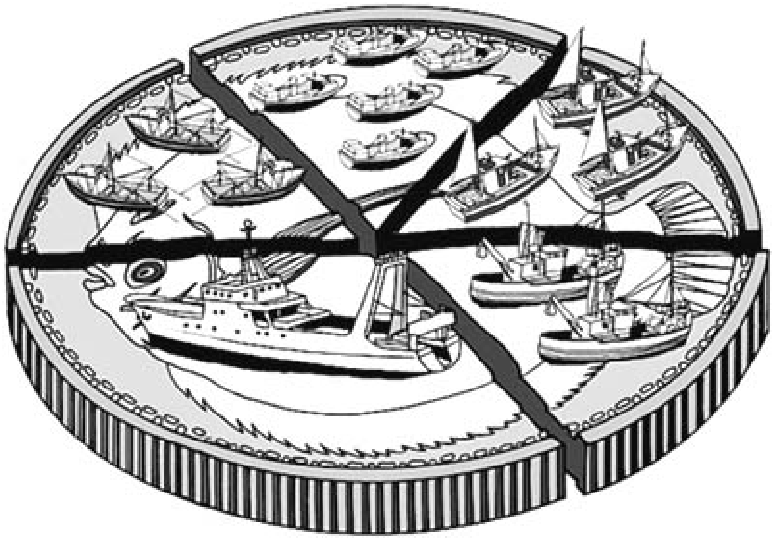
Modeling the impacts of a discard ban in a mixed fishery under catch-quota management

Olivier Thébaud, S. Gourguet, P. Lelong, L. Doyen, R. Little, T. Smith and S. Pascoe



IIFET 2016, Aberdeen, Scotland

Picture: http://www.fao.org/docrep/005/y2498e/y2498e00.htm

Outline

I. Background
II. Modelling Approach
III. A stylized case study
IV. Simulation results
V. Discussion

I

Background

- Ecosystem approach to fisheries management → move towards more comprehensive catch-quota management systems

- Individual Transferable Quotas (ITQs) in multi-species fisheries

  - Potential gains in economic yield & ecological sustainability

  - But, problems related to joint production (by-catch & discards)

  - Response of these systems with / without landing obligation (and the need to account for unwanted catch in quota allocations)?

Modelling approach

- Bio-economic modelling framework (extended from Péreau et al., 2012)
  - N fishing companies (vessels) with:
    - Different technical and economic characteristics ("métiers")
    - Individual variability in performance (catchability of species)
    - Fish prices are fixed outside the fishery
  - S ecologically independent species (Fox population dynamics)
  - Possibility of a quota leasing market for individual species
- Assumptions
  - TACs are set by species
  - Efforts of individual companies set to maximize profit

    → sum of individually optimal harvests entails total demand for quota of each species on quota leasing market (if this exists)

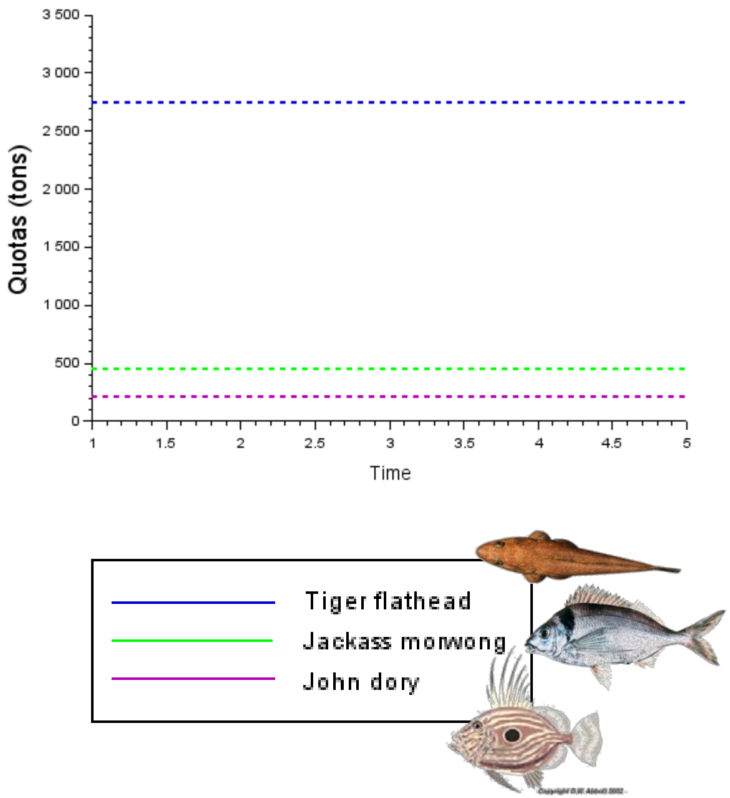
  - Quota market clearing condition (demand=TAC) → quota leasing price
- Scenario: Quota leasing is possible or not / Discards allowed or banned

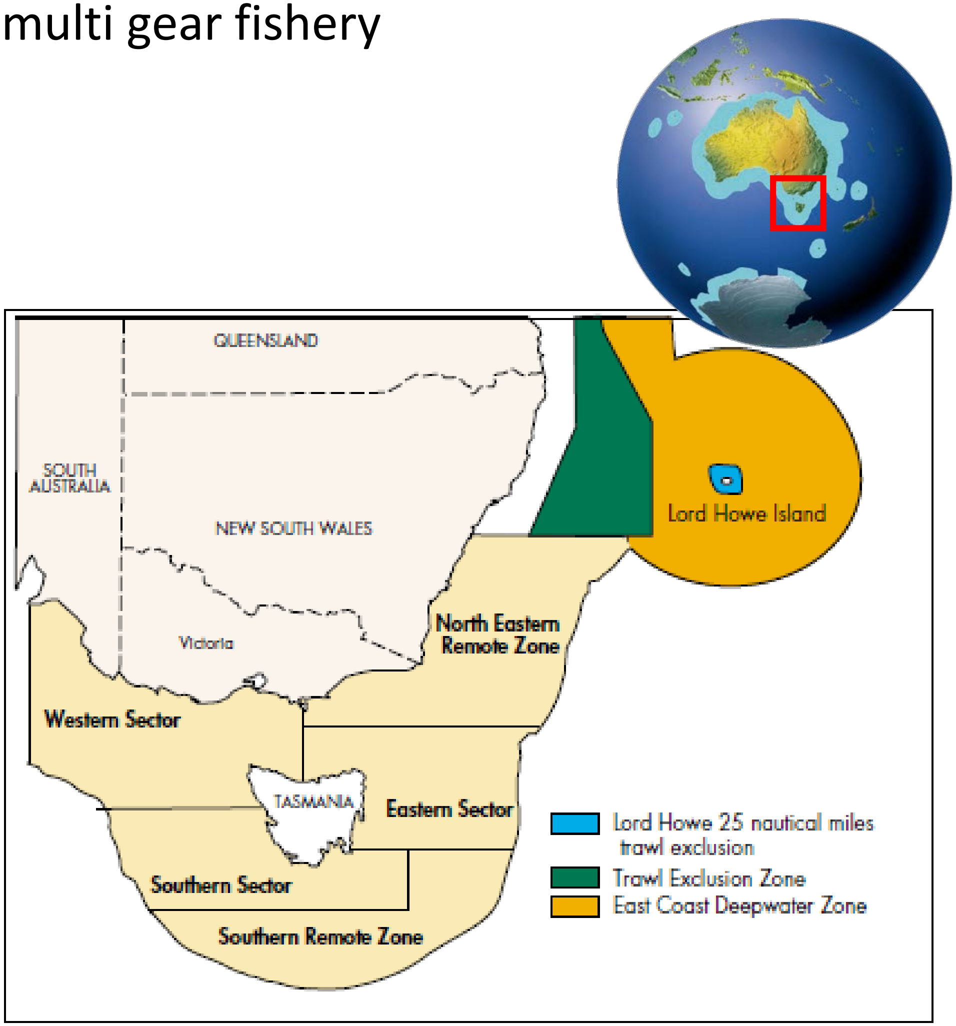
III

The Australian South East Trawl Fishery

A quota-managed multi-species and multi gear fishery

TACs





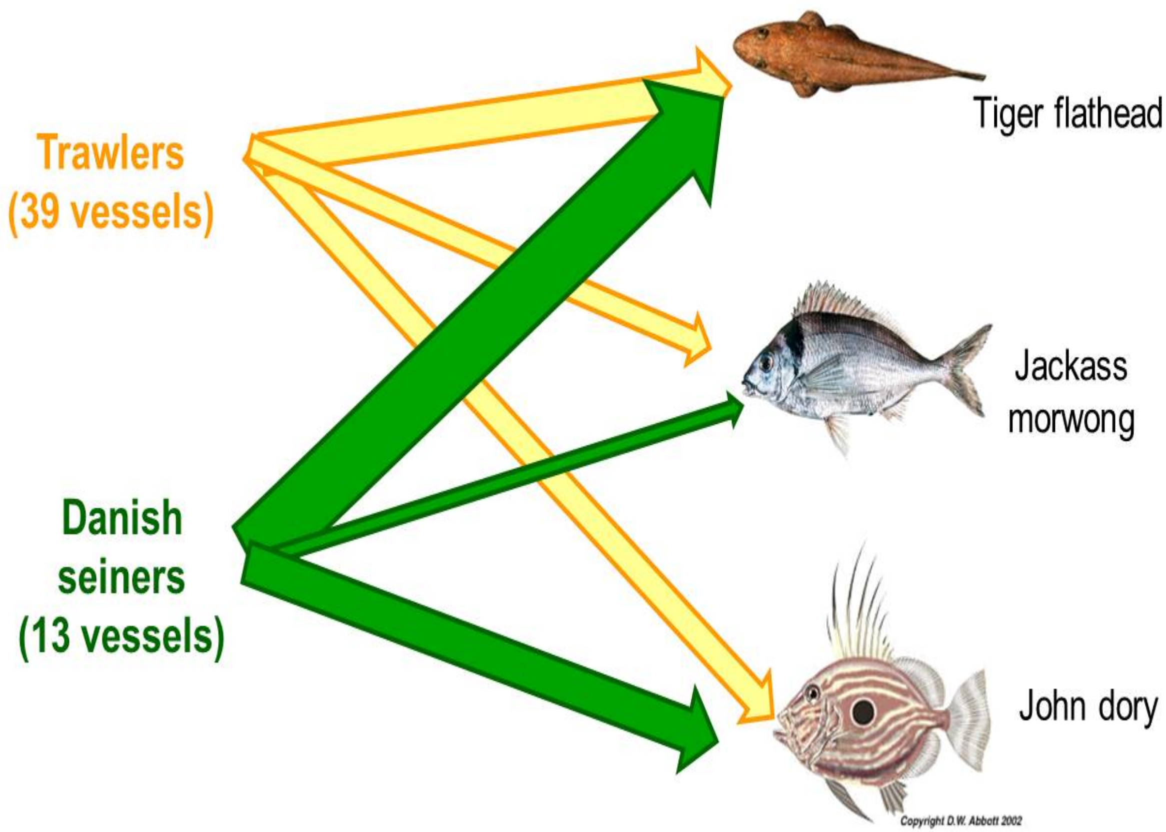
South east trawl fishery territory from Elliston et al (2004)

III

A stylized bio-economic model of the fishery

Multiple fleets

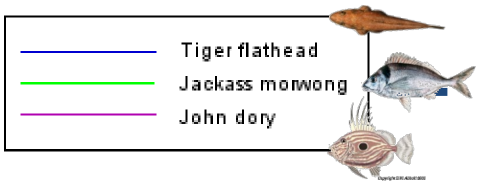
Multiple species



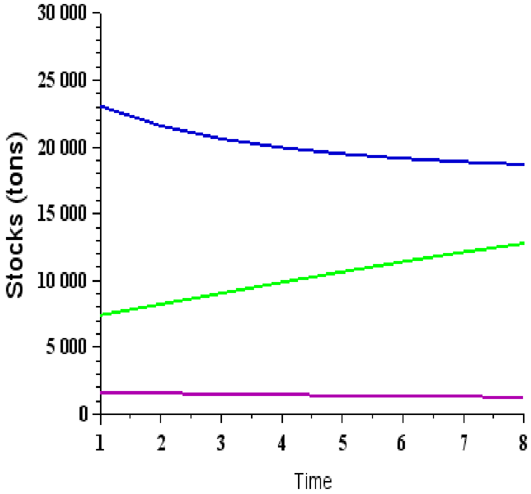
Width of arrows proportional to fleet.species specific catchabilities

IV

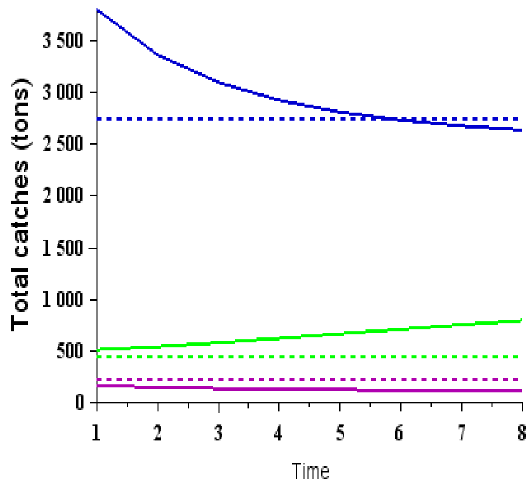
Results – No quota tradeability, Discards allowed

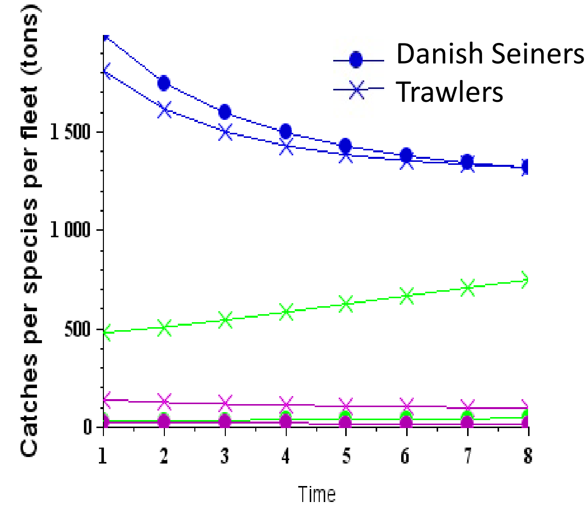


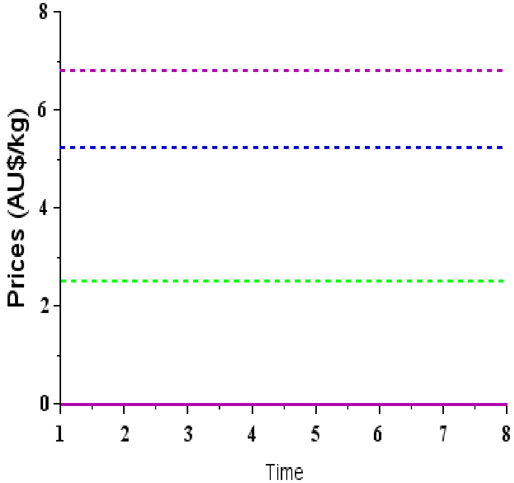
Stocks



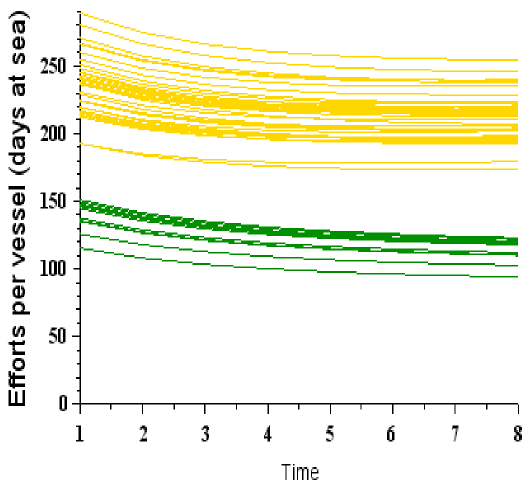
TACs (---) and **catches**



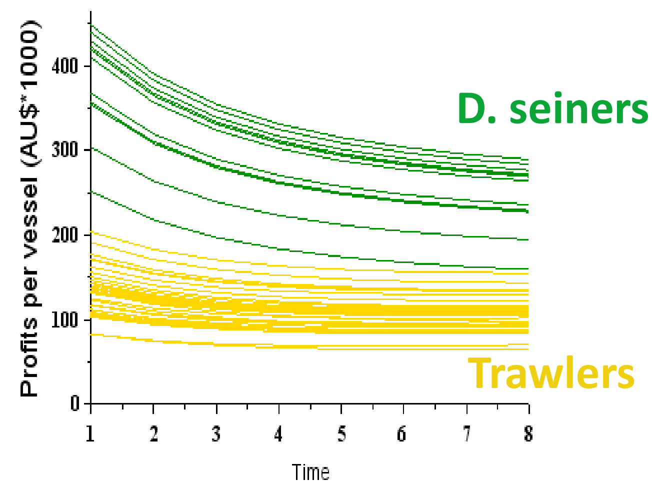




Fish (---) and **quota price**

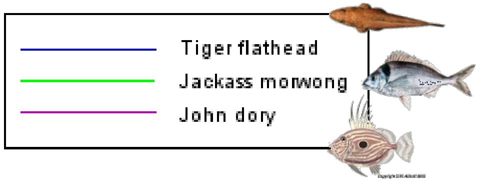


Effort per boat



Rent per boat

Results – No quota tradeability, Discards banned



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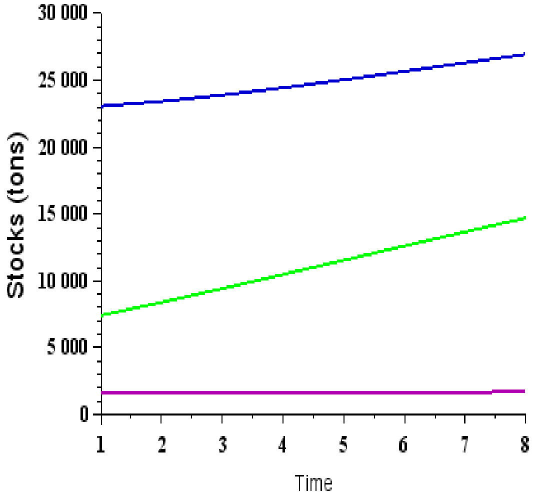

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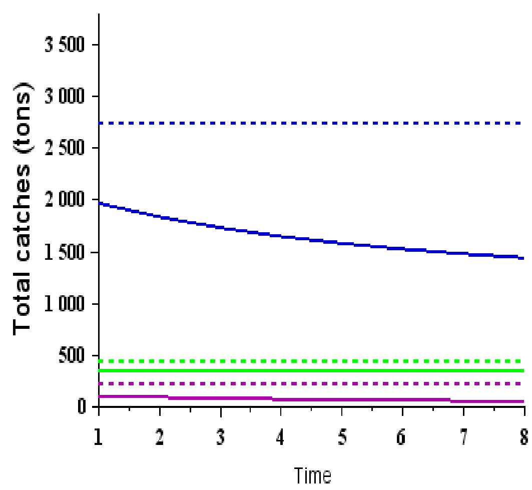
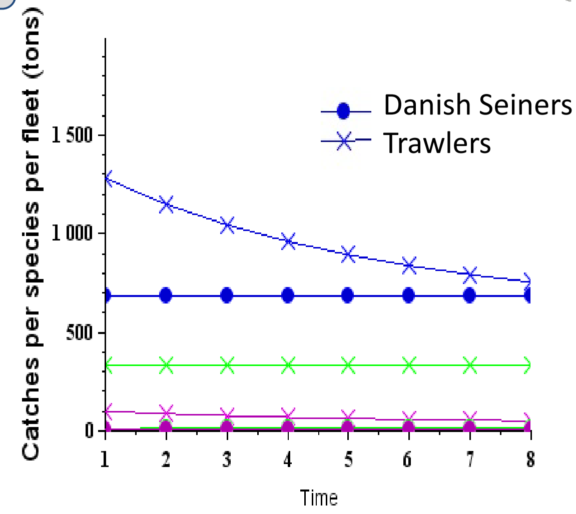
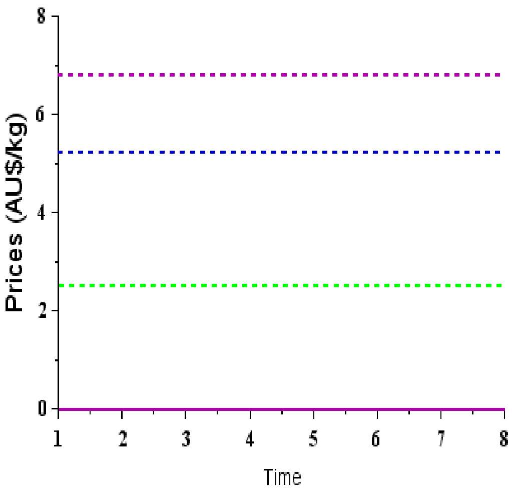
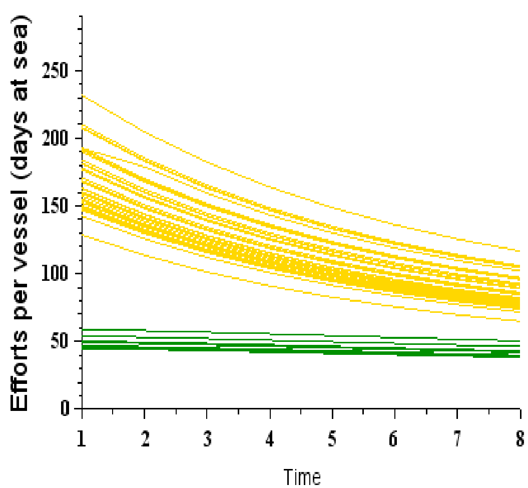
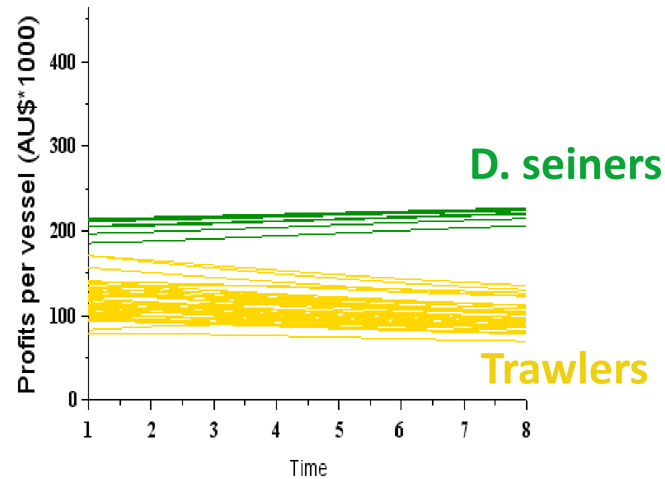










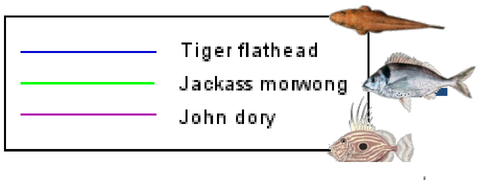
Fish (---) and **quota price**

Effort per boat

Rent per boat

IV

Results – Quota tradeability, Discards allowed



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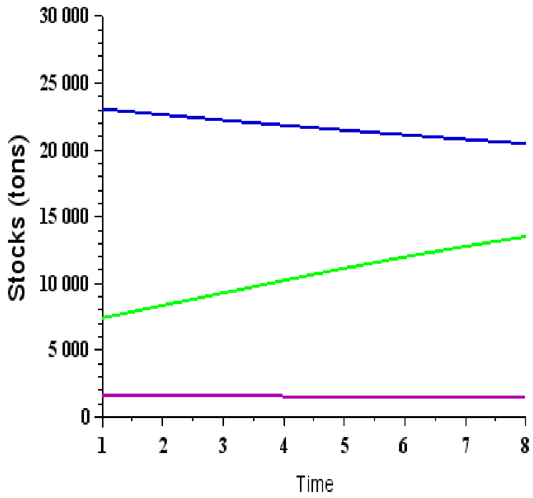

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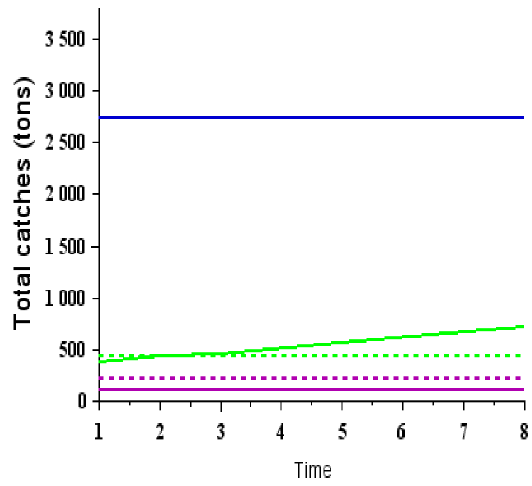

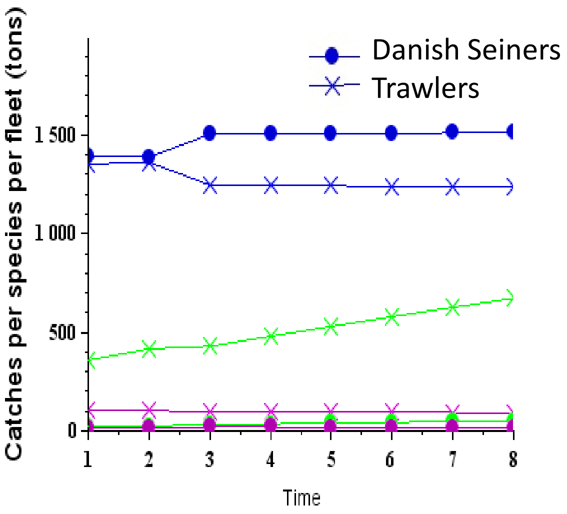

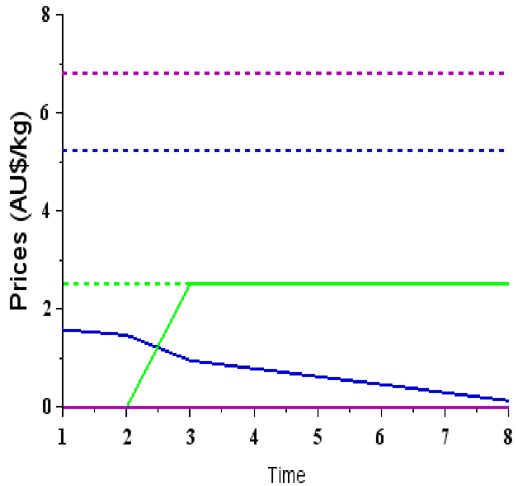

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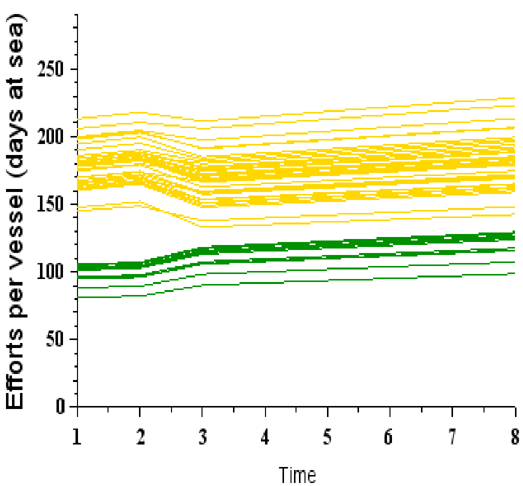
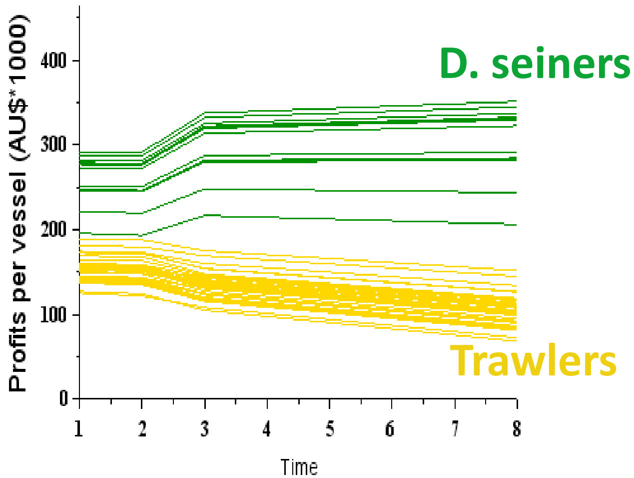


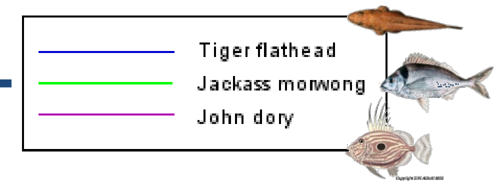
Effort per boat



Rent per boat

IV

Results – Quota tradeability, Discards banned



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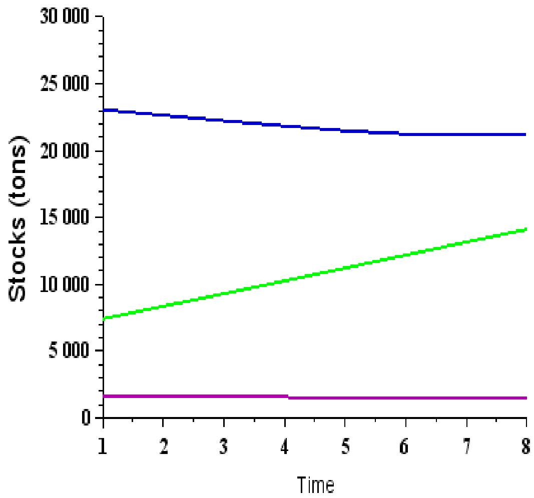

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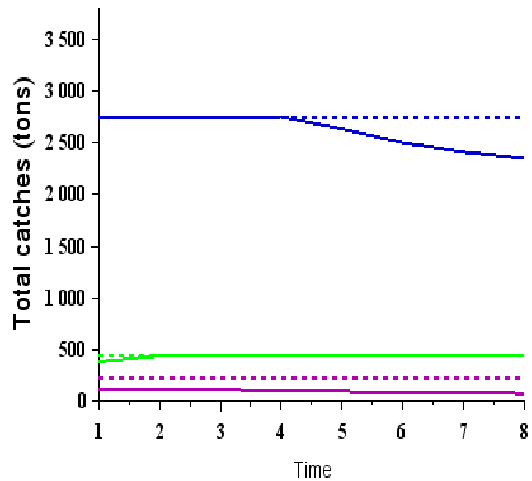

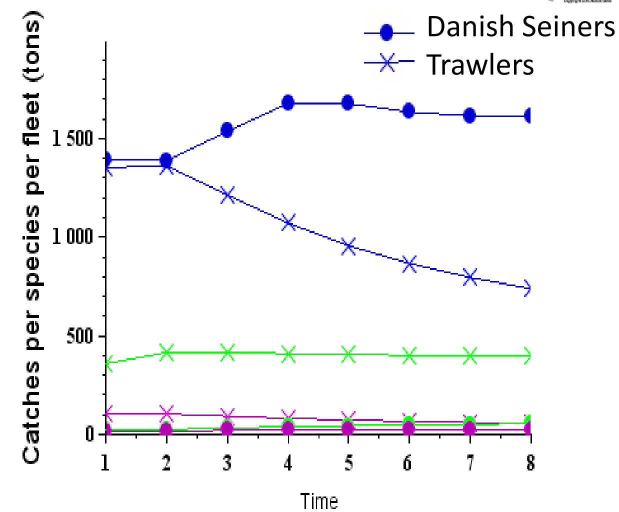

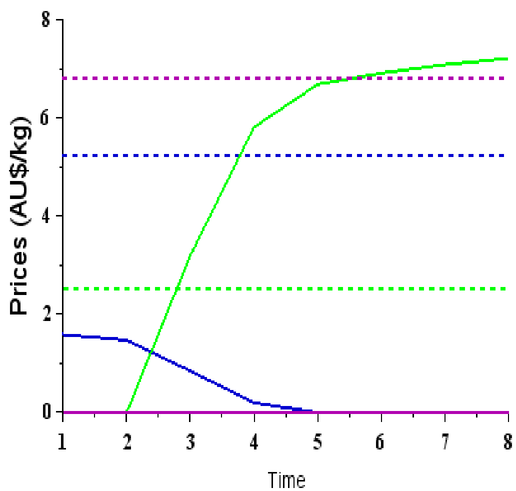

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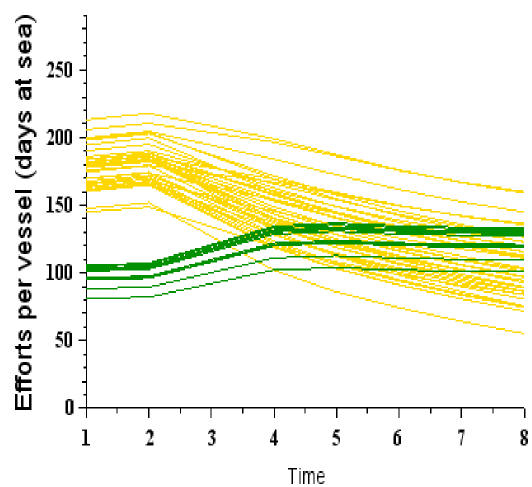
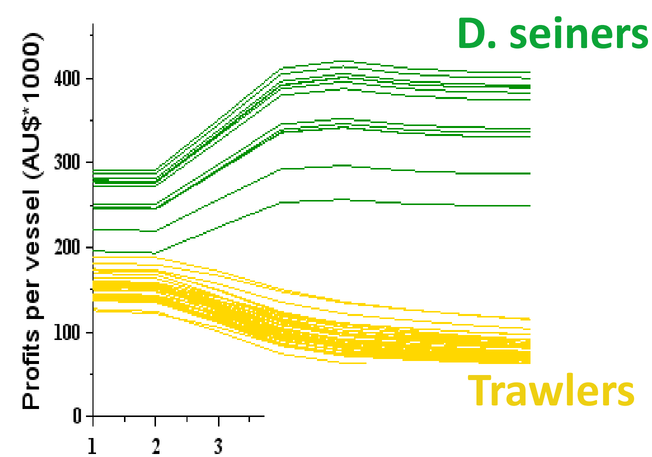


Effort per boat

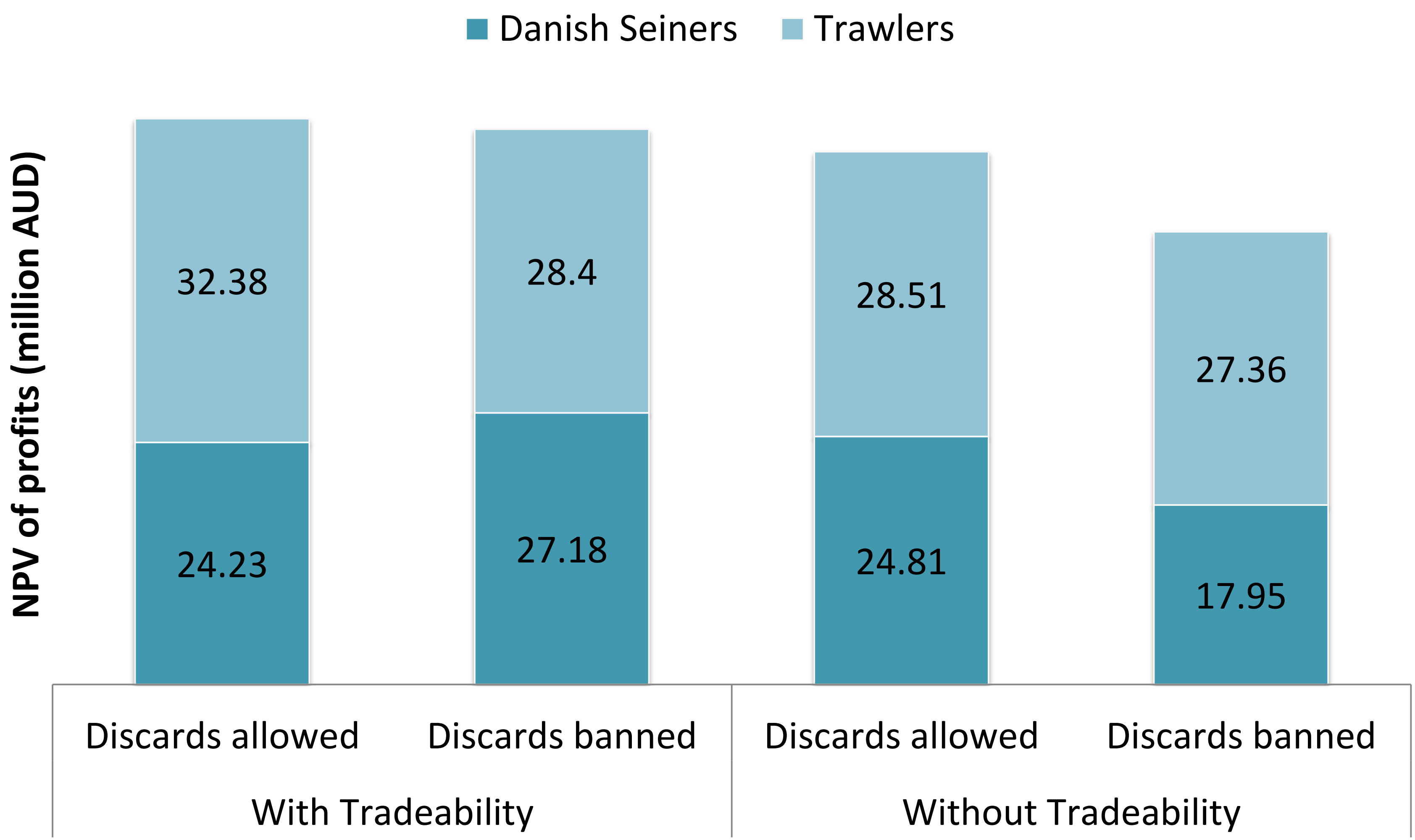


Rent per boat

Results – NPV of profits: comparison of alternative scenarios

$$NPV_f = \sum_{t=t0}^{T} \frac{\pi_f(t)}{(1+\sigma)^t}$$

With σ, the discount rate set at 5%
$\pi_f(t)$ the annual profit of fleet f at time t



Results – Fleet adaptation to maintain level of fishing activity?

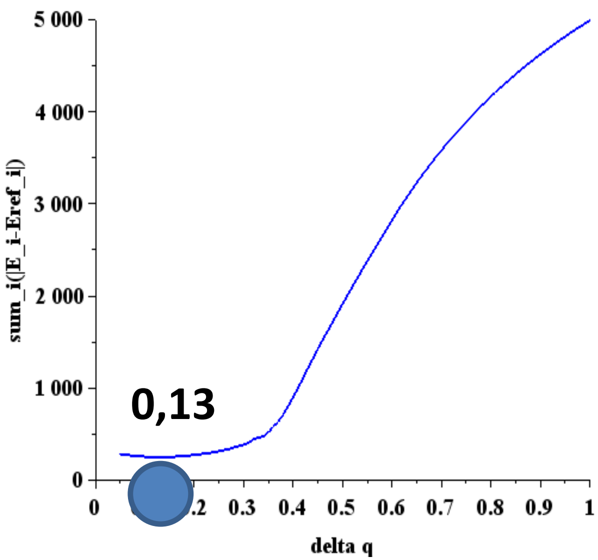
→ Could the industry adapt to this increased cost of fishing due to Morwong bycatch?

Search for $delta\_q$ where $q_{MW,TWi} = q_{ref} * delta\_q$

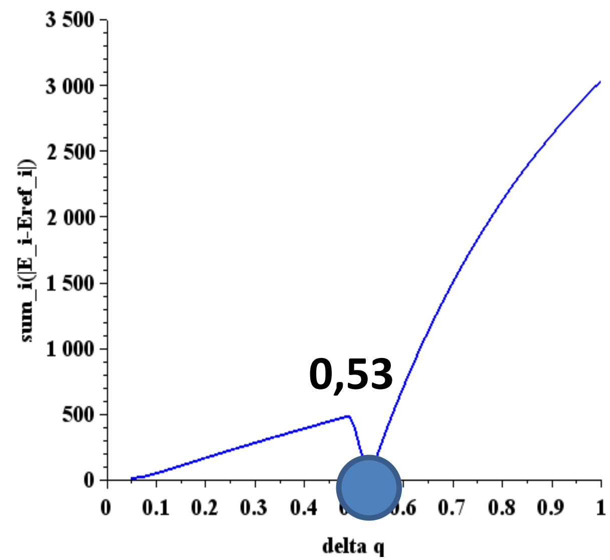
such as to minimize the square of the difference between the E_i and the $E_{ref,i}$ for trawlers in t = 8

→ $Min_{delta\_q} \left(\sum_{i=1}^{nb\_TW} \left(E_{TWi,t=8} - E_{ref,TWi,t=8}\right)\right)^2$

Without tradeability

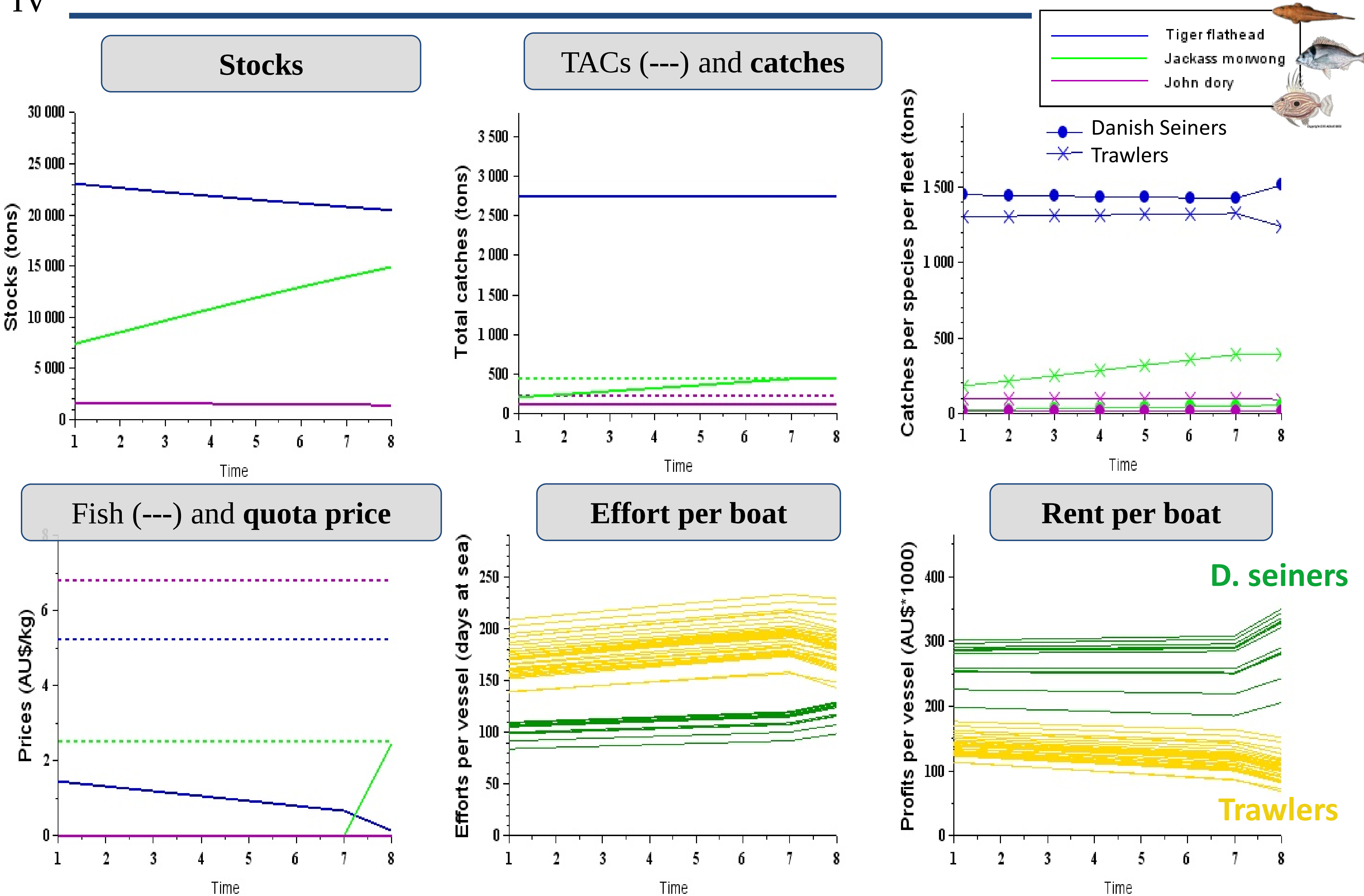


With tradeability



IV

Results – Quota tradeability, Discard banned - delta_q= 0,53



Discussion

- Modeling framework: allows comparison of alternative approaches to setting TACs and managing by-catch and discards in a mixed fishery

- Discard ban (provided effectively implemented) entails greater variability in economic returns between fleets in the short run (even without accounting for non-quota costs to vessels of landing obligation)

- Key question: assessment of adaptations (technical change, spatial and temporal fishing behavior, information sharing, …) required to maintain fleet activity

- Further research:

    - TAC schedules across species that meet multiple sustainability criteria

    - Inclusion of uncertainty in key economic and ecological processes

Thank you for your attention!

Population dynamics

- Assumptions:
  - Discrete time (typically yearly discretization)

$$X_i(t+1) = X_i(t)\left(1 + r_i \ln\left(\frac{K_i}{X_i(t)}\right)\right) - H_i(t)$$

X, r, K, H:

- Biomass
- Reproduction parameter
- Carrying capacity
- Harvest function

Harvesting dynamics

– Companies are price-takers

– Cost function: $C_k(e_k) = c_0^k + c_1^k e_k + c_2^k \frac{e_k^2}{2}$

– Goal: maximize their profit by choosing the optimal effort

$$\max_{sc\ e_k \geq 0} \sum_{i=1}^{S} p_i q_{i,k} X_i e_k - C_k(e_k) - \sum_{i=1}^{S} m_i (q_{i,k} X_i e_k - Q_{i,k})$$

Harvesting dynamics – ctd.

- Results:
  - F.O.C. gives :

$$e_k^* = \frac{1}{c_2^k}\left(\sum_{i=1}^{S}(p_i - m_i)q_{i,k}X_i - c_i^k\right)$$

  - Determines optimal harvest per species & per company

$$H_i^* = \sum_{k=1}^{N} q_{i,k}X_i \frac{1}{c_2^k}\left(\sum_{i=1}^{S}(p_i - m_i)q_{i,k}X_i - c_1^k\right)$$

  - Leads to equilibrium quota prices (via a Walras adjustment process)

$$m_i^*$$

  - *m** decreases with quota supply (TAC), and increases with stock increase

Parameters values

Biological parameters and fish sale prices (p)

	r	K (in tons)	X (2009) (in tons)	p (in AU$ per ton)
Tiger Flathead	0.153	44 566	23 070	5 230
Jackass Morwong	0.128	30 231	7 412	2 520
John Dory	0.044	5 431	1 666	6 800

Estimated mean catchabilities (in days-1 *10-6)

	q mean catchabilities	
	trawlers	Danish seiners
Tiger Flathead	8.4	46.6
Jackass Morwong	7.2	2.4
John Dory	7.9	8.2

Efforts and cost parameters

- <u>Efforts</u>

	Nb of boats in 2009	Mean annual effort per boat (days at sea)
Trawlers (TW)	39	210
Danish Seiners (DS)	13	96

- <u>Cost parameters per boat</u>

$$C_k(e_k) = c_0^k + c_1^k e_k + \frac{c_2^k}{2} e_k^2$$

with k a fishing firm (i.e. a boat) and e_k its annual effort

❖ In our model: trawlers and Danish seiners can fish only 3 species
❖ These 3 species : 13% and 43% of their fishing incomes (respectively)

} adjusted costs (AUD)

	c_0	c_1	c_2
Trawlers	13 411	21.59	5.21
Danish Seiners	24 342	55.55	41.43

The quota leasing market model