NOAA FISHERIES

Northwest Fisheries Science Center

Condition and Health: Connections to Ecology, Feeding, Social Behavior and Human Impacts

NOAA

Dawn P. Noren

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Key Risk Factors

- Lack of sufficient prey (quantity and/or quality)
- Disturbance from vessels and sound
- Chemical contaminants (POPs)
- Small population size

Bioenergetics

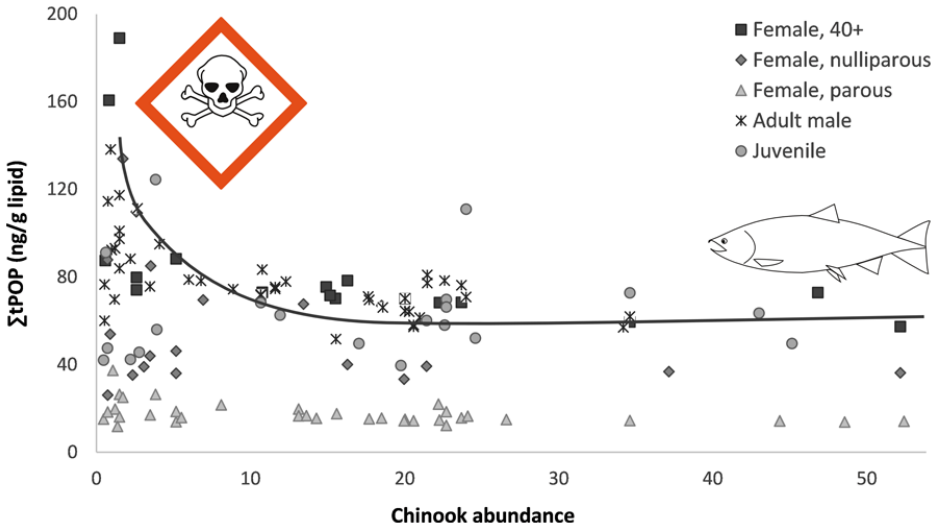
- Relevant to assessing impacts of reduced prey availability/quality and biological significance of behavioral responses to disturbance
- Energy In = Energy Out (Neutral)
- Energy In < Energy Out (Mass Loss, Poor Condition, Susceptibility to Disease)
- Energy In > Energy Out (Growth, Reproduction)

Prey Issues – Confounding Factors

- Competition with other predators and fisheries (Chasco et al. 2017a, b)
- Social dynamics (e.g., group size, cohesion) and habitat use patterns related to population dynamics and prey availability (Foster et al. 2012, Lusseau et al. 2004 (NRKWs), McCluskey 2006, Parsons et al. 2009, Shields et al. 2018)
  - Smaller SRKW groups during periods of population decline
  - Greater movement, reduced presence in core habitat, less connected social networks, and smaller groups during years of low salmon abundance
  - May reduce competition for limited prey resources, but at the expense of social benefits (prey sharing, calf rearing assistance, reproducing)

Prey Issues – Confounding Factors

- Fecal hormones suggest inadequate prey in some years, but vessels may also contribute to SRKW stress, particularly during years with low prey availability (Ayres et al. 2012)
- Fecal [POP] tend to be higher when prey abundance is low (Lundin et al. 2016)
- Body condition could decline during periods of reduced prey availability

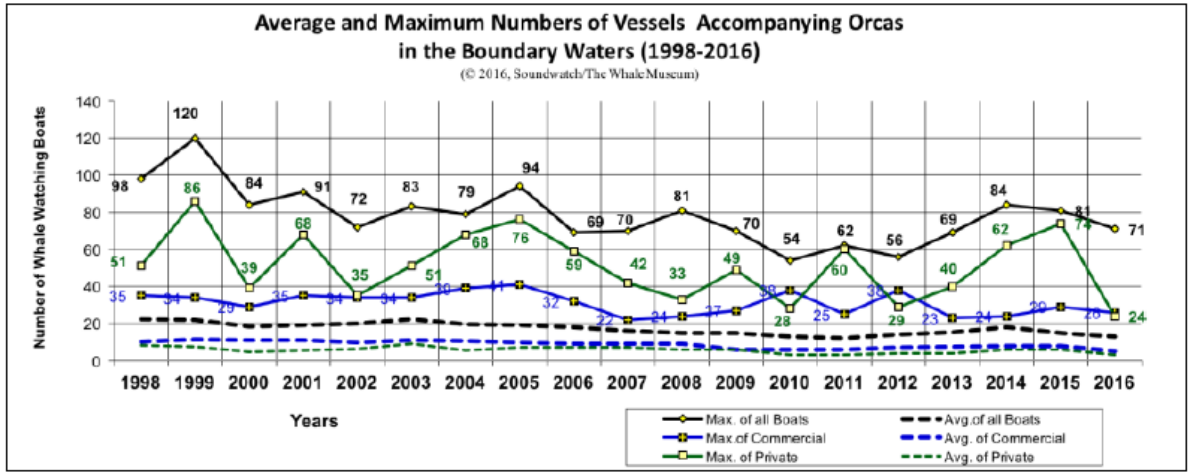


Lundin et al. 2016

L25 (robust) J28 (lean, 1 mo. before death)
(NOAA SWFSC, SR3, Vancouver Aquarium)

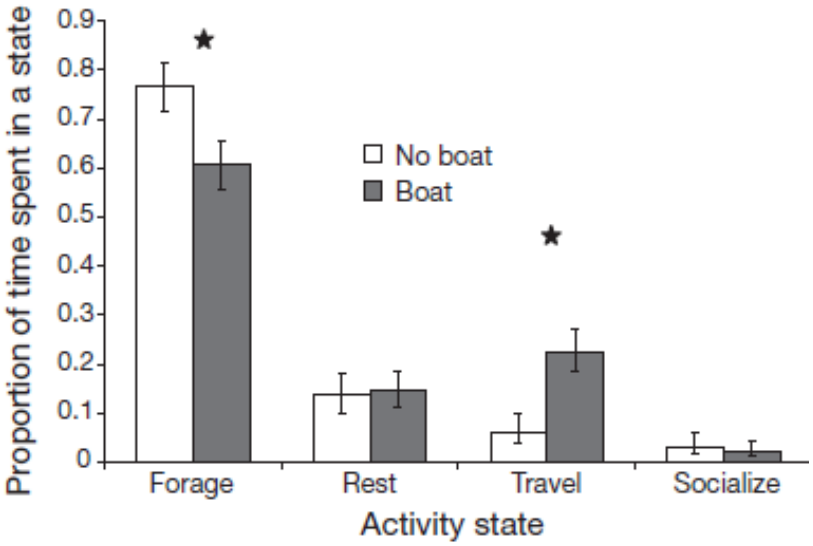
Vessel Impacts – Behavioral/Physiological Responses

- High vessel presence in summer core habitat (> 9 hrs/day, Soundwatch data)
- Ephemeral behavior changes
  - Δ respiration rate, swim speed, path directedness when boats are within 400 m (Williams et al. 2009)
  - ↑ Surface active behaviors (SABs) in response to close approaches and ↑ number of boats within 400 m (Noren et al. 2009, Williams et al. 2009)
- ↑ Call amplitude (loudness) with ↑ background noise which ↑ with number of boats within 1000 m (Holt et al. 2009)
- ↓ Foraging and ↑ travel when boats are within 400 m (Lusseau et al. 2009)
- Vessels may contribute to ↑ stress hormones when prey is limited (Ayres et al. 2012)

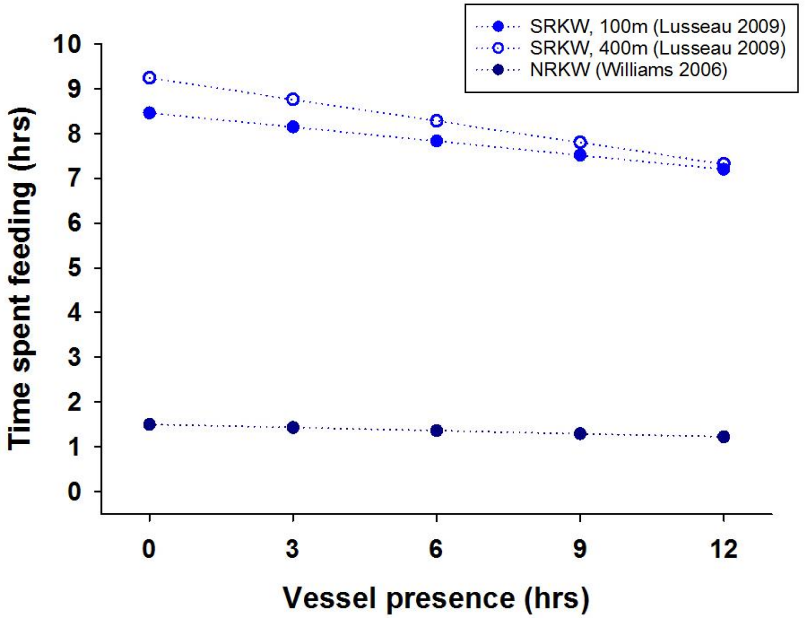


Vessel Impacts – Energetic Cost of Behavioral Responses

- Energetic costs of ephemeral behavior changes and acoustic responses to vessels are small (Holt et al. 2015, 2017; Noren et al. 2012, 2013, 2017a, b)
- Energetic cost of modifying daily activity budget is small (Noren et al. 2017b, Williams et al. 2006)
- Major impact may be reduced foraging (Noren et al. 2017b, Williams et al. 2006)
  - SRKW: 15-21%, NRKW:18%



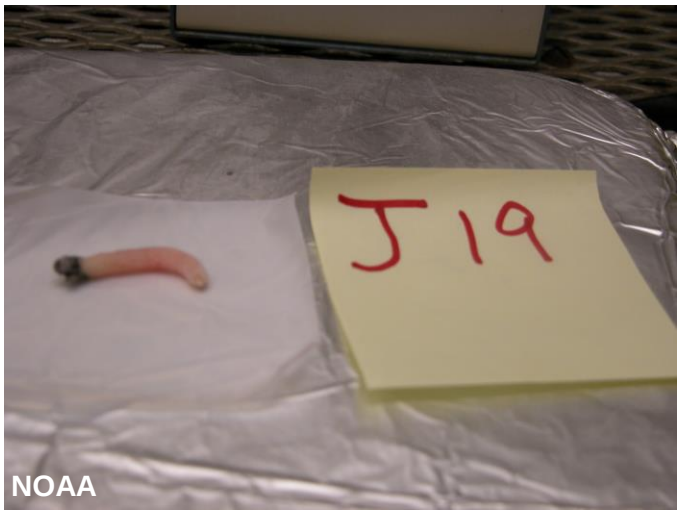
Lusseau et al. 2009



Noren et al. 2017b ONR report

Contaminants – S.R. Killer Whale Levels


NOAA (research under permit)



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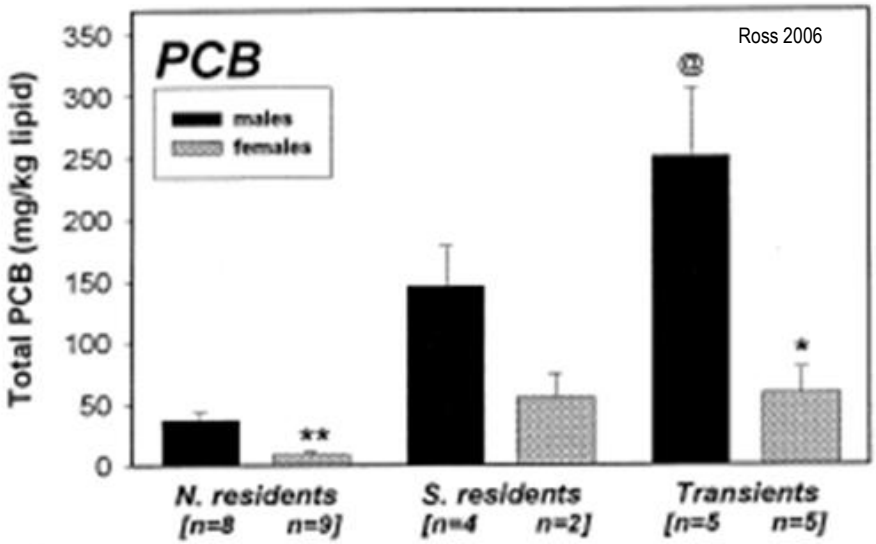


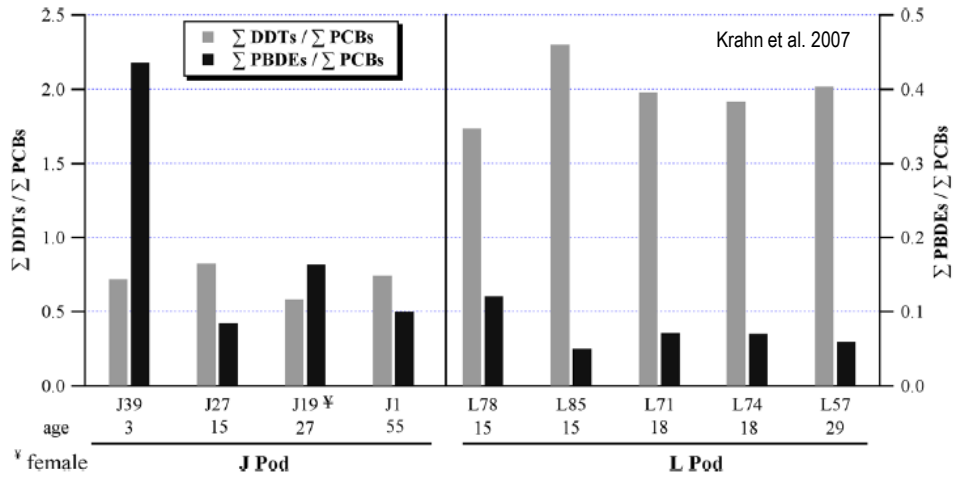


Fig. 2. The ratios ∑DDTs/∑PCBs and ∑PBDEs/∑PCBs in individual Southern Resident killer whales.

Contaminants – Risk & Maternal Transfer

- POP exposure linked to immunosuppression, endocrine disruption, and reproductive failure in marine mammals (O'Hara and O'Shea 2001)
- POP exposure can interfere with developmental processes in mammals (Eriksson et al. 2002, 2006)
- POPs may ↓ ♀ reproductive success and ↓ calf survival

Contaminants – Risk & Maternal Transfer

- Risk likely varies with ♀ reproductive history and body condition
- Primiparous ♀ have higher serum and milk [POPs] than multiparous ♀ (Noren et al., unpub. data)
  - 1st born killer whales have greater blubber [POPs] (Ylitalo et al. 2001)
- ♀ serum and milk [POPs] significantly ↓ within 1-5 months post-partum (Noren et al., unpub. data)
  - 1st born calves are exposed to higher [POPs] for longer periods during critical development
- Greatest risk to primiparous ♀ and their calves
- Risk to ♀ (especially lean ♀) likely ↑ during prey limitation (e-seal study, Debier et al. 2006)

Southern Resident Killer Whale Pregnancy Loss

- Photogrammetry can detect pregnancy as early as 4-5 months into the 18 month gestation period
  - High rate of reproductive failure
- Fecal hormones (Wasser et al. 2017)
  - Up to 69% detectable SRKW pregnancies unsuccessful in 2008-2014
    - Up to 33% of those (~25% all pregnancies) failed late gestation/early post-partum
    - Possible link to Chinook abundance (thyroid hormones)

Stillborn fetus pushed to the water's surface by the presumed mother (K27, 22 yrs old). Smaller whale is her first and only surviving calf (K44, a 5-yr old male) from Durban et al. 2016. Photogrammetry: NOAA SWFSC, SR3, Vancouver Aquarium

J32 (18 yrs old) died Dec. 2014 with an unborn calf lodged in her body. She may have miscarried at least 2X previously (Wasser, Encyclopedia of Puget Sound). Photo: Marcie Callewaert

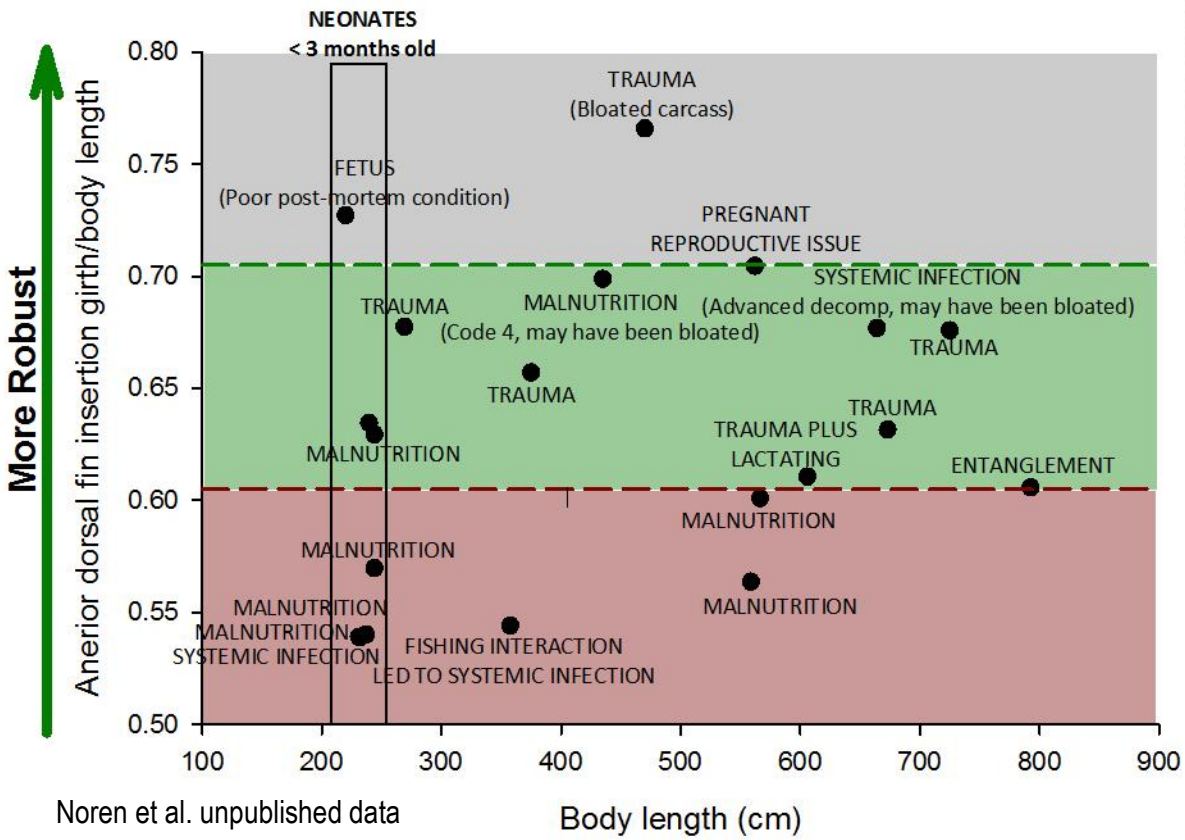
Southern Resident Killer Whale Body Condition

- Documented decline in condition before death in 5 out of last 6 SRKW deaths (all Js)
  - Exception was J34, killed by blunt-force trauma and in good body condition
  - Earlier helicopter work documented declines in condition prior to death for two other individuals (J and L)

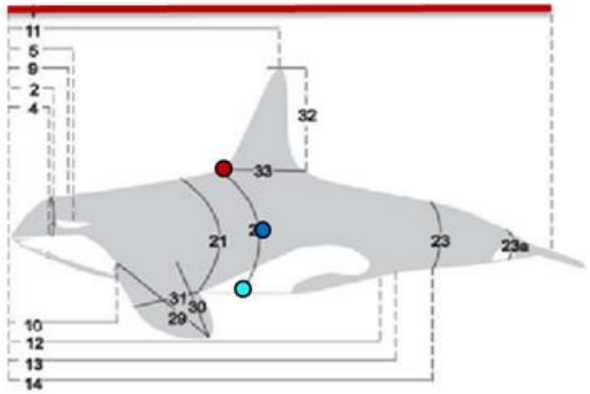
NOAA SWFSC, SR3, Vancouver Aquarium

- Decline in some individuals' body condition from 2008-2013 (Fearnbach et al. 2018)
  - Disease or prey limitations?

Health – COD and Body Condition



Noren et al. unpublished data



Killer whales that died from trauma had better body condition.

Killer whales that died from malnutrition or infection had poor body condition.

Low recovery rate for dead killer whales (SRKW: 20%, NRKW: 3% from 1974-2008) limits ability to assign COD and assess all life-threatening risks (Barbieri et al. 2013)

Health – Pathogens and Disease

- SRKW exhaled breath health assessment identified bacteria that were resistant to antibiotics (Raverty et al. 2017)
  - Salmonella enterica Heidelberg is a pathogen that is resistant to 3 different antibiotics
- Fungal infections present in one stranded SRKW (L95, 20-yr old male) and stranded sympatric harbor porpoises .
  - At least 2 species of fungi (*Rhizomucor pusillus*, *Lichtheimia corymbifera*) are indicators of poor health status
- Communicable diseases have a potentially large impact on the Southern Resident killer whale population due to their social behavior

Other Issues – Direct Human Impact

- Fisheries can cause entanglement, injury, infections from injuries
  - 2015: SRKW J39 (12 yr-old male) had a flasher exiting left side of mouth (WA)
  - 2005: NRKW calf had traumatic perforation of the oropharynx and septicemia from halibut hook (AK)
  - 2015: Transient adult male entangled with rope and crab pot buoys (CA)

Other Issues – Direct Human Impact

- Killer whale COD (2004-2016) includes ship strikes and blunt-force trauma
  - Three SRKWs
    - L98 (7-yr old ♂) – tugboat propeller strike (CAN)
    - L112 (3-yr old ♀) – BFT, unknown origin (OR)
    - J34 (18-yr old ♂) – probable ship strike (CAN)
  - One NRKW
    - C21 – (subadult ♀) – definitive ship strike (CAN)
  - One offshore male
    - O319 (> 12-yr old ♂) – BFT, unknown origin
  - Two Transients
    - T86 (adult ♀, died 2007) – definitive ship strike (WA)
    - N18 (adult ♀, died 2005) – bacterial infection that likely resulted from prior traumatic wound (CA)
  - Eight other killer whales struck by boats (Williams and O'Hara 2010)
    - 5 non-fatal, 2 serious injury, 1 died within 1 year

L98 (7-yr old male) solitary whale developed affinity for people and boats. From video by: Chantelle Tucker

Photo: Cottrell, DFO

J34 (18-yr old male) found on December 21, 2016. Blunt-force trauma to the head and neck. Had a hematoma, indicating he was alive for a time after the injury. PHOTO: SUBMITTED / PNG (VANCOUVER SUN)

Other Issues – SRKW Social Structure

- Potential inbreeding effects (Ford et al. 2018)
  - Two males sired 52% of sampled progeny born since 1990
- The three pods (J,K, L) have different habitat use patterns
  - Relative effects of the different risk factors and anthropogenic impacts could differ

Conclusions

- SRKWs face key risk factors but additional threats have been identified
  - Impacts of all risk factors and additional threats are not fully understood
- Small population size and the multiple threats that may be monotonically increasing or decreasing make it difficult to tease threats apart
  - Potentially important additive effects (e.g., vessel impacts on foraging, contaminant effects on health and reproduction) may be masked
- Direct human impacts may significantly effect the SRKW population