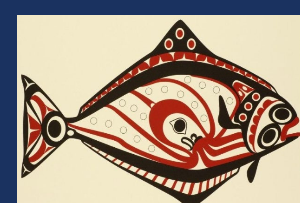
MERCURY RISING…

IN SOME STELLER SEA LIONS: IS IT CHANGE IN ALEUTIAN FOOD WEBS?






MERCURY HAS BEEN SHOWN TO:

- Bioaccumulate and biomagnify
- Be toxic to humans and other fish-eating mammals
- Act on the nervous system (nerves and brain)
- Cause neurochemical changes that impact mammalian health and survival
- Lower reproductive rates (*e.g.,* mink)
- Transfer across the placenta to expose fetus

YOUNG STELLER SEA LION PUPS IN LANUGO

- Lanugo (natal hair) is grown in utero and so reflects the mercury concentrations the fetus is exposed to during development
- Index of maternal total mercury concentrations
- Stable isotope ratios of carbon and nitrogen also measured in lanugo and whiskers and used to model diet of adult female SSL

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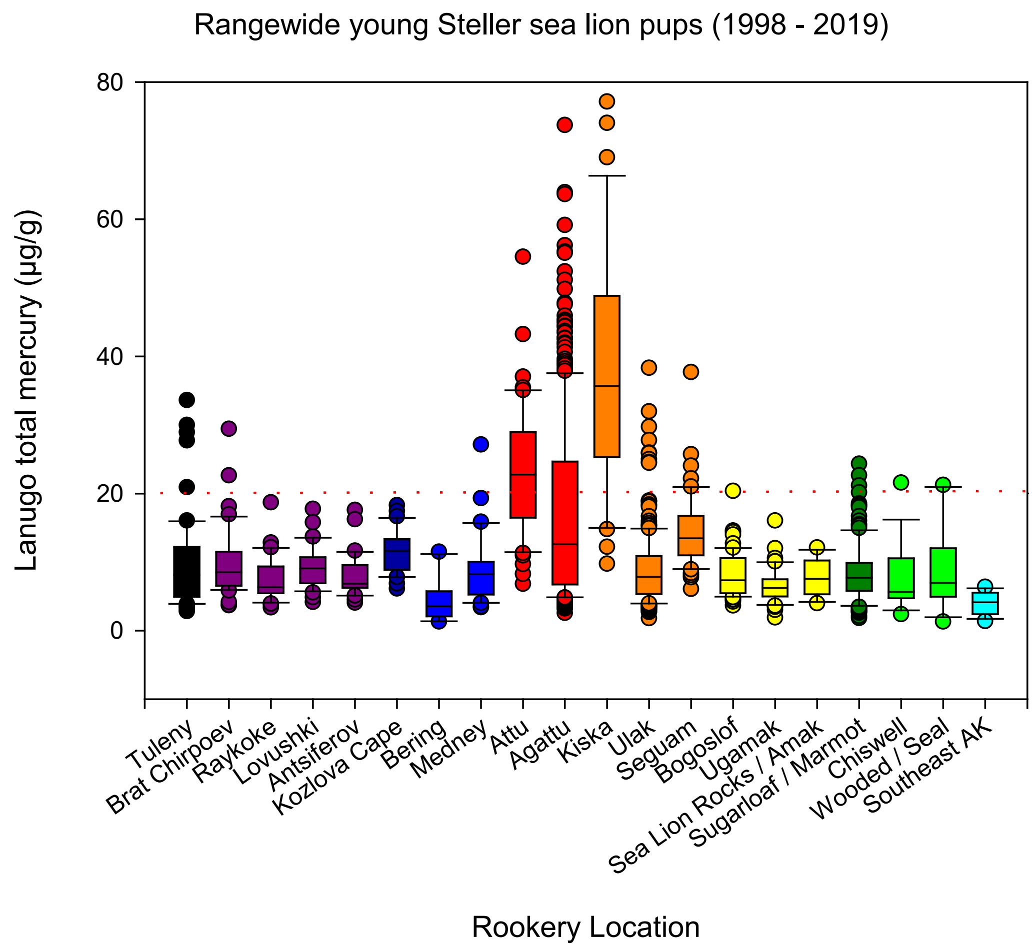
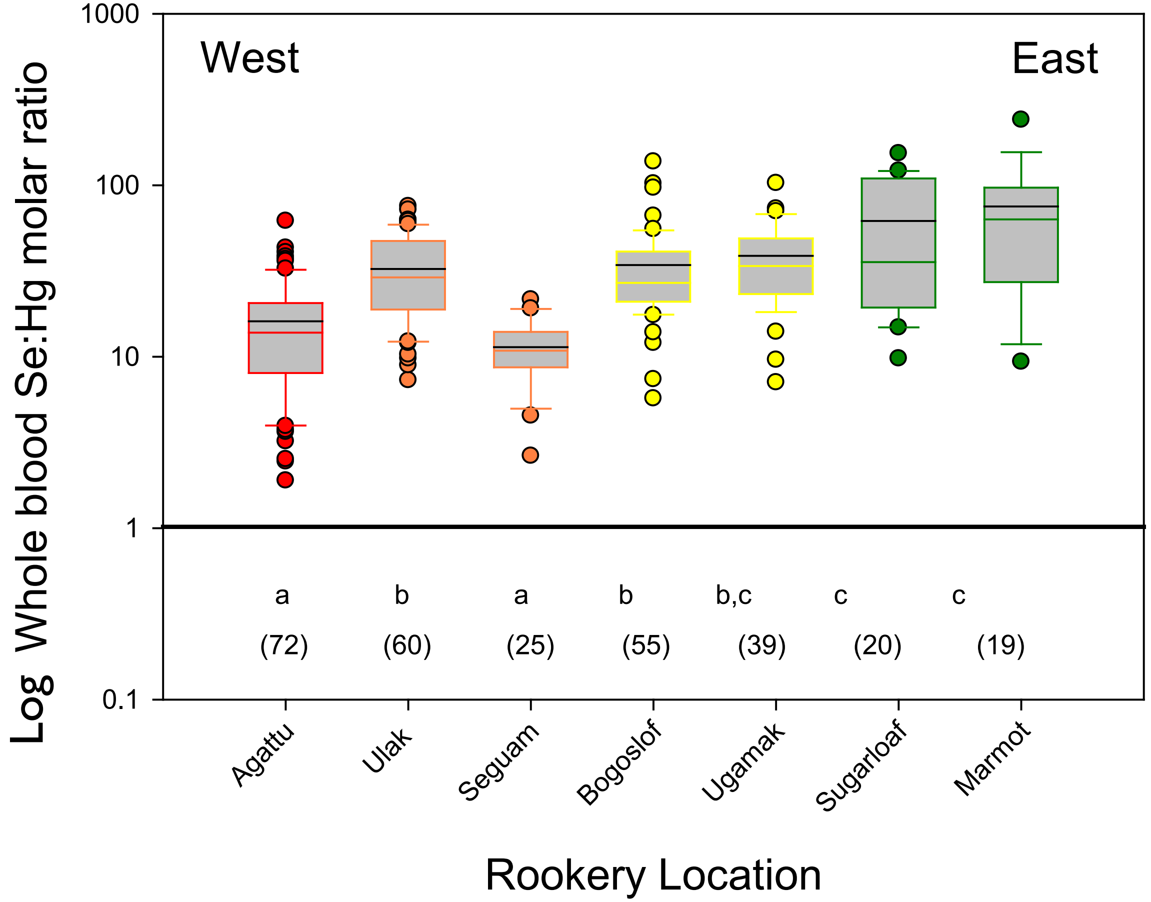
HIGHEST MERCURY IN W AND C ALEUTIAN IS.



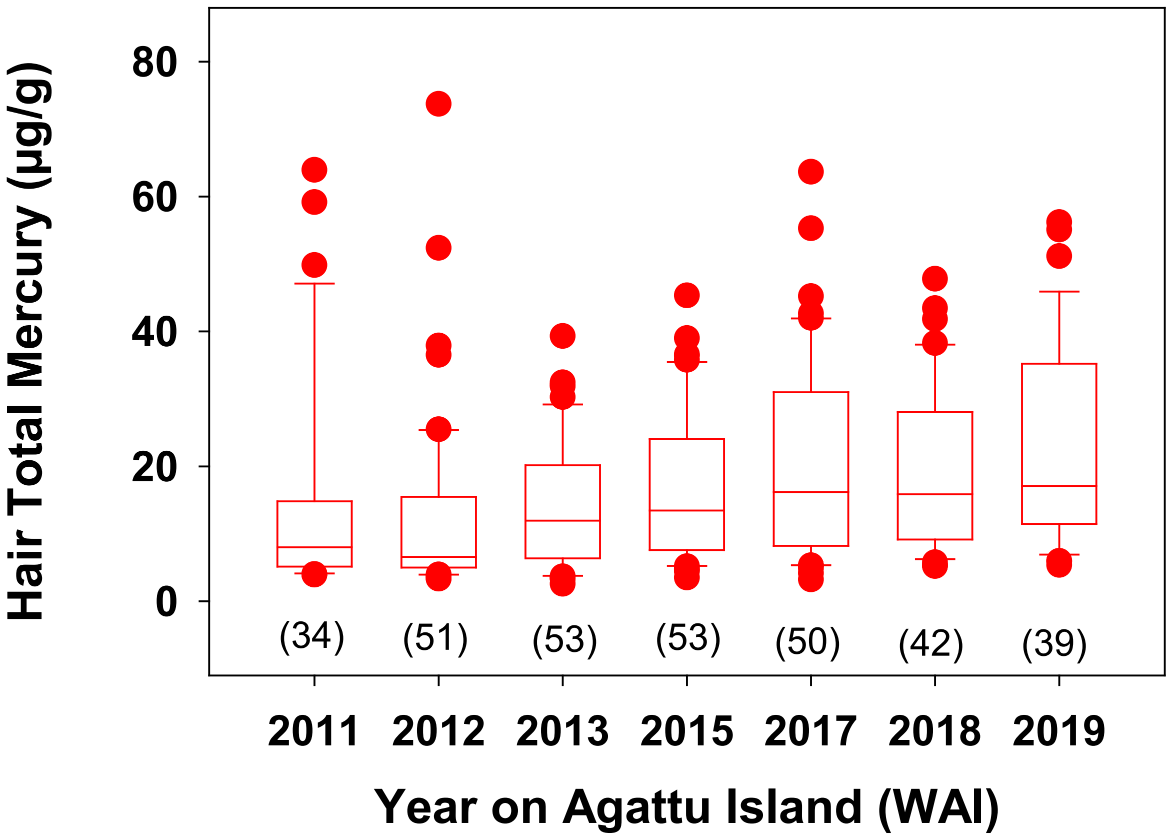
n=1277

DIETARY SELENIUM IS NOT ENOUGH

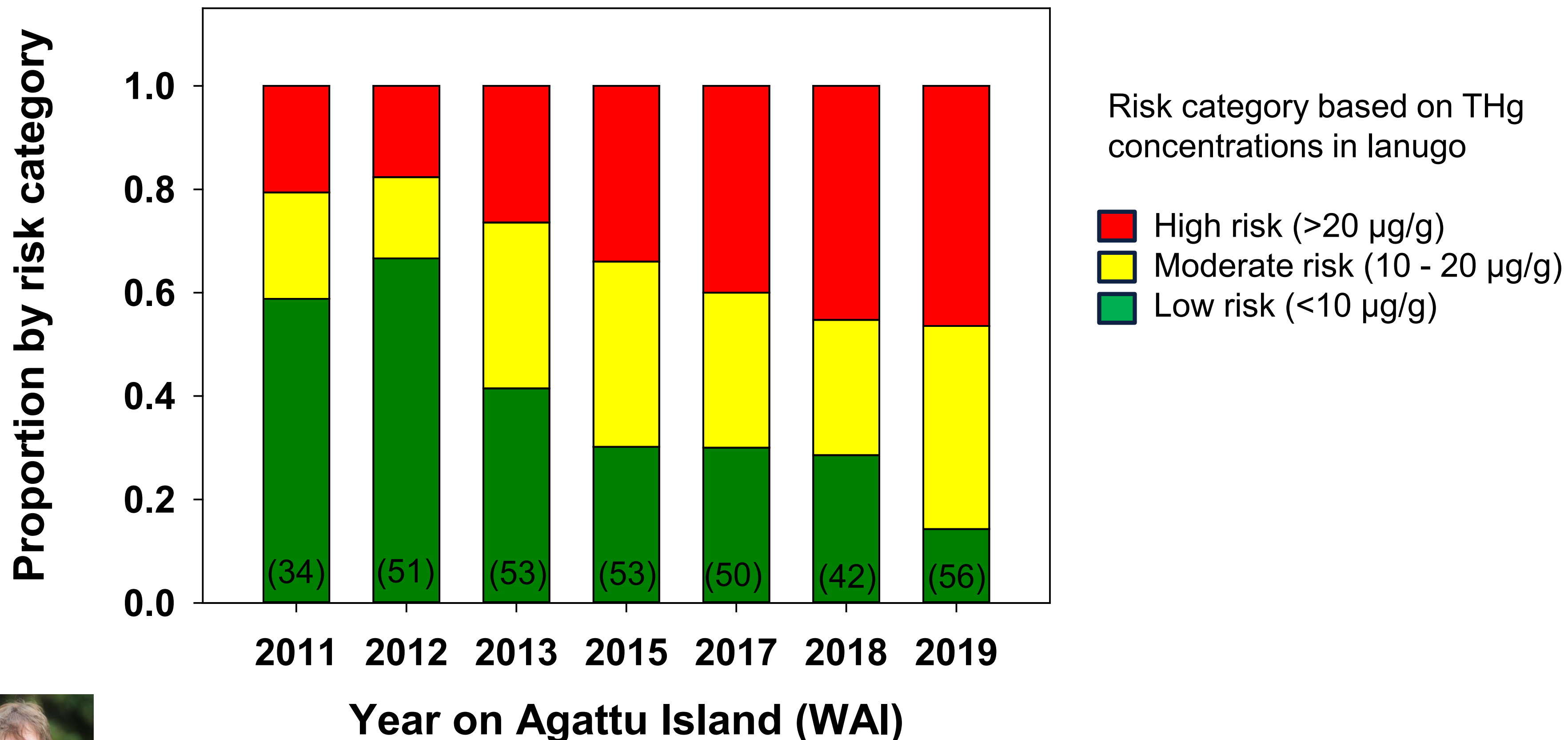


Potential for mercury-induced selenium deficiency

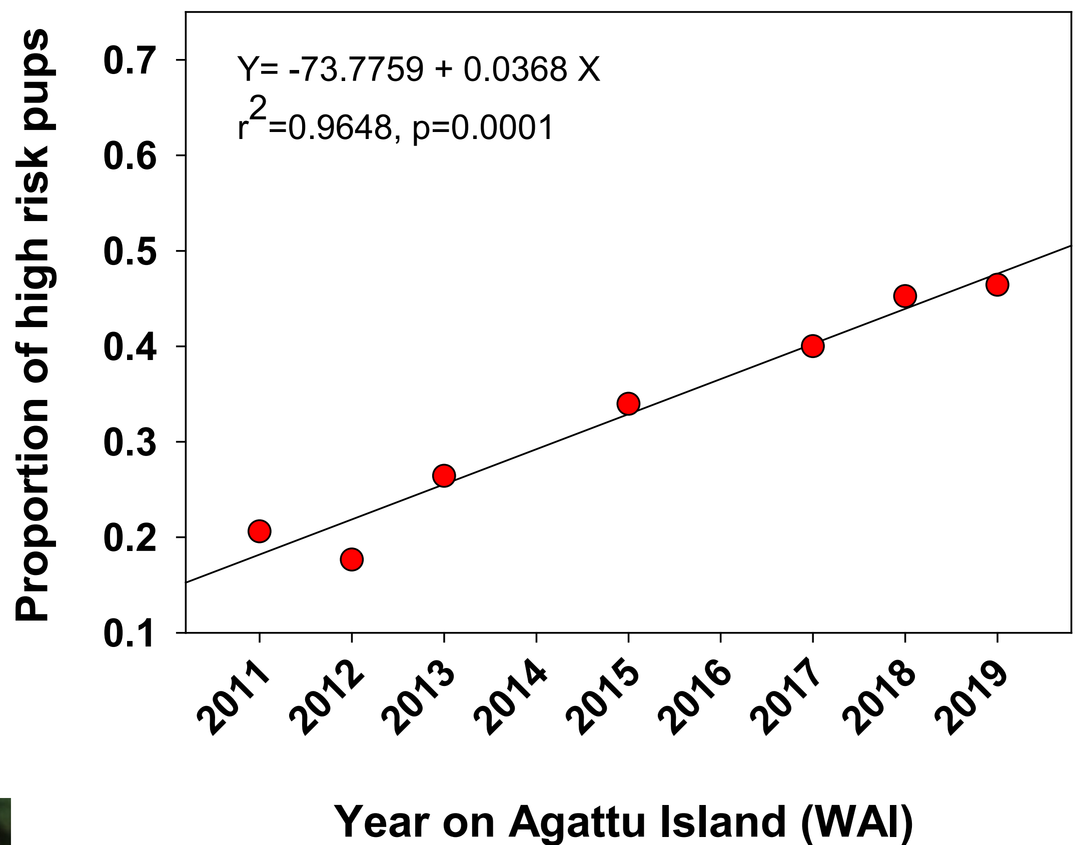
MERCURY RISING



INCREASING PROPORTION OF PUPS AT RISK



INCREASING PROPORTION OF PUPS AT RISK



Proportion of pups in the high risk category ([THg] in lanugo >20 µg/g) increased more than 2-fold between 2011 & 2019

Annual rate of increase is **3.7%**

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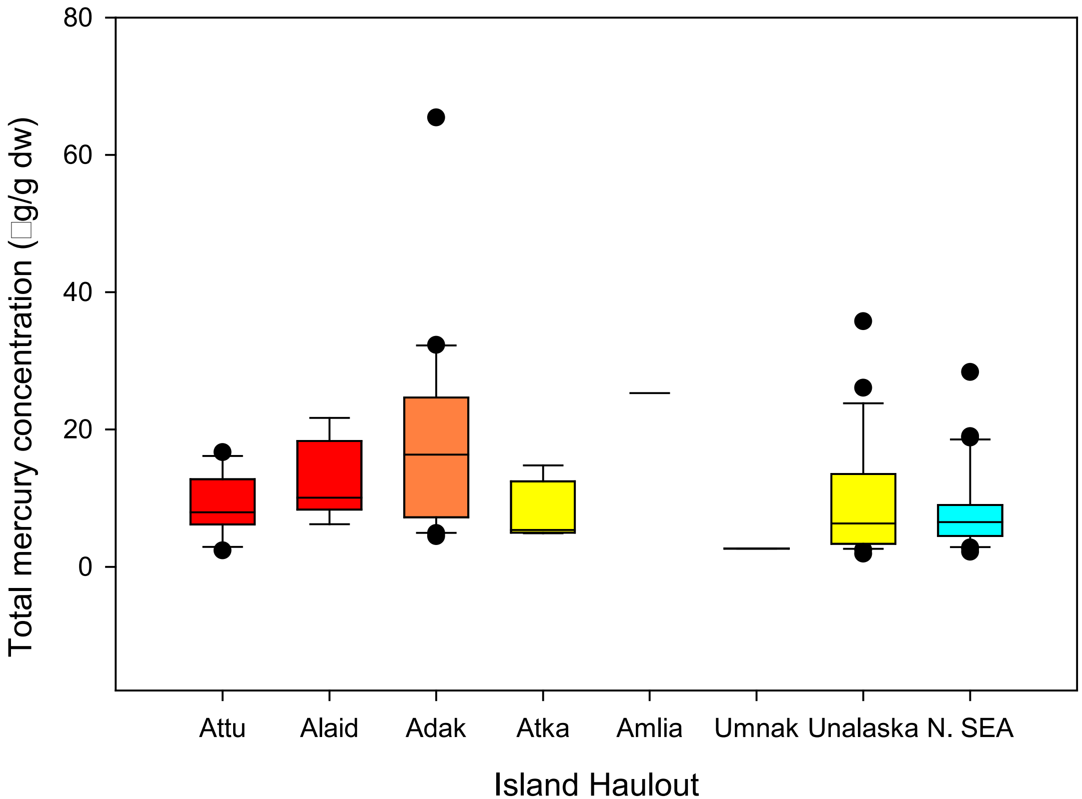
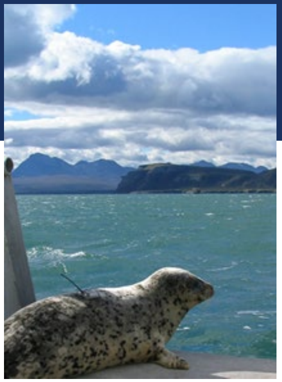
MERCURY IN HARBOR SEALS

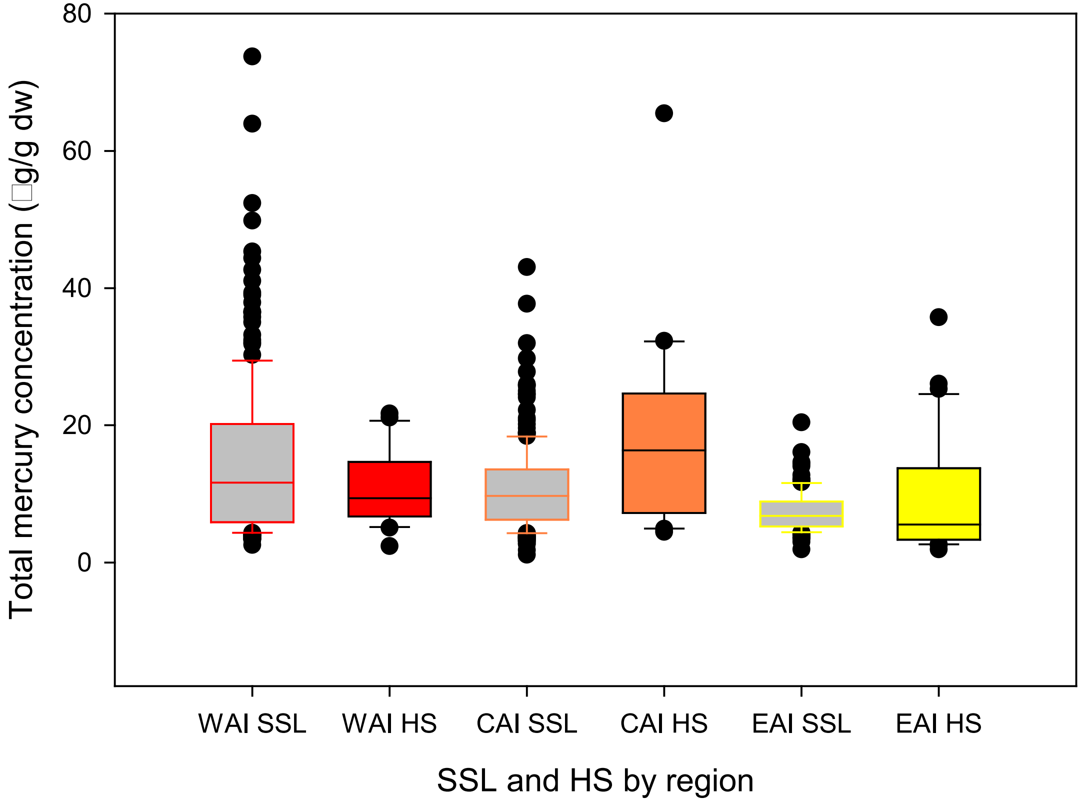


Harbor seals (n=123) sampled by NOAA between 2014 and 2016 in western (red), central (orange) and eastern (yellow) Aleutian Islands and northern Southeast Alaska (cyan).

Caution: mixed ages.

MERCURY IN HARBOR SEALS

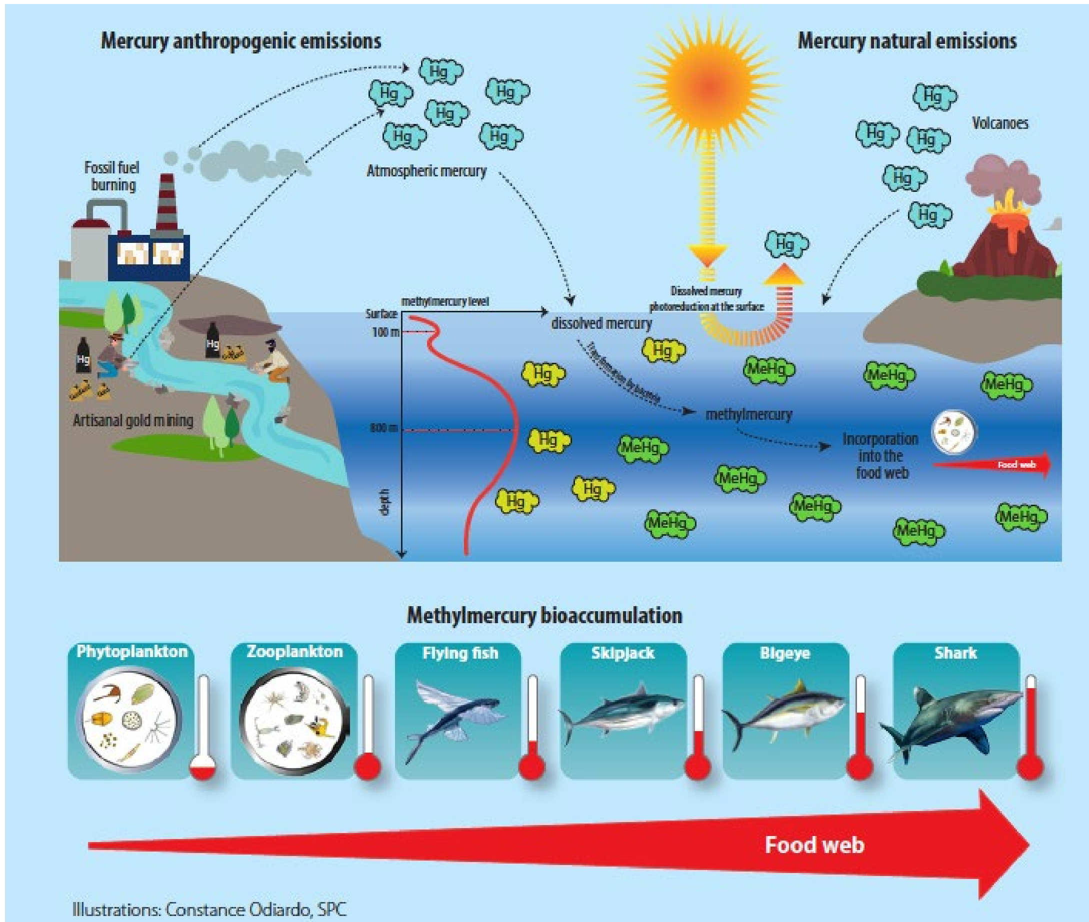




Harbor seals (n=80) sampled by NOAA between 2014 and 2016 in western (red), central (orange) and eastern (yellow) Aleutian Islands.

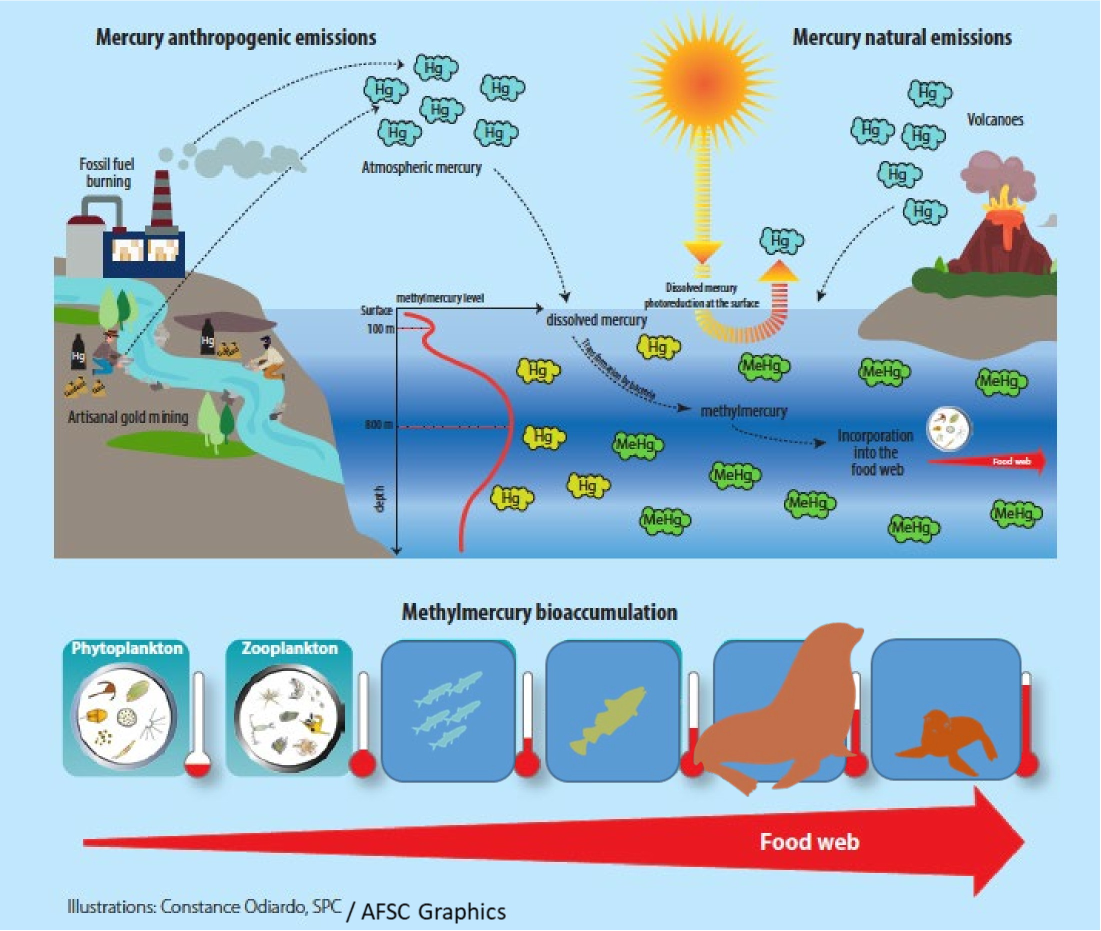
Caution: SSL pups vs HS mixed ages.

MERCURY IN THE MARINE FOOD WEB



Lorrain et al. 2019. SPC Fisheries Newsletter #158

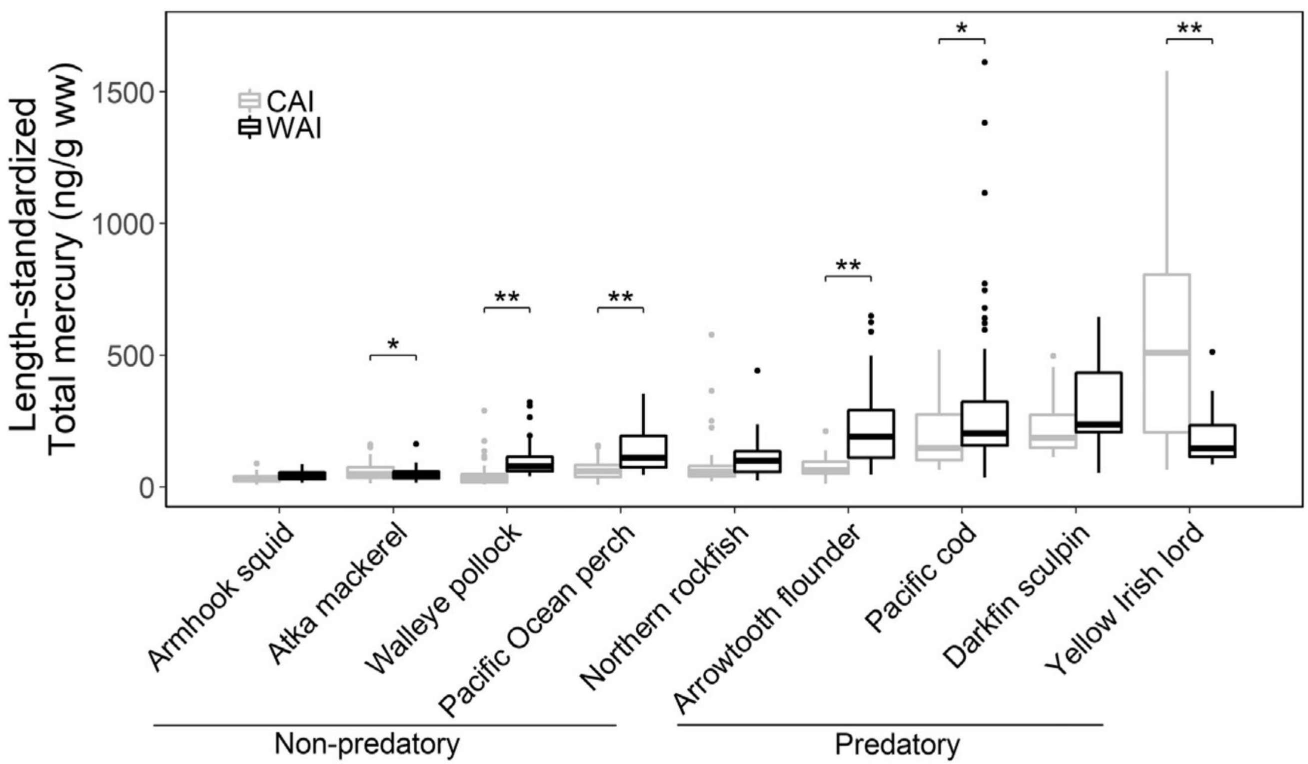
MERCURY IN THE MARINE FOOD WEB



Lorrain et al. 2019. SPC Fisheries Newsletter #158 (Fadely et al. 2022)

ALEUTIAN ISLAND FISH AND CEPHALOPS

A. Cyr et al. / Science of the Total Environment 664 (2019) 761–770



ALEUTIAN ISLAND FISH AND CEPHALOPS

- Previous study included 2013-2015 collections by Ocean Peace (n=1105)
- Expanded fish investigations to include additional collections in 2011, 2020 and 2021 (n=506)
- Master's student Scott Chandler began Fall 2021 under Ocean Peace Research Partnership funding
- Model temporal changes in mercury concentrations with spatial delineation based on 5 major passes (central and western Aleutian Islands)
- Total number of fish: 1611
- Total number of species: 14 with >5 specimen
- Of 1611 fish measured, 13 have total mercury concentrations above 1 ppm (11 Yellow Irish Lord, 1 Pacific Ocean perch, 1 walleye pollock)

ADULT FEMALE STELLER SEA LION DIET

- **Is higher mercury in the west due to diet differences in adult female Steller sea lions?**
- **Has diet of adult females changed over time, potentially leading to increase of mercury transferred *in utero* to their pups?**
- Diet modeling led by Brian Taras (ADF&G) and supported through NOAA funds to Rea, O’Hara and Taras (2019-2022).
- Using carbon and nitrogen bulk isotope ratio and total mercury concentration data supported through several projects (NOAA, PCCRC and Ocean Peace).
- Includes fish 2011-2015 matched to SSL pups sampled 2011-2015 and fish sampled 2020-2021 matched to SSL pups sampled 2017-2019.

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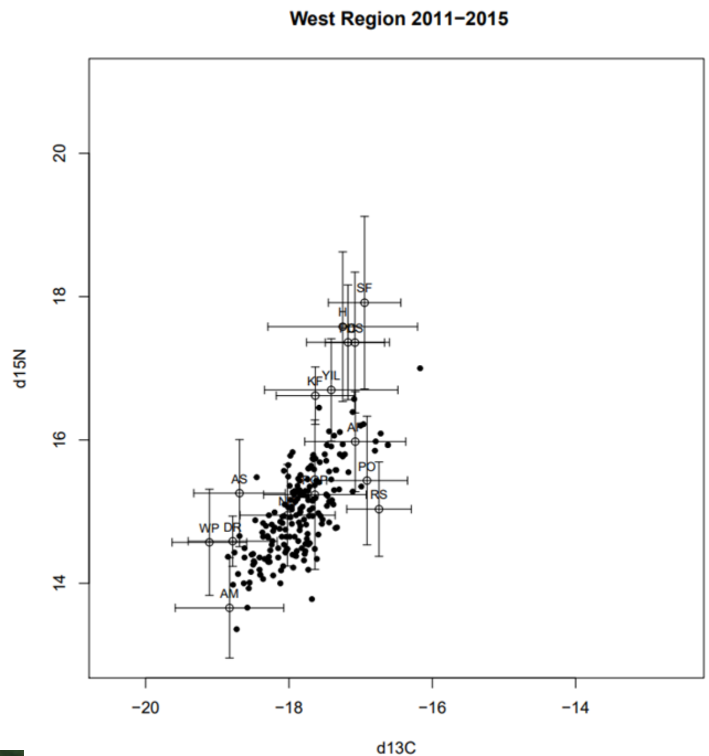
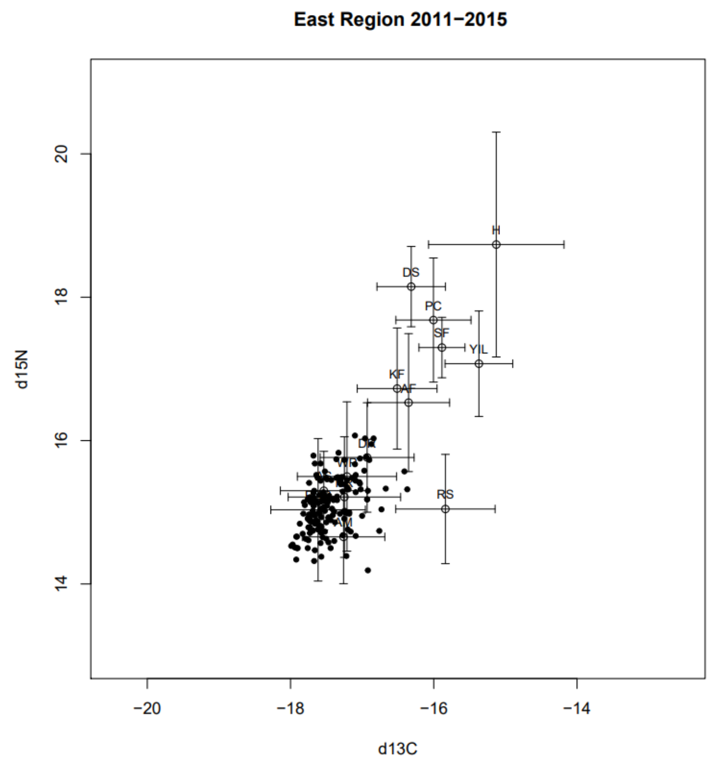
ISOTOPE SPACE FOR FISH AND SSL PUPS

West of Amchitka Pass



East of Amchitka Pass



ADULT FEMALE STELLER SEA LION DIET

Preliminary data: MixSIAR model of proportion of adult female Steller sea lion diet contributed by 14 potential prey species. Fish and pups sampled west of Amchitka Pass 2011-2015.

Predatory
Non Predatory

	AF	AM	AS	DR	DS	H	KF	NR	PC	PO	POP	RS	SF	WP	YIL	Predatory
H11	0.10	0.12	0.03	0.04	0.04	**0.08**	0.03	**0.07**	0.05	0.11	**0.08**	0.13	0.05	0.03	0.05	0.64
H12	0.18	**0.08**	0.03	0.05	0.04	0.11	0.05	0.05	0.05	**0.08**	0.04	**0.08**	0.05	0.03	**0.09**	0.72
H13	**0.06**	0.25	0.03	**0.08**	0.02	0.03	0.02	**0.09**	0.02	**0.09**	**0.06**	0.17	0.02	0.04	0.03	0.45
H15	**0.06**	0.46	0.02	0.03	0.03	0.04	0.02	**0.06**	0.03	0.05	0.05	0.05	0.03	0.02	0.04	0.35
M11	**0.07**	0.18	0.03	**0.06**	0.03	0.04	0.03	**0.08**	0.03	0.10	**0.07**	0.20	0.03	0.03	0.03	0.57
M12	0.12	0.14	0.04	**0.07**	0.03	**0.06**	0.05	**0.06**	0.04	**0.08**	0.05	0.13	0.03	0.04	**0.06**	0.61
M13	0.03	0.33	0.02	**0.09**	0.01	0.01	0.01	**0.08**	0.01	**0.08**	0.04	0.23	0.01	0.04	0.01	0.41
M15	0.03	0.58	0.02	0.03	0.02	0.02	0.02	**0.06**	0.02	0.04	0.04	**0.07**	0.02	0.02	0.02	0.26
L11	0.05	0.15	0.03	0.05	0.02	0.03	0.02	0.15	0.02	0.13	0.14	0.12	0.02	0.03	0.03	0.45
L12	**0.09**	0.14	0.05	**0.08**	0.03	0.05	0.05	0.11	0.04	**0.08**	**0.08**	**0.09**	0.03	0.05	0.05	0.51
L13	0.03	0.28	0.03	**0.09**	0.01	0.01	0.01	0.14	0.01	0.10	**0.09**	0.14	0.01	0.04	0.01	0.33
L15	0.03	0.53	0.02	0.04	0.01	0.02	0.02	**0.09**	0.02	**0.06**	**0.07**	0.05	0.01	0.02	0.02	0.22
																0.46 mean

PRELIMINARY SEA LION DIET MODELING

2011-2015

Prey Type	Min	Max
AF	0.028	0.179
DS	0.010	0.037
H	0.012	0.109
KF	0.013	0.051
PC	0.010	0.053
PO	0.044	0.131
RS	0.048	0.226
SF	0.009	0.048
YIL	0.014	0.091
AM	0.077	0.584
AS	0.015	0.049
DR	0.027	0.091
NR	0.049	0.147
POP	0.039	0.138
WP	0.016	0.048

2017-2019

Table 1: West top model: Minimum and Maximum Prey Proportions across Year and THg Categories. Last 6 (AF-YIL) are predatory first 6 (Ssp-WP) are non predatory.

Prey Type	Min	Max
SSp	0.039	0.055
AM	0.082	0.281
LS	0.022	0.057
NR	0.054	0.104
POP	0.077	0.225
WP	0.097	0.385
AF	0.040	0.093
DS	0.020	0.053
KF	0.037	0.076
PC	0.030	0.174
PO	0.035	0.139
YIL	0.026	0.115

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PRELIMINARY CONCLUSIONS: DIET MODELS

- **Is higher mercury in the west due to diet differences in adult female Steller sea lions?**
- Standard errors are relatively large so hard to interpret data for individual prey contributions to diet.
- In general the percentage of predatory prey decreases from High, to Medium to Low total mercury concentration categories.
- Depending on the year and total mercury concentration category, contribution of predatory fish ranged from 0.21 to 0.6 of the diet in the west region for animals sampled 2017-2019. During this time non-predatory prey dominated the diet of animals from the east. In the earlier time period (2011-2015) contribution of predatory fish ranged from 0.22 to 0.72 of the diet in the west region.

ALEUTIAN ISLAND INVERTEBRATES

Total mercury concentrations (µg/kg dw or **ppb**; mean, standard deviation (sd), minimum and maximum values) in 3 species of algae and 9 species of marine invertebrate collected near Kiska Island in 2014 (n=97).

Species	Common Name	n	mean	sd	minimum	maximum
Alaria marginata	winged kelp	2	9.59	0.64	9.13	10.04
Fucus gardneri	rockweed	2	12.25	3.51	9.77	14.73
Hedophyllum sessile	sea cabbage	2	61.40	35.77	36.11	86.69
Katharina tunicata	black Katy chiton	22	36.34	13.96	15.87	64.81
Leptasterias sp.	genus of seastar in family Asteriidae	12	155.69	78.77	65.33	347.49
Littorina	periwinkle	3	52.66	5.82	45.98	56.66
Lottia pelta	shield limpet	8	30.38	5.84	23.10	30.38
Mytilus sp.	Mussel	24	124.76	57.22	59.57	287.89
Nucella lima	File dog winkle	2	55.09	13.28	45.70	64.48
Semibalanus cariosus	thatched barnacle	9	81.11	21.84	51.15	114.88
Strongylocentrotus droebachiensis	green sea urchin	4	37.69	5.50	34.66	45.93
Tectura persona	masked limpet	8	42.98	19.04	20.45	74.51

ALEUTIAN ISLAND INVERTEBRATES

Importance: relatively immobile species compared to pinnipeds and fish which we hope will help us determine if there is a “point source” of mercury in the Aleutian Islands

- Also important prey for the southwest stock of sea otters
- We have partnered with USFWS to further study invertebrates in the western and central Aleutian Islands
- In August 2021 USFWS and USGS biologists collected 697 invertebrates from 12 genera at 9 islands (between Adak and Attu)
- Funding to measure total mercury, methylmercury, stable isotopes of C and N, and trace elements including selenium in up to 250 of these

UAF INE WERC

ACKNOWLEDGEMENTS

We thank the members of our field collection teams at Alaska Department of Fish and Game (ADF&G), The Marine Mammal Laboratory/NOAA, the Alaska SeaLife Center and in Russia and the vessel crews who brought them all home safely. We also acknowledge tireless hours of mercury analysis in the laboratory by L. Correa, A. Gastaldi, J. Harding, J. Harley, G. Johnson, S. Kennedy, T. Lamken, L. O'Hara, S. Rouse, and M. Templeton.

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ALEUTIAN ISLAND INVERTEBRATES

			ISLAND									
	Genus	**Species**	**Adak**	**Agattu**	**Alaid**	**Amchitka**	**Attu**	**Kiska**	**Nizki**	**Ogliuga**	**Shemya**	**SPECIES TOTALS**
Crustacean	*Pugettia*	spp	6	2			4		2		1	**15**
Echinoderm	*Evasterias*	spp	1									**1**
	Evasterias	*troschelli*			5							**5**
	Leptasterias	spp	11	10	5	9	16	10		6		**67**
	Strongylocentrotus	*polyacanthus*		22			16					**38**
	Strongylocentrotus	spp	46		4	28	12	32		24	25	**171**
Mollusc	*Cryptochiton*	*stelleri*				4				8		**12**
	Fusitron	spp	11				1			5		**17**
	Katharina	spp			9		5					**14**
	Katharina	*tunicata*		4								**4**
	Lottia	*pelta*	5	1	3	2	5	3		2		**21**
	Lottia	spp	15	2	8	8	13	5		12		**63**
	Modiolus	spp	9			12		1		28		**50**
	Mytilus	spp	37	26	25	26		26		1		**141**
	Pododesmus	spp	11			19	1	7		11		**49**
	Tonicella	spp	16			12				1		**29**
		ISLAND TOTALS	**168**	**67**	**59**	**120**	**73**	**84**	**2**	**98**	**26**	**697**