Alaska Dept. of Fish & Game Steller Sea Lion Research Program

Provide evidence with which to weigh the validity of trade-offs between protective zones around different haulouts and rookeries inhabited by the western stock of Steller sea lions.

We have been unable to conduct the studies which would directly test the impact of fisheries exclusion zones on the health, condition and population dynamics of sea lions.

If we can't answer the question directly…

find parts of the equation that we can address with existing methods and also develop new techniques to tackle the elusive problems

- Use of mark recapture to look at reproductive rates of females in Southeast Alaska
- Use of stable isotopes to identify a weaning signature in the whiskers of juvenile sea lions

Population Dynamics

Population Counts
- Aerial survey of Coastline

Survival, Reproduction and Recruitment
- Pup branding
- Winter and summer brand resighting throughout SE AK
- Field camp at Lowrie Island – brand resights

Physiological Studies

Identification of Weaning & Diet
- Stable isotopes (whiskers), Fatty acids (blubber), Scats

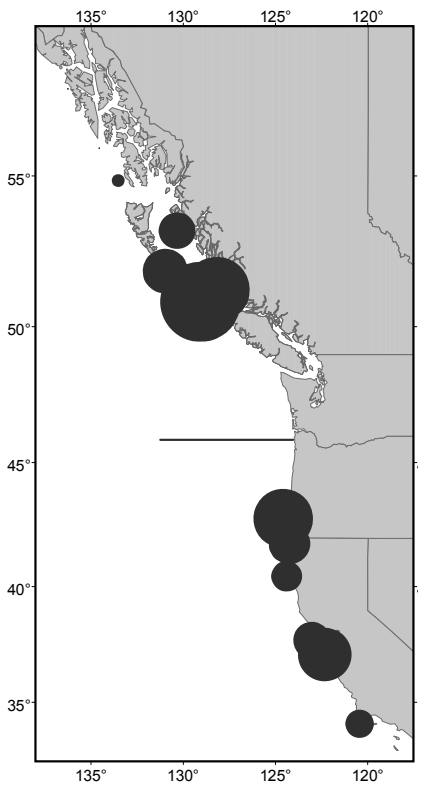
Body Condition & Nutrition
- Morphometrics
- Deuterium, BIA
- Blood chemistry
- Muscle biochemistry

Contaminants & Disease
- Serology, Parasitology, Virology, Contaminants

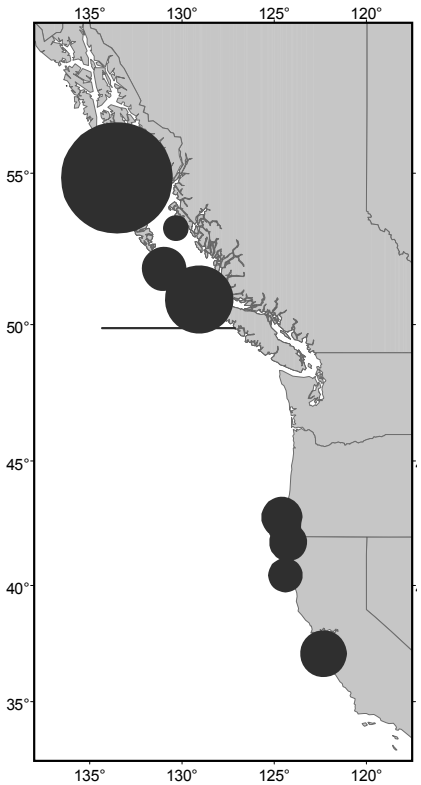
Foraging Ecology

Juvenile Movement & Dive Ontogeny
-Dispersal, development of diving duration and depth
-Organization of diving behavior
- deploy 30 TDR and 15 satellite transmitters during fall, recaptures in spring with diet and condition assessments

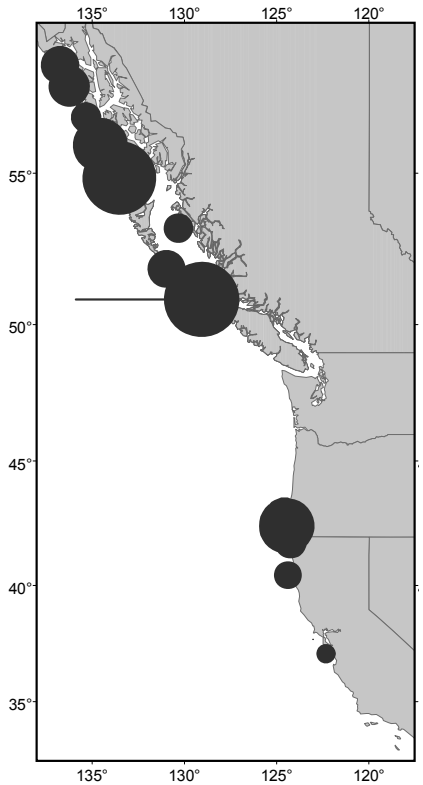
1920's Total Counts for Rookeries



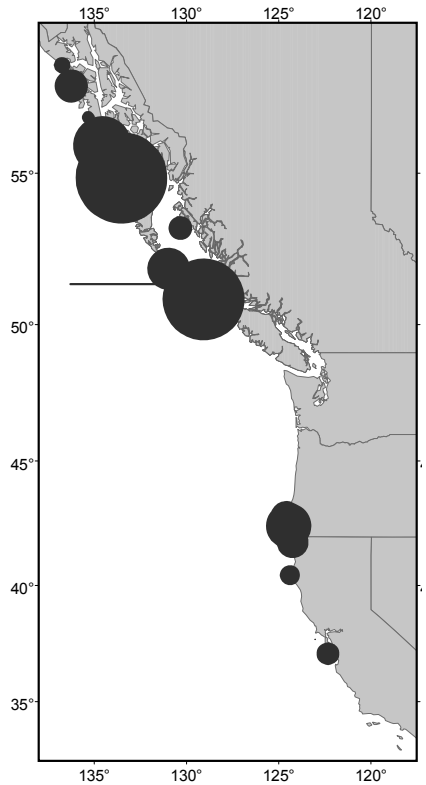
1970's Total Counts for Rookeries



2002 Non-Pups on Rookeries



2002 Pup Production



- Eastern population of SSL has increased at an average annual rate of 3.1% since 1970's
- Number of breeding sites has remained constant (n= 11 to 13)
- There has been a northward shift in distribution
- 2002 - pup production about 11,000 (82% in SEA and BC), total population 45,000 to 57,000

Pitcher, K., P. Olesiuk, R. Brown, M. Lowry, S. Jeffries, J. Sease, W. Perryman, C. Stinchcomb and L. Lowry. Status and trends in abundance and distribution of the eastern population of Steller sea lions (*Eumetopias jubatus*). Accepted. Fisheries Bulletin.

Marked animal studies ADFG

Age-specific survival: includes pup-marking @ 4 rookeries
3-wk-long resight trip: all haul-outs SE/BC

Age-specific reproductive rates: (1) Forrester Island study: May 25 – July 15
(2) SE-wide study (1.5 wk long resight trip mid-July)

Proportion weaned: sampling every 1.5 mo @ few haul-outs (Dec-April)
(by age/birth rookery/sex) (Gran Pt, Benjamin, Southwest Bros, S. Marble, Biali)

Winter/summer distribution: 2 week long resight trip Feb-March to compliment
(by age/birth rookery/sex) summer resight trip

Pup survival post-branding: (1) 2001-02 Lowrie study (to 3-mo post-branding)
(2) 2005: data collected during repro surveys (2 wks post-branding – (White sisters, Graves Rock, Hazy Islands)

Tag-Loss: 2001-2002 Lowrie animals

Review of brand loss/misreading/brand healing


W12

Number of pups branded at rookeries in Southeast AK

	1994 & 1995	2001	2002	2003	2004	2005	Total
Forrester (F)	799	286	141	291	277		1794
Hazy Islands (H)		213		101		225	539
White Sisters (W)			127		94	147	368
Graves Rock (V)			50			43	93
Total	799	499	318	392	371	415	2794

Graves Rocks

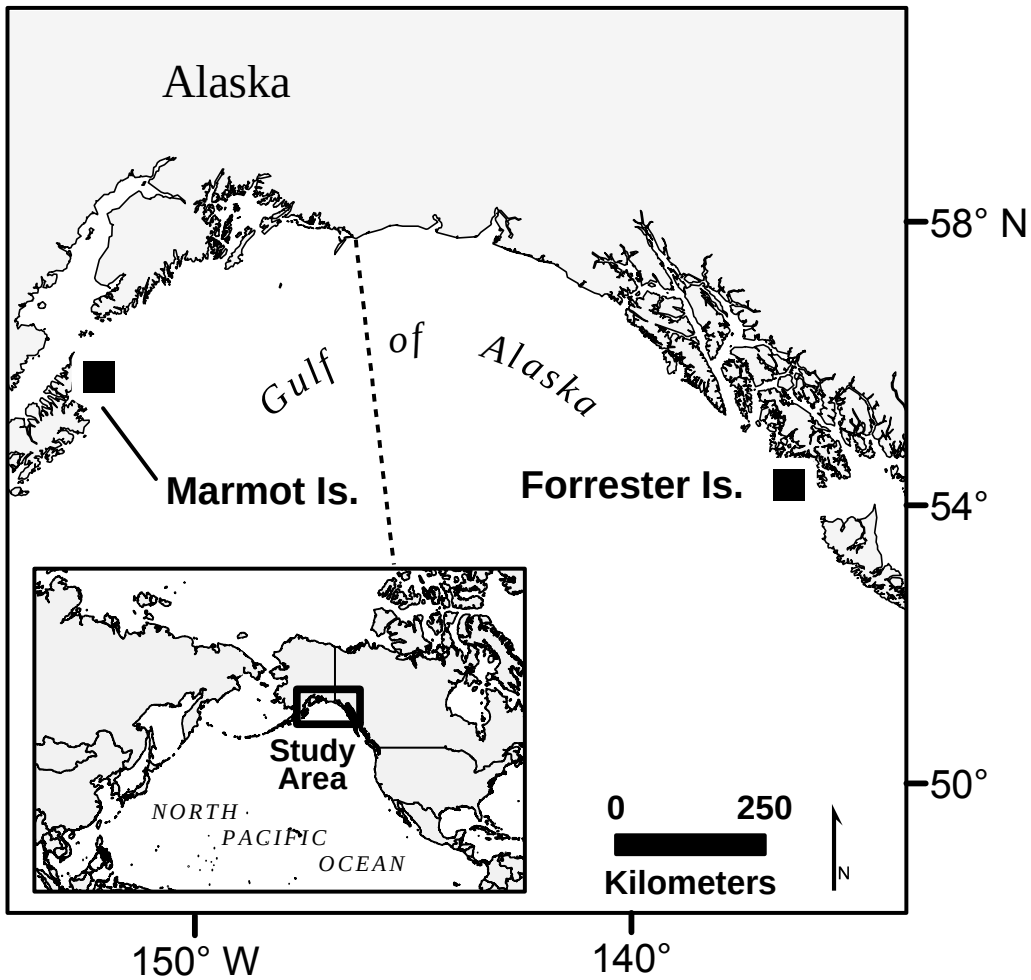
White Sisters

Hazy Islands

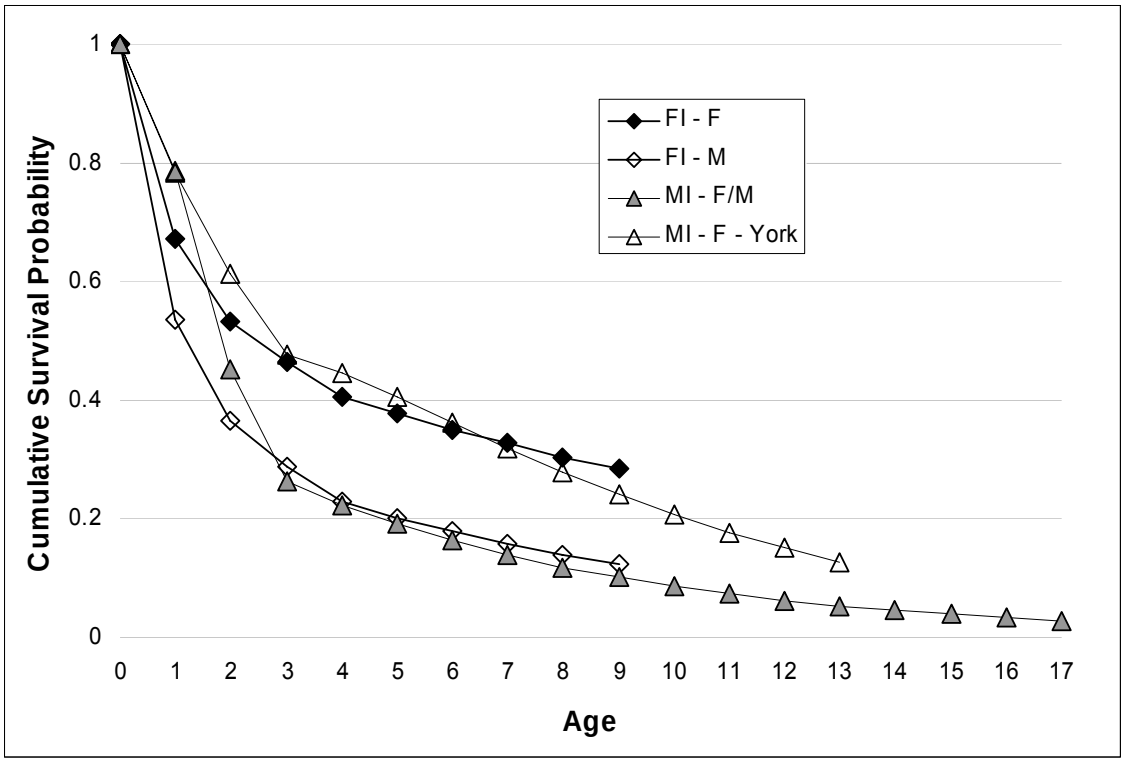
Forrester Is. complex

ALASKA

CANADA



Pendleton, G., K. Pitcher, L. Fritz, A. York, K. Raum-Suryan, T. Loughlin, D. Calkins, K. Hastings, T. Gelatt. Survival of Steller sea lions in Alaska: a comparison of increasing and decreasing populations.



Cumulative survival curves for Steller sea lions branded at Marmot Island (western population, 1987-1988) and Forrester Island (eastern population, 1994-1995) and as estimated for the 1970's for the western population by York (1994). (FI=Forrester Is. [1994-2003], MI=Marmot Is. [1987-2003], F=female, M=male, York=estimates for MI from York 1994 [1975-1978].)

Survival of Steller sea lions in Alaska…

- Juvenile survival probability at Marmot Is. from 1988-1991 was lower than at that location in 1970's, and lower than at Forrester Is. from 1995-1998

- Adult female survival at Marmot Island was slightly reduced compared to 1970's and was substantially lower than at Forrester Island (1999-2003)

- Adult female survival probabilities at Marmot Island were indistinguishable from adult male survival probabilities

Conclusion:
regardless of which factors altered the dynamics of the western population , they differentially affected females.

Age-specific survival 2001 - 03 cohorts :

preliminary results

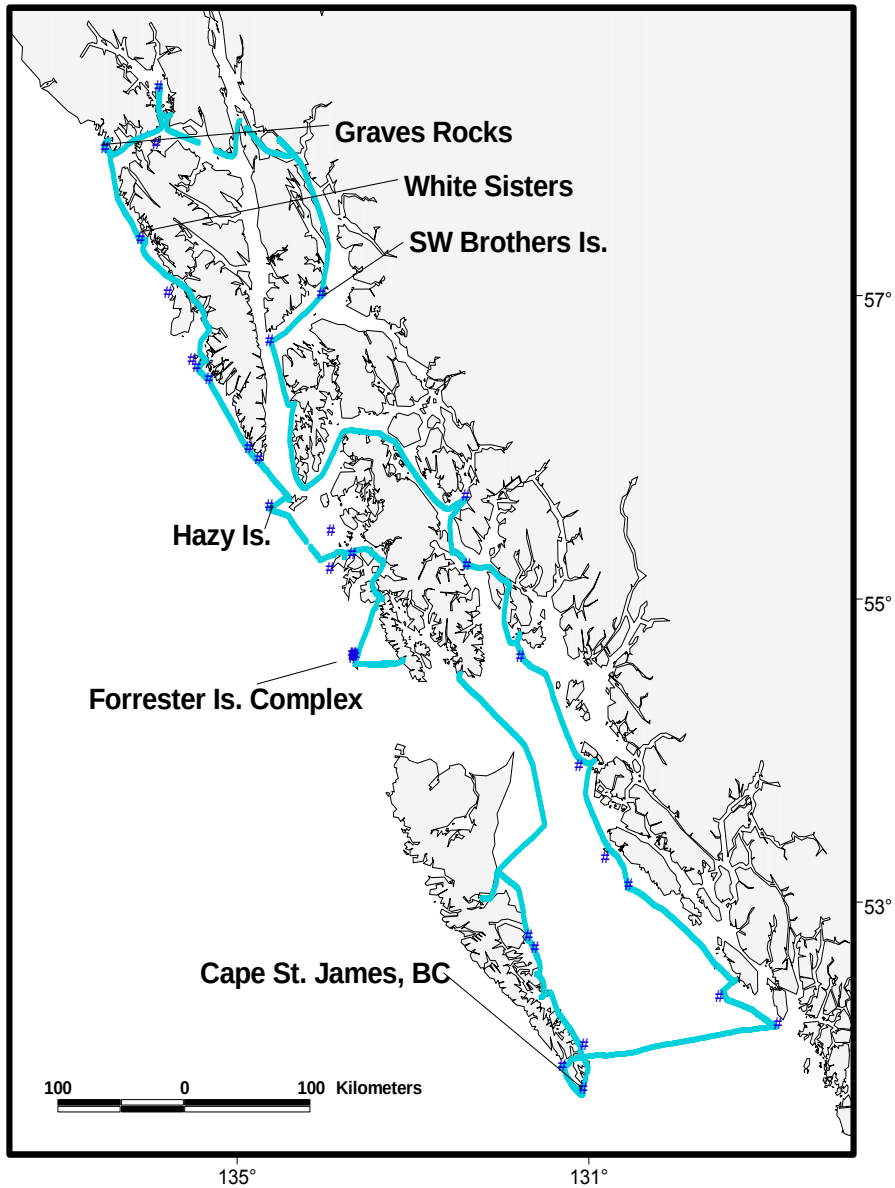
Marking

Birth Year	Natal Rookery	F	M	U	TOTAL
2001	FOR	137	147	2	286
2001	HAZY	100	112	1	213
2002	FOR	73	68	0	141
2002	GRAVRK	16	34	0	50
2002	WHSI	57	69	1	127
2003	FOR	105	186	0	291
2003	HAZY	43	57	1	101
		531	673	5	1209

Resighting:

- Data from May – August each year pooled into single annual occasion
- Only sightings with photo documentation with identities confirmed against a photo library (83% of resights)
- Most data from annual June resight trip - all major rookeries and haul-outs in Southeast and Northern BC – resights outside this area excluded

Example of Brand Resight Trackline



MARK results: GOF = best model, p = 0.77

Model	AICc	AICc Weights	Num. Par	Deviance
Resight rate				
{(01) s(main 2way 3way:sat nrsa nrst) p(main 2way 3way:sat nrsa nrs)}	3780.112	0.000	68	56.418
{(02) s(main 2way 3way:sat nrsa nrst) p(main 2way 3way:sat nrst)}	3781.686	0.000	67	60.131
{(03) s(main 2way 3way:sat nrsa nrst) p(main 2way 3way:nrst)}	3780.084	0.000	66	60.668
{(04) s(main 2way 3way:sat nrsa nrst) p(main 2way)}	3772.652	0.000	62	61.763
{(05) s(main 2way 3way:sat nrsa nrst) p(main 2way - nr:a)}	3770.600	0.000	61	61.837
{(06) s(main 2way 3way:sat nrsa nrst) p(main 2way - nr:s)}	3770.689	0.000	59	66.174
{(07)s(main 2way 3way:sat nrsa nrst) p(main 2way - nr:t)}	3770.538	0.000	61	61.776
{(08) s(main 2way 3way:sat nrsa nrst) p(main s:a a:t t:s)}	3761.941	0.000	54	68.004
{(09) s(main 2way 3way:sat nrsa nrst) p(main s:a a:t t:s a:t:s)}	3763.530	0.000	55	67.482
{(10) s(main 2way 3way:sat nrsa nrst) p(main s:a t:s)}	3759.929	0.000	53	68.103
{(11)s(main 2way 3way:sat nrsa nrst) p(main s:a)}	3756.164	0.000	51	68.550
{(12 s(main 2way 3way:sat nrsa nrst) p(main)}	3760.227	0.000	49	76.818
{(13) s(main 2way 3way:sat nrsa nrst) p(a s t s:a)}	**3752.388**	**0.000**	**48**	**71.078**
{(14) s(main 2way 3way:sat nrsa nrst) p(a s s:a)}	3755.236	0.000	45	80.211
{(15) s(main 2way 3way:sat nrsa nrst) p(s a t t:s)}	3758.230	0.000	48	76.920
Survival rate				
{(20) s(main 2way 3way:nrsa nrst) p(a s t s:a)}	3748.207	0.000	46	71.089
{(21) s(main 2way 3way:nrsa) p(a s t s:a)}	3745.500	0.000	44	72.566
{(22) s(main 2way) p(a s t s:a)}	3736.414	0.000	38	75.980
{(23) s(main 2way - s:nr) p(a s t s:a)}	3731.704	0.001	35	77.492
{(24) s(main 2way - nr:t) p(a s t s:a)}	3734.929	0.000	37	76.571
{(25) s(main 2way - s:t) p(a s t s:a)}	3733.048	0.001	35	78.837
{(26) s(main 2way - a:t) p(a s t s:a)}	3733.533	0.001	35	79.322
{(27) s(main 2way - nr:a) p(a s t s:a)}	3734.039	0.000	36	77.755
{(28) s(main 2way - s:a) p(a s t s:a)}	3735.928	0.000	36	79.645
{(29) s(main s:t nr:a a:t s:a) p(a s t s:a)}	3730.286	0.003	34	78.145
{(30) s(main nr:a a:t s:a) p(a s t s:a)}	3726.214	0.022	31	80.270
{(31) s(main nr:a s:a) p(a s t s:a)}	3722.367	0.148	28	82.603
{(32) s(main nr:a) p(a s t s:a)}	3721.914	0.185	26	86.259
{(33) s(main s:a) p(a s t s:a)}	3724.764	0.045	23	95.258
{(34) s(nr t a nr:a) p(a s t s:a)}	3729.739	0.004	25	96.135
{(35) s(s nr a nr:a) p(a s t s:a)}	**3719.790**	**0.536**	**23**	**90.284**
{(36) s(s nr) p(a s t s:a)}	3773.386	0.000	15	160.189
{(37) s(s a s:a) p(a s t s:a)}	3729.659	0.004	17	112.397
{(38) s(s a) p(a s t s:a)}	3729.368	0.004	15	116.171
{(39) s(nr a nr:a) p(a s t s:a)}	3727.951	0.009	22	100.490
{(40) s(a) p(a s t s:a)}	3737.436	0.000	14	126.269
{(41) s(s nr a nr:a s:a) p(a s t s:a)}	3725.124	0.037	27	87.416

Variables in models

1. Time *(Year):*

   2001-2005

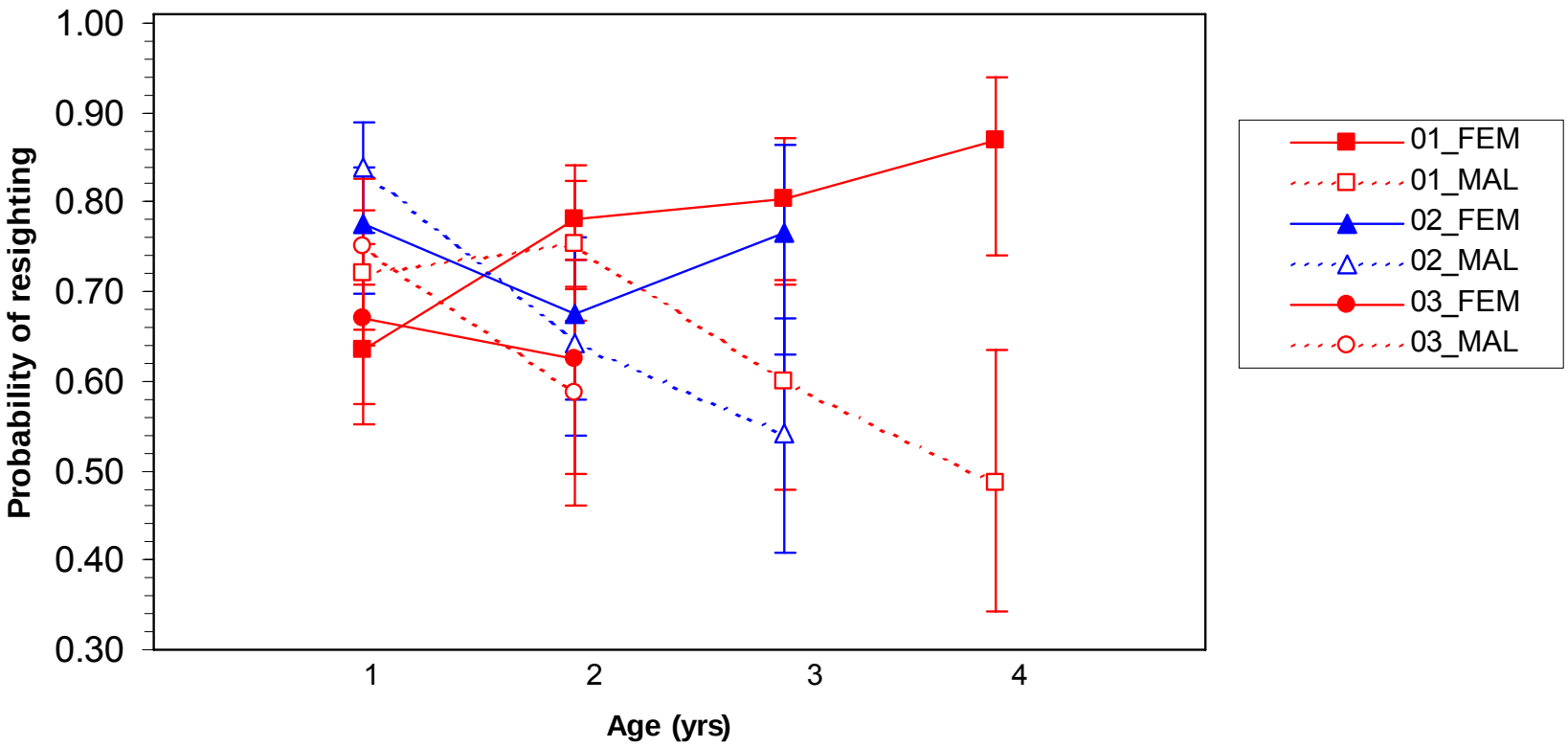
2. Sex
3. Natal Rookery: (4)

   FOR, HAZY, WHSI, GRAV

4. Age: 1-4 yrs

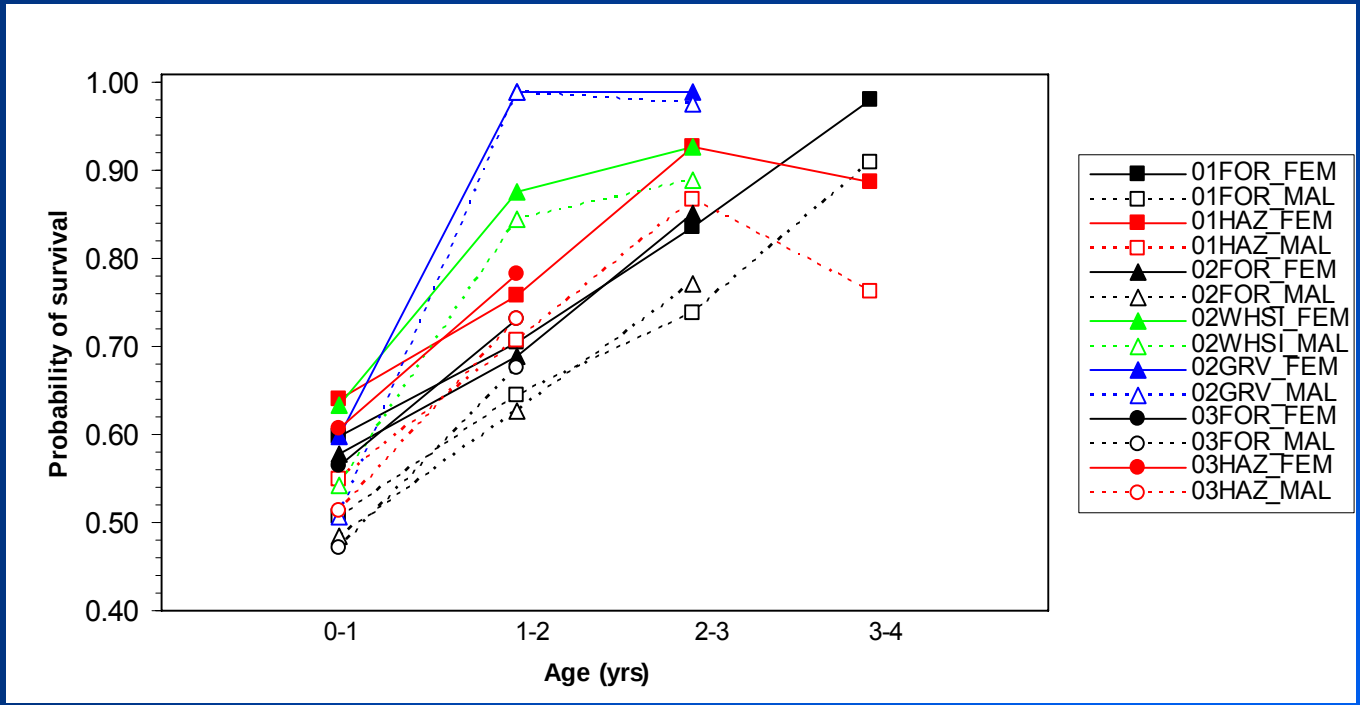
Estimates: Resighting Rate (from best model)

Best model: p (age sex year age*sex)



Estimates: Survival Rate (from model averaging)

Best model: s (age sex nr age*nr)

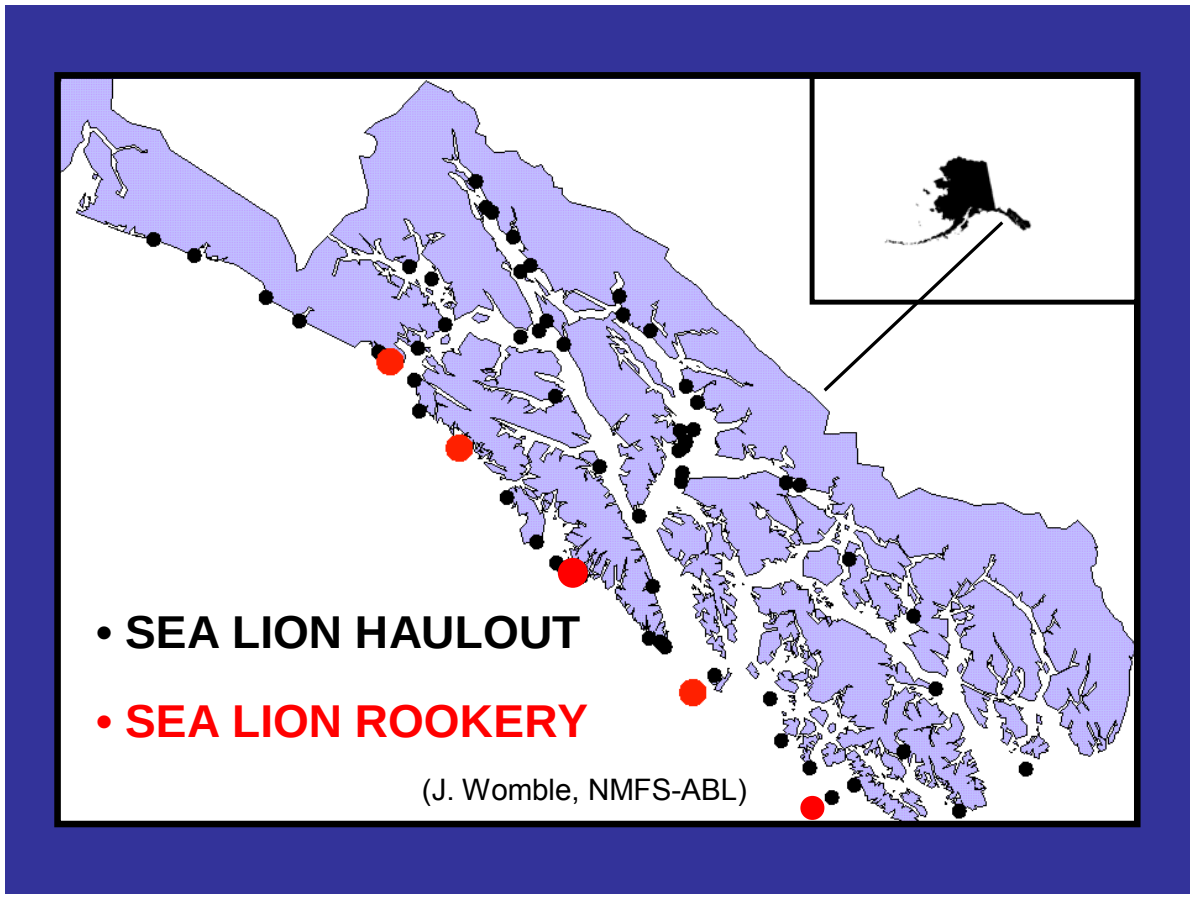


Conclusions:

- survival differs among natal rookeries
- particularly high 2-3 yr survival at WHSI, GRV; HAZ survival slightly higher than FOR
- survival of males lower than females at all ages: but this pattern varies among natal rookeries
- increases from 0.45 – 0.65 to age 1 to 0.70 > 0.95 by age 3-4.

Mark-recapture reproductive rate study: Southeast Alaska

2 studies: (1) Forrester Islands May 15 – July 15
(2) Proportion with pup by ~July 15-20: all SE rookeries
(Forrester, Hazy, White Sisters, Graves Rk, Biali)



Objectives – Reproductive rate study

- Long-term monitoring: annual age-specific reproductive rates and age of first reproduction in SEA
- Long-term monitoring: early pup mortality (May 15 – July 15) at Forrester Island complex
- Seasonal patterns in birth rates and pup mortality rates at Forrester Island complex
- Mark-recapture estimates of breeding and natal site fidelity in SEA

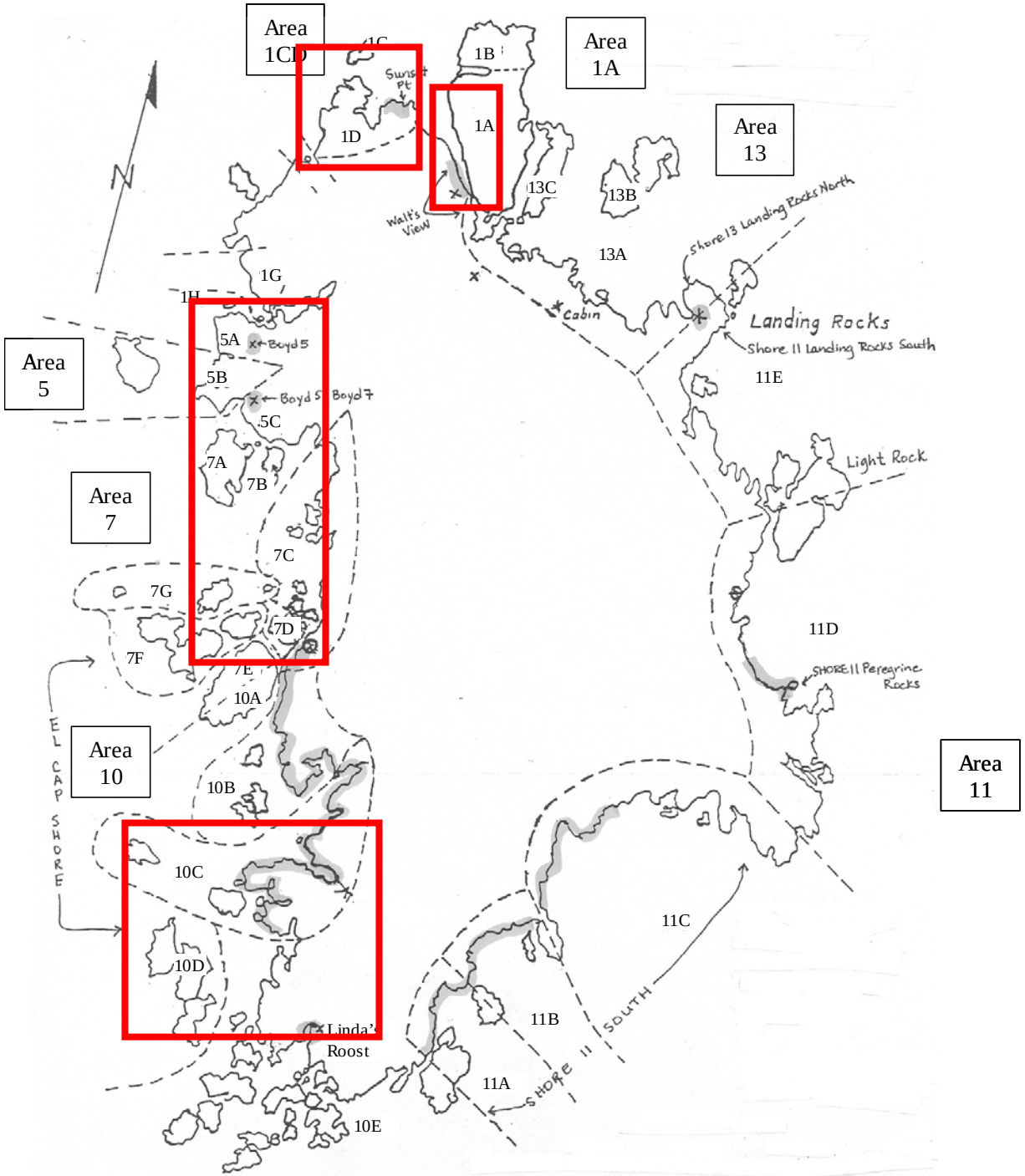
Robust design: *p* varies breeders/non-breeders and estimates corrected for pup detection probabilities

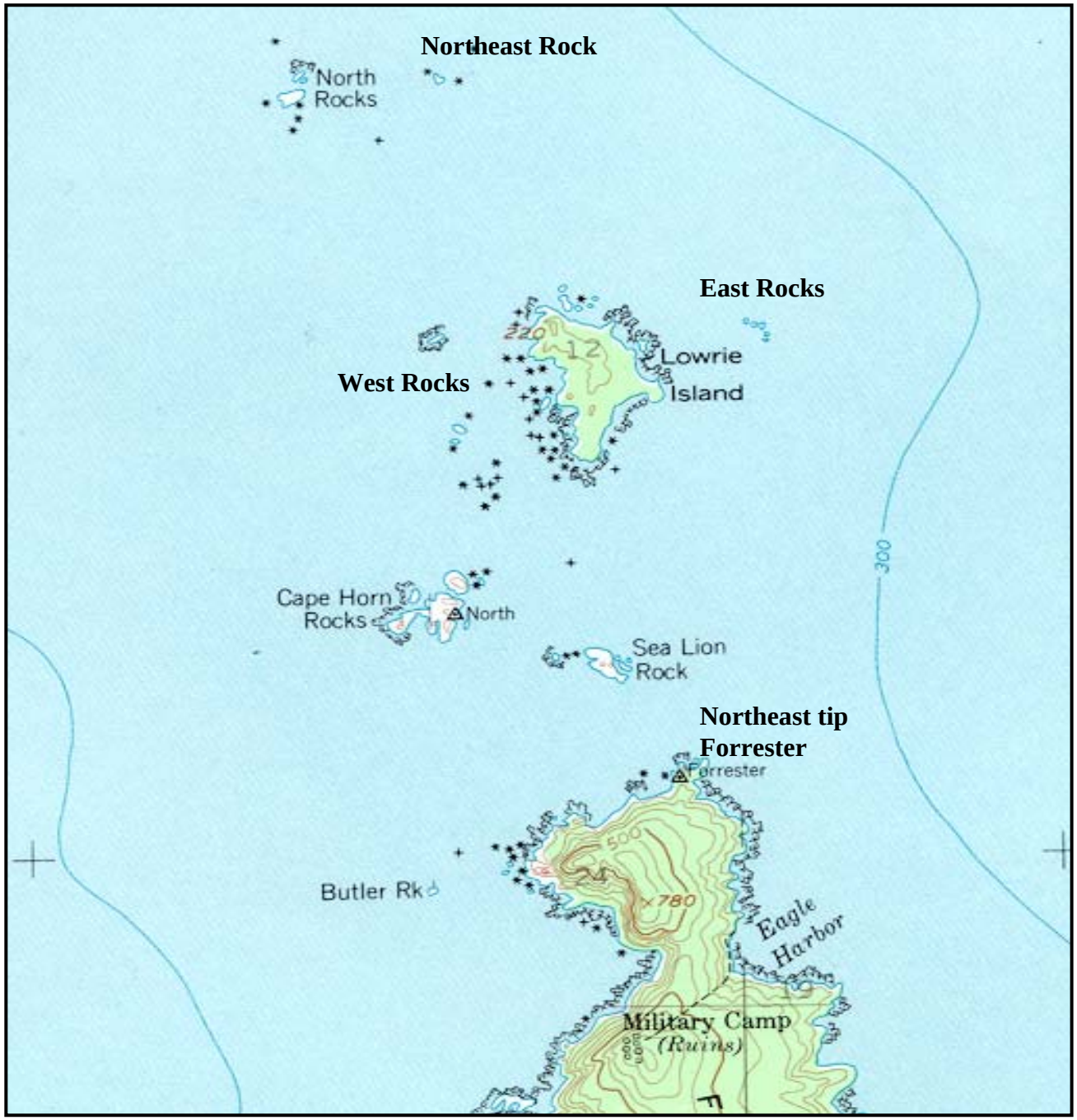
Kendall, W.L., C.A. Langtimm, C.A. Beck, and M.C. Runge. 2004. Capture-recapture analysis for estimating manatee reproductive rates. Marine Mammal Science 20:424-437

Design: Study 1 FOR – Proportion producing pup – pup survival

- 8 primary weekly surveys, May 25 – July 15: 2-4 secondary surveys per primary survey
- All islands but Lowrie surveyed by 2 small boats morning/afternoon for two consecutive days
- Lowrie surveyed by land morning/evening of the following 2 days
- Maintain min time interval (> 5-6 days) between primary surveys

Survey:		1	2	3	4	5	6	7	8
F200	0N0	00	NN0P	PP	P0N	00	PN	NN	
F201	0NN	NP	PN00	P0	PP0	N0	PP	NP	
F407	NNN	N0	P00P	00	NNP	PP	NN	PP	


Area 1CD
Area 1A
Area 13
Area 5
Area 7
Area 10
Area 11
1C
1B
1D
1A
13C
13B
13A
1G
1H
5A
Boyd 5
5B
Boyd 5
Boyd 7
5C
7A
7B
7C
7G
7D
7F
7E
10A
10B
10C
10D
10E
11A
11B
11C
11D
11E
Swiss Pt
Walt's View
Cabin
Shore 13 Landing Rocks North
Landing Rocks
Shore 11 Landing Rocks South
Light Rock
SHORE 11 Peregrine Rocks
EL CAP SHORE
Linda's Roost
SHORE 11 SOUTH


Northeast Rock
North Rocks
East Rocks
220
12
Lowrie Island
West Rocks
Cape Horn Rocks
North
Sea Lion Rock
300
Northeast tip Forrester
Forrester
500
780
Butler Rk
Eagle Harbor
Military Camp
(Ruins)


YAMAHA
25
AVON


F941 WITH PUP

Design: Study 2 all SE –

Proportion producing “viable” pup (pup survived to mid-July)

- Survey week long period starting ~ July 15 by 2 larger boats
- One boat surveys North: Graves - 2 consecutive days and White Sisters - 3 consecutive days
- One boat surveys South: Lowrie crew surveys FOR - 3 consecutive days, then Hazy – 3 consecutive days and Biali for 1.5 days
- 2 surveys/day (morning/evening) - secondary samples range from 3-6 among rookeries/yr

($_{H = HAZY, F= FORRESTER, W = WHSI}$):

	2005	2006	2007	2008
F200	$0N_wP_wN_w$	$P_FP_FN_FN_F00$	$000N_w$	$0P_w0N_w$
F201	$0N_FN_F\ N_F\ 00_w$	$0P_F0N_FP_F0$	$0N_HN_HP_H00$	$0P_FP_FN_F00$
F407	$0N_FN_FN_F0P_F$	$P_HP_H0N_HN_H0$	$0N_HN_H00N_H$	$P_HN_H00P_HN_H$

Return rates – reproductive study:

FORRESTER : observations during entire pupping season 2005

10-11 yr olds	0.615 females seen with pup (strong behavioral evidence; n = 40/65)
	*0.754 females seen with pup (all behavioral evidence; n = 49/65)
4 yr olds	1 female of 37 seen with pup (nursing observed)

OTHER SOUTHEAST ROOKERIES:
Hazy, White Sisters, Graves Rock, Biali; observations ~ July15-25, 2005

10-11 yr olds seen at rookeries	0.615 females seen with pup (n = 8/13)
5-6 yr olds (equal brands)**	0.555 females seen with pup (n = 5/9)
4 yr olds	2 of 32 females seen with pup

**Includes one “T” branded animal: born at Marmot Island nursing a pup at Graves Rock

Conclusions:

- Return rates shows: few 4 yr olds pupped in 2005
- Return rates are biased: mark-recapture estimates will account for
  1) Probability of resighting females with vs. w/out pups
  2) Probability of detecting pups with females

Marked animal studies ADFG

Age-specific survival: includes pup-marking @ 4 rookeries
3-wk-long resight trip: all haul-outs SE/BC

Age-specific reproductive rates: (1) Forrester Island study: May 25 – July 15
(2) SE-wide study (1.5 wk long resight trip mid-July)

Proportion weaned: sampling every 1.5 mo @ few haul-outs (Dec-April)
(by age/birth rookery/sex) (Gran Pt, Benjamin, Southwest Bros, S. Marble, Biali)

Winter/summer distribution: 2 week long resight trip Feb-March to compliment
(by age/birth rookery/sex) summer resight trip

Pup survival post-branding: (1) 2001-02 Lowrie study (to 3-mo post-branding)
(2) 2005: data collected during repro surveys (2 wks post-branding – (White sisters, Graves Rock, Hazy Islands)

Tag-Loss: 2001-2002 Lowrie animals

Review of brand loss/misreading/brand healing

Age of Weaning

• needed to model productivity in SSL populations

•mark-resight models to estimate the probability of young SSL being weaned during their first, second or third years
•accounts for misclassification of weaned status

Estimates of the probability that a juvenile sea lion was weaned, that it would be sighted, and that it would be observed suckling if still dependent. Benjamin Island, SEA 2003-2004

Age (yrs)	Probability weaned	95% C.I.	Sighting probability	Probability observe suckling
0	**0.103**	0-0.285	0-0.81[1]	0.11-0.50*
1	**0.153**	0-0.389	0-1[2]	0.303
2	**0.910**	0.775-1	0.47-1.0[3]	0.14-0.56

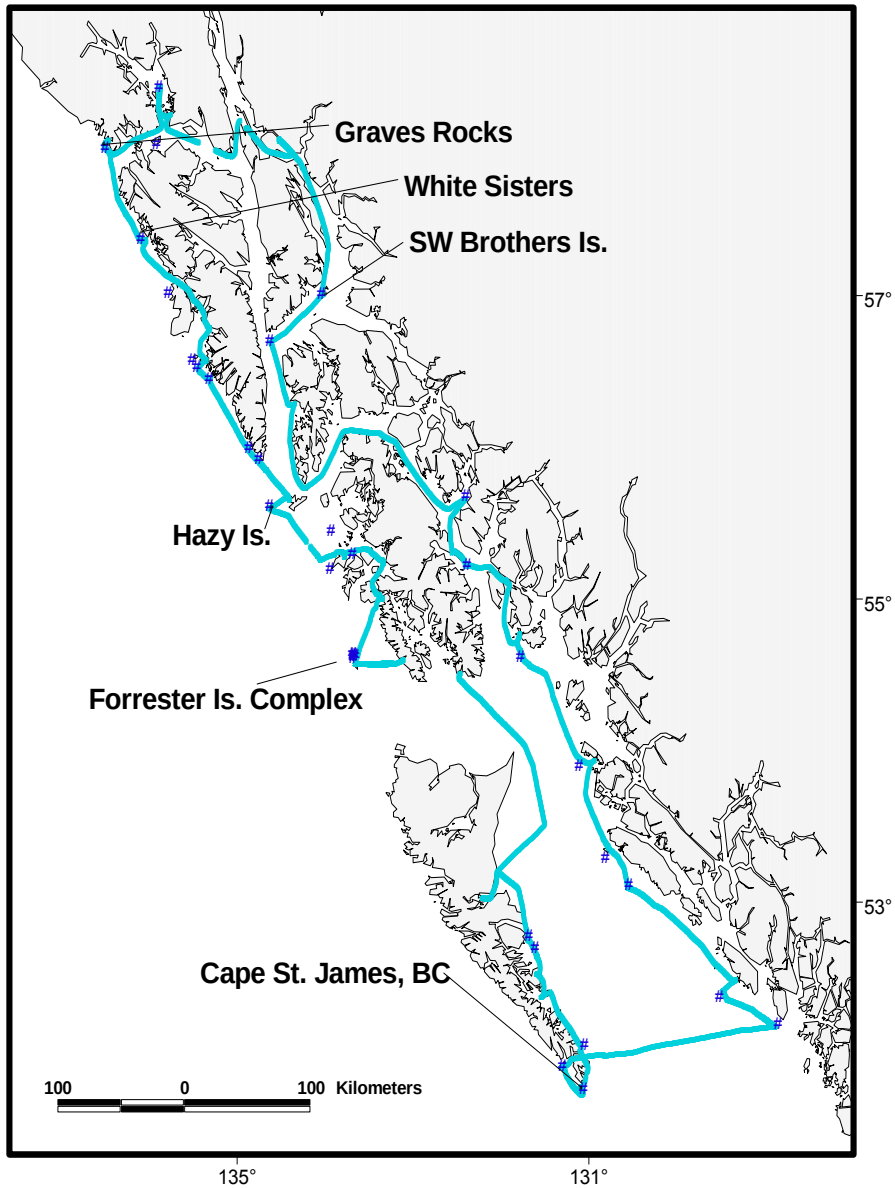
[1]Varies with time
[2]Varies with weaning status & time, poorly estimated
[3]Varies with weaning status

Age of Weaning in Southeast Alaska

- Many juvenile SSL are suckling into their second year
- Study expanded to multiple sites in SEA in 04-05 and 05-06
- Similar patterns, possible high annual variability in proportion of juveniles weaned in their 3rd winter

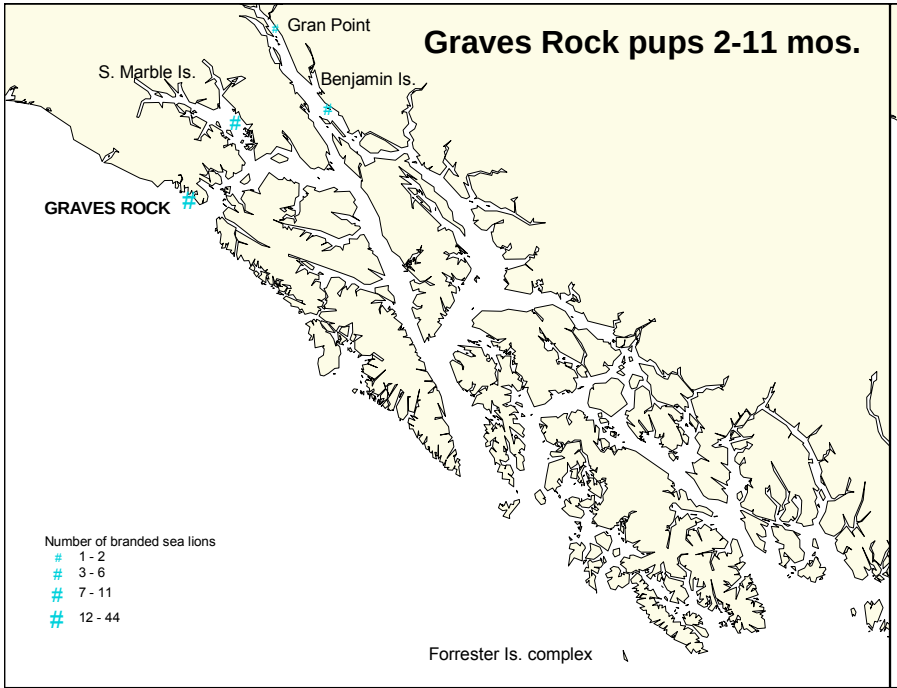
- Reproduction in this population might be reduced from potential if all females were producing surviving pups annually
- Might enhance the survival of the juvenile during periods of suboptimal environmental conditions
- Life history strategy called “bet-hedging”

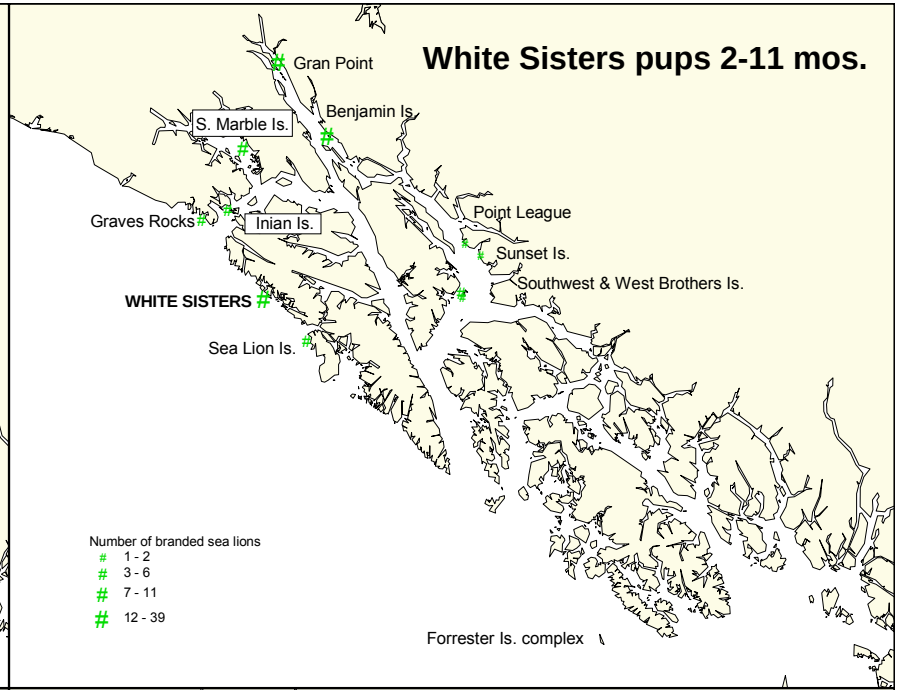
Example of Brand Resight Trackline

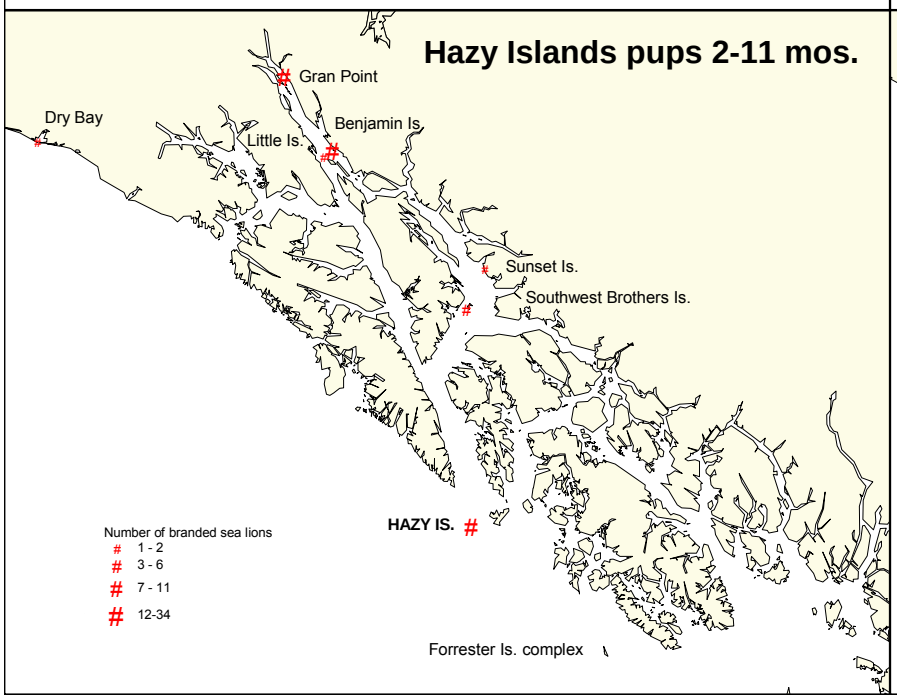


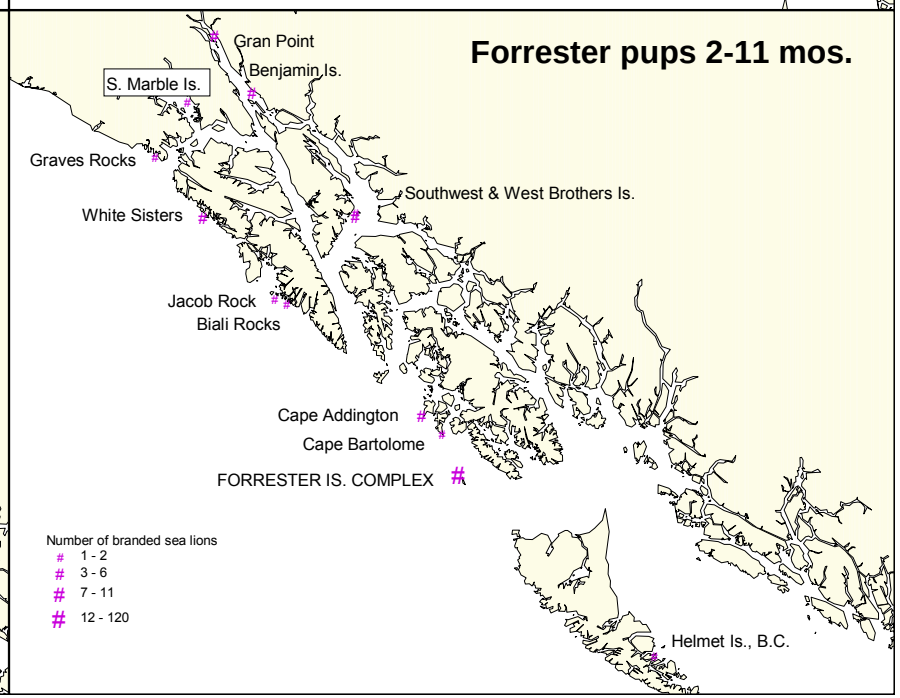
Distribution of animals

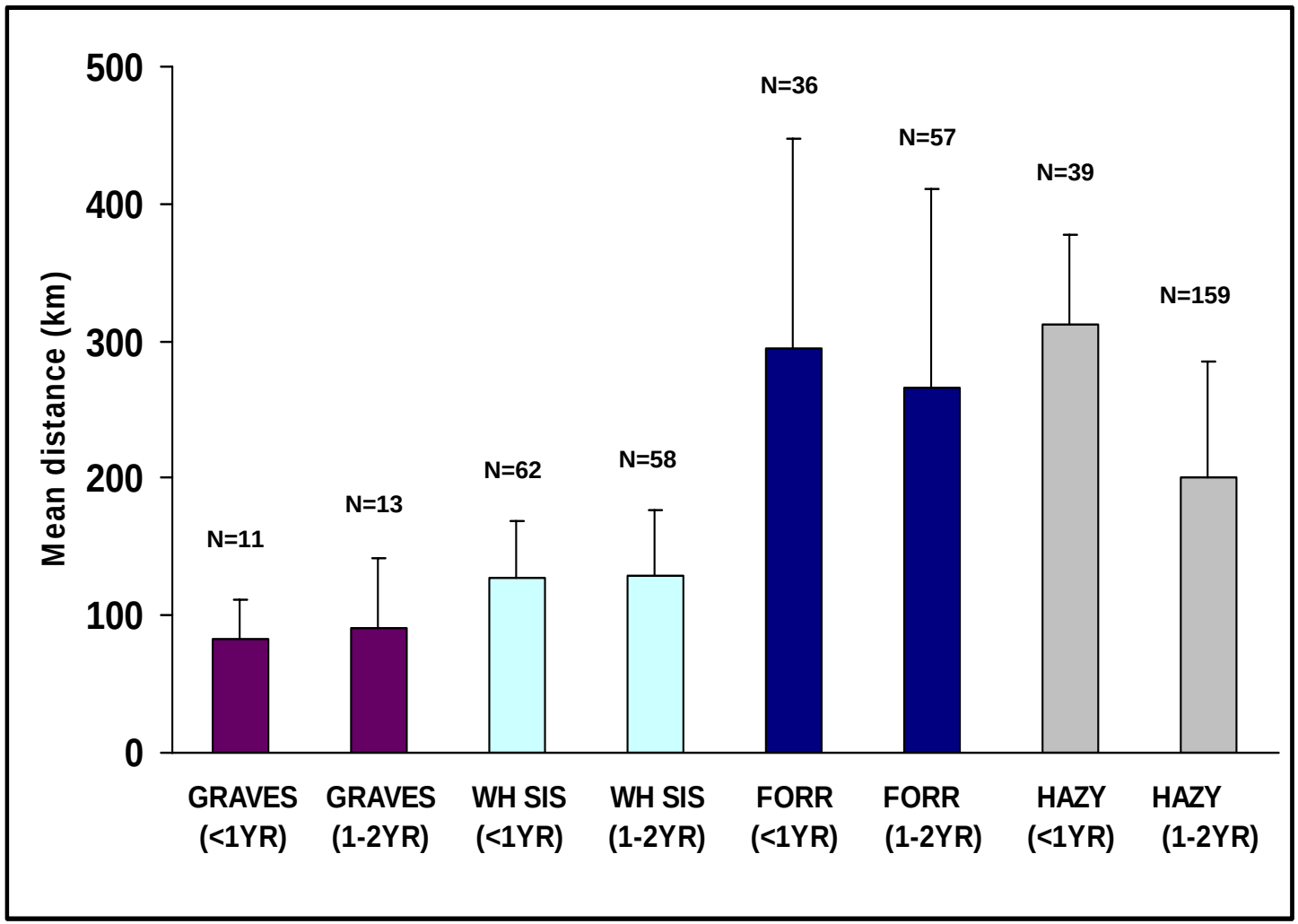
- Raum-Suryan et al. 2002 – dispersal patterns, movement between stocks, natal site fidelity based on animals marked at Forrester Islands complex 1994 and 1995.
- Expand this research to compare summer (May-Aug) and winter (Feb-Mar) distribution of all marked animals in SEA
- With animals marked from 2001 to 2005 can now determine the influence of natal rookery, age, sex on distribution and look at natal rookery differences in movement between stocks
- Possibly gain understanding of how new rookeries are established (Biali and Graves Rock both established in last 5-7 years)

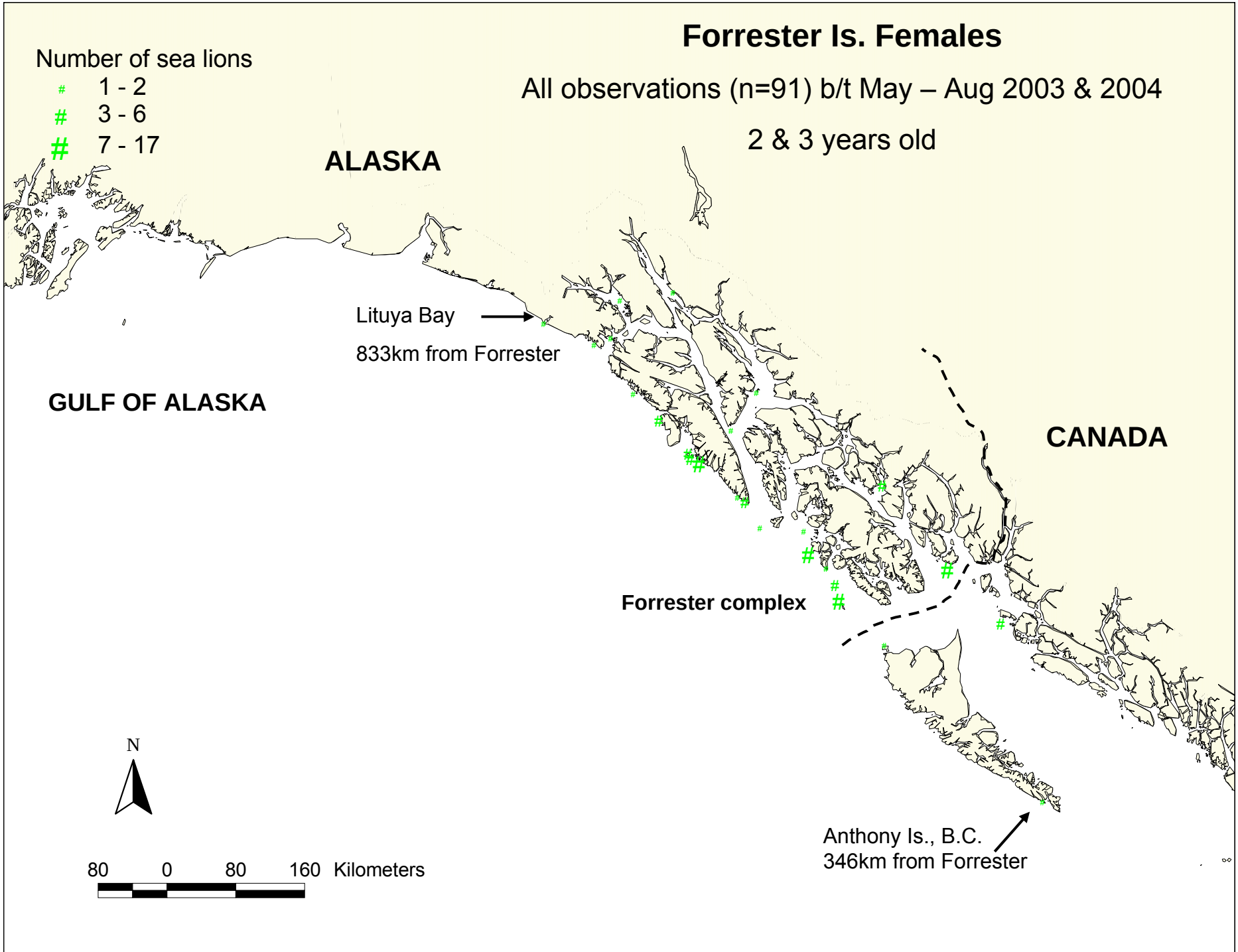

Graves Rock pups 2-11 mos.
Gran Point
S. Marble Is.
Benjamin Is.
GRAVES ROCK
Number of branded sea lions
1 - 2
3 - 6
7 - 11
12 - 44
Forrester Is. complex

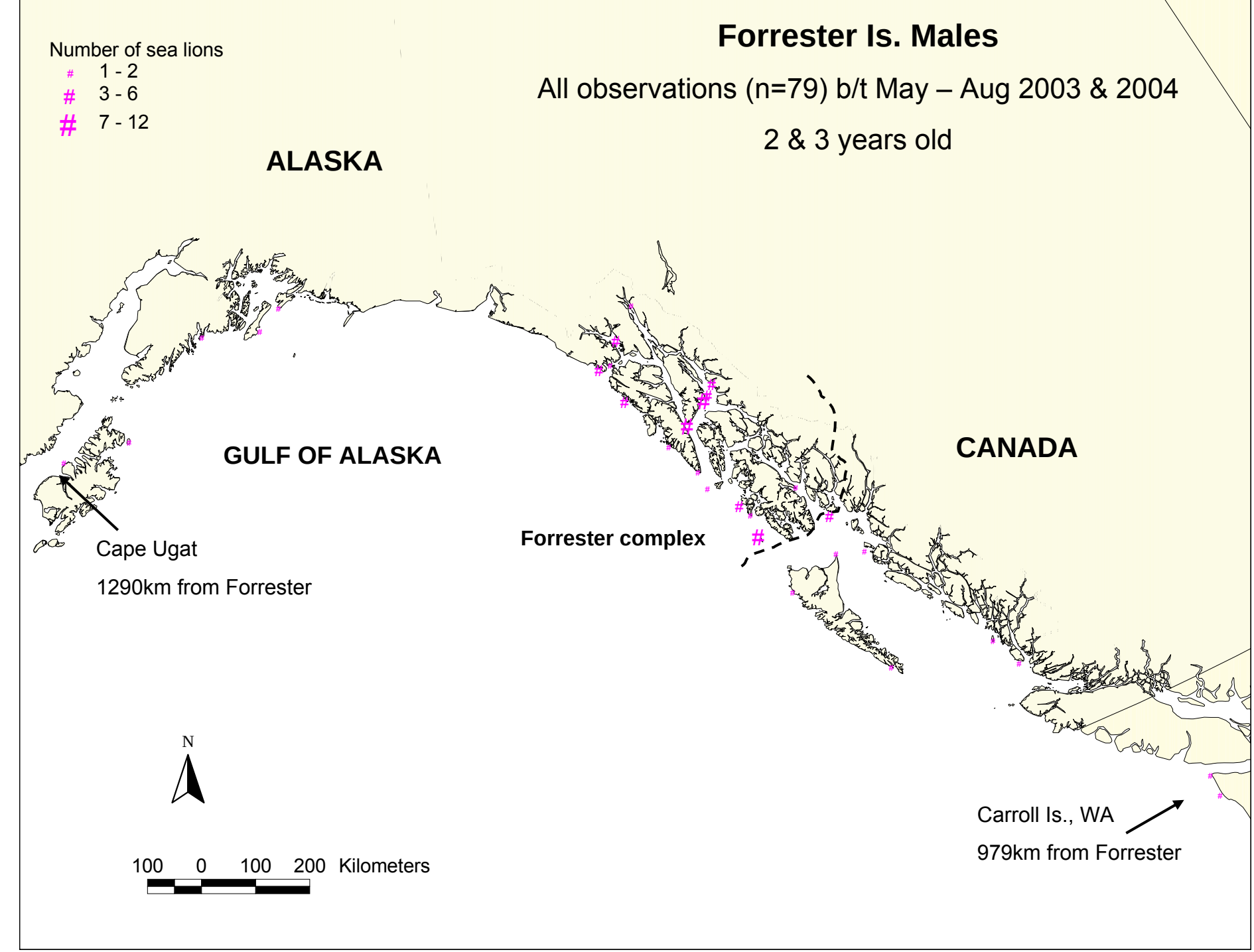

White Sisters pups 2-11 mos.
Gran Point
Benjamin Is.
S. Marble Is.
Graves Rocks
Inian Is.
Point League
Sunset Is.
Southwest & West Brothers Is.
WHITE SISTERS
Sea Lion Is.
Number of branded sea lions
1 - 2
3 - 6
7 - 11
12 - 39
Forrester Is. complex


Hazy Islands pups 2-11 mos.
Gran Point
Dry Bay
Little Is.
Benjamin Is.
Sunset Is.
Southwest Brothers Is.
HAZY IS.
Number of branded sea lions
1 - 2
3 - 6
7 - 11
12-34
Forrester Is. complex


Forrester pups 2-11 mos.
Gran Point
Benjamin Is.
S. Marble Is.
Graves Rocks
Southwest & West Brothers Is.
White Sisters
Jacob Rock
Biali Rocks
Cape Addington
Cape Bartolome
FORRESTER IS. COMPLEX
Number of branded sea lions
1 - 2
3 - 6
7 - 11
12 - 120
Helmet Is., B.C.


Mean distance (km)
500
400
300
200
100
0
N=11
N=13
N=62
N=58
N=36
N=57
N=39
N=159
GRAVES (<1YR)
GRAVES (1-2YR)
WH SIS (<1YR)
WH SIS (1-2YR)
FORR (<1YR)
FORR (1-2YR)
HAZY (<1YR)
HAZY (1-2YR)


Forrester Is. Females
All observations (n=91) b/t May – Aug 2003 & 2004
2 & 3 years old
Number of sea lions
1 - 2
3 - 6
7 - 17
ALASKA
Lituya Bay
833km from Forrester
GULF OF ALASKA
CANADA
Forrester complex
N
80 0 80 160 Kilometers
Anthony Is., B.C.
346km from Forrester


Forrester Is. Males
All observations (n=79) b/t May – Aug 2003 & 2004
2 & 3 years old
Number of sea lions
1 - 2
3 - 6
7 - 12
ALASKA
GULF OF ALASKA
CANADA
Forrester complex
Cape Ugat
1290km from Forrester
Carroll Is., WA
979km from Forrester
N
100 0 100 200 Kilometers

F443 – MALE

Born: June 1994

Resighted on 11 days

ALASKA

Dry Bay
Apr 2004

Sail Is.
Nov 1995

SW Brothers
Jul 1995
Sep 2000

Marmot Is.
Jul 1999

Biali Rocks
Jun 00, 01, 04

GULF OF ALASKA

CANADA

FORRESTER COMPLEX

Wouwer Is.
Sep 1997

Carroll Is.
Aug 1997

F443 at Dry Bay

N

0 200 400 Kilometers

Graves Rock and South Marble Island

- **587 sightings of branded animals (1994-2004)**
  - **186 unique brands**
    - **Forrester: 55**
    - **Graves: 45**
    - **White Sisters: 26**
    - **Hazy Islands: 22**
    - **= brands: 12**
    - **WA & CAL brands: 2**
    - **Sugarloaf: 8**
    - **Marmot: 7**
    - **Seal Rocks: 7**
    - **Fish Island: 2**

More western stock animals seen in GBNP than anywhere else in SEA

Jun & Jul 2005 – Graves Rock with pup

April 18, 2006 – S. Marble Is.

T23 – born 2000, Marmot Is.

Marked animal studies ADFG

Age-specific survival: includes pup-marking @ 4 rookeries
3-wk-long resight trip: all haul-outs SE/BC

Age-specific reproductive rates: (1) Forrester Island study: May 25 – July 15
(2) SE-wide study (1.5 wk long resight trip mid-July)

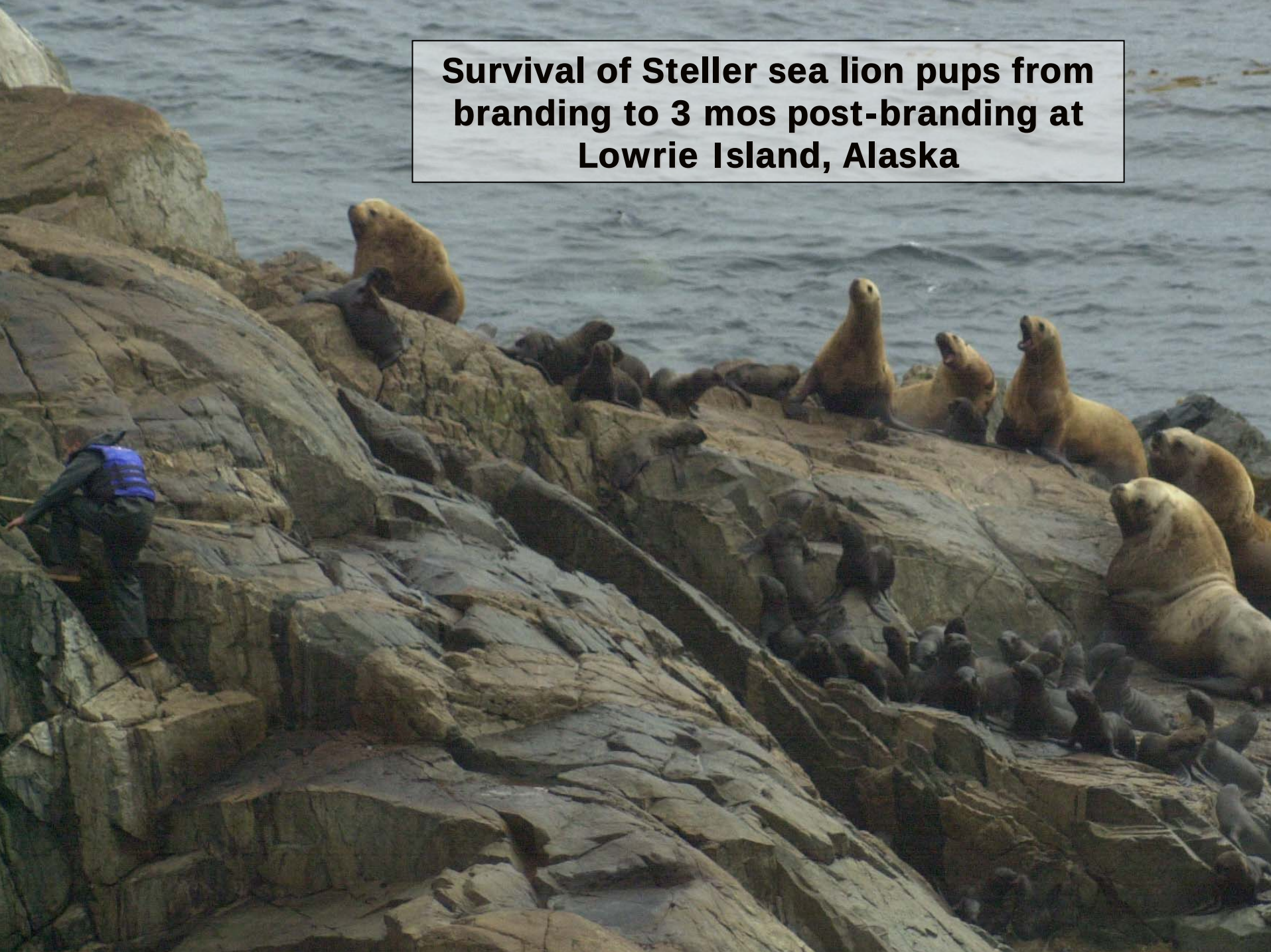
Proportion weaned: sampling every 1.5 mo @ few haul-outs (Dec-April)
(by age/birth rookery/sex) (Gran Pt, Benjamin, Southwest Bros, S. Marble, Biali)

Winter/summer distribution: 2 week long resight trip Feb-March to compliment
(by age/birth rookery/sex) summer resight trip

Pup survival post-branding: (1) 2001-02 Lowrie study (to 3-mo post-branding)
(2) 2005: data collected during repro surveys (2 wks post-branding – (White sisters, Graves Rock, Hazy Islands)

Tag-Loss: 2001-2002 Lowrie animals

Review of brand loss/misreading/brand healing


Survival of Steller sea lion pups from branding to 3 mos post-branding at Lowrie Island, Alaska

Objectives

Pup survival estimates - branding to 3 mos post-branding

- Brand/tag misread rates
- Maximum potential mortality caused by the branding event

S < 2 wks after branding ⇩ S > 2 wks post-branding

	2001 Lowrie Island	2002 Lowrie Island
Branded only	140	0
Branded + tagged	146	80
Total Marked	**286**	**80**
Resight rate	94%	99%

Total = 366

Hastings, K., T. Gelatt and J. King. In prep. Survival of Steller sea lion pups to 3-months post branding at Lowrie Island, Southeast Alaska.

Branded Pup Resight Survey: Methods

- **Standardized:**
  - **Geographical coverage** 8 standard observation points (all of Lowrie Island)
  - **Effort** at each site with pups until no new resights for 20 minutes

- **Independent readings:** resight quality & misread rates
  - 2 observers record data for each individual simultaneously and independently
  - After recording data: compare observations to detect misreads
  - If brand and tag read – handheld computer used in field to check independent readings (2002 only)

- **Survey schedule**

2001: less effort	**2002: greater effort**
2 observers	4- 2 observers
1-2 consecutive days every week	2 consecutive days every week
8 areas covered 1x per survey	8 areas covered 2x per survey

Misread rates: results

Observers 3x as likely to misread a brand than a tag; but **misread rates were low**:

Brand misread rate = 0.031 (min-max = 0.025 – 0.320)

Tag misread rate = 0.009 (min–max = 0.007 – 0.014)

Only brand double-reading affected misread rate (reduced misread rate to 0.027)

(observation site quality, independent reading, minimum observer experience: all P > 0.20)

Digit placement and value affected brand misread rates:

(1) Most likely to misread digits 5 (73%) and 4 (27%); first 3 digits never misread

(2) 3 and 8: most likely to be misread (23% of misreads each);

4, 6, 7 and 9: next most likely to be misread (13% of misreads each);

2 misread only once; 0, 1 and 5 never misread

3: most often misread as 9 or 7 (less frequently as 8 and 2)

8: equally misread as 0, 1, 2, 3, or 6

6: 3 of 4 misreads were as 5; 5 was never misread.

MARK analyses: survival to 3 months after branding

- Capture histories: pooled multiple resights/survey into a single resighting ; 10 occasions, 6/28 – 9/17 (tag-only resights excluded; 8%)

- 2 Datasets:
  Survey-only dataset = data only from 6/26 – 9/18 in year of branding, After-survey dataset = 2 additional occasions, seen at 1 and 2 yrs of age (photo-confirmed resights only May-Aug).

- Test goodness-of-fit of global model using bootstrap procedure

- Parameter estimates based on the entire set of models fit - model averaging to incorporate model uncertainty

Variables in models

1. Time *(Week after branding)*
2. Sex
3. Capture area (3) *Area top-1a*
   Area 1a
   Area 5A/B
4. Year (2) *2001*
   2002

Summary

Weekly survival = high for SSL pups from Lowrie Island after 4-6 wks of age (0.99/week)

A potential 3-5% maximum mortality (due to drowning and/or mother pup separation) may be attributable to the branding event.

However…

- natural and branding-related mortality cannot be distinguished
- Age may be factor: most pups are only 2-4 weeks of age at the time of branding
- Vulnerable time: potential mortality related to their tendency to enter the water, begin swimming and relocate to other areas of the island during mid-early July

•Females more susceptible than males to mortality: first 2 wks post-branding

- smaller size and/or younger age?
- future: body size into mark-recapture models

=171 (male)

Jul 19, 2005 – 6 years old – at Inian Islands

Dead Aug 12, 2005 – Pt. Gustavus

=171

Types of marine debris affecting Steller sea lions on haulouts and rookeries in Alaska and Northern British Columbia during 2000-2005 surveys.

Line around neck

49%

N = 280

38%

Flasher

4%

1%

8%

Packing Band

Netting around neck

Hook/Line

Population Dynamics

Population Counts
- Aerial survey of Coastline

Survival, Reproduction and Recruitment
- Pup branding
- Winter and summer brand resighting throughout SE AK
- Field camp at Lowrie Island – brand resights

Physiological Studies

Identification of Weaning & Diet
- Stable isotopes (whiskers), Fatty acids (blubber), Scats

Body Condition & Nutrition
- Morphometrics
- Deuterium, BIA
- Blood chemistry
- Muscle biochemistry

Contaminants & Disease
- Serology, Parasitology, Virology, Contaminants

Foraging Ecology

Juvenile Movement & Dive Ontogeny
-Dispersal, development of diving duration and depth
-Organization of diving behavior
-- deploy 30 TDR and 15 satellite transmitters during fall, recaptures in spring with diet and condition assessments

Dive Capture of Steller sea lions

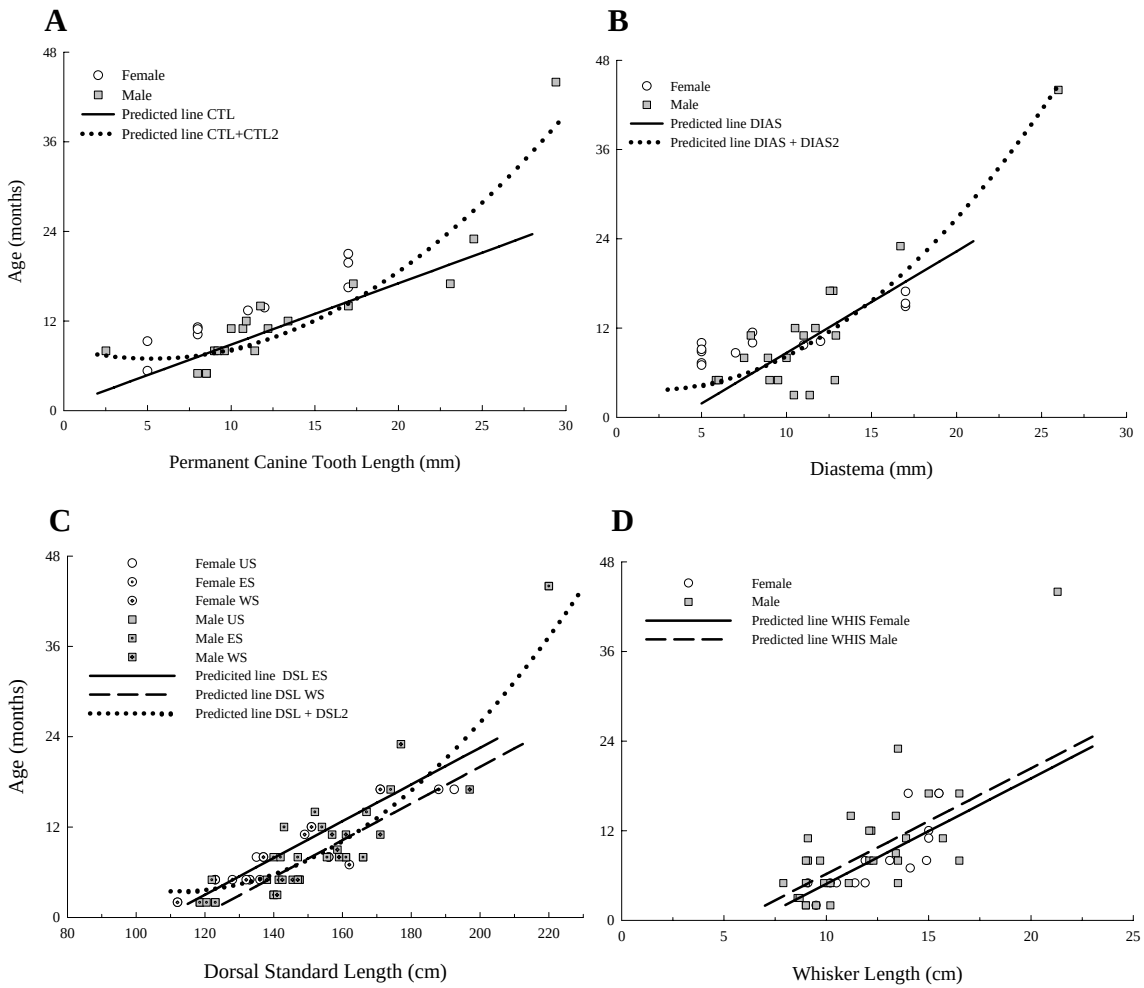
Photo: Shane Moore

Age distribution of blood samples collected from captures – As of April 2006

Age (mo)	0-1 Jun/July	2-4 Aug/Sept/Oct	5-7 Nov/Dec/Jan	8-10 Feb/Mar/Apr	11-13 May/June/July	14-16 Aug/Sep/Oct	17-19 Nov/Dec/Jan	20-22 Feb/Mar/Apr	23-25 May/June/July	26-28 Aug/Sep/Oct	29-36	37 and older
SE	16 (98) 95 (01) 110 (02) 75 (03) 0 (04) 86 (05)	12 (99) 13 (00) 12 (01) 27 (04)	18 (98) 11 (00) 12 (02) 8 (03)	13 (98) 20 (04)	32 (01) 17 (02)	20 (00) 26 (01) 10 (04)	1 (98) 4 (00) 12(02) 8 (03)	5 (04)	5 (01) 4 (02)	1 (01) 4 (04)	1 (01) 4 (03)	
total	382	64	49	33	49	56	25	5	9	5	5	
PWS		13 (00) 6 (02)	21 (01) 18 (03) 30 (05) 32 (05)	12 (00) 10 (05) 14 (06)	20 (02)	16 (00) 8 (02)	8 (01) 12 (03) 4 (05)	4 (00) 8 (05) 1 (06)	8 (02)	1 (00) 4 (02)	1(02) 1(05)	1 (03) 1 (05)
total		19	101	36	20	24	24	13	8	5	2	2
Kodiak				13 (01)								
total				13								
CAI		17 (01)		13 (02) 7 (03)	9 (04) 17 (05)	1 (01)		2 (03)				
total		17		30	26	1		2				

Blue indicates total sample size per age (all years).
Year of collection is indicated in parentheses.

n = 1025


A
Female
Male
Predicted line CTL
Predicted line CTL+CTL2
Age (months)
Permanent Canine Tooth Length (mm)
B
Female
Male
Predicted line DIAS
Predicited line DIAS + DIAS2
Diastema (mm)
C
Female US
Female ES
Female WS
Male US
Male ES
Male WS
Predicited line DSL ES
Predicted line DSL WS
Predicted line DSL + DSL2
Age (months)
Dorsal Standard Length (cm)
D
Female
Male
Predicted line WHIS Female
Predicted line WHIS Male
Whisker Length (cm)

Accurately aging Steller sea lions

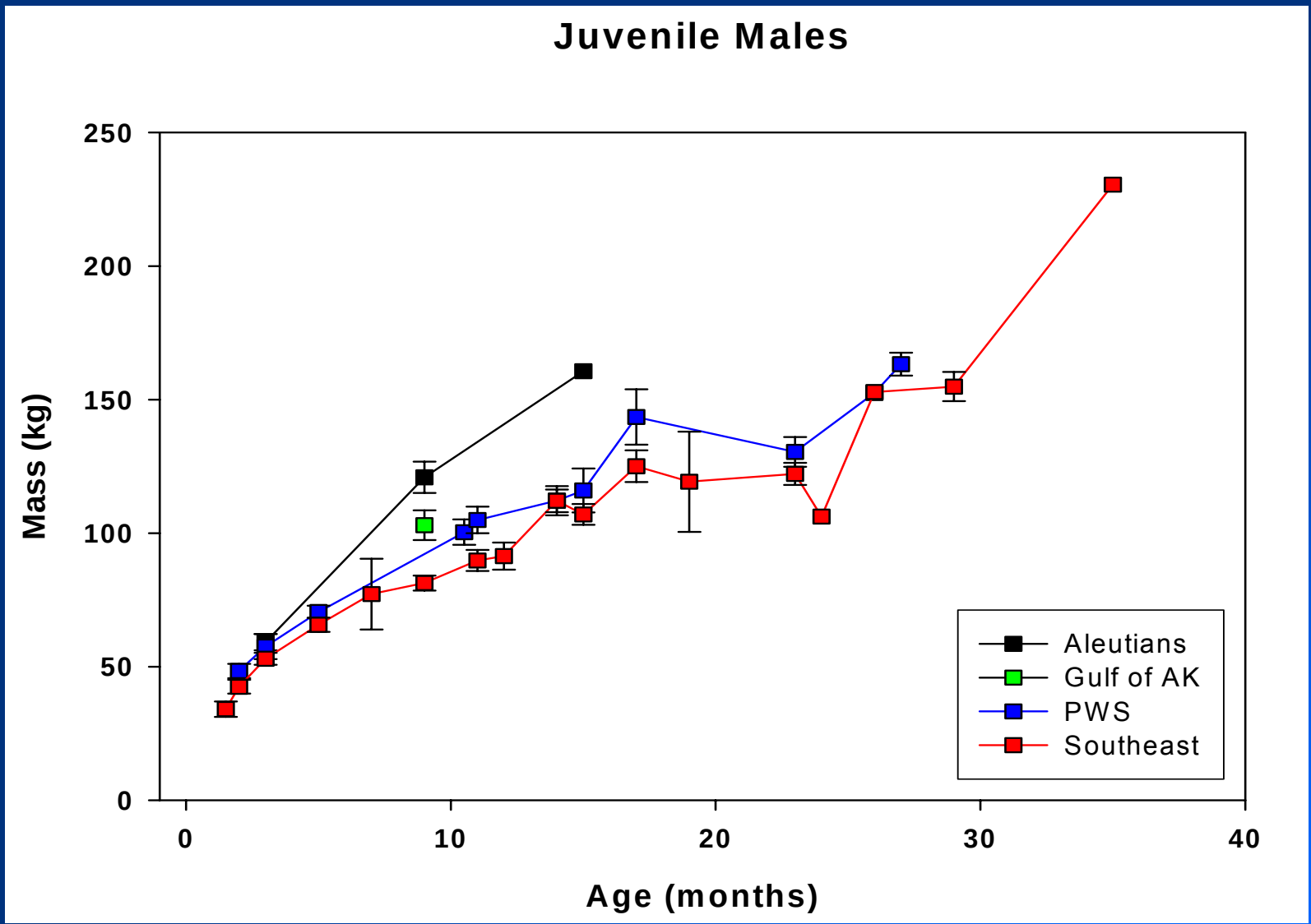
- 46 individual Steller sea lions originally branded or tagged at $\leq$ 6 months of age were recaptured

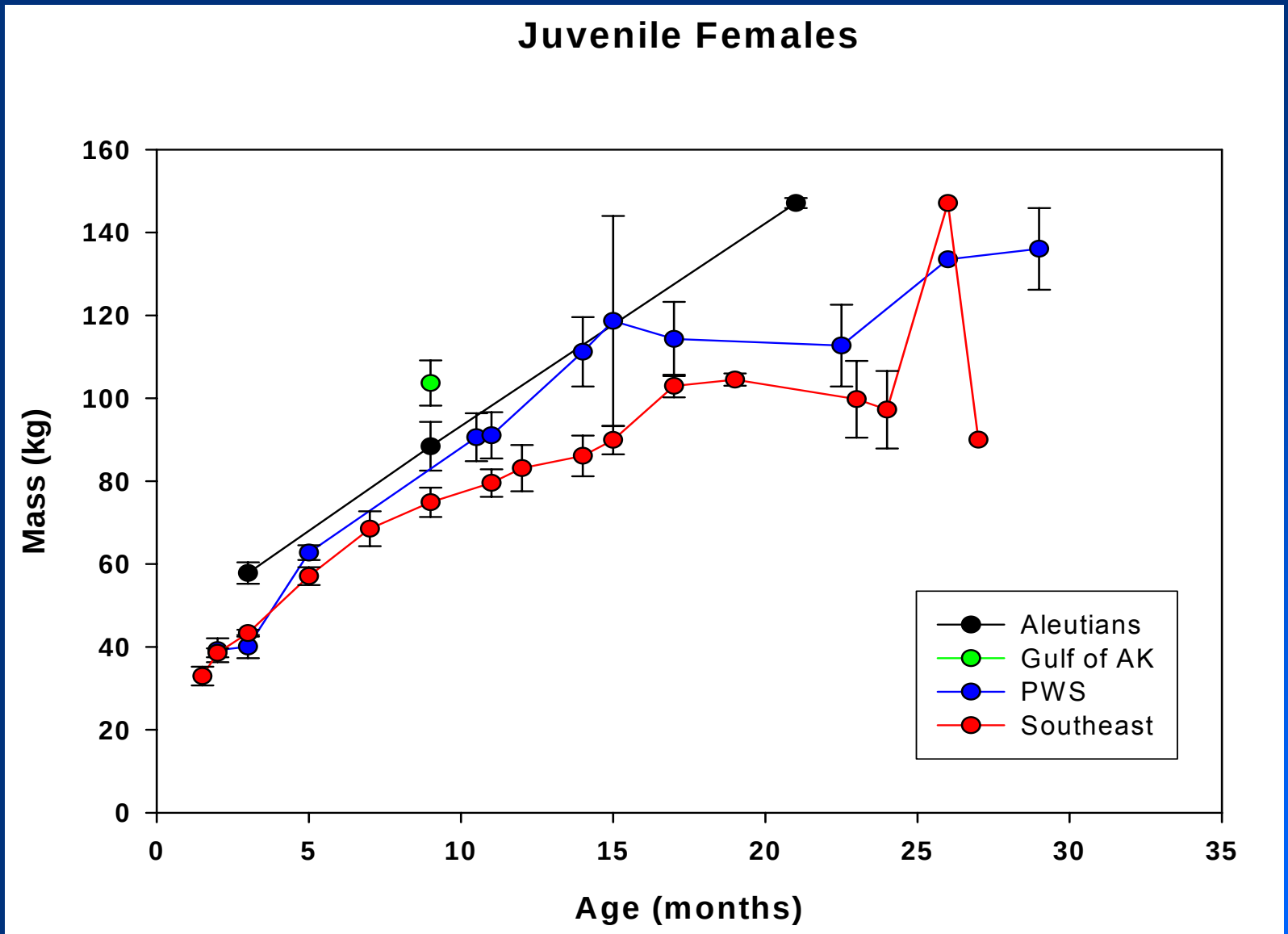
- permanent canine tooth length (CTL) was the strongest individual predictor (r^2 =0.80); followed by dorsal standard length, diastema, and whisker length (r^2 =0.70, 0.56, and 0.45 respectively).

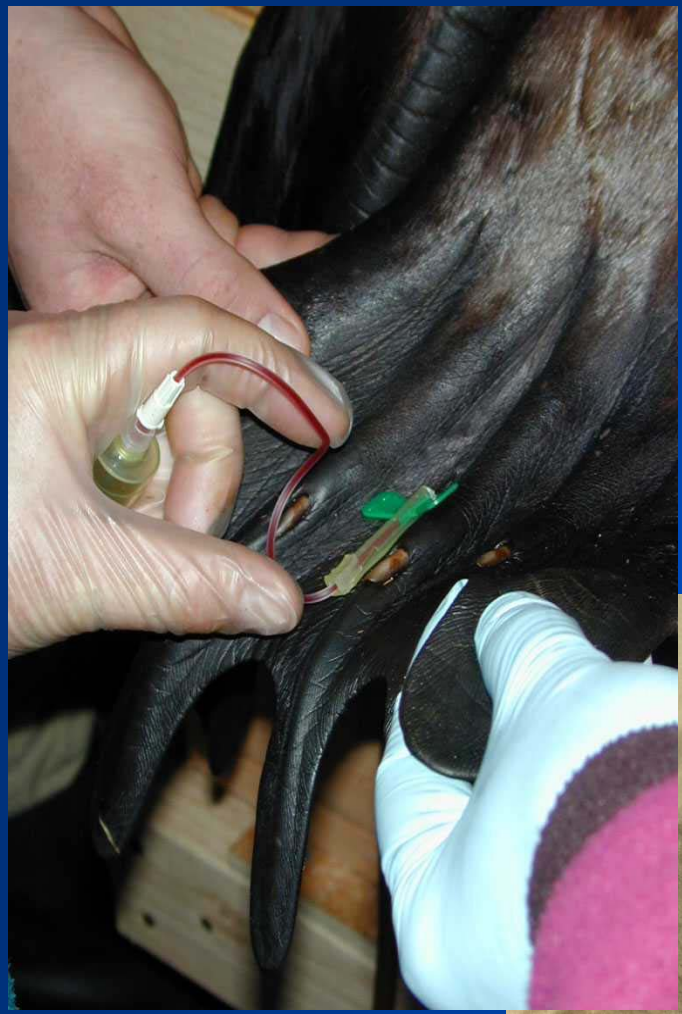
- only models including CTL predicted age to within 6 months of known age

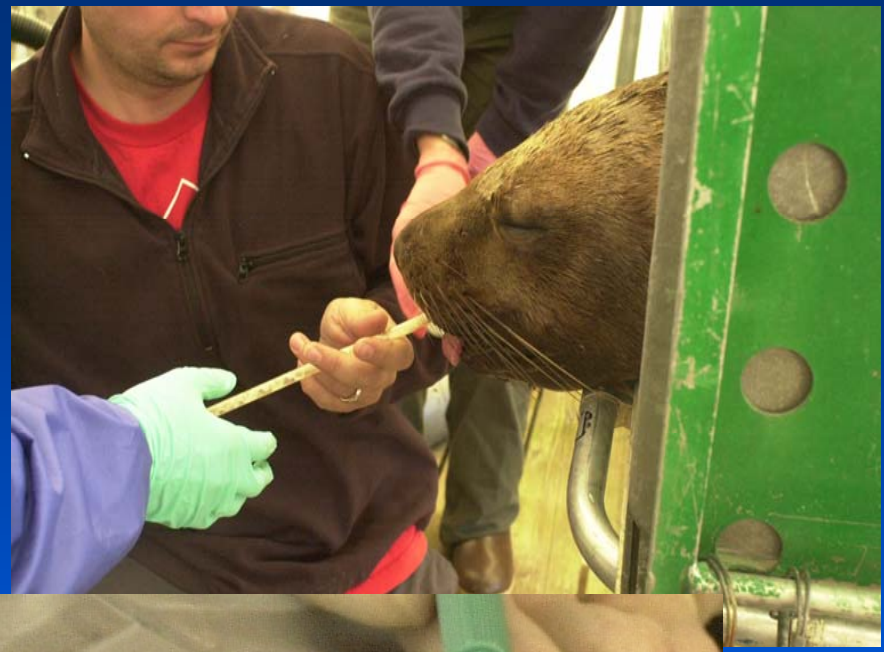
- allows for accurate age estimates of SSL $\leq$ 23 mo for both sexes

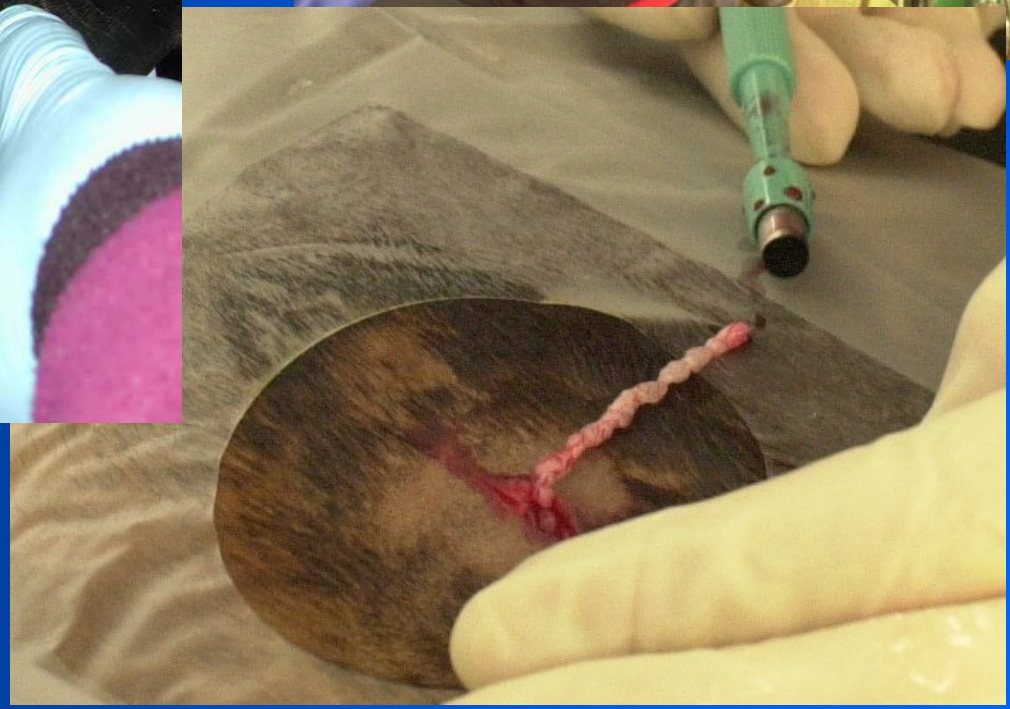
King, J., T. Gelatt, K. Pitcher and G. Pendleton, In review. A Field-based method for estimating age in free-ranging Steller sea lions (*Eumetopias jubatus*) less than twenty four months of age. Marine Mammal Science.

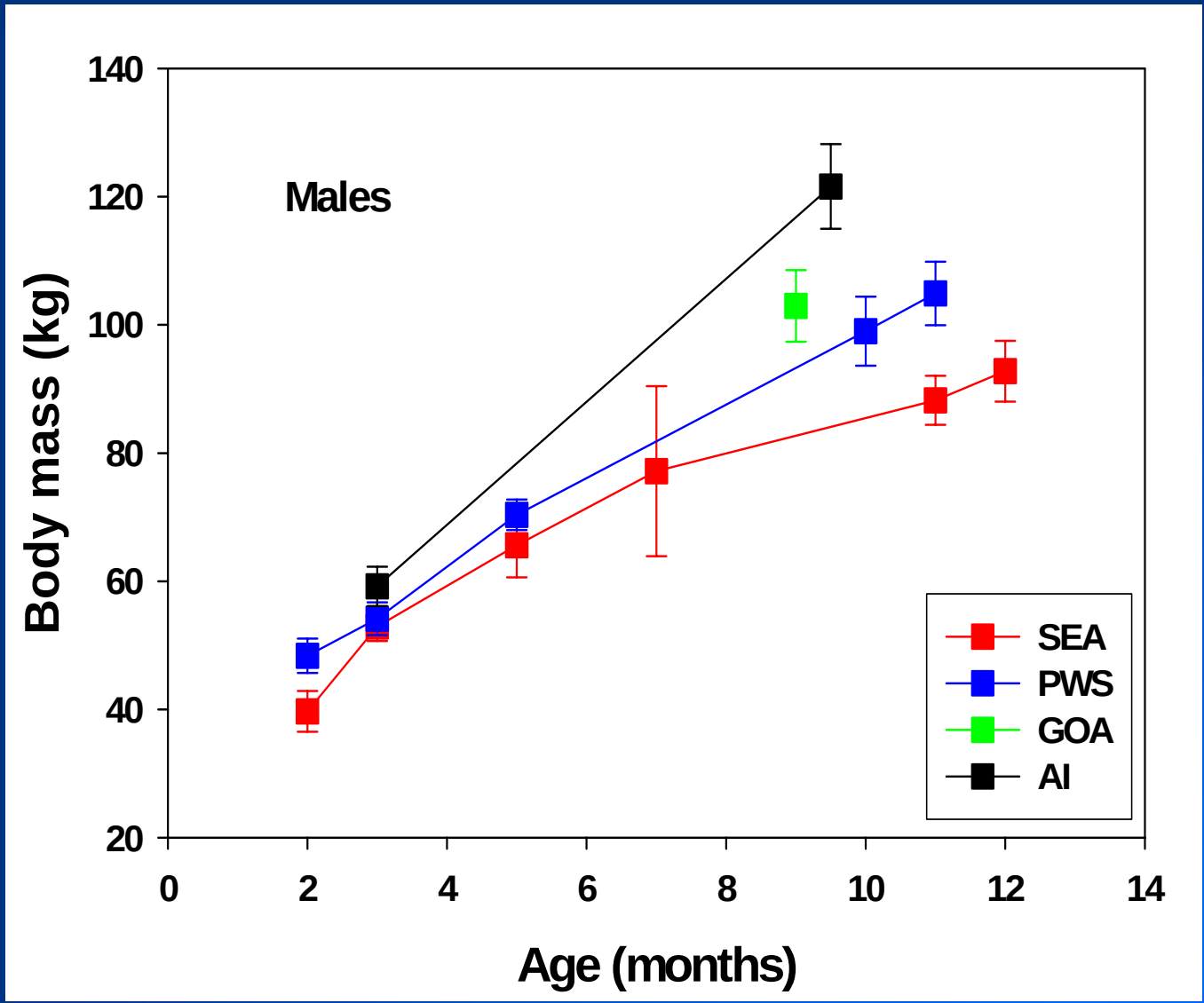

Juvenile Males
Mass (kg)
250
200
150
100
50
0
0
10
20
30
40
Age (months)
Aleutians
Gulf of AK
PWS
Southeast

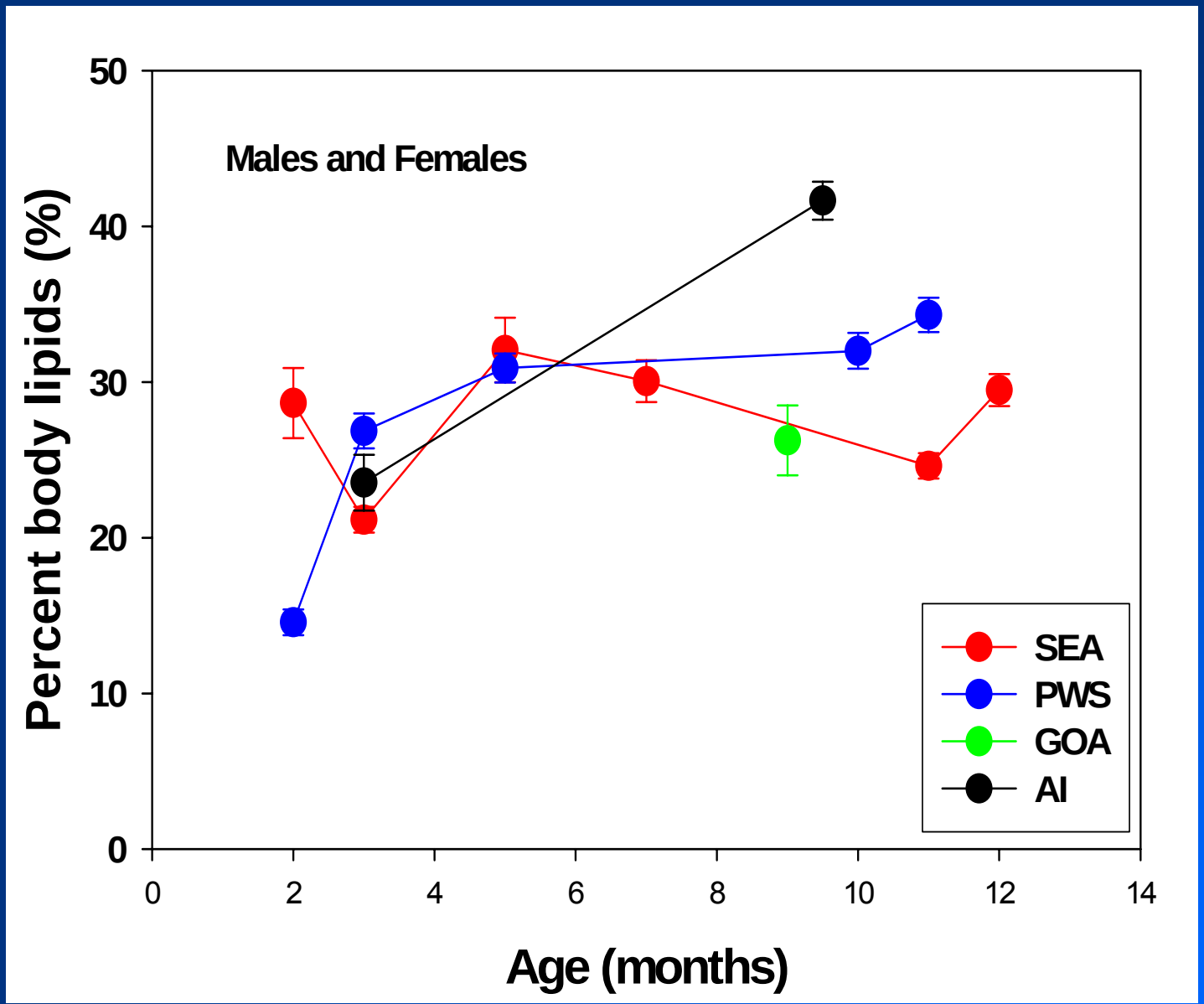

Juvenile Females
Mass (kg)
160
140
120
100
80
60
40
20
0
0
5
10
15
20
25
30
35
Age (months)
Aleutians
Gulf of AK
PWS
Southeast








Males
Body mass (kg)
Age (months)
140
120
100
80
60
40
20
0
2
4
6
8
10
12
14
SEA
PWS
GOA
AI

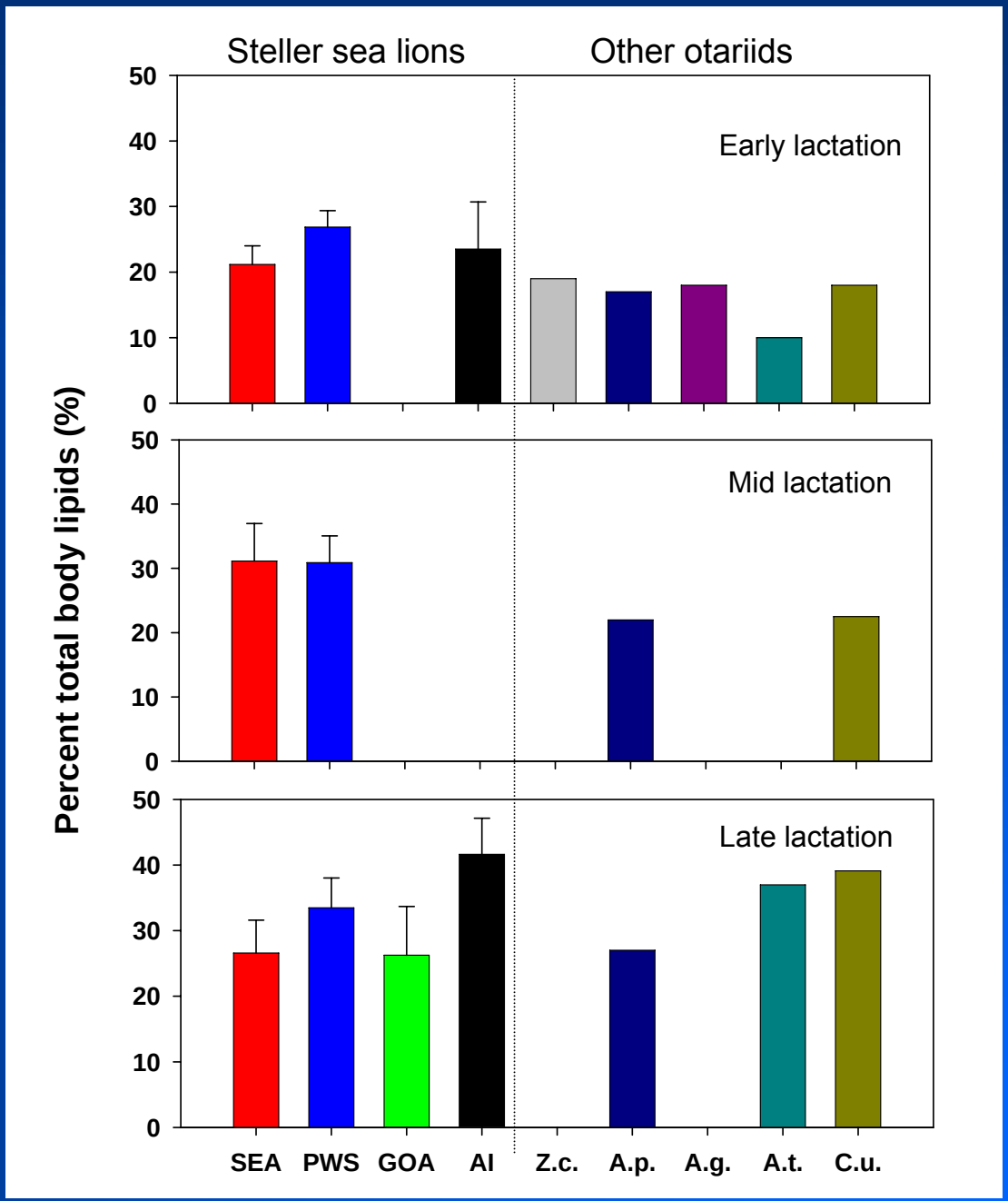

Males and Females
Percent body lipids (%)
Age (months)
0
10
20
30
40
50
0
2
4
6
8
10
12
14
SEA
PWS
GOA
AI

Percent body fat by region

Statistical comparison for 3 age groups:
3 mo., 5 mo., and 9 - 12 months.

3 months	SEA < PWS	$p < 0.001$
5 months	SEA = PWS	$p = 0.561$
9 – 12 mo	SEA < PWS < AL	$p < 0.001$

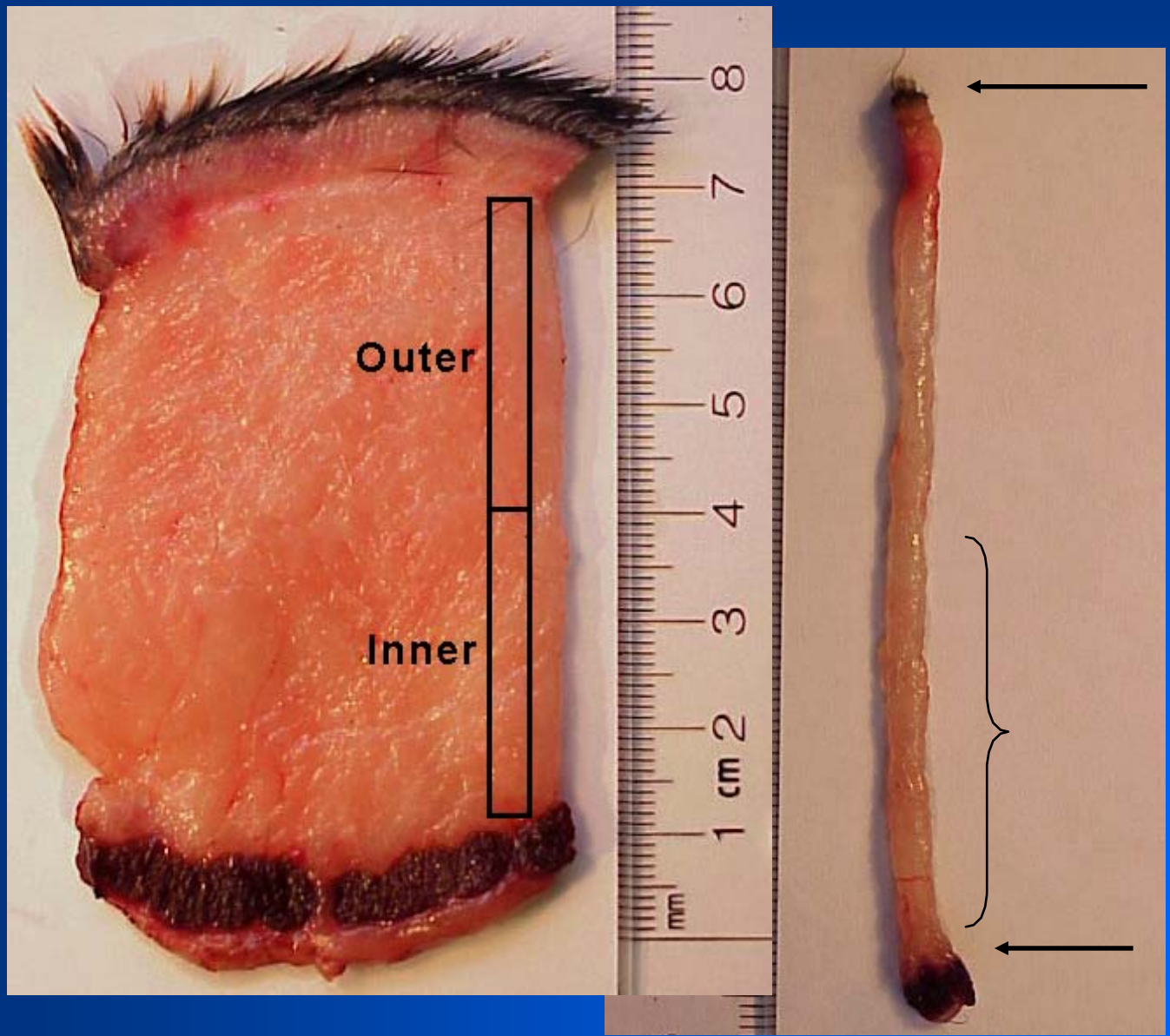
Total body lipids of otariid pups:



Conclusions:

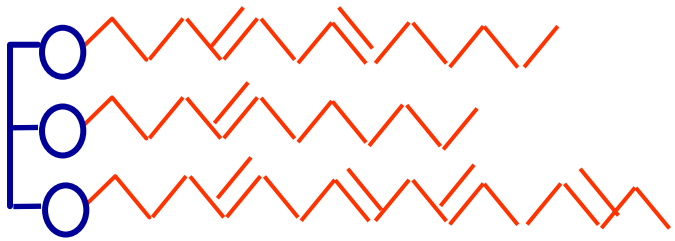
1) Percent total body lipid content was higher in the western population
2) Mean body mass of late lactation male pups was higher in the western population
3) Compared to other otariid species there was no evidence of poor body condition in Steller sea lion pups during the first year of development

Blubber biopsy

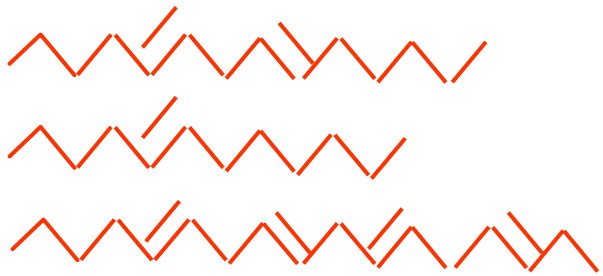


Digestion of Fatty Acids

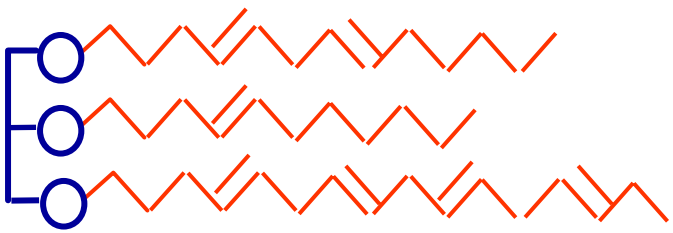
consumed in diet



absorbed



deposited

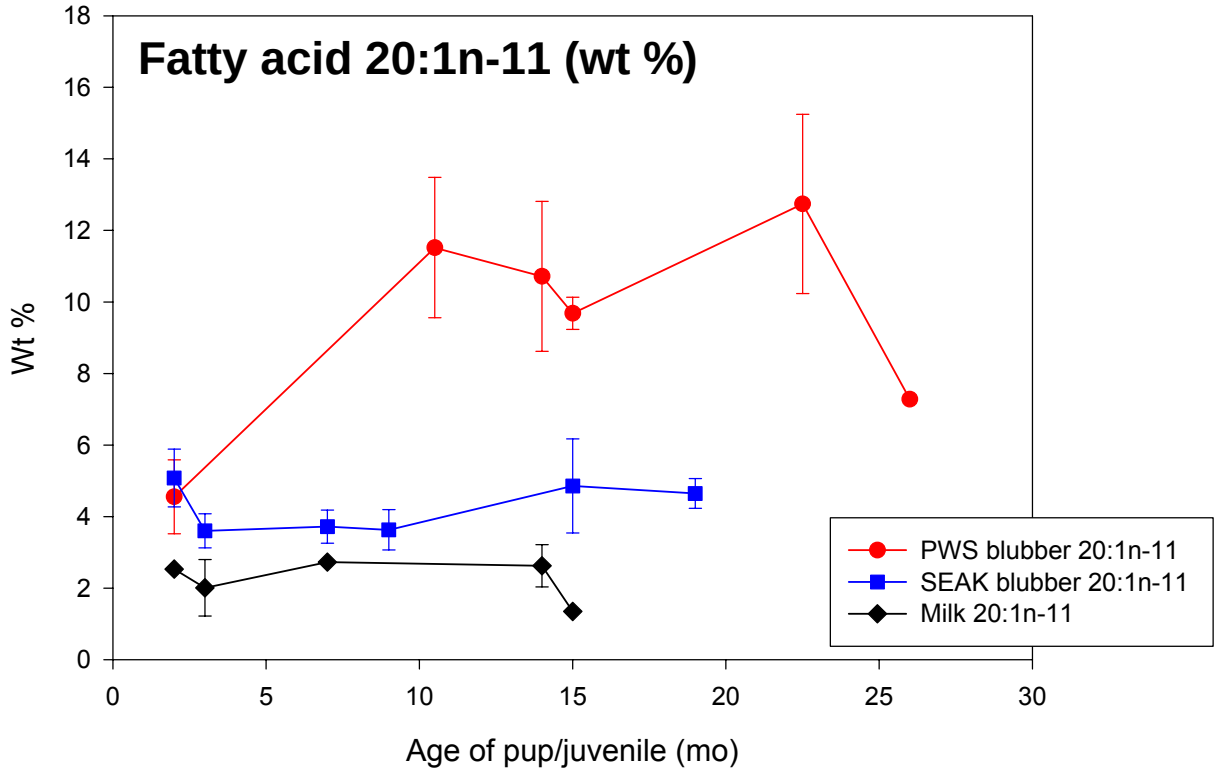


Advantages of Fatty Acid Signature Analysis

~ samples are collected directly from individuals

~ adipose tissue signature represents an integration of diet over a larger time and spatial scale

~ able to detect prey items that do not contain hard parts



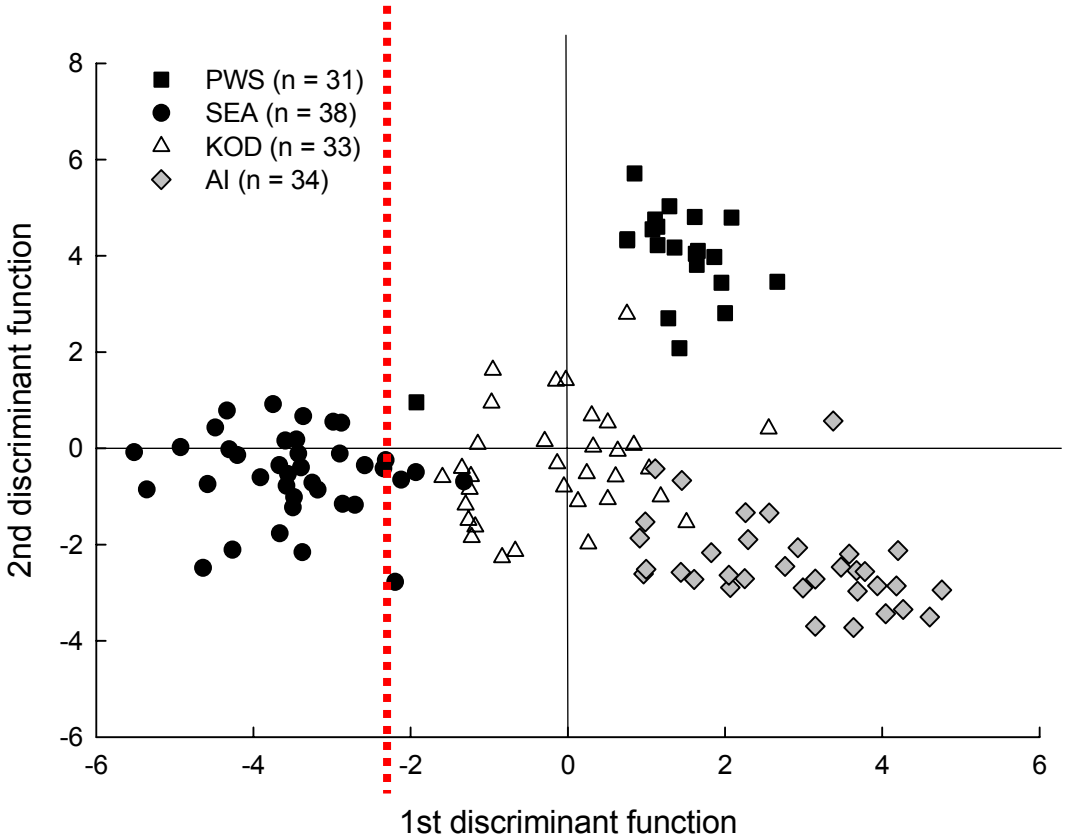
Weight percent (wt %) of 20:1n-11 fatty acids in Steller sea lion blubber and ingested milk samples; represented by age of pup/juvenile at capture.

Table 1. Numbers of sea lions with 20:1n-11 levels (wt %) below and **above prey ingestion** thresholds in Prince William Sound (PWS) and Southeast Alaska (SEAK), Kodiak and the Aleutian Islands.

20:1n-11

Age (mo)	PWS		SEAK		Kodiak		Aleutians	
	< 7wt%	>7wt%	< 7wt%	> 7wt%	< 7wt%	>7wt%	< 7wt%	> 7wt%
2	12		12					
3	4	**2**	13					
7			10					
9			10		26	**2**	10	
11	6	**27**						
14		**13**			5	**2**		
15	3	**7**	19	**1**				
19			4					
23	4	**8**						
26		**1**			7	**1**		
27	1	**4**						

Discriminant function (DFA) plot of blubber fatty acid profiles from spring pups (9-12 months old) in Southeast Alaska, Prince William Sound, Kodiak and the Aleutian Islands.



Beck, C., L. Rea, S. Iverson, J. Kennish, K. Pitcher and B. Fadely. In review. Blubber fatty acid profiles reveal regional, seasonal, sex and age-class differences in the diet of young Steller sea lions in Alaska. MEPS.

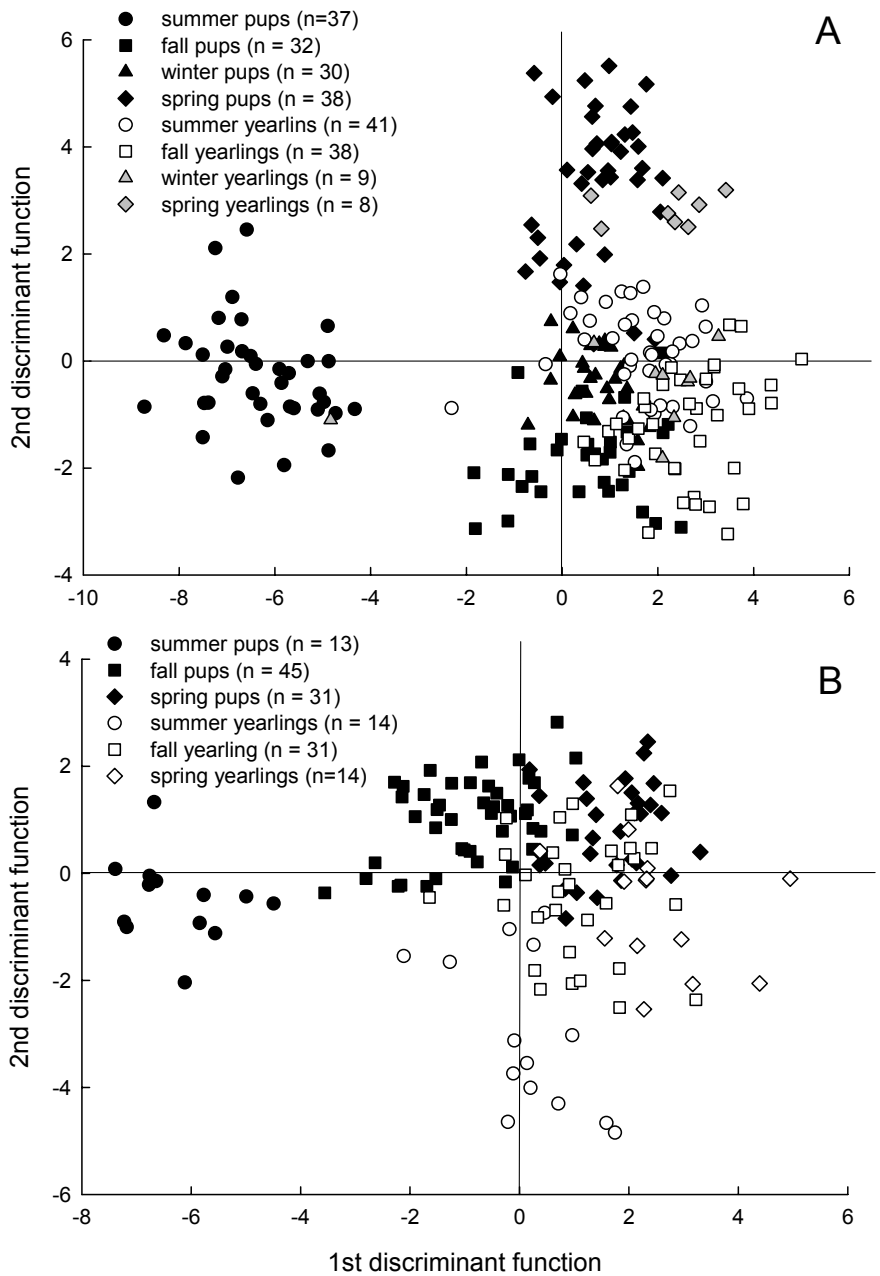
Regional differences in the fatty acids of spring pups

• blubber profiles of spring pups (March-May) differed significantly by region

•spring pups range in age from 9 to 12 months and may have been nutritionally dependent, at least in part, on their mother's milk

•if completely dependent, regional differences in pup blubber FA profiles would be a reflection of regional differences in the FA composition of adult female diets that were passed on to offspring through milk

•if weaned, regional differences in the blubber FA profile of pups may also result from regional differences in prey consumption or in the timing of when pups begin to forage independently



Southeast Alaska

•Summer pups different than all other groups (females move from rookeries to inshore haulouts with pups)

•Seasonal differences same in pups and yearlings

Prince William Sound

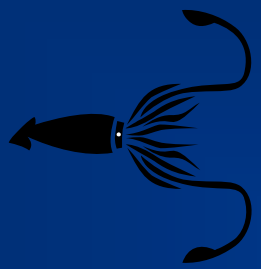
•Seasonal patterns in pups and yearlings different

•Male yearlings ≠ Female yearlings

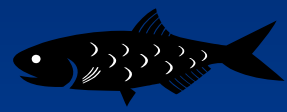
Fatty acids change with age and season

Difference in how fatty acid profiles change with age and with season between Southeast Alaska and Prince William Sound suggest either differences in timing of weaning between areas or shifts in the diet of lactating females, or both.

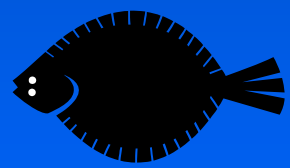
This analysis cannot tell us what species composition of the diet changes, only that the mixture of prey changes.



How does QFASA work?



- determine what mixture of prey fatty acid signatures comes the closest to matching the fatty acid signature of the predator after accounting for the deposition and biosynthesis characteristics of individual fatty acids within the predator

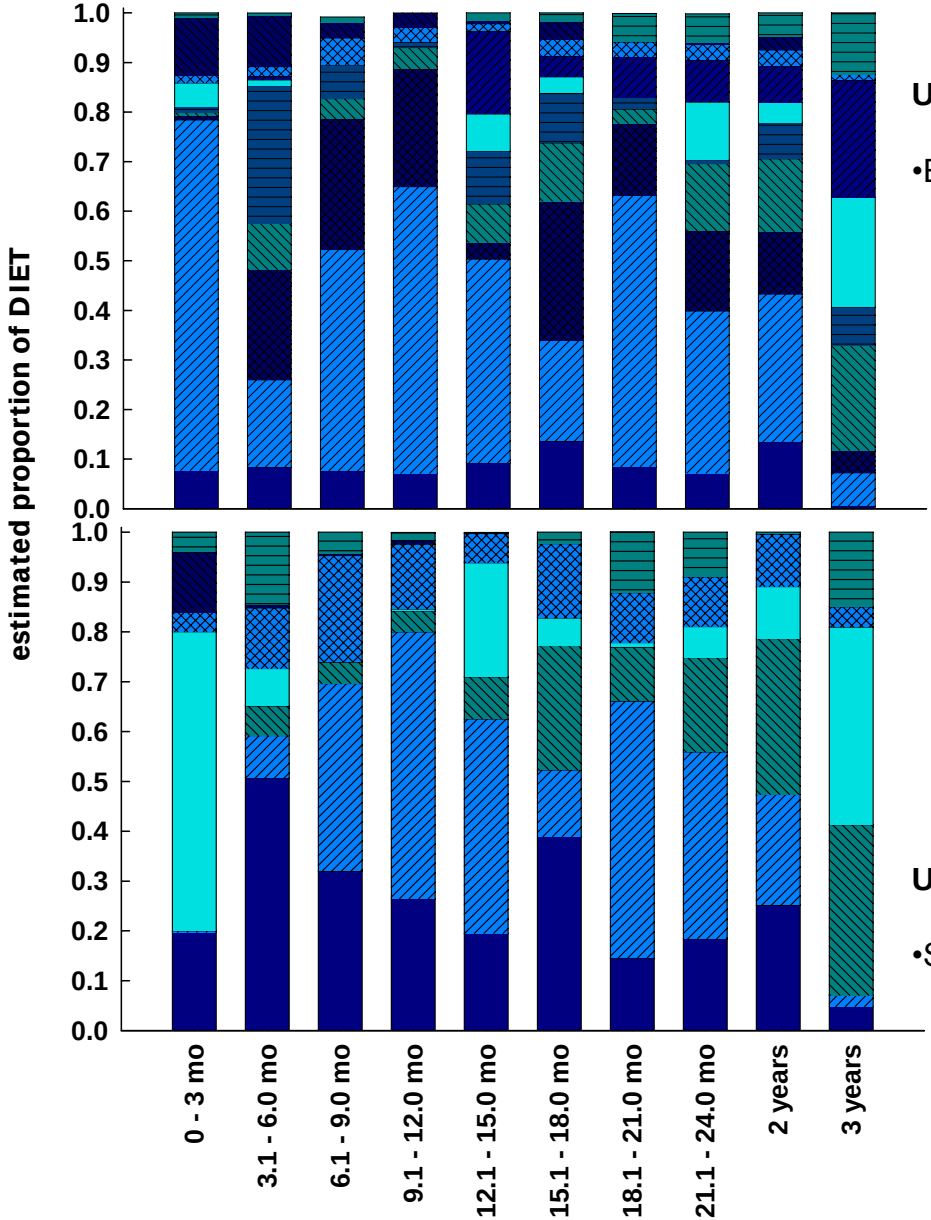


Iverson, S.J., Field, C., Bowen, W.D. and Blanchard, W. Quantitative Fatty Acid Signature Analysis: a new method of estimating predator diets. Ecological Monographs, 2003.

How does QFASA work?

Requirements:

1. Appropriate sampling of predator FAS
2. Database of all potential prey species FAS
    - understanding of prey FA variability
3. Calibration coefficients
    - understand how ingested FAs are metabolized and deposited in the predator
4. A quantitative model
    - distance measure
    - which fatty acids to used in modeling



Using SSL calibrations – captive feeding on herring

•Estimates approximately 8% milk in all animals

Using grey seal pup calibrations – milk intake only

•Significant negative correlation of milk intake with age

Modeling diet with fatty acids

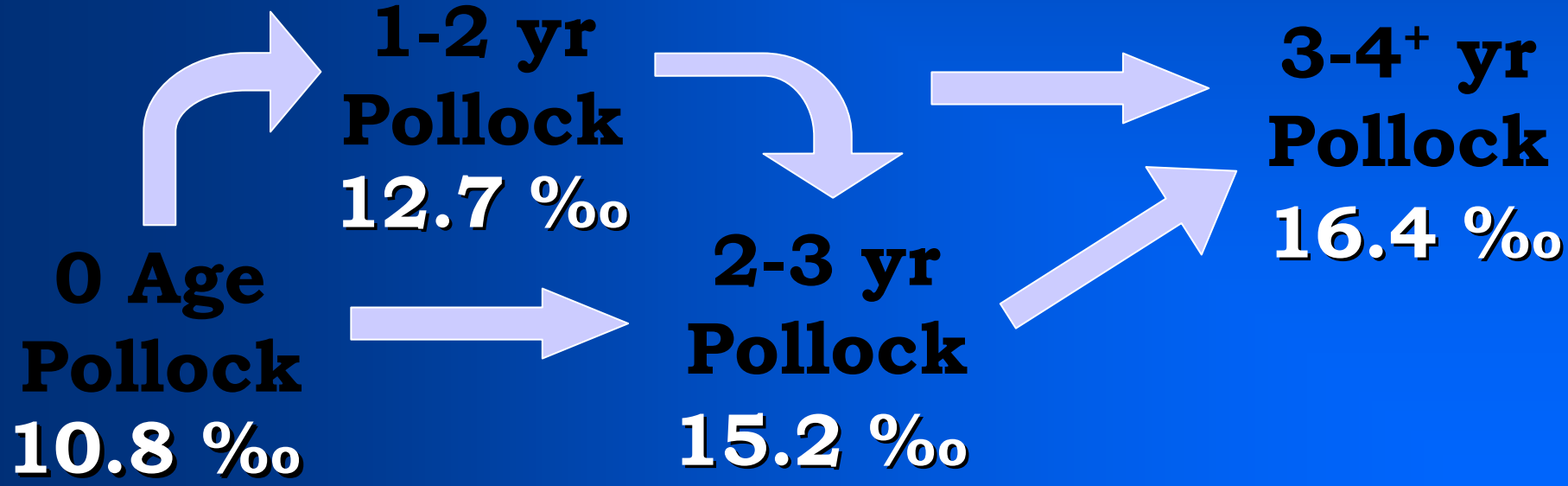
- It is not yet possible to model the species composition of the diet reliably

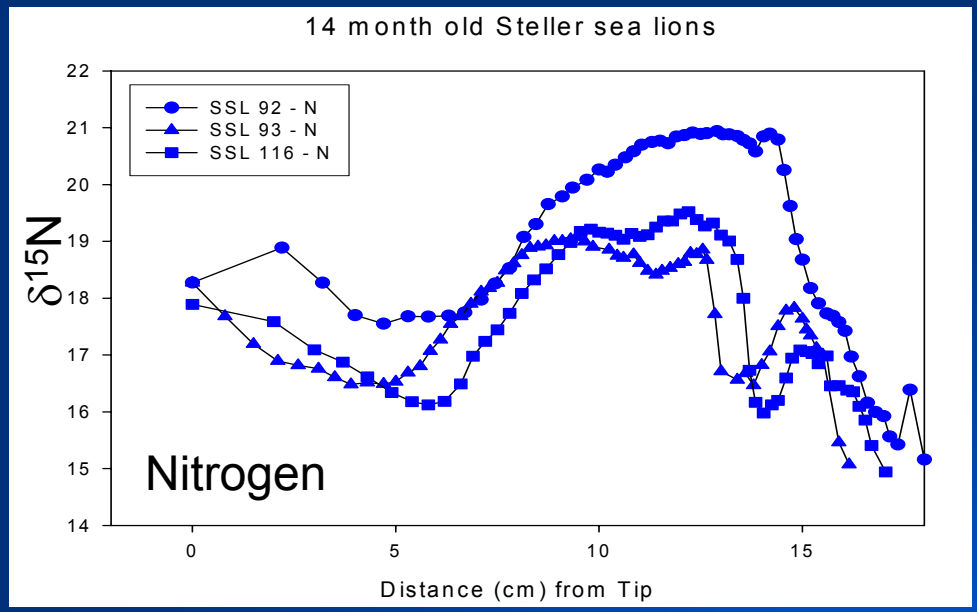
- Lack appropriate calibration coefficients for the modeling exercise

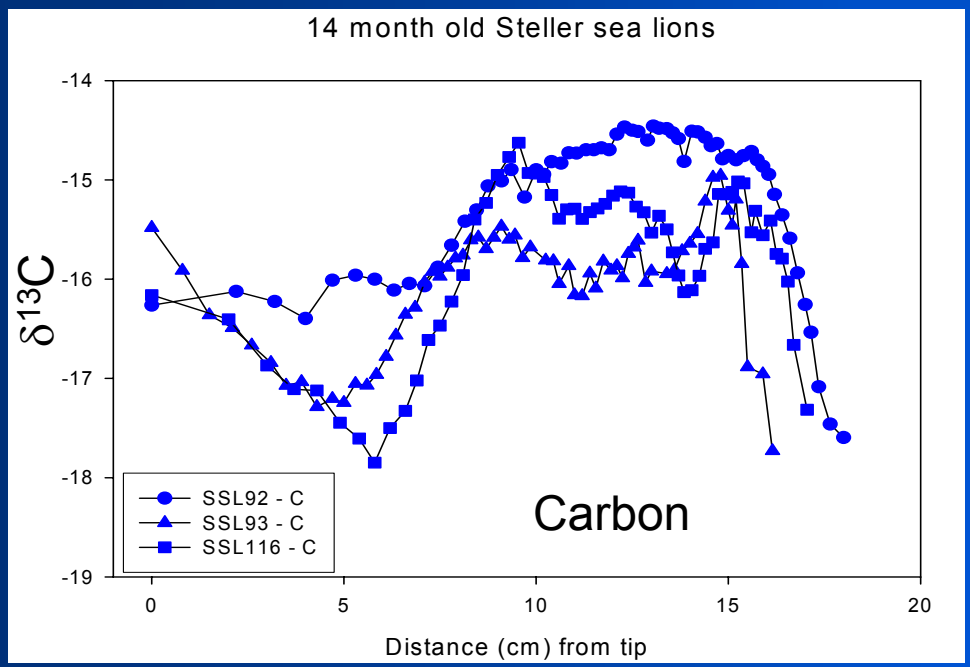
How do Isotopes Work?

Nitrogen Ratios:

The ratios of heavy (^{15}N) to light (^{14}N) isotopes in tissues increase by ~3‰ with each successive trophic level.







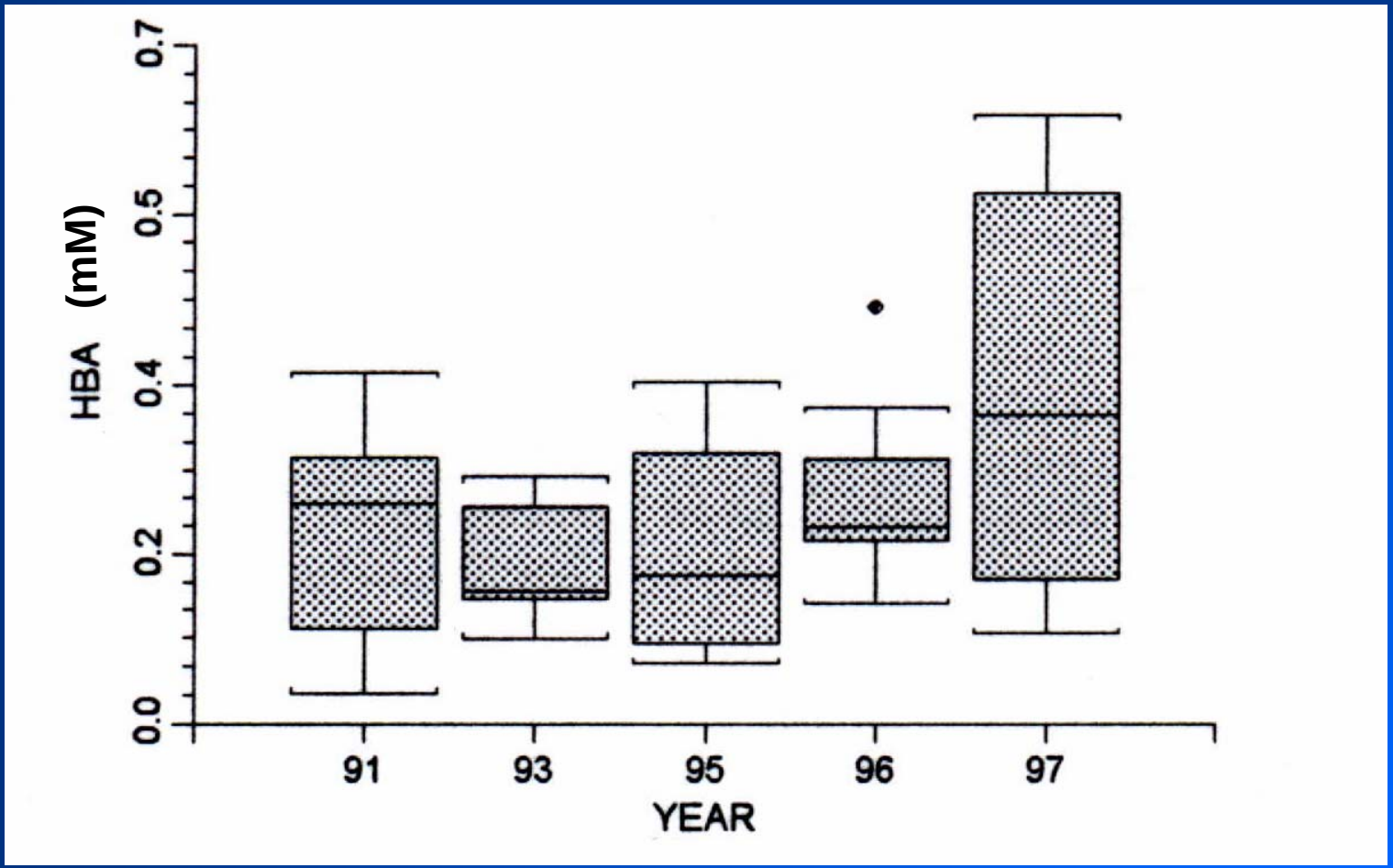
δ13C and δ15N values increased slowly during the nursing period (2.0‰ and 2.9 ‰ respectively) while pups were ingesting low protein content milk.

Peak δ15N values of 20.0 ± 0.1‰ in the vibrissae represent an equilibrium nursing signature that is one trophic level higher than the mean δ15N value of milk (15.3 ± 1.1‰).

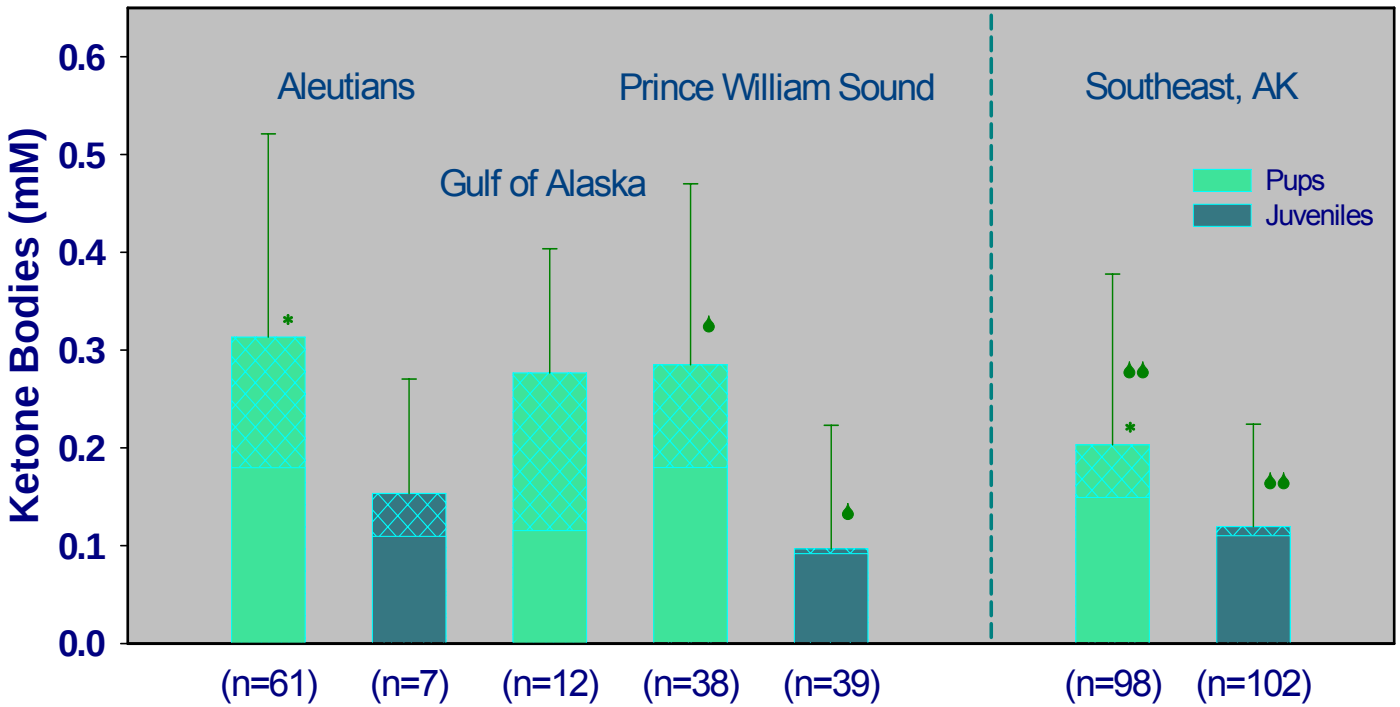
In juveniles (14 to 27 months) from both populations peak δ15N values were followed by decreases of 2.3 to 5.0‰, indicative of independent foraging.

This decrease following peak nursing values provides a biochemical marker of weaning.

Ugamak Island - ketone bodies

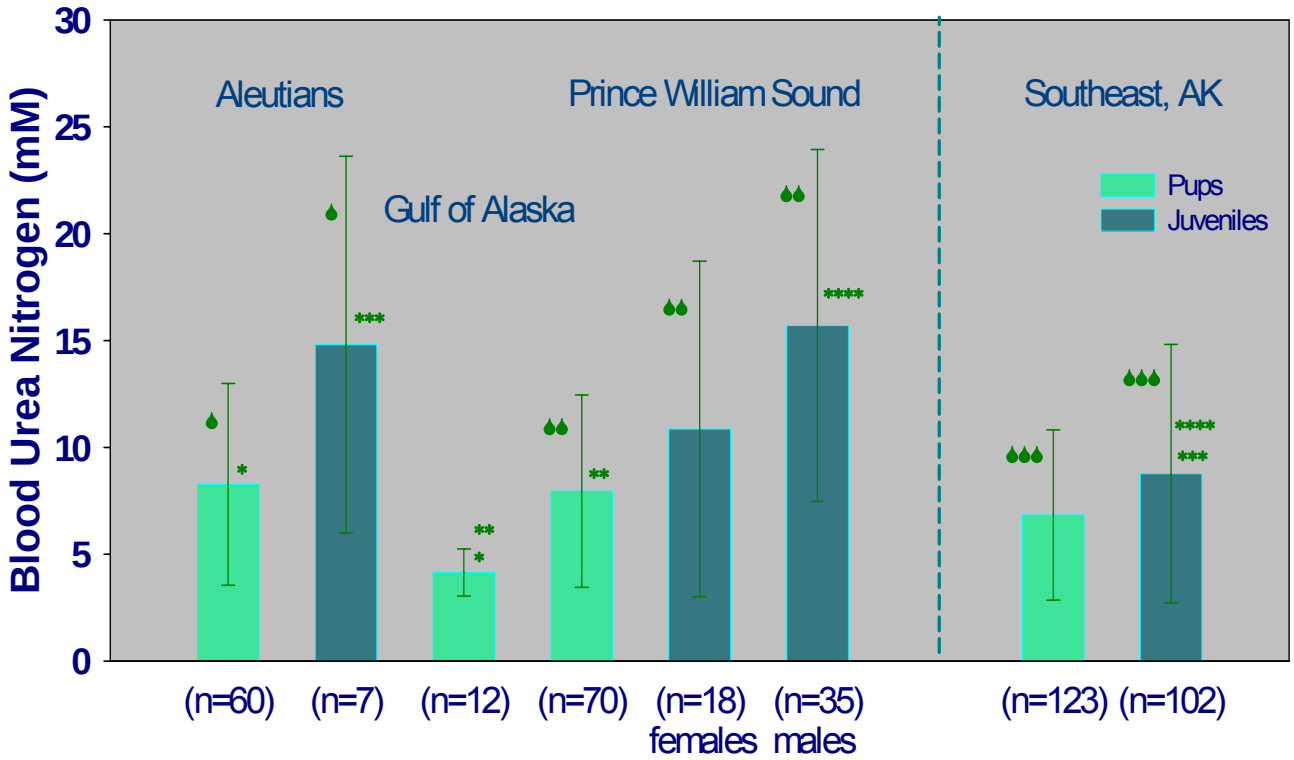


Mean [HBA] by Region and Age



Mean ketone body concentrations ± s.d. by age class and region. Significant difference at $p<0.01$ by region(*) or by age class (S). Cross hatched areas indicate % individuals with [HBA] greater than fasting threshold (0.30 mM).

Mean [BUN] by Region and Age



Mean BUN concentrations ± s.d. by age class and region. Significant difference at $p<0.01$ by region (*) or by age class (S) unless otherwise indicated below.

No evidence of starvation in the western stock

- While ketone body (HBA) results suggest a slightly higher proportion of western stock pups were fasting, there is no evidence of elevated BUN to indicate longer than expected maternal foraging trips.

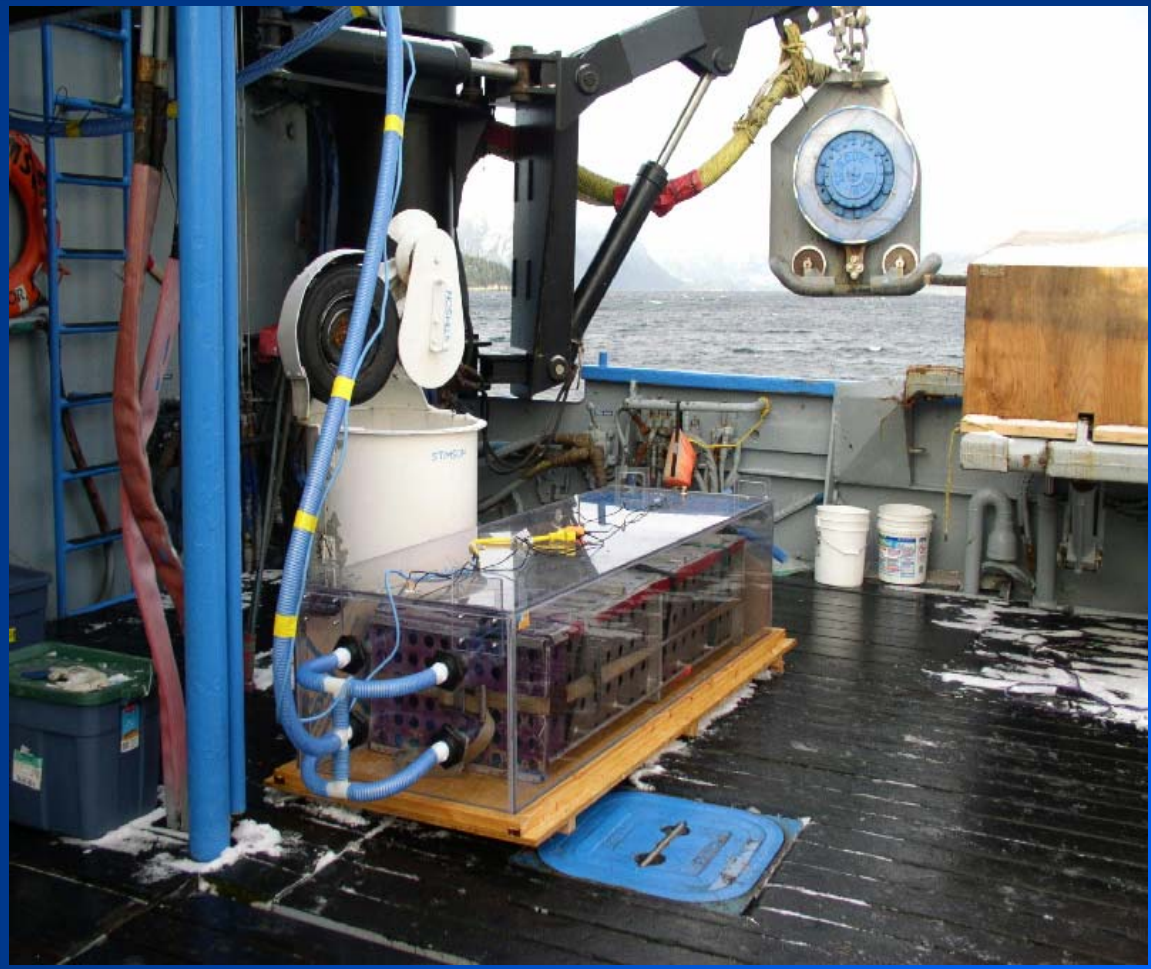
- Plasma BUN concentrations in juveniles were significantly higher than pups, consistent with a diet higher in protein from fish compared with milk from suckling.

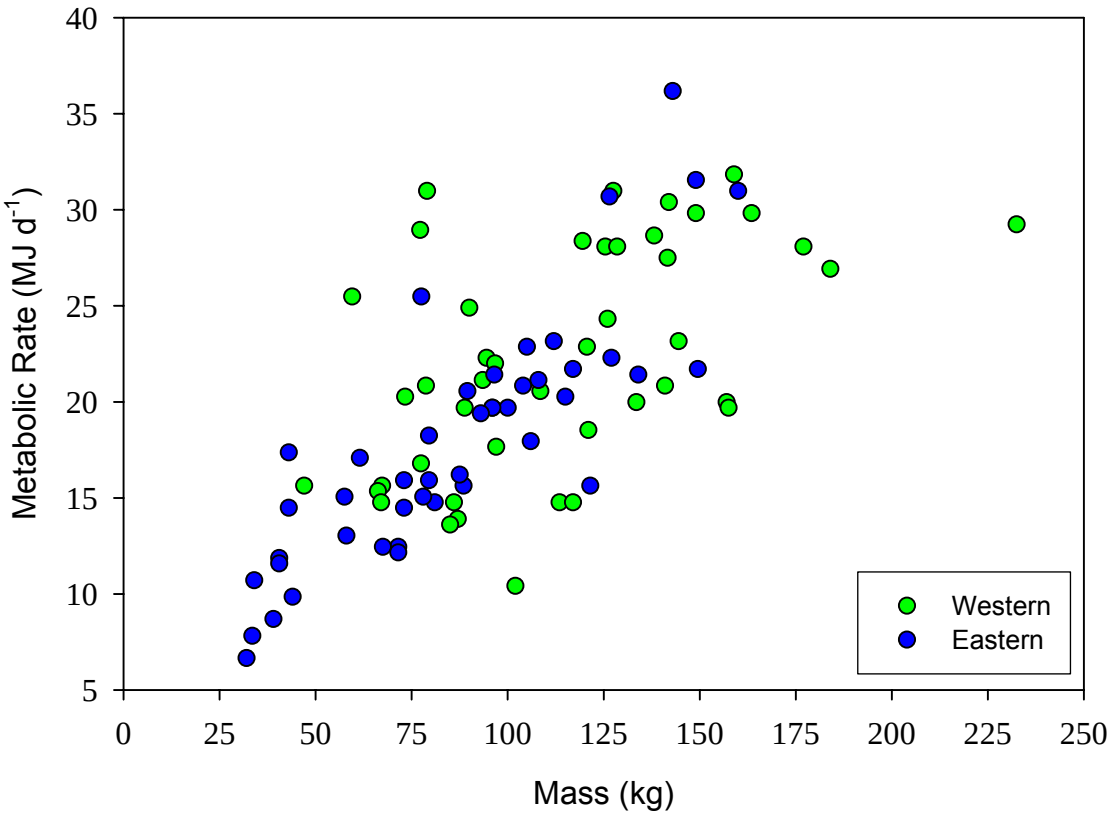
- Lower BUN concentrations in **SEA** juveniles may be due to lower dietary protein intake which may be coincidental with some behavioral evidence that SSL juveniles nurse into their second year in **SEA**.

Metabolic depression

- Steller sea lions decrease their metabolic rate (oxygen consumption) by 15 – 24% when fed a diet that was low in energy over a 2 week period

- Measured metabolic rate of 93 free-ranging SSL (2 to 44 months of age) in eastern and western populations to determine if there was any evidence of metabolic depression in either stock





Metabolic rate (MJ d^{-1}) as a function of body mass (kg) for Steller sea lions captured in eastern (blue) and western (green) Alaska. No differences in metabolic rate (oxygen consumption) were observed between sea lions sampled from eastern and western populations.

No evidence of metabolic depression

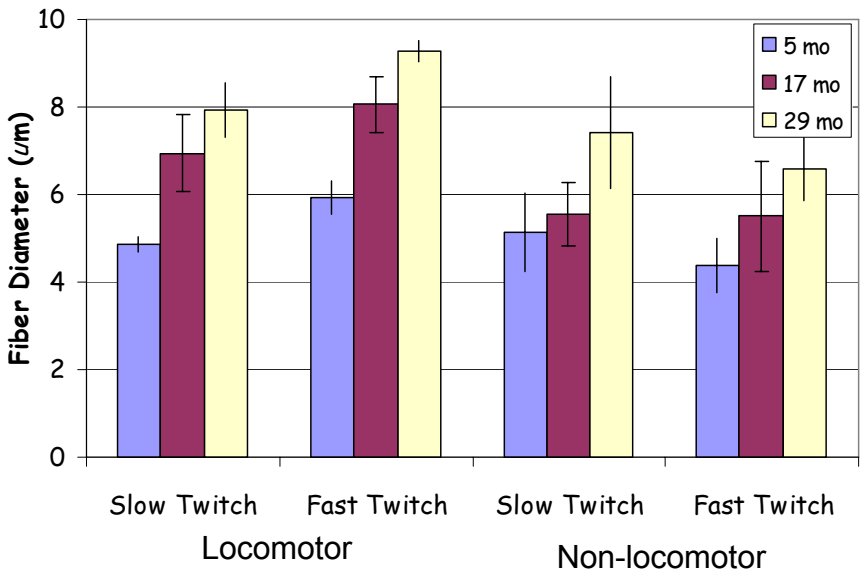
- Rates of oxygen consumption were comparable to values measured in other species of sea lions

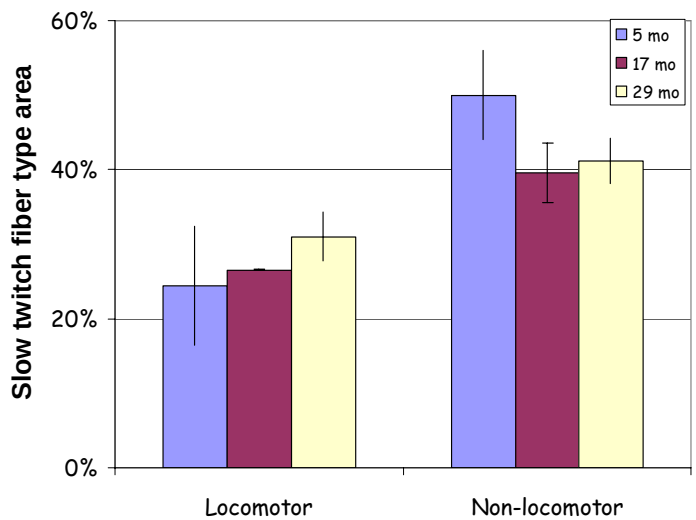
- No differences in the rate of oxygen consumption were detected between the eastern and western populations

Development of muscle morphology

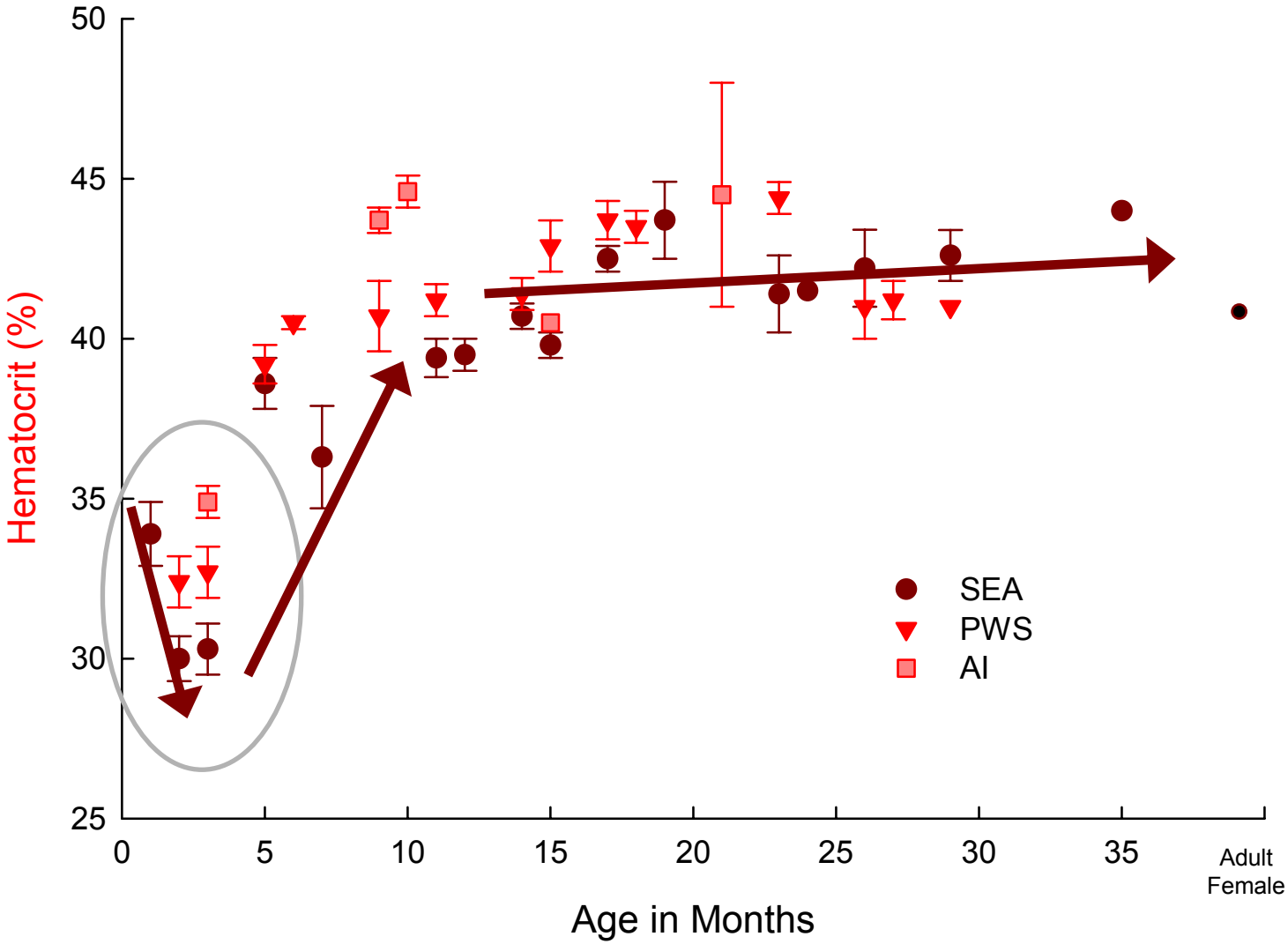
During starvation or chronic undernutrition muscle morphology is impacted; fiber diameters are decreased, and the proportion of fast and slow twitch fibers is altered. These factors also change with age.

Step 1. determine pattern of muscle development in eastern stock SSL
Step 2. compare patterns of muscle development between eastern and western stock juvenile SSL





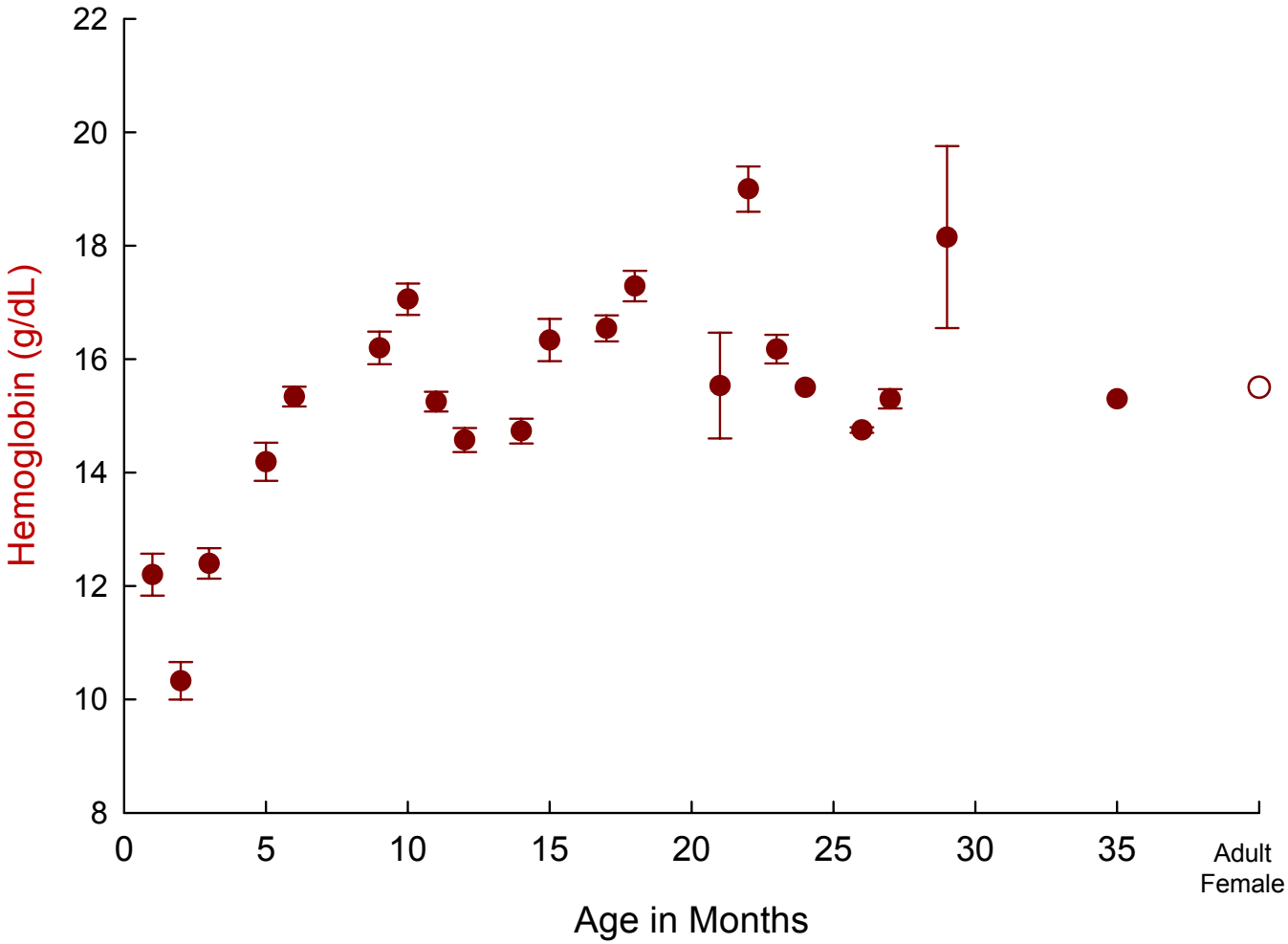
Average Hematocrit Change with Age by Population



Mean adult female hematocrit value shown for comparison from Castellini et al. 1996

Richmond et al., 2005. Gen Comp Endo 141:240-47

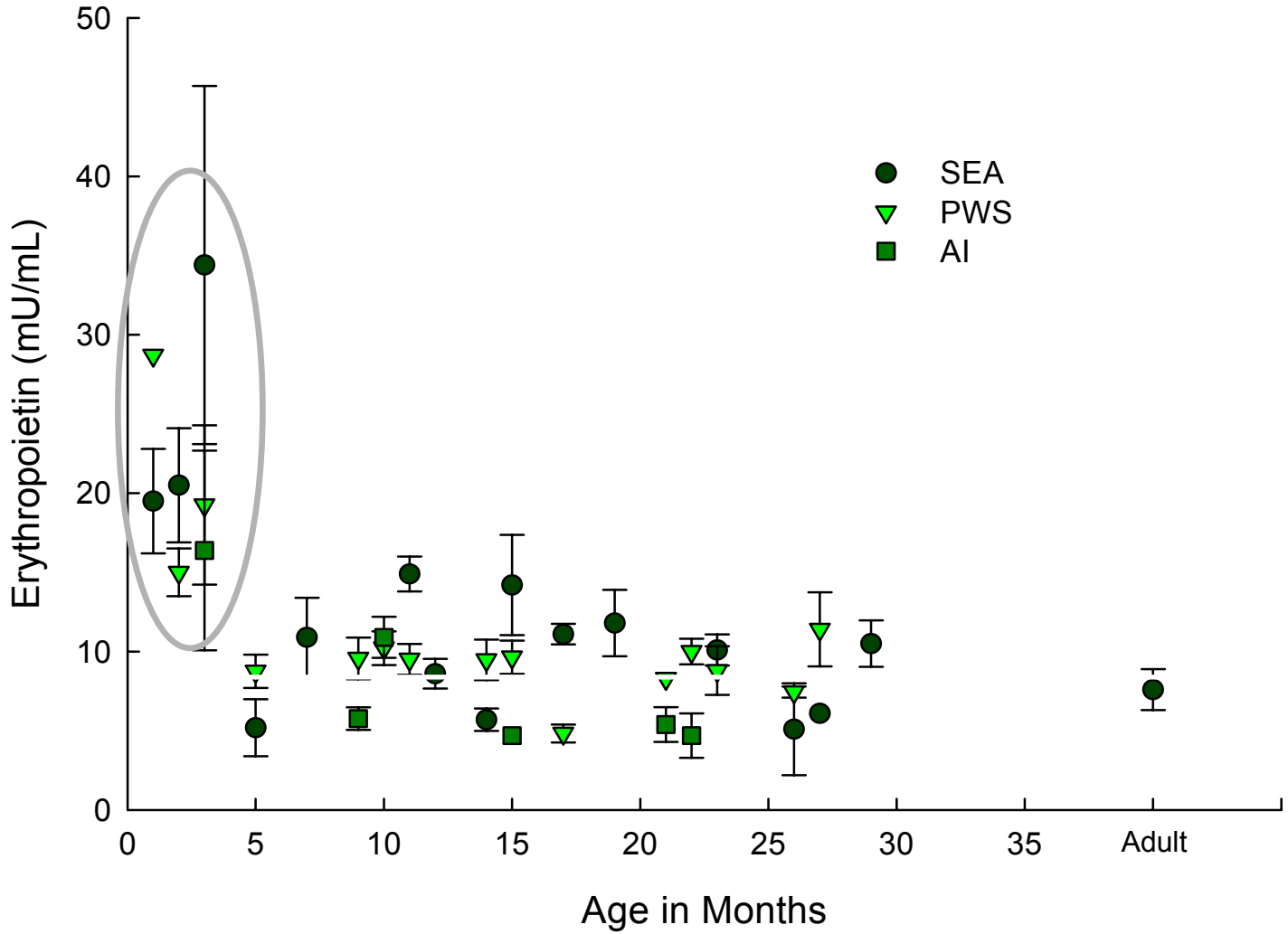
Average Hemoglobin Change with Age



Adult female hemoglobin values from Castellini et al. unpublished shown for comparison

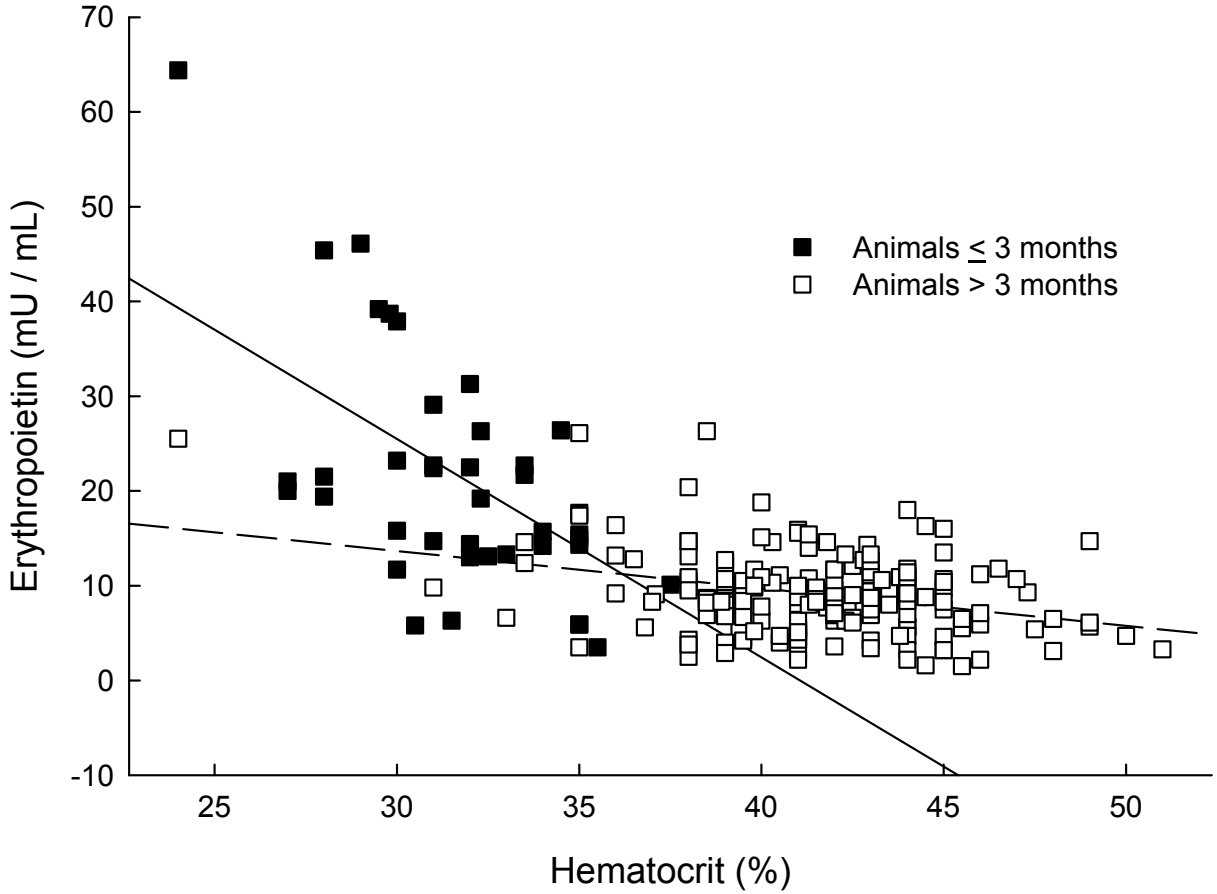
Richmond et al., 2005. Gen Comp Endo 141:240-47

Average Concentration of EPO by Age



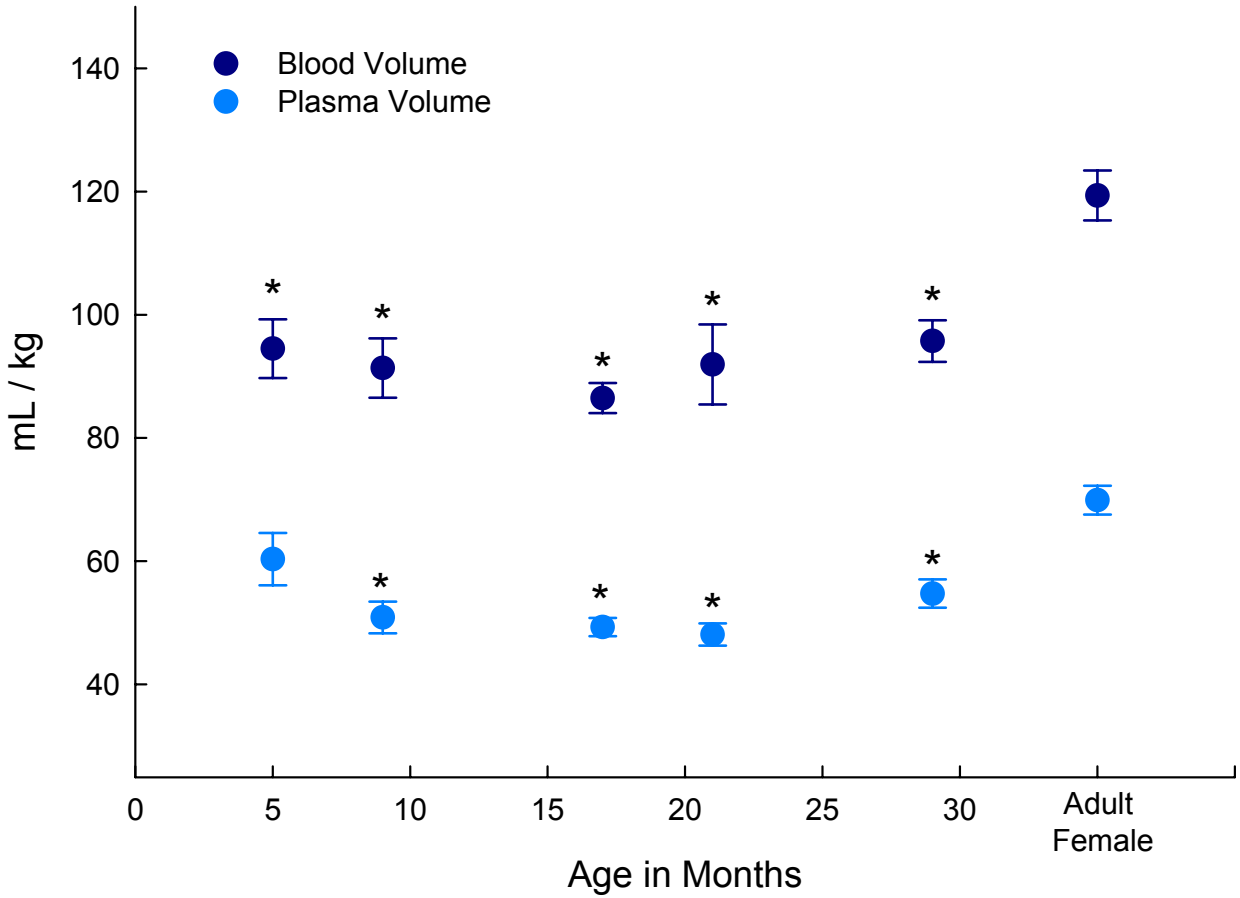
Richmond et al., 2005. Gen Comp Endo 141:240-47

EPO & Hematocrit



Richmond et al., 2005. Gen Comp Endo 141:240-47

Average Blood & Plasma Volume Change with Age

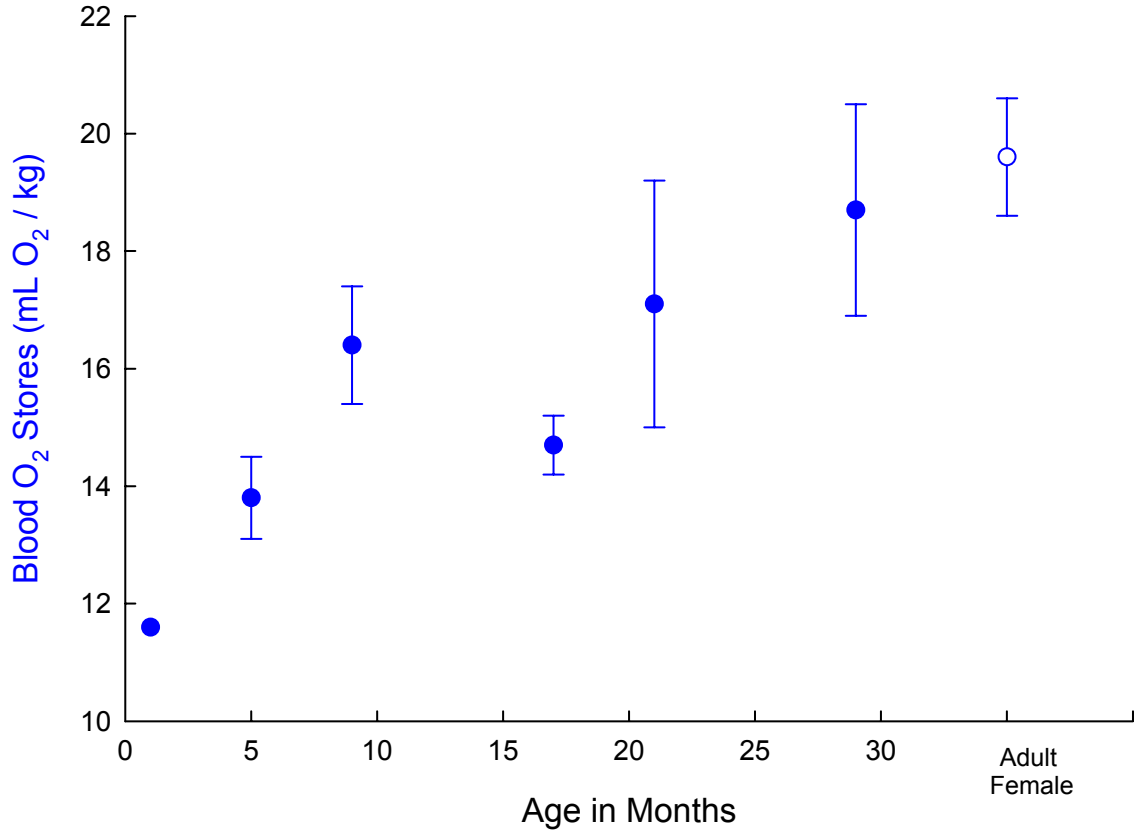


Adult female BV values provided by Castellini et al. unpublished

Richmond et al., 2006. J Comp Physiol B

Blood Oxygen Stores

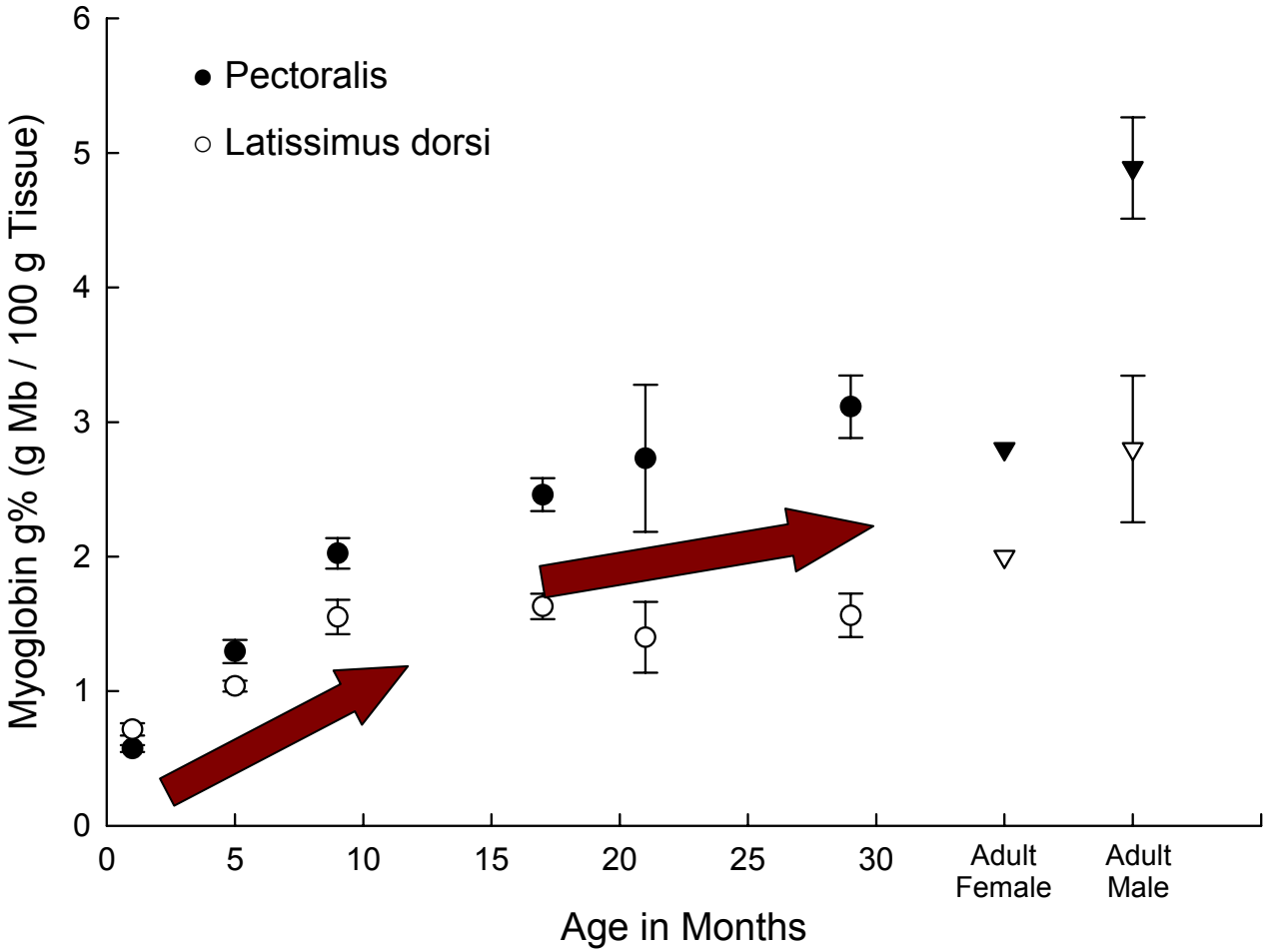
- Hematocrit
- Hemoglobin
- Plasma Volume



Adult female values provided by Castellini et al. unpublished

Richmond et al., 2006. J Comp Physiol B

Average Myoglobin Concentration



* Average adult female values from Kanatous *et al*. 1999 shown for comparison

Richmond et al., 2006. J Comp Physiol B

Development of oxygen carrying capacity (a.k.a. the physiological ability to dive)

•Hematology values similar to adults are reached by 5 months of age (through influence of EPO).

•Rapid development of muscle myoglobin during year 1, but development slowed during year 2, and did not reach adult levels within first 2 years.

•Both muscle myoglobin and enzyme profiles indicate that juvenile SSL muscle is very different from adult. Young animals have lower Mb concentrations and lack differentiation in Mb and enzyme activities. In adults swimming vs non-swimming muscles are distinct.

•**Overall reduced aerobic capacity may limit a juvenile's ability to forage efficiently.**

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-- deploy 30 TDR and 15 satellite transmitters during fall, recaptures in spring with diet and condition assessments


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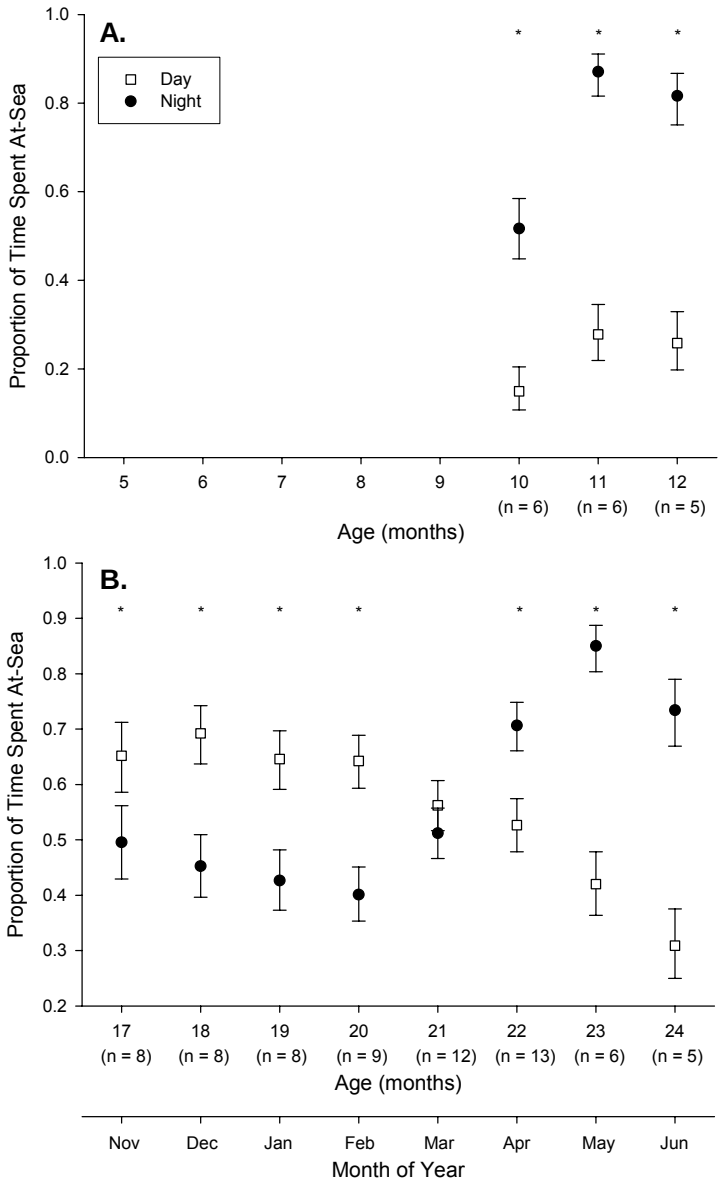
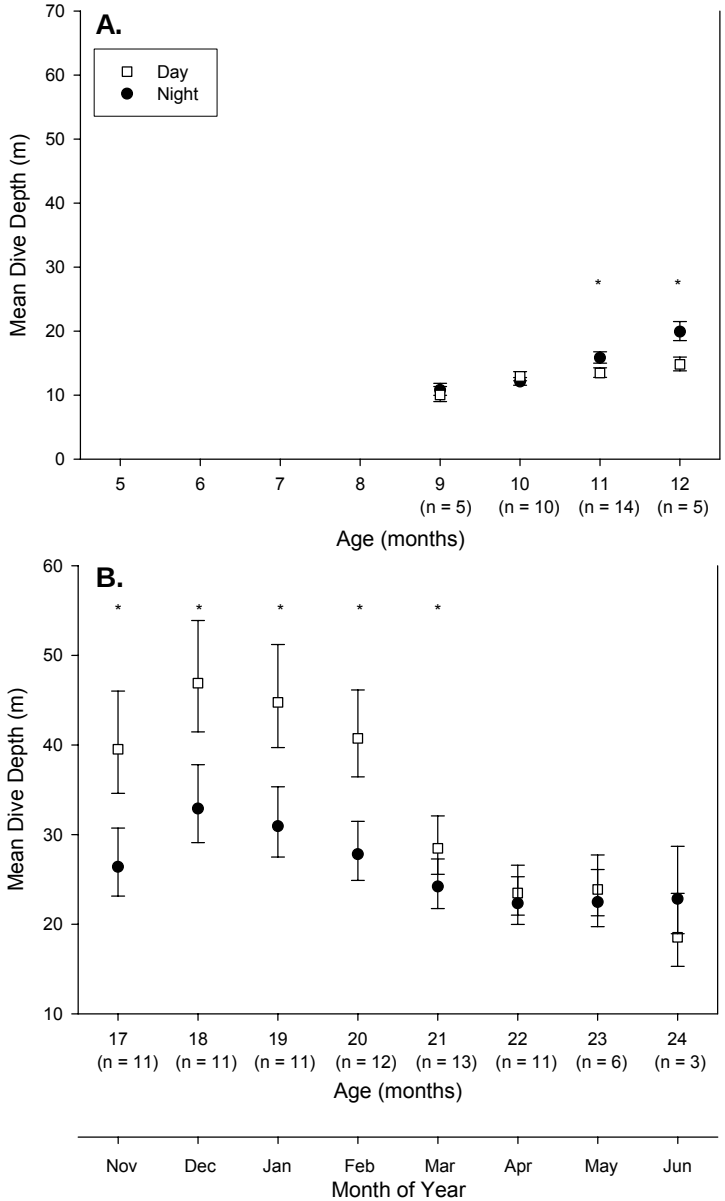


Juveniles shift timing of at-sea behavior with change in season in western stock

Proportion of time at sea increases with age in pups (ontogeny of diving ability or onset of independent foraging), but time at sea changes seasonally in juveniles (possibly in response to seasonal changes in the prey field).

Rehberg, M. 2006. Pattern matters: changes in the swimming and diving behavior of Steller sea lion juveniles. M.S. thesis, UAA



Juveniles shift from diurnal dive depth contrast in winter to no difference by time-of-day in spring

•Pups are increasing mean dive depth with age.

•Juveniles are acting like predators who are switching from a vertically migrating prey in the winter (deeper diving and longer and more time spent at sea during the day) to seasonal breeding aggregations of prey which do not vertically migrate (ie. salmon, herring, eulachon).

Rehberg, M. 2006. Pattern matters: changes in the swimming and diving behavior of Steller sea lion juveniles. M.S. thesis, UAA

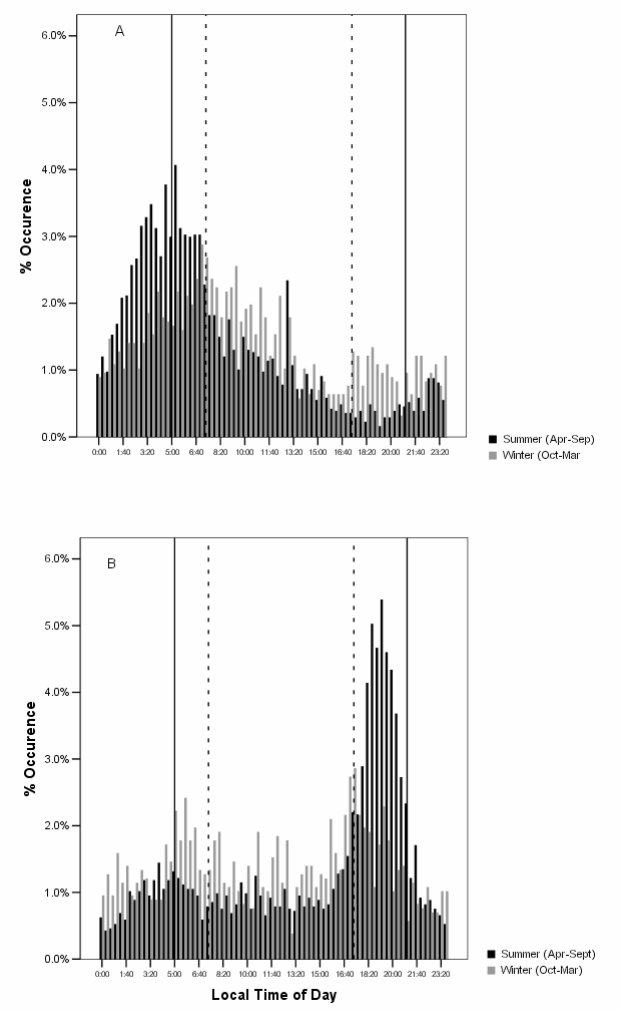
Regional Difference in Diurnal Arrival/Departure Timing at Haulouts

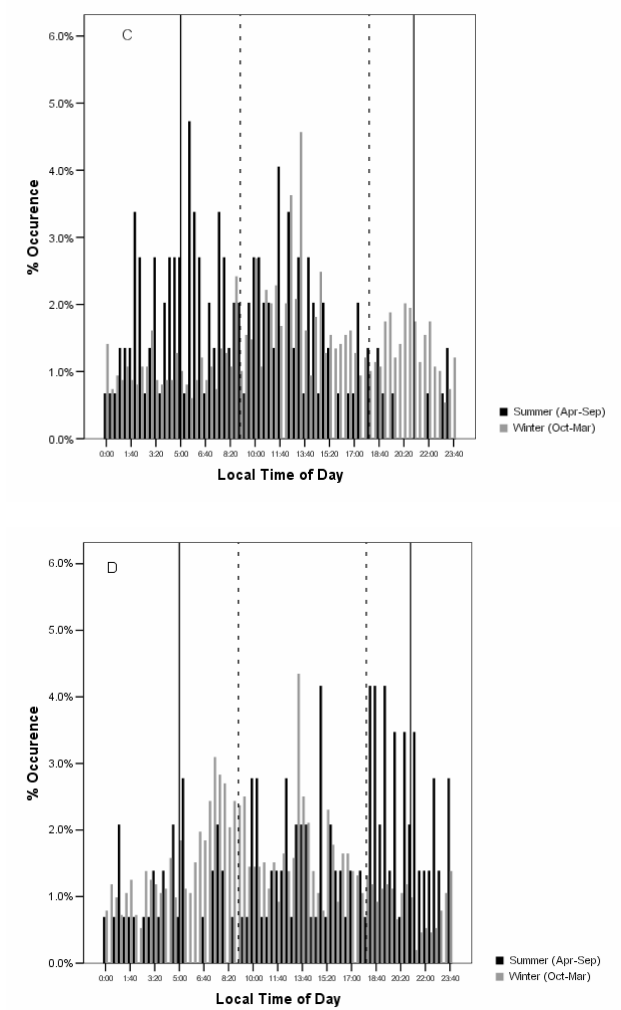
Central Aleutian Islands

Prince William Sound

Arrival time at haulout

Departure time from haulout





Call et al. Accepted. At-sea and on-shore cycles of juvenile Steller sea lions(Eumetopias jubatus) derived from satellite data recorders: a comparison between declining and increasing populations. Deep Sea Research

Regional Difference in Diurnal Arrival and Departure Timing at Haulouts

- strong pattern of early morning arrivals and early evening departures in Aleutians and Kodiak, accompanied by shallow diving
- may be targeting vertically migrating prey that go deeper in daylight (e.g. walleye pollock)

- arrival and departure times in PWS or SEA not related to sunrise or sunset
- suggests different prey, different environmental factors or regional differences in the age of onset of independent foraging

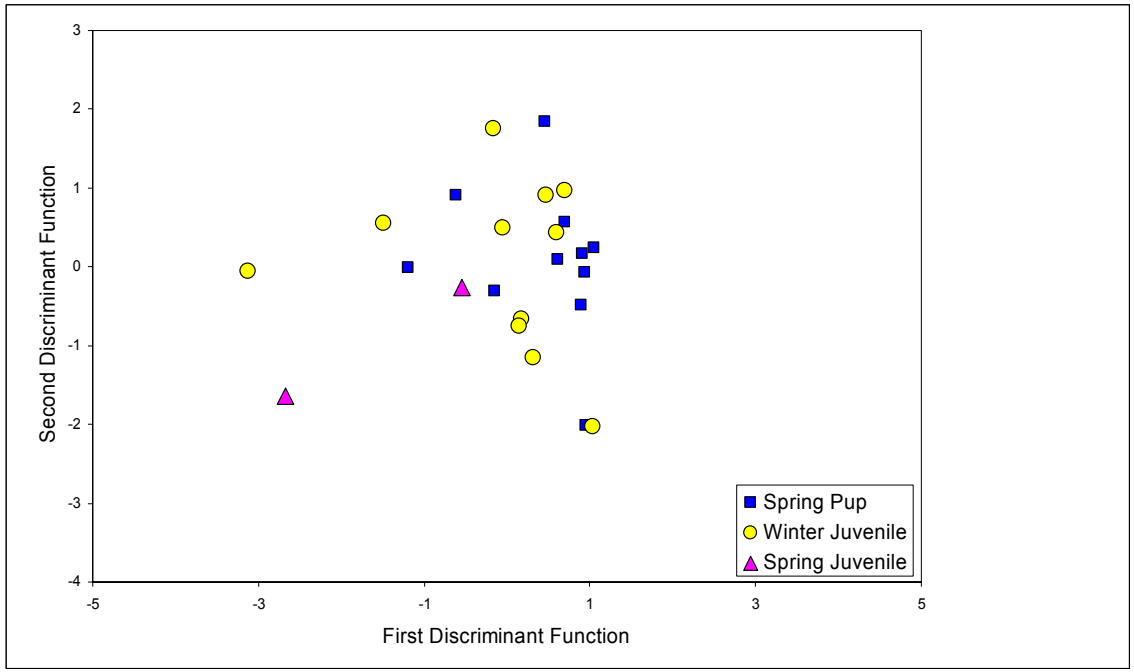
Call et al. Accepted. At-sea and on-shore cycles of juvenile Steller sea lions(Eumetopias jubatus) derived from satellite data recorders: a comparison between declining and increasing populations. Deep Sea Research

Organization of diving behavior distinguishes pup from juvenile

- Attempt to classify individual SSL juvenile behavior in western stock using the organization of their behavior
- n=32, deployed 2001 to 2005
- consider behavior at 3 scales: where time is spent in individual dives (dive shape), how grouped into bouts of similar diving, and how diving is allocated among trips-to-sea
- The foraging predator should be expected to organize its behavior into dives that maximize bottom-time in contact with submerged prey patches, and that concentrate at-sea diving activity over prey patches.
- Juveniles can be distinguished from pups only when this organization of behavior is considered simultaneously with simple measures of magnitude such as dive depth or duration
- Caution: depth and duration also can distinguish between juveniles from different regions – indicates danger of using depth and duration alone to infer foraging (regional prey type likely influence depth and duration)

Rehberg, M. 2006. Pattern matters: changes in the swimming and diving behavior of Steller sea lion juveniles. M.S. thesis, UAA

Differences Among Individuals



Assignment Accuracy = 63 %

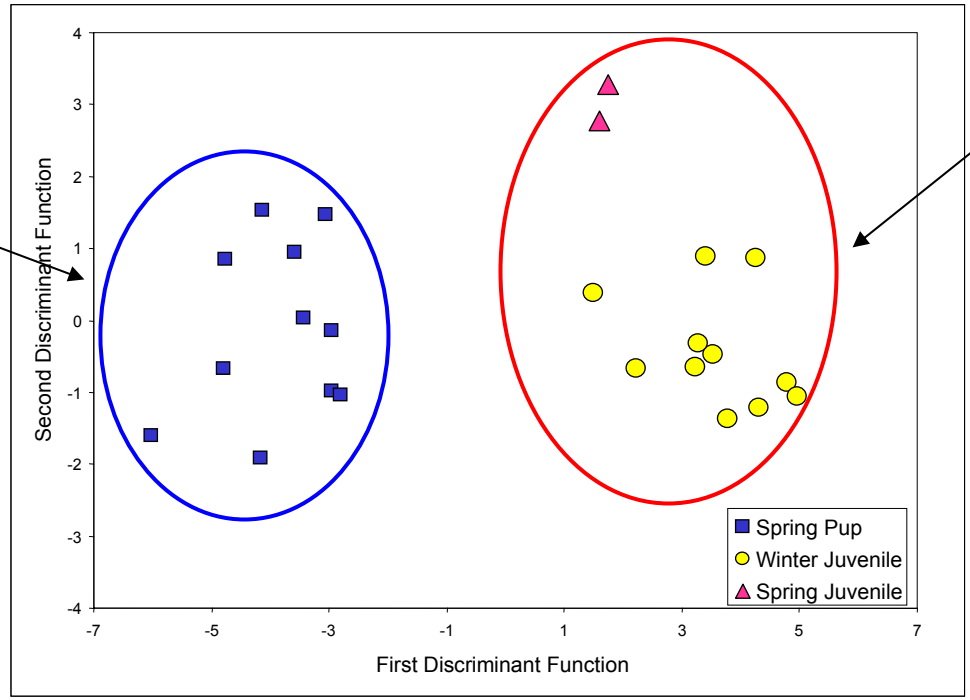
Using characteristics of temporal organization alone:

Proportions of:

- dive bout types *
- square-shaped dives
- dives within bouts
- time-at-sea within bouts
- trip types

Rehberg, M. 2006. Pattern matters: changes in the swimming and diving behavior of Steller sea lion juveniles. M.S. thesis, UAA

Differences Among Individuals



Using characteristics of diving behavior *at appropriate scale of organization*:

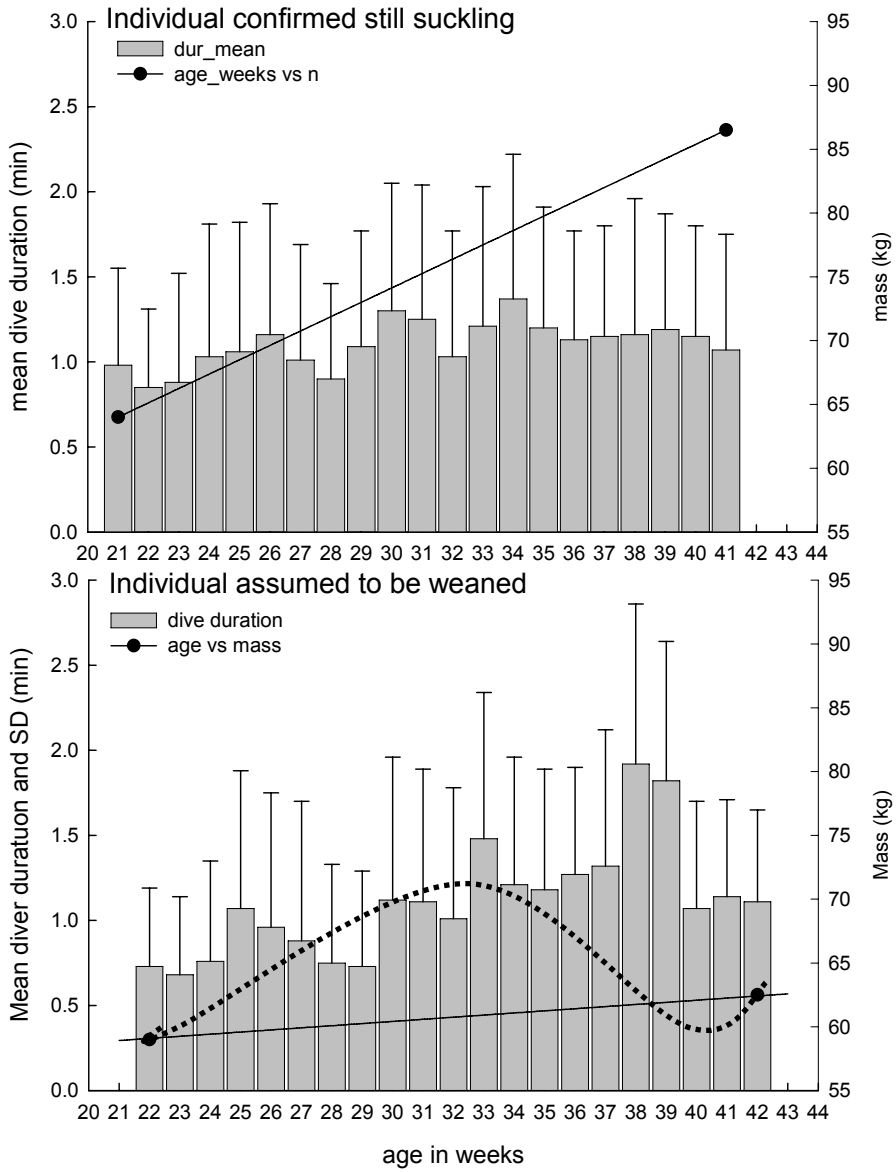
Mean:

- dive depth *
- dive duration *
- post-dive surface interval

Proportions of:

- dive bout types *
- square-shaped dives
- dives within bouts
- time-at-sea within bouts
- trip types

Rehberg, M. 2006. Pattern matters: changes in the swimming and diving behavior of Steller sea lion juveniles. M.S. thesis, UAA



Ontogeny of foraging

- Nov 2005 – 30 5-month old pups instrumented (TDR) and physiology assessment
- Mar/Apr 2006 – 14 9.5-month old pups recaptured – physiology assessment and matching fine scale dive records for 8 animals
- 4 of 8 seen suckling in Apr 2006 gained 18.8 ± 4.2 kg
- 4 of 8 not seen suckling gained 3.5, 6.5, 10 and 32 kg respectively

- Analysis of dive behavior underway to compare difference in activity between known dependent animals and those not seen nursing at recapture
- Physiological ‘result’ of different diving patterns

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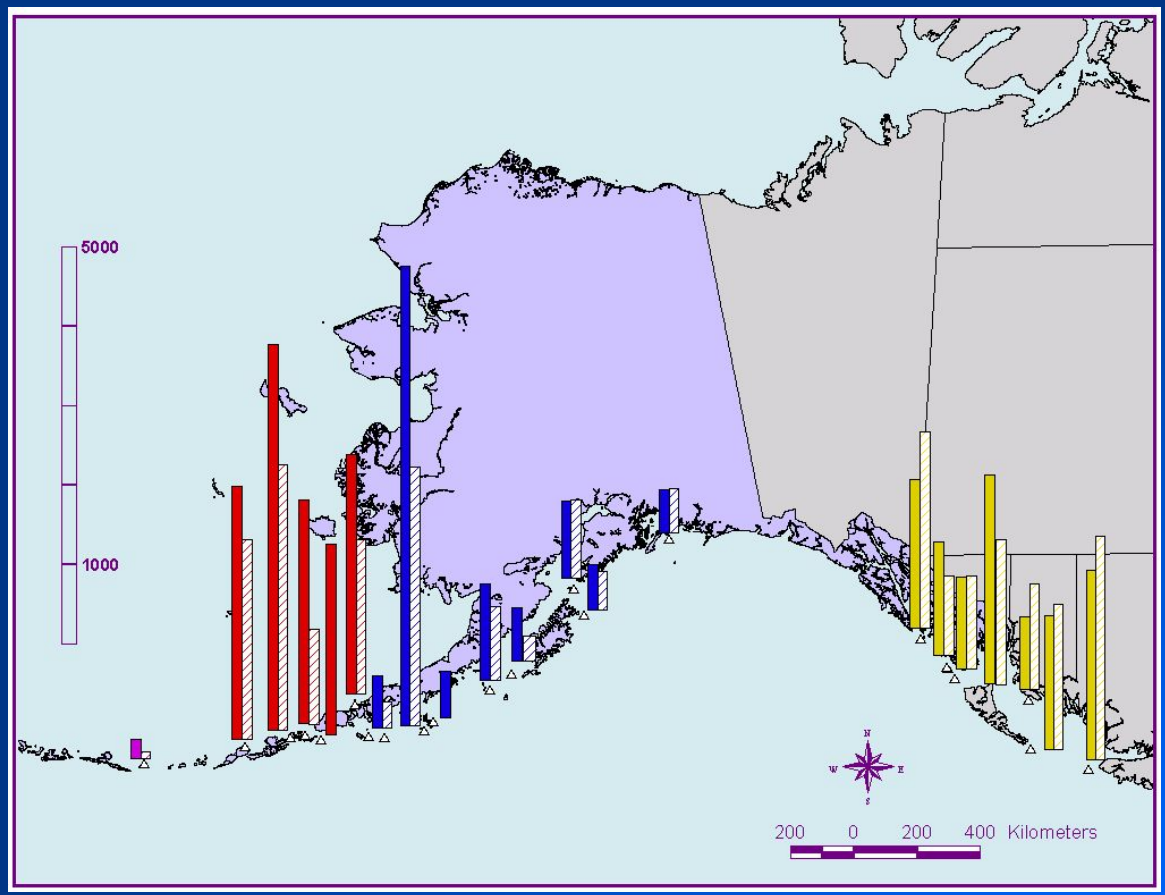
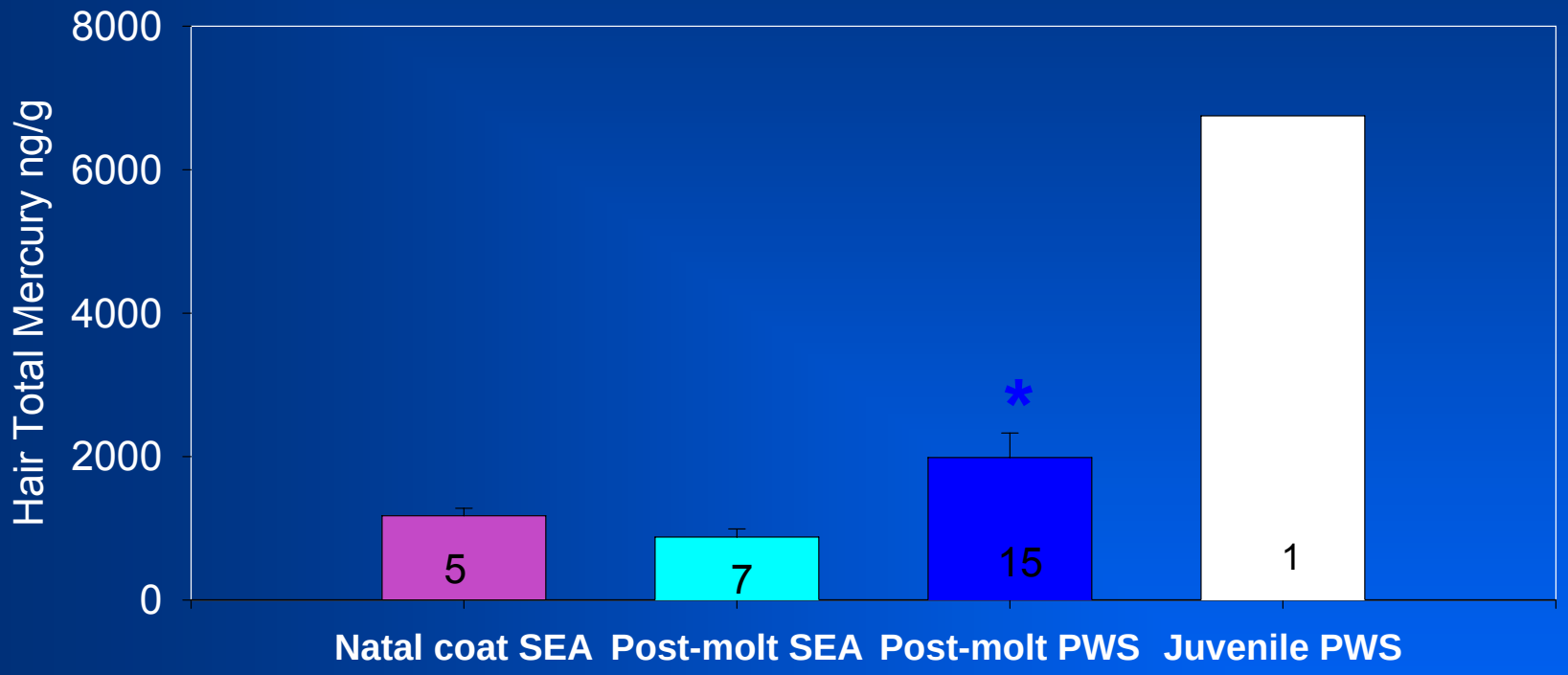
PCB concentrations ng/g l.w. & DDT (striped bars) in SSL scats, 1998-2001



Far ranging environmental contamination in SSL that varies on a finer regional scale than just eastern and western stock

Beckmen, K., K. Pitcher, K. Burek, and G. Ylitalo In revision. Organochlorine contaminant concentrations in scats collected on Steller sea lion (*Eumetopias jubatus*) rookeries. Archives of Environmental Contamination and Toxicology.

Total mercury (ng/g) in hair of SSL pups and a juvenile in Southeast AK ('98) or Prince William Sound ('00)



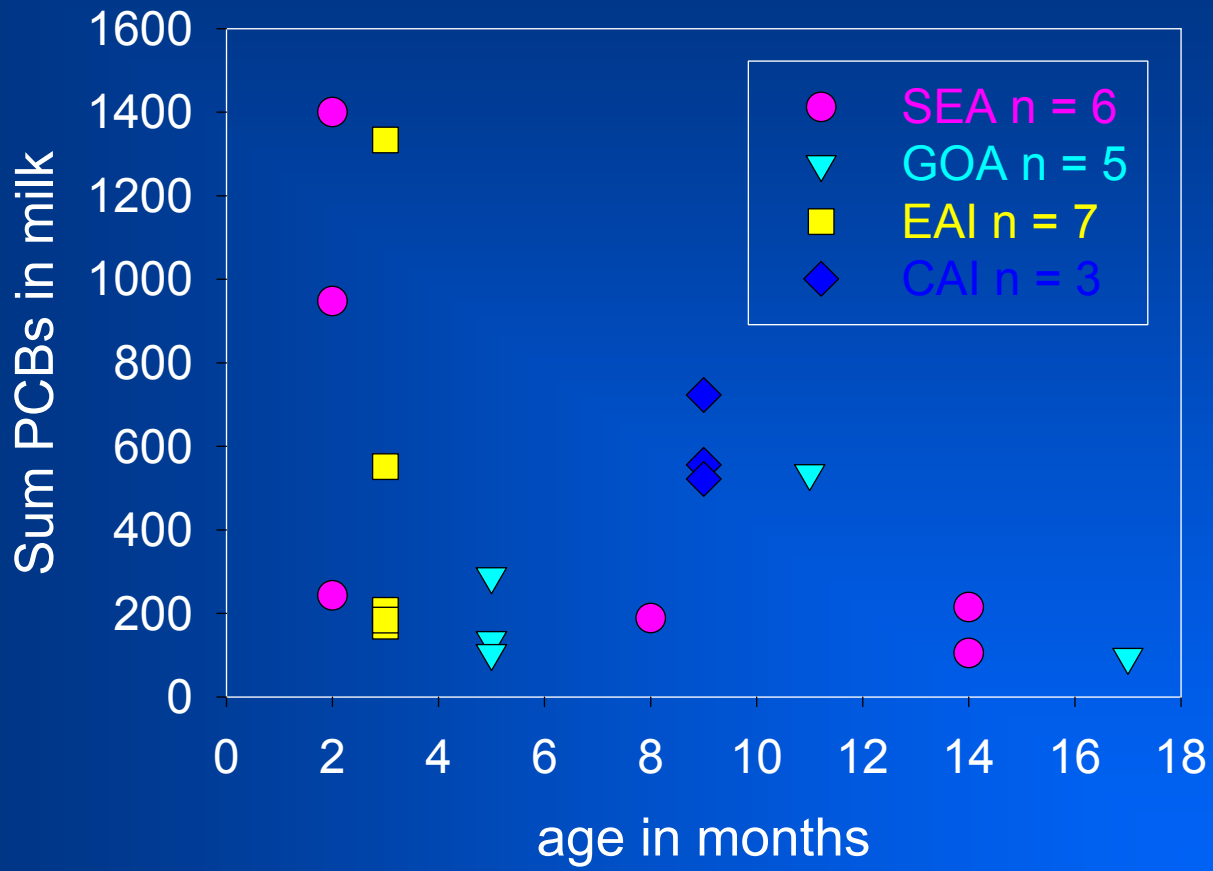
***Significantly greater than similar age from SEA, *p* = 0.043**

Beckmen, K., L. Duffy, X. Zhang, and K. Pitcher. 2002. Mercury concentrations in the fur of Steller sea lions and northern fur seals from Alaska. Marine Pollution Bulletin 44:1130-1135.

OC contaminant exposure in free-ranging juvenile Steller sea lions

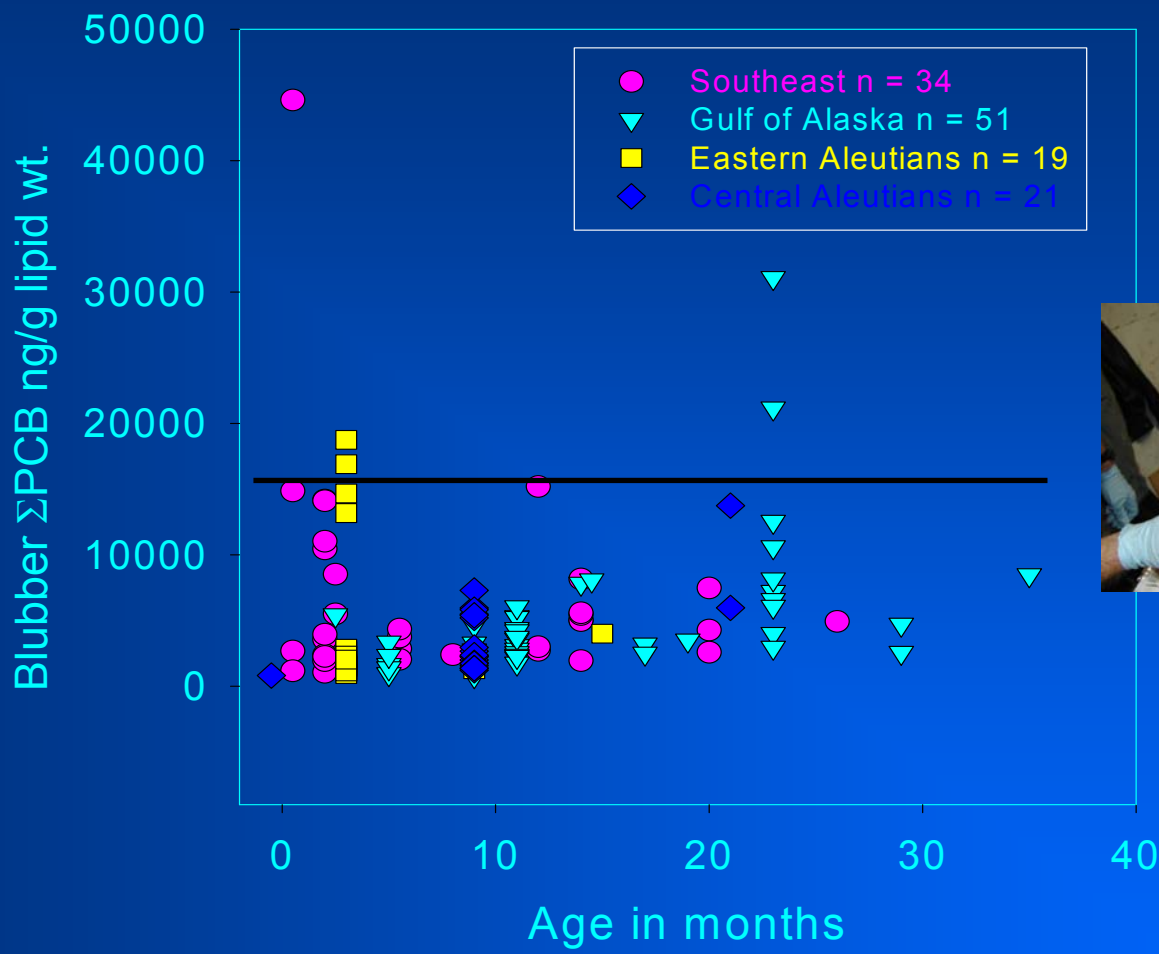
- Pup to juvenile Steller sea lions from SEA, GOA, EAI, CAI rookeries/haulouts
- 130 animals ranging from 0.5 months to 2+ yrs.
- Blubber (n=125), milk (n=21), blood (n=13), and feces (n=34)
- In conjunction with larger foraging/nutritional studies
- Extensive health/disease surveillance
- Congener-specific OC screening by HPLC

PCBs ng/g l.w. in milk obtained by orogastric gavage



PCBs are off-loaded from the adult female during lactation, the concentration in milk decreases later in lactation

Blubber PCBs



PCB concentrations are age and regionally dependent, typically decreasing with age (exception are 21 mo. juveniles in GOA). Black line is concentration at which immunosuppression evident in harbor seals

Immune function

Objectives:

1) Establish preliminary baselines of immune parameters in free-ranging population juvenile Steller sea lions

2) Determine if there are correlations in organochlorine contaminant exposure and perturbations in immune function

- Collect blood samples from free-ranging pups and juveniles from SEA, PWS, and the EAI
- Utilize a suite of immunoassays
- Lymphoproliferation responses
- Humoral immune response
  - Immunoglobulin concentrations
- Inflammatory indicators
  - IL-6 and Haptoglobins
  - Hemograms
- Analyze OC contaminant concentrations in blubber on a subset.

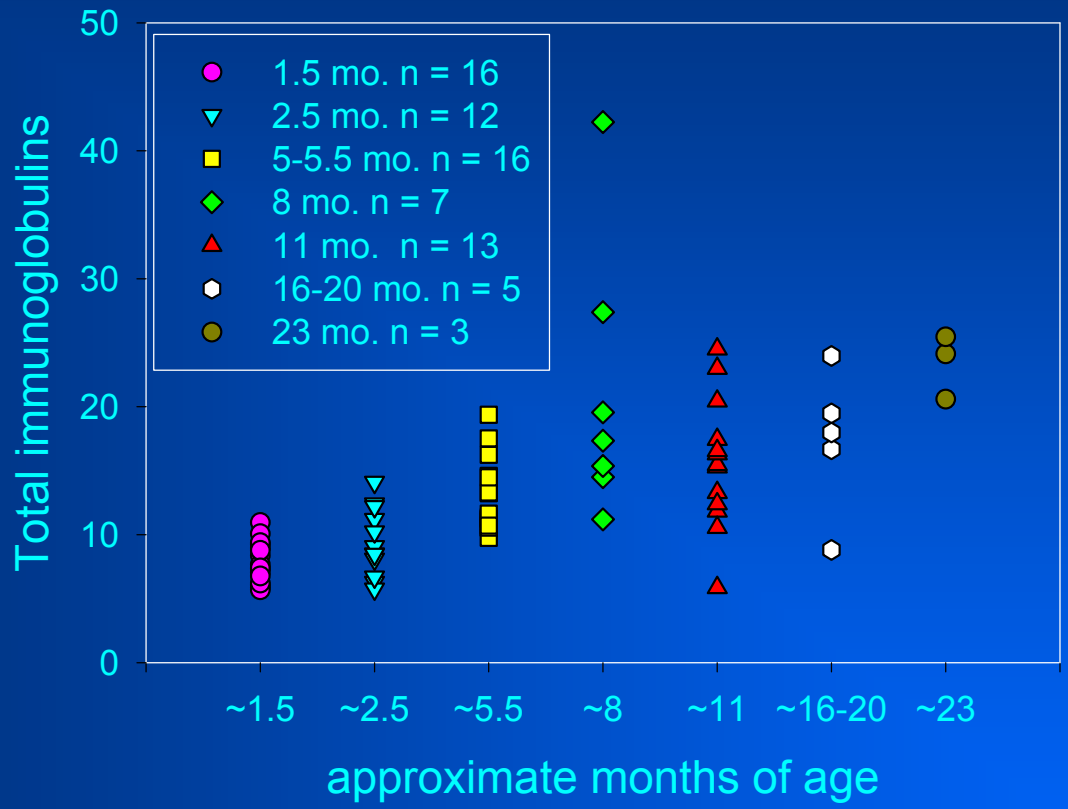
Regional differences in leukocyte counts

Mean ± SD reference range of leukogram parameters in Steller sea lion juveniles ≥11 month old by region and age from 1998-2001.								
	SEA 14-16 mo. *n* =43		PWS 11-14 mo. *n* =29		SEA 18-26 mo. *n* =7		PWS 17-29 mo. *n* =13	
Total Leukocytes/µl	11398	±3326	*13699	±3251	9293	±2388	11818	±3751
Neutrophils:Lymphocytes	2	±1.2	1.9	±0.9	1.18	±0.46	†1.77	±0.50
Neutrophils/µl	5898	±2363	6655	±2236	4408	±1308	†5651	±1635
Band neutrophils/µl	173	±155	152	±153	86	±94	108	±111
Lymphocytes/µl	3511	±1448	4068	±1295	3721	±1183	3494	±1361
Monocytes/µl	852	±535	1148	±671	523	±200	*1121	±458
Eosinophils/µl	927	±631	1678	±1223	936	±663	1455	±1124
Basophils/µl	0		0		0		7	±25

***** indicates significantly elevated in PWS sea lion juveniles than in SEA of both age groups, $p < 0.01$

† indicates significantly elevated in PWS sea lions than similarly aged juveniles in SEA, $p < 0.05$

Concentrations of total immunoglobulins (mg/ml) in frozen serum from free-ranging Steller sea lion pups and juveniles from Alaska, 1998-2000.



Animals appear to become immunocompetent at 5-6 months of age. Consider the period prior to that an extremely vulnerable period for adverse effects of contaminant exposure.

Results: Necropsy Materials

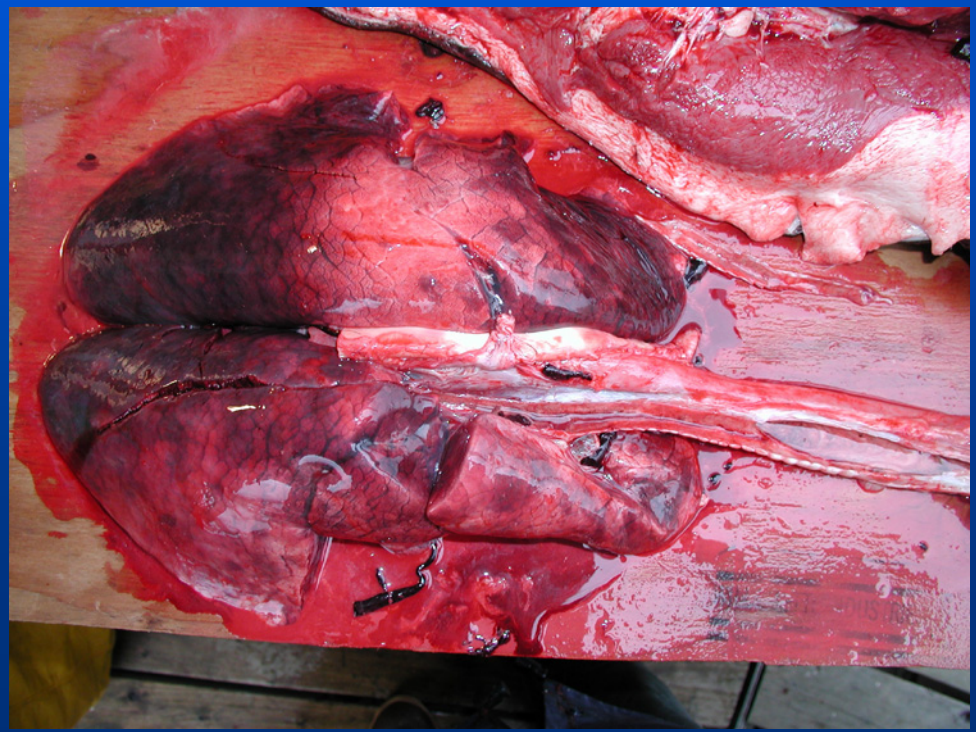
- Placentas (5)
- Fetuses (premature births -- 5 full, 4 partial)
- Young pups (30)
  - 20 found dead
  - 10 branding related
- 11 mo old (1)
- Juveniles (2)
- Adults (1F, 2M)

Necropsy Results

- Young pups
  - Malnutrition
  - Septicemia, omphalitis/bite wounds
  - Embolic pneumonia
  - Trauma
  - Hookworms

Necropsy Results

- **Capture-related mortalities**
  - Drowning
  - Asphyxiation/aspiration
  - Trauma
  - Post-anesthesia



Serology results: Disease agents under surveillance

- *Chlamydophila psittaci*
- Caliciviruses
- Phocid herpesvirus-1
- *Toxoplasma gondii*
- Morbilliviruses
- *Leptospira interrogans*
- Influenza A
- *Brucella spp.*
- Canine parvovirus
- Canine adenoviruses

Burek, K.A., F. Gulland , K. Beckmen, G. Sheffield , E. Keyes, T. Spraker, A. W. Smith, D. E. Skilling, J. Evermann, J. Saliki, J. Stott and A. W. Trites 2005. Infectious disease and the decline of Steller sea lions (*Eumetopias jubatus*) in Alaska: insights from serology data. *Journal of Wildlife Diseases*

Endemic disease agents

- Caliciviruses
- *Chlamydophila sp.*
- Herpesvirus
- Canine adenovirus
- *T. gondii*

Negative or negligible results

Agent	# tested
Morbilliviruses	351
Leptospira interrogans	403
Influenza A	102
Brucella abortus	383
Canine parvovirus	125

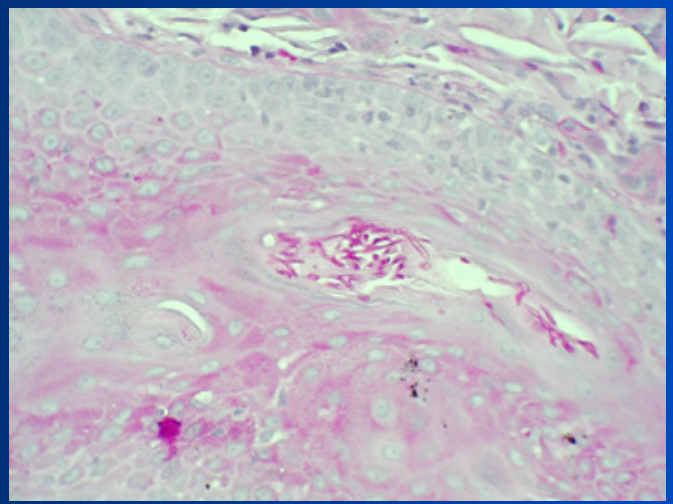
Herpesvirus

- 3 new herpesviruses sequenced from nasal swabs.
  - N = 67
  - alpha herpesvirus subfamily
  - two (from SW brothers) were almost identical. Most closely related to pseudorabies virus (~80%) and HSV-1 and cercopithine herpes 1 (~50-80%).
  - The 3rd isolate was identical to Otarine herpesvirus-1 (gamma herpesvirus associated with urogenital cancer in CSLs).

Chlamydophila (Chlamydia) psittaci Preliminary PCR results:

Site	% positive by PCR
Overall	73% (44)
Eye	17% (40)
Oral	43% (39)
Vaginal	50% (12)
Rectal	45% (42)

Disease agents- Fungal



- Target lesions = fungal patches
- Culture identified by PCR as *Trichophyton tonsurans*

Bacterial flora - oral swabs

- Consistently looked for but did not see *Bordetella sp*., coagulase positive *Staphylococcus sp*. (1 pos), *Actinobacillus sp.*, *Erysipelas* and *Listeria*
- Cultured a variety common in oral flora
- Streptococcus bovis group
- One Vibrio parahemolyticus
- No obvious patterns by region or age of animal.

Bacterial flora -- rectal

Cultured consistently for *Salmonella*, hemolytic & non- hemolytic *E coli*, *Campylobacter*, *Yersinia*, *Edwardsiella*, and *Pleisiomonas*.

PCR for virulence factors in E. coli

- Variety of *Campylobacter* types with highest shedding (34%) in the older SE animals.
- eae+ *E coli* in all three regions (2-17%)
- Very low prev *Edwardsiella tarda* (2-5%)
- No *Yersinia*, *Pleisomonas*.

Disease agents-*Salmonella*

Age	EAI	PWS	SE
3 mo	47% (17) *S. Stanley*	0% (6)	--
5 mo	--	56% (39) *S. newport* S. enteriditis	20% (20) *S. reading* *S. infantis*
9/11 mo	0% (22)	0% (15)	--
>12 mo	0% (3)	0% (22)	3%(35) *S. reading*

Hookworm – Initial Findings

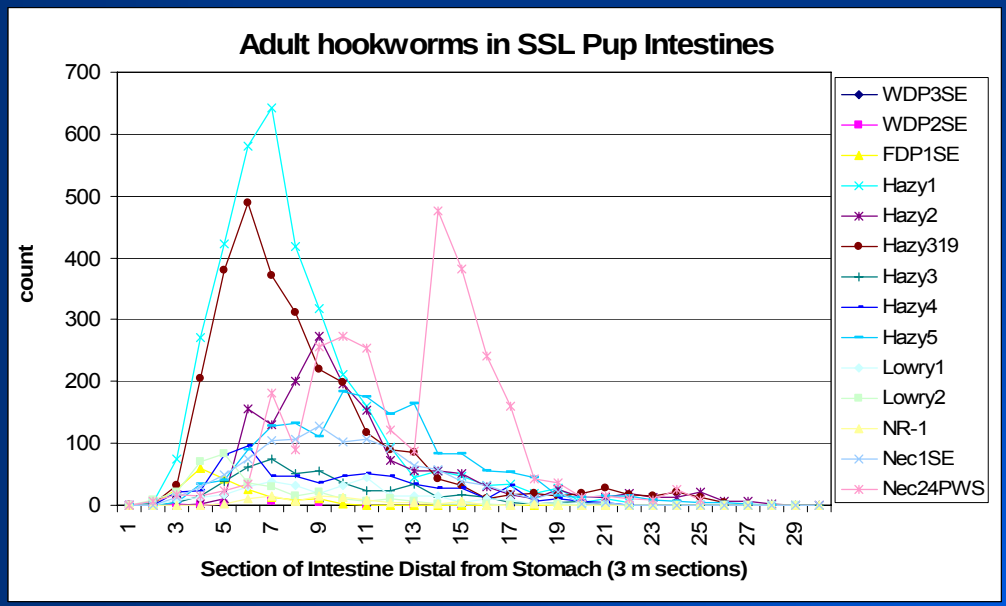
- High prevalence of hookworm in pups under 5 mos. (near 100% at 2-3 mo.)
- High worm burdens (over 3,000) and high egg counts
- Anemias at 2-3 mos, often severe, and normal hematocrits rare
- Lesions at necropsy

Hookworm - Results

Prevalence of hookworm in SSL rookery pups

- Prevalence of patent infections in 2-4 wk old pups varied by rookery sampled 2003-2005
- Prevalence significantly lower at western stock (5.6%) vs. eastern stock (43.9%) consistent with declining density
- Prevalence at 2-3 mos. of age in SE was highest at 69%
- Prevalence was 0% in pups >5 months old

Hookworm - Results



Intestinal hookworm burden, this study compared to other *Uncinaria spp*. in other otariids

	n	Mean	SD	Range
Steller SL	14	1,121	± 1,202	18-3,477
CA SL*	51	1,284	± 1,190	14-4,521
NFS*	23	606	± 643	5-1,175

*Lyons et al 1997. J.Wildl.Dis. 33:848-852

- Fecal egg counts in 2-4 wk old pups (*n*=61)
  - Mean 1,171 ± 1,842 (range 25–9,333) eggs/g
- Worm burden similar in CSLs (Table)
- Worm intensity was highest in the upper to middle jejunum (Figure above)
  - Similar to distribution in CSLs
  - Contrary to the ileocecal distribution in NFS
- Worm burden was significantly higher in pups from Hazy Isl. 1,657 ± 1,102 than Forrester complex 231 ± 112, *p*=0.033

A Health Assessment Approach to Steller Sea Lion Research in Alaska – Epidemiology project

Modeling of disease occurrence patterns from an epidemiology perspective :

- Body condition
- Clinical chemistry
- Metabolite levels
- Hematology
- Contaminants
- Immunology
- Bacteriology
- Virology
- Serology
- Parasitology

Kathy Burek (AK Vet. Path. Services), Kimberlee Beckmen, Camilla Lieske, Lorrie Rea (ADF&G) and Tom Gelatt (NMML)

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