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Pacific Region

Canadian Science Advisory Secretariat
Science Advisory Report 2026/039

OPERATING MODEL CODE TRANSITION AND STOCK STATUS UPDATE (2024) FOR OUTSIDE YELLOWEYE ROCKFISH (*SEBASTES RUBERRIMUS*) IN BRITISH COLUMBIA

CONTEXT

This work presents the transition of Outside Yelloweye Rockfish (OYE, *Sebastes ruberrimus*) operating models (OMs) from AD Model Builder (ADMB) to Template Model Builder (TMB) platform and incorporates new data through 2024. The ADMB Foundation announced in 2023 that the software will be retired, hence the need to transition the OYE OMs to TMB.

The Outside Yelloweye Rockfish stock is assessed in outside waters (PMFC[1] Areas 3CD + 5ABCDE, excluding 4B), while management advice is provided for northern (5BCDE) and southern (3CD, 5A) subunits (Figure 1) to inform Total Allowable Catch (TAC) allocation.

The work supports the second Management Strategy Evaluation (MSE) cycle for Outside Yelloweye Rockfish management, providing updated stock status (in 2024) and reference points for continued management under the current framework. The paper also extends the previous work of Cox et al. (2020) and DFO (2023), which transitioned the stock assessment paradigm from a surplus production model to an age-structured model, as well as developing the MSE approach and simulation-tested the management procedure currently in use.

This Fisheries Science Advisory Report is from the regional peer review meeting of February 11-12, 2026, on Outside Yelloweye Status in 2024 and Operating Model Update. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SCIENCE ADVICE

Status

- Estimated coastwide spawning biomass (SSB) for Outside Yelloweye is estimated to be 9,900 tonnes (5,200–18,300)[2]. The probabilities for beginning-of-year spawning biomass in 2024 being greater than the Limit Reference Point (LRP: $0.4B_{MSY}$) and Upper Stock Reference (USR: $0.8B_{MSY}$) are >99% and 96%, respectively, placing the stock in the Healthy Zone of the Precautionary Approach (PA) Framework.
- The 2024 stock status SSB_{2024}/B_{MSY} = 1.48 (0.75 – 2.54)[2]

[1] Pacific States Marine Fisheries Commission. PMFC areas are similar to but differ slightly from GMU areas.

[2] 95% Credible Interval

Trends

- **Coastwide (Northern and Southern combined):** Coastwide SSB was broadly stable and near unfished levels through the mid-1980s, supported by variable but occasionally strong recruitment in both sub-units and low fishing mortality. The sharp increase in fishing mortality during the late 1980s and 1990s — well above the current Removal Reference (FMSY) of 0.041 per year — drove a rapid, coastwide decline in SSB, with recruitment pulses insufficient to offset removals. Despite declines, the SSB never went below the USR. Following reductions in fishing mortality in the 2000s, coastwide SSB stabilized near its current level, with only limited increases under moderate recruitment and lower fishing mortality.
- **Northern sub-unit:** After fishing mortality rates declined in the 2000s, SSB stabilized around 4,700 tonnes on average (ranging between 4,500 and 5,100 tonnes from 2010 to 2024), with only modest recent increases consistent with continued moderate recruitment and reduced fishing mortality.
- **Southern sub-unit:** As fishing mortality rates declined in the 2000s, SSB stabilized around 4,400 tonnes on average (ranging between 4,300 and 4,900 tonnes from 1994 to 2024) with limited increases, reflecting continued modest recruitment and reduced but persistent fishing mortality.

Ecosystem and Climate Change Considerations

- OYE Operating Models aim to capture the broad set of characteristics (e.g., biological properties, model fits, productivity) observed in the 24 OMs originally explored in Cox et al. (2020) based on three axes of uncertainty: data assumptions, model structure, and natural mortality. The current OYE OMs do this using a range of productivity and mortality scenarios that could be influenced by different environmental conditions.
- No statistically significant associations were found between recruitment and 35 environmental variables.

Stock Advice

- Harvest advice, which is not within scope for this process, will be provided for the 2027/28 and 2028/29 fishing seasons using the current Hard Bottom Long Line (HBLL) 3-year management procedure (HBLL 3YR) described in DFO (2023).

Other Management Questions

- The OMs are used to update the probability of decline over three generations for coastwide OYE spawning biomass to provide relevant metrics for the COSEWIC A Criterion. The weighted coastwide OYE spawning biomass (B_{2024}) had a 6%, 71%, and 99% probability of having declined ≥70%, ≥50%, and ≥30%, respectively, relative to unfished spawning biomass (B_0) over the 1960-2024 period.

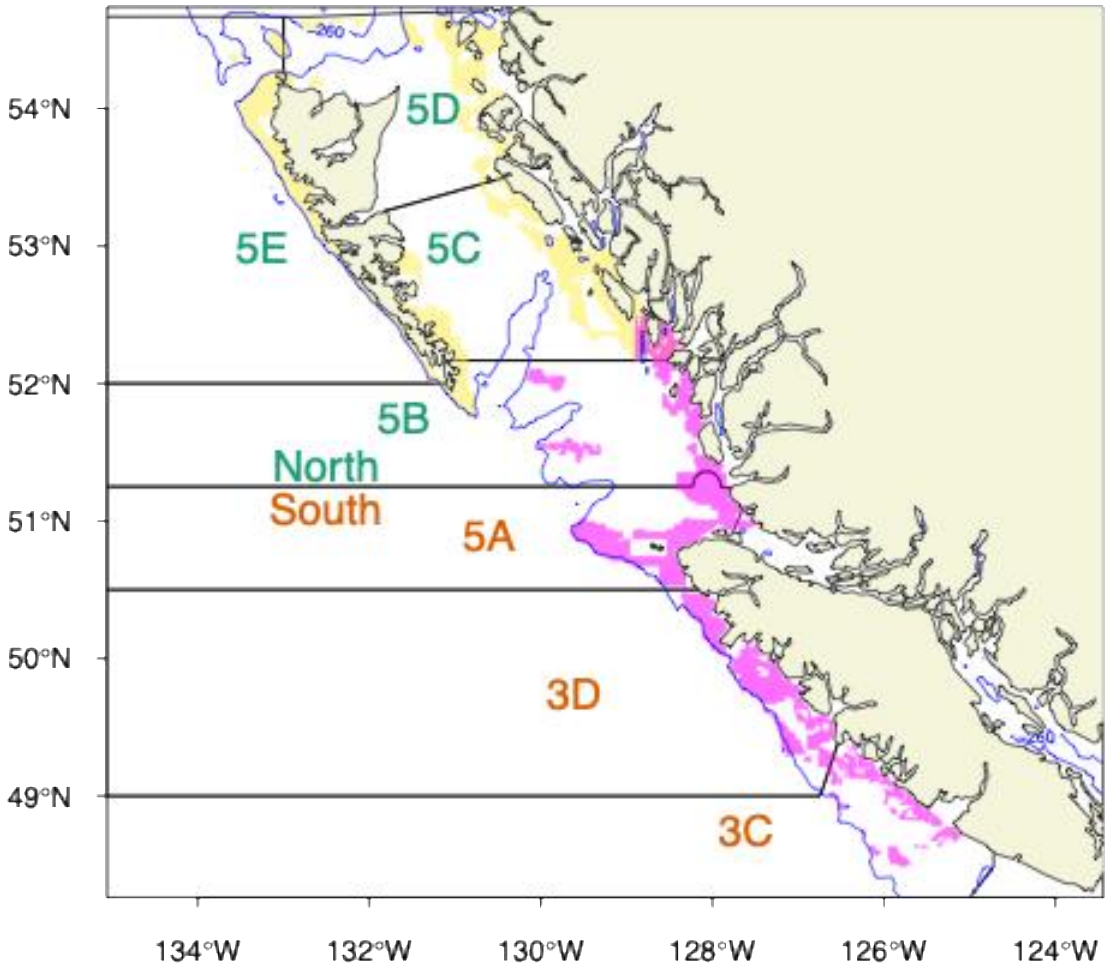

Figure 1. BC groundfish major management areas used to bound the Northern Outside Yelloweye subunit in areas 5BCDE (green) and the Southern Outside Yelloweye subunit in areas 3CD5A (orange). The HBLL northern survey grid (yellow) and southern survey grid (pink) are shown along with 260 m contour lines at the deep end of the depth range for Yelloweye habitats.

BASIS FOR ASSESSMENT

Assessment Details

Year Assessment Approach was Approved

2020

Assessment Type

Interim Year Update

Most Recent Assessment Date

1. Last Full Assessment: 2020, Cox et al. (2020)
2. Last Interim-Year Update: 2023, DFO (2023)

Assessment Approach

1. Broad category: MSE; OM update
2. Specific category: Statistical catch-at-age

Ecosystem and Climate Change Assessment Approach

A suite of environmental variables that were hypothesized to be important for OYE parturition and larval survival based on available information on spawn timing were considered as part of an environmental analysis. The potential effects of these variables on recruitment of OYE were evaluated utilizing univariate linear and quadratic regression models. No statistically significant associations were identified.

Operating Models

This Research Document describes the transition of the Outside Yelloweye Rockfish (*Sebastes ruberrimus*, OYE) operating model (OM) to a new modelling platform and data updates to 2024. The former includes a code transition for the 2018 OMs (Cox et al. 2020) from AD Model Builder (ADMB) to the Template Model Builder (TMB) platform.

Transition analyses confirm that the platform shift from assessCA (ADMB) to the SISCAY model (TMB) using the same likelihood formulations had little effect on key parameter and reference point estimates (<5%), ensuring consistency with previous OYE OMs. A new age composition likelihood (Francis 2014) methodology resulted in lower estimates of B_0 (8-16%), B_{MSY} (10-17%), and B2018 (37-45%), which were justified given the improved fits to age composition data.

Alternative OM scenarios that consider three main axes of uncertainty, including alternative catch time series, alternative model start dates (1918 or 1960), and prior assumptions about natural mortality were explored in detail during the 2018 OM development (Cox et al. 2020). Four representative OM scenarios including a 'most plausible' baseOM scenario and three alternatives were identified that captured the main properties of the larger suite of OMs. The models were weighted based on previously established criteria (Cox et al 2020), with a weighting of 50% for the baseOM and 16.67% for alternatives (OM2, OM3, OM4).

1. The baseOM scenario uses a 1918 start year, the reconstructed commercial catch data, and a normal prior on the aggregate-level natural mortality rate with mean M = 0.0345/yr and standard deviation σ_M = 0.01/yr.
2. The OM2 scenario uses a 1960 start year, the raw commercial catch data, and a normal prior on the aggregate-level natural mortality rate with mean M = 0.0345 and standard deviation σ_M = 0.01/yr.
3. The OM3 scenario uses a 1960 start year, the reconstructed commercial catch data, and a very informative normal prior on the aggregate-level natural mortality rate with mean M = 0.03 and standard deviation σ_M = 0.0001/yr.
4. The OM4 scenario uses a 1918 start year, the raw commercial catch data, and a normal prior on the aggregate-level natural mortality rate with mean M = 0.0345 and standard deviation σ_M = 0.01/yr.

Stock Structure Assumption

OYE represents a single genetic population and is treated as a single coastwide stock (excluding 4B), However, the stock is split into separate northern and southern subunits for assessment and management purposes. Different exploitation histories, abundances, and probable limited connectivity on short time-scales support this delineation.

Reference Points

- Limit Reference Point (LRP): $0.4B_{MSY}$
- Upper Stock Reference (USR): $0.8B_{MSY}$
- Removal Reference (RR): F_{MSY} (*F* that achieves Target Reference Point at equilibrium)
- Target Reference Point (TRP): B_{MSY}

Data

Data sources for stock assessment include historical catch, fishery-independent survey indices from the Hard-bottom longline survey (HBLL) and the International Pacific Halibut Commission (IPHC Fishery) -Independent Setline Survey (FISS), age-composition, and biological characteristics (maturity, length), summarized as:

- Catch (1918-2024):
    - Commercial: Hook & line, trawl
    - Recreational fishery
    - Reconstructed time series accounting for historical discards
- Survey indices (1998-2024):
    - HBLL North for 2006-2023 (biennial)
    - HBLL South for 2007-2024 (biennial)
    - IPHC FISS for 1998-2018
- Age composition (1986-2018):
    - HBLL North for 2006-2019
    - HBLL South for 2007-2018
    - IPHC FISS for 2003-2017
    - Commercial hook & line for 1986-2001
    - Trawl for 1999

ASSESSMENT

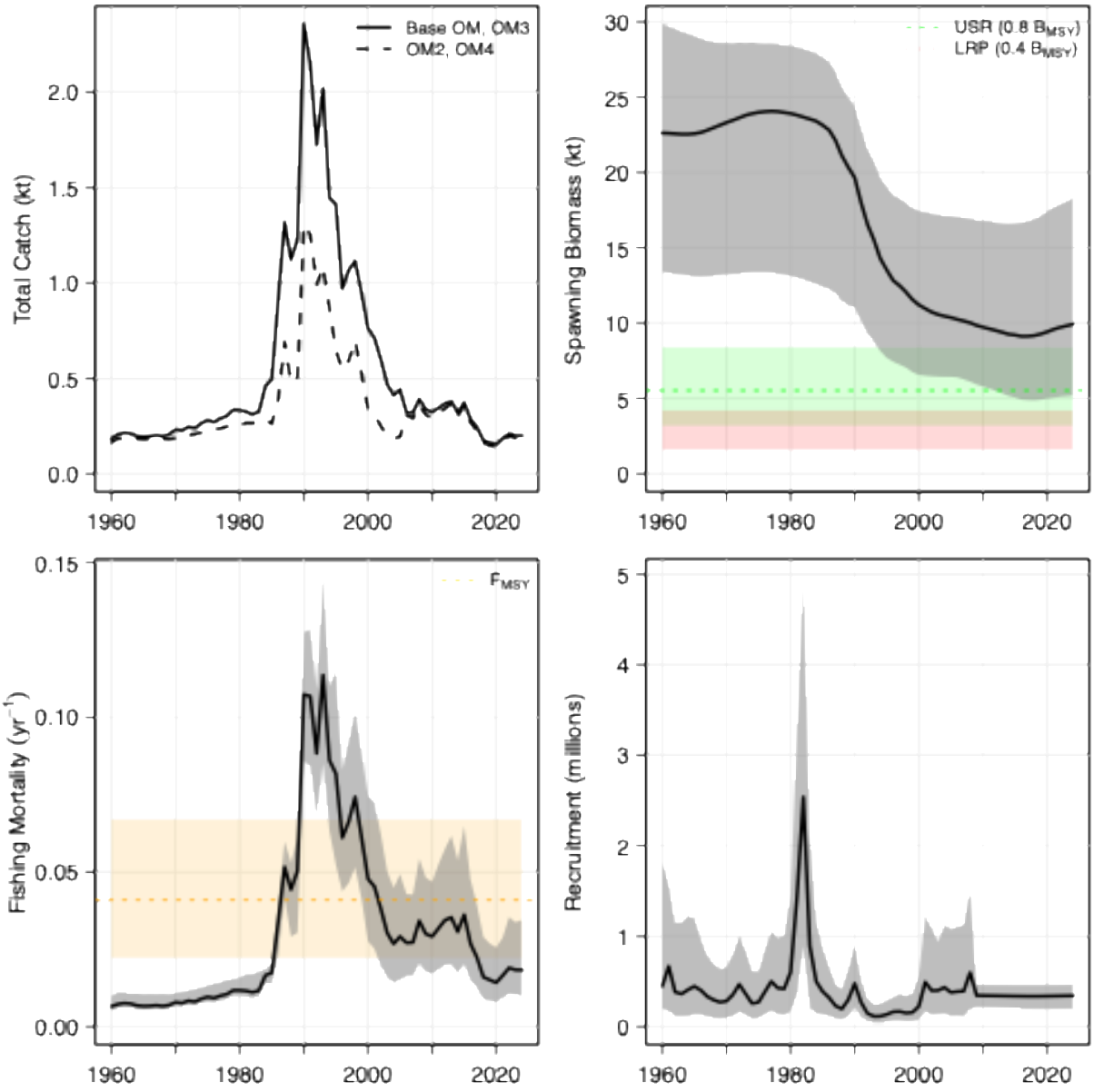

Figure 2. (upper left panel) ***Coastwide*** *total catch (kt) for operating model scenarios, (upper right panel) coastwide spawning biomass from 1960 to 2024 for weighted OM in relation to the Limit Reference Point (LRP, 0.4B_{MSY} pink dotted line) and Upper Stock Reference (USR, 0.8B_{MSY} green dotted line), (bottom left panel) coastwide fishing mortality for weighted OM in relation to the Removal Reference F_{MSY}, and (bottom right panel) coastwide age-1 recruitment (millions) for weighted OM.*

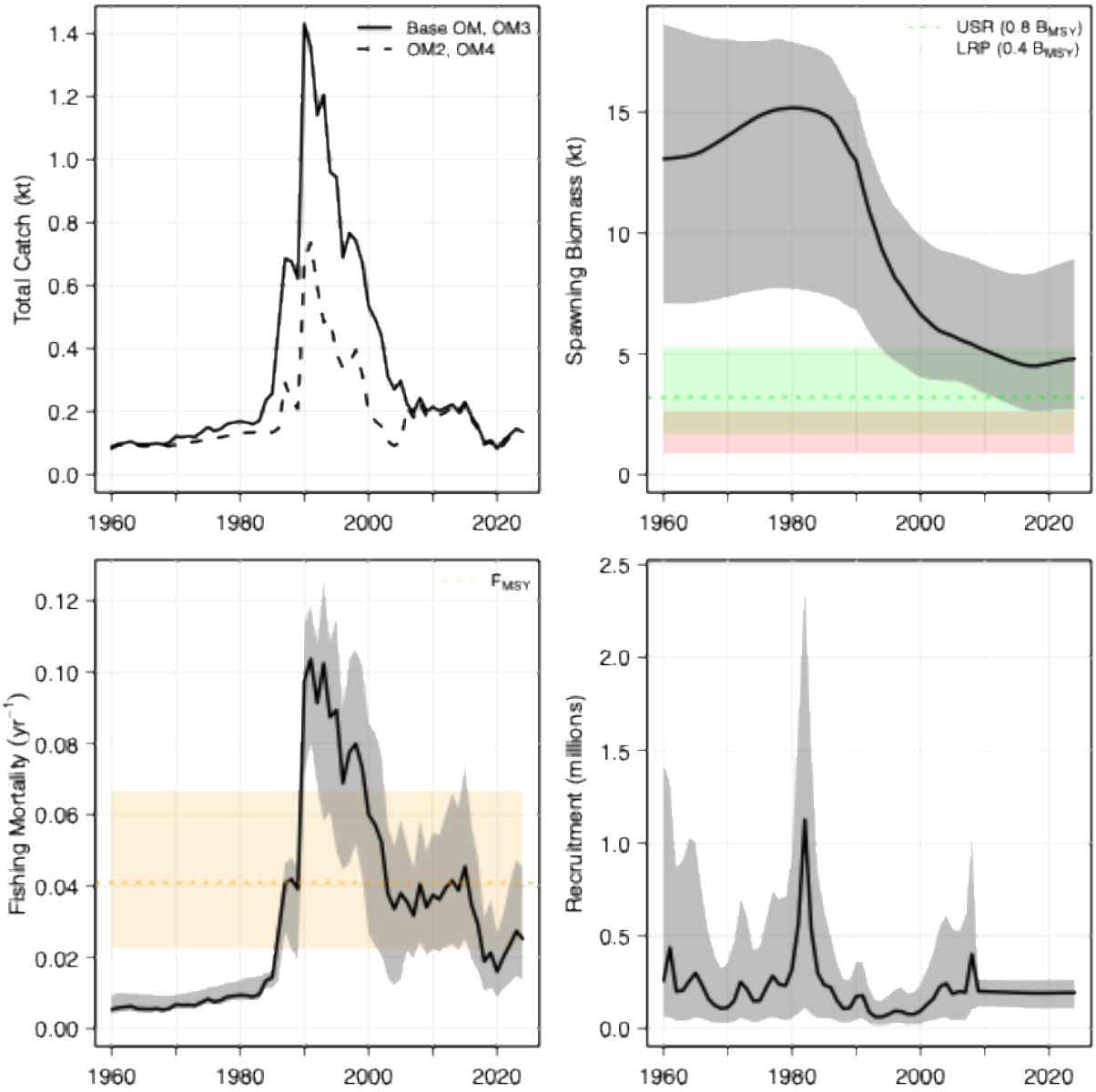

Figure 3. (upper left panel) ***Northern sub-unit*** *total catch (kt) for operating model scenarios, (upper right panel) northern sub-unit area spawning biomass from 1960 to 2024 for weighted OM in relation to the Limit Reference Point (LRP, 0.4B_{MSY}) and Upper Stock Reference (USR, 0.8B_{MSY}), (bottom left panel) northern sub-unit fishing mortality for the weighed OM in relation to the Removal Reference F_{MSY}, and (bottom right panel) northern sub-unit age-1 recruitment (millions) for weighted OM.*

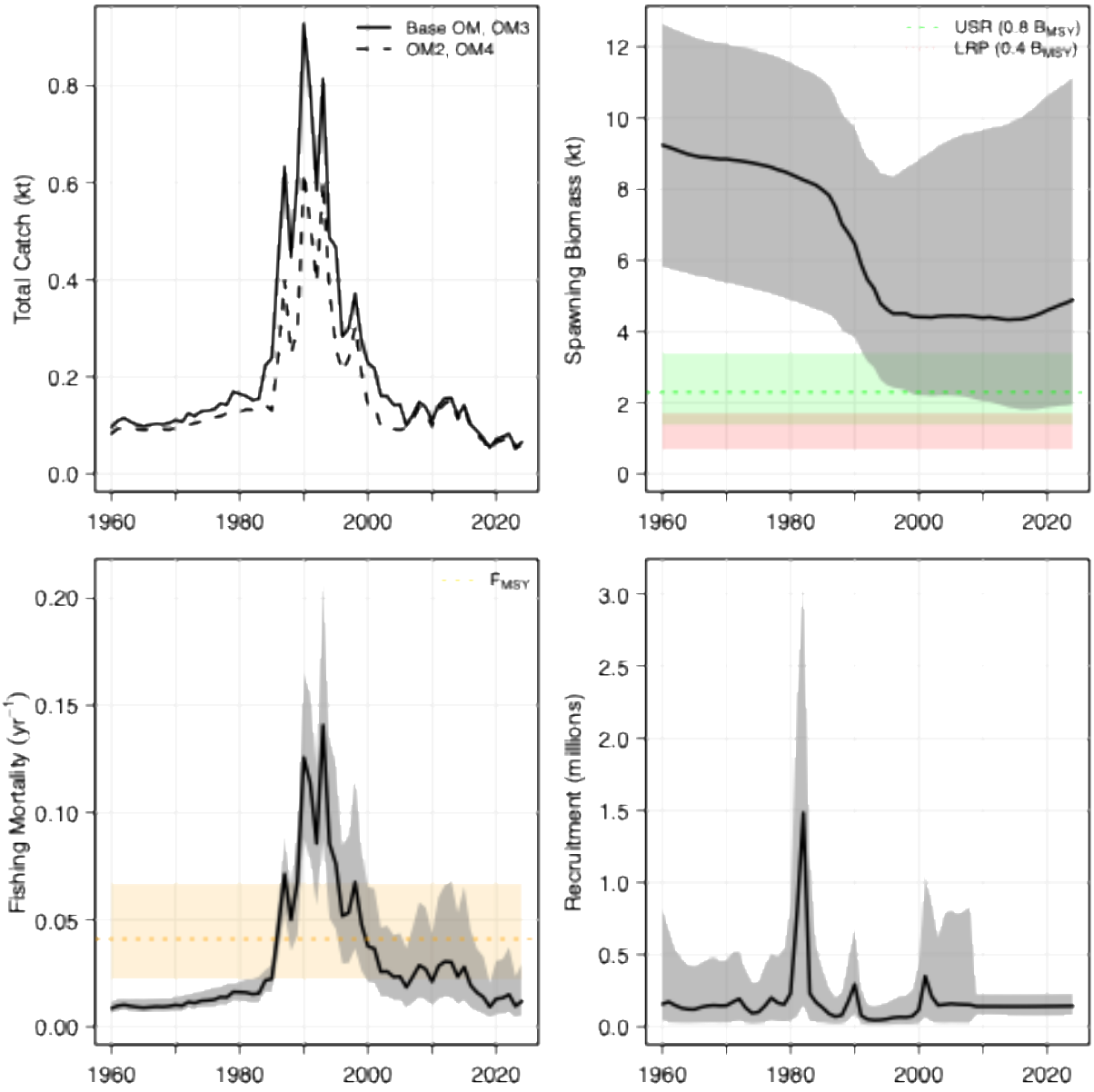

Figure 4. (upper left panel) ***Southern sub-unit*** *total catch (kt) for operating model scenarios, (upper right panel) southern sub-unit spawning biomass from 1960 to 2024 for weighted OM in relation to the Limit Reference Point (LRP, 0.4B_{MSY}) and Upper Stock Reference (USR, 0.8B_{MSY}), (bottom left panel) southern sub-unit fishing mortality for weighted OM in relation to the Removal Reference F_{MSY}, and (bottom right panel) southern sub-unit age-1 recruitment (millions) for weighted OM.*

Stock Status and Trends

Coastwide stock status estimates for the weighted OM in 2024 indicate the OYE stock is in the healthy zone with 96% probability of being above the Upper Stock Reference (USR) of 0.8B_{MSY} and >99% probability of being above the LRP of 0.4B_{MSY}. Coastwide spawning biomass in 2024 was estimated at 9.9 kt (95% CI: 5.2-18.3 kt), which is 1.48 times B_{MSY} (B_{2024}/B_{MSY} = 1.48; 95% CI: 0.75-2.54) and 0.45 times B_0 (B2024/B0 = 0.45; 95% CI: 0.27-0.67).

Variation among operating models in current stock status reflects the underlying uncertainty in historical catch reconstruction, productivity, natural mortality, and observation error. The baseOM and OM4 (which use the longer time series starting in 1918) estimate higher relative stock status compared to OM2 and OM3 (which start in 1960), though all models indicate the stock is currently above the LRP with >99% probability.

Current Status

Coastwide estimated spawning biomass (SSB) is in the Healthy Zone of the Precautionary Approach (PA) Framework with a 96% probability of being above the Upper Stock Reference of $0.8*B_{MSY}$. SSB is estimated to be 9,900 tonnes (95% Confidence Interval: 5,200 – 18,300). SSB_{2024}/B_{MSY} = 1.48 (95% Confidence Interval: 0.75 – 2.54).

Table 1. Median posterior biological parameter and management reference point values with 95% CIs for four OYE operating models and weighted values. Spawning Biomass at MSY (B_{MSY}) and MSY units in kt.

	Reference Points				Current Status			
OM	B_{MSY}	LRP	F_{MSY}	MSY	B_{2024}/B_0	B_{2024}/B_{MSY}	P (B_{2024} > LRP)	P (B_{2024} > USR)
baseOM	7.3 (5.5 - 9.8)	2.9 (2.2 - 3.9)	0.0427 (0.025 - 0.068)	0.344 (0.246 - 0.451)	0.48 (0.32 - 0.69)	1.61 (0.99 - 2.61)	1	0.99
OM2	5.7 (4.2 - 7.6)	2.3 (1.7 - 3.1)	0.0399 (0.02 - 0.068)	0.242 (0.157 - 0.328)	0.4 (0.27 - 0.61)	1.28 (0.73 - 2.28)	1	0.95
OM3	8.9 (6.7 - 11.5)	3.5 (2.7 - 4.6)	0.0366 (0.02 - 0.058)	0.349 (0.238 - 0.441)	0.35 (0.23 - 0.54)	1.13 (0.6 - 1.93)	1	0.86
OM4	4.7 (3.4 - 6.3)	1.9 (1.4 - 2.5)	0.042 (0.023 - 0.068)	0.212 (0.146 - 0.275)	0.47 (0.34 - 0.67)	1.58 (0.96 - 2.54)	1	1
wtd	6.9 (4 – 10.5)	2.8 (1.6 - 4.2)	0.041 (0.022 - 0.067)	0.313 (0.171 - 0.439)	0.45 (0.27 - 0.67)	1.48 (0.75 - 2.54)	1	0.96

History of OYE Stock Assessment and Management Strategy Evaluation

OYE populations in British Columbia were designated as threatened by COSEWIC in 2008 due to significant population declines attributed to overfishing in the latter half of the 20th century (Yamanaka and Logan 2010). The 2014 stock assessment (Yamanaka et al. 2018), using a Schaefer surplus production model, indicated that OYE stocks were in the Critical Zone under DFO's Sustainable Fisheries Framework, triggering the development of a rebuilding plan as required under the Department's Precautionary Policy. Fisheries and Oceans Canada (DFO), in collaboration with the Pacific Halibut Management Association (PHMA), began the OYE MSE process in 2019–2020 (Cox et al. 2020), which focused heavily on the development of new age-structured operating models (OMs) to represent alternative hypotheses about OYE population dynamics and fisheries. The OMs incorporated data up to 2018 (Cox et al. 2020), with four scenarios to account for major structural uncertainties:

1. model start date (1918 vs. 1960);
2. alternative historical catch data series (reconstructions vs. raw data inputs); and
3. natural mortality assumptions.

Results from the 2018 OM indicated that OYE stocks were above the LRP of 0.4 B_{MSY} with high probability and that a rebuilding plan was no longer needed.

Ecosystem and Climate Change Considerations

The potential effects of a variety of environmental indices on recruitment of Outside Yelloweye Rockfish were evaluated using univariate linear and quadratic regressions. No identifiable associations were found, but future work on this is recommended. Given the lack of a clear or strong relationship linking environmental conditions to recruitment, there is no basis for

incorporating climate-change considerations into management advice for OYE at this time. Tactical decision-making that includes climate change considerations should be simulation-tested consistent with the MSE-approach that OYE management falls under. If pursued, investigating the ecosystem and climate change effects should be addressed by including additional OMs that test for an effect on a key stock assessment parameter, such as recruitment, natural mortality, or individual growth, as advised by a Technical Working Group.

Stock Advice

Harvest advice, which is not within scope for this process, will be provided for the 2027/28 and 2028/29 fishing seasons using the current management procedure (HBLL 3YR), described in DFO (2023).

Harvest Decision Rule

A hockey stick harvest control rule is in effect, with different control points for the northern and southern subunits. Above the upper control point, the target fishing rate F_{ref} is 0.0343 and 0.0355 for the north and south, respectively. The fishing rate declines linearly between the upper control point and lower control point, and drops to 0 below the lower control point. The lower and upper control points are 1,600 tonnes and 3,200 tonnes for the northern subunit, and 1,200 tonnes and 2,400 tonnes for the southern subunit.

Exceptional Circumstances

Exceptional circumstances that warrant interim OM or MP re-evaluation should be triggered when HBLL survey indices or annual catch levels fall outside the 95% projection envelopes from MSE simulations.

PROCEDURE FOR INTERIM-YEAR UPDATES

Evaluation of Assessment Triggers

Formal stock assessments are recommended every six years, or sooner if exceptional circumstance are triggered. Abundance trends and potential triggers during intervening years should be tracked using the model-based coast-wide index presented annually in the groundfish synopsis report (Anderson et al. 2025). Potential trigger situations should be brought forward for discussion regarding an early re-assessment. The annual State of the Pacific Ocean report is an additional resource that could be helpful in viewing the coastwide geostatistical index in relation to the stock assessment estimates (Boldt et al, 2025).

OTHER MANAGEMENT QUESTIONS

The COSEWIC A criterion of probability of decline over 3 generations for the coastwide OYE spawning biomass is also assessed with the OMs. The weighted coastwide OYE spawning biomass (B_{2024}) had a 6%, 71%, and 99% probability of having declined ≥70% (Endangered), ≥50% (Threatened), and ≥30% (Special Concern), respectively, relative to unfished spawning biomass (B_0) over the 1960-2024 period.

SOURCES OF UNCERTAINTY

The following represent key sources of uncertainty captured by the OYE ensemble operating model and posterior distributions

- Parameter estimation for mortality and steepness
- Historical catch uncertainty
- Observation uncertainty in the data

While the updated OMs incorporate the best available data, several data limitations remain, including:

- Major spatial and temporal gaps in commercial longline age composition data
- Lack of recreational age composition data, which forces the use of *a priori* selectivity assumptions
- Yelloweye are not well-selected by surveys that don't recruit fish until approximately age 15 years, which leaves a large delay in detecting possible recruitment changes
- Additionally, the two-area OM and MP simplify potentially complex spatial population structure, which may not provide the spatial resolution needed for all future management advice.

The following questions warrant further investigation that may be addressed in future research:

- Observed differences between commercial fishery CPUE and survey CPUE
- Design considerations for HBLL surveys (e.g., timing and overlap)

Research Recommendations

The research priorities below aim to address key uncertainties and improvements to the OYE stock assessment and management system.

Short-Term Science Priorities

- Evaluate utility of spatial-temporal models for survey indices
- Optimize age sampling design
- Refine HBLL survey design and stratification for improved abundance indices
- Compare abundance trends from commercial and survey CPUE

Long-Term Science Priorities

- Investigate new strategies to reduce OYE bycatch
- Evaluate the impact of large-scale marine spatial planning on the OYE assessment and management.

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SOURCES OF INFORMATION

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