

# Estimating Minimum Population Size from Satellite Monitoring

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# Marine Mammal Protection Act

requires

- minimum population size
- regional seasonal distribution
- site-specific monitoring for managers



Enacted  
by 92nd Congress

Signed into law 1972  
by President Nixon



# Human dimension

Chukotka



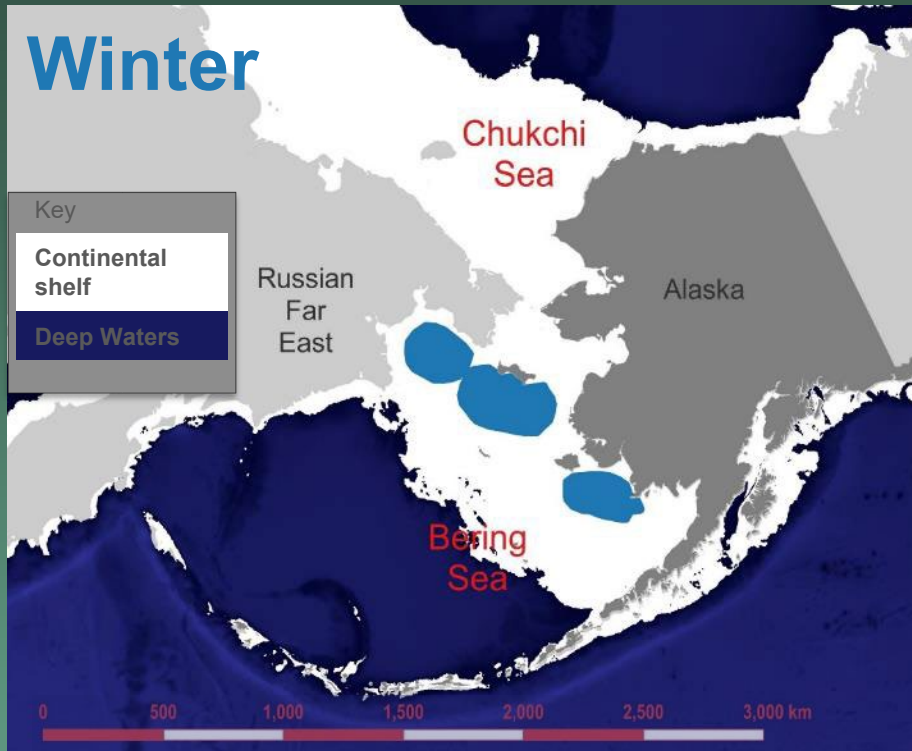
Photo: USGS / C. Jay

Alaska

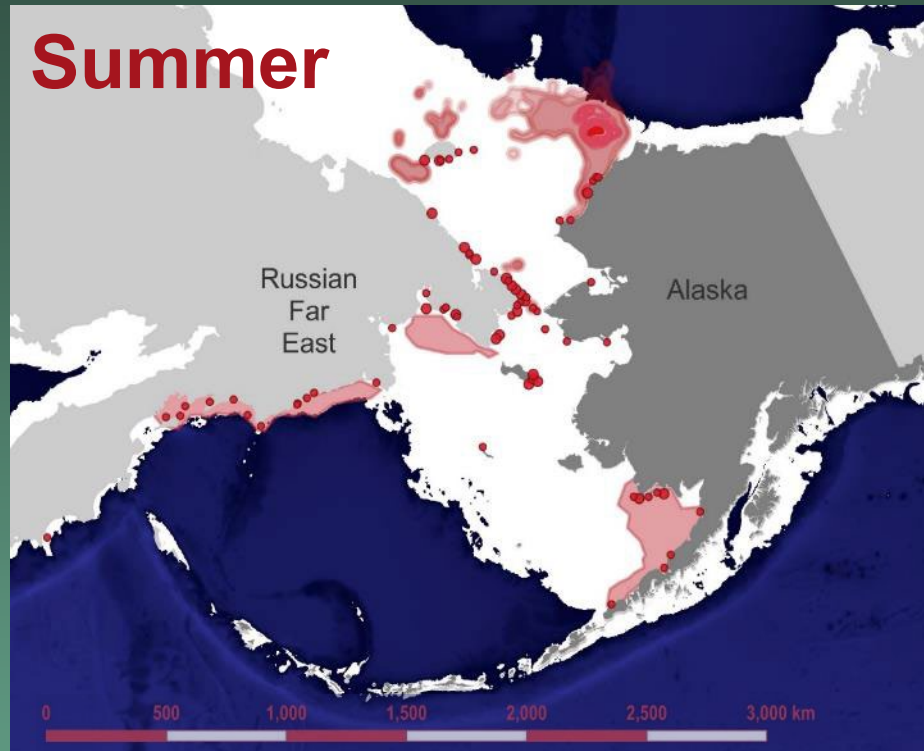


Photo: USGS / A. Finley

# Pacific walrus range



Jay et al. 2014. PLoS One  
<https://doi.org/10.1371/journal.pone.0093035>



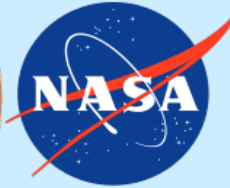
Jay et al. 2010. Marine Ecology Progress Series  
<https://doi.org/10.3354/meps08575>

Beatty et al. 2016. Biological Conservation  
<https://doi.org/10.1016/j.biocon.2016.08.035>

Fischbach et al. 2016. Haulout Database  
<https://doi.org/10.5066/F7RX994P>

# Sources for Satellite Monitoring

Agency  
Sources:



Commercial  
Sources:



**MAXAR**



**ICEYE**



**UMBRA**



# Outline

- Findings**
  - Herd Occurrence and Area
  - Herd Abundance from Density Data
  - MMPA Stock Assessment Report  $N_{\min}$
- Ongoing research**
  - Improving Abundance Precision



Photo E. Powers / USGS



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Photo: E. Powers / USGS



What  
can  
we see  
from  
above?

Drone  
Survey  
Imagery

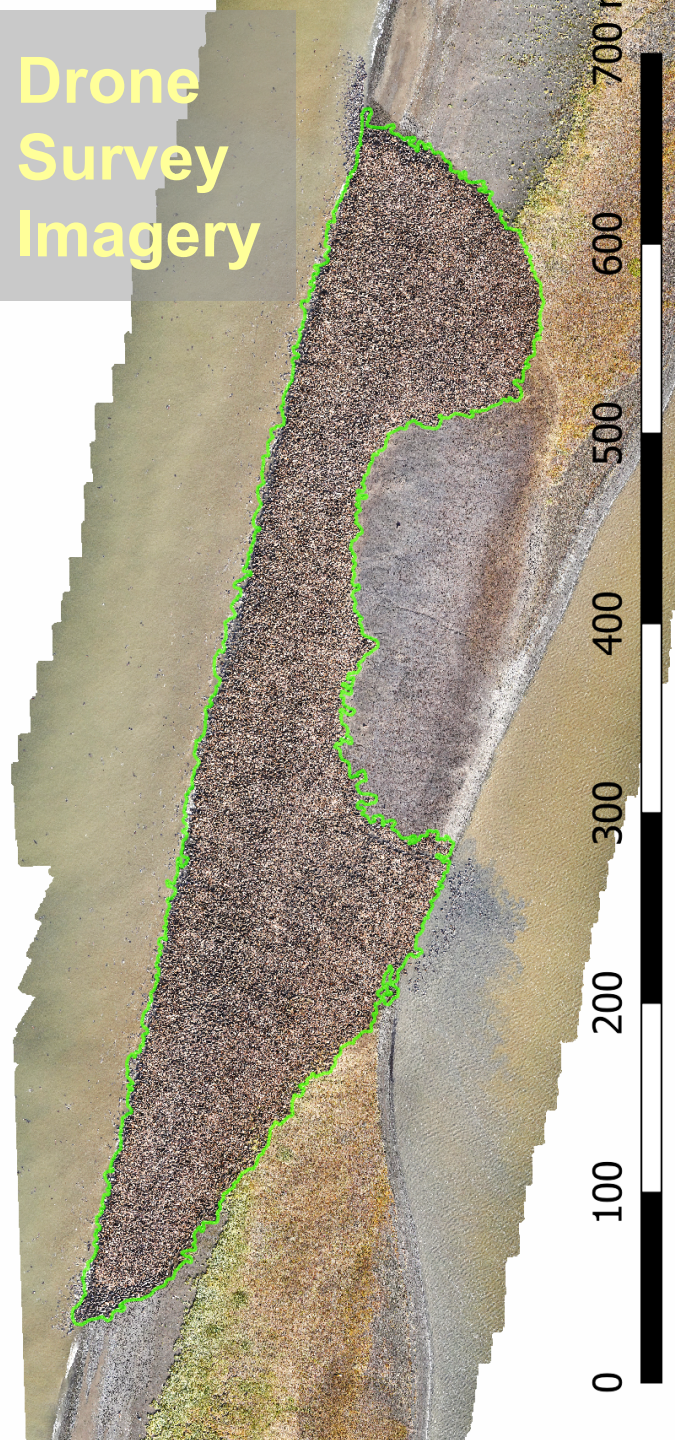
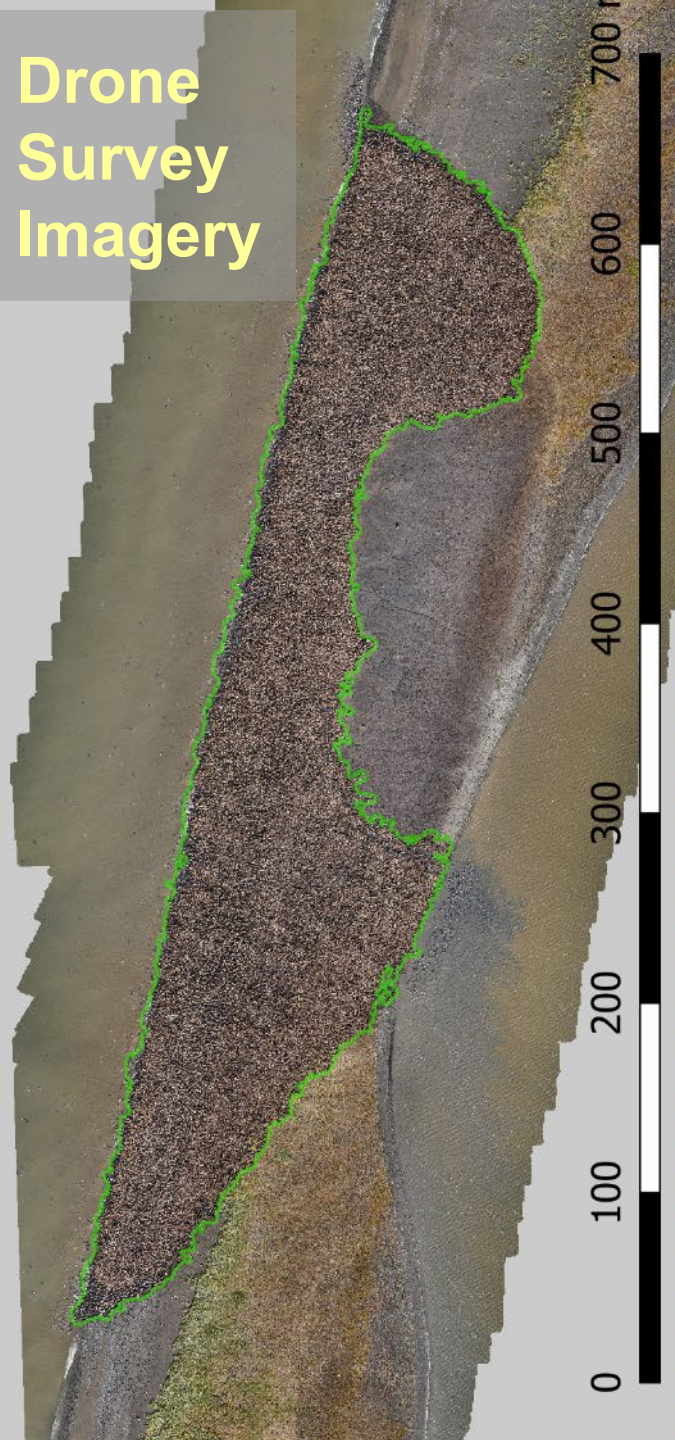


Photo A. Fischbach / USGS

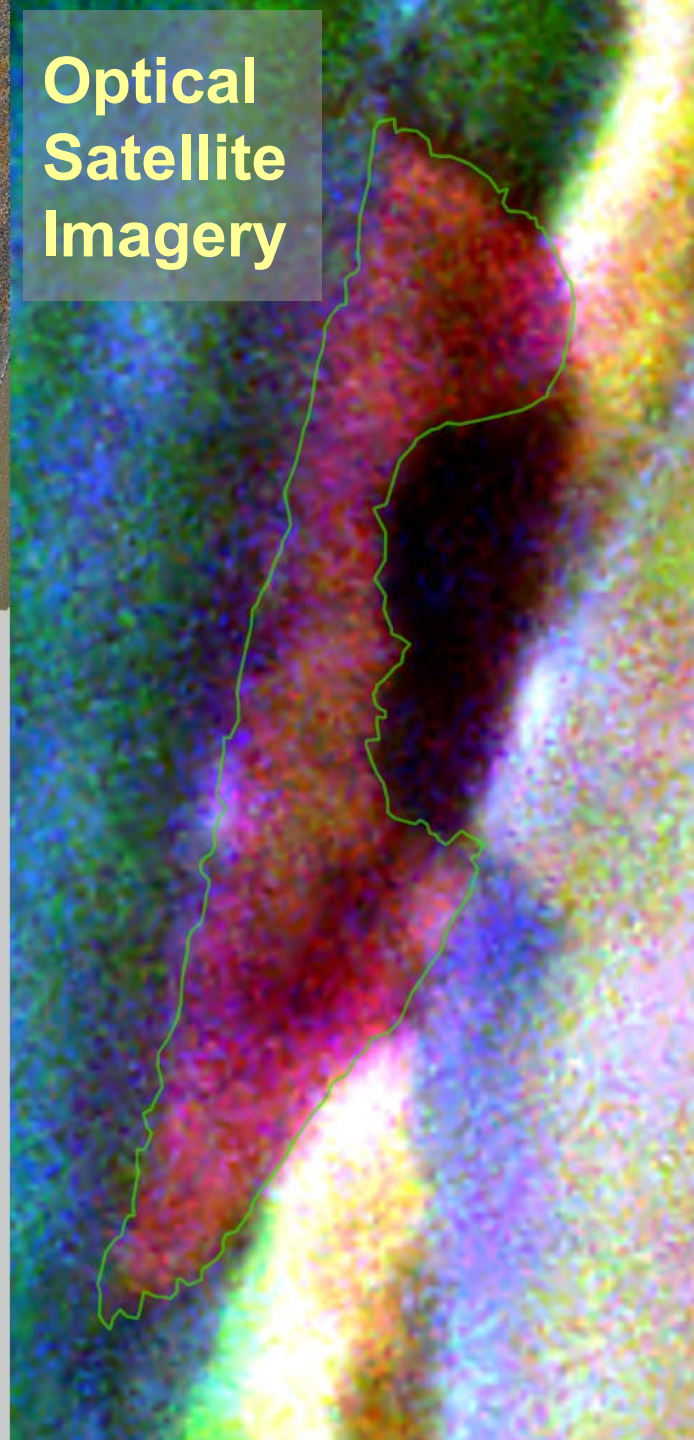


# What can we see from orbit?

Drone  
Survey  
Imagery



Optical  
Satellite  
Imagery



Method Paper:  
Fischbach & Douglas 2021  
<https://doi.org/10.3390/rs13214266>

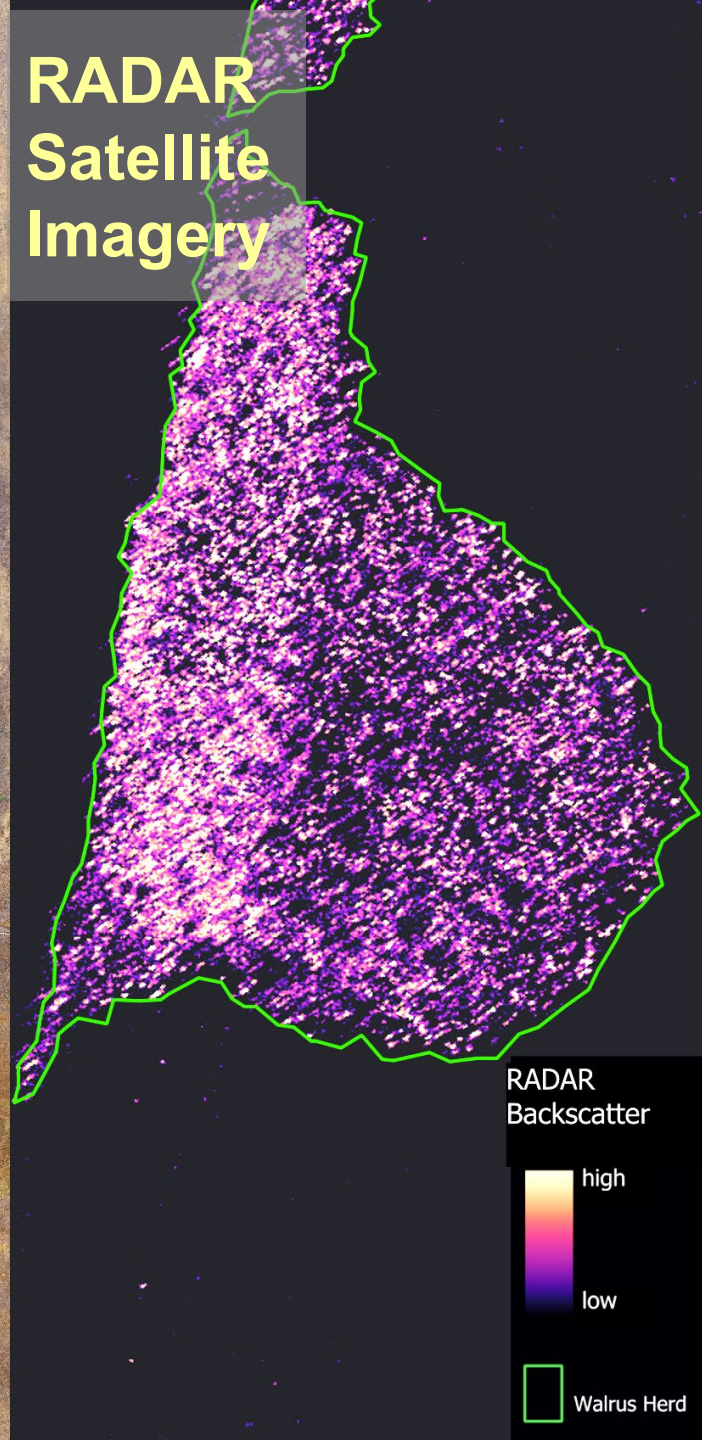


# What can we see from orbit?

Drone  
Survey  
Imagery



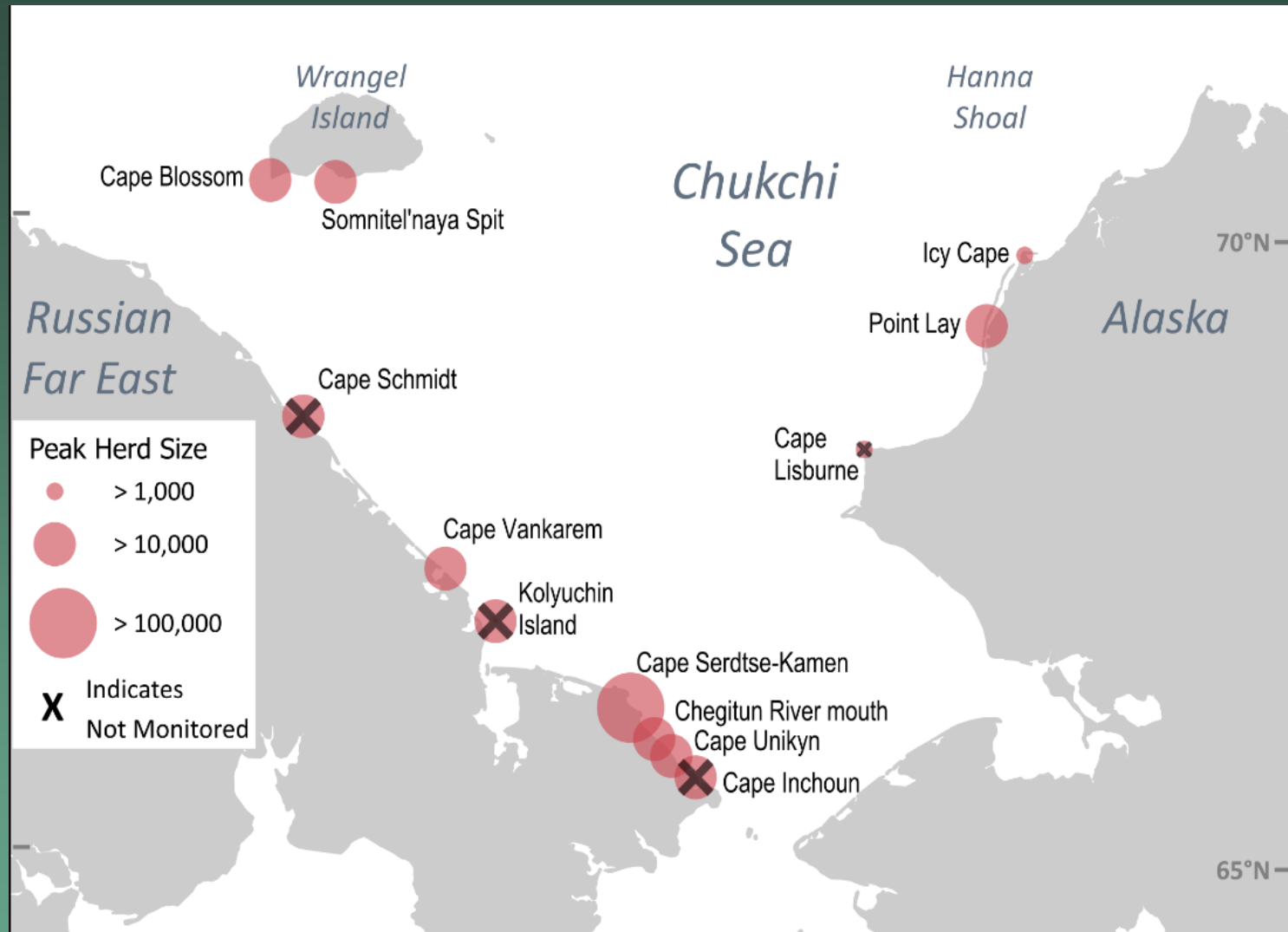
RADAR  
Satellite  
Imagery



Method Paper:  
Fischbach & Douglas 2021  
<https://doi.org/10.3390/rs13214266>



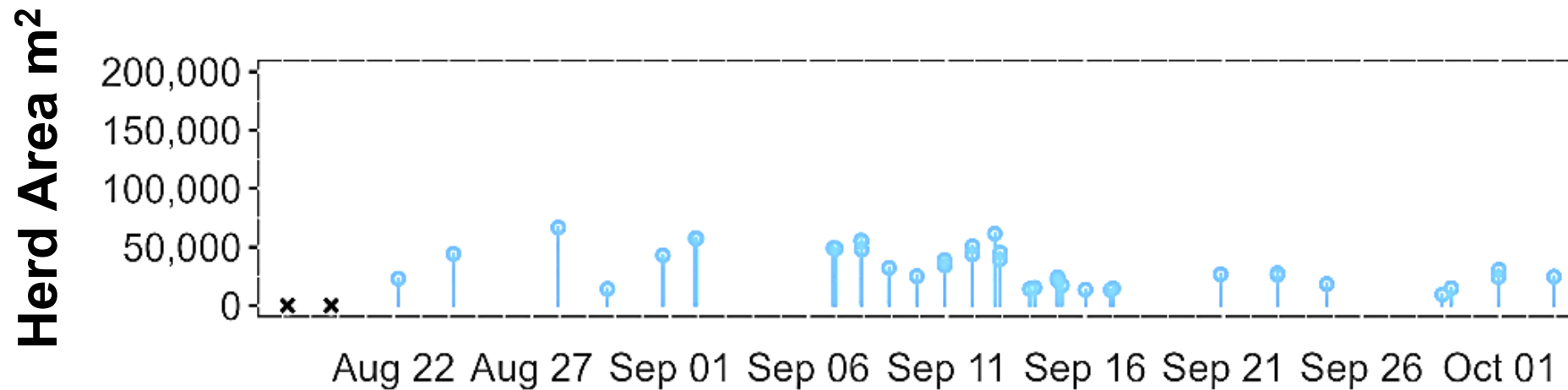
# Where have we looked from orbit?





What  
did  
we see  
from  
orbit?

## Herd Occurrence and Area



Data:  
Fischbach & Douglas 2022.(v. 5.0)  
<https://doi.org/10.5066/P9CSM0KN>



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Photo E. Powers / USGS

# Herd Abundance

~ herd area \* herd density



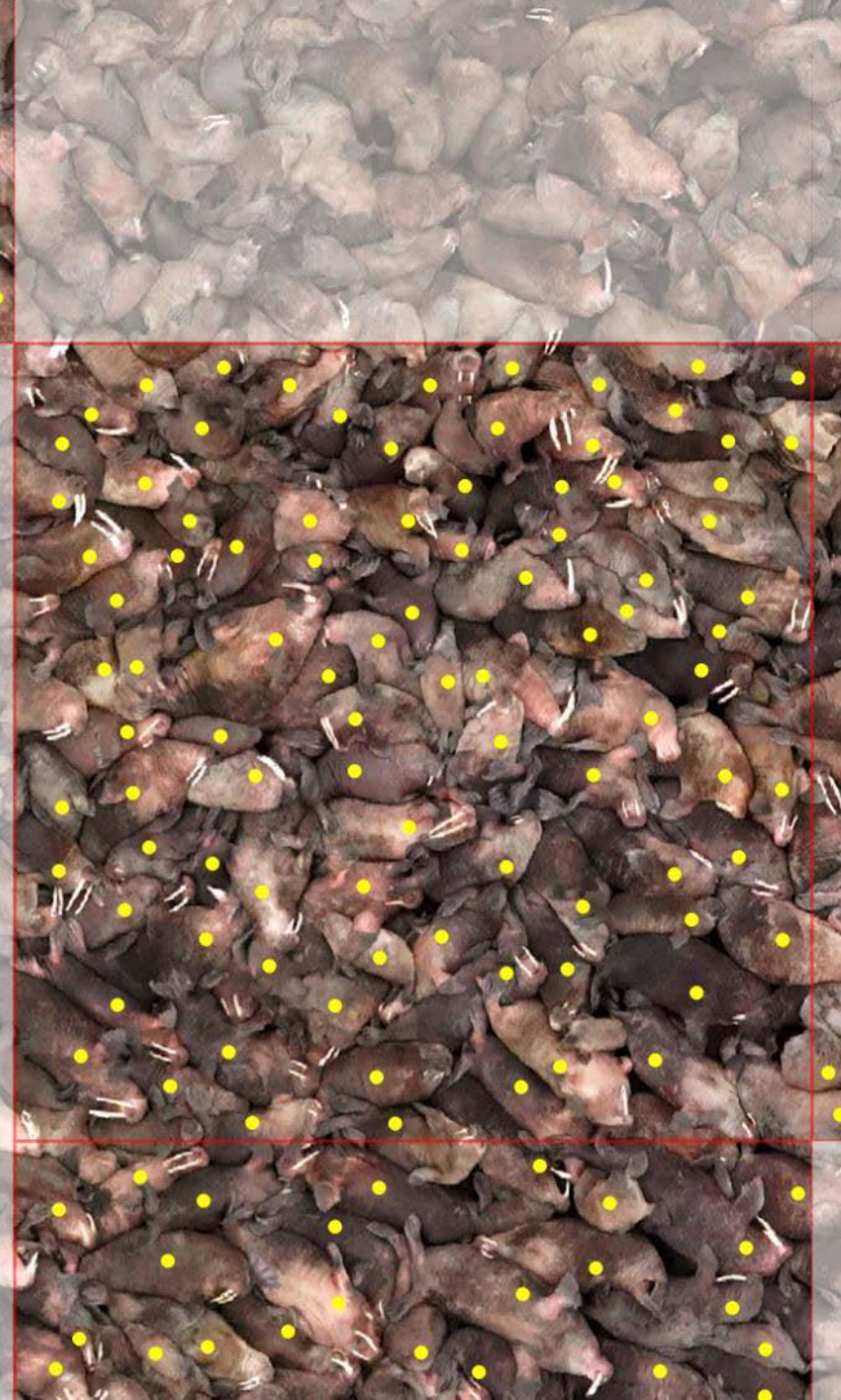
## Herd Density Data from Drone Surveys:

Altukhov, et al. 2024.

[https://www.ebi.ac.uk/biostudies/  
studies/S-BSST1263](https://www.ebi.ac.uk/biostudies/studies/S-BSST1263)

Fischbach et al. 2021.

<https://doi.org/10.5066/P959H1EH>



# Mean Herd Density Varies between sites and surveys

## *Example Grid Cell Images*

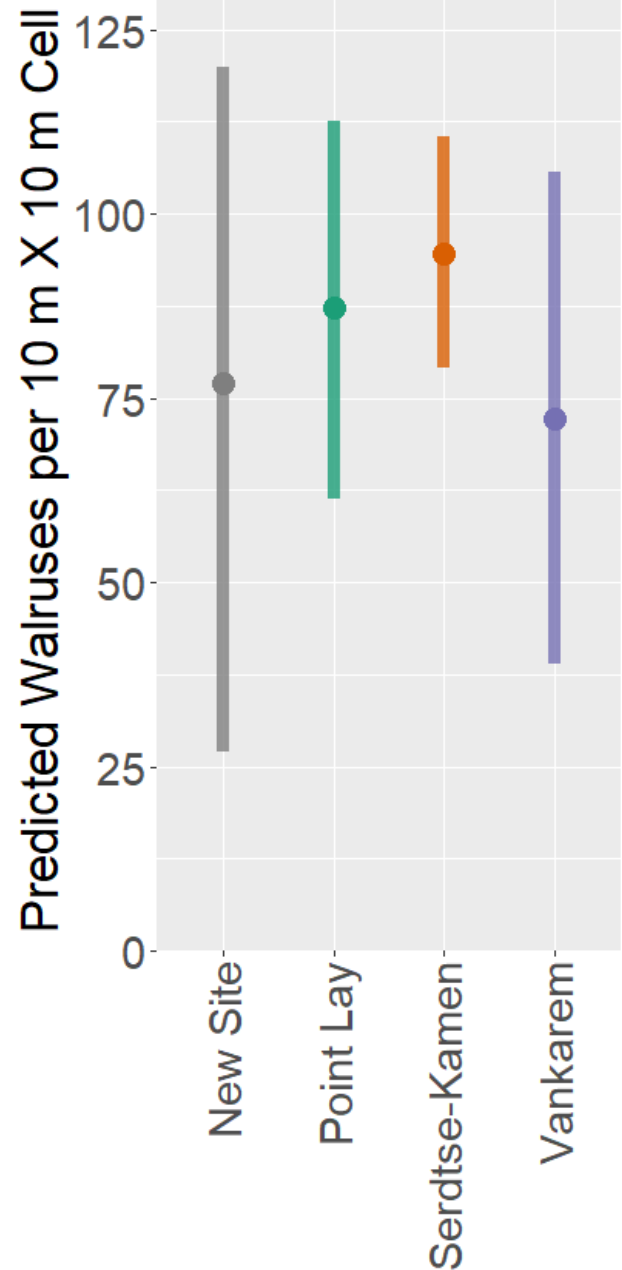
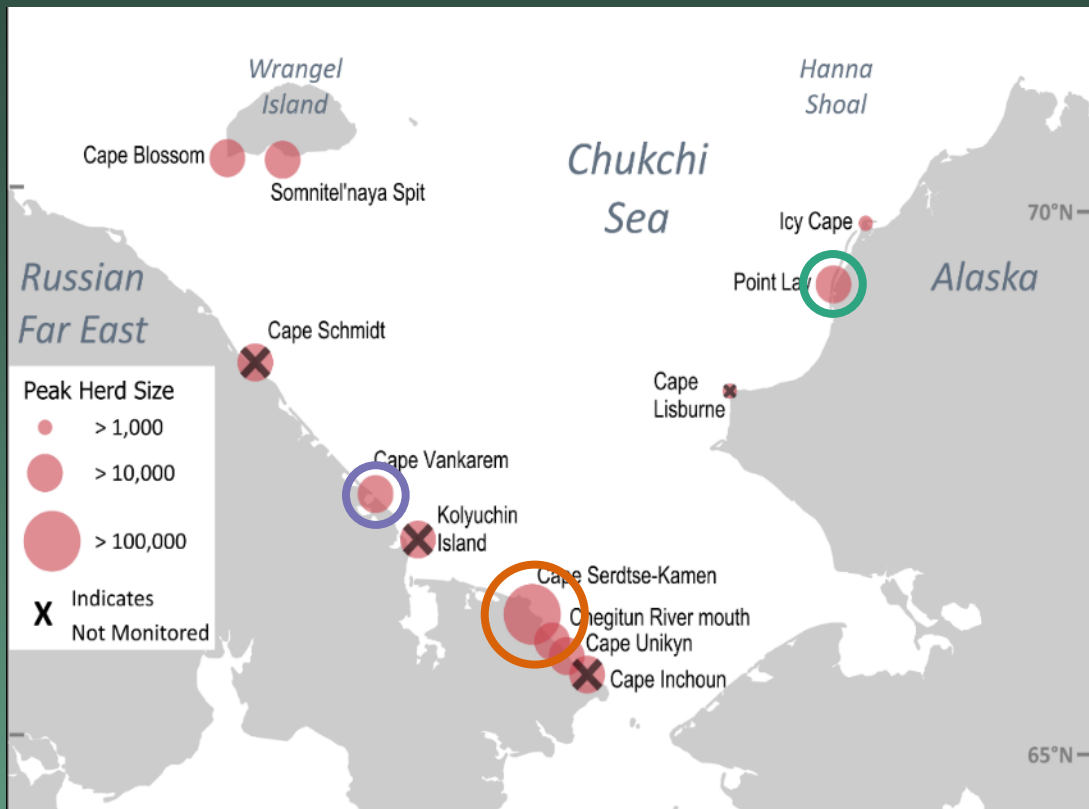


*50 Walruses / 100 m<sup>2</sup>*



*100 Walruses / 100 m<sup>2</sup>*

# Herd Density Results



Fischbach, Taylor & Douglas  
2025 Wildlife Society Bulletin  
(In Press)

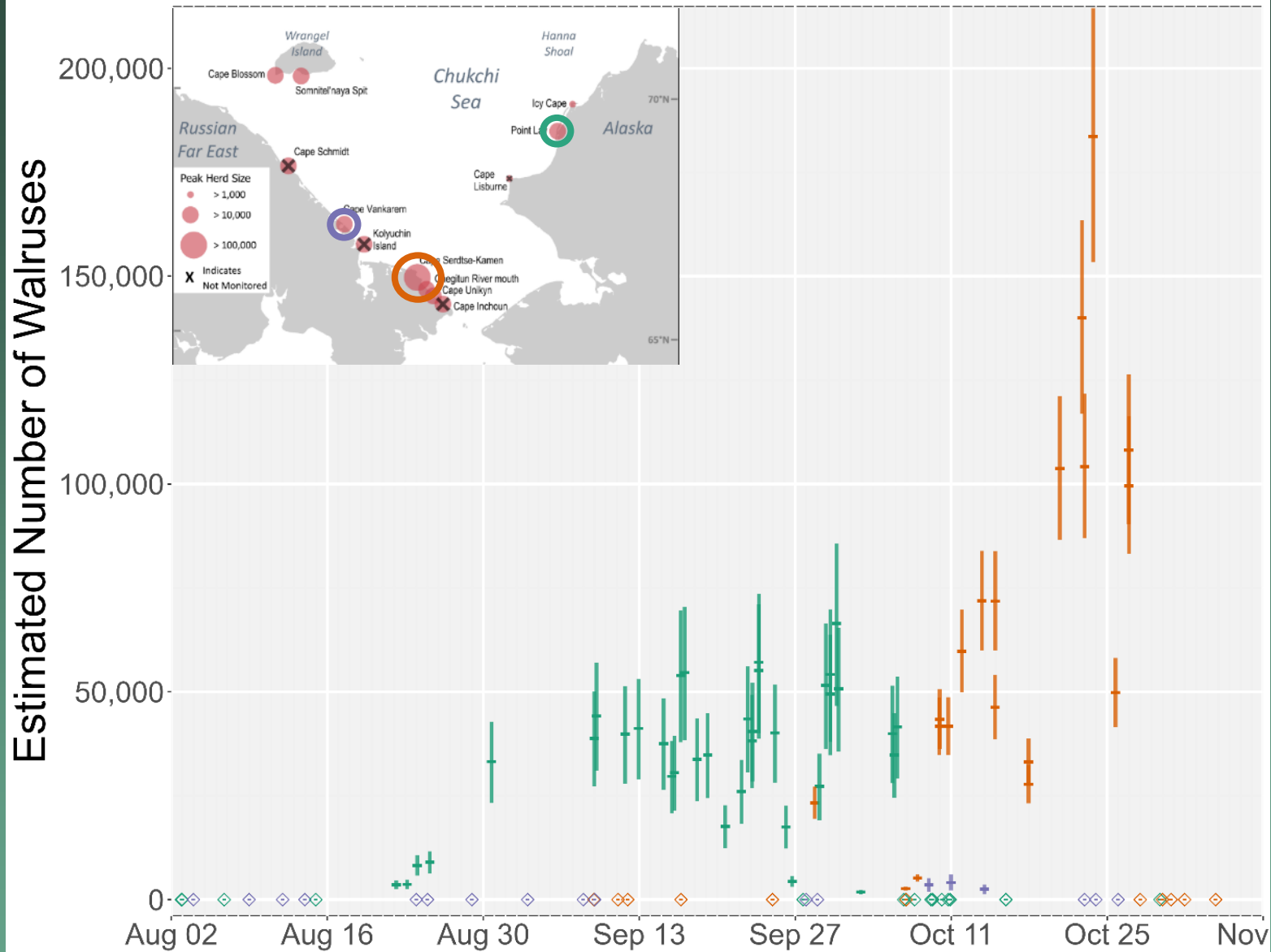


Preliminary Data Not for Dissemination or Citation

Marine Mammal Commission 2025 Sept 9

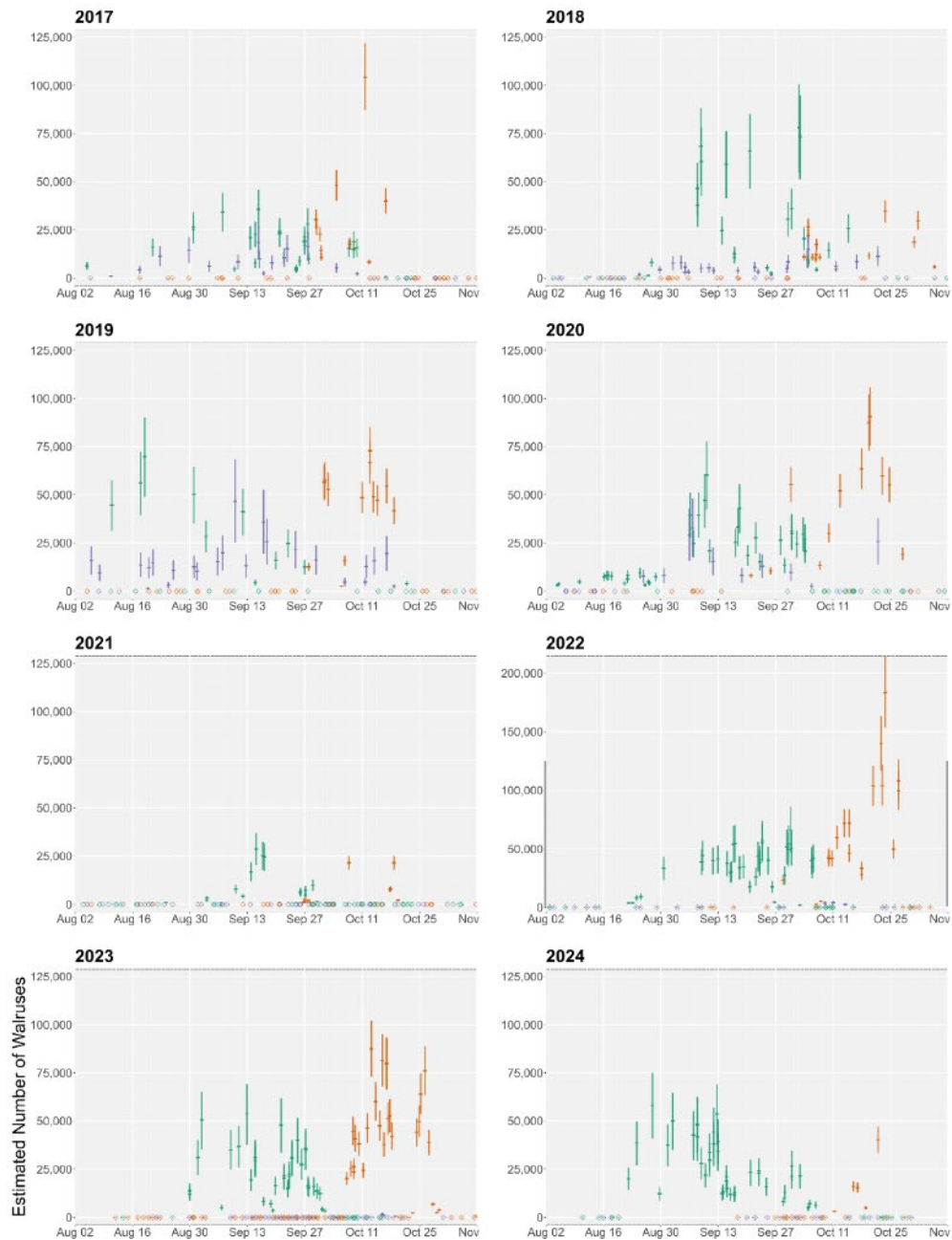


2022





Fischbach, Taylor & Douglas  
2025 Wildlife Society Bulletin  
(In Press)





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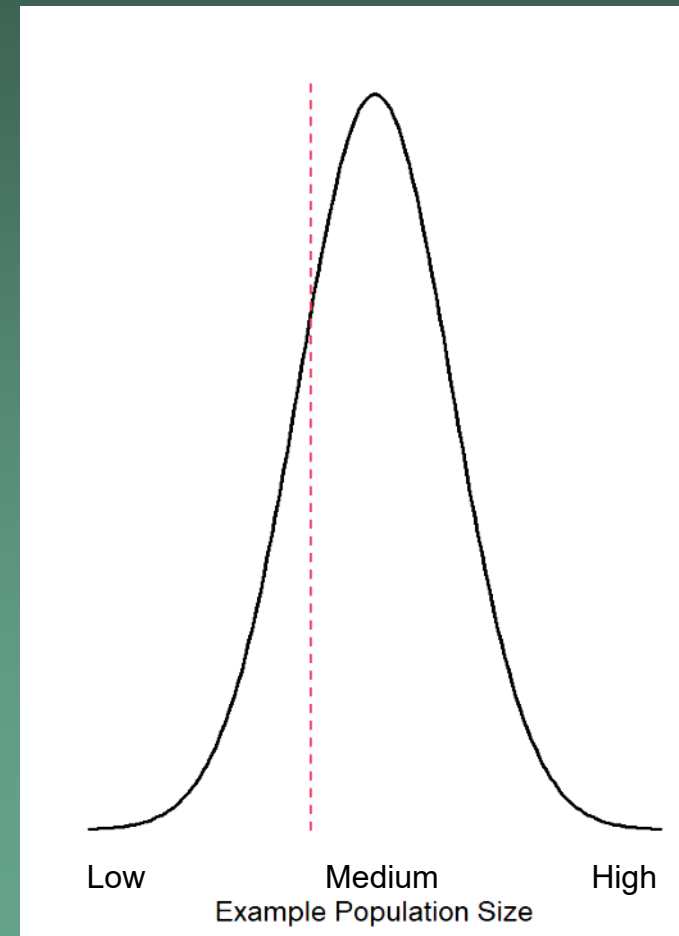
Photo E. Powers / USGS

# MMPA Stock Assessment Report $N_{\min}$

$N_{\min}$  is used to calculate  
Potential Biological Removal

Default method to calculate  $N_{\min}$ :

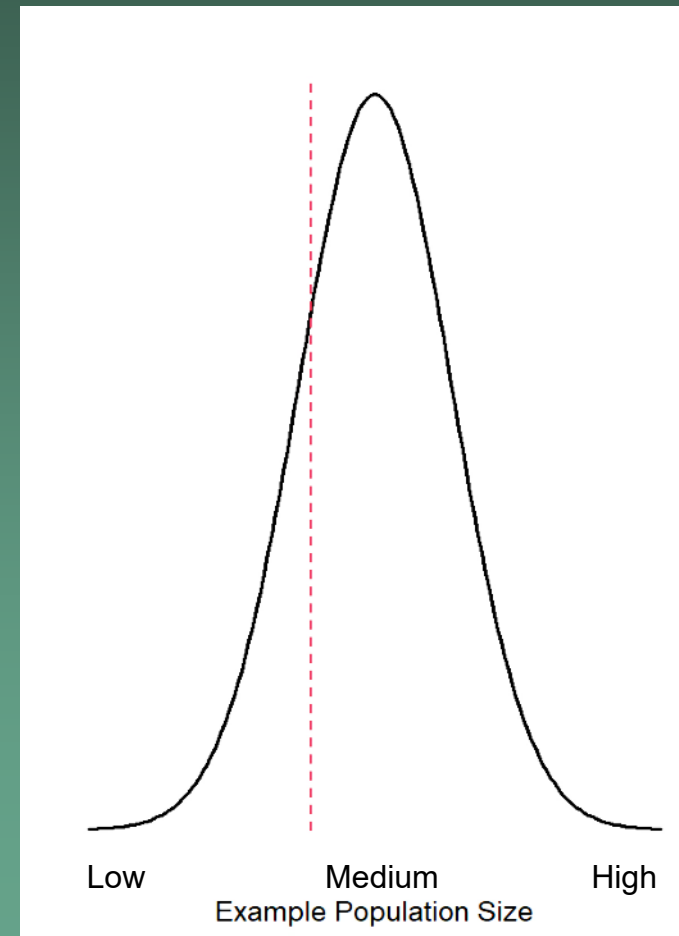
- Estimate total population mean and CV
- Apply formula based on log normal distribution
- Take the 20<sup>th</sup> percentile



# MMPA Stock Assessment Report $N_{\min}$

Other methods to calculate  $N_{\min}$  allowed if justifiable

- 2023 Stock Assessment used 20<sup>th</sup> percentile of posterior distribution of population size
- 2014 Stock Assessment used mean of population size estimate





# MMPA Stock Assessment Report $N_{\min}$

Walrus  $N_{\min}$  has been calculated from total population size, but total population size estimates very difficult to obtain

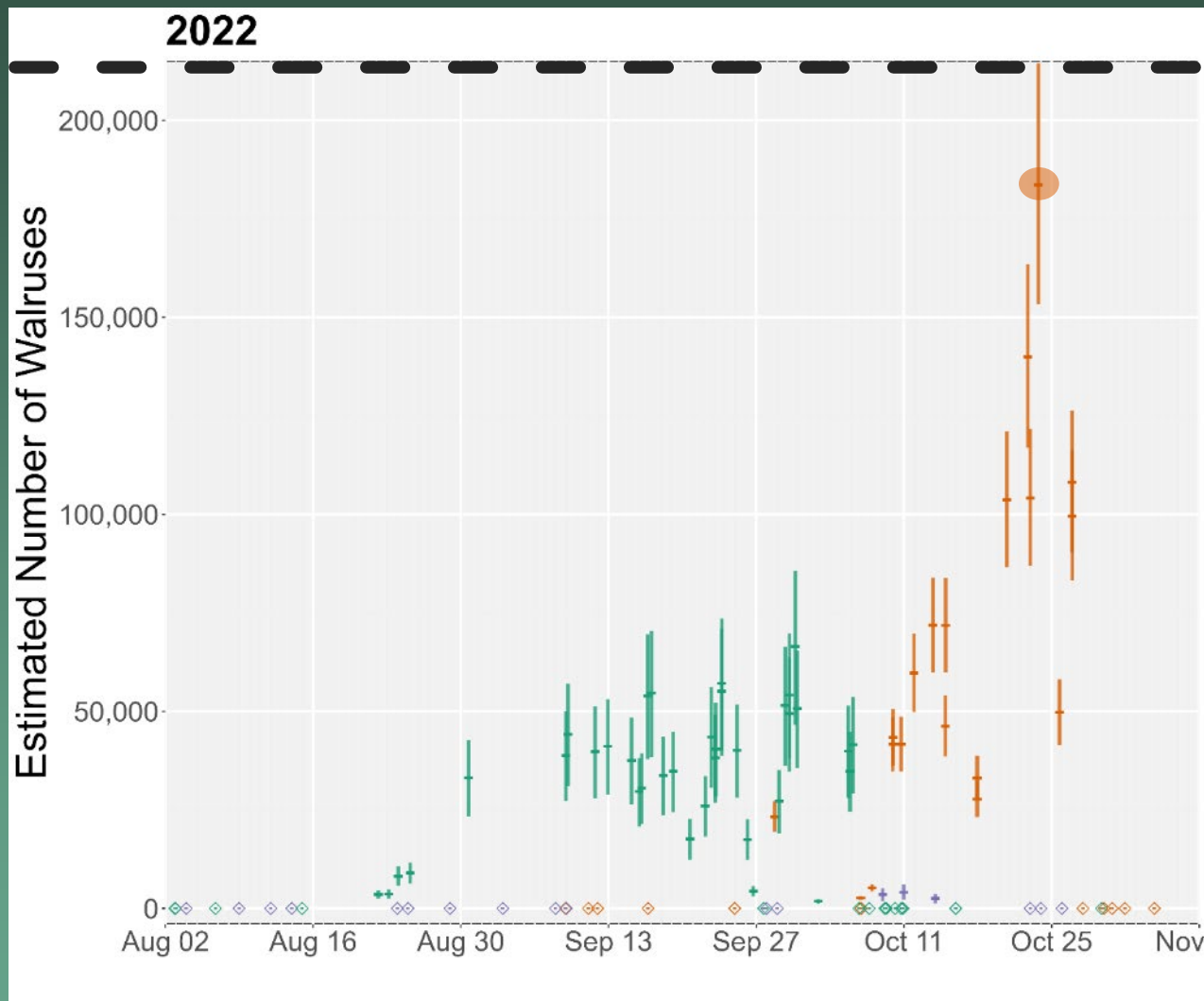
## Recent total population size estimates

|           |                                    |
|-----------|------------------------------------|
| 1990      | <i>(aerial survey)</i>             |
| 2006      | <i>(aerial survey)</i>             |
| 2013–2017 | <i>(a mark-recapture estimate)</i> |

If data for  $N_{\min}$  > 8 years old  
it is considered out of date

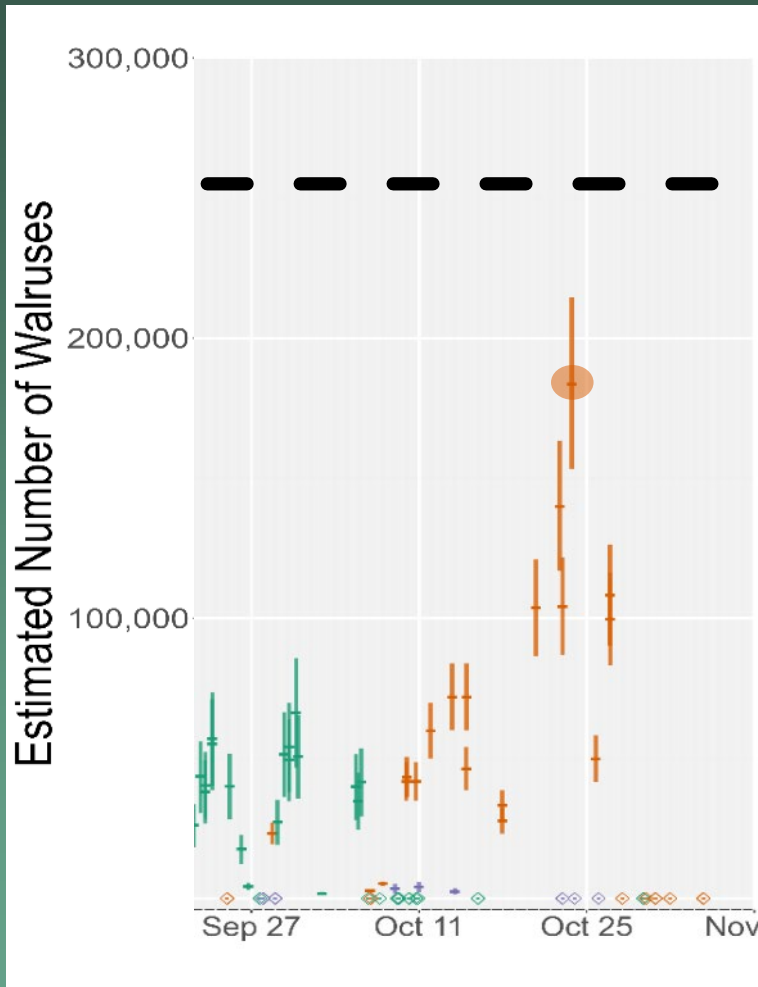


# MMPA Stock Assessment Report $N_{\min}$



2023 SAR  $N_{\min}$

# MMPA Stock Assessment Report $N_{\min}$



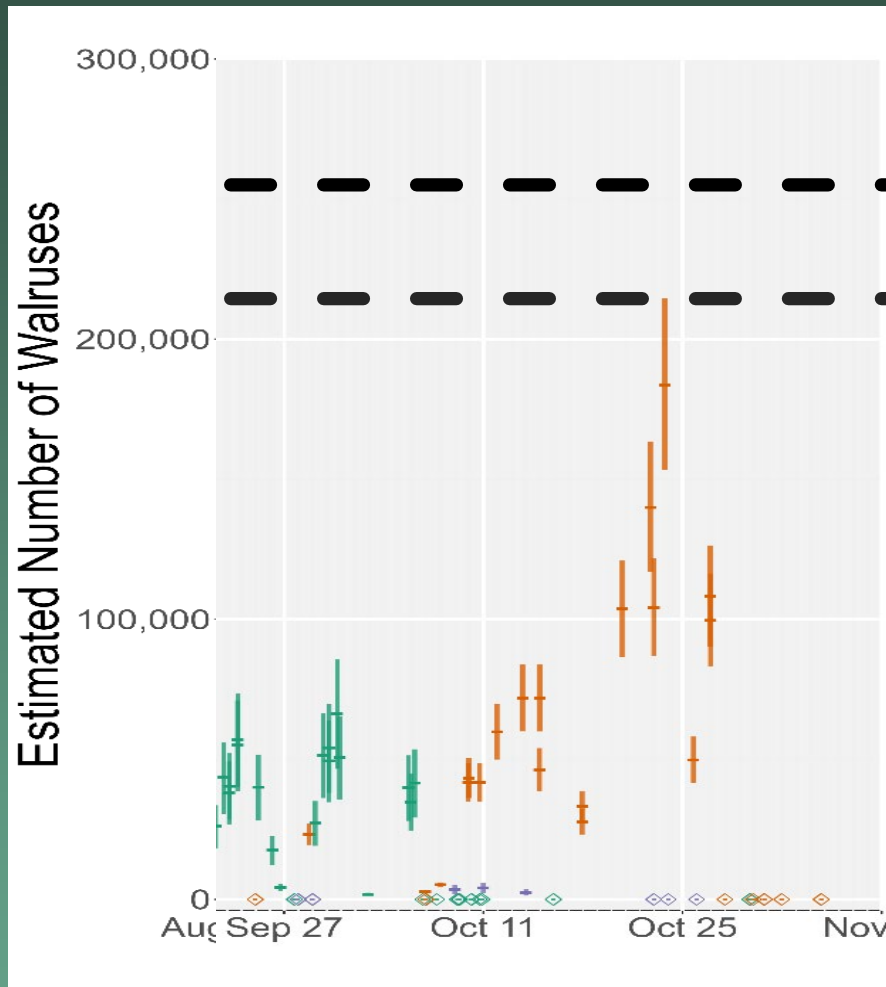
$$N_{\min} = \text{peak abundance} / p(\text{HO})_{\max}$$

$$N_{\min} = 184,000 / 0.727 = 250,000$$

$p(\text{HO})_{\max}$  = max proportion  
out of water  
during a survey

Fischbach, Taylor & Douglas  
2025 Wildlife Society Bulletin  
(In Press)

# MMPA Stock Assessment Report $N_{\min}$



$N_{\min} = \text{peak abundance} / p(\text{HO})_{\max}$

2023 SAR  $N_{\min}$

Fischbach, Taylor & Douglas  
2025 Wildlife Society Bulletin  
(In Press)



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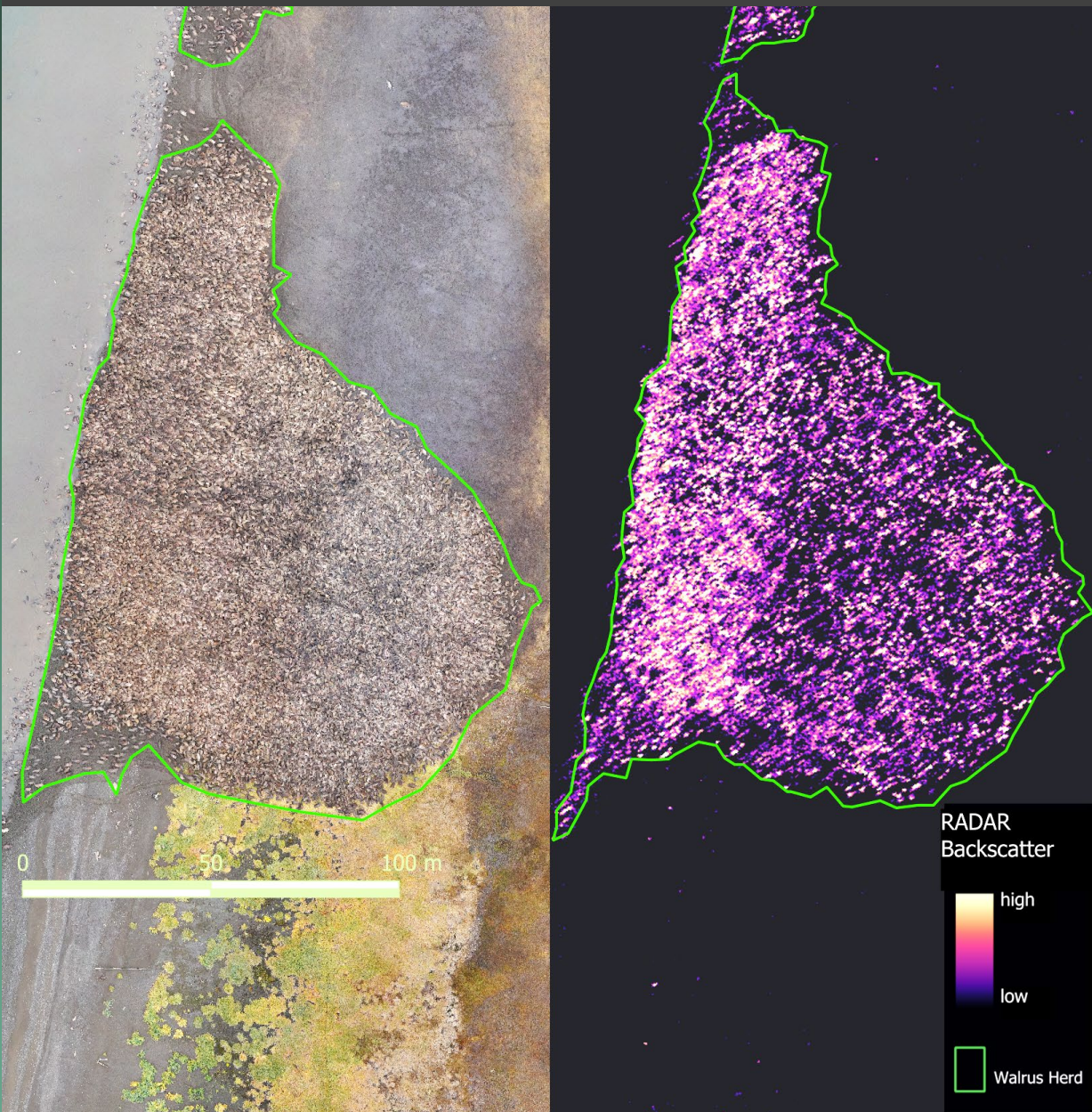
Ongoing research

- Improving  $N_{\min}$  estimate
  - Herd Abundance from radar backscatter
  - Telemetry Concurrent with Satellite Images



Photo E. Powers / USGS

# Herd Abundance Precision



Can RADAR  
backscatter  
improve abundance  
estimates?

Fischbach and Racenet. 2025  
<https://doi.org/10.5066/P134RT9M>

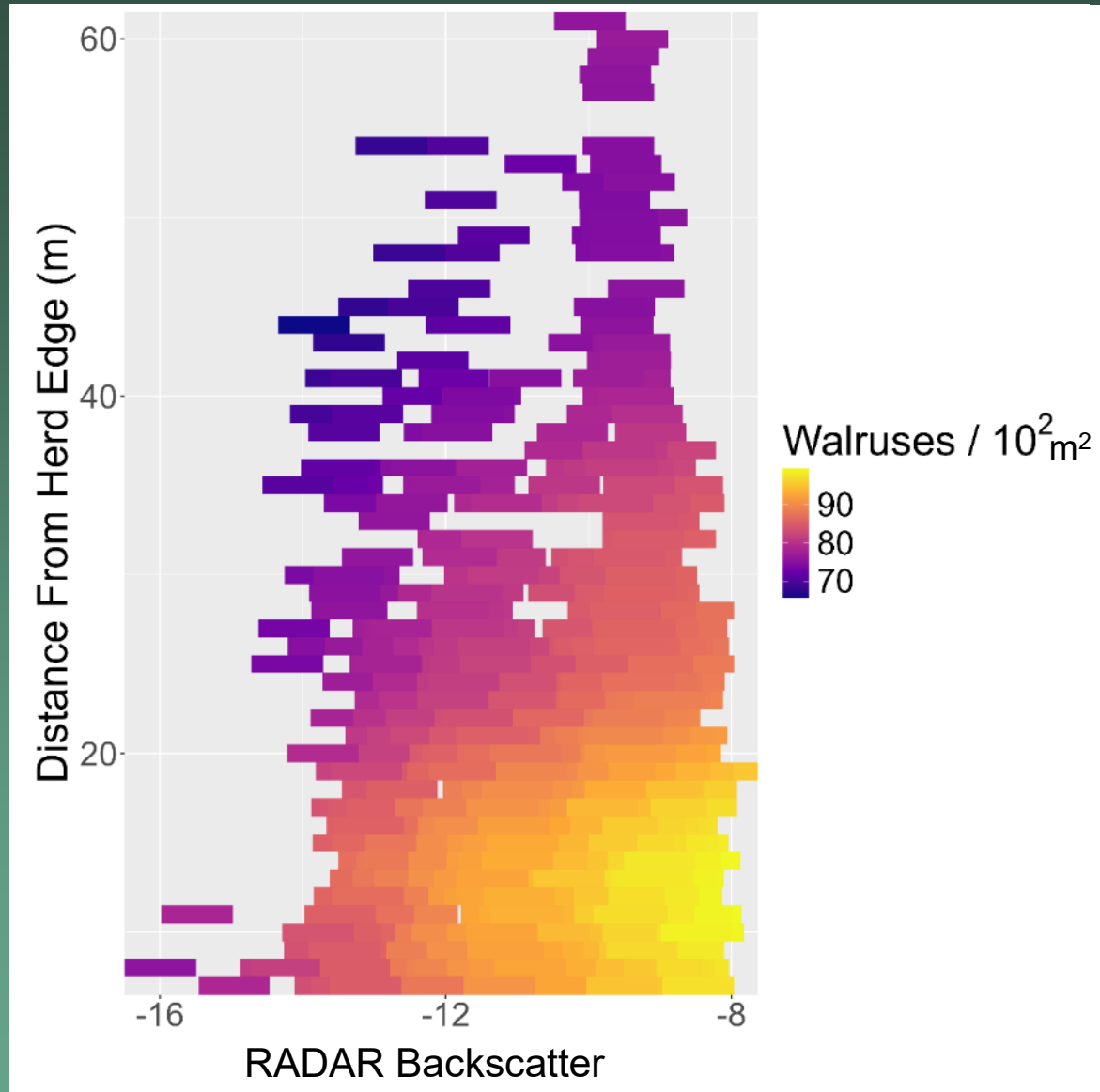




# Herd Abundance Precision

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Preliminary Data Not for Dissemination or Citation





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  - **Telemetry Concurrent with Satellite Images**



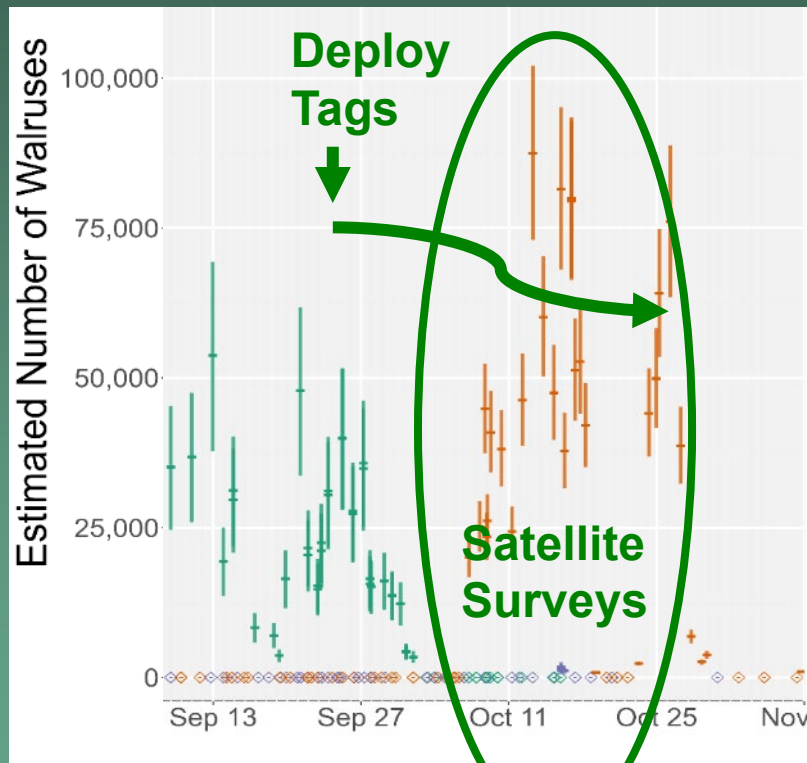
# Telemetry Concurrent with Surveys

## Strategy:

- + Deploy tags in Alaska prior to migration

- + Monitor herd size with satellite images

- + Estimate abundance from herd size adjusted with haulout proportion from telemetry



# Telemetry Concurrent with Surveys

## 2006 Aerial Survey Estimate <sub>1</sub>

Speckman et al. (2011)  
Population abundance  
<https://doi.org/10.3354/meps14131>

improved precision:

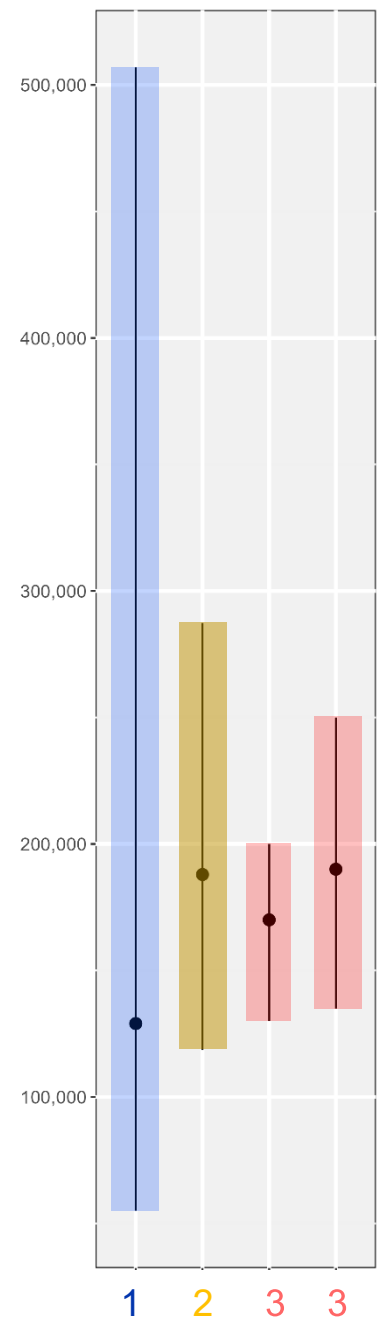
## 5-years sampling for Mark-Recapture <sub>2</sub>

Beatty et al. (2022)  
Population abundance  
<https://doi.org/10.3354/meps14131>

improved precision:

## Telemetry Combined with Imagery <sub>3</sub>

Fischbach et al. (2022)  
Regional abundance  
<https://doi.org/10.1002/jwmg.22256>





# Thank you

This material will be available in  
Fischbach, Taylor & Douglas  
Wildlife Society Bulletin  
(In Press)



Photo A. Fischbach / USGS



# Potential Biological Removal

“the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population.”

$$\text{PBR} = N_{\min} \times 1/2 \times r_{\max} \times F_r$$