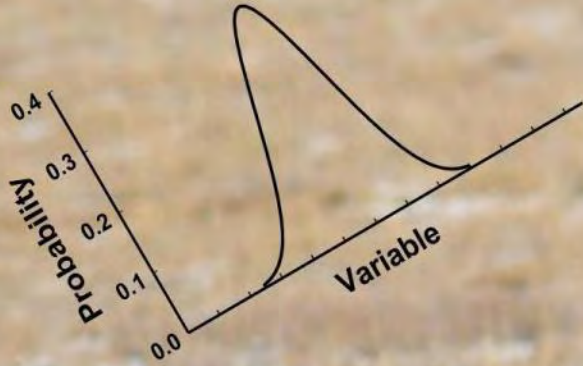
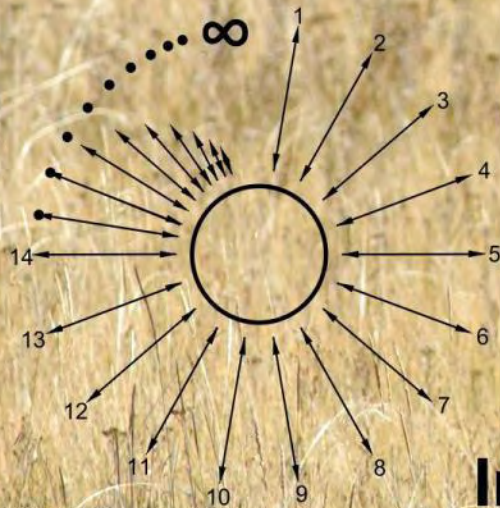


# Coevolutionary Interactions

$$= \sum_{i=0}^{\infty} f(e_i)$$



Health



Interdisciplinary Studies

Patterns

Predator/Prey Relationships

Emergence  
Higher Order Interactions

Biodiversity

Complexity



# Ecosystem-based Management: A Step Toward More Holistic Management

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Swedish Board of Fisheries  
Institute of Marine Research, Lysekil, Sweden

November 10, 2009

Lowell Wakefield Symposium

Ecosystems 2010: Global Progress on Ecosystem-based  
Fisheries Management



# Ecosystem-based Management: A Step Toward More Holistic Management

Holistic Management or Reality-based  
Management (ecosystems are part of reality)

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Pattern-Based Management

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Macroecological Patterns

# Holistic Management (examples)

## Harvests

- Single species application

- Multispecies application

- Ecosystem application

- Oceanic application

- Refined/extrapolated single species application

## Selectivity

- Ecosystem-based application

- Single species application

## MPAs

- Ecosystem application

# Holistic Management (examples)

## Harvests

Single species application

Multispecies application

Ecosystem application

Oceanic application

Refined/extrapolated single species application

## Selectivity

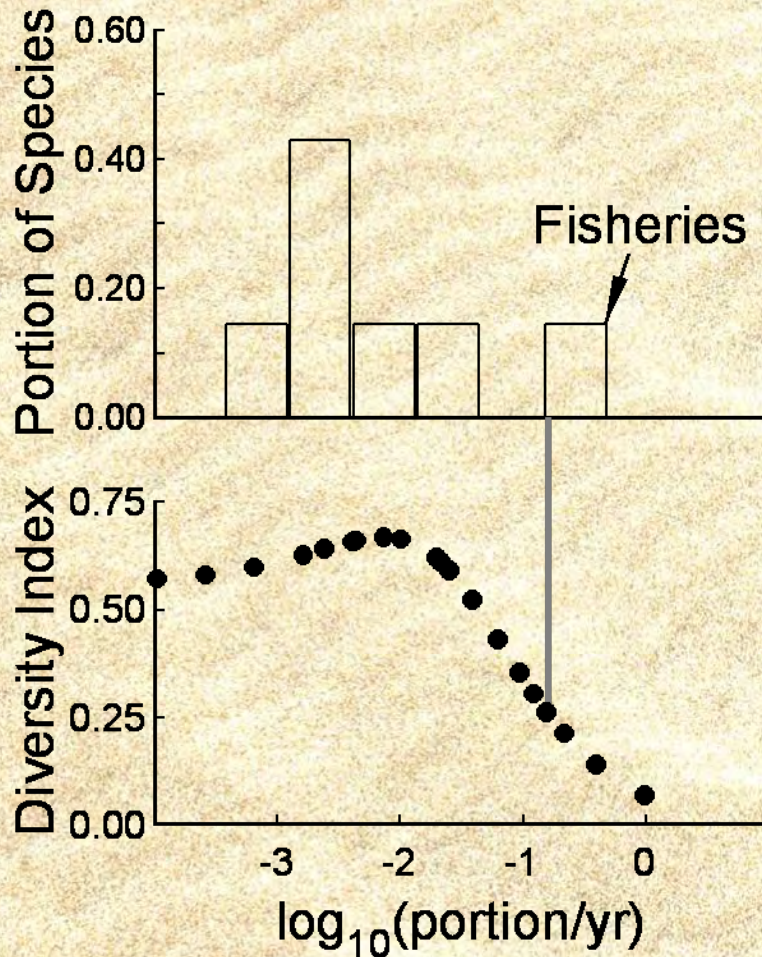
Ecosystem-based application

Single species application

## MPAs

Ecosystem application

## Portion of Pollock Biomass Consumed



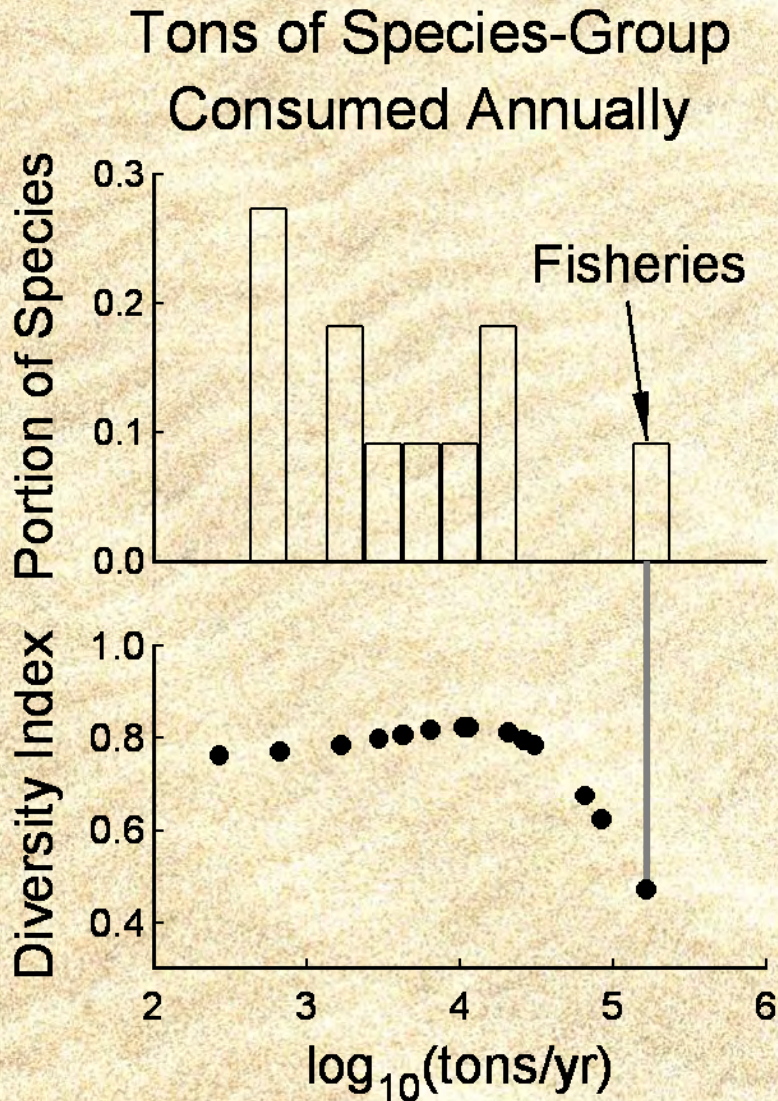
Single-species  
application

Pollock in  
eastern Bering  
Sea

Six species of marine  
mammals – late 1980s  
OI (overfishing index) = 16

# Multi-species application

## Hake, mackerel, and herring in the northwest Atlantic

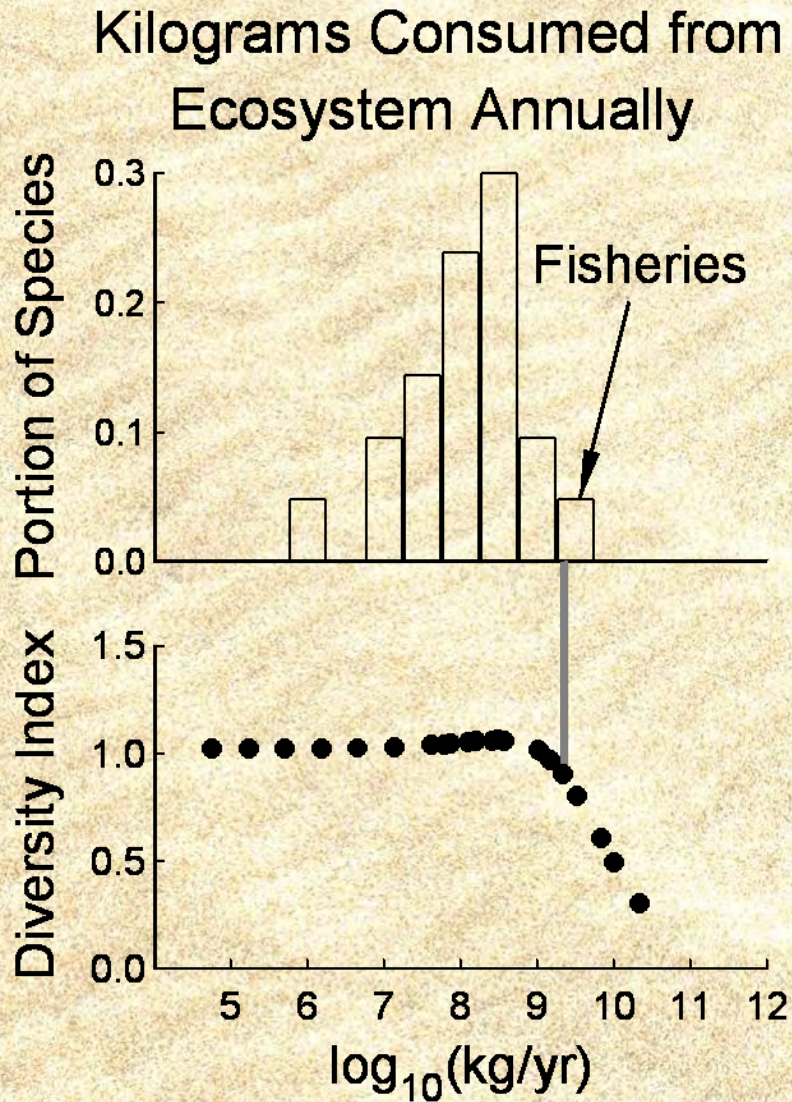


Ten species of marine mammals – late 1980s  
OI = 14

# Ecosystem application

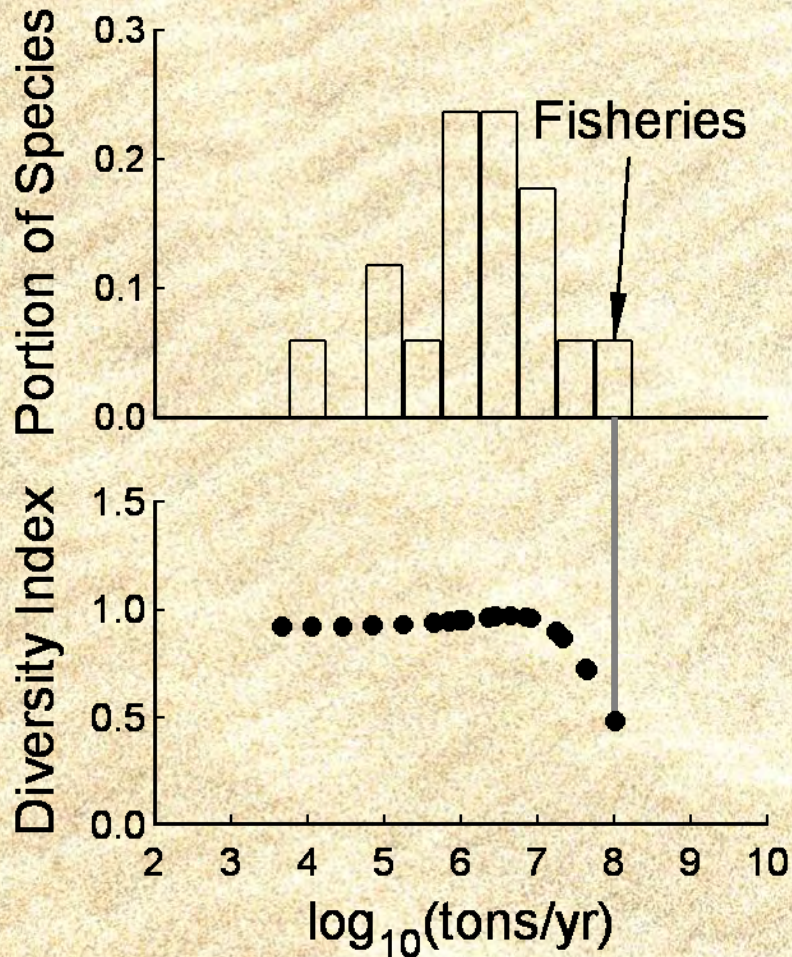
## Eastern Bering Sea

Twenty species of marine mammals – late 1980s  
OI = 7





## Tons Consumed from Marine Environment Annually



Full marine  
environment  
application

World's Oceans

Sixteen species of marine  
mammals – late 1990s  
OI = 23

# Holistic Management (examples)

## Harvests

- Single species application

- Multispecies application

- Ecosystem application

- Oceanic application

- Refined/extrapolated single species application

## Selectivity

- Ecosystem-based application

- Single species application

## MPAs

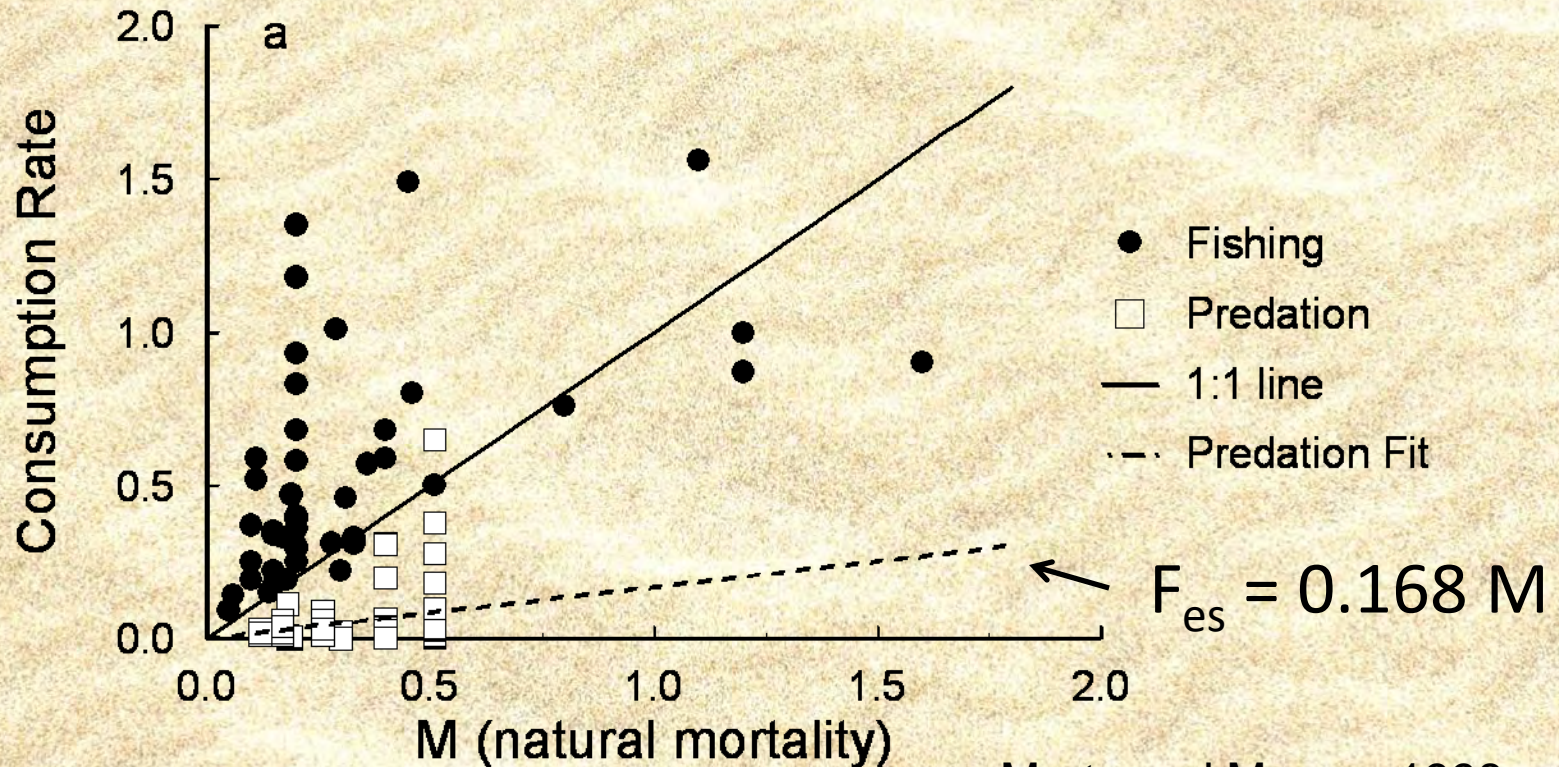
- Ecosystem application

Extrapolation to other resource  
species

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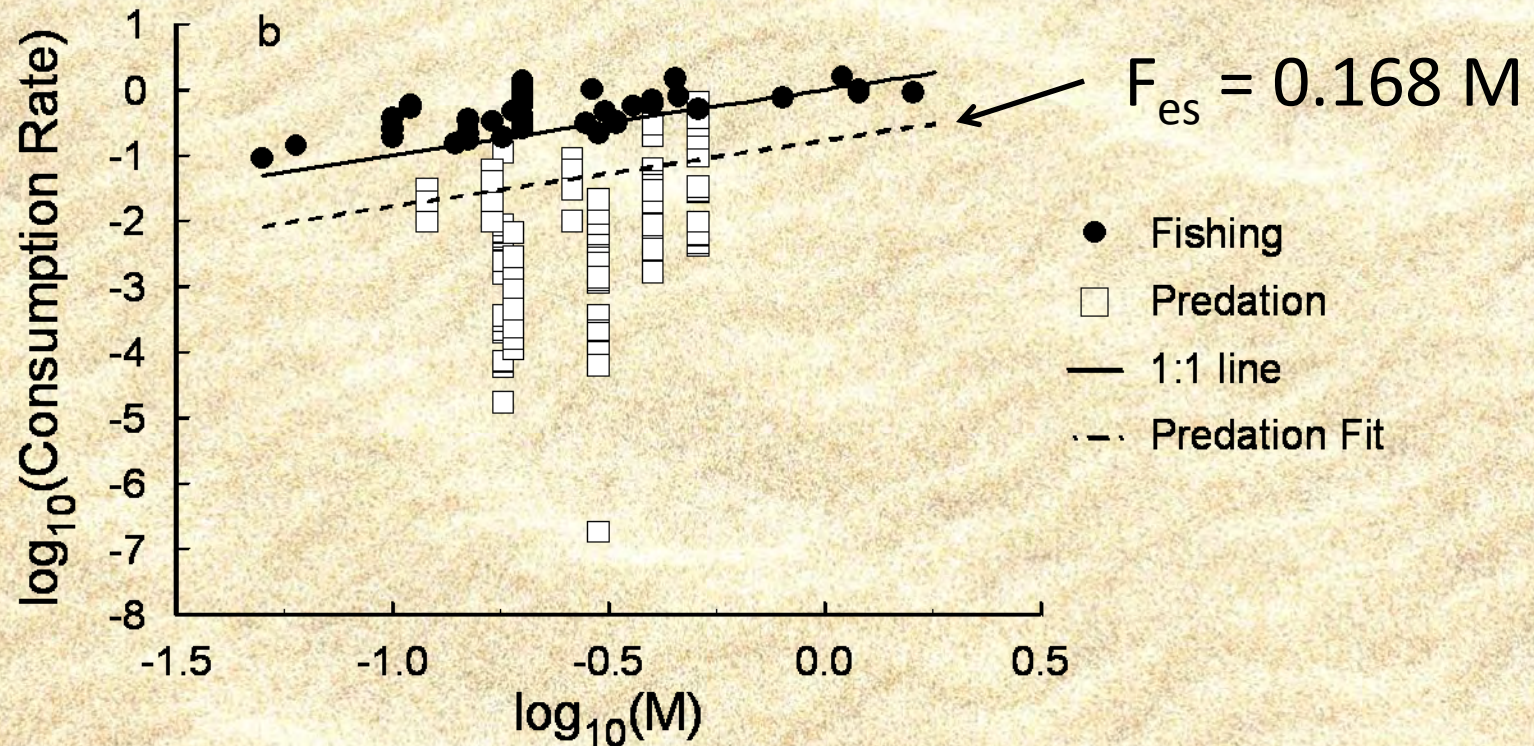
Makes use of macroecological  
pattern relating sustainable  
consumption rates to  $M$   
(total natural mortality)

# Species-specific predation rates compared to 44 empirically observed fishing rates

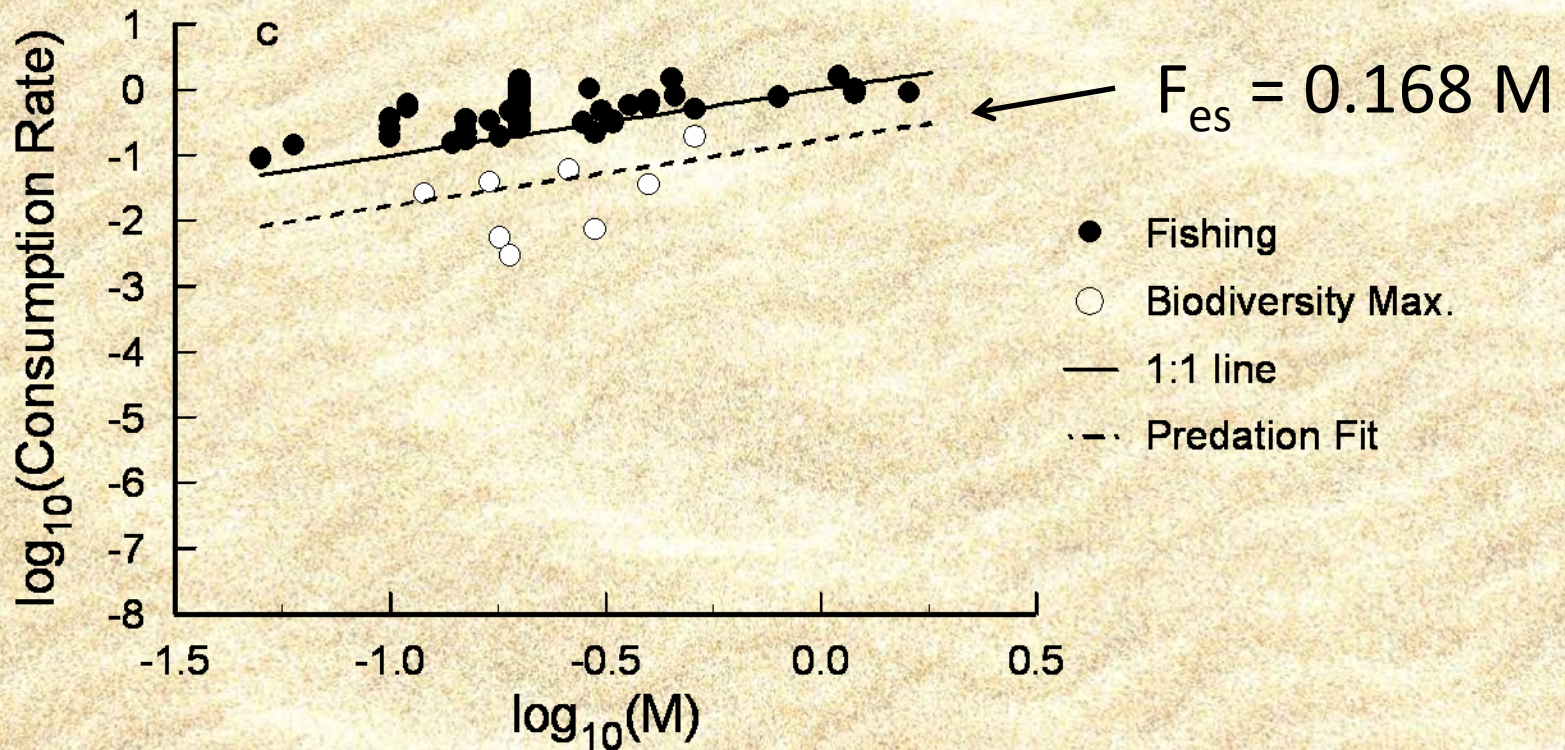


Mertz and Meyers 1998  
Belgrano and Fowler 2011

# Species-specific predation rates compared to 44 empirically observed fishing rates

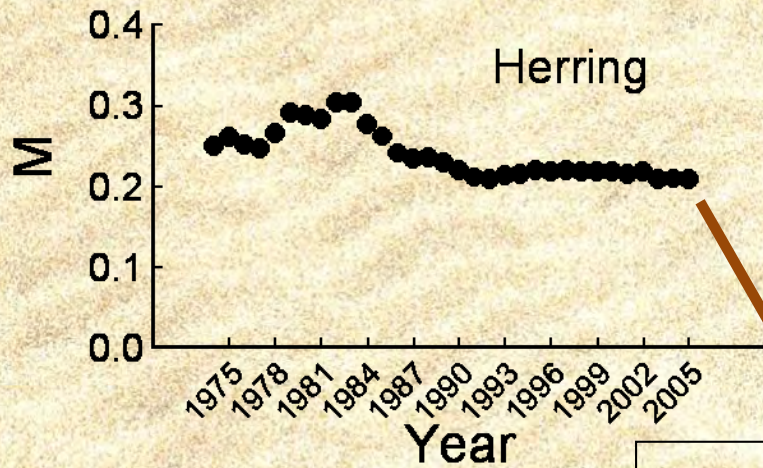


# Species-specific predation rates compared to 44 empirically observed fishing rates

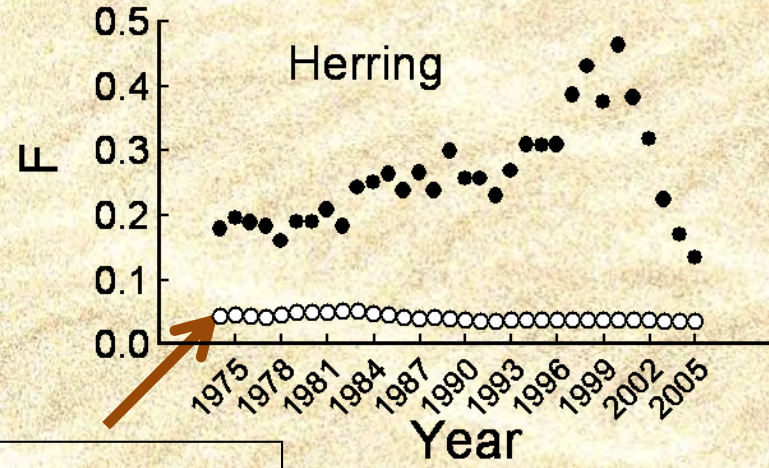


# Herring Fishery, Baltic Sea

Total Natural Mortality (M)

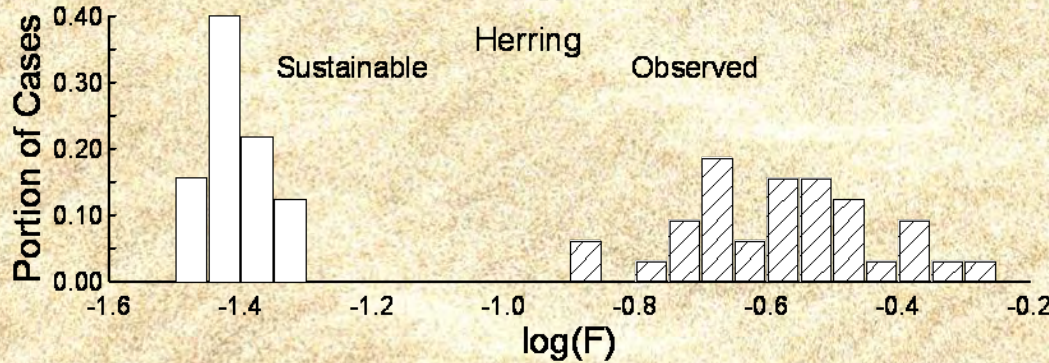


$F_{ob}$  (•) and  $F_{es}$  (◦)

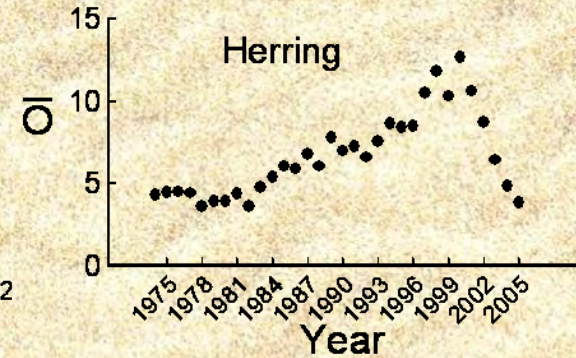


$F_{es} = 0.168 M$

Comparison of Observed ( $F_{ob}$ ) and Sustainable ( $F_{es}$ ) Fishing Rates

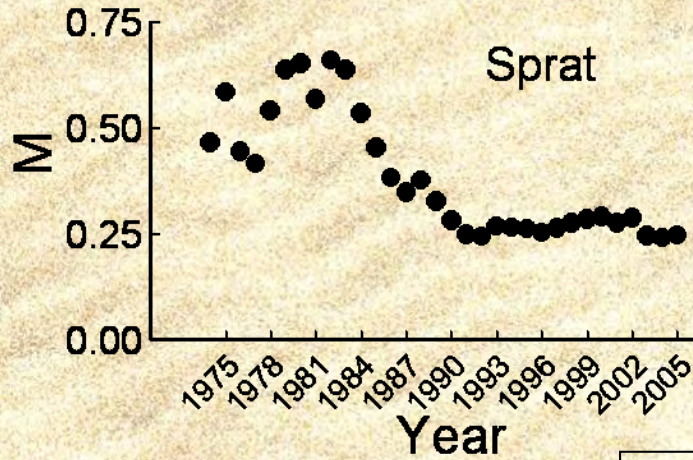


Overfishing Index (OI)

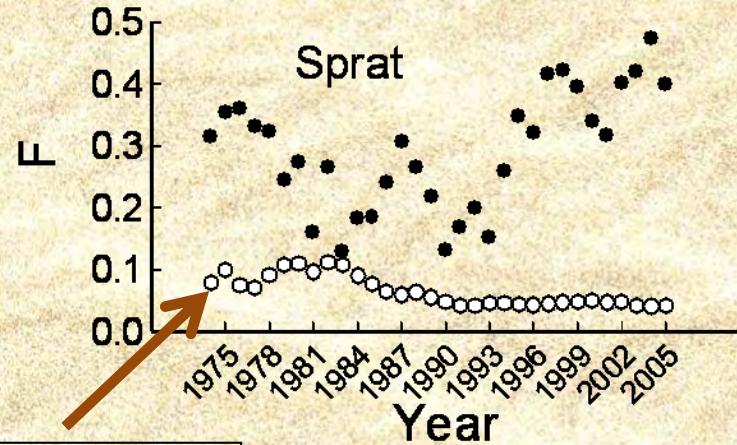


# Sprat Fishery, Baltic Sea

Total Natural Mortality (M)

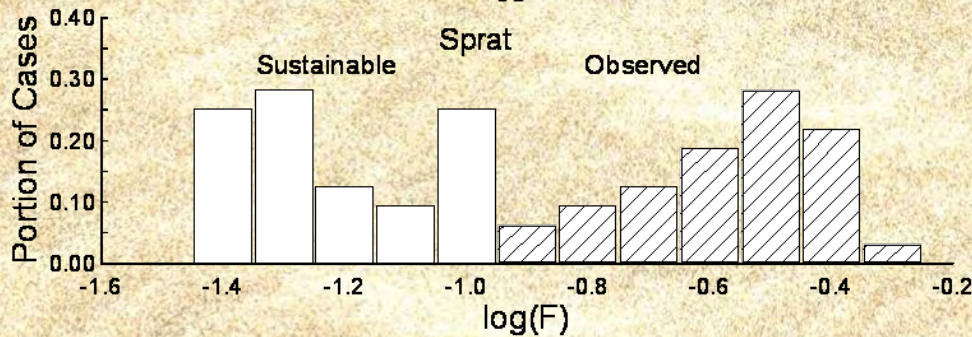


$F_{ob}$  (•) and  $F_{es}$  (◦)

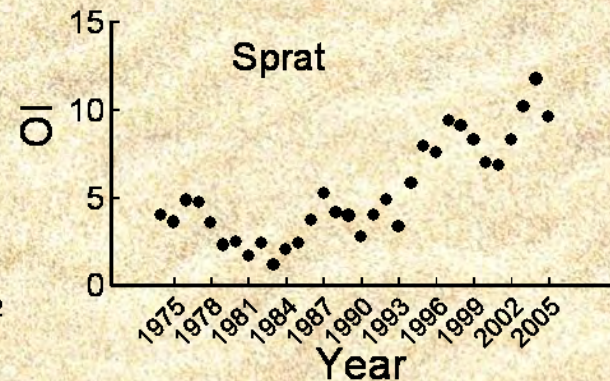


$$F_{es} = 0.168 M$$

Comparison of Observed ( $F_{ob}$ ) and Sustainable ( $F_{es}$ ) Fishing Rates



Overfishing Index (OI)





# Holistic Management (examples)

## Harvests

Single species application

Multispecies application

Ecosystem application

Oceanic application

Refined/extrapolated single species application

## Selectivity

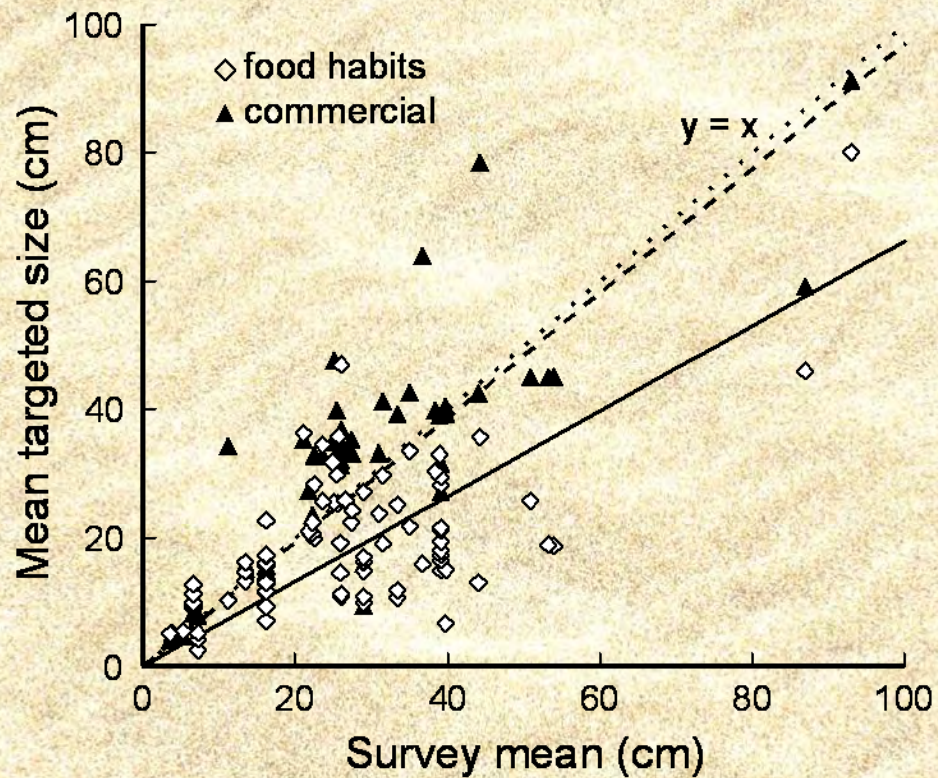
Ecosystem-based application

Single species application

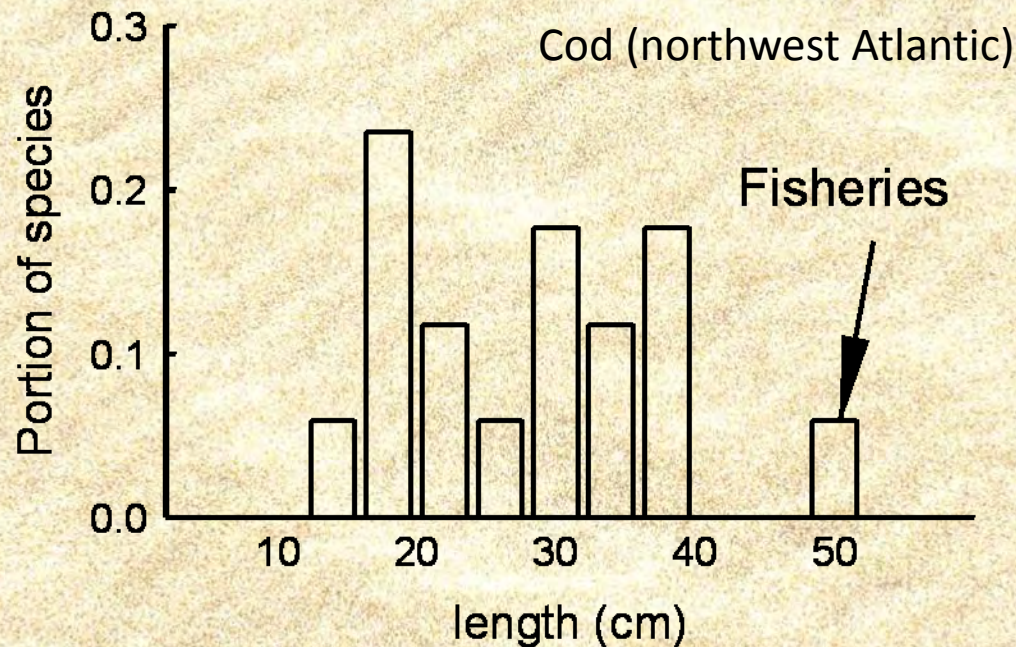
## MPAs

Ecosystem application

# Ecosystem-based management



# Ecosystem-based management (single-species application)



# Holistic Management (examples)

## Harvests

Single species application

Multispecies application

Ecosystem application

Oceanic application

Refined/extrapolated single species application

## Selectivity

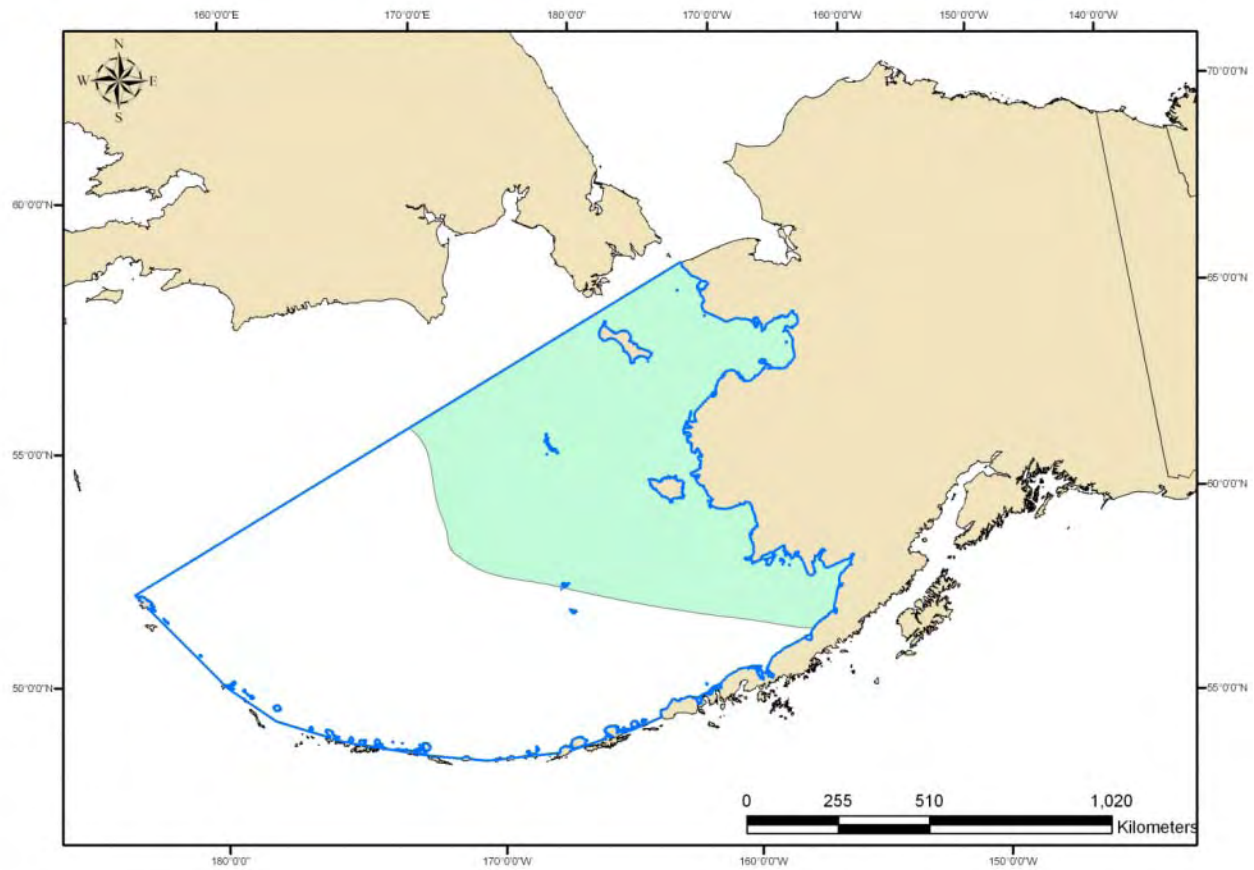
Ecosystem-based application

Single species application

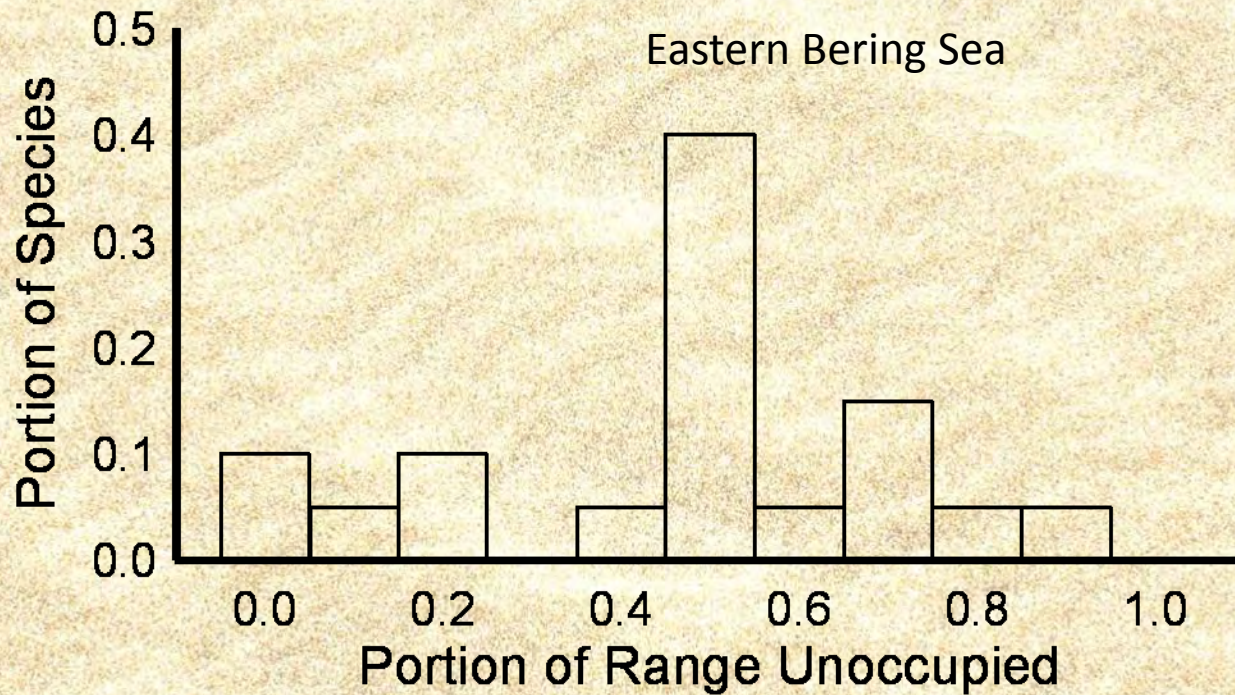
## MPAs

Ecosystem application

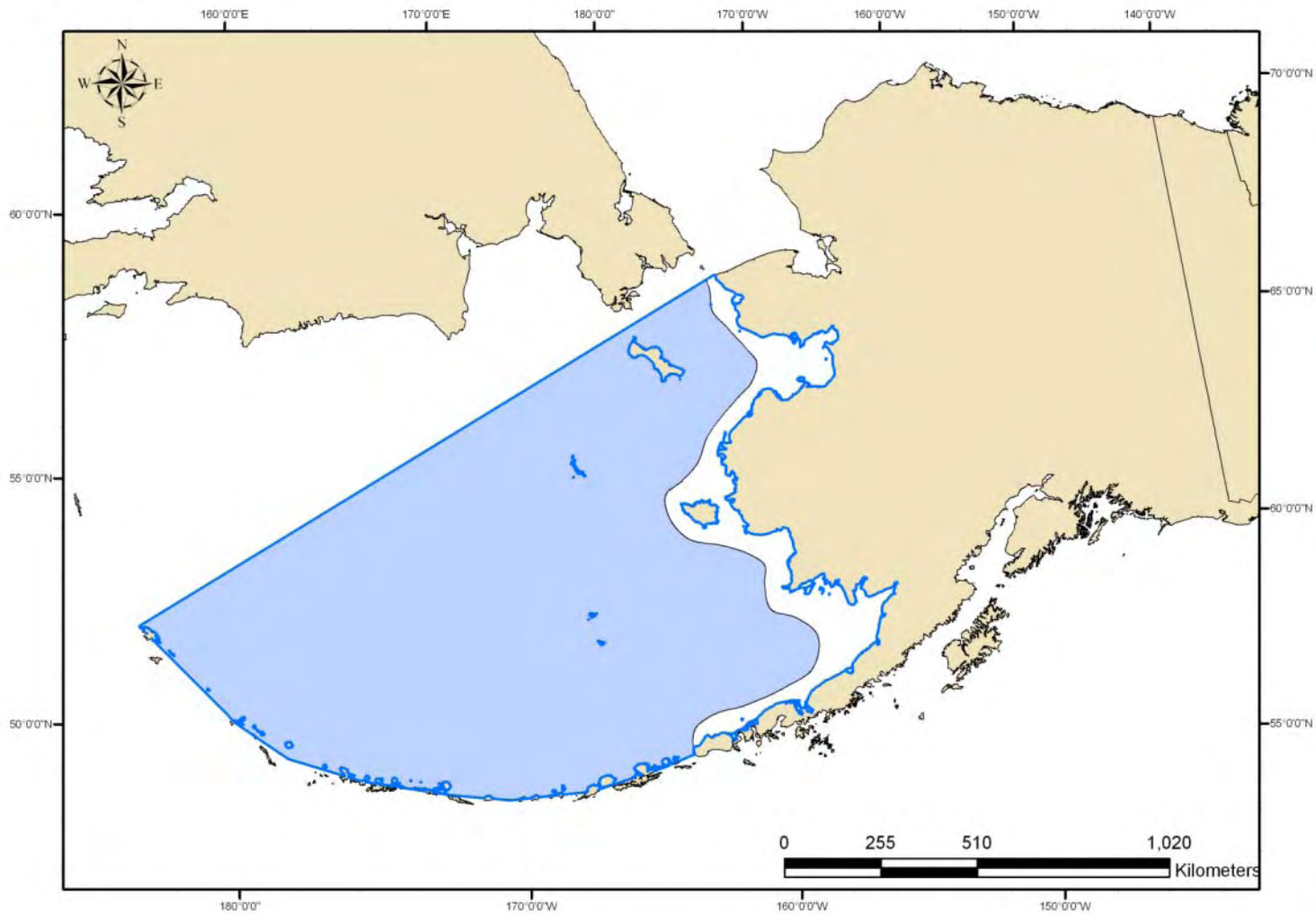
Ringed Seal 56% (0.56)



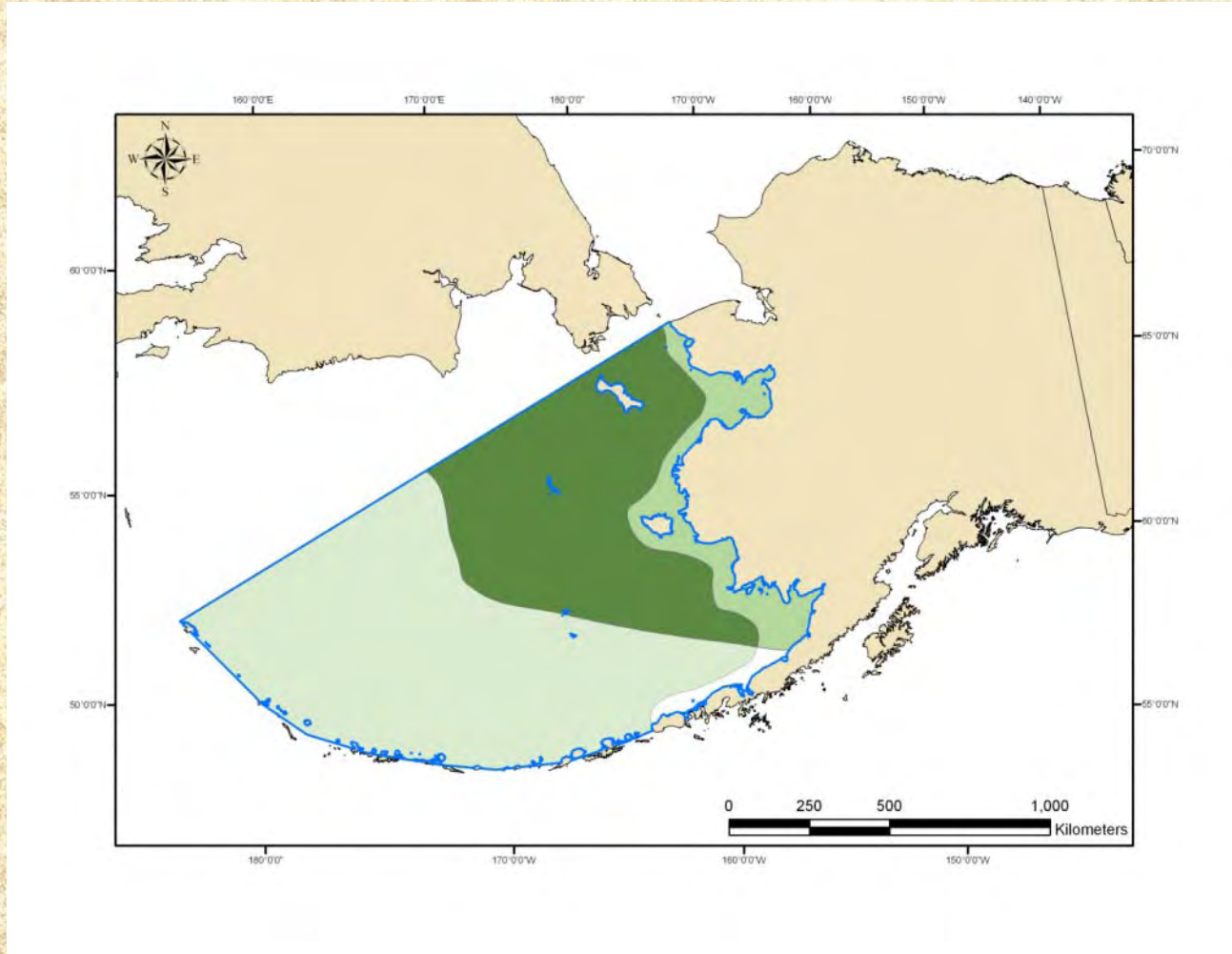
# Marine Protected Areas (ecosystem application)



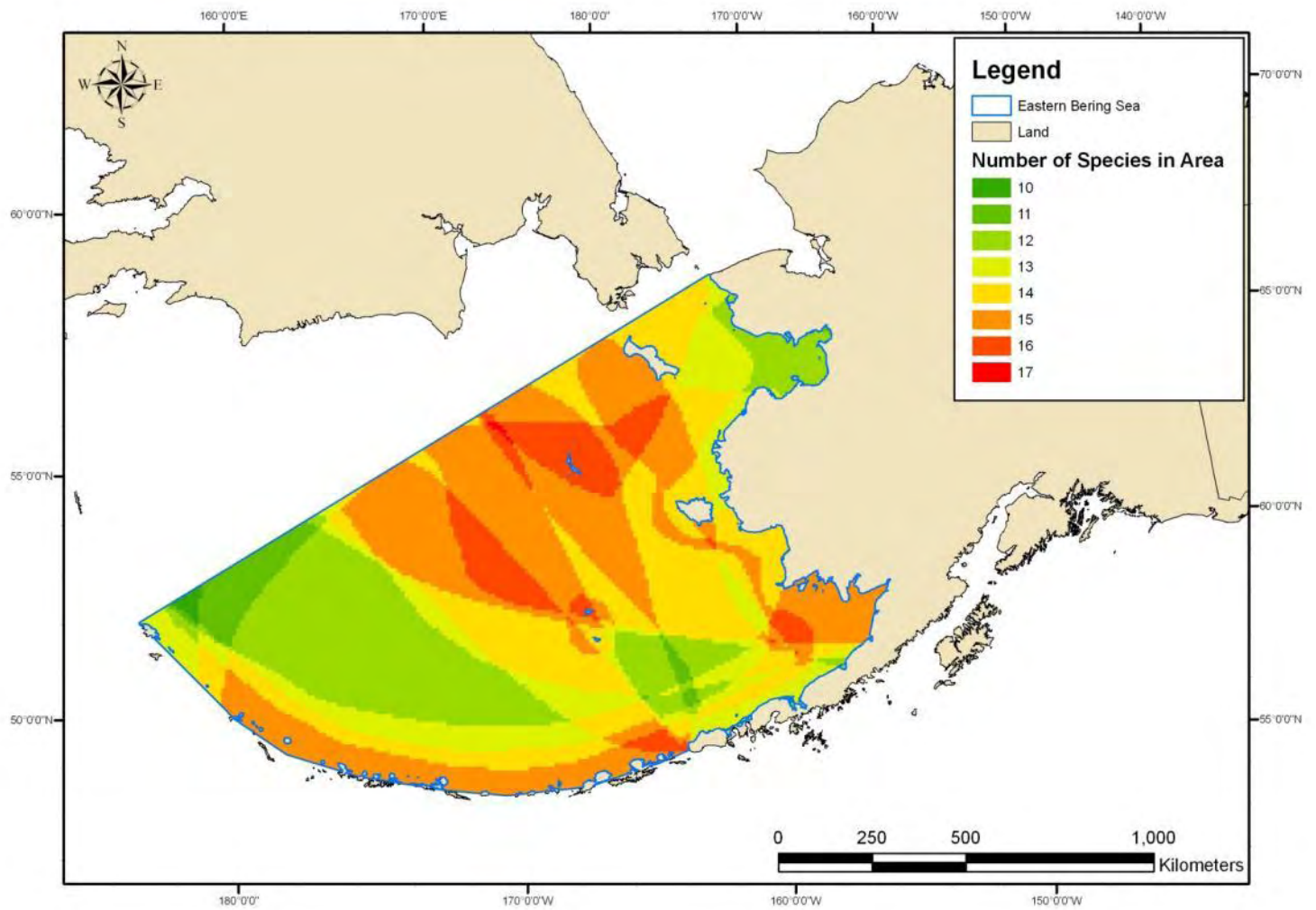
# Ribbon Seal 11% (0.11)



Ribbon Seal/Ringed Seal = 21% (of Ringed Seal's geographic range)







# Holistic Management (examples)

## Harvests

- Single species application

- Multispecies application

- Ecosystem application

- Oceanic application

- Refined/extrapolated single species application

## Selectivity

- Ecosystem-based application

- Single species application

## MPAs

- Ecosystem application

# Thank You!

Charles.Fowler@noaa.gov

