History of alternative models developed for assessing Pacific cod in the EBS, AI, and GOA

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For 2005 and beyond, the SSC's final model from the November assessment is shown in **bold red**.

Pre-2005

- EBS:
  - Pre-1985: Simple projections of current survey nos. at age
  - 1985: Projections based on 1979-1985 survey nos. at age
  - 1986-1991: *ad hoc* separable age-structured model
  - 1992: Stock Synthesis 1 (SS1), with age-based data
    - Strong 1989 cohort "disappears;" production ageing ceased
  - 1993-2003: SS1, with length-based data only
  - 2001: CIE review of code for proposed "ALASKA" (Age-, Length-, and Area-Structured Kalman Assessment) model and methodology for decision-theoretic estimation of OFL and ABC
    - Although review was favorable, use of ALASKA was postponed "temporarily"
  - 2004: SS1, with length- *and* age-based data
    - New age data, based on revised ageing protocol
    - Agecomp data used in "marginal" form
- GOA:
  - Pre-1988: MSY = 0.5 × M × current survey biomass
  - 1988-1993: Stock reduction analysis (Kimura et al. 1984)
  - 1994-2004: SS1, with length-based data
- Main features of SS1 models (EBS and GOA):
  - Start year = 1977
  - Three seasons (Jan-May, Jun-Aug, Sep-Dec)
  - Four fisheries (Jan-May trawl, Jun-Dec trawl, longline, pot)
  - M constant at 0.37 in both BS and GOA
  - Q constant at 1.00 in both BS and GOA
  - Efforts at internal estimation of M, Q unsuccessful
  - Double-logistic selectivity for all fleets (fisheries and survey)
  - No fleets constrained to exhibit asymptotic selectivity
  - Sizecomp input sample size = square root of true sample size
  - Survey index standard deviations set to values reported by RACE Division

2005

- Three models for both EBS and GOA:
  - Model 1 was identical to last year's final model (configured under SS1), except for use of new maturity schedule developed by Stark
  - **Model 2** was configured under SS2, and was designed to be as close as possible to Model 1 given the limitations of the respective software packages, except:

        - Nonuniform priors used throughout
        - *M* fixed at 0.37, *Q* fixed at 1.00
    - Model 3 was identical to Model 2 except that *M* and *Q* were estimated internally
- Weight-length and length-age data examined for evidence of sexual dimorphism in both areas; none found

2006

- Nine models for the EBS, consisting of last year's final model and a 3-way factorial design of alternative models (the factorial models all differed from last year's final model in that they estimated trawl survey *Q* internally—in last year's final model, it was fixed at 1.0; and they estimated all selectivity parameters except for selectivity at the minimum size bin internally—in last year's final model, a few selectivity parameters were fixed externally):
    - Model 0 was identical to last year's final model
    - Model A1 was identical to Model 0 except as noted above, with:
        - NMFS longline survey data omitted
        - Double logistic selectivity
        - Prior emphasis = 1.0
    - Model A2 was identical to Model 0 except as noted above, with:
        - NMFS longline survey data omitted
        - Double logistic selectivity
        - Prior emphasis = 0.5
    - **Model B1** was identical to Model 0 except as noted above, with:
        - NMFS longline survey data omitted
        - Double normal (four parameter) selectivity
        - Prior emphasis = 1.0
    - Model B2 was identical to Model 0 except as noted above, with:
        - NMFS longline survey data omitted
        - Double normal (four parameter) selectivity
        - Prior emphasis = 0.5
    - Model C1 was identical to Model 0 except as noted above, with:
        - NMFS longline survey data included
        - Double logistic selectivity
        - Prior emphasis = 1.0
    - Model C2 was identical to Model 0 except as noted above, with:
        - NMFS longline survey data included
        - Double logistic selectivity
        - Prior emphasis = 0.5
    - Model D1 was identical to Model 0 except as noted above, with:
        - NMFS longline survey data included
        - Double normal (four parameter) selectivity
        - Prior emphasis = 1.0
    - Model D2 was identical to Model 0 except as noted above, with:
        - NMFS longline survey data included
        - Double normal (four parameter) selectivity
        - Prior emphasis = 0.5
- Only one model for the GOA, due to the fact that the assessments were conducted simultaneously with an external review:
    - **Model 1** was identical to last year's final model

April 2007 (technical workshop)

- Model 0 prepared ahead of workshop for both EBS and GOA:
  - *M* estimated internally
  - Length-at-age parameters estimated internally
  - Disequilibrium initial age structure
  - Regime shift recruitment offset estimated internally
  - Start year changed from 1964 to 1976
  - New six-parameter double normal selectivity function used
    - Previous double normal had only four parameters
  - Prior distributions reflect 50% CV for most parameters
- Twenty-one other models prepared ahead of workshop for both EBS and GOA, each of which was based on Model 0:
  - Two models to examine inside/outside growth estimation:
    - Model 1 was identical to Model 0 except length-at-age parameters estimated outside the model
    - Model 2 was identical to Model 0 except standard deviation of length at age 12 estimated internally
  - Two models to examine *M* conditional on *Q,* vice-versa:
    - Model 3 was identical to Model 0 except *M* fixed at 0.37 and *Q* free
    - Model 4 was identical to Model 0 except *Q* fixed at 0.75 and *M* free
  - Six models to examine effects of prior distributions:
    - Model 5 was identical to Model 0 except 30% CV instead of 50%
    - Model 6 was identical to Model 0 except 40% CV instead of 50%
    - Model 7 was identical to Model 0 except emphasis = 0.2 instead of 1.0
    - Model 8 was identical to Model 0 except emphasis = 0.4 instead of 1.0
    - Model 9 was identical to Model 0 except emphasis = 0.6 instead of 1.0
    - Model 10 was identical to Model 0 except emphasis = 0.8 instead of 1.0
  - Four models to examine effects of asymptotic selectivity:
    - Model 11 was identical to Model 0 except Jan-May trawl fishery selectivity forced asymptotic
    - Model 12 was identical to Model 0 except longline fishery selectivity forced asymptotic
    - Model 13 was identical to Model 0 except pot fishery selectivity forced asymptotic
    - Model 14 was identical to Model 0 except shelf trawl survey selectivity forced asymptotic
  - One model to examine estimation of stock-recruit relationship:
    - Model 15 was identical to Model 0 except parameters of a Ricker stock-recruitment relationship estimated internally
  - Six models to address EBS-specific comments from the public:
    - Model 16 was identical to Model 0 except input *N* determined by iterative re-weighting
    - Model 17 was identical to Model 0 except input *N* for mean-size-at-age data decreased by an order of magnitude
    - Model 18 was identical to Model 0 except standard error from the shelf trawl survey doubled
    - Model 19 was identical to Model 0 except all age data removed
    - Model 20 was identical to Model 0 except slope survey data removed
    - Model 21 was identical to Model 0 except start year changed to 1982

- Immense factorial grid of fixed $M \times Q$ models also prepared ahead of workshop, for which only partial results were presented
- Eight models developed during workshop (EBS only):
    - Model 22 was identical to Model 0 except "old" (pre-Stark) maturity schedule used
    - Model 23 was identical to Model 0 except priors turned off and separate *M* estimated for ages 1-2
    - Model 24 was identical to Model 0 except priors turned off and longline fishery CPUE included as an index of abundance
    - Model 25 was identical to Model 0 except priors turned off and Pcod bycatch from IPHC survey included as an index of abundance
    - Model 26 was identical to Model 0 except priors turned off and either *Q* (=0.75) or *M* (=0.37) fixed
    - Model 27 was identical to Model 0 except all priors turned off other than that for Jan-May trawl selectivity in largest size bin
    - Model 28 was identical to Model 0 except survey selectivity forced asymptotic and *Q* fixed at 0.5
    - Model 29 was identical to Model 0 except separate *M* estimated for ages 9+

September 2007 (EBS only)

- In general:
    - Agecomp data presented as "age conditioned on length" (i.e., not marginals)
    - Length-at-age SD a linear function of age
    - Annual *dev*s for length at age 1, sigma=0.11
    - Annual *dev*s for recruitment, sigma=0.6, 1973-2005
    - Annual *dev*s for ascending selectivity, sigma=0.4
    - All parameters estimated internally
    - Except selectivity parameters pinned against bounds
    - Uniform priors used exclusively
    - Monotone selectivity for Jan-May trawl fishery
    - All other selectivities new "double normal" (see next 4 slides)
- Four models considered, all of which were identical to last year's final model except as specified above:
    - Model 1:
        - Estimated effect of 1976 regime shift on median recruitment
        - Addeda large constant to fishery CPUE sigmas
    - Model 2 was identical to Model 1 except age-dependent *M* estimated for ages 8+
    - Model 3 was identical to Model 1 except that it did not add the large constant to longline CPUE sigmas
    - Model 4 was identical to Model 1 except:
        - Effect of regime shift assumed to be zero
        - Did not add large constant to longline CPUE sigmas
        - Zero emphasis placed on initial catch and age composition
        - Iteratively re-weighted input sigmas and input *N*
- Also attempted but not included:
    - Simplified model with only a single fishery and no seasons

November 2007

- Four models for the EBS:
    - **Model 1** (with comparisons to last year's final model):

        - *M* fixed at 0.34 (*M* fixed at 0.37 last year)
        - Length-at-age parameters estimated internally (fixed at point estimates from raw data last year)
        - Start year set at 1977 (start year set at 1964 last year)
        - Three age groups in initial state vector estimated (initial state vector assumed to be in equilibrium last year)
        - 6-parameter double normal selectivity (4-parameter version used last year)
        - Uniform priors used exclusively (informative normal priors used for many parameters last year)
        - Fishery selectivities constant across all years (approximately decadal "time blocks" used last year)
        - Ascending limb of survey selectivity varies annually with σ=0.2 (survey selectivity assumed to be constant last year)
        - Survey selectivity based on age (length-based selectivity used last year)
        - Some fishery selectivities forced asymptotic (all selectivities free last year)
        - Fishery CPUE data included for comparison (not included last year)
        - Age-based maturity schedule (length-based schedule used last year)
        - All fisheries seasonally structured (trawl partially seasonal, other gears non-seasonal last year)
        - Trawl survey abundance measured in numbers (abundance measured in biomass last year)
        - Multinomial *N* based on rescaled bootstrap (sample size set equal to square root of actual *N* last year)
    - Model 2 was identical to Model 1 except *M* fixed at 0.37
    - Model 3 was identical to Model 1 except *M* estimated internally
    - Model 4 was identical to Model 1 except:
        - *M* estimated internally
        - Survey selectivities forced to be asymptotic
        - Age data ignored
        - Start year set at 1982; 1977 regime shift ignored
        - Length-based maturity used
        - Length-based survey selectivity used
        - Sigma=0.4 for annual deviations in selectivity parameters
        - Initial catch ignored in estimating initial fishing mortality
- One model for the GOA:
    - Model was based largely on EBS Model 1
    - Large number of changes undertaken in the EBS assessment resulted in little time being left for development of the GOA assessment
    - Making things even worse, a very small error in EBS data file, with very large implications, was discovered very late in the cycle
    - As a consequence, GOA SAFE chapter was incomplete and was delivered late to Plan Team
    - Although both Teams participated fully in the development and evaluation of EBS Model 1 (which was accepted by the BSAI Team and accepted "in principle" by the SSC), the GOA Team and SSC rejected the GOA assessment due to insufficient time for review

September 2008

- Five models included for the EBS:
    - Model 1 was identical to last year's final model
    - Model 2 was identical to Model 1 except growth parameter *L2* estimated externally

    - Model 3 was identical to Model 1 except exponential-logistic selectivity used instead of double normal
    - Model 4 was identical to last year's Model 4
    - Model 5 was identical to Model 1 except:
        - Fishery selectivity blocks (5 yr, 10 yr, 20 yr, or no blocks) chosen by AIC
        - Lower bound of descending "width" = 5.0
        - Regime-specific recruitment "dev" vectors
        - "SigmaR" set equal (iteratively) to stdev(dev) from current regime
        - Seasonal weight-length, based on fishery data
        - Number of free initial ages chosen by AIC
        - Size-at-age data used if modes ambiguous
- Three models included for the GOA:
    - Model 1 was identical to the 2006 final model
    - Model 2 was identical to the 2007 model
    - Model 3 was similar to EBS Model 5, except:
        - Size at age data included
        - Survey sizecomp, agecomp data downweighted
        - Time series of survey abundance, sizecomps split into separate "sub-27" and "27-plus" time series:
        - 27-plus survey split into pre-1996, post-1993 eras, to coincide with switch from 30-min. to 15-min. tows
        - 27-plus *Q* fixed for post-1993, free for pre-1996
        - Sub-27 *Q* free, estimated as random walk

November 2008

- Eight models for the EBS:
    - Model A1 was identical to Model 5 from September except lower bound on selectivity descending "width" parameter relaxed so as not to be constraining
    - Model A2 was identical to Model A1, except without age data
    - **Model B1** was identical to Model A1, except:
        - "Asymptotic algorithm" used to determine which fisheries will be forced to exhibit asymptotic selectivity
        - "Constant-parameters-across-blocks algorithm" used to determine which selectivity parameters can be held constant across blocks
    - Model B2 was identical to Model B1, except without age data
    - Model C1 was identical to Model B1, except with M estimated internally
    - Model D2 was identical to Model B1, except:
        - No age data
        - Maturity modeled as function of length rather than age
        - M estimated iteratively, based on mat. at len and len. at age
    - Model E2 was identical to Model B1, except:
        - No age data
        - Post-1981 trawl survey selectivity forced to be asymptotic
        - M estimated internally
    - Model F2 was identical to last year's Model 4, except start year = 1977
- Two models for the GOA:
    - Model A was identical to Model 3 from September except:
        - Lower bound on selectivity descending "width" parameter relaxed so as not to be constraining
    - **Model B** was identical to Model A, except:

        - "Constant-parameters-across-blocks algorithm" used
        - Constant *Q* for 27-plus survey assumed (needed to keep pre-1996 *Q* from going too high)
        - Input sample sizes for age data decreased from 100 to 12 (needed to achieve good fit to survey nos. given constant *Q*)

September 2009

- Eight models for the EBS, based on factorial design of the following:
    - Selectivity functional form: double normal or exponential-logistic?
    - Catchability: free or fixed at 1.0?
    - Survey selectivity estimation: free or forced asymptotic?
- Partial results presented for a model with prior distribution for *Q* based on archival tags
    - Prior had virtually no impact, which was why only partial results were presented
- Other features explored but not included in the above models:
    - Fixing trawl survey catchability at the mean of the above normal prior distribution
    - Allowing trawl survey catchability to vary as a random walk
    - Fixing trawl survey catchability at a value of 1.00 for the pre-1982 portion of the time series, but allowing it to be estimated freely for the post-1981 portion of the time series
    - Reducing the number of survey selectivity parameters subject to annual deviations
    - Use of additive, rather than multiplicative, deviations for certain survey selectivity parameters
    - Decreasing the value of the σ parameter used to constrain annual survey selectivity deviations
    - Turning off annual deviations in survey selectivity parameters for the three most recent years
    - Turning off all annual deviations in survey selectivity parameters
    - Forcing trawl survey selectivity to peak at age 6.5, the approximate mid-point of the size range of 60-81 cm spanned by the results of Nichol et al. (2007)
    - Imposing a beta prior distribution on the shape parameter of the exponential-logistic selectivity function in the trawl survey.
- Eleven models for the GOA, based on a not-quite-factorial design of the following:
    - Include recently discovered sizecomp data from early years?
    - Agecomp emphasis : 0.12 or 1.00?
    - Pre-1996 Q: 0.92 or 1.00?
    - 27-plus selectivity: age-based or length-based?
    - Selectivity functional form: double normal or exponential-logistic?
    - Jan-May trawl fishery selectivity estimation: free or forced asymptotic?
    - 27-plus selectivity estimation: free or forced asymptotic?
- Other features explored but not included in the above models:
    - Decreasing size composition emphasis
    - Decreasing age composition emphasis (including zero emphasis)
    - Decreasing size-at-age emphasis (including zero emphasis)
    - Adding a constant to the 27-plus trawl survey "sigma"
    - Decreasing the 27-plus trawl survey "sigma"
    - Turning off size composition data for various blocks of years
    - Turning off size composition data one year at a time
    - Turning off size composition data one fleet at a time
    - Freeing catchability for the 27-plus trawl survey
    - Freeing pre-1996 catchability for the 27-plus trawl survey
    - Imposing an informative normal prior on pre-1996 *Q* for the 27-plus trawl survey

- Allowing catchability in the 27-plus trawl survey to follow a random walk
- Allowing all double normal selectivity parameters to change in each survey year
- Introducing cohort-specific length at age, with varying amounts of freedom
- Changing the age range from 0-20+ to 1-12+ or 1-13+
- Doubling the amount ageing error
- Setting the natural mortality rate equal to 0.40
- Freeing *M*
- Freeing *M* at ages 0 and 1
- Forcing *M* at ages 0 and 1 to be higher than at ages 2 and above
- Imposing symmetric beta priors on exponential-logistic selectivity parameters
- Relaxing the assumption that at least one fleet must exhibit asymptotic selectivity
- Changing from size-based to age-based selectivity for fisheries
- Estimating a separate, *time-invariant*, selectivity for each age in the 27-plus survey
- Estimating a separate, *time-variant*, selectivity for each age in the 27-plus survey

November 2009

- Fourteen models for the EBS (all new since September except for Model A1):
  - Models without mean-size-at-age data:
    - Model A1 was identical to last year's final model, with the addition of new data, including the first available fishery agecomp data (from the 2008 Jan-May longline fishery)
    - Model A2 was identical to Model A1, except all agecomp data omitted
    - Model A3 was identical to Model A1, except 2008 Jan-May longline fishery agecomp data omitted
    - Model F2 was identical to last year's Model F2
  - Models with mean-size-at-age data and agecomp data:
    - **Model B1** was identical to Model A1 except:
      - Survey selectivity held constant for most recent two years
      - Cohort-specific growth included
      - Input standard deviations of all "dev" vectors were set iteratively by matching the standard deviations of the set of estimated *dev*s
      - Standard deviation of length at age was estimated outside the model as a linear function of mean length at age
      - Selectivity at maximum size or age was treated as a controllable parameter
      - *Q* for the post-1981 trawl survey was fixed at the value that sets the average (weighted by numbers at length) of the product of *Q* and selectivity for the 60-81 cm size range equal to the point estimate of 0.47 obtained by Nichol et al. (2007)
      - Potential ageing bias was accounted for in the ageing error matrix by examining alternative bias values in increments of 0.1 for ages 2 and above (age-specific bias values were also examined, but did not improve the fit significantly).
    - Model C1 was identical to Model B1 except:
      - Input standard deviations for all "dev" vectors and the amount of ageing bias fixed at the values obtained iteratively in Model B1
      - *Catchability itself* (rather than the average product of catchability and selectivity for the 60-81 cm size range) set equal to 0.47
    - Model D1 was identical to Model B1 except:

            - Input standard deviations for all "dev" vectors and the amount of ageing bias fixed at the values obtained iteratively in Model B1
            - Selectivity at maximum size or age was removed from the set of controllable parameters (instead, selectivity at maximum size or age becomes a function of other selectivity parameters)
        - Model E1 was identical to Model B1 except:
            - Input standard deviations for all "dev" vectors and the amount of ageing bias fixed at the values obtained iteratively in Model B1
            - Selectivity at maximum size or age for all non-asymptotic fleets was set equal to a single value that was constant across fleets
        - Model G1 was identical to Model B1 except:
            - Input standard deviations for all "dev" vectors and the amount of ageing bias fixed at the values obtained iteratively in Model B1
            - Survey selectivity was held constant across all years (i.e., no selectivity *dev*s are estimated for any years)
    - Models with mean-size-at-age data and without agecomp data:
        - Models B2, C2, D2, E2, and G2 were identical to their B1, C1, D1, E1, and G1 counterparts except that agecomp data were ignored and the corresponding sizecomp data were active.
- Ten models for the GOA:
    - Models based on last year's final model, with different uses of agecomp data:
        - Model A1 was identical to last year's final model, with the addition of new data, including the first available fishery agecomp data (from the 2008 Jan-May longline fishery)
        - Model A2 was identical to Model A1, except all agecomp data omitted
        - Model A3 was identical to Model A1, except 2008 Jan-May longline fishery agecomp data omitted
        - Model A4 was identical to Model A1, except standard deviations in the ageing error matrix were doubled for ages 2-4
    - Substantially revised models with age composition data:
        - **Model B1** was identical to Model A1 except:
            - Survey selectivity held constant for most recent two years
            - Cohort-specific growth included
            - Input standard deviations of all "dev" vectors were set iteratively by matching the standard deviations of the set of estimated *dev*s
            - Standard deviation of length at age was estimated outside the model as a linear function of mean length at age
            - Selectivity at maximum size or age was treated as a controllable parameter
            - *Q* for the pre-1996 years of the 27-plus survey was estimated freely
            - *Q* for the post-1993 years was fixed at the value that sets the average (weighted by numbers at length) of the product of *Q* and selectivity for the 60-81 cm size range equal to the point estimate of 0.92 obtained by Nichol et al. (2007)
            - Potential ageing bias was accounted for in the ageing error matrix by examining alternative bias values in increments of 0.1 for ages 2 and above (age-specific bias values were also examined, but did not improve the fit significantly).
        - Model D1 was identical to Model B1 except:

            - Input standard deviations for all "dev" vectors and the amount of ageing bias were fixed at the values obtained iteratively in Model B1
            - Selectivity at maximum size or age was removed from the set of controllable parameters (instead, selectivity at maximum size or age becomes a function of other selectivity parameters)
        - Model E1 was identical to Model B1 except:
            - Input standard deviations for all "dev" vectors and the amount of ageing bias were fixed at the values obtained iteratively in Model B1
            - Selectivity at maximum size or age for all non-asymptotic fleets was set equal to a single value that was constant across fleets
    - Substantially revised models without age composition data:
        - Models B2, D2, and E2 were identical to their B1, D1, and E1 counterparts except that agecomp data were ignored and the corresponding sizecomp data were active

September 2010

- Six models for the EBS and five models for the GOA:
    - Model 1 (EBS and GOA) was identical to last year's final model
    - Model 2 (EBS and GOA) was identical to Model 1 except:
        - Input standard deviations for all "dev" vectors fixed at the values obtained iteratively in Model 1
        - IPHC survey data omitted
        - fishery age data omitted
        - Traditional 3-or-5 cm size bins replaced with 1 cm size bins
        - Traditional 3-season structure replaced with new, 5-season structure
        - Spawn time changed from beginning of season 1 to beginning of season 2
    - Model 3 (EBS and GOA) was identical to Model 2 except:
        - Non-uniform prior distributions used for selectivity parameters and Q
    - Model 4 (EBS and GOA) was identical to Model 2 except:
        - All age data omitted
        - Maturity schedule was length-based rather than age-based
    - Model 5 (EBS and GOA) was identical to Model 4 except:
        - Parameters governing spread of lengths at age around mean length at age estimated internally
    - Model 6 (EBS only) was identical to Model 5 except:
        - Cohort-specific growth replaced by annual variability in each of the three von Bertalanffy parameters

November 2010

- Three models for both the EBS and GOA:
    - Model A was identical to Model 1 from September
    - **Model B** was identical Model 2 from September, except cohort-specific growth replaced by constant growth
    - Model C: same as Model 4 from September, except cohort-specific growth replaced by constant growth

March 2011 (CIE review)

- Exploratory EBS model developed prior to review:

    - Same as last year's final model, except:
        - All sizecomp data turned on
        - Nine season × gear fisheries consolidated into five seasonal fisheries
        - Pre-1982 trawl survey data omitted
        - Mean-size-at-age data omitted
        - Fishery CPUE data omitted
        - Average input *N* set to 100 for all fisheries and the survey
        - First reference age for length-at-age relationship set at 0.833333
        - Richards growth implemented
        - Ageing bias estimated internally
        - Selectivities modeled as random walks with age (constant for ages 8+)
- Twelve new models for the EBS developed during the review:
    - Model 1 was identical to last year's final model except:
        - Length at age 0 constrained to be positive
        - Richards growth implemented
    - Model 2 was identical to last year's final model except length at age 0 constrained to be positive
    - Model 3 was identical to last year's final model except:
        - All time blocks removed
        - All selectivity parameters freed except fishery selectivity at initial age
        - All selectivity parameters initialized at mid-point of bounds
    - Model 4 was identical to last year's final model except:
        - All time blocks removed
        - Emphasis on fishery sizecomps set to 0.001
    - Model 5 was identical to last year's final model except:
        - Richards growth implemented
        - Ageing bias estimated internally
    - Model 6 was identical to Model 4 except time blocks included
    - Model 7 was identical to last year's final model except *Q* estimated internally
    - Model 8 was identical to last year's final model except *M* estimated internally with an informative prior
    - Model 9 was identical to last year's final model except tail compression increased
    - Model 10 was identical to last year's final model except mean-size-at-age data turned off
    - Model 11 was the same the "exploratory" model except:
        - Pre-1982 trawl survey data included
        - All time blocks removed
        - Fishery CPUE data included (but not used for estimation)
        - Input *N* set as in last year's final model
        - First reference age for length-at-age relationship set at as in last year's final model
    - Model 12 was identical to Model 11 except two iterations of survey variance and input *N* re-weighting added
- Three new models for the GOA developed during the review:
    - Model 1 was identical to EBS Model 1
    - Model 3 was identical to EBS Model 3
    - Model 9 was identical to EBS Model 9

September 2011 (EBS only)

- Seven models included:
    - Model 1 was identical to last year's final model

- Model 2a was identical to Model 1 except for use of spline-based selectivity
- Model 2b was identical to Model 1 except for omission of pre-1982 survey data
- Model 3 was identical to Model 2b except:
    - Ageing bias estimated internally rather than by trial and error
    - First reference age for length-at-age relationship (*amin*) set at 1.0
    - Standard deviation of length at age *amin* tuned iteratively to match the value predicted externally by regression
- Model 4 was identical to Model 2b except:
    - All agecomp data turned off
    - All sizecomp data turned on
    - First reference age for length-at-age relationship (*amin*) set at 1.0
    - Parameters governing standard deviation of length at age estimated internally
- Model A was identical to Model 2b except:
    - First reference age in the mean length-at-age relationship was set at 1.41667, to coincide with age 1 at the time of year when the survey takes place (in Models 1-2b, first reference age was set at 0; in Models 3-4, it was set at 1)
    - Richards growth equation was used (in Models 1-4, von Bertalanffy was used)
    - Ageing bias was estimated internally (as in Model 3; in Models 1-2 and 4, ageing bias was left at the values specified in the 2009 and 2010 assessments—although this was irrelevant for Model 4, which did not attempt to fit the age data)
    - σR was estimated internally (in Models 1-4, this parameter was left at the value used in the 2009 and 2010 assessments)
    - Fishery selectivity curves were defined for each of the five seasons, but were not stratified by gear type (in Models 1-4, seasons 1-2 and 4-5 were lumped into a pair of "super" seasons, and fisheries were also *gear*-specific)
    - Selectivity curve for the fishery that came closest to being asymptotic on its own (in this case, the season 4 fishery) was forced to be asymptotic by fixing both *width_of_peak_region* and *final_selectivity* at a value of 10.0 and *descending_width* at a value of 0.0 (in Models 1-4, the Jan-Apr trawl fishery was forced to exhibit asymptotic selectivity)
    - Survey selectivity was modeled as a function of length (in Models 1-4, survey selectivity was modeled as a function of age)
    - Number of estimated year class strengths in the initial numbers-at-age vector was set at 10 (in Models 1-4, only 3 elements were estimated)
    - The following parameters were tuned iteratively:
        - Standard deviation of length at the first reference age was tuned iteratively to match the value from the regression of standard deviation against length at age presented in last year's assessment (as in Model 3; in Models 1-2, this parameter was set at 0.01 because the first reference age was 0; in Model 4, it was estimated internally)
        - Base value for *Q* was tuned iteratively to set the average of the product of *Q* and survey selectivity across the 60-81 cm range equal to 0.47, corresponding to the Nichol et al. (2007) estimate (in Models 1-4, the base value was left at the value used in the 2009 and 2010 assessments)
        - *Q* was given annual (but not random walk) *dev*s, with σdev tuned iteratively to set the root-mean-squared-standardized-residual of the survey abundance estimates equal to 1.0 (in Models 1-4, *Q* was constant)
        - All estimated selectivity parameters were given annual random walk *dev*s with *σdev* tuned iteratively to match the standard deviation of the estimated *dev*s, except that the *dev*s for any selectivity parameter with a

tuned σdev less than 0.005 were removed (in Models 1-4, certain fishery selectivity parameters were estimated independently in pre-specified blocks of years; the only time-varying selectivity parameter for the survey was *ascending_width*, which had annual—but not random walk—*dev*s with *σdev* set at the value used in the 2009 and 2010 assessments)
        - Age composition "variance adjustment" multiplier was tuned iteratively to set the mean effective sample size equal to the mean input sample size (in Models 1-4, this multiplier was fixed at 1.0)
    - Model 5 was identical to Model A except that it used the time series of selectivity parameters estimated (using random walk *dev*s) in Model A to identify appropriate breakpoints for defining block-specific selectivity parameters
- Other model features explored but not included in any of the above:
    - Annually varying Brody growth parameter
    - Annually varying length at the first reference age
    - Internal estimation of standard deviation of length at age
    - Ordinary (not random walk) *dev*s for annually varying selectivity parameters
    - One selectivity parameter for each age (up to some age-plus group) and fleet, either with ordinary or random walk *dev*s or constant
    - Not forcing any fleet to exhibit asymptotic selectivity
    - Internal estimation of survey catchability
    - Iterative re-weighting of size composition likelihood components
    - Internal estimation of the natural mortality rate
    - Changing the SS parameter *comp_tail_compression* (the tails of each age or size composition record are compressed until the specified amount was reached; sometimes referred to as "dynamic binning")
    - Changing the SS parameter *add_to_comp* (this amount was added to each element of each age or size composition vector—both observed and expected, which avoids taking the logarithm of zero and may also have robustness-related attributes)
    - Internal estimation of ageing error variances

November 2011

- Five models for the EBS:
    - Model 1 was identical to last year's final model (and Model 1 from September)
    - Model 2b was identical to Model 2b from September
    - Model 3 was identical to Model 3 from September
    - **Model 3b** was identical to Model 3 from September except:
        - Parameters governing variability in length at age estimated internally
        - All sizecomp data turned on
        - Mean-size-at-age data turned off
    - Model 4 was identical to Model 4 from September
- Four models for the GOA:
    - Model 1 was identical to last year's final model
    - **Model 3** was identical to Model 1 except:
        - First reference age for length-at-age relationship set at 1.3333
        - Parameters governing variability in length at age estimated by trial and error
        - Column for age 0 fish added to the agecomp and mean-size-at-age portions of the data file
        - Ageing bias estimated internally
    - Model 3b was identical to Model 3 except:
        - Parameters governing variability in length at age estimated internally

        - All sizecomp data turned on
        - Mean-size-at-age data turned off
        - Selectivity and catchability for 27-plus survey forced to be constant
        - Catchability *dev*s in the sub-27 survey were given normal priors with mean = 0 and standard deviation = 0.46
    - Model 4 was identical to Model 3b except:
        - Variability in survey catchability and selectivity was configured as in Models 1 and 3
        - All agecomp data turned off
        - Ageing bias was not estimated internally
        - Mean recruitment in the pre-1977 environmental regime was constrained to be less than mean recruitment in the post-1976 environmental regime.

September 2012

- Five primary and nine secondary models for the EBS (names of secondary models have decimal points; full results presented for primary models only):
    - Model 1 was identical to last year's final model
        - Model 1.1: Same as Model 1, except survey catchability estimated internally
        - Model 1.2: Same as Model 1, except ageing bias parameters fixed at GOA values
        - Model 1.3 Same as Model 1, except with revised weight-length representation
    - Model 2 was identical to Model 1, except survey catchability re-tuned to match archival tag data
    - Model 3 was identical to Model 1, except new fishery selectivity period beginning in 2008
    - Model 4 was identical to last year's Model 4 (also identical to Model 1 except that age data ignored)
        - Model Pre5.1: Same as Model 1.3, except for three minor changes to the data file
        - Model Pre5.2: Same as Model Pre5.1, except ages 1-10 in the initial vector estimated individually
        - Model Pre5.3: Same as Model Pre5.2, except Richards growth curve used
        - Model Pre5.4: Same as Model Pre5.3, except σ for recruitment *dev*s estimated internally as a free parameter
        - Model Pre5.5: Same as Model Pre5.4, except survey selectivity modeled as a function of length
        - Model Pre5.6: Same as Model Pre5.5, except fisheries defined by season only (not season-and-gear)
    - Model 5: Same as Model Pre5.6, except four quantities estimated iteratively:
        - Survey catchability tuned to match archival tag data
        - Agecomp *N* tuned to set the mean ratio of effective *N* to input *N* equal to 1
        - Selectivity *dev* sigmas tuned according to the new method described in Annex 2.1.1 of the SAFE chapter
- Two models for the AI:
    - Model 1 was similar to last year's final EBS model except:
        - Only one season
        - Only one fishery
        - AI-specific weight-length parameters used
        - Length bins (1 cm each) extended out to 150 cm instead of 120 cm
        - Fishery selectivity forced asymptotic
        - Fishery selectivity constant over time
        - Survey samples age 1 fish at true age 1.5

        - Ageing bias not estimated (no age data available)
        - *Q* tuned to match the value from the archival tagging data relevant to the GOA/AI survey net
    - Model 2 was identical to Model 1 except with time-varying *L1* and *Linf*
    - Six other models considered in a factorial design in order to determine which growth parameters would be time-varying in Model 2, but only partial results presented
- Twelve models for the GOA:
    - Model 1 was identical to last year's final model
    - Model 1Q was identical to Model 1 except mean *Q* for the 27-plus survey tuned iteratively to match archival tagging results
    - Model A was identical to Model 1 except tail compression turned off
    - Model AQ was identical to Model A except mean *Q* for the 27-plus survey tuned iteratively to match archival tagging results
    - Model B was identical to Model A except:
        - Sub-27 survey changed from time-varying *Q* and constant selectivity to two blocks for both *Q* and selectivity (split at 1996)
        - Initial value for the pre-1996 *Q* deviation for both the 27-plus and sub-27 surveys set to 0.0
    - Model BQ was identical to Model B except mean *Q* for the 27-plus survey tuned iteratively to match archival tagging results
    - Model C was identical to Model B except:
        - Initial value for pre-1977 recruitment offset changed to 0.0
        - Upper bound on pre-1977 recruitment offset increased to allow positive values
    - Model CQ was identical to Model C except mean *Q* for the 27-plus survey tuned iteratively to match archival tagging results
    - Model D was identical to Model C except 27-plus survey selectivity changed from 11 blocks to 2 (split at 1996)
    - Model E was identical to Model A except:
        - *Q* for the 27plus survey estimated
        - Initial value for the pre-1996 *Q* deviation for both the 27-plus and sub-27 surveys set to 0.0
    - Model 1B was identical to Model B except tail compression set to the value used in Model 1
    - Model 1C was identical to Model C except tail compression set to the value used in Model 1

November 2012

- Four models for the EBS:
    - **Model 1** was identical to last year's final model
    - Model 2 was identical to Model 1 except *Q* was estimated freely
    - Model 3 was identical to Model 1 except:
        - Ageing bias was not estimated internally
        - All agecomp data are ignored
    - Model 4 was identical to Model 5 from the September assessment
- Four models for the AI:
    - Model 1 was identical to Model 1 from September
    - Model 2 was identical to Model 2 from September
    - Model 3 was identical to Model 1 except that input *N* values were multiplied by 1/3
    - Model 4 was identical to Model 1 except:
        - Survey data from years prior to 1991 were omitted

        - Q was allowed to vary randomly around a base value
        - Survey selectivity was forced asymptotic
        - Fishery selectivity was allowed to be domed
        - Input N values for sizecomp data were estimated iteratively by setting the root-mean-squared-standardized-residual of the survey abundance time series equal to unity
        - All fishery selectivitiy parameters except *initial_selectivity* and the *ascending_width* survey selectivity parameters were allowed (initially) to vary randomly, with the input standard deviations estimated iteratively by matching the respective standard deviations of the estimated *dev*s
        - Input standard deviation for log-scale recruitment *dev*s was estimated internally (i.e., as a free parameter)
    - None of the models was accepted by the Team or SSC
- Ten models for the GOA:
    - Model A was identical to last year's final model
    - Model B was identical to last year's final model except tail compression turned off
    - Model 1 was identical to Model C from September
    - Model 1Q was identical to Model 1 except *Q* fixed at 1.04 (the value used in 2011)
    - **Model 2** was identical to Model A except:
        - *Q* fixed at 1.0
        - All sub-27 survey data omitted
    - Model 2Q was identical to Model 2 except *Q* fixed at 1.04 (the value used in 2011)
    - Model 3 was identical to Model A except:
        - *Q* fixed at 1.0
        - 2 periods of catchability and selectivity for the sub-27 survey
        - All sub-27 and 27-plus survey mean-length-at-age data omitted
    - Model 3Q was identical to Model 3 except *Q* fixed at 1.04 (the value used in 2011)
    - Model 4 was identical to Model 2 except all 27-plus mean-length-at-age data omitted
    - Model 5 was identical to Model 1 except all sub-27 mean-length-at-age data omitted

September 2013

- Four models for the EBS:
    - Model 1 was identical to last year's final model
    - Model 2 was identical to last November's Model 4 except *Q* estimated internally using a non-constraining uniform prior distribution
    - Model 3 was identical to last November's Model 4 except:
        - *Q* estimated internally using a prior distribution based on archival tagging data
        - Survey selectivity forced asymptotic
    - Model 4 was identical to last November's Model 4
- Three models for the AI:
    - Model 1 was identical to Model 1 from last year's assessment except:
        - Fishery selectivity was not forced asymptotic
        - Selectivity was estimated as a random walk with respect to age instead of the double normal, with normal priors tuned so that the prior mean is consistent with logistic selectivity and the prior standard deviation is consistent with apparent departures from logistic selectivity
        - Potentially, length and age composition input sample sizes could be tuned so that the harmonic mean effective sample size is at least as large as the arithmetic mean input sample size (if it turned out that the initial average *N* of 300 already satisfied this criterion, no tuning was done)

        - Potentially, each selectivity parameter could be time-varying with annual additive *dev*s, where the sigma term is tuned to match the standard deviation of the estimated *dev*s (if this tuning resulted in a sigma that was essentially equal to zero, time variability was turned off)
    - Model 2 was identical to Model 1 except that *Q* was estimated with an informative prior developed from a meta-analysis of other AI assessments
    - Model 3 was identical to Model 1 except that both *M* and *Q* were estimated freely
- Eighteen models for the GOA (the "N" series represents runs with alternative initial values):
    - Models 1 and 1N are identical to the 2011 (not 2012) final model
    - Models 2 and 2N are identical to Models 1 and 1N except tail compression turned off
    - Models 3 and 3N are identical to Models 1 and 1N except:
        - Tail compression turned off
        - Number of periods for *Q* in the sub-27 survey changed from 11 to 2
        - Number of periods for selectivity in the sub-27 survey changed from 1 to 2
    - Models 4 and 4N are identical to the 2012 (not 2011) final model
    - Models 5 and 5N are identical to Models 4 and 4N except 27-plus mean-length-at-age data omitted
    - Models 6 and 6N are identical to Models 5 and 5N except:
        - All selectivity curves forced to equal zero at age 0
        - Growth parameters fixed at the values estimated in last year's final model
        - Number of blocks for selectivity in the 27-plus survey changed from 11 to 2
    - Models 7 and 7N are identical to Models 4 and 4N except:
        - Survey agecomps turned off
        - Corresponding survey sizecomps turned on
    - Models 8 and 8N are identical to Models 4 and 4N except Richards growth model used instead of von Bertalanffy
    - Models 9 and 9N are identical to Models 4 and 4N except 27-plus mean-length-at-age emphasis decreased from 1.0 to 0.25
    - In addition, preliminary work was presented on two sex-specific GOA models, featuring:
        - Three gear types
        - One fishery selectivity "season"
        - Three periods for the trawl and longline fishery selectivity curves
        - Two periods for the pot and survey selectivity curves
        - Two periods for survey *Q*

November 2013

- One model for the EBS:
    - **Model 1** was identical to last year's final model
- Two models for the AI:
    - Model 1 was identical to Model 1 from September, except that *Q* was fixed at 1.0
    - Model 2 was identical to Model 1 except:
        - *Q* was estimated with the same prior as in Model 2 from September
        - Survey selectivity was forced asymptotic
    - Neither of the models was accepted by the Team or SSC
- Two models for the GOA:
    - Model 1 was identical to last year's final model
    - **Model 2** was identical to Model 1 except age 0 recruitment for the four most recent years fixed at time series average (Model 1 estimated age 0 recruitment in 2010 and 2011)