MARINE BIODIVERSITY RESEARCH

Prediction and Management of Australia's Marine Biodiversity

How optimal is optimal: Do behavioural adaptations by fishers affect the cost of marine reserves?

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Outline

- Background
- Estimating cost of reserves?
- The eastern tuna and billfish fishery (ETBF)
- Fleet dynamics models
  - Model fishery
  - Simulation of closure scenarios
- Results
- Conclusions and further development

Background

- Conventions to protect marine biodiversity resulting in increased areas closed to fishing
    - International: UNCED (10% mar env MPA by 2012), UNCLOS
    - Regional: Natura 2000 (EU), UN Nairobi convention
- Australia – process of marine bioregional planning
  - National representative system of MPAs, 5 regions
    - Objective: establish & manage a comprehensive, adequate & representative system of marine reserves
  - Where deemed incompatible some exclusion / displacement of fisheries is likely
    - Loss of revenue from previously exploited areas
    - Can also impose costs on management authority via compensatory payments
  - Desire to limit costs whilst still achieving management goals

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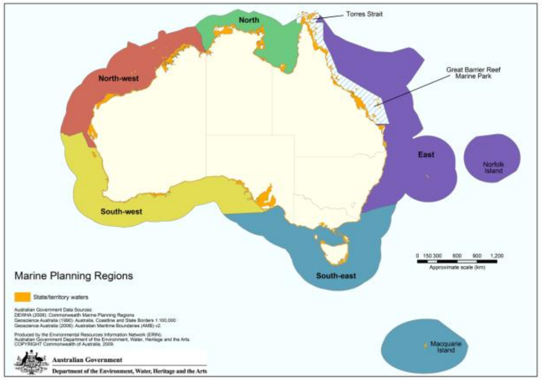
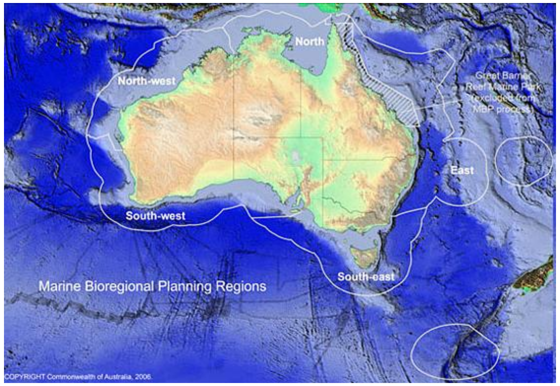
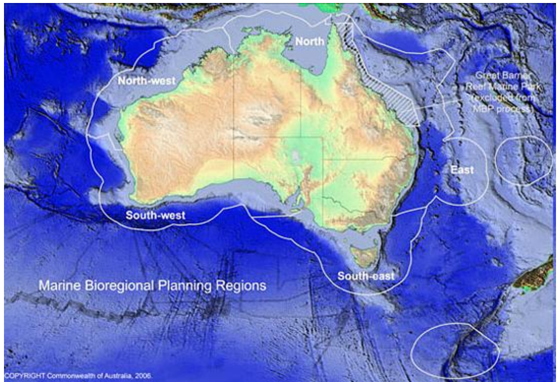




Estimating the Cost of Reserves?

- Gross value of production (GVP) estimates previously used as proxy cost measures when planning reserves to:
  - Estimate magnitude of impact on fishers
  - Guide placement of reserves so that costs may be reduced
- GVP does not account for displacement of effort
  - Is GVP adequate proxy for impacts on fishers?
  - Distributional effects?
    - Extent of adaption and how effort relocates is also of interest
- Can the magnitude of any compensatory payments be determined prior to implementation?
- We use two fleet dynamic modelling approaches to estimate the impacts of alternative reserve scenarios for ETBF



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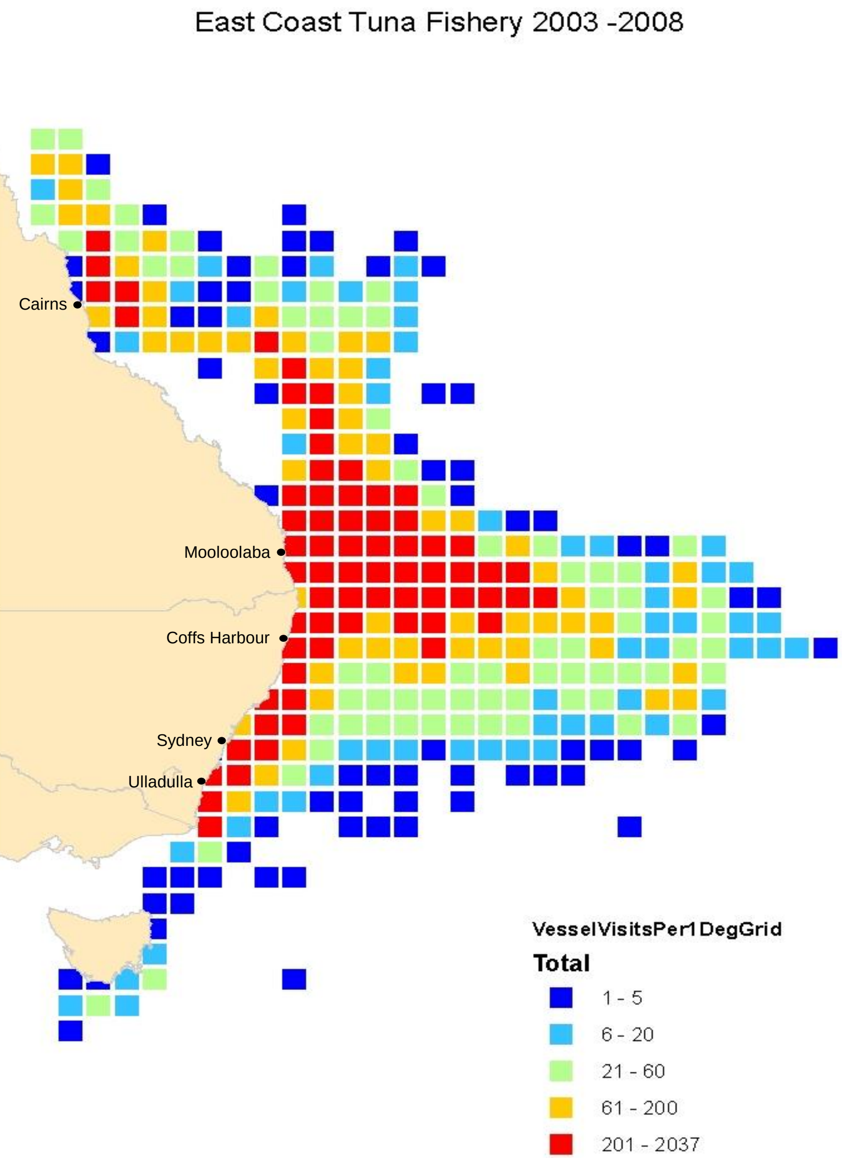
Eastern Tuna and Billfish Fishery - ETBF



- Eastern Planning Region
- Commonwealth fishery
  - 3 to 200nm limit
- 2007-08
  - $32m AUS (6,452t), 57 active vessels
- Primarily longline
  - Tuna - yellowfin, bigeye, skipjack & albacore
  - Billfish - broadbill swordfish, marlin
- Major ports
  - Cairns, Mooloolaba, Coffs Harbour, Sydney & Ulladulla
- Effort unevenly distributed over range
  - Heterogeneity in fishing location characteristics
  - Heterogeneity in fishers choices of location

Fleet Dynamics Models - ETBF

1. Model the fishery

- Random utility model (RUM)
  - Probabilistic
  - Based on previously observed behaviour
- Dynamic state variable model (DSVM)
  - Optimisation
  - Assumes perfect knowledge and instant adaptability

2. Define and impose closure scenarios
  - Simulate and compare impact estimates
  - Comparison with GVP based rank

More detail on earlier versions of both models
  - 2010 FRDC Report: Predicting the impact of hook decrements on the distribution of fishing effort in the ETBF. 2008/058.

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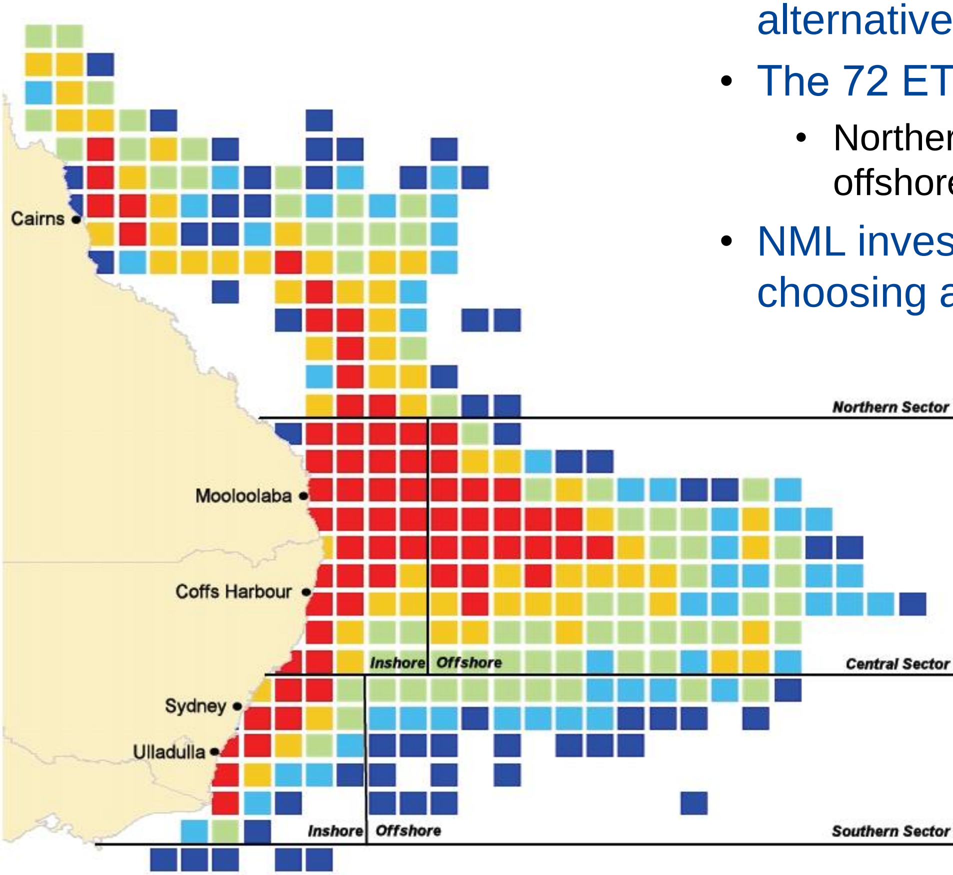
1. Modelling ETBF - Location Choice

- Range divided into 290 1x1 degree cells, then to 72 possible fishing locations (*j*)
  - Closer locations are likely to share similar characteristics



- Random Utility Model - Nested multinomial logit (NML)
  - Allows for some correlation between sub-sets of alternatives
  - The 72 ETBF fishing locations divided into 6 'zones' (*k*):
    - Northern Inshore, Northern Offshore, Central inshore, Central offshore, Southern inshore, Southern offshore
  - NML investigates the conditional probability in a given trip of choosing alternative *j* after going to zone *k* (i.e. *j* *k*)

$$\Pr(j|k) = \frac{\exp(\beta_j^{'} z_{j|k})}{\sum_{j\in k} \exp(\beta_j^{'} z_{j|k})}$$

1. Modelling ETBF - Location Choice

Data

- Logbook at shot level 2003-08
  - Catch by species, Lat Long, trip length, power, hook count
  - Mostly 2 day trips (fishing time), 1 shot per day
  - Aggregated to trip level (9951)
- Prices (2007-08 real)
  - Main target species, Fuel

3 NL separate models estimated

- Cairns,
- Mooloolaba,
- Sydney, Ulladulla & Coffs

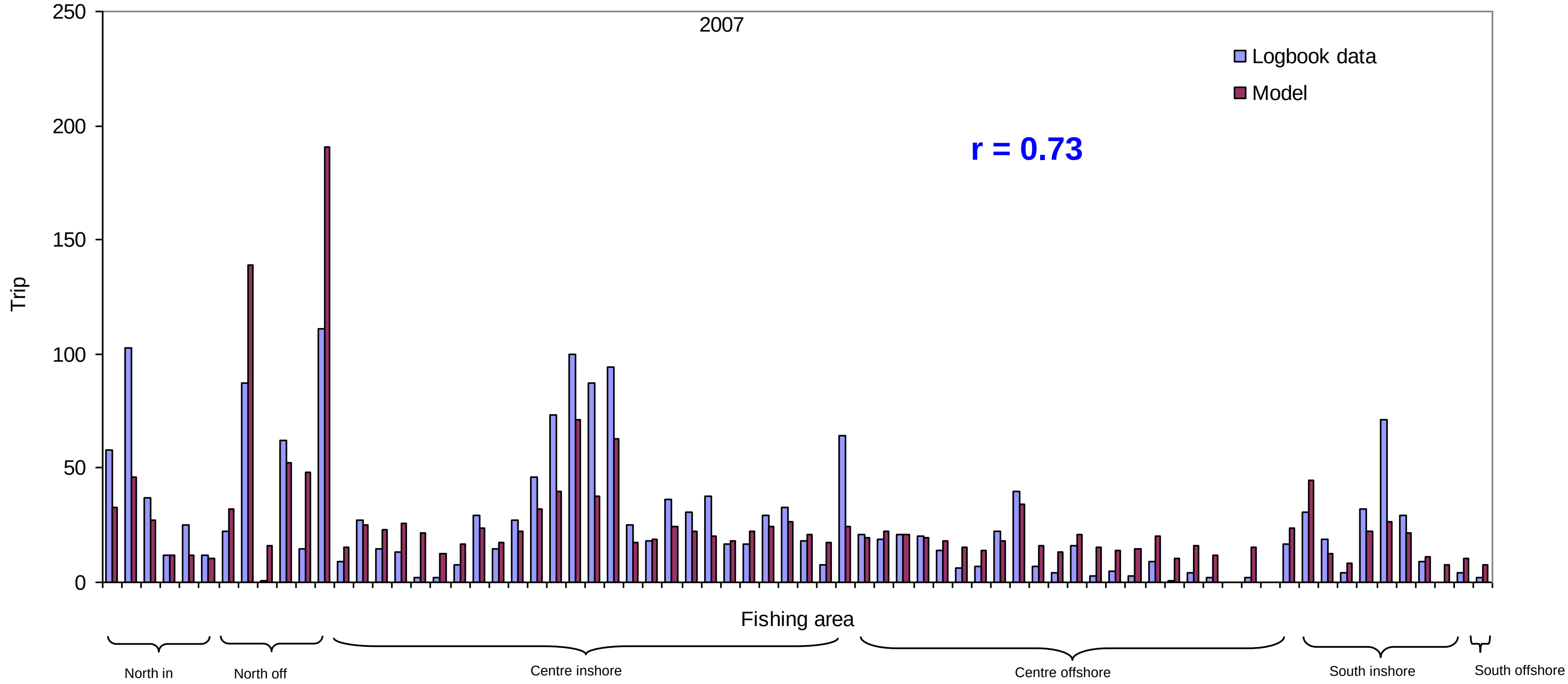
Estimated Parameters - RUM

Port:	Cairns					Mooloolaba					Coffs Harbour, Sydney & Ulludulla			
Variable	Coeff	St. Er.	b/St.Er.	P[Z>z]		Coeff	St. Er.	b/St.Er.	P[Z>z]		Coeff	St. Er.	b/St.Er.	P[Z>z]
Utility model														
VPH Week-1	0.067	0.008	8.615	***		0.137	0.005	25.151	***		0.076	0.007	10.720	***
VPH Year-1	0.006	0.006	1.019			0.038	0.005	8.139	***		0.014	0.009	1.609	
Density Week-1	0.147	0.014	10.724	***		0.160	0.006	28.055	***		0.193	0.015	12.566	***
Density Year-1	0.006	0.012	0.536			0.042	0.007	5.900	***		0.075	0.017	4.300	***
Coeff. Variation	0.943	0.124	7.609	***		0.759	0.057	13.242	***		0.465	0.098	4.770	***
P*distance	0.006	0.003	1.770	*		0.015	0.001	17.331	***		0.006	0.001	6.261	***
P*distance/days	-0.005	0.003	-1.785	*		-0.004	0.001	-5.282	***		-0.002	0.000	-3.694	***
P*distance/length	-0.141	0.059	-2.405	**		-0.293	0.017	-17.425	***		-0.133	0.020	-6.525	***
Location Week-1	0.615	0.069	8.973	***		1.989	0.045	44.511	***		1.543	0.068	22.548	***
Location Year-1	0.517	0.076	6.790	***		0.574	0.080	7.147	***		0.269	0.102	2.632	***
Inclusive values														
North in	0.641	0.067	9.554	***	North in	0.768	0.043	17.825	***	In	1.000	...(Fixed Parameter)...		
North off	0.804	0.074	10.857	***	Noff	1.000	...(Fixed Parameter)...			Off	0.894	0.048	18.503	***
South	1.000	...(Fixed Parameter)...			C in+off	0.920	0.014	68.036	***					
					South in	0.640	0.028	22.956	***					
					South off	0.746	0.028	8.147	***					
Underlying standard errors														
North in	1.999	0.209	9.554	***	North in	1.670	0.094	17.825	***	In	1.283	...(Fixed Parameter)...		
North off	1.595	0.147	10.857	***	N off	1.283	...(Fixed Parameter)...			Off	1.435	0.078	18.503	***
South	1.283	...(Fixed Parameter)...			C in+off	1.394	0.020	68.036	***					
					South in	2.004	0.087	22.956	***					
					South off	1.719	0.211	8.147	***					
Model diagnostics														
Chi squared			4209.7					18587					8768.8	
Log likelihood			-3509.8					-19441.9					-6512.7	
McFadden Pseudo R-squared			0.375					0.323					0.402	
AIC			3.651					6.96					5.448	

*** significant at 1% level, ** significant at 5% level, * significant at 10% level

Logbook Trips vs Model

- Fishery modelled in GAMS



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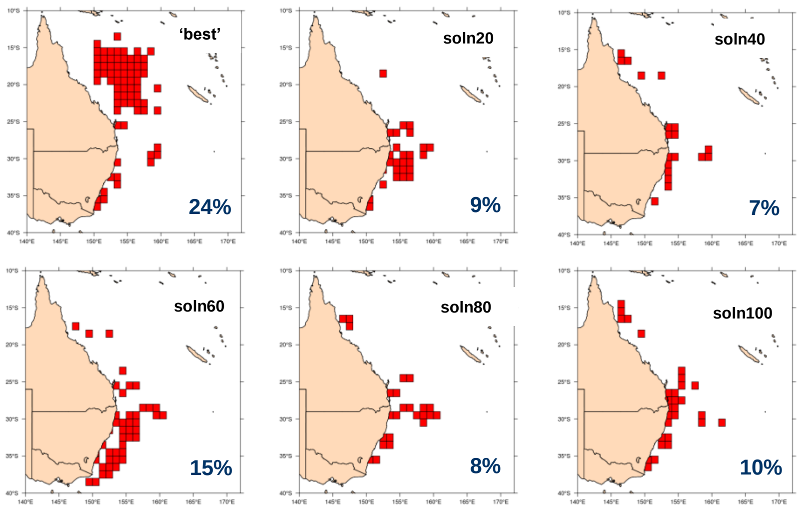
Dynamic State Variable Model

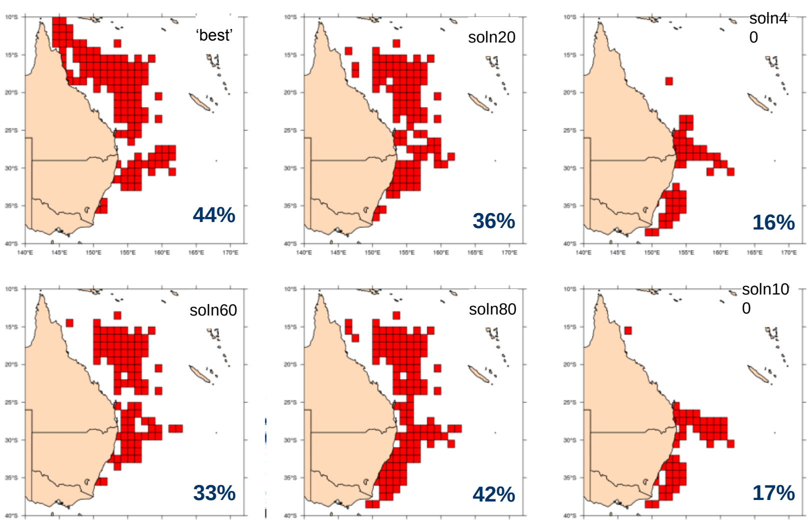
- Backward-iterative optimisation
  - As optimal choice in each period depends on the expected returns in the future
- Calculates maximum expected profit and the optimal choice at each time across all states
  - State variable is effort remaining at time *t* in the season
  - Species specific price, accounting for landings
  - Number of trips matched to logbook and (RUM) in same period
- Maximises vessel profit via;
  - Choice of location, targeting behaviour, trip timing in season
  - Opportunity cost accounted for
- Computational demand limits resolution 5x5 degree areas (24)
- Parameterised using set level logbook data
  - Quarterly patterns of fish movement

2. Marine Reserve Scenarios

Conservation value & cost



Conservation value only

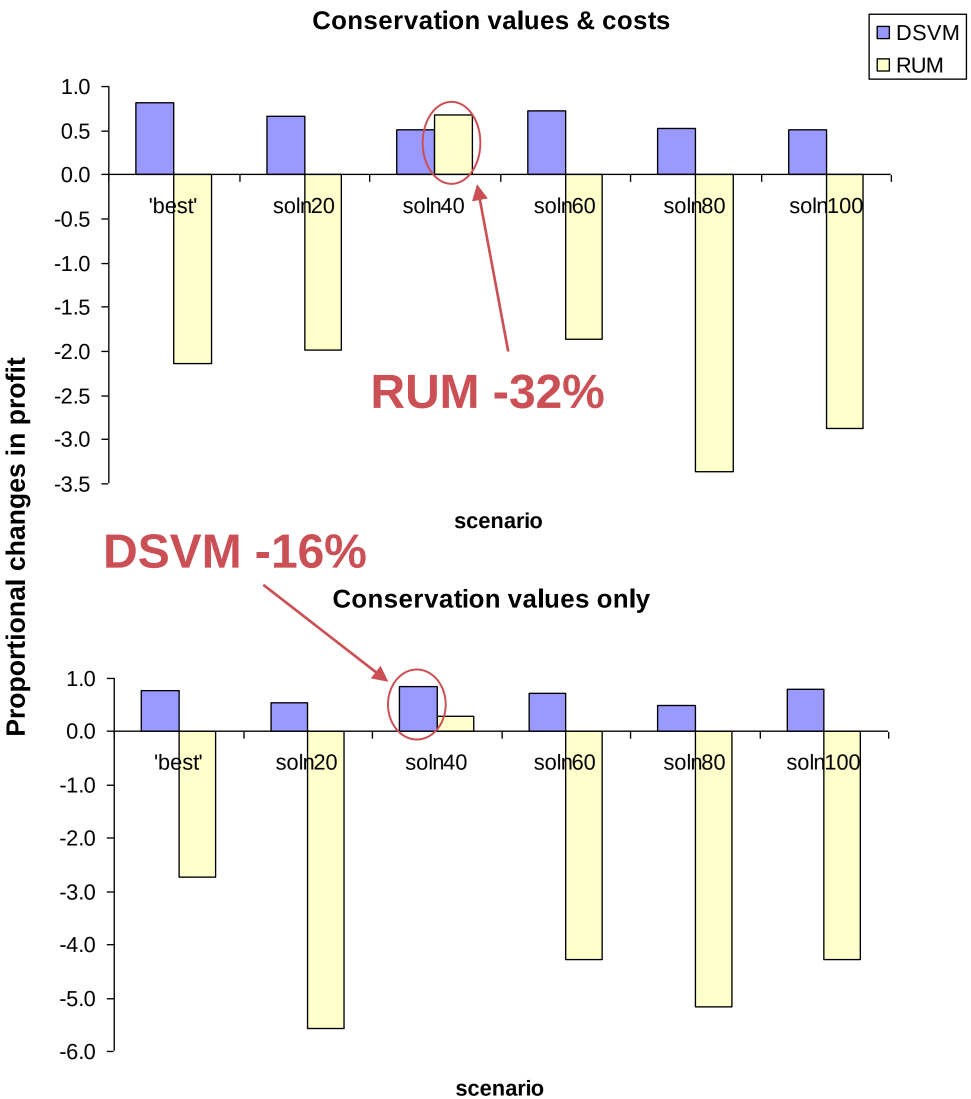


- Conservation planning software (Marxan)
  - Aids design of reserve systems
  - Attempts to optimise reserve location whilst achieving specific goals
  - Costs defined as lost fishing opportunity for area closed (GVP)
- Bioregional assessments
  - 2 sets of hypothetical closure scenarios
    - Conservation values and costs inputs (100 solutions)
    - Conservation values only (100 solutions)
  - Solution deemed to best meet the targets and 5 others selected
- Closure polygons fitted to scale of model
  - 1x1 degree cells 'closed' for RUM
  - Relative availability of stocks scaled down across 5x5 areas in DSVM

2. Simulation Model – RUM closure scenarios

- Profitability impacts estimated in GAMS using;
  - Revenue obtained from modelled choice of location
  - ABARES avg. costs and revenue data
    - Assumes similar cost structure across ports
  - Benchmark (no change) vs closure scenarios
  - Δ revenue = ABARES avg. revenue * modelled Δ revenue (%)
  - Δ fuel cost = Δ distance travelled * ABARES avg. fuel cost
  - Δ crew cost = adjusted by modelled Δ revenue (%)
  - Δ π = Δ revenue – Δ fuel costs & Δ crew costs
    - Other costs assumed constant

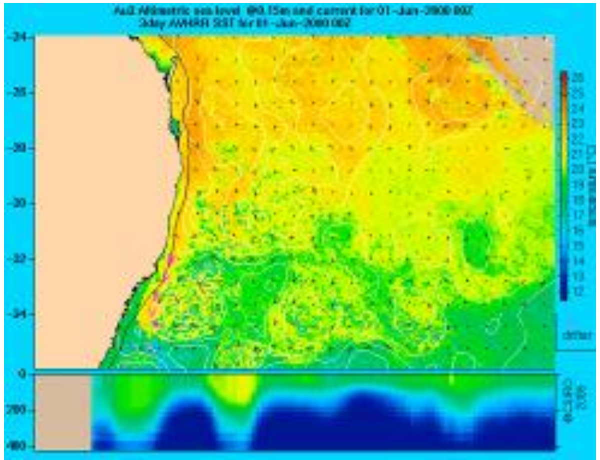
Results – Profit (DSVM vs RUM)



- All ports, 2007
- Variability in magnitude
  - Profit change -16% < -557%
- Variability in rank
- 'best' scenario with costs:
  - DSVM: -19% profit (2nd)
  - RUM: -214% profit (5th)
- 'best' without costs
  - DSVM: -24% profit (4th)
  - RUM: -273% profit (6th)
- Scenarios with 'costs' (GVP) not always lowest impact to fishery

Conclusions

- Work in progress
  - Estimated impacts on profit differ substantially under alternate scenarios and modelling approaches
    - DSVM – possibly over optimistic scenario
    - RUM – excessively pessimistic (shorter run indicator?)
    - From these reliable estimation of compensatory payments unlikely
  - GVP based measures
    - Probably not good proxy for costs when choosing between alternative reserve sites
  - Temporal influence in species distribution
    - Same closures will have different impacts across time
  - Distributional effects
    - Variation between impacts at port level
  - For RUM
    - incorporate measure of sea surface temperature
    - Allow vessels to not fish?



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