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Earth Systems Science Course in Watersheds &
Coastal Zone Simulation Modeling
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"Overfishing"

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Overfishing

I. Definitions

"Growth overfishing" = average weight decreases over time due to increased harvest of younger stages.

"Recruitment overfishing" = spawning stock reduced to too low a level to insure adequate production of young.

Components of Overfishing

1) Uncontrollable effort

2) Overcapitalized, extremely efficient fishery

3) Bycatch

- non-target species
- habitat destruction

4) Increasing demand

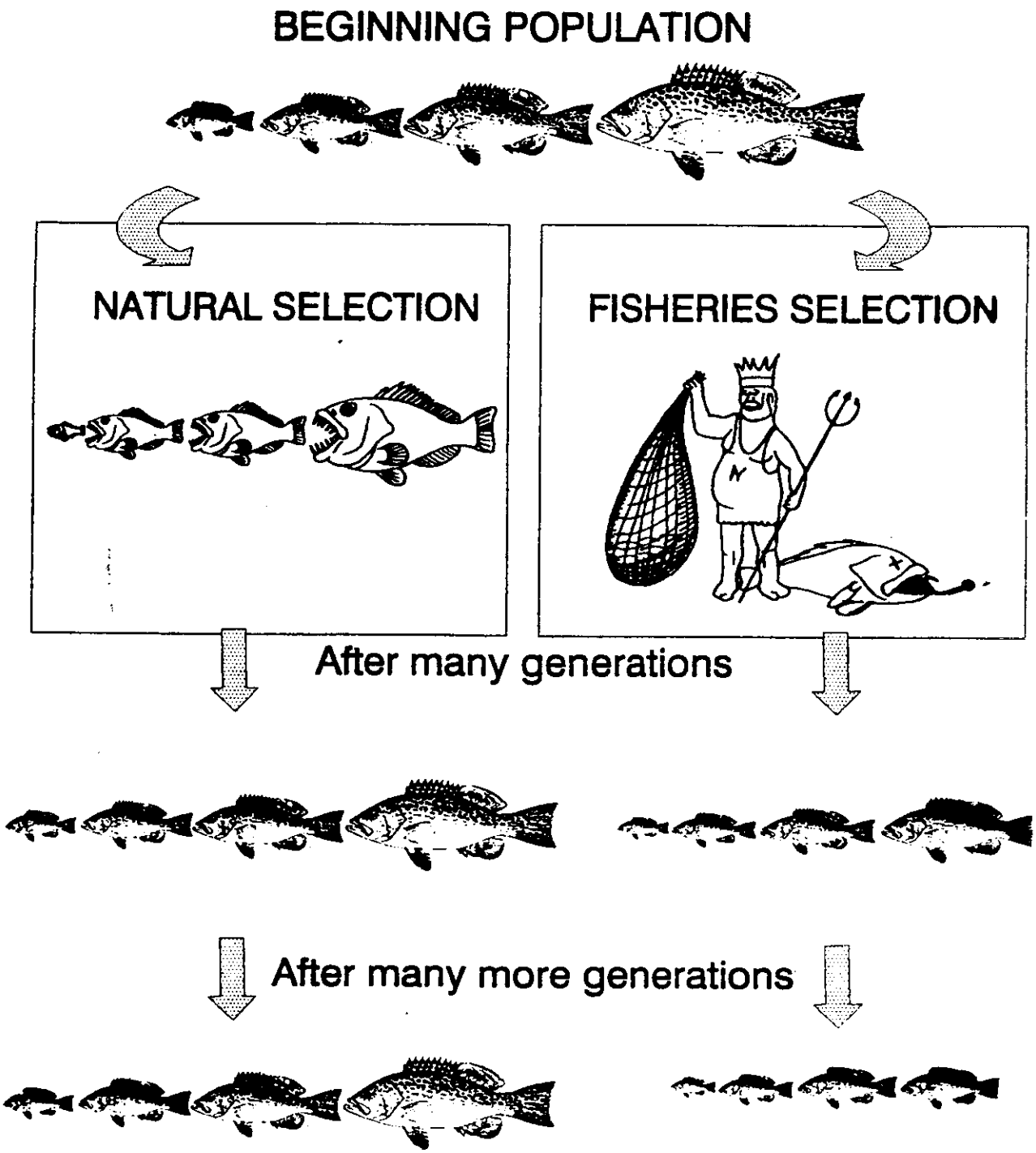
Why?

1. Greed + Politics
2. Lack of political + scientific consensus
3. Large levels of natural variability mask effects of overfishing

How do we deal with it?

1. economists
2. sociologists
3. fisheries scientists
4. political pressure by voters / economic pressure by consumers.

Figure 5. Intense adult mortality favors selection for smaller adult size and earlier reproduction.



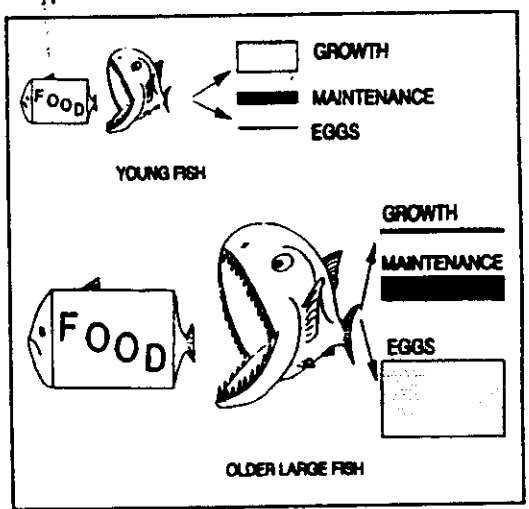


Figure 4 Food conversion model. Young fish divert more food resources into growth than reproduction. Adults divert more food resources into reproduction than growth.

Figure 6 Equivalent red snapper fecundity. One 61 cm (12.5 kg) female has the same number of eggs (9,300,000) as 212 females at 42 cm (1.1 kg each).

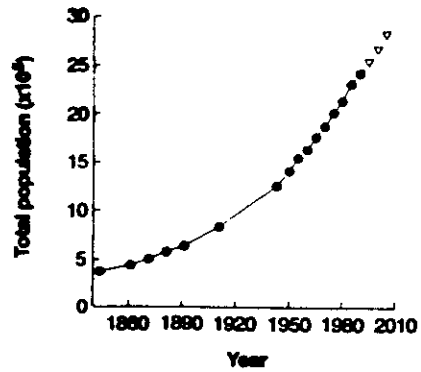


Fig. 1. Population growth of Jamaica, based on numerous sources (*5*).

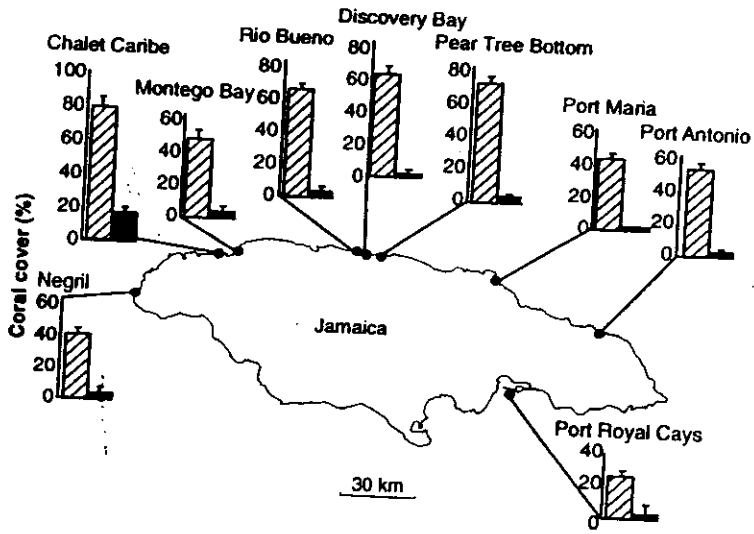


Fig. 5. Large-scale changes in community structure at fore-reef sites along >300 km of the Jamaican coastline, surveyed in the late 1970s (1977, hatched bars) and the early 1990s (1993, solid bars) (*34*).

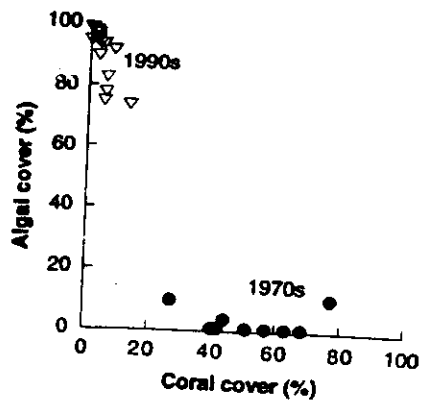


Fig. 6. Large-scale community phase shifts on Jamaican reefs, from coral- to algal-dominated systems (*34*).

Human Impacts to Coral Reefs

1) Overfishing
2) Increased input of nutrients + sediments
   (deforestation, dredging, sewage, pollution)
3) Physical Destruction

Phase Shifts in a Coral Reef

Coral/algal Ratio	Caribbean	Changes in Community
50:50	200 yrs. ago	Dominated by lge. vertebrates
	↓	
50:50	1970's	Lge. fishes removed Low urchin densities
	↓	
50:50	1980's	Dramatic loss of sea urchins; small fish present
	↓	
10:90	1990's	Loss of small fishes + low urchin densities
	↓	
	?	

... another vivid example of an "ecological cascade" operating on a vast scale.....

"Killer Whale Predation on Sea Otters: Linking Oceanic + Nearshore Ecosystems"

Estes et al. (1998) Science 282: 473-476.

Alaska	Otters	Kelp/Urchins	Community
arly 1900's	near extinction	?/?	?
960's	Fur Seal Treaty; Pops. recovering	?/?	Geographically discordant recovery across range (dispersal limitation).
970's	Areas with: Max. densities → High/low Rapid growth → High/low Absent → Low/high		Otters are "Keystone species".. Numbers of Sea Lions and Seals declined due to overfishing forage base.
990's	90% reduction in population	Low/high	Shift in prey for Orcas led to "switch" from marine mammals ("steaks") to otters ("popcorn") Proliferation of kelp forest barrens.

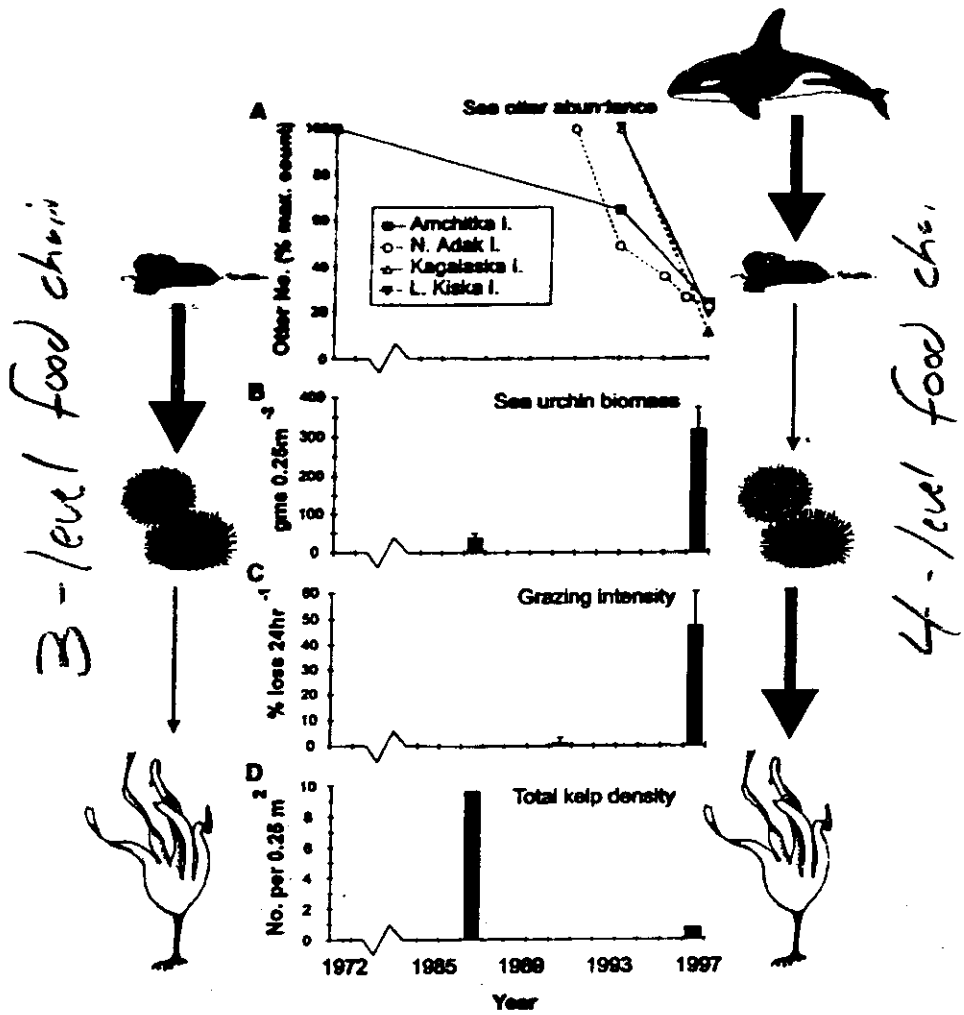


Fig. 1. (A) Changes in sea otter abundance over time at several islands in the Aleutian archipelago and concurrent changes in (B) sea urchin biomass, (C) grazing intensity, and (D) kelp density measured from kelp forests at Adak Island. Error bars in (B) and (C) indicate 1 SE. The proposed mechanisms of change are portrayed in the marginal cartoons—the one on the left shows how the kelp forest ecosystem was organized before the sea otter's decline and the one on the right shows how this ecosystem changed with the addition of killer whales as an apex predator. Heavy arrows represent strong trophic interactions; light arrows represent weak interactions.

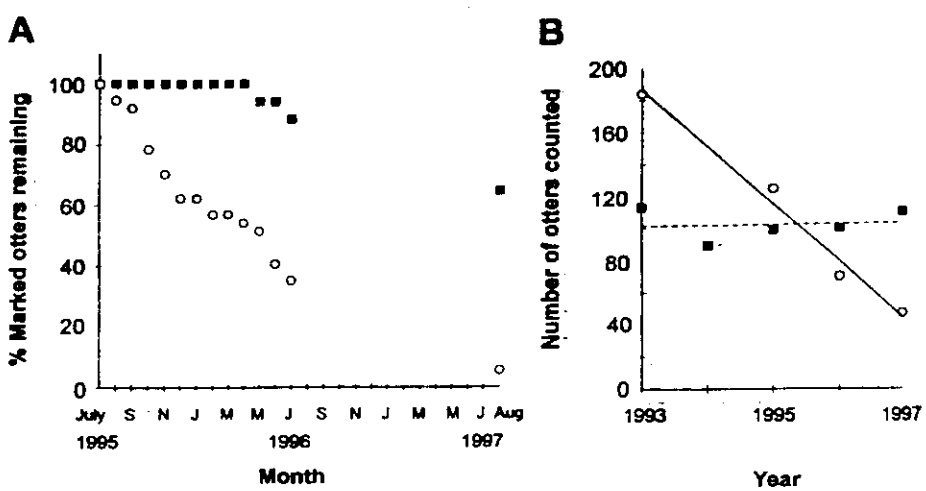


Fig. 2. Population trends and survival rates of sea otters in Clam Lagoon (solid squares) and adjacent Kuluk Bay (open circles), Adak Island, Alaska. (A) The rate of population change r, calculated as the slope of the linear best fit to the natural log of the number of otters counted versus year, for Kuluk Bay between 1993 and 1997 was −0.345 (SE = 0.058), which is significantly different from 0 (R^2 = 0.946, P = 0.027). In Clam Lagoon, the rate of change over this same period was 0.006 (SE = 0.094), which is not significantly different from 0 [R^2 = 0.011, P = 0.867; statistical power to detect $r \geq 0.1$ = 0.9]. The measured rates in Kuluk Bay and Clam Lagoon differed significantly (χ^2 = 27.26, 1 df, $P < 0.001$). (B) Survival rates of marked sea otters differed significantly between Clam Lagoon (0.88 year^{-1}) and Kuluk Bay (0.35 year^{-1}; χ^2 = 13.52, 1 df, $P < 0.001$).

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