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Stock assessment of the Longnose Skate (*Beringraja rhina*) in state and Federal waters off California, Oregon and Washington

by

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Table of Contents

Acronyms used in this document

ABC	Acceptable Biological Catch
ACL	Annual Catch Limit
AFSC	Alaska Fisheries Science Center
CDFW	California Department of Fish and Wildlife
DFO	Canada's Department of Fisheries and Oceans
DTS	Dover-Thornyheads-Sablefish Complex
DOVR	Dover Sole Complex
DW	Disk Width
GMT	Groundfish Management Team
IFQ	Individual Fishing Quota
INPFC	International North Pacific Fisheries Commission
IPHC	International Pacific Halibut Commission
ISW	Interspiracular Width
NMFS	National Marine Fisheries Service
NWFSC	Northwest Fisheries Science Center
ODFW	Oregon Department of Fish and Wildlife
OFL	Overfishing Limit
OY	Optimum Yield
PacFIN	Pacific Fisheries Information Network
PFMC	Pacific Fishery Management Council
SPR	Spawning Potential Ratio
SSC	Scientific and Statistical Committee
SWFSC	Southwest Fisheries Science Center
TL	Total Length
VAST	Vector Autoregressive Spatio-Temporal Package
WCGBT Survey	West Coast Groundfish Bottom Trawl Survey
WCGOP	West Coast Groundfish Observer Program
WDFW	Washington Department of Fish and Wildlife

Executive Summary

Stock

This assessment reports the status of the Longnose Skate (*Beringraja rhina*) resource off the coast of the United States from Southern California to the U.S. - Canadian border using data through 2018. The species is modeled as a single stock, as there is currently no biological and genetic data supporting the presence of multiple stocks within the assessment region.

Catches

Longnose Skate historically have not been a prized catch. Commercially, they are caught incidentally in the trawl groundfish fishery and often discarded. Skate landings remained low through the mid-1990s, but increased after 1995, when the fishery started to retain skates following the appearance of a market for whole skates (not only the pectoral fins, often referred to as “wings”). Currently, West Coast skates are marketed both whole and as wings.

Landed catch for Longnose Skate is reported from 2009 forward. Prior to that, the landed catch of skates is documented through fish tickets, but most records are for a combined-skate category. Separating Longnose Skate from combined skate landings as well as estimating historical discard has been a challenge for many skate species around the world. For this assessment, historical landings of Longnose Skate were reconstructed for each state, through a coordinated effort among NMFS and state agencies. Historical time series of Longnose Skate discards were also reconstructed from a variety of fishery-independent and fishery-dependent data sources.

Table ES-1: Recent Longnose Skate landings in commercial fisheries by state; tribal fishery landed catch reported separately.

Years	Washington landings (mt)	Oregon landings (mt)	California landings (mt)	Tribal fishery (mt)	Total dead catch (mt) (landings and dead discard)
2009	136	675	128	27	1,152
2010	66	764	152	13	1,165
2011	76	550	171	22	916
2012	116	588	192	40	1,030
2013	85	654	151	68	1,051
2014	54	581	169	36	926
2015	41	546	170	72	904
2016	59	614	140	83	980
2017	78	547	147	67	913
2018	71	470	114	53	771

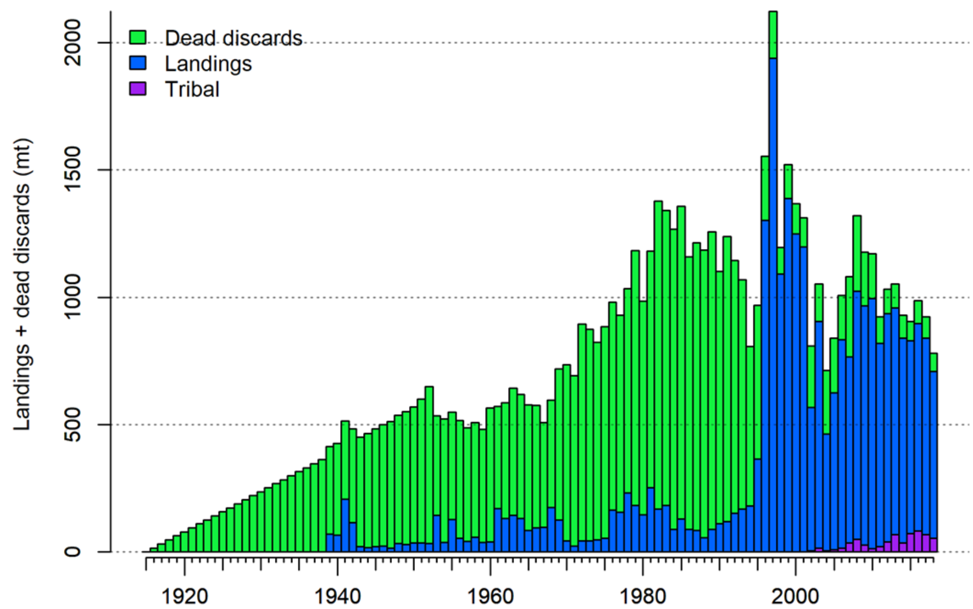

Figure ES-1: Longnose Skate catch history between 1916 and 2018, used in the assessment. Commercial catches (landings and dead discard) are shown separately tribal catches.

Data and assessment

The Longnose Skate population on the West Coast of the United States was assessed only once before, in 2007, using the Stock Synthesis 2 modeling framework. This current assessment uses Stock Synthesis version 3.30.13, released in March 2019.

The assessed period begins in 1916, when skate catch started to first appear in fisheries records, with the assumption that previously the stock was in an unfished equilibrium condition. Types of data that inform the model include catch, length and age frequency data from commercial and tribal fishing fleets. Commercial fishery data are divided among three coastwide fleets, which include the current fishery (1995-present), historical landings and historical discard. Fishery-dependent biological data used in the assessment originated from both port-based and on-board observer sampling programs. Relative biomass indices and information from biological sampling from four bottom trawl surveys were included; these trawl surveys were conducted by the Northwest Fisheries Science Center (NWFSC) and the Alaska Fisheries Science Center (AFSC) of the National Marine Fisheries Service (NMFS). Longnose Skate catch in the International Pacific Halibut Commission's (IPHC's) long-line survey is also included via an index of relative abundance; IPHC length frequency data are used.

Growth is assumed to follow the von Bertalanffy growth model, and the assessment explicitly estimates all parameters describing somatic growth. Females and males are combined in the model, since estimates of growth parameters, and length-weight relationship did not differ between the sexes. Externally estimated life history parameters, including those defining the length-weight relationship and maturity schedule, were revised for this assessment to incorporate new information. Female fecundity is assumed to be proportional to spawning biomass. Recruitment dynamics are assumed to follow the Beverton-Holt stock-recruit function, and recruits are taken deterministically from the stock-recruit curve. Natural mortality and catchability of the current bottom trawl survey are estimated using prior probability distributions.

Stock biomass

The unexploited level of spawning stock output is estimated to be 12,252 metric tons (95 percent confidence interval: 9,155–15,350 metric tons) (Figure ES-2). At the beginning of 2019, the spawning stock output is estimated to be 6,923 metric tons (95 percent confidence interval: 3,283–10,563 metric tons), which represents 57 percent of the unfished spawning biomass.

The assessment described the dynamics of the Longnose Skate stock to be slowly declining from the unfished conditions, with a flat trend from early 2000s (Figure ES-3).

Table ES-2: Recent trends in estimated Longnose Skate spawning biomass, recruitment and relative spawning biomass.

Years	Spawning Biomass	~95% Asymptotic Interval	Recruitment	~95% Asymptotic Interval	Estimated Depletion (%)	~95% Asymptotic Interval
2009	7,046	3,549–10,544	10,144	6,049–17,010	57.5	43.3–71.7
2010	7,009	3,499–10,518	10,116	6,018–17,004	57.2	42.8–71.6
2011	6,962	3,439–10,485	10,082	5,980–16,995	56.8	42.2–71.4
2012	6,966	3,428–10,504	10,084	5,977–17,015	56.9	42.1–71.6
2013	6,940	3,387–10,493	10,065	5,953–17,019	56.6	41.8–71.5
2014	6,908	3,339–10,476	10,041	5,923–17,020	56.4	41.3–71.5
2015	6,902	3,318–10,485	10,036	5,913–17,035	56.3	41.1–71.5
2016	6,902	3,303–10,500	10,036	5,907–17,053	56.3	41.0–71.7
2017	6,887	3,274–10,499	10,025	5,890–17,062	56.2	40.7–71.7
2018	6,888	3,262–10,514	10,026	5,885–17,080	56.2	40.6–71.8
2019	6,923	3,283–10,563	10,052	5,904–17,114	56.5	40.9–72.1

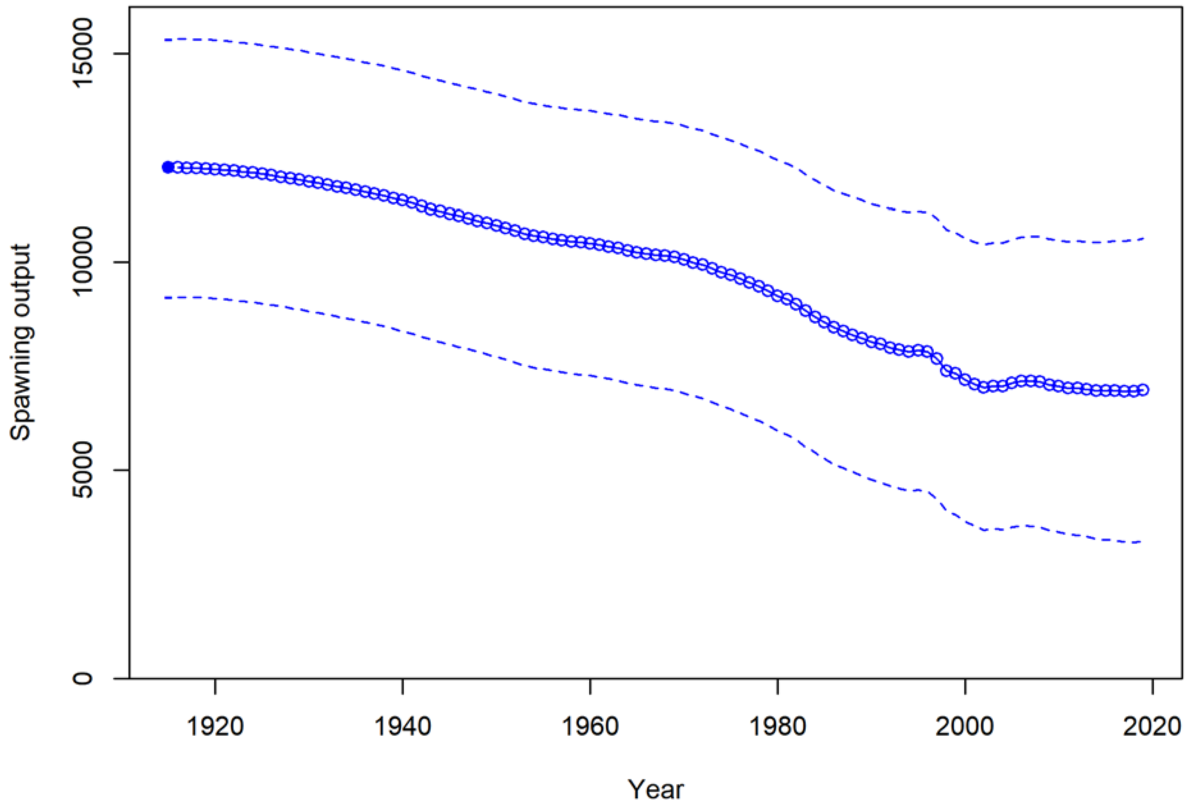

Figure ES-2: Time series of estimated spawning output for the base model (circles) with ~ 95 percent confidence interval (dashed lines). Spawning output is expressed in metric tons.

Recruitment

Recruitment dynamics of Longnose Skate are assumed to follow a Beverton-Holt stock-recruit function. The steepness parameter (h) is fixed at the value of 0.4, which was used in the previous assessment, to reflect the equilibrium life history strategy of the species. The level of virgin recruitment (R_0) is estimated to inform the magnitude of the initial stock size. Recruits are taken deterministically from the stock-recruit curve.

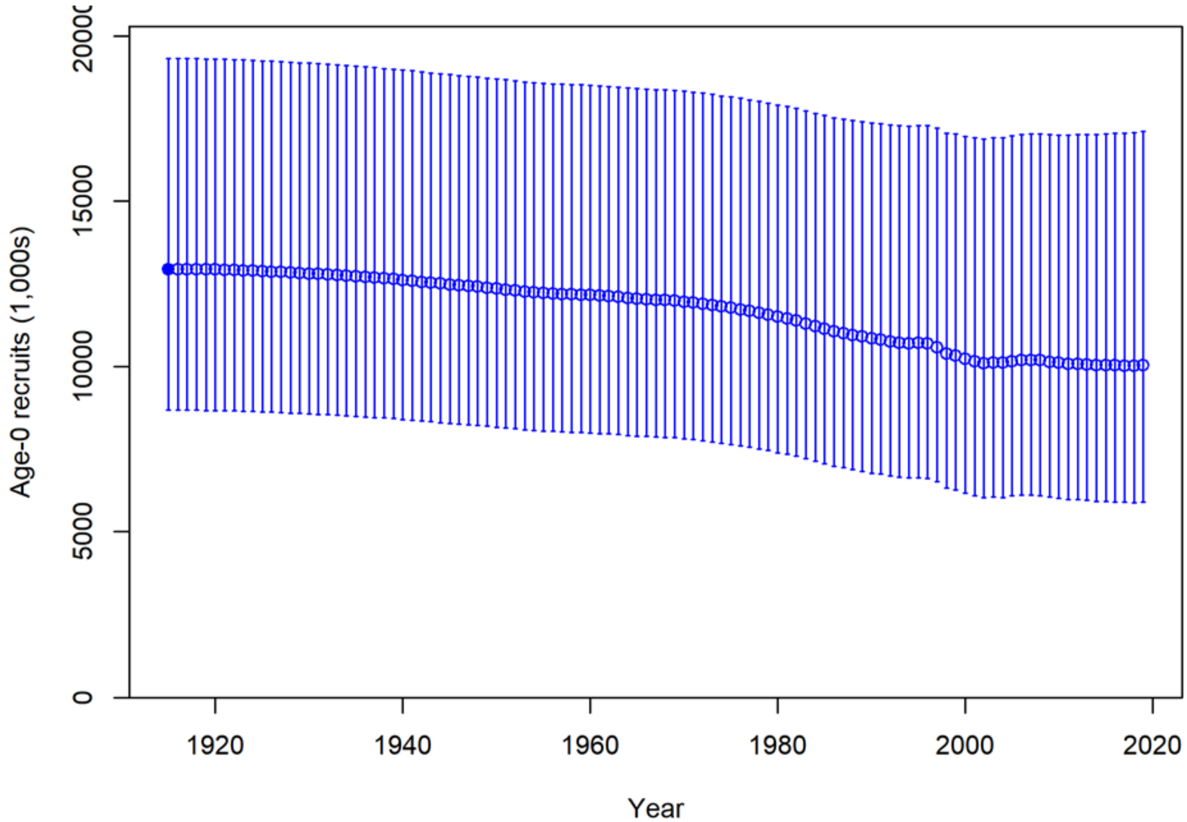

Figure ES-3: Time series of estimated Longnose Skate recruitments for the base model (circles) with approximate 95 confidence intervals (vertical lines).

Exploitation status

This assessment estimates that the stock of Longnose Skate off the continental U.S. Pacific Coast is currently at 57 percent of its unexploited level (Figure ES-4). This is above the overfished threshold of $SB_{25\%}$ and the management target of $SB_{40\%}$ of unfished spawning biomass.

The Spawning Potential Ratio (SPR) used for setting the OFL is 50 percent. Relative exploitation rates (calculated as dead catch/biomass of age-2 and older fish) are estimated to have been below one percent during the last decade (Figure ES-5). For the recent and historical period, the assessment estimates that Longnose Skate was fished at a rate below the relative SPR target (calculated as 1-SPR/1-$SPR_{Target=0.5}$) (Figure ES-6). Relative SPR for 2018 is estimated to be 48 percent, which is below SPR target.

Table ES-3: Recent trend in relative spawning potential ratio and exploitation rate (dead 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
2009	65.05	39.93–90.18	0.023	0.012–0.034
2010	65.94	40.23–91.65	0.023	0.012–0.034
2011	54.79	31.97–77.62	0.018	0.009–0.027
2012	60.25	35.67–84.83	0.021	0.011–0.031
2013	61.4	36.31–86.49	0.021	0.011–0.031
2014	55.62	32.10–79.13	0.019	0.009–0.028
2015	54.52	31.28–77.76	0.018	0.009–0.027
2016	58.15	33.72–82.59	0.02	0.010–0.029
2017	54.99	31.45–78.53	0.018	0.009–0.027
2018	47.81	26.63–68.98	0.016	0.008–0.023

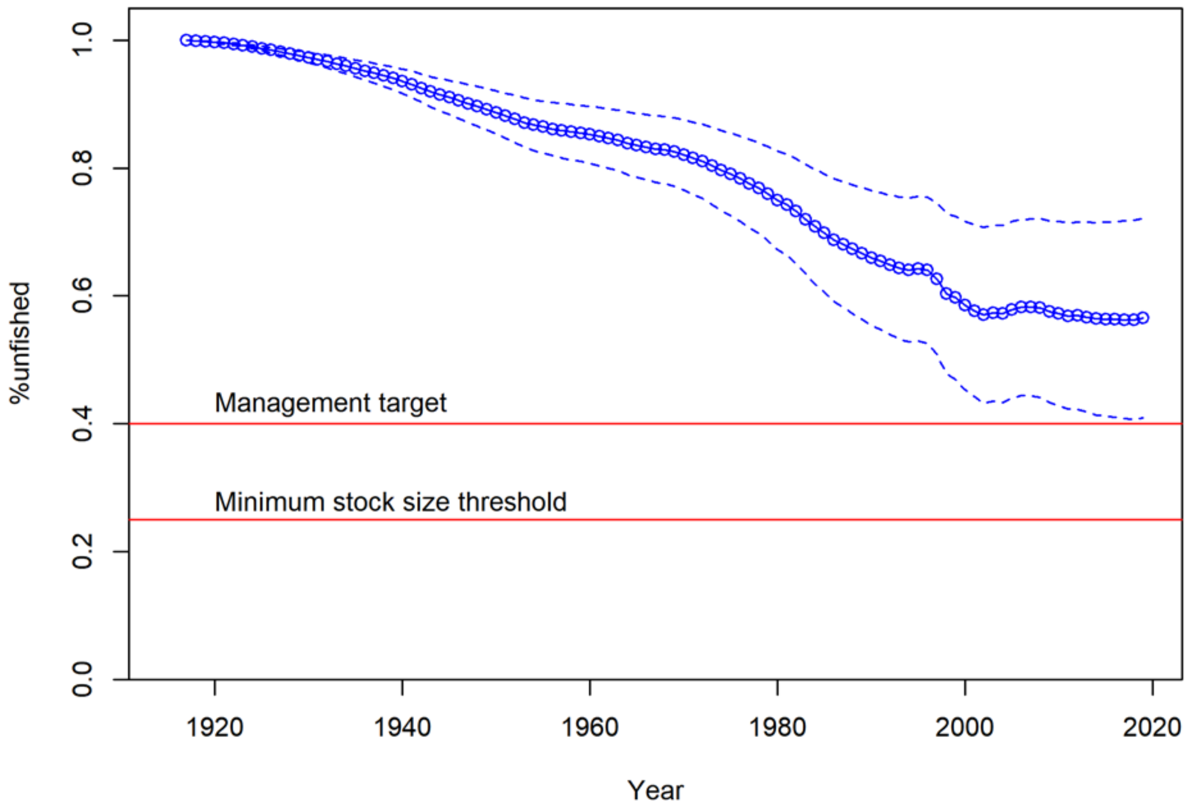

Figure ES-4: Estimated relative spawning biomass with approximate 95 percent asymptotic confidence intervals (dashed lines) for the base model.

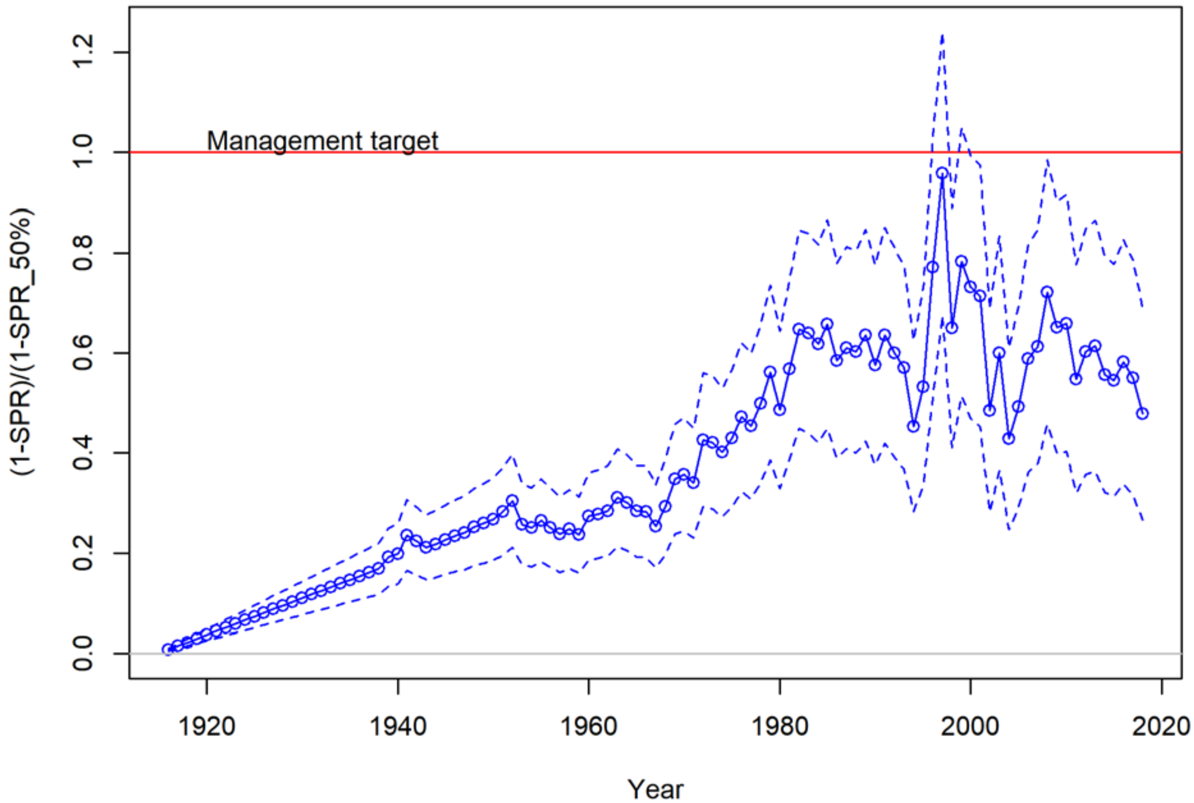

Figure ES-5: Estimated spawning potential ratio (SPR) for the base model with approximate 95 percent asymptotic confidence intervals. One minus SPR standardized to the target is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as the red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the $SPR_{50\%}$.

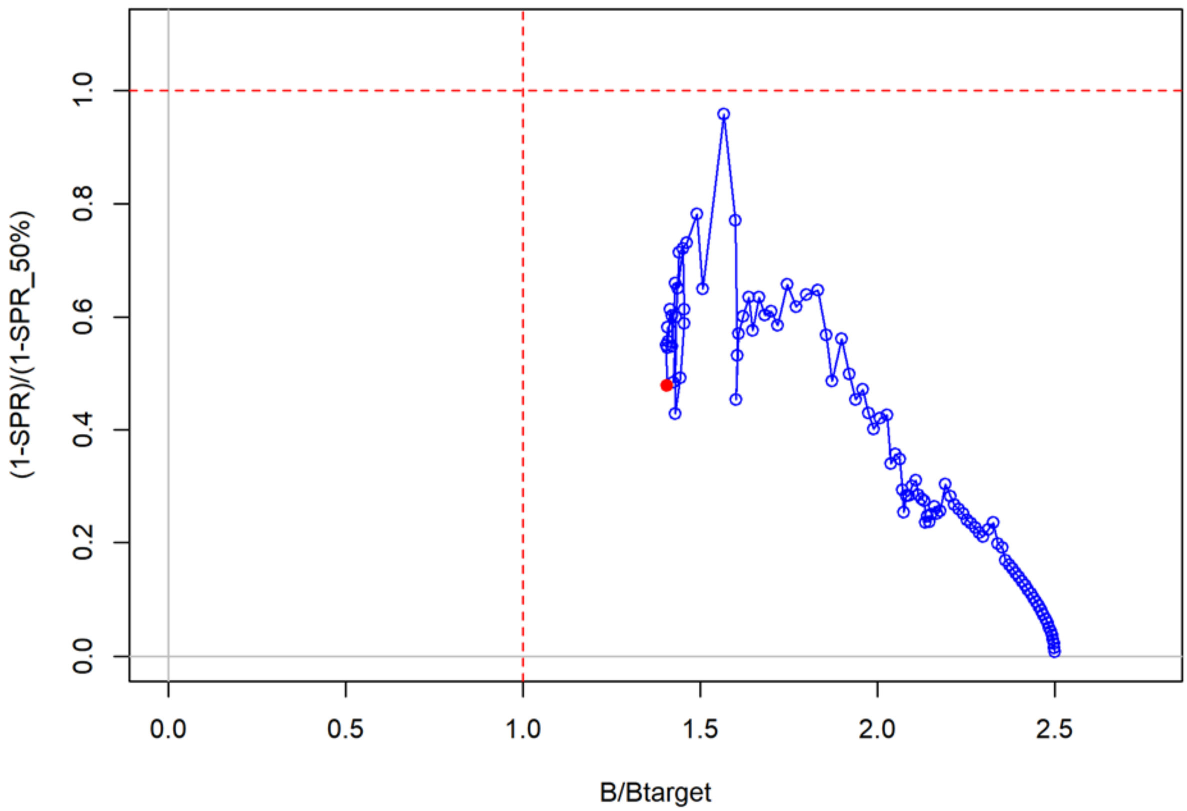

Figure ES-6: Phase plot of estimated relative (1-SPR) vs. relative spawning biomass for the base model. The relative (1-SPR) is (1-SPR) divided by 0.5 (the SPR target). Relative spawning output is the annual spawning biomass divided by the spawning biomass corresponding to 40 percent of the unfished spawning biomass. The red point indicates the year 2018.

Ecosystem considerations

In this assessment, ecosystem considerations were not explicitly included in the analysis. This is primarily due to a lack of relevant data that could contribute ecosystem-related quantitative information for the assessment.

Reference points

Unfished spawning stock output (biomass) for Longnose Skate was estimated to be 12,252 metric tons (95 percent confidence interval: 9,155–15,350 metric tons). The management target for Longnose Skate is defined as 40 percent of the unfished spawning output ($SB_{40\%}$), which is estimated by the model to be 4,901 metric tons (95 percent confidence interval: 3,662–6,140); this corresponds to an exploitation rate of 0.027. This harvest rate provides an equilibrium yield of 1,028 mt at $SB_{40\%}$ (95 percent confidence interval: 708–1,348 mt). The model estimate of maximum sustainable yield (MSY) is 2,812 mt (95 percent confidence interval: 2,042-3,582 mt). The estimated spawning stock output at MSY is 1,030 metric tons (95 percent confidence interval: 709–1,351 metric tons). The exploitation rate corresponding to the estimated SPR_{MSY} is 0.028. The equilibrium estimates of yield relative to biomass is provided in Figure ES-7.

Table ES-4: Summary of reference points for the base model.

Quantity	Estimate	~95% Asymptotic Interval
Unfished Spawning Biomass (mt)	12,252	9,155–15,350
Unfished Age 2+ Biomass (mt)	73,298	51,204–95,392
Spawning Biomass (2019)	6,923	3,283–10,563
Unfished Recruitment (R_0)	12,954	7,722–18,186
Depletion (2019)	56.5	40.86–72.14
Reference Points Based $SB_{40\%}$		
Proxy Spawning Biomass ($SB_{40\%}$)	4,901	3,662–6,140
SPR resulting in $SB_{40\%}$	0.625	0.625–0.625
Exploitation Rate Resulting in $SB_{40\%}$	0.027	0.026–0.027
Yield with SPR Based On $SB_{40\%}$ (mt)	1,028	708–1,348
Reference Points based on SPR proxy for MSY		
Proxy Spawning Biomass ($SPR_{50\%}$)	2,450	1,831–3,070
SPR_{50}	0.5	NA
Exploitation rate corresponding to $SPR_{50\%}$	0.039	0.038–0.040
Yield with $SPR_{50\%}$ at SB_{SPR} (mt)	860	590–1,129
Reference points based on estimated MSY values		
Spawning Biomass at MSY (SB_{MSY})	4,632	3,472–5,792
SPR_{MSY}	0.611	0.610–0.612
Exploitation rate corresponding to SPR_{MSY}	0.028	0.027–0.028
MSY (mt)	1,030	709–1,351

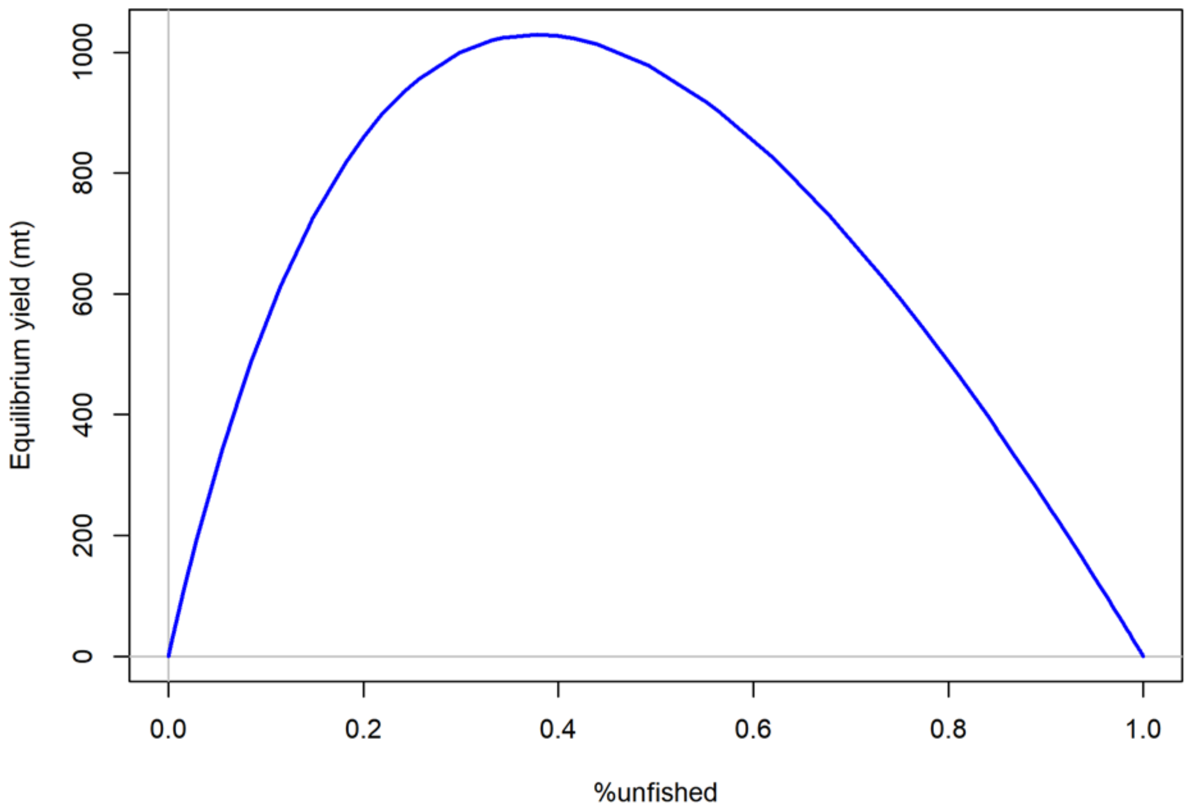

Figure ES-7: Equilibrium yield curve (derived from reference point values reported in Table ES-5) for the base model. Values are based on the 2018 fishery selectivity and distribution with steepness fixed at 0.4. The depletion is relative to unfished spawning output.

Management performance

Before 2009, Longnose Skate was managed together with many other species on the West Coast, in the "Other Fish" complex. Stocks in that complex have been generally managed without individual assessments and with harvest specifications determined through data-poor methods. Since landings have been routinely well below ABCs for this category, trip limits have not been used for inseason management.

Following the 2007 Longnose Skate assessment (Gertseva and Schirripa 2008), Longnose Skate was pulled out of the "Other Fish" category in 2009. Since then, there has been stock-specific management of Longnose Skate and total catch of this species has been below both the overfishing limit (OFL) and acceptable biological catch (ABC) for Longnose Skate each year (Table ES-5).

Table ES-5: Recent trend in total dead catch and commercial landings (mt) relative to the management guidelines. Estimated total dead catch reflects commercial landings plus the model estimated discarded dead biomass*.

Years	OFL	ABC	ACL	Landings	Total Catch
2009	3,428	NA	1,349	966	1,152
2010	3,269	NA	1,349	995	1,165
2011	3,128	2,990	1,349	819	916
2012	3,006	2,873	1,349	936	1,030
2013	2,902	2,774	2,000	958	1,051
2014	2,816	2,692	2,000	839	926
2015	2,449	2,341	2,000	829	904
2016	2,405	2,299	2,000	896	980
2017	2,556	2,444	2,000	840	913
2018	2,526	2,415	2,000	709	771
2019	2,499	2,389	2,000	NA	NA

* The current OFL was called the ABC prior to 2011. The ABCs provided in this table for 2011-2018 refer to the new definition of ABC implemented with FMP Amendment 23. The current ACL was called the OY prior to 2011.

Unresolved problems and major uncertainties

Approximate asymptotic confidence intervals were estimated within the model for key parameters and management quantities and reported throughout the assessment. To explore uncertainty associated with alternative model configurations and evaluate the responsiveness of model outputs to changes in key model assumptions, a variety of sensitivity runs were performed, including runs with different assumptions regarding fishery removals, life-history parameters, shape of selectivity curves, stock-recruitment parameters, and many others. Uncertainty in natural mortality, stock-recruit steepness and the unfished recruitment level was also explored through likelihood profile analysis. Additionally, a retrospective analysis was conducted where the model was run after successively removing data from recent years, one year at a time.

In this assessment, the WCGBT Survey catchability coefficient is highly influential upon the assessment output and continues to be a major source of uncertainty. The lack of contrast in the data resulted in implausible model results under a variety of configurations when the WCGBT Survey catchability was freely estimated. To aid in estimating catchability, a prior was used that relies on current understanding of factors affecting survey catchability, such as latitudinal, depth and vertical availably of Longnose Skate to the survey as well as probability of being caught in the survey net's path. Alternative assumptions about this parameter were used to define alternative states of nature in the Decision table.

Stock-recruit curve steepness generally contributes significant uncertainty to stock assessments as it determines the productivity of the stock, and alternative values of this parameter were explored through both sensitivity and likelihood profile analyses.

Although significant progress has been made in reconstructing historical catches of Longnose Skate on the U.S. West Coast, survival rates of discarded skates are continue to be uncertain, especially given that many factors, such as trawl time, handling techniques, and time spent on the deck certainly affect skate survival.

Several tagging studies have found that elasmobranchs, such as sharks and skates, can undertake extensive migrations within their geographic range (Martin and Zorzi 1993, McFarlane and King 2003). One tagging study of Big Skate described long-range movements (up to 2340km) undertaken by a percentage of the recaptured fish, when Big Skates tagged in British Columbia, Canada, were recaptured in waters off of Oregon, Washington, throughout the Gulf of Alaska and the Bering Sea (King and McFarlane 2010). No large-scale migrations or movements studies have been conducted for Longnose Skate, and, therefore uncertainty remains about possible movements (and their extent) of Longnose Skate between U.S. and Canadian waters. Genetic and tagging studies would help improve our understanding of stock structure and movement patters of Longnose Skate and identify whether there is a need for a regional management approach.

Decision table

The base model estimate for 2019 spawning depletion is 57%. The primary axis of uncertainty about this estimate used in the decision table was based on West Coast Groundfish Bottom Trawl (WCGBT) Survey catchability (*q*). WCGBT Survey *q* in the assessment model is estimated using the prior developed as described later in this report. The base model estimate has q=1.57, log(q) =0.45, with estimated standard deviation of log(q) = 0.237. The 12.5 and 87.5 quantiles of the log (q) were calculated to determine alternative states of nature. The low log(q) =0.178, q =1.19 was used to define the high state of nature. The 2019 biomass estimate resultant from the run with the low q value exceeded the 87.5th percentile of the 2019 spawning biomass estimated by the base model. The high q value (estimated from q prior) was above 12.5th percentile of the 2019 base model estimate of spawning biomass. Therefore, model with log(q) =0.77, q = 2.16 was used as a low state of nature, as it provided a close match to the 12.5th percentile for the 2019 spawning biomass estimate in the base model.

Twelve-year forecasts for each state of nature were calculated for three catch scenarios. All three scenarios assumed the 2017-2018 average total dead catch for 2019 and 2020 catches. The first scenario assumed 1,000 metric tons per year for years between 2021 and 2030. The second scenario assumed 2,000 metric tons per year for years between 2021 and 2030. The third scenario assumed year-specific ACL = ABC (P* = 0.45) for years between 2021 and 2030. The sigma estimated from the base model is 0.26; therefore, the category 2 sigma schedule recommended by the SSC was used in this scenario.

Projected Landings, OFLs and Time-varying ACLs

Potential OFLs projected by the model are shown in Table ES-6. These values are based on an SPR target of 50%, a P* of 0.45, and a time-varying Category 2 Sigma which creates the buffer shown in the right-hand column. The OFL and ACL values for 2019 and 2020 are the current harvest specifications (also shown in Table ES-5) while the total mortality for 2019 and 2020 represent 2017-2018 average catch.

Table ES-6: Projections of landings, total mortality, OFL, and ACL values.

Years	Landings (mt)	Estimated total mortality (mt)	OFL (mt)	ACL (mt)	Buffer
2019	775	842	2,079	2,000	1.000
2020	775	842	2,082	2,000	1.000
2021	1,676	1,823	2,086	1,823	0.874
2022	1,618	1,761	2,036	1,761	0.865
2023	1,566	1,708	1,993	1,708	0.857
2024	1,520	1,660	1,955	1,660	0.849
2025	1,479	1,617	1,922	1,617	0.841
2026	1,443	1,578	1,895	1,578	0.833
2027	1,412	1,546	1,872	1,546	0.826
2028	1,383	1,515	1,852	1,515	0.818
2029	1,357	1,487	1,836	1,487	0.810
2030	1,335	1,462	1,821	1,462	0.803

Research and data needs

In this assessment, several critical assumptions were made based on limited information. The following research could improve the ability of future stock assessments to determine the status and productivity of the Longnose Skate population. It is also important to continue to collect species-specific information from the fishery, and monitor discard of Longnose Skate to improve the accuracy of fishery catch data.

Data needs:

1. Ages - Estimate additional ages for Longnose Skate, which would better inform the age-structured model. The NWFSC ageing lab is currently able to age skate vertebrae, and many structures have already been collected across several years in surveys and fisheries.
2. Maturity - Generate additional maturity data using the most accurate/precise method developed in Research Need #1, below.

Research needs:

1. Maturity - Conduct studies incorporating histological analysis into evaluation of skate maturity, which would evaluate error and bias in macroscopic evaluation, and develop a feasible method which would produce the most accurate and consistent maturity data. Histological examination is widely accepted as the best available approach, while macroscopic evaluation (used up to this point) has been demonstrated to be less accurate, precise and more prone to reader bias (Vitale et al. 2006, Brown-Peterson et al. 2011, Kjesbu 2009).
2. Survey q - Develop a well-informed prior on survey catchability, as this parameter is highly influential upon the assessment model. Evaluate Longnose Skate behavior/interaction with trawl gear, and distribution among habitats, to better understand catchability by survey gear type, and ultimately provide more precise estimates of biomass from the surveys.
3. Life history – Conduct studies to better quantitatively understand life history of Longnose Skates; e.g. to inform time-varying estimation of natural mortality and recruitment.

Research to better estimate growth, as well as enhanced understanding of reproduction (e.g., frequency, seasonality, number or eggs per year) is also needed. Studies to better understand Longnose Skate productivity, and accurately inform stock-recruit steepness for this species would also be beneficial.

4. Catch - Continue to explore methods to estimate historical removals of Longnose Skate and associated uncertainty, particularly model-based solutions where feasible;
5. Discard mortality - Conduct studies to evaluate survival rates of discarded Longnose Skate, especially with trawl gear, so that total fishing mortality can be estimated more accurately;
6. Movement and migration - Conduct spatial studies of movement and migration of Longnose Skate, with special attention to potential extent of movement across the U.S.-Canada border;
7. Genetics - Conduct genetic studies to evaluate the potential for stock structure of Longnose Skate in the waters off the U.S. Pacific Coast.

Table ES-7: 12-year projections for alternate states of nature defined based on WCGBT Survey catchability. Columns range over low, mid, and high state of nature, and rows range over different assumptions of catch levels.

			States of nature					
			Low state: q =2.16		Base model: q =1.57		High state: q =1.19	
Management decision	Year	Catch (mt)	Spawning biomass	Depletion	Spawning biomass	Depletion	Spawning biomass	Depletion
2017-2018 average total catch for 2019 and 2020 catches; 1,000 mt/year after that	2019	842	4,787	45%	6,923	57%	9,371	65%
	2020	842	4,797	45%	6,943	57%	9,398	65%
	2021	1,000	4,807	45%	6,964	57%	9,425	65%
	2022	1,000	4,780	45%	6,947	57%	9,414	65%
	2023	1,000	4,752	45%	6,929	57%	9,401	65%
	2024	1,000	4,722	45%	6,910	56%	9,388	65%
	2025	1,000	4,690	44%	6,889	56%	9,373	65%
	2026	1,000	4,657	44%	6,867	56%	9,357	65%
	2027	1,000	4,624	44%	6,845	56%	9,340	65%
	2028	1,000	4,590	43%	6,823	56%	9,324	65%
	2029	1,000	4,558	43%	6,802	56%	9,308	65%
	2030	1,000	4,527	43%	6,782	55%	9,294	65%
2017-2018 average total catch for 2019 and 2020 catches; 2,000 mt/year after that	2019	842	4,787	45%	6,923	57%	9,371	65%
	2020	842	4,797	45%	6,943	57%	9,398	65%
	2021	2,000	4,807	45%	6,964	57%	9,425	65%
	2022	2,000	4,558	43%	6,724	55%	9,190	64%
	2023	2,000	4,310	41%	6,486	53%	8,957	62%
	2024	2,000	4,066	38%	6,251	51%	8,728	61%
	2025	2,000	3,829	36%	6,024	49%	8,506	59%
	2026	2,000	3,601	34%	5,806	47%	8,293	58%
	2027	2,000	3,386	32%	5,599	46%	8,092	56%
	2028	2,000	3,186	30%	5,407	44%	7,905	55%
	2029	2,000	3,000	28%	5,230	43%	7,733	54%
	2030	2,000	2,830	27%	5,067	41%	7,575	53%
2017-2018 average total catch for 2019 and 2020 catches; ACL = ABC (P* = 0.45) as in base model after that	2019	842	4,787	45%	6,923	57%	9,371	65%
	2020	842	4,797	45%	6,943	57%	9,398	65%
	2021	1,823	4,807	45%	6,964	57%	9,425	65%
	2022	1,761	4,597	43%	6,765	55%	9,229	64%
	2023	1,708	4,401	41%	6,581	54%	9,049	63%
	2024	1,660	4,219	40%	6,411	52%	8,883	62%
	2025	1,617	4,051	38%	6,255	51%	8,732	61%
	2026	1,578	3,899	37%	6,114	50%	8,597	60%
	2027	1,546	3,762	35%	5,990	49%	8,479	59%
	2028	1,515	3,642	34%	5,881	48%	8,376	58%
	2029	1,487	3,537	33%	5,788	47%	8,290	58%
	2030	1,462	3,448	33%	5,711	47%	8,220	57%

Table ES-8: Summary table of the results.

Years	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Landings (mt)	966	995	819	936	958	839	829	896	840	709	NA
Estimated Total catch (mt)	1,152	1,165	916	1,030	1,051	926	904	980	913	771	NA
OFL (mt)	3,428	3,269	3,128	3,006	2,902	2,816	2,449	2,405	2,556	2,526	2,499
ACL (mt)	1,349	1,349	1,349	1,349	2,000	2,000	2,000	2,000	2,000	2,000	2,000
1-SPR	0.65	0.66	0.55	0.60	0.61	0.56	0.55	0.58	0.55	0.48	NA
Exploitation_Rate	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	NA
Age 2+ Biomass (mt)	50,468	50,222	49,978	49,981	49,872	49,750	49,748	49,761	49,696	49,694	49,819
Spawning Biomass (mt)	7,046	7,009	6,962	6,966	6,940	6,908	6,902	6,902	6,887	6,888	6,923
95% Confidence Interval	3,549–10,544	3,499–10,518	3,439–10,485	3,428–10,504	3,387–10,493	3,339–10,476	3,318–10,485	3,303–10,500	3,274–10,499	3,262–10,514	3,283–10,563
Recruitment	10,144	10,116	10,082	10,084	10,065	10,041	10,036	10,036	10,025	10,026	10,052
95% Confidence Interval	6,049–17,010	6,018–17,004	5,980–16,995	5,977–17,015	5,953–17,019	5,923–17,020	5,913–17,035	5,907–17,053	5,890–17,062	5,885–17,080	5,904–17,114
Depletion (%)	57.5	57.2	56.8	56.9	56.6	56.4	56.3	56.3	56.2	56.2	56.5
95% Confidence Interval	43.3–71.7	42.8–71.6	42.2–71.4	42.1–71.6	41.8–71.5	41.3–71.5	41.1–71.5	41.0–71.7	40.7–71.7	40.6–71.8	40.9–72.1