IIFET 2012 conference, Dar es Salaam, July 19th, 2012

Sustainable Management of the Shrimp Trawl Fishery in Tonkin Gulf, Vietnam

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Outline

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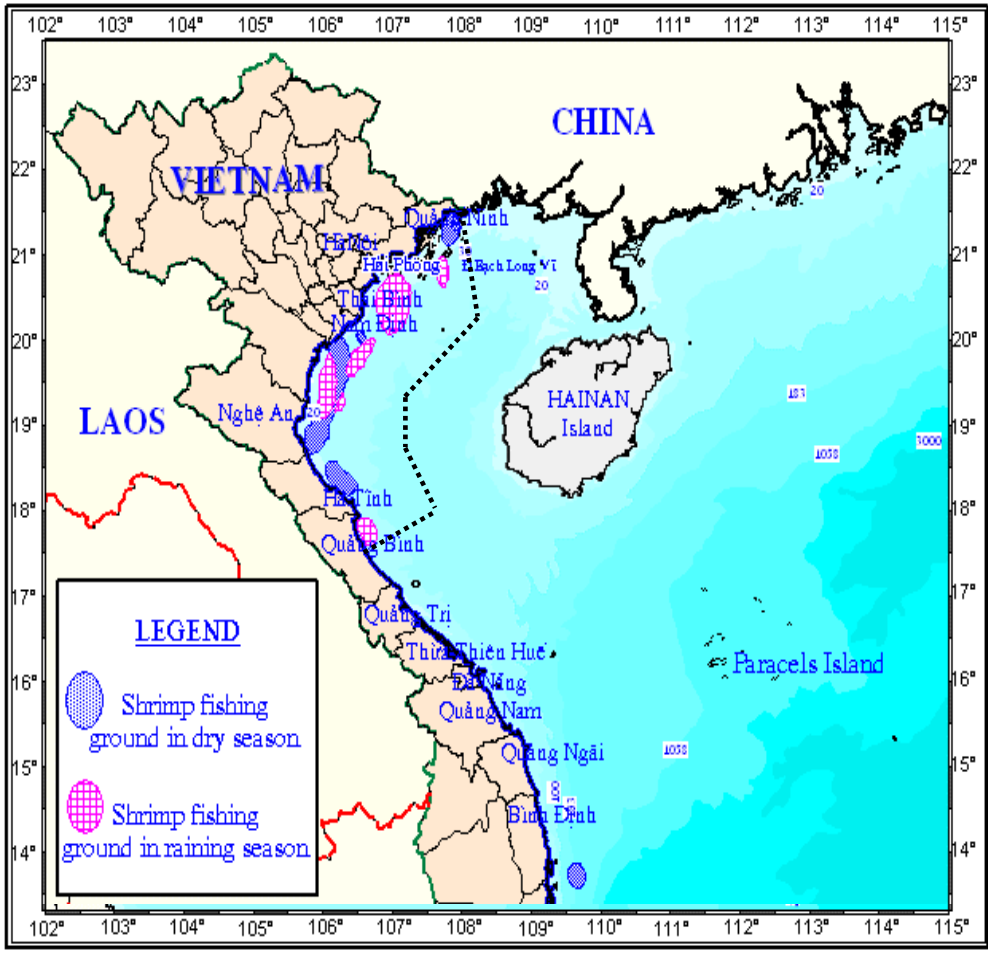
- ❑ Models
- ❑ Data
- ❑ Results
- ❑ Conclusion

Introduction

- The Tonkin Gulf is a semi-closed gulf in the northwest of the South China Sea.
- The Gulf contributed aboaut 16% to Vietnamese marine resources, 30% to total fishing boats and about 20% to total marine landing annually.
- Fisheries in the Gulf are small scale, multi-species and multi-gears.

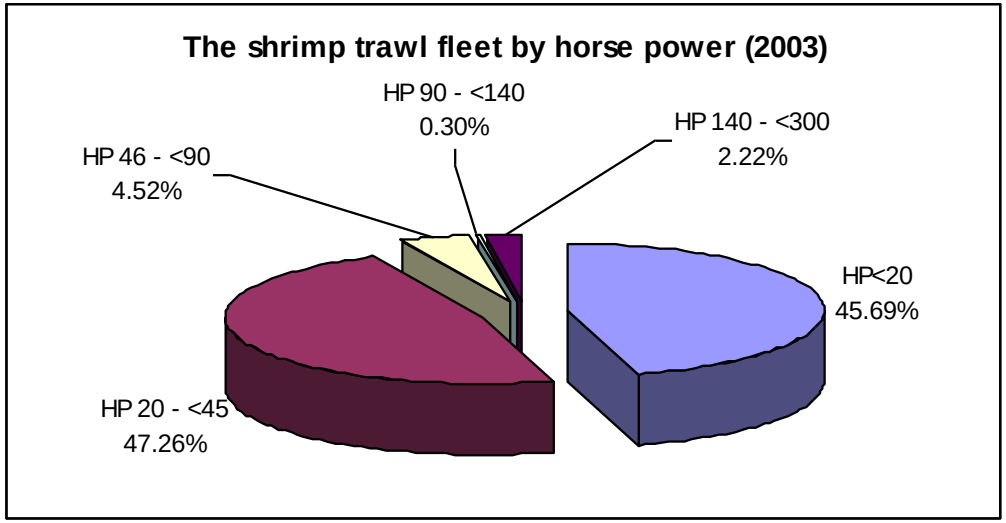
Introduction (contd.)

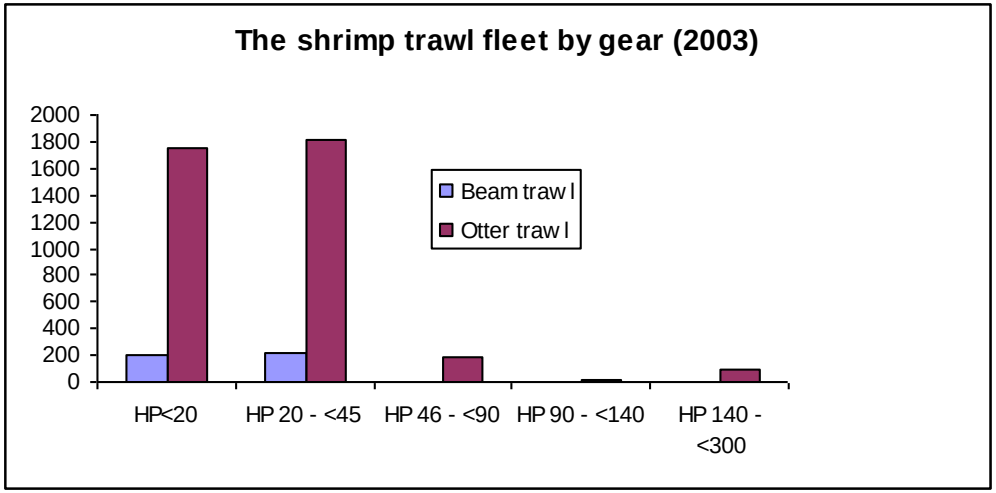
- There have been found 58 shrimp species in Tonkin Gulf, mainly belong to the family of *Penaeidae*.
- Most shrimp species are distributed along the coastal areas (shrimp fishing grounds are showed in the map)
- Shrimp spawning seasons are twice per year: February-March and June-July.



Introduction (contd.)

- The shrimp fleet (4000 fishing boats) occupied about 18% of the total fleet in the Gulf.
- About 93% fishing boats have engine lower than 45 HP.
- Otter trawl and beam trawl are two main fishing gears (otter trawlers are dominant).





Introduction (contd.)

- Shrimp landings from trawlers were about 11,445 tones accounted for about 4.6% of the total catch in the Tonkin Gulf in 2003 (Chinh, 2005).
- The catch per unit of effort (CPUE) globally declined from 1.34 to 0.34 ton/HP/year from 1985-1997 (Son *at el*, 2003)
- Surveys by RIMF showed that density of shrimp species (*Penaeidae*) reduced a half between the period 1975-1978 (66kg/km^2) and 2002 (32.01kg/km^2)

Introduction (contd.)

The sustainability of the shrimp stock in the trawl fishery in the Tonkin Gulf is investigated. Two questions will be addressed:

- What are the sustainable optimal stock level and the associated harvest?
- How should the optimal stock level be approached?

Models

- A discrete-time model for exploited shrimp stock can be expressed as follows

$$X_{t+1} - X_t = F(X_t) - H(E_t, X_t)$$

- Verhulst-Schaefer model (1954)

$$X_{t+1} - X_t = rX_t\left(1 - \frac{X_t}{K}\right) - qE_tX_t$$

- Gompertz-Fox model (1970)

$$X_{t+1} - X_t = rX_t \ln\ln\left(\frac{K}{X_t}\right) - qE_tX_t$$

Models (contd.)

- Constant price per unit of harvested biomass and constant cost per unit effort are assumed

$$\prod(t) = TR(t) - TC(t) = p * H(E(t), X(t)) - c * E(t)$$

- Effort and yield in open access situation (OA)

Models	Effort	Yield
Verhulst-Schaefer	$E_{OA1} = \frac{c - p\gamma}{p\gamma_1} = \frac{r}{q}\left(1 - \frac{c}{pqK}\right)$	$Y_{OA1} = \frac{c^2 - pc\gamma}{p^2\gamma_1} = \frac{rc}{pq}\left(1 - \frac{c}{pqK}\right)$
Gompertz-Fox	$E_{OA2} = \frac{\ln c - \ln p - \gamma}{\gamma_1} = \frac{r}{q}\ln\frac{pqK}{c}$	$Y_{OA2} = \frac{c(\ln c - \ln p - \gamma)}{py_1} = \frac{cr}{pq}\ln\frac{pqK}{c}$

Models (contd.)

- Effort and yield at MSY

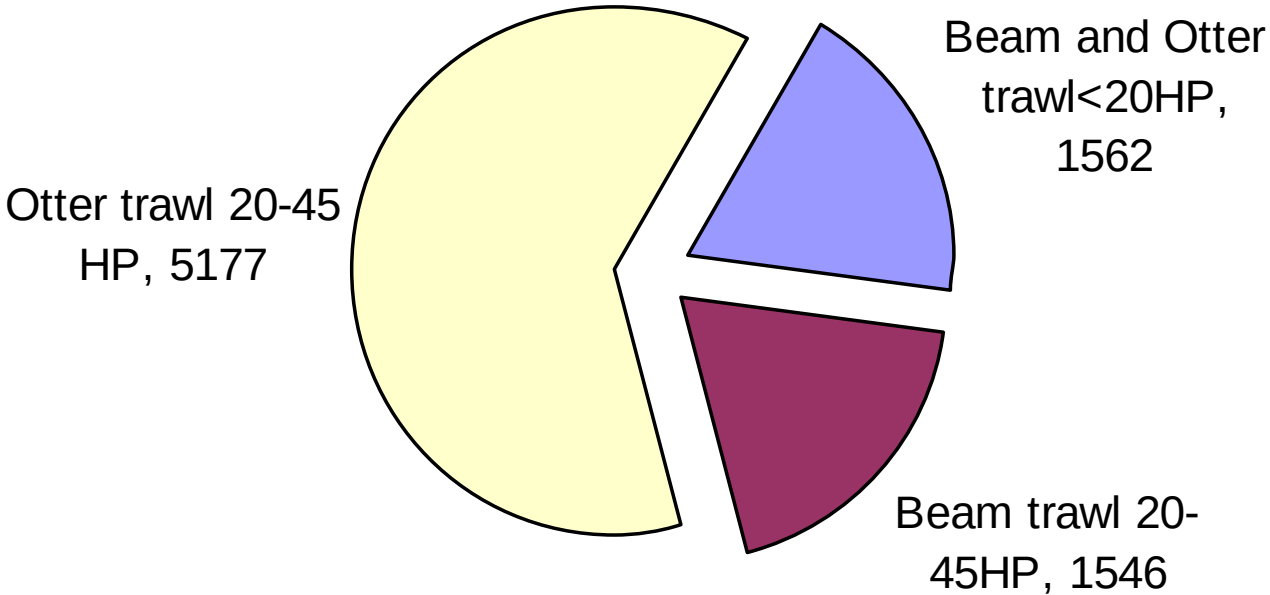
Models	Effort	Yield
Verhulst-Schaefer	$E_{MSY1} = -\frac{\gamma}{2\gamma_1} = \frac{r}{2q}$	$MSY_1 = -\frac{\gamma^2}{4\gamma_1} = \frac{rK}{4}$
Gompertz-Fox	$E_{MSY2} = -\frac{1}{\gamma_1} = \frac{r}{q}$	$MSY_2 = -\frac{1}{\gamma_1} e^{\gamma - 1} = \frac{rK}{e}$

- Effort and yield at MEY

Models	Effort	Yield
Verhulst-Schaefer	$E_{MEY1} = \frac{c - p\gamma}{2p\gamma_1} = \frac{r(pqK - c)}{2pq^2K}$	$MEY_1 = \frac{c^2 - p^2\gamma^2}{4p^2\gamma_1} = \frac{r(p^2q^2K^2 - c^2)}{4p^2q^2K}$
Gompertz-Fox	$E_{MEY2} = \frac{-1 + w}{\gamma_1}$	$E_{MEY2} = \frac{e^{-1+\gamma+w} + \frac{c}{p}}{\gamma_1}$

Data

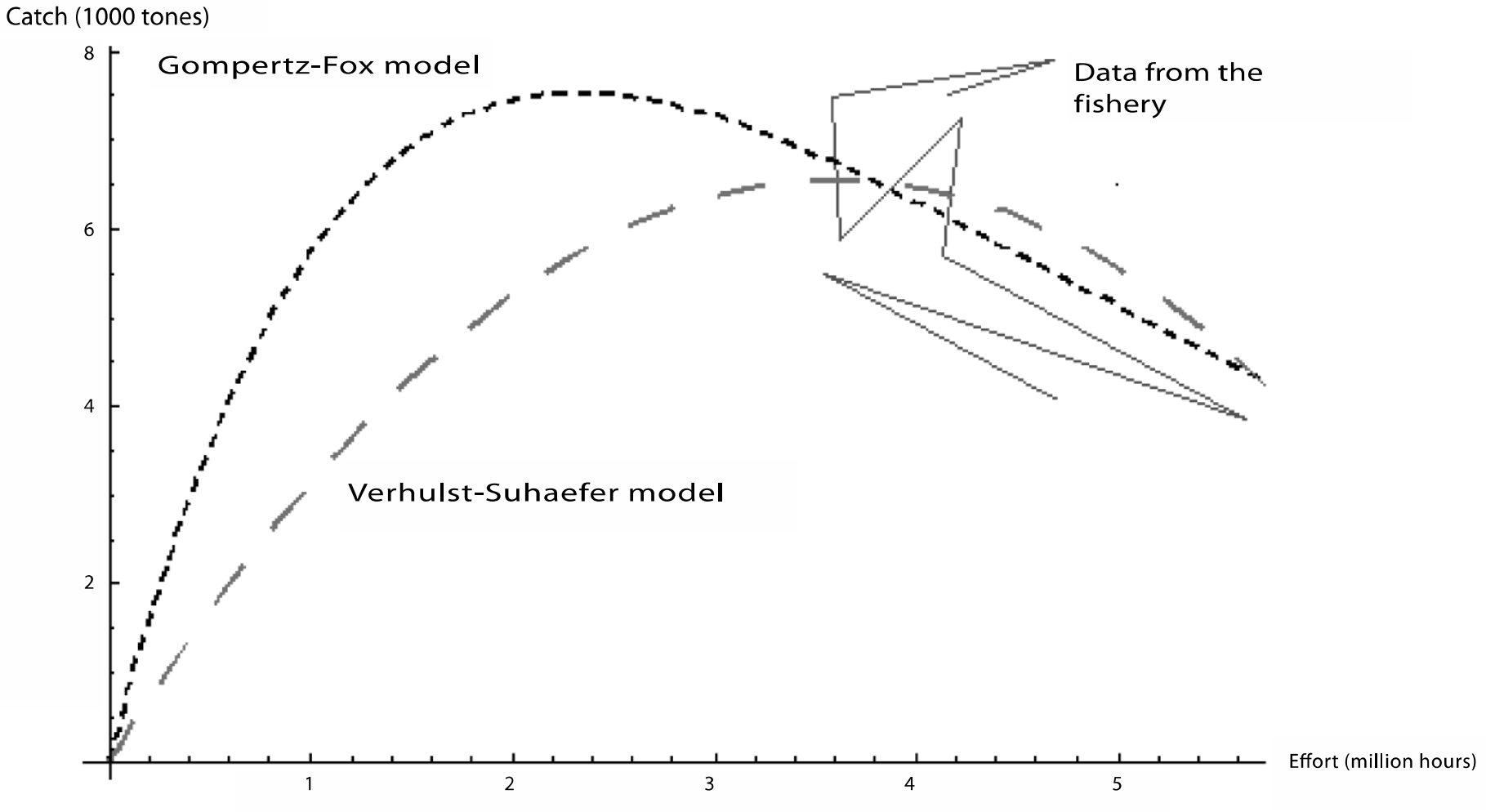
- Economic data are derived from the ALRMV project carried out in Vietnam from 2000 to 2004.
- A half year catch and effort data are used in accordance with the biological year of the shrimp stock
- Shrimp trawlers (with engine lower than 45 HP) are divided into three groups.



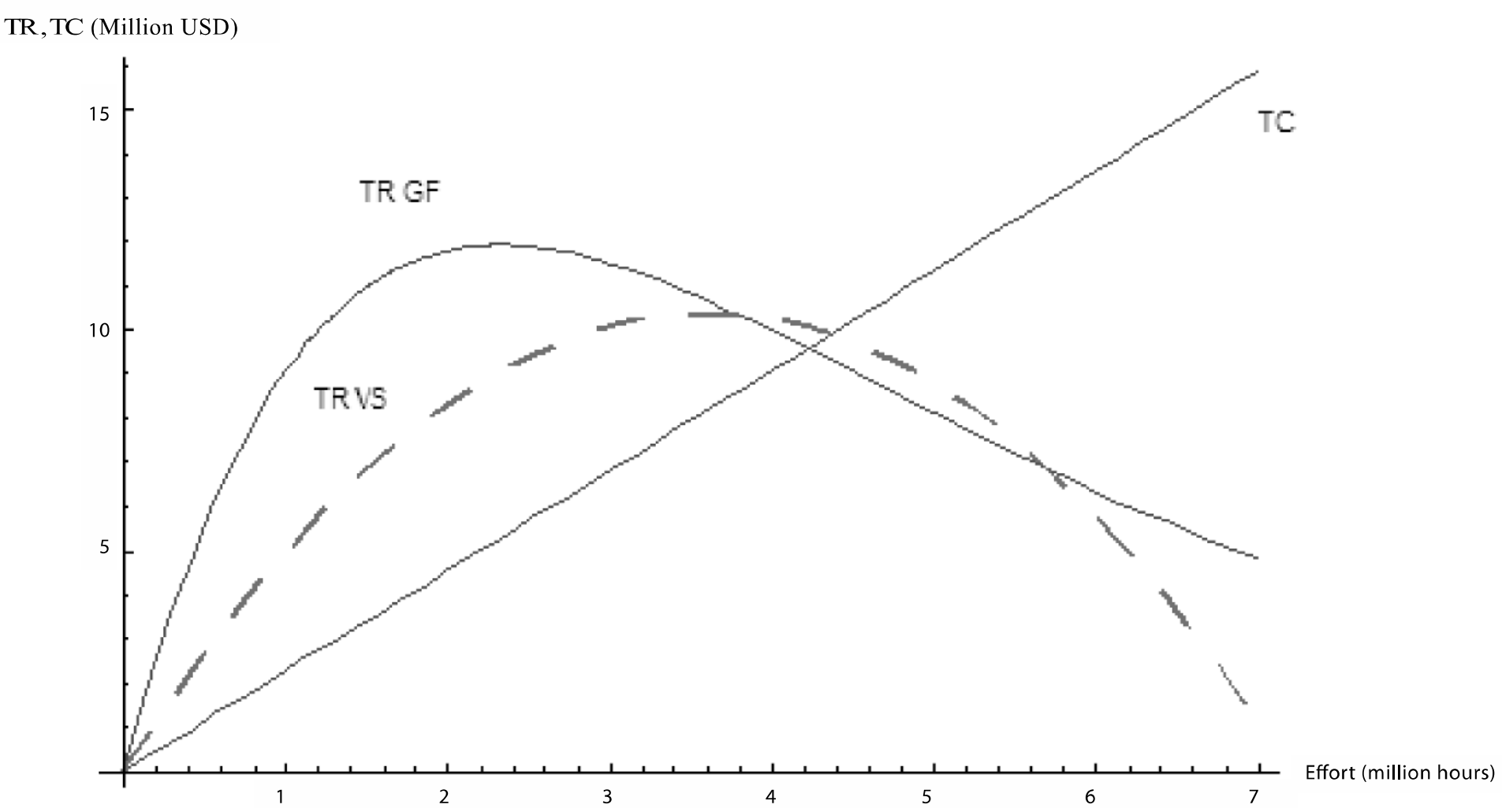
Data (contd.)

- Otter trawlers with the engine 20-45 HP, the biggest group, are chosen as the standard group for aggregating effort of the fishery.
- Otter trawlers and beam trawlers with the engine lower than 20 HP are assumed homogeneous and will be consider as one group.
- The third group is the beam trawlers with the engine from 20-45 HP.

Results


Catch (1000 tones)
8
6
4
2
Gompertz-Fox model
Data from the fishery
Verhulst-Suhaefer model
1
2
3
4
5
Effort (million hours)

Results (contd.)



Results (contd.)

- The two models showed that the fishery was overexploited both in terms of maximizing yield and maximizing profits.

	Data from the fishery (2004)	MSY		MEY	
		Verhulst-Schaefer	Gompertz-Fox	Verhulst-Schaefer	Gompertz-Fox
Catch (10^6 kg)	4.780080	6.54969	7.53417	5.53345	7.05241
Effort (10^6 towing hours)	4.126225	3.59904	2.32426	2.18137	1.57845

Results (contd.)

- The two models showed the same trends of optimal reference points over the range of the discount rate (δ = 0% - 20%)

Models	δ (%)	Y^* (1,000 tons)	E^* (10^6 hour)	X^* (1,000 tons)	π^* (Million USD)	$CPUE^*$ (10^{-3} ton/hour)
Verhulst-	0	5.53345	2.18137	11.66760	3.810	2.536686
Schaefer	5	5.60297	2.23073	11.55280	3.808	2.511720
	10	5.66832	2.27880	11.44100	3.803	2.487414
	20	5.78732	2.37115	11.22620	3.782	2.440723
	∞	6.25477	4.36275	6.59427	0	1.433676
Gompertz-Fox	0	7.05241	1.57845	20.55050	7.585	4.467934
	5	7.20065	1.69317	19.56080	7.559	4.252763
	10	7.31203	1.80103	18.67380	7.491	4.059916
	20	7.45235	1.99751	17.16010	7.267	3.730820
	∞	6.05070	4.22040	6.59427	0	1.433679

Results (contd.)

The current fishing effort should be reduced to achieve selected reference points

Reference point	Verhulst-Schaefer model	Gompertz-Fox model
MSY	12 %	44 %
MEY(at 10% discounted rate)	45 %	56 %

Tax policies to achieve MSY

Model	Landing tax (USD/ton)	Effort tax (USD/hour)	Entry tax (USD/boat/month)
MSY			
- Verhulst-Schaefer	336	0.612	92.379
- Gompertz-Fox	883	2.863	279.293
MEY			
- Verhulst-Schaefer	689	1.747	159.926
- Gompertz-Fox	1076	4.805	318.343

Results (contd.)

- Tax policies to achieve optimal reference points

Model	δ (%)	Landing tax (USD/ton)	Effort tax (USD/hour)	Entry tax (USD/boat/month)
Verhulst-	0	689	1.747	159.926
Schaefer	5	680	1.707	159.844
	10	671	1.669	159.607
	20	653	1.595	158.716
	∞	0	0	0
Gompertz-Fox	0	1076	4.805	318.343
	5	1050	4.464	317.265
	10	1024	4.159	314.389
	20	975	3.638	304.993
	∞	0	0	0

Conclusion

- The two models indicate that the fishery is overexploited both in terms of maximizing yield and maximizing profit.

- The results from the two models showed the open access yield of the fishery was about 12,000 tones per year which is in accordance with the official catch statistic (about 11,445 tones in 2003);

- The entry tax was applied effectively to the shrimp trawl fishery. However, the current tax is 6.67 USD/boat/month. It should be increased to achieve the reference points of the fishery.

Conclusion (contd.)

- An entry tax should be between 92-279 USD/boat/month to achieve the MSY.

- At the social discounted rate of 10%, an entry tax of 160-314 USD/month/boat should be imposed to attain the MEY. The current tax should thus be increased 14-47 fold to achieve the selected reference points.

- Data ranges of catch and effort were small which may give poor background for choosing a priority model. It also need more data in order to have reasonable advice for the fishery

Acknowledgements

- I am very grateful for advice from **Arne Eide** (University of Tromso) and **Niels Vestergaard** (University of Southern Denmark);
- I would like to thank **Japan International Fisheries Research Society (JIFRS)** for financial support and giving an opportunity to present this paper today.
- Thank you very much for your attention