

CRESCENDOS in HEAVY METAL:



<http://www.schmetzpetz.us/>

Increasing mercury concentrations in Steller sea lion pups
at Agattu Island, western Aleutian Islands, Alaska

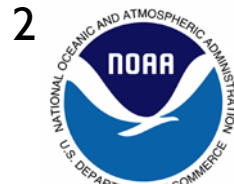
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Julie Avery^{1A}, Brian Fadely², Mandy Keogh^{3D}, Michael Rehberg^{3E}, and Lorrie Rea^{1A}



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Alaska Fisheries Science Center
Marine Mammal Laboratory
Seattle, Washington



Division of Wildlife Conservation
Steller Sea Lion Research Program

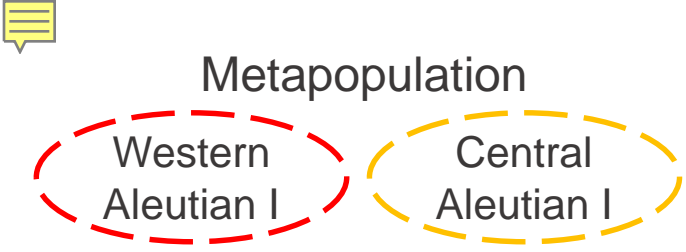
D Douglas, Alaska

E Anchorage, Alaska

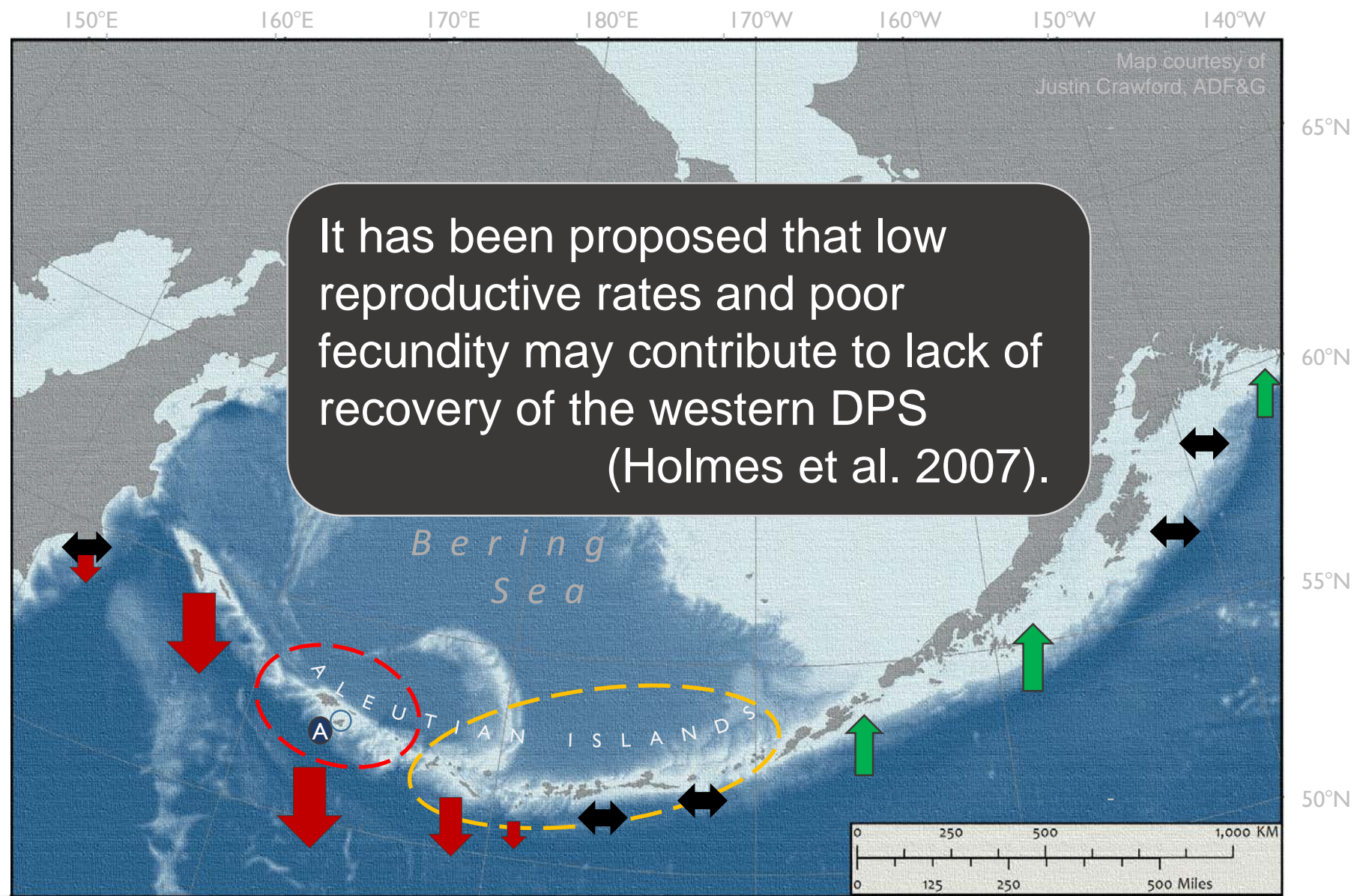
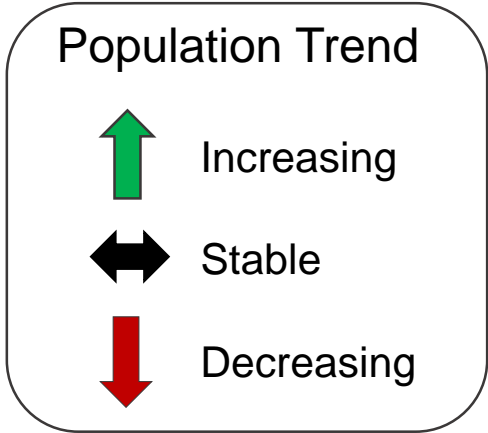
Large bodied,
long-lived marine predators
which bioaccumulate
environmental contaminants

Share marine fish and
cephalopod diet with
humans & important
to subsistence hunters

Widely distributed, but locally-foraging marine
apex predator → sentinels of contaminants in
Bering Sea & North Pacific food webs



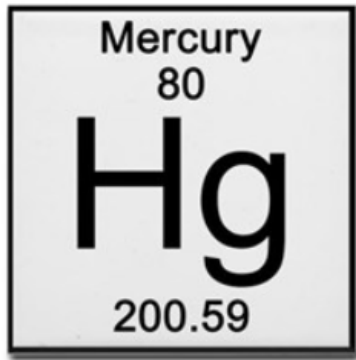
A Agattu Island



Current trends data: Fritz et al. 2014. Recent increases in survival of western Steller sea lions in Alaska and implications for recovery. *Endangered Species Research*. 26 (1): 13-24.

Altukhov et al. 2015. Age specific survival rates of Steller sea lions at rookeries with divergent population trends in the Russian Far East. *PLoS One*. 10(5).

Holmes et al. 2007. Age-structured modeling reveals long-term declines in the natality of western Steller sea lions. *Ecological Applications*. 17(8): 2214-2232.



Mercury

Much is known about mercury...

Bacteria transform to MeHg+

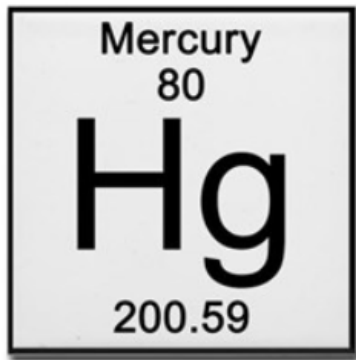
- Bioaccumulates → individuals
- Biomagnifies → throughout food web
- Neurotoxic → humans/other piscivorous mammals
- Neurochemical changes → impact mammalian health & survival
- Crosses blood-brain and placental barriers → exposing fetus



EXPERIMENTAL STUDIES

Lower reproductive rates
(mink)

Reduced foraging efficiency
(diving piscivorous birds)



Mercury

All humans exposed to some level of Hg, with two groups being of higher sensitivity

- (1) fetuses
- (2) those chronically exposed

The dose makes the poison.
~Paracelsus

**Threshold of
Potential Adverse Effects
= 20 µg/g = 20 PPM**

(World Health Organization 1990,
Thompson 1996)

.....

World Health Organization. 1990. Environmental health criteria for methylmercury: Evaluation of human health risks. WHO, Geneva, Switzerland.

Thompson, D. R. 1996. Mercury in birds and terrestrial mammals. Pages 341-356 in W. N. Beyer, G. H. Heinz, and A. W. Redmon-Norwood, editors. Environmental Contaminants in Wildlife. Interpreting Tissue Concentrations. CRC Press, SETAC Special Publications Series, New York.

Mercury Assessment

FIELD

Collect lanugo from young Steller sea lion pups on natal rookeries.

LAB

Wash fur with a mild detergent, then freeze dry.

Process lanugo through Direct Mercury Analyzer (Milestone, Inc.) to obtain total mercury concentration, [THg].

Need ~ 20-30 mg washed fur for analysis.



Washed
Steller sea lion
lanugo

Direct
Mercury
Analyzer



Lanugo

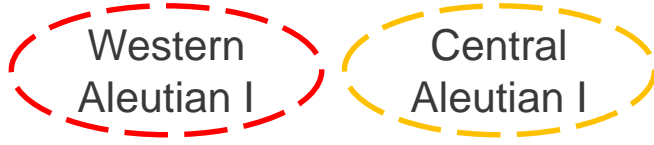
Grown *in utero*

Reflects the
dam's diet during
late gestation

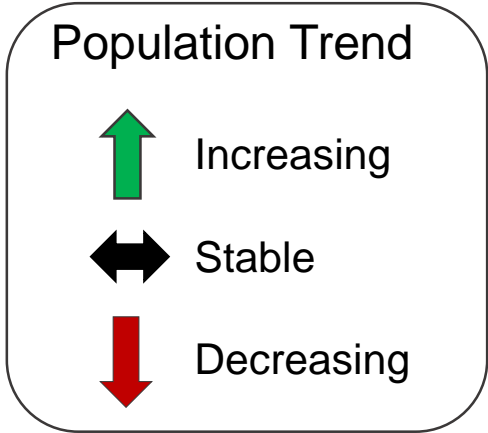




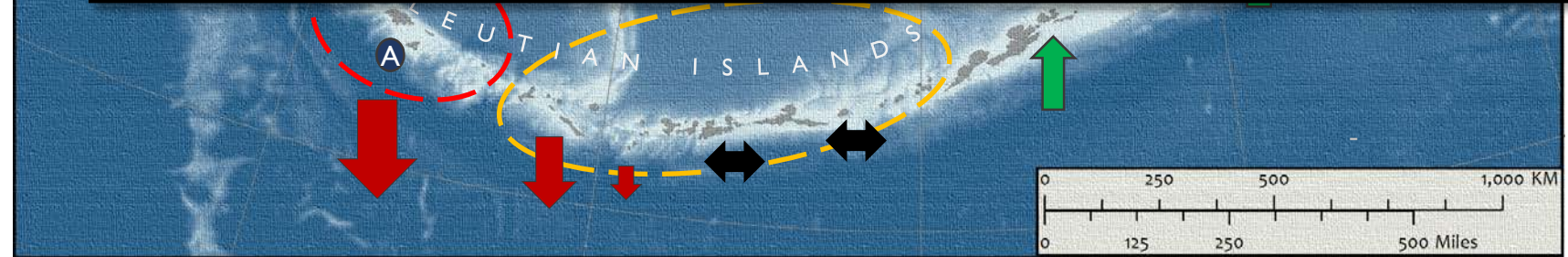
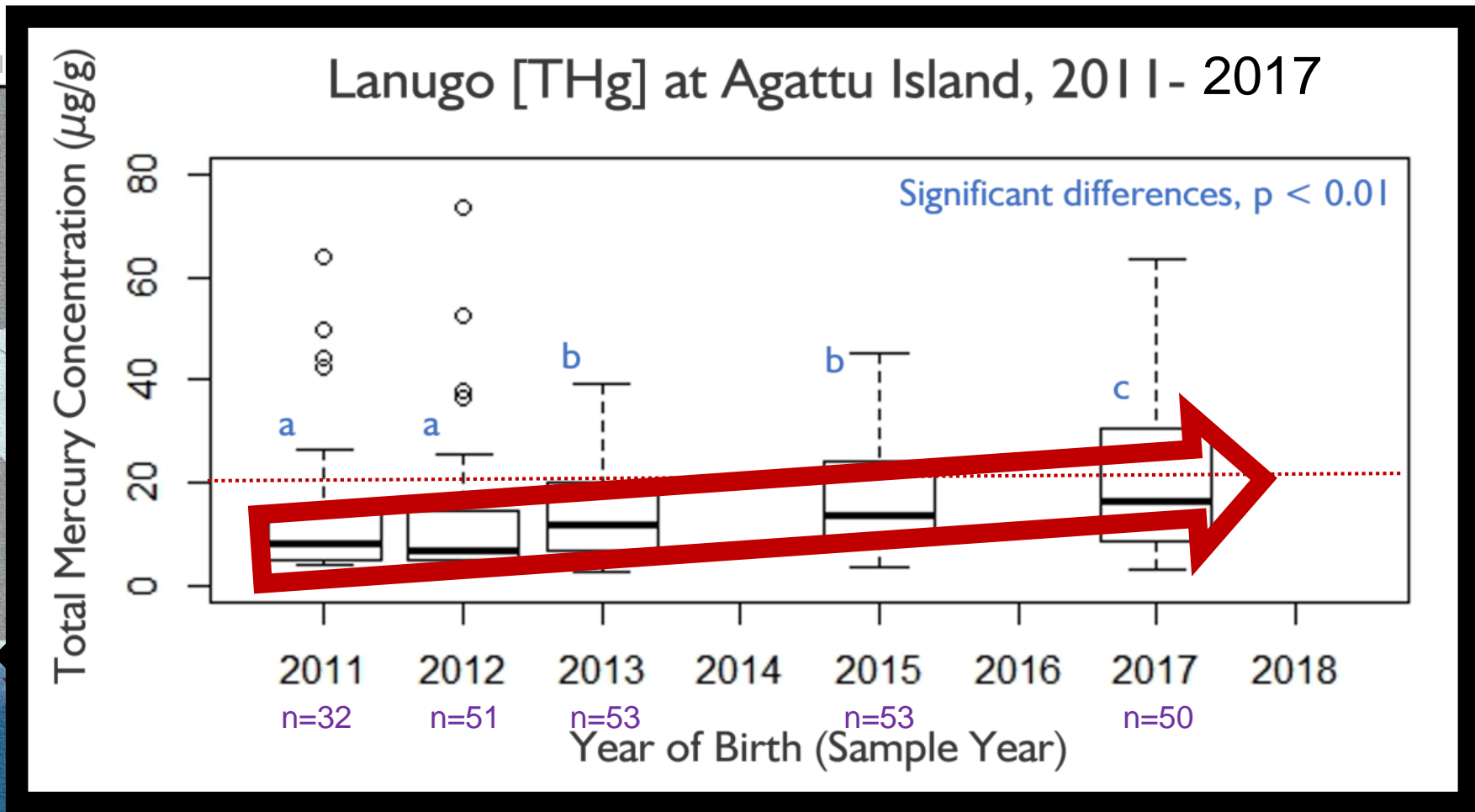
Metapopulation



A Agattu Island



In toxicology, typically changes are detected *between* decades (plural), not *within* a decade.

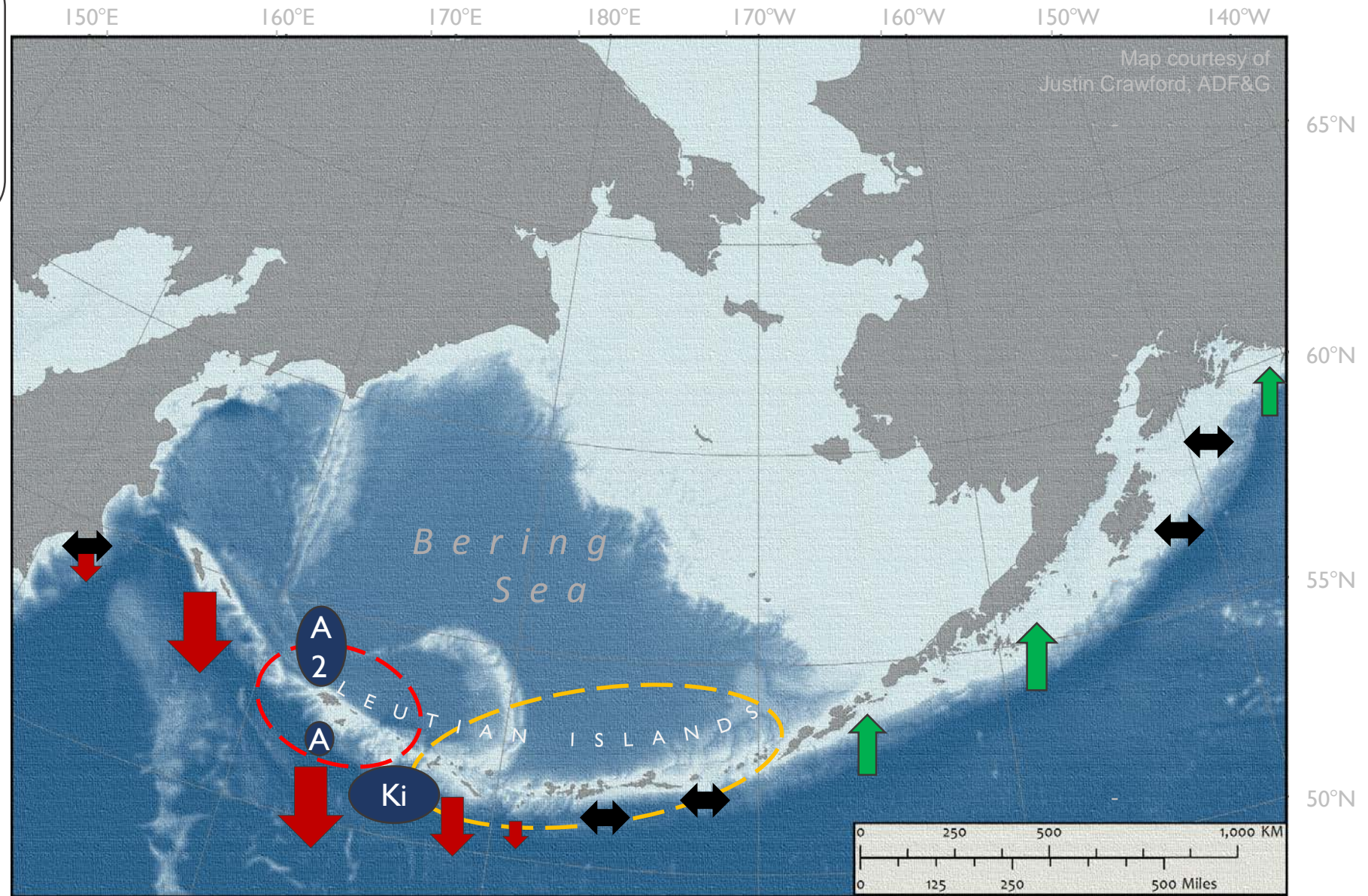


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HOT OFF THE MACHINE... 2018 SAMPLES

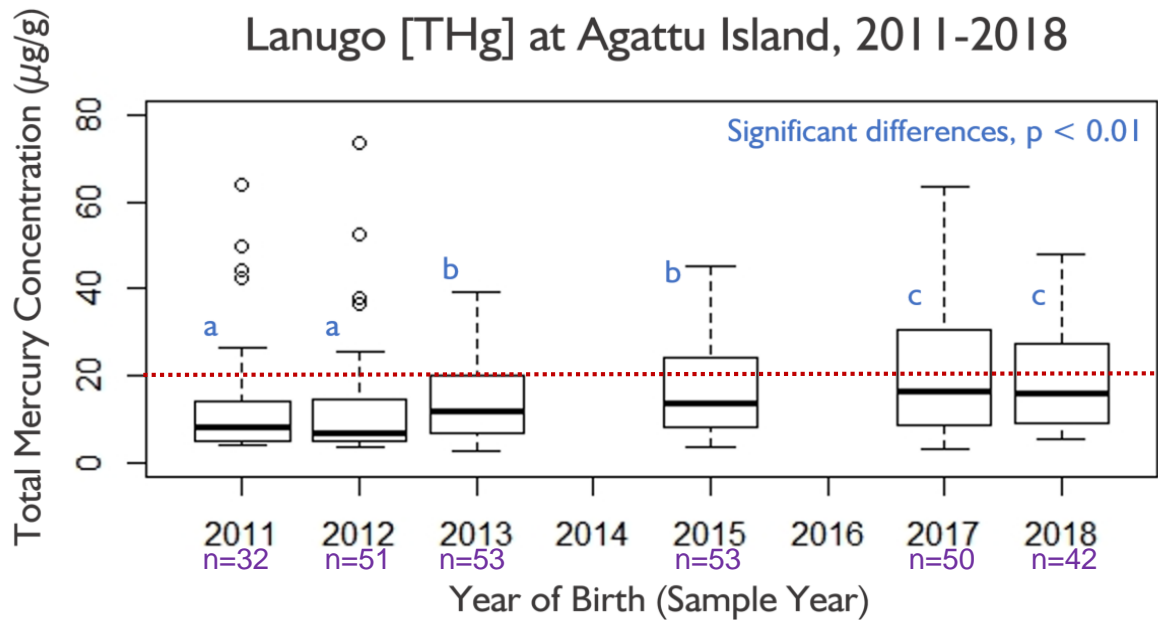
- Western Aleutian I
- A** Agattu Island
- A** Attu Island
- 2
- Central Aleutian I
- Ki** Kiska Island



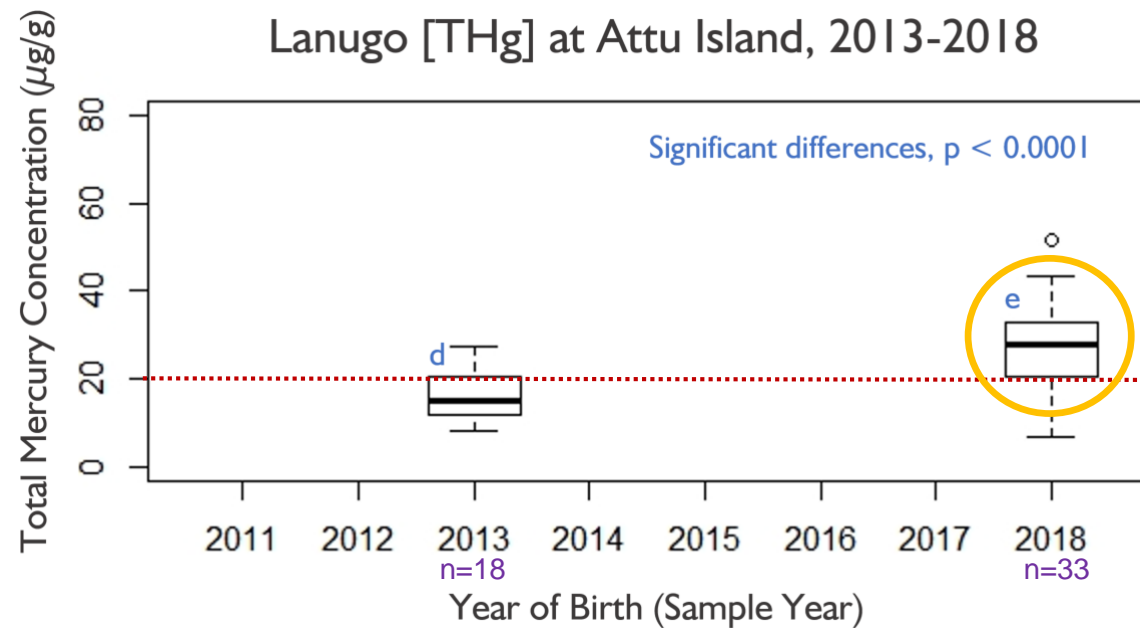
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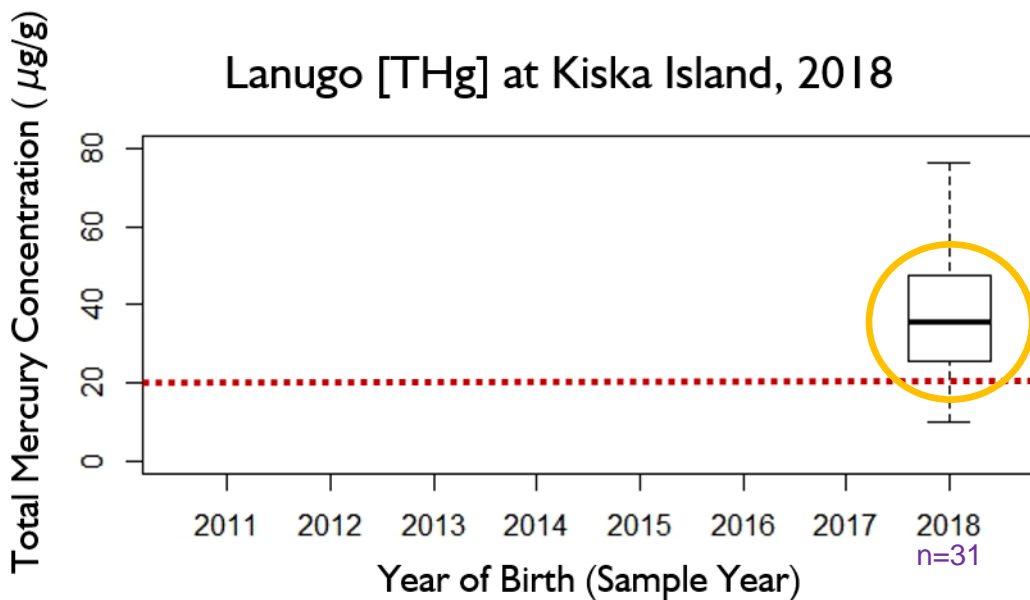
Lanugo [THg] at Agattu Island, 2011-2018



Lanugo [THg] at Attu Island, 2013-2018



Lanugo [THg] at Kiska Island, 2018

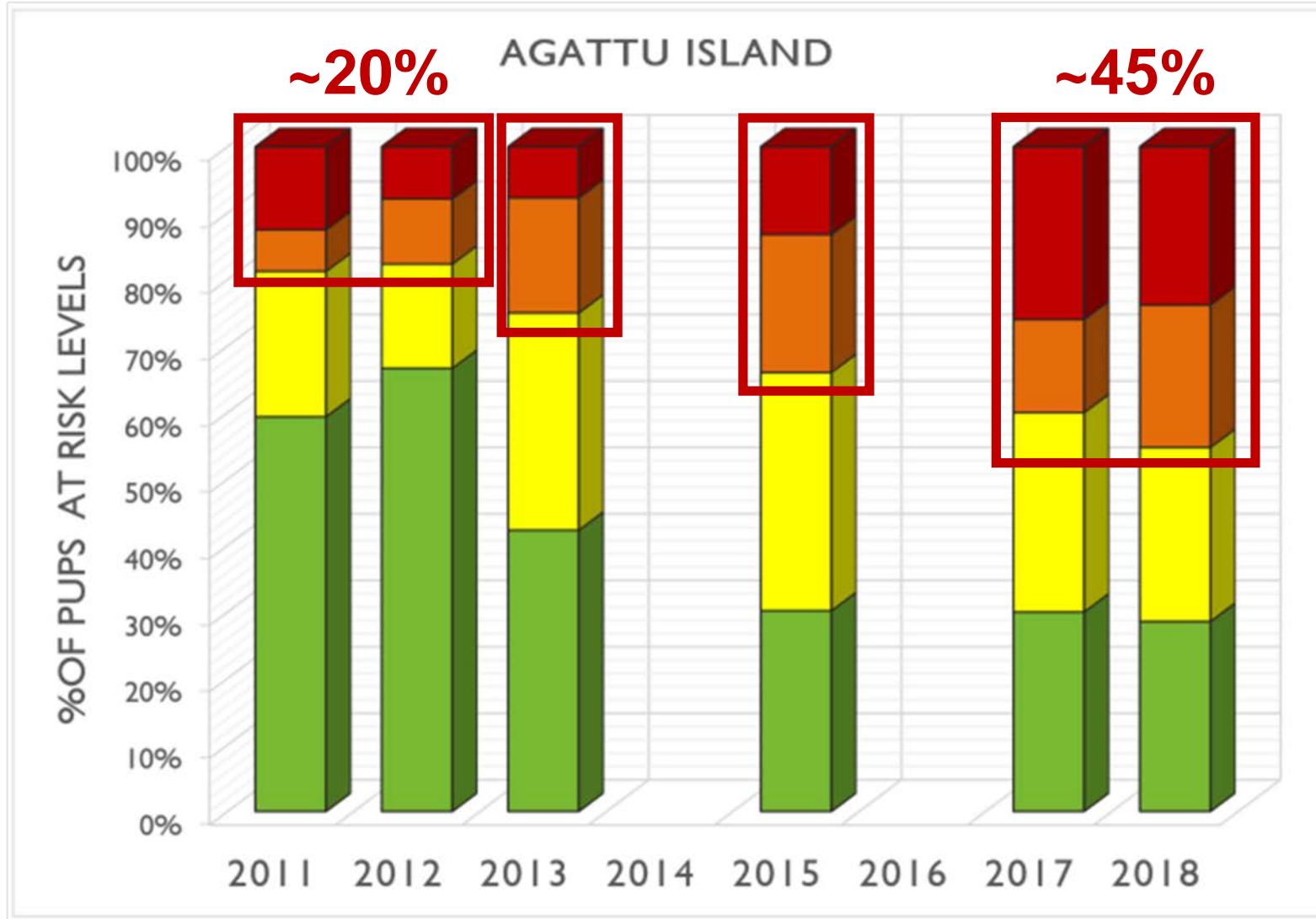


Median Exceeds
Threshold of
Potential
Adverse Effects
20 PPM

2018 marks the
first year that
median [THg] has
exceeded 20 PPM

Observed at Attu & Kiska,
27.73 and 37.71 $\mu\text{g/g}$,
respectively.

Risk Category Over Time → Agattu

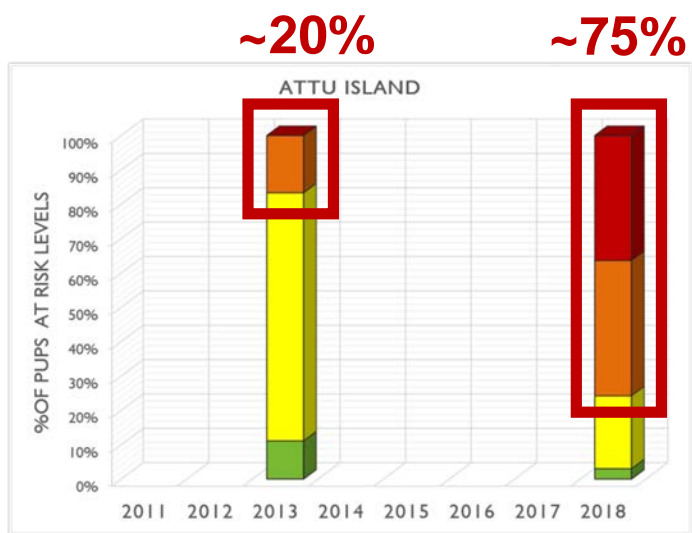
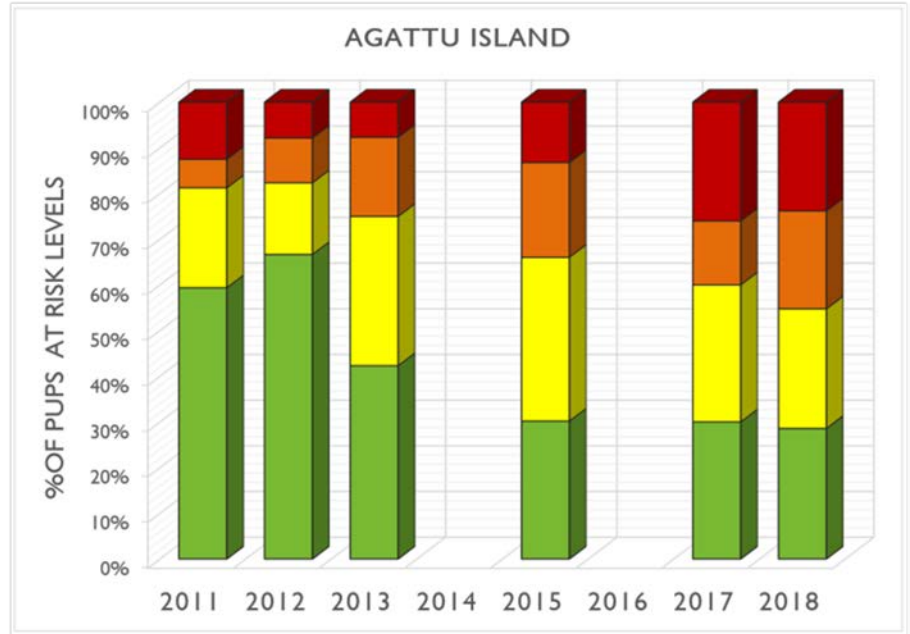
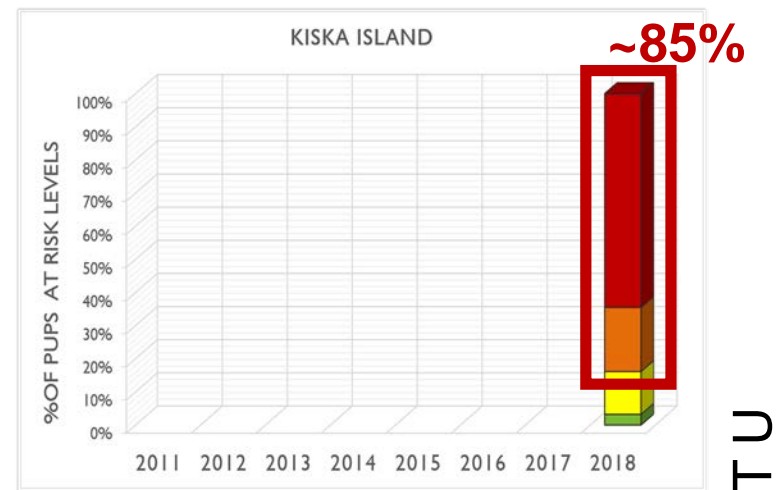
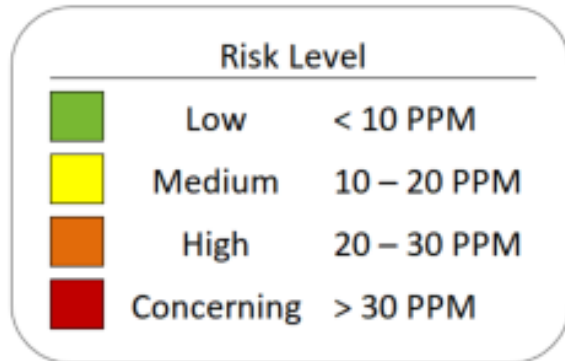


The percent of pups above threshold(s) of concern HAS MORE THAN DOUBLED at Agattu Island within the last decade.

Risk Level		
Green	Low	< 10 PPM
Yellow	Medium	10 – 20 PPM
Orange	High	20 – 30 PPM
Red	Concerning	> 30 PPM



WEST OF AGATTU



EAST OF AGATTU



Data Quality Assessment & Quality Control

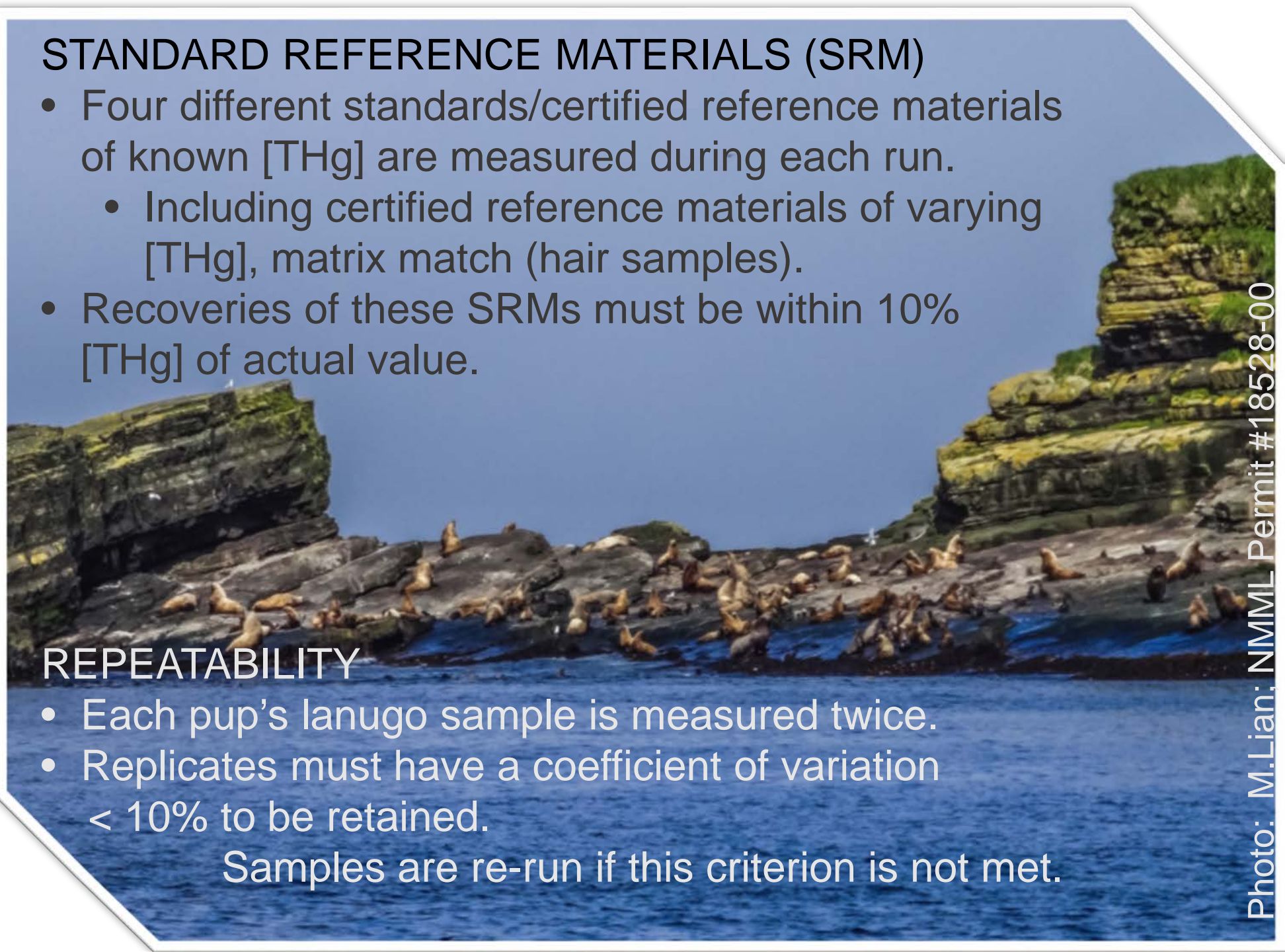
STANDARD REFERENCE MATERIALS (SRM)

- Four different standards/certified reference materials of known [THg] are measured during each run.
 - Including certified reference materials of varying [THg], matrix match (hair samples).
- Recoveries of these SRMs must be within 10% [THg] of actual value.

REPEATABILITY

- Each pup's lanugo sample is measured twice.
- Replicates must have a coefficient of variation < 10% to be retained.

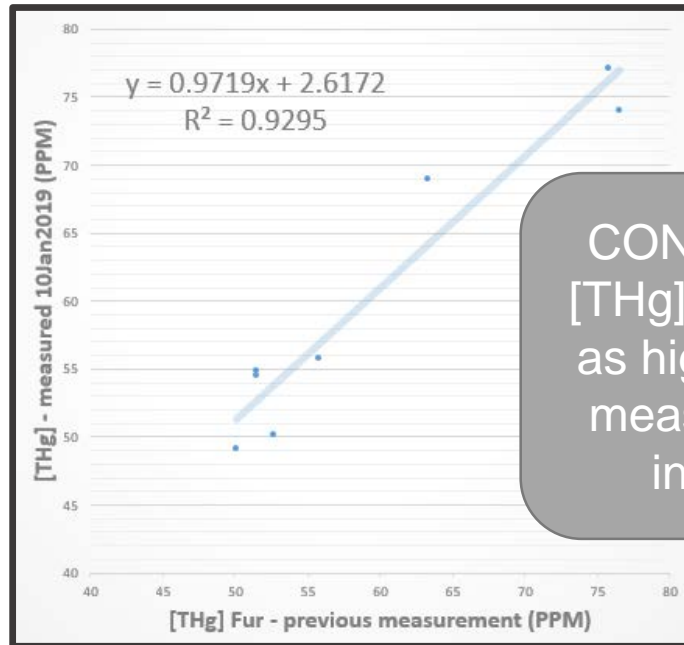
Samples are re-run if this criterion is not met.



Data Quality Assessment & Quality Control

HIGH VALUES of [THg]

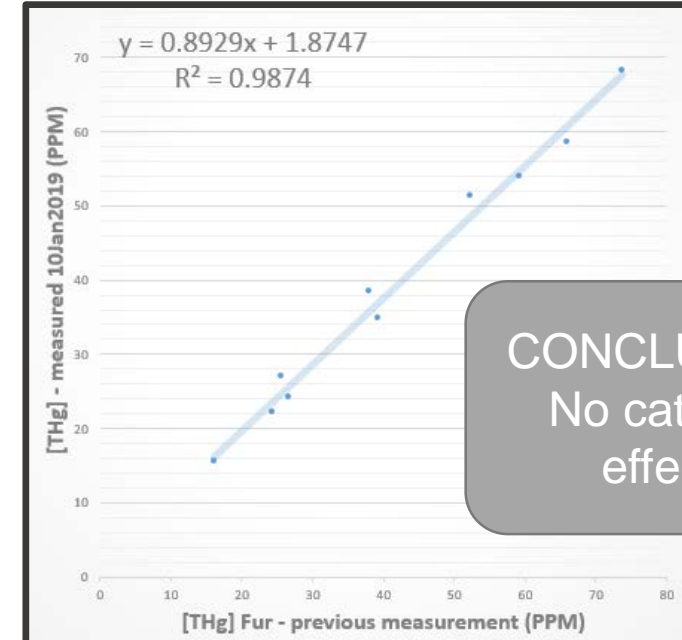
- All [THg] presented that exceeded 50 PPM were re-run at $\frac{1}{2}$ sample mass, to force the measurement away from the end of the standard curve towards the middle.



CONCLUSION
[THg] are indeed
as high as initial
measurements
indicated

CATALYST EFFECT

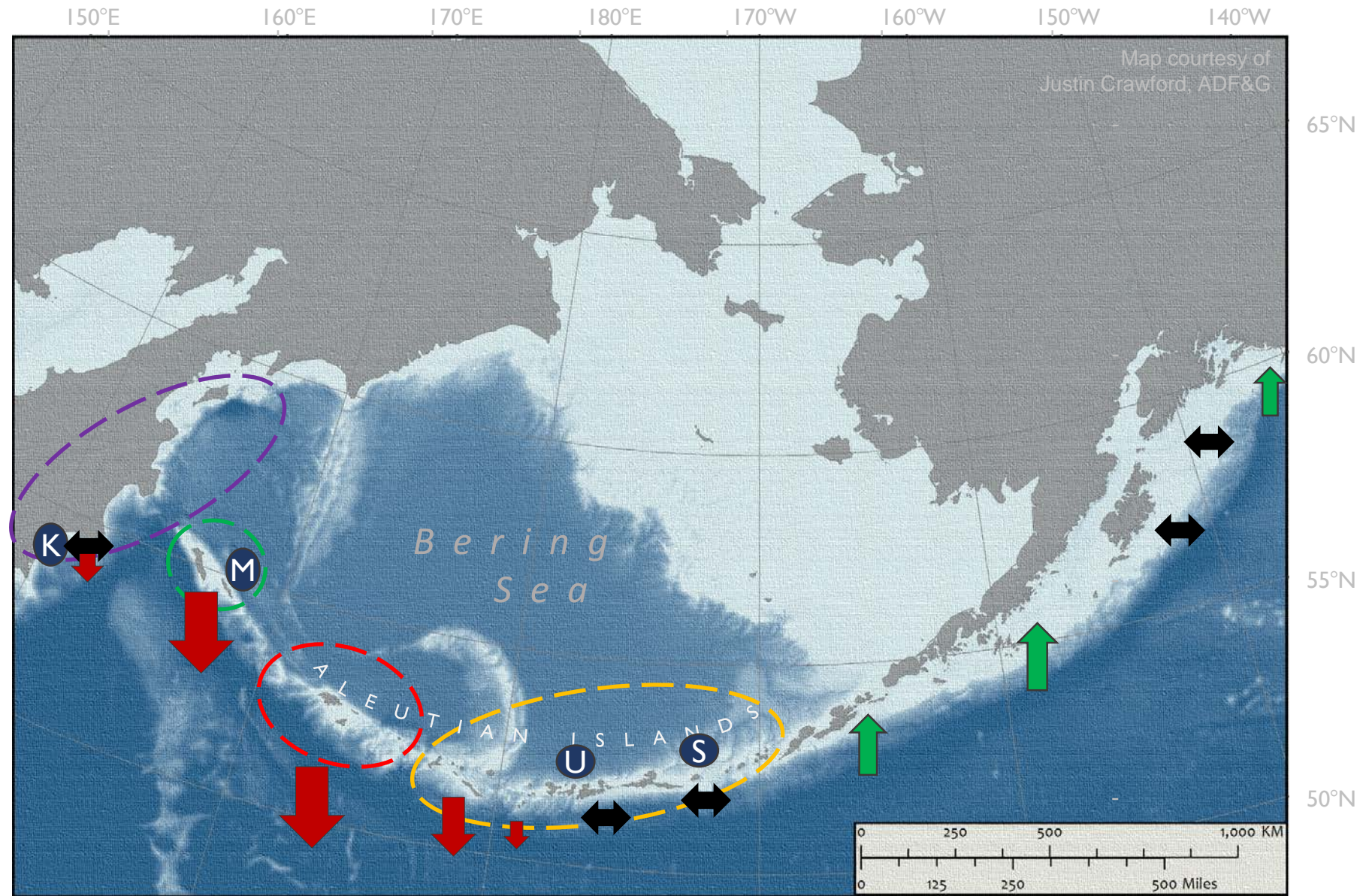
- The manufacturer of the Direct Mercury Analyzer changed the catalyst supplied ~2014.
- To ensure that there were not catalyst effect artifacts in the data, samples (of varying concentrations) originally analyzed 2011-2013 were re-measured in early 2019.



CONCLUSION
No catalyst
effect.

SAMPLES FROM NEARBY ROOKERIES

-  Central Aleutian I
-  Ulak Island
-  Seguam Island
-  Commander I, Russia
-  Medny Island
-  Kamchatka Pen, Russia
-  Kozlova Cape

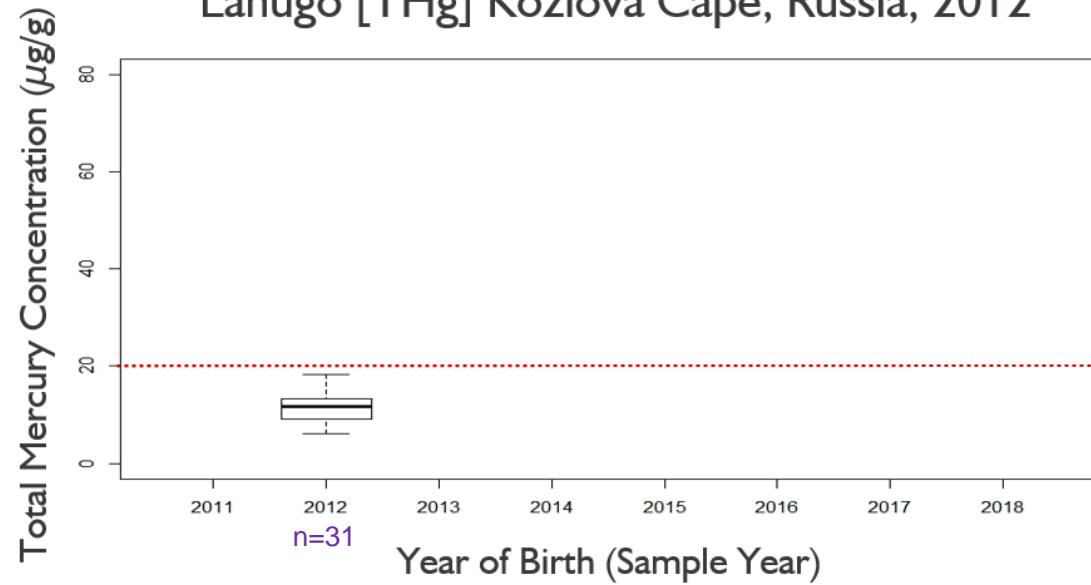


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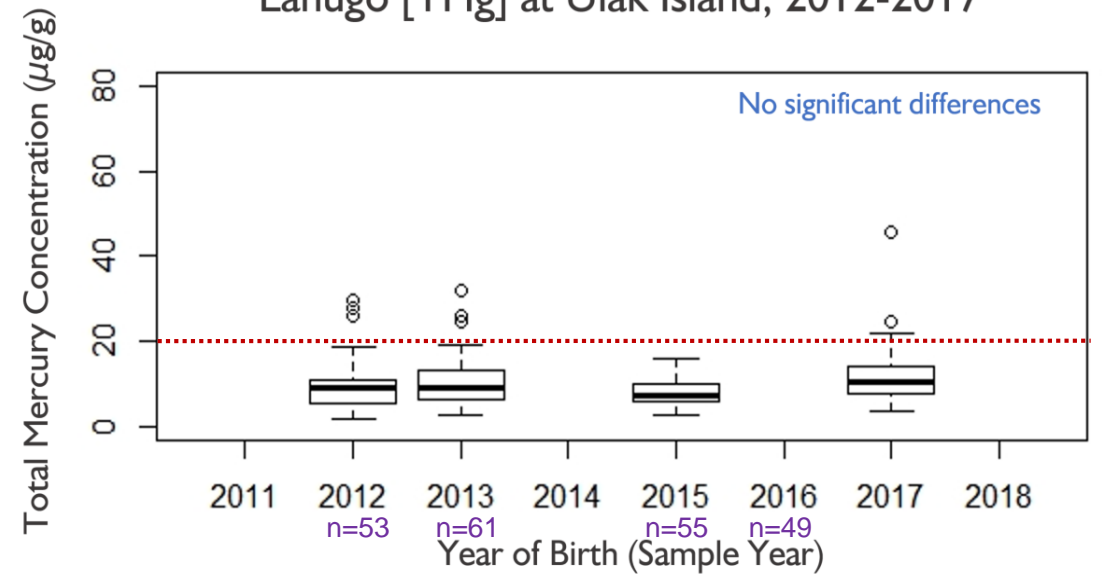
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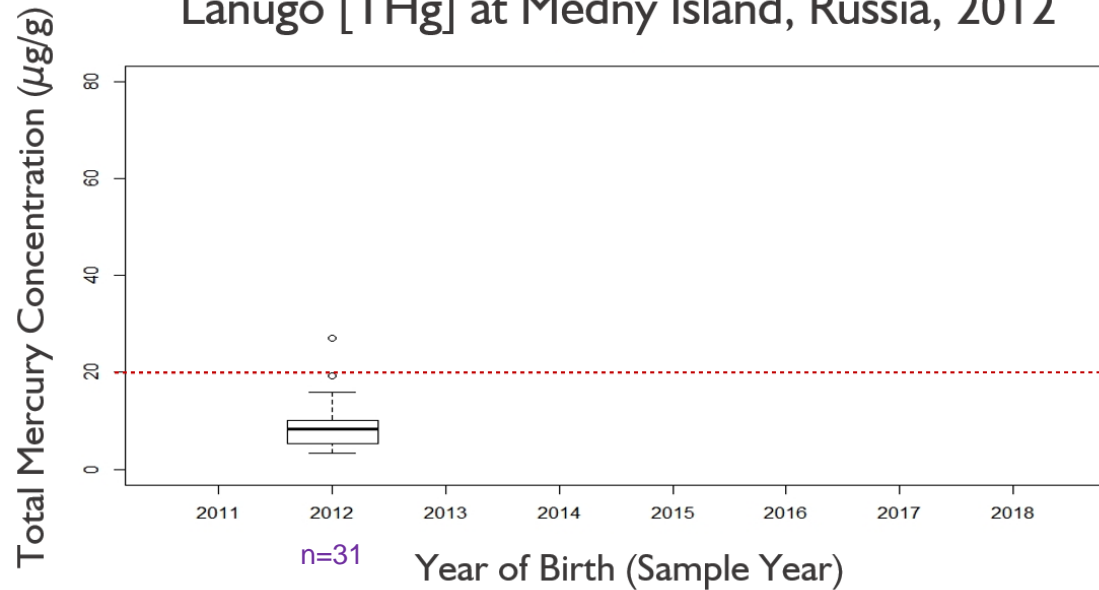
Lanugo [THg] Kozlova Cape, Russia, 2012



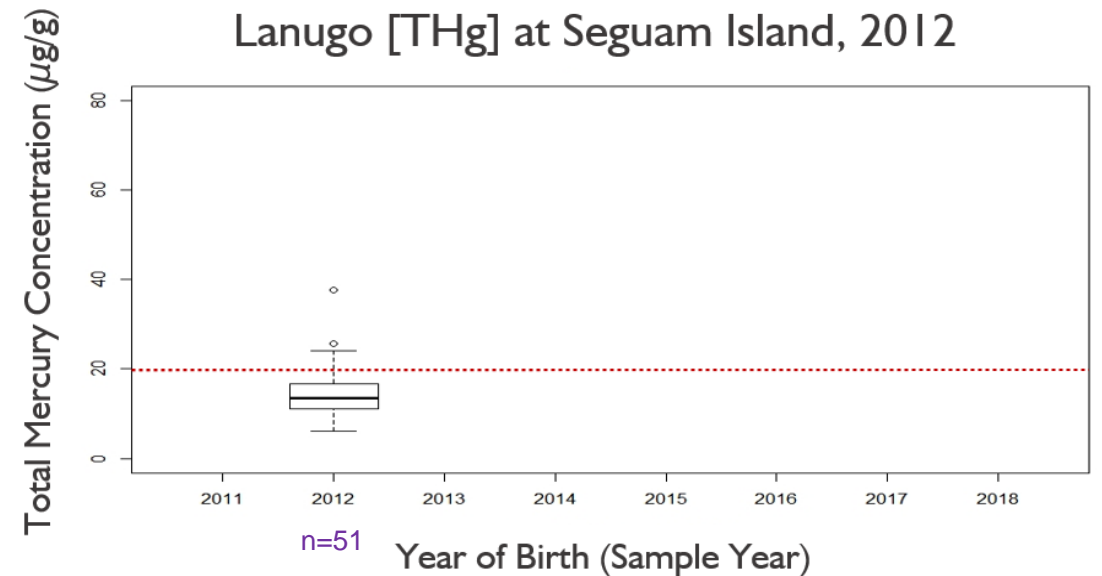
Lanugo [THg] at Ulak Island, 2012-2017



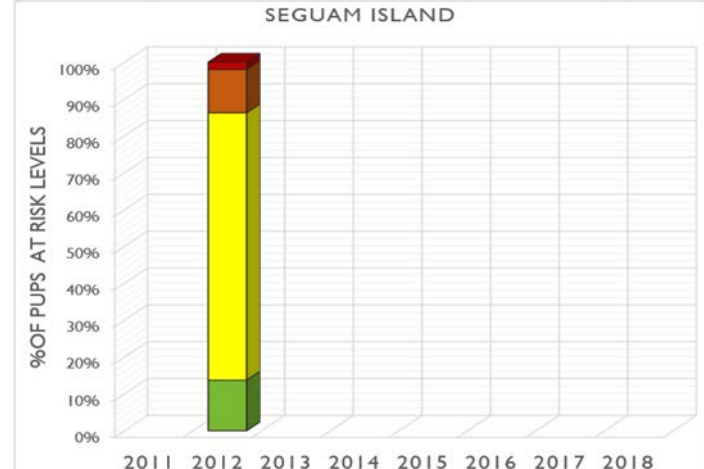
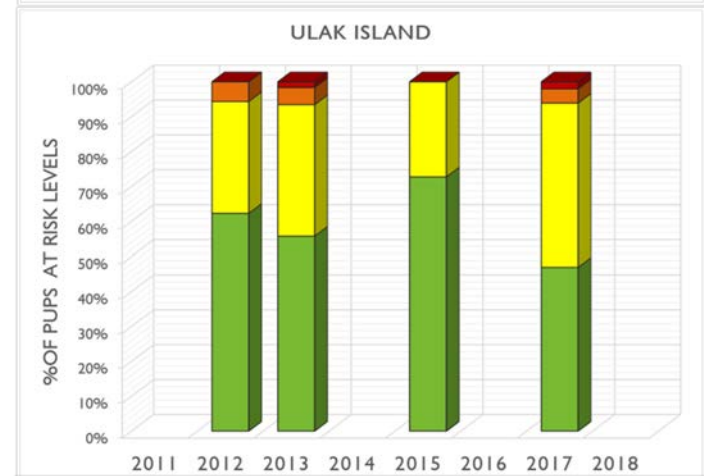
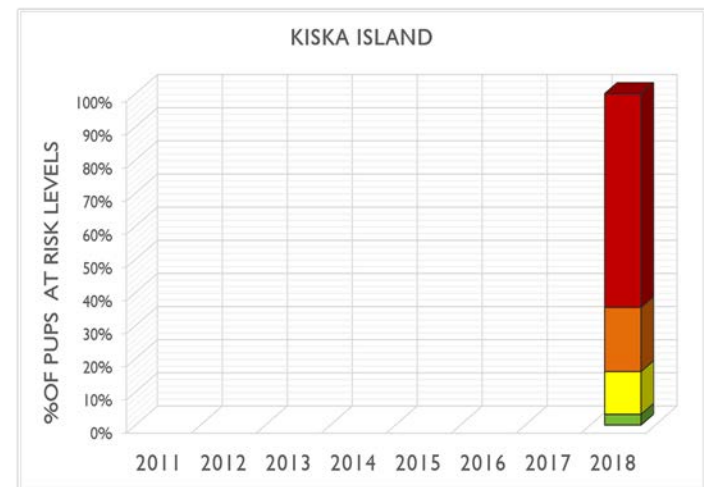
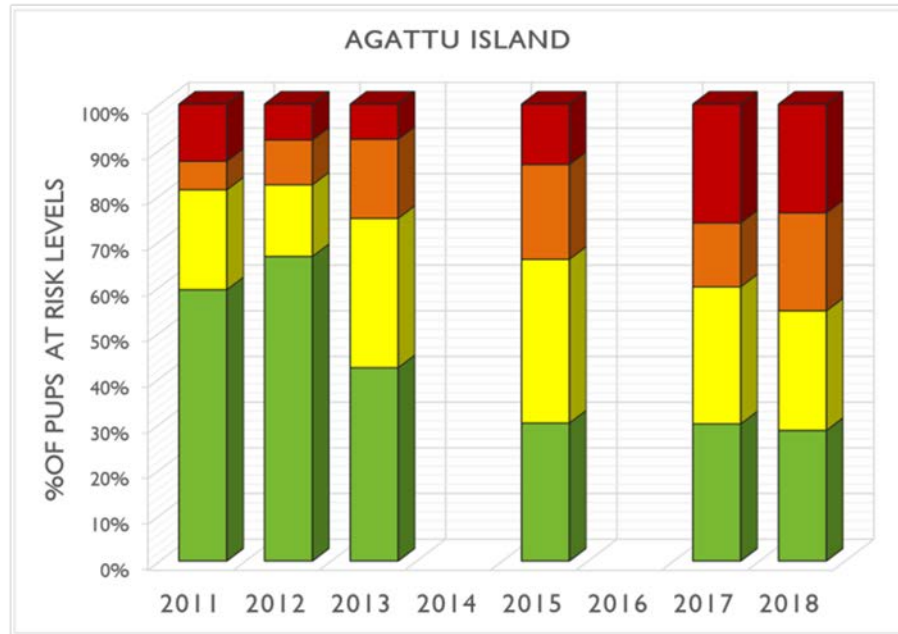
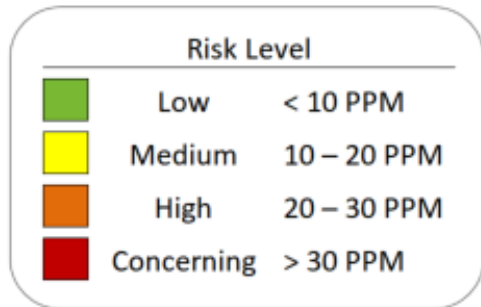
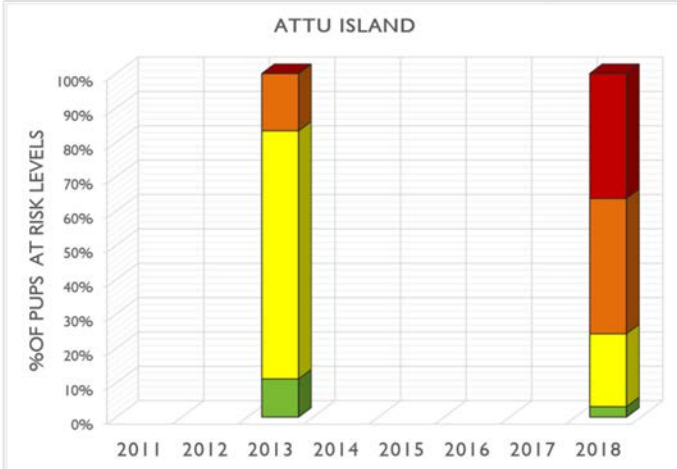
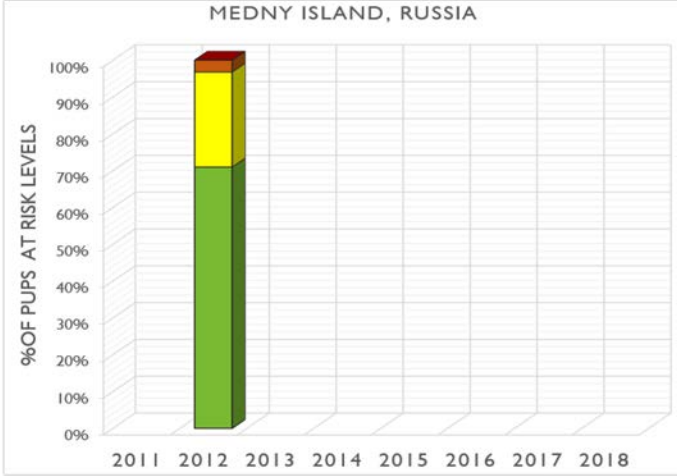
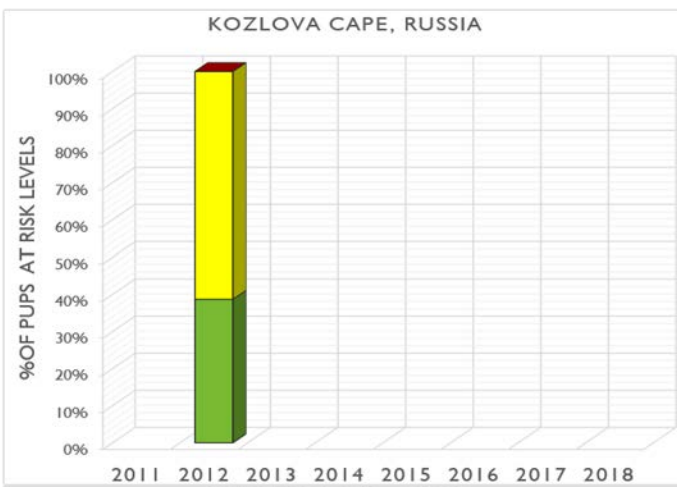
Lanugo [THg] at Medny Island, Russia, 2012



Lanugo [THg] at Seguam Island, 2012



WEST OF AGATTU

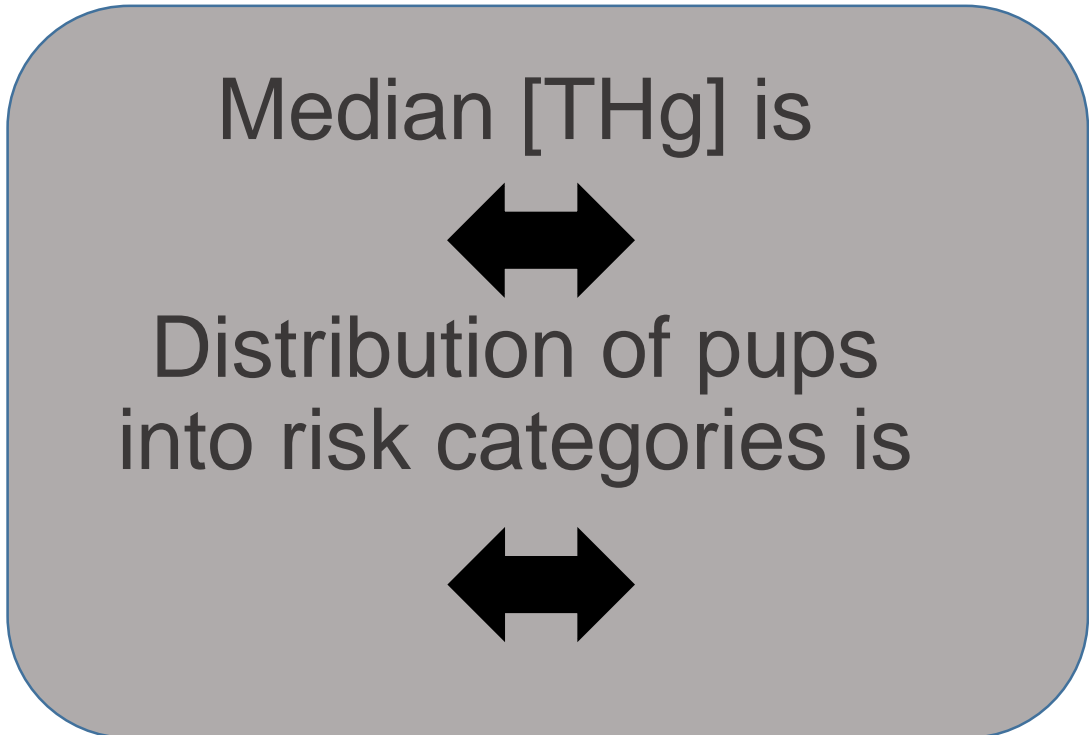


EAST OF AGATTU

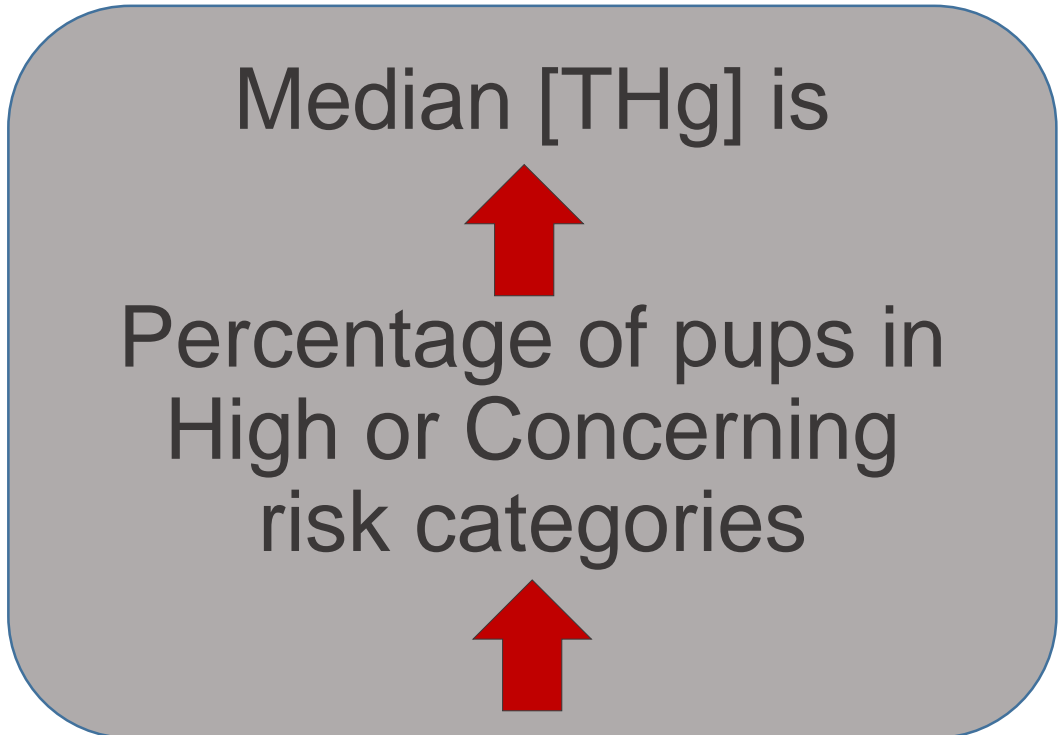


In summary, where the rookery...

population is stable
& sampled > 1 year



population is declining
& sampled > 1 year

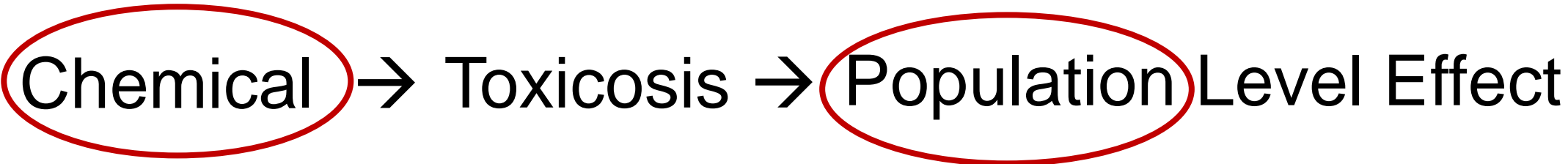


Our ability to evaluate change at additional rookeries
is limited by sample availability.



Cause & Effect in Toxicology

In wild populations, it is exceedingly rare to conclusively show cause & effect relationship that demonstrates a clear connection from



Logistically complicated to evaluate
Many cofactors and interactions

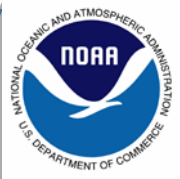


CONCLUSIONS

The **RATE** of change and **PERCENT** of **PUPS** with **HIGH [THg]** is **CONCERNING**, warranting further investigations into adverse effects assessments & pathways of mercury transfer throughout the food web in this region.

ACKNOWLEDGEMENTS

FUNDING



NOAA Cooperative Agreement
(NA16NMF4390031)

Ocean Peace
Research

FIELD SAMPLING

Countless dedicated
Federal and State
Biologists



LABORATORY

Lucero Correa
Amanda Grimes
Claire Montgomerie
Dylan Spargo
Claire Squires



Photo: I. Mamaeva; NMML Permit #14326-02

QUESTIONS?

Contact

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sgcrawford@alaska.edu



Agattu

	Median	Mean	SE	Min	Max
2011	8.01	14.27	2.67	3.92	63.95
2012	6.57	12.47	1.87	3.34	73.74
2013	11.96	13.93	1.27	2.55	39.32
2014					
2015	13.45	16.83	1.45	3.51	45.32
2016					
2017	16.19	20.25	2.05	3.21	63.67
2018	15.85	19.72	1.84	5.20	47.79

Attu

	Median	Mean	SE	Min	Max
2011					
2012					
2013	15.11	15.99	1.24	8.27	27.23
2014					
2015					
2016					
2017					
2018	27.77	27.50	1.50	6.82	51.47

Kiska

	<u>2018</u>
Median	35.71
Mean	37.78
SE	3.02
Min	9.76
Max	<u>76.50</u>

Ulak

	<i>2011</i>	2012	2013	<i>2014</i>	2015	<i>2016</i>	2017	<i>2018</i>
Median		9.08	8.85		7.12		7.69	
Mean		9.46	10.46		7.90		11.45	
SE		0.82	0.78		0.43		0.94	
Min		1.78	2.69		2.74		3.45	
Max		29.75	31.97		15.68		45.60	