Stock Assessment Of The Torres Strait Spanish Mackerel Fishery

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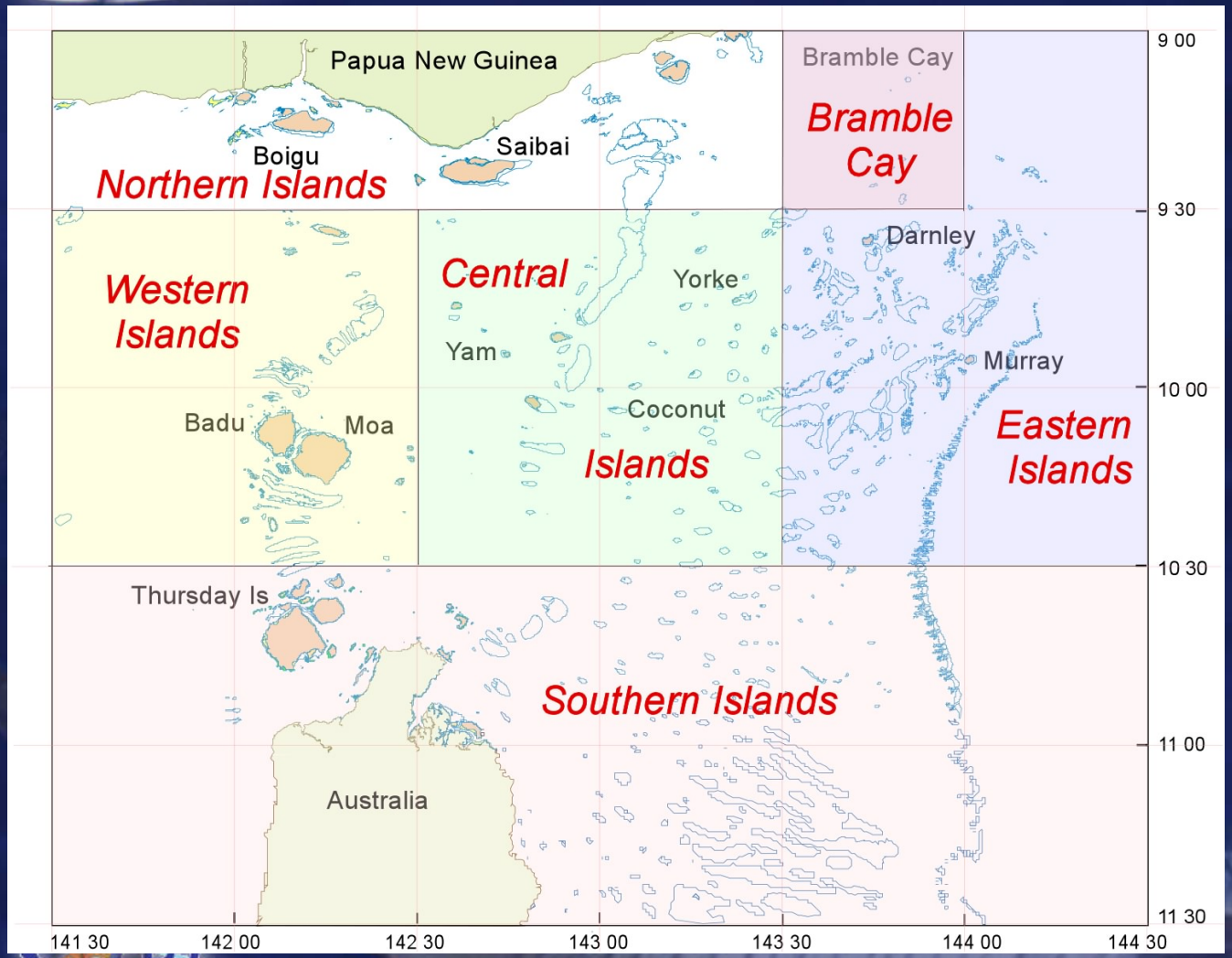
Location



- Lat 9s-11.5 s
- Long 141.5E-144.5E
- Between the Cape York and PNG
- Divided into 6 regions (using AFMA 30” Grid)
  - Bramble Cay
  - Central Islands
  - Easter Islands
  - Northern Islands
  - Southern Islands
  - Western Islands

Background: Fishery Description

- Commercial:
  - Commence: 1930s
  - Increase from 1950
  - From 2003, non-islander licenses is limited to 17
  - Operation
    - Small dories (5-6 m) operated from larger primary vessel (9-16m)
    - Trolling, Hand lines
    - 2 sessions (am, pm)
- Islanders (Commercial and Subsistence):
  - Livelihood for traditional, culture and subsistence
  - Main Independent financial resources
  - Operated from the Islands
  - Community and council freezer: Murray, Darnley and York Island
- Illegal Foreign Fishing Fleets
  - Taiwanese gill net fishers
  - Indonesian fishers
  - Effect unknown

Background: Management History

Year	Management
1985	Torres Strait Treaty. Torres Strait Fisheries Act dictates joint authority and management of Spanish mackerel fishery between Australia and Papua New Guinea, including catch sharing arrangements. Establishment of Torres Strait Protected Zone Joint Authority (TSPZJA) to regulate all fisheries in Torres Strait. Transferable licences issued to non traditional inhabitants who could demonstrate history and commitment to fishing in Torres Strait. Licences subject to strict vessel replacement regulations related to vessel size. Vessels restricted to less than 20 m in length. Traditional inhabitants could obtain the commercial fishing license from TPZJA. Ban on netting of Spanish mackerel. Minimum legal size of 45 cm TL for Spanish mackerel.
1988	SM01 logbook introduced (compulsory for non-Islander and PNG fishers)[1].
1990	SM02 logbook introduced (compulsory for non-Islander and PNG fishers).
1998	Fishing methods restricted to trolling, hand-lining and drop-lining. Licence holders allowed to carry no more than 50 kg of other finfish besides mackerel. Minimum legal size of 45 cm TL for all mackerel.
1999	Traditional inhabitants required to hold a current Torres Strait Traditional Inhabitant Fishing Boat Licence (TIB) or Torres Strait Fishing Boat Licence for commercial fishing in TSPZ. Fishery expanded to include spotted, school, shark and grey mackerel. Transfer of fisheries management jurisdiction from Queensland to PZJA.
2003	TSF01 logbook introduced (compulsory for non-Islander and PNG fishers).
2004	Islander docket book introduced. Minimum legal size increased to 75 cm TL for Spanish mackerel.

Background: Research History

Year	Author	Research
1943	Munro	Revision of Australian *Scomberomorus* species, including Spanish mackerel.
1974	Lewis *et al.*	Spawning season of *Scomberomorus commerson* in Papua New Guinea.
1984	Collette and Russo	Morphology, systematics and biology of *Scomberomorus* species, including Spanish mackerel.
1985	Chapau and Opnai	Taiwanese gill net fishing in the Gulf of Papua.
1985	McPherson	Preliminary review of Torres Strait Spanish mackerel fishery.
1985	Shaklee	Genetic variation and population structure of Torres Strait Spanish Mackerel.
1988	McPherson	Spanish mackerel stock structure and movements in Torres Strait.
1992	McPherson	Age and growth of Spanish mackerel in north-eastern Queensland waters including Torres strait.
1994	O'Brien	Preliminary assessment of Torres Strait Spanish mackerel fishery.
1997	Haywood and Die	Assessment of Torres Strait Spanish mackerel fishery. Due to poor data quality assessment not conducted; recommendations made concerning data issues.
1998	Williams and O'Brien	Assessment of Torres Strait Spanish mackerel fishery.
2000	Lilly	Review of the SM02 logbook for Spanish mackerel fishery.
2001	Lester *et al.*	Stock structure of Spanish mackerel in northern Australia based on parasites.
2002	Lilly	Historical catch and effort data for the Spanish mackerel fishery.
2003	Moore *et al.*	Stock structure of Spanish mackerel in northern Australia based on parasites.
2004	Begg and Murchie	Islander community freezers catch data for the eastern Torres Strait.
2004	Ovenden	Population genetic analysis of Spanish mackerel stock structure in the Gulf of Carpentaria and Torres Strait
2005	Buckworth *et al.*	Stock structure of Spanish mackerel in northern Australia.
In prep	Rose *et al.*	DPI&F Long Term Monitoring Program of Torres Strait Spanish mackerel.
Present	Begg *et al.*	Assessment of Torres Strait Spanish mackerel fishery.

Background: Monitoring History

- Monitored by
  - AFMA and QDPI&F using commercial non-islanders compulsory logbooks,
  - AFMA Islander docket book (2004)
  - a part of QDPI&F LTMP project
  - AFMA Voluntary logbook recording sex and length (2004)
  - CRC Sex, age and length collection (2005)

Objectives

- Describe the current trends and the status of fishery
- Advice the monitoring, reporting and further research required

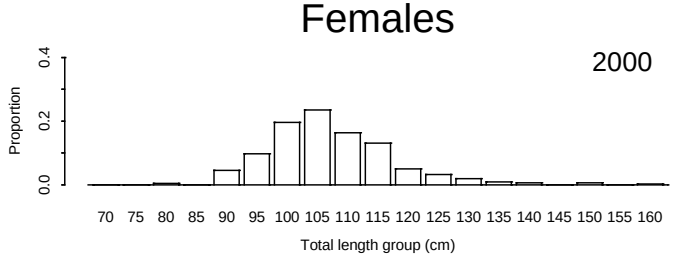
Outline

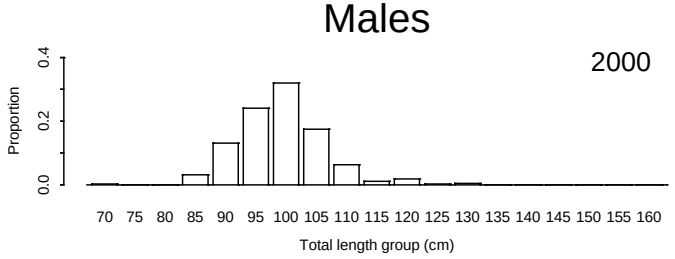
- Biology
- Fishery and Total Catch
- Catch Rate (CPUE)
- Stock assessment model
- Management Strategy Evaluation
- Monitoring
- Discussion

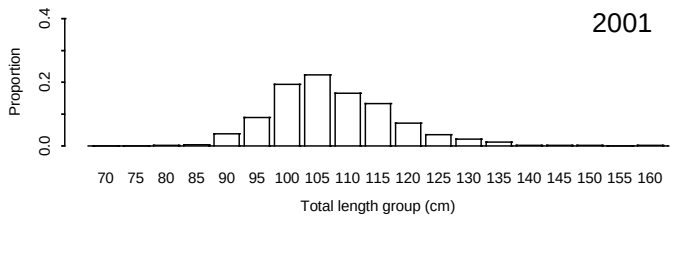
Biology

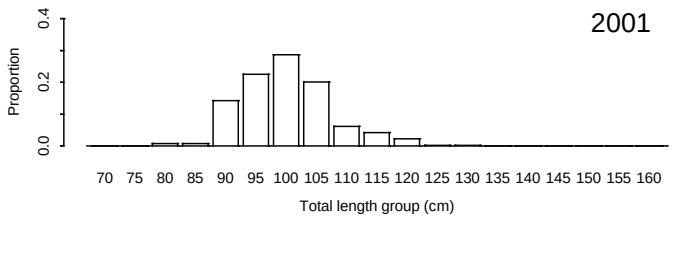
- Data: QDPI&F LTMP and AFMA Volunteering logbook
  - Age was read by 3 individuals and adjusted
  - 2000-2002
  - <14 days in the October around Bramble Cay
  - Gonad was staged using Macroscopic staging scheme (stages 4-9 indicates mature females)
- Biology
  - Oldest age: 12 yrs old (128cm, unknown sex)
  - female: Oldest, 10 yrs old (137cm), largest 168 cm (8 yrs old) and heaviest 26 Kg (Age unknown, 161cm)
  - male: Oldest, 10 yrs old (12, 129cm), largest 133 cm (5,6 yrs old) and heaviest 15 Kg (6 yrs old)
  - Female grow faster than male (K female: 0.16, male:0.12) and female tends to be large than male (Lmax female:159 and male: 144 cm TL)
  - Fecundity: Gonad weight as indication (on average, 1 kg body mass 135g gonad wt)
  - Maturity: (Mackie 2002)
    - Female: 60% matured at 1+, 99% matured at 4+
    - Male: 60% matured at 1+, 99% matured at 3+

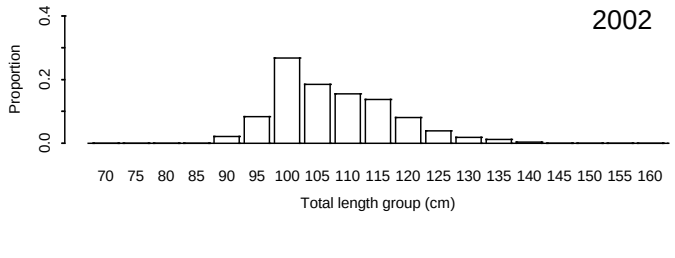
Length frequency distribution

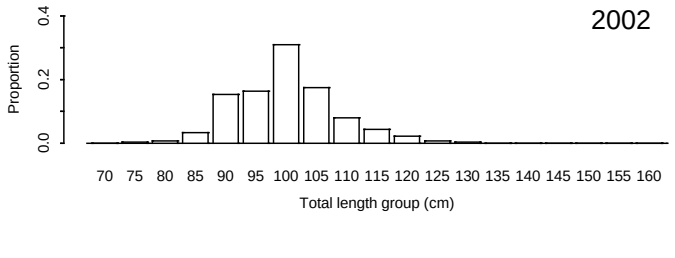


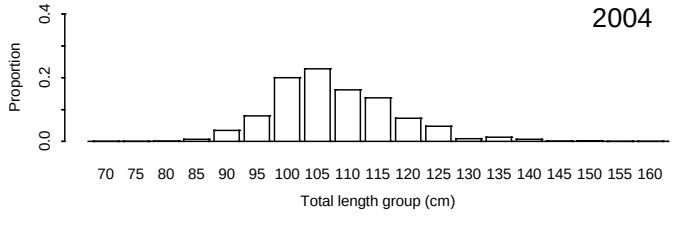


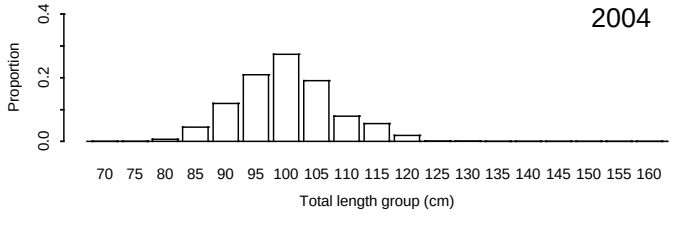




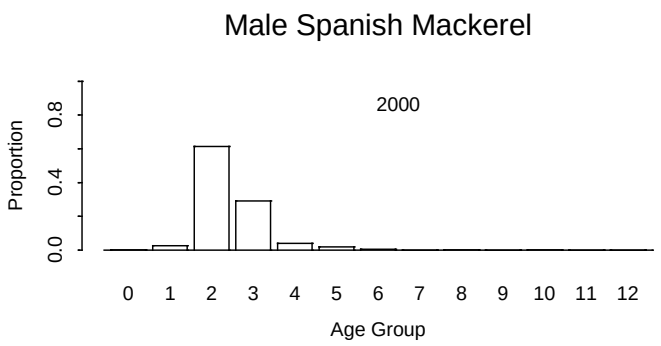


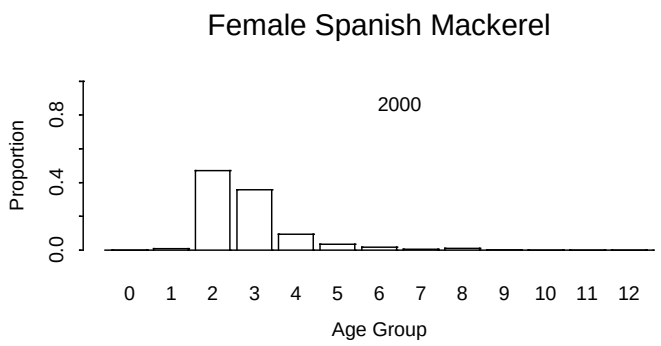


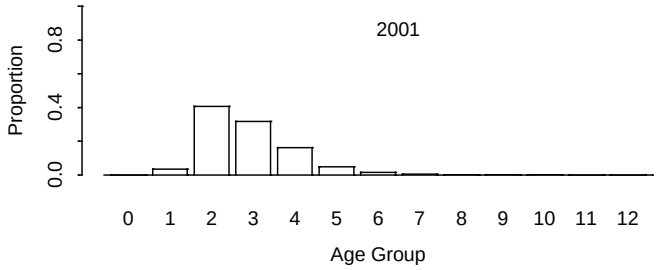


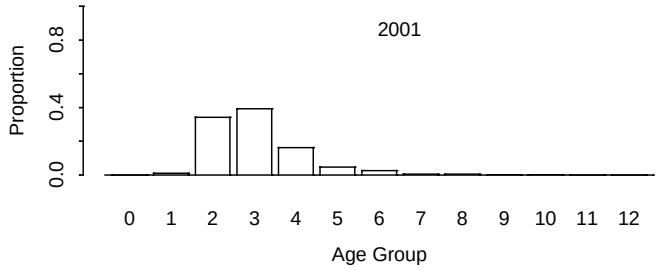


Age Frequency Distribution



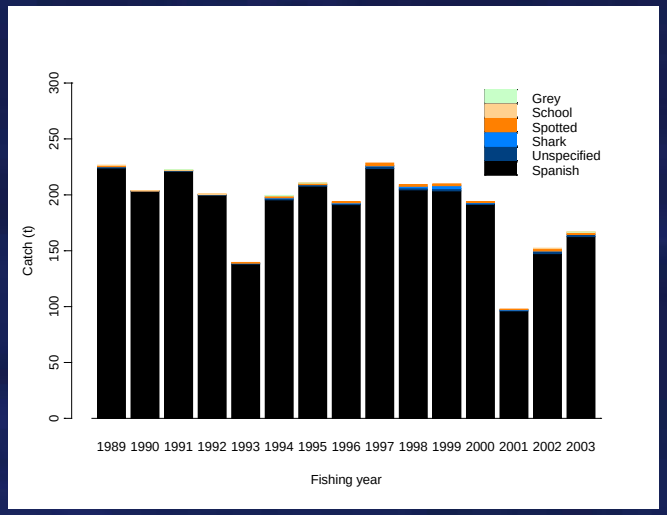






Fishery: Commercial Non-Islanders

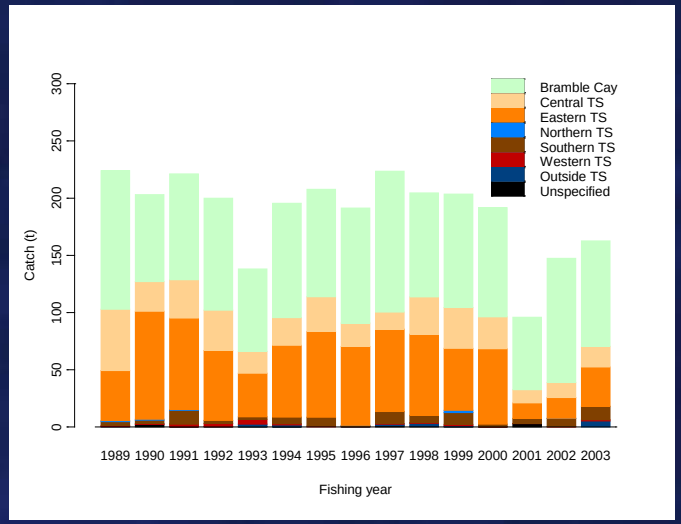
- All species of mackerel
  - Large proportion of Spanish mackerel (*S. commerson*)
  - Small proportion of grey, school, shark mackerels (0.7-6.3 t)
- Mackerels catches from
  - Mackerel Fishers
  - Dual Fisher (both Mackerel and Reef line license holder)
  - Reef line fishers
  - Rock lobster and Prawn

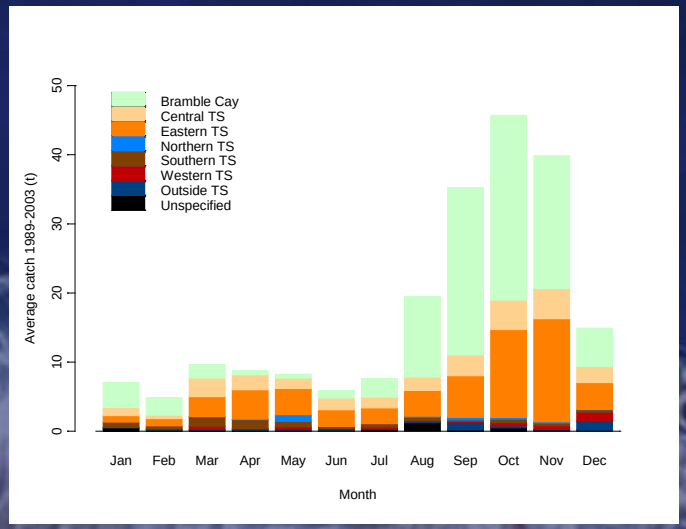


Fishing year	Non-Islander Torres Strait Commercial Fishery Total Mackerel Catch (t)				
	Mackerel	Dual	Reef	Lobster	Prawn
1989	184	39	3		
1990	187	16	<1		
1991	208	12	2		
1992	192	8	1		
1993	136	2	1	0.2	
1994	170	26	2	0.3	
1995	209			0.3	
1996	183	8		1.4	
1997	200	26		0.5	
1998	192	16		0.1	0.1
1999	182	26		0.1	0.4
2000	173	20		0.1	0.2
2001	96	<1		0.3	0.7
2002	141	4	4	0.6	0.2
2003	142	12	10	0.4	0.1
Average	*173*	*15*	*3*	*0.4*	*0.3*

Fishery: Commercial Non-Islanders

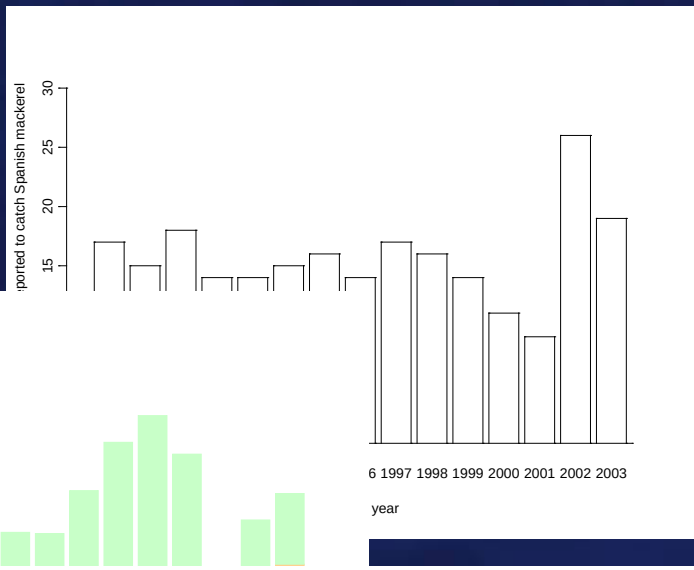
- Annual Catches:
  - Fairly constant in 90's (except '93)
  - Reduction in 2001 (1/2 of previous year)
  - Graduate increase after 2003
- Month Catches:
  - Peak Sep-Nov for Bramble Cay regions
  - Two peaks for Eastern TS region:
    - Spring and Autum.
- Bramble Cay is major fishing ground and well-know spawning ground

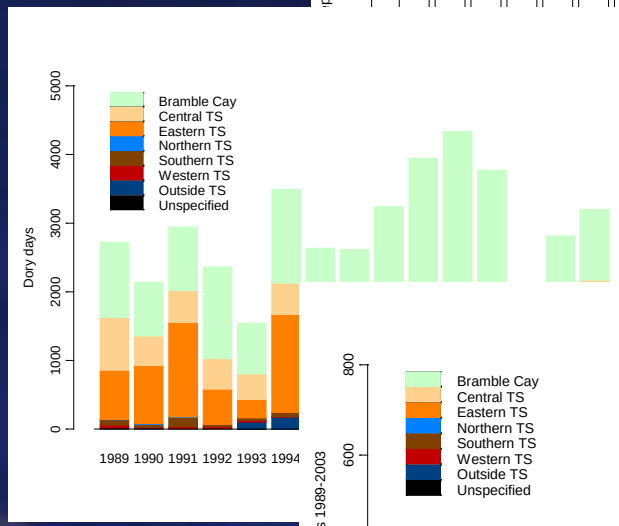


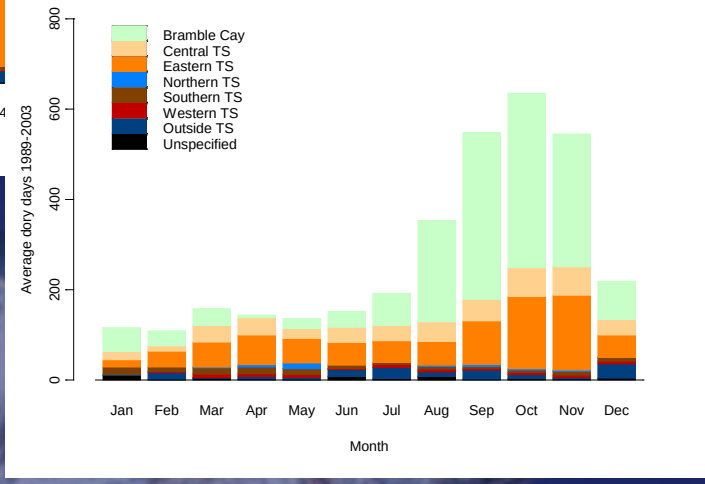


Fishery: Commercial Non-Islanders Efforts

- Number of boats:
  - Constant late 80's and early 90's
  - Drop in late 90's
  - Highest number in 2002 and 2003
- Annual effort:
  - Fluctuate
  - Bramble cay and Eastern TS
- Monthly effort:
  - High level effort between Sep-Nov
  - Bramble cay: Sep-Nov
  - Eastern TS:
    - Sep-Nov
    - Constant within year

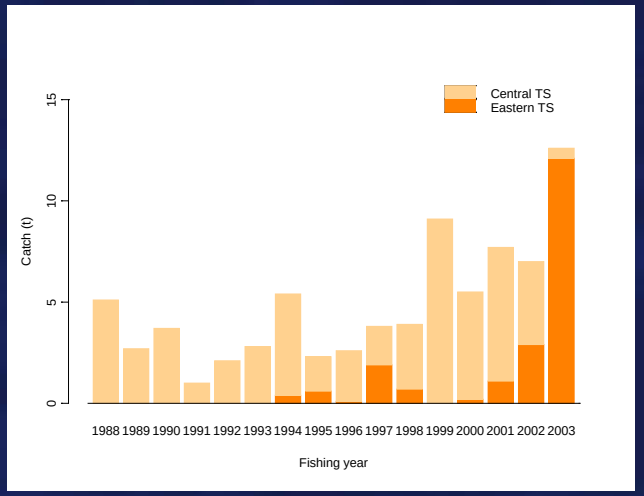


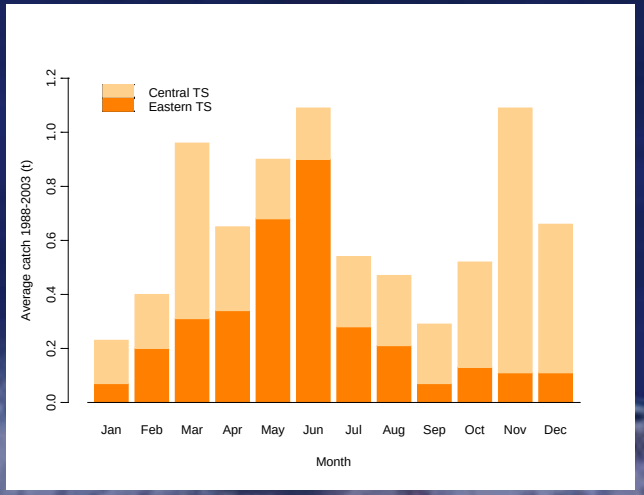




Fishery: Commercial Islander

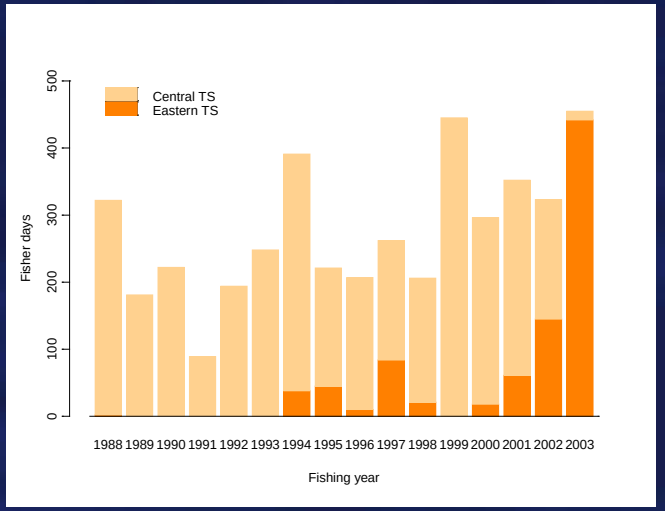
- Annual Catches:
  - 3 islands (Darney, York, Murray)
  - Increase from mid 90's
  - In 2003, large proportion of mackerel catches from Eastern Is.
  - No catch records available for Eastern Is. Prior to 94.
- Monthly Catches:
  - Two peaks:
    - Mar-Jun
    - Sep-Nov

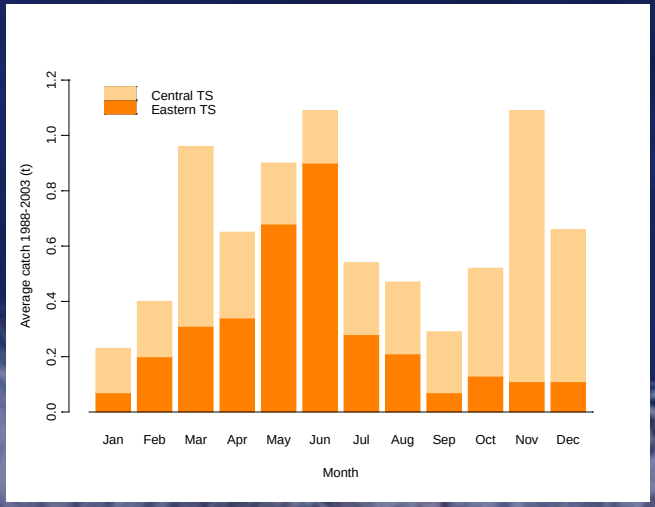




Fishery: Commercial Islander

- Annual effort
  - No obvious pattern
  - No effort records for Eastern Is prior to ’94.
- Monthly effort:
  - Two peaks:
    - Mar-Jun: Eastern Is.
    - Oct-Dec: Central Is.





Total Catches

- Combined from all available data sources
- Extrapolated to Virgin biomass (1940) by:
  1. GAM: Logbook data and McPherson (1985)
  2. Linear Extrapolation: Logbook data

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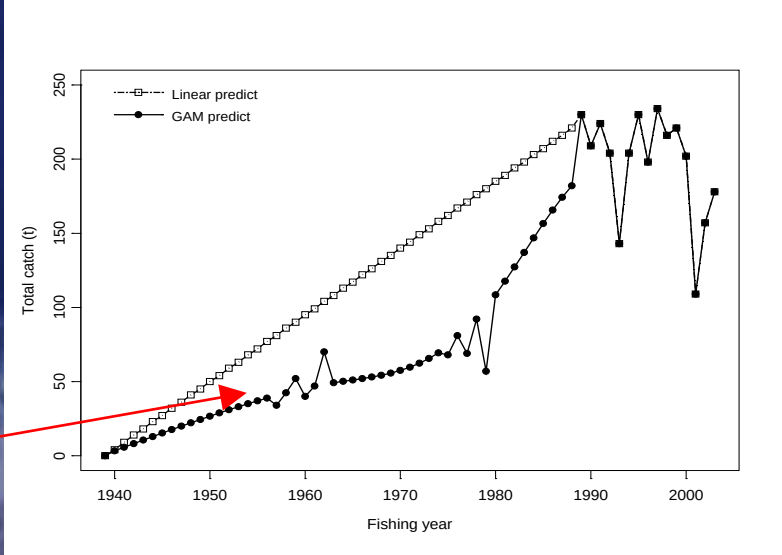
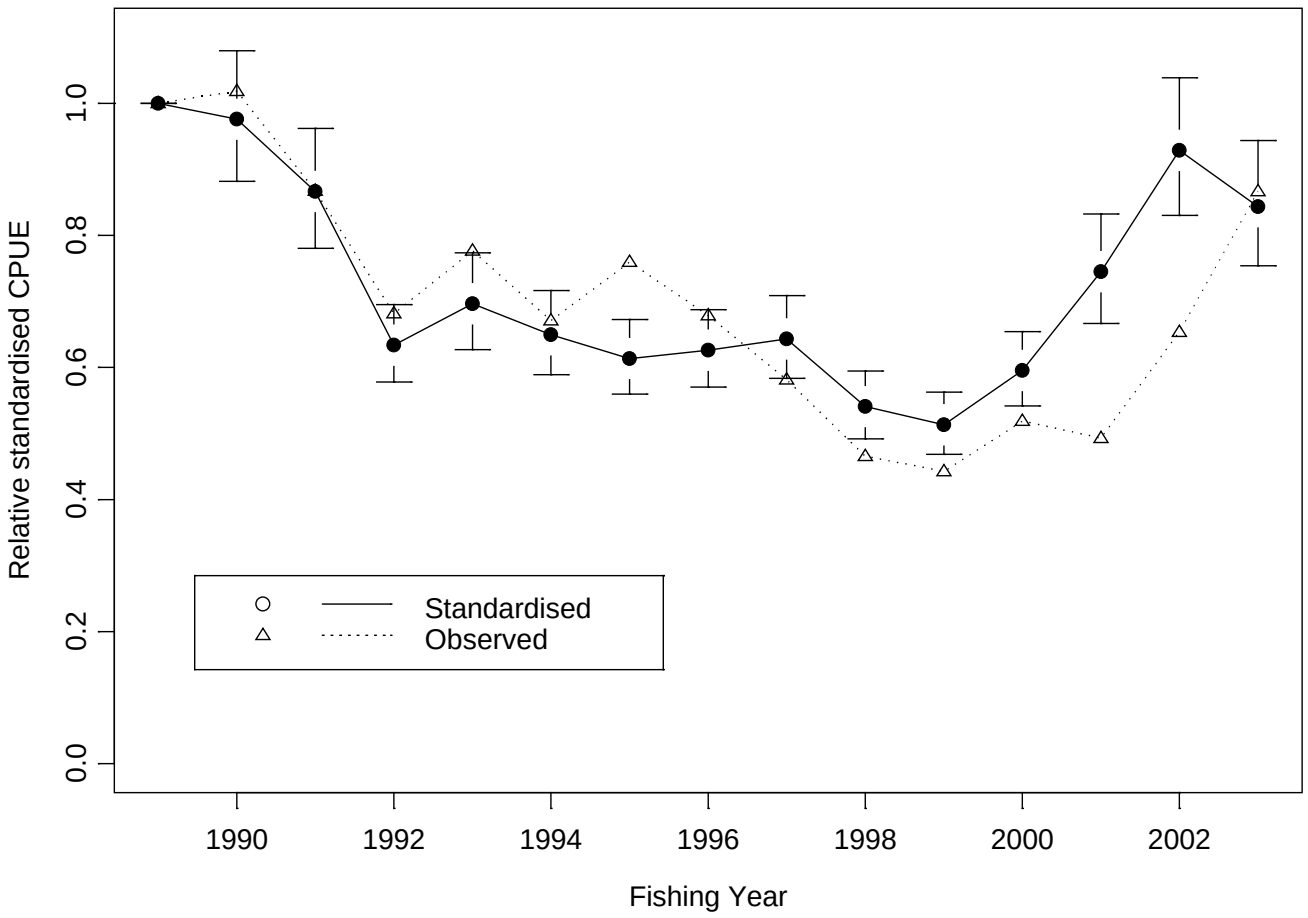


McPherson

Catch Rate (CPUE)

- Data: AFMA and QDPI&F non-islander commercial compulsory logbook and Council/community freezer records
  - Fishing over 7 years
- Standardized
  - Environmental factors: SOI, Wind direction composition, SST, Lunar phases
  - Month, region, Fishing type, Vessel
- Method:
  - Generalize linear mixed effect model

Catch Rate (CPUE)



Stock Assessment Model

- Sex-Specific Age structure model
  - Model is developed for NT SPM fishery (Buckworth, 2004)
  - Program: R
  - Input: Total catches, standardized catch rate and bio parameters
  - Output: Extrapolate of biomass to 1940
  - Maximum age: 12
  - Conduct forward projection

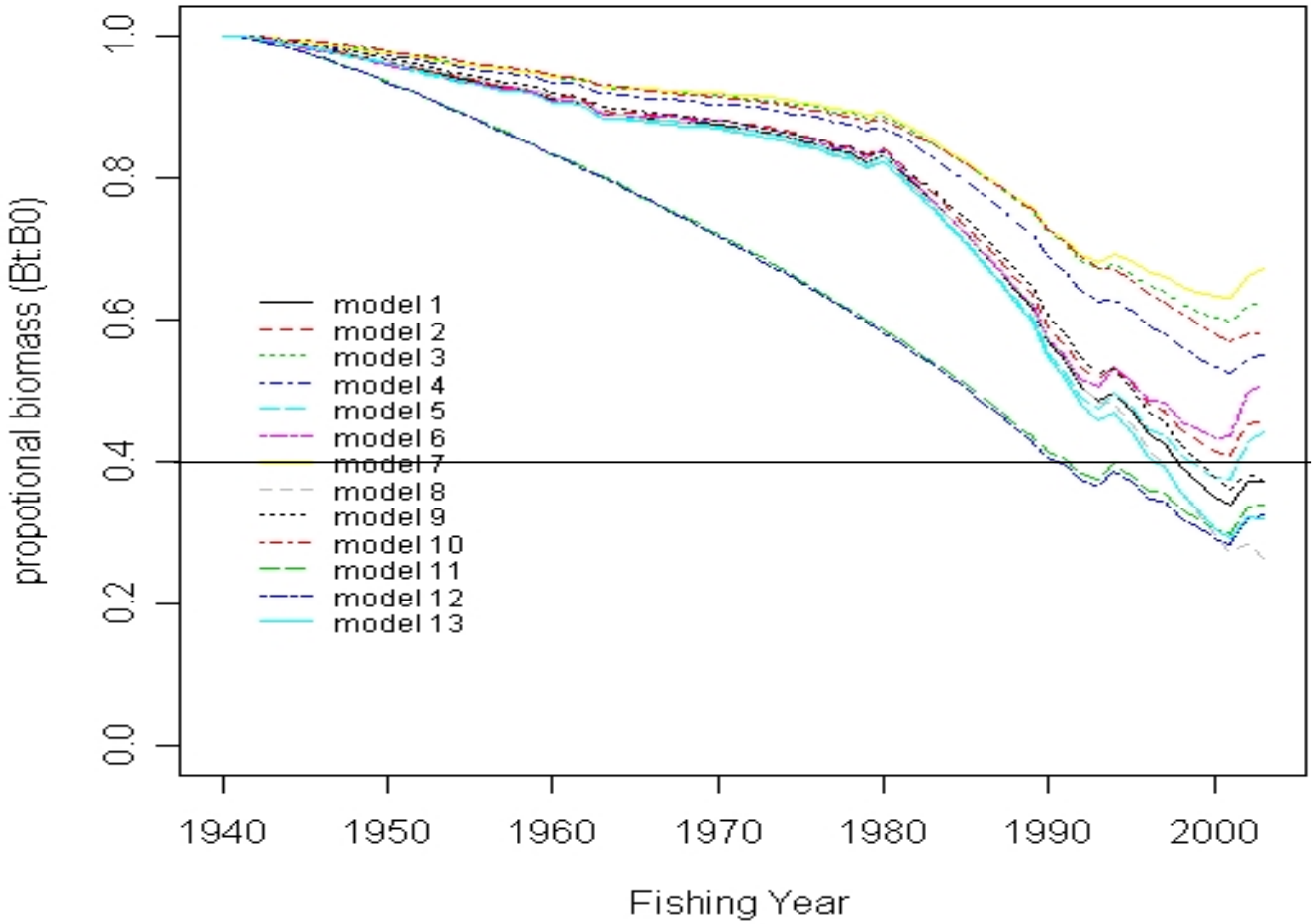
Stock Assessment Model

- Model assumption
  - Stock equilibrium in 1940
  - Steepness is 5.2 (rmax is 4.5)
  - No recruitment deviation
  - Constant annual natural mortality (12 years, M=0.37)
  - Constant average fish growth
  - Constant maturity, fecundity, selectivity
  - Accurate total catch and catch rate
  - Std catch rate s index of abundance
  - Single stock
  - Max age is 12 yrs old
  - TS stock have similar maturity and fecundity as the stock in Kimberly regions WA.

Sensitivity runs

Model sensitivity run	M	r_{max}	Age data	CPUE data	Others
1	0.37	4.5	Yes	Yes	Base case
2	0.44	4.5	Yes	Yes	
3	0.30	4.5	Yes	Yes	
4	0.26	4.5	Yes	Yes	Based on max age 17 years
5	0.37	9.3	Yes	Yes	
6	0.44	9.3	Yes	Yes	
7	0.30	9.3	Yes	No	
8	0.37	2.4	Yes	Yes	
9	0.44	2.4	Yes	Yes	
10	0.30	2.4	Yes	Yes	
11	0.37	4.5	Yes	Yes	Linear interpolation of catch data
12	0.37	4.5	Yes	No	Linear interpolation of catch data
13	0.37	4.5	Yes	No	GAM fitted catch data

Results


propotional biomass (Bt:B0)
0.0
0.2
0.4
0.6
0.8
1.0
1940
1950
1960
1970
1980
1990
2000
Fishing Year
model 1
model 2
model 3
model 4
model 5
model 6
model 7
model 8
model 9
model 10
model 11
model 12
model 13

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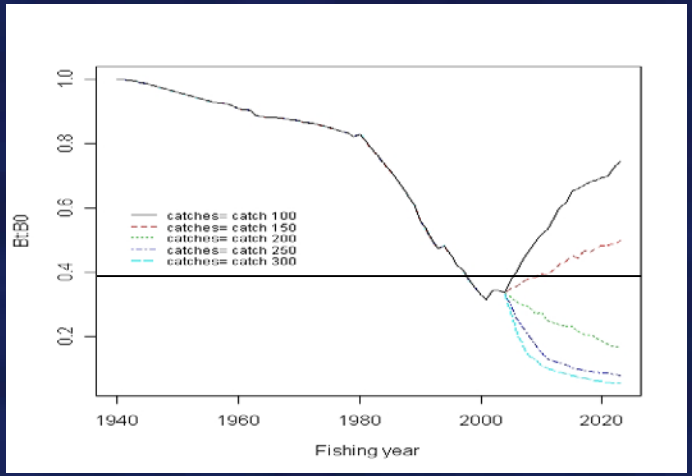
MSE: Forward Projection

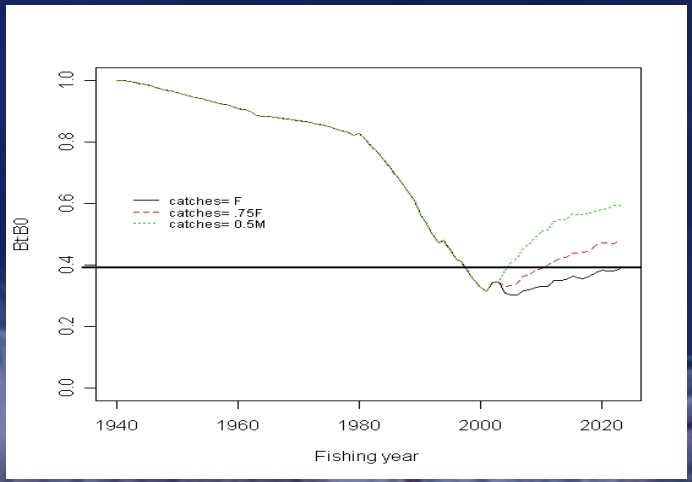
- Method: Monte Carlo forward projection by Richard *et al*(1998)
- 20 Years projection (~2023)
- Catch strategies:
  - Constant catches: 100, 150, 200, 250, 300 (t)
  - Catch rate: FMSY, 0.75FMSY, F=0.5M

Notation: MSY, Fmsy, 0.75FMSY, F=0.5m

MSE: Results

- Projected to 2023
- When fixing catches:
  - <150(t): increase biomass and B_{2023}>MSY
  - >150(t): reduction, $B_{2023} \leq 0.2B0$
- When fixing catch rate:
  - Increase
  - F=Fmsy, $B_{2023}<0.4B_0$

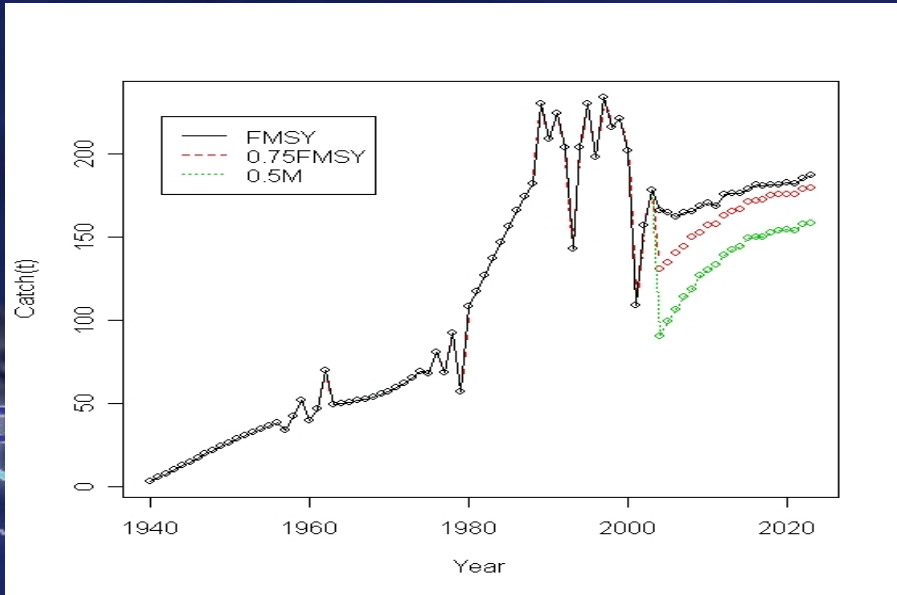




MSE: Forward Projection

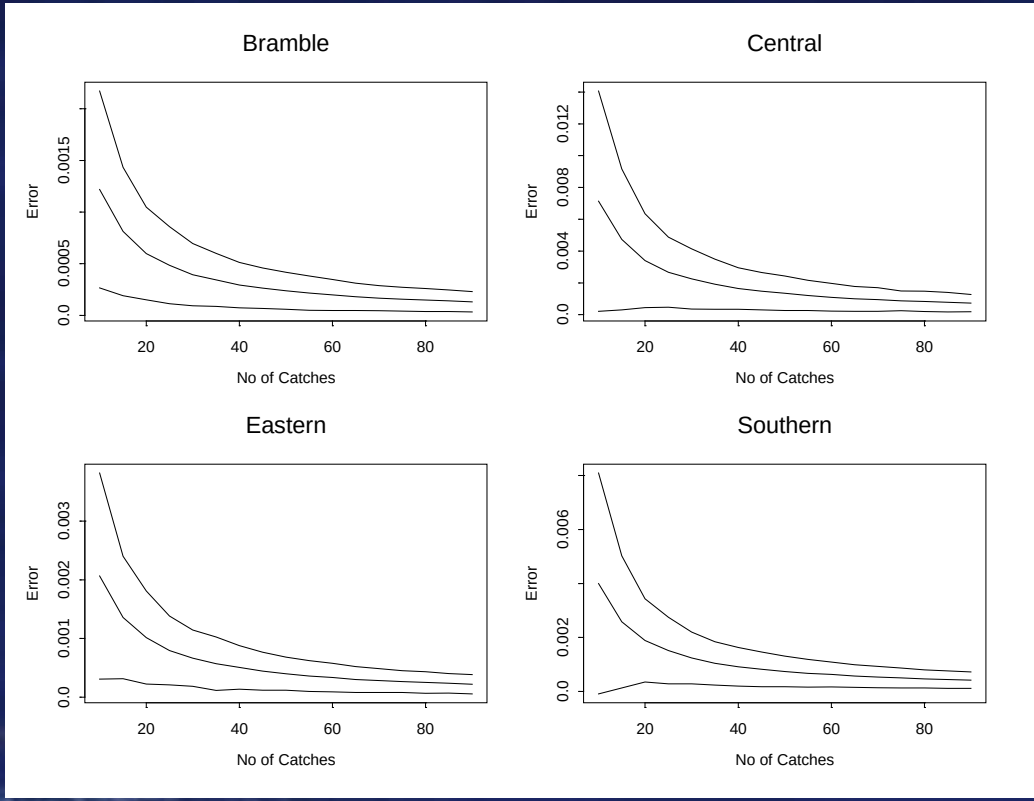
Catch (tonne)	P(B2023<BMSY)	B2023/B0
100	0.254	0.744
150	0.381	0.497
200	0.528	0.168
250	0.663	0.079
300	0.773	0.054

Catch rate	Catch 2023	$P(B_{2023} < B_{MSY})$	B_{2023}/B_0
Fmsy	187.49	0.349	0.388
$0.75F_{msy}$	180.52	0.1433	0.481
F=0.5M	158.97	0.092	0.596



Monitoring: sample sizes

- Method: Randomization (Sumpton and O'Neill, 2000)
- Optimum catches: ~30 from each regions (~80 fish per catches, 2400 individuals)
- During Ash's trip in TS, he collected ~700 samples in the duration ~ 10 days- but may not be cost-effective.



Discussion

Uncertainty

- In the data:
  - Illegal foreign fishing (Taiwanese gillnet)
  - Lack historical data
  - Foreign fishing pressure (PNG)
- For the model: biology, stock structure

- Data Limitation
  - Extend the data too far (~ 3 years data)
  - Missing data (Reef sector, 1993 to 2001)

Research and monitoring Recommendations

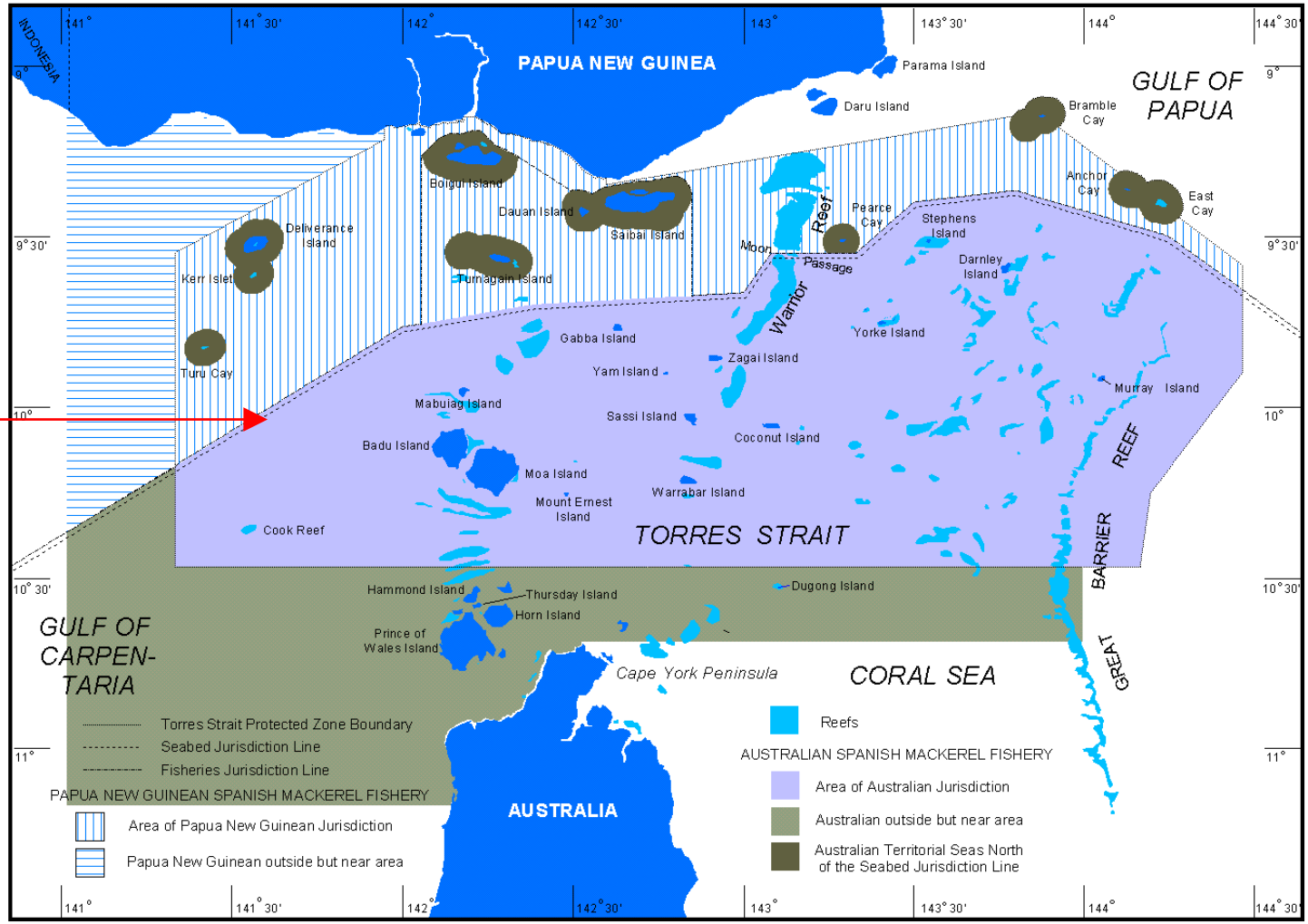
- Biology-need to know more
  - Biology of the Species (Growth, Mean age-length, weight, fecundity and maturity etc…)
  - Stock Structure
  - Movement
  - Age structure
- Data/Log book
  - Better database management
  - Lack historical fishing pressure (legal and illegal)
  - Logbook improvement
    - recording by-catch and number of under size fish caught and condition of release may need to be incorporated in future logbooks (Lilly 2000)
    - integration of reef line and Spanish mackerel logbooks
    - Species ID (combine all species of mackerels)
    - Effort Information
  - implementation of Islander logbook program
  - Validation of records (transshipment records vs Logbook)
- Potential of Genetag

Acknowledgement

- CRC Torres Strait
- Mick Mackie of WA fishery
- George Leigh of UQ
- Malcolm Haddon of UTAS
- John Marrington, Anne Shepherd and Thim Skousen of AFMA
- Inoni Harris of QDPI&F
- And many many more…
- Of course, the most important CRC Reef Fishing and fishery team.

Background: Management History

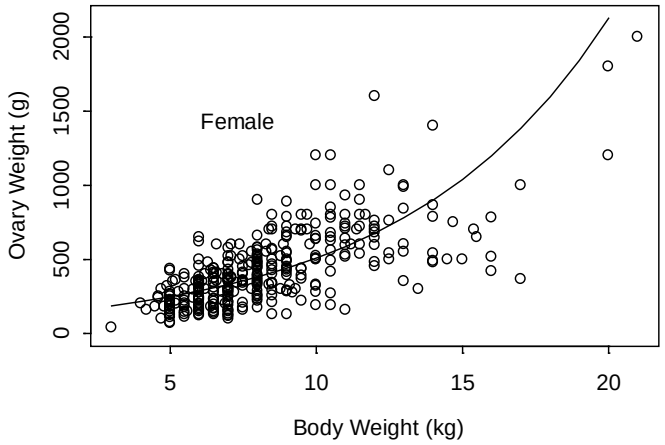
TZJA

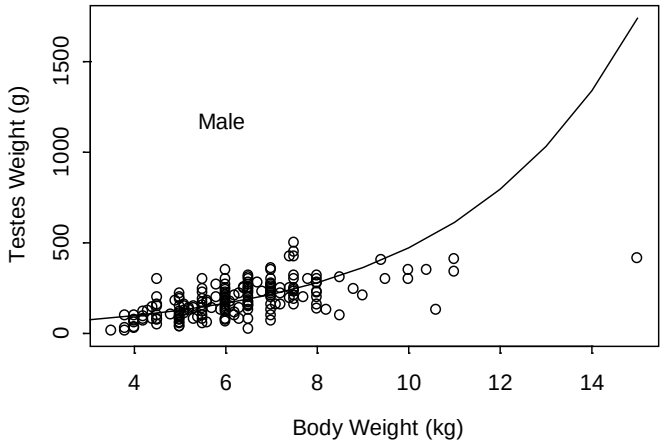


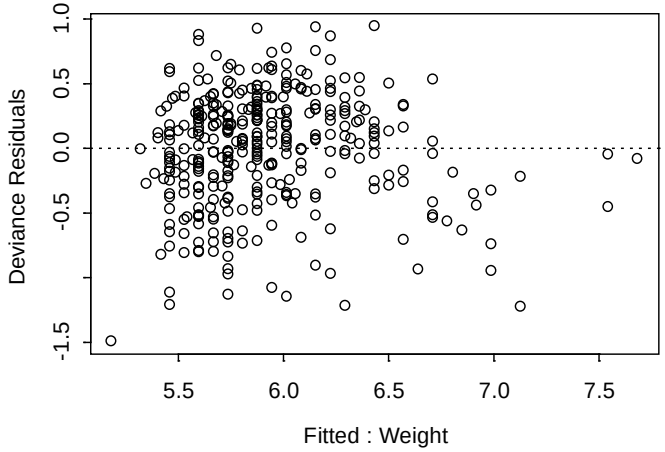
Background: Research History

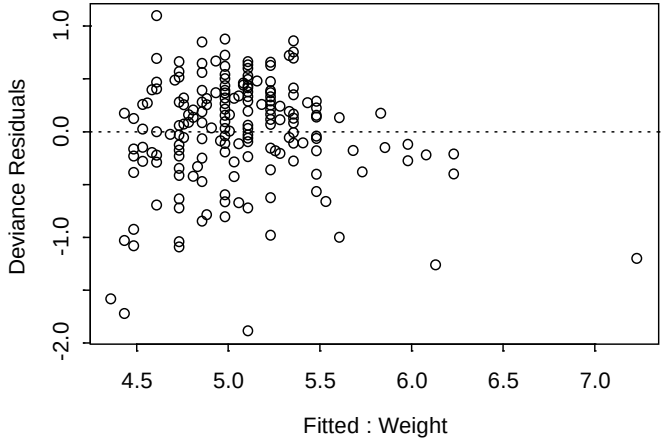
- Limited number of studies on TS Spanish mackerel
  - Stock structure
  - Few preliminary Stock assessment
    - Limited due to data quality
  - Little is known about the population dynamics

Fecundity

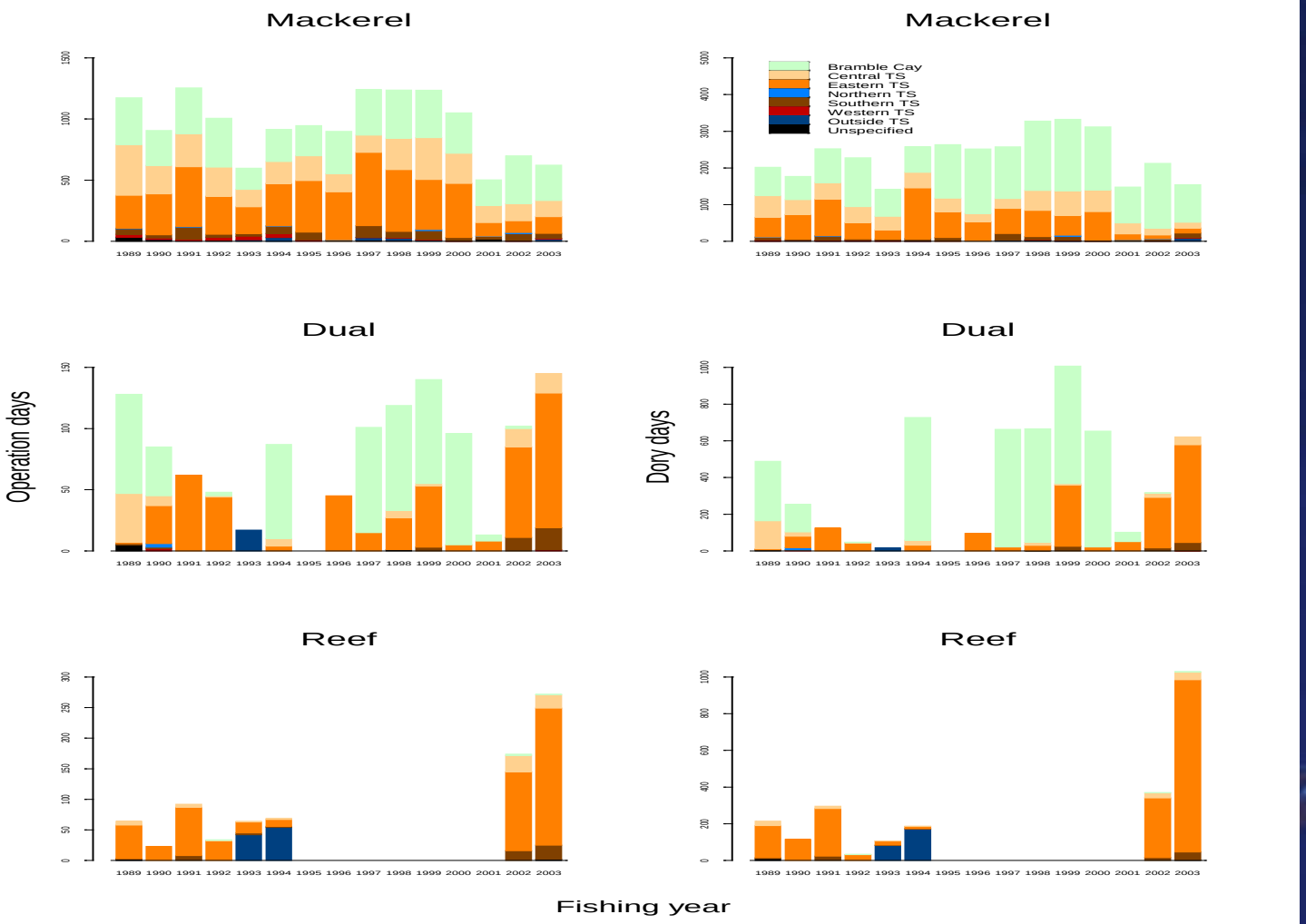

Female
Ovary Weight (g)
0
500
1000
1500
2000
5
10
15
20
Body Weight (kg)


Male
Testes Weight (g)
0
500
1000
1500
4
6
8
10
12
14
Body Weight (kg)

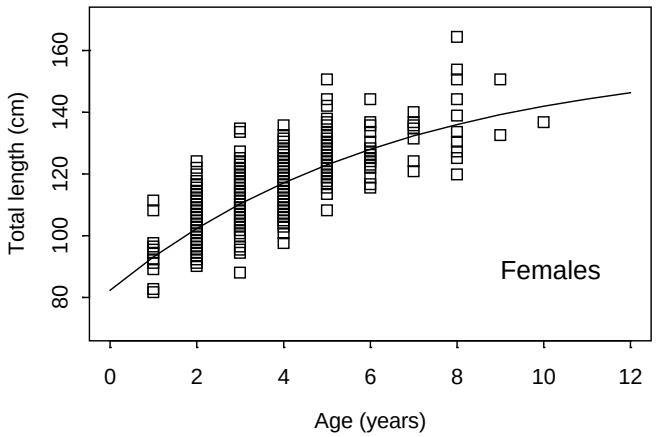

Deviance Residuals
-1.5
-0.5
0.0
0.5
1.0
5.5
6.0
6.5
7.0
7.5
Fitted : Weight

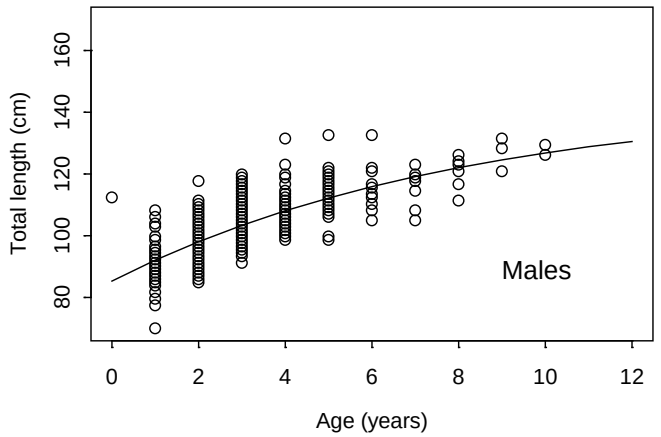

Deviance Residuals
-2.0
-1.0
0.0
1.0
4.5
5.0
5.5
6.0
6.5
7.0
Fitted : Weight

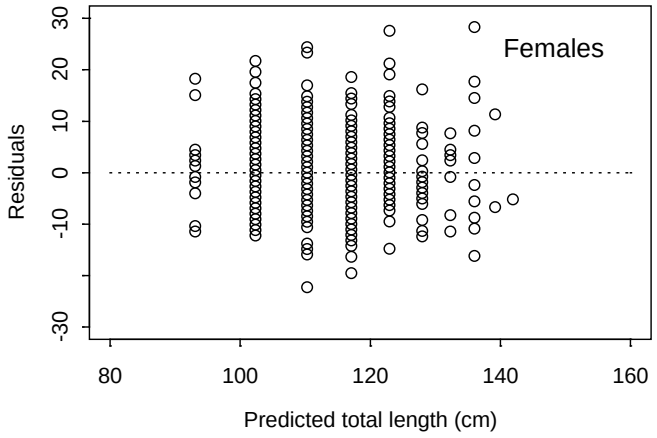
Fishery: Commercial Non-Islanders Effort allocation

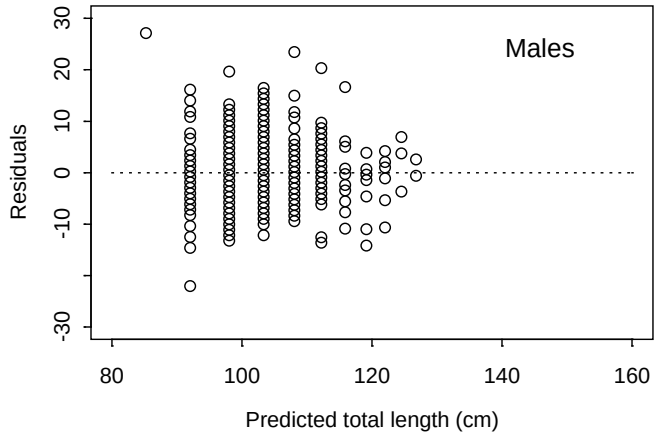


VB Growth Function

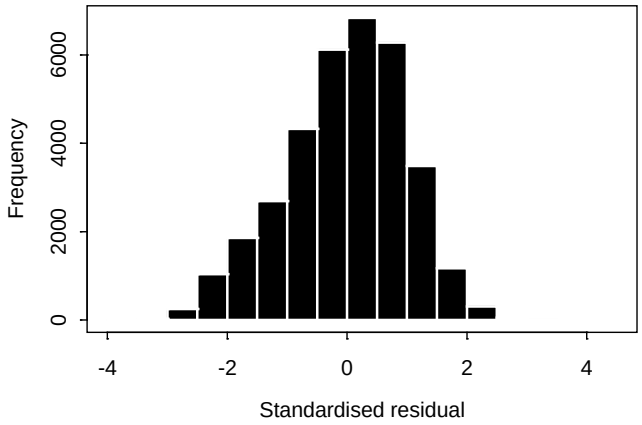


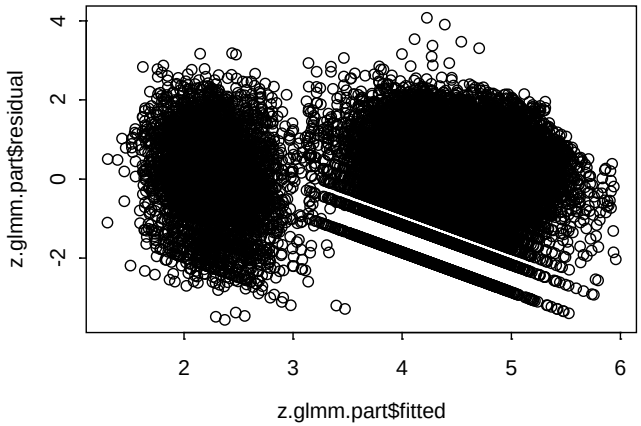


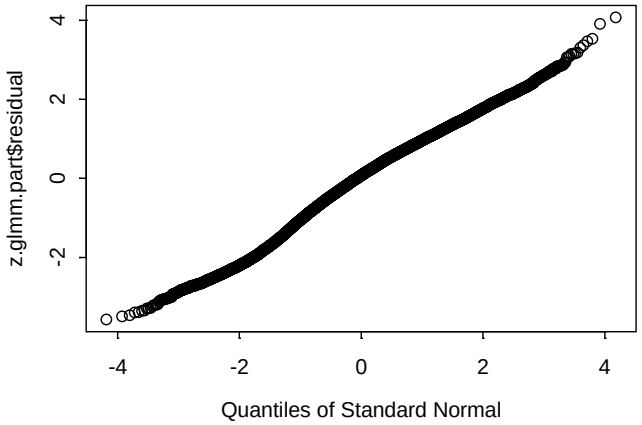


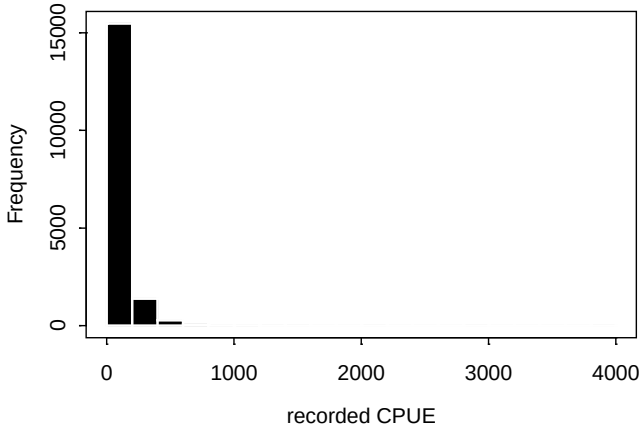


Catch Rates


Frequency
0
2000
4000
6000
-4
-2
0
2
4
Standardised residual


z.glmm.part$residual
-2
0
2
4
2
3
4
5
6
z.glmm.part$fitted

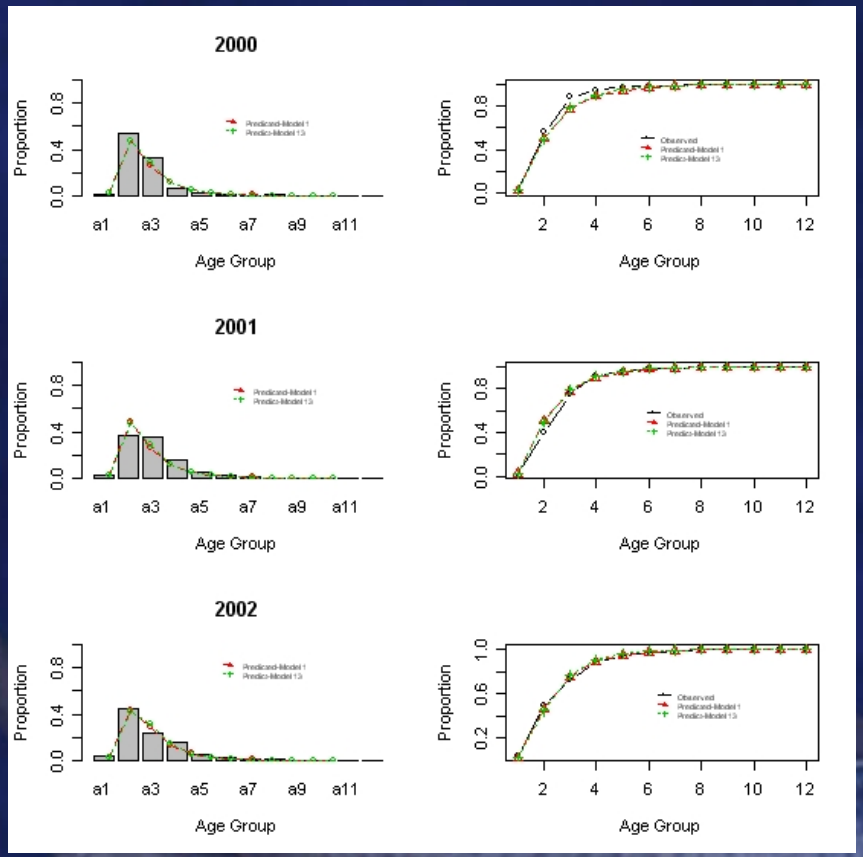

z.glmm.part$residual
-2
0
2
4
-4
-2
0
2
4
Quantiles of Standard Normal

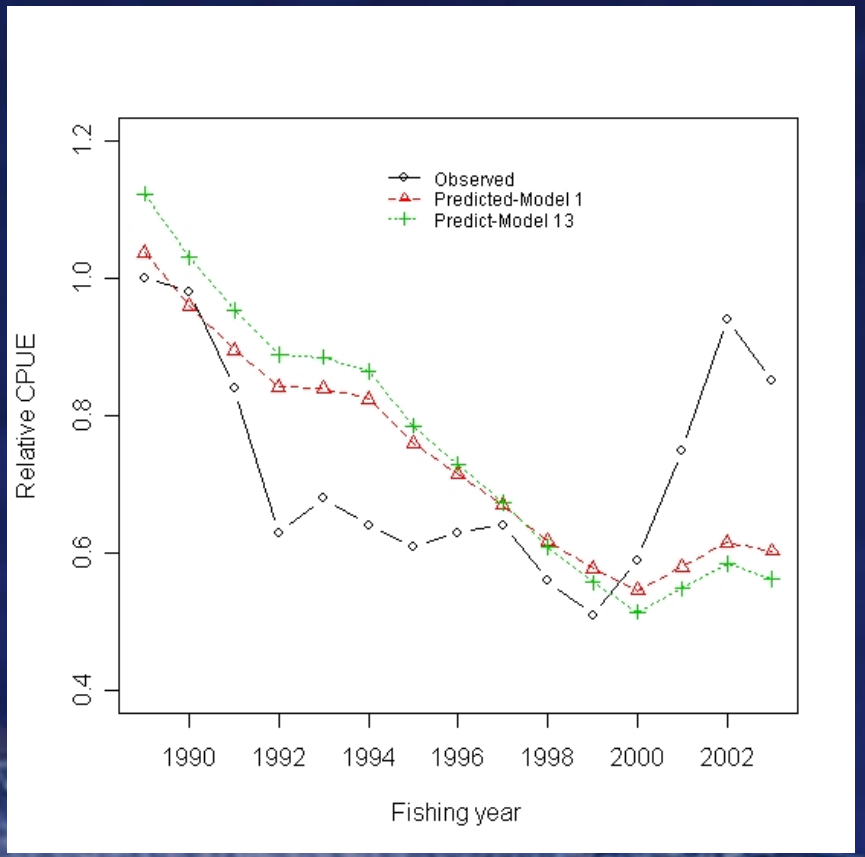

Frequency
0
5000
10000
15000
0
1000
2000
3000
4000
recorded CPUE

Results

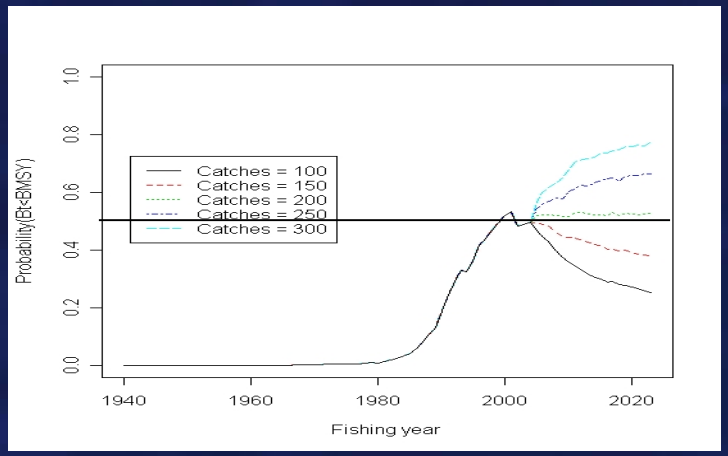
Model sensitivity run	$Y(F_{MSY})$ (t)	$Y(0.75F_{MSY})$ (t)	Y(0.5M) (t)
1	169.16	164.97	146.24
2	195.63	190.86	156.41
3	208.68	201.04	210.16
4	173.28	166.94	181.30
5	146.28	142.70	140.03
6	169.22	165.19	147.13
7	187.24	180.39	221.05
8	211.23	205.95	129.08
9	248.82	242.64	148.09
10	264.42	254.75	147.59
11	182.06	177.60	156.91
12	180.57	176.16	155.34
13	162.42	158.47	139.66

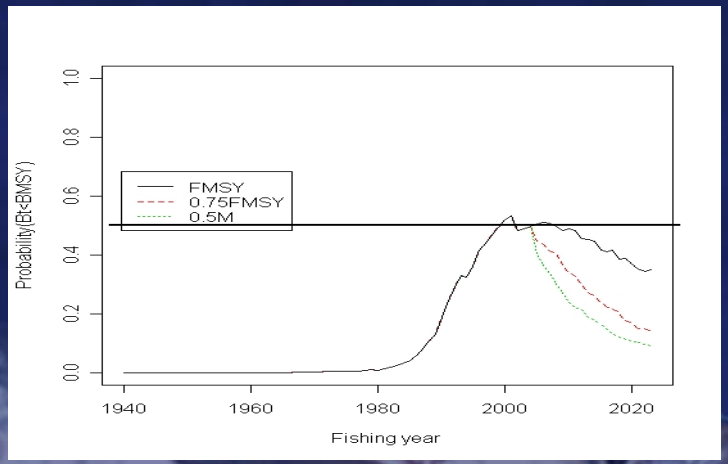
Results


2000
2001
2002
Proportion
Age Group
a1
a3
a5
a7
a9
a11
2
4
6
8
10
12


Observed
Predicted-Model 1
Predict-Model 13
Relative CPUE
Fishing year
0.4
0.6
0.8
1.0
1.2
1990
1992
1994
1996
1998
2000
2002

MSE Risks


Probability(Bt<BMSY)
0.0
0.2
0.4
0.6
0.8
1.0
1940
1960
1980
2000
2020
Fishing year
Catches = 100
Catches = 150
Catches = 200
Catches = 250
Catches = 300


Probability(Bt<BMSY)
0.0
0.2
0.4
0.6
0.8
1.0
1940
1960
1980
2000
2020
Fishing year
FMSY
0.75FMSY
0.5M