Risk Analyses in Ecosystem Management and Environmental Impact Assessment

生態系管理と環境影響評価におけるリスク解析

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Today's my talk 今日のお話

- **Discount mean time to extinction;**割引平均絶滅待ち時間
- **Current problems in Environmental impact assessment and ecological risk assessment** 環境影響評価と生態リスク評価の今日的問題

Extinction risk 絶滅の恐れ

- $G(t)$: Cumulative extinction probability累積絶滅確率
- $G'(t)/[1-G(t)]$:The extinction probability in t years after. t年後の絶滅確率
- Mean time to extinction 絶滅待ち時間

$$T = \int_0^\infty [1 - G(t)] dt$$

Lande & Orzack (1988)

Cumulative Probability累積絶滅確率

$$G(t) = \frac{(x_0 - x_c)}{\sqrt{2\pi\sigma^2 t^3}} \exp\left[-\frac{(x_0 + r * t - x_c)^2}{2\sigma^2 t} \right]$$

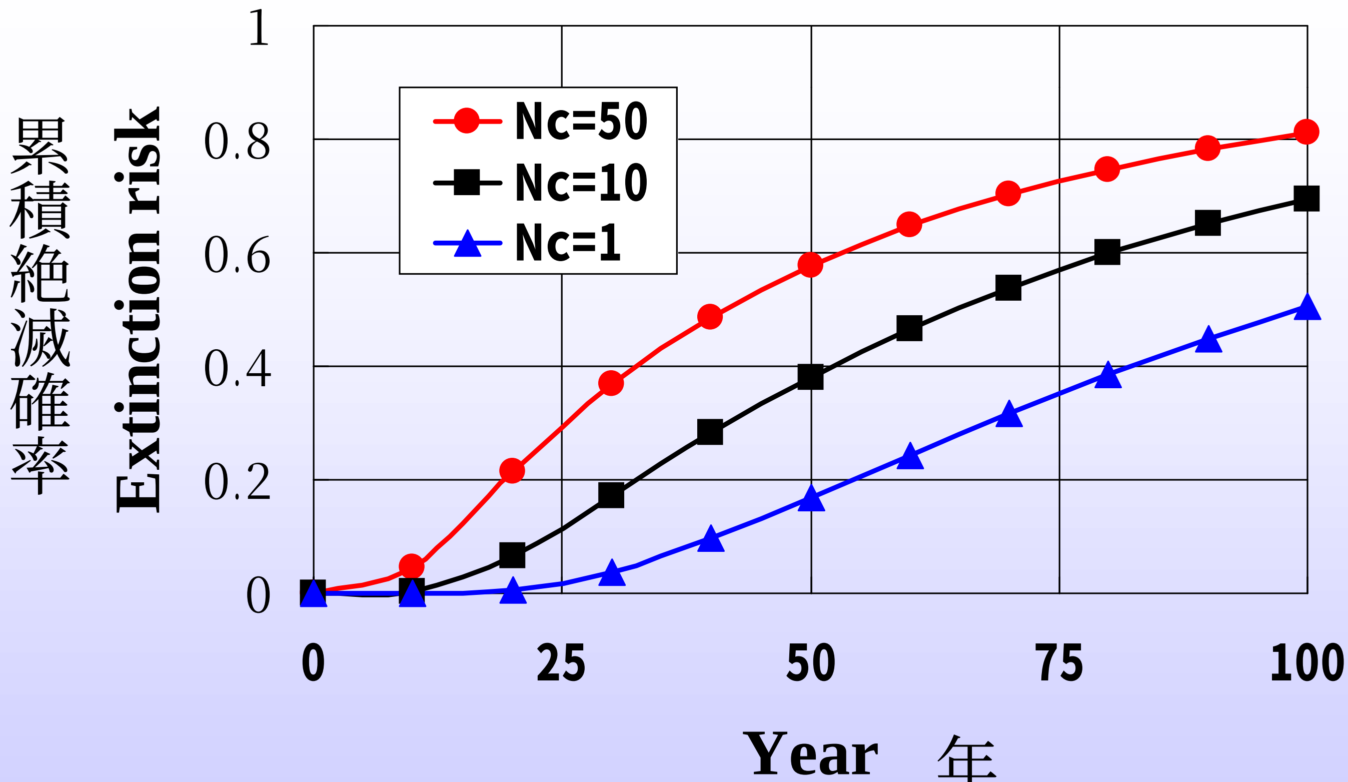
Variance in decline rate 減少率のばらつき

$$\sigma^2 = \sigma_r^2 \left[1 + 2\sum_{\tau=1}^{\infty} \rho(\tau) \right]$$

Cumulative Extinction Probability

for Steller Sea Lionsトドの累積絶滅確率

(Takahashi & Matsuda in prep.)



平均絶滅待ち時間 T=66 yr.

Ecological risk ≠ loss of T
生態リスク≠絶滅待ち時間の短縮

- Background “Longevity” is quite different between species（平均余命は多種多様）
- 1 year saving of endangered species is more important than 1 year saving of secure species. （絶滅危惧種の１年延命≠普通種の１年延命）

Discount mean time to extinction
割引平均絶滅待ち時間 (余命)*T**

$$T^* = \int_0^\infty e^{-\delta t}[1 - G(t)]dt$$

$$T^* = (1 - e^{-\delta T})/\delta$$

$$T^* = 1/(\delta + 1/T)$$

δ discount rate 割引率=0.01/yr.

How to evaluate ecological impact? 生態影響をどう評価するか

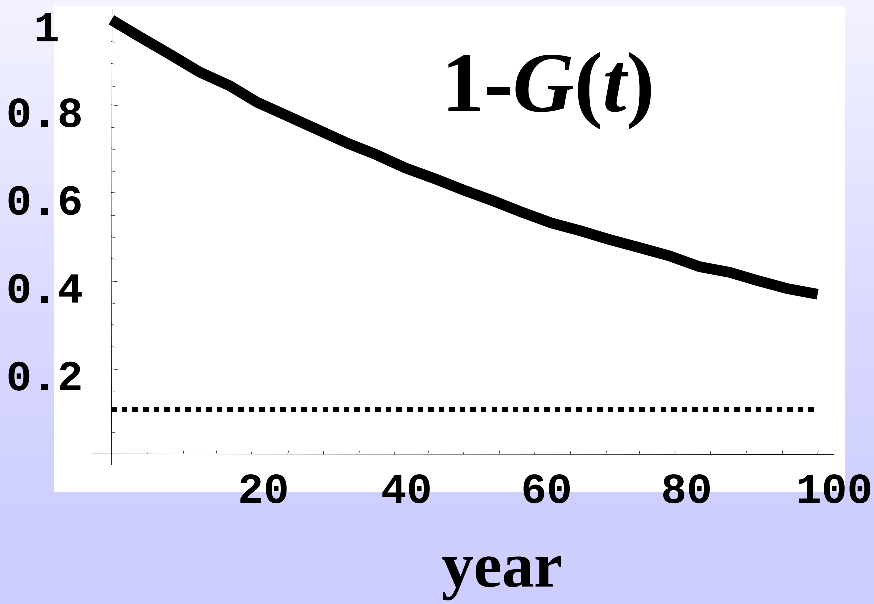
ΔT^* (loss of discount mean time to extinction) as a measure of ecological impact.

割引平均絶滅待ち時間（余命）の短縮により、生態影響を計る

3 ways to extinction
絶滅に至る３つの途

(1) Decrease of carrying capacity (*e.g.* habitat destruction), 環境容量の減少（生息地破壊など）**: *T*=100, *T**=50**

Extinction probability is constant, 絶滅確率は毎年一定 **1/*T*.**

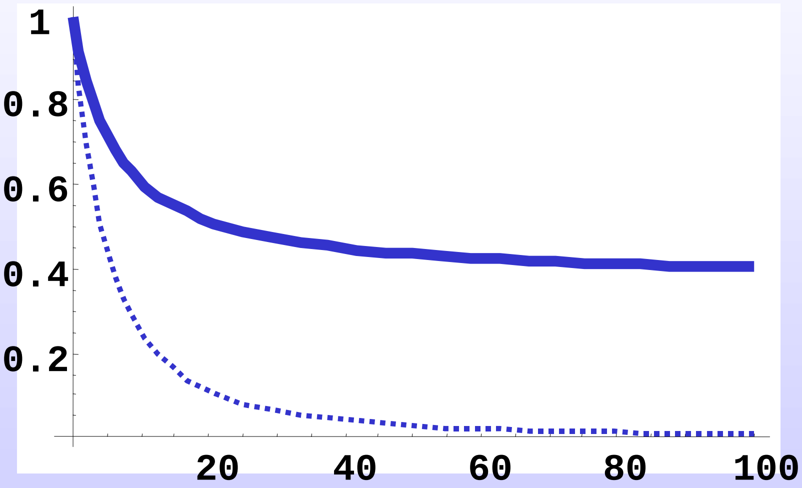


3 ways to extinction
絶滅に至る３つの途

(2) Reviving population 回復途中の集団:

***<u>T=∞</u>* , *T**=46**

No extinction after recovery 回復するまでが山



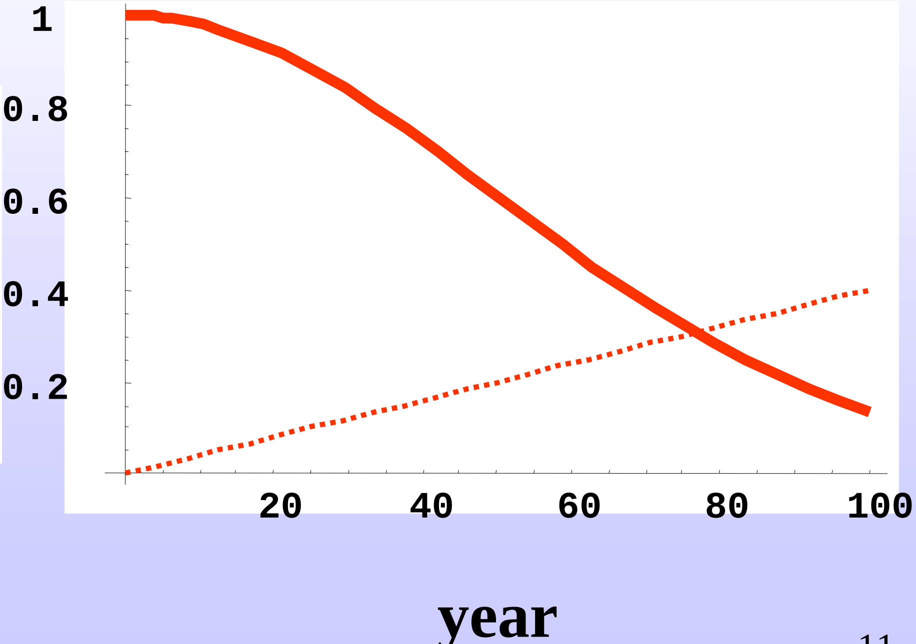
year

3 ways to extinction
絶滅に至る３つの途

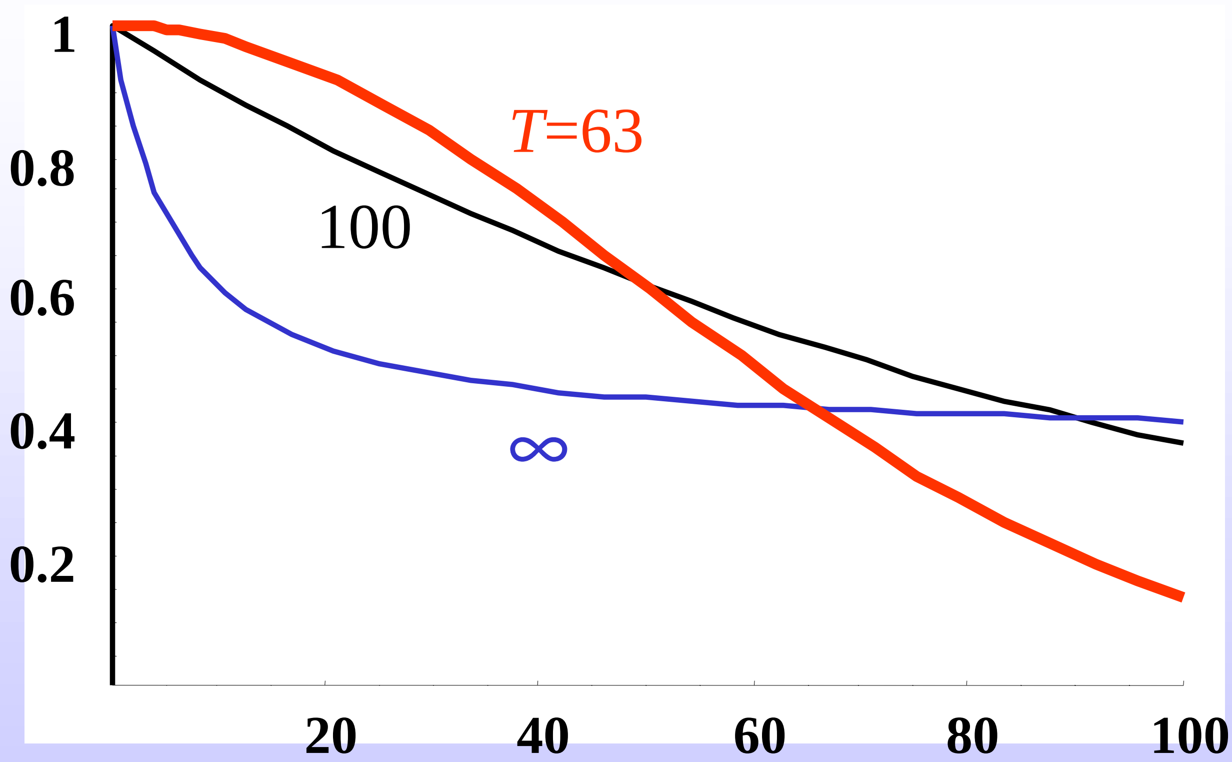
(3) Decreasing population (*e.g.*, overfishing)（乱獲などで）減り続けている集団:

***T*=63, *T**=44**

Extinction probability increases with *t*. 絶滅確率は年とともに上昇



Most of threatened species is continuously decreasing ほとんどの絶滅危惧種は減り続けている



Population declining due to
個体数減少の原因

Lake Biwa 琵琶湖

- habitat destruction; 生息地破壊

  “Shore protection” 護岸工事

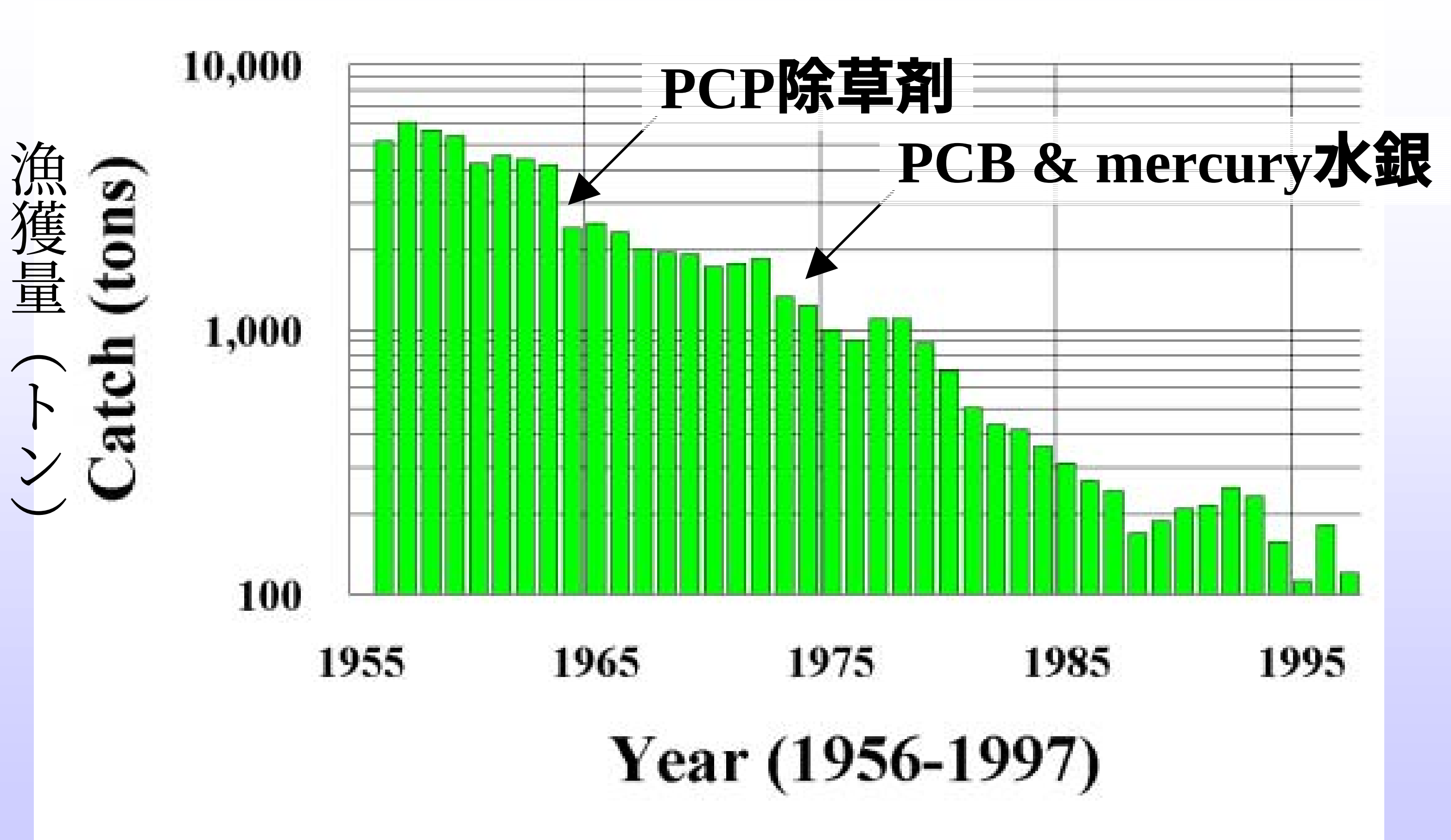
- pollutions; 環境汚染

  PCP, PCB, mercury, eutrophication
  除草剤・水銀の流出、富栄養化

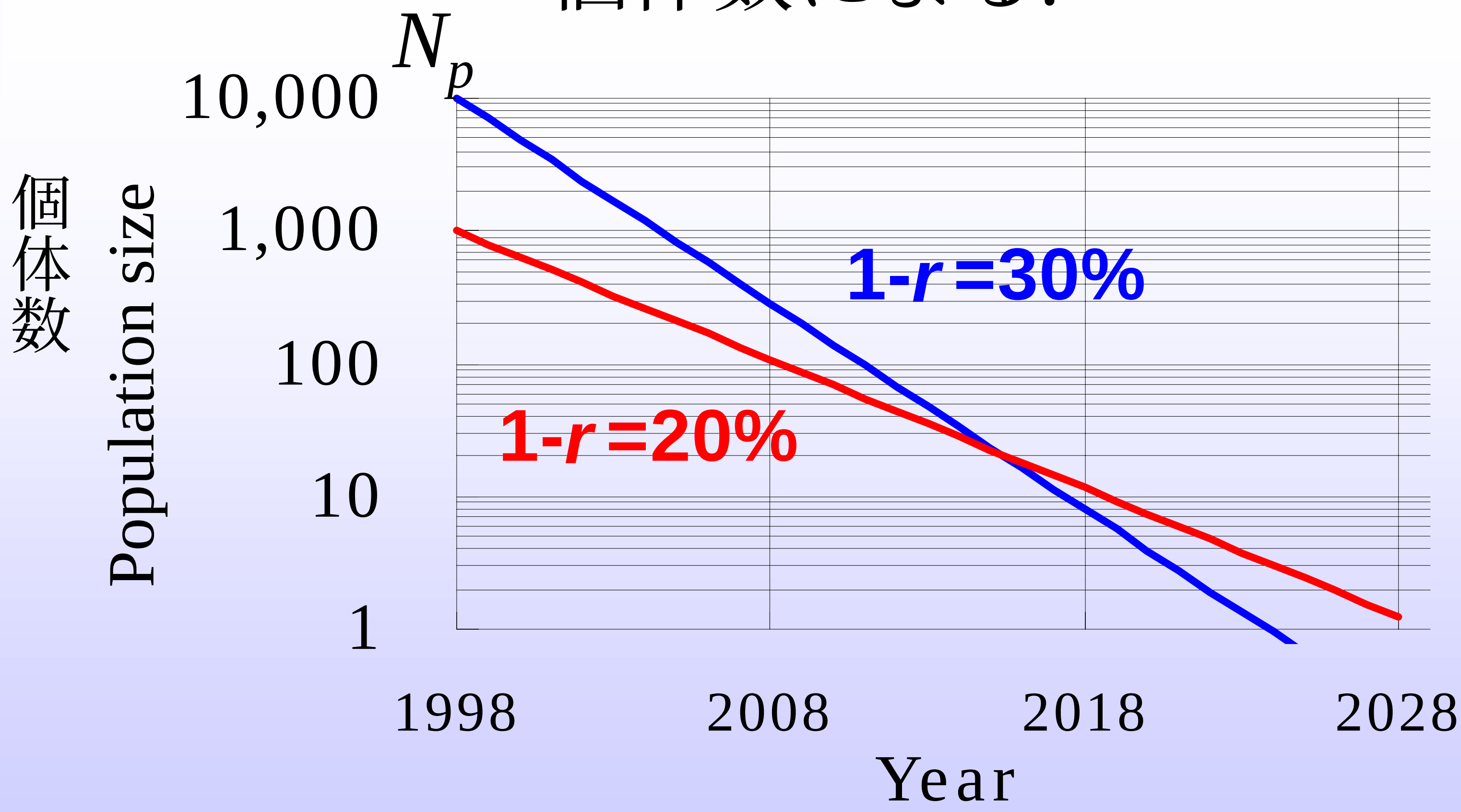
- overharvesting; 乱獲
- invasion of exotic species. 外来種

  Bass, Bluegill

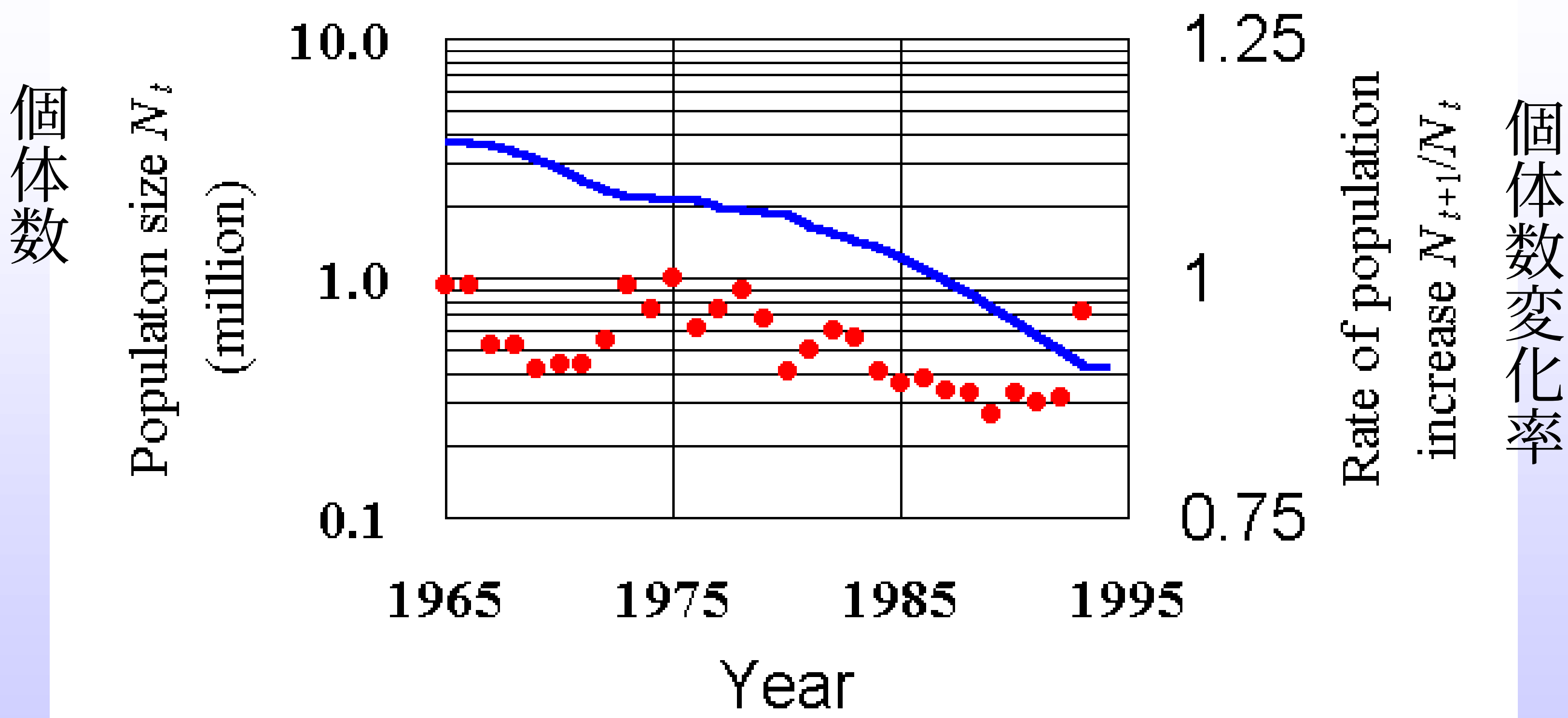
Crisis of shellfish *Corbicula sandai* in Lake Biwa琵琶湖セタシジミ の危機



Extinction risk depends on decline rate & population size 絶滅の恐れは減少率と個体数による.



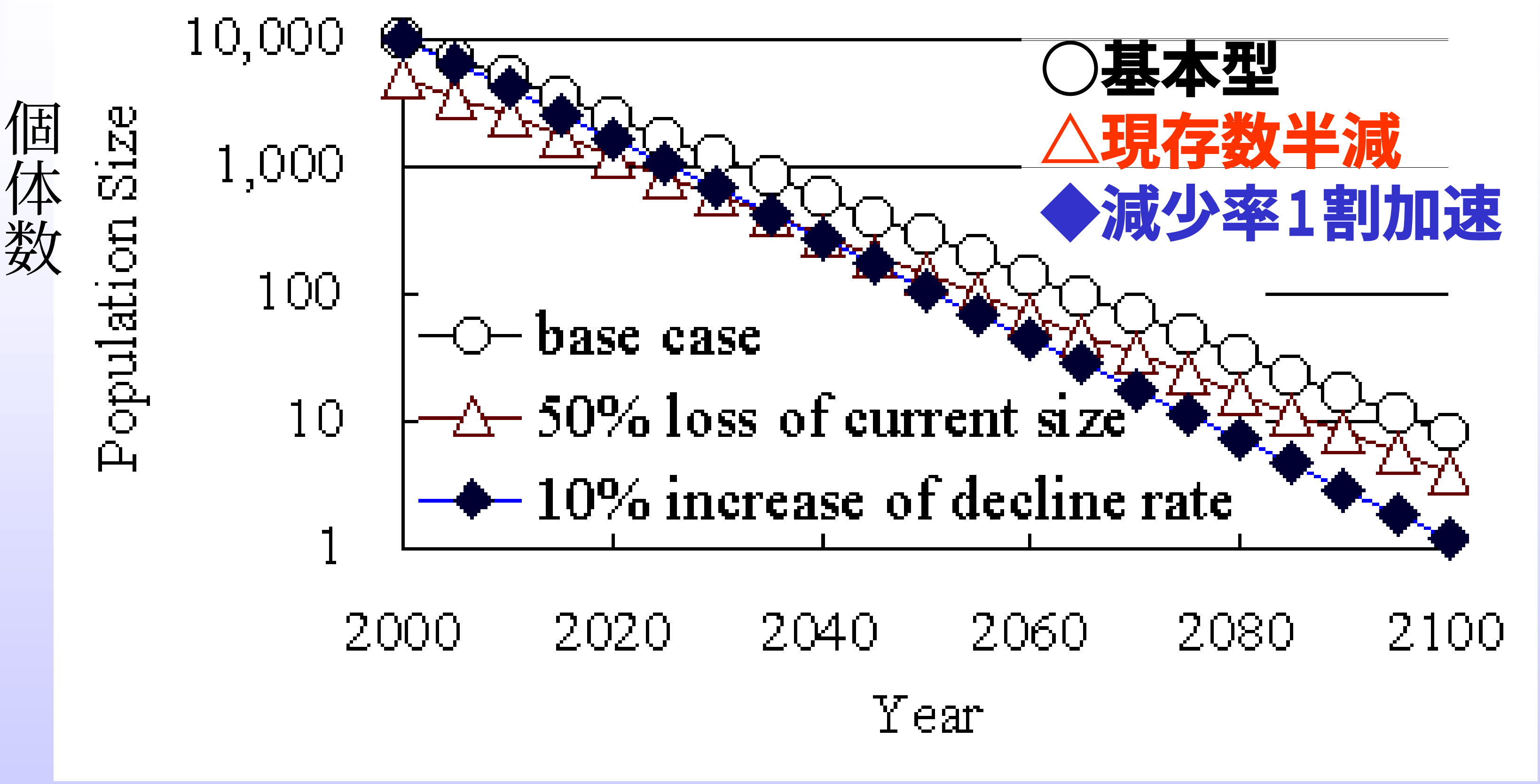
ミナミマグロ
Southern bluefin tuna (SBT)



Is the SBT critically endangered? ミナミマグロは絶滅寸前か？

- Extinction risk of SBT within the next half century is negligible,あと半世紀以内の絶滅の恐れは無視できるが
- but that within the next 1 century is probably more than 90%, if recent population decline rate continues in the future.もし過去の減少傾向が続くなら、１世紀以内では90%以上の恐れがある。

Impacts due to (1) increasing decline rate & (2) loss of present size減少率の加速と現存数の目減りの効果

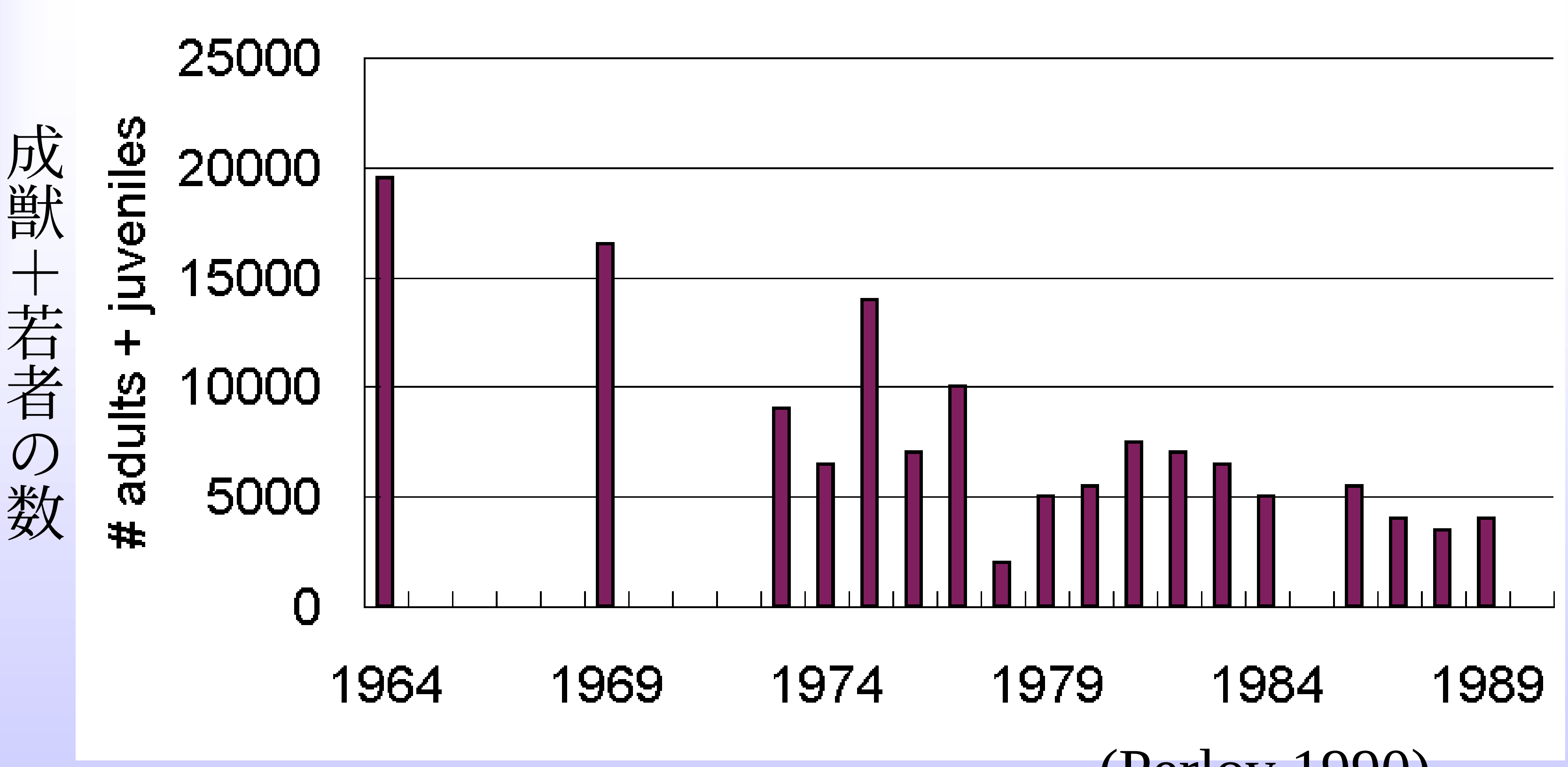


Loss of discount mean time to extinction 割引絶滅平均待ち時間の減少

Case	T_0	T_1	$\Delta T*$	$\Delta(1/T)$	$\Delta \log T$
(1) bluefin tuna	1million	90	40.7	0.011	9.316
(2) star magnolia	251	250	0.1	0.00001	0.003
(3) bell flower	71	71	0.1	0.00006	0.004
(4) an “nt” sp.	1000	500	0.7	0.001	0.693
(5) an “EN” sp.	16	1	13.5	0.936	2.747
(6) an orchid	16	15	0.3	0.0013	0.019
(7) Sea lions	2400	31	73.3	0.032	4.349

(1)**ミナミマグロ**、(2)**シデコブシ**、(3)**キキョウ**、(4)**準絶滅危惧種**、(5)**絶滅危惧種**、(6)**ランの1種**、(7)**トド**

Steller sea lion (Kuril population 千島のトド)



(Perlov 1990)

Steller sea lion (Kuril population 千島のトド)

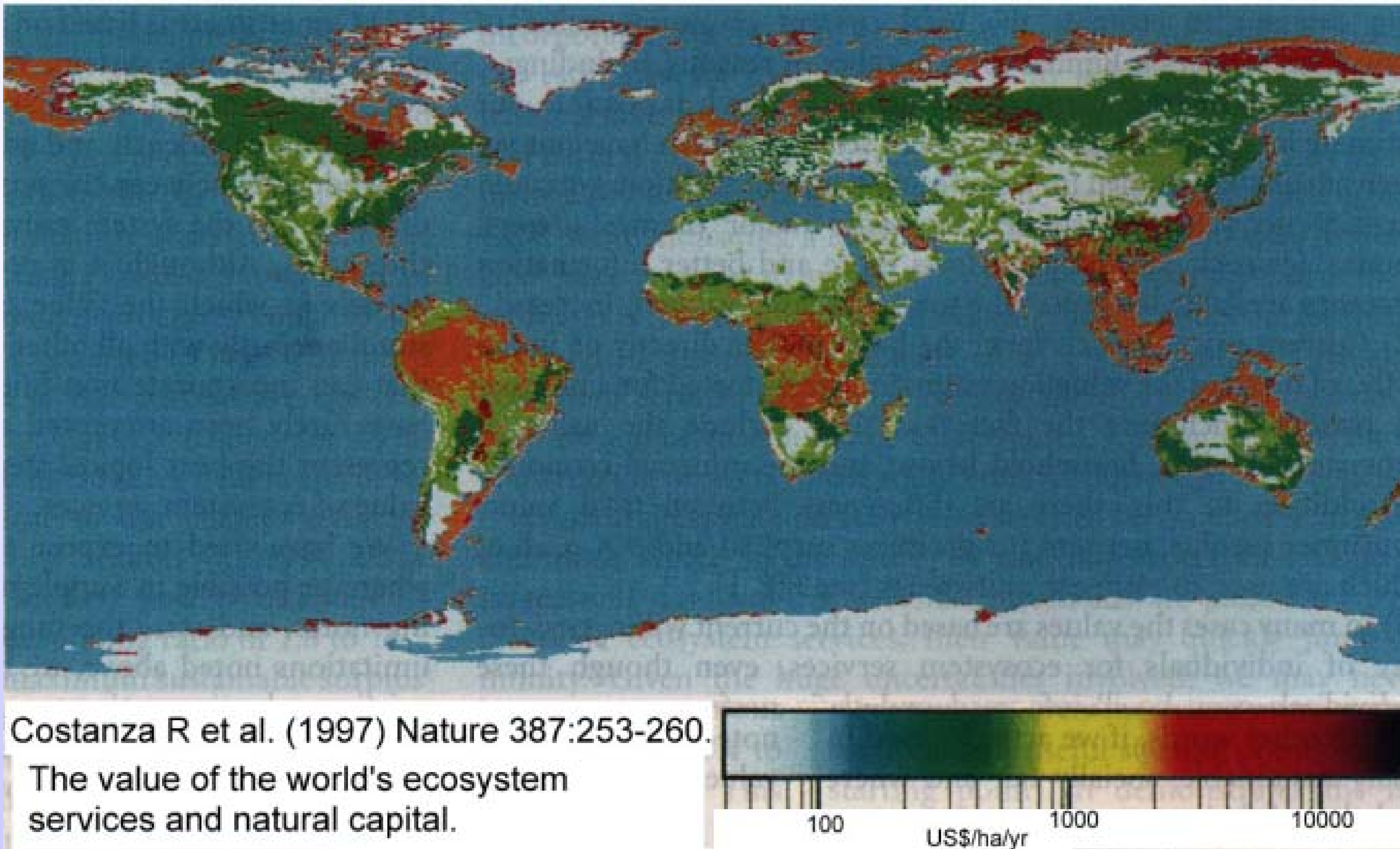
N_p=4000 in 1989 (York 1994);

- Catch and bycatch during 1964-1989: 捕獲と混獲T_1=66.1yrs; ΔT^*＝73/yr
- Juvenile survival rate of the sea lions may have decreased by 60%. 最近、若者の生存率は６割減少している？

Uncertainty in current extinction risk assessment現在の生態リスク評価の不確実性

- Lack of ecological information情報欠如
- Indirect effect in ecosystem process 生態系過程の間接効果
- Complex impact on a single population 複合効果
- Future change in conservation policy 保全政策の将来の変更

Ecosystem Services and Natural Capital
世界の生態系サービスと自然資産の価値



Costanza R et al. (1997) Nature 387:253-260.
The value of the world's ecosystem services and natural capital.

トリブチルスズ規制成功を悔いるアメリカの環境化学者

The Squeeze On Tributyltins

Former EPA adviser voices doubts over regulations restricting antifouling paints

Champ: law is shortsighted and foolish

チャンプ氏：法は近視眼的で馬鹿げていた。

People rarely regret their successes. But that's how Michael A. Champ feels about the success of regulations restricting use of tributyltins (TBTs).

APRIL 27, 1998 C&EN 41

TBT-based paints save $6 billion for the world's commercial fleet. TBT塗料は年間8千億円の便益

Limit of environmental impact assessment (EIA) 環境影響評価の限界

- On-site assessment to the open ecosystem 開放系なのに事業予定地だけを調査
- 1 year assessment to the nonequilibrial ecosystem 非定常生態系を１年だけ調査
- Point estimation or qualitative assessment of ecological impacts 生態系への影響を点推定や定性的評価しかしない

Succession & Natural disturbance 遷移＋自然かく乱

- Japan’s typical ecosystem = “Satoyama” (secondary) Forest日本の典型＝里山
- Biodiversity=Mosaic maintained by balance of succession and reset due to natural disturbance. 生物多様性＝遷移と自然かく乱の釣り合いがもたらすモザイク
- Japan’s guideline for EIA neither refer to succession or natural disturbance.日本のアセス法基本的事項には書いてない

Nonequilibrium & Heterogeneiety 非定常性と不均一性

- Alternation of good and bad conditions 好条件と悪条件の年変動
  - （阪神タイガース問題）
- No data of natural disturbance自然かく乱の規模と頻度を調べていない
- Illusion of equilibrium 定常状態の幻想

Accountability & Adaptability 改善責任と順応性

- We should take into account of new data and knowledge (新たな知見を取り入れる).
- We change conservation actions with change of ecosystem state (生態系の状態変化に応じて政策も変える).
- JEA guideline refers to monitoring only.日本のアセスには監視だけ