

DRAFT

This information is distributed solely for the purpose of pre-dissemination peer review under applicable information quality guidelines. It has not been formally disseminated by NOAA Fisheries. It does not represent and should not be construed to represent any agency determination or policy.

Status and Future Prospects for the Darkblotched Rockfish Resource in Waters off Washington, Oregon, and California as Updated in 2009

by

John R. Wallace
Owen S. Hamel

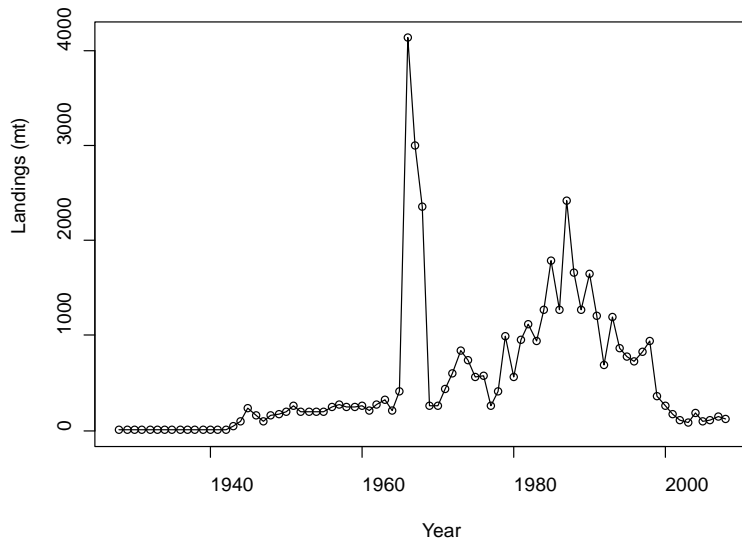
May 27, 2009

Northwest Fisheries Science Center
U. S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
2725 Montlake Blvd East
Seattle, Washington 98112-2097

Status and Future Prospects for the Darkblotched Rockfish Resource in Waters off Washington, Oregon, and California as Updated in 2009

This assessment applies to the darkblotched rockfish (*Sebastes crameri*) resource in the combined US Vancouver, Columbia, Eureka and Monterey INPFC areas. The largest landings (removals between 2,300 and 4,200 metric tons (mt)) of darkblotched were taken from 1966-1968, primarily by foreign vessels. From 1969 to 1981, the fishery proceeded with more moderate landings of between 200 and 1000 mt per year, with the foreign fishery ending in 1977. A second peak in landings occurred between 1982 and 1993, with landings exceeding 1,100 mt in 10 of 12 years, reaching over 2,400 mt in 1987. Management measures reduced landings to below 950 mt since 1994, below 400 mt since 1999, and below 200 mt in recent years.

Landings history from 1928-2006



Landings estimates for the past 10 years

<i>Year</i>	<i>Landings(mt)</i>
1999	362
2000	262
2001	173
2002	113
2003	80
2004	189
2005	98
2006	109
2007	145
2008	117

This assessment used the SS model, version 3.03a. New data and updates to the data used in the previous assessment were used in this new assessment. They are as follows:

Landings data for 1983-2006 were checked, and new landings data were added for 2007 and 2008. Fishery length compositions for 1983-2006 were updated, with new 2007 and 2008 length compositions added. New pairs of discard estimates and discard length compositions for 2006 and 2007 were both added. The 1999-2008 NWFSC Slope and the 2003-2008 NWFSC Survey GLMM-based biomass indices and CV's were recalculated and used. All the length compositions for the NWFSC Slope and NWFSC Survey were updated and used. The "super years" from the AFSC Slope Survey continue to be excluded, as is the 1977 Triennial Shelf Survey. The fishery conditional age-at-length data were updated, using otoliths from 1991, 1998, and 2003-2008. The NWFSC slope and shelf conditional age-at-length from 2003-2008 were updated. Lastly, the AFSC Slope Survey conditional age-at-length from 2001 and the fishery discard otoliths from 2004 and 2005 remain unchanged.

A number of sources of uncertainty were explicitly included in this assessment. For example, allowance was made for uncertainty in natural mortality and the parameters of the stock-recruitment relationship.

There were also other sources of uncertainty that were not included in the current model, including the degree of connection between the stocks of darkblotched rockfish off British Columbia and those in PFMC waters; the effect of the PDO, ENSO and other climatic variables on recruitment, growth and survival of darkblotched rockfish; and gender-based differences in survival.

The reference case, on which this update is based, was selected by extensive model testing with an attempt to balance the sources of uncertainty.

Summary of past 10 years

<i>Year</i>	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
<i>ABC</i>	256	256	302-349	187	205	240	269	294	456	487	437
<i>OY</i>			130	168	172	240	269	200	290	330	285
<i>Landings(mt)</i>	362	262	173	113	80	189	98	109	145	117	
<i>Discards(mt)*</i>	10	152	101	66	47	63	31	91	119	96	
<i>Catch (mt)*</i>	372	414	274	179	127	252	129	200	264	213	
<i>F</i>	0.086	0.091	0.056	0.033	0.021	0.035	0.015	0.021	0.025	0.020	
<i>Expl. Rate</i>	0.068	0.072	0.044	0.025	0.016	0.028	0.013	0.018	0.023	0.018	
<i>I+ Biomass</i>	5,462	5,776	6,280	7,109	8,122	9,161	10,018	10,935	11,672	12,180	12,579
<i>Sp. Output</i>	3,279	3,131	3,050	3,197	3,510	3,928	4,384	5,132	6,048	6,951	7,782
<i>Sp. Out. sd</i>	323	333	350	383	428	483	553	650	774	903	1021
<i>Sp. Out. cv</i>	0.10	0.11	0.11	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13
<i>Recruits(10³)</i>	5,757	6,519	967	949	2,298	2,758	2,424	532	45	1,969	
<i>Rec. sd</i>	742	833	178	155	330	417	409	134	23	1582	
<i>Rec. cv</i>	0.13	0.13	0.18	0.16	0.14	0.15	0.17	0.25	0.51	0.80	
<i>Depletion</i>	0.115	0.110	0.107	0.113	0.124	0.138	0.154	0.181	0.213	0.245	0.274
<i>Depl. sd</i>	0.010	0.010	0.011	0.012	0.014	0.015	0.018	0.021	0.025	0.029	0.032
<i>Depl. cv</i>	0.086	0.094	0.102	0.107	0.109	0.110	0.113	0.114	0.115	0.117	0.118

* Discard is a model estimate, and catch is landings plus the model based discard.

The point estimate for the depletion of the spawning output at the start of 2009 is 19.6%. The ABC (using the F50% MSY proxy) and OY (from the rebuilding plan) for 2009 in the above table reflect current management based on the 2007 assessment. Under the current model the OFL (Over Fishing Limit or ABC) for 2009 is lower at 342 mt. 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 is considered to be occurring when catch exceeds the ABC specified for a particular year. Based on this assessment, darkblotched rockfish on the West Coast remain below the overfished threshold, but the spawning output appears to have increased steadily over the past 7 or 8 years (which is essentially the same period in which a formal rebuilding plan has been in place). Since 2003, overfishing is estimated to have occurred once, with estimated catch exceeding the ABC by 12 mt (5%) in 2004. However, due to the uncertainty in actual discard, overfishing may or may not have occurred in that year.

With the stock extending northwards into Canadian waters, management and assessment of stock status might be improved through greater cooperation with British Columbia.

Major quantities from assessment

	<i>Value</i>	<i>sd</i>	<i>cv</i>
<i>SpOut₀ (10⁸ eggs)</i>	28,394	626	0.022
<i>B₀ (mt)(1+ Biomass)</i>	32,303	730	0.023
<i>R₀ (10³ fish)</i>	2,982	73	0.024
<i>SpOut_{msy} (10⁸ eggs)</i>	11,358	250	0.022
<i>F_{msy}</i>	0.041		
<i>Basis for above</i>	<i>F_{50%SPR}</i>		
<i>Exploitation rate at MSY</i>	0.037		
<i>MSY</i>	575		

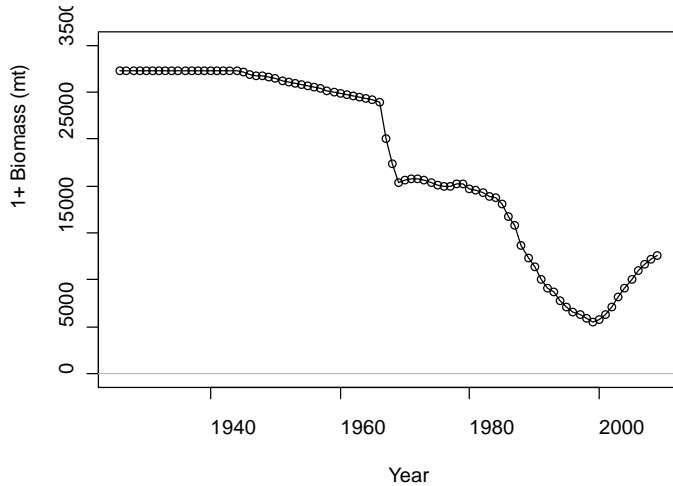
Reference points

	F_{msy}=F_{spr} (0.5)	F_{msy} = F_{Btarg}(B₄₀)	Calculated F_{msy}
SPR	0.5	0.5	0.421
F	0.041	0.041	0.054
Exploitation Rate	0.037	0.037	0.051
MSY (mt)	575	575	597
Sp. Out. _{msy}	11,358	11,358	8,663
B/B₀ (Sp. Out.)	0.40	0.40	0.305
Age 1+ Biomass	15,532	15,532	11,708

*Note that when steepness (h) = 0.6, the reference F_{spr} = 0.5 will result in an equilibrium biomass of B₄₀; therefore, the first two columns in the above table are identical (since when h = 0.6 and biomass = B₄₀, expected recruitment = 0.8R₀)

The point estimates of summary (age 1+) biomass show an upward trend over the past ten years, nearly doubling during that time.

1+ Biomass Levels from 1928 to 2009

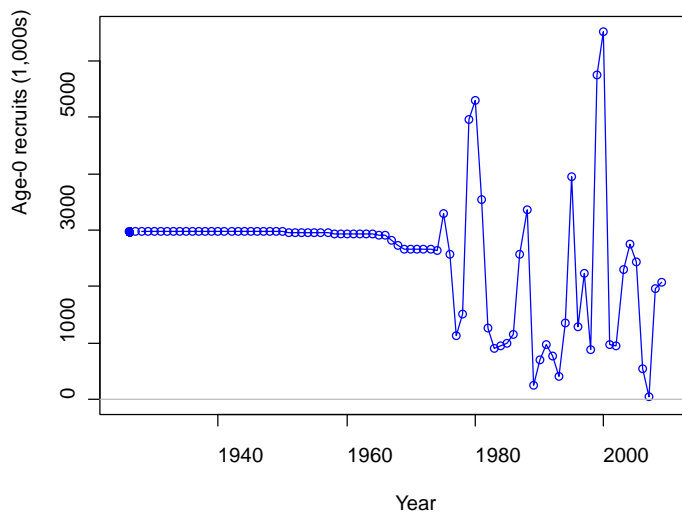


Biomass estimates for the past 10 years

<i>Year</i>	<i>Total 1+ biomass(mt)</i>
2000	5,462
2001	5,776
2002	6,280
2003	7,109
2004	8,122
2005	9,161
2006	10,018
2007	10,935
2008	11,672
2009	12,180

The first year for which recruitment appears to be reliably estimated is 1975. The recruitment pattern for darkblotched rockfish is similar to that of many rockfish species, with highly variable recruitment from year to year. With a few exceptions, the 1980's and 1990's provided rather poor year-classes compared with average historical recruitment levels, although the 1999 and 2000 year-classes appear to be two of the four largest year-classes since 1975. The most recent year of 2008 shows recruitment closer to those seen in 2003-2005 after very low recruitment in 2006 and 2007. These low estimates appear to reflect the low 2008 shelf survey index.

Recruitment estimates (1928-2008)

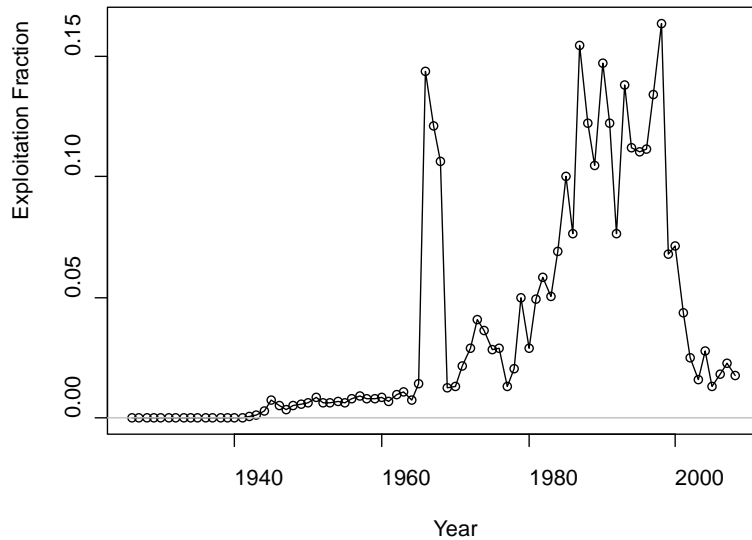


*Recruitment estimates for the past 10 years
(Thousands of age-0 recruits)*

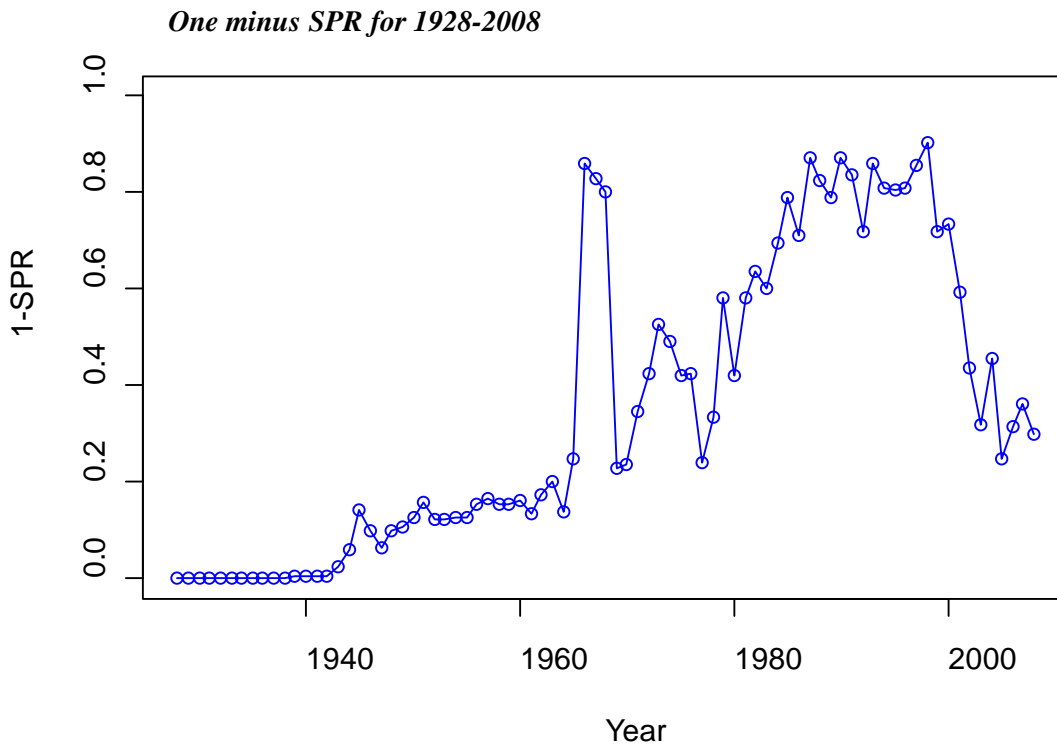
<i>Year</i>	<i>Recruitment</i>
1999	5,757
2000	6,519
2001	967
2002	949
2003	2,298
2004	2,758
2005	2,424
2006	532
2007	45
2008	1,969

The exploitation rate (percent of biomass taken) on fully-selected animals peaked near 15% 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 the late 1970's to 1987 at 15% and stayed high until 1998 with the continuing decline in exploitable biomass. Over the past 10 years the exploitation rate has fallen from over 6% (with a peak of 7% in 2000) to 2%.

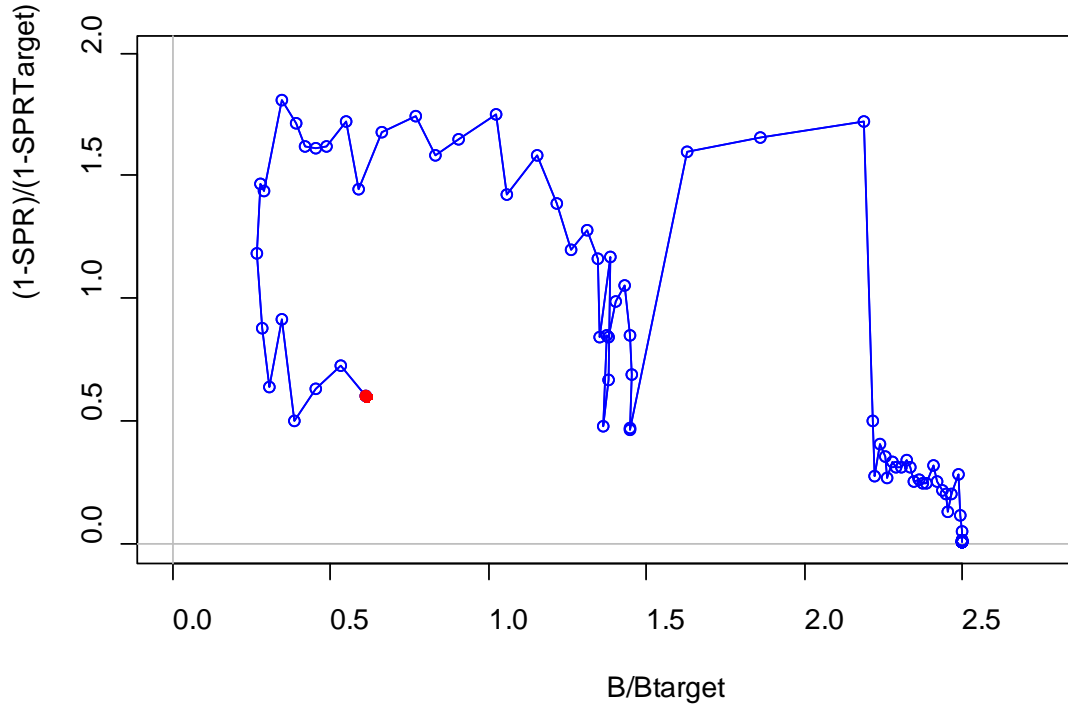
Exploitation Fraction (1928-2008)



Exploitation Fraction the past 10 years



Relative Fishing Intensity versus B/Btarget for 1928-2008



Percent of B_0 for 1928 to 2009 for the new model (circles) and 1928 to 2007 for the 2007 model (squares).

The major axes of uncertainty are steepness and natural mortality. The decision table below uses natural mortality (M) as the major axis of uncertainty. The three landings series are based upon 2008 fishing mortality rate (F_{2008} ; “Low Landings”), 40:10 rule catches (with 2009 and 2010 landings to meet catch OYs; “Medium Landings”), and 2005 rebuilding plan SPR (0.50) = ABC, with 2009-10 OYs; “High Landings”). Discard, and thus total catch, is estimated within the model.

	Year	Landings	LOW STATE M = 0.05			MEDIUM STATE M = 0.07			HIGH STATE M = 0.09		
			Catch	Sp. Out.	Depl.	Catch	Sp. Out.	Depl.	Catch	Sp. Out.	Depl.
Low Landings	2009	105	191	2,763	9.5%	190	7,782	27.4%	189	16,769	55.1%
	2010	115	209	2,982	10.3%	208	8,523	30.0%	207	18,221	59.9%
	2011	122	221	3,155	10.9%	220	9,179	32.3%	219	19,485	64.1%
	2012	125	228	3,276	11.3%	226	9,734	34.3%	225	20,533	67.5%
	2013	126	231	3,333	11.5%	229	10,133	35.7%	228	21,243	69.8%
	2014	128	234	3,331	11.5%	232	10,370	36.5%	231	21,591	71.0%
	2015	130	239	3,301	11.4%	236	10,510	37.0%	235	21,706	71.4%
	2016	133	244	3,271	11.3%	241	10,627	37.4%	240	21,730	71.4%
	2017	136	250	3,254	11.2%	247	10,756	37.9%	246	21,743	71.5%
2018	139	256	3,253	11.2%	253	10,911	38.4%	252	21,774	71.6%	
Medium Landings	2009	157	287	2,763	9.5%	285	7,782	27.4%	284	16,769	55.1%
	2010	161	293	2,911	10.0%	291	8,453	29.8%	290	18,151	59.7%
	2011	252	458	3,013	10.4%	455	9,039	31.8%	454	19,348	63.6%
	2012	251	459	2,934	10.1%	455	9,398	33.1%	453	20,204	66.4%
	2013	248	454	2,777	9.6%	449	9,590	33.8%	448	20,715	68.1%
	2014	245	451	2,563	8.8%	445	9,622	33.9%	443	20,869	68.6%
	2015	244	449	2,333	8.0%	443	9,570	33.7%	441	20,804	68.4%
	2016	244	450	2,116	7.3%	444	9,506	33.5%	441	20,664	67.9%
	2017	245	453	1,921	6.6%	446	9,468	33.3%	444	20,527	67.5%
	2018	248	458	1,746	6.0%	450	9,464	33.3%	448	20,421	67.1%
High Landings	2009	157	287	2,763	9.5%	285	7,782	27.4%	284	16769	55.1%
	2010	161	293	2,911	10.0%	291	8,453	29.8%	290	18151	59.7%
	2011	275	501	3,013	10.4%	497	9,039	31.8%	496	19348	63.6%
	2012	269	491	2,900	10.0%	487	9,364	33.0%	485	20170	66.3%
	2013	263	481	2,713	9.3%	476	9,527	33.6%	474	20653	67.9%
	2014	259	476	2,474	8.5%	470	9,534	33.6%	467	20784	68.3%
	2015	257	475	2,221	7.6%	468	9,460	33.3%	465	20698	68.0%
	2016	258	476	1,983	6.8%	469	9,375	33.0%	466	20538	67.5%
	2017	259	479	1,767	6.1%	471	9,316	32.8%	469	20382	67.0%
	2018	261	483	1,573	5.4%	475	9,292	32.7%	473	20258	66.6%

Future research needs include:

Inclusion of the recently revised historical rockfish landings.

Investigation into the best available methods and data for constructing and using conditional age at length compositions from data taken across space and time within years.

A thorough investigation of historical darkblotched rockfish mortality in the shrimp fishery.

Mapping of “trawlable” and “untrawlable” habitat and construction of a prior on survey q .