Stock Assessment Of The Torres Strait Spanish Mackerel Fishery

Gavin A. Begg[1], Carla Chia-Ming Chen [1], Michael F. O’Neill[2], Darren Rose[3], Sue Helmke3

[1] CRC Reef Research Centre and School of Tropical Environment Studies and Geography, James Cook University, QLD, 4811, Australia.
[2] Southern Fisheries Centre, Sustainable Fisheries, Animal Science, Department of Primary Industries and Fisheries, Deception Bay, QLD, 4508, Australia.
[3] Northern Fisheries Centre, Department of Primary Industries and Fisheries, Cairns, QLD, 4870, Australia.
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
<table>
<thead>
<tr>
<th>Year</th>
<th>Management</th>
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<tr>
<td>1985</td>
<td>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.</td>
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<tr>
<td>1988</td>
<td>SM01 logbook introduced (compulsory for non-Islander and PNG fishers).</td>
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<td>1990</td>
<td>SM02 logbook introduced (compulsory for non-Islander and PNG fishers).</td>
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<td>1998</td>
<td>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.</td>
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<td>1999</td>
<td>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.</td>
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<td>2004</td>
<td>Islander docket book introduced. Minimum legal size increased to 75 cm TL for Spanish mackerel.</td>
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Background: Monitoring History

- Monitored by
  - AFMA and QDPI&F using commercial non-islanders compulsory logbooks,
  - 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


Graphs showing the proportion of total length groups for both males and females across different years.
Age Frequency Distribution

Male Spanish Mackerel

2000

Female Spanish Mackerel

2000

2001

2001

2002

2002
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

![Graph showing fishery catch data]

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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:
    - 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

### Fishing Non-Islander Torres Strait Commercial Fishery Total Mackerel Catch (t)

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

![Graph showing the relative standardised CPUE from 1990 to 2002. The graph compares standardised and observed catch rates, indicating a decrease followed by an increase in catch rates over the years.](image-url)

- **Catch Rate (CPUE)**
- **Fishing Year**
- **Relative standardised CPUE**

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- **Standardised**: Line graph
- **Observed**: Dotted line graph
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

<table>
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<tr>
<th>Model sensitivity run</th>
<th>$M$</th>
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Results
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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, $B_{2023} \leq 0.2B_0$
- When fixing catch rate:
  - Increase
  - $F = F_{msy}$, $B_{2023} < 0.4B_0$
### MSE: Forward Projection

#### Catch (tonne) | \( P(B_{2023} < B_{MSY}) \) | \( B_{2023}/B_0 \) | \( F_{msy} \) | \( 0.75F_{msy} \) | \( F = 0.5M \)
--- | --- | --- | --- | --- | ---
100 | 0.254 | 0.744 | 187.49 | 0.349 | 0.388
150 | 0.381 | 0.497 | 180.52 | 0.1433 | 0.481
200 | 0.528 | 0.168 | 158.97 | 0.092 | 0.596
250 | 0.663 | 0.079 | | | |
300 | 0.773 | 0.054 | | | |

---

![Graph showing catch rates over time](image-url)
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: 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) vs. Body Weight (kg)
  - Deviance Residuals vs. Fitted Weight

- **Male**
  - Testes Weight (g) vs. Body Weight (kg)
  - Deviance Residuals vs. Fitted Weight
Catch Rates

![Histogram of Standardised Residuals](histogram)

![Scatterplot of z.glmm.part$fitted vs z.glmm.part$residual](scatterplot)

![Quantiles of Standard Normal Distribution](quantiles)

![Frequency Distribution of CPUE](frequency_distribution)
## Results

<table>
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<tr>
<th>Model sensitivity run</th>
<th>Y($F_{\text{MSY}}$) (t)</th>
<th>Y($0.75F_{\text{MSY}}$) (t)</th>
<th>Y($0.5M$) (t)</th>
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</table>
Results
MSE Risks

![Graph showing probability of fishing yield (P_fish) over fishing years for different catch levels (Catches = 100, 150, 200, 250, 300). The graph demonstrates the impact on MSE risks over time.]