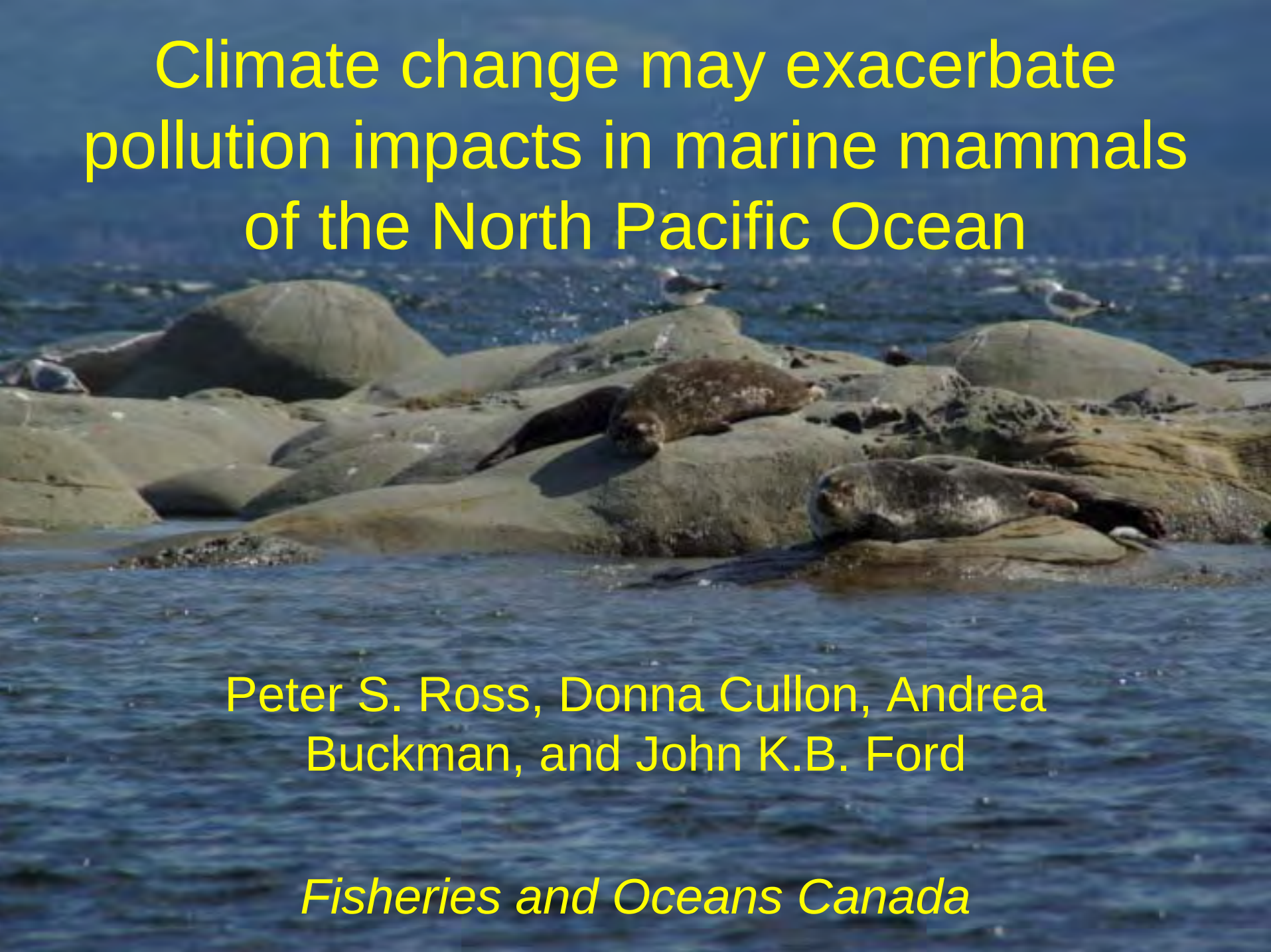
Climate change may exacerbate pollution impacts in marine mammals of the North Pacific Ocean

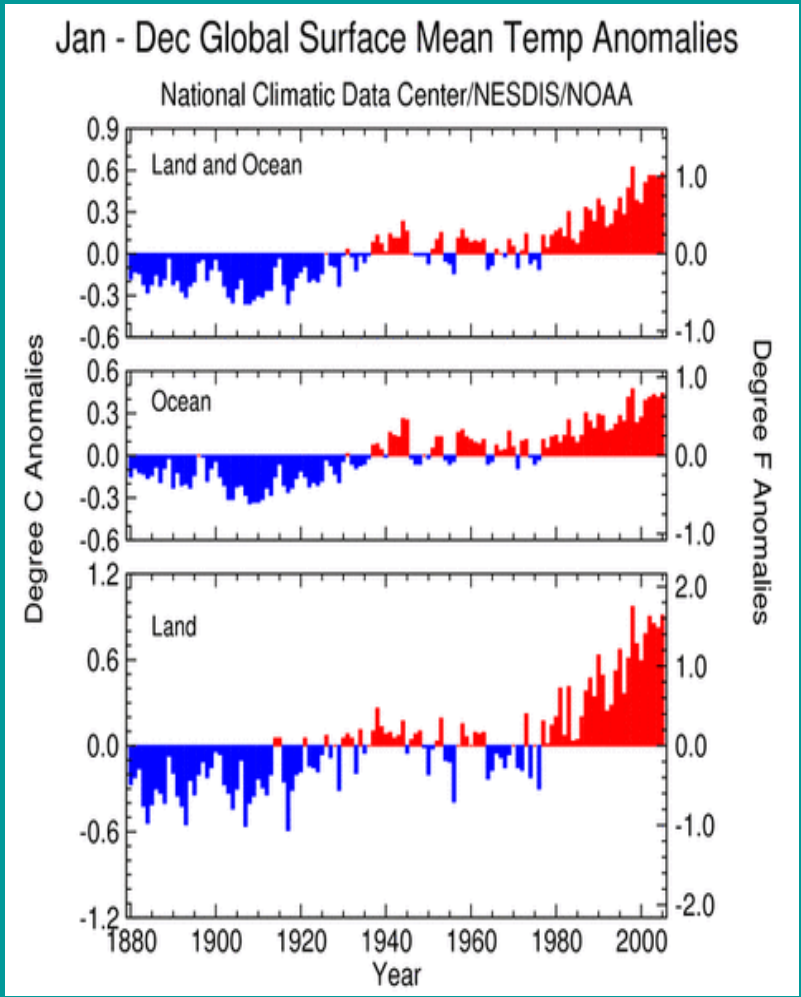


Peter S. Ross, Donna Cullon, Andrea Buckman, and John K.B. Ford

Fisheries and Oceans Canada

Marine mammals come in all shapes and sizes, but all rely exclusively on marine food webs

Climate change: Sea surface temperature on the rise



- Oceans have warmed by 0.13°C per decade since 1880.
- Climate change alters physical habitat (e.g. ice), currents and upwellings.
- Ocean productivity may decline in some areas, and affect the prey base for some marine mammals.

Reduced prey availability: climate change affects vulnerable marine mammals

- Polar bears are getting thinner, reflecting altered Arctic sea ice season and availability of pinnipeds as prey (Stirling and Parkinson 2006).

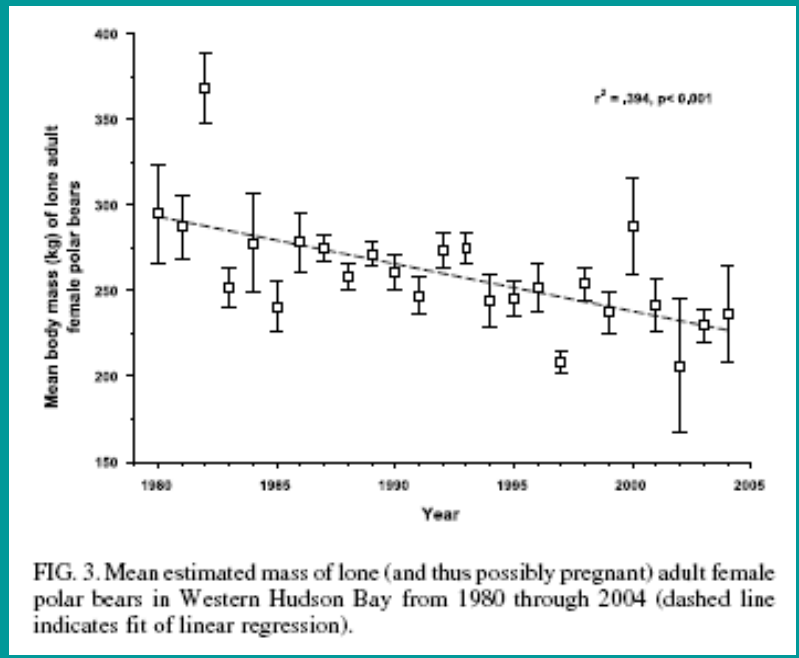


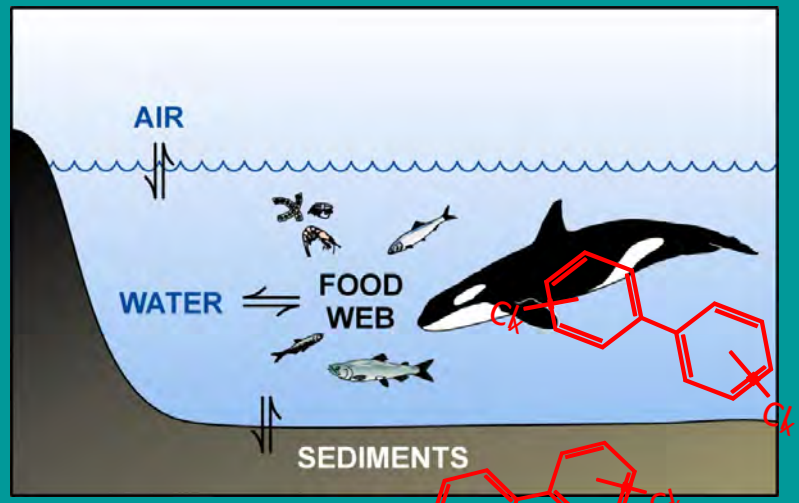
FIG. 3. Mean estimated mass of lone (and thus possibly pregnant) adult female polar bears in Western Hudson Bay from 1980 through 2004 (dashed line indicates fit of linear regression).

Photo Juan Jose Alava

- Fur seals and sea lions decline dramatically following El Nino conditions in the Eastern Pacific Ocean

Persistent Organic Pollutants (POPs) in marine mammals

- POPs comprise a family of chemicals deemed *persistent*, *bioaccumulative* and *toxic*.
- Long-lived, high trophic level marine mammals are often highly contaminated with POPs, even in remote regions.
- POPs have been associated with health effects in marine mammals, including reproductive impairment, immunotoxicity, endocrine disruption, and developmental abnormalities.



POPs are found in fat

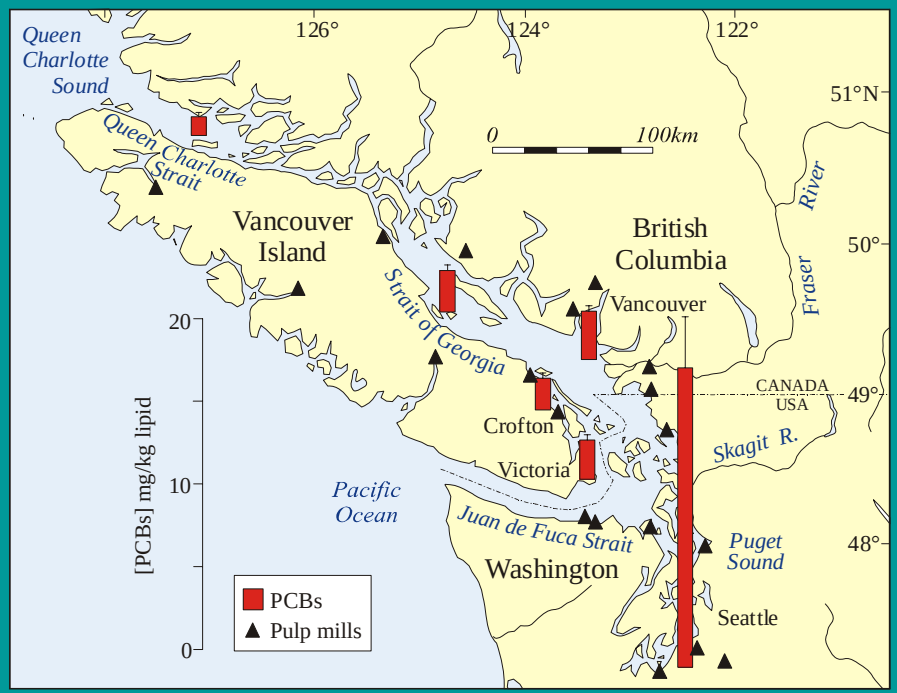
- POPs are fat-soluble, and partition readily into fat.
- POPs have an octanol:water partitioning coefficient (Log k/ow) range of 4.5 to 10.5.
- When fats are utilized, the recalcitrant POPs remain in the body as metabolism of these contaminants is very slow.
- Lipids are the currency of energy in aquatic food webs upon which marine mammals depend.
- As climate change affects feeding ecology of some marine mammals, blubber quality may decline and POP concentrations will rise on a fat-weight basis.

(Photo Lisa Loseto)

(Photo Juan Jose Alava)

Harbour seals rely on coastal food webs and are vulnerable to coastal pollution

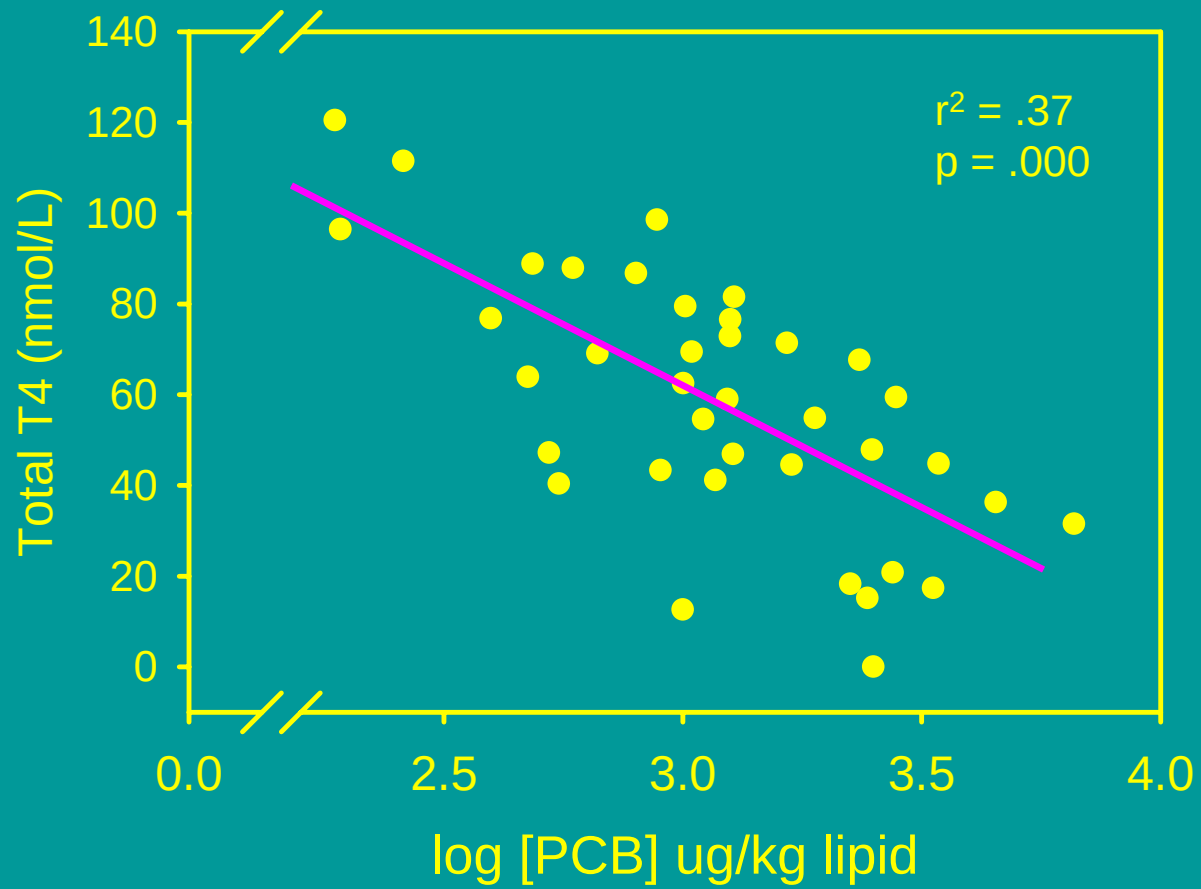
1) If lipid (fat) content in prey is low, seals appear to eat more: *evidence from contaminant research*



(Ross et al 2004, ET&C; Cullon et al 2005, ET&C)

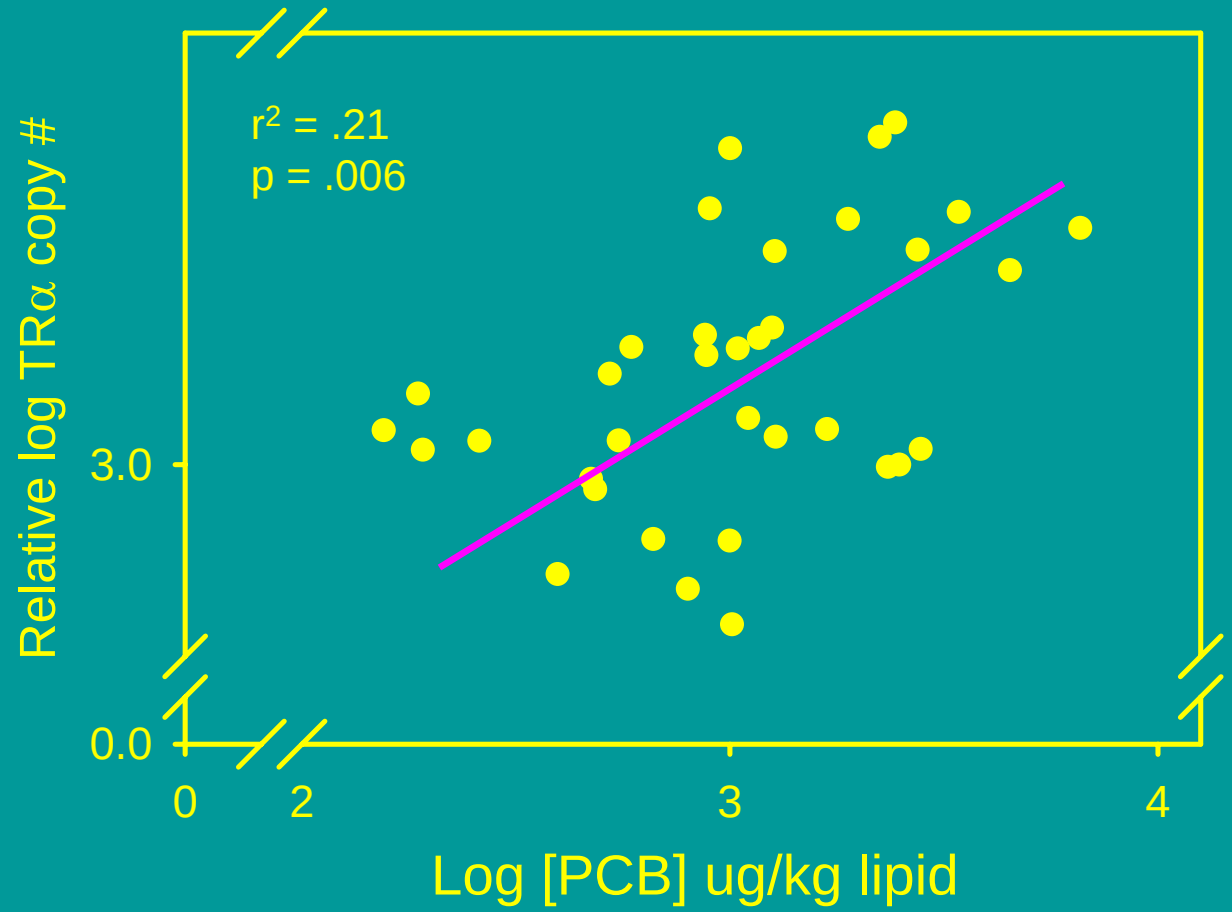
- Washington seals have 7x the PCBs compared to their British Columbia counterparts, but their prey has only 3x the PCBs;
- Washington prey has less than half the lipid content (food basket 1.9%) compared to prey in Strait of Georgia BC (4.4%);
- The only way to explain this difference is if harbour seals eat on a fat-weight basis, or eat twice as much, in Washington.

2) PCBs reduce thyroid hormones in seals



(Tabuchi et al EHP 114: 1024-1031, 2006)

PCBs also increase thyroid hormone receptor (TRα) expression in seals: *Results suggest that PCBs increase metabolic turnover*

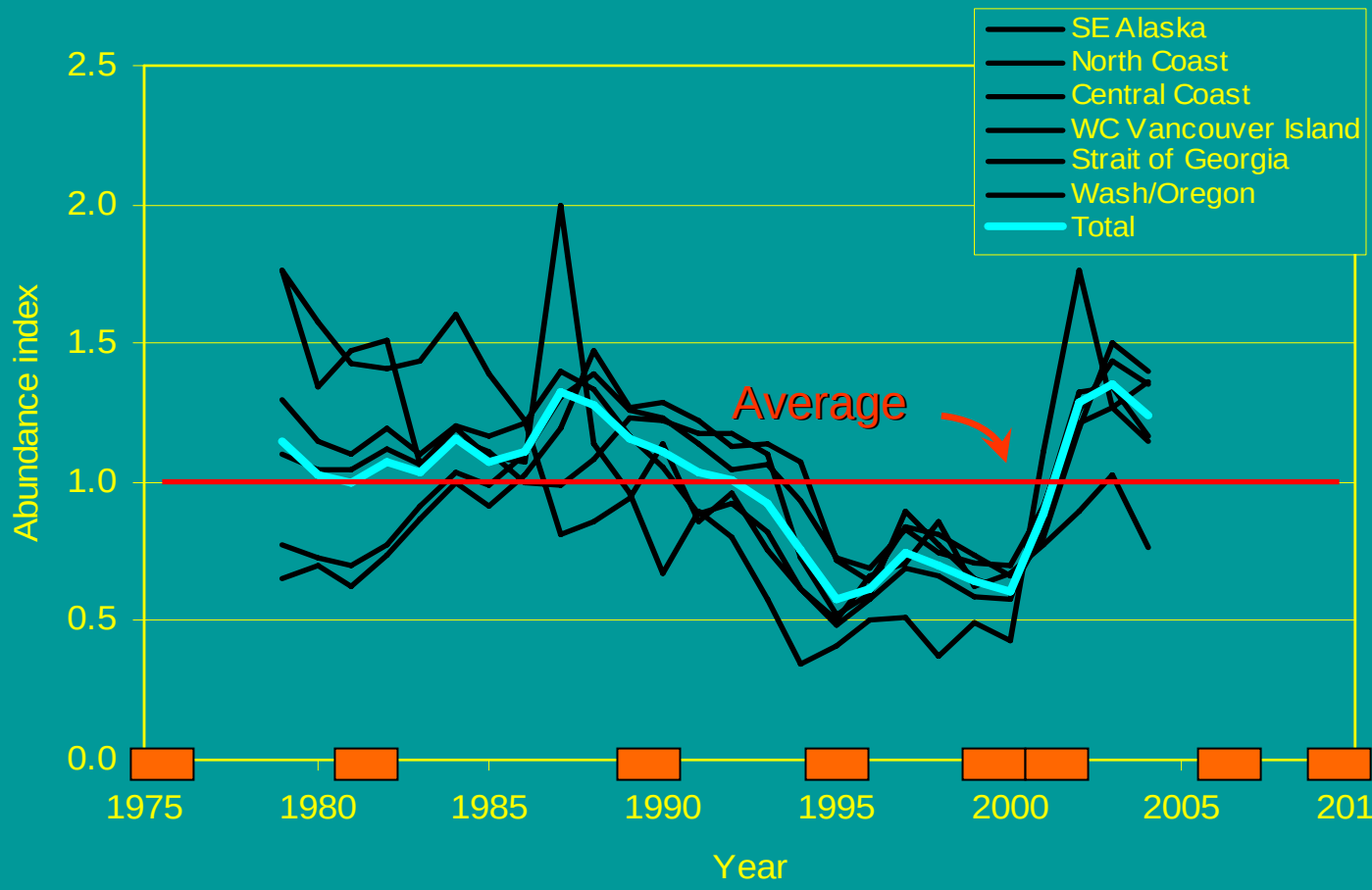


(Tabuchi et al EHP 114: 1024-1031, 2006)

Resident killer whales of the NE Pacific are salmon specialists and are vulnerable to global pollution

Chinook salmon abundance varies from year-to-year and is in part dependent on ocean temperatures

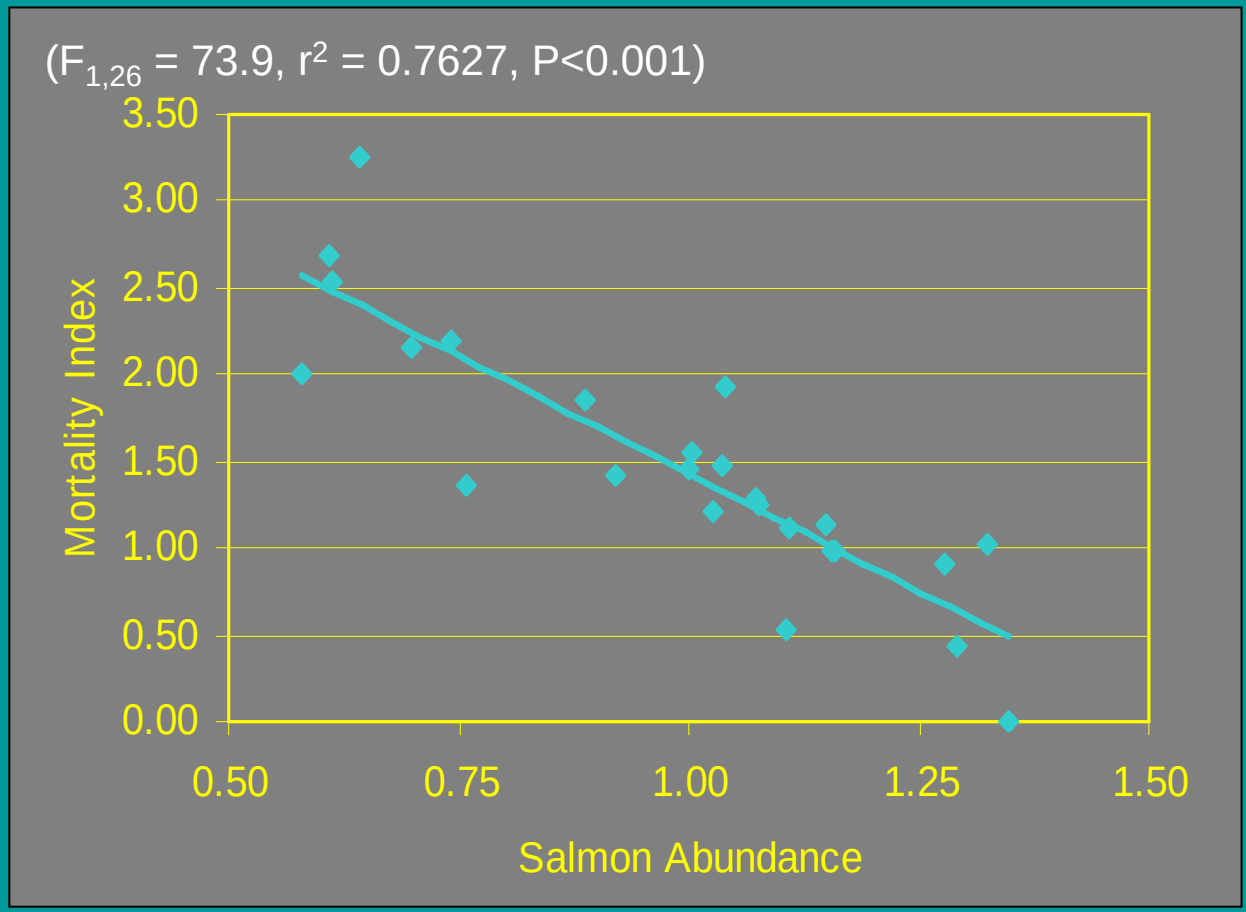
ratio of annual abundance over long-term average



(Ford et al 2010)

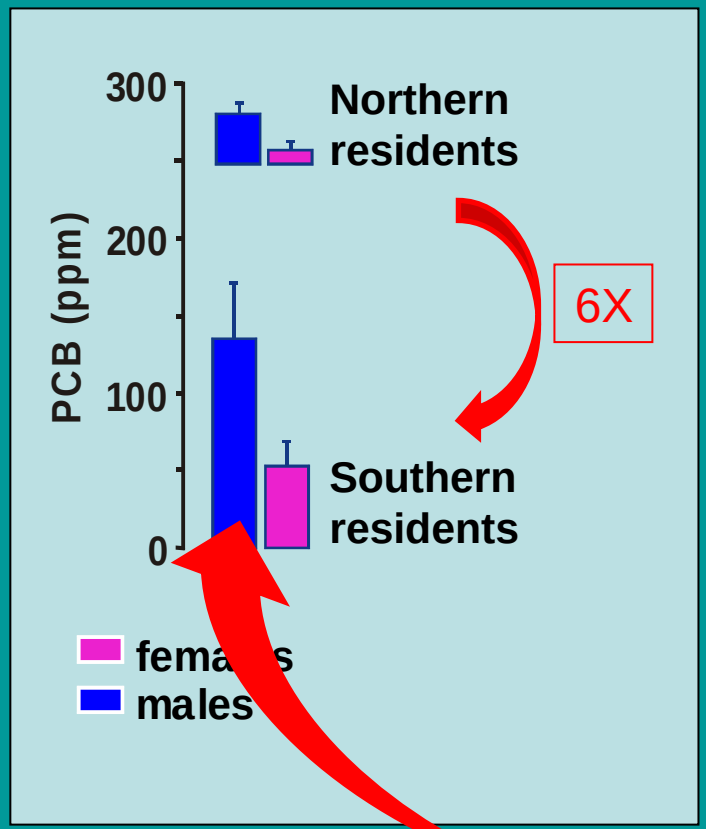
Mortality in resident killer whales tied to chinook abundance: climate change, or climate change plus contaminants…?

Coast-wide chinook, 1979-2004, mortality lagged one year



(Ford et al 2009)

1) If lipid content in chinook salmon is lower, resident killer whales appear to eat more: evidence from contaminant research



Wet weight scenario for daily PCB intakes:

N Residents: 308 ug

S Residents: 1248 ug (4x)

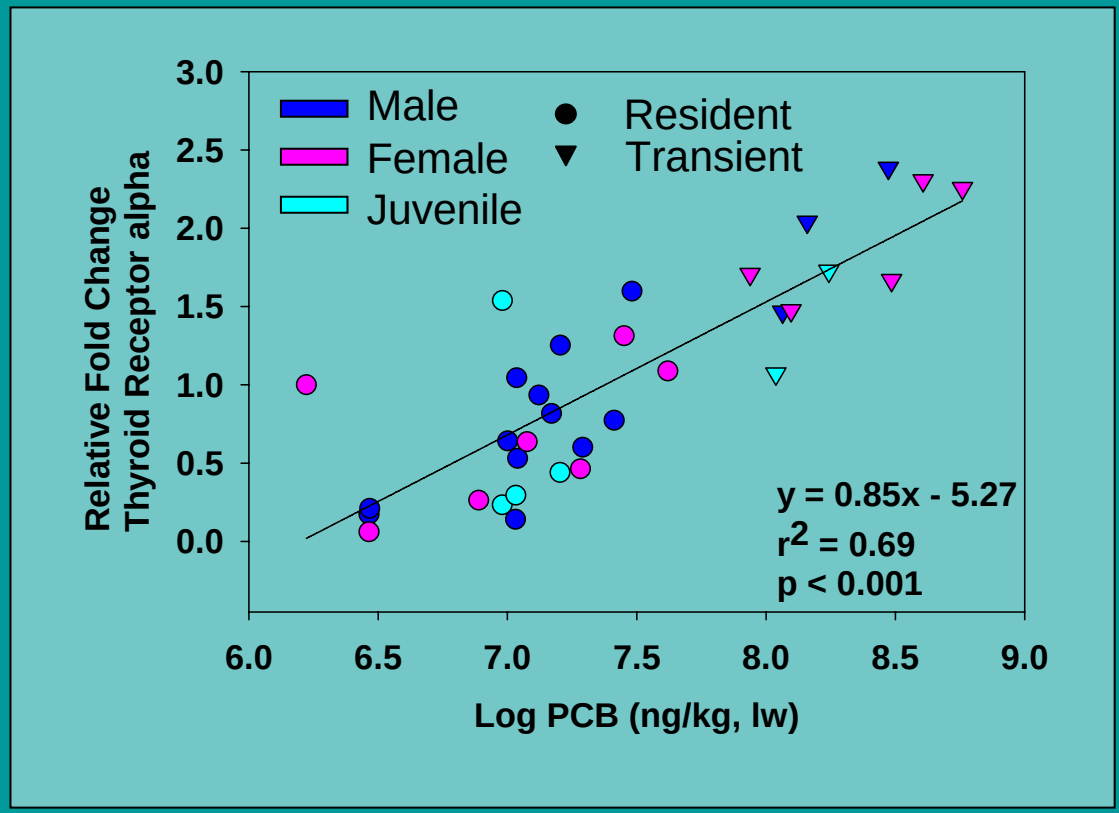
Lipid adjusted scenario for daily PCB intakes:

N Residents: 308 ug

S Residents: 2051 ug (6X)

(Ross et al 2000 MPB; Cullon et al ET&C 2009)

2) PCBs increase Thyroid Receptor gene expression in killer whales: *Results suggest that PCBs increase metabolic turnover*



(Buckman et al, 2010 submitted)

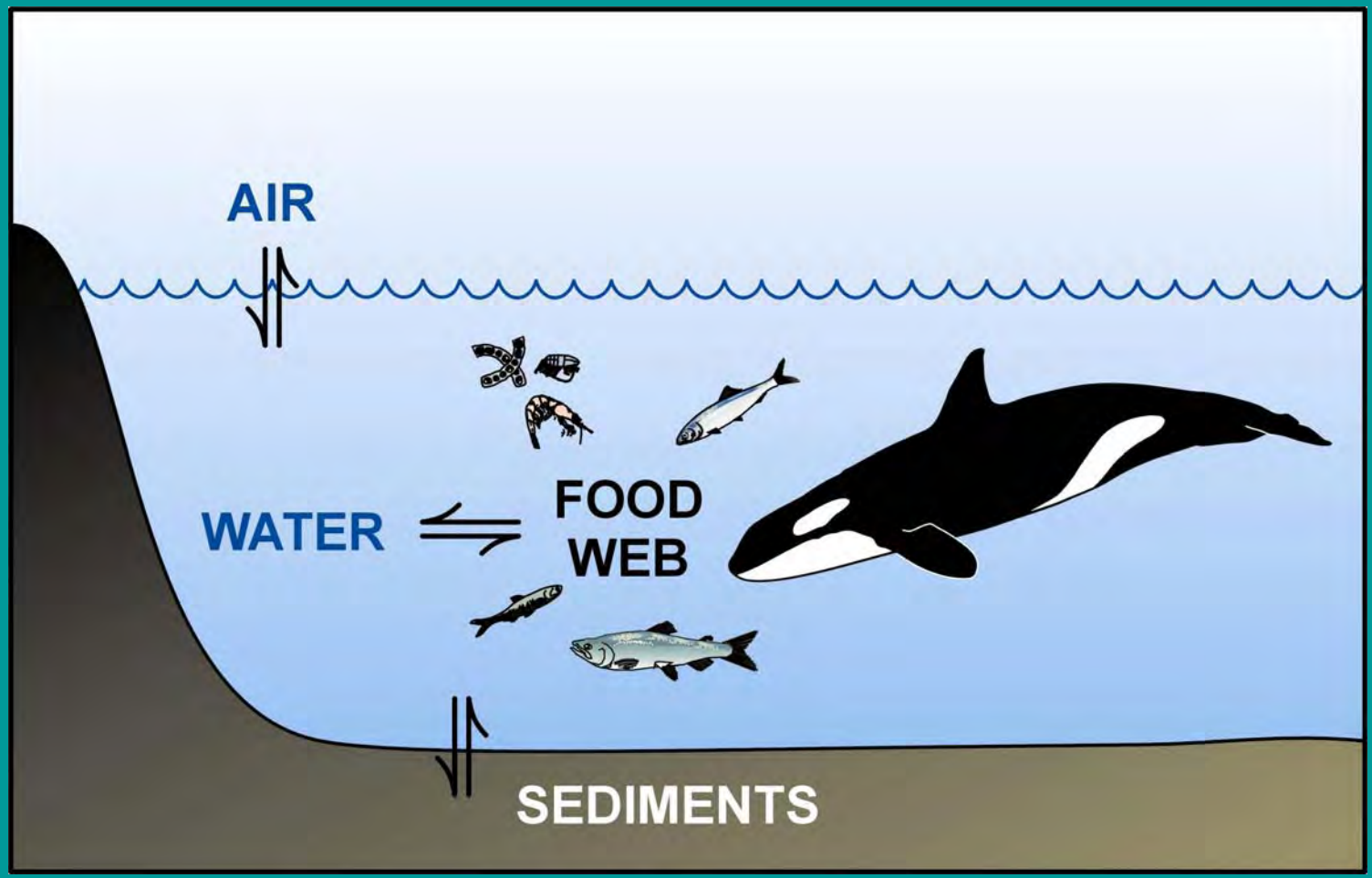
This would suggest that two scenarios may underlie increased feeding requirements of marine mammals, one climate-related and the other contaminant-related

1) when prey contains less lipid (climate change scenario);

2) when PCBs and related contaminants increase metabolic turnover by affecting thyroid hormone physiology (PCB toxicity).

Or both: Climate change and persistent organic pollutants may conspire together against marine mammals by causing them to eat more, ingest more POPs, and face increased risk of contaminant effects.

Vulnerable *and* informative: Marine mammals integrate pollution and ocean productivity signals



Thank you

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- Graeme Ellis, Neil Dangerfield, Lance Barrett-Lennard, Lisa Loseto, Maki Tabuchi, Nik Veldhoen
- Photo credits Graeme Ellis, Brian Gisborne, Peter S. Ross, John K.B. Ford