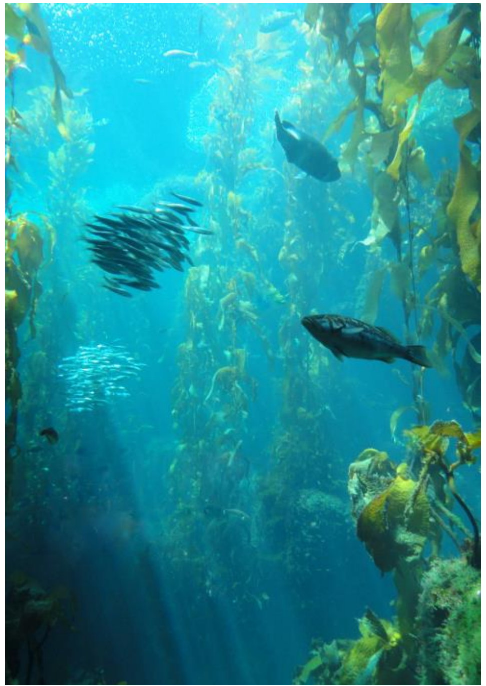







Unstable system: Kelp forest in Tasmania

Colloquium by Tamara Gademann

Supervisor: Karin de Boer

Kelp forest

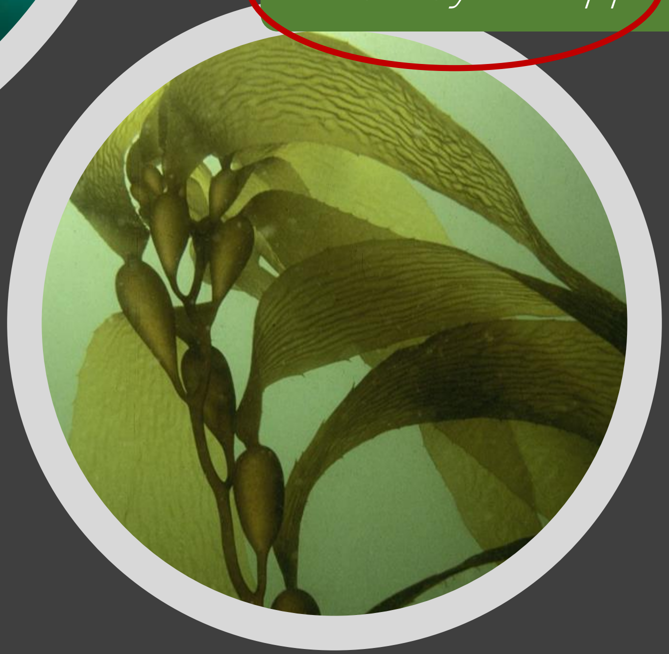
= phyletically diverse, structurally complex and highly productive components of cold-water rocky marine coastlines

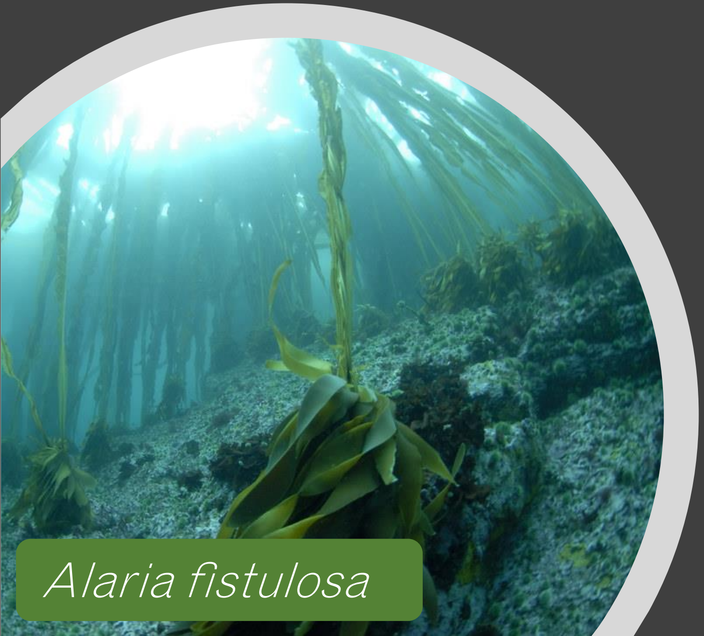
- Global distribution is constrained by:
    - light at high latitudes
    - nutrients
    - warm temperatures
    - other macrophytes at low latitudes
- Threats: (mid-latitude belts)
    - by herbivory: usually sea urchins
    - Overfishing
    - ➢ extirpation of predators → herbivore population increases
    - → leading to widespread kelp deforestation
    - Climate change

Characteristics

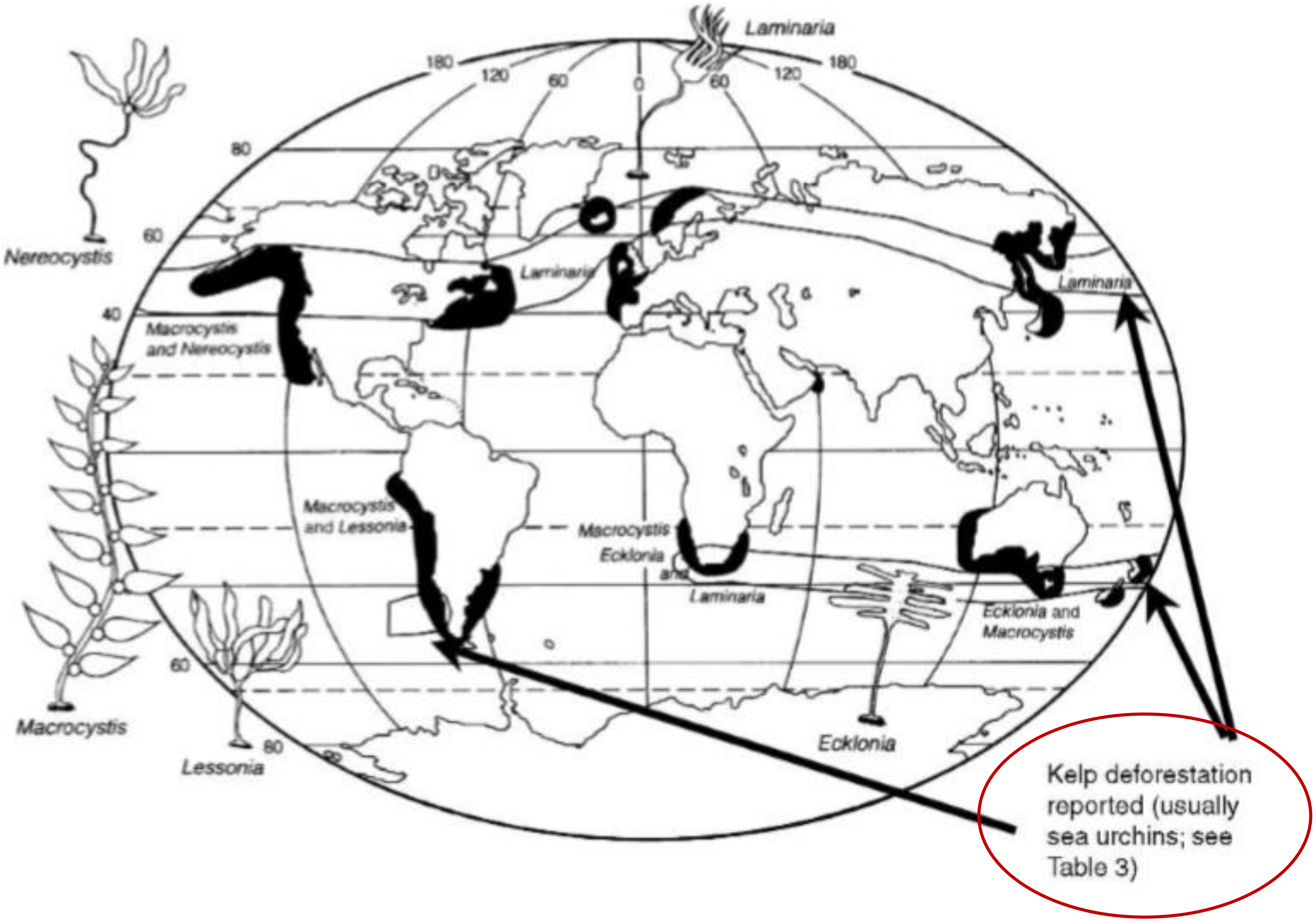
- dominate shallow rocky coasts
- cold-water marine habitats
- brown algae
- Family: *Laminariales*
- produce the largest biogenic structures found in benthic marine systems
- Kelp ecosystems include structure-producing kelps and their associated biota
  - marine mammals
  - fishes
  - crabs
  - sea urchins
  - molluscs
  - other algae
  - epibiota

Morphological groups





- defined by the canopy height of their fronds
- *Macrocystis spp.*
  - grows to 45m long
  - ➢ North + South America
  - ➢ South Pacific Ocean + South Africa
  - ➢ southern Australia
  - ➢ New Zealand
- *Nereocystis leutkeana*
  - ~ 10 m
  - ➢ Central California to Alaska
  - ➢ South Africa
- *Alaria fistulosa*
  - reach about 10m in length
  - ➢ Alaska
  - ➢ Pacific coast of Asia



Laminaria
180
120
60
0
60
120
180
80
60
40
60
80
Nereocystis
Macrocystis
and Nereocystis
Laminaria
Laminaria
Macrocystis
and Lessonia
Macrocystis
Ecklonia
and
Laminaria
Ecklonia and
Macrocystis
Macrocystis
Lessonia
Ecklonia
Kelp deforestation
reported (usually
sea urchins; see
Table 3)

Sea urchin induced deforestation

- Globally increased over the past 2–3 decades
- Continued fishing down of coastal food webs
- hunt of sea urchin predators
  - as the sea otter in the North Pacific
  - predatory fishes like the cod in the North Atlantic
- largescale removal of predators for export markets increased sea urchin abundances
- → Cascade effect

What happens to the kelp when the sea urchin population increases?

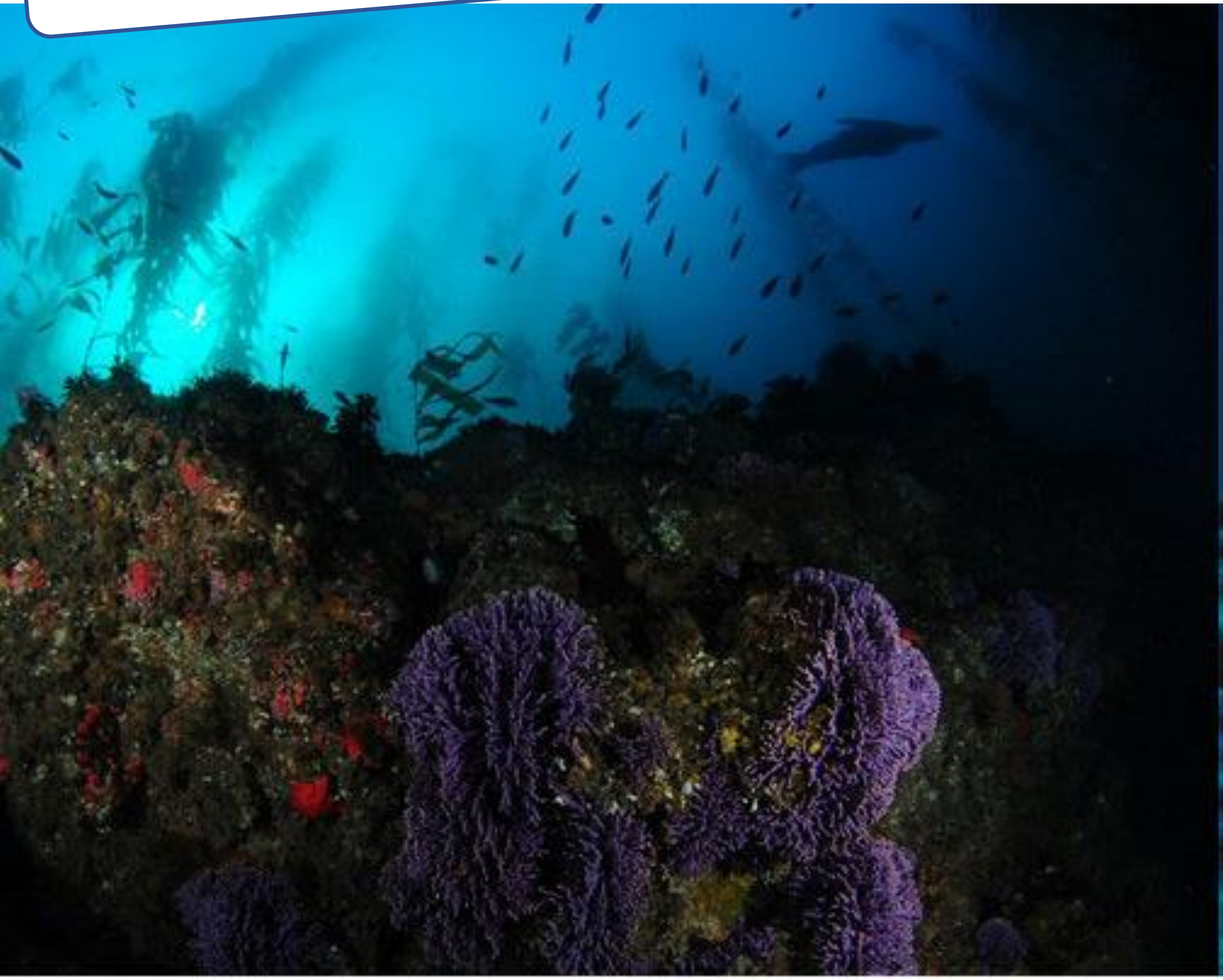
- Kelp forests = extremely productive ecosystems
- Support a huge amount of marine life
- Sea urchins eat the roots of kelps
- No predators → population multiply

➢ forming herds

➢ Sweep across the ocean floor

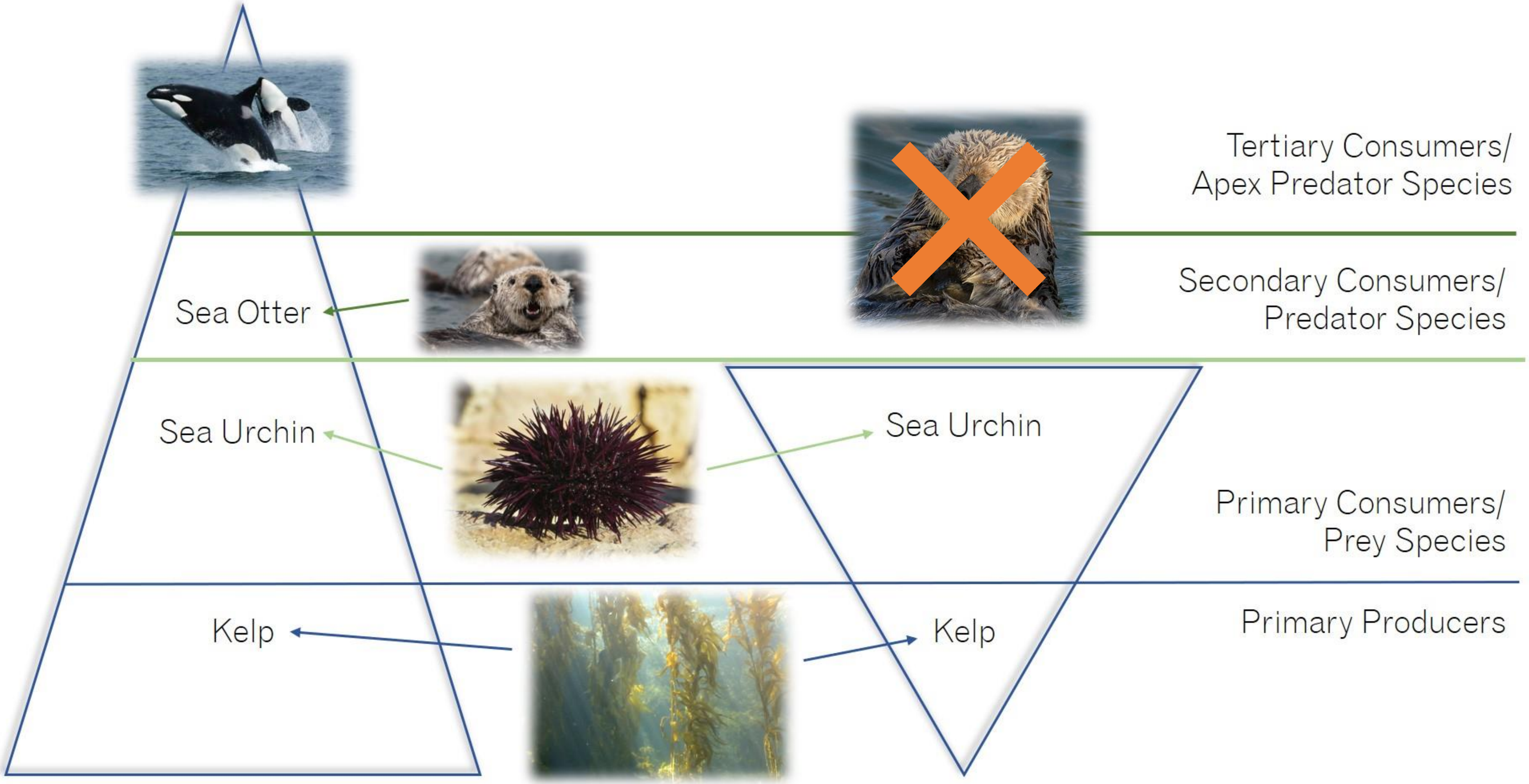
➢ Leaving "urchin barrens"

Before



After

Cascade Effect



An Example

Sea Urchins & Sea Otters– West Coast, US

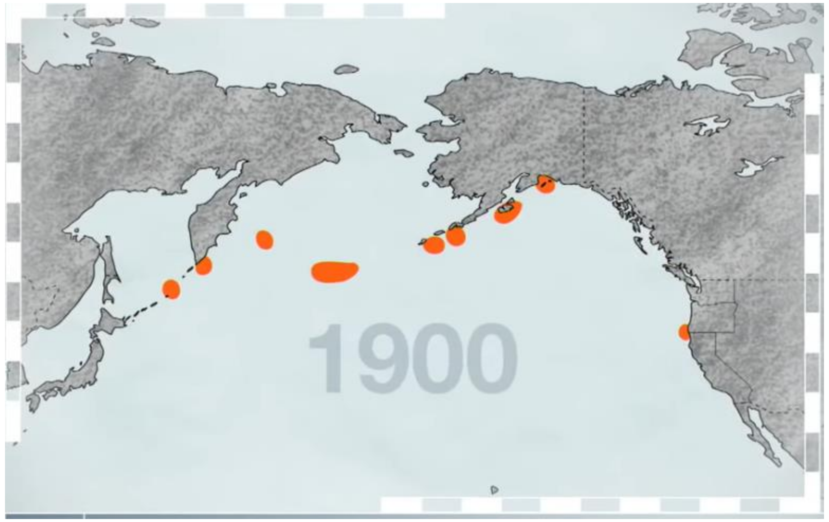
- Kelp = one of the worlds most efficient absorbers of CO_2
- Kelp needs sea otters around to defend from predators
- mid 1700 - 1900 otters were hunted for their fur

→ Decrease of population

- End of the fur trade: 1911

→Only ~ 1000 otters remained

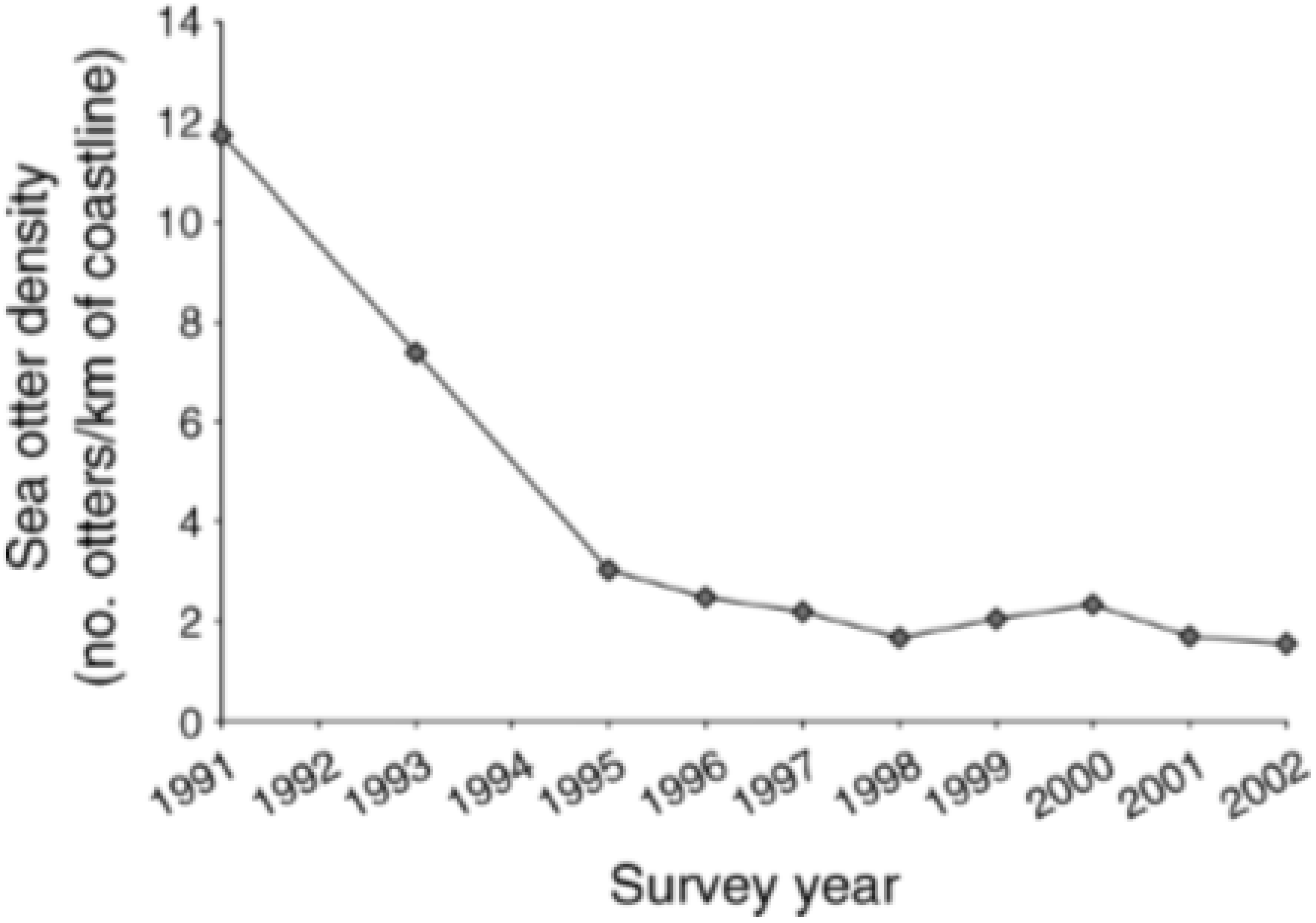
- 1960/1970 trying to restore them to their previous range
- Captured in Alaska and brought to the US coasts




Monterey Bay Aquarium

Sea otter population decreased

- Sea otter density – Number of otters per km of coastline – Alaska, 1991-2002



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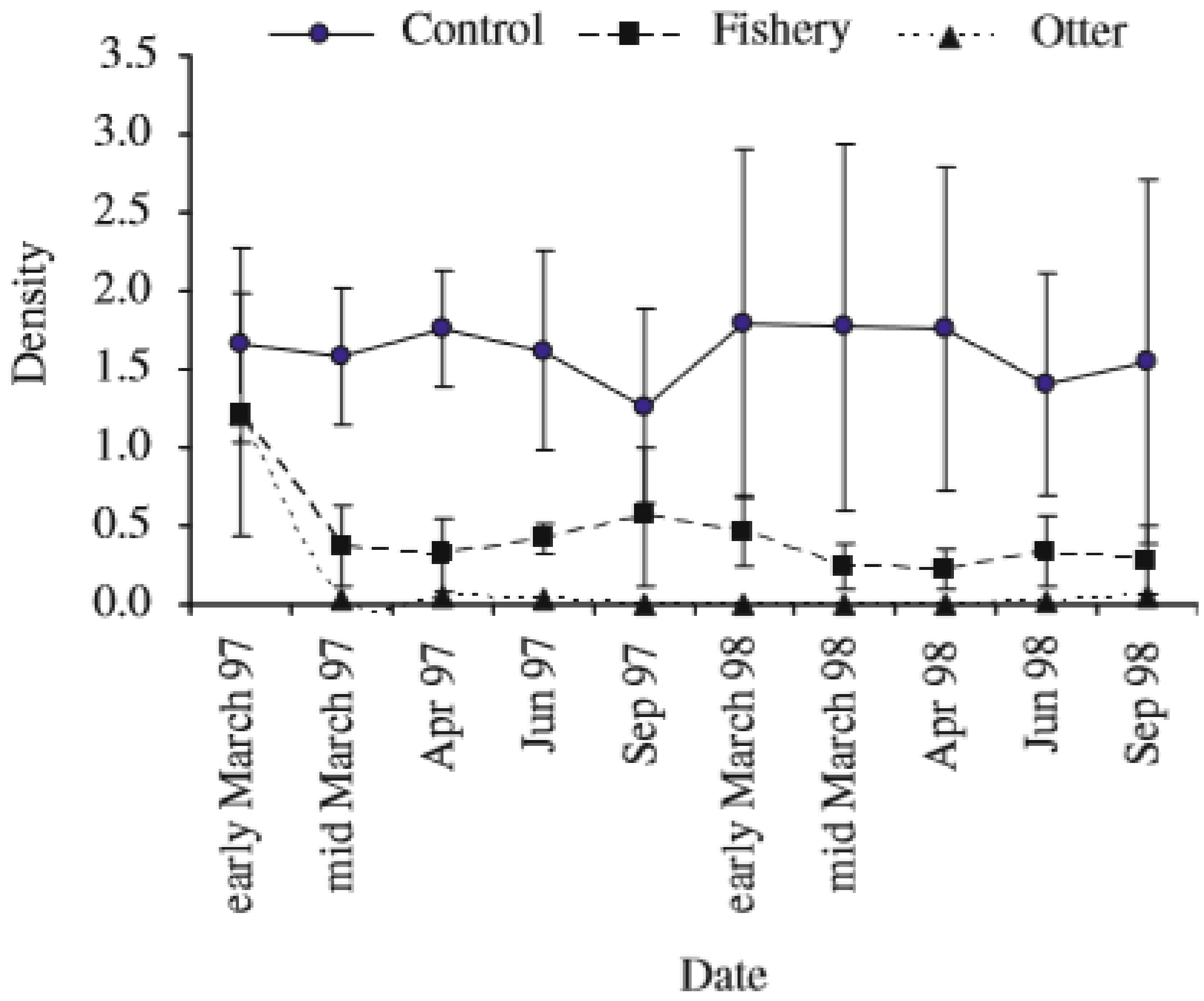
The effect of Sea otters on Sea Urchins

Otter: Simulated sea otter predation (monthly complete harvest of sea urchins)

Fishery: simulated commercial sea urchin harvest

Control: no harvest

- Simulated sea otter predation reduced urchin density by 98% initially



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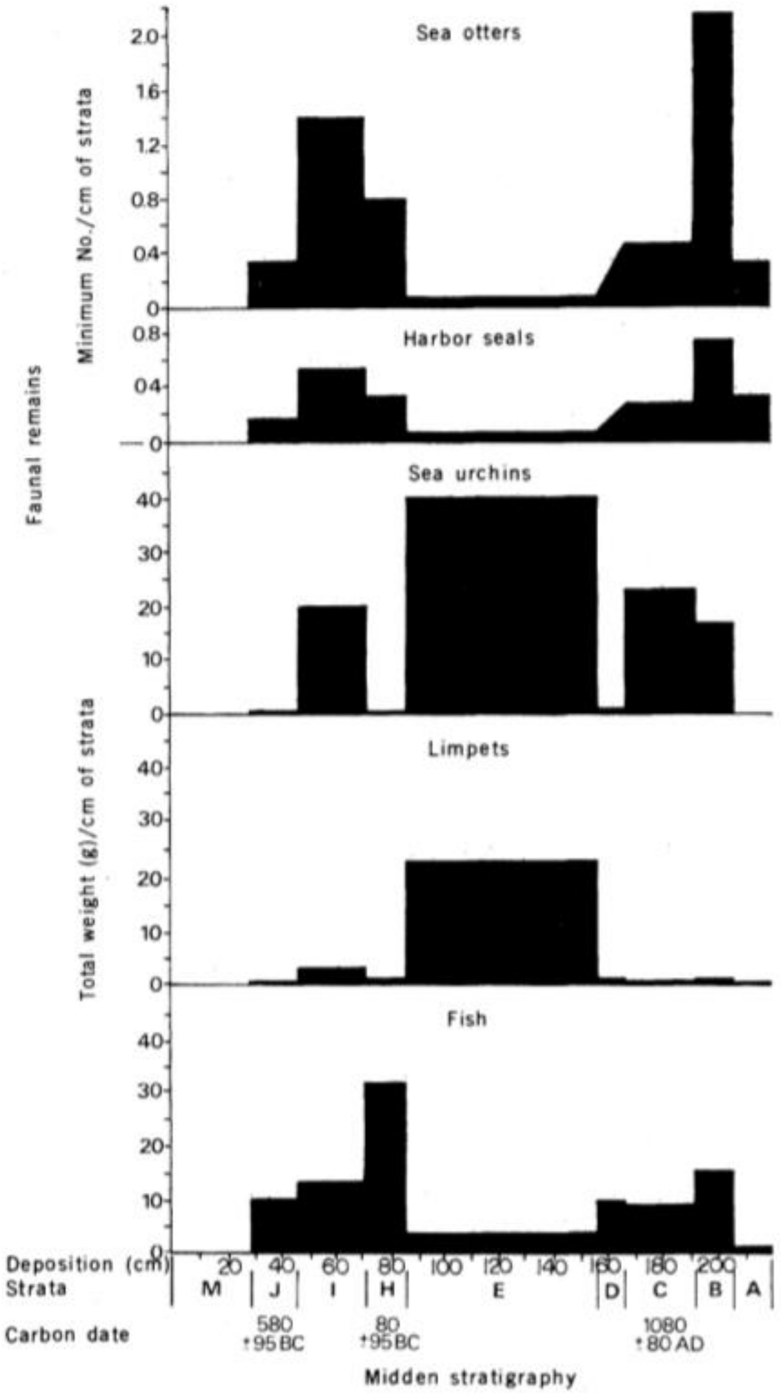


Over-exploration of sea otters causes faunal shift

Fish abundance correlates with the abundance of sea otters

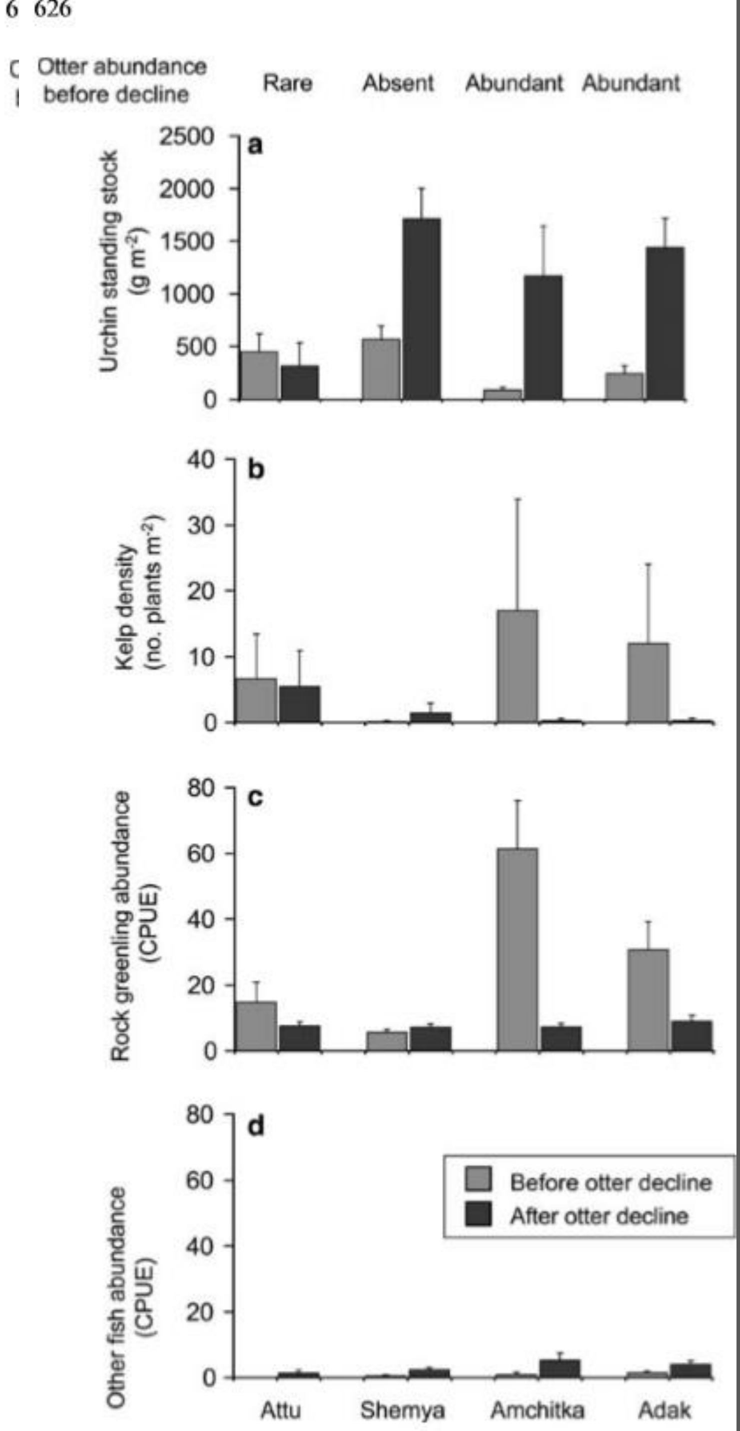
- When sea otters are absent → urchin population increases
- Relatively high abundance of harbor seals as consequence of predictable sea otters

➢ Seals feed on fish → no fish, no seals

Simenstad, C. A., Estes, J. A., & Kenyon, K. W. (1978). Aleuts, sea otters, and alternate stable-state communities. *Science*, *200*(4340), 403-411.

The trophic cascade linked sea otters with sea urchins

- Measured: abundance of sea urchins (biomass density), kelp (numerical density) and fish (Catch per unit effort) at four islands in the mid-1980s (when otters were abundant at two of the islands and rare at the two others)
- And in 2000 (after otters had become rare at all four islands)



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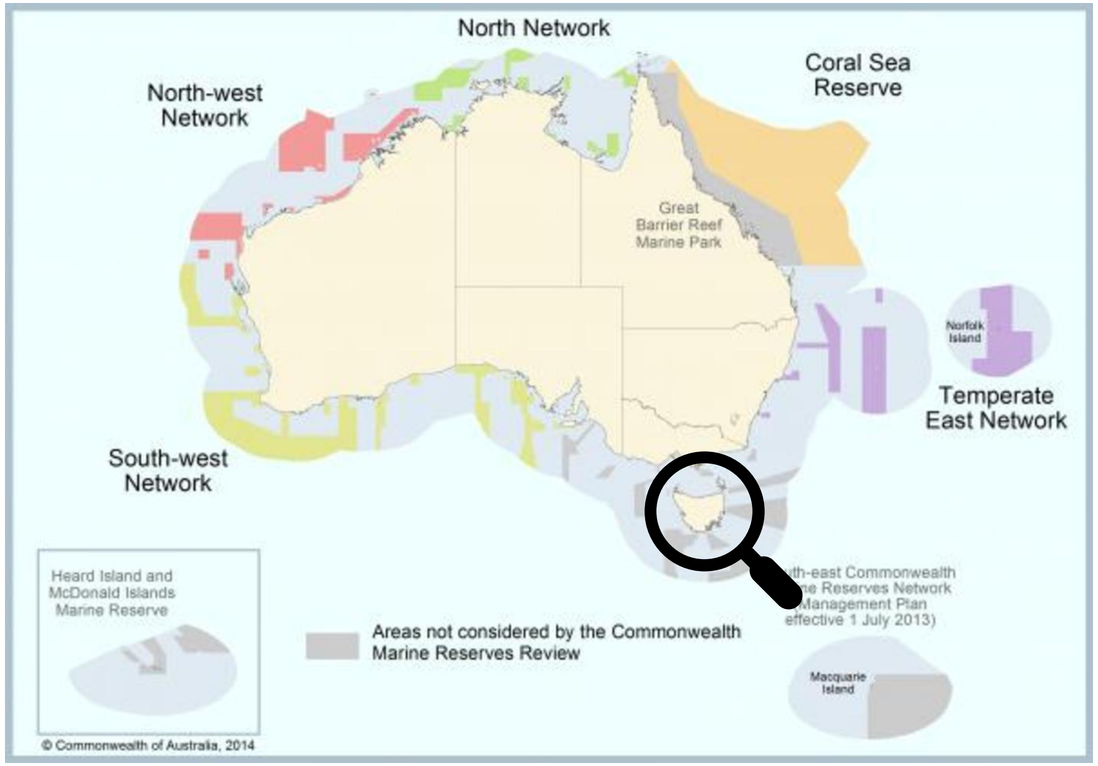
The story of Tasmanian kelp forest

Tasmania's Rocky Reef diversity



Commonwealth Government, 2014

- Marine areas around Tasmania not part of marine reserve

Threats:

➢Overfishing

➢Climate change

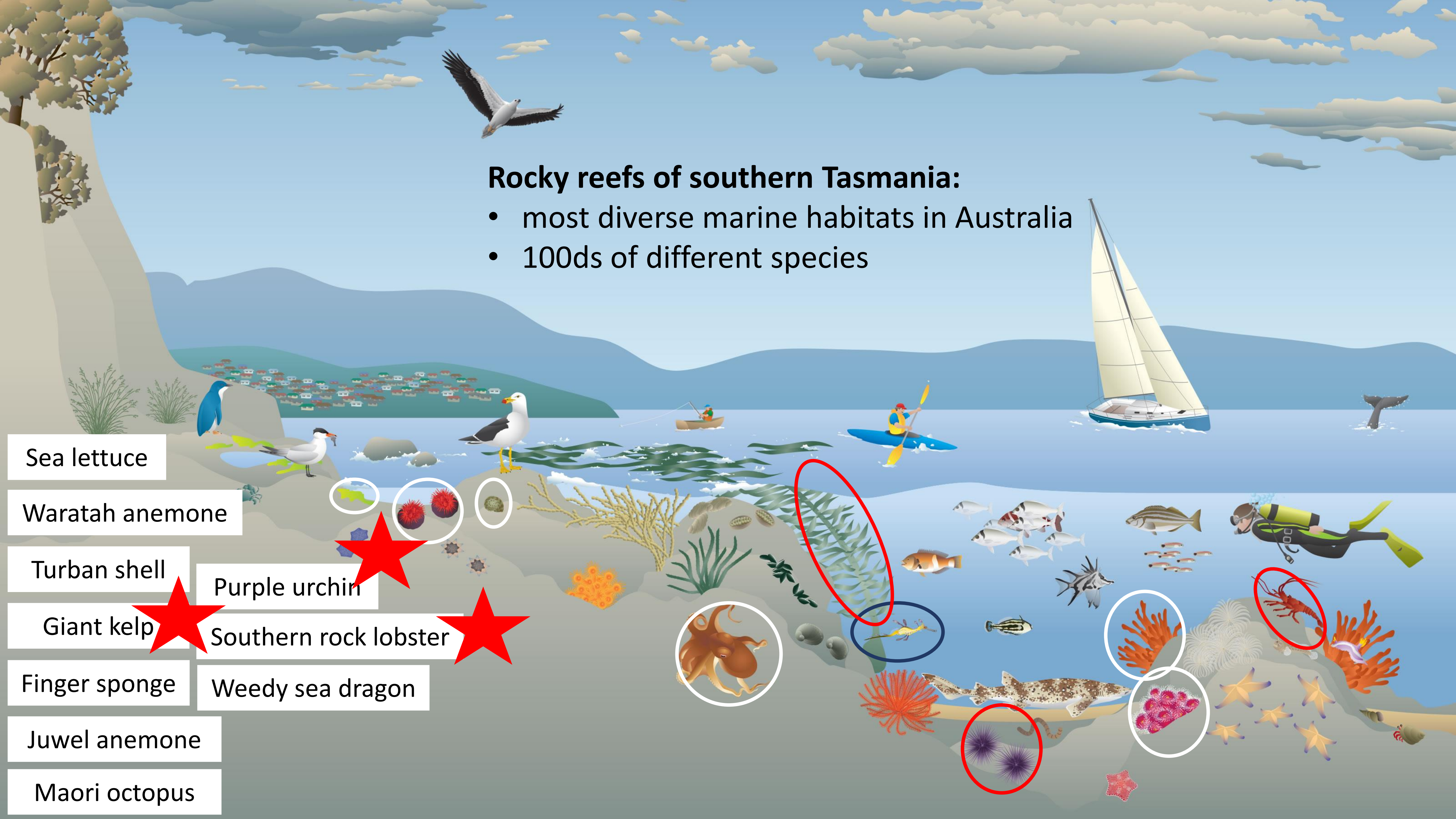
➢Direct human impact – plastics…

- Only 5% of the original forest remains
- Giant Kelp: *Macrocystis Pyrifera*

2012 → Australian Government declaierd remaining forest = endangered habitat

Rocky reefs of southern Tasmania:

- most diverse marine habitats in Australia
- 100ds of different species

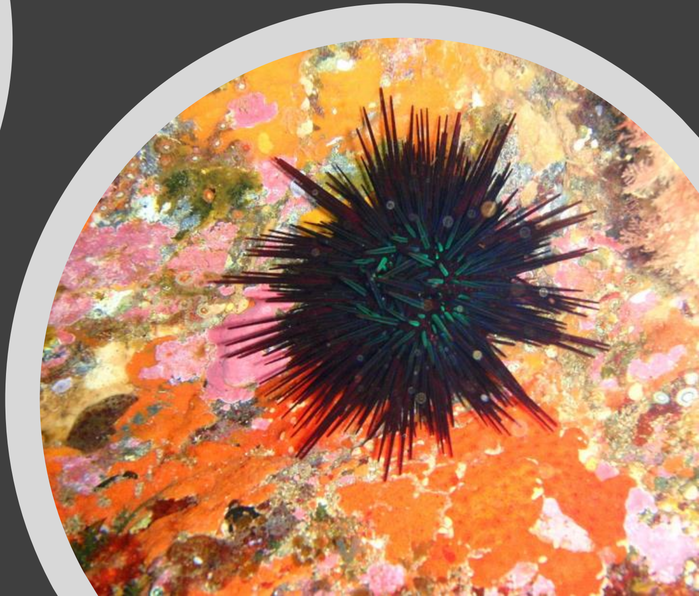


An Experiment: Using molecular prey detection to quantify rock lobster predation on barrens-forming sea urchins.

What is it about?

Detection of in sito consumption rates of sea urchins by rock lobsters

- *Sea urchin: Centrostephanus rodgersii* and *Heliocidaris erythrogramma*
- *Rock lobster: Jasus edwardsii*



Materials & Methods

- Collect faecal samples from trap caught lobsters
- over 2 years
- two no-take research reserves
    1. Elephant Rock Research Reserve (north Tasmania) = ERRR
        - an area of extensive overgrazed *Centrostephanus rodgersii* barrens
    2. North Bay Research Reserve (south-east Tasmania) = NBRR
        - incipient *C. rodgersii* barrens occurred within intact seaweed beds across the reef
- rebuild a population of large lobsters (≥140 mm) capable of preying on C. rodgersii translocated to the reserves

→ sourced from remote areas by commercial fishers

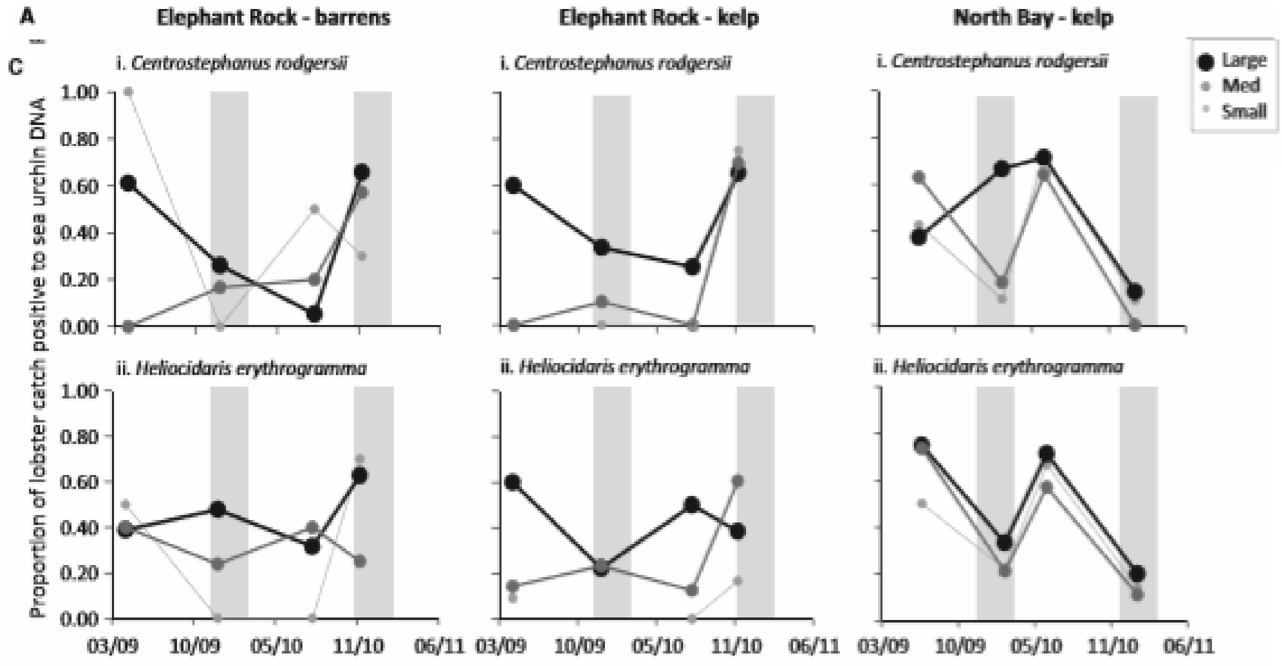
- Total: 1665 large lobsters (140–220 mm)
    - 933 to ERRR
    - 732 to NBRR
- faecal samples from individual lobsters were obtained by trapping lobsters

→ during winter and summer seasons

- DNA extraction

Results

- Detection rates of sea urchin DNA in lobster faeces at ERRR and NBRR indicated ingestion of both *Centrostephanus rodgersii* and *Heliocidaris erythrogramma* tissue across all lobster size-classes examined
- high variability in the proportion of lobsters with faeces positive for sea urchin DNA across years and seasons dependent on lobster size



Summary

- large rock lobsters [≥140 mm carapace length] = principal predators of *C. rodgersii*

➢ large predatory capable lobsters are currently rare due to intense fishing pressure

- detection rates varied significantly across, at both sites depending on lobster size and season
- the proportion of positive assays to sea urchin DNA increased with increasing lobster size
- the proportion of smaller lobsters (<140 mm CL) testing positive for sea urchin DNA was higher than expected



Discussion

- ➢ The rate of molecular prey detection is probably overestimated
- small lobsters → known to be unable of directly predating emergent sea urchins
- ➢ showed relatively high rates of positive tests
- indicate that some lobsters ingest non-predatory sources of sea urchin DNA
    - ingestion of *C. rodgersii* DNA from the benthos
- DNA-based approach & direct monitoring of urchin populations → both indicate high predation rates of large lobsters on emergent urchins

Working with natural enemies

Comparison

Otters

- Overfishing
- Cascade Effect!
- Abundance of otters = decrease of urchins
- Sea urchins = preferred food

Lobsters

- Overfishing
- Cascade Effect?
- Not clear yet if sea urchins are the preferred food
- Lobsters do feed on sea urchins

A future project could look like:

Research question

How does prey preference, optimal foraging and ocean warming affect consumption of the sea urchin (*Centrostephanus rodgersii*) by different rock lobster species (*Jasus edwardsii* and *Sagmariasus verreauxi*)?

Lab Experiments/ Questions & Methods?

1. Are sea urchins the preferred pray of lobsters?
   - Prey choice experiment
2. What is the actual size a lobster needs to feed on sea urchins? Does size matter?
   - Prey choice in small (less than 140 mm) and big (more than 140 mm) lobsters
3. Energetics of optimal foraging to develop the energetic cost-benefit relation of choosing prey → Exp. 1
4. Temperature effects on prey & consumption?

Is the cascade effect the only explanation for the increase of sea urchin population?

Thank you for your attention

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