# Status of Yellowtail Rockfish (*Sebastes flavidus*) Along the U.S. Pacific Coast in 2017


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DRAFT SAFE

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## Contents

# Executive Summary

executive-summary

## Stock

stock

This assessment reports the status of the Yellowtail Rockfish (*Sebastes flavidus*) resource in U.S. waters off the coast of the California, Oregon, and Washington using data through 2016.

The Pacific Fishery Management Council (PFMC) manages the U.S. fishery as two stocks separated at Cape Mendocino, California (40° 10'N). This assessment analyzes those two areas as independent stocks, with the southern stock extending southward to the U.S./Mexico border and the northern stock extending northward to the U.S./Canada border.

The previous assessment (Wallace and Lai 2005), following the pattern of prior assessments, included only the Northern stock which it divided into three assessment areas with divisions at Cape Elizabeth (47° 20'N) and Cape Falcon (45° 46'N). However, a more recent genetic analysis (Hess et al. n.d.) found distinct stocks north and south of Cape Mendocino but did not find stock differences within the northern area, with the genetic stock extending northward through British Colombia, Canada to Southeast Alaska. However, Canada and Alaska are not included in this assessment. Since the previous assessment, reconstruction of historical catch by Washington and Oregon makes any border but the state line incompatible with the data. Additionally, much of the groundfish catch landed in northern Oregon is caught in Washington waters.

## Catches

catches

Catches from the Northern stock were divided into four categories: commercial catch, bycatch in the at-sea hake fishery, recreational catch in Oregon and California (north of 40° 10'N), and recreational catch in Washington. The first three of these fleets were entered in metric tons, but the recreational catch from Washington was entered in the model as numbers of fish with the average weight calculated internally in the model.

Catches from the Southern stock were divided into two categories: commercial and recreational catch, both of which were entered as metric tons.

Include: trends and current levels-include table for last ten years and graph with long term data

Catch figures: (Figures a-b)
Catch tables: (Tables a-b)

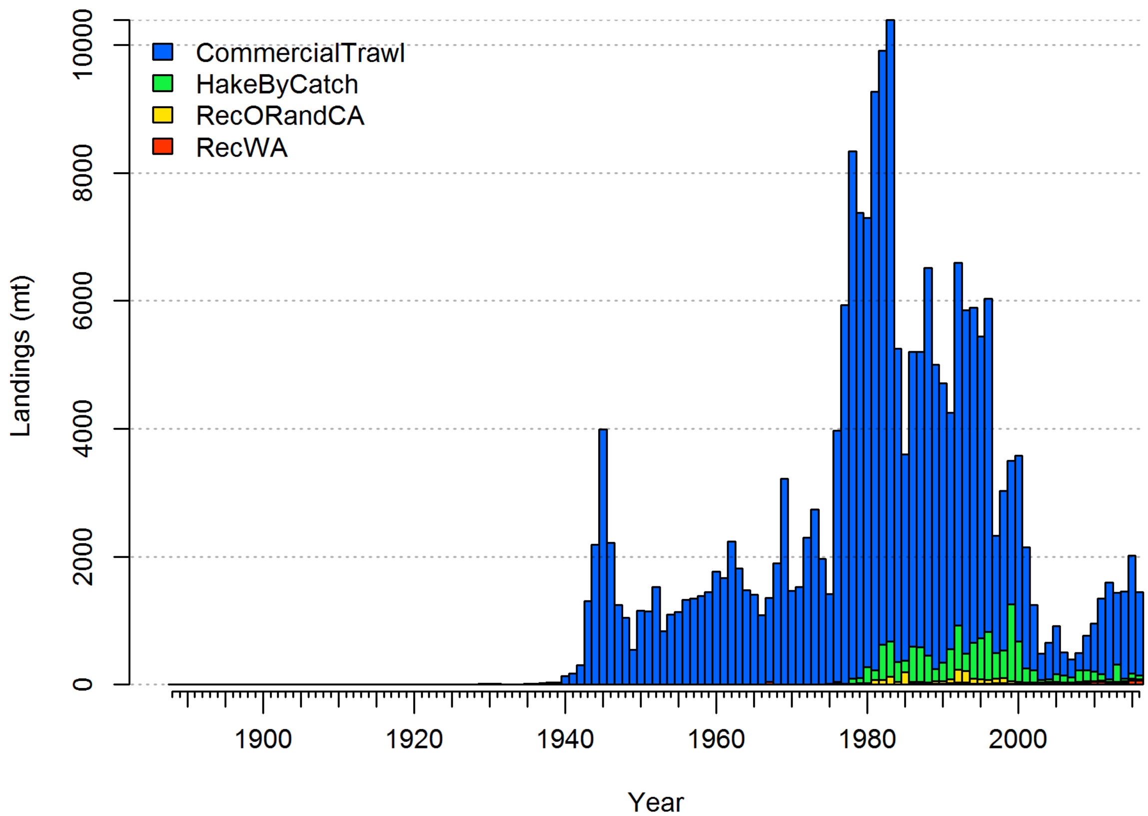



Figure a: Estimated catch history of Yellowtail Rockfish in the Northern model. Recreational catches in Washington are model estimates of total weigth converted from input catch in numbers using model estimates of growth and selectivity. fig:r4ss_catch_N

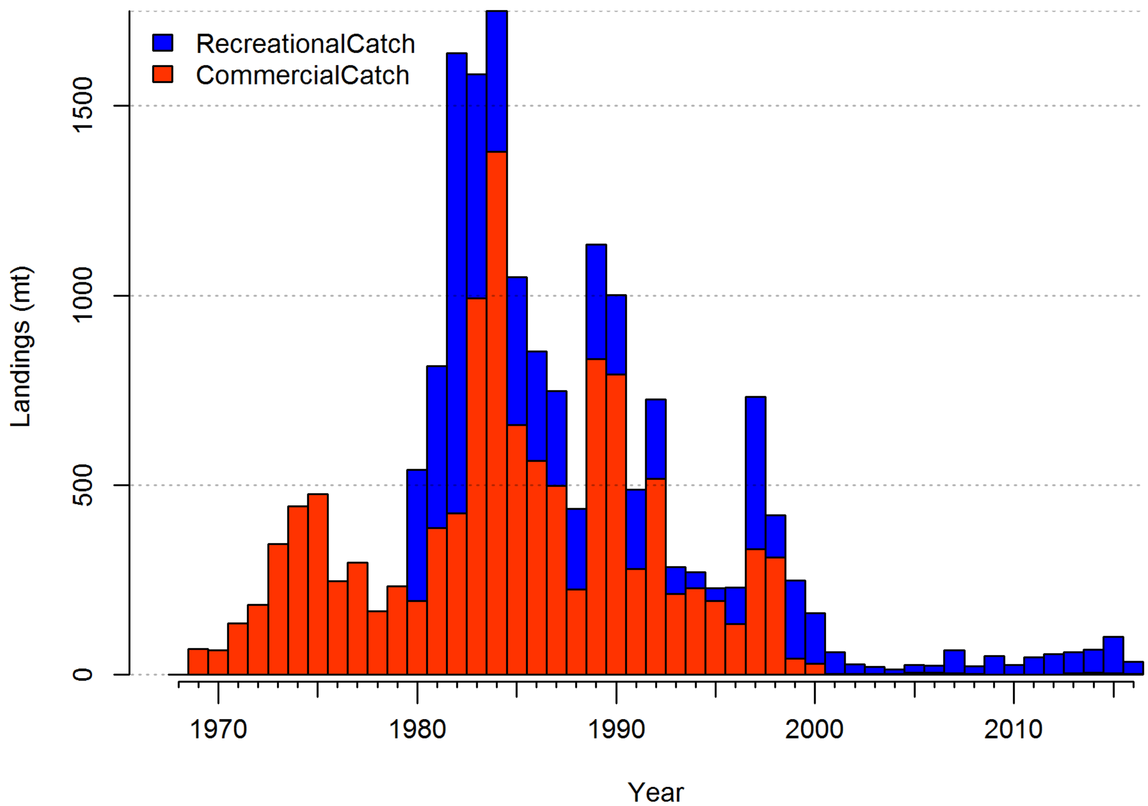



Figure b: Estimated catch history of Yellowtail Rockfish in the Southern model. fig:r4ss_catch_S

Table a: Recent Yellowtail Rockfish catch by fleet for the Northern stock (north of 40° 10'N). tab:Exec_catch_N

| Year | Commercial (t) | At-sea hake bycatch (t) | Recreational OR+CA (t) | Recreational WA (1000s) |
|---|---|---|---|---|
| 2007 | - | - | - | - |
| 2008 | - | - | - | - |
| 2009 | - | - | - | - |
| 2010 | - | - | - | - |
| 2011 | - | - | - | - |
| 2012 | - | - | - | - |
| 2013 | - | - | - | - |
| 2014 | - | - | - | - |
| 2015 | - | - | - | - |
| 2016 | - | - | - | - |

Table b: Recent Yellowtail Rockfish catch by fleet for the Southern stock (south of 40° 10'N). tab:Exec_catch_S

| Year | Recreational (t) | Commercial (t) |
|---|---|---|
| 2007 | - | - |
| 2008 | - | - |
| 2009 | - | - |
| 2010 | - | - |
| 2011 | - | - |
| 2012 | - | - |
| 2013 | - | - |
| 2014 | - | - |
| 2015 | - | - |
| 2016 | - | - |

# Data and Assessment

data-and-assessment

Include: date of last assessment, type of assessment model, data available, new information, and information lacking.

Yellowtail Rockfish was assessed.... This assessment uses the newest version of Stock Synthesis (3.xxx). The model begins in 1889, and assumes the stock was at an unfished equilibrium that year.

Map of assessment region: (Figure c).

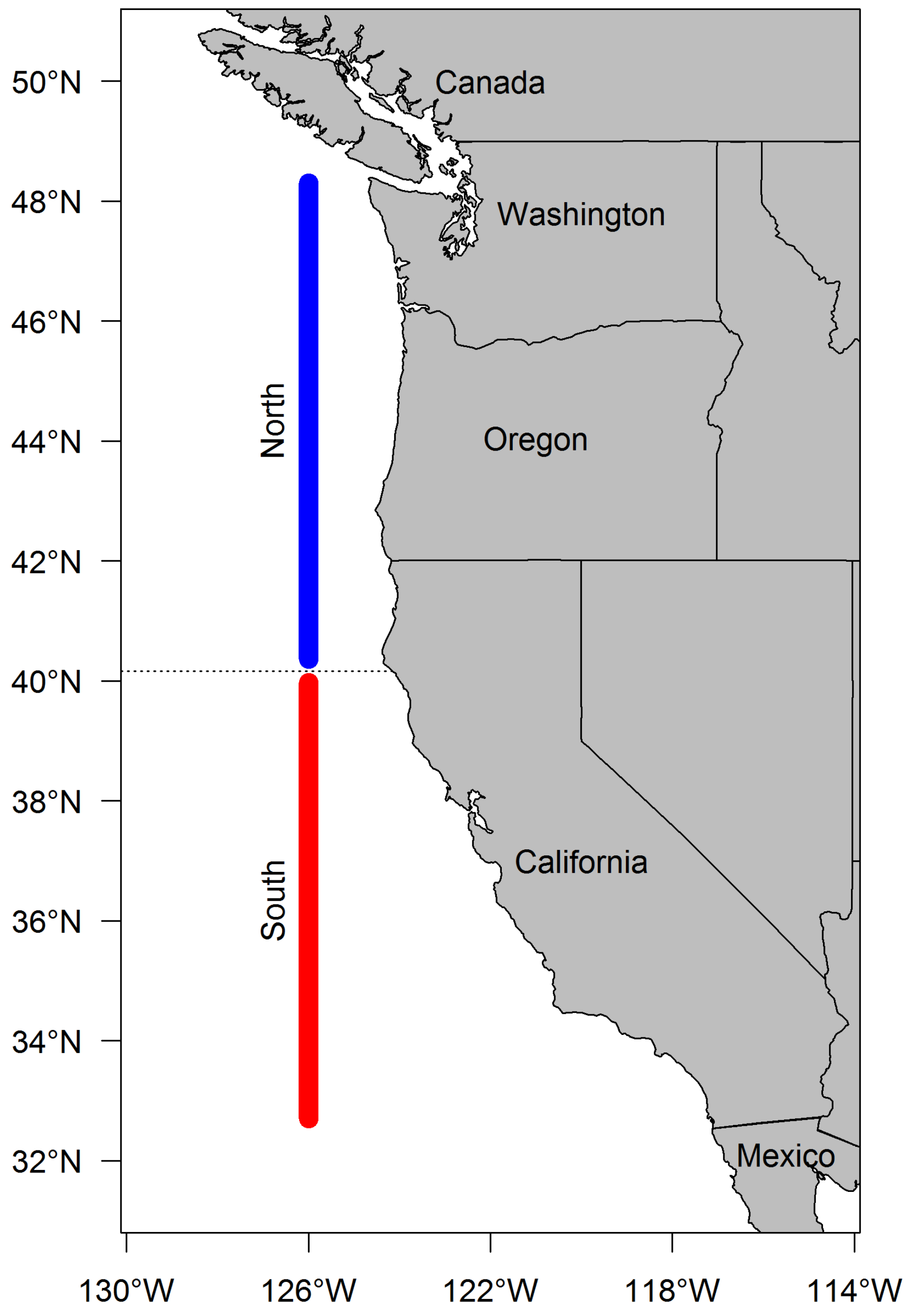



Figure c: Map depicting the boundaries for the base-case model. fig:assess_region_map

# Stock Biomass

stock-biomass

Include: trends and current levels relative to virgin or historic levels, description of uncertainty-include table for last 10 years and graph with long term estimates.

Spawning output Figure: Figure d
Spawning output Table(s): Table c
Relative depletion Figure: Figure e

Example text (remove Models 2 and 3 if not needed - if using, remove the # in-line comments!!!) The estimated relative depletion level (spawning output relative to unfished spawning output) of the the base-case model in 2016 is 53% (~95% asymptotic interval: ± 41.3%-64.8%) (Figure e).

The estimated relative depletion level of model 2 in 2016 is 92.2% (~95% asymptotic interval: ± 72.1%-112%) (Figure e).

The estimated relative depletion level of model 3 in 2016 is (~95% asymptotic interval: ± ) (Figure e).

Table c: Recent trend in beginning of the year spawning output and depletion for the Northern model for Yellowtail Rockfish.

tab:SpawningDeplete_mod1

| Year | Spawning Output (trillion eggs) | ~ 95% confidence interval | Estimated depletion | ~ 95% confidence interval |
|---|---|---|---|---|
| 2008 | 7.307 | (5.31-9.3) | 0.497 | (0.368-0.627) |
| 2009 | 7.713 | (5.65-9.78) | 0.525 | (0.394-0.656) |
| 2010 | 7.991 | (5.87-10.12) | 0.544 | (0.412-0.676) |
| 2011 | 8.105 | (5.94-10.27) | 0.552 | (0.42-0.683) |
| 2012 | 8.160 | (5.98-10.34) | 0.555 | (0.426-0.685) |
| 2013 | 8.101 | (5.91-10.29) | 0.551 | (0.425-0.677) |
| 2014 | 8.021 | (5.83-10.21) | 0.546 | (0.423-0.669) |
| 2015 | 7.943 | (5.75-10.14) | 0.541 | (0.421-0.661) |
| 2016 | 7.806 | (5.6-10.02) | 0.531 | (0.413-0.65) |
| 2017 | 7.791 | (5.55-10.03) | 0.530 | (0.413-0.648) |

Table d: Recent trend in beginning of the year spawning output and depletion for the Southern model for Yellowtail Rockfish.

tab:SpawningDeplete_mod2

| Year | Spawning Output (trillion eggs) | ~ 95% confidence interval | Estimated depletion | ~ 95% confidence interval |
|---|---|---|---|---|
| 2008 | 1.983 | (-0.76-4.72) | 0.588 | (0.45-0.726) |
| 2009 | 1.975 | (-0.74-4.69) | 0.586 | (0.453-0.718) |
| 2010 | 1.989 | (-0.73-4.71) | 0.590 | (0.461-0.719) |
| 2011 | 2.027 | (-0.73-4.78) | 0.601 | (0.473-0.729) |
| 2012 | 2.084 | (-0.73-4.9) | 0.618 | (0.489-0.747) |
| 2013 | 2.177 | (-0.75-5.11) | 0.646 | (0.512-0.779) |
| 2014 | 2.298 | (-0.78-5.38) | 0.682 | (0.543-0.821) |
| 2015 | 2.478 | (-0.83-5.79) | 0.735 | (0.584-0.886) |
| 2016 | 2.743 | (-0.91-6.39) | 0.814 | (0.643-0.984) |
| 2017 | 3.109 | (-1.02-7.23) | 0.922 | (0.721-1.123) |

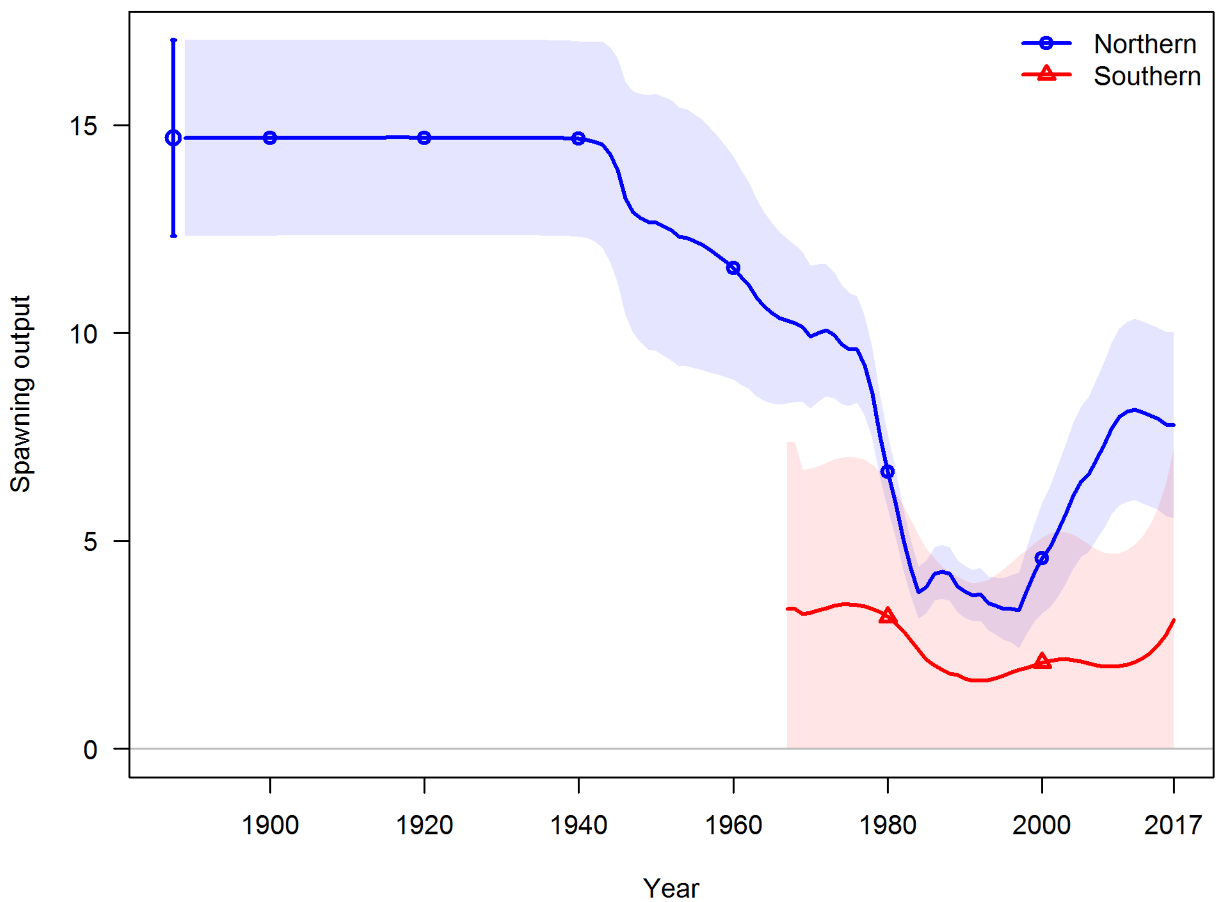



Figure d: Time series of spawning output trajectory (circles and line: median; light broken lines: 95% credibility intervals) for the base case assessment model. fig:Spawnbio_all

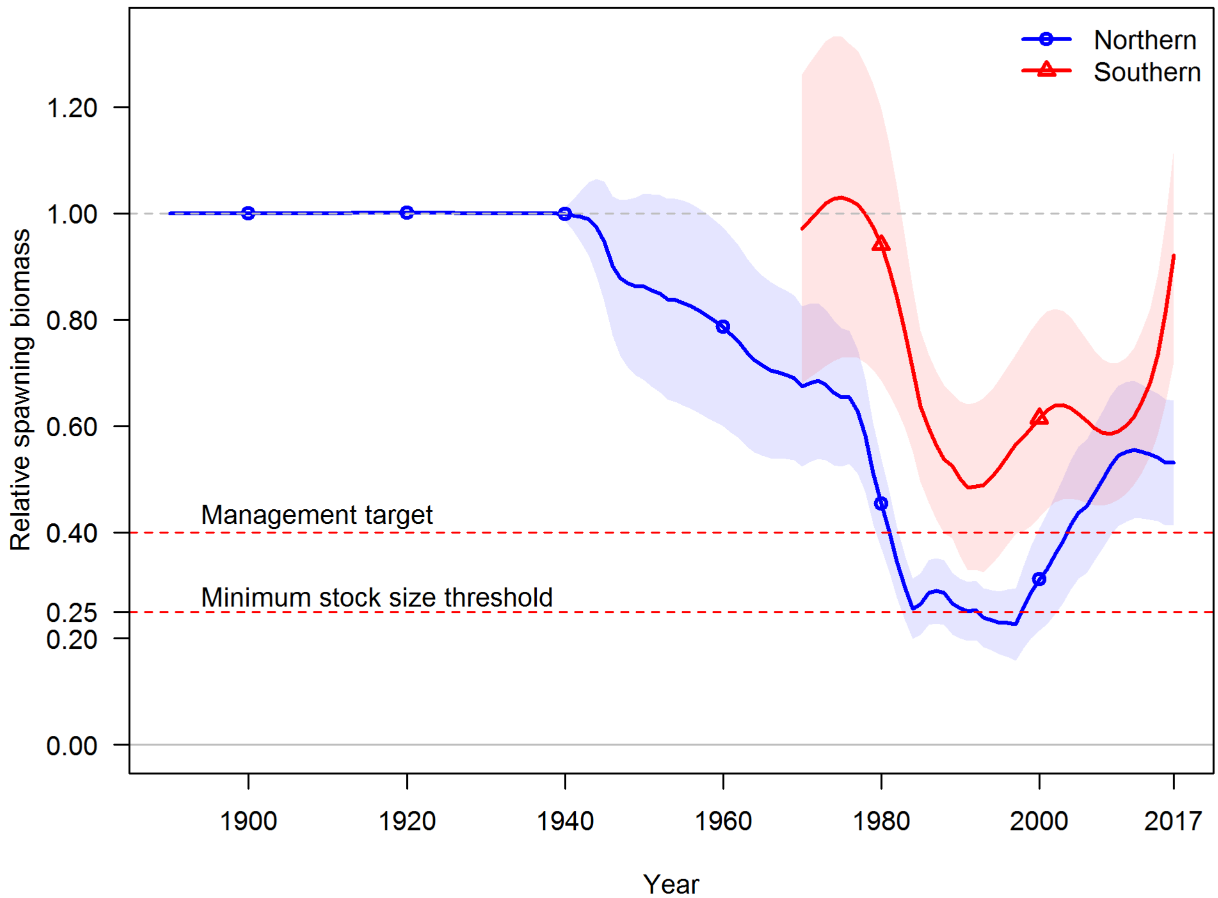



Figure e: Estimated relative depletion with approximate 95% asymptotic confidnce intervals (dashed lines) for the base case assessment model. fig:RelDeplete_all

# Recruitment

recruitment

Include: trends and current levels relative to virgin or historic levels-include table for last 10 years and graph with long term estimates.

Recruitment Figure: (Figure f)
Recruitment Tables: (Tables e, f and **??**)

Table e: Recent recruitment for the Northern model.

tab:Recruit_mod1

| Year | Estimated Recruitment (millions) | ~ 95% confidence interval |
|---|---|---|
| 2008 | 34.46 | (20.8 - 57.08) |
| 2009 | 10.44 | (5.04 - 21.65) |
| 2010 | 22.11 | (11.8 - 41.43) |
| 2011 | 15.15 | (6.89 - 33.31) |
| 2012 | 15.95 | (6.29 - 40.42) |
| 2013 | 25.87 | (8.87 - 75.43) |
| 2014 | 24.05 | (8.24 - 70.21) |
| 2015 | 24.51 | (8.62 - 69.71) |
| 2016 | 24.35 | (8.57 - 69.16) |
| 2017 | 24.34 | (8.57 - 69.13) |

Table f: Recent recruitment for the Southern model.

tab:Recruit_mod2

| Year | Estimated Recruitment (millions) | ~ 95% confidence interval |
|---|---|---|
| 2008 | 123.60 | (31.9 - 478.95) |
| 2009 | 61.44 | (9.88 - 382.1) |
| 2010 | 84.06 | (14.63 - 483.13) |
| 2011 | 68.11 | (12.28 - 377.66) |
| 2012 | 35.52 | (6.07 - 207.89) |
| 2013 | 41.50 | (8.35 - 206.26) |
| 2014 | 32.55 | (6.23 - 170.09) |
| 2015 | 25.26 | (4.87 - 131.01) |
| 2016 | 21.17 | (3.94 - 113.89) |
| 2017 | 21.81 | (4.06 - 117.31) |

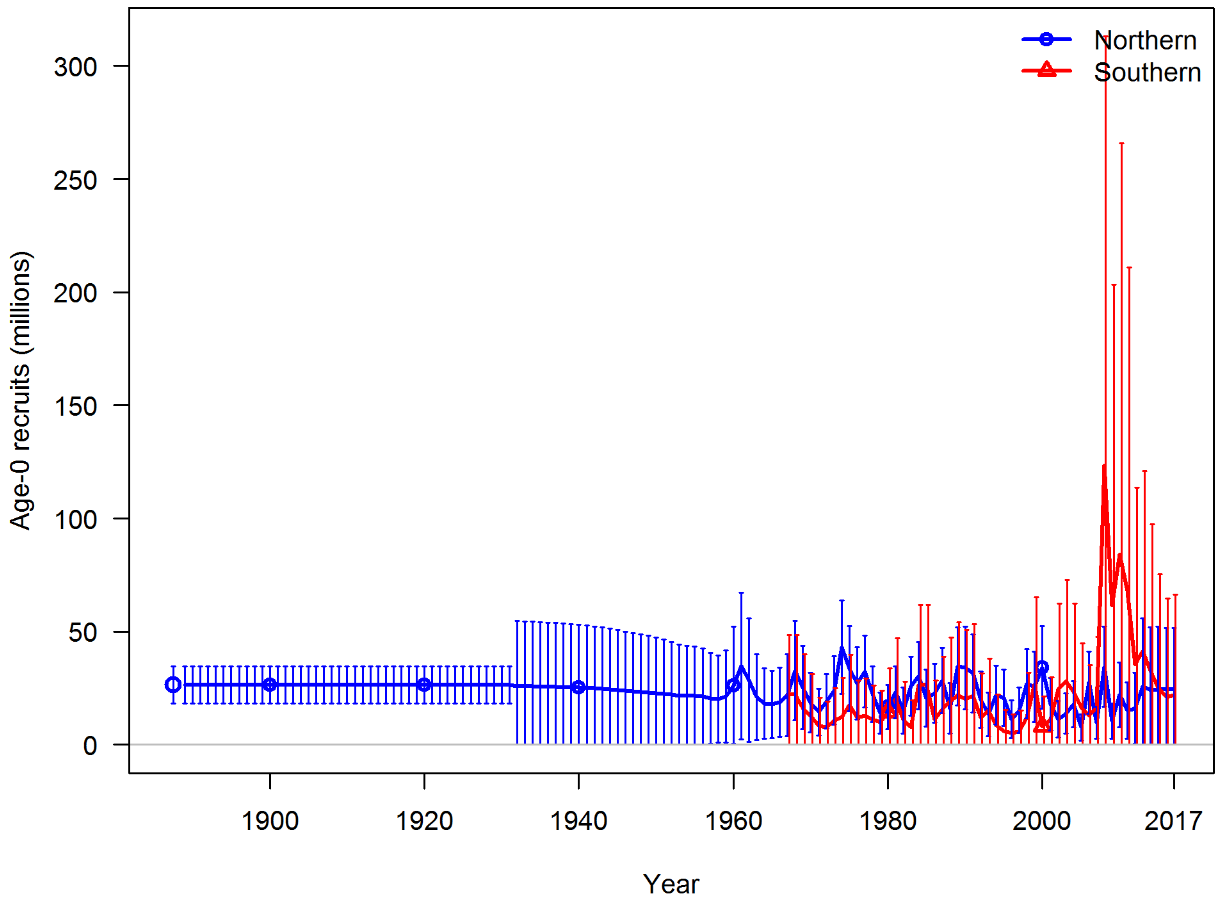



Figure f: Time series of estimated Yellowtail Rockfish recruitments for the base-case model with 95% confidence or credibility intervals. fig:Recruits_all

# Exploitation status

exploitation-status

Include: exploitation rates (i.e., total catch divided by exploitable biomass, or the annual SPR harvest rate) include a table with the last 10 years of data and a graph showing the trend in fishing mortality relative to the target (y-axis) plotted against the trend in biomass relative to the target (x-axis).

Exploitation Tables: Table g, Table h, Table **??** Exploitation Figure: Figure g).

A summary of Yellowtail Rockfish exploitation histories for base model is provided as Figure h.

Table g: Recent trend in spawning potential ratio and exploitation for Yellowtail Rockfish in the Northern model. Fishing intensity is (1-SPR) divided by 50% (the SPR target) and exploitation is F divided by $F_{SPR}$.

tab:SPR_Exploit_mod1

| Year | Fishing intensity | ~ 95% confidence interval | Exploitation rate | ~ 95% confidence interval |
|---|---|---|---|---|
| 2007 | 0.33 | (0.12-0.55) | 0.01 | (0-0.02) |
| 2008 | 0.21 | (0.14-0.28) | 0.01 | (0-0.01) |
| 2009 | 0.39 | (0.24-0.54) | 0.01 | (0.01-0.02) |
| 2010 | 0.52 | (0.27-0.77) | 0.02 | (0.01-0.03) |
| 2011 | 0.45 | (0.33-0.58) | 0.02 | (0.01-0.02) |
| 2012 | 0.52 | (0.38-0.65) | 0.02 | (0.01-0.03) |
| 2013 | 0.49 | (0.36-0.62) | 0.02 | (0.01-0.02) |
| 2014 | 0.49 | (0.36-0.62) | 0.02 | (0.01-0.02) |
| 2015 | 0.63 | (0.48-0.79) | 0.03 | (0.02-0.03) |
| 2016 | 0.50 | (0.36-0.63) | 0.02 | (0.01-0.02) |

Table h: Recent trend in spawning potential ratio and exploitation for Yellowtail Rockfish in the Southern model. Fishing intensity is (1-SPR) divided by 50% (the SPR target) and exploitation is F divided by $F_{SPR}$.

tab:SPR_Exploit_mod2

| Year | Fishing intensity | ~ 95% confidence interval | Exploitation rate | ~ 95% confidence interval |
|---|---|---|---|---|
| 2007 | 0.04 | (-0.01-0.1) | 0.00 | (0-0) |
| 2008 | 0.02 | (0-0.04) | 0.00 | (0-0) |
| 2009 | 0.03 | (-0.01-0.07) | 0.00 | (0-0) |
| 2010 | 0.01 | (0-0.03) | 0.00 | (0-0) |
| 2011 | 0.02 | (-0.01-0.05) | 0.00 | (0-0) |
| 2012 | 0.02 | (-0.01-0.05) | 0.00 | (0-0) |
| 2013 | 0.02 | (-0.01-0.05) | 0.00 | (0-0) |
| 2014 | 0.02 | (-0.01-0.05) | 0.00 | (0-0) |
| 2015 | 0.03 | (-0.01-0.07) | 0.00 | (0-0) |
| 2016 | 0.01 | (0-0.02) | 0.00 | (0-0) |

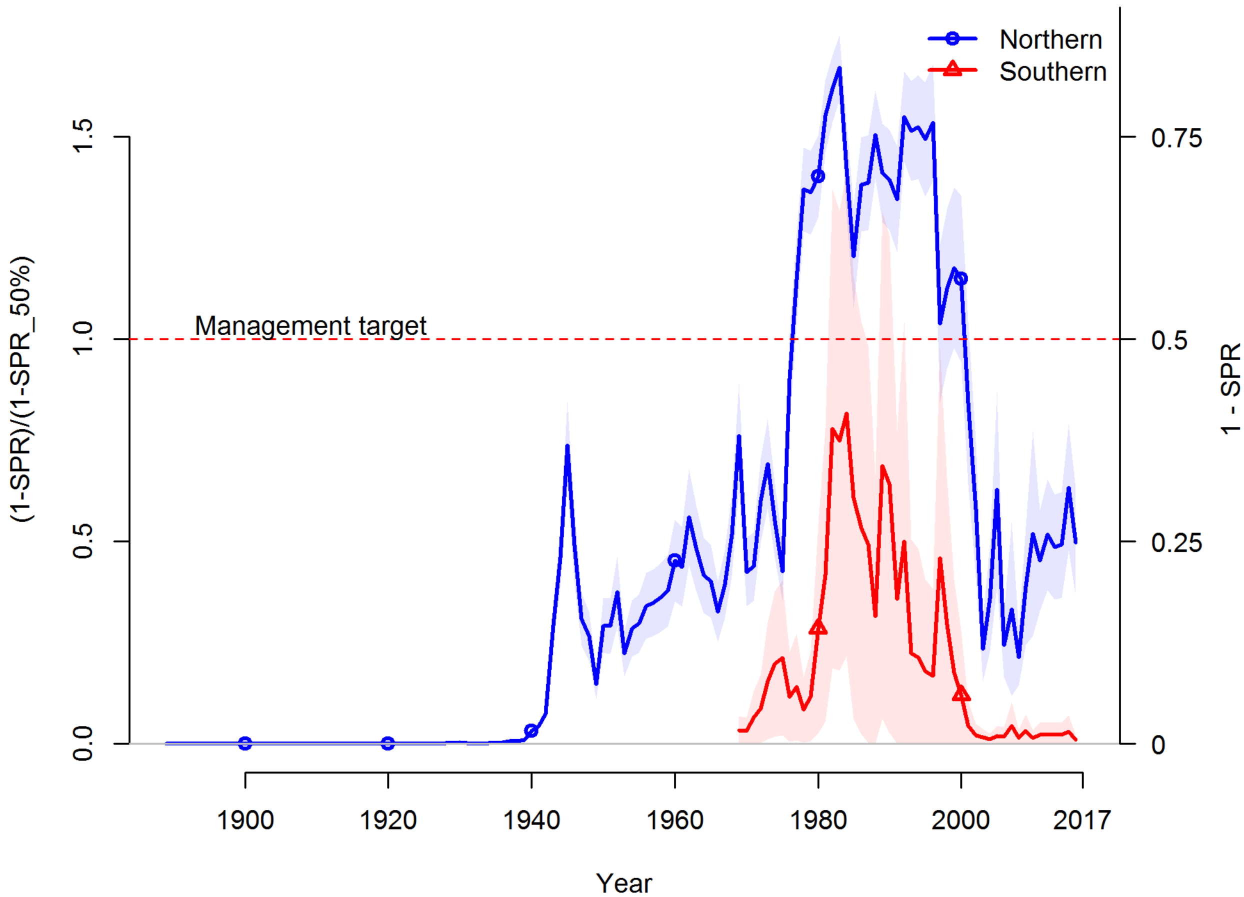



Figure g: Estimated spawning potential ratio (SPR) for the base-case model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the $SPR_{50\%}$ harvest rate. The last year in the time series is 2016. fig:SPR_all

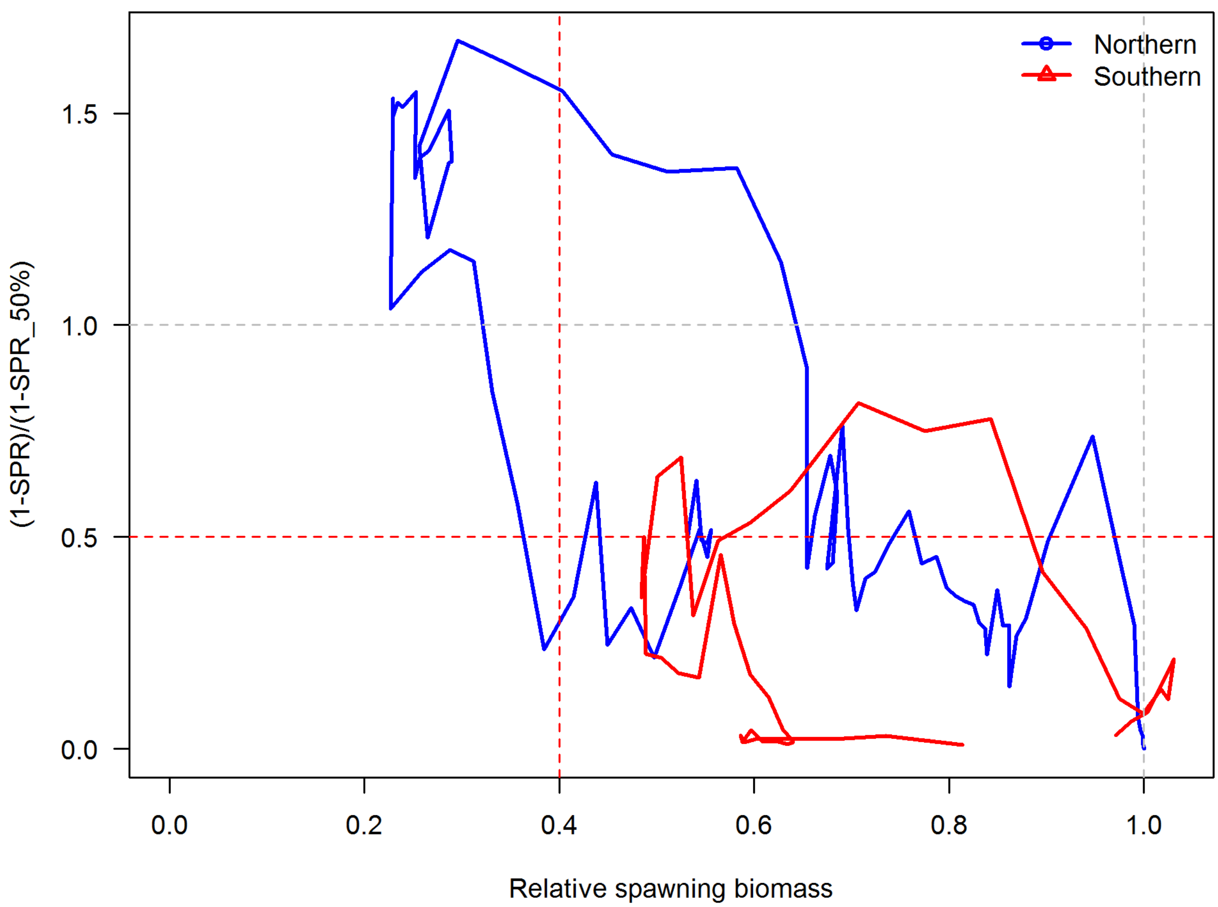



Figure h: Phase plot of estimated relative (1-SPR) vs. relative spawning biomass for the base case model. The relative (1-SPR) is (1-SPR) divided by 50% (the SPR target). Relative depletion is the annual spawning biomass divided by the unfished spawning biomass. fig:Phase_all

# Ecosystem Considerations

ecosystem-considerations

In this assessment, ecosystem considerations were. . . ..

# Reference Points

reference-points

Include: management targets and definition of overfishing, including the harvest rate that brings the stock to equilibrium at $B_{40\%}$ (the $B_{MSY}$ proxy) and the equilibrium stock size that results from fishing at the default harvest rate (the $F_{MSY}$ proxy). Include a summary table that compares estimated reference points for SSB, SPR, Exploitation Rate and Yield based on SSBproxy for MSY, SPRproxy for MSY, and estimated MSY values

Write intro paragraph....and remove text for Models 2 and 3 if not needed

This stock assessment estimates that Yellowtail Rockfish in the Northern model are above the biomass target, but above the minimum stock size threshold. Add sentence about spawning output trend. The estimated relative depletion level for Model 1 in 2016 is 53% (~95% asymptotic interval: $\pm$ 41.3%-64.8%, corresponding to an unfished spawning output of 7.79131 trillion eggs (~95% asymptotic interval: 5.55-10.03 trillion eggs) of spawning output in the base model (Table i). Unfished age 4+ biomass was estimated to be 128999 mt in the base case model. The target spawning output based on the biomass target ($SB_{40\%}$) is 5.9 trillion eggs, which gives a catch of 3910.4 mt. Equilibrium yield at the proxy $F_{MSY}$ harvest rate corresponding to $SPR_{50\%}$ is 3691.6 mt.

This stock assessment estimates that Yellowtail Rockfish in the Southern model are above the biomass target, but above the minimum stock size threshold. Add sentence about spawning output trend. The estimated relative depletion level for Model 2 in 2016 is 92.2% (~95% asymptotic interval: $\pm$ 72.1%-112%), corresponding to an unfished spawning output of 3.10871 trillion eggs (~95% asymptotic interval: ) of spawning output in the base model (Table j). Unfished age 4+ biomass was estimated to be 71633.9 mt in the base case model. The target spawning output based on the biomass target ($SB_{40\%}$) is 1.3 trillion eggs, which gives a catch of mt. Equilibrium yield at the proxy $F_{MSY}$ harvest rate corresponding to $SPR_{50\%}$ is 1890.2 mt.

This stock assessment estimates that Yellowtail Rockfish in the are

the biomass target, but
the minimum stock size threshold. Add sentence about spawning output trend. The estimated relative depletion level or Model 3 in 2016 is (~95% asymptotic interval: $\pm$ ), corresponding to an unfished spawning output of (~95% asymptotic interval: ) of spawning output in the base model (Table **??**). Unfished age 4+ biomass was estimated to be mt in the base case model. The target spawning output based on the biomass target ($SB_{40\%}$) is , which gives a catch of mt. Equilibrium yield at the proxy $F_{MSY}$ harvest rate corresponding to $SPR_{50\%}$ is mt.

Table i: Summary of reference points and management quantities for the base case Northern model.

tab:Ref_pts_mod1

| **Quantity** | **Estimate** | **95% Confidence Interval** |
|---|---|---|
| Unfished spawning output (trillion eggs) | 14.7 | (12.3-17) |
| Unfished age 4+ biomass (mt) | 128999 | (110839.6-147158.4) |
| Unfished recruitment (R0, thousands) | 26398.3 | (18222.3-34574.3) |
| Spawning output(2016 trillion eggs) | 7.8 | (5.6-10) |
| Depletion (2016) | 0.5313 | (0.413-0.6496) |
| **Reference points based on $\mathbf{SB_{40\%}}$** | | |
| Proxy spawning output ($B_{40\%}$) | 5.9 | (4.9-6.8) |
| SPR resulting in $B_{40\%}$ ($SPR_{B40\%}$) | 0.4589 | (0.4589-0.4589) |
| Exploitation rate resulting in $B_{40\%}$ | 0.0539 | (0.0514-0.0564) |
| Yield with $SPR_{B40\%}$ at $B_{40\%}$ (mt) | 3910.4 | (3265-4555.8) |
| ***Reference points based on SPR proxy for MSY*** | | |
| Spawning output | 6.5 | (5.5-7.6) |
| $SPR_{proxy}$ | 0.5 | |
| Exploitation rate corresponding to $SPR_{proxy}$ | 0.0477 | (0.0455-0.05) |
| Yield with $SPR_{proxy}$ at $SB_{SPR}$ (mt) | 3691.6 | (3085.6-4297.5) |
| ***Reference points based on estimated MSY values*** | | |
| Spawning output at $MSY$ ($SB_{MSY}$) | 3.5 | (2.9-4.1) |
| $SPR_{MSY}$ | 0.3118 | (0.3067-0.3169) |
| Exploitation rate at $MSY$ | 0.0821 | (0.0779-0.0863) |
| $MSY$ (mt) | 4347.6 | (3612-5083.2) |

Table j: Summary of reference points and management quantities for the base case Southern model.

tab:Ref_pts_mod2

| **Quantity** | **Estimate** | **95% Confidence Interval** |
|---|---|---|
| Unfished spawning output (trillion eggs) | 3.4 | (-0.6265-7.4) |
| Unfished age 4+ biomass (mt) | 71633.9 | (-12564.9768-155832.8) |
| Unfished recruitment (R0, thousands) | 22259.8 | (-3949.6224-48469.2) |
| Spawning output(2016 trillion eggs) | 2.7 | (-0.9069-6.4) |
| Depletion (2016) | 0.8136 | (0.643-0.9843) |
| **Reference points based on $\mathbf{SB_{40\%}}$** | | |
| Proxy spawning output ($B_{40\%}$) | 1.3 | (-0.2506-2.9) |
| SPR resulting in $B_{40\%}$ ($SPR_{B40\%}$) | 0.4589 | (0.4589-0.4589) |
| Exploitation rate resulting in $B_{40\%}$ | 0.0576 | (0.0559-0.0593) |
| Yield with $SPR_{B40\%}$ at $B_{40\%}$ (mt) | 1997 | (-354.5756-4348.5) |
| ***Reference points based on SPR proxy for MSY*** | | |
| Spawning output | 1.5 | (-0.2791-3.3) |
| $SPR_{proxy}$ | 0.5 | |
| Exploitation rate corresponding to $SPR_{proxy}$ | 0.0508 | (0.0493-0.0522) |
| Yield with $SPR_{proxy}$ at $SB_{SPR}$ (mt) | 1890.2 | (-335.3679-4115.8) |
| ***Reference points based on estimated MSY values*** | | |
| Spawning output at $MSY$ ($SB_{MSY}$) | 0.8199 | (-0.1516-1.8) |
| $SPR_{MSY}$ | 0.3175 | (0.3141-0.3208) |
| Exploitation rate at $MSY$ | 0.0885 | (0.0861-0.0909) |
| $MSY$ (mt) | 2197.8 | (-391.3228-4786.9) |

# Management Performance

management-performance

Include: catches in comparison to OFL, ABC and OY/ACL values for the most recent 10 years (when available), overfishing levels, actual catch and discard. Include OFL(encountered), OFL(retained) and OFL(dead) if different due to discard and discard mortality.

Management performance table: Table k

Table k: Recent trend in total catch and commercial landings (mt) relative to the management guidelines. Estimated total catch reflect the commercial landings plus the model estimated discarded biomass.

tab:mnmgt_perform

| Year | OFL (mt; ABC prior to 2011) | ABC (mt) | ACL (mt; OY prior to 2011) | Estimated total catch (mt) |
|---|---|---|---|---|
| **2007** | - | - | - | - |
| **2008** | - | - | - | - |
| **2009** | - | - | - | - |
| **2010** | - | - | - | - |
| **2011** | - | - | - | - |
| **2012** | - | - | - | - |
| **2013** | - | - | - | - |
| **2014** | - | - | - | - |
| **2015** | - | - | - | - |
| **2016** | - | - | - | - |
| **2017** | - | - | - | - |
| **2018** | - | - | - | - |

# Unresolved Problems And Major Uncertainties

unresolved-problems-and-major-uncertainties

TBD after STAR panel

# Decision Table(s) (groundfish only)

decision-tables-groundfish-only

Include: projected yields (OFL, ABC and ACL), spawning biomass, and stock depletion levels for each year. Not required in draft assessments undergoing review.

OFL projection table: Table l

Decision table(s) Table m, Table n, Table **??**

`Yield curve: Figure \ref{fig:Yield_all}`

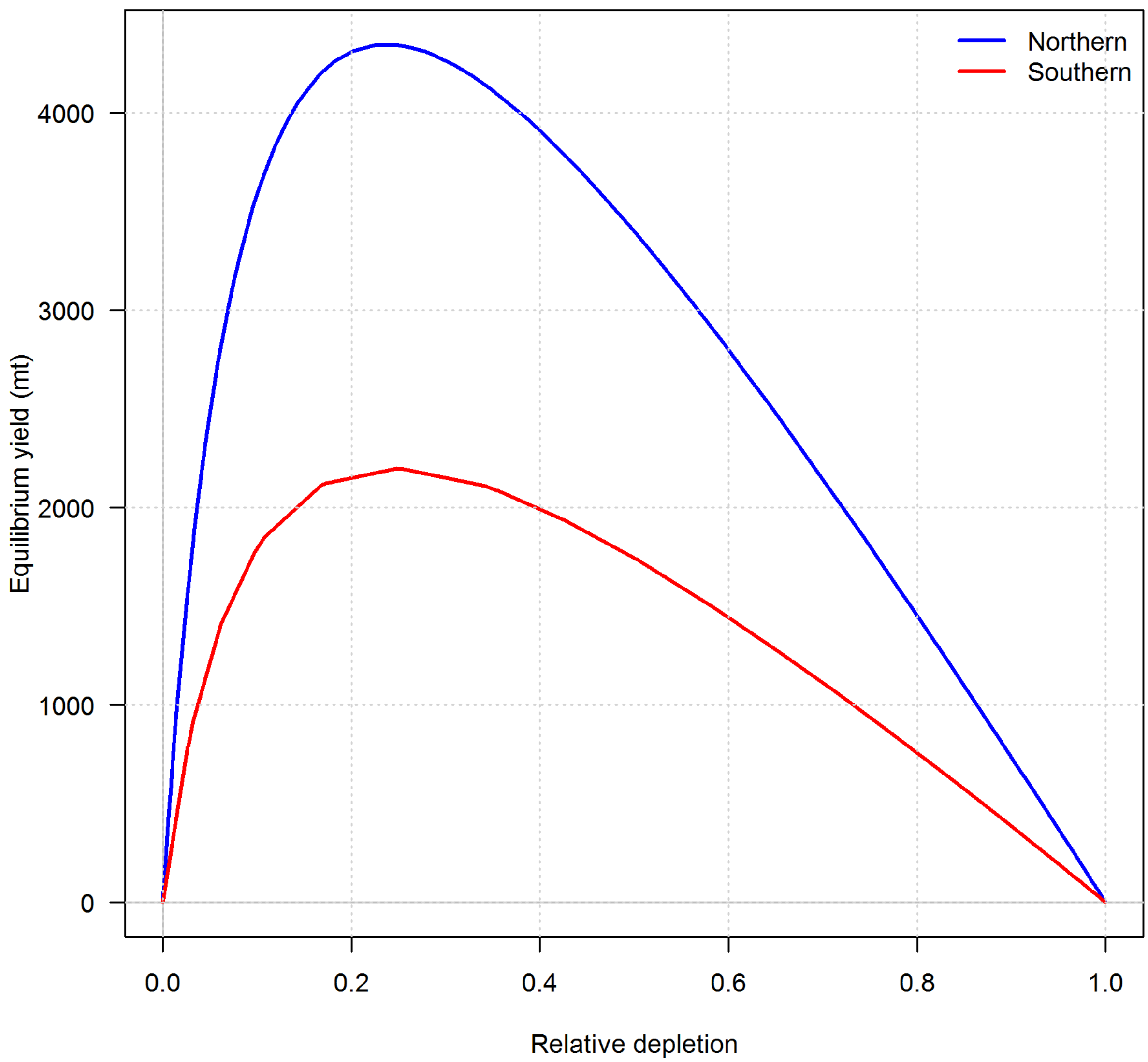



Figure i: Equilibrium yield curve for the base case model. Values are based on the 2016 fishery selectivity and with steepness fixed at... fig:Yield_all

Table l: Projections of potential OFL (mt) for each model, using the base model forecast.

tab:OFL_projection

| Year | Model 1 | Model 2 | Total |
|---|---|---|---|
| 2017 | 3988.81 | 5152.74 | 9141.55 |
| 2018 | 3840.38 | 5006.04 | 8846.42 |
| 2019 | 3712.42 | 4801.18 | 8513.60 |
| 2020 | 3611.38 | 4566.83 | 8178.21 |
| 2021 | 3544.46 | 4324.17 | 7868.63 |
| 2022 | 3513.29 | 4085.35 | 7598.64 |
| 2023 | 3512.56 | 3857.50 | 7370.06 |
| 2024 | 3532.98 | 3645.03 | 7178.01 |
| 2025 | 3564.86 | 3450.44 | 7015.30 |
| 2026 | 3600.46 | 3274.82 | 6875.28 |
| 2027 | 3634.58 | 3118.20 | 6752.78 |
| 2028 | 3664.30 | 2979.81 | 6644.11 |

Table m: Summary of 10-year projections beginning in 2018 for alternate states of nature based on an axis of uncertainty for the Northern model. Columns range over low, mid, and high states of nature, and rows range over different assumptions of catch levels. An entry of "–" indicates that the stock is driven to very low abundance under the particular scenario.

tab:Decision_table_mod1

| | | | **States of nature** | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Low M 0.05 | | Base M 0.07 | | High M 0.09 | |
| | Year | Catch | Spawning Output | Depletion | Spawning Output | Depletion | Spawning Output | Depletion |
| | 2019 | - | - | - | - | - | - | - |
| | 2020 | - | - | - | - | - | - | - |
| | 2021 | - | - | - | - | - | - | - |
| 40-10 Rule, Low M | 2022 | - | - | - | - | - | - | - |
| | 2023 | - | - | - | - | - | - | - |
| | 2024 | - | - | - | - | - | - | - |
| | 2025 | - | - | - | - | - | - | - |
| | 2026 | - | - | - | - | - | - | - |
| | 2027 | - | - | - | - | - | - | - |
| | 2028 | - | - | - | - | - | - | - |
| | 2019 | - | - | - | - | - | - | - |
| | 2020 | - | - | - | - | - | - | - |
| | 2021 | - | - | - | - | - | - | - |
| 40-10 Rule | 2022 | - | - | - | - | - | - | - |
| | 2023 | - | - | - | - | - | - | - |
| | 2024 | - | - | - | - | - | - | - |
| | 2025 | - | - | - | - | - | - | - |
| | 2026 | - | - | - | - | - | - | - |
| | 2027 | - | - | - | - | - | - | - |
| | 2028 | - | - | - | - | - | - | - |
| | 2019 | - | - | - | - | - | - | - |
| | 2020 | - | - | - | - | - | - | - |
| | 2021 | - | - | - | - | - | - | - |
| 40-10 Rule, High M | 2022 | - | - | - | - | - | - | - |
| | 2023 | - | - | - | - | - | - | - |
| | 2024 | - | - | - | - | - | - | - |
| | 2025 | - | - | - | - | - | - | - |
| | 2026 | - | - | - | - | - | - | - |
| | 2027 | - | - | - | - | - | - | - |
| | 2028 | - | - | - | - | - | - | - |
| | 2019 | - | - | - | - | - | - | - |
| | 2020 | - | - | - | - | - | - | - |
| | 2021 | - | - | - | - | - | - | - |
| Average Catch | 2022 | - | - | - | - | - | - | - |
| | 2023 | - | - | - | - | - | - | - |
| | 2024 | - | - | - | - | - | - | - |
| | 2025 | - | - | - | - | - | - | - |
| | 2026 | - | - | - | - | - | - | - |
| | 2027 | - | - | - | - | - | - | - |
| | 2028 | - | - | - | - | - | - | - |

Table n: Summary of 10-year projections beginning in 2018 for alternate states of nature based on an axis of uncertainty for the Southern model. Columns range over low, mid, and high states of nature, and rows range over different assumptions of catch levels. An entry of "–" indicates that the stock is driven to very low abundance under the particular scenario.

tab:Decision_table_mod2

| | | | **States of nature** | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Low M 0.05 | | Base M 0.07 | | High M 0.09 | |
| | Year | Catch | Spawning Output | Depletion | Spawning Output | Depletion | Spawning Output | Depletion |
| 40-10 Rule, Low M | 2019 | - | - | - | - | - | - | - |
| | 2020 | - | - | - | - | - | - | - |
| | 2021 | - | - | - | - | - | - | - |
| | 2022 | - | - | - | - | - | - | - |
| | 2023 | - | - | - | - | - | - | - |
| | 2024 | - | - | - | - | - | - | - |
| | 2025 | - | - | - | - | - | - | - |
| | 2026 | - | - | - | - | - | - | - |
| | 2027 | - | - | - | - | - | - | - |
| | 2028 | - | - | - | - | - | - | - |
| 40-10 Rule | 2019 | - | - | - | - | - | - | - |
| | 2020 | - | - | - | - | - | - | - |
| | 2021 | - | - | - | - | - | - | - |
| | 2022 | - | - | - | - | - | - | - |
| | 2023 | - | - | - | - | - | - | - |
| | 2024 | - | - | - | - | - | - | - |
| | 2025 | - | - | - | - | - | - | - |
| | 2026 | - | - | - | - | - | - | - |
| | 2027 | - | - | - | - | - | - | - |
| | 2028 | - | - | - | - | - | - | - |
| 40-10 Rule, High M | 2019 | - | - | - | - | - | - | - |
| | 2020 | - | - | - | - | - | - | - |
| | 2021 | - | - | - | - | - | - | - |
| | 2022 | - | - | - | - | - | - | - |
| | 2023 | - | - | - | - | - | - | - |
| | 2024 | - | - | - | - | - | - | - |
| | 2025 | - | - | - | - | - | - | - |
| | 2026 | - | - | - | - | - | - | - |
| | 2027 | - | - | - | - | - | - | - |
| | 2028 | - | - | - | - | - | - | - |
| Average Catch | 2019 | - | - | - | - | - | - | - |
| | 2020 | - | - | - | - | - | - | - |
| | 2021 | - | - | - | - | - | - | - |
| | 2022 | - | - | - | - | - | - | - |
| | 2023 | - | - | - | - | - | - | - |
| | 2024 | - | - | - | - | - | - | - |
| | 2025 | - | - | - | - | - | - | - |
| | 2026 | - | - | - | - | - | - | - |
| | 2027 | - | - | - | - | - | - | - |
| | 2028 | - | - | - | - | - | - | - |

Table o: Yellowtail Rockfish base case results summary.

tab:base_summary

| Model Region | Quantity | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Landings (mt) | | | | | | | | | | |
| | Total Est. Catch (mt) | | | | | | | | | | |
| | OFL (mt) | | | | | | | | | | |
| | ACL (mt) | | | | | | | | | | |
| Model 1 | (1-$SPR$)(1-$SPR_{50\%}$) | 0.21 | 0.39 | 0.52 | 0.45 | 0.52 | 0.49 | 0.49 | 0.63 | 0.50 | |
| Base Case | Exploitation rate | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.02 | |
| | Age 4+ biomass (mt) | 76365.3 | 77111.1 | 76466.7 | 77313.9 | 75707.8 | 77354.4 | 76340.3 | 76683.8 | 76225.2 | 75174.0 |
| | Spawning Output | 7.3 | 7.7 | 8.0 | 8.1 | 8.2 | 8.1 | 8.0 | 7.9 | 7.8 | 7.8 |
| | 95% CI | (5.31-9.3) | (5.65-9.78) | (5.87-10.12) | (5.94-10.27) | (5.98-10.34) | (5.91-10.29) | (5.83-10.21) | (5.75-10.14) | (5.6-10.02) | (5.55-10.03) |
| | Depletion | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 |
| | 95% CI | (0.368-0.627) | (0.394-0.656) | (0.412-0.676) | (0.42-0.683) | (0.426-0.685) | (0.425-0.677) | (0.423-0.669) | (0.421-0.661) | (0.413-0.65) | (0.413-0.648) |
| | Recruits | 34.46 | 10.44 | 22.11 | 15.15 | 15.95 | 25.87 | 24.05 | 24.51 | 24.35 | 24.34 |
| | 95% CI | (20.8 - 57.08) | (5.04 - 21.65) | (11.8 - 41.43) | (6.89 - 33.31) | (6.29 - 40.42) | (8.87 - 75.43) | (8.24 - 70.21) | (8.62 - 69.71) | (8.57 - 69.16) | (8.57 - 69.13) |
| Model 2 | (1-$SPR$)(1-$SPR_{50\%}$) | 0.02 | 0.03 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.01 | |
| Base Case | Exploitation rate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | Age 4+ biomass (mt) | 41317.6 | 43306.9 | 44211.0 | 44337.0 | 44909.1 | 63175.4 | 72683.3 | 85860.8 | 96433.1 | 101051.0 |
| | Spawning Output | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| | 95% CI | (-0.76-4.72) | (-0.74-4.69) | (-0.73-4.71) | (-0.73-4.78) | (-0.73-4.9) | (-0.75-5.11) | (-0.78-5.38) | (-0.83-5.79) | (-0.91-6.39) | (-1.02-7.23) |
| | Depletion | 0.59 | 0.59 | 0.59 | 0.60 | 0.62 | 0.65 | 0.68 | 0.74 | 0.81 | 0.92 |
| | 95% CI | (0.45-0.726) | (0.453-0.718) | (0.461-0.719) | (0.473-0.729) | (0.489-0.747) | (0.512-0.779) | (0.543-0.821) | (0.584-0.886) | (0.643-0.984) | (0.721-1.123) |
| | Recruits | 123.60 | 61.44 | 84.06 | 68.11 | 35.52 | 41.50 | 32.55 | 25.26 | 21.17 | 21.81 |
| | 95% CI | (31.9 - 478.95) | (9.88 - 382.1) | (14.63 - 483.13) | (12.28 - 377.66) | (6.07 - 207.89) | (8.35 - 206.26) | (6.23 - 170.09) | (4.87 - 131.01) | (3.94 - 113.89) | (4.06 - 117.31) |

# Research And Data Needs

research-and-data-needs

Include: identify information gaps that seriously impede the stock assessment.

We recommend the following research be conducted before the next assessment:

1. List item No. 1 in the list
2. List item No. 2 in the list, etc.

# Rebuilding Projections

rebuilding-projections

Include: reference to the principal results from rebuilding analysis if the stock is overfished. This section should be included in the Final/SAFE version assessment document but is not required for draft assessments undergoing review. See Rebuilding Analysis terms of reference for detailed information on rebuilding analysis requirements.

# 1 Introduction

introduction

## 1.1 Basic Information

basic-information

Include: Scientific name, distribution, the basis of the choice of stock structure, including regional differences in life history or other biological characteristics that should form the basis of management units.

## 1.2 Map

map

A map showing the scope of the assessment and depicting boundaries for fisheries or data collection strata is provided in Figure 1.

## 1.3 Life History

life-history

Include: Important features of life history that affect management (e.g., migration, sexual dimorphism, bathymetric demography).

## 1.4 Ecosystem Considerations

ecosystem-considerations-1

Include: Ecosystem considerations (e.g., ecosystem role and trophic relationships of the species, habitat requirements/preferences, relevant data on ecosystem processes that may affect stock or parameters used in the stock assessment, and/or cross-FMP interactions with other fisheries). This section should note if environmental correlations or food web interactions were incorporated into the assessment model. The length and depth of this section would depend on availability of data and reports from the IEA, expertise of the STAT, and whether ecosystem factors are informational to contribute quantitative information to the assessment.

## 1.5 Fishery Information

fishery-information

Include: Important features of current fishery and relevant history of fishery.

Rockfish example: The rockfish fishery off the U.S. Pacific coast first developed off California in the late 19th century as a hook-and-line fishery (Love et al. 2002).
The rockfish trawl fishery was established in the early 1940s, when the United States became involved in World War II and wartime shortage of red meat created an increased demand for other sources of protein (Harry and Morgan 1961, Alverson et al. 1964). Etc. . . .

## 1.6 Summary of Management History

summary-of-management-history

Include: Summary of management history (e.g., changes in mesh sizes, trip limits, or other management actions that may have significantly altered selection, catch rates, or discards).

## 1.7 Management Performance

management-performance-1

Include: Management performance, including a table or tables comparing Overfishing Limit (OFL), Annual Catch Limit (ACL), Harvest Guideline (HG) [CPS only], landings, and catch (i.e., landings plus discard) for each area and year.

Management performance table: (Table k)
A summary of these values as well as other base case summary results can be found in Table o.

## 1.8 Fisheries off Canada, Alaska, and/or Mexico

fisheries-off-canada-alaska-andor-mexico

Include if necessary.

# 2 Data

data

Data used in the Northern and Southern yellowtail rockfish assessments are summarized in Figures 3 and 3.

Data sources for the two models are largely distinct. Northern fisheries and surveys had very sparse data (if any) for the south and vice-versa. Among the 12 data sources referenced below, only 2 data sources are common to both models. These are the MRFSS/RecFIN recreational dockside survey, which focuses on California and Oregon, and the CalCOM California commercial dataset, which contributed data from the northern-most California counties (Eureka and Del Norte) to the Northern model. The CalCOM data account for less than five percent of the commercial landings in the Northern model, and less than 1% of the biological samples.

Commercial landings are not differentiated in either model. For the Northern model, this is due to the very small portion (1.15 %) of the landings that are attributed to non-trawl gear. For the Southern model, this is due to the paucity of data.

A description of each model's data sources follows.

## 2.1 Northern Model Data

northern-model-data

### 2.1.1 Commercial Fishery Landings

commercial-fishery-landings

**Washington Catch Information**

The Washington Department of Fisheries and Wildlife (WDFW) provided historical yellowtail catch for 1889–1980. Landings for 1981-2016 came from the Pacific Fisheries Information Network (PacFIN) database. WDFW also provided catches for the period 1981 – 2016 to include the re-distribution of the unspeciated "URCK" landings in PacFIN; this information is currently not available from PacFIN.

**Oregon Catch Information**

The Oregon Department of Fisheries and Wildlife (ODFW) provided historical yellowtail catch from 1892-1985. ODFW also provided estimates of yellowtail rockfish in the in the un-speciated PacFIN "URCK" and "POP1" catch categories for recent years, and those estimates were combined with PacFIN landings for 1986-2016.

**Northern California Catch**

The California Commercial Fishery Database (CalCOM) provided landings for the Northern model for the two counties north of 40.10 (Eureka and Del Norte) for 1969-2016.

**Hake Bycatch**

The Alaska Fisheries Science Center (AFSC) provided data for yellowtail bycatch in the hake fishery from 1976-2016.

### 2.1.2 Sport Fishery Removals

sport-fishery-removals

**Washington Sport Catch**

WDFW provided recreational catches for 1967 and 1975-2016.

**Oregon Sport Catch**

ODFW provided recreational catch data for 1979-2016.

### 2.1.3 Estimated Discards

estimated-discards

**Commercial Discards**

The West Coast Groundfish Observing Program (WCGOP) is an onboard observer program that has extensively surveyed fishing practices since 2002, with nearly 100% observer coverage in the trawl sector in recent years. WCGOP provided discard ratios for yellowtail rockfish from 2002 to 2015.

**Pikitch Study**

The Pikitch study was conducted between 1985 and 1987 (Pikitch et al. 1988). The northern and southern boundaries of the study were 48°42′ N latitude and 42°60′ N. latitude respectively, which is primarily within the Columbia INPFC area (Pikitch et al. 1988 , Rogers and Pikitch 1992).

Participation in the study was voluntary and included vessels using bottom, midwater, and shrimp trawl gears. Observers of normal fishing operations on commercial vessels collected the data, estimated the total weight of the catch by tow and recorded the weight of species retained and discarded in the sample.

Pikitch study discards were aggregated due to small sample size and included in the data as representing a single year mid-way through the study.

### 2.1.4 Abundance Indices

`abundance-indices`

**Commercial Logbook CPUE**

The commercial logbook (fish-ticket) data in PacFIN was used to generate an index for the years 1987-1998, a period in which management of the fishery was stable, i.e., regulations weren“t changing fishery practices.

**Hake Bycatch Index**

The Hake bycatch data provided by AFSC was used to generate an index of abundance for 1985-1999.

**Pikitch Study**

The Pikitch data referenced above provided an index for years 1981-91.

### 2.1.5 Fishery-Independent Data

`fishery-independent-data`

**Northwest Fisheries Science Center (NWFSC) shelf-slope survey**

This survey, referred to as the “NWFSCcombo Survey”, has been conducted annually since 2003. The survey consistently covers depths between 30 and 700 fm.

Data from this survey for yellowtail rockfish was available for 2003-2016, and provided an index in addition to length and age data.

**Alaska Fisheries Science Center (AFSC) shelf survey**

The survey, often referred to as the “Triennial Survey”” was conducted by the AFSC every third year between 1977 and 2001, (and was conducted in 2004 by the NWFSC using the same protocols). The Triennial Survey trawled in depths of 30 to 275 fm.

The Triennial Survey provided yellowtail rockfish length and age data, as well as an index of abundance from 1997-2004.

### 2.1.6 Biological Samples

biological-samples

**Length And Age Compositions**

Length composition data were compiled from PacFIN for Oregon and Washington for the Northern model and combined with raw (unexpanded) length data from CalCOM for the two California counties north of 40.10 (Eureka and Del Norte counties).

Note that sample-sizes are the number of fish for recreational sources (since "tow" data is missing for most sources, we prefer to let each fish represent itself), and for commercial and survey data model input sample sizes are calculated as:

SampleSize = Ntows + 0.138 if Nfish/Ntows $<$ 44; Ntows * 7.06 otherwise (Ian Stewart, pers. comm.)

Length compositions were provided from the following sources:

Table 1: Summary of the time series of lengths used in the stock assessment.

tab:Length_sources

| Source | Type | Lengths | Tows | Years |
|---|---|---|---|---|
| PacFIN | commercial | 186161 | 3830 | 1968-2016 |
| CalCOM | commercial | 2340 | | 1978-2015 |
| MRFSS | recreational | 4125 | | 1980-2003 |
| RecFIN | recreational | 432 | | 2004-2016 |
| WASport | recreactional | 11099 | | 1975-2015 |
| Triennial | survey | 16262 | 465 | 1977-2004 |
| NWFSCcombo | survey | 940 | 564 | 2004-2016 |

Model input sample-sizes for age data were calculated according to the same algorithm as for lengths, except that the conditional age-at-length sample sizes are the number of fish, regardless of the source of the data.

Age structure data were available from the following sources:

Table 2: Summary of the time series of age data used in the stock assessment.
tab:Age_sources

| Source | Type | Ages | Tows | Years |
|---|---|---|---|---|
| PacFIN | commercial | 138854 | | 1972-2016 |
| CalCOM | commercial | 3546 | | 1980-2002 |
| WASport | recreational | 4027 | | 1997-2016 |
| Triennial | survey | 6553 | 278 | 1997-2004 |
| NWFSCcombo | survey | 2990 | 544 | 2003-2016 |

## 2.2 Southern Model Data

southern-model-data

### 2.2.1 Commercial Fishery Landings

commercial-fishery-landings-1

**California Commercial Landings**
The California Commercial Fishery Database (CalCOM) provide landings in California south of 40.10 for 1969-2016.

### 2.2.2 Sport Fishery Removals

sport-fishery-removals-1

**MRFSS Estimates and RecFIN**
CDFW provided estimated yellowtail removals for the MRFSS period 1980-1989, 1993-2003. RecFIN provided landings for 2004-2016.

**Small Research Study** A small number of fish were collected from the recreational fishery by the Southwest Fisheries Science Center and are included in the data for 1978-1984.

### 2.2.3 Estimated Discards

estimated-discards-1

No discard data were available for the Southern model.

### 2.2.4 Abundance Indices

abundance-indices-1

**MRFSS Index**
An index of abundance was developed from trip-aggregated MRFSS data for the years 1980-1989, 1992-2003.

**California Onboard Survey**
An Onboard recreational survey provided data for an index of abundance provided by the SWFSC for 1987-2016.

### 2.2.5 Fishery-Independent Data

fishery-independent-data-1

**Hook and Line Survey**

The NWFSC Hook and Line survey provided data for an index in the Southern California Bight from 2004-2016.

### 2.2.6 Biological Samples

biological-samples-1

Length composition samples were available for the Southern model from 5 sources, and ages from 3.

Note that sample-sizes are the number of fish for recreational sources (since "tow" data is missing for most sources, we prefer to let each fish represent itself), and for commercial and survey data model input sample sizes are calculated as:

SampleSize = Ntows + 0.138 if Nfish/Ntows < 44; Ntows * 7.06 otherwise (Ian Stewart, pers. comm.)

Length compositions were provided from the following sources:

Table 3: Summary of the time series of lengths used in the stock assessment.

tab:Length_sources

| Source | Type | Lengths | Tows | Years |
|---|---|---|---|---|
| CalCOM | commercial | 4836 | 1294 | 1978-2015 |
| MRFSS | recreational | 39425 | | 1980-2003 |
| RecFIN | recreational | 49136 | | 2004-2016 |
| Onboard | recreational | 76740 | | 1987-2016 |
| Small Study | recreational | 909 | | 1978-1984 |
| Hook and Line | survey | 1339 | 174 | 2004-2016 |

Model input sample-sizes for age data were calculated according to the same algorithm as for lengths, except that the conditional age-at-length sample sizes are the number of fish, regardless of the source of the data.

Age structure data were available from the following sources:

Table 4: Summary of the time series of age data used in the stock assessment.

tab:Age_sources

| Source | Type | Ages | Years |
|---|---|---|---|
| CalCOM | commercial | 7875 | 1980-2004 |
| Small Study | recreational | 400 | 1978-1984 |
| Hook and Line | survey | 248 | 2004 |

## 2.3 Biological Parameters Common to Both Models

`biological-parameters-common-to-both-models`

### Aging Precision And Bias

Age error matrices were developed for double-reads at the PFMC aging lab in Newport, OR and for double reads within the WDFW aging lab. The Newport lab has done all of the Survey aging for the NWFSC, along with some commercial ages and the 400 fish from the Small Study. WDFW provided the bulk of recreational and commercial ages. Between-lab differences in aging were minute, as were within-lab differences.

### Weight-Length

The weight-length relationship is based on the standard power function: $W = \alpha(L^{\beta})$ where $W$ is individual weight (kg), $L$ is length (cm), and $\alpha$ and $\beta$ are coefficients used as constants.

To estimate this relationship, 12,778 samples with both weight and length measurements from the fishery independent surveys were analyzed. These included 6,354 samples from the NWFSC Combo survey, 5,085 from the Triennial survey, and 1,339 from the Hook and Line survey. All Hook and Line survey samples were from the Southern area, along with 910 samples from the other two surveys (Figure 43). A single weight-length relationship was chosen for females and males in both areas after examining various factors that may influence this relationships, including sex, area, year, and season. None of these factors had a strong influence in the overall results. Season was one of the bigger factors, with fish sampled later in the year showing a small increase in weight at a given length (2-6% depending on the other factors considered). However, season was confounded with area because most of the samples from the Southern area were collected from the Hook and Line survey which takes place later in the year (mid-September to mid-November) and the resolution of other data in the model do not support modeling the stock at a scale finer than a annual time step. Males and females did not show strong differences in either area, and the estimated differences were in opposite directions for the two areas, suggesting that this might be a spurious relationship or confounded with differences timing of the sampling relative to spawning.

The estimated coefficients resulting from this analysis were $\alpha = 1.1843e-05$ and $\beta = 3.0672$.

**Maturity And Fecundity** Maturity was estimated from histological analysis of

141 samples collected in 2016. These include 96 from the NWFSC Combo survey, 25 from mid-water catches in the NWFSC acoustic/trawl survey, 13 from the Hook and Line survey, and 7 from Oregon Department of Fish and Wildlife. The sample sizes were not adequate to estimate differences in maturity by area. Length at 50% maturity was estimated at 42.49cm (Figure **??**) which was consistent with the range 37-45cm cited in the previous assessment (Wallace and Lai 2005).

#### Natural Mortality

Natural mortality estimates used as priors for the Northern model and as fixed values for the Southern model were provided by Owen Hamel (pers. comm.).

#### Sex ratios

The largest fish seen in the data are females, however the oldest are males. The sex ratio falls off differently in each model, as can be seen in Figs(x,y).

### 2.3.1 Environmental Or Ecosystem Data Included In The Assessment

`environmental-or-ecosystem-data-included-in-the-assessment`

No environmental index is present in either model.

# 3 Assessment

`assessment`

## 3.1 History Of Modeling Approaches Used For This Stock

`history-of-modeling-approaches-used-for-this-stock`

### 3.1.1 Previous Assessments

`previous-assessments`

### 3.1.2 Previous Assessment Recommendations

`previous-assessment-recommendations`

Include: Response to STAR panel recommendations from the most recent previous assessment.

**Recommendation 1: blah blah blah.**

STAT response: blah blah blah....

**Recommendation 2: blah blah blah.**

STAT response: blah blah blah....

**Recommendation 3: blah blah blah., etc.**

STAT response: Continue recommendations as needed

## 3.2 Model Description

model-description

### 3.2.1 Transition To The Current Stock Assessment

transition-to-the-current-stock-assessment

Include: Complete description of any new modeling approaches

Below, we describe the most important changes made since the last full assessment and explain rationale for each change.:

1. Change No. 1. *Rationale*: blah blah blah.
2. Change No. 2. *Rationale*: blah blah blah.
3. Change No. 3. *Rationale*: Continue list as needed.

### 3.2.2 Definition of Fleets and Areas

definition-of-fleets-and-areas

We generated data sources for each of the models. Fleets by model include:

**Model Region 1 or remove this line if only one model**

*Commercial*: The commercial fleets include…

*Recreational*: The recreational fleets include…

*Research*: Research derived-data include…

### 3.2.3 Summary of Data for Fleets and Areas

summary-of-data-for-fleets-and-areas

### 3.2.4 Modeling Software

modeling-software

The STAT team used Stock Synthesis 3 version 3.24u by Dr. Richard Methot at the NWFSC. This most recent version (SS-V3.24u) was used, since it included improvements and corrections to older versions.

### 3.2.5 Data Weighting

data-weighting

Citation for Francis method (Francis 2011)
Citation for Ianelli-McAllister harmonic mean method (McAllister and Ianelli 1997)

### 3.2.6 Priors

`priors`

Citation for Hamel prior on natural mortality (Hamel 2015)

### 3.2.7 General Model Specifications

`general-model-specifications`

Citation for posterior predictive fecundity relationship from Dick (2009)
Model data, control, starter, and forecast files can be found in Appendices A-D.

### 3.2.8 Estimated And Fixed Parameters

`estimated-and-fixed-parameters`

A full list of all estimated and fixed parameters is provided in Tables.... Estimated and fixed parameters tables currently read in from .csv file, EXAMPLE: Table **??**

## 3.3 Model Selection and Evaluation

`model-selection-and-evaluation`

### 3.3.1 Key Assumptions and Structural Choices

`key-assumptions-and-structural-choices`

Include: Evidence of search for balance between model realism and parsimony.
Comparison of key model assumptions, include comparisons based on nested models (e.g., asymptotic vs. domed selectivities, constant vs. time-varying selectivities).

### 3.3.2 Alternate Models Considered

`alternate-models-considered`

Include: Summary of alternate model configurations that were tried but rejected.

### 3.3.3 Convergence

`convergence`

Include: Randomization run results or other evidence of search for global best estimates.

Convergence testing through use of dispersed starting values often requires extreme values to actually explore new areas of the multivariate likelihood surface. Jitter is a SS option that generates random starting values from a normal distribution logistically transformed into each parameter's range (Methot 2015). Table 7 shows the results of running 100 jitters for each pre-STAR base model....

## 3.4 Response To The Current STAR Panel Requests

response-to-the-current-star-panel-requests

**Request No. 1: Add after STAR panel.**

**Rationale:** Add after STAR panel.

**STAT Response:** Add after STAR panel.

**Request No. 2: Add after STAR panel.**

**Rationale:** Add after STAR panel.

**STAT Response:** Add after STAR panel.

**Request No. 3: Add after STAR panel.**

**Rationale:** Add after STAR panel.

**STAT Response:** Add after STAR panel.

**Request No. 4: Example of a request that may have a list:**

- **Item No. 1**
- **Item No. 2**
- **Item No. 3, etc.**

**Rationale:** Add after STAR panel.

**STAT Response:** Continue requests as needed.

## 3.5 Model 1

model-1

### 3.5.1 Model 1 Base Case Results

model-1-base-case-results

Table **??**

### 3.5.2 Model 1 Uncertainty and Sensitivity Analyses

model-1-uncertainty-and-sensitivity-analyses

Table 8

#### 3.5.3 Model 1 Retrospective Analysis

`model-1-retrospective-analysis`

#### 3.5.4 Model 1 Likelihood Profiles

`model-1-likelihood-profiles`

#### 3.5.5 Model 1 Harvest Control Rules (CPS only)

`model-1-harvest-control-rules-cps-only`

#### 3.5.6 Model 1 Reference Points (groundfish only)

`model-1-reference-points-groundfish-only`

Intro sentence or two. . . .(Table 9).

Equilibrium yield at the proxy $F_{MSY}$ harvest rate corresponding to $SPR_{50\%}$ is 3691.6 mt. Table i shows the full suite of estimated reference points for the northern area model and Figure i shows the equilibrium yield curve.

## 3.6 Model 2

model-2

### 3.6.1 Model 2 Base Case Results

model-2-base-case-results

### 3.6.2 Model 2 Uncertainty and Sensitivity Analyses

model-2-uncertainty-and-sensitivity-analyses

### 3.6.3 Model 2 Retrospective Analysis

model-2-retrospective-analysis

### 3.6.4 Model 2 Likelihood Profiles

model-2-likelihood-profiles

### 3.6.5 Model 2 Harvest Control Rules (CPS only)

model-2-harvest-control-rules-cps-only

### 3.6.6 Model 2 Reference Points (groundfish only)

model-2-reference-points-groundfish-only

## 3.7 Model 3

model-3

### 3.7.1 Model 3 Base Case Results

model-3-base-case-results

### 3.7.2 Model 3 Uncertainty and Sensitivity Analyses

model-3-uncertainty-and-sensitivity-analyses

### 3.7.3 Model 3 Retrospective Analysis

model-3-retrospective-analysis

### 3.7.4 Model 3 Likelihood profiles

model-3-likelihood-profiles

### 3.7.5 Model 3 Harvest Control Rules (CPS only)

model-3-harvest-control-rules-cps-only

### 3.7.6 Model 3 Reference Points (groundfish only)

model-3-reference-points-groundfish-only

# 4 Harvest Projections and Decision Tables

harvest-projections-and-decision-tables

Table k

**Model 1 Projections and Decision Table (groundfish only)** (Table 10

Table m

**Model 2 Projections and Decision Table (groundfish only)**

**Model 3 Projections and Decision Table (groundfish only)**

# 5 Regional Management Considerations

`regional-management-considerations`

1. For stocks where current practice is to allocate harvests by management area, a recommended method of allocating harvests based on the distribution of biomass should be provided. The MT advisor should be consulted on the appropriate management areas for each stock.
2. Discuss whether a regional management approach makes sense for the species from a biological perspective.
3. If there are insufficient data to analyze a regional management approach, what are the research and data needs to answer this question?

# 6 Research Needs

`research-needs`

1. Research need No. 1
2. Research need No. 2
3. Research need No. 3
4. etc.

# 7 Acknowledgments

`acknowledgments`

Include: STAR panel members and affiliations as well as names and affiliations of persons who contributed data, advice or information but were not part of the assessment team. Not required in draft assessment undergoing review.

# 8 Tables

tables

Table 5: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD).

| No. | Parameter | Value | Phase | Bounds | Status | SD | Prior (Exp.Val, SD) |
|---|---|---|---|---|---|---|---|
| 1 | NatM_p_1_Fem_GP_1 | 0.141 | 2 | (0.02, 0.25) | OK | 0.009 | None |
| 2 | L_at_Amin_Fem_GP_1 | 14.879 | 3 | (1, 25) | OK | 0.575 | None |
| 3 | L_at_Amax_Fem_GP_1 | 53.827 | 2 | (35, 70) | OK | 0.235 | None |
| 4 | VonBert_K_Fem_GP_1 | 0.137 | 3 | (0.1, 0.4) | OK | 0.004 | None |
| 5 | CV_young_Fem_GP_1 | 0.101 | 5 | (0.03, 0.16) | OK | 0.010 | None |
| 6 | CV_old_Fem_GP_1 | 0.043 | 5 | (0.03, 0.16) | OK | 0.003 | None |
| 7 | Wtlen_1_Fem | 0.000 | -50 | (0, 3) | | | None |
| 8 | Wtlen_2_Fem | 3.067 | -50 | (2, 4) | | | None |
| 9 | Mat50%_Fem | 42.490 | -50 | (30, 56) | | | None |
| 10 | Mat_slope_Fem | -0.401 | -50 | (-2, 1) | | | None |
| 11 | Eggs_scalar_Fem | 0.000 | -50 | (0, 6) | | | None |
| 12 | Eggs_exp_len_Fem | 4.590 | -50 | (2, 7) | | | None |
| 13 | NatM_p_1_Mal_GP_1 | -0.142 | 2 | (-3, 3) | OK | 0.017 | None |
| 14 | L_at_Amin_Mal_GP_1 | 0.000 | -2 | (-1, 1) | | | None |
| 15 | L_at_Amax_Mal_GP_1 | -0.148 | 2 | (-1, 1) | OK | 0.005 | None |
| 16 | VonBert_K_Mal_GP_1 | 0.369 | 3 | (-1, 1) | OK | 0.027 | None |
| 17 | CV_young_Mal_GP_1 | 0.000 | -5 | (-1, 1) | | | None |
| 18 | CV_old_Mal_GP_1 | 0.172 | 5 | (-1, 1) | OK | 0.070 | None |
| 19 | Wtlen_1_Mal | 0.000 | -50 | (0, 3) | | | None |
| 20 | Wtlen_2_Mal | 3.067 | -50 | (2, 4) | | | None |
| 24 | CohortGrowDev | 1.000 | -50 | (0, 2) | | | None |
| 25 | FracFemale_GP_1 | 0.500 | -99 | (0.001, 0.999) | | | None |
| 26 | SR_LN(R0) | 10.181 | 1 | (5, 20) | OK | 0.158 | None |
| 27 | SR_BH_steep | 0.718 | -6 | (0.2, 1) | | | None |
| 28 | SR_sigmaR | 0.546 | -6 | (0.5, 1.2) | | | None |
| 29 | SR_regime | 0.000 | -50 | (-5, 5) | | | None |

Continued on next page

Table 5: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD).

| No. | Parameter | Value | Phase | Bounds | Status | SD | Prior (Exp.Val, SD) |
|---|---|---|---|---|---|---|---|
| 30 | SR_autocorr | 0.000 | -50 | (0, 2) | | | None |
| 140 | LnQ_base_CommercialTrawl(1) | -4.397 | -1 | (-30, 15) | | | None |
| 141 | LnQ_base_HakeByCatch(2) | -9.820 | -1 | (-30, 15) | | | None |
| 142 | Q_extraSD_HakeByCatch(2) | 0.278 | 1 | (0, 0.5) | OK | 0.083 | None |
| 143 | LnQ_base_Triennial(5) | -1.003 | -1 | (-30, 15) | | | None |
| 144 | LnQ_base_NWFSCcombo(6) | -0.559 | -1 | (-30, 15) | | | None |
| 145 | SizeSel_P1_CommercialTrawl(1) | 48.717 | 1 | (20, 55) | OK | 0.724 | None |
| 146 | SizeSel_P2_CommercialTrawl(1) | 70.000 | -4 | (-20, 70) | | | None |
| 147 | SizeSel_P3_CommercialTrawl(1) | 4.296 | 3 | (-5, 20) | OK | 0.095 | None |
| 148 | SizeSel_P4_CommercialTrawl(1) | 70.000 | -4 | (-5, 70) | | | None |
| 149 | SizeSel_P5_CommercialTrawl(1) | -999.000 | -99 | (-999, 25) | | | None |
| 150 | SizeSel_P6_CommercialTrawl(1) | -999.000 | -99 | (-999, 25) | | | None |
| 151 | Retain_P1_CommercialTrawl(1) | 24.506 | 3 | (20, 55) | OK | 3.272 | None |
| 152 | Retain_P2_CommercialTrawl(1) | 1.597 | 3 | (0.1, 40) | OK | 0.700 | None |
| 153 | Retain_P3_CommercialTrawl(1) | 3.070 | 3 | (-10, 20) | OK | 0.706 | None |
| 154 | Retain_P4_CommercialTrawl(1) | 0.000 | -4 | (-3, 3) | | | None |
| 155 | SizeSel_P1_HakeByCatch(2) | 52.341 | 1 | (20, 55) | OK | 0.878 | None |
| 156 | SizeSel_P2_HakeByCatch(2) | 70.000 | -4 | (-20, 70) | | | None |
| 157 | SizeSel_P3_HakeByCatch(2) | 4.301 | 3 | (-5, 20) | OK | 0.113 | None |
| 158 | SizeSel_P4_HakeByCatch(2) | 70.000 | -4 | (-5, 70) | | | None |
| 159 | SizeSel_P5_HakeByCatch(2) | -999.000 | -99 | (-999, 25) | | | None |
| 160 | SizeSel_P6_HakeByCatch(2) | -999.000 | -99 | (-999, 25) | | | None |
| 161 | SizeSel_P1_RecORandCA(3) | 30.578 | 1 | (20, 55) | OK | 0.710 | None |
| 162 | SizeSel_P2_RecORandCA(3) | -19.161 | 4 | (-20, 7) | OK | 3239.790 | None |
| 163 | SizeSel_P3_RecORandCA(3) | 3.117 | 3 | (-5, 20) | OK | 0.237 | None |
| 164 | SizeSel_P4_RecORandCA(3) | 6.734 | 4 | (-5, 20) | OK | 0.566 | None |
| 165 | SizeSel_P5_RecORandCA(3) | -999.000 | -99 | (-999, 25) | | | None |

Continued on next page

Table 5: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD).

| No. | Parameter | Value | Phase | Bounds | Status | SD | Prior (Exp.Val, SD) |
|---|---|---|---|---|---|---|---|
| 166 | SizeSel_P6_RecORandCA(3) | -999.000 | -99 | (-999, 25) | | | None |
| 167 | SizeSel_P1_RecWA(4) | 28.338 | 6 | (20, 55) | OK | 0.950 | None |
| 168 | SizeSel_P2_RecWA(4) | 70.000 | -4 | (-20, 70) | | | None |
| 169 | SizeSel_P3_RecWA(4) | -1.407 | 6 | (-5, 20) | OK | 2.463 | None |
| 170 | SizeSel_P4_RecWA(4) | 70.000 | -4 | (-5, 70) | | | None |
| 171 | SizeSel_P5_RecWA(4) | -999.000 | -99 | (-999, 25) | | | None |
| 172 | SizeSel_P6_RecWA(4) | -999.000 | -99 | (-999, 25) | | | None |
| 173 | SizeSel_P1_Triennial(5) | 54.364 | 1 | (20, 55) | OK | 3.966 | None |
| 174 | SizeSel_P2_Triennial(5) | 70.000 | -4 | (-20, 70) | | | None |
| 175 | SizeSel_P3_Triennial(5) | 5.128 | 3 | (-5, 20) | OK | 0.308 | None |
| 176 | SizeSel_P4_Triennial(5) | 70.000 | -4 | (-5, 70) | | | None |
| 177 | SizeSel_P5_Triennial(5) | -999.000 | -99 | (-999, 25) | | | None |
| 178 | SizeSel_P6_Triennial(5) | -999.000 | -99 | (-999, 25) | | | None |
| 179 | SizeSel_P1_NWFSCcombo(6) | 49.696 | 1 | (20, 55) | OK | 2.906 | None |
| 180 | SizeSel_P2_NWFSCcombo(6) | 70.000 | -4 | (-20, 70) | | | None |
| 181 | SizeSel_P3_NWFSCcombo(6) | 4.551 | 3 | (-5, 20) | OK | 0.433 | None |
| 182 | SizeSel_P4_NWFSCcombo(6) | 70.000 | -4 | (-5, 70) | | | None |
| 183 | SizeSel_P5_NWFSCcombo(6) | -999.000 | -99 | (-999, 25) | | | None |
| 184 | SizeSel_P6_NWFSCcombo(6) | -999.000 | -99 | (-999, 25) | | | None |
| 185 | Retain_P3_CommercialTrawl(1)_BLK1repl_2002 | 2.228 | 6 | (-10, 20) | OK | 0.457 | None |
| 186 | Retain_P3_CommercialTrawl(1)_BLK1repl_2003 | 3.708 | 6 | (-10, 20) | OK | 0.756 | None |
| 187 | Retain_P3_CommercialTrawl(1)_BLK1repl_2004 | 1.128 | 6 | (-10, 20) | OK | 0.522 | None |
| 188 | Retain_P3_CommercialTrawl(1)_BLK1repl_2005 | -0.115 | 6 | (-10, 20) | OK | 0.400 | None |
| 189 | Retain_P3_CommercialTrawl(1)_BLK1repl_2006 | 1.760 | 6 | (-10, 20) | OK | 0.260 | None |
| 190 | Retain_P3_CommercialTrawl(1)_BLK1repl_2007 | -0.516 | 6 | (-10, 20) | OK | 0.625 | None |
| 191 | Retain_P3_CommercialTrawl(1)_BLK1repl_2008 | 2.373 | 6 | (-10, 20) | OK | 0.820 | None |
| 192 | Retain_P3_CommercialTrawl(1)_BLK1repl_2009 | 0.480 | 6 | (-10, 20) | OK | 0.495 | None |

Continued on next page

Table 5: List of parameters used in the base model, including estimated values and standard deviations (SD), bounds (minimum and maximum), estimation phase (negative values indicate not estimated), status (indicates if parameters are near bounds, and prior type information (mean, SD).

| No. | Parameter | Value | Phase | Bounds | Status | SD | Prior (Exp.Val, SD) |
|---|---|---|---|---|---|---|---|
| 193 | Retain_P3_CommercialTrawl(1)_BLK1repl_2010 | 0.159 | 6 | (-10, 20) | OK | 0.678 | None |
| 194 | Retain_P3_CommercialTrawl(1)_BLK1repl_2011 | 7.327 | 6 | (-10, 20) | OK | 0.670 | None |

tab:model_params

Table 6: Summary of the biomass/abundance time series used in the stock assessment.

tab:Index_summary

| Region | ID | Fleet | Years | Name | Fishery ind. | Filtering | Method | Endorsed |
|---|---|---|---|---|---|---|---|---|
| WA | 1 | 4 | 1981-2014 | Dockside CPUE | No | trip, area, month, Stephens-MacCall | delta-GLM (bin-gamma) | SSC |
| - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - |

Table 7: Results from 100 jitters from each of the three models.

tab:jitter

| Status | Model.1 | Model.2 | Model.3 |
|---|---|---|---|
| Returned to base case | - | - | - |
| Found local minimum | - | - | - |
| Found better solution | - | - | - |
| Error in likelihood | - | - | - |
| Total | 100 | 100 | 100 |

Table 9: Time-series of population estimates from the base-case model.

| Yr | Total biomass (mt) | Spawning biomass (mt) | Depletion | Age-0 recruits | Total catch (mt) | Relative exploitation rate | SPR |
|---|---|---|---|---|---|---|---|
| 1889 | 128998 | 15 | 0.00 | 26416 | 0 | 0.00 | 1.00 |
| 1890 | 128998 | 15 | 1.00 | 26416 | 0 | 0.00 | 1.00 |
| 1891 | 128997 | 15 | 1.00 | 26416 | 0 | 0.00 | 1.00 |
| 1892 | 128977 | 15 | 1.00 | 26416 | 2 | 0.00 | 1.00 |
| 1893 | 128980 | 15 | 1.00 | 26416 | 2 | 0.00 | 1.00 |
| 1894 | 128980 | 15 | 1.00 | 26416 | 2 | 0.00 | 1.00 |
| 1895 | 128994 | 15 | 1.00 | 26416 | 1 | 0.00 | 1.00 |
| 1896 | 128998 | 15 | 1.00 | 26416 | 0 | 0.00 | 1.00 |
| 1897 | 128998 | 15 | 1.00 | 26416 | 0 | 0.00 | 1.00 |
| 1898 | 128998 | 15 | 1.00 | 26416 | 0 | 0.00 | 1.00 |
| 1899 | 128998 | 15 | 1.00 | 26416 | 0 | 0.00 | 1.00 |
| 1900 | 128997 | 15 | 1.00 | 26416 | 0 | 0.00 | 1.00 |
| 1901 | 128997 | 15 | 1.00 | 26416 | 0 | 0.00 | 1.00 |
| 1902 | 128996 | 15 | 1.00 | 26416 | 0 | 0.00 | 1.00 |
| 1903 | 128996 | 15 | 1.00 | 26416 | 0 | 0.00 | 1.00 |
| 1904 | 128993 | 15 | 1.00 | 26416 | 1 | 0.00 | 1.00 |
| 1905 | 128995 | 15 | 1.00 | 26416 | 0 | 0.00 | 1.00 |
| 1906 | 128995 | 15 | 1.00 | 26417 | 1 | 0.00 | 1.00 |
| 1907 | 128994 | 15 | 1.00 | 26417 | 1 | 0.00 | 1.00 |
| 1908 | 128992 | 15 | 1.00 | 26417 | 1 | 0.00 | 1.00 |
| 1909 | 128993 | 15 | 1.00 | 26417 | 1 | 0.00 | 1.00 |
| 1910 | 128993 | 15 | 1.00 | 26417 | 1 | 0.00 | 1.00 |
| 1911 | 128992 | 15 | 1.00 | 26417 | 1 | 0.00 | 1.00 |
| 1912 | 128992 | 15 | 1.00 | 26417 | 1 | 0.00 | 1.00 |
| 1913 | 128991 | 15 | 1.00 | 26417 | 1 | 0.00 | 1.00 |
| 1914 | 128991 | 15 | 1.00 | 26417 | 1 | 0.00 | 1.00 |
| 1915 | 128989 | 15 | 1.00 | 26417 | 1 | 0.00 | 1.00 |
| 1916 | 128989 | 15 | 1.00 | 26417 | 1 | 0.00 | 1.00 |
| 1917 | 128988 | 15 | 1.00 | 26417 | 1 | 0.00 | 1.00 |
| 1918 | 128963 | 15 | 1.00 | 26417 | 4 | 0.00 | 1.00 |
| 1919 | 128979 | 15 | 1.00 | 26417 | 2 | 0.00 | 1.00 |
| 1920 | 128980 | 15 | 1.00 | 26417 | 2 | 0.00 | 1.00 |
| 1921 | 128981 | 15 | 1.00 | 26417 | 2 | 0.00 | 1.00 |
| 1922 | 128983 | 15 | 1.00 | 26417 | 2 | 0.00 | 1.00 |
| 1923 | 128982 | 15 | 1.00 | 26417 | 2 | 0.00 | 1.00 |
| 1924 | 128976 | 15 | 1.00 | 26417 | 3 | 0.00 | 1.00 |
| 1925 | 128972 | 15 | 1.00 | 26417 | 3 | 0.00 | 1.00 |
| 1926 | 128963 | 15 | 1.00 | 26417 | 4 | 0.00 | 1.00 |
| 1927 | 128955 | 15 | 1.00 | 26417 | 5 | 0.00 | 1.00 |
| 1928 | 128948 | 15 | 1.00 | 26417 | 6 | 0.00 | 1.00 |

Table 9: Time-series of population estimates from the base-case model.

| Yr | Total biomass (mt) | Spawning biomass (mt) | Depletion | Age-0 recruits | Total catch (mt) | Relative exploitation rate | SPR |
|---|---|---|---|---|---|---|---|
| 1929 | 128895 | 15 | 1.00 | 26417 | 12 | 0.00 | 1.00 |
| 1930 | 128855 | 15 | 1.00 | 26417 | 16 | 0.00 | 1.00 |
| 1931 | 128906 | 15 | 1.00 | 26416 | 11 | 0.00 | 1.00 |
| 1932 | 128972 | 15 | 1.00 | 25869 | 3 | 0.00 | 1.00 |
| 1933 | 128961 | 15 | 1.00 | 25816 | 4 | 0.00 | 1.00 |
| 1934 | 128936 | 15 | 1.00 | 25755 | 7 | 0.00 | 1.00 |
| 1935 | 128911 | 15 | 1.00 | 25686 | 10 | 0.00 | 1.00 |
| 1936 | 128873 | 15 | 1.00 | 25606 | 14 | 0.00 | 1.00 |
| 1937 | 128765 | 15 | 1.00 | 25516 | 27 | 0.00 | 1.00 |
| 1938 | 128739 | 15 | 1.00 | 25415 | 30 | 0.00 | 1.00 |
| 1939 | 128664 | 15 | 1.00 | 25306 | 38 | 0.00 | 1.00 |
| 1940 | 127810 | 15 | 1.00 | 25186 | 137 | 0.00 | 0.98 |
| 1941 | 127419 | 15 | 1.00 | 25051 | 182 | 0.00 | 0.98 |
| 1942 | 126278 | 15 | 0.99 | 24902 | 316 | 0.00 | 0.96 |
| 1943 | 118201 | 15 | 0.99 | 24735 | 1363 | 0.01 | 0.85 |
| 1944 | 111879 | 14 | 0.97 | 24527 | 2291 | 0.02 | 0.77 |
| 1945 | 101159 | 14 | 0.95 | 24284 | 4177 | 0.03 | 0.63 |
| 1946 | 110770 | 13 | 0.90 | 23931 | 2315 | 0.02 | 0.75 |
| 1947 | 117634 | 13 | 0.88 | 23608 | 1304 | 0.01 | 0.85 |
| 1948 | 119213 | 13 | 0.87 | 23335 | 1094 | 0.01 | 0.87 |
| 1949 | 123621 | 13 | 0.86 | 23082 | 570 | 0.01 | 0.93 |
| 1950 | 118250 | 13 | 0.86 | 22821 | 1208 | 0.01 | 0.85 |
| 1951 | 118297 | 13 | 0.86 | 22467 | 1194 | 0.01 | 0.85 |
| 1952 | 115125 | 12 | 0.85 | 22053 | 1594 | 0.01 | 0.81 |
| 1953 | 120832 | 12 | 0.84 | 21672 | 870 | 0.01 | 0.89 |
| 1954 | 118529 | 12 | 0.84 | 21493 | 1141 | 0.01 | 0.86 |
| 1955 | 118066 | 12 | 0.83 | 21469 | 1189 | 0.01 | 0.85 |
| 1956 | 116427 | 12 | 0.82 | 21229 | 1382 | 0.01 | 0.83 |
| 1957 | 116142 | 12 | 0.82 | 20596 | 1403 | 0.01 | 0.83 |
| 1958 | 115689 | 12 | 0.81 | 20155 | 1444 | 0.01 | 0.82 |
| 1959 | 115004 | 12 | 0.80 | 21249 | 1512 | 0.01 | 0.81 |
| 1960 | 112205 | 12 | 0.79 | 26215 | 1850 | 0.02 | 0.77 |
| 1961 | 112783 | 11 | 0.77 | 34817 | 1743 | 0.02 | 0.78 |
| 1962 | 108082 | 11 | 0.76 | 28452 | 2342 | 0.02 | 0.72 |
| 1963 | 111006 | 11 | 0.74 | 20940 | 1897 | 0.02 | 0.76 |
| 1964 | 113580 | 11 | 0.72 | 18139 | 1548 | 0.02 | 0.79 |
| 1965 | 114117 | 10 | 0.71 | 17896 | 1466 | 0.02 | 0.80 |
| 1966 | 116975 | 10 | 0.70 | 18720 | 1135 | 0.01 | 0.84 |
| 1967 | 114315 | 10 | 0.70 | 21822 | 1420 | 0.01 | 0.80 |
| 1968 | 109723 | 10 | 0.70 | 32764 | 1985 | 0.02 | 0.74 |

Table 9: Time-series of population estimates from the base-case model.

| Yr | Total biomass (mt) | Spawning biomass (mt) | Depletion | Age-0 recruits | Total catch (mt) | Relative exploitation rate | SPR |
|---|---|---|---|---|---|---|---|
| 1969 | 100189 | 10 | 0.69 | 25306 | 3364 | 0.03 | 0.62 |
| 1970 | 113265 | 10 | 0.67 | 18555 | 1530 | 0.02 | 0.79 |
| 1971 | 112767 | 10 | 0.68 | 14419 | 1598 | 0.02 | 0.78 |
| 1972 | 106461 | 10 | 0.68 | 19106 | 2400 | 0.03 | 0.70 |
| 1973 | 102941 | 10 | 0.68 | 23959 | 2865 | 0.03 | 0.65 |
| 1974 | 108465 | 10 | 0.66 | 43111 | 2055 | 0.02 | 0.72 |
| 1975 | 113173 | 10 | 0.65 | 33612 | 1480 | 0.02 | 0.79 |
| 1976 | 94517 | 10 | 0.65 | 27068 | 4151 | 0.05 | 0.55 |
| 1977 | 84114 | 9 | 0.63 | 32309 | 6205 | 0.07 | 0.43 |
| 1978 | 73977 | 9 | 0.58 | 22366 | 8721 | 0.10 | 0.31 |
| 1979 | 74340 | 8 | 0.51 | 13972 | 7712 | 0.09 | 0.32 |
| 1980 | 72474 | 7 | 0.45 | 16706 | 7625 | 0.09 | 0.30 |
| 1981 | 64605 | 6 | 0.40 | 23192 | 9692 | 0.12 | 0.22 |
| 1982 | 61042 | 5 | 0.34 | 15076 | 10338 | 0.14 | 0.19 |
| 1983 | 57786 | 4 | 0.30 | 25907 | 10842 | 0.16 | 0.16 |
| 1984 | 71611 | 4 | 0.26 | 30505 | 5477 | 0.09 | 0.29 |
| 1985 | 81228 | 4 | 0.26 | 20605 | 3751 | 0.06 | 0.40 |
| 1986 | 73723 | 4 | 0.29 | 22826 | 5412 | 0.09 | 0.31 |
| 1987 | 73504 | 4 | 0.29 | 28515 | 5419 | 0.09 | 0.31 |
| 1988 | 67338 | 4 | 0.29 | 16021 | 6800 | 0.11 | 0.25 |
| 1989 | 71983 | 4 | 0.27 | 34522 | 5227 | 0.09 | 0.29 |
| 1990 | 72925 | 4 | 0.26 | 33940 | 4916 | 0.08 | 0.30 |
| 1991 | 75372 | 4 | 0.25 | 31514 | 4418 | 0.07 | 0.33 |
| 1992 | 64703 | 4 | 0.25 | 19984 | 6857 | 0.11 | 0.22 |
| 1993 | 66430 | 4 | 0.24 | 13490 | 6104 | 0.10 | 0.24 |
| 1994 | 66346 | 3 | 0.23 | 21921 | 6140 | 0.10 | 0.24 |
| 1995 | 68115 | 3 | 0.23 | 20802 | 5657 | 0.09 | 0.25 |
| 1996 | 65907 | 3 | 0.23 | 11261 | 6275 | 0.10 | 0.23 |
| 1997 | 89311 | 3 | 0.23 | 15130 | 2412 | 0.04 | 0.48 |
| 1998 | 85488 | 4 | 0.26 | 26917 | 3142 | 0.05 | 0.44 |
| 1999 | 84144 | 4 | 0.29 | 25511 | 3599 | 0.06 | 0.41 |
| 2000 | 84704 | 5 | 0.31 | 34151 | 3716 | 0.06 | 0.43 |
| 2001 | 97218 | 5 | 0.33 | 17903 | 2236 | 0.04 | 0.58 |
| 2002 | 107616 | 5 | 0.36 | 11227 | 1356 | 0.02 | 0.71 |
| 2003 | 120377 | 6 | 0.38 | 13806 | 491 | 0.01 | 0.88 |
| 2004 | 115717 | 6 | 0.41 | 17951 | 839 | 0.01 | 0.82 |
| 2005 | 105479 | 6 | 0.44 | 7619 | 1753 | 0.02 | 0.69 |
| 2006 | 120140 | 7 | 0.45 | 27431 | 565 | 0.01 | 0.88 |
| 2007 | 116755 | 7 | 0.47 | 9802 | 852 | 0.01 | 0.83 |
| 2008 | 121368 | 7 | 0.50 | 34459 | 520 | 0.01 | 0.89 |

Table 9: Time-series of population estimates from the base-case model.

| Yr | Total biomass (mt) | Spawning biomass (mt) | Depletion | Age-0 recruits | Total catch (mt) | Relative exploitation rate | SPR |
|---|---|---|---|---|---|---|---|
| 2009 | 114737 | 8 | 0.53 | 10442 | 1095 | 0.01 | 0.80 |
| 2010 | 109749 | 8 | 0.54 | 22111 | 1600 | 0.02 | 0.74 |
| 2011 | 112174 | 8 | 0.55 | 15149 | 1348 | 0.02 | 0.77 |
| 2012 | 109683 | 8 | 0.56 | 15950 | 1593 | 0.02 | 0.74 |
| 2013 | 111229 | 8 | 0.55 | 25871 | 1432 | 0.02 | 0.76 |
| 2014 | 110627 | 8 | 0.55 | 24047 | 1460 | 0.02 | 0.75 |
| 2015 | 105097 | 8 | 0.54 | 24513 | 2017 | 0.03 | 0.68 |
| 2016 | 110396 | 8 | 0.53 | 24346 | | | |

tab:Timeseries_mod1

Table 8: Sensitivity of the base model to dropping or down-weighting data sources and alternative assumptions about growth.

tab:Sensitivity_model1

| Label | Base (Francis weights) | Harmonic mean weights | Drop index | Drop ages | Down-weight lengths | Free size Age0 | Free CV Amin | External growth |
|---|---|---|---|---|---|---|---|---|
| TOTAL_like | - | - | - | - | - | - | - | - |
| Catch_like | - | - | - | - | - | - | - | - |
| Equil_catch_like | - | - | - | - | - | - | - | - |
| Survey_like | - | - | - | - | - | - | - | - |
| Length_comp_like | - | - | - | - | - | - | - | - |
| Age_comp_like | - | - | - | - | - | - | - | - |
| Parm_priors_like | - | - | - | - | - | - | - | - |
| SSB_Unfished_thousand_mt | - | - | - | - | - | - | - | - |
| TotBio_Unfished | - | - | - | - | - | - | - | - |
| SmryBio_Unfished | - | - | - | - | - | - | - | - |
| Recr_Unfished_billions | - | - | - | - | - | - | - | - |
| SSB_Btgt_thousand_mt | - | - | - | - | - | - | - | - |
| SPR_Btgt | - | - | - | - | - | - | - | - |
| Fstd_Btgt | - | - | - | - | - | - | - | - |
| TotYield_Btgt_thousand_mt | - | - | - | - | - | - | - | - |
| SSB_SPRtgt_thousand_mt | - | - | - | - | - | - | - | - |
| Fstd_SPRtgt | - | - | - | - | - | - | - | - |
| TotYield_SPRtgt_thousand_mt | - | - | - | - | - | - | - | - |
| SSB_MSY_thousand_mt | - | - | - | - | - | - | - | - |
| SPR_MSY | - | - | - | - | - | - | - | - |
| Fstd_MSY | - | - | - | - | - | - | - | - |
| TotYield_MSY_thousand_mt | - | - | - | - | - | - | - | - |
| RetYield_MSY | - | - | - | - | - | - | - | - |
| Bratio_2015 | - | - | - | - | - | - | - | - |
| F_2015 | - | - | - | - | - | - | - | - |
| SPRratio_2015 | - | - | - | - | - | - | - | - |
| Recr_2015 | - | - | - | - | - | - | - | - |
| Recr_Virgin_billions | - | - | - | - | - | - | - | - |
| L_at_Amin_Fem_GP_1 | - | - | - | - | - | - | - | - |
| L_at_Amax_Fem_GP_1 | - | - | - | - | - | - | - | - |
| VonBert_K_Fem_GP_1 | - | - | - | - | - | - | - | - |
| CV_young_Fem_GP_1 | - | - | - | - | - | - | - | - |
| CV_old_Fem_GP_1 | - | - | - | - | - | - | - | - |

Table 10: Projection of potential OFL, spawning biomass, and depletion for the base case model.

tab:Forecast_mod1

| Yr | OFL contriubtion (mt) | ACL landings (mt) | Age 5+ biomass (mt) | Spawning Biomass (mt) | Depletion |
|---|---|---|---|---|---|
| 2017 | 3988.81 | 3660.21 | 75949.10 | 7.79 | 0.53 |
| 2018 | 3840.38 | 3524.14 | 74683.90 | 7.43 | 0.51 |
| 2019 | 3712.42 | 3406.90 | 74047.40 | 7.11 | 0.48 |
| 2020 | 3611.38 | 3314.36 | 73875.00 | 6.83 | 0.46 |
| 2021 | 3544.46 | 3253.15 | 74067.80 | 6.60 | 0.45 |
| 2022 | 3513.29 | 3224.88 | 74487.30 | 6.43 | 0.44 |
| 2023 | 3512.56 | 3224.60 | 75022.20 | 6.34 | 0.43 |
| 2024 | 3532.98 | 3243.48 | 75582.80 | 6.32 | 0.43 |
| 2025 | 3564.86 | 3272.58 | 76107.30 | 6.34 | 0.43 |
| 2026 | 3600.46 | 3304.98 | 76561.10 | 6.38 | 0.43 |
| 2027 | 3634.58 | 3336.05 | 76932.40 | 6.44 | 0.44 |
| 2028 | 3664.30 | 3363.16 | 77224.20 | 6.49 | 0.44 |

# 9 Figures

figures

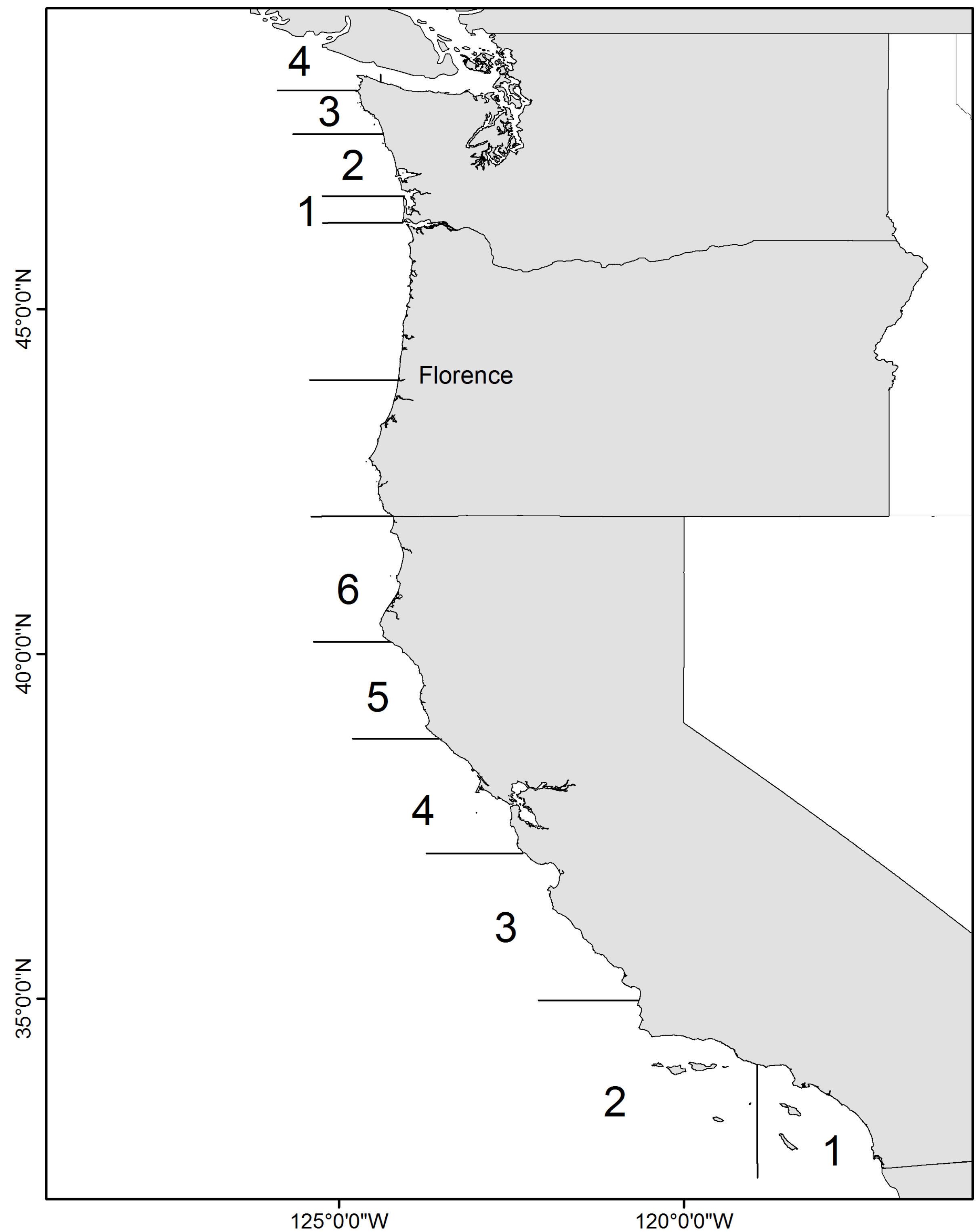



Figure 1: Map showing the state boundary lines for management of the recreational fishing fleets. CRFS Districts 1-6 in California are presented as well as the WDFW Recreational Management Areas in Washington. Florence, OR is shown as a potential location of model stratification. fig:boundary_map

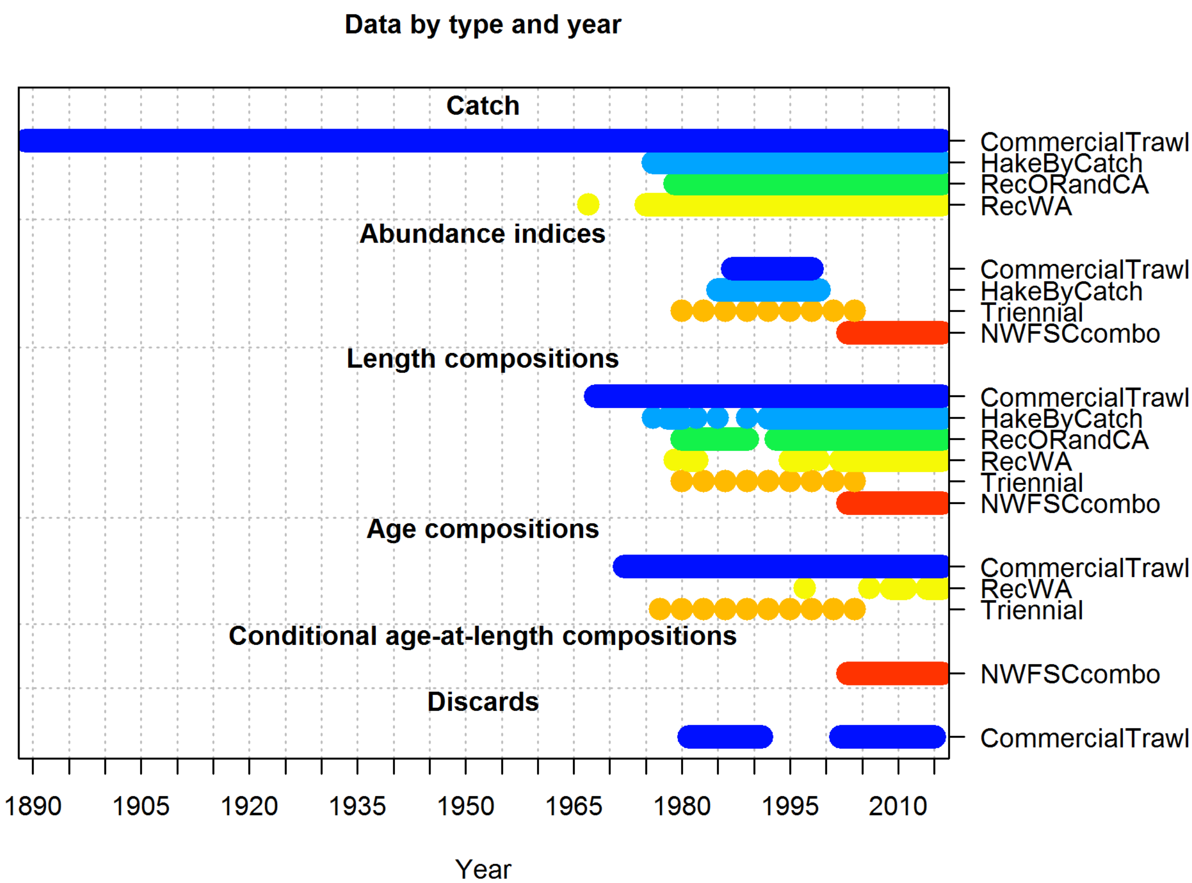



Figure 2: Summary of data sources used in the Northern model. fig:data_plot

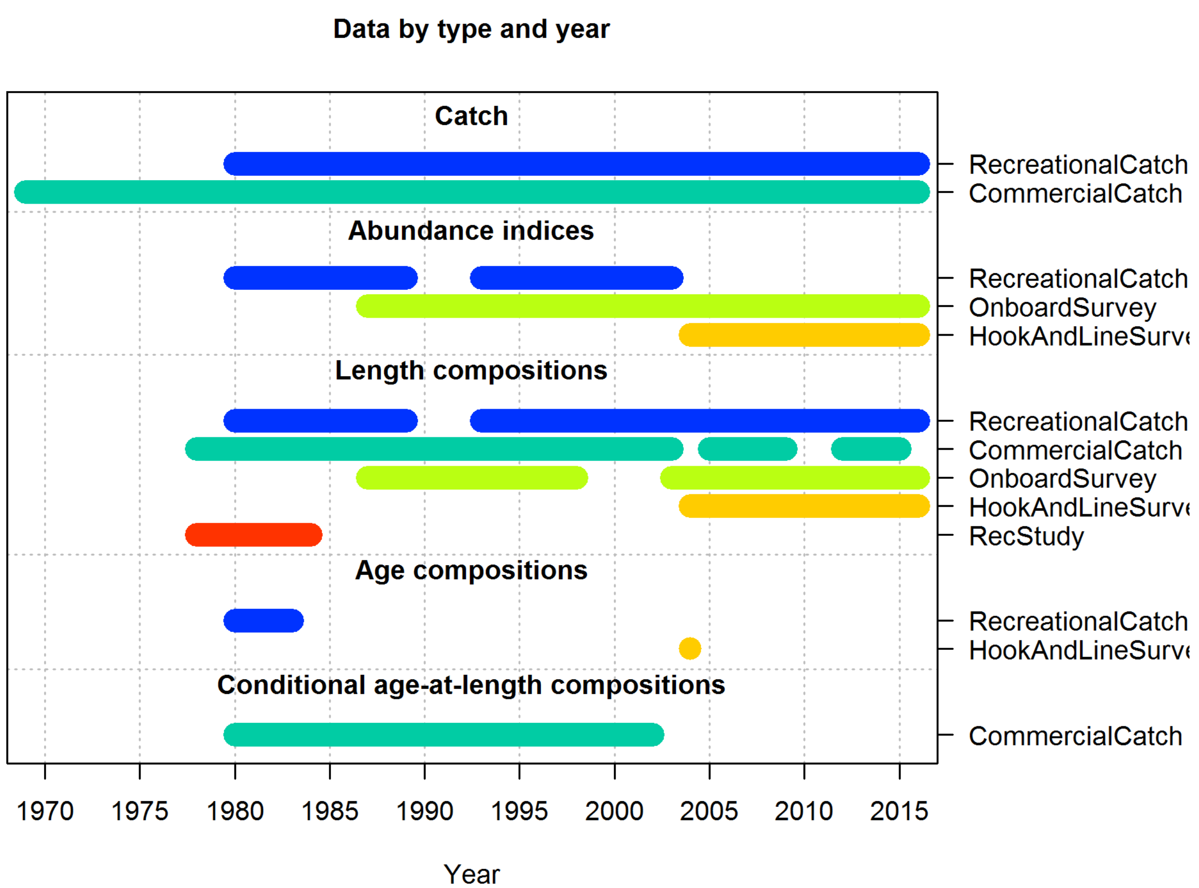



Figure 3: Summary of data sources used in the Southern model. fig:data_plot

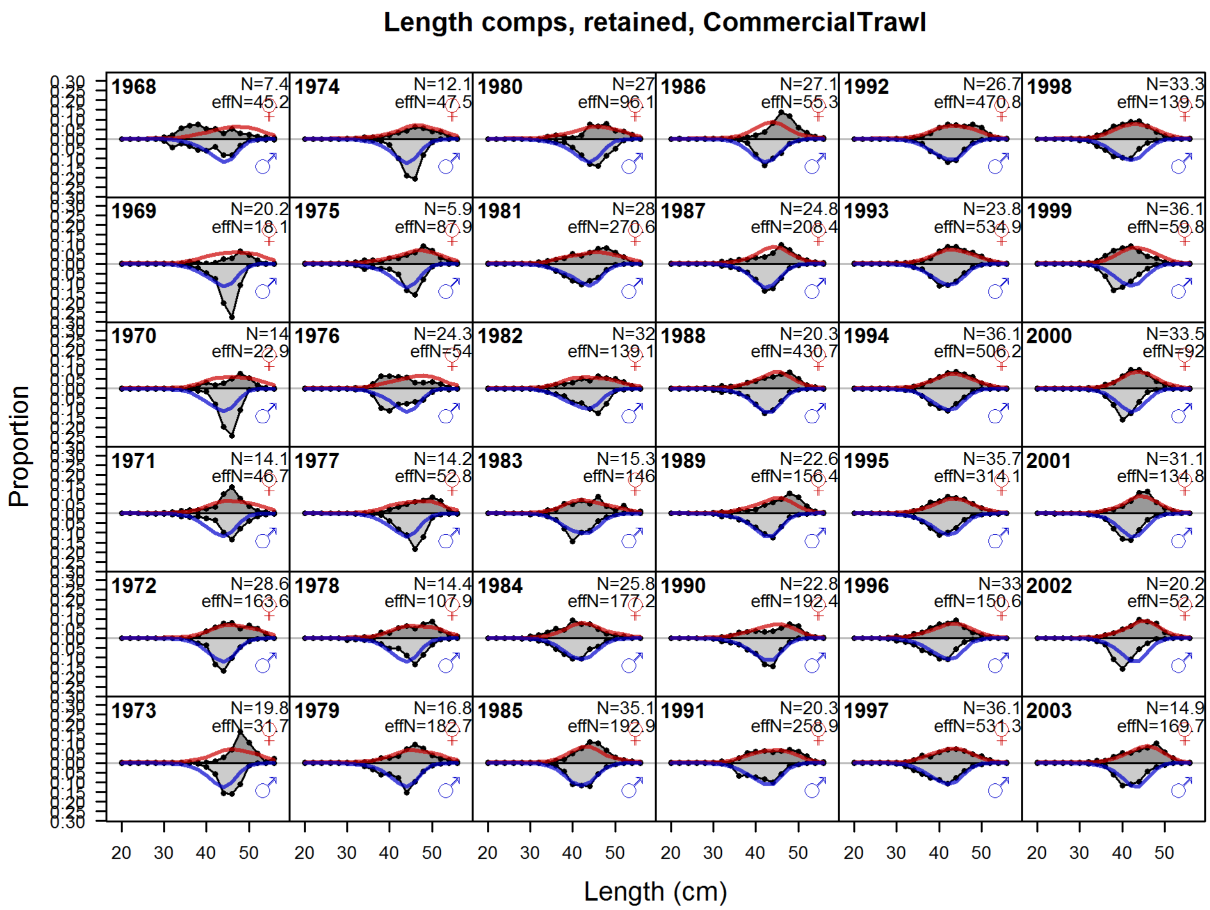
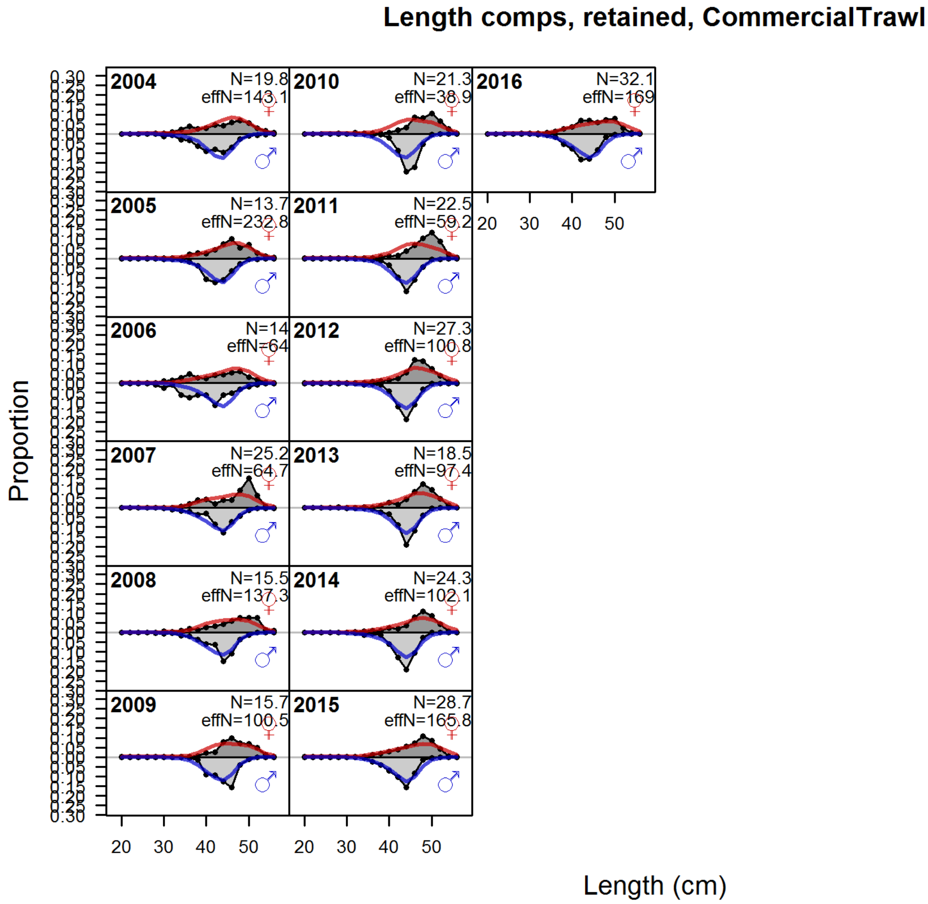



Figure 4: Length comps, retained, CommercialTrawl (plot 1 of 2) fig:mod1_1_comp_lenfit_f

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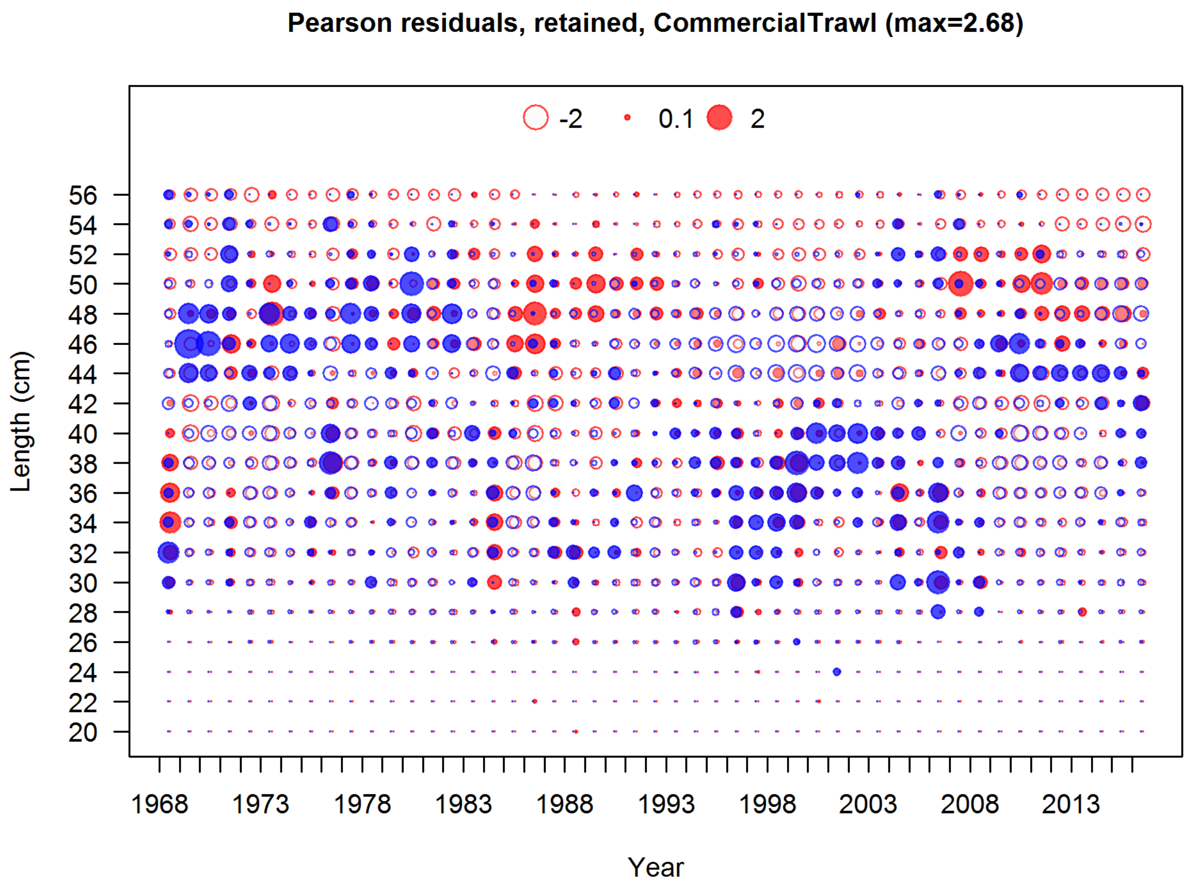
573 Figure continued from previous page

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575 Figure continued from previous page

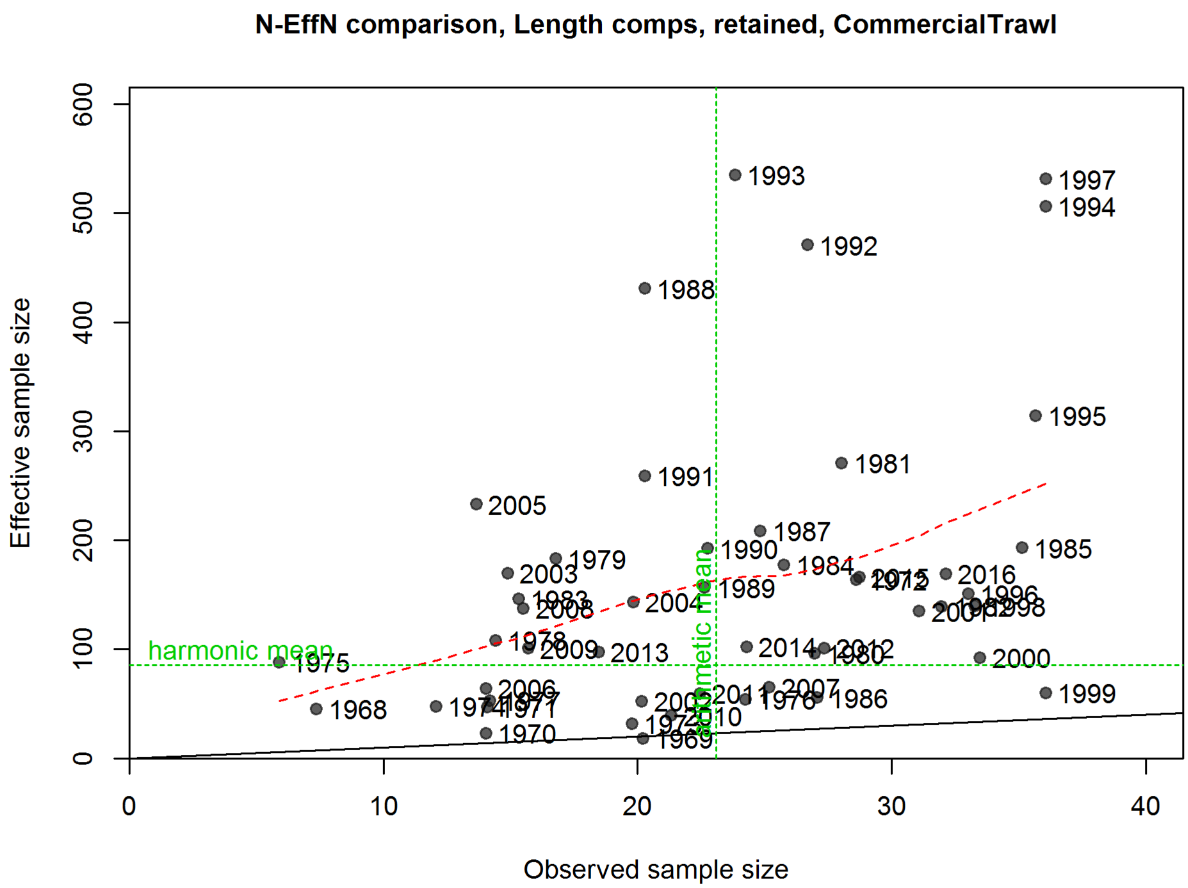


Figure 5: N_EffN comparison, Length comps, retained, CommercialTrawl fig:mod1_4_comp_lenf

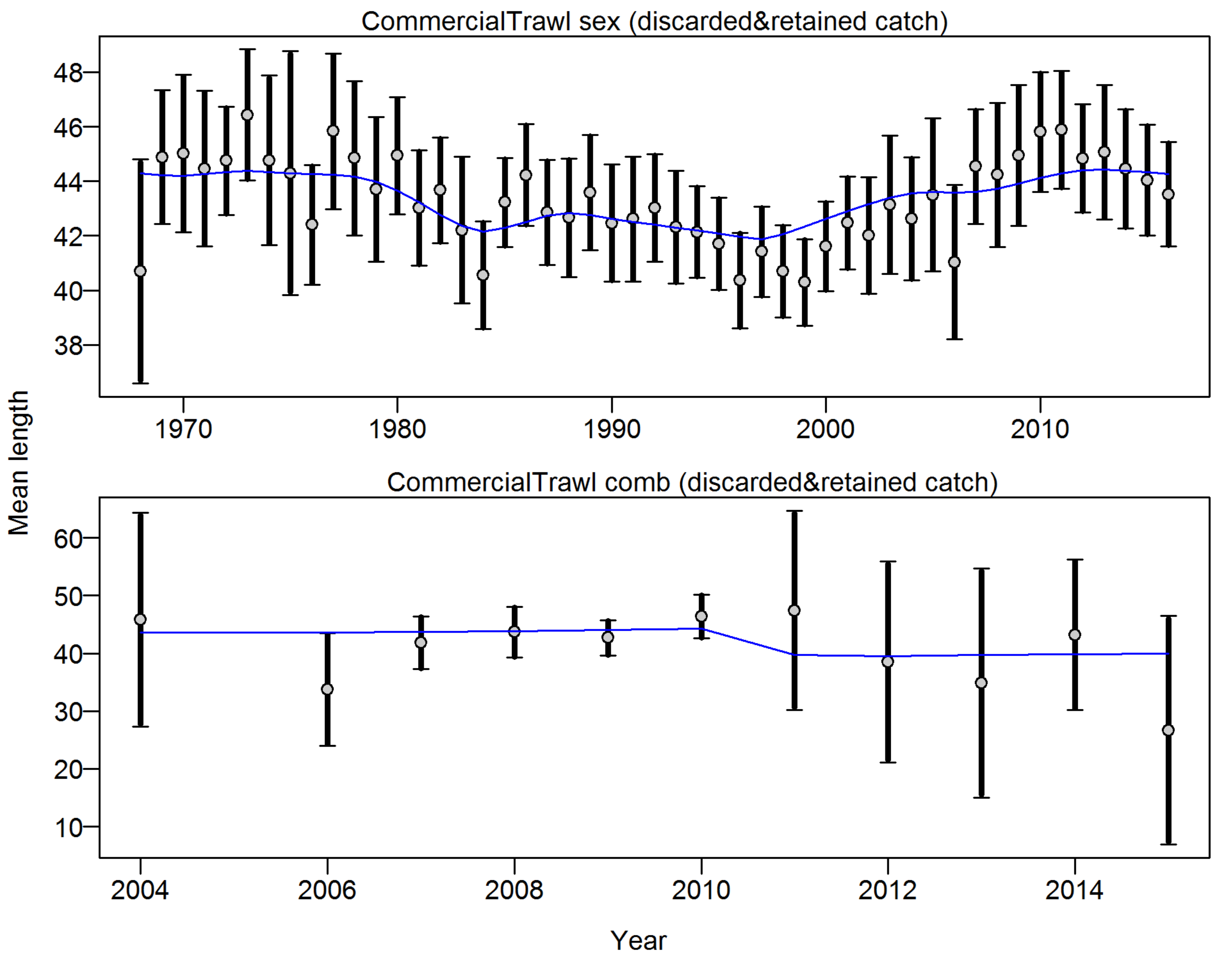


Figure 6: Francis data weighting method TA1.8: CommercialTrawl Suggested sample size adjustment (with 95% interval) for len data from CommercialTrawl: 0.9488 (0.7164_1.4056) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod1_5_comp_lenfit_data_weighting_T

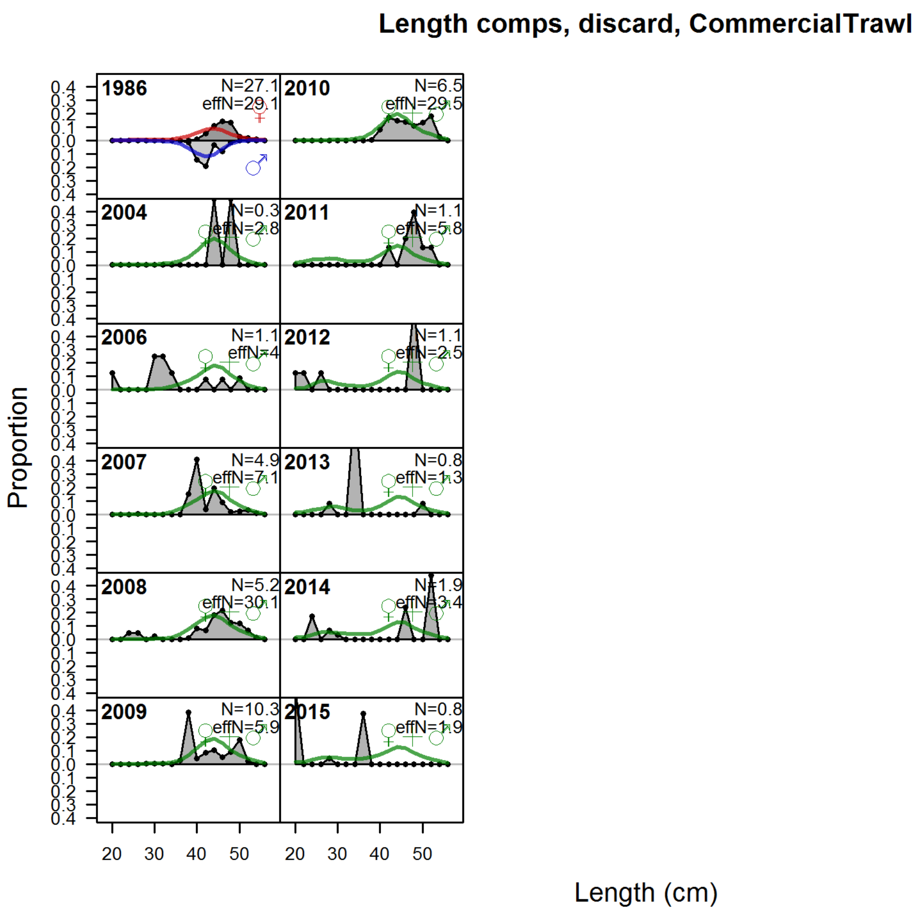


Figure 7: Length comps, discard, CommercialTrawl fig:mod1_6_comp_lenfit_flt1mkt

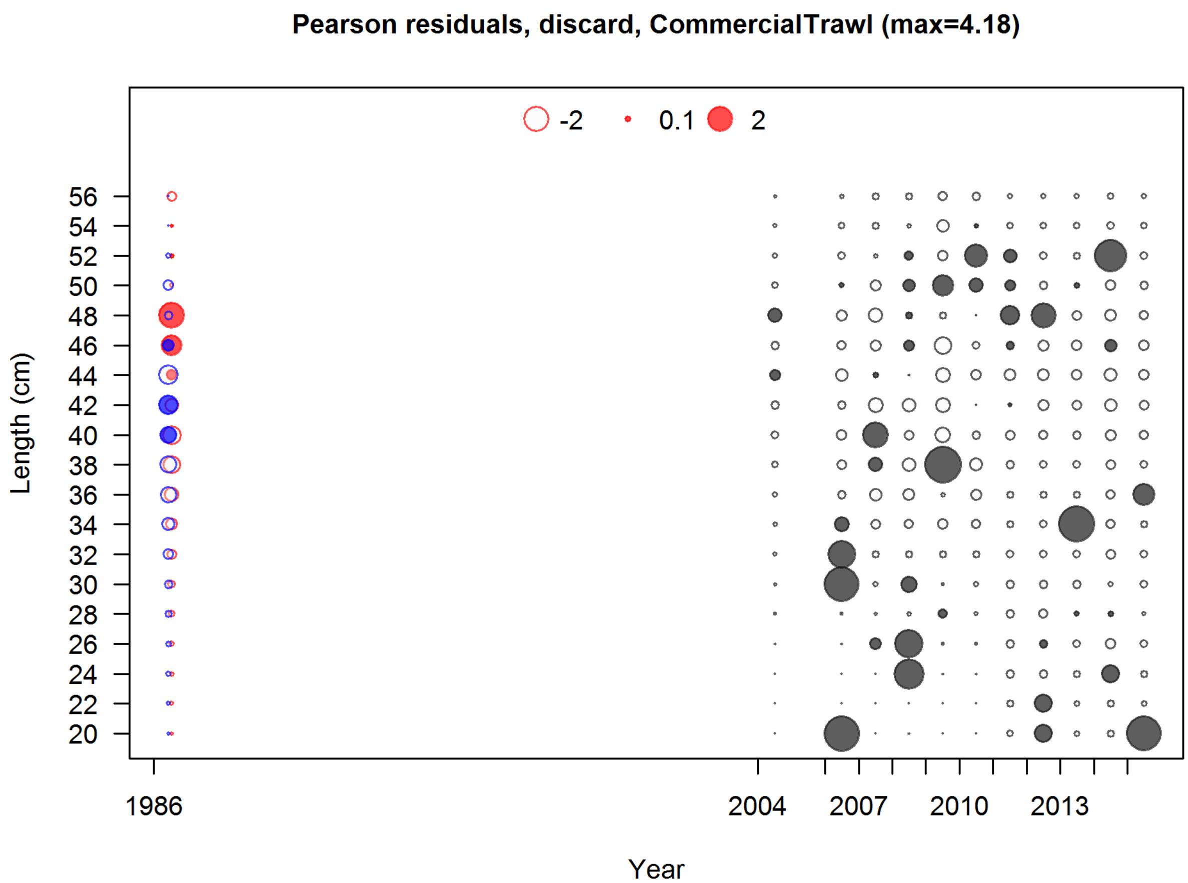


Figure 8: Pearson residuals, discard, CommercialTrawl (max=4.18)
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_7_comp_lenfit_residsflt1mkt1

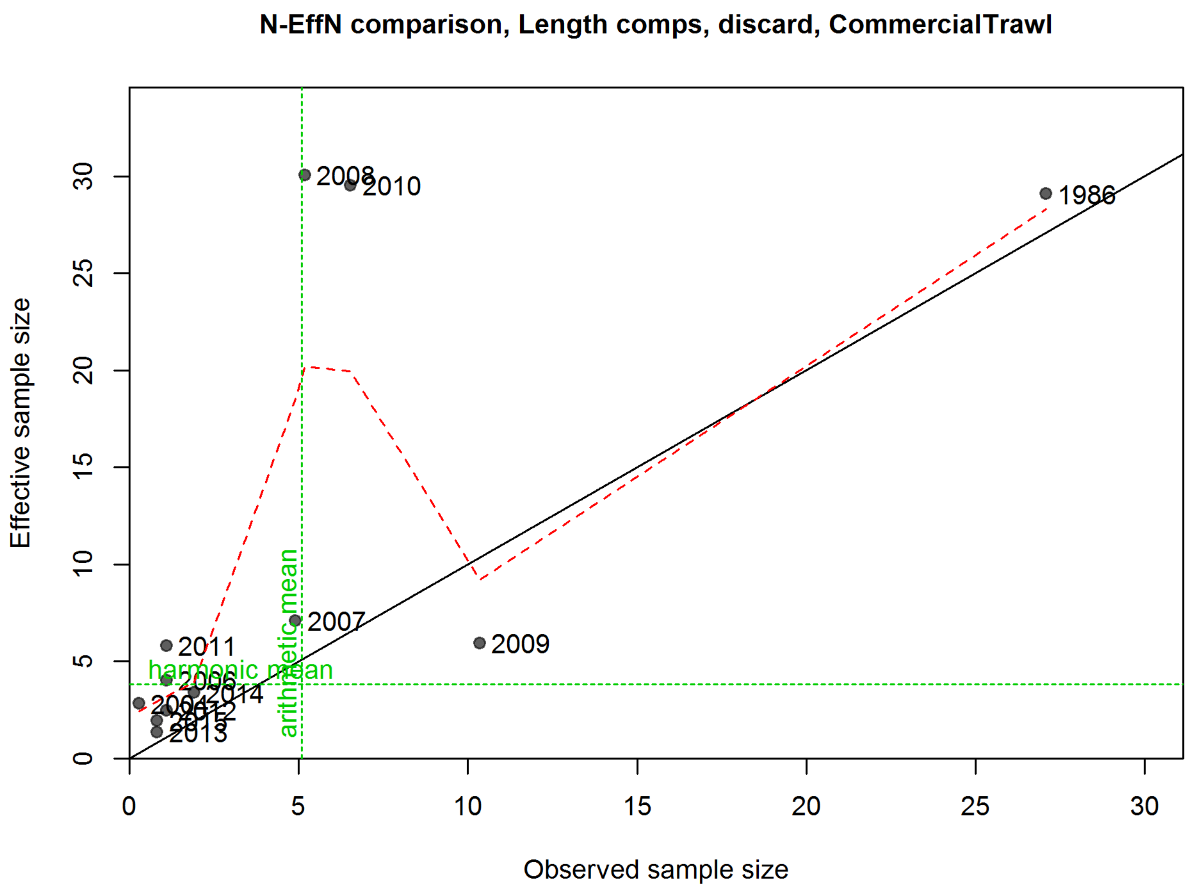


Figure 9: N_EffN comparison, Length comps, discard, CommercialTrawl fig:mod1_8_comp_lenfi

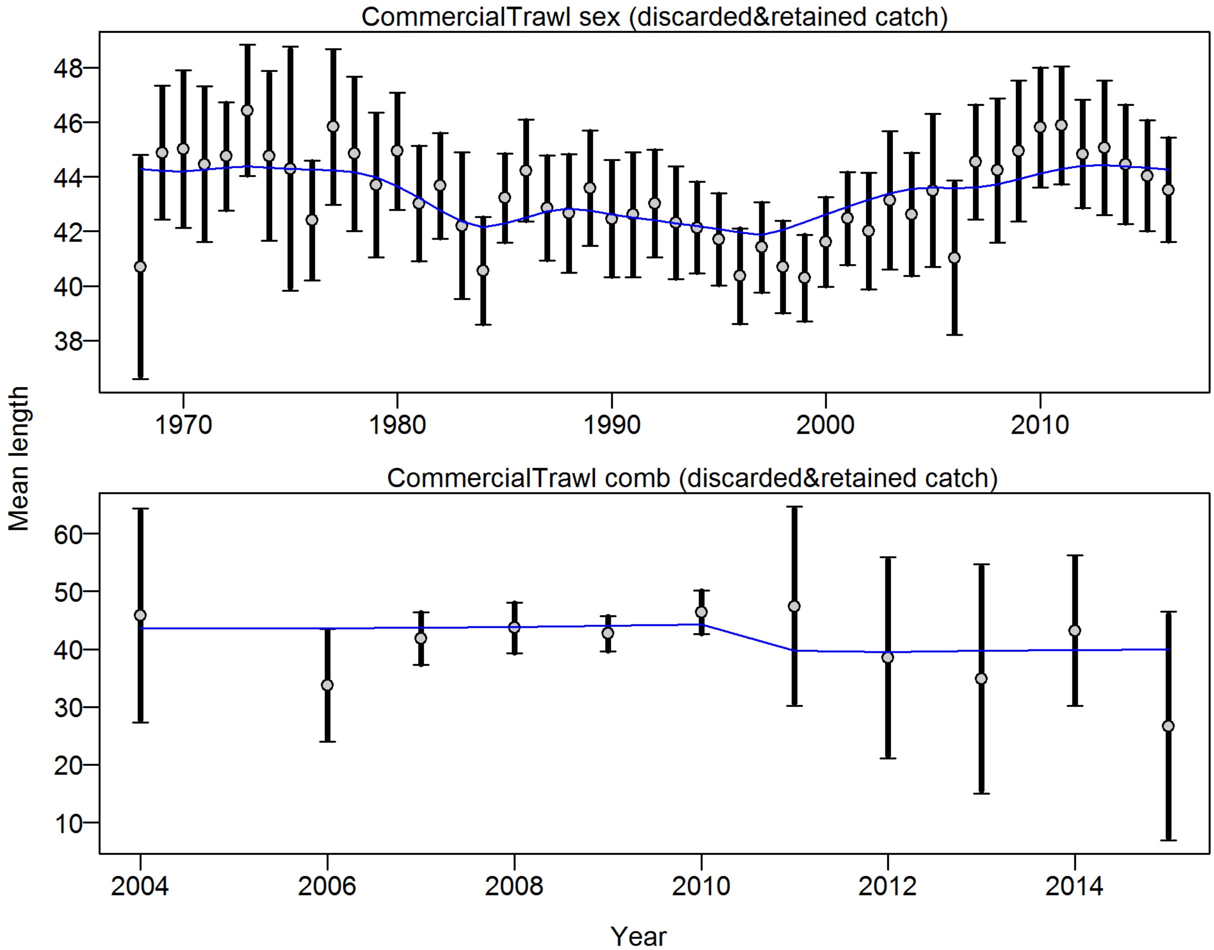


Figure 10: Francis data weighting method TA1.8: CommercialTrawl Suggested sample size adjustment (with 95% interval) for len data from CommercialTrawl: 0.9488 (0.7195_1.4058) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod1_9_comp_lenfit_data_weighting_T

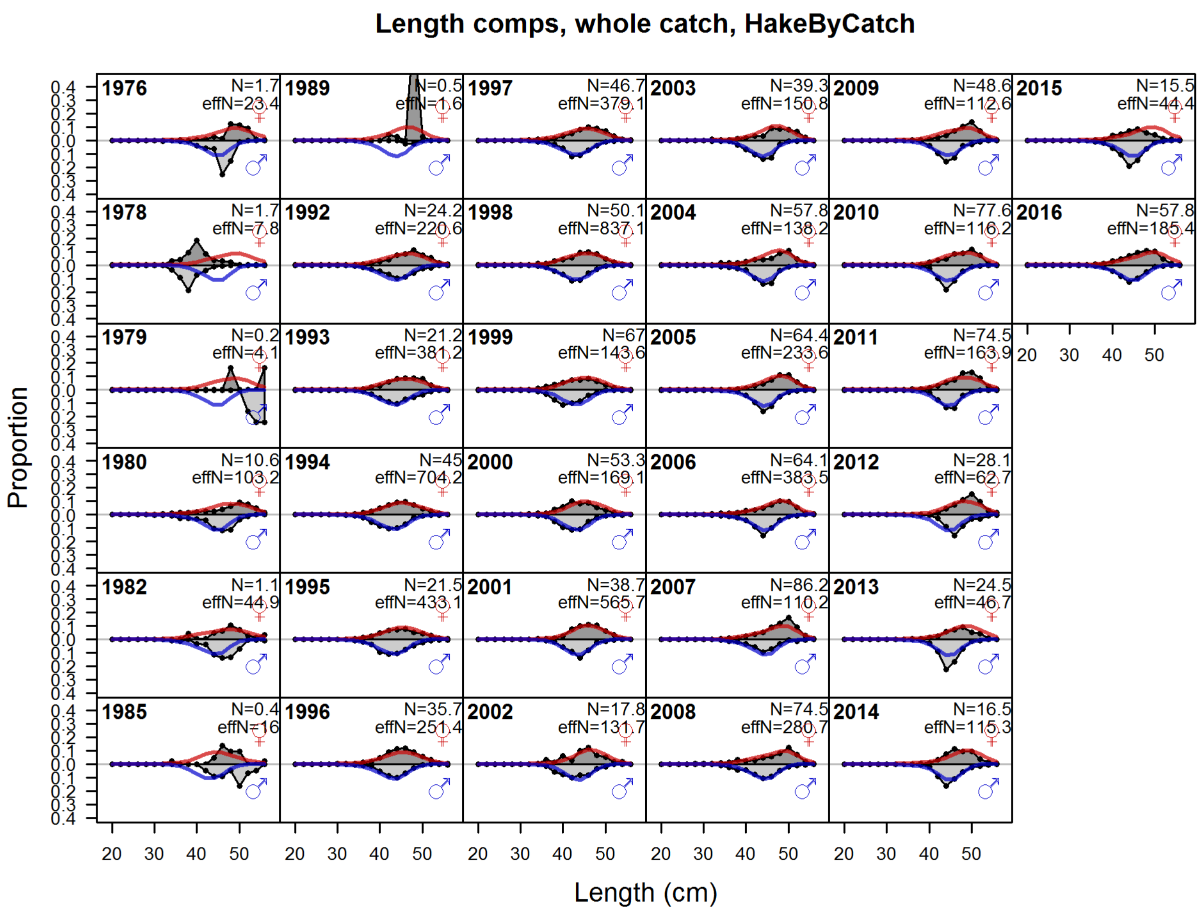


Figure 11: Length comps, whole catch, HakeByCatch fig:mod1_10_comp_lenfit_flt2ml

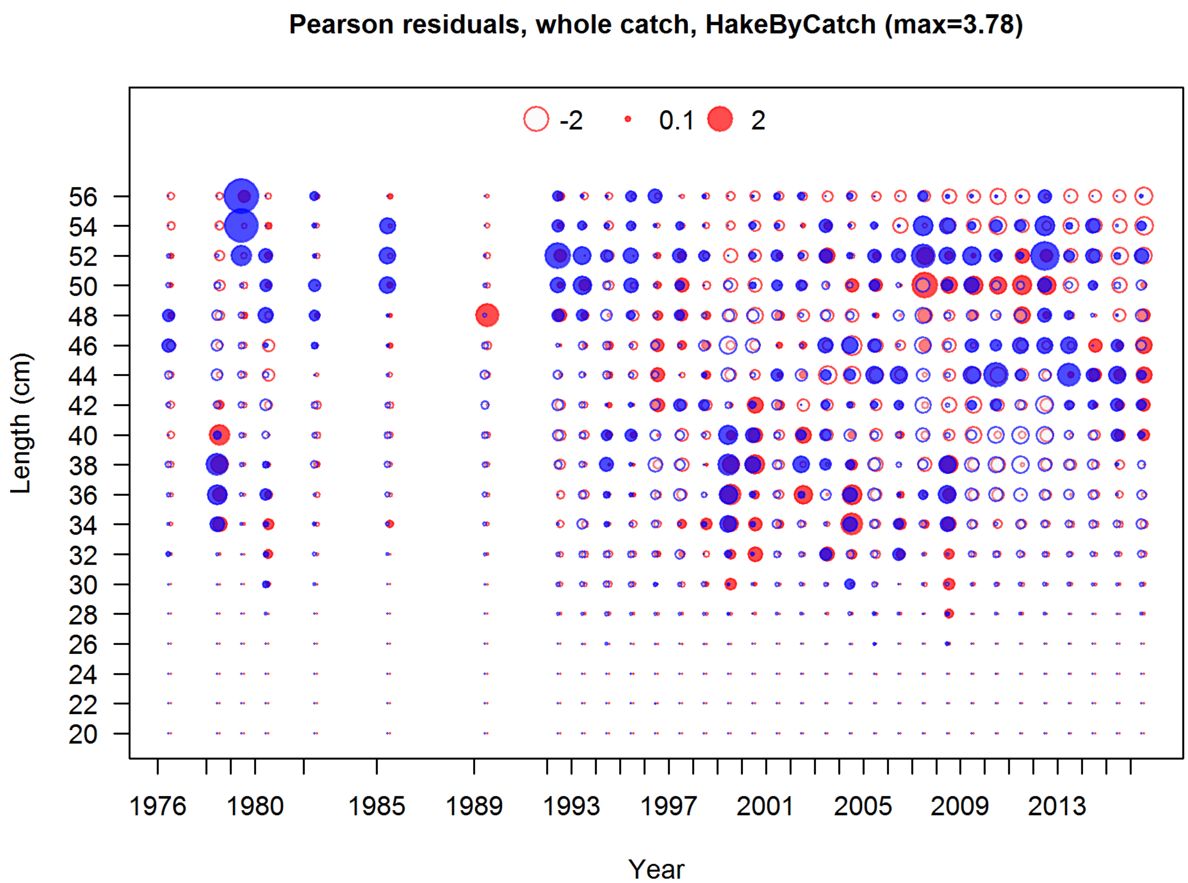


Figure 12: Pearson residuals, whole catch, HakeByCatch (max=3.78)
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_11_comp_lenfit_residsflt2mkt0

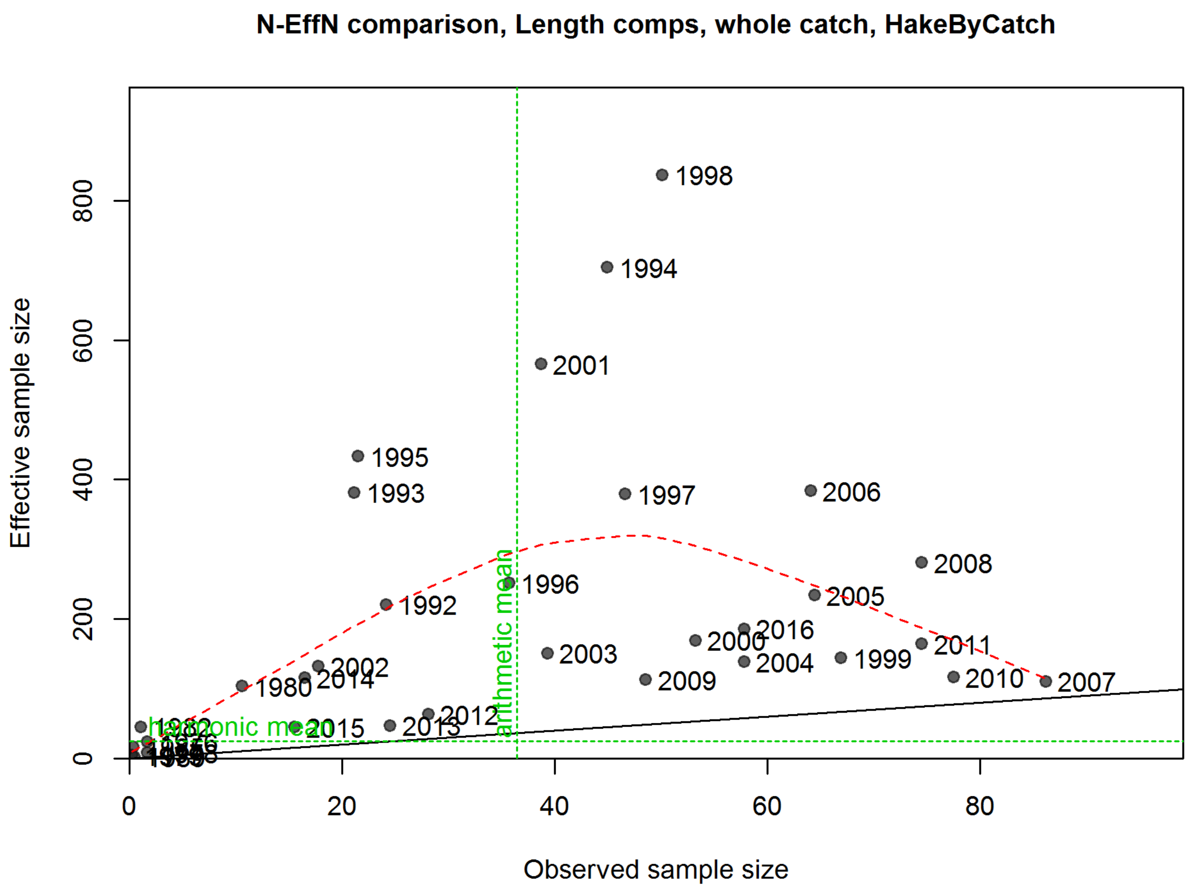


Figure 13: N_EffN comparison, Length comps, whole catch, HakeByCatch fig:mod1_12_comp_len

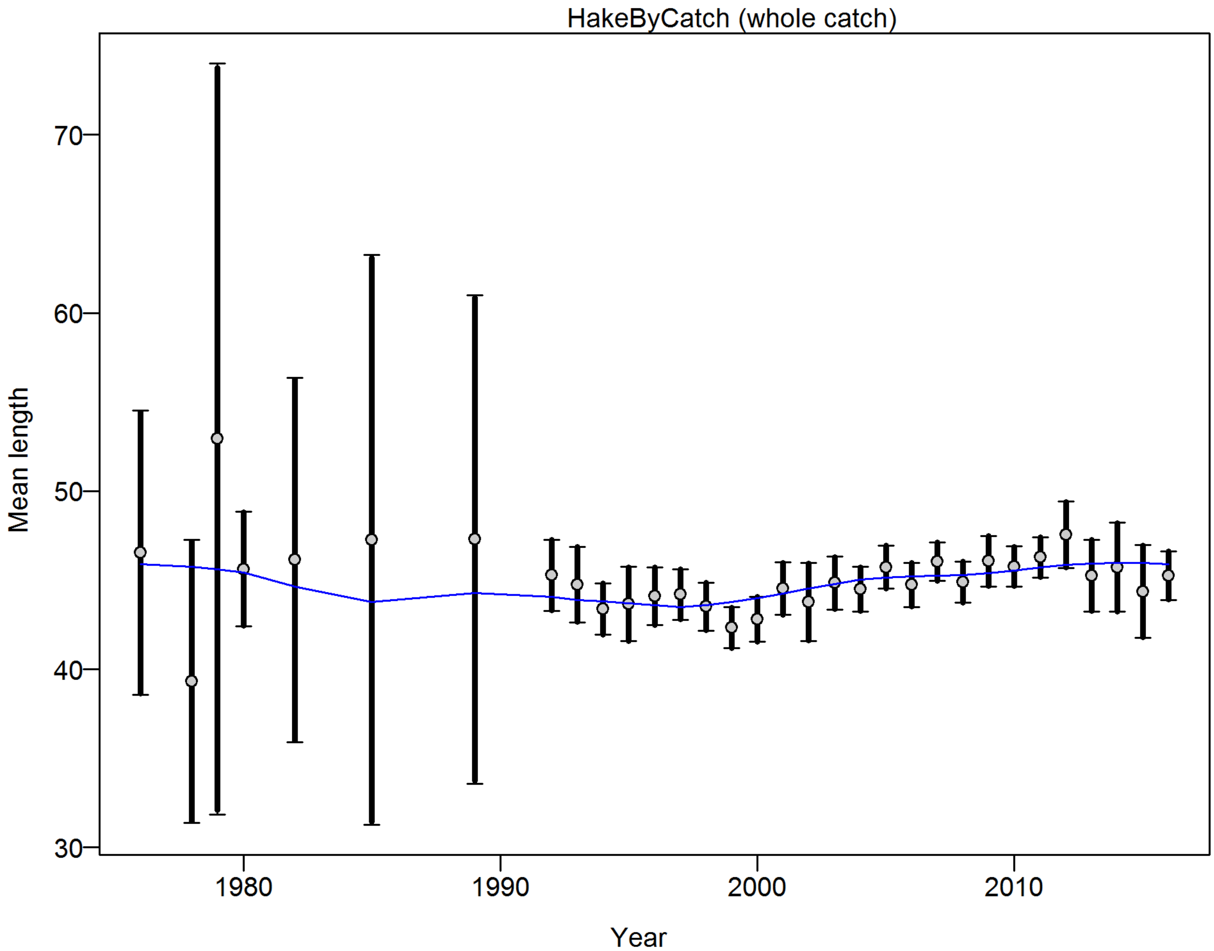


Figure 14: Francis data weighting method TA1.8: HakeByCatch Suggested sample size adjustment (with 95% interval) for len data from HakeByCatch: 0.9774 (0.6751_1.6973) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod1_13_comp_lenfit_data_weighting_TA1.8_Hake

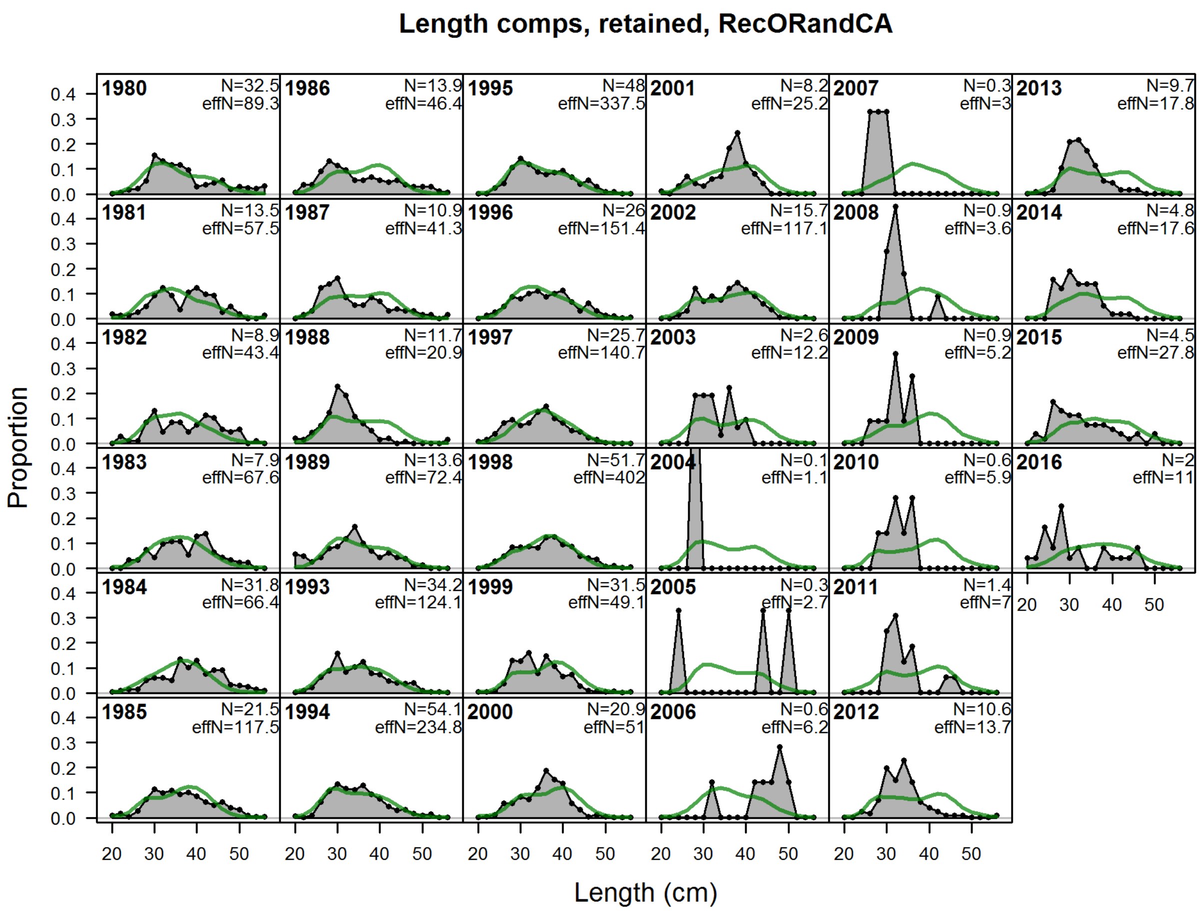


Figure 15: Length comps, retained, RecORandCA fig:mod1_14_comp_lenfit_flt3mkt

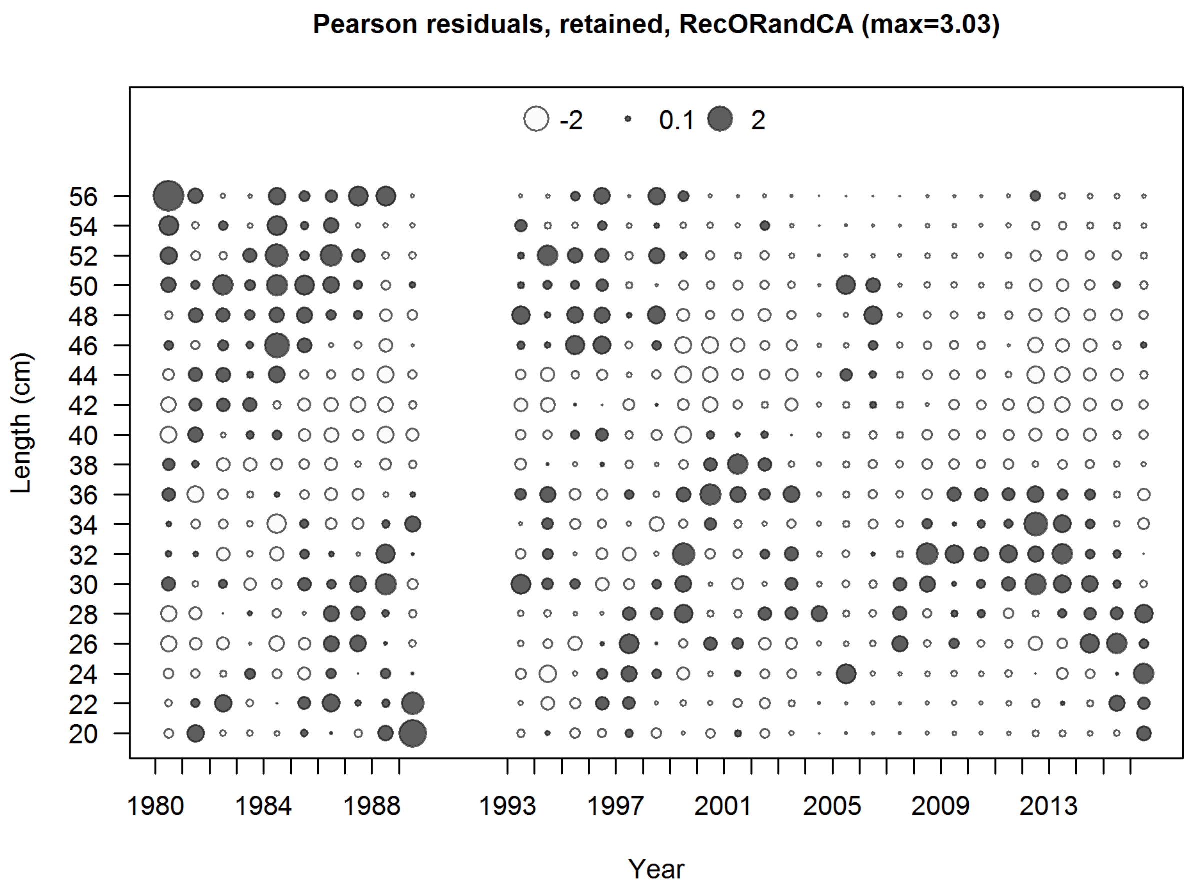


Figure 16: Pearson residuals, retained, RecORandCA (max=3.03)
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_15_comp_lenfit_residsflt3mkt2

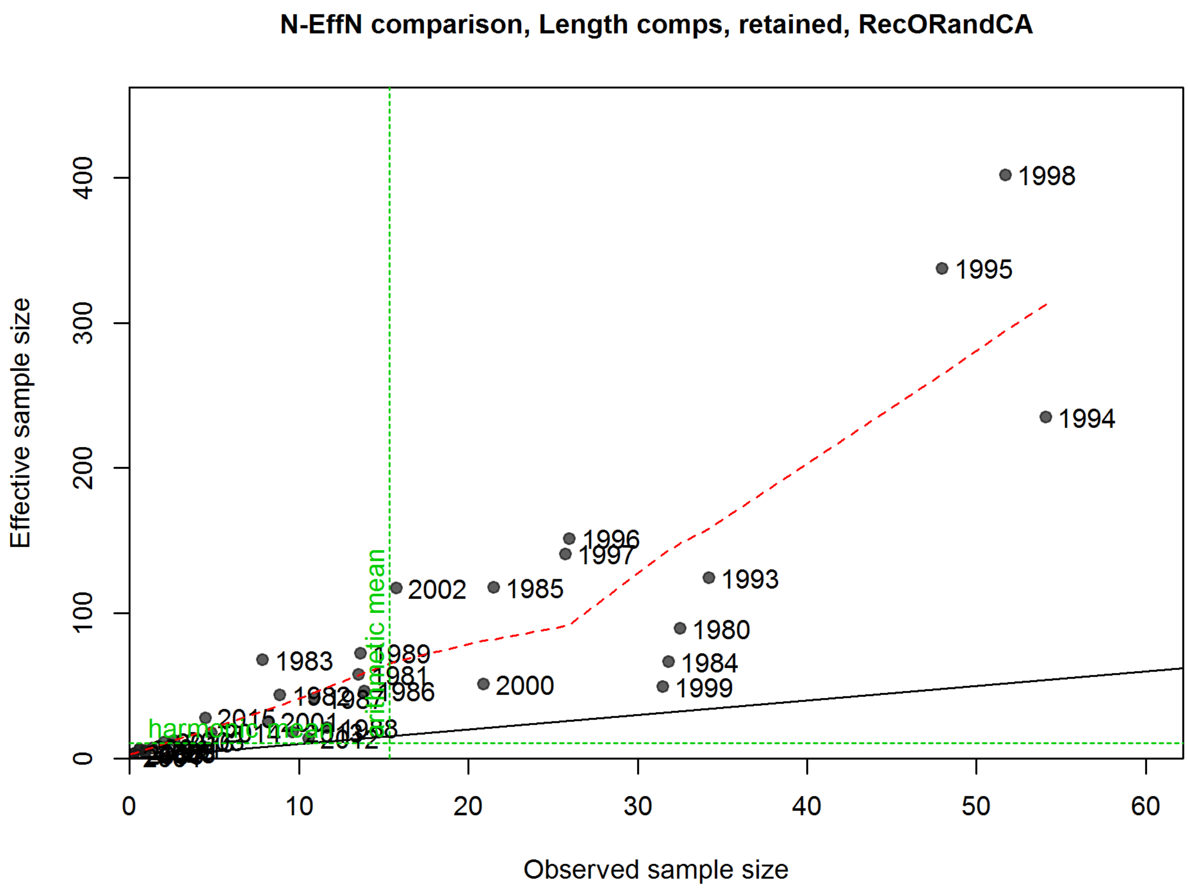


Figure 17: N_EffN comparison, Length comps, retained, RecORandCA fig:mod1_16_comp_lenf

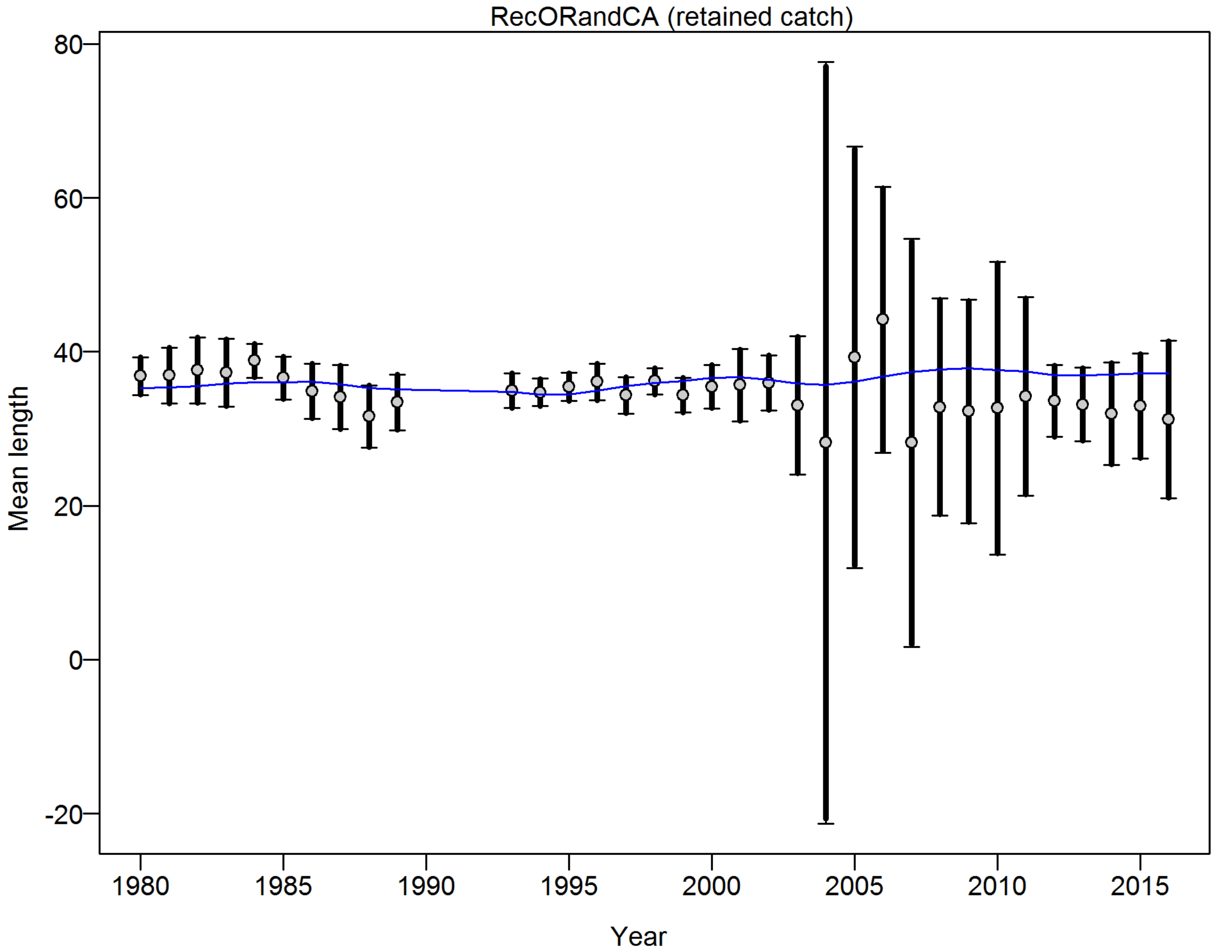


Figure 18: Francis data weighting method TA1.8: RecORandCA Suggested sample size adjustment (with 95% interval) for len data from RecORandCA: 0.9761 (0.6621_1.774) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod1_17_comp_lenfit_data_weighting_TA1.8_RecO

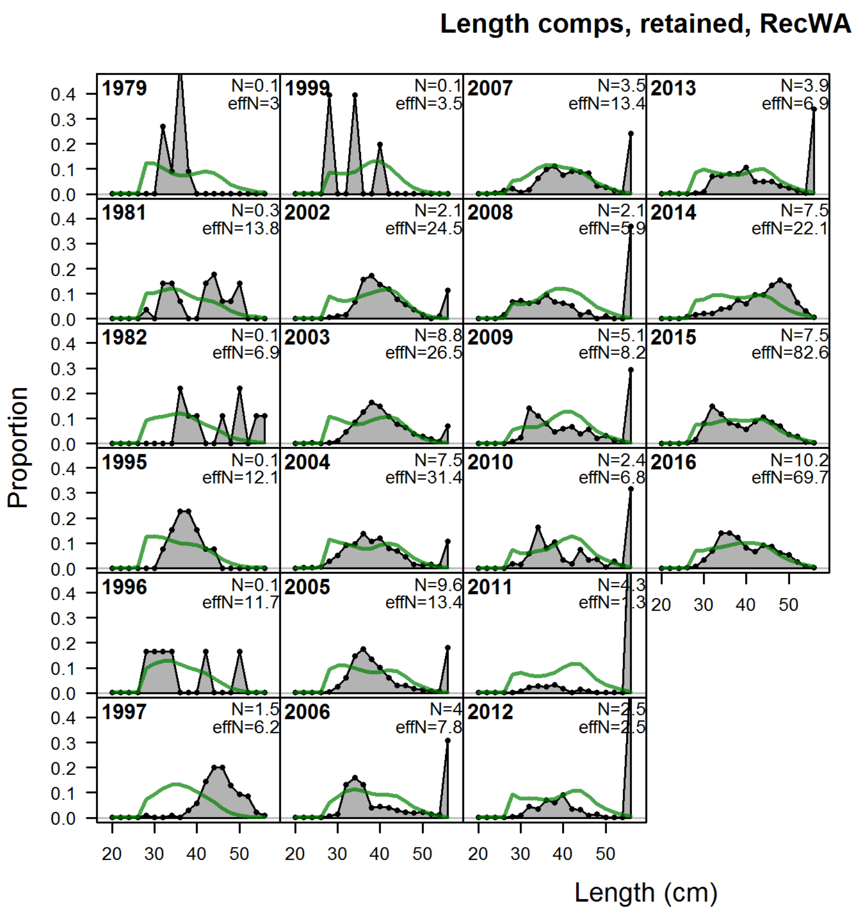


Figure 19: Length comps, retained, RecWA fig:mod1_18_comp_lenfit_flt4mkt2

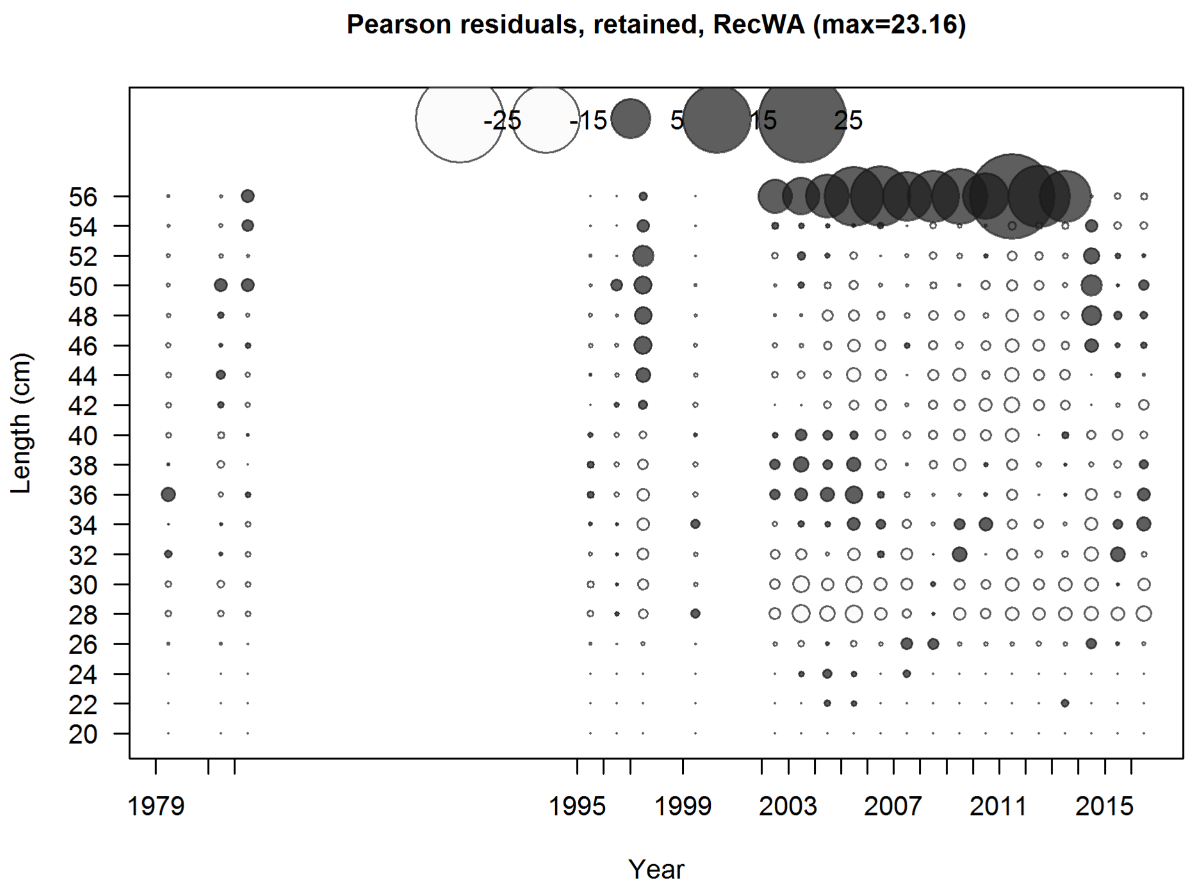


Figure 20: Pearson residuals, retained, RecWA (max=23.16)
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_19_comp_lenfit_residsflt4mkt2

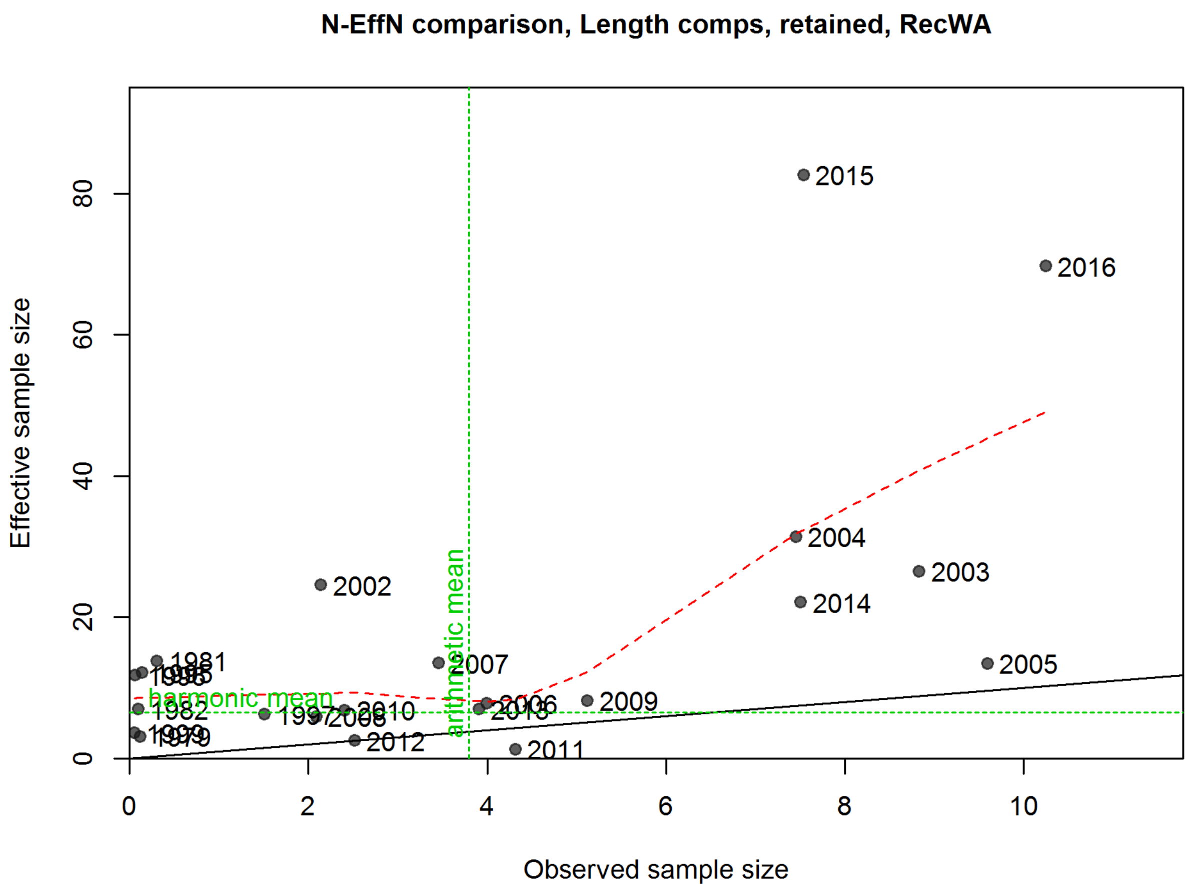


Figure 21: N_EffN comparison, Length comps, retained, RecWA fig:mod1_20_comp_lenfit_s

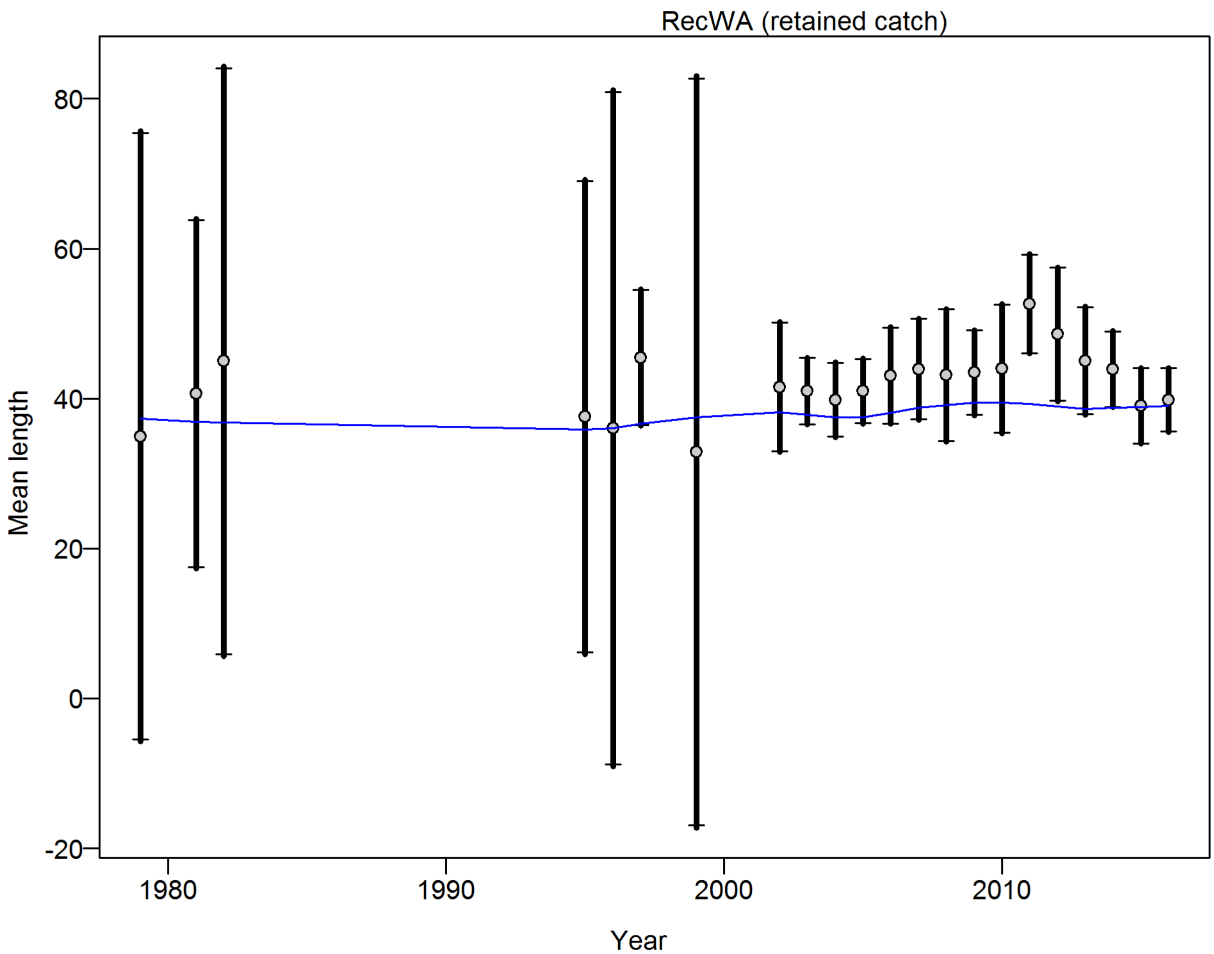


Figure 22: Francis data weighting method TA1.8: RecWA Suggested sample size adjustment (with 95% interval) for len data from RecWA: 1.0134 (0.5588_2.3419) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod1_21_comp_lenfit_data_weighting_TA1.8_RecWA

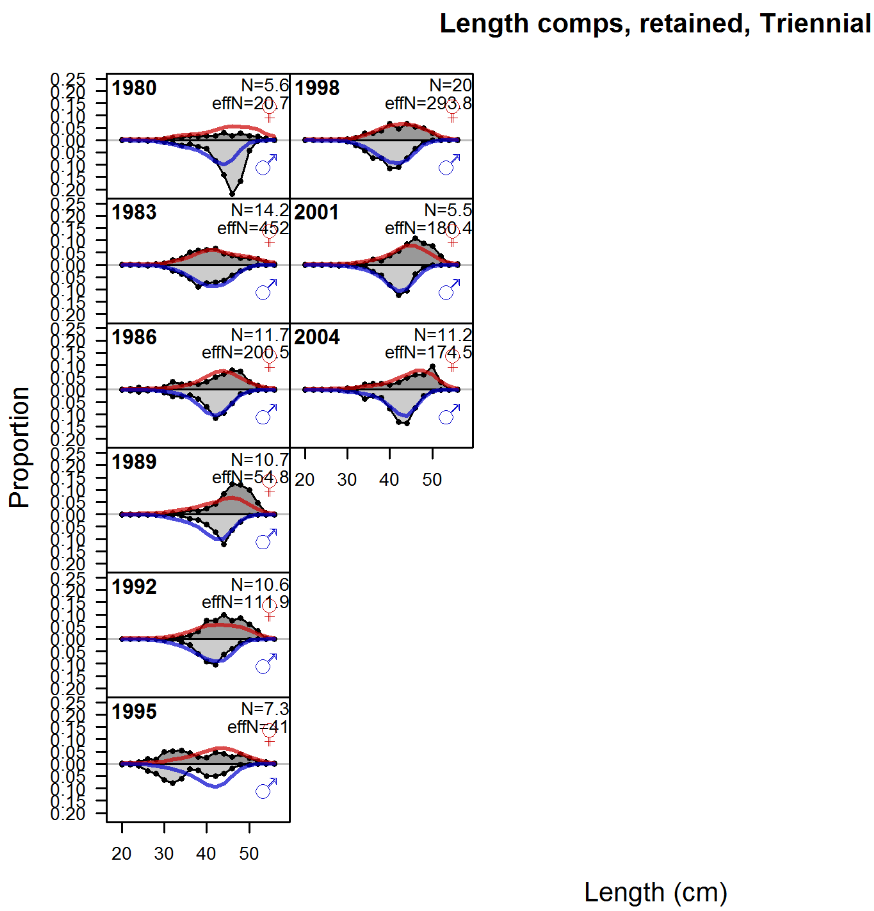


Figure 23: Length comps, retained, Triennial fig:mod1_22_comp_lenfit_flt5mkt2

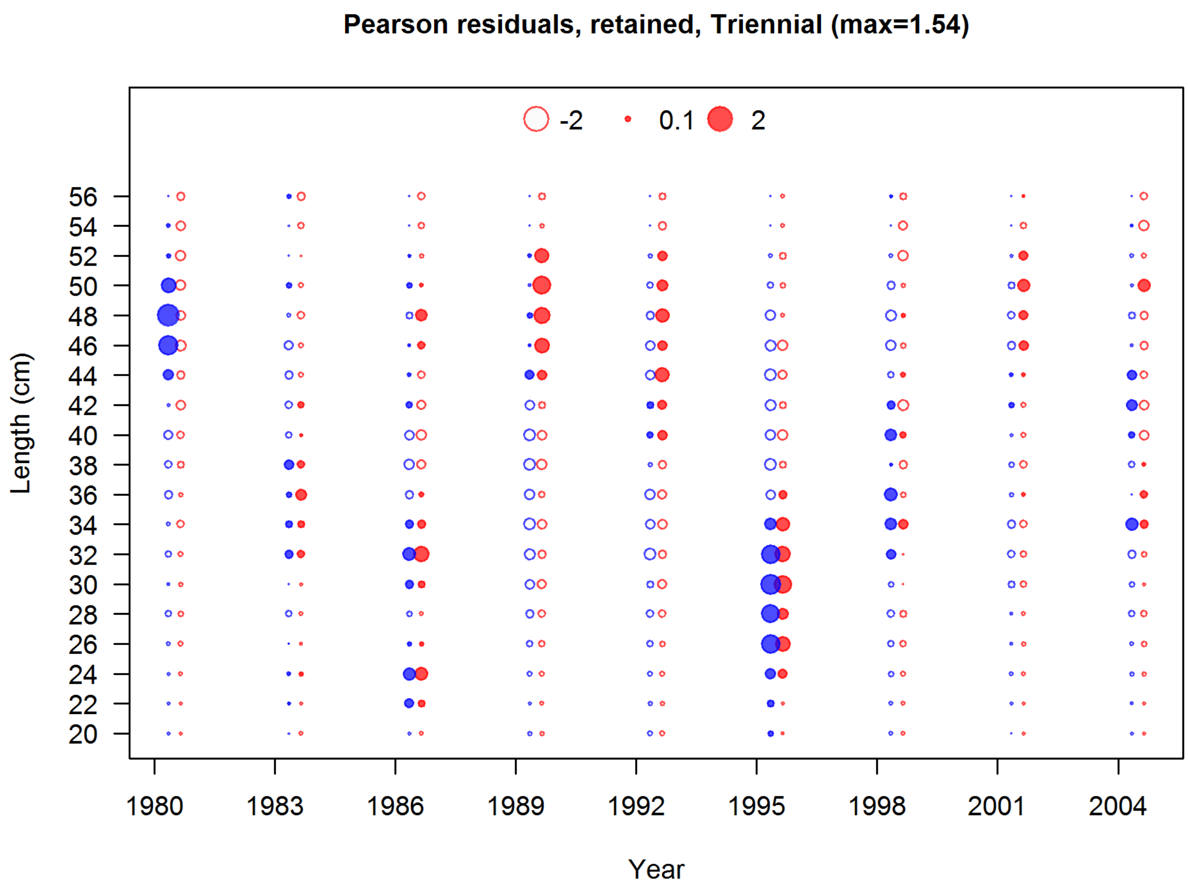


Figure 24: Pearson residuals, retained, Triennial (max=1.54)
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_23_comp_lenfit_residsflt5mkt2

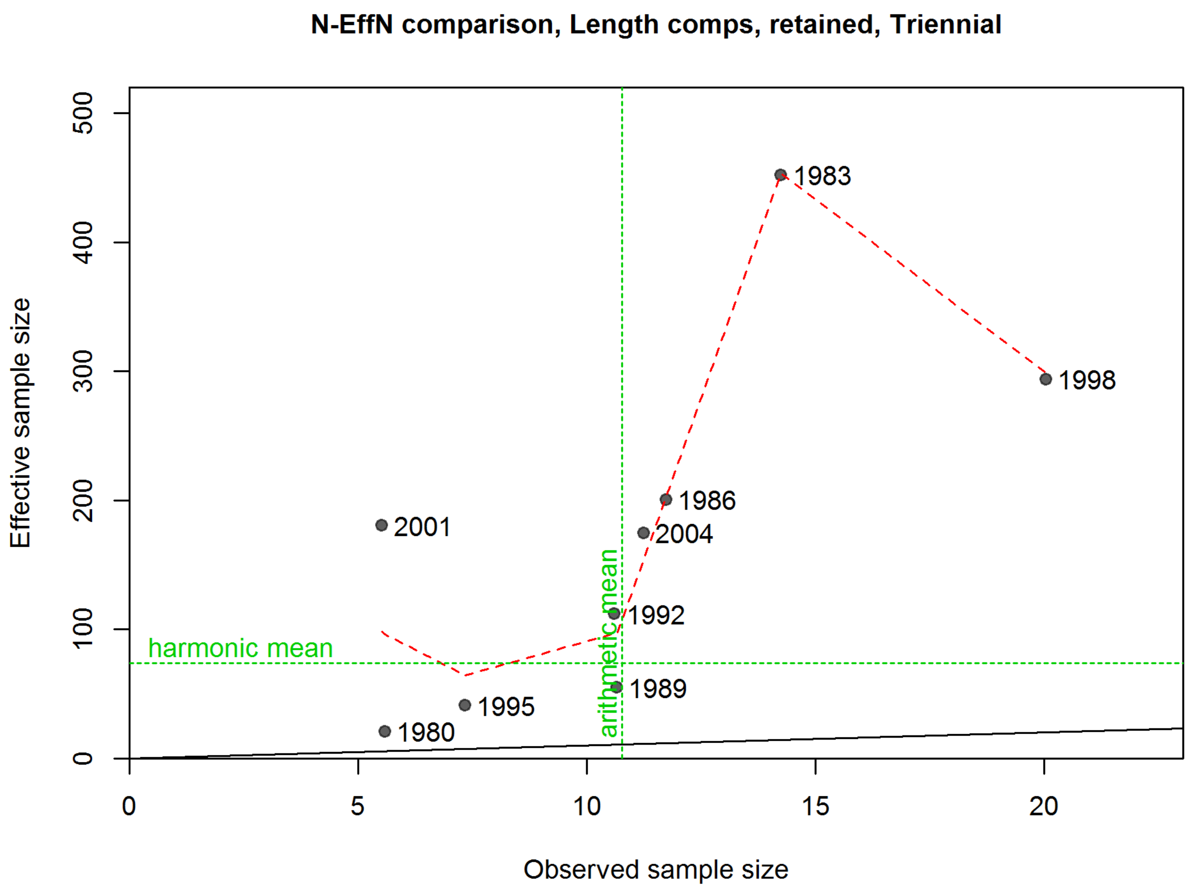


Figure 25: N_EffN comparison, Length comps, retained, Triennial fig:mod1_24_comp_lenfit_

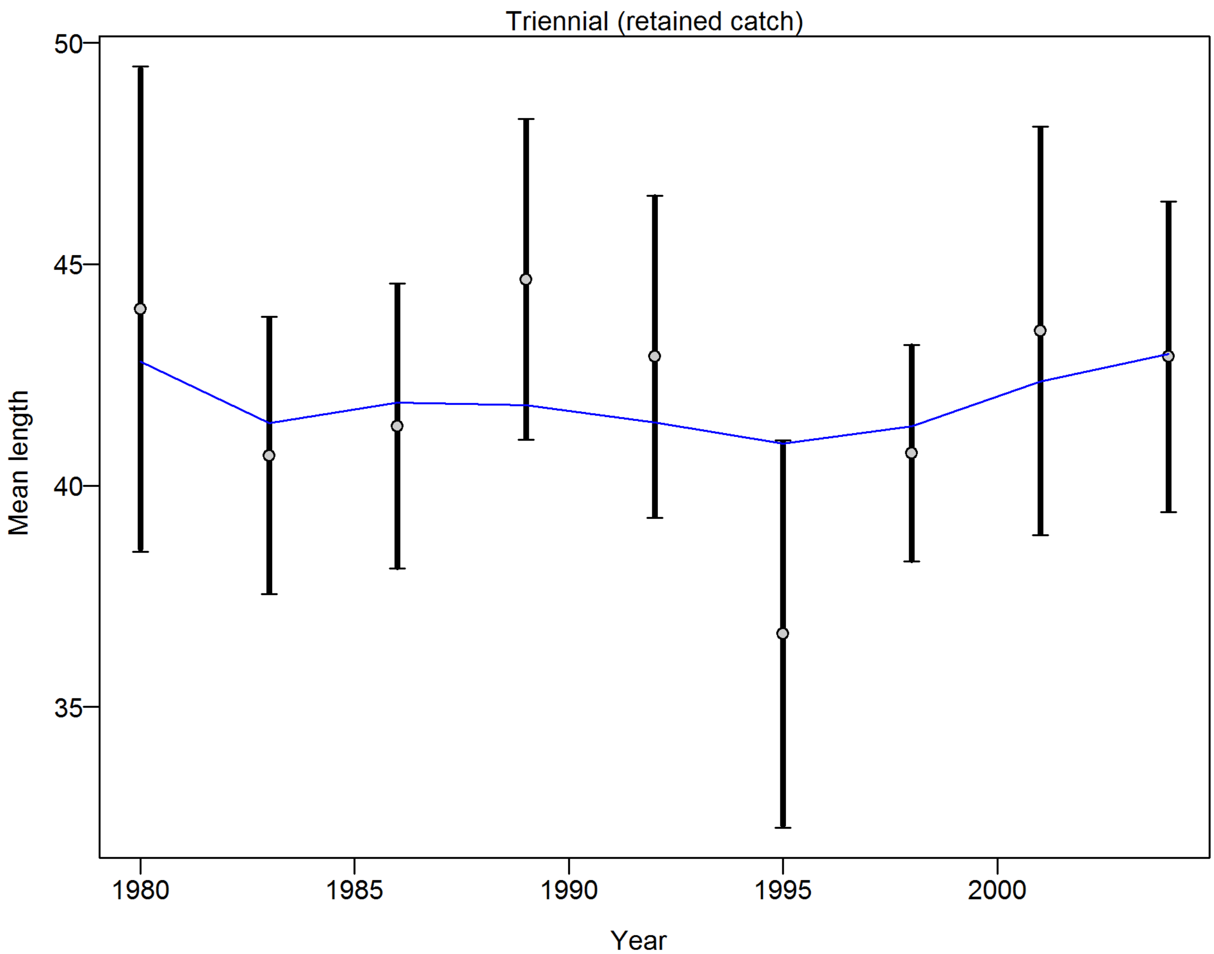


Figure 26: Francis data weighting method TA1.8: Triennial Suggested sample size adjustment (with 95% interval) for len data from Triennial: 0.9781 (0.5131_5.1969) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod1_25_comp_lenfit_data_weighting_TA1.8_Triennial

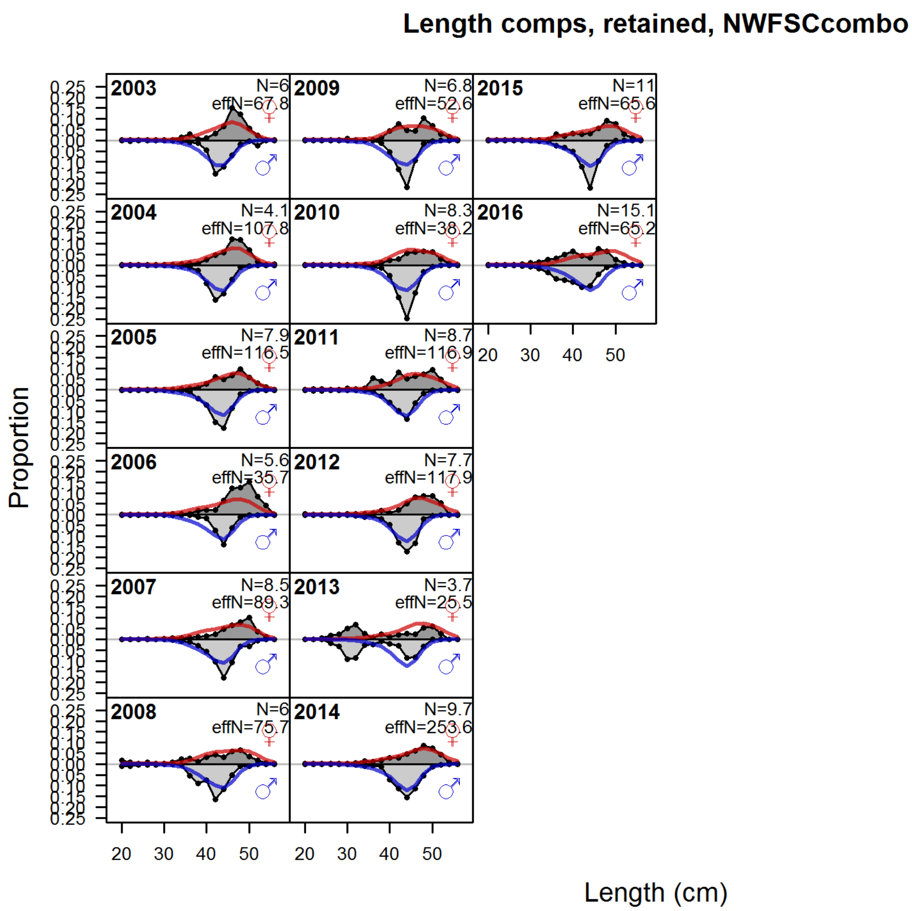


Figure 27: Length comps, retained, NWFSCcombo fig:mod1_26_comp_lenfit_flt6mk

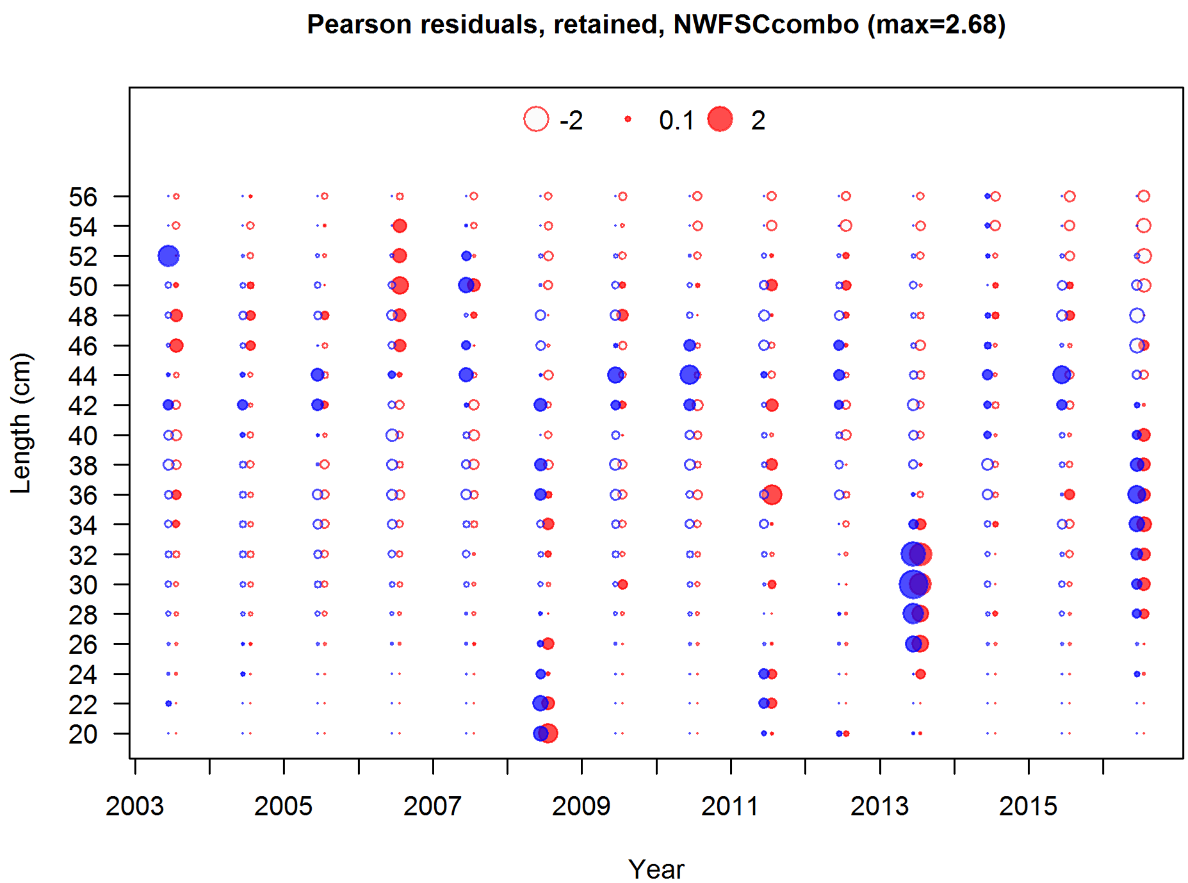


Figure 28: Pearson residuals, retained, NWFSCcombo (max=2.68)
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_27_comp_lenfit_residsflt6mkt2

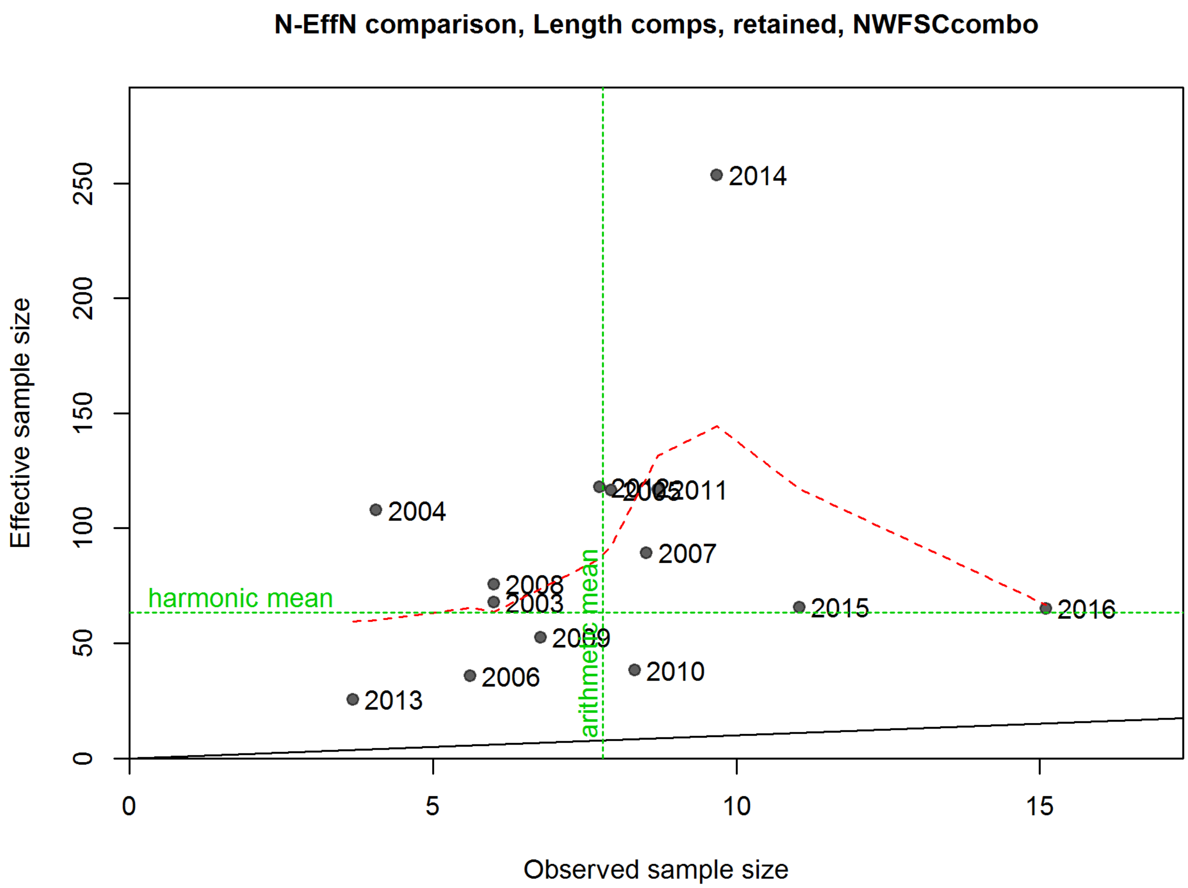


Figure 29: N_EffN comparison, Length comps, retained, NWFSCcombo fig:mod1_28_comp_lenf

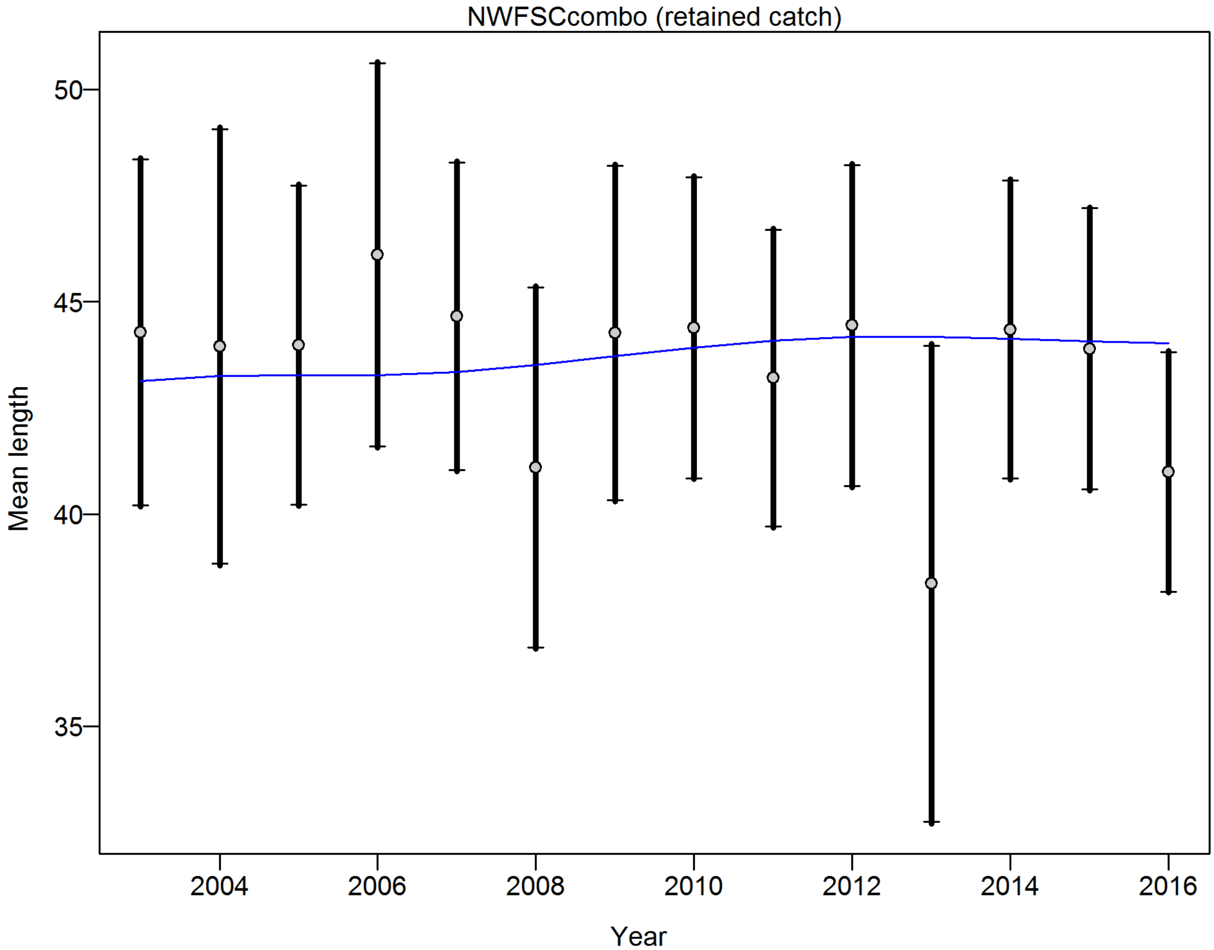


Figure 30: Francis data weighting method TA1.8: NWFSCcombo Suggested sample size adjustment (with 95% interval) for len data from NWFSCcombo: 1.0144 (0.6332_5.1343) For more info, see Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124_1138. fig:mod1_29_comp_lenfit_data_weighting_

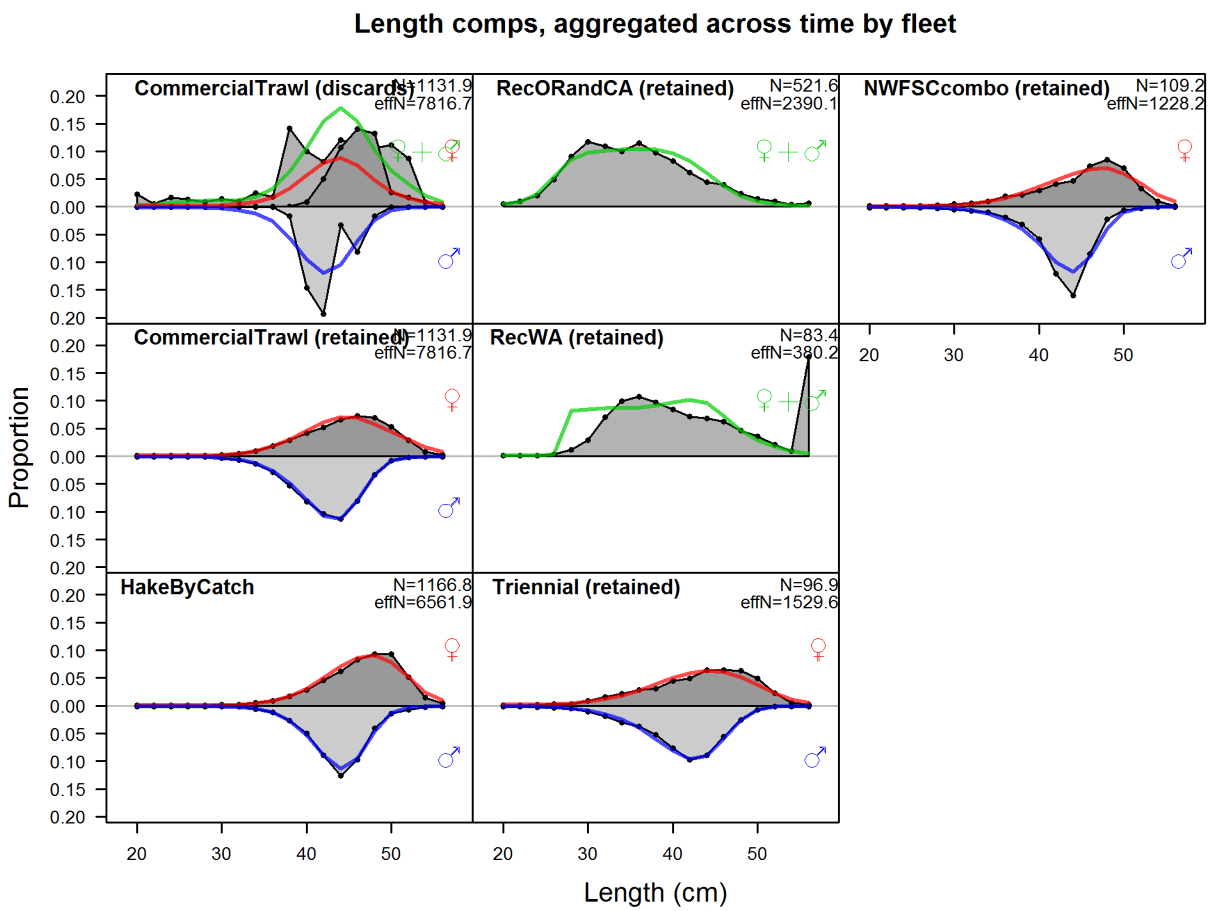


Figure 31: Length comps, aggregated across time by fleet. Labels 'retained' and 'discard' indicate discarded or retained sampled for each fleet. Panels without this designation represent the whole catch. fig:mod1_30_comp_lenfit__aggregated_across_time

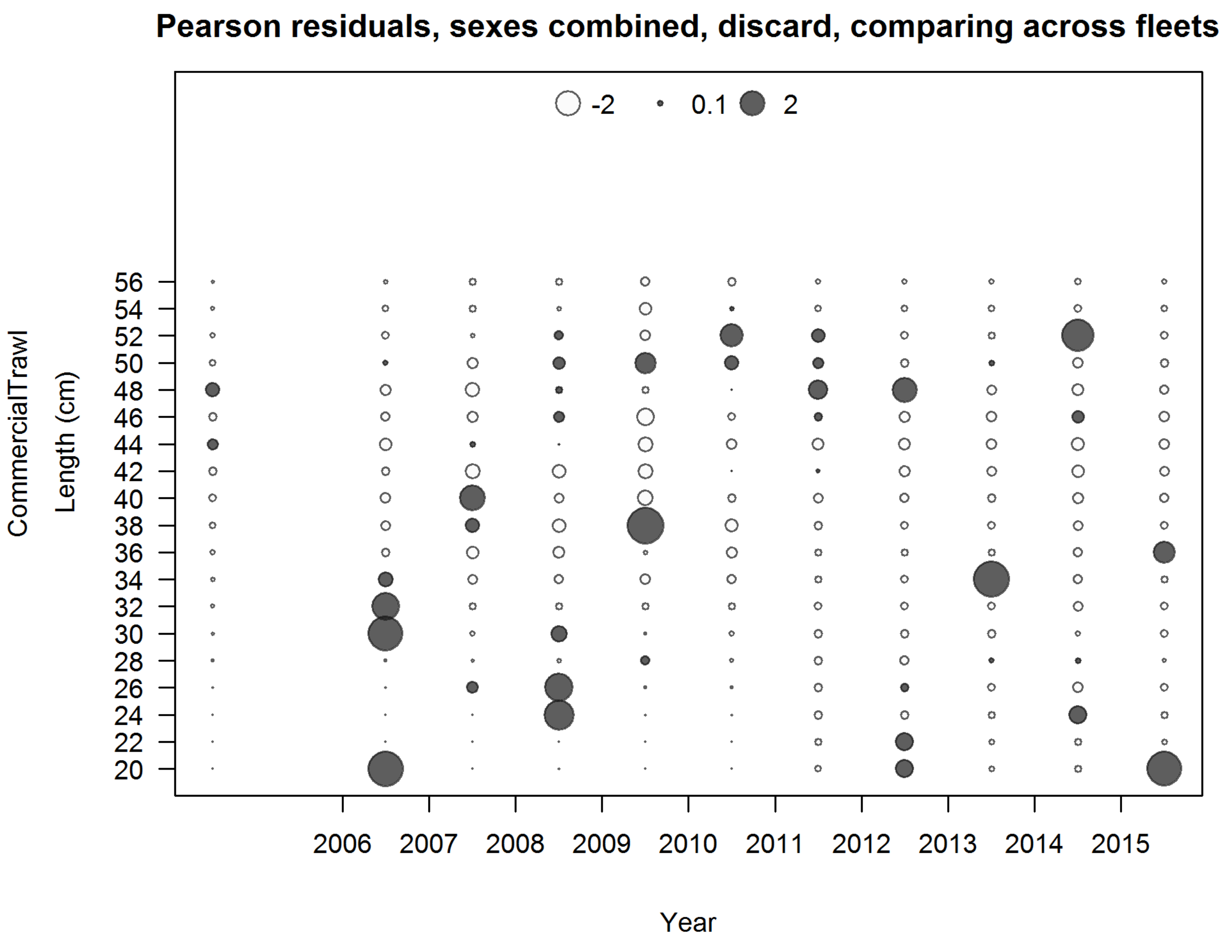


Figure 32: Note: this plot doesn't seem to be working right for some models. Pearson residuals, sexes combined, discard, comparing across fleets
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_31_comp_lenfit_sex1mkt1_multi-fleet_comparison

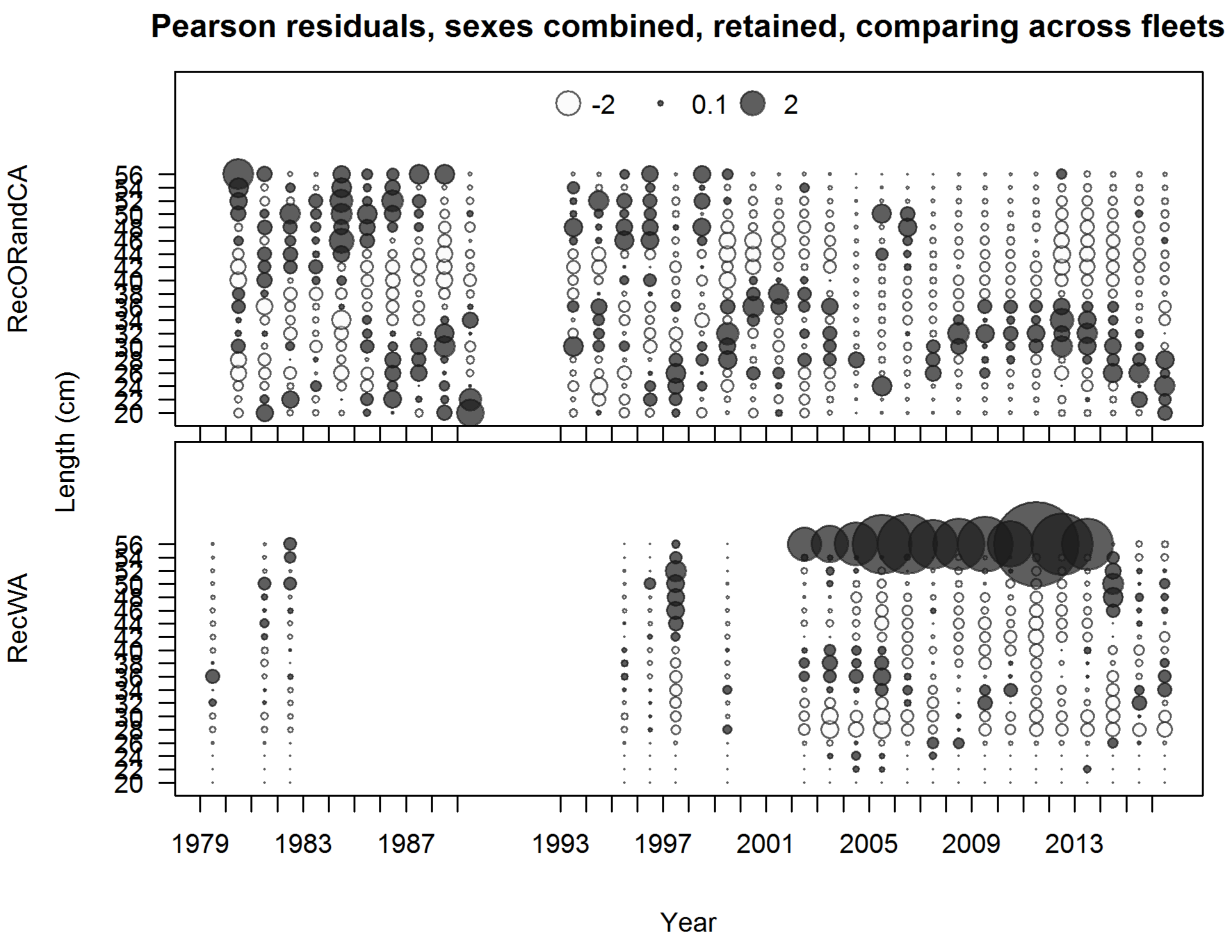


Figure 33: Note: this plot doesn't seem to be working right for some models. Pearson residuals, sexes combined, retained, comparing across fleets
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_32_comp_lenfit_sex1mkt2_multi-fleet_comparison

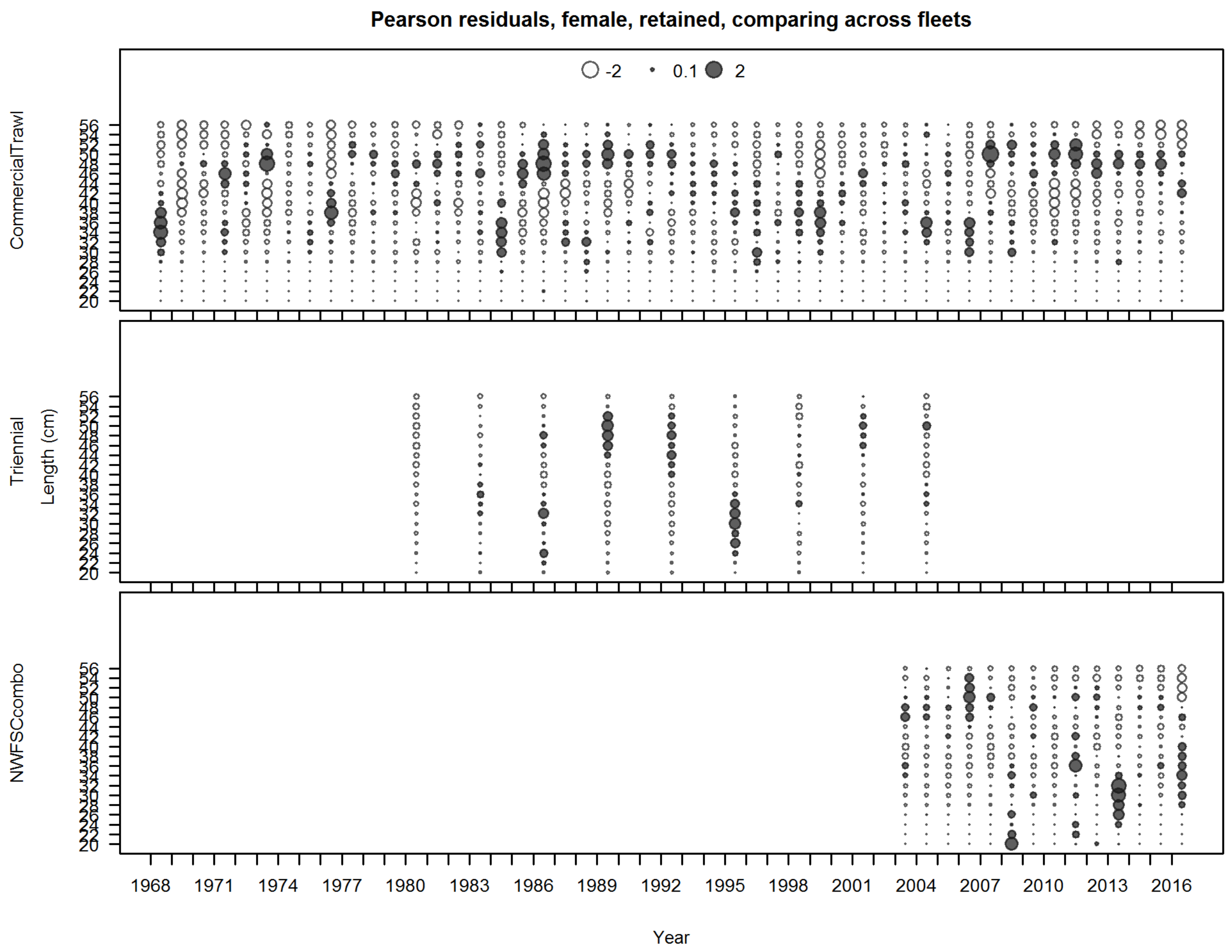


Figure 34: Note: this plot doesn't seem to be working right for some models. Pearson residuals, female, retained, comparing across fleets
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_33_comp_lenfit_sex2mkt2_multi-fleet_comparison

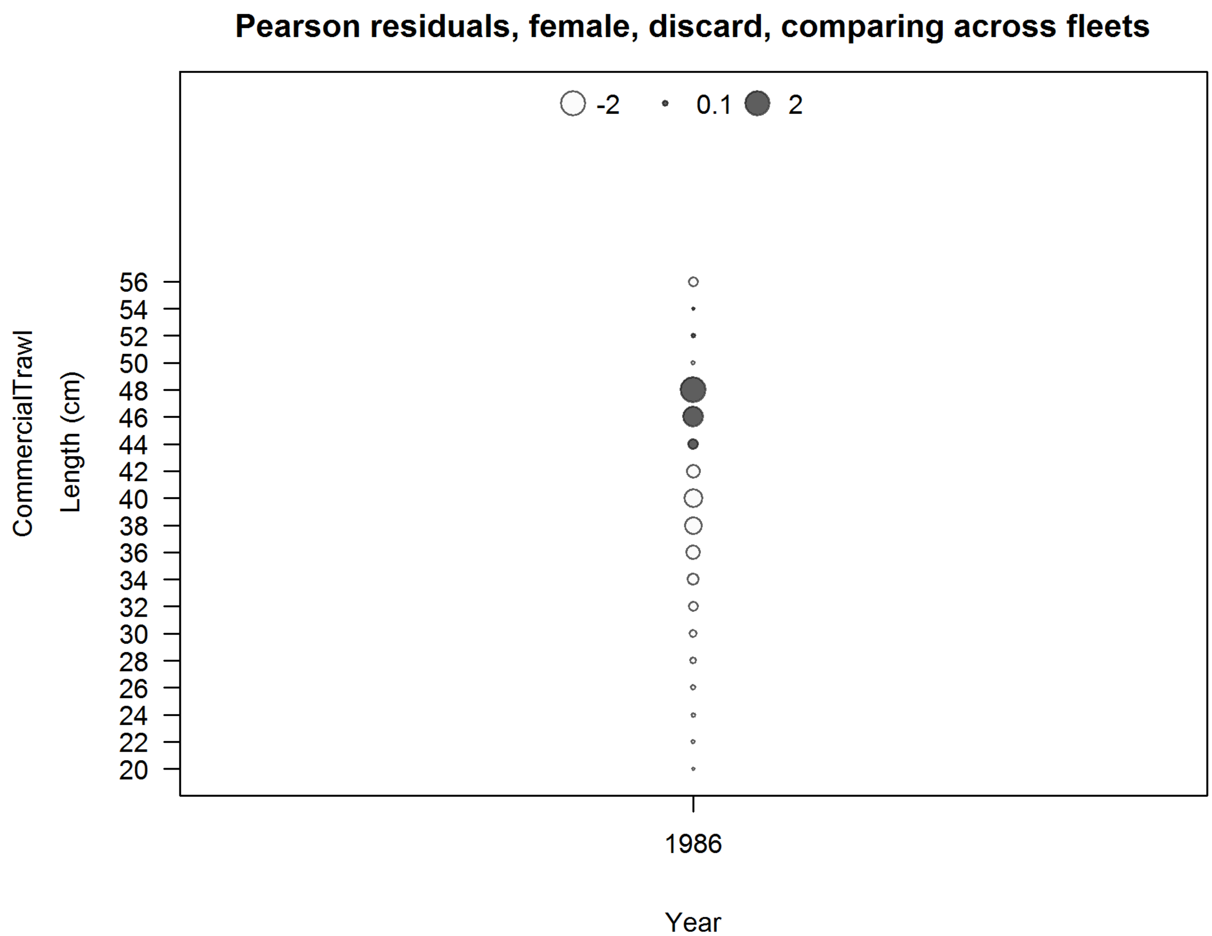


Figure 35: Note: this plot doesn't seem to be working right for some models. Pearson residuals, female, discard, comparing across fleets
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_34_comp_lenfit_sex2mkt1_multi-fleet_comparison

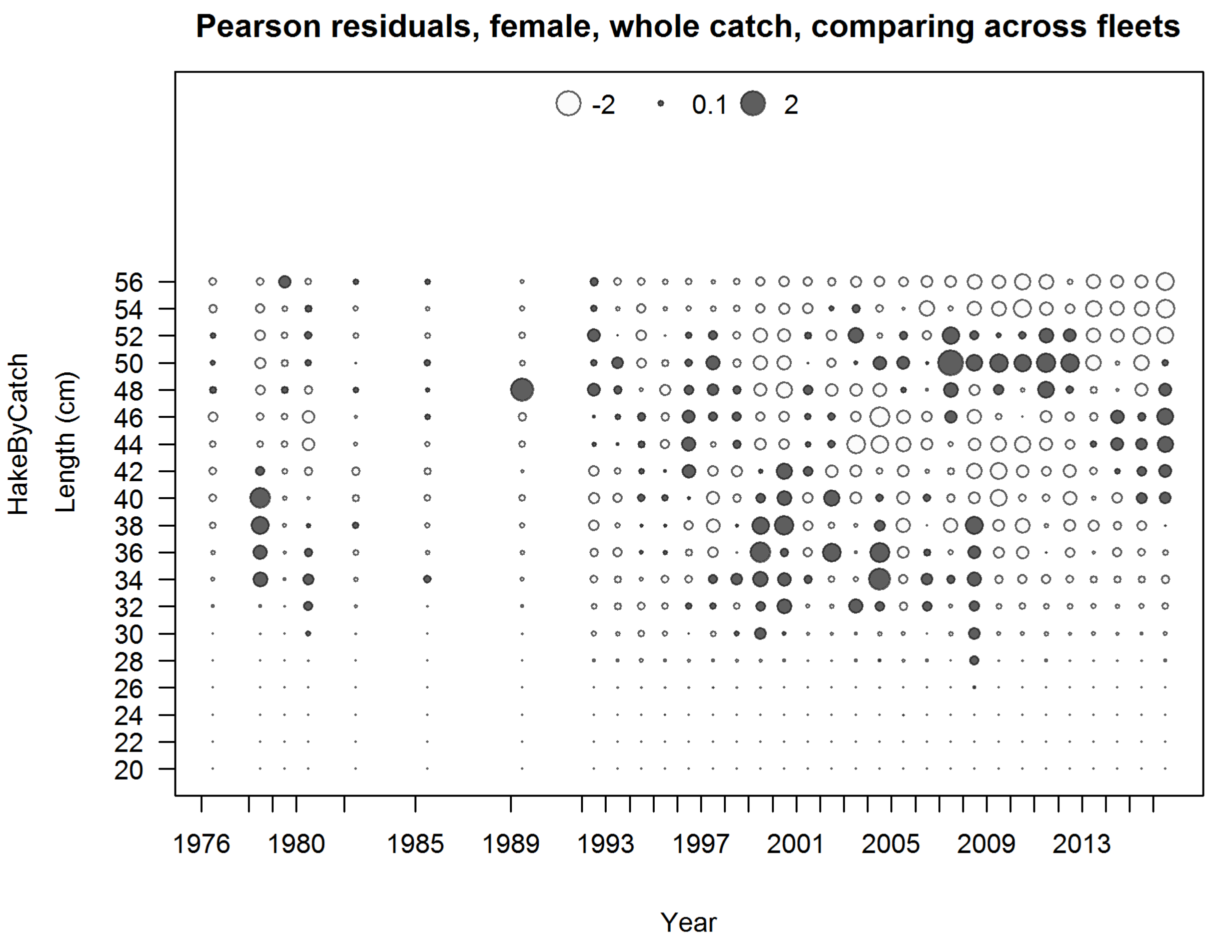


Figure 36: Note: this plot doesn't seem to be working right for some models. Pearson residuals, female, whole catch, comparing across fleets
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_35_comp_lenfit_sex2mkt0_multi-fleet_comparison

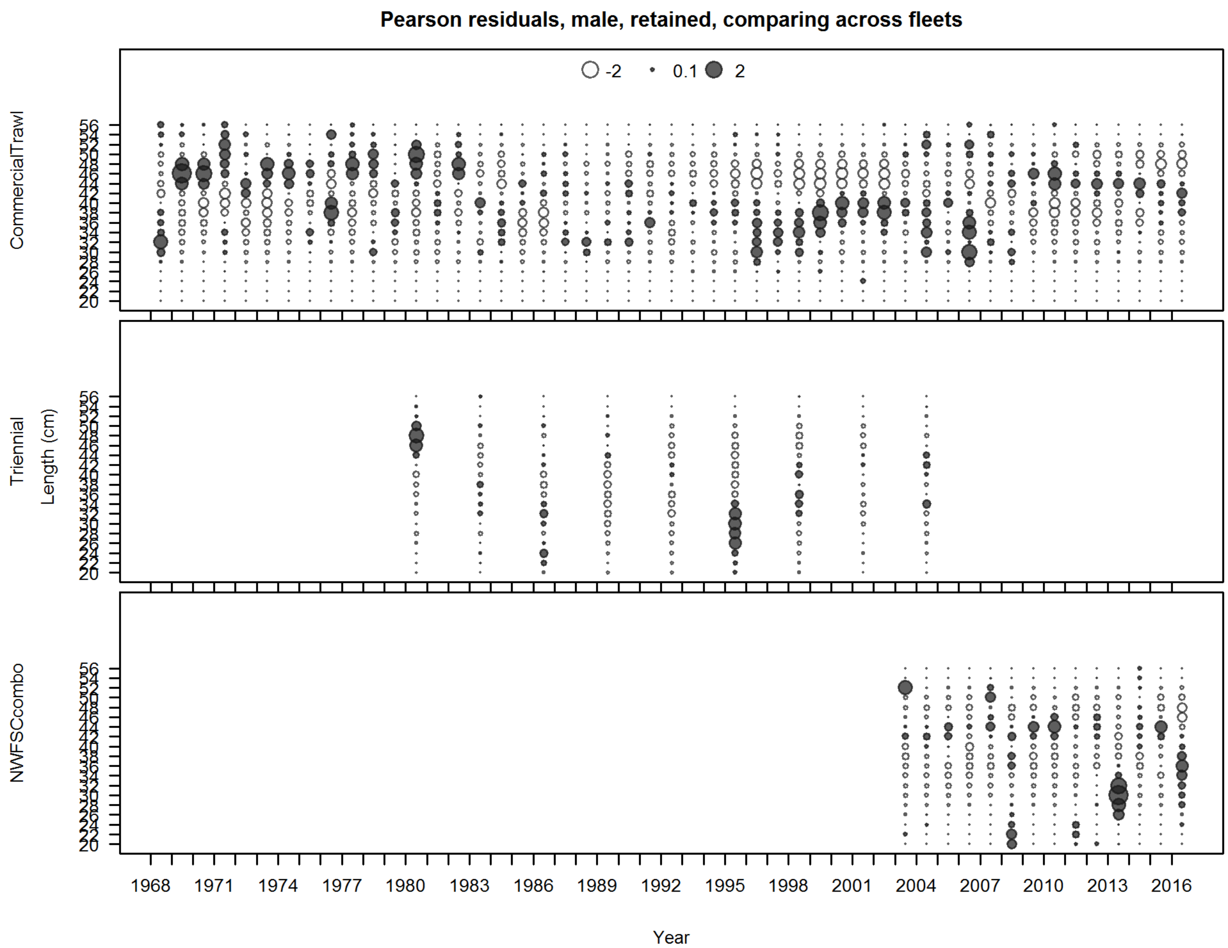


Figure 37: Note: this plot doesn't seem to be working right for some models. Pearson residuals, male, retained, comparing across fleets
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_36_comp_lenfit_sex3mkt2_multi-fleet_comparison

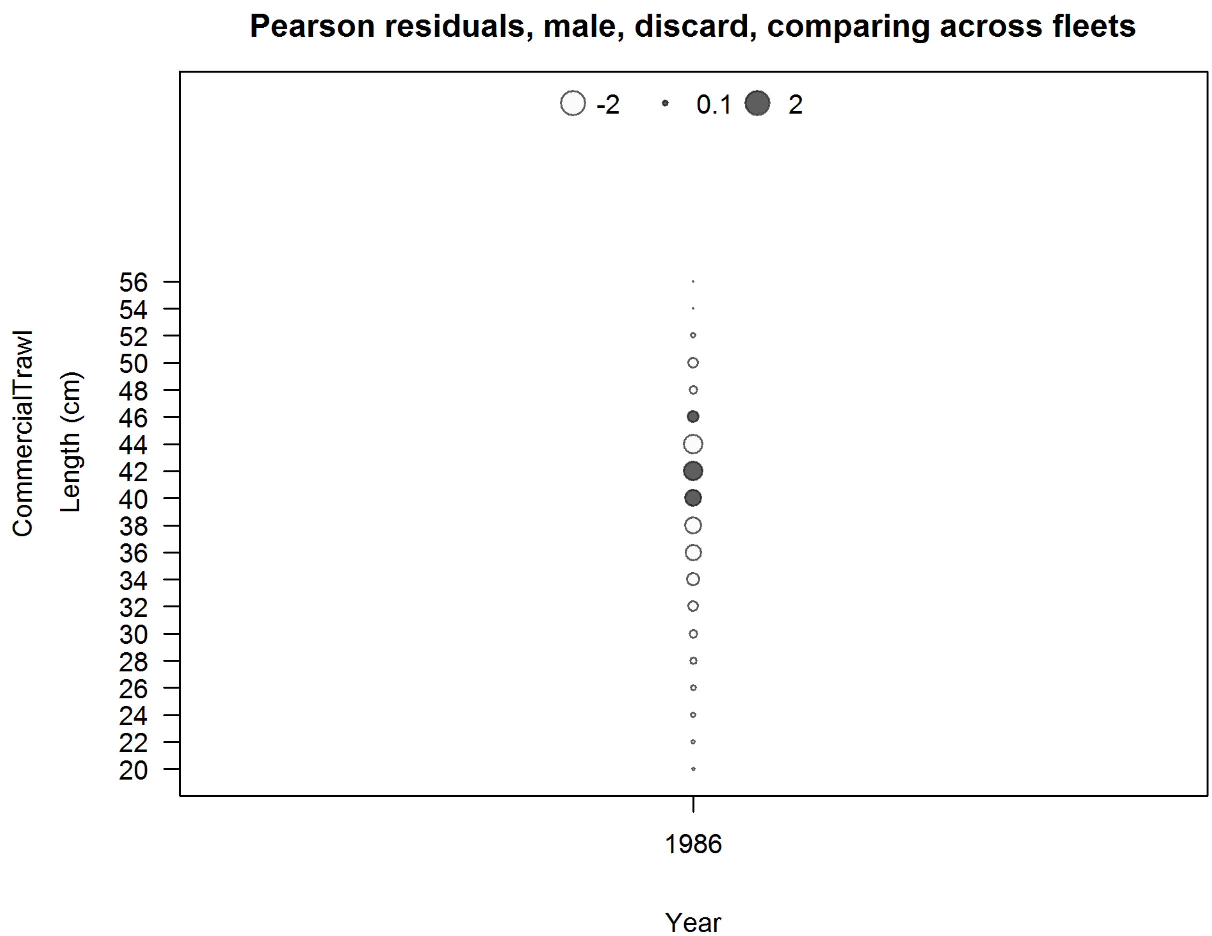


Figure 38: Note: this plot doesn't seem to be working right for some models. Pearson residuals, male, discard, comparing across fleets
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_37_comp_lenfit_sex3mkt1_multi-fleet_comparison

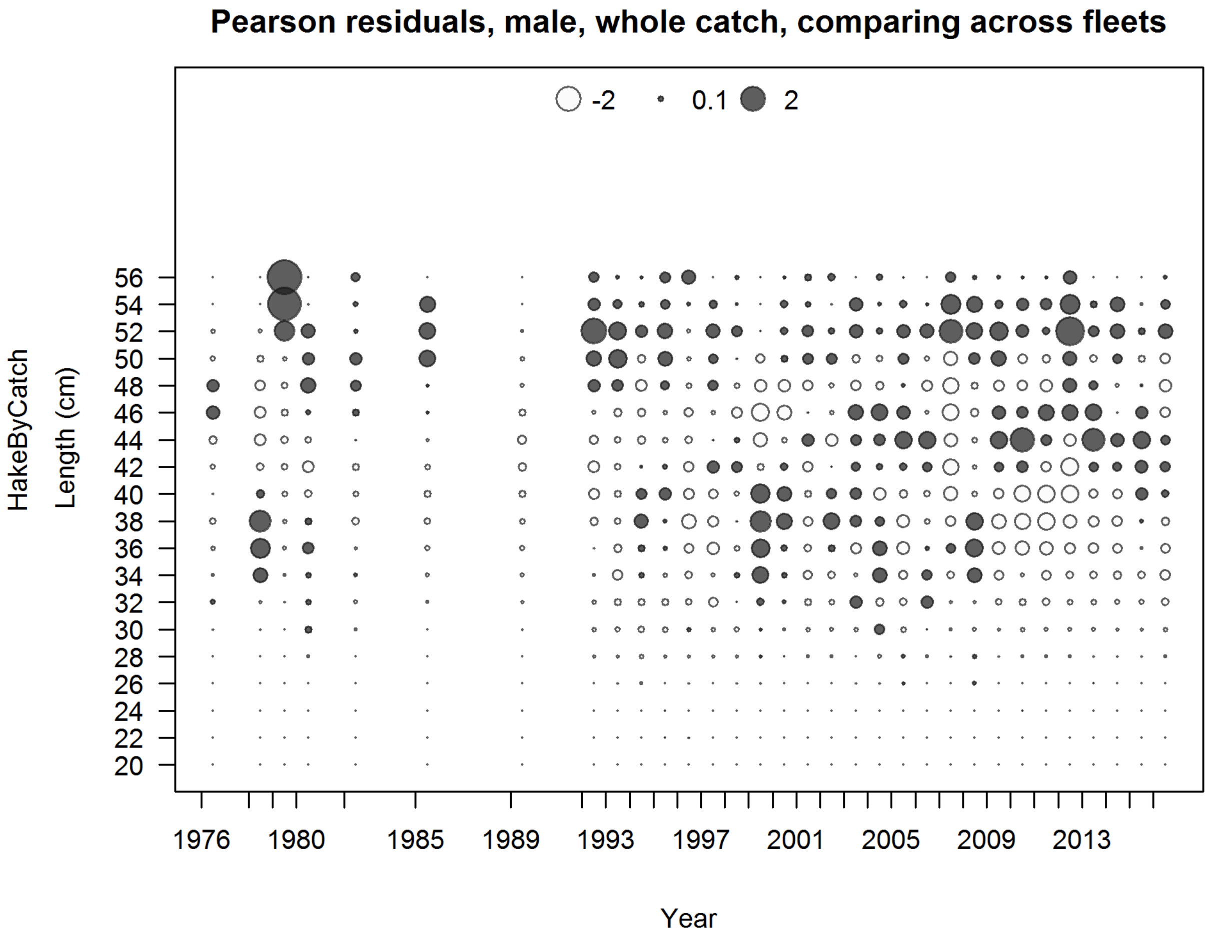


Figure 39: Note: this plot doesn't seem to be working right for some models. Pearson residuals, male, whole catch, comparing across fleets
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_38_comp_lenfit_sex3mkt0_multi-fleet_comparison

Ghost length comps, retained, CommercialTrawl

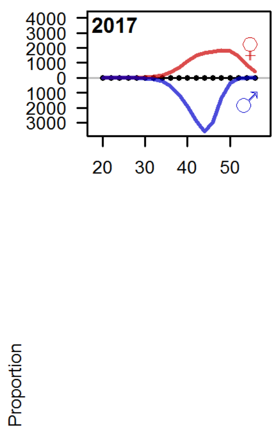


Figure 40: Ghost length comps, retained, CommercialTrawl fig:mod1_39_comp_gstlenfit_

Figure 41: Pearson residuals, retained, CommercialTrawl (max=NA)
Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). fig:mod1_40_comp_gstlenfit_residsflt1mkt2

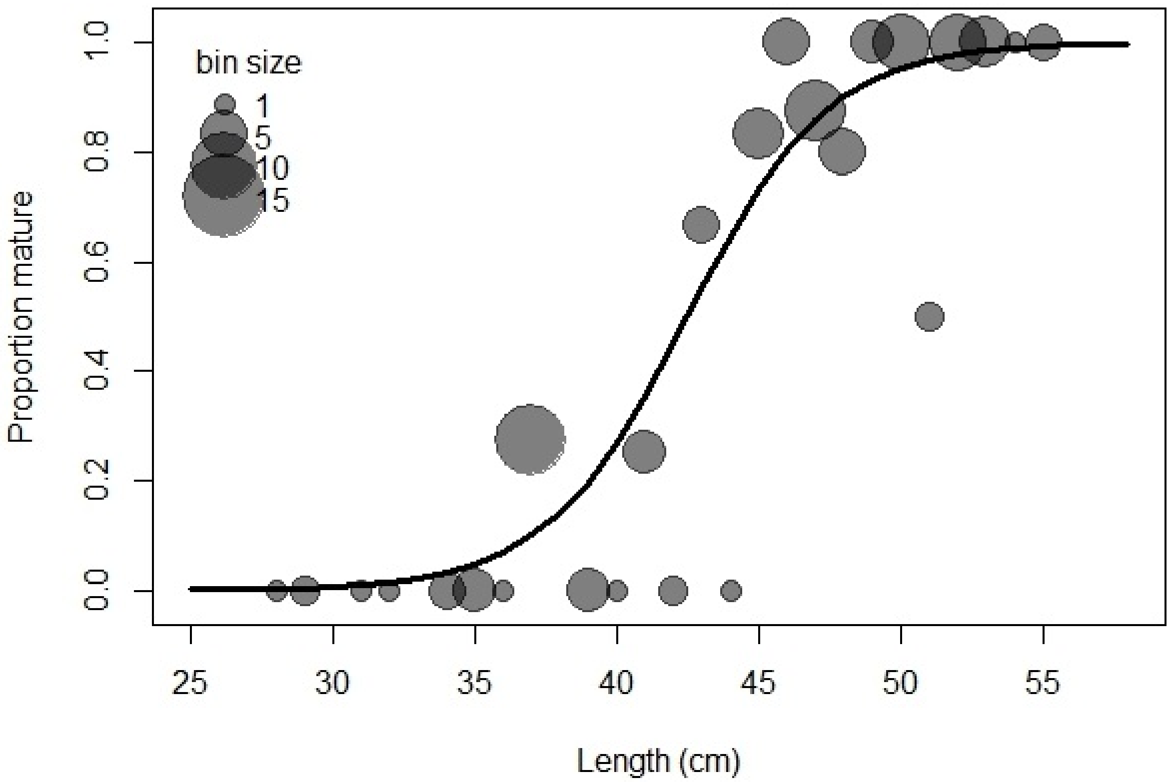


Figure 42: Estimated maturity relationship for Yellowtail Rockfish used in both models. Gray points indicate average observed functional maturity within each length bin with point size proportional to the number of samples. fig:maturity

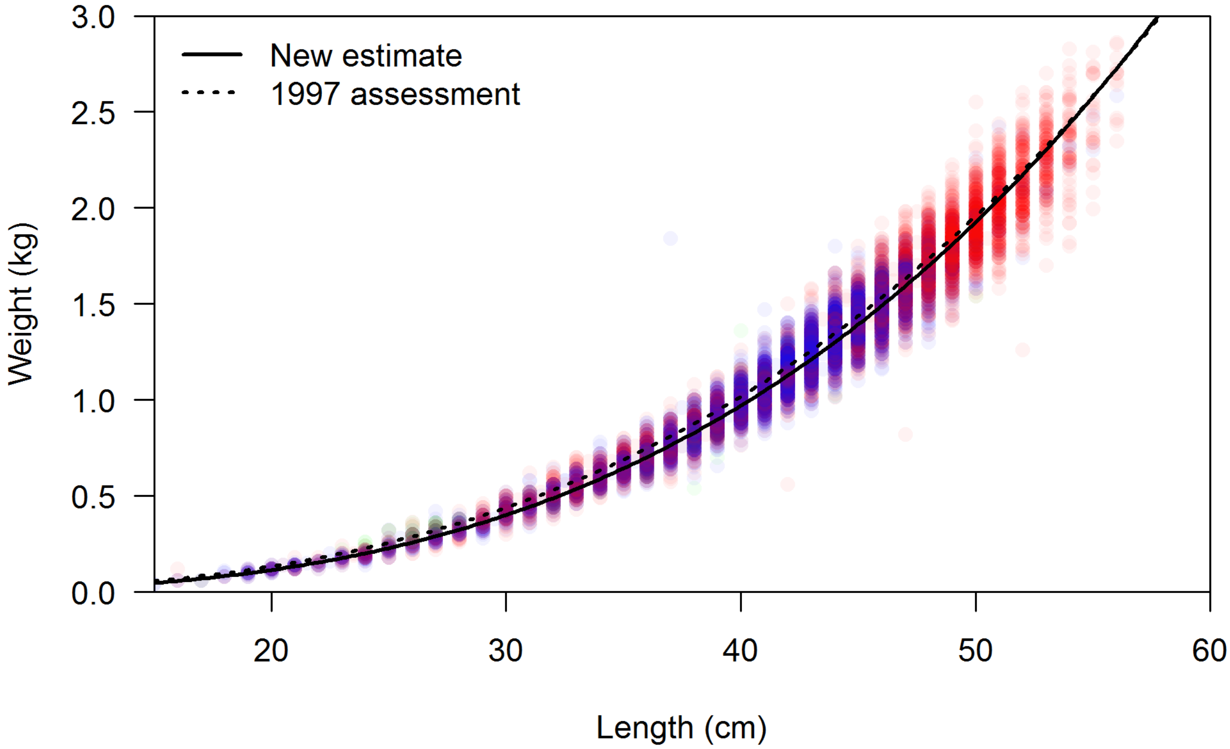


Figure 43: Estimated weight-length relationship for Yellowtail Rockfish used in both models. Colored points show observed values (red for females, blue for males, and green for unsexed). The black line indicates the estimated relationship $W = 0.000011843L^{3.0672}$. fig:weight-length

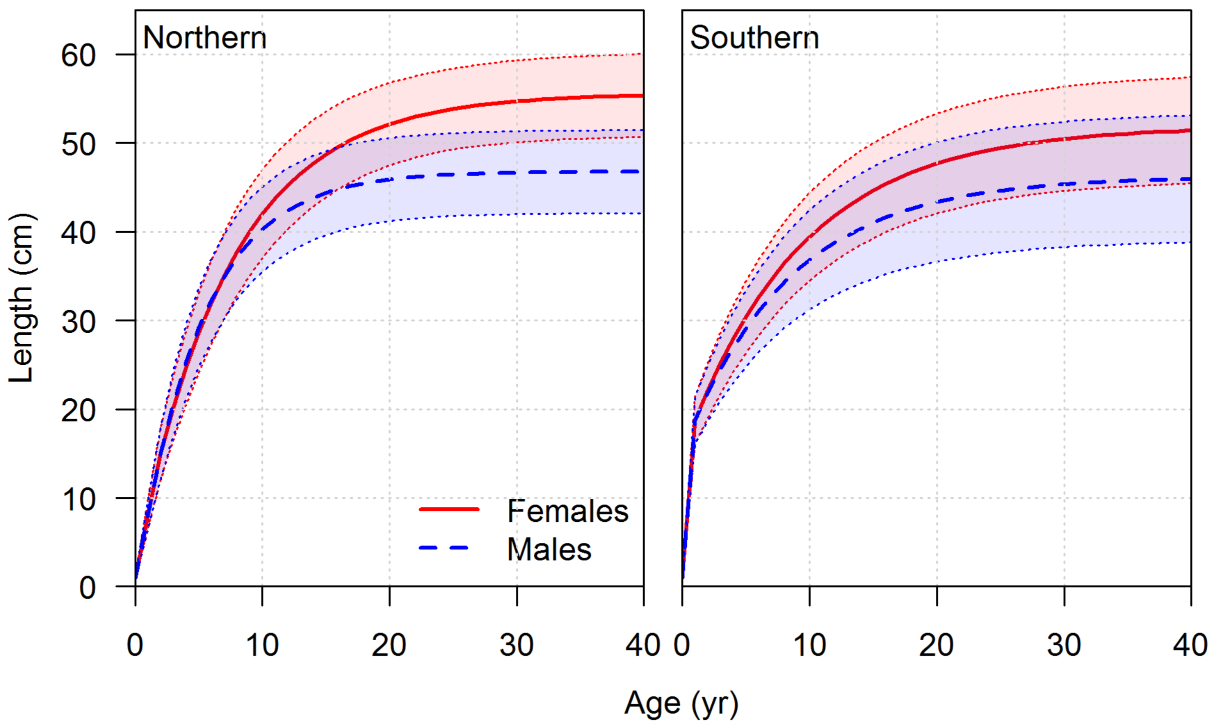


Figure 44: Estimated length-at-age for female and male Yellowtail Rockfish in each model. Shaded areas indicate 95% intervals for distribution of lengths at each age. Values represent beginning-of-year growth. fig:growth

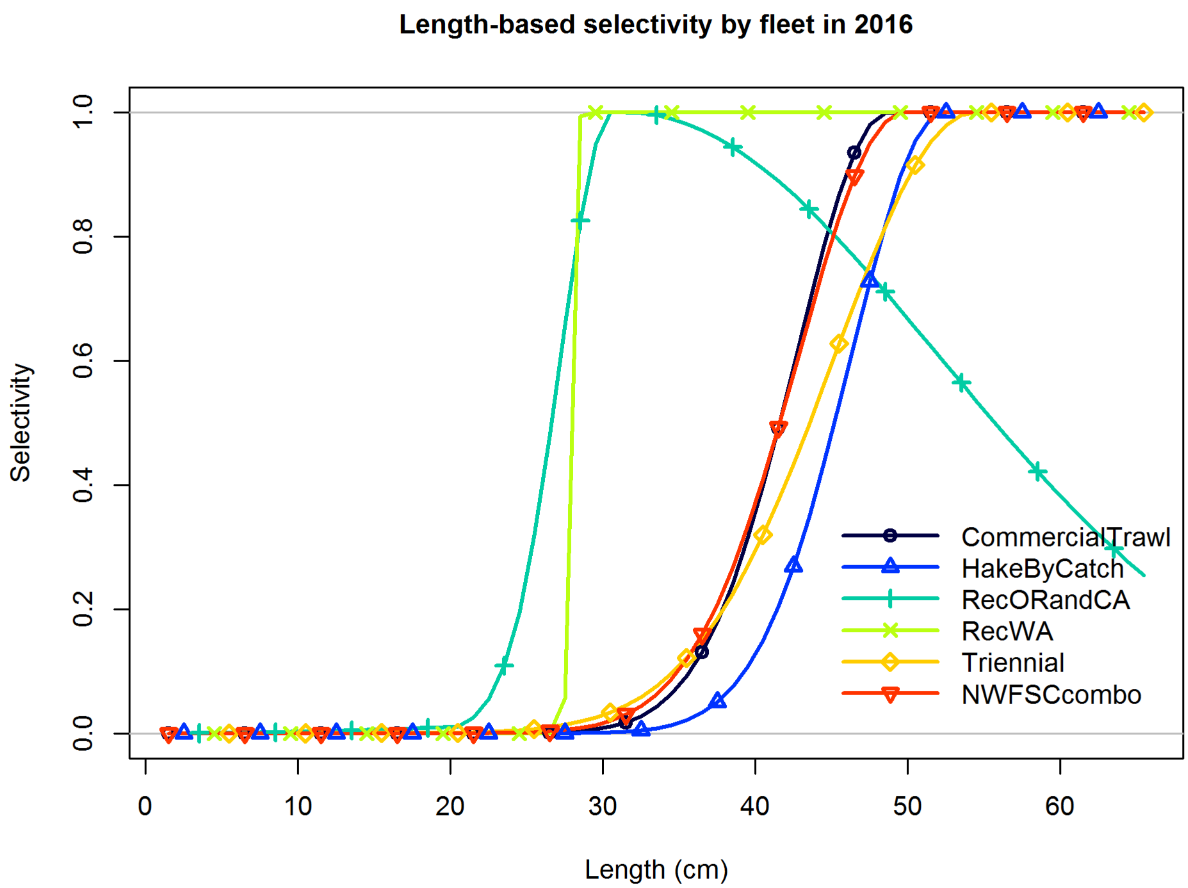


Figure 45: Estimated selectivity by length by each fishery and survey in the `mod1_label`. fig:selex

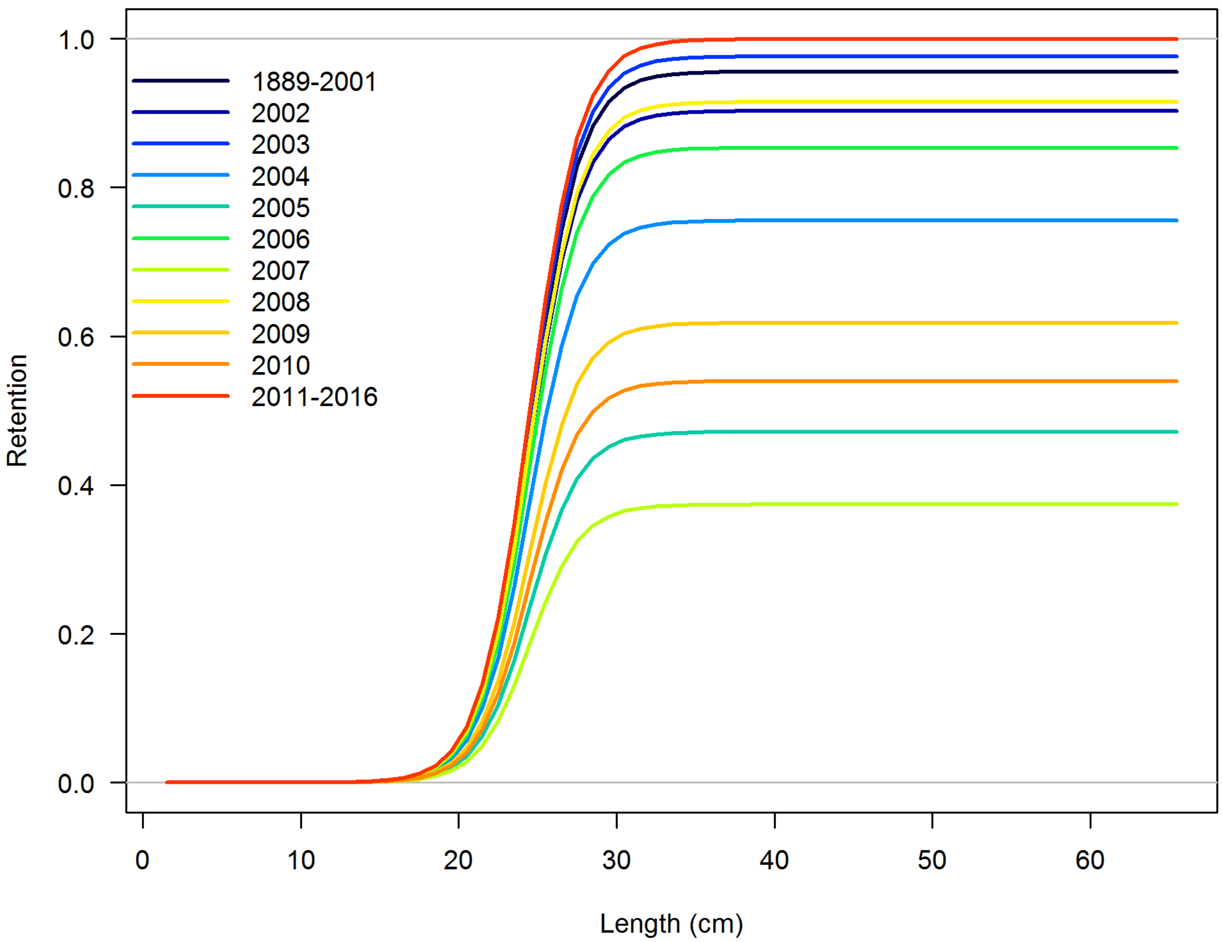


Figure 46: Estimated retention by length by the Commercial Fishery in the mod1_label. fig:retention

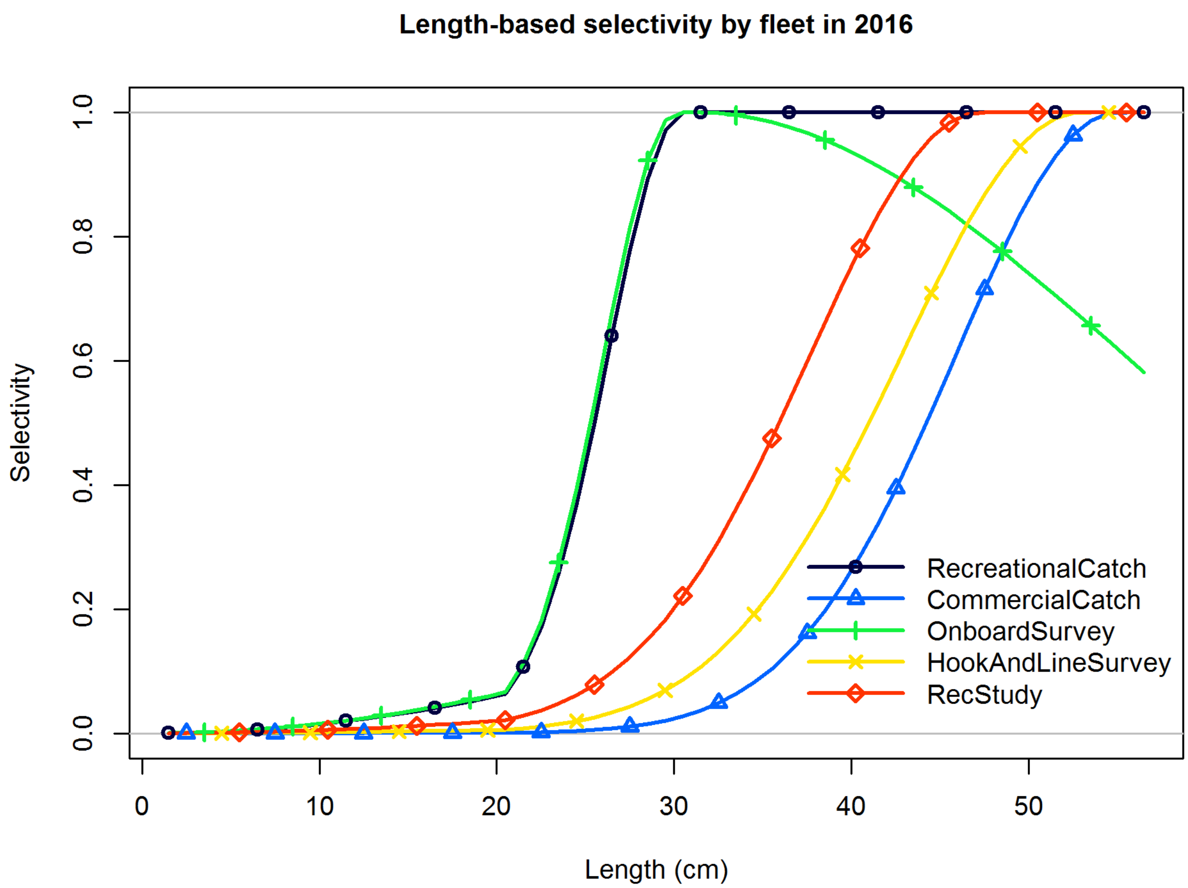


Figure 47: Estimated selectivity by length by each fishery and survey in the `mod2_label`. fig:selex

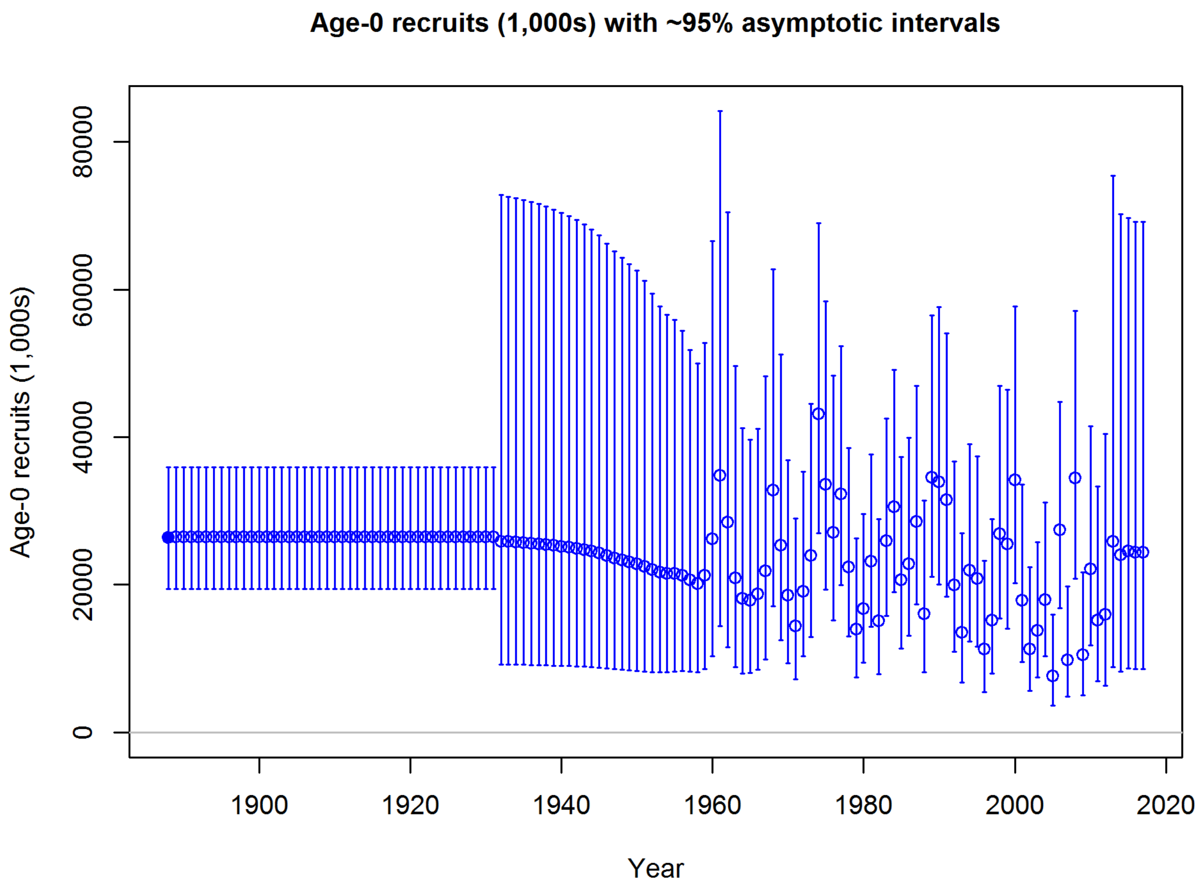


Figure 48: Estimated time-series of recruitment for the `mod1_label`. fig:recruits1

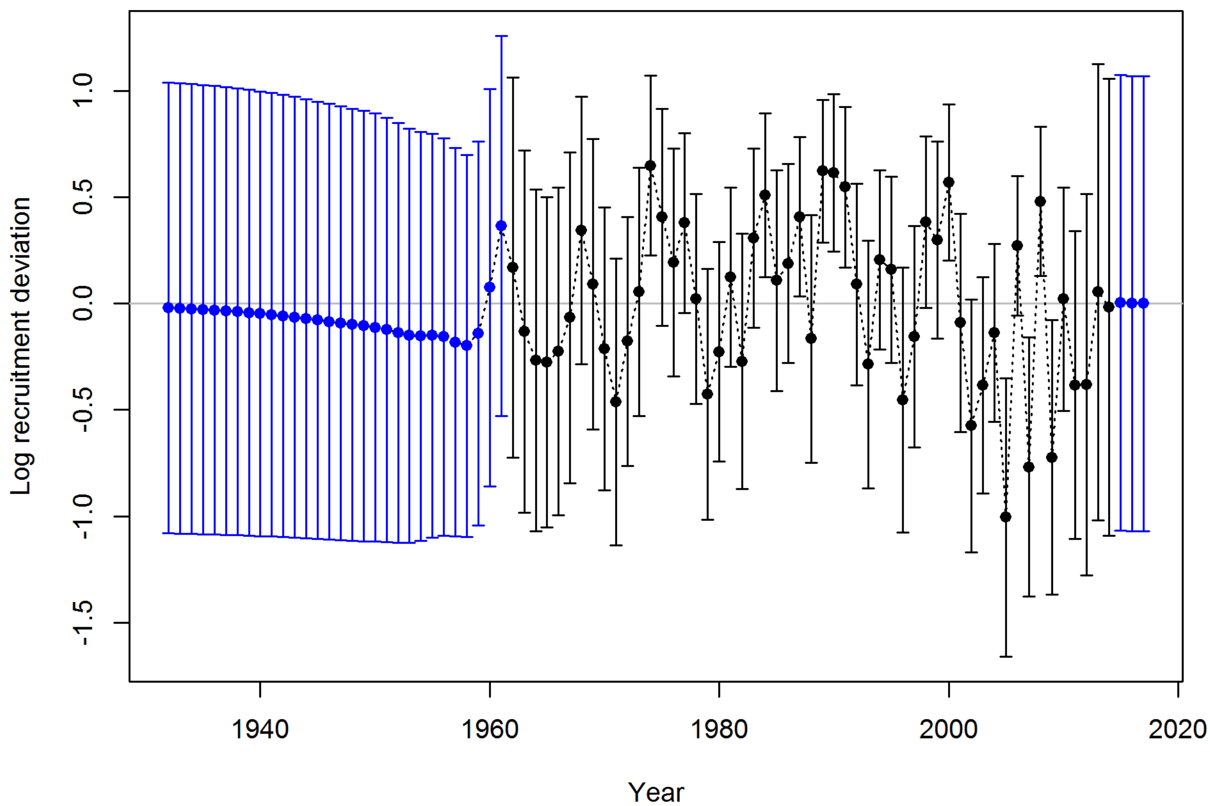


Figure 49: Estimated time-series of recruitment deviations for the `mod1_label`. fig:recdevs1

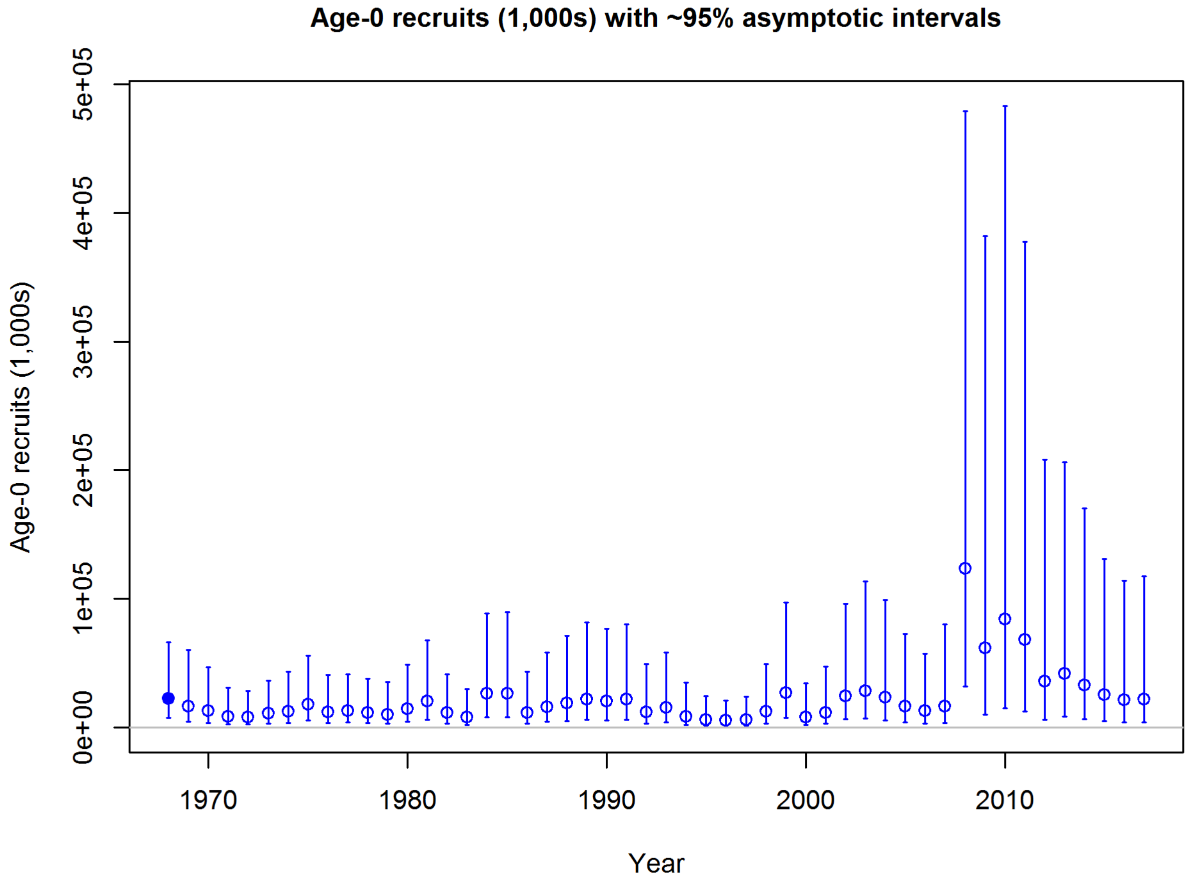


Figure 50: Estimated time-series of recruitment for the `mod2_label`. fig:recruits2

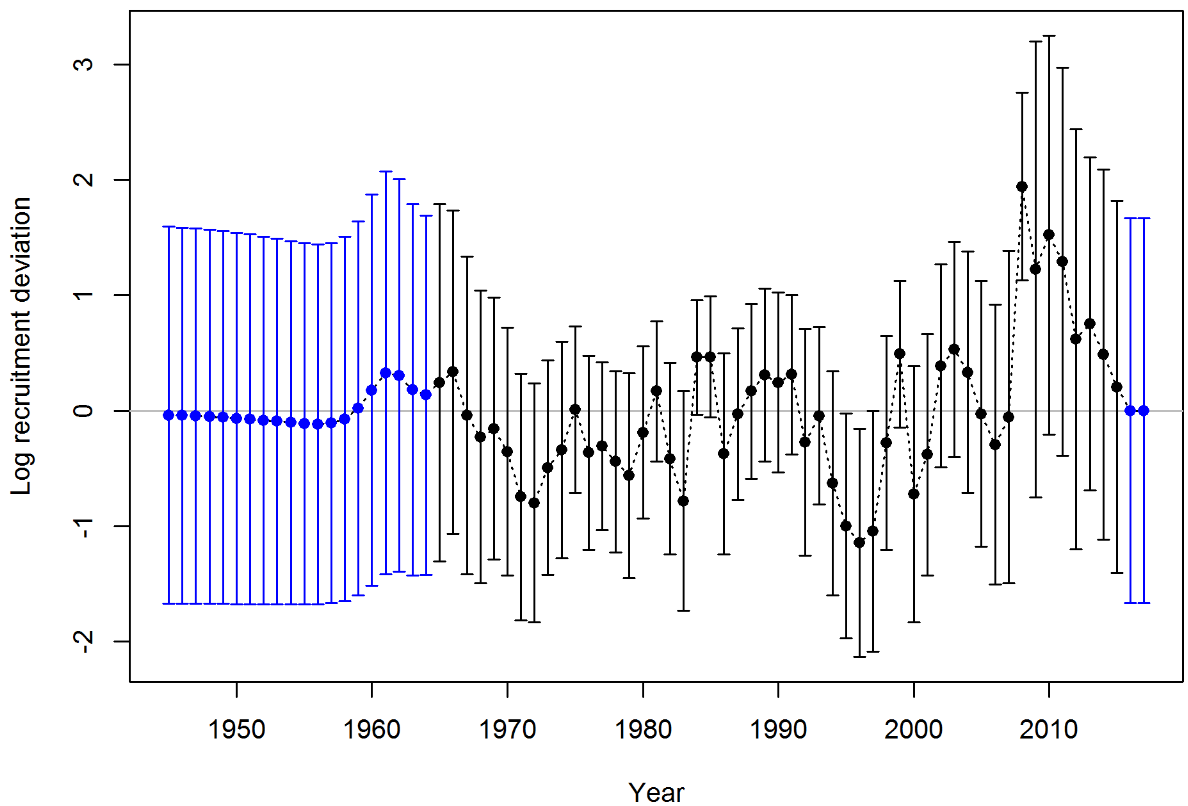


Figure 51: Estimated time-series of recruitment deviations for the `mod2_label`. fig:recdevs2

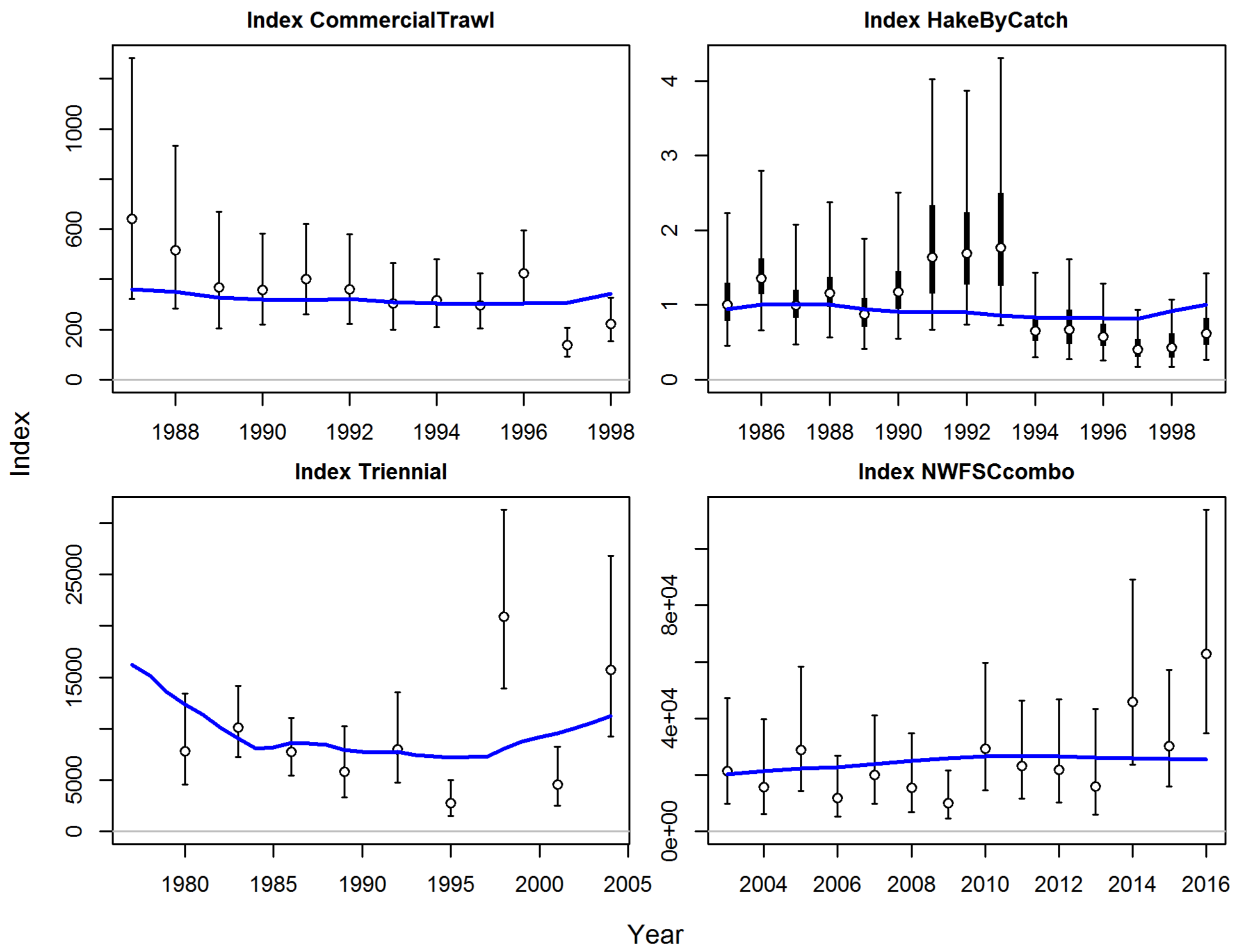


Figure 52: Estimated fits to the CPUE and survey indices for the mod1_label. fig:index_fits1

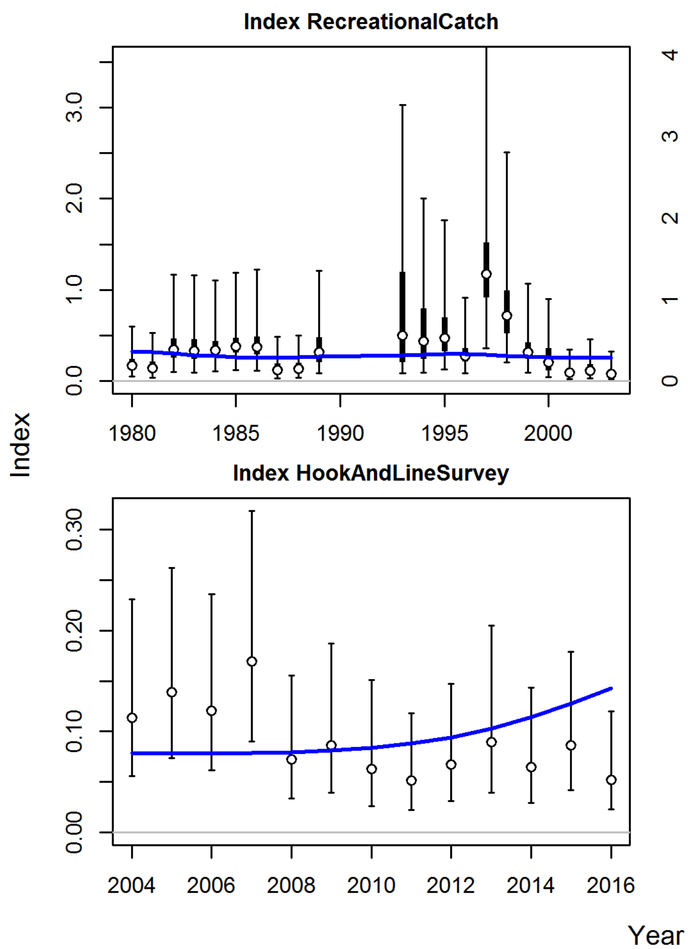


Figure 53: Estimated fits to the CPUE and survey indices for the mod2_label. fig:index_fits2

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