STOCK ASSESSMENT OF ALBACORE TUNA IN THE NORTH PACIFIC OCEAN IN 2011

Report of the ISC-Albacore Working Group
Stock Assessment Workshop

3rd Science Advisory Committee Meeting
Inter-American Tropical Tuna Commission
La Jolla, CA

15-18 May 2012

Program

- Methodology
- Model structure
  - Fisheries
  - Input data
  - Assumptions & Parameterization
- Base-case results
  - Fit diagnostics & parameter estimates
  - Biomass (B, SSB), recruitment, & F-at-age
- Sensitivity & Fishery Impact analyses
- VPA Reference Run
- Projections
- Conclusions on status and advice

Logistics

- Originally scheduled 14-29 March 2011 in Shimizu, Japan, but rescheduled because of earthquake/tsunami
- Modeling Subgroup Meeting 30 May-3 June
  - Develop recommended base-case model, sensitivity analyses, & future projection scenarios for assessment workshop
  - Alex da Silva (IATTC) attended and helped with important decisions
  - Simon Hoyle (SPC) helped develop model via email discussions
- Assessment Workshop 4-11 June
  - Full assessment of the north Pacific albacore stock using fishery data through 2009
  - Develop scientific advice & recommendations on current stock status, future trends, and conservation.

Methodology

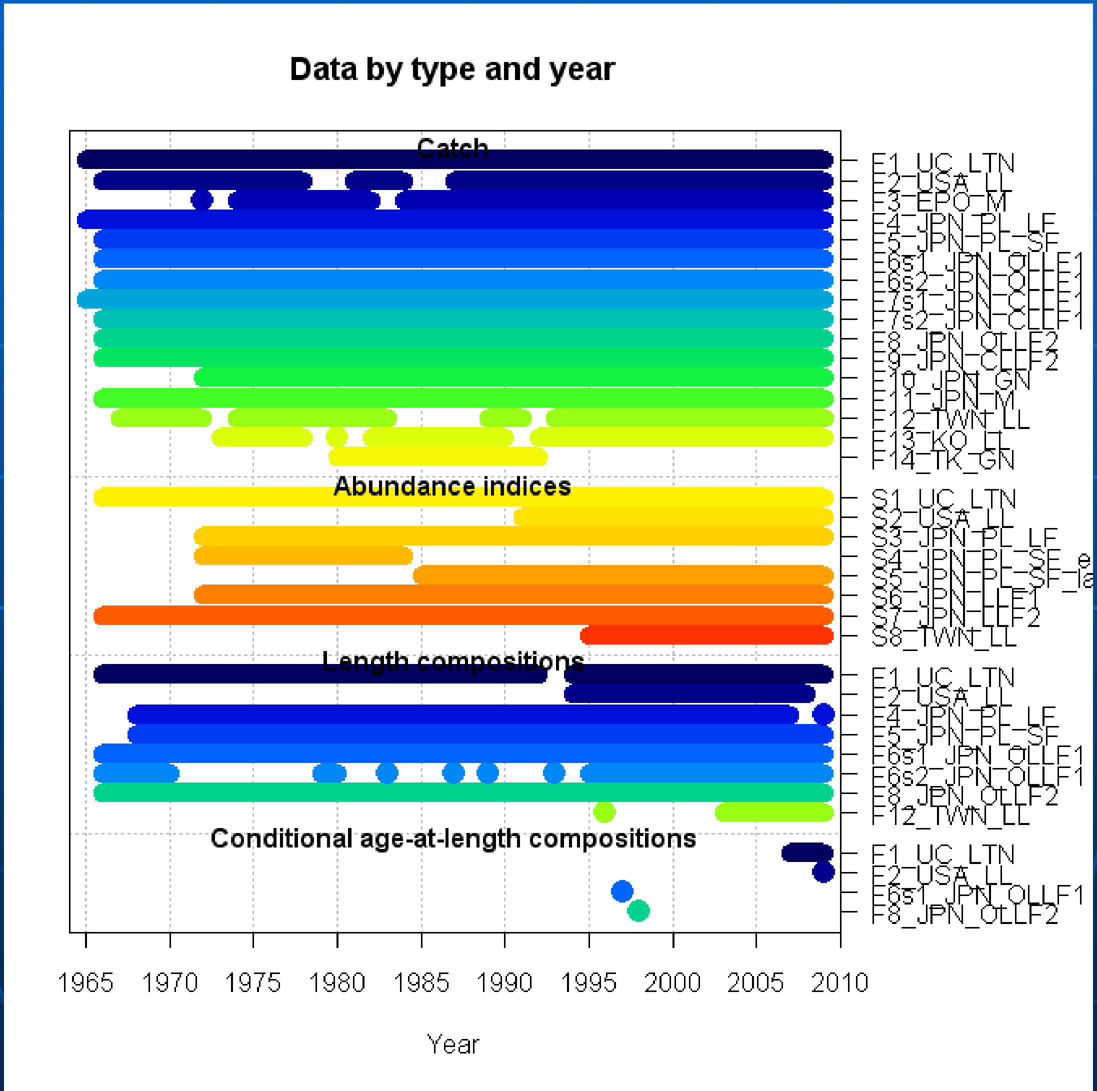
- Stock Synthesis (SS) Ver 3.11b modeling platform; key advancement relative to 2006 (VPA model)
- Seasonal, length-based, age-structured, forward-simulation population model
- VPA reference run for model-related changes
- Projections of albacore population dynamics used to assess the impact of current fishing mortality and management on future harvest and stock status

Input Data

- 16 fisheries defined by gear, location, season, and the unit of catch (numbers or weight)
- Quarterly Catch for each fishery (weight)
- Quarterly length comps for each fishery (8)
  - Bin range: 26 - 140 cm
- CPUE indices (8 indices)
- Conditional length-at-age data from otoliths (Wells et al. 2011) for F1, F2, F6s1, F8

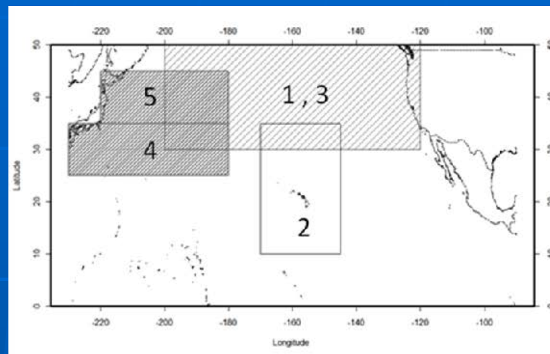
Fishery	Description
F1	CAN/USA Troll
F2	USA LL
F3	EPO Miscellaneous
F4	Japan Pole-and-line (south)
F5	Japan Pole-and-line (north)
F6s1	Japan offshore longline (north/season 1/number of fish)
F6s2	Japan offshore longline (north/season 2/numbers of fish)
F7s1	Japan coastal longline (north/season 1/weight)
F7s2	Japan coastal longline (north/season 2/weight)
F8	Japan offshore longline (south/north season 3-4/number of fish)
F9	Japan coastal longline (south/north season 3-4/weight)
F10	Japan gillnet
F11	Japan miscellaneous
F12	Taiwan longline
F13	Korea and others longline
F14	Taiwan and Korea gillnet

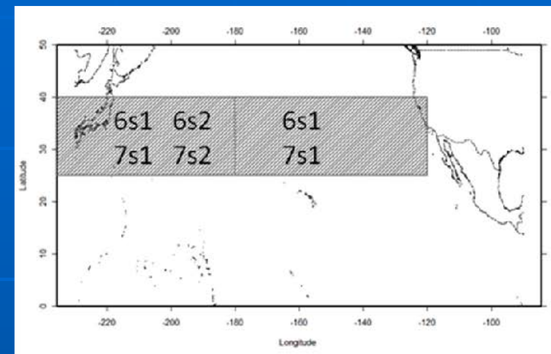
Albacore Time Series Length by Data Type & Fishery



Spatial Definition of Fisheries

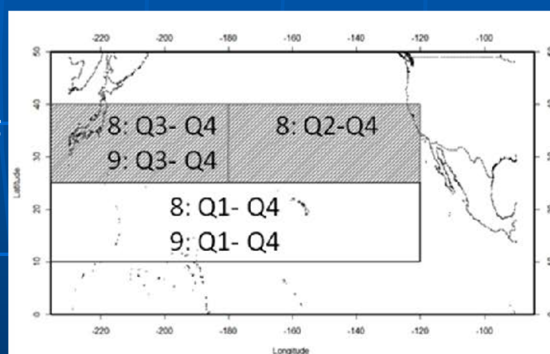
F1 – Can/US troll
F2 – USA LL
F3 – EPO misc.
F4 – JPN PL LF
F5 – JPN PL SF

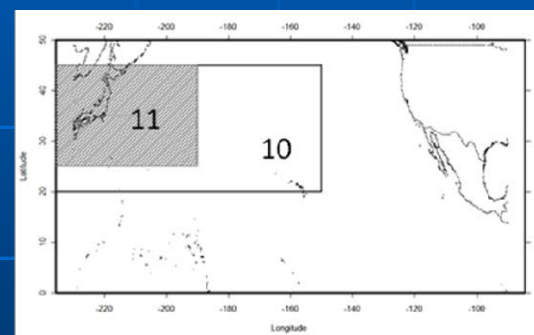




F6 – JPN OLLF1 SF
F7 – JPN CLLF1 SF

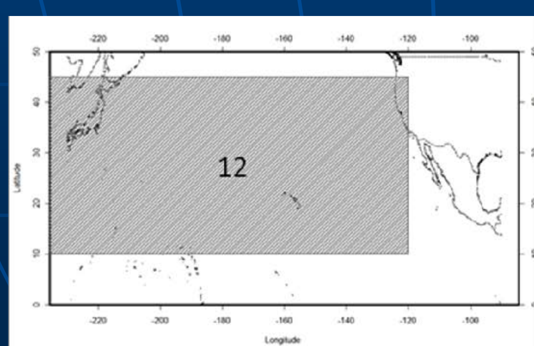
F8 – JPN OLLF2 LF
F9 – JPN CLLF2 SF

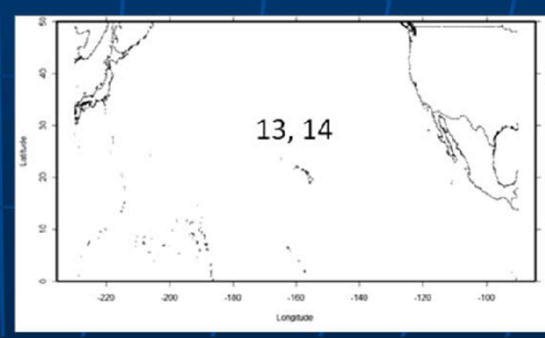




F10 – JPN GN
F11 – JPN Misc.

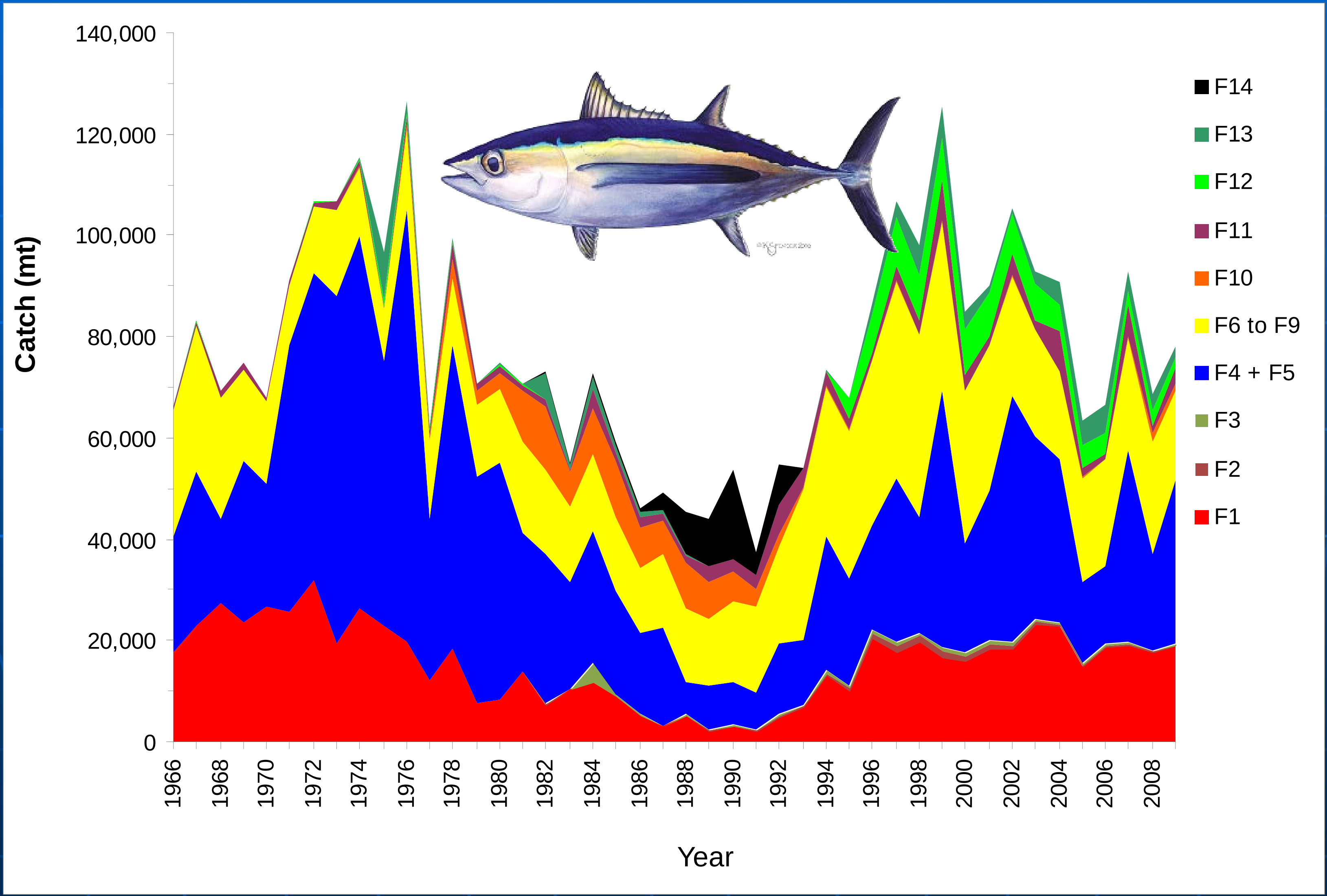
F12 - TWN LL



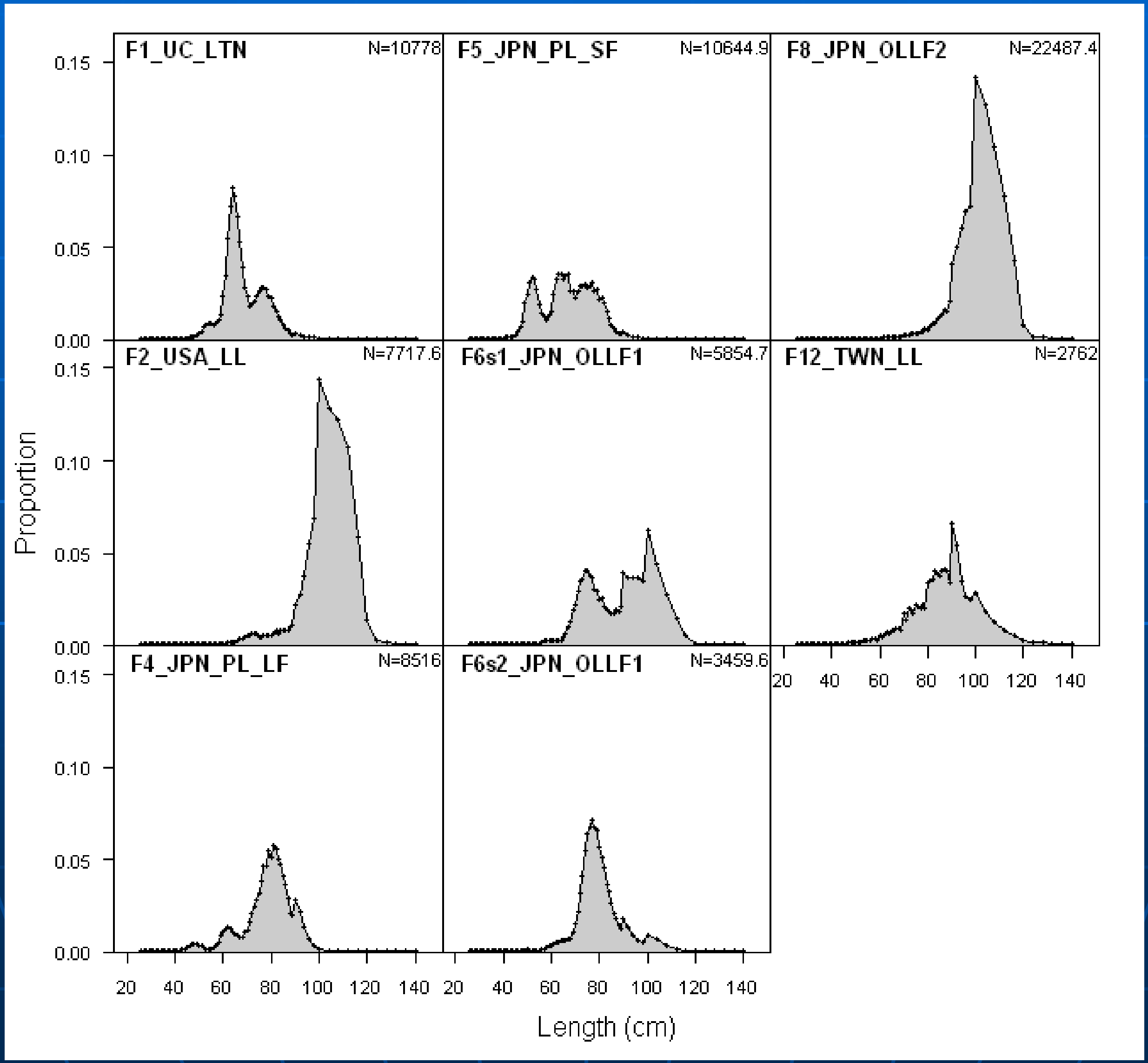


F13 – KO LL (Korea & others)
F14 – TK GN (Taiwan & Korea)

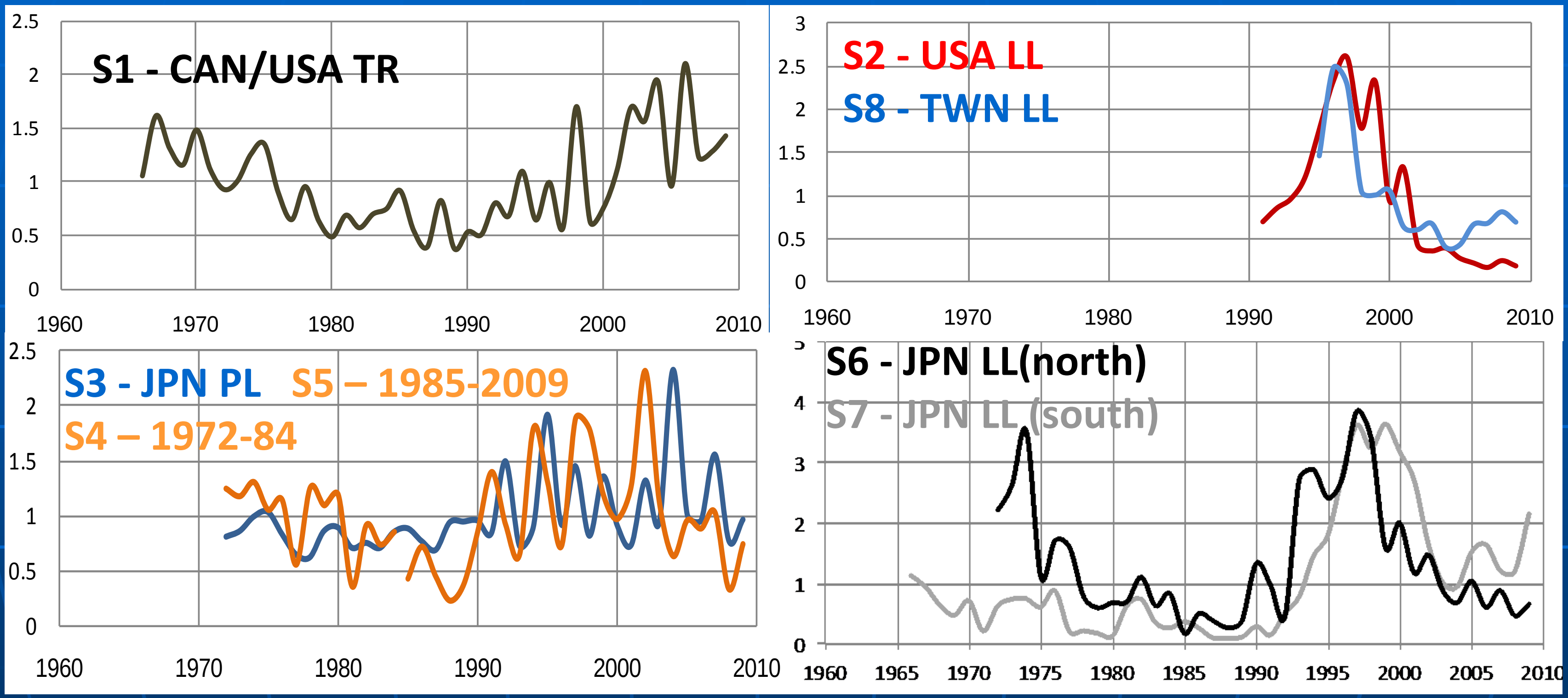
Catch History



Average Length Compositions



Input CPUE Data – 8 indices



Surface fisheries

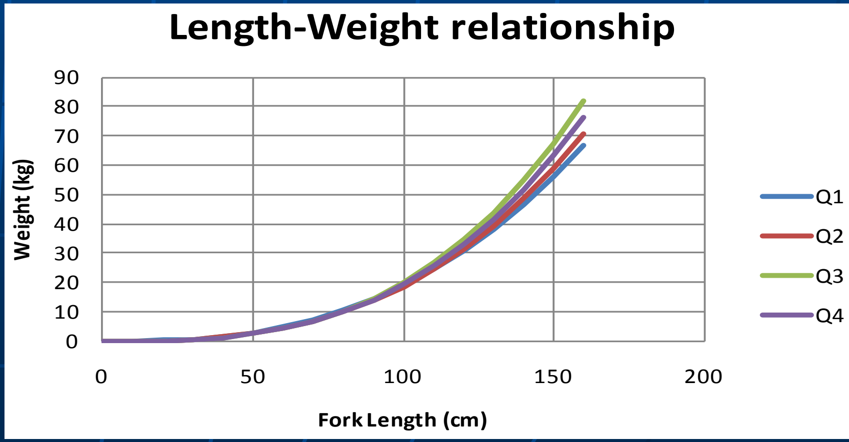
- Can/USA troll – S1
- JPN P&L – S3, S4, S5

Longline fisheries

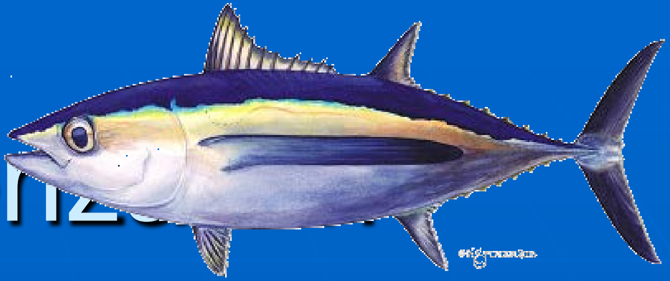
- USA – S2
- JPN Offshore – S6
- JPN Coastal – S7
- TWN Offshore – S8

Base-case Assumptions

- Basic
  - Modeled period: 1966 – 2009
  - Area: 120° E–120° W, 10° ～ 55° N
  - Stock: one stock, well mixed
  - Sexes: combined
  - Movement: not explicitly modeled
- Biological
  - Spawning period: Q2
  - Recruitment: once a year in Q2
  - M= 0.3 yr^{-1} fixed for all ages
  - Maturity (Ueyanagi 1957)
    - 50% age-5, 100% ≥ age-6
  - Maximum age: 15 years
  - Quarterly W-L relationships (Watanabe et al. 2006)
- Stock-recruitment
  - Beverton and Holt model
  - Steepness (*h*) = 1
- Data Weighting
  - Downweight length comp (0.01) & otolith data (0.1)
  - CPUE CVs fixed; S6 – JPN LL CPUE (CV = 0.2) used as abundance indicator



Growth Parameterization



- Key change from 2006 assessment
- VB growth model parameters estimated by SS (L_1, L_∞, K, CVs)
- Conditional length-at-age data from otoliths (Wells et al. 2011: ISC/11/ALBWG/02)
- 2006 assessment fixed growth curve to Suda (1966) growth parameters

Parameterization

- Initial F estimated for F1, F4 (surface fisheries) & F7 (LL)
- Initial equilibrium catch = 14 year average of total catch (1952-1965). Average catches were:
    - F1 = 19,499 t
    - F4 = 28,575 t
    - F7 = 18,180 t

Parameterization

- Relative weighting of CPUE indices (CVs)
  - S1 (F1) = 0.4 (1966-1999),
    = 0.5 (2000-2009);
  - S2 (F2) = 0.5;
  - S3 (F4) = 0.3;
  - S4 (F5) = 0.3 (1972-1984);
  - S5 (F5) = 0.4 (1985-2003),
    = 0.5 (2004-2009);
  - **S6 (F6s1) = 0.2 (model tuned to this index)**
  - S7 (F8&F9) = 0.4;
  - S8 (F12) = 0.5.

Selectivity

Fishery	**Description**	**Selectivity Pattern**
F1	CAN/USA Troll	Dome-shape
F2	USA LL	**Asymptotic (catches largest fish)**
F3	EPO Miscellaneous	Mirror F1
F4	Japan Pole-and-line (south)	Dome-shape
F5	Japan Pole-and-line (north)	Dome-shape
F6s1	Japan offshore longline (north/season 1/number of fish)	Dome-shape (2 time periods)
F6s2	Japan offshore longline (north/season 2/numbers of fish)	Dome-shape
F7s1	Japan coastal longline (north/season 1/weight)	Mirror F6s1
F7s2	Japan coastal longline (north/season 2/weight)	Mirror F6s2
F8	Japan offshore longline (south/north season 3-4/number)	**Asymptotic (catches largest fish)**
F9	Japan coastal longline (south/north season 3-4/weight)	Mirror F8
F10	Japan gillnet	Mirror F5
F11	Japan miscellaneous	Mirror F5
F12	Taiwan longline	Dome-shape (2 time periods)
F13	Korea and others longline	Mirror F6s1
F14	Taiwan and Korea gillnet	Mirror F5

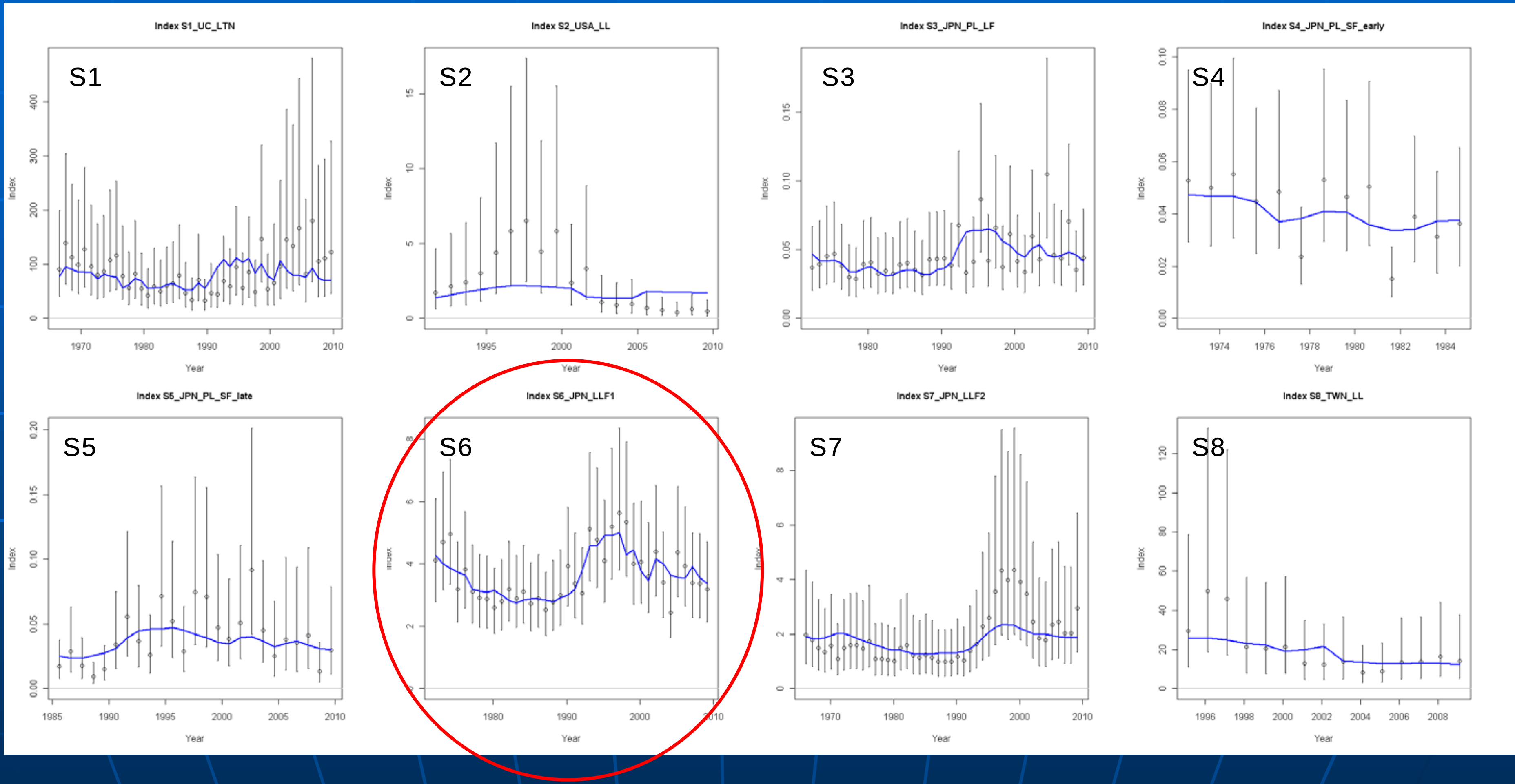
Time Blocks for Selectivity

- Time-varying selectivity noted in length data from 3 fisheries so blocking implemented as follows:
  - F2 (USA LL): 2001-04, other years
  - F6s1 (JPN Offshore LL): 1966-1992, 1993-2009
  - F12 (TWN LL): 1995-2002, 2003-2009

Base-case Model Results

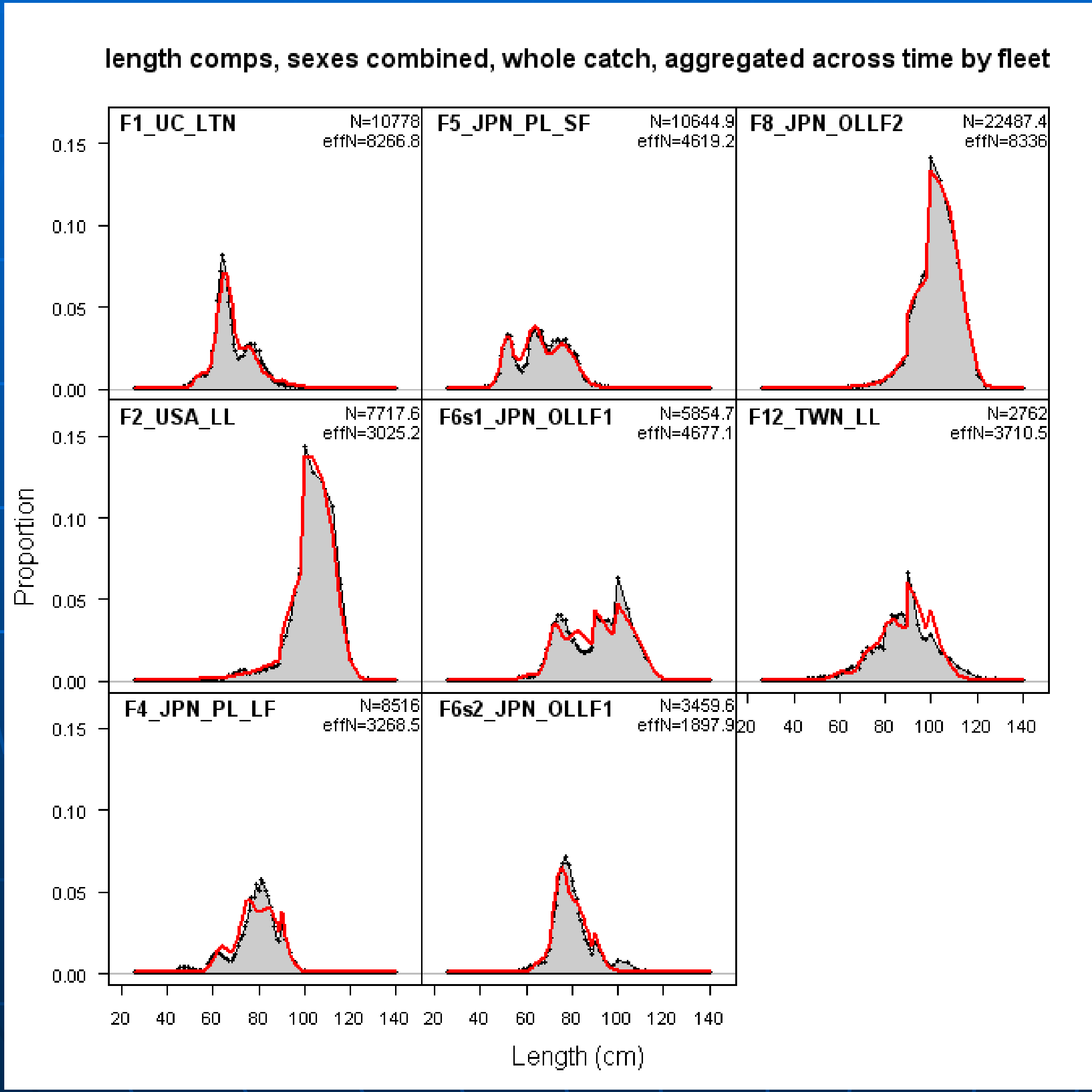
- Model Fit Diagnostics
  - CPUE
  - Length composition data
- Model Parameter Estimates
  - Growth
  - Estimated selectivity patterns
- Stock Assessment Results
  - Biomass
  - Recruitment
  - F-at-age

Model Fits to CPUE Indices



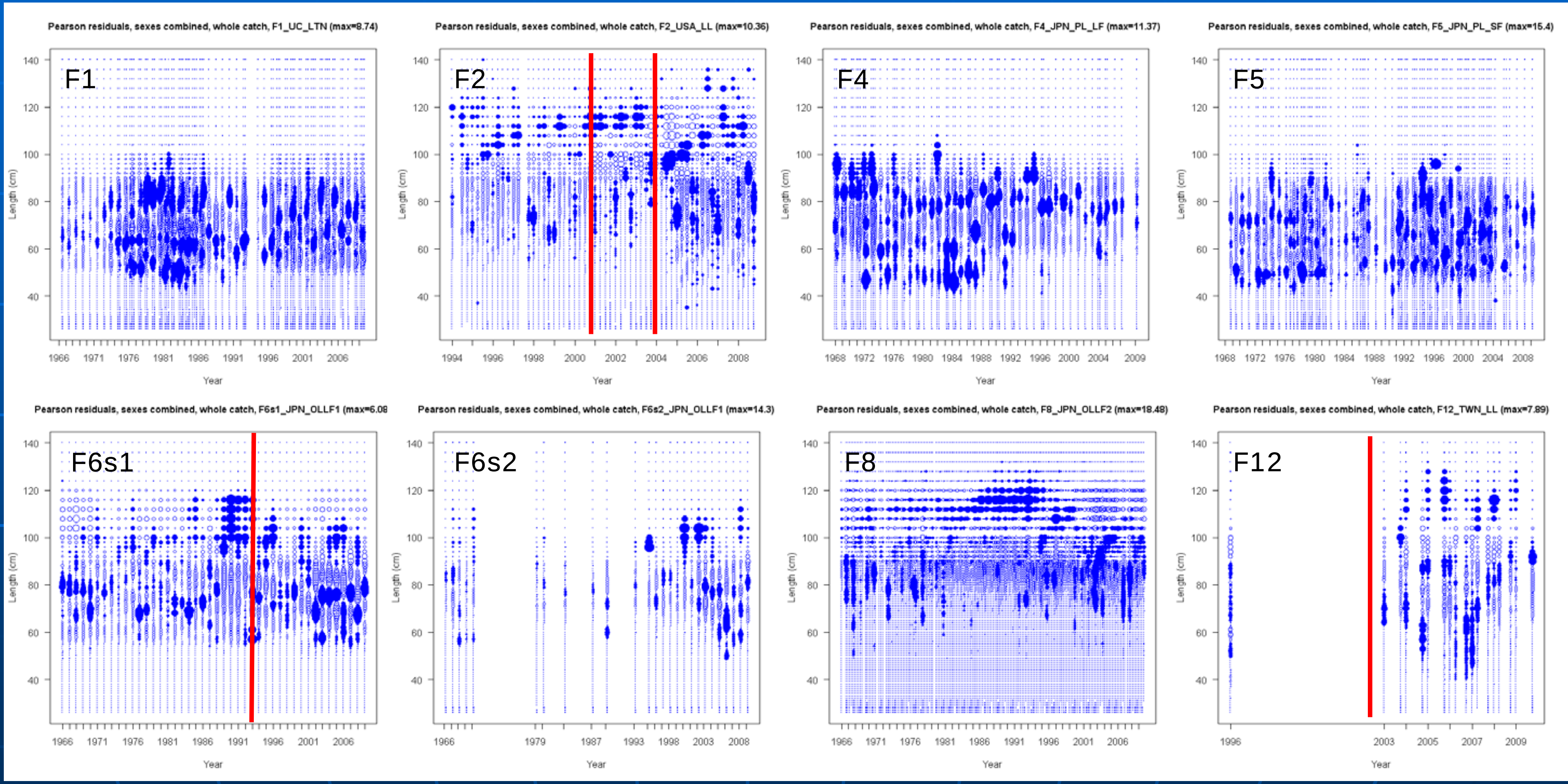
Fits considered cceptable given the relative weightings (CVs) on indices

Aggregated Length Composition Data



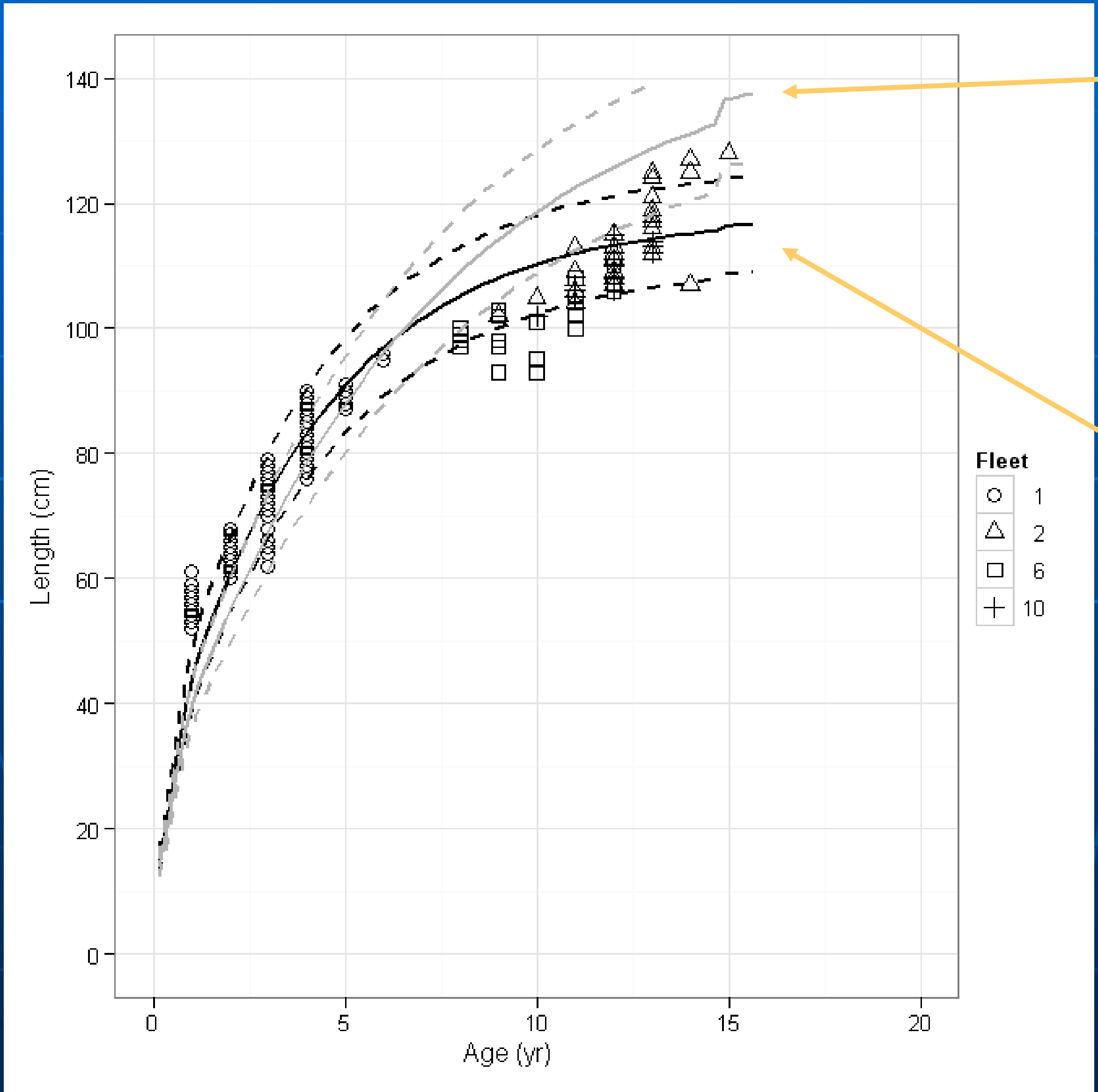
- Fits to length composition data were good considering down-weighted with lambda = 0.01
- Fits may be the result of the clear and relatively stationary modes in the data

Length Composition Residuals



Positive residual patterns, especially for large fish in F6s1 (mid-1980s to early 1990s) and F8 (1980s to mid-1990s)

Growth Comparison

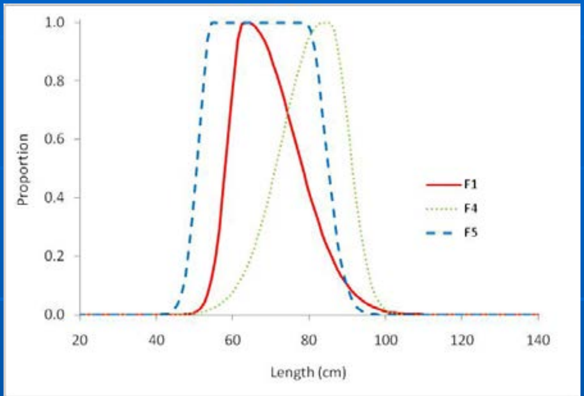


Suda Growth Curve
L1 =40.2 cm
L∞ = 146.46 cm
K = 0.149 yr^{-1}

Model estimates
L1 = 44.4 cm
L∞ = 118.0 cm
K = 0.2495 yr^{-1}

Wells et al. (2011)
L1 ~ 50 cm
L∞ = 120.0 cm
K = 0.184 yr^{-1}

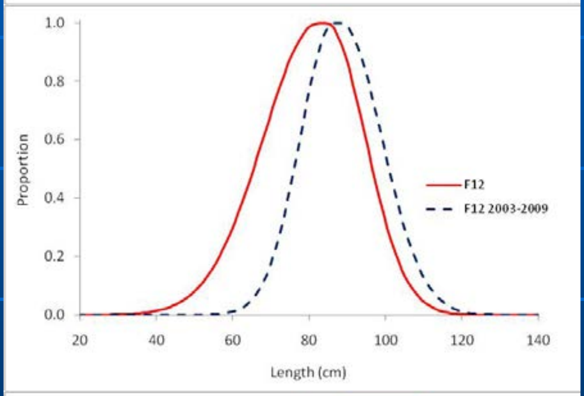
Selectivity Patterns



F1

F4

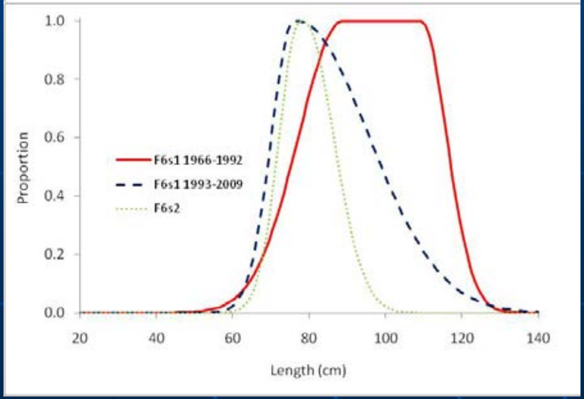
F5



F12

1995-2002

2003-2009

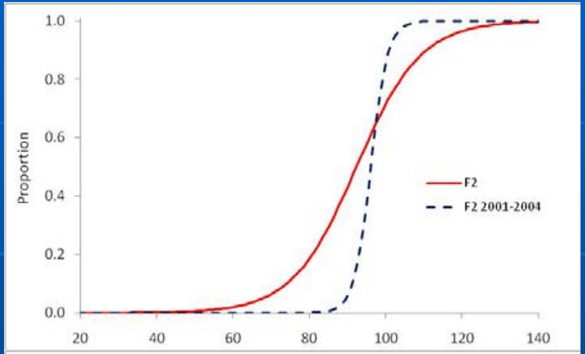


F6s1

1966-92

1993-2009

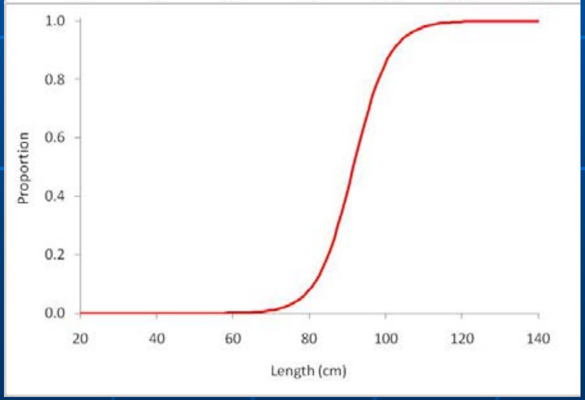
F6s2



F2

2001-2004

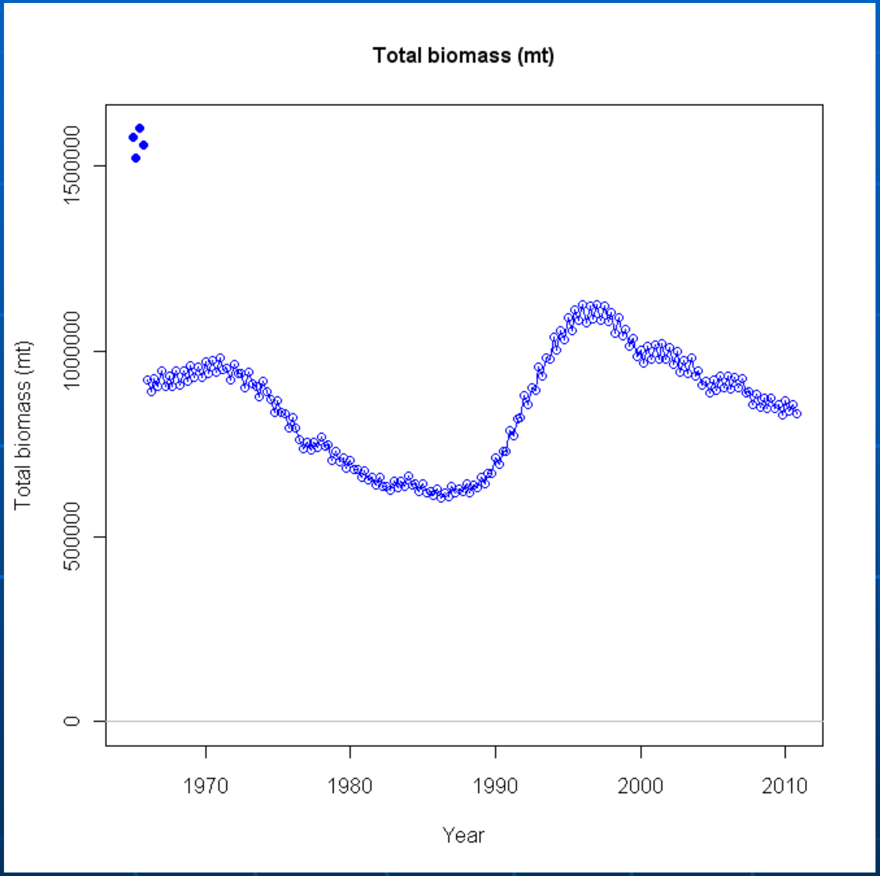
Other years

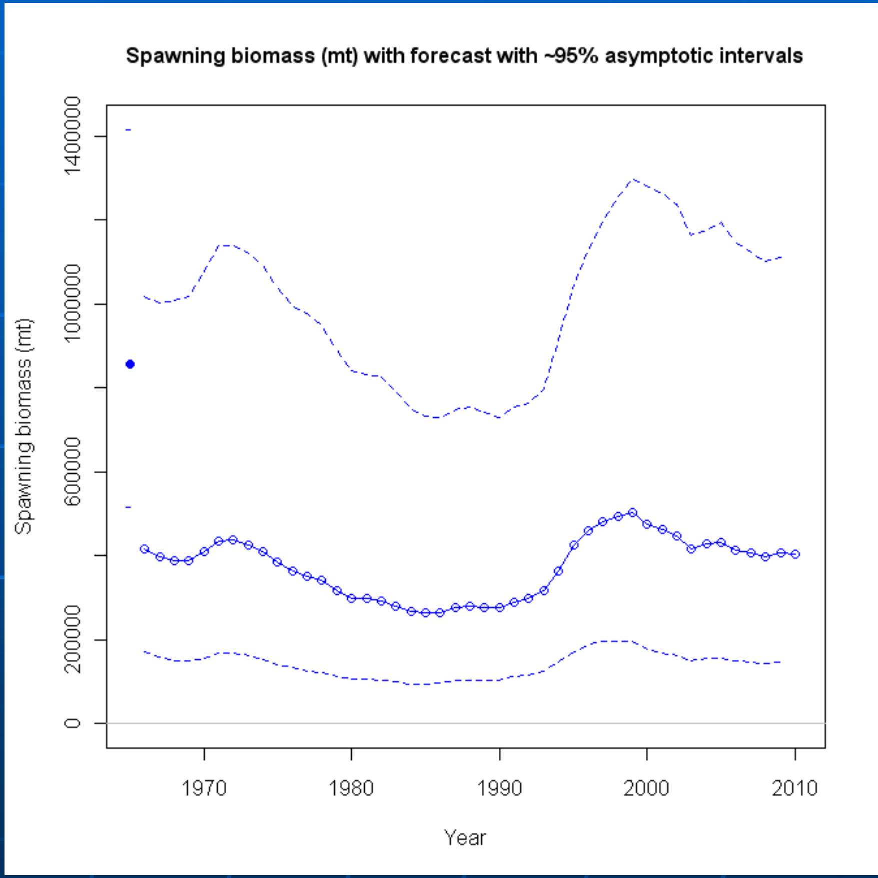


F8

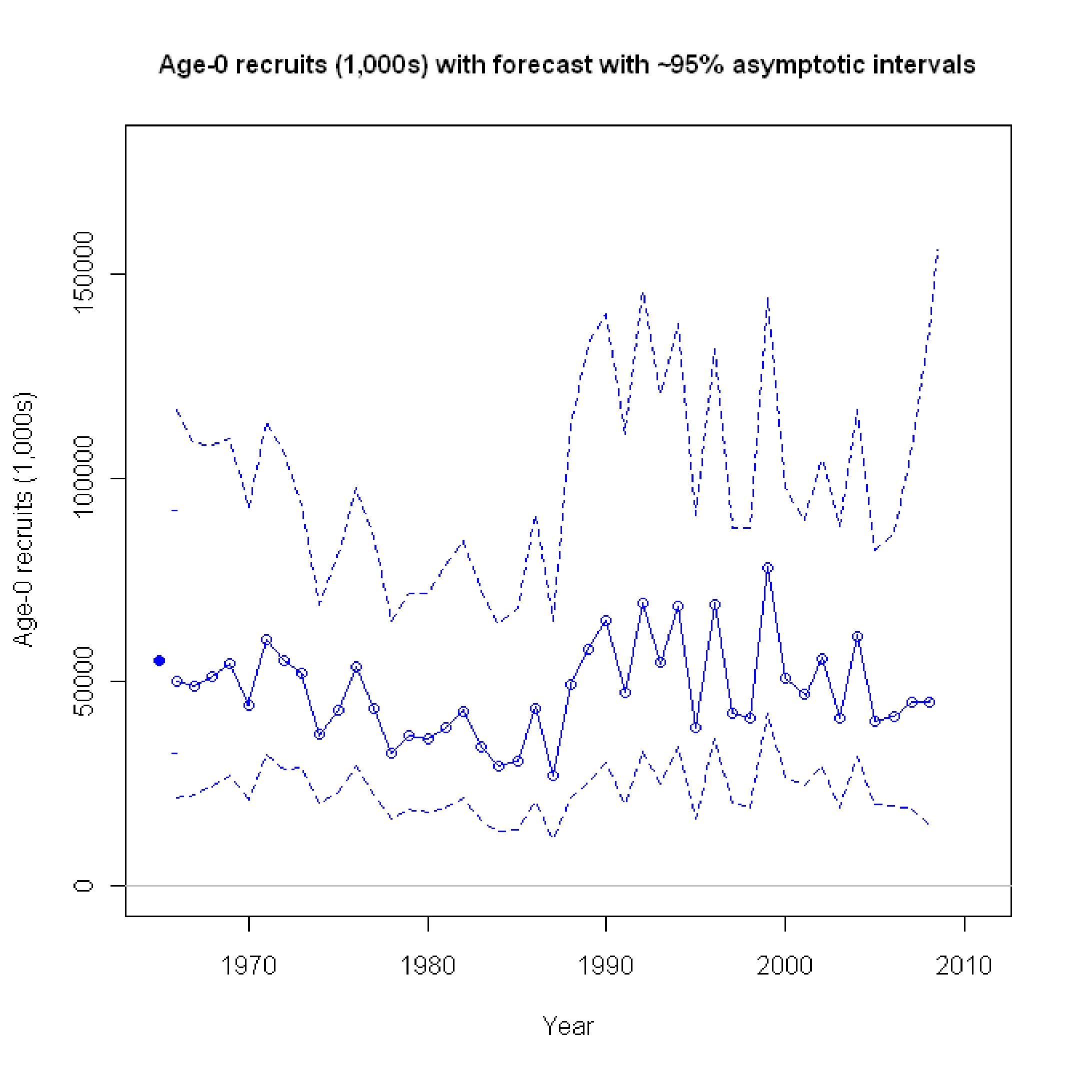
Selectivity of other fisheries mirrored to these fisheries

Biomass Results

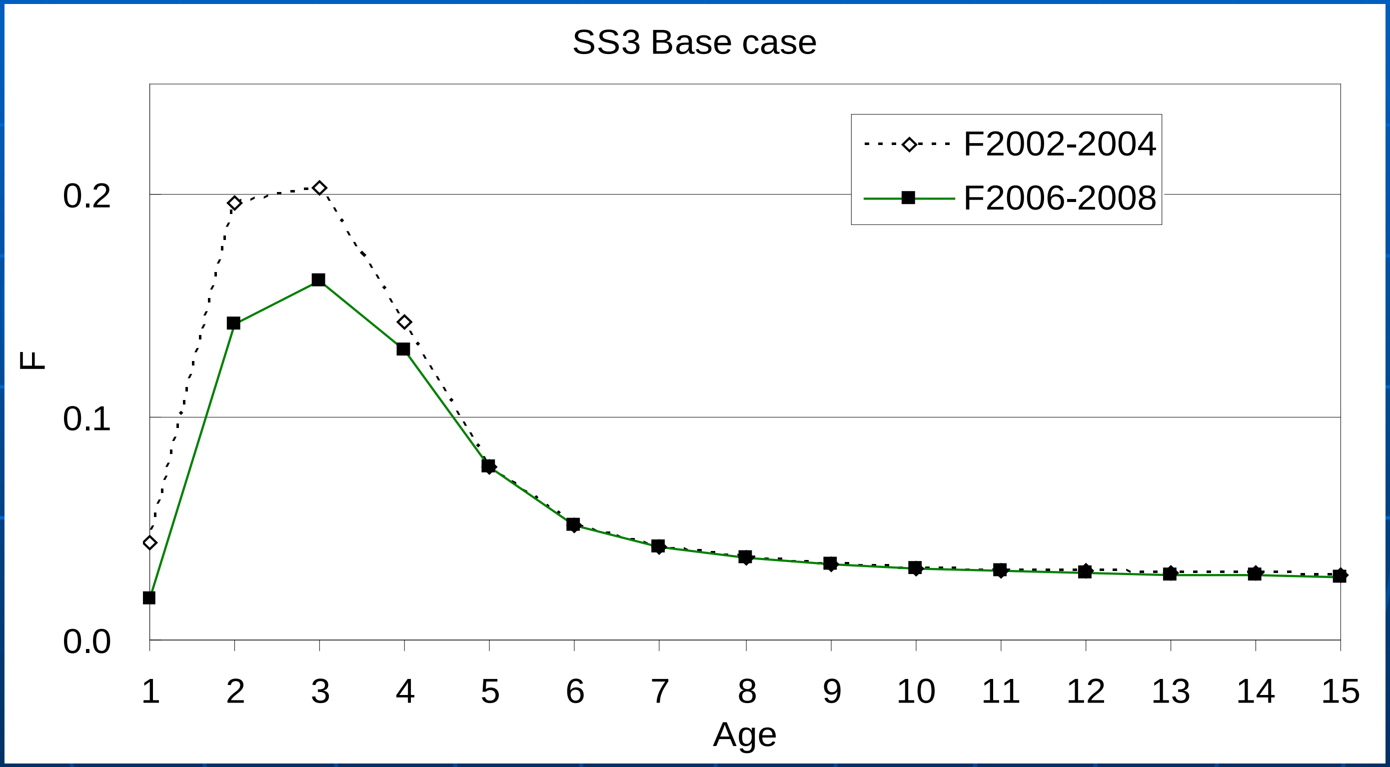




Recruitment – Age 0



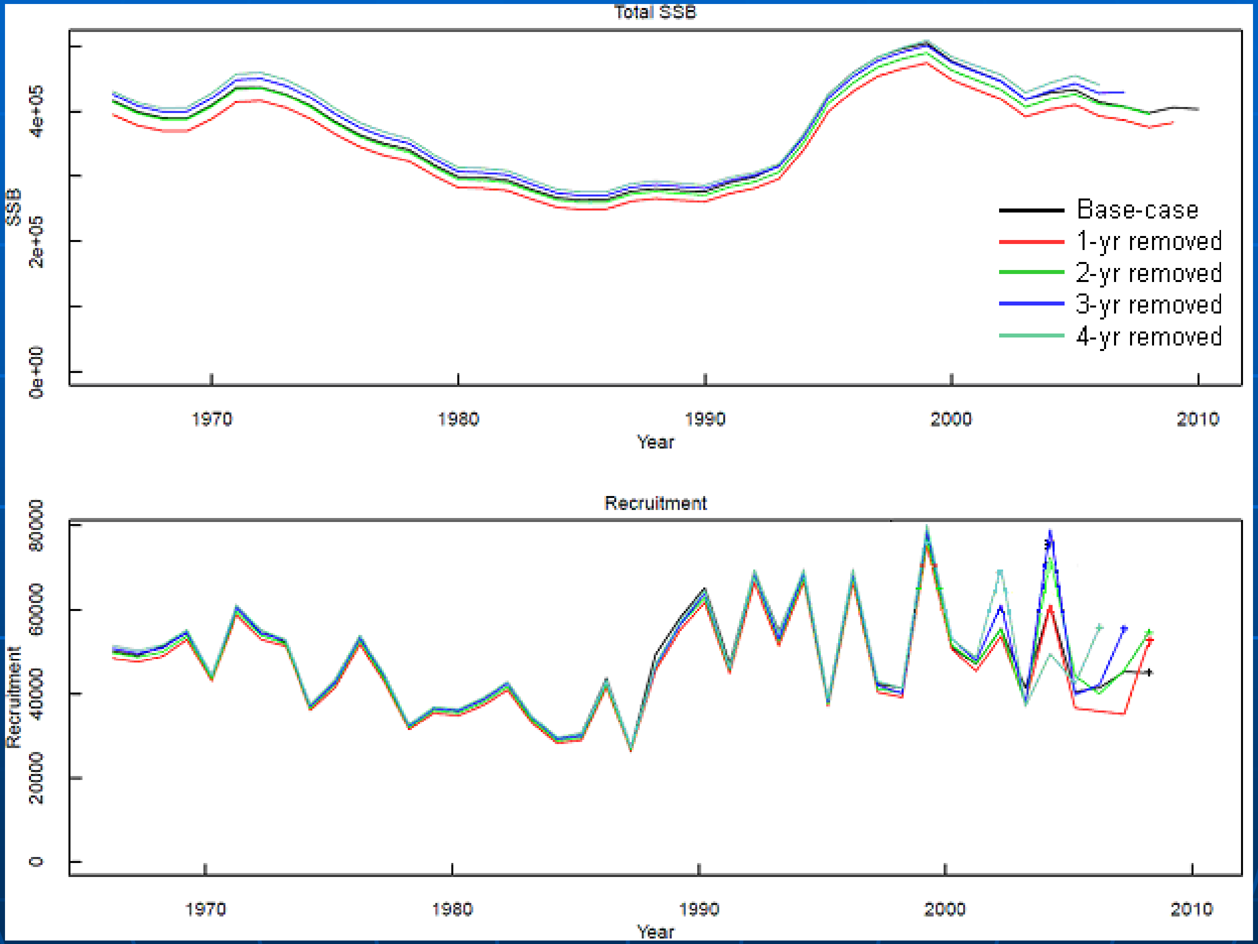
Fishing Mortality



Current F = geometric mean of 2006-2008 (this assessment)

$F_{2002-2004}$ – current F in 2006 assessment (geometric mean of 2002-2004)

Retrospective Analysis

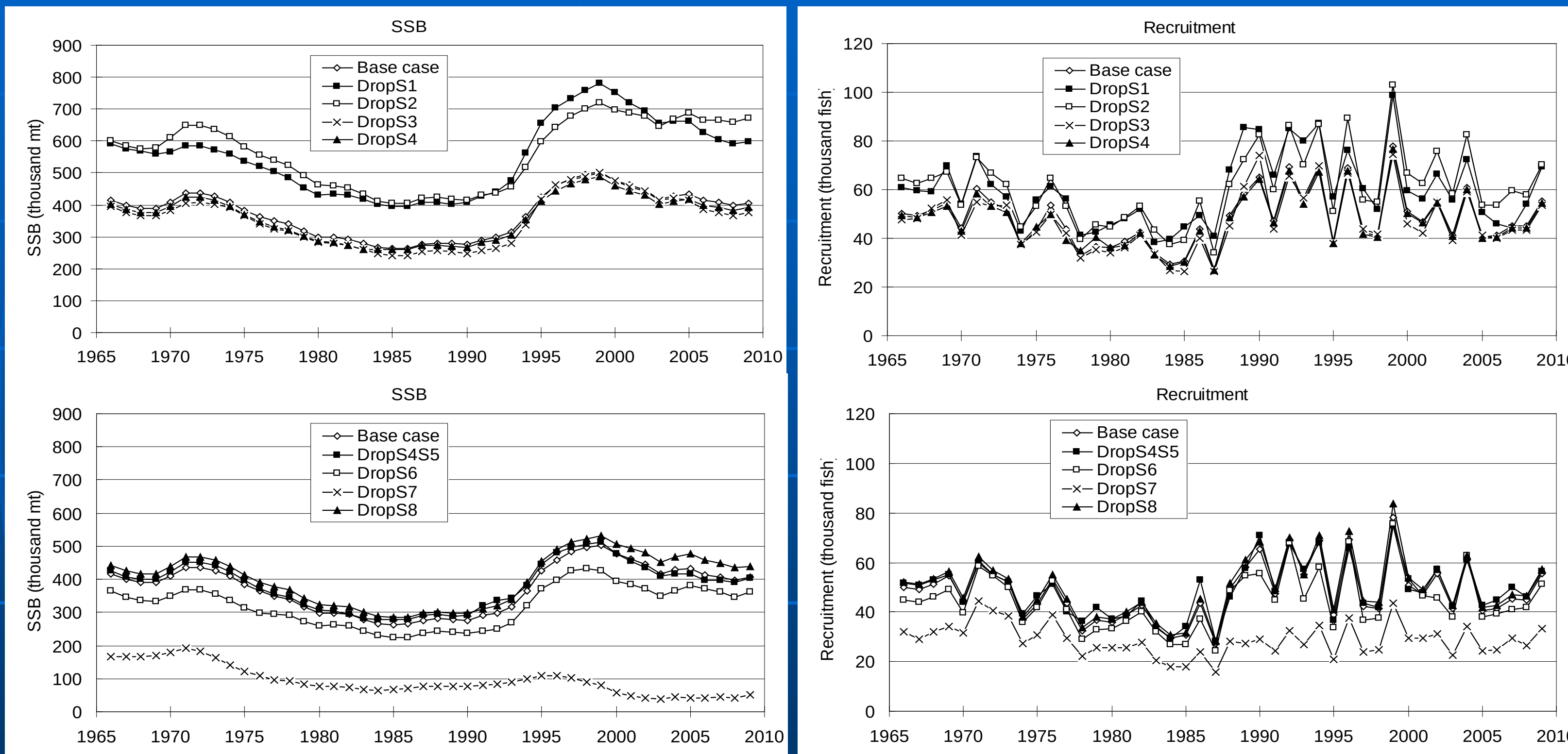


- Uncertainty in terminal year estimates, particularly recruitment, but not biased

Sensitivity Analyses

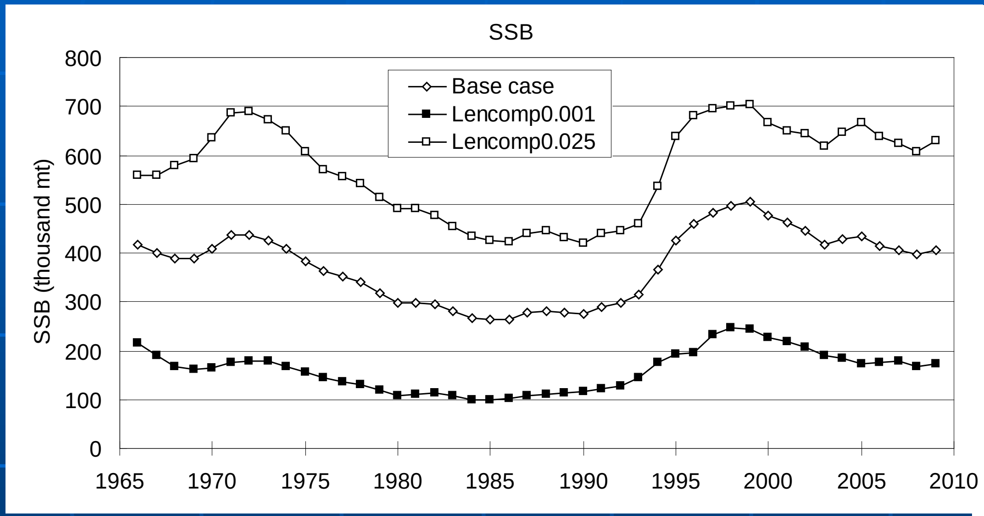
- **Data Weighting**
  - Drop each CPUE → set lambda = 0 for each fishery
  - Length lambda → 0.025, 0.001
  - Estimate CV for CPUE → fix JPN LL =0.2 estimate other CVs
- **Biological assumption**
  - Fix growth to Suda growth curve
  - Up-weighting of age composition data → lambda = 1.0
  - Steepness: h=0.85
  - M=0.4 yr^{-1} all ages
  - Length-based maturity schedule
- **Selectivity**
  - Change selectivity of JPN LL(Fnorth) from dome shape to Flat top
  - No time block for USA LL, TWN LL, JPN LL
- **Fishery Impact Analysis**

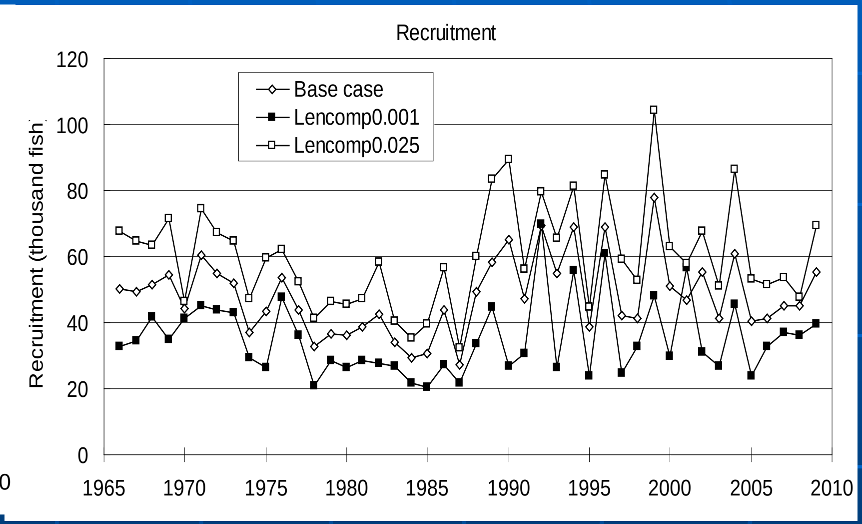
Sensitivity Results – Dropping CPUEs



- S7 was the most influential index for scaling & trends in SSB & recruitment
- Dropping S1 and S2 scaled SSB up relative to the base-case

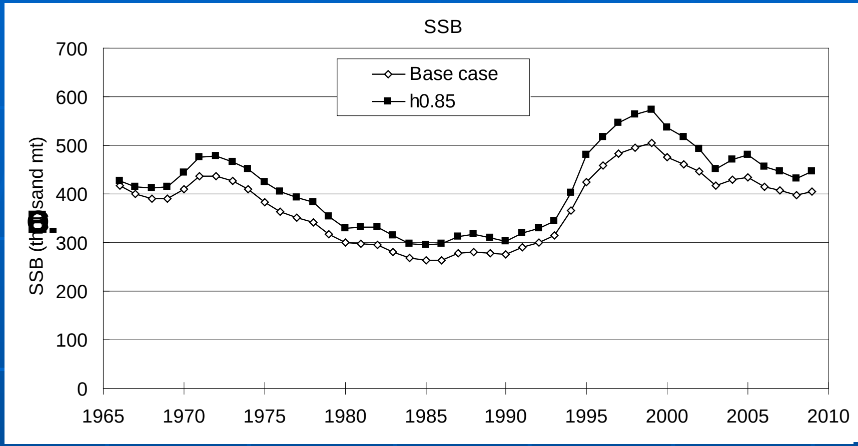
Sensitivity Results - Length Composition Data Weighting

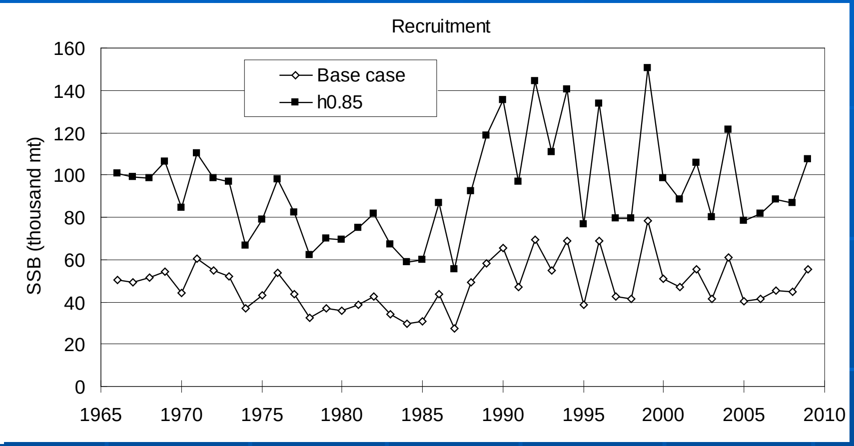




- Up-weighting (lambda = 0.025) & down-weighting (lambda = 0.001) scales SSB and recruitment up & down relative to base-case.
- Changing lambda does not alter trends or trajectories in either quantity.

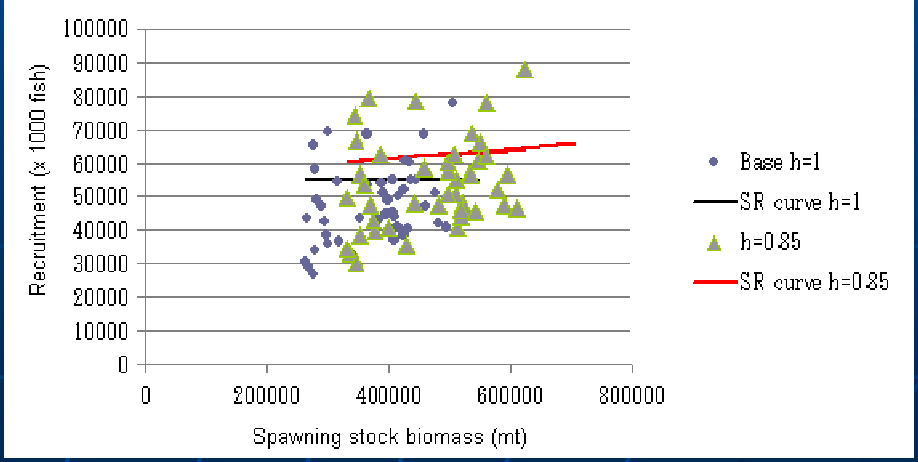
Sensitivity Results – Steepness, *h* = 0.85



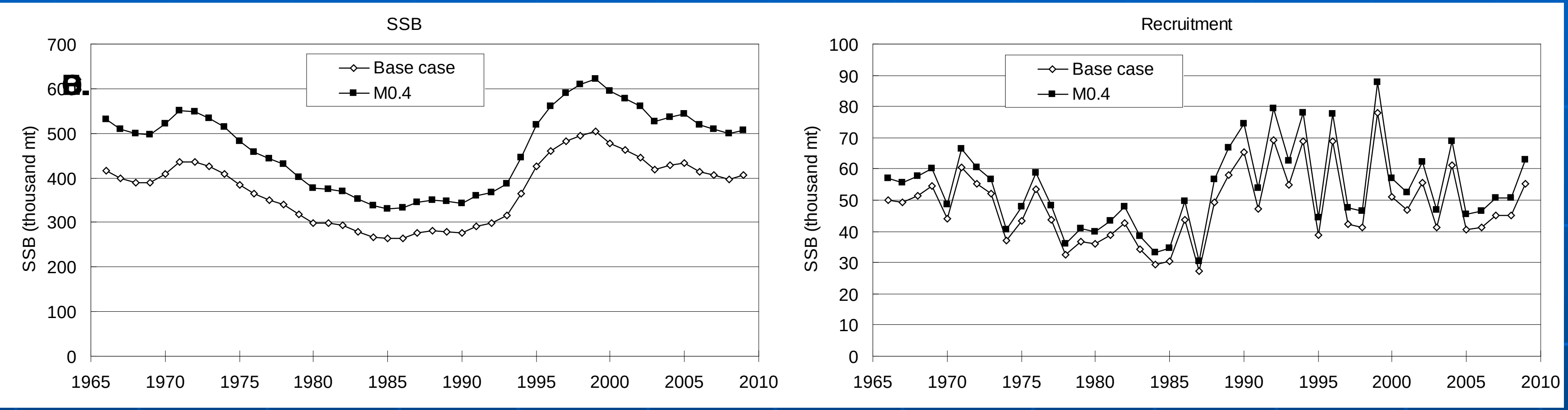


- *h* = 0.85 increased the scaling of SSB & recruitment

- Increases are likely related to the model having relatively little information on virgin biomass & recruitment to anchor the stock-recruitment relationship

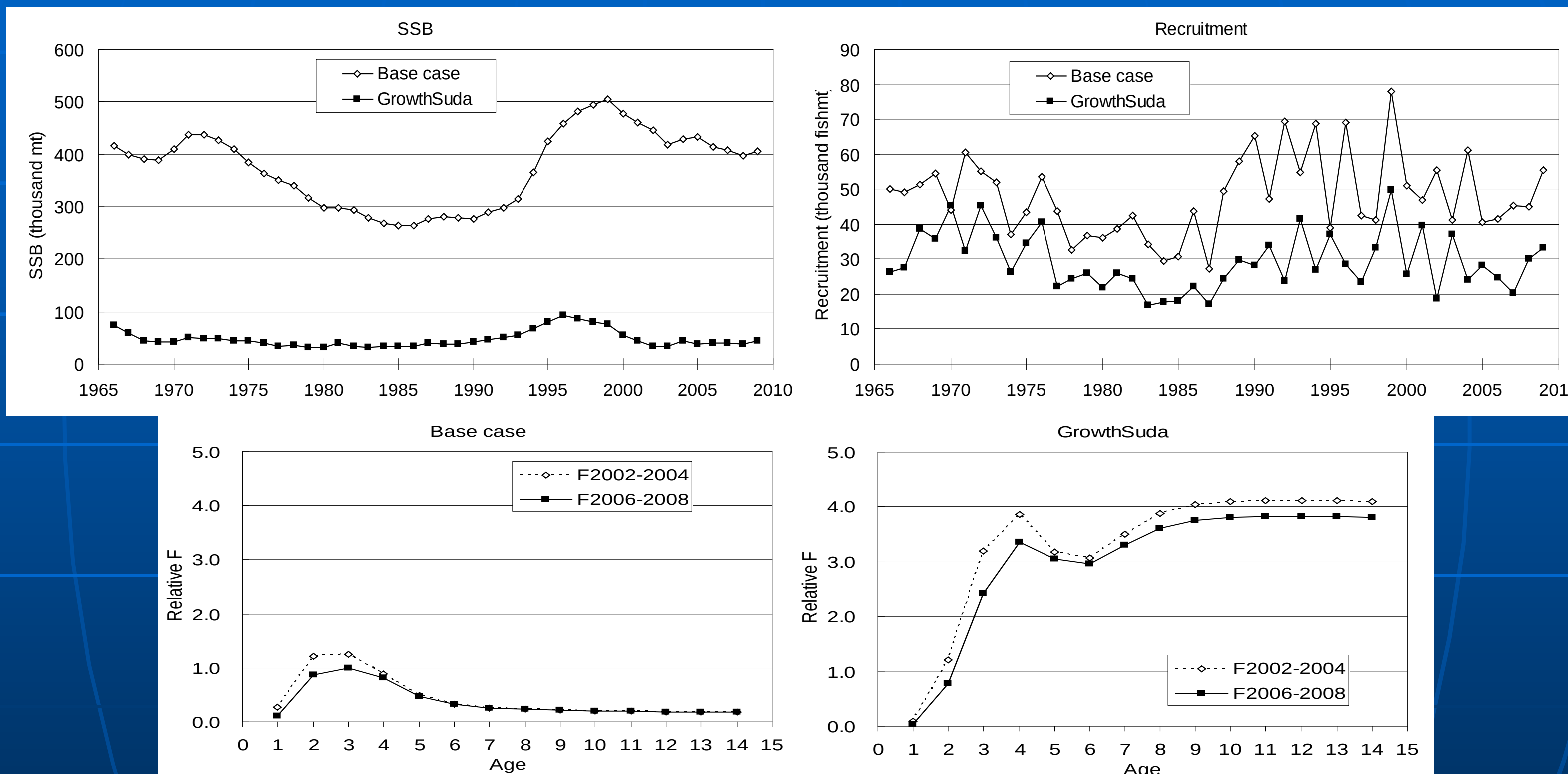


Sensitivity Results – M = 0.4 yr^{-1}



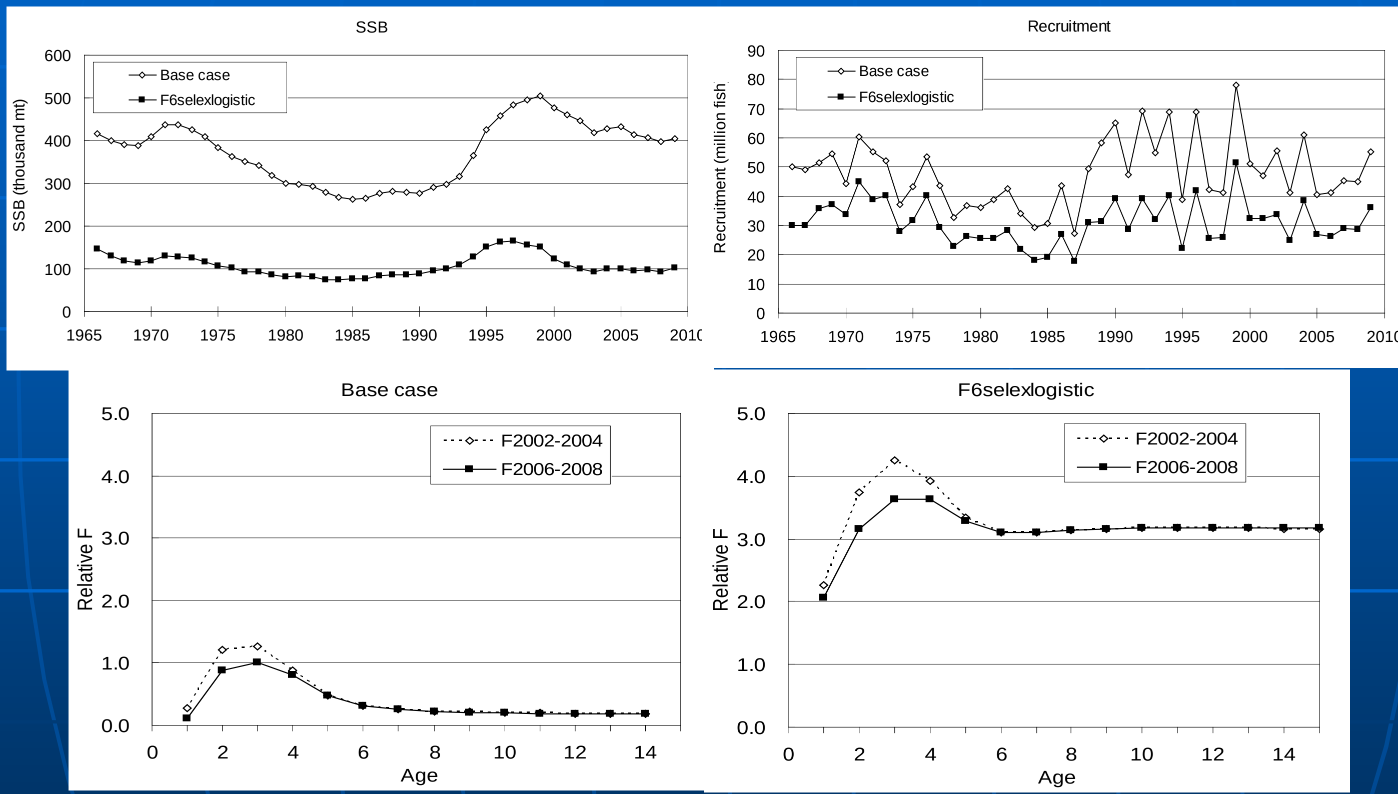
Higher scaling of SSB & recruitment

Sensitivity Results – Growth fixed to Suda growth parameters



- SSB & recruitment decreased relative to the base-case model
- F-at-age was much higher for all age classes, with a different pattern & higher F at older ages than in the base-case model
- Total likelihood of the base-case model was more than 100 units better than the Suda sensitivity run

Sensitivity Results - Asymptotic Selectivity for F6

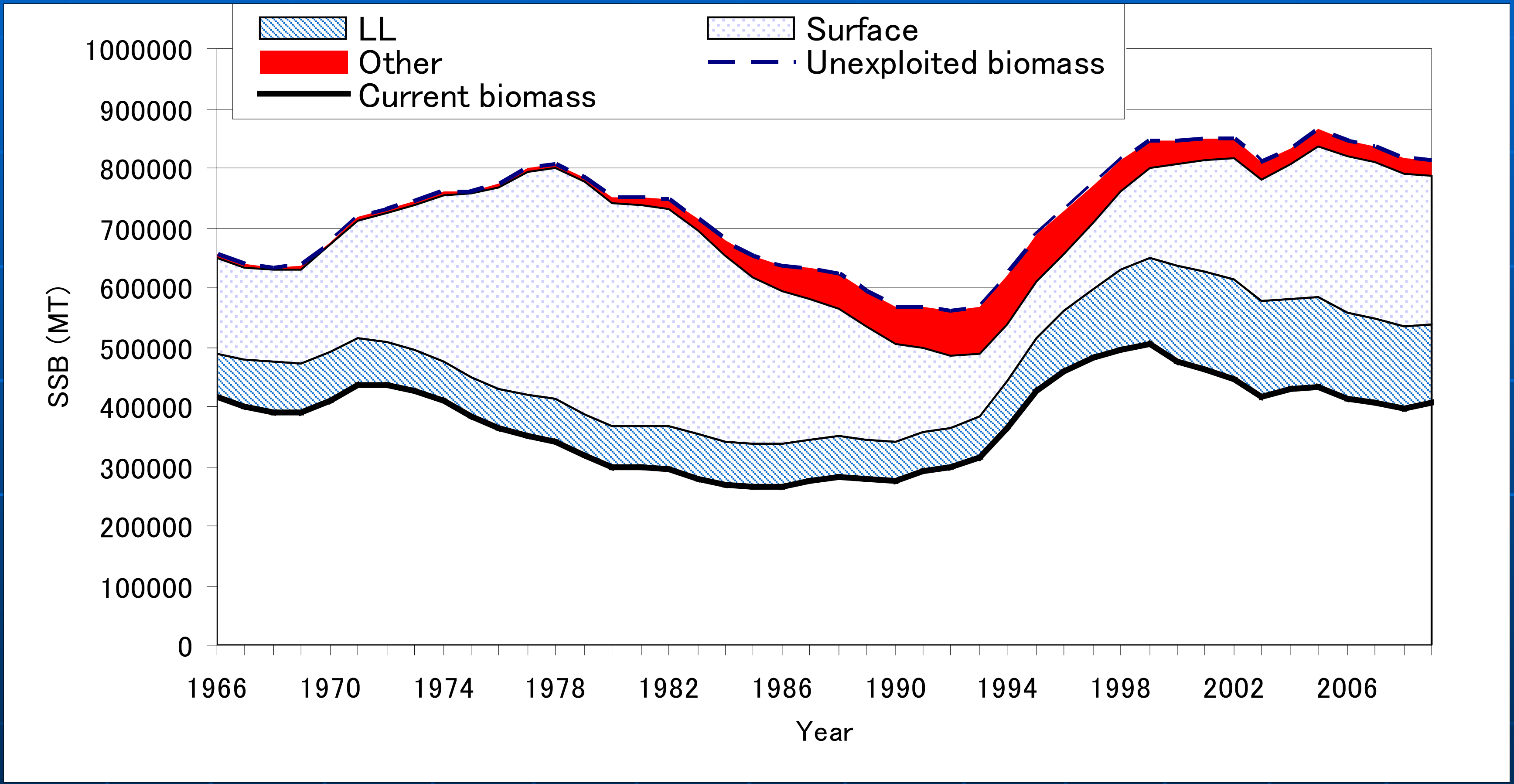


- Lower SSB & recruitment relative to the base-case, no changes in the trends
- F-at-age is higher & for large fish is higher relative to younger fish
- Total likelihood increased by more than 10 units relative to the base-case, i.e., the assumption of asymptotic selectivity for F6 leads to a poorer fitting model.

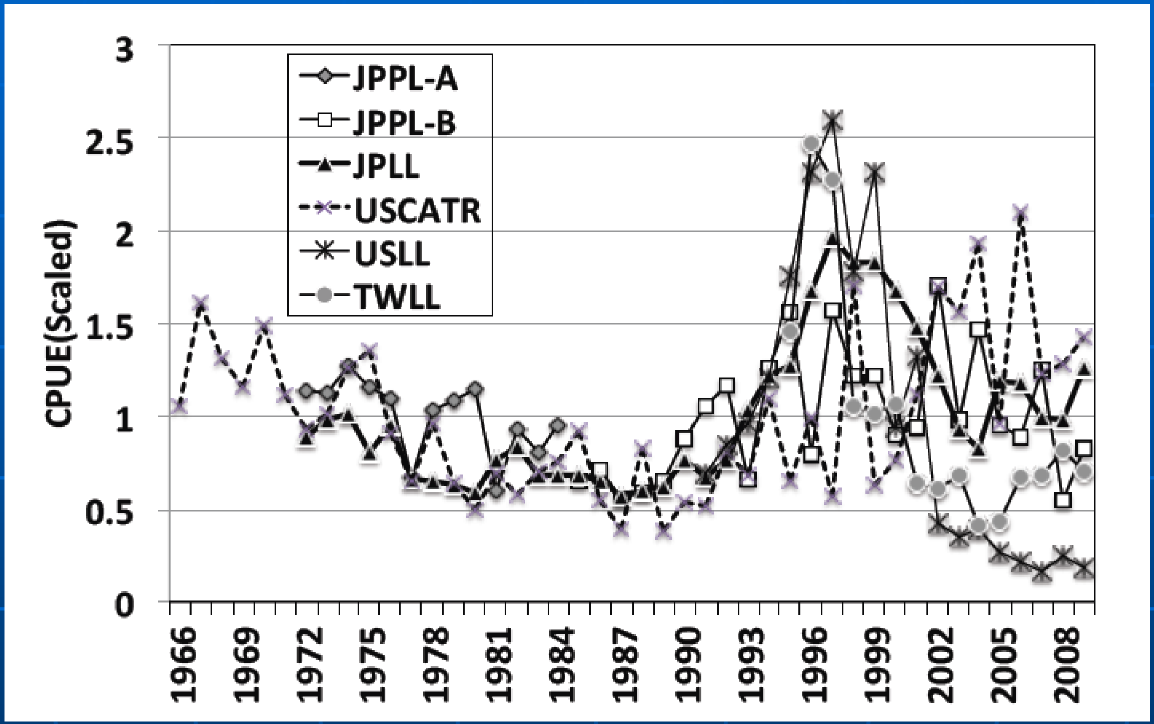
Sensitivity Analyses - Summary

- Scaling of SSB is substantially affected by:
  - the weighting of CPUE & length composition data;
  - dropping S7 (JPN OLLF – larger-average sized fish);
  - the selectivity assumption for fishery F6; and
  - the growth curve.
- Magnitude of change in recruitment estimates was less than observed for SSB estimates
- F-at-age pattern affected by fixing the growth curve to the Suda (1966) parameter estimates & selectivity assumption for F6
- Sensitivity runs with Suda growth parameters and F6 asymptotic selectivity produced biomass estimates similar in scale to VPA reference run

Fishery Impact Analysis

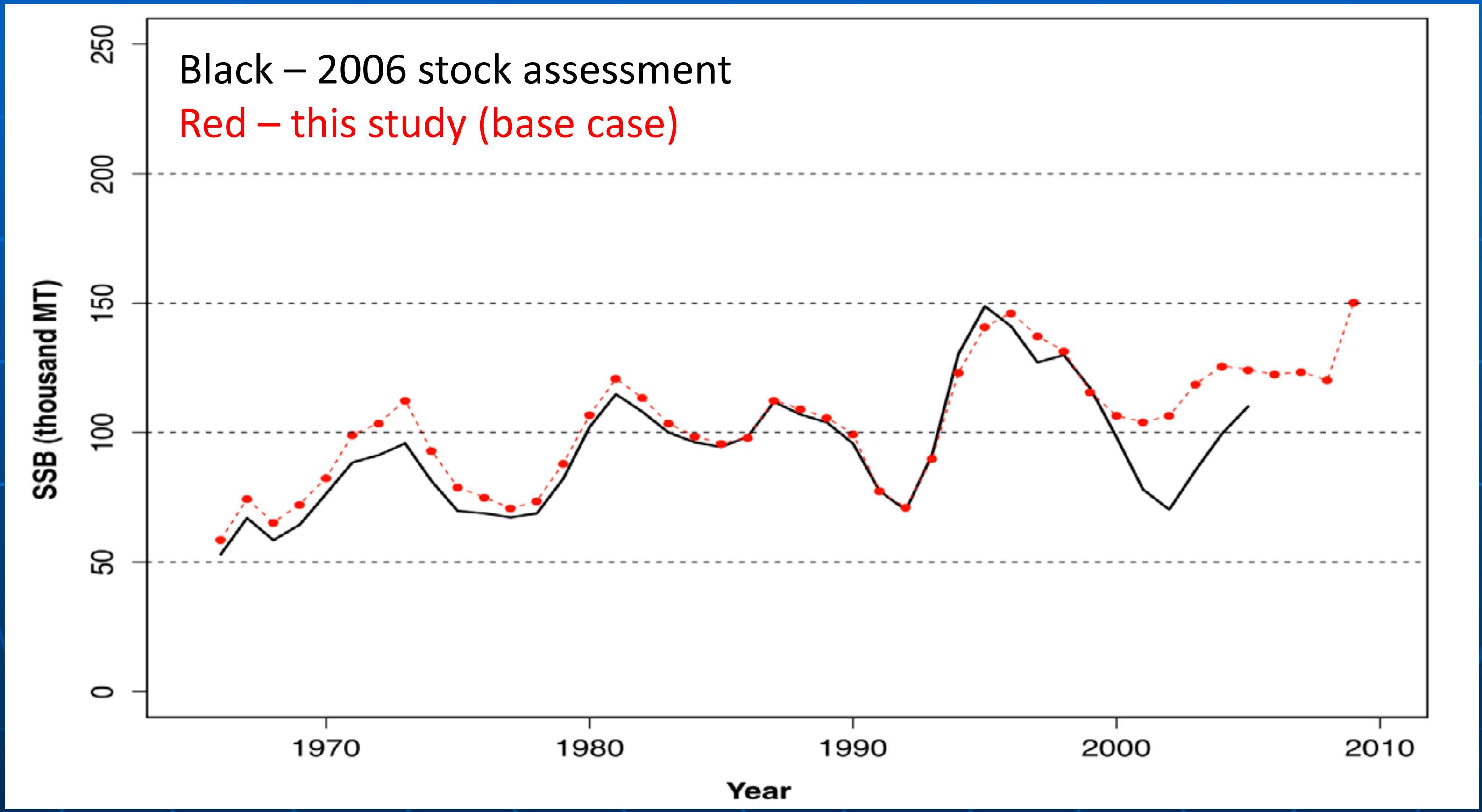


VPA Reference Run



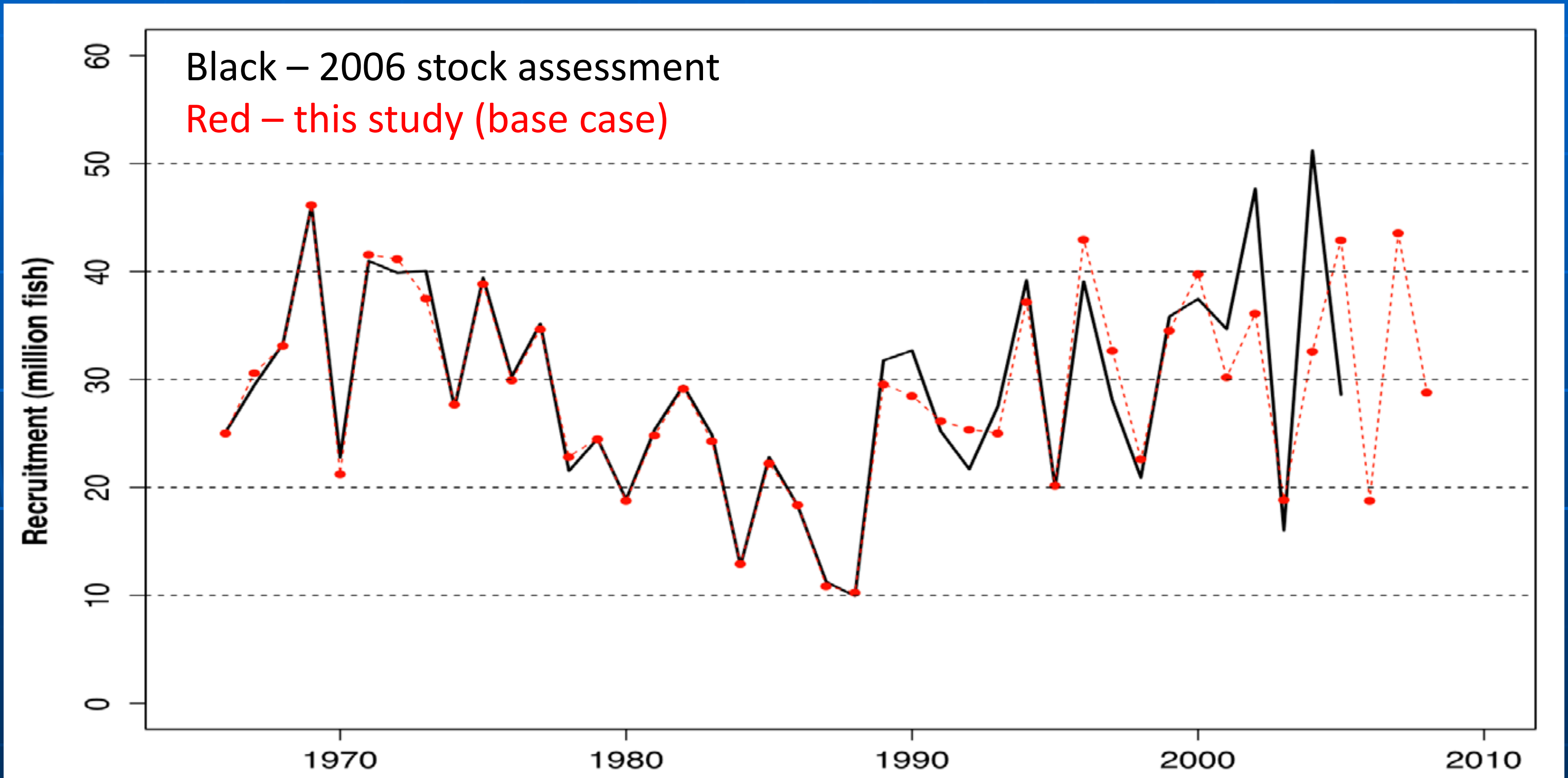
- Assumptions
  - 6 age-aggregated fisheries and CPUE indices
  - Growth: fixed to Suda(1966) growth parameters
  - M = 0.3 yr^{-1} fixed for all ages
  - Maturity: 50% age 5, 100% ≥ age 6 (Ueyanagi 1957)
  - CAA updated through 2009

VPA - SSB

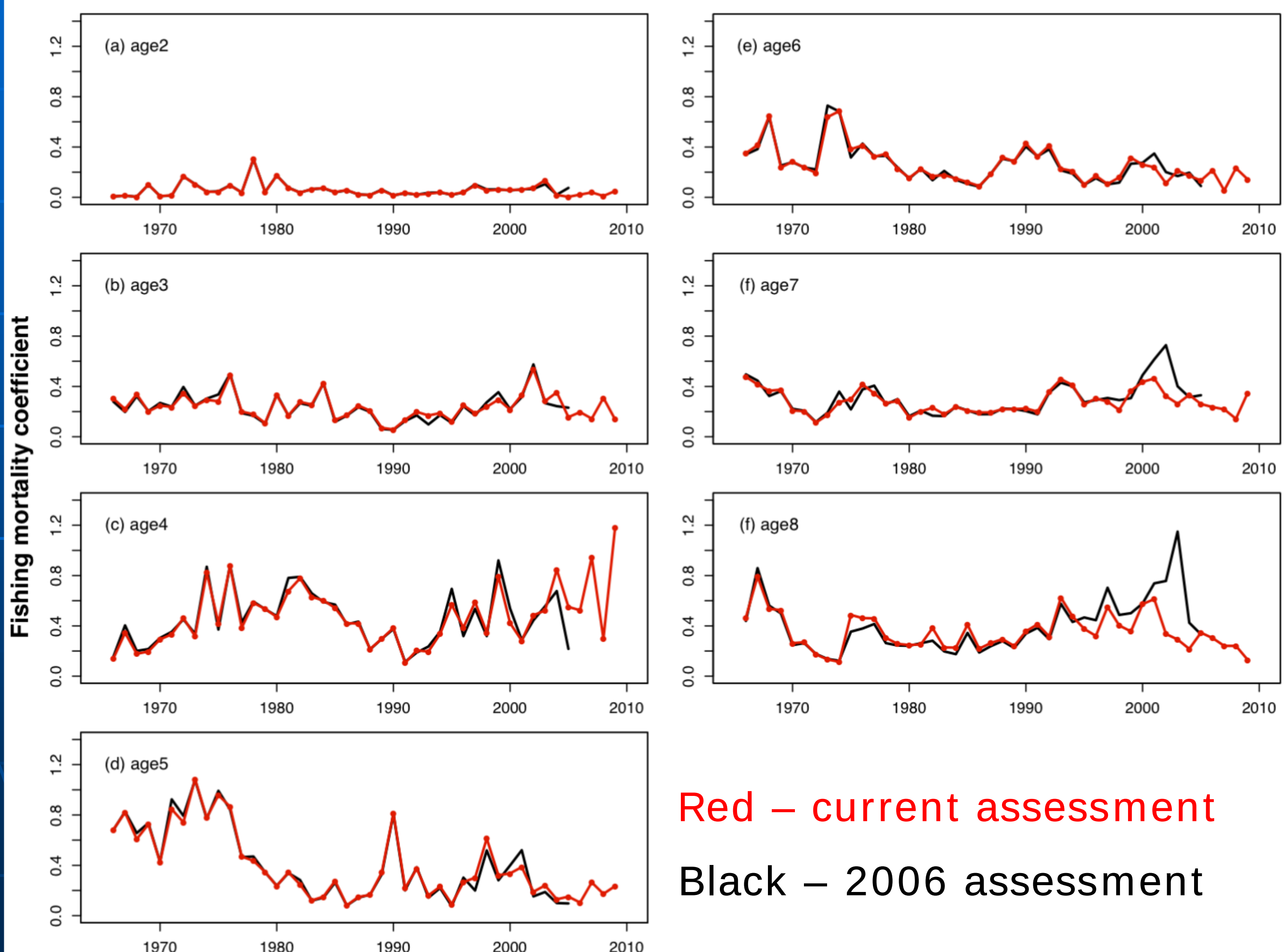


Black – 2006 stock assessment
Red – this study (base case)
SSB (thousand MT)
0
50
100
150
200
250
1970
1980
1990
2000
2010
Year

VPA – Recruitment at Age 1



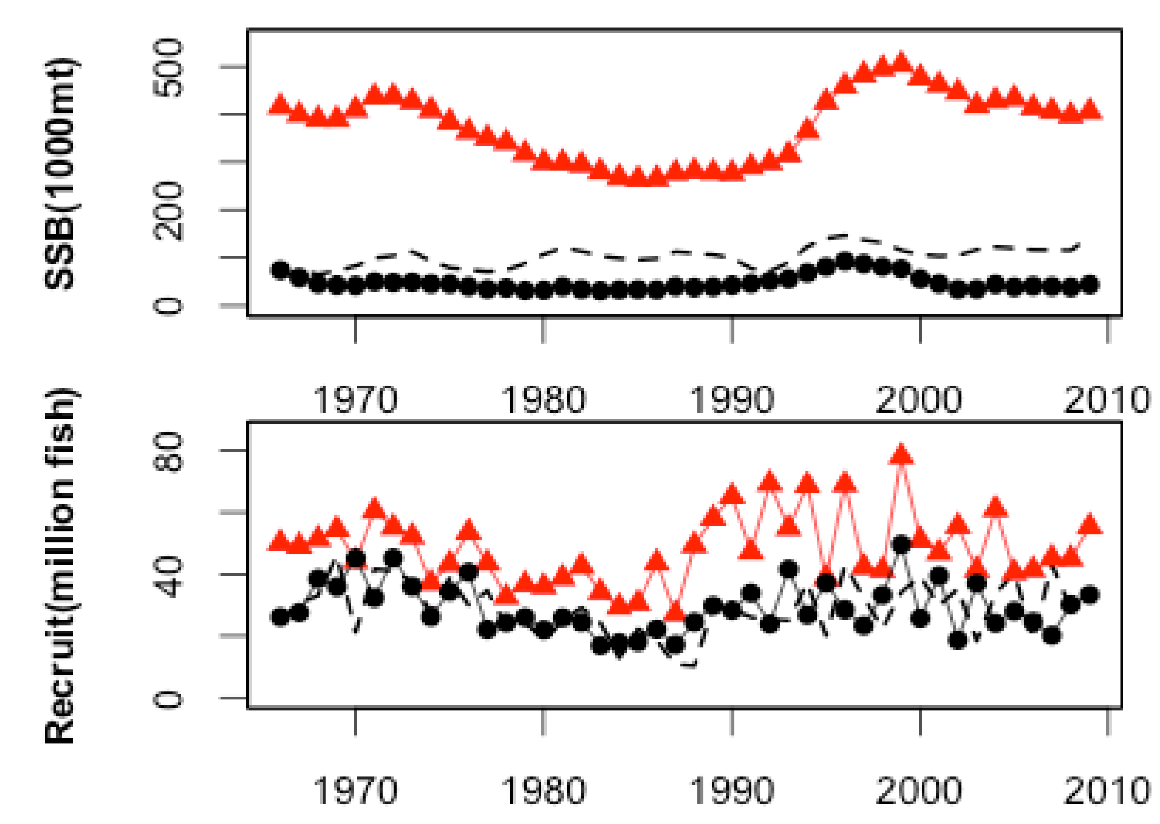
VPA – Fishing Mortality



Red – current assessment

Black – 2006 assessment

VPA – SS3 Output Comparison



Red – SS3 base-case

Black dashed – VPA reference

Black circles – SS3 using growth fixed to Suda curve

Future Projections

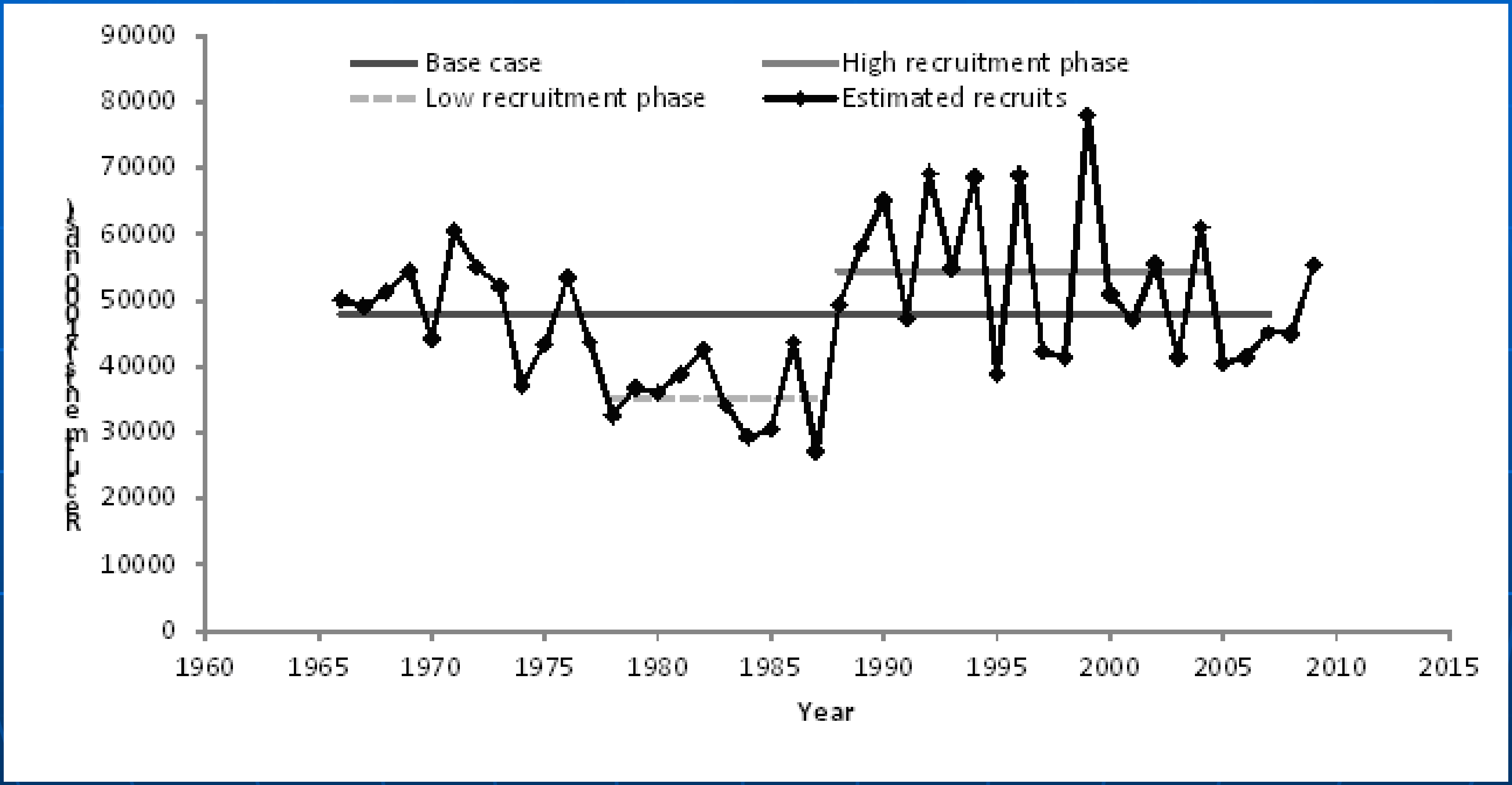
- Base-case scenario
  - F : constant at $F_{2006\text{-}2008}$
  - Recruitment : average 1966-2007 = 47.9 million
  - Start year : 2008

- Harvest scenarios
  - $F_{2002\text{-}2004}$
  - Constant catch treated as sensitivity run

- Recruitment scenarios
  - low recruitment phase (1978 to 1987): 35.2 million
  - high recruitment phase (1988-2004): 54.4 million

- Sensitivity Runs
  - Fix growth parameters to Suda estimates
  - SR steepness, *h* = 0.85
  - Length comp data weighting, lambda = 0.001

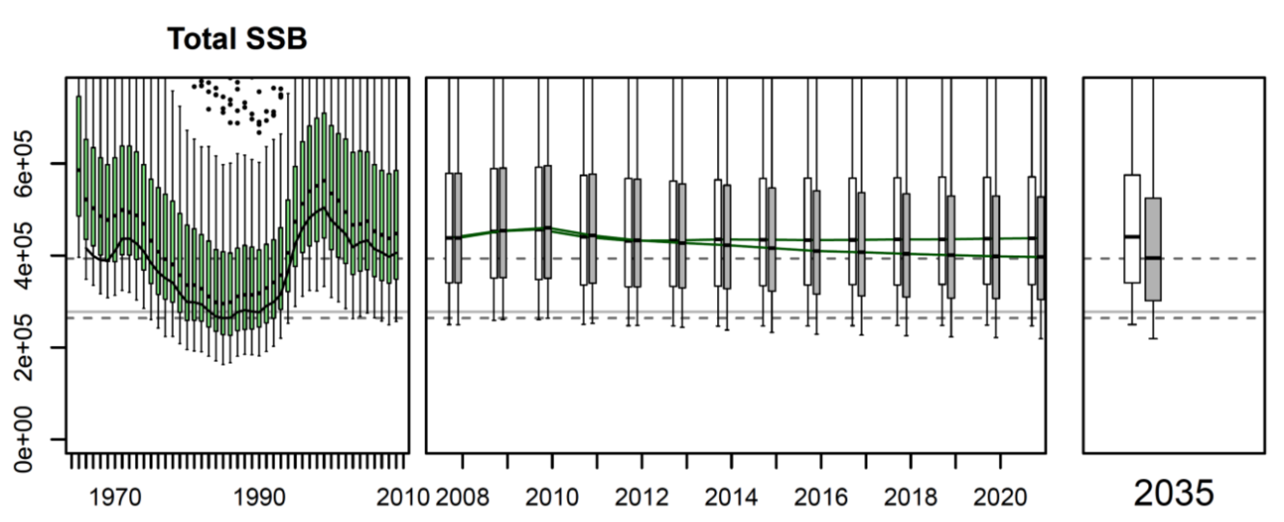
Future Recruitment

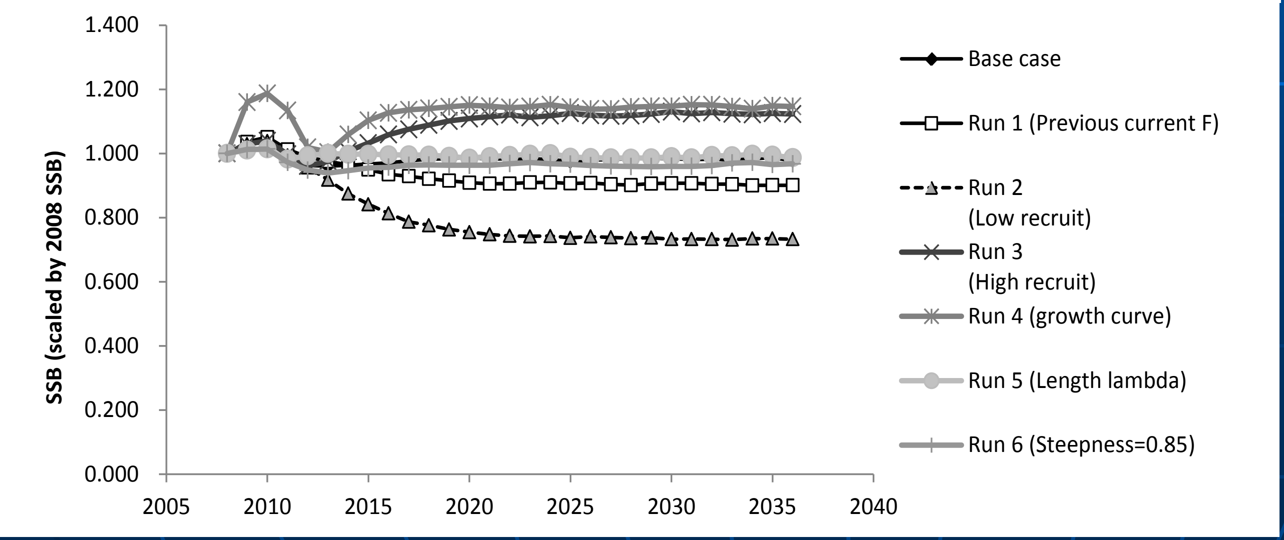


Recruitment

- Base-case: 1966 to 2007: 47.9 million
- low recruitment phase (1978 to 1987): 35.2 million
  high recruitment phase (1988-2004): 54.4 million

Future Projection Results





$F_{2006\text{-}2008}$ – white

$F_{2002\text{-}2004}$ - grey

Historical median SSB

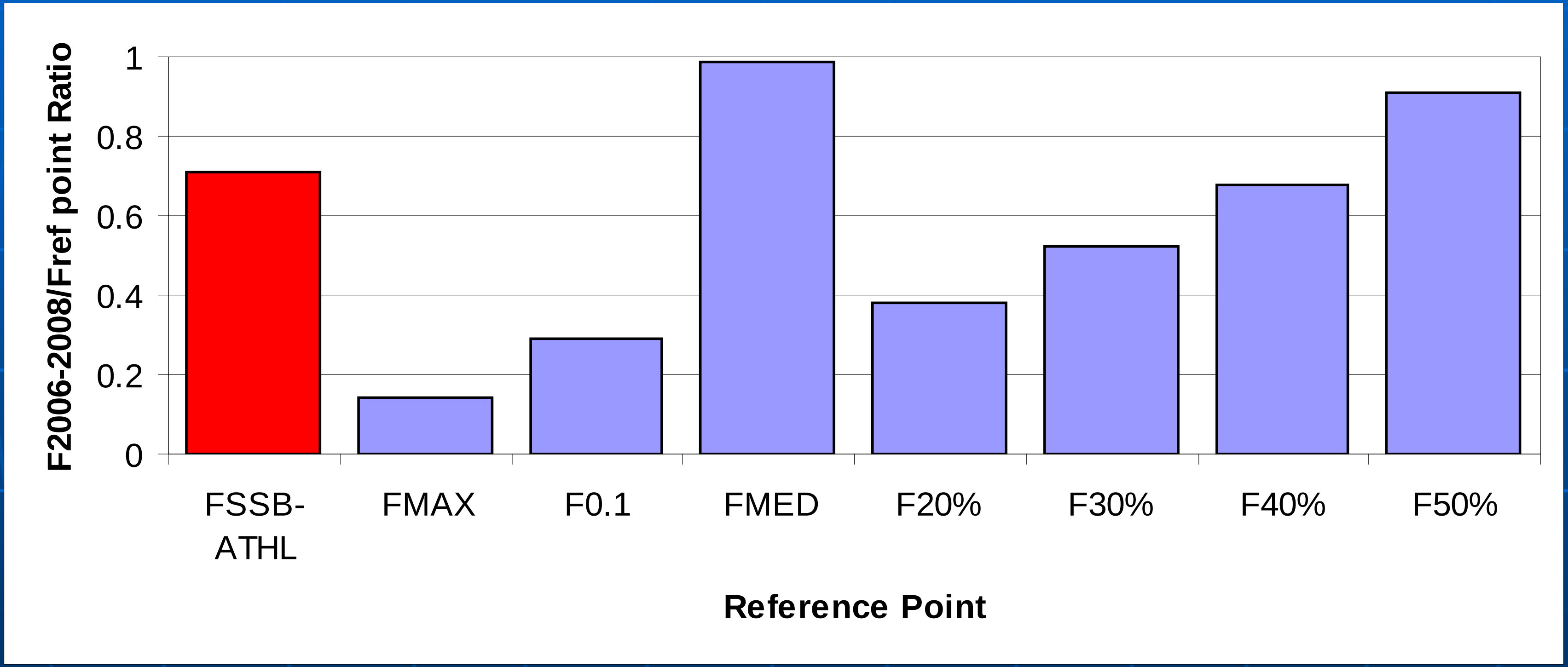
Lower 25th percentile

Lower 10th percentile & ATHL

Scaled to SSB_{2008}

Biological Reference Points

Ratio: $F_{2006\text{-}2008}/F_{ref\ point}$



Assessment Conclusions

- Uncertainty in estimates of biomass (total and SSB) and fishing mortality
- Trends in SSB & recruitment are robust to the different plausible assumptions tested by the WG
- Estimates of $F_{2006-2008}$ (current F) expressed as ratio relative to several F-based reference points are less than 1.0
- SSB is currently around the long-term median of the stock and is expected to fluctuate around the historical median SSB in the future assuming constant $F_{2006-2008}$ and average historical recruitment persist

Assessment Conclusions

- The current assessment results confirm that F has declined relative to the 2006 assessment and that this conclusion is robust to the different plausible assumptions tested by the WG

- The lower F found by this assessment is consistent with the intent of the previous (2006) WG recommendation, which was that "...current fishing mortality rate [$F_{2002-2004}$] should not be increased. ... However, with the projection based on the continued current high F, the fishing mortality rate will have to be reduced".

Stock Status

- WG concludes that overfishing likely is not occurring

- The stock likely is not in an overfished condition (e.g., $F_{cur}/F_{20\text{-}50\%} < 1.0$), but no biomass-based reference points established for the stock

Conservation Advice

- Stock is considered to be healthy at current levels of recruitment (historical average) and fishing mortality ($F_{2006\text{-}2008}$)

- The stock is expected to fluctuate around the long-term median SSB (~400,000 t) in the short-term under these conditions

Conservation Advice

- Status is based on average historical recruitment, but recruitment is quite variable over this period
- A more pessimistic recruitment scenario (e.g., 25% below average, which is within estimated variability) will increase the likelihood that the impact of current F ($F_{2006-2008}$) on the stock is not sustainable

Peer-review

- External review of assessment was conducted by CIE in 2011-2012 and reviews will be discussed by WG at July 2012 meeting
- Goal of review was to assess strengths and weaknesses of assessment and identify improvements

Research to Improve Assessment

1. **Age and growth modeling** – need samples of small (<60 cm) & large fish (>120 cm); look at other growth models
2. **Spatial Pattern Analyses** – movement patterns; spatial size patterns to support appropriate selectivity pattern choices
3. **CPUE Analyses** – investigate discrepancies among indices
4. **Maturity** – develop length-based maturity schedule
5. **Data Issues** – size comp anomalies, socio-economic factors affecting fisheries, national sampling programs
6. **Model Improvements** – weighting of info sources, stock-recruitment relationship, explicit spatial structure, environmental covariates

This Assessment is Brought to You by US!

The END!

- Questions?

Y/R and SPR Analysis