Agenda Item H.5
Attachment 25
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A 2019 catch-only projection from the 2013 Stock Assessment of Shortspine Thornyhead

by

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Executive Summary

Stock

This assessment applies to shortspine thornyhead (*Sebastolobus alascanus*) off of the west coast of the United States from the U.S.-Canadian border in the north to the U.S.-Mexico border in the south. Shortspine thornyheads have been reported as deep as 1,524 m, and this assessment applies to their full depth range although survey and fishery data are only available down to 1,280 m. This resource is modeled as a single stock because genetic analyses do not indicate significant stock structure within this range. This is the same stock assumption made in the most recent assessment of shortspine thornyhead in 2005 (Hamel, 2005).

Catches

Landings of shortspine are estimated to have risen to a peak of 4,815 mt in 1989, followed by a sharp decline during a period of trip limits and other management measures imposed in the 1990s. Since the institution of separate trip limits for shortspine and longspine thornyheads, the fishery had more moderate removals of between 1,000 and 2,000 mt per year from 1995 through 1998. Landings fell below 1,000 mt per year from 1999 through 2006, then rose to 1,531 in 2009 and have ranged from 800-1,000 mt per year from 2011 onward. Recreational fishery landings of thornyheads were negligible, so only commercial landings were included in the model. Trawl landings represent only bottom trawl gear and non-trawl landings include all other gears, the majority of which is longline, with some catch by pot gear. Both trawl and non-trawl landings are divided into North (the waters off Washington and Oregon) and South (the waters off California) fleets although they are assumed to be fishing on the same unit stock. Discard rates (landings divided by total catch) for shortspine have been estimated as high as 43% per year, but are more frequently below 20%. Discard rates in the trawl fisheries declined over the period where they are available from West Coast Groundfish Observer Program (WCGOP) from 2003–2011 and dropped to less than 1% in 2011, the only estimate available under catch shares system that began that year. For this catch-only projection, discards were calculated outside of the model (using the sector-specific, model-estimated discard rates in 2011) and included in total catch estimates for the years 2013-2018. The discard rates used were 0.7% for Trawl North, 0.9% for Trawl South, 8% for Non-trawl North and 5.5% for Non-trawl South). The calculated discards represented about 2% of the landings for the years 2011 onward, which is slightly higher than the 1% rate in 2011 due to the model not perfectly fitting the observed rate. Total catch was projected for the years 2019-2030 using GMT provided catch projections for 2019 and 2020, and model forecasted ABC values for 2021-2030.

Table a: Recent Landings and estimated total dead catch (landings + dead discards)

Year	Landings (mt)					Dead catch (mt)
	Trawl N	Trawl S	Non-trawl N	Non-trawl S	Total	Total
2007	562	279	16	143	1000	1058
2008	902	325	20	175	1423	1507
2009	948	382	29	172	1531	1619
2010	770	357	22	206	1355	1431
2011	424	287	24	237	972	994
2012	381	323	36	155	894	911
2013	516	327	19	147	1009	1026
2014	410	277	20	128	835	850
2015	479	268	19	112	879	893
2016	533	231	27	142	933	950
2017	551	214	39	187	991	1011
2018	493	153	32	152	830	847

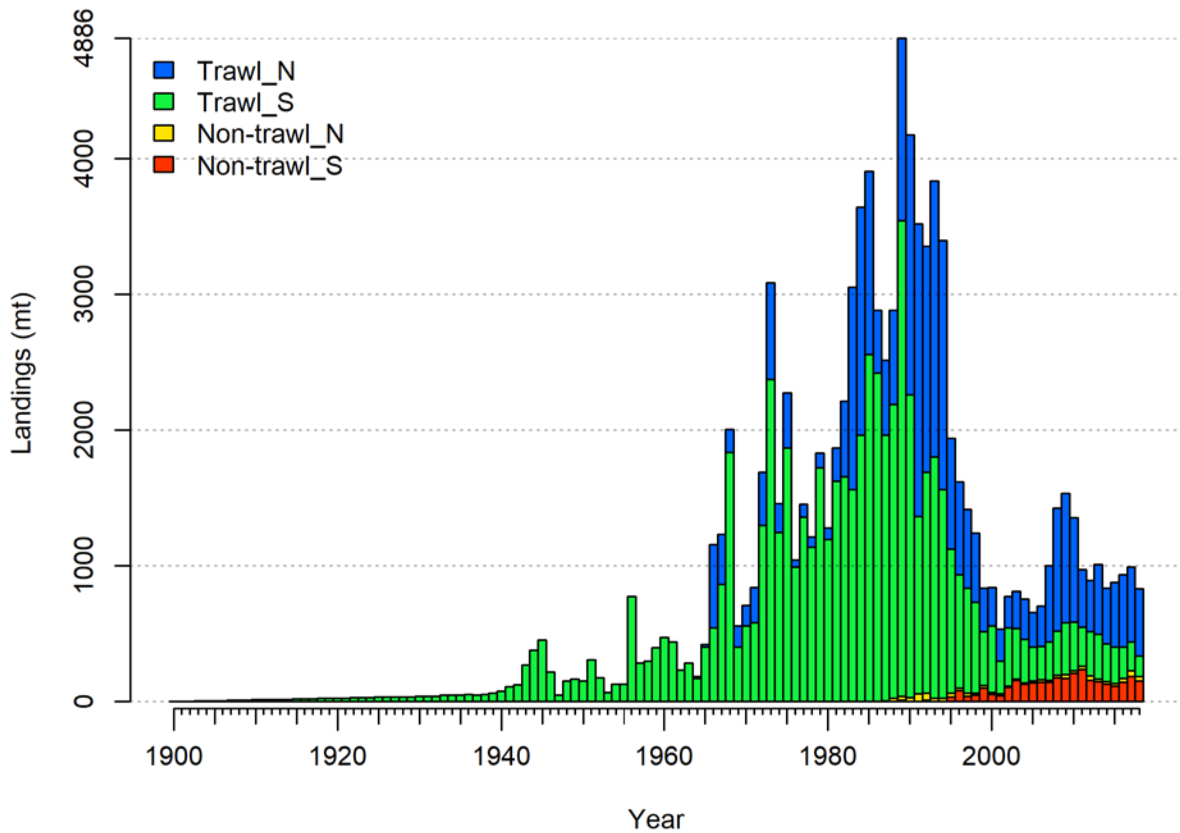

Figure a: Landings History

Data and assessment

The most recent full assessment for shortspine thornyhead was conducted in 2013. Stock status was determined to be above the target biomass and catches did not attain the full management limits so reassessment of thornyheads has not been a higher priority. This catch-only update of that model retains the use of Stock Synthesis Version 3.24o.

The data are divided into four fisheries: trawl and non-trawl gears, which are each divided into North (the waters off Washington and Oregon) and South (the waters off California) and five surveys: the Alaska Fisheries Science Center (AFSC) triennial shelf survey from 55-366 meters (1980-2004), the deeper range of triennial shelf survey from 366-500 meters for the later years (1995-2004), the AFSC slope survey (1997, 1999-2001), the Northwest Fisheries Science Center (NWFSC) slope survey (1998-2002) and the NWFSC combined shelf-slope survey (2003-2012).

Catches for the years 2013-2018 were added for this catch-only update, but otherwise the data were unchanged. Those data included length compositions from each fishing fleet and survey, indices of abundance derived from GLMM analyses of survey data, discard rates, and the time series of catch

No age data are used in this analysis and growth parameters are fixed at the same values used in 2005 and 2013. Parameters for steepness of the stock-recruit relationship and natural mortality are likewise fixed in this assessment. There are 229 estimated parameters in the assessment. The log of the unfished equilibrium recruitment, log(R_0), controls the scale of the population, annual deviations around the stock-recruit curve (169 parameters) allow for more uncertainty in the population trajectory, and selectivity and retention of the 4 fishing fleets and 5 surveys, including estimates of changes in retention over time (58 parameters). Finally, there is a single parameter which represents additional variability in one of the surveys that is added to the estimate of sampling error for that index.

Stock biomass

Unfished equilibrium spawning biomass (B_0) is estimated to be 189,765 mt, with a 95% confidence interval of 57,435 – 322,095 mt. The B_0 estimate represents an increase from the 130,646 mt estimate for B_0 in the previous assessment although this previous estimate falls well within the uncertainty interval around the current estimate. Spawning biomass is estimated to have remained stable until the mid-1970s and then declined from the 1970s to about 80% in the 1990s, followed by a slower decline under the lower catch levels in the 2000s. The estimated spawning biomass in 2019 is 139,049, very similar to the 2013 estimate of 140,753 mt. This value represent a stock status or “%unfished” (represented as spawning biomass divided by B_0) of 73.3% in 2019. The standard deviation of the log of spawning biomass in 2019 is $\sigma = 0.46$, which is lower than the default values used in p* adjustments to OFL values for either Category 1 or 2 stocks.

Table b: Recent trend in beginning of the year biomass and %unfished

Year	Spawning biomass (1000 mt)	~95% confidence interval	Estimated %unfished	~95% confidence interval
2007	144,319	14,063–274,575	76.1	59.7–92.4
2008	143,841	13,439–274,243	75.8	59.2–92.4
2009	143,121	12,559–273,683	75.4	58.4–92.4
2010	142,330	11,613–273,047	75	57.7–92.3
2011	141,628	10,773–272,483	74.6	57.0–92.3
2012	141,166	10,194–272,138	74.4	56.5–92.3
2013	140,753	9,673–271,833	74.2	56.1–92.3
2014	140,299	9,103–271,495	73.9	55.6–92.2
2015	139,993	8,657–271,329	73.8	55.3–92.3
2016	139,717	8,212–271,222	73.6	55.0–92.3
2017	139,454	7,759–271,149	73.5	54.6–92.3
2018	139,191	7,294–271,088	73.3	54.3–92.4
2019	139,049	6,950–271,148	73.3	54.1–92.5

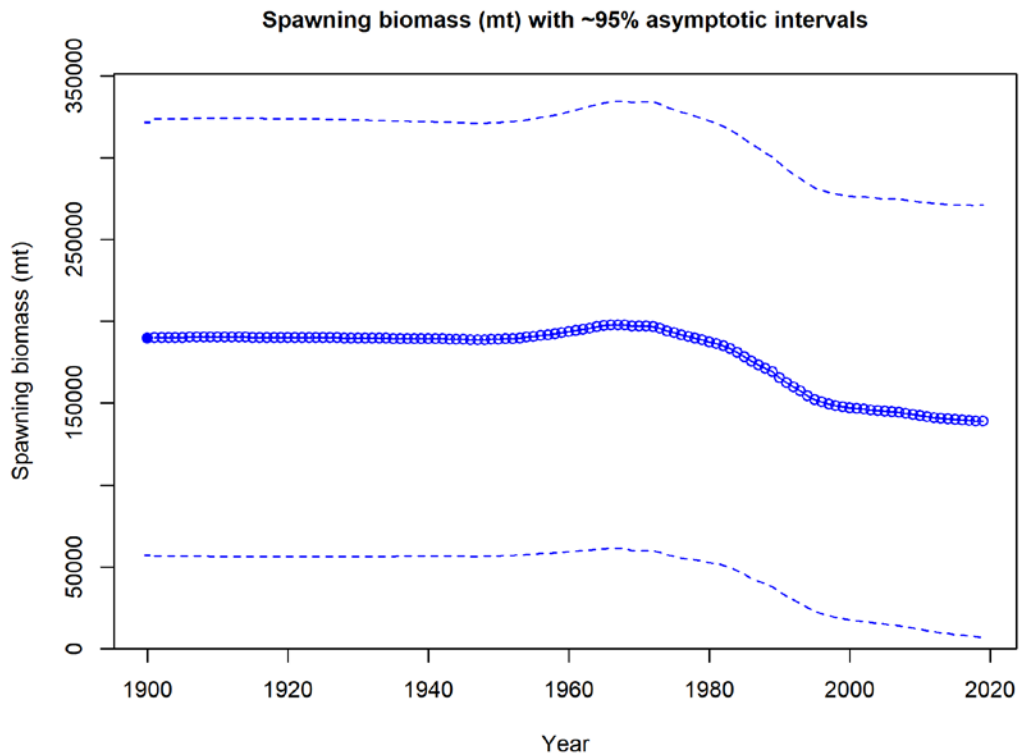

Figure b: Biomass trajectory

Recruitment

This assessment assumed a Beverton-Holt stock recruitment relationship. Steepness (the fraction of expected equilibrium recruitment associated with 20% of equilibrium spawning biomass) was kept at the value of 0.6 that was assumed in the previous assessment, although the results were relatively insensitive to alternative assumptions about steepness. The scale of the population is estimated through the log of the initial recruitment parameter (R_0). Recruitment deviations were estimated for the years 1850 through 2018, although there is no length composition data to influence the estimates in the later years so the deviations from 2013 to 2018 are all estimated at 0. The values estimated in the years 1850 through 1900 are used to estimate a non-equilibrium age-structure in 1901, which is the first year of the population projection. Estimated recruitments do not show high variability, and the uncertainty in each estimate is greater than the variability between estimates.

Table c: Recent recruitment

Year	Estimated recruitment (thousands)	+-~95% confidence interval
2007	33,038	10,832–100,770
2008	30,920	10,134–94,341
2009	30,194	9,864–92,425
2010	30,469	9,934–93,455
2011	27,420	8,978–83,740
2012	28,800	9,290–89,282
2013	28,770	9,285–89,142
2014	28,750	9,275–89,121
2015	28,737	9,267–89,110
2016	28,725	9,260–89,104
2017	28,713	9,253–89,099
2018	28,701	9,246–89,096

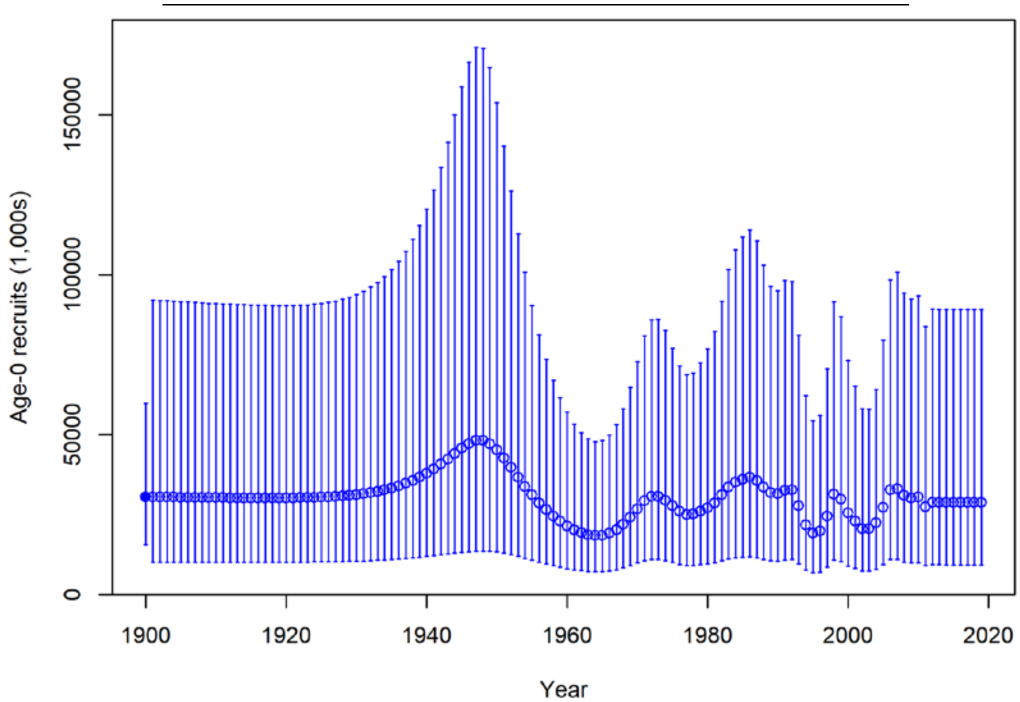

Figure c: Recruitment

Exploitation status

The summary harvest rate (total catch divided by age-1 and older biomass) closely follows the patterns of landings. The harvest rates are estimated to have never exceeded 2% and have remained below 1% in the past decade. Expressing exploitation rates in terms of spawning potential ratio (SPR) indicates that the exploitation slightly exceeded the target reference point associated with $SPR_{50\%}$ for a single year in 1985 and then for the period 1989-1994. However, the stock status is estimated to have never fallen below the $B_{40\%}$ management target.

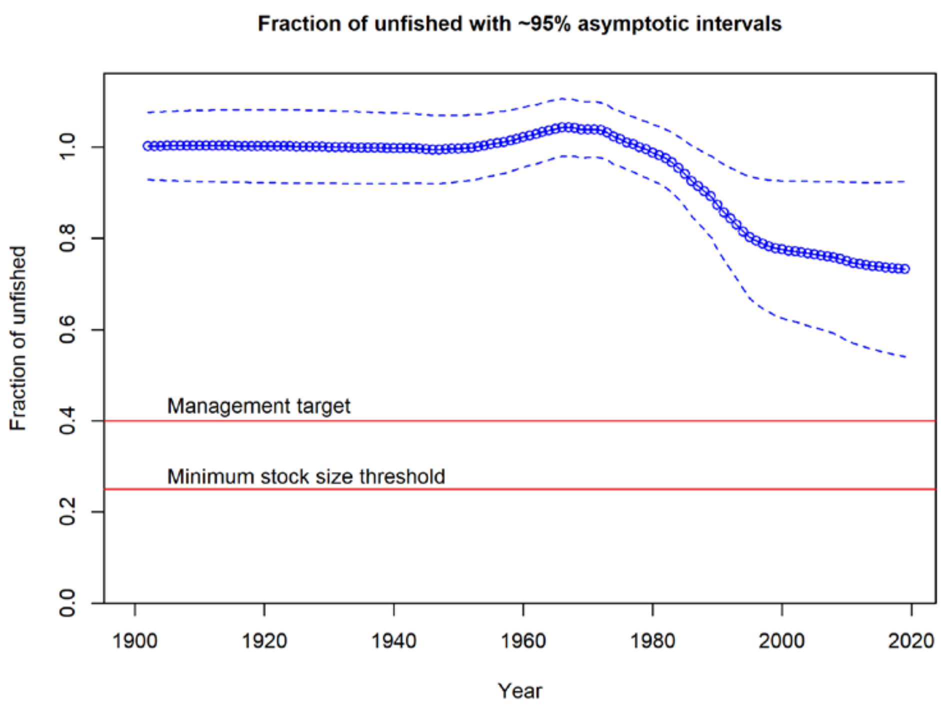

Figure d. Estimated fraction unfished with approximate 95% asymptotic confidence intervals (shaded area) for the base case assessment model.

Table d. Recent trend in fishing intensity represented as (1-SPR)/(1-SPR_{target}) = (1-SPR)/0.5 and summary exploitation rate (catch divided by biomass of age-1 and older fish).

Year	Estimated fishing intensity (%)	~95% confidence interval	Harvest rate (proportion)	~95% confidence interval
2007	43.6	9.17–78.03	0.0042	0.0004–0.0081
2008	59.36	15.22–103.50	0.0061	0.0005–0.0116
2009	62.78	16.48–109.07	0.0065	0.0005–0.0126
2010	56.53	13.36–99.70	0.0058	0.0004–0.0112
2011	40.53	7.33–73.73	0.0041	0.0003–0.0078
2012	37.35	6.29–68.41	0.0037	0.0002–0.0072
2013	42.15	7.63–76.67	0.0042	0.0003–0.0082
2014	35.55	5.60–65.51	0.0035	0.0002–0.0068
2015	37.48	6.07–68.90	0.0037	0.0002–0.0071
2016	39.72	6.63–72.80	0.0039	0.0002–0.0076
2017	41.76	7.15–76.38	0.0042	0.0002–0.0081
2018	35.94	5.43–66.45	0.0035	0.0002–0.0068

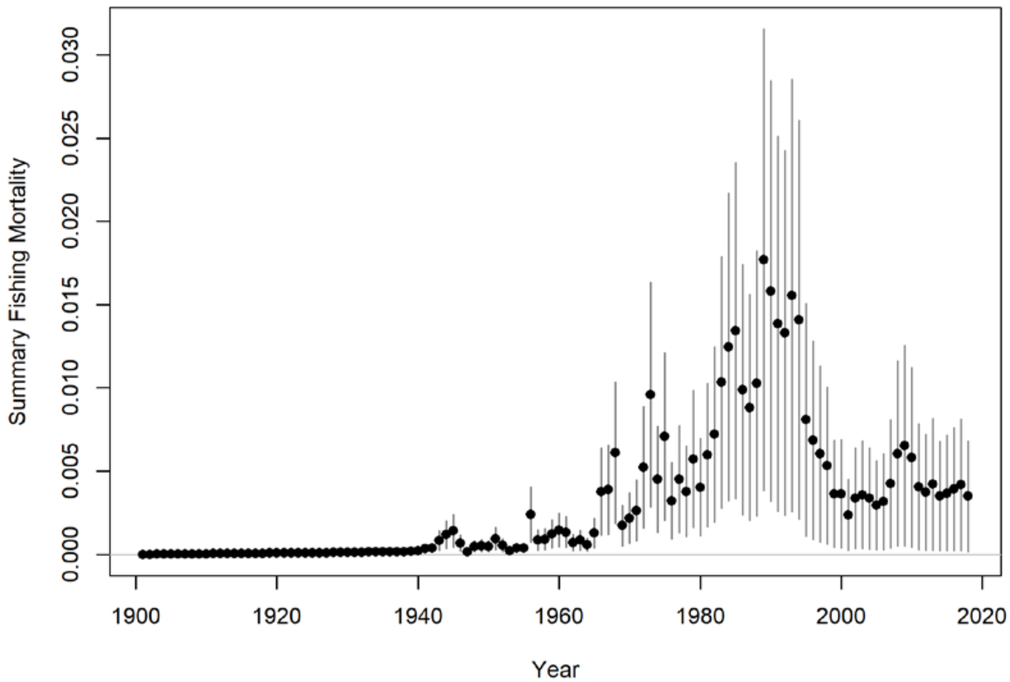

Figure e. Time-series of estimated summary harvest rate (total catch divided by age-1 and older biomass) for the base case model (round points) with approximate 95% asymptotic confidence intervals (grey lines).

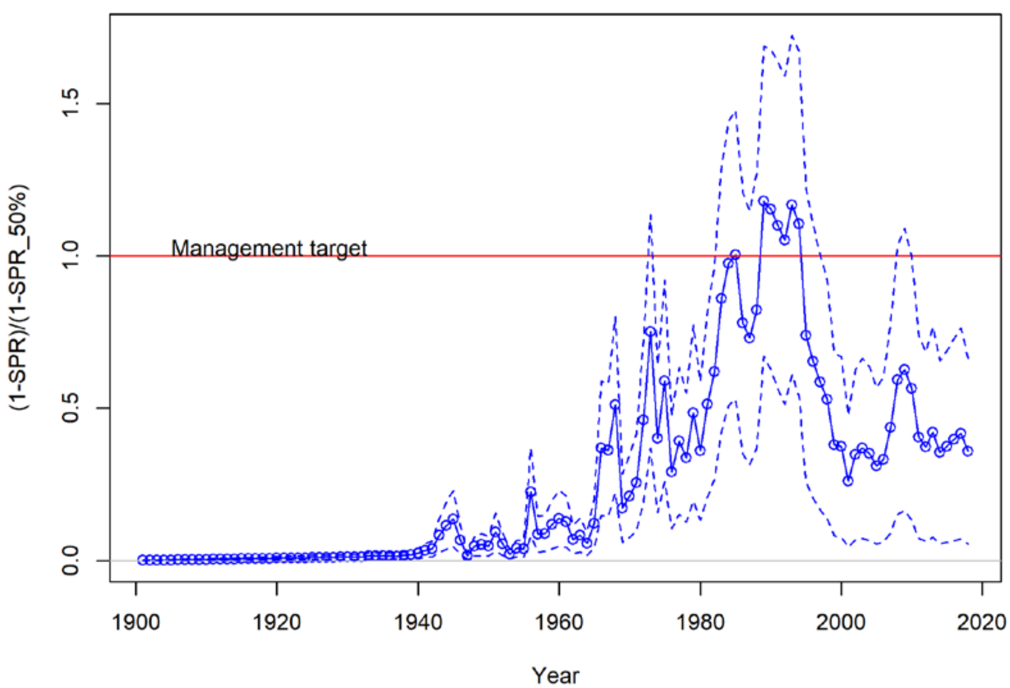

Figure f. Estimated spawning potential ratio (SPR) for the base case model with approximate 95% asymptotic confidence intervals. Both one minus SPR (right y-axis) and the ratio of this quantity to the associated target (1 - $SPR_{50\%}$) (left y-axis) are shown. These quantities are chosen so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the $SPR_{50\%}$.

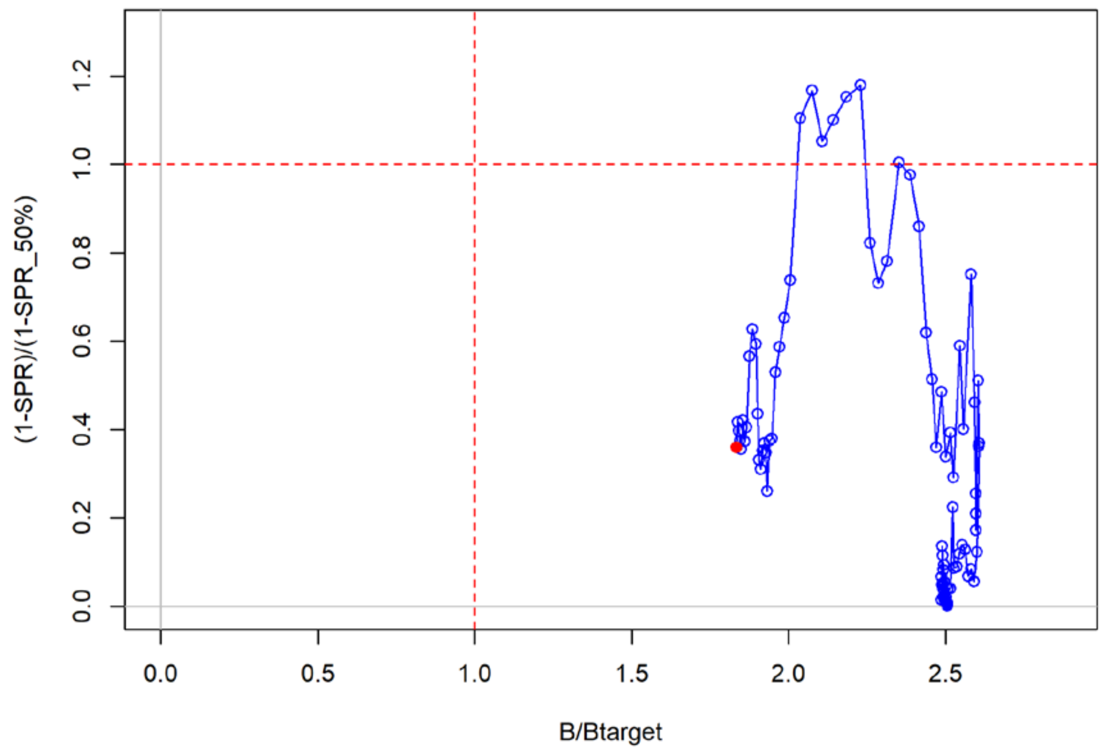

Figure g. Phase plot of estimated relative (1-SPR) vs. relative spawning biomass for the base case model. The relative (1-SPR) is (1-SPR) divided by 50% (the SPR target). B/Btarget is the %unfished, the annual spawning biomass divided by the spawning biomass corresponding to 40% of the unfished spawning biomass. The red point indicates the year 2018.

Ecosystem considerations

Shortspine and longspine thornyheads have historically been caught with each other and with Dover sole and sablefish, making up a "DTS" fishery. Other groundfishes that frequently co-occur in these deep waters include a complex of slope rockfishes, rex sole, longnose skate, roughtail skate, Pacific grenadier, giant grenadier, Pacific flatnose as well as non-groundfish species such as Pacific hagfish and a diverse complex of eelpouts. Shortspine thornyheads typically occur in shallower water than the shallowest longspine thornyheads, and migrate to deeper water as they age. When shortspines have reached a depth where they overlap with longspines, they are typically larger than the largest longspines. Shortspine thornyhead stomachs have been found to include longspine thornyheads, suggesting a predator-prey linkage between the two species.

Thornyheads spawn gelatinous masses of eggs which float to the surface. This may represent a significant portion of the upward movement of organic carbon from the deep ocean (Wakefield, 1990). Thornyheads have been observed in towed cameras beyond the 1280 meter limit of the current fishery and survey, but their distribution, abundance, and ecosystem interactions in these deep waters are relatively unknown.

Reference points

Reference points were calculated using the estimated catch distribution among fleets in the last year of the model (2012), and the estimated values are dependent on this assumption. In general, the population is at a healthy status relative to the reference points. Sustainable total yield (landings plus discards) was estimated at 2,034 mt when using an $SPR_{50\%}$ reference harvest rate and ranged from 633 – 3,435 mt based on estimates of uncertainty. The spawning biomass equivalent to 40% of the unfished spawning output ($B_{40\%}$) was 75,906 mt. The most recent catches (landings plus discards) have been lower than the estimated long-term yields calculated using an $SPR_{50\%}$ reference point, but not as low as the lower bound of the 95% uncertainty interval. However, this is due to the fishery not fully attaining the full ACL. As a result of the 2013 assessment, the OFL and ACL values increased in 2015 to just over 3,000 mt and around 2,600 mt respectively..

Table e. Summary of reference points and management outputs for the base case model.

Quantity	Estimate	~95% confidence interval
Unfished Spawning biomass (mt)	189,765	(57,435 – 322,095)
Unfished age 1+ biomass (mt)	331,047	(100,196 – 561,898)
Unfished recruitment (R0, millions)	30.4	(15.2 – 61.1)
%Unfished (2019)	73.3%	(54.1% – 92.5%)
Spawning Biomass (2019)	139,109	(6,950 – 271,148)
SD of log Spawning Biomass (2019)	0.46	–
Reference points based on $B_{40\%}$		
Proxy spawning biomass ($B_{40\%}$)	75,906	(22,974 – 128,838)
SPR resulting in $B_{40\%}$ ($SPR_{SB40\%}$)	50.0%	–
Exploitation rate resulting in $B_{40\%}$	0.015	(0.015 – 0.016)
Yield with $SPR_{50\%}$ at $B_{40\%}$ (mt)	2,034	(633 – 3,435)
Reference points based on SPR proxy for MSY		
Spawning biomass	75,906	(22,974 – 128,838)
SPR_{proxy}	50.0%	–
Exploitation rate corresponding to SPR_{proxy}	0.015	(0.015 – 0.016)
Yield with SPR_{proxy} at SB_{SPR} (mt)	2,034	(633 – 3,435)
Reference points based on estimated MSY values		
Spawning biomass at MSY (SB_{MSY})	64,600	(19,517 – 109,683)
SPR_{MSY}	45.0%	(44.9% – 45.2%)
Exploitation rate corresponding to SPR_{MSY}	0.018	(0.018 – 0.019)
MSY (mt)	2,062	(642 – 3,482)

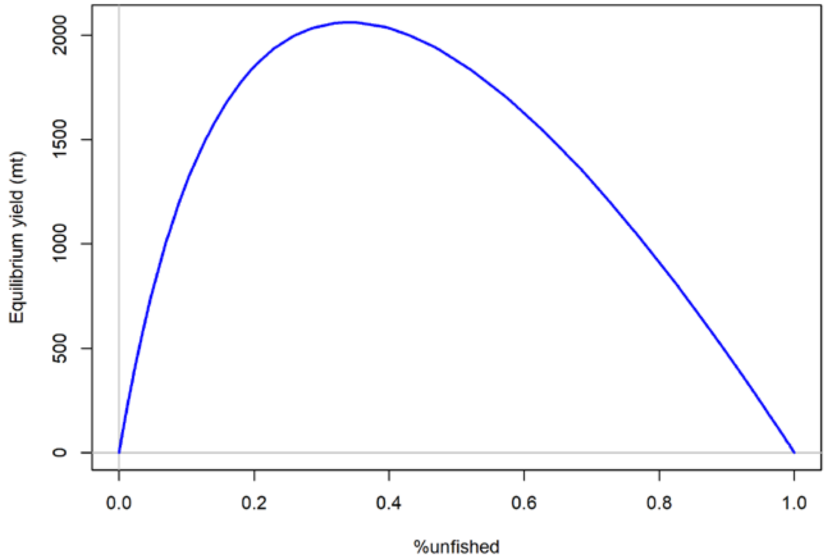

Figure h. Equilibrium yield curve (derived from reference point values reported in Table i) for the base case model. Values are based on 2012 relative catch among fleets. The %unfished is relative to unfished spawning biomass.

Management performance

Catches for shortspine thornyheads have not fully attained the catch limits in recent years. Increases in ACLs in 2007 was associated with higher catch levels in 2006–2010, but in 2011 and 2012, catches were about half of the allowed limit. The fishery for shortspine thornyhead may be limited more by the ACLs on sablefish with which they co-occur and by the challenging economics of deep sea fishing, than by the management measures currently in place. Total annual catch including estimated discards added to this catch-only update for the years 2013-2018 ranged from 1,026 mt in 2013 to 847 in 2018. The catch limits for this period increased from 2,230 in 2013 to 2,573 in 2018 causing the ratio of estimated total catch to catch limit to decrease from 46% in 2013 to 33% in 2018.

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.

Year	OFL (mt)	ACL (mt)	Commercial Landings (mt)	Estimated Total Catch (mt)
2007	2,476	2,055	1,006	1,058
2008	2,476	2,055	1,427	1,507
2009	2,437	2,022	1,531	1,619
2010	2,411	2,001	1,353	1,431
2011	2,384	1,978	974	994
2012	2,358	1,957	894	911
2013	2,333	2,230	1009	1026
2014	2,310	2,208	835	850
2015	3,202	2,668	879	893
2016	3,169	2,640	933	950
2017	3,144	2,619	991	1011
2018	3,116	2,596	830	847
2019	3,089	2,573		

Unresolved problems and major uncertainties

The absence of a reliable ageing method provides a significant hindrance to estimating growth and natural mortality of shortspine thornyhead. New maturity data made available for this assessment indicate puzzling patterns of maturity, with higher rates of maturity in the north than in the south and a higher fraction of mature fish in the samples with length 20–30 cm than in the samples from 30–40cm. The relative distribution of different sizes of shortspine thornyheads, with smaller fish occurring shallower and further the north, suggests an ontogenetic migration pattern to deeper and more southern waters, with a potentially J-shaped pattern of migration. Understanding the rates and patterns of thornyhead migration and any potential interaction or confounding with spatial patterns of fishing would be valuable for understanding better appropriate ways to model this stock.

The indices of abundance are all relatively flat, providing little information about the scale of the population (other than providing evidence that it has not been declining). The current NWFSC index has the largest number of data points of any available index on the west coast, and each additional year of this index will be valuable for understanding any changes in size composition or abundance. However, in the absence of large changes in shortspine catch, the population is estimated to remain similar to its current state.

Projections and Decision table

The 2013 assessment estimated the standard deviation of the log of spawning biomass in 2013 at $\sigma = 0.45$. This value was greater than the 0.36 minimum used for Category 1 stocks and was initially used in the p^* calculations in the decision table. However, the shortspine thornyhead assessment was later assigned to Category 2, where the default minimum was $\sigma = 0.72$. The associated offset associated with the $\sigma = 0.45$ was a multiplication of the OFL by 94.5% to calculate the ACL. This catch-only update applies the new time-varying buffer associated with a higher initial default $\sigma = 1.0$ for Category 2 stocks with the multiplier on the OFL decreasing from 0.826 in 2021 to 0.758 in 2030. Twelve-year projections through 2030 were conducted with a total catch assumed equal to the ACL calculated by applying these adjustments to the estimated OFLs for each year. The retention function was assumed to match the average values for 2011–2012 (the only years with composition data in which the trawl fishery was operating under IFQs). Catch projections provided by the Groundfish Management Team were used for the years 2019 and 2020 for which harvest specifications have already been set. The allocation among fleets for the years 2021–2030 was based on the estimated 2020 catch which was 54% for Trawl North, 26% for Trawl South, 3% for Non-trawl North, and 17% for Non-trawl South.

This default harvest rate projection applied to the base model indicated that the stock status would slowly decline from 73.3% in 2019 to 68.3% in 2024, still far above the 40% biomass target and 25% minimum stock size threshold. The associated OFL values over the period 2021–2030 would average 3,106 mt. ACL values would decrease from 2,652 in 2021 to 2,285 in 2030 due to the increasing buffer associated with the time-varying σ. These ACL values are below recent catch limits, but well above recent catches. In these projections, the stock status was always above 40%, so the 40-10 adjustment in the control rule had no impact on the projections.

Table g. Projection of potential OFL, ACL, and associated p* buffer, summary biomass (age-1 and older), spawning biomass, and %Unfished for the base case model projected from 2019 onward. The OFL for 2021 and onward is the calculated total catch determined by F_{SPR}.

Year	Predicted OFL (mt)	ACL Catch (mt)	Buffer	Age 1+ biomass (mt)	Spawning Biomass (mt)	%Unfished
2019	3,202	919	NA	241,457	139,049	73.3
2020	3,206	913	NA	241,199	138,884	73.2
2021	3,211	2,652	0.826	240,983	138,739	73.1
2022	3,185	2,605	0.818	238,919	137,590	72.5
2023	3,160	2,560	0.810	236,918	136,471	71.9
2024	3,136	2,518	0.803	234,982	135,384	71.3
2025	3,113	2,475	0.795	233,108	134,328	70.8
2026	3,091	2,436	0.788	231,298	133,305	70.3
2027	3,070	2,395	0.780	229,549	132,313	69.7
2028	3,051	2,358	0.773	227,865	131,356	69.2
2029	3,032	2,322	0.766	226,241	130,432	68.7
2030	3,014	2,285	0.758	224,677	129,540	68.3

Additional projections were conducted for the base model and low and high states of nature (columns) under three catch streams (rows). The uncertainty in spawning biomass associated with the base model was very broad, so states of nature were chosen based on this range. The axis of uncertainty was equilibrium recruitment, with the low and high states of nature having fixed log(R_0) values of 9.8 and 10.8 respectively, compared to an estimate for the base model of 10.32. More detail on the derivation of these values is provided in the 2013 assessment report.

The catch streams chosen for the decision table were represented as total catch rather than landed catch, but discard rates were low under IFQs, so the difference in between total catch and landings is small. The low catch stream was retained from the 2013 assessment, which used average total catch over the years 2011–2012, the years in which the trawl fishery was operating under IFQs was used as a low catch stream. This was a total catch of 952 mt, which is similar to the 929 mt average total catch for the years 2013–2018. The high catch stream used the default harvest rate projection described above. The middle catch stream was a constant total catch of 1,700 mt, which was approximately half-way between the low catch stream and the high catch stream. This replaced a SPR = 65% projection in the 2013 assessment.

The most pessimistic forecast scenario, combining the low state of nature with the high catch stream, resulted in a projected stock status of 46.1%, above the target value. All other projections led to a higher projected status, with a maximum of 83.5% for the combination of the high state of nature and low catch. Forecasts under the base case led to estimated status in 2030 ranging from values of 68.3% in the high catch stream to 72.7% in the low catch stream.

No projections were done to explore changes in ratio of trawl to non-trawl or north to south. Due to differences in selectivity and retention among the fleets, these projections could be expected to provide slightly different results, although the general pattern of the projections suggesting stocks above target levels as described above is unlikely to change as a result of alternative ratios among the fleets.

Table h. Summary table of 12-year projections beginning in 2015 for alternate states of nature based on an axis uncertainty. Columns range over low, mid, and high state of nature, and rows range over different assumptions of catch levels.

			State of nature					
			Low		Base case		High	
Relative probability of log(R_0)			0.25		0.5		0.25	
Management decision	Year	Total catch (mt)	Spawning biomass (mt)	%Unfished	Spawning biomass (mt)	%Unfished	Spawning biomass (mt)	%Unfished
Low catch stream from 2013 assessment (similar to recent average)	2021	952	61,794	55.0%	138,739	73.1%	254,769	83.4%
	2022	952	61,567	54.8%	138,587	73.0%	254,755	83.4%
	2023	952	61,357	54.6%	138,452	73.0%	254,752	83.4%
	2024	952	61,164	54.4%	138,336	72.9%	254,762	83.4%
	2025	952	60,989	54.2%	138,237	72.8%	254,787	83.4%
	2026	952	60,830	54.1%	138,156	72.8%	254,824	83.4%
	2027	952	60,688	54.0%	138,092	72.8%	254,875	83.4%
	2028	952	60,560	53.9%	138,045	72.7%	254,938	83.4%
	2029	952	60,446	53.8%	138,012	72.7%	255,011	83.4%
	2030	952	60,347	53.7%	137,995	72.7%	255,096	83.5%
Constant catch of 1,700 mt	2021	1,700	61,794	55.0%	138,739	73.1%	254,769	83.4%
	2022	1,700	61,128	54.4%	138,148	72.8%	254,316	83.2%
	2023	1,700	60,472	53.8%	137,568	72.5%	253,867	83.1%
	2024	1,700	59,825	53.2%	136,998	72.2%	253,426	82.9%
	2025	1,700	59,188	52.6%	136,441	71.9%	252,992	82.8%
	2026	1,700	58,561	52.1%	135,895	71.6%	252,567	82.6%
	2027	1,700	57,944	51.5%	135,362	71.3%	252,150	82.5%
	2028	1,700	57,336	51.0%	134,841	71.1%	251,742	82.4%
	2029	1,700	56,739	50.5%	134,332	70.8%	251,343	82.2%
	2030	1,700	56,151	49.9%	133,834	70.5%	250,951	82.1%
ACL (associated with SPR = 50%), including time-varying *p** offset	2021	2,652	61,794	55.0%	138,739	73.1%	254,769	83.4%
	2022	2,605	60,570	53.9%	137,590	72.5%	253,758	83.0%
	2023	2,560	59,374	52.8%	136,471	71.9%	252,772	82.7%
	2024	2,518	58,206	51.8%	135,384	71.3%	251,814	82.4%
	2025	2,475	57,066	50.8%	134,328	70.8%	250,883	82.1%
	2026	2,436	55,956	49.8%	133,305	70.2%	249,982	81.8%
	2027	2,395	54,874	48.8%	132,313	69.7%	249,111	81.5%
	2028	2,358	53,823	47.9%	131,356	69.2%	248,270	81.2%
	2029	2,322	52,801	47.0%	130,432	68.7%	247,459	81.0%
	2030	2,285	51,809	46.1%	129,540	68.3%	246,677	80.7%

Table i. Summary table of the results.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Commercial landings (mt)	1000	1423	1531	1355	972	894	993	821	865	918	972	815	1000
Estimated Total catch (mt)	1058	1507	1619	1431	994	911	1009	835	879	933	991	830	1058
OFL (mt)	2,476	2,476	2,437	2,411	2,384	2,358	2,333	2,310	3,202	3,169	3,144	3,116	3,089
ACL (mt)	2,055	2,055	2,022	2,001	1,978	1,957	2,230	2,208	2,668	2,640	2,619	2,596	2,573
Fishing intensity (%)	43.6	59.4	62.8	56.5	40.5	37.4	42.2	35.6	37.5	39.7	41.8	35.9	NA
Exploitation rate (catch/ age 1+ bio.)	0.0042	0.0061	0.0065	0.0058	0.0041	0.0037	0.0042	0.0035	0.0037	0.0039	0.0042	0.0035	NA
Age 1+ biomass (mt)	249,505	248,709	247,448	246,086	244,953	244,325	243,824	243,234	242,872	242,500	242,102	241,673	241,457
Spawning Biomass (mt)	144,319	143,841	143,121	142,330	141,628	141,166	140,753	140,299	139,993	139,717	139,454	139,191	139,049
~95% Confidence Interval	14,063–274,575	13,439–274,243	12,559–273,683	11,613–273,047	10,773–272,483	10,194–272,138	9,673–271,833	9,103–271,495	8,657–271,329	8,212–271,222	7,759–271,149	7,294–271,088	6,950–271,148
Recruitment (millions)	33,038	30,920	30,194	30,469	27,420	28,800	28,770	28,750	28,737	28,725	28,713	28,701	28,695
~95% Confidence Interval	10,832–100,770	10,134–94,341	9,864–92,425	9,934–93,455	8,978–83,740	9,290–89,282	9,285–89,142	9,275–89,121	9,267–89,110	9,260–89,104	9,253–89,099	9,246–89,096	9,241–89,100
%Unfished (%)	76.1	75.8	75.4	75.0	74.6	74.4	74.2	73.9	73.8	73.6	73.5	73.3	73.3
~95% Confidence Interval	59.7–92.4	59.2–92.4	58.4–92.4	57.7–92.3	57.0–92.3	56.5–92.3	56.1–92.3	55.6–92.2	55.3–92.3	55.0–92.3	54.6–92.3	54.3–92.4	54.1–92.5

Research and data needs

Research and data needs for future assessments include the following:

1) More investigation into maturity of shortspine is necessary to understand the patterns in maturity observed in the samples collected in 2011 and 2012.
2) Information on possible migration of shortspine thornyheads would be valuable for understanding stock dynamics. Analysis of trace elements and stable isotopes in shortspine otoliths is ongoing and may provide valuable information on the extent of potential migrations. Possible connections between migration and maturity could likewise be explored.
3) A greater understanding of catchability of thornyheads would help define the scale of the populations. This could include a survey using a towed camera to assess the abundance in water beyond the 1280 m range of the trawl surveys. Further exploration of perceived differences in catchability between towed cameras and trawl nets could also be explored. Understanding the relative catchability of shortspine and longspine thornyhead, which are difficult to distinguish in camera observations, would have to be a component of such investigations. Differences in selectivity between the AFSC Slope survey and the NWFSC surveys may be the result of behavioral interactions with different footropes. Understanding these interactions would also improve understanding of catchability.
4) Age data would be valuable for future stock assessments. Otoliths have been collected in good quantities from the NWFSC survey, but at this time the ageing methods are not believed to be reliable. Additional research on ageing methods for thornyheads would be valuable.
5) A greater understanding of the connection between thornyheads and bottom type could be used to refine the indices of abundance. Thornyheads are very well sampled in trawlable habitat, but the extrapolation of density to a survey stratum could be improved by accounting for the proportion of different bottom types within a stratum and the relative density of thornyheads within each bottom type.
6) A comprehensive catch reconstruction for shortspine and longspine thornyheads should be completed to estimate landings for each species prior to 1981 in each of the three states.
7) Exploration of simpler assessment methods for thornyheads and evaluation of whether such methods would provide a more robust management strategy than the current approach. It is likely that any significant reduction in the size of the shortspine thornyhead population would be apparent in the NWFSC Combo Survey index. A method for setting and/or adjusting catch limits based on either absolute values or trends in the survey has the potential to be much less labor intensive than the current assessment approach.
8) More tows or visual surveys south of 34.5 deg. N. lat. including the large Cowcod Conservation Area. Because the southern Conception Area is a large potential habitat for thornyheads, more sampling effort would help refine the estimations of their abundance in this area.