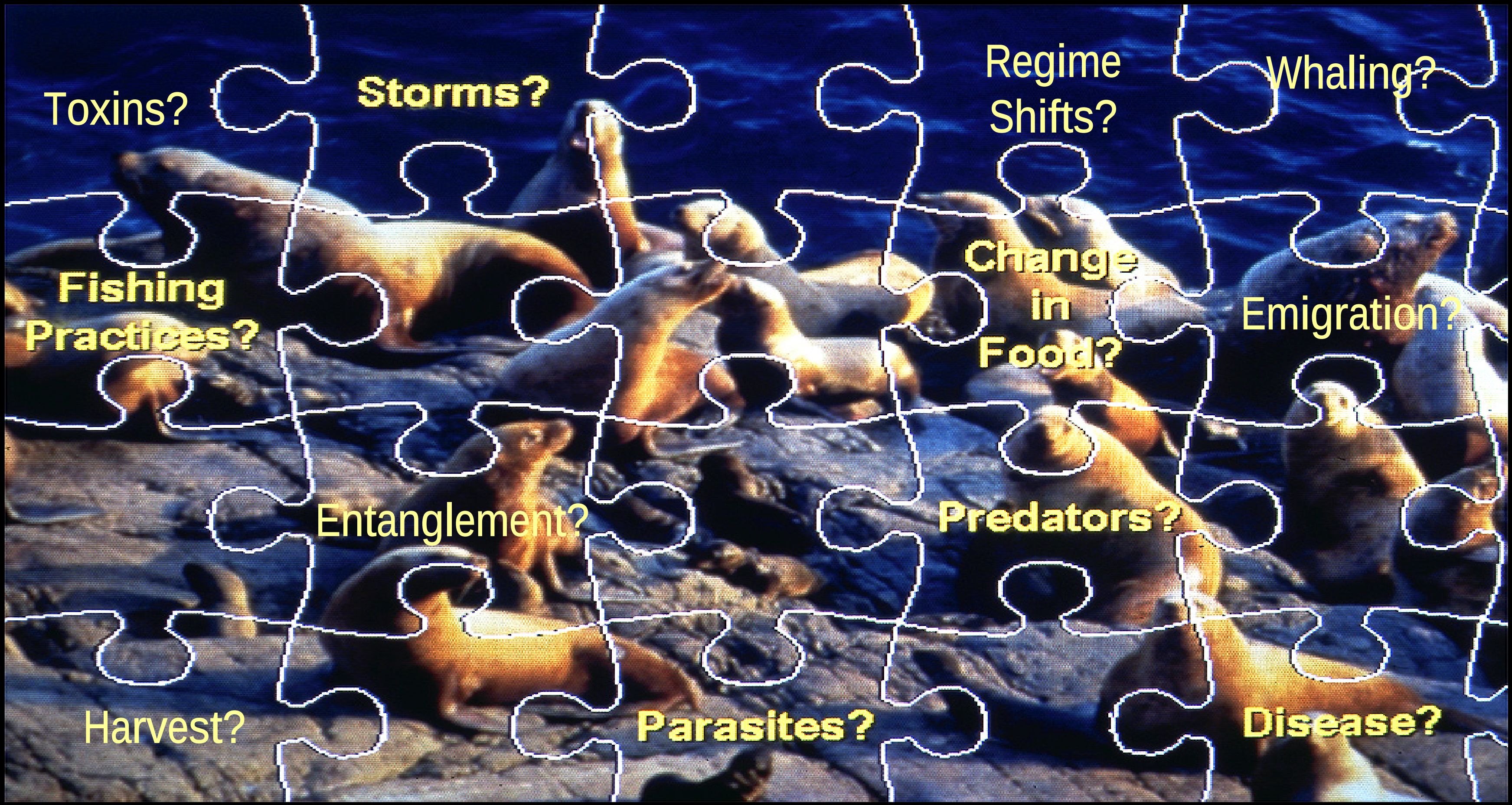
North Pacific Universities Marine Mammal Research Consortium



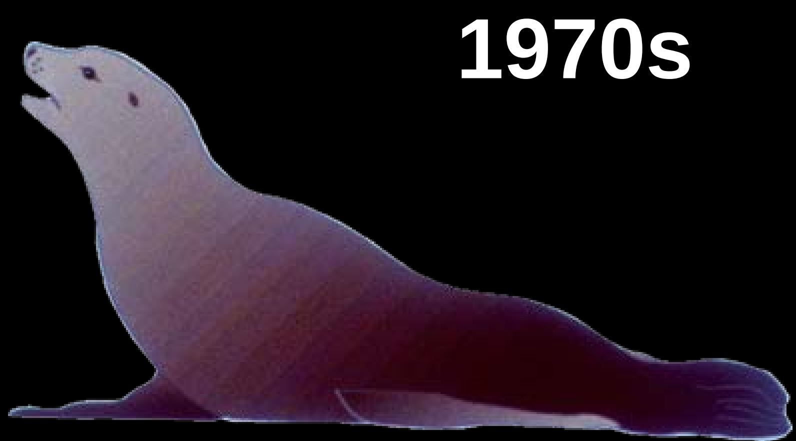
Andrew W Trites

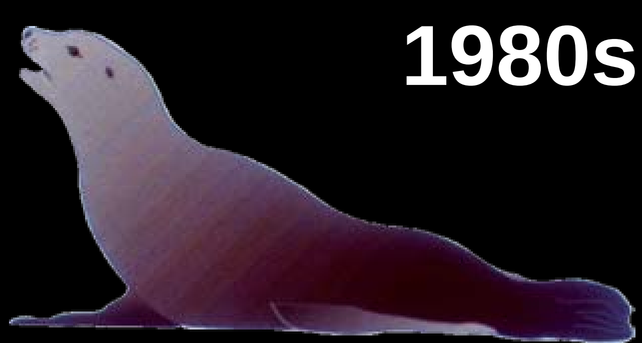
Marine Mammal Research Unit
Fisheries Centre, UBC

4 Clues

?

Body Size





Calkins *et al*. 1998. Mar. Mamm. Sci. 12: 232-244.

Birth Rates

- 30-40% failures
- Pregnancy rates declined among lactating females during 1980s

Pitcher *et al*. 1998. Can. J. Zool. 76: 2075-2083.

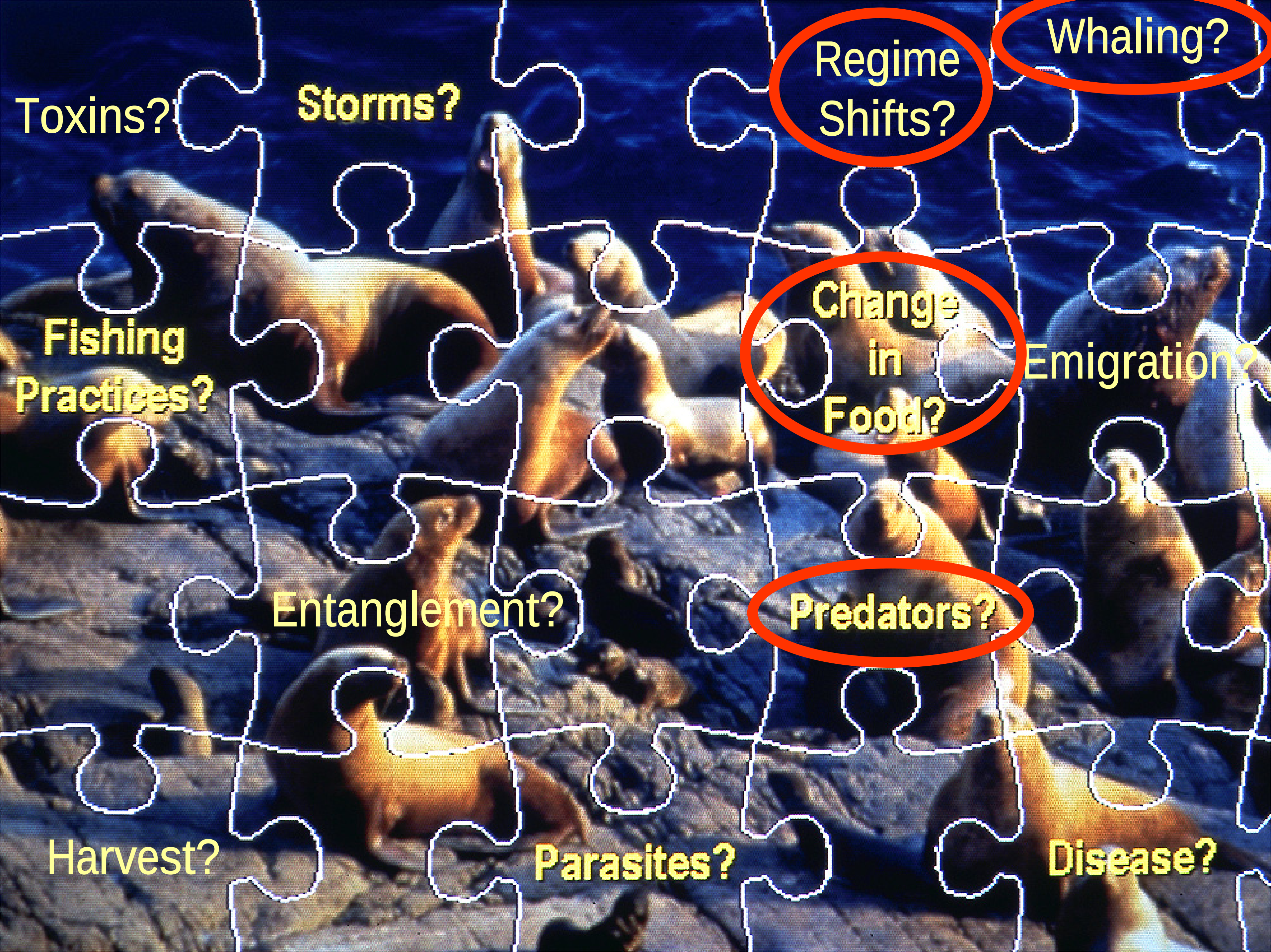
Juvenile Survival

York. 1994. Mar. Mamm. Sci. 10: 38-51.

Diet

	Gadids	Flatfish	Pelagics
1990-93	85%	13%	18%
1985-86	60%	5%	20%
1976-78	32%	0%	61%
1950-60s	few	none	mostly

from Merrick *et al.* 1997 Can. J. Fish. Aquat. Sci. 54: 1342-1348.
Alverson 1992 Rev. Aquat. Sci. 6: 206-254.


Toxins?
Storms?
Regime Shifts?
Whaling?
Fishing Practices?
Change in Food?
Emigration?
Entanglement?
Predators?
Harvest?
Parasites?
Disease?

Over-fishing

Nutritional Stress?

Over-fishing

- Loughlin & Merrick (1988)
- Trites & Larkin (1992)
- Ferrero and Fritz (1994)
- Sampson (1996)
- Hennen (2004, 2006)
- Dillingham *et al*. (2006)

Over-fishing

- Acute Nutritional Stress (starvation)
- No global stock reduction
- Localized depletion?

Trites & Donnelly. 2003.
***Mammal Review* 33: 3-28.**

Over-fishing
Abundance

Over-Abundance

- “junk food” hypothesis
- too many low energy prey (cod, pollock, etc.)
- not enough fatty fish (sandlance, herring)
- Chronic Nutritional Stress (poor health)

Trites & Donnelly. 2003.
Mammal Review 33: 3-28.

Field Studies

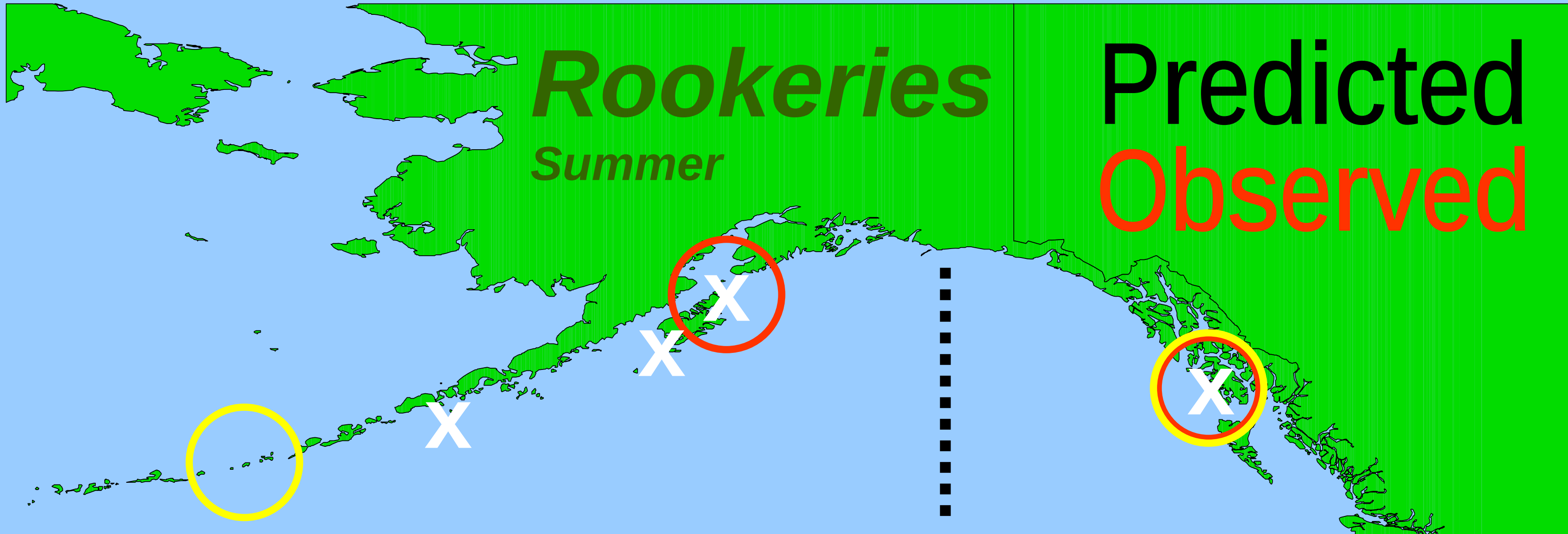
BC & SE Alaska Cruises

Brand Resights

Scat Collecting

Behavioral Observations

Foraging Ecology



	Declining	Increasing
Feeding Trips	Long	Short
telemetry	**7.5 h**	**39.1 h**
first ingestion	**0.9 h**	**4.7 h**
behavior	shorter	longer
Pup Weights	Light	Heavy
	Heavy	**Light**

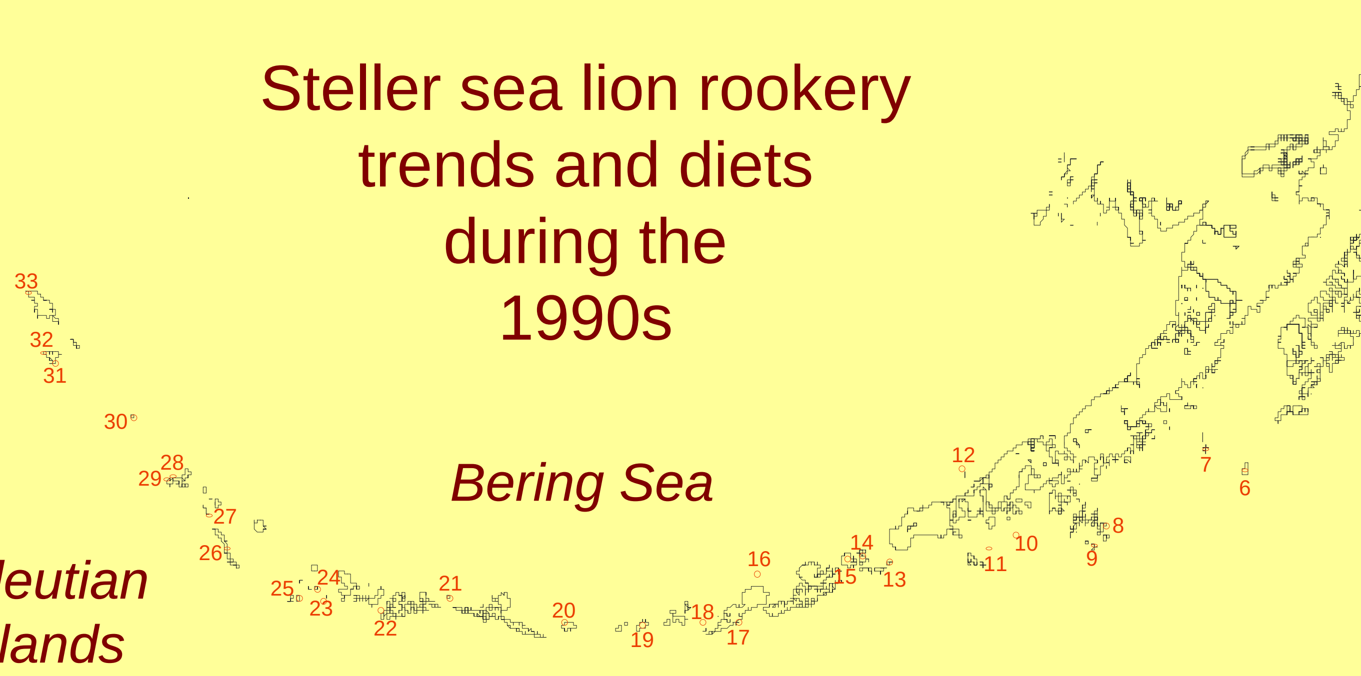
Sources: Andrews *et al*. Unpub. Data.; Milette & Trites 2003. Can. J. Zool. 81:340-348; Merrick *et al*. 1995. Fish. Bull. 93: 735-758.

Preferred Species

+ sculpins

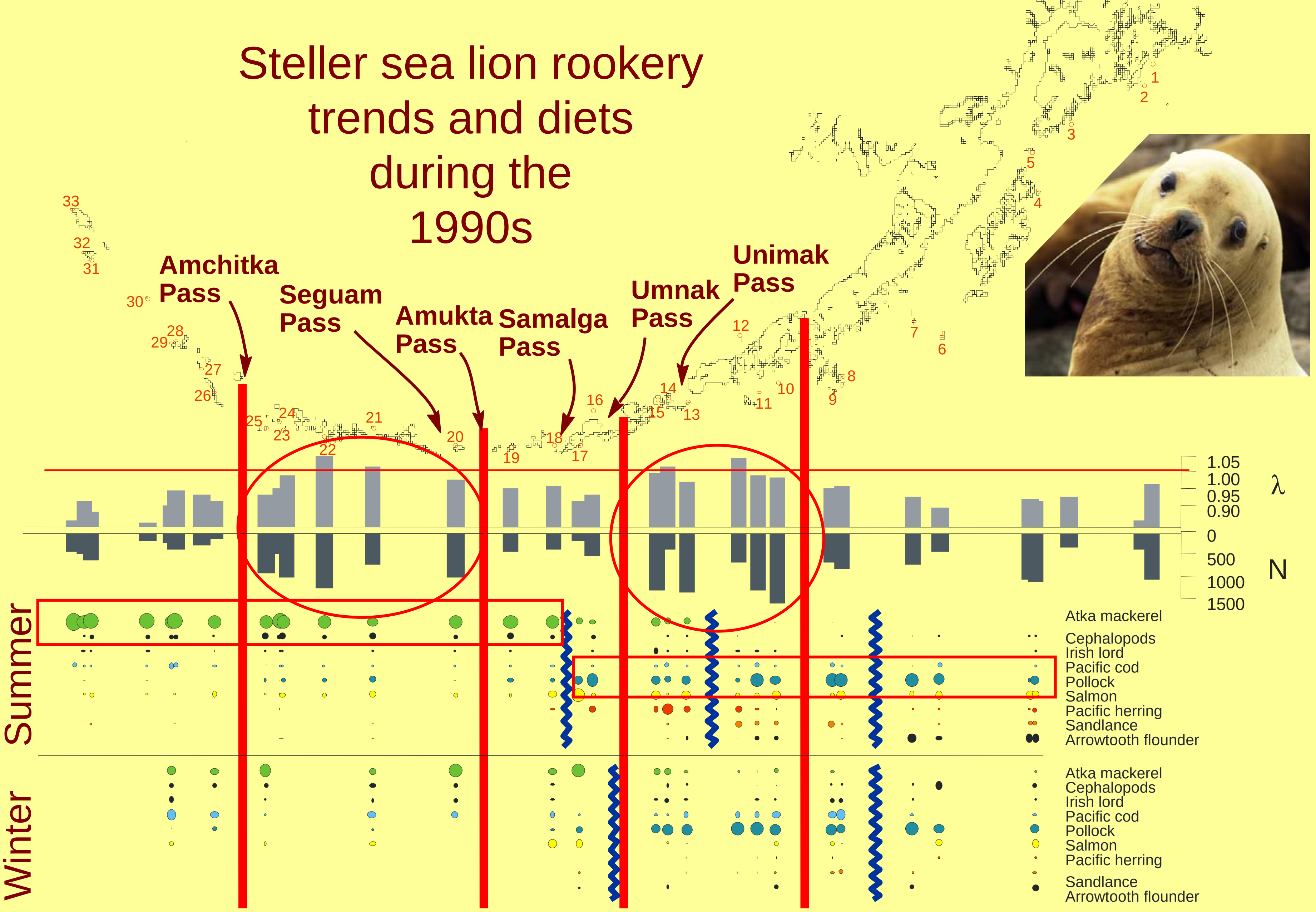
herring, sandlance, capelin, smelts, salmon, flatfish, cod, pollock, rockfish, Atka mackerel, octopus, squid

Steller sea lion rookery trends and diets during the 1990s



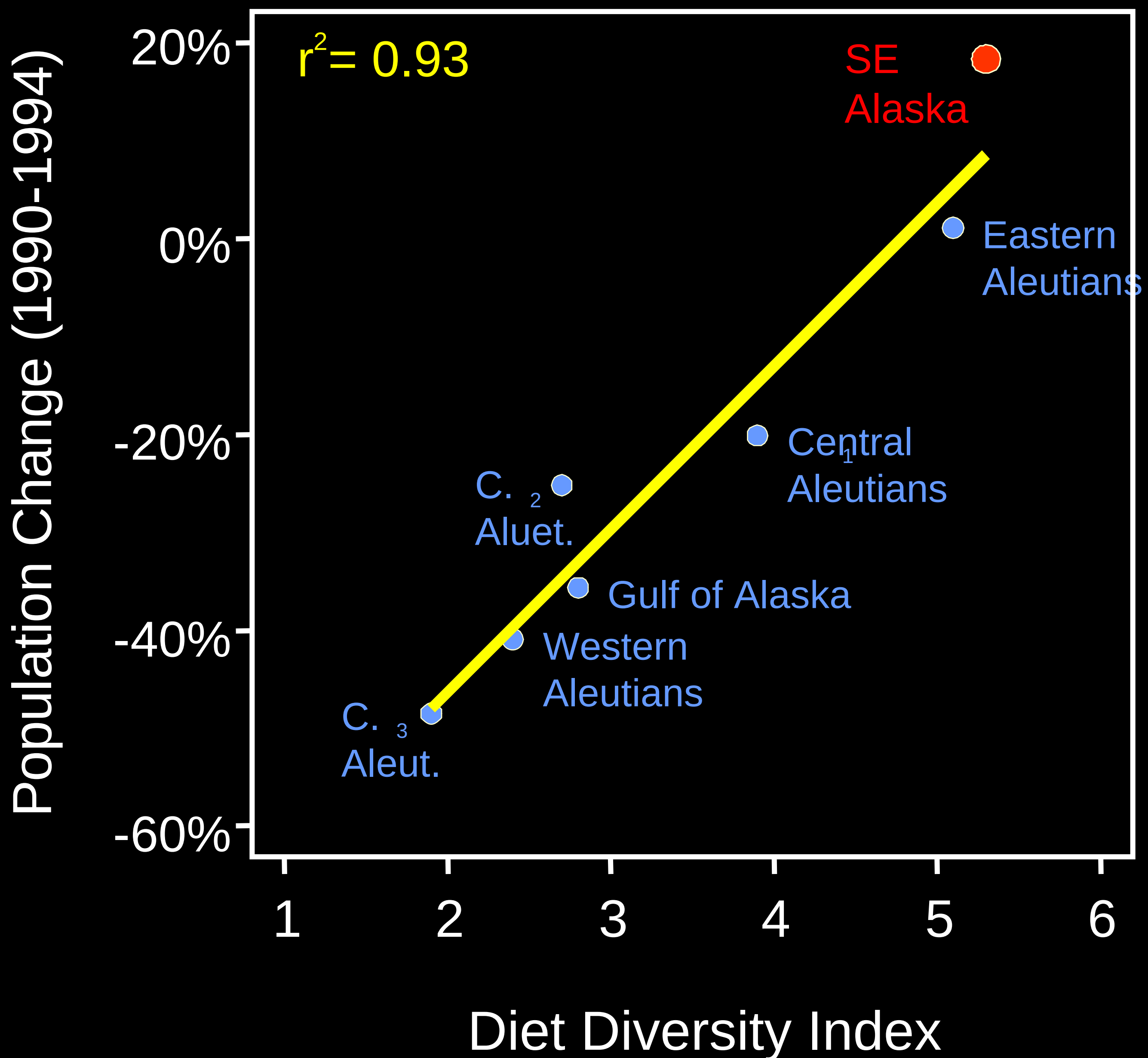
Trites et al. (*in press*). Bottom-up forcing and the decline of Steller sea lions in Alaska: assessing the ocean climate hypothesis. *Fisheries Oceanography*

Steller sea lion rookery trends and diets during the 1990s



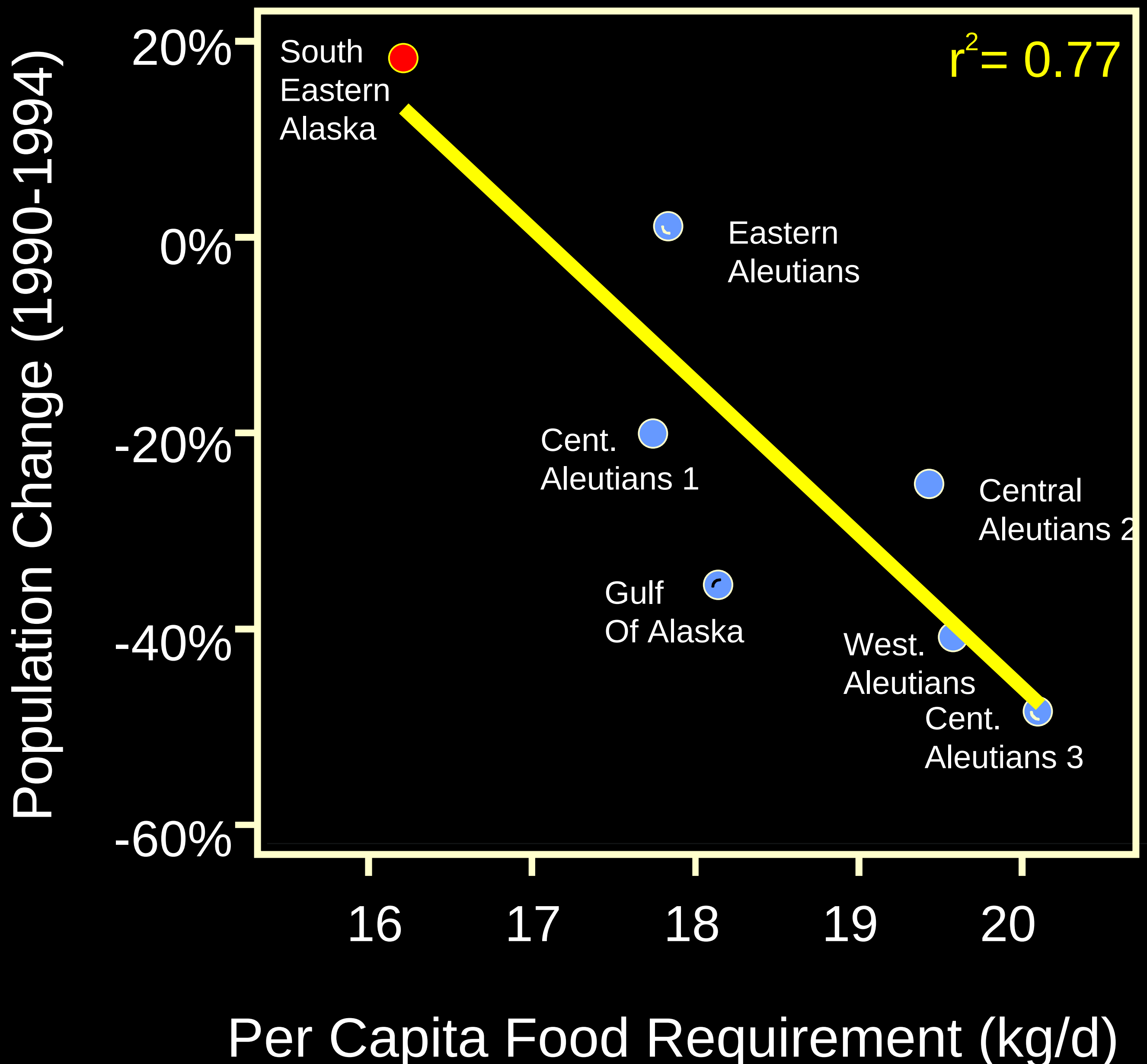
Trites et al. (*in press*). Bottom-up forcing and the decline of Steller sea lions in Alaska: assessing the ocean climate hypothesis. *Fisheries Oceanography*

Diet Diversity



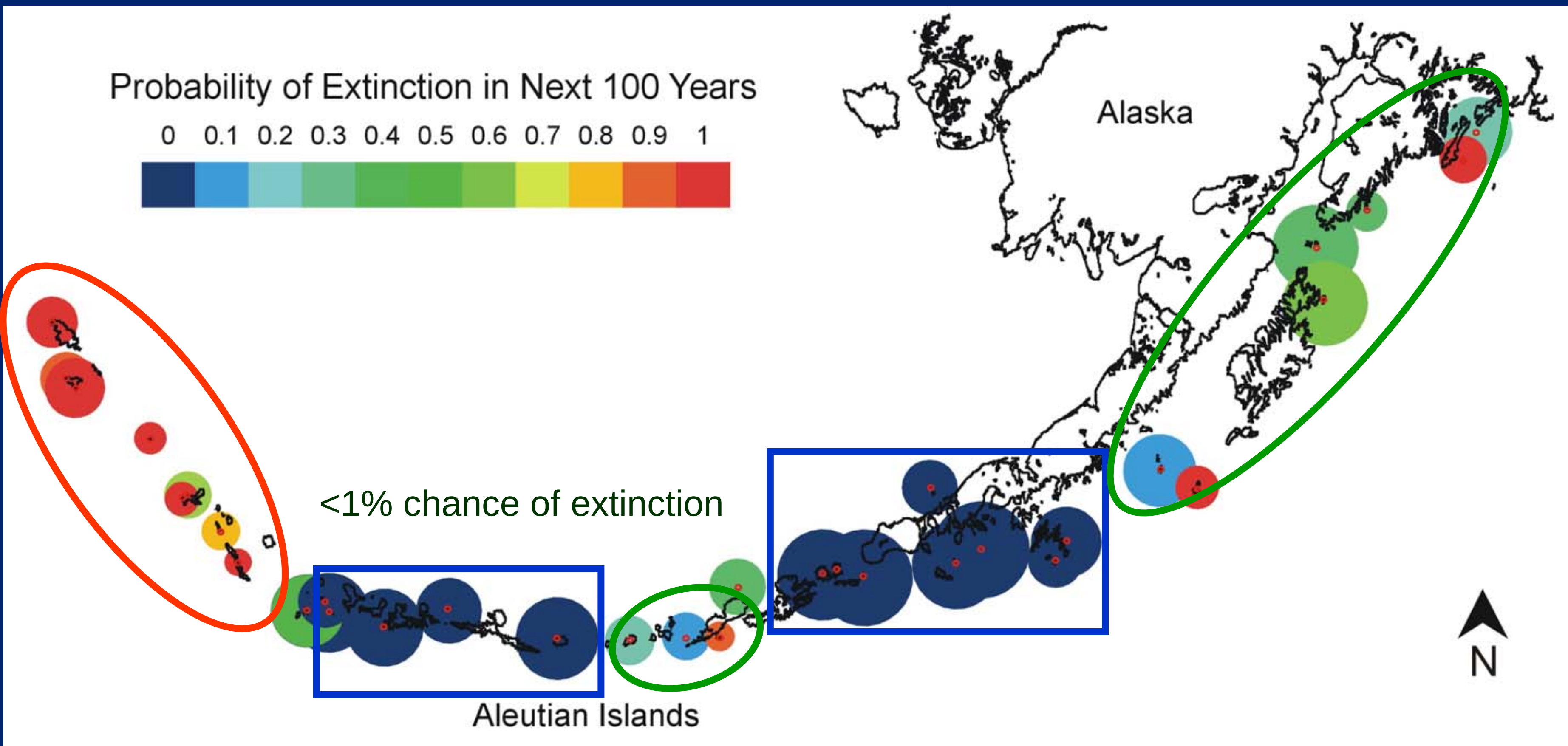
Merrick et al. 1997

Food Required

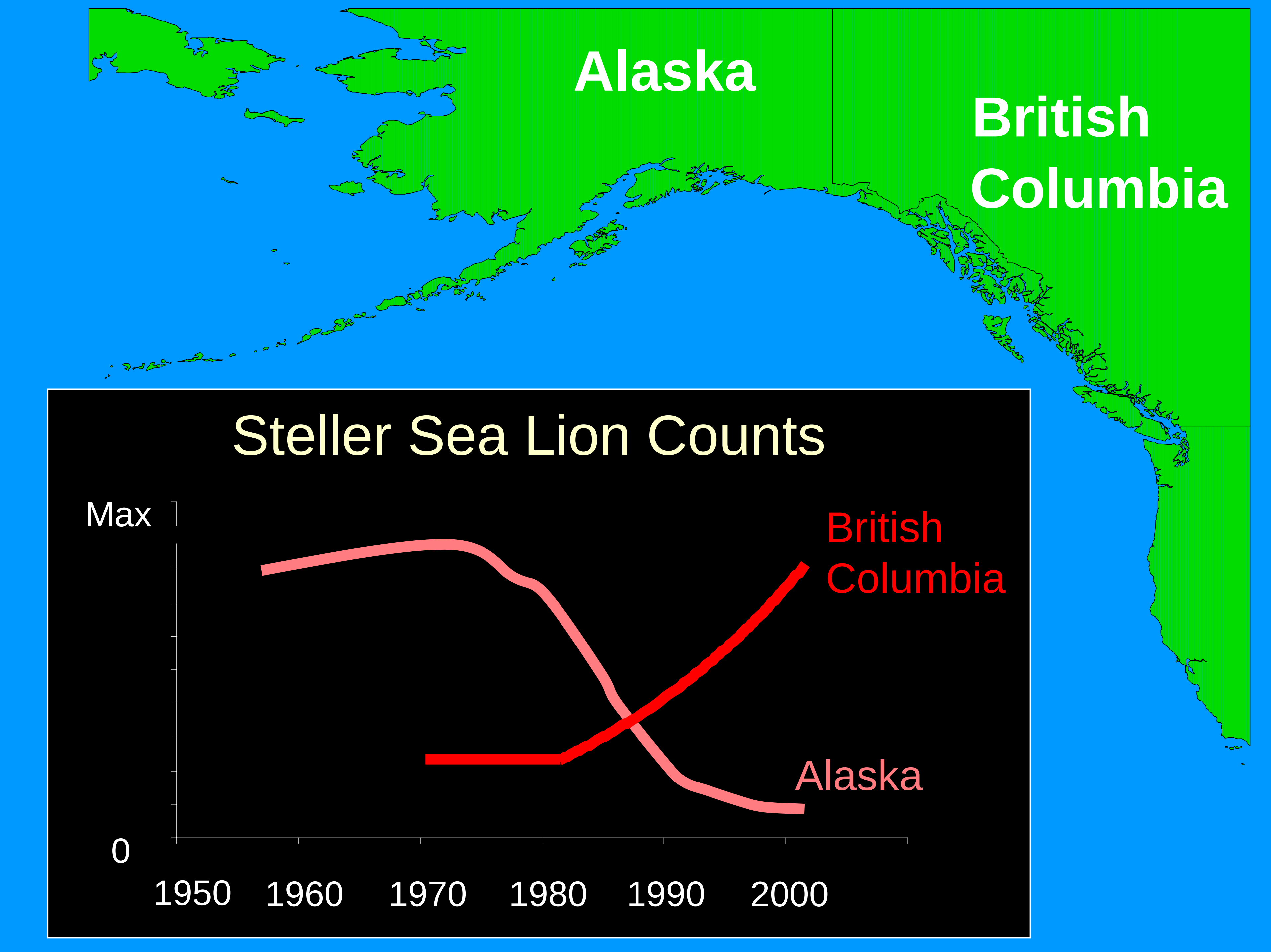


Winship & Trites 2003. Fish. Bull. 101:147-167.

Regional Population Trends

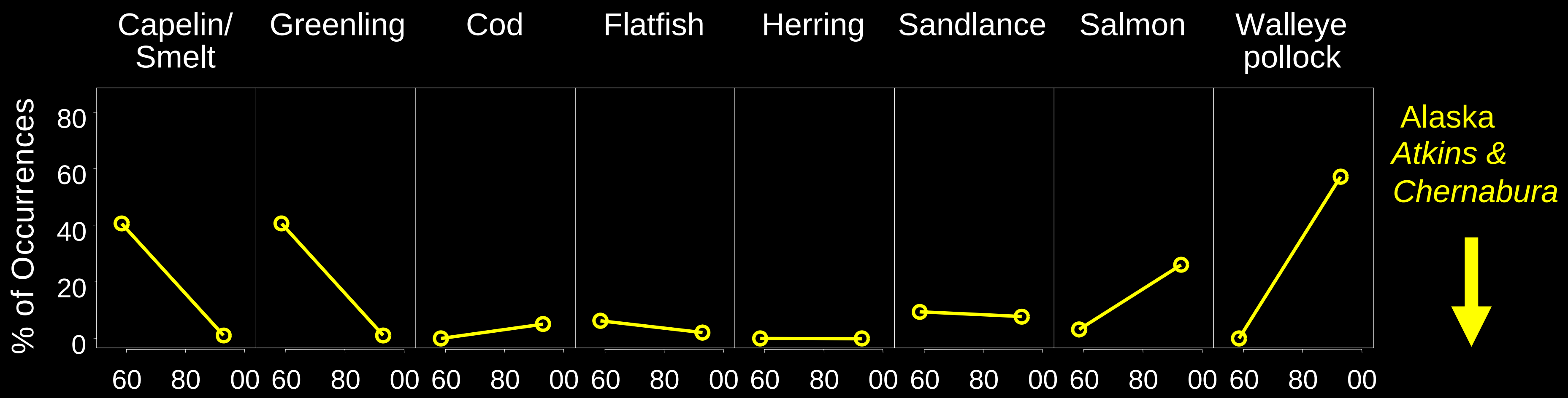


Winship & Trites (2006) Mar. Mamm. Sci. 22: 124-155



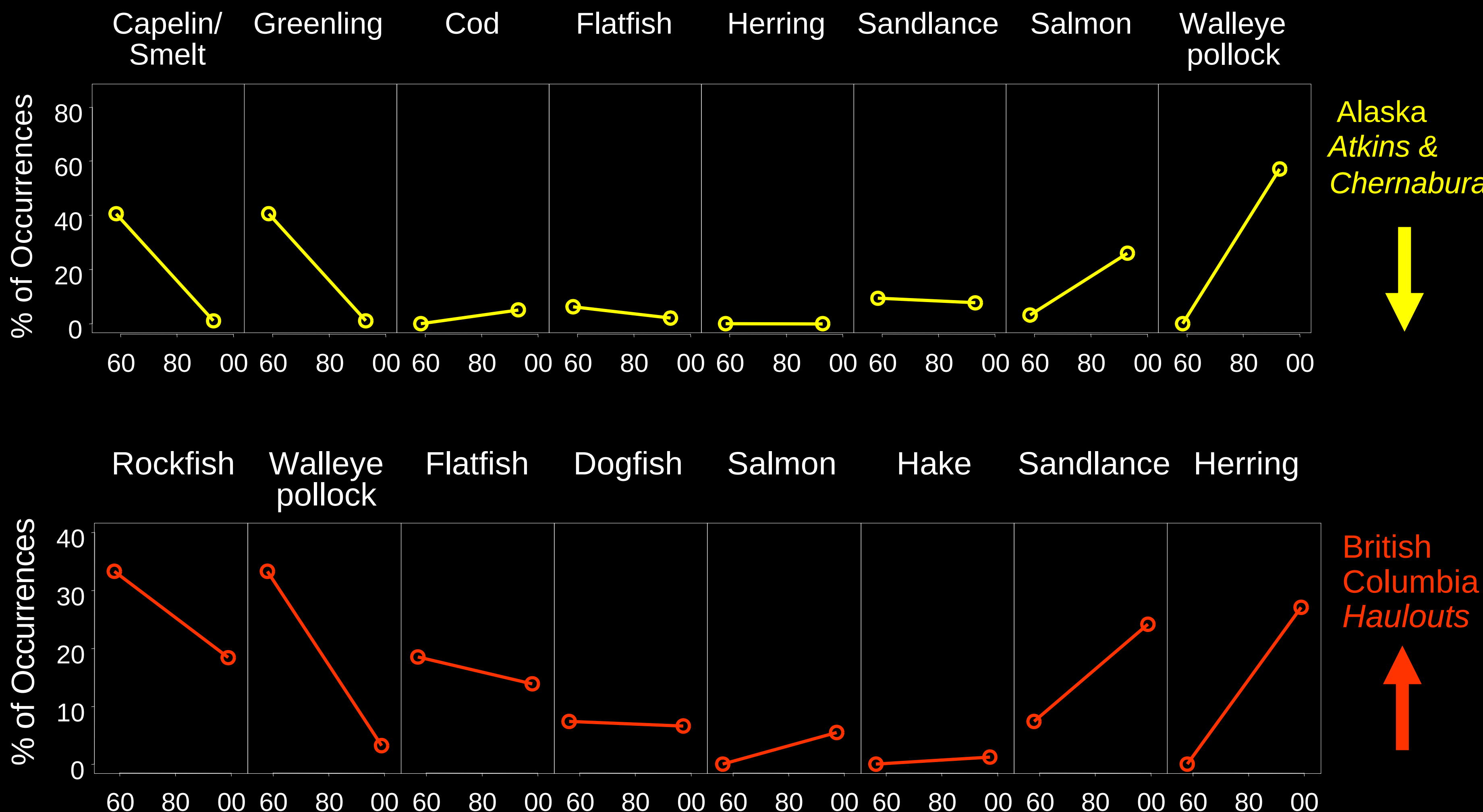
Alaska
British Columbia
Steller Sea Lion Counts
Max
0
1950
1960
1970
1980
1990
2000
British Columbia
Alaska

Dietary Shifts



Trites et al. (*in prep*). A review of Steller sea lion diets and the evidence for dietary change in the North Pacific.

Dietary Shifts



Trites et al. (*in prep*). A review of Steller sea lion diets and the evidence for dietary change in the North Pacific.

Gulf of Alaska trawl catches

1960’s 1970’s 1980’s

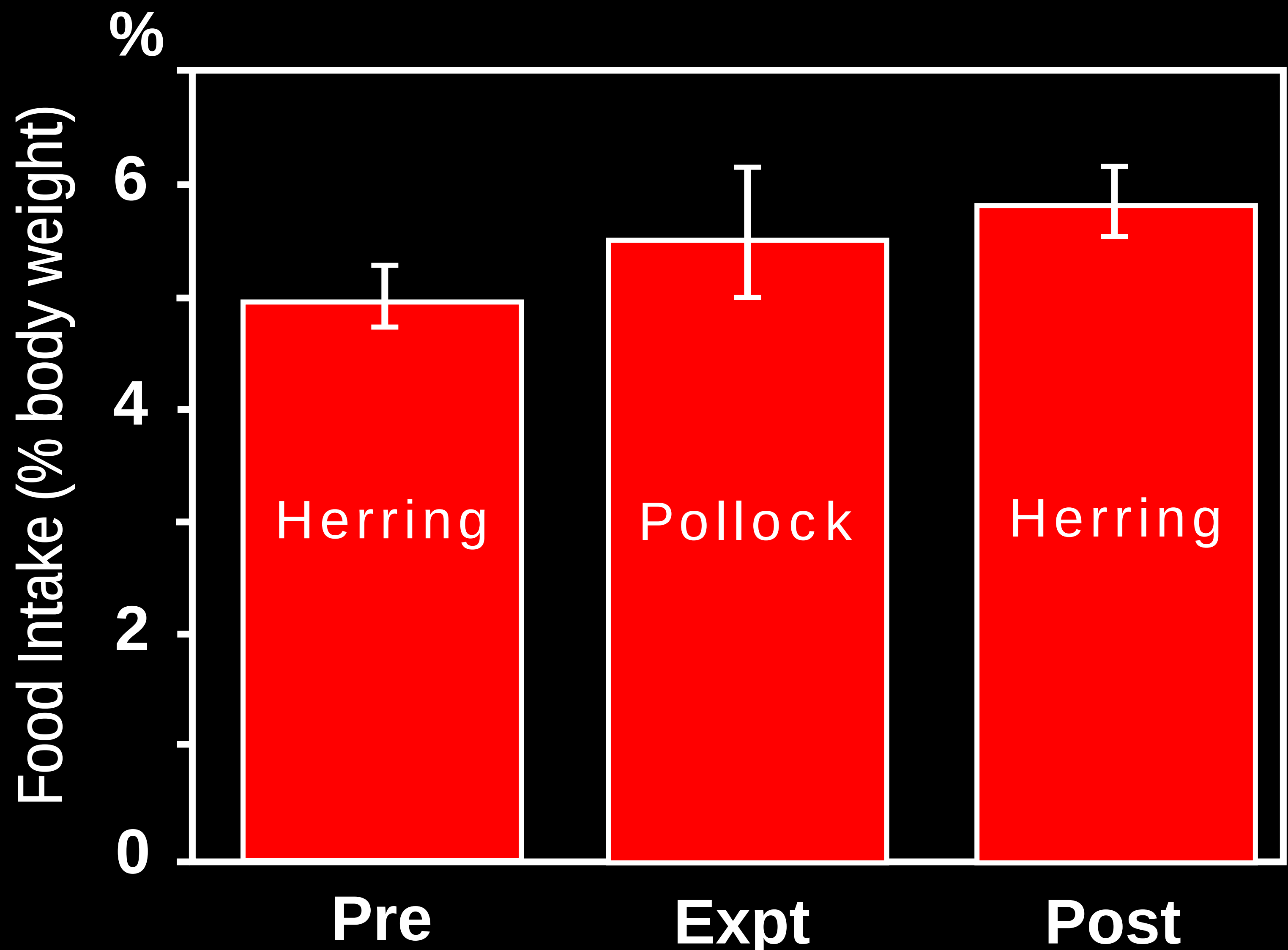
Traditional Knowledge

"Cod were almost unknown until the sea lion herds diminished in 1873; now they are very common. The Atka mackerel was unknown on Attu before 1875, when it appeared unexpectedly. The natives say that it drove the sea lions away."

Weissinger (1961)

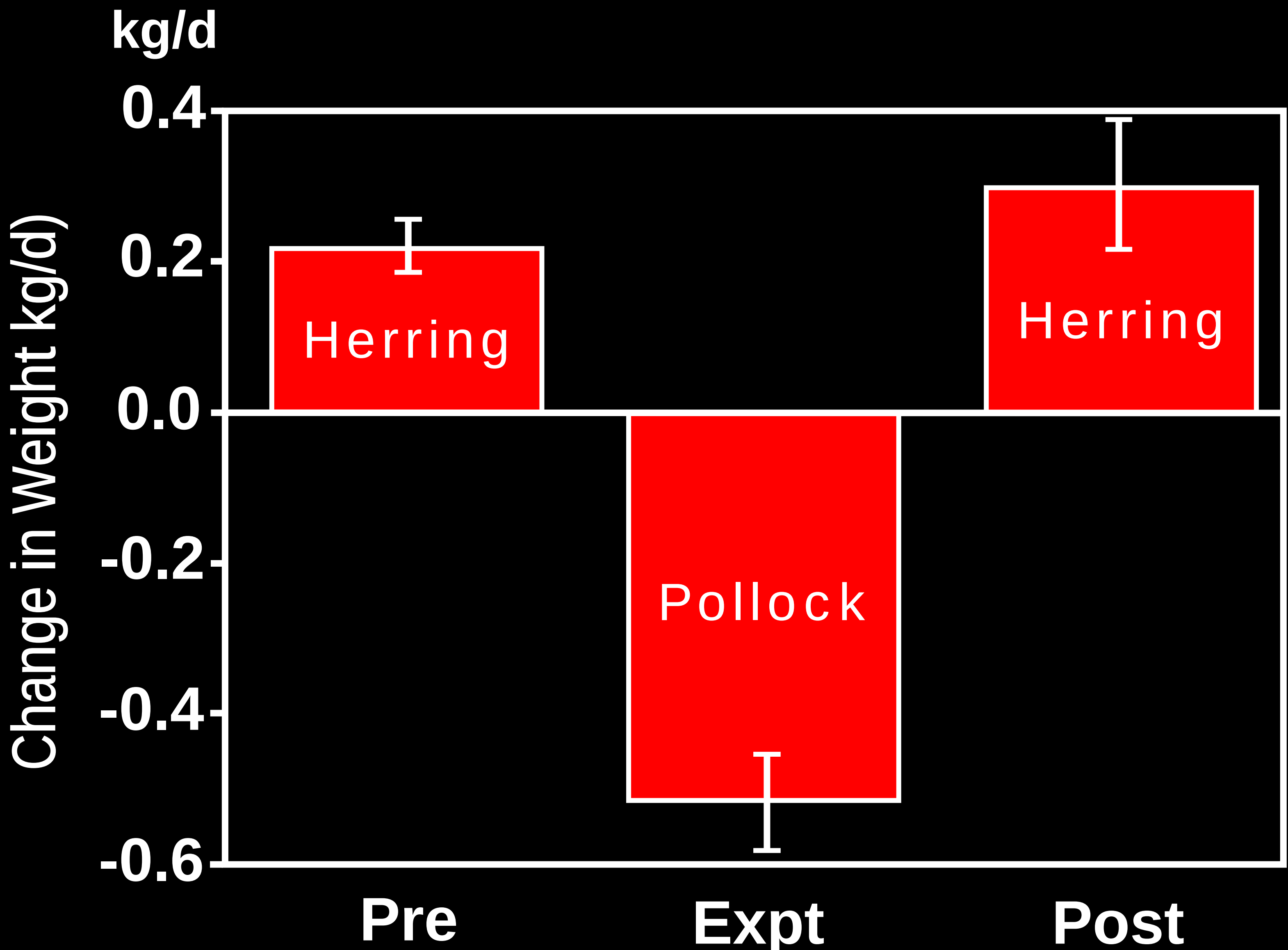
Captive Studies

Percent Consumption



from Rosen & Trites 2000a Can. J. Zool. 78:1243-1258

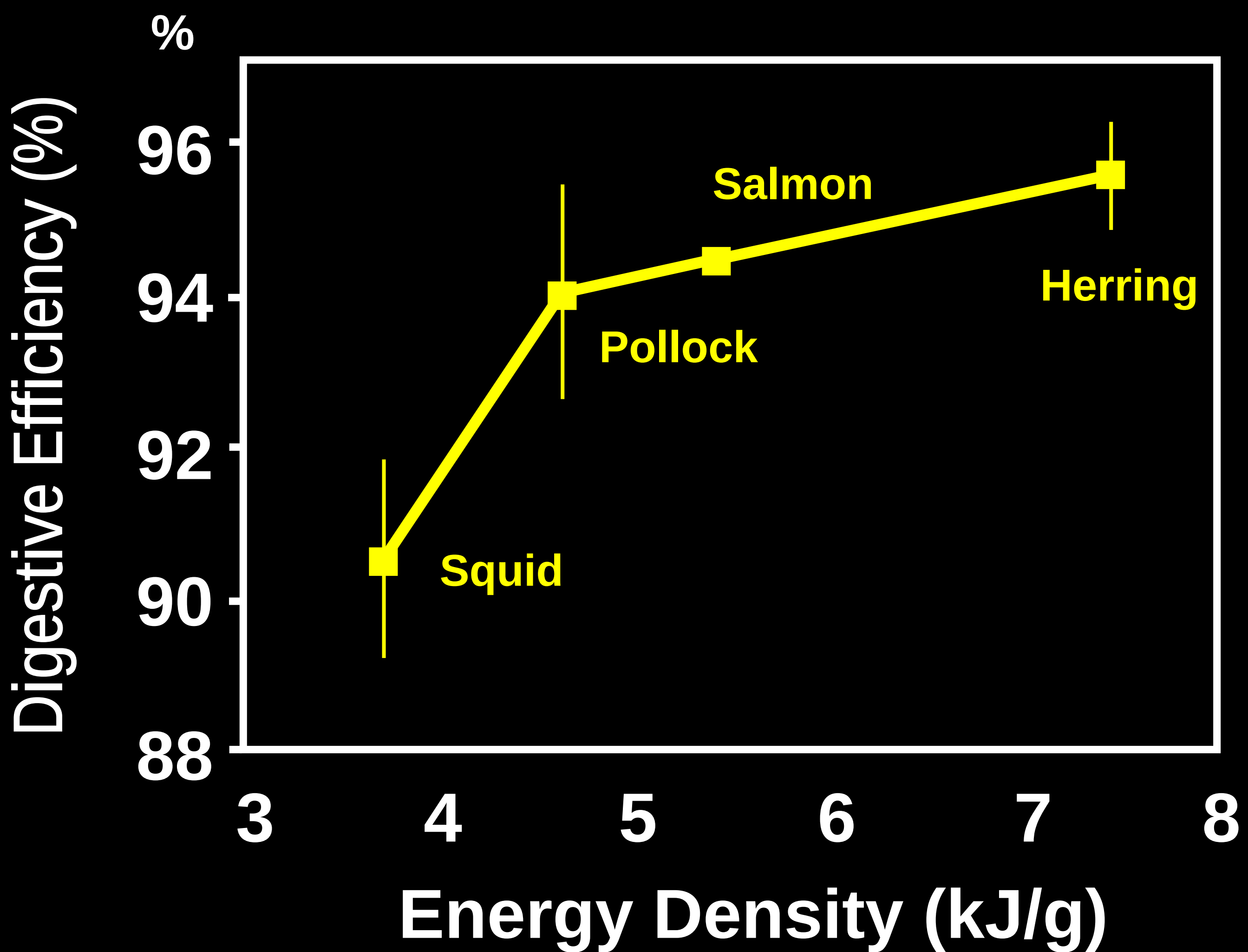
Change in Sea Lion Weight



from Rosen & Trites 2000a Can. J. Zool. 78:1243-1258

Digestive Efficiency

Digestive Efficiency

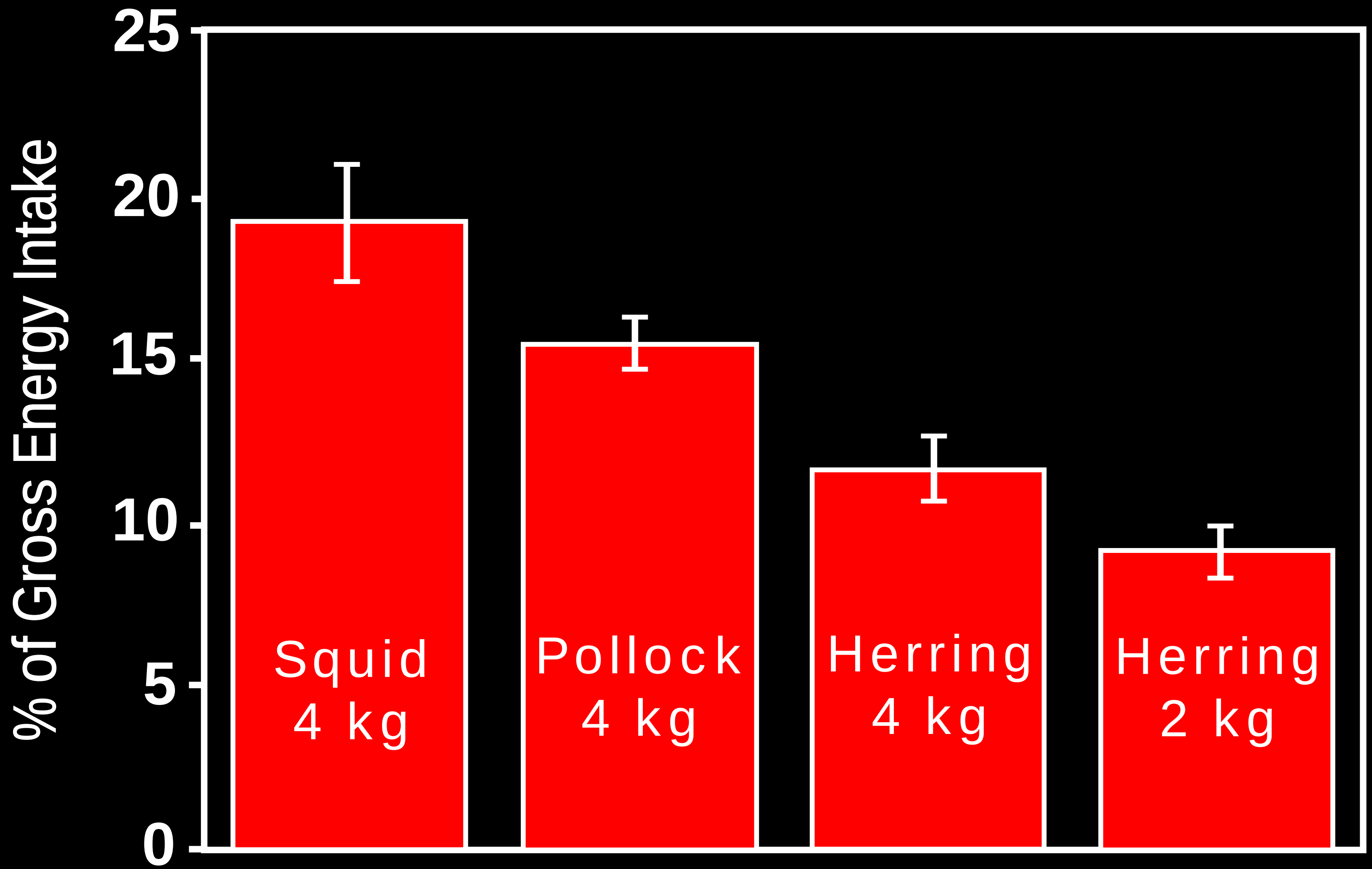


from Rosen & Trites 2000b Can. J. Zool. 78:1-6234-239

Heat Increment of Feeding

Metabolism

Heat Increment of Feeding



Rosen & Trites 1997 Comp. Biochem. Phys. 118A: 877-881.

Captive Feeding Trials

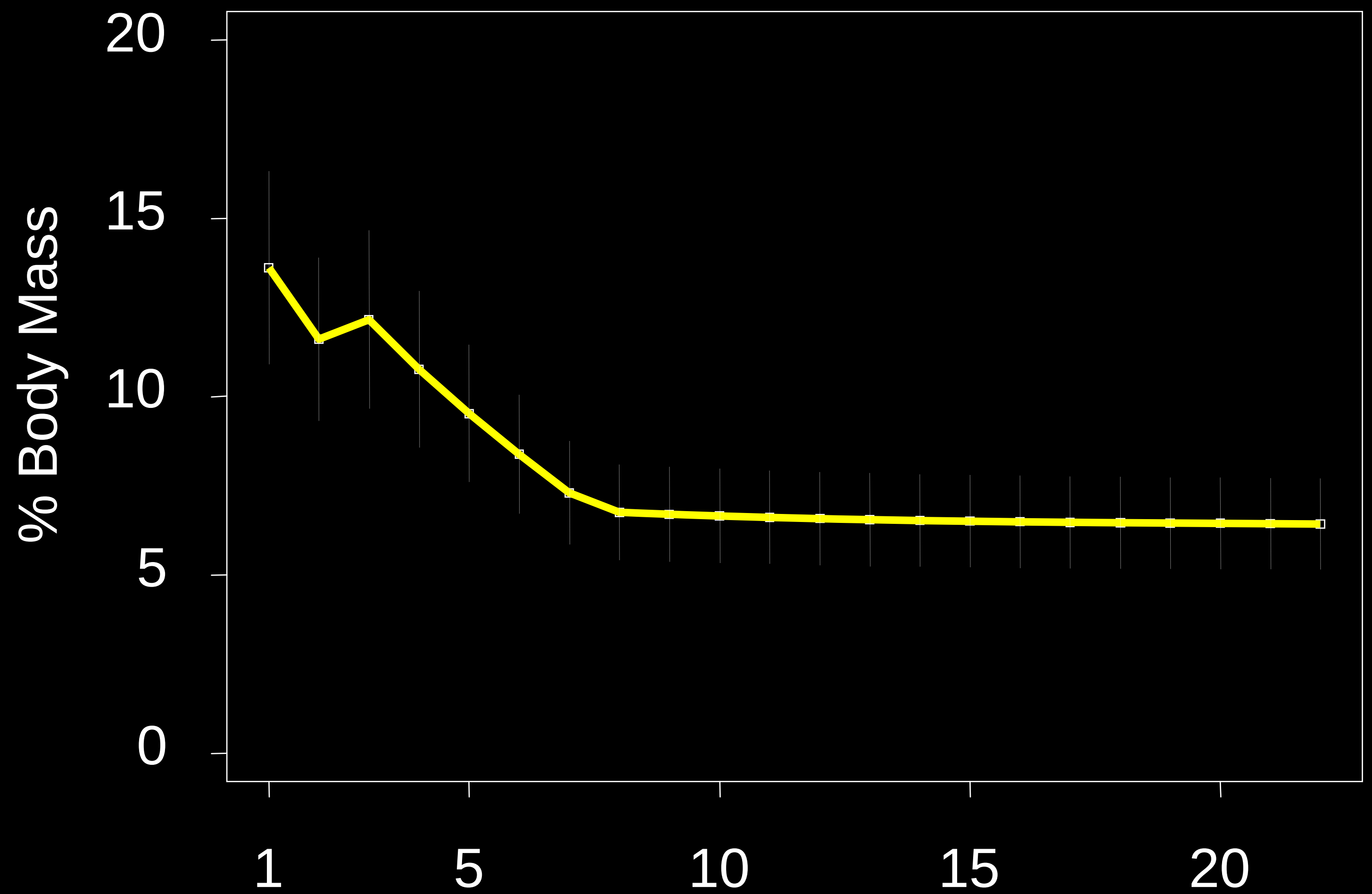
- Require 35-80% more pollock than herring

from Rosen & Trites 2000a Can. J. Zool. 78:1243-1258

Mathematical Models

Mean Daily Consumption

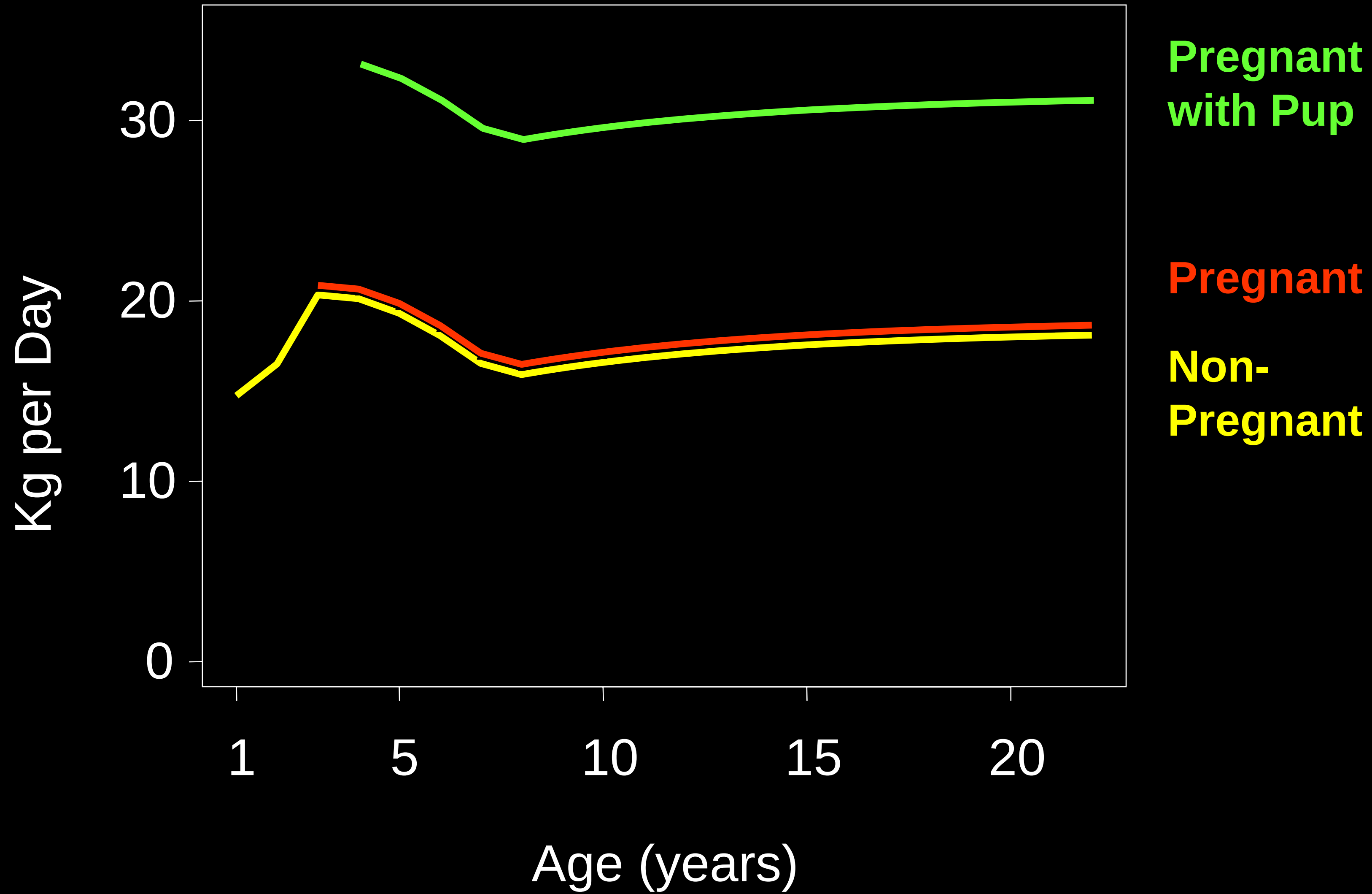
Non-pregnant females (±1SD)



Winship, Rosen & Trites 2002. Mar. Ecol. Prog. Ser. 229: 291-312

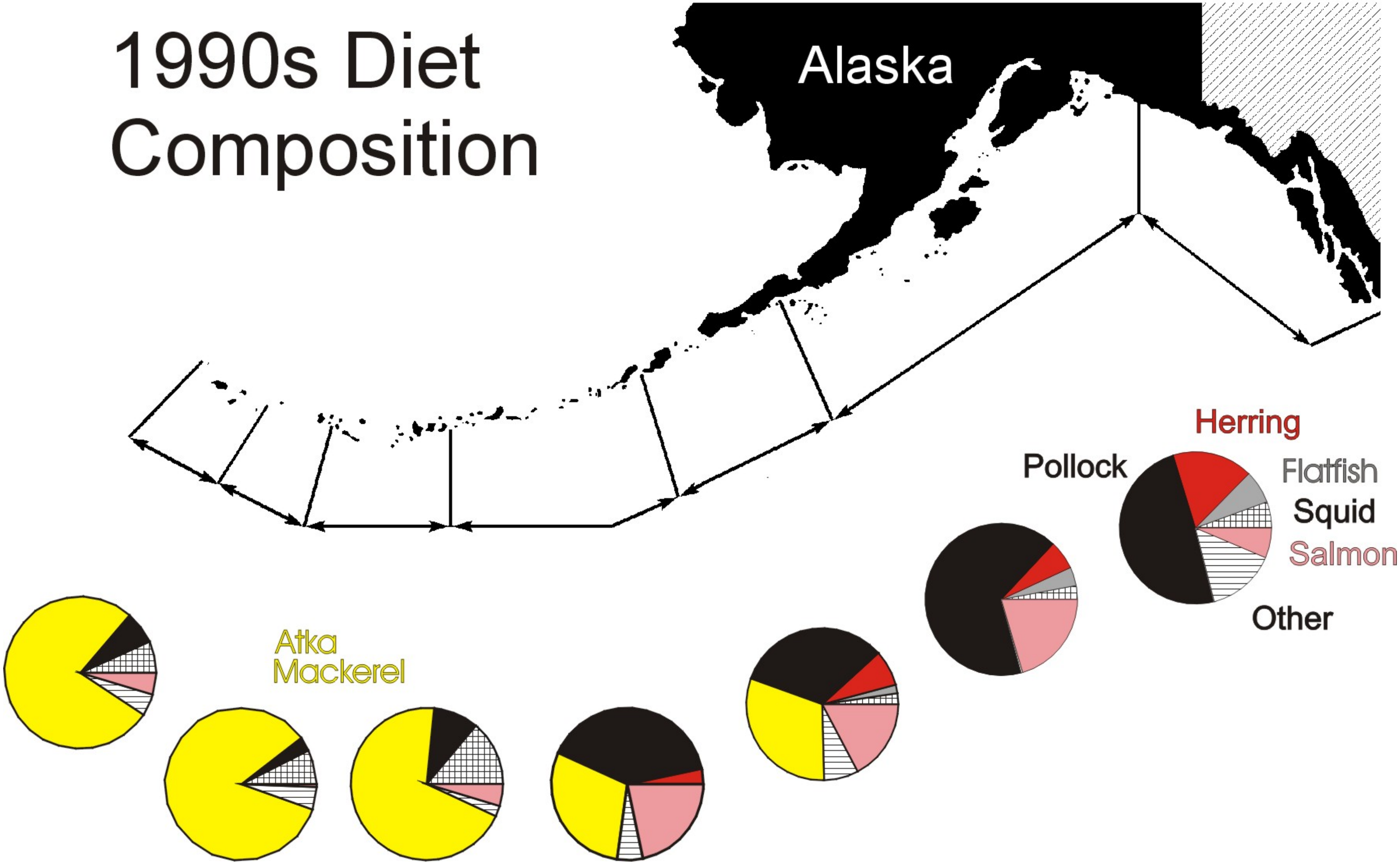
Mean Daily Consumption

Females



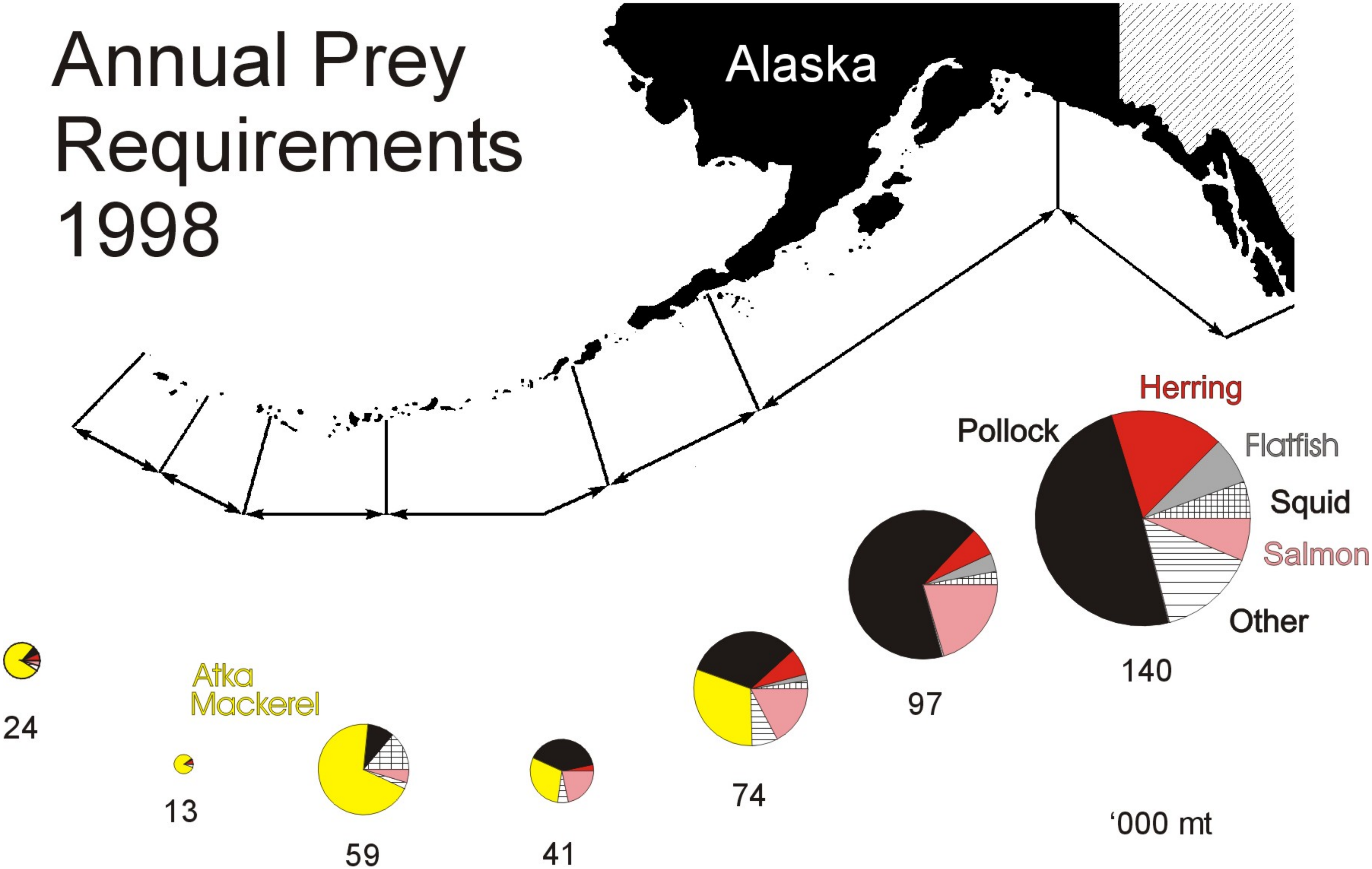
Winship, Rosen & Trites 2002. Mar. Ecol. Prog. Ser. 229: 291-312

1990s Diet Composition



Merrick et al. 1997; Trites et al 2006.

Annual Prey Requirements 1998



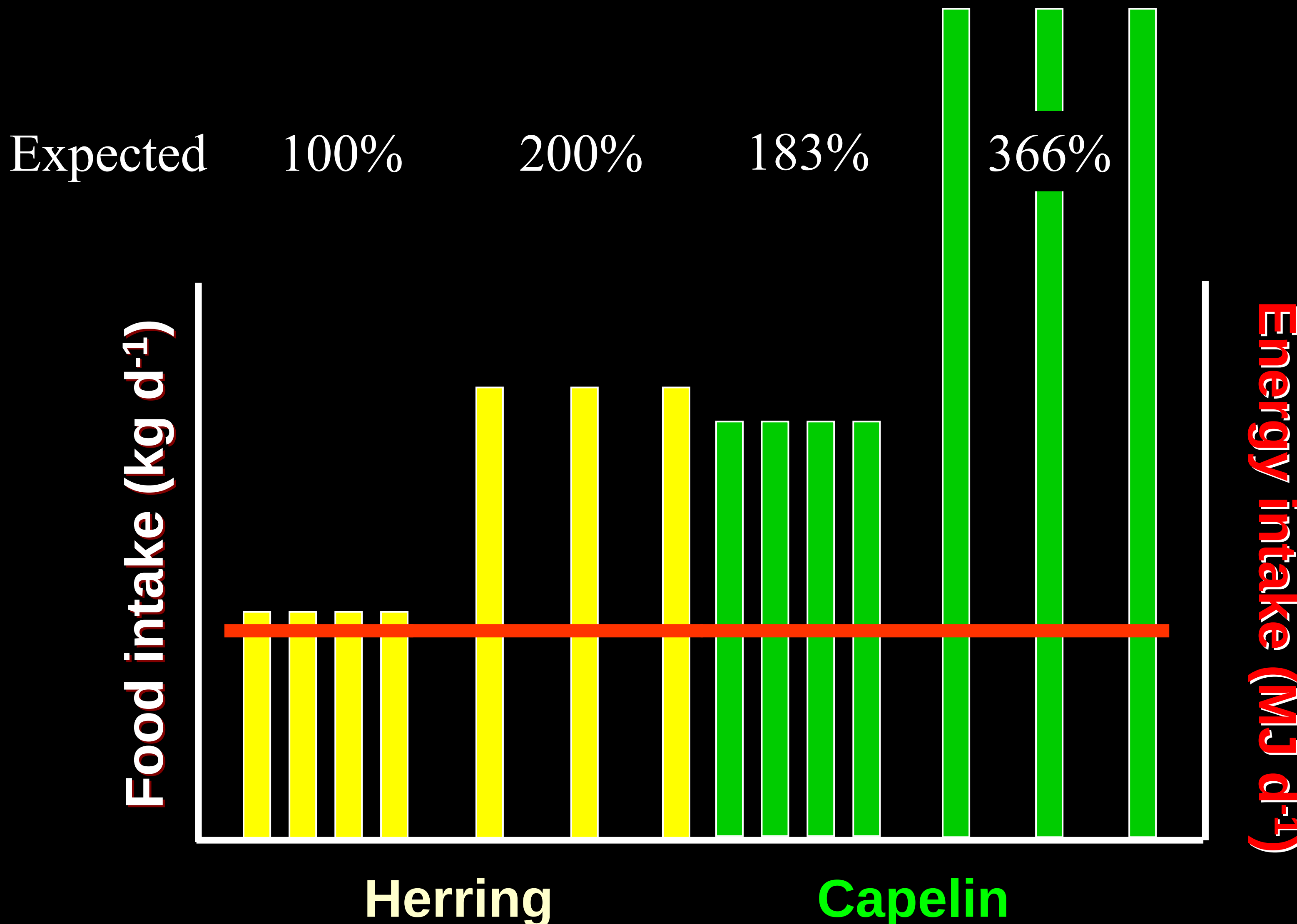
Winship & Trites 2003. Fish. Bull.. 101:147-167

Satiation Feeding Expt.

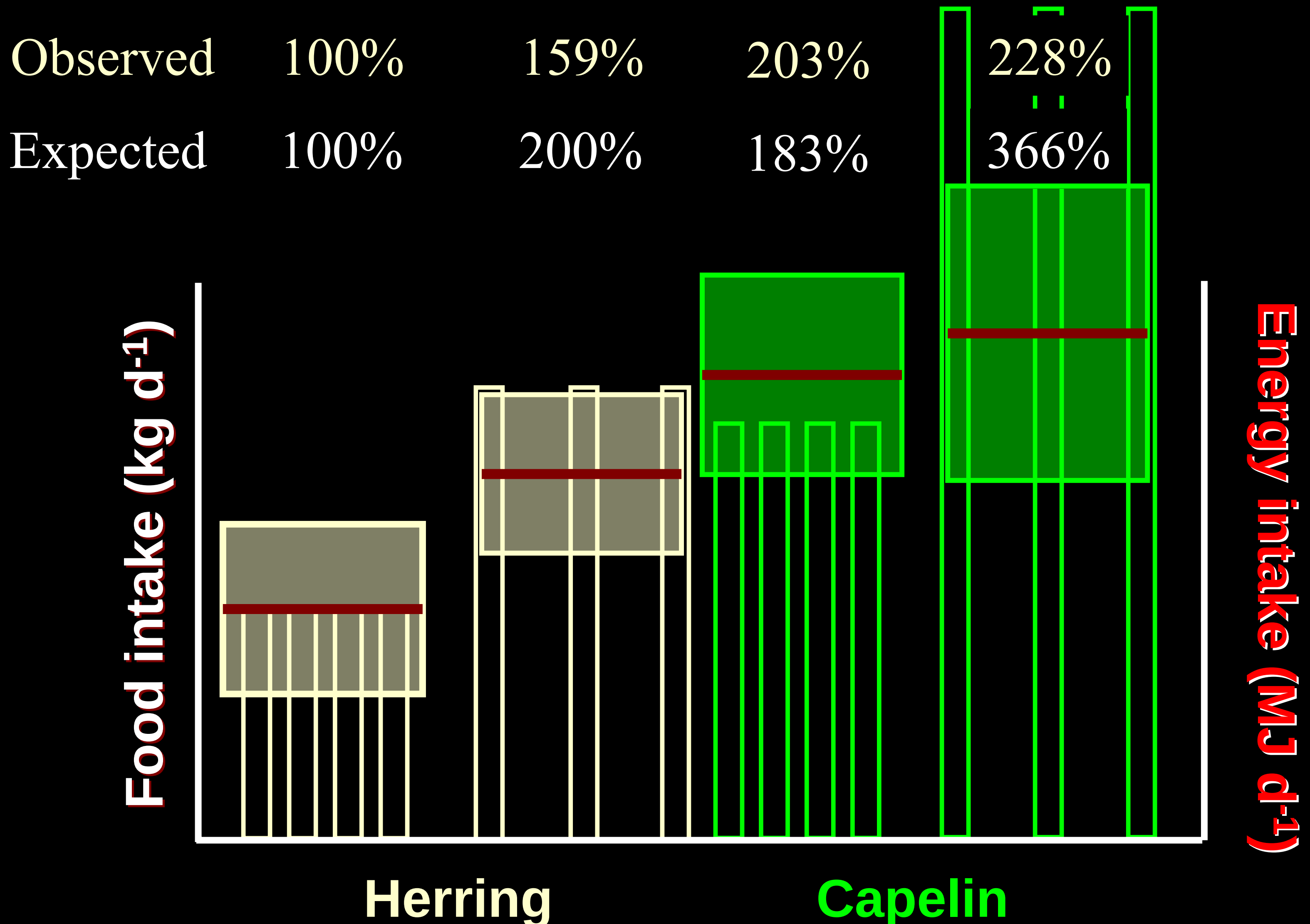
- How much food can a sea lion consume?
- How do they compensate for changes in quality?
- Four 2-yr females
  - Food: Herring (high E), Capelin (low E)
  - Availability: Daily or every other; 7 hr per day
  - Four times per year

Rosen & Trites 2004. Can. J. Zool. 82: 1061-1069

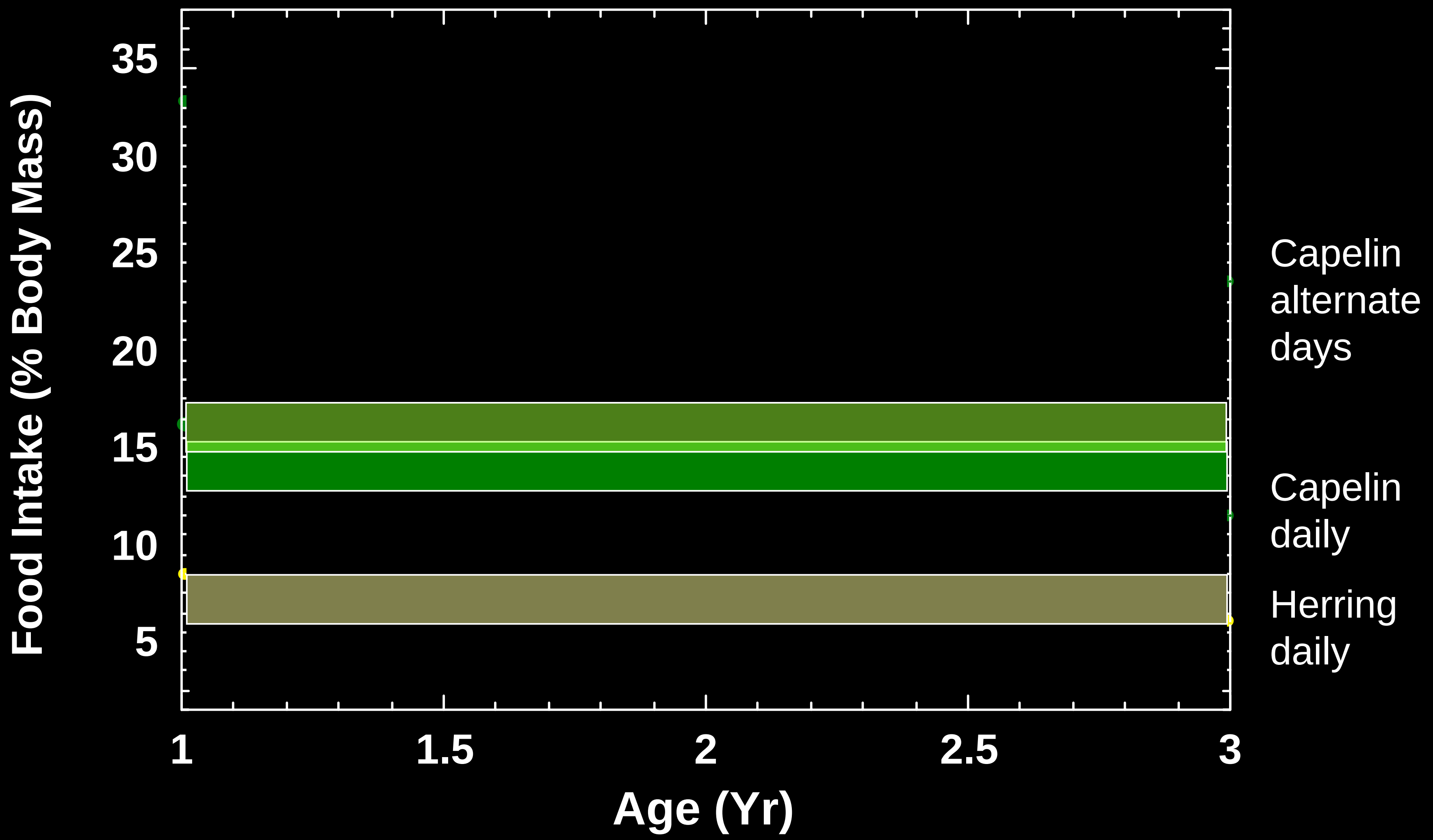
Satiation Feeding Expt.



Satiation Feeding Results



Satiation Feeding Results



Captive Studies

- Maximum consumption (16-18%)

Rosen & Trites 2004. Satiation and compensation for short-term changes in food quality and availability in young Steller sea lions (*Eumetopias jubatus*). Can. *J. Zool*. 82: 1061-1069

Juveniles

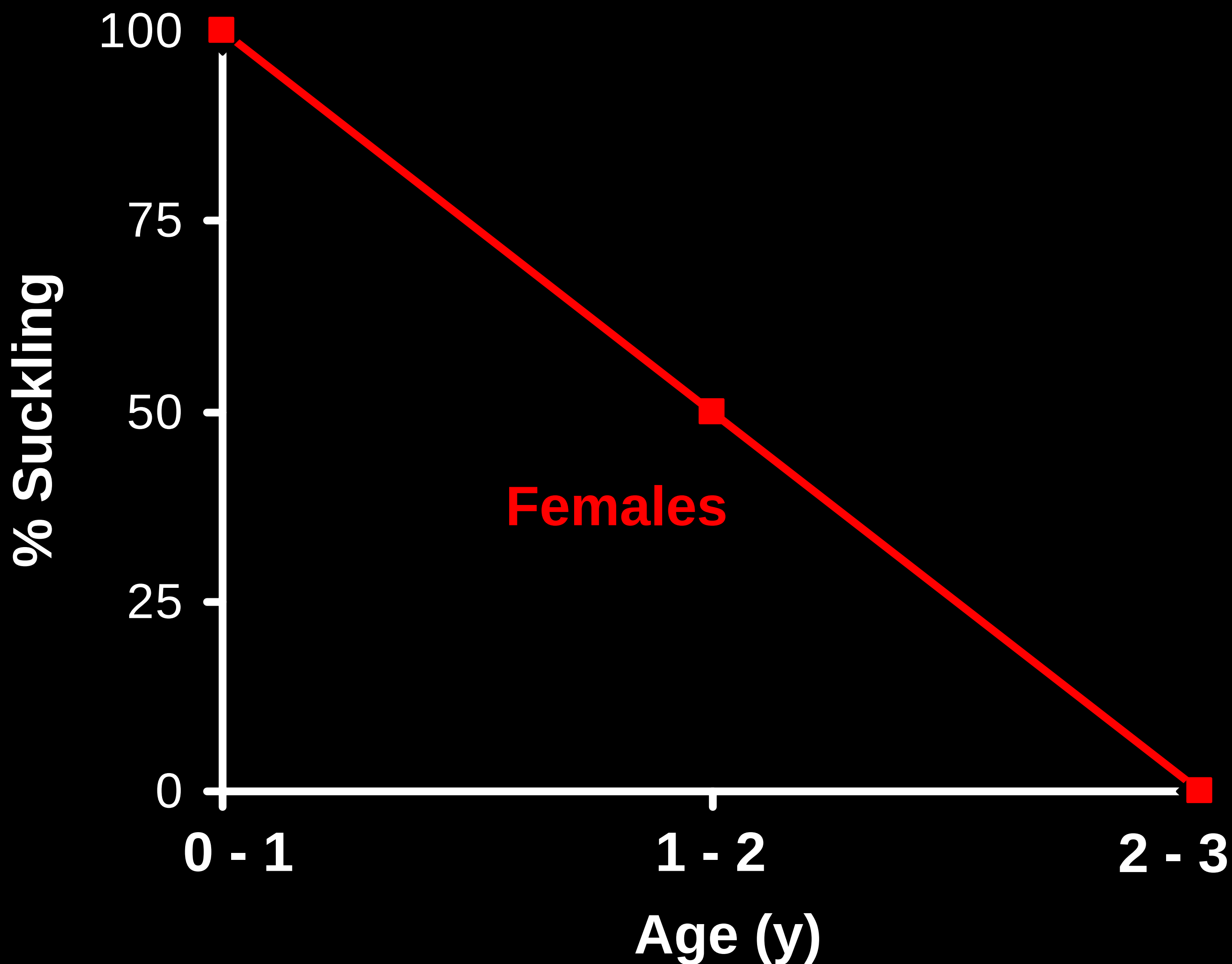
- Energetically living on the edge
- Low energy prey may lead to stunted growth, delayed age at first birth & increased risk of disease and predation

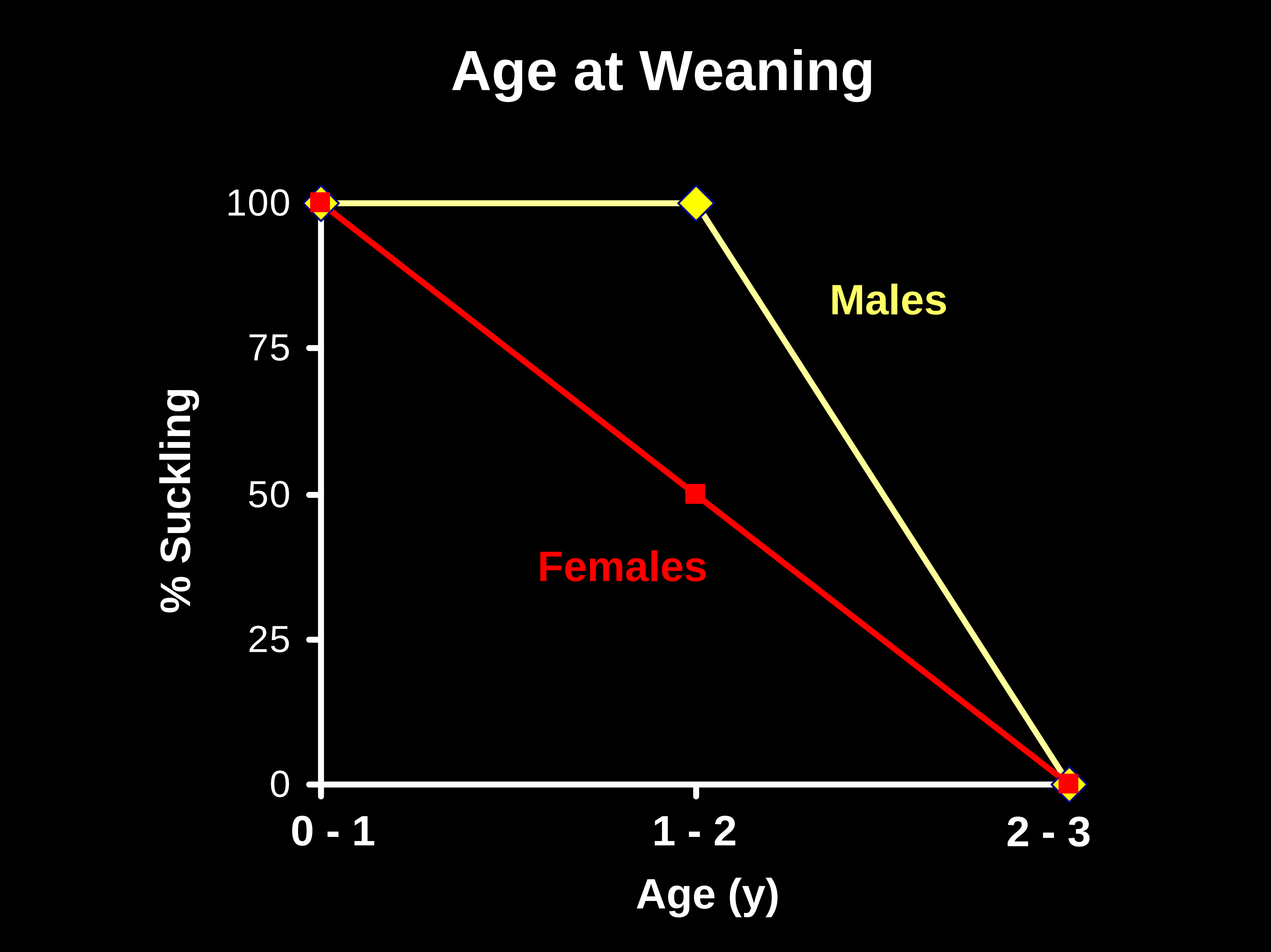
Timing of Weaning

Trites *et al*. (*2006*) Aquat. Mamm.

Weaning: 1, 2, or 3 y

Age at Weaning





Age at Weaning
100
75
50
25
0
% Suckling
Males
Females
0 - 1
1 - 2
2 - 3
Age (y)

Individuals can be negatively affected by changes in:

- **Quantity**
  - presence or absence of prey
  - Affects young & old
- **Quality**
  - low-energy versus high-energy prey
  - Affects young

Paleo-Perspective

- Productivity has changed in the past
- SSL have been more & less abundant
- *Today is a drop in the bucket of time*

Mashner *et al*. (*in* review).
Trites *et al*. (*in press*). Fish. Oceanog.

Ocean Climate Change

Bottom-up forcing and the decline of Steller sea lions in Alaska: assessing the ocean climate hypothesis

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[7]*University of Alaska Fairbanks, Fairbanks, AK, USA*
[8]*Georgia Institute of Technology, Atlanta, GA, USA*
[9]*Old Dominion University, Norfolk, VA, USA*
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[12]*University of Washington, Seattle, WA, USA*
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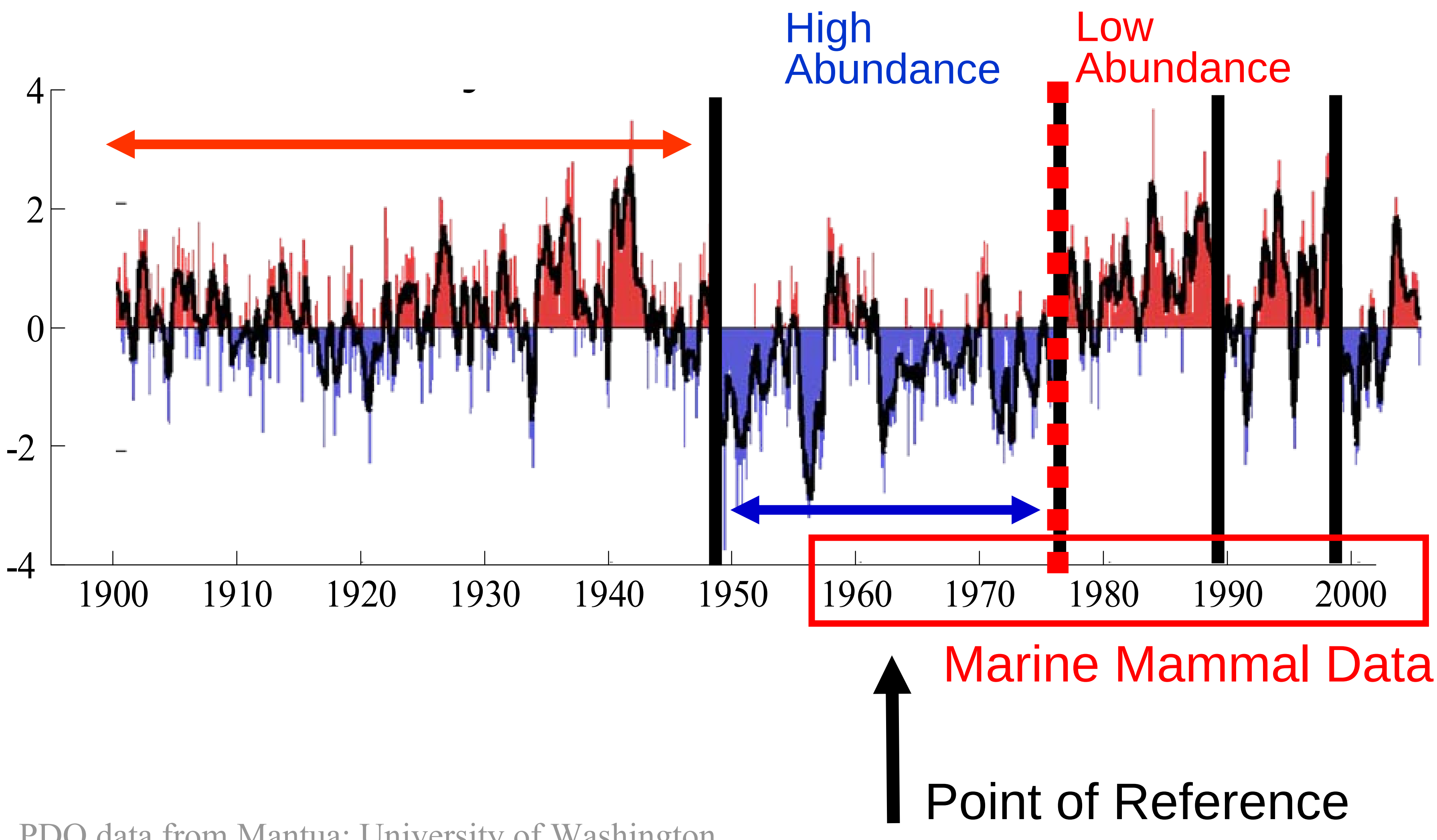
ABSTRACT

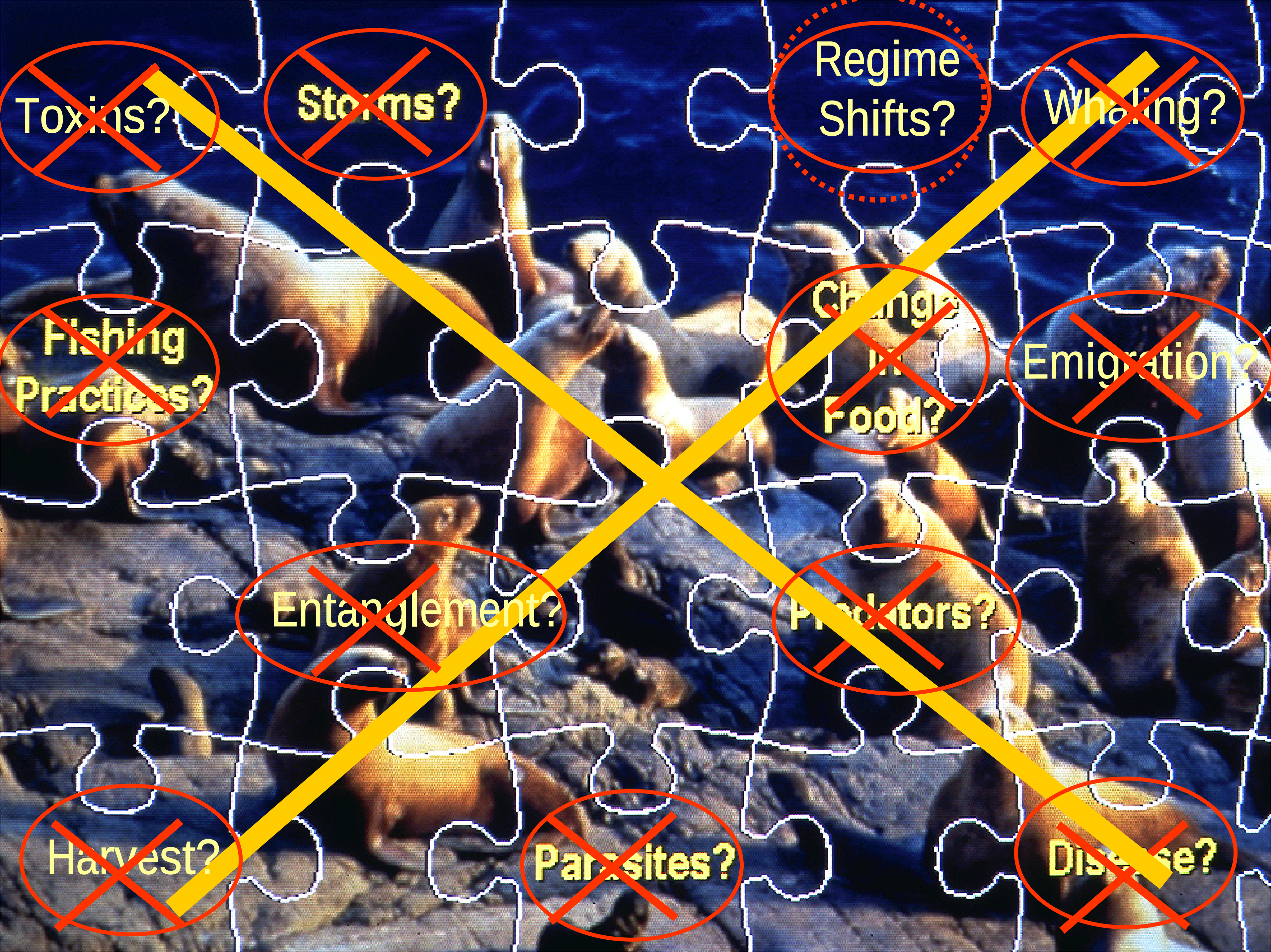
Declines of Steller sea lion (*Eumetopias jubatus*) populations in the Aleutian Islands and Gulf of Alaska could be a consequence of physical oceanographic changes associated with the 1976–77 climate regime shift. Changes in ocean climate are hypothesized to have affected the quantity, quality and accessibility of prey, which in turn may have affected the rates of birth and death of sea lions. Recent studies of the spatial and temporal variations in the ocean climate system of the North Pacific support this hypothesis. Ocean climate changes appear to have created adaptive opportunities for various species that are preyed upon by Steller sea lions at mid-trophic levels. The east–west asymmetry of the oceanic response to climate forcing after 1976–77 is consistent with both the temporal aspect (populations decreased after the late 1970s) and the spatial aspect of the decline (western, but not eastern, sea lion populations decreased). These broad-scale climate variations appear to be modulated by regionally sensitive biogeographic structures along the Aleutian Islands and Gulf of Alaska, which include a transition point from coastal to open-ocean conditions at Samalga Pass westward along the Aleutian Islands. These transition points delineate distinct clusterings of different combinations of prey species, which are in turn correlated with differential population sizes and trajectories of Steller sea lions. Archaeological records spanning 4000 yr further indicate that sea lion populations have experienced major shifts in abundance in the past. Shifts in ocean climate are the most parsimonious underlying explanation for the broad suite of ecosystem changes that have been observed in the North Pacific Ocean in recent decades.

Pacific Decadal Oscillation

Monthly Index (1900-2004)



PDO data from Mantua: University of Washington


Toxins?
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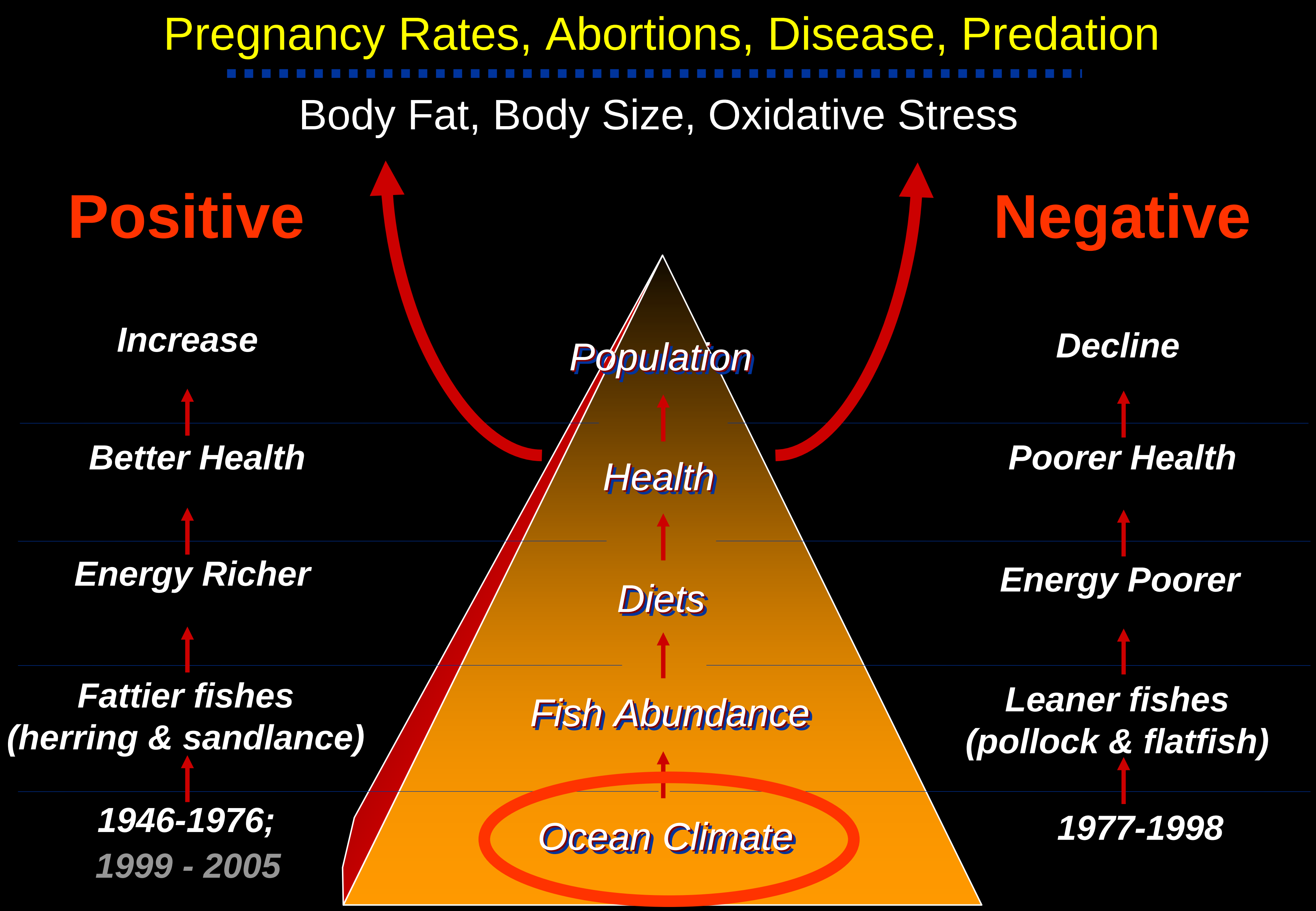
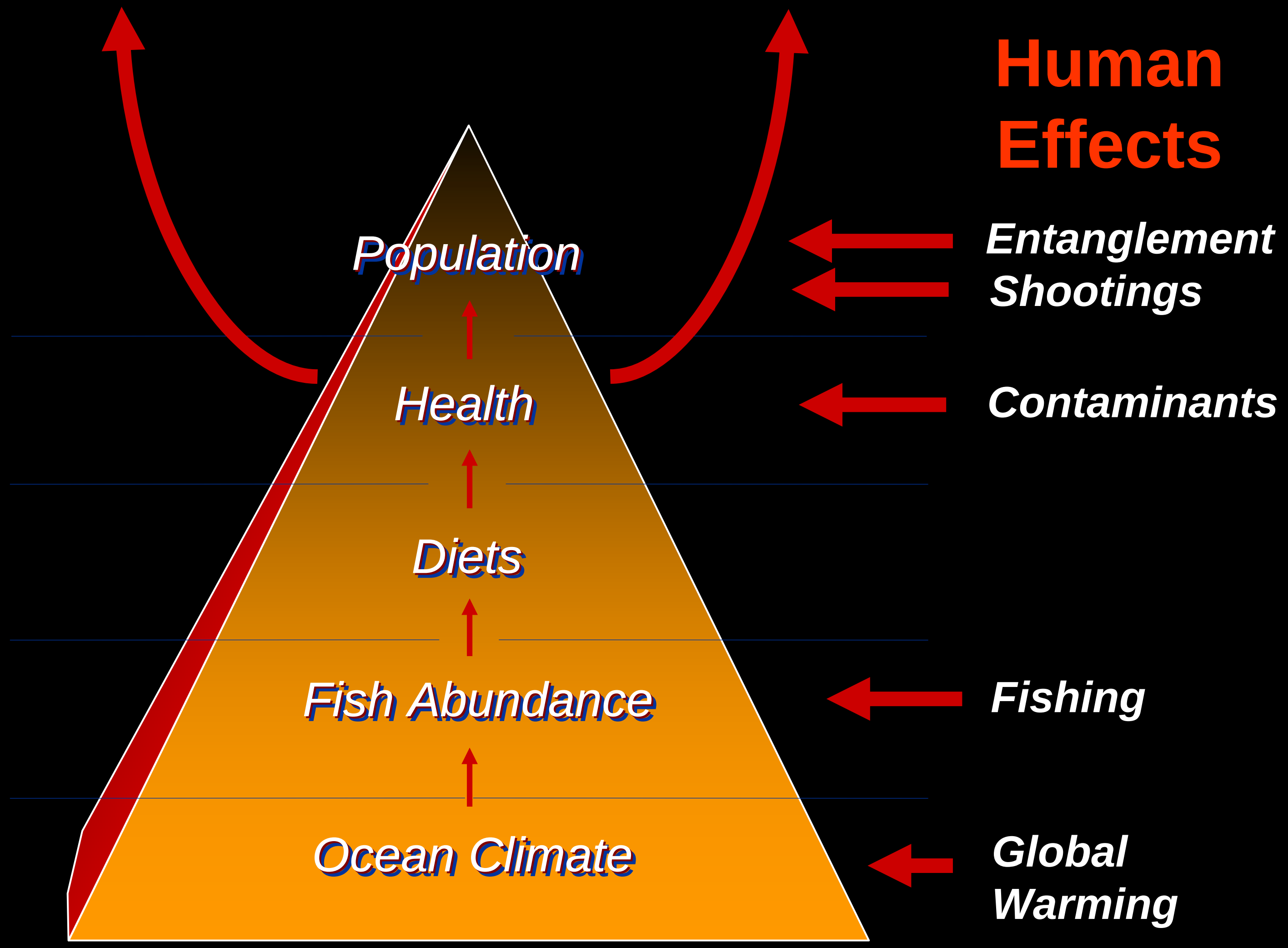


Trites et al. (*in press*). Bottom-up forcing and the decline of Steller sea lions in Alaska: assessing the ocean climate hypothesis. *Fisheries Oceanography*

Pregnancy Rates, Abortions, Disease, Predation

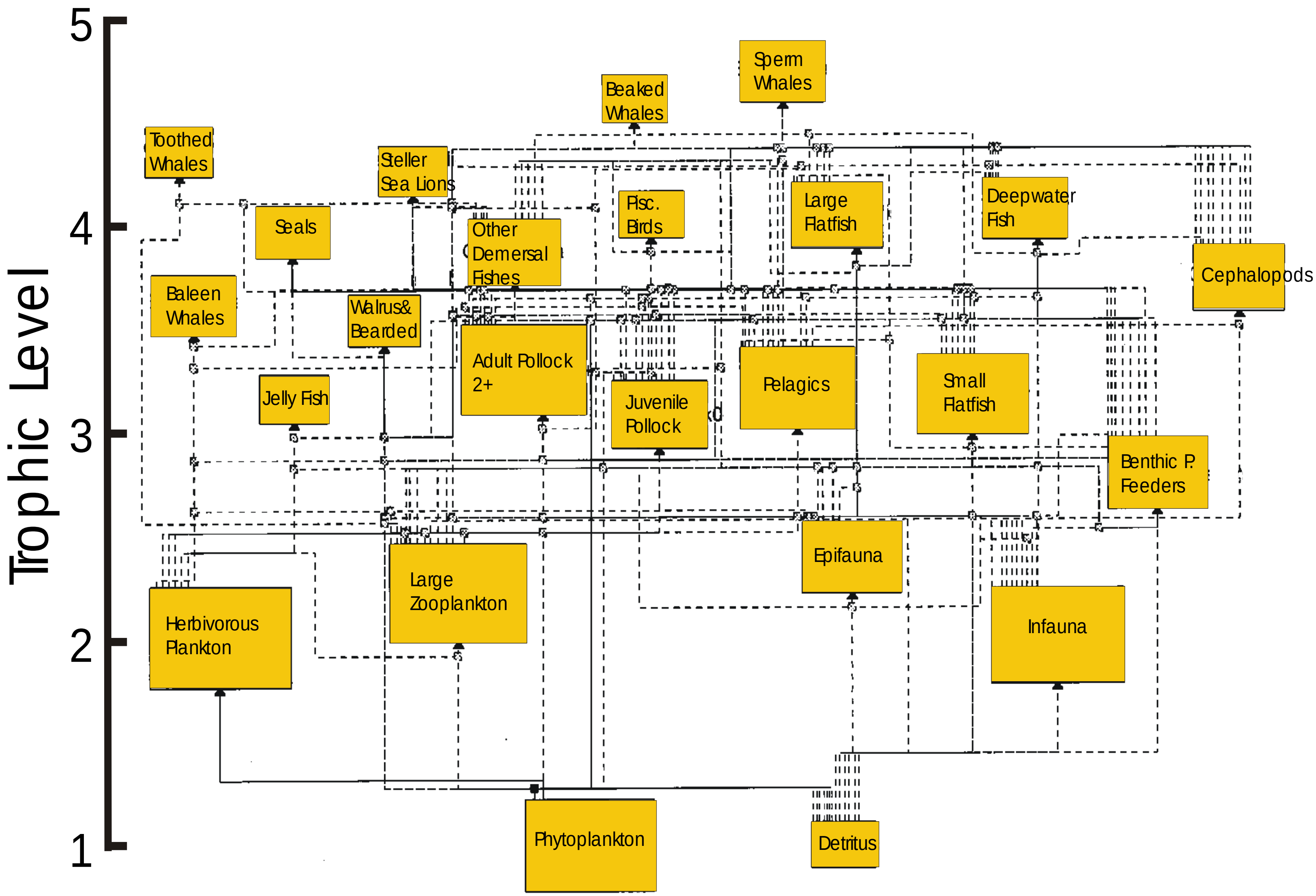
Body Fat, Body Size, Oxidative Stress



Trites et al. (*in press*). Bottom-up forcing and the decline of Steller sea lions in Alaska: assessing the ocean climate hypothesis. *Fisheries Oceanography*

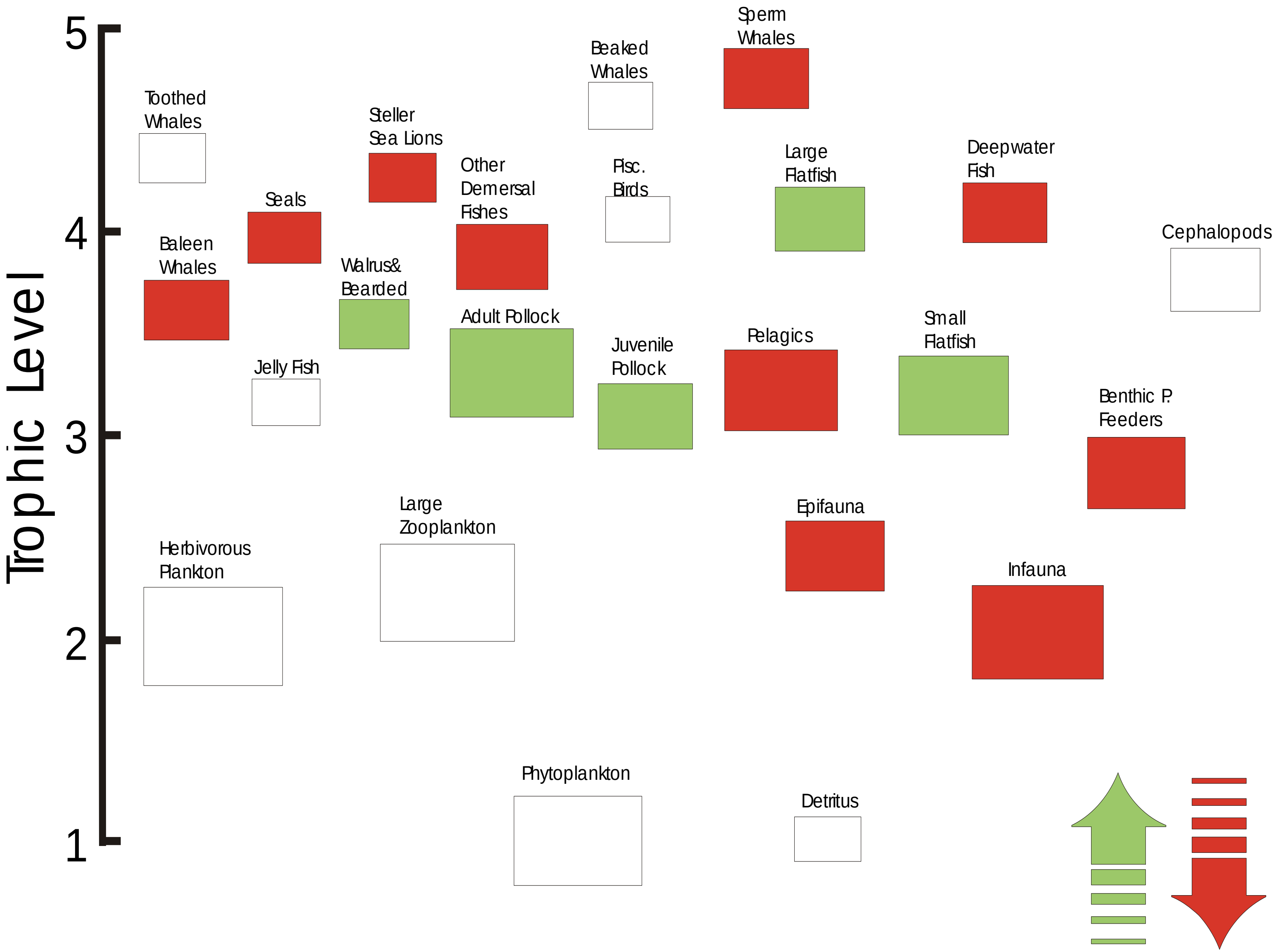
Ecosystem Model

Bering Sea Trophic Interactions - 1980s



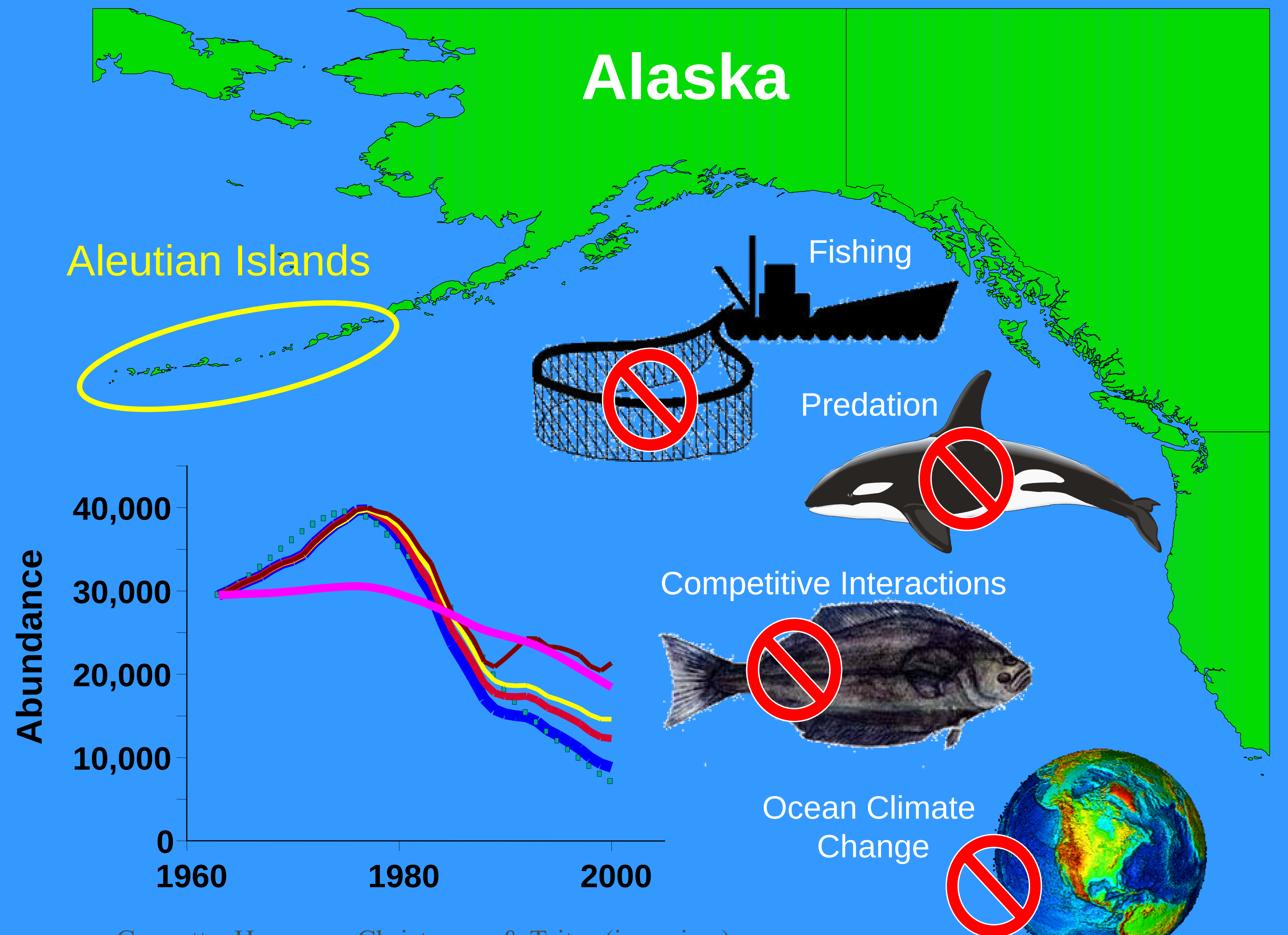
Trites *et al.*1999. Fish. Cent. Res. Rep. 7, 106 p.

Relative Abundances 1950s ➠ 1980s



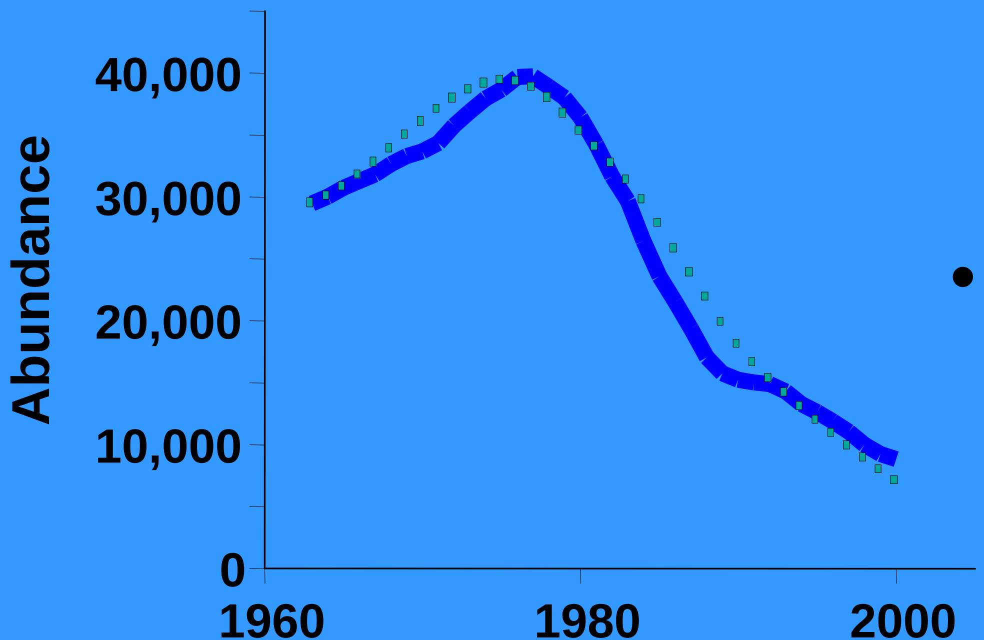
Trites *et al.*1999. Fish. Cent. Res. Rep. 7, 106 p.

Whaling?



Guenette, Heymans, Christensen & Trites (in review)

- Sea lion decline primarily explained by Ocean Climate and Predation
- Fishing and competition with flatfish contributed to a lesser degree



Guenette, Heymans, Christensen & Trites (in review)

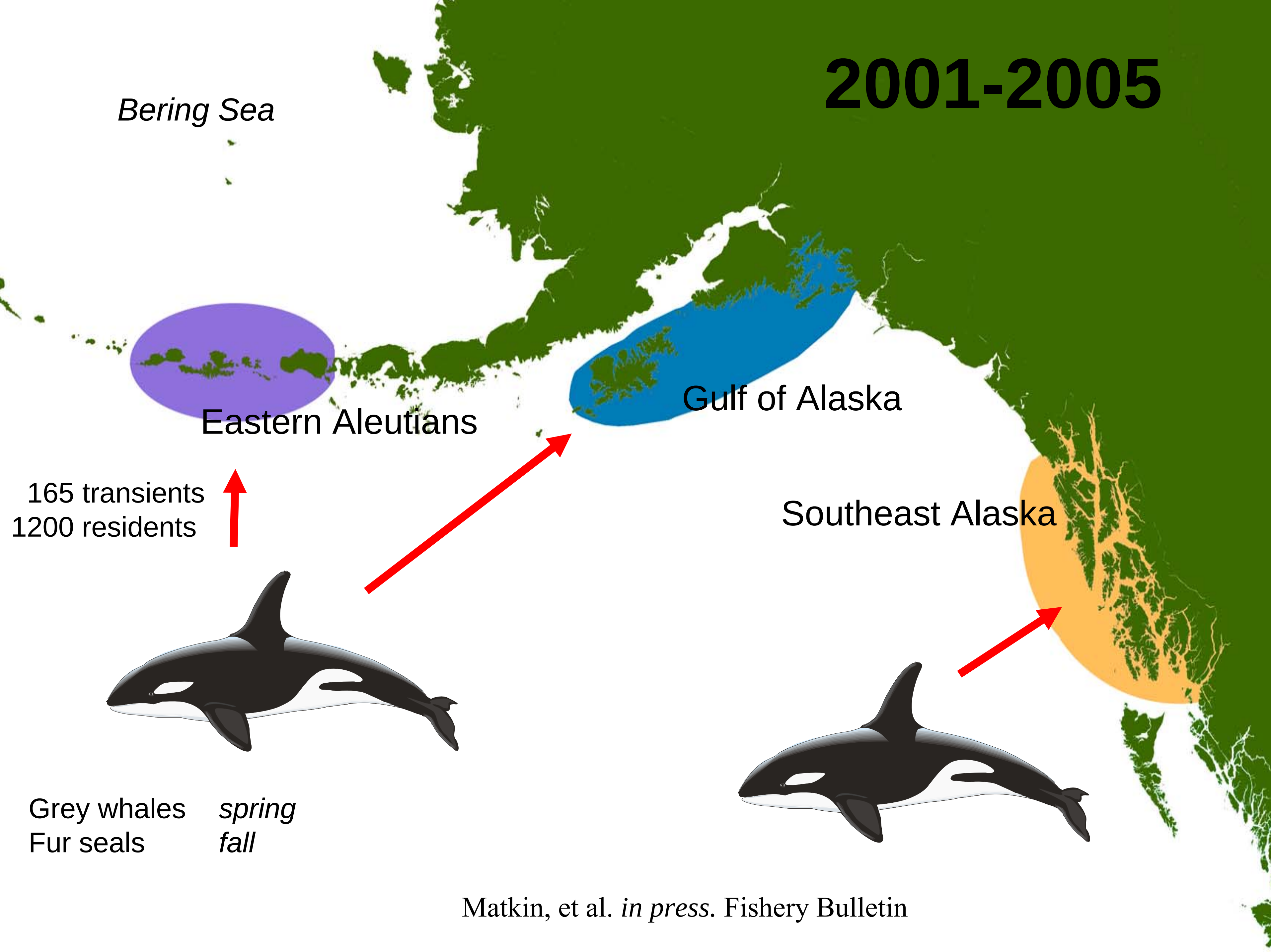
Killer whales?

Barrett-Lennard et al. 1995. Unpublished Report

Predation

- 58 whales eating 100% Steller sea lions
- 250 whales – 28% increase in diet
- Could be preventing recovery

from Barrett-Lennard, Heise, Martell, DeMaster & Trites, *in prep.* Ecological Applications



Matkin, et al. *in press*. Fishery Bulletin

Grey Whale Predation

Predation

- Likely *in*significant at *high* populations
- But *very* significant when populations are *low*

Conclusions

- Pinniped declines (1970s-90s) likely related
- Juveniles most vulnerable
- Ocean climate is the likely force that links all of the trophic levels of the ecosystem
- The Perfect Storm?

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