Status of Pacific ocean perch (*Sebastes alutus*) along the U.S. west coast in 2017

Chantel R. Wetzel[1]
Kelli Johnson[1]
Lee Cronin-Fine[2]

[1]Northwest Fisheries Science Center, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, 2725 Montlake Boulevard East, Seattle, Washington 98112

[3]University of Washington, School of Aquatic and Fishery Sciences

DRAFT SAFE

Status of Pacific ocean perch (*Sebastes alutus*) along the U.S. west coast in 2017

Contents

Executive Summary 1
Stock . . . 1
Catches . . . 1
Data and Assessment . . . 3
Stock Biomass . . . 3
Recruitment . . . 4
Exploitation status . . . 5
Ecosystem Considerations . . . 8
Reference Points . . . 8
Management Performance . . . 9
Unresolved Problems And Major Uncertainties . . . 9
Decision Table(s) (groundfish only) . . . 10
Research And Data Needs . . . 14
Rebuilding Projections . . . 14

1 Introduction 15
1.1 Basic Information . . . 15
1.2 Map . . . 16
1.3 Life History . . . 16
1.4 Ecosystem Considerations . . . 17
1.5 Fishery Information . . . 17
1.6 Summary of Management History . . . 17
1.7 Management Performance . . . 17
1.8 Fisheries off Canada, Alaska, and/or Mexico . . . 17

2 Assessment **18**

2.1 Data . . . 18

2.1.1 Commercial Fishery Landings . . . 18

2.1.2 Abundance Indices . . . 19

2.1.3 Fishery-Independent Data: possible sources . . . 19

2.1.4 Biological Parameters and Data . . . 21

2.1.5 Environmental Or Ecosystem Data Included In The Assessment . . . 23

2.2 History Of Modeling Approaches Used For This Stock . . . 23

2.2.1 Previous Assessments . . . 23

2.2.2 Previous Assessment Recommendations . . . 23

2.3 Model Description . . . 24

2.3.1 Transition To The Current Stock Assessment . . . 24

2.3.2 Definition of Fleets and Areas . . . 24

2.3.3 Summary of Data for Fleets and Areas . . . 25

2.3.4 Modeling Software . . . 25

2.3.5 Data Weighting . . . 25

2.3.6 Priors . . . 25

2.3.7 General Model Specifications . . . 25

2.3.8 Estimated And Fixed Parameters . . . 25

2.4 Model Selection and Evaluation . . . 25

2.4.1 Key Assumptions and Structural Choices . . . 25

2.4.2 Alternate Models Considered . . . 26

2.4.3 Convergence . . . 26

2.5 Response To The Current STAR Panel Requests . . . 26

2.6 Model 1 . . . 27

2.6.1 Model 1 Base Case Results . . . 27

2.6.2 Model 1 Uncertainty and Sensitivity Analyses . . . 27

2.6.3 Model 1 Retrospective Analysis . . . 27

2.6.4 Model 1 Likelihood Profiles . . . 27

2.6.5 Model 1 Harvest Control Rules (CPS only) . . . 27

2.6.6 Model 1 Reference Points (groundfish only) . . . 27

2.7 Model 2 . . . 28

2.7.1 Model 2 Base Case Results 28
2.7.2 Model 2 Uncertainty and Sensitivity Analyses 28
2.7.3 Model 2 Retrospective Analysis 28
2.7.4 Model 2 Likelihood Profiles 28
2.7.5 Model 2 Harvest Control Rules (CPS only) 28
2.7.6 Model 2 Reference Points (groundfish only) 28
2.8 Model 3 28
2.8.1 Model 3 Base Case Results 28
2.8.2 Model 3 Uncertainty and Sensitivity Analyses 28
2.8.3 Model 3 Retrospective Analysis 28
2.8.4 Model 3 Likelihood profiles 28
2.8.5 Model 3 Harvest Control Rules (CPS only) 28
2.8.6 Model 3 Reference Points (groundfish only) 28

3 Harvest Projections and Decision Tables **28**

4 Regional Management Considerations **29**

5 Research Needs **29**

6 Acknowledgments **29**

7 Tables **30**

8 Figures **47**

References

Executive Summary

executive-summary

Stock

stock

This assessment reports the status of the Pacific ocean perch (*Sebastes alutus*) speciess off rockfish off the U.S. West Coast from Northern California to the Canadian Border using data through 2017. Pacific ocean perch are most abundant in the Gulf of Alaska and have observed off of Japan, in the Bering Sea, and south to Baja California, although they are sparse south of Oregon and rare in southern California. Composition data indicate that good recruitment years coincide in Oregon and Washington. To date, no significant genetic differences have been found in the range covered by this assessment.

Catches

catches

The first year that harvest of Pacific ocean perch exceeded 1 mt off the U.S. West Coast first occured in 1929. Catches ramped up in the 1940s with large removals in Washington waters. During the 1950s the removals primarily occured in Oregon waters with catches from Washington declining following the 1940s. The largest removals in 1966-1968 were largely a result of harvest by foreing vessels. The fishery proceed with more moderate removals ranging between 1,200 to 2,600 metric tons per year between 1969 to 1980. Removals generally decined from 1981 to 1994 to between 1,000 and 1,700 metric tons per year. Pacific ocean perch was declared overfished in 1999 resulting in large reduction in harvest in recent years since the declaration.

Table a: Landings (mt) for the past 10 years forPacific ocean perch by fleet.

tab:Exec_catch

Year	California	Oregon	Washington	At-sea-hake	Survey	Total Catch
2007	0.15	83.65	45.11	4.05	0.58	133.54
2008	0.39	58.64	16.61	15.93	0.80	92.37
2009	0.92	58.75	33.22	1.56	2.70	97.14
2010	0.14	58.00	22.29	16.87	1.62	98.92
2011	0.12	30.26	19.57	9.17	1.19	60.31
2012	0.18	30.41	21.79	4.52	1.59	58.49
2013	0.08	34.86	14.54	5.41	1.71	56.60
2014	0.18	30.64	9.55	3.92	0.56	44.85
2015	0.12	38.12	11.41	8.71	1.51	59.87
2016	0.19	34.15	12.23	10.30	0.00	56.86

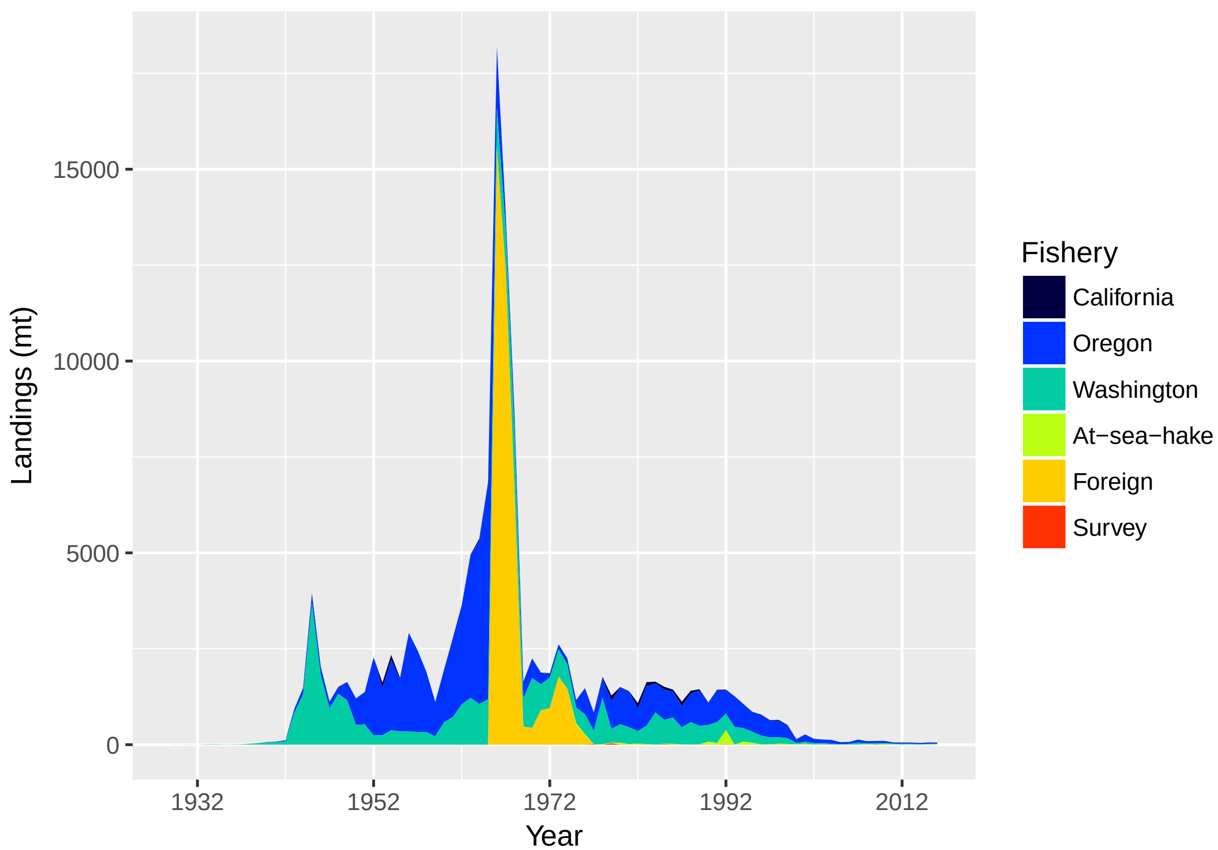

Figure a: Landings of Pacific ocean perch for California, Oregon, Washington, the foriegn fishery (1966-1976), at-sea-hake fishery, and fishery independent surveys. fig:Exec_catch1

Data and Assessment

data-and-assessment

This a new full assessment for Pacific ocean perch which was last assessed in 2011. In this assessment, all aspects of the model including catches, data, and modelling assumptions were re-evaluated as much as possible. The assessment was conducted using the length- and age-structured modeling software Stock Synthesis (version 3.30). The coastwide population was modeled assuming separate growth and mortality parameters for each sex (a two-sex model) from 1892 to 2017, and forecasted beyond 2017.

Stock Biomass

stock-biomass

Include: trends and current levels relative to virgin or historic levels, description of uncertainty-include table for last 10 years and graph with long term estimates.

Spawning output Figure: Figure
Spawning output Table(s): Table b
Relative depletion Figure: Figure

Example text (remove Models 2 and 3 if not needed - if using, remove the # in-line comments!!!)
The estimated relative depletion level (spawning output relative to unfished spawning output) of the the base-case model in 2017 is 23% (˜95% asymptotic interval: ± 23%-23%) (Figure).

The estimated relative depletion level of model 2 in 2017 is (˜95% asymptotic interval: ±) (Figure).

The estimated relative depletion level of model 3 in 2017 is (˜95% asymptotic interval: ±) (Figure).

Table b: Recent trend in beginning of the year spawning output and depletion for the Base model for Pacific ocean perch.

tab:SpawningDeplete_mod1

Year	Spawning Output (billion eggs)	~ 95% confidence interval	Estimated depletion	~ 95% confidence interval
2008	12648.00	12648 - 12648	0.19	0.188 - 0.188
2009	12994.00	12994 - 12994	0.19	0.193 - 0.193
2010	13132.00	13132 - 13132	0.20	0.195 - 0.195
2011	13211.00	13211 - 13211	0.20	0.196 - 0.196
2012	13347.00	13347 - 13347	0.20	0.198 - 0.198
2013	13684.00	13684 - 13684	0.20	0.203 - 0.203
2014	14133.00	14133 - 14133	0.21	0.210 - 0.210
2015	14644.00	14644 - 14644	0.22	0.218 - 0.218
2016	15081.00	15081 - 15081	0.22	0.224 - 0.224
2017	15448.00	15448 - 15448	0.23	0.230 - 0.230

Time series of spawning output trajectory (circles and line: median; light broken lines: 95% credibility intervals) for the base case assessment model. fig:Spawnbio_all

Estimated relative depletion with approximate 95% asymptotic confidnce intervals (dashed lines) for the base case assessment model. fig:RelDeplete_all

Recruitment

recruitment

Include: trends and current levels relative to virgin or historic levels-include table for last 10 years and graph with long term estimates.

Recruitment Figure: (Figure)
Recruitment Tables: (Tables c, **??** and **??**)

Table c: Recent recruitment for the Base model.

tab:Recruit_mod1

Year	Estimated Recruitment (1,000s)	~ 95% confidence interval
2008	10654.00	10654 - 10654
2009	2373.00	2373 - 2373
2010	3035.00	3035 - 3035
2011	3048.00	3048 - 3048
2012	3299.00	3299 - 3299
2013	3611.00	3611 - 3611
2014	3972.00	3972 - 3972
2015	4078.00	4078 - 4078
2016	4166.00	4166 - 4166
2017	4240.00	4240 - 4240

Time series of estimated Pacific ocean perch recruitments for the base-case model with 95% confidence or credibility intervals. fig:Recruits_all

Exploitation status

exploitation-status

Include: exploitation rates (i.e., total catch divided by exploitable biomass, or the annual SPR harvest rate) include a table with the last 10 years of data and a graph showing the trend in fishing mortality relative to the target (y-axis) plotted against the trend in biomass relative to the target (x-axis).

Exploitation Tables: Table d, Table **??**, Table **??** Exploitation Figure: Figure).

A summary of Pacific ocean perch exploitation histories for base model is provided as Figure b.

Table d: Recent trend in spawning potential ratio and exploitation for Pacific ocean perch in the Base model. Fishing intensity is (1-SPR) divided by 50% (the SPR target) and exploitation is F divided by F_{SPR}.

tab:SPR_Exploit_mod1

Year	Fishing intensity	~ 95% confidence interval	Exploitation rate	~ 95% confidence interval
2007	0.296	0.296 - 0.296	0.006	0.006 - 0.006
2008	0.264	0.264 - 0.264	0.006	0.006 - 0.006
2009	0.352	0.352 - 0.352	0.008	0.008 - 0.008
2010	0.268	0.268 - 0.268	0.006	0.006 - 0.006
2011	0.169	0.169 - 0.169	0.003	0.003 - 0.003
2012	0.164	0.164 - 0.164	0.003	0.003 - 0.003
2013	0.158	0.158 - 0.158	0.003	0.003 - 0.003
2014	0.125	0.125 - 0.125	0.002	0.002 - 0.002
2015	0.160	0.160 - 0.160	0.003	0.003 - 0.003
2016	0.148	0.148 - 0.148	0.003	0.003 - 0.003

Estimated spawning potential ratio (SPR) for the base-case model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the $SPR_{50\%}$ harvest rate. The last year in the time series is 2016. fig:SPR_all

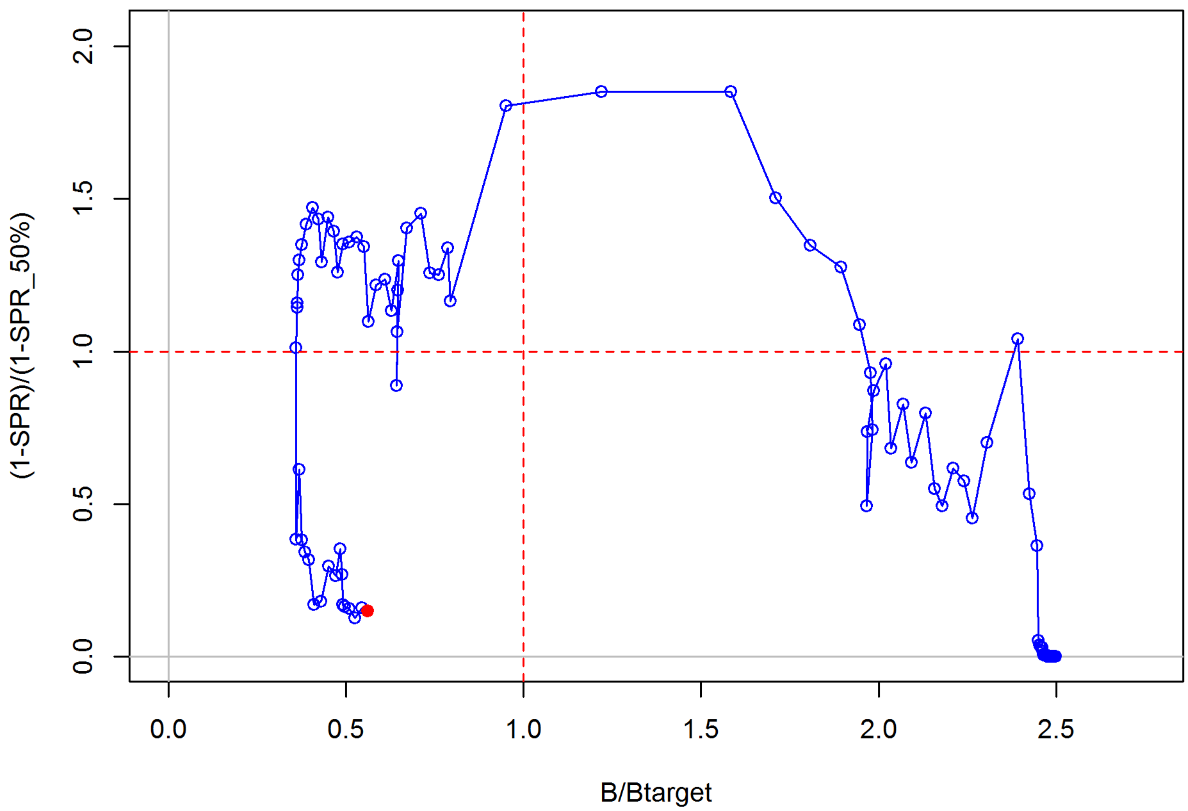

Figure b: Phase plot of estimated relative (1-SPR) vs. relative spawning biomass for the base case model. The relative (1-SPR) is (1-SPR) divided by 50% (the SPR target). Relative depletion is the annual spawning biomass divided by the unfished spawning biomass. fig:Phase_all

Ecosystem Considerations

ecosystem-considerations

In this assessment, ecosystem considerations were. . . ..

Reference Points

reference-points

Include: management targets and definition of overfishing, including the harvest rate that brings the stock to equilibrium at $B_{40\%}$ (the B_{MSY} proxy) and the equilibrium stock size that results from fishing at the default harvest rate (the F_{MSY} proxy). Include a summary table that compares estimated reference points for SSB, SPR, Exploitation Rate and Yield based on SSBproxy for MSY, SPRproxy for MSY, and estimated MSY values

Write intro paragraph....and remove text for Models 2 and 3 if not needed

This stock assessment estimates that Pacific ocean perch in the Base model are below the biomass target, but below the minimum stock size threshold. Add sentence about spawning output trend. The estimated relative depletion level for Model 1 in 2017 is 23% (˜95% asymptotic interval: ± 23%-23%, corresponding to an unfished spawning output of 15448 billion eggs (˜95% asymptotic interval: 15448.2-15448.2 billion eggs) of spawning output in the base model (Table e). Unfished age 3+ biomass was estimated to be 123687 mt in the base case model. The target spawning output based on the biomass target ($SB_{40\%}$) is 26914.1 billion eggs, which gives a catch of 1083.8 mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$ is 885 mt.

This stock assessment estimates that Pacific ocean perch in the are

the biomass target, but the minimum stock size threshold. Add sentence about spawning output trend. The estimated relative depletion level for Model 2 in 2017 is (˜95% asymptotic interval: ±), corresponding to an unfished spawning output of (˜95% asymptotic interval:) of spawning output in the base model (Table **??**). Unfished age 3+ biomass was estimated to be mt in the base case model. The target spawning output based on the biomass target ($SB_{40\%}$) is , which gives a catch of mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$ is mt.

This stock assessment estimates that Pacific ocean perch in the are

the biomass target, but the minimum stock size threshold. Add sentence about spawning output trend. The estimated relative depletion level or Model 3 in 2017 is (˜95% asymptotic interval: ±), corresponding to an unfished spawning output of (˜95% asymptotic interval:) of spawning output in the base model (Table **??**). Unfished age 3+ biomass was estimated to be mt in the base case model. The target spawning output based on the biomass target ($SB_{40\%}$) is , which gives a catch of mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$ is mt.

Table e: Summary of reference points and management quantities for the base case Base model.

tab:Ref_pts_mod1

Quantity	Estimate	95% Confidence Interval
Unfished spawning output (billion eggs)	67285.2	67285.2 - 67285.2
Unfished age 3+ biomass (mt)	123687	123687 - 123687
Unfished recruitment (R0, thousands)	9574.5	9574.5 - 9574.5
Spawning output(2017 billion eggs)	15448.2	15448.2 - 15448.2
Depletion (2017)	0.23	0.23 - 0.23
Reference points based on $\mathbf{SB_{40\%}}$		
Proxy spawning output ($B_{40\%}$)	26914.1	26914.1 - 26914.1
SPR resulting in $B_{40\%}$ ($SPR_{B40\%}$)	0.625	0.625 - 0.625
Exploitation rate resulting in $B_{40\%}$	0.021	0.021 - 0.021
Yield with $SPR_{B40\%}$ at $B_{40\%}$ (mt)	1083.8	1083.8 - 1083.8
Reference points based on SPR proxy for MSY		
Spawning output	13457	13457 - 13457
SPR_{proxy}	0.5	
Exploitation rate corresponding to SPR_{proxy}	0.032	0.032 - 0.032
Yield with SPR_{proxy} at SB_{SPR} (mt)	885	885 - 885
Reference points based on estimated MSY values		
Spawning output at MSY (SB_{MSY})	26279.6	26279.6 - 26279.6
SPR_{MSY}	0.619	0.619 - 0.619
Exploitation rate at MSY	0.021	0.021 - 0.021
MSY (mt)	1084.2	1084.2 - 1084.2

Management Performance

management-performance

Include: catches in comparison to OFL, ABC and OY/ACL values for the most recent 10 years (when available), overfishing levels, actual catch and discard. Include OFL(encountered), OFL(retained) and OFL(dead) if different due to discard and discard mortality.

Management performance table: Table f

Unresolved Problems And Major Uncertainties

unresolved-problems-and-major-uncertainties

TBD after STAR panel

Table f: Recent trend in total catch and commercial landings (mt) relative to the management guidelines. Estimated total catch reflect the commercial landings plus the model estimated discarded biomass.

tab:mnmgt_perform

Year	OFL (mt; ABC prior to 2011)	ABC (mt)	ACL (mt; OY prior to 2011)	Estimated total catch (mt)
2007	-	-	-	-
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	-	-	-	-
2014	-	-	-	-
2015	-	-	-	-
2016	-	-	-	-

Decision Table(s) (groundfish only)

decision-tables-groundfish-only

Include: projected yields (OFL, ABC and ACL), spawning biomass, and stock depletion levels for each year. Not required in draft assessments undergoing review.

OFL projection table: Table g

Decision table(s) Table h, Table **??**, Table **??**

```
Yield curve: Figure \ref{fig:Yield_all}
```

Table g: Projections of potential OFL (mt) and the ACL (mt) using the base model forecast.

tab:OFL_projection

Year	OFL	ACL
2017	989.34	

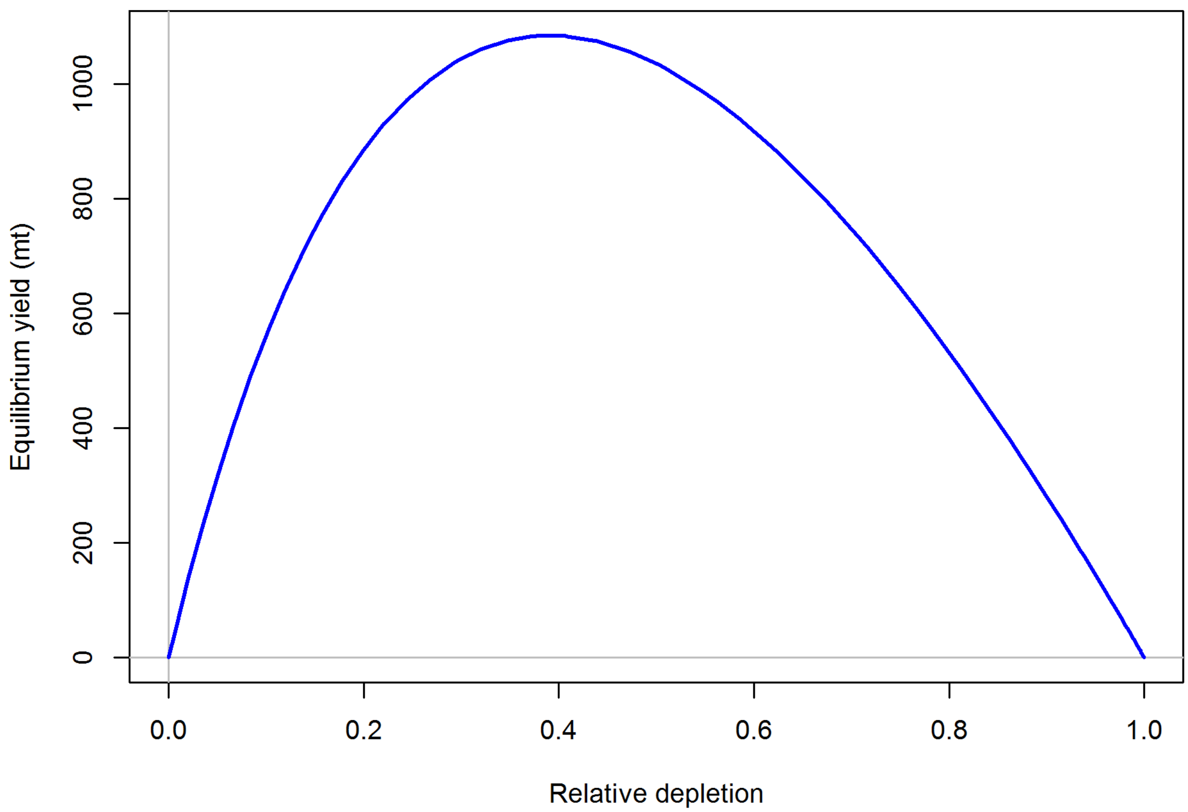

Figure c: Equilibrium yield curve for the base case model. Values are based on the 2016 fishery selectivity and with steepness fixed at... fig:Yield_all

Table h: Summary of 10-year projections beginning in 2019 for alternate states of nature based on an axis of uncertainty for the Base model. Columns range over low, mid, and high states of nature, and rows range over different assumptions of catch levels. An entry of ”–” indicates that the stock is driven to very low abundance under the particular scenario.

tab:Decision_table_mod1

			States of nature					
			Low M 0.05		Base M 0.07		High M 0.09	
	Year	Catch	Spawning Output	Depletion	Spawning Output	Depletion	Spawning Output	Depletion
40-10 Rule, Low M	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-
40-10 Rule	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-
40-10 Rule, High M	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-
Average Catch	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-

Table i: Base case results summary.

tab:base_summary

Quantity	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Landings (mt)										
Total Est. Catch (mt)										
OFL (mt)										
ACL (mt)										
(1-SPR)(1-$SPR_{50\%}$)	0.26	0.35	0.27	0.17	0.16	0.16	0.13	0.16	0.15	
Exploitation rate	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	
Age 3+ biomass (mt)	25305.3	25578.9	25651.6	26743.3	27334.8	27963.1	28570.0	29189.2	29794.3	30433.8
Spawning Output	12648	12994	13132	13211	13347	13684	14133	14644	15081	15448
95% CI	12648 - 12648	12994 - 12994	13132 - 13132	13211 - 13211	13347 - 13347	13684 - 13684	14133 - 14133	14644 - 14644	15081 - 15081	15448 - 15448
Depletion	0.188	0.193	0.195	0.196	0.198	0.203	0.210	0.218	0.224	0.230
95% CI	0.188 - 0.188	0.193 - 0.193	0.195 - 0.195	0.196 - 0.196	0.198 - 0.198	0.203 - 0.203	0.210 - 0.210	0.218 - 0.218	0.224 - 0.224	0.230 - 0.230
Recruits	10654	2373	3035	3048	3299	3611	3972	4078	4166	4240
95% CI	10654 - 10654	2373 - 2373	3035 - 3035	3048 - 3048	3299 - 3299	3611 - 3611	3972 - 3972	4078 - 4078	4166 - 4166	4240 - 4240

Research And Data Needs

research-and-data-needs

Include: identify information gaps that seriously impede the stock assessment.

We recommend the following research be conducted before the next assessment:

1. List item No. 1 in the list
2. List item No. 2 in the list, etc.

Rebuilding Projections

rebuilding-projections

Include: reference to the principal results from rebuilding analysis if the stock is overfished. This section should be included in the Final/SAFE version assessment document but is not required for draft assessments undergoing review. See Rebuilding Analysis terms of reference for detailed information on rebuilding analysis requirements.

1 Introduction

introduction

1.1 Basic Information

basic-information

Pacific ocean perch (*Sebastes alutus*) are most abundant in the Gulf of Alaska, and have been observed off of Japan, in the Bering Sea, and south to Baja California, although they are sparse south of Oregon and rare in southern California. While genetic studies have found three populations of Pacific ocean perch off of British Columbia (Seeb and Gunderson 1988, Withler et al. 2001) with, notably, a separate stock off of Vancouver Island, no significant genetic differences have been found in the range covered by this assessment. Pacific ocean perch show dimorphic growth, with females reaching a slightly large size than males. Males and females are equally abundant on rearing grounds at age 1.5.

The Pacific ocean perch population has been modeled as a single stock off of the U.S. West Coast (essentially northern California to the Canadian border, since Pacific ocean perch are seen extremely rarely in central and southern California). Good recruitments show up in size-composition data throughout all portions of this area, which supports the single stock hypothesis. This assessment includes landings and catch data for Pacific ocean perch from the states of Washington, Oregon and California, along with records from foreign fisheries, the at-sea hake fleet, and surveys.

Prior to 1966, the Pacific ocean perch resource off of the northern portion of the U.S. West Coast was harvested almost entirely by Canadian and United States vessels. Harvest was negligible prior to 1940, reached 1,000 mt in 1951, 3,000 mt in 1961 and exceeded 7,000 mt in 1965. Catches increased dramatically after 1965, with the introduction of large distant-water fishing fleets from the Soviet Union and Japan. Both nations employed large factory stern trawlers as their primary method for harvesting Pacific ocean perch. Peak removals by all foreign nations combined are estimated at over 15,000 mt in 1966 and remained over 12,000 mt in 1967. These numbers are based upon a re-analysis of the foreign catch data (Rogers 2003), which focused on deriving a more realistic species composition for catches previously identified only as Pacific ocean perch. Catches declined rapidly following these peak years, and Pacific ocean perch stocks were considered to be severely depleted throughout the Oregon-Vancouver Island region by 1969 (Gunderson 1977, Gunderson et al. 1977). Landed harvest averaged 1,500 mt over the period 1977-94. Landings have continued to decline since 1994, primarily due to more restrictive management.

Prior to 1977, Pacific ocean perch in the northeast Pacific were managed by the Canadian Government in its waters and by the individual states in waters off of the United States. With implementation of the Magnuson Fishery Conservation and Management Act (MFCMA) in 1977, U.S. territorial waters were extended to 200 miles from shore, and primary responsibility for management of the groundfish stocks off Washington, Oregon and California shifted from the states to the Pacific Fishery Management Council (PFMC) and the National Marine Fisheries Service (NMFS). At that time, however, a Fishery Management Plan (FMP) for the west coast groundfish stocks had not yet been approved. In the interim, the state agencies worked with the PFMC to address conservation issues. In 1981, the PFMC adopted a management strategy to rebuild the depleted Pacific ocean perch stocks to levels that would produce Maximum Sustainable Yield (MSY) within 20 years. On the basis of cohort analysis (Gunderson 1978), the PFMC set Acceptable Biological Catch (ABC) levels at 600 mt for the US portion of the Vancouver INPFC area and 950 mt for the Columbia INPFC area. To implement this strategy, the states of Oregon and Washington each established landing limits for Pacific ocean perch. Trawl trip limits of various forms remained in effect through 2010 (Table 1).

Age estimates for Pacific ocean perch prior to the 1980s were made via surface ageing of otoliths, which misses the very tight annuli at the edge of the otolith once the fish reaches near maximum size. Ages are biased by around age 10-12, and maximum age was estimated to be in the 20s, which lead to an overestimate of the natural mortality rate and the productivity of the stock. Using break and burn methods, Pacific ocean perch have been aged to over 100 years, and we now know that the underlying assumptions of the early models were overly optimistic about productivity. Research surveys have been used to provide fishery-independent information about the abundance, distribution, and biological characteristics of Pacific ocean perch. A coast-wide survey of the rockfish resource was conducted in 1977 (Gunderson and Sample 1980) and was repeated every three years through 2004. The National Marine Fisheries Service (NMFS) coordinated a cooperative research survey of the Pacific ocean perch stocks off Washington and Oregon with the Washington Department of Fisheries (WDFW) and the Oregon Department of Fish and Wildlife (ODFW) in March-May 1979 (Wilkins and Golden 1983). This survey was repeated in 1985. Two slope surveys have been conducted on the west coast in recent years, one using the research vessel Miller Freeman, which ended in 2001, and another ongoing cooperative survey using commercial fishing vessels which began in 1998 as a DTS (Dover sole, thornyhead and sablefish) survey, was expanded to other groundfish in 1999. In 2003, this survey was expanded spatially to include the shelf. This last survey, conducted by the NWFSC, continues to cover depths from 30-700 fathoms (55-1280 meters) on an annual basis.

1.2 Map

`map`

A map showing the scope of the assessment and depicting boundaries for fisheries or data collection strata is provided in Figure 1.

1.3 Life History

`life-history`

Include: Important features of life history that affect management (e.g., migration, sexual dimorphism, bathymetric demography).

1.4 Ecosystem Considerations

`ecosystem-considerations-1`

Include: Ecosystem considerations (e.g., ecosystem role and trophic relationships of the species, habitat requirements/preferences, relevant data on ecosystem processes that may affect stock or parameters used in the stock assessment, and/or cross-FMP interactions with other fisheries). This section should note if environmental correlations or food web interactions were incorporated into the assessment model. The length and depth of this section would depend on availability of data and reports from the IEA, expertise of the STAT, and whether ecosystem factors are informational to contribute quantitative information to the assessment.

1.5 Fishery Information

`fishery-information`

Include: Important features of current fishery and relevant history of fishery.

1.6 Summary of Management History

`summary-of-management-history`

Include: Summary of management history (e.g., changes in mesh sizes, trip limits, or other management actions that may have significantly altered selection, catch rates, or discards).

1.7 Management Performance

`management-performance-1`

Include: Management performance, including a table or tables comparing Overfishing Limit (OFL), Annual Catch Limit (ACL), Harvest Guideline (HG) [CPS only], landings, and catch (i.e., landings plus discard) for each area and year.

Management performance table: (Table f)
A summary of these values as well as other base case summary results can be found in Table i.

1.8 Fisheries off Canada, Alaska, and/or Mexico

`fisheries-off-canada-alaska-andor-mexico`

Include if necessary.

2 Assessment

assessment

2.1 Data

data

Data used in the Pacific ocean perch assessment are summarized in Figure 2. A description of each data source is below.

2.1.1 Commercial Fishery Landings

commercial-fishery-landings

Washington

Historical commercial fishery landigns of Pacific ocean perch from Washington for the years 1918-1980 were obtained from Theresa Tsou (WDFW) and Phillip Weyland (WDFW). This assessment is the first Pacific ocean perch assessment to include a state provide historical catch reconstruction and hence, the historical catches for Washington vary markedly from those used in the 2011 assessment. Recent landings (1981-2016) were obtained from PacFIN (Pacific Fisheries Information Network (PacFIN) retrieval dated March 3, 2015, Pacific States Marine Fisheries Commission, Portland, Oregon; www.psmfc.org).

Oregon

Historical commercial fishery landings of Pacific ocean perch from Oregon for the years 1892-1986 were obtained from Alison Dauble (ODFW). A description of the methods can be found in (Karnowski et al. 2014). Recent landings (1987-2016) were obtained from PacFIN (Pacific Fisheries Information Network (PacFIN) retrieval dated March 3, 2015, Pacific States Marine Fisheries Commission, Portland, Oregon; www.psmfc.org).

California

Historical commercial fishery landings of Pacific ocean perch were obtained from the on-line database of the California Cooperative Groundfish Survey, also known as CALCOM (128.114.3.187) for the years 1916-1980. A description of the methods can be found in (Ralston et al. 2010). Recent landings (1981-2016) were obtained from PacFIN (Pacific Fisheries Information Network (PacFIN) retrieval dated March 3, 2015, Pacific States Marine Fisheries Commission, Portland, Oregon; www.psmfc.org).

At-sea fishery

Catches of Pacific ocean perch are monitored aboard the vessel by observers in the At-Sea hake Observer program (ASHOP) and were available for the years of 1975-2016. Observers use a spatial sample design, based on weight, to randomly choose a portion of the haul to sample for species composition. For the last decade, this is typically 30-50% of the total weight. The total weight of the sample is determined by all catch passing over a flow scale. All species other than hake are removed and weighed, by species, on a motion compensated flatbed scale. Observers record the weights of all non-hake species. Non-hake species total weights are expanded in the database by using the proportion of the haul sampled to the total weight of the haul. The catches of non-hake species in unsampled hauls is determined using bycatch rates determined from sampled hauls. Since 2001, more than 97% of the hauls have been observed and sampled.

Foreign

From the 1960s through the early 1970s, foreign trawling enterprises harvested considerable amounts of rockfish off Washington and Oregon, and along with the domestic trawling fleet, landed large quantities of 'r spp'. Foreign catches of individual species were estimated by Rogers (2003) and attributed to INPFC areas for the years of 1966-1976 for 'r spp'. The foreign catches were combined across areas for a coastwide removal total.

Discards

2.1.2 Abundance Indices

abundance-indices

Sub-heading 1

Sub-heading 2

2.1.3 Fishery-Independent Data: possible sources

fishery-independent-data-possible-sources

Northwest Fisheries Science Center (NWFSC) shelf-slope survey

The NWFSC shelf-slope survey is based on a random-grid design; covering the coastal waters from a depth of 55 m to 1,280 m (Bradburn et al. 2011). This design uses four chartered industry vessels in most years, assigned to a roughly equal number of randomly selected grid cells. The survey, which has been conducted from late-May to early-October each year, is divided into two 2-vessel passes of the coast, which are executed from north to south. This design therefore incorporates both vessel-to-vessel differences in catchability as well as variance associated with selecting a relatively small number (˜700) of cells from a very large population of possible cells (greater than 11,000) distributed from the Mexican to the Canadian border.

Northwest Fisheries Science Center (NWFSC) slope survey

The NWFSC slope survey covered waters throughout the summer from 183 m to 1280 m north of 34°30′ S, which is near Point Conception. The survey strata used to expand the biomass data for this assessment are shown in Table 5.

Alaska Fisheries Science Center (AFSC) slope survey

The AFSC slope survey operated during autumn (October-November) aboard the R/V Miller Freeman. Partial survey coverage of the U.S. west coast occurred during 1988-96 and complete coverage (north of 34°30′ S) during 1997, 1999, 2000, and 2001. Only the four years of consistent and complete surveys plus 1996, which surveyed north of 43° N latitude to the U.S.-Canada border, were used in this assessment. The number of tows ranged from 8 in 2001 to 26 in 1996 (Table 7). The numbers of tows with length data for 'r spp' are also shown in Table 7. Because a large number of positive tows occurred in 1996, it was decided to include that year, which surveyed from 43° N latitude to the U.S.-Canada border. Therefore, only tows from 43° N latitude to the U.S.-Canada border were used.

Triennial Bottom Trawl Survey

The triennial survey was first conducted by the AFSC in 1977 and spanned the timeframe from 1977-2004. The survey's design and sampling methods are most recently described in (Weinberg et al. 2002). Its basic design was a series of equally-spaced transects from which searches for tows in a specific depth range were initiated (Figure 5). The survey design has changed slightly over the period of time (Table 4, Figure 3). In general, all of the surveys were conducted in the mid-summer through early fall: the 1977 survey was conducted from early July through late September; the surveys from 1980 through 1989 ran from mid-July to late September; the 1992 survey spanned from mid-July through early October; the 1995 survey was conducted from early June to late August; the 1998 survey ran from early June through early August; and the 2001 and 2004 surveys were conducted in May-July (Figure 4).

Haul depths ranged from 91-457 m during the 1977 survey with no hauls shallower than 91 m. The surveys in 1980, 1983, and 1986 covered the West Coast south to 36.8° N latitude and a depth range of 55-366 meters. The surveys in 1989 and 1992 covered the same depth range but extended the southern range to 34.5° N (near Point Conception). From 1995 through 2004, the surveys covered the depth range 55-500 meters and surveyed south to 34.5° N. In the final year of the triennial series (2004), the NWFSC's Fishery Resource and Monitoring division (FRAM) conducted the survey and followed very similar protocols as the AFSC.

Given the different depths surveyed during 1977, the data from that year were not included in this assessment. Water hauls (Zimmermann et al. 2003) and tows located in Canadian waters were also excluded from the analysis of this survey. The survey was analyzed as an early series (1980-1992) and a late series (1995-2004), as has been done in other West Coast rockfish assessments.

Pacific ocean perch Survey

Pikitch Study

The Pikitch study was conducted between 1985 and 1987 (Pikitch et al. 1988). The northern and southern boundaries of the study were 48°42′ N latitude and 42°60′ N. latitude respectively,

which is primarily within the Columbia INPFC area (Pikitch et al. 1988 , Rogers and Pikitch 1992). Participation in the study was voluntary and included vessels using bottom, midwater, and shrimp trawl gears.
Observers of normal fishing operations on commercial vessels collected the data, estimated the total weight of the catch by tow and recorded the weight of species retained and discarded in the sample.

2.1.4 Biological Parameters and Data

`biological-parameters-and-data`

Length And Age Compositions

Include: Sample size information for length and age composition data by area, year, gear, market category, etc., including both the number of trips and fish sampled.

Length compositions were provided from the following sources, by region, with brief descriptions below:

Model 1

- Source No. 1 (*ex. research, commerical dead fish, live fish, etc*, date range (ex. 2010-2011)
- Source No. 2 (*ex. research, commerical dead fish, live fish, etc*, date range (ex. 2010-2011)
- etc...
- Begin sublist if desired
  - Sublist source No. 1
  - Sublist source No. 2
  - etc...
- Back to main list, next Source
- Last Source

Can duplicate this list if you have more than one assessment model

Possible sources of age and length data:

Recreational: Washington (WDFW)

Recreational: California MRFSS And CRFS Length Composition Data Individual fish lengths recorded by MRFSS (1980-2003) and CRFS (2004-2011) samplers were downloaded from the RecFIN website (www.recfin.org). CRFS data from 2012-2014 were obtained directly from CDFW.

Recreational: Oregon Recreational Boat Survey (ORBS) Biological data from the ORBS program were provided by ODFW. The ORBS is a dockside sampling program for the both the recreational CPFV and private modes. Length composition samples from north of Florence for the CPFV and private fleets were provided from 1980-2014. Samples from south of Florence spanned 1984-2014

Recreational: Miller and Gotshall (???)
The Northern California Marine Sport Fish Survey conducted an assessment survey with goals that included estimation of annual fishing effort by all recreational fishing modes, catch by weight, CPUE, and collection of data to analyze length compositions

Commercial: PacFIN (Oregon and California)

Research: NMFS Groundfish Ecology Survey

From 2001-2005, the SWFSC Fisheries Ecology Division conducted longline surveys aboard a chartered commercial longline vessel at various stations between Monterey and Davenport, CA (36° N. latitude to 37.5° N. latitude) (pers. comm. Don Pearson, SWFSC). Longline gear was set in various depths from 10 meters to 700 meters, parallel to the depth contour. Each longline set consisted of 3-5 skates, each with about 250 2/0 circle hooks baited with squid. In nearshore habitats, the gear soaked for roughly 30 minutes.

Research: California Collaborative Fisheries Research Program (CCFRP)

Research: NWFSC shelf-slope survey

Research: NWFSC slope survey

Research: Abrams Thesis

Age Structures

Age structure data were available from the following sources:

Model Region 1

- Source No. 1 (*ex. research, commericla dead fish, live fish, etc*, date range (ex. 2010-2011)
- Source No. 2 (*ex. research, commericla dead fish, live fish, etc*, date range (ex. 2010-2011)
- etc...
- Begin sublist if desired
  - Sublist source No. 1
  - Sublist source No. 2
  - etc...
- Back to main list, next Source

- Last Source

Can duplicate this list if you have more than one assessment model

Length-at-age was initially estimated external to the population dynamics models using the von Bertalanffy growth curve (**???**), $L_i = L_\infty e^{(-k[t-t_0])}$, where L_i is the length (cm) at age i, t is age in years, k is rate of increase in growth, t_0 is the intercept, and L_∞ is the asymptotic length.

Aging Precision And Bias

Weight-Length

The weight-length relationship is based on the standard power function: $W = \alpha(L^\beta)$ where W is individual weight (kg), L is length (cm), and α and β are coefficients used as constants.

Maturity And Fecundity

Natural Mortality

Natural mortality for wild fish populations is extremely difficult to estimate.

Sex ratios

2.1.5 Environmental Or Ecosystem Data Included In The Assessment

`environmental-or-ecosystem-data-included-in-the-assessment`

2.2 History Of Modeling Approaches Used For This Stock

`history-of-modeling-approaches-used-for-this-stock`

2.2.1 Previous Assessments

`previous-assessments`

2.2.2 Previous Assessment Recommendations

`previous-assessment-recommendations`

Include: Response to STAR panel recommendations from the most recent previous assessment.

Recommendation 1: blah blah blah.

STAT response: blah blah blah....

Recommendation 2: blah blah blah.

STAT response: blah blah blah....

Recommendation 3: blah blah blah., etc.

STAT response: Continue recommendations as needed

2.3 Model Description

model-description

2.3.1 Transition To The Current Stock Assessment

transition-to-the-current-stock-assessment

Include: Complete description of any new modeling approaches

Below, we describe the most important changes made since the last full assessment and explain rationale for each change.:

1. Change No. 1. *Rationale*: blah blah blah.
2. Change No. 2. *Rationale*: blah blah blah.
3. Change No. 3. *Rationale*: Continue list as needed.

2.3.2 Definition of Fleets and Areas

definition-of-fleets-and-areas

We generated data sources for each of the models. Fleets by model include:

Model Region 1 or remove this line if only one model

Commercial: The commercial fleets include…

Recreational: The recreational fleets include…

Research: Research derived-data include…

2.3.3 Summary of Data for Fleets and Areas

summary-of-data-for-fleets-and-areas

2.3.4 Modeling Software

modeling-software

The STAT team used Stock Synthesis 3 version 3.24u by Dr. Richard Methot at the NWFSC. This most recent version (SS-V3.24u) was used, since it included improvements and corrections to older versions.

2.3.5 Data Weighting

data-weighting

Citation for Francis method (**???**)
Citation for Ianelli-McAllister harmonic mean method (**???**)

2.3.6 Priors

priors

Citation for Hamel prior on natural mortality (Hamel 2015)

2.3.7 General Model Specifications

general-model-specifications

Citation for posterior predictive fecundity relationship from Dick (2009) and (2017)
Model data, control, starter, and forecast files can be found in Appendices A-D.

2.3.8 Estimated And Fixed Parameters

estimated-and-fixed-parameters

A full list of all estimated and fixed parameters is provided in Tables.... Estimated and fixed parameters tables currently read in from .csv file, EXAMPLE: Table **??**

2.4 Model Selection and Evaluation

model-selection-and-evaluation

2.4.1 Key Assumptions and Structural Choices

key-assumptions-and-structural-choices

Include: Evidence of search for balance between model realism and parsimony.
Comparison of key model assumptions, include comparisons based on nested models (e.g., asymptotic vs. domed selectivities, constant vs. time-varying selectivities).

2.4.2 Alternate Models Considered

alternate-models-considered

Include: Summary of alternate model configurations that were tried but rejected.

2.4.3 Convergence

convergence

Include: Randomization run results or other evidence of search for global best estimates.

Convergence testing through use of dispersed starting values often requires extreme values to actually explore new areas of the multivariate likelihood surface. Jitter is a SS option that generates random starting values from a normal distribution logistically transformed into each parameter's range (Methot and Wetzel 2013). Table 14 shows the results of running 100 jitters for each pre-STAR base model....

2.5 Response To The Current STAR Panel Requests

response-to-the-current-star-panel-requests

Request No. 1: Add after STAR panel.

Rationale: Add after STAR panel.

STAT Response: Add after STAR panel.

Request No. 2: Add after STAR panel.

Rationale: Add after STAR panel.

STAT Response: Add after STAR panel.

Request No. 3: Add after STAR panel.

Rationale: Add after STAR panel.

STAT Response: Add after STAR panel.

Request No. 4: Example of a request that may have a list:

- **Item No. 1**
- **Item No. 2**
- **Item No. 3, etc.**

Rationale: Add after STAR panel.

STAT Response: Continue requests as needed.

2.6 Model 1

model-1

2.6.1 Model 1 Base Case Results

model-1-base-case-results

Table **??**

2.6.2 Model 1 Uncertainty and Sensitivity Analyses

model-1-uncertainty-and-sensitivity-analyses

Table 15

2.6.3 Model 1 Retrospective Analysis

model-1-retrospective-analysis

2.6.4 Model 1 Likelihood Profiles

model-1-likelihood-profiles

2.6.5 Model 1 Harvest Control Rules (CPS only)

model-1-harvest-control-rules-cps-only

2.6.6 Model 1 Reference Points (groundfish only)

model-1-reference-points-groundfish-only

Intro sentence or two. . . .(Table 16).

Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$ is 885 mt. Table e shows the full suite of estimated reference points for the northern area model and Figure c shows the equilibrium yield curve.

2.7 Model 2

model-2

2.7.1 Model 2 Base Case Results

model-2-base-case-results

2.7.2 Model 2 Uncertainty and Sensitivity Analyses

model-2-uncertainty-and-sensitivity-analyses

2.7.3 Model 2 Retrospective Analysis

model-2-retrospective-analysis

2.7.4 Model 2 Likelihood Profiles

model-2-likelihood-profiles

2.7.5 Model 2 Harvest Control Rules (CPS only)

model-2-harvest-control-rules-cps-only

2.7.6 Model 2 Reference Points (groundfish only)

model-2-reference-points-groundfish-only

2.8 Model 3

model-3

2.8.1 Model 3 Base Case Results

model-3-base-case-results

2.8.2 Model 3 Uncertainty and Sensitivity Analyses

model-3-uncertainty-and-sensitivity-analyses

2.8.3 Model 3 Retrospective Analysis

model-3-retrospective-analysis

2.8.4 Model 3 Likelihood profiles

model-3-likelihood-profiles

2.8.5 Model 3 Harvest Control Rules (CPS only)

model-3-harvest-control-rules-cps-only

2.8.6 Model 3 Reference Points (groundfish only)

model-3-reference-points-groundfish-only

3 Harvest Projections and Decision Tables

harvest-projections-and-decision-tables

Table f

Model 1 Projections and Decision Table (groundfish only) (Table 17

Table h

Model 2 Projections and Decision Table (groundfish only)

Model 3 Projections and Decision Table (groundfish only)

4 Regional Management Considerations

regional-management-considerations

1. For stocks where current practice is to allocate harvests by management area, a recommended method of allocating harvests based on the distribution of biomass should be provided. The MT advisor should be consulted on the appropriate management areas for each stock.
2. Discuss whether a regional management approach makes sense for the species from a biological perspective.
3. If there are insufficient data to analyze a regional management approach, what are the research and data needs to answer this question?

5 Research Needs

research-needs

1. Research need No. 1
2. Research need No. 2
3. Research need No. 3
4. etc.

6 Acknowledgments

acknowledgments

Include: STAR panel members and affiliations as well as names and affiliations of persons who contributed data, advice or information but were not part of the assessment team. Not required in draft assessment undergoing review.

7 Tables

tables

Table 1: Summary of commercial fishery length samples used in the stock assessment. tab:Comm_Lengths

Year	Trips	Fish	Sample Size
1966	1	238	7
1967	5	1020	35
1968	3	912	21
1969	4	1213	28
1970	13	1830	92
1971	22	4698	155
1972	23	4561	162
1973	17	4134	120
1974	20	4806	141
1975	19	3637	134
1976	21	3677	148
1977	32	4846	226
1978	52	7715	367
1979	34	3414	240
1980	55	5426	388
1981	40	3921	282
1982	48	4824	339
1983	39	3944	275
1984	31	3103	219
1985	45	4509	318
1986	40	4005	282
1987	43	3056	304
1988	9	602	64
1989	16	798	113
1990	12	599	85
1991	8	216	38
1994	43	2608	304
1995	49	3161	346
1996	64	3085	452
1997	76	3570	537
1998	56	3450	395
1999	58	2812	409
2000	49	2004	326
2001	59	1696	293
2002	50	1666	280

Year	Trips	Fish	Sample Size
2003	68	1685	301
2004	53	1202	219
2005	50	1270	225
2006	59	1486	264
2007	81	2248	391
2008	101	3058	523
2009	108	3208	551
2010	131	2829	521
2011	100	1944	368
2012	97	1873	355
2013	117	2168	416
2014	140	2850	533
2015	107	2459	446
2016	92	1271	267

Table 2: Summary of Pacific ocean perch survey length samples used in the stock assessment. tab:Comm_Lengths

Year	Tows	Fish	Sample Size
1979	125	2375	303
1985	126	2558	306

Table 3: Summary of Triennial survey length samples used in the stock assessment. tab:Comm_Lengths

Year	Tows	Fish	Sample Size
1980	18	1315	43
1983	40	2820	97
1986	17	877	41
1989	42	1851	102
1992	33	1182	80
1995	71	1136	172
1998	81	1482	196
2001	74	669	179
2004	63	1240	153

Table 4: Summary of AFSC slope survey length samples used in the stock assessment. tab:Comm_Lengths

Year	Tows	Fish	Sample Size
1996	48	1396	116
1997	21	347	51
1999	21	562	51
2000	19	353	46
2001	23	390	55

Table 5: Summary of NWFSC slope survey length samples used in the stock assessment. tab:Comm_Lengths

Year	Tows	Fish	Sample Size
2001	18	27	43
2002	24	54	58

Table 6: Summary of NWFSC shelf/slope survey length samples used in the stock assessment. tab:Comm_Lengths

Year	Tows	Fish	Sample Size
2003	46	80	111
2004	34	56	82
2005	38	81	92
2006	33	73	80
2007	50	74	121
2008	39	75	94
2009	46	61	111
2010	53	73	128
2011	53	72	128
2012	50	79	121
2013	45	76	109
2014	52	77	126
2015	69	67	167

Table 7: Summary of commercial fishery age samples used in the stock assessment. tab:Comm_Lengths

Year	Trips	Fish	Sample Size
1981	11	1027	78
1982	40	2776	282
1983	33	3320	233
1984	27	2625	191
1985	21	2097	148
1986	17	1696	120
1987	24	1196	169
1988	4	200	28
1994	8	238	41
1999	18	863	127
2000	14	677	99
2001	40	1349	226
2002	38	1414	233
2003	41	1333	225
2004	30	854	148
2005	37	1018	177
2006	49	1259	223
2007	63	1825	315
2008	44	1129	200
2009	76	1549	290
2010	53	1258	227
2011	86	1251	259
2012	7	331	49

Table 8: Summary of Pacific ocean perch survey age samples used in the stock assessment. tab:Comm_Lengths

Year	Tows	Fish	Sample Size
1985	29	1635	70

Table 9: Summary of Triennial survey age samples used in the stock assessment. tab:Comm_Lengths

Year	Tows	Fish	Sample Size
1989	15	577	36
1992	10	373	24
1995	12	275	29
1998	28	352	68
2001	43	342	104
2004	57	416	138

Table 10: Summary of NWFSC slope survey age samples used in the stock assessment. tab:Comm_Lengths

Year	Tows	Fish	Sample Size
2001	17	125	41
2002	24	216	58

Table 11: Summary of NWFSC shelf/slope survey age samples used in the stock assessment. tab:Comm_Lengths

Year	Tows	Fish	Sample Size
2003	45	265	109
2004	34	149	82
2005	38	192	92
2006	33	170	80
2007	50	228	121
2008	39	218	94
2009	45	190	109
2010	53	292	128
2011	53	258	128

Table 12: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
1	NatM_p_1_Fem_GP_1	0.050	-2	(0.02, 0.1)			None
2	L_at_Amin_Fem_GP_1	21.211	-3	(15, 25)			None
3	L_at_Amax_Fem_GP_1	41.983	-2	(35, 45)			None
4	VonBert_K_Fem_GP_1	0.159	-3	(0.1, 0.4)			None
5	CV_young_Fem_GP_1	0.072	-5	(0.03, 0.16)			None
6	CV_old_Fem_GP_1	0.064	-5	(0.03, 0.16)			None
7	Wtlen_1_Fem	0.000	-50	(0, 3)			None
8	Wtlen_2_Fem	3.080	-50	(2, 4)			None
9	Mat50%_Fem	8.000	-50	(2, 12)			None
10	Mat_slope_Fem	-2.000	-50	(-2, 4)			None
11	Eggs_scalar_Fem	1.086	-50	(0, 6)			None
12	Eggs_exp_wt_Fem	1.440	-50	(-3, 3)			None
13	NatM_p_1_Mal_GP_1	0.027	2	(-1, 1)	OK	0.000	Normal (0.05, 0.1)
14	L_at_Amin_Mal_GP_1	0.000	-2	(-1, 1)			None
15	L_at_Amax_Mal_GP_1	-0.059	-2	(-1, 1)			None
16	VonBert_K_Mal_GP_1	0.195	-2	(-1, 1)			None
17	CV_young_Mal_GP_1	0.049	-2	(-1, 1)			None
18	CV_old_Mal_GP_1	-0.189	-2	(-1, 1)			None
19	Wtlen_1_Mal	0.000	-50	(0, 3)			None
20	Wtlen_2_Mal	3.000	-50	(2, 4)			None
24	CohortGrowDev	1.000	-50	(0, 2)			None
25	FracFemale_GP_1	0.500	-99	(0.000001, 0.999999)			None
26	SR_LN(R0)	9.167	1	(5, 20)	OK	0.000	None
27	SR_BH_steep	0.400	-3	(0.2, 1)			None
28	SR_sigmaR	0.700	-6	(0.5, 1.2)			None
29	SR_regime	0.000	-50	(-5, 5)			None

Continued on next page

Table 12: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
30	SR_autocorr	0.000	-50	(0, 2)			None
31	Early_InitAge_12	-0.004	3	(-6, 6)	act	0.000	dev (NA, NA)
32	Early_InitAge_11	-0.005	3	(-6, 6)	act	0.000	dev (NA, NA)
33	Early_InitAge_10	-0.005	3	(-6, 6)	act	0.000	dev (NA, NA)
34	Early_InitAge_9	-0.005	3	(-6, 6)	act	0.000	dev (NA, NA)
35	Early_InitAge_8	-0.005	3	(-6, 6)	act	0.000	dev (NA, NA)
36	Early_InitAge_7	-0.005	3	(-6, 6)	act	0.000	dev (NA, NA)
37	Early_InitAge_6	-0.006	3	(-6, 6)	act	0.000	dev (NA, NA)
38	Early_InitAge_5	-0.006	3	(-6, 6)	act	0.000	dev (NA, NA)
39	Early_InitAge_4	-0.006	3	(-6, 6)	act	0.000	dev (NA, NA)
40	Early_InitAge_3	-0.006	3	(-6, 6)	act	0.000	dev (NA, NA)
41	Early_InitAge_2	-0.006	3	(-6, 6)	act	0.000	dev (NA, NA)
42	Early_InitAge_1	-0.006	3	(-6, 6)	act	0.000	dev (NA, NA)
170	LnQ_base_Fishery(1)	-12.080	-1	(-15, 15)			None
171	LnQ_base_POP(2)	-0.232	-1	(-15, 15)			None
172	LnQ_base_EarlyTriennial(3)	-1.457	-1	(-15, 15)			None
173	LnQ_base_LateTriennial(4)	-1.747	-1	(-15, 15)			None
174	LnQ_base_AFSCSlope(5)	-1.361	-1	(-15, 15)			None
175	LnQ_base_NWFSCSlope(6)	-1.814	-1	(-15, 15)			None
176	LnQ_base_NWFSCcombo(7)	-0.778	-1	(-15, 15)			None
177	SizeSel_P1_Fishery(1)	36.570	2	(20, 45)	OK	0.000	None
178	SizeSel_P2_Fishery(1)	-5.000	-2	(-6, 4)			None
179	SizeSel_P3_Fishery(1)	3.251	3	(-1, 9)	OK	0.000	None
180	SizeSel_P4_Fishery(1)	0.657	3	(-1, 9)	OK	0.000	None
181	SizeSel_P5_Fishery(1)	-2.694	4	(-5, 9)	OK	0.000	None
182	SizeSel_P6_Fishery(1)	0.990	2	(-5, 9)	OK	0.000	None

Continued on next page

Table 12: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD).

No.	Parameter	Value	Phase	Bounds	Status	SD	Prior (Exp.Val, SD)
183	Retain_P1_Fishery(1)	31.015	1	(15, 45)	OK	0.000	None
184	Retain_P2_Fishery(1)	1.969	1	(0.1, 10)	OK	0.000	None
185	Retain_P3_Fishery(1)	0.779	1	(-10, 10)	OK	0.000	None
186	Retain_P4_Fishery(1)	0.000	-3	(0, 0)			None
187	SizeSel_P1_POP(2)	23.130	2	(20, 70)	OK	0.000	None
188	SizeSel_P2_POP(2)	9.463	3	(0.001, 50)	OK	0.000	None
189	SizeSel_P1_EarlyTriennial(3)	20.368	2	(18, 70)	OK	0.000	None
190	SizeSel_P2_EarlyTriennial(3)	5.454	3	(0.001, 50)	OK	0.000	None
191	SizeSel_P1_NWFSCcombo(7)	25.648	2	(20, 70)	OK	0.000	None
192	SizeSel_P2_NWFSCcombo(7)	17.500	3	(0.001, 50)	OK	0.000	None
193	Retain_P3_Fishery(1)_BLK1repl_1940	10.000	-1	(-10, 10)			None
194	Retain_P3_Fishery(1)_BLK1repl_1982	10.000	-1	(-10, 10)			None
195	Retain_P3_Fishery(1)_BLK1repl_1989	3.505	1	(-10, 10)	OK	0.000	None
196	Retain_P3_Fishery(1)_BLK1repl_1995	2.323	1	(-10, 10)	OK	0.000	None
197	Retain_P3_Fishery(1)_BLK1repl_2009	0.003	1	(-10, 10)	OK	0.000	None

tab:model_params

Table 13: Summary of the biomass/abundance time series used in the stock assessment.
tab:Index_summary

Region	ID	Fleet	Years	Name	Fishery ind.	Filtering	Method	Endorsed
WA	1	4	1981-2014	Dockside CPUE	No	trip, area, month, Stephens-MacCall	delta-GLM (bin-gamma)	SSC
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-

Table 14: Results from 100 jitters from each of the three models.

tab:jitter

Status	Model.1	Model.2	Model.3
Returned to base case	-	-	-
Found local minimum	-	-	-
Found better solution	-	-	-
Error in likelihood	-	-	-
Total	100	100	100

Table 16: Time-series of population estimates from the base-case model.

Year	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative exploitation rate	SPR
1892	123686	66128	0.00	9339	0	0.00	1.00
1893	123686	66041	0.00	9279	0	0.00	1.00
1894	123686	65950	0.00	9193	0	0.00	1.00
1895	123687	65841	0.00	9130	0	0.00	1.00
1896	123687	65262	0.00	9109	0	0.00	1.00
1897	123687	64378	0.00	9215	0	0.00	1.00
1898	123687	62072	0.00	9423	0	0.00	1.00
1899	123687	60916	0.00	9929	0	0.00	1.00
1900	123687	60315	0.00	10708	0	0.00	1.00
1901	123687	59504	0.00	11554	0	0.00	1.00
1902	123687	58639	0.00	12371	0	0.00	1.00
1903	123687	58052	0.00	13617	0	0.00	1.00
1904	123687	57411	0.00	15069	0	0.00	1.00
1905	123687	56308	0.00	14230	0	0.00	1.00
1906	123687	55691	0.00	11925	0	0.00	1.00
1907	123687	54777	0.00	9988	0	0.00	1.00
1908	123687	54363	0.00	8721	0	0.00	1.00
1909	123687	53448	0.00	7689	0	0.00	1.00
1910	123687	52974	0.00	6725	0	0.00	1.00
1911	123687	52940	0.00	6411	0	0.00	1.00
1912	123687	53368	0.00	7917	0	0.00	1.00
1913	123687	53212	0.00	12969	0	0.00	1.00
1914	123687	52417	0.00	10720	0	0.00	1.00
1915	123687	50961	0.00	6890	0	0.00	1.00
1916	123683	48630	0.00	5870	0	0.00	1.00
1917	123681	46010	0.00	5162	0	0.00	1.00
1918	123679	42622	0.00	3956	0	0.00	1.00
1919	123682	32825	0.00	3303	0	0.00	1.00
1920	123683	25585	0.00	3653	0	0.00	1.00
1921	123683	21380	0.00	5644	0	0.00	1.00
1922	123683	21168	0.00	10235	0	0.00	1.00
1923	123682	20464	0.00	4799	0	0.00	1.00
1924	123681	19831	0.00	2544	0	0.00	1.00
1925	123680	19133	0.00	1940	0	0.00	1.00
1926	123678	18047	0.00	2437	0	0.00	1.00
1927	123678	17330	0.00	3035	0	0.00	1.00
1928	123678	17365	0.00	2521	0	0.00	1.00
1929	123638	17273	0.00	3195	2	0.00	1.00
1930	123637	17439	0.00	3491	2	0.00	1.00

Table 16: Time-series of population estimates from the base-case model.

Year	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative exploitation rate	SPR
1931	123636	16885	0.00	4103	2	0.00	1.00
1932	123648	16410	0.00	3294	2	0.00	1.00
1933	123419	15722	0.00	6858	12	0.00	1.00
1934	123336	15126	0.00	2675	15	0.00	1.00
1935	123530	14808	0.00	3007	7	0.00	1.00
1936	123473	14251	0.00	4367	9	0.00	1.00
1937	123354	13693	0.00	4686	14	0.00	1.00
1938	122830	13224	0.99	1873	37	0.00	0.99
1939	122140	12792	0.98	3220	67	0.00	0.99
1940	122005	12525	0.98	3696	73	0.00	0.98
1941	121733	12088	0.98	4468	85	0.00	0.98
1942	120878	11604	0.98	3815	123	0.00	0.97
1943	104097	11340	0.98	4336	979	0.01	0.82
1944	94916	10898	0.97	997	1551	0.01	0.73
1945	67128	10429	0.96	1788	4134	0.04	0.48
1946	85770	10105	0.92	4383	2132	0.02	0.65
1947	99265	9902	0.91	3031	1179	0.01	0.77
1948	92655	9812	0.90	1454	1582	0.01	0.71
1949	90399	9762	0.88	1513	1714	0.02	0.69
1950	97068	9754	0.87	2609	1267	0.01	0.75
1951	94004	9678	0.86	6731	1443	0.01	0.73
1952	80504	9675	0.85	7296	2398	0.02	0.60
1953	89354	9913	0.84	3248	1703	0.02	0.68
1954	78940	10092	0.83	2076	2467	0.02	0.59
1955	86788	10334	0.81	837	1841	0.02	0.66
1956	71658	10631	0.81	3027	3087	0.03	0.52
1957	76462	11018	0.79	2079	2610	0.03	0.56
1958	83855	11547	0.79	1285	2018	0.02	0.63
1959	97060	12146	0.79	1184	1187	0.01	0.75
1960	83516	12648	0.79	10654	2084	0.02	0.63
1961	73301	12994	0.79	2373	2951	0.03	0.54
1962	64570	13132	0.78	3035	3842	0.04	0.46
1963	53866	13211	0.76	3048	5221	0.05	0.36
1964	49813	13347	0.72	3299	5657	0.06	0.33
1965	40847	13684	0.68	3611	7210	0.08	0.25
1966	18483	14133	0.63	3972	19195	0.23	0.07
1967	18438	14644	0.49	4078	14711	0.23	0.07
1968	21721	15081	0.38	4166	9239	0.18	0.10
1969	60208	15448	0.32	4240	1769	0.04	0.42

Table 16: Time-series of population estimates from the base-case model.

Year	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative exploitation rate	SPR
1970	50341	66128	0.31	9339	2416	0.06	0.33
1971	55385	66041	0.30	9279	2011	0.05	0.37
1972	55051	65950	0.29	9193	1990	0.05	0.37
1973	43762	65841	0.28	9130	2793	0.07	0.27
1974	46533	65262	0.27	9109	2402	0.07	0.30
1975	65826	64378	0.26	9215	1247	0.04	0.47
1976	58186	62072	0.26	9423	1581	0.05	0.40
1977	75581	60916	0.26	9929	906	0.03	0.56
1978	52715	60315	0.26	10708	1883	0.06	0.35
1979	62021	59504	0.25	11554	1363	0.04	0.43
1980	56230	58639	0.24	12371	1590	0.05	0.38
1981	57288	58052	0.23	13617	1474	0.05	0.39
1982	63975	57411	0.22	15069	1148	0.04	0.45
1983	50032	56308	0.22	14230	1727	0.06	0.33
1984	48259	55691	0.21	11925	1742	0.06	0.31
1985	49300	54777	0.20	9988	1608	0.06	0.32
1986	49661	54363	0.20	8721	1536	0.06	0.32
1987	54837	53448	0.19	7689	1270	0.05	0.37
1988	47209	52974	0.19	6725	1605	0.06	0.30
1989	44502	52940	0.18	6411	1711	0.07	0.28
1990	52947	53368	0.17	7917	1256	0.05	0.35
1991	44836	53212	0.17	12969	1615	0.07	0.28
1992	42655	52417	0.16	10720	1683	0.08	0.26
1993	45846	50961	0.16	6890	1449	0.07	0.29
1994	49772	48630	0.15	5870	1235	0.06	0.33
1995	52587	46010	0.15	5162	1110	0.05	0.35
1996	55340	42622	0.15	3956	1011	0.05	0.37
1997	61400	32825	0.15	3303	836	0.04	0.43
1998	60577	25585	0.14	3653	858	0.04	0.42
1999	68701	21380	0.14	5644	661	0.03	0.49
2000	103031	21168	0.14	10235	171	0.01	0.81
2001	90570	20464	0.15	4799	317	0.02	0.69
2002	103064	19831	0.15	2544	178	0.01	0.81
2003	105315	19133	0.15	1940	158	0.01	0.83
2004	106674	18047	0.16	2437	148	0.01	0.84
2005	114601	17330	0.16	3035	77	0.00	0.92
2006	114018	17365	0.17	2521	86	0.00	0.91
2007	107724	17273	0.18	3195	158	0.01	0.85
2008	109480	17439	0.19	3491	144	0.01	0.87

Table 16: Time-series of population estimates from the base-case model.

Year	Total biomass (mt)	Spawning biomass (mt)	Depletion	Age-0 recruits	Total catch (mt)	Relative exploitation rate	SPR
2009	104702	16885	0.19	4103	207	0.01	0.82
2010	109247	16410	0.20	3294	153	0.01	0.87
2011	114575	15722	0.20	6858	93	0.00	0.92
2012	114878	15126	0.20	2675	90	0.00	0.92
2013	115184	14808	0.20	3007	88	0.00	0.92
2014	116957	14251	0.21	4367	70	0.00	0.94
2015	115075	13693	0.22	4686	93	0.00	0.92
2016	115712	13224	0.22	1873	89	0.00	0.93
2017	123687	12792	0.23	3220			

tab:Timeseries_mod1

Table 15: Sensitivity of the base model to dropping or down-weighting data sources and alternative assumptions about growth.

tab:Sensitivity_model1

Label	Base (Francis weights)	Harmonic mean weights	Drop index	Drop ages	Down-weight lengths	Free size Age0	Free CV Amin	External growth
TOTAL_like	-	-	-	-	-	-	-	-
Catch_like	-	-	-	-	-	-	-	-
Equil_catch_like	-	-	-	-	-	-	-	-
Survey_like	-	-	-	-	-	-	-	-
Length_comp_like	-	-	-	-	-	-	-	-
Age_comp_like	-	-	-	-	-	-	-	-
Parm_priors_like	-	-	-	-	-	-	-	-
SSB_Unfished_thousand_mt	-	-	-	-	-	-	-	-
TotBio_Unfished	-	-	-	-	-	-	-	-
SmryBio_Unfished	-	-	-	-	-	-	-	-
Recr_Unfished_billions	-	-	-	-	-	-	-	-
SSB_Btgt_thousand_mt	-	-	-	-	-	-	-	-
SPR_Btgt	-	-	-	-	-	-	-	-
Fstd_Btgt	-	-	-	-	-	-	-	-
TotYield_Btgt_thousand_mt	-	-	-	-	-	-	-	-
SSB_SPRtgt_thousand_mt	-	-	-	-	-	-	-	-
Fstd_SPRtgt	-	-	-	-	-	-	-	-
TotYield_SPRtgt_thousand_mt	-	-	-	-	-	-	-	-
SSB_MSY_thousand_mt	-	-	-	-	-	-	-	-
SPR_MSY	-	-	-	-	-	-	-	-
Fstd_MSY	-	-	-	-	-	-	-	-
TotYield_MSY_thousand_mt	-	-	-	-	-	-	-	-
RetYield_MSY	-	-	-	-	-	-	-	-
Bratio_2015	-	-	-	-	-	-	-	-
F_2015	-	-	-	-	-	-	-	-
SPRratio_2015	-	-	-	-	-	-	-	-
Recr_2015	-	-	-	-	-	-	-	-
Recr_Virgin_billions	-	-	-	-	-	-	-	-
L_at_Amin_Fem_GP_1	-	-	-	-	-	-	-	-
L_at_Amax_Fem_GP_1	-	-	-	-	-	-	-	-
VonBert_K_Fem_GP_1	-	-	-	-	-	-	-	-
CV_young_Fem_GP_1	-	-	-	-	-	-	-	-
CV_old_Fem_GP_1	-	-	-	-	-	-	-	-

Table 17: Projection of potential OFL, spawning biomass, and depletion for the base case model.

tab:Forecast_mod1

Year	OFL contriubtion (mt)	ACL landings (mt)	Age 5+ biomass (mt)	Spawning Biomass (mt)	Depletion
2017	989.34		30433.80	15448.20	0.23

8 Figures

figures

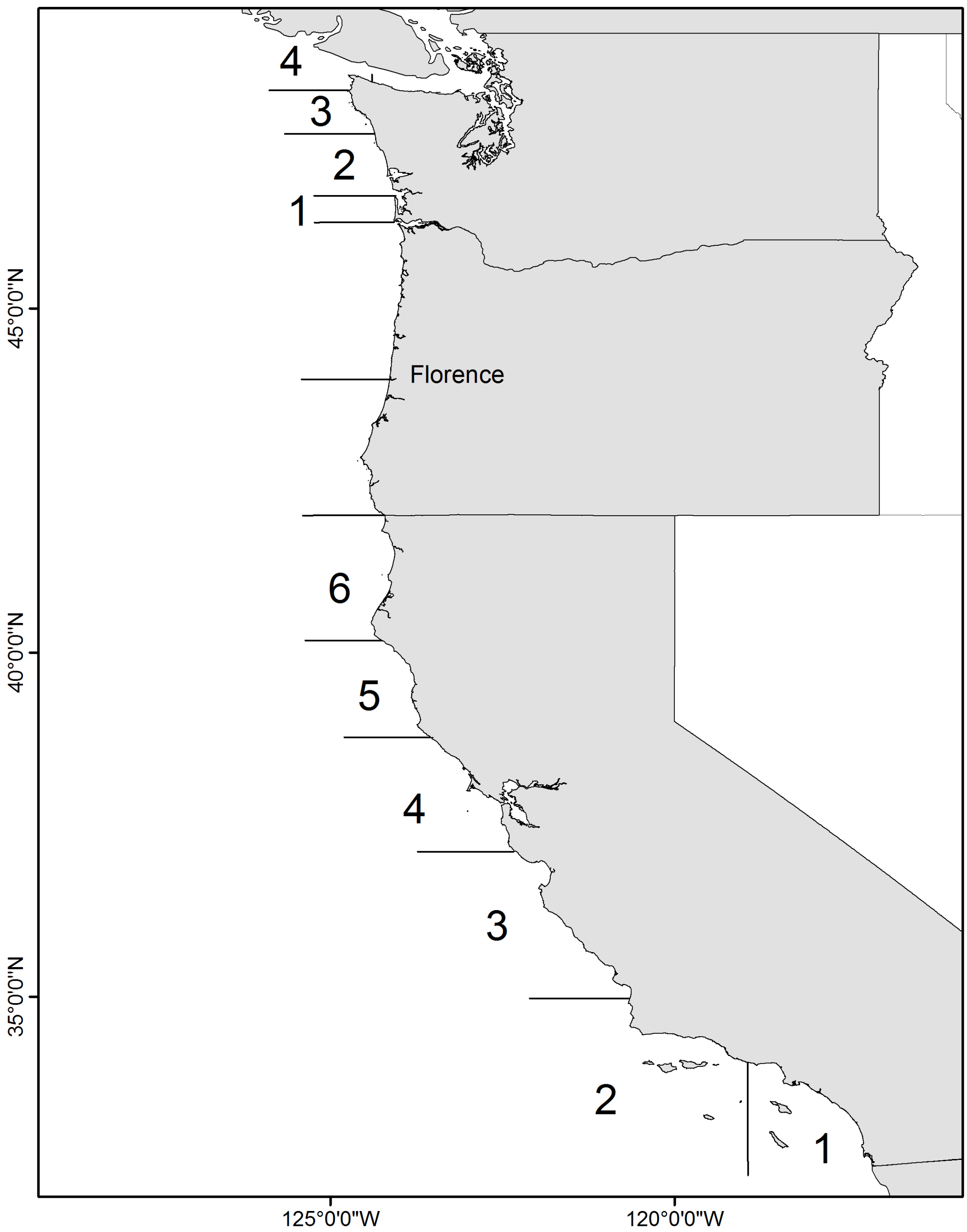

Figure 1: Map showing the state boundary lines for management of the recreational fishing fleets. CRFS Districts 1-6 in California are presented as well as the WDFW Recreational Management Areas in Washington. Florence, OR is shown as a potential location of model stratification. fig:boundary_map

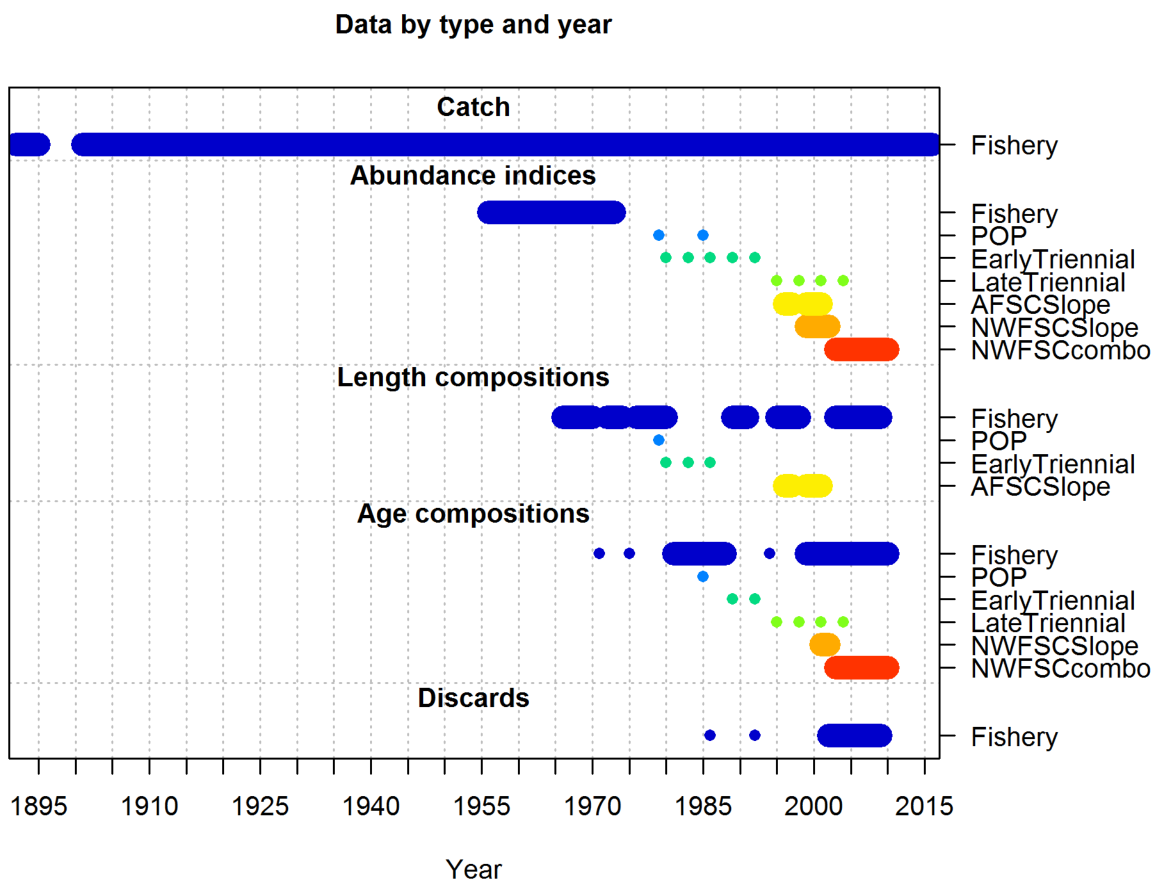

Figure 2: Summary of data sources used in the Base model. fig:data_plot

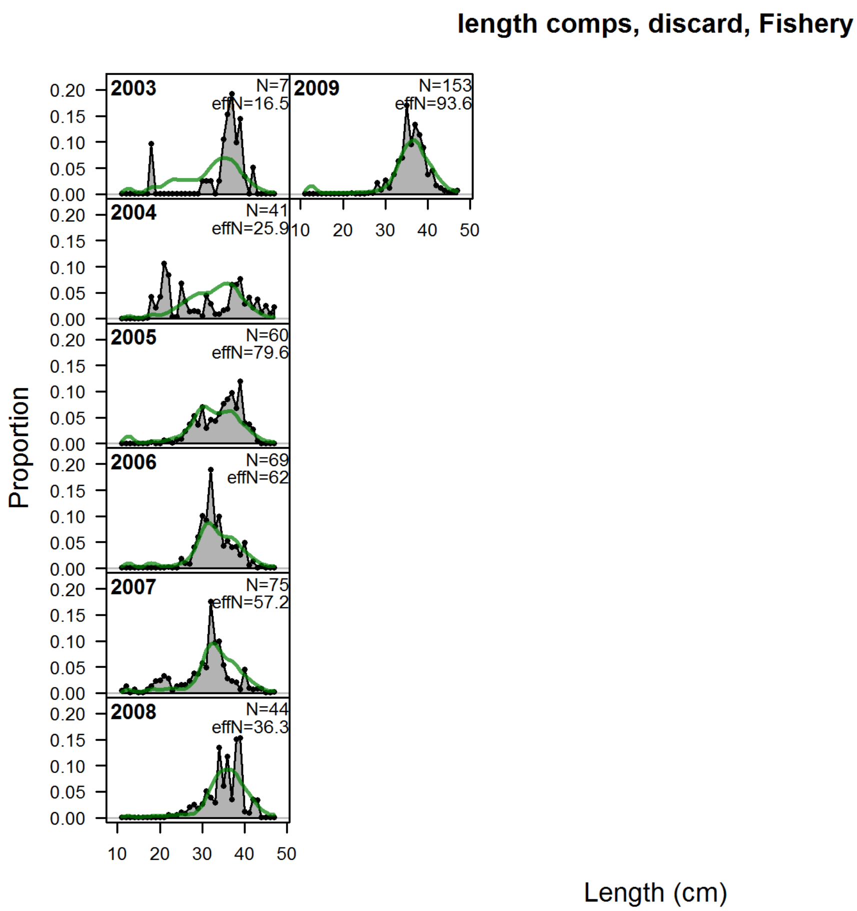

Figure 3: length comps, discard, Fishery fig:mod1_1_comp_lenfit_flt1mkt1

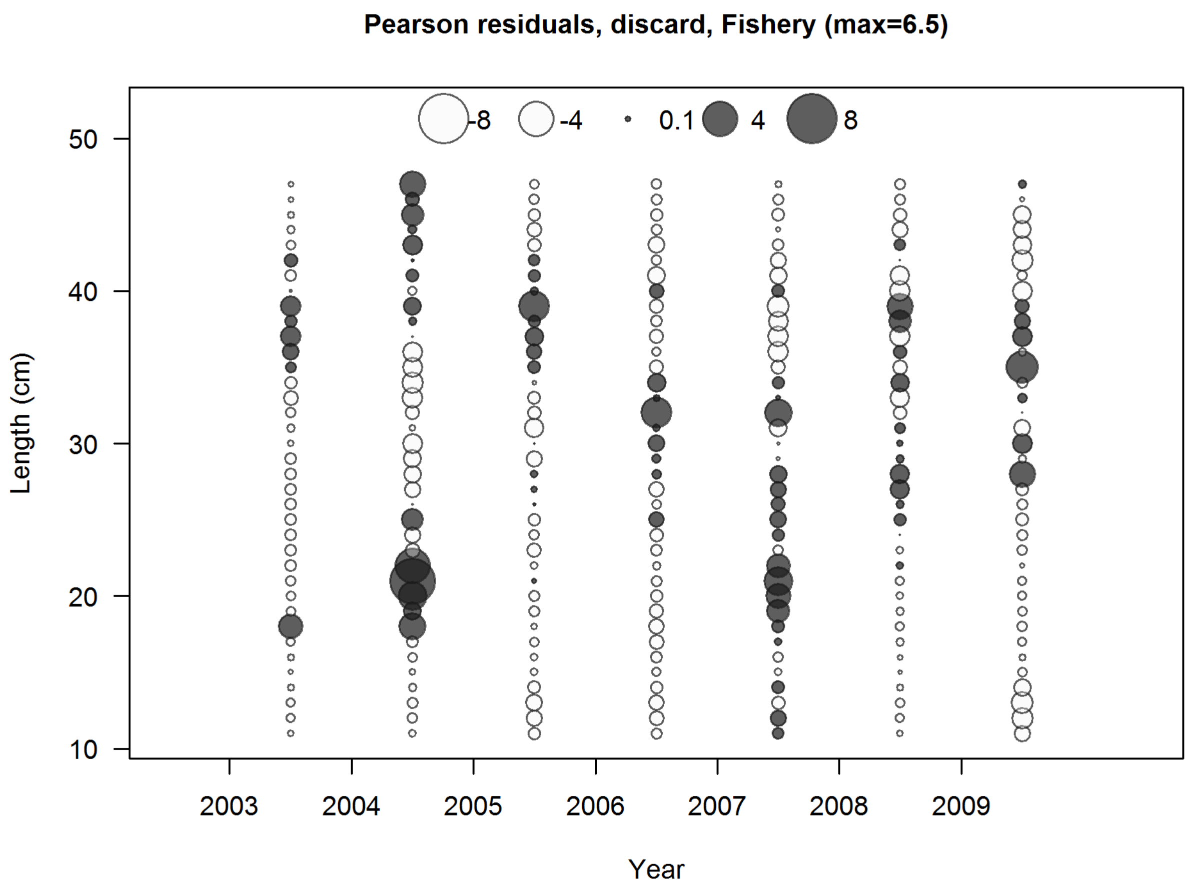

Figure 4: Pearson residuals, discard, Fishery (max=6.5)
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_2_comp_lenfit_residsflt1mkt1

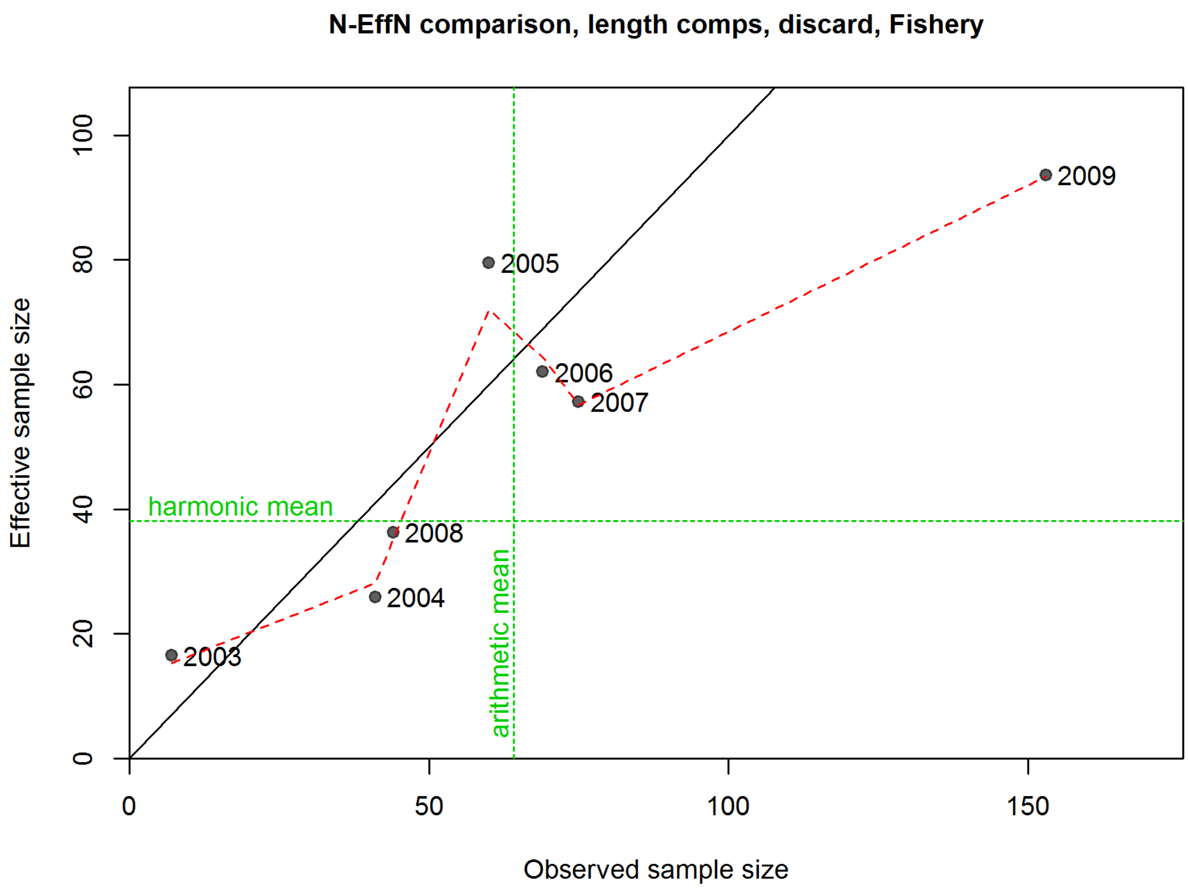

Figure 5: N_EffN comparison, length comps, discard, Fishery fig:mod1_3_comp_lenfit_sam

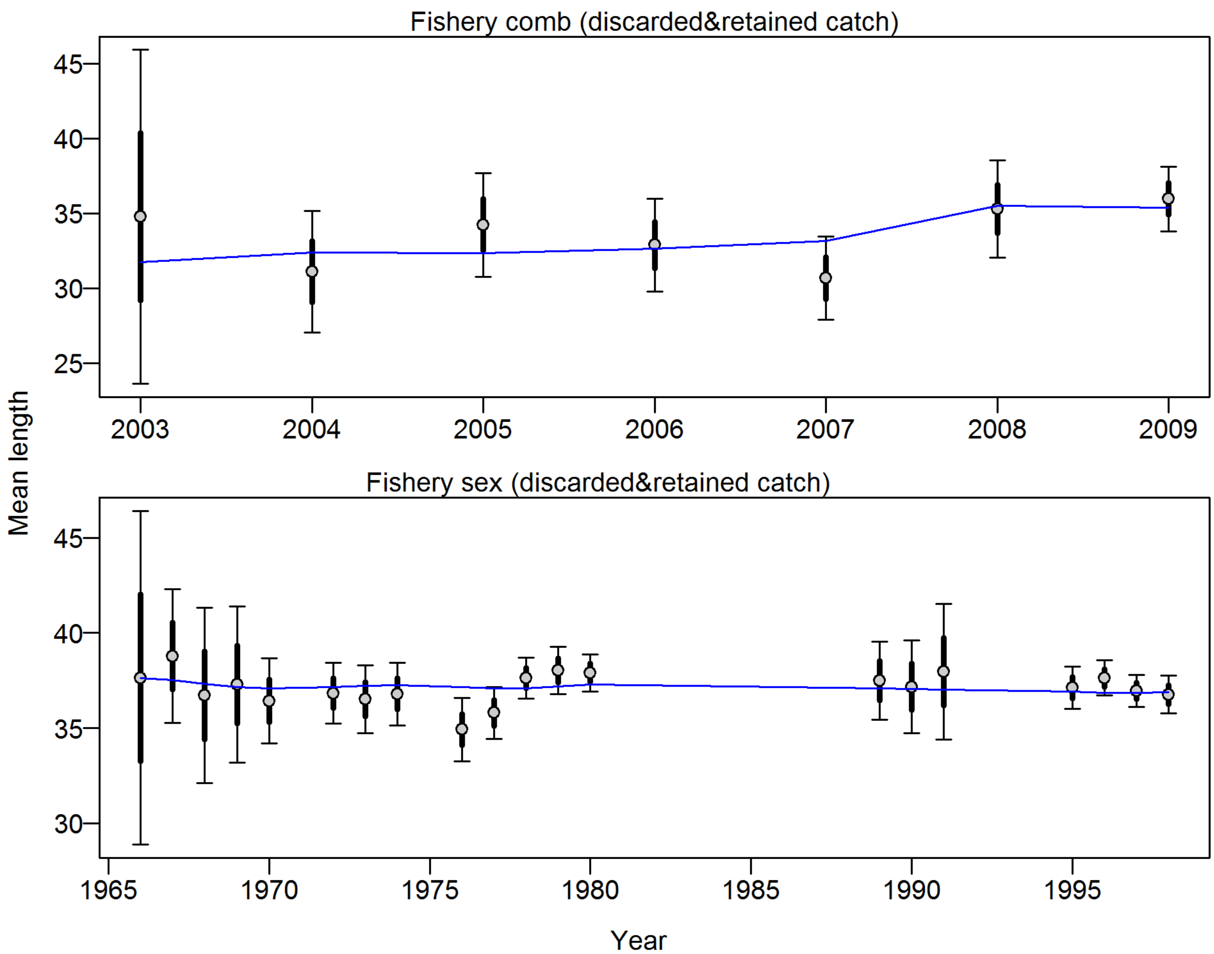

Figure 6: Francis data weighting method TA1.8 Fishery Suggested sample size adjustment (with 95% interval) for len data from Fishery: 0.2517 (0.1529_0.5741) fig:mod1_4_comp_lenfit_data_weig

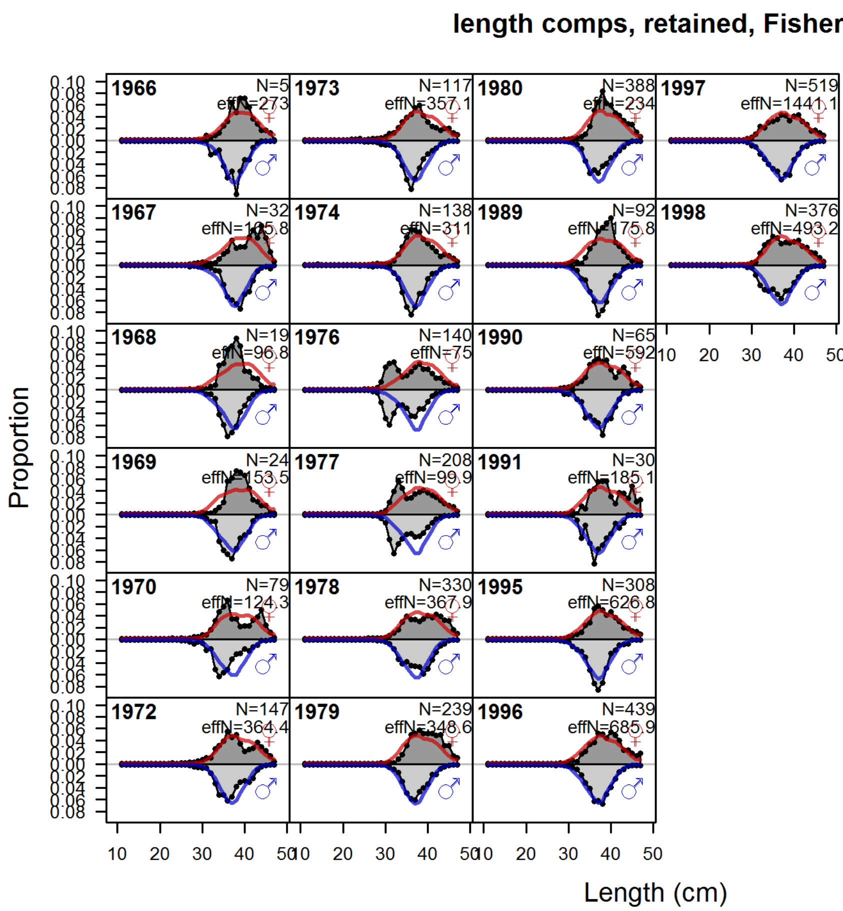

Figure 7: length comps, retained, Fishery fig:mod1_5_comp_lenfit_flt1mkt2

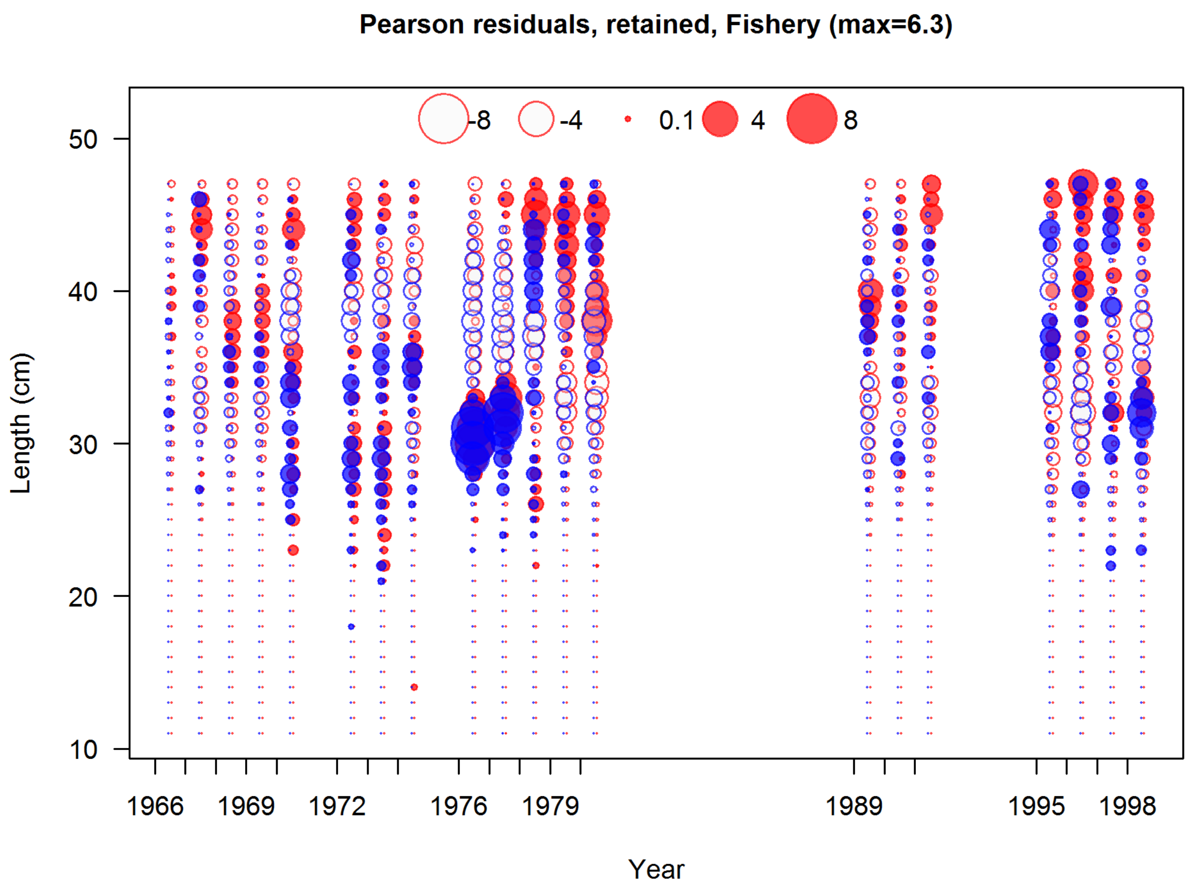

Figure 8: Pearson residuals, retained, Fishery (max=6.3)
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_6_comp_lenfit_residsflt1mkt2

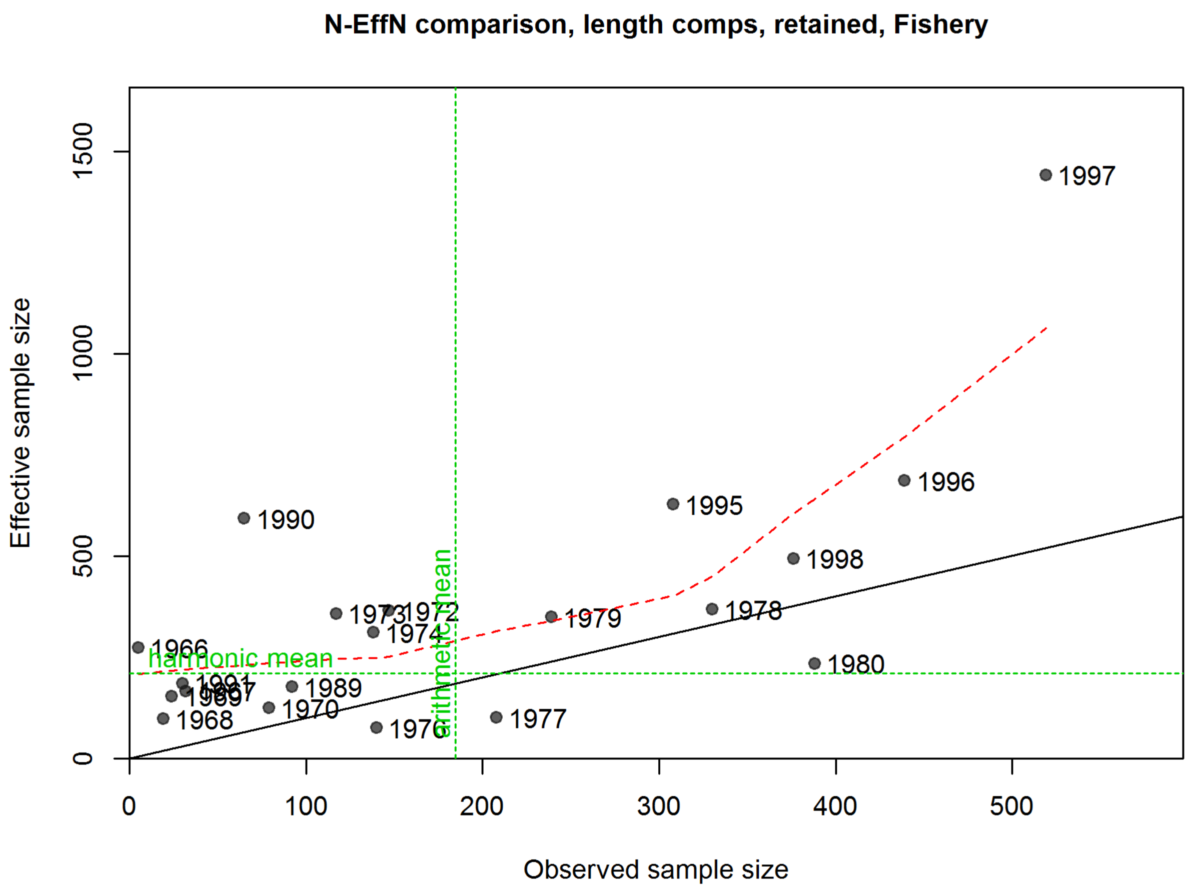

Figure 9: N_EffN comparison, length comps, retained, Fishery [fig:mod1_7_comp_lenfit_sa

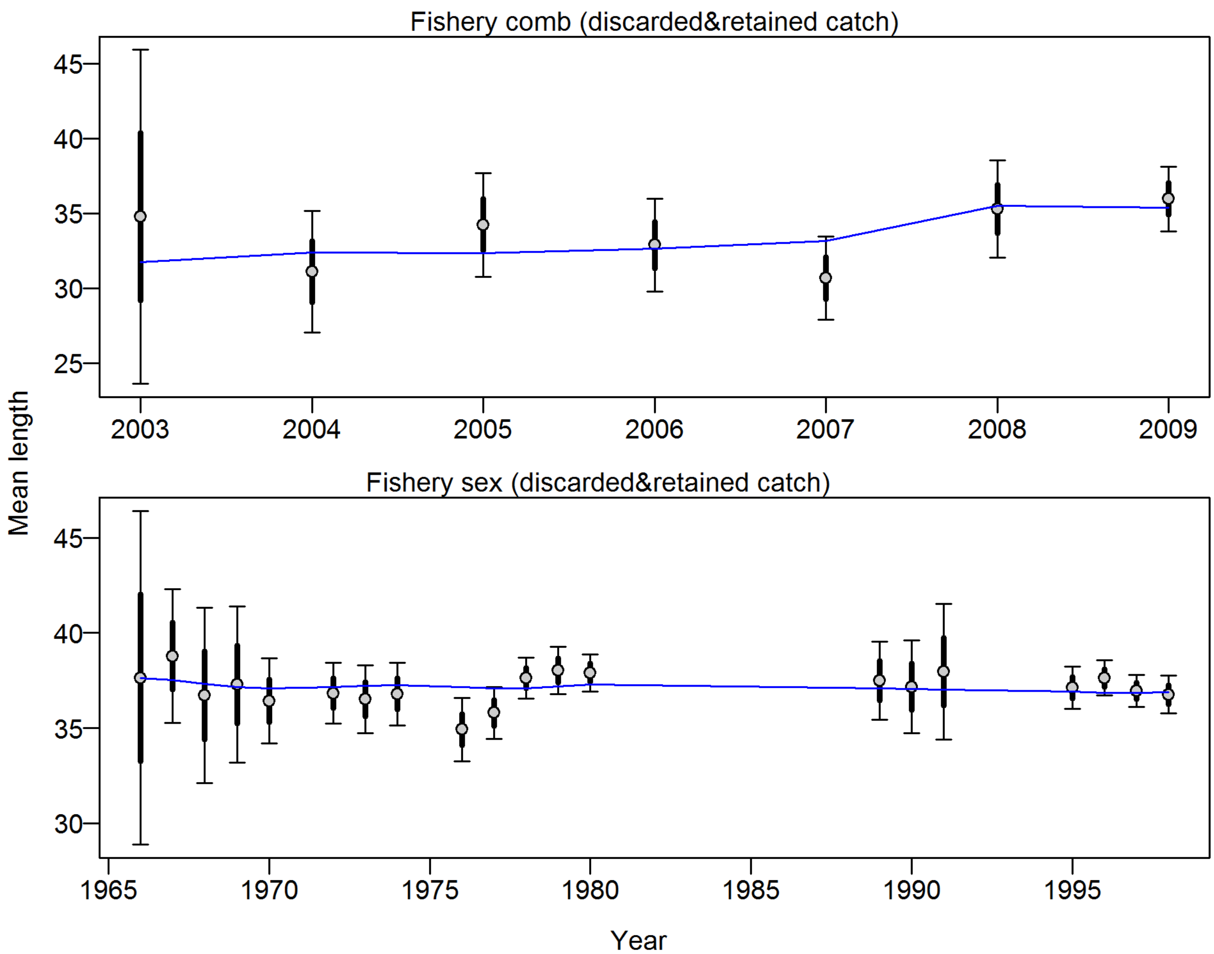

Figure 10: Francis data weighting method TA1.8 Fishery Suggested sample size adjustment (with 95% interval) for len data from Fishery: 0.2517 (0.1519_0.5947) fig:mod1_8_comp_lenfit_data_weig

length comps, whole catch, POP

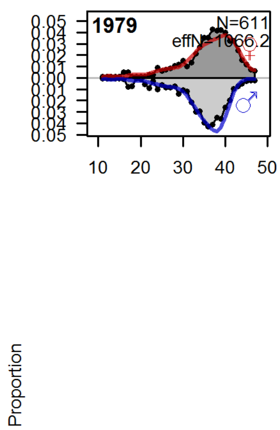

Figure 11: length comps, whole catch, POP fig:mod1_9_comp_lenfit_flt2mkt0

Figure 12: Pearson residuals, whole catch, POP (max=3.28)
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_10_comp_lenfit_residsflt2mkt0

¡!– ***********MODEL 2 REFERENCE POINTS FIGURES – IF NEEDED ************ −¿

References

references

Bradburn, M., Keller, A., and Horness, B. 2011. The 2003 to 2008 US West Coast bottom trawl surveys of groundfish resources off Washington, Oregon, and California: Estimates of distribution, abundance, length, and age composition. US Department of Commerce, National Oceanic; Atmospheric Administration, National Marine Fisheries Service.

Dick, E., Beyer, S., Mangel, M., and Ralston, S. 2017. A meta-analysis of fecundity in rockfishes (genus *Sebastes*). Fisheries Research **187**: 73–85. doi: 10.1016/j.fishres.2016.11.009.

Dick, E.J. 2009. Modeling the Reproductive Potential of Rockfishes (*Sebastes* Spp.). ProQuest. Available from http://books.google.com/books?hl=en&lr=&id=0d6-3rhfynkC&oi=fnd&pg=PR7&dq=%22Synthesis+of+findings+regarding+the+reproductive%22+%22C:+Linear+interpolation+algorithms%22+%22for+yellowtail+rockfish+(S.+flavidus)%22+%22greater+than+zero,+based+on+the+2-level+relative+fecundity%22+%22A:+Methods+for+data+recovery+from+published%22+&ots=NR0UylgymD&sig=58IaN_a3pJeYTPYVmJ1NYMABmvE [accessed 27 February 2017].

Gunderson, D.R. 1977. Population biology of Pacific ocean perch, *Sebastes alutus*, stocks in the WashingtonQueen Charlotte Sound region and their response to fishing. Fishery Bulletin **75**: 369–403. Available from http://fishbull.noaa.gov/75-2/gunderson.pdf [accessed 27 February 2017].

Gunderson, D.R. 1978. Results of cohort analysis for Pacific ocean perch stocks off British Columbia, Washington, and Oregon and an evaluation of alternative rebuilding strategies for these stocks. Pacific Fishery Management Council, 7700 Ambassador Place NE, Suite 200, Portland, OR 97220.

Gunderson, D.R., and Sample, T.M. 1980. Distribution and abundance of rockfish off Washington, Oregon and California during 1977. Northwest; Alaska Fisheries Center, National Marine Fisheries Service. Available from http://spo.nmfs.noaa.gov/mfr423-4/mfr423-42.pdf [accessed 28 February 2017].

Gunderson, D.R., Westrheim, S., Demory, R., and Fraidenburg, M. 1977. The status of Pacific ocean perch (*Sebastes alutus*) stocks off British Columbia, Washington, and Oregon in 1974.

Hamel, O.S. 2015. A method for calculating a meta-analytical prior for the natural mortality rate using multiple life history correlates. ICES Journal of Marine Science: Journal du Conseil **72**(1): 62–69. doi: 10.1093/icesjms/fsu131.

Karnowski, M., Gertseva, V., and Stephens, A. 2014. Historical Reconstruction of Oregon's Commercial Fisheries Landings. Oregon Department of Fish; Wildlife, Salem, OR.

Methot, R.D., and Wetzel, C.R. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fisheries Research **142**: 86–99. doi: 10.1016/j.fishres.2012.10.012.

Pikitch, E.K., Erickson, D.L., and Wallace, J.R. 1988. An evaluation of the effectiveness of trip limits as a management tool. Northwest; Alaska Fisheries Center, National Marine Fisheries Service NWAFC Processed Report. Available from https://www.afsc.noaa.gov/Publications/ProcRpt/PR1988-27.pdf [accessed 28 February 2017].

Ralston, S., Pearson, D.E., Field, J.C., and Key, M. 2010. Documentation of the California catch reconstruction project. US Department of Commerce, National Oceanic; Atmospheric Adminstration, National Marine.

Rogers, J. 2003. Species allocation of *Sebastes* and *Sebastolobus* species caught by foreign countries off Washington, Oregon, and California, U.S.A. in 1965-1976. Unpublished document.

Rogers, J.B., and Pikitch, E.K. 1992. Numerical definition of groundfish assemblages caught off the coasts of Oregon and Washington using commercial fishing strategies. Canadian Journal of Fisheries and Aquatic Sciences **49**(12): 2648–2656. Available from http://www.nrcresearchpress.com/doi/abs/10.1139/f92-293 [accessed 9 March 2017].

Seeb, L.W., and Gunderson, D.R. 1988. Genetic variation and population structure of Pacific ocean perch (*Sebastes alutus*). Canadian Journal of Fisheries and Aquatic Sciences **45**(1): 78–88. Available from http://www.nrcresearchpress.com/doi/abs/10.1139/f88-010 [accessed 28 February 2017].

Weinberg, J.R., Rago, P.J., Wakefield, W.W., and Keith, C. 2002. Estimation of tow distance and spatial heterogeneity using data from inclinometer sensors: An example using a clam survey dredge. Fisheries Research **55**(1–3): 49–61. doi: 10.1016/S0165-7836(01)00292-2.

Wilkins, M., and Golden, J. 1983. Condition of the Pacific ocean perch resource off Washington and Oregon during 1979: Results of a cooperative trawl survey. North American Journal of Fisheries Management **3**: 103–122.

Withler, R., Beacham, T., Schulze, A., Richards, L., and Miller, K. 2001. Co-existing populations of Pacific ocean perch, Sebastes alutus , in Queen Charlotte Sound, British Columbia. Marine Biology **139**(1): 1–12. doi: 10.1007/s002270100560.

Zimmermann, M., Wilkins, M., Weinberg, K., Lauth, R., and Shaw, F. 2003. Influence of improved performance monitoring on the consistency of a bottom trawl survey. ICES Journal of Marine Science **60**(4): 818–826. doi: 10.1016/S1054-3139(03)00043-2.