

# Western Steller Sea Lions:

Population Trends, Vital Rates,  
Composition and Movement



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NOAA Fisheries

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Seattle, WA



# Outline

## Abundance and Trends

- 2011 pups and non-pups - wDPS
- 2012 update - Aleutians

## Survival (Vital Rates)

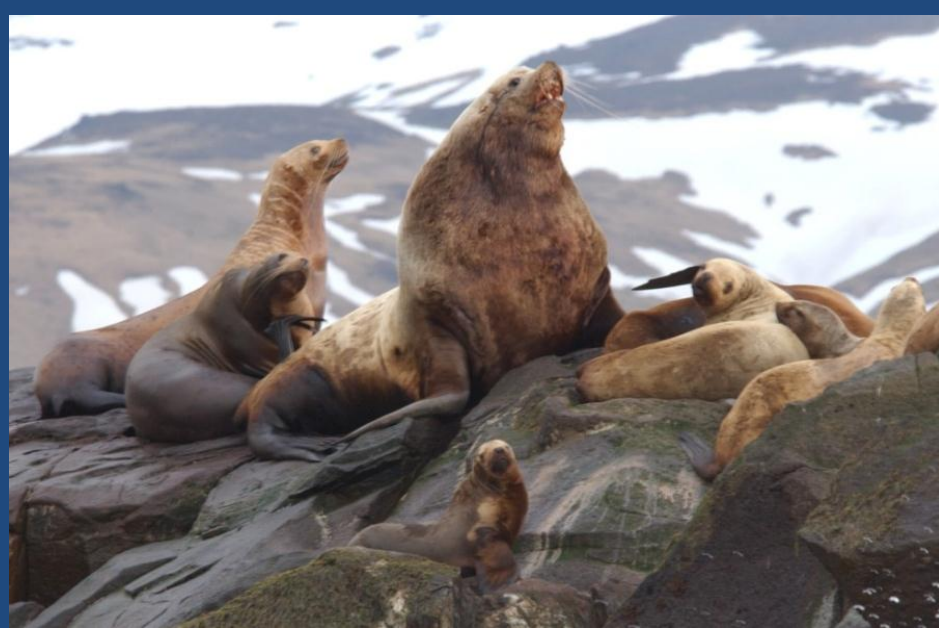
- wDPS: E Aleutians – E Gulf of Alaska
- Comparisons with SE AK (eDPS)
- Changes in wDPS survival 1970s-2000s
- Possible relationships between survival, natality, population trends and differences in life history between E & W DPSs

## Composition

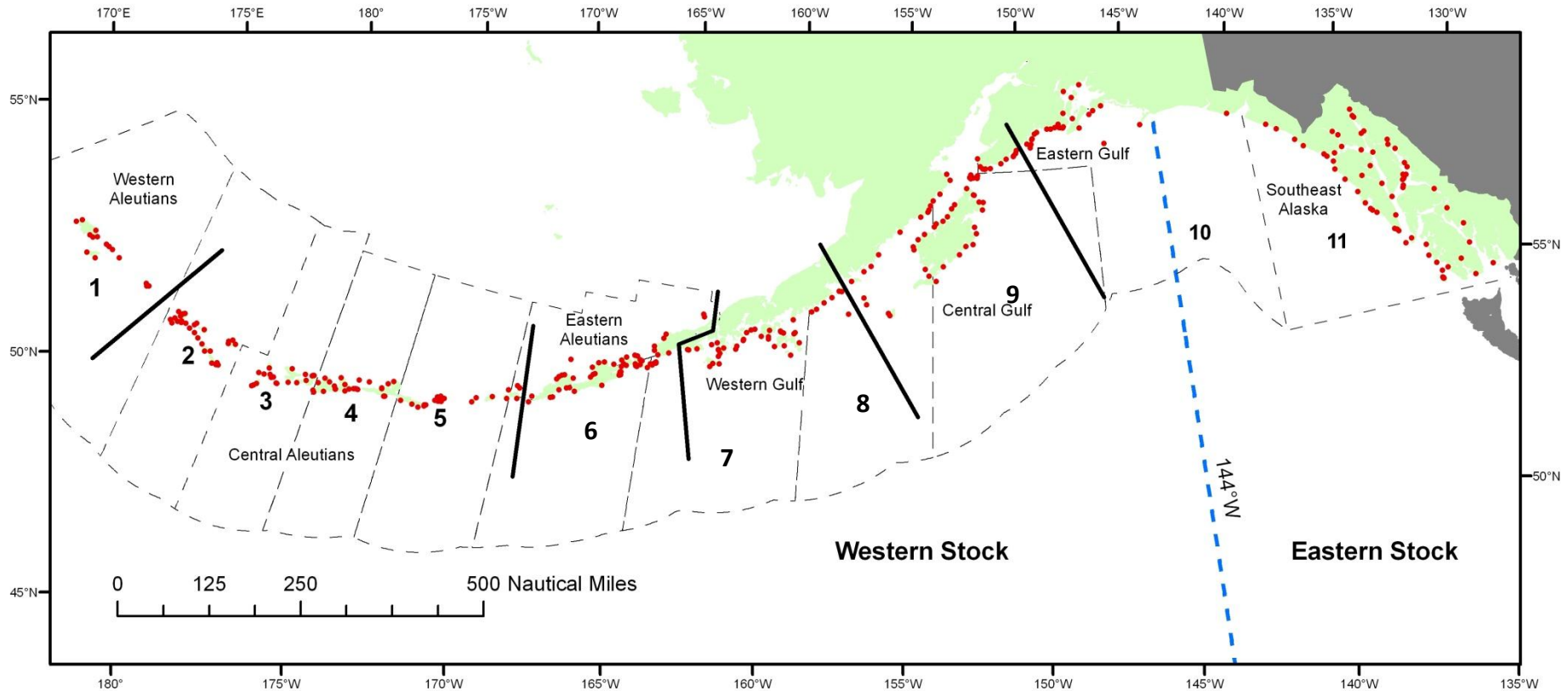
- Pup/Female ratios by region in AK – relative natality
- Length Distribution by region in AK
  - Sizes of adult females
  - Proportion juvenile – implications for vital rates

## Movement to and from Aleutians and Russia

- Russian branded sea lions in US and vice versa
- eDPS and Gulf of Alaska brands in the Aleutians



# Steller Sea Lion Stocks and Regions in AK



- Eastern and Western Distinct Population Segments (DPS)
- Eastern, Central, Western Aleutians & Gulf of Alaska; SE AK
- Rookery Cluster Areas 1-11

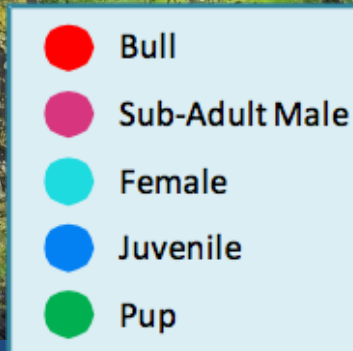
# Steller Sea Lion Aerial Surveys



# Western Stock

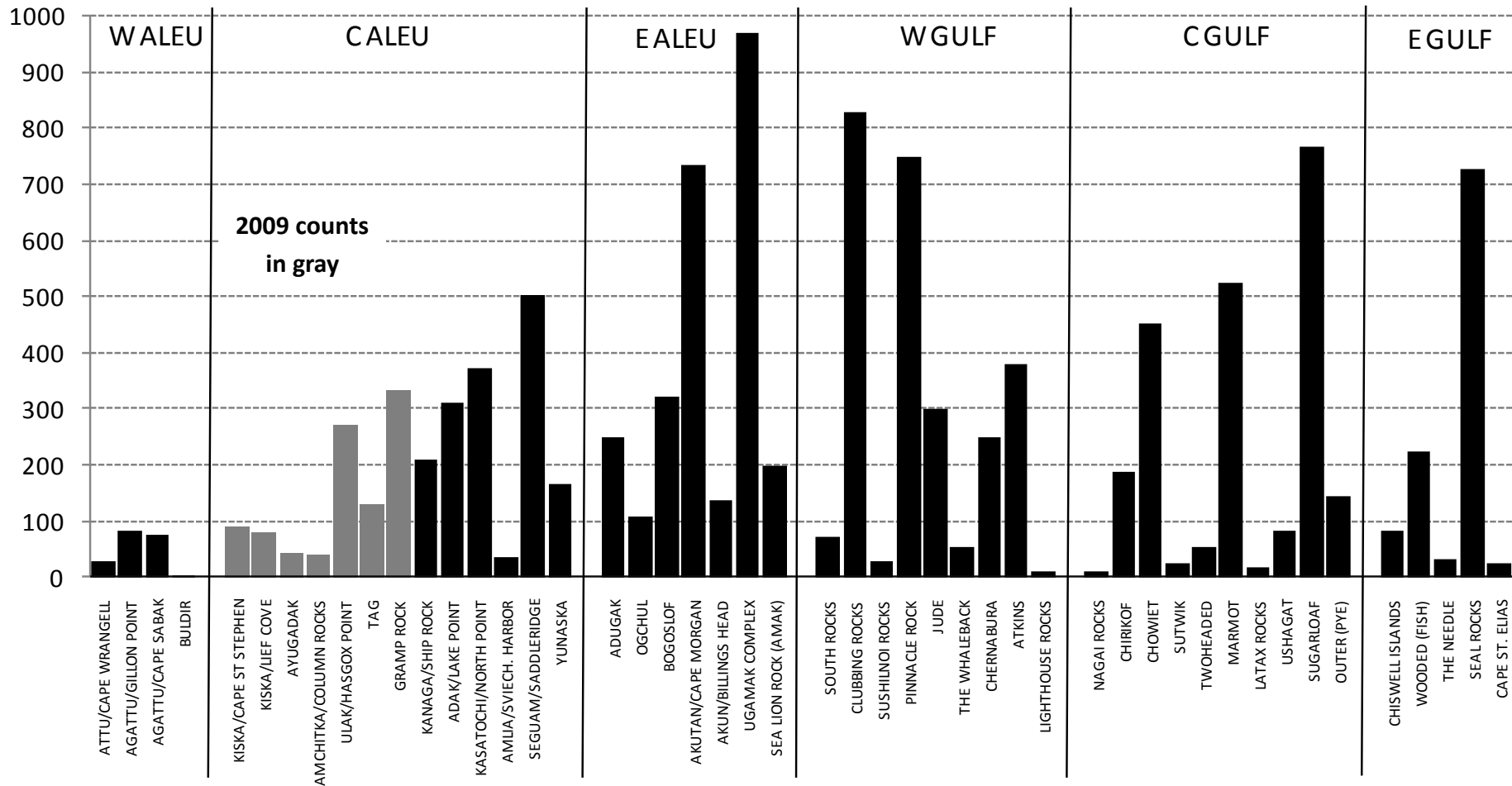
Ulak/Hasgox Point – Central Aleutians

Decreasing: 272 Pups  
515 Adults and Juveniles



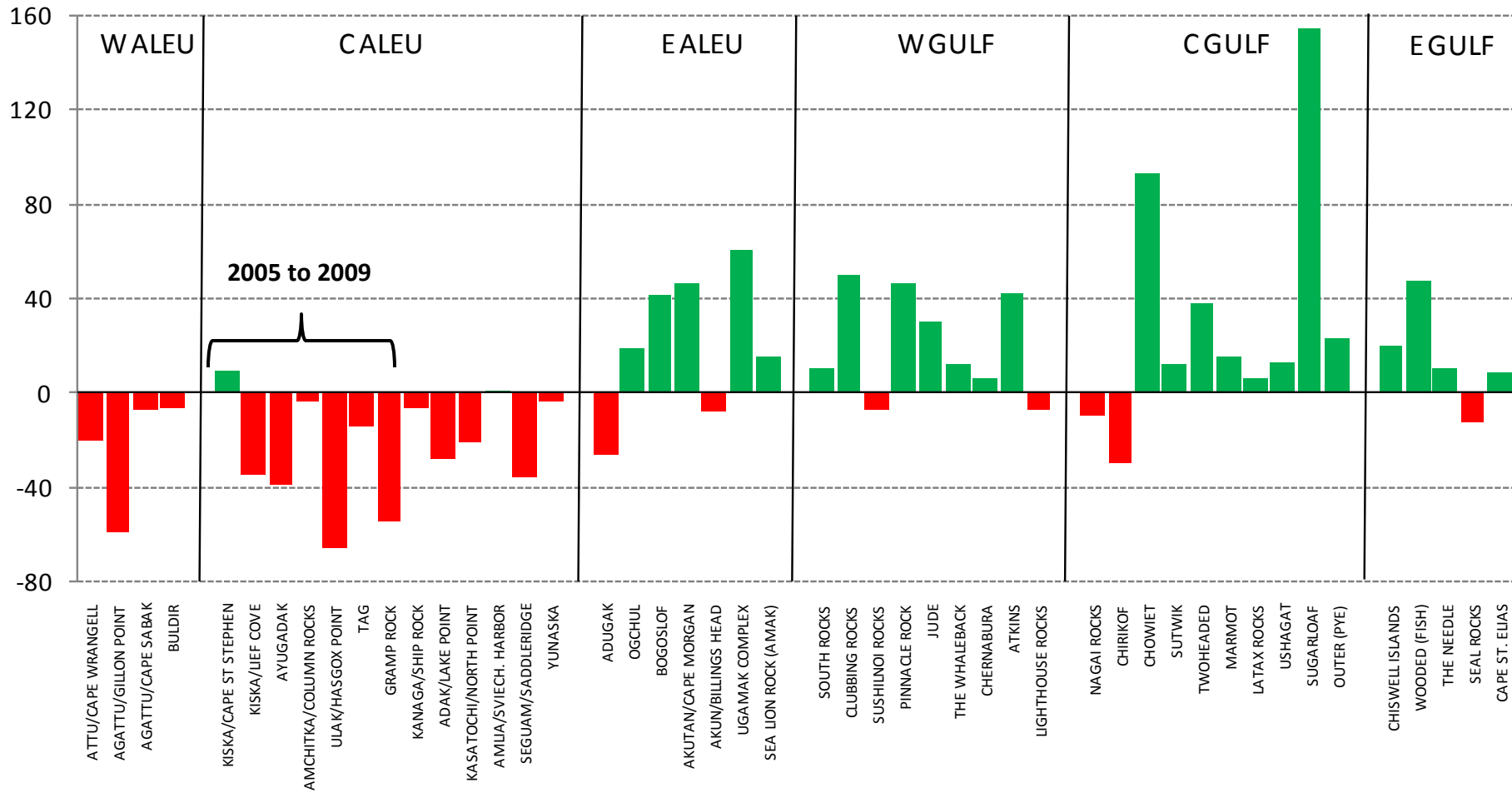
# SSL Pup Counts 2009 & 2011

- All rookeries
- Major haulouts
- Western DPS in AK



# Change in SSL Pup Counts 2009 to 2011

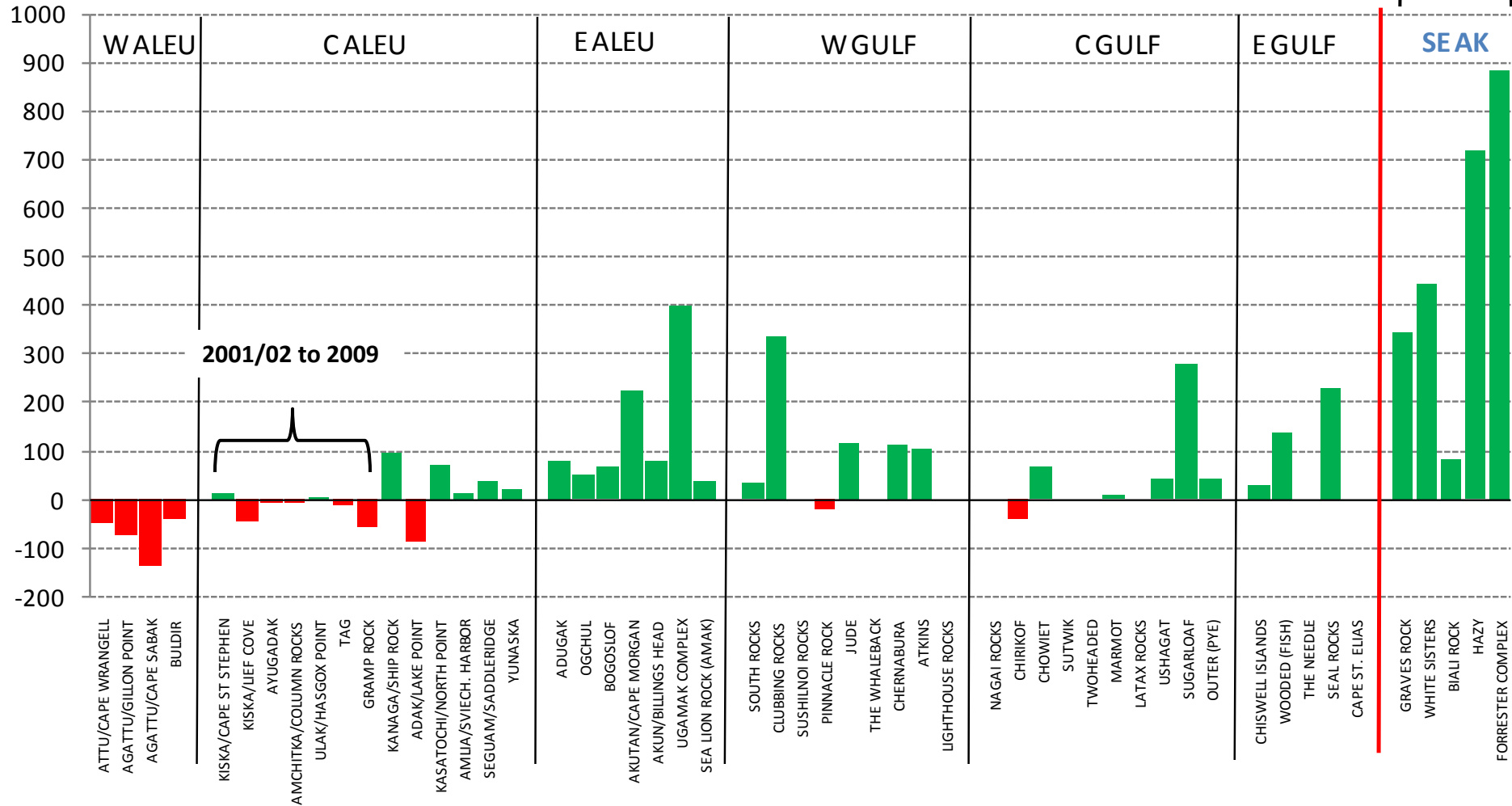
- All rookeries
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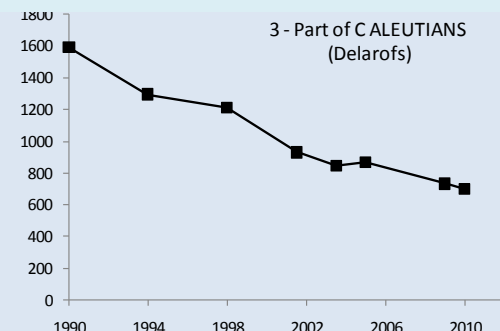
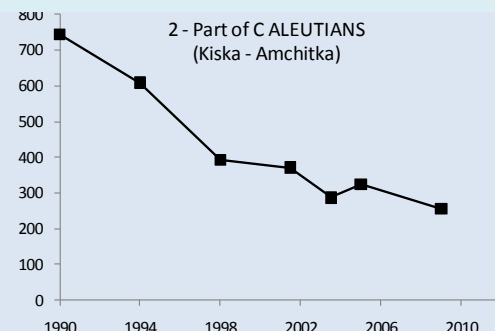
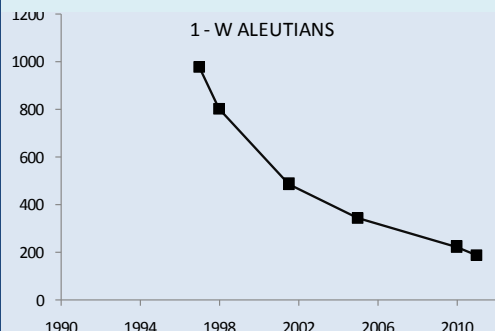
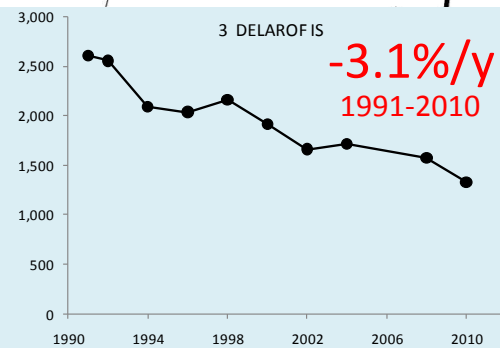
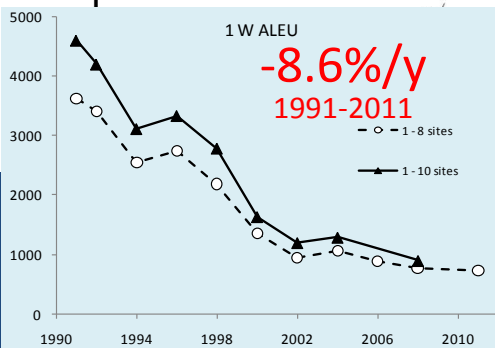
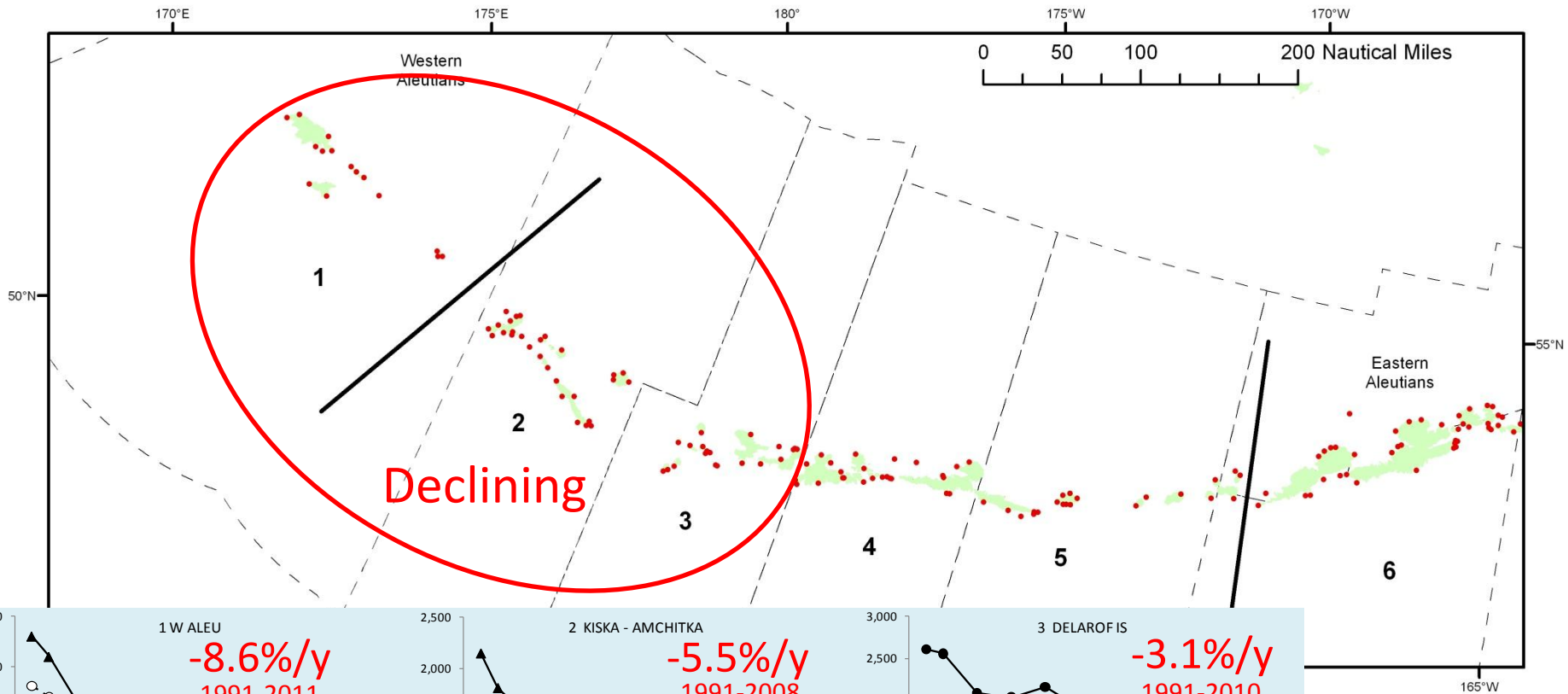
# Change in SSL Pup Counts 2001/02 to 2009 or 2011

- All rookeries
- Major haulouts
- Eastern & Western DPS in AK

2001/02 to 2009

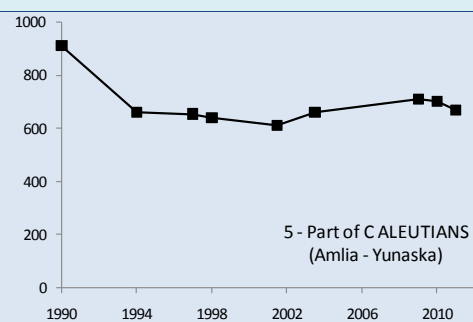
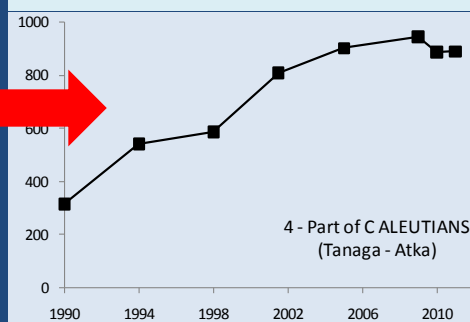
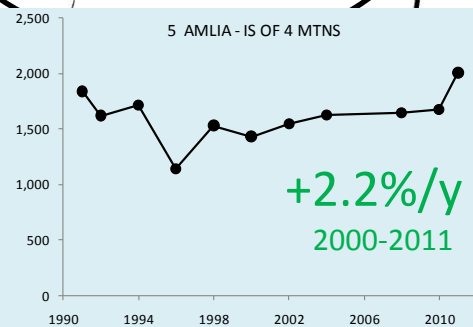
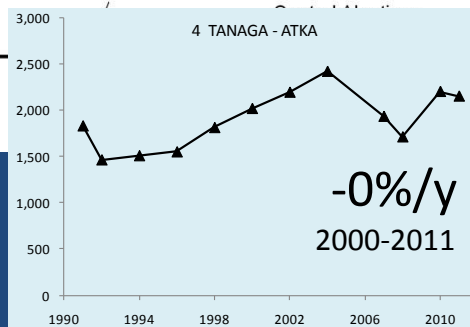
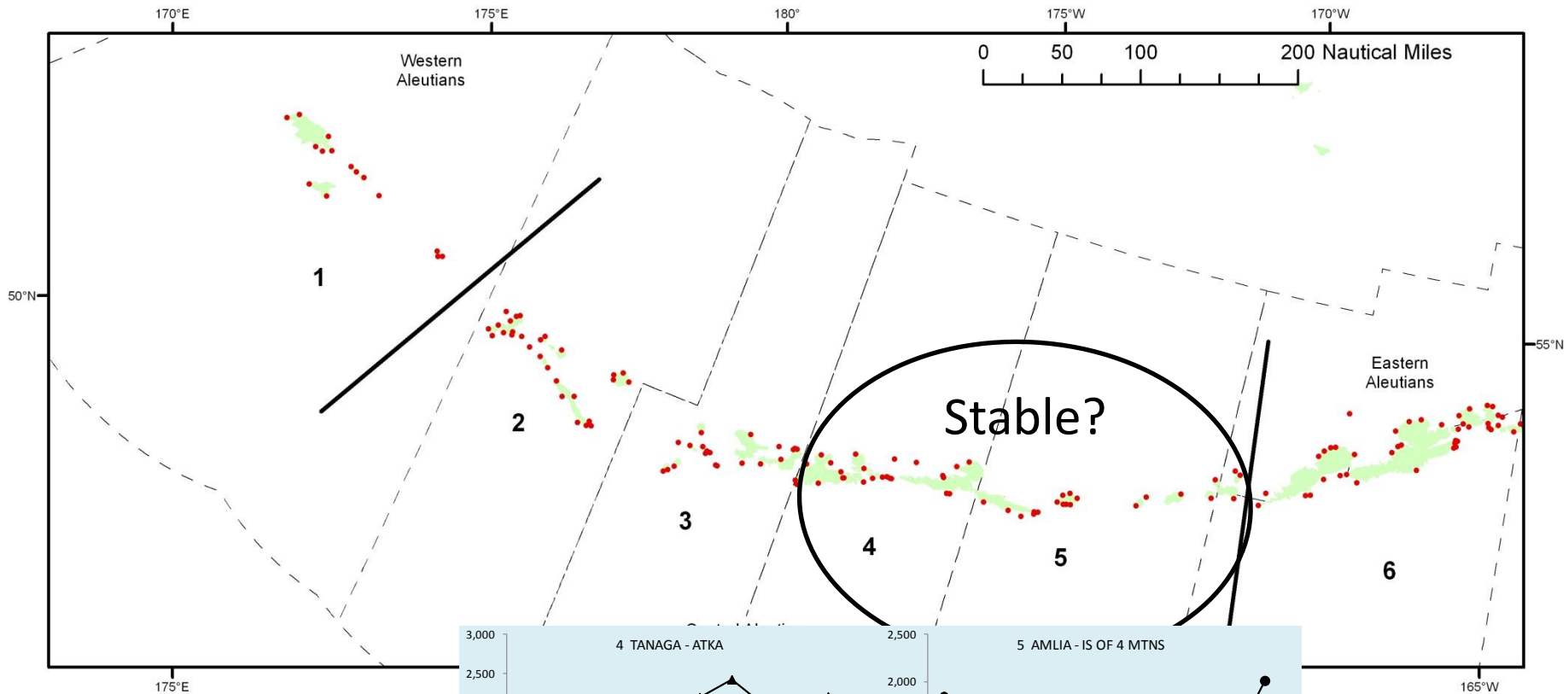






Non-Pups

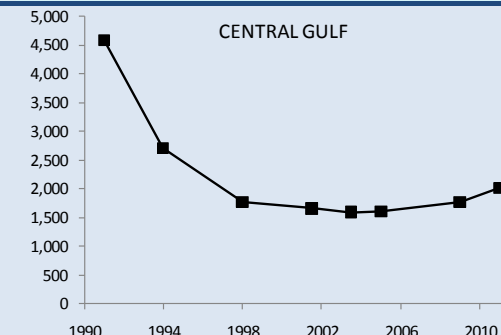
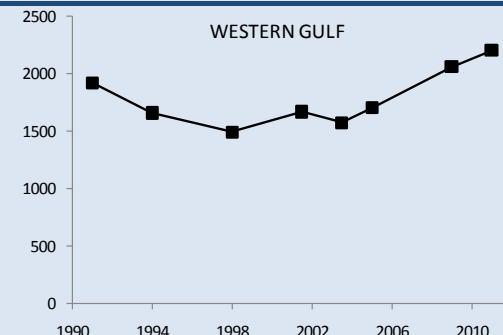
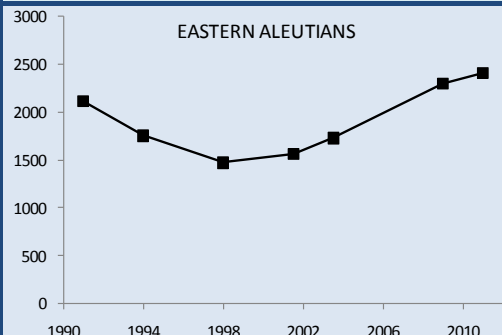
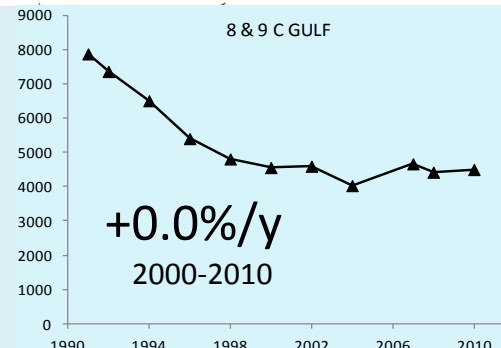
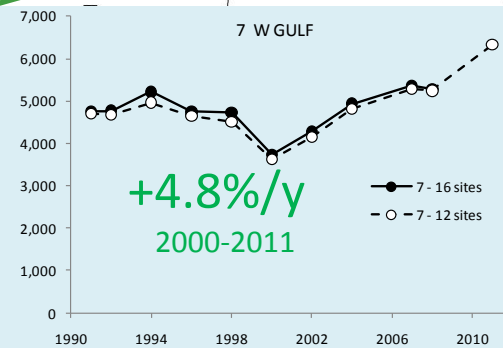
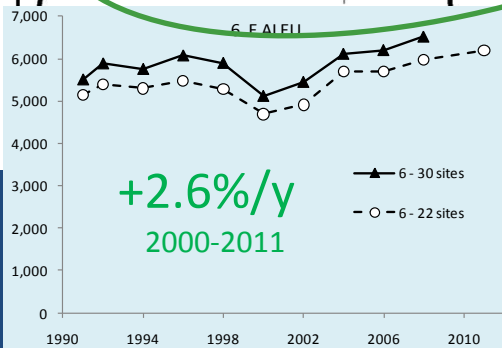
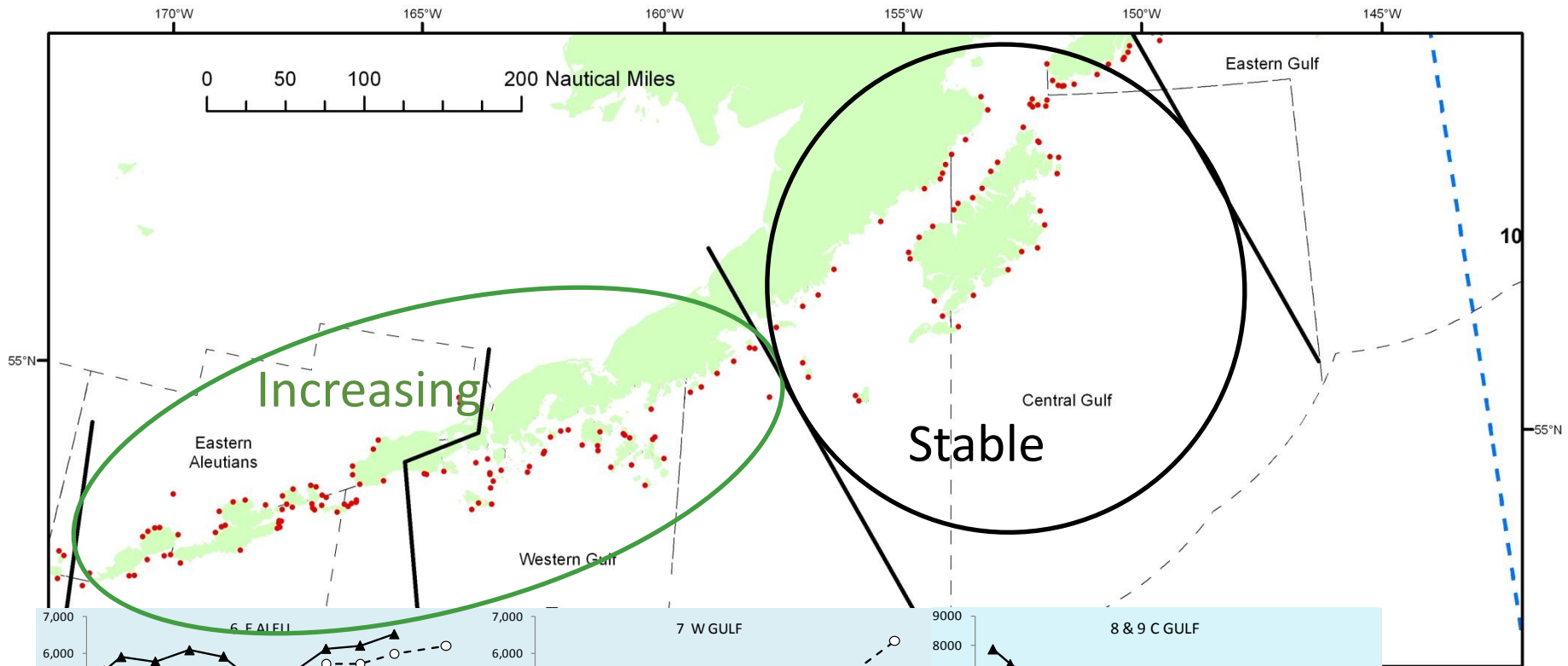
Pups



Non-Pups

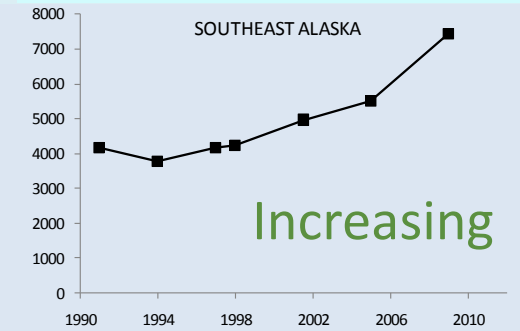
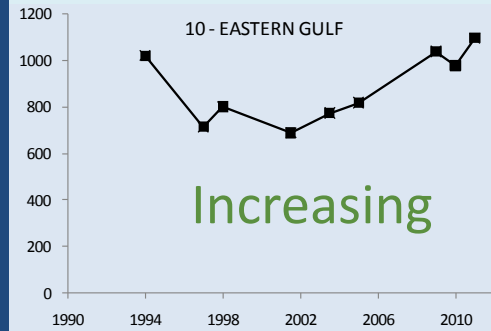
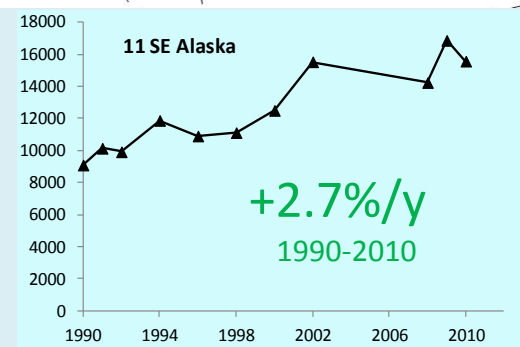
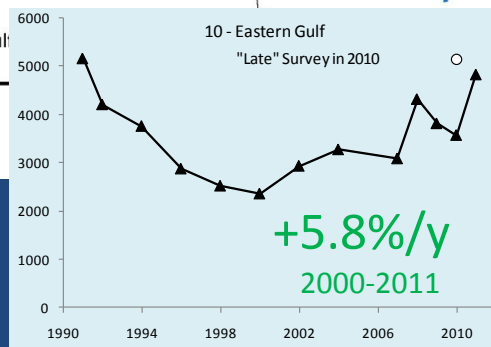
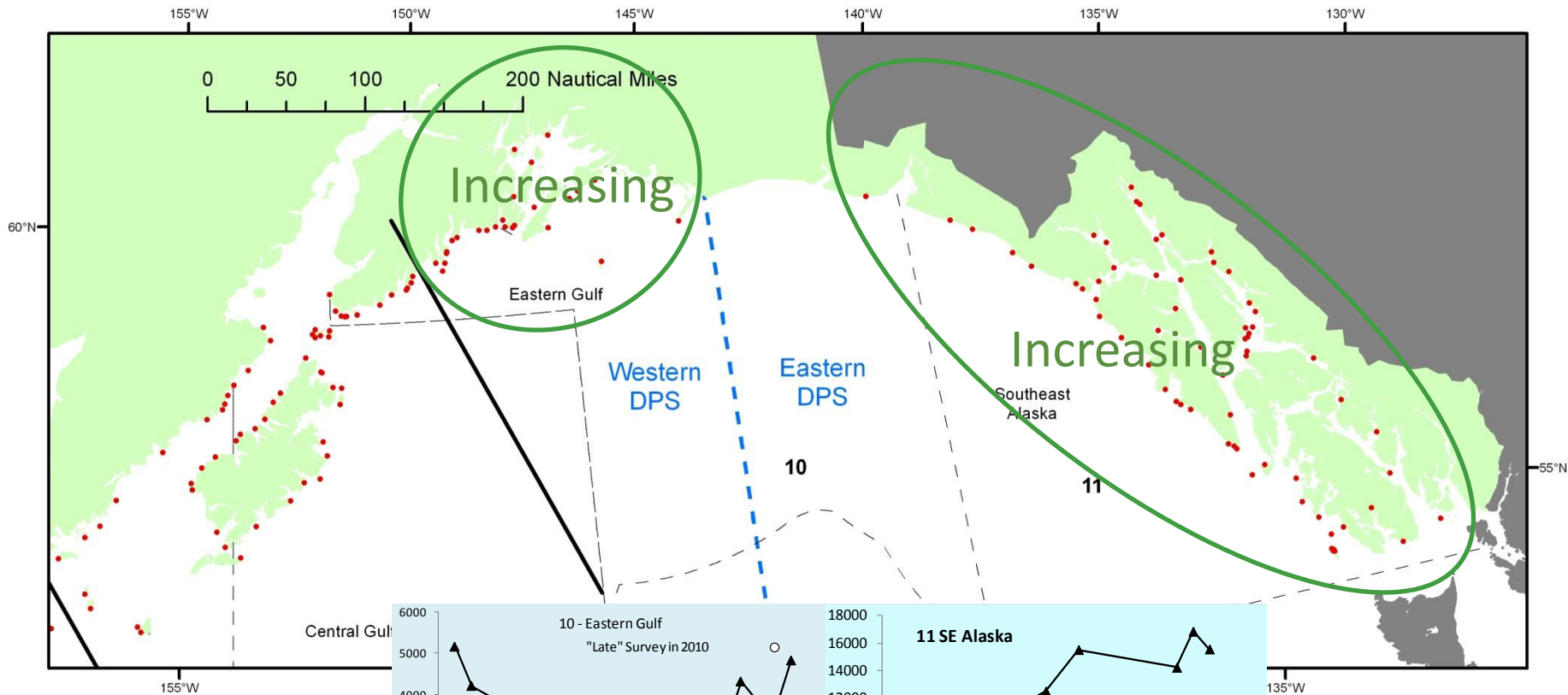
Pups

AREA 4 – ONLY PART OF CENTRAL/WESTERN ALEUTIANS THAT HAD AN INCREASING PUP TREND 1990-2011



Non-Pups

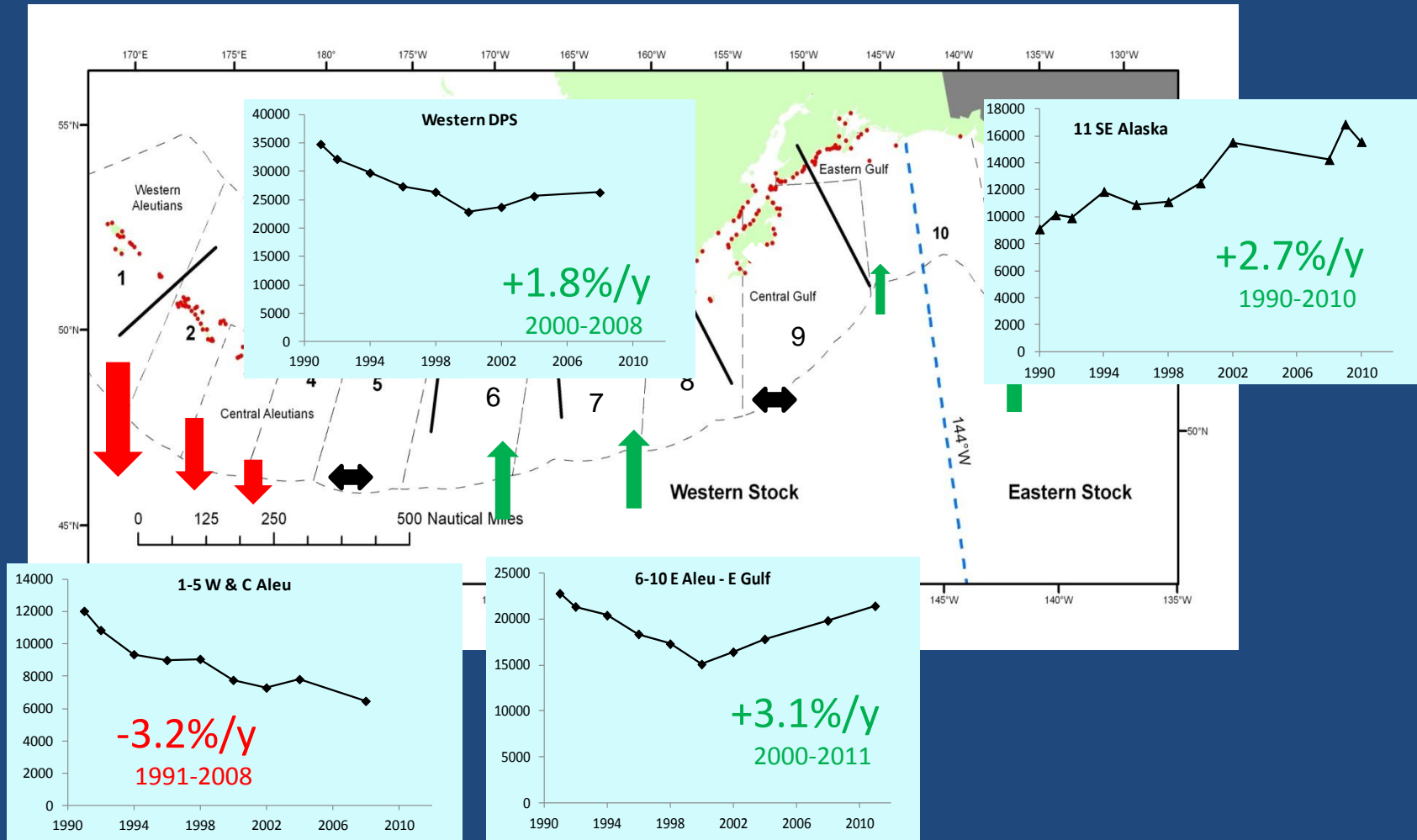
Pups



Non-Pups

Pups

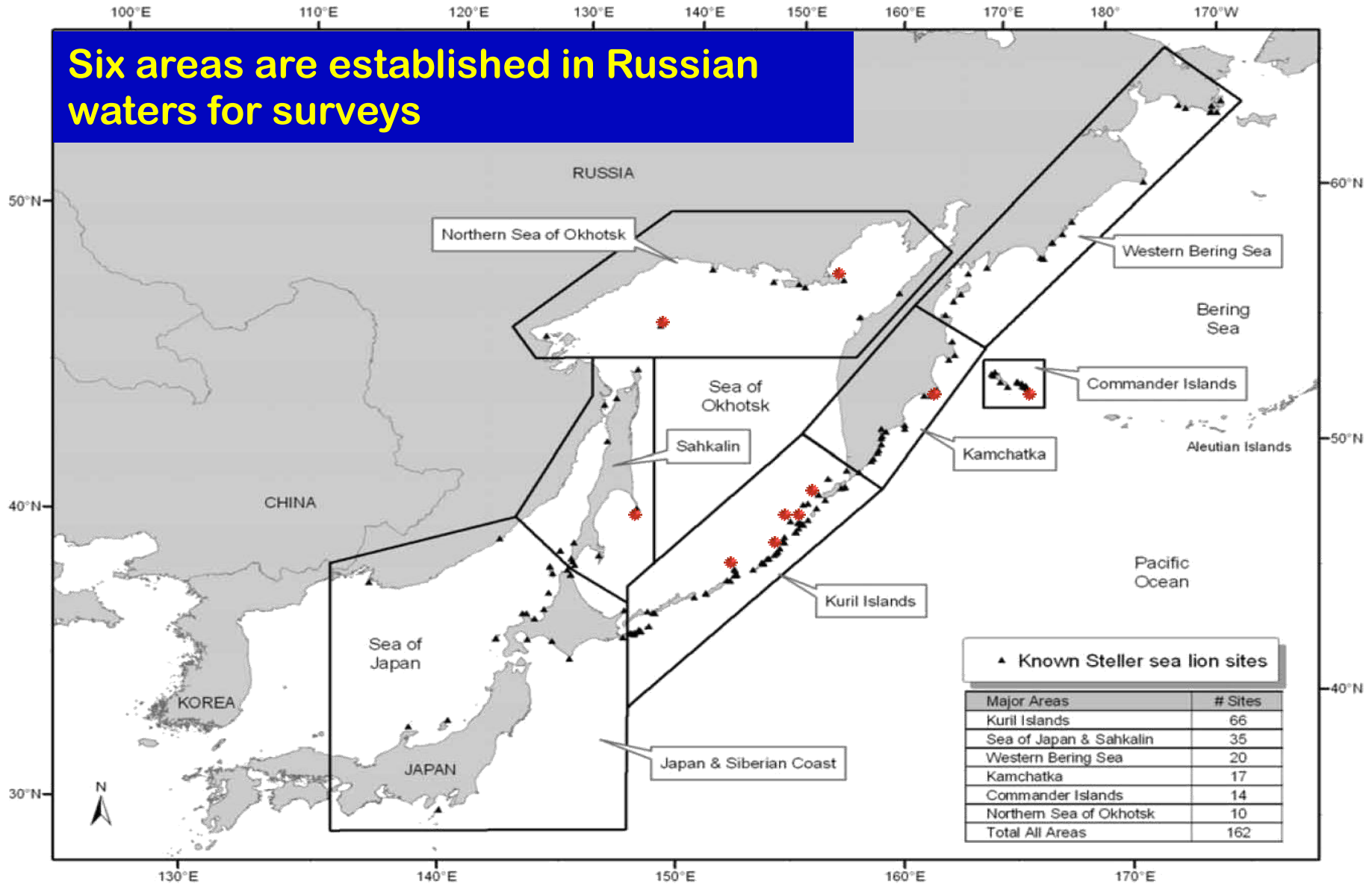
# Steller Sea Lion Non-Pup Population Trends in AK



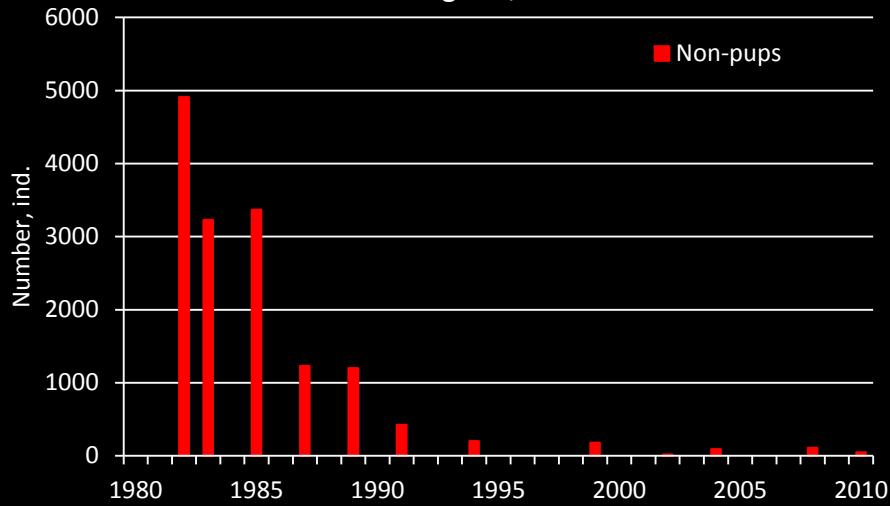
- Similar increasing trends in EAI-EGOA and SE AK ( $\sim+3\%/y$ )
- Decreasing trend in W&C Aleutians ( $\sim-3\%/y$ )
- Increasing trend in western DPS ( $\sim2\%/y$ )

# SSL survey areas in Russian waters

Six areas are established in Russian waters for surveys



Western Bering Sea, 1980-2010



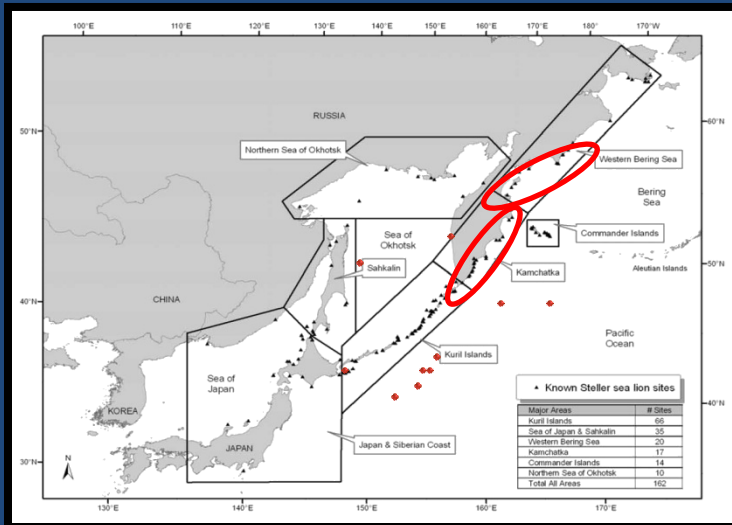
## Western Bering Sea Non-Pups

\* 98% decline since 1982

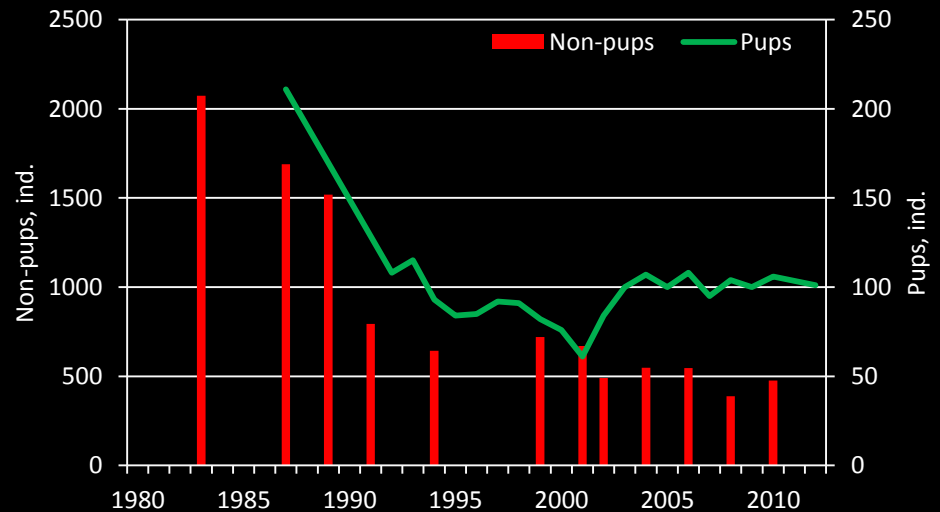
## Eastern Kamchatka:

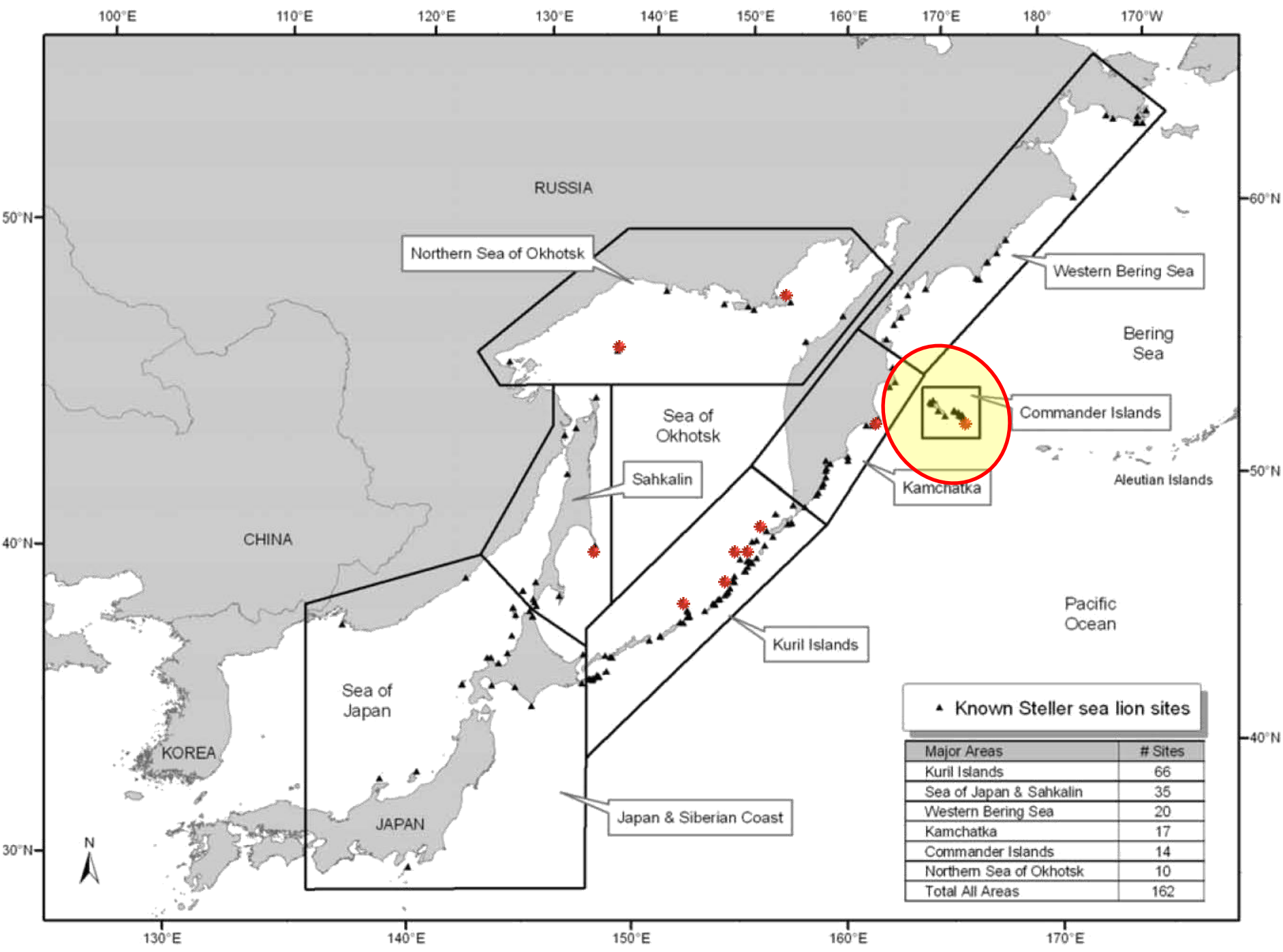
\* non-pups 81% decline since 1983

\* pups 50% decline since 1986



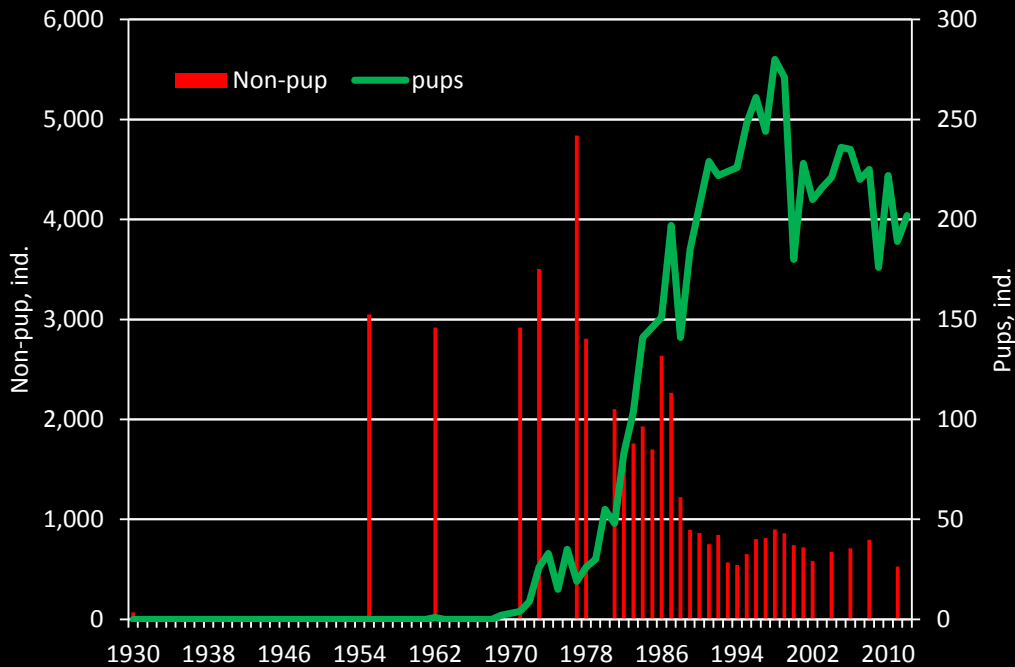
Eastern Kamchatka, 1983-2012







Commander Islands, 1930-2011



## Commander Island SSLs

- Non-Pups increase 1930-1950s followed by decline through 80s
- Rookery reestablished late 70s
- Pups increase through 1990s
- 2000-2008 fluctuating at low level
  - 500-800 non-pups
  - 180-220 pups

## Medny I. rookery 2011:

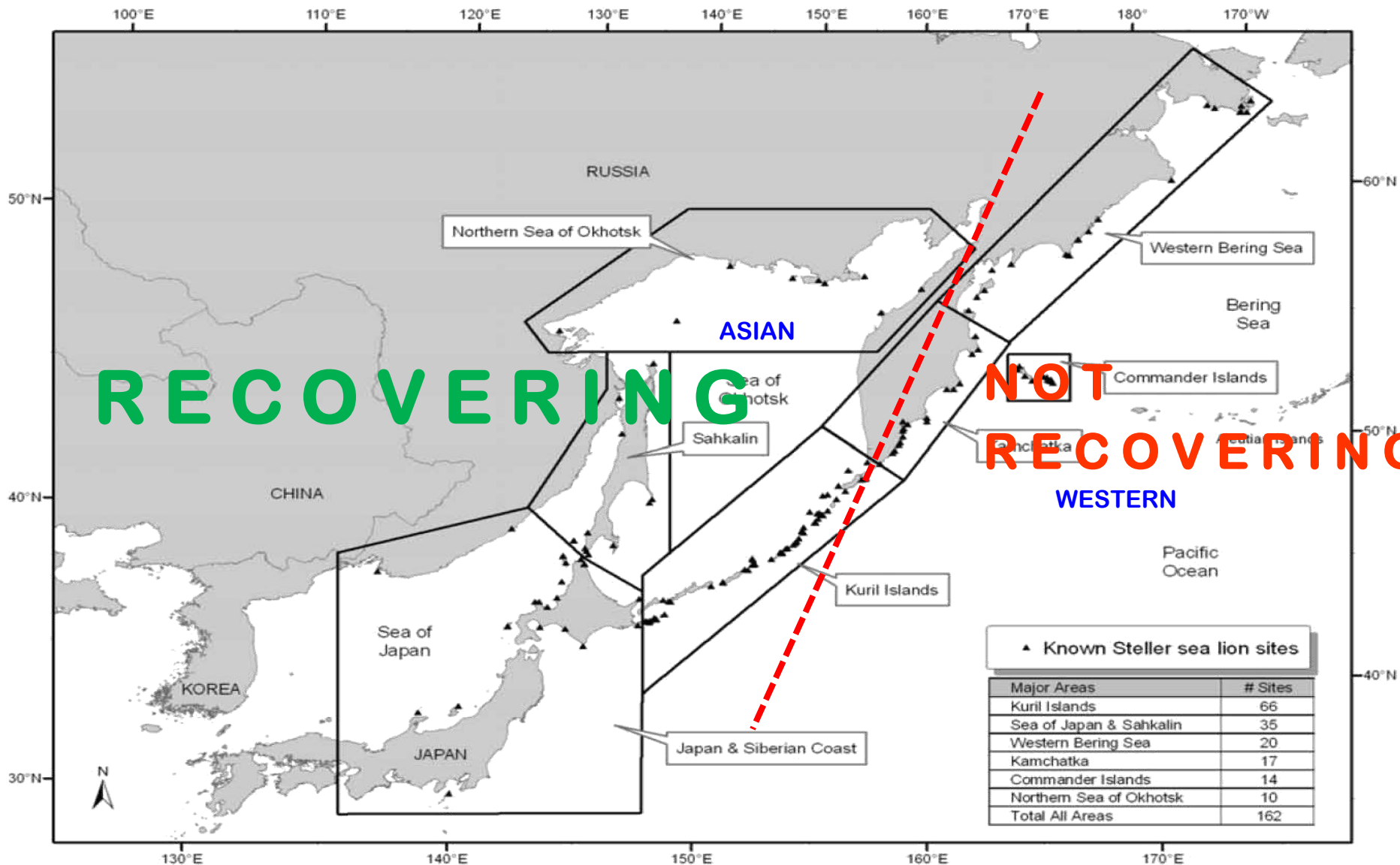
- pup born 189 -10%
- non-pup, max 297 -30%
- females, max 205 -20%
- Bulls total, max 67 -20%
- Bulls ter., max 46 -18%

**No decline in number “M” branded animals resighted in 2009-2011**

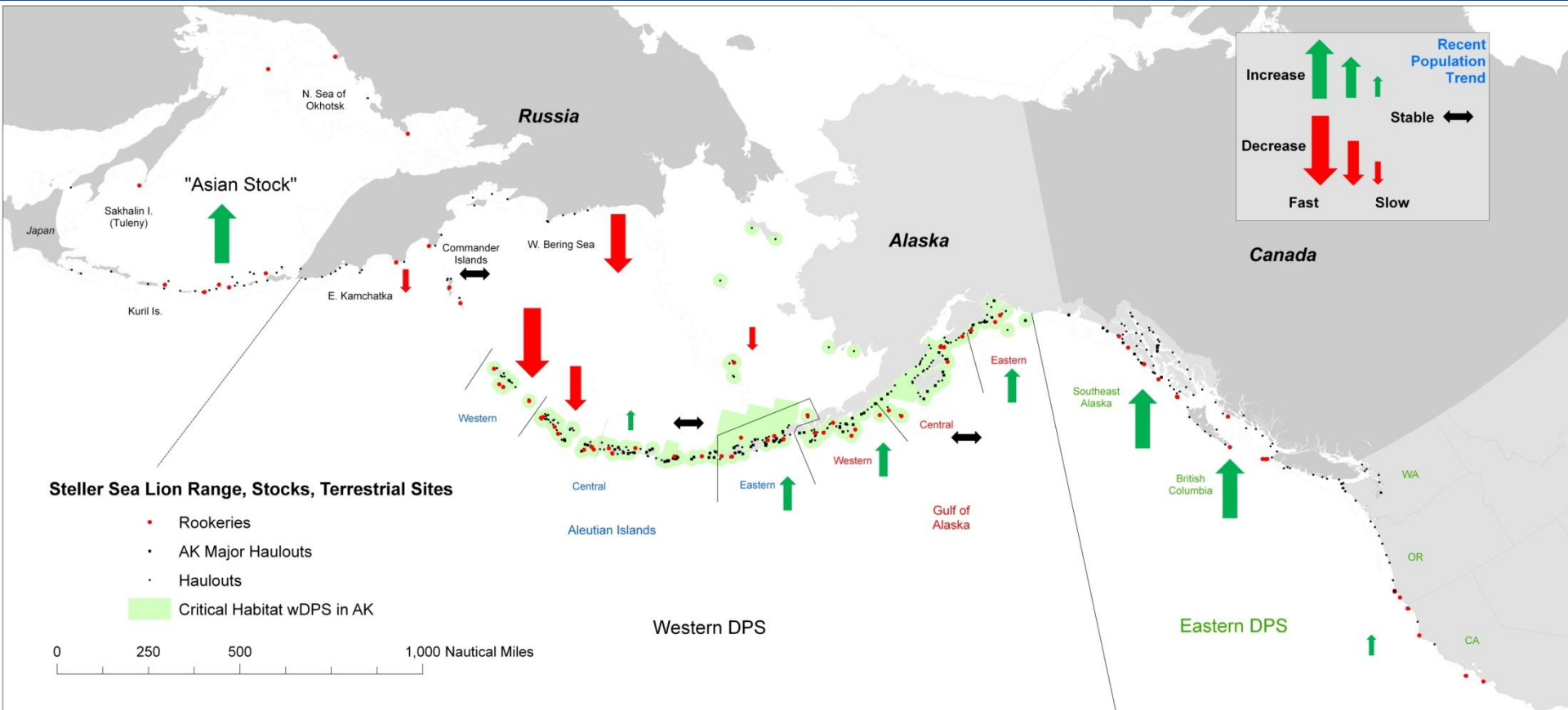
**Clear negative trend in female birth rates** (preliminary estimates, analysis in progress)

**No significant changes in survival rates** (preliminary estimates, analysis in progress)

# SSL survey areas along coast of Asia



# SSL Range-wide Non-pup Trends



# Questions on Abundance and Trend?

**Next:** Survival – Model and Branding Results

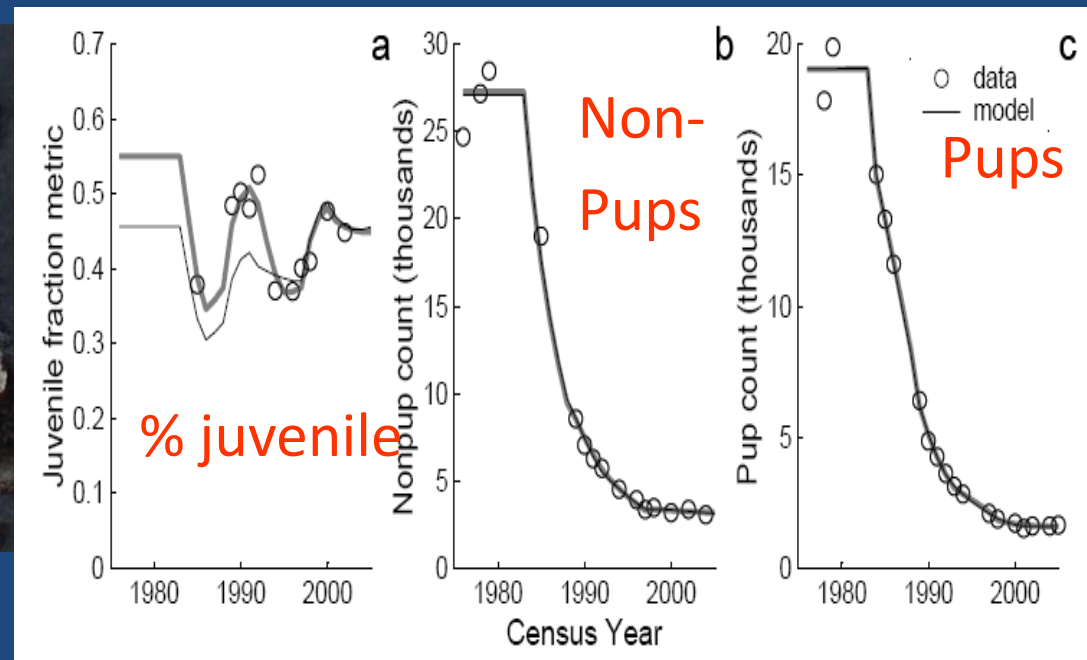
# How can we estimate vital rate changes?

## Modeling - time-varying Leslie matrix (Holmes & York 2003; Holmes et al. 2007)

- Used data from CGOA aerial surveys – pup and non-pup counts
- Developed a recruitment index (% juvenile based on size)
- Change survival and reproductive rates to fit observed counts and % juvenile
- Start with estimates from the mid 1970s based on lethal sample

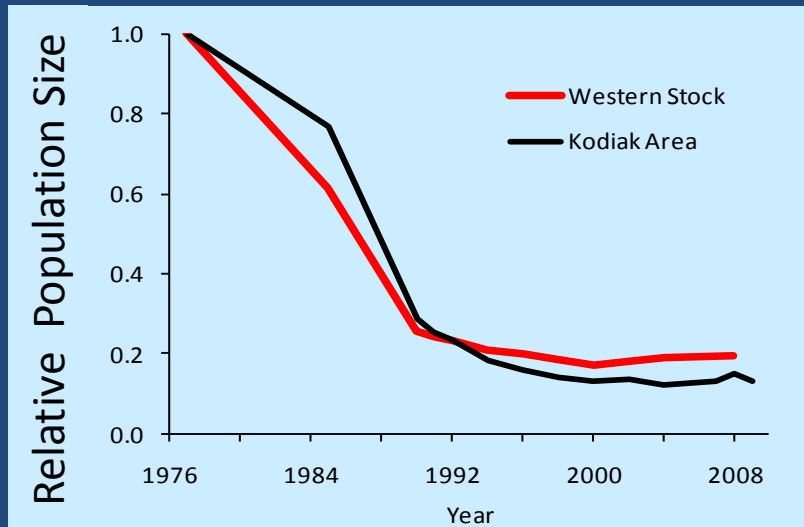


Steller sea lion length measurements from aerial photograph taken over Kodiak's Cape Ugat on 12 June 2008

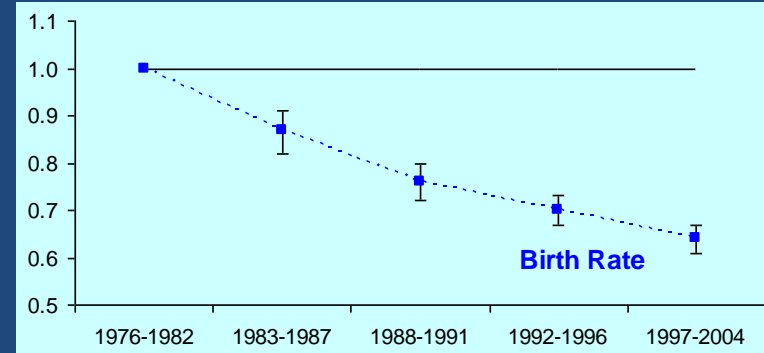
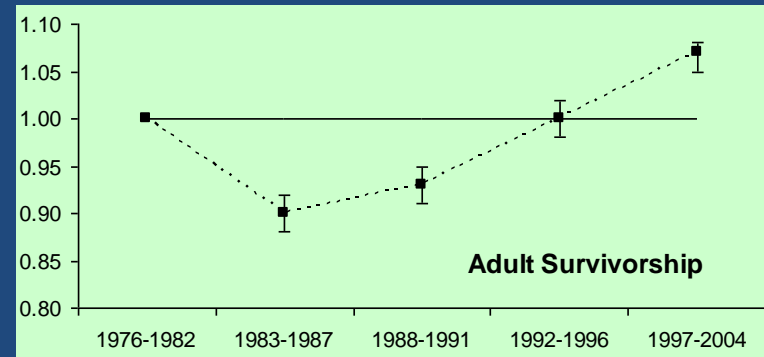
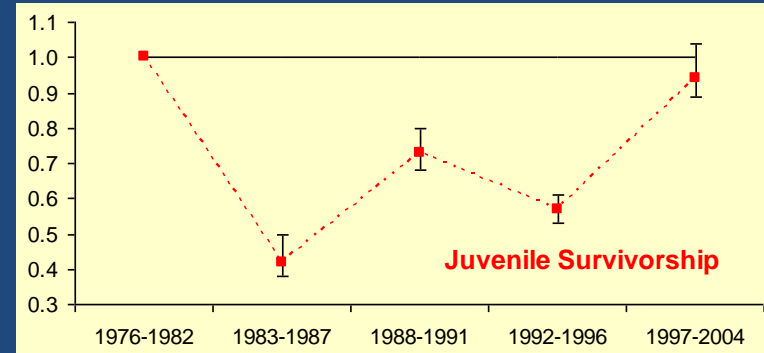


# CGOA Female Vital Rate Changes over Time

- Vital Rates of 1970s are baseline
- 'Low' survival in late 80s-early 90s
- 'High' survival in 2000s
  - Similar or greater than 1970s
- Decline in birth rate
- Rebound in survival suggests direct mortality factors (e.g. predation) not affecting recovery



Changes in Vital Rates to Fit Counts and Age Structure

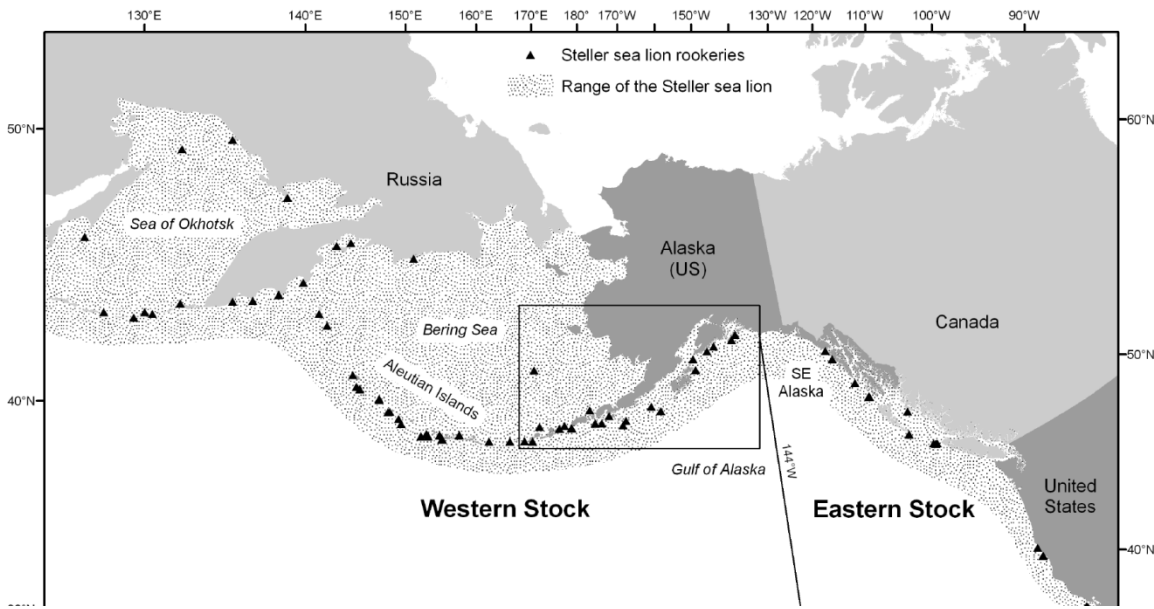


# Steller Sea Lion Survival: Branding and LHX

## Populations, Time Periods and Methods

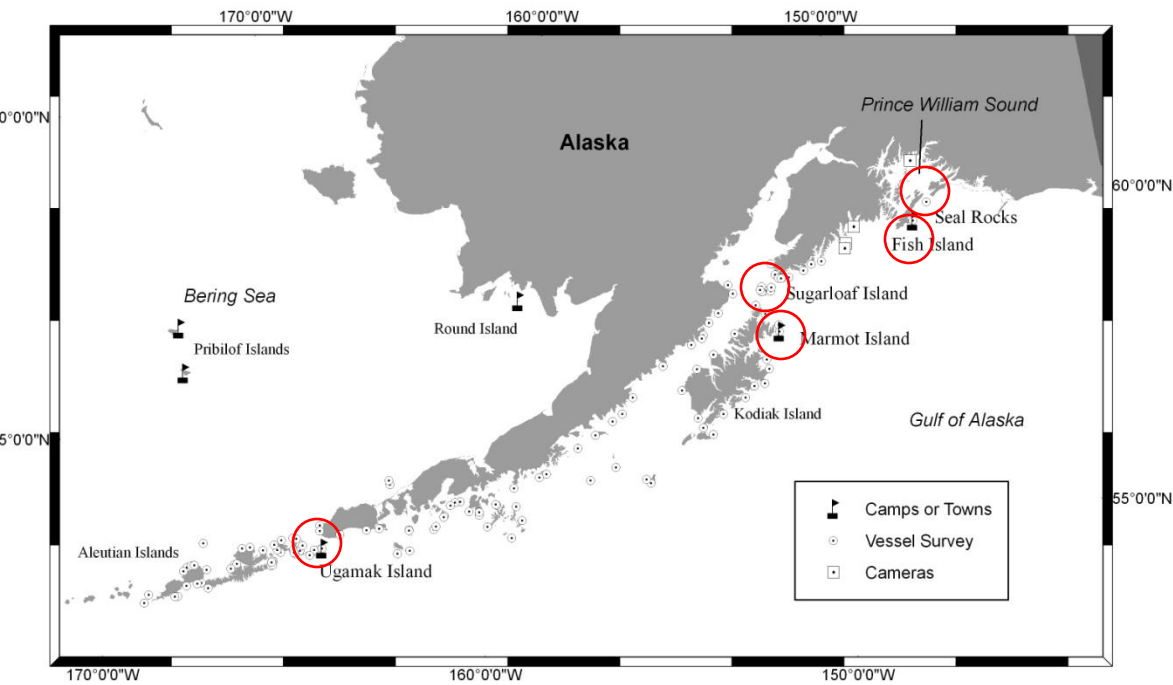
- Eastern DPS
  - Pups branded 2001-2005 SEAK N=1995; sightings through 2009 (Hastings et al. 2011)
- Western DPS
  - Pups branded 2000-05 EAI-EGOA N=1449; sightings through 2011 (NMML)
  - Life History Transmitter (LHX) 2005-11 EGOA N=36; (Horning and Mellish 2012)
  - Pups branded 1987-88 CGOA N=751; sightings through 2003 (Pendleton et al. 2006)





# Steller Sea Lion Branding Western DPS

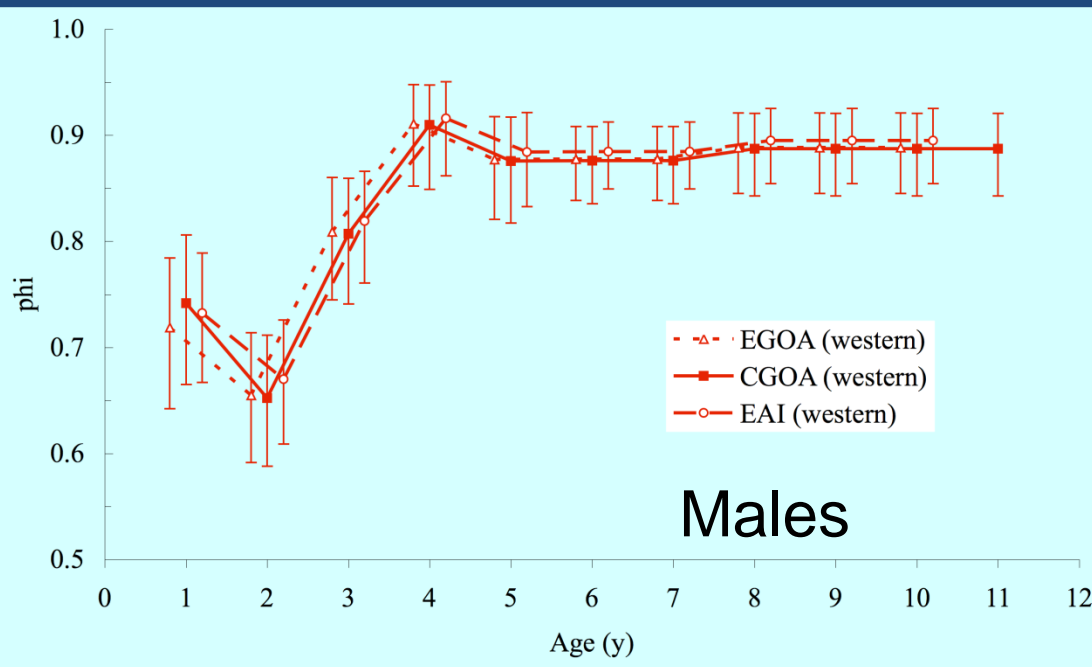
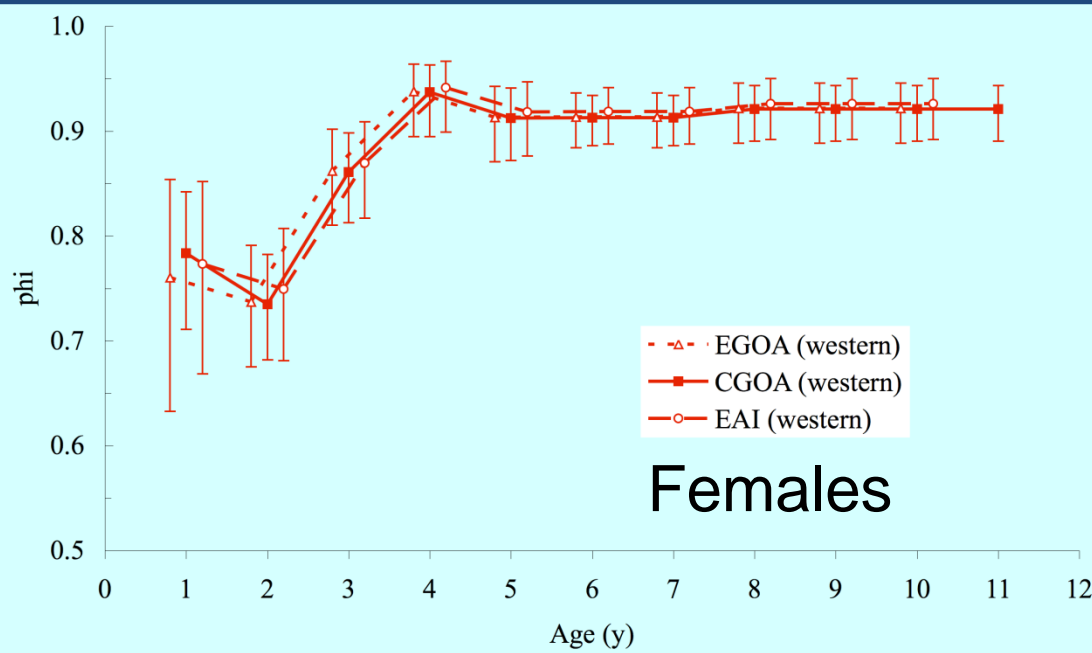
- 1,449 pups
- 5 rookeries in the E Aleu through EGOA
- 6 cohorts: 2000-2005
- Sightings thru 2011
- 60% of all branded animals observed at least once



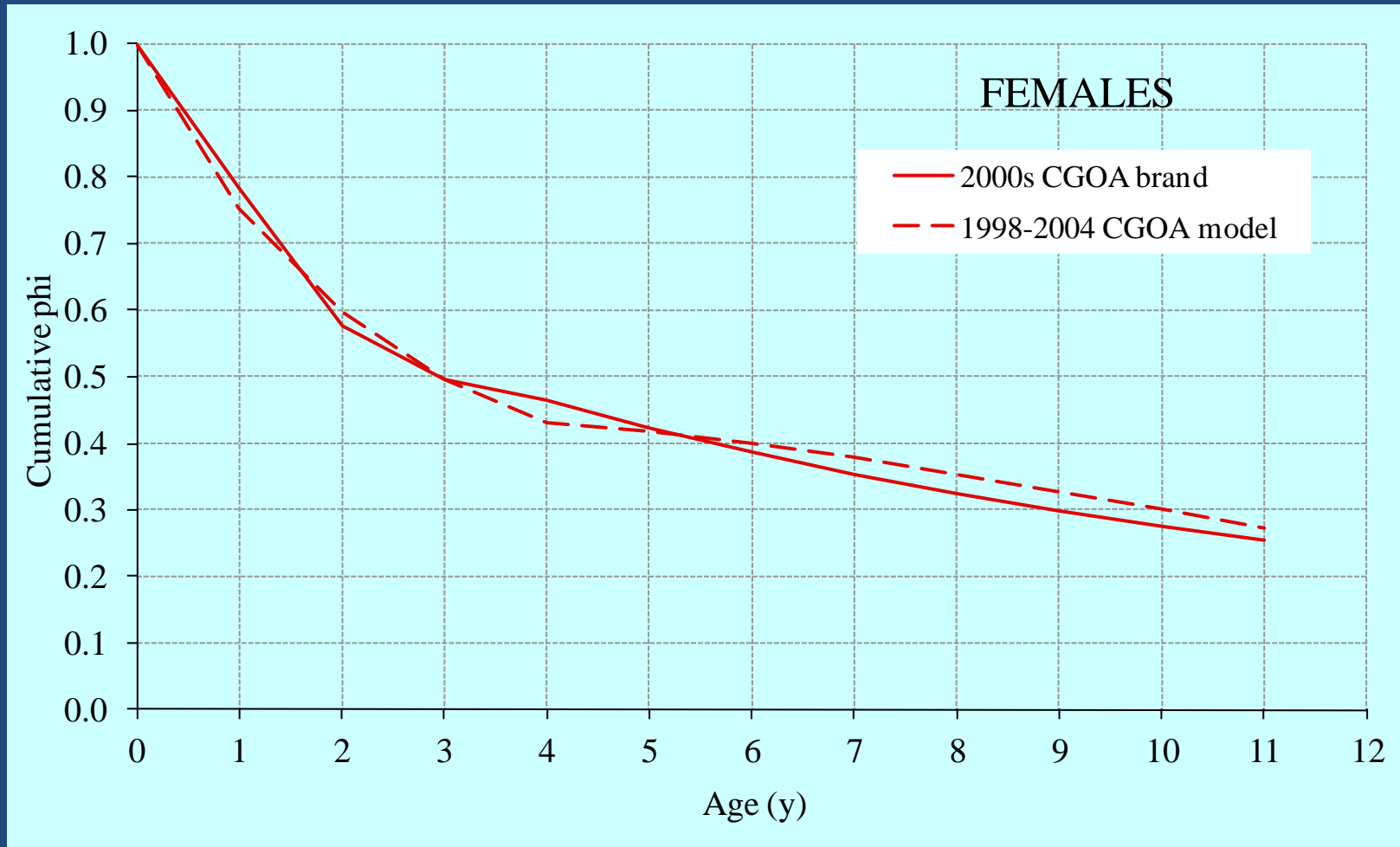


# Western DPS Survival at Age

- No regional differences
- Females > Males
- 1st year > 2nd year
- More pronounced in males
- No cohort differences

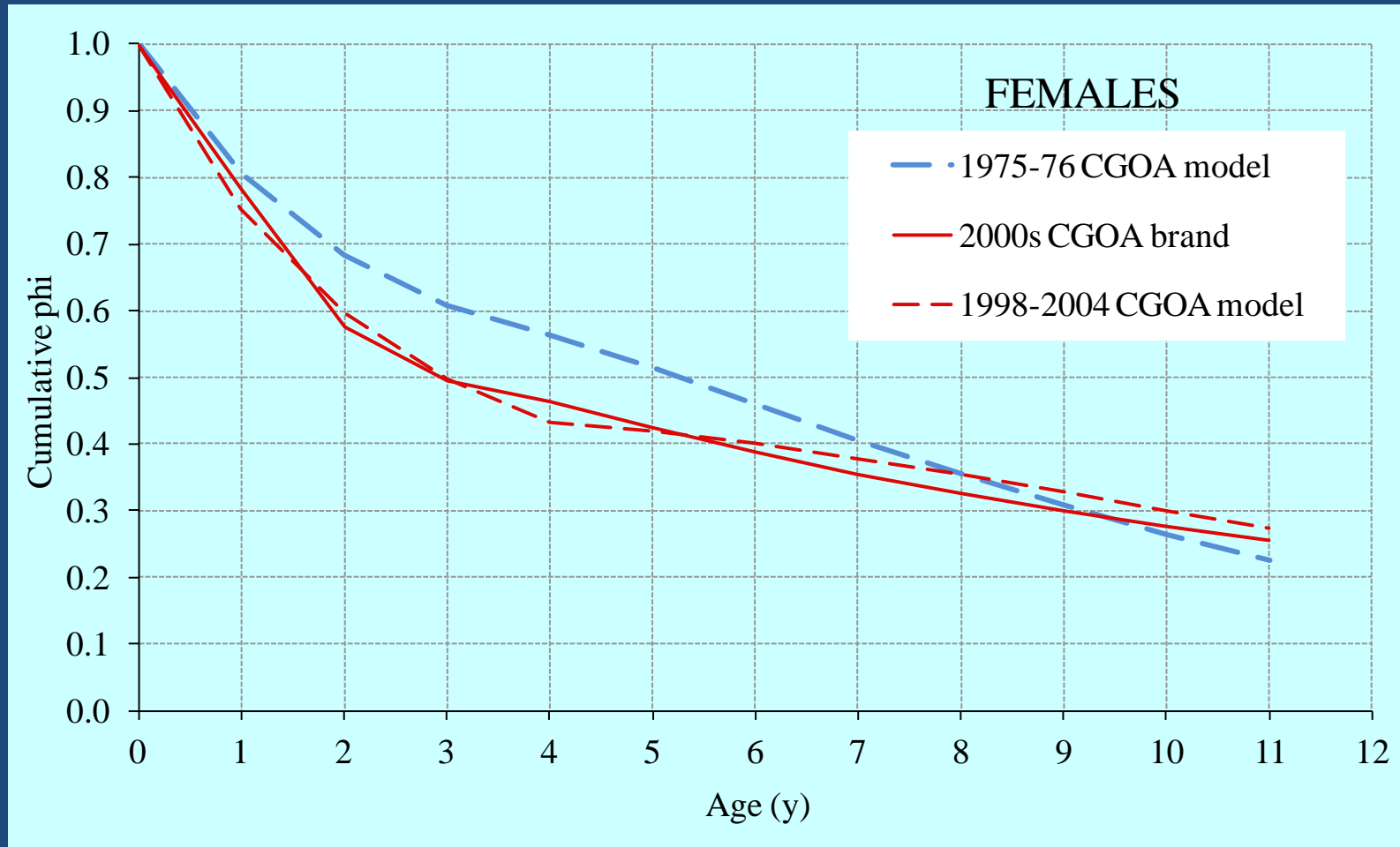


# Cumulative Female Survival to Age



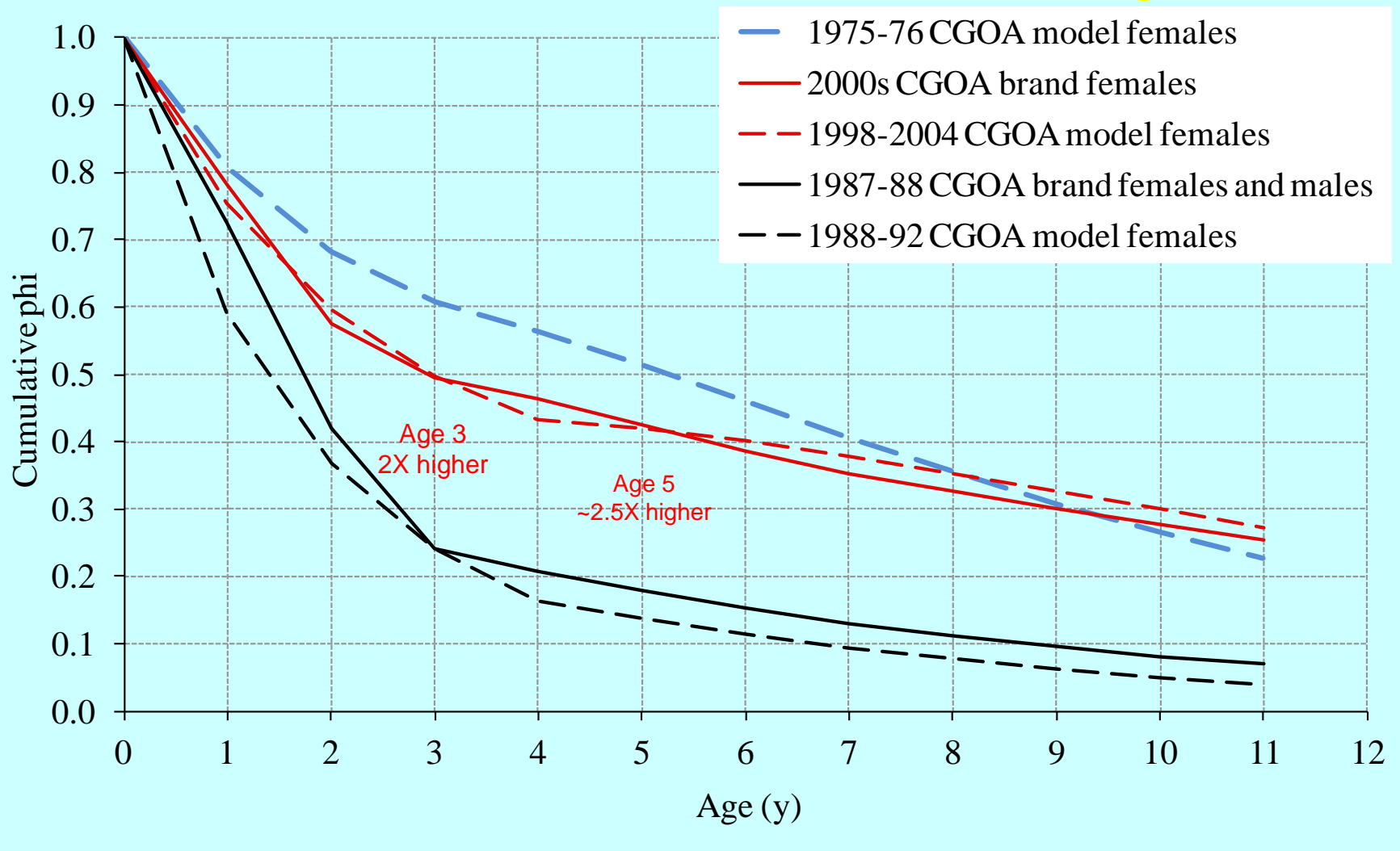
2000s branding and model results nearly identical

# Cumulative Female Survival to Age



- Survival to ages 3-5 10-20% lower in 2000s than 1970s
- Survival to ages 7-11 similar in 2000s than 1970s

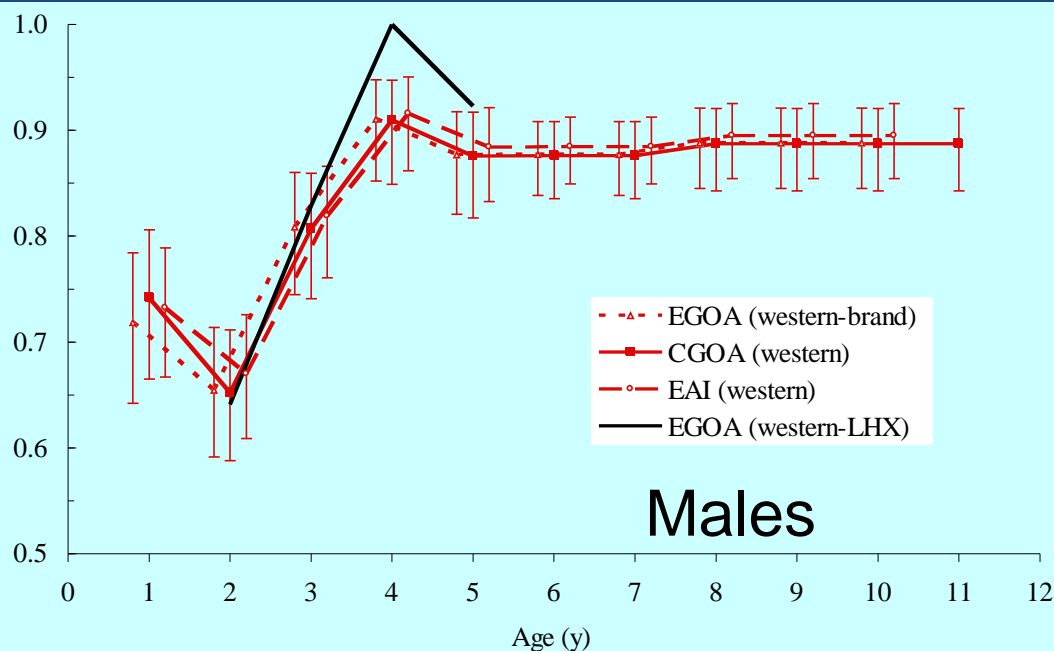
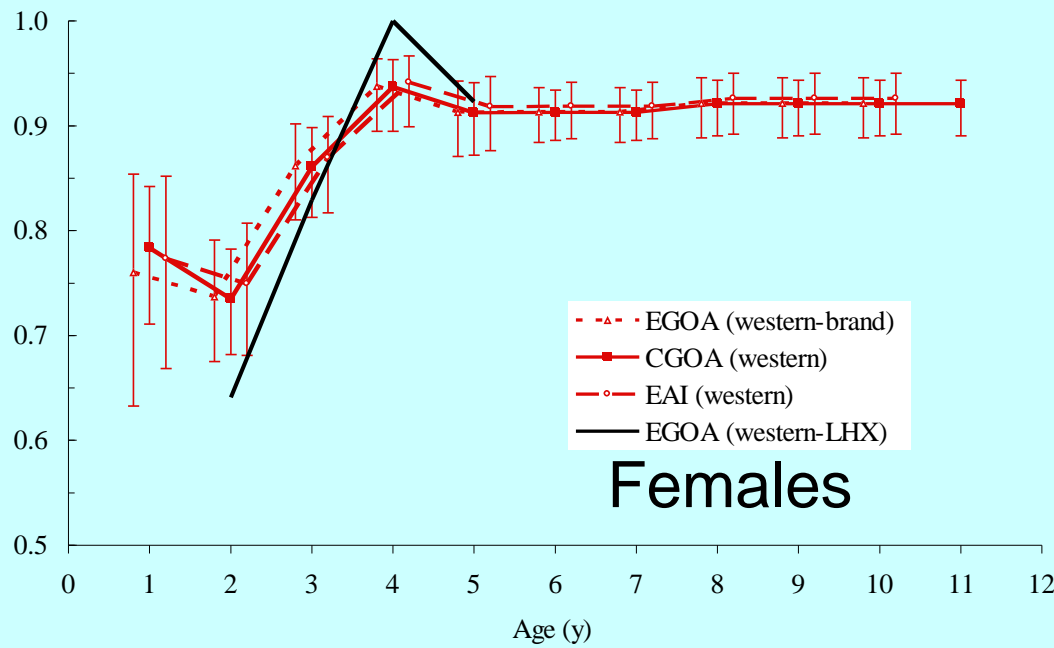
# Cumulative Survival to Age



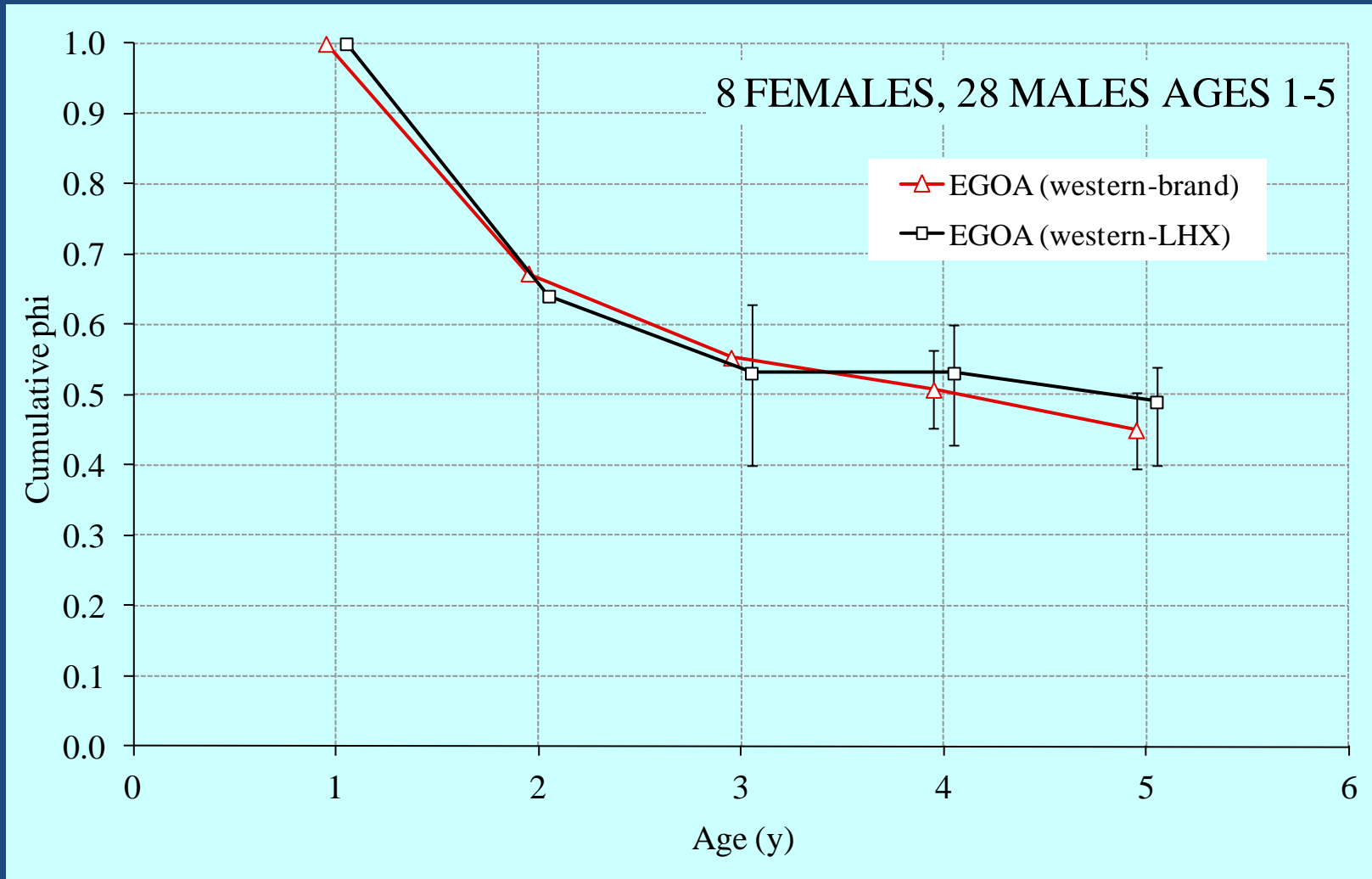
CGOA Survival in 2000s much greater than in late 80s-early 90s

# Brand & LHX

- LHX data ages 2-5 only
- LHX 8 females, 28 males
- LHX results similar to branded males ages 2 & 3
- Both peak age 4
- LHX:  $S = 1$  age 4 (realistic?)

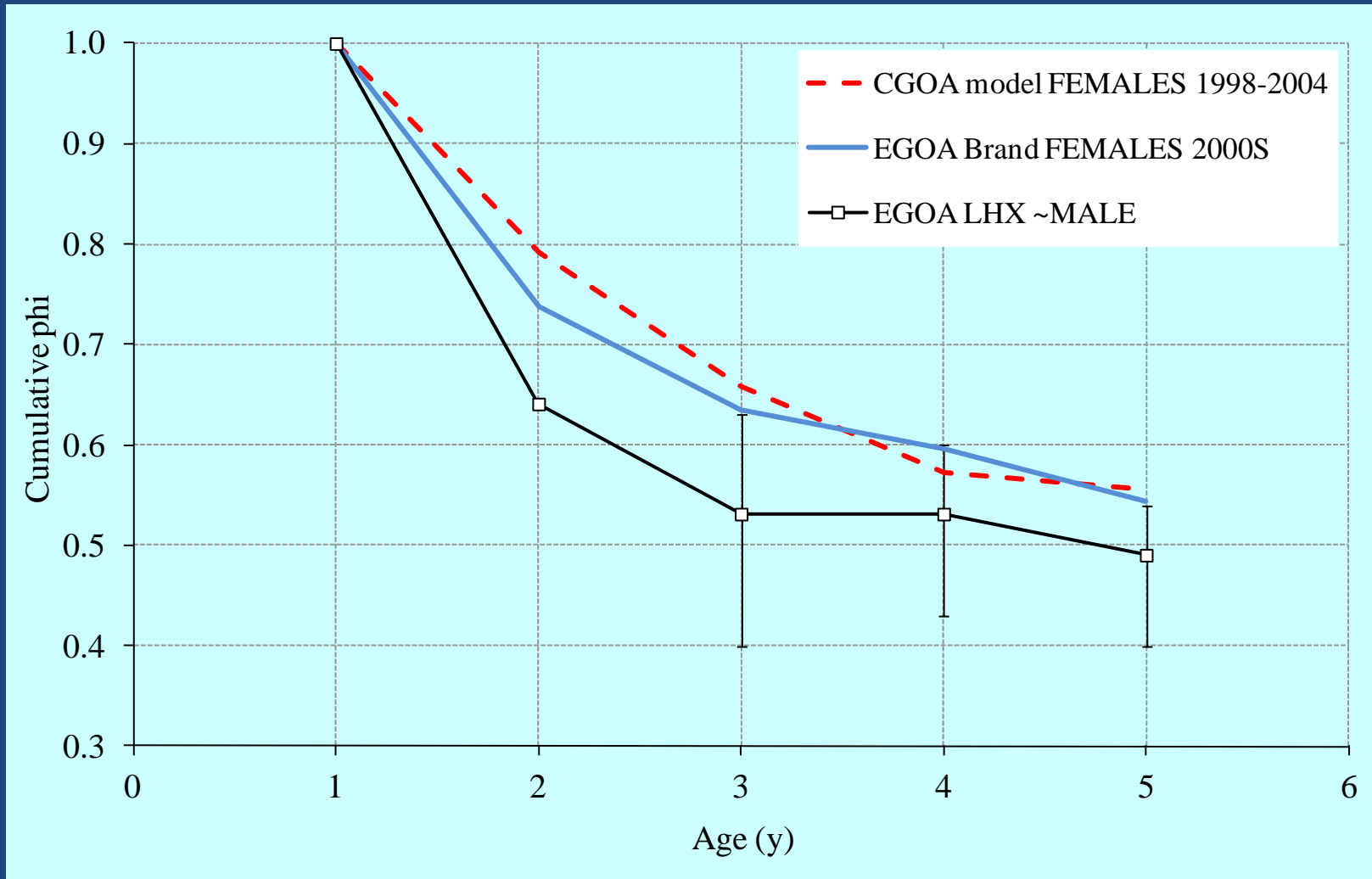


# Cumulative Survival to Age: Brand & LHX



Brand and LHX survival nearly identical ages 1-5 in the 2000s

# Cumulative Survival to Age: Brand, LHX & Model



Brand and Model FEMALE Survival to Ages 3-5 > LHX ~MALE

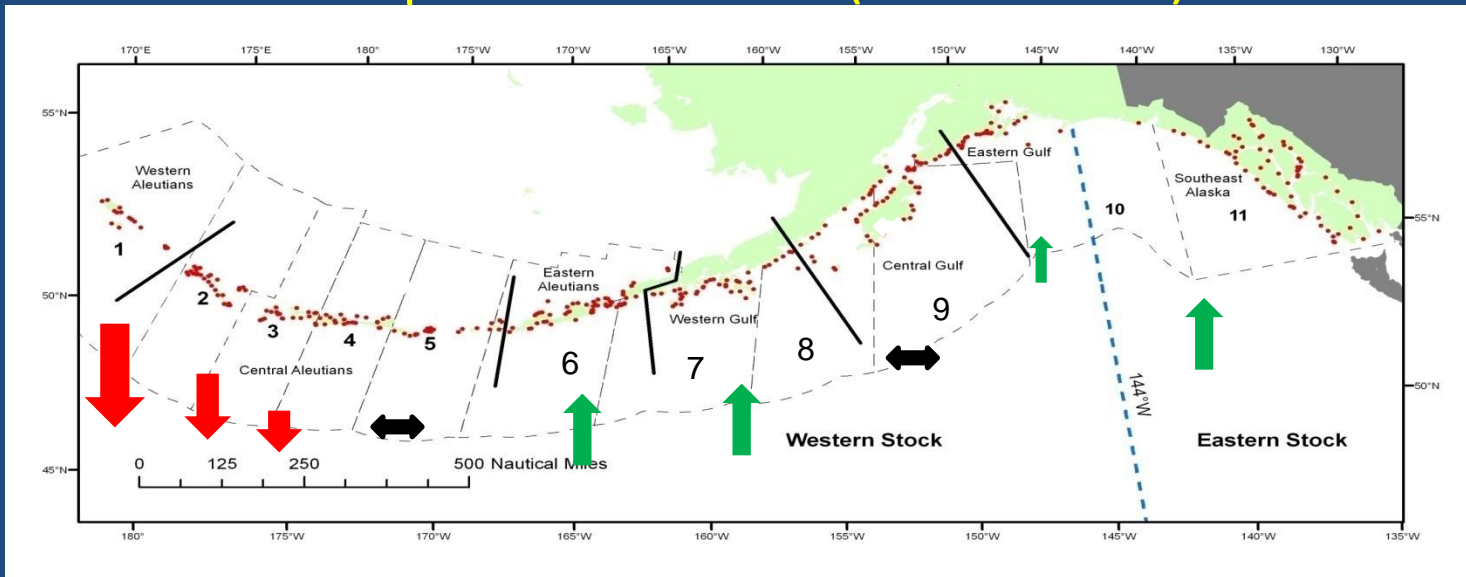
## Are our conclusions different from Horning and Mellish's?

- Yes and No
- H&M: "...our data demonstrate **continued low juvenile survival** in the Prince William Sound/Kenai Fjords region of the Gulf of Alaska..."
- Juvenile survival in 2000s 2X higher than 80s and slightly lower than in 1970s
  - **1970s > 2000s >> 1980s**
  - **Not continued low juvenile survival**
- In 2000s, **LHX results = Branding results** for sample with same sex composition
  - 28 males, 8 females
- Survival of **Females > Males**
- H&M compared mostly male (LHX) with female (Holmes et al. 2007) survival
- Survival in 2000s is NOT lower than estimated by Holmes et al.
  - **We found that LHX=Brand=Model for 2000s**
- Survival in 2000s is NOT stalling recovery
  - **Survival to maturity is not currently low**
  - **E Gulf population (Prince William Sound/Kenai Fjords) is increasing**
- Killer whale predation is likely a major component of total juvenile sea lion mortality but it is not likely a threat to recovery in the EGOA-EAI region



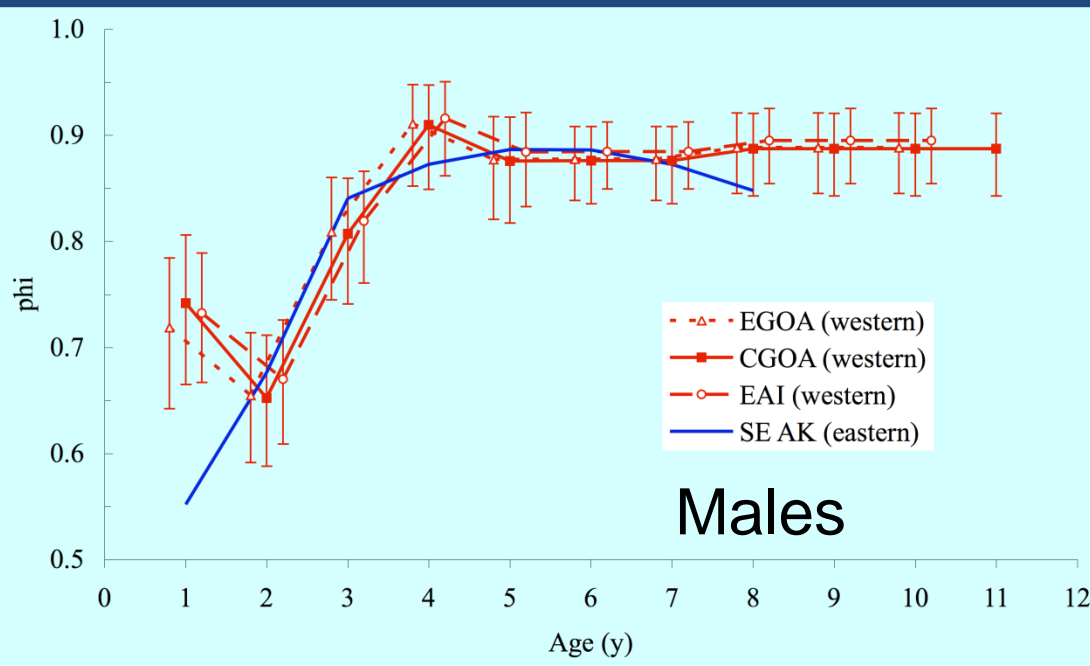
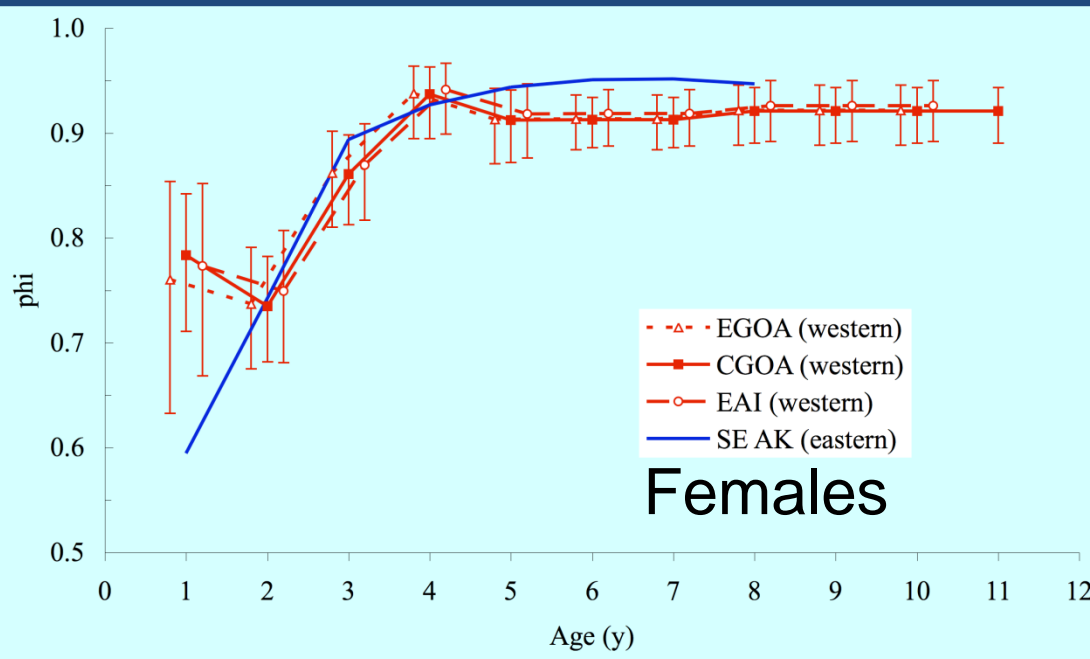
# Western DPS 2000s Survival Summary

- Females > Males
- No cohort differences 2000-2005
- No regional differences in survival EAI through EGOA
- 1st year > 2nd year
  - Consistent with older weaning age
- Brand = LHX in EGOA ages 2-5
- Population Trend:
  - EAI and EGOA are INCREASING
  - CGOA is STABLE
- Consistent with Reproductive Rate: (EAI & EGOA) > CGOA

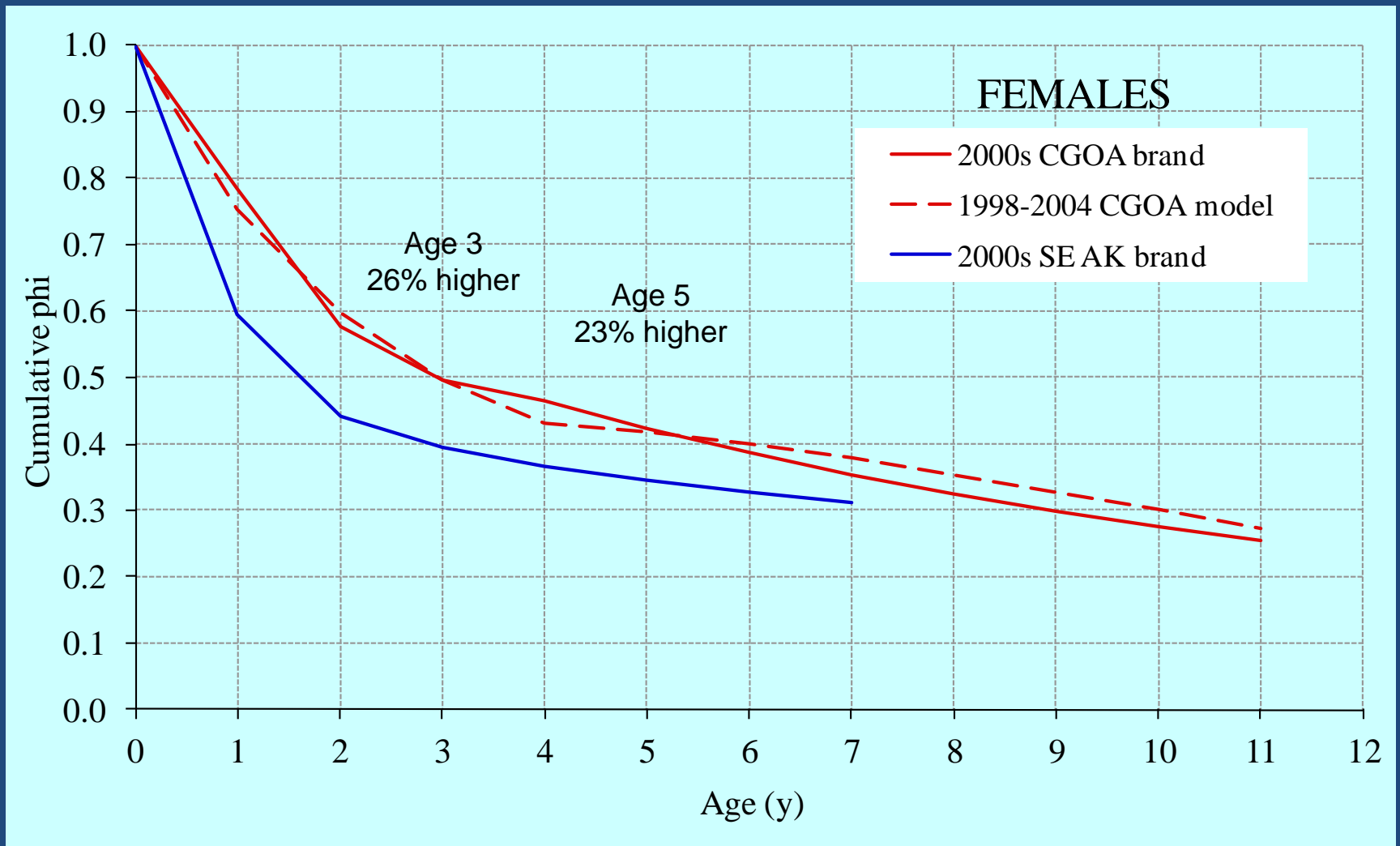


# Western DPS vs Eastern DPS

- East: 1st year < 2nd year
- West: 1st year > 2nd year
- Ages 2-8 Similar



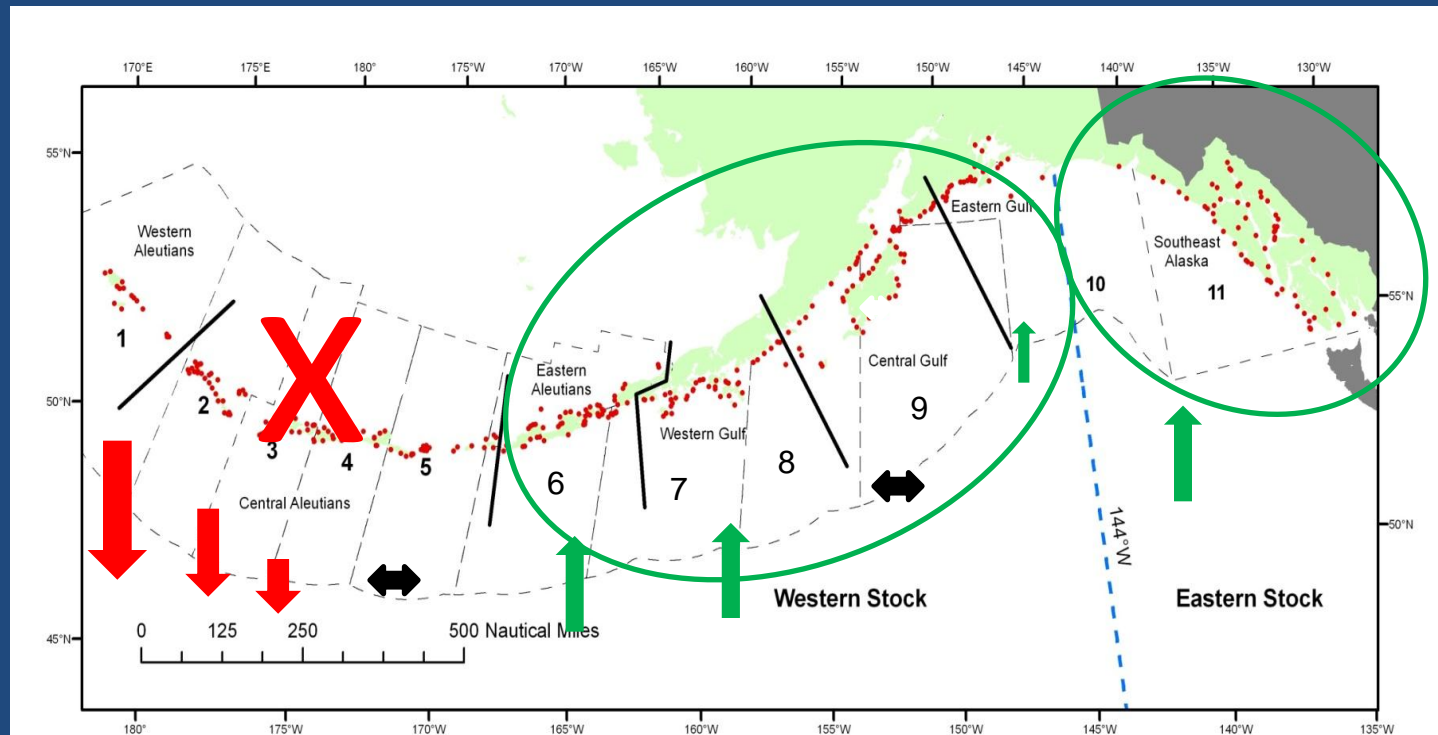
# Cumulative Female Survival to Age



CGOA (west) higher survival than SE AK (east)

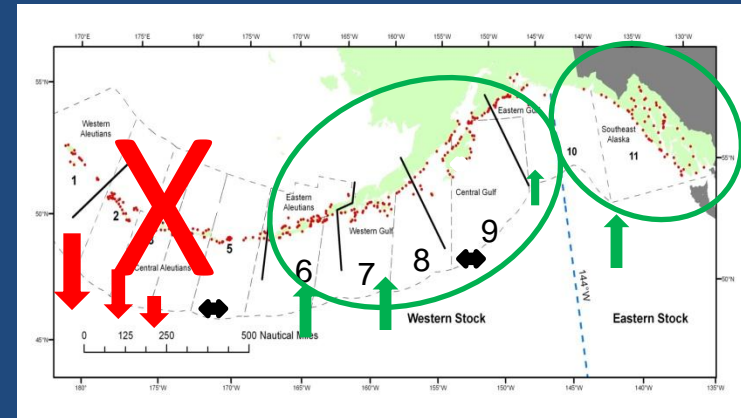
# Western DPS vs Eastern DPS

- Survival to adulthood: West (EGOA-EAI) > East (SE AK)
- Survival in 1st year: West > East
- Population trend: East  $\approx$  West
- **Consistent with Reproductive Rate: East > West**



# Western DPS vs Eastern DPS (2)

- Consistent with West more 'K' and East more 'r' selected
- 'K' selection - West
  - Higher survival rate (shown here)
  - Longer maternal care (1<sup>st</sup> yr higher survival?)
  - Lower reproductive rate (hypothesized)
  - Larger body size (next section)
- 'r' selection - East
  - Lower survival rate (shown here)
  - Shorter maternal care (1<sup>st</sup> yr lower survival?)
  - Higher reproductive rate (hypothesized)
  - Smaller body size (next section)
- If true, West would take longer to recover than East once direct mortality threats removed since it has lower reproductive rate



# Questions on Survival and Vital Rates?

**Next:** Composition – Age, Sex, Length

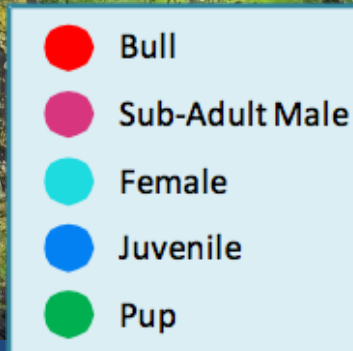
# Composition and Length

- Aerial survey data
- Across all of Alaska, not just where we branded
- Pup-Female Ratios
  - Relative 'natality'
- Length distribution and Modeling
  - Regional Variation in Adult Female length
    - Identified with Pups or Juveniles
    - Eastern vs. Western DPS
    - Within Western DPS
  - Finite Mixture Distribution Modeling
    - Juvenile proportion within Western DPS
    - Compare Increasing vs. Decreasing Areas
    - EGOA-EAI (brand data) vs. CAI-WAI (no brand data yet)

# Western Stock

Ulak/Hasgox Point – Central Aleutians

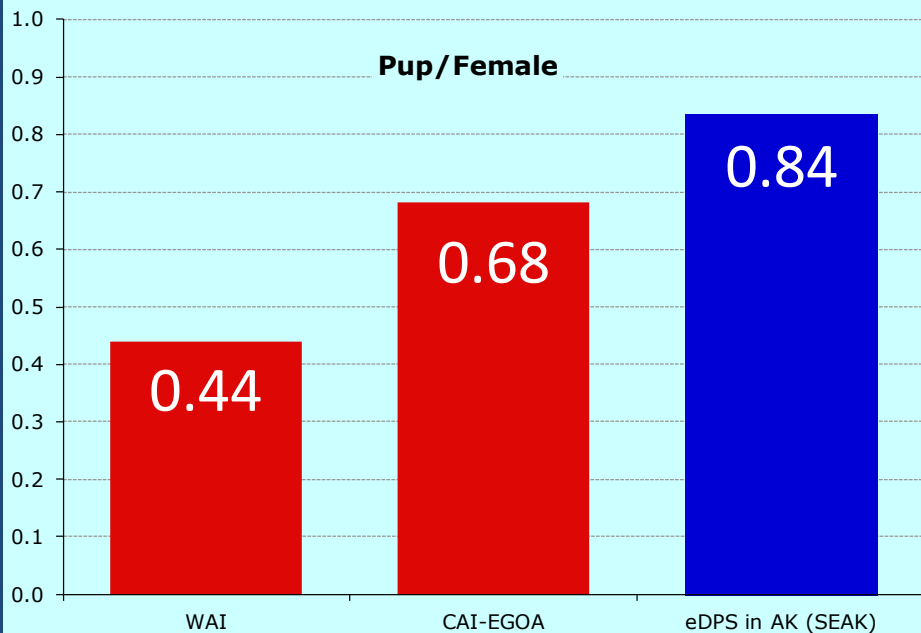
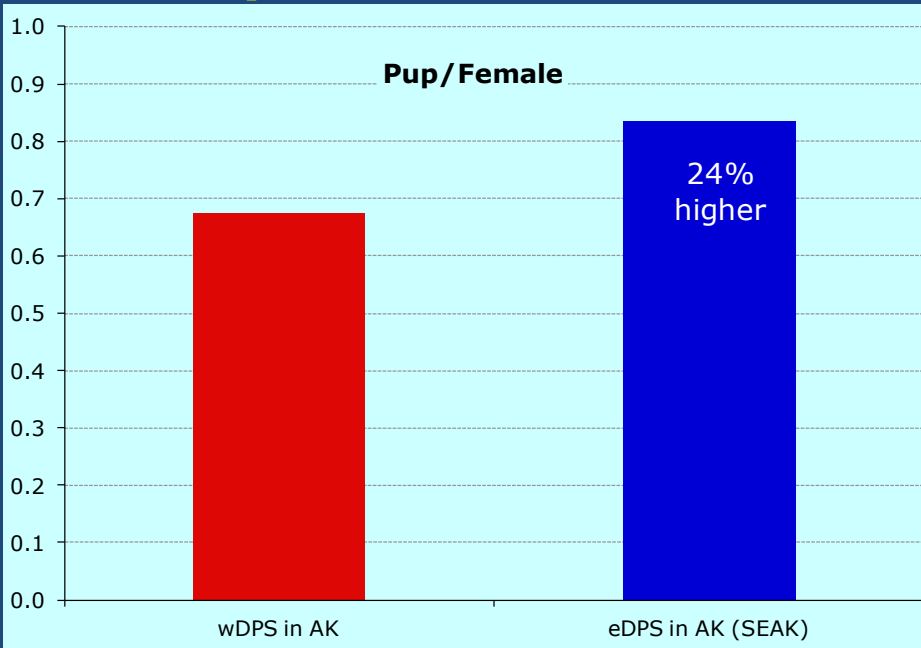
Decreasing: 272 Pups  
515 Adults and Juveniles





# Pup:Adult Female Ratios (2008-11)

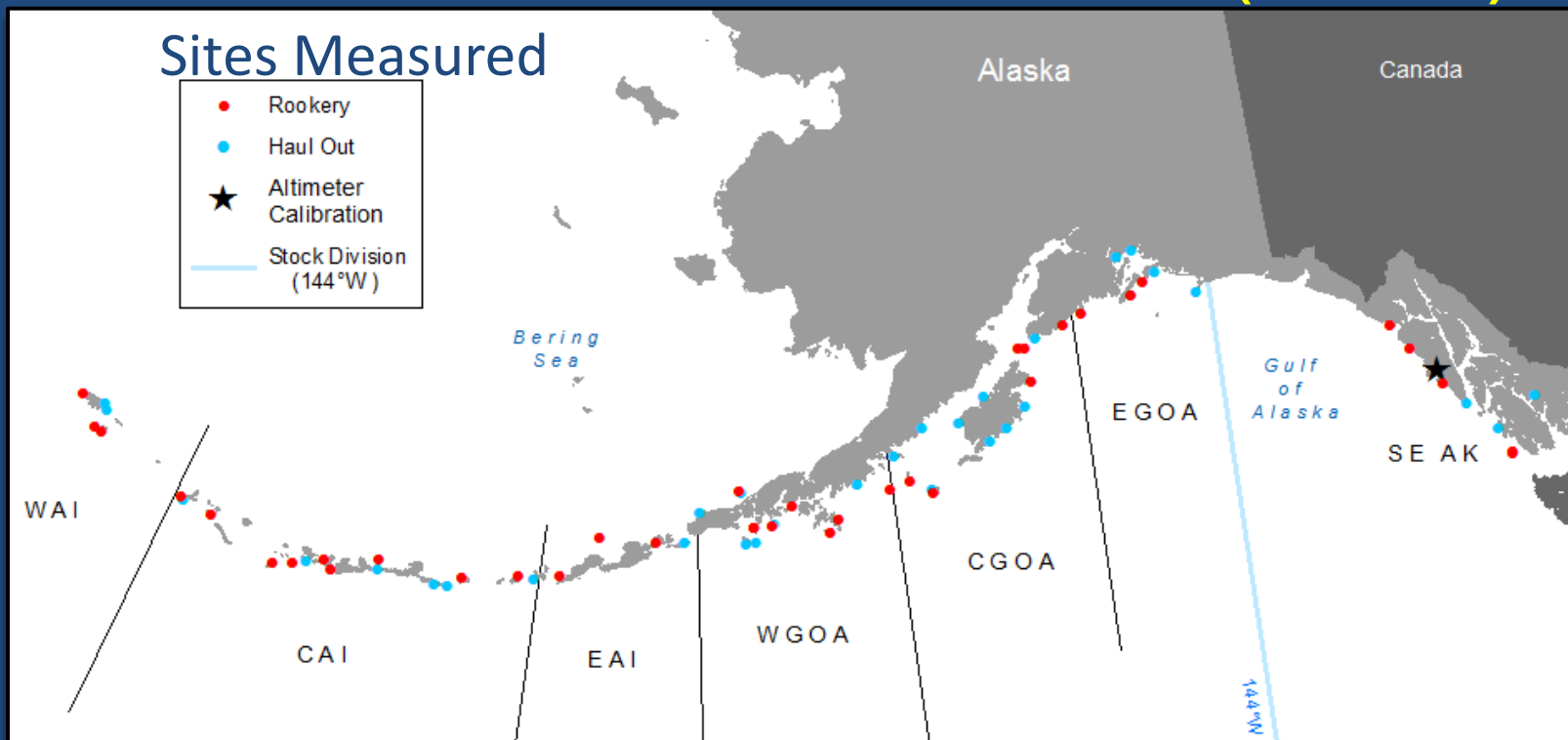
- $eDPS > wDPS$
- $WAI < \text{rest of } wDPS$
- Consistent with:
  - Natality higher in eDPS than wDPS
  - Natality low in WAI



# Length Data and Population Demographics

- Photogrammetric methods and marine mammals
  - Steller Sea Lions (Holmes & York 2003; Holmes et al. 2007)
  - Cetaceans (SWFSC 1998, 2008)
- Fisheries: Length frequency data and **Finite Mixture Distribution Model**
  - Size composition for age-sex classes (Everitt & Hand 1981; Wolfe 1970)
  - Identify individual fish stocks in mixed-stock distribution of length data (Millar 1987; Wood et al. 1987)
- **Steller sea lion length data & Finite Mixture Distribution Model**
  - Estimate mean length and population proportion of three age-sex classes: **Juvenile, adult female, and adult male** (Bull and sub-adult male)
  - Use photogrammetry to measure lengths from 2008 aerial survey images (Alaskan range-wide survey)
    - **“observed known adult female”**

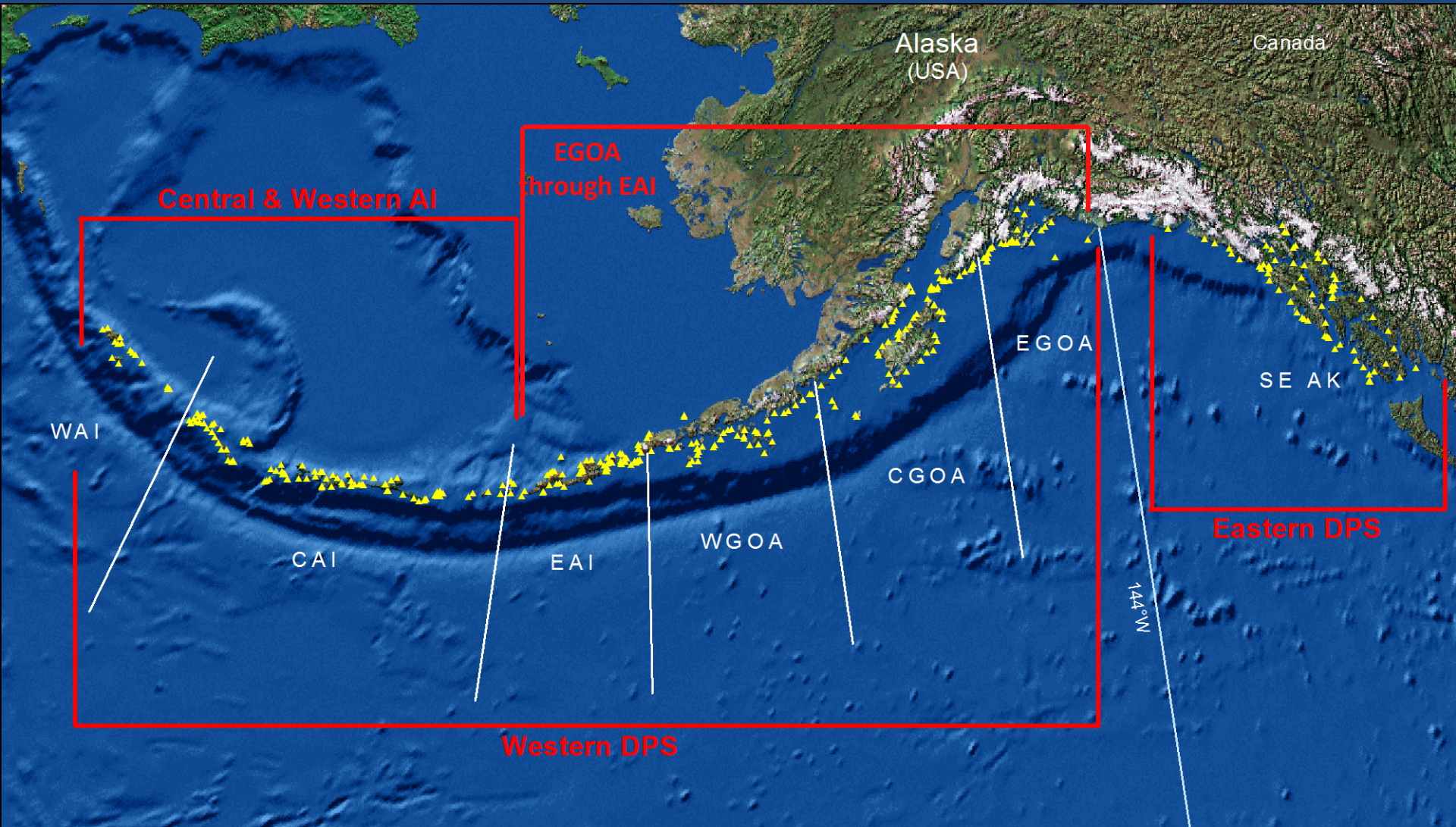
# Measurement Collection (SC 3)



- Sites with:
  - Highest relative abundance
  - At least one rook/HO site selected from each RCA
  - Associated altitude data

Region	Sites	# Lengths	# Female
SE AK (eDPS)	8	1284	241
wDPS	60	4737	1001
EGOA	7	865	66
CGOA	15	783	221
WGOA	11	1365	258
EAI	7	725	193
CAI	15	861	225
WAI	5	138	38
<b>Total</b>	<b>68</b>	<b>6021</b>	<b>2243</b>

# Broad Regional Comparisons

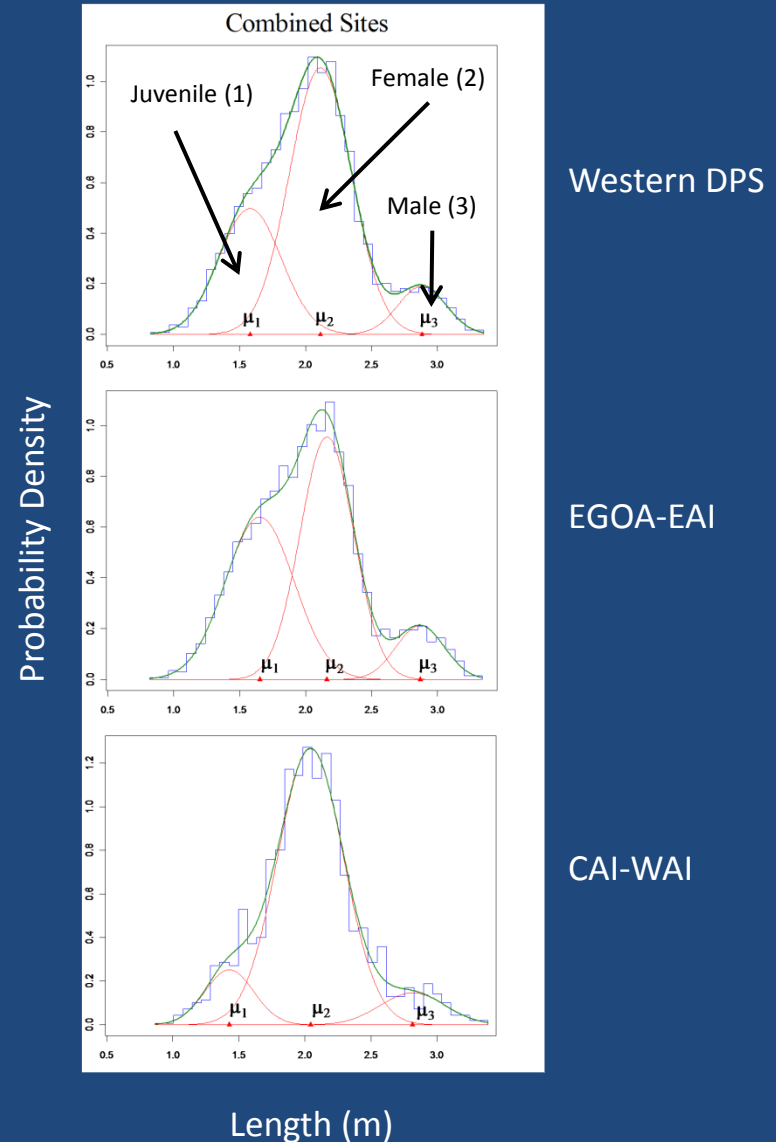


# FMD Modeling Results

- Mean length and range of Juveniles and Adults (F & M)
- Proportion of measured sample (area under curve) composed of Juveniles and Adults (F & M)



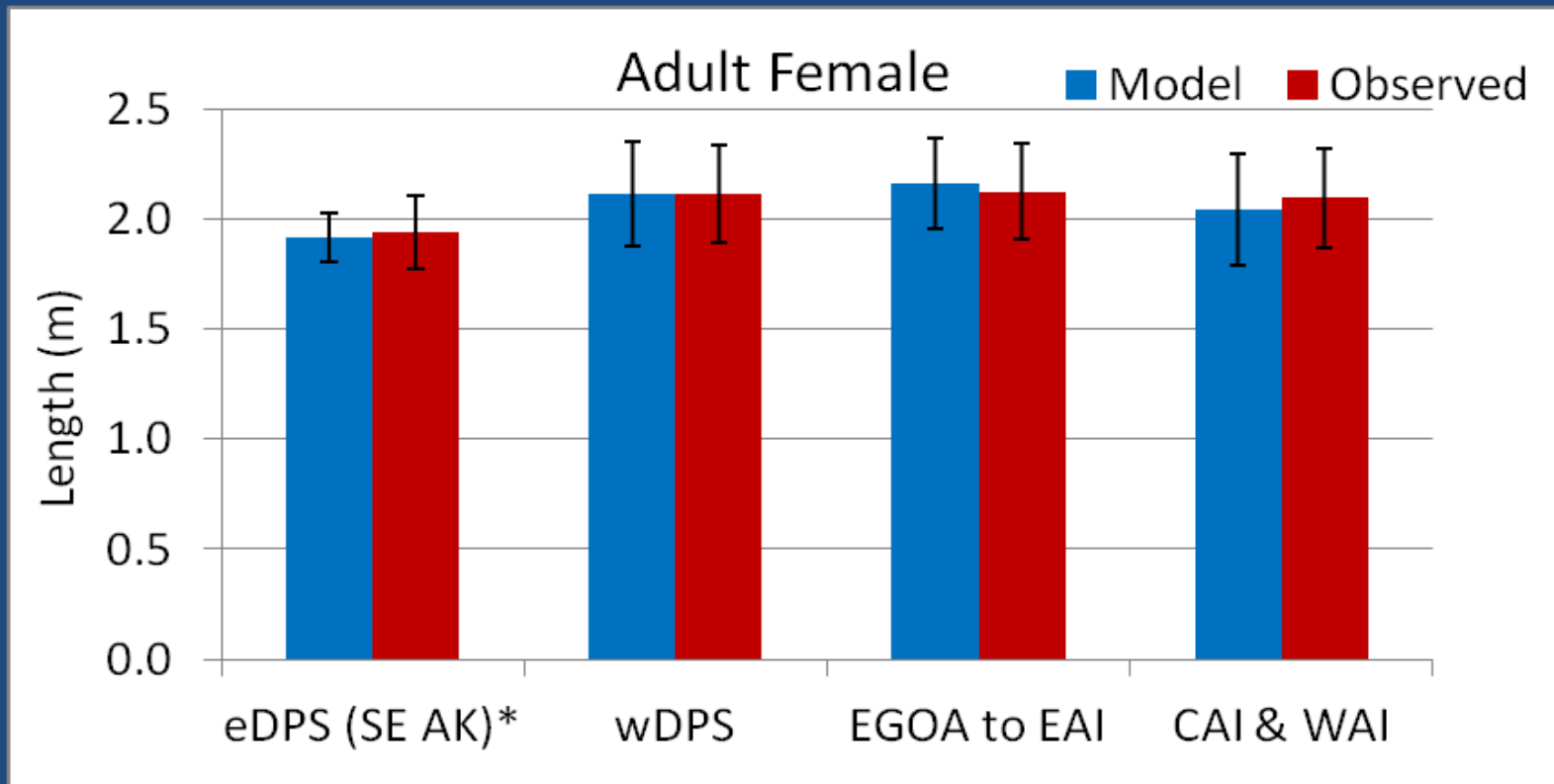
## Rookeries and Haulouts



# FMD Modeling Results

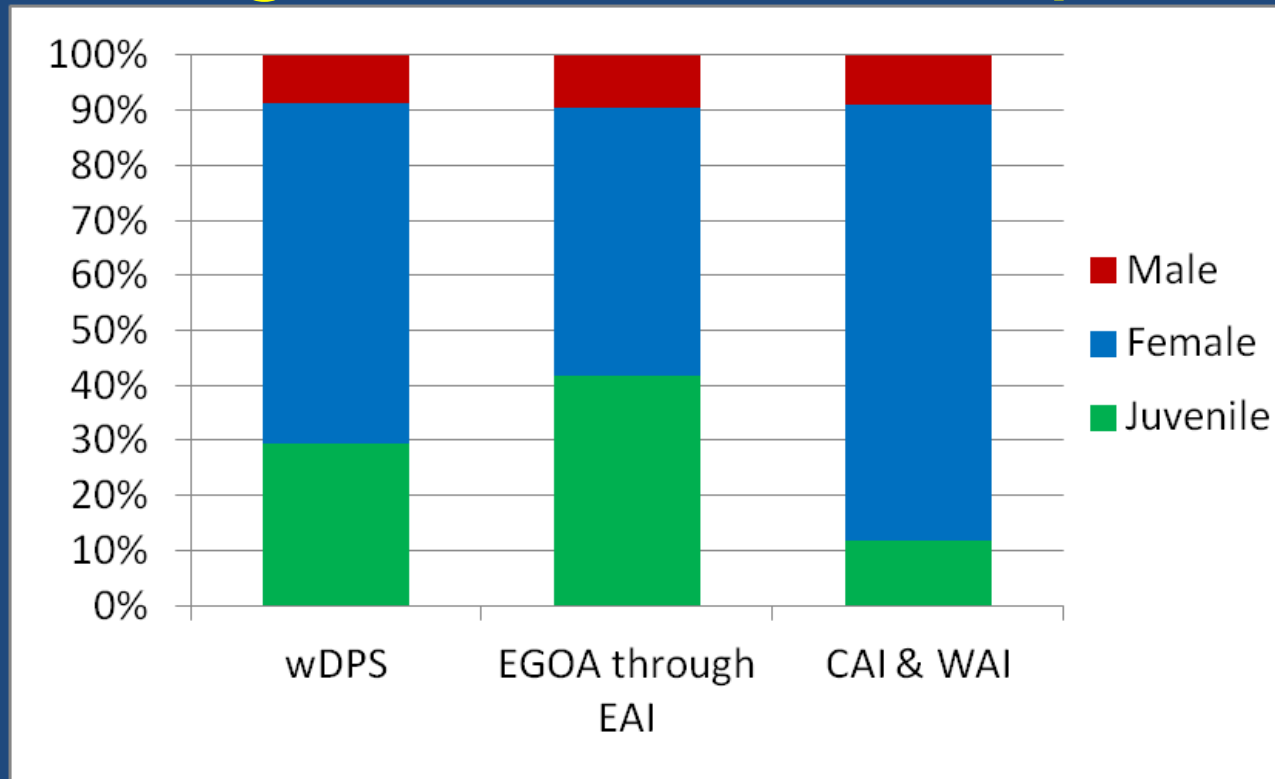
Eastern DPS  
females are  
significantly  
smaller than the  
Western DPS

No difference  
between Model  
and Observed  
female length



\*significantly smaller

# FMD Modeling Results: Age-sex Class Proportions



- Proportion juvenile: EGOA-EAI > CAI-WAI
- Population trend: EGOA-EAI > CAI-WAI
- Juvenile survival and/or natality low?


Questions on Composition – Age, Sex, Length?

**Next:** Movement to and from  
Aleutian Islands and Russia



# Movement of Branded Sea Lions to and from Aleutian Islands and Russia

- Russian brands in US
- US brands
  - Eastern DPS
    - SE AK, OR & CA
  - Western DPS
    - E Gulf, C Gulf & E Aleutians
    - W Aleutians – Agattu
      - ~ brands
      - 2011, N=54



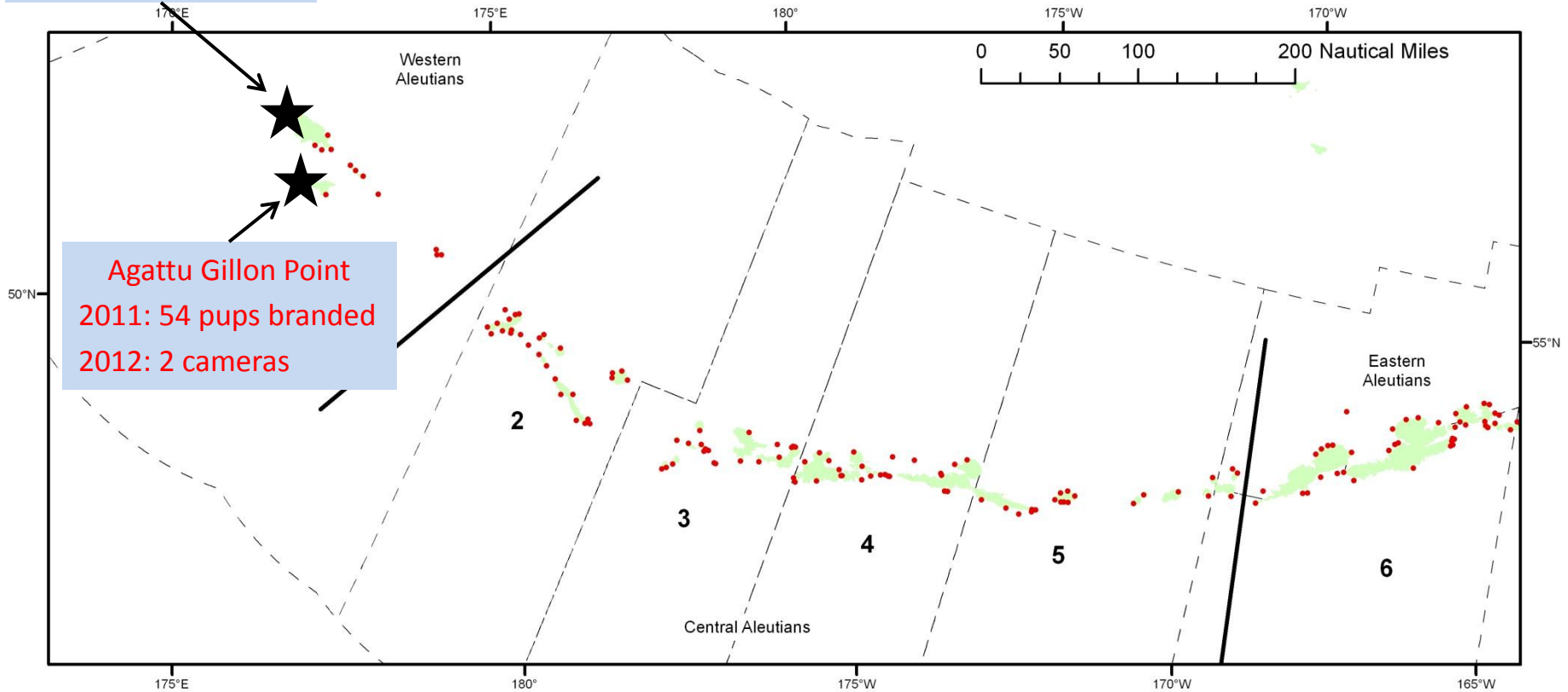
~5: 5-month old pup branded  
On Agattu 6/24/2011  
Observed 11/13/2011 on Bering I,  
Commander Islands, Russia



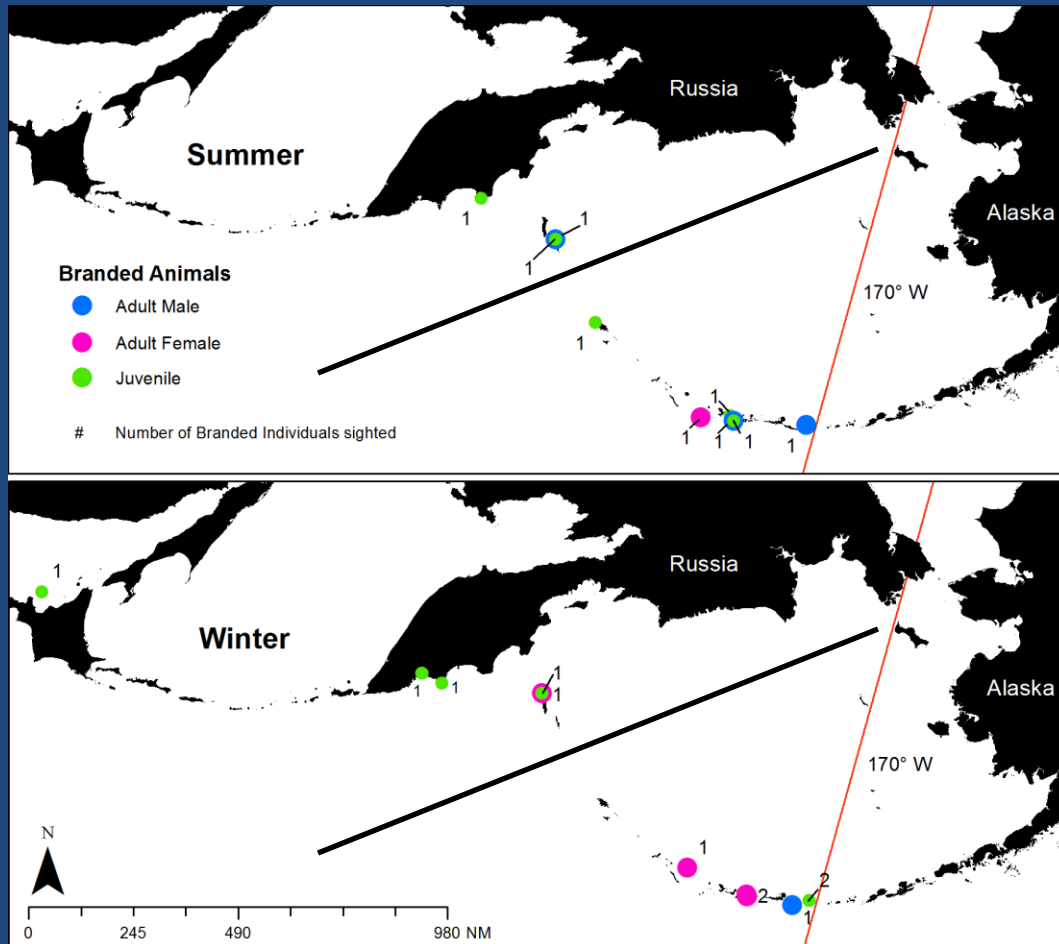
# NMML Branding and Camera Installations in Western Aleutians 2011-12

Attu Cape Wrangell  
2012: 4 cameras

Agattu Gillon Point  
2011: 54 pups branded  
2012: 2 cameras



# Movement of E Aleu – E Gulf (w DPS) brands

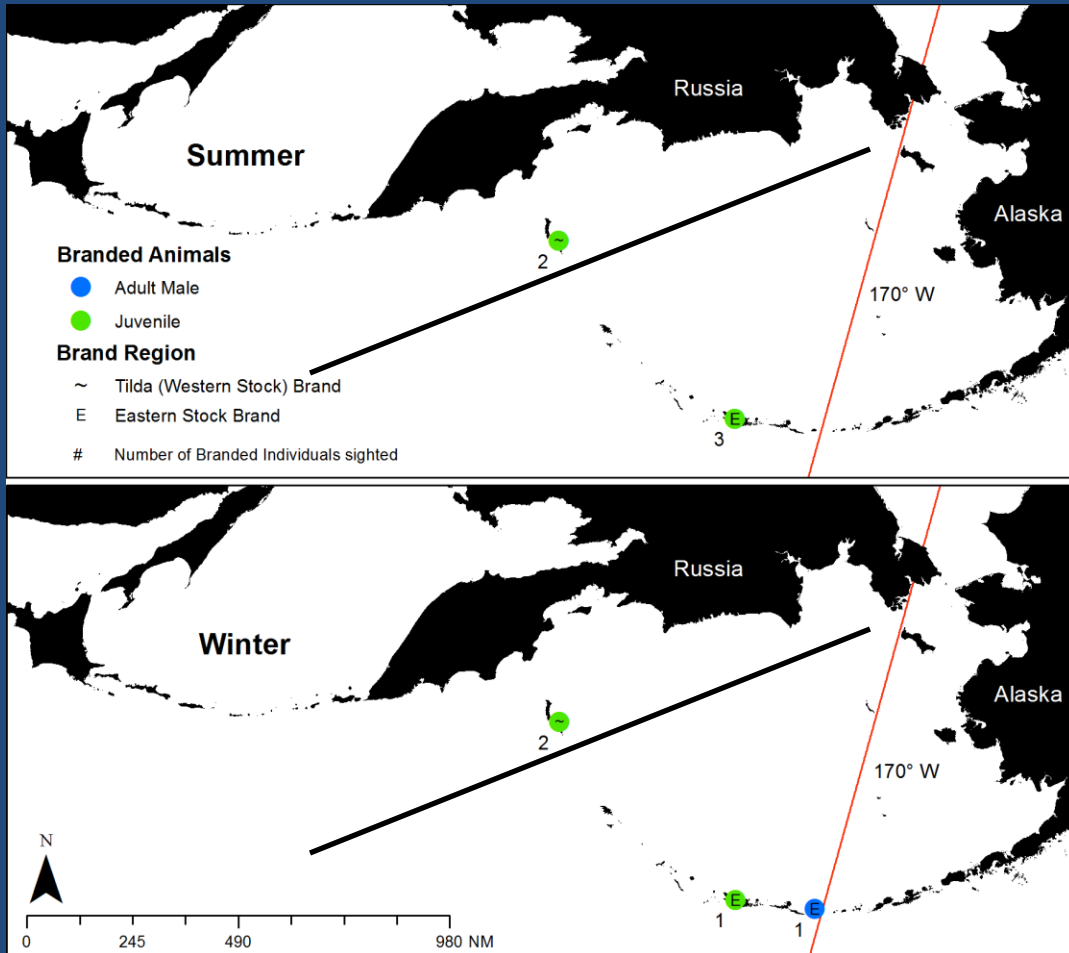


- Few West of Samalga Pass 170W
  - 9 in summer
  - 13 in winter
- **Summer (breeding)**
  - 3 in Russia - all juveniles
  - 1 adult female in Aleu
  - 2 adult males in Aleu
- **Winter (non-breeding)**
  - 5 in Russia – all juveniles
  - 3 adult females in Aleu

Rookery	Summer	Winter
Marmot	5	-
wDPS Sugarloaf	1	2
Ugamak	2	9
<b>Total Individuals</b>	<b>8</b>	<b>11</b>

note: branded individuals seen multiple times at new locations

# Movement of Eastern DPS and Agattu ~ brands



- Few eDPS West of Samalga Pass 170W
  - 3 males in summer
  - 2 males in winter
- W Aleutian ~ brands move to Russia
  - Commander Islands
  - 2 ~ yearlings in summer
  - 2 ~ pups in winter

Rookery	Summer	Winter
~ Agattu Gillon Point	2	2
Forrester	-	1
eDPS Rogue Reef (OR)	2	1
St. George Reef (CA)	1	-
<b>Total Individuals</b>	<b>5</b>	<b>4</b>

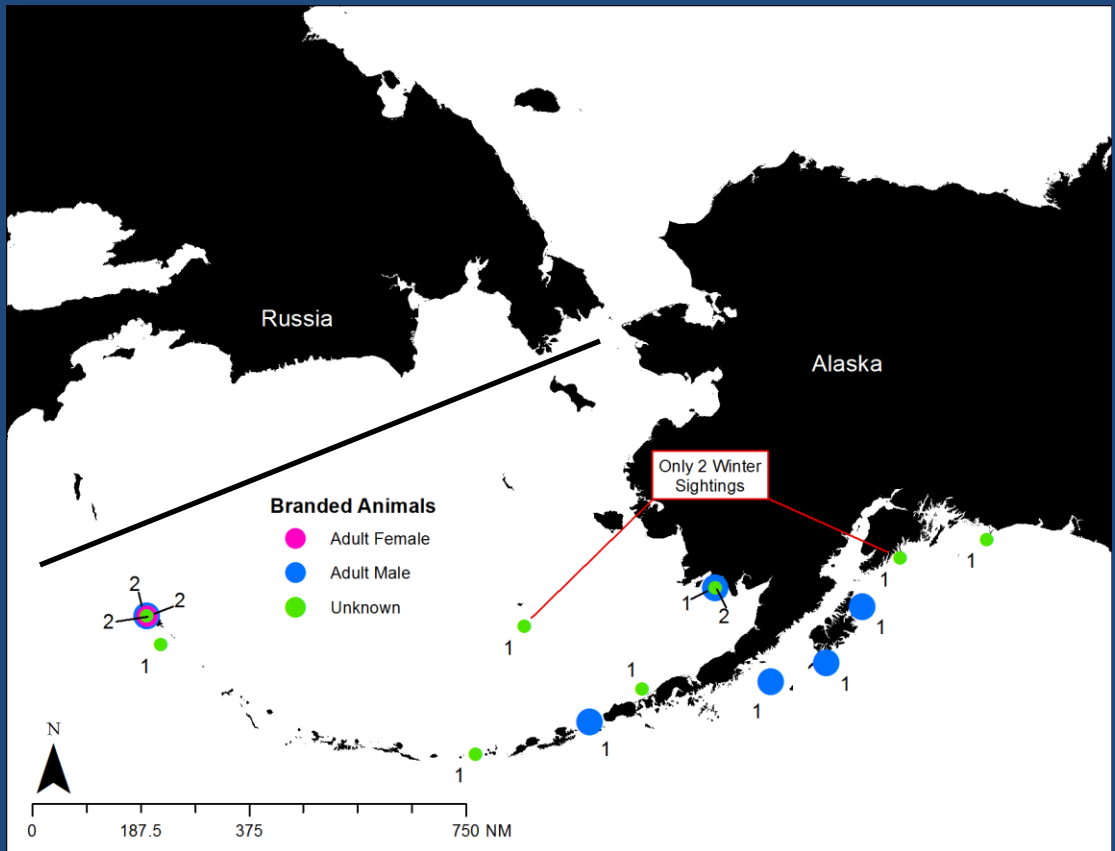
note: branded individuals seen multiple times at new locations

# Movement of Russian brands

- **Summer (breeding)**
  - 2 adult females on Attu
  - 7 adult/sub-adult males as far as CGOA
  - 17 individuals
- **Winter (non-breeding)**
  - 2 individuals (juveniles)

Rookery	Summer	Winter
Srednego	1	-
Kozlova Cape	2	-
Antsiferov	3	-
Medny	11	2
<b>Total Individuals</b>	<b>17</b>	<b>2</b>

note: M642 observed in summer & winter season



# Future Research



- Publish wDPS survival paper (brand) in 2012
- Initiate natality estimation (brand)
- Continue development of size distribution methods
  - Juvenile recruitment in areas with no marked animals
- Development of age-structured model
  - All areas using counts, survival, size, natality
- **Field Work 2012-13**
  - Aerial surveys to count pups and non-pups
    - SE AK – EAI: manned; part of post de-listing monitoring for eDPS
    - CAI – WAI: possible use of unmanned aircraft (UAS)
  - Brand sighting camps and cruises

