

# Ecosystems

## TROPHIC CASCADES

### Keystone Species and Trophic Cascades

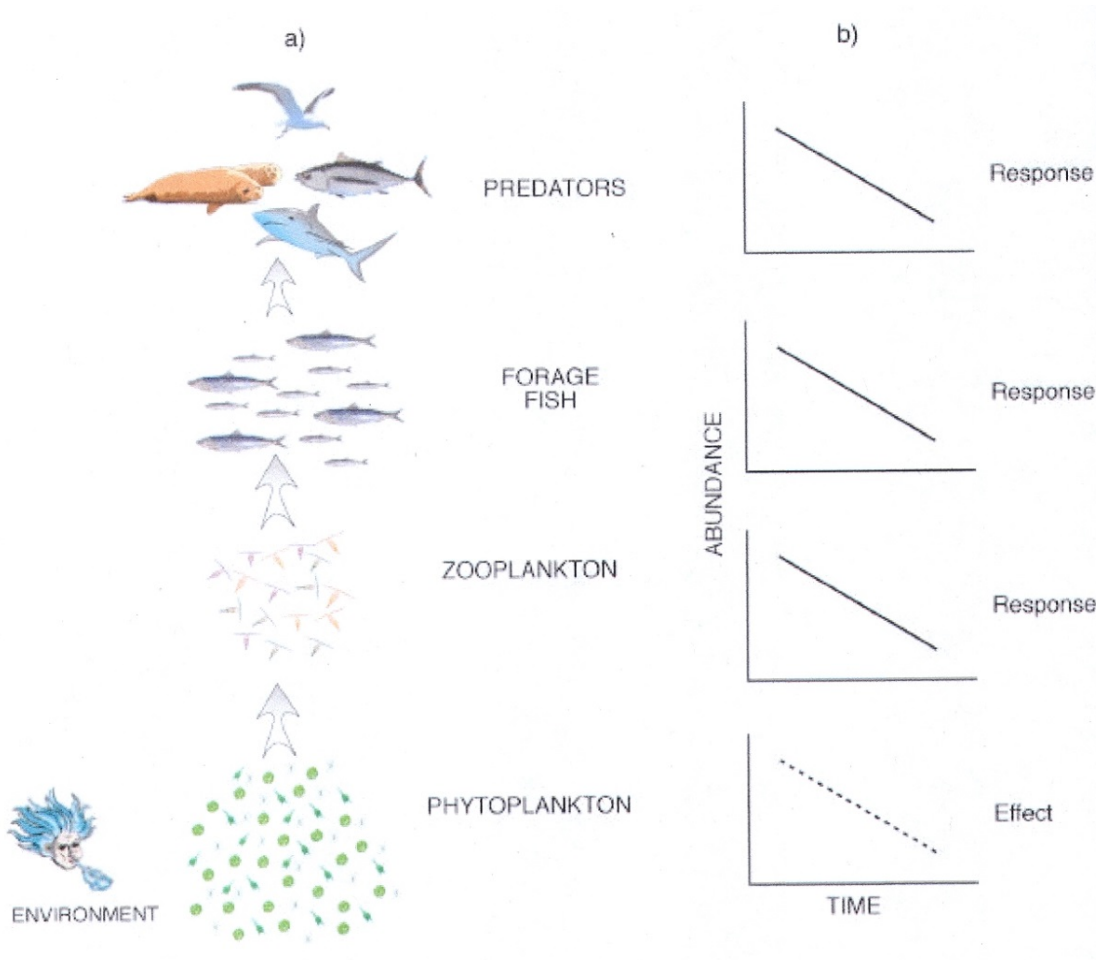


# Trophic Cascades

## Definitions of Terms (1)

- Trophic level: the position of an organism in a food web.
- Primary producers: plants that produce sugars through photosynthesis
- Primary consumers: animals that eat primary producers.
- Secondary consumers (predators): animals that eat other animals.
- Bottom-up Control: Enhancement of primary production as result of less consumption by predators/herbivores, or input of higher nutrients
- Top-down Control: Regulatory impact on food webs of consumers

# BOTTOM- UP Control

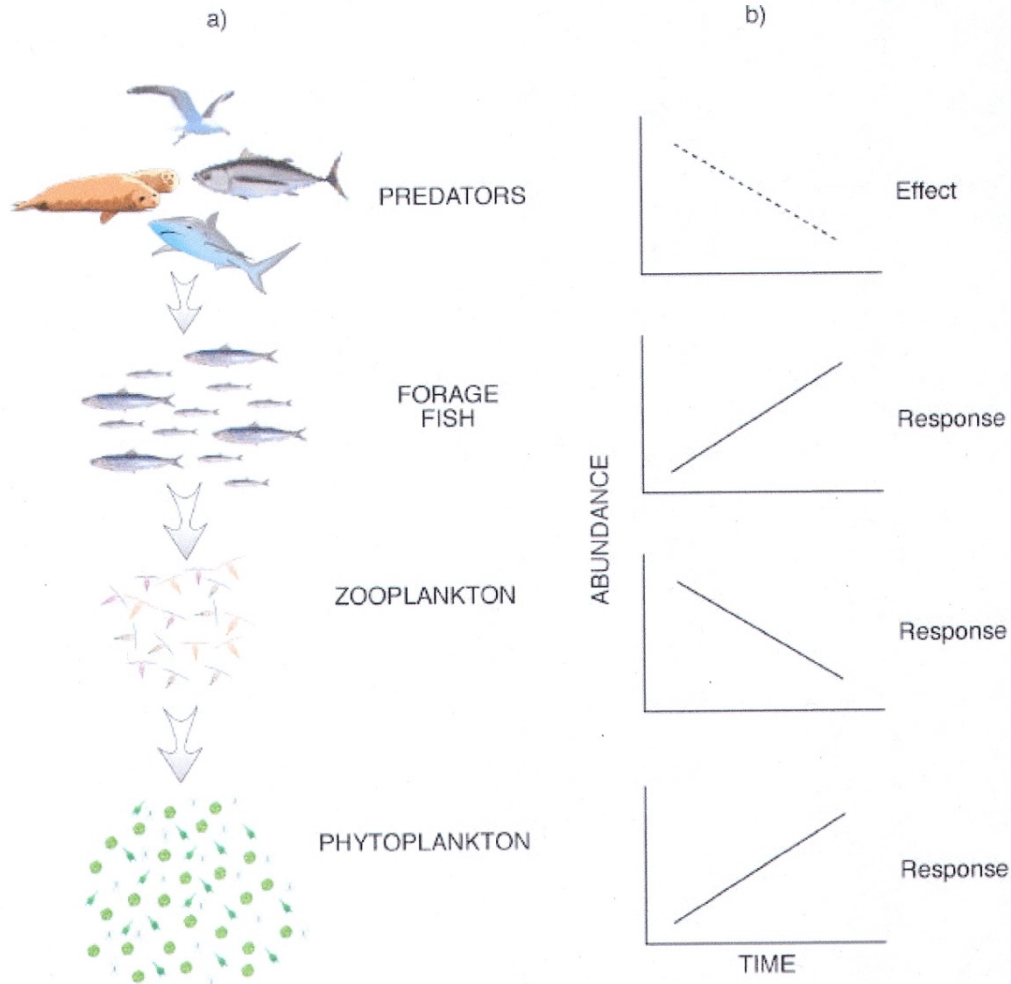


BOTTOM- UP Control within a simplified four-level food web in a marine ecosystem (Cury *et al* 2001, redrawn from Estes *et al.* 1998)

- An input of nutrients to the sea (e.g. an upwelling event) results in high production of phytoplankton. This EFFECT declines over time (shown by dotted line on lower graph)
- Responses to this decline in phytoplankton are mirrored throughout the food web by similar declines in Zooplankton, Forage Fish and Predators, which are dependent on this upwelling and primary production.



# TOP-DOWN Control

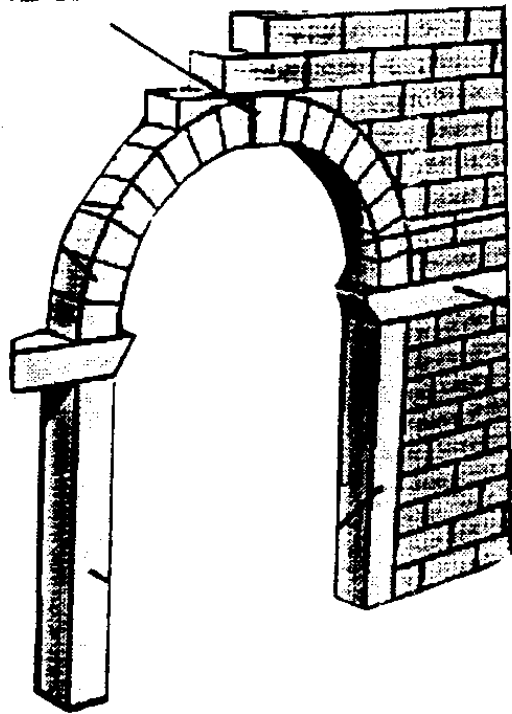


- A region is subject to recruitment of predators or migratory movement of predators, such as Tuna. This EFFECT may decline over time (shown by dotted line on top graph).
- Responses to this decline in top-down predation are an increase in Forage Fish. These predate on Zooplankton, which declines.
- A decline in grazing Zooplankton enables growth of Phytoplankton.
- This may be described as a Cascade

TOP-DOWN CONTROL within a simplified food web in a marine ecosystem (Cury *et al* 2001).

# Keystone Species concept

KEYSTONE SPECIES



- Keystone Species are NOT the Dominant species or have highest Biomass
- A *Keystone Species* is one whose ecological effect is large, and disproportionately large relative to its abundance
- Removal leads to local extinctions and/or large changes in abundance of other species

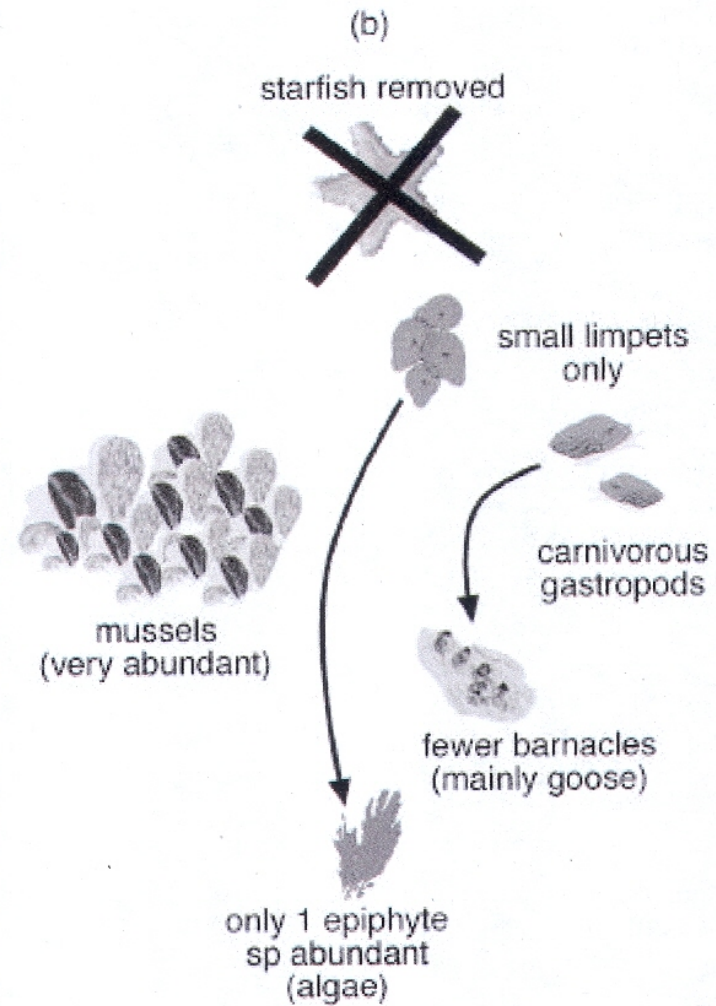
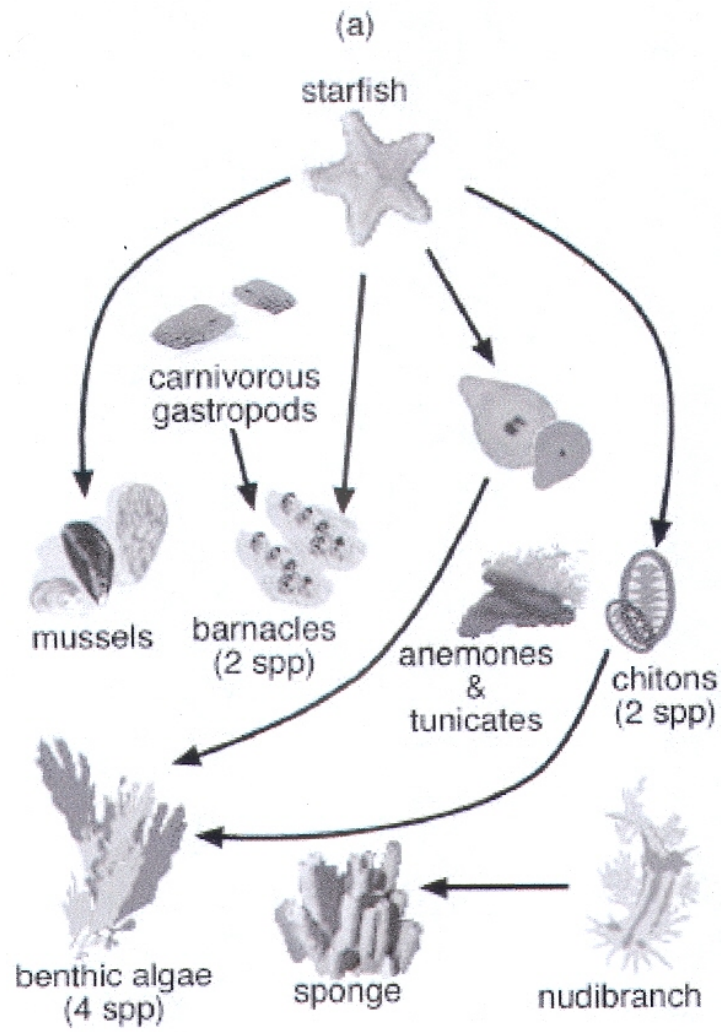
# Keystone Species concept



Starfish *Pisaster ochraceus* on beds of mussel *Mytilus californianus*.

- Classic experimental work by Robert Paine and others (1966,1969) on Californian shores showed that top-down predatory effects of the starfish *Pisaster ochraceus* on mussel beds had a remarkable influence on the community of animals and seaweeds.
- Mussels were the dominant species, but the starfish created patches within the mussel bed and enabled other species to find space and colonise. Here, the starfish were *Keystone* species

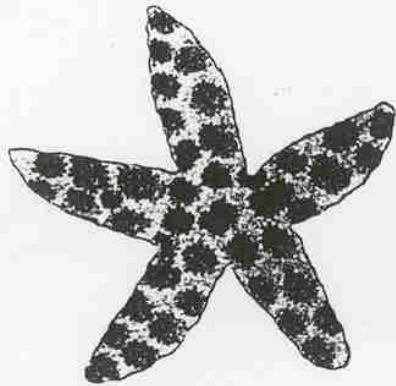
# Keystone Species concept



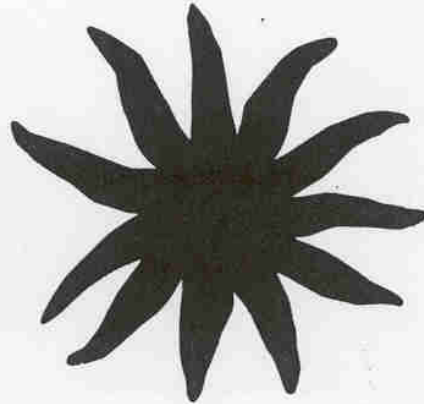
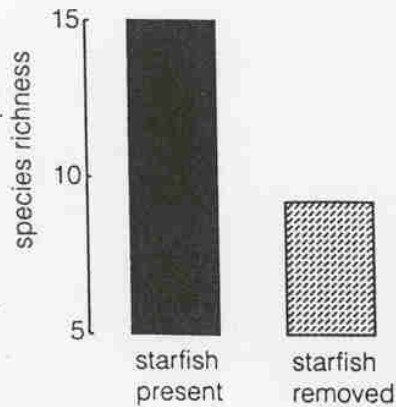
Starfish *Pisaster ochraceus* are keystone species on Pacific shore of the US



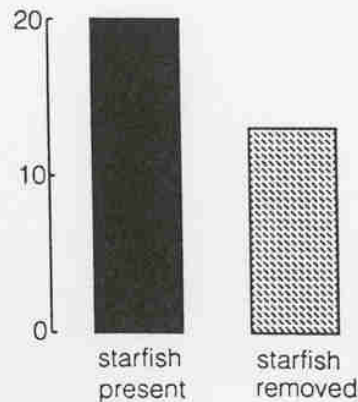
# Keystone Species concept



*Pisaster*, USA



*Stichaster*, New Zealand



Replicated experiments in New Zealand showed that the reef starfish *Stichaster australis* had a similar Keystone effect on the species richness of beds of mussel *Perna canaliculus*.



# Keystone Species

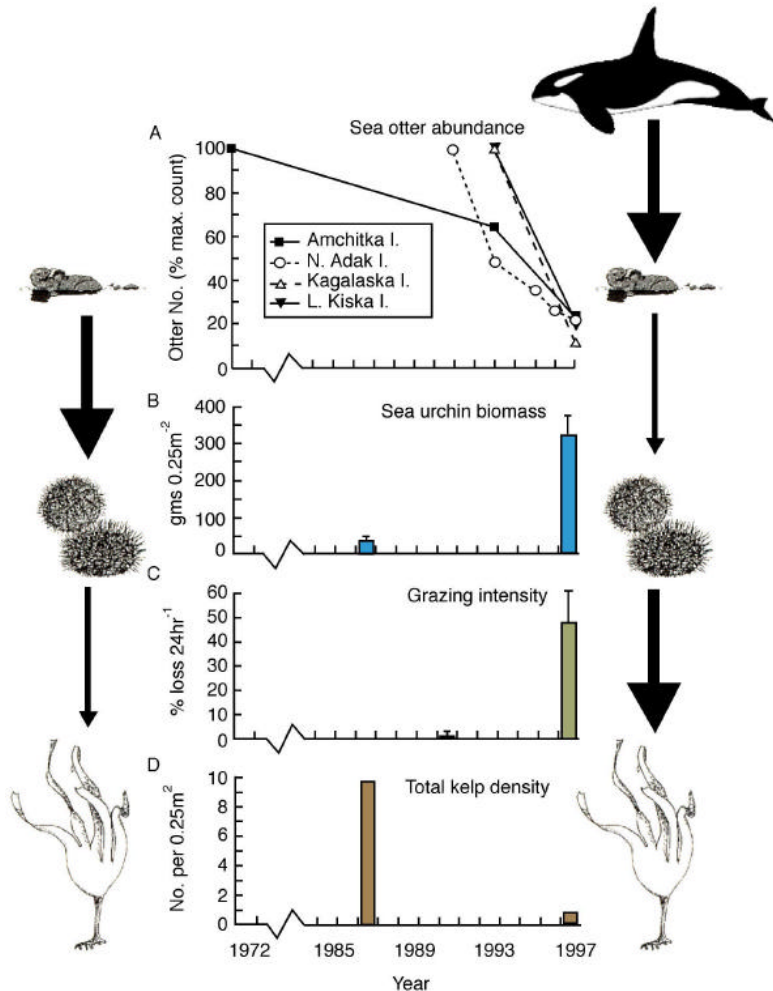
- How widespread are *Keystone* species across ecosystems?
- The Keystone species concept is applied quite broadly – perhaps beyond its original definition. Is this a problem?
- Does the Keystone species concept have application to modern Conservation Ecology and Management?

# Trophic Cascades

- A Definition: Predator-prey effects that alter the abundance, biomass or productivity of a population community or trophic level across more than one link in a food web (Pace *et al.*, 1999)
- True trophic cascades involve '*keystone species*' (Paine, 1969,1980), with such '*top-down*' dominance that their removal causes precipitous change in the system.
- *Initially* thought to be restricted to particular types of marine and freshwater ecosystems; we now know differently and can occur in terrestrial ecosystems too.
- Trophic cascades can have strong impacts on ecosystems and can stabilize them in alternate states.

# Trophic cascades: Aleutian archipelago, western Alaska

(Estes et al 1998; Cury et al. 2001)



- When sea otters are abundant they predate heavily on sea urchin biomass, which remains low;
- When sea otters are scarce, sea urchins can increase and kelp density can decline;
- Addition of killer whales as an apex predator limits sea otter abundance, so sea urchin biomass can develop and the resulting grazing intensity constrains the kelp density to lower levels.

Which is the Keystone Species?

Heavy arrows represent strong trophic interactions; light arrows represent weak interactions (from Estes et al. 1998)

Cury et al. 2001. Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem 15, Reykjavik, Iceland, 1-4 October 2001

# Trophic Cascades



What could be happening here?



# Some Animals Are More Equal than Others: Keystone Species and Trophic Cascades

<https://www.youtube.com/watch?v=hRGg5it5FMI>

# References

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