Sei Whales (Balaenoptera borealis) 2012-2018

Bibliography

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Background & Scope

Sei whales occur in subtropical, temperate, and subpolar waters around the world. Often found with pollack in Norway, the name "sei" comes from the Norwegian word for pollack, "seje."
The sei whale population has been greatly decreased by commercial whaling. During the 19th and 20th centuries, sei whales were targeted and greatly depleted by commercial hunting and whaling, with an estimated 300,000 animals killed for their meat and oil. Commercial whaling ended for this species in 1980. Although whaling is no longer a major threat to this species, some scientific whaling continues today in Iceland and Japan. Vessel strikes and entanglement pose the biggest threat to sei whales today. The sei whale is listed as endangered under the Endangered Species Act and depleted under the Marine Mammal Protection Act.

This bibliography focuses on any relevant sei whale literature (peer-reviewed, technical reports, memos, biological opinions, International Whaling Commission (IWC) reports, etc.) since 2012. It is intended as a reference resource for ESA staff of the NOAA Fisheries Office of Protected Resources when compiling and summarizing any relevant new (i.e. 2012-present) information for this cetacean species. It is organized into four sections: Biology (life history), Ecology (interaction with the environment), Population Abundance and Trends, and Threats.

Section I – Biology

Section one is intended to provide an overview of the life history of the sei whale. The research in this area includes a compilation of diet, lifespan and habitat, migration patterns, behavior, feeding, and reproduction as well as any current literature on sei whale biology.

Section II – Ecology

Section two is intended to provide an overview of how the sei whale interacts with the environment. The research in this area includes a compilation of feeding ecology, social ecology, food resources, prey composition and how climate change affects the sei whale.

Section III – Population Abundance and Trends

Section three is intended to provide an overview of the latest population estimates and trends for sei whales.

Section IV – Threats

A threat is defined as any factor that could represent an impediment to a species' recovery. Thus, section four is intended to provide an overview of any new and/or existing threats to the sei whale (i.e. anthropogenic noise, injury or mortality from gear entanglement, ship noise, oil and gas activities, military sonar and explosives, offshore energy development, ship strikes/vessel interactions, disease, injury from marine debris, predation and natural mortality, directed hunts, contaminants/pollutants, loss of prey base due to climate change, competition for resources, disturbance due to research, and any new threats that may be documented in the literature).

Sources Reviewed

Along with a web search for relevant materials the following databases were used to identify sources: Clarivate Analytics' Web of Science: Science Citation Index Expanded, ProQuest's Science and Technology, ScienceDirect, BioOne Complete, Google Scholar, and JSTOR. Only English language materials were included. A date range specification of only material published from 2012 onward informs the depth and breadth of this bibliography.

Section I: Biology

Canada. Department of Fisheries and Oceans. (2012, October 17-21, 2011). *Annual Meeting of the National Marine Mammal Peer Review Committee*. Ottawa, ON. Retrieved from http://publications.gc.ca/site/eng/437607/publication.html

The National Marine Mammal Peer Review Committee (NMMPRC) holds an annual meeting to conduct scientific peer review of marine mammal issues. This approach gives the opportunity to bring together experts on marine mammals from Fisheries and Oceans Canada (DFO) with specific contributions from non-DFO experts to ensure high quality peer review of the scientific results and to provide sound scientific advice as the basis for the management and conservation of marine mammals in Canada. When time permits, this annual meeting is also an opportunity to review ongoing research projects and provide feedback or guidance to the scientists involved. This meeting, which is part of the Canadian Science Advisory Secretariat's scientific advisory process of the DFO Ecosystems & Ocean Science Sector, was held October 17-21, 2011, at the Lord Elgin Hotel in Ottawa, Ontario. This year, the papers reviewed pertained to walrus, grey, harp and ringed seals, fur seals, beluga, narwhal, killer whale, fin, blue, sei and North Pacific right whales, bowhead, and Trans North Atlantic Sightings Survey (TNASS) survey estimates.

Canada. Department of Fisheries and Oceans. (2012). *Information relevant to the assessment of critical habitat for Blue, Fin, Sei and North Pacific Right Whales in British Columbia.* Science Advisory Report 2011/078. Retrieved from http://www.dfo-mpo.gc.ca/Library/346381.pdf

The Blue whale was listed as Endangered in the Pacific before the Species at Risk Act (SARA) came into effect in 2003 and that status was reaffirmed by COSEWIC in 2005. Fin Whales in the Pacific were listed as Threatened under SARA in 2006, the Sei whale was listed as Endangered in 2005 and the North Pacific Right whale was listed as Endangered in 2006. A Recovery Strategy was completed in 2006 for the Blue, Fin, and Sei Whales and a draft Recovery Strategy was developed for the North Pacific Right whale in 2009. A draft Action Plan for these species has also been prepared but Critical Habitats have not yet been identified. A schedule of studies to support identification of Critical Habitat is included in both the Recovery Strategy and the Action Plan, however, the Action Plan development process also requires an in-depth understanding of the current state of knowledge and documentation of the effort thus far to identify Critical Habitat. This document addresses this requirement and presents the available information and current state of knowledge regarding habitat(s) for these species which can then be incorporated into the draft Action Plan for Blue, Fin, Sei, and North Pacific Right Whales as required under SARA S. 49(1)(a)

Hunt, K. E., Lysiak, N. S., Robbins, J., Moore, M. J., Seton, R. E., Torres, L., & Buck, C. L. (2017). Multiple steroid and thyroid hormones detected in baleen from eight whale species. *Conservation Physiology, 5*, 14. https://doi.org/10.1093/conphys/cox061

Recent studies have demonstrated that some hormones are present in baleen powder from bowhead (Balaena mysticetus) and North Atlantic right (Eubalaena glacialis) whales. To test the potential generalizability of this technique for studies of stress and reproduction in large whales, we sought to determine whether all major classes of steroid and thyroid hormones are detectable in baleen, and whether these hormones are detectable in other mysticetes. Powdered baleen

samples were recovered from single specimens of North Atlantic right, bowhead, blue (Balaenoptera [B.] musculus), sei (B. borealis), minke (B. acutorostrata), fin (B. physalus), humpback (Megaptera novaeangliae) and gray (Eschrichtius robustus) whales. Hormones were extracted with a methanol vortex method, after which we tested all species with commercial enzyme immunoassays (EIAs, Arbor Assays) for progesterone, testosterone, 17 beta-estradiol, cortisol, corticosterone, aldosterone, thyroxine and triiodothyronine, representing a wide array of steroid and thyroid hormones of interest for whale physiology research. In total, 64 parallelism tests (8 species x 8 hormones) were evaluated to verify good binding affinity of the assay antibodies to hormones in baleen. We also tested assay accuracy, although available sample volume limited this test to progesterone, testosterone and cortisol. All tested hormones were detectable in baleen powder of all species, and all assays passed parallelism and accuracy tests. Although only single individuals were tested, the consistent detectability of all hormones in all species indicates that baleen hormone analysis is likely applicable to a broad range of mysticetes, and that the EIA kits tested here perform well with baleen extract. Quantification of hormones in baleen may be a suitable technique with which to explore questions that have historically been difficult to address in large whales, including pregnancy and inter-calving interval, age of sexual maturation, timing and duration of seasonal reproductive cycles, adrenal physiology and metabolic rate.

Ishii, M., Murase, H., Fukuda, Y., Sawada, K., Sasakura, T., Tamura, T., Nakatsuka, S. (2016). *A short note on feeding behavior of sei whales observed in JARPNII*. Paper presented at the JARPNII special permit expert panel review workshop, Tokyo. IWC. Retrieved from https://www.icrwhale.org/pdf/SC-F16-JR25.pdf

Diving behaviour of sei whales and vertical distribution of their prey were recorded simultaneously in 2013 JARPNII to study their feeding behaviour at micro scale. This was the first attempt of this kind of observation targeting on this species. Small acoustic time depth transmitters (pingers) were attached to two sei whales and their behaviours were recorded for 10.2 and 32.0 hours, respectively. Vertical distributions and densities (volume backscattering strength, SV) of their prey were recorded by an echosounder following swimming path of the individuals. The diving behaviour deeper than 10 m was classified into two shapes (U-shape, V-shape). It was assumed that U-shape was related to feeding behaviour, especially lunge feeding, while V-shape was related to prey searching dive. Sei whales showed diel patterns in mean diving depth (day: 19 ± 14 m and 16 ± 10 m, night: 12 ± 5 m and 10 ± 5 m). Dense scattering layers (presumably zooplankton) were observed around 40 m during the daytime, and they migrated closer to the surface in the evening. Diving depth of the whales followed the changes in the scattering layers (i.e. diving depth was same as depth of scattering layers). U-shape diving was associated with higher SV values than V-shape diving in daytime. The number of U-shape diving increased around dusk. The results suggested that sei whales frequently lunged to prey around dusk. First-Passage Time (FPT) of sei whales as an indicator of feeding was calculated using the cruise track as a proxy of horizontal movement of tagged individuals. Large FPT can be considered as feeding behaviour. FPT was increased around dusk and it was corresponding to increase in U-shape diving. Combining these results, it could be said sei whales actively fed on prey around dusk. Swimming depth of the whales was shallower than 10 m after sunset while deep scattering layers (presumably myctophids) were migrated from below 60 m to around 30 m. The results might indicate that they did not feed on prey in deep scattering layers at night. However, it could not preclude a possibility that sei whales fed on prey near surface at night because data on behaviour and prey distribution near surface could not recorded by the acoustic devices (pinger and echosounder) used in this study. The results of this study revealed that sei whales changed their diving behaviour in response to availability of their prey.

Konishi, K. (2016). *Analyses of body condition in sei, Bryde's and common minke whales in the western North Pacific with JARPN and JARPN II dataset*. Paper presented at the JARPNII special permit expert panel review workshop, Tokyo. IWC. Retrieved from https://www.icrwhale.org/pdf/SC-F16-JR27.pdf

The annual trend in energy storage in sei Balaenoptera borealis and Bryde's B. edeni during the JARPN II period and common minke whales B. acutorostrata during the JARPN and JARPN II period were examined. Regression analyses showed that blubber thickness and half girth in sei whales have been increasing during 2002-2015. The increase per year is estimated at 0.109 ±0.038 SE cm for mid-lateral blubber thickness and 2.183 ±1.379 SE cm for axillary half-girth. The regression analyses also showed negative year effects on blubber thickness in common minke whale while Bryde's whale, year effects were not seen. The regression analyses also showed that sei and Bryde's whale have good body condition with larger body length and in later days. Some analyses also showed body condition and its seasonal increase differ among maturity stages. Meanwhile, prey species and surface water temperature where whale were caught were not selected as predictors. The reasons for increase body condition in sei and decrease body condition in minke whale are difficult to identify. However, increase trend of body condition in sei whales suggest the favourable food availability change for sei whale in the study area. The regression also showed decrease body condition in common minke whale using JARPN and JARPNII (both Offshore and Coastal components) suggesting unfavourable food availability change and difference between stocks, however the analysis for the minke whale leave to be improved.

Mogoe, T., Isoda, T., Yoshida, T., Nakai, K., Kanbayashi, J., Ono, K., Yoshimura, I., Ueda, Y., Mure, H., Ueta, E., Wada, A., Eguchi, H. and Tamura, T. (2017). *Results of the second biological field survey of NEWREP-A during the 2016/17 austral summer season*. Paper presented at the NEWREP-A. http://www.icrwhale.org/NEWREP-AProtocol.html

This paper reports the results of biological sampling of the Antarctic minke whale during the second New Scientific\Whale Research Program in the Antarctic Ocean (NEWREP-A) survey conducted in Area III-E (45°E-70°E) and IV (70°E-130°E), south of 60°S during the 2016/17 austral summer season. The paper also presents the results of the sighting surveys and photo-ID and biopsy sampling of large whales by the sighting sampling vessels (SSVs). Three SSVs and one research base vessel were engaged in the survey for 83 days. A total of 311 primary sightings (involving 526 individuals) of Antarctic minke whale were made during 3,274 n.miles of searching distance. A total of 333 Antarctic minke whales (178 females and 155 males) were sampled, and a number of biological samples and data required for the two main objectives of NEWREP-A were obtained from each whale taken. Earplugs for age determination were collected from all whales. A total of 24 whales were photo-identified: humpback whale (20) and killer whale (4) in the research area. A total of four biopsy samples of humpback whale were collected from photo-identified individuals. The samples and data collected in this survey are available for interested national and international scientists under the guidelines for research collaboration posted at the home page of the Institute of Cetacean Research (ICR): http://www.icrwhale.org/NEWREP-AProtocol.html.

Pastene, L. A., Goto, M., Taguchi, M., & Kitakado, T. (2016). *Genetic analyses based on mtDNA control region sequencing and microsatellite DNA confirmed the occurrence of a single stock of sei whales in oceanic regions of the North Pacific*. Paper presented at the JARPNII special permit expert panel review workshop, Tokyo. IWC. Retrieved from https://www.icrwhale.org/pdf/SC-F16-JR46.pdf

A total of 1,554 sei whales were examined genetically (mtDNA control region sequencing, 487bp and microsatellite DNA at 17 loci) to investigate population genetic structure of this species in the North Pacific. Samples were available from different sources, JARPNII (catches) (2002-2014), POWER (biopsy) (2010-2012) and past commercial (catches) (1972-73). For the heterogeneity test two longitudinal sectors were defined in the North Pacific: Western and Eastern at 180°, which covered this ocean basin widely from approximately 145°E to 135°W. No significant spatial genetic heterogeneity was found by the two genetic markers. A phylogenetic tree of 82 mtDNA haplotypes showed several clusters, but none was supported by high bootstrap values. Whales from both Western and Eastern sectors were widely distributed through the clusters. Taken as a whole, the genetic information in this study is consistent with the view that the oceanic regions of the North Pacific is occupied by a single stock of sei whale.

Wang, D. L., Huang, W., Garcia, H., & Ratilal, P. (2016). Vocalization Source Level Distributions and Pulse Compression Gains of Diverse Baleen Whale Species in the Gulf of Maine. *Remote Sensing, 8*(11), 20. https://doi.org/10.3390/rs8110881

The vocalization source level distributions and pulse compression gains are estimated for four distinct baleen whale species in the Gulf of Maine: fin, sei, minke and an unidentified baleen whale species. The vocalizations were received on a large-aperture densely-sampled coherent hydrophone array system useful for monitoring marine mammals over instantaneous wide areas via the passive ocean acoustic waveguide remote sensing technique. For each baleen whale species, between 125 and over 1400 measured vocalizations with significantly high Signal-to-Noise Ratios (SNR > 10 dB) after coherent beamforming and localized with high accuracies (<10% localization errors) over ranges spanning roughly 1 km-30 km are included in the analysis. The whale vocalization received pressure levels are corrected for broadband transmission losses modeled using a calibrated parabolic equation-based acoustic propagation model for a random range-dependent ocean waveguide. The whale vocalization source level distributions are characterized by the following means and standard deviations, in units of dB re 1 mu Pa at 1 m: 181.9 +/- 5.2 for fin whale 20-Hz pulses, 173.5 +/- 3.2 for sei whale downsweep chirps, 177.7 +/- 5.4 for minke whale pulse trains and 169.6 +/- 3.5 for the unidentified baleen whale species downsweep calls. The broadband vocalization equivalent pulse-compression gains are found to be 2.5 +/- 1.1 for fin whale 20-Hz pulses, 24 +/- 10 for the unidentified baleen whale species downsweep calls and 69 +/- 23 for sei whale downsweep chirps. These pulse compression gains are found to be roughly proportional to the inter-pulse intervals of the vocalizations, which are 11 +/- 5 s for fin whale 20-Hz pulses, 29 +/- 18 for the unidentified baleen whale species downsweep calls and 52 +/- 33 for sei whale downsweep chirps. The source level distributions and pulse compression gains are essential for determining signal-to-noise ratios and hence detection regions for baleen whale vocalizations received passively on underwater acoustic sensing systems, as well as for assessing communication ranges in baleen whales.

Werth, A. J., Potvin, J., Shadwick, R. E., Jensen, M. M., Cade, D. E., & Goldbogen, J. A. (2018). Filtration area scaling and evolution in mysticetes: trophic niche partitioning and the curious cases of sei and pygmy right whales. *Biological Journal of the Linnean Society*, 125 (2), 264-279. https://doi.org/10.1093/biolinnean/bly121

We analysed the functional morphology and hydrodynamics of the filtering apparatus in ten species of baleen whales (Mysticeti). Our results demonstrate a clear demarcation in baleen scaling of continuous ram filter feeders (Balaenidae; right and bowhead whales) and intermittent lunge/suction feeders: rorquals (Balaenopteridae) and the grey whale (Eschrichtiidae). In addition to different scaling trajectories, filter area varies widely among taxa. Balaenid baleen has four to five times the area of that of similarly sized rorquals (by body length and mass). Filter areas correlate with morphology; lineages evidently evolved to exploit different types of patchy prey. Feeding performance data from hydrodynamic modelling and tagged whales suggest that drag forces limit balaenids, whereas time required to purge and filter engulfed water appears to limit rorquals. Because scaling of engulfment volume outpaces increases in baleen area, large rorquals must devote greater proportions of dive time to filtration. In contrast, balaenids extend dive duration, but as a trade-off are limited to low engulfment speeds and therefore can only target prey with low escape capabilities. The sei whale, Balaenoptera borealis, has a mid-range filter reflecting its transitional diet and intermediate morphology, embodying generalized characteristics of both continuous ram and intermittent lunge filtration. The pygmy right whale, Caperea marginata, has a balaenid-type filter via 2D analysis, but enhanced 3D modelling shows Caperea's baleen fits better with rorquals. Allometric equations relating body and filter size address phylogenetic questions about filtration in extinct lineages, including future ancestor state reconstruction analyses. Based on baleen and body size (~5 m) and skull morphology, the earliest edentulous mysticetes were probably intermittent rather than continuous filterers, with simple baleen.

Werth, A. J. (2013). Flow-dependent porosity and other biomechanical properties of mysticete baleen. *The Journal of Experimental Biology, 216*(7), 1152. https://doi.org/10.1242/jeb.078931

Despite its vital function in a highly dynamic environment, baleen is typically assumed to be a static material. Its biomechanical and material properties have not previously been explored. Thus I tested sections of baleen from bowhead whales, Balaena mysticetus, and humpback whales, Megaptera novaeangliae, alone or in groups representing miniature 'racks', in a flow tank through which water and buoyant particles circulated with variable flow velocity. Kinematic sequences were recorded through an endoscopic camera or viewing window. One set of experiments investigated particle capture; another series analyzed biomechanical behavior, including fringe spacing, movement and interaction. Baleen fringe porosity directly correlates, in a mostly linear fashion, with velocity of incident water flow. However, undulation and interaction of fringes (especially of bowheads) at higher flow velocities can decrease porosity. Fringe porosity depends on distance from the baleen plate. Porosity also varies, with fringe length, by position along the length of an individual plate. Plate orientation, which varied from 0 to 90 deg relative to water flow, is crucial in fringe spacing and particle capture. At all flow velocities, porosity is lowest with plates aligned parallel to water flow. Turbulence introduced when plates rotate perpendicular to flow (as in cross-flow filtration) increases fringe interaction, so that particles more easily strike fringes yet more readily dislodge. Baleen of bowhead whales, which feed by continuous ram filtration, differs biomechanically from that of humpbacks, which use intermittent lunge filtration. The longer, finer fringes of bowhead baleen readily form a mesh-like mat, especially at higher flow velocities, to trap tiny particles.

Section II: Ecology

Konishi, K., Isoda, T., & Tamura, T. (2016). *Decadal change of feeding ecology in sei, Bryde's and common minke whales in the offshore of the Western North Pacific.* Paper presented at the JARPNII special permit expert panel review workshop, Tokyo. IWC. https://www.icrwhale.org/pdf/SC-F16-JR23.pdf

Stomach contents from sei, Bryde's and common minke whales sampled by JARPNII cruises in May-October during 2000-2013 (2002-2015 for sei whale) off the Pacific coast of Japan were used to examine yearly trend in prey composition. Stomach content analysis showed that the three whale species are highly dependent on small pelagic fish, in addition to planktonic crustaceans. The change of prey compositions in sei whales among years drastically changed from Japanese anchovy in the early 2000s to Japanese sardine in 2014 and 2015, while Neocalanus copepod steadily occurred throughout the years. This decreasing Japanese anchovy synchronized with the catch record of Pacific stocks in Japanese fisheries. Furthermore sea water temperature and school size were different by prey species. Bryde's whale has a more simple prey composition, mostly of Japanese anchovy and euphausiid, and were highly variable among years with no remarkable change during 2000-2013. Prey composition in common minke whales offshore (east of 146°E) showed Japanese anchovy and Pacific saury are the majority species, but the composition differs among years. Japanese anchovy used to be consumed by minke whales around 40°N, but euphausiid was consumed in recent years. These results suggesting a decrease in the amount of Japanese anchovy transported offshore is an important factor to determine the composition of the three baleen whales in the JARPNII study area.

Konishi, K., Isoda, T., & Tamura, T. (2017). Overview of stomach content analyses for sei, Bryde s and common minke whales under the offshore component of JARPNII, and temporal changes in feeding habits. *Technical Reports of the Institute of Cetacean Research (TEREP-ICR)*, p44. Retrieved from https://www.icrwhale.org/pdf/TEREP00144-57.pdf

This study presents an overview of the stomach content analyses for sei, Bryde's and common minke whales off the Pacific coast of Japan based on data and samples collected by the offshore component of JARPNII during 2000–2016. The three species were highly dependent on small pelagic fish, in addition to planktonic crustaceans. The prey species composition in sei whales drastically changed from Japanese anchovy in the early 2000s to Japanese sardine in 2014 to 2016, while copepods (Neocalanus spp.) steadily occurred throughout the years in offshore waters. Bryde's whale had a simple prey composition involving mainly Japanese anchovy, but a lesser amount of this prey species was observed during the last three years. Prey composition in common minke whales in offshore waters showed that Japanese anchovy and Pacific saury are the main prey species, while in the vicinity of northern Japan, Japanese anchovy and walleye pollock were the dominant prey species. These three whale species showed diversities in their feeding habits reflecting changes in prey species populations and availability through the years.

Surma, S., & Pitcher, T. J. (2015). Predicting the effects of whale population recovery on Northeast Pacific food webs and fisheries: an ecosystem modelling approach. *Fisheries Oceanography, 24*(3), 291-305. https://doi.org/10.1111/fog.12109

The recovery of whale populations from historical depletion may have the potential to noticeably affect Northeast Pacific ecosystems and fisheries. Surplus production models based on whaling catch records were used to reconstruct the historical abundances of five large whale species in the waters surrounding Haida Gwaii, British Columbia. The results suggest that the local abundances of all five species were vastly higher before the onset of modern whaling. A comparison of ecosystem models representing the states of the local marine food web before and after full whale recovery indicates that abundant whales could consume large proportions of the annual production of their principal prey, ranging up to 87% for Pacific herring (Clupea pallasii) and 72% for piscivorous rockfish (Sebastes spp.). Dynamic modelling of the food web effects of whale recovery, including simulations of simultaneous top-down and bottom-up forcing and a Monte Carlo sensitivity analysis, revealed noticeable (?6?12%) top-down effects on Pacific herring biomass owing to increased predation by humpback and fin whales. However, these effects cannot explain the magnitude of recent declines in local herring biomass. The dynamic modelling results also suggest that top-down effects of whale recovery could result in reduced biomasses of large rockfish as a result of predation by sperm whales, as well as potential cascading effects on many demersal fish groups. These findings have numerous practical implications for ecosystem-based fisheries management and whale conservation strategies in Northeast Pacific waters.

Tamura, T., Konishi, K., & Isoda, T. (2016). *Updated estimation of prey consumption by common minke, Bryde's and sei whales in the western North Pacific*. Paper presented at the JARPNII special permit expert panel review workshop, Tokyo. IWC. Retrieved from https://www.icrwhale.org/pdf/SC-F16-JR15.pdf

The stomach contents of common minke (Balaenoptera acutorostrata), Bryde's (B. edeni) and sei (B borealis) whales, sampled in the western North Pacific from May to October in 2000-2014 by the Japanese Whale Research Program under Special Permit in the western North Pacific (JARPNII) were collected and examined. The main purpose of this study was to estimate the amount of fish resources consumed by the three baleen whale species, accounting for some uncertainties. Prey species of whales were identified by examining their stomach contents, and the amount of prey consumed in the research area was estimated by using information on prey consumption per capita and the numbers of whales distributed. There were seasonal and geographical changes of the prey species of each whale species. The extent of differences of estimates of consumptions among several models was 2.4-3.6 times. Based on the results obtained by three equations combined and Monte Carlo simulations, the daily prey consumptions per capita of common minke whales were 86-94kg and 83-94kg for immature male and female; and 129-141kg and 158-166kg for mature male and female, respectively. The daily prey consumptions per capita of Bryde's whales were 419-434kg and 417-428kg for immature male and female; and 577-637kg and 642-707kg for mature male and female, respectively. The daily prey consumptions per capita of sei whales were 397-421kg and 436-468kg for immature male and female; and 524-539kg and 610-647kg for mature male and female, respectively. The CVs of the daily prey consumption consumed by whales per capita were in the range 0.2-0.3. The seasonal prey consumption during May-September in the two periods (2000-2007, 2008-2013) by three baleen whale species were 1.1 and 1.2 million tons, respectively. The prey consumption of Japanese anchovy, mackerels and Pacific saury by three baleen whale species in the two periods were estimated as 674-724 thousand tons, 43-70 thousand tons and 48-56 thousand tons, respectively. The CVs of the seasonal prey consumption consumed

by whales were in the range 0.3-0.4. These values were equivalent to 22-48%, 5-66% and 2-7% of the biomass of each fish resources in the western North Pacific. These estimates on prey consumption will be useful as input data in ecosystem models.

Willis, J. (2014). Whales maintained a high abundance of krill; both are ecosystem engineers in the Southern Ocean. *Marine Ecology Progress Series, 513*, 51-69. https://doi.org/10.3354/meps10922

Krill abundance was predicted to rise after the end of commercial whaling in the Southern Ocean due to the release of predatory pressure from 2 million whales that were killed between 1915 and 1970, but contrary to expectations, there has been a substantial decline in abundance of krill since the end of whaling. I presented a model 7 yr ago which explained how krill behaviour, in response to the threat of predation by whales, may provide an answer to this paradox. The original model contained a speculative link: a mechanism by which krill could detect the presence of whales over a wide area, and therefore could behave in response to a credible threat. Recently, iron has been implicated in a positive feedback cycle between whales, krill and primary production. The cycle depends on the buoyant faeces of whales fertilising surface layers. This is both a plausible way for krill to detect whales over a wide area and an explanation for enhanced feeding at the surface, but this was not incorporated in the original model. Thus, nutrient retention and behavioural control are probably an example of niche construction and ecosystem engineering by both krill and whales. In this paper I revisit and update the simple model of krill mentioned above. The model is calibrated against known system states and is used to imply the ecosystem level changes caused by commercial whaling. This improved model may explain the reduction in krill abundance after the end of commercial whaling. Untested hypotheses which can be falsified in designed experiments are listed.

Section III: Population Abundance and Trends

Anonymous. (2013). Gliders Used to Locate, Track Whales for First Time. *Sea Technology, 54*(2), 82-83. Retrieved from https://sea-technology.epubxp.com/i/112603-feb-2013/81

The gliders were equipped with a WHOI-developed digital acoustic monitoring (DMON) instrument and pitch-tracking software, allowing the vehicle to detect and classify calls from four species of baleen whales: sei, fin, humpback and right whales.

Canada. Department of Fisheries and Oceans. (2017). *Action plan for blue, fin, sei and North Pacific right whales (Balaenoptera musculus, B. physalus, B. borealis, and Eubalaena japonica) in Canadian Pacific waters*. Ottawa, ON. Retrieved from https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/action-plans/various-species-whales-pacific-waters.html

This action plan addresses the entire set of populations of Blue, Fin, Sei and North Pacific Right Whales (Balaenoptera musculus, B. physalus, B. borealis, and Eubalaena japonica) in Canadian Pacific waters. It identifies recovery measures to implement the broad goals and objectives outlined in the Recovery Strategy for Blue, Fin and Sei Whales in Pacific Canadian Waters (Gregr et al. 2006),

and the Recovery Strategy for North Pacific Right Whales (DFO 2011). All four species are being considered together because of their similar geographic distribution, common threats to survival, and the efficiency of integrating activities and resources required for recovery.

Clapham, P. (2016). Managing Leviathan: Conservation Challenges for the Great Whales in a Post-Whaling World. *Oceanography, 29*(3). https://doi.org/10.5670/oceanog.2016.70

Perhaps no group of animals has come to better symbolize human misuse of the global environment than the great whales. Whaling killed almost three million whales in the twentieth century alone, with some populations estimated to have been reduced by 99% of their pristine abundance. Attempts to promote regulated, sustainable whaling by international agreement, notably through the International Convention for the Regulation of Whaling (1946), were almost immediately derailed by over-capitalization and profit-based self-interest. The major whaling nations used uncertainties in abundance estimates to ignore increasing evidence of population declines, and consistently exploited procedural flaws in the Convention to obstruct either the passage of rules designed to enact conservation measures or proposals for independent inspection of the industry. This major failure of regulatory efforts was exacerbated by secret, large-scale illegal whaling by the former Soviet Union and Japan that remained undisclosed for decades. Today, the status of the great whales varies widely: some species or populations are recovering strongly from exploitation, while a few others remain critically endangered. Although some whaling continues, the scale is greatly reduced from that of the twentieth century, and in this largely post-whaling world, other threats to whales are more significant. These include well-documented problems such as ship strikes and entanglement in fishing gear, as well as issues for which population-level impacts are unclear (ocean noise) or largely unknown. The removal of so many whales by whaling likely significantly impacted the ecosystems in which they played a major role as consumers and, through their transport and recycling of nutrients, enhanced primary productivity. As populations recover, the effect of their reintegration into the marine environment represents a fascinating issue in ecosystem dynamics. Overall (and with some notable exceptions), whale populations will likely continue to recover; however, this generally optimistic outlook is clouded by the potential for large-scale oceanic ecosystem changes precipitated by global warming.

Hakamada, T., & Matsuoka, K. (2016). The number of western North Pacific common minke, Bryde's and sei whales distributed in JARPNII Offshore survey area. Paper presented at the JARPNII special permit expert panel review workshop, Tokyo. IWC. Retrieved from https://www.icrwhale.org/pdf/SC-F16-JR12.pdf

In order to examine the impact of large whales, such as common minke (Balaenoptera acutorostrata), Bryde's (Balaenoptera edeni) and sei whales (Balaenoptera borealis) on Japanese fisheries through estimating the amount of prey consumed by these whales or using ecosystem models, it was required to estimate the number of these whales in the JARPNII survey area (east of Japanese coast, west of 170oE, north of 35oN, south of Russian and US EEZ). Considering the migration pattern of these whales in the area suggested by previous analysis, the number of the whales needed to be estimated separately for the early and late seasons for each of the whale species. The estimates were 3,629 (in 2009) and 2,122 (in 2011 and 2012) in the early and 3,080 (in 2008) in the late season for the common minke assuming g(0) = 0.789, 2,957 (in 2009) and 1,851 (in 2011 and 2012) in the early and 13,306 (in 2008) in the late season for the Bryde's whales, 4,734 (in 2009) and 2,988 (in 2011 and 2012) in the early and 5,086 (in 2008) in the late season for the sei whales, assuming g(0)=1. It is important to note that these estimates should not

be used for assessment because the estimated figures represent only a part of the population considered.

International Whaling Commission (2015). Report of the Scientific Committee, Annex G. Report of the Sub-Committee on In-Depth Assessments. *J. Cetacean Res. Manage., 16 suppl.*, 176-195. Retrieved from https://archive.iwc.int/?r=5047&k=cbc1e0262d

Annex G of the Report of the Scientific Committee; Report of the Sub-Committee on In-Depth Assessments. Covers an in-depth assessment on North Pacific sei whales.

Isoda, T., Konishi, K., Yamaguchi, F., Kawabe, S., Moriyama, R., & Kasai, H., Igarashi, Y., Mogoe, M. and Matsuoka, K. (2017). *Results of the NEWREP-A dedicated sighting survey during the 2016/17 austral summer season.* Retrieved from https://www.icrwhale.org/pdf/SC-67a-ASI7.pdf

The results of the 2016/17 NEWREP-A dedicated whale sighting survey in Antarctic Area V (south of 60°S) are reported. Two dedicated sighting vessels (SVs) were engaged and successfully conducted the survey for 33 days, from 13 December 2016 to 14 January 2017 in the western sector of Areas V (130°E - 165°E), under two survey modes (Normal Passing mode NSP and Independent Observer mode IO), and based on IWC/IDCR-SOWER survey procedures. The total searching distance in the research area was 2,937.1n.miles (5439.5km), including 1,542.0n.miles covered in NSP and 1,395.1n.miles in IO mode. The survey coverage was 77% in the northern stratum and 91% in the southern stratum. Five baleen whale species, i.e. blue (11 schools/13 individuals), fin (21/67), Antarctic minke (115/223), southern right (1/1 humpback (253/516) and at least three toothed whale species (sperm (30/30), southern bottlenose (4/8), killer (4/26)), were sighted in the research area. Antarctic minke whales were mainly encountered in the northern and southern stratum of the western part of the research area. Humpback whales were the most frequently sighted large whale species, and were widely distributed longitudinally throughout the research area. Blue whales were found mainly in the western part of the research area. Estimated Angle and Distance Experiments were completed as in previous years. Routine photo-ID and biopsy sampling on large whales were also conducted, and a total of 20 photos (9 blue, 1 southern right and 10 humpback whales), were obtained. A total of 10 biopsy (skin and blubber) samples were also collected from 2 blue, 1 southern right and 7 humpback whales using the Larsen system. A total of eight marine debris were observed. The sighting data were validated and already submitted to the IWC secretariat. During this survey, feasibility studies on telemetry and biopsy sampling of Antarctic minke whales were continued, and the results are presented in this paper. Krill and oceanographic surveys were also conducted along the tracklines designed for sighting, and results are reported by Wada et al. (2017).

Ivashchenko, Y., Clapham, P. J., & Brownell Jr., R. L. (2013). Soviet catches of whales in the North Pacific: revised totals. *Journal of Cetacean Research and Management, 13*(1), 59-71. Retrieved from https://archive.iwc.int/?r=1469&k=84bc14c818

The USSR conducted a global campaign of illegal whaling beginning in 1948. Catch records for Soviet pelagic operations in the Southern Hemisphere (and the northern Indian Ocean) have been largely corrected, but major gaps have remained for the North Pacific. Here, using newly discovered whaling industry reports, corrected figures for Soviet catches in this ocean are provided. During the period 1948–79, a minimum of 190,183 whales were killed by the USSR in the North Pacific

(195,783 if one includes an estimate for sperm whales taken in years for which there are no true data); of these, only 169,638 were reported to the IWC, a difference of 20,568 whales (26,168 including the sperm whale estimate). Figures were falsified for 8 of 12 hunted species, with some catches over-reported to camouflage takes of illegal species. Revised catch totals (caught vs. reported) are as follows: blue whale – 1,621 vs. 858; fin whale – 14,167 vs. 15,445; humpback whale – 7,334 vs. 4,680; sperm whale – 153,686 vs. 132,505; sei whale – 7,698 vs. 11,363; North Pacific right whale – 681 vs. 11; bowhead whale – 145 vs. 0; gray whale – 172 vs. 24. Bryde's, minke, killer and Baird's beaked whale catches were reported correctly. Of all the hunted species, sperm and North Pacific right whales were the most heavily impacted. Major falsifications for sperm whales involved figures for both total catch and sex ratio.

Madin, K. (Spring 2017). Eavesdropping on Whales off New York City. *Oceanus, 52,* 14-15. Retrieved from https://www.whoi.edu/oceanus/feature/eavesdropping-on-whales

New Yorkers have been surprised to learn that a wide variety of whales are swimming in their watery backyard, cruising New York Harbor sometimes within sight of the Statue of Liberty. Sounds from humpback, fin, sei, and endangered North Atlantic right whales have been detected in New York waters by an ocean mooring developed at Woods Hole Oceanographic Institution. The instrument relays the signals via satellite in near real time to scientists and citizens. Signals have come in nearly every day since the buoy was deployed in 2016. WHOI biologist Mark Baumgartner teamed up with New York's Wildlife Conservation Society to deploy a digital acoustic monitoring instrument, or "DMON," about 22 miles off Fire Island near busy shipping lanes entering and leaving New York Harbor. The DMON sits in a weighted frame at the bottom of the ocean.

Martin, B., Kowarski, K., Mouy, X., Moors-Murphy, H. (2014). Recording and Identification of Marine Mammal Vocalizations on the Scotian Shelf and Slope, presented at Oceans 2014, St. John's, Newfoundland and Labrador. IEEE. https://doi.org/10.1109/OCEANS.2014.7003212

In October 2012, Fisheries and Oceans Canada began collection of two years of near-continuous autonomous acoustic recordings in the Gully Marine Protected Area and adjacent slope areas between the Gully and Shortland canyon, and between Shortland and Haldimand canyons south of Nova Scotia, Canada. Data were sampled at 16 ksps for 13 min alternating with either 128 ksps or 375 ksps for 2 min to overlap the full bandwidth of marine mammal vocalizations likely to be present in the area. Each recorder produced similar to 3.5TB (similar to 286 days) of acoustic data per year, for a full data set of similar to 20TB. To efficiently analyze this data, species-specific automated detectors were developed. We created a set of 'ground truth' data by manually annotating an average of 1000 calls for each species of interest, which included calls from 1 to 6 geographic environments (recording locations). For each species, the entire dataset was split in three equal independent subsets. Two of these subsets were used at a time to determine the optimal parameters of the detectors by quantifying their performance using the precision and recall metric. Thus far, six species detectors have been developed and evaluated for the detection of marine mammals on the Scotian shelf and slope: northern bottlenose, right, blue, fin, sei, and humpback whales. We present an overview of the detectors, the methods used to test and refine the detectors, the precision and recall of each detector as a function of signal-to-noise ratio, and an overview of cetacean vocalization presence in 2013 on the Shortland-Haldimand station.

Matsuoka, K., James W. Gilpatrick, J., Kim, J. H., & Yoshimura, I. (2016). *Cruise report of the 2016 IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER)*. Retrieved from https://iwc.int/power

IWC-POWER cruises in the North Pacific follow the series of IWC/IDCR-SOWER (Southern Ocean Whale and Ecosystem Research) cruises that were conducted in the Antarctic since 1978. The 7th annual IWC-POWER cruisewas successfully conducted between 02 July to 30 August, 2016 in the central North Pacific (with the dedicated research area located between 20°N-30°N Latitude and between 135°W - 160°W Longitude). Areas of the US EEZ were included within this research area. The survey was conducted aboard the Japanese R/V Yushin-Maru No.3. The cruise was organized as a joint project between the IWC and Japan. The cruise plan was endorsed at the 66a IWC/Scientific Committee (IWC/SC) meeting. Researchers from Japan, the US and Republic of Korea participated in the survey. The cruise had five main objectives: (a) provide information for the proposed future in-depth assessment of sei whales in terms of both abundance and stock structure; (b) provide information relevant to the Implementation Reviews of whales in terms of both abundance and stock structure (e.g. Bryde's whales); (c) provide baseline information on distribution and abundance for an area of the North Pacific not recently and systematically surveyed for several large whale species/populations, including those that were known to have been depleted in the past, but whose status is unclear; (d) provide biopsy samples and photo-identification data to contribute to discussions of stock structure for several large whale species/populations, including those that were known to have been depleted in the past but whose status is unclear, and; (e) provide essential information for the intersessional workshop to plan for a medium to long term international programme in the North Pacific. At the pre-cruise meeting, the Captain and crew of the vessel and international researchers agreed on the procedures and objectives of the survey. The survey was conducted using methods based on the guidelines of the IWC/SC. The predetermined transect lines were completed within the anticipated time schedule. Survey track line coverage was 97.2% within the designated survey area and a total of 2,237.5 n.miles was surveyed in the Passing with abeam closing mode (NSP) and the Independent Observer passing mode (IO). Additionally, 626.2 and 580.1 n.miles were surveyed during transit to and from the research area respectively. Sightings of: Blue (1 school / 1 individual), sei (1/1), Bryde's (28/32), sperm (32/125), Cuvier's beaked (2/5), Mesoplodon spp. (2/3), Ziphiidae (7/11), short finned pilot (2/31), pygmy killer (1/16) whales; Risso's (2/19), bottlenose (1/37), common (8/217), striped (5/378) and spotted (1/133) dolphins were observed during the cruise. Bryde's and sperm whales were the most frequently sighted large whale species. The Estimated Angle and Distance Training Exercises and Experiments were completed with improvements following SC suggestions. Photoidentification data for 12 Bryde's whales, 2 sperm whales were collected. A total of 23 biopsy (skin and blubber) samples was collected from 1 blue, 1 sei, 16 Bryde's whales and 5 sperm whales using the Larsen biopsy rifle/darts system. In the case of Bryde's whale, 3 samples (individuals) were collected from Sub-area 1 (west of 180°E) and 13 samples from Sub-area 2 (east of 180°E). These biopsy samples will enable genetic studies on stock structure to be conducted in contribution to the North Pacific Bryde's whale Implementation Review to be held at the 2017 SC meeting. A total of 153 objects of marine debris were observed. All survey procedures were in accordance with the guidelines set forth and agreed upon by the SC. The 7th annual cruise of the IWC-POWER programme was completed and provided important information on cetacean distribution in an area where no survey had been conducted in recent decades. These results will contribute to the aforementioned objectives of the IWC/SC.

Murase, H., Hakamada, T., Sasaki, H., Matsuoka, K., & Kitakado, T. (2016). *Seasonal spatial distributions of common minke, sei and Bryde's whales in the JARPNII survey area from 2002 to 2013*. Paper presented at the JARPNII special permit expert panel review workshop, Tokyo. IWC. Retrieved from https://www.icrwhale.org/pdf/SC-F16-JR7.pdf

Seasonal spatial distributions of common minke, sei and Bryde's whales in the JARPNII survey area from 2002 to 2013 were estimated by using generalized additive models (GAM). All species shifted their distribution area toward the north of the survey area as season progress but the extents were different among species. Relative abundance of common minke whales was high in coastal area of Japan. Relative abundance of sei whales was high in the offshore area of the survey area where SST was moderate within the area. Relative abundance of Bryde's whales was high in the southern part of the survey area where SST was high. The results suggested that spatial distributions of three baleen whale species were segregated in the JARPNII survey area although some overlaps were occurred. Extent of direct competition (e.g. competitive exclusion of feeding area) could be minimal among the species but indirect competition for prey might be occurs as they share same prey species.

Nøttestad, L., Krafft, B. A., Søiland, H., & Skaret, G. (2014). Observations of cetaceans in the south-east Atlantic sector of the Southern Ocean, during summer 2008. *Polar Biology, 37*(6), 891-895. https://doi.org/10.1007/s00300-014-1477-y

Knowledge of cetacean species composition and their distribution in the south-east Atlantic sector of the Southern Ocean is scarce. During a survey in February–March 2008, systematic whale sightings were carried out along transect lines following the 5° and 15° E meridians between 35° and 67° S. In total, 67 toothed whales and 126 baleen whales were observed. Both fin whales (four animals) and Antarctic minke whales Balaenoptera bonaerenses (three animals) in addition to 16 individuals of unidentified species were among the observed baleen whales. The dominating baleen whale species in our study was humpback whales Megaptera novaeangliae with 108 individuals observed. They occurred single or in groups up to seven individuals (N mean = 2.5 ind) and eight of the counts were of calves. The relationship between humpback whale occurrence and environmental variables including Antarctic krill (Euphausia superba) abundance from acoustic recordings, hydrography, bathymetry and production was tested using general additive models. Only temperature increased the predictive power of the model with whale occurrence increasing with the decreasing temperature in more southern areas.

Weir, C., Sei, W., Conservation, F., Villas, J., & Islands, F. (2017). Developing a site for sei whales Balaenoptera borealis at Berkeley Sound, Falkland Islands. *Falklands Conservation*. Retrieved from http://www.falklandsconservation.com/projects/sei-whale-project

Falklands Conservation received funding from the EU BEST 2.0 Small Grants fund to conduct a pilot study of endangered sei whales at one coastal site, the Berkeley Sound candidate Key Biodiversity Area (cKBA), in the Falkland Islands during 2017. The objectives of the work were: (1) to increase knowledge of sei whales through field research; (2) to raise awareness of sei whales in the Falkland Islands among the public, relevant stakeholders and decision-makers; and (3) to provide management recommendations with regard to mitigating any potential impacts on whales from human activities in Berkeley Sound. The site choice was of particular relevance in a conservation and management context because Berkeley Sound is located close to Stanley and comprises one of the busiest shipping areas in the Falkland Islands. It is also the proposed location for a mooring

facility for carrying out inshore oil transshipments between tankers, and is the only area in the Falklands where commercial whale-watching currently occurs. All of the sei whale fieldwork was led by the Falklands Conservation Sei Whale Project Officer and was carried out under a Research Licence (No. R23/2016) granted by the Environmental Planning Department (EPD) of the Falkland Islands Government. Three different survey platforms were used for collecting sei whale data during the fieldwork: shore, aerial and small boat surveys.

Section IV: Threats

Baulch, S., & Perry, C. (2014). Evaluating the impacts of marine debris on cetaceans. *Mar Pollut Bull, 80*(1), 210-221. https://doi.org/10.1016/j.marpolbul.2013.12.050

Global in its distribution and pervading all levels of the water column, marine debris poses a serious threat to marine habitats and wildlife. For cetaceans, ingestion or entanglement in debris can cause chronic and acute injuries and increase pollutant loads, resulting in morbidity and mortality. However, knowledge of the severity of effects lags behind that for other species groups. This literature review examines the impacts of marine debris on cetaceans reported to date. It finds that ingestion of debris has been documented in 48 (56% of) cetacean species, with rates of ingestion as high as 31% in some populations. Debris-induced mortality rates of 0–22% of stranded animals were documented, suggesting that debris could be a significant conservation threat to some populations. We identify key data that need to be collected and published to improve understanding of the threat that marine debris poses to cetaceans.

Canada. Department of Fisheries and Oceans. (2017). Assessing the risk of ship strikes to humpback (Megaptera novaeangliae) and fin (Balaenoptera physalus) whales off the west coast of Vancouver Island, Canada. Science Advisory Report 2017/038. Ottawa, ON. Retrieved from http://waves-vagues.dfo-mpo.gc.ca/Library/40619709.pdf

Vessel collisions with whales have been identified as a key threat to the recovery of humpback whales (Megaptera novaeangliae), fin whales (Balaenoptera physalus), blue whales (Balaenoptera musculus), North Pacific right whales (Eubalaena japonica), and sei whales (Balaenoptera borealis) in British Columbia. These species are listed under the Species-at-Risk Act (SARA) as 'Special Concern' (humpback), 'Threatened' (fin and sei) or 'Endangered', (blue and right). DFO SARA Program requested that DFO Science provide advice regarding methods to assess the threat from ship strikes and to provide estimates of the risk of mortality to large baleen whales off the west coast of Vancouver Island. Results of the assessment and advice will assist both the SARA program and the Fisheries Protection Program when considering potential impacts to species and habitats arising from projected increases in shipping traffic, and will provide information for consideration in the development and management of a protected areas network.

Cassoff, R. M., Moore, K. M., McLellan, W. A., Barco, S. G., Rotstein, D. S., & Moore, M. J. (2011). Lethal entanglement in baleen whales. *Diseases of Aquatic Organisms, 96*(3), 175-185. https://doi.org/10.3354/dao02385

Understanding the scenarios whereby fishing gear entanglement of large whales induces mortality is important for the development of mitigation strategies. Here we present a series of 21 cases

involving 4 species of baleen whales in the NW Atlantic, describing the available sighting history, necropsy observations, and subsequent data analyses that enabled the compilation of the manners in which entanglement can be lethal. The single acute cause of entanglement mortality identified was drowning from entanglement involving multiple body parts, with the animal's inability to surface. More protracted causes of death included impaired foraging during entanglement, resulting in starvation after many months; systemic infection arising from open, unresolved entanglement wounds; and hemorrhage or debilitation due to severe gear-related damage to tissues. Serious gear-induced injury can include laceration of large vessels, occlusion of the nares, embedding of line in growing bone, and massive periosteal proliferation of new bone in an attempt to wall off constricting, encircling lines. These data show that baleen whale entanglement is not only a major issue for the conservation of some baleen whale populations, but is also a major concern for the welfare of each affected individual.

Endo, T., Hotta, Y., Hisamichi, Y., Kimura, O., Sato, R., Haraguchi, K., Baker, C. S. (2012). Stable isotope ratios and mercury levels in red meat products from baleen whales sold in Japanese markets. *Ecotoxicology and Environmental Safety, 79*, 35-41. https://doi.org/10.1016/j.ecoenv.2012.01.020

We analyzed the δ13C, δ15N and δ18O values and Hg concentration in red meat products originating from the predominant types sold in Japan for human consumption: two populations of common minke (J- and O-types), Bryde's and sei whales in the western North Pacific Ocean, and fin and Antarctic minke whales in the Southern Ocean. The order of the trophic positions, evaluated by δ15N values and Hg concentrations, coincided with their known feeding habits: common minke (J-type)=common minke (O-type)>Bryde's≥sei≥Antarctic minke≥fin. The Hg concentrations in the combined samples from the six samples were significantly correlated with their δ15N values (γ=0.455, n=66, $p<0.05$), reflecting overall differences in the trophic level. This correlation was not significant for within-species comparison for the common minke (J- and O-types) or the Bryde's whale, probably reflecting the higher δ15N value and lower Hg concentration in the North Pacific Ocean around Japan. Determination of δ13C, δ15N and δ18O could be used to discriminate between the red meat products originating from the whale species in the North Pacific and Southern Oceans. However, the four whale species or populations in the Pacific Ocean could not be discriminated on basis of these values, nor could the two species in the Southern Ocean. Positive correlations between the δ13C and δ15N values and negative correlations between the δ15N and δ18O values and the δ13C and δ18O values, probably reflecting migration patterns, were found in some whale species in the North Pacific and Southern Oceans.

Evans, S., Briz i Godino, I., Álvarez, M., Rowsell, K., Collier, P., de Goodall, R. N. P., Speller, C. (2016). Using combined biomolecular methods to explore whale exploitation and social aggregation in hunter–gatherer–fisher society in Tierra del Fuego. *Journal of Archaeological Science: Reports, 6*, 757-767. https://doi.org/10.1016/j.jasrep.2015.10.025

Cetaceans were an important food and raw material resource for the South American hunter–gatherer–fisher (HGF) communities of Tierra del Fuego. Historic ethnographic evidence suggests that relatively mobile HGF groups came together in large numbers to exploit carcasses from individual cetacean stranding events. Substantial accumulations of whale bones within shell middens in the Lanashuaia locality of the Beagle Channel suggests that these social aggregation events may also have occurred in pre-historic periods. The difficulty in assigning taxonomic identifications to the fragmentary whale remains, however, made it difficult to explicitly test this

hypothesis. Here, we applied two different biomolecular techniques, collagen peptide mass fingerprinting (ZooMS) and ancient mitochondrial DNA analysis to 42 archeological bone fragments from the Lanashuaia locality to provide accurate species identifications. There was a clear correspondence between ZooMS and DNA results, identifying five different cetacean species (Southern bottlenose, blue, humpback, right, and sei whale) as well as human and sea lion remains. The biomolecular results were not conclusively consistent with HGF social aggregation, revealing an unexpectedly diverse range of cetaceans within the Lanashuaia middens. However, the results could not fully refute the hypothesis that cetacean remains can be used as anthropic markers of aggregation events, as the observed species and haplotypes revealed potential shared exploitation of some whale resources between midden sites.

Häussermann, V., Gutstein, C. S., Bedington, M., Cassis, D., Olavarria, C., Dale, A. C., Valenzuela-Toro, A. M., . . . Försterra, G. (2017). Largest baleen whale mass mortality during strong El Niño event is likely related to harmful toxic algal bloom. *PeerJ* 5: e3123. Retrieved from https://doi.org/10.7717/peerj.3123

While large mass mortality events (MMEs) are well known for toothed whales, they have been rare in baleen whales due to their less gregarious behavior. Although in most cases the cause of mortality has not been conclusively identified, some baleen whale mortality events have been linked to bio-oceanographic conditions, such as harmful algal blooms (HABs). In Southern Chile, HABs can be triggered by the ocean–atmosphere phenomenon El Niño. The frequency of the strongest El Niño events is increasing due to climate change. In March 2015, by far the largest reported mass mortality of baleen whales took place in a gulf in Southern Chile. Here, we show that the synchronous death of at least 343, primarily sei whales can be attributed to HABs during a building El Niño. Although considered an oceanic species, the sei whales died while feeding near to shore in previously unknown large aggregations. This provides evidence of new feeding grounds for the species. The combination of older and newer remains of whales in the same area indicate that MMEs have occurred more than once in recent years. Large HABs and reports of marine mammal MMEs along the Northeast Pacific coast may indicate similar processes in both hemispheres. Increasing MMEs through HABs may become a serious concern in the conservation of endangered whale species.

Hernández-Mora, G., Palacios-Alfaro, J. D., & González-Barrientos, R. (2013). Wild reservoirs of brucellosis: Brucella in aquatic environments. *Rev. Sci. Tech. Off. Int. Epizoot., 32*, 89-103. http://dx.doi.org/10.20506/rst.32.1.2194

Neurobrucellosis and osteomyelitis are common pathologies of humans and cetaceans infected with Brucella ceti or B. pinnipedialis. Currently, 53 species of marine mammal are known to show seropositivity for brucellae, and B. ceti or B. pinnipedialis have been isolated or identified in polymerase chain reaction assays in 18 of these species. Brucellae have also been isolated from fish and identified in lungworm parasites of pinnipeds and cetaceans. Despite these circumstances, there are no local or global requirements for monitoring brucellosis in marine mammals handled for multiple purposes such as capture, therapy, rehabilitation, investigation, slaughter or consumption. Since brucellosis is a zoonosis and may be a source of infection to other animals, international standards for Brucella in potentially infected marine mammals are necessary.

Hofman, R. J. (2016). Sealing, whaling and krill fishing in the Southern Ocean: past and possible future effects on catch regulations. *Polar Record, 53*(1), 88-99. https://doi.org/10.1017/S0032247416000644

This paper (1) reviews the history of sealing and whaling in the Southern Ocean to illustrate how market demands combined with no or ineffective regulation of catches led to the overexploitation and near extinction of southern fur seals, southern elephant seals and all but one of the Southern Ocean populations of large whales; (2) indicates how the overexploitation and depletion of krill-eating whales led to the Krill Surplus Hypothesis, and the development of the Antarctic krill fishery and the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR); (3) points out how misinterpretation of the reference to 'rational use' in CCAMLR Article II(2), combined with consensus decision-making and the potential growth of markets for Antarctic krill, could lead to ineffective regulation of the krill fishery and adverse effects on the krill resource, on recovery of depleted populations of krill-dependent whales, and on other ecologically related species and populations; and (4) identifies reasonable actions that could be taken cooperatively by the International Whaling Commission and the CCAMLR Commission to minimise the risk that the krill fishery will prevent or impede recovery of depleted populations of krill-dependent whales.

Government of Japan (2017). *Research Plan for New Scientific Whale Research Program in the western North Pacific (NEWREP-NP)*. Retrieved from https://www.icrwhale.org/pdf/170606newrep-np.pdf

This document presents the research plan for the New Scientific Whale Research Program in the western North Pacific (NEWREP-NP), which takes into consideration the comments made by the Expert Panel Workshop held from 30 January to 3 February 2017 and by the International Whaling Commission's Scientific Committee (IWC SC) 2017 annual meeting, in conformity with paragraph 30 of the Schedule to the International Convention for the Regulation of Whaling (ICRW) and Annex P (IWC, 2013a; 2016a). This research plan forms the basis for the Government of Japan to issue a special permit, in accordance with Article VIII, paragraph 1 of the ICRW. In the process of drafting and developing this research plan, Japan also take account of the reasoning and conclusions of the Judgment of the International Court of Justice (ICJ) in the case concerning Whaling in the Antarctic (Australia v. Japan: New Zealand intervening) (for further details, see Annex 1).

Liu, M., Lin, M., Turvey, S. T., & Li, S. (2016). Fishers' knowledge as an information source to investigate bycatch of marine mammals in the South China Sea. *Animal Conservation, 20*(2), 182-192. https://doi.org/10.1111/acv.12304

Bycatch mortality is a significant driver of marine mammal population declines. However, there is little information available on patterns or magnitude of bycatch mortality in many heavily fished Asian marine systems such as the South China Sea (SCS). To address this limited knowledge base, we conducted interviews with fishers to gather local ecological knowledge on marine mammal bycatch around Hainan Island, China. Gillnets were the primary fishing gear used in local fisheries, and were also responsible for the majority of reported marine mammal bycatch events in recent decades. Bycatch events were reported from all seasons but were most frequent in spring (38.4%), which might relate to seasonal variation in fishing activities. The spatial pattern of relative bycatch densities for Indo-Pacific humpback dolphins, Indo-Pacific finless porpoises and unidentified small dolphins varied around Hainan and neighbouring waters. A substantial proportion of informants (36.1 and 9.2% respectively) reported that they have eaten or sold marine mammal meat,

demonstrating the continued existence of cultural practices of consuming marine mammals on Hainan. Responses of fishers to bycatch events were dependent both on their existing attitudes and perceptions towards marine mammals and on other sociocultural factors. Almost half of informants agreed that marine mammal populations in the SCS have decreased. Declines were thought by informants to have been caused by overfishing, water pollution and vessel collisions, with bycatch responsible for further declines in dolphins.

Liu, M., Lin, M., Zhang, P., Xue, T., & Li, S. (2018). An overview of cetacean stranding around Hainan Island in the South China Sea, 1978–2016: Implications for research, conservation and management. *Marine Policy*. https://doi.org/10.1016/j.marpol.2018.04.029

The South China Sea (SCS) is known to support diverse cetacean species, yet their stranding information has not been well documented. To fill this knowledge gap, available records on cetacean stranding around Hainan Island in the SCS from 1978 to 2016 were collected and overviewed. In total, 112 records were obtained. Among them, 19 records involved 19 baleen whales (5 mysticeti species) and 93 records involved 134 toothed whales (12 odontoceti species). More stranding events occurred in the waters along the east coast than in the waters along the west coast, which was especially true for toothed whales stranding events. This may reflect the distribution patterns of cetaceans around Hainan Island. The spatial distribution of stranding events might be driven by different oceanographic features between the east and west offshore waters of the Hainan Island. The number of stranding events increased gradually from 1978 to 2000 and more rapidly from 2000 to 2016, which is likely due to both increasing public attentions and increasing anthropogenic activities within the SCS in recent decades. Stranding events were recorded throughout the year but peaked in spring ($p = 0.016$). In sum, cetacean stranding events occurred rather frequently around Hainan Island. The establishment of a regional stranding network in the SCS is conducive for further research, conservation and management of cetaceans in this region. More scientific data about the survival status of cetaceans and threats to them in the SCS are also needed.

Ohishi, K., Bando, T., Abe, E., Kawai, Y., Fujise, Y., & Maruyama, T. (2016). Long-term and large-scale epidemiology of Brucella infection in baleen whales and sperm whales in the western North Pacific and Antarctic Oceans. *Journal of Veterinary Medical Science, 78*(9), 1457-1464. https://doi.org/10.1292/jvms.16-0076

In a long-term, large-scale serologic study in the western North Pacific Ocean, anti-Brucella antibodies were detected in common minke whales (Balaenoptera acutorostrata) in the 1994-2010 offshore surveys (21%, 285/1353) and in the 2006-2010 Japanese coastal surveys (20%, 86/436), in Bryde's whales (B. edeni brydei) in the 2000-2010 offshore surveys (9%, 49/542), in sei whales (B. borealis) in the 2002-2010 offshore surveys (5%, 40/788) and in sperm whales (Physeter macrocephalus) in the 2000-2010 offshore surveys (8%, 4/50). Anti-Brucella antibodies were not detected in 739 Antarctic minke whales (B. bonaerensis) in the 2000-2010 Antarctic surveys. This suggests that Brucella was present in the four large whale populations inhabiting the western North Pacific, but not in the Antarctic minke whale population. By PCR targeting for genes of outer membrane protein 2, the Brucella infection was confirmed in tissue DNA samples from Bryde's whales (14%, 2/14), sei whales (11%, 1/9) and sperm whales (50%, 2/4). A placental tissue and an apparently healthy fetus from a sperm whale were found to be PCR-positive, indicating that placental transmission might have occurred and the newborn could act as a bacterial reservoir. Marked granulomatous testes were observed only in mature animals of the three species of baleen

whales in the western North Pacific offshore surveys, especially in common minke whales, and 29% (307/1064) of total mature males had abnormal testes. This study provides an insight into the status of marine Brucella infection at a global level.

Simmonds, M. P. (2012). Cetaceans and Marine Debris: The Great Unknown. *Journal of Marine Biology, 2012*, 8. http://dx.doi.org/10.1155/2012/684279

Plastics and other marine debris have been found in the gastrointestinal tracts of cetaceans, including instances where large quantities of material have been found that are likely to cause impairment to digestive processes and other examples, where other morbidity and even death have resulted. In some instances, debris may have been ingested as a result of the stranding process and, in others, it may have been ingested when feeding. Those species that are suction or “ram” feeders may be most at risk. There is also evidence of entanglement of cetaceans in marine debris. However, it is usually difficult to distinguish entanglement in active fishing gear from that in lost or discarded gear. The overall significance of the threat from ingested plastics and other debris remains unclear for any population or species of cetaceans, although there are concerns for some taxa, including at the population level, and marine debris in the oceans continues to grow. Further research including the compilation of unpublished material and the investigation of important habitat areas is strongly recommended.

Surma, S., Pakhomov, E. A., & Pitcher, T. J. (2014). Effects of whaling on the structure of the Southern Ocean food web: insights on the "krill surplus" from ecosystem modelling. *Plos One, 9*(12), e114978. https://doi.org/10.1371/journal.pone.0114978

The aim of this study was to examine the ecological plausibility of the "krill surplus" hypothesis and the effects of whaling on the Southern Ocean food web using mass-balance ecosystem modelling. The depletion trajectory and unexploited biomass of each rorqual population in the Antarctic was reconstructed using yearly catch records and a set of species-specific surplus production models. The resulting estimates of the unexploited biomass of Antarctic rorquals were used to construct an Ecopath model of the Southern Ocean food web existing in 1900. The rorqual depletion trajectory was then used in an Ecosim scenario to drive rorqual biomasses and examine the "krill surplus" phenomenon and whaling effects on the food web in the years 1900-2008. An additional suite of Ecosim scenarios reflecting several hypothetical trends in Southern Ocean primary productivity were employed to examine the effect of bottom-up forcing on the documented krill biomass trend. The output of the Ecosim scenarios indicated that while the "krill surplus" hypothesis is a plausible explanation of the biomass trends observed in some penguin and pinniped species in the mid-20th century, the excess krill biomass was most likely eliminated by a rapid decline in primary productivity in the years 1975-1995. Our findings suggest that changes in physical conditions in the Southern Ocean during this time period could have eliminated the ecological effects of rorqual depletion, although the mechanism responsible is currently unknown. Furthermore, a decline in iron bioavailability due to rorqual depletion may have contributed to the rapid decline in overall Southern Ocean productivity during the last quarter of the 20th century. The results of this study underscore the need for further research on historical changes in the roles of top-down and bottom-up forcing in structuring the Southern Ocean food web.

Themelis, D., Harris, L., & Hayman, T. (2016). *Preliminary analysis of human-induced injury and mortality to cetaceans in Atlantic Canada*. Fisheries and Oceans Canada: CSAS, Dartmouth, NS (Canada). Retrieved from http://waves-vagues.dfo-mpo.gc.ca/Library/40575287.pdf

Information on human-induced injuries to cetaceans occurring in Atlantic Canada is required to evaluate the effectiveness of recovery strategies for species at risk and to support management decisions on mitigation measures to reduce risk of entanglement of cetacean species from commercial fisheries. Fisheries and Oceans Canada (DFO) undertook an analysis of available data to calculate the average annual rate of human-caused serious injury and mortality of marine mammals (excluding pinnipeds) in Atlantic Canada over the period of 2008 to 2014. Observed incidents of injured and dead cetaceans were compiled from opportunistic sightings of marine mammal strandings and human interactions reported to marine mammal response networks, entanglements recorded by at-sea observers during commercial fishing, and mortalities reported from platforms of opportunity such as Transport Canada pollution patrols and PAL Surveillance flights for DFO Conservation and Protection Division. More than 800 incidents were reported by marine mammal response networks. Small odontocetes (Pygmy Sperm Whale, White-sided, Common, Risso's, Striped and White-beaked dolphins and Harbour Porpoise) were most commonly reported, followed by baleen whales (North Atlantic Right, Humpback, Minke, Fin, Sei, Blue, and Bowhead whales) and large odontocetes (Beluga, Northern Bottlenose, Sowerby's Beaked, Sperm, and Pilot whales). The animal was reported dead in 65% of all observed incidents and the cause of death was unknown for 80% of these mortalities. A third of all observed incidents were attributable to fishing operations or collisions with vessels. Entanglement in fishing gear was the most common type of incident reported for North Atlantic Right Whale and Humpback Whale and for approximately half of the incidents reported for Minke Whales and Harbour Porpoise. Identifiable gear types were pot and trap (crab or lobster trap), fixed traps (capelin, cod, mackerel, weir), and nets (seine, gillnet). The estimated annual injury rate for North Atlantic Right Whale exceeds the potential biological removal estimated for the population. Fisheries-specific bycatch of small odontocetes could be estimated from at-sea observations of fishing operations, but coverage is low and data were not available from all regions of Atlantic Canada. Standardizing data collection and reporting protocols, prioritizing the collection of detailed information and necropsies, and enhancing the existing national database would improve identifying the causes of human-induced mortality and implementation of mitigating strategies.

Van Der Hoop, J. M., Moore, M. J., Barco, S. G., Cole, T. V. N., Daoust, P.-Y., Henry, A. G., . . . Solow, A. R. (2012). Assessment of Management to Mitigate Anthropogenic Effects on Large Whales. *Conservation Biology, 27*(1), 121-133. https://doi.org/10.1111/j.1523-1739.2012.01934.x

United States and Canadian governments have responded to legal requirements to reduce human-induced whale mortality via vessel strikes and entanglement in fishing gear by implementing a suite of regulatory actions. We analyzed the spatial and temporal patterns of mortality of large whales in the Northwest Atlantic (23.5°N to 48.0°N), 1970 through 2009, in the context of management changes. We used a multinomial logistic model fitted by maximum likelihood to detect trends in cause-specific mortalities with time. We compared the number of human-caused mortalities with U.S. federally established levels of potential biological removal (i.e., species-specific sustainable human-caused mortality). From 1970 through 2009, 1762 mortalities (all known) and serious injuries (likely fatal) involved 8 species of large whales. We determined cause of death for 43% of all mortalities; of those, 67% (502) resulted from human interactions. Entanglement in fishing gear was the primary cause of death across all species (n = 323), followed by natural causes (n = 248) and vessel strikes (n = 171). Established sustainable levels of mortality were consistently

exceeded in 2 species by up to 650%. Probabilities of entanglement and vessel-strike mortality increased significantly from 1990 through 2009. There was no significant change in the local intensity of all or vessel-strike mortalities before and after 2003, the year after which numerous mitigation efforts were enacted. So far, regulatory efforts have not reduced the lethal effects of human activities to large whales on a population-range basis, although we do not exclude the possibility of success of targeted measures for specific local habitats that were not within the resolution of our analyses. It is unclear how shortfalls in management design or compliance relate to our findings. Analyses such as the one we conducted are crucial in critically evaluating wildlife-management decisions. The results of these analyses can provide managers with direction for modifying regulated measures and can be applied globally to mortality-driven conservation issues.

Yasunaga, G., & Fujise, Y. (2017). Temporal trend of total mercury levels in common minke, sei and Bryde s whales in the western North Pacific in the period 1994–2014. *Technical Reports of the Institute of Cetacean Research (TEREP-ICR)*, p58. Retrieved from https://www.icrwhale.org/pdf/TEREP00158-67.pdf

To examine yearly changes of total mercury (Hg) concentrations in common minke (Balaenoptera acutorostrata), sei (B. borealis) and Bryde's (B. edeni) whales in the western North Pacific, total Hg concentrations were measured in muscle samples from whales collected between 1994 and 2014 by JARPN/JARPNII. Averages and standard deviations of total Hg concentrations in the samples of mature male common minke whales from coastal area off Kushiro and Sanriku were 0.22±0.05, 0.22±0.06, ppm wet wt, and from offshore sub-areas 7, 8 and 9 were 0.22±0.05, 0.22±0.06 and 0.24±0.10 ppm, respectively. The concentration in sei whales from sub-area 9 was 0.044±0.013 ppm, and that in Bryde's whales from sub-areas 8 and 9 was 0.044±0.013 ppm. Multiple robust linear regression analysis was carried out considering several variables: sampling year, sampling location (longitude and latitude), sampling date, body length, blubber thickness and main prey item observed in their stomach. Results of the analyses can be summarized as follow: no significant yearly changes of total Hg concentrations in muscle of common minke whales off Kushiro, Sanriku and subarea 8; no significant yearly changes of total Hg concentrations in muscle of Bryde's whales in sub-areas 8 and 9; significant yearly changes of total Hg concentrations in muscle of minke whales from sub-areas 7 and 9, and significant yearly changes of total Hg concentrations in muscle of sei whales from sub-area 9. Temporal trends of total Hg concentrations have not been observed in environmental samples, lower trophic organisms and baleen whales, except for those cases mentioned above. Temporal changes in total Hg concentrations in common minke whales (sub-areas 7 and 9) and sei whales (sub-area 9) may reflect changes in their food habits rather than changes of background levels of total Hg in the marine environment. Consequently, it is concluded that the temporal trend of total Hg concentrations in the marine habitat of baleen whales in the western North Pacific remained stable in the research period.