Chesapeake Bay Blue Crab Stock Assessment 2011

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Review comments

- Billy Ernst
  - " The 2010 assessment is a major improvement to is predecessors and is a valid approach. … This is a major advance with respect to previous models."
- Cathy Dichmont
  - "This is a major advance and is highly supported."
- Julian Addison
  - " I would fully support the approach taken in the assessment."

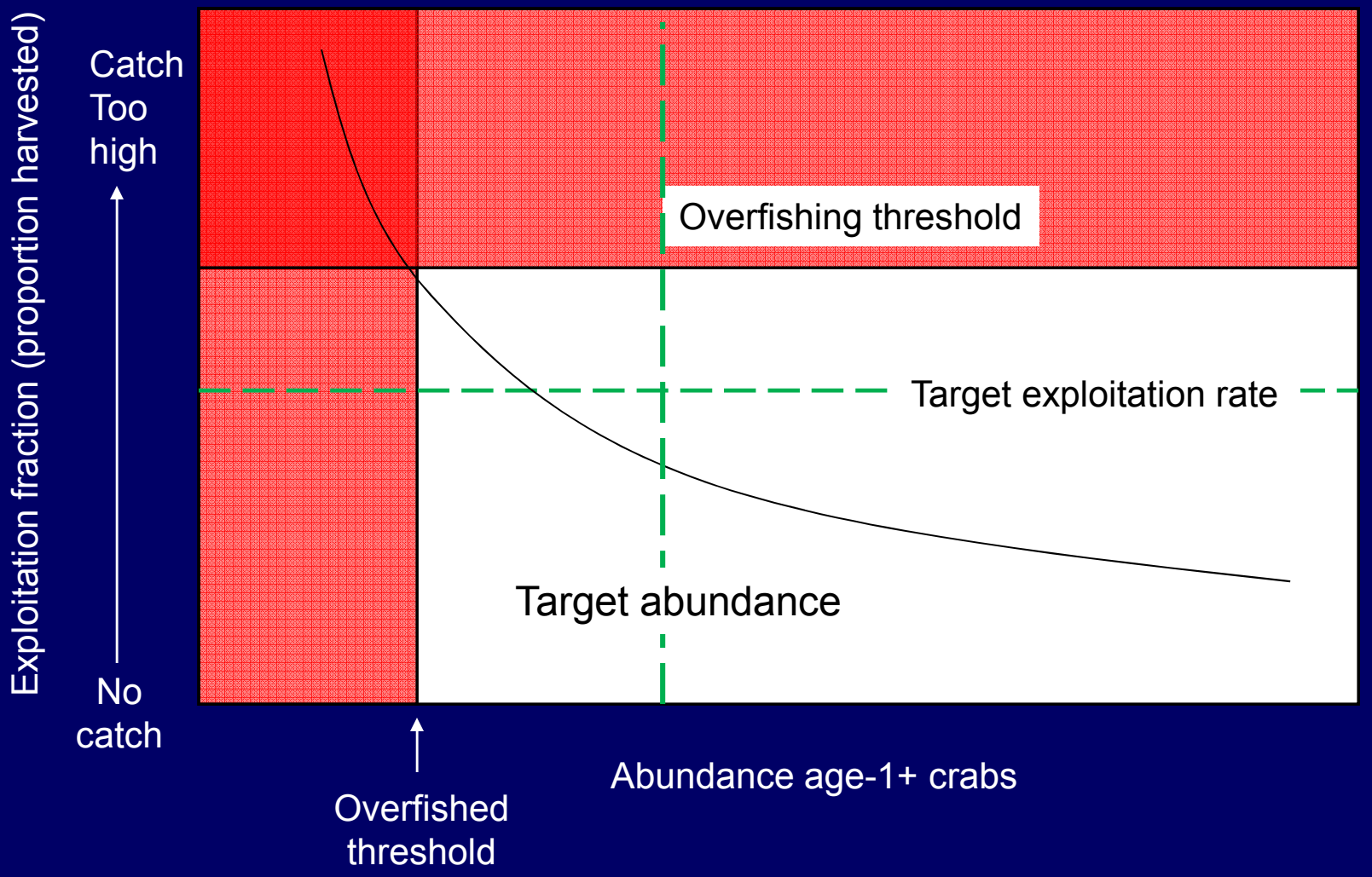
Assessment team

- T. J. Miller, M. J. Wilberg, A. R. Colton. *Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, Solomons, MD*
- G. R. Davis, A. F. Sharov. *Fisheries Service, Maryland Department of Natural Resources, Annapolis, MD*
- R. N. Lipcius, G. Ralph. *Virginia Institute of Marine Science, Gloucester Point, VA*
- E. G. Johnson, A. G. Kaufman, *Smithsonian Environmental Research Center, Edgewater, MD*

Assessment history

- Rugolo et al. (1995) conducted index-based assessment and did not recommend reference points.
- Miller and Houde (1999) recommended three F-based reference points for sustainability, reducing overfishing and recovering from overfished
- BBCAC TSC recommended first analytical F-based reference points based on SPR analysis and index-based minimum abundance reference points. Recommended a management control rule
- Miller et al. (2005) recommended revised SPR reference points based exploitation fractions developed in an IBM and minimum abundance reference points
- CBSAC recommended interim abundance target reference point based on recruitment variability

Biological reference points



Blue crab assessment

- TOR 1: Critically assess and where necessary revise the life history and vital rates of blue crab in the Chesapeake Bay that are relevant to an assessment of the stock.
- TOR 3: Describe and quantify patterns in fishery-independent surveys. Analyses should include an evaluation of the impacts of environmental and abiotic factors on survey catches, to maximize the information content of resultant survey time series.
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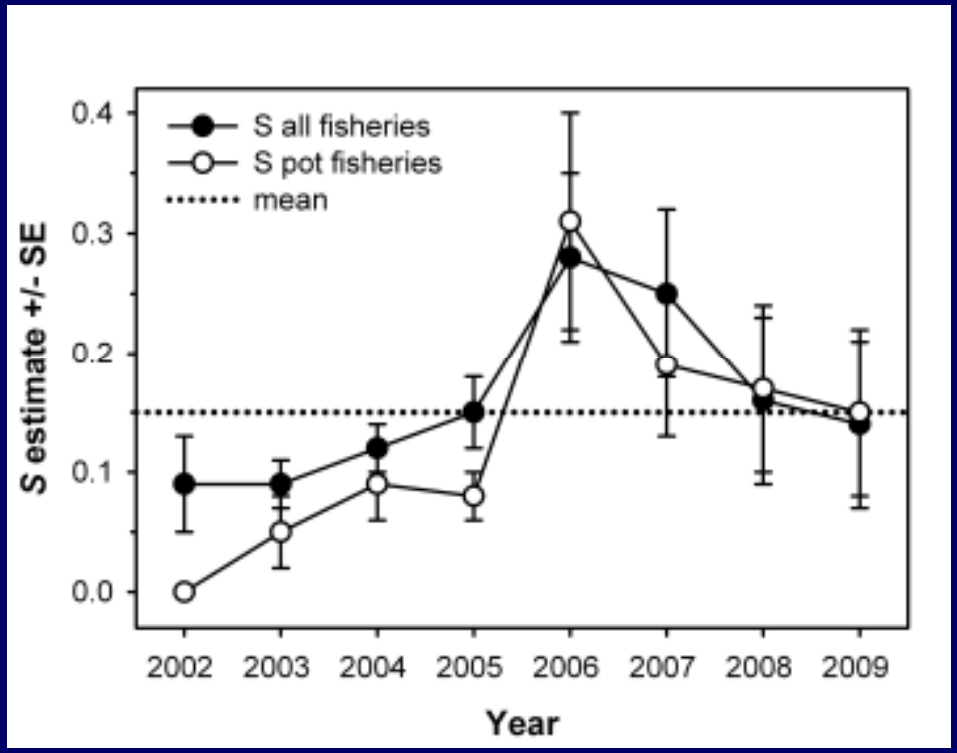
- TOR 8: Evaluate stock status with respect to reference points.
- TOR 7: Characterize scientific uncertainty with respect to assessment inputs and stock status.

Updating M



- Tag-recapture- based estimates of annual survival of adult females available 2002-2009.
  - 4400 tagged & released
  - 20.8% returned
  - Inter-annual variability in S
  - Indirect estimate of M based on time-at-large data used to estimate max age
    - M=0.65-0.79

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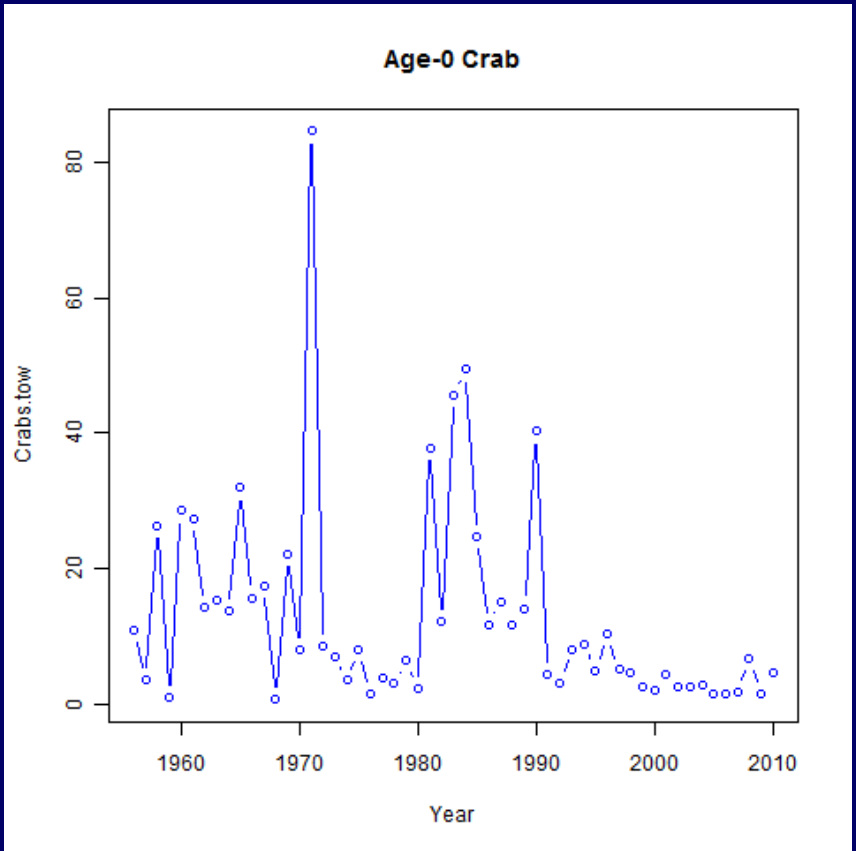
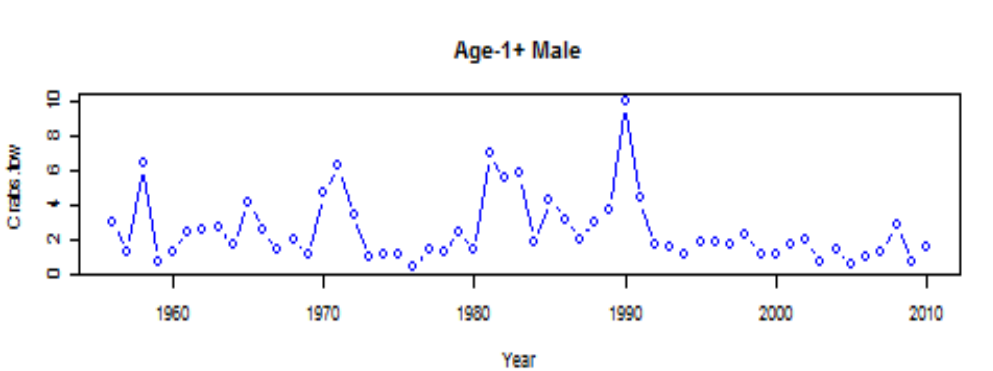
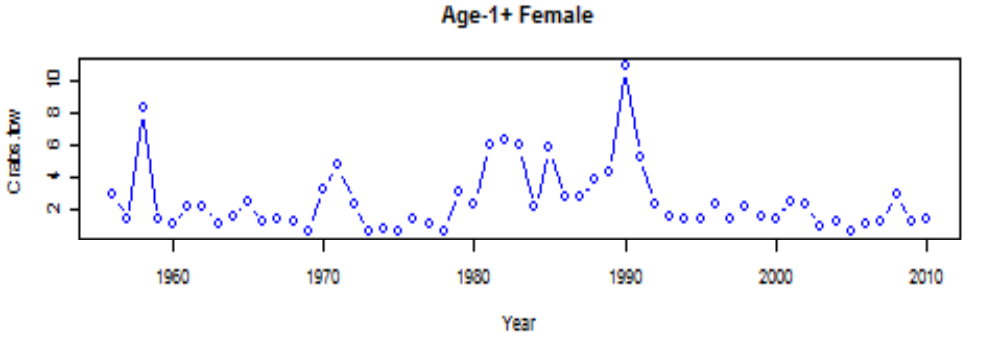
Fishery-independent surveys

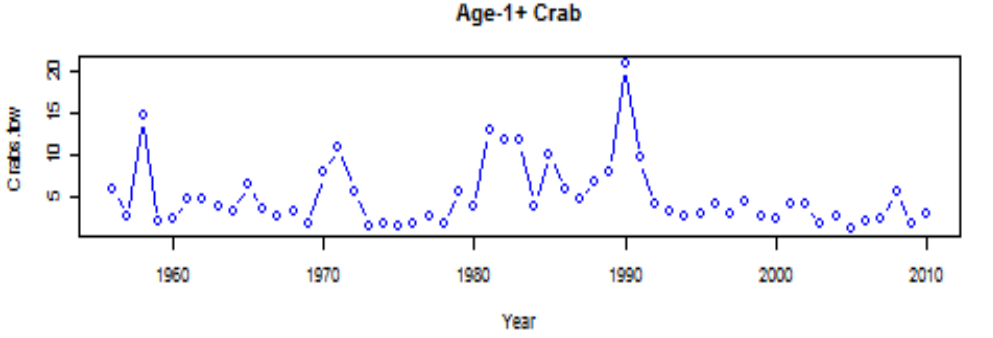
- Multiple candidate fishery-independent surveys
- Three selected for use in assessment based on spatial coverage, survey length and consistency with other assessments
- GLM used to adjust for changes in survey design and for inter-annual variability in environmental factors for MD trawl and WDS

VA trawl time series



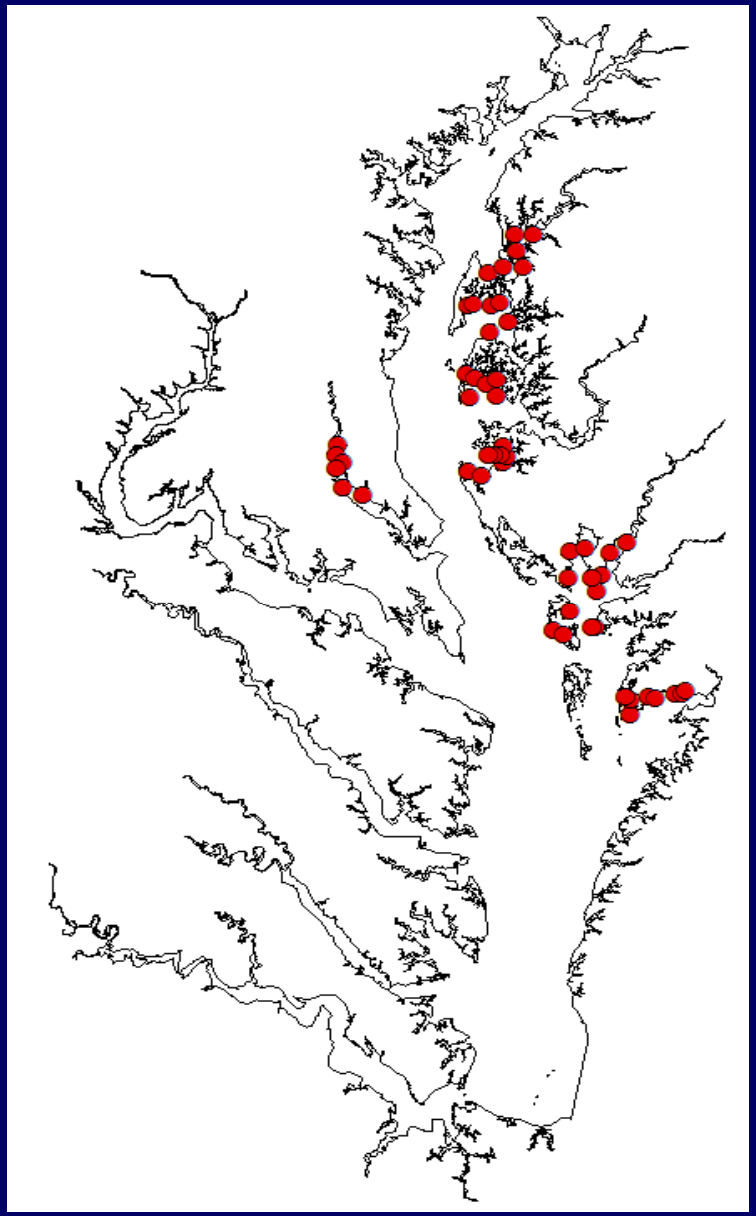




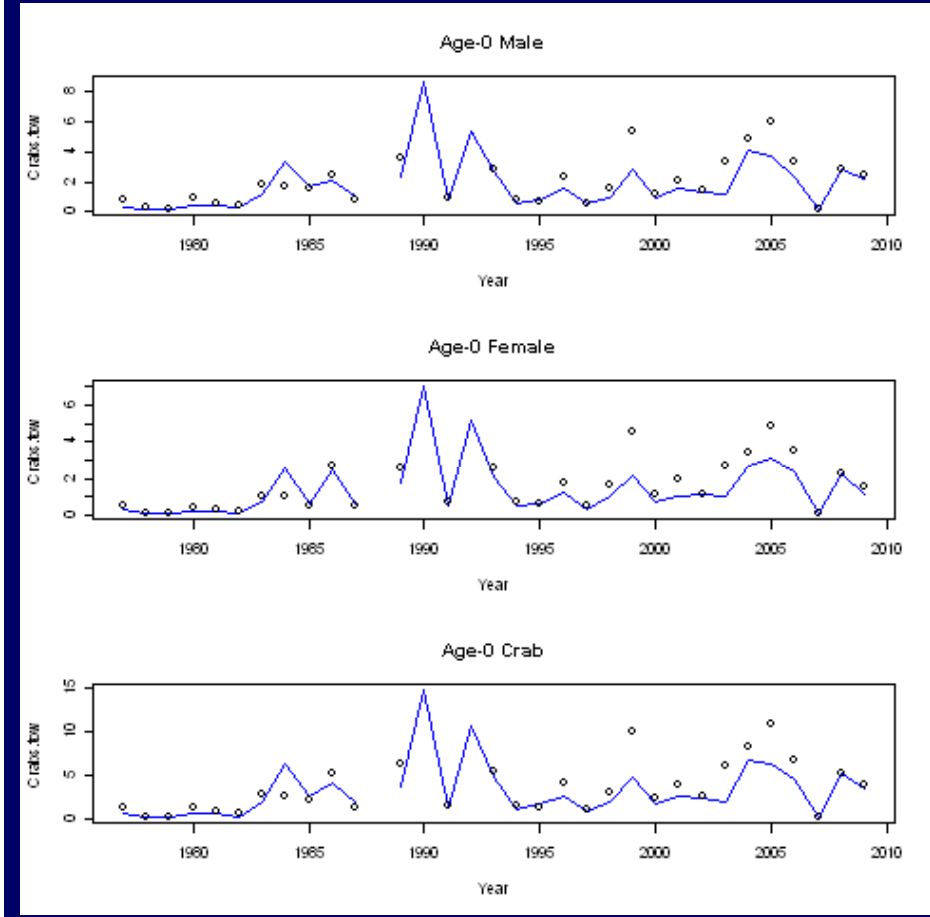


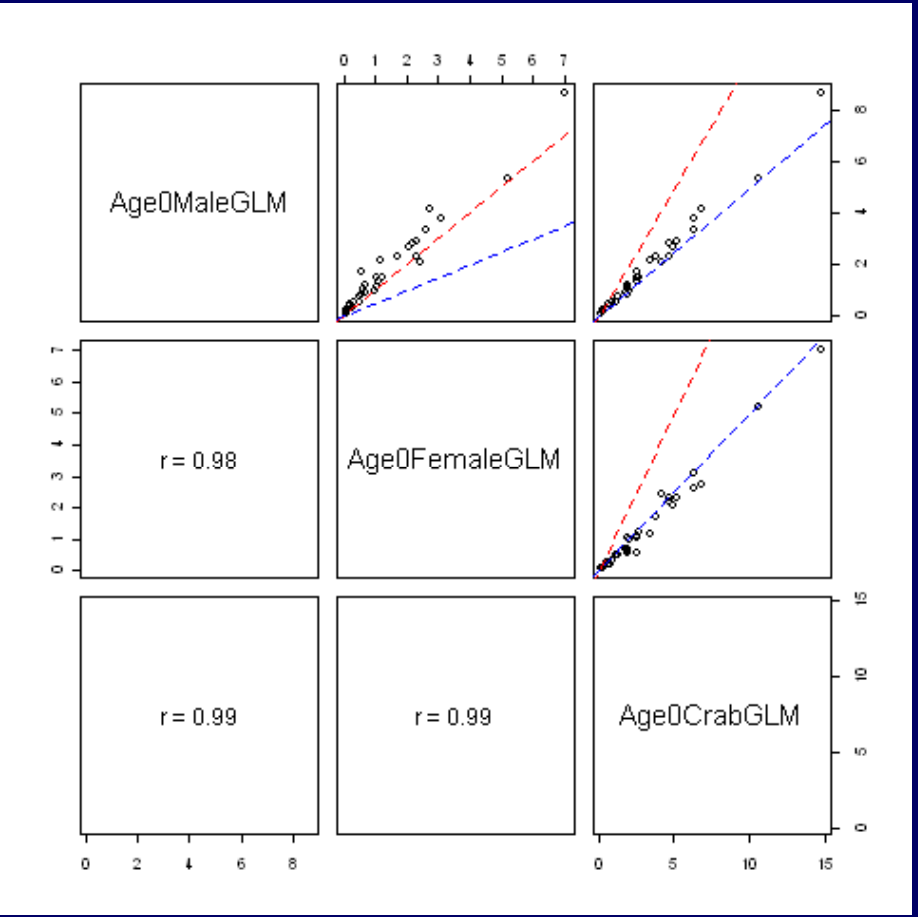
Maryland trawl survey

- Initiated in 1977, sampling May-November using fixed stations
- Design expanded
- Gear fixed
- All crabs enumerated and either tallied or measured by size and sex
- Analyses focus on Sept-Nov for age-0 and May-July for age-1+
- Two-stage GLM involving design- and environmental data used to develop survey indices based on best fitting models
  - Design factors always important
  - Environmental factor importance varied by stage and sex

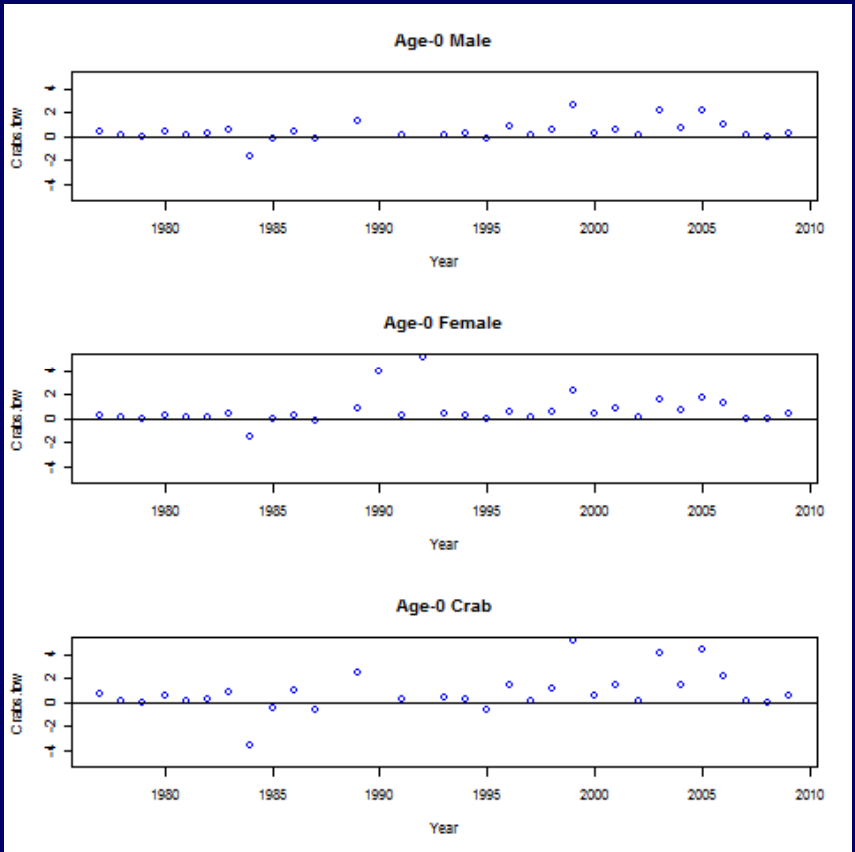


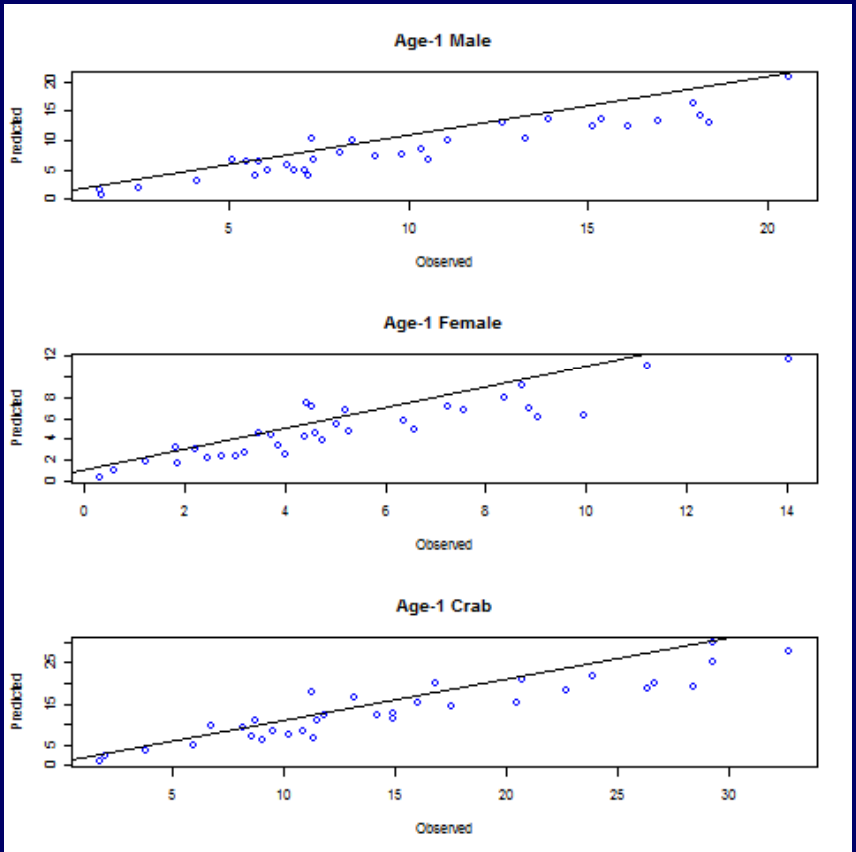
Age-0 crabs


Age-0 Male
Crabs.tow
Year
Age-0 Female
Crabs.tow
Year
Age-0 Crab
Crabs.tow
Year


Age0MaleGLM
r = 0.98
Age0FemaleGLM
r = 0.99
r = 0.99
Age0CrabGLM

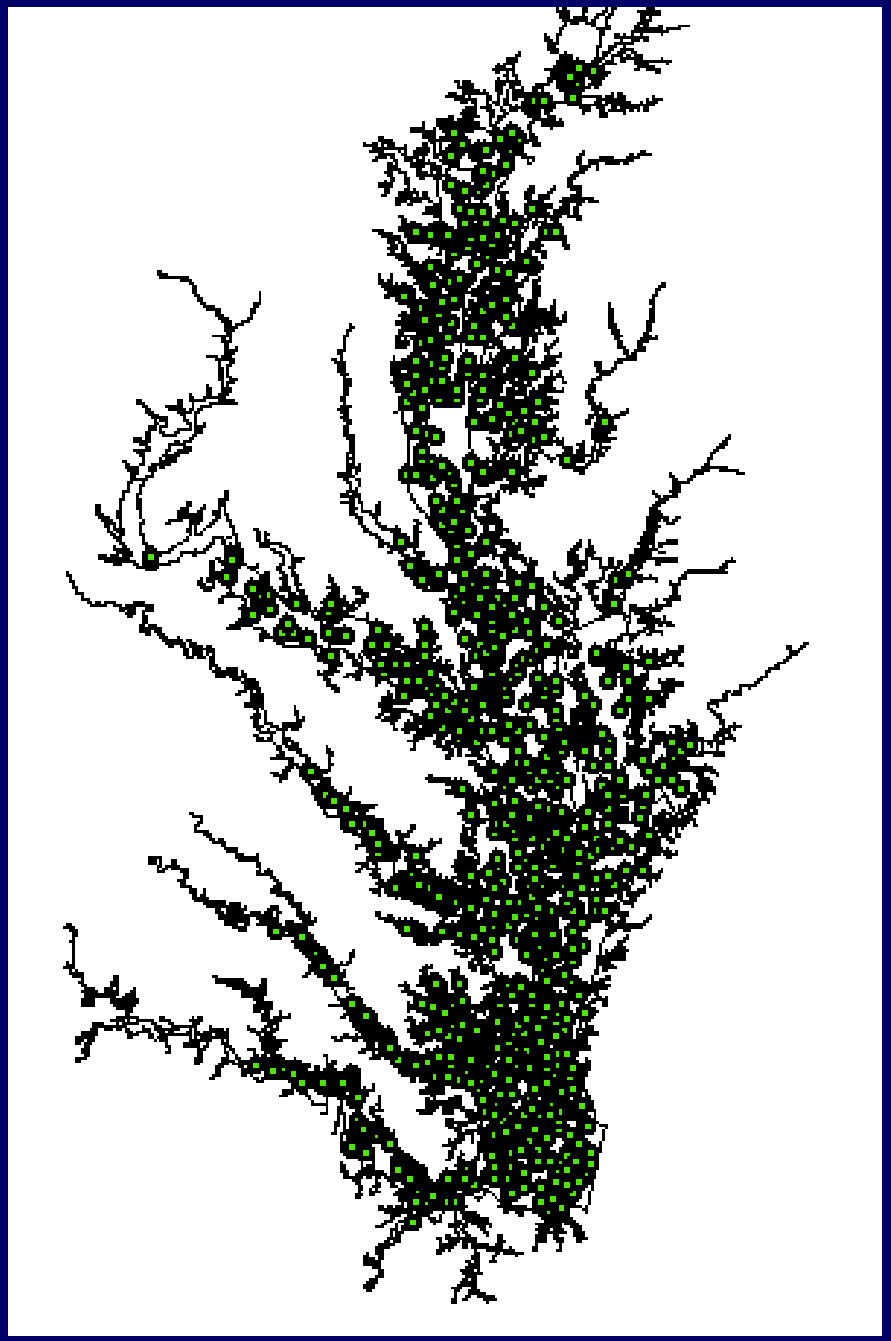
Age-0 fits


Age-0 Male
Crabs.tow
Year
Age-0 Female
Crabs.tow
Year
Age-0 Crab
Crabs.tow
Year

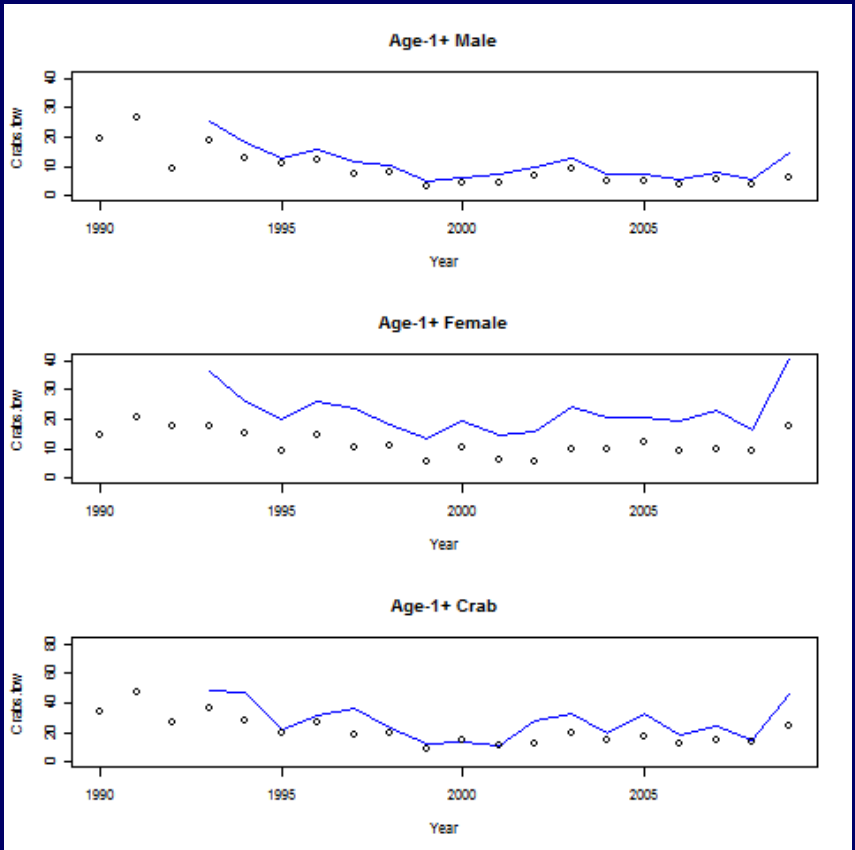

Age-1 Male
Predicted
Observed
Age-1 Female
Predicted
Observed
Age-1 Crab
Predicted
Observed

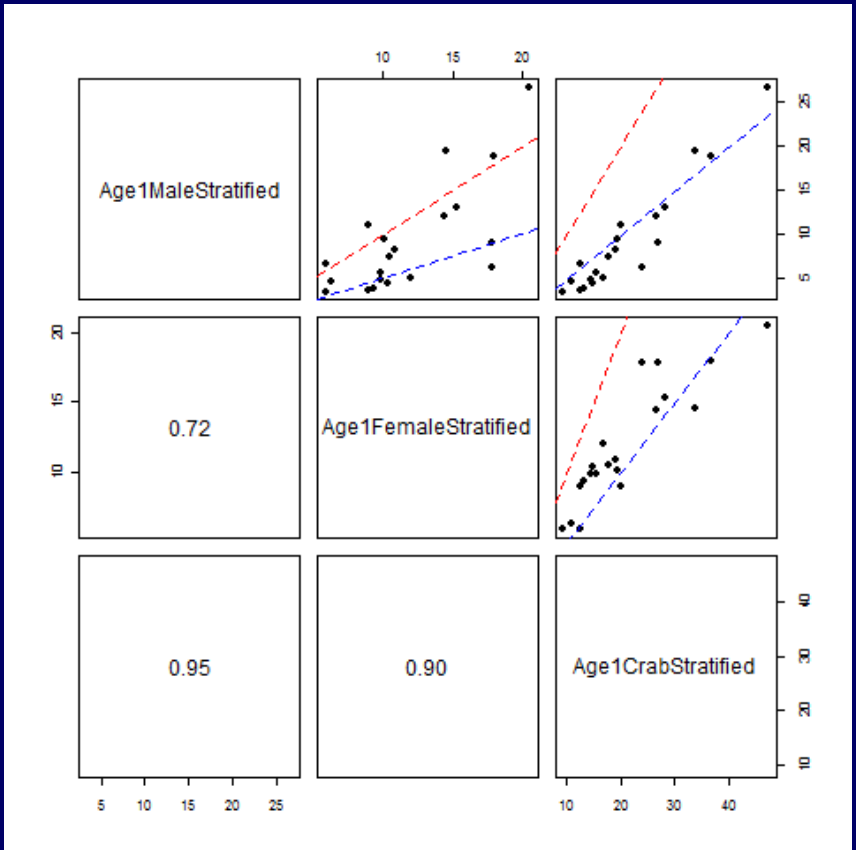
Winter dredge survey

- Initiated in 1989/90, uses a stratified random design with a standard commercial dredge
- Annual mortality and efficiency studies conducted to provide foundation for absolute abundance
- All crabs enumerated, measured and sexed
- Two-stage GLM involving design- and environmental data used to develop survey indices based on best fitting models
  - Both design and environmental factors always important

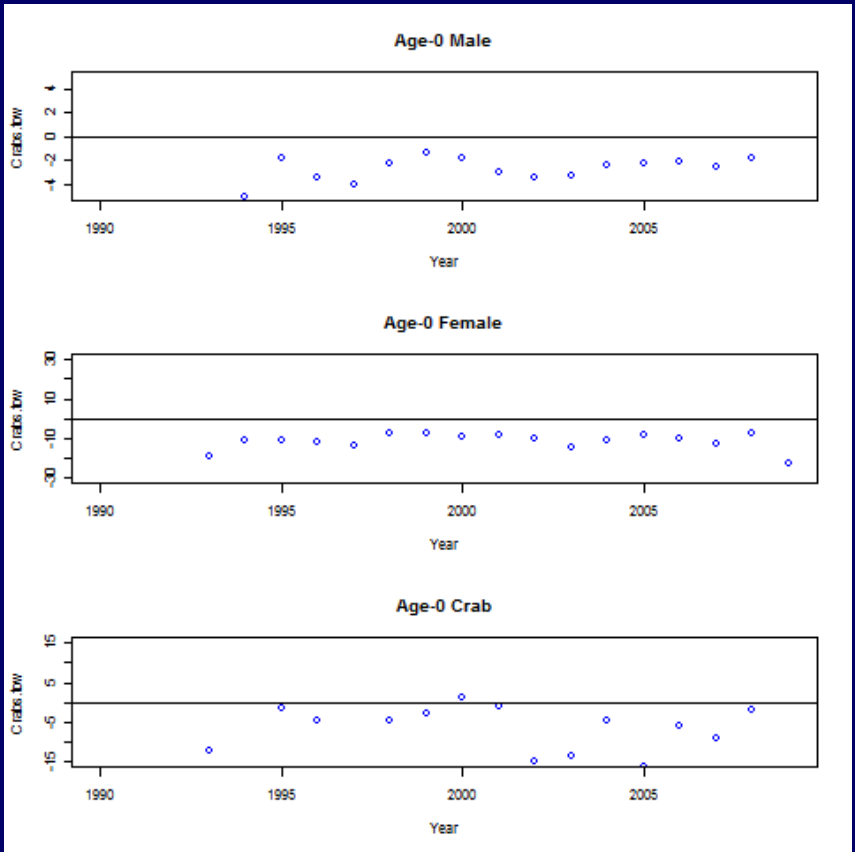


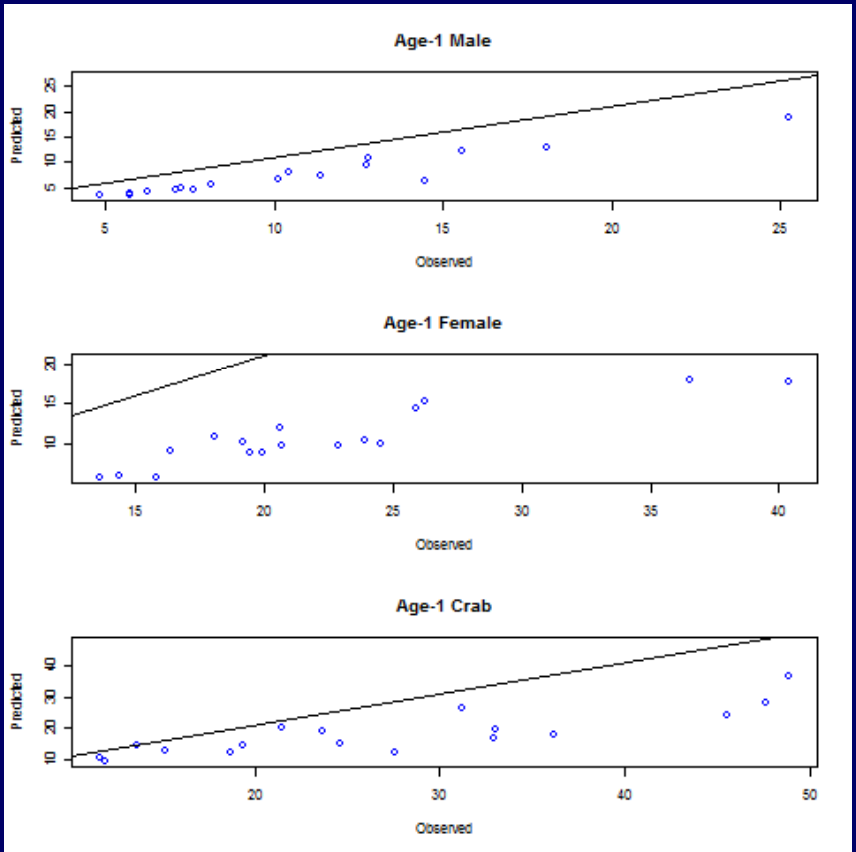
Age-1+ crabs


Age-1+ Male
Crabs.tow
Year
Age-1+ Female
Crabs.tow
Year
Age-1+ Crab
Crabs.tow
Year

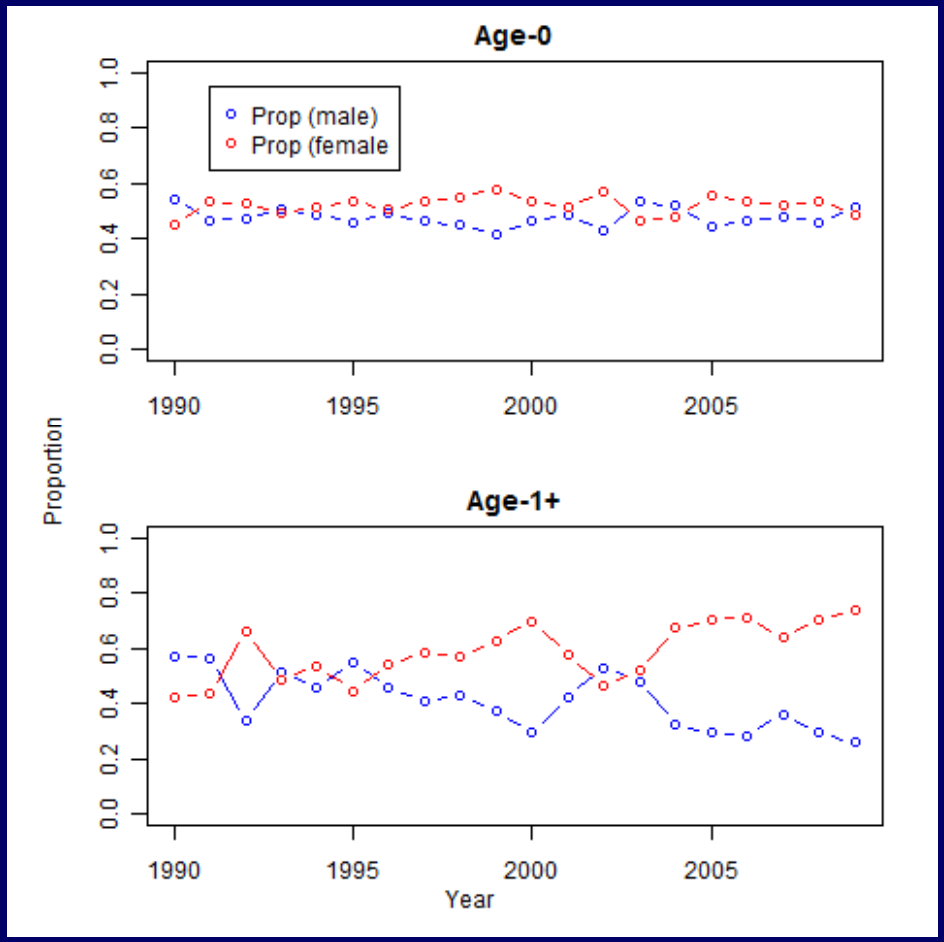

Age1MaleStratified
0.72
Age1FemaleStratified
0.95
0.90
Age1CrabStratified

Age-1+ fits


Age-0 Male
Crabs.tow
Year
Age-0 Female
Crabs.tow
Year
Age-0 Crab
Crabs.tow
Year


Age-1 Male
Predicted
Observed
Age-1 Female
Predicted
Observed
Age-1 Crab
Predicted
Observed

Sex-specific patterns



- Female bias in age-0 abundance (52% female), but without trend
- Female bias in age-1+ abundance. Female bias stronger in most recent years.

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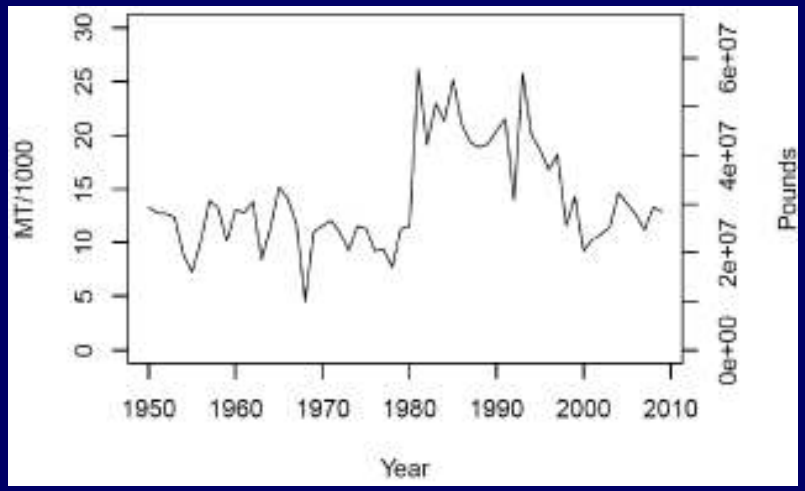
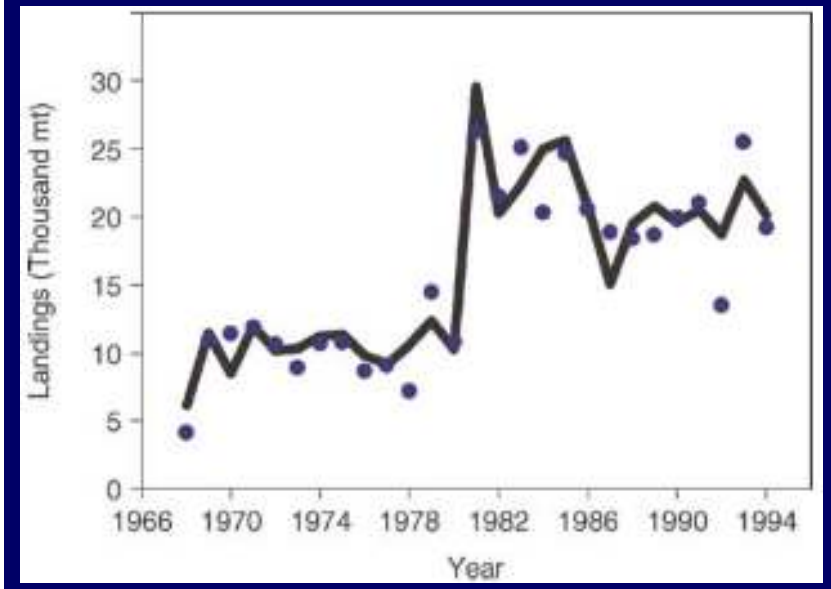
Interpreting reporting changes

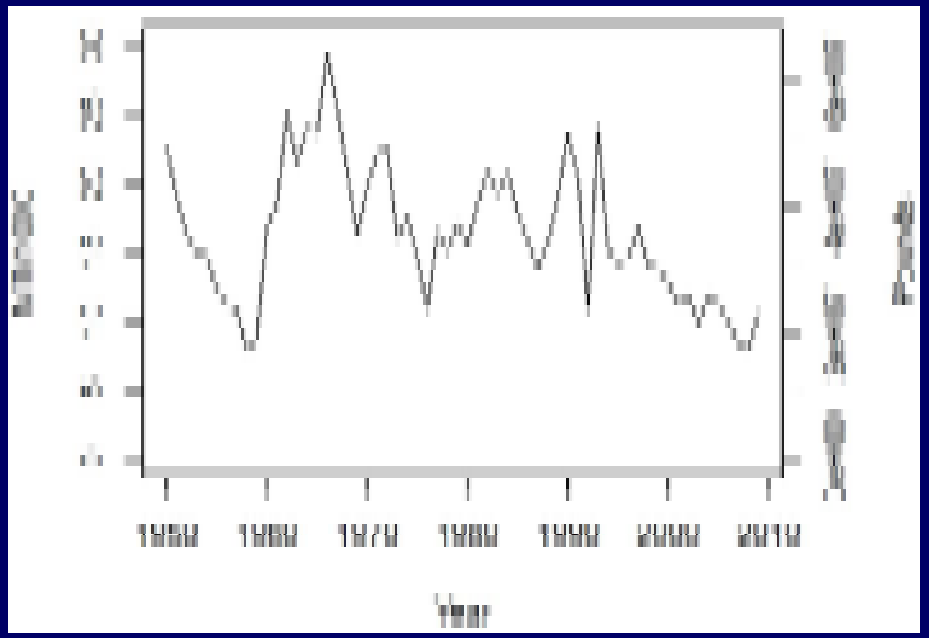


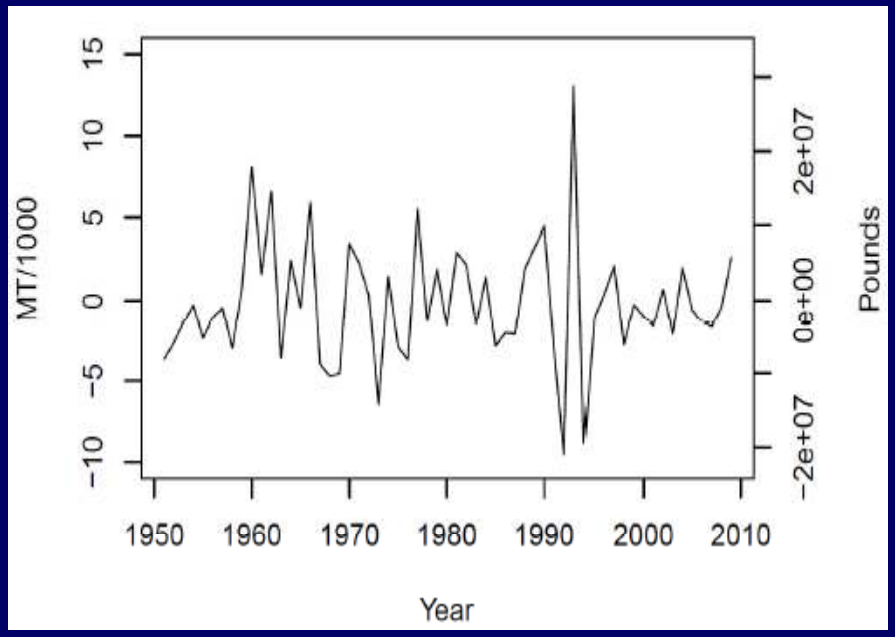


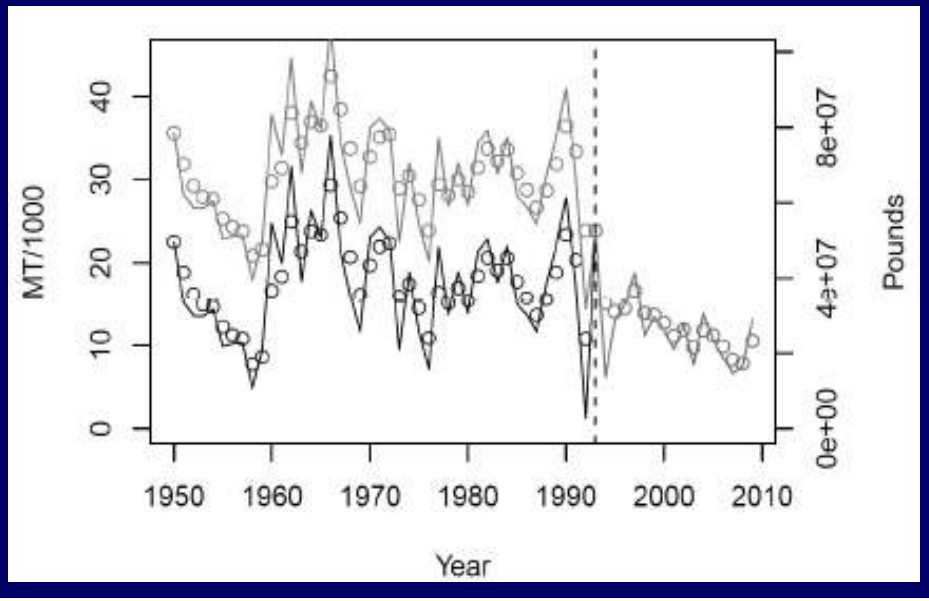
- Interpretation of reporting changes has been controversial
  - Rugolo et al. (1995) assumed no reporting change effect
  - Miller and Houde (1999) assumed total reporting change effect
- Fogarty and Miller (2004) used time series intervention analysis to assess patterns.
  - Evidence suggested both reporting change and abundance effect
- For this assessment similar methodology, but focused on reporting changes only.

Fogarty, M. J. and T. J. Miller. 2004. Impact of changes in reporting systems in the Maryland blue crab fishery. Fisheries Res. 68:37-43

VA landings



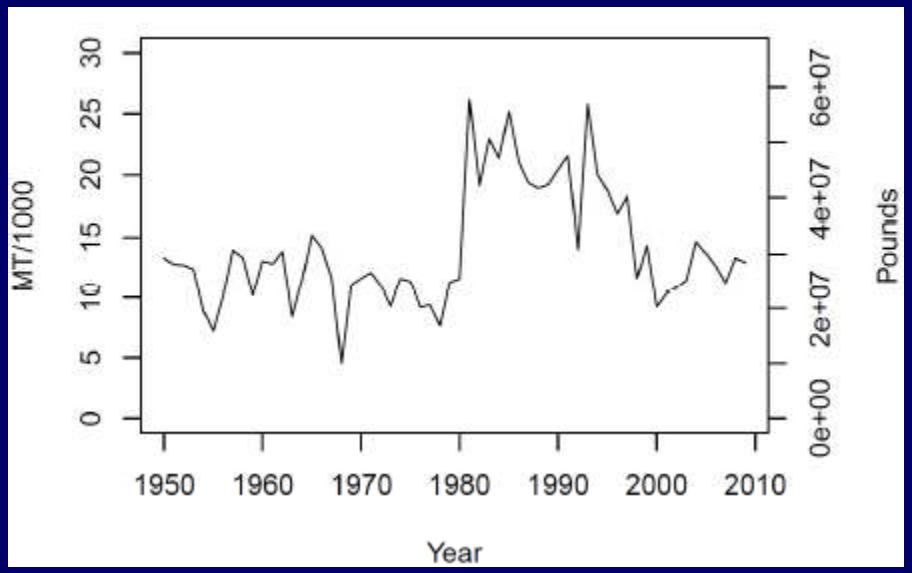


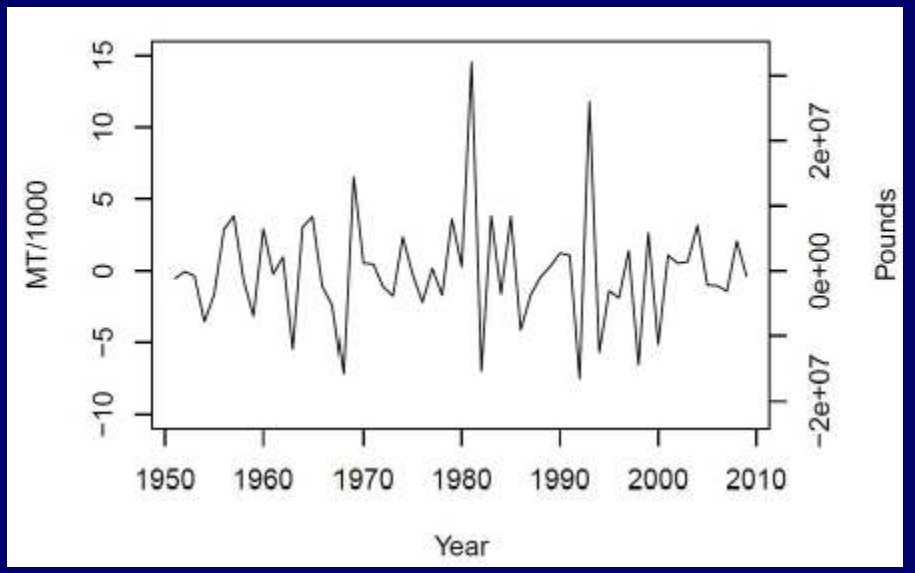


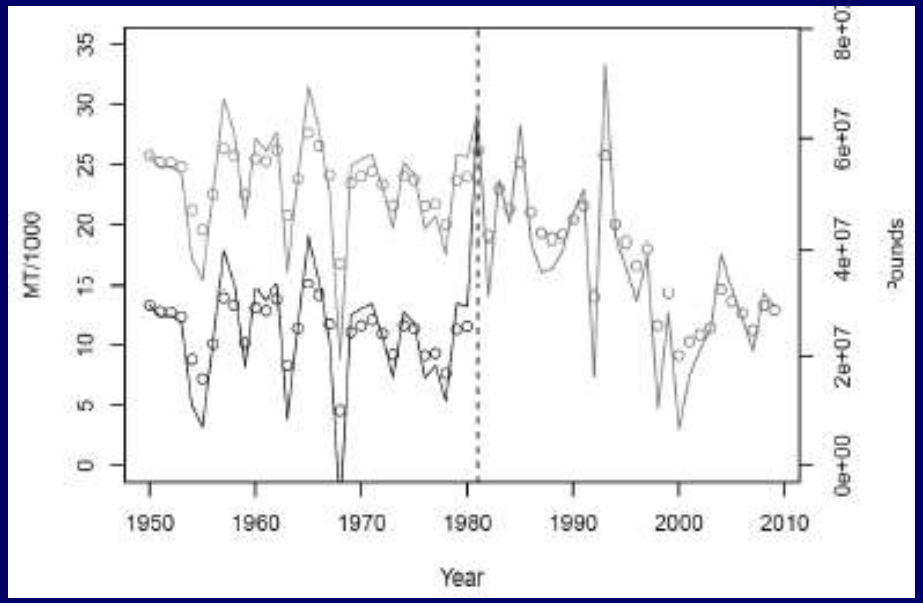
Significant reporting change in 1992/1993

Under-estimation of previous landings

MD landings



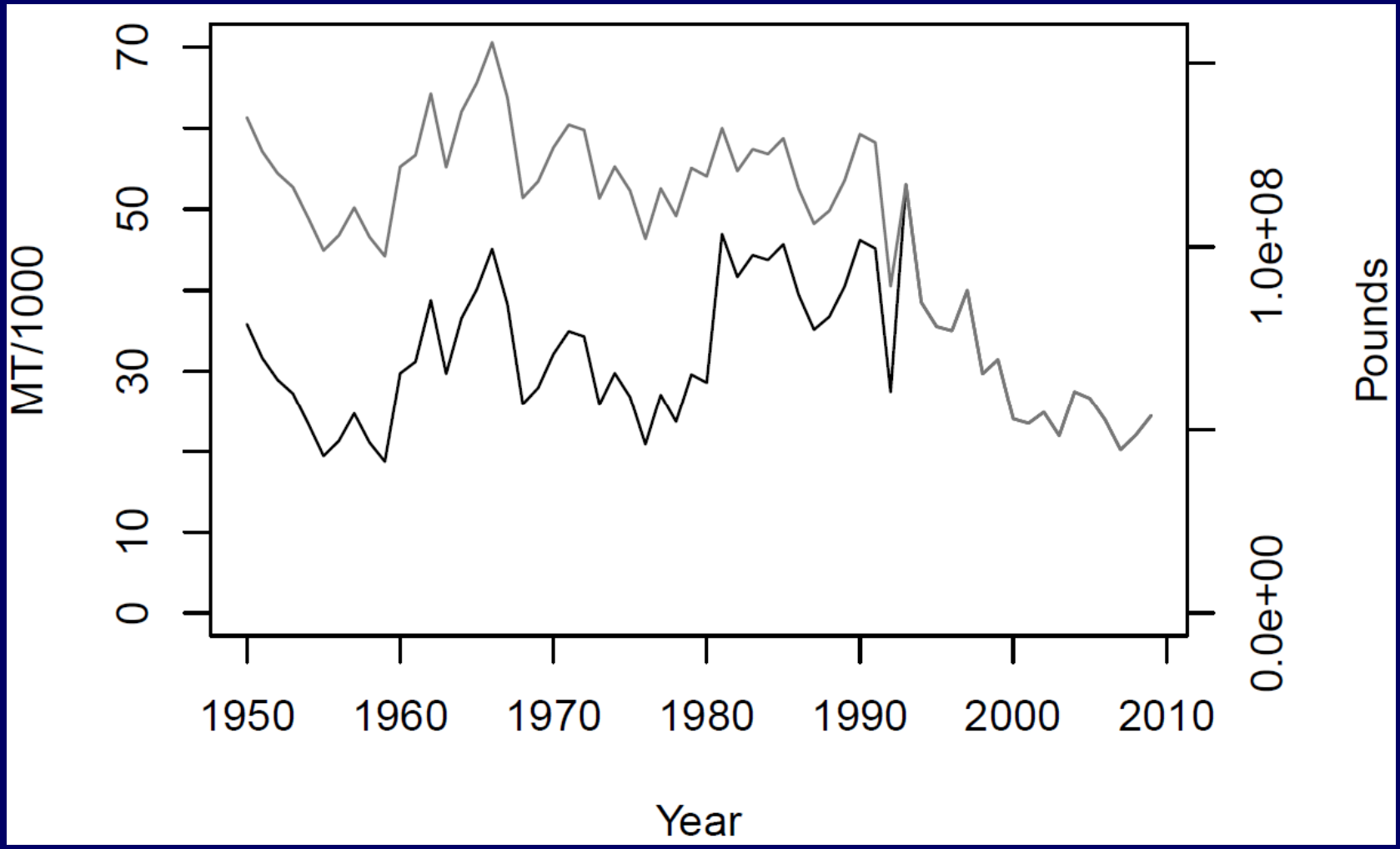




Significant reporting change in 1981

Under-estimation of previous landings

Combined baywide landings



Adjusted data average = 47,523 ± 13,304
Raw data average = 29,900 ± 7,301

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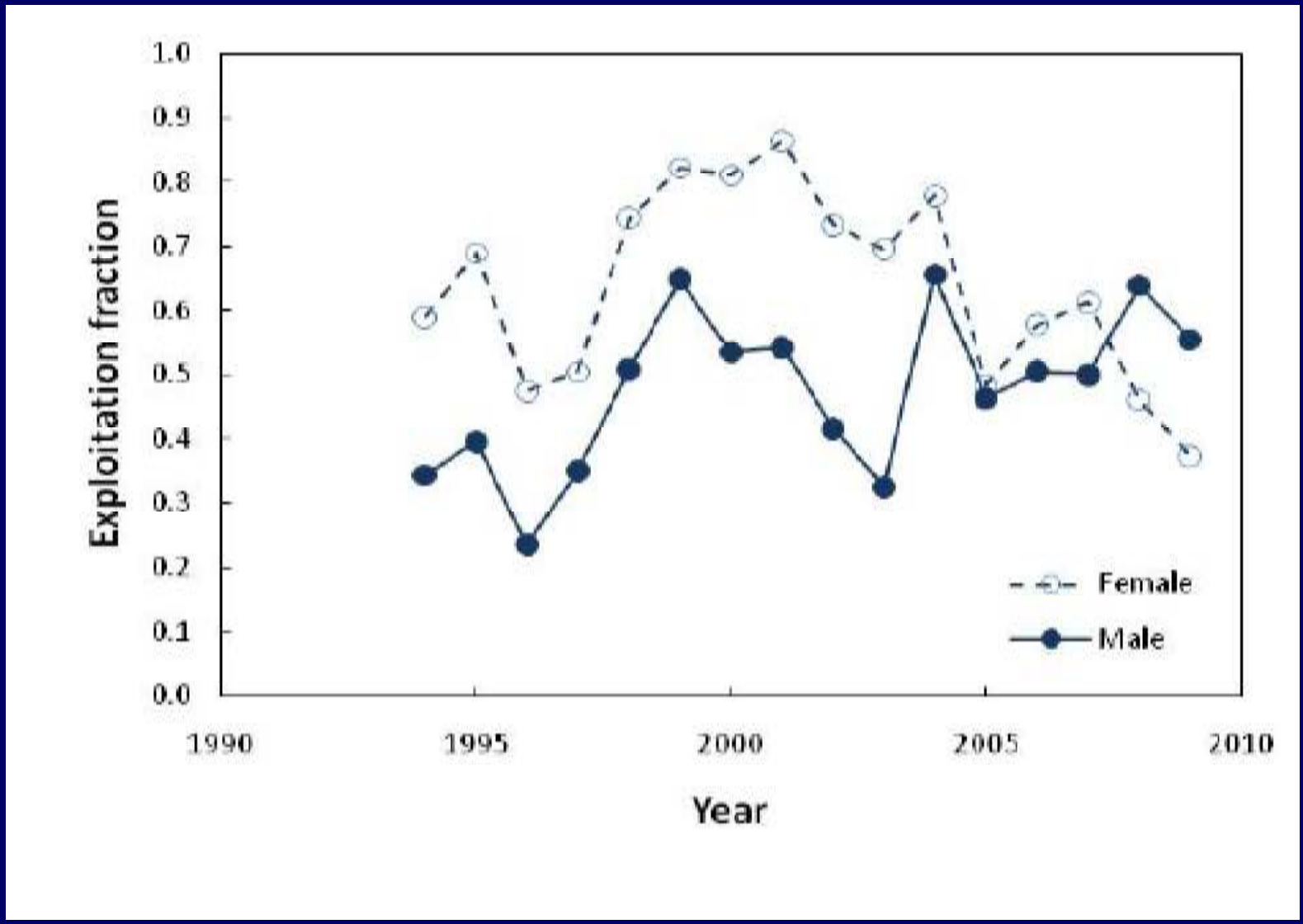
Empirical estimates of exploitation



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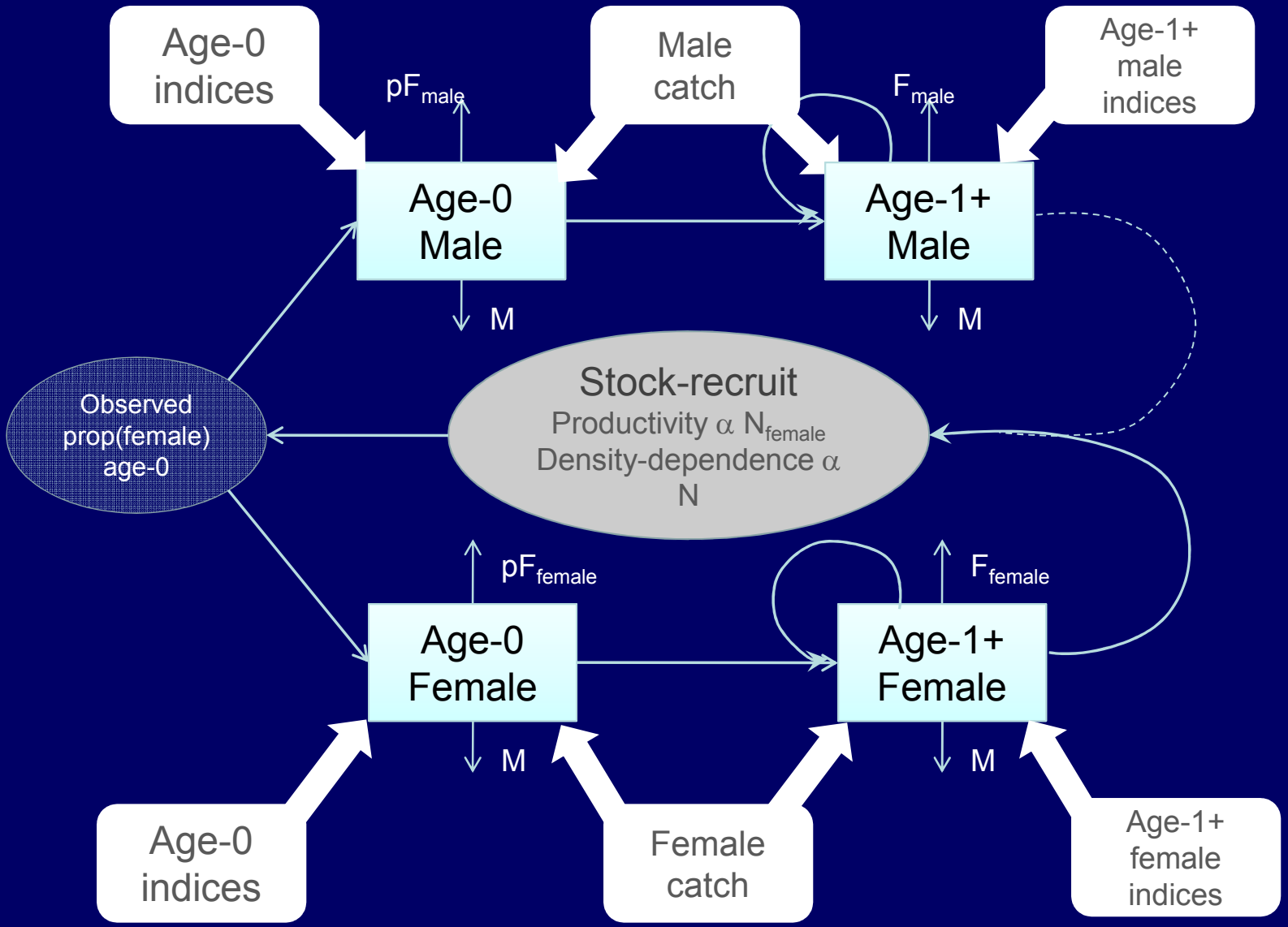
Assessment goals

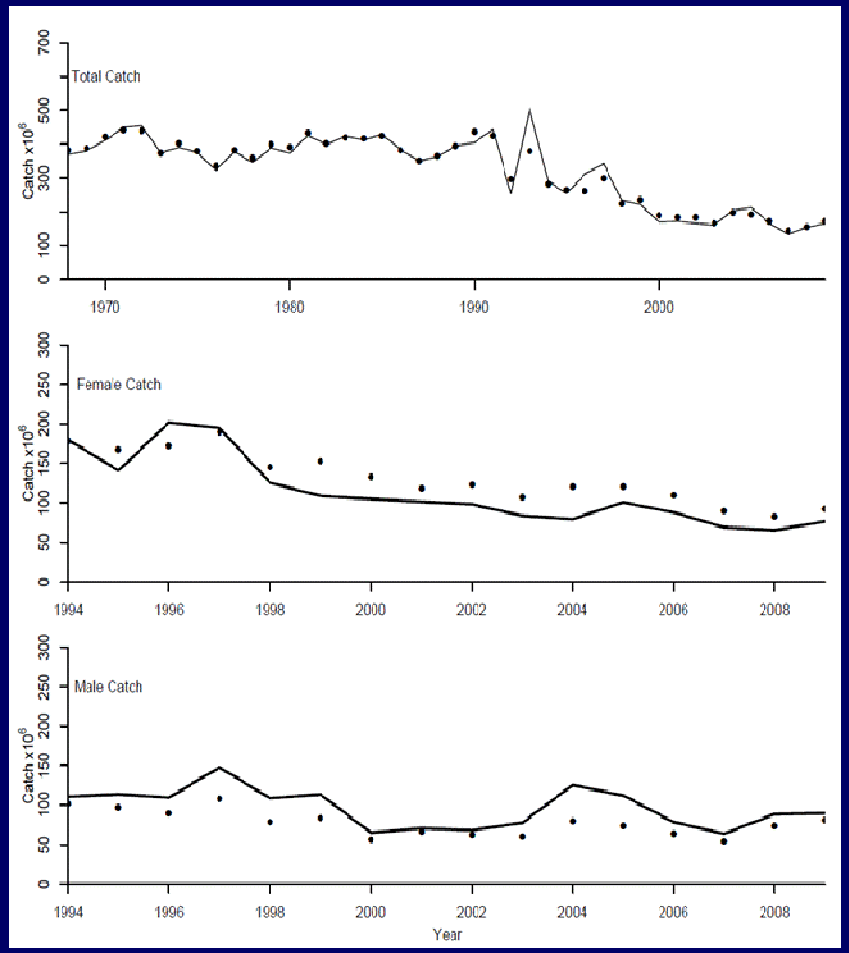
- No prior assessments produced integrated abundance and exploitation-based reference points
  - No guarantee that abundance and exploitation-based targets are attainable simultaneously
- No prior assessment produced integrated framework for reference points and stock status determination
  - Lack of an integrated renewal function
- Previous models were not sex-specific
  - Yet management policies and the life history of the crab have strong sex-specific patterns.

Stock assessment model

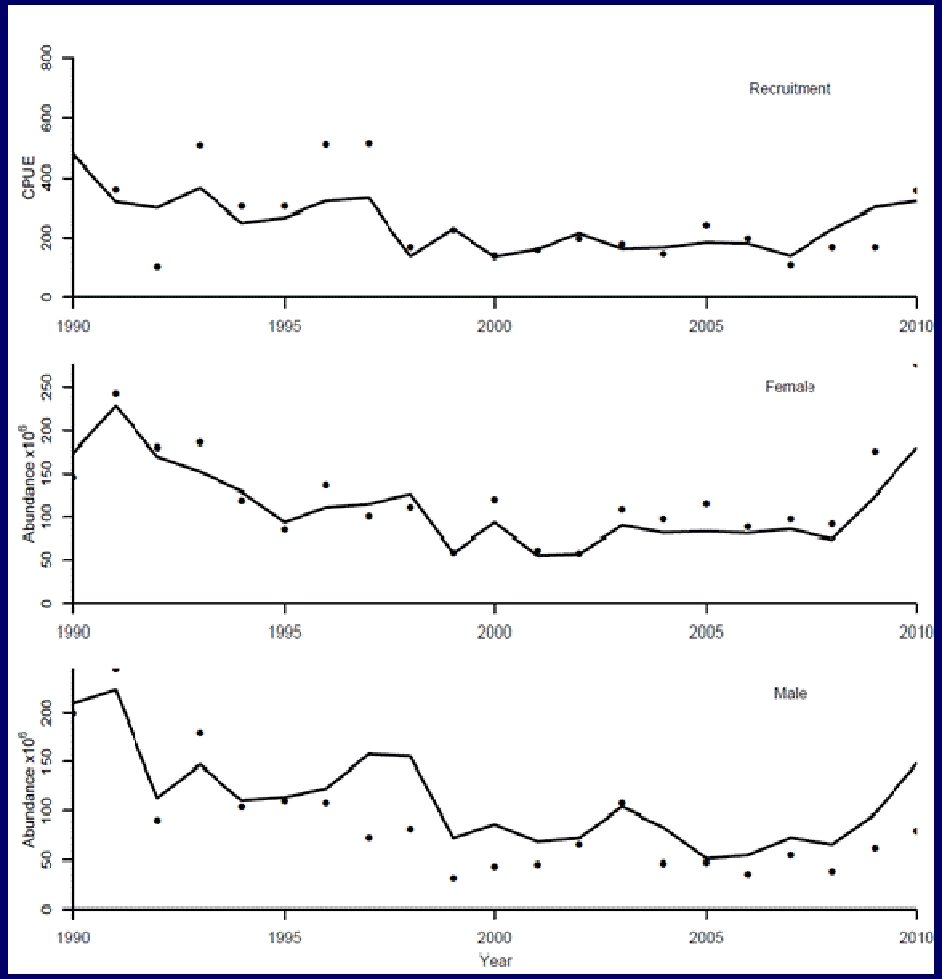


Model results

Catch

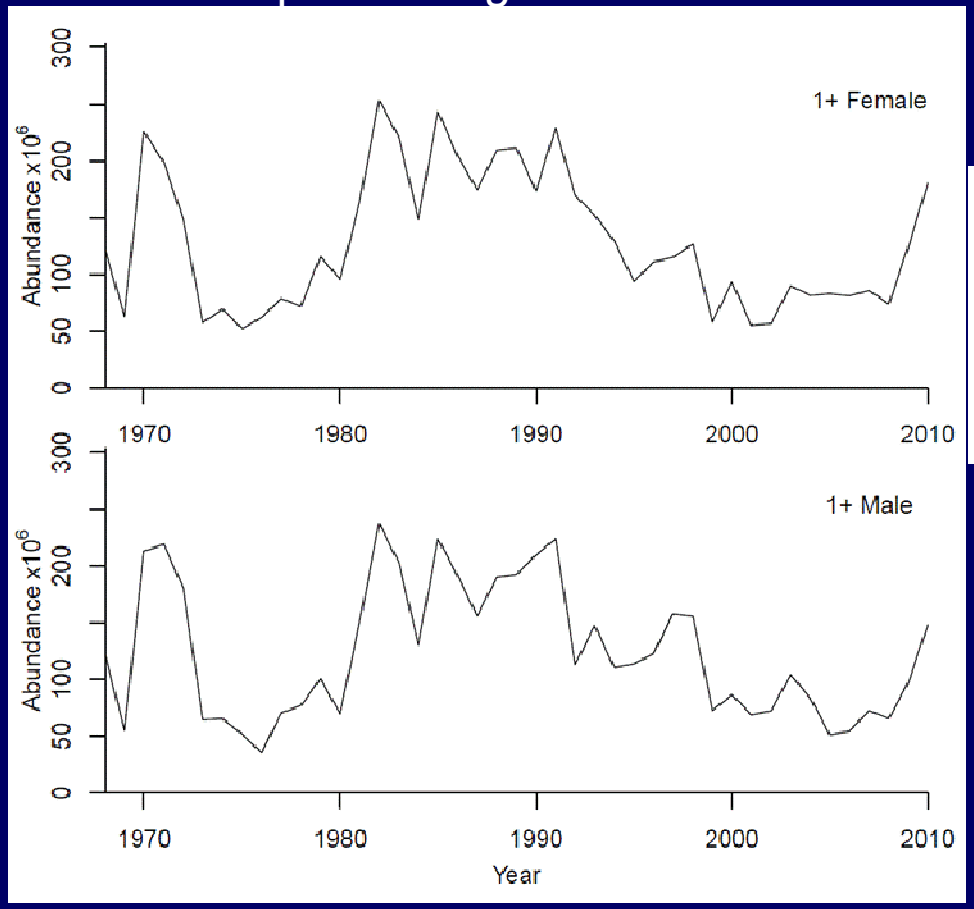


WDS

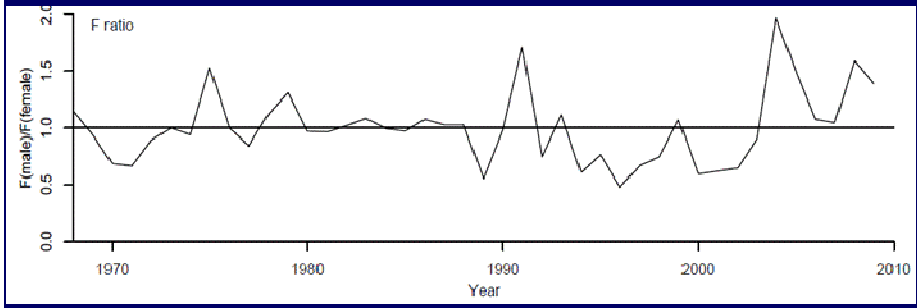


Sex-specific estimates

Population age-1+ abundance



Ratio of sex-specific exploitation rates



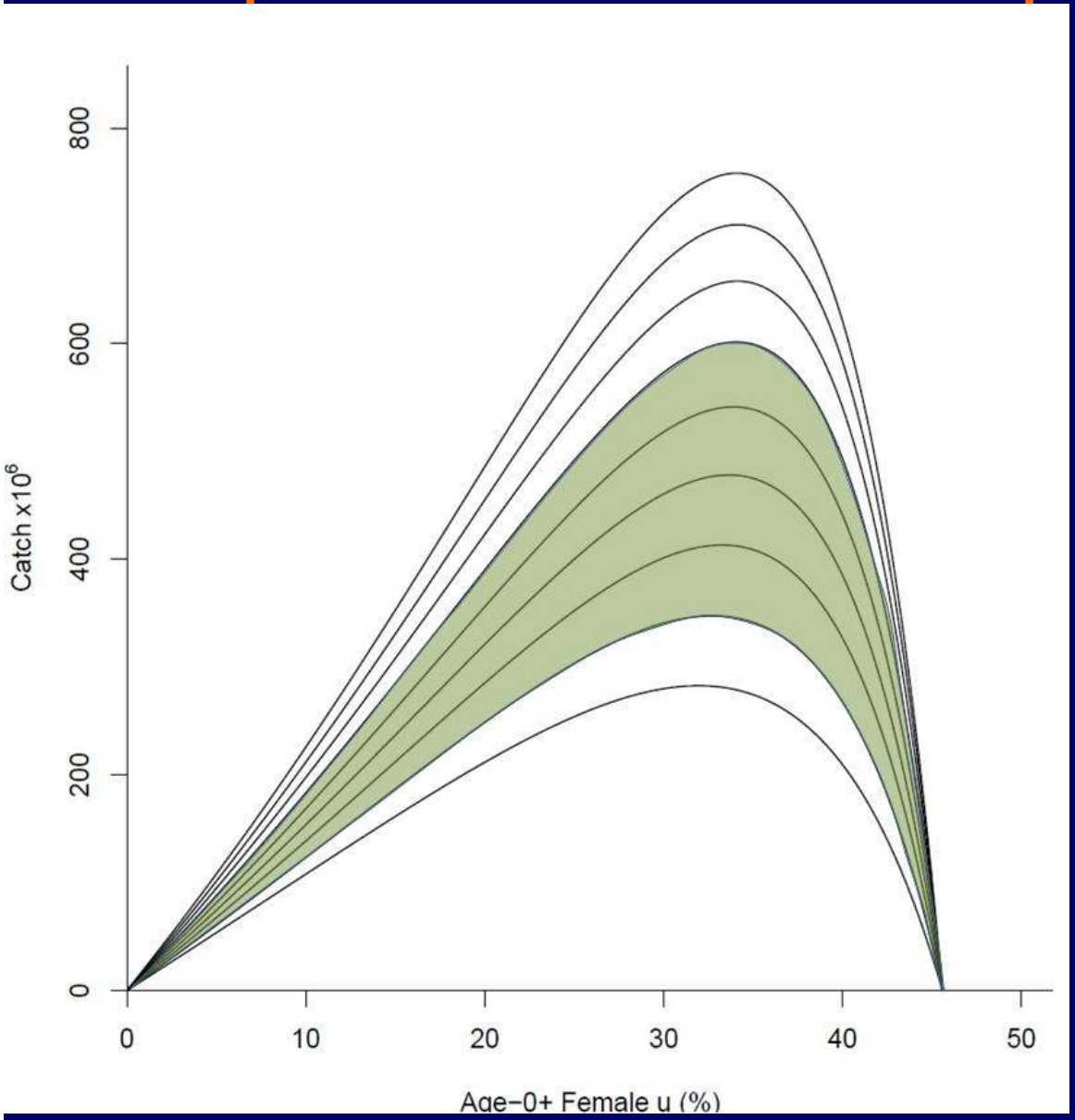
Key results

- WDS is a reliable measure of absolute age-1+ abundance
- WDS is a reliable index of age-0 crab abundance with a catchability ~0.4
- Neither the VIMS nor the MD trawl provide reliable information regarding recruitment
- Exploitation rates have become increasing male-biased since 2005

Reference points

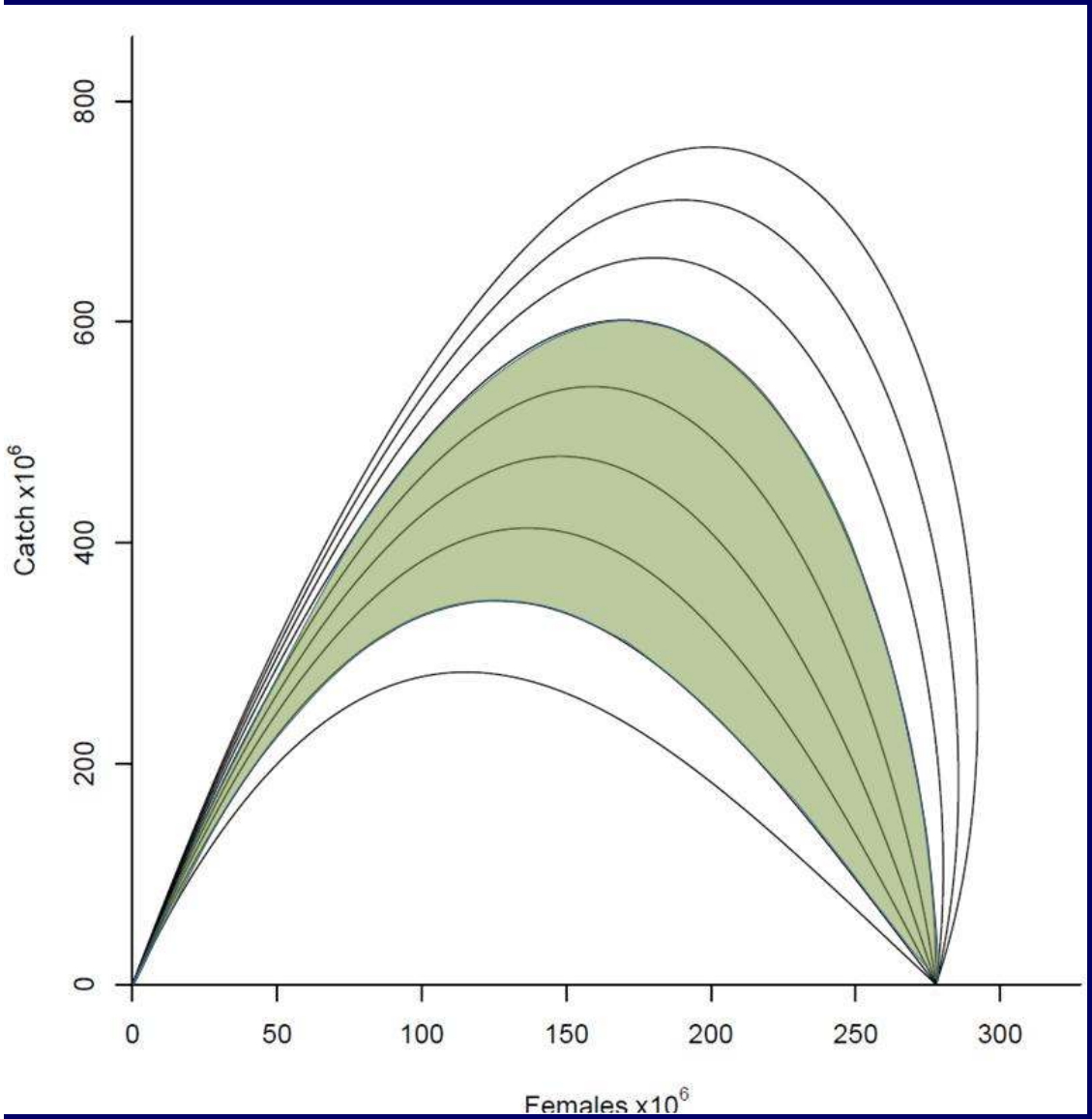
- SPR and YPR were calculated from direct calculation from equilibrium abundances in assessment model
- Used federal guidelines to develop limit reference points (U_{MSY} and ½ N_{MSY})
- Target reference points based on 0.75 U_{MSY}

Exploitation reference points and MSY



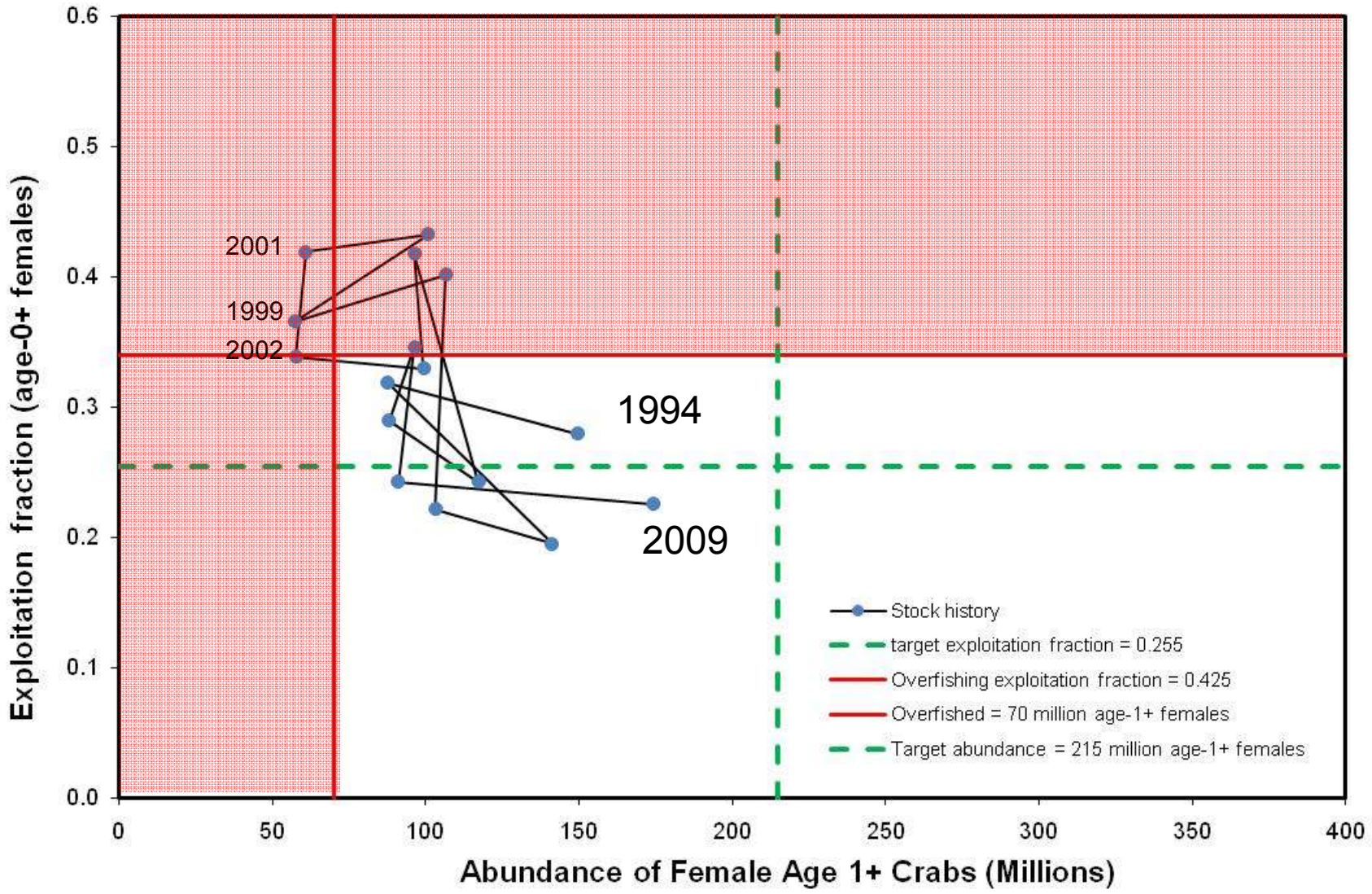
- Estimates MSY and U_{MSY}
  - U=0.34
  - $MSY_{94\text{-}07} \sim 380 \times 10^6$
- Estimate of benefits of maintaining current pattern of exploitation
  - $MSY_{2009} \sim 580 \times 10^6$
  - 52% increase

Abundance reference points and MSY



- MSY abundance responds to sex-ratio
- $N_{MSY94-07}$ ~$125x10^6$
- N_{MSY09} ~ $140x10^6$
- Overfished =½ N_{MSY}
- Overfished= $70x10^6$

Control rule



Conclusions ToR 2,5 & 8

- Integrated assessment model estimated reference points and stock status simultaneously
- In 2009, crab population in Chesapeake Bay was not overfished, nor was experiencing overfishing.
- In 2009, exploitation was below target exploitation rate, but below target abundance
- Preliminary evidence suggest population will be above target abundance in 2010.

Recommendations (assessment)

- Assessment models
  - The new SSCMSA is a substantial step forward as it provides integrated estimation of reference points and stock status. However, a more complete understanding of the sensitivity of model outputs to parameter values. We also recommend an evaluation of the impacts of uncertainty in parameter estimates on reference points.
  - Evaluate the effects of possible miss-specification of model structure to explain the inability to match the sex-specific catch levels in the model (sex specific ratio at recruitment, sex-specific differences in M, sex-specific differences in catcability, alternative stock recruitment models).
  - The efficacy of alternative fishery-independent time series, such as the ChesMAPP samples, in assessment models should be evaluated.
  - The ecology and fisheries for blue crab exhibit considerable spatial variability – much of which coincides with the divisions among management jurisdictions. We recommend evaluation of spatially-explicit assessment models.
  - Additionally modeling work that specifically represents the diversity of fishery sectors, with different seasonalities and catchabilities would be beneficial.

Recommendations (review)

- Fishery-dependent data
  - The monitoring of removals by the different fisheries has improved. However, efforts to validate landings are currently inconsistently implemented across jurisdictions. Efforts to validate landings should be a high priority. These approaches could include directing monitoring of purchases by wholesalers or by indirect expansion of sentinel fishery data.
  - Although time series approaches to correcting landings for reporting changes appear successful, their use for any future reporting changes should be discouraged in favor of direct empirical estimates of the effects of the change from studies implemented contemporaneously with the reporting change.
  - We recommend that attention be given to ensuring that the biological characteristics of each fishery be quantified, and that the spatial and temporal distribution of the removals be quantified.
  - The recreational catch remains poorly described and its inter annual variability is largely unknown. Monitoring programs and surveys to quantify the recreational harvest should have a high priority.
  - There have been efforts to improve information on the distribution and dynamics of effort in the different fisheries exploiting blue crab in the Chesapeake Bay. These efforts should be expanded to a consistent baywide coverage and continued.

Research recommendations (review)

- Management
  - Coordination among management jurisdictions is commendable. However, there remain important difference in the availability and format of data. We recommend that efforts be implemented to make harvest and survey data widely available and consistently managed. This would reduce time invested in data qa/qc during the assessment process and likely improve the reliability of future assessments.
  - The sex-specific approach to management recommended here has implications for new decisions management has to make regarding the future of the fisheries. Management should engage stakeholders to develop a vision for the fishery in light the adoption of a sex-specific approach.
  - There have been no efforts in this assessment to consider blue crab management from an ecosystem view point. The exploration of both the impact of the ecosystem on the productivity of blue crab fisheries and of the impacts of the blue crab fisheries on the ecosystem are warranted.

Research recommendations (review)

- Fishery-independent data
  - Fishery-independent surveys are critical to the assessment, particularly the winter dredge survey. Continuing investments in these surveys are important for ongoing assessment efforts.
  - Efforts to estimate gear catchability coefficients should be expanded. In particular, these efforts should focus on the interaction between the spatial distribution of crabs and area-specific patterns in catchability.
  - Additional analysis of the survey time series to understand their coherence, and their ability to track population variation would be beneficial. A thorough evaluation of survey efficiency and options for enhancing their utility should be undertaken.
  - Indices for age-0 and recruits are lacking other than for WDS. Exploration of alternative indices of age-0 crabs is a priority.
- Ecology and Biology
  - Research that quantifies size-dependent, sex-specific and inter-annual patterns in natural mortality would greatly improve future assessments.
  - Understanding of growth as it affects recruitment of age-0 crabs to different fishery sectors is uncertain. Studies of the temporal and spatial variability in growth would improve our understanding.
  - The reproductive potential of the crab population likely varies with stock abundance and the sex ratio on the stock. Research on the variability of reproductive parameters (e.g., maturity, fecundity and batch production) is a high priority. Additionally, research on the impact of variation in the sex-ratio on the reproductive potential of the population would be beneficial.
  - Evaluation of how productivity may have changed over time in response to changes in availability of quality habitat