SPECIES in the SPOTLIGHT

NOAA FISHERIES

Cook Inlet Beluga Whales: Trends, Movements, and Prey

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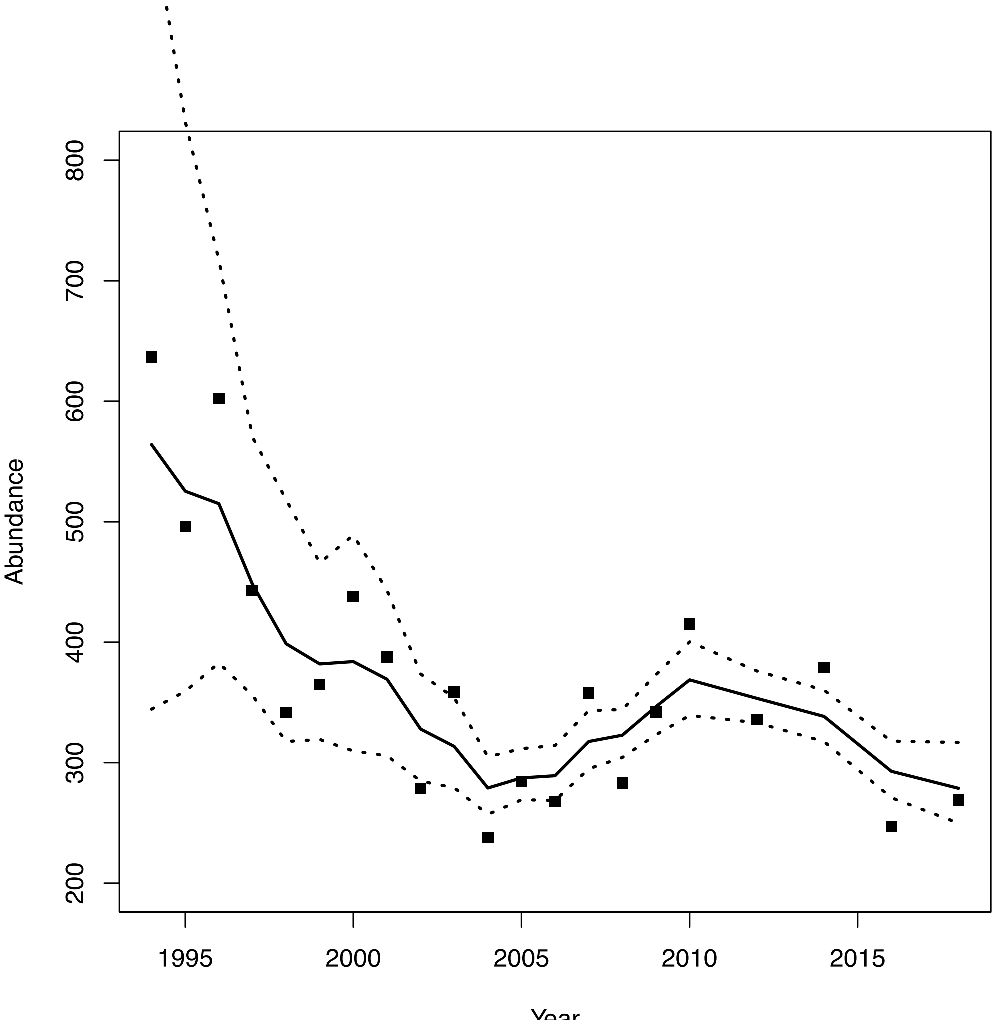
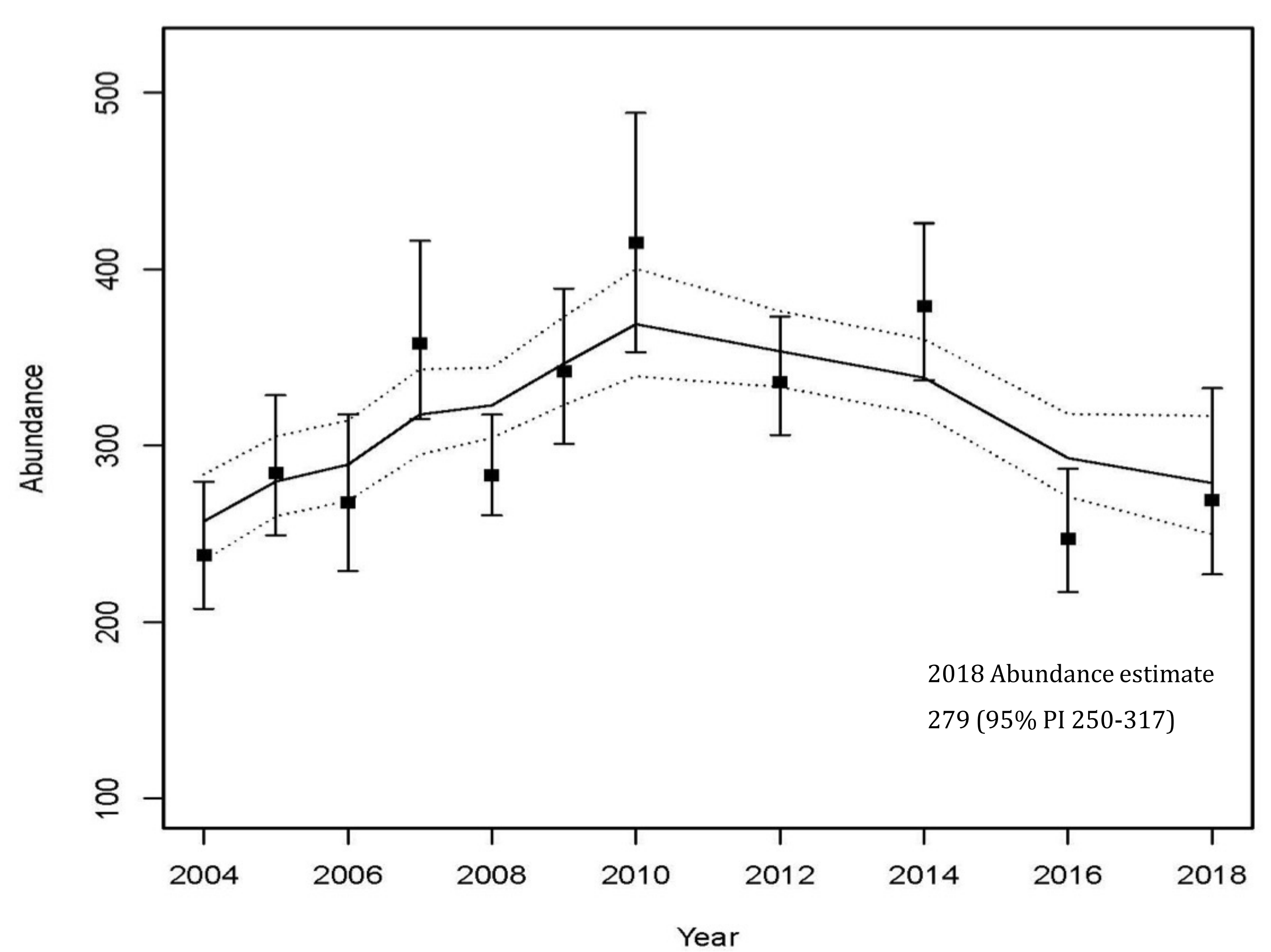
Abundance and trends

- Aerial surveys flown since 1994
- Census of groups in the upper Cook Inlet, with video data used to estimate group sizes
- Consistent methods since 2004
- Most recent survey conducted in 2018
- Revised methods for estimating group size from video data (Boyd et al. 2019)





500
400
300
200
100
Abundance
2004
2006
2008
2010
2012
2014
2016
2018
Year
2018 Abundance estimate
279 (95% PI 250-317)

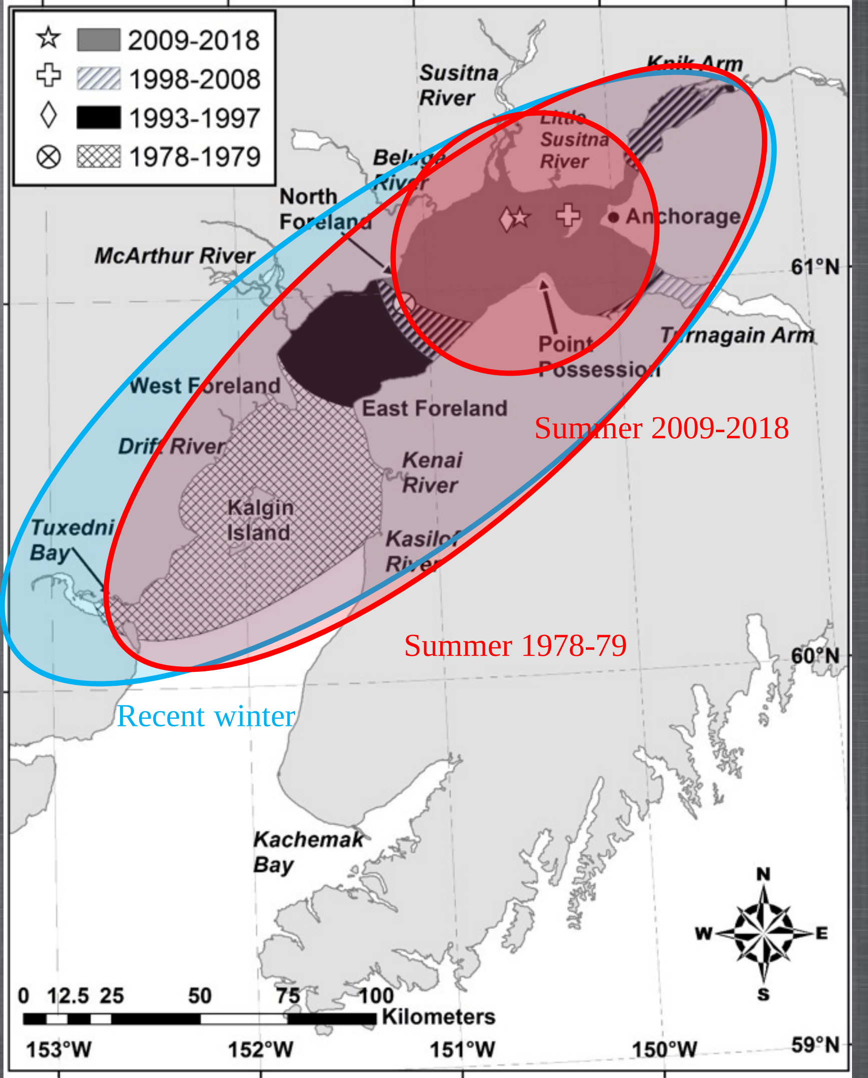
Summer Range

- Cook Inlet belugas have contracted their summer range into the upper Cook Inlet since the 1970s (~75% pop. Decline)
    - Rugh et al. 2010, Shelden et al. 2020

- Nelson et al. (2018)
    - Stable isotopes in annual layers in teeth show a concurrent decline indicating feeding ecology changed
    - Shift in strontium isotopes likely due to contraction in range to the upper Inlet, and consumption of more fresh-water influenced prey

Winter/Spring Range

- Still use parts of upper Inlet where ice free
- Also found in the middle Inlet:
    - Kenai/Kasilof Rivers
    - Trading Bay (McArthur River)
    - Kalgin Island area
    - Tuxedni Bay
- Rarer sightings in lower Inlet



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Diet of Beluga Whales, *Delphinapterus leucas*, in Alaska from Stomach Contents, March–November

LORI T. QUAKENBUSH, ROBERT S. SUYDAM, ANNA L. BRYAN, LLOYD F. LOWRY, KATHRYN J. FROST, and BARBARA A. MAHONEY

Quakenbush et al. 2015. Marine Fisheries Review 77(1):70-84

Cook Inlet beluga stomachs, 2000-2010, March to November
N=24 (6 were empty, so 18 with prey contents)

<u>% stomachs occurrence</u>	
Salmonids (coho, chum, chinook)	67%
Gadids (Saffron cod, pollock, Pacific cod)	42%
Shrimp (Caridea, Crangonidae)	39%
Eulachon	11%

<u>Numerical % of all fish (sums to 100%) (Shrimp not included)</u>	
Gadids	42%
Salmonids	38%
Eulachon	12%
Other	8%

Another 24 stomachs looked at qualitatively in 1992-2001 were found to only have eulachon and chinook.

Summer movements with tides

- Low tide
  - Edge of tidal mudflats in deeper water
- High tide
  - On tidal mudflats and entering river mouths

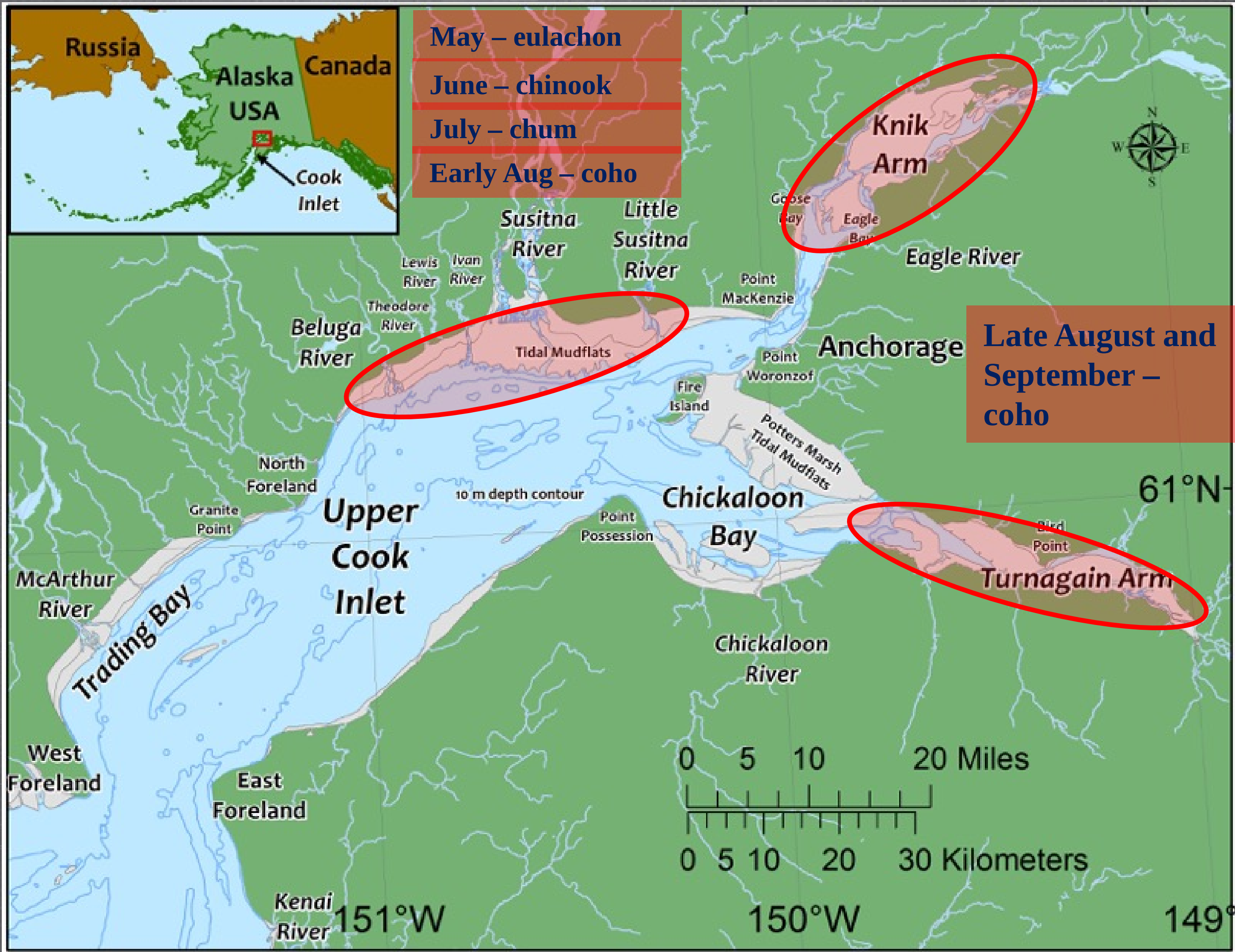
Summer aggregations on single prey types

- May - Susitna
  - eulachon
- June - Susitna
  - chinook
- July – Susitna
  - chum
  - but also sockeye and pink
- Early August – Susitna
  - coho
- Late Aug/September – Knik and Turnagain Arms
  - coho

This represents most of the biggest runs of chinook, chum, and coho in the middle and upper Inlet, except:

- Kenai River chinook
- Kasilof River chinook

- Not clear why those runs are not used
  - One hypothesis is human disturbance from boat traffic and dipnetters



Declines in upper Cook Inlet salmon?

A. M. Reiner and N. A. DeCovich 2020
ADF&G Fishery Manuscript No. 20-01

Susitna River Chinook Salmon Run Reconstruction and Escapement Goal Analysis

"…All stocks have been near historical minimums in the last 10 years…"

Appendix C1-4
Annual abundance estimates
Total in-river run size estimates

2004-2009: 121,552
2010-2017: 72,221 (59% of previous)

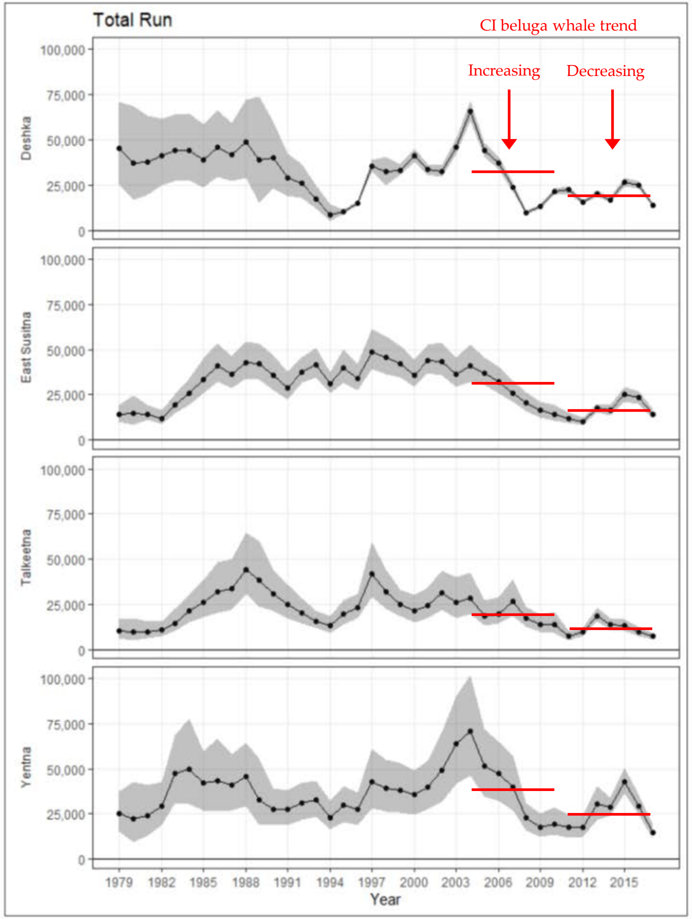


Figure 23.–Point estimates (posterior medians; solid lines) and 95% credibility intervals (shaded areas) of total run abundance from a state-space model by stock, 1979–2017.

66

Mauger, S., R. Shaftel, J. C. Leppi, and D. Rinella. 2017. Summer temperature regimes in southcentral Alaska streams: watershed drivers of variation and potential implications for Pacific Salmon. Canadian Journal of Fisheries and Aquatic Sciences 74:702–715.

Indicates water temperature in upper Cook Inlet rivers routinely exceeds threshold that effects salmon survival.

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NMFS ESA/MMPA Permit #20465


NMFS ESA/MMPA Permit #20465

Main prey by month
Summary of data, TEK, inference from aggregations of whales

Small, Quakenbush, and Willette 2013

Month	Main Prey	Location
All months	Saffron cod?	Various locations
	Shrimp?	Various locations
March	Herring?	Lower and Middle inlet (Kamishak Bay)
April	Eulachon	Tyonek, Beluga River
May	Eulachon	Susitna Delta rivers upper Turnagain Arm
June/early July	Chinook	Susitna Delta rivers
Late July/early Aug	Chum	Susitna Delta rivers
Late Aug/Sept	Coho	Knik Arm Turnagain Arm Chickaloon River
	Eulachon	Kenai River
October	Coho	Turnagain Arm (6 Mile) Chickaloon River
November	Longfin smelt?	Knik Arm

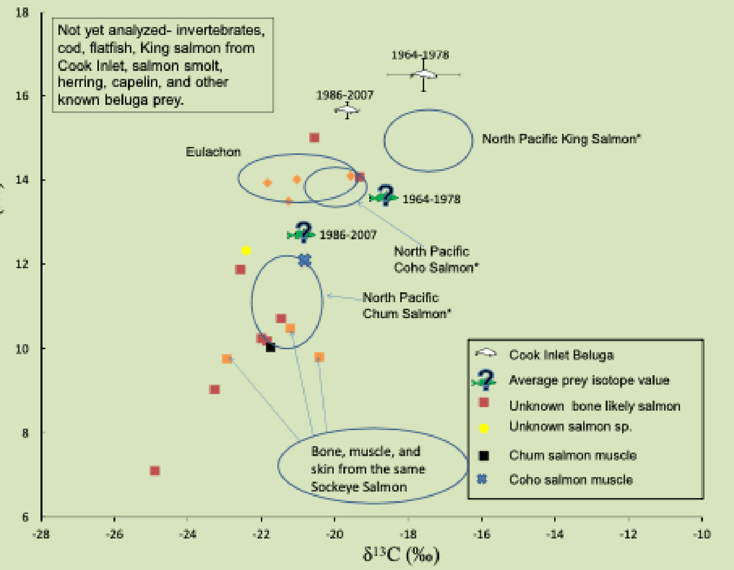

Figure 4. Values of adult belugas, extrapolated prey, and potential prey items in Cook Inlet. * Values for North Pacific salmon from *F.R. Satterfield IV and B.P. Finney. Progress in Oceanography 53 (2002) 231–246*

esa ECOSPHERE

Relationship between per capita births of Cook Inlet belugas and summer salmon runs: age-structured population modeling

STEPHANIE A. NORMAN,[1,5,†] RODERICK C. HOBBS,[2] LAUREL A. BECKETT,[3] STEPHEN J. TRUMBLE,[4] AND WOUTRINA A. SMITH[1]

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[2]Marine Mammal Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, Washington 98115 USA
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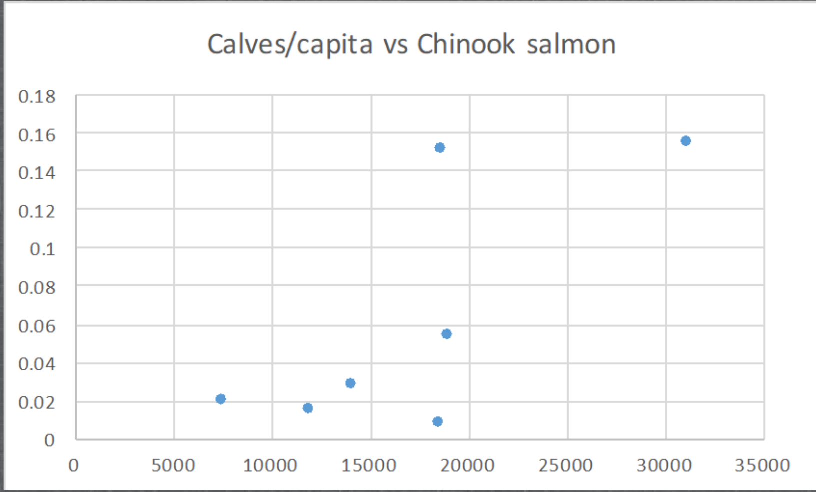
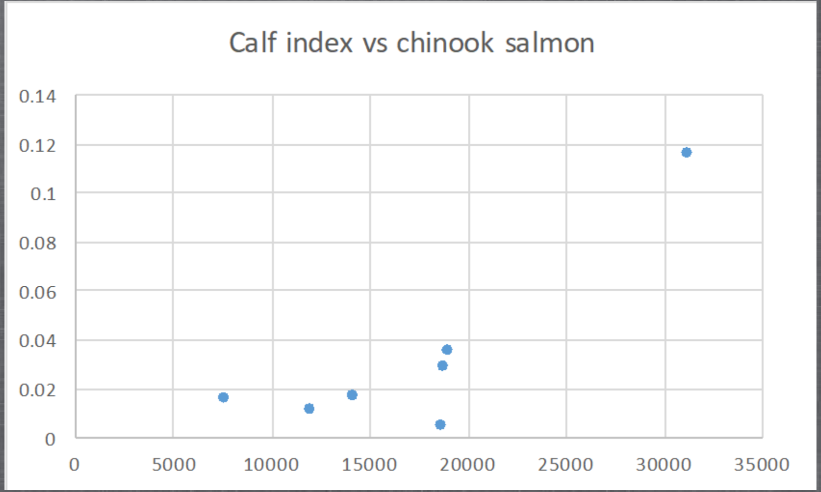
[4]Department of Biology, Baylor University, Waco, Texas 76798 USA

Citation: Norman, S. A., R. C. Hobbs, L. A. Beckett, S. J. Trumble, and W. A. Smith. 2019. Relationship between per capita births of Cook Inlet belugas and summer salmon runs: age-structured population modeling. Ecosphere 11(1): e02955. 10.1002/ecs2.2955

Concerns regarding results they report:

1. Only 7 years data (2006-2012)
2. Calf index based on proximity to adult, so smears across multiple age classes (~0-4 year olds)
3. Calf index is modified in an un-described way to account for calves born after calf survey in August.
4. Salmon data are only chinook and coho escapement from Deshka River.
5. Model selection is based on unmodified R^2.
6. They do not show the correlation (see below).
7. Relationship driven by just 2 high values.





Important changes to the abundance estimation and time-series

- (1) Established consistent criteria for whether a survey day should be included or excluded from the analysis
- (2) Now using median (instead of mean) across all acceptable survey days to produce an annual estimate
- (3) Developed a new statistical method for estimating group size from video data collected during the aerial survey
- Applied these changes across all the survey data 2004 to 2018

Marine Mammal Science

MARINE MAMMAL SCIENCE, 9999(9999): 1–25 (2019)

DOI: 10.1111/mms.12592

Bayesian estimation of group sizes for a coastal cetacean using aerial survey data

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ABSTRACT

Many small cetacean, sirenian, and pinniped species aggregate in groups of large or variable size. Accurate estimation of group sizes is essential for estimating the abundance and distribution of these species, but is challenging as individuals are highly mobile and only partially visible. We developed a Bayesian approach for estimating group sizes using wide-angle aerial photographic or video imagery. Our approach accounts for both availability and perception bias, including a new method (analogous to distance sampling) for estimating perception bias due to small image size in wide-angle images. We demonstrate our approach through an application to aerial survey data for an endangered population of beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska. Our results strengthen understanding of variation in group size estimates and allow for probabilistic statements about the size of detected groups. Aerial surveys are a standard tool for estimating the abundance and distribution of various marine mammal species. The role of aerial photographic and video data in wildlife assessment is expected to increase substantially with the widespread uptake of unmanned aerial vehicle technology. Key aspects of our approach are relevant to group size estimation for a broad range of marine mammal, seabird, other waterfowl, and terrestrial ungulate species.

Correction factors for group size estimation

- Availability bias due to diving behavior
    - individuals unavailable in video data because submerged ("availability bias")
- Perception (detection) bias
    - individuals not detected because of small image size in video data
- Availability bias due to proximity in video data
    - individuals unavailable because concealed by another animal ("proximity bias")
- Individual observer bias
    - the tendency for individual observers to under- or over-count whales – only applied to estimate group size if no video available

Improvements to the group size estimation

- The important assumption was added that the true group size was the same for all video passes
  - i.e., observations of the same group surveyed on a particular day

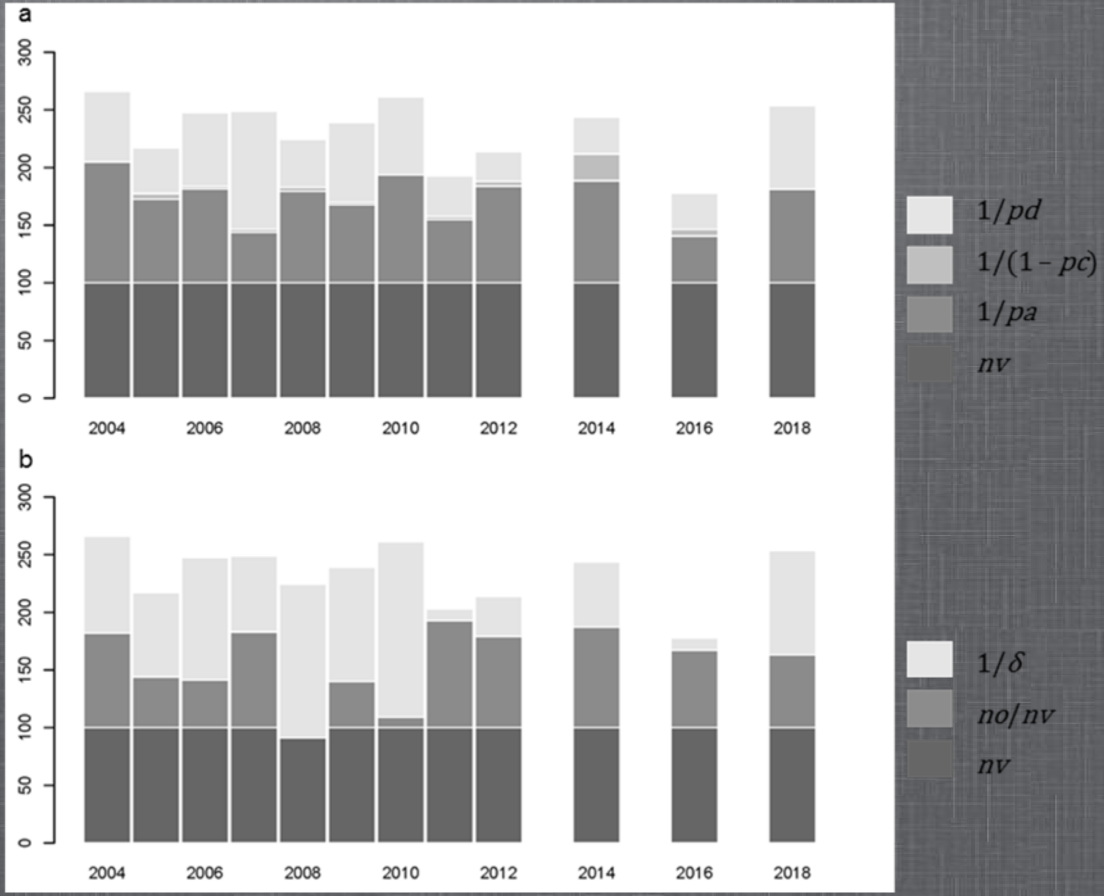
- A broad distribution for mean dive time was used instead of a single fixed value to better capture uncertainty

- To correct for whales too small to be seen in the video image (perception bias), two distributions are simultaneously estimated rather than using *ad hoc* methods as was previously done

- Uncertainty in the parameter estimates is more fully accounted for using more modern statistical methods (i.e., Bayesian hierarchical modeling).

(a) Standardized representation of median correction factors for video counts by survey year (pa is availability bias; pc is proximity bias; and pd is detection bias), based on 100 hypothetical individuals detected in a wide-angle video clip (nv) in each survey year.

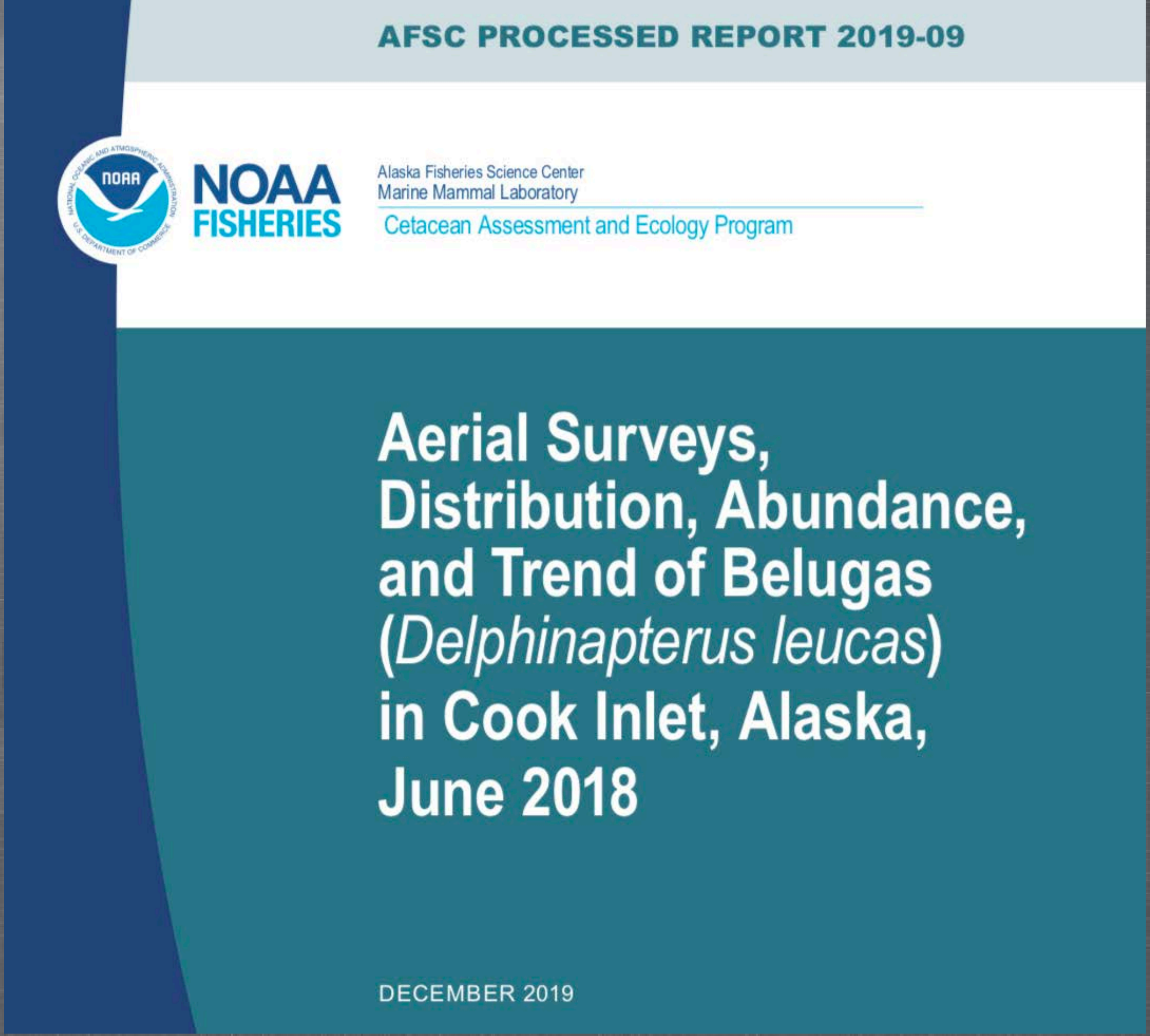
(b) (b) Standardized representation of the median correction factor for observer bias (δ) by survey year

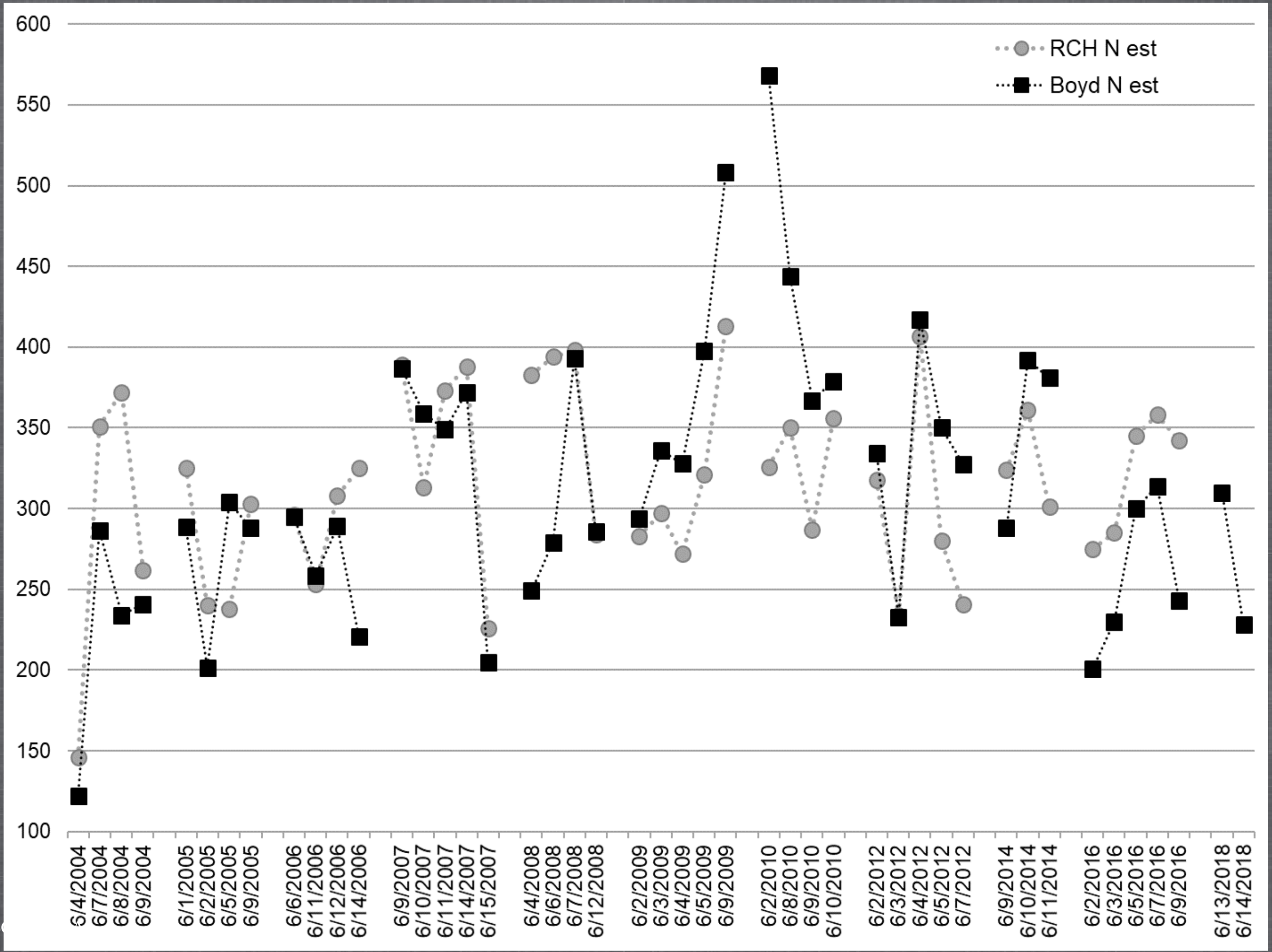


Shelden, K. E. W. and P. R. Wade (editors). 2019. Aerial surveys, distribution, abundance, and trend of belugas (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2018. AFSC Processed Rep. 2019-09, 95 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

CHAPTER 2: Group Size Estimates and Revised Abundance Estimates and Trend for the Cook Inlet Beluga Population

P. R. Wade, C. Boyd, K. E. W. Shelden, and C. L. Sims





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Boyd N est
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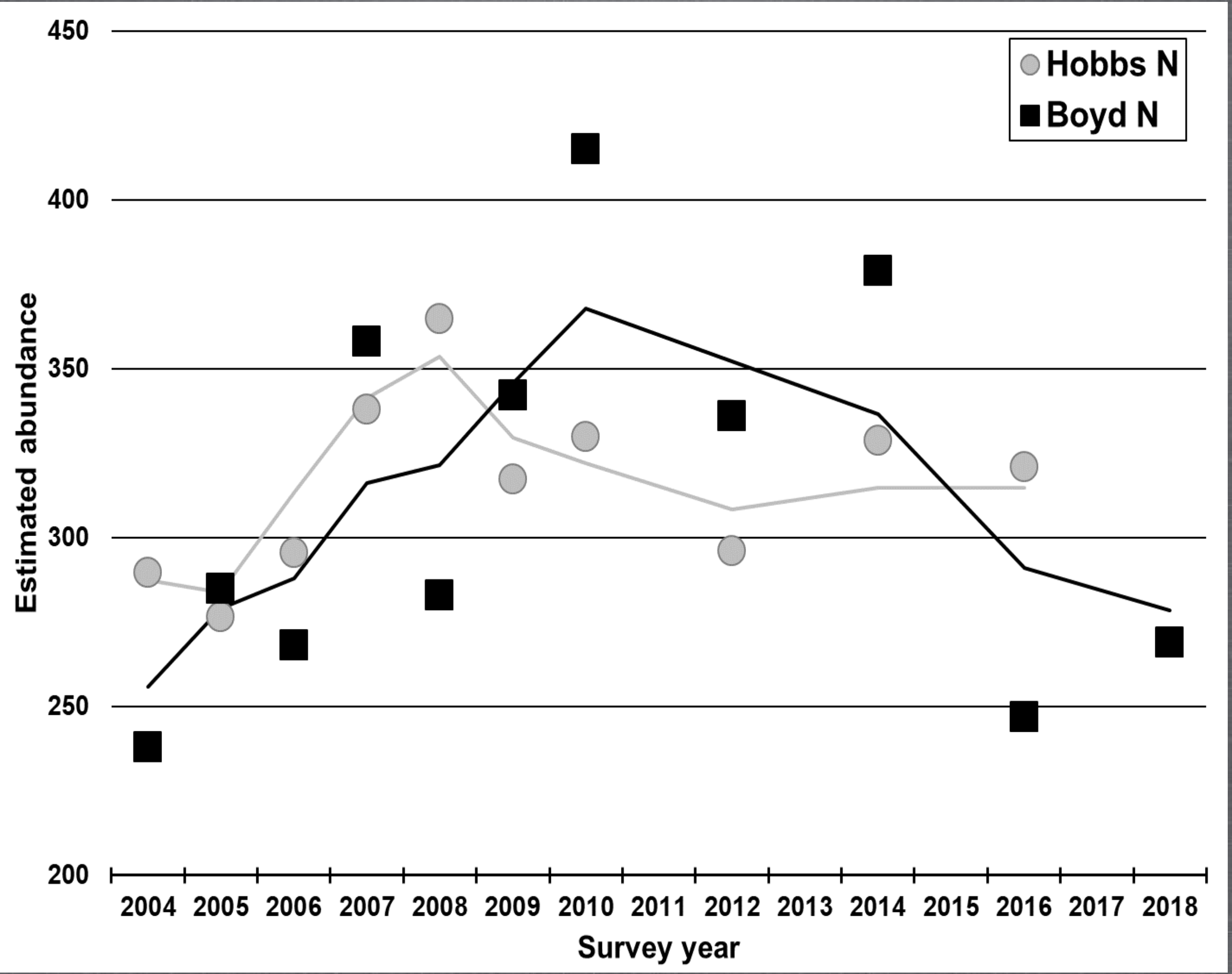

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