Remote video monitoring of Steller sea lions in Kenai Fjords: Eleven years and 50,000 hours of details

PI: John M. Maniscalco
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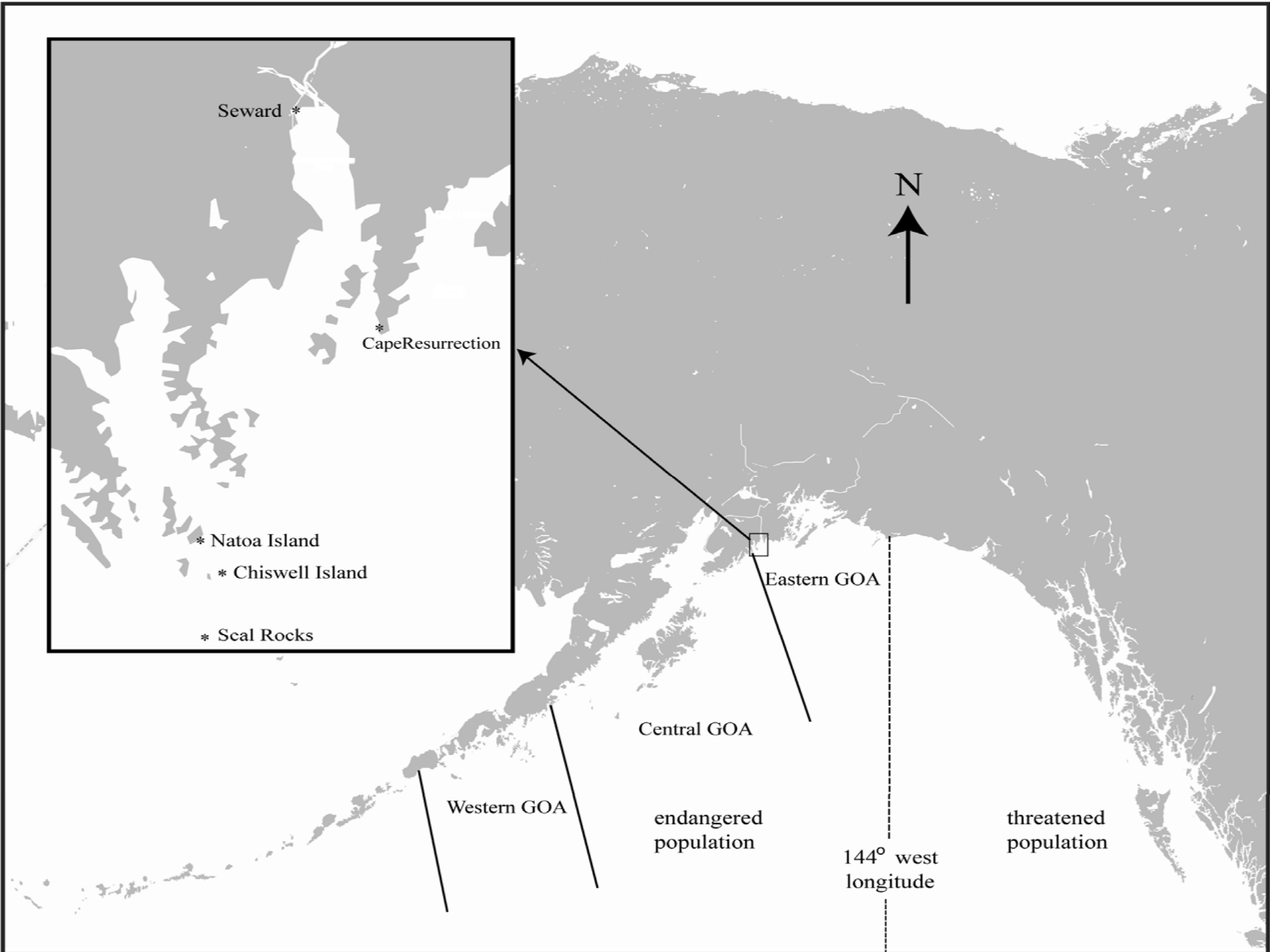
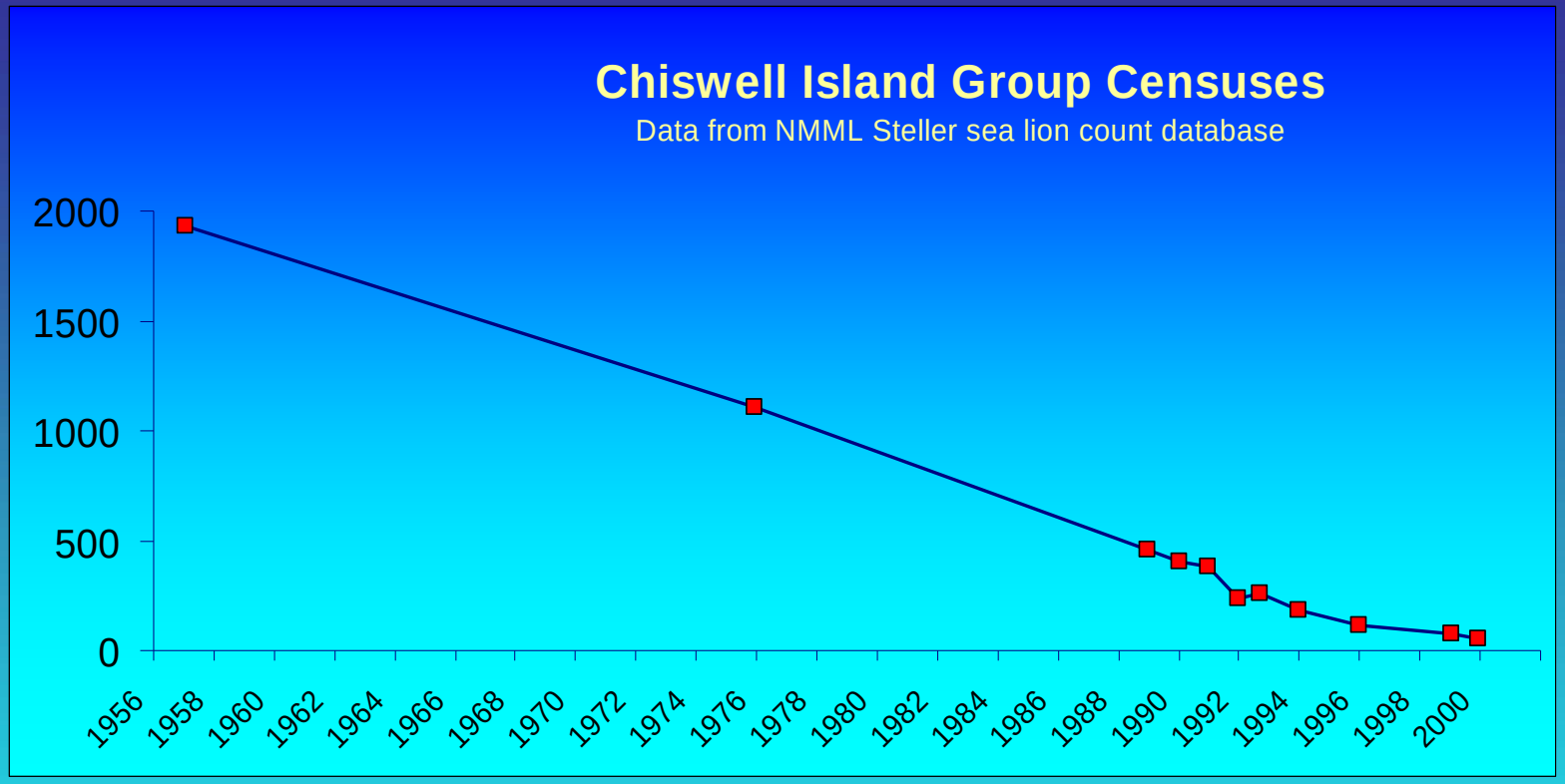
Photo by Elizabeth Moundalexis


Seward
CapeResurrection
Natoa Island
Chiswell Island
Seal Rocks
N
Eastern GOA
Central GOA
Western GOA
endangered
population
144° west
longitude
threatened
population


Chiswell Island Group Censuses
Data from NMML Steller sea lion count database
2000
1500
1000
500
0
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000


Summer of 1982


Summer of 2002

1998: Birth of the Chiswell Project

Don Calkins

Daniel Zatz

Remote-control cameras
Equipped with
***Zoom**
***Pan/Tilt**
***Windshield**
washer/wipers

SEEMORE WILDLIFE SYSTEMS

Control tower

Microwave

VHF antennas

Solar panels

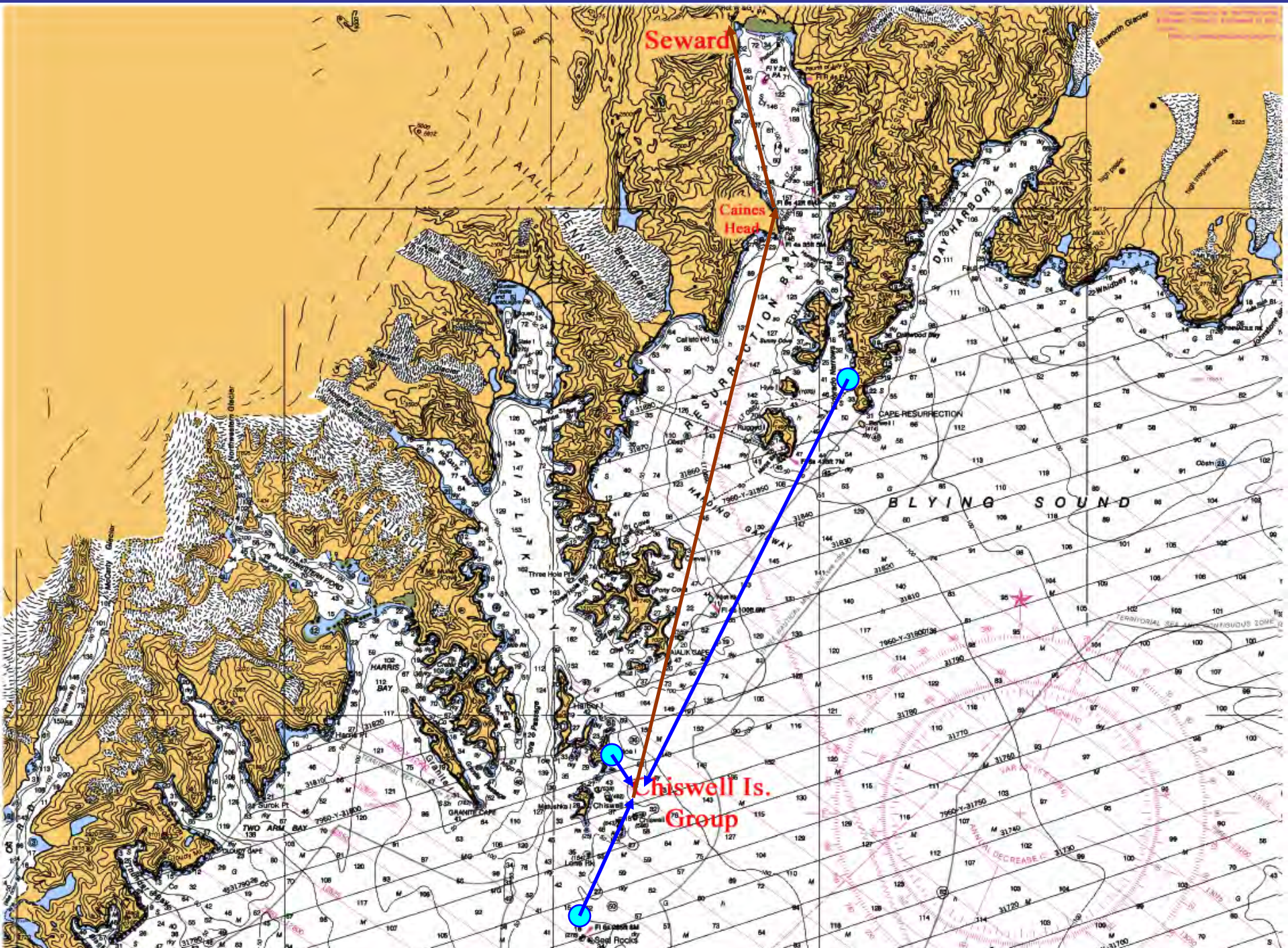
Wind generators

***Methanol fuel cell**

Weather station

***Digital antenna**

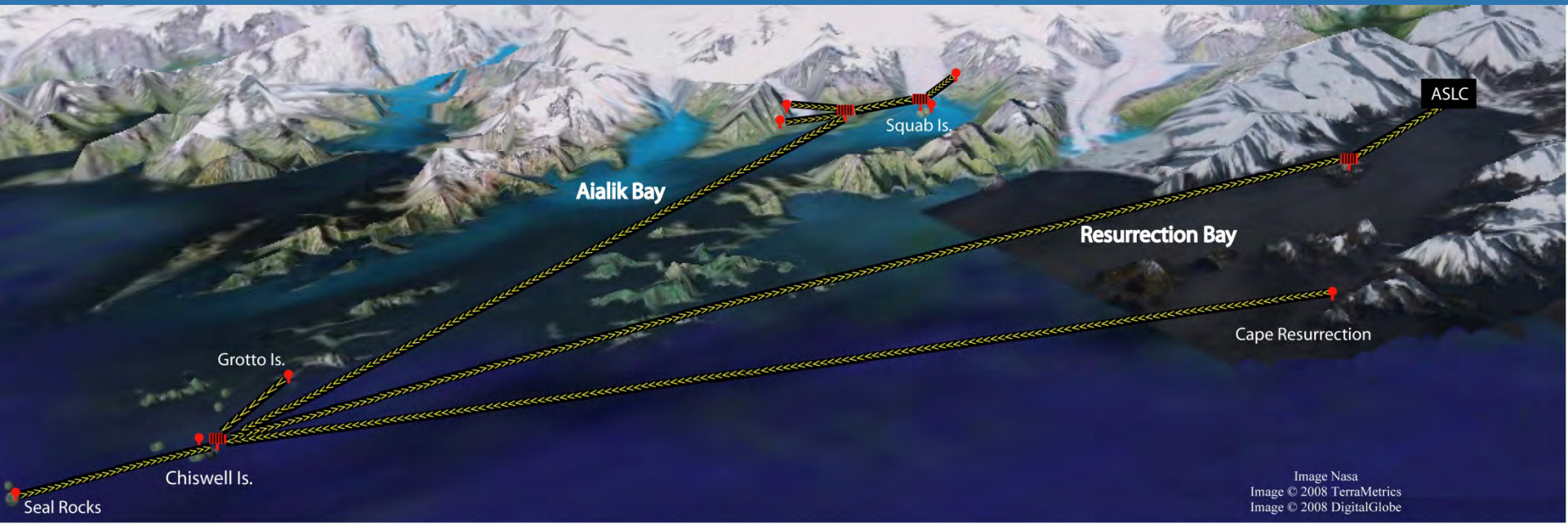
*** New in 2008**


Seward
Caines Head
Chiswell Is. Group
BLYING SOUND
AIALIK BAY
DAY HARBOR
CAPE RESURRECTION
HARRIS BAY
TWO ARM BAY
GRANITE CAPE
Seal Rocks


Harbor Seals: Tractable Sensors of Ecological Change?
SONY

Video System Demonstration

The Complete Remote Video Network



Base image courtesy Google Earth™ mapping service

Camera Site(s) Repeater Site Signal Transmission

NATIONAL WILDLIFE REFUGE SYSTEM

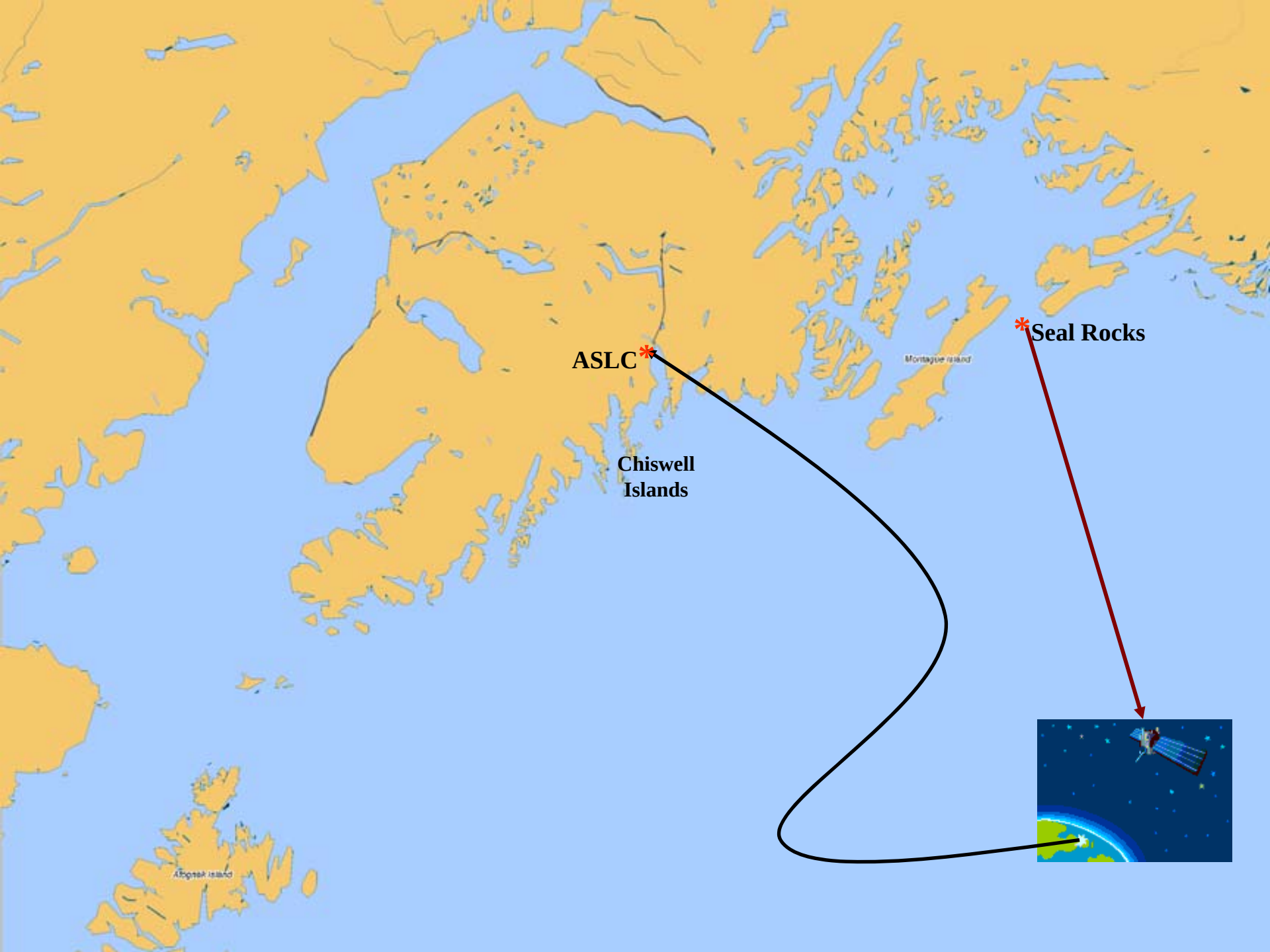
NATIONAL PARK SERVICE

PORT GRAHAM CORPORATION

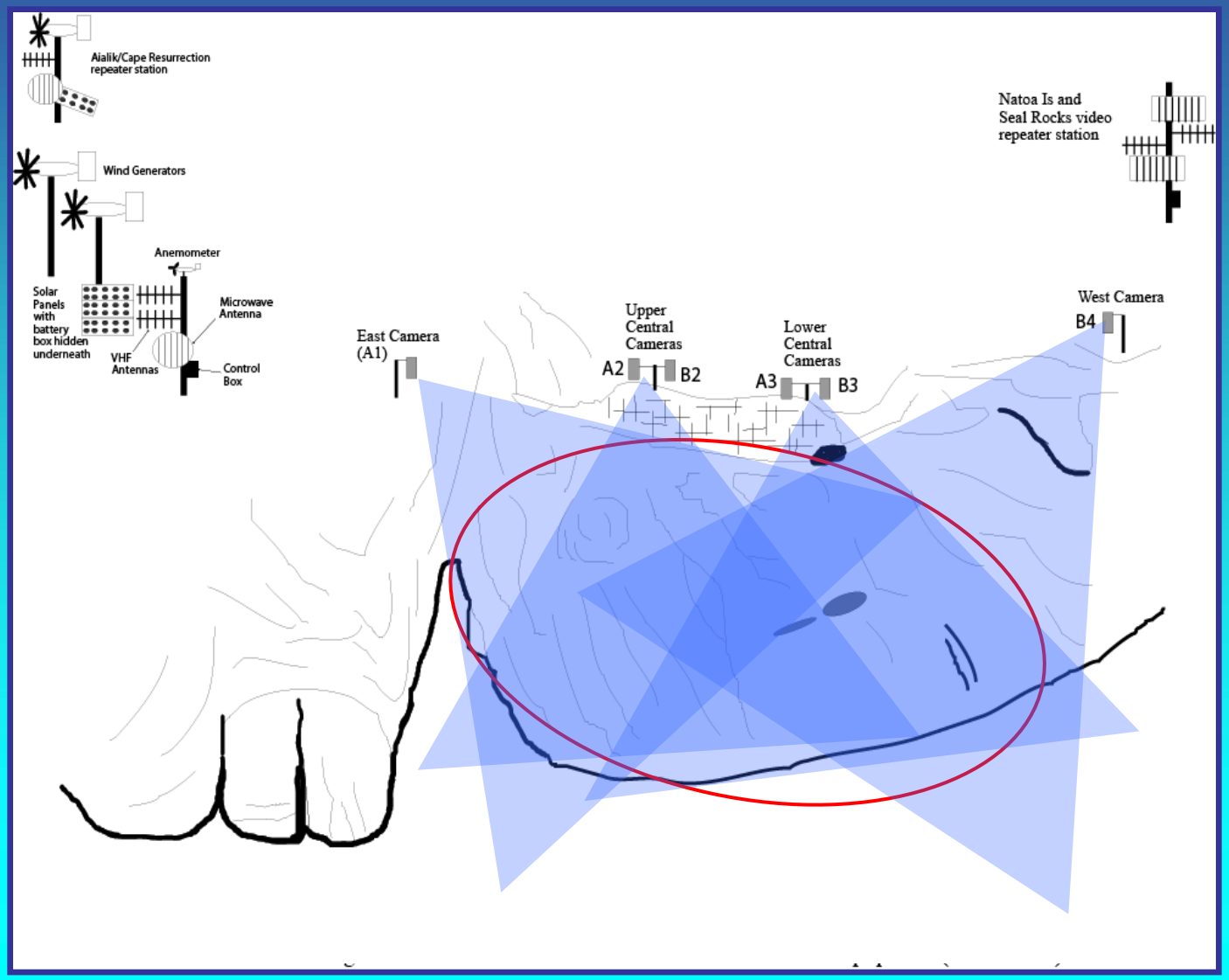
United States Coast Guard
U.S. Department of Homeland Security

Division of Parks and Outdoor Recreation
Alaska Department of Natural Resources

DNR's Mission:
To develop, conserve and enhance natural resources for present and future Alaskans.


ASLC
Seal Rocks
Chiswell
Islands
Montague Island
Alaska Island

Remote Video System Layout on Chiswell Is.



Advantages and Disadvantages of Remote Video System

Advantages

1. **Weather conditions not a concern**
2. **Data recording**
3. **Multiple angle views of animals**
4. **Safety**
5. **Convenience**

Disadvantages

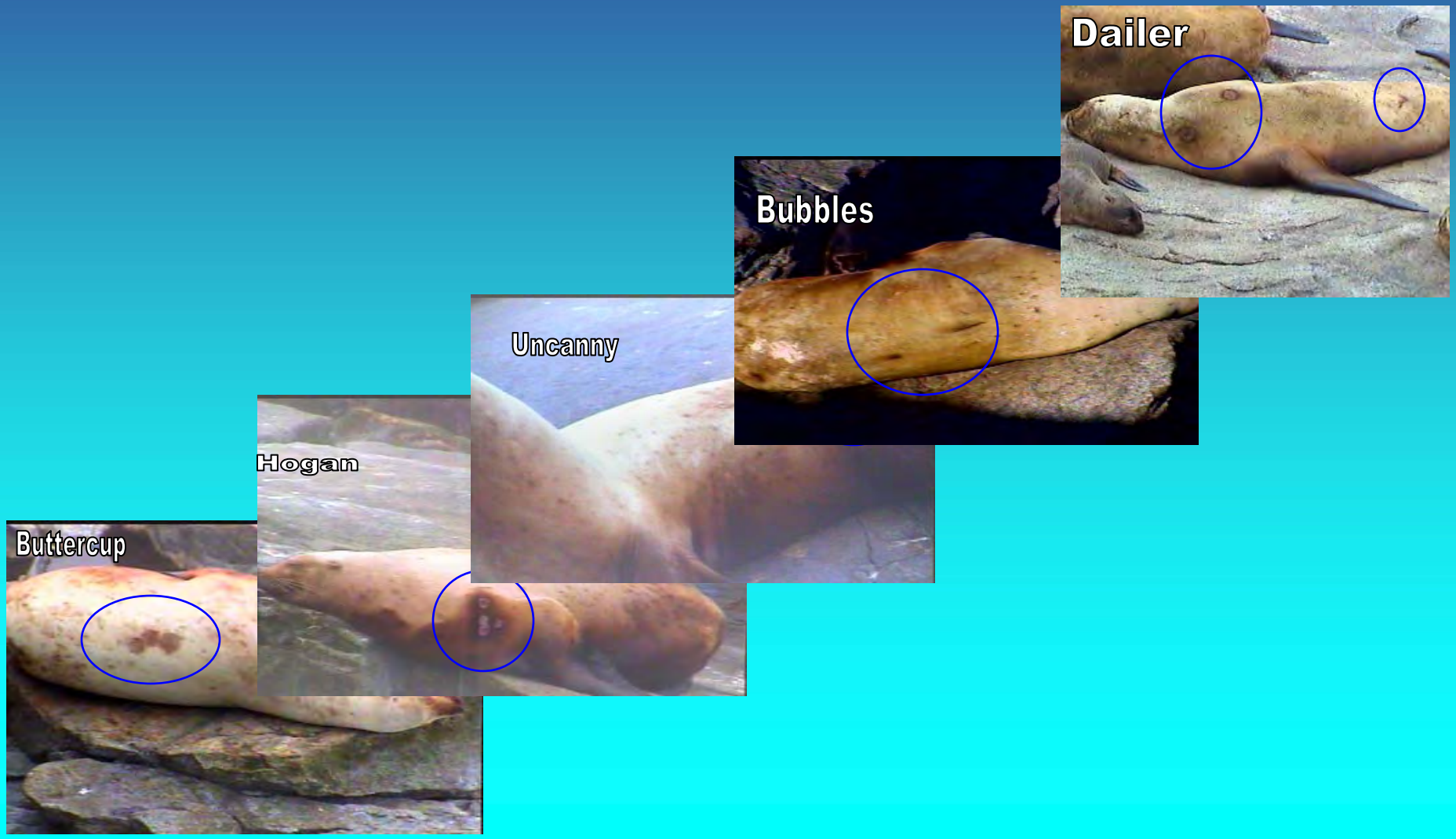
1. **Cost**
2. **Peripheral vision limited**
3. **Not all rookeries can be easily monitored remotely**

Studies Being Accomplished

1. **Maternal Investment**
2. **Characteristics of Parturition**
3. **Alloparental Care**
4. **Pupping Site Fidelity**
5. **Pup Health, Mortality, Weaning**
6. **Killer Whale Predation**
7. **Vital Rates (natality & surival)**
8. **Effects of Branding**
9. **Effects of Rookery Disturbance**
10. **Breeding Bull Dynamics & Repro. Success**
11. **Long-term changes in pup size and growth**
12. **Factors affecting natality (age, diet, & contaminants)**
13. **Entanglement Rates**

****14. Broader Ecosystem Studies**

Identification of Individuals



Sampling Day

04:00 scan / pup count
05:00 scan
06:00 scan
07:00 focal samples
08:00 scan
09:00 focal samples
10:00 scan
11:00 census
12:00 scan
13:00 focal samples
14:00 scan
15:00 focal samples
16:00 scan
17:00 census
18:00 scan
19:00 focal samples
20:00 scan
21:00 focal samples
22:00 scan
23:00 scan
24:00 extended scan if light allows

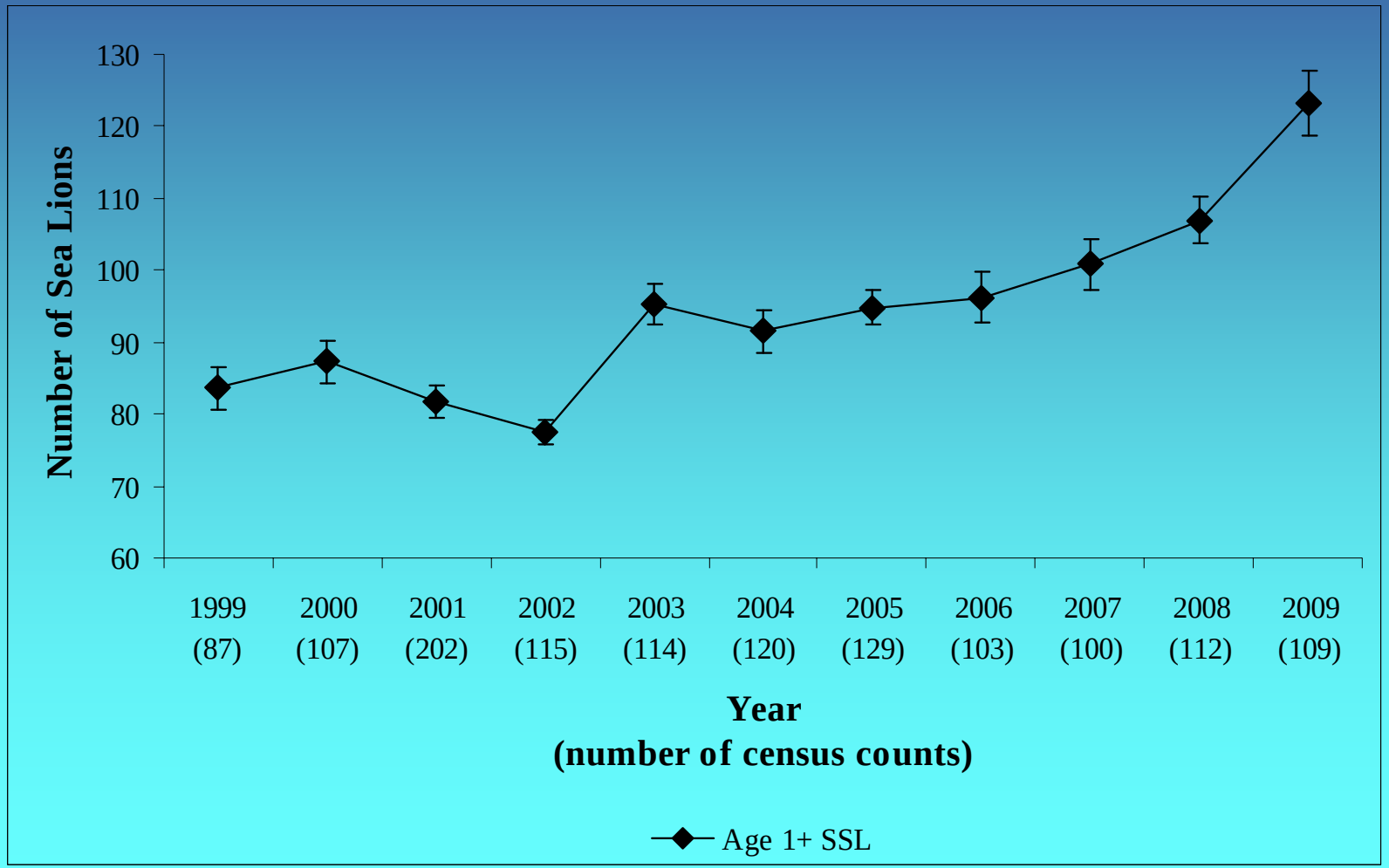
Number of Animals Marked

	2000	2001	2005	2007	2008
Tagged	30	17	13		
Branded			27	51	62

Total = 200 marked (30% live born pups 2000-2009)

Populations trends of age 1+ sea lions on Chiswell Island

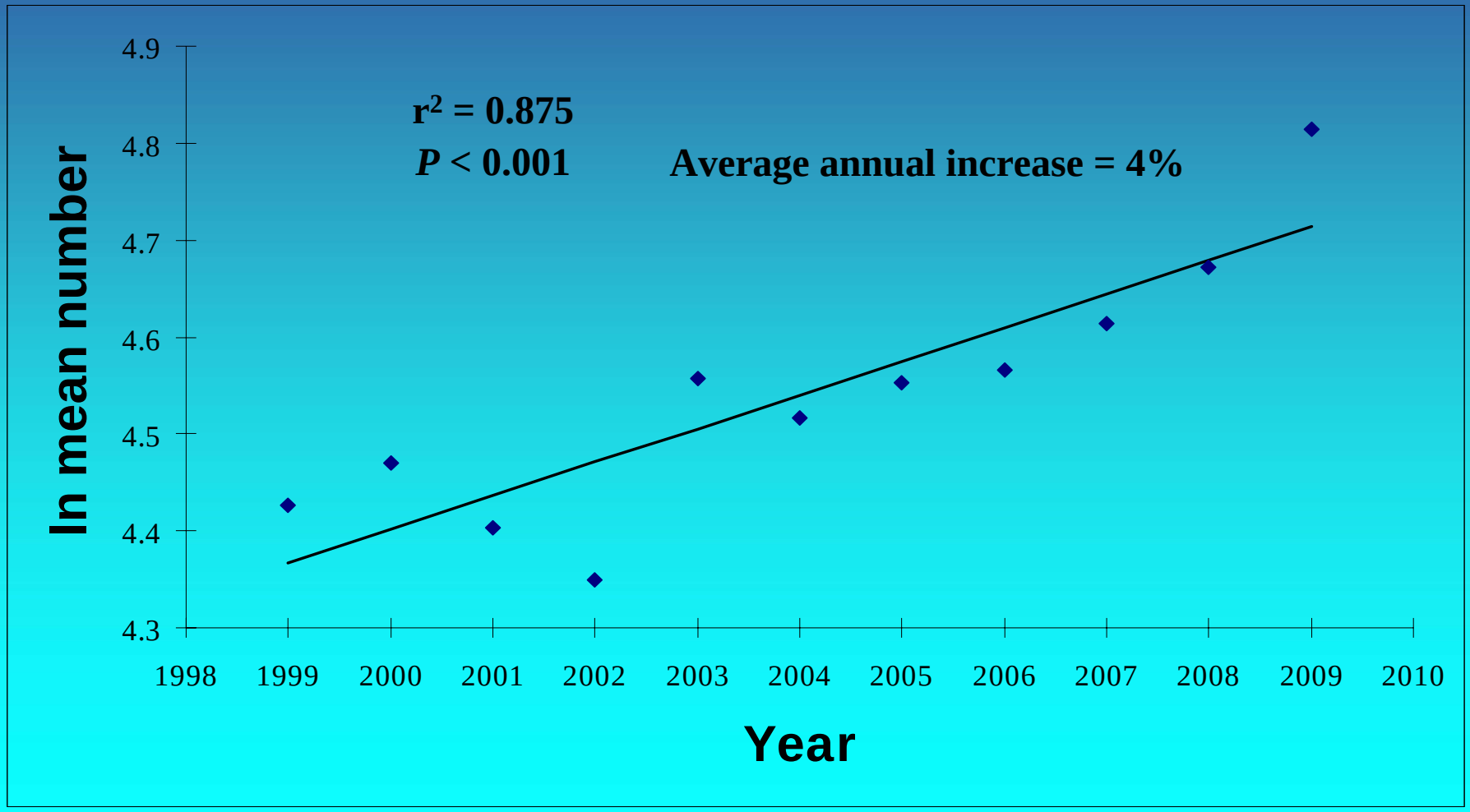
Average number during July-August



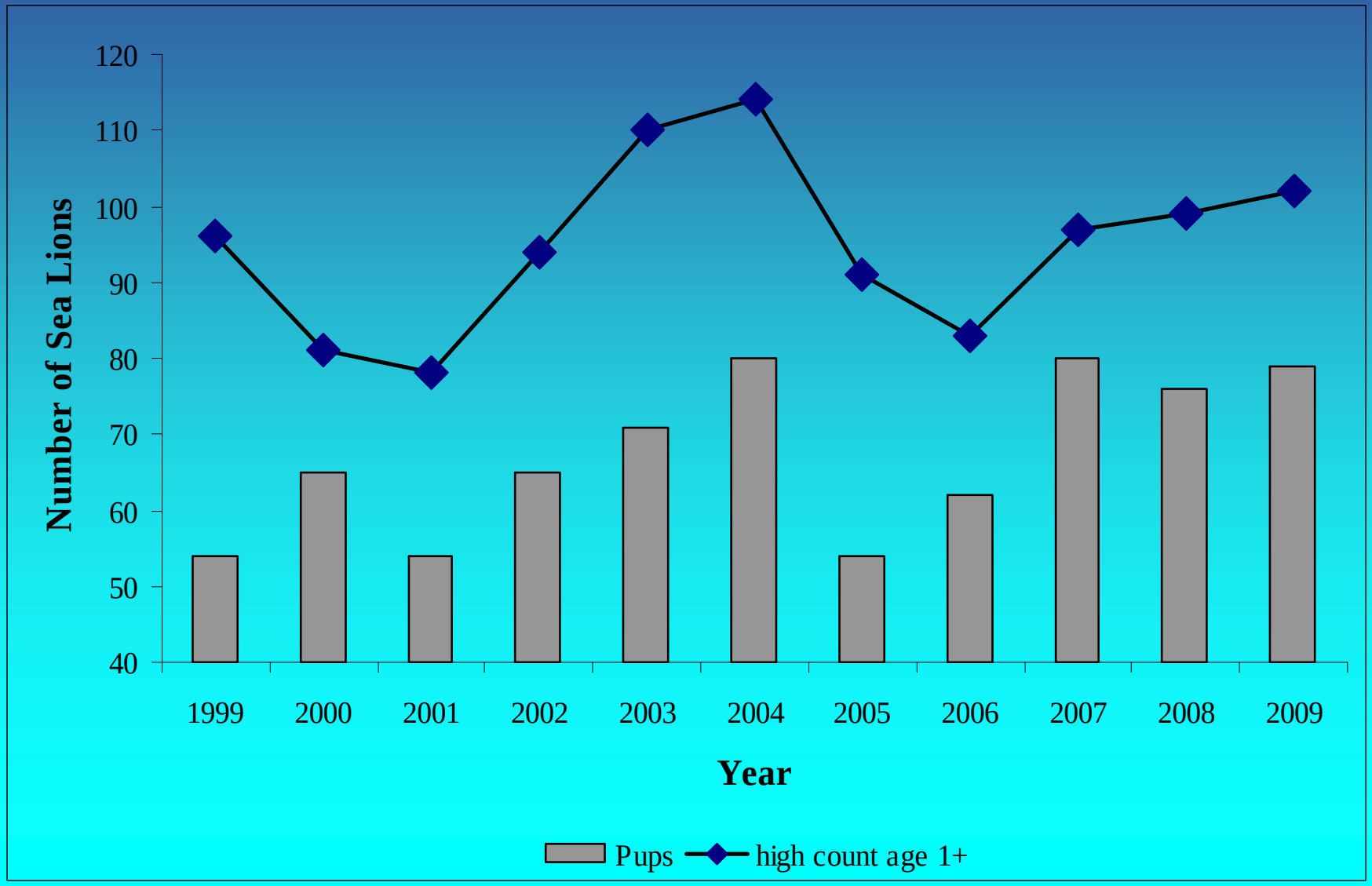
Total number of census counts = 1298

Populations trends of age 1+ sea lions on Chiswell Island

Average number during July-August (1999-2009)

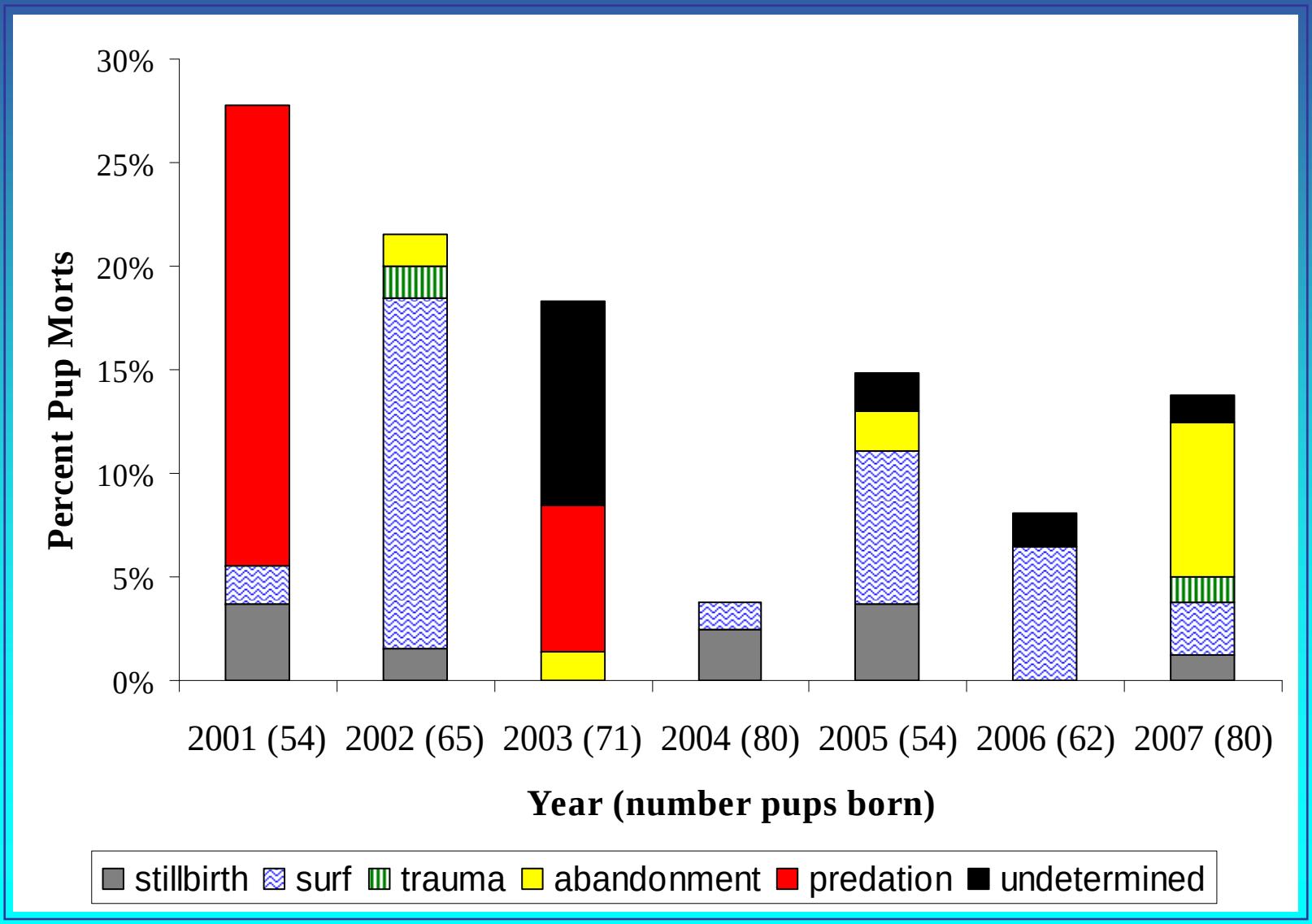


June Counts and Births

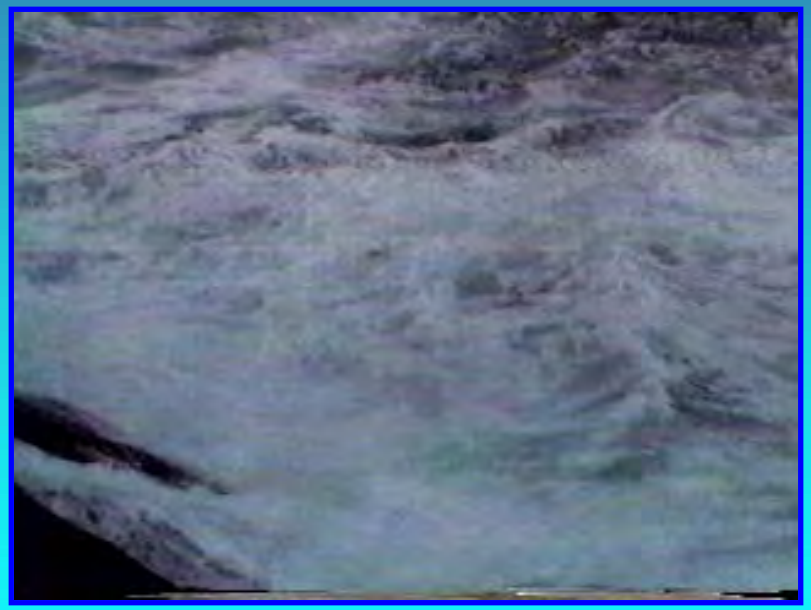


Pup Mortality

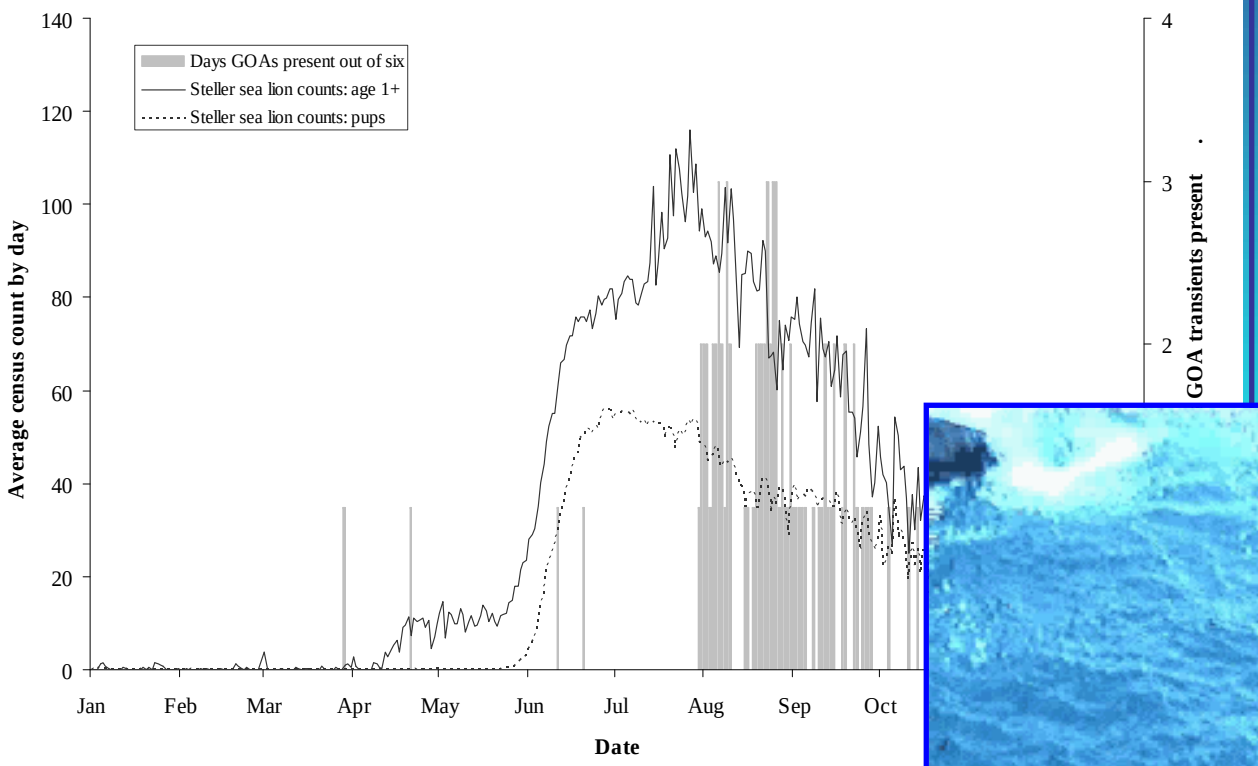
Source of pup mortalities by year

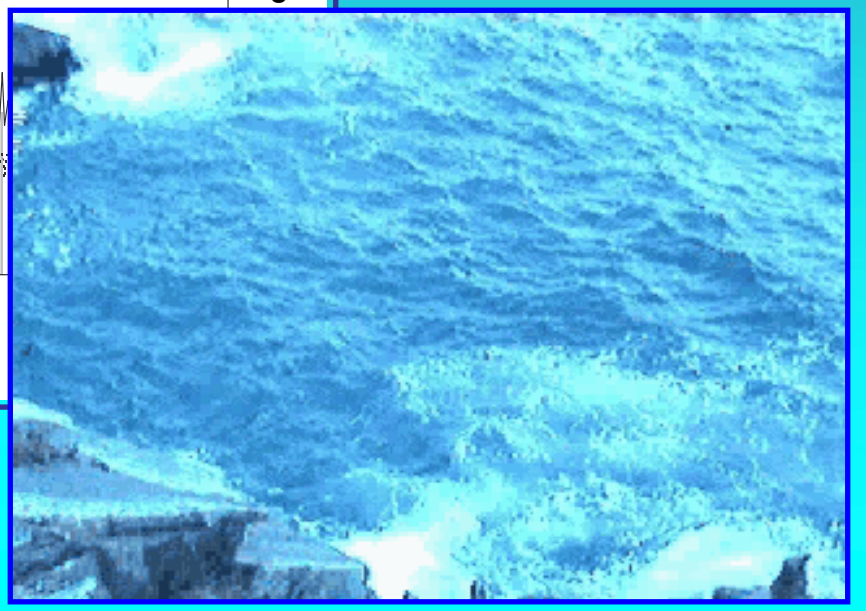


Surf Mortalities



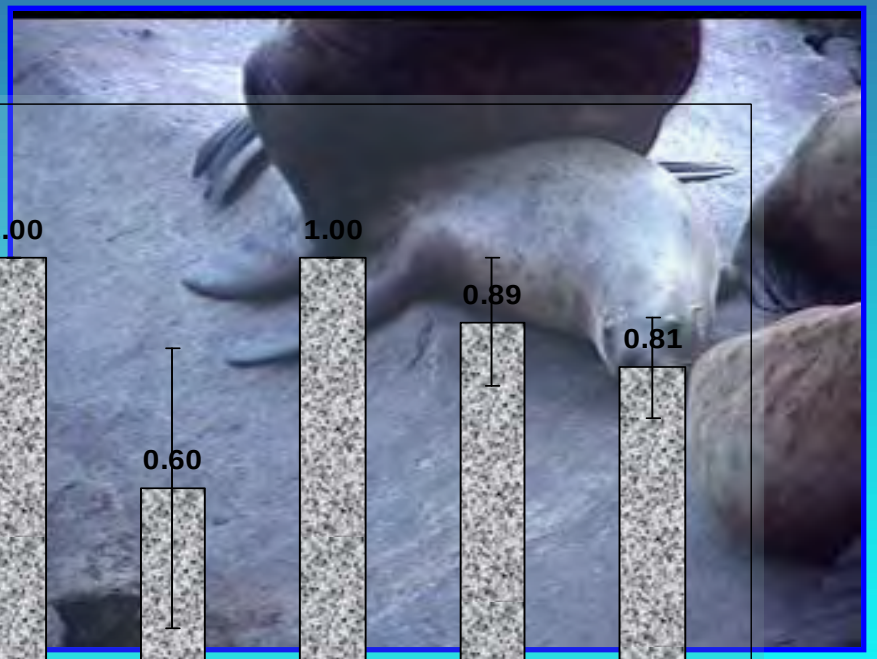
Predation


Days GOAs present out of six
Steller sea lion counts: age 1+
Steller sea lion counts: pups
Average census count by day
GOA transients present
0
20
40
60
80
100
120
140
2
3
4
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Date



Male Reproductive Success

- **Does copulation success equal reproductive success for males?**



Female Reproductive Strategies

Aborted Pregnancies:
Mid-January through April

Full-term Births:
Late May through early July

Twins!

Natality Rates

The Standards that we are comparing to:

Unpublished work: **Calkins and Pitcher 1982**

Calkins and Goodwin 1988

Published work: **Pitcher et al. 1998**

67% in 1970s

55% in 1980s

Natality Rates

The Standards that we are comparing to:

Published work: **Pitcher et al. 1998**

67% in 1970s

55% in 1980s

Based on late-term pregnancy status

***Full-term stillbirths should be included in natality estimates**

Only considered reproductively mature females

***Important to know age at first reproduction but inclusion of immature animals in natality rate analyses is probably inappropriate**

Age at First Pupping

974

born in 2000

974

gave birth in 2004, 2006, 2007, 2009

Tag or Brand	Year of 1st pup	Age at 1st pupping (yrs)
974	2004	4
=278	2006	5
961	2006	6
971	2006	6
977	2006	6
F90620	2009	5
X352	2009	5
	Avg. age	5.3

Natality Rates

Multi-state Modeling with Program MARK

- **Female data 2003 - 2009**
- **Dataset still includes females not present on Chiswell Island in any given year**
  - They are generally assumed to be at haulouts outside of our study area and not giving birth
- **Dataset now includes females seen at local haulouts**
- **First year of data for all females excluded whether or not observed giving birth**
- **Known-age females included if ≥ 5 years old**

Natality Rates

Multi-state Modeling with Program MARK

2 states given as 'b' – giving birth and 'n' – not giving birth

S_t^x = probability that a female in state x at time t survives until t + 1

p_t^x = probability that a female is sighted at time t in state x, given that it is alive at time t

ψ_t^{xy} = probability that a female in state x at time t is in state y at time t + 1, given that the animal survived from time t to t + 1

γ_t^x = The proportion of females at time t that are in state x

***Natality Rate (γ_t^b) = $N_t^b/(N_t^b + N_t^n)$; where $N_t^x = n_t^x/p_t^x$**

**from Nichols et al. (1994) Ecology 75:2052-2065*

Natality Rates

Multi-state Modeling with Program MARK

GOF test of fully time and state dependant model

$\hat{c} = 1.10$

$(\chi^2 = 51.67; \text{d.f.} = 47; P = 0.296)$

insignificant overdispersion of data

Natality Rates

Multi-state Modeling with Program MARK

Chiswell data 2003 - 2009

Model	#Par	QAICc	ΔQAICc	Weight	QDeviance
$S_{st}\ p_{st}\ \psi_{st}$	6	698.062	0.00	0.456	235.592
$S.\ p_{st}\ \psi_{st}$	5	698.151	0.09	0.436	237.751
$S_{t}\ p_{st}\ \psi_{st}$	10	701.873	3.81	0.068	231.006
$S_{st.t}\ p_{st}\ \psi_{st}$	16	703.552	5.49	0.029	219.715
$S_{st}\ p_{st}\ \psi_{st*t}$	16	706.039	7.98	0.008	222.201
$S_{st}\ p_{st.t}\ \psi_{st}$	16	708.604	10.54	0.002	224.767
$S_{st}\ p_{st}\ \psi_{\cdot}$	5	715.785	17.72	0.000	255.385
$S_{st}\ p_{st*t}\ \psi_{st*t}$	26	719.762	21.70	0.000	213.254

Natality Rates

Multi-state Modeling with Program MARK

Standard Error and Confidence Intervals Corrected for c-hat = 1.100

Real Function Parameters of S_{st} p_{st} ψ_{st}

Parameter	Estimate	S.E.	95% Confidence Interval Lower	Upper
1:S Pup	0.851	0.0254	0.7940	0.8941
2:S NoPup	0.777	0.0440	0.6797	0.8518
3:p Pup	0.999	0.0000	0.9999	0.9999
4:p NoPup	0.843	0.0491	0.7219	0.9173
5:Psi P to N	0.283	0.0330	0.2230	0.3519
6:Psi N to P	0.584	0.0576	0.4687	0.6909

Natality Rates

Multi-state Modeling with Program MARK

Estimation of gamma^{b} – Natality Rate

Model: $S_{st}\ p_{st}\ \psi_{st}$

$$\gamma_{.}^{b} = 69.2\% \pm 2.5\%$$

Natality Rates

Multi-state Modeling with Program MARK

Next step

Robust Design Methods

to estimate unobserved states

Natality Rates

Multi-state Modeling with Program MARK

Non-Chiswell Females

Taking a broader look at natality in the Gulf of Alaska

X32

Pinto

Natality Rates

Multi-state Modeling with Program MARK

Cost of Reproduction

Cost implied if survival is lower for females that give birth in the previous year compared to those that don't

Cost also implied if giving birth in one year reduces the probability of giving birth in the following year

Pitcher et al. 1998 – reproductive cost implied by negative correlation between lactational status and pregnancy in 1980s

Natality Rates

Multi-state Modeling with Program MARK

Cost of Reproduction

State dependant survival & transitions

Real Function Parameters of S_{st} p_{st} ψ_{st}

Parameter	Estimate	S.E.	95% Confidence Interval Lower	Upper
1:S Pup	0.851	0.0254	0.7940	0.8941
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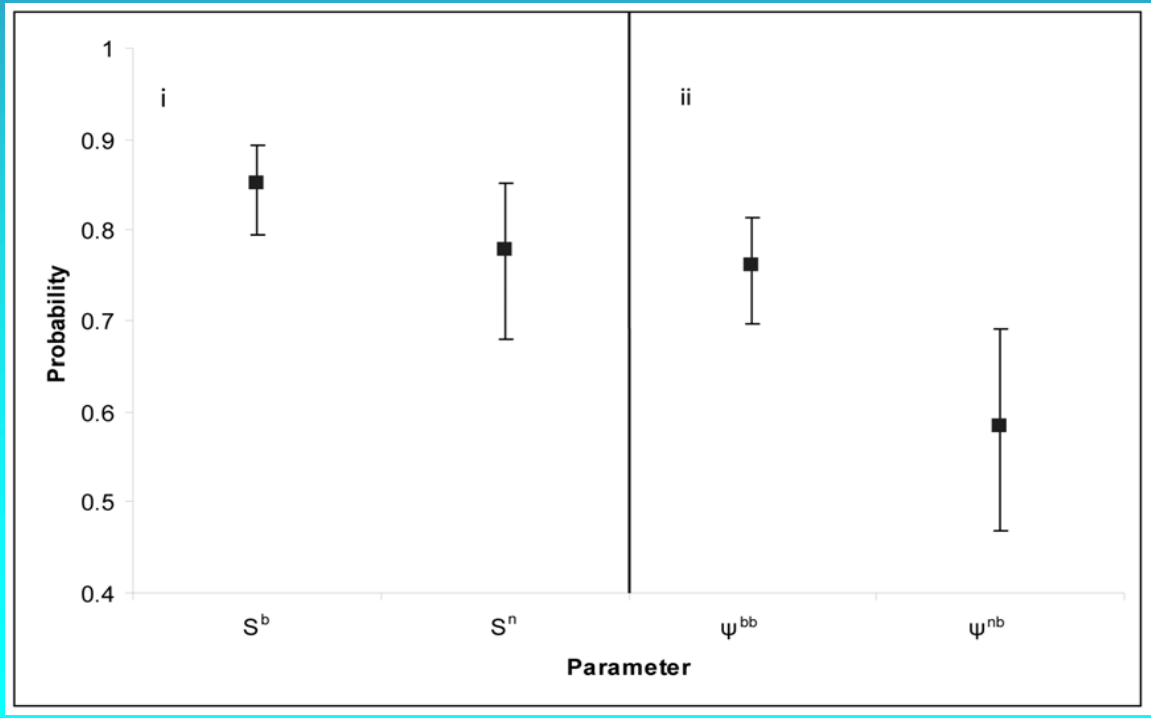
4:p NoPup	0.843	0.0490	0.7213	0.9173
5:Psi P to N	0.283	0.0330	0.2230	0.3519
6:Psi N to P	0.584	0.0576	0.4687	0.6909
7:Psi P to P	0.760	0.0309	0.6930	0.8041

Natality Rates

Multi-state Modeling with Program MARK

Cost of Reproduction

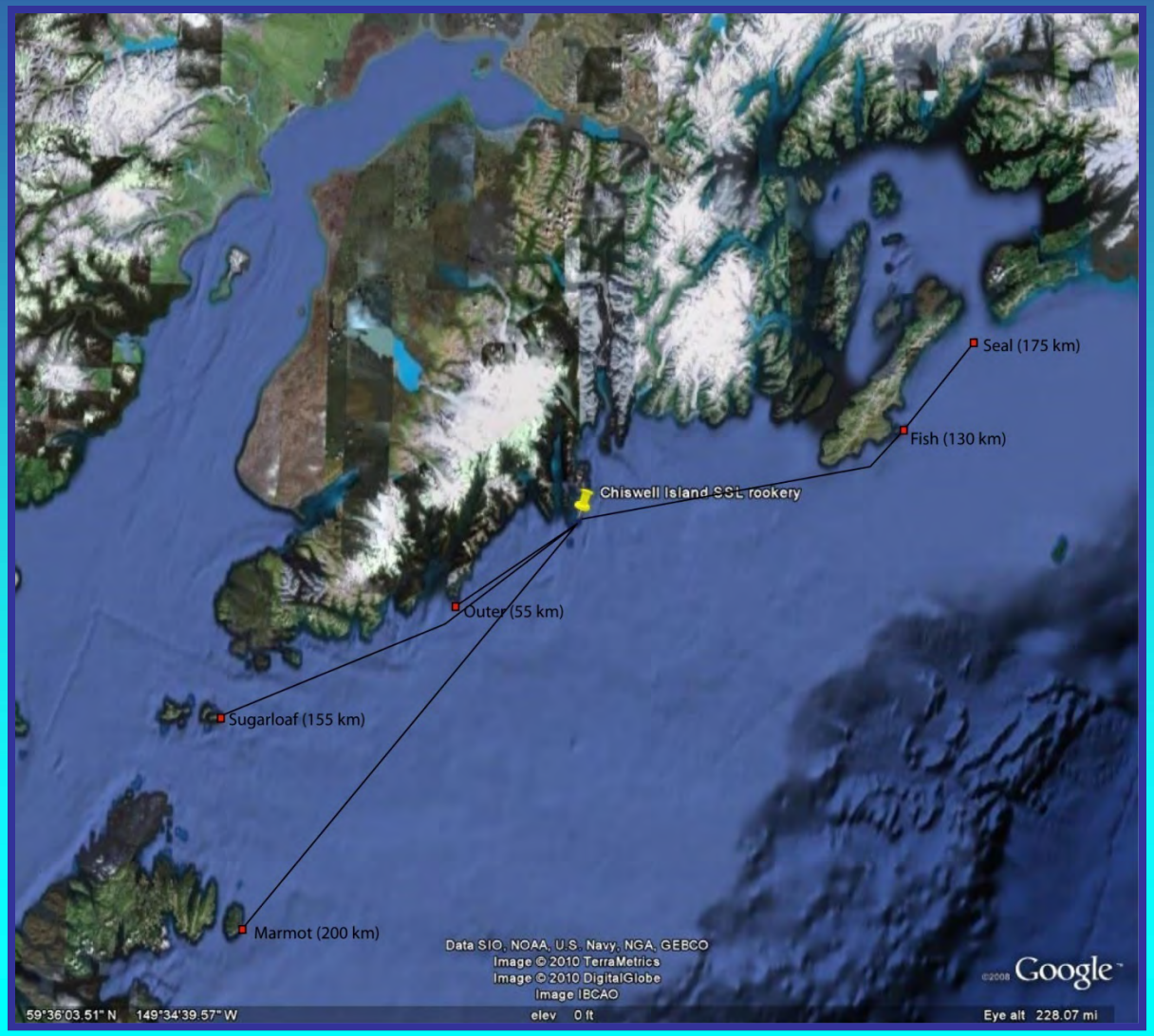
State dependent survival(?) & transitions



Is Chiswell Island representative of the eastern and central Gulf of Alaska?

Is Chiswell Island representative of the eastern and central Gulf of Alaska?

Distance to other rookeries



Is Chiswell Island representative of the eastern and central Gulf of Alaska?

Population decline: ***similar (80%+)***

Recent population changes: ***higher according to flight surveys***

Based on data in NMFS-AFSC-183

but low or similar by our census counts Slide 21

Ratios of non-pups to pups: ***similar***

Median: Chiswell = 1.64, Other = 1.71 (n.s.)

Based on data in NMFS-AFSC-183

Maternal care: ***similar***

Compared to Sugarloaf Is. (Milette & Trites 2003)

Twinning: **?**

Additional Forthcoming Analysis

Daily, Seasonal, Interannual Sighting Probabilities

Capture-recapture analysis of 100s of individual animals with a combined history covering 9-years and 500,000(!) records of presence/absence

Plans for 2010 -11

Remote blubber biopsy of adults

Photos courtesy of Laura Hoberecht

Branding/sampling of pups at Chiswell

Acknowledgments

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Don Calkins, Shannon Atkinson, Alan Springer: support and guidance for this research

Daniel Hennen, Jim Nichols: statistical advice

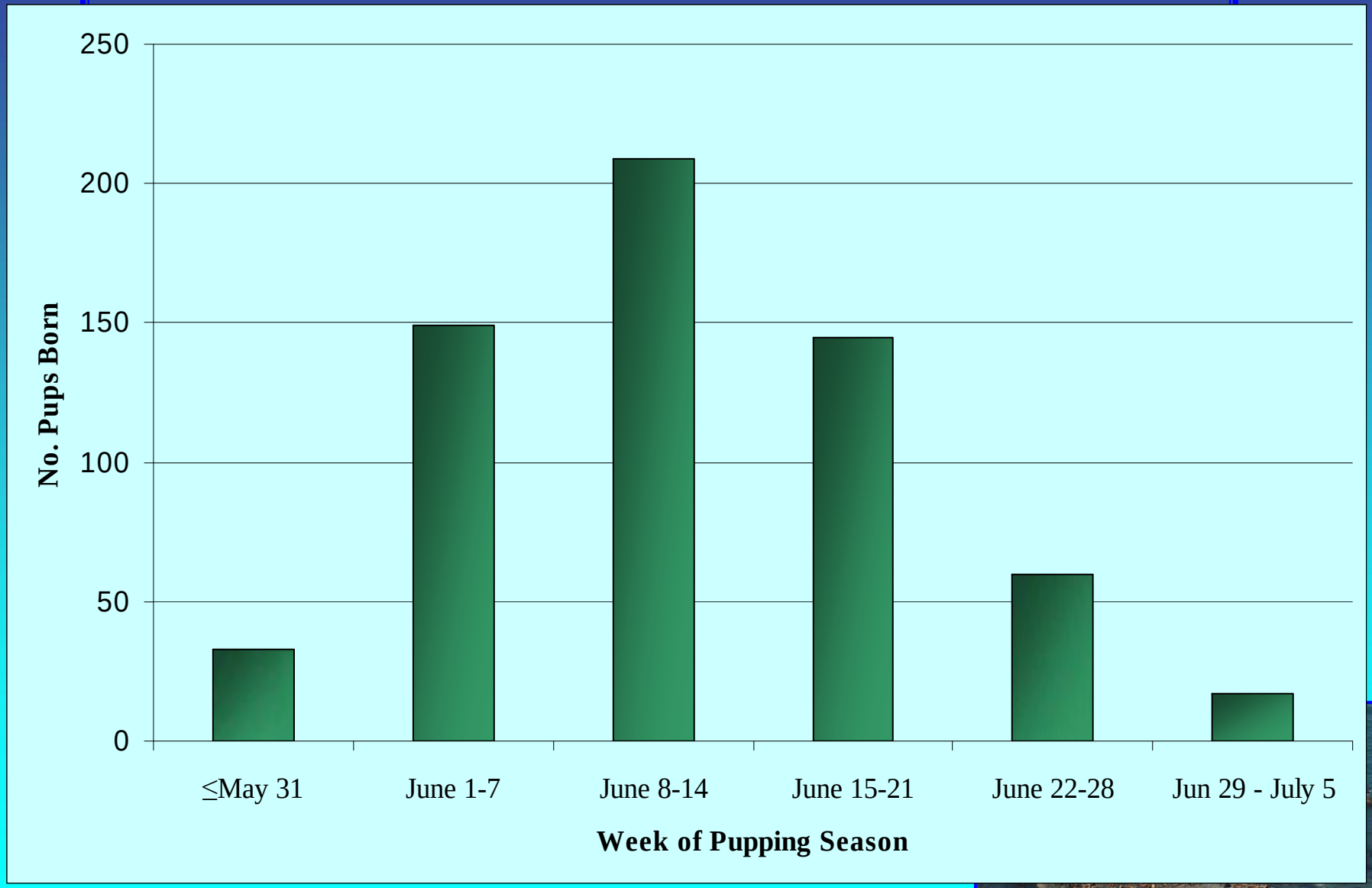
Techs & Interns: Kim Smelker, Carly Miller, Juliana Kim, *et alii*: much hard work and dedication to the project

Daniel Zatz & Konrad Schaad: maintenance and repair of remote video equipment

Tara Jones, Jilian Chapman, Jessica Vaughn: administrative support

Chip Arnold, Karla Backlund, Dustin Phillips: tech support

The Chiswell Island group is part of the U.S. Fish & Wildlife Service Alaska Maritime National Wildlife Refuge. The placement of equipment and research conducted on refuge land was done under a special use permit issued by the U.S. Fish & Wildlife Service and under NMFS permits No. 782-1532-00 & 881-1668-00 issued under the authority of the Marine Mammal Protection Act and the Endangered Species Act.


250
200
150
100
50
0
No. Pups Born
≤May 31
June 1-7
June 8-14
June 15-21
June 22-28
Jun 29 - July 5
Week of Pupping Season

Female Reproductive (Natality) Rates

Why declining natality rates may be illusory

One man(iscalco)'s theory:

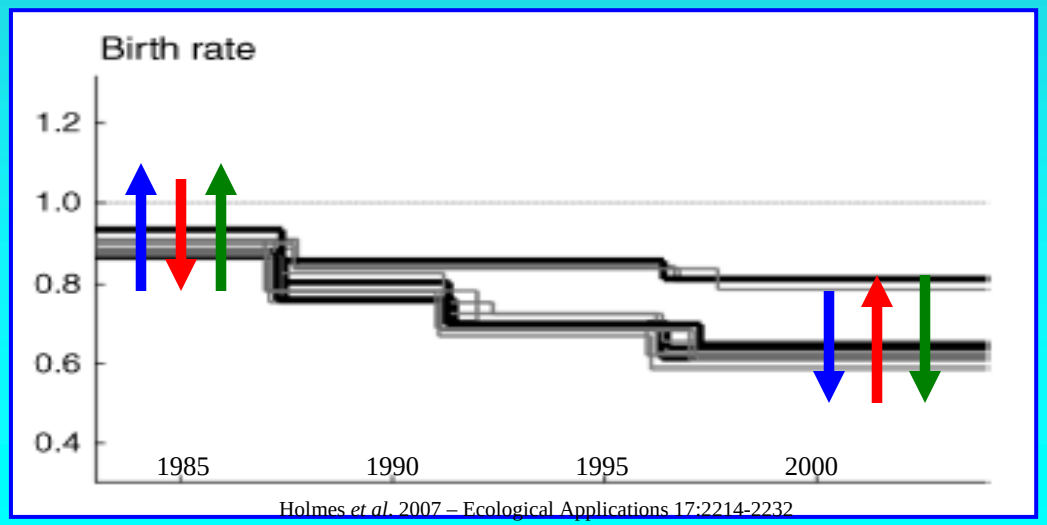
- **Female otariids are known to spend more time foraging during periods of food limitation/stress**

  (e.g. Boyd 1999, Heath et al. 1991, Hood and Ono 1997 Lunn et al. 1993, Majluf 1991, Ono et al. 1987)

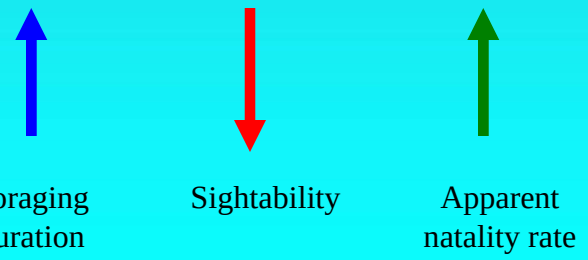
- **Evidence suggests that western SSLs were nutritionally stressed in the 1980s**

  Low reproductive rates (Pitcher et al. 1998) and Reduced female size (Calkins et al. 1998)

- **Western SSLs no longer appear to be nutritionally stressed** (Pitcher 2002, Trites and Donnelly 2003) **and therefore, should spend less time foraging than in the 1980s**



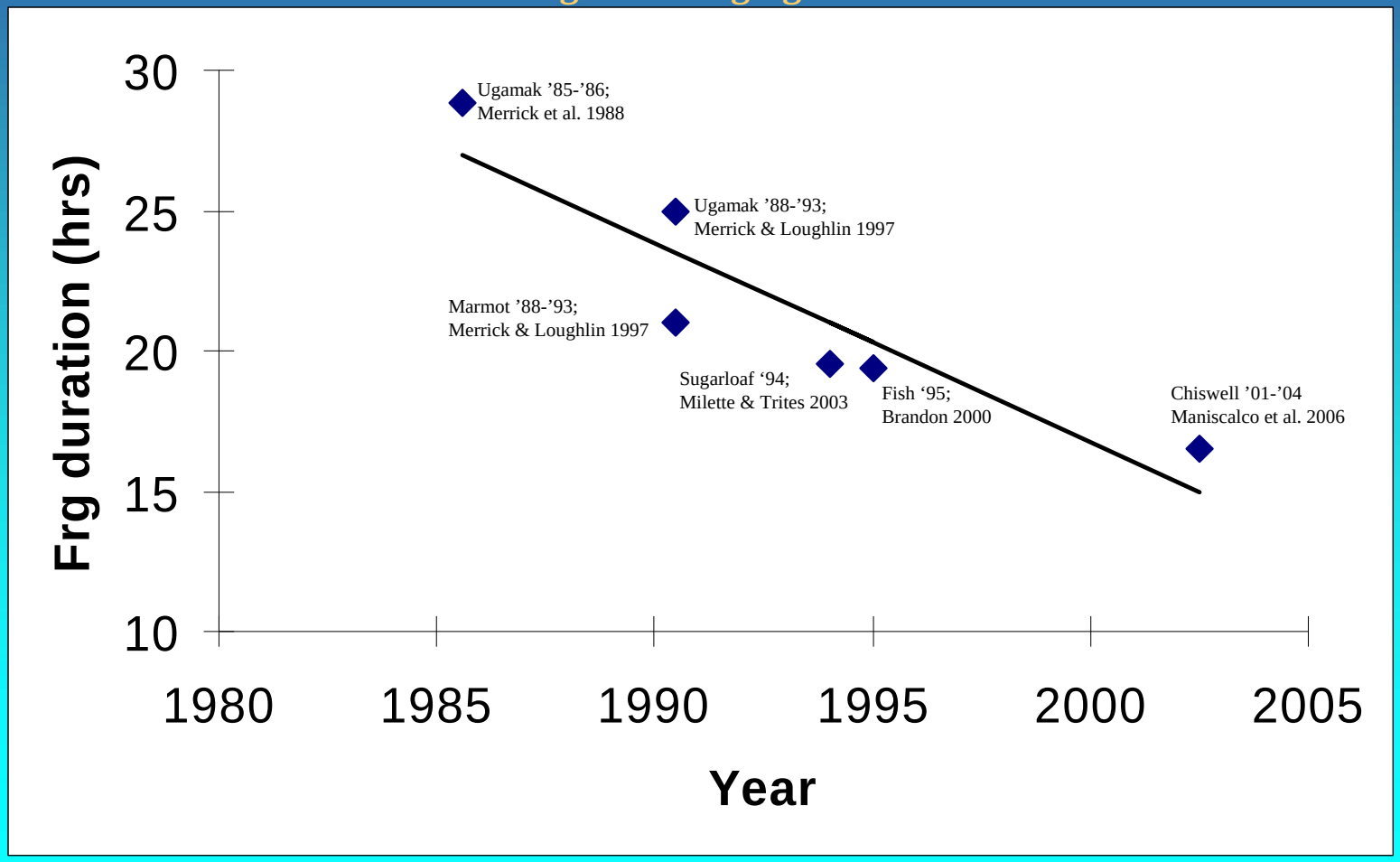
Holmes *et al.* 2007 – Ecological Applications 17:2214-2232



Female Reproductive (Natality) Rates

Suggestive evidence of increasing sightability?

Changes in foraging durations



Female Reproductive (Natality) Rates

Summary

Counting age-classes of Steller sea lions hauled out is an ineffective way to determine natality rates because:

1. Potentially large error in the proper identification of age-classes.

2. Pup mortality is determined more by weather conditions than counts of live and dead pups on rookeries.

3. Sightability of adult females may vary greatly during different regimes and needs to be properly accounted for.

The best way to determine natality rates in the current era is to track individually identifiable females throughout a significant portion of their life.

*****Our long-term tracking of individuals suggest that natality rates are at least as good as prior to the decline*****