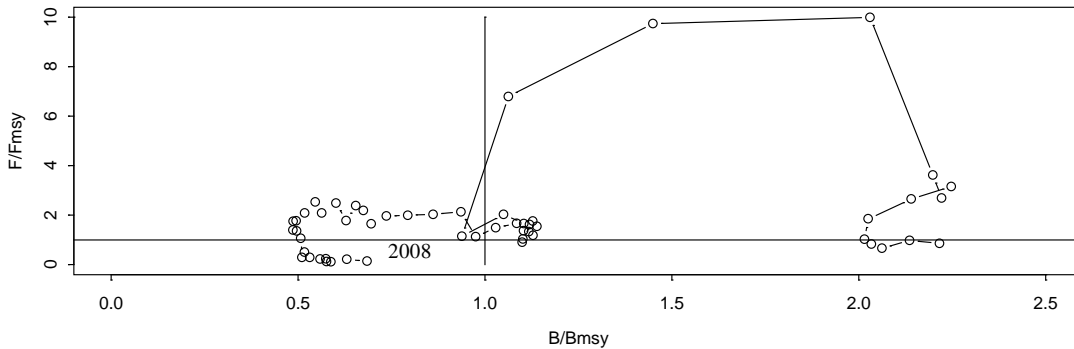
<i>Year</i>	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
<i>Total Catch</i>	593	171	307	178	145	150	81	82	156	106	
<i>Discards</i>	95	27	49	28	18	27	16	10	22	17	
<i>Landings</i>	498	144	258	150	127	123	65	72	134	89	
<i>ABC</i>	695	713	1541	640	689	980	966	934	900	911	1160
<i>OY</i>	595	270	303	350	377	444	447	447	150	150	189
<i>F</i>	0.048	0.013	0.023	0.013	0.010	0.010	0.005	0.005	0.009	0.006	
<i>Expl. Rate</i>	0.032	0.009	0.016	0.009	0.007	0.007	0.004	0.004	0.007	0.005	
<i>3+ Biomass</i>	18,481	18,366	18,710	19,926	20,908	21,593	22,104	22,563	23,128	23,492	23,844
<i>Biom. sd</i>	2,590	2,627	2,675	2,889	3,061	3,188	3,295	3,390	3,530	3,661	3,817
<i>Biom. cv</i>	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.16	0.16
<i>Sp Biomass</i>	7,669	7,711	7,811	8,025	8,448	8,676	8,708	8,884	9,528	10,342	10,794
<i>Sp Bio. sd</i>	1,078	1,107	1,116	1,152	1,211	1,244	1,251	1,277	1,385	1,543	1,644
<i>Sp Bio. cv</i>	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.15
<i>Recruitment</i>	0.45	0.73	1.45	7.71	3.62	1.21	0.71	0.72	2.15	1.62	
<i>Rec. sd</i>	0.27	0.35	0.58	1.98	1.29	0.66	0.52	0.57	2.91	1.46	
<i>Rec. cv</i>	0.61	0.48	0.40	0.26	0.36	0.54	0.73	0.79	1.36	0.90	
<i>Depletion</i>	0.203	0.204	0.207	0.212	0.224	0.230	0.231	0.235	0.252	0.274	0.286
<i>Depl. sd</i>											0.054
<i>Depl. cv</i>											0.189

The point estimate (maximum of the posterior density function, MPD) for the depletion of the spawning biomass at the start of 2009 is 28.6%. The ABC for 2009 based on the MPD point estimate is 811 mt. The OY for 2009 based upon the 40-10 rule is 703 mt (The ABC and OY for 2009 in the above table are based on current management and the 2007 assessment). For West Coast rockfish, a stock is considered overfished when it is below 25% of virgin spawning biomass, and recovered when it reaches 40% of virgin spawning biomass. Overfishing for POP is considered to be occurring when F is above $F_{msy} = 0.0406$ according to the current assessment base model. Based on this assessment, POP on the West Coast are recovering, and overfishing is not occurring.

POP are essentially managed on a regional basis, as they occur almost exclusively off of Oregon and Washington for the West Coast. Management and assessment of stock status might be improved through greater cooperation with British Columbia, as the stock extends northward into Canadian waters.

Major quantities from assessment

	<i>Value</i>	<i>sd</i>	<i>cv</i>
SB_0	37,780	5,030	0.13
B_0	75,760	6,254	0.09
R_0	5.05	0.99	0.20
SB_{msy}	15,112	2,535	0.17
F_{msy}	0.0406	0.0151	0.37
<i>Basis for above</i>	F at equilibrium 40% biomass with S-R curve		
<i>Exploitation rate at MSY</i>	0.0310	0.0104	0.33
MSY	1,124	346	0.31

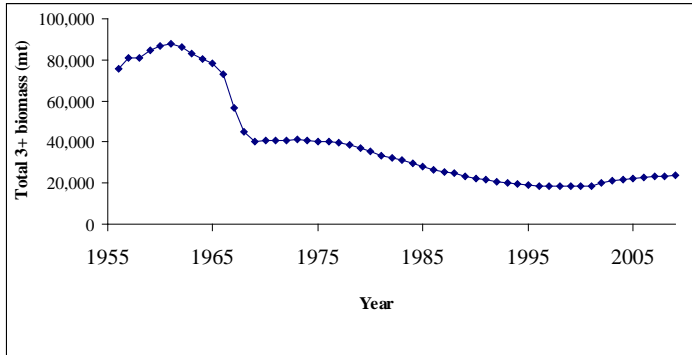


F/F_{msy} versus B/B_{msy} for all years of catch data and the last 30 years

The point estimates of summary (age 3+) biomass show an upward trend over the past ten years, increasing by about 30% in that time.

3+ Biomass Levels from 1956 to 2007

Biomass estimates for the past 10 years



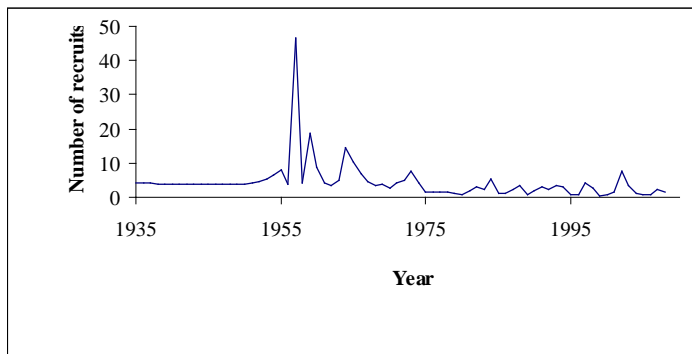
<i>Year</i>	<i>Total 3+ biomass(mt)</i>
2000	18,366
2001	18,710
2002	19,926
2003	20,908
2004	21,593
2005	22,104
2006	22,563
2007	23,128
2008	23,492
2009	23,844

The recruitment pattern for POP is similar to that of many rockfish species. Recent decades have provided rather poor year-classes compared with the 1950s and 1960s, although the 1999 year class (the 2002 recruitment year) appears to be larger than has occurred since the 1960's, and the 2000 year class appears to be relatively large as well, however this may be due to some small amount of overall bias in ageing with age.

The first year for which there are age-composition data to support an estimate of recruitment is 1956, which also happens to be the first year for which catch data are available. The estimates of recruitment for the years prior to 1956 are close to the equilibrium estimate from the stock-recruitment relationship. The first few years with recruitment estimates that are informed by data are, however, still highly uncertain. The extremely large recruitment for 1957 may therefore partly reflect slightly higher average recruitment over the years 1935-56. Only by the early to mid-1960s are the estimates of recruitment reliable. Recent (1999-2008 in the table below) estimates of recruitment are highly variable by year, and lower on average than those for 1960-74, though higher on average than those for 1975-1994. The estimate of recruitment for 2008 is based on very limited information.

Recruitment estimates (1935-2008)

**Recruitment estimates for the past 10 years
(millions of age-3 recruits)**

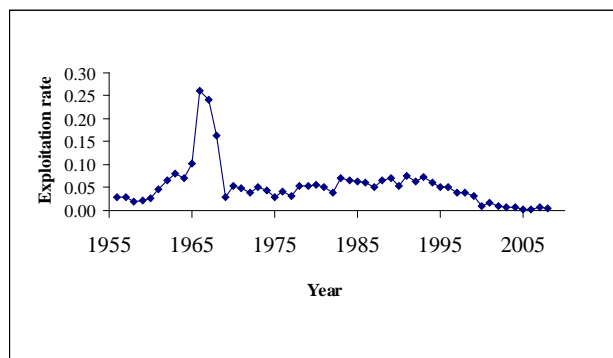


<i>Year</i>	<i>Recruitment</i>
1999	0.45
2000	0.73
2001	1.45
2002	7.71
2003	3.62
2004	1.21
2005	0.71
2006	0.72
2007	2.15
2008	1.62

The exploitation rate (percent of biomass taken) on fully-selected animals peaked near 25% in the mid-1960's when foreign fishing was intensive. The exploitation rate dropped by the late 1960's, but increased

slowly and steadily from 1975 to the early 1990's, due to decreasing exploitable biomass. Over the past 10 years the exploitation rate has fallen from over 3% to well under 1%.

Exploitation rate estimates (1956-2008)



Exploitation estimates for the past 10 years

Year	Exploitation rate
1999	0.032
2000	0.009
2001	0.016
2002	0.009
2003	0.007
2004	0.007
2005	0.004
2006	0.004
2007	0.007
2008	0.005

Near term projections show a slow monotonic increase in exploitable biomass. These were calculated with a new module within the assessment model using fishing mortality rates (F^* - when average selectivity across ages is 1, rather than maximum selectivity being 1) of 0.01 and 0.02 (or $F = 0.0137$ and 0.0275). This module projects recruitment from the estimated spawner recruit curve.

Catch, Spawning Biomass and Depletion MPD projections with $F^* = 0.01$ and 0.02

Year	$F^*=0.01$			$F^*=0.02$		
	Catch	Sp. Bio.	Depletion	Catch	Sp. Bio.	Depletion
2009	266	10794	0.286	530	10794	0.286
2010	274	10828	0.287	538	10695	0.283
2011	278	10735	0.284	538	10473	0.277
2012	278	10698	0.283	533	10311	0.273
2013	277	10743	0.284	525	10238	0.271
2014	279	10870	0.288	523	10255	0.271
2015	283	11107	0.294	526	10388	0.275
2016	290	11395	0.302	533	10576	0.280
2017	297	11709	0.310	543	10795	0.286
2018	305	12037	0.319	555	11026	0.292
2019	314	12366	0.327	567	11256	0.298
2020	322	12685	0.336	578	11475	0.304

To create three different possible states of nature for the two fishing mortality rates, we took the medians of the lowest 25%, the middle 50% and the highest 25% for each quantity and year from the 2400 saved model runs from the MCMC analysis. These projections are based upon the estimated spawner recruit curve and current spawning biomass and age composition estimates. A more thorough analysis will be done for the rebuilding analysis, upon which management actions will be based, which will likely result in different projections than those seen here.

Catch, Spawning Biomass and Depletion MCMC projections with $F^* = 0.01$

	Catch (mt)			Spawning biomass			Depletion		
	0-25%	25-75%	75-100%	0-25%	25-75%	75-100%	0-25%	25-75%	75-100%
2009	240	284	341	9816	11695	14040	0.263	0.332	0.415
2010	246	294	353	9869	11755	14101	0.264	0.334	0.419
2011	250	301	362	9788	11677	14080	0.261	0.332	0.417
2012	252	304	368	9791	11698	14135	0.262	0.333	0.419
2013	255	307	372	9830	11822	14388	0.264	0.337	0.426
2014	256	309	379	9922	12022	14787	0.267	0.343	0.437
2015	259	314	385	10114	12295	15127	0.273	0.352	0.447
2016	264	321	394	10381	12617	15527	0.279	0.361	0.458
2017	270	329	403	10641	12979	15934	0.286	0.371	0.469
2018	277	338	414	10903	13330	16372	0.294	0.381	0.481
2019	284	347	426	11193	13657	16806	0.301	0.391	0.491
2020	290	355	437	11442	13988	17216	0.308	0.401	0.504

Catch, Spawning Biomass and Depletion MCMC projections with $F^* = 0.02$

	Catch (mt)			Spawning biomass			Depletion		
	0-25%	25-75%	75-100%	0-25%	25-75%	75-100%	0-25%	25-75%	75-100%
2009	477	564	677	9816	11695	14040	0.263	0.332	0.415
2010	484	577	694	9750	11615	13929	0.261	0.330	0.414
2011	485	582	702	9551	11402	13747	0.255	0.325	0.407
2012	483	582	705	9441	11277	13636	0.253	0.321	0.404
2013	482	581	706	9373	11275	13739	0.252	0.322	0.407
2014	480	580	711	9358	11365	13972	0.252	0.324	0.412
2015	481	583	716	9448	11527	14189	0.255	0.330	0.418
2016	486	591	727	9642	11726	14468	0.259	0.335	0.426
2017	494	602	738	9806	11980	14752	0.264	0.342	0.433
2018	502	613	753	9984	12213	15056	0.269	0.350	0.440
2019	512	625	768	10177	12439	15348	0.274	0.357	0.448
2020	519	637	784	10326	12660	15627	0.279	0.363	0.457

Research and data needs for future assessments include information on the relationship of individual female age and biomass to maturity, fecundity and survival of offspring; information on the accuracy of POP ageing; information on the relative density of POP in trawlable and untrawlable areas and differences in age and/or length compositions between those areas; and information on the status of the British Columbia stock of POP and its relationship to that off of Oregon and Washington.