Assessment of the trophic impacts of fishing in the central Pacific Ocean

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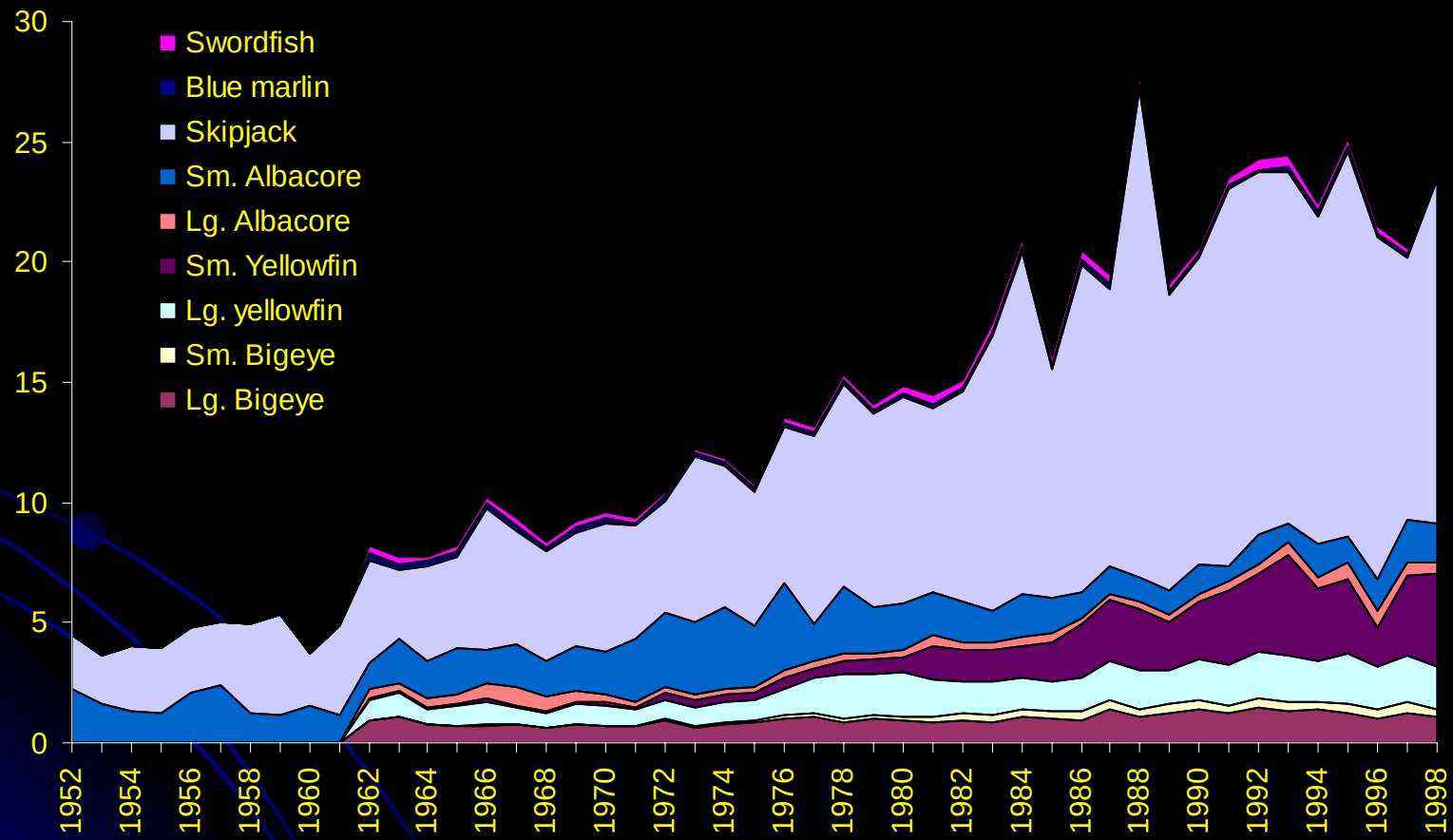
CNP Landings



CNP Fishing Fleets

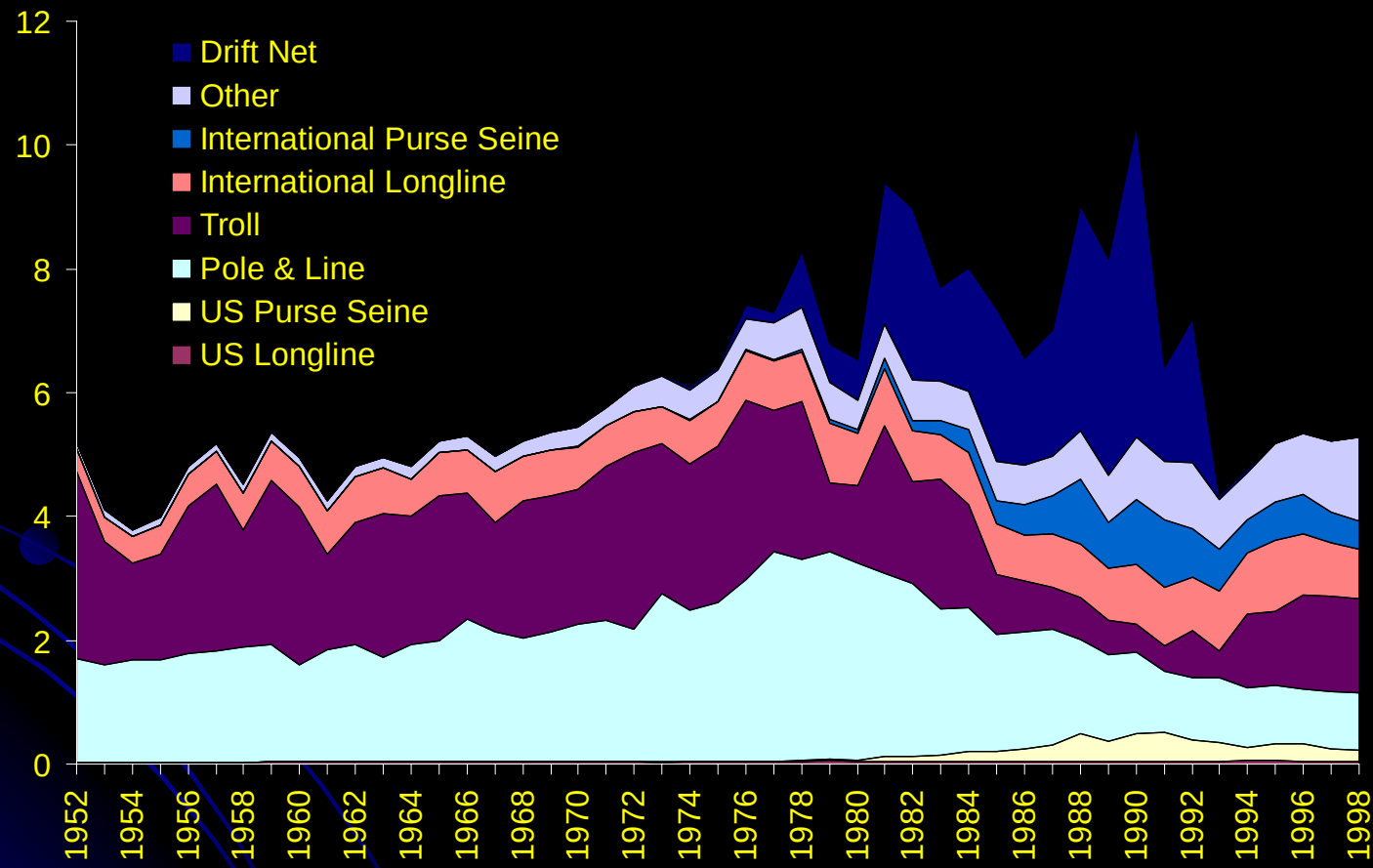
Pole and line

Longline

Driftnet

Purse seine

CNP Effort by gear



Some Burning Questions

1. Can an ecosystem-model (Ecosim) reproduce dynamics of apex predators as predicted by the single-species approach?

2. Have apex predator dynamics affected recruitment of tunas?

More Burning Questions

-Direct harvest tradeoffs among fleets are better analyzed from a single-species perspective.

-Indirect harvest tradeoffs owing to predator/prey interactions cannot be addressed using single-species approach.

3. So, where do the main effects of fishing appear in the CNP ecosystem?
4. Does the ecosystem model imply indirect harvest trade-offs?

Single Species Assessment Model

Biomass next year = Growth/survival of biomass this year + Biomass of new recruits

Stochastic variation in juvenile survival

$$B_{t+1} = g_t B_t + R_t \exp(v_t)$$

Constant survival

Survival from fishing

Body mass growth

$$g_t = S[1-\exp(qE_t)][\alpha/m_t+\rho]$$

- We used a delay-difference model, with full age structured accounting for juveniles

Multi-species production model (Ecosim)

Biomass next year = Growth/survival of biomass this year + Biomass of new recruits

Deterministic variation due to predation, feeding, & growth

$$B_{t+1} = g_t B_t + R_t \exp(v_t)$$

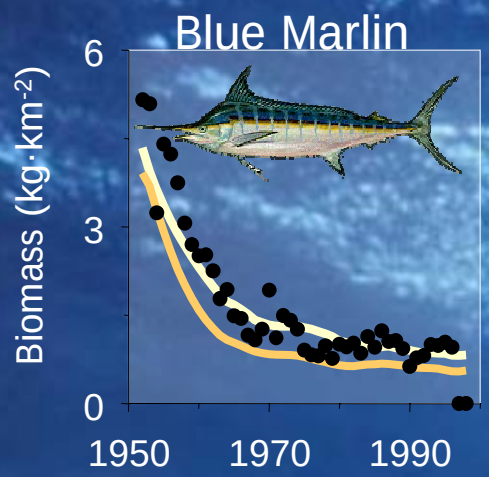
Survival from predation

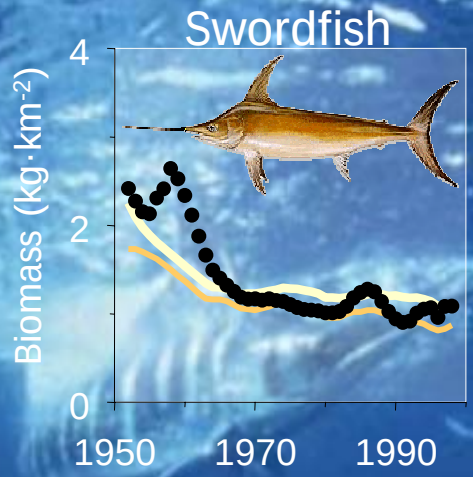
Survival from fishing

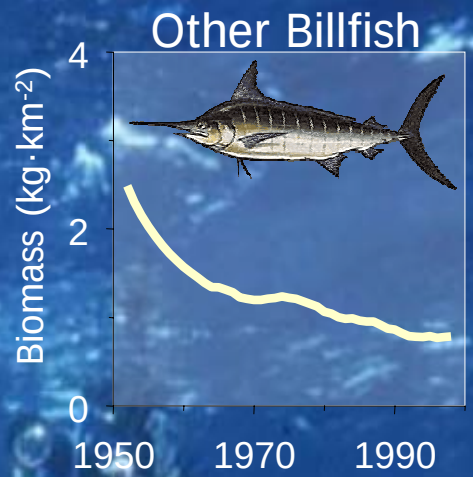
Body mass growth from prey consumption

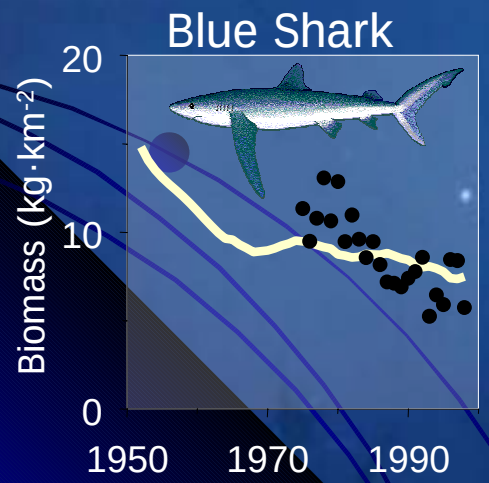
$$g_t = S[1-\exp(qE_t)][\alpha/m_t+\rho]$$

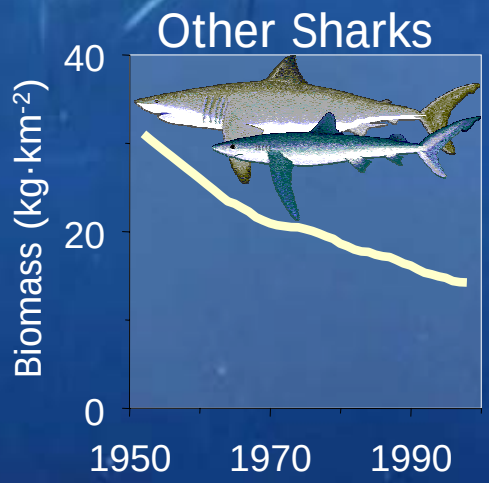
Biomass trends: Apex Predators







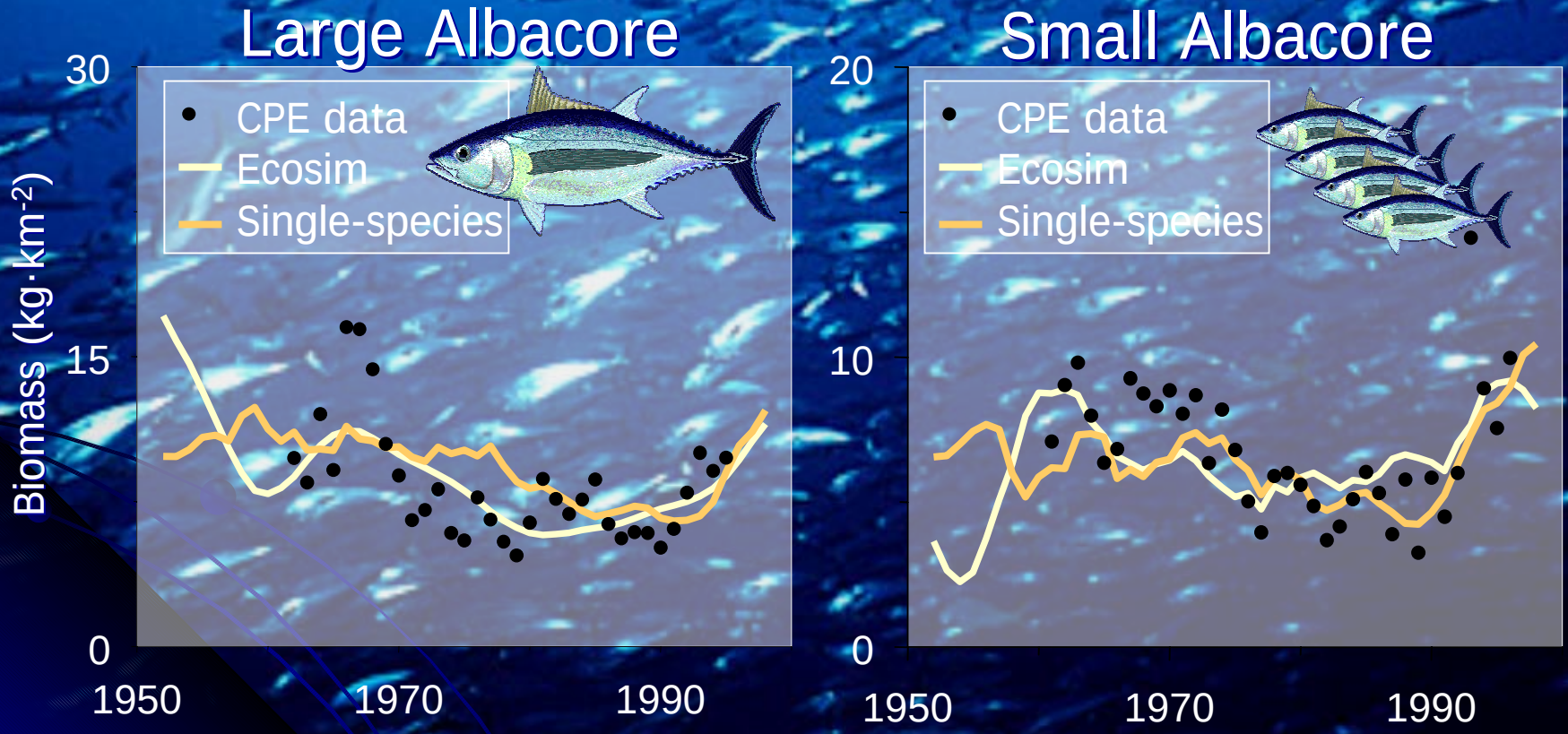




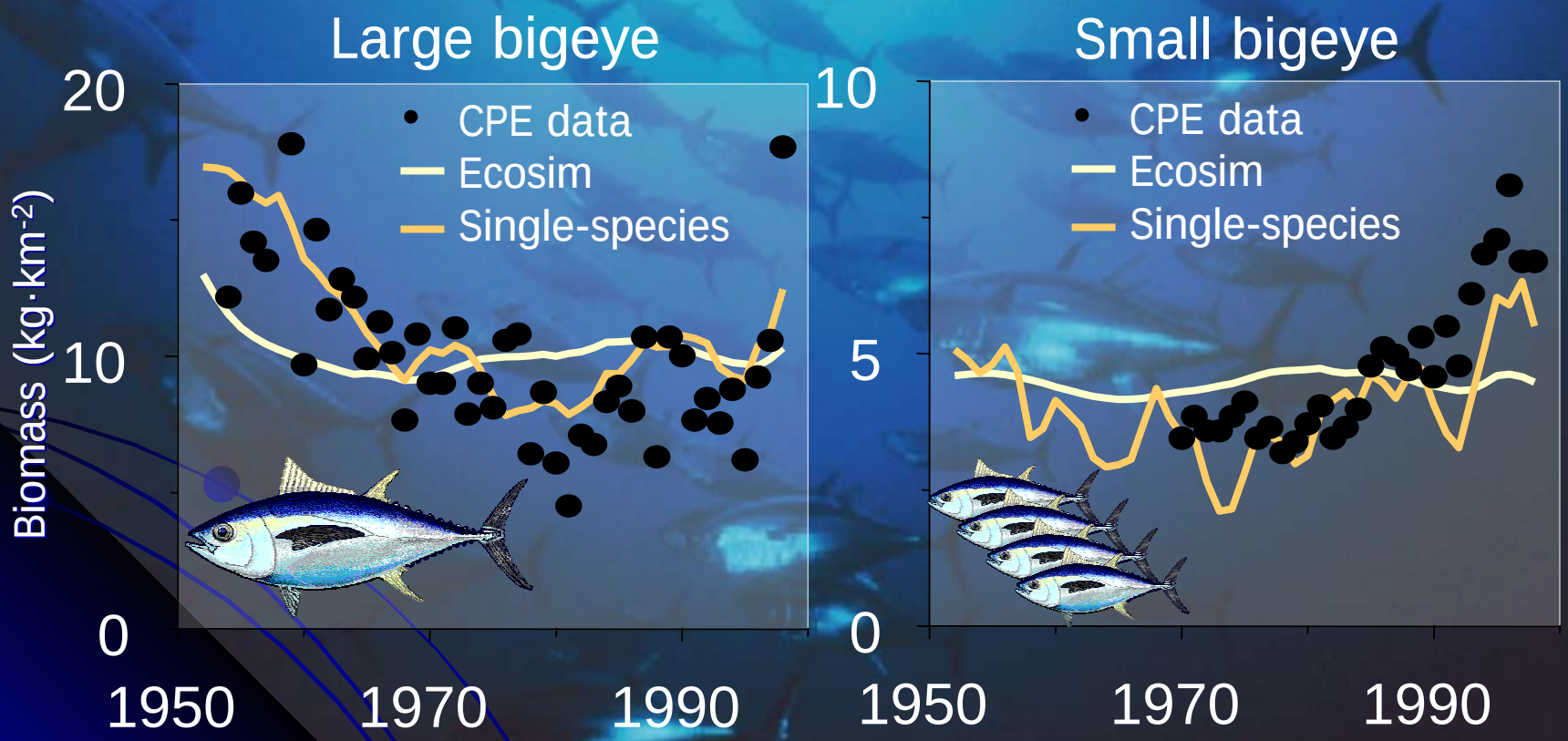
CPE data
Ecosim
Single-species

CPE data are scaled to Ecosim fits for trend comparison

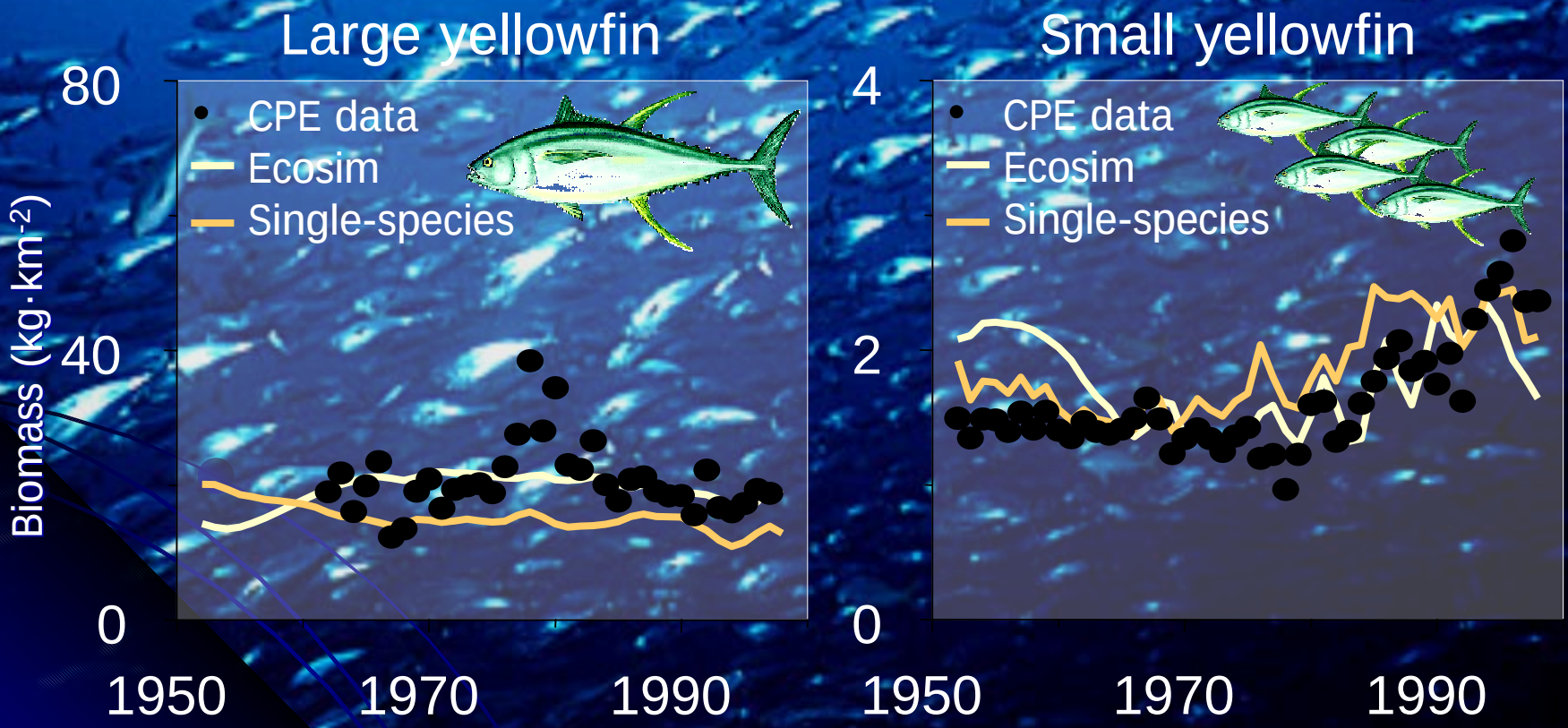
Biomass trends: Albacore Tuna



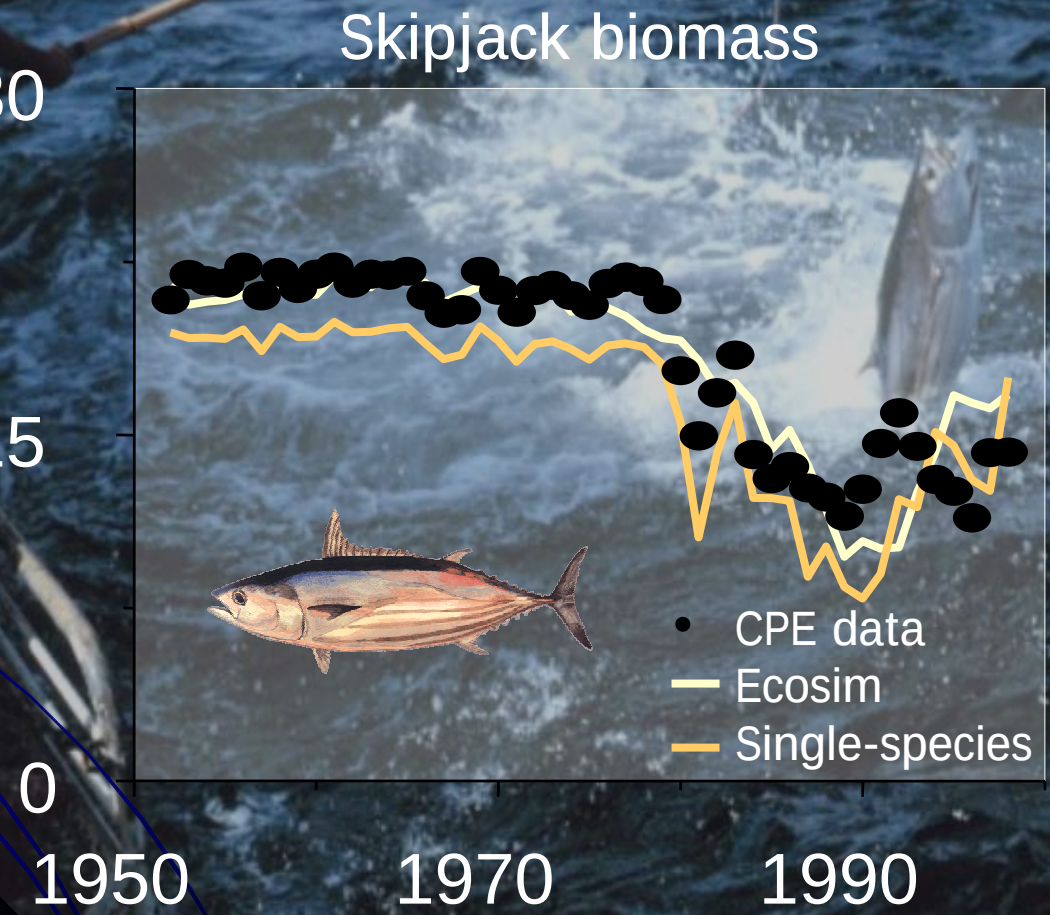
Biomass trends: Bigeye Tuna



Biomass trends: Yellowfin Tuna



Biomass trends: Skipjack tuna

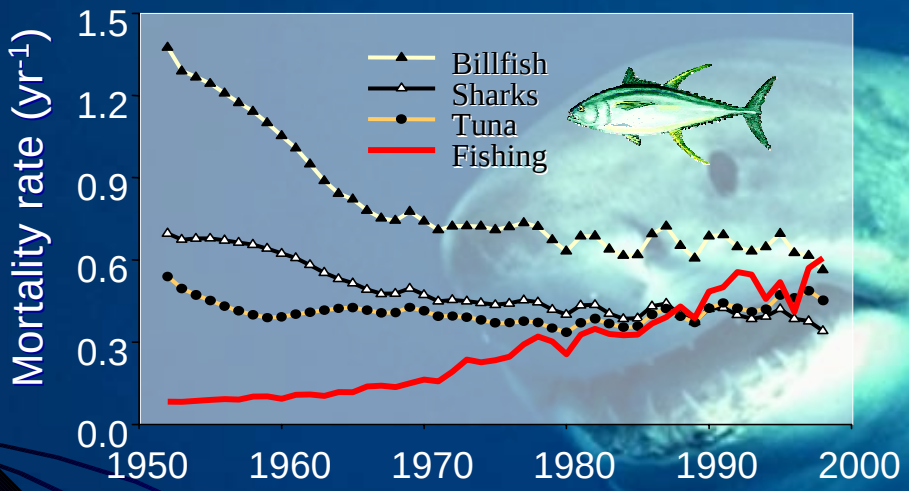


Answer to Question 1

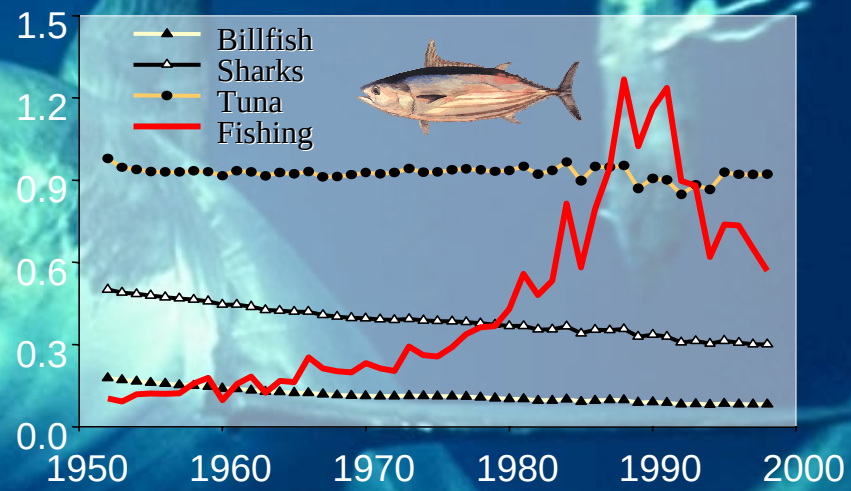
1. Can an ecosystem-model (Ecosim) reproduce dynamics of apex predators as predicted by single-species approach?
   - ☑ Apex Predators: captures declining trends
   - ☑ Albacore: matches decadal trends
   - ☒ Bigeye tuna: not so well
   - ☑ Yellowfin tuna: surprisingly good for juveniles
   - ☑ Skipjack tuna: almost identical

Mortality Components

Small yellowfin mortality



Skipjack mortality

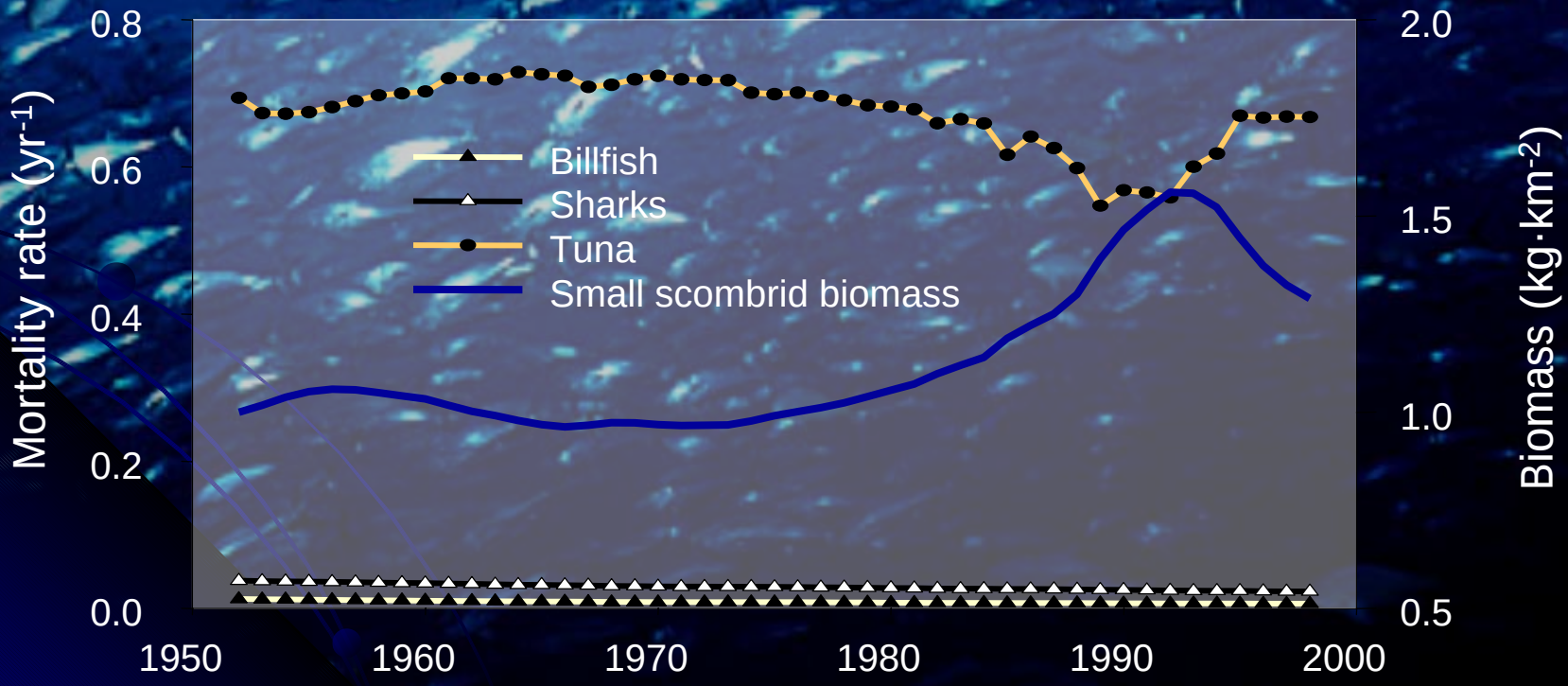


Answer to Question 2

2. Have apex predator dynamics affected recruitment of tunas?
   - Bigeye: an effect on recruitment causes large discrepancies from single-species. Unlikely
   - Yellowfin: predicted apex predator declines cause similar juvenile dynamics as single-species. Possible
   - Skipjack: fishing appears to be main factor, not apex predators. Unlikely

Answer to Question 3

3. So, where do the main effects of fishing appear in the CNP ecosystem? Small scombrids
   - But, such data do not exist…of course!

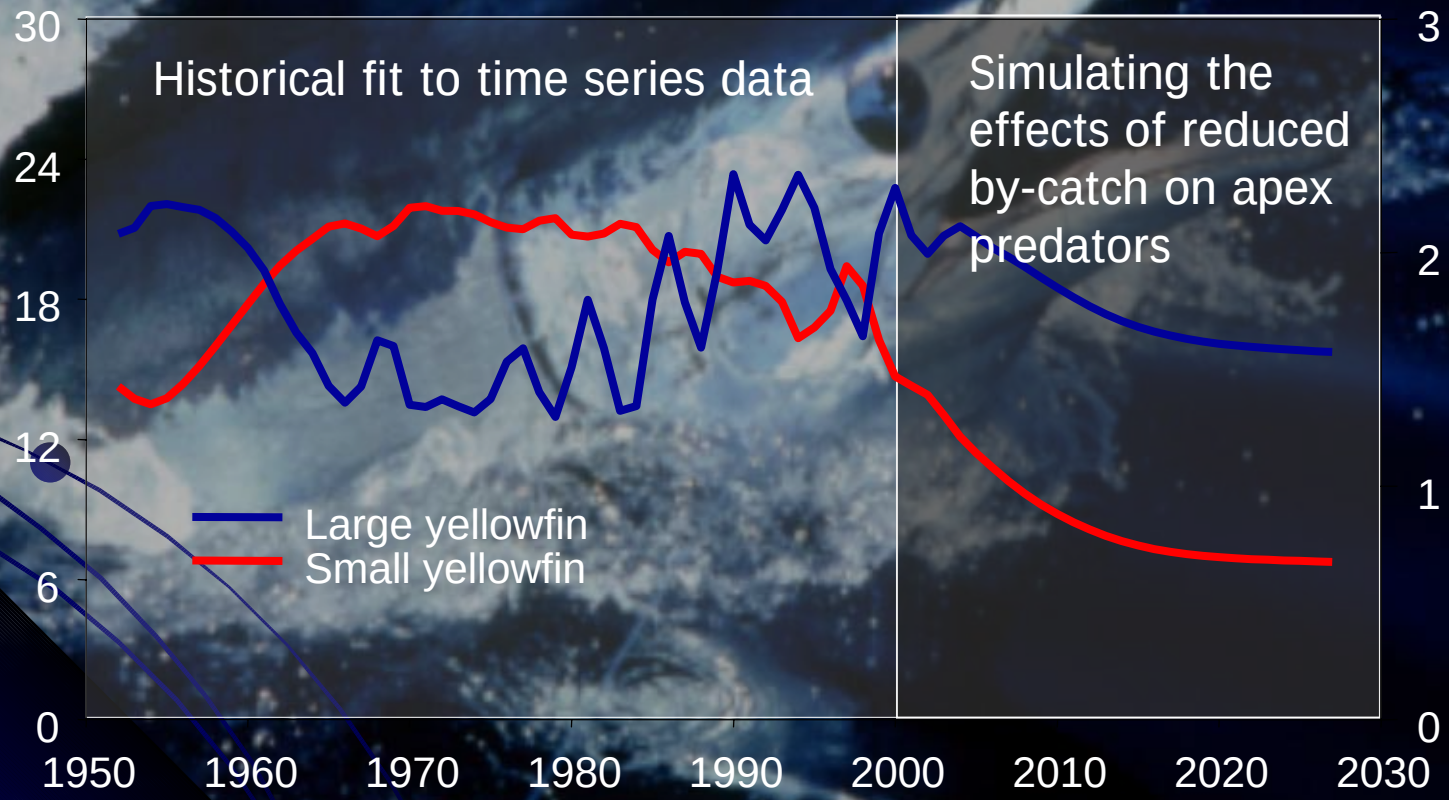


Answer to Question 4

4. Does the ecosystem model imply indirect harvest trade-offs?
   - Suppose a miracle device is developed to reduce or eliminate by-catch of apex predators in longline fisheries.
   - Simulation: this device only reduces F on apex predators and F on all remaining species remains constant at present rates.

Question 4: By-catch reduction

- Would a single-species model make this prediction?



Conclusions

- Ecosystem models require same tenuous assumptions as single-species.
- “Fish gotta eat somethin”. Beyond that, ecosystem models contain multiple layers of uncertainty that we have yet to evaluate quantitatively.
- Evaluating indirect harvest trade-offs or environmental forcing must consider how effects propagate through food webs.