PACIFIC MACKEREL BIOMASS PROJECTION ESTIMATE FOR USA MANAGEMENT IN 2017-18 AND 2018-19

P. R. Crone and K. T. Hill
NOAA / NMFS
Southwest Fisheries Science Center
8901 La Jolla Shores Dr.
La Jolla, CA 92037

Submitted to

Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, Oregon 97220

Introduction

Beginning in 2015, the Pacific Fishery Management Council (Council) began an assessment/management schedule for Pacific mackerel (*Scomber japonicus*) based on: 1) conducting a *full* (benchmark) assessment every four years starting in 2015; 2) conducting a catch-only projection assessment every four years starting in 2017; and 3) setting harvest and management guidelines as biennial specifications that serve for two consecutive (fishing) years. In 2015, a full assessment was conducted for purposes of providing management advice that served for two (fishing) years, 2015-16 and 2016-17. A catch-only projection assessment is presented here, which provides harvest guidelines (HG) for managing the Pacific mackerel resource for fishing years 2017-18 and 2018-19. The next benchmark assessment and review will take place during the spring 2019. The most recent management guidelines regarding allowable catches for Pacific mackerel through the 2016-17 fishing year are presented in Table 1.

Methods and Results

Details regarding the assessment model *H3*, which has served as the baseline model for advising management since 2015, are presented in the stock assessment report (see Crone and Hill 2015). The projection model this year was parameterized similarly as the previous catch-only projections conducted in 2013 and 2014 (e.g., see Crone and Hill 2014), whereby only catch time series were updated in model *H3*, with no other changes to data or parameterizations in the model. Also, as for previous projections: 1) sensitivity analysis was conducted to address uncertainty regarding forecasted catch and most importantly, recent recruitment strength that is typically variable and poorly informed in the model; and 2) harvest control rule estimates were based on a tier-2 σ value = 0.72 and probability level (P*) = 0.45 for calculating an acceptable biological catch (ABC), i.e., both σ and P* are presented as placeholders, given final values are based on SSC/PFMC decisions (See Appendices for additional tables that present yields for a range of P* values based on tier-1 and tier 2 categories. Important assessment model information follows, including data, parameterizations, and sensitivity analyses.

- Recent Pacific mackerel landings (catch) are presented in Table 2. See footnotes for particular catch estimates.

- No other data or parameterizations were changed in the baseline model, including no changes to the underlying stock-recruitment relationship (e.g., estimates of virgin recruitment, steepness, and recruitment deviations), growth estimates, natural mortality assumptions, selectivity parameterizations, etc.
- Sensitivity analyses.
  - As performed in past projection analyses, estimated biomass and derived management quantities were robust to alternative catch time series assumed in the model. This sensitivity analysis was conducted to evaluate how uncertainty in predicting future catches affects estimated management quantities (metrics such as OFL, ABC, and HG) from the projection model. Model scenarios assuming both reduced and increased levels for forecasted catch had relatively little influence on estimates of abundance and associated stock status, primarily given that landings have remained at low levels over an extended timeframe.
    - For example, using average catches (2014-16) instead of the HG associated with USA commercial fisheries had a minor impact on management metrics and only for the 2nd year of the projection period, e.g., roughly, 15% increase in yields for fishing year 2018-19.
    - Increasing forecasted landings also had little impact on management quantities and only for the 2nd year of the projection period, e.g., doubling expected landings in the future (which would reflect an extreme case) resulted in roughly 20% reduction in yields for fishing year 2018-19.
    - Finally, note that uncertainty surrounding future catches of Pacific mackerel is largely related to Mexico's contribution to the overall landings in very recent years, with more certainty associated with predicting landings for USA fisheries (at least in the short-term).
  - Derived management quantities were sensitive to alternative assumptions regarding recent recruitment success, which resulted in differences in estimated stock biomass (age 1+ fish, mt) time series used for advising management (Table 3 and Figure 1).
    - In addition to the default projection for the baseline model, two alternative recruitment scenarios were evaluated, including assuming forecasted recruitment was equal to: 1) recent 3-yr average recruitment (2012-14); and historical 3-yr (continuous low) average recruitment (1997-99). See Figure 2 for magnitude of recent vs. historical (low) 3-yr running average for estimated recruitment.
    - Alternative recruitment (age-0 fish) scenarios were implemented internally in the model via adjusting forecast recruitment deviations in an iterative manner over a series of model runs for the projection period. This method of evaluating future recruitment success in an integrated population dynamics model produces results that better reflect the assumptions and parameterizations of the baseline model (i.e., more internally consistent) than fixing recruitment external to the model via adjustments to the estimated number-at-age matrix generated from the model and subsequently, manually implementing fixed levels of both natural (M) and fishing mortality (F) over time. Both the internal and external methods for evaluating different assumptions regarding future recruitment success resulted in generally similar estimates of important management quantities. Finally, only the external method was conducted in past projections.
    - Estimated stock biomass (age-1+ fish, mt) and recruitment (age-0 fish, 1,000s) time series associated with the three recruitment scenarios are presented in Figures 1 and 2, respectively.

References

Crone, P. R., and K. T. Hill. 2014. Pacific mackerel biomass projection estimate for USA management (2014-15). Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR, 97220. Agenda Item G.2.b, Projection Estimate Report, June 2014. 3 p. http://www.pcouncil.org/wp-content/uploads/G2b_Pmack_ProjectnEst_JUNE2014BB.pdf

Crone, P.R., and K.T. Hill. 2015. Pacific mackerel (*Scomber japonicus*) stock assessment for USA management in the 2015-16 fishing year. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon, 97220. 131 p. http://www.pcouncil.org/wp-content/uploads/2015/05/G2a_PMackerel_Assmt_Full_E-Only_JUN2015BB.pdf

Table 1. Pacific mackerel harvest specifications for fishing years 2015-16 and 2016-17, which are based on the most recent SSC/PFMC deliberations conducted in June 2015. Acronyms follow: OFL is overfishing limit; $ABC_{0.45}$ is acceptable biological catch for tier-2 $\sigma = 0.72$ and $P^* = 0.45$; ACL is acceptable catch limit; HG is harvest guideline; Incidental is incidental catch allowed; and ACT is acceptable catch target.

Harvest statistic	Fishing year	
	2015-16 (mt)	2016-17 (mt)
Biomass	120,435	118,968
OFL	25,291	24,983
$ABC_{0.45}$	23,104	22,822
ACL	23,104	22,822
HG	21,469	21,161
Incidental	1,000	1,000
ACT	20,469	20,161

Table 2. Pacific mackerel landings (mt) for fishing years 2014 to 2018.

Fishing year	Commercial				Recreational	Total
	MX	CA	OR	WA	CA	
2014-15[a]	1,241 (2,825)	3,765 (5,446)	1,215 (1,172)	502 (545)	100 (136)	**6,823** (10,124)
2015-16	4,938	4,367	7	2	99	**9,413**
2016-17[b]	6,551	2,700	6	2	66	**9,325**
2017-18[c]	4,247	NA	NA	NA	88	**30,624**
2018-19[d]	4,247	NA	NA	NA	88	**28,171**

[a]2014-15 catch estimates were updated, given landings included in last assessment (2015) reflected forecasted catches (presented in parentheses).
[b]2016-17 catch estimates reflect forecasted landings, given catch estimates for fishing year 2016-17 were only available through fall 2016 or early winter 2017, depending on the fishery.
[c]2017-18 catch estimates are as follows: MX=avg. catch 2014-16; CA/OR/WA=HG 2017-18; Recreational=avg. catch 2014-16.
[d]2018-19 catch estimates are as follows: MX=avg. catch 2014-16; CA/OR/WA=HG 2018-19; Recreational=avg. catch 2014-16.

Table 3. Pacific mackerel harvest control rules (HCR) for fishing year: A) 2017-18; and B) 2018-19. Acronyms follow: OFL is overfishing limit; ABC is acceptable biological catch; HG is harvest guideline; E_{MSY} is proxy for exploitation rate at maximum sustainable yield; σ is sigma uncertainty level; and P* is the overfishing probability value for ABC calculation. See report for other terms presented in the table. Note that the following HCR table is a placeholder presently, based on previous decisions used in past projections for this stock. See Appendices for HCR tables that present yields associated with tier-1 and tier-2 σ levels across a range of P* values for each recruitment scenario, which are intended to aid the decision process for adopting appropriate levels of uncertainty when setting final management guidelines in June 2017.

A) Fishing year (2017-18)

Harvest control rule formulas

OFL = BIOMASS x E_{MSY} x DISTRIBUTION

ABC_{P*} = BIOMASS x $BUFFER_{P*}$ x E_{MSY} x DISTRIBUTION

HG = (BIOMASS - CUTOFF) x E_{MSY} x DISTRIBUTION

HCR value	Baseline model	Avg. R (2012-14)	Avg. R (1997-99)
Tier-2 σ	0.72	0.72	0.72
P*	0.45	0.45	0.45
ABC buffer for tier-2 P*=0.45	0.9135	0.9135	0.9135
CUTOFF (mt)	18,200	18,200	18,200
$E_{MSY} \equiv$ FRACTION	0.3	0.3	0.3
DISTRIBUTION (U.S.)	0.7	0.7	0.7
BIOMASS (age-1+ fish, mt)	143,403	152,790	96,436

HCR statistic	Baseline model	Avg. R (2012-14)	Avg. R (1997-99)
OFL (mt)	30,115	32,086	20,252
ABC (mt)	27,510	29,311	18,500
HG (mt)	26,293	28,264	16,430

B) Fishing year (2018-19)

Harvest control rule formulas

OFL = BIOMASS x E_{MSY} x DISTRIBUTION

ABC_{P*} = BIOMASS x $BUFFER_{P*}$ x E_{MSY} x DISTRIBUTION

HG = (BIOMASS - CUTOFF) x E_{MSY} x DISTRIBUTION

HCR value	Baseline model	Avg. R (2012-14)	Avg. R (1997-99)
Tier-2 σ	0.72	0.72	0.72
P*	0.45	0.45	0.45
ABC buffer for tier-2 P*=0.45	0.9135	0.9135	0.9135
CUTOFF (mt)	18,200	18,200	18,200
$E_{MSY} \equiv$ FRACTION	0.3	0.3	0.3
DISTRIBUTION (U.S.)	0.7	0.7	0.7
BIOMASS (age-1+ fish, mt)	131,724	139,820	58,323

HCR statistic	Baseline model	Avg. R (2012-14)	Avg. R (1997-99)
OFL (mt)	27,662	29,362	12,248
ABC (mt)	25,269	26,822	11,188
HG (mt)	23,840	25,540	8,426

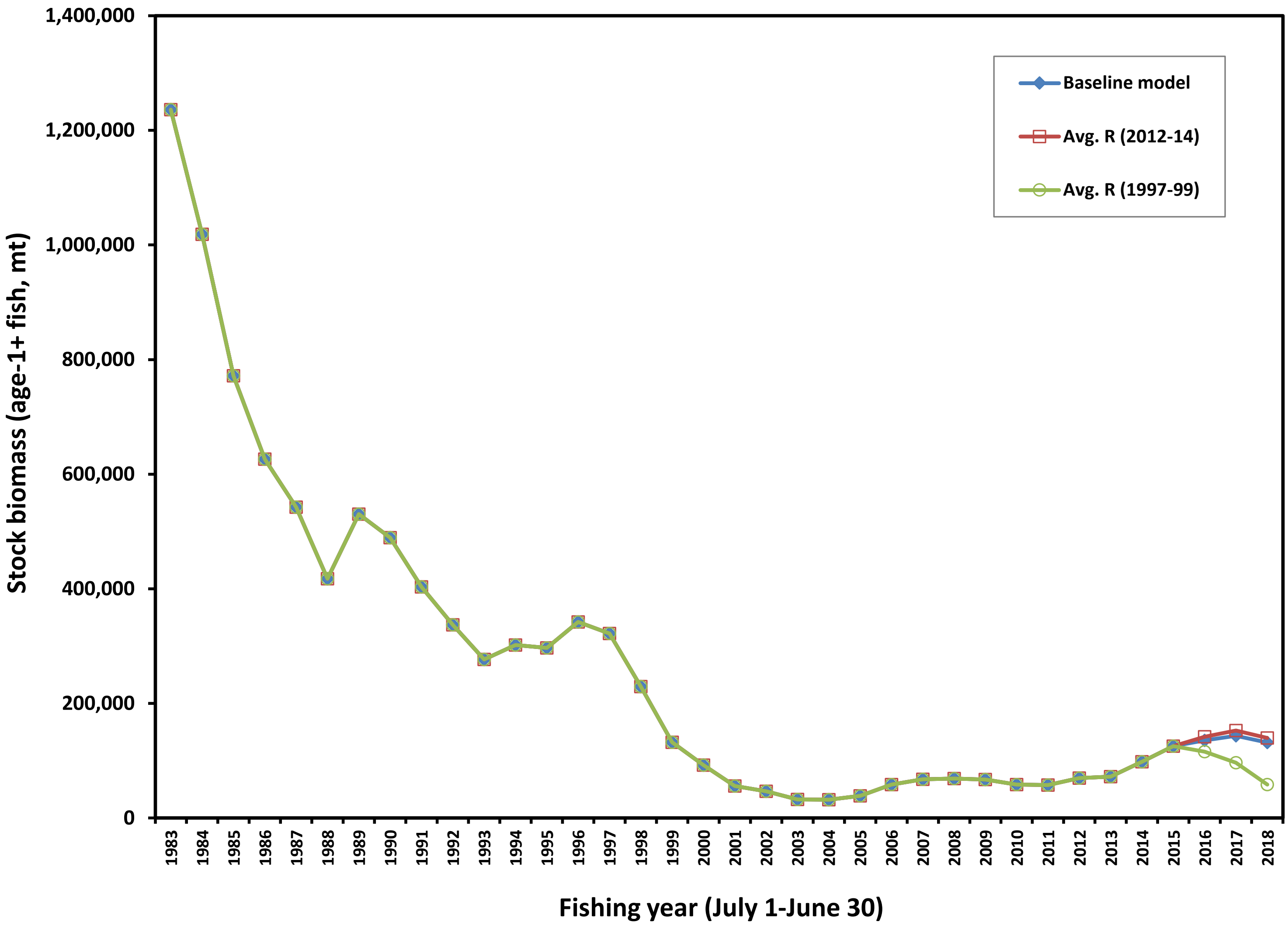

Figure 1. Estimates of Pacific mackerel stock biomass (age 1+ fish, mt) associated with alternative assumptions (model scenarios) regarding recent recruitment success.

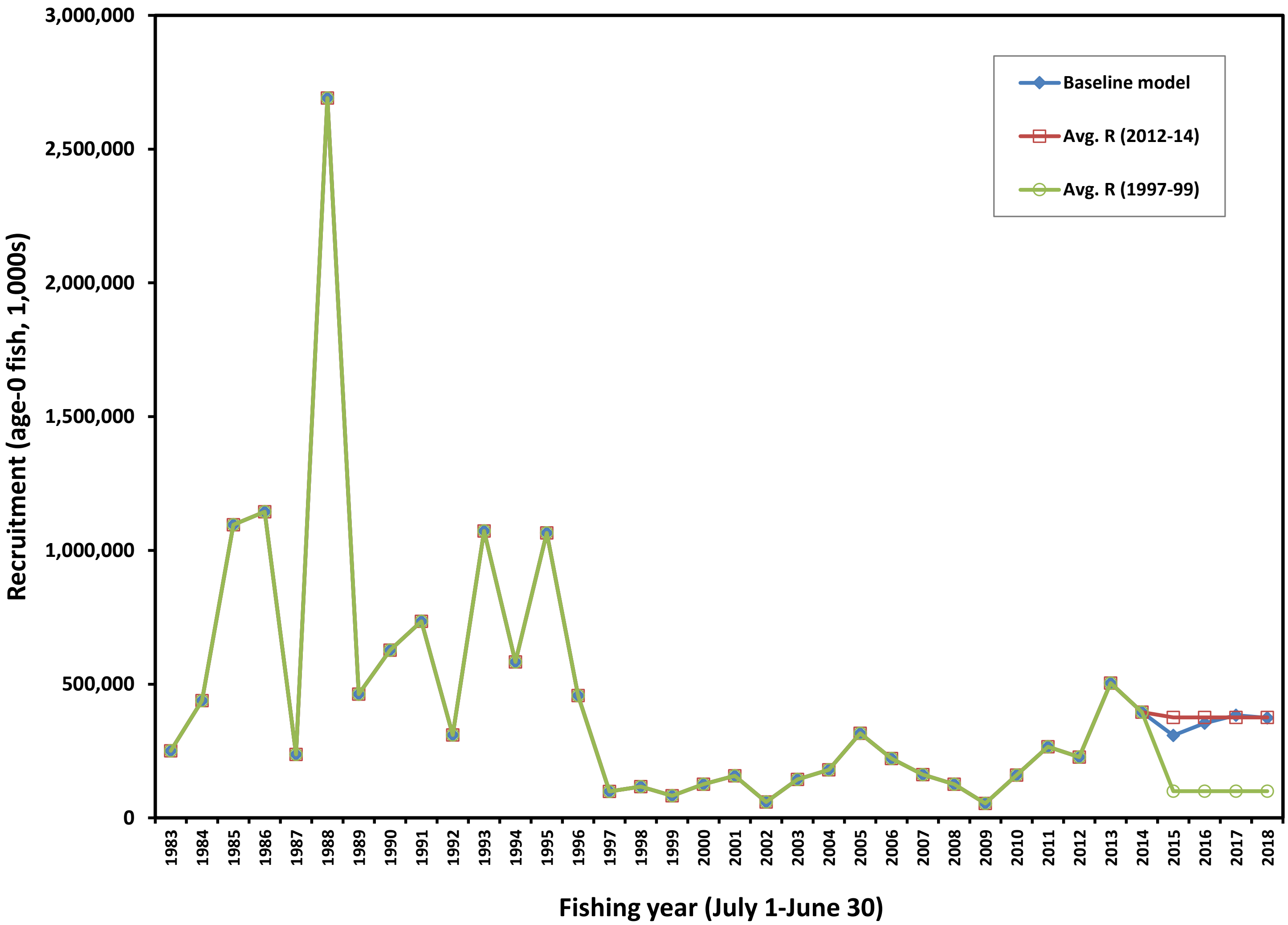

Figure 2. Estimates of Pacific mackerel recruitment (age-0 fish, 1,000s) associated with alternative assumptions (model scenarios) regarding recent recruitment success.

APPENDIX A

Table A1-A3. Pacific mackerel harvest control rule (HCR) tables for baseline model and two alternative recruitment scenarios using the **tier-1 σ category**: A1 is baseline model; A2 is average recruitment (2012-14); and A3 is average recruitment (1997-99). For each recruitment scenario (A1-A3), tables are presented for two consecutive fishing years: A) 2017-18; and B) 2018-19. See Table 3 for acronym definitions.

A1) Baseline model

A) Fishing year (2017-18)

Harvest Control Rule Formulas									
OFL = BIOMASS * E_{MSY} * DISTRIBUTION									
ABC_{P*} = BIOMASS * $BUFFER_{P*}$ * E_{MSY} * DISTRIBUTION									
HG = (BIOMASS - CUTOFF) * E_{MSY} * DISTRIBUTION									
Harvest Formula Parameters									
BIOMASS (ages 1+, mt)	143,403								
P*	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC $Buffer_{Tier-1}$	0.9558	0.9128	0.8705	0.8280	0.7844	0.7386	0.6886	0.6304	0.5531
E_{MSY} ≡ FRACTION	0.30								
CUTOFF (mt)	18,200								
DISTRIBUTION (U.S.)	0.7								
Harvest Control Rule Values (MT)									
OFL =	**30,115**								
ABC_{Tier-1} =	28,783	27,490	26,214	24,934	23,622	22,243	20,736	18,985	16,658
HG =	**26,293**								

B) Fishing year (2018-19)

Harvest Control Rule Formulas									
OFL = BIOMASS x E_{MSY} x DISTRIBUTION									
ABC_{P*} = BIOMASS x $BUFFER_{P*}$ x E_{MSY} x DISTRIBUTION									
HG = (BIOMASS - CUTOFF) x E_{MSY} x DISTRIBUTION									
Harvest Formula Parameters									
BIOMASS (ages 1+, mt)	131,724								
P*	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC $Buffer_{Tier-1}$	0.9558	0.9128	0.8705	0.8280	0.7844	0.7386	0.6886	0.6304	0.5531
E_{MSY} ≡ FRACTION	0.30								
CUTOFF (mt)	18,200								
DISTRIBUTION (U.S.)	0.7								
Harvest Control Rule Values (MT)									
OFL =	**27,662**								
ABC_{Tier-1} =	26,439	25,251	24,079	22,903	21,699	20,431	19,048	17,439	15,301
HG =	**23,840**								

A2) Average recruitment (2012-14)

A) Fishing year (2017-18)

Harvest Control Rule Formulas									
OFL = BIOMASS x E_{MSY} x DISTRIBUTION									
ABC_{P*} = BIOMASS x $BUFFER_{P*}$ x E_{MSY} x DISTRIBUTION									
HG = (BIOMASS - CUTOFF) x E_{MSY} x DISTRIBUTION									
Harvest Formula Parameters									
BIOMASS (ages 1+, mt)	152,790								
P*	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC $Buffer_{Tier-1}$	0.9558	0.9128	0.8705	0.8280	0.7844	0.7386	0.6886	0.6304	0.5531
$E_{MSY} \equiv$ FRACTION	0.30								
CUTOFF (mt)	18,200								
DISTRIBUTION (U.S.)	0.7								
Harvest Control Rule Values (MT)									
OFL =	**32,086**								
ABC_{Tier-1} =	30,667	29,289	27,930	26,566	25,169	23,699	22,094	20,228	17,748
HG =	**28,264**								

B) Fishing year (2018-19)

Harvest Control Rule Formulas									
OFL = BIOMASS x E_{MSY} x DISTRIBUTION									
ABC_{P*} = BIOMASS x $BUFFER_{P*}$ x E_{MSY} x DISTRIBUTION									
HG = (BIOMASS - CUTOFF) x E_{MSY} x DISTRIBUTION									
Harvest Formula Parameters									
BIOMASS (ages 1+, mt)	139,820								
P*	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC $Buffer_{Tier-1}$	0.9558	0.9128	0.8705	0.8280	0.7844	0.7386	0.6886	0.6304	0.5531
$E_{MSY} \equiv$ FRACTION	0.30								
CUTOFF (mt)	18,200								
DISTRIBUTION (U.S.)	0.7								
Harvest Control Rule Values (MT)									
OFL =	**29,362**								
ABC_{Tier-1} =	28,064	26,803	25,559	24,311	23,032	21,687	20,218	18,511	16,241
HG =	**25,540**								

A3) Average recruitment (1997-99)

A) Fishing year (2017-18)

Harvest Control Rule Formulas									
OFL = BIOMASS x E_{MSY} x DISTRIBUTION									
ABC_{P*} = BIOMASS x $BUFFER_{P*}$ x E_{MSY} x DISTRIBUTION									
HG = (BIOMASS - CUTOFF) x E_{MSY} x DISTRIBUTION									
Harvest Formula Parameters									
BIOMASS (ages 1+, mt)	96,436								
P*	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC $Buffer_{Tier-1}$	0.9558	0.9128	0.8705	0.8280	0.7844	0.7386	0.6886	0.6304	0.5531
$E_{MSY} \equiv$ FRACTION	0.30								
CUTOFF (mt)	18,200								
DISTRIBUTION (U.S.)	0.7								
Harvest Control Rule Values (MT)									
OFL =	**20,252**								
ABC_{Tier-1} =	19,356	18,486	17,628	16,768	15,886	14,958	13,945	12,767	11,202
HG =	**16,430**								

B) Fishing year (2018-19)

Harvest Control Rule Formulas									
OFL = BIOMASS x E_{MSY} x DISTRIBUTION									
ABC_{P*} = BIOMASS x $BUFFER_{P*}$ x E_{MSY} x DISTRIBUTION									
HG = (BIOMASS - CUTOFF) x E_{MSY} x DISTRIBUTION									
Harvest Formula Parameters									
BIOMASS (ages 1+, mt)	58,323								
P*	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC $Buffer_{Tier-1}$	0.9558	0.9128	0.8705	0.8280	0.7844	0.7386	0.6886	0.6304	0.5531
$E_{MSY} \equiv$ FRACTION	0.30								
CUTOFF (mt)	18,200								
DISTRIBUTION (U.S.)	0.7								
Harvest Control Rule Values (MT)									
OFL =	**12,248**								
ABC_{Tier-1} =	11,706	11,180	10,661	10,141	9,607	9,046	8,434	7,721	6,775
HG =	**8,426**								

APPENDIX B

Table B1-B3. Pacific mackerel harvest control rule (HCR) tables for baseline model and two alternative recruitment scenarios using the **tier-2 σ category**: B1 is baseline model; B2 is average recruitment (2012-14); and B3 is average recruitment (1997-99). For each recruitment scenario (B1-B3), tables are presented for two consecutive fishing years: A) 2017-18; and B) 2018-19. See Table 3 for acronym definitions.

B1) Baseline model

A) Fishing year (2017-18)

Harvest Control Rule Formulas									
OFL = BIOMASS x E_{MSY} x DISTRIBUTION									
ABC_{P*} = BIOMASS x $BUFFER_{P*}$ x E_{MSY} x DISTRIBUTION									
HG = (BIOMASS - CUTOFF) x E_{MSY} x DISTRIBUTION									
Harvest Formula Parameters									
BIOMASS (ages 1+, mt)	143,403								
P*	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC $Buffer_{Tier-2}$	0.9135	0.8333	0.7577	0.6855	0.6153	0.5455	0.4741	0.3974	0.3060
$E_{MSY} \equiv$ FRACTION	0.30								
CUTOFF (mt)	18,200								
DISTRIBUTION (U.S.)	0.7								
Harvest Control Rule Values (MT)									
OFL =	**30,115**								
ABC_{Tier-2} =	27,510	25,093	22,819	20,644	18,530	16,429	14,279	11,969	9,214
HG =	**26,293**								

B) Fishing year (2018-19)

Harvest Control Rule Formulas									
OFL = BIOMASS x E_{MSY} x DISTRIBUTION									
ABC_{P*} = BIOMASS x $BUFFER_{P*}$ x E_{MSY} x DISTRIBUTION									
HG = (BIOMASS - CUTOFF) * E_{MSY} * DISTRIBUTION									
Harvest Formula Parameters									
BIOMASS (ages 1+, mt)	131,724								
P*	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC $Buffer_{Tier-2}$	0.9135	0.8333	0.7577	0.6855	0.6153	0.5455	0.4741	0.3974	0.3060
$E_{MSY} \equiv$ FRACTION	0.30								
CUTOFF (mt)	18,200								
DISTRIBUTION (U.S.)	0.7								
Harvest Control Rule Values (MT)									
OFL =	**27,662**								
ABC_{Tier-2} =	25,269	23,050	20,960	18,963	17,021	15,091	13,116	10,994	8,464
HG =	**23,840**								

B2) Average recruitment (2012-14)

A) Fishing year (2017-18)

Harvest Control Rule Formulas									
OFL = BIOMASS x E_{MSY} x DISTRIBUTION									
ABC_{P*} = BIOMASS x $BUFFER_{P*}$ x E_{MSY} x DISTRIBUTION									
HG = (BIOMASS - CUTOFF) x E_{MSY} x DISTRIBUTION									
Harvest Formula Parameters									
BIOMASS (ages 1+, mt)	152,790								
P*	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC $Buffer_{Tier-2}$	0.9135	0.8333	0.7577	0.6855	0.6153	0.5455	0.4741	0.3974	0.3060
E_{MSY} ≡ FRACTION	0.30								
CUTOFF (mt)	18,200								
DISTRIBUTION (U.S.)	0.7								
Harvest Control Rule Values (MT)									
OFL =	**32,086**								
ABC_{Tier-2} =	29,310	26,736	24,312	21,996	19,743	17,504	15,214	12,752	9,817
HG =	**28,264**								

B) Fishing year (2018-19)

Harvest Control Rule Formulas									
OFL = BIOMASS x E_{MSY} x DISTRIBUTION									
ABC_{P*} = BIOMASS x $BUFFER_{P*}$ x E_{MSY} x DISTRIBUTION									
HG = (BIOMASS - CUTOFF) x E_{MSY} x DISTRIBUTION									
Harvest Formula Parameters									
BIOMASS (ages 1+, mt)	139,820								
P*	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC $Buffer_{Tier-2}$	0.9135	0.8333	0.7577	0.6855	0.6153	0.5455	0.4741	0.3974	0.3060
E_{MSY} ≡ FRACTION	0.30								
CUTOFF (mt)	18,200								
DISTRIBUTION (U.S.)	0.7								
Harvest Control Rule Values (MT)									
OFL =	**29,362**								
ABC_{Tier-2} =	26,822	24,466	22,249	20,129	18,067	16,018	13,922	11,670	8,984
HG =	**25,540**								

B3) Average recruitment (1997-99)

A) Fishing year (2017-18)

Harvest Control Rule Formulas									
OFL = BIOMASS x E_{MSY} x DISTRIBUTION									
ABC_{P*} = BIOMASS x $BUFFER_{P*}$ x E_{MSY} x DISTRIBUTION									
HG = (BIOMASS - CUTOFF) x E_{MSY} x DISTRIBUTION									
Harvest Formula Parameters									
BIOMASS (ages 1+, mt)	96,436								
P*	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC $Buffer_{Tier-2}$	0.9135	0.8333	0.7577	0.6855	0.6153	0.5455	0.4741	0.3974	0.3060
E_{MSY} ≡ FRACTION	0.30								
CUTOFF (mt)	18,200								
DISTRIBUTION (U.S.)	0.7								
Harvest Control Rule Values (MT)									
OFL =	**20,252**								
ABC_{Tier-2} =	18,500	16,875	15,345	13,883	12,461	11,048	9,602	8,049	6,196
HG =	**16,430**								

B) Fishing year (2018-19)

Harvest Control Rule Formulas									
OFL = BIOMASS x E_{MSY} x DISTRIBUTION									
ABC_{P*} = BIOMASS x $BUFFER_{P*}$ x E_{MSY} x DISTRIBUTION									
HG = (BIOMASS - CUTOFF) x E_{MSY} x DISTRIBUTION									
Harvest Formula Parameters									
BIOMASS (ages 1+, mt)	58,323								
P*	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC $Buffer_{Tier-2}$	0.9135	0.8333	0.7577	0.6855	0.6153	0.5455	0.4741	0.3974	0.3060
E_{MSY} ≡ FRACTION	0.30								
CUTOFF (mt)	18,200								
DISTRIBUTION (U.S.)	0.7								
Harvest Control Rule Values (MT)									
OFL =	**12,248**								
ABC_{Tier-2} =	11,188	10,206	9,280	8,396	7,536	6,682	5,807	4,868	3,747
HG =	**8,426**								