

# **Could the Collapse of the Bristol Bay Red King Crab Stock in the Early 1980s Have Been Avoided? ---A Case Study for Ecosystem-based Management**

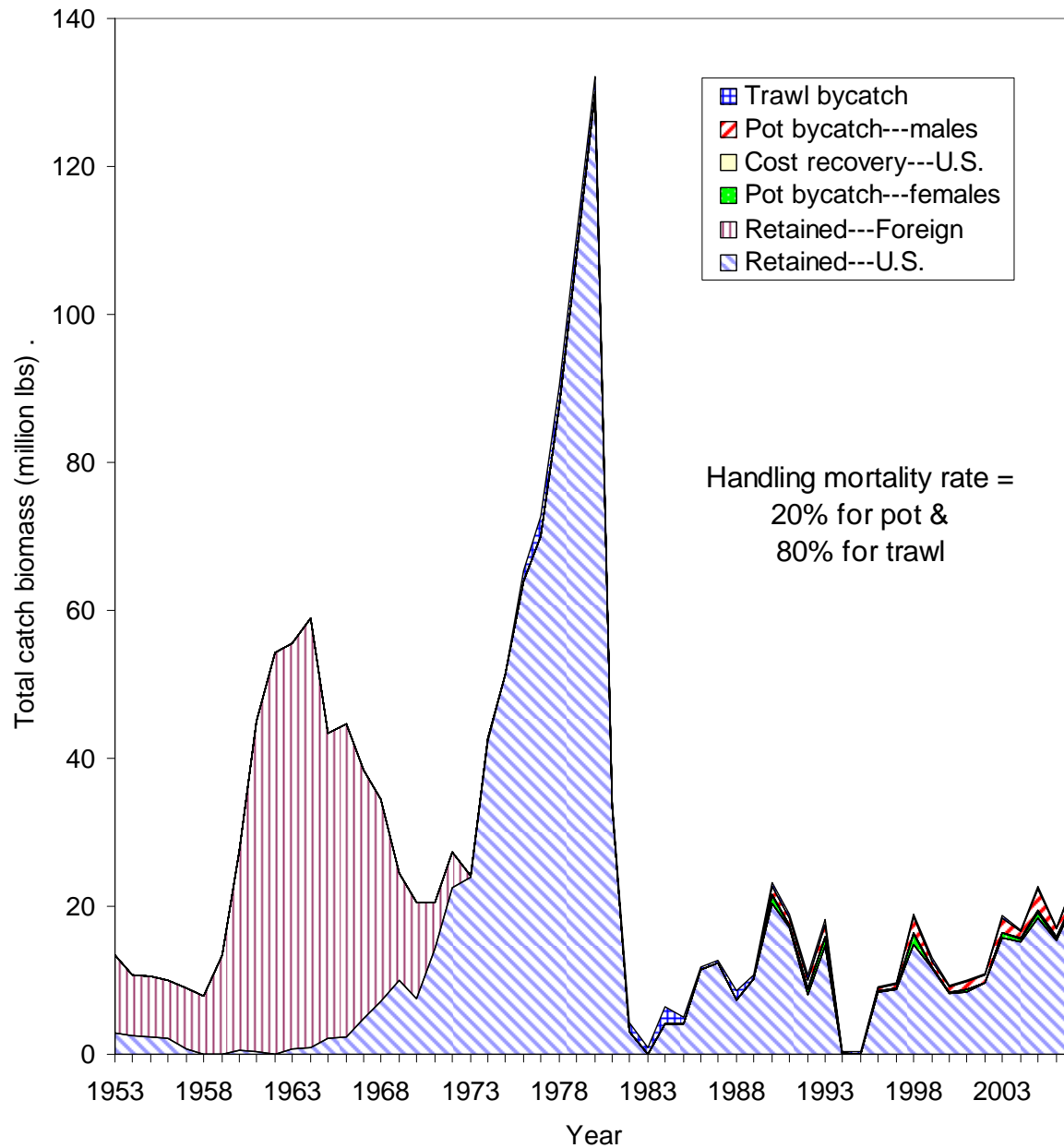
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**<sup>1</sup>ADF&G and <sup>2</sup>UAF, Juneau, Alaska, USA**

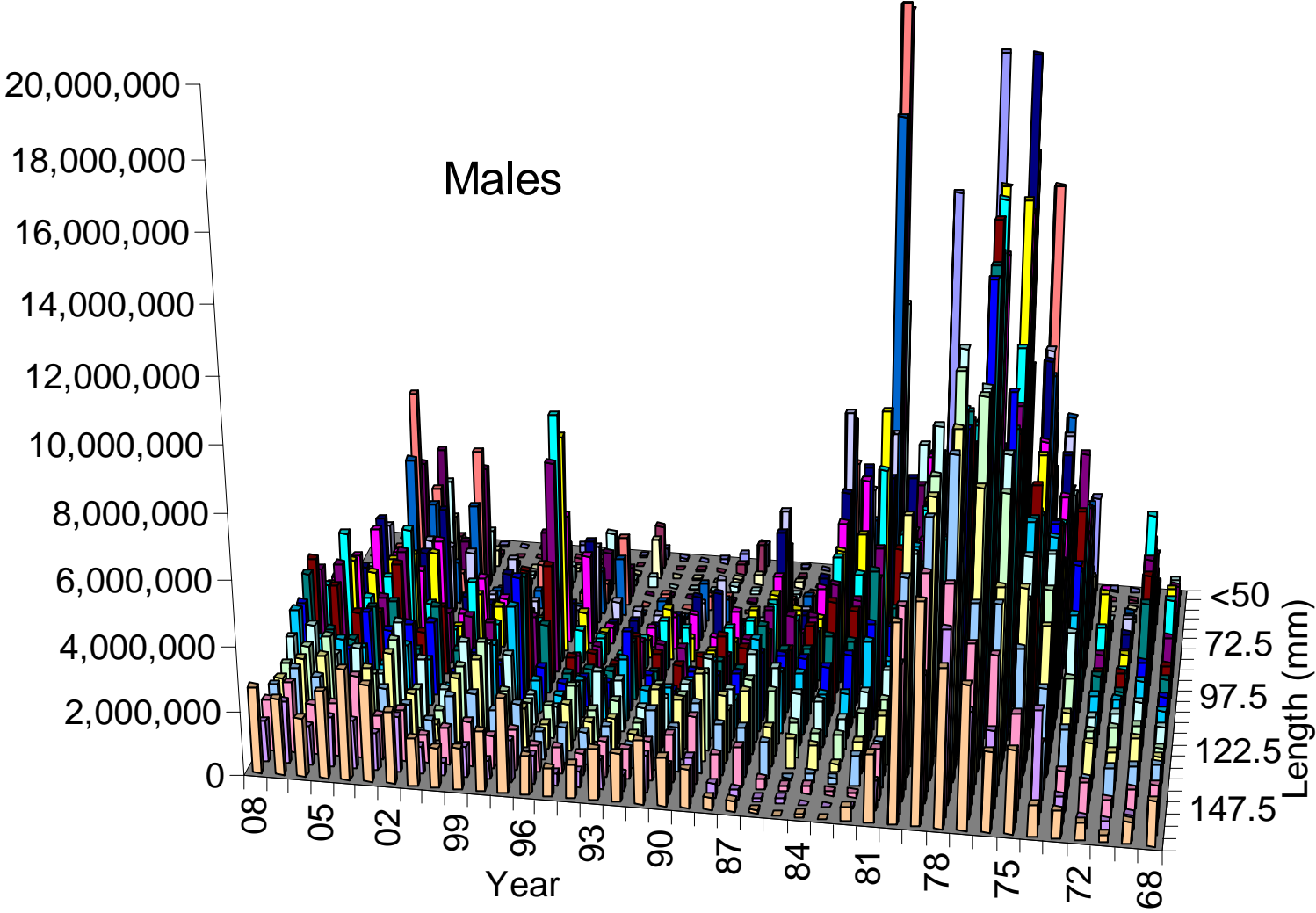
# THE BERING SEA



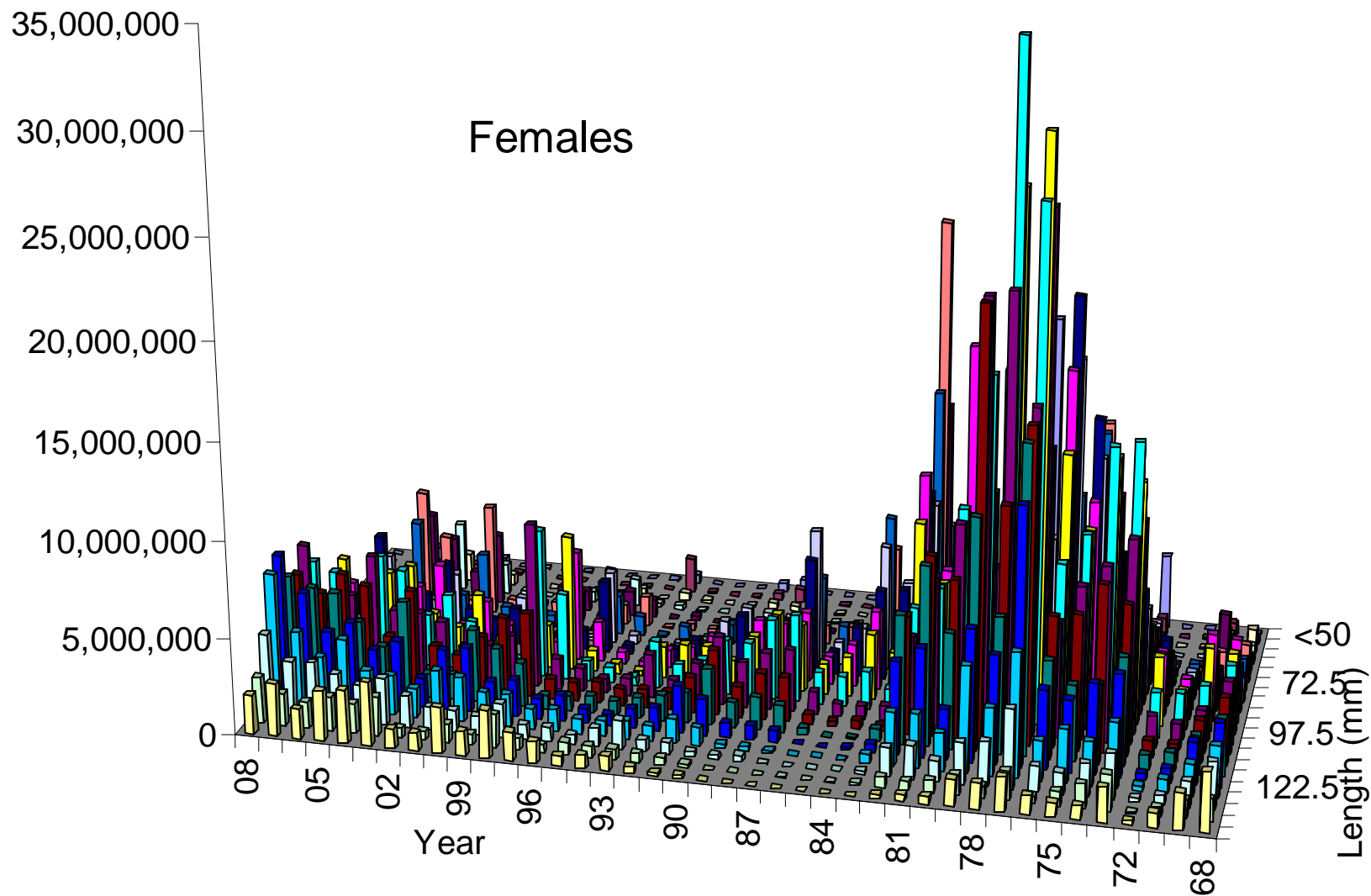
# Historical catch of Bristol Bay red king crab

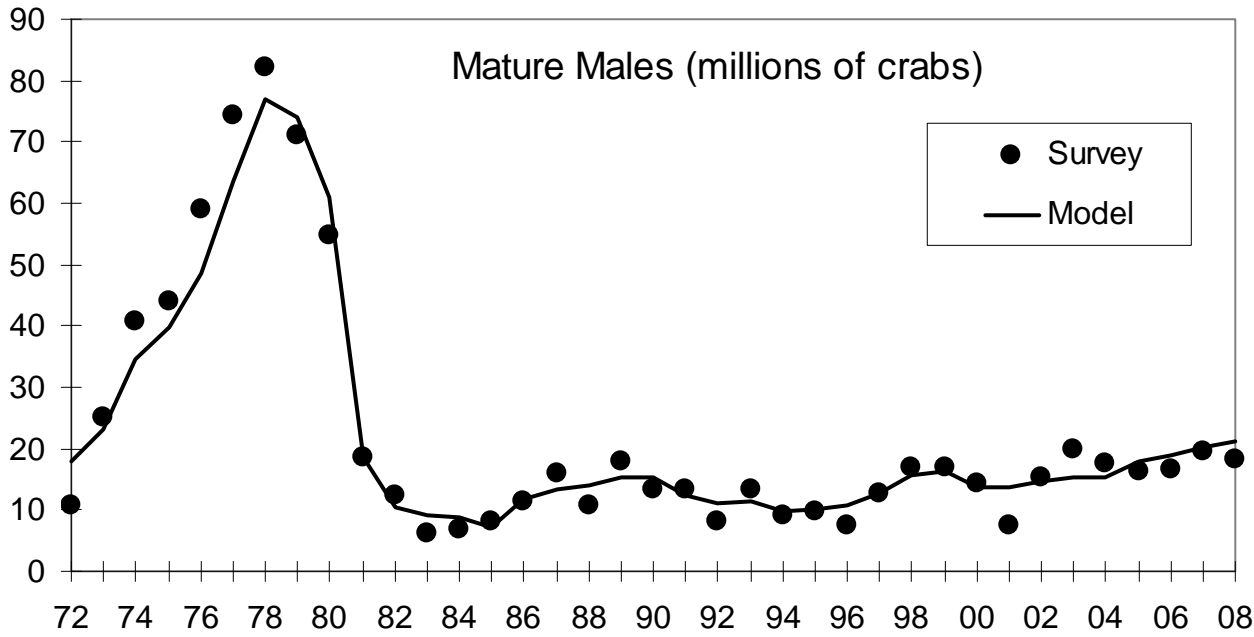


# Survey abundances by length for male Bristol Bay red king crabs from 1968 to 2008

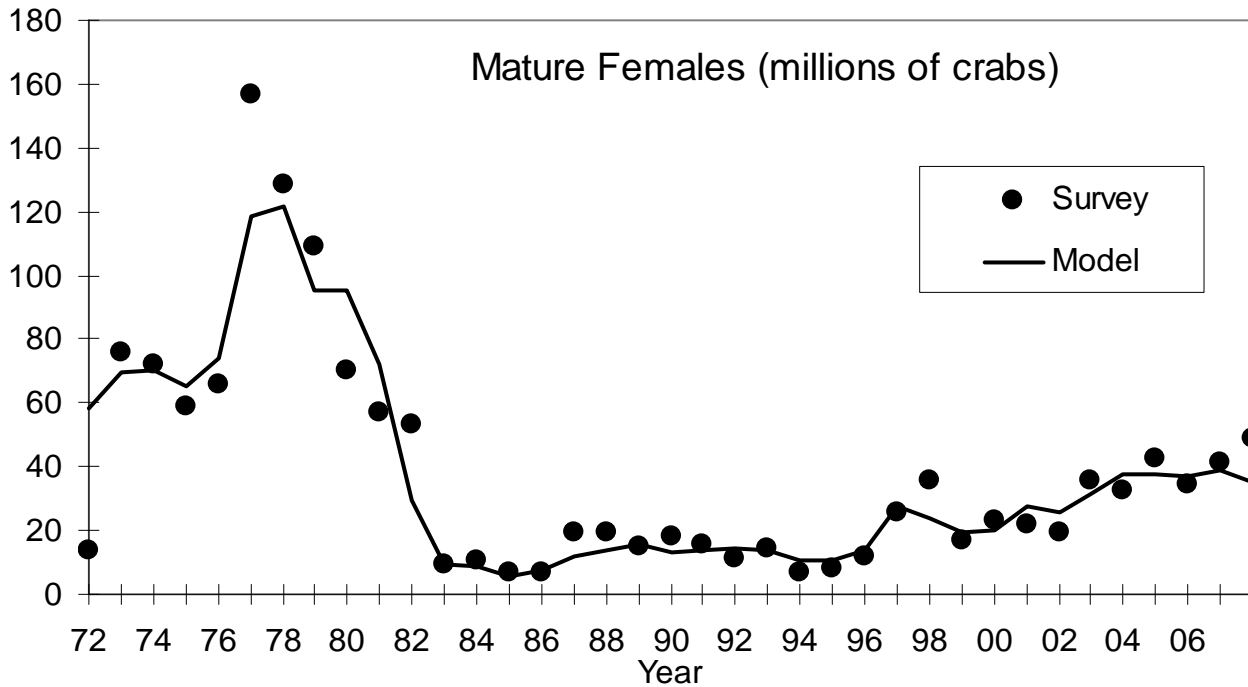


# Survey abundances by length for female Bristol Bay red king crabs from 1968 to 2008





Large decline in the early 1980s



# What Occurred During Early 1980s?

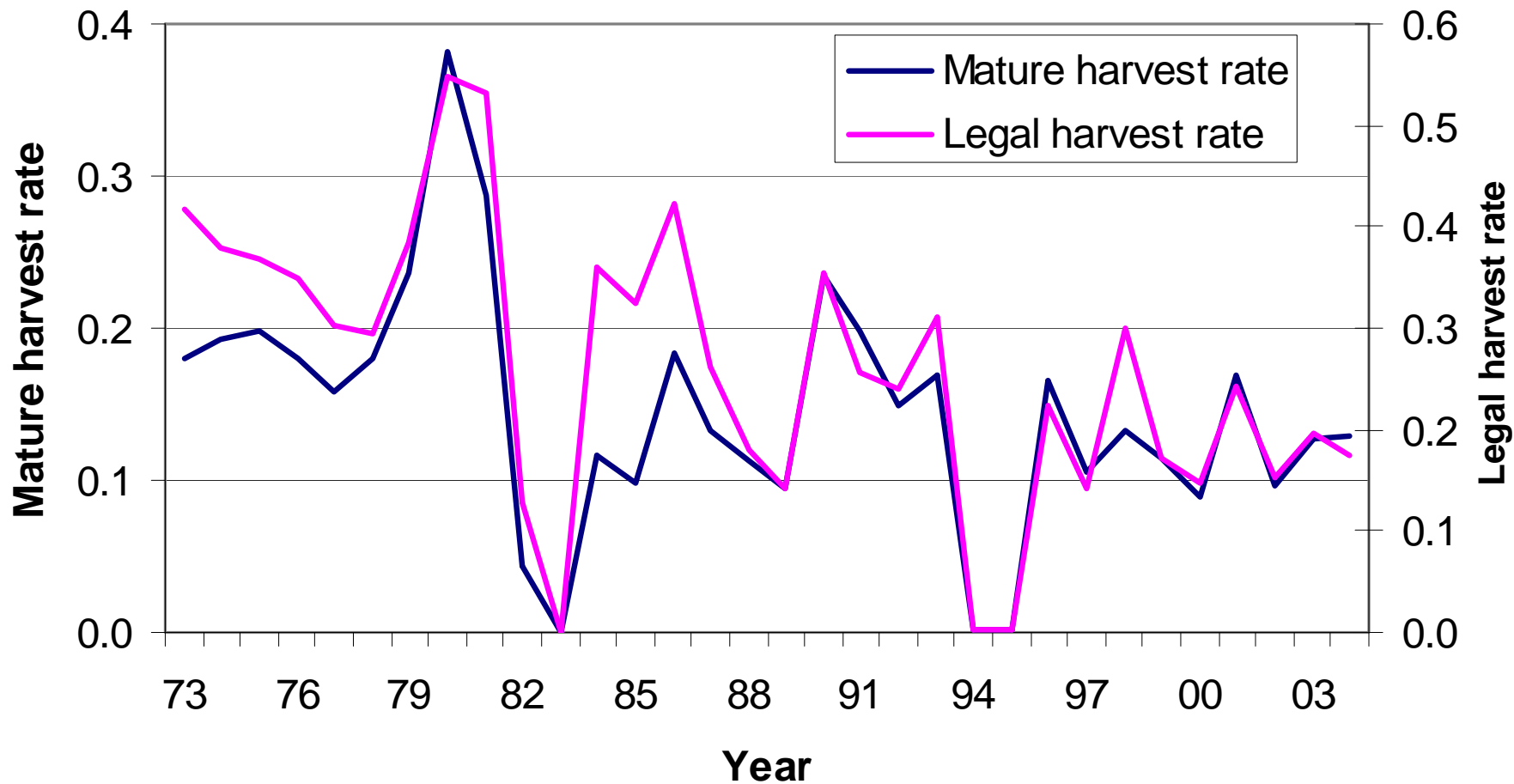
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## Speculation:

- 1) Completely wiped out by fishing:
  - ✓ Directed pot fishery
  - ✓ Indirected pot fishery (Tanner crab fishery)
  - ✓ Bottom trawling
- 2) High fishing and natural mortality

# Harvest Rates by Directed Pot Fishery

on survey abundance and time



# Directed Pot Fishery

Sharp decline of males  
during 1980-1984

Harvest Rate		Year
Matures	Legals	
0.19	0.36	73-79
0.38	0.55	1980
0.29	0.53	1981
0.04	0.13	1982
0.00	0.00	1983
0.12	0.36	1984
0.15	0.28	85-93

Sharp decline of females  
During 1981-1984

Harvest Rate		Year
Matures	Legals	
0.21	0.38	73-80
0.29	0.53	1981
0.04	0.13	1982
0.00	0.00	1983
0.12	0.36	1984
0.15	0.28	85-93

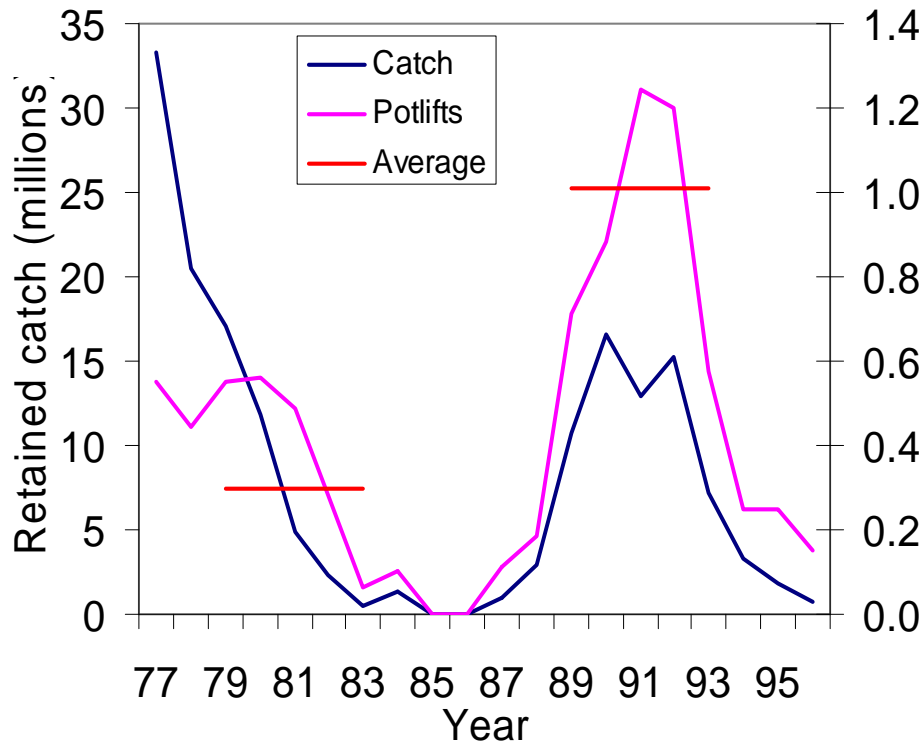
# Directed Pot Fishery

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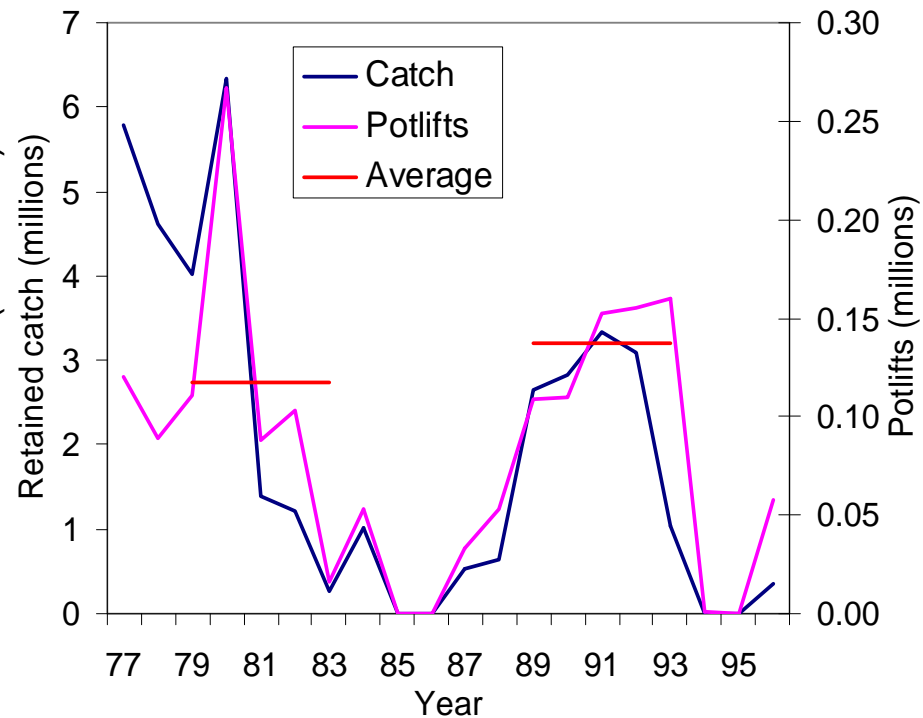
- Harvest rates in 1980 and 1981 are among the highest → directed fishing definitely had a big impact on stock decline, especially legal and mature males.
- For sharp decline during 1980-1984 for males, 3 out of 5 years with low mature harvest rates. During 1981-1984 for females, 3 out of 4 years with low mature harvest rates.
- Pot catchability for females and immature males are generally much lower than for legal males. →  
Directed pot fishing alone cannot explain sharp decline for all segments of the stock during the early 1980s.

# Bycatch Mortality From Tanner Crab Fishery

## Total Fishery

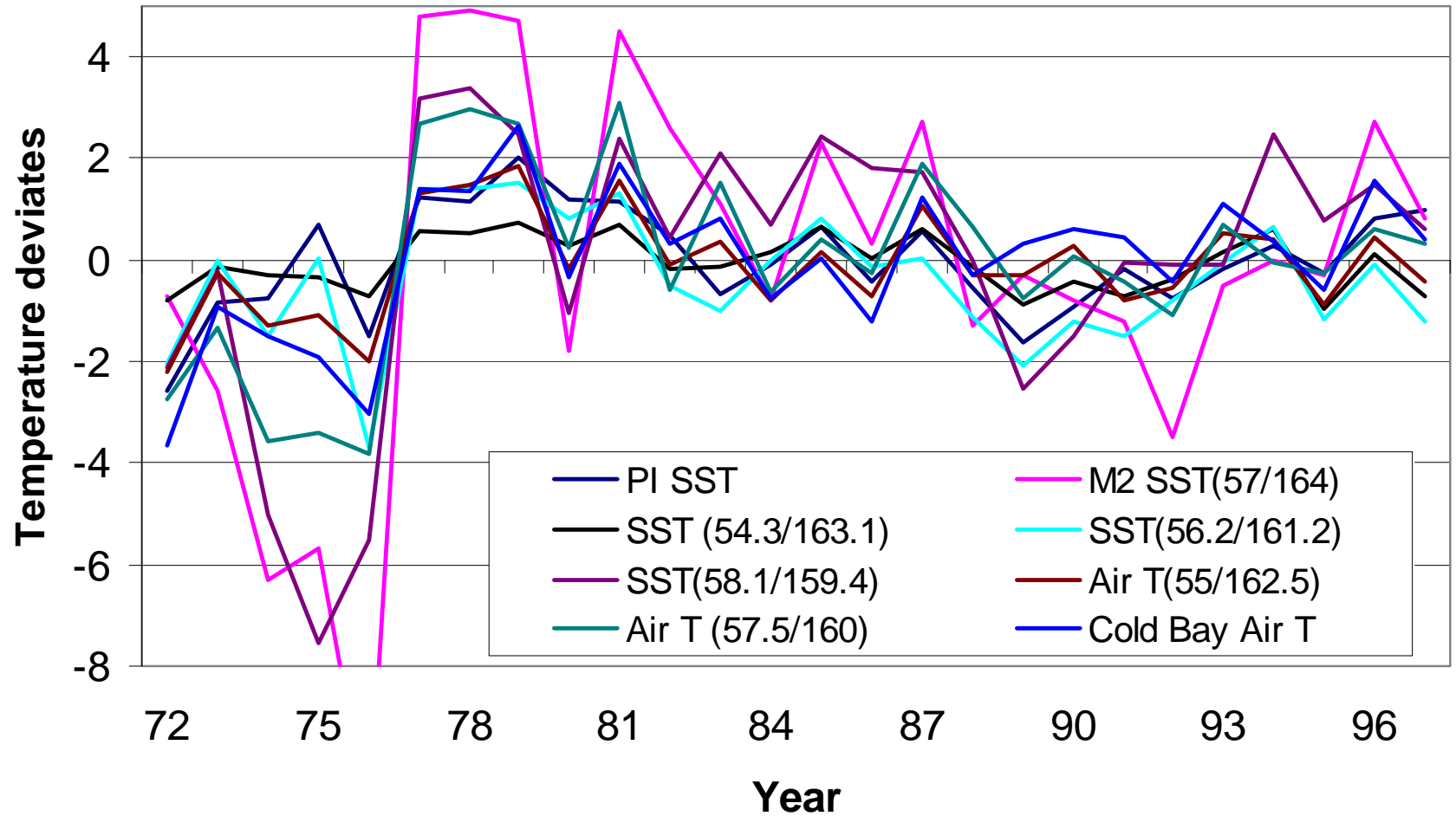


## East of 163 W



Seasons: 77-79:~11-5; 80:1/15-4/15; 81-83: 2/15-6/15; 84: 1/15-6/15;  
87-89: ~1/15-4/24; 90-92:~11/15-3/31;93-96: ~11-12.

# Bycatch Mortality From Tanner Crab Fishery



Low temperatures generally result in higher handling mortality rates

## Bycatch Mortality From Tanner Crab Fishery

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- No sufficient data to fully evaluate impact
- Red king crab bycatch could be high before 1992
- Winter SST and air T were warmer and potlifts were lots less during the early 1980s than during the early 1990s.
- Catchability for immature crabs are much lower than mature crabs

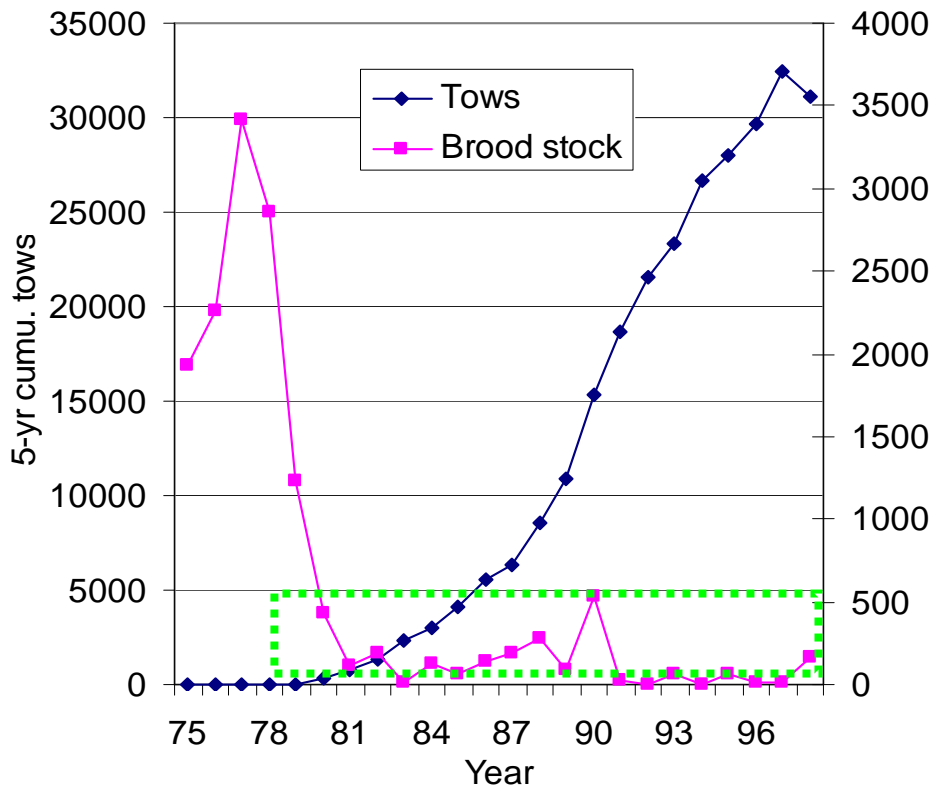
# Trawl Bycatch

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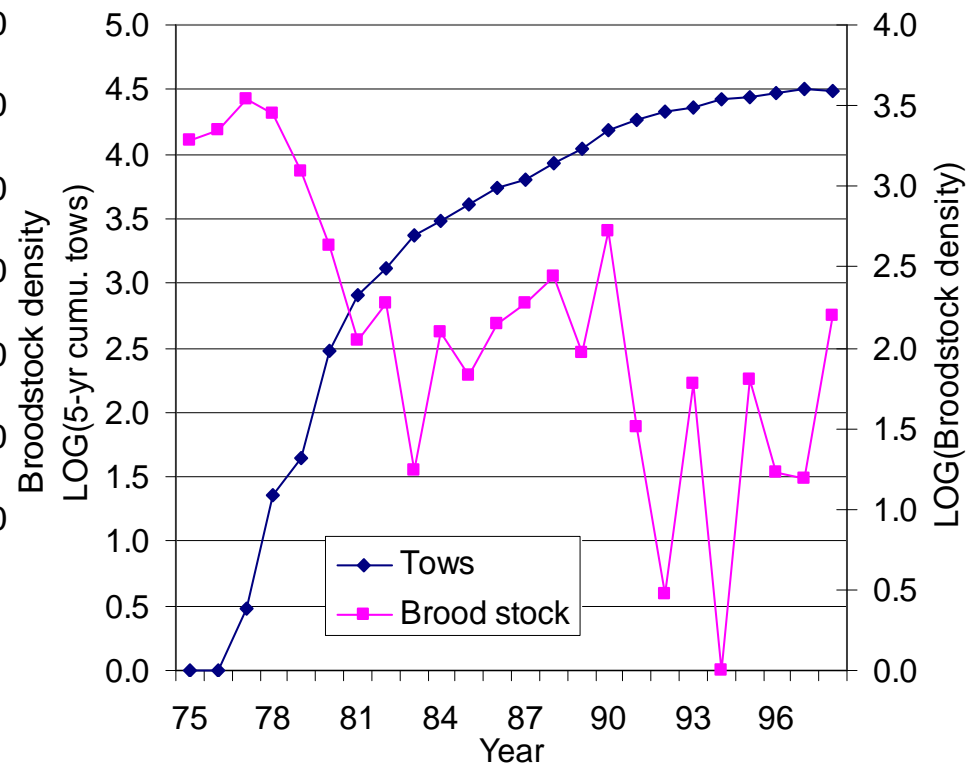
- Observed bycatch was very small relative to red king crab abundance
- Unobserved bycatch: ???
  - Incomplete bycatch reporting
  - Habitat damage

# Heavily Trawled Unimak & Amak

## Normal scale



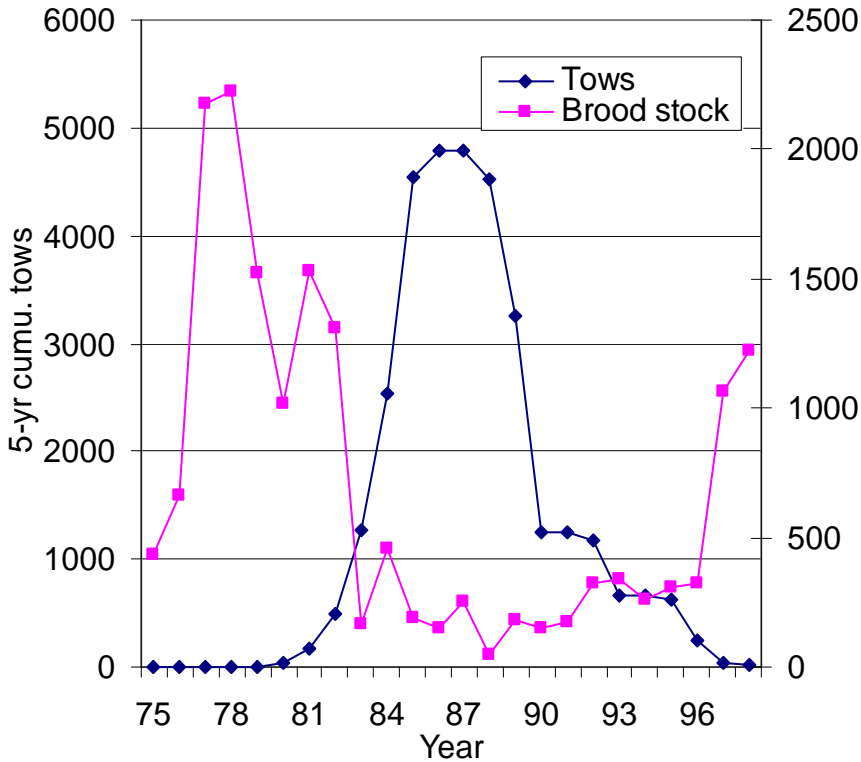
## Log scale



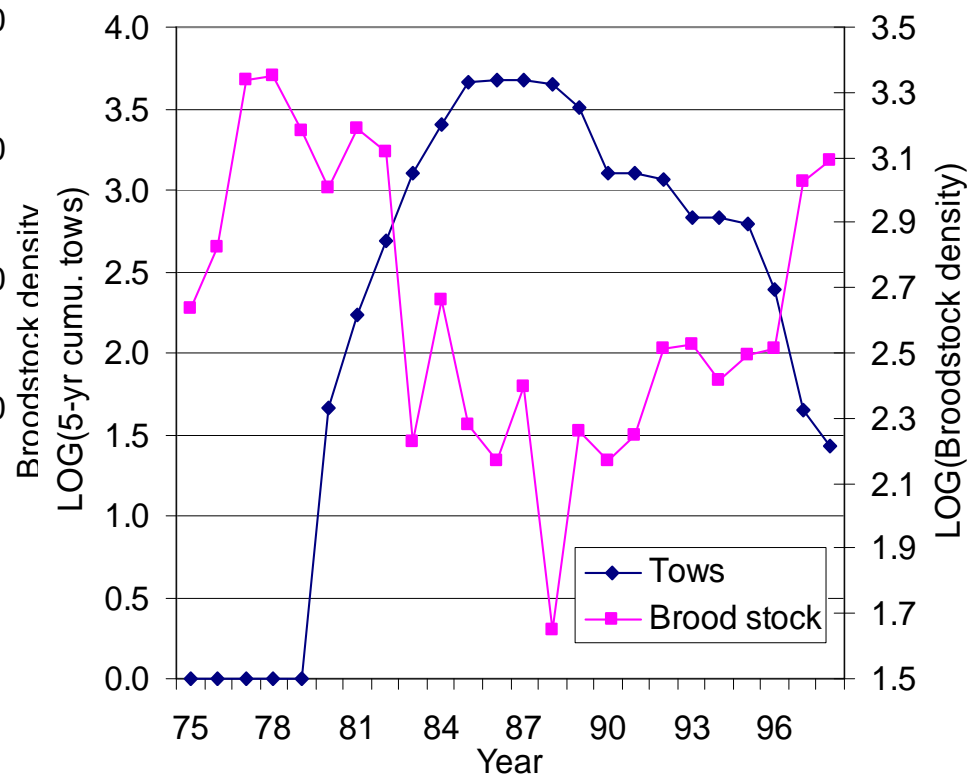
All data from Table 4 of Dew & Mcconnaughey (2005)

# Lightly Trawled North Of Port Moller

Normal scale

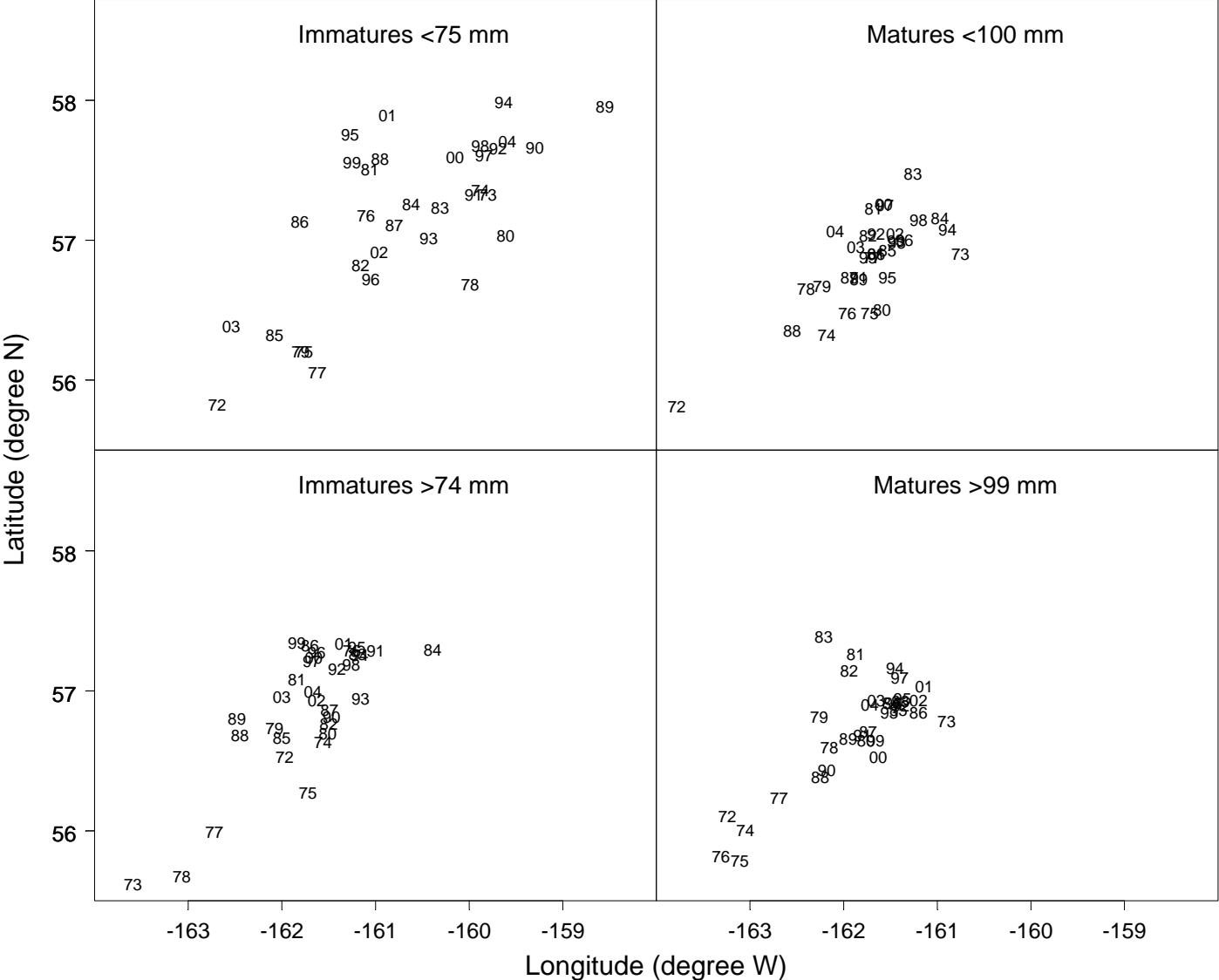


Log scale

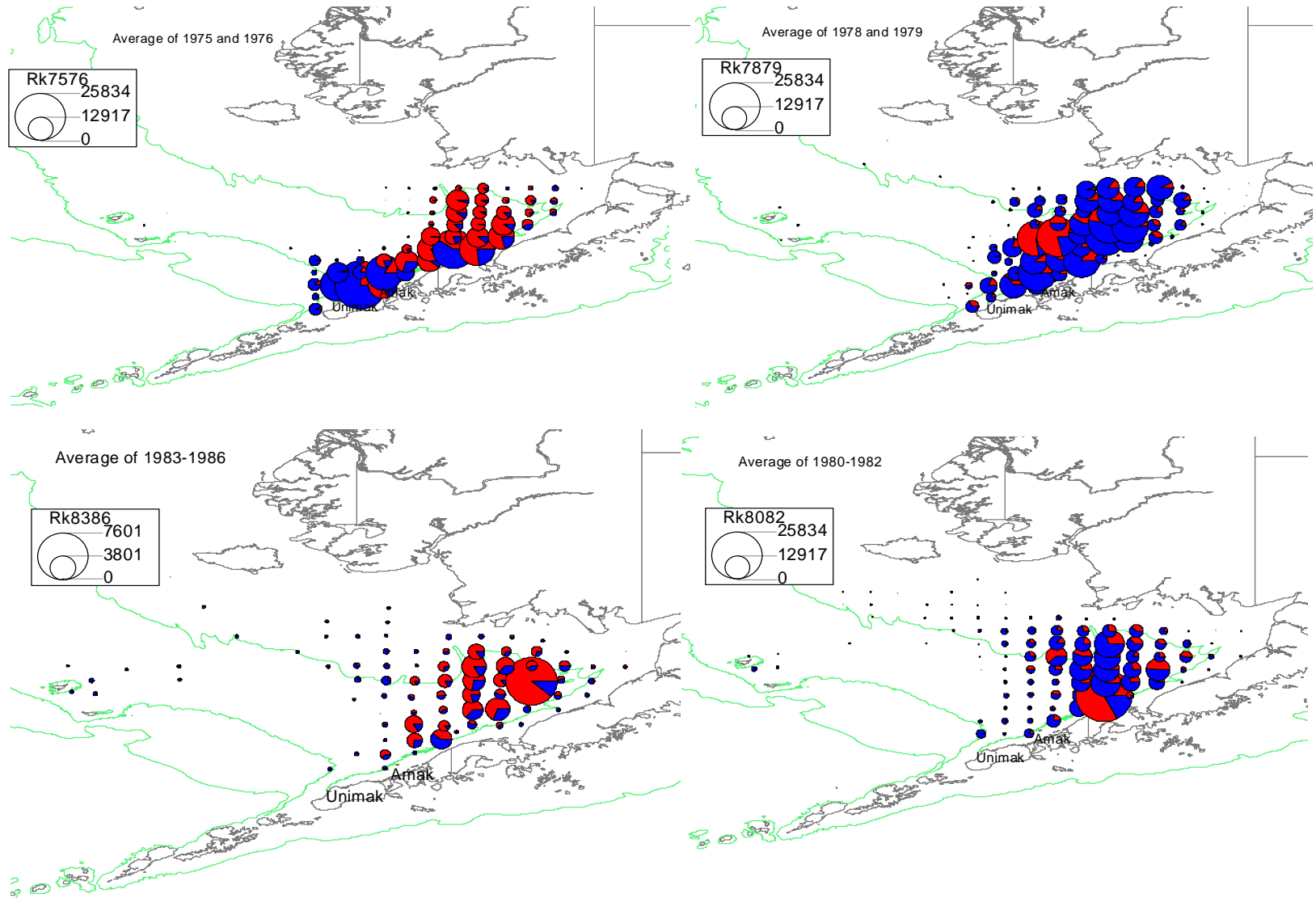


All data from Table 4 of Dew & Mcconnaughey (2005)

Distribution centers of female abundance for Bristol Bay red king crabs. Matures >99 mm CL is an approximation of multiparous females.



Geographic distributions of mature female red king crabs from 1975 to 1986 in the EBS derived from NMFS summer trawl survey data. Red color is for females <100 mm CL (primarily primiparous) and blue color for females >99 mm CL (primarily multiparous). The diameter of each pie represents crab density expressed as the number of crab per square nautical mile.



# Bottom Trawling

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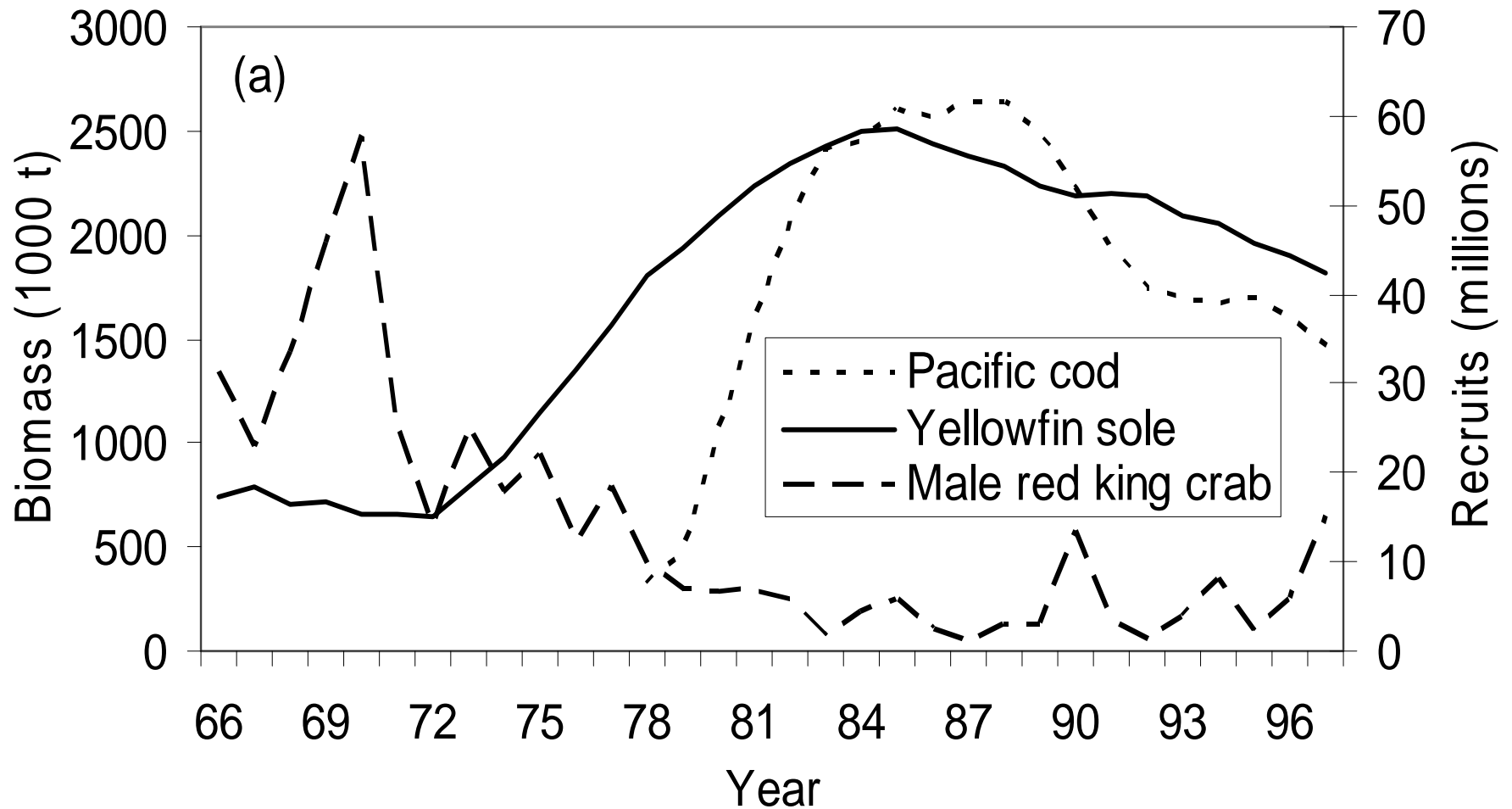
- Because of space and time mismatch of crab distribution, the bottom trawling effect may not have had a great impact on the stock decline in the early 1980s
- The distribution started to shift in 1977, and a large majority of mature females have been far away from Unimak and Amak area since 1978
- Focus should be the central Bristol Bay area where trawling and broodstocks overlapped in the mid 1980s which may have impacted crab stock rebuilding
- Unobserved bycatch could be an important factor, but there are not enough data to make a conclusion

# What Could Cause High M In Early 1980s?

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- Diseases. Diseases in the early 1980s were documented by Sparks and Morado (1985), but inadequate data were collected to examine their effects on the stock
- Senescence. Stevens (1990) speculated that senescence may be a factor because many crabs in the early 1980s were very old due to low temperature in the 1960s and early 1970s
- Groundfish predation. The biomass of the main crab predator, Pacific cod, increased about 10 times during the late 1970s and early 1980s. Yellowfin sole biomass also increased substantially during this period. Predation is primarily on juvenile and molting/softshell crabs. But we lack stomach samples in shallow waters (juvenile habitat) and during the period when red king crabs molt.

## Pacific cod and yellowfin sole biomass in the eastern Bering Sea and Bristol Bay male red king crab recruitment



# Summary of Early 1980s

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- High fishing mortality in 1980 and 1981
- Bycatch from the Tanner crab fishery
- Trawl observed and unobserved bycatch
- Older crabs due to slow growth in late 60s and early 1970s
- Disease due to record population density
- Main predator biomass increased 10 times within a few years and highly concentrated in Bristol Bay
- Due to lack of data, unable to quantify the extent to which each factor contributed to the stock decline
- Likely causes: Pot fisheries on legal males, bycatch and predation on females and juvenile and sublegal males, senescence on older crabs, and disease on all crabs

# Key Features of Ecosystem-based Management since 1994

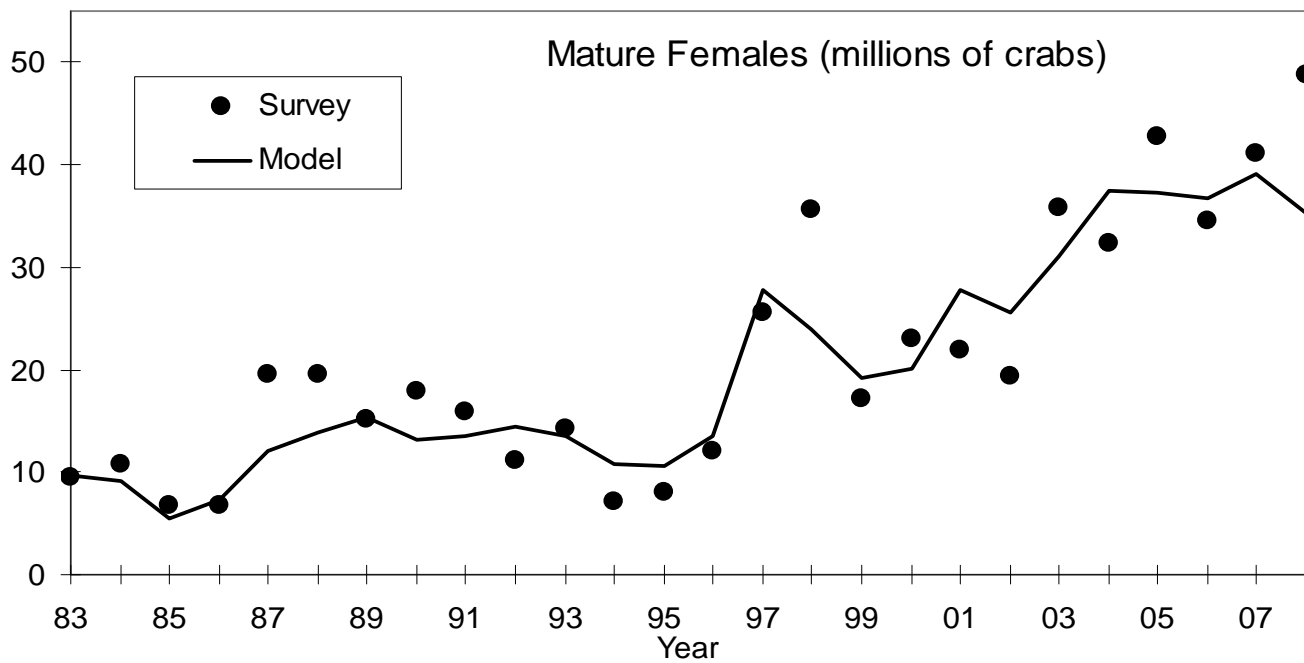
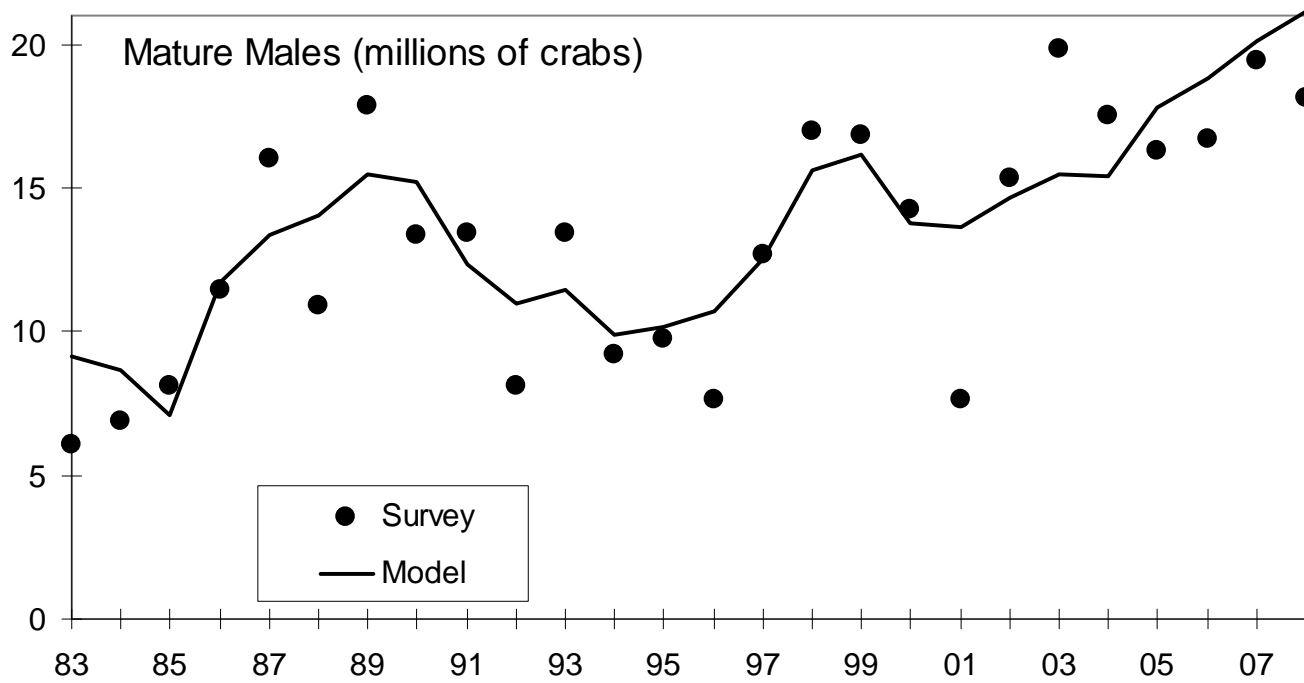
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- Length-based analysis removes subjectivity from annual assessments
- Reduced harvest rate and threshold provide for conservative harvest strategy
- Bycatch caps and area closures constrain trawling impacts
- Fishing effort reduced from 302 vessels in 1991 to 81 vessels in 2006
- Restricted Tanner crab fishing grounds to reduce red king crab bycatch
- Stock appears to have responded to ecosystem-based management approach since 1994 including reduced fishing mortality, low bycatch, habitat protections, and reduced fishing effort.



Thanks

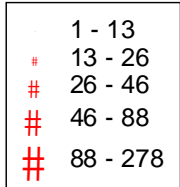




Pacific cod cpue  
1982-84

# No.1 crab predator

Pacific cod cpue  
1985-88, 1991-96



Pacific cod cpue  
1989-90

Pacific cod cpue  
1997-04

