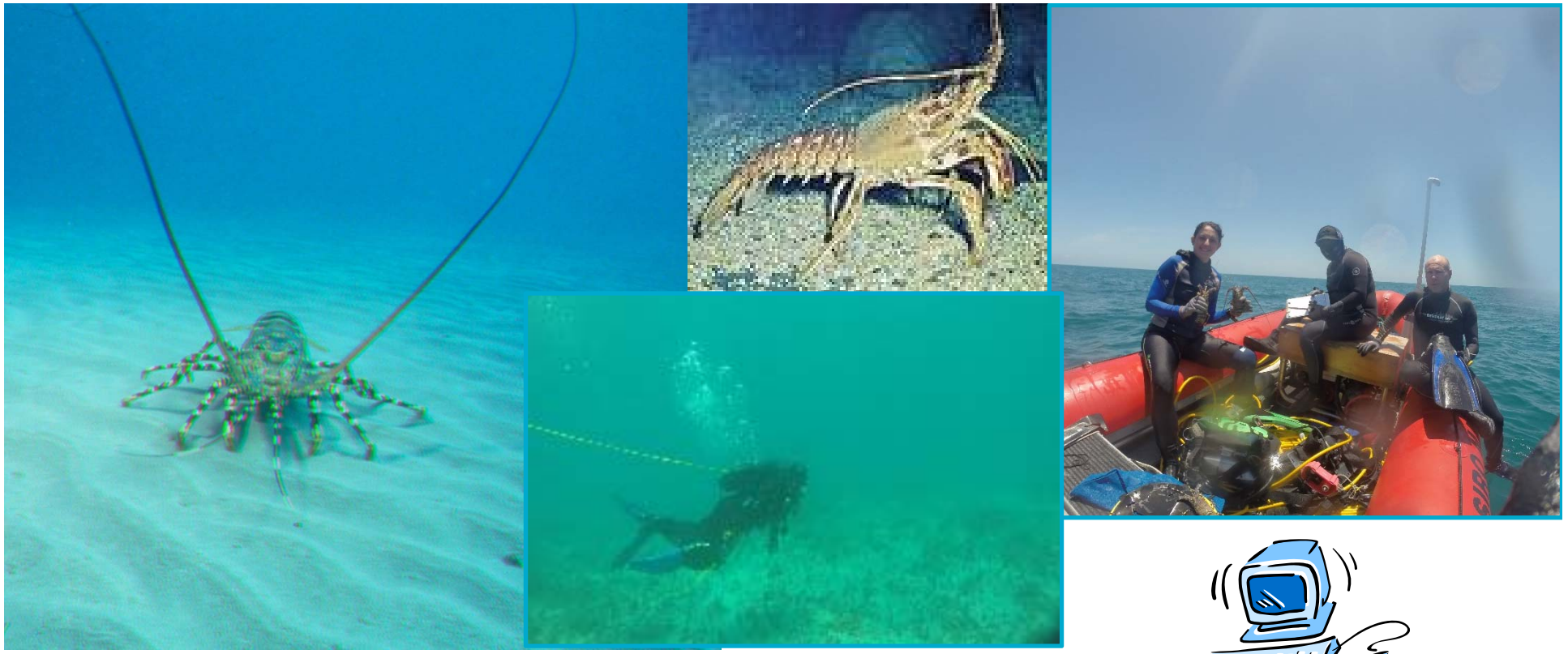


Updated 2016 Integrated Stock Assessment to provide management advice on the Torres Strait rock lobster fishery

Éva Plagányi, Darren Dennis, Rob Campbell, Mark Tonks, Roy Deng, Mick Haywood

CSIRO Oceans & Atmosphere, Brisbane

December 2016

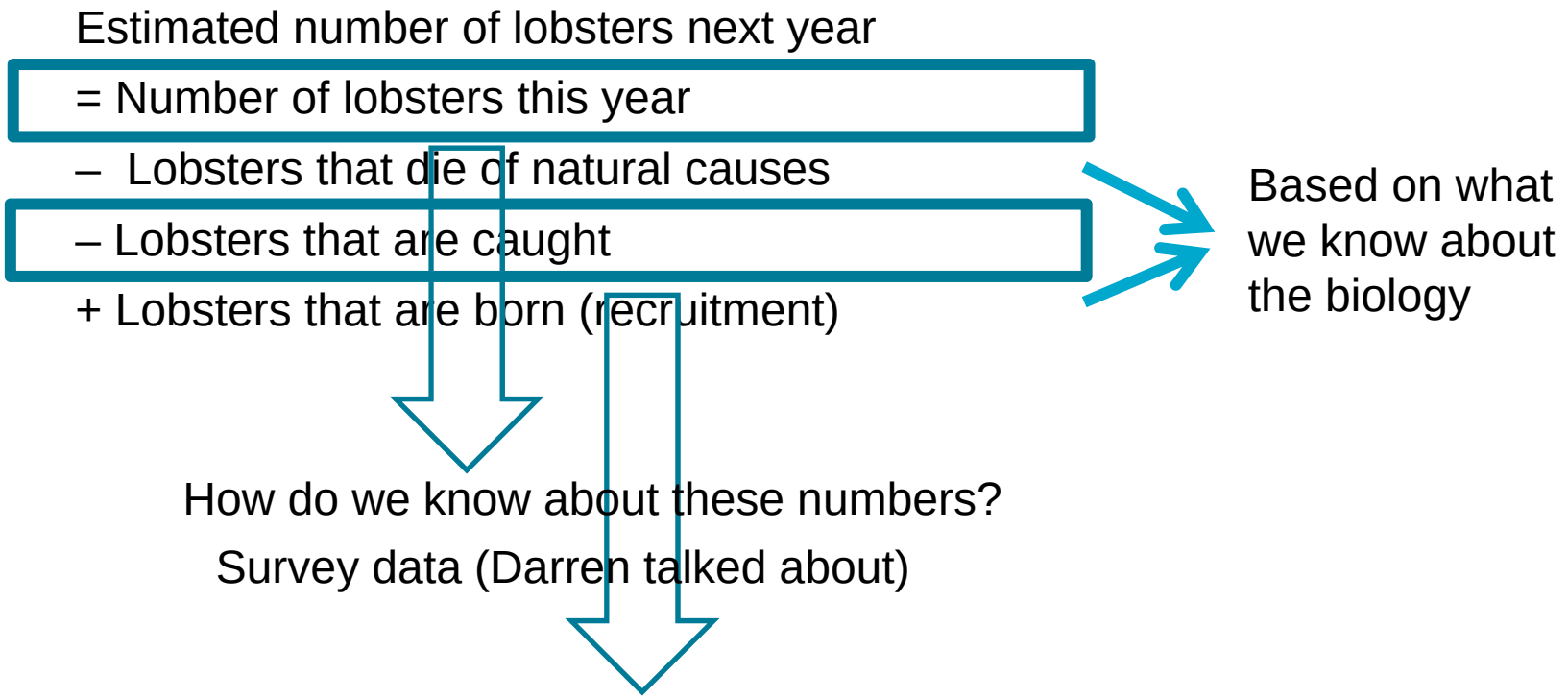
Overview of Fisheries Modelling

- Fisheries stock assessments range from fairly simple models, to very complicated models that only a few people in the world understand
- The Torres Strait model developed is similar to that applied to many of the world's major fisheries
- It uses all our biological knowledge of the fishery and all available data and puts these together to objectively provide an assessment of how much lobsters there are, what the impact of fishing is and what management advice should be given to ensure future sustainability of the stock
- The statistical methods are able to account for some of the uncertainty

SUMMARY OF MODEL

- Age Structured Production Model (ASPMs) - corresponds to Statistical Catch-at-Age Analysis (SCAA) as the data fitted include catch-at-age information
- Integrated assessment with everything included in the same DYNAMIC framework
- Widely used approach for providing TAC advice with associated uncertainties
- Fits to all data including Pre-season data and standardised CPUE data
- Outputs a RBC (Recommended Biological Catch) (with Confidence Interval) for each year, which is an integrated estimate that takes into account all available sources of information

How to predict the number of lobsters



Model equations

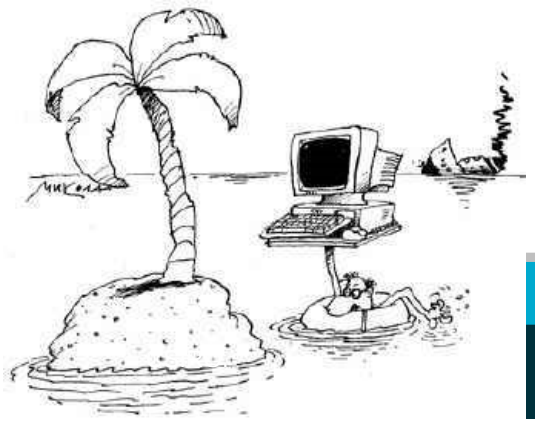
1. Basic population dynamics model – Age 1+ caught on average at end of September:

$$N_{y+1,a+1} = \left(N_{y,a}\, e^{-3M_a/4} - C_{y,a}\right) e^{-M_a/4}$$

(Numbers – Catches) * survival

2. Age 2+ caught around midyear:

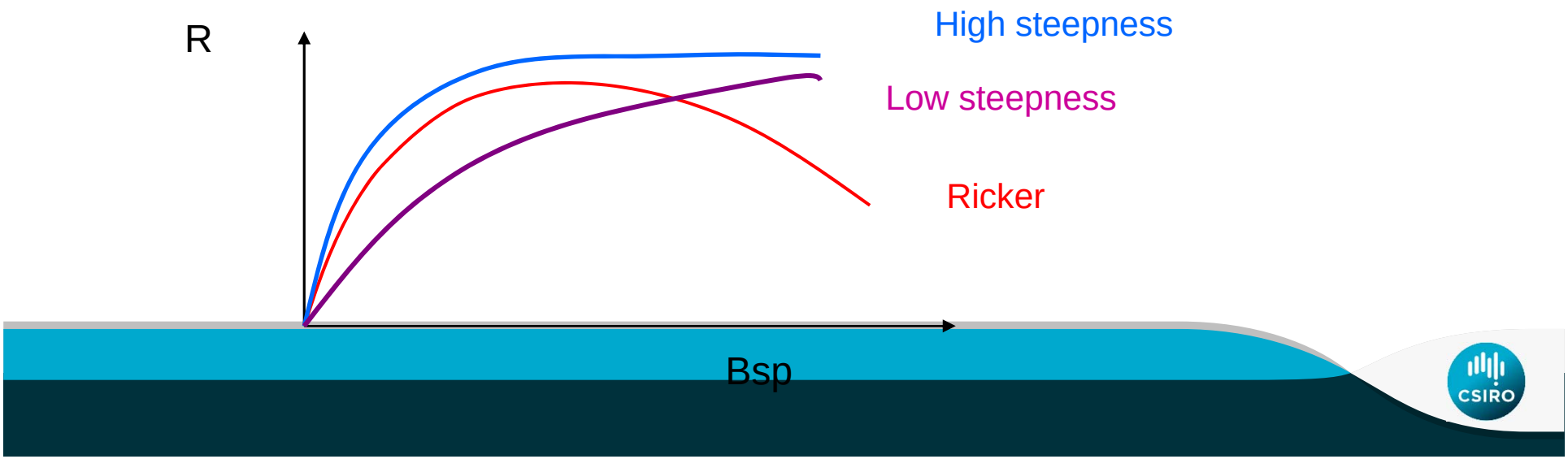
$$N_{y+1,a+1} = \left(N_{y,a}\, e^{-M_a/2} - C_{y,a}\right) e^{-M_a/2}$$



Example model equations

3. Number of recruits (i.e. new 1-year old lobsters) at the start of year *y* is assumed to be related to the spawning stock size (i.e. the biomass of mature lobsters) by a modified Beverton-Holt stock-recruitment relationship, allowing for annual fluctuation about the deterministic relationship

$$R_y = \frac{\alpha B_{y-1}^{sp}}{\beta + \left(B_{y-1}^{sp}\right)^{\gamma}} e^{(\varsigma_y - (\sigma_R)^2/2)}$$



Example equations cont.

4. The model constructed thus far has a number of unknown parameters. Values are selected in such a way that the probability that the model generated the data is as high as possible

i.e. compute the likelihood function:

$$L(Data \mid Hypothesis)\, or: L(\mathbf{D} \mid \underline{\theta})$$

5. Compute contribution of e.g. abundance data to the negative of the log-likelihood function (assume observed abundance index is log-normally distributed about its expected value):

$$-\ln L = \sum_{s}\left[\sum_{y} \ln \sigma_y^s + \left(\varepsilon_y^s\right)^2 / 2\left(\sigma_y^s\right)^2\right]$$

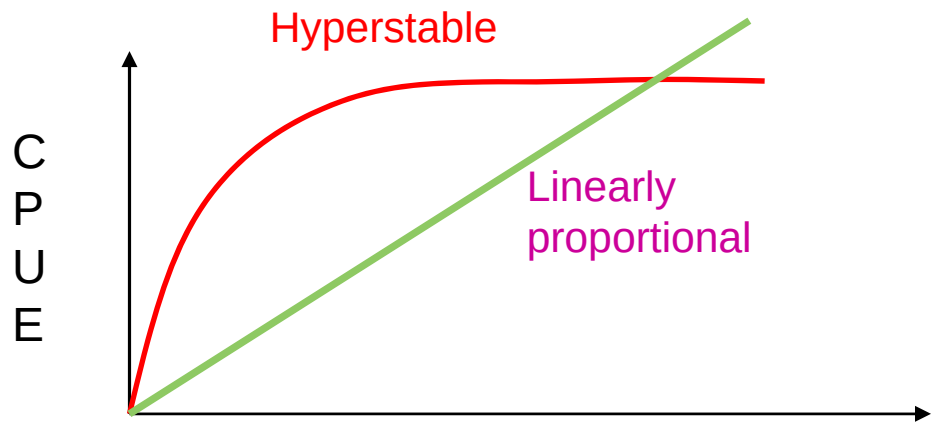
6. Minimisation achieved using AD Model Builder - quasi-Newton minimisation approach; code is C+ based

Changes to 2016 assessment model

- Data updates, incl 2016 preseason survey
- No 2015 or 2016 midyr survey
- Catch data time series revised
- The TVH CPUE data input series have been revised, with alternative standardised series available for the period 1989-2016
- The TIB CPUE data input series have been revised, with alternative standardised series available for the period(1994-2012, 2014-2016)

Earlier updates maintained

- Recruitment residual variability assumed higher (sigma=0.5 vs 0.3)
- Relationship between stock abundance and CPUE was explored, and found to be better represented by a hyperstable relationship, than the assumption that CPUE is proportional to stock abundance - suggests that CPUE remains high while stock abundance declines
- Used a power curve with a hyperstability shape parameter of 0.75 for TVH and 0.5 for TIB, and tested sensitivity to other values. This is consistent also with results from considering an ecometric production function approach (Pascoe et al. 2013).



Data used in the assessment

- Data
  - Pre-season survey (7 yrs – gap in data)
  - Mid-year survey data 1989-2014
  - Catch statistics from TS, all sectors
  - Length frequency data (Australian & PNG)
  - CPUE data from TVH sector
  - CPUE data from TIB sector
  - Historic information

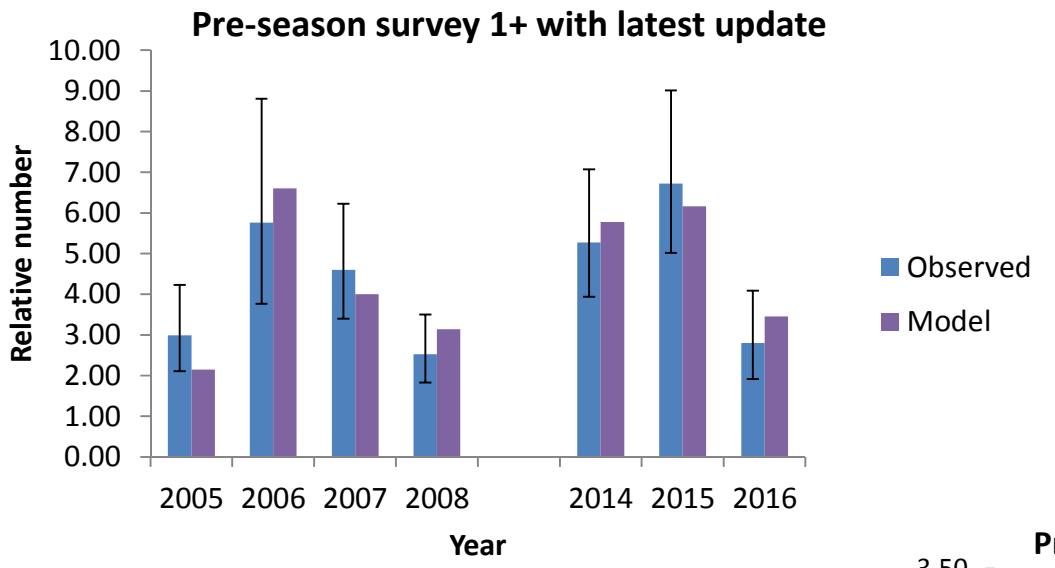
- Future:
  - Environmental correlates?

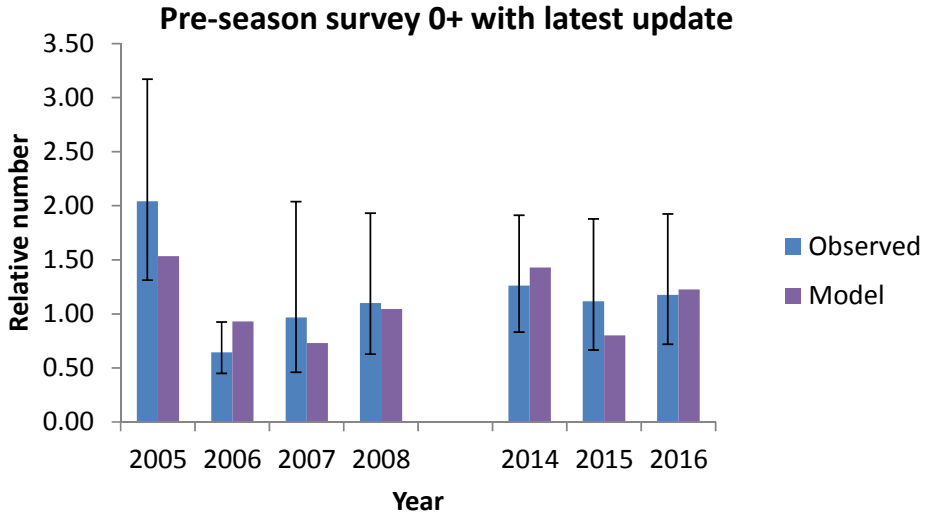
CATCH DATA

Year	TiB	TVH	PNG	TS_Total	Aus_TAC	Catch as % of TAC
2004	235.1	481.0	182.0	898.1		
2005	358.5	545.0	228.0	1131.5		
2006	152.3	135.4	142.0	429.7	471	91%
2007	260.0	268.6	228.0	756.6	842	90%
2008	183.9	100.4	221.0	505.4	751	67%
2009	135.9	91.1	161.4	388.4	450	86%
2010	143.3	282.6	292.8	718.7	853	84%
2011	200.7	503.5	165.0	869.2	803	108%
2012	152.9	370.5	173.7	697.0	964	72%
2013	134.2	361.7	108.3	604.2	871	69%
2014	148.5	272.7	151.4	572.6	616	93%
2015	173.9	152.7	235.7	562.3	769	73%
2016	207.1	237.6	127.1	571.8	796	72%

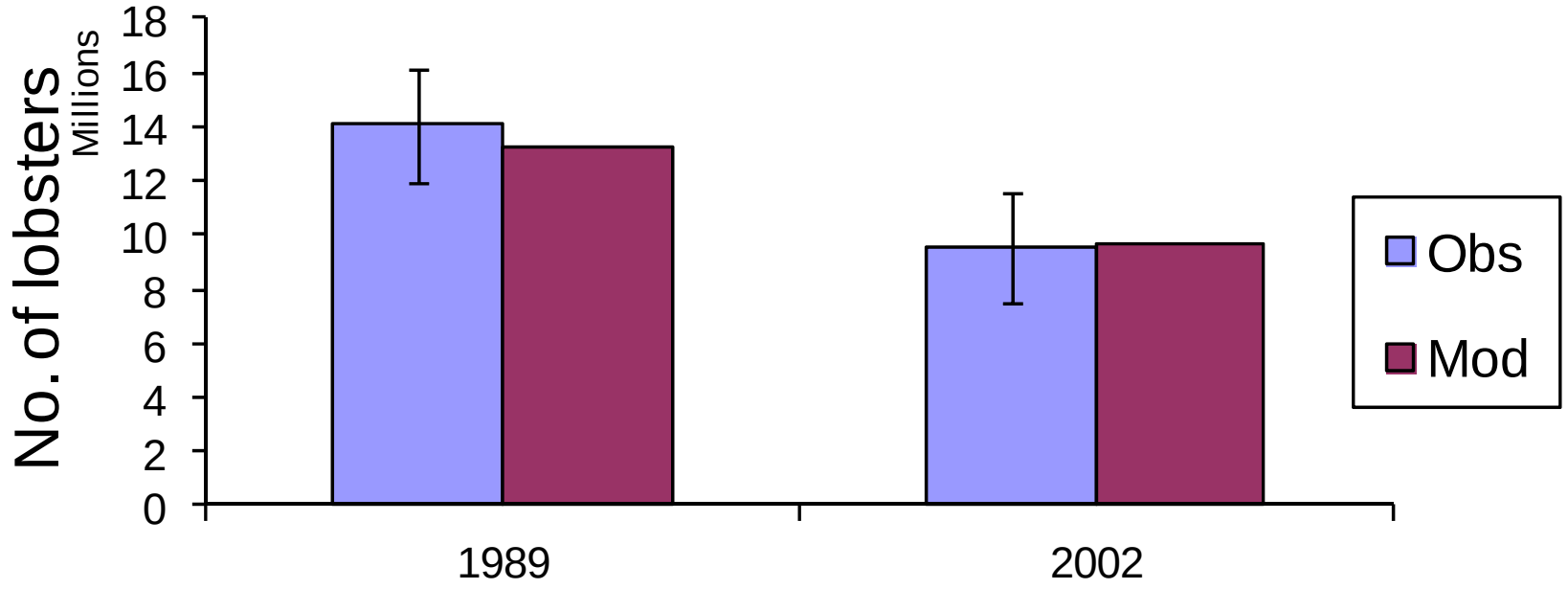
2016 Total Catch = 572 t

Fit to Pre-season survey

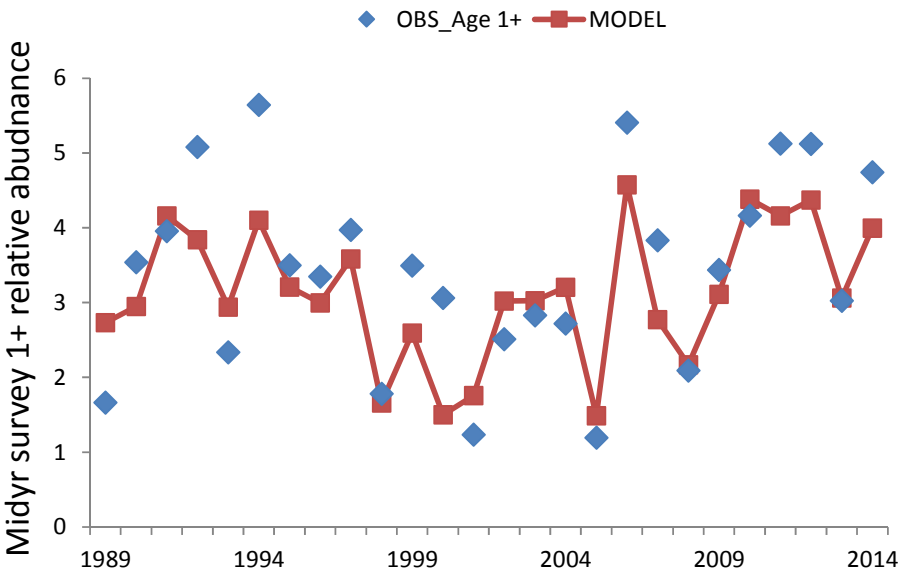


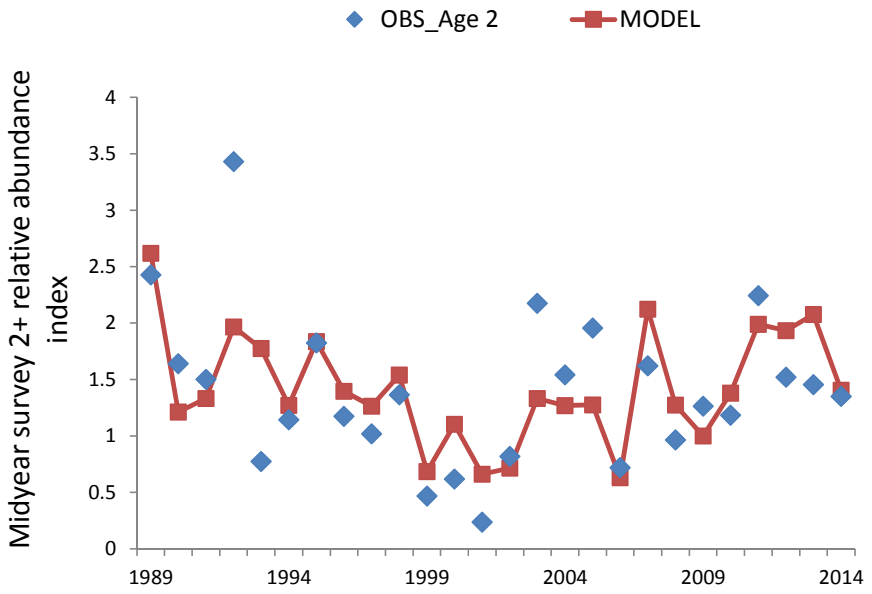


Benchmark surveys & Absolute abundance



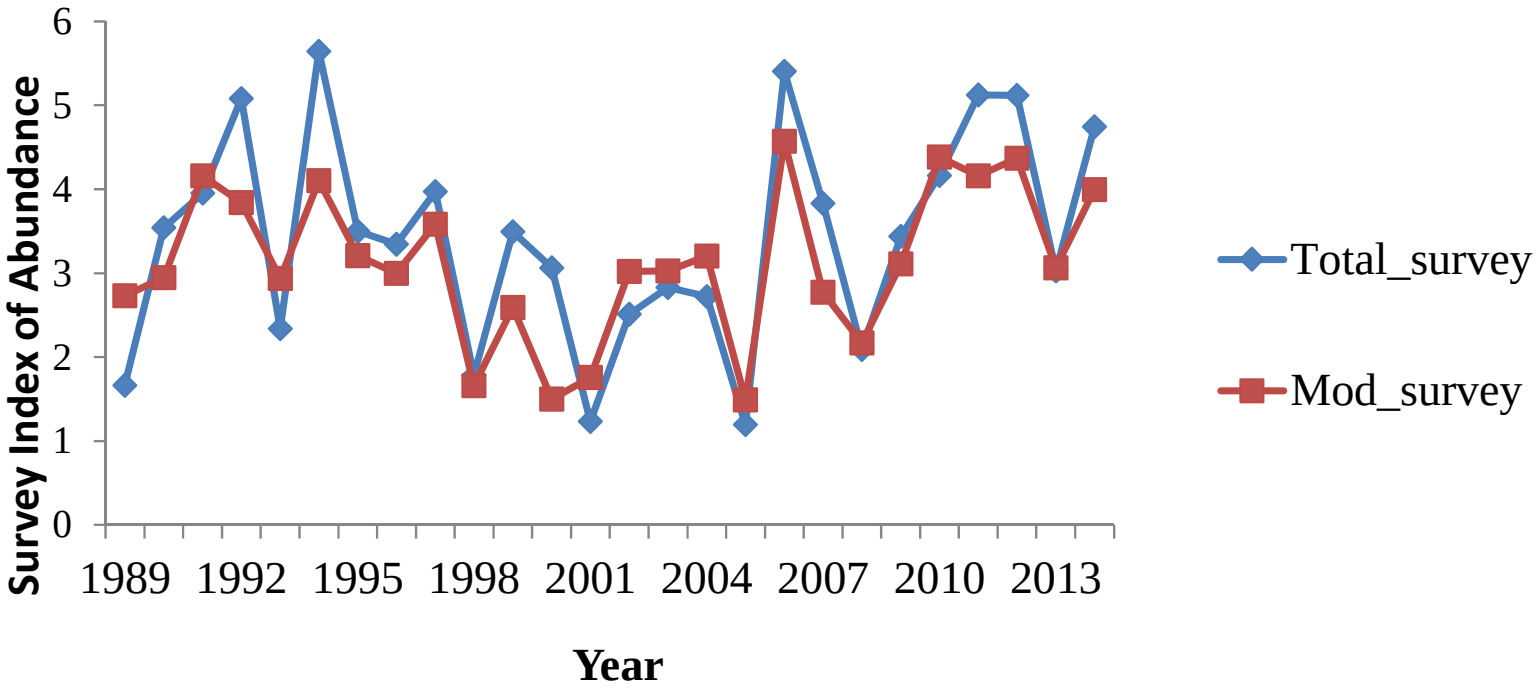
Midyear survey 1+ and 2+ relative abundance





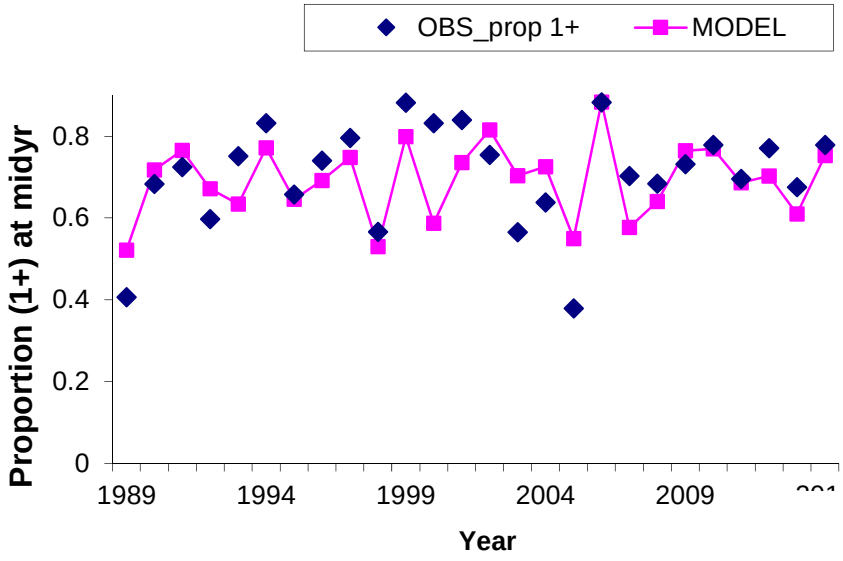
Observed vs Model survey midyear index of abundance

(in terms of total numbers of 1+ and 2+ lobsters)

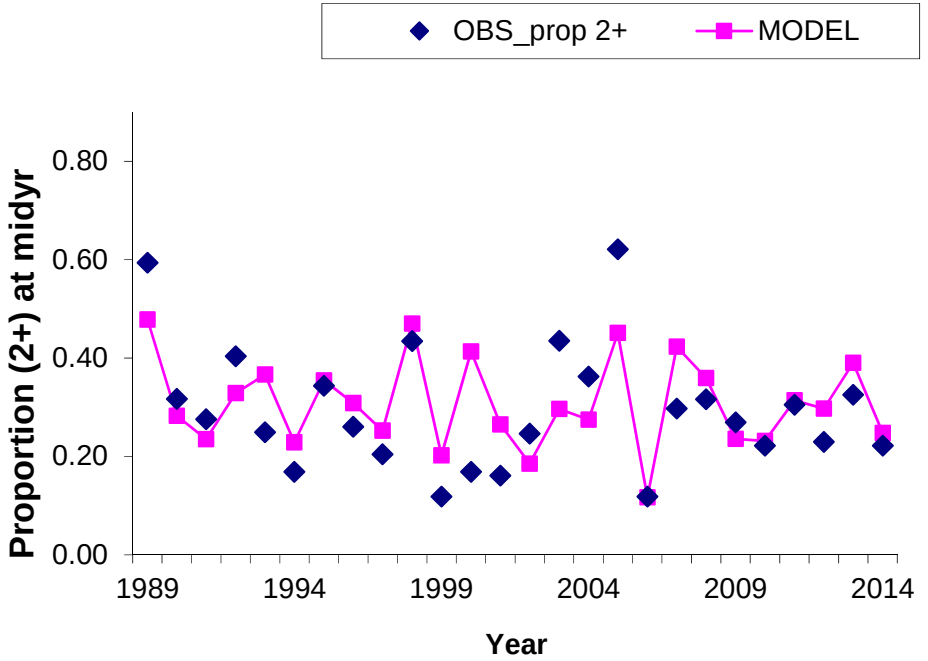


Comparison between observed and model-predicted proportions of 1+ and 2+ lobsters in the midyear survey

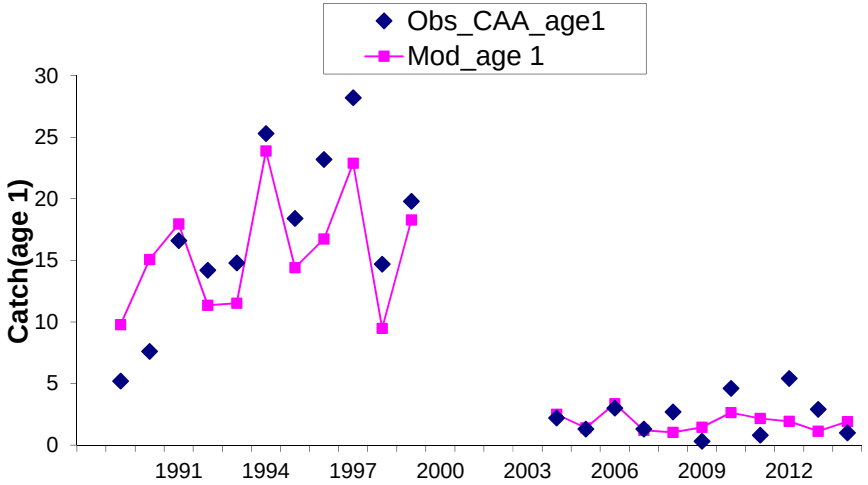
Age 1+

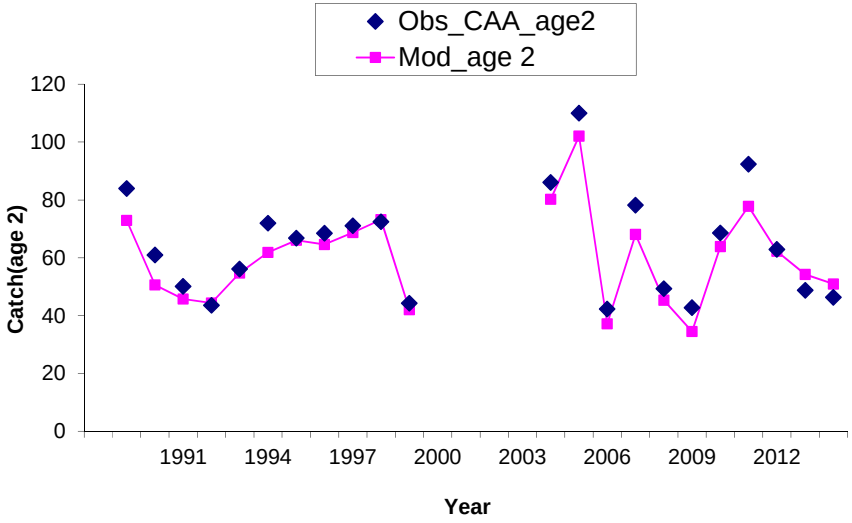


Age 2+



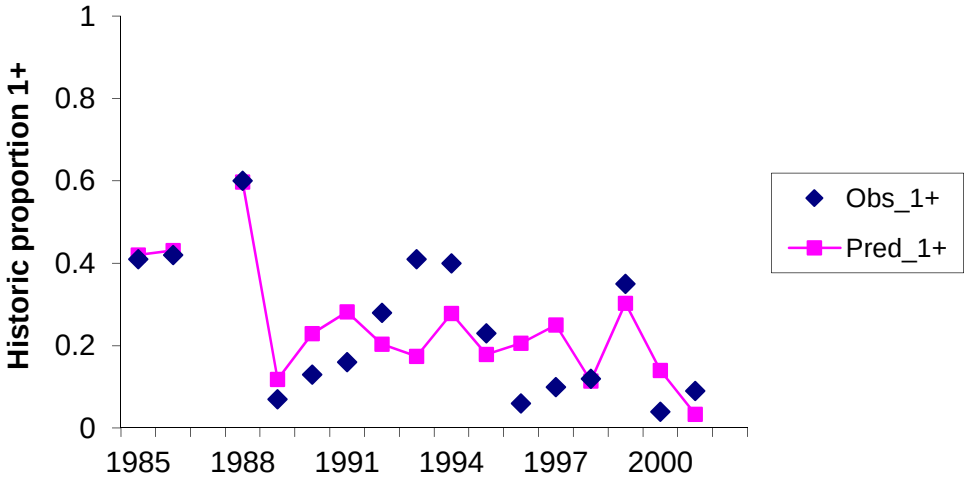
Comparison between observed and model catch-at-age from commercial catch data

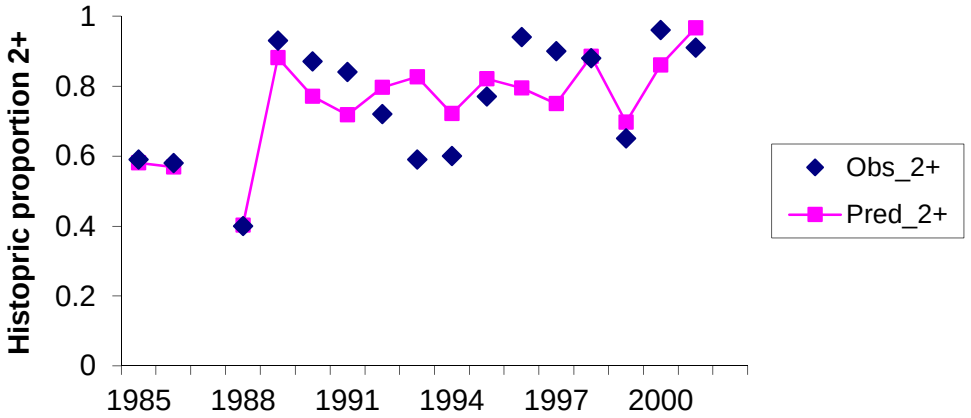




Missing data excluded

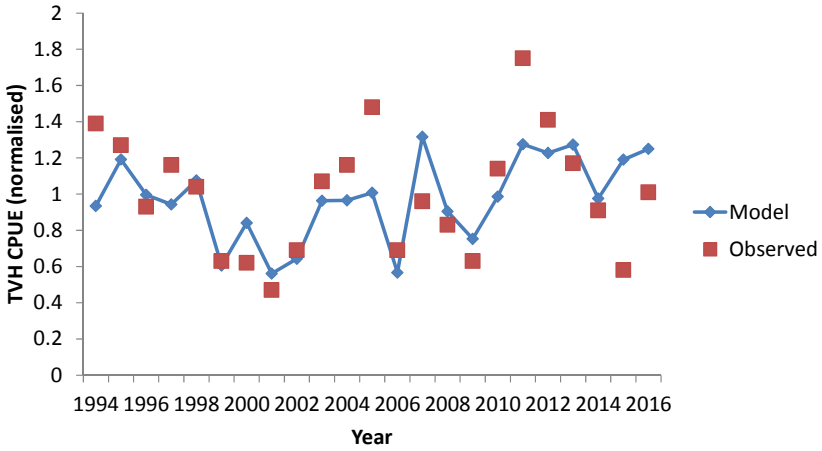
Comparison between historic data and model estimates of the proportions of 1+ and 2+ lobsters in the catch



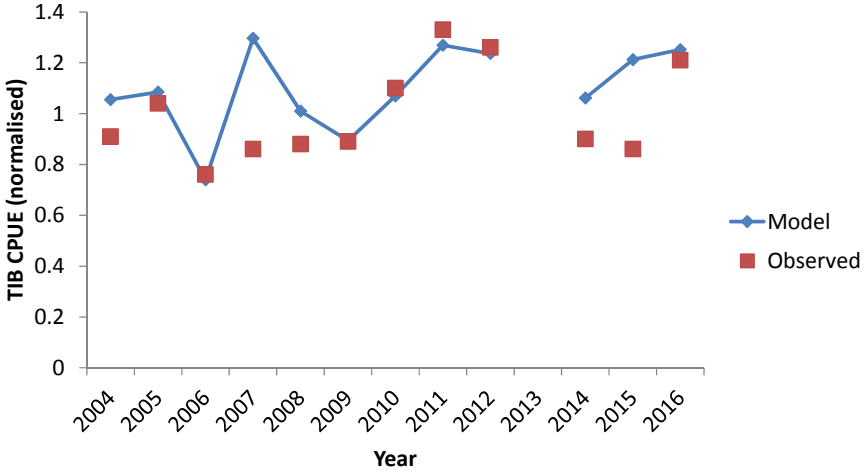


TVH & TIB CPUE data – standardised series

TVH – Main Effects Int1

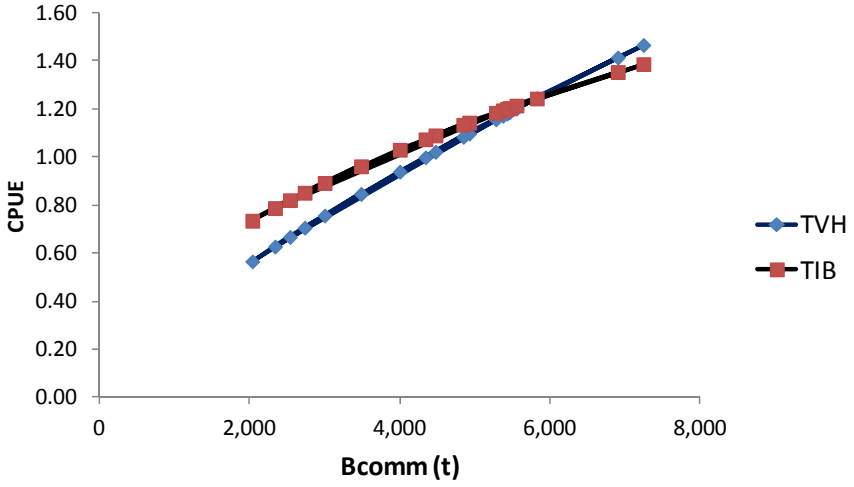


TIB – Seller&QA



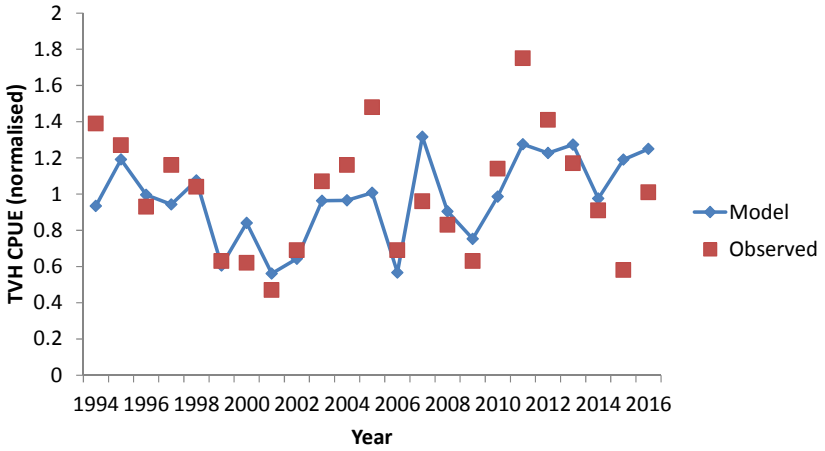
b) Hyperstable relationship

(shape parameter = 0.75 for TVH & 0.5 for TIB)

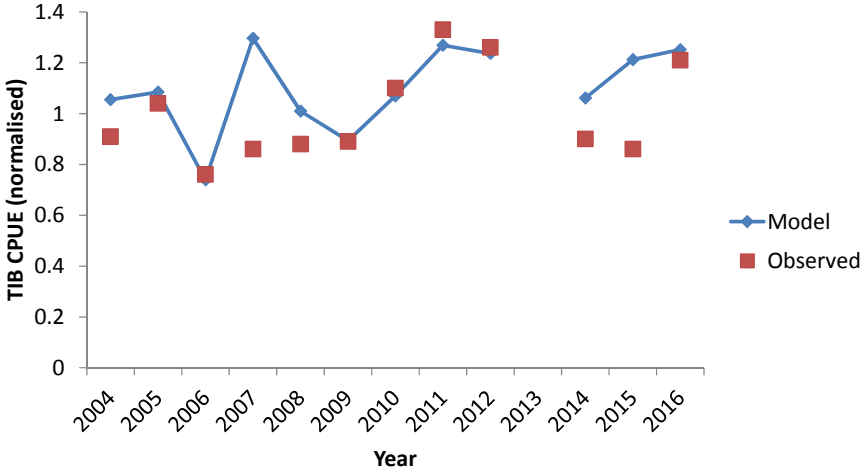


Comparing indices of abundance

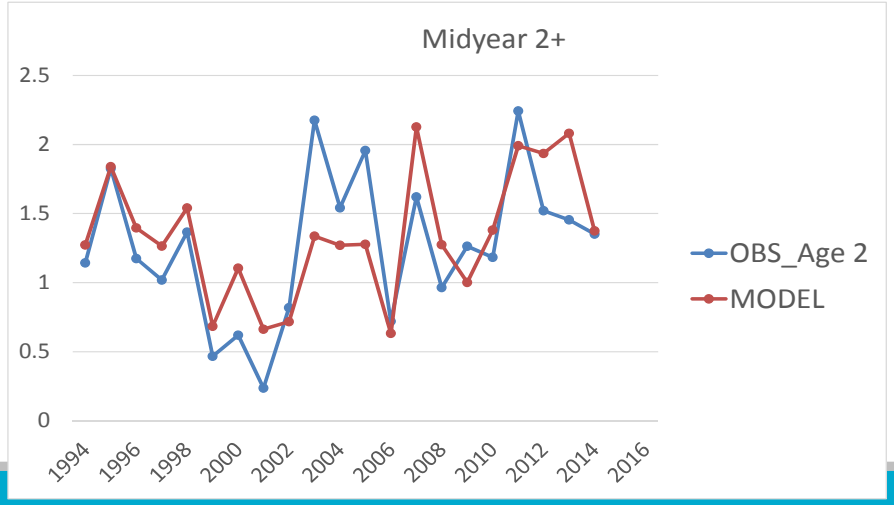
TVH – Main Effects Int1



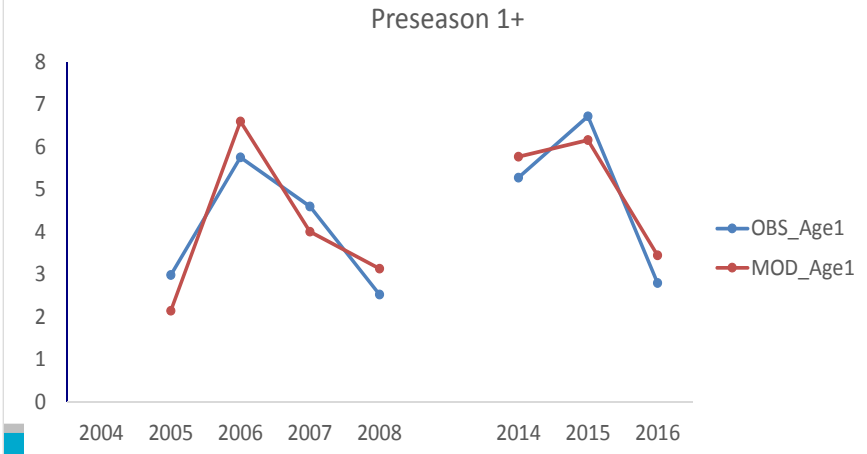
TIB – Seller&QA



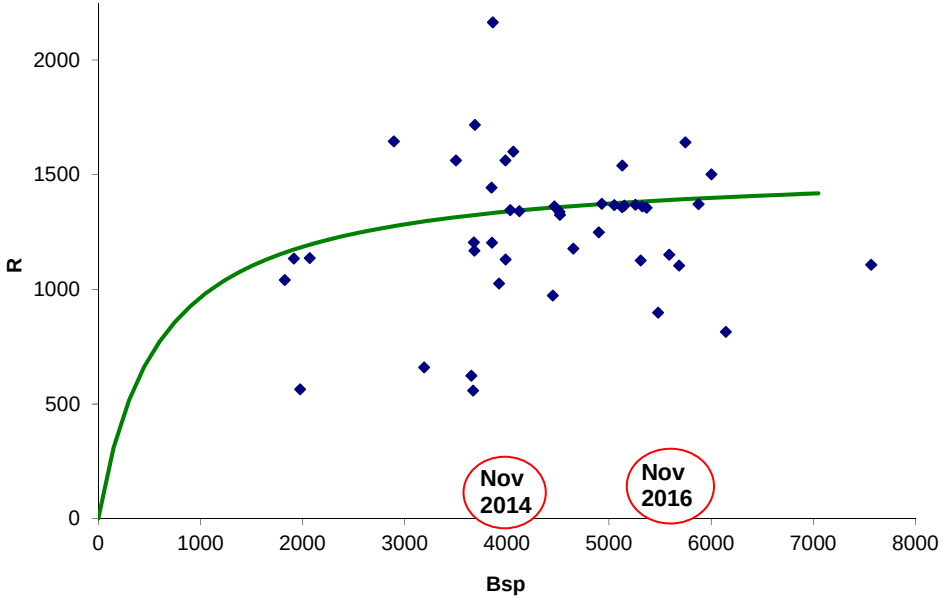
Midyear survey

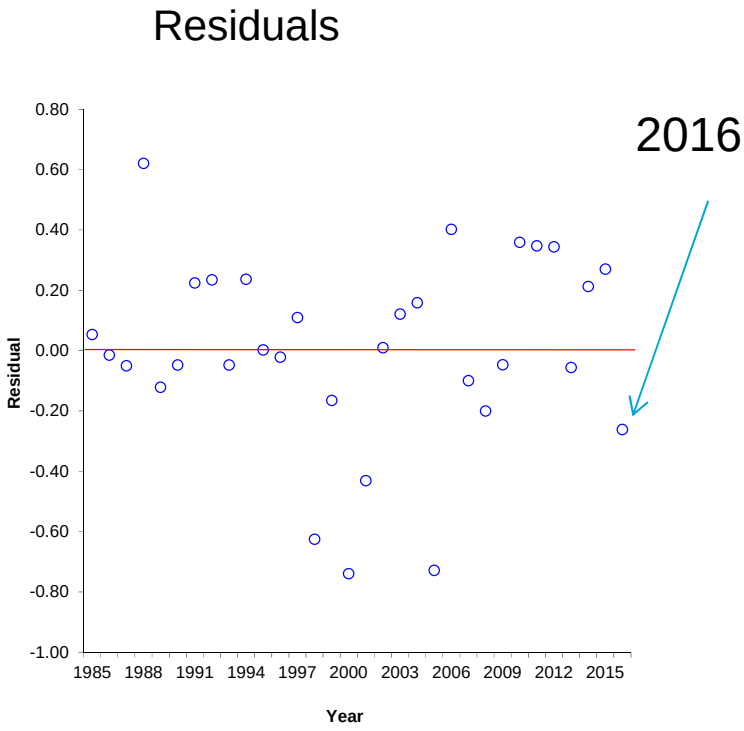


Preseason survey

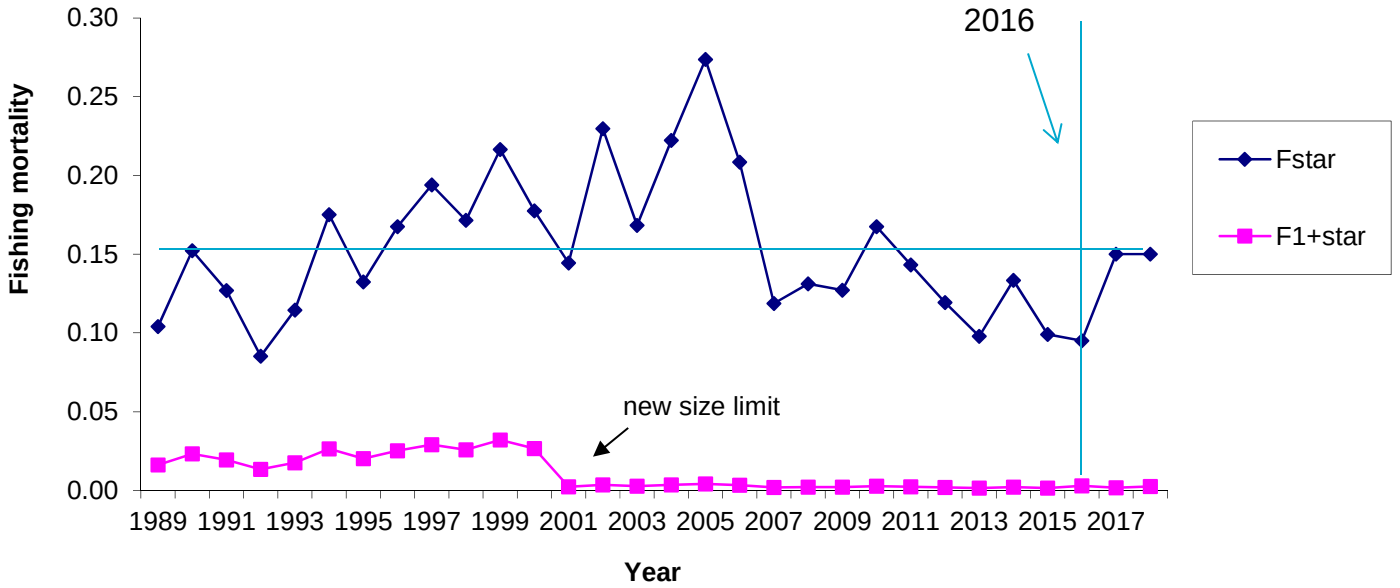


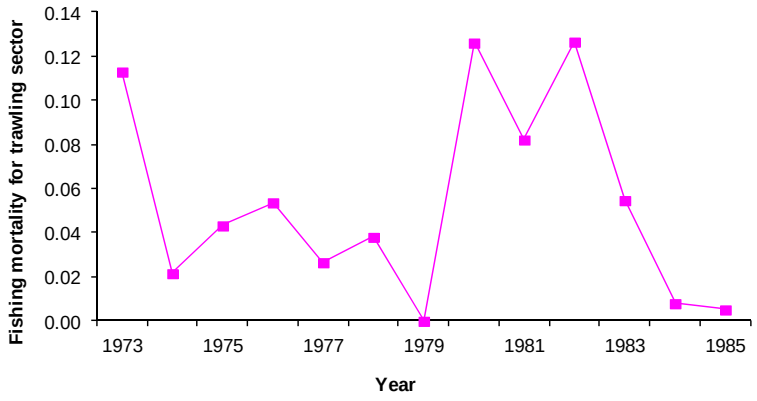
Stock recruitment relationship





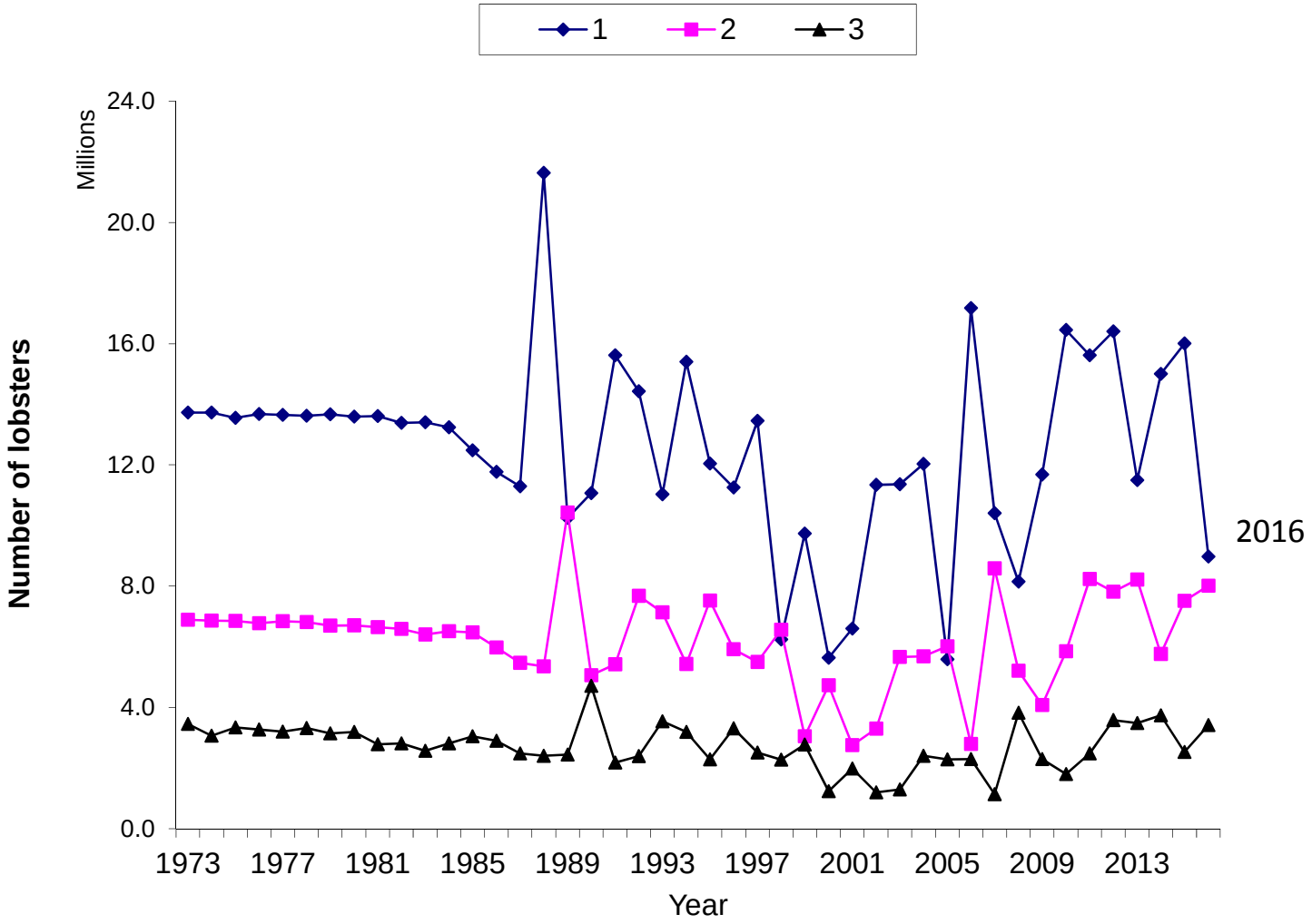
Model-estimated fishing mortality trends for 1+ and 2+ lobsters



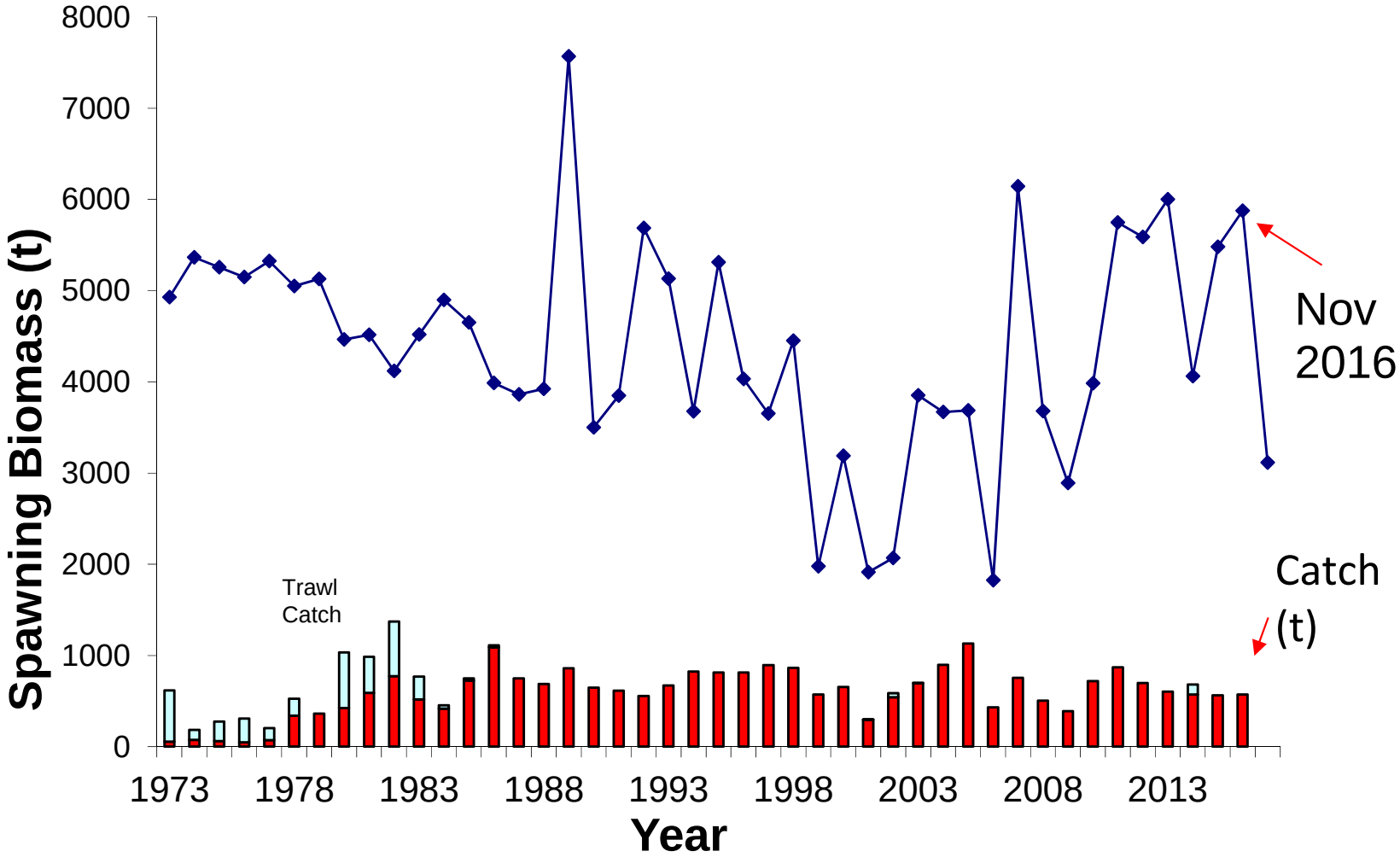


Trawling sector fishing mortality for 1973-1985

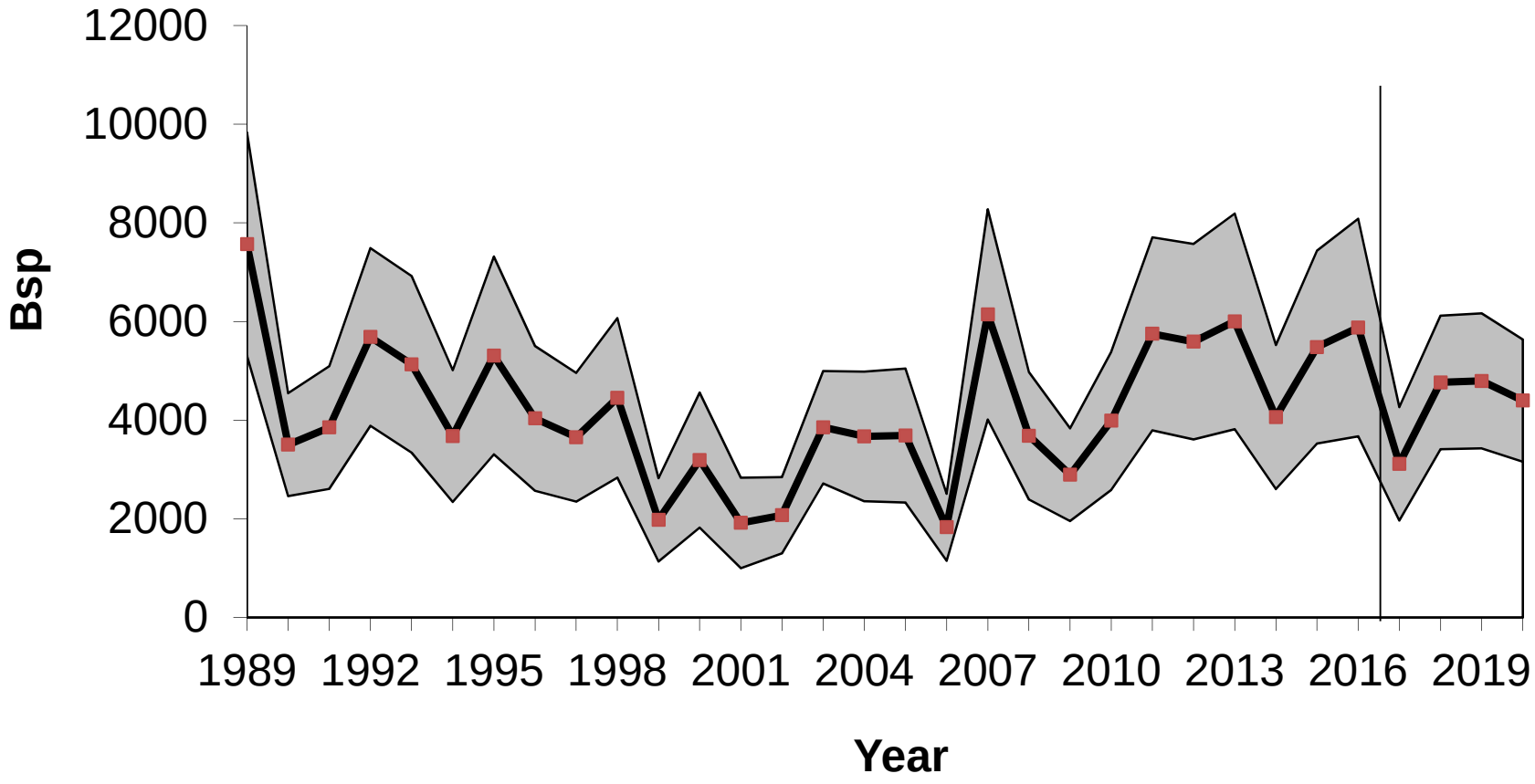
Model trajectories of the annual numbers of lobsters in each age class for years 1973 to 2016



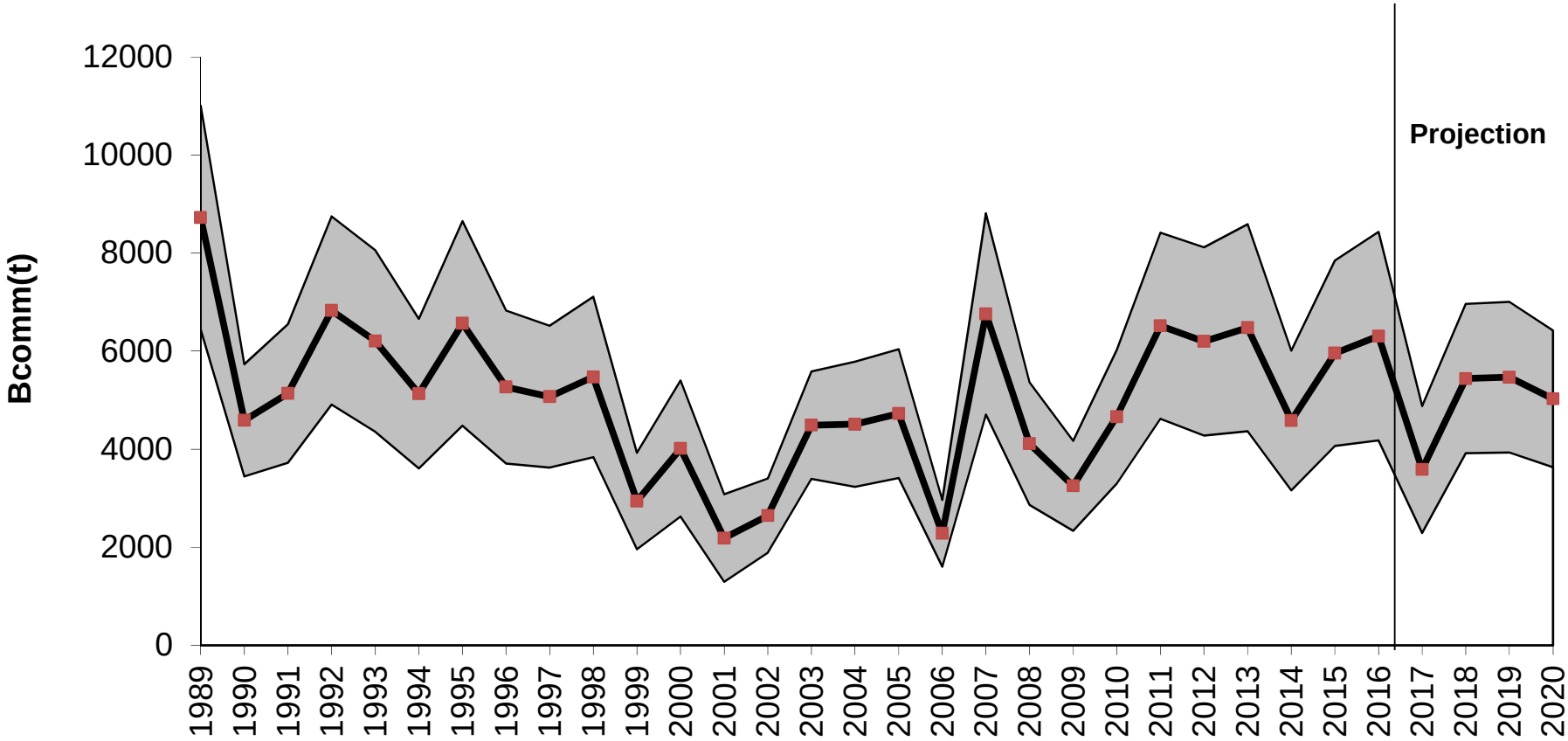
Spawning biomass



Spawning Biomass trajectory with Hessian-based 90% Confidence Interval



Commercially exploitable biomass (Bcomm) trajectory with Hessian-based 90% Confidence Interval



MODEL PARAMETER ESTIMATES

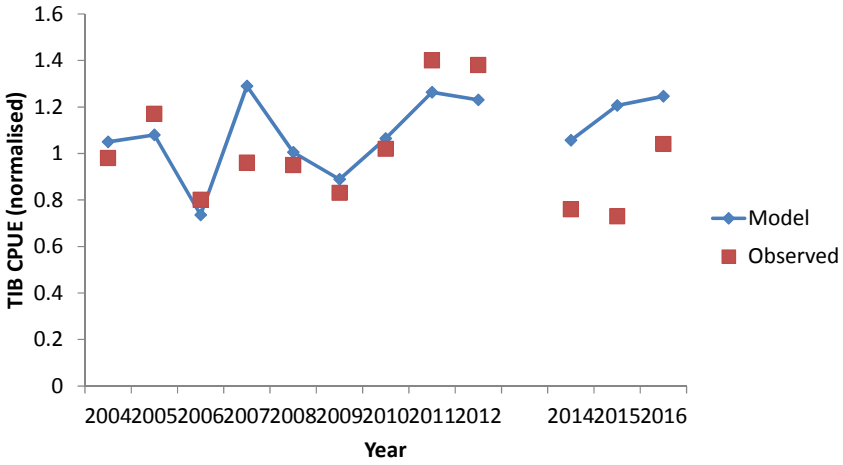
Parameter	Value	90% Confidence Interval	
$B(1973)^{sp}$	4947	3497	6397
M	0.69	0.56	0.82
Sel (age 1+) 1973-1988	0.44	0.24	0.63
Sel (age 1+) 1989-2001	0.16	0.14	0.19
Sel (age 1+) post2002	0.02	0.00	0.03
Prelim RBC(2017)	495	315	676
Prelim RBC(2018)	758	546	970
$B(2016)^{sp}$	5877	3671	8083
$B(1973)^{sp}$	4929	3331	6527
Current Depletion (Nov) $B(2016)^{sp} / B(1973)sp$	1.19	0.84	1.55
Bcomm(2016)	6306	4179	8432
N1+ (mid 2016) million	6.4		
N2+ (mid 2016) million	3.9		
F (2016)	0.10		

Key Sensitivities

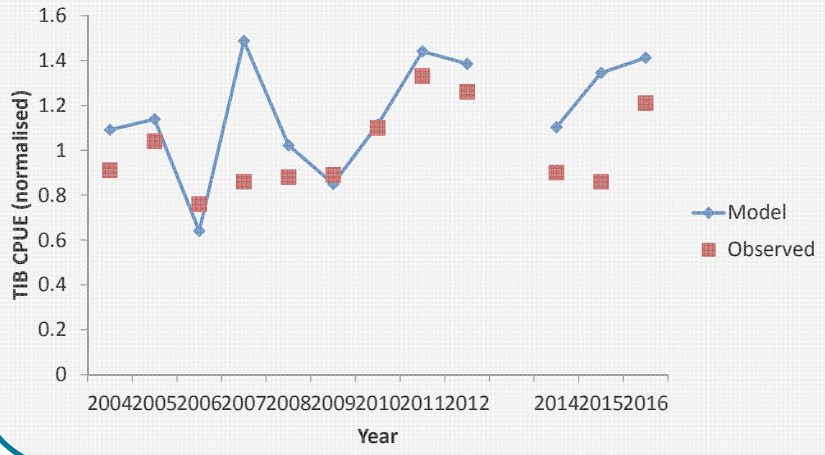
- A) Pre-RAG Reference Case
- B) Alternative CPUE TVH & TIB standardisation series (Main effects)
- C) Alternative CPUE TIB - nominal series
- D) TIB hyperstability par = 0.75 vs 0.5
- E) Higher natural (environmental) mortality rate in 2015

Sensitivity – TIB nominal CPUE

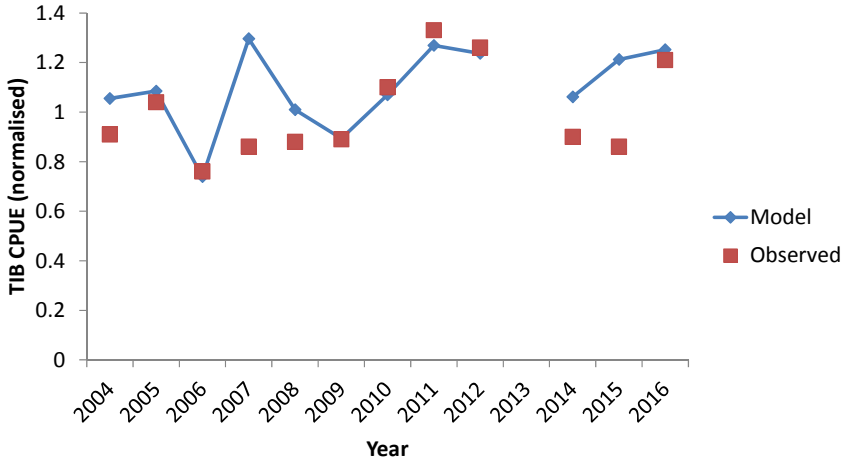
Nominal TIB CPUE & Hyps = 0.5



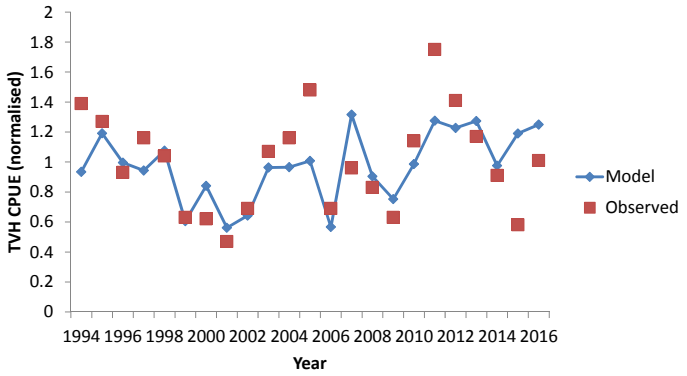
Hyps = 0.75; Ref Case CPUE



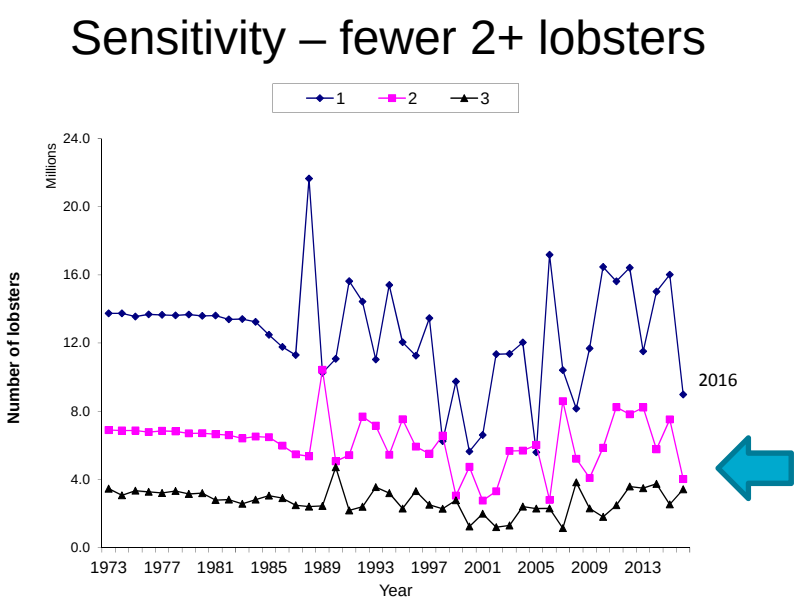
Reference Case, with Hyps = 0.5 & Seller+QA GLM

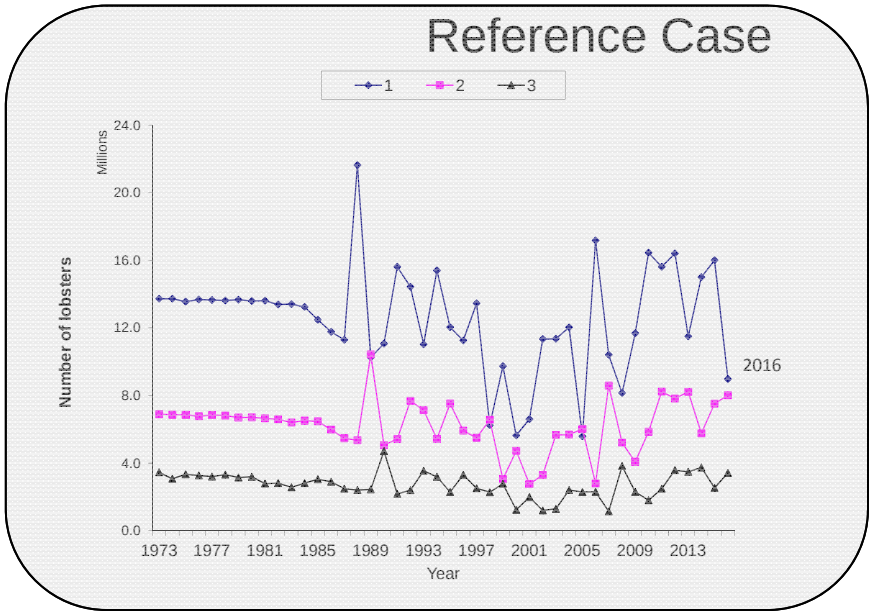


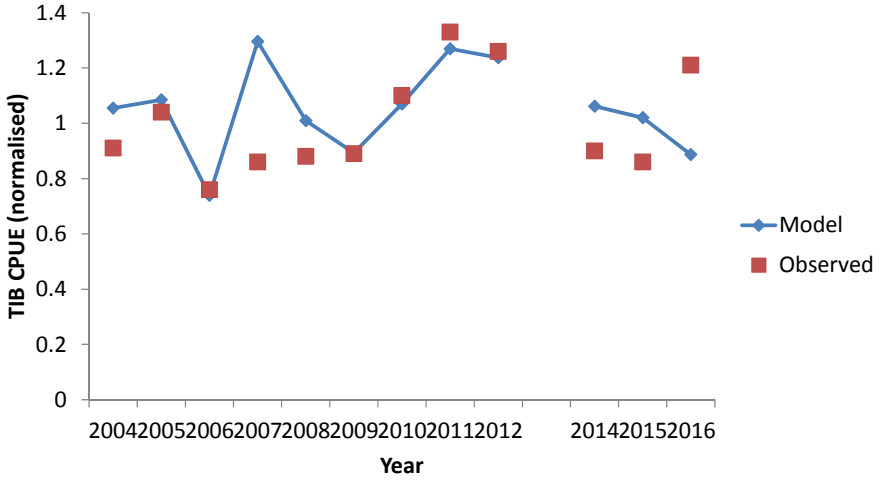
TVH

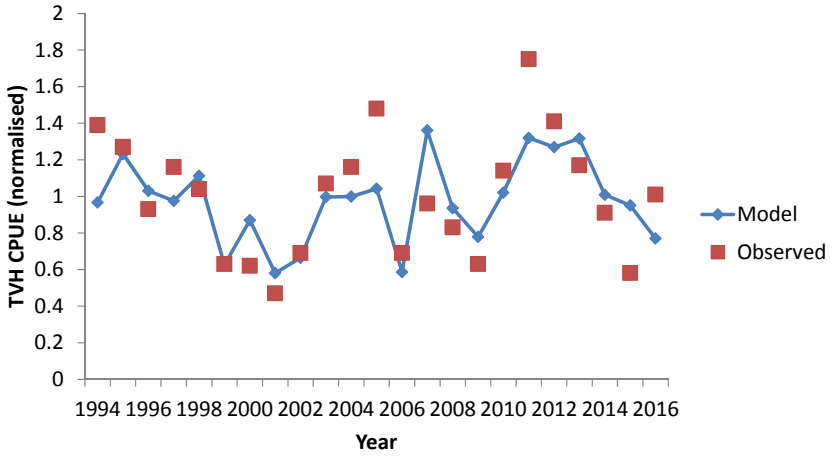


Sensitivity: 2015 higher mortality rate (natural)









TAC/Catch (t)	2012	2013	2014	2015	2016	2017
Forecast TAC (90% CI)	532 (282-782)	769 (485-1053)	767 (518-1016)	751 (556-945)	719 (515-923)	677 (489-866)
Preliminary TAC (90% CI)	964 (497-1432)	871 (445-1298)	616 (294-938)	894 (571-1217) TIB: 328 t TVH: 251 t PNG: 285 t	704 (510-897) Aug 2015 Dec 2015 update	495 (315-676) TIB: 188 t TVH: 144 t PNG: 163 t
Preliminary TAC allocation* (lower 75th percentile)	637	573	391	668 TIB: 254 t TVH: 194 t PNG: 220 t	568t TIB: 216 t TVH: 165 t PNG: 187 t	
Final TAC	964	871	616	Mar 2015 (revision with preseason survey = 769t)	796	Dec 2016
Catch	697t	604t	682t	562t	572t	-

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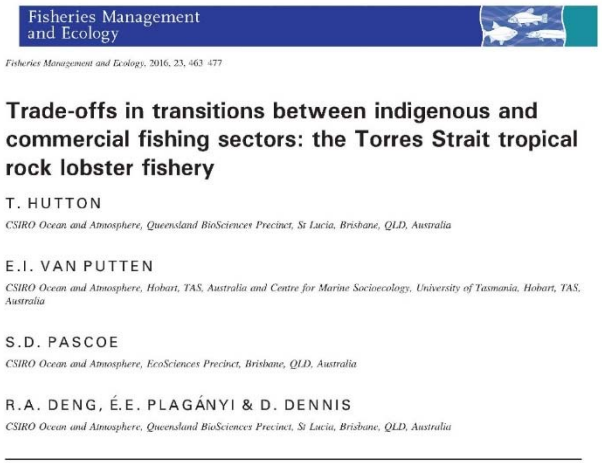

Fisheries Management and Ecology

Fisheries Management and Ecology, 2016, 23, 463–477

Trade-offs in transitions between indigenous and commercial fishing sectors: the Torres Strait tropical rock lobster fishery

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