

Mutualism (+,+) leaf cutter ants (*Atta spp*) culture fungi (Ignacio Chapela, ESPM)



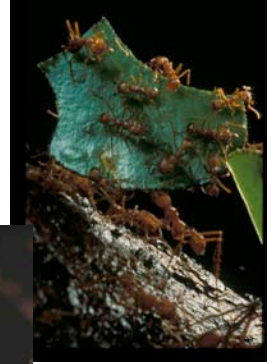
Mark Moffett photos

1

Herbivory/fungivory: leaf cutter ants



Minors defend workers from parasitic phorid flies



2



Fungal garden in underground chamber of ant colony



Young queen carries bit of fungus to start new colony

Mutualisms (+,+)



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Extrafloral nectaries on Acacia feed ants that protect the Acacia trees from herbivores and vines



5

Clown fish live in mutualistic symbiosis with sea anemone

- Clown fish mucus protects it from anemone sting, and clown fish feeding imports crumbs that feed anemone



6

3 species interactions: Mutualists and cheaters...

Cleaner wrasses, host fish, cheater blennies

Milkweed, bee, cheater orchid

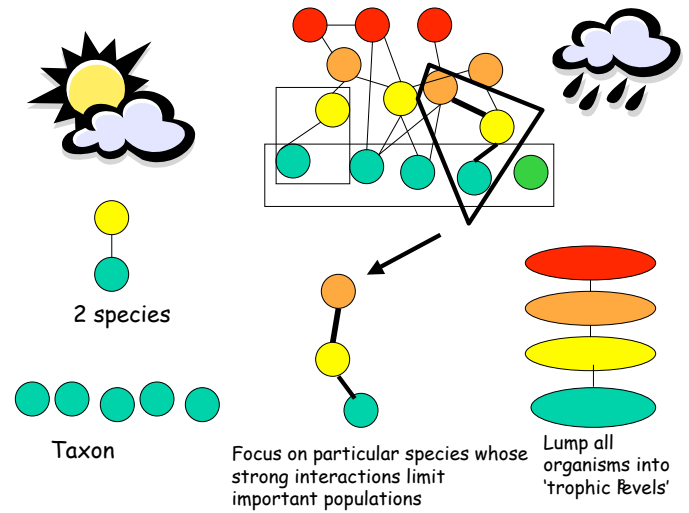
Pollinator, moth, bumblebee nectar burglar

Selection for refinement of cues and mimicry in co-evolutionary race

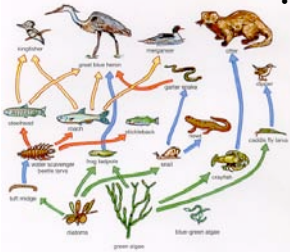
How much cheating can be tolerated before mutualism breaks down?



7



Interaction webs, food webs, food chains

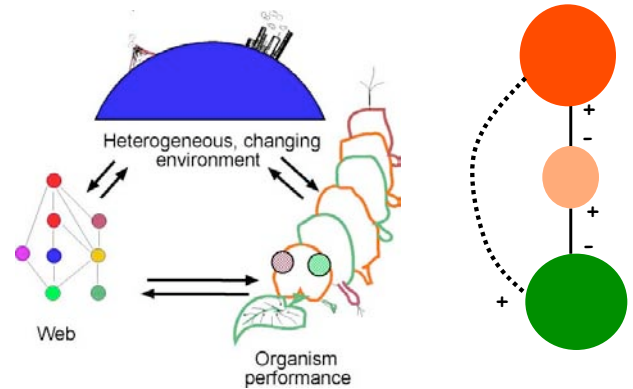


- **Community:** a group of species that co-occur in time and space
- **Food (interaction) webs** depict feeding (or other significant (e.g. population limiting or regulating)) relationships among members of a community

Some of these interactions are strong, others are weak.

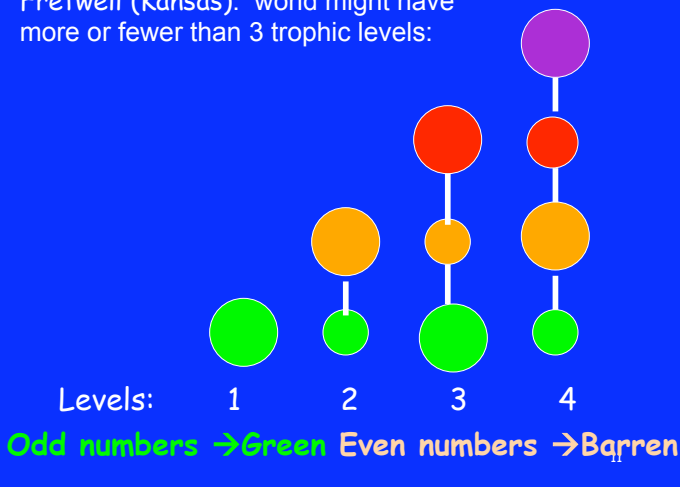
System: group of entities united by interaction or interdependence to form or act as an entire unit

How to simplify for study?



Sometimes strong effects are mediated through food chains. Hairston, Slobodkin and Smith (1960): "The world is green because predators hold herbivores in check." (assumes a 3 level food chain)

Fretwell (Kansas): world might have more or fewer than 3 trophic levels:



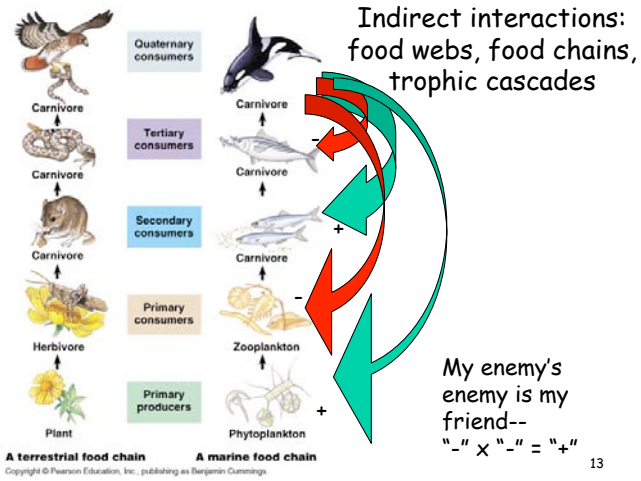
Odd number of levels: green (plants resource limited = "bottom up" limitation)

Even number of levels: barren (plants consumer limited = "top down" limitation)

- Trophic level: functional grouping of organisms according to their primary food source

- Bottom up level: number of energy transfers from fixation of organic carbon to reach level
- Top down level: number of lower levels that are alternatively released and suppressed when this level is removed (plus one).

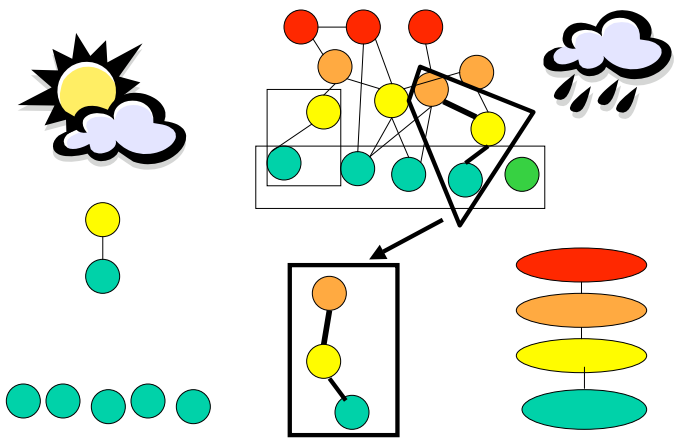
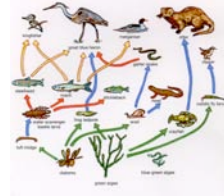
Need to test which factor is limiting to understand food web controls on population abundance....



Why food chain theory shouldn't work:



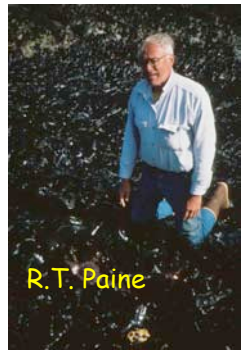
1. Green stuff could be inedible (world is one trophic level)
2. Consumers are co-limited by predators and food (or other factors)
3. Omnivory blurs trophic levels
4. Factors other than consumers or food limit populations

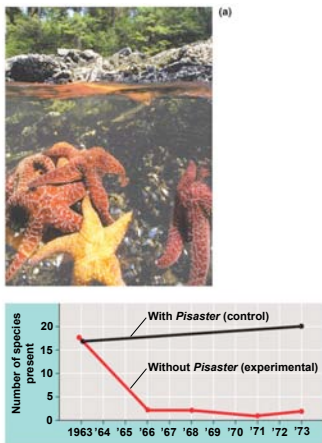


Focus on **Keystone Species** whose strong interactions limit potentially **Dominant** populations

Species traits and interaction strength

Not all species are created equal...

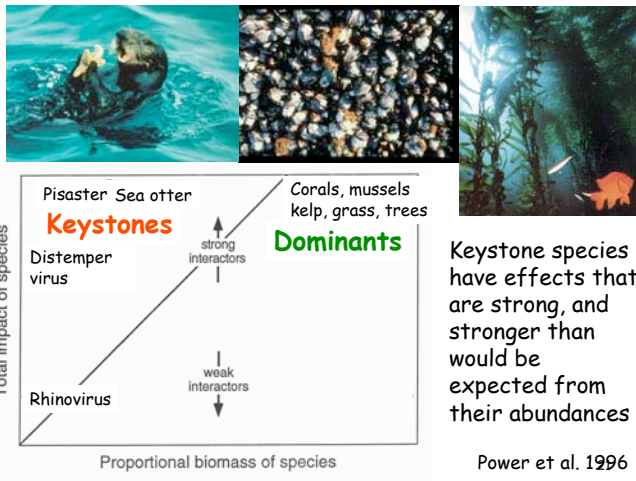
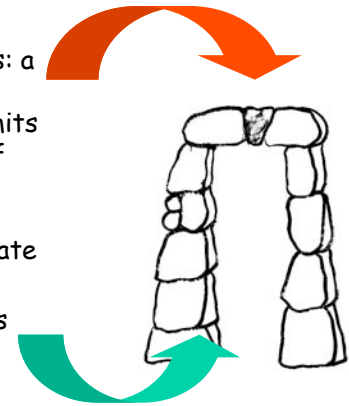




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Paine 1969 "Keystone Species"

- Keystone species: a species that consumes and limits the population of another species that would otherwise dominate the system
- Dominant species



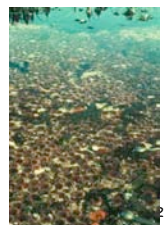
Strong interactors that trigger trophic cascades: Sea otters (Jim Estes et al.)

- Can forage down to 60 m
- Voracious-eat 20-25% body weight per day
- Prey on sea urchins, voracious grazers that can extirpate kelp
- Kelp is a potential dominant, structuring immediate subtidal and adjacent intertidal ecosystems



Urchins as strong interactors

- Can graze and detach kelp, boring through basal stipe, exporting huge amounts
- Collectively, urchins can wrestle kelp and weight it down
- Can persist/subsist on uptake of dissolved organic matter, or grazing microalgae, so can persist without large kelp, graze all new sporelings, and maintain "urchin barrens"

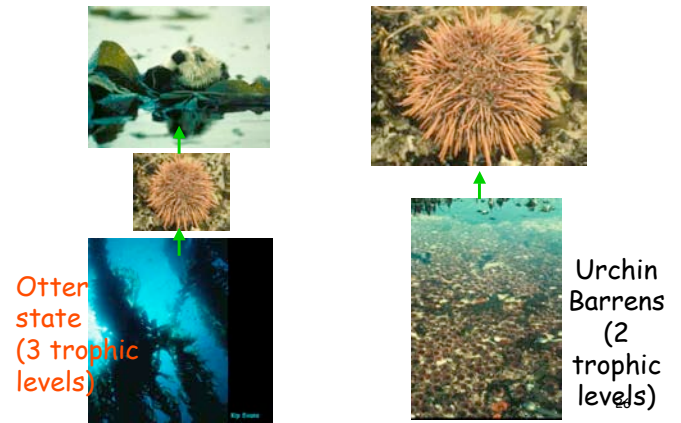


Kelp as strong interactor

- Prodigious growth rates and huge biomass
- Refuge for fin fish
- Wave break, decreases erosion in intertidal, causing sediment deposition
- Supplies intertidal with detritus and allows mudflats to be deposited (Duggins)



2 vs 3-level food chains: Aleutian Islands, SE Alaska



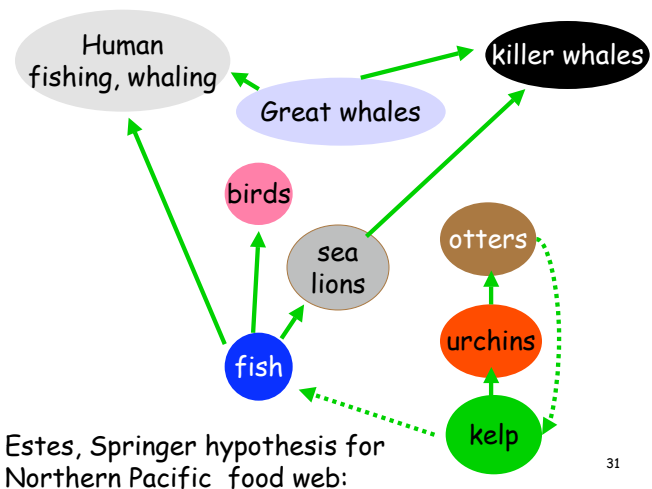
Evidence (Estes and Palmisano 1974)

- Rat Island (otters)
 - Complete cover of offshore kelp
 - Rare urchins
 - Lots of fin fish, harbor seals, bald eagles
- Near Island (no otters)
 - Urchin barrens covered in mussels and barnacles
 - Dense large mussels
 - Few fish, harbor seals, or birds

Killer whale link (Estes et al. 1998, Campbell Fig. 53.15)

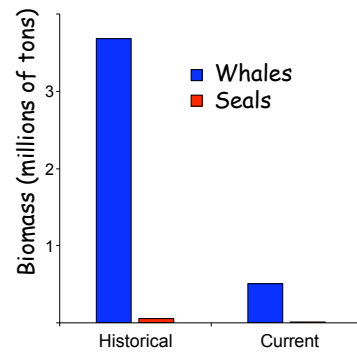
- 27 years of monitoring the northeastern Atlantic revealed precipitous sea otter decline in 1990s throughout archipelago off western Alaska, down to 10% of 1980s populations
- Hypotheses:
 - Toxins (PCBs)
 - Disease
 - Starvation
 - Climate stress
 - Predation
- 1st killer whale attack on otter observed in 1991. Computed probability that if rate of whale predation constant over 27 y of census, probability of not observed before 1990 = 0.006.
- Ecosystem responses—urchins increasing 8x and kelp decreasing 10x over 12 y where otters missing
- Clam Lagoon (otter refuge too shallow for whales to enter) otters still present, no other food web or ecosystem changes (urchins rare and small, kelp communities intact).



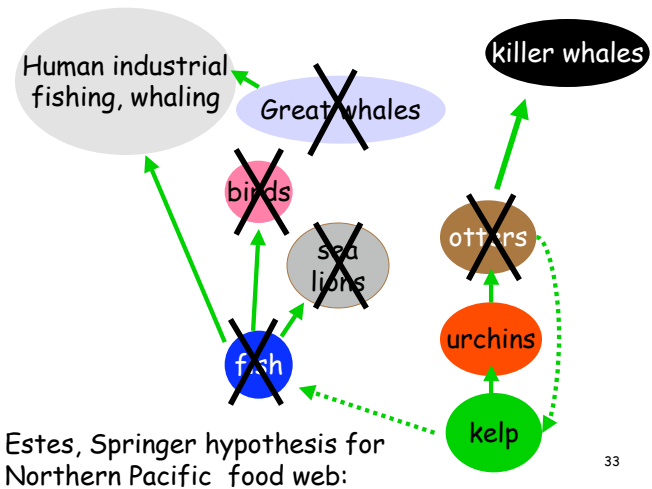


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Biomass estimates for great whales (blue) and seals (red) before and after their recent declines in the Aleutian Islands and Bering Sea region. Springer et al. 2003.

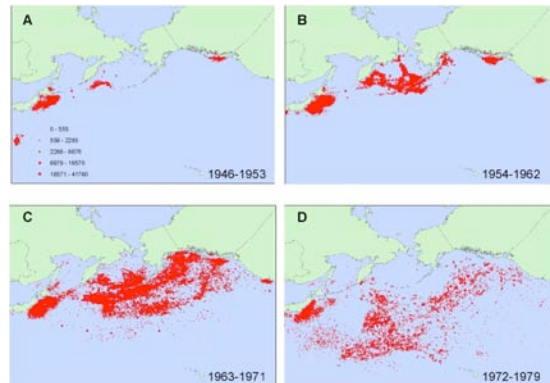


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Geography of reported whale harvests (all species) in the North Pacific Ocean and Bering Sea from 1946 through 1976. Springer et al. 2003.



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Springer et al., PNAS 2003: Marine megafaunal collapse in N. Pacific

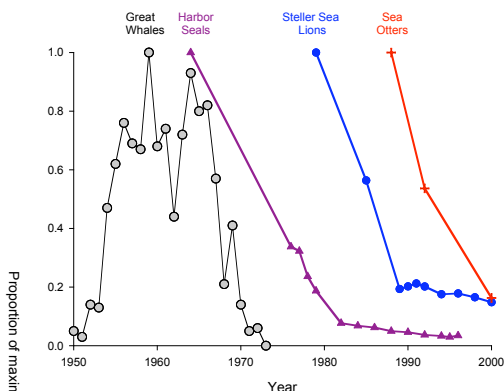


Figure 2. The sequential collapse of marine mammals in the North Pacific Ocean and southern Bering Sea, all shown as proportions of annual maxima. *Great whales*—IWC reported landings (in biomass) within 200 nm of the Aleutian archipelago and coast of the western Gulf of Alaska. *Harbor seals*—counts of Tugidak Island. *Fur seals*—average sheep production on St. Paul and St. George Islands, Pribilof Islands. *Steller sea lions*—estimated abundance of the Alaska western stock. *Sea otters*—counts of Aleutian Islands.



