Polycyclic aromatic hydrocarbon (PAH) contamination in Cook Inlet belugas

Presented by: John Reynolds and Dana Wetzel
Mote Marine Laboratory, Sarasota FL

With thanks to:

- **NMFS: Barbara Mahoney**
- **CIRCAC: Sue Saupe**
- **US Army: Chris Garner**
- **NIST: Rebecca Pugh**

CIB conservation status

- **Genetically distinct; geographically isolated**
- **Abundance estimates < 400 individuals for ~ the past decade**
- **Lack of recovery stimulated intense interest**
- **October 2008:**
  - **Listed as endangered under the ESA**
  - **Final Conservation Plan available**

Threats and recovery

- **Subsistence hunting contributed to the reduction in population size, but has not been significant (5 animals total) since 1998**
- **Conservation Plan identified potential threats that may impede recovery, but data are insufficient in most cases to assess real impacts**
- **An identified concern: pollution associated with oil and gas development and other activities that could introduce PAHs into beluga habitat**

Our overall study goals include

- Examine levels of toxic chemicals (called polycyclic aromatic hydrocarbons or PAHs) in whales, their prey, & sediments
- Assess, as possible, effects of exposure to PAHs on belugas
- Opportunistically assess levels of other organic contaminants
- Develop and communicate recommendations for management actions, if appropriate

© Franco Banfi/ Barcroft Media

Goals of this presentation:

- Provide background information regarding possible effects of exposure to PAHs
- Discuss results of our PAH analyses on Cook Inlet belugas
- Provide data from related studies
- Assess what our results may mean for conservation

What are PAHs?

- Polycyclic aromatic hydrocarbons-most toxic
- Exist naturally as in seeps, but are associated with oil and gas activities
- Sixteen PAHs are considered “priority pollutants” by WHO and EPA
- Can be “fingerprinted” to determine the type of source
- Metabolites may be more toxic than original compounds

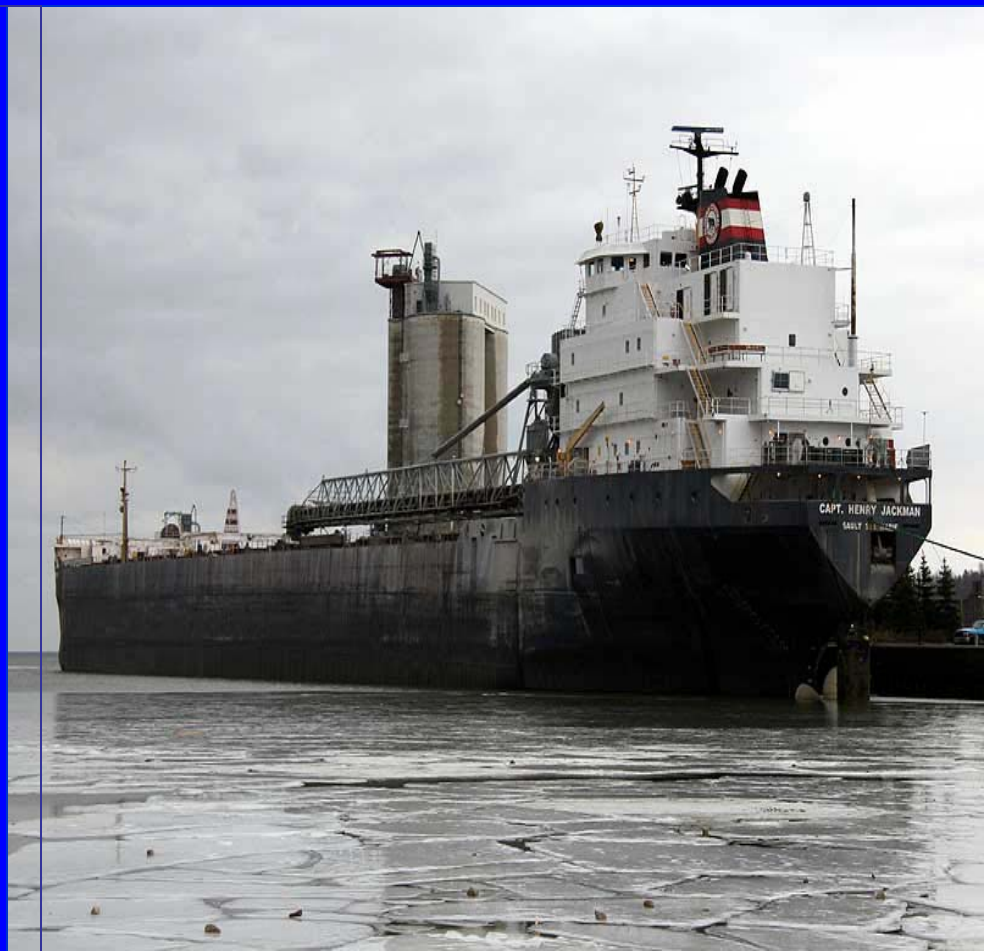
Why do we know so little about PAHs and marine mammals?

- Most contaminant research has focused on pesticides, PCBs, and certain metals
- Even where good data exist regarding body burdens of contaminants, effects are poorly understood—a critical uncertainty.
- There is a need to combine assessments of body burdens, environmental levels, & clinical diagnostic markers of exposure and effects

Case studies: oil and marine mammals

Exxon Valdez oil spill—1987
--Produced a wide range of effects on killer whales, pinnipeds and sea otters.

St. Lawrence Seaway beluga whales---prevalence of cancer & benzo-a-pyrene



Additional Evidence of Body Burdens

- Hellou et al.- Northwest Atlantic; seals and small whales
- Marsili et al.- Mediterranean; fin whales and striped dolphins
- Leung et al.- Hong Kong; dolphins

Range of PAH effects on wildlife

- Cytotoxic, genotoxic, immunotoxic and carcinogenic effects have been correlated with high PAH levels
- Disruption of immune and reproductive systems
- Manifested at four levels of biological organization:

  ---Biochemical, cellular, tissular

  ---Organismal

  ---Population

  ---Community

Effects of exposure documented in marine mammals

- Carcinogenic effects
- Dermal irritation
- Conjunctivitis
- Thermoregulatory effects
- Hepatic & hypothalamic lesions
- Hepatic necrosis
- Reduced survival of young

Routes of exposure and accumulation

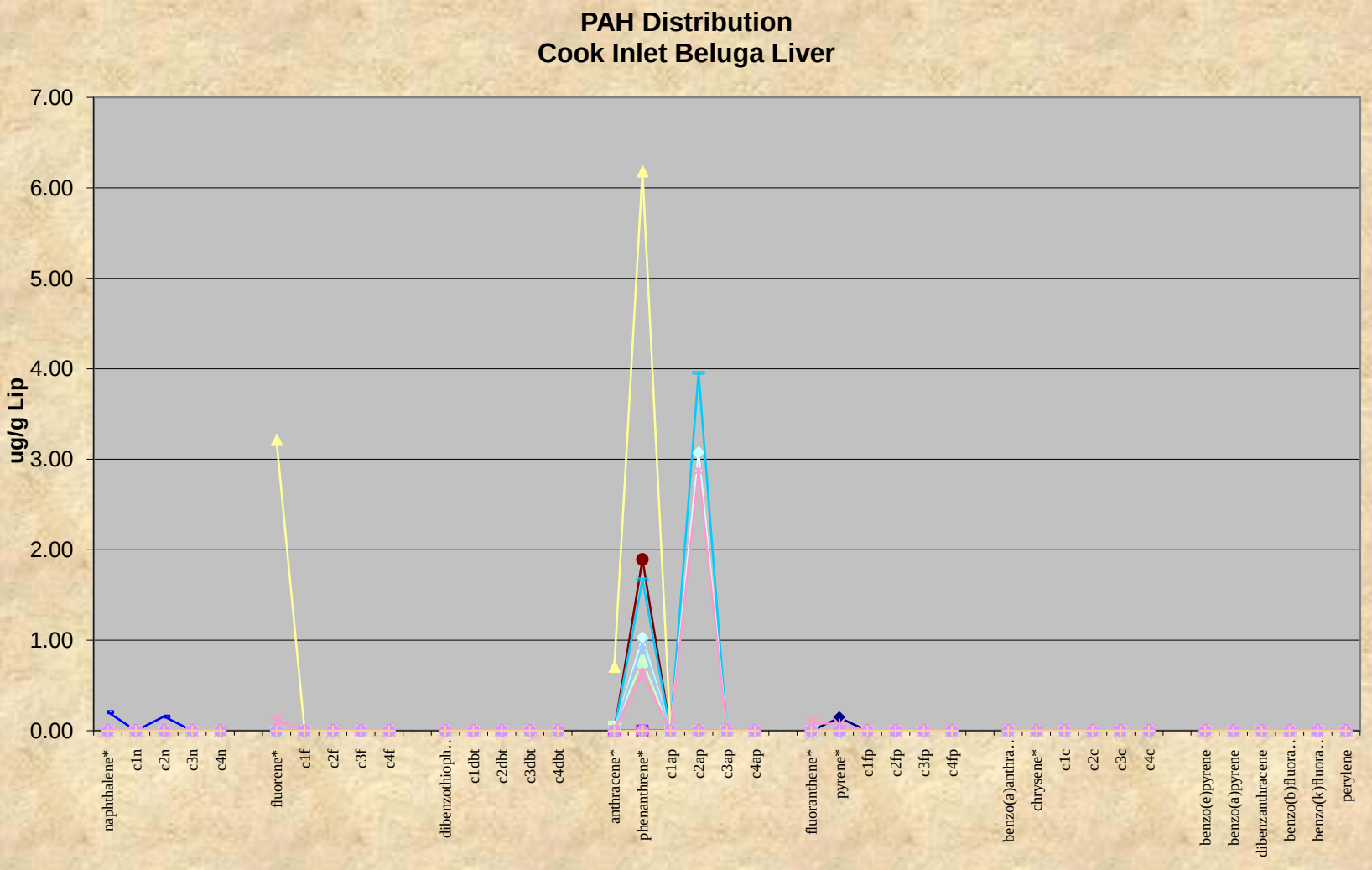
- Direct Contact
- Inhalation of volatile fraction
- Ingestion, directly or through prey

Emerging theory regarding marine mammal exposure to oil

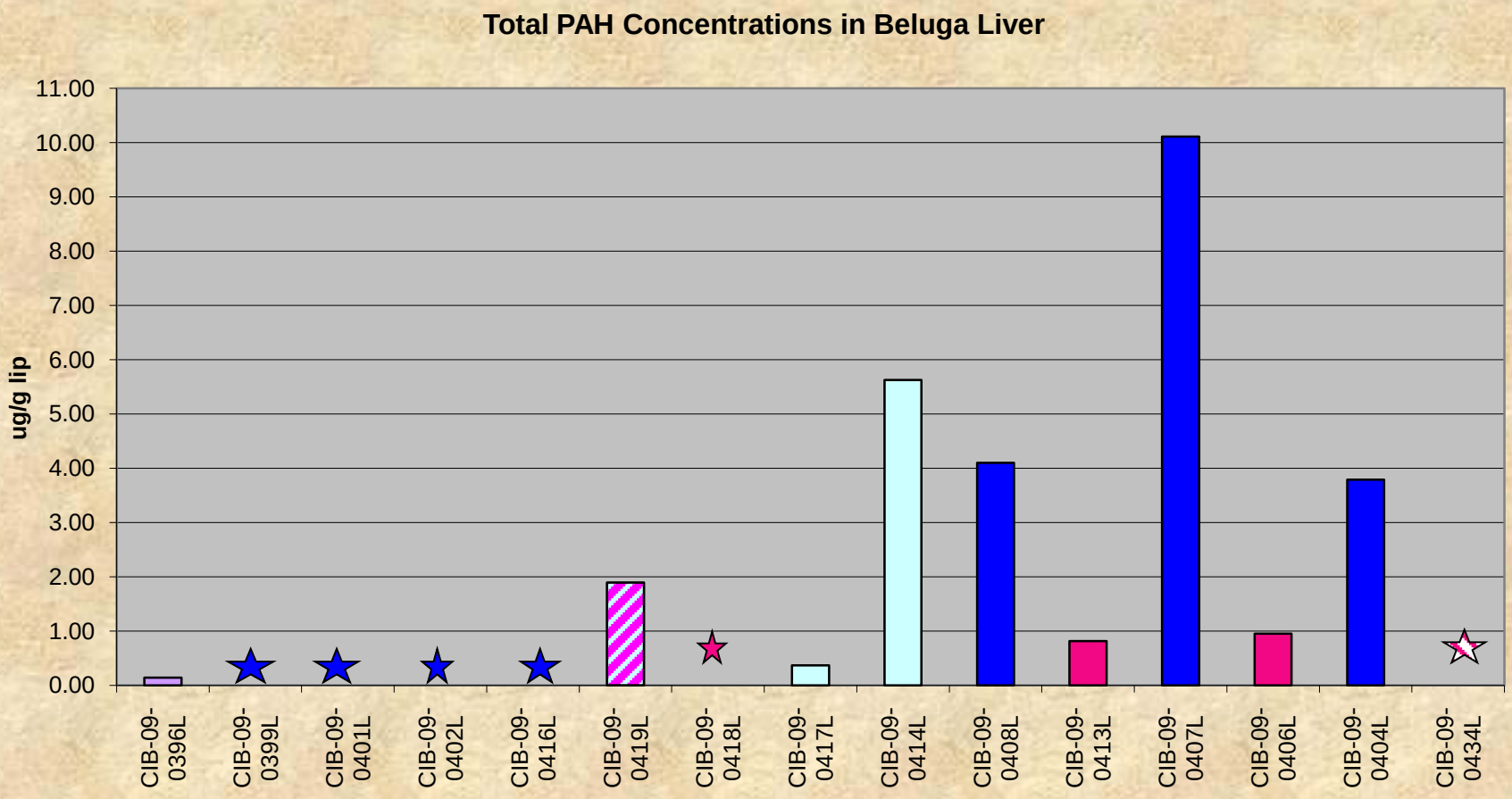
Old paradigm: short-term acute exposure only

New appreciation: long-term effects, compromised health through chronic exposure and environmental stress

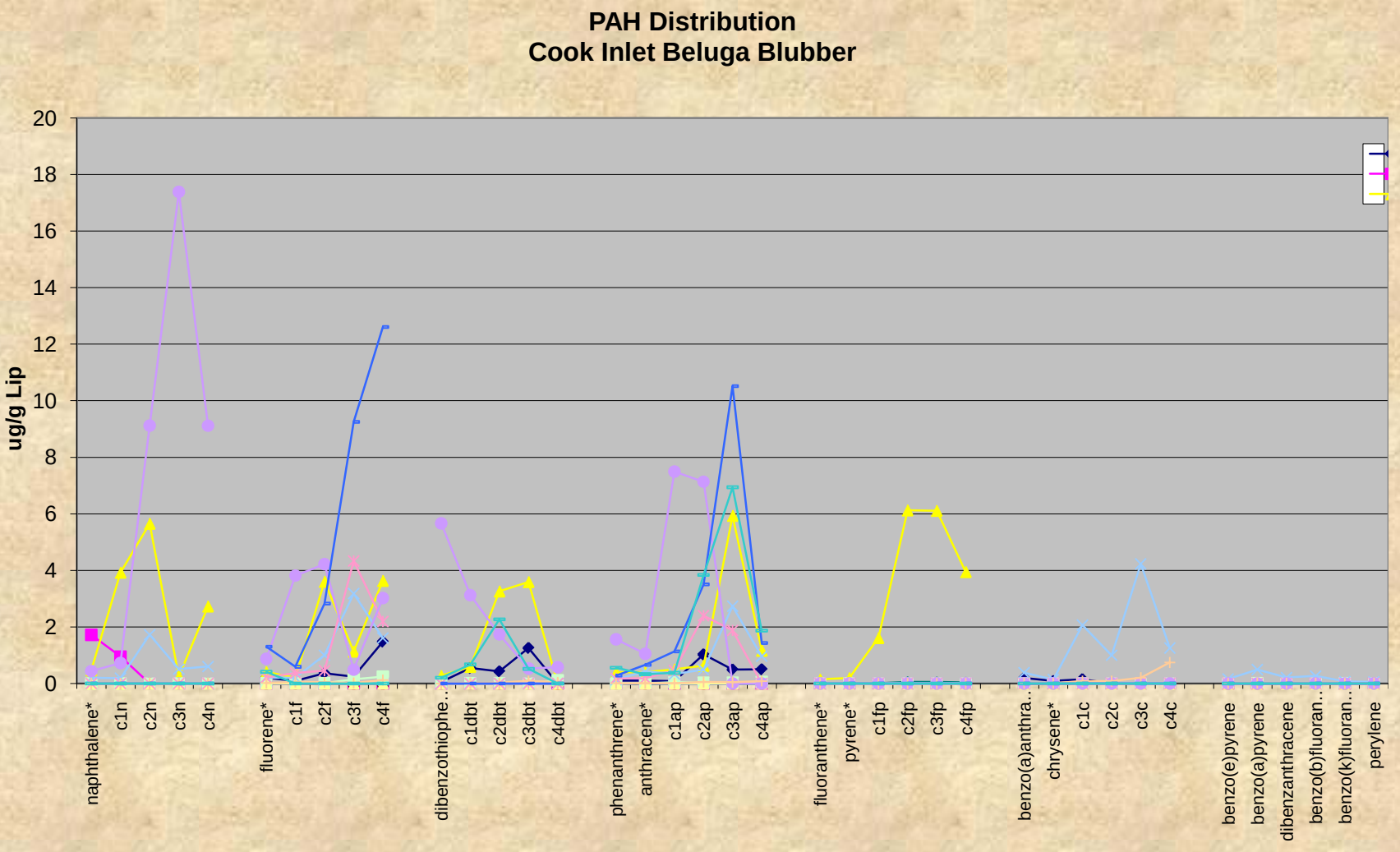
PAH Distribution-CIB liver



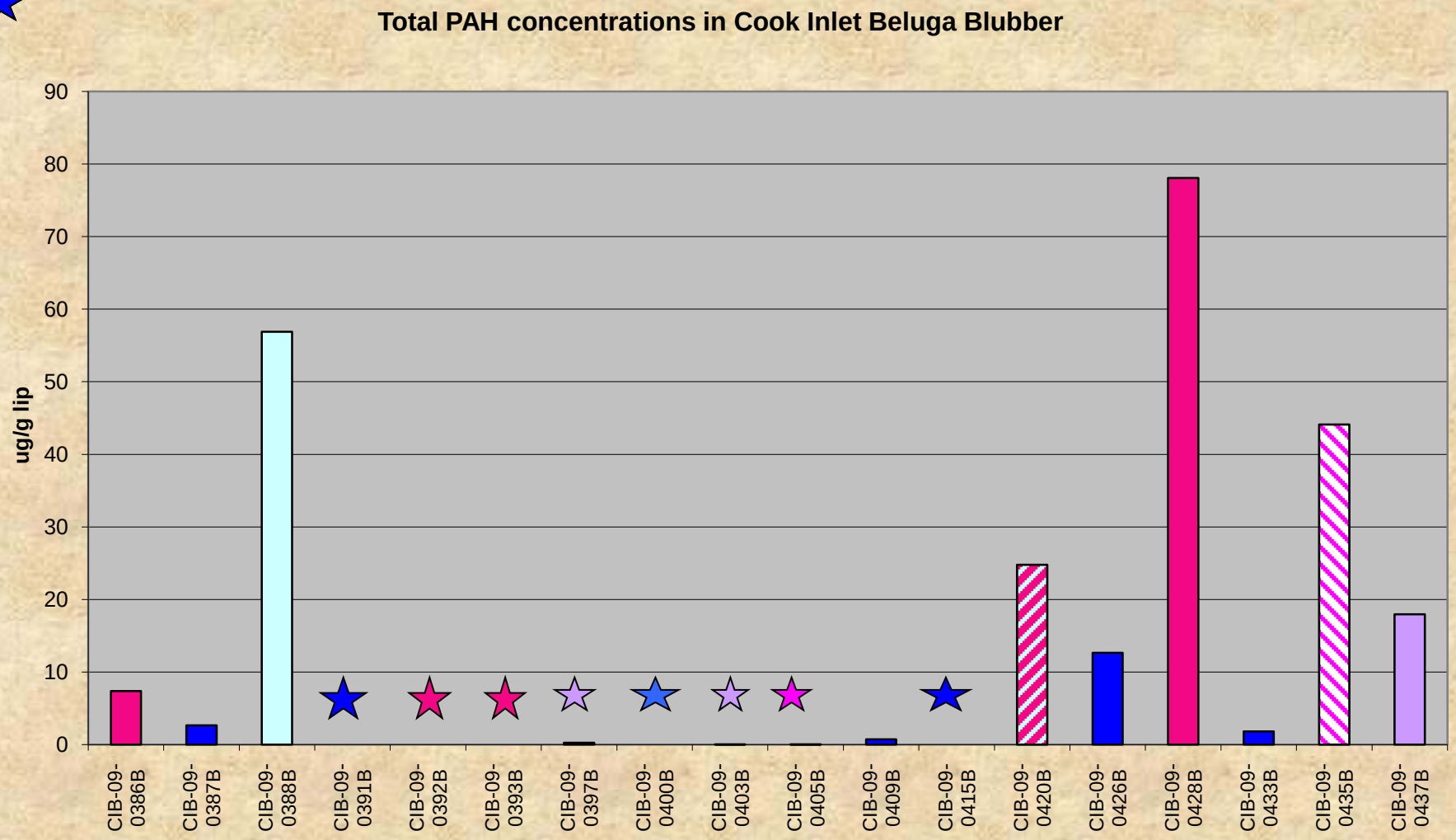
Total PAH Concentrations- CIB liver



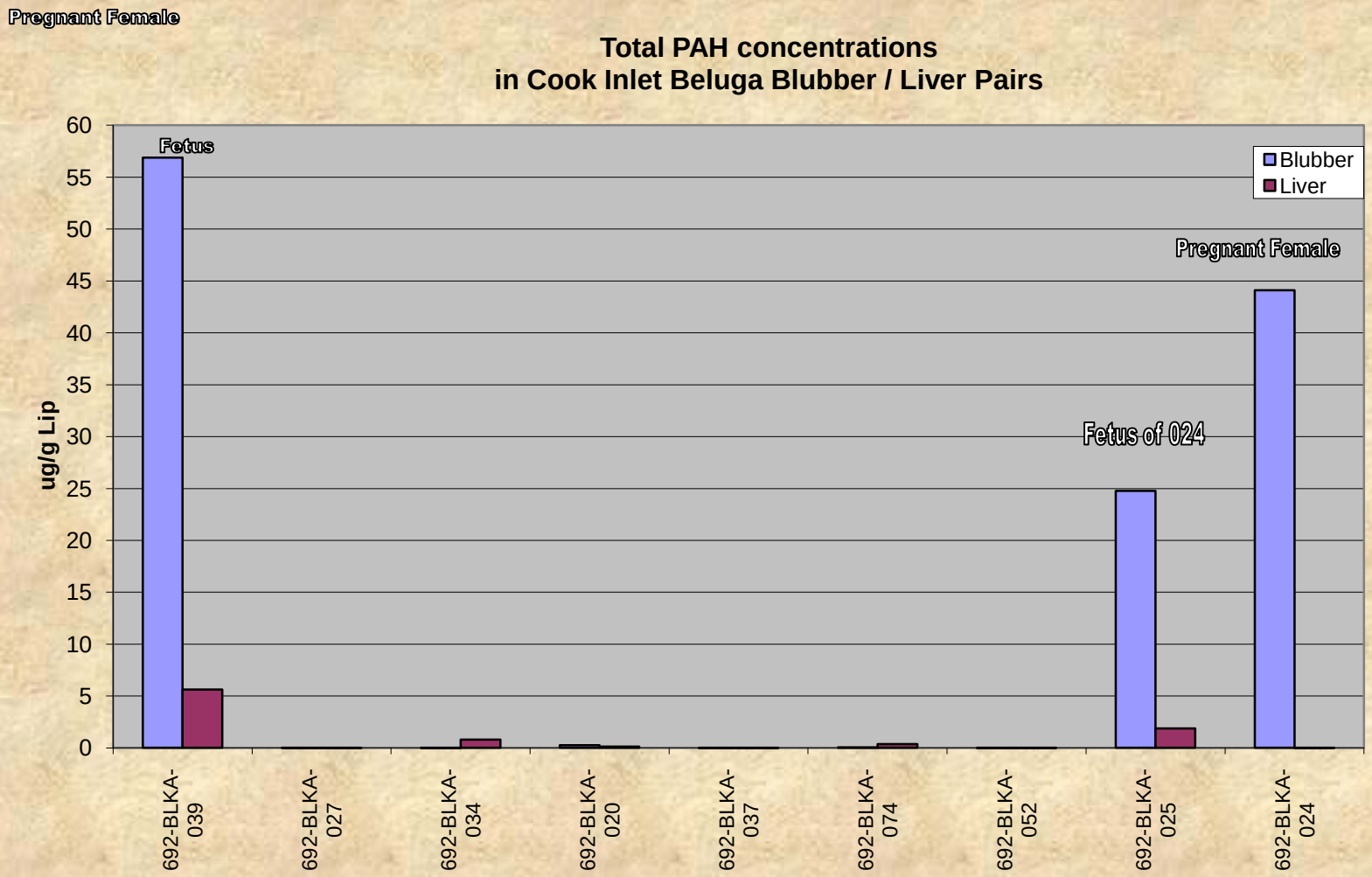
PAH Distribution-CIB blubber



Total PAH Concentration—CIB Blubber



Total PAHs—Liver-Blubber Pairs

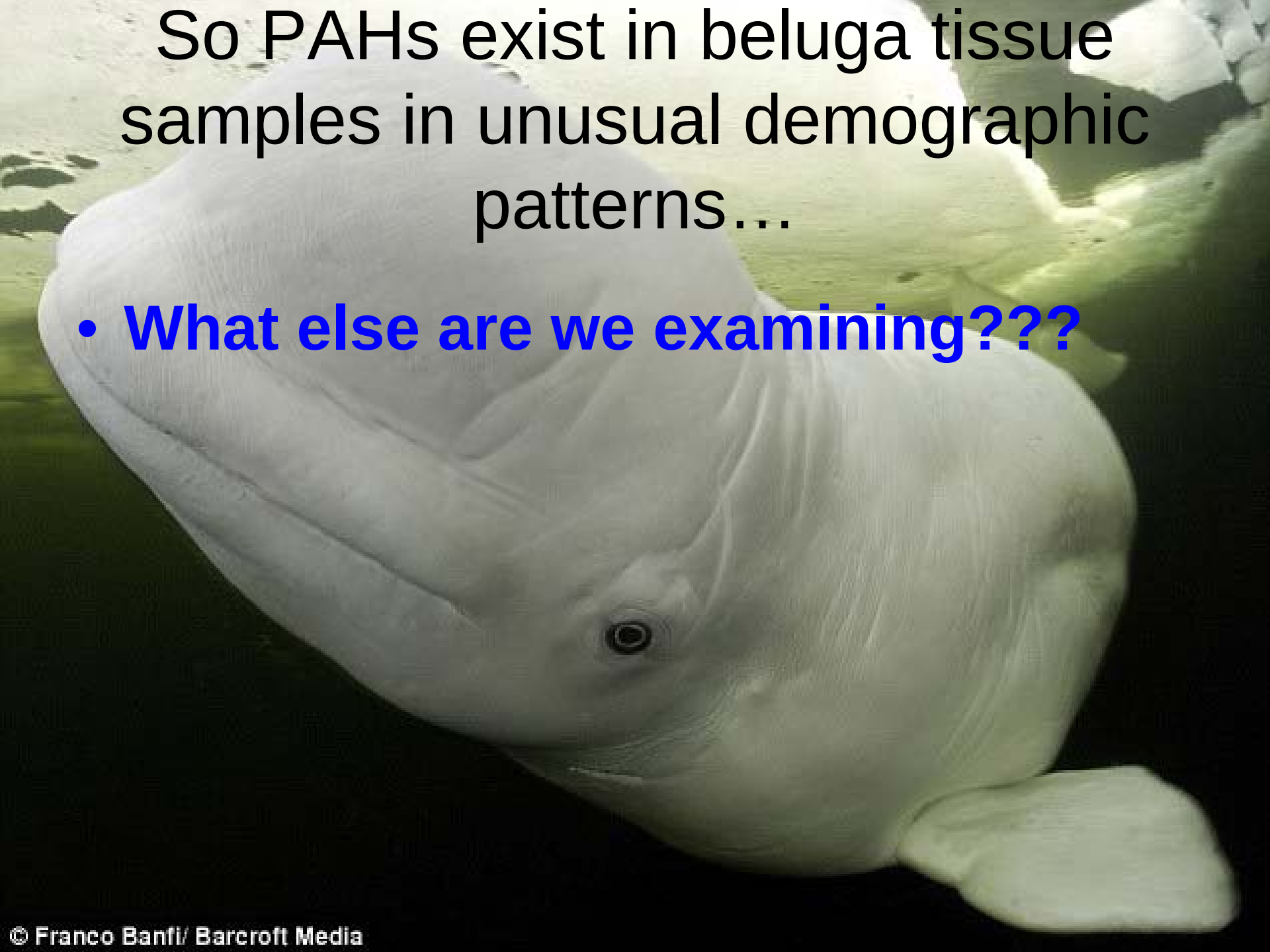


Summary, PAHs in CIB

- CIB appear to be bioaccumulating PAHs from their environment and prey
- CIB have much higher levels than do MacKenzie River delta belugas
- Highest liver levels are in 3 adult males (expected) and a female fetus (!!)
- Highest blubber values are in females and fetus
- Very high values in two fetuses

So PAHs exist in beluga tissue samples in unusual demographic patterns…

- **What else are we examining???**



© Franco Banfi/ Barcroft Media

What is a biomarker?

- a substance used as a biological indicator of normal or abnormal state

- physical or chemical response used to measure the stress effects on an organism from:
  - disease
  - poor nutrition,
  - or exposure to environmental contaminants

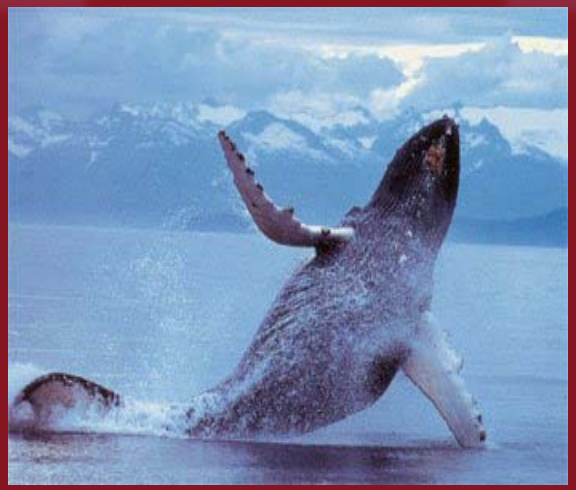
Why are biomarkers useful?

- **Consequences of stressors are what matter**
- **Biomarkers provide early warning systems by allowing assessments of normal vs abnormal**
- **Promotes proactive, not crisis-driven management**

photo by Sue Moore

Two of the biggest concerns for animal conservation are:

Reproduction



Health & Immunity

ELISA assays for fertility potential

We quantify two hormones found in male and female mammal serum which has been proven to work well in humans

With proper validation, the level of the hormone indicates reproductive potential

We can ultimately relate hormone levels, and therefore reproductive potential, to various stressors: age, contaminants, disease, nutritional status, etc.

Photo credit: USGS

Hormones tested

- AMH and Inhibin-B are both protein hormones and are members of the transforming growth factor-β (TGF-β) family and perform various physiological functions.

- In males, these are secreted by the Sertoli cells.
- In females, they are secreted by granulosa cells.

- Production is age and maturity dependent.

- ***Fertility assays work well in captive belugas (+ sirenians + other odontocetes) and we are working with R. Suydam to establish baselines in healthy, wild belugas

Multiplexed immune function assays

- **The Luminex instrument simultaneously permits measures of up to 500 analytes (e.g., cytokines, interleukins, and growth factors). Works well to date on manatee samples—interleukins are highly conserved evolutionarily. We are using a 27 cytokine assay kit to quantify immune function.**

Our goal:

We are working to cause reproductive potential, immune function, and other biomarkers to become commonly measured attributes of taxa of concern; these measures of “quality” of individuals comprising a group could become an extremely informative criterion for understanding true conservation status…and be a proactive factor to promote targeted mitigation of threats before the crisis stage

For now we can only conclude that:

- PAH levels are higher than expected in tissues of Cook Inlet belugas
- Surprising levels of PAHs in tissues of mature females and fetuses mean that effects of PAHs cannot be ruled out as a factor potentially affecting CIB status and non-recovery