Status of the Longnose Skate (*Raja rhina*)
off the continental US Pacific Coast in 2007

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EXECUTIVE SUMMARY

Stock
Longnose skates (*Raja rhina*) are found from Navarin Canyon in the Bering Sea and Unalaska Island in Alaska to Cedros Island, Baja California in Mexico. This assessment is for the population occupying the waters off California, Oregon and Washington, bounded by Canada in the north and Mexico in the south. Within this study area, the longnose skate population is treated as one fishery stock, due to the lack of biological and genetic data supporting the presence of multiple stocks.

Catches
The longnose skate is not a commercially important target species. It is caught primarily as bycatch in trawl fisheries, where most are discarded. Although the landed catch of skates is documented through fish tickets, most records are for a combined-skate category. There are also apparent reporting inconsistencies with regard to the condition of landed skates (e.g., as whole fish or as wings). The extent to which landings in the combined-skate category were comprised by longnose skate is informed by limited periods of species-composition sampling in Oregon and Washington. Historical landed catch was reconstructed from variety of sources. Over the last 57 years, longnose skate landings ranged between 35 and 1,721 mt. Landings peaked in the mid-1990s, due to increased demand from Asian markets. Discards rates were estimated at 93% prior to 1995 and 53% after 1995, which corresponds to changes in skate markets in the mid-1990s.

Table ES-1. Recent landings (mt) for longnose skate by year and state.

<table>
<thead>
<tr>
<th>Year</th>
<th>California</th>
<th>Oregon</th>
<th>Washington</th>
<th>Total (mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>779</td>
<td>771</td>
<td>171</td>
<td>1,721</td>
</tr>
<tr>
<td>1998</td>
<td>509</td>
<td>218</td>
<td>55</td>
<td>782</td>
</tr>
<tr>
<td>1999</td>
<td>518</td>
<td>562</td>
<td>97</td>
<td>1,177</td>
</tr>
<tr>
<td>2000</td>
<td>352</td>
<td>804</td>
<td>196</td>
<td>1,351</td>
</tr>
<tr>
<td>2001</td>
<td>380</td>
<td>410</td>
<td>71</td>
<td>860</td>
</tr>
<tr>
<td>2002</td>
<td>49</td>
<td>123</td>
<td>141</td>
<td>313</td>
</tr>
<tr>
<td>2003</td>
<td>74</td>
<td>629</td>
<td>145</td>
<td>848</td>
</tr>
<tr>
<td>2004</td>
<td>66</td>
<td>238</td>
<td>69</td>
<td>373</td>
</tr>
<tr>
<td>2005</td>
<td>55</td>
<td>508</td>
<td>51</td>
<td>615</td>
</tr>
<tr>
<td>2006</td>
<td>70</td>
<td>581</td>
<td>91</td>
<td>742</td>
</tr>
</tbody>
</table>
**Figure ES-1.** Reconstructed historical landings (mt) for longnose skate.

**Data and Assessment**
This is the first assessment for longnose skate on the U.S. West Coast. The Stock Synthesis 2 (version 2.00e) modeling program was used to conduct the analysis and to estimate model parameters and management quantities. Since there are no apparent differences in biological and life history parameters as well as length and age frequencies between females and males, the assessment uses a single-sex model. The model starts in 1916, assuming an unfished equilibrium state of the stock in 1915. The assessment model includes one fishery that operates within the entire area of assessment. Fishery dependent data used in the assessment include combined-skate landings (1950-2006), fishery length compositions (1995-2006) and limited age data (2003-2004). Fishery independent data include biomass estimates (1980-2006) and length compositions (1997-2006) from four NMFS surveys conducted on the continental shelf and slope, as well as age data from one of the surveys (2003). The model uses discard data from Rogers and Pikitch’s study (1986-1987), the Enhanced Data Collection Project (1996-1998), and the NMFS West Coast Groundfish Observer Program (2004-2005).

**Stock biomass**
This assessment uses a single-sex model; therefore, spawning biomass is the sum of the mature biomasses of both sexes. Using the base model, the unexploited level of spawning stock biomass for longnose skate is estimated to be 14,069 mt. At the beginning of 2007, the spawning stock biomass is estimated to be 9,268 mt, which represents 66% of the unfished stock level.
Table ES-2. Recent trend in longnose skate spawning biomass and depletion.

<table>
<thead>
<tr>
<th>Year</th>
<th>Estimated spawning biomass (mt)</th>
<th>95% Confidence interval</th>
<th>Estimated depletion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>10,622</td>
<td>9,712-11,532</td>
<td>75%</td>
</tr>
<tr>
<td>1997</td>
<td>10,490</td>
<td>9,581-11,399</td>
<td>75%</td>
</tr>
<tr>
<td>1998</td>
<td>10,065</td>
<td>9,164-10,966</td>
<td>72%</td>
</tr>
<tr>
<td>1999</td>
<td>9,964</td>
<td>9,064-10,864</td>
<td>71%</td>
</tr>
<tr>
<td>2000</td>
<td>9,716</td>
<td>8,821-10,611</td>
<td>69%</td>
</tr>
<tr>
<td>2001</td>
<td>9,407</td>
<td>8,519-10,294</td>
<td>67%</td>
</tr>
<tr>
<td>2002</td>
<td>9,275</td>
<td>8,392-10,158</td>
<td>66%</td>
</tr>
<tr>
<td>2003</td>
<td>9,342</td>
<td>8,458-10,225</td>
<td>66%</td>
</tr>
<tr>
<td>2004</td>
<td>9,234</td>
<td>8,354-10,114</td>
<td>66%</td>
</tr>
<tr>
<td>2005</td>
<td>9,302</td>
<td>8,422-10,183</td>
<td>66%</td>
</tr>
<tr>
<td>2006</td>
<td>9,300</td>
<td>8,421-10,179</td>
<td>66%</td>
</tr>
<tr>
<td>2007</td>
<td>9,268</td>
<td>8,391-10,146</td>
<td>66%</td>
</tr>
</tbody>
</table>

**Figure ES-2.** Estimated spawning biomass time-series with 95% confidence interval.

**Recruitment**
In the assessment, we used the Beverton-Holt model to describe the stock-recruitment relationship. Recruits were taken deterministically from the stock-recruit curve. The
level of virgin recruitment $R_0$ was estimated to assess the magnitude of the initial stock size. Steepness of the stock-recruitment curve was fixed at a value of 0.4, to reflect the $K$-type reproductive strategy of the longnose skate.

**Table ES-3.** Recent estimated trend in longnose skate recruitment.

<table>
<thead>
<tr>
<th>Year</th>
<th>Estimated recruitment (1000s)</th>
<th>95% Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>13,778</td>
<td>12,745-14,811</td>
</tr>
<tr>
<td>1997</td>
<td>13,701</td>
<td>12,667-14,735</td>
</tr>
<tr>
<td>1998</td>
<td>13,448</td>
<td>12,414-14,482</td>
</tr>
<tr>
<td>1999</td>
<td>13,386</td>
<td>12,351-14,421</td>
</tr>
<tr>
<td>2000</td>
<td>13,231</td>
<td>12,195-14,267</td>
</tr>
<tr>
<td>2001</td>
<td>13,032</td>
<td>11,995-14,069</td>
</tr>
<tr>
<td>2002</td>
<td>12,945</td>
<td>11,908-13,982</td>
</tr>
<tr>
<td>2003</td>
<td>12,989</td>
<td>11,951-14,027</td>
</tr>
<tr>
<td>2004</td>
<td>12,918</td>
<td>11,880-13,956</td>
</tr>
<tr>
<td>2005</td>
<td>12,963</td>
<td>11,926-14,000</td>
</tr>
<tr>
<td>2006</td>
<td>12,962</td>
<td>11,925-13,999</td>
</tr>
<tr>
<td>2007</td>
<td>12,941</td>
<td>11,905-13,978</td>
</tr>
</tbody>
</table>

**Figure ES-3.** Time-series of estimated recruitment for longnose skate.
Reference Points
For the longnose skate, the management target is defined as 40% of the unfished spawning stock biomass (SB\textsubscript{40%}), which is estimated to be 5,627 mt (95% Confidence Interval: 5,217-6,036 mt) in the base model. The stock is declared overfished if the current spawning biomass is estimated to be below 25% of unfished level. The MSY-proxy harvest rate for longnose skate is SPR=F\textsubscript{45%}, which corresponds to an exploitation rate of 0.043. This harvest rate provides an equilibrium yield of 1,264 mt (95% Confidence Interval: 1,194-1,334 mt) at SB\textsubscript{40%}. The model estimate of maximum sustainable yield (MSY) is 1,268 mt (95% Confidence Interval: 1,198-1,338). The estimated spawning stock biomass at MSY is 5,253 mt (95% Confidence Interval: 4,867-5,638 mt). The exploitation rate corresponding to the estimated SPR\textsubscript{msy} of F\textsubscript{61%} is 0.027.

Reference point results are calculated on both a per-recruit and total-recruits basis. The total-recruits results take into account the spawner-recruitment relationship with the steepness as defined in the base model (h=0.4). Because of this low steepness and other reproductive characteristics of the stock, fishing at the target SPR of 45% is expected to reduce the spawning biomass to less than 13% of the unfished level over the long term (Table ES-9). Conversely, fishing at a rate that would maintain spawning biomass near 40% of the unfished level would require a target SPR much higher than 45%. The Council’s Scientific and Statistical Committee should consider the appropriateness of using the current proxy harvest rate for setting the Allowable Biological Catch for longnose skate.

Exploitation Status
The assessment shows that the stock of the longnose skate in the US West Coast is not overfished. Currently, the stock is at 66% of its unfished level. Historically, the exploitation rate for the longnose skate has been low. It reached its maximum level of 4.02 % in 1981. Currently, it is at the level of 1.25 %.

Table ES-4. Recent trend in longnose skate exploitation.

<table>
<thead>
<tr>
<th>Year</th>
<th>Exploitation rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>1.66%</td>
</tr>
<tr>
<td>1999</td>
<td>2.50%</td>
</tr>
<tr>
<td>2000</td>
<td>2.90%</td>
</tr>
<tr>
<td>2001</td>
<td>1.87%</td>
</tr>
<tr>
<td>2002</td>
<td>0.68%</td>
</tr>
<tr>
<td>2003</td>
<td>1.84%</td>
</tr>
<tr>
<td>2004</td>
<td>0.81%</td>
</tr>
<tr>
<td>2005</td>
<td>1.33%</td>
</tr>
<tr>
<td>2006</td>
<td>1.60%</td>
</tr>
<tr>
<td>2007</td>
<td>1.25%</td>
</tr>
</tbody>
</table>
Management
The longnose skate is grouped with other unrelated species (“Other Fish”) for the purposes of specifying annual Allowable Biological Catches and Optimum Yields (OY). Combined landings of species within this category are typically well below the specified OY. As a result, landings of species in this category are not actively monitored throughout the year, nor have they been subject to trip-limit management. In most areas of the world, management of skates has generally been a low priority and where management and assessments are implemented, the available data are generally inadequate. The longnose skate, like other elasmobranches, presents an array of problems for fisheries management. Given the low economic value of skates, information about their fisheries and basic biology is scarce. However, skate life history characteristics make them more susceptible to overfishing than teleost fishes. Vulnerability of this group and the past history of elasmobranch fisheries collapses are general causes for concern. At the same time, the absence of a strong directed fishery for skates in this region, combined with reductions in trawl effort shoreward of 150 fm to promote rockfish stock rebuilding, reflect a different fishing environment than has characterized these other collapses.

Forecast
Projections of future catches, summary biomass, spawning biomass and stock depletion were made based on F45%, as well as the current rate of fishing mortality. The projected spawning biomasses are greater than 40% of the unfished level for both approaches. No
40:10 harvest control rule reductions were applied. Optimum yield catch values were equivalent to ABC values.

Table ES-5. 10-year forecast of longnose skate catch, summary biomass, spawning biomass and stock depletion estimated based on F45%.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total catch (mt)</th>
<th>Summary biomass (mt)</th>
<th>Spawning Biomass (mt)</th>
<th>Depletion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>3,428</td>
<td>71,184</td>
<td>9,347</td>
<td>66%</td>
</tr>
<tr>
<td>2010</td>
<td>3,269</td>
<td>68,833</td>
<td>8,847</td>
<td>63%</td>
</tr>
<tr>
<td>2011</td>
<td>3,128</td>
<td>66,836</td>
<td>8,389</td>
<td>60%</td>
</tr>
<tr>
<td>2012</td>
<td>3,006</td>
<td>65,135</td>
<td>7,970</td>
<td>57%</td>
</tr>
<tr>
<td>2013</td>
<td>2,902</td>
<td>63,676</td>
<td>7,587</td>
<td>54%</td>
</tr>
<tr>
<td>2014</td>
<td>2,816</td>
<td>62,403</td>
<td>7,241</td>
<td>51%</td>
</tr>
<tr>
<td>2015</td>
<td>2,745</td>
<td>61,264</td>
<td>6,930</td>
<td>49%</td>
</tr>
<tr>
<td>2016</td>
<td>2,686</td>
<td>60,211</td>
<td>6,654</td>
<td>47%</td>
</tr>
<tr>
<td>2017</td>
<td>2,638</td>
<td>59,208</td>
<td>6,411</td>
<td>46%</td>
</tr>
<tr>
<td>2018</td>
<td>2,598</td>
<td>58,226</td>
<td>6,201</td>
<td>44%</td>
</tr>
</tbody>
</table>

Table ES-6. 10-year forecast of longnose skate catch, summary biomass, spawning biomass and stock depletion estimated based on current rate of fishing mortality.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total catch (mt)</th>
<th>Summary biomass (mt)</th>
<th>Spawning Biomass (mt)</th>
<th>Depletion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>176</td>
<td>71,184</td>
<td>9,347</td>
<td>66%</td>
</tr>
<tr>
<td>2010</td>
<td>175</td>
<td>71,129</td>
<td>9,394</td>
<td>67%</td>
</tr>
<tr>
<td>2011</td>
<td>175</td>
<td>71,060</td>
<td>9,442</td>
<td>67%</td>
</tr>
<tr>
<td>2012</td>
<td>175</td>
<td>70,986</td>
<td>9,486</td>
<td>67%</td>
</tr>
<tr>
<td>2013</td>
<td>174</td>
<td>70,914</td>
<td>9,525</td>
<td>68%</td>
</tr>
<tr>
<td>2014</td>
<td>174</td>
<td>70,848</td>
<td>9,556</td>
<td>68%</td>
</tr>
<tr>
<td>2015</td>
<td>173</td>
<td>70,794</td>
<td>9,578</td>
<td>68%</td>
</tr>
<tr>
<td>2016</td>
<td>173</td>
<td>70,754</td>
<td>9,590</td>
<td>68%</td>
</tr>
<tr>
<td>2017</td>
<td>173</td>
<td>70,727</td>
<td>9,593</td>
<td>68%</td>
</tr>
<tr>
<td>2018</td>
<td>172</td>
<td>70,714</td>
<td>9,589</td>
<td>68%</td>
</tr>
</tbody>
</table>

Rebuilding Projection
Since the longnose skate stock is estimated to be above the overfished level, no rebuilding is required.

Unresolved Problems and Major Uncertainties
The major uncertainties for the assessment include uncertainties in the longnose skate catch history, particularly in proportion of longnose skate in combined-skate landings, discard and discard mortality rates, and Northwest Fishery Science Center (NWFSC) shelf-slope survey catchability Q. To address uncertainties related to longnose skate catches, alternative catch histories were developed, which reflect variations in proportion of longnose skate in combined-skate landings, as well as discard and discard mortality rates. These alternative histories include the base scenario, which was reconstructed using the best information available, along with “high” and “low” catch scenarios. To explore uncertainty regarding the estimation of the NWFSC shelf-slope survey Q, the base-case model (with Q fixed at 0.83) results were contrasted with “high” and “low” Q scenarios.
Alternative catch histories and $Q$ values were used to define alternative states of nature and develop the decision table.

**Decision Table**

Three states of nature were defined based on the alternative longnose skate catch history and values of NWFSC shelf-slope survey $Q$. The base scenario uses the base catch history and base $Q$ ($Q=0.83$), the “low” scenario uses the low catch history and low $Q$ ($Q=0.654$), and the “high” scenario uses the high catch history and high $Q$ ($Q=1.046$). Ten-year forecasts for each state of nature were calculated based on F45% for the base scenario. Ten-year forecasts were also produced with future catch fixed at the average amount (using the base catch history) for last three years (2004-2006) and at 150% of that three-year average. Under the “high” scenario, the F45% harvest rate is projected to reduce the spawning stock biomass below 40% of the unfished level within two years. In all other scenarios covered by the decision table, the spawning biomass remains above the target level throughout the 10-year projection period. The current rate of fishing mortality is significantly lower than F45% (current exploitation rate is 1.25%). Therefore, it is very unlikely that the stock, even under the “high” scenario will fall below 40% of its virgin state in the next 10 years.

**Research and Data Needs**

This assessment reflects a data-moderate to data-poor circumstance with respect to several influential model elements, including catch history, survey catchability, and some life history characteristics. Consequently, some critical assumptions were based on very limited supporting data and research. There are several data and research needs which, if satisfied, could improve the assessment.

Data needs:

1) Continue species-specific identification in fishery to improve the accuracy of fishery catch data;
2) Continue monitoring discard of the longnose skate;
3) Resume collecting and processing of vertebra samples for age determination to improve the accuracy of growth model parameters and size-at-age relationships.

Research needs:

1) Conduct studies to determine survival rates of discarded longnose skate, especially with trawl gear, so that total fishing mortality can be estimated more precisely;
2) Conduct studies on life history characteristics, especially those related to maturity and reproduction;
3) Conduct age-validation studies;
4) Conduct studies of longnose skate catchability by survey gear types.
Table ES-7. Decision table based on three states of nature, defined based on alternative catch histories and levels of NWFSC shelf-slope survey catchability $Q$.

<table>
<thead>
<tr>
<th>Forecast Year</th>
<th>Low Q ($Q=0.654$)</th>
<th>Q=0.83</th>
<th>High Q ($Q=1.046$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total catch (mt)</td>
<td>SSB (mt)</td>
<td>Depletion</td>
</tr>
<tr>
<td></td>
<td>(landings and</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>discard mortality)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>3,428</td>
<td>11,711</td>
<td>80%</td>
</tr>
<tr>
<td>2010</td>
<td>3,269</td>
<td>11,154</td>
<td>76%</td>
</tr>
<tr>
<td>2011</td>
<td>3,128</td>
<td>10,643</td>
<td>72%</td>
</tr>
<tr>
<td>2012</td>
<td>3,006</td>
<td>10,175</td>
<td>69%</td>
</tr>
<tr>
<td>2013</td>
<td>2,902</td>
<td>9,749</td>
<td>66%</td>
</tr>
<tr>
<td>2014</td>
<td>2,816</td>
<td>9,363</td>
<td>64%</td>
</tr>
<tr>
<td>2015</td>
<td>2,745</td>
<td>9,015</td>
<td>61%</td>
</tr>
<tr>
<td>2016</td>
<td>2,686</td>
<td>8,706</td>
<td>59%</td>
</tr>
<tr>
<td>2017</td>
<td>2,638</td>
<td>8,434</td>
<td>57%</td>
</tr>
<tr>
<td>2018</td>
<td>2,598</td>
<td>8,196</td>
<td>56%</td>
</tr>
<tr>
<td></td>
<td><strong>F45% for base scenario</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>899</td>
<td>11,711</td>
<td>80%</td>
</tr>
<tr>
<td>2010</td>
<td>899</td>
<td>11,700</td>
<td>80%</td>
</tr>
<tr>
<td>2011</td>
<td>899</td>
<td>11,691</td>
<td>80%</td>
</tr>
<tr>
<td>2012</td>
<td>899</td>
<td>11,679</td>
<td>80%</td>
</tr>
<tr>
<td>2013</td>
<td>899</td>
<td>11,665</td>
<td>79%</td>
</tr>
<tr>
<td>2014</td>
<td>899</td>
<td>11,645</td>
<td>79%</td>
</tr>
<tr>
<td>2015</td>
<td>899</td>
<td>11,620</td>
<td>79%</td>
</tr>
<tr>
<td>2016</td>
<td>899</td>
<td>11,589</td>
<td>79%</td>
</tr>
<tr>
<td>2017</td>
<td>899</td>
<td>11,553</td>
<td>79%</td>
</tr>
<tr>
<td>2018</td>
<td>899</td>
<td>11,513</td>
<td>78%</td>
</tr>
<tr>
<td></td>
<td><strong>Average landings and discard mortality for base scenario 2004-2006</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>1,349</td>
<td>11,711</td>
<td>80%</td>
</tr>
<tr>
<td>2010</td>
<td>1,349</td>
<td>11,603</td>
<td>79%</td>
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<tr>
<td>2011</td>
<td>1,349</td>
<td>11,497</td>
<td>78%</td>
</tr>
<tr>
<td>2012</td>
<td>1,349</td>
<td>11,392</td>
<td>78%</td>
</tr>
<tr>
<td>2013</td>
<td>1,349</td>
<td>11,286</td>
<td>77%</td>
</tr>
<tr>
<td>2014</td>
<td>1,349</td>
<td>11,179</td>
<td>76%</td>
</tr>
<tr>
<td>2015</td>
<td>1,349</td>
<td>11,072</td>
<td>75%</td>
</tr>
<tr>
<td>2016</td>
<td>1,349</td>
<td>10,964</td>
<td>75%</td>
</tr>
<tr>
<td>2017</td>
<td>1,349</td>
<td>10,857</td>
<td>74%</td>
</tr>
<tr>
<td>2018</td>
<td>1,349</td>
<td>10,753</td>
<td>73%</td>
</tr>
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</table>
Table ES-8. Summary of recent trends in longnose skate exploitation and estimated population levels.

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Landings (mt)</td>
<td>782</td>
<td>1,177</td>
<td>1,351</td>
<td>860</td>
<td>313</td>
<td>848</td>
<td>373</td>
<td>615</td>
<td>742</td>
<td>576</td>
</tr>
<tr>
<td>Estimated Discards (mt)</td>
<td>438</td>
<td>659</td>
<td>757</td>
<td>482</td>
<td>175</td>
<td>475</td>
<td>209</td>
<td>344</td>
<td>415</td>
<td>323</td>
</tr>
<tr>
<td>Estimated Total Catch (mt)</td>
<td>1,220</td>
<td>1,835</td>
<td>2,108</td>
<td>1,342</td>
<td>488</td>
<td>1,323</td>
<td>582</td>
<td>959</td>
<td>1,157</td>
<td>*899</td>
</tr>
<tr>
<td>ABC (mt)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OY * (if different from ABC) (mt)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPR</td>
<td>74.28%</td>
<td>64.22%</td>
<td>59.83%</td>
<td>71.03%</td>
<td>87.96%</td>
<td>71.56%</td>
<td>85.99%</td>
<td>78.42%</td>
<td>74.81%</td>
<td>79.65%</td>
</tr>
<tr>
<td>Exploitation Rate (total catch/summary bio)</td>
<td>1.66%</td>
<td>2.50%</td>
<td>2.90%</td>
<td>1.87%</td>
<td>0.68%</td>
<td>1.84%</td>
<td>0.81%</td>
<td>1.33%</td>
<td>1.60%</td>
<td>1.25%</td>
</tr>
<tr>
<td>Summary Age 2+ Biomass (B) (mt)</td>
<td>72.877</td>
<td>72.599</td>
<td>71.802</td>
<td>70.844</td>
<td>70.671</td>
<td>71.272</td>
<td>71.027</td>
<td>71.445</td>
<td>71.439</td>
<td>71.217</td>
</tr>
<tr>
<td>Uncertainty in Spawning Stock Biomass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomass estimate</td>
<td>9,164-10,966</td>
<td>9,064-10,864</td>
<td>8,821-10,611</td>
<td>8,519-10,294</td>
<td>8,392-10,158</td>
<td>8,458-10,225</td>
<td>8,354-10,114</td>
<td>8,422-10,183</td>
<td>8,421-10,179</td>
<td>8,391-10,146</td>
</tr>
<tr>
<td>Recruitment at age 0</td>
<td>13,448</td>
<td>13,386</td>
<td>13,232</td>
<td>13,032</td>
<td>12,945</td>
<td>12,989</td>
<td>12,918</td>
<td>12,963</td>
<td>12,962</td>
<td>12,941</td>
</tr>
<tr>
<td>Uncertainty in Recruitment estimate</td>
<td>12,414-14,482</td>
<td>12,351-14,421</td>
<td>12,195-14,267</td>
<td>11,995-14,069</td>
<td>11,908-13,982</td>
<td>11,951-14,027</td>
<td>11,880-13,956</td>
<td>11,926-14,000</td>
<td>11,925-13,999</td>
<td>11,905-13,978</td>
</tr>
<tr>
<td>Depletion (SB/SB0)</td>
<td>71.54%</td>
<td>70.82%</td>
<td>69.06%</td>
<td>66.86%</td>
<td>65.93%</td>
<td>66.40%</td>
<td>65.64%</td>
<td>66.12%</td>
<td>66.13%</td>
<td>66.44%</td>
</tr>
<tr>
<td>Uncertainty in Depletion estimate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>64.15%-68.11%</td>
</tr>
</tbody>
</table>

* indicates values calculated as the average for the last three years (2004-2006)
### Table ES-9. Summary of longnose skate reference points.

<table>
<thead>
<tr>
<th></th>
<th>Point estimate</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unfished Spawning Stock Biomass (SB₀) (mt)</td>
<td>14,069</td>
<td>13,042-15,096</td>
</tr>
<tr>
<td>Unfished Summary Age 2+ Biomass (B₀) (mt)</td>
<td>90,955</td>
<td></td>
</tr>
<tr>
<td>Unfished Recruitment (R₀) at age 0</td>
<td>15,454</td>
<td>14,403-16,505</td>
</tr>
<tr>
<td><strong>Reference points based on SB₄₀%</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSY Proxy Spawning Stock Biomass (SB₄₀%)</td>
<td>5,627</td>
<td>5,217-6,036</td>
</tr>
<tr>
<td>SPR resulting in SB₄₀% (SPR₄₀%)</td>
<td>62.50%</td>
<td>62.4999%-62.500059%</td>
</tr>
<tr>
<td>Exploitation rate resulting in SB₄₀%</td>
<td>2.67%</td>
<td>N/A</td>
</tr>
<tr>
<td>Yield with SPR₄₀% at SB₄₀% (mt)</td>
<td>1,264</td>
<td>1,194-1,334</td>
</tr>
<tr>
<td><strong>Reference points based on SPR proxy for MSY</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spawning Stock Biomass at SPR (SB₅₄₄) (mt)</td>
<td>1,688</td>
<td>1,565-1,812</td>
</tr>
<tr>
<td>SPR₅₄₄ proxy</td>
<td>45%</td>
<td></td>
</tr>
<tr>
<td>Exploitation rate corresponding to SPR</td>
<td>4.26%</td>
<td>N/A</td>
</tr>
<tr>
<td>Yield with SPR₅₄₄ proxy at SB₅₄₄ (mt)</td>
<td>787</td>
<td>744-831</td>
</tr>
<tr>
<td><strong>Reference points based on estimated MSY values</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spawning Stock Biomass at MSY (SB₅₄₄) (mt)</td>
<td>5,253</td>
<td>4,867-5,638</td>
</tr>
<tr>
<td>SPR₅₄₄</td>
<td>60.84%</td>
<td>60.80%-60.86%</td>
</tr>
<tr>
<td>Exploitation Rate corresponding to SPR₅₄₄</td>
<td>2.71%</td>
<td>N/A</td>
</tr>
<tr>
<td>MSY (mt)</td>
<td>1,268</td>
<td>1,198-1,338</td>
</tr>
</tbody>
</table>
INTRODUCTION

General information about the species

Skates are the largest and most widely distributed group of batoid fish with approximately 230 species ascribed to two families (Martin and Zorzi 1993, McEachran 1990). Skates are benthic fish that are found in all coastal waters but are most common in cold temperatures and polar waters.

There are about 12 species of skates from either of two genera (*Raja* and *Bathyraja*) present in the northeast Pacific Ocean off California, Oregon and Washington. Of that number, just three species (longnose skate *Raja rhina*, big skate *Raja binoculata*, and sandpaper skate *Bathyraja interrupta*) make up over 95% of survey catches in terms of biomass and numbers, with the longnose skate leading in both categories (62% of biomass and 56% of numbers). Species compositions of fishery landings also show that longnose skate dominates commercial catches. On average, longnose skate represents 75% of total skate landings in Oregon for the last 12 years and 45% in Washington for the last three years. There are no species composition data available for commercial landings in California, but anecdotal evidence suggests that the majority of skates landed there are longnose skates.

The longnose skate or *Raja rhina* belongs to the family Rajidae (skates), the order Rajiformes (skates and rays), and the subclass Elasmobranchii (cartilaginous fish) that includes skates, rays and sharks (Compagno1999, McEachran and Aschliman 2004). Like other skates, longnose skate is a dorso-ventrally compressed animal with large pectoral fins (often called “wings”), a long whip-like tail and a stiff, long snout (Compagno 1999). A photograph of the longnose skate is shown in Figure 1.

The distribution of the longnose skate is limited to the eastern Pacific Ocean between 61° N Lat. and 28° N Lat. It is found as far north as Navarin Canyon in the Bering Sea and Unalaska Island in Alaska to as far south as Cedros Island, Baja California in Mexico at depths of 25-684 m (Lamb and Edgel 1986). Longnose skates do not exhibit a size-specific pattern in distribution relative to bottom depth; average fish size does not vary greatly with depth (Figure 2).

Currently, there is no information available that indicates the existence of multiple breeding units in the Northeast Pacific Ocean. Several tagging studies have found that elasmobranchs, such as sharks and skates, can undertake extensive migrations within their geographic range. This behavior suggests the likelihood that there is a high degree of genetic mixing within the population, across its range (Martin and Zorzi 1993, McFarlane and King 2003). As a result, the longnose skate population off California, Oregon and Washington is modeled in this assessment as a single stock. A map depicting the scope of the assessment is presented in Figure 3.

Life history of longnose skate

The life history of skates is characterized by late maturity, low fecundity and slow growth to large body size (King and McFarlane 2003, Moyle and Cech 1996, Walker and Hislop 1998). The characteristics are associated with a *K*-type reproductive strategy, as opposed
to \( r \)-type strategy, wherein reproductive success is achieved by high productivity and early maturity (Hoenig and Gruber 1990).

The longnose skate is oviparous (egg-laying) and invests considerable energy in developing a few large, well-protected embryos. There are three major stages in the life cycle of the longnose skate: the egg, the juvenile and the adult stages. After fertilization, the female forms a large tough, leathery yet permeable egg case (about 10×6 cm) that surrounds one or more eggs. After several months the female deposits the egg case onto the sea floor. The eggs incubate for several months in a benthic habitat where there is some exposure to predation and damage. Inside the egg case, the embryos develop with nourishment provided by a yolk. When the yolk is depleted and the juvenile fully formed, it exits the egg case. Once hatched, the young skate is similar in appearance to an adult, but smaller in size. The juvenile stage lasts from the time of hatching to the onset of maturity (Frisk et al. 2002, Pratt and Casey 1990). On average, longnose skate mature at ages ranging from six to nine years. Upon reaching maturity, skates enter the reproductive adult stage, which characterizes the remainder of their lives. The life span of this species is not well known, although individuals up to 23 years of age have been found. Longnose skates attain a maximum length of about 145 cm (Zeiner and Wolf 1993). The average size is about 60-90 cm (Thompson 2006, Zeiner and Wolf 1993).

The reproductive cycle of oviparous skates has been observed for a few species but not for longnose skate. These studies indicate that egg production generally occurs throughout the year although there have been some instances where seasonality in egg laying was observed (Hamlett and Koob 1999). Information on fecundity of longnose skate is extremely limited. Holden (1974) found that species of genus Rajidae are the most fecund of all elasmobranches and can lay 100 egg cases per year, although eggs may not be produced every year. Frisk et al. (2002) estimated that annual fecundity for medium-sized skates like longnose may be less than 50 eggs per year; however, those eggs exhibit high survival rates due to the large parental investment. Typically, an egg case houses 4-5 embryos although the numbers can go as low as one to as high as seven (Thompson 2006). Overall, little is known about breeding frequency, egg survival, hatching success and other early life history characteristics of the longnose skate.

**Fishery off the US west coast**

Historically, skates in general, and longnose skate in particular, have not been high-priced fishery products. They are taken mostly as bycatch in other commercially important fisheries (Bonfil 1994). Although skates are caught in almost all demersal fisheries and areas off the U.S. West Coast, the vast majority (almost 97%) are caught with trawl gear. Figure 4 shows the distribution of skate landings among gears, averaged over the last 25 years.

Landing records indicate that skates have been retained on the U.S. Pacific Coast at least since 1916 (Martin and Zorzi 1993). Little is known about the species composition of West Coast skate fisheries, particularly prior to 1990. With few exceptions, longnose skate landings have been reported, along with other skate species, under the market category “unspecified skates.” In recent years, the species composition of this market category has been sampled by state port samplers in Oregon and Washington.
Skate retention is probably influenced by the success of the target fisheries in which they occur as bycatch. A high catch of the target species could result in limited storage space for skate and subsequent drop in skate landings (Martin and Zorzi 1993). Martin and Zorzi (1993) have found that skate landings do partially reflect changes in landings in other trawl fisheries, particularly rockfish and flatfish, but findings of direct correlations are inconsistent and there is often a time lag of several years. Frey (1971) found that fluctuations in skate landings roughly followed general economic trends such that peaks in production occur at about the same period as economic peaks.

Historically, only the skinned pectoral fins, or “wings” were sold, although a small portion of catch would be marketed round. The wings were cut onboard the boat and the remainder discarded. Currently, West Coast skates are marketed both whole and as wings. Skates wings are sold fresh or fresh-frozen, as well as dried or salted and dehydrated, for sale predominantly in Asian markets (Bonfil 1994, Martin and Zorzi 1993). There is no information to suggest change in skate markets prior to the mid 1990s. However, it appears that the demand for whole skates did increase greatly during the mid-1990s, as evidenced by the increase in the number of trips where skates were landed (Figure 5). While skates were encountered predominantly as bycatch previously, landings data from this period reveal greater targeting of skates by some vessels. After a few years, the whole-skate market cooled due to downturns in Asian financial markets (Peter Leipzig, Fishermen’s Marketing Association, personal communication).

Fishery and assessment off Alaska and Canada
In Alaska, skates were primarily taken as bycatch in both longline and trawl fisheries until 2003 when a directed skate fishery developed in the Gulf of Alaska. Longnose skates, as well as big skates, comprise the majority of the skate biomass in the Gulf of Alaska. In 2003 skate species in the Gulf of Alaska, and the Bering Sea and Aleutian Islands were assessed as a group rather than as separate species. In 2005 the skate assessments were updated, with the recommendation that no directed fisheries for skates be conducted in the Gulf of Alaska due to high incidental catch in groundfish and halibut fisheries. Also, the area-specific Allowable Biological Catches for big and longnose skates were recommended (Gaichas et al. 2003, Matta et al. 2006).

In Canada historic information regarding skate catches goes back to the 1950’s. Prior to 1990’s skates were taken mostly as bycatch and landings were reported as part of a skate complex (not by species). As with the West Coast, the trawl fishery is responsible for the largest amount of bycatch. Skate catches off British Columbia accelerated in the early 1990’s, partly due to emerging Asian markets. Since 1996, longnose skate has been targeted by the B.C. trawl fishery and, as a result, catches have been more accurately reported. A longnose skate assessment has not been done for B.C., but in 2001 a review of elasmobranch biology, fisheries, assessment, and management was conducted to assess the current state of knowledge and to examine possible methods for assessing elasmobranch species, including longnose skates (Benson et al. 2001).

Management
On the West Coast, longnose skate has been grouped with other species in an “Other Fish” category, for purposes of setting Allowable Biological Catches and Optimum Yields (OY). Since landings are routinely well below OYs for this category, trip limits
have not been used for inseason management. In most areas of the world, management of skates has been a low priority, and where management and assessments are implemented, the available data are generally inadequate (Shotton 1999). The longnose skate, like other elasmobranches, present an array of potential problems for fisheries management. Skates’ life history characteristics make them more susceptible to overfishing than teleost fishes. The most extreme case of overexploitation has been reported in the North Atlantic, where the common skate _Dipturus batis_ has disappeared from the Irish Sea (Brander 1981) and much of the North Sea (Walker and Hislop 1998). However, given the low economic value of skates, information about their fisheries and even their basic biology is scarce, patchy and scattered (Bonfil 1994). The vulnerability of these species, combined with past collapses of elasmobranches fisheries elsewhere, underscores the importance of ascertaining the status of longnose skate on the West Coast.

**ASSESSMENT**

**DATA**

For this assessment we used the following data sources: (1) commercial landings (1950-2006), (2) fishery biological data (1995-2006), (3) NWFSC slope survey (1999-2002), (4) NWFSC shelf-slope survey (2003-2006), (5) AFSC shelf (triennial) survey (1980-2004), and (6) AFSC slope survey (1997-2001). These data sources are divided into two major categories: fishery-dependent and fishery-independent data. Summaries of the fishery-dependent and fishery-independent data used in this assessment, by source and year, are presented in Tables 1 and 2, respectively.

**Fishery dependent data**

**Landed catch**

Historically, landed catch of longnose skate has been reported under the market category “unspecified skates” along with other skate species. Hence, skate landings records, themselves, are not species-specific. In order to reconstruct landed catch of longnose skate we first, reconstructed the historical landings of “unspecified skates” market category, and then estimated the proportion of the longnose skate within this category.

To reconstruct the time series of combined-skate landed catch, we used several data sources that included both published reports and databases. The most recent and detailed information, for the period between 1981 and 2006, was obtained from the Pacific Fisheries Information Network database (PacFIN, Daspit et al. 1997). For the period between 1950 and 1980, combined-skate landings were obtained from annual publications of Fisheries Statistics of US. From historical data, we excluded all skate catches landed in any other areas, except for five INPFC areas covered by this assessment (these five INPFC areas included US Vancouver, Columbia, Eureka, Monterey and Conception). Overall combined-skate landings between 1950 and 2006 are shown in Figures 6.

In recent years, the Oregon and Washington Department of Fish & Wildlife (ODFW and WDFW) have started to collect species compositions of the “unspecified skate” market category. From ODFW and WDFW we obtained data for species compositions of skate
catches landed in Oregon in 1995-2006 and in Washington in 2004-2006 respectively. No species-specific information was available for California landings.

To estimate the proportion of longnose skates within the “unspecified skate” market category between 1950 and 2006, we used data from ODFW and WDFW for years when skate species compositions were available. For other relatively recent (since 1981) years/areas, species-composition data from the NMFS shelf (triennial) survey, conducted principally by the Alaska Fisheries Science Center (AFSC), were used to represent species proportions in the fisheries. This survey was conducted every third year from 1980 to 2004. For each of these years, the survey’s proportion of total skate catch comprised by longnose skates was calculated for the area off each state. These proportions were applied directly to the commercial landings data from the same year. For years in which the survey was not conducted, the proportions of longnose skate were estimated using a linear function connecting the two closest available data points. The final percentages of longnose skate that were applied to generic skate landings since 1981, by year and state, are shown in Table 3. For the period between 1950 and 1980, when we did not have any survey catches available, we applied the overall average percentage of the longnose skate within the “unspecified skate” market category (62%) for the last 25 years. The resultant time series of longnose skate landed catch for the years 1950-2006 are shown in Figure 7. These time series show the increase in landings in the mid-1990’s, which corresponds to the time of increased demand from the Asian skate market.

**Gear**
As a bycatch species, skates have been caught on the West Coast by a variety of gears. The vast majority (almost 97%), however, are caught in trawl gear (Figure 4). Consequently, this assessment focuses on the catch of longnose skate by the trawl fishery. Other fisheries are assumed to have the same fishery characteristics and selectivity.

**Condition code**
As described above, most skates have been landed as either “wings” or “round”. PacFIN records indicate that skates were landed as wings, round, alive, dressed (head on), dressed (general), dressed (head off), and dressed (head and tail off). To be able to convert landed weight into round weight correctly, we discussed the ways in which skates were landed with representatives of the State agencies, who helped us refine the use of condition code information. For example, we discovered that in Oregon, the condition code “dressed” was used for “wings” because, at the time when differentiating skate wings was initiated, there were no available new codes to be used. For Washington, PacFIN data also included “dressed” records which were actually “wings.” In California, prior to 1995, the only condition code used to describe how skates were landed was “wings” (Gerry Kobylnski, California PacFIN Coordinator, pers. com.) although PacFIN data contain several condition codes for this period.

**Conversion factor**
Since “wings” comprise only a portion of total skate body, state agencies use a conversion factor to convert landed weight into round weight. Based on research conducted by ODFW a conversion factor of 2.6 is used for Oregon (Johnson and Hosie
1996). Other states relied upon literature reviews to determine their conversion factors. Currently, Washington uses conversion factor of 3, and California 3.1 (prior to this year, California was using the value of 4.3).

**Discard**

**Discard rate**
For this assessment, we used three sources of information to characterize fishery discards. The first source was a discard study in Oregon and Washington in 1986 and 1987 (Rogers and Pikitch 1992). This study found that 93% of the trawl fishery longnose skate catch (by weight) was discarded. Marketing problems were indicated as the main reason for the skate discard. The second source of discard data was the Enhanced Data Collected Project (EDCP), conducted by ODFW between 1996 and 1998 in the waters off Oregon. The discard rate for skates was 53% on trips included in this project, although most observed trips were directed at deep-water species. The third source of discard data is the NMFS West Coast Groundfish Observer Program (WCGOP), which provided discard rate data for 2005. As in the EDCP observations, analysis of WCGOP data indicates that the discard rate for the skates in 2005 was 53%. None of the sources collected size-specific discard information.

Since the rate of skate discard is highly dependent on market acceptance (Rogers and Pikitch 1992), we modeled discard mortality for two time periods – one is before 1995, and the second is from 1995 till present time, when skate market demands increased. In the base model, for the first period we assumed the discard rate of 93% estimated in Rogers and Pikitch (1992); for the second period we used the discard rate of 53% estimated from EDCP and WCGOP data.

**Discard mortality**
To date, no studies have been conducted to estimate the mortality of discarded longnose skate or any other skate. In tagging studies conducted in Canada (Gordon McFarlane, pers. com.), tagged skates were recovered several times in trawl surveys, indicating that skates can survive trawl capture and on-deck sorting time. Anecdotal evidence from commercial fisheries also indicates that skates are generally durable, and can handle capture and release well. However, many factors, such as trawl time, handling techniques, and time spent on the deck certainly affect skate survival. For the base model in this assessment, we assumed that 50% of discarded skates die, and performed a sensitivity analyses on this assumption.

**Biological data**
Very limited biological data on longnose skate have been collected over the years. For this assessment, biological information was provided primarily by ODFW and WDFD.

**Size**
Size-composition data was provided by ODFW for Oregon catches landed between 1995 and 2006 and by WDFW for Washington catches landed between 2004 and 2006. No size-composition data were available for California landings. In the assessment we combined the data from Oregon and Washington and used it to represent the size compositions of the longnose skate caught in coast-wide commercial fishery. Sizes of
longnose skates were recorded as total length (TL) from the tip of the snout to the end of the tail. TL of longnose skates in fishery catches ranged from 40 to 140 cm, except for two fish with recorded TLs of 165 and 180 cm. These two lengths are considerably larger than any recorded longnose skates in the area, and were subsequently excluded from our analysis, due to the likelihood that they represent data entry errors. Size data were aggregated into 5-cm length bins. Fishery skate size compositions for longnose skate, by year, are shown in Figure 8.

Age
No fishery age-composition data are available for longnose skate. Thompson (2006) conducted a study on age and growth of longnose skate as a part of her MS research. For this study, she drew two small samples of longnose skate from catches landed in Oregon (one in 2003 and one in 2004). Since elasmobranches do not have otoliths, the most common structure used to age cartilaginous species is vertebrae (Cailliet and Goldman 2004). The ages of longnose skates collected in these samples were identified through the analysis of annual rings, or “annuli,” on the vertebra centra. Since the sample sizes of Thompson’s data were small (N=38 for 2003 and N=102 for 2004) and represented only a small portion of the study area of the assessment, we used these data only to calculate mean size-at-age in the model and not to describe age composition of fisheries data.

Fishery independent data
In this assessment we used four surveys conducted by NMFS as fishery-independent data sources. These surveys are the NWFSC slope and shelf-slope surveys, and the AFSC shelf (triennial) and slope surveys. Details on latitudinal and depth ranges of these surveys, by year, are presented in Table 4. Below we give an overview of each survey and describe data that were used in our assessment.

NWFS slope survey
The NWFSC slope survey was conducted annually from 1999 to 2002. Survey methods are described in Keller et al. (2006). This survey was conducted between 35° and 48°07’ N. Lat., encompassing all of the US Vancouver, Columbia, Eureka, Monterey INPFC areas, and a portion of the Conception area. The survey covered depths from 183 to 1280 m (100-700 fathoms).

Biological information
No biological data on longnose skate was collected during this survey.

NWFSC shelf-slope survey
The NWFSC shelf-slope survey was conducted annually from 2003 to 2006. Survey methods are described in Keller et al. (2007). This survey ranged from 32°34’ to 48°22’ N.Lat., encompassing all five INPFC areas included in the scope of this assessment (US Vancouver, Columbia, Eureka, Monterey, Conception). The survey covered depths between 55 and 1280 m (30-700 fathoms), which is almost the entire depth distribution of longnose skate.

Biological information
Size
Size data were collected in all years. In 2003, 2004, and 2005, longnose skates were measured in total length (TL), while in 2006 in disc width (DW), which is the distance across pectoral fins. To convert DW data to TL, we used the conversion equation, derived from the AFSC slope survey in 1999, when a sample of 457 longnose skates was measured in both TL and DW. Figure 9 shows the relationship between TL and DW for longnose skate obtained from that study \( TL = 7.36 + 1.41 \cdot DW, r^2=0.99 \). Size of longnose skates collected in this survey ranged from 15 to 140 cm.

**Age**

A limited-sample of longnose skate age structures (vertebra) was collected from 2003 NWFSC shelf-slope survey and processed by Thompson (2006) as a part of her MS research. The ages of longnose skates were identified through the analysis of annuli on the vertebra centra of skates. The degree of age-reader agreement was explored through comparing the readings of the same age structures by two other readers (Thompson 2006). Although this provides some information regarding the precision of the age determinations, they have not been validated with regard to potential bias.

**AFSC shelf (triennial) survey**

The AFSC shelf (triennial) survey was conducted every third year between 1977 and 2004 (in 2004 this survey was conducted by the NWFSC). Survey methods are described in Weinberg et al. (1994), Zimmermann et al. (1994), Wilkins et al. (1998) and Winberg et al. (2002). Over this period, the survey area varied in depth and latitudinal range (Table 4). In order to utilize as many years as possible, we used data only from the common depth and latitude range for analysis. Our analysis included data from four INPFC areas (Monterey, Eureka, Columbia and U.S. Vancouver) and depths between 55 and 366 meters.

**Biological information**

Longnose skate size data were collected in 1998, 2001 and 2004. In 1998, sample size was very small and was not included in our analysis. In 2001 and 2004, individuals were measured in total length (TL). Size of longnose skates collected in this survey ranged from 15 to 145 cm. No age data for longnose skate was available for this assessment.

**AFSC slope survey**

The AFSC slope survey was initiated in 1984. The survey methods are described in Lauth (1999, 2000). Prior to 1997, this survey was conducted in different latitudinal ranges in each year (Table 4). Therefore, in this assessment we used data from surveys conducted in 1997, 1999, 2000 and 2001, which were consistent in latitudinal range (from 34°30’ to the U.S.-Canadian border) and depth (183-1280 m; 100-700 fathoms).

**Biological information**

Longnose skate size data were collected in 1997, 1999, 2000 and 2001. In 1997, longnose skates were measured in disc width (DW), while all other years (1999, 2000 and 2001) were measured in total length (TL). In 1999, longnose skates (457 individuals) were measured in both TL and DW. These data were used as the basis for converting 1997 DW data to TL. Figure 9 shows the relationship between TL and DW for longnose skate that we used \( TL = 7.36 + 1.41 \cdot DW, r^2=0.99 \). Size of longnose skates collected in this survey ranged from 15 to 140 cm.
Survey biomass indices and length compositions


Survey biomass indices (mt) and standard deviation of log (index), calculated as $\sqrt{\ln(1+CV^2)}$ are presented in Table 5. Biomass indices are also shown in Figures 10-13.

The size data were aggregated into 27 size bins, with 5-cm bin length. Size compositions were calculated as described in Weinberg et al. (1994), Zimmermann et al. (1994), Wilkins et al. (1998), Winberg et al. (2002), Lauth (1999, 2000), Keller et al. (2006), Keller et al. (2007) and Hamel (2005). The size compositions for each survey, by year, are presented in Figures14-16. Age composition for 2003 NWFSC shelf-slope survey from Thompson (2006) are shown in Figure 17. The size-at-age data plotted for fishery and NWFSC shelf-slope survey are presented in Figures 18-19. Sample sizes of organisms measured in all length and age samples by year are given in Tables 6-7.

Biological Parameters

Using the data described above, biological parameters, such as somatic growth of individual fish, maturity-at-length, and the length-weight relationship were estimated. There were no apparent differences found between females and males in any of these parameters.

Growth

Several studies of longnose skate growth (Zeiner and Wolf 1993, Thompson 2006, McFarlane and King 2006, Gburski 2007) showed that growth of longnose skate is best described by von Bertalanffy growth model (Bertalanffy 1938). Growth parameters of von Bertalanffy model estimated in different studies are summarized in Table 8.

SS2 uses the following version of the von Bertalanffy growth model:

$$L_A = L_\infty + (L_1 - L_\infty) e^{-K(1-A)}$$

Where asymptotic length, $L_\infty$, is calculated as:

$$L_\infty = L_1 + \frac{L_2 - L_1}{1 - e^{-K(17-1)}}$$

In these equations, $L_A$ is length (cm) at age $A$, $K$ is growth coefficient, $L_\infty$ is asymptotic length, and $L_1$ and $L_2$ are the sizes associated with a reference ages near the youngest and the oldest ages that are well represented in the data. For longnose skate, this reference ages were 1 and 17 correspondingly.

Maturity

To estimate the relationship between size and maturity, SS2 employs the logistic function:
Where $M\%$ is the proportion mature, $\beta$ is coefficient used as a constant, and $L_{50\%}$ is the length at 50% maturity. For longnose skate, $\beta$ was estimated as -0.0986, and $L_{50\%}$ as 120 cm (Thompson 2006).

McFarlane and King (2006), while studying maturity of longnose skate in the British Columbia waters, estimated $\beta$ for maturity logistic function as -0.078, and $L_{50\%}$ as 83cm, which is significantly lower than estimated by Thompson (2006). Criteria to distinguish mature individuals from immature differed between Thompson’s and McFarlane and King’s studies. Neither approach, however, could be considered superior to the other. For the base model, we used Thompson’s data, which is more likely to underestimate the proportion of mature skates. However, we explored the uncertainly of this estimation through the sensitivity analysis, as described later in this report.

**Length-weight relationships**

To establish the relationship between length and weight, the following equation was used:

$$W = \alpha(L)^\beta$$

Where $W$ is weight (kg), $L$ is length (cm) and $\alpha$ and $\beta$ are coefficients used as constants. For longnose skate $\alpha$ was estimated as 0.00000428 and $\beta$ as 3.05975.

**MODEL DESCRIPTION**

This report describes the latest version of the assessment model for the longnose skate, which includes changes made according to STAR Panel requests. The list of STAR Panel requests is presented in Appendix 1.

**Overview**

This assessment uses the Stock Synthesis 2 (SS2) modeling program developed by Richard Methot at the NWFSC. We used the most recent version of the program (version 2.00e) distributed on April 18, 2007 (Methot 2007).

In this assessment, it was assumed that one stock of longnose skate occupies the waters off the continental West Coast area, from the US-Canadian border in the north to US-Mexican border in the south. The vast majority of longnose skates (97%) were caught in trawl fisheries; therefore this stock was modeled with a single fishery. Since there were no apparent differences between females and males in their biological parameters or fishery and survey length and age frequencies, the assessment uses a single sex model. Since this is a single-sex model, spawning biomass is the sum of the mature biomasses of both sexes.
The likelihood components of the model included (1) survey abundance indices, (2) fishery and survey length compositions, (3) NWFSC shelf-slope survey age compositions, and (4) fishery and NWFSC shelf-slope survey mean size-at-age. In the model, likelihood estimates for the various data components were obtained by comparing expected values from the model with the actual observations from sample data based on “goodness of fit” procedures for log \( L \). Emphasis levels were set to 1.0 for each likelihood component listed above.

The earliest record of skate catches in the US west coast is dated at 1916 (Martin and Zorzi 1993, Bonfil 1994). Therefore, the modeling period of our assessment begins in 1916, assuming that in 1915 the population was in an unfished equilibrium condition. To fill the historical catches between unfished equilibrium in 1915 and the time when longnose skate catch data were available (1950-2006), we linearly ramped data from zero in 1915 up to the average catch level for the period of 1950-1980 in 1949 (we assumed catch in 1949 to be the average for the period between 1950-1980).

In the assessment, we reconstructed a time series of total catch for the longnose skate outside of SS2 and then entered these time series in the SS2 data file. The total catch time series included both landed catch and discard mortality. For the base model, we assumed a 93% discard rate prior to 1995 and 53% from 1995 forward to reflect skate market changes. We also assumed 50% discard mortality for the entire time series. Figure 20 shows longnose skate total catch over time as used in the base model. The uncertainties associated with discard and discard mortality assumptions were explored in the sensitivity analysis, the results of which are presented later in this report.

Model parameters

The model utilizes 34 parameters. No prior assumptions were made regarding the estimated parameters (the emphasis level “lambda” on all prior distributions was set to 0). However, bounds were established on all parameters, including life history, stock-recruitment, and selectivity. Based on the information about survey coverage and behavior of longnose skate in the natural environment, the catchability coefficient \( Q \) for the NWFSC shelf-slope survey was fixed at the level of 0.83. The determination of this value is described later in the report. Values of \( Q \) for other surveys were estimated within the model. Ageing error was input as data to the model and was not estimated. Input variance factors were adjusted for length sample sizes in fishery and surveys as well as AFSC shelf (triennial) survey CV.

All the explicit parameters used for the base model and their values are given in Table 9. If parameters were estimated, initial values as well as parameters bounds are also given. The phases in which estimated parameters were calculated by the model are indicated in parentheses.

Natural mortality

To estimate natural mortality \( M \), we explored several methods that relate \( M \) with different life history parameters, including time of sexual maturation and longevity (Charnov 1993, Frisk et al. 2001, Hoenig 1983, Rikhter and Efano 1976, Roff 1986).
Based on published life-history parameters of skates, sharks and rays over a wide geographic range, Frisk et al. (2001) developed models that relate natural mortality of elasmobranch fishes with maximum age and age of maturity. Based on both of these models, the natural mortality of longnose skate was estimated at 0.2. Hoenig (1983) developed a model that related total mortality to the maximum age of fish. Since Hoenig’s analysis was based largely on unexploited fish stocks, total mortality in his model is often assumed to be natural mortality. Based on Hoenig’s model, longnose skate natural mortality was also estimated as 0.2. In our model, natural mortality was thus fixed at the level of 0.2.

**Growth and maturity parameters**

The von Bertalanffy growth parameters \(K\), length at age 1 \(L_1\) and length at age 17 \(L_2\) were estimated within the model. Age 1 and age 17 were chosen for \(L_1\) and \(L_2\) because they are extreme points that are still well represented in the data. All three von Bertalanffy parameters were estimated within the model. Other growth and maturity parameters, such as CVs for \(L_1\) and \(L_2\), weight-at-length, maturity-at-length and fecundity-at-weight, were fixed at the levels estimated outside of SS2.

**Stock-recruitment relationship**

A Beverton-Holt model was used to describe the stock-recruitment relationship for longnose skate. The level of virgin recruitment \(R_0\) was estimated using this relationship, in order to estimate the magnitude of the initial spawning biomass. In the assessment model, recruits were taken deterministically from the stock-recruit curve, largely due to extremely limited age data and in order to avoid fitting noise. Steepness \(h\) was fixed at a value of 0.4, to reflect the \(K\)-type reproductive strategy of this species.

**Selectivity**

Selectivity parameters used in this assessment are specified as functions of size. Separate size-based selectivity curves were fit to the fishery and each survey, except for the NWFSC slope survey, which was assumed to have the same selectivity as the NWFSC shelf-slope survey and, therefore, was set to mirror it. To depict selectivity for the fishery and the three surveys (except for the NWFSC slope survey), we used a double-normal function, which has six parameters, including (1) peak, which is the length at which selectivity is fully selected; (2) width of plateau on the top; (3) width of the ascending part of the curve; (4) width of the descending part of the curve; (5) selectivity at first size bin; and (6) selectivity at last size bin.

In all cases, we fixed the selectivity of the first size bin (parameter 5), based on the examination of size-composition data. Also, the size selectivity of NWFSC shelf-slope survey (and, therefore, NWFSC slope survey) and AFSC slope survey were assumed to be asymptotic. Figure 21 shows frequency of occurrence of longnose skate in the AFSC slope survey catches by depth. In the last depth stratum of the survey (between 1098 and 1280 m), longnose skate was not found, which indicates that the survey went deep enough and can be assumed to be asymptotic. NWFSC shelf-slope and slope surveys extended to the same depth as the AFSC slope survey (Table 4). We fixed the selectivity at last size bin (parameter 6) and width of the descending part of the curve (parameter 4) at their maximum values to allow selectivity of these surveys to be asymptotic. All other
size selectivity parameters were estimated in the model. Since we had limited age information, age-based selectivity was set to 1.0 for all ages beginning at age 1.

**NWFSC shelf-slope survey catchability \( Q \)**

The value of the NWFSC shelf-slope survey catchability \( Q \) used for the base model was calculated during the STAR Panel. First, a prior for \( Q \) was developed following the methodology presented by Patrick Cordue. Catchability depends on several factors such as latitudinal, vertical and depth availabilities of fish to the survey gear and the probability of spatially “available” fish being caught and retained by the gear. To develop a prior on \( Q \), the potential range in the proportion of vulnerable skates for each factor was specified and “best guesses” for each range were assumed. Latitudinal and depth availability was specified based on the survey coverage of the assessment area. Vertical availability and probability of catch was specified based on the known behavior of the longnose skate.

The NWFSC shelf-slope survey covers the entire latitudinal range of the assessment (Table 4); therefore latitudinal availability was assumed to be 1. The survey appears to exceed the maximum depth distribution of longnose skate (Figure 21) but may not fully cover the shallow end of the skate distribution. Therefore, the range for the depth availability was assumed between 0.95 and 1. Longnose skates are known to bury in the sand to escape predators, which might cause a portion of skates be unavailable to the bottom trawl gear. Therefore a range for vertical availability was assumed between 0.75 and 0.95. Finally, the probability of spatially available skates being captured and retained was assumed to be between 0.75 and 1.5, since it is possible that longnose skate might either avoid trawl nets or (similar to some flatfish) be herded by trawl gear. “Best guess” estimates were set at the mid-point of the range for individual factors and the overall best guess for the survey \( Q \) was 0.83. The minimum, maximum and mid-point values for each category used to develop prior on \( Q \) is summarized in Table 10.

We did not use an informative prior on \( Q \) for the base model, but fixed \( Q \) at 0.83, the value of \( Q \), estimated as described above. The normal prior on \( \log(Q) \) was used to provide “low” and “high” \( Qs \) for different states of nature used to address uncertainty in survey catchability.

**Age-determination error**

To establish the level of accuracy of age determination, we used age readings of the same age structures made by three different readers and calculated standard deviations of age determination for each true age (assumed as read by reader 1).

**MODEL SELECTION AND EVALUATION**

**Alternative model configurations**

In order to produce a model that would provide parsimony relative to the available data and at the same time realistically describe the underlying population dynamics of the longnose skate, we explored a variety of alternative model configurations that included different levels of complexity. The alternative models were evaluated based on the overall model fit as well as convergence criteria. The alternative configurations included two-sex versus single sex models; models that estimates recruitment deviations versus
treating recruits deterministically; and configurations starting in 1980 in a non-equilibrium state versus starting in 1915 with unfished equilibrium. We explored asymptotic versus dome-shaped size selectivities, as well as fixed versus estimated von Bertalanffy growth parameters.

The base run model reflects the best aspects from these exploratory analyses. It appears to be parameterized enough to fit the observed data, while maintaining reasonable parameter values and parsimonious explanations for the underlying model processes. A summary of likelihood components for the base model is presented in Table 11.

Conversion criteria
Convergence of the base run model was assessed according to the ability of the model to recover similar likelihood estimates when initialized from dispersed starting points. The results of a set of 15 convergence tests showed minor variability in the objective function and current depletion. For all tests the Hessian matrix was positive definite. The maximum gradient component for the base run was 0.000201095.

Likelihood profile analysis
The chosen base model included several key parameters for which assumptions had to be made in the absence of data. These parameters were fixed based on general information about the species. The key model parameters that were fixed included natural mortality $M$, steepness of stock-recruitment curve $h$, and catchability coefficient $Q$ of NWFS shelf-slope survey and discard mortality. Uncertainties in NWFS shelf-slope survey $Q$ and discard mortality were addressed through sensitivity analyses described later in this report. To explore how informative the data were with regard to natural mortality and steepness of the stock-recruitment curve, we performed likelihood profile analyses where we varied the values of $M$ and $h$ and recorded the overall fit of the model. We also looked at how sensitive model outcome was to these variations.

Likelihood profiles of $M$ and $h$ along with subsequent changes in the stock depletion are presented in Figures 22 and 23. For natural mortality, the best fit of the model was achieved with $M$ values of 0.18 and 0.2 (in the base model $M$ is fixed at 0.2). For these values of $M$, the levels of spawning biomass depletion are essentially the same (65% and 66% respectively). Likelihood profiles on steepness (values from 0.3-1) showed better fit for the model with high values of $h$. However, all available information about elasmobranches suggests that the longnose skate is not likely to be a highly productive species. The depletion rates for various levels of $h$ ranged between 61% and 74% (Figure 23). Since little is known about longnose skate productivity, in the base model we selected a value for $h$ (0.4) that is towards the low end of the examined range. This value is precautionary, relative to values with better fits, but it is also more consistent with the productivity of other elasmobranches.

BASE RUN RESULTS

Model fit
Comparisons between observed and estimated survey biomasses are shown in Figures 24-27. The model was able to capture general trends for indices in all surveys except for the AFSC shelf (triennial). The estimated biomass in the 2004 AFSC shelf (triennial)
appeared to be twice as high as any other estimates in the survey time series. Other surveys conducted around this time did not detect an increases in stock biomass. In 2004, the shelf (triennia) survey was conducted by the NWFSC, not by the AFSC, as in all previous years. Although an effort was made to replicate AFSC protocols as closely as possible, this change may have contributed to the substantial increase in the longnose skate biomass index. Based on similar observed increases in the indices for several flatfish stocks during the 2005 assessment cycle, a review of 2004 survey implementation was conducted by the NWFSC. However, that review did not find any obvious implementational reasons for the increases in flatfish CPUE. We will explore this issue in the future.

Fit to length- and age-frequency data are shown in Figures 28-32. Fits to length compositions was good. However, the estimated age compositions did not exhibit a very good fit, which could be explained by the combination of deterministic recruitment and variations in catch history. Fit to size-at-age data is presented in Figures 33-34.

Model estimates
Figures 35-37 show growth and maturity curves, as well as length-weight relationship estimated by the model. Table 12 and Figures 38-43 show the total, summary, and spawning biomass, as well as depletion rate relative to $B_0$, recruitment and harvest rate time-series, as estimated by the base model. Population numbers-at-age by year are given in Table 13. The stock-recruitment relationship is presented in Figure 44. Selectivity estimates for the fishery and surveys are shown in Figures 45-49.

State of the stock
The summary of the recent trends in longnose skate exploitation and estimated population levels are presented in Table 14. Currently, the stock of the longnose skate in the US West Coast is not overfished (Figure 50). Historically, the exploitation rate for the longnose skate has been low. It reached its maximum level of 4.02% in 1981. Currently, the stock is at 66% of its unfished level. Since the longnose skate stock is estimated to be above the overfished level, no rebuilding is required.

UNCERTAINTY AND SENSITIVITY ANALYSIS
This assessment reflects a data-moderate to data-poor circumstance with respect to several influential model elements. The major uncertainties for the assessment include the longnose skate catch history, Northwest Fishery Science Center (NWFSC) shelf-slope survey catchability $Q$ and the female maturity schedule.

Catch history
The catch history of longnose skate reflects retained catch (catch that was retained and landed), discard and discard mortality. In addition to uncertainty in those estimates, uncertainty is involved in estimating the proportion of longnose skate in combined-skate landings, since historically landings were recorded within the “unspecified skate” market category. For recent years, the data on longnose skate landings and discards are reasonably good, however since the discard rate is high and discard mortality is essentially unknown, there is still considerable uncertainty about the level of fishing mortality. To address uncertainties related to longnose skate catch, alternative catch
histories, which reflect variations in the proportion of longnose skate in combined-skate landings, as well as discard and discard mortality rates, were developed. In addition to catch history used for the base model, two alternative catch history scenarios were developed by the STAR Panel. These alternative catch histories include “low” and “high” histories, compared with the base model scenario, which was reconstructed based on the best information about longnose skate catch history available. Figures 51-53 show base, “low” and “high” longnose skate catch histories respectively.

The “low” and “high” catch histories were constructed from the landings estimates presented earlier in this report, but used different assumptions regarding the proportion of longnose skate in the total skate landings, the discard, and discard mortality rates. As catch history in base model, the “low” and “high” catch histories were constructed outside the model and were entered into an SS2 data file as total catch. The following formula, developed by STAR Panel, was used to translate combined-skate landings into longnose skate total catch ($TC$):

$$TC = e^b \left[ 1 + \frac{dm}{1-d} \right]$$

Where $TC$ is total catch of longnose skate; $e$ is estimated longnose skate landing, $b$ is the proportion of longnose skate in the combined- skate landing, used to get $e$ from a combined-skate landings; $p$ is proportion of longnose skate in the total skate landing to be applied to construct “low” and high” catch histories, $d$ is discard rate to be applied to construct “low” and high” catch histories, and $m$ is discard mortality rate to be applied to construct “low” and high” catch histories.

Based on the quality of landed catch records (prior to 1981 records were less detailed and involved more uncertainty that after 1981) and changes in skate markets (skate market increased in 1995), three time periods were defined for the catch history of longnose skate: years up through 1980, 1981-1994, and 1995-present.

In the base model, for the first time period, a constant value ($b = 0.62$) for proportion of longnose skate in the combined-skate landing had been used. Since 1981 annual values for $b$ were estimated from fishery species compositions and survey catches (as described earlier in this report). Prior to 1995 (when the skate market changed) discard rate $d$ was assumed to be equal 93% based on Rogers and Pikitch’s study (1992), while since 1995 forward $d$ was equal to 53%, based on the data from ODCP and WCGOP. Discard mortality rate for the entire time of the assessment was assumed to be 50%. For the “low” and “high” catch histories, alternative values of $b$, $d$ and $m$, calculated by STAR Panel and shown in Table 15, were used.

Using the parameter values presented in the Table15 for corresponding time periods, we reconstructed time series for “low” and “high” catch histories, and conducted alternative runs for each of these scenarios, tiering off the base model specification. Depletion was estimated to be 75% and 46% for the “low” and “high” catch histories, respectively (depletion for the base model was estimated as 66%). We used the alternative catch
histories (along with different values of NWFSC shelf-slope survey catchability $Q$) to define three different states of nature and to develop decision table (Table 19).

**NWFSC shelf-slope survey catchability $Q$**

To address uncertainty in NWFSC shelf-slope survey $Q$, model runs were performed under base, “low”, and “high” levels of $Q$. The value of $Q$ used for the base model was 0.83. For the “low” and “high” levels, we used values of $Q$ calculated by STAR Panel based on the normal prior on $\log(Q)$. A random sample of size 10,000 was generated from the normal distribution and the mean of the samples below the 25th percentile of the normal distribution was exponentiated to provide the “low” $Q$ (low $Q=0.654$). The mean of the samples above the 75th percentile was exponentiated to provide the “high” $Q$ (high $Q=1.046$). Alternative values of NWFSC shelf-slope survey catchability $Q$ (along with alternative catch histories) were used to define three different states of nature and to develop the decision table (Table 19).

**Maturity**

Uncertainty in female maturity was also explored. A maturity study of the longnose skate, conducted by McFarlane and King (2006) in the British Columbia waters, reported that parameters of the maturity curve were significantly lower than those used in our assessment, as estimated by Thompson (2006). McFarlane and King (2006) estimated slope of the maturity function $\beta$ as -0.078, and length at 50% maturity ($L_{50}$%) as 83 cm, while Thomson (2006) estimated $\beta$ as -0.098 and $L_{50}$% as 120 cm. Criteria to distinguish mature individuals from immature differed between Thompson’s and McFarlane and King’s studies, but neither approach could be considered superior to the other. We ran our model with the values of the maturity function estimated by Thompson (2006) and then with the values estimated by McFarlane and King (2006). The depletion of longnose skate in these two runs was 66% and 78% respectively. For the base model, we used Thompson’s data, which is more likely to understate the proportion of mature skates. However, we recommend conducting an additional study of longnose skate maturity to clarify this issue.

**REFERENCE POINTS**

The summary of reference points for the longnose skate is presented in Table 16. For the longnose skate, the management target is defined as 40% of the unfished spawning stock biomass (SB$_{40\%}$), which is estimated to be 5,627 mt (95% Confidence Interval: 5,217-6,036 mt) in the base model. The stock is declared overfished if the current spawning biomass is estimated to be below 25% of unfished level. The MSY-proxy harvest rate for longnose skate is SPR=$F_{45\%}$, which corresponds to an exploitation rate of 0.043. This harvest rate provides an equilibrium yield of 1,264 mt (95% Confidence Interval: 1,194-1,334 mt) at SB$_{40\%}$. The model estimate of maximum sustainable yield (MSY) is 1,268 mt (95% Confidence Interval: 1,198-1,338). The estimated spawning stock biomass at MSY is 5,253 mt (95% Confidence Interval: 4,867-5,638 mt). The exploitation rate corresponding to the estimated SPR$_{msy}$ of $F_{61\%}$ is 0.027.

Reference point results are calculated on both a per-recruit and total-recruits basis. The total-recruits results take into account the spawner-recruitment relationship with the steepness as defined in the base model ($h=0.4$). Because of this low steepness and other
reproductive characteristics of the stock, fishing at the target SPR of 45% is expected to reduce the spawning biomass to less than 13% of the unfished level over the long term (Table 16). Conversely, fishing at a rate that would maintain spawning biomass near 40% of the unfished level would require a target SPR much higher than 45%. The Council’s Scientific and Statistical Committee should consider the appropriateness of using the current proxy harvest rate for setting the Allowable Biological Catch for longnose skate.

HARVEST PROJECTIONS
Tables 17 and 18 shows projections of future catches, summary biomass, spawning biomass and stock depletion were made based on the current rate of fishing mortality, as well as F45%. The projected spawning depletion based on the current level of fishing and F 45% is shown in Figures 54 and 55. The projected spawning biomass was greater than 40% of unfished level in both cases; therefore no 40:10 harvest control rule adjustment was made. Optimum yield catch values were equivalent to the values of ABC.

For this assessment, three states of nature were defined based on the alternative longnose skate catch history and NW FSC shelf-slope survey $Q$. The base scenario uses the base catch history and base $Q$ ($Q=0.83$), the “low” scenario uses the low catch history and low $Q$ ($Q=0.654$), and the “high” scenario uses the high catch history and high $Q$ ($Q=1.046$). Ten-year forecasts for each state of nature were calculated based on F45% for the base scenario. Ten-year forecasts were also produced with future catch fixed at the average amount (using the base catch history) for last three years (2004-2006) and at 150% of that three-year average. Under the “high” scenario, the F45% harvest rate is projected to reduce the spawning stock biomass below 40% of the unfished level within two years. In all other scenarios covered by the decision table, the spawning biomass remains above the target level throughout the 10-year projection period. The current rate of fishing mortality is significantly lower than F45% (current exploitation rate is 1.25%). Therefore, it is very unlikely that the stock, even under the “high” scenario will fall below 40% of its virgin state in the next 10 years.

RESEARCH AND DATA NEEDS
This assessment reflects a data-moderate to data-poor circumstance with respect to several influential model elements, including catch history, survey catchability, and some life history characteristics. Consequently, some critical assumptions were based on very limited supporting data and research. There are several data and research needs which, if satisfied, could improve the assessment.

Data needs:

4) Continue species-specific identification in fishery to improve the accuracy of fishery catch data;
5) Continue monitoring discard of the longnose skate;
6) Resume collecting and processing of vertebra samples for age determination to improve the accuracy of growth model parameters and size-at-age relationships.

Research needs:
5) Conduct studies to determine survival rates of discarded longnose skate, especially with trawl gear, so that total fishing mortality can be estimated more precisely;
6) Conduct studies on life history characteristics, especially those related to maturity and reproduction;
7) Conduct age-validation studies;
8) Conduct studies of longnose skate catchability by survey gear types.

ACKNOWLEDGMENTS

The authors would like wholeheartedly thank everyone who contributed to the development of this assessment. Rick Methot (NWFSC) for his constructive suggestions on model design and prompt help with model files, Beth Horness (NWFSC) and Mark Wilkins (AFSC) for providing survey data, William Daspit (PacFIN) for providing fishery data, Mark Karnowski (ODFW) for supplying Oregon fishery and ODCP data, Theresa Tsou (WDFW) and Gerry Kobylnski (CaDFG) for providing Washington and California fishery data, Jim Hastie (NWFSC) for supplying WCGOP discard data, editing this assessment and all helpful suggestions, Peter Leipzig (Fishermen's Marketing Association) for skate market information, Ian Stewart for useful discussions of assessment reference points and decision table, Jean Rogers for her helpful advice and Sean Matson (OSU) for proofreading this manuscript. Special thanks goes to STAR Panel members Martin Dorn, Vivian Haist and Patrick Cordue, who significantly improved this assessment model.
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Table 1. Summary of fishery-dependent data used in the assessment by source and year since 1980.

| YEAR | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| CATCHES | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Landings | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Unspecified Skate (PacFIN) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OR (longnose skate) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WA (longnose skate) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CA (longnose skate) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Discard | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OR | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BIOLOGICAL DATA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Length | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OR | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sex | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OR | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Age | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OR | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
Table 2. Summary of fishery-independent data used in the assessment by source and year.

| YEAR | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| BIOMASS |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| NWFSC Slope |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| NWFSC Shelf-Slope |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| AFSC Shelf Triennial |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| AFSC Slope |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| BIOLOGICAL DATA |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Length |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| NWFSC Slope |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| NWFSC Shelf-Slope |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| AFSC Shelf Triennial |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| AFSC Slope |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Age |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| NWFSC Slope |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| NWFSC Shelf-Slope |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| AFSC Shelf Triennial |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| AFSC Slope |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
Table 3. Estimated percentage of longnose skate in combined-skate landings by state and year (for the pre-1981, percentage of longnose skate in combined-skate landings is assumed as 62%).

<table>
<thead>
<tr>
<th>Year</th>
<th>CA</th>
<th>OR</th>
<th>WA</th>
<th>Average</th>
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<tbody>
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<td>50</td>
<td>79</td>
<td>64</td>
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<td>1982</td>
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<td>1984</td>
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<td>1987</td>
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<td>65</td>
<td>58</td>
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<td>1988</td>
<td>44</td>
<td>67</td>
<td>66</td>
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<td>63</td>
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<td>2006</td>
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<td>74</td>
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Table 4. Surveys used in the assessment by year, latitudinal and depth ranges.

<table>
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<th>Survey</th>
<th>Year</th>
<th>Latitudes</th>
<th>Depths (fm)</th>
</tr>
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<td>1999</td>
<td>35° 00'- 48° 10'</td>
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</tr>
<tr>
<td></td>
<td>2000</td>
<td>35° 00'- 48° 07'</td>
<td>100-700</td>
</tr>
<tr>
<td></td>
<td>2001</td>
<td>35° 00'- 48° 08'</td>
<td>100-700</td>
</tr>
<tr>
<td></td>
<td>2002</td>
<td>35° 51'- 48° 07'</td>
<td>100-700</td>
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<tr>
<td>NWFSC shelf-slope</td>
<td>2003</td>
<td>32° 34'- 48° 27'</td>
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</tr>
<tr>
<td></td>
<td>2004</td>
<td>32° 34'- 48° 27'</td>
<td>30-700</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>32° 34'- 48° 27'</td>
<td>30-700</td>
</tr>
<tr>
<td></td>
<td>2006</td>
<td>32° 34'- 48° 27'</td>
<td>30-700</td>
</tr>
<tr>
<td>AFSC Shelf (triennial)</td>
<td>1977</td>
<td>34° 00'- Border</td>
<td>50-250</td>
</tr>
<tr>
<td></td>
<td>1980</td>
<td>36° 48'- 49° 15'</td>
<td>30-200</td>
</tr>
<tr>
<td></td>
<td>1983</td>
<td>36° 48'- 49° 15'</td>
<td>30-200</td>
</tr>
<tr>
<td></td>
<td>1986</td>
<td>36° 48'- Border</td>
<td>30-200</td>
</tr>
<tr>
<td></td>
<td>1989</td>
<td>34° 30'- 49° 40'</td>
<td>30-200</td>
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<tr>
<td></td>
<td>1992</td>
<td>34° 30'- 49° 40'</td>
<td>30-200</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>34° 30'- 49° 40'</td>
<td>30-275</td>
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<td></td>
<td>1998</td>
<td>34° 30'- 49° 40'</td>
<td>30-275</td>
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<td></td>
<td>2001</td>
<td>34° 30'- 49° 40'</td>
<td>30-275</td>
</tr>
<tr>
<td></td>
<td>2004</td>
<td>34° 30'- Border</td>
<td>30-275</td>
</tr>
<tr>
<td>AFSC Slope</td>
<td>1988</td>
<td>44° 05'- 45° 30'</td>
<td>100-700</td>
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<tr>
<td></td>
<td>1990</td>
<td>40° 30'- 43° 00'</td>
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</tr>
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<td>1991</td>
<td>36° 20'- 40° 30'</td>
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<td>1992</td>
<td>45° 30'- Border</td>
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Table 5. Survey biomass indices (mt) and standard deviation of log (index), calculated as $\sqrt{\ln(1 + CV^2)}$.

<table>
<thead>
<tr>
<th>Year</th>
<th>NWFS shelf-slope survey</th>
<th>NWFS slope survey</th>
<th>AFSC triennial survey</th>
<th>AFSC slope survey</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Biomass (mt)  s</td>
<td>Biomass (mt)  s</td>
<td>Biomass (mt)  s</td>
<td>Biomass (mt)  s</td>
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<td>1983</td>
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<td>1986</td>
<td>1552.00 0.16</td>
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<td>3049.00 0.18</td>
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<td>1999</td>
<td>28431.14 0.13</td>
<td></td>
<td>14199.00 0.11</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>24002.33 0.17</td>
<td></td>
<td>13748.00 0.13</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>24150.44 0.14</td>
<td></td>
<td>3180.00 0.08</td>
<td>14278.00 0.12</td>
</tr>
<tr>
<td>2002</td>
<td>27022.31 0.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>50768.03 0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>55648.34 0.07</td>
<td></td>
<td></td>
<td>7827.00 0.09</td>
</tr>
<tr>
<td>2005</td>
<td>50762.13 0.06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>55267.93 0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6. Sample size for size composition data (both sexes combined) by source.

<table>
<thead>
<tr>
<th>Year</th>
<th>Fishery</th>
<th>NWFSC shelf-slope survey</th>
<th>AFSC shelf triennial survey</th>
<th>AFSC slope survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>53</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>99</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>459</td>
<td></td>
<td></td>
<td>764</td>
</tr>
<tr>
<td>1998</td>
<td>84</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>311</td>
<td></td>
<td></td>
<td>731</td>
</tr>
<tr>
<td>2000</td>
<td>299</td>
<td></td>
<td></td>
<td>743</td>
</tr>
<tr>
<td>2001</td>
<td>457</td>
<td></td>
<td>796</td>
<td>681</td>
</tr>
<tr>
<td>2002</td>
<td>235</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>2003</td>
<td>518</td>
<td>2675</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>149</td>
<td>2647</td>
<td>794</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>248</td>
<td>3326</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>603</td>
<td>3325</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7. Sample size for age data (both sexes combined) by source.

<table>
<thead>
<tr>
<th>Year</th>
<th>Fishery</th>
<th>NWFSC shelf-slope survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>102</td>
<td>258</td>
</tr>
</tbody>
</table>

Table 8. von Bertalanffy growth parameters estimated in different studies.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year of study</th>
<th>Area</th>
<th>K</th>
<th>L_inf (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thompson</td>
<td>2006</td>
<td>US West Coast</td>
<td>0.047</td>
<td>194</td>
</tr>
<tr>
<td>Gburski</td>
<td>2007</td>
<td>Gulf of Alaska</td>
<td>0.046</td>
<td>202</td>
</tr>
<tr>
<td>McFarlane</td>
<td>2006</td>
<td>British Columbia</td>
<td>0.065</td>
<td>135</td>
</tr>
<tr>
<td>Zeiner</td>
<td>1993</td>
<td>California</td>
<td>0.2</td>
<td>102</td>
</tr>
</tbody>
</table>
Table 9. Parameters used for the base model.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>VALUE</th>
<th>MIN</th>
<th>MAX</th>
<th>FIXED</th>
<th>ESTIMATED (PHASE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Mortality</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td><strong>Growth</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size (cm) at age 1</td>
<td>18.7</td>
<td>15</td>
<td>40</td>
<td>x (4)</td>
<td></td>
</tr>
<tr>
<td>Size (cm) at age 17</td>
<td>105.9</td>
<td>70</td>
<td>130</td>
<td>x (4)</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>0.064</td>
<td>0.05</td>
<td>0.15</td>
<td>x (4)</td>
<td></td>
</tr>
<tr>
<td>CV in size at age 1</td>
<td>0.14</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>CV in size at age 17</td>
<td>-0.71</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td><strong>Biologi parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coefficient to convert L(cm) to W(kg)</td>
<td>4.28E-06</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Exponent in female L-W conversion</td>
<td>3.05975</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Maturity logistic inflection</td>
<td>120.753</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Maturity slope</td>
<td>-0.09859</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>eggs/gm intercept</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>eggs/gm slope</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td><strong>Weight at length</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coefficient</td>
<td>4.28E-06</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Exponent</td>
<td>3.05975</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>Stock-Recruitment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log of virgin recruitment level</td>
<td>9.65</td>
<td>5</td>
<td>15</td>
<td>x (1)</td>
<td></td>
</tr>
<tr>
<td>Steepness of stock-recruitment curve</td>
<td>0.4</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>Survey catchability as Log (Q)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NWFSC shelf slope survey</td>
<td>-0.19</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>NWFSC slope survey</td>
<td>-0.87</td>
<td>-7</td>
<td>0</td>
<td>x (1)</td>
<td></td>
</tr>
<tr>
<td>AFSC triennial slope survey</td>
<td>-3.14</td>
<td>-7</td>
<td>0</td>
<td>x (1)</td>
<td></td>
</tr>
<tr>
<td>AFSC slope survey</td>
<td>-1.45</td>
<td>-7</td>
<td>0</td>
<td>x (1)</td>
<td></td>
</tr>
<tr>
<td><strong>Size selectivity parameters Fishery</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak</td>
<td>93.5</td>
<td>80</td>
<td>100</td>
<td>x (2)</td>
<td></td>
</tr>
<tr>
<td>Top</td>
<td>0.55</td>
<td>-6</td>
<td>4</td>
<td>x (2)</td>
<td></td>
</tr>
<tr>
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<td>5.73</td>
<td>-1</td>
<td>9</td>
<td>x (2)</td>
<td></td>
</tr>
<tr>
<td>Descending slope</td>
<td>8.3</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Selectivity at first bin</td>
<td>-5</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Selectivity at last bin</td>
<td>2.05</td>
<td>-5</td>
<td>9</td>
<td>x (2)</td>
<td></td>
</tr>
<tr>
<td><strong>Size selectivity parameters NEFSC shelf-slope survey</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak</td>
<td>80</td>
<td>20</td>
<td>80</td>
<td>x (2)</td>
<td></td>
</tr>
<tr>
<td>Top</td>
<td>-2.95</td>
<td>-6</td>
<td>4</td>
<td>x (2)</td>
<td></td>
</tr>
<tr>
<td>Ascending slope</td>
<td>8.09</td>
<td>-1</td>
<td>9</td>
<td>x (2)</td>
<td></td>
</tr>
<tr>
<td>Descending slope</td>
<td>6</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Selectivity at first bin</td>
<td>-4.8</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Selectivity at last bin</td>
<td>9</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>Size selectivity parameters NEFSC shelf-slope survey</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First size bin (mirror)</td>
<td>1</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Last size bin (mirror)</td>
<td>27</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>Size selectivity parameters AFSC triennial shelf survey</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Peak</td>
<td>75</td>
<td>50</td>
<td>75</td>
<td>x (2)</td>
<td></td>
</tr>
<tr>
<td>Top</td>
<td>-0.07</td>
<td>-6</td>
<td>4</td>
<td>x (2)</td>
<td></td>
</tr>
<tr>
<td>Ascending slope</td>
<td>7.69</td>
<td>-1</td>
<td>9</td>
<td>x (2)</td>
<td></td>
</tr>
<tr>
<td>Descending slope</td>
<td>-0.008</td>
<td>-1</td>
<td>9</td>
<td>x (2)</td>
<td></td>
</tr>
<tr>
<td>Selectivity at first bin</td>
<td>-5</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Selectivity at last bin</td>
<td>-0.71</td>
<td>-5</td>
<td>9</td>
<td>x (2)</td>
<td></td>
</tr>
<tr>
<td><strong>Size selectivity parameters AFSC slope survey</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak</td>
<td>55</td>
<td>50</td>
<td>60</td>
<td>x (2)</td>
<td></td>
</tr>
<tr>
<td>Top</td>
<td>-0.87</td>
<td>-6</td>
<td>4</td>
<td>x (2)</td>
<td></td>
</tr>
<tr>
<td>Ascending slope</td>
<td>6.06</td>
<td>-1</td>
<td>9</td>
<td>x (2)</td>
<td></td>
</tr>
<tr>
<td>Descending slope</td>
<td>7.7</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Selectivity at first bin</td>
<td>-4</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Selectivity at last bin</td>
<td>9</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>
Table 10. Minimum, maximum and mid-point values of different factors affecting survey catchability used to estimate prior of NWFSC shelf-slope survey log (Q).

<table>
<thead>
<tr>
<th></th>
<th>minimum</th>
<th>maximum</th>
<th>mid-point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth availability</td>
<td>0.95</td>
<td>1</td>
<td>0.975</td>
</tr>
<tr>
<td>Latitudinal availability</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Vertical availability</td>
<td>0.75</td>
<td>0.95</td>
<td>0.85</td>
</tr>
<tr>
<td>Probability of capture</td>
<td>0.75</td>
<td>1.5</td>
<td>1</td>
</tr>
<tr>
<td>Product of all factors</td>
<td>0.53</td>
<td>1.43</td>
<td>0.83</td>
</tr>
</tbody>
</table>
Table 11. The summary of likelihood components for the base model.

| LIKELIHOOD  | 1055.67 |
| indices     | 17.0821 |
| discard     | 0       |
| length_comps| 595.302 |
| age_comps   | 23.2279 |
| size-at-age | 420.056 |
| mean_body_wt| 0       |
| Equil_catch | 0       |
| catch       | 0       |
| Recruitment | 0       |
| Parm_priors | 0       |
| Parm_devs   | 0       |
| penalties   | 0       |
| Forecast_Recruitment | 0 |

<table>
<thead>
<tr>
<th>Fleet</th>
<th>surv_lambda</th>
<th>surv_like</th>
<th>disc_lambda</th>
<th>disc_like</th>
<th>length_lambda</th>
<th>length_like</th>
<th>age_lambda</th>
<th>age_like</th>
<th>sizeage_lambda</th>
<th>sizeage_like</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>269.514</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>389.397</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0.938181</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>183.105</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>30.6588</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0.463396</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>183.105</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>30.6588</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>14.8925</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>47.3419</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>0.788065</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>95.3409</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Fleet 1=fishey
Fleet 2=NWFSC shelf-slope survey
Fleet 3=NWFSC slope survey
Fleet 4=AFSC shelf (triennial) survey
Fleet 5=AFSC slope survey
Table 12. Estimated time-series for total, summary and spawning biomass, recruitment harvest rate and depletion (continued on the next page).

<table>
<thead>
<tr>
<th>year</th>
<th>Total biomass</th>
<th>Summary biomass</th>
<th>Spawning biomass</th>
<th>Recruitment</th>
<th>Harvest rate</th>
<th>Depletion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1915</td>
<td>91,855</td>
<td>90,955</td>
<td>14,069</td>
<td>15,454</td>
<td>0.00%</td>
<td>100%</td>
</tr>
<tr>
<td>1916</td>
<td>91,855</td>
<td>90,955</td>
<td>14,069</td>
<td>15,454</td>
<td>0.04%</td>
<td>100%</td>
</tr>
<tr>
<td>1917</td>
<td>91,837</td>
<td>90,937</td>
<td>14,064</td>
<td>15,452</td>
<td>0.07%</td>
<td>100%</td>
</tr>
<tr>
<td>1918</td>
<td>91,803</td>
<td>90,904</td>
<td>14,055</td>
<td>15,449</td>
<td>0.11%</td>
<td>100%</td>
</tr>
<tr>
<td>1919</td>
<td>91,755</td>
<td>90,855</td>
<td>14,041</td>
<td>15,443</td>
<td>0.14%</td>
<td>100%</td>
</tr>
<tr>
<td>1920</td>
<td>91,693</td>
<td>90,794</td>
<td>14,023</td>
<td>15,435</td>
<td>0.18%</td>
<td>100%</td>
</tr>
<tr>
<td>1921</td>
<td>91,619</td>
<td>90,721</td>
<td>14,000</td>
<td>15,426</td>
<td>0.21%</td>
<td>100%</td>
</tr>
<tr>
<td>1922</td>
<td>91,535</td>
<td>90,637</td>
<td>13,974</td>
<td>15,415</td>
<td>0.25%</td>
<td>99%</td>
</tr>
<tr>
<td>1923</td>
<td>91,440</td>
<td>90,543</td>
<td>13,944</td>
<td>15,403</td>
<td>0.28%</td>
<td>99%</td>
</tr>
<tr>
<td>1924</td>
<td>91,335</td>
<td>90,439</td>
<td>13,911</td>
<td>15,389</td>
<td>0.32%</td>
<td>99%</td>
</tr>
<tr>
<td>1925</td>
<td>91,221</td>
<td>90,326</td>
<td>13,875</td>
<td>15,374</td>
<td>0.36%</td>
<td>99%</td>
</tr>
<tr>
<td>1926</td>
<td>91,098</td>
<td>90,204</td>
<td>13,837</td>
<td>15,358</td>
<td>0.39%</td>
<td>98%</td>
</tr>
<tr>
<td>1927</td>
<td>90,967</td>
<td>90,073</td>
<td>13,795</td>
<td>15,340</td>
<td>0.43%</td>
<td>98%</td>
</tr>
<tr>
<td>1928</td>
<td>90,826</td>
<td>89,934</td>
<td>13,752</td>
<td>15,322</td>
<td>0.47%</td>
<td>98%</td>
</tr>
<tr>
<td>1929</td>
<td>90,678</td>
<td>89,786</td>
<td>13,707</td>
<td>15,303</td>
<td>0.50%</td>
<td>97%</td>
</tr>
<tr>
<td>1930</td>
<td>90,521</td>
<td>89,631</td>
<td>13,661</td>
<td>15,283</td>
<td>0.54%</td>
<td>97%</td>
</tr>
<tr>
<td>1931</td>
<td>90,356</td>
<td>89,467</td>
<td>13,612</td>
<td>15,262</td>
<td>0.58%</td>
<td>97%</td>
</tr>
<tr>
<td>1932</td>
<td>90,183</td>
<td>89,295</td>
<td>13,563</td>
<td>15,241</td>
<td>0.62%</td>
<td>96%</td>
</tr>
<tr>
<td>1933</td>
<td>90,003</td>
<td>89,116</td>
<td>13,513</td>
<td>15,219</td>
<td>0.65%</td>
<td>96%</td>
</tr>
<tr>
<td>1934</td>
<td>89,815</td>
<td>88,929</td>
<td>13,461</td>
<td>15,197</td>
<td>0.69%</td>
<td>96%</td>
</tr>
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<td>1935</td>
<td>89,619</td>
<td>88,735</td>
<td>13,408</td>
<td>15,174</td>
<td>0.73%</td>
<td>95%</td>
</tr>
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<td>89,417</td>
<td>88,534</td>
<td>13,354</td>
<td>15,150</td>
<td>0.77%</td>
<td>95%</td>
</tr>
<tr>
<td>1937</td>
<td>89,207</td>
<td>88,326</td>
<td>13,299</td>
<td>15,126</td>
<td>0.81%</td>
<td>95%</td>
</tr>
<tr>
<td>1938</td>
<td>88,992</td>
<td>88,112</td>
<td>13,243</td>
<td>15,101</td>
<td>0.85%</td>
<td>94%</td>
</tr>
<tr>
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<td>88,770</td>
<td>87,891</td>
<td>13,186</td>
<td>15,076</td>
<td>0.89%</td>
<td>94%</td>
</tr>
<tr>
<td>1940</td>
<td>88,541</td>
<td>87,665</td>
<td>13,127</td>
<td>15,050</td>
<td>0.93%</td>
<td>93%</td>
</tr>
<tr>
<td>1941</td>
<td>88,307</td>
<td>87,432</td>
<td>13,068</td>
<td>15,023</td>
<td>0.97%</td>
<td>93%</td>
</tr>
<tr>
<td>1942</td>
<td>88,068</td>
<td>87,194</td>
<td>13,007</td>
<td>14,995</td>
<td>1.01%</td>
<td>92%</td>
</tr>
<tr>
<td>1943</td>
<td>87,823</td>
<td>86,951</td>
<td>12,945</td>
<td>14,967</td>
<td>1.05%</td>
<td>92%</td>
</tr>
<tr>
<td>1944</td>
<td>87,573</td>
<td>86,703</td>
<td>12,882</td>
<td>14,938</td>
<td>1.09%</td>
<td>92%</td>
</tr>
<tr>
<td>1945</td>
<td>87,318</td>
<td>86,449</td>
<td>12,818</td>
<td>14,909</td>
<td>1.13%</td>
<td>91%</td>
</tr>
<tr>
<td>1946</td>
<td>87,058</td>
<td>86,191</td>
<td>12,753</td>
<td>14,878</td>
<td>1.17%</td>
<td>91%</td>
</tr>
<tr>
<td>1947</td>
<td>86,794</td>
<td>85,928</td>
<td>12,686</td>
<td>14,848</td>
<td>1.21%</td>
<td>90%</td>
</tr>
<tr>
<td>1948</td>
<td>86,525</td>
<td>85,661</td>
<td>12,619</td>
<td>14,816</td>
<td>1.26%</td>
<td>90%</td>
</tr>
<tr>
<td>1949</td>
<td>86,251</td>
<td>85,389</td>
<td>12,551</td>
<td>14,784</td>
<td>1.30%</td>
<td>89%</td>
</tr>
<tr>
<td>1950</td>
<td>85,973</td>
<td>85,113</td>
<td>12,483</td>
<td>14,751</td>
<td>0.72%</td>
<td>89%</td>
</tr>
<tr>
<td>1951</td>
<td>85,982</td>
<td>85,123</td>
<td>12,488</td>
<td>14,754</td>
<td>0.52%</td>
<td>89%</td>
</tr>
<tr>
<td>1952</td>
<td>86,070</td>
<td>85,211</td>
<td>12,519</td>
<td>14,769</td>
<td>0.58%</td>
<td>89%</td>
</tr>
<tr>
<td>1953</td>
<td>86,105</td>
<td>85,245</td>
<td>12,544</td>
<td>14,781</td>
<td>1.78%</td>
<td>89%</td>
</tr>
<tr>
<td>1954</td>
<td>85,562</td>
<td>84,703</td>
<td>12,426</td>
<td>14,724</td>
<td>0.65%</td>
<td>88%</td>
</tr>
<tr>
<td>1955</td>
<td>85,589</td>
<td>84,732</td>
<td>12,446</td>
<td>14,734</td>
<td>1.86%</td>
<td>88%</td>
</tr>
<tr>
<td>1956</td>
<td>85,043</td>
<td>84,187</td>
<td>12,322</td>
<td>14,674</td>
<td>0.83%</td>
<td>88%</td>
</tr>
<tr>
<td>1957</td>
<td>85,022</td>
<td>84,168</td>
<td>12,323</td>
<td>14,675</td>
<td>0.72%</td>
<td>88%</td>
</tr>
<tr>
<td>1958</td>
<td>85,048</td>
<td>84,194</td>
<td>12,338</td>
<td>14,682</td>
<td>0.75%</td>
<td>88%</td>
</tr>
<tr>
<td>1959</td>
<td>85,050</td>
<td>84,195</td>
<td>12,349</td>
<td>14,687</td>
<td>1.02%</td>
<td>88%</td>
</tr>
<tr>
<td>1960</td>
<td>84,918</td>
<td>84,063</td>
<td>12,328</td>
<td>14,677</td>
<td>0.62%</td>
<td>88%</td>
</tr>
<tr>
<td>1961</td>
<td>84,976</td>
<td>84,121</td>
<td>12,353</td>
<td>14,689</td>
<td>3.10%</td>
<td>88%</td>
</tr>
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</table>
Table 12 (continuation). Estimated time-series for total, summary and spawning biomass, recruitment harvest rate and depletion.

<table>
<thead>
<tr>
<th>year</th>
<th>Total biomass</th>
<th>Summary biomass</th>
<th>Spawning biomass</th>
<th>Recruitment</th>
<th>Harvest rate</th>
<th>Depletion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1962</td>
<td>83,878</td>
<td>83,027</td>
<td>12,084</td>
<td>14,558</td>
<td>1.77%</td>
<td>86%</td>
</tr>
<tr>
<td>1963</td>
<td>83,511</td>
<td>82,665</td>
<td>11,981</td>
<td>14,506</td>
<td>2.01%</td>
<td>85%</td>
</tr>
<tr>
<td>1964</td>
<td>83,068</td>
<td>82,226</td>
<td>11,853</td>
<td>14,442</td>
<td>1.98%</td>
<td>84%</td>
</tr>
<tr>
<td>1965</td>
<td>82,682</td>
<td>81,843</td>
<td>11,736</td>
<td>14,382</td>
<td>1.14%</td>
<td>83%</td>
</tr>
<tr>
<td>1966</td>
<td>82,705</td>
<td>81,868</td>
<td>11,720</td>
<td>14,374</td>
<td>1.40%</td>
<td>83%</td>
</tr>
<tr>
<td>1967</td>
<td>82,595</td>
<td>81,759</td>
<td>11,680</td>
<td>14,353</td>
<td>1.39%</td>
<td>83%</td>
</tr>
<tr>
<td>1968</td>
<td>82,482</td>
<td>81,647</td>
<td>11,645</td>
<td>14,336</td>
<td>2.45%</td>
<td>83%</td>
</tr>
<tr>
<td>1969</td>
<td>81,892</td>
<td>81,060</td>
<td>11,498</td>
<td>14,259</td>
<td>1.60%</td>
<td>82%</td>
</tr>
<tr>
<td>1970</td>
<td>81,723</td>
<td>80,894</td>
<td>11,454</td>
<td>14,236</td>
<td>0.89%</td>
<td>81%</td>
</tr>
<tr>
<td>1971</td>
<td>81,866</td>
<td>81,037</td>
<td>11,495</td>
<td>14,257</td>
<td>0.39%</td>
<td>82%</td>
</tr>
<tr>
<td>1972</td>
<td>82,197</td>
<td>81,365</td>
<td>11,594</td>
<td>14,309</td>
<td>0.59%</td>
<td>82%</td>
</tr>
<tr>
<td>1973</td>
<td>82,385</td>
<td>81,551</td>
<td>11,672</td>
<td>14,349</td>
<td>0.60%</td>
<td>83%</td>
</tr>
<tr>
<td>1974</td>
<td>82,534</td>
<td>81,698</td>
<td>11,749</td>
<td>14,389</td>
<td>0.59%</td>
<td>84%</td>
</tr>
<tr>
<td>1975</td>
<td>82,662</td>
<td>81,824</td>
<td>11,827</td>
<td>14,429</td>
<td>0.66%</td>
<td>84%</td>
</tr>
<tr>
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<td>81,895</td>
<td>11,892</td>
<td>14,462</td>
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<td>85%</td>
</tr>
<tr>
<td>1977</td>
<td>82,283</td>
<td>81,442</td>
<td>11,821</td>
<td>14,425</td>
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<td>84%</td>
</tr>
<tr>
<td>1978</td>
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<td>81,031</td>
<td>11,743</td>
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<td>83%</td>
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<tr>
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<td>80,160</td>
<td>11,531</td>
<td>14,276</td>
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<td>82%</td>
</tr>
<tr>
<td>1980</td>
<td>80,129</td>
<td>79,301</td>
<td>11,298</td>
<td>14,153</td>
<td>2.13%</td>
<td>80%</td>
</tr>
<tr>
<td>1981</td>
<td>79,848</td>
<td>79,026</td>
<td>11,191</td>
<td>14,095</td>
<td>6.88%</td>
<td>80%</td>
</tr>
<tr>
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<td>77,574</td>
<td>76,763</td>
<td>10,578</td>
<td>13,752</td>
<td>4.85%</td>
<td>75%</td>
</tr>
<tr>
<td>1983</td>
<td>76,465</td>
<td>75,670</td>
<td>10,222</td>
<td>13,543</td>
<td>3.84%</td>
<td>73%</td>
</tr>
<tr>
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<td>75,891</td>
<td>75,106</td>
<td>9,993</td>
<td>13,404</td>
<td>2.00%</td>
<td>71%</td>
</tr>
<tr>
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<td>76,082</td>
<td>75,303</td>
<td>9,963</td>
<td>13,386</td>
<td>2.86%</td>
<td>71%</td>
</tr>
<tr>
<td>1986</td>
<td>75,865</td>
<td>75,088</td>
<td>9,866</td>
<td>13,326</td>
<td>2.36%</td>
<td>70%</td>
</tr>
<tr>
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<td>75,811</td>
<td>75,036</td>
<td>9,834</td>
<td>13,306</td>
<td>2.70%</td>
<td>70%</td>
</tr>
<tr>
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<td>74,793</td>
<td>9,786</td>
<td>13,276</td>
<td>1.74%</td>
<td>70%</td>
</tr>
<tr>
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<td>74,894</td>
<td>9,845</td>
<td>13,312</td>
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<td>70%</td>
</tr>
<tr>
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<td>74,858</td>
<td>9,898</td>
<td>13,345</td>
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<td>70%</td>
</tr>
<tr>
<td>1991</td>
<td>75,717</td>
<td>74,939</td>
<td>9,997</td>
<td>13,406</td>
<td>1.27%</td>
<td>71%</td>
</tr>
<tr>
<td>1992</td>
<td>75,642</td>
<td>75,060</td>
<td>10,120</td>
<td>13,482</td>
<td>0.75%</td>
<td>72%</td>
</tr>
<tr>
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<td>75,348</td>
<td>10,293</td>
<td>13,586</td>
<td>1.16%</td>
<td>73%</td>
</tr>
<tr>
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<td>75,418</td>
<td>10,419</td>
<td>13,660</td>
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<td>74%</td>
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<tr>
<td>1995</td>
<td>76,076</td>
<td>75,280</td>
<td>10,486</td>
<td>13,699</td>
<td>0.82%</td>
<td>75%</td>
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<td>76,292</td>
<td>75,492</td>
<td>10,622</td>
<td>13,778</td>
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<td>76%</td>
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<td>74,687</td>
<td>10,490</td>
<td>13,701</td>
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<td>75%</td>
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<tr>
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<td>72,877</td>
<td>10,065</td>
<td>13,448</td>
<td>2.85%</td>
<td>72%</td>
</tr>
<tr>
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</tr>
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<td>71,802</td>
<td>9,716</td>
<td>13,232</td>
<td>5.07%</td>
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<td>9,406</td>
<td>13,032</td>
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<td>12,945</td>
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</tr>
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<td>71,272</td>
<td>9,342</td>
<td>12,989</td>
<td>3.23%</td>
<td>66%</td>
</tr>
<tr>
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<td>71,027</td>
<td>9,234</td>
<td>12,918</td>
<td>1.42%</td>
<td>66%</td>
</tr>
<tr>
<td>2005</td>
<td>72,198</td>
<td>71,445</td>
<td>9,302</td>
<td>12,963</td>
<td>2.32%</td>
<td>66%</td>
</tr>
<tr>
<td>2006</td>
<td>72,194</td>
<td>71,439</td>
<td>9,300</td>
<td>12,962</td>
<td>2.73%</td>
<td>66%</td>
</tr>
<tr>
<td>2007</td>
<td>71,971</td>
<td>71,217</td>
<td>9,268</td>
<td>12,941</td>
<td>2.16%</td>
<td>66%</td>
</tr>
</tbody>
</table>
Table 13. Numbers of longnose skate at age, estimated by the base model (continued on the next page).

| Age (years) | 0   | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  | 21  | 22  | 23  | 24  |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1915        | 15454 | 12653 | 10359 | 8481 | 6944 | 5685 | 4655 | 3811 | 3120 | 2555 | 2092 | 1712 | 1402 | 1148 | 940 | 769 | 630 | 516 | 422 | 346 | 283 | 232 | 190 | 155 |
| 1916        | 15455 | 12654 | 10359 | 8481 | 6944 | 5685 | 4655 | 3811 | 3120 | 2555 | 2092 | 1712 | 1402 | 1148 | 940 | 769 | 630 | 516 | 422 | 346 | 283 | 232 | 190 | 155 |
| 1917        | 15455 | 12655 | 10359 | 8481 | 6944 | 5685 | 4655 | 3811 | 3120 | 2555 | 2092 | 1712 | 1402 | 1148 | 940 | 769 | 630 | 516 | 422 | 346 | 283 | 232 | 190 | 155 |
| 1918        | 15455 | 12655 | 10359 | 8481 | 6944 | 5685 | 4655 | 3811 | 3120 | 2555 | 2092 | 1712 | 1402 | 1148 | 940 | 769 | 630 | 516 | 422 | 346 | 283 | 232 | 190 | 155 |
| 1919        | 15455 | 12655 | 10359 | 8481 | 6944 | 5685 | 4655 | 3811 | 3120 | 2555 | 2092 | 1712 | 1402 | 1148 | 940 | 769 | 630 | 516 | 422 | 346 | 283 | 232 | 190 | 155 |
| 1920        | 15455 | 12655 | 10359 | 8481 | 6944 | 5685 | 4655 | 3811 | 3120 | 2555 | 2092 | 1712 | 1402 | 1148 | 940 | 769 | 630 | 516 | 422 | 346 | 283 | 232 | 190 | 155 |
| 1921        | 15455 | 12655 | 10359 | 8481 | 6944 | 5685 | 4655 | 3811 | 3120 | 2555 | 2092 | 1712 | 1402 | 1148 | 940 | 769 | 630 | 516 | 422 | 346 | 283 | 232 | 190 | 155 |
| 1922        | 15455 | 12655 | 10359 | 8481 | 6944 | 5685 | 4655 | 3811 | 3120 | 2555 | 2092 | 1712 | 1402 | 1148 | 940 | 769 | 630 | 516 | 422 | 346 | 283 | 232 | 190 | 155 |
| 1923        | 15455 | 12655 | 10359 | 8481 | 6944 | 5685 | 4655 | 3811 | 3120 | 2555 | 2092 | 1712 | 1402 | 1148 | 940 | 769 | 630 | 516 | 422 | 346 | 283 | 232 | 190 | 155 |
| 1924        | 15455 | 12655 | 10359 | 8481 | 6944 | 5685 | 4655 | 3811 | 3120 | 2555 | 2092 | 1712 | 1402 | 1148 | 940 | 769 | 630 | 516 | 422 | 346 | 283 | 232 | 190 | 155 |

Source: DRAFT
Table 13 (continuation). Numbers of longnose skate at age, estimated by the base model.

<table>
<thead>
<tr>
<th>Year</th>
<th>Age (years)</th>
<th>1962</th>
<th>1963</th>
<th>1964</th>
<th>1965</th>
<th>1966</th>
<th>1967</th>
<th>1968</th>
</tr>
</thead>
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<tr>
<td>1962</td>
<td>12027</td>
<td>8936</td>
<td>8059</td>
<td>6595</td>
<td>5396</td>
<td>4417</td>
<td>3629</td>
<td>2964</td>
</tr>
<tr>
<td>1963</td>
<td>11919</td>
<td>9845</td>
<td>8052</td>
<td>6597</td>
<td>5399</td>
<td>4417</td>
<td>3629</td>
<td>2964</td>
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<td>1981</td>
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<td>8931</td>
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<td>5775</td>
<td>5229</td>
<td>4579</td>
<td>3626</td>
<td>2954</td>
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</table>
Table 14. Summary of recent trends in longnose skate exploitation and estimated population levels.

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Landings (mt)</td>
<td>782</td>
<td>1,177</td>
<td>1,351</td>
<td>860</td>
<td>313</td>
<td>848</td>
<td>373</td>
<td>615</td>
<td>742</td>
<td>*576</td>
</tr>
<tr>
<td>Estimated Discards (mt)</td>
<td>438</td>
<td>659</td>
<td>757</td>
<td>482</td>
<td>175</td>
<td>475</td>
<td>209</td>
<td>344</td>
<td>415</td>
<td>323</td>
</tr>
<tr>
<td>Estimated Total Catch (mt)</td>
<td>1,220</td>
<td>1,835</td>
<td>2,108</td>
<td>1,342</td>
<td>488</td>
<td>1,323</td>
<td>582</td>
<td>959</td>
<td>1,157</td>
<td>*999</td>
</tr>
<tr>
<td>ABC (mt)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OY * (if different from ABC) (mt)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPR</td>
<td>74.28%</td>
<td>64.22%</td>
<td>59.83%</td>
<td>71.03%</td>
<td>87.96%</td>
<td>71.56%</td>
<td>85.99%</td>
<td>78.42%</td>
<td>74.81%</td>
<td>79.65%</td>
</tr>
<tr>
<td>Exploitation Rate (total catch/summary biomass)</td>
<td>1.66%</td>
<td>2.50%</td>
<td>2.90%</td>
<td>1.87%</td>
<td>0.68%</td>
<td>1.84%</td>
<td>0.81%</td>
<td>1.33%</td>
<td>1.60%</td>
<td>1.25%</td>
</tr>
<tr>
<td>Summary Age 2+ Biomass (B) (mt)</td>
<td>72,877</td>
<td>72,599</td>
<td>71,802</td>
<td>70,844</td>
<td>70,671</td>
<td>71,272</td>
<td>71,027</td>
<td>71,445</td>
<td>71,439</td>
<td>71,217</td>
</tr>
<tr>
<td>Spawning Stock Biomass (SB) (mt)</td>
<td>10,065</td>
<td>9,964</td>
<td>9,716</td>
<td>9,406</td>
<td>9,275</td>
<td>9,342</td>
<td>9,234</td>
<td>9,302</td>
<td>9,300</td>
<td>9,268</td>
</tr>
<tr>
<td>Uncertainty in Spawning Stock Biomass estimate</td>
<td>9,164-10,966</td>
<td>9,064-10,864</td>
<td>8,821-10,611</td>
<td>8,519-10,294</td>
<td>8,392-10,158</td>
<td>8,458-10,225</td>
<td>8,354-10,114</td>
<td>8,422-10,183</td>
<td>8,421-10,179</td>
<td>8,391-10,146</td>
</tr>
<tr>
<td>Recruitment at age 0</td>
<td>13,448</td>
<td>13,386</td>
<td>13,232</td>
<td>13,032</td>
<td>12,945</td>
<td>12,989</td>
<td>12,918</td>
<td>12,963</td>
<td>12,962</td>
<td>12,941</td>
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<tr>
<td>Uncertainty in Recruitment estimate</td>
<td>12,414-14,482</td>
<td>12,351-14,421</td>
<td>12,195-14,267</td>
<td>11,995-14,069</td>
<td>11,908-13,962</td>
<td>11,951-14,027</td>
<td>11,880-13,956</td>
<td>11,926-14,000</td>
<td>11,925-13,999</td>
<td>11,905-13,978</td>
</tr>
<tr>
<td>Depletion (SB/SB0)</td>
<td>71.54%</td>
<td>70.82%</td>
<td>69.06%</td>
<td>68.86%</td>
<td>65.93%</td>
<td>66.40%</td>
<td>65.64%</td>
<td>66.12%</td>
<td>64.15%-68.11%</td>
<td>64.46%-68.41%</td>
</tr>
</tbody>
</table>

* indicates values calculated as the average for the last three years (2004-2006)
Table 15. Longnose skate proportion, discard and discard mortality rates used to reconstruct alternative catch histories.

<table>
<thead>
<tr>
<th></th>
<th>Longnose proportion, (b) (≤ 1980)</th>
<th>Discard rate, (d) (≤ 1980)</th>
<th>Discard rate, (d) (1981-1994)</th>
<th>Discard mortality rate, (m) (all years)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base</strong></td>
<td>0.62</td>
<td>0.93</td>
<td>0.93</td>
<td>0.5</td>
</tr>
<tr>
<td>&quot;Low&quot; catch history</td>
<td>0.5</td>
<td>0.85</td>
<td>0.91</td>
<td>0.3</td>
</tr>
<tr>
<td>&quot;High&quot; catch history</td>
<td>0.75</td>
<td>0.97</td>
<td>0.95</td>
<td>0.7</td>
</tr>
</tbody>
</table>
Table 16. Summary of reference points for the longnose skate.

<table>
<thead>
<tr>
<th>Reference points based on SB 40%</th>
<th>Point estimate</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unfished Spawning Stock Biomass (SB₀) (mt)</td>
<td>14,069</td>
<td>13,042-15,096</td>
</tr>
<tr>
<td>Unfished Summary Age 2+ Biomass (B₀) (mt)</td>
<td>90,955</td>
<td></td>
</tr>
<tr>
<td>Unfished Recruitment (R₀) at age 0</td>
<td>15,454</td>
<td>14,403-16,505</td>
</tr>
<tr>
<td>Exploitation rate resulting in SB40%</td>
<td>2.67%</td>
<td>N/A</td>
</tr>
<tr>
<td>Yield with SPRSB₀ at SB40% (mt)</td>
<td>1,264</td>
<td>1,194-1,334</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reference points based on SPR proxy for MSY</th>
<th>Point estimate</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spawning Stock Biomass at SPR (SBₚSPR)(mt)</td>
<td>1,688</td>
<td>1,565-1,812</td>
</tr>
<tr>
<td>Exploitation rate corresponding to SPR</td>
<td>4.26%</td>
<td>N/A</td>
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<tr>
<td>Yield with SPRSPRMSY-proxy at SBₚSPR (mt)</td>
<td>787</td>
<td>744-831</td>
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</table>

<table>
<thead>
<tr>
<th>Reference points based on estimated MSY values</th>
<th>Point estimate</th>
<th>95% confidence interval</th>
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</thead>
<tbody>
<tr>
<td>Spawning Stock Biomass at MSY (SBₚMSY) (mt)</td>
<td>5,253</td>
<td>4,867-5,638</td>
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<tr>
<td>SPRMSY</td>
<td>60.84%</td>
<td>60.80%-60.86%</td>
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<tr>
<td>Exploitation Rate corresponding to SPRMSY</td>
<td>2.71%</td>
<td>N/A</td>
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<tr>
<td>MSY (mt)</td>
<td>1,268</td>
<td>1,198-1,338</td>
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Table 17. 10-year forecast of longnose skate catch, summary biomass, spawning biomass and stock depletion estimated based on current rate of fishing mortality.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total catch (mt)</th>
<th>Summary biomass (mt)</th>
<th>Spawning Biomass (mt)</th>
<th>Depletion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>176</td>
<td>71,184</td>
<td>9,347</td>
<td>66%</td>
</tr>
<tr>
<td>2010</td>
<td>175</td>
<td>71,129</td>
<td>9,394</td>
<td>67%</td>
</tr>
<tr>
<td>2011</td>
<td>175</td>
<td>71,060</td>
<td>9,442</td>
<td>67%</td>
</tr>
<tr>
<td>2012</td>
<td>175</td>
<td>70,986</td>
<td>9,486</td>
<td>67%</td>
</tr>
<tr>
<td>2013</td>
<td>174</td>
<td>70,914</td>
<td>9,525</td>
<td>68%</td>
</tr>
<tr>
<td>2014</td>
<td>174</td>
<td>70,848</td>
<td>9,556</td>
<td>68%</td>
</tr>
<tr>
<td>2015</td>
<td>173</td>
<td>70,794</td>
<td>9,578</td>
<td>68%</td>
</tr>
<tr>
<td>2016</td>
<td>173</td>
<td>70,754</td>
<td>9,590</td>
<td>68%</td>
</tr>
<tr>
<td>2017</td>
<td>173</td>
<td>70,727</td>
<td>9,593</td>
<td>68%</td>
</tr>
<tr>
<td>2018</td>
<td>172</td>
<td>70,714</td>
<td>9,589</td>
<td>68%</td>
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</table>

Table 18. 10-year forecast of longnose skate catch, summary biomass, spawning biomass and stock depletion estimated based on F45%.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total catch (mt)</th>
<th>Summary biomass (mt)</th>
<th>Spawning Biomass (mt)</th>
<th>Depletion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>3,428</td>
<td>71,184</td>
<td>9,347</td>
<td>66%</td>
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<tr>
<td>2010</td>
<td>3,269</td>
<td>68,833</td>
<td>8,847</td>
<td>63%</td>
</tr>
<tr>
<td>2011</td>
<td>3,128</td>
<td>66,836</td>
<td>8,389</td>
<td>60%</td>
</tr>
<tr>
<td>2012</td>
<td>3,006</td>
<td>65,135</td>
<td>7,970</td>
<td>57%</td>
</tr>
<tr>
<td>2013</td>
<td>2,902</td>
<td>63,676</td>
<td>7,587</td>
<td>54%</td>
</tr>
<tr>
<td>2014</td>
<td>2,816</td>
<td>62,403</td>
<td>7,241</td>
<td>51%</td>
</tr>
<tr>
<td>2015</td>
<td>2,745</td>
<td>61,264</td>
<td>6,930</td>
<td>49%</td>
</tr>
<tr>
<td>2016</td>
<td>2,686</td>
<td>60,211</td>
<td>6,654</td>
<td>47%</td>
</tr>
<tr>
<td>2017</td>
<td>2,638</td>
<td>59,208</td>
<td>6,411</td>
<td>46%</td>
</tr>
<tr>
<td>2018</td>
<td>2,598</td>
<td>58,226</td>
<td>6,201</td>
<td>44%</td>
</tr>
</tbody>
</table>
Table 19. Decision table based on alternative states of nature, defined based on alternative catch histories and different levels of NWFSC shelf-slope survey catchability $Q$.

<table>
<thead>
<tr>
<th>Forecast</th>
<th>Year</th>
<th>Low Q (Q=0.654) Low historical catch</th>
<th>Q=0.83 BASE</th>
<th>High Q (Q=1.046) High historical catch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total catch (mt) (landings and discard mortality)</td>
<td>SSB (mt) Depletion</td>
<td>Total catch (mt) (landings and discard mortality)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 11,711 80%</td>
<td>899 9,347 66%</td>
<td>899 8,042 41%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 11,700 80%</td>
<td>899 9,387 66%</td>
<td>899 8,065 41%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 11,691 80%</td>
<td>899 9,431 67%</td>
<td>899 8,188 42%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 11,665 79%</td>
<td>899 9,527 68%</td>
<td>899 8,253 43%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 11,645 79%</td>
<td>899 9,599 68%</td>
<td>899 8,353 43%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 11,620 79%</td>
<td>899 9,580 68%</td>
<td>899 9,000 46%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 11,589 79%</td>
<td>899 9,591 68%</td>
<td>899 9,111 46%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 11,553 79%</td>
<td>899 9,594 68%</td>
<td>899 9,359 47%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 11,513 78%</td>
<td>899 9,588 68%</td>
<td>899 9,440 48%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 11,711 80%</td>
<td>899 9,347 66%</td>
<td>899 8,042 41%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 11,603 79%</td>
<td>899 9,297 66%</td>
<td>899 8,153 41%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 11,497 78%</td>
<td>899 9,248 66%</td>
<td>899 8,261 42%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 11,392 78%</td>
<td>899 9,198 65%</td>
<td>899 8,358 42%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 11,286 77%</td>
<td>899 9,143 65%</td>
<td>899 8,441 43%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 11,179 76%</td>
<td>899 9,084 65%</td>
<td>899 8,506 43%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 11,072 75%</td>
<td>899 9,019 64%</td>
<td>899 8,553 43%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 10,964 75%</td>
<td>899 8,950 64%</td>
<td>899 8,583 43%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 10,857 74%</td>
<td>899 8,878 63%</td>
<td>899 8,600 44%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>899 10,753 73%</td>
<td>899 8,805 63%</td>
<td>899 8,606 44%</td>
</tr>
</tbody>
</table>
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APPENDIX 1: List of STAR Panel requests
During the STAR Panel review of the assessment, analysis and evaluation of the base model were performed. These analyses and evaluations caused changes in the base model specifications. These changes significantly improved the assessment model. This appendix provides an overview of changes to the base model that were implemented during the STAR panel review, as well as requests by the STAR Panel for additional model runs that were conducted during the review.

Prior to the STAR Panel, the base model had the following characteristics:

- The model began in 1980 and assumed non-zero equilibrium catch in 1979;
- Landed and discarded catch were entered separately in the SS2 data file;
- Historical landed catch records (1951-1980) were used only to estimate initial equilibrium catch;
- Model included two sexes;
- Natural mortality \( M \) was fixed at 0.1;
- Two out of three parameters of von Bertalanffy growth model \( (L_1, L_2) \) were estimated, while the third parameter \( K \) was fixed;
- From 1984 forward, the model treated recruits stochastically and recruitment deviations were estimated;
- NWFSC slope-shelf survey \( Q \) was fixed at 1;
- Selectivities of slope surveys were not fixed asymptotic;
- The model used a “data point” approach for iterative re-weighting.

After the STAR Panel, the base model for the longnose skate has the following features:

- The model begins in 1916 and assumes unfished equilibrium in 1915;
- Landed catch and discard mortality are combined in the data file as total catch, estimated outside of SS2;
- Historical records (1951-1980) are used to reconstruct time-series of longnose skate catches, with a linear increase in catches from 1916 to 1951;
- Model includes one sex;
- Natural mortality \( M \) is fixed at 0.2;
- All three parameters of von Bertalanffy growth parameters \( (L_1, L_2, K) \) are estimated;
- Recruits are treated deterministically, and are taken from the estimated stock-recruit curve;
- NWFSC slope-shelf survey \( Q \) is fixed at 0.83;
- Selectivities of slope surveys are fixed asymptotic;
- NWFSC shelf-slope survey selectivity is modeled as asymptotic;
- Iterative re-weighting was conducted by applying the same adjustment to all points in each data series.

The STAR Panel requested model changes in five series. All of the STAR Panel requests were reflected in new base model and current assessment report.
STAR panel requests for longnose skate analyses (Series 1)

Modify base case (from current formulation):
- One sex model
- No recruitment deviations
- Use F45% proxy for MSY
- Do not assume discards on historical catch estimates, rather adjust the catch series to account for discarding, proportion of longnose skate in skate catch, discard mortality, etc.

A. Do fits using the base case formulation as adjusted above, with the equilibrium non-zero catch initialization (in 1980) to:
   1. The “best” historical catch (same as current)
   2. The low historical catch (see below)
   3. The high historical catch (see below)

For these three series we are interested to see the biomass trajectories and a summary of the likelihood components.

B. Do a fit initializing the population at equilibrium conditions in 1915, with catches ramping up from 0 to the high historical catch between 1915 and 1950 and constant at the high historical level from 1951 to 1980. Show a comparison of the estimated 1980 age structure from this run and from run A3 above. This run is formulated the same as the runs “A” above, other than in how the population is initialized.

C. Based on run A1 above: Modify selectivity for the two slope surveys to be asymptotic. Do a profile on $q$.

D. AFSC triennial survey data. Jim Hastie is getting summary information so that potential bias in catchability in the 2004 survey can be investigated.

STAR panel requests for longnose skate analyses (Series 2)

The updated base case continues from changes made under the Series 1 requested changes (One sex model, no recruitment deviations). Additional changes to the new update base case will include:
- Washington State 1950-1979 catches will be removed
- $M=0.2$ (subject to evaluating basis for this)
- Population to be initialized at equilibrium in 1916
- Re-do the iterative re-weighting of fishery sample sizes using the output from SS2 (i.e., rescale a series, rather than individual samples)
- Slope surveys selectivity parameters; asymptotic selectivity, estimate peak parameter, and no estimation of descending width parameters (because it had no influence on the fits)

For this new base case:

A. Fit to the “best” catch data series
B. Separate fits to the “low catch” and “high catch” series
C. Profile on $q$ (NWFSC shelf-slope survey) for the “best” catch series run
D. Do a fit using the B.C. estimates of maturity at length (“best” catch series)
E. Provide supporting information for $M=0.2$
F. For one run (e.g., base case with “best” catch series) try different techniques to see if you find alternative minima (jittering or other method to begin with different initial parameter estimates and different phases for the parameters).

STAR panel requests for longnose skate analyses (Series 3)

New base case:
- fix one parameter (descending limb) of fishery selectivity
- add priors for $q$ and $M$
- finish iterative re-weighting for sample sizes
- keep the Thompson estimates of maturity for base case
- add extra error to AFSC shelf survey (so that the RMSEs are similar to SEs)

1) Run base case scenario with “best” catch series. Produce R graphics for this run.
2) Run base case formulation with low catch series
3) Run base case formulation with high catch series
4) Run model with B.C. maturity estimates (otherwise same formulation as base case)

STAR panel requests for longnose skate analyses (Series 4)

Base case as defined in previous request:

1) Run base case formulation using the low catch series but fixing the shelf-slope survey $q$ at the value estimated for the base case run (using the “best” catch series)
2) Run base case formulation using the high catch series but fixing the shelf-slope survey $q$ at the value estimated for the base case run (using the “best” catch series)

STAR panel requests for longnose skate analyses (Series 5)

Base case as defined in previous request, except that $M$ is fixed 0.2 and the NWFSC shelf-slope survey $q$ is fixed at 0.83. Three runs:

1) Low $q$ (0.654) and low catch history
2) Mid $q$ (0.83) and mid catch history
3) High $q$ (1.046) and high catch history
APPENDIX 2: Codes for the longnose skate assessment model
SS2 data file

1916  #_styr
2008  #_endyr
1    #_nseas
12   #_months/season
1    #_spawn_seas
1    #_Nfleet
4    #_Nsurv

fishery1%survey1_NWFSC_slope%survey2_NWFSC_slope%survey3_Triennial%Survey4_AFSC_Slope
0.5 0.5 0.66 0.66 0.9  #_surveytiming_in_season
1    #_Ngenders
24   #_Nages
    #_catch_biomass(mtons): _columns_are_fisheries, _rows_are_year*season"

0    # init_equil_catch_for_each_fishery (1915)
 19.62103302  #1916
 39.24206604  #1917
 58.86309906  #1918
 78.48413208  #1919
 98.1051651   #1920
117.7261981  #1921
137.3472311  #1922
156.9682642  #1923
176.5892972  #1924
196.2103302  #1925
215.8313632  #1926
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274.6944623  #1929
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| # Yr | Seas | Flt/Svy | Gender | Part | Nsamp | datavector(female-male)
| # Fishery
| 1995 | 1 | 1 | 0 | 0 | 53 | 0 | 0 | 0 | 0 | 0.075471698 | 0.188679245 | 0.113207547 | 0.075471698 | 0.150943396 | 0.094339623 | 0.037735849 | 0.056603774 | 0.18867925 |
| 1996 | 1 | 1 | 0 | 0 | 99 | 0 | 0 | 0 | 0 | 0.101010100 | 0.151515152 | 0.181818182 | 0.111111111 | 0.111111111 | 0.111111111 | 0.050050050 | 0.040040040 | 0.03030303 |
| 1997 | 1 | 1 | 0 | 0 | 459 | 0 | 0 | 0 | 0 | 0.021786492 | 0.004357298 | 0.013071895 | 0.021786492 | 0.047930283 | 0.054466231 | 0.087145969 |
| 1998 | 1 | 1 | 0 | 0 | 84 | 0 | 0 | 0 | 0 | 0.011904762 | 0.047619048 | 0.023809524 | 0.047619048 | 0.047619048 | 0.011904762 | 0.071428571 | 0.083333333 |
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Control file

1   #_N_Growth_Patterns
1   #_N_submorphs
1   #_N_areas
1   1  1  1  1  #_area_assignments_for_each_fishery_and_survey
1   #_recruit_design_(G_Pattern_x_birthseas_x_area)_X_(0/1_flag)
0   #_recr_distr_interaction
0   #_Do_migration
0   0  0   #_movement_pattern_(season_x_source_x_destination)_x_(0/1_flag)_minage_maxage
0   #_Nblock_Designs
0.5  #_fracfemale
1   #_submorph_between/within
-1  #vector_submorphdist_(-1_first_val_for_normal_approx)
1   #_natM_amin
3   #_natM_amax
1   #_Growth_Age-at-L1
17  #_Growth_Age-at-L2
0   #_SD_add_to_LAA
0   #_CV_Growth_Pattern
1   #_maturity_option
8   #_First_Mature_Age
3   #_parameter_offset_approach
1   #_new_flag_for_selection_of_env_and_block_adjustment_method
-1  #_MGparm_Dev_Phase

#_growthParms

#_LO  HI   NIT   PRIOR  PR_type  SD  PHASE  env-var  use_dev  dev_minyr  dev_maxyr  dev_stdderv  Block  Block_Fxn
0.01  0.8  0.2   0  0  0.04  -3  0  0  0  0  0  0.5  0  #_pattern: 1
-3   3  0   0   -1  99   -3  0  0  0  0  0.5  0  #_Mi_natM_old_as
15  40  26.958 26.958  -1  99   4  0  0  0  0  0.5  0  #_Mi_Lmin
70  130 109.74 109.74  -1  99   4  0  0  0  0.5  0  #_Mi_Lmax
0.05 0.15 0.047   0.047 -1  99   -3  0  0  0  0  0.5  0  #_Mi_VBK
0.1  0.5 0.1394 0.1394  -1  99   -3  0  0  0  0.5  0  #_MiCV_young
-1  1  0.708 -0.708 -1  99   -3  0  0  0  0.5  0  #_MiCV_old
-3   3  4.28e-006 4.28e-006  -1  99   -3  0  0  0  0  0.5  0  #_wt_len&maturity
2   4  3.05975 3.05975  -1  99   -3  0  0  0  0  0.5  0  #_Female wt-len-2
10  140 120.753 120.753  -1  99   -3  0  0  0  0  0.5  0  #_Female mat-len-1
-0.09 -0.05 -0.0985876 -0.0985876  -1  99   -3  0  0  0  0  0.5  0  #_Female mat-len-2
-3   3  1   1   -1  99   -3  0  0  0  0  0.5  0  #_Female eggs/gm_intercept
```
-3 3 0 0 -1 99 -3 0 0 0 0.5 0 0 #Female eggs/gm slope
-4 4 0 0 -1 99 -3 0 0 0 0.5 0 0 #reccdistribution_by_growth_pattern
-4 4 0 0 -1 99 -3 0 0 0 0.5 0 0 #reccdistribution_by_areal
-4 4 0 0 -1 99 -3 0 0 0 0.5 0 0 #reccdistribution_by_season 1
1 1 1 1 -1 99 -3 0 0 0 0.5 0 0 #cohort_growth_deviation

0 # custom MG-env_setup
0 # custom MG-block_setup

# Spawner-Recruitment
1 # SR_function: 1=Beverton-Holt
# LO HI INIT PRIOR PR_type SD PHASE
5 15 13 11.1 -1 10 1 #Ln(R0)
0.2 1 0.4 0.6 -1 0.2 -1 #steepness
0 0.4 0.3 0.3 -1 0.8 -3 #SD_recruitments
0 0 0 0 -1 99 -3 #Env_link
-2 2 0 0 -1 99 -1 #init_eq
0 0 0 0 -1 0 -99 # new parameter Line reserved For future use as autocorrelation
0 # SR_env_link
3 # SR_env_target_1=devs; 2=R0; 3=steepness
0 #do_recDev: 0=none; 1=devvector; 2=simple deviations
1984-2005 -15 15 3 #recr_devs
1492 #first_yr_fullbias_adj_in_MP

# initial_F_parms
# LO HI INIT PRIOR PR_type SD PHASE
0 1 0 0.03 -1 99 -1

# Q_setup
# A=do power, B=env-var, C=extra SD, D=devtype(<0=mirror, 0/1=none, 2=cons, 3=ran, 4=ranwalk); E=0=num/1=biu, F=err_type
# A B C D E F
0 0 0 0 1 0 #Fishery
0 0 0 2 1 0 #Survey1_NWFSC_shelf_slope
0 0 0 2 1 0 #Survey2_NWFSC_slope
0 0 0 2 1 0 #Survey3_Triennial
0 0 0 2 1 0 #Survey4_AFSC_Slope

# QParms(if any)
# LO HI INIT PRIOR PR_type SD PHASE
-7 5 -0.19 -0.19 0 0.187 -1
-7 0 -0.6 0 0 99 1
-7 0 -0.6 0 0 99 1
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# size_selex_types
# Pattern Discard Male Special
24 0 0 0 # 1
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5 0 0 0 # 3
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1 # new flag For environment and block adjustment method
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0 #_custom_sel-block_setup
-1 #_selparmdev-phase
# Variance_adjustments_to_input_values

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# add_to_survey_CV
# add_to_discard_CV
# add_to_bodywt_CV

# mult_by_lencomp_N
# mult_by_agecomp_N
# mult_by_size-at-age_N

30 # DF_for_discard_like
30 # DF_for_meanbodywt_like

1 # maxlambdaphase
0 # sd_offset

# lambdas (columns_for_phases)
0 # CPUE/survey: 1
1 # CPUE/survey: 2
1 # CPUE/survey: 3
1 # CPUE/survey: 4
1 # CPUE/survey: 5
1 # discard: 1
1 # discard: 2
1 # discard: 3
1 # discard: 4
1 # discard: 5
1 # meanbodyweight
1 # lencomp: 1
1 # lencomp: 2
1 # lencomp: 3
1 # lencomp: 4
1 # lencomp: 5
1 # agecomp: 1
1 # agecomp: 2
1 # agecomp: 3
1 # agecomp: 4
1 # agecomp: 5
1 # size-age: 1
1 # size-age: 2
1 # size-age: 3
1 # size-age: 4
1 # size-age: 5
1 # init_equ_catch
1 # recruitments
0 # parameter-priors
1 # parameter-dev-vectors
100 # crashPenLambda
0.7 # maximum allowed harvest rate