SEDAR 42: US Gulf of Mexico Red grouper assessment

NOAA FISHERIES

SEFSC

Review Workshop

Life history and assessment model configuration

July 14 - 16, 2015

SEDAR 42 Red Grouper Assessment

- Data inputs
- Assessment model and configuration
  - Overview of configuration
  - Life history
  - Other model assumptions
- Model fit to data
- Model diagnostics
- Stock status determination
- Projections

Assessment model

- Stock Synthesis (Methot and Wetzel 2013) as the proposed assessment modeling platform
  - Integrated stock assesment model
  - Forward projecting statistical catch at age model
- Advantages
  - Do not have to split time series
    - Time varying selectivity and retention functions, time blocks
  - Can use both length and age composition data
  - Can link parameters to environmental series
  - Explicitly incorporates imprecision of observation processes (e.g., aging imprecision)

Assessment model configuration

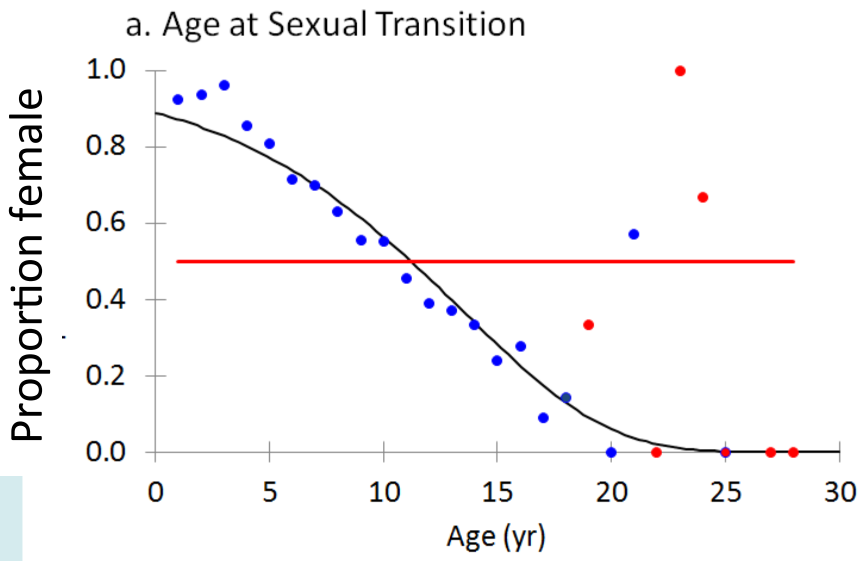
- 1986 - 2013
- 1 area, 1 season model
- Combined gender model
- Maturity, protogyny, and fecundity a function of age
- von Bertalanffy growth
- Lorenzen natural mortality
- Beverton-Holt spawner-recruitment relationship
- 6 fishing fleets – landings and discards
- 3 fishery-independent indices of abundance
- Red tide mortality in 2005
- Age-based selectivity
    - Fleets
- Length-based selectivity
    - Fishery-independent surveys
- Time-varying retention to account for changes in regulations

Life history

- Reproductive biology
  - Maturity
  - Hermaphroditism
  - Fecundity
- Age and growth
- Meristics
- Natural mortality

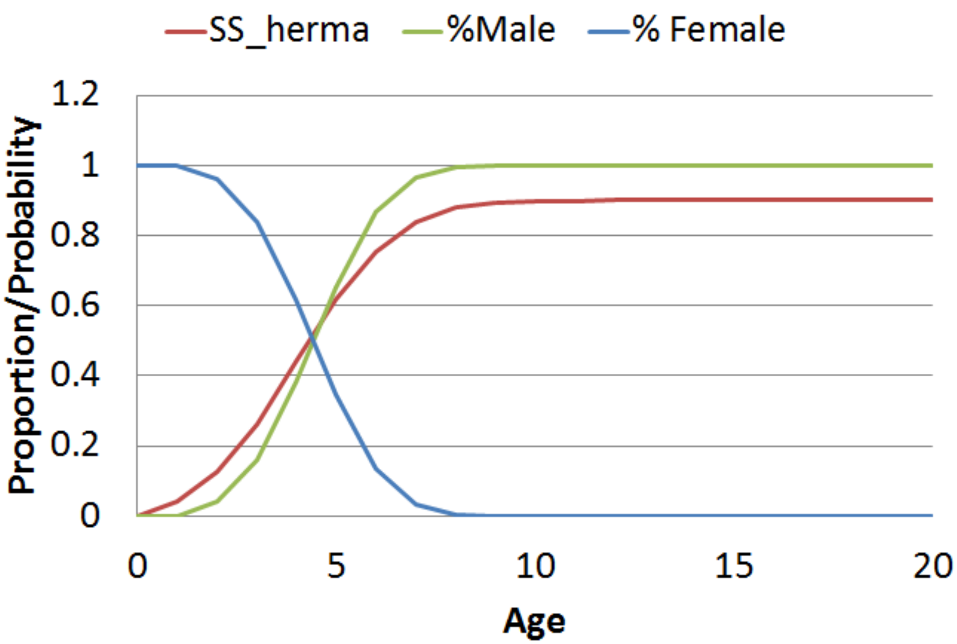
Reproductive biology

- Red grouper are protogynous hermaphrodites
  - Transition from females to males
- Histological data from NMFS PC Lab and FWC-FWRI (1992 – 2013)
- Logistic model
  - 50% male - 11.2 years
- Life history group recommended this relationship for use in the assessment model (do not estimate within SS)



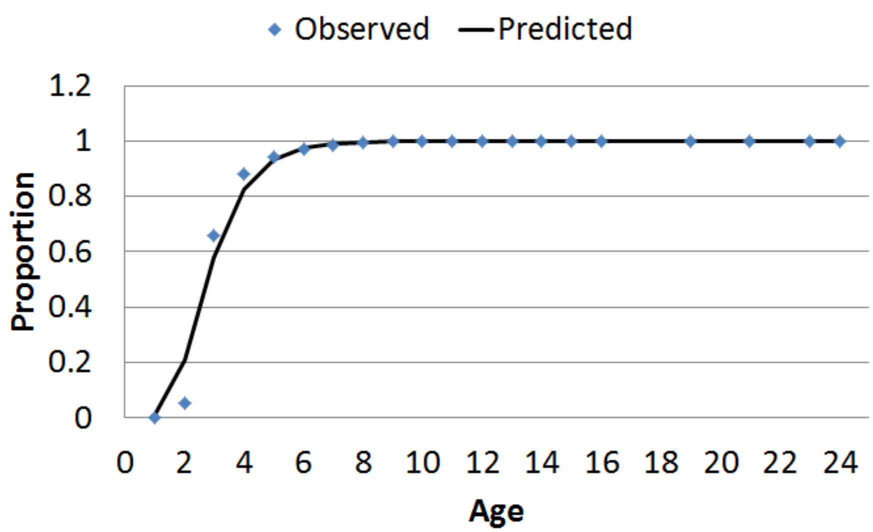
Hermaphroditism in Stock Synthesis

- Defines the probability of transition using a cumulative normal distribution
  - Scaled so that age-0 are 100% female
  - Over-estimate proportion of female at younger ages
- Assessment panel did not recommend using the hermaphroditism function in Stock Synthesis



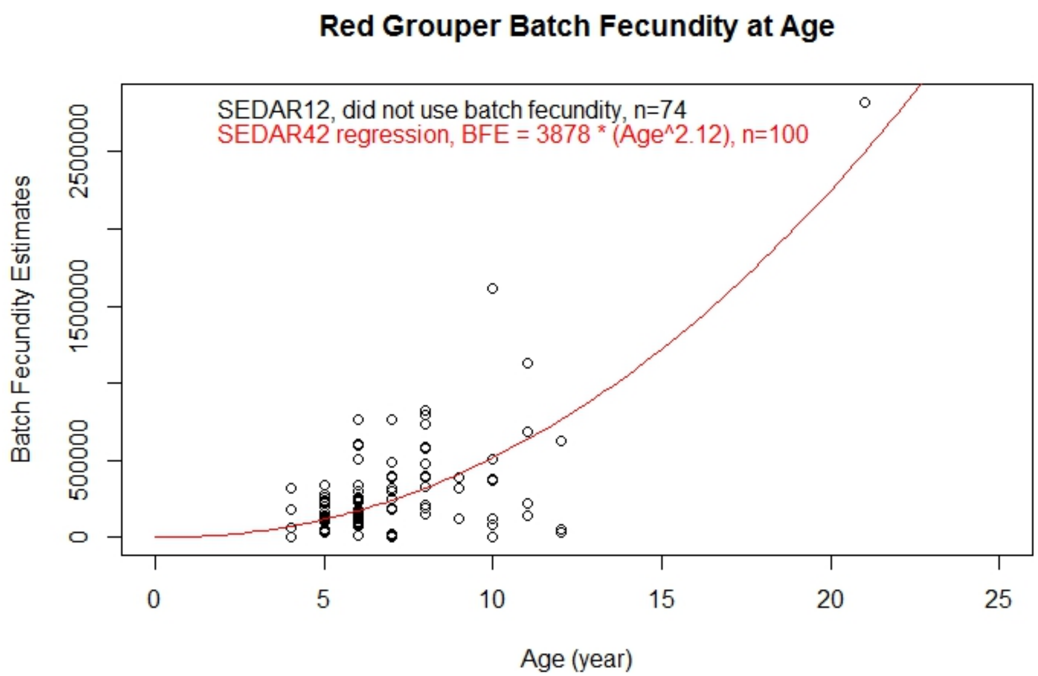
Reproductive biology

- Maturity
  - Data collected from fishery-dependent and fishery-independent surveys (1991 – 2013)
    - Provided by NMFS Panama City Laboratory and FWC-FWRI
  - Gompertz model most parsimonious
    - Age at 50% maturity – 2.8 years



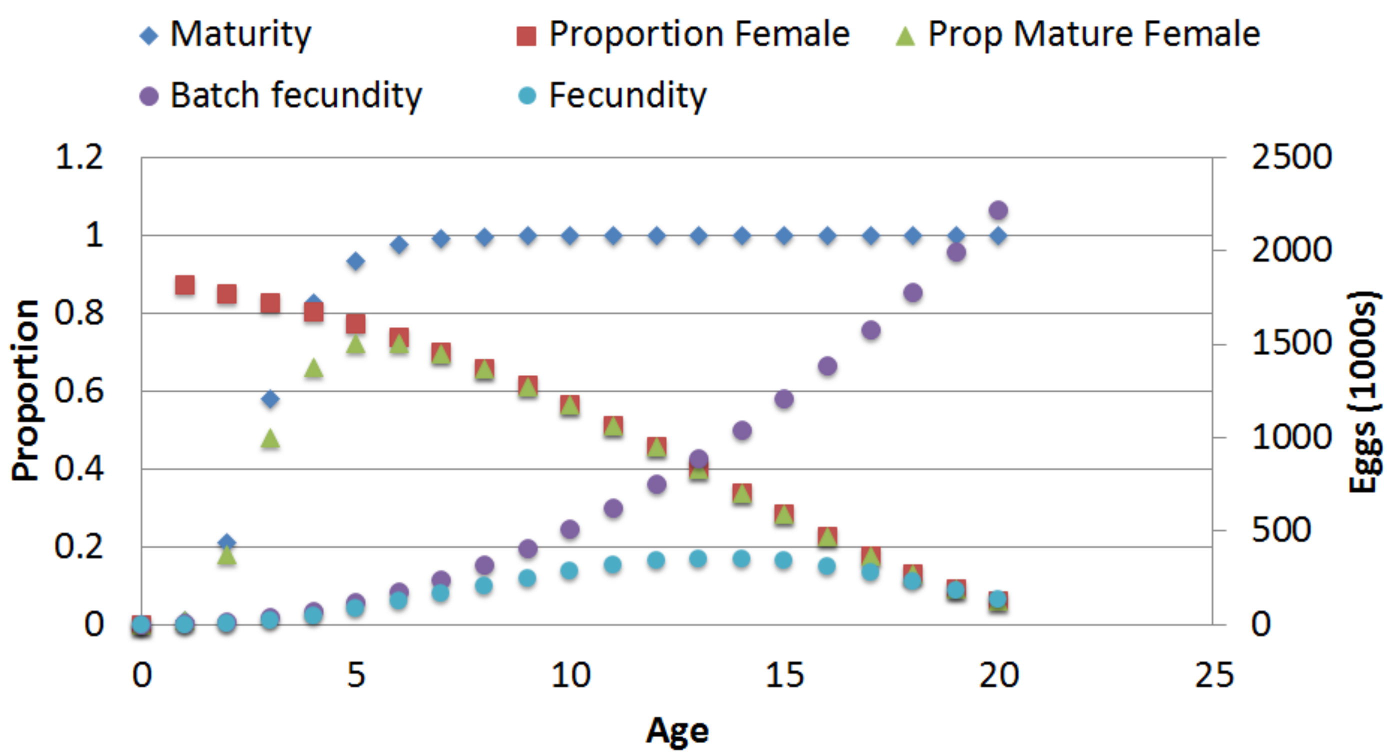
Reproductive biology

- Life history work group recommended batch fecundity estimates for use in the assessment model
  - Better proxy for fecundity than gonad weight, which was used in previous assessment



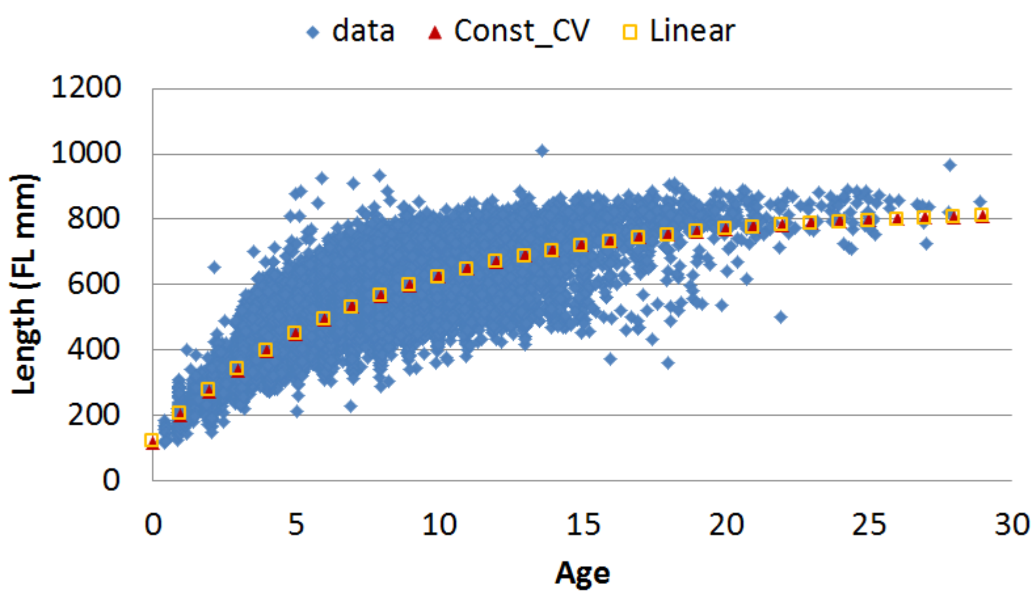
Reproductive biology

- Fecundity
  - Fixed input vector in assessment model
  - Fecundity = proportion mature females * batch fecundity



Age and growth

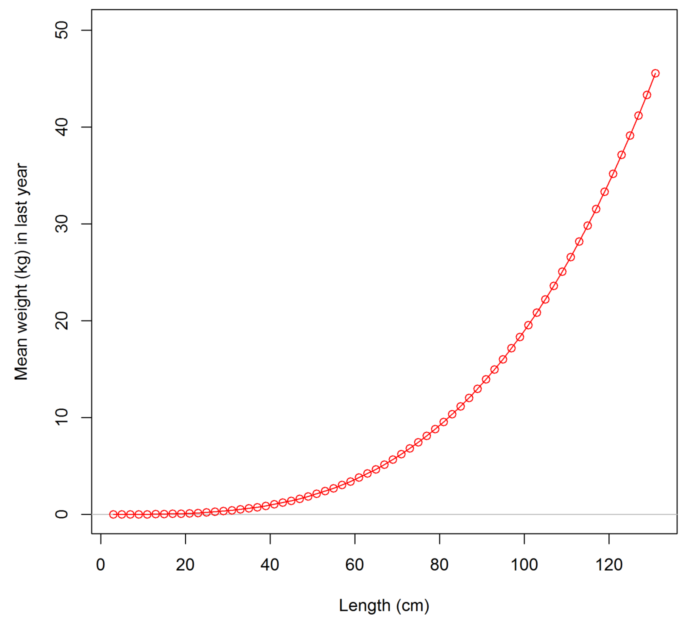
- Life history working group recommended using the von Bertalanffy model assuming a constant CV with age
  - Compared three models with different variance structure:
    - Constant CV with age, constant standard deviation with age, and linearly increasing CV with age
- During assessment workshop evaluated model assuming linearly increasing CV with length



Parameter	Constant CV with age	Linear increase in CV with length
Linf	82.89	82.7
k	0.125	0.124
to	-1.20	-1.27

Meristics

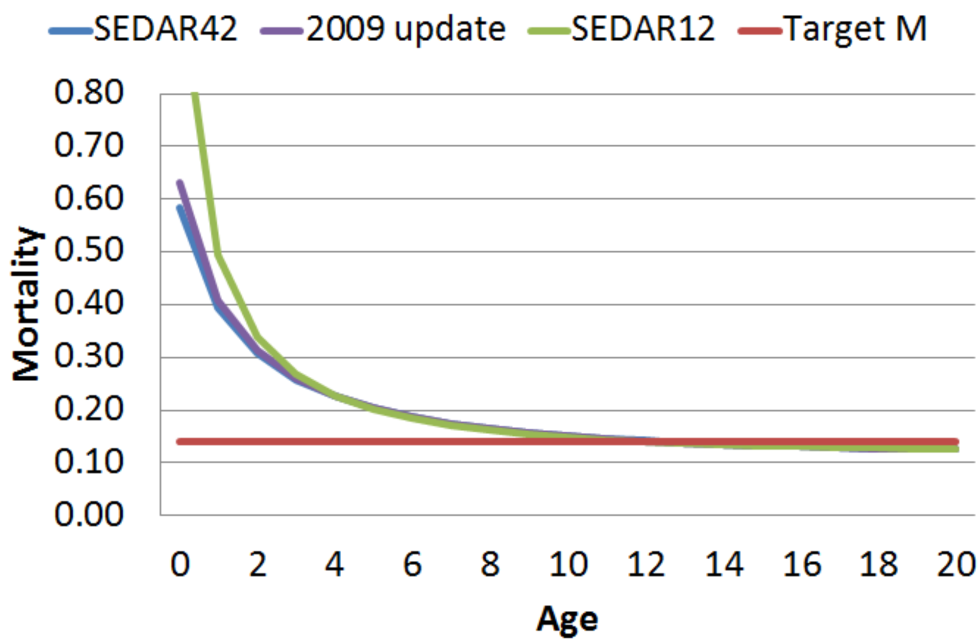
Regression	Equation	statistic	N	Data Range
Max TL to FL	FL = 5.35 + max_TL *0.95	r^2=0.9963	5818	Max TL: 120 – 954; FL: 116 – 910
Nat TL to FL	FL = 5.71 + nat_TL * 0.95	r^2=0.9909	3901	Nat TL: 151 – 957; FL: 149 – 910
FL to G Wt	GWT= 3.37 10^{-09} * ($FL^{\wedge 3.25}$)	RSE = 0.3499	37414	FL: 230 – 935; G WT: 0.26 – 16.96



- Length-weight relationship fixed in the assessment model

Natural mortality

- Natural mortality calculated as a function of age using the Lorenzen (2005) estimator
  - Adjusted to account for May 15 peak spawning period
  - Target M determined using Hoenig (1983) and maximum age of 29: M = 0.14
  - Input as a fixed vector



Other model assumptions

- Stock recruitment
- Initial conditions
- Selectivity
- Retention
- Red tide

Stock recruitment

- Beverton-Holt stock recruitment model
- Estimated 4 parameters
  - log(R0): unexploited equilibrium recruitment
  - log(R1): offset parameter for initial equilibrium recruitment relative to virgin recruitment
  - Steepness (h): fraction of the unexploited recruits produced at 20% of the equilibrium spawning biomass level
  - SigmaR: standard deviation in recruitment
- Recruitment deviations estimated in two periods
  - Early recruitment devs (1969 - 1985)
  - Main recruitment devs (1986 - 2013)
- Bias adjustment for main recruitment deviations (1986 - 2012)

Initial conditions

- Starting year of assessment model is 1986
- Given that removals occurred prior to 1986, we started the model in a non-equilibrium state and estimated:
  - Equilibrium catch
  - Initial fishing mortality
  - R1: initial recruitment relative to virgin recruitment

Selectivity

- Age based selectivity was used for all fleets
  - Random walk
- Length-based selectivity was used for the fishery-independent surveys
  - Double normal
- Assumed constant selectivity for all fleets and surveys
- Modeled time-varying retention to account for changes in management regulations

Selectivity

- Age based random walk selectivity
  - One parameter for each age
    - Age-0 parameter fixed at zero, all other parameters (age-1 thru age-20) were estimated
    - 95 estimated parameters total
  - A normal prior was used for each estimated parameter
      - Age-1 thru age-10 ~ N(0, 0.25)
      - Age-11 thru age-20 ~N(0, 0.1)

Selectivity

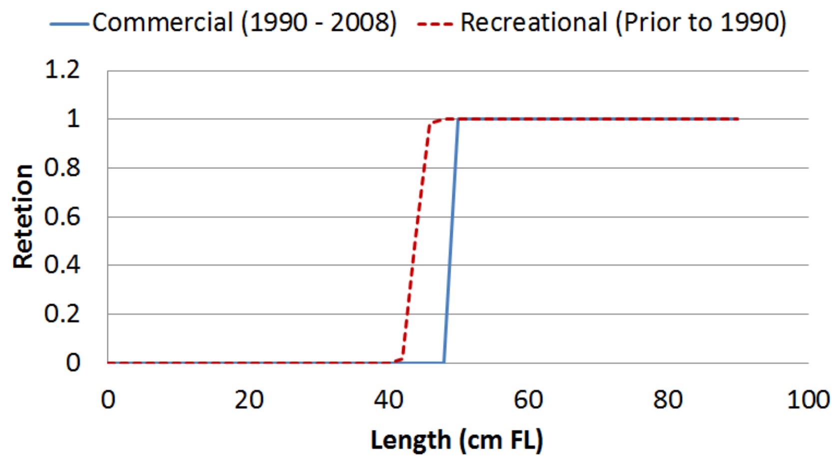
- Length based double normal selectivity
  - Six parameters, all estimated, for each survey (18 estimated parameters total)
    - Peak – beginning size for the plateau
    - Top – width of plateau
    - Ascending width – parameter describing incline to plateau
    - Descending width – parameter describing decline from plateau to final size bin
    - Init – selectivity of first size bin
    - Final – selectivity of final size bin

Retention

- Management regulations influence retention
  - Size limits, bag limits, closed seasons, quota
- Retention was assumed to be most effected by changes in the size limit
  - Commercial
    - Prior to 1990: Assumed no discards
    - 1990 – 2008 : 20 inch TL size limit (48.79 cm FL)
      - Fixed
    - 2009 – 2013: 18 inch TL size limit (43.96 cm FL)
  - Recreational
    - Prior to 1990: 18 inch TL size limit in state waters (43.96 cm FL)
    - 1990 – 2013 : 20 inch TL size limit (48.79 cm FL)
- Retention modeled as a logistic relationship

Retention

- Retention fixed assuming100% retention above the size limit
  - Commercial handline, longline, and trap (1990 – 2008)
  - Recreational (prior to 1990)
- Retention estimated for:
  - Commercial handline (2009 - 2013)
  - Commercial longline (2009 – 2013)
  - Charter/Private (1990 – 2013)
  - Headboat (1990 – 2013)
  - Three estimated parameters for each fleet (12 parameters)
    - Asymptote
    - Inflection
    - Slope of increase



Red tide: data

- Generalized additive model
    - Predict probability of bloom
- Satellite derived products from SeaWiFS
    - Operational from 1998–2010
- Harmful algal bloom (HAB) cell counts from FWRI

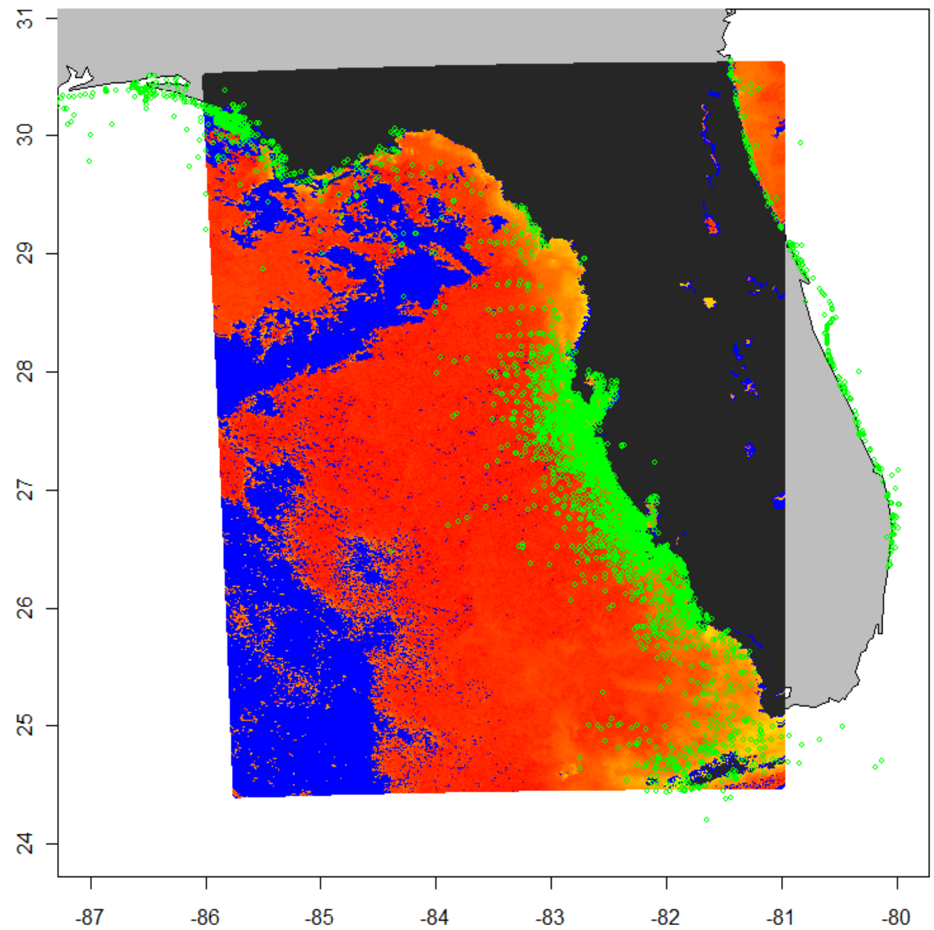
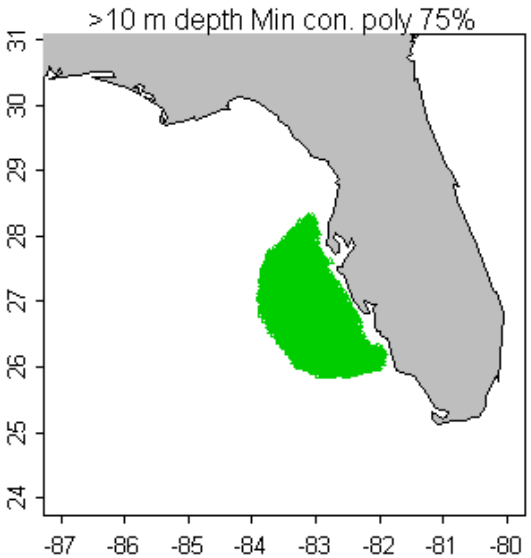


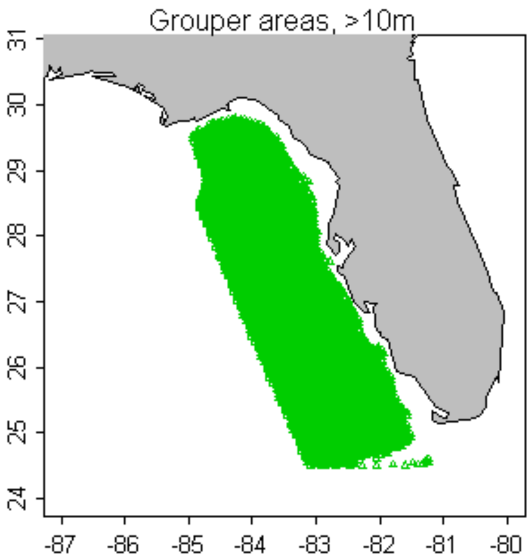
Image: Walter et al. 2013
Plot of all red tide water monitoring data (green points) for 1998-2010 and the spatial domain for satellite imagery. Blue = cloud cover, shading = satellite-derived chlorophyll.

Red tide: indices of red tide severity



10mMCP75 (MCP)

- Minimum convex polygon that encompasses 75% of the HAB data
  - Minimizes prediction error but misses grouper habitat



Grouper (GRP)

- Covers critical grouper habitat (West Florida Shelf)
  - May introduce error due to predictions outside spatial range of HAB data

Image: Walter et al. 2013

Red tide: indices of red tide severity

Threshold (THR)

- Negative effects may occur solely when a red tide exceeds a given threshold

  = 1: Average index value ≥ cutoff

  = 0: otherwise

  Cutoff = value where (sensitivity + specificity) is at a maximum on the receiver operating characteristic curve (ROC)

- No associated variance

Red tide: index of red tide mortality

- 1998 – 2009
- Ecosystem approach
  - Red tide affects a full suite of predator and prey species
- Ecopath with Ecosim
  - Includes species and life-history stages sensitive to red tide (Gray 2014)
  - Pseudo fishing fleet represents a red tide mortality driver

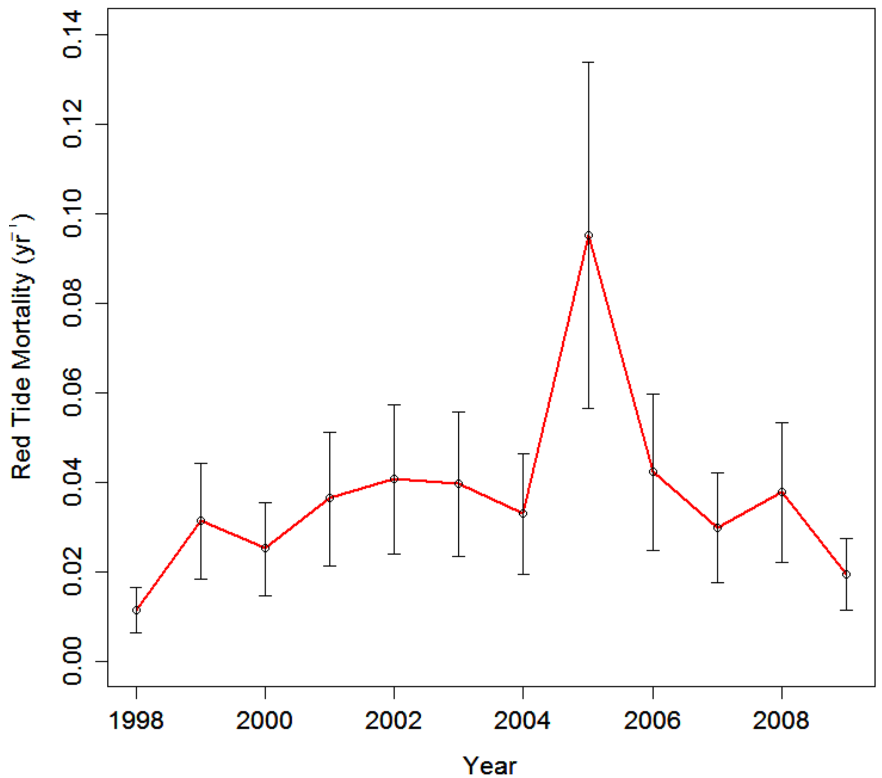
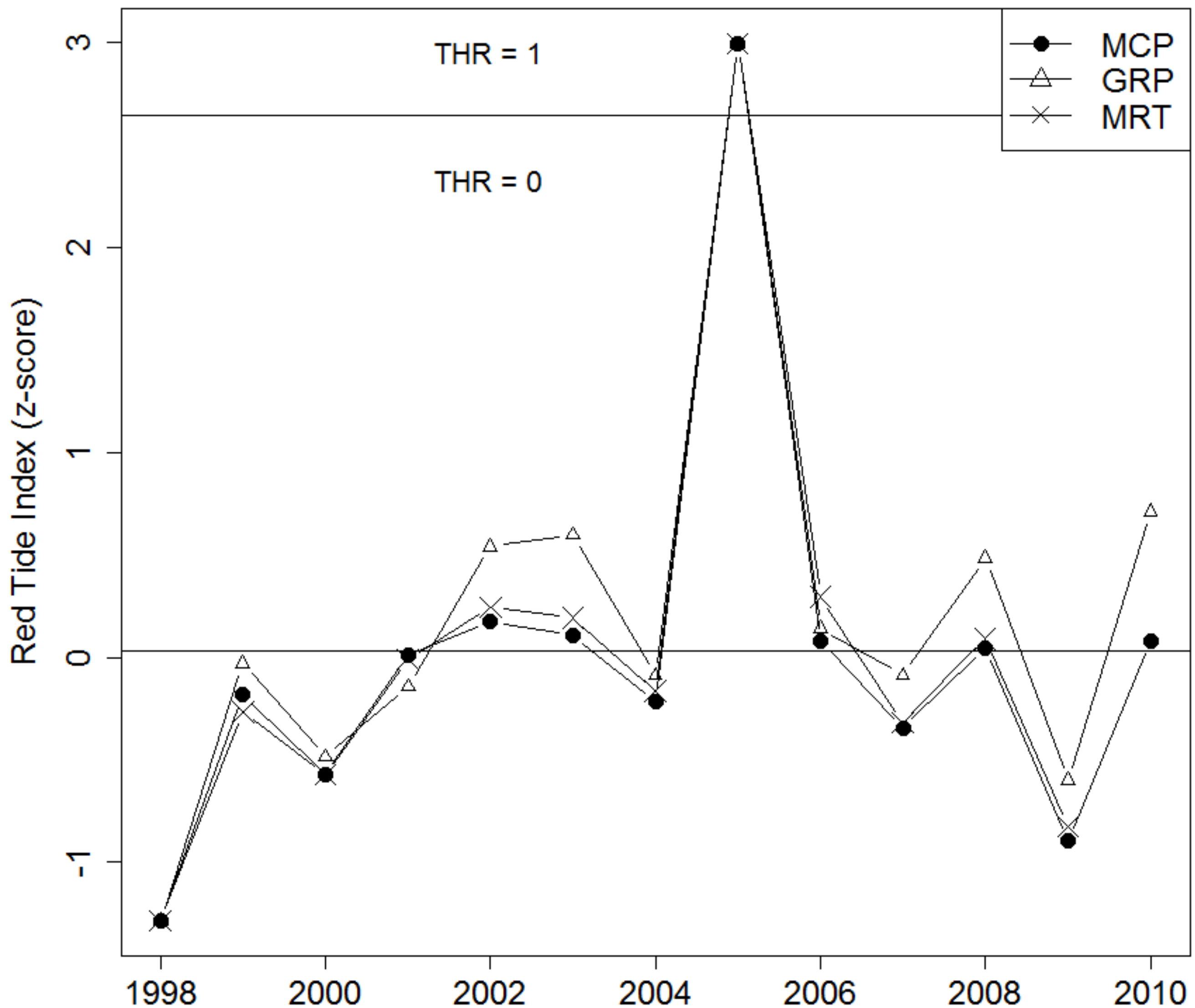


Image: Sagarese et al. 2015

Red tide: indices

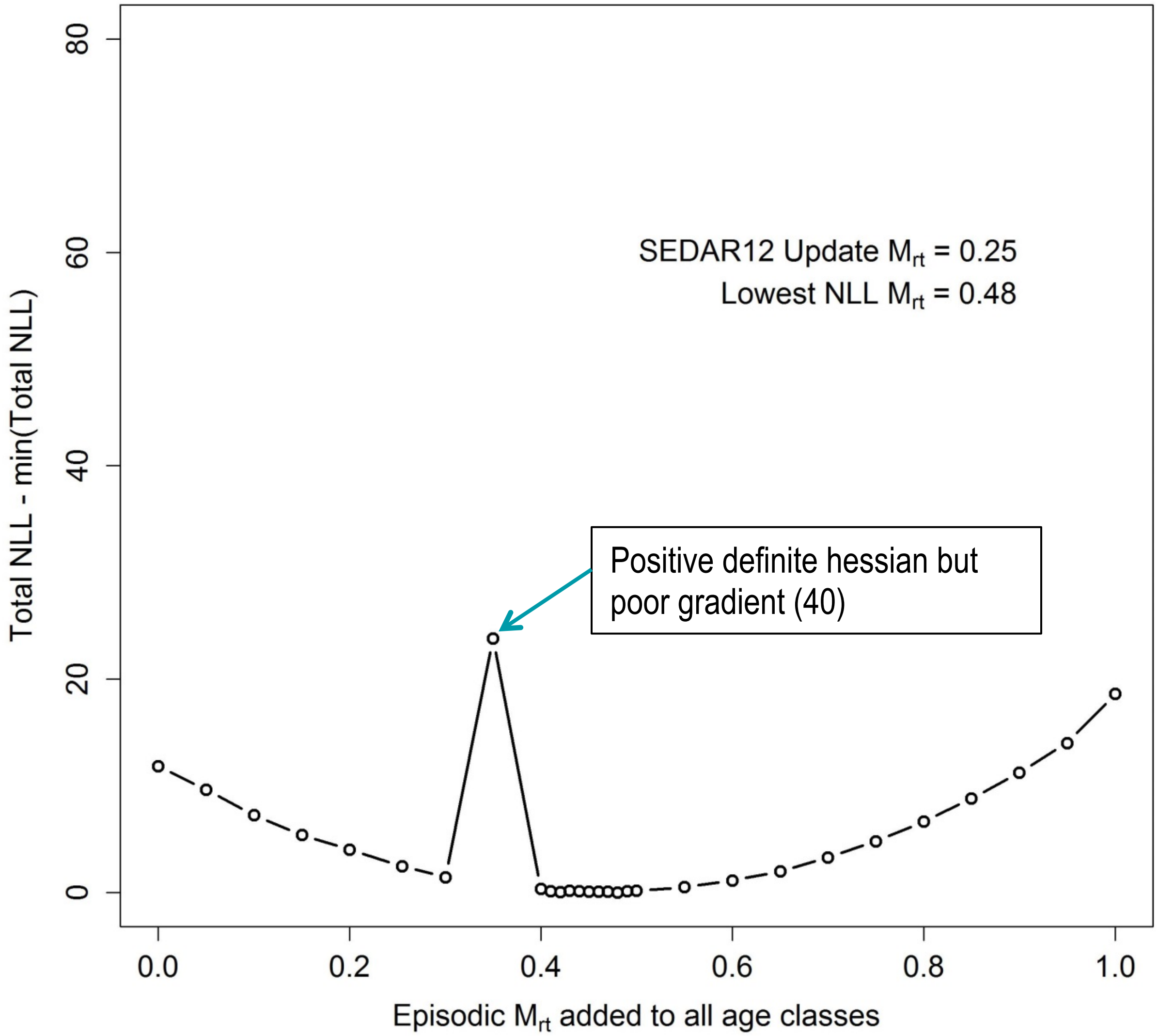


Red tide: incorporation into Stock Synthesis

- Method 1: Addition of episodic red tide mortality (M_{rt})
  - Detailed in assessment report and SEDAR42-RW01
  - Similar to approach used in SEDAR 2009 Update

- Method 2: Red tide fishing fleet
  - Detailed in assessment report and SEDAR42-RW01

Red tide: likelihood profile of M_{rt}

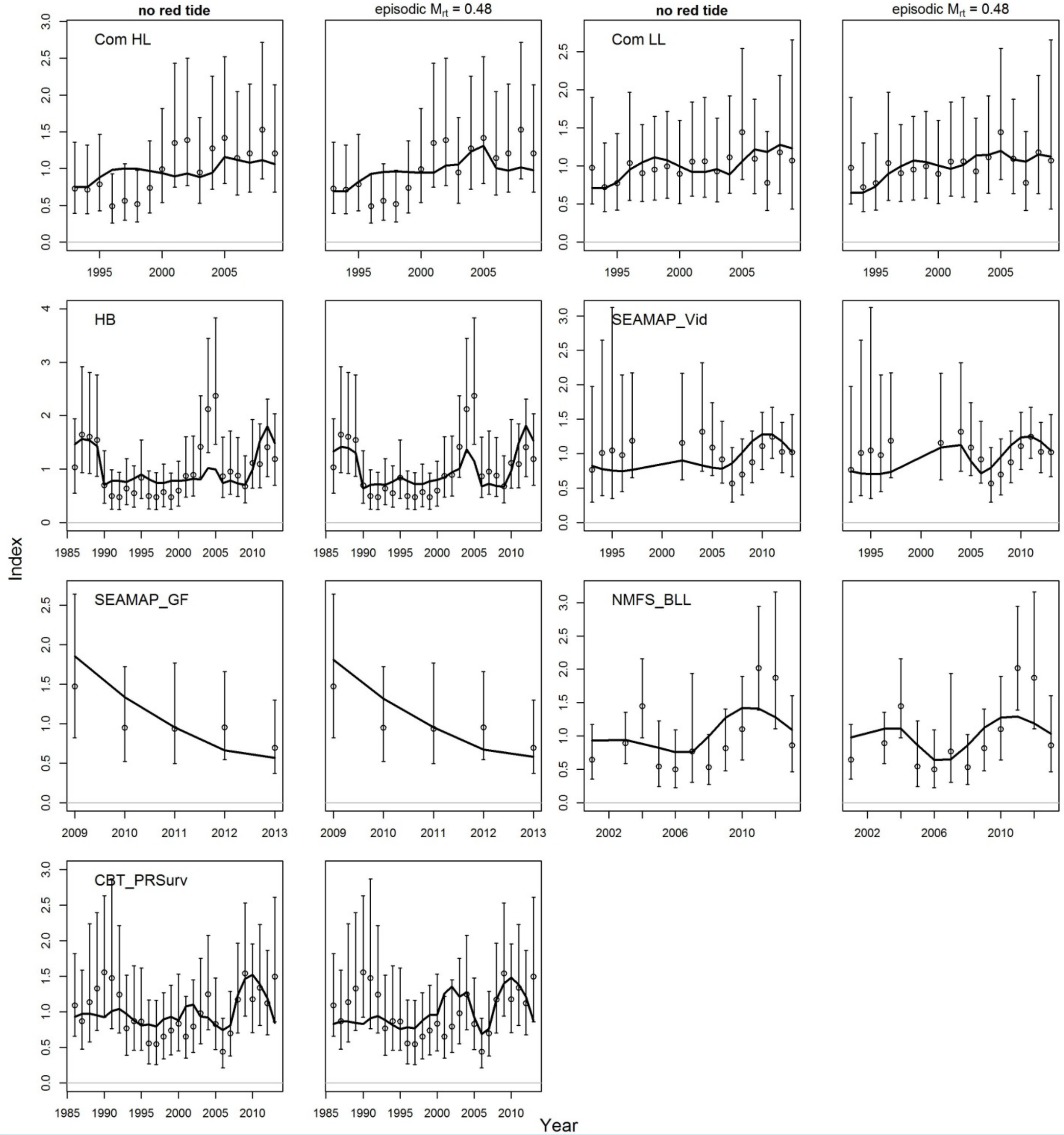


Red tide: comparison

	NoRT	M_{rt} = 0.25	M_{rt} = 0.48
Gradient	0.005	0.047	0.021
wAICc	0	8%	92%
wBIC	0	8%	92%
Likelihood			
Total	2925	2917	2915
Discard	320	318	316
Length composition (Lcomp)	1079	1083	1086
Age composition (Acomp)	1454	1453	1452
Recruitment (Recr)	18	17	17
Survey	-80	-88	-90
Commercial Handline (comHL)	-10	-11	-12
Commercial Longline (comLL)	-17	-18	-18
Recreational Headboat (HB)	-11	-15	-18
Recreational Charterboat/Private (CBT_PRSurv)	-22	-20	-18
Combined Video Survey (SEAMAP_Vid)	-13	-14	-15
SEAMAP Groundfish Survey (SEAMAP_GF)	-4	-4	-4
NMFS Bottom Longline Survey (NMFS_BLL)	-3	-5	-5

Red tide:

Fits to indices of abundance



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Red tide: red tide fishing fleet

- Pseudo-fishery, discard only with 100% mortality
- Indices of abundance from the red tide fishery were derived from red tide indices
- Selectivity of the red tide fishing fleet assumed constant at age
- Compare model fits by looking at residual fits to survey indices

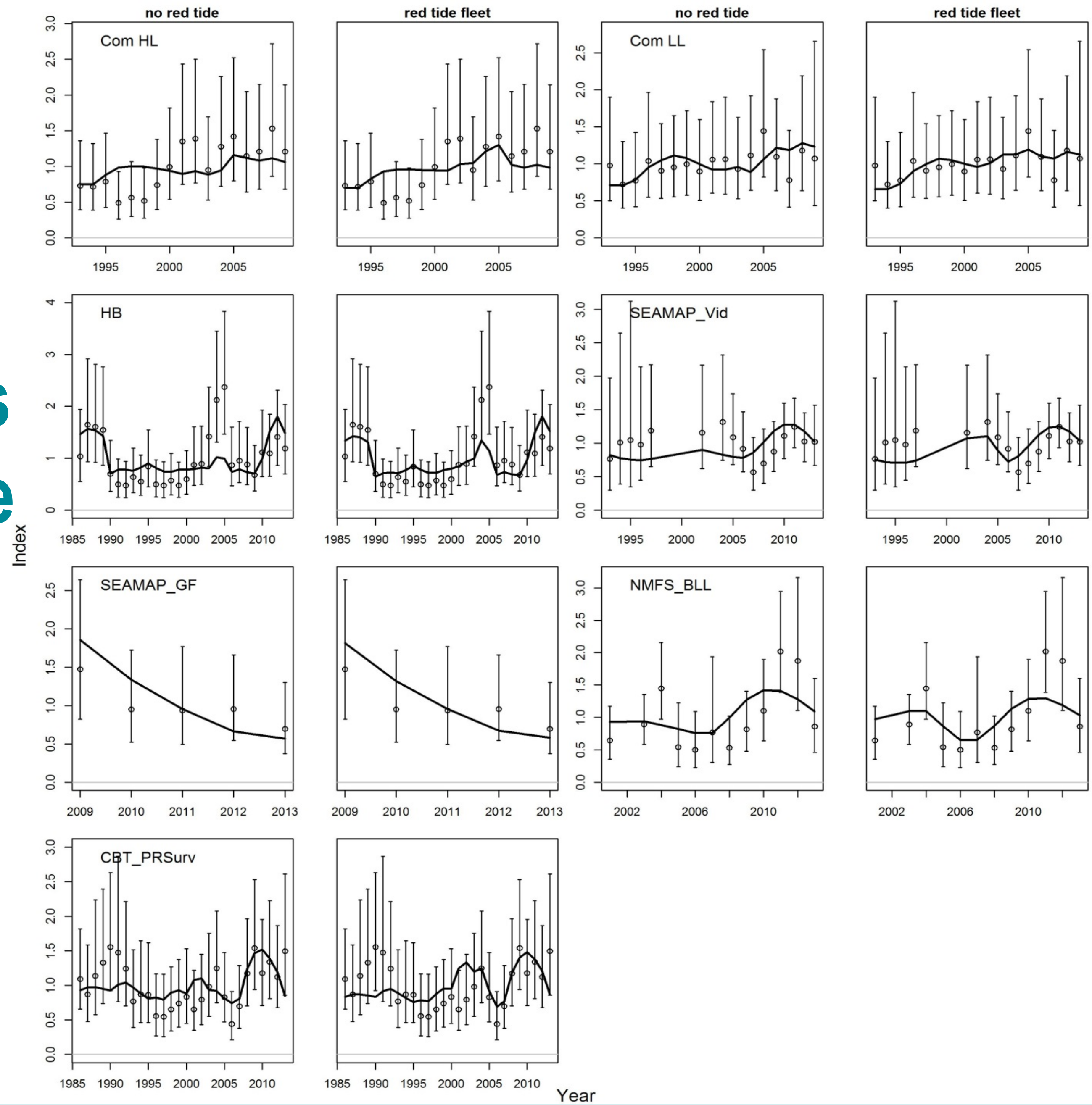
Red tide: red tide fishing fleet comparison

	THR (base)	MCP	GRP	MRT
Gradient	**0.300**	1.019	0.104	10.115
AICc	**-13645**	-9264	-9221	-8256
BIC	**7584**	7680	7724	7640
Likelihood				
Total	**2837**	2887	2908	2867
Discard	**311**	312	310	312
Lcomp	**1086**	1082	1085	1082
Acomp	**1451**	1453	1452	1453
Survey	**-164**	-115	-93	-134
ComHL	**-12**	-11	-12	-11
ComLL	**-18**	-18	-18	-18
HB	**-18**	-14	-16	-13
CBT_PRSurv	**-18**	-19	-18	-19
SEAMAP_Vid	**-15**	-14	-14	-14
SEAMAP_GF	**-4**	-4	-4	-4
NMFS_BLL	**-5**	-3	-4	-3
RT q	**0.816**	0.713	0.394	0.208
F_2005	**0.442**	0.095	0.224	0.077

Red tide:

Method 2 fits to indices of abundance

THR index



Red tide: why use the red tide fishing fleet?

- Red tide fishing fleet chosen as the central approach for incorporating red tide mortality:
  - Results similar to the approach that used a fixed constant M applied to all ages
  - Level of mortality estimated by the assessment model rather than input as a fixed parameter
  - Better represents model uncertainty regarding the 2005 red tide mortality event

Red tide: conclusions

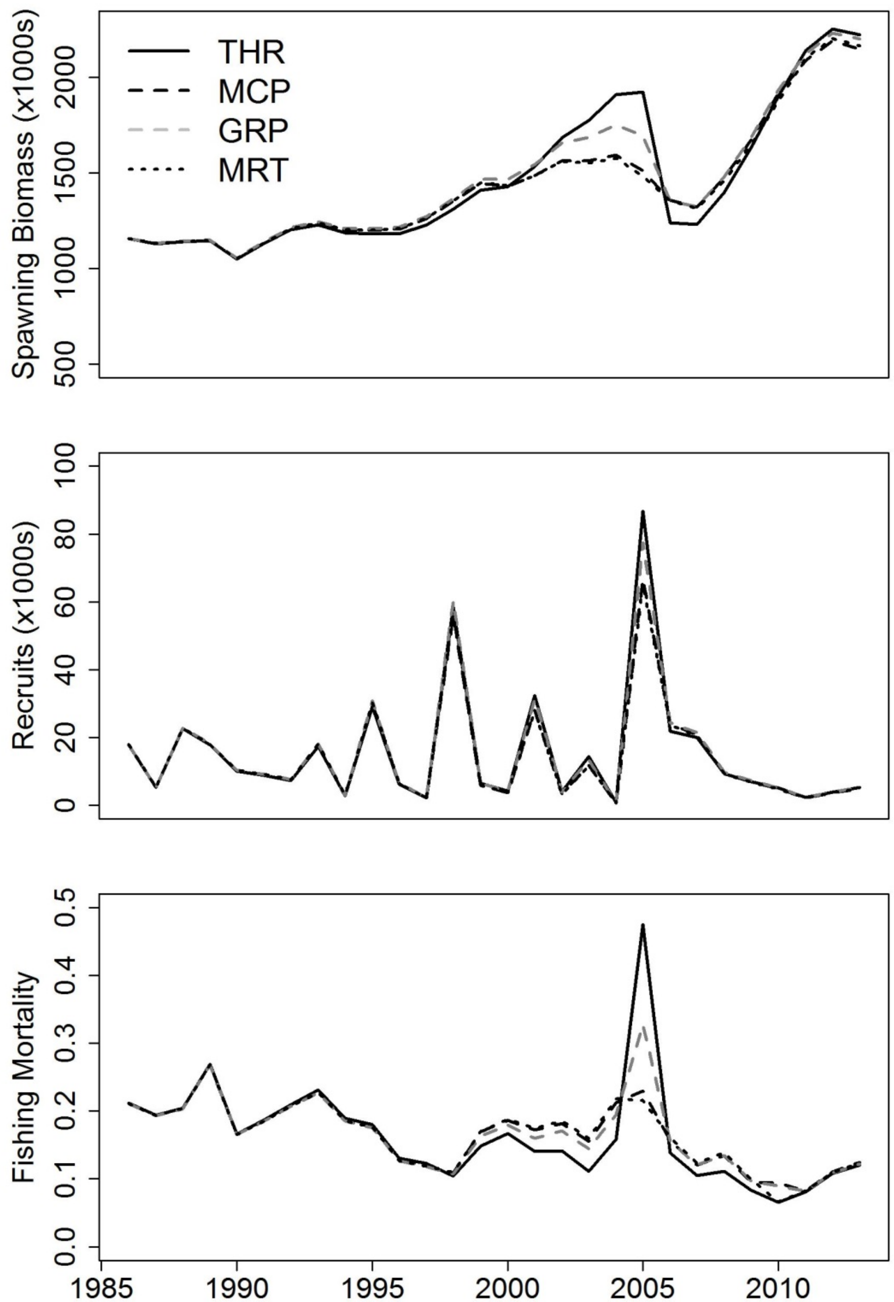
- Red tide fishing fleet with the threshold index driving red tide fleet effort best approach
  - No associated variance
  - Most parsimonious of available indices
  - Negative effects on grouper may only occur under conditions where a red tide is above a threshold
- Additional work needed on size/age specific mortality effects of red tides on grouper populations

EXTRA SLIDES

Red tide:

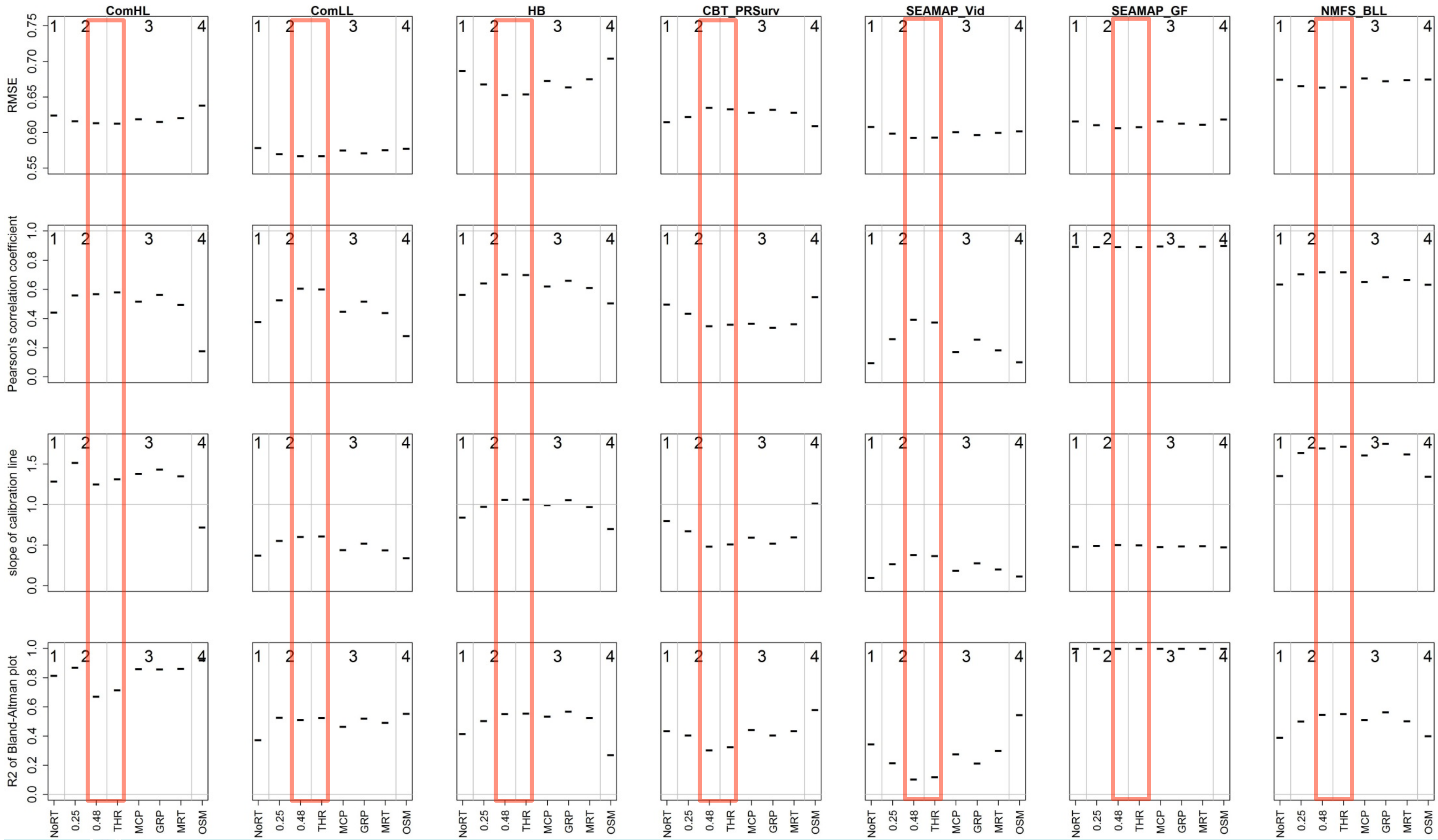
Method 2 fits to indices of abundance

THR index



Red tide: overall comparison

1 = No red tide 2 = Episodic *M*
3 = Red tide fleet 4 = OSMOSE-WFS *M*



Red tide: ages susceptible

- Tested different selectivity patterns

- Results suggest age-0 and older affected by red tide
  - wAICc = 85.6%
  - wBIC = 85.6%