Agenda Item H.5
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Catch Only Update: Stock Assessment and Status of Longspine Thornyhead (*Sebastolobus altivelis*) off California, Oregon and Washington in 2019

by

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Executive Summary

Stock

This is a catch-only update to the 2013 assessment (Stephens & Taylor, 2013) of the longspine thornyhead (*Sebastolobus altivelis*) population located off the west coast of the continental USA, from the US/Canadian border in the north to the southern end of the Conception INPFC area (32.5° latitude). Longspine thornyheads have been reported from 200 meters to as deep as 1,755 m, however 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 longspine thornyhead in 2005 (Fay, 2005).

Landings and Catch

Landings of longspine were modeled as a single coast-wide fishery. Very small amounts of longspine thornyhead are caught using gears other than trawl; this catch was combined with the trawl catch. Recreational fishery landings of thornyheads were negligible, so only commercial landings were included in the model.

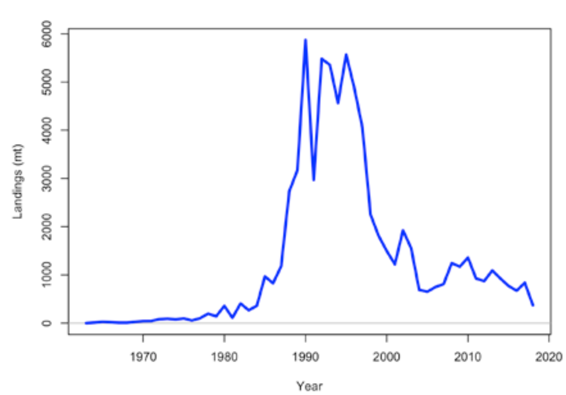
The fishery for thornyheads increased gradually during the 1960s and 1970s, but did not expand significantly until the late 1980s with the development of a market for smaller thornyheads. At their peak in the early 1990s, annual landings were over 6,000 mt. Landings have declined in recent years in response to increased management restrictions. Landings in this assessment were estimated for the period 1964-2012.

Discard rates (landings divided by total catch) for longspine have been estimated as high as 46% per year, but are more frequently below 20%. Discard rates in the trawl fisheries observed by the West Coast Groundfish Observer Program (WCGOP) from 2003–2011 were less than 20%, except in 2009 when they were 28%. Discard rates dropped to less than 5% in 2011.

Table a: Recent Catches

Years	Total Catch	Total Dead
2007	810	958
2008	1,243	1,467
2009	1,171	1,379
2010	1,359	1,593
2011	926	972
2012	871	912
2013	1,094	1,142
2014	926	964
2015	772	803
2016	673	698
2017	838	870
2018	371	385

Figure a: Catch History



Data and assessment

This is a catch-only update to the fifth stock assessment of West Coast longspine thornyhead (Stephens & Taylor, 2013). The previous stock assessments were conducted in 1990, 1992, 1994, and 1997, 2005, and most recently in 2013. Data sources, model structure, and assumptions made were the same as the 2013 assessment. Data sources included in the assessment are:

1. Commercial landings (1964-2018) and length composition information (1978-2012) from California, Oregon and Washington obtained from the PACFIN database;
2. Commercial landings from the California Department of Fish and Wildlife (CDFW, 1934-1980);
3. Commercial landings from the Oregon Department of Fish and Wildlife (ODFW, 1932-1986);
4. Discard rates and length compositions from an Oregon State University observer study (Pikitch, 1985-87);
5. Discard rates from the Enhanced Data Collection Project (EDCP, 1995-99);
6. Discard rates, length compositions, and mean body weights from the West Coast Groundfish Observer Program (WGCOP, 2002-2011);
7. Biomass indices and length-composition information from the Alaska Fisheries Science Center (AFSC 1997, 1999-2001) and Northwest Fisheries Science Center (NWFSC, 1998-2002) FRAM slope surveys.
8. Biomass indices and length-composition information from the Northwest Fisheries Science Center (NWFSC, 2003-2012) combined shelf-slope survey.

All data except commercial landings between 2013 and 2018 were used to fit an age-structured population dynamics model using the length-age-structured model Stock Synthesis 3, version 24o (Methot 2013). Parameters for this assessment included a natural mortality rate (M) of 0.11, and Beverton-Holt steepness (h) of 0.6. Fishery and survey selectivities were estimated as asymptotic, with the exception of the AFSC slope survey, which is domed.

All of the data used in the previous assessment has been retained and include: the time-series of landings from 1981-2012, the estimated historic catch for the years up to 1980, length compositions from each fishing fleet and survey, indices of abundance derived from new GLMM analyses of survey data, discard rates from both the 1980s Pikitch study and the current West Coast Groundfish Observer Program (WCGOP), and the discard rates from the EDCP study in the 1990s. As in the 2013 assessment, no age data is used in this analysis and growth parameters are fixed at the same values used in 2005. Additional years (2013-2018) of landings data were included in the catch only update and the population projected forward in time with the additional catches.

There are 103 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 allow for uncertainty in the population trajectory, as well as in the selectivity and retention in the fishery and surveys.

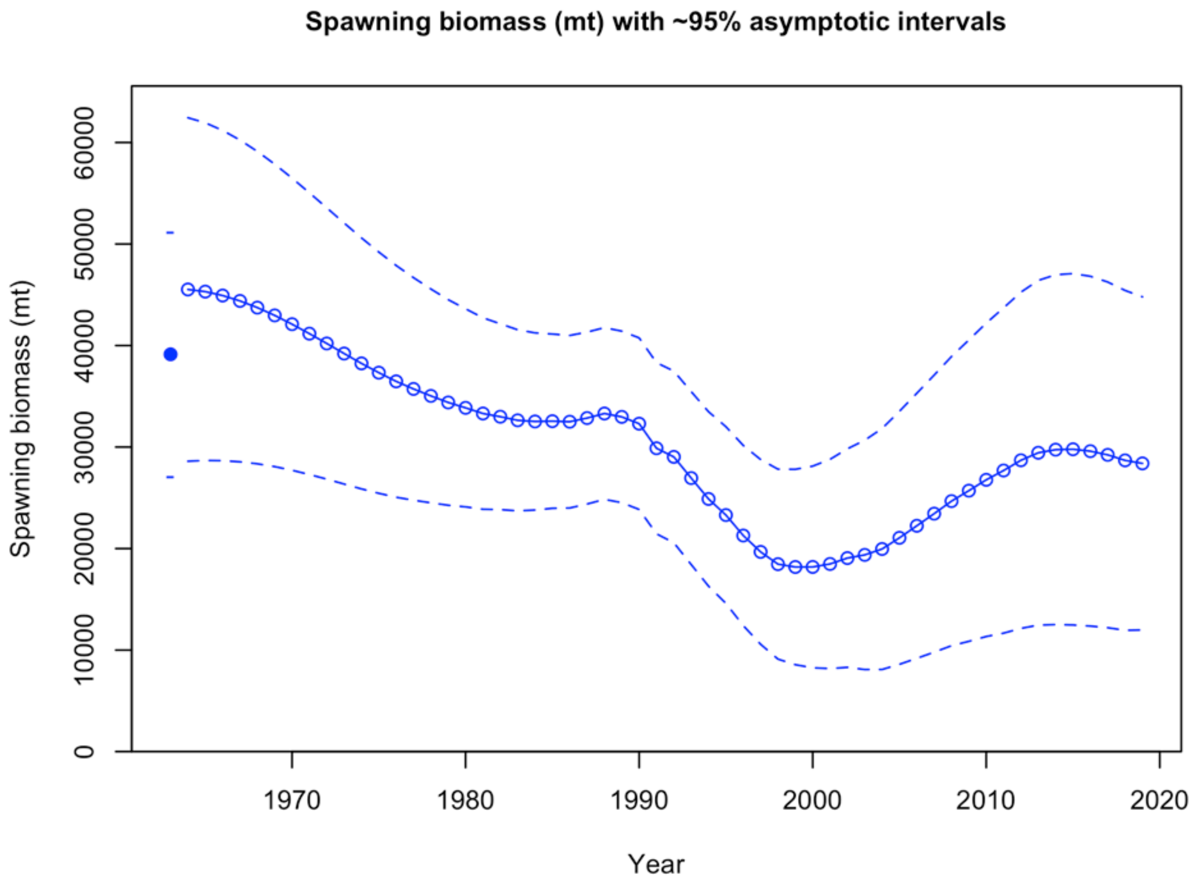
Stock biomass

Total and spawning biomass of longspine thornyhead declined from the beginning of the modeled period, in 1964, until the late 1990s, with the rate of this decline being highest from the late 1980s until the mid to late-1990s due to peak catches during that period. Total biomass reached a low of 48,200 mt (compared to an unexploited level of 91,509 mt) in 1998, and spawning biomass reached a low of 18,184 mt in 1999 (a depletion level of 46.5% of the unfished equilibrium level of 39,134). The stock, is currently only lightly exploited, and the current spawning biomass is estimated to be 28,687.8 mt (a depletion of 73%), with a 95% confidence interval of 11,982 - 44,796 mt.

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

Year	Spawning biomass (1000 mt)	~95% confidence interval	Estimated depletion	~95% confidence interval
2007	23,440	9,794-37,087	59.9	42.5-77.3
2008	24,674	10,432-38,917	63.1	45.0-81.1
2009	25,705	10,863-40,547	65.7	46.8-84.5
2010	26,771	11,336-42,206	68.4	48.8-88.0
2011	27,689	11,669-43,710	70.8	50.3-91.2
2012	28,698	12,138-45,257	73.3	52.2-94.5
2013	29,436	12,458-46,414	75.2	53.5-96.9
2014	29,744	12,514-46,974	76	53.8-98.2
2015	29,782	12,476-47,089	76.1	53.7-98.5
2016	29,593	12,365-46,820	75.6	53.3-98.0
2017	29,231	12,205-46,257	74.7	52.5-96.8
2018	28,688	11,949-45,427	73.3	51.5-95.1
2019	28,389	11,982-44,796	72.5	51.3-93.7

Figure b: Biomass trajectory



Recruitment

Expected annual recruitment was described by a Beverton-Holt function of spawning biomass. Annual deviations about this stock-recruitment curve were estimated for the years 1944 through 2018. The steepness parameter (*h*) was fixed at 0.6, and a likelihood profile conducted in 2013 over this parameter showed little sensitivity in the results to the value assumed for this parameter (Stephens & Taylor, 2013). They found that changing *h* to 0.779, the mean of the prior used in recent rockfish assessments (Thorson, 2013), changes the estimate of unfished equilibrium biomass by less than 1%. The impact of recruitment variability on the biomass for longspine thornyhead is low due to the long-lived nature of the species. The bulk of the biomass for this stock is contained in a large number of old age-classes. In addition, no age data are available for this species (other than that used to estimate growth). Estimation of recruitment events is therefore difficult, and information is only available to estimate recruitment for recent years when size-composition data from the slope surveys are available.

Table c: Recent recruitment

Year	Estimated recruitment (millions)	95% confidence interval
2007	65,196	27,452-154,838
2008	72,369	31,234-167,677
2009	67,170	27,834-162,096
2010	68,454	27,483-170,503
2011	92,717	35,502-242,135
2012	132,555	41,580-422,583
2013	129,422	40,852-410,013
2014	129,705	40,943-410,896
2015	129,740	40,952-411,025
2016	129,567	40,894-410,518
2017	129,232	40,783-409,511
2018	128,718	40,611-407,981
2019	128,428	40,528-406,968

Figure c: Recruitment

Exploitation status

The 2019 spawning biomass of longspine thornyhead is estimated to be 73% of the unexploited equilibrium level. The stock is therefore well above the management target of $SB_{40\%}$. The current fishing mortality rate is also well below the F_{msy} proxy ($F_{50\%}$).

Table d. Recent trend in spawning potential ratio (entered as (1-SPR)/(1-$SPR_{50\%}$)) and summary exploitation rate (catch divided by biomass of age-2 and older fish)

Years	Estimated (1-SPR)/(1-$SPR_{50\%}$) (%)	95% Asymptotic Interval	Harvest Rate (proportion)	95% Asymptotic Interval
2007	40.63	21.25-60.01	0.015	0.006-0.024
2008	54.05	30.58-77.51	0.023	0.009-0.036
2009	50.15	27.77-72.54	0.021	0.009-0.033
2010	54.16	30.64-77.68	0.024	0.010-0.038
2011	36.16	18.52-53.80	0.014	0.006-0.023
2012	33.23	16.82-49.63	0.013	0.006-0.021
2013	37.52	19.54-55.50	0.016	0.007-0.025
2014	32.08	16.18-47.98	0.014	0.006-0.022
2015	27.07	13.25-40.89	0.011	0.005-0.018
2016	23.71	11.37-36.04	0.01	0.004-0.016
2017	28.46	14.07-42.85	0.012	0.005-0.020
2018	13.71	6.17-21.25	0.006	0.002-0.009

Figure d. Estimated relative depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model.

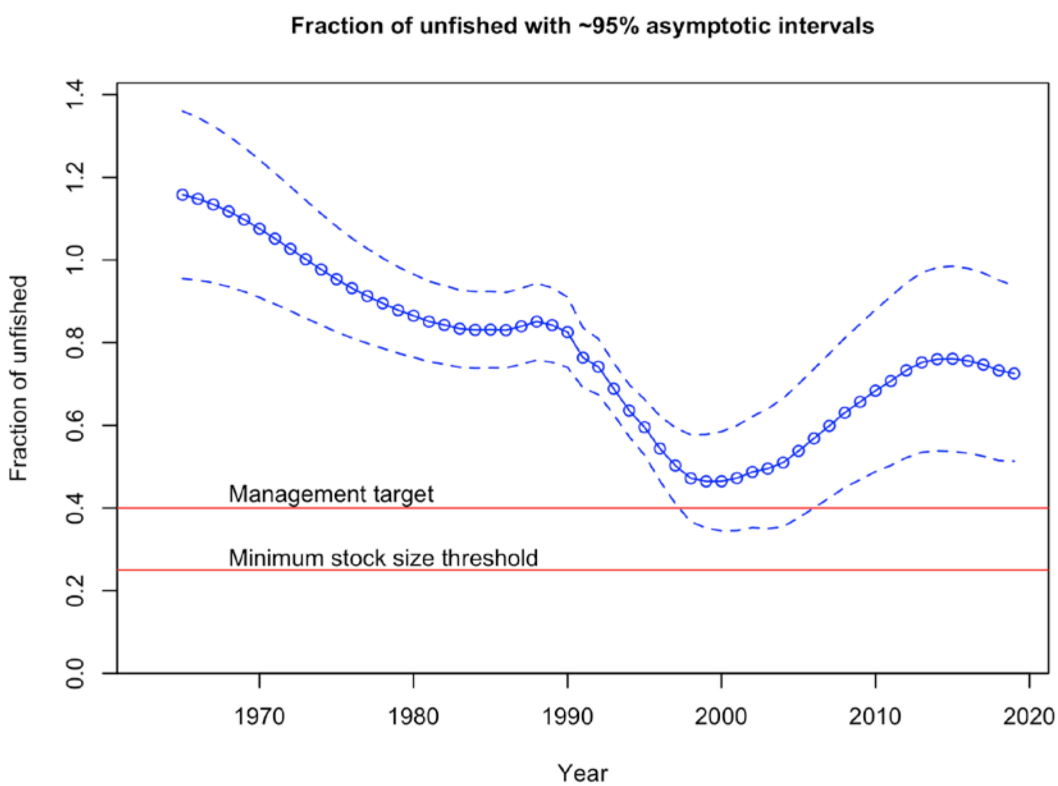


Figure e. Time-series of estimated summary harvest rate (total catch divided by age-2 and older biomass) for the base case model (round points) with approximate 95% asymptotic confidence intervals (grey lines).

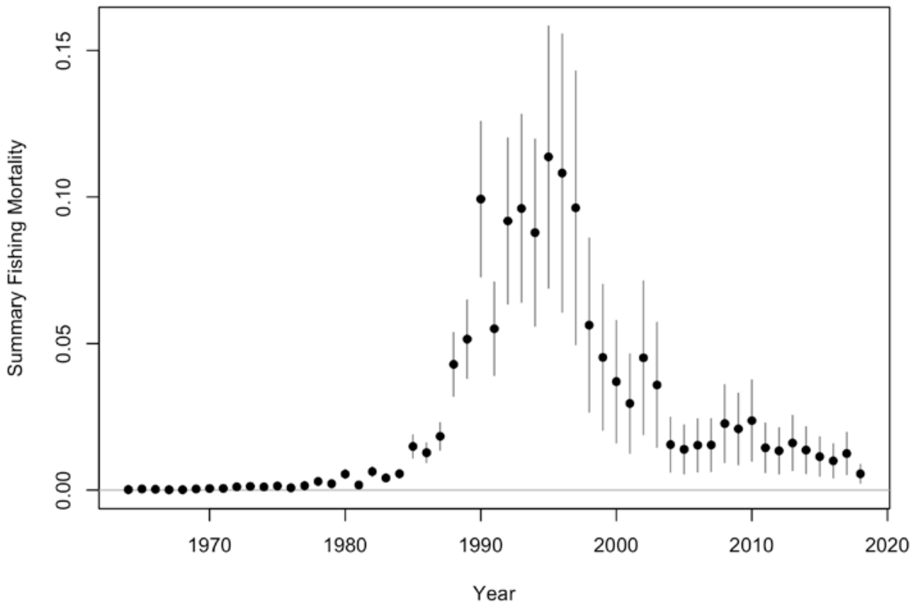


Figure f. Estimated spawning potential ratio (SPR) for the base case model with approximate 95% asymptotic confidence intervals. The ratio shown in the figure is (1-SPR)/(1-SPR$_{50\%}$), which is twice (1-SPR). This ratio is chosen so that higher exploitation rates occur on the upper portion of the 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$_{50\%}$.

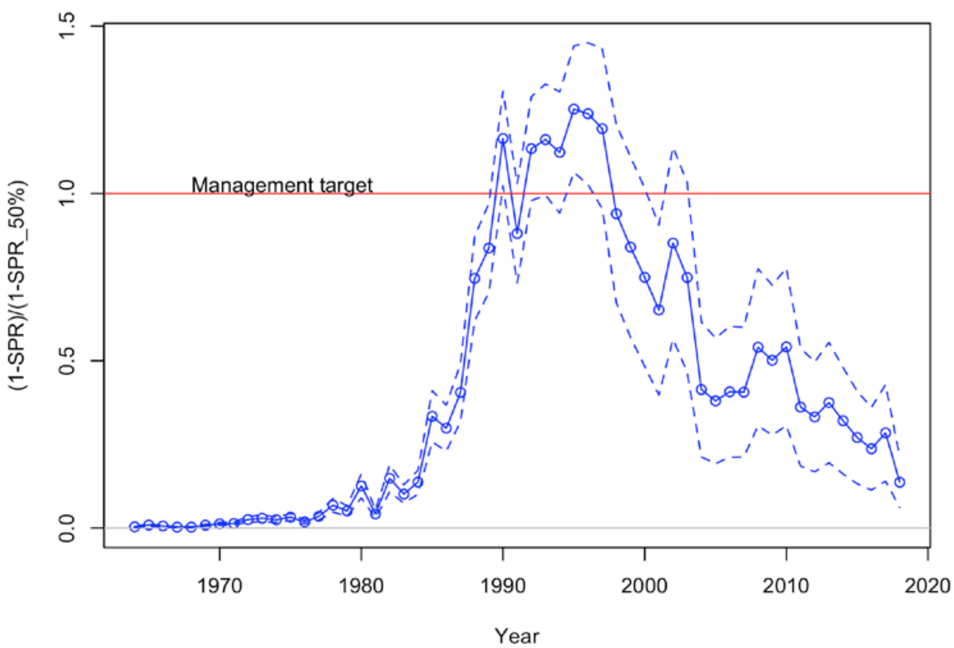
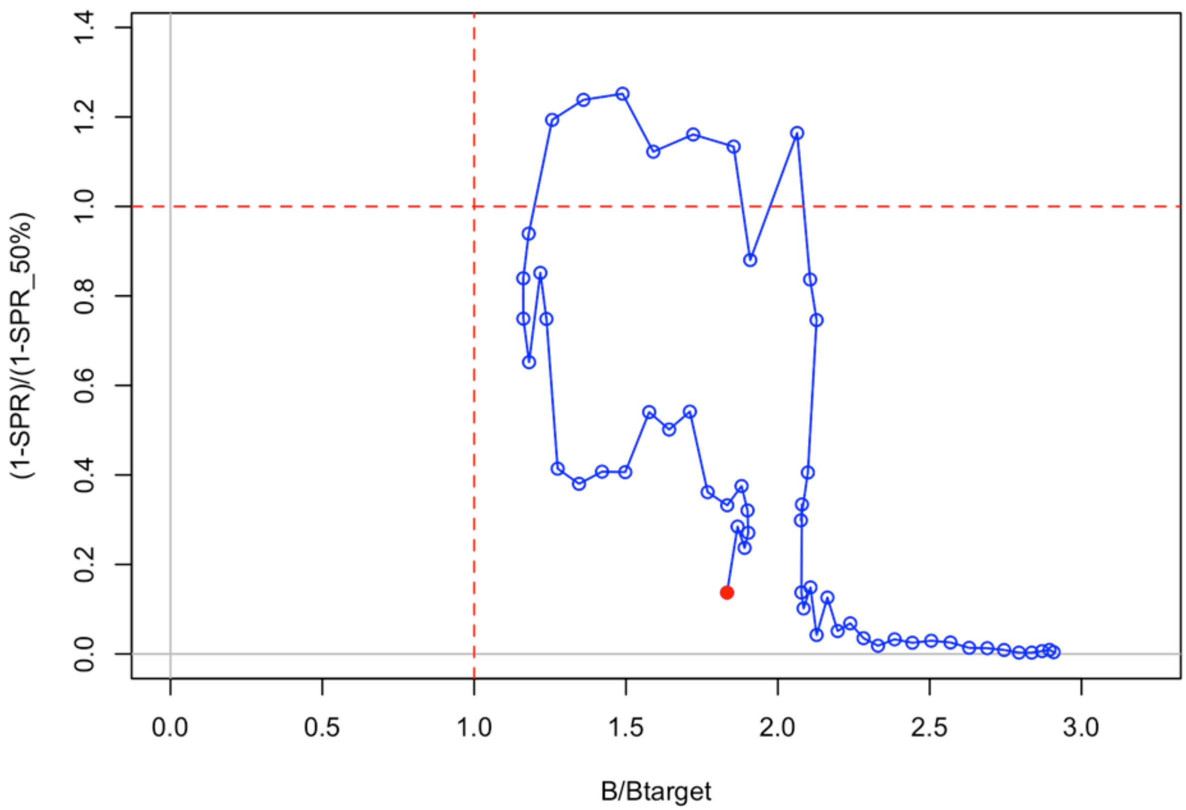


Figure g. Phase plot of estimated relative (1-SPR) vs. relative spawning biomass for the base case model. The relative (1-SPR) is (1-SPR) divided by 1-$SPR_{50\%}$ (the SPR target). Relative depletion is the annual spawning biomass divided by the spawning biomass corresponding to 40% of the unfished 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. Longspine thornyheads have been found in stomachs of shortspine thornyheads and sablefish, leading to the hypothesis that changes in abundance of these species could be linked through predation mortality. Because juvenile longspine thornyheads settle directly into adult habitat, there may be significant cannibalism, as well.

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 1,280 meter limit of the current fishery and survey, but their distribution, abundance, and ecosystem interactions in these deep waters are relatively unknown. Longspine thornyheads are estimated to occur to a maximum depth of 1,700 meters.

Reference points

Reference points were calculated using the estimated selectivity in the last year of the model (2012, and the estimated values are dependent on these assumptions. Sustainable total yield (landings plus discards) was estimated at 2,550 mt when using an $SPR_{50\%}$ reference harvest rate and ranged from 1,737-3,363 mt based on estimates of uncertainty. The spawning biomass equivalent to 40% of the unfished spawning output ($B_{40\%}$) was 16,070 mt. The most recent catches (landings plus discards) have been lower than the lower confidence bound of potential long-term yields calculated using an $SPR_{50\%}$ reference point.

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

Quantity	Estimate	95% Asymptotic Interval
Unfished Spawning Biomass (mt)	39,134	27,093-51,175
Unfished Age 2+ Biomass (mt)	91,049	61,394-120,704
Spawning Biomass (2019)	28,389	11,982-44,796
Unfished Recruitment (R0)	136,529	81,733-191,325
Depletion (2019)	72.54	51.35-93.74
Reference Points Based $SB_{40\%}$		
Proxy Spawning Biomass ($SB_{40\%}$)	15,654	10,837-20,470
SPR resulting in $SB_{40\%}$	0.5	0.500-0.500
Exploitation Rate Resulting in $SB_{40\%}$	0.06	0.058-0.063
Yield with SPR Based On $SB_{40\%}$ (mt)	2,487	1,718-3,255
Reference Points based on SPR proxy for MSY		
Proxy spawning biomass ($SPR_{50\%}$)	15,654	10,837-20,470
$SPR_{50\%}$	0.5	NA
Exploitation rate corresponding to $SPR_{50\%}$	0.06	0.058-0.063
Yield with $SPR_{50\%}$ at SBSPR (mt)	2,487	1,718-3,255
Reference points based on estimated MSY values		
Spawning biomass at MSY (SBMSY)	13,107	9,110-17,104
SPRMSY	0.446	0.444-0.447
Exploitation rate corresponding to SPRMSY	0.071	0.068-0.075
MSY (mt)	2,528	1,746-3,310

Management performance

Catches for longspine thornyheads have not approached the catch limits in recent years. ACLs increased in 2007, however catch remained low. The fishery for longspine thornyhead may be limited by the ACLs on sablefish, with which they co-occur, and by the challenging economics of deep sea fishing.

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)	ABC (mt)	Commercial Landings (mt)	Estimated Total Catch (mt)
2007	3,907	2,696	810	958
2008	3,907	2,696	1,243	1,467
2009	3,766	2,626	1,171	1,379
2010	3,671	2,560	1,359	1,593
2011	3,571	2,495	926	972
2012	3,483	2,430	871	912
2013	4,788	942	1,094	1,142
2014	4,915	942	926	964
2015	5,008	4,171	772	803
2016	4,797	3,996	673	698
2017	4,571	3,808	838	870
2018	4,339	3,614	371	385

Table g. Projection of potential OFL, ABC, and catch, summary biomass (age-2 and older), spawning biomass, and depletion for the base case model projected with status quo catches in 2019 and 2020, and catches at the OFL adjusted by a P*of 0.4 with uncertainty of 1 from 2021 onward. The 2019 and 2020 OFL's are values specified by the PFMC and not predicted by this assessment. The OFL in years later than 2020 is the calculated total catch determined by F_{SPR}.

Year	Predicted OFL (mt)	Predicted ABC/ *Catch* (mt)	Age 2+ biomass (mt)	Spawning Biomass (mt)	Depletion (%)
2019	5,147.24	815.22	67,212.50	28,389.10	72.54
2020	5,122.93	793.39	67,176.80	28,024.00	71.61
2021	5,096.83	3,463.45	67,270.50	27,846.40	71.16
2022	4,837.84	3,225.58	65,003.20	26,625.90	68.04
2023	4,616.49	3,020.07	63,179.80	25,684.00	65.63
2024	4,432.59	2,845.18	61,736.40	24,961.80	63.79
2025	4,283.80	2,697.92	60,612.70	24,412.90	62.38
2026	4,166.41	2,574.60	59,750.50	24,001.20	61.33
2027	4,076.10	2,471.39	59,097.80	23,698.60	60.56
2028	4,008.46	2,384.63	58,610.10	23,482.50	60.01
2029	3,959.31	2,311.06	58,251.10	23,333.70	59.63
2030	3,924.92	2,247.87	57,991.50	23,235.40	59.37

Unresolved problems and major uncertainties

The absence of a reliable ageing method provides a significant hindrance to estimating growth and natural mortality of longspine thornyhead. Uncertainty persists as to both the maximum age and asymptotic length of longspines, since various values of each have been reported in the literature. Additionally, the indices of abundance are all relatively flat, providing little information about the scale of the population. 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 longspine catch, the current state of the population is likely to persist.

Projections and Decision table

Axes of uncertainty for this assessment are the size of initial recruitment and the size of future catch. Initial recruitment is here represented by the log of the initial recruitment, $\ln(R_0)$. Table h displays the projected percent depletion and spawning biomass (in metric tons) for the base model using three values of $\mathrm{LN}(R_0)$, to represent three states of nature, and three catch streams. The high state of nature was taken as the model in the profile over the equilibrium recruitment that had a change in negative log-likelihood equal to 1.2 units, which is an alternative way to calculate the approximate center of the upper 25% of probable possibilities. This high state better reflected the asymmetry in uncertainty about the scale of the population (with more information about the lower range than the upper range of probable population sizes).

The SSC assigned this longspine thornyhead assessment to Category 2, which is associated with a minimum value of $\sigma = 1$ for adjustment of quotas based on scientific uncertainty (a process referred to by the notation “p*”). The Pacific Fisheries Management Council chose a p* value of 0.40 for longspine thornyheads, which leads to a multiplication of the OFL by 83.3%, which is the 40% quantile of a log-normal distribution with $\sigma = 1$.

The catch streams chosen for the decision table were the total catch, rather than landed catch, but discard rates were low under IFQs, so the difference between total catch and landings is small. The default catch stream was chosen based on applying the SPR = 50% default harvest control rule to the base model, including a p* = 0.40 and associated uncertainty of 1. The high catch stream was chosen based on applying the SPR = 50% default harvest control rule to the base model, including a p* = 0.45 and associated uncertainty of 1. The low catch stream was assumed to have total catch equal to the average over the years 2011–2012 or 942 mt.

The stock status remained above 25% in all years, regardless of the state of nature or management decision. The most pessimistic forecast scenario, combining the low state of nature with the high catch stream (p* = 0.45), resulted in a projected stock status of 38.4% in 2030, above the minimum stock size value. All other projections led to a higher projected status, with a maximum of 88.8% in 2021 for the combination of the high state of nature and low catch. Forecasts under the base case led to estimated status ranging from 2030 spawning depletion values of 54.8% in the high catch stream to 73.9% in the low catch stream.

Table h. Summary table of 12-year projections beginning in 2021 for alternate states of nature based on the axis of uncertainty (ln(R0). Columns range over low, mid, and high state of nature, and rows range over different assumptions of total catch levels (discards + retained). The 2019 and 2020 OFL's are values specified by the PFMC and not predicted by this assessment.

				State of nature					
				Low		Base case		High	
LN(R0)				11.5		11.8243		12.3	
Relative probability				0.25		0.5		0.25	
Management decision	Year	OFL	Catch (mt)	Spawning biomass (mt)	Depletion (%)	Spawning biomass (mt)	Depletion (%)	Spawning biomass (mt)	Depletion (%)
942 mt	2021	5,097	942	17,902	57.7	27,846	71.2	50,722	88.8
	2022	5,060	942	17,951	57.8	27,755	70.9	50,211	87.9
	2023	5,031	942	18,082	58.3	27,774	71	49,880	87.3
	2024	5,011	942	18,263	58.8	27,868	71.2	49,676	87
	2025	5,001	942	18,473	59.5	28,007	71.6	49,558	86.8
	2026	5,002	942	18,697	60.2	28,173	72	49,499	86.7
	2027	5,011	942	18,926	61	28,353	72.5	49,480	86.6
	2028	5,027	942	19,155	61.7	28,540	72.9	49,489	86.7
	2029	5,049	942	19,378	62.4	28,727	73.4	49,515	86.7
	2030	5,074	942	19,595	63.1	28,911	73.9	49,552	86.8
ACL p* = 0.40 sigma = 1.0	2021	5,097	3,463	17,902	57.7	27,846	71.2	50,722	88.8
	2022	4,838	3,226	16,819	54.2	26,626	68.0	49,084	85.9
	2023	4,616	3,020	15,980	51.5	25,684	65.6	47,798	83.7
	2024	4,433	2,845	15,334	49.4	24,962	63.8	46,788	81.9
	2025	4,284	2,698	14,840	47.8	24,413	62.4	45,995	80.5
	2026	4,166	2,575	14,467	46.6	24,001	61.3	45,375	79.5
	2027	4,076	2,471	14,190	45.7	23,699	60.6	44,890	78.6
	2028	4,008	2,385	13,990	45.1	23,483	60.0	44,515	77.9
	2029	3,959	2,311	13,848	44.6	23,334	59.6	44,227	77.4
	2030	3,925	2,248	13,748	44.3	23,235	59.4	44,007	77.1
ACL p* = 0.45 sigma = 1.0	2021	5,097	4,208	17,902	57.7	27,846	71.2	50,722	88.8
	2022	4,772	3,903	16,485	53.1	26,293	67.2	48,752	85.4
	2023	4,494	3,641	15,359	49.5	25,066	64.1	47,182	82.6
	2024	4,262	3,421	14,466	46.6	24,100	61.6	45,931	80.4
	2025	4,072	3,237	13,759	44.3	23,343	59.7	44,934	78.7
	2026	3,919	3,086	13,200	42.5	22,751	58.1	44,138	77.3
	2027	3,797	2,963	12,758	41.1	22,293	57.0	43,504	76.2
	2028	3,703	2,862	12,410	40.0	21,939	56.1	42,999	75.3
	2029	3,629	2,779	12,131	39.1	21,667	55.4	42,597	74.6
	2030	3,573	2,710	11,900	38.4	21,456	54.8	42,275	74.0

Research and data needs

Research and data needs for future assessments include the following:

1) Age and growth information are needed 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.
2) A survey using a towed camera to assess the abundance in deeper water. The proportion of the stock and its size range in deeper water is unknown. Further exploration of perceived differences in catchability between towed cameras and trawl nets should also be explored.
3) More tows or visual surveys south of 34.5 deg. N. latitude. Because the southern Conception Area is a large potential habitat for thornyheads, more effort should be directed to describing their distribution in this area, for inclusion in future assessments.
4) An investigation of the possible discontinuity in the reconstructed thornyhead historical catches would be useful for future assessments.

Table i. Summary table of the results.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Commercial landings (mt)	1,171	1,359	926	871	1,094	926	772	673	838	371	NA
Estimated Total catch (mt)	1,379	1,593	972	912	1,142	964	803	698	870	385	NA
OFL (mt)	3,766	3,671	3,571	3,483	4,788	4,915	5,008	4,797	4,571	4,339	4,112
ABC (mt)	2,626	2,560	2,495	2,430	942	942	4,171	3,996	3,808	3,614	3,425
1-SPR	0.5	0.54	0.36	0.33	0.38	0.32	0.27	0.24	0.28	0.14	NA
Exploitation rate (catch/ age 2+ biomass)	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	NA
Age 2+ biomass (mt)	65,827	66,957	67,398	67,937	67,212	67,177	67,270	64,616	62,483	60,732	59,304
Spawning Biomass	25,705	26,771	27,689	28,698	29,436	29,744	29,782	29,593	29,231	28,688	28,389
~95% Confidence Interval	10,863-40,547	11,336-42,206	11,669-43,710	12,138-45,257	12,458-46,414	12,514-46,974	12,476-47,089	12,365-46,820	12,205-46,257	11,949-45,427	11,983-44,796
Recruitment	67,170	68,454	92,717	132,555	129,423	129,705	129,740	129,567	129,232	128,718	128,428
~95% Confidence Interval	27,834-162,097	27,483-170,503	35,502-242,135	41,580-422,583	40,853-410,013	40,943-410,896	40,952-411,025	40,894-410,518	40,783-409,511	40,610-407,981	40,528-406,968
Depletion (%)	65.7	68.4	70.8	73.3	75.2	76	76.1	75.6	74.7	73.3	72.5
~95% Confidence Interval	46.8-84.5	48.8-88.0	50.3-91.2	52.2-94.5	53.5-96.9	53.8-98.2	53.7-98.5	53.3-98.0	52.5-96.8	51.5-95.1	51.3-93.7

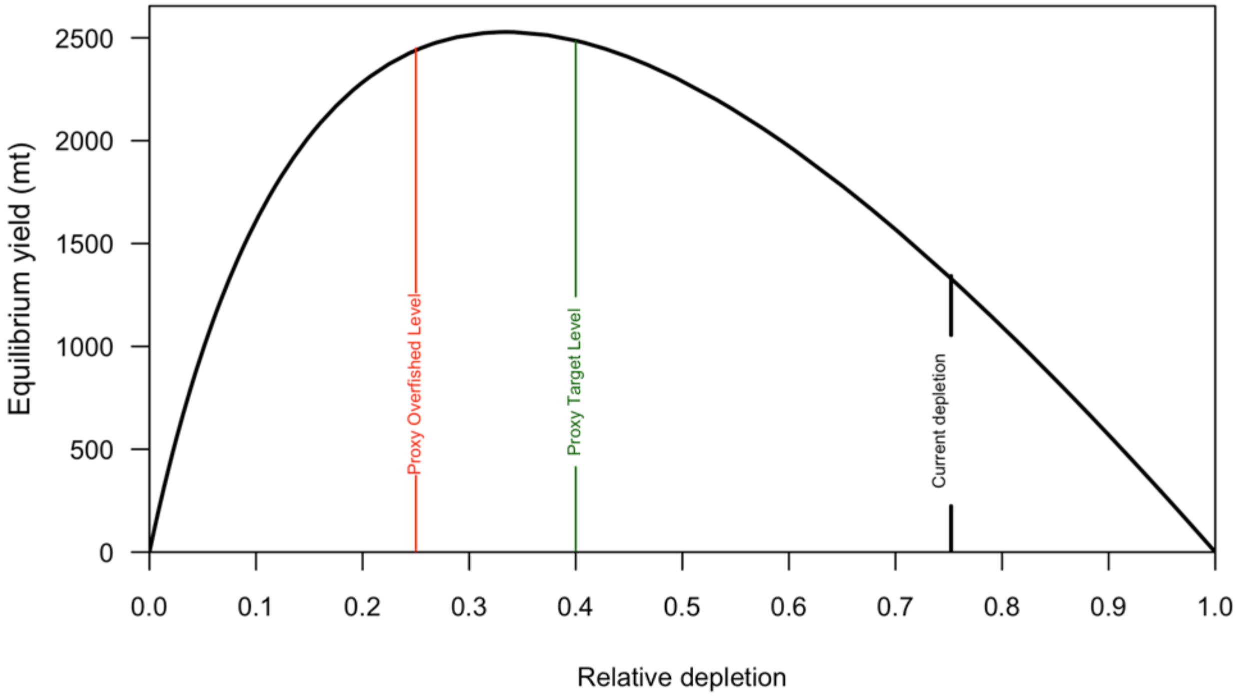


Figure h. Equilibrium yield curve (derived from reference point values reported in Table i) for the base case model. Values are based on 2010 fishery

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