# A Bioeconomic Model for Marine Ecosystems

## Tourism, fishing and marine reserves

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- System at equilibrium

$$\boxed{D\frac{d^2 N}{dx^2} = qEN - g(N,E)}$$

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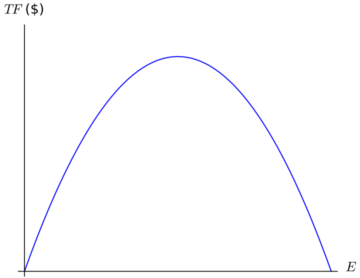

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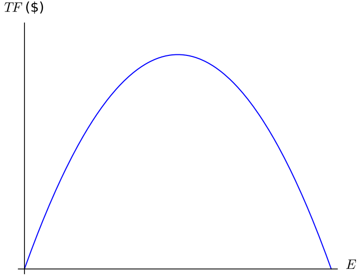


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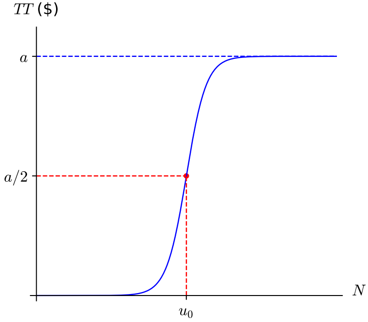

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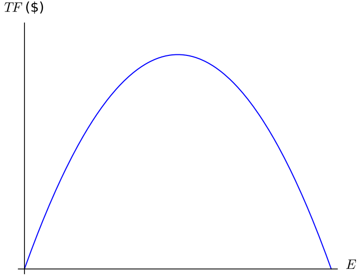


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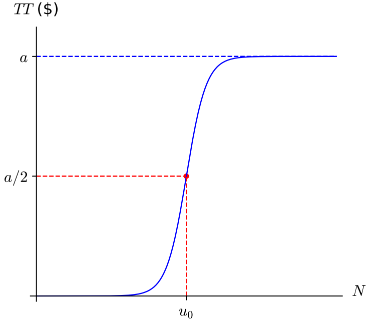


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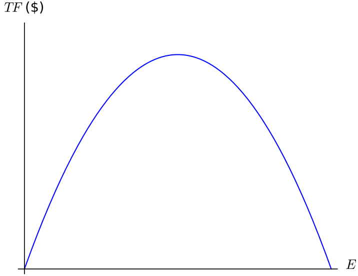


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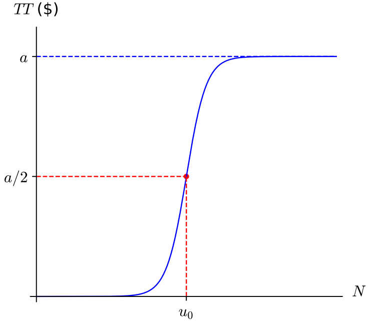


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- Use Optimal Control Theory! Maximize a function $H(E)$ at each point.

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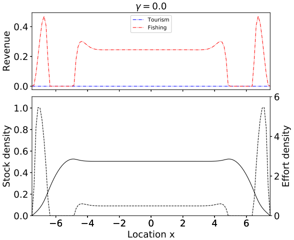
Fishing revenue $\Pi_f$. Tourism revenue $\Pi_t = 0$.

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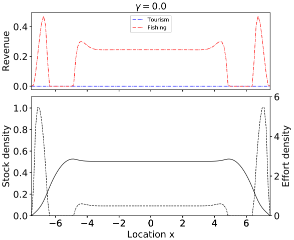


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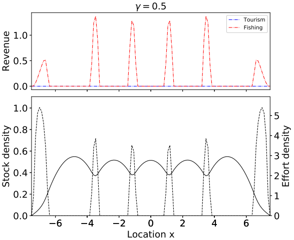
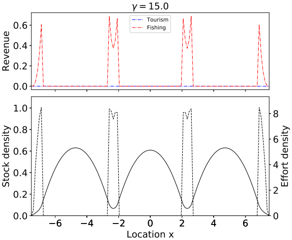



$\Pi_f = 2.46$

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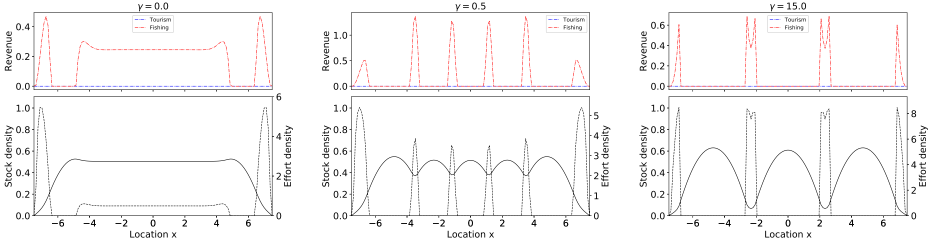


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- Other important metrics: Biomass, Reserve length, Capture.

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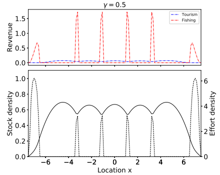
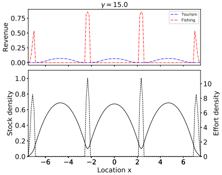
- $\alpha = 0.1$




- $\Pi_t = 0.67 \quad \Pi_f = 2.24$

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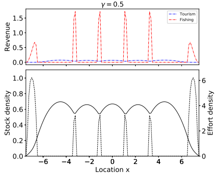


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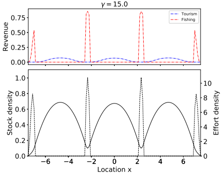


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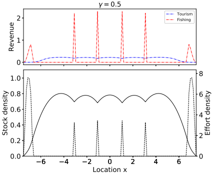
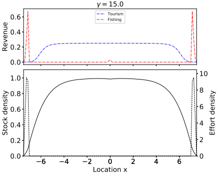



- $\Pi_t = 2.45 \quad \Pi_f = 1.75$

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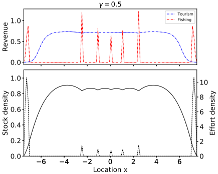
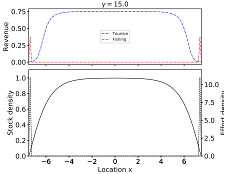



- $\Pi_t = 8.70 \quad \Pi_f = 1.00$




- $\Pi_t = 9.21 \quad \Pi_f = 0.09$

# Other ideas

- Study of heteregoneous systems. Habitats with spatially varying sensitivity.

$$h \longmapsto h(x)/\gamma \longmapsto \gamma(x)$$

- Restricting tourism to areas with limited fishing. Parameter analogous to $u_0$