THE NEW ZEALAND SEAFOOD INDUSTRY COUNCIL LTD

Estimation of a non-linear parameter when relating CPUE to abundance in an orange roughy fishery

Allan Hicks

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SCHOOL OF AQUATIC & FISHERY SCIENCES
COLLEGE OF OCEAN AND FISHERY SCIENCES • UNIVERSITY OF WASHINGTON

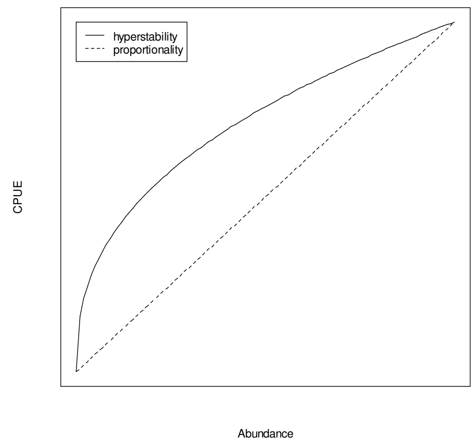
Relationship between CPUE and Abundance

$$U=\alpha N^{\beta}$$

- Usually assume a straight-line relationship
- However, it may be non-linear

Hyperstability

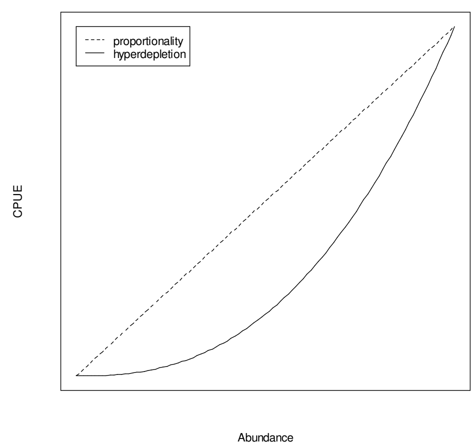
- $0 < \beta < 1$
- Abundance declines faster than CPUE
- Effort concentrates where fish are abundant
  - Efficient searching for the majority of biomass



Harley, Myers, & Dunn (2001) concluded hyperstability

Hyperdepletion

- $\beta > 1$
- CPUE declines faster than abundance
- Differential behavior response to gear, taking more susceptible fish first
- Few high density aggregations and a large low density abundance



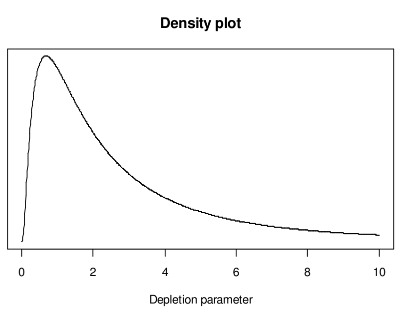
Tuna fisheries have seen hyperdepletion (Sosa-Lopez & Manzo-Monroy 2002)
Walters (2003) suggested improper spatial analysis can result in hyperdepletion

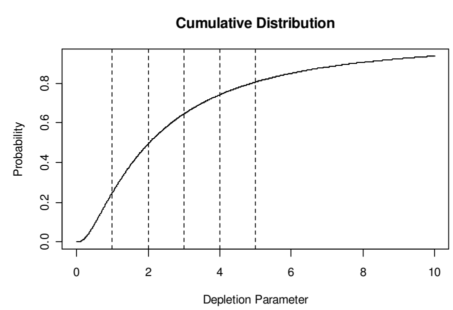
Hyperdepletion in orange roughy fisheries

- Hicks 2004 found hyperdepletion in 3 of 4 orange roughy stocks
- Can be the result of a number of reasons
  - Methods of CPUE analysis (Walters 2003)
  - Fish behaviour
  - Fishing behaviour
- What can we do?
  1. Ignore non-linearity
  2. Exclude CPUE from assessments
  3. Estimate β in the assessment
  4. Estimate β in the assessment with a prior

Hyperdepletion in orange roughy fisheries

- Developed a prior on β using that analysis
  - Median = 2.03
  - CV = 1.406





Hyperdepletion in orange roughy fisheries

- Two assessments in 2004 estimated hyperdepletion
  - MEC: $\beta = 1.71$
  - NWCR: $\beta = 2.22$
- If hyperdepletion is present, can it be estimated
- Simulations done to try and answer that question

Software packages

- Software packages
  - Coleraine
    - Estimates log(β)
    - α estimated analytically
  - CASAL
    - Estimates $1/\beta$
    - α estimated freely
    - Biomass standardized by maximum

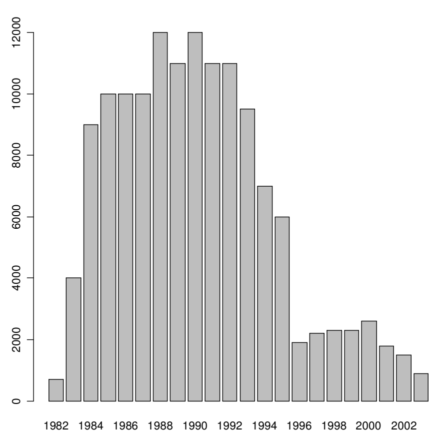
$$U = \alpha' \left(N / \max(N) \right)^{1/\beta'}$$

Operating Model

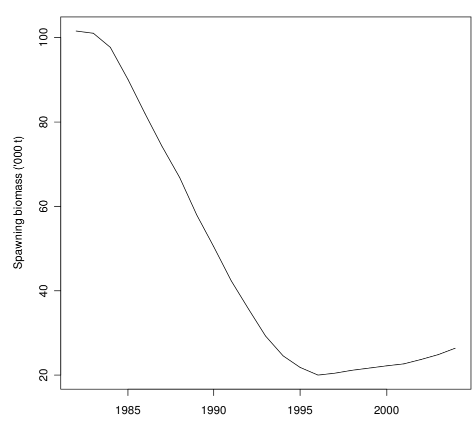
- Each package used itself as the operating model
- Population similar to the MEC stock in terms of
  - Catches
  - Biomasses
    - B0 ≈ 101 650, B2004 ≈ 26 000
  - Selectivities
    - a50 = 40; aTo95 = 12
  - TZ maturity
    - a50 = 31.31; aTo95 = 7.07
  - Growth, etc.

Operating Model

Catches



Spawning Biomass



Observations

- CPUE
  - 19 observations
  - 1984-1988, 1990-2003
  - CV's around 0.28, unless specified
- Relative surveys
  - 3 observations 1992-1994
  - CV's 0.34, 0.25, 0.27
- Absolute surveys
  - 2 observations 2001 and 2003
  - CV's 0.38 and 0.76
- Simulated from biomasses
  - Using lognormal distribution with above CV's

Simulation Design

- Estimating model same as operating model
- Three sets of simulations
  1. CPUE only
  2. CPUE and relative surveys
  3. CPUE and absolute surveys
- 1000 (Coleraine) or 500 (CASAL) simulations
  - Simulations with unclear convergence deleted
- True β values of 1.6, 1.0, and 0.625
- Mat2Sel in most runs

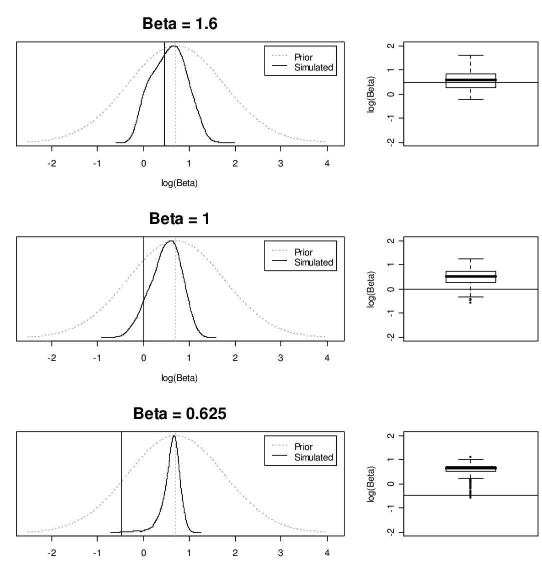
CPUE only

- Six runs explore the different *β*'s and the effect of the prior
  - *β* equals 0.625, 1.0, and 1.6
- One run explores the effect of using *β*=1 when hyperdepletion is present (*β*=1.6)
- Then explore the effect of cv's on the estimate of *β*

CPUE only; with prior

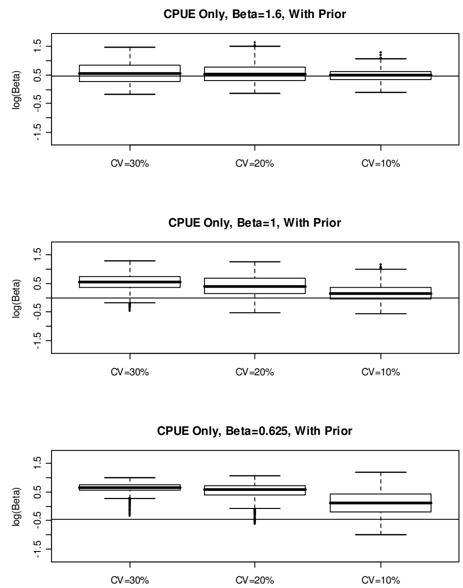
- Prior has influence

Beta	MSE	Bias	Var
1.6	0.134	0.092	0.126
1	0.339	0.486	0.103
0.625	1.195	1.074	0.041



Different CV's; with a prior

- Simulated CPUE and estimated parameters with CV's
  - 0.10, 0.20, & 0.30
- Estimation done with a prior



MSE

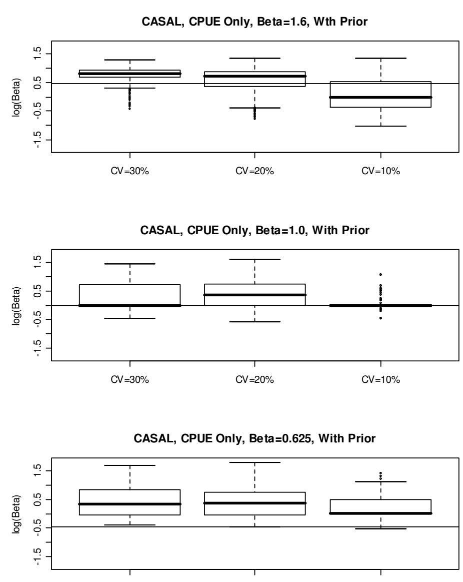
Beta	**cv=30**	**cv=20**	**cv=10**
1.6	0.129	0.117	0.058
1	0.381	0.291	0.129
0.625	1.213	1.047	0.520

Bias

Beta	**cv=30**	**cv=20**	**cv=10**
1.6	0.077	0.064	0.005
1	0.541	0.399	0.156
0.625	1.086	0.984	0.586

CASAL: CPUE only, with prior

- Beta=1 didn't move much



MSE

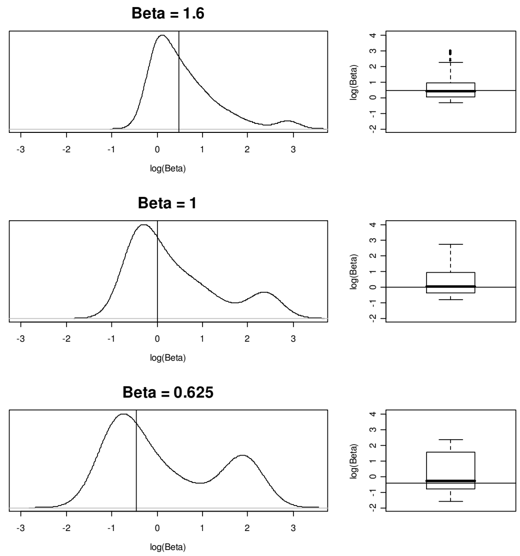
Beta	**cv=30**	**cv=20**	**cv=10**
1.6	0.168	0.191	0.467
1	0.295	0.382	0.012
0.625	1.067	0.979	0.579

Bias

Beta	**cv=30**	**cv=20**	**cv=10**
1.6	0.312	0.112	-0.413
1	0.311	0.413	0.014
0.625	0.895	0.869	0.672

CPUE only; no prior

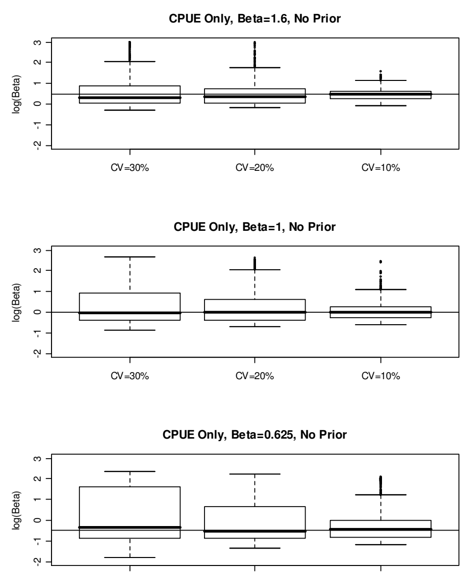
- Without prior highly variable estimates



Beta	MSE	Bias	Var
1.6	0.532	0.124	0.517
1	0.967	-0.074	0.961
0.625	1.469	-0.289	1.386

Different CV's; no prior

- Simulated CPUE and estimated parameters with different CV's
  - 0.10, 0.20, & 0.30
- Estimation done without a prior



MSE

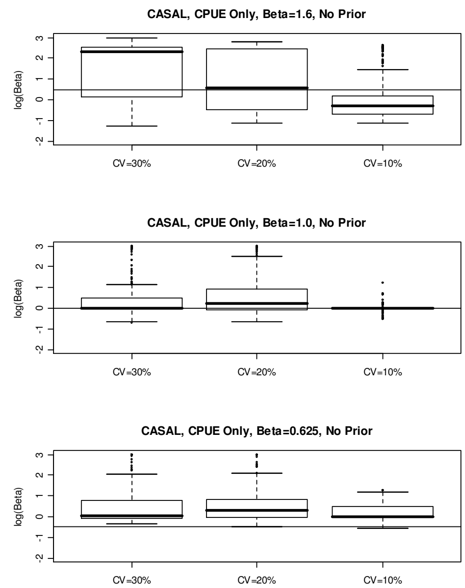
Beta	cv=30	cv=20	cv=10
1.6	0.532	0.259	0.071
1	1.217	0.727	0.177
0.625	1.902	1.317	0.495

Bias

Beta	cv=30	cv=20	cv=10
1.6	0.095	0.004	-0.018
1	0.403	0.259	0.042
0.625	0.635	0.438	0.170

CASAL: CPUE only, no prior

- Beta=1 didn't move



MSE

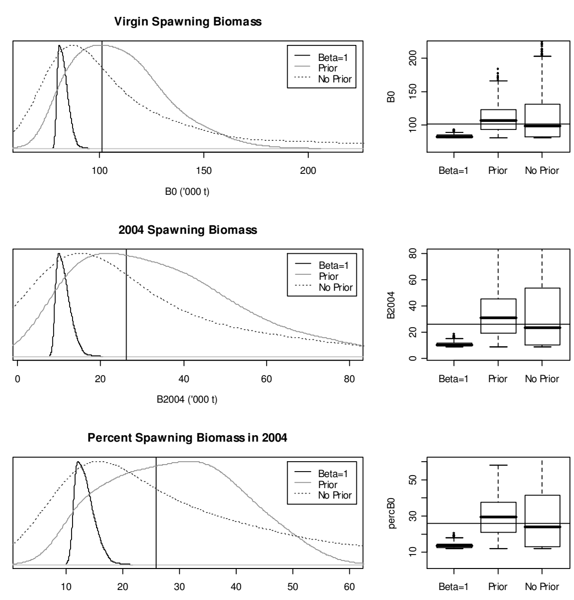
Beta	cv=30	cv=20	cv=10
1.6	3.006	2.075	1.094
1	1.399	1.318	0.010
0.625	1.686	1.288	0.587

Bias

Beta	cv=30	cv=20	cv=10
1.6	1.083	0.392	-0.554
1	0.500	0.553	0.002
0.625	0.966	0.929	0.671

CPUE only β fixed at 1

- True β=1.6
- Biomass estimates biased low
- Trade-off between variance and bias
  - What is a good measure of bias when the density is skewed



CPUE only β fixed at 1

- Statistics

MSE	beta1	prior	noPrior
B0	354.93	507.20	12477.68
B2004	230.72	440.86	12200.73
percB0	156.67	134.71	427.12

Variance	beta1	prior	noPrior
B0	5.29	440.34	11492.79
B2004	2.62	372.64	11164.59
percB0	2.37	122.44	408.70

Bias (mean)	beta1	prior	noPrior
B0	-18.70	8.18	31.38
B2004	-15.10	8.26	32.19
percB0	-12.42	3.50	4.29

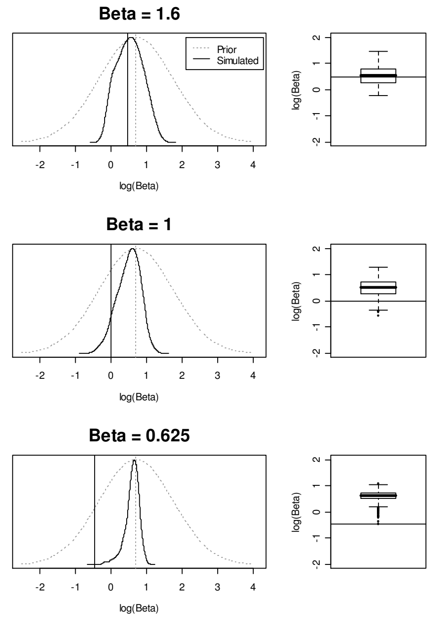
Bias (median)	beta1	prior	noPrior
B0	-19.14	5.54	-3.43
B2004	-15.45	5.03	-3.04
percB0	-12.73	3.36	-2.19

CPUE and relative abundances

- Nine runs
  - Three years of relative abundances in 1992, 1993, 1994
  - Three years of relative abundances in 1990, 1993, 1996
  - Three years of relative abundances in 1992, 1993, and 1994 with no prior on β

1992, 1993, 1994 relative abundances

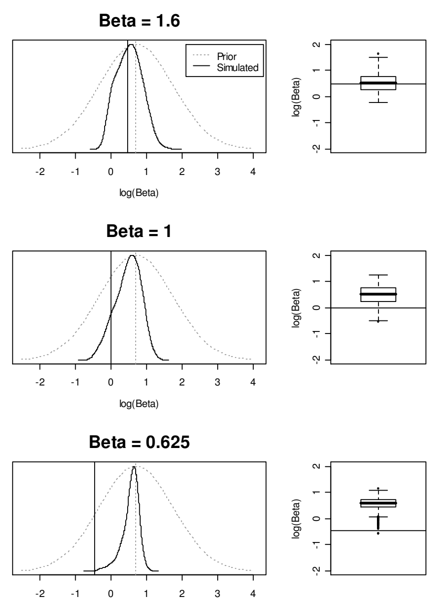
- Similar results as CPUE only
- Prior swamps the estimate of β



Beta	MSE	Bias	Var
1.6	0.130	0.063	0.126
1	0.344	0.493	0.101
0.625	1.173	1.063	0.043

1990, 1993, 1996 relative abundances

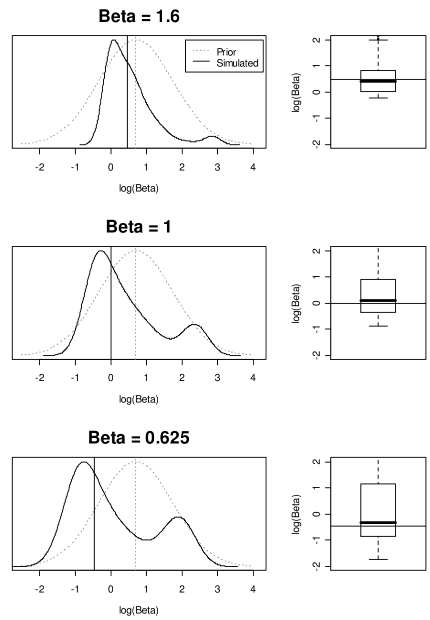
- Slightly wider range of estimates



Beta	MSE	Bias	Var
1.6	0.122	0.047	0.120
1	0.347	0.472	0.124
0.625	1.104	1.023	0.058

1992, 1993, 1994 relative abundances with no prior

- Wide range of estimates
- Less bias with smaller true values



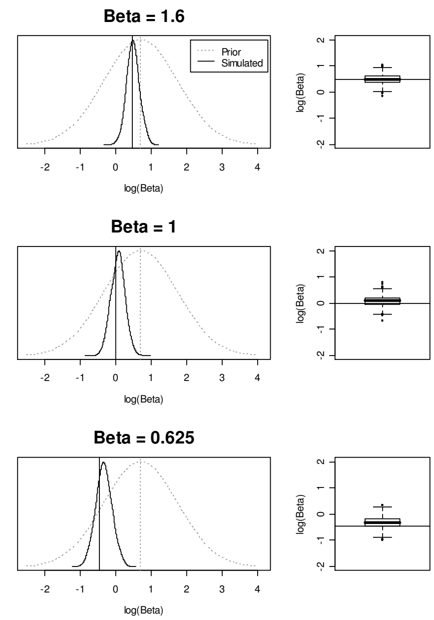
Beta	MSE	Bias	Var
1.6	0.478	0.086	0.471
1	1.145	0.416	0.972
0.625	1.651	0.574	1.322

CPUE and absolute abundance

- Three runs with the prior
- Absolute abundances in 2001 and 2003
  - Cv’s of 0.38 and 0.76

CPUE and absolute abundance

- Data able to overtake prior even with high cv's



Beta	MSE	Bias	Var
1.6	0.032	0.021	0.031
1	0.043	0.066	0.038
0.625	0.069	0.139	0.050

Conclusions

- Prior has a lot of influence with CPUE and relative abundances
  - Can estimate β without prior, but with low precision
  - Catchability is the difficulty
    - Fix catchability at true value in relative time series and it performs well
- Absolute abundance has a lot of information
  - Even with high cv's
- Making a wrong assumption of β=1 can have large effects on the interpretation of the stock

Further work

- Study the large estimates without a prior
- Look closer at relative surveys
  - Determine what is needed from a relative series to estimate β
    - Initial work indicates lower cv's and a long time series
- Absolute abundance
  - Precision with lower cv's and longer series
- Incorporate catch at age and catch at length
  - Effects of estimating selectivity
  - Need to adequately simulate the data