

# Patterns in seabird diet and persistent organic pollutants in Puget Sound forage fish



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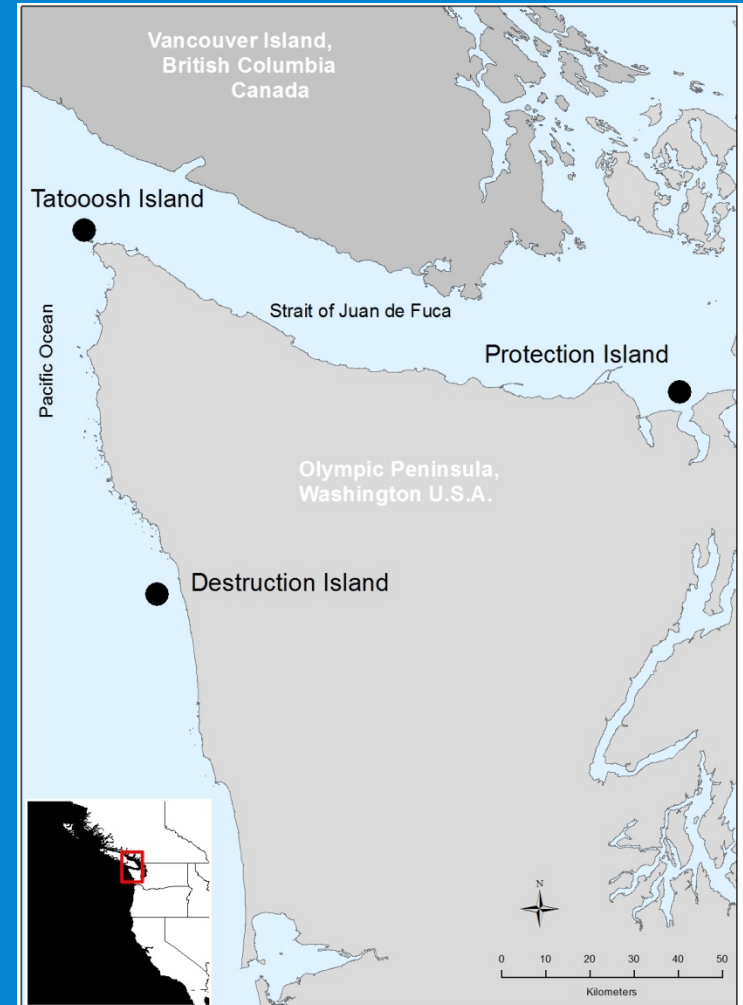
# Seabird-forage fish studies/analyses

- Literature review database
- Diet collection database
- ***Rhinoceros auklet diet studies***
  - *Present/historical patterns*
  - *Persistent organic pollutants*



# Rhinoceros auklet diet study

- **Sampled auklet chick diet:**
  - Protection Island (Puget Sound)
  - Destruction Island (outer coast)
  - Tatoosh Island (confluence)
- **Collected 5729 samples/968 bill loads during three sampling trips per island per season from 2006-2010**



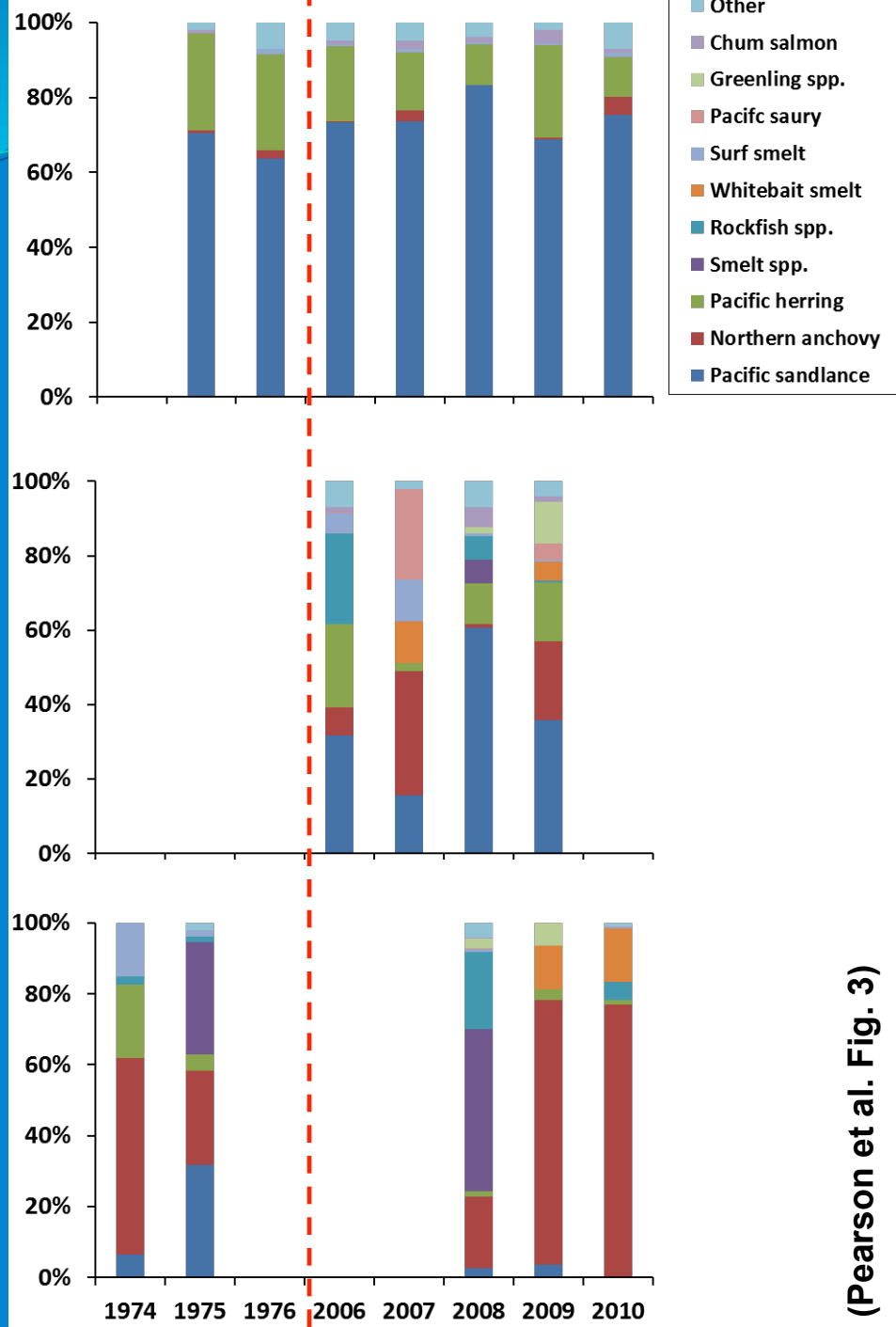






# Fish sample collection

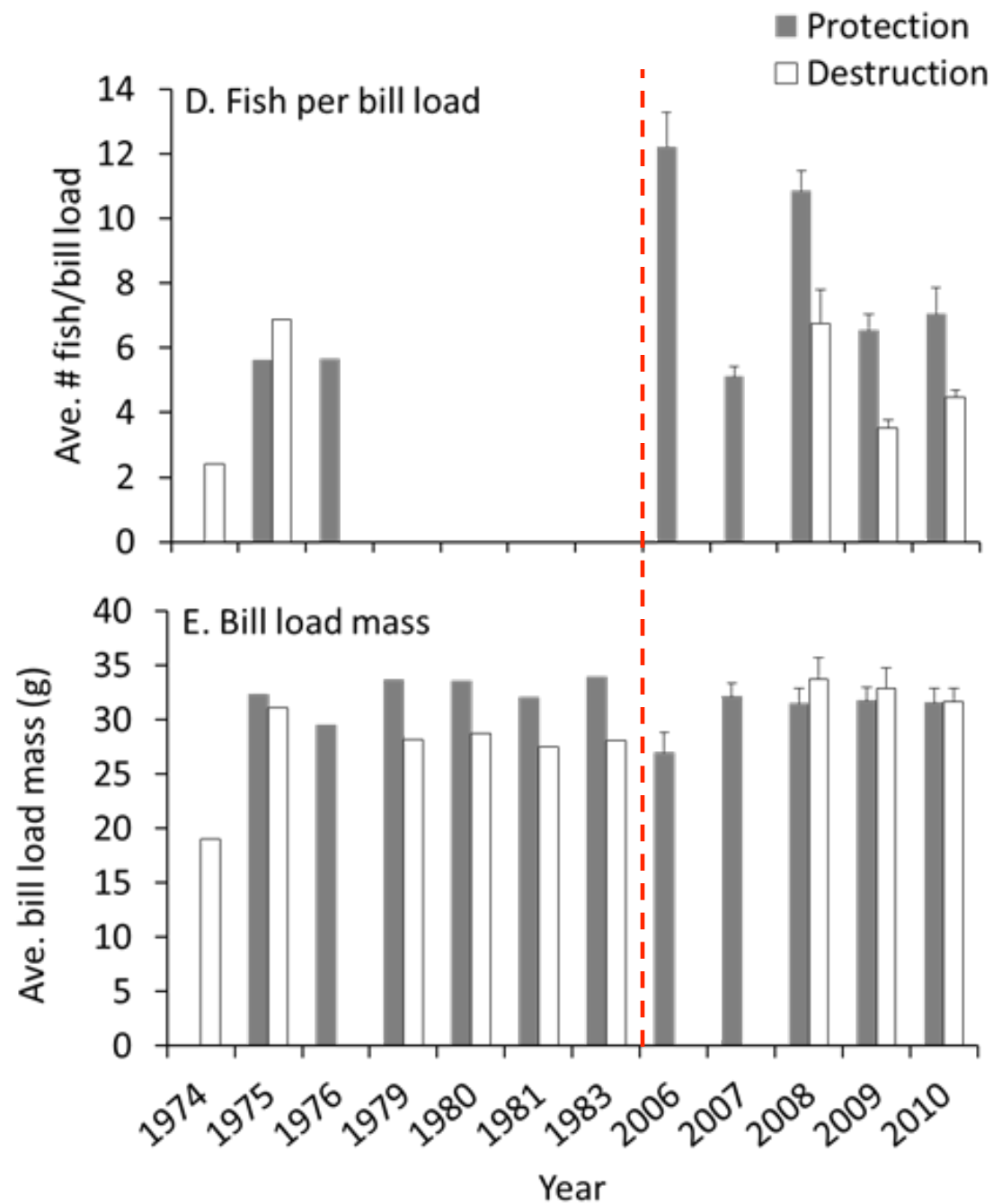




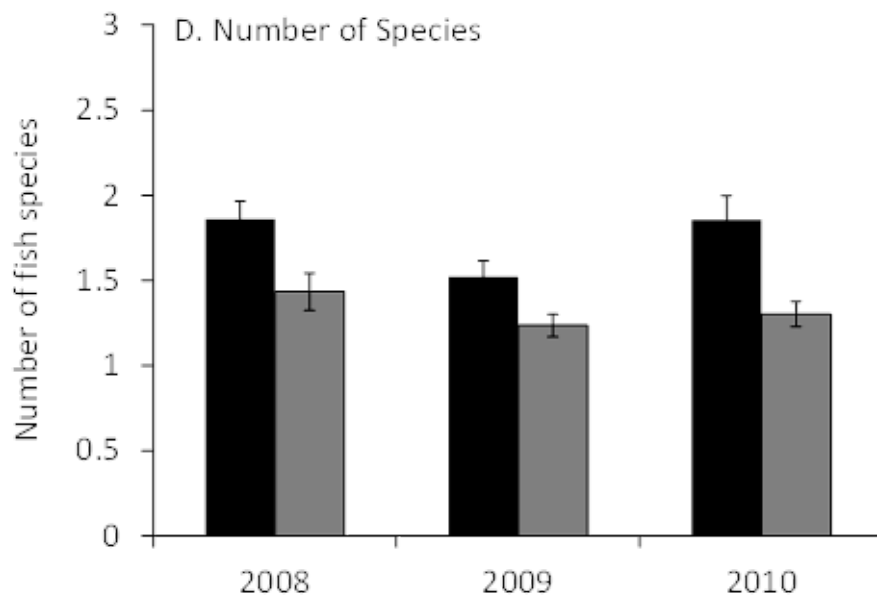
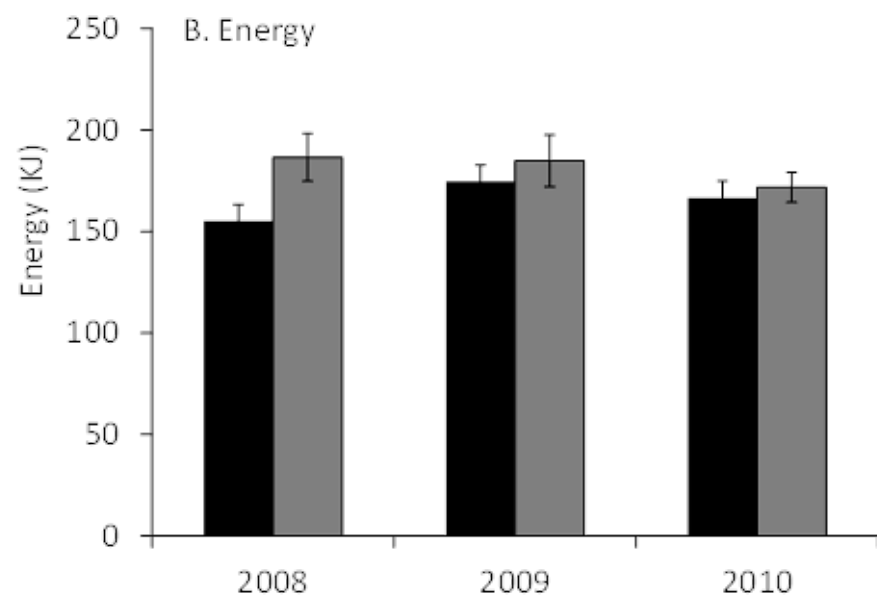
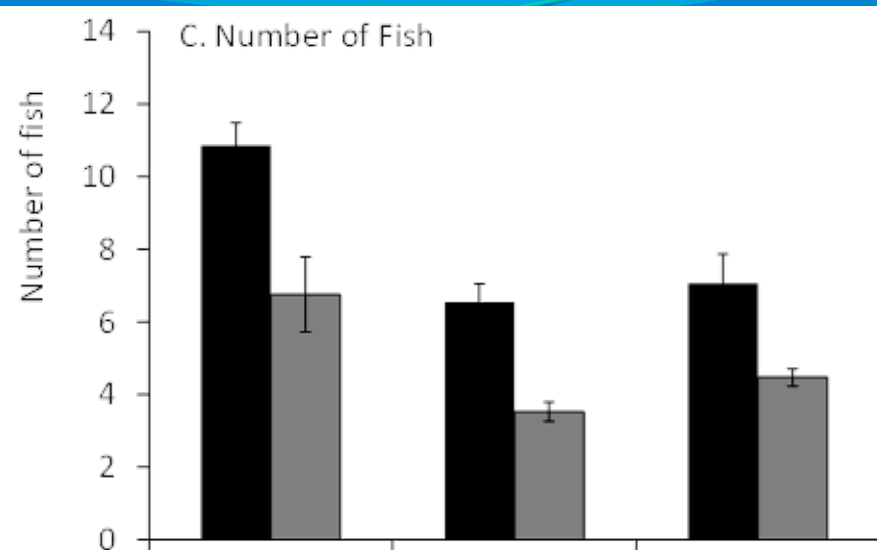
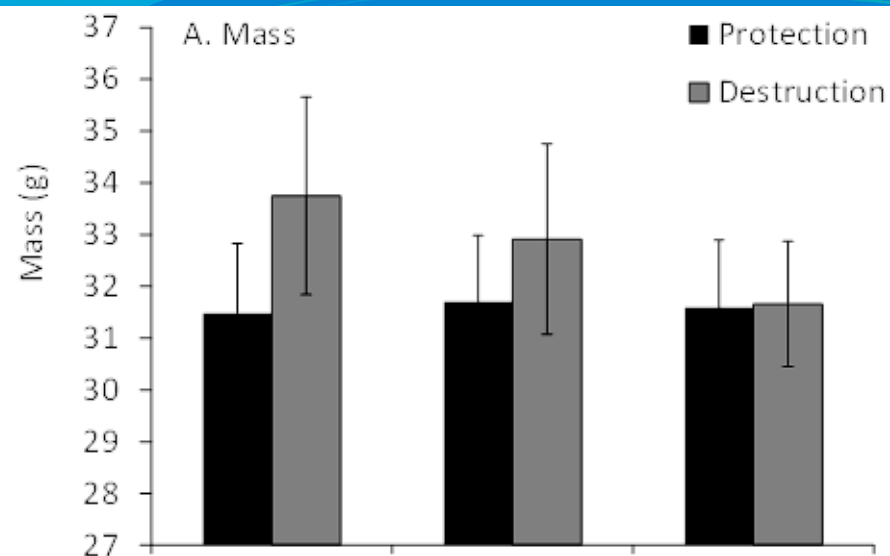
(Pearson et al. Fig. 3)







(Pearson et al. Fig. 4)





# Pearson et al. (submitted)

- **Auklet diet: Puget Sound less diverse than outer coast**
- **Diet diversity appears stable over 30 years**
- **Bill load mass and energy similar among islands and years (and not related to oceanographic conditions)**
- **Adults fed chicks more fish and species per bill load in Puget Sound and fewer heavier fish in California Current**

# Rhinoceros auklets in WA

- **Protection Island: 5<sup>th</sup> largest RHAU colony in N.A.**
  - **Despite degraded Puget Sound ecosystem**
- **Destruction Island population << in 1970s**
  - **Found lower burrow density and occupancy**
- **Diet varies among breeding colonies**
  - **Puget Sound colony: narrow (76% sandlance, 16% herring)**
  - **Outer coast colonies: broader, more variable diet**

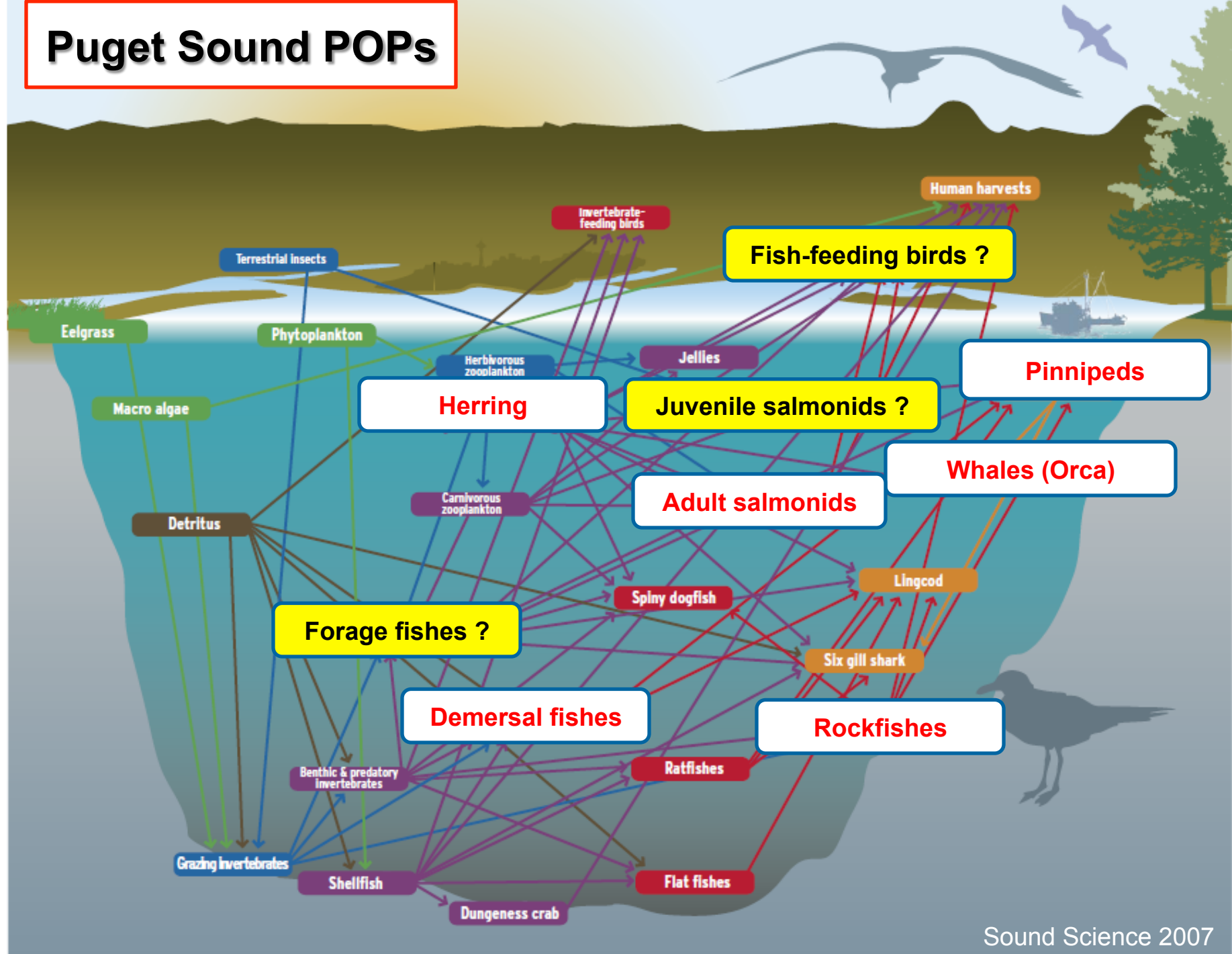
SF Pearson, PJ Hodum, M Schrimpf, J Dolliver, TP Good & JK Parrish (2009)

SF Pearson, PJ Hodum, TP Good, M Schrimpf & SM Knapp (2013)

SF Pearson, PJ Hodum, M Schrimpf, JK Parrish, TP Good, & J Dolliver (in prep.)



# Puget Sound POPs



# Persistent organic pollutants (POPs)

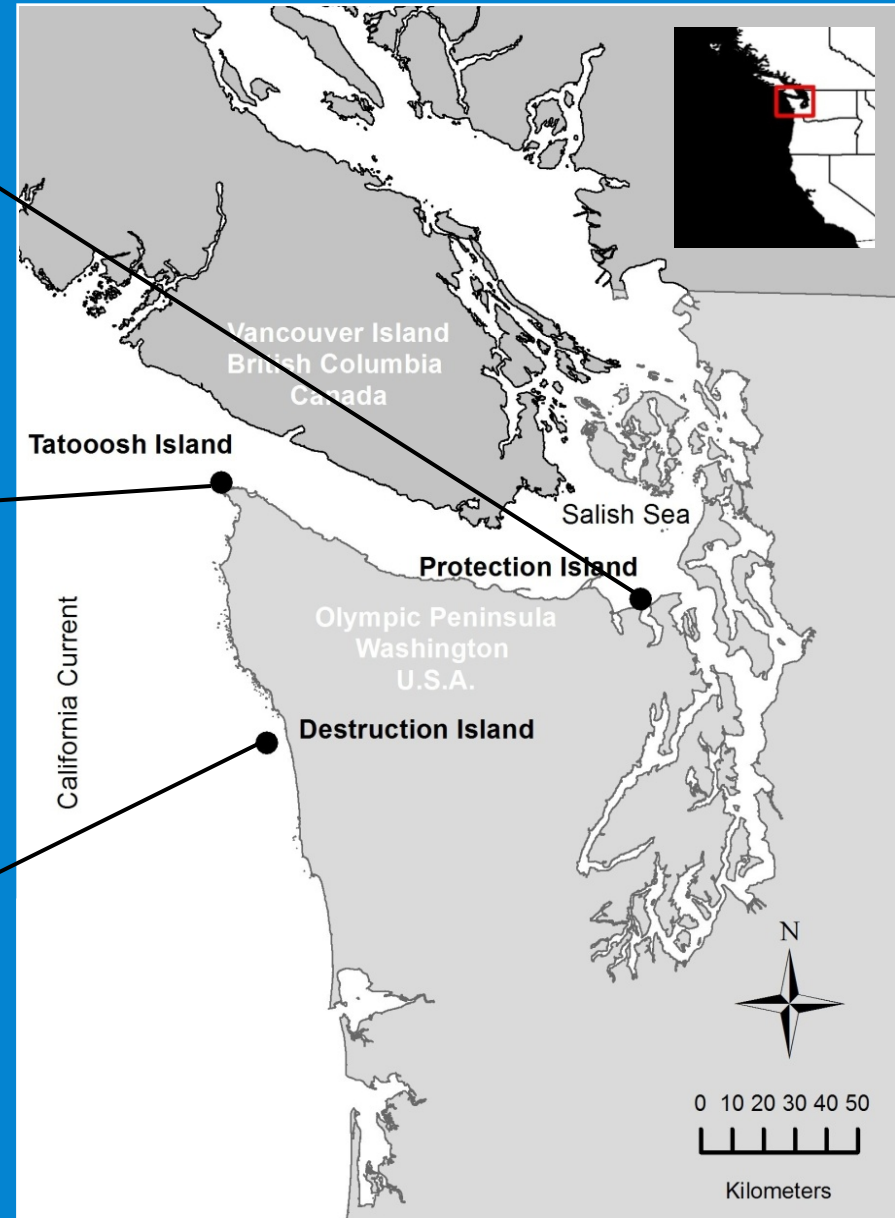
- **Multiple sources:**
  - Industrial use (PCBs)
  - Insecticides (DDT, HCHs, chlordanes)
  - Flame retardants (PBDEs)
  - Industrial byproducts (HCB)
- Current use and legacy contaminants
- Resistant to environmental degradation
- Bioaccumulate (w/in) and bio-magnify (up)

# Questions

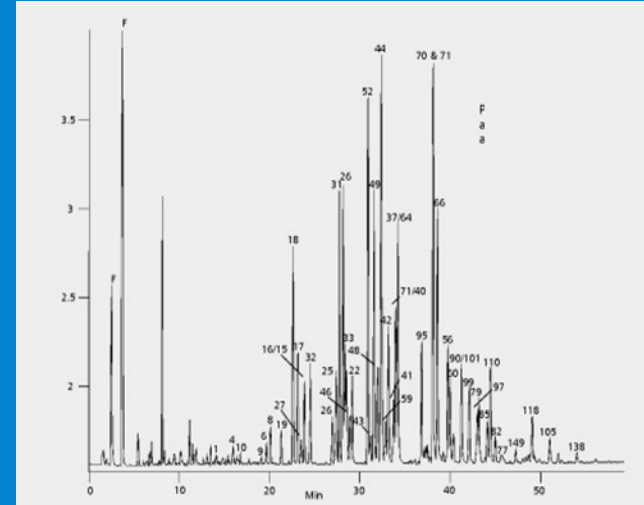
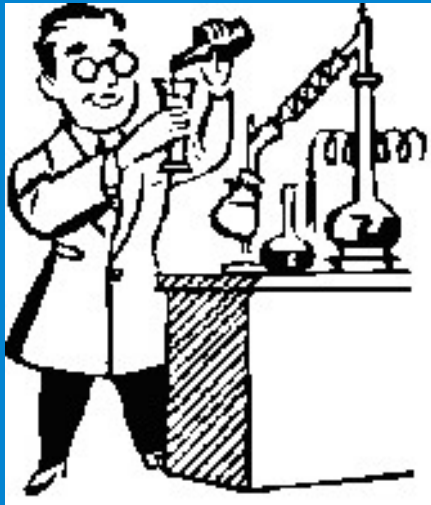
- **Do concentrations of POPs in fish captured by auklets differ among prey species?**
- **Do concentrations of POPs in captured fish differ among colonies?**
- **Do nestling period contaminant burdens differ among observed diets on colonies?**



# POPs sampling sites



# Laboratory analyses (Gina works her magic)



# Prey species analyzed (whole bodies)

SAND



HERR



ANCH



SURF



CHUM



CHIN





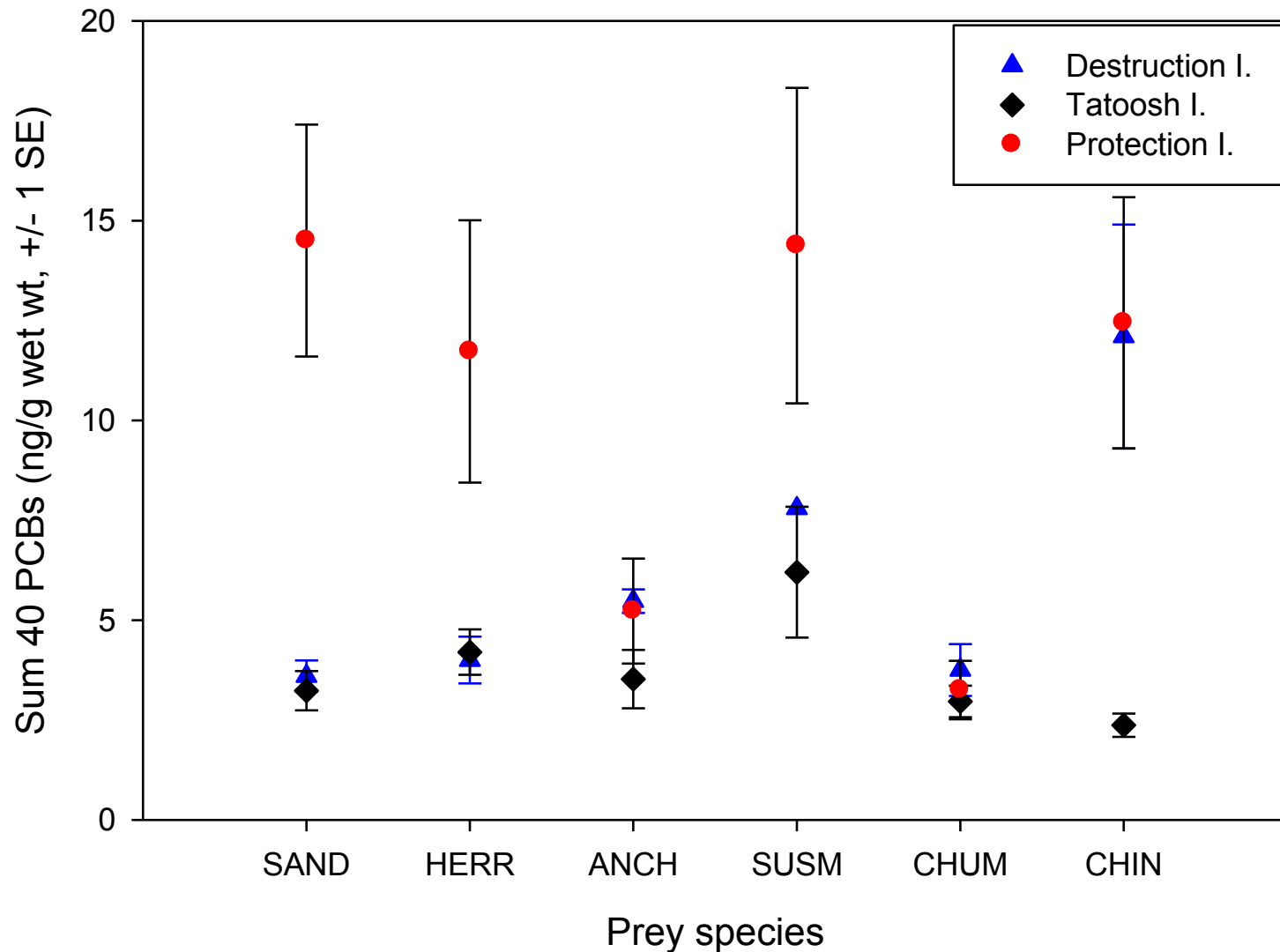
# POP congeners analyzed

- ***PCBs (polychlorinated biphenyls; n=40)***
- ***DDTs (dichloro-diphenyl-trichloroethane; n=6)***
- ***PBDEs (polybrominated diphenyl ethers; n=15)***
- ***Chlordanes (chlorinated insecticides; n=8)***
- ***HCHs (hexachlorocyclohexanes; n=3)***
- ***HCB (hexachlorobenzene; n=1)***

# Testing species/island differences

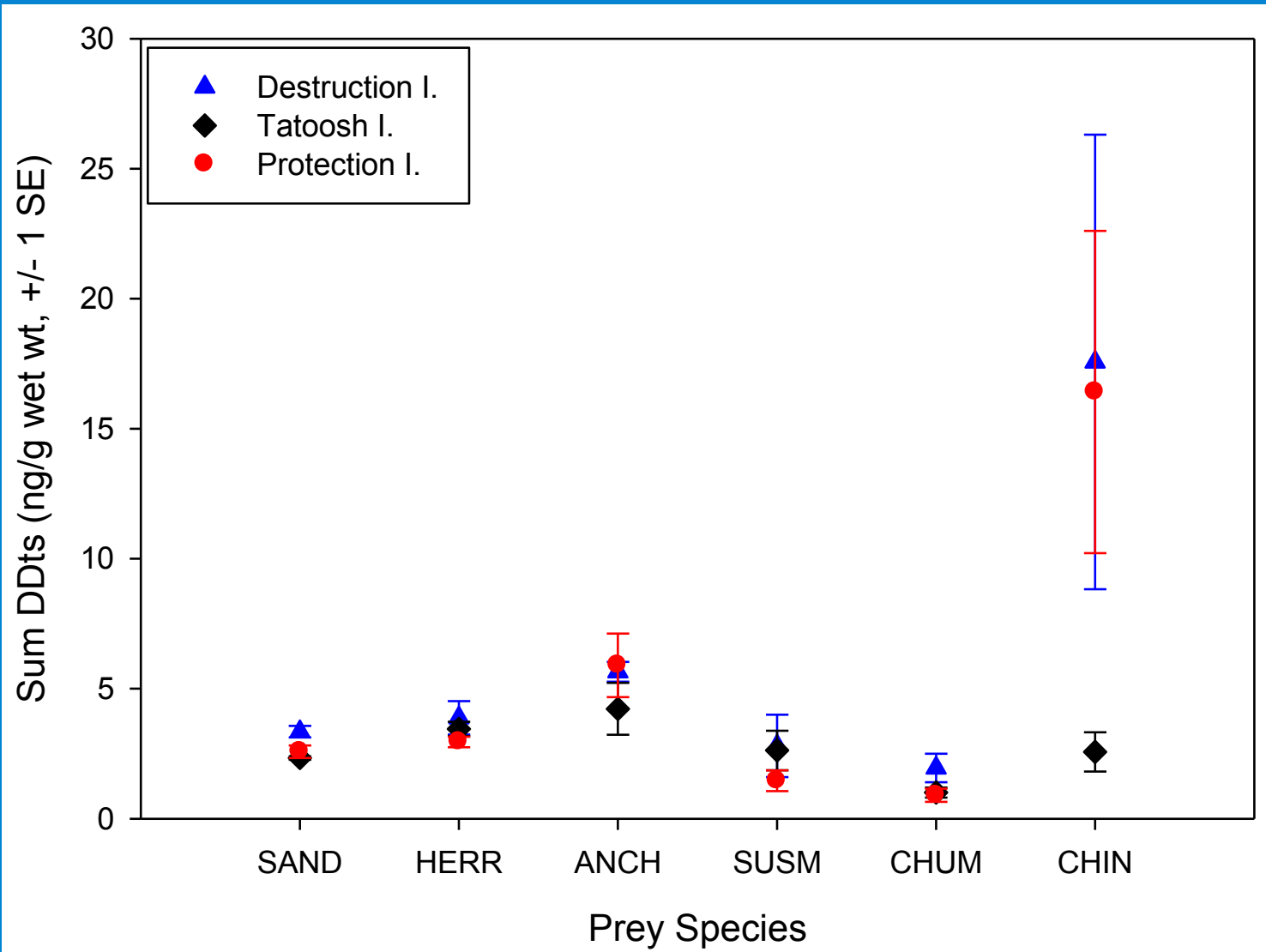
- ***Stepwise GLMs***
  - **Primary factors**
    - **Species**
    - **Island**
  - **Covariates**
    - **Fish length or weight**
    - **Lipid concentration**
    - **Trophic status ( $\delta^{15}\text{N}$ )**
- ***MDS (Primer)***
  - **Species, island**

# *PCBs: species\* island\*\**

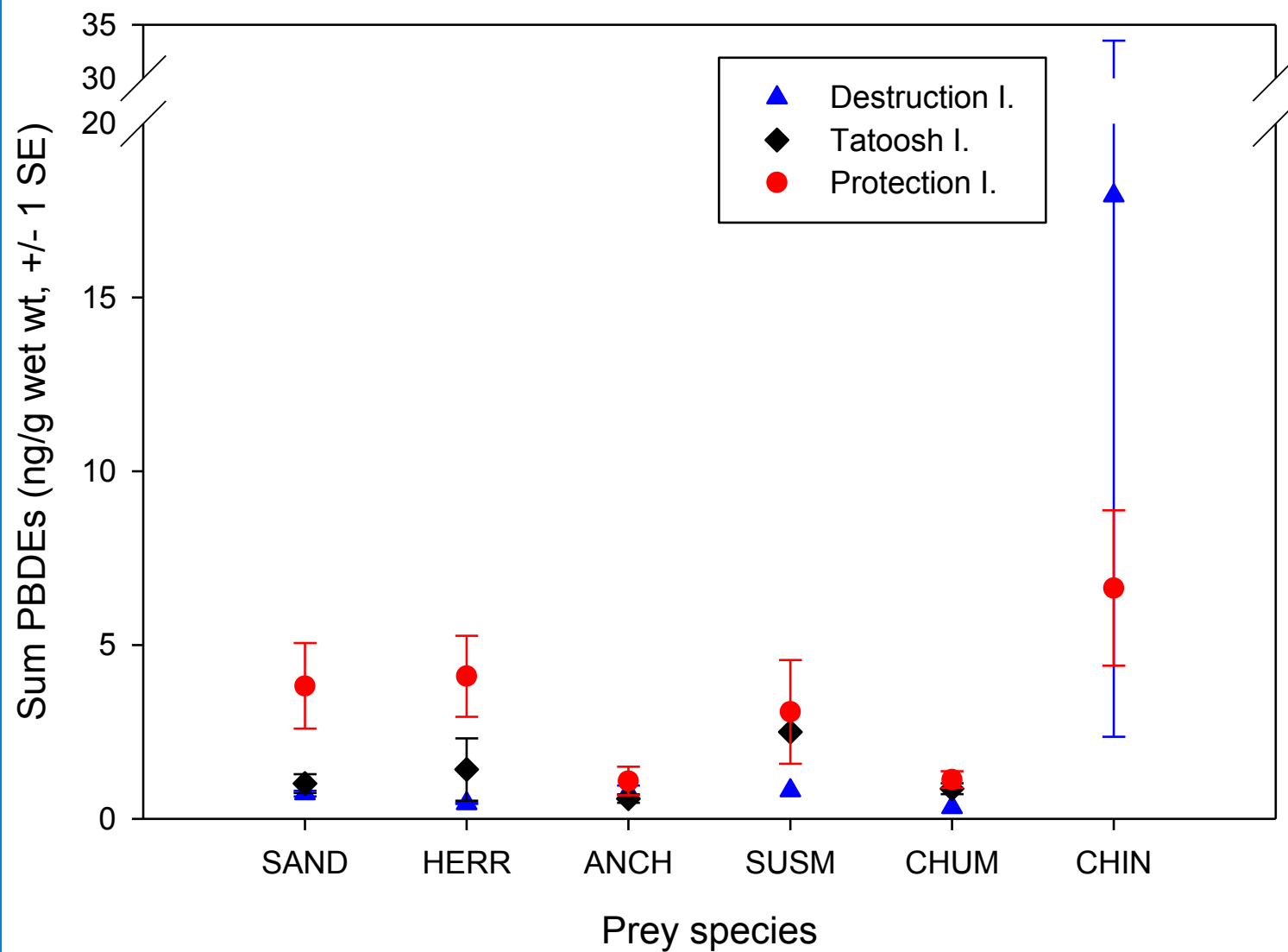




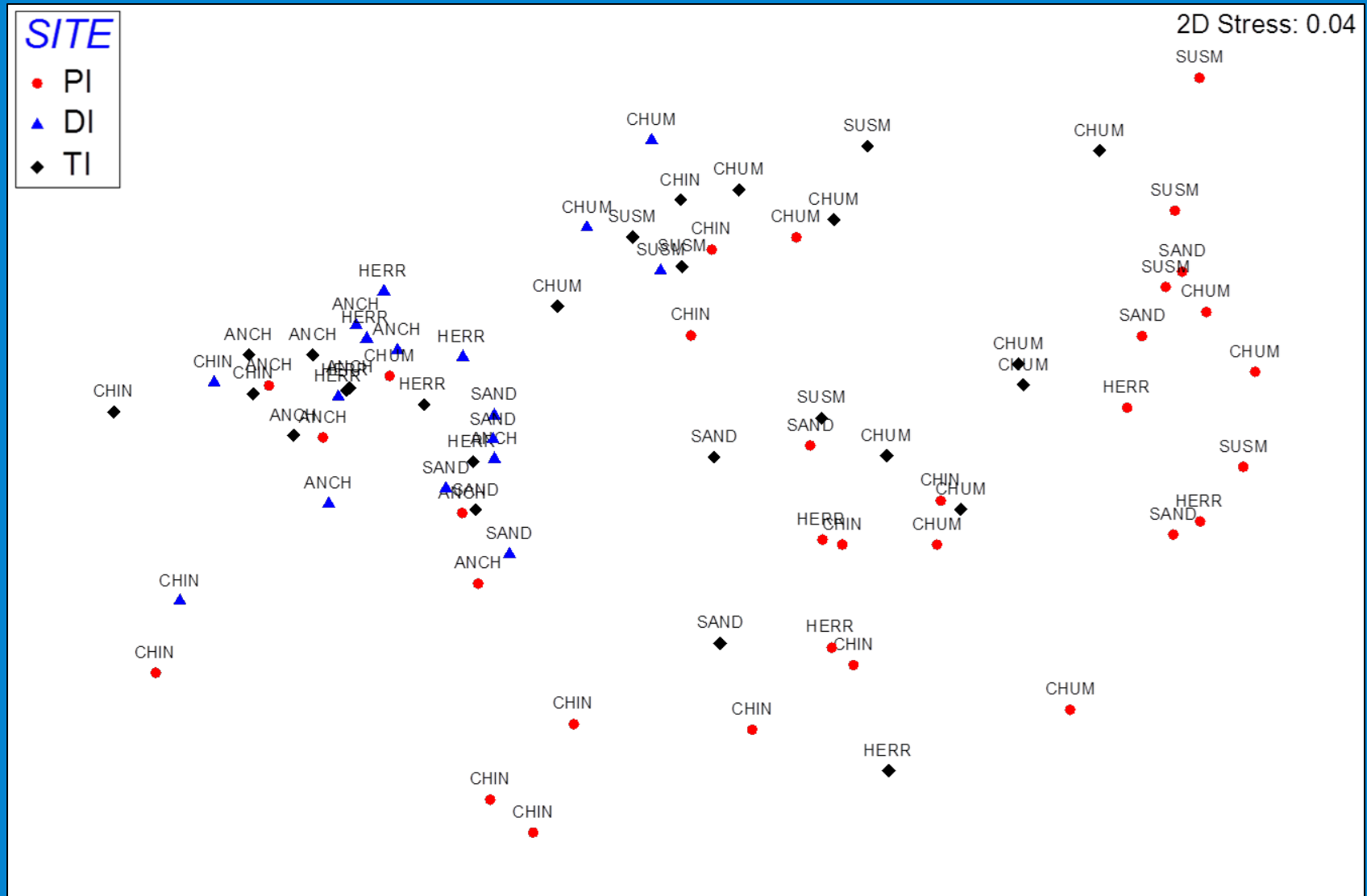
# *DDTs: species\*\* island p=0.057*



# *PBDEs: species\* colony\*\**



# Primer analysis





# 2-way ANOSIM (PCBs, DDTs, PBDEs)

	R statistic	Significance level (p)
<b>Global Test (island)</b>	<b>0.334</b>	<b>&lt;0.001</b>
<b>Pairwise tests</b>		
PI, DI	0.484	<0.001
PI, TI	0.356	<0.001
DI, TI	0.132	<0.103
<b>Global Test (species)</b>	<b>0.385</b>	<b>&lt;0.001</b>
<b>Pairwise tests</b>		
CHIN, CHUM	0.372	<0.004
CHIN, ANCH	0.216	<0.044
CHIN, HERR	0.130	<0.169
CHIN, SAND	0.412	<0.011
CHIN, SUSM	0.672	<0.001
CHUM, ANCH	0.746	<0.001
CHUM, HERR	0.396	<0.004
CHUM, SAND	0.301	<0.016
CHUM, SUSM	-0.024	<0.555
ANCH, HERR	0.361	<0.003
ANCH, SAND	0.626	<0.001
ANCH, SUSM	0.996	<0.001
HERR, SAND	0.264	<0.044
HERR, SUSM	0.597	<0.001
SAND, SUSM	0.402	<0.007

# Summary: island differences

- **PCBs & PBDEs in prey delivered to auklet chicks greater in Puget Sound vs. outer WA coast**
  - **Herring, sandlance, surf smelt**
    - **Less wide-ranging/local spawning populations ?**
- **Anchovy, chum, Chinook salmon**
  - **More wide-ranging populations ?**
  - **Note: Chinook salmon from Destruction I. likely from urbanized estuary (Columbia River ? Grays Harbor ?)**

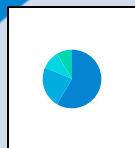
# Summary: species differences

- **PCBs & PBDEs differ among auklet fish prey species**
  - **Sandlance\*, surf smelt\*, herring\* and Chinook salmon > chum salmon, anchovy**
  - **POPs: << central Puget Sound herring (West et al. 2008)**
    - **Smaller fish (170mm, 60g vs. 120mm, 22g)**
    - **Probably from eastern SJdeF/Admiralty Inlet/Whidbey I. area**
  - **Chinook salmon:**
    - **PCBs: rival Columbia R. and South Puget Sound sites), and 3/10 Puget Sound fish > adverse health effects threshold**
    - **DDTs: > Columbia R. and South Puget Sound sites; consistent with interior Columbia R. basin sites**
    - **PBDEs: PI, DI fish >> Columbia R. hatchery fish and 2/10 PI fish > disease susceptibility threshold**

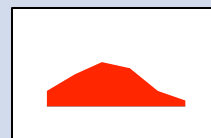
(Meador et al. 2003; Johnson et al. 2007, 2010, 2013; Arkoosh et al. 2010)



**PI > TI & DI  
(PCBs & PBDEs;  
SAND, HERR,  
SUSM)**



**Observed diet varies  
among locations  
PI: SAND, HERR  
TI: SAND, HERR, ANCH  
DI: ANCH, ROCK  
(Pearson et al. submitted)**



**Calculate RHAU chick  
consumption during  
50-day chick period  
prior to fledging**



**Compare POPs  
load for RHAU  
chicks among  
locations**

# Cumulative POPs burden (ng) during nestling period

PCBs	<b>41,549</b>
DDTs	8,317
PBDEs	<b>11,518</b>

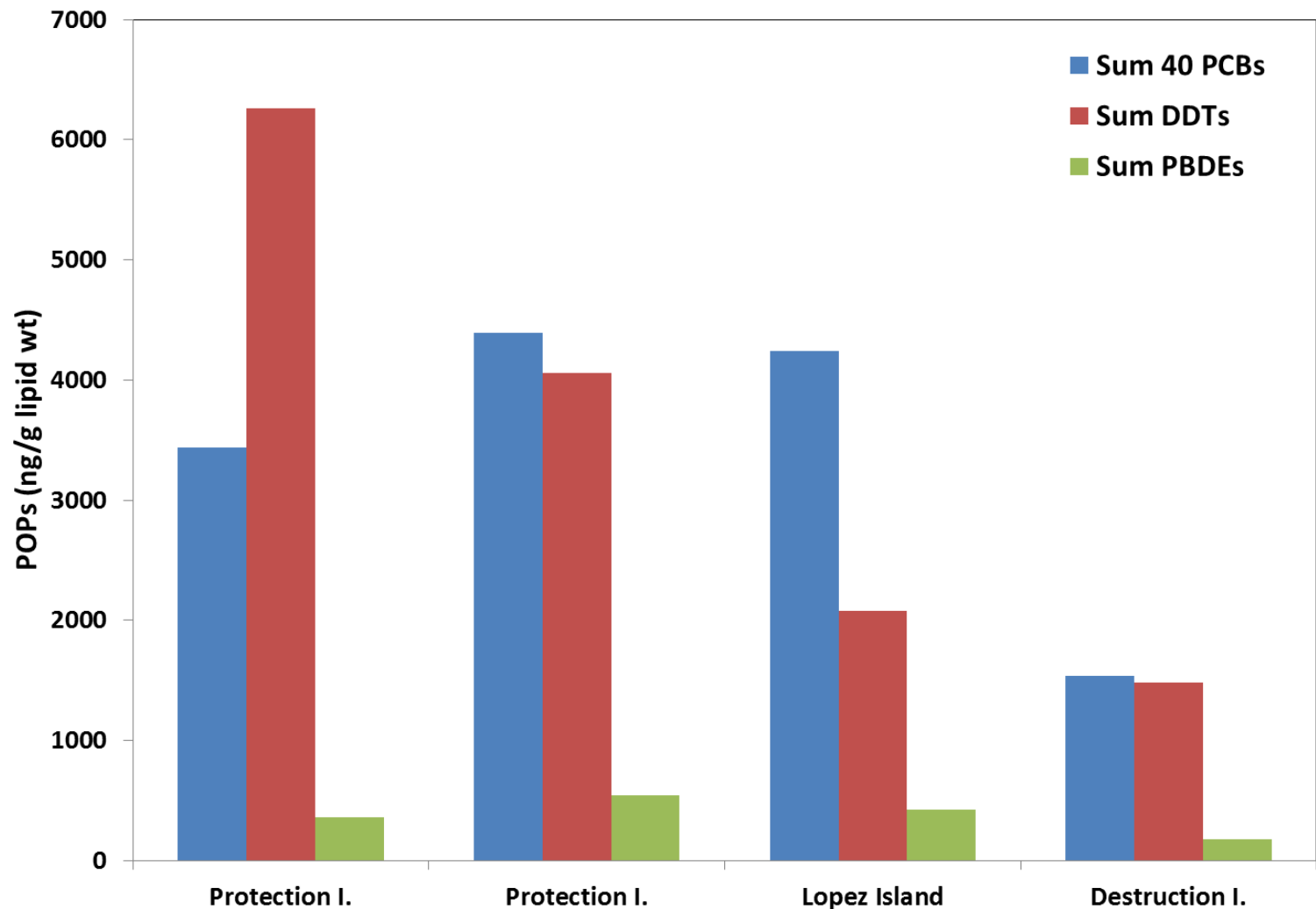
PCBs	9,379
DDTs	7,306
PBDEs	2,825

PCBs	9,533
DDTs	9,918
PBDEs	1,523





# POPs in rhinoceros auklets



# Summary: RHAU POPs

- Nestling POPs burden may be significant and function of island (POPs levels in fish; colony diet)
- Adult POPs levels greatest in Puget Sound
- Similar to patterns found in Harbor seals studies:
  - Puget Sound POPs 7x > than Strait of Georgia (Ross et al. 2004)
  - Puget Sound diet POPs of harbor seals >> Georgia Strait diet
- *Potential for sampling both prey and avian predator*

**You are what you  
eat...**

