

REVIEW OF RECENT RESEARCH ON SOUTHERN RESIDENT KILLER WHALES TO DETECT EVIDENCE OF POOR BODY CONDITION IN THE POPULATION

FINAL REPORT OF THE INDEPENDENT SCIENCE PANEL

PREPARED FOR:

THE SEADOC SOCIETY
KAREN C. DRAYER WILDLIFE HEALTH CENTER
UC DAVIS SCHOOL OF VETERINARY MEDICINE - ORCAS ISLAND OFFICE
942 DEER HARBOR ROAD
EASTSOUND, WA 98245
360-376-3910
WWW.SEADOC SOCIETY.ORG

PREPARED BY:

CRAIG O. MATKIN, NORTH GULF OCEANIC SOCIETY
MICHAEL J. MOORE, WOODS HOLE OCEANOGRAPHIC INSTITUTION
FRANCES M.D. GULLAND, THE MARINE MAMMAL CENTER

WITH:

BOB FRIEL, SEADOC AFFILIATE, WRITER

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Introduction

This review was commissioned by the SeaDoc Society in light of major concern for the population trajectory of the SRKW population.

The review focuses on identifying evidence for poor body condition in the SRKW population from information presented in Seattle, March 6 2017 (see Appendix 1 Agenda). Body condition can be influenced by food availability (quantity and quality), energy balance, disease, toxin exposure, physiological status, genetics and stress from noise and vessel traffic, amongst other factors, although food availability is the most common cause in wild mammalian populations. For SRKW, food availability to individuals is determined by both prey availability and time to find, catch, share and consume prey. Anthropogenic disturbance will reduce food consumption and thus influence body condition.

The small population size and complex social structure of SRKW complicate detection of associations between measures of body condition and population dynamics. Stochastic events can skew population-wide trends substantially. Therefore, individual cases must be considered rather than analyses of trends and correlations on limited-sample-sizes. The small sample size problem hinders many analyses of this population's ecology.

A recent shift in distribution of Northern Resident Killer Whales (NRKW) into offshore SRKW range complicates choice of a control population. NRKW could compete for space and prey, and may be influenced by environmental variables that influence SRKW. Thus when using a case control approach, and comparing parameters between SRKW and a reference population, care should be taken when using the NRKW, and another population should be used such as the southern Alaskan residents.

Lines of Evidence

Photo-identification, mortality and other sighting data

These data provide critical information on population dynamics, whale distribution and social cohesion. Photo ID has provided inference correlating mortality and reproductive parameters with indices of Chinook salmon abundance, as previously published. This pattern has been further confirmed in recent years. There is annual variability in the incidence of whale occurrence of inland waters of the Salish Sea. Notably, SRKW were present in the Salish Sea on fewer days between April-September in 2013 and 2016. Changes in whale distribution typically indicate changes in prey distribution.

Photogrammetry

Aerial photogrammetry provide valuable data on body condition (fatness). There is inter-annual and seasonal variability in body condition as measured by head width and an indicator of head fatness (Eye Patch Ratio, EPR). In 2008 and 2013, 43 individuals were measured in each year for head width to length ratios (25 females, 18 males). Of these, 11 had significant declines in

proportional head width compared to only five with significant increases. Seven of the 11 declines were in reproductive-aged females, an age class with higher energetic requirements to support rearing offspring; 6 of these either had new calves between the samplings or were pregnant in the later sample. Notably, the individual with the smallest proportional head width died two weeks after being photographed in 2008, and two of the 11 individuals with significant declines died shortly after being photographed in 2013. Similarly comparing repeated images from September 2015 and 2016 (analysis is ongoing) suggests evidence exists for poor body condition within the SRKW population.

From September 2015 to May 2016, five of six animals had declines in EPR. From May to September 2016, three of these six animals had increases in EPR over the summer, three had decreases. All three animals that had continued declines in EPR over the summer of 2016 died.

Photogrammetry data also provide insight into growth. Graphs of length at age for 14 adult females 2008-2013 show older females grew to a greater adult length than younger adults (asymptote of age/length curve). This suggests recent adults have grown to a shorter total length, presumably due to slower growth rates.

Photogrammetry data on breadth/length ratios give data on reproductive rates. Calving data are obtained from direct observations of animals on the water. Calving rates vary annually, with years of low and high calf production observed. In 2013, 12 females were determined as pregnant from width measurements. In 2014, two of these had calves (2/12, 17%). In contrast, analysis of data to date from 2015 reveals four pregnancies were detected in summer 2015, three of these animals had calves in 2016 (3/4). Thus there are years of low reproduction resulting from loss of pregnancies at mid to late term. A reproductive rate of 17% is low compared to data on killer whales from Norwegian whaling data (50%).

Significantly, both 2013 and 2016 had relatively low CPUE for Chinook salmon returns to the Fraser River. Diet analysis has revealed that Fraser River Chinook are an important prey item for SRKWs in the summer.

Mortality data

Information on mortality is available from stranded carcasses and photo-identification. Comparison of these two data sources shows only few carcasses are recovered despite known mortalities, thus necropsy data on SRKW from carcass recovery are limited. None of the animals that died after being observed to be in declining body condition were found to necropsy. Necropsy data provided cause of death for five SRKW. Two of these died with trauma consistent with ship strikes. One that was tagged died from a fungal septicemia about a month later. Two had complications of pregnancy or parturition. Thus necropsy examination is vital to detection of anthropogenic trauma. This cause of death can confound relationships among food availability, body condition and mortality, as it is a stochastic event that can kill an animal in any body condition.

Stranded carcasses can be used to examine blubber measurements and composition. Blubber composition after death is influenced by decomposition, as lipid is lost from the blubber

adipocytes during decomposition and collection. Measurements can be influenced by compression and bloating.

Social dynamics and relationships

Social structure and prey sharing patterns in resident killer whales must be considered in evaluating mortality patterns. Between 2015 and 2016 animals identified as in poor condition by photogrammetry that subsequently died likely had higher nutritional demands because of their social position. For example, the older female J2 was likely provisioning the two orphaned offspring of the deceased J14. The reproductive female J28 died as well as her new calf J54 and she was likely provisioning other members of her matriline as well as nursing her calf. Adult males are provisioned by their mothers and tend to show reduced declines in body condition.

Fecal hormones

Measurement of levels of fecal thyroid, reproductive and stress hormones and their metabolites offer a non-invasive method to evaluate endocrine status of individual whales. These data can be used to track pregnancy changes and stress responses. Declines in fecal thyroid levels were observed in summer months. These could reflect changes in nutritional status, as well as responses to stress, photoperiod and temperature.

Conclusion

There are multiple lines of evidence that indicate the presence of poor body condition in SRKW. This review found that poor body condition is associated with loss of fetuses, calves and adults. The causes of this are complex, and analysis is further compounded by stochastic events such as vessel strike. However food availability, contaminant burden and noise and vessel stress would all appear to be acting in concert causing the decline of this population.

Acknowledgements

Forty-three scientists took time out of their busy schedules to participate in this process. We are grateful to them (see Appendix II for participant names) and their sponsoring organizations including the Center for Whale Research, Fisheries and Oceans Canada, National Marine Mammal Foundation, NOAA Fisheries, North Gulf Oceanic Society, Sea World, Sealife Response, Rehabilitation and Research, The Marine Mammal Center, University of British Columbia, University of Washington, Vancouver Aquarium, and Woods Hole Oceanographic Institution. This work was funded by the private individuals that have invested in the work of the SeaDoc Society as well as a grant from the National Fish and Wildlife Foundation with funding from SeaWorld, and support from NOAA Fisheries. In-kind support was provided for all participants through their supporting agency.

Appendix 1. Agenda

Killer Whale Health Assessment Workshop March 6 and 7, 2017
Silver Cloud Inn, University District, 5036 25th Avenue NE, Seattle, WA 98105

Independent Science Panel Review of Southern Resident Killer Whale Nutritional Condition

Goals:

1. Recent and review published and unpublished data to evaluate changes in and current status of southern resident killer whale body condition, nutritional status and health over time, location and demographics.
2. Produce an independent science panel report on the latest findings to inform ongoing efforts to understand the extent to which nutritional status is impacting health of Southern Residents (future workshop will overlay findings with prey availability data).

8:00AM Group Introductions and rules of engagement for presenters and group

8:15 AM Overview -

Stephanie Venn-Watson (NMMF), Moderator

Independent Panelists: Frances Gulland, Craig Matkin, & Michael Moore

Overarching Questions:

1. Is there evidence of malnutrition in individual southern resident killer whales?
2. Is nutritional condition influencing southern resident fecundity, survival and demography?
Specifically, we will try and answer:
 - What is the evidence that the whales are malnourished?
 - What additional evidence needs to be collected to further understand this?
 - Of known deaths, in how many cases was the primary cause of death confirmed to be malnourishment? How does this compare to other sources of known mortality?
 - Is there evidence that nutritional status changes seasonally?
 - What is the relationship between nutritional status and body condition?
 - What are potential causes of changes in body condition seasonally and over time?
What evidence for these causes?
 - Is there evidence that nutritional status and/or body condition is causing reproductive and / or recruitment failure?

8:30 AM Whale sighting frequency, time budget, and boat-based body condition

Debbie Giles, Center for Whale Research

8:45 AM Aerial photogrammetry measures of growth and body condition to assess

SRKW health and nutritional status; comparison to NRKWs John Durban (NOAA), Holly Fearnbach (SR3), Lance Barrett-Leonard (Vancouver Aquarium), Dave Ellifrit, Jane Cogan, Mark Malleson (Center for Whale Research), Molly Groskreutz (NOAA), Jared Towers and John Ford (DFO)

9:45 AM Cause of death and nutritional condition in stranded animals

Steve Raverty (UBC), Judy St. Leger (SeaWorld), and Joe Gaydos

10:00 AM Blubber thickness and nutritional condition of stranded killer whales
Dawn Noren (NOAA), Judy St. Leger (SeaWorld), Steve Raverty (UBC), and Joe Gaydos

10:30 AM Break

10:45 AM Fatty acids, microbiomes, contaminants and other markers of condition
Gina Ylitalo (NOAA)

11:00 AM Fecal hormones (stress, nutrition, and pregnancy) Sam Wasser (UW)

11:30 PM Respiratory and skin microbiomes versus pelagic marine waters Linda Rhodes
(NOAA)

11:45 PM Killer whale gut microbiome as a potential health indicator Kim Parsons (NOAA)

12:00 PM Lunch (provided on site)

12:45 PM Skin condition as an indicator of health and nutritional condition Joe Gaydos
(SeaDoc), Judy St. Leger (SeaWorld), Steve Raverty (UBC), Ken Balcomb (CWR), Debbie
Giles (CWR), Dave Ellifrit (CWR), Candi Emmons (NOAA), Brad Hanson (NOAA), Eric Ward
(NOAA), Hendrik Nollens (SeaWorld),

1:00 PM Southern Resident inbreeding and implications for health Mike Ford and Kim Parsons
(NOAA)

1:30 PM Update on preferred prey, prey availability, prey quality, and prey interactions from
other species (to set the stage for next workshop evaluating food availability and nutritional
status) Brad Hanson and Eric Ward (NOAA)

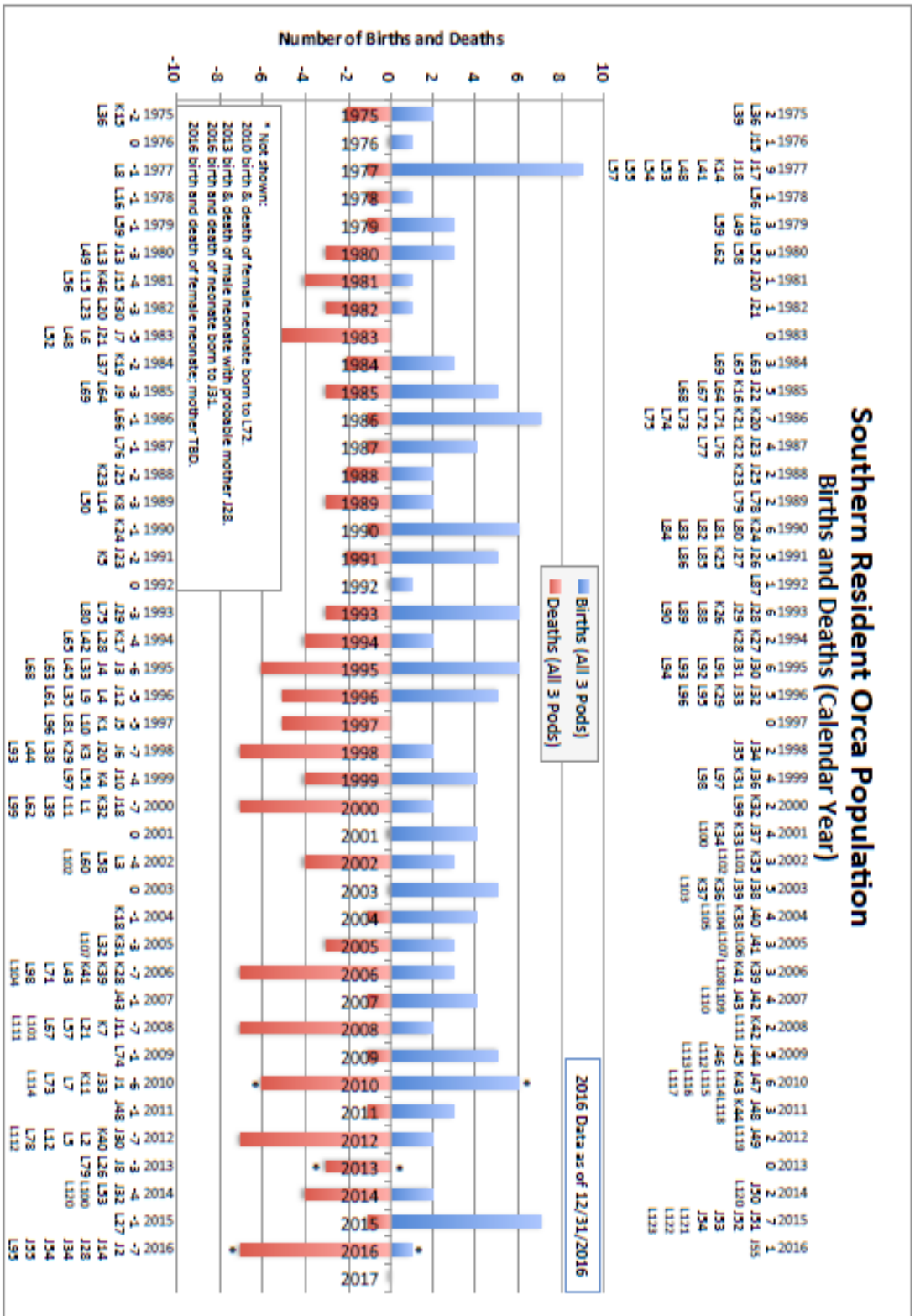
2:00 PM Break

2:30 PM Panel-guided questions and discussion All Participants

4:30 PM Wrap up and plan for completion of independent panel review

5:00 PM Adjourn

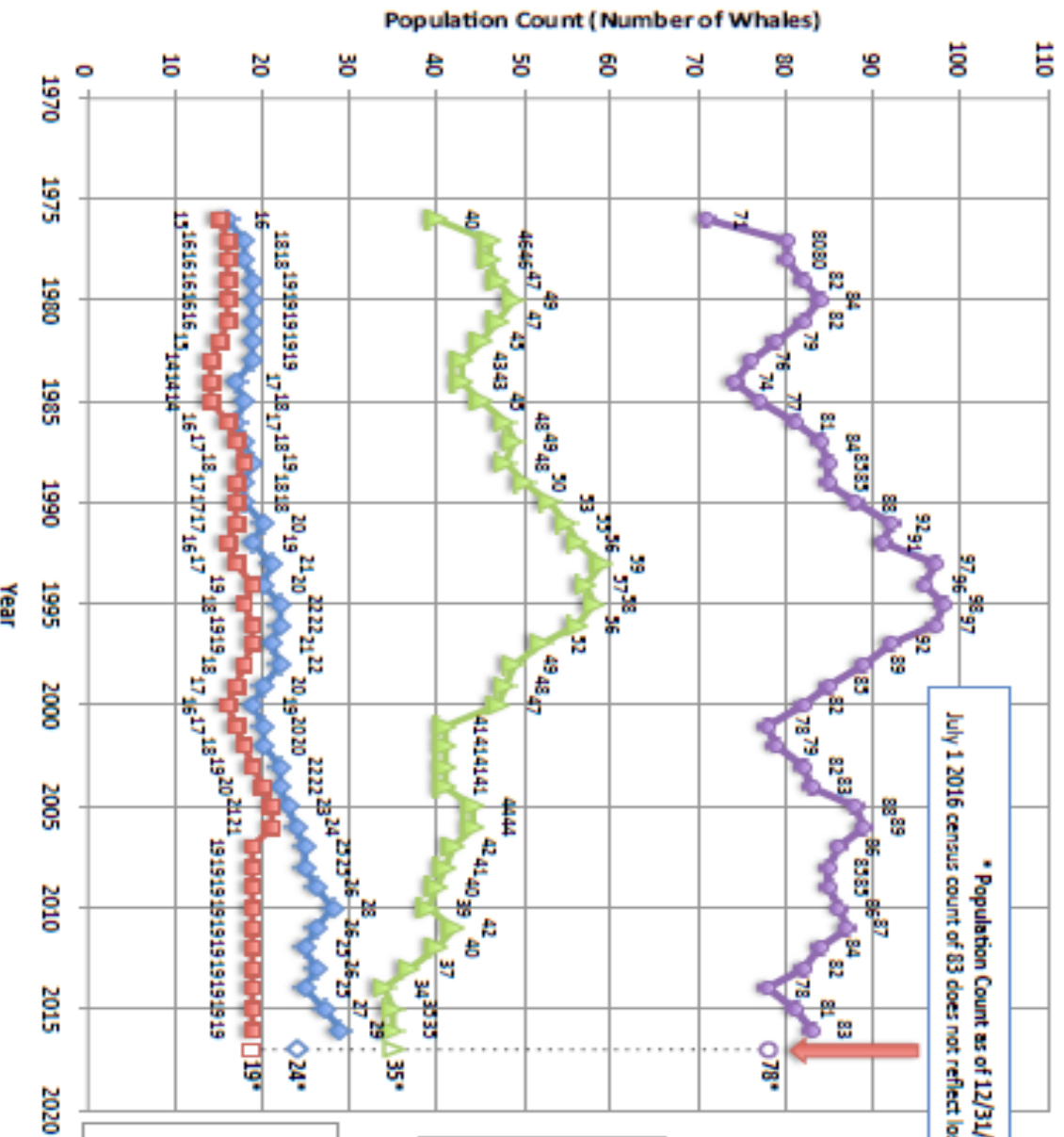
Appendix 2. SRKW Population Assessment



3/4/17

2016 SRKW Population Update & 2016 Whale Sighting Data - Health Workshop 20170306
 Center for Whale Research & J. Cogan

Southern Resident Orca Population J, K, and L Pod Census as of July 1 Each Year



* Population Count as of 12/31/2016 is 78
July 1 2016 census count of 83 does not reflect loss of 12, 114, 128, 134, or 154

Census as of July 1

- ◆ J Population (CWR)
- K Population (CWR)
- ▲ L Population (CWR)
- JKL Population (CWR)

Primary Sources:
 • Center for Whale Research Orca Survey July 1, 2016 + 2016 Population Updates
 • Center for Whale Research Web Site
 • Killer Whales (John K. B. Ford, Graeme M. Ellis, Kenneth C. Balcomb)

Appendix 3. Workshop Participants

| Name | Affiliation |
|-------------------------|---------------------------------------|
| Balcomb, Ken (by phone) | Center for Whale Research |
| Ballance, Lisa | NOAA |
| Barbieri, Michelle | NOAA |
| Barre, Lynne | NOAA |
| Barrett-Leonard, Lance | Vancouver Aquarium |
| Brodsky, Micah | Independent |
| Clowers, Lisa | National Marine Mammal Foundation |
| Cottrell, Paul | Fisheries and Oceans Canada |
| Durban, John | NOAA |
| Ellis, Graeme | Fisheries and Oceans Canada - Retired |
| Emmons, Candice | NOAA |
| Fauquier, Deb | NOAA |
| Fearnbach, Holly | SR3 |
| Ford, John | Fisheries and Oceans Canada |
| Ford, Mike | NOAA |
| Friel, Bob | SeaDoc / UC Davis |
| Gaydos, Joe | SeaDoc / UC Davis |
| Giles, Debbie | Center for Whale Research |
| Gulland, Frances | The Marine Mammal Center |
| Hanson, Brad | NOAA |
| Harrington, Monica | SR3 |
| Haulena, Martin | Vancouver Aquarium |
| Lahner, Lesanna | SR3 |
| Lutmerding, Betsy | National Marine Mammal Foundation |
| Matkin, Craig | North Gulf Oceanic Society |
| Mongillo, Teresa | NOAA |
| Moore, Michael | Woods Hole Oceanographic Institution |
| Nollens, Hendrick | SeaWorld |
| Noren, Dawn | NOAA |
| Norman, Stephanie | Independent |
| Parsons, Kim | NOAA |
| Raverty, Steve | University of British Columbia |

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|---------------------------|-----------------------------------|
| Rhodes, Linda | NOAA |
| Rowles, Teri | NOAA |
| Schroeder, Pete | Independent |
| Smith, Cynthia (by phone) | National Marine Mammal Foundation |
| Thornton, Sheila | Fisheries and Oceans Canada |
| Venn-Watson, Stephanie | National Marine Mammal Foundation |
| Ward, Eric | NOAA |
| Wasser, Sam | University of Washington |
| Wright, Brianna | Fisheries and Oceans Canada |
| Yates, Chris | NOAA |
| Ylitalo, Gina | NOAA |