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The effect of climate change on fishing behaviour in the Australian Eastern Tuna and Billfish fishery (ETBF)

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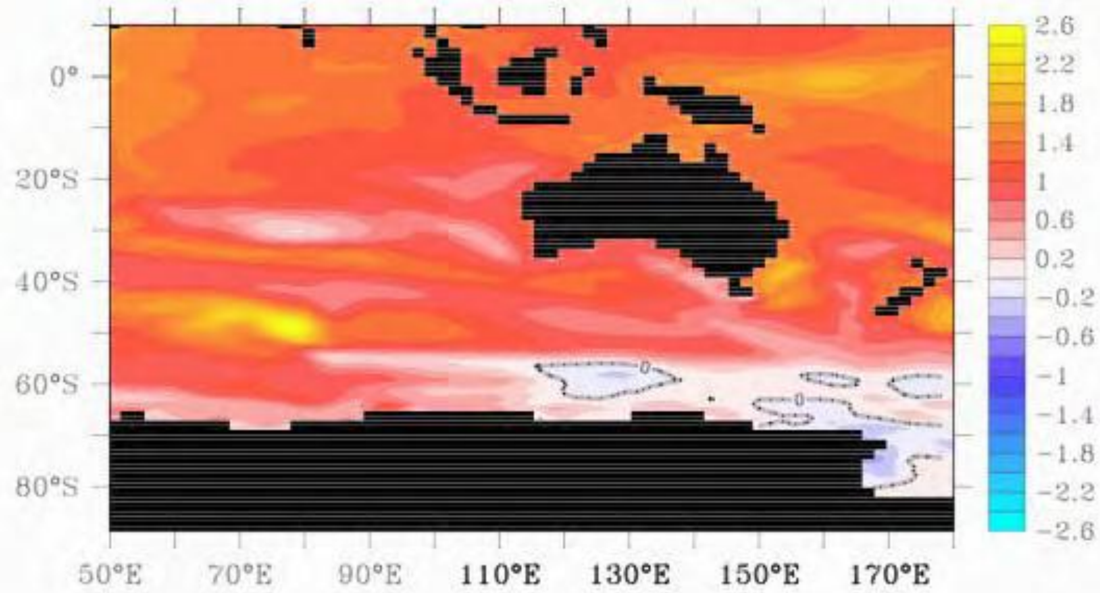
Outline of the presentation

- Impacts of climate change
  - Australia
  - Eastern Tuna and Billfish Fishery (ETBF)
- Background to ETBF and ports investigated
- Steps used in this analysis
  1. Modelling impacts of climate change in the ETBF
  2. Modelling fishers' behaviour
  3. Scenario analysis: linking 1 and 2
- Preliminary results
- Next steps

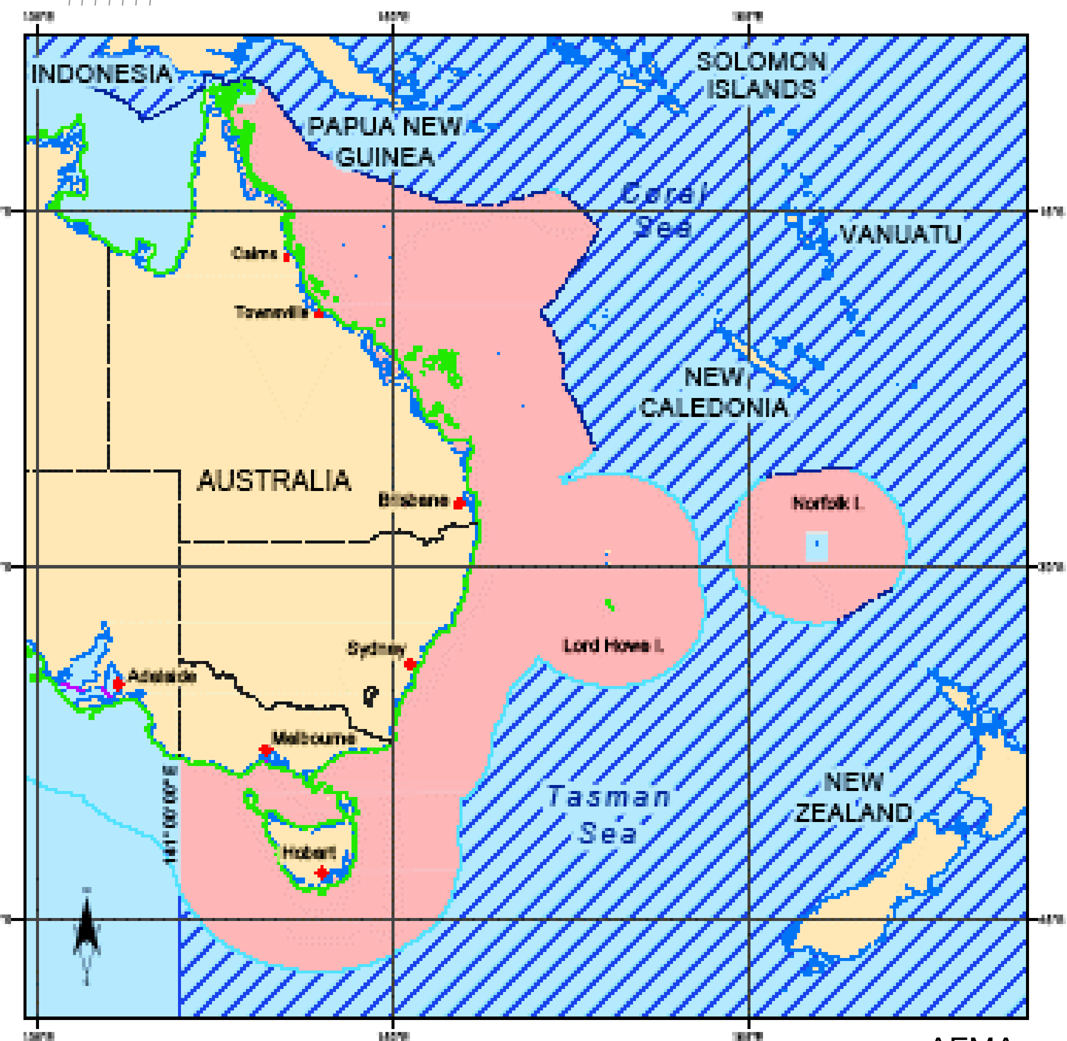
Impacts of climate change in Australia

- By 2030, SST is likely to increase by 1-2^{o}C
- Highest warming off south-east Australia, which occurs with the strengthening southern flow of the East Australian Current (EAC)
- Changes in EAC due to large-scale changes in the winds in southern hemisphere
- Increased SST and strengthening of EAC is a robust feature of all IPCC climate models with only the magnitude of change differing among models



Projected annual mean change in sea-surface temperature (^{o}C) by 2030s (from Hobday *et al*. 2008)

Impacts of climate change in ETBF



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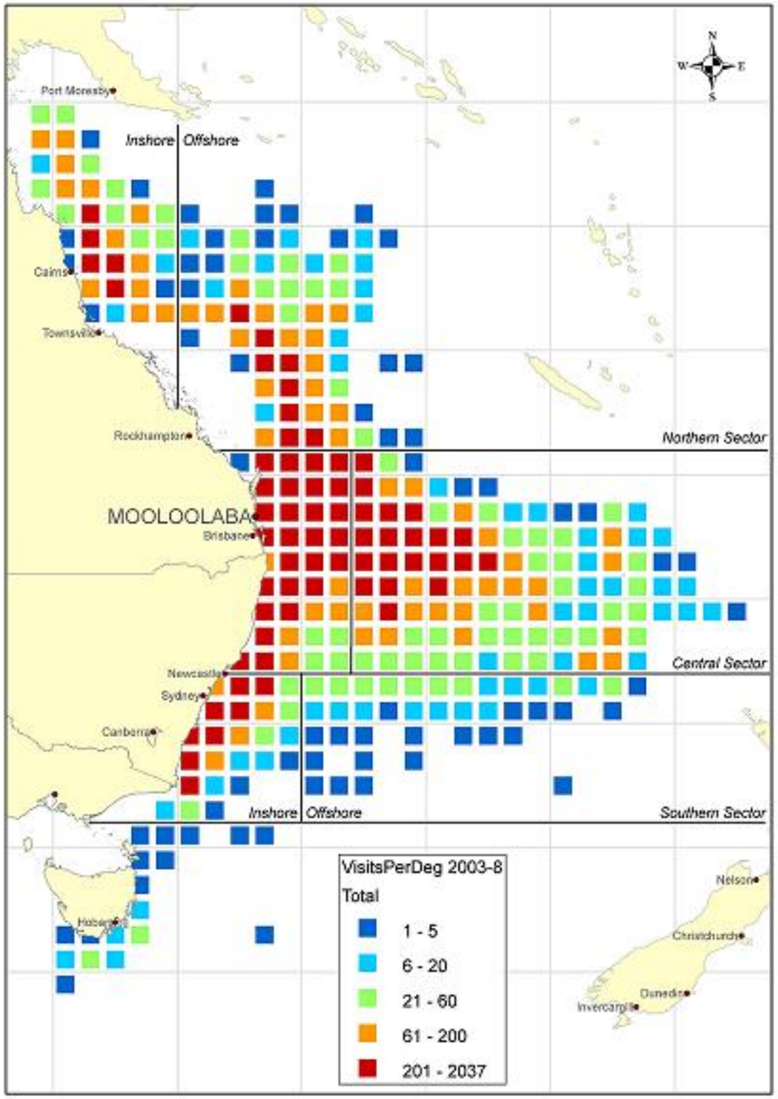
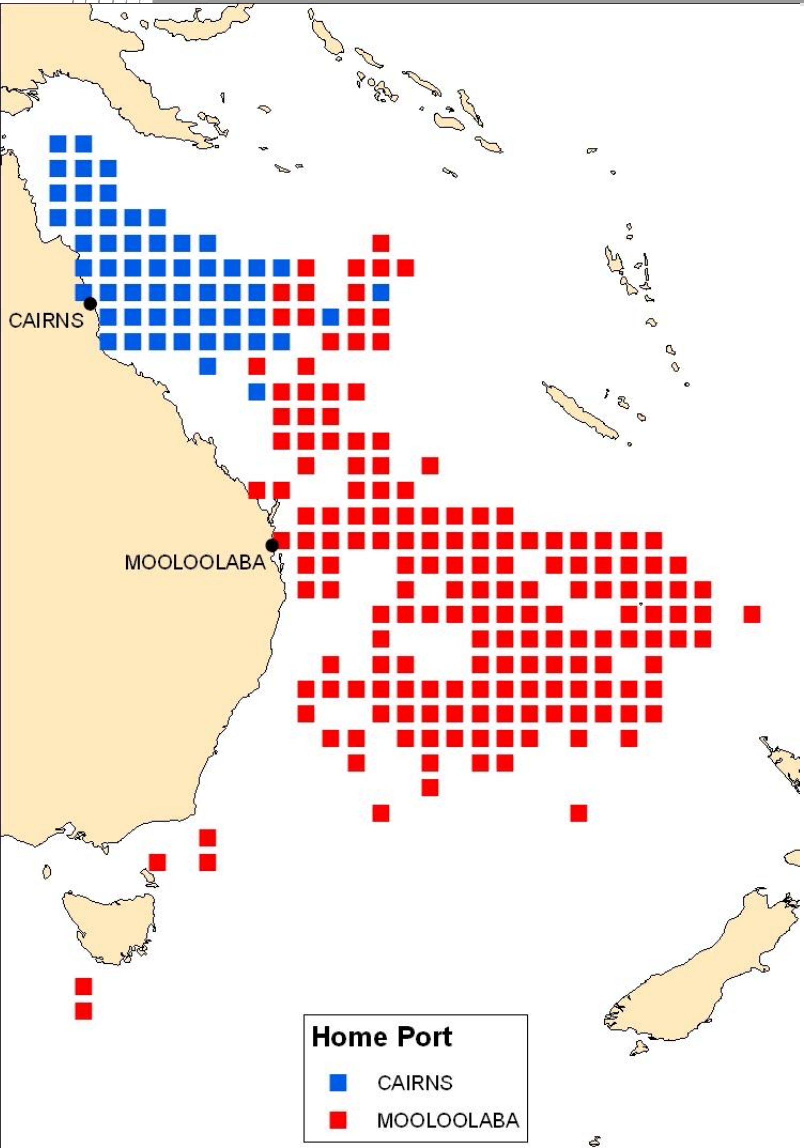
- With a higher SST and a stronger EAC, tropical tuna and billfish species are likely to move further south
- This may impact the location of the ETBF fishery, which currently extends from Cape York to the southern most point of the AFZ
- With ports located as far North as Cairns and South as Hobart fishers located in northern ports could be impacted the most

Current situation of the ETBF



- Multi-species and multi-gear fishery
- Main spp: yellowfin tuna, skipjack tuna, albacore tuna, bigeye tuna, broadbill swordfish and striped marlin
- Main fishing method: longline and minor line
- Total production and value:
  5.7('000 t) ~ 27 M US$ in 2008
- Major ports are Mooloolaba, Ulladulla, Coffs Harbour and Cairns
- The fleet is relatively homogeneous wrt vessel size and engine power with a mix of smaller and larger vessels
- The distribution of fishing effort varies disproportionally over the range of the fishery suggesting
  - Heterogeneity in the characteristics of fishing locations
  - Heterogeneity in the location choice of fishers

Specific ports investigated in the analysis

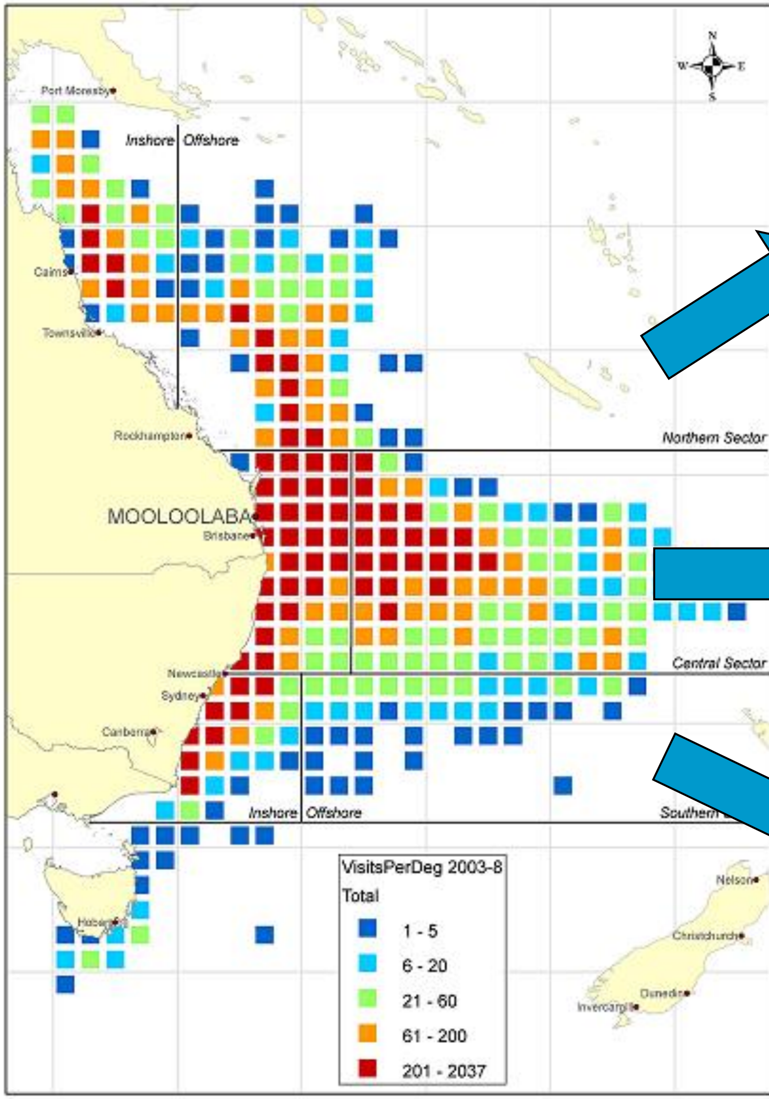


- This study concentrates in vessels fishing out of Cairns (most northern port) and Mooloolaba (largest single port)
- Vessels fishing from Cairns fish in the most northern ranges of the ETBF
  - In 2008, Cairns boats fished 5% of the total value of the ETBF
  - Yellowfin (47%), Bigeye (22%) and Albacore (7%) represented ~ ¾ of the total catch in tonnes
- Vessels fishing from Mooloolaba fish in the central and southern ranges of the ETBF
  - In 2008, Mooloolaba boats fished 45% of the total value of the ETBF
  - Swordfish and striped marlin (30%), Albacore (23%) and Yellowfin (21%) represented ~ ¾ of the total catch in tonnes

Predicting climate change impact in the ETBF

- Three steps in the analysis
- 1. Model impacts of climate change on main species caught by the ETBF (yellowfin, skipjack, albacore, bigeye, striped marlin and swordfish) by 2030
- 2. Model the location choice of ETBF vessels from Cairns and Mooloolaba
- 3. Simulate the change in location choice preference between 2008 and 2030

1. Modelling impacts of climate change in ETBF



- % Change in abundance (2008-2030)

North inshore		
Yell	Bigey	Alb
-7.4%	**-5.4%**	3.9%
Skip	Swrd	Marl
-0.2%	2.2%	**-9.7%**

North offshore		
Yell	Bigey	Alb
-3.4%	**-3.4%**	0.9%
Skip	Swrd	Marl
-0.2%	**-1.8%**	**-8.7%**

Centre inshore		
Yell	Bigey	Alb
-3.4%	**-3.3%**	0.9%
Skip	Swrd	Marl
-0.2%	**-1.8%**	**-8.6%**

Centre offshore		
Yell	Bigey	Alb
-2.5%	**-2.3%**	1.0%
Skip	Swrd	Marl
0.0%	**-1.1%**	**-6.0%**

South inshore		
Yell	Bigey	Alb
2.4%	2.1%	0.2%
Skip	Swrd	Marl
1.4%	0.6%	3.2%

South offshore		
Yell	Bigey	Alb
2.6%	2.5%	0.3%
Skip	Swrd	Marl
1.3%	1.0%	4.6%

2. Modelling fishers' location

- Random utility models (RUM) examine the variability in behavioural response in a sampled population for a finite number of alternatives
- Individuals make choices that maximise their level of utility (subject to constraints)
  - In commercial fisheries, the utility is assumed to relate to profits; hence location choice is based on the expected profitability at each alternative location
  - The ETBF fishing area is initially divided into 1 degree grids with a total initial number of 290 boxes, which later was aggregated to 72 alternative locations
- We chose the Mixed Logit model (ML)
  - Least restrictive
  - Behavioural heterogeneity
  - Correlation between the parameters
- Harder to estimate since the relationship between the error terms of the alternatives are not IID

2. Modelling fishers' location choice

- Explanatory variables

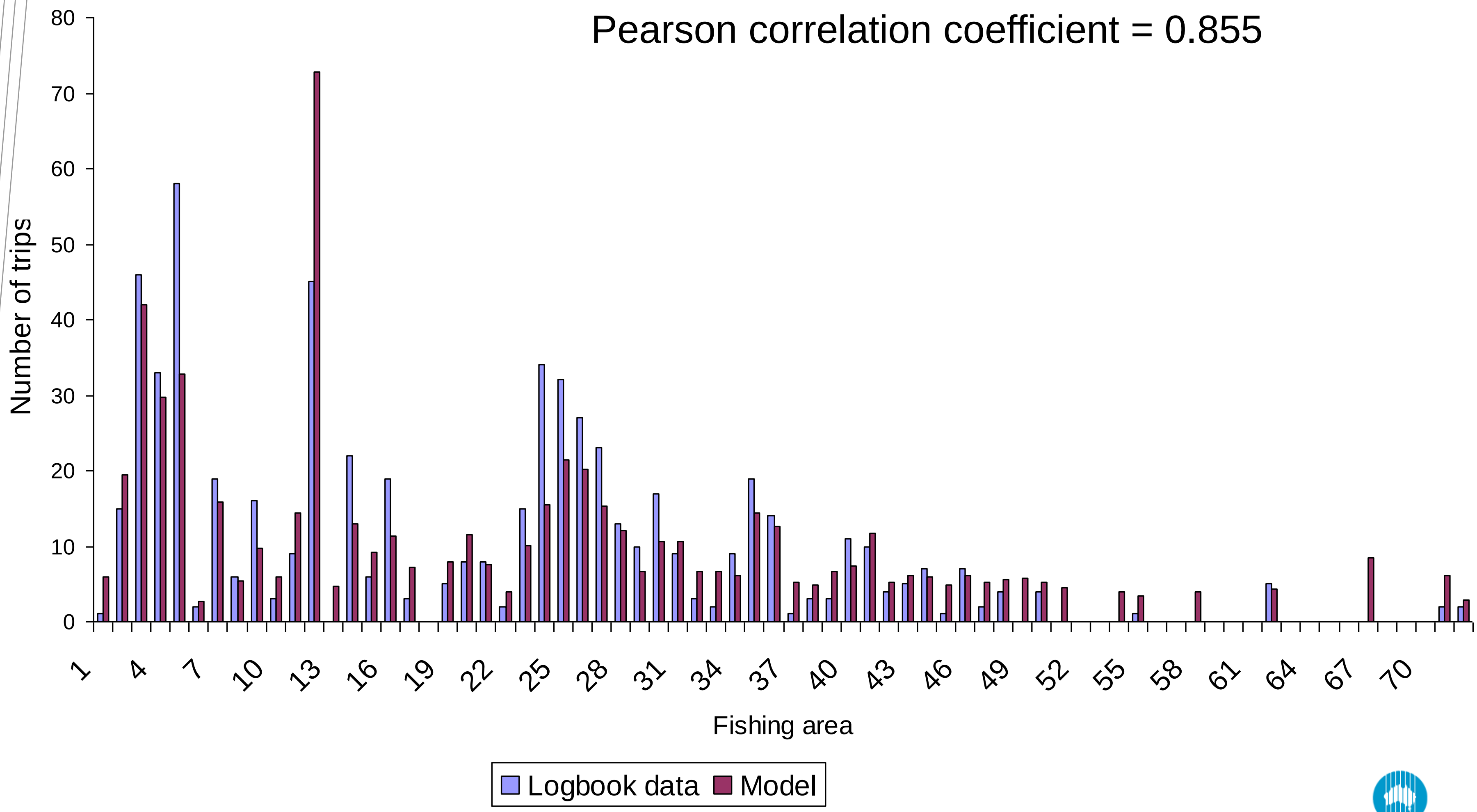
  - VPUEW and VPUEY – Expected revenue from fishing in a particular location the previous week and previous year. (Expectations vary by port)
  - DensityW and DensityY – Number of trips in each location the previous week and year
  - CV – Coefficient of variation to represent risk attitude
  - PDISTTRI – Fuel price*Distance to port is a proxy to fishing costs
  - PDISTLEG – (PDISTTRI)/days per trip, short trips will be closer to port
  - DISTLEN – (PDISTTRI)/boat length, smaller boats will fish closer to port
  - LW and LY – dummy variable to represent whether a boat was in a particular location the previous week and/or year

2. Modelling fishers' location choice - ML results

```
      Random Parameters Logit Model  Maximum Likelihood Estimation
Observations                  5238      Replications for simulations= 2000
Log likelihood           -15272.56      Info.Criterion: AIC=             5.836
McFadden Psd R-squared .31823          Chi squared            14257.23 (13 df)
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]
---------+Random parameters in utility functions				
VPUEW	.12120365	.00635768	19.064	.0000
CV	.33824981	.08751393	3.865	.0001
---------+Nonrandom parameters in utility functions				
VPUEY	.00992224	.00473777	2.094	.0362
DENSW	.14001655	.00615739	22.740	.0000
DENSY	.01645602	.00723185	2.275	.0229
PD	.01425771	.00098892	14.417	.0000
PL	-.00443283	.00087679	-5.056	.0000
DL	-.28465005	.01826574	-15.584	.0000
LW	1.50631291	.03501649	43.017	.0000
LY	.63801647	.05142130	12.408	.0000
---------+Diagonal values in Cholesky matrix, L.				
NsVPUEW	.11697748	.01194000	9.797	.0000
NsCV	1.18711751	.17427272	6.812	.0000
---------+Below diagonal values in L matrix. V = L*Lt				
CV:VPU	-.10089569	.24830126	-.406	.6845
---------+Standard deviations of parameter distributions				
sdVPUEW	.11697748	.01194000	9.797	.0000
sdCV	1.19139747	.16747387	7.114	.0000

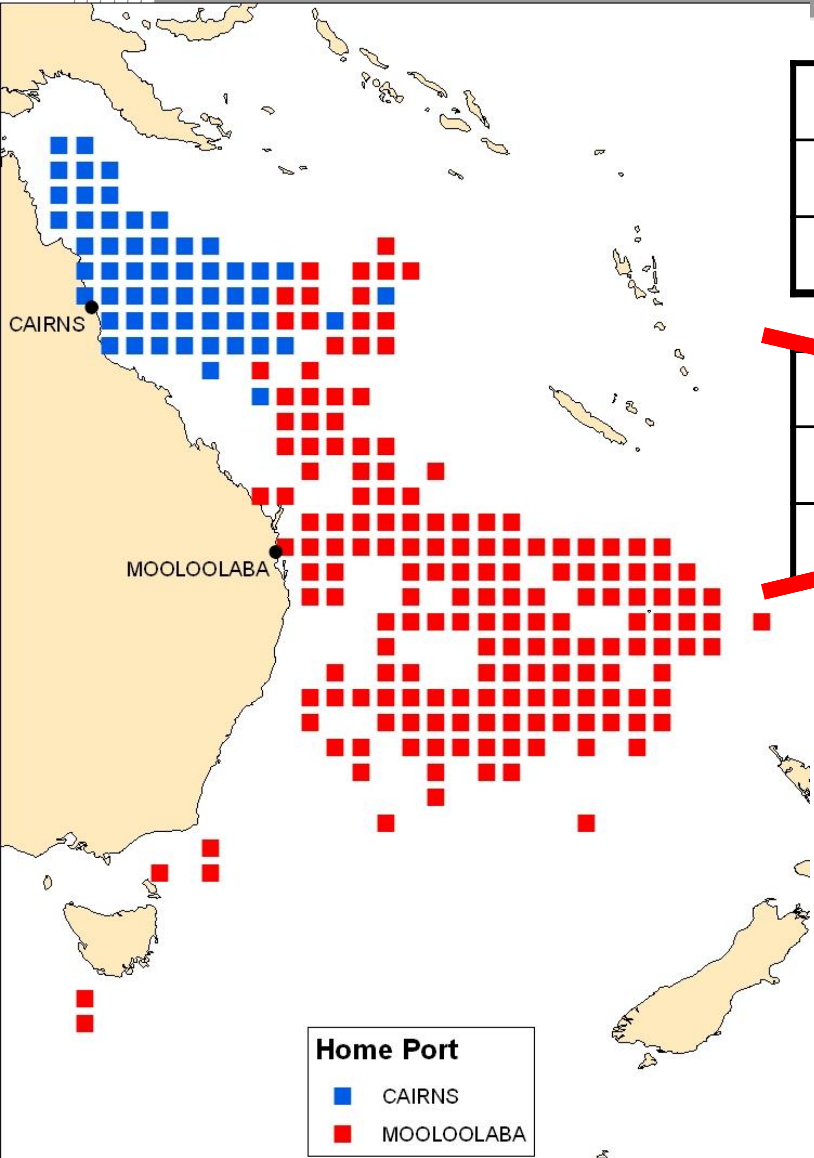
Actual and estimated distribution of fishing in Mooloolaba and Cairns, 2008



3. Simulating changes in location choice

- Climatic changes to the presence of different tuna and broadbill species caught in different locations by the ETBF will impact
  - The expectations that fishers have on the profitability of different locations in the previous week and year (VPUEW and VPUEY)
  - The riskiness of fishers (CV) due to the variation in VPH
- We used projections (2008-2030) from section 1 to derive the changes in expected VPUEW, VPUEY and CV in each trip for every possible location for 2008, as well as the realised VPH in the cell that is chosen.
- The changes to the different parameters are then used together with the utility expression derived from the ML model (section 2) to estimate the impact of climate change on revenue, fuel costs and profits.
- Estimate the effect of climate change on effort reallocation in 2 scenarios
  - No adaptation scenario: Fishers continue fishing in the same locations despite CC
  - Adaptation scenario: Fishers are able to move within their choice set

3. Simulating changes in location choice: Preliminary results



No adaptation	Revenue	Fuel	Profits
Mooloolaba	-28%	0%	-21%
Cairns	-30%	0%	-22%

Adaptation	Revenue	Fuel	Profits
Mooloolaba	-32%	0.2%	-24%
Cairns	-63%	-3.3%	-44%

- Reduction in profits (compared to 2008) in both ports with and without adaptation
  - Possible since a decline is projected in most locations
  - BUT, adaptation results indicate a larger decline in profits!!

3. Simulating changes in location choice: Preliminary results

- The adaptation scenario was expected to provide at least the same revenue as the no adaptation scenario

  - Changes to expected vpuew and vpuey and the perception of risk (CV) under the CC projections might not have provided enough information to fishers on effort reallocation

  - The RUM identified densities and previous trips as significant to determine fishers location choices

Conclusion – Next steps

- The results are preliminary
- Next steps require adjustments to the three steps in this analysis
  - Step 1. Modelling impacts of climate change in ETBF
    - Include other environmental variables, dissolve oxygen and temperature at depth as well as SST
    - Perform the analysis with other GCM models
  - Step 2. Modelling fishers' location choice
    - SST will be included into the model to provide a better explanation of location choice by fishers.
    - Other ports in southern locations (e.g., Coffs Harbour) will be added
    - The location choice model will be repeated with all ports together as well as separate to choose the analysis that provides the best fit to the data
  - Step 3. Simulation
    - Add other variables that might explain better effort reallocation under climate change; densw and SST
    - Consider other scenarios; relocation and/or trips of northern ports (Cairns) to southern locations

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Thank you

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