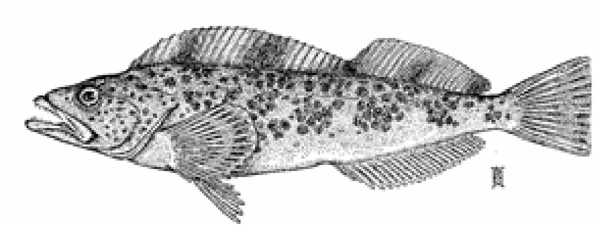
Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Pacific Region

Canadian Science Advisory Secretariat
Science Advisory Report 2015/014

STOCK ASSESSMENT FOR LINGCOD *(OPHIODON ELONGATUS)* FOR THE STRAIT OF GEORGIA, BRITISH COLUMBIA IN 2014



Lingcod (Ophiodon elongatus).
Credit: Image from Hart, J.L. 1973. Pacific Fishes of Canada. Fish. Res. Bd. Can. Bull. 180. 740 p.

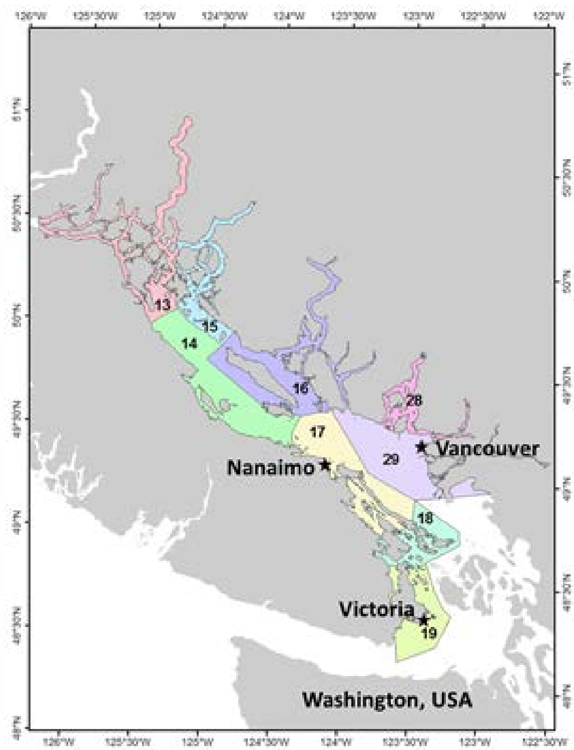


Figure 1. Minor Statistical Areas within Major Area 4B used to define the Strait of Georgia Lingcod stock for this assessment.

Context

Lingcod (Ophiodon elongatus) are an important component of First Nations, commercial, and recreational fisheries off British Columbia, Canada. This assessment provides stock status for the inside Lingcod stock in the Strait of Georgia (Figure 1). Fisheries Management Branch has requested that stock status for Strait of Georgia Lingcod be assessed relative to reference points that are consistent with the Fishery Decision-making Framework Incorporating the Precautionary Approach (DFO 2009). This advice will allow managers to evaluate whether the current management regime has been successful at increasing abundance. Updated harvest advice for the inside Lingcod stock has not been requested at this time.

This Science Advisory Report is from the December 10-11, 2014 Lingcod Assessment (Ophiodon elongatus) for the Strait of Georgia (Area 4B), British Columbia in 2014. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- Lingcod (*Ophiodon elongatus*) are an important component of both the commercial and recreational groundfish fisheries off British Columbia, Canada. This stock assessment updates stock status for the inside stock in the Strait of Georgia, British Columbia.
- Large estimated declines in Strait of Georgia Lingcod abundance between 1927 and the late 1980s led to the closure of Lingcod retention by commercial fisheries in this area starting in 1990, and subsequently by the recreational fishery in 2002. Since 2006, a limited recreational fishery has been permitted in some areas of the Strait of Georgia.
- This assessment updates the 2005 assessment framework developed for Strait of Georgia Lingcod with new data, and characterizes how stock status has changed since the current management regime was introduced in 2006. In addition, spawning biomass levels in 2014 are compared to biomass-based reference points.
- A two-sex statistical catch-at-age model in a Bayesian estimation framework was used. The model was fit to catch data and two indices of abundance, based on fishery catch-per-unit effort. Age composition data was insufficient for model fitting.
- Nine stock assessment scenarios were used to characterize a range of stock status estimates in 2014. The scenarios differed in: (i) their treatment of historic catch, (ii) assumptions about density-dependent mortality and density-dependent catchability relationships, and (iii) the natural mortality rate M.
- For each scenario, two sets of reference points were used to characterize stock status: the reference points developed by the 2005 Lingcod Management Framework Committee, which are relative to unfished spawning biomass, B_0, and provisional reference points identified by the more recent DFO Decision-making Framework Incorporating the Precautionary Approach (DFO PA Framework), which are relative to the level of spawning biomass associated with maximum sustainable yield, B_{MSY}.
- In all scenarios, spawning biomass in 2014 was predicted with 100% certainty to be greater than spawning biomass at the start of the current management regime in 2006. However, current stock status relative to reference points was dependent on both the treatment of historical catch from the Dominion Bureau of Statistics' District 1 (1927-1946) and the assumption made about density-dependent catchability.
- When the 2005 Lingcod Management Framework reference points were used to classify stock status, two of nine scenarios estimated that B_{2014} was most likely above the short-term recovery target of $0.25B_0$ but below the long-term recovery target of $0.40B_0$, while the remaining seven scenarios estimated that B_{2014} was most likely above the limit reference point of $0.10B_0$, but below $0.25B_0$. A model-averaging approach to status estimation, in which the Bayesian posterior distributions from all nine scenarios were combined with equal weights, estimated that B_{2014} had a 71% probability of being between the limit reference point ($0.10B_0$) and the short-term recovery target ($0.25B_0$). .
- When the DFO PA Framework reference points were used to classify stock status, six of nine scenarios estimated that B_{2014} was most likely in the cautious zone (between $0.4B_{\mathrm{MSY}}$ and $0.8B_{\mathrm{MSY}}$), while the remaining three scenarios estimated that B_{2014} was most likely in the critical zone (below $0.4B_{\mathrm{MSY}}$). The model-averaging approach estimated that B_{2014} had a 58% probability of being in the cautious zone, a 37% probability of being in the critical zone, and a 5% probability of being in the healthy zone (above $0.8B_{\mathrm{MSY}}$).
- No harvest advice was requested.

INTRODUCTION

Lingcod are unique to the west coast of North America, with a range extending from Baja, California to the Shumagin Islands, Alaska. Adults typically inhabit nearshore waters. They can occur at depths ranging up to 450 m; however, they are most often found in rocky habitats between 10 to 100 m, especially during spawning season. Lingcod are one of the few marine fish species in Canada that exhibit parental care for incubating eggs.

Commercial fishing for Lingcod in British Columbia began in about 1860 and catches in the Strait of Georgia reached a historic high level in the 1930s and 1940s (Figure 2). Overall the hook and line fishery accounted for over 80% of the commercial catch, averaging 2800 tonnes in the 1930s and 1940s. Hook and line catch declined through to the early 1980s when it reached an average of 280 tonnes, a decline of about 90% from catches in the mid-1940s. During the 1930s, trawlers began fishing for Lingcod and use of this gear increased during World War II. In 1947, large areas of the Strait of Georgia were closed to trawling due to concerns about conflicts with hook and line fisheries; however, by 1955 most grounds were reopened to the trawl fishery. Anecdotal information prior to 1954, and and catch records between 1954 and 1989, show that the proportion of lingcod caught by trawl fisheries in the Strait of Georgia has remained less than 20%, and has often been less than 10%.

The commercial Lingcod fishery has been subject to a variety of management measures including size limits and seasonal closures starting as early as 1931 to protect spawning individuals. Since 1990, the retention of Lingcod by the commercial fishery has been prohibited due to conservation concerns.

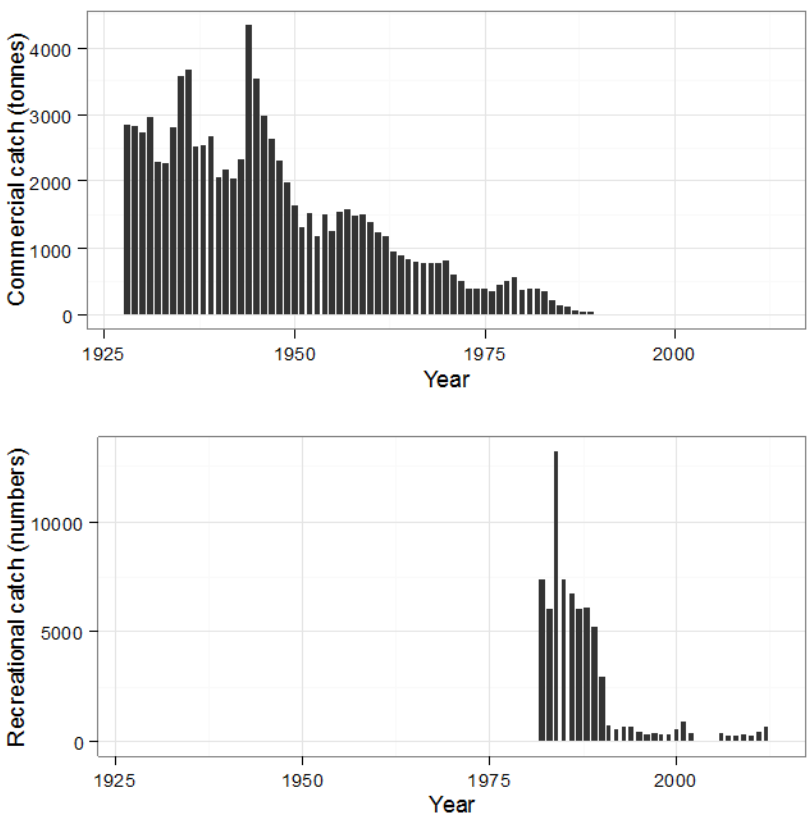


Figure 2. Available catch data from directed Lingcod commercial (hook & line and trawl gear combined) and recreational fisheries in the Strait of Georgia (defined as minor Statistical Areas 13-19, 28, 29).

Recreational fisheries in the Strait of Georgia underwent a rapid expansion in the 1960s and, as the commercial catch declined in the 1980s, the recreational fishery accounted for a relatively large proportion (approximately 35%) of Lingcod landed (Figure 2). However, Lingcod have typically been a small component in the recreational catch of all species; the fishery has historically focused on Coho (*Oncorhynchus kisutch*) and Chinook (*O. tshawytscha*) salmon. Lingcod accounted for about 7% of the recreational catch in the 1980s, and only 1.5% in the 1990s as a result of increased restrictions on Lingcod retention.

The recreational fishery has undergone various changes in the timing of seasonal openings, bag limits and minimum size limits since the 1980s. Due to conservation concerns the recreational fishery was closed to the retention of Lingcod between 2002 and 2006.

Strait of Georgia Lingcod were last assessed in 2005, at which time both the stock assessment and the development of management advice were overseen by a Lingcod Management Framework Committee (LMFC) that included stakeholder representatives. That assessment showed increased Lingcod abundance since the commercial closure in 1990 and provided advice that allowed the opening of limited recreational fishing opportunities in minor statistical areas 13-19 starting in 2006. The LMFC provided several recommendations for recreational fishery management, including a total annual harvest of 5000 – 7000 pieces in minor Statistical Area 13-19, a minimum size limit of 65 cm, a limited fishing season of June to September, a daily limit of one Lingcod per person, an annual limit of ten Lingcod per person, and no retention of Lingcod in minor Statistical Areas 28 and 29 (DFO 2005; Logan et al. 2005). Management decisions for Strait of Georgia Lingcod between 2006 and 2013 have closely followed the advice of the LMFC, with the exception of a brief decrease in the size limit to 60 cm during 2008 and 2009, and the fishing season starting in May since 2009. Minor Statistical Areas 28 and 29 have remained closed to Lingcod retention since 2002.

This assessment updates stock status advice for the inside Lingcod stock in the Strait of Georgia, British Columbia, which is defined as Minor Statistical Areas 13-19, 28 and 29 within Major Statistical Area 4B (Figure 1). Harvest advice has not been requested at this time. Instead, this assessment focuses on characterizing how stock status has changed since the current management regime was introduced in 2006, as well as how current spawning biomass compares to biomass-based reference points.

ASSESSMENT

Methods

A two-sex statistical catch-at-age model in a Bayesian estimation framework was used to assess Strait of Georgia Lingcod abundance. Bayesian estimation was done using the Markov Chain Monte Carlo (MCMC) method. The model was fit to catch data and two indices of abundance based on fishery catch-per-unit effort (CPUE). No age composition data were used to fit the model, although cohorts were tracked through time through the structural dynamics of the model. Several of the data inputs and model assumptions used to model Strait of Georgia Lingcod in 2005 were incorporated into the current assessment in order to maintain consistency between assessments.

Catch data include commercial catch data (in biomass) from the hook and line and trawl fisheries combined and recreational catch data (in numbers). Discard mortality was not estimated and all released Lingcod are therefore assumed to survive. Similar to 2005, catch reported by the nine statistical areas were grouped into four quadrants (northwest, northeast, southwest and southeast) for use in scenarios where catch was removed or adjusted in the southeast quadrant to deal with uncertainty in historical (1927-1946) commercial landings in this area.

Lingcod abundance from fishery-independent surveys is limited and, as a result, the two abundance indices used in this assessment are based on the commercial hook and line fishery and recreational fishery catch-per-unit effort (CPUE).

Estimated model parameters included unfished equilibrium recruitment of age-1 fish (R_0), steepness for the Ricker stock recruitment curve (*h*), average recruitment ($\bar{R}$), a vector of instantaneous fishing mortality rates for each catch observation, annual log recruitment deviations from the underlying stock recruitment model, and a precision parameter that is the inverse of total variance. All estimated parameters had uninformative prior distributions. Fixed model parameters included natural mortality (*M*), fishery-specific selectivity parameters, and a parameter ρ that described the proportion of total variance attributed to observation error (where, $1 - \rho$ represents the portion of total variance attributed to process error in recruitment). Length-at-age, weight-at-length, and proportion mature-at-age were also input to the model as fixed values that were held constant over time.

Assessment Scenarios

Nine stock assessment scenarios are used to characterize a range of stock status estimates in 2014. The scenarios differ in: (i) their treatment of historic catch, (ii) assumptions about density-dependent mortality and density-dependent catchability relationships, and (iii) the natural mortality rate *M* (Table 1). All scenarios are weighted equally when characterizing stock status. A scenario-averaging approach, in which estimated Bayesian posterior distributions from all nine scenarios are combined with equal weights, is used to represent structural uncertainty across all scenarios.

Scenarios about the treatment of historic catch arise from uncertainty in the accuracy of District 1 catch values recorded by the Dominion Bureau of Statistics between 1927 and 1946 that have previously been documented for both Lingcod and rockfish species in the Strait of Georgia (Logan et al. 2005). The boundaries of District 1 approximate Pacific Fishery Management Council PFMC Areas 28 and 29 (Figure 1) and are captured by the southeast (SE) quadrant applied in the 2005 stock assessment (Logan et al., 2005). Hypotheses about potential discrepancies in District 1 Lingcod catch include the possibilities that (i) Lingcod were caught outside of District 1 but landed in District 1, or (ii) that Lingcod were caught outside of District 1, recorded in their District of capture, and then subsequently landed and recorded again in District 1 at the port of Vancouver. Three “District 1 catch scenarios” were used to bracket a range of uncertainty around historical District 1 catches between 1927 and 1946 (i) onlySEpre1947: exclude all catch not from Southeast quadrant prior to 1947, (ii) noSEpre1947: exclude all catch from Southeast quadrant prior to 1947, and (iii) SoG: use all catch data as recorded from the entire Strait of Georgia. In the 2005 stock assessment (Logan et al., 2005), uncertainty in the accuracy of District 1 catch values were addressed with a scenario that excluded the SE quadrat from the complete time series, with no harvest advice provided for those corresponding Minor Areas (28 and 29). That scenario is not included in these analyses.

Two different options for including density-dependent effects were considered within the nine scenarios. In the first option, both density-dependent *M* and density-dependent catchability were assumed to exist. In the second option, neither of these effects were included. Density-dependent *M* and density-dependent catchability relationships were specified in the same manner as was done for the 2005 assessment (Logan et al. 2005).

Two different options for the assumed rate of natural mortality, *M*, were also considered: *M* = 0.2 and *M* = 0.3.

Table 1. Description of stock assessment scenarios used to explore uncertainties in stock status in 2014.

Scenario ID	Approach to District 1 Catch	DD M?	DD q?	M
onlySEpre1947	Only SE catch < 1947	Yes	Yes	0.2
onlySEpre1947_noDD	Only SE catch < 1947	No	No	0.2
onlySEpre1947_noDD +highM	Only SE catch < 1947	No	No	0.3
noSEpre1947	Exclude SE catch < 1947	Yes	Yes	0.2
noSEpre1947_noDD	Exclude SE catch < 1947	No	No	0.2
noSEpre1947_noDD +highM	Exclude SE catch < 1947	No	No	0.3
SoG	Use all catch as recorded	Yes	Yes	0.2
SoG_noDD	Use all catch as recorded	No	No	0.2
SoG_noDD +highM	Use all catch as recorded	No	No	0.3

Results

All scenarios showed a similar spawning biomass trajectory since 1927, with a large decline in spawning biomass between 1927 and the late 1980s, followed by a gradual increase between the 1990s and 2014 (Figure 3). The relative magnitude of the recent increase is highly dependent on both the approach taken to deal with the uncertainty in historical catch and the inclusion of density-dependent catchability relationships. Scenarios with the highest catch between 1927 and 1946 (e.g., the SoG catch scenarios) estimated higher B_0 values and lower ratios of B_{2014} / B_0 compared to those with the lowest historical catches during this period (the noSEpre1947 scenarios) (Figure 3, panel a).

In the most optimistic scenario considered, the “noSEpre1947_noDD” scenario, the median posterior estimate of B_{2014} / B_0 was 0.306, while that of the lowest predicted year, 1989, was 0.069, indicating that spawning biomass has increased from 6.9% of B_0 in 1988 to 30.6% of B_0 in 2014 (Figure 3, panel b). In the most pessimistic scenario, the “SoG” scenario, the median posterior estimate of B_{2014} / B_0 was 0.138 while that of the lowest predicted year, 1989, was 0.057. In the scenario-average case, the combined posterior median estimate of B_{2014} / B_0 was 0.212 while that of 1989 was 0.060.

Parameter estimates of steepness (*h)* and unfished equilibrium recruitment (R_0) were negatively confounded in MCMC chains for all scenarios. Estimated catchability coefficients for both the commercial and recreational CPUE series were confounded with each other, as well as with average recruitment ($\bar{R}$), *h*, and to a lesser extent, R_0. Model parameters were also highly confounded with derived estimates of reference point quantities. Estimates of R_0 showed a high positive correlation with B_0 and B_{MSY}, while estimates of steepness showed a high positive correlation with F_{MSY}.

Reference Points

For each scenario, two sets of reference points were used to characterize stock status: B_0-based reference points and B_{MSY}-based reference points. Both types of reference points were calculated from assessment model fits. The B_0-based reference points were developed by the LMFC in 2005 and approved by the 2005 groundfish Canadian Science Advice Pacific (CSAP) sub-committee (DFO 2005). They include: (i) a limit reference point below which fishing should not occur set at $0.1B_0$, (ii) a short-term recovery target below which the number of allowable removals was limited such that there was a <10% probability of future stock decline, set at $0.25B_0$, and (iii) a long-term target reference point at which the stock is considered rebuilt set at $0.4B_0$. The B_{MSY}-based reference points are consistent with the more recent provisional recommendations contained in the DFO Fishery Decision-making Framework Incorporating the

Precautionary Approach (DFO 2009), and include (i) a Limit Reference Point (LRP) set at $0.4B_{MSY}$, (ii) an Upper Stock Reference (USR) set at $0.8B_{MSY}$, and (iii) B_{MSY}.

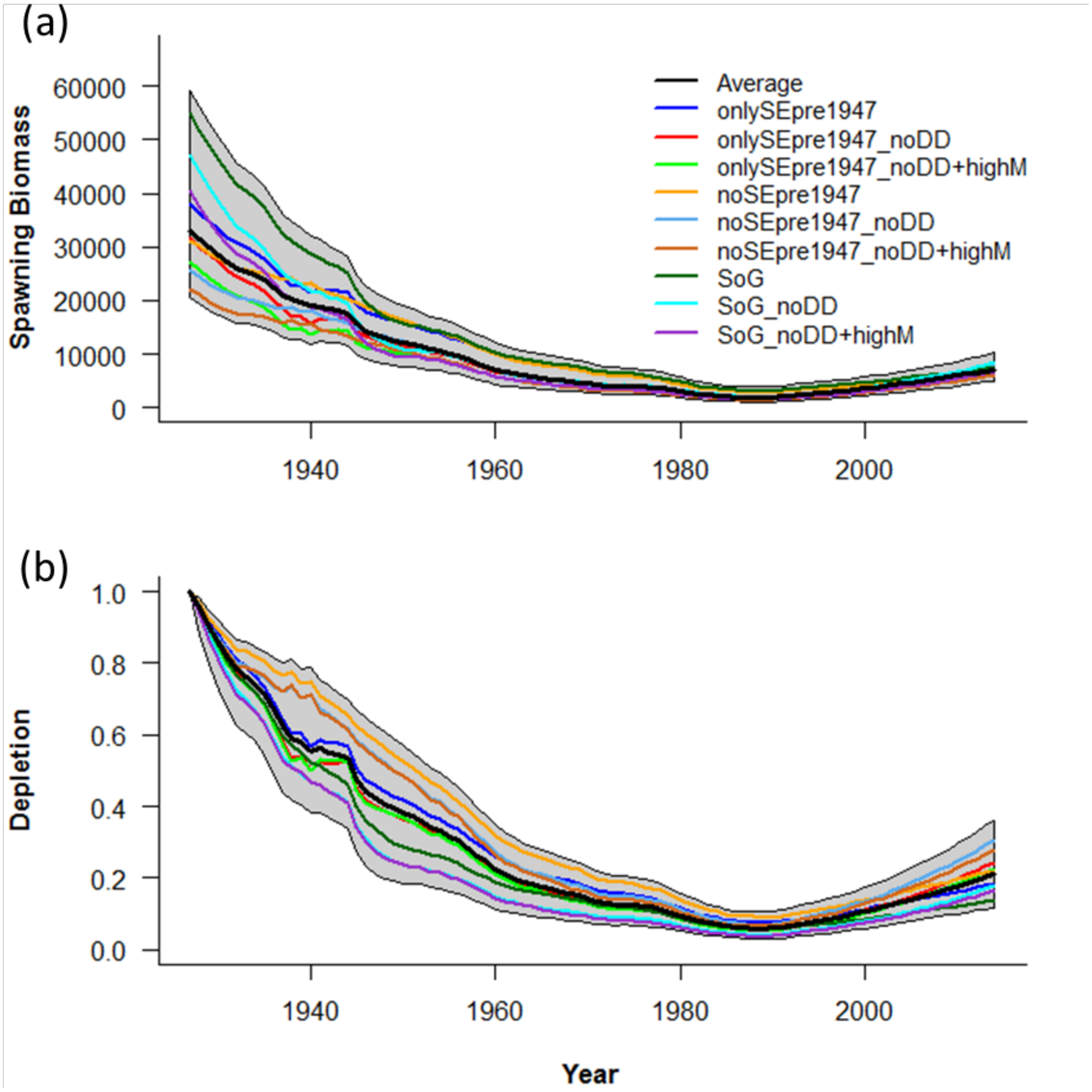


Figure 3. Panel a: Posterior median estimates of spawning biomass (in tonnes) over time for the scenario-averaging approach (solid black line). Grey shading shows the 5th and 95th percentiles of the scenario-averaged trajectory, while the multi-coloured solid lines show the posterior median estimates from each of the nine individual scenarios. Panel b: Posterior median estimates of depletion (B_{2014} / B_0) over time for the scenario-averaging approach (solid black line). Grey shading and multi-coloured lines are the same as panel a.

In all scenarios, spawning biomass in 2014 was predicted with 100% certainty to be greater than spawning biomass at the start of the current management regime in 2006. Estimates of current stock status relative to reference points were dependent on both the treatment of historical catch from the DBS District 1 (1927-1946) and the assumption made about density-dependent catchability.

When the 2005 Lingcod Management Framework reference points were used to classify stock status, two of nine scenarios estimated B_{2014} was most likely above the short-term recovery target of $0.25B_0$ but below the long-term recovery target of $0.40B_0$, while the remaining seven scenarios estimated that B_{2014} was most likely above the limit reference point of $0.10B_0$ but below $0.25B_0$ (Table 2, panel a of Figure 4). The scenario-averaging approach to status estimation predicted that B_{2014} had a 71% probability of being between the limit reference point ($0.10B_0$) and the short-term recovery target ($0.25B_0$).

When the DFO PA Framework reference points were used to classify stock status, six of nine scenarios estimated that B_{2014} was most likely in the cautious zone (between $0.4B_{\text{MSY}}$ and $0.8B_{\text{MSY}}$), while the remaining three scenarios predicted that B_{2014} was most likely in the critical zone (below $0.4B_{\text{MSY}}$; Table 2, panel b of Figure 4). The scenario-averaging approach to status estimation predicted that B_{2014} had a 58% probability of being in the cautious zone, a 37% probability of being in the critical zone, and a 5% probability of being in the healthy zone (above $0.8B_{\text{MSY}}$).

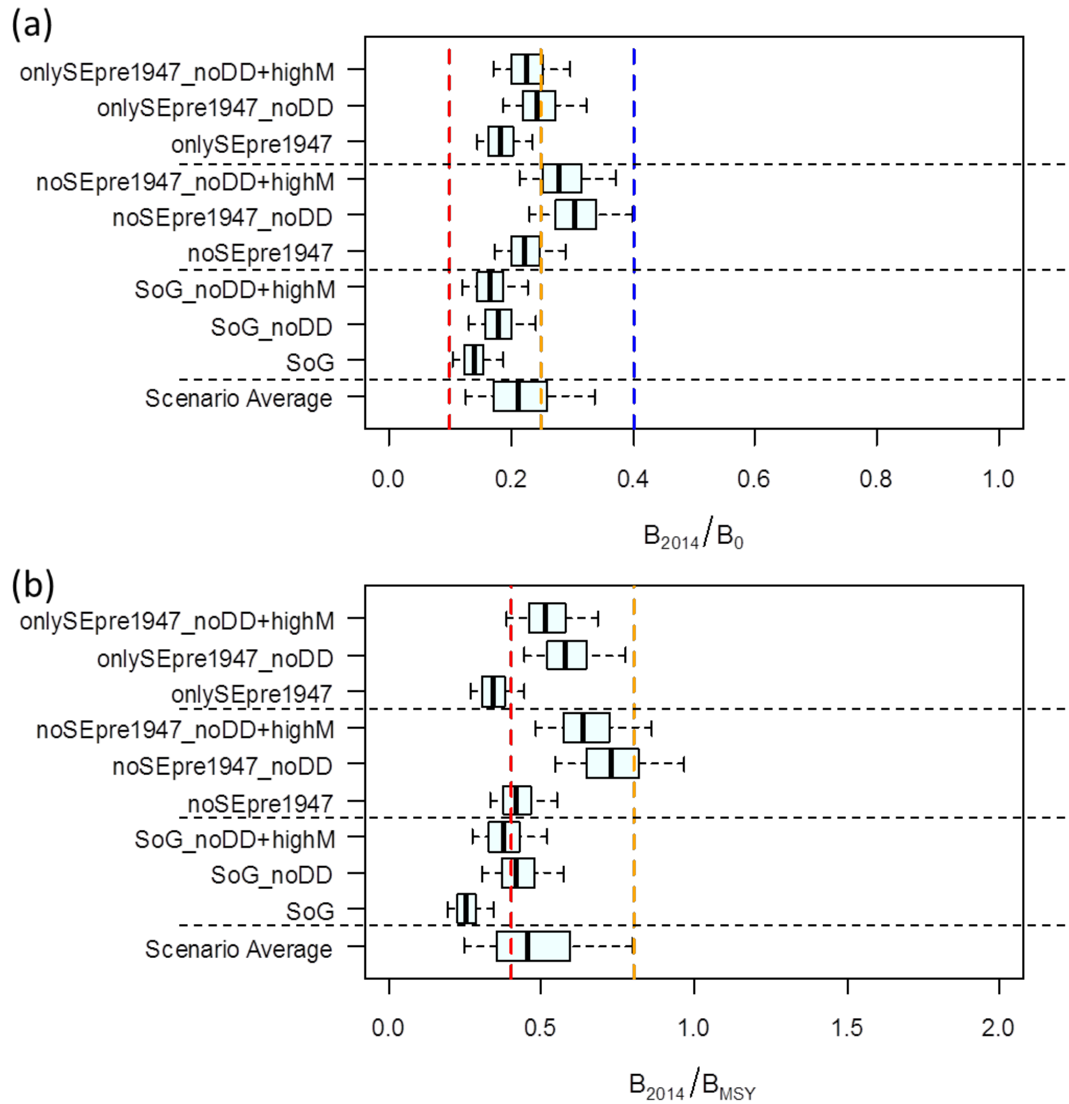


Figure 4. Panel a: Current stock status (represented as the ratio of B_{2014} to B_0) relative to the reference points recommended by the 2005 Lingcod Assessment and Management Framework for each of the nine assessment scenarios as well as the scenario-average case (red vertical dashed line = limit reference point of $0.1B_0$, orange vertical dashed line = short-term recovery target of $0.25B_0$, blue vertical dashed line = long-term recovery target of $0.4B_0$). Panel b: Current stock status (represented as the ratio of B_{2014} to B_{MSY}) relative to the provisional reference points recommended by the DFO PA Framework for each of the nine assessment scenarios as well as the scenario-average case (red vertical dashed line = limit reference point of $0.4B_{MSY}$, orange vertical dashed line = upper stock reference at $0.80B_{MSY}$). Boxplots show the 5, 25, 50, 75, and 95 percentiles from the MCMC results.

Sources of Uncertainty

Uncertainty in lead model parameters and derived management parameters was quantified in several ways. First, the sensitivity of the stock reconstruction to structural assumptions and data choices was examined by configuring the model into nine scenarios that bracketed a range of hypotheses about historical catch data, density-dependent catchability in CPUE series, and the rate of natural mortality. Second, the modelled uncertainty within a scenario was represented by using a MCMC approximation to the posterior probability density. Finally, a model-averaging approach in which MCMC posterior distributions from all nine scenarios were combined with equal weights was used to characterize stock status given structural uncertainty among scenarios. The list of uncertainties represented in the nine scenarios is not comprehensive however, so uncertainty is under-represented in this assessment.

The use of fishery CPUE to represent trends in abundance over time is a key source of uncertainty in this stock assessment. Fishery CPUE indices are prone to time-varying catchability, which can bias CPUE indices. Sources of time varying catchability for Lingcod fisheries in the Strait of Georgia include changes in fishery targeting behaviour over time for both commercial and recreational fisheries, changes in seasonal closures, size and bag limits, increased use of electronic downriggers in the recreational fishery, and the introduction of closed areas via Rockfish Conservation Areas. While some scenarios used in this assessment assumed that catchability was constant over time, others attempted to address the potential for time-varying catchability by modelling CPUE as a function of biomass (i.e., density-dependent catchability). Density-dependent catchability is just one mechanism by which catchability can change over time, however. Other forms of time-varying catchability were not considered. Given that recreational CPUE is the only source of information on recent abundance trends, the development of a fishery-independent abundance index for Strait of Georgia Lingcod is a high priority if estimates of current biomass are to be used as a basis of recommending total allowable catch in the future.

Another important source of uncertainty in this stock assessment is the assumption that all fishing mortality comes from landed catch in both commercial and recreational fisheries. In other words, all released Lingcod are assumed to survive. Release (or discard) mortality was not accounted for based on the lack of historical data on Lingcod discards prior to the 2000s, which is when the majority of Lingcod catch was taken. Future stock assessments for Strait of Georgia Lingcod should look for a method to incorporate discard mortality into catch data. Catch misreporting has also not been considered in this assessment.

Additional uncertainties that could affect Lingcod population dynamics, but that were not considered in this assessment, include increased predation on Lingcod over time by Pinniped populations and decreased food sources for juvenile Lingcod due to changes in productivity of the Strait of Georgia ecosystem. Life history relationships used as inputs to the assessment model have not been updated for several years, so changes in growth and maturity over time have not been examined in this assessment.

Estimates of B_0 and B_{MSY} used as a basis for defining reference points were derived from assessment model fits. Examination of MCMC chains showed that both of these reference point quantities were highly confounded with model parameters (e.g., steepness) as well as with each other. In addition, posterior median estimates of B_0 and B_{MSY}, as well as posterior median estimates of B_{2014}/B_0 and $B_{2014}/B_{\mathrm{MSY}}$, were dependent on uncertain assumptions made about density-dependent catchability and the rate of natural mortality. These observations suggest that estimates of B_0 and B_{MSY} used to define reference points are unreliable.

Ecosystem Considerations

Since 2002, the establishment of a network of Rockfish Conservation Areas (RCAs) in BC has limited the geographic extent of Lingcod fishing in the Strait of Georgia. Within Minor Areas 13-19, 28 and 29, 95 RCAs have been established. Fishing activities that encounter rockfish have been prohibited within these areas, including recreational and commercial hook and line fisheries.

Dramatic changes in the Strait of Georgia ecosystem have been documented, from physical forcing to lower trophic levels up through top predators. Studies have shown that changes in the timing of the spring freshet of the Fraser River have reduced copepod abundance, which is a prey item for planktonic and juvenile Lingcod. The abundance of Lingcod predators have also changed; marine mammals such as Harbour Seals (*Phoca vitulina*) are at historic high abundance in the Strait of Georgia (Olesiuk 2010) since visual surveys were initiated in the 1970s and Steller Sea Lions (*Eumetopias jubatus*) have exponentially increased in abundance in British Columbia (DFO 2010). These changes suggest that the population response of Lingcod in the Strait of Georgia to management measures is likely confounded by environmental drivers, which may affect the rate of rebuilding for this stock.

CONCLUSIONS AND ADVICE

All stock assessment scenarios estimate a continued recovery in Strait of Georgia spawning biomass to 2014 from historically low levels in the late 1980s. In all scenarios, spawning biomass in 2014 was estimated with 100% certainty to be greater than spawning biomass at the start of the current management regime in 2006.

When the 2005 Lingcod Management Framework reference points were used to classify stock status, two of nine scenarios estimated B_{2014} was most likely above the short-term recovery target of $0.25B_0$ but below the long-term recovery target of $0.40B_0$, while the remaining seven scenarios estimated that B_{2014} was most likely above the limit reference point of $0.10B_0$ but below $0.25B_0$ (Table 2) When the DFO PA Framework reference points were used to classify stock status, six of nine scenarios estimated that B_{2014} was most likely in the cautious zone (between $0.4B_{\text{MSY}}$ and $0.8B_{\text{MSY}}$), while the remaining three scenarios predicted that B_{2014} was most likely in the critical zone (below $0.4B_{\text{MSY}}$; Table 2).

Results from the model averaging approach, in which results from all nine scenarios were combined with equal weight to represent structural uncertainty among scenarios, showed that B_{2014} had a 71% probability of being above the limit of $0.10B_0$ but below the short-term recovery target of $0.25B_0$ (based on the 2005 Lingcod Management Framework reference points) and a 58% probability of being in the cautious zone (based on the PA Framework reference points).

Given the relatively data-poor nature of this stock, the scenario-based approach taken allows the representation of data and biological uncertainties. Future assessments that seek to provide harvest advice should continue to consider a model-averaging approach that incorporates large structural uncertainties into harvest advice.

Table 2. Characterization of stock status in 2014 for all nine stock assessment scenarios and the average of all scenarios. For each scenario (i.e., row) values are the probability that spawning biomass in 2014, B_{2014}, is greater than the reference point specified in the column header.

		2005 Management Framework			***DFO PA Framework***		
Scenario ID	$P(B_{2014} > B_{2006})$	$P(B_{2014} > 0.10B_0)$	$P(B_{2014} > 0.25B_0)$	$P(B_{2014} > 0.40B_0)$	$P(B_{2014} > 0.40B_{MSY})$	$P(B_{2014} > 0.80B_{MSY})$	$P(B_{2014} > B_{MSY})$
onlySEpre1947	1.00	1.00	0.03	0.00	0.16	0.00	0.00
onlySEpre1947_noDD	1.00	1.00	0.45	0.00	0.99	0.04	0.00
onlySEpre1947_noDD +highM	1.00	1.00	0.26	0.00	0.92	0.01	0.00
noSEpre1947	1.00	1.00	0.21	0.00	0.62	0.00	0.00
noSEpre1947_noDD	1.00	1.00	0.89	0.05	1.00	0.29	0.03
noSEpre1947_noDD +highM	1.00	1.00	0.75	0.02	1.00	0.10	0.01
SoG	1.00	0.97	0.00	0.00	0.01	0.00	0.00
SoG_noDD	1.00	1.00	0.03	0.00	0.60	0.00	0.00
SoG_noDD +highM	1.00	0.99	0.01	0.00	0.36	0.00	0.00
Scenario Average	1.00	1.00	0.29	0.01	0.63	0.05	0.00

SOURCES OF INFORMATION

This Science Advisory Report is from the December 10-11, 2014 Lingcod Assessment (*Ophiodon elongatus*) for the Strait of Georgia (Area 4B), British Columbia in 2014. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

DFO. 2005. Strait of Georgia Lingcod (*Ophiodon elongatus*) Assessment and Advice for Fishery Management. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2005/042. (Accessed 15 January 2015)

DFO. 2009. A fishery decision-making framework incorporating the Precautionary Approach. (Accessed 15 January 2015)

DFO. 2010. Management Plan for the Steller Sea Lion (*Eumetopias jubatus*) in Canada [Final]. *Species at Risk Act* Management Plan Series. Fisheries and Oceans Canada, Ottawa. vi + 69 pp.

Logan, G., de la Mare, W., King, J., and Haggarty, D. 2005. Management Framework for Strait of Georgia Lingcod. DFO Can. Sci. Advis. Sec. Res. Doc. 2005/048. xiii + 102. (Accessed 15 January 2015)

Olesiuk, P.F. 2010. An assessment of population trends and abundance of harbour seals (*Phoca vitulina*) in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/105. vi + 157 p. (Accessed 15 January 2015)

THIS REPORT IS AVAILABLE FROM THE:

Centre for Science Advice
Pacific Region
Fisheries and Oceans Canada
3190 Hammond Bay Road
Nanaimo, BC V9T 6N7

Telephone: 250-756-7208
E-Mail: csap@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-5087

Correct Citation for this Publication:

DFO. 2015. Stock assessment for Lingcod (*Ophiodon elongatus*) for the Strait of Georgia, British Columbia in 2014. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/014.

Aussi disponible en français :

MPO. 2015. Évaluation du stock de morues-lingues (Ophiodon elongatus) en 2014 dans le détroit de Georgie, Colombie-Britannique. Secr. can. de consult. sci. du MPO, Avis Sci. 2015/014.