Emerging ocean pollution issues in the NE Pacific Ocean vary by matrix: Lessons from sediments, shellfish and marine mammals

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Ocean Pollution Research Program

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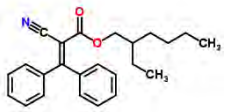
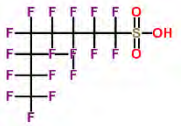
Pollution priorities: where do we start?

- Over 100,000 chemicals on the global marketplace, with 1,000 new chemicals every year;
- Thousands of point sources;
- The vagaries of non-point source release;
- Local vs global pollutants;
- Wide variety of physico-chemical properties (water soluble -> fat-soluble);
- Range of emissions histories;
- Proprietary data (e.g. pesticide formulants);
- Different receptors or species at risk





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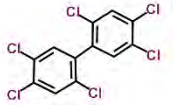

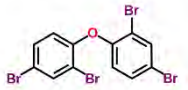

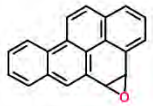

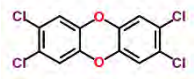

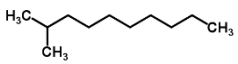

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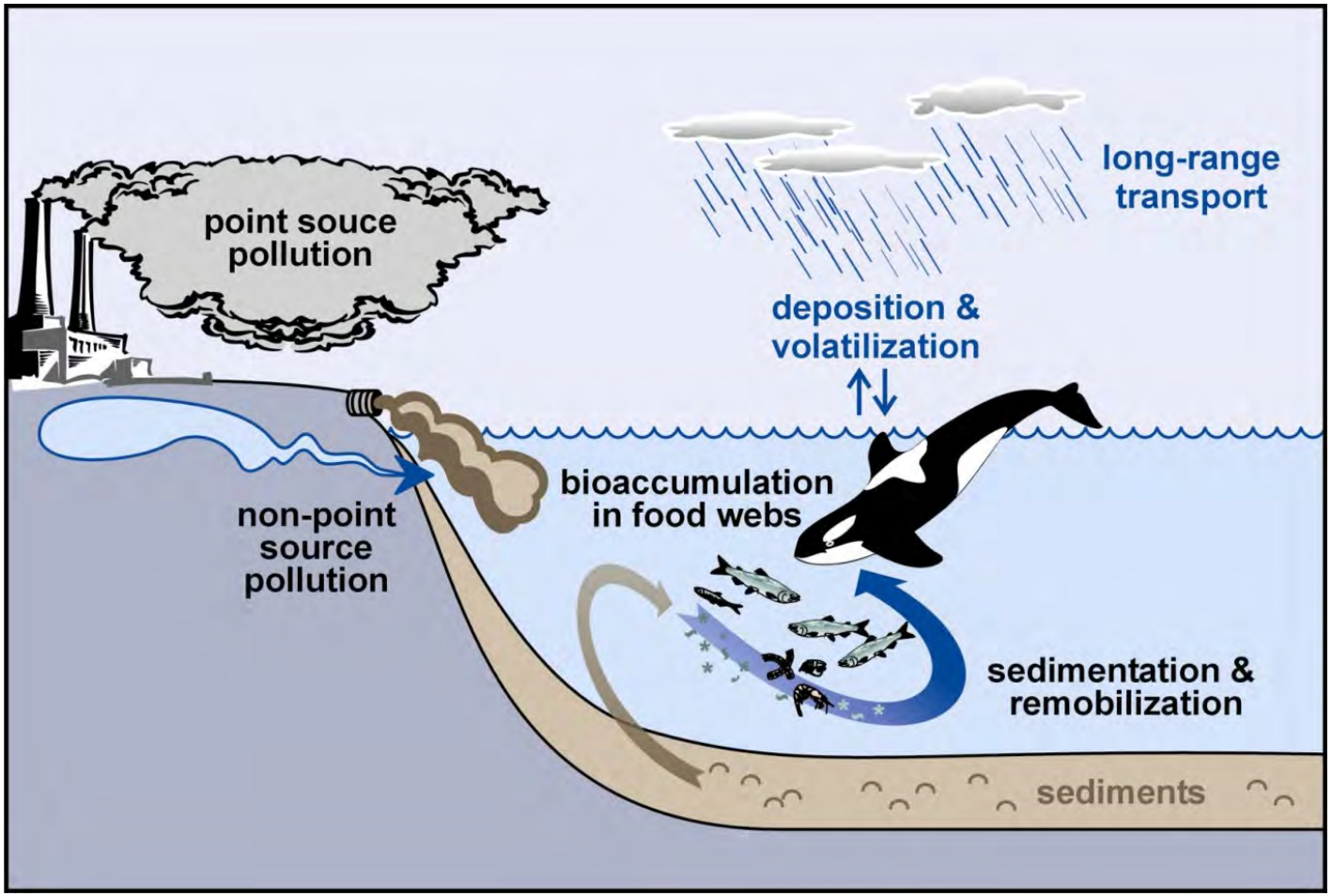
End-of-pipe discharges and non-point source pollutants contribute to complex mixtures in the ocean

NJIT Vector

Pollution: “The presence in or introduction into the environment of a substance which has harmful or poisonous effects”.
- *(Oxford Dictionary)*

Florida Water Coalition

Contaminants are found in water, but most end up in sediments or food webs



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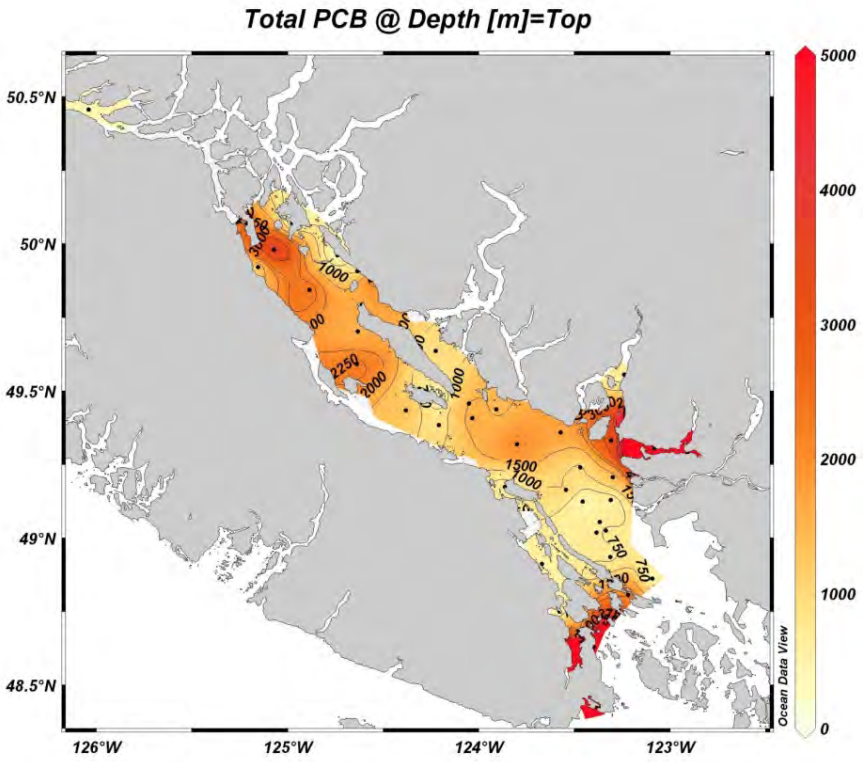
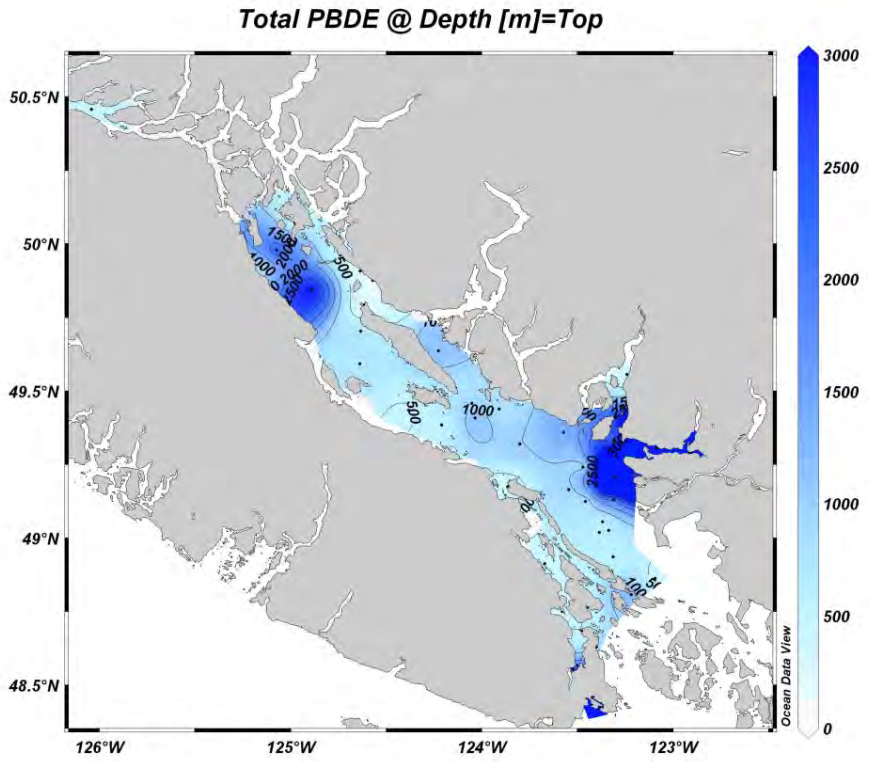
Sediments reveal hotspots for Persistent, Bioaccumulative & Toxic contaminants (PCBs and PBDEs) in British Columbia





(Grant et al., 2011)

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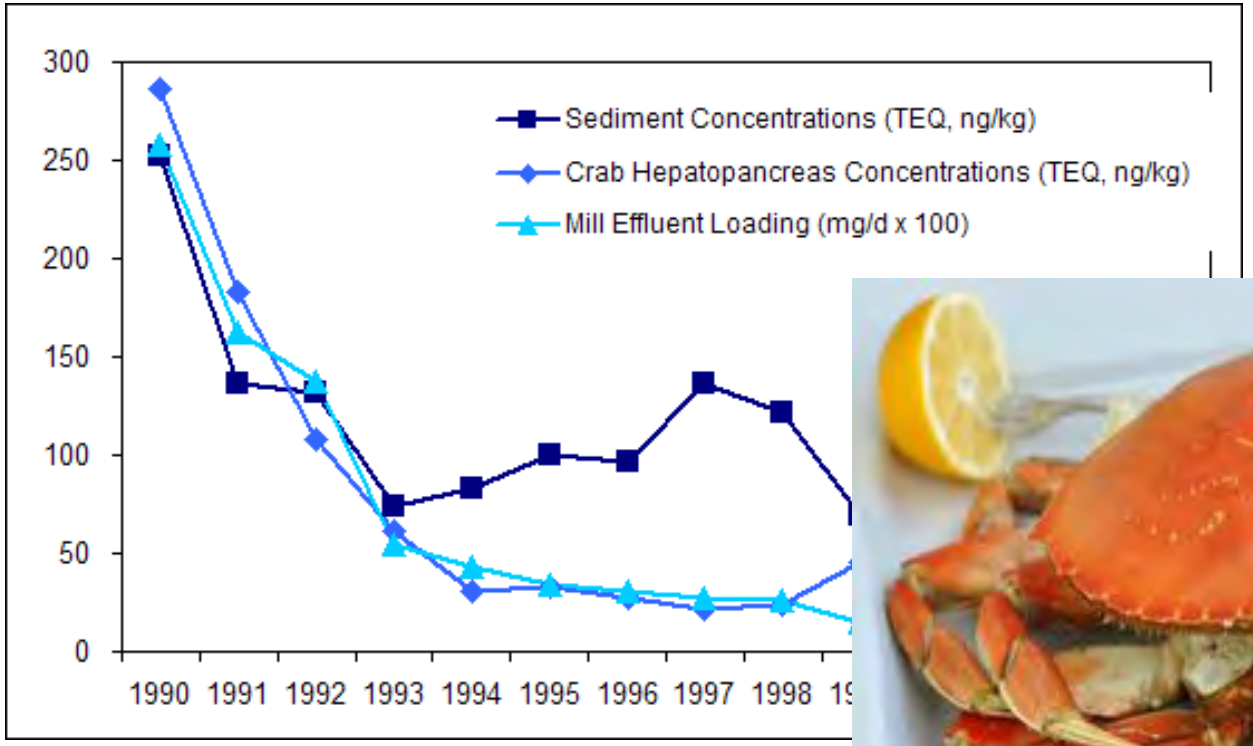
Time-series for sediment dioxins and furans illustrate effectiveness of regulations for pulp and paper mills



(Hagen et al., 2004)

Good news for seafood safety!

Sediments are an important matrix for monitoring

- ‘easy’ to collect
- No conservation implications
- Well studied
- Accumulate a wide range of contaminants
- Links to regulations, guidelines
- Represent both a sink and a source
- Provide integrated assessment of the current state of the coastal environment
- Common matrix across North Pacific

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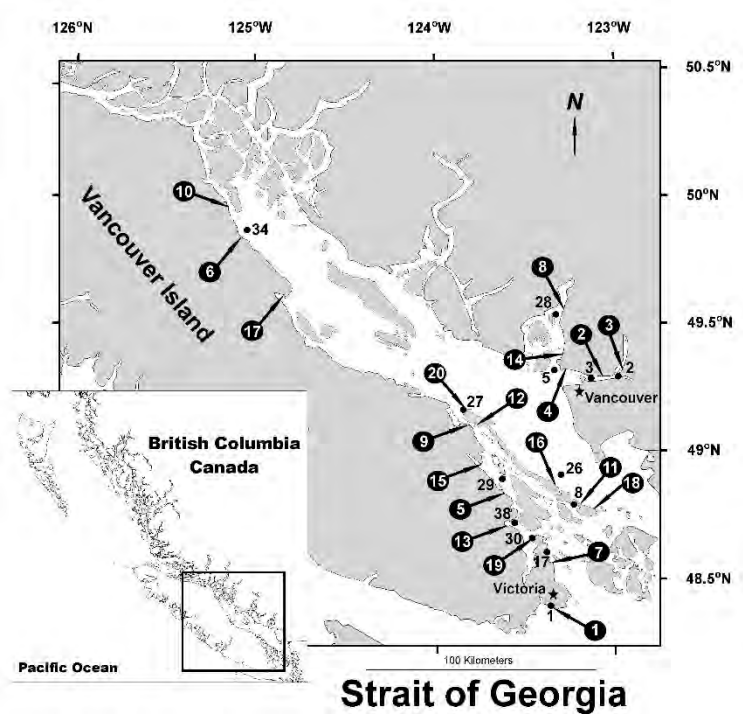
Mussels are intertidal shellfish that integrate contaminants from water & particles



- Sessile
- Coastal
- Filter feeders

Site	Location	%MOISTURE	%LIPID	PCB-153	PCB-138	PCB-118	PCB-101	PCB-149	PCB-110	TOTAL PCB	BDE-47	BDE-99	BDE-100	BDE-209	BDE-153	BDE-154	TOTAL PBDE	PBDE/(PCB+PBDE)
1	Inner Harbour	91.36	0.52	5340	4340	3750	3120	2520	2430	48600	5000	4010	1290	193	178	166	11700	0.19
2	Burrard Inlet	91.65	0.28	1660	1400	886	735	712	407	14800	3490	2800	1040	1700	136	113	10300	0.41
3	Moody Arm	89.44	0.51	799	684	462	418	407	245	7900	1490	901	311	196	44	43	3260	0.29
4	West Van Labs	91.21	0.38	407	311	211	170	173	105	4900	2040	1750	586	174	74	76	5050	0.51
5	Crofton	90.47	0.44	676	463	139	169	297	83	4360	919	869	252	258	60	49	2570	0.37
6	Oyster River	91.90	0.20	452	358	200	166	153	84	4090	793	363	181	151	63	65	1820	0.31
7	Sanichton Bay	91.19	0.36	479	358	185	160	183	95	3760	928	663	215	108	37	36	2160	0.36
8	Porteau Cove	89.56	0.50	175	163	107	96	83	59	3600	1620	1010	356	213	41	41	3480	0.49
9	Cable Bay	90.44	0.33	256	212	108	93	103	58	2980	602	401	142	114	14	19	1390	0.32
10	Campbell River	91.61	0.25	400	305	154	132	118	79	2750	802	497	206	202	28	29	1900	0.41
11	Samuel Island	90.04	0.48	290	238	119	125	107	68	2170	1410	802	293	24	40	37	2760	0.56
12	Brickyard Beach	90.78	0.32	165	138	76	68	73	42	1970	668	461	162	185	27	21	1660	0.46
13	Cowichan Bay	90.53	0.40	267	220	114	103	91	43	1970	1130	1090	340	53	49	50	2940	0.60
14	Ansel Point	93.01	0.27	159	123	82	70	63	38	1800	1010	699	293	291	31	26	2500	0.58
15	Wallis Point	90.36	0.47	181	144	101	98	74	62	1690	1120	922	286	100	57	47	2750	0.62
16	Galiano Island	92.34	0.42	216	175	106	94	80	54	1680	1580	1070	377	399	41	41	3700	0.69
17	Goose Spit Comox	90.48	0.38	222	181	103	81	67	40	1670	445	307	114	191	20	20	1170	0.41
18	Saturna Island	92.14	0.33	223	195	92	73	80	45	1390	2030	1360	487	105	64	54	4400	0.76
19	Moses Point	89.50	0.52	142	129	90	74	62	47	1140	677	595	179	65	31	28	1690	0.60
20	Orlebar Point	88.03	0.55	109	79	47	45	37	26	910	482	293	111	127	16	17	1140	0.56

But how do PCBs and PBDEs in invertebrates compare to sediments? A tale of two species in a controlled study: *Macoma baltica & Neanthes arenacoedentata*

(Marine polychate; deposit feeder; Naturplan, DK)

(deposit-feeding bivalve; Biopix, NL)

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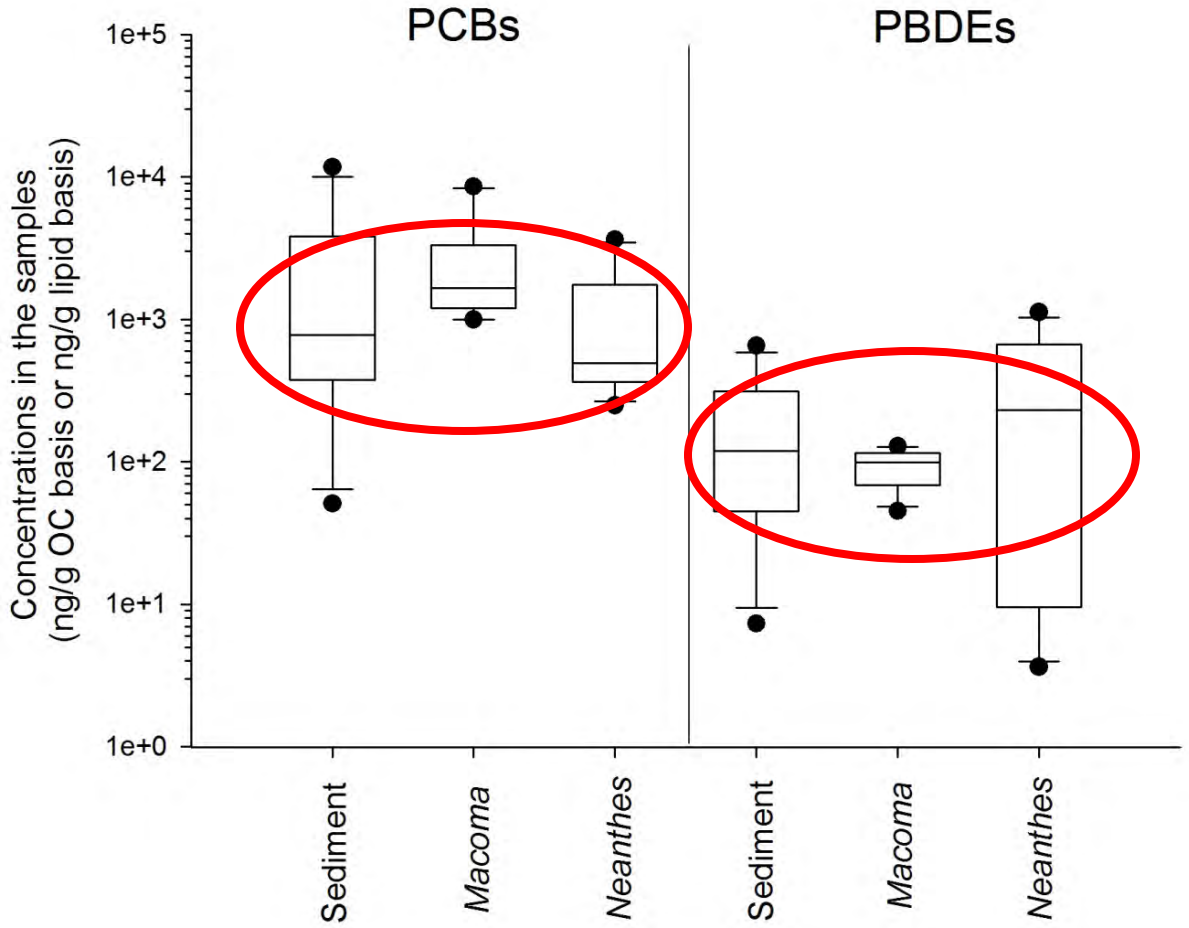
At a glance, total PCBs and PBDEs are taken up from contaminated sediments by two invertebrates in a controlled study



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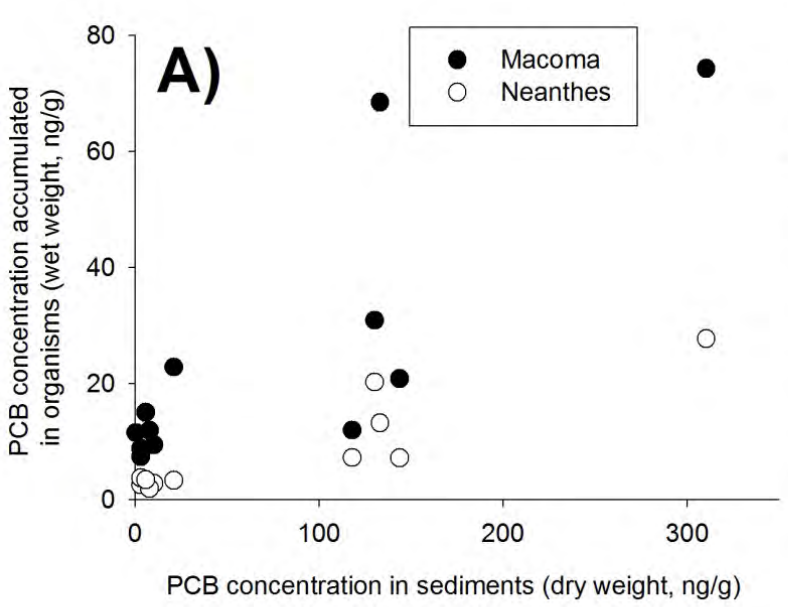
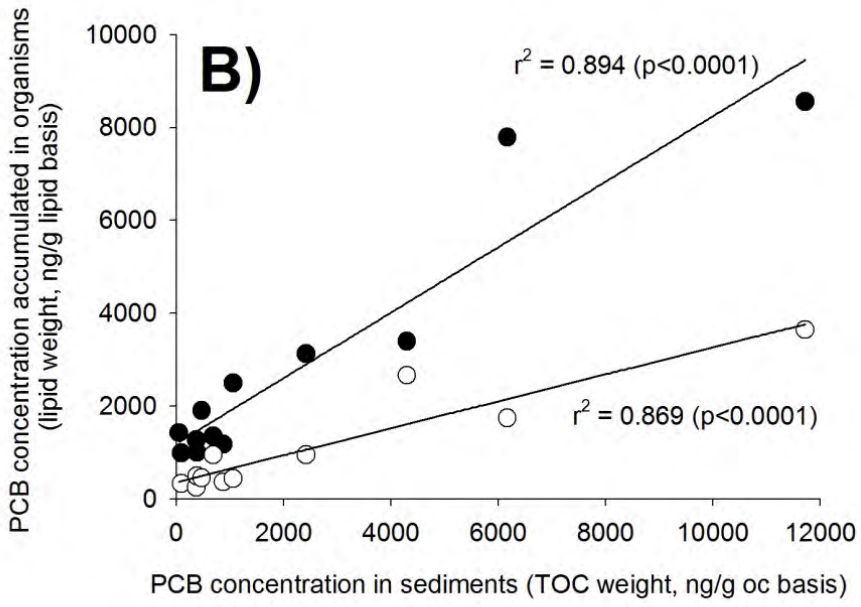
Total PCB uptake is best explained by organic carbon (TOC) and lipid corrections



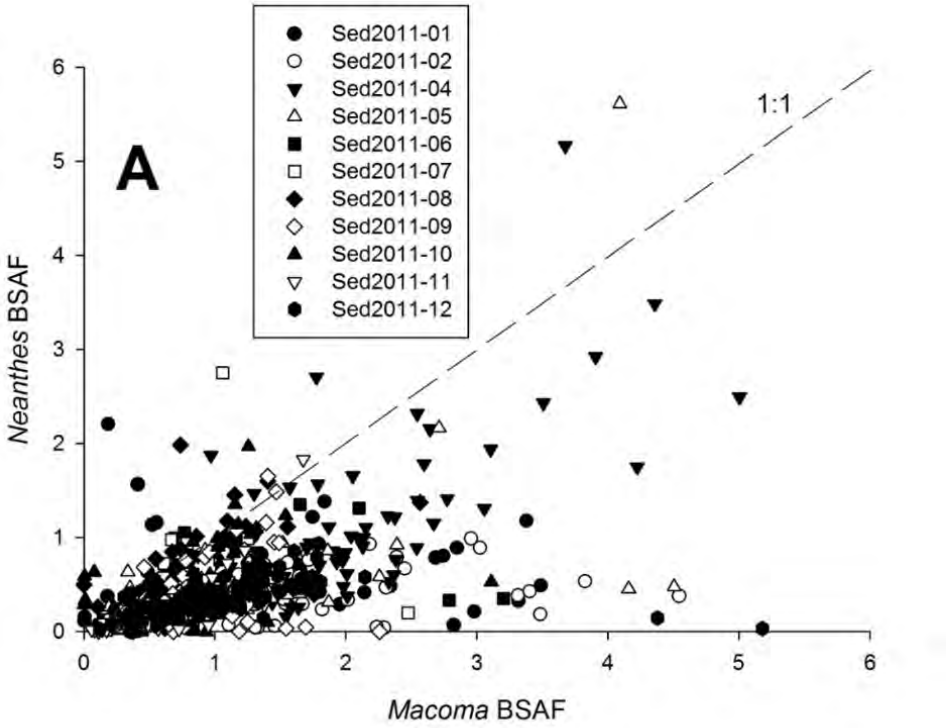


Dry weight corrected data

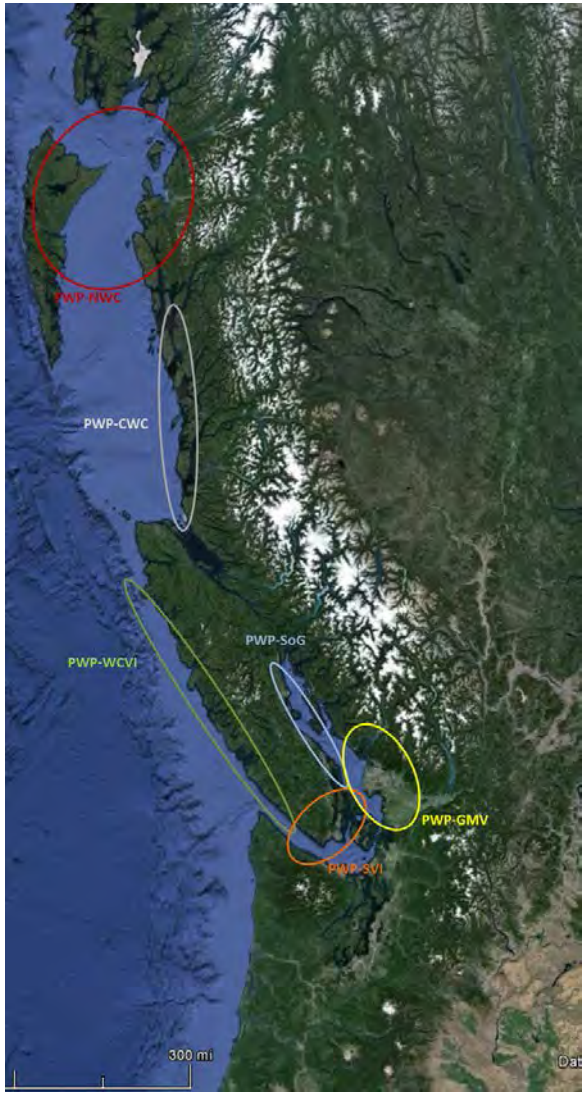
TOC & lipid corrected data

Big inter-species differences in uptake of PCB congeners in invertebrates incubated on sediments (BSAFs) for 28 days

Bivalves accumulate less PCBs in the same period of time compared to the sediment worm *Neanthes sp.*



The *PollutionTracker* Project



A new initiative that will:

- document contaminants in BC coastal environment;
- generate comparable, high quality baseline data;
- document pollution trends over time and space;
- provide baselines to compare against spills, discharges & global pollutants;
- enable priority setting and best practices;
- Comparable to Mussel Watch programs adopted by several nations.

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A ‘state of the food web’ indicator

- Long-lived
- High trophic level
- Consume a wide variety of fish & invertebrates
- Non-migratory
- Widely distributed
- Relatively easy to sample
- Well studied

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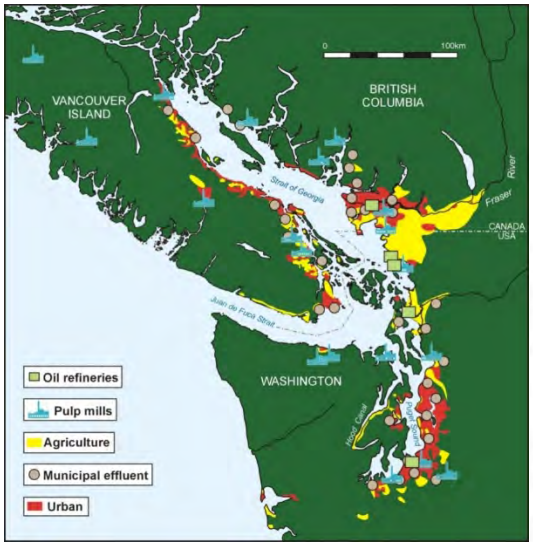
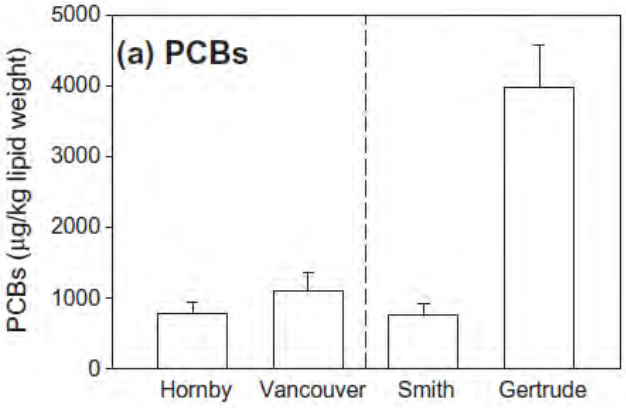
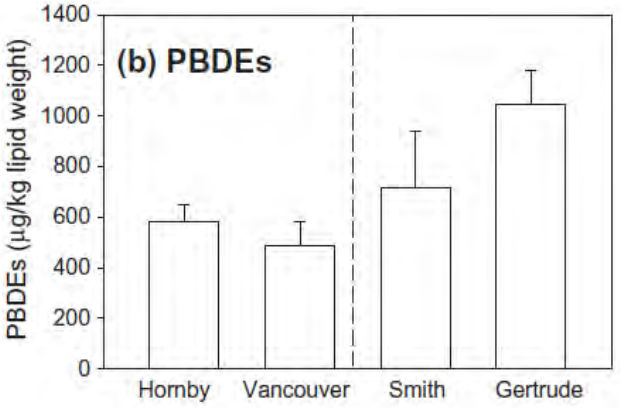
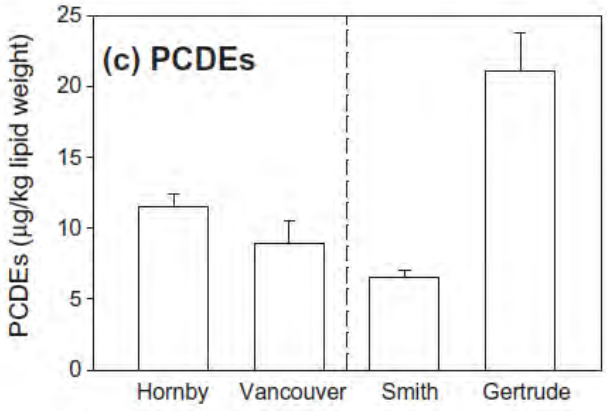
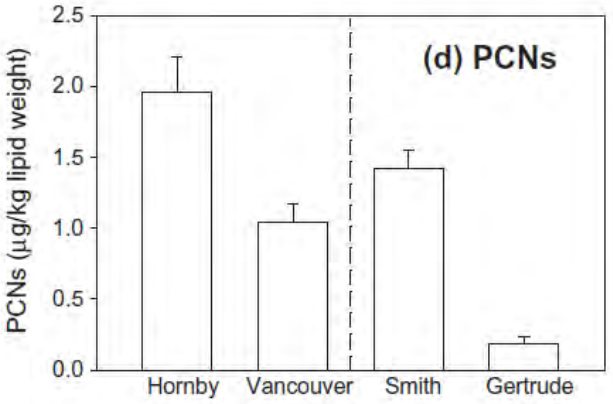
Harbour seals reveal spatial variation in contamination of coastal food web



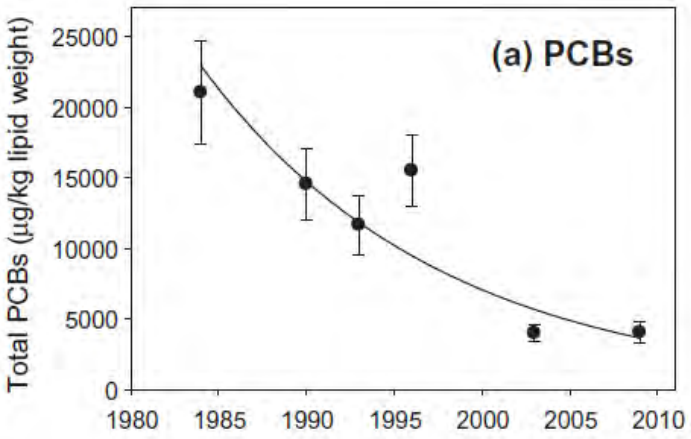


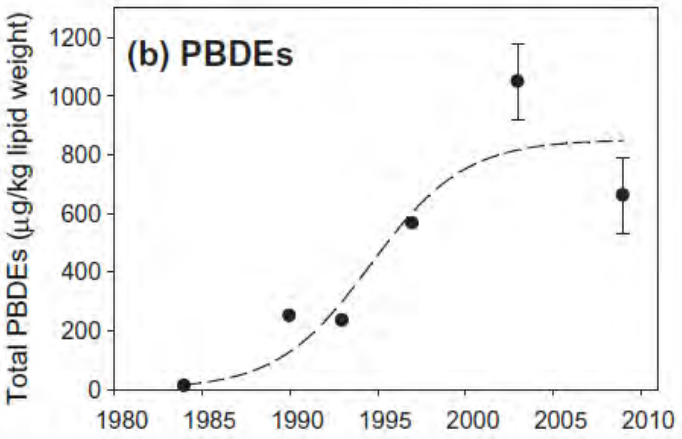


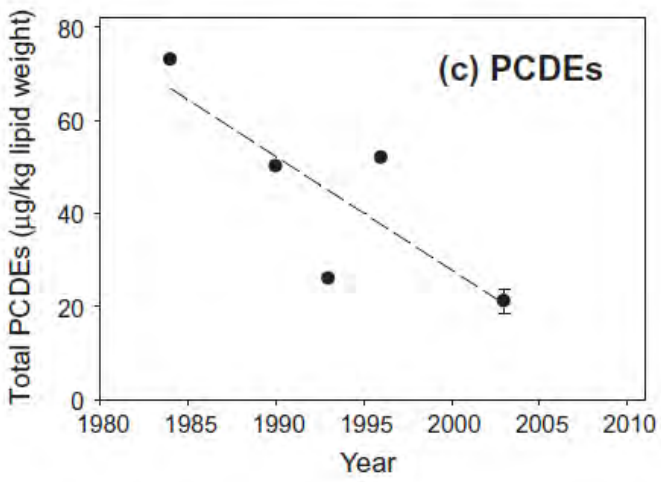


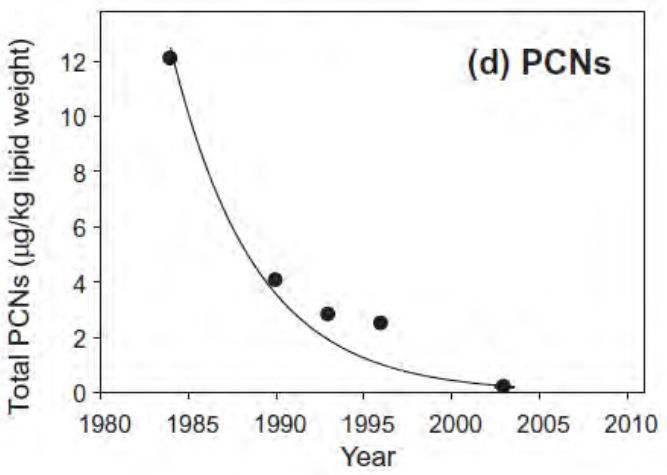


Time series: Harbour seals reveal response of coastal food web to regulations









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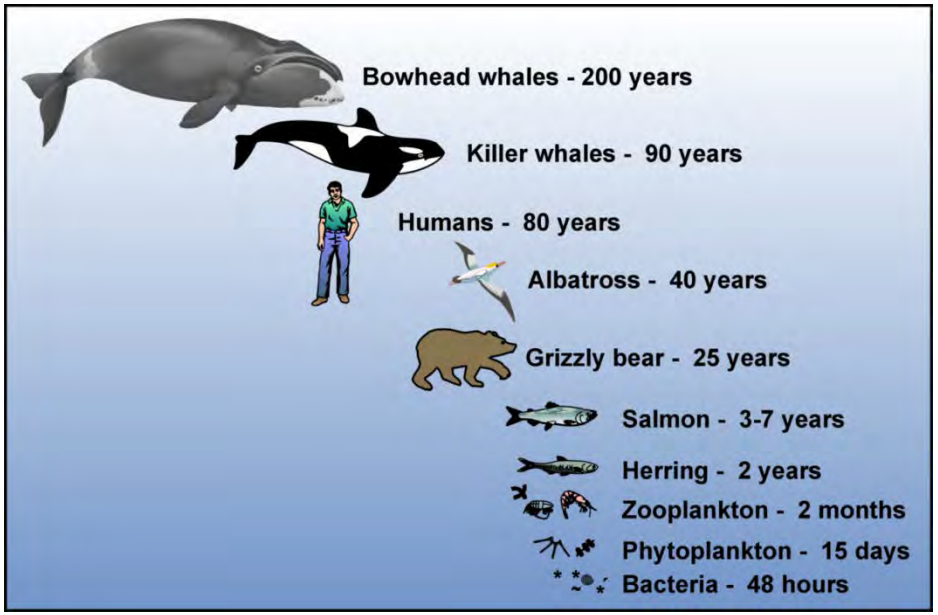
Can we monitor the marine environment with a suitable indicator AND protect humans and wildlife?



The answer:
It's complicated

- 100,000+ chemicals with different emissions histories;
- Different physico-chemical properties;
- They move, partition, amplify & dilute;
- They interact with different receptors (biota);
- There exists no easy 'indicator' matrix; indicator selection depends on the question;
- Both problem chemicals and vulnerable biota almost always surprise the regulators and risk assessors;
- There exists no easy 'indicator' matrix; indicator selection depends on the question;
- Best option is to select a few different indicators covering different parts of the coastal environment.

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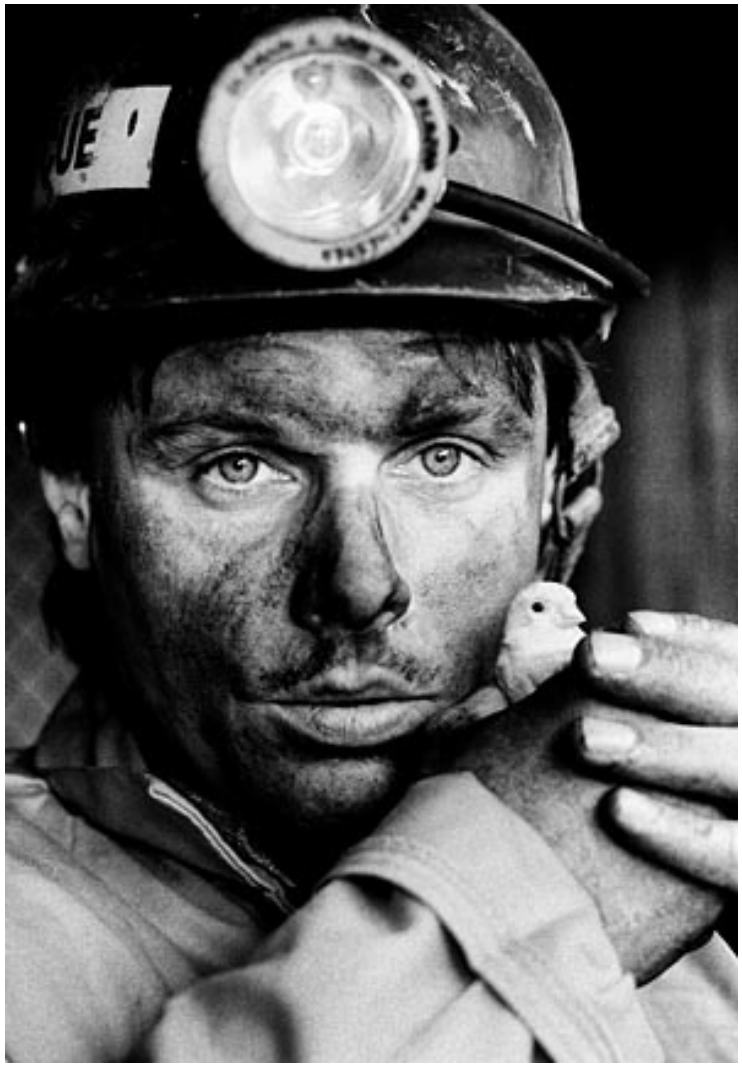
Indicators are useful, but they are not perfect

- Indicators do not always provide an early warning of pollution threats or issues;
- monitoring the receiving environment typically reveals our failure to prevent release of pollutants;
- Preventing releases of harmful chemicals is cheaper & more effective:
  - Precaution
  - Regulations
  - Source control
  - Consumer choices
  - Best practices




Thank you

Domestic sewage is more complex today: thousands of chemicals, pharmaceuticals and personal care products are delivered to the ocean

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Careful selection of indicator matrix in coastal environments can help identify sources or source categories, thereby informing regulations, source control and best practices

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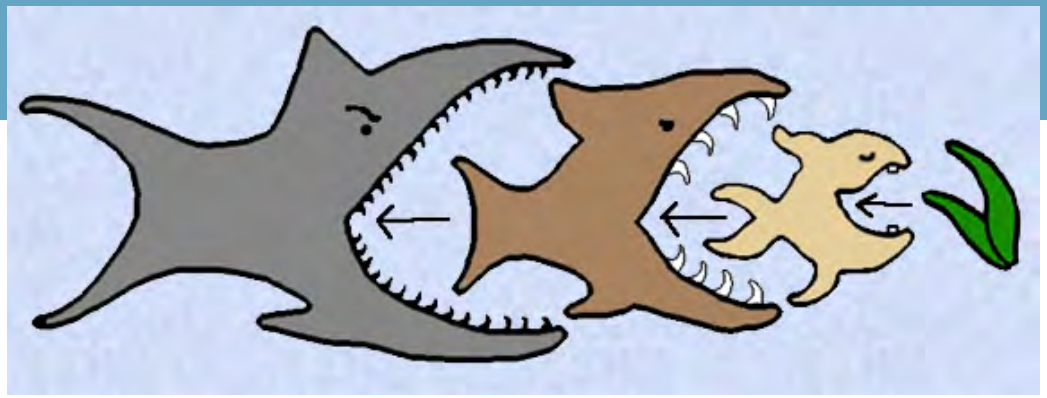

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