Status of Yellowtail Rockfish (*Sebastes flavidus*) Along the U.S. Pacific Coast in 2017

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Contents

Executive Summary

executive-summary

Stock

stock

This assessment reports the status of the Yellowtail Rockfish (*Sebastes flavidus*) resource in U.S. waters off the coast of the California, Oregon, and Washington using data through 2016.

The Pacific Fishery Management Council (PFMC) manages the U.S. fishery as two stocks separated at Cape Mendocino, California (40° 10'N). This assessment analyzes those two areas as independent stocks, with the southern stock extending southward to the U.S./Mexico border and the northern stock extending northward to the U.S./Canada border.

The previous assessment (Wallace and Lai 2005), following the pattern of prior assessments, included only the Northern stock which it divided into three assessment areas with divisions at Cape Elizabeth (47° 20'N) and Cape Falcon (45° 46'N). However, a more recent genetic analysis (Hess et al. n.d.) found distinct stocks north and south of Cape Mendocino but did not find stock differences within the northern area, with the genetic stock extending northward through British Colombia, Canada to Southeast Alaska. However, Canada and Alaska are not included in this assessment. Since the previous assessment, reconstruction of historical catch by Washington and Oregon makes any border but the state line incompatible with the data. Additionally, much of the groundfish catch landed in northern Oregon is caught in Washington waters.

Catches

catches

Catches from the Northern stock were divided into four categories: commercial catch, bycatch in the at-sea hake fishery, recreational catch in Oregon and California (north of 40° 10'N), and recreational catch in Washington. The first three of these fleets were entered in metric tons, but the recreational catch from Washington was entered in the model as numbers of fish with the average weight calculated internally in the model.

Catches from the Southern stock were divided into two categories: commercial and recreational catch, both of which were entered as metric tons.

Include: trends and current levels-include table for last ten years and graph with long term data

Catch figures: (Figures a-b)
Catch tables: (Tables a-b)

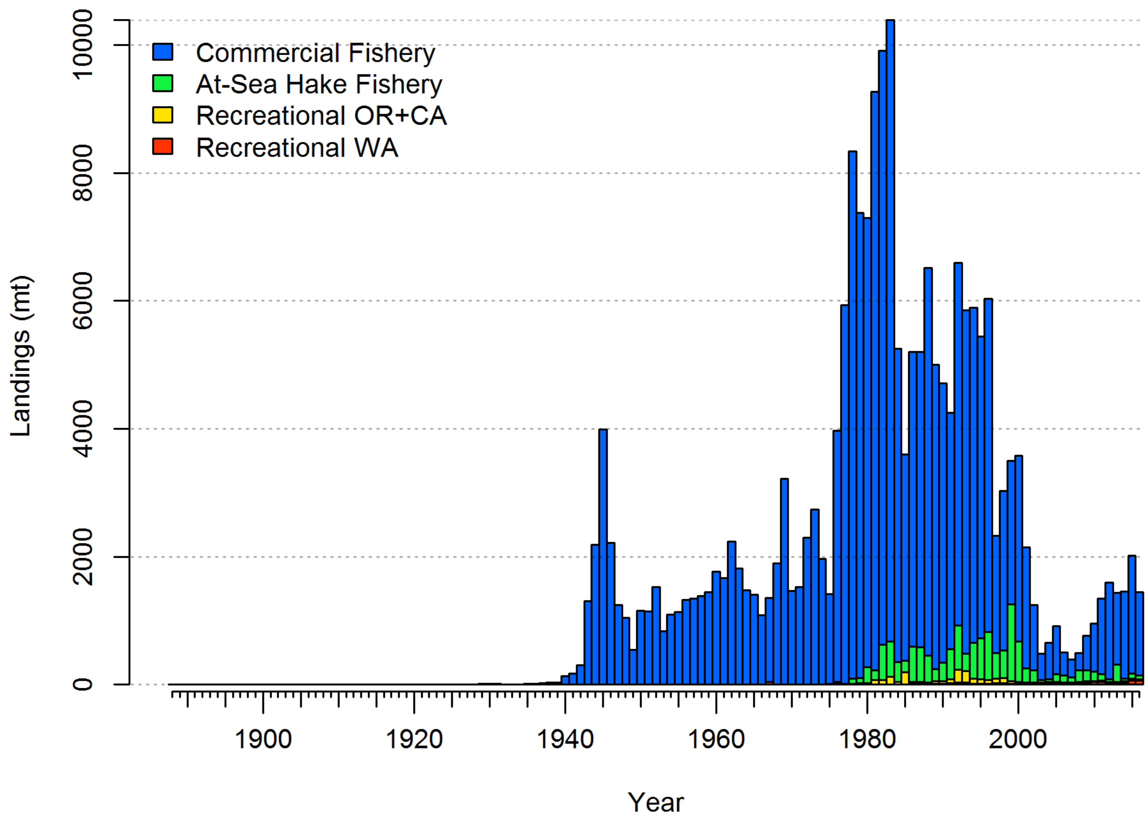

Figure a: Estimated catch history of Yellowtail Rockfish in the Northern model. Recreational catches in Washington are model estimates of total weigth converted from input catch in numbers using model estimates of growth and selectivity. fig:r4ss_catch_N

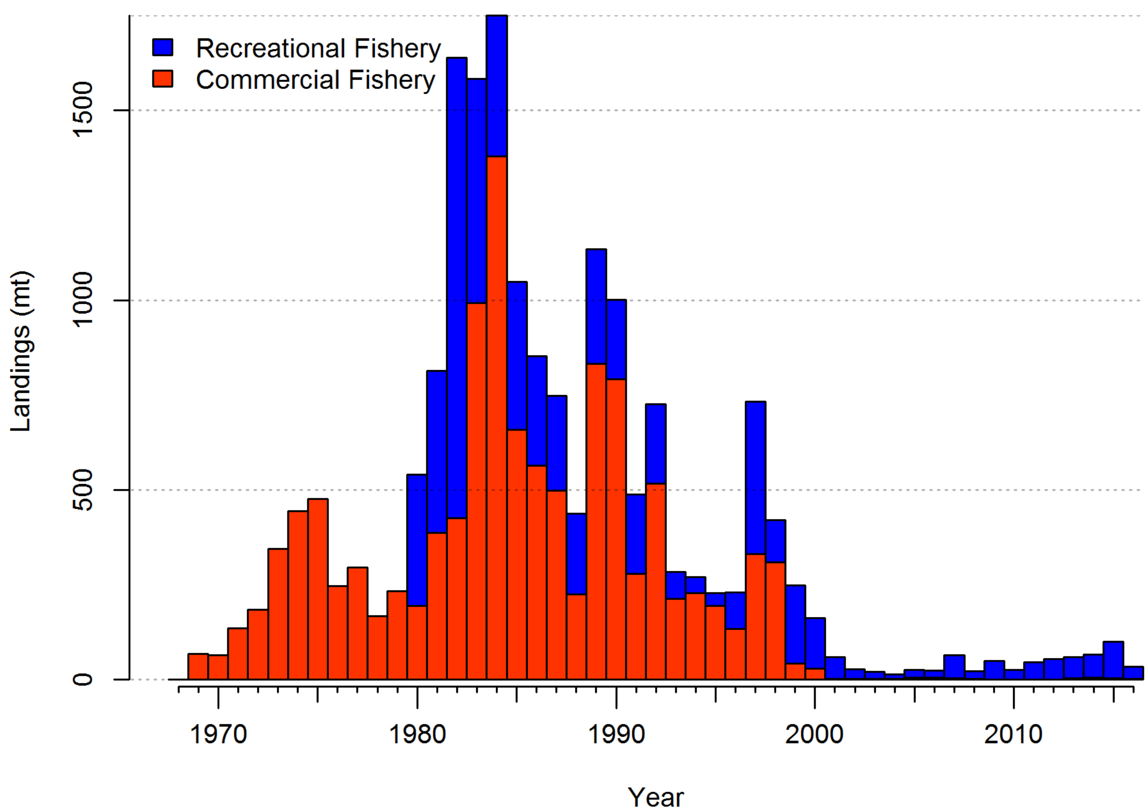

Figure b: Estimated catch history of Yellowtail Rockfish in the Southern model. fig:r4ss_catch_S

Table a: Recent Yellowtail Rockfish catch by fleet for the Northern stock (north of 40° 10'N). tab:Exec_catch_N

Year	Commercial (t)	At-sea hake bycatch (t)	Recreational OR+CA (t)	Recreational WA (1000s)
2007	-	-	-	-
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	-	-	-	-
2014	-	-	-	-
2015	-	-	-	-
2016	-	-	-	-

Table b: Recent Yellowtail Rockfish catch by fleet for the Southern stock (south of 40° 10'N). tab:Exec_catch_S

Year	Recreational (t)	Commercial (t)
2007	-	-
2008	-	-
2009	-	-
2010	-	-
2011	-	-
2012	-	-
2013	-	-
2014	-	-
2015	-	-
2016	-	-

Data and Assessment

data-and-assessment

Include: date of last assessment, type of assessment model, data available, new information, and information lacking.

Yellowtail Rockfish was assessed.... This assessment uses the newest version of Stock Synthesis (3.xxx). The model begins in 1889, and assumes the stock was at an unfished equilibrium that year.

Map of assessment region: (Figure c).

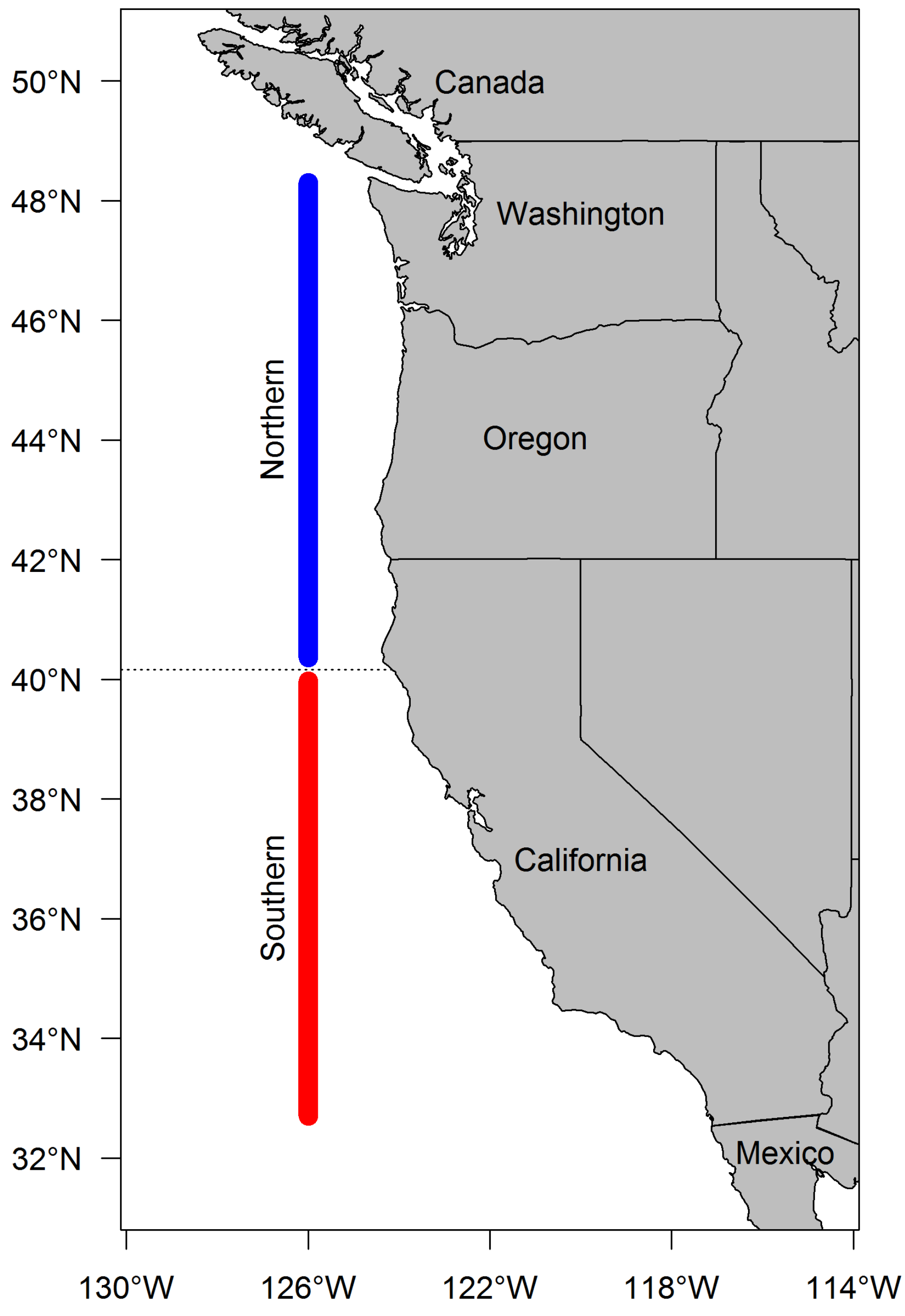

Figure c: Map depicting the boundaries for the base-case model. fig:assess_region_map

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 d
Spawning output Table(s): Table c
Relative depletion Figure: Figure e

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 2016 is 53% (~95% asymptotic interval: ± 41.3%-64.8%) (Figure e).

The estimated relative depletion level of model 2 in 2016 is 92.2% (~95% asymptotic interval: ± 72.1%-112%) (Figure e).

The estimated relative depletion level of model 3 in 2016 is (~95% asymptotic interval: ±) (Figure e).

Table c: Recent trend in beginning of the year spawning output and depletion for the Northern model for Yellowtail Rockfish.

tab:SpawningDeplete_mod1

Year	Spawning Output (trillion eggs)	~ 95% confidence interval	Estimated depletion	~ 95% confidence interval
2008	7.307	(5.31-9.3)	0.497	(0.368-0.627)
2009	7.713	(5.65-9.78)	0.525	(0.394-0.656)
2010	7.991	(5.87-10.12)	0.544	(0.412-0.676)
2011	8.105	(5.94-10.27)	0.552	(0.42-0.683)
2012	8.160	(5.98-10.34)	0.555	(0.426-0.685)
2013	8.101	(5.91-10.29)	0.551	(0.425-0.677)
2014	8.021	(5.83-10.21)	0.546	(0.423-0.669)
2015	7.943	(5.75-10.14)	0.541	(0.421-0.661)
2016	7.806	(5.6-10.02)	0.531	(0.413-0.65)
2017	7.791	(5.55-10.03)	0.530	(0.413-0.648)

Table d: Recent trend in beginning of the year spawning output and depletion for the Southern model for Yellowtail Rockfish.

tab:SpawningDeplete_mod2

Year	Spawning Output (trillion eggs)	~ 95% confidence interval	Estimated depletion	~ 95% confidence interval
2008	1.983	(-0.76-4.72)	0.588	(0.45-0.726)
2009	1.975	(-0.74-4.69)	0.586	(0.453-0.718)
2010	1.989	(-0.73-4.71)	0.590	(0.461-0.719)
2011	2.027	(-0.73-4.78)	0.601	(0.473-0.729)
2012	2.084	(-0.73-4.9)	0.618	(0.489-0.747)
2013	2.177	(-0.75-5.11)	0.646	(0.512-0.779)
2014	2.298	(-0.78-5.38)	0.682	(0.543-0.821)
2015	2.478	(-0.83-5.79)	0.735	(0.584-0.886)
2016	2.743	(-0.91-6.39)	0.814	(0.643-0.984)
2017	3.109	(-1.02-7.23)	0.922	(0.721-1.123)

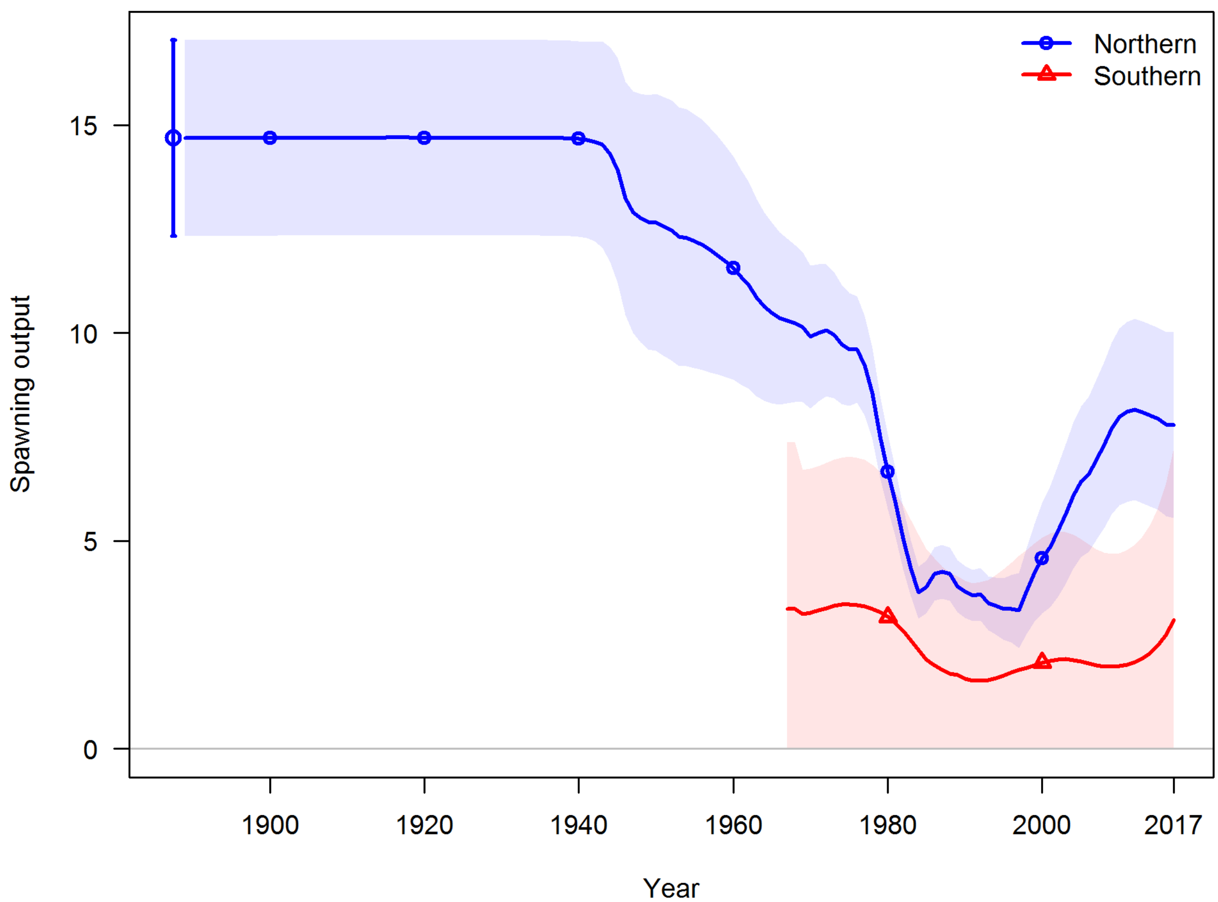

Figure d: Time series of spawning output trajectory (circles and line: median; light broken lines: 95% credibility intervals) for the base case assessment model. fig:Spawnbio_all

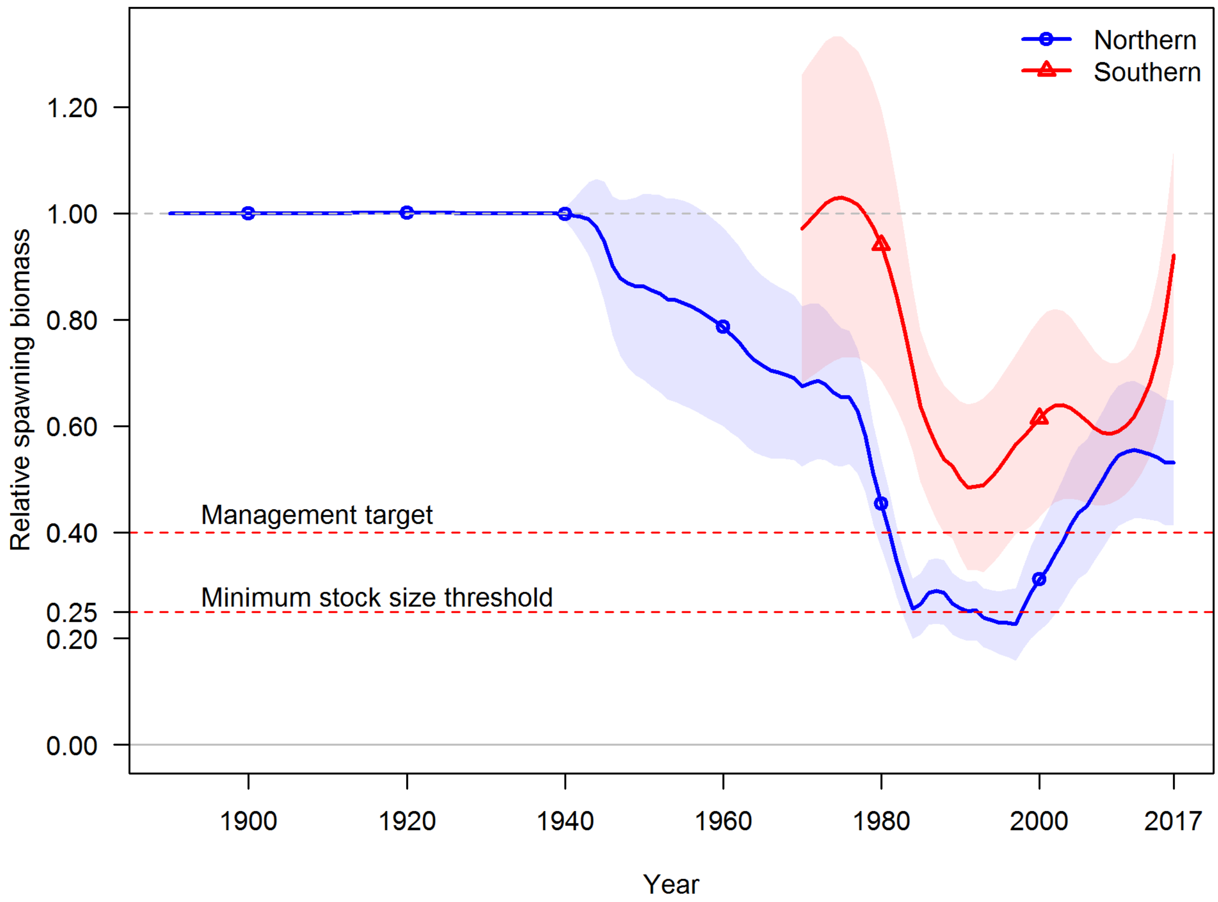

Figure e: Estimated relative depletion with approximate 95% asymptotic confidnce intervals (dashed lines) for the base case assessment model. fig:RelDeplete_all

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 f)
Recruitment Tables: (Tables e, f and **??**)

Table e: Recent recruitment for the Northern model.

tab:Recruit_mod1

Year	Estimated Recruitment (millions)	~ 95% confidence interval
2008	34.46	(20.8 - 57.08)
2009	10.44	(5.04 - 21.65)
2010	22.11	(11.8 - 41.43)
2011	15.15	(6.89 - 33.31)
2012	15.95	(6.29 - 40.42)
2013	25.87	(8.87 - 75.43)
2014	24.05	(8.24 - 70.21)
2015	24.51	(8.62 - 69.71)
2016	24.35	(8.57 - 69.16)
2017	24.34	(8.57 - 69.13)

Table f: Recent recruitment for the Southern model.

tab:Recruit_mod2

Year	Estimated Recruitment (millions)	~ 95% confidence interval
2008	123.60	(31.9 - 478.95)
2009	61.44	(9.88 - 382.1)
2010	84.06	(14.63 - 483.13)
2011	68.11	(12.28 - 377.66)
2012	35.52	(6.07 - 207.89)
2013	41.50	(8.35 - 206.26)
2014	32.55	(6.23 - 170.09)
2015	25.26	(4.87 - 131.01)
2016	21.17	(3.94 - 113.89)
2017	21.81	(4.06 - 117.31)

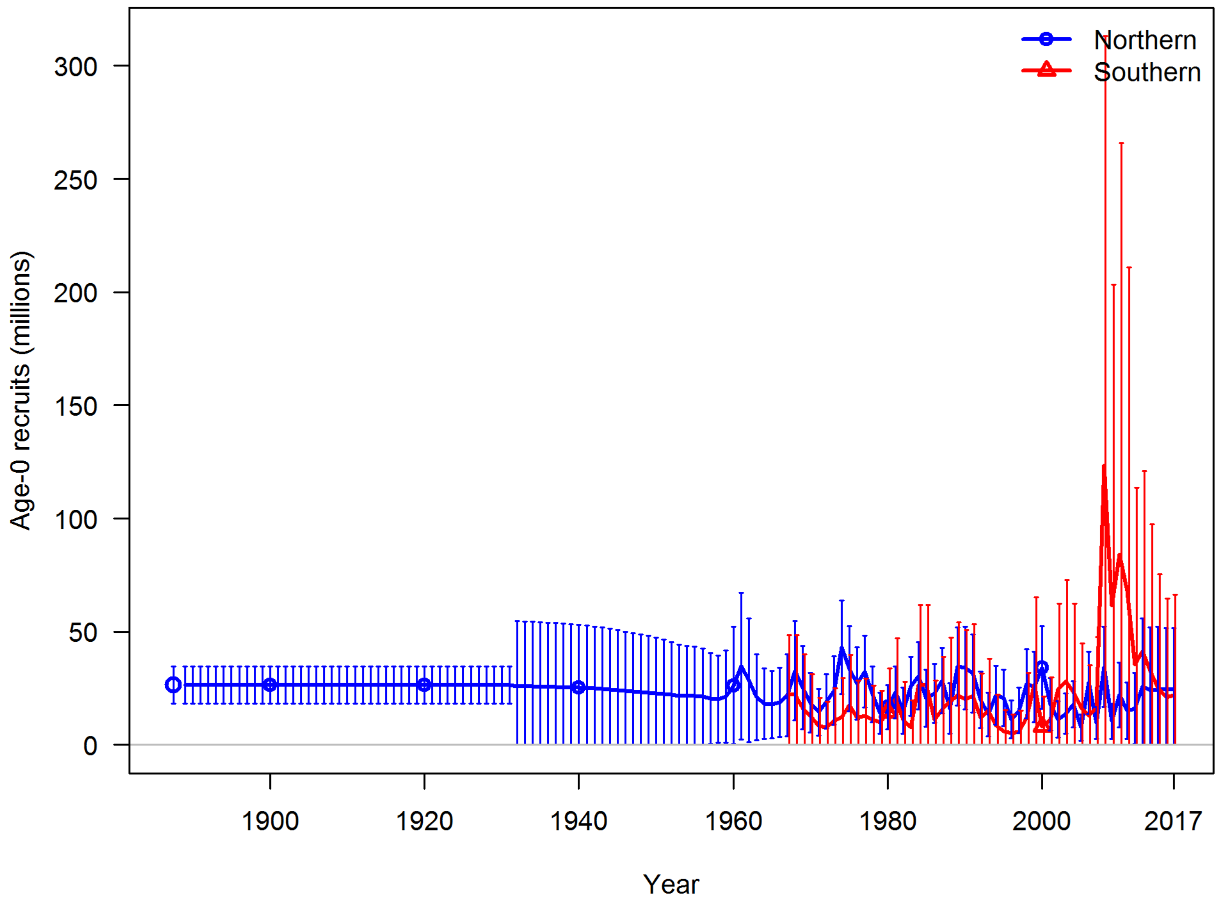

Figure f: Time series of estimated Yellowtail Rockfish recruitments for the base-case model with 95% confidence or credibility intervals. fig:Recruits_all

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 g, Table h, Table **??** Exploitation Figure: Figure g).

A summary of Yellowtail Rockfish exploitation histories for base model is provided as Figure h.

Table g: Recent trend in spawning potential ratio and exploitation for Yellowtail Rockfish in the Northern 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	0.33	(0.12-0.55)	0.01	(0-0.02)
2008	0.21	(0.14-0.28)	0.01	(0-0.01)
2009	0.39	(0.24-0.54)	0.01	(0.01-0.02)
2010	0.52	(0.27-0.77)	0.02	(0.01-0.03)
2011	0.45	(0.33-0.58)	0.02	(0.01-0.02)
2012	0.52	(0.38-0.65)	0.02	(0.01-0.03)
2013	0.49	(0.36-0.62)	0.02	(0.01-0.02)
2014	0.49	(0.36-0.62)	0.02	(0.01-0.02)
2015	0.63	(0.48-0.79)	0.03	(0.02-0.03)
2016	0.50	(0.36-0.63)	0.02	(0.01-0.02)

Table h: Recent trend in spawning potential ratio and exploitation for Yellowtail Rockfish in the Southern model. Fishing intensity is (1-SPR) divided by 50% (the SPR target) and exploitation is F divided by F_{SPR}.

tab:SPR_Exploit_mod2

Year	Fishing intensity	~ 95% confidence interval	Exploitation rate	~ 95% confidence interval
2007	0.04	(-0.01-0.1)	0.00	(0-0)
2008	0.02	(0-0.04)	0.00	(0-0)
2009	0.03	(-0.01-0.07)	0.00	(0-0)
2010	0.01	(0-0.03)	0.00	(0-0)
2011	0.02	(-0.01-0.05)	0.00	(0-0)
2012	0.02	(-0.01-0.05)	0.00	(0-0)
2013	0.02	(-0.01-0.05)	0.00	(0-0)
2014	0.02	(-0.01-0.05)	0.00	(0-0)
2015	0.03	(-0.01-0.07)	0.00	(0-0)
2016	0.01	(0-0.02)	0.00	(0-0)

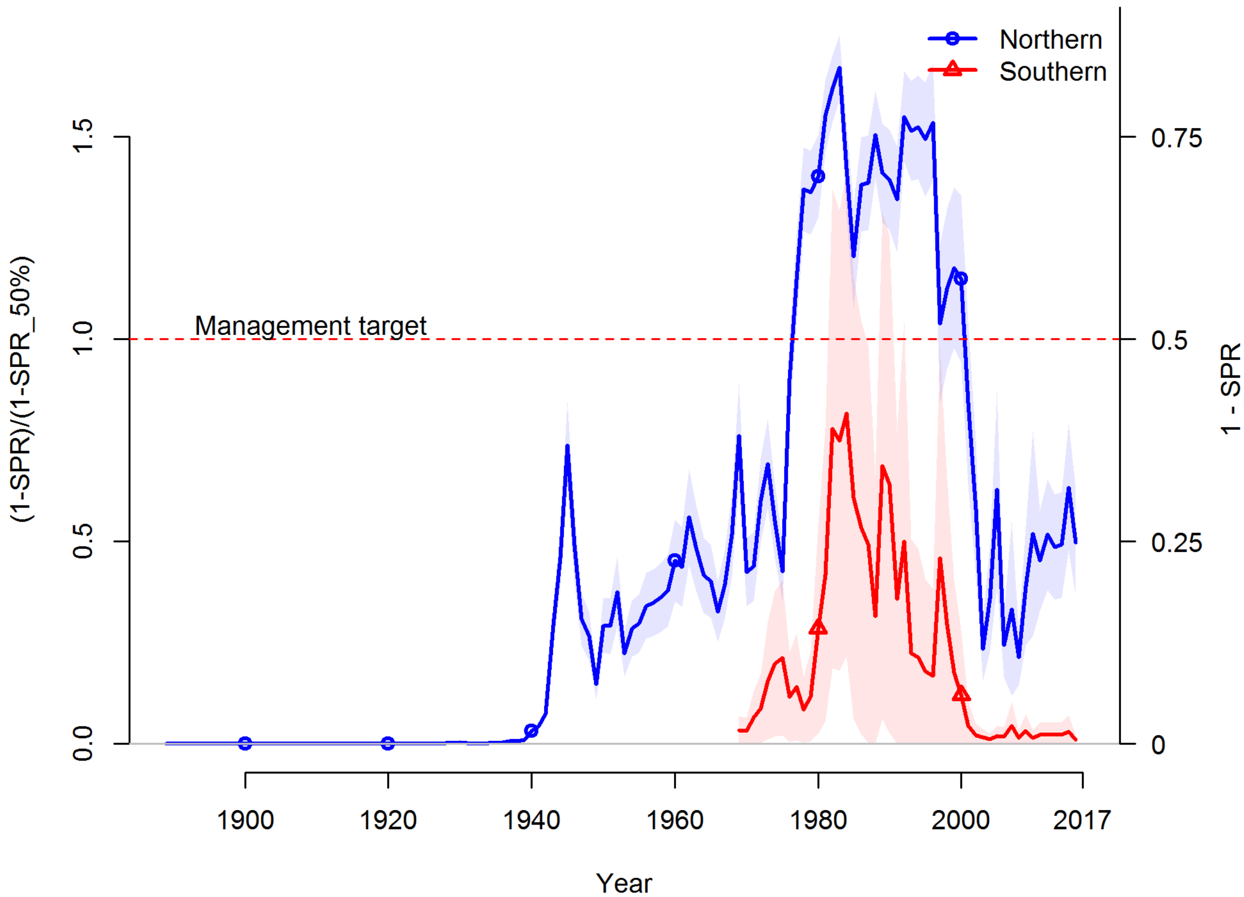

Figure g: Estimated spawning potential ratio (SPR) for the base-case model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing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

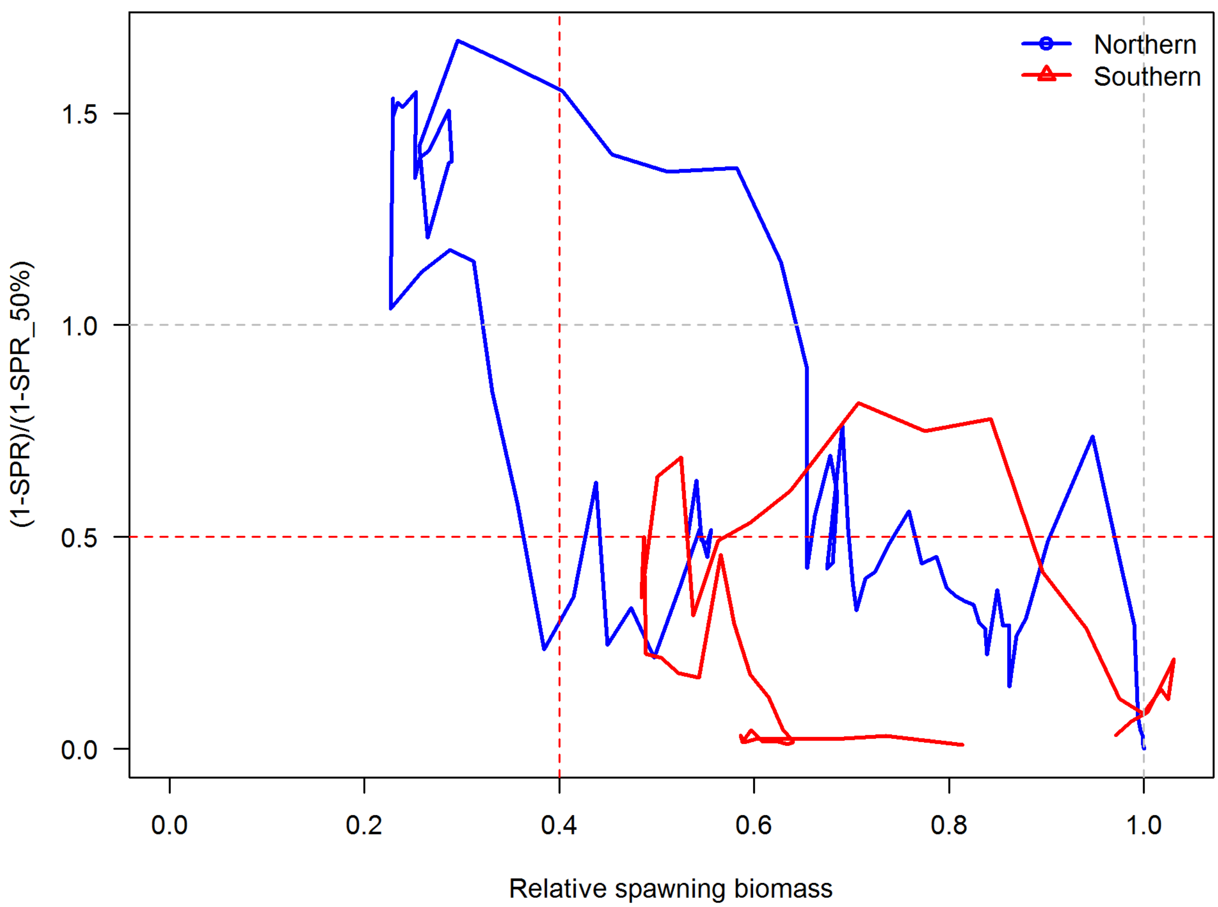

Figure h: Phase plot of estimated relative (1-SPR) vs. relative spawning biomass for the base case model. The relative (1-SPR) is (1-SPR) divided by 50% (the SPR target). Relative depletion is the annual spawning biomass divided by the unfished spawning biomass. fig:Phase_all

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 Yellowtail Rockfish in the Northern model are above the biomass target, but above the minimum stock size threshold. Add sentence about spawning output trend. The estimated relative depletion level for Model 1 in 2016 is 53% (~95% asymptotic interval: ± 41.3%-64.8%, corresponding to an unfished spawning output of 7.79131 trillion eggs (~95% asymptotic interval: 5.55-10.03 trillion eggs) of spawning output in the base model (Table i). Unfished age 4+ biomass was estimated to be 128999 mt in the base case model. The target spawning output based on the biomass target ($SB_{40\%}$) is 5.9 trillion eggs, which gives a catch of 3910.4 mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$ is 3691.6 mt.

This stock assessment estimates that Yellowtail Rockfish in the Southern model are above the biomass target, but above the minimum stock size threshold. Add sentence about spawning output trend. The estimated relative depletion level for Model 2 in 2016 is 92.2% (~95% asymptotic interval: ± 72.1%-112%), corresponding to an unfished spawning output of 3.10871 trillion eggs (~95% asymptotic interval:) of spawning output in the base model (Table j). Unfished age 4+ biomass was estimated to be 71633.9 mt in the base case model. The target spawning output based on the biomass target ($SB_{40\%}$) is 1.3 trillion eggs, which gives a catch of mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$ is 1890.2 mt.

This stock assessment estimates that Yellowtail Rockfish 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 2016 is (~95% asymptotic interval: ±), corresponding to an unfished spawning output of (~95% asymptotic interval:) of spawning output in the base model (Table **??**). Unfished age 4+ 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 i: Summary of reference points and management quantities for the base case Northern model.

tab:Ref_pts_mod1

Quantity	**Estimate**	**95% Confidence Interval**
Unfished spawning output (trillion eggs)	14.7	(12.3-17)
Unfished age 4+ biomass (mt)	128999	(110839.6-147158.4)
Unfished recruitment (R0, thousands)	26398.3	(18222.3-34574.3)
Spawning output(2016 trillion eggs)	7.8	(5.6-10)
Depletion (2016)	0.5313	(0.413-0.6496)
Reference points based on $\mathbf{SB_{40\%}}$		
Proxy spawning output ($B_{40\%}$)	5.9	(4.9-6.8)
SPR resulting in $B_{40\%}$ ($SPR_{B40\%}$)	0.4589	(0.4589-0.4589)
Exploitation rate resulting in $B_{40\%}$	0.0539	(0.0514-0.0564)
Yield with $SPR_{B40\%}$ at $B_{40\%}$ (mt)	3910.4	(3265-4555.8)
Reference points based on SPR proxy for MSY		
Spawning output	6.5	(5.5-7.6)
SPR_{proxy}	0.5	
Exploitation rate corresponding to SPR_{proxy}	0.0477	(0.0455-0.05)
Yield with SPR_{proxy} at SB_{SPR} (mt)	3691.6	(3085.6-4297.5)
Reference points based on estimated MSY values		
Spawning output at MSY (SB_{MSY})	3.5	(2.9-4.1)
SPR_{MSY}	0.3118	(0.3067-0.3169)
Exploitation rate at MSY	0.0821	(0.0779-0.0863)
MSY (mt)	4347.6	(3612-5083.2)

Table j: Summary of reference points and management quantities for the base case Southern model.

tab:Ref_pts_mod2

Quantity	**Estimate**	**95% Confidence Interval**
Unfished spawning output (trillion eggs)	3.4	(-0.6265-7.4)
Unfished age 4+ biomass (mt)	71633.9	(-12564.9768-155832.8)
Unfished recruitment (R0, thousands)	22259.8	(-3949.6224-48469.2)
Spawning output(2016 trillion eggs)	2.7	(-0.9069-6.4)
Depletion (2016)	0.8136	(0.643-0.9843)
Reference points based on $\mathbf{SB_{40\%}}$		
Proxy spawning output ($B_{40\%}$)	1.3	(-0.2506-2.9)
SPR resulting in $B_{40\%}$ ($SPR_{B40\%}$)	0.4589	(0.4589-0.4589)
Exploitation rate resulting in $B_{40\%}$	0.0576	(0.0559-0.0593)
Yield with $SPR_{B40\%}$ at $B_{40\%}$ (mt)	1997	(-354.5756-4348.5)
Reference points based on SPR proxy for MSY		
Spawning output	1.5	(-0.2791-3.3)
SPR_{proxy}	0.5	
Exploitation rate corresponding to SPR_{proxy}	0.0508	(0.0493-0.0522)
Yield with SPR_{proxy} at SB_{SPR} (mt)	1890.2	(-335.3679-4115.8)
Reference points based on estimated MSY values		
Spawning output at MSY (SB_{MSY})	0.8199	(-0.1516-1.8)
SPR_{MSY}	0.3175	(0.3141-0.3208)
Exploitation rate at MSY	0.0885	(0.0861-0.0909)
MSY (mt)	2197.8	(-391.3228-4786.9)

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 k

Table k: 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	-	-	-	-
2017	-	-	-	-
2018	-	-	-	-

Unresolved Problems And Major Uncertainties

unresolved-problems-and-major-uncertainties

TBD after STAR panel

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 l

Decision table(s) Table m, Table n, Table **??**

Yield curve: Figure \ref{fig:Yield_all}

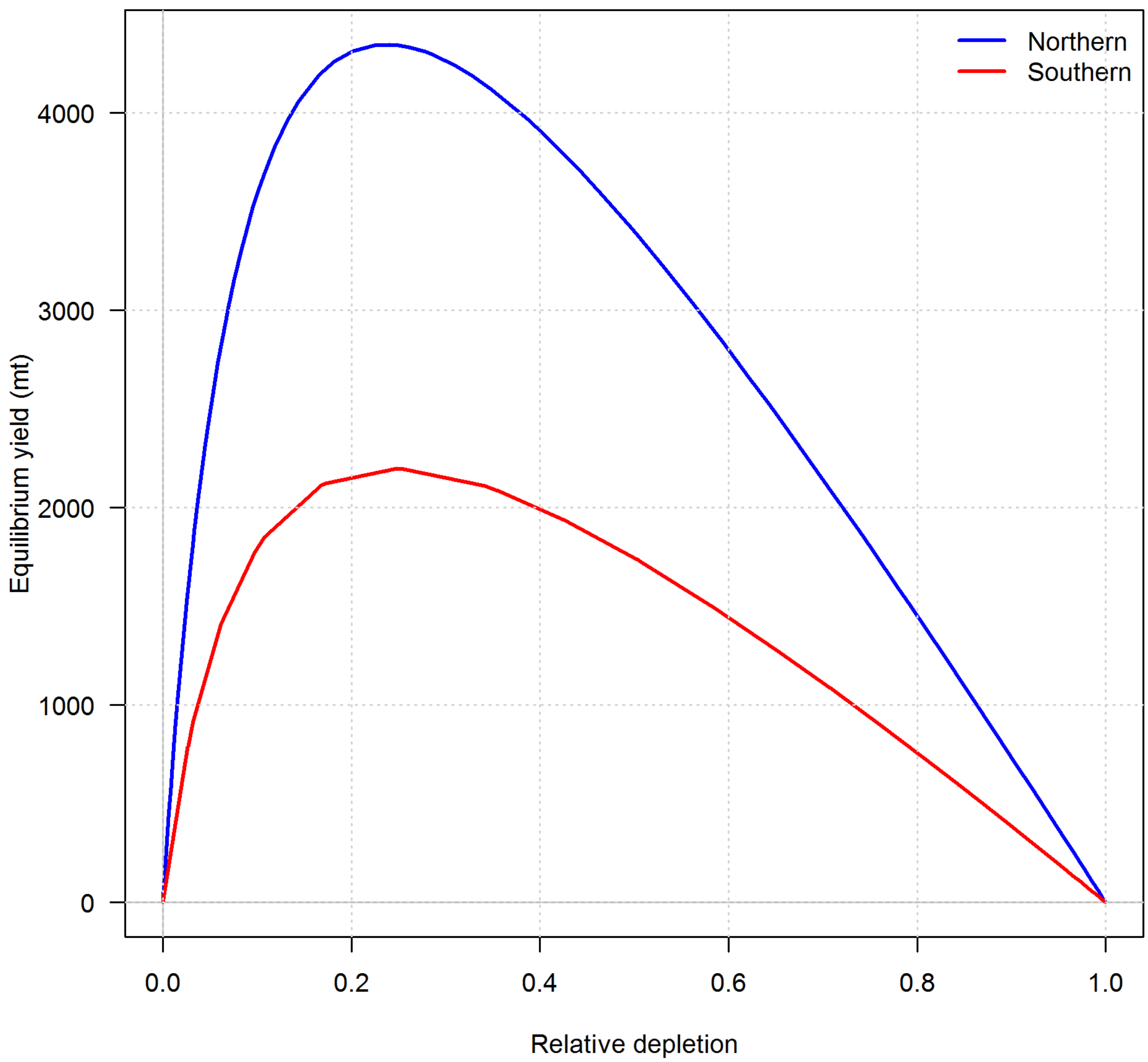

Figure i: Equilibrium yield curve for the base case model. Values are based on the 2016 fishery selectivity and with steepness fixed at... fig:Yield_all

Table l: Projections of potential OFL (mt) for each model, using the base model forecast.
tab:OFL_projection

Year	Model 1	Model 2	Total
2017	3988.81	5152.74	9141.55
2018	3840.38	5006.04	8846.42
2019	3712.42	4801.18	8513.60
2020	3611.38	4566.83	8178.21
2021	3544.46	4324.17	7868.63
2022	3513.29	4085.35	7598.64
2023	3512.56	3857.50	7370.06
2024	3532.98	3645.03	7178.01
2025	3564.86	3450.44	7015.30
2026	3600.46	3274.82	6875.28
2027	3634.58	3118.20	6752.78
2028	3664.30	2979.81	6644.11

Table m: Summary of 10-year projections beginning in 2018 for alternate states of nature based on an axis of uncertainty for the Northern 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 n: Summary of 10-year projections beginning in 2018 for alternate states of nature based on an axis of uncertainty for the Southern 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_mod2

			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 o: Yellowtail Rockfish base case results summary.

tab:base_summary

Model Region	Quantity	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	Landings (mt)										
	Total Est. Catch (mt)										
	OFL (mt)										
	ACL (mt)										
Model 1	(1-SPR)(1-$SPR_{50\%}$)	0.21	0.39	0.52	0.45	0.52	0.49	0.49	0.63	0.50	
Base Case	Exploitation rate	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.02	
	Age 4+ biomass (mt)	76365.3	77111.1	76466.7	77313.9	75707.8	77354.4	76340.3	76683.8	76225.2	75174.0
	Spawning Output	7.3	7.7	8.0	8.1	8.2	8.1	8.0	7.9	7.8	7.8
	95% CI	(5.31-9.3)	(5.65-9.78)	(5.87-10.12)	(5.94-10.27)	(5.98-10.34)	(5.91-10.29)	(5.83-10.21)	(5.75-10.14)	(5.6-10.02)	(5.55-10.03)
	Depletion	0.5	0.5	0.5	0.6	0.6	0.6	0.5	0.5	0.5	0.5
	95% CI	(0.368-0.627)	(0.394-0.656)	(0.412-0.676)	(0.42-0.683)	(0.426-0.685)	(0.425-0.677)	(0.423-0.669)	(0.421-0.661)	(0.413-0.65)	(0.413-0.648)
	Recruits	34.46	10.44	22.11	15.15	15.95	25.87	24.05	24.51	24.35	24.34
	95% CI	(20.8 - 57.08)	(5.04 - 21.65)	(11.8 - 41.43)	(6.89 - 33.31)	(6.29 - 40.42)	(8.87 - 75.43)	(8.24 - 70.21)	(8.62 - 69.71)	(8.57 - 69.16)	(8.57 - 69.13)
Model 2	(1-SPR)(1-$SPR_{50\%}$)	0.02	0.03	0.01	0.02	0.02	0.02	0.02	0.03	0.01	
Base Case	Exploitation rate	0	0	0	0	0	0	0	0	0	
	Age 4+ biomass (mt)	41317.6	43306.9	44211.0	44337.0	44909.1	63175.4	72683.3	85860.8	96433.1	101051.0
	Spawning Output	2	2	2	2	2	2	2	2	3	3
	95% CI	(-0.76-4.72)	(-0.74-4.69)	(-0.73-4.71)	(-0.73-4.78)	(-0.73-4.9)	(-0.75-5.11)	(-0.78-5.38)	(-0.83-5.79)	(-0.91-6.39)	(-1.02-7.23)
	Depletion	0.59	0.59	0.59	0.60	0.62	0.65	0.68	0.74	0.81	0.92
	95% CI	(0.45-0.726)	(0.453-0.718)	(0.461-0.719)	(0.473-0.729)	(0.489-0.747)	(0.512-0.779)	(0.543-0.821)	(0.584-0.886)	(0.643-0.984)	(0.721-1.123)
	Recruits	123.60	61.44	84.06	68.11	35.52	41.50	32.55	25.26	21.17	21.81
	95% CI	(31.9 - 478.95)	(9.88 - 382.1)	(14.63 - 483.13)	(12.28 - 377.66)	(6.07 - 207.89)	(8.35 - 206.26)	(6.23 - 170.09)	(4.87 - 131.01)	(3.94 - 113.89)	(4.06 - 117.31)

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

Yellowtail rockfish, *Sebastes flavidus, occur off the West Coast of the US from Baja California to the Aleutian Islands. Once thought to comprise a single stock, a recent genetic study has shown them to be two sub-species, with a genetic cline at Cape Mendocino, California, roughly 40-10 North Latitude[@Hess2011]. Yellowtail rockfish is an aggregating, midwater species usually caught between 60 and 120 fathoms. Off Washington and Oregon, yellowtail are largely caught in the commercial trawl fishery; in California there is a large recreational fishery for yellowtail. They are colloquially known as "greenies", although flavidus is Latin for "yellow"[@Love2011].*

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 **??**.

1.3 Life History

life-history

*Yellowtail rockfish are among those that are fertilized internally and release live young. Spawning aggregations occur in the fall, and parturition in the winter and spring (January-May)(**???**). Young-of-the-year recruit to nearshore waters from April through August, migrating to deeper water in the fall. Preferred habitat is the midwater over reefs and boulder fields. They are extremely motile, and make rapid and frequent ascents and descents of 40 meters; they also exhibit strong homing tendencies.(**???**). They are able to quickly release gas from their swim bladders, perhaps making them less susceptible to barotrauma than similar species(**???**).*

1.4 Fishery Information

fishery-information

The rockfish fishery off the U.S. Pacific coast first developed off California in the late 19th century as a hook-and-line fishery (Love et al. 2002). The rockfish trawl fishery was established in the early 1940s, when the United States became involved in World War II and wartime shortage of red meat created an increased demand for other sources of protein (Harry and Morgan 1961, Alverson et al. 1964).

*Today yellowtail remains a major commercial species, captured mostly in trawls from Central California to British Columbia(**???**).*

1.5 Summary of Management History

summary-of-management-history

Yellowtail rockfish co-occur with canary, widow rockfish and several other rockfishes (Nagtegaal 1983; Tagart 1987; Rogers and Pikitch 1992). Association with these and other rockfish species has substantially altered fishing opportunity for yellowtail rockfish. Canary rockfish stocks are currently at very low levels of abundance and have been declared overfished by National Marine Fisheries service. In order to achieve the necessary reduction in the canary rockfish catch, the Council adopted stringent management measures in 2000. Harvest of canary rockfish and their co-occurring species was limited.

Beginning in 2000, shelf rockfish species (including yellowtail) could no longer be retained by vessels using bottom trawl footropes with a diameter of greater than 8 inches. The use of small footrope gear increases the risk of gear loss in rocky areas. This restriction was intended to provide an incentive for fishers to avoid high-relief, rocky habitat, thus reducing the exposure of many depleted species to trawling. This incentive was reinforced through reductions in landing limits for most shelf rockfish species.

Since September 2002, managers have employed closed areas, referred to as Rockfish Conservation Areas (RCAs), in addition to landings limits and gear restrictions. The boundaries of the northern trawl RCA, delineated by waypoints approximating depth contours, have varied between and within years. The seaward boundary of the trawl RCA has ranged from 150-250 fm, while the shoreward boundary has ranged from 100 fm to the shore. Following implementation of this closed area, only small footrope gear could be used shoreward of the RCA. Beginning in 2005, additional gear restrictions were imposed in the northern area. Based on several years of testing and evaluation, a more flatfish-selective net design is now required for use in waters shoreward of the RCA.

Since the end of 2002, there have been no landings limits that provide directed mid-water fishing opportunities for yellowtail rockfish. From 2001 through 2004, yellowtail rockfish could be landed in amounts up to one-third the weight of most flatfish onboard (not to exceed 7,500 lb/trip or 15,000 lb/2-months). With the requirement to use selective flatfish gear in 2005, the yellowtail allowance was reduced to 2,000 lb/2-month period.

<TOADS: Since 2005>

1.6 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 k)

A summary of these values as well as other base case summary results can be found in Table o.

1.7 Fisheries off Canada, Alaska, and/or Mexico

fisheries-off-canada-alaska-andor-mexico

*Limited fishing for yellowtail occurs as far south as Baja California(**???**).*

2 Data

data

Data used in the Northern and Southern yellowtail rockfish assessments are summarized in Figures ?? and ??.

Data sources for the two models are largely distinct. Northern fisheries and surveys had very sparse data (if any) for the south and vice-versa. Among the 12 data sources referenced below, only 2 data sources are common to both models. These are the MRFSS/RecFIN recreational dockside survey, which focuses on California and Oregon, and the CalCOM California commercial dataset, which contributed data from the northern-most California counties (Eureka and Del Norte) to the Northern model. The CalCOM data account for less than five percent of the commercial landings in the Northern model, and less than 1% of the biological samples.

Commercial landings are not differentiated in either model. For the Northern model, this is due to the very small portion (1.15 %) of the landings that are attributed to non-trawl gear. For the Southern model, this is due to the paucity of data.

A description of each model's data sources follows.

2.1 Northern Model Data

northern-model-data

Summary of the data sources in the Northern model.

tab:Data_sources

Source	Landings	Lengths	Ages	Indices	Discard	Type
PacFIN	Y	Y	Y	Y		Commercial
WCGOP		Y			Y	Commercial Discards
Hake Bycatch	Y	Y	Y	Y		Commercial
CalCOM	Y	Y	Y			Commercial
WaSport	Y	Y	Y			Recreational
MRFSS	Y	Y				Recreational
RecFIN	Y	Y				Recreational
Triennial		Y	Y	Y		Survey
NWFSCcombo		Y	Y	Y		Survey
Pikitch		Y			Y	Commercial Study
ODFW	Y					Historical data
WDFW	Y					Historical data

2.1.1 Commercial Fishery Landings

`commercial-fishery-landings`

Washington and Oregon Landings *The bulk of the commercial landings for Washington and Oregon came from the from the Pacific Fisheries Information Network (**PacFIN**) database.*

Washington Catch Information
*The Washington Department of Fisheries and Wildlife (**WDFW**) provided historical yellowtail catch for 1889–1980. Landings for 1981-2016 came from the PacFIN database. WDFW also provided catches for the period 1981 – 2016 to include the re-distribution of the unspeciated "URCK" landings in PacFIN; this information is currently not available from PacFIN.*

Oregon Catch Information
*The Oregon Department of Fisheries and Wildlife (**ODFW**) provided historical yellowtail catch from 1892-1985. ODFW also provided estimates of yellowtail rockfish in the in the un-speciated PacFIN "URCK" and "POP1" catch categories for recent years, and those estimates were combined with PacFIN landings for 1986-2016.*

Northern California Catch
*The California Commercial Fishery Database (**CalCOM**) provided landings for the Northern model for the two counties north of 40.10 (Eureka and Del Norte) for 1969-2016.*

Hake Bycatch
*The Alaska Fisheries Science Center (**AFSC**) provided data for yellowtail bycatch in the hake fishery from 1976-2016.*

2.1.2 Sport Fishery Removals

`sport-fishery-removals`

Washington Sport Catch
WDFW provided recreational catches for 1967 and 1975-2016.

Oregon Sport Catch
ODFW provided recreational catch data for 1979-2016.

MRFSS and RecFIN *Data from Northern California came from the Marine Recreational Fisheries Statistical Survey (**MRFSS**) and from the Recreational Fisheries Information Network (**RecFIN**). These are dockside surveys focused on California and Oregon. MRFSS was conducted from 1980-1989 and 1993-2003, RecFIN from 2004 to the present.*

2.1.3 Estimated Discards

`estimated-discards`

Commercial Discards
*The West Coast Groundfish Observing Program (**WCGOP**) is an onboard observer program*

that has extensively surveyed fishing practices since 2002, with nearly 100% observer coverage in the trawl sector in recent years. WCGOP provided discard ratios for yellowtail rockfish from 2002 to 2015.

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.

Pikitch study discards were aggregated due to small sample size and included in the data as representing a single year mid-way through the study.

2.1.4 Abundance Indices

abundance-indices

Commercial Logbook CPUE

The commercial logbook (fish-ticket) data in PacFIN was used to generate an index for the years 1987-1998, a period in which management of the fishery was stable, i.e., regulations weren"t changing fishery practices.

The data were modeled with a modified Stephens-MacCall approach (Stephens and MacCall 2004). This approach uses the species composition of the catch to evaluate the per-haul probability of encountering a particular species; in this case, yellowtail rockfish. The intent of the analysis is to eliminate all hauls from the index that could not encounter yellowtail.

Usually, the Stephens-MacCall approach is a simple binomial model for presence-absence of the predictive species and the target, however a generalized linear mixed-effects approach – modeling the species as binomial and adding random effects for the interaction of year and vessel, for haul duration, and for month improved the model fit.

The hauls identified with a reasonable probability of encountering yellowtail were then modeled in a delta-lognormal glm to produce an annual index of abundance, bootstrapped 500 times to evaluate uncertainty.

Hake Bycatch Index

The Hake bycatch data provided by the Alaska Fisheries Science Center (AFSC) was used to generate an index of abundance for 1985-1999.

Data on haul-by-haul catch of Yellowtail Rockfish and Pacific Hake for the period 1976-2016 were obtained from the At-Sea Hake Observer Program along associated information including the location of each tow and the duration. Previous Yellowtail assessments used an index of abundance for the years 1978-1999. The most recent assessment (Wallace and Lai, 2005) stated that the index was not updated to include years beyond 1999 "because subsequent changes in fishery regulations and behavior have altered the statistical properties of these abundance indices". The ending year of 1999 was retained for this analysis. However, the years up to 1984 have relatively few tows with adequate information for CPUE analysis, and fishing effort off the coast of Washington where yellowtail are most commonly encountered (Figure X1). Therefore, for this new analysis, 1985 was chosen as the starting year.

The hake fishery was evolving during the chosen 15 year period (1985-1999), which included a transition from foreign to domestic fleets fishing for Pacific Hake (Figure X2). The index from the at-sea hake fishery used in previous assessments standardized for changes in catchability by using a ratio estimator relating yellowtail catch to hake catch and then scaling by an estimate of fishing effort for hake (Equation 1 in Wallace and Lai, 2005). However, that approach does not take into account differences in the spatial distribution of the at-sea hake fishery relative to the distributions of hake and yellowtail.

For this new analysis, changes in catchability were estimated by comparing an index based on a geostatistical analysis of the hake CPUE from VAST (Thorson et al. YYYY) to the estimated available hake biomass from the most recent stock assessment (Berger et al. 2017). The relative catchability was then used to adjust an independent geostatistical index of yellowtail CPUE (Figure X3). In order to capture the general trend in catchability, reducing the variability among years, linear, exponential, and locally smoothed (LOWESS) models were fit to the time series of individual estimates of hake index to available biomass (Figure X3b). Of these, the LOWESS model best captured the pattern of fastest change in the middle of the time series. The average rate of increase in the resulting estimated catchability time series is 13% per year.

VAST was then used to conduct a geostatistical standardization of the CPUE of yellowtail caught as bycatch in the at-sea hake fishery. The resulting yellowtail index after adjustment by the estimated changes in catchability is qualitatively more similar to the index used in previous assessments (Figure X4) than the index resulting from assuming constant catchability.

Pikitch Study

The Pikitch data referenced above provided an index for years 1981-91. need information about developing the index.

NWFSCcombo Index

Triennial Index

2.1.5 Fishery-Independent Data

fishery-independent-data

Northwest Fisheries Science Center (NWFSC) shelf-slope survey

*This survey, referred to as the **NWFSCcombo Survey**, has been conducted annually since 2003.*
The survey consistently covers depths between 30 and 700 fm.

Data from this survey for yellowtail rockfish was available for 2003-2016, and provided an index in addition to length and age data.

Alaska Fisheries Science Center (AFSC) Triennial shelf survey

*The **Triennial Survey** was conducted by the AFSC every third year between 1977 and 2001, (and was conducted in 2004 by the NWFSC using the same protocols). The Triennial Survey trawled in depths of 30 to 275 fm.*

The Triennial Survey provided yellowtail rockfish length and age data, as well as an index of abundance from 1997-2004.

2.1.6 Biological Samples

biological-samples

Length And Age Compositions

Length composition data were compiled from PacFIN for Oregon and Washington for the Northern model and combined with raw (unexpanded) length data from CalCOM for the two California counties north of 40.10 (Eureka and Del Norte counties).

Length compositions were provided from the following sources:

Summary of the time series of lengths used in the stock assessment.

tab:Length_sources

Source	Type	Lengths	Tows	Years
PacFIN	commercial	186161	3830	1968-2016
CalCOM	commercial	2340		1978-2015
MRFSS	recreational	4125		1980-2003
RecFIN	recreational	432		2004-2016
WASport	recreactional	11099		1975-2015
Triennial	survey	16262	465	1977-2004
NWFSCcombo	survey	940	564	2004-2016

Age structure data were available from the following sources:

Summary of the time series of age data used in the stock assessment.

tab:Age_sources

Source	Type	Ages	Tows	Years
PacFIN	commercial	138854		1972-2016
CalCOM	commercial	3546		1980-2002
WASport	recreational	4027		1997-2016
Triennial	survey	6553	278	1997-2004
NWFSCcombo	survey	2990	544	2003-2016

2.2 Southern Model Data

southern-model-data

Summary of the data source in the Southern model.

tab:Data_sources

Source	Landings	Lengths	Ages	Indices	Discard	Type
CalCOM	Y	Y	Y			Commercial
MRFSS	Y	Y				Recreational
RecFIN	Y	Y				Recreational
HookandLine		Y	Y	Y		Survey
Onboard		Y	Y	Y		Survey
SmallResearch		Y	Y			Study

2.2.1 Commercial Fishery Landings

commercial-fishery-landings-1

California Commercial Landings
*The California Commercial Fishery Database (**CalCOM**) provided landings in California south of 40.10 for 1969-2016.*

2.2.2 Sport Fishery Removals

sport-fishery-removals-1

MRFSS Estimates and RecFIN
*The California Department of Fish and Wildlife (**CDFW**) provided estimated yellowtail removals for the Marine Recreational Fisheries Statistical Survey (**MRFSS**) from 1980-1989, 1993-2003. The Recreational FIsheries Information Network, (**RecFIN**) provided landings for 2004-2016.*

Small Research Study *A small number of fish were collected from the recreational fishery by the Southwest Fisheries Science Center (**SWFSC**) and are included in the data for 1978-1984.*

2.2.3 Estimated Discards

estimated-discards-1

No discard data were available for the Southern model.

2.2.4 Abundance Indices

abundance-indices-1

MRFSS Index
An index of abundance was developed from trip-aggregated MRFSS data for the years 1980-1989, 1992-2003.

California Onboard Survey

An Onboard recreational survey conducted by provided data for an index of abundance provided by the SWFSC for 1987-2016.

2.2.5 Fishery-Independent Data

fishery-independent-data-1

Hook and Line Survey

The NWFSC Hook and Line survey provided data for an index in the Southern California Bight from 2004-2016.

2.2.6 Biological Samples

biological-samples-1

Length composition samples were available for the Southern model from 5 sources, and ages from 3.

Length compositions were provided from the following sources:

Summary of the time series of lengths used in the stock assessment.

tab:Length_sources

Source	Type	Lengths	Tows	Years
CalCOM	commercial	16160	1543	1978-2015
MRFSS	recreational	39425		1980-2003
RecFIN	recreational	49136		2004-2016
Onboard	recreational	76740		1987-2016
Small Study	recreational	909		1978-1984
Hook and Line	survey	1339	174	2004-2016

Age structure data were available from the following sources:

Summary of the time series of age data used in the stock assessment.

tab:Age_sources

Source	Type	Ages	Years
CalCOM	commercial	7875	1980-2004
Small Study	recreational	400	1978-1984
Hook and Line	survey	248	2004

2.3 Biological Parameters Common to Both Models

biological-parameters-common-to-both-models

Aging Precision And Bias

Age error matrices were developed for double-reads at the PFMC aging lab in Newport, OR and for double reads within the WDFW aging lab. The Newport lab has done all of the Survey aging for the NWFSC, along with some commercial ages and the 400 fish from the Small Study. WDFW provided the bulk of recreational and commercial ages. Between-lab differences in aging were minute, as were within-lab differences. This result is supported by the primary age reader's assessment: yellowtail rockfish are extremely easy to age (B. Kamikawa, pers. comm.).

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.*

To estimate this relationship, 12,778 samples with both weight and length measurements from the fishery independent surveys were analyzed. These included 6,354 samples from the NWFSC Combo survey, 5,085 from the Triennial survey, and 1,339 from the Hook and Line survey. All Hook and Line survey samples were from the Southern area, along with 910 samples from the other two surveys (Figure **??***). A single weight-length relationship was chosen for females and males in both areas after examining various factors that may influence this relationships, including sex, area, year, and season. None of these factors had a strong influence in the overall results. Season was one of the bigger factors, with fish sampled later in the year showing a small increase in weight at a given length (2-6% depending on the other factors considered). However, season was confounded with area because most of the samples from the Southern area were collected from the Hook and Line survey which takes place later in the year (mid-September to mid-November) and the resolution of other data in the model do not support modeling the stock at a scale finer than a annual time step. Males and females did not show strong differences in either area, and the estimated differences were in opposite directions for the two areas, suggesting that this might be a spurious relationship or confounded with differences timing of the sampling relative to spawning.*

The estimated coefficients resulting from this analysis were $\alpha = 1.1843e-05$ *and* $\beta = 3.0672$.

Maturity And Fecundity *Maturity was estimated from histological analysis of*

141 samples collected in 2016. These include 96 from the NWFSC Combo survey, 25 from mid-water catches in the NWFSC acoustic/trawl survey, 13 from the Hook and Line survey, and 7 from Oregon Department of Fish and Wildlife. The sample sizes were not adequate to estimate differences in maturity by area. Length at 50% maturity was estimated at 42.49cm

*(Figure **??**) which was consistent with the range 37-45cm cited in the previous assessment (Wallace and Lai 2005).*

Natural Mortality

Natural mortality estimates used as priors for the Northern model and as fixed values for the Southern model were provided by Owen Hamel (pers. comm.).

Sex ratios

The largest fish seen in the data are females, however the oldest are males. The sex ratio falls off differently in each model, as can be seen in Figs(x,y).

2.3.1 Environmental Or Ecosystem Data Included In The Assessment

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

No environmental index is present in either model.

3 Assessment

assessment

3.1 History Of Modeling Approaches Used For This Stock

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

Yellowtail rockfish was previously modeled as a 3-area stock north of 40.10 using a model written in ADMB need citation in 1999. Need citation, with an update assessment in 2004(Wallace and Lai 2005). That assessment divided the stock into 3 INPFC areas which are not coincident with state boundaries; this is a concern in that recent reconstructions of historical catch are state-by-state along the West Coast. Because we cannot produce data that conform to the areas previously assessed, we have made no effort to reproduce the previous model.

3.1.1 Previous Assessment Recommendations

previous-assessment-recommendations

Many of the recommendations of the previous STAR panel are not relevant to this assessment, as they related to data deficiencies at that time that have since been resolved. The 2004 STAR particularly recommended a focus on abundance indices, which they noted might require further survey information.

This assessment provides four indices for the Northern model, and three for the Southern model. All indices are newly developed for this analysis.

3.2 Model Description

`model-description`

3.2.1 Transition To The Current Stock Assessment

`transition-to-the-current-stock-assessment`

These are the main changes from the previous model, and our rationale for them:

1. *Transition to Stock Synthesis.* Rationale*: The Pacific Fishery Management Council's preferred modeling platform for stock assessments is Stock Synthesis (Methot 2015), developed since the last full assessment of yellowtail rockfish.*
2. *Addition of Southern model.* Rationale*: Hess, et al. determined that the West Coast yellowtail stocks show a genetic cline occurring near Cape Mendocino, which is roughly 40.10 north latitude (Hess et al. n.d.). This divides the stock into two genetically distinct substocks which we model independently.*
3. *Availability of recent data.* Rationale*: Ten years of data collection have occurred since the last update assessment, and the data necessary for an assessment of the Southern stock is now available.*
4. *Historical catch reconstructions.* Rationale*: Reconstruction of catch timeseries in California, Washington and Oregon clarify stock history as far back as 1898.*

3.2.2 Definition of Fleets and Areas

`definition-of-fleets-and-areas`

Northern Model

Commercial*: The commercial fleet consists primarily of bottom and midwater trawl. No attempt was made to analyze the fishery separately by gear, particularly since it seems that in the fishery in the 1980s and 1990s, "bottom trawl" gear was used in the midwater as well as on the bottom, and "midwater gear" was sometimes dragged across soft bottoms (Craig Goode, ODFW Port Sampler, pers. comm).*

At-Sea Hake Fishery*: Yellowtail Rockfish are frequently caught in mid-water trawls associated with the At-Sea Hake Fishery (consisting of the Catcher-Processor and Mothership sectors). These catches are recorded and biological sampling takes place but the fish are processed at sea (typically into fish meal) and are not included in the PacFIN database so require separate analysis.*

Recreational*: The recreational fleet includes data from sport fisheries off Washington, Oregon, and northern California (Eureka and Del Norte counties)*

Research*: Research derived-data include observations from the West Coast Groundfish Observing Program (WCGOP) which documents discarding in the commercial fishery, the Alaska*

Fisheries Science Center's Triennial Trawl survey, and the Northwest Fisheries Science Center's NWFSCcombo survey.

Southern Model

Commercial*: The commercial fleet consists primarily of hook and line and trawl gear. Hook and line gear account for 78% of the landings by weight in the recent period (1978-2016).*

Recreational*: The recreational fleet includes data from sport fishery off the California coast south of Cape Mendocino.*

Research*: Research derived-data include observations from the Northwest Fisheries Science Center's NWFSCcombo survey, and California Onboard recreational survey.*

3.2.3 Modeling Software

`modeling-software`

The STAT team used Stock Synthesis 3 version 3(Methot 2015).

3.2.4 Data Weighting

`data-weighting`

Commercial and survey length composition and marginal age composition data are weighted according to the method of Ian Stewart (pers.comm):

*Sample Size = 0.138 * Nfish + Ntows if Nfish/Ntows < 44, and Ntows * 7.06 otherwise.*

Age-at-Length samples are unwieghted; that is, each fish is assumed to represent an independent sample.

Recreational trips (the analogue of tows in the commercial fishery) are difficult to define in most cases. Since much of the recreational data are from the dockside interview MRFSS program, which didn't anticipate the need to delineate samples as belonging to particular trips, we chose to use all recreational data "as-is", with the initial weights entered as number of fish.

Weighting among fleets uses either the Francis method (Francis 2011) or the Ianelli-McAllister harmonic mean method (McAllister and Ianelli 1997). The Francis method was used for all fleets, except for the age data from the Southern model's Hook and Line survey, which is a single year of data to which we applied the Ianelli-McAllister method.

3.2.5 Priors

priors

Natural Mortality (M) priors were provide by Owen Hamel prior on natural mortality (Hamel 2015). Natural mortality priors were based on examination of 99% quantile of the observed ages early in the time-series before the full impact of fishing would have taken place. For the Northern model, these quantiles were approximately 35 years for females and 45 years for males, resulting in median M values of 0.15 and 0.12 for females and males. For the Southern model, the 99% quantile of the early age observations were approximately 30 and 40 years for females and males, resulting in median M prior values of 0.18 and 0.135, respectively. In both models, M for males was represented as an offset from females. In the Northern model, both the female value and the male offset could be estimated without priors so the priors were not used. For the southern model, M was fixed at the median prior values for the two sexes.

The prior for steepness (h, 0.718) was provided by James Thorson and used as a fixed parameter in both models. <TOADS: Citation>

3.2.6 General Model Specifications

general-model-specifications

Citation for posterior predictive fecundity relationship from Dick (2009)
Model data, control, starter, and forecast files can be found at https://DEVORE .

3.2.7 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 **??**

3.3 Model Selection and Evaluation

model-selection-and-evaluation

3.3.1 Key Assumptions and Structural Choices

key-assumptions-and-structural-choices

Selectivity in both models is asymptotic, with the exception of the OR-CA MRFSS recreational fleet in the Northern model, and the Onboard recreational fleet in the Southern model.

3.3.2 Alternate Models Considered

alternate-models-considered

Time-blocked selectivity and retention were investigated in the Northern model, as were domed selectivities.

We also explored time-blocks on selectivity in the Southern model, and domed selectivity for the MRFSS/RecFIN data.

These approaches resulted in model fits to data that were obviously poor, and so they were rejected

3.3.3 Convergence

convergence

Boilerplate, revisit:

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 Stock Synthesis option that generates random starting values from a normal distribution logistically transformed into each parameter's range (Methot 2015). Table **??** *shows the results of running 100 jitters for each pre-STAR base model. . . .*

3.4 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.*

##Model 1 ###Model 1 Base Case Results

Table **??**

3.4.1 Model 1 Uncertainty and Sensitivity Analyses

`model-1-uncertainty-and-sensitivity-analyses`

Table **??**

3.4.2 Model 1 Retrospective Analysis

`model-1-retrospective-analysis`

3.4.3 Model 1 Likelihood Profiles

`model-1-likelihood-profiles`

3.4.4 Model 1 Harvest Control Rules (CPS only)

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

3.4.5 Model 1 Reference Points (groundfish only)

`model-1-reference-points-groundfish-only`

Intro sentence or two....(Table **??***).*

Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$ is 3691.6 mt. Table i shows the full suite of estimated reference points for the northern area model and Figure i shows the equilibrium yield curve.

3.5 Model 2

model-2

3.5.1 Model 2 Base Case Results

model-2-base-case-results

3.5.2 Model 2 Uncertainty and Sensitivity Analyses

model-2-uncertainty-and-sensitivity-analyses

3.5.3 Model 2 Retrospective Analysis

model-2-retrospective-analysis

3.5.4 Model 2 Likelihood Profiles

model-2-likelihood-profiles

3.5.5 Model 2 Harvest Control Rules (CPS only)

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

3.5.6 Model 2 Reference Points (groundfish only)

model-2-reference-points-groundfish-only

4 Harvest Projections and Decision Tables

harvest-projections-and-decision-tables

Table k

Model 1 Projections and Decision Table (groundfish only) *(Table* **??**

Table m

Model 2 Projections and Decision Table (groundfish only)

Model 3 Projections and Decision Table (groundfish only)

5 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?*

6 Research Needs

research-needs

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

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