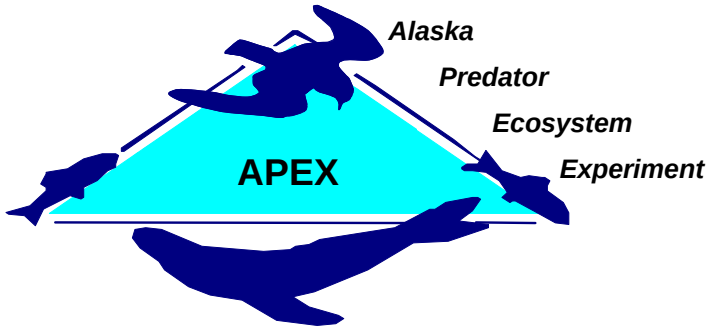
Site-specific Factors Affecting Productivity Of An Upper Trophic Level Marine Predator:

Bottom-up, Top-down, And Mismatch Effects On Reproduction In A Colonial Seabird



Rob Suryan
Pat Jodice
Dan Roby

David Irons

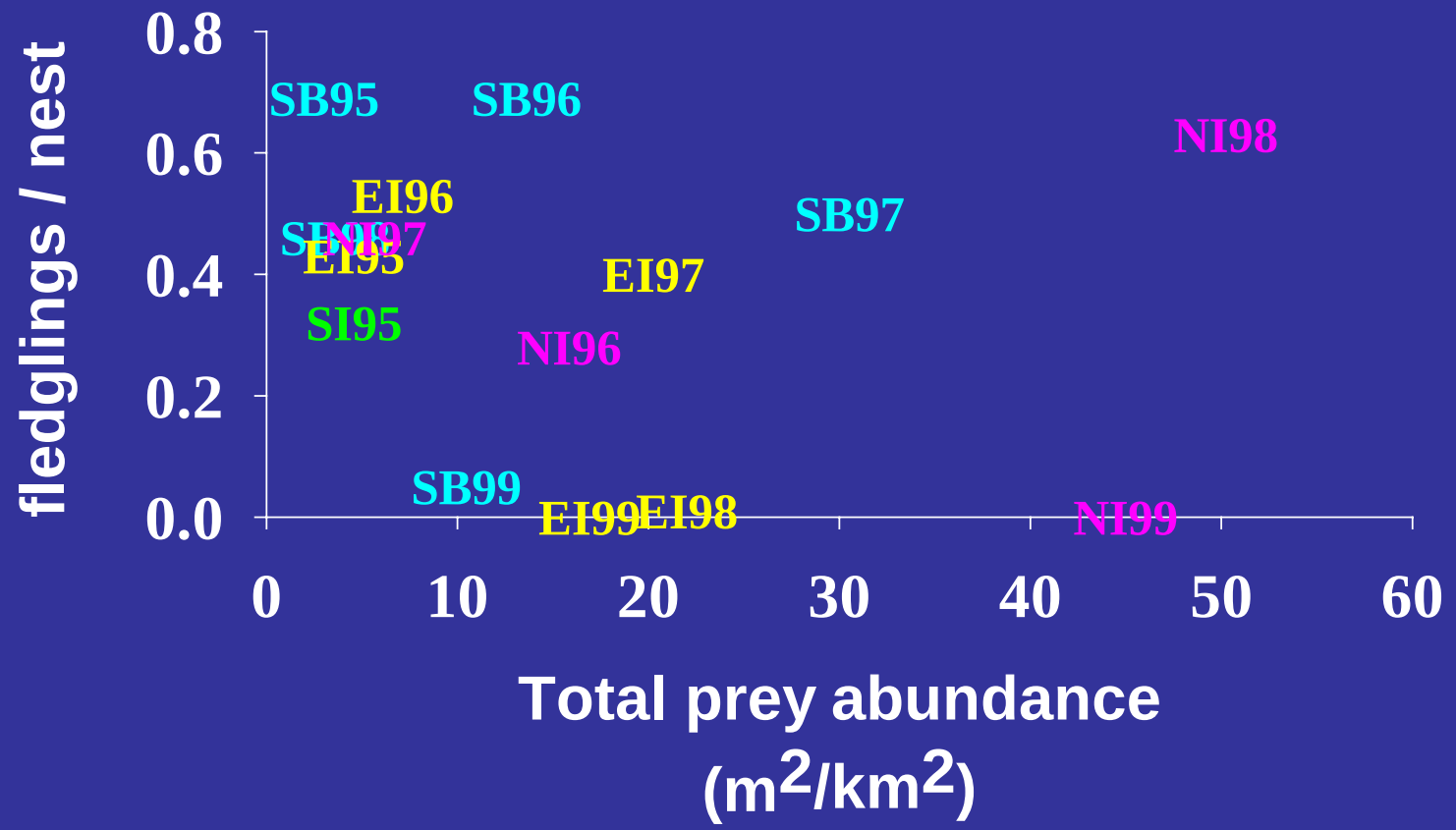
U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

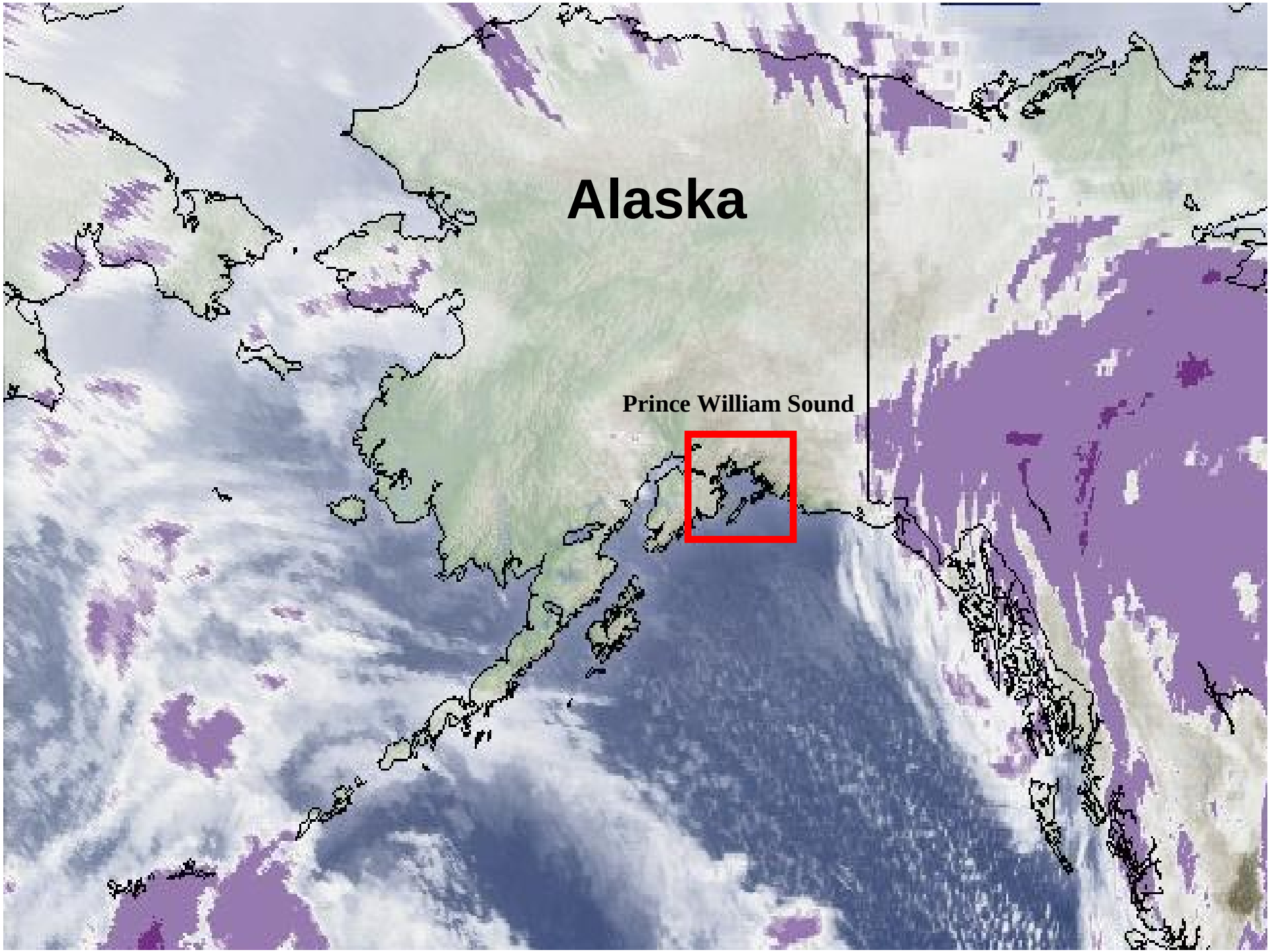
OREGON STATE UNIVERSITY

Evelyn Brown

UAF
UNIVERSITY OF ALASKA FAIRBANKS

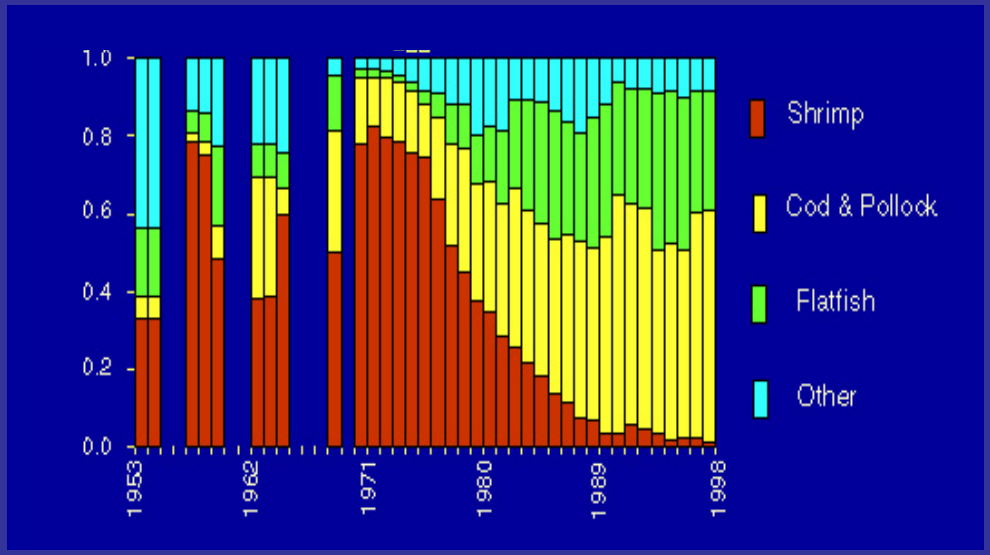
Breeding Success & Prey Abundance




Alaska
Prince William Sound

Reasons for Study

Exxon Valdez
Oil Spill



Regime Shift in the Gulf of Alaska

Anderson and Piatt. 1999. Mar. Ecol. Progr. Ser. 189:117-123

Black-legged Kittiwakes

24 days

37 days

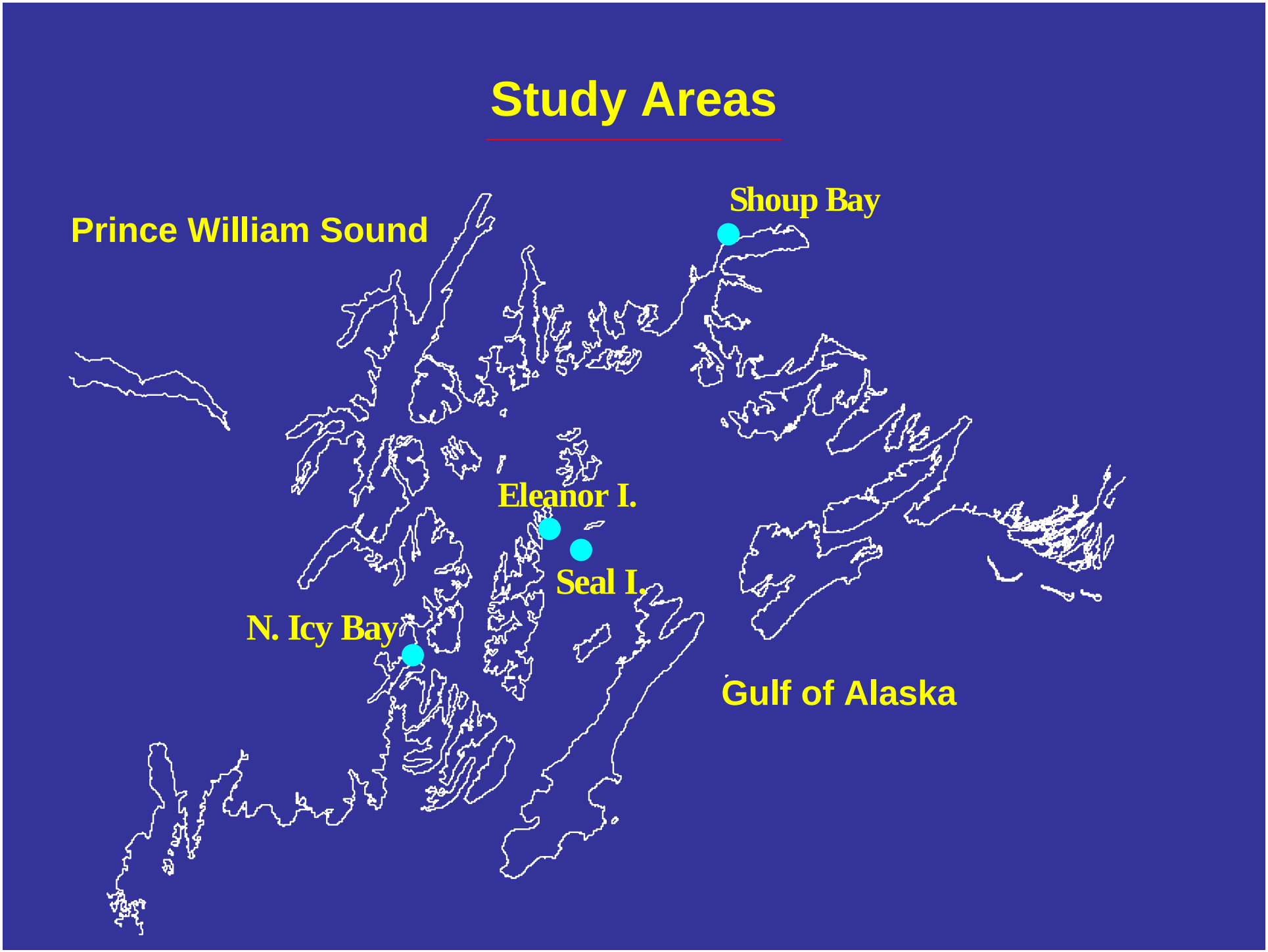
Egg (1-3) → Chick (1-3) → Fledgling

Chick Provisioning = 2 to 4+ meals/day

Adult Foraging Range = 5 to 60 km

(Range < 1 to > 100km)

Study Areas

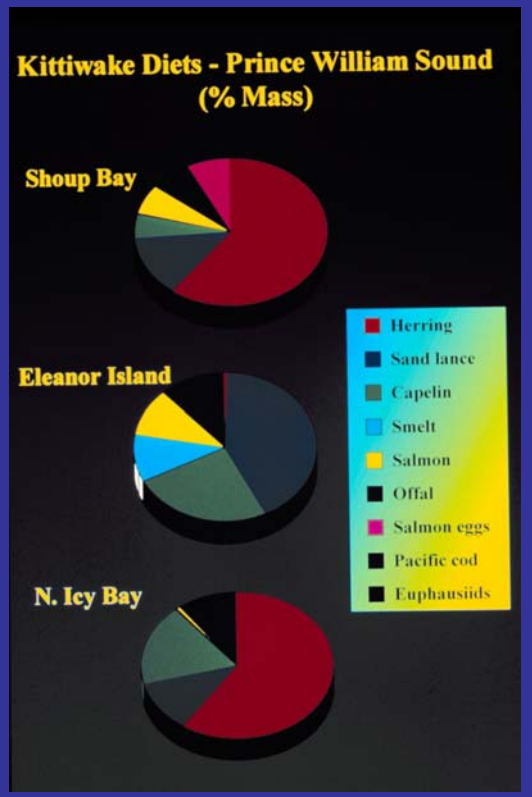

Prince William Sound
Shoup Bay
Eleanor I.
Seal I.
N. Icy Bay
Gulf of Alaska

Shoup Bay
~7,000 pairs

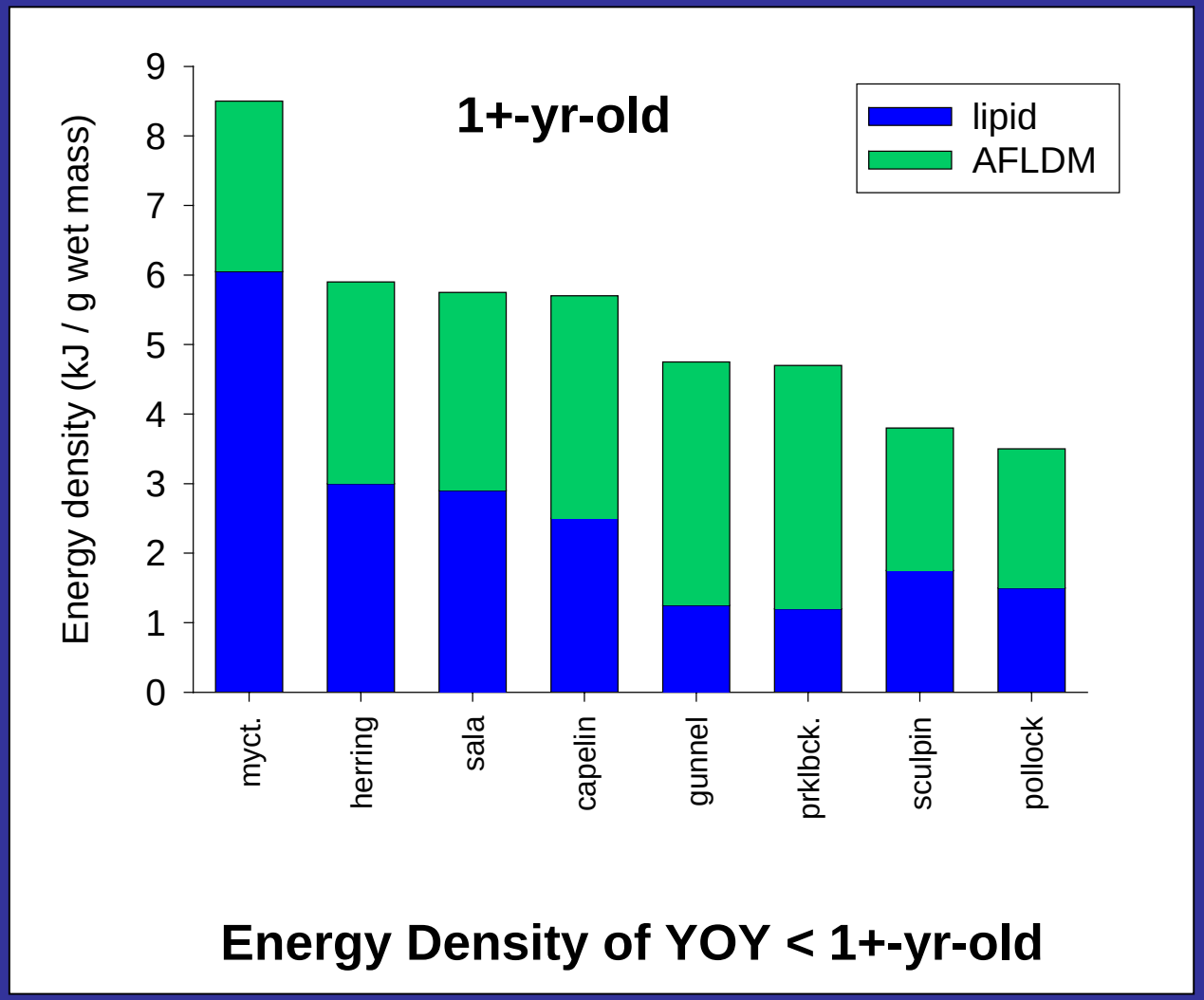
Eleanor & Seal Isles.
~500 pairs

N. Icy Bay
~1,800 pairs

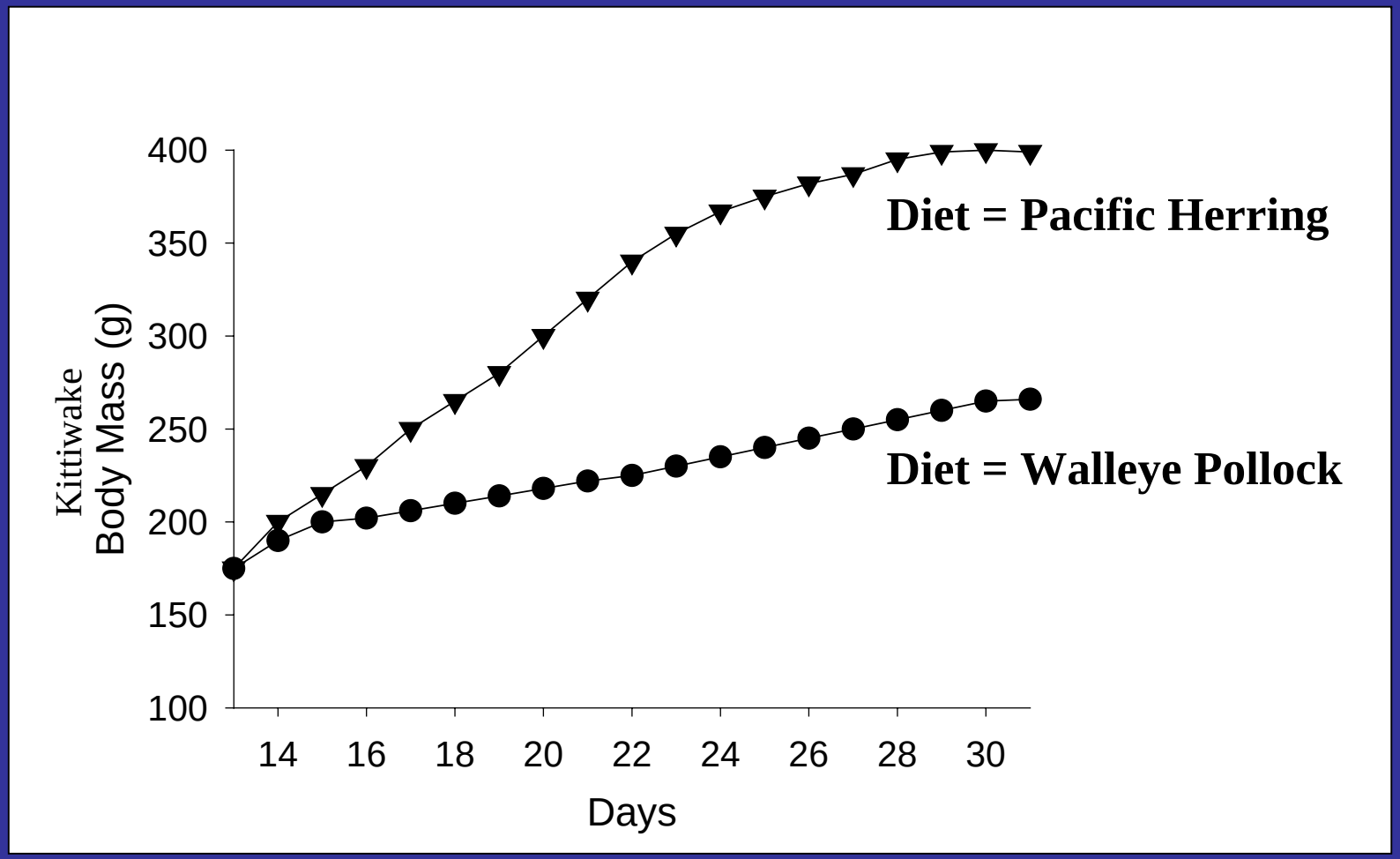
Reproductive Success & Diets



Energy Density of Forage Fishes



Kittiwake Diet and Growth – Experimental Feeding



Romano et al.

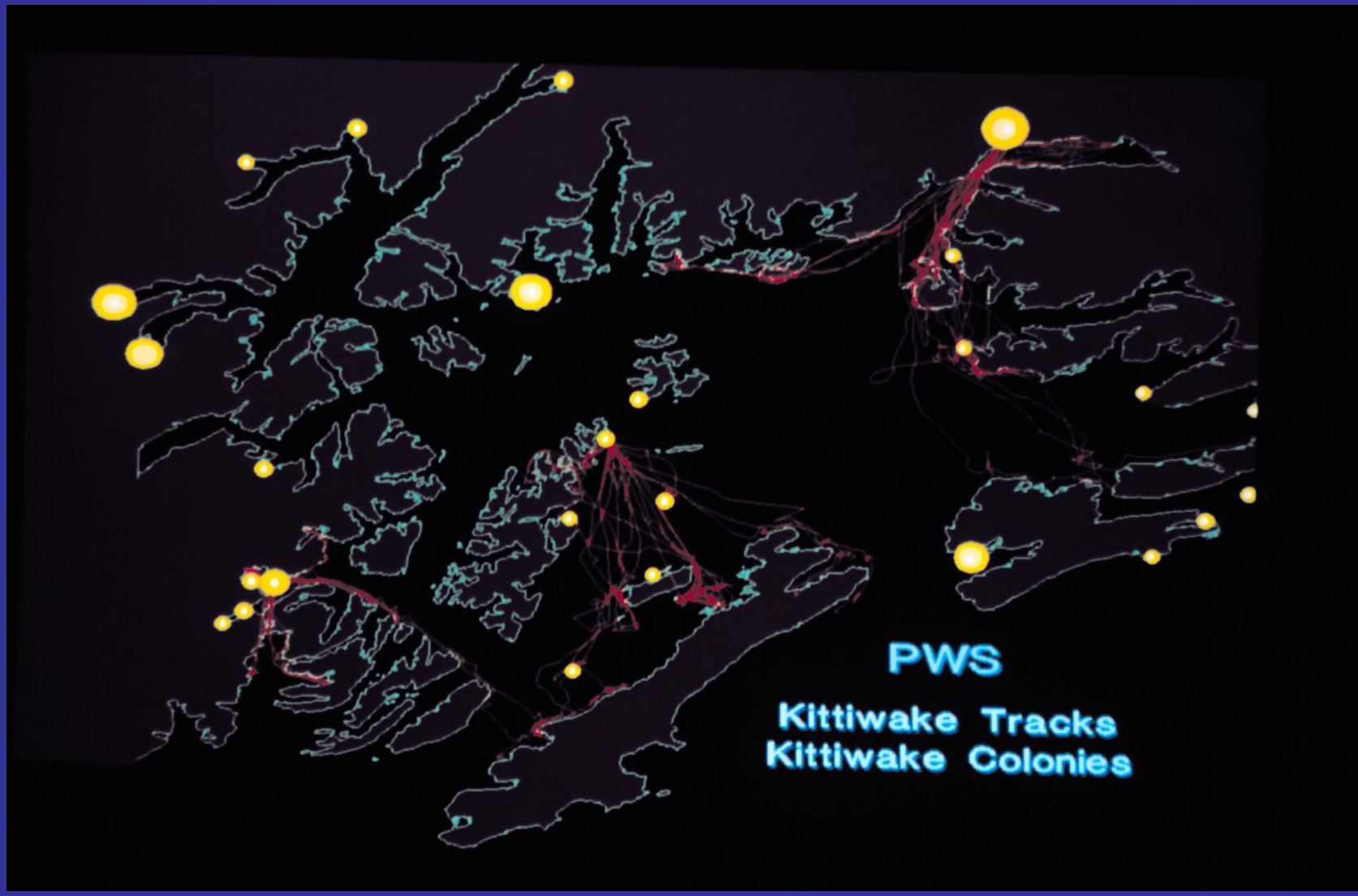
Monitoring Foraging Activities

Transmitter Attachment

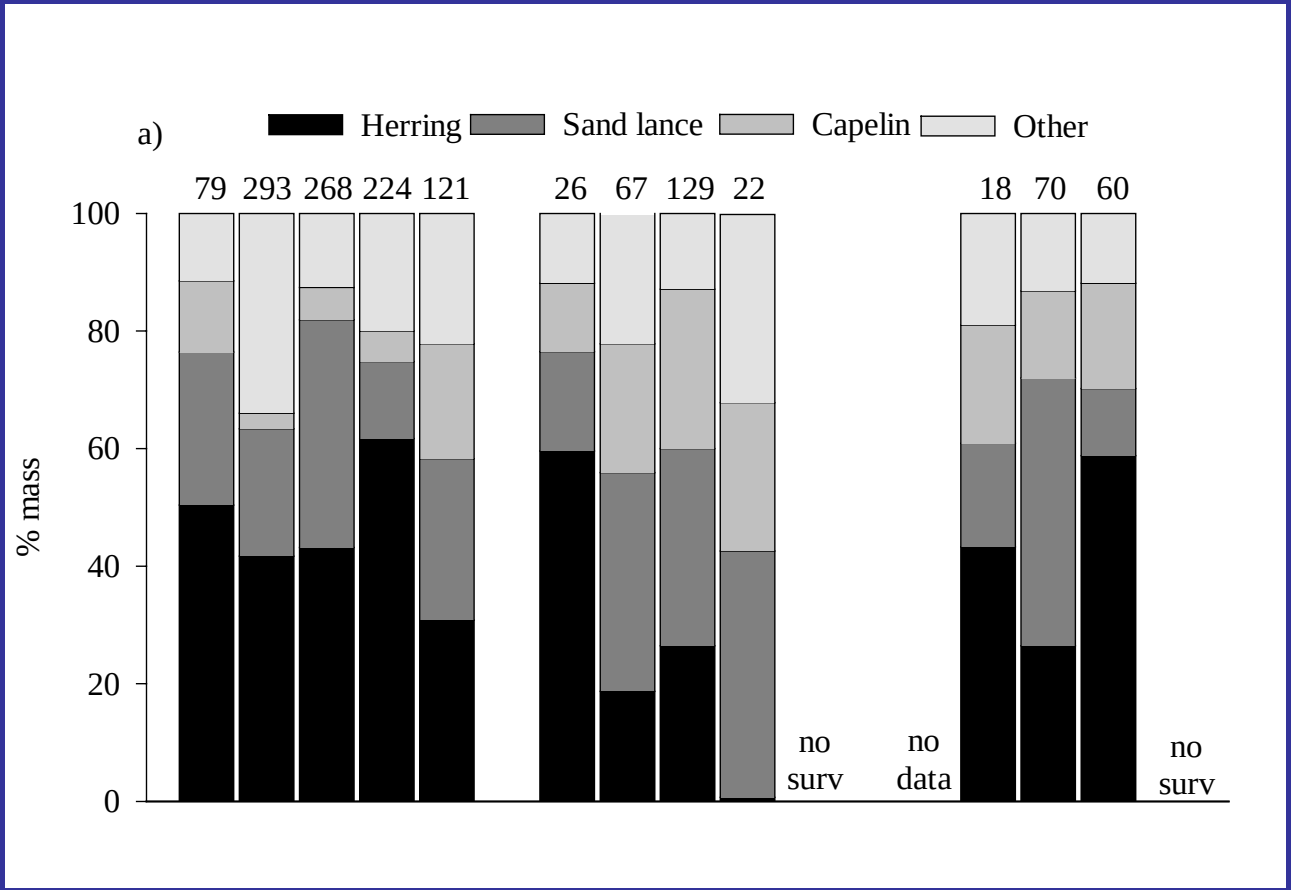
Data Logger At Colony

Tracking by Boat

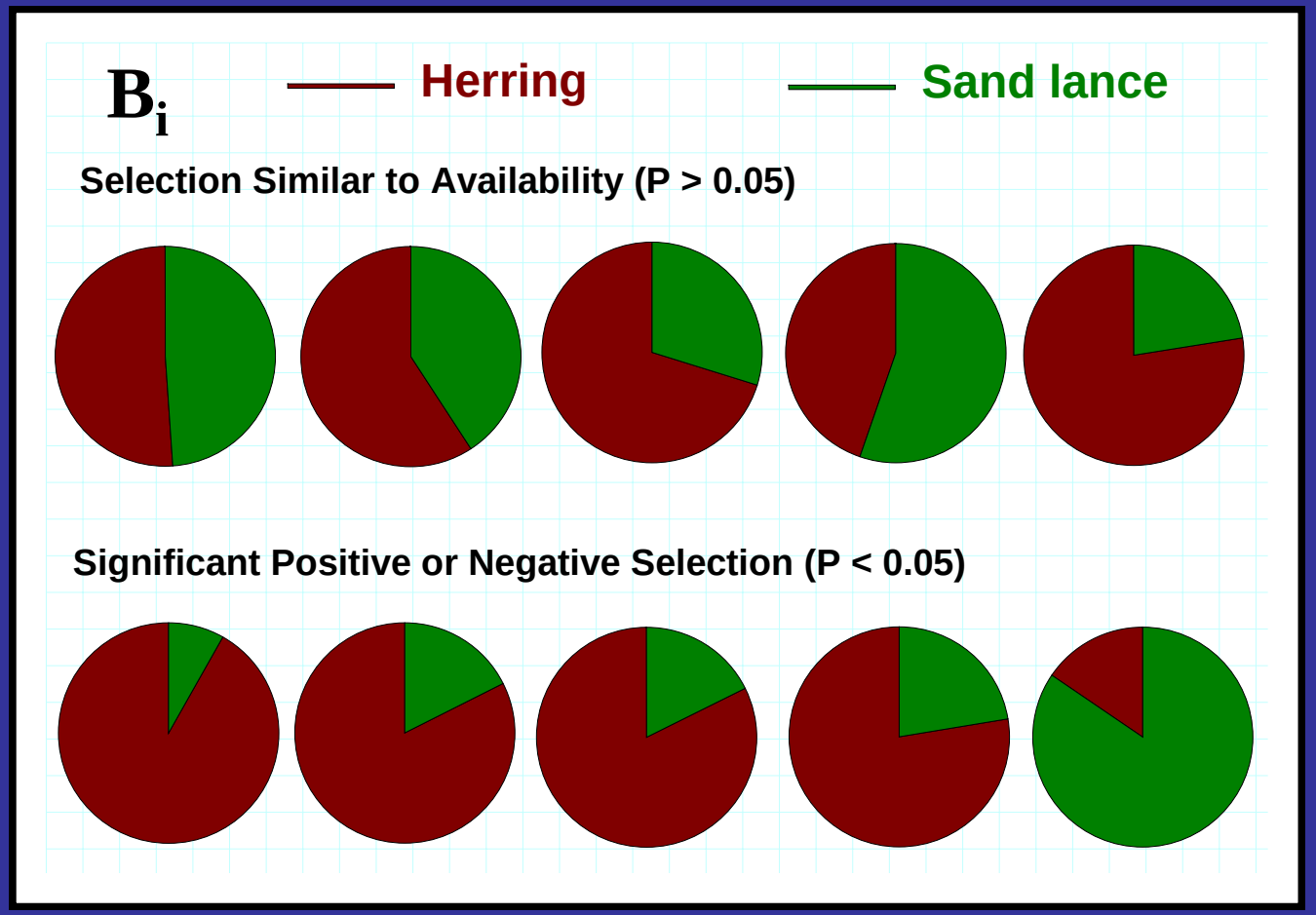
Foraging Trips



Diets

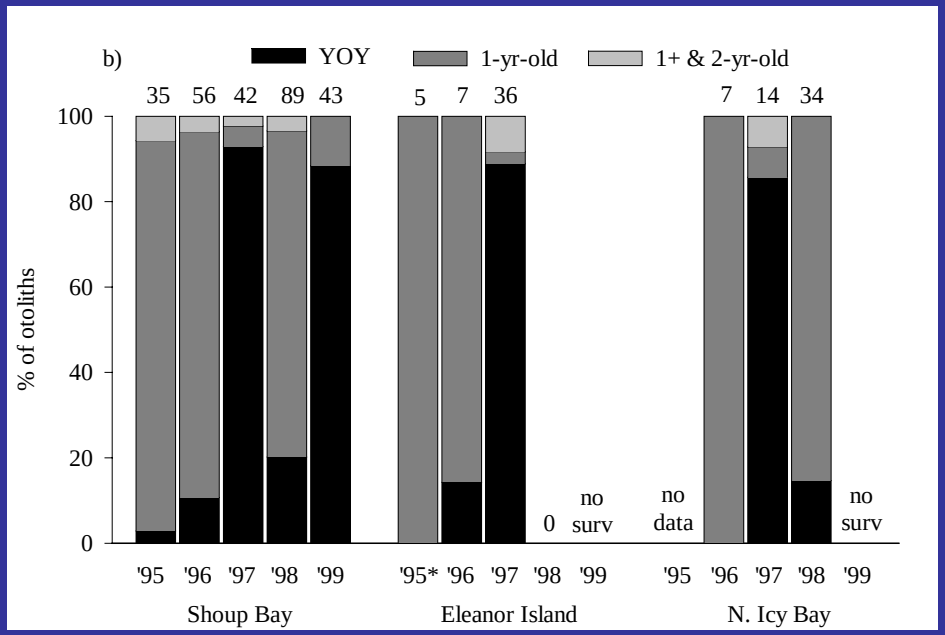

a)
Herring
Sand lance
Capelin
Other
% mass
100
80
60
40
20
0
79
293
268
224
121
26
67
129
22
18
70
60
no surv
no data
no surv

Preferential Selection of Prey Type



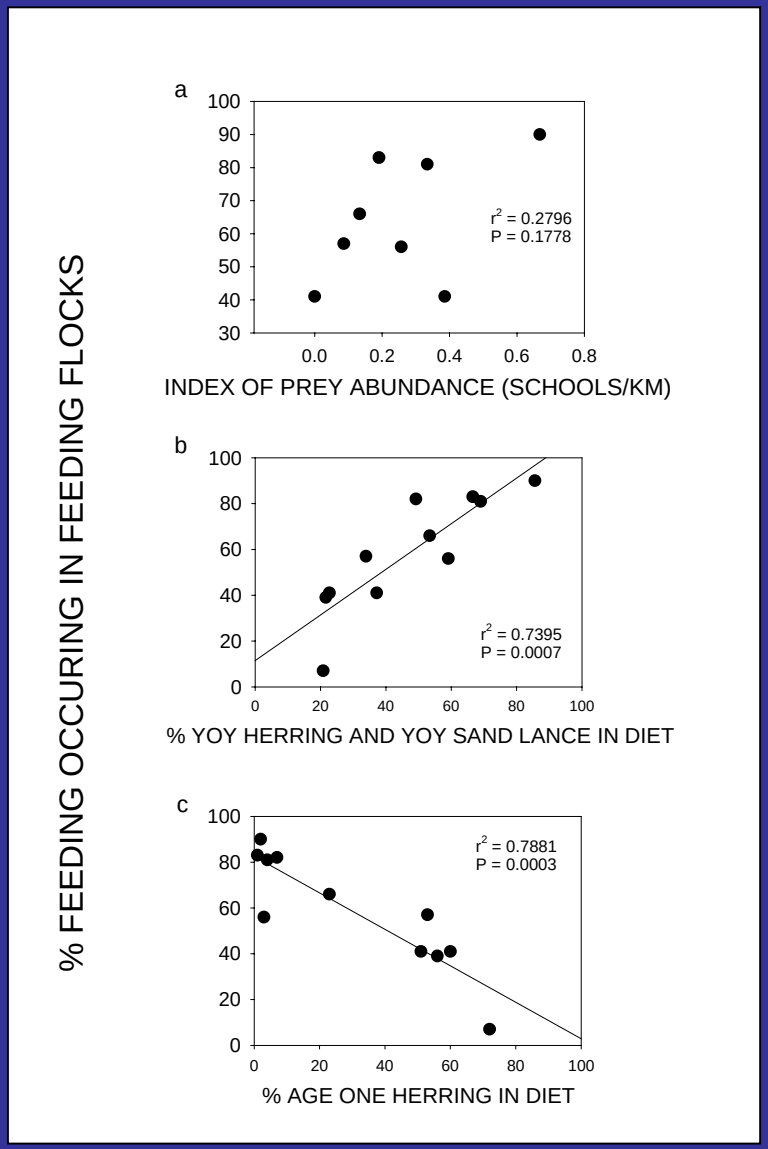
Age Classes of Forage Fish in Kittiwake Diets

Herring

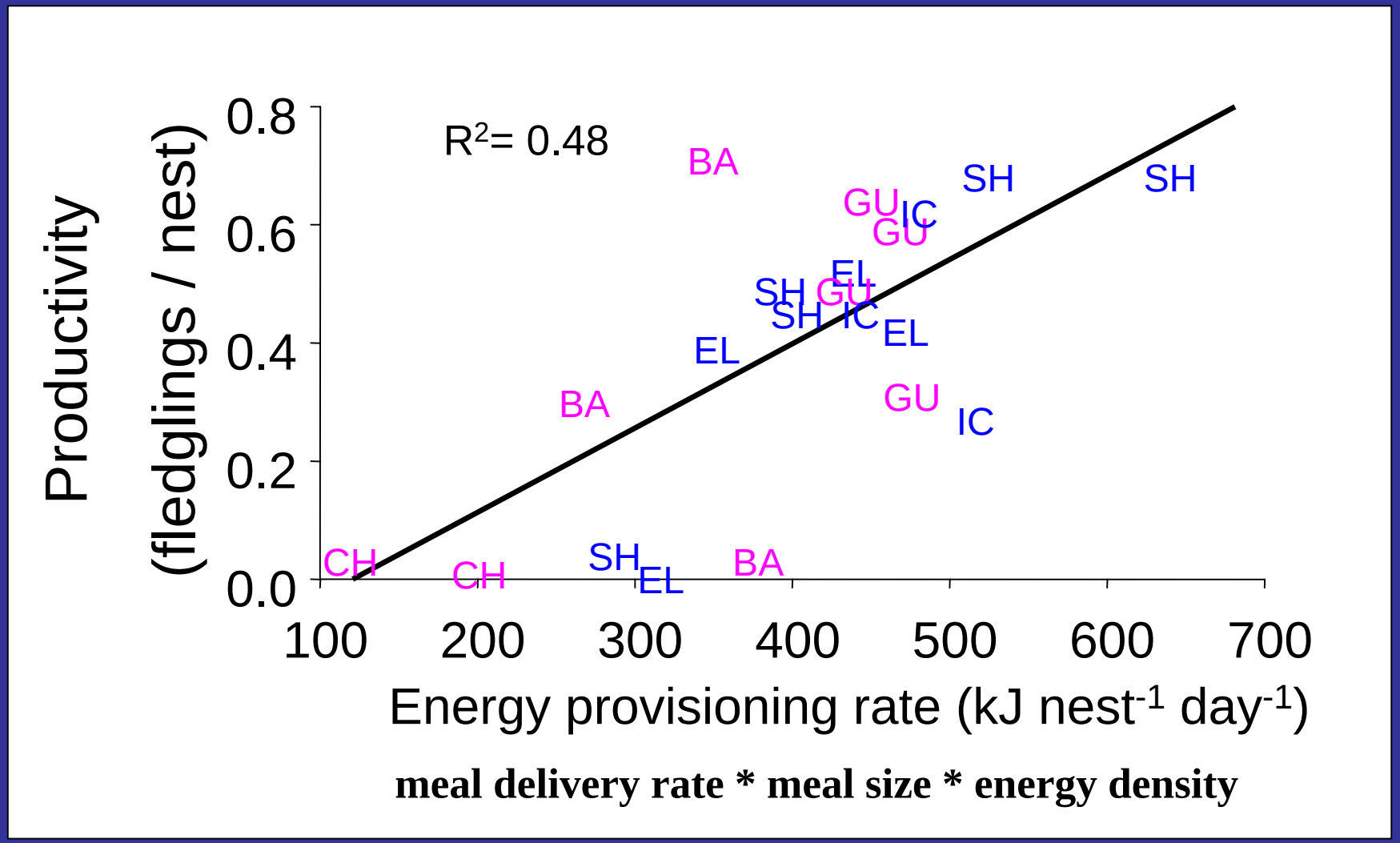


96 % of Sand lance were YOY

Prey Type and Feeding Flock Use

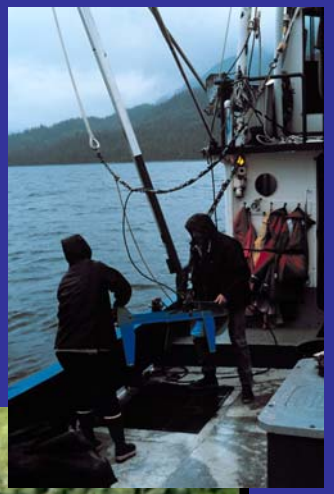


Feeding Frequency vs. Productivity



Jodice et al. 2000

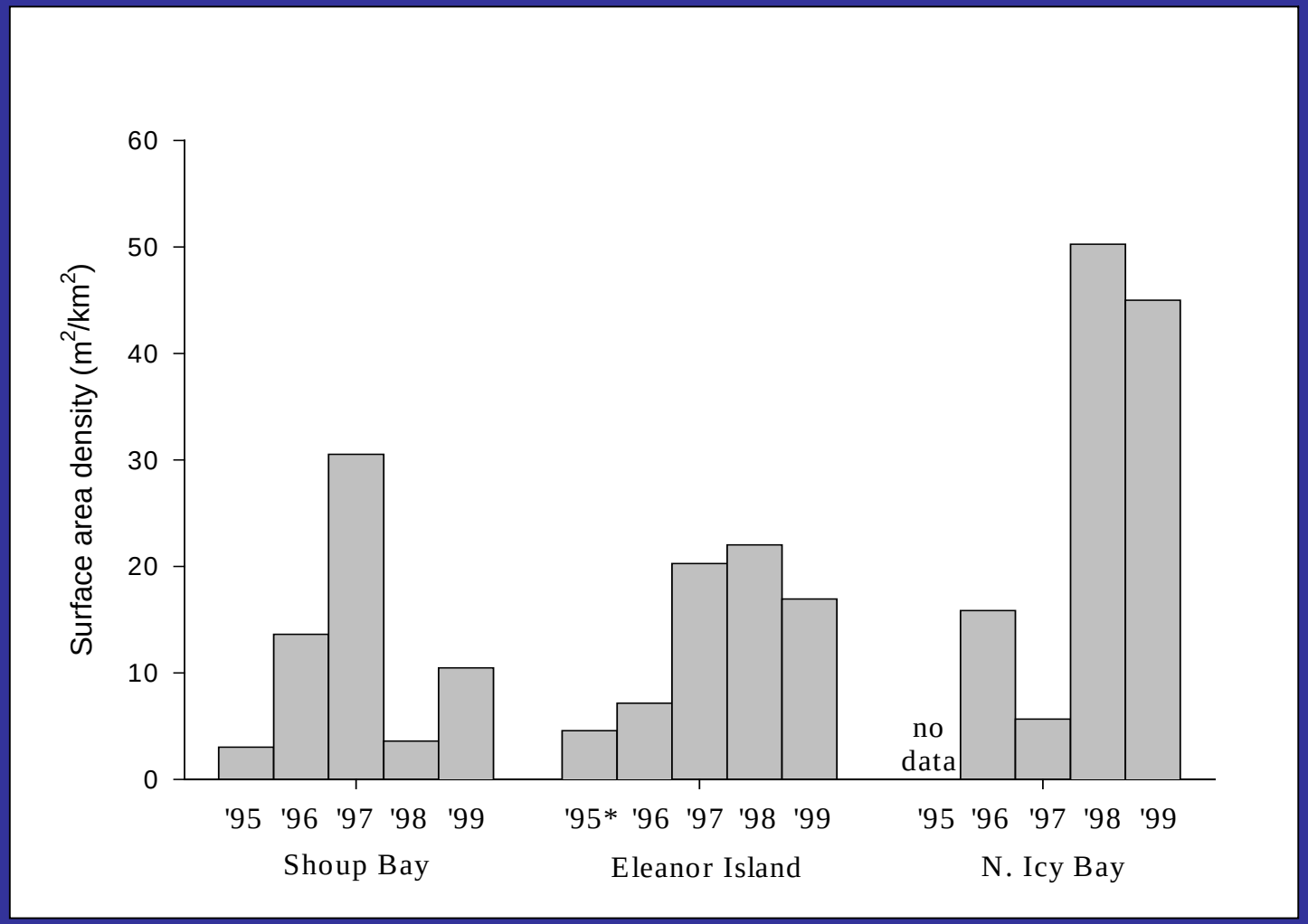
Forage Fish Sampling



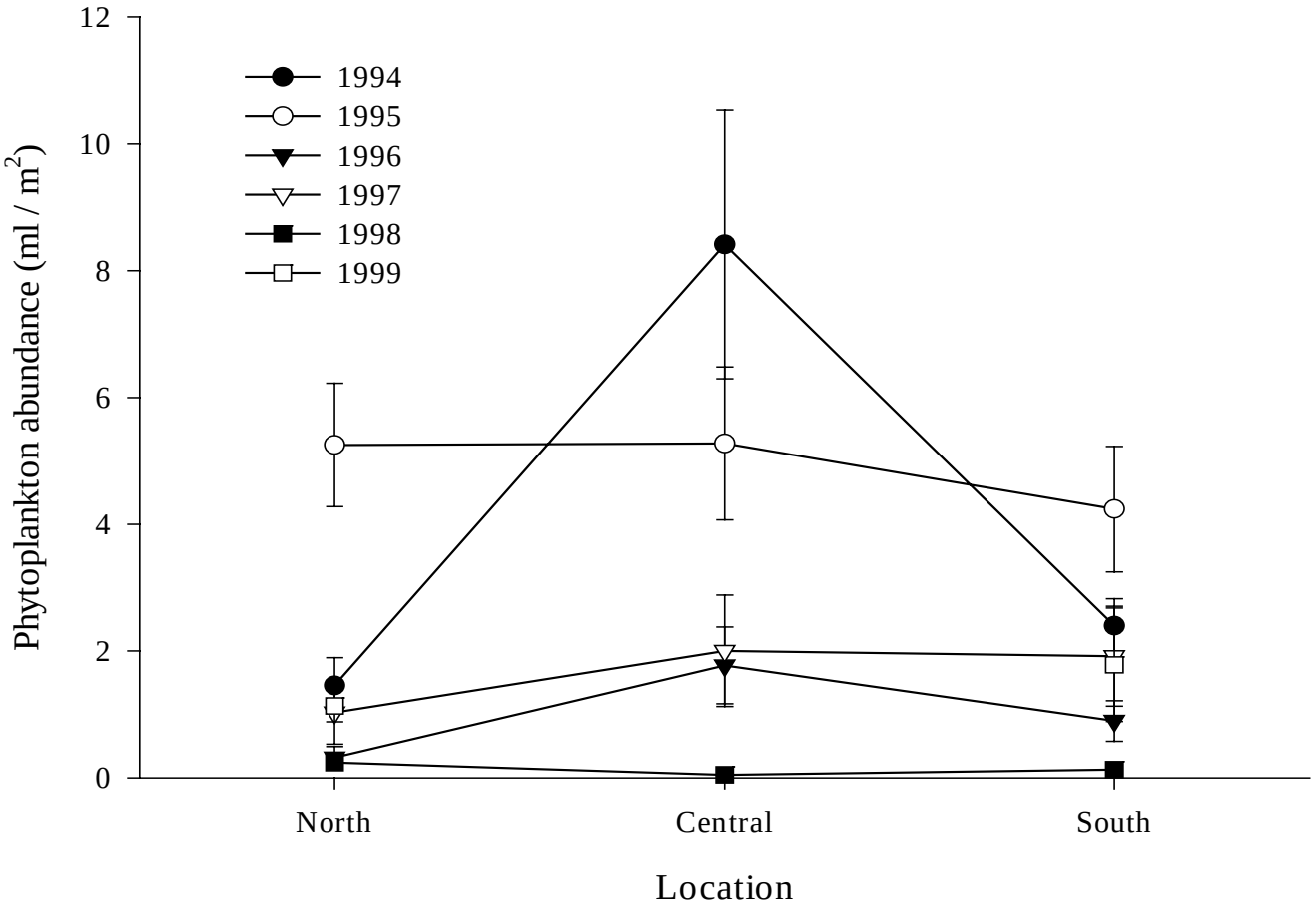
Clupea pallasi

Ammodytes hexapterus

Forage Fish Abundance (surface area density [m^2/km^2])



Phytoplankton Abundance



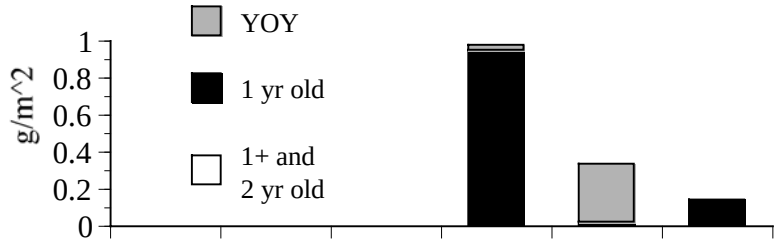
Data courtesy of Prince William Sound Aquaculture Corporation

Shoup Bay

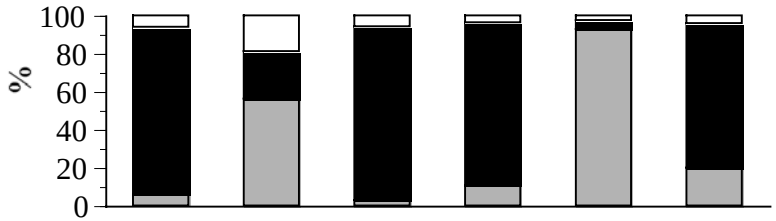
Hydroacoustic Data - Juvenile Herring

A

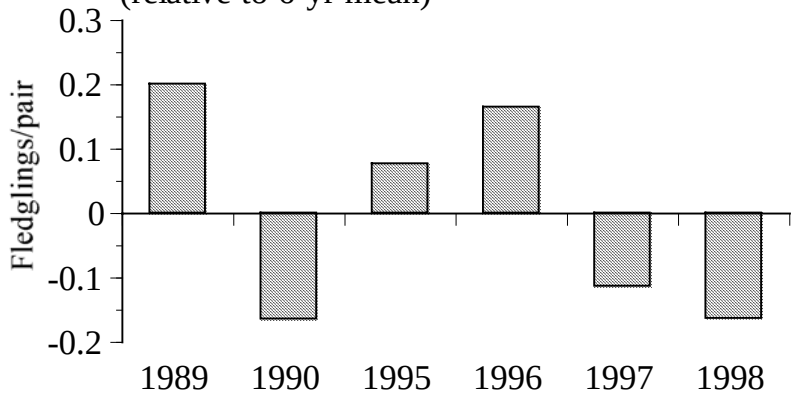
Biomass Density



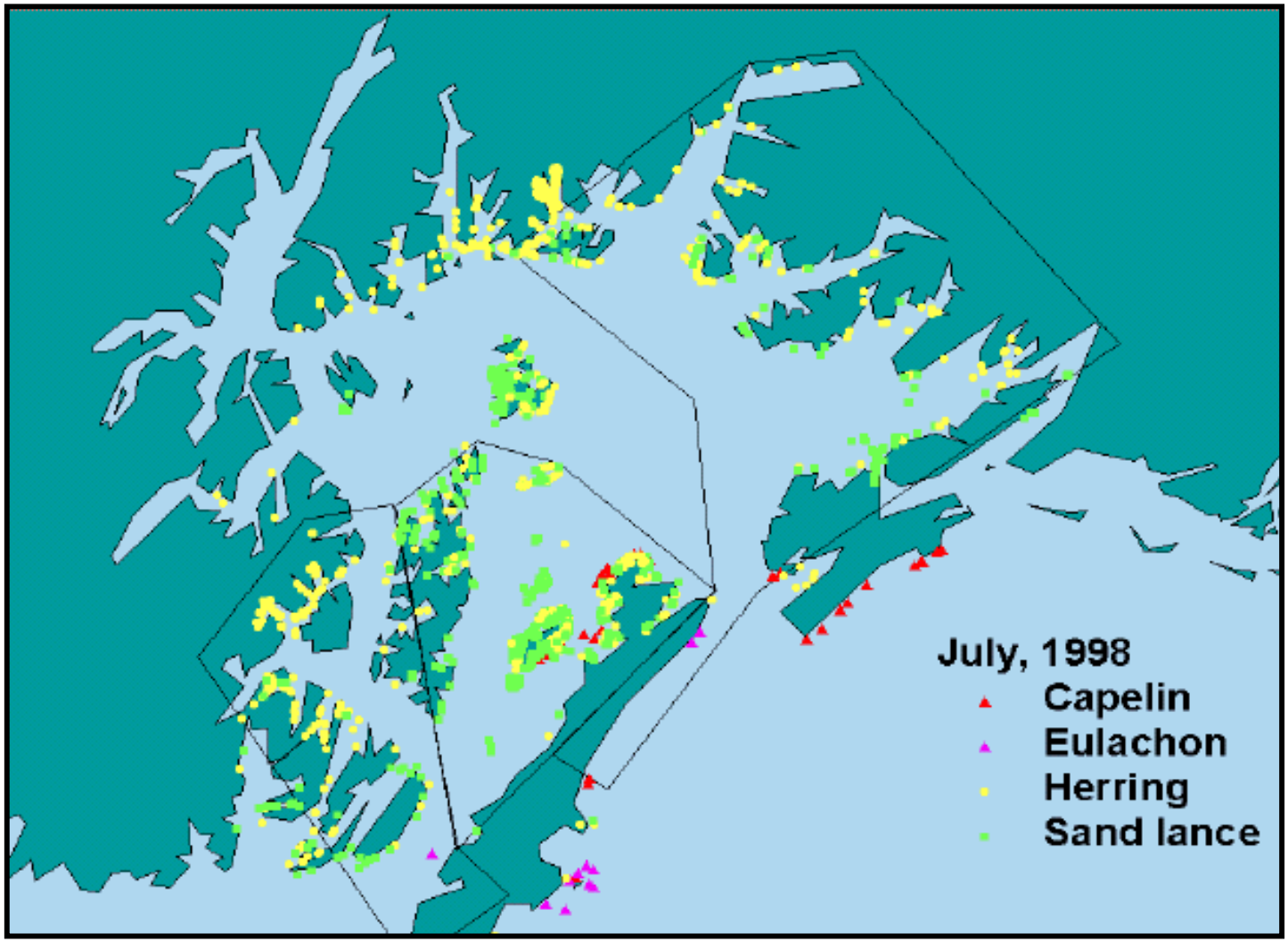
B Kittiwake Diets - Ages of Herring Consumed



C Kittiwake Reproductive Success
(relative to 6-yr mean)

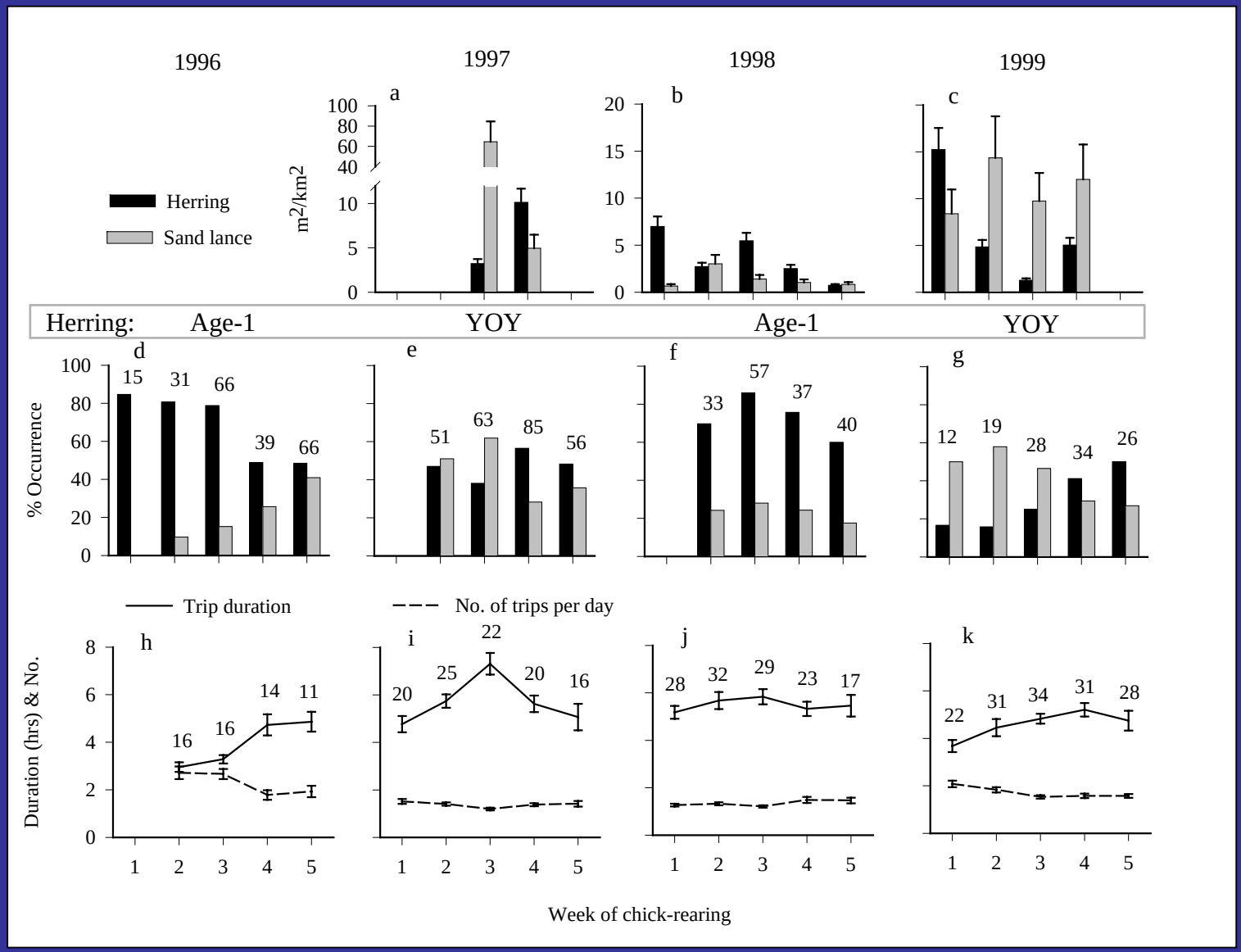


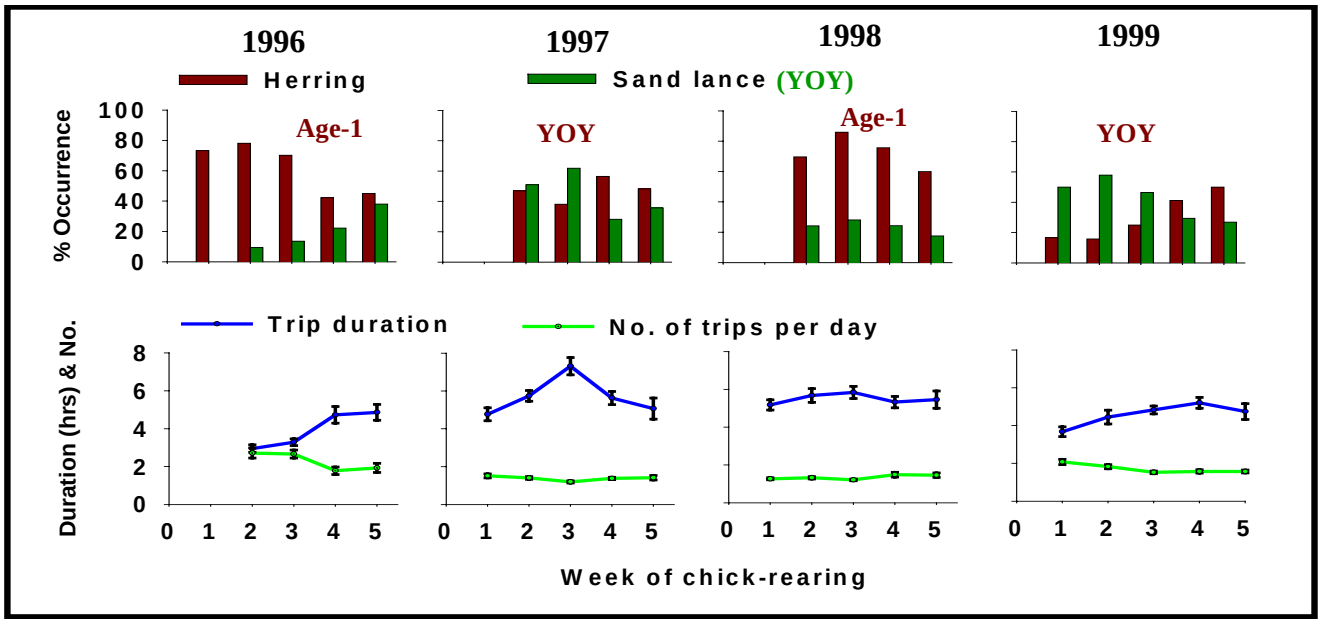
Forage Fish Distribution

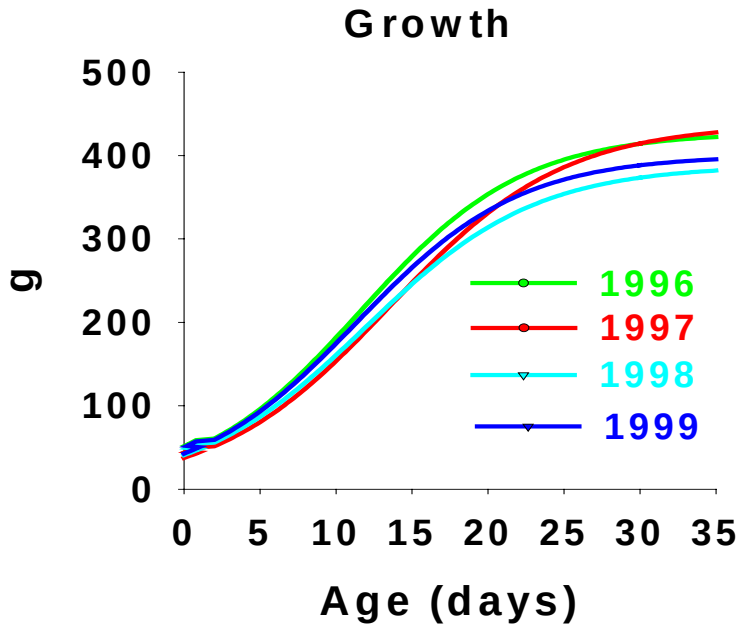


Brown and Moreland 2000

Response to Weekly Fluctuations in Prey Abundance




1996
1997
1998
1999
Herring
Sand lance (YOY)
% Occurrence
Age-1
YOY
Age-1
YOY
Trip duration
No. of trips per day
Duration (hrs) & No.
Week of chick-rearing

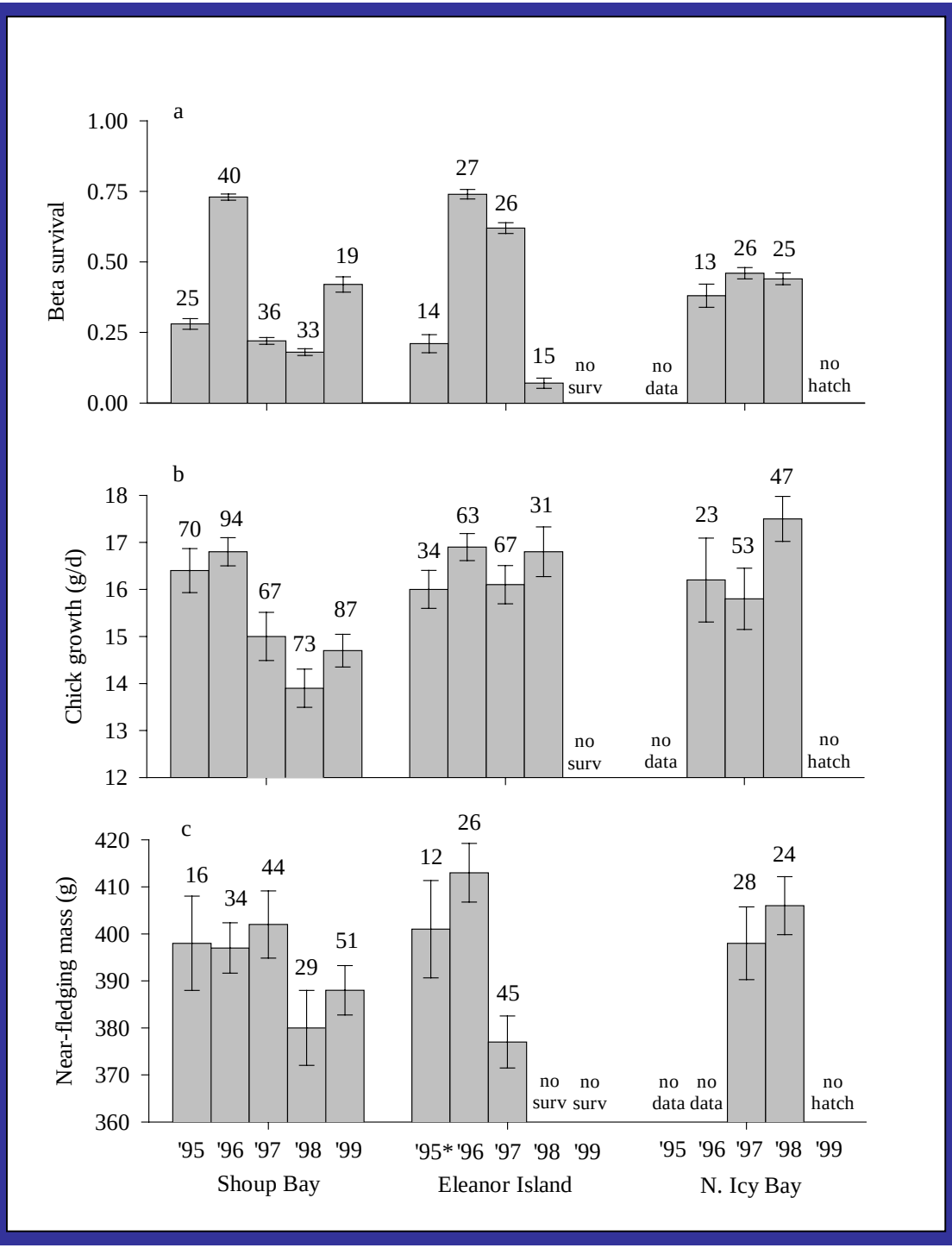

Growth
g
1996
1997
1998
1999
Age (days)

Chick Survival and Growth

Beta Chick Survival

Chick Growth

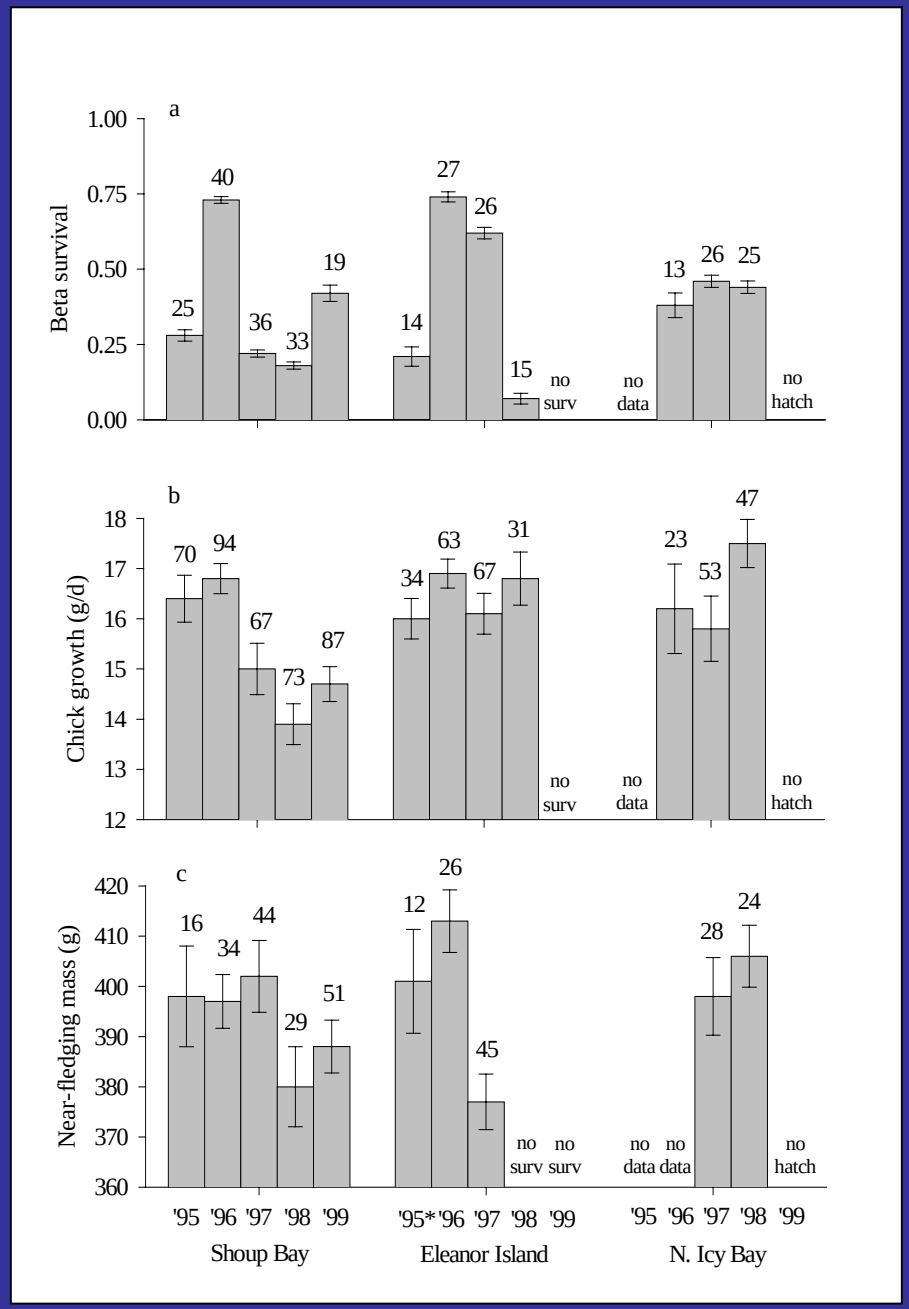
Fledging Mass

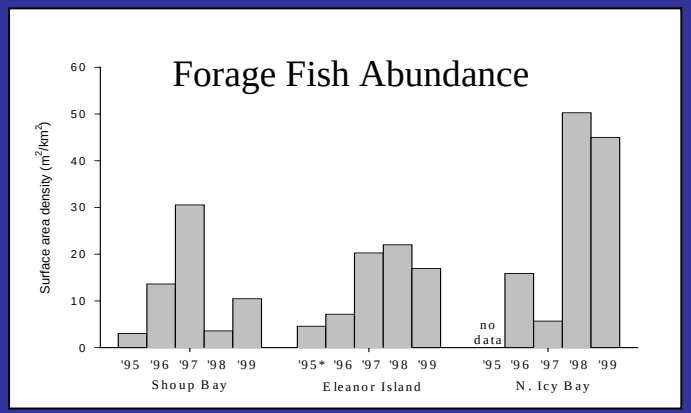


Beta Chick Survival

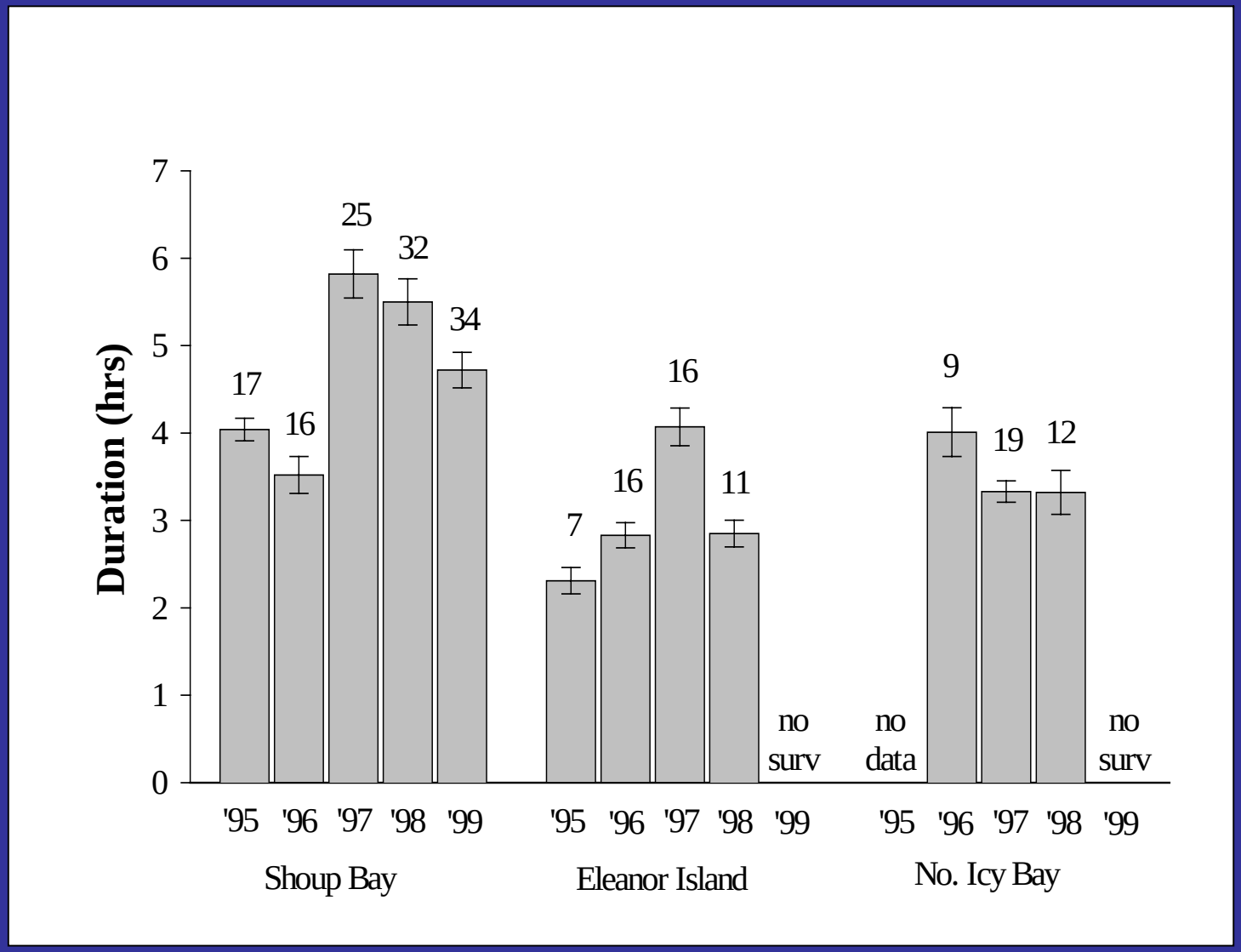
Chick Growth

Fledging Mass

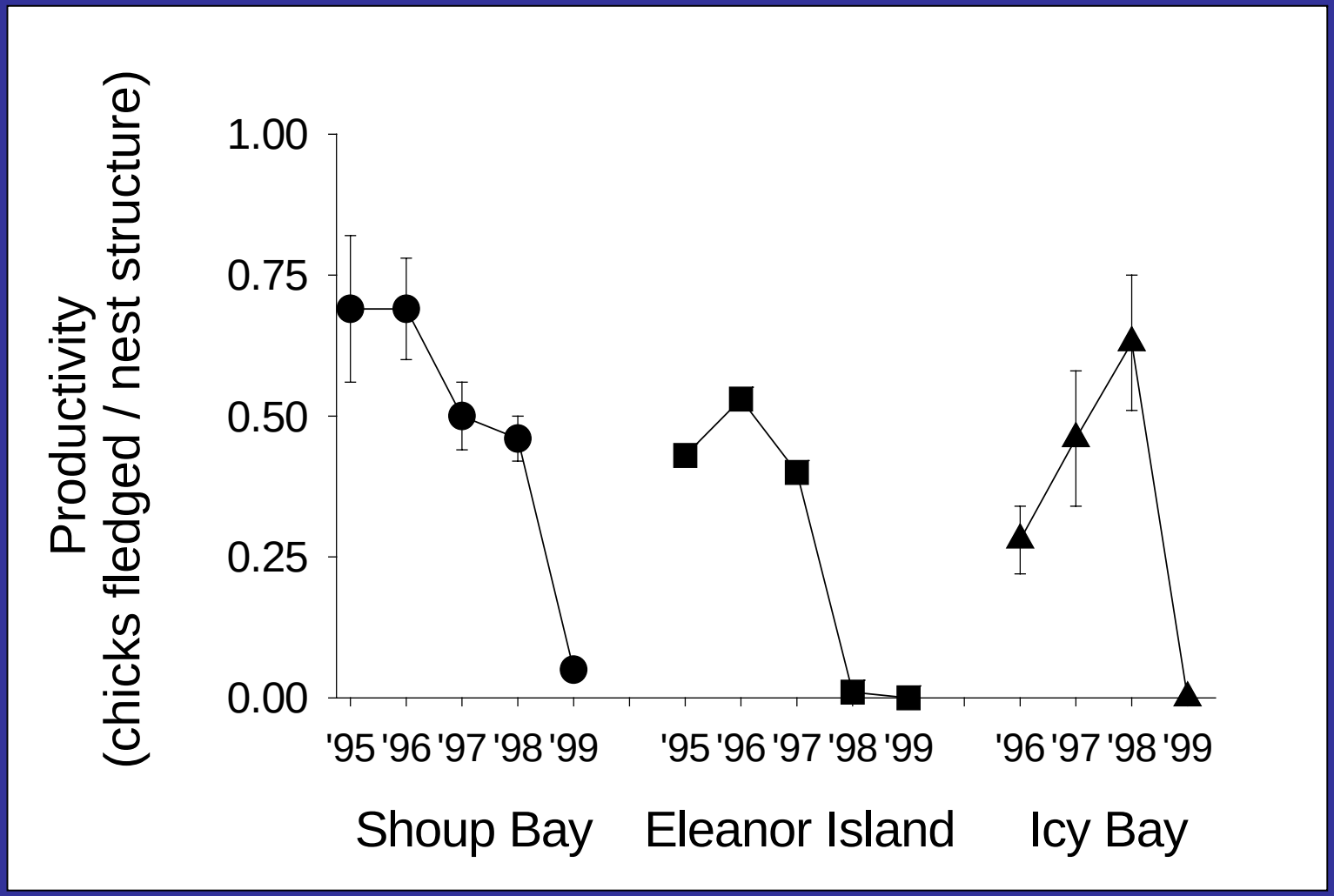




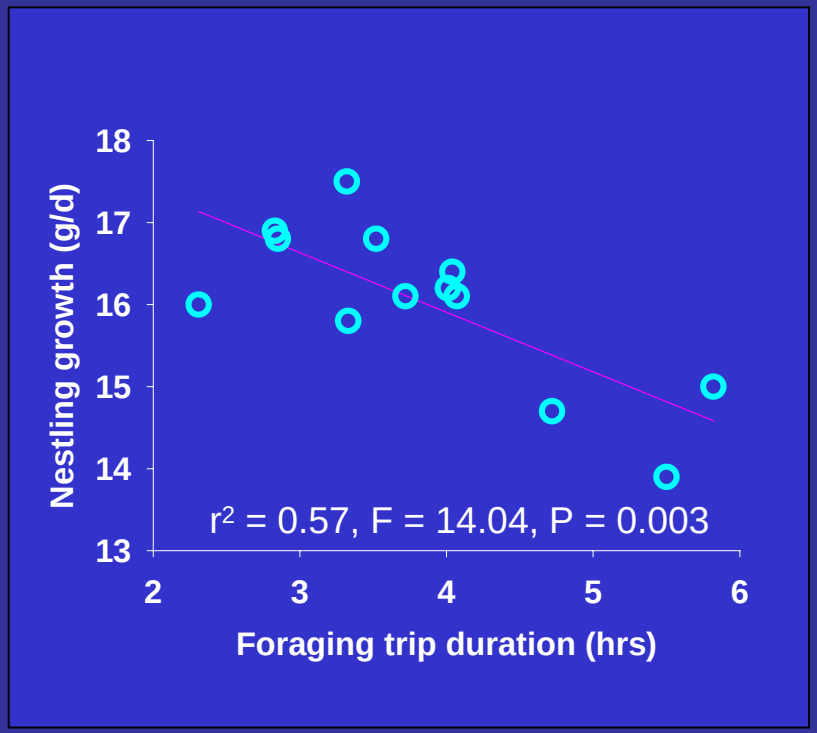
Foraging Trip Duration
Chick-rearing

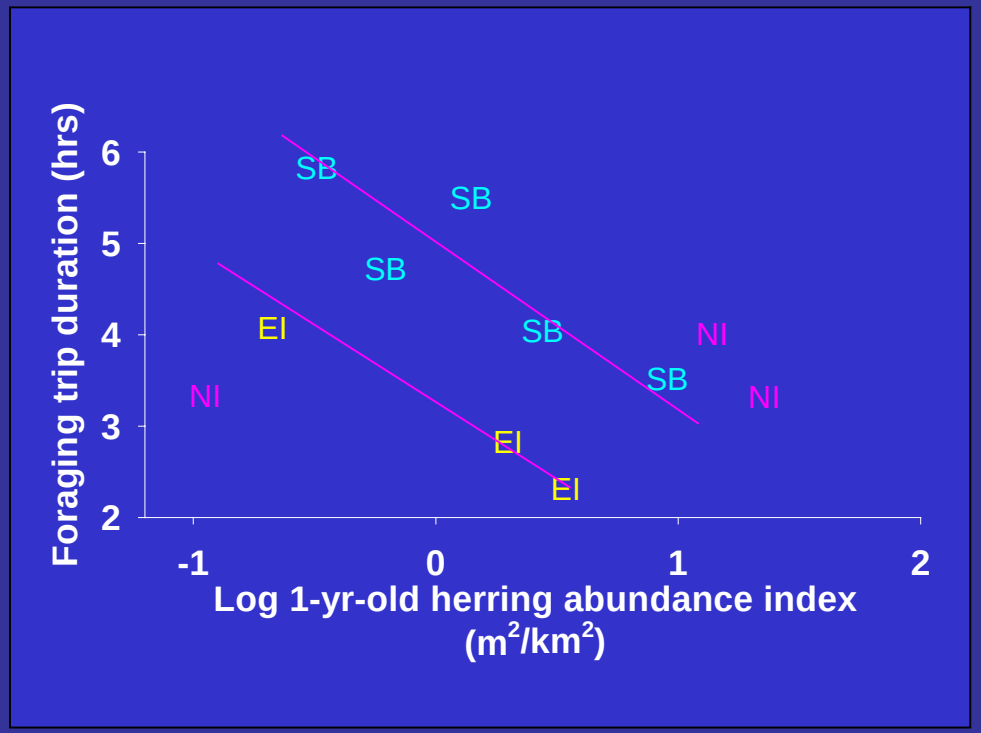


Kittiwake Productivity



Factors Affecting Chick Growth and Provisioning Rate





Feeding rate is very important

Effect of prey abundance varies with colony & prey type

Top Down Effects

Egg and Nest Predators:

Primary: Bald Eagle, Common Raven, Peregrine Falcon

Opportunists: Glaucous-winged Gulls, Northwestern Crow, Black-billed Magpie

Top Down Effects

Predation Rate and Predator Swamping:

Example of intensity: 2 hr period = 36 eggs taken at Shoup Bay and 14 eggs taken at N. Icy Bay. Falcons observed taking up to 6 chicks per day.

At 3 chicks per day 1 falcon pair could remove > 50% of chicks at Eleanor Island, but only 10% of chicks at N. Icy Bay and 3% at Shoup Bay.

Multiple Linear Regression Analysis

Lower Trophic Level Processes

Independent Variables	Laying & Incubation	Nestling
Phytoplankton abundance	X	
Phytoplankton abundance in year t-1*	X	
Timing of peak phytoplankton abund.	X	
Spring SST (March to May)	X	
SST May	X	
SST June	X	

Prey Abundance

Independent Variables	Laying & Incubation	Nestling
Total prey abundance		X
Herring abundance		X
Sand lance abundance	X	X
Capelin abundance		X
1-yr-old herring abundance index*	X	X
1-yr-old herring and sand lance abundance index*	X	X

Colony Effect, Prey Consumption and Foraging Effort

Independent Variables	Laying & Incubation	Nestling
Colony size	X	X
% mass of herring		X
% mass of sand lance		X
% mass of capelin		X
% mass of 1-yr-old herring		X
Age class of herring		X
Foraging trip duration	X	X

Dependent Variables

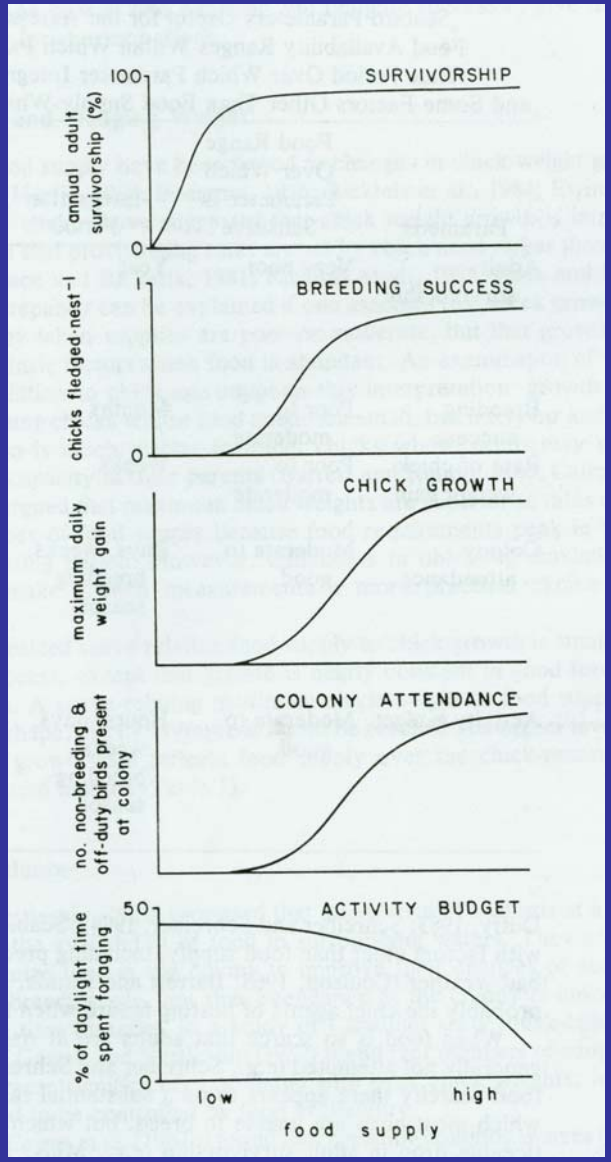
Egg laying	Incubation	Nestling
Laying success (% of nests with ≥ 1 egg)	**Median hatch date**	**Nestling growth**
Mean clutch size	**Hatching success** (% of eggs hatched)	**Beta chick survival**
		Near-fledging mass
		Fledging success (% of chicks fledged)

MLR Results

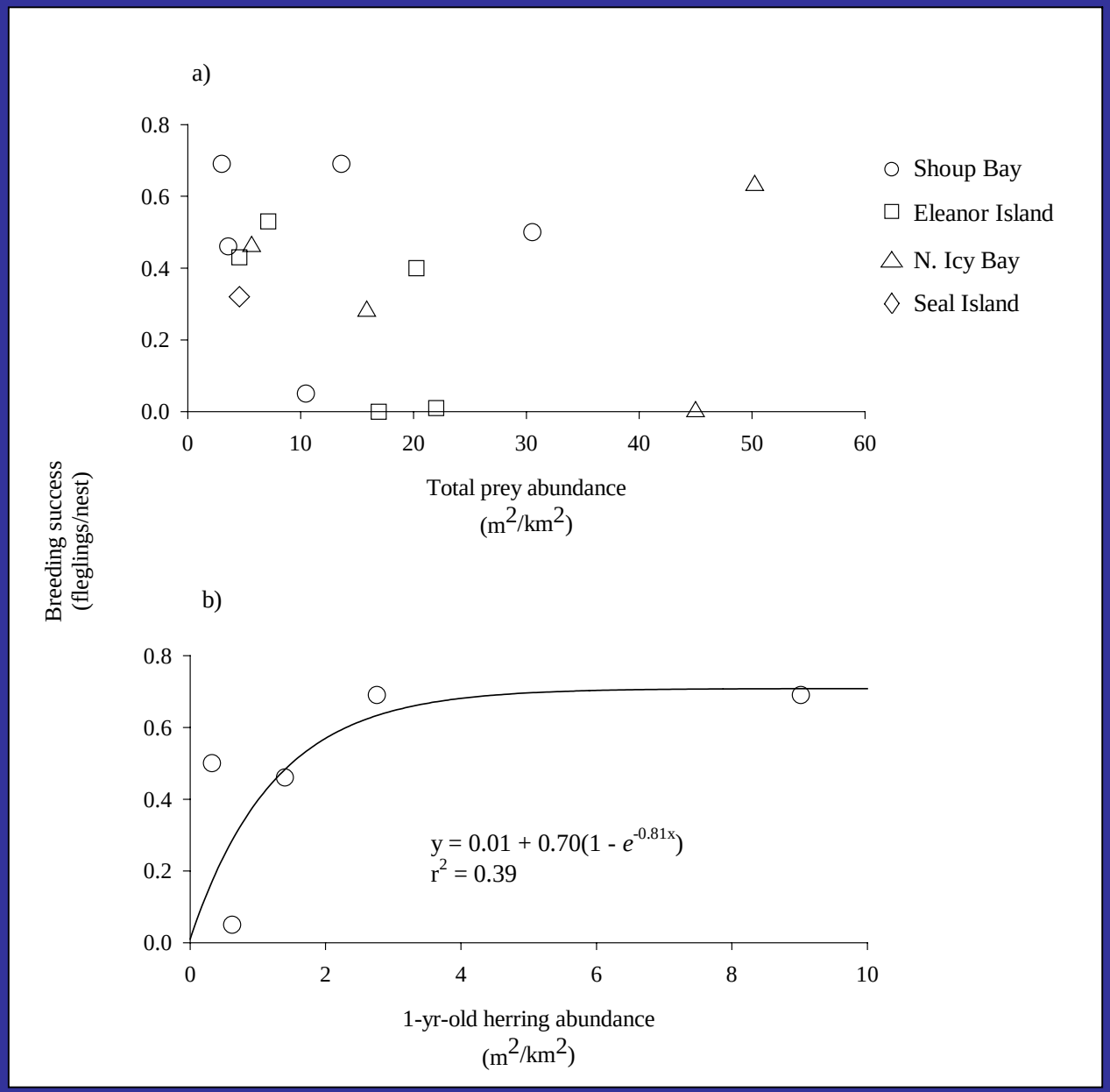
Nestling Growth = Dependent Variable

Ind. Variable	Coeff	Std. Error	t value	Pr(>|t|)
(Intercept)	-60.1906	27.9667	-2.1522	0.0977
Year	0.0422	0.0140	3.0054	0.0397
Size	0.0004	0.0000	8.5458	0.0010
Dur	-1.9430	0.0691	-28.1085	0.0000
lPr1yrHerr	-5.7378	0.1994	-28.7791	0.0000
Size:lPr1yrHerr	0.0001	0.0000	6.5023	0.0029
Size:Dur	-0.0001	0.0000	-14.7983	0.0001
lPr1yrHerr:Dur	1.4904	0.0542	27.5194	0.0000

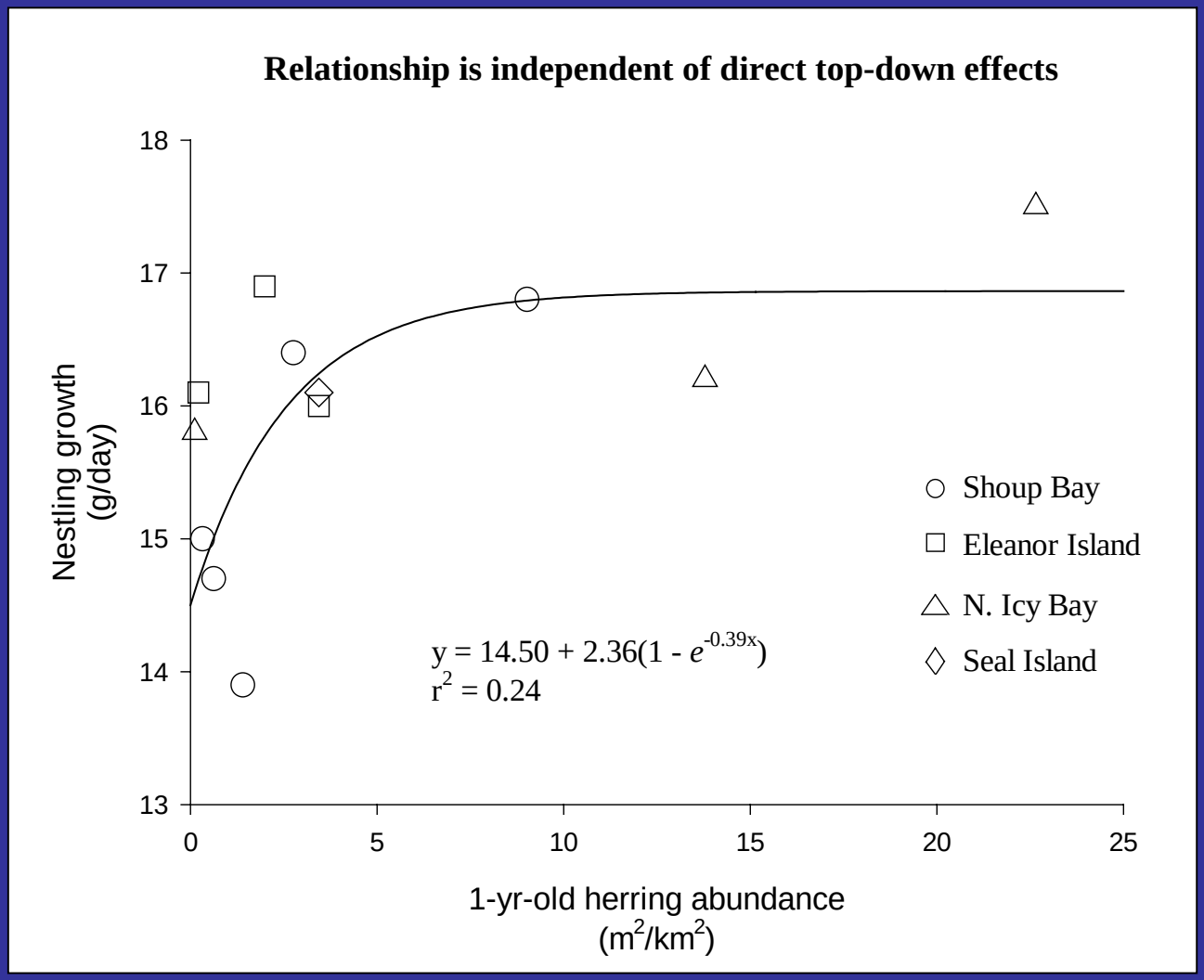
Functional Response Curves (Cairns 1987)



Breeding Success vs. Prey Abundance



Growth vs. Age-1 Herring Abundance



Conclusions
Bottom-up & Colony Specific Effects

Important characteristics of Kittiwake Prey

- **Geographic distribution and abundance**
- **Age class**
- **Energy density (kJ/g)***

Important factors affecting Chick Survival and Growth

- **Feeding frequency (trip duration)**
- **Energy density of prey**

Important factors affecting Foraging Trip Duration

- **Prey Abundance**
- **Age-class of prey (capture time, feeding flock use)**

Colony-specific Kittiwake-Prey Relationships

- **Shoup Bay: 1-yr-old herring critical for maximum productivity**
- **N. Icy Bay and Eleanor Island: can maintain high feeding frequency with YOY fish**

Conclusions
Timing Mismatch and Top-Down Effects

Forage Fishes – timing of arrival and peak abundance

Early Season

- **Age 1 fish available early in breeding season**
- **YOY sand lance available early but availability limited**

Late Season

- **YOY Herring**
- **YOY sand lance more available**

Top-Down Control

- **Predators that specialize on kittiwake colonies**
- **Reduced availability of alternative prey**
- **Predator swamping at large colonies**


Expeditions Alaska
Fishing for Bristol Bay Trout
Alaska
alaskamagazine.com
Exploring Life on the Last Frontier
Why
Wild Salmon
Is Better For You
Kittiwakes
Denali's Old Master
Doggy-gone, It's Nice
To Remember Charlie Ott
An Island Apart
St. Matthew Is a Pristine Wonder
The Edge of Alaska
Images of Beauty Where
the Land Meets the Sea
Ghosts of the Rain Forest
Southeast's Blacktail Deer
Are a Bowhunter's Dream
July 2004
$3.99US $4.99CAN
Display until July 26

Acknowledgments

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***Exxon Valdez* Oil Spill Trustee Council**

U.S. Fish and Wildlife Service

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Prey I.D.

Kathy Turco & Greg Golet

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