Report of the 2016 Workshop to inform the DFO Five-year Research Plan for Atlantic Walruses in Canada

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REPORT OF THE 2016 WORKSHOP TO INFORM THE DFO FIVE-YEAR RESEARCH PLAN FOR ATLANTIC WALRUSES IN CANADA

by

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In April 2016, the Science Branches of Fisheries and Oceans, Central and Arctic Region and Quebec Region, hosted a two-day workshop to gather advice for the development of a 5-year research plan on Atlantic walrus (*Odobenus rosmarus rosmarus*) in Canada. The workshop brought together researchers and co-managers from across Canada, and from Greenland and Alaska. It began with short presentations on recent and ongoing walrus research in these jurisdictions. Smaller groups were then formed to discuss research needs in Canada related to walrus: Abundance, Population Biology, Management Science, Threats /Stressors, Distribution and Movements, and Ecosystems and Habitat. This report summarizes those discussions and proposes priority issues for future research.

Key words: Atlantic walrus, *Odobenus rosmarus rosmarus*, biology, stressors, population management, research planning, eastern Arctic Canada

RÉSUMÉ

Stewart, R.E.A., Stewart, D.B. and Higdon, J.W. 2017. Report of the 2016 workshop to inform the DFO five-year research plan for Atlantic walruses in Canada. Canadian Technical Report of Fisheries and Aquatic Sciences 3200: vi + 90.

En avril 2016, la Direction des sciences de Pêches et Océans Canada, la Région du Centre et de l'Arctique et la Région du Québec ont organisé un atelier de deux jours afin d'obtenir des conseils pour l'élaboration d'un plan quinquennal de recherche sur le morse de l'Atlantique (*Odobenus rosmarus rosmarus*) au Canada. L'atelier a réuni des chercheurs et des cogestionnaires de partout au Canada, ainsi que du Groenland et de l'Alaska. Il a commencé par de courtes présentations sur les recherches récentes et en cours sur le morse réalisées dans ces pays. De petits groupes ont ensuite été formés pour discuter des besoins en matière de recherche sur les morses au Canada : l'abondance, la biologie de la population, la science de la gestion, les menaces et les agents de stress, la répartition et les déplacements, et enfin les écosystèmes et l'habitat. Le présent rapport résume les discussions et propose des thèmes prioritaires pour les recherches futures.

Mots clés : morse de l'Atlantique, *Odobenus rosmarus rosmarus*, biologie, agents de stress, gestion de la population, planification de la recherche, est de l'Arctique canadien.

INTRODUCTION

Fisheries and Oceans Canada (DFO) does not currently have a dedicated walrus research program and has only a few staff members with experience in walrus research. DFO Central and Arctic and Quebec Regions, the two DFO regions with extant walrus populations, therefore convened a meeting to plan a walrus science research program that would deliver walrus management advice. The meeting, held in Winnipeg on 26 and 27 April 2016 brought together DFO and Fisheries Management sectors from across the country with co-management representatives from the Nunavut Wildlife Management Board (NWMB), Government of Nunavut (GN), Nunavik Marine Regional Wildlife Board (NMRWB), Qikiqtaluk Wildlife Board (QWB) and Regional Nunavimmi Umajulivijiit Katujaqatigininga (RNUK, also known as the Nunavik Hunting Fishing Trapping Association or NHFTA) and Makivik Corporation. Joining them were DFO scientists from the Central and Arctic, Newfoundland, Pacific, and Quebec Regions as well as invited experts from Alaska, Canada and Greenland (Appendix 1).

Sustainable management of walrus in Canada is part of DFO's mandate (Figure 1). Increasing national and international attention requires that DFO demonstrates sustainable harvest or takes appropriate actions if current harvesting is deemed unsustainable. In Canada, walruses are primarily harvested for subsistence, although some communities engage in a limited and regulated sports hunt. Walrus hunting is co-managed in accordance with Land Claim Agreements and the *Fisheries Act* and its regulations. DFO's Fisheries Management efforts are guided by Sustainable Fisheries Framework policies that incorporate precautionary and ecosystem approaches to protect the health and productivity of Canada's fisheries and healthy fish stocks, while protecting biodiversity and fisheries habitat.

The Committee on Species of Endangered Wildlife in Canada (COSEWIC) assessed Atlantic walrus as 'Special Concern' (COSEWIC 2006). Walrus are also listed under Appendix III of the Convention on International Trade in Endangered Species (CITES), which means that a permit from the Canadian CITES authorities is required to export walrus parts from Canada.

As stated in the Terms of Reference (Appendix 2), the intention of the meeting was to *"bring together walrus researchers and management practitioners to identify data gaps and information needs, and develop a five-year research plan to help inform management and policy decisions for the conservation of walrus and their habitats to ensure long-term sustainability*." Key objectives included:

1. Review management objectives and priorities;
2. Overview of current walrus research initiatives (Alaska, Canada, Greenland);
3. Review research approaches;
4. Identify information gaps; and
5. Prioritize research needs and establish a five-year implementation plan.

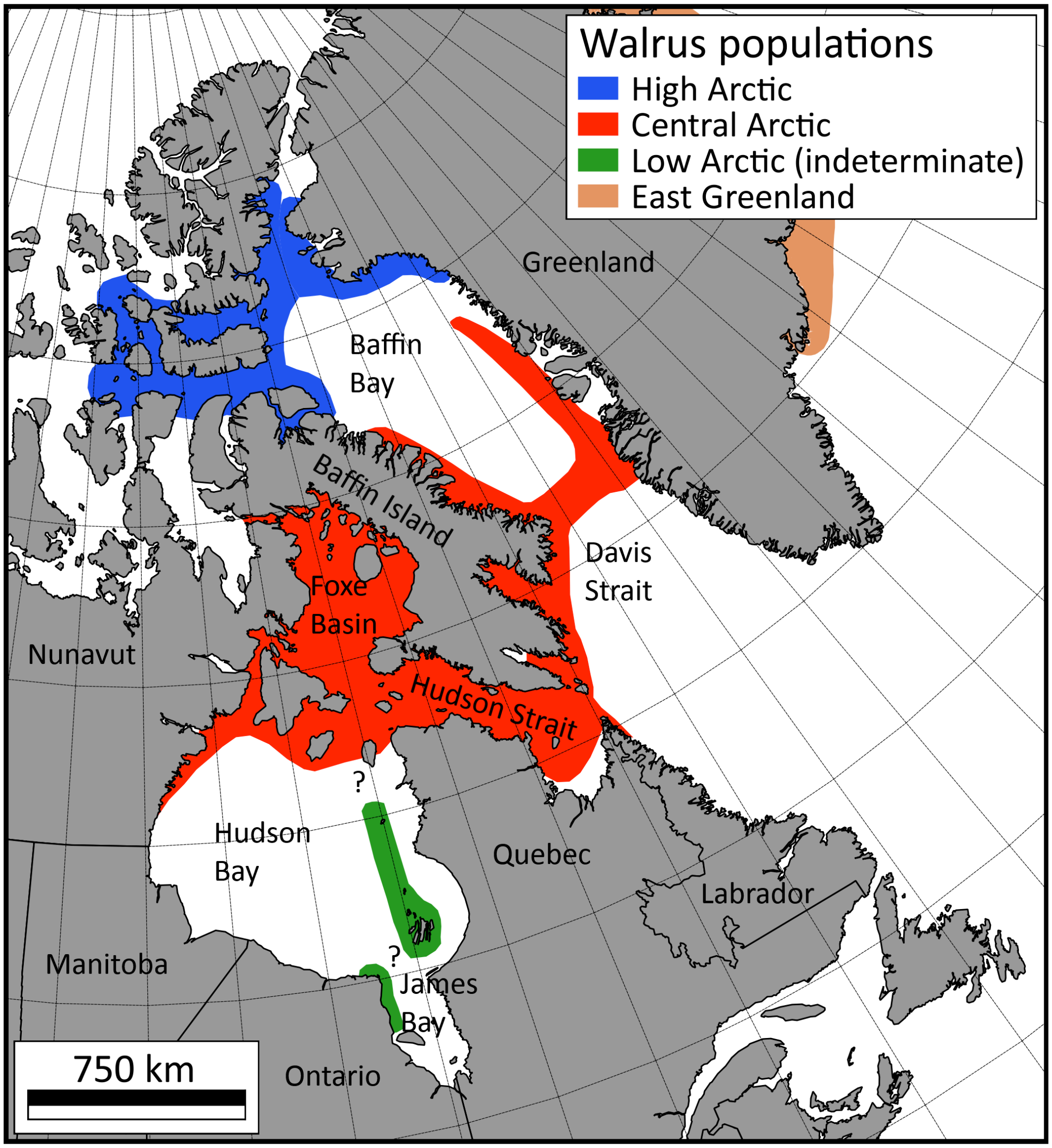

Figure 1. Walrus populations in Canada as defined by Shafer et al. (2014). Stocks or management units currently used by DFO (Stewart 2008) are the Baffin Bay, West Jones Sound and Penny Strait-Lancaster Sound stocks of the High Arctic population; Foxe Basin and Hudson Bay-Davis Strait stocks of the Central Arctic population; and the South and East Hudson Bay stock which is unassigned to a population due to lack of data.

DAY 1 – RECENT WALRUS RESEARCH AND MANAGEMENT ACTIVITIES

Dr. Robert Young, Division Manager of Arctic Research Division, Central and Arctic Region, welcomed participants and wished them success. Then, after introductions and housekeeping items, Day 1 consisted of presentations on recent walrus research and management activities and methods in Alaska, Greenland and Canada (Appendix 3). Copies of the presentations are appended with sufficient resolution that the small print is readable when they are expanded using a computer monitor (Appendices 4A-L). Reference material mentioned on the slides or provided by the presenter is cited in full in the References section. Presentations and relevant discussion are summarized here.

DFO WALRUS RESEARCH PLANNING MEETING INTRODUCTION – PAUL BLANCHFIELD

The rationale for the meeting and its objectives outlined above were reiterated in the introductory presentation (Appendix 4A). The need to better understand the effects of a changing ice environment on walruses and walrus hunters were emphasized. There is uncertainty for example about how climate change in the eastern Canadian Arctic may affect benthic production that walruses rely upon for food. Progress over the past 15 years in understanding Canadian walrus population distributions and movements, and the knowledge gaps remaining, were illustrated (Slide 8).

Discussion: The emphasis that walruses are obligate ice-riders is more applicable to Alaskan waters where there are not extensive coastlines near feeding areas.

WALRUS MANAGEMENT IN NUNAVUT - ALLISON MCPHEE

There are 7 stocks/6 management units (North and Central Foxe Basin are pooled) in Canada (Slide 3), some of which are shared internationally (Appendix 4B). Walruses are co-managed under federal legislation and land claims agreements (Slides 4 and 5). There is increasing national and international interest in how the walrus fishery is managed (Slides 6 and 7). An *Integrated Fisheries Management Plan (IFMP) for Atlantic Walrus in the Nunavut Settlement Area* has been developed; a plan for Nunavik is in the offing (Slides 7-10). Main issues for Fisheries Management are: stock delineation, abundance estimates, sustainable harvest levels, struck and lost rates (S&L), harvest monitoring and reporting, and increased shipping (Slides 11-14).

Discussion: There is a need to move away from a PBR (potential biological removal) approach to a more defined risk-based model of population management that includes *limit reference points (LRP). Coordination of IFMPs among jurisdictions would be beneficial in addressing inter-jurisdictional issues (domestic and international). Other protection activities such as the Nunavut land use planning and protected area status identification require similar information.*

PACIFIC WALRUS RESEARCH - CHADWICK JAY

Activities related to Pacific Walrus are shared by the USGS (U.S. Geological Service) and USFWS (U.S. Fish and Wildlife Service) (Appendix 4C). Climate change is the main issue affecting Pacific walruses since they are closely linked to sea ice, the amount and distribution of which are changing rapidly. USGS developed a conceptual model in 2011 to explicitly state abiotic and biotic linkages to population size to help develop their research plan. Chad presented detail of the execution of the research plan including changes in seasonal distribution, response to survey aircraft, tagging results, identification of foraging areas, female energetics, and population structure based on visual surveys. Reference material was cited in relation to projected changes in the extent of sea ice (Slide 8; Douglas 2010), projected status of Pacific walruses in the 21st century (Slide 12; Jay et al. 2011), estimating age ratios and herd size using video imaging (Slide 17; Monson et al. 2013), calf mortality (Slide 19; Fishbach et al. 2009), female energetics (Slides 28-32; Noren et al. 2014), and modelling demographic rates (Slides 34 and 35; Taylor and Udevitz. 2014).

Discussion: Chad clarified some details: tags lasted 1.5-2 months on average; physical consequences of changes in female condition are difficult to establish because of selection bias in the samples; at large haulouts there may be some increase in mortality (stampedes) though they have not found increased incidence of disease. Pacific walruses are not yet affected by changes in benthic productivity, but rather by the spatial disconnect between productive feeding areas and suitable resting habitats on land or ice within feeding range, particularly for females with calves. New haulouts are appearing as walrus distribution changes. Chad indicated the decreasing harvest success in Alaska has been related to sea ice changing hunter access rather than to a decline in walrus abundance.

CANADIAN WALRUS RESEARCH - PAUL BLANCHFIELD

Recent research focused on stock delineation and aerial surveys (Appendix 4D). Methods were developed over the years and South and East Hudson Bay (S&EHB) was surveyed only recently. Some areas were surveyed 5-8 years ago and estimates are therefore dated. Various estimates were used to attempt to generate total population estimates. PBR was used to estimate allowable harvest levels.

Discussion: Walrus surveys focus on walruses that are hauled out, so animals in the water are not included. Best practices include satellite tags that are operating at the time of the survey, so the proportion of tags at sea can be used to transform the counts of hauled out walrus into a total population estimate. Participants re-enforced the approach of deploying 30+ tags concurrent with the counting to reduce variance in the adjustment factors used to estimate the proportion of the population in the water, and counting animals at terrestrial haulouts at the season of maximum use. Local tag deployment is also important, as haulout corrections are location, weather, and time specific and walruses exhibit coordinated haulout behaviour (Slide 16; Lydersen et al. 2008).

TRADITIONAL ECOLOGICAL KNOWLEDGE (TEK) OF WALRUS IN FOXE BASIN AND THE HIGH ARCTIC - ALLISON MCPHEE

Several community walrus workshops were held during the development of the IFMP for Walrus in the Nunavut Settlement Area (Appendix 4E). Management issues and objectives were prioritized, and local traditional ecological knowledge maps were developed based on information shared on the geographical range and distribution, by sex, age and season, of walrus. Nunavut Tungavik Incorporated (NTI) and DFO jointly produced an educational video that follows a subsistence walrus hunt through the eyes of an experienced Elder, describing the planning, hunting, caching and reporting of a traditional walrus harvest that will be used for youth and hunter training purposes. A Walrus Traditional Knowledge Workshop will be held in November 2016 with Nunavut communities that harvest from the Hudson Strait area.

USING NUNAVIMMIUT KNOWLEDGE AND SCIENCE TO STUDY WALRUS IN NUNAVIK - KAITLIN BRETON-HONEYMAN

Nunavik has been working to combine scientific and TEK observations on walruses, including a study of the possible effects of UV radiation (Martinez-Levasseur et al. 2015, 2016) (Appendix 4F). The work was used as a practical example to illustrate how a research question can be approached using both TEK and western science, and to demonstrate the validation process with the community. Local knowledge can address issues such as the distribution of walrus hunting and walrus migration through Hudson Strait, especially with respect to changing ice patterns. An example of such a distribution change is the abandonment to the haulout at Digges Island. Many communities are concerned about these changes and associated increases in ship traffic.

Discussion (last two talks combined): There was interest in modern struck and lost rates and seasonal distribution. G. Gilbert noted that walrus management and IFMPs should not focus on geopolitical lines, which the walruses ignore. J. Arnaituk noted that walruses overwinter around the Sleeper Islands. Recently Hall Beach collected TEK from 3 generations of hunters covering as far back as the 1940's. The group agreed the information which included harvest levels (landed catch, struck and lost), walrus use, and changes in population size will be useful.

There were then several shorter presentations on specific methods applicable to walrus research.

WALRUS BIOPSY SAMPLING - BLAIR DUNN

DFO has been using CO_2 guns, which are more accurate than a crossbow but lack a tether to the dart, making the darts more difficult to retrieve (Appendix 4G). Most darts fall out within 15-20 minutes. Biopsies are not taken from walruses in large herds for fear of causing a stampede.

Discussion: Interest centered on the missile projector and how to get biopsies from large herds without causing undue distress or causing a stampede.

GENETIC CAPTURE-MARK-RECAPTURE FOR CANADIAN ARCTIC ATLANTIC WALRUS STOCK DELINEATION AND ABUNDANCE ESTIMATION - LIANNE POSTMA

A model has been developed by Tim Frasier (St. Mary's University, Halifax, NS) to explore the applicability of genetic mark-recapture studies on walruses (Appendix 4H). The issues of a wide survey area and clumped walrus distribution apply to this method as well as aerial surveys. Initial trials with the current iteration of the model and existing DFO data were not successful at predicting population size of walrus, usually because of limited recapture data. Sampling effort should approximate 15% of the population on different occasions within a short time frame. A simplified version of the model may hold some promise. Appropriate genetic markers are available. Recent work on microsatellite assessment of walrus stocks in Canada was cited (Slide 3, Shafer et al. 2014).

Discussion: Participants clarified that the 15% estimate applies to each sampling period. Concern was raised regarding potential bias of population estimates related to resampling the same sites, which could increase the likelihood of recaptures and thereby reduce population estimates.

Editorial comment: There was no discussion about the feasibility of achieving the 15% target for larger populations, in the range of 10-15,000 animals.

WALRUS ABUNDANCE: AERIAL SURVEYS - MIKE HAMMILL

In parallel with Blanchfield's presentation, this one noted best practices (to date) which include: counting at known haul-outs, consulting with hunters, including the communities in the research, using photographs (versus relying on visual counts), and considering highly variable hauling out behaviour and site fidelity (Appendix 4I). Replicates within a year decreased the variance. The proportion hauled-out affects expansion of counts to a population estimate and follows a beta-binomial distribution. Modelling is being used to help establish the maximum proportion hauling out. Examples of systematic surveys were cited (Slides 4 and 5; Speckman et al. 2011; Elliot et al. 2013; Heide-Jørgensen et al. 2014; Slide 22; Born et al. 2009; Heide-Jørgensen et al. 2013, 2014). Variation between visual and photographic counts (Slide 8; Stewart et al. 2014), variability in haulout use (Slide 8; Mansfield and St. Aubin. 1993) and methods of data analysis (Slide 10; Udevitz et al. 2009; Martin et al. 2011; Doniol-Valcroze et al. 2016) were also discussed.

Discussion: Participants noted that there is high variability in the number of walruses hauled out within and among sites in their areas too. It was suggested that drones may be a useful tool for obtaining photographic survey data.

WALRUS MANAGEMENT AND RESEARCH IN GREENLAND - FERNANDO UGARTE (VIA TELECONFERENCE)

The Greenland Institute of Natural Resources (GINR) provides advice to the Greenland government on sustainable exploitation of living resources, including the Atlantic walrus, and safeguarding of the environment and biodiversity (Appendix 4J). It also provides modelling advice in the North Atlantic Marine Mammal Commission (NAMMCO) working group. Greenland has had to conduct Non-Detrimental Finding (NDF) evaluations several times (e.g., Slide 6; Ugarte 2015). The latest, in 2016, had a negative NDF for the Baffin Bay walrus stock, which is shared with Canada (Slides 9, 23, 25). Struck and lost remains an important source of uncertainty when determining whether hunting removals are sustainable (Slide 13, 25, 26). Surveys and satellite tagging of walrus from the Baffin Bay stock have been carried out in the last 5 years and the tagging showed movement into the Canadian Archipelago.

Discussion: R. Stewart provided additional information about the tagging in NW Greenland (Heide-Jørgensen et al. in press). Walrus movements were consistent with *the Shafer et al. (2014) model of populations, but challenge the discreteness of stocks proposed by Stewart (2008) in that some tagged walruses crossed stock boundaries into Jones and Lancaster sounds, moving westward well into the Canadian Arctic Archipelago.*

HIGH ALTITUDE IMAGERY - ROB STEWART

Using the basic approach of comparing new types of imagery to older images, orthogonal high-resolution images appear to have fewer walruses obscured than in oblique images (Appendix 4K). There is also potential for automatic counting. Although it has improved since DFO's first foray into satellite imagery for walruses, commercially available satellite imagery still does not have high enough resolution to be used as a method to enumerate walruses for estimates of abundance. It may be possible to develop a walrus/hectare algorithm and IR imagery might be particularly useful for this application. Even with good images, it may take several platforms to obtain contiguous imagery of the survey area, although the area can be covered quickly.

Discussion: C. Jay indicated that the results reported exactly reflect the experience of Alaskan researchers.

REMOTELY–DEPLOYED SATELLITE RADIO-TAGS - CHADWICK JAY

Remotely deployed tags were investigated as an alternative to tagging with immobilization and its attendant challenges of drug mortalities, lost animals on ice, and being time and labour expensive (Slide 8, Jay et al. 2006) (Appendix 4L). Using a crossbow, it is sometimes possible to deploy 3 or 4 tags in one small group; 70 were installed in a very large group near Point Lay. Longevity is variable with a maximum of around 2 months. Increasing the transmitting life of the tags is the focus of ongoing research.

Discussion: DFO has obtained similar results with remotely applied satellite tags.

DEVELOPMENT OF A 5-YEAR SCIENCE PLAN FOR WALRUS: BREAKOUT SESSIONS – LIANNE POSTMA

This final presentation of Day 1 set the stage for Day 2 by explaining how breakout groups would be used to meet the workshop objective (Appendix 5). There was some discussion about a separate TEK group but it was concluded that as TEK is important to all knowledge topics a separate group was not advisable.

DAY 2 – BREAKOUT SESSIONS

On Day 2 of the workshop, breakout sessions were used to help identify the data gaps, information needs, possible protocols, and timelines for key walrus research themes in order to develop a robust 5-year plan (Appendix 5).

Groups were assigned two topics apiece and provided with a short list of aspects to be considered (Table 1). Each topic included consideration of both scientific and traditional ecological knowledge (TEK). The six topics were:

1. Abundance
2. Population Biology
3. Management Science
4. Threat /Stressors
5. Distribution and Movements
6. Ecosystems and Habitat (how ecosystem affects population biology)

Details of sub-topics are presented in Appendix 5 and short explanatory notes were incorporated into the summaries of the break-out groups (Table 2).

Table 1. Break-out group members and topics.

Group	Participants	Themes Discussed
1	Anne-Marie Cabana, Brandon Laforest, Danica Crystal, Gregor Gilbert, Johnny Arnaituk, Lianne Postma, Mike Hammill, Rob Stewart, Dave Yurkowski (Abundance only)	1. Abundance 4. Threats Assessment
2	Chadwick Jay, Denise Tenkula, Jason Mikki, Kaitlin Breton-Honeyman, Paul Blanchfield, Robert Moshenko, Sam Stephenson, Steve Ferguson	2. Population Biology 5. Distribution/migration
3	Allison McPhee, Blair Dunn, Bruce Stewart, Garry Stenson, Maha Ghazal, Manasie Naullaq, Mariane Marcoux, Sheena Majewski	3. Management Science 6. Ecosystems/Habitats

Table 2. Issues, knowledge gaps, approaches, and timelines identified for each walrus theme by the breakout groups or discussion that followed. Some approaches are emphasized for future reference.

1. ABUNDANCE	Obtaining counts and generating estimates. Knowing how many animals are in the management unit is the first essential step in determining status and population trends resulting from human intervention.		
Main Issues	**Knowledge gaps**	**Approaches**	**Timelines**

• Survey design (haulout locations, timing, interval, time series)
• Walruses are widely distributed but clumped
• Numbers hauled out vary greatly and can change rapidly (tagging data narrowly applicable in time and space)
• Some stocks cover vast areas
• May be both residents and visitors* among counted walrus
• Community-level ability to detect need for survey (i.e., triggers)
 	
* see Editors'
	• Season of maximal terrestrial hauling out (assume it is when ice is seasonally minimal)
	• Location of all haulouts
	• Age structure at various sites
	• Need survey-specific supporting data on:
	  ○ environmental conditions (e.g., ice cover)
	  ○ walrus distribution and behaviour
	• Can HBDS surveys be partitioned?
	• Amount, timing and significance of exchange among stocks (affects survey frequency and timing)
	• Is there a threshold of exchange below which impacts on abundance estimates can be ignored?
	• How to distinguish between residents and visitors*
		Use **existing data** on:
		• Ice abundance (maps, local knowledge, historical tag data)
		• General haulout behaviour
		• Movements
		• Distribution
		
		Model impacts of movements within and between survey areas to determine effect on estimates and level to which assumptions can be violated without degradation of estimates (includes mark-recapture (M/R) and any new methods)
		
		New data:
		• Replicate surveys within year and at least 2 consecutive years (disparity informs 3rd survey yr)
		• Survey-specific tagging
		• Growth layer group (GLG) isotopes, tagging to assess stock exchange and movement within stock (haulouts)
		• Develop method for
			Use existing data now
			• Inventory, catalogue and mine existing data and sample mining (TEK, ice distribution, GLG isotopes, proportion calves in archived photos)
			
			Timing of future surveys based on
			• Time since last survey
			• Urgency of management issue (observed changes e.g., age structure)
			• Difficulty (geographical expanse, human and financial resources)

comments		**<u>communities</u>** to detect population change (e.g., interim surveys using boats or drones) • **<u>Community</u>** reports on annual state of the walrus population (changes in age structure, proportion of calves, etc.) New methods MUST be validated against previous results to ensure: • Different result is not solely due to change in method • Retrospective adjustment of photo surveys is possible	
Editor's Comments	• It is becoming apparent that at least a few walruses, both male and female, move from one stock to another (Stewart et al. 2003; Heide-Jørgensen et al. in press). At Hall Beach, dental isotopes showed some walruses are **residents** with no evidence of living elsewhere, some are **visitors** from other locations, and some were born near Hall Beach, left, and returned several years later (**rovers**) (Stewart et al. 2003). These itinerant walruses are different than annual migrants although migration is also complicated. Virtually all walruses from West Greenland summer in Canada where they join walruses that spent the previous winter in Canada (Dietz et al. 2014). Methods for distinguishing permanent residents of an area (if they exist) and transient visitors or seasonal migrants are important for accurate allocation of harvests. Genetics may lack the power to do so (mixed outside the breeding season, low levels of interbreeding remove genetic differences). However tagging, isotopes, and natural markings/re-sightings might be useful approaches. Isotopes in soft tissues can provide information about recent movements. • Local data collection directed toward CPUE changes in abundance may be worth exploring.		

2. POPULATION BIOLOGY	The biology of individuals, how fast they grow, their body condition, when and how often they reproduce, the age at which they die, all feed into how fast a population can renew itself. A population size at time-2 (N_2) depends on the previous population size (N_1) plus births (B) minus mortality (natural and anthropogenic) (M) (i.e., $N_2 = N_1 + B – M$).		
Main Issues	**Knowledge Gaps**	**Approaches**	**Timelines**
• Population size (see above) • Birth rates • Natural mortality rates • Hunting mortality rates • Other sources and rates of anthropogenic mortality • Community participation and support	• Age-specific birth rates • Presence and degree of variation in birth rates among stocks • Causes and rates of natural mortality • Stock specific hunt removals (landed catch plus animals struck and lost by all jurisdictions that hunt a particular stock)	Use **existing data**: • Model maximal rate of natural population increase (R_{max}) to inform PBR-based assessments*. • Retroactive visual estimates of age structure Gather new data: • **Community** hunt sampling (condition, hunter selection, female reproduction, aging) • Visual age structure surveys: Spring (calving), Fall (recruitment), key sites – modal system • Biopsy sampling by community (information on sex and age (telomere) structure) contaminants, and biomarkers indication feeding patterns. • Test key assumptions – e.g., Fay's (1981) ID key * R_{max} is a variable in the PBR model and stock- or population-	Use existing data now • Archived survey photos. Tongues sent for trichinosis testing are valuable for other analyses (e.g., genetics, contaminants) and should be archived (they are currently destroyed). Biopsy samples used to collect genetic data could also be archived for stable isotope and fatty acid analyses.

		specific estimates of R_{max} are needed. DFO currently relies on models for Pacific walrus.	
Editors' Comments	• Wear rates of walrus teeth should be re-examined with a view to both better age estimation and to assess the impact of minimum ages on population models. • Archival records of body condition (e.g., body mass, blubber depth, length) could serve as a benchmark to detect changes in relative abundance. • Trophic-level isotopes could be used on archived and new samples to explore potential changes. • Biopsies often yield too little blubber and skin for extensive subsampling for fatty acid, isotope, and telomere analysis. • No mention was made of walrus social behaviour as a fundamental aspect of walrus biology. Better understanding of herd structure and dynamics, mating and birthing behaviour, haulout and feeding behaviour, and mother-calf interactions is required to underpin threats assessments (see later section).		
3. MANAGEMENT SCIENCE	Management science is defined here as the science that identifies risk levels associated with population estimates: PBR uses few data and is inherently conservative. With more data, complex models can attach risk levels to population estimates. While science can generate such estimates and calculate the associated risks, managers must weight various options and decide on their acceptable risk level.		
Main Issues	**Knowledge Gaps**	**Approaches**	**Timelines**

• Walrus is a data-poor species for which DFO policy defaults to PBR, which does not include a quantifiable risk assessment
• Goal: Move walrus to data-rich
	• Precise abundance estimates
	• Reproductive rates
	• Human-induced mortality (timely, accurate data)
	  ○ Landed catch
	  ○ Struck and lost (S&L)
	  ○ Other (e.g., ship strikes, stampede-related mortality)
	• Natural mortality
	• PBR Recovery factors
	• Formal mechanism for
		Use **existing data**:
		• Model optimal frequency of assessments, replicates
		• Explore impact of multi-year quotas (consider tying schedule of assessments to multi-year quotas)
		Gather new data:
		• **TEK/community-**based monitoring (landed catch/S&L buy-in, calendars, follow-up to determine accuracy and
			Use existing data now
			
			New data:
			• Develop effective community-based monitoring program within 5 years.
			• DFO data collection to supplement sampling and train monitors.

	international stock management	precision) • Catch per unit effort (to better understand factors influencing catch changes and provide early warning of possible changes in population distribution or abundance) • Ship monitoring to assess potential effects on walrus distribution, abundance, and catches • Land claims/ Inter-jurisdictional issues (more info for managers on these issues, which influence management options, particularly with respect to harvests)	
Editors' comments	• Although identified as a Knowledge Gap, Canada's lack of formal international agreements about walrus management was not discussed further. It is not strictly a science Gap but the presence of such agreements can foster international science ventures and cooperation. • Given the vast and remote areas in which walruses reside and the well-documented extreme variation in numbers at haulouts both within and between years (necessitating replicate surveys), moving to 'data rich' may not be attainable with foreseeable DFO resources. • PBR estimates would be more useful if they could be presented in a manner that allows managers to assess the risk associated with different removal levels based on different parameter choices (i.e., values chosen for R_{max} and especially the Recovery Factor). • Science requires more complete data on landed catch and loss rates. • The lack of sufficient information to satisfy the requirements for current Management Science was one factor causing participants to examine ways communities and resource users could assist DFO in the collection of data relevant to walrus abundance, distribution, health, etc.		
4. THREATS ASSESSMENT	The group started by noting that scientific results relevant to threats assessments usually will be used in an adversarial setting (environmental review) and need to survive in a quasi-judicial setting; there will be a need		

	to establish cause and effect. Dealing with cumulative impacts was discussed. The group noted that this is a scientific discipline in itself and a complex subject. It chose to focus instead on solidifying evidence of individual impacts, to provide the building blocks for the assessment of cumulative impacts.		
Main issues	**Knowledge gaps**	**Approaches**	**Timelines**
Direct impacts: • Noise: shipping, seismic, mining etc. • Repeated handling by researchers • Stress on animals from inexperienced hunters • Tourists harassing walruses (haulouts & foraging areas) Damage to physical habitat: • Ballast-water • Ship tracks in ice • Freshwater input (e.g., S&EHB, Nelson River) • Climate change (relocated ice edges, higher sea level etc.) • Dust (mines, terminals) Damage to biotic habitat: • Fisheries interactions (damage clam beds,	• Little baseline (current conditions) information • Foraging areas – important habitat • Baseline acoustic environment • Walrus auditory thresholds • Effects of changes in physical oceanography related to hydroelectric developments around east and west Hudson and James bays on walruses Education issue: • Are tour ships filing travel routes?	Use **existing data** (current state and hindcasting): • Baseline: ○ Map feeding/important areas (**TEK**, archived Arctic Biological Station data) ○ Archived physical samples (bivalve shells for isotope mapping, shell thickness, age structure) ○ Disturbance (e.g., Round Island, AK monitoring reports) ○ Background acoustic (DFO Quebec hydrophone array, Ocean Tracking Network (OTN) tracking of ship noise and vessel traffic) ○ Ballast water dispersal (bathymetry, water temperature and salinity profiles) Gather new data: • Tagging for offshore feeding locations • Abundance and distribution of key foods (bivalve molluscs) and	Use existing data now (e.g., time series using archived data): • What data are available? • What archived samples are available? • Map feeding, mating, calving areas • Map haulouts New data – especially Sleeper Islands, Foxe Basin, Northwest Passage

direct competition) • Climate change - ocean acidification, silt clam beds, epontic detritus to clams • Invasive species • Timing and spacing of stressors will change with climate change		other foods • Sampling - ○ Quantify clam density at key areas ○ **<u>Community</u>** collect grab samples from clam beds – benthic environment • Freshwater input - monitor effects of changes in the seasonality of freshwater inputs on offshore sea ice (e.g., Belcher Islands). • Controlled disturbance experiments (test sites) • Quantified observations (**<u>community</u>** observations of reactions of walruses to ships - develop rating scale/score card	
Editors' comments	• Understanding of the characteristics of Atlantic walrus audio signals is needed to better understand what frequencies and levels would potentially cause acoustic disturbance and interfere with their communications. • Audiograms are available for the Pacific walrus. A first step might be to test how applicable they are to Atlantic walrus and if they can be used to examine the potential impact of noise. • Archival clam samples from DFO environmental testing in the early 1980s might be examined for changes in clam populations and ocean acidification. • Long term goals: ○ Develop a robust baseline so changes and anthropogenic causes can be identified before populations are damaged ○ Develop predictive modelling capability that can be used to assess potential impacts from key threats such as noise disturbances. ○ Develop precautionary thresholds (e.g., approach distances, frequency and duration of disturbance) that can be used to regulate activities that threaten walrus health and fitness.		

5. DISTRIBUTION & MOVEMENTS	Two of the walrus populations identified in Canada have multiple stocks or management units (Figure 1). The wide and clumped distribution of walruses is a challenge for each population survey. Long-range movements alter our understanding of stock discreteness and short-range movements (e.g., among adjacent haulout sites or haulouts and feeding areas) introduce uncertainty into population counts.		
Main Issues	**Knowledge Gaps**	**Approaches**	**Timelines**

• Stock boundaries previously proposed appear porous.
• There are no stock data for some stocks
• Haulout behaviour is highly variable as walruses move to and from haulout sites.
	• Stock discrimination
	  o HB-DS (1 stock?)
	  o S&E HB – interchange with HBDS
	  o James Bay
	• Large scale seasonal movements
	• Feeding habitat
	• Haulout complexes
	• Bias in population estimates
	• Spatial and temporal variation in distributions and movements
	• Sex/age segregation?
	
	Effects of hydroelectric development and changes in freshwater distribution on sea ice and walruses
		• Sampling (harvest, biopsy winter & spring)
		
		Telemetry of females from known breeding areas, follow for 1 year
		
		• Photo ID for movements within stock areas
		• Focus on areas with potential disturbance (e.g. shipping, tourism)
		• Method for **communities** to document disturbances (e.g., tourism in the Igloolik area cf. haulout abandonment)
		• Maintain interchange with Greenland (e.g., exchange genetic samples for analysis)	

Editors' comments	• See also Comments under ABUNDANCE about residents, visitors, and migrants. • The breakout group did not provide timelines but, as with other topics, there are existing data that may provide insights. • For mixed stocks modelling the consequences for management of various degrees of mixing could indicate a threshold level of exchange at which stock or management unit boundaries no longer apply. For example, do biological significance and management implications become serious when 10% of the stock is from		

	away? 15%? • The group identified exchange of genetic samples with Greenland as a specific approach. There has been good rapprochement among researchers of the two countries and the relationship needs to be maintained. Mark-recapture methods, including genetics, are the best tool to tease out interbreeding, migratory movements, and occasional visitors. • DFO has ground-level photos that, in the short-term, could be reviewed for photo-ID captures.		
6. ECOSYSTEM and HABITAT	Walruses occupy a relatively narrow ecological niche. They rely on benthic foods (mostly bi-valve molluscs) at depths of 100 m or less. They are obligate haulers-out and need places to rest near food sources. In winter, polynyas are where food, resting places, and access to air are all available.		
Main Issues	**Knowledge Gaps**	**Approaches**	**Timelines**
• Primary & secondary production • Environmental changes • Critical habitat • Food web, foraging • Marine Protected Areas/Ecological and Biological Significant Areas Habitat mapping/ oceanography • Ocean acidification • Freshwater input	• Substrate close to shore • Diet study in high Arctic • Benthic species • What will climate change do to walrus habitat • Region specific differences • Timing of production and access to food • Usage of ice • Breeding areas (mating, birthing)	Use **existing data**: • Identify important habitat (TEK, map depth/ice/haulouts, long-lived satellite-tags, acoustics) • Data on feeding behaviour or diets from other regions, TEK? • Data on substrate (e.g., 2016 in Hudson Bay, around Qikiqtarjuaq, from industry or ArcticNet?) • Use diet info from other areas? Gather new data: • Direct studies at specific important habitat sites • Benthic species & densities • Characterize important habitat – by sex** • Upcoming TEK workshop / **Community** based monitoring • Distribution of feeding habitat	Year 1 • Gather existing data (Spatial, Bathymetry, Benthic mapping) • TEK workshop (fall 2016) • Develop community channel • Develop tagging • ID priority areas Year 2 • Start community based monitoring – continue all years • Habitat mapping based on priority areas Year 3 • Habitat mapping

		birthing habitat, (**<u>community</u>** observers could ID in stomachs and record feeding locations) **scat sampling was considered but collection was deemed impractical	
Editors' comments	• The information on diets is largely transferrable – bivalve molluscs are the predominant prey everywhere although there may be differences in the species composition. • An unidentified information gap is the amount of standing biomass of walrus food that is required to support a given number of walruses. Existing data might be used to model requirements.		

PARTNERS/COLLABORATORS AND RESOURCES

Table 2 does not include group suggestions for Partners/Collaborators or Resources. All groups identified the need for more skilled, knowledgeable people and more funding, without quantifying either. Areas of expertise identified included:

- traditional knowledge
- resource co-management
- social sciences
- population genetics
- satellite tagging
- habitat use
- oceanography
- remote sensing
- sea ice
- population survey techniques, and
- population modelling

Identified partners and collaborators included:

- communities/harvesters
- co-management boards (NWMB, NMRWB)
- Greenland Institute of Natural Resources
- NAMMCO
- Government of Nunavut (Department of Environment)
- Environment and Climate Change Canada (ECCC)
- Ocean Tracking Network (OTN)
- Center for Earth Observation Science (CEOS), and
- Genomics Canada

RECURRING THEMES

Several recurring themes were discussed by the focus groups (Table 2). Although charged with considering **TEK**, each group clearly noted the importance and enumerated the benefits of doing so. Local **communities** are important as sources of local knowledge not otherwise available, as sources of informed people to implement or assist with the collection of new information and, perhaps foremost, as the interested consumers of science generated in their areas. In this latter role communities need a voice in shaping research priorities for their area. Such a voice assists in meeting local needs and fosters local support for the activities. Community involvement should be an over-arching principle in DFO's research plan. In addition, it is essential that the results of the scientific research be presented to and discussed with the communities in a meaningful way.

In terms of scientific information, the most common theme is to explore currently **available data**—a different kind of traditional knowledge, and **modeling** with those data. The use of existing data to provide starting points for modeling and to be mined for applications not originally intended are clearly two aspects of a research plan that can and should be implemented at the earliest opportunity. When possible, the original data collectors should be consulted to ensure the data are appropriate for the new application. Existing data may also provide information (body condition, abundance) for trend analysis. An inventory and catalogue of currently available DFO data with respect to information needs should be the starting point for DFO's research plan.

Only group 3 (MANAGEMENT SCIENCE) explicitly stated the need to move our knowledge base for the Atlantic walrus from DFOs 'data poor' classification to 'data rich' but it was clear from the very fact that a well-attended workshop was taking place that all recognize the need to learn more about walruses in Canada. The group noted that being data-rich implies much more than simply better counts.

Finally, while it was mentioned only once (Table 2) the editors consider one more theme of universal application. **Overlapping new and old methods** is essential to ensure that data sets collected using different methods can be usefully compared over time. For example, vertical photos may be the best option for assessing abundance but they should be calibrated to oblique photos for long-term comparisons. **Identifying commonalities in data requirements** for different studies/research (e.g., abundance, movement, genetics, and habitat characteristics) will provide important economies of scale that will improve the use of resources (time, effort, money) and provide improved understanding that is out of proportion to the incremental cost. Related to this is a precaution against adopting a method because it is new or faddish. Several participants identified drones as a solution to several problems but one must first decide if airborne sensors are the solution to a particular issue. Then the appropriate platform(s) can be selected.

With these generalizations, there were specific topics that merit elaboration and comment.

SPECIFIC THEMES/TOPICS

Community-Based Monitoring/ Local Engagement

Community-based monitoring (CBM) and increased local engagement should be a keystone of future walrus studies, long-term monitoring, and understanding social and environmental changes. CBM provides communities, co-management organizations, researchers, non-governmental organizations and other parties enhanced ability to observe and responded to changes and actively participate in decision making. It enhances co-management and local stewardship, provides training opportunities, increases support and recognition of local traditional knowledge, and enables local communities to have direct input into decisions that affect them.

CBM and local engagement can assist with the collection of important information such as:

- Biological samples (tissue samples and other morphometric data)
- Location and dates of harvest
- Landed catch data (CPUE, age, sex, condition, health, pregnancy rates (from reproductive tract examination)
- Struck and lost data
- Habitat utilization
- Important ecological areas identification (e.g. feeding areas, mating areas, birthing areas)
- Identification of changes in local conditions (e.g. temporal and geographical distribution of ice)
- Temporal and geographical distribution of walrus in the area

Using CBM and increasing local engagement in walrus research can further the understanding of critical biological and ecological factors and increase local involvement in decision-making. Good catch per unit effort data can provide early warning of changes in walrus abundance by improving understanding of the dynamics of factors that affect catches and hunting success, such as changes in demand for meat, hunter population, equipment or cost, time spent hunting, spatial geographical coverage, seasonality, and walrus availability. Changes in distribution may reflect environmental changes, both natural and anthropogenic. Local observations can inform future research.

Establishing a successful program takes time and effort and requires long-term commitments of time and resources on the part of both the community/worker(s) and government (funding, training, sample and data analysis, reporting back to the community, etc.). Good advice is available from several programs that have had long-term success monitoring catches (e.g., ringed seal, beluga) as well as the recently released “Community-Based Monitoring and Indigenous Knowledge in a Changing Arctic: A Review for the Sustaining Arctic Observing Networks” (Johnson 2016). The data collected will have greater value for identifying trends and early warning signs, and their underlying causes, if the program covers the widest possible area and uses similar protocols. Optimally the same program would be developed simultaneously in both Nunavik and Nunavut. Annual hunter/community reporting on the state of walruses could be used to inform research and to inform mitigation and monitoring responses to anthropogenic impacts.

Stock Delineation/Movement

The movement of walruses within and among management units or stocks has an impact on survey design, abundance estimates, and ultimately harvest allocation both domestically and internationally. Stewart (2008) employed Secor's (2005) definition of stock: a specific segment of a population that is affected by humans in a manner that alters population productivity. The stocks identified (Stewart 2008) have been adopted by DFO for walrus management (Figure 1). Stewart (2008) accommodated the roving male concept (Stewart et al. 2003) noting that at least some males appeared to reside several years in stock areas other than their natal area. About 20% of a sample of 35 walruses from Hall Beach had isotope signatures in their teeth that were statistical outliers (Outridge and Stewart 1999). Not all outliers were amenable to isotope analysis by GLG but 2 of 11 adult males examined left their natal area for several years before maturing and returning. Such exchange rates could reduce or nullify genetic differences (Stewart 2008; Shafer et al. 2014) but their impacts on population dynamics and productivity have not been quantified. DFO should model the impact of various levels of interchange among current stocks to determine the level at which removals impact the productivity of the stocks involved. Interchange likely occurs in both sexes (Outridge and Stewart 1999; Stewart et al. 2003; Heide-Jørgensen et al. in press) and calves may travel with some of those females (Outridge and Stewart 1999; Stewart et al. 2003; Dietz et al. 2014, Heide-Jørgensen et al. in press); modelling should examine interchange by age and sex.

DFO, primarily C&A, has extensive and varied data on walrus in their archives that would be useful for several germane research activities. Ground-level and low-level aerial images could be used to explore identifying individuals, thence site-fidelity and movements among haulout sites, to assess age structure, and to obtain estimates of gross annual reproductive rate. Data on variance in numbers (Stewart et al. 2014) could be analysed quantitatively to inform survey design. Modelling exercises may draw on archived data. Mark/recapture, for example, makes assumptions about the redistribution of the marks before recapture, immigration and emigration, mortality and births, which may all be violated by walruses. The impacts of violating these assumptions should be modelled specifically for walrus before a great deal of effort is devoted to obtaining more samples, to assess their impact on mark/recapture estimates. Data exist to inform that modelling.

Alternatives to PBR: Risk-assessment Models of Population Management

By current DFO standards (Stenson and Hammill 2008; Stenson et al. 2012), to be data-rich requires that population estimates are no more than 5 years old. Given the resources required for a comprehensive walrus survey, for which high variance demands replicates, becoming 'data rich' may not be logistically possible for all stocks. Until new methods of dealing with data-poor populations are developed, the default option will continue to be PBR. R_{max} is a factor in PBR calculations and existing data might be useful in modelling this parameter for Atlantic walrus. More important in PBR however is the recovery factor (F_R). The objective of PBR is to permit the stock to reach, or remain at, its optimal production level. To do this, F_R is adjusted to increase the rate of recovery of depleted populations and as a precaution against uncertainties other than the precision of the abundance estimate (Wade 1998). F_R was designed to ensure recovery within a specified period to a specified population size. However, it may be possible to simulate walrus population growth with various F_R values to assess the risk (time to a population size, probability of attaining that goal) associated with each one. Managers could then evaluate the level of risk associated with a suite of PBR estimates.

Trichinella

DFO also has some archival samples available for time-series analysis or new analysis. Unfortunately, samples collected for *Trichinella* testing, which represent an important source of tissue for studying population genetics and contaminant levels, have not been archived. DFO should develop the appropriate partnerships to save these samples and, if possible, augment them with a tooth for age estimation purposes. Research is needed to establish the source(s) of *Trichinella* sp. in walruses. Geographical variation in the incidence of infection might be a useful starting point.

Herd Structure (age and sex)

Both community members and the scientific community want to conduct studies with the least possible disturbance to the walrus for reasons of animal health and data integrity. Moreover, samples from the hunt may not be representative of the whole population and tooth wear makes maximal age estimation problematic (Stewart and Stewart 2005) Non-invasive methods of assessing herd structure (age and sex) at particular haulouts or particular seasons would be useful for establishing mortality estimates and gross annual reproductive rate, and for population-dynamics models. A visual key for assessing age and sex structure has been developed for the Pacific walrus (Fay 1981). This key needs to be validated and/or adjusted for use with the Atlantic walrus. Coupled with this approach could be photo-ID of individual walruses to explore site fidelity, movements among haulouts and, eventually perhaps, information on age-specific reproduction and longevity.

Satellite Tagging

The use of satellite tags in walrus studies continues to provide new and important information. Larger satellite-linked time-depth recorders are usually tusk-mounted. They can have lengthy transmission lives but can only be applied to walruses with sufficiently large tusks. These tags require chemical immobilization of the walrus during attachment and are expensive in time and money to deploy, but they are required to obtain certain types of data. Skin-mounted tags cause less disturbance to the herd and tagged animal, are faster and easier to deploy and cost less, so they can be deployed in statistically significant numbers. They are, however, generally short-lived and limited in the types of data they provide. They are well suited for collecting hauling-out data concurrent with surveys.

Remotely Operated Vehicles

Remotely Operated Vehicles as well as remotely operated stationary systems, submersible and airborne, may be useful platforms for future research. For example, submersibles (occupied or robotic) are capable of video/photo surveys of clam beds, benthic mapping, and acoustic monitoring. Acoustic and visual recorders may be able to collect and transmit data. Unmanned aerial vehicles (UAVs) can carry the same or more sensors as a typical occupied aircraft. With its strong tradition of aerial surveys, DFO needs to consider the advantages of UAVs (range, endurance, several platforms in the air concurrently) against having human observers on board (serendipity of unexpected observations, meteorological limits to range and endurance, safety) in each particular survey scenario. Serendipity in particular is not to be undervalued given the high variation in hauling out behaviour (Stewart et al. 2013) and the re-occupation of formerly abandoned haulouts or the establishment of new haulout sites (Stewart et al. 2014).

Anthropogenic Threats and Cumulative Impacts

Many of the knowledge gaps affect the ability of government and industry to assess and avoid or mitigate anthropogenic threats to walruses. They make it difficult or impossible to detect changes and ascribe their causes unless the impacts are severe or even irreversible. This puts walrus populations at risk and will only increase as climate change makes northern resource development more accessible and economically attractive. Shipping in particular is likely to greatly increase disturbances to walruses, potentially year-round in some areas.

The focus group did not consider the science of cumulative effects, which has its own extensive literature and expertise. The effects of anthropogenic activities do not act in isolation but instead can interact and combine to have cumulative effects. These cumulative effects may be greater than the sum of their parts. The potential impacts of human activities are typically viewed in isolation to one another, rarely in the cumulative manner they are received by the walruses (see DFO 2012 Section 3.5 for example compared to Stewart et al. 2012 and DFO 2014). Planning now and in the future should be done within the framework of what is needed to properly assess the cumulative effects of anthropogenic activities on walruses, so significant adverse effects can be avoided or mitigated.

Government must work closely with communities and potential developers to identify the effects of anthropogenic activities so they can be used to assess potential impacts and set regulatory thresholds (e.g., underwater noise levels, approach distances to haulouts). Government and industry must work together to develop baselines against which changes can be measured. These baselines must be sufficiently robust that they can be used to identify the natural and/or anthropogenic factors that are causing the change, before population damage occurs, so these changes can be avoided or mitigated

EDITORS' CHOICES

In general, timelines for future research were not specified. The Ecosystem and Habitat Group noted important TEK workshops to be held in 2016, but otherwise there was no discussion on when the five-year plan would actually start. Given that most fieldwork related to walrus research will occur in summer-fall (surveys, biopsy sampling, etc.), the meeting and associated reporting did not occur in time to allow planning for the summer 2016 field season. As such, the report editors suggest that 2017 be considered year 1 of 5 in the 5-year plan. This gives the remainder of 2016 for DFO to finalize reporting, discuss priorities, and establish partnerships for the research and management activities that are proposed to occur.

Having the 5-year plan start in 2017 also does not preclude starting some work in late 2016. For example, available Inuit knowledge could be compiled, gaps identified, and the walrus range maps used by DFO and included in the meeting Terms of Reference (see Figure 1) could be edited and updated to reflect current knowledge. These activities could occur prior to the initiation of the 2017 fiscal year.

In addition, there was no substantive discussion on research priorities and steps, and DFO should carefully consider this before 2017. The editors picked the following activities to start the program:

1. Nurture working relationships with the communities, co-management organizations and international research colleagues.

   a. Exchange of updates on DFO and community activities and concerns
   b. Training of future research assistants
   c. Exploring feasibility of CPUE data collection
   d. Establishing indices by which communities could monitor relative abundance in their areas
   e. Obtaining recent TEK on distribution
   f. Improving harvest records
2. Review existing data to assess their potential for answering key questions and modelling the impacts of key assumptions. This might best be done by a small group of researchers who could recognize valuable data even if they lack the expertise to use them. Appropriate expertise should then be sought to apply the data. Specifically:
   a. Abundance/Distribution
      i. are photos suitable for individual identification?
      ii. do GLG signatures in areas other than Foxe Basin suggest interchange between stocks (see Stewart and Outridge 2003)?
      iii. are levels of exchange (Stewart and Outridge 2003; Dietz et al. 2014; Heide-Jørgensen et al. in press) sufficient to nullify detectable genetic differences?
   b. Population Biology
      i. Effects of minimum ages on estimating age-specific parameters (longevity, age of maturation and senescence, thence R_{max})
      ii. Temporal changes in body condition may indicate population changes relative to K. Are there sufficient data to warrant a new sample of body condition as a possible index of population change?

3. Even without knowing details of DFO resources, or potential resources, for walrus research, it is evident that surveying all walrus populations in Canada at 5-year intervals is unlikely to happen. DFO could revise its definition of data rich or, more usefully, examine more powerful ways of presenting estimated removals for data-poor species. Explore the feasibility of expanding the F_R of PBR so managers can assess the risk of accepting one F_R value over others.

4. In terms of new data, abundance estimates with attendant data on movements and distribution, are required:
   a. for the Hudson Bay-Davis Strait stock (HBDS) because it supports hunts in several Canadian communities, is shared with Greenland, and will be exposed to increased shipping through Hudson Strait;

b. for walruses in south and east Hudson Bay (S&EHB), because little is known about them, their area of occupancy has shrunk, and they may or may not be part of the HBDS stock.
c. then, the High Arctic population needs revisiting because surveys are almost a decade old and there are new data on the geographical range in which these walrus are shared with Greenland.

SUMMARY

The Terms of Reference stipulated five specific objectives for the workshop.

1. <u>Review management objectives and priorities;</u>

   DFO's main management objective is sustainable resource use that recognizes the needs and demands of resource users, competing demands of development, and the international community. Currently, its information needs are: abundance estimates, sustainable harvest levels, struck and lost rates (S&L), improved harvest reporting, shipping impacts, and stock delineation. Such information would allow moving away from a PBR (potential biological removal) approach to a more risk-based model, such as limit reference points (LRP).

2. <u>Overview of current walrus research initiatives (Alaska, Canada, Greenland);</u>
3. <u>Review research approaches;</u>

   Both these objectives were met via the presentations (see Appendix 4).

4. <u>Identify information gaps;</u>

   Key information gaps (Table 2) relate to population structure (stock boundaries, age and sex distribution) and abundance and are not mutually exclusive. For example one needs to know distribution both to plan surveys and to interpret survey data. Managing direct removals requires information about other removals (threats). Many of those threats operate indirectly through ecosystem changes. Collapsing all groups, key information gaps are:
   - How many walrus are there and how do we best obtain that number?
   - How might that number change (increase or decrease) in the future and how would co-managers best detect the change?
   - How are walruses in Canada distributed and how does that distribution change within and between years?

- Why are walruses where they are (i.e., seasonal habitat use) and are these habitat attributes vulnerable to anthropogenic change?

Within this general framework the workshop identified many specific questions and approaches for finding timely answers.

5. Prioritize research needs and establish a five-year implementation plan.

The workshop had no priority-setting component so the editors offer some suggestions.

1. Foster working relationships with relevant communities, organizations and research colleagues.
2. Review existing data to assess their applicability to modelling and addressing new questions.
3. Alter the working definition of ‘data-rich’ or develop risk assessments for dealing with perpetually data-poor species.
4. Collect new data for distribution, movements and abundance estimates, focussing on the Hudson Bay-Davis Strait stock (HBDS) and South and East Hudson Bay (S&EHB), followed by stocks for which estimates are several years old.

These activities should keep DFO well occupied for at least five years because each area should be surveyed in at least two consecutive years, perhaps more.

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APPENDIX 1. PARTICIPANTS

NAME	POSITION/ASSOCIATION	ORGANIZATION
Johnny Arnaituk	Member from Kangiqsujuaq	RNUK
Paul Blanchfield	Research Scientist, Representing DFO Nunavut walrus	DFO Science, Central and Arctic Region
Kaitlin Breton-Honeyman	Acting Executive Director	Nunavik Marine Region Wildlife Board (NMRWB)
Anne-Marie Cabana	Quebec Region walrus lead	DFO Fisheries Management, Quebec Region
Andrew J. Chapelsky (day 1 only)	Biologist, Rapporteur	DFO Science, Central and Arctic Region
Danica Crystal	Marine Biologist, Member of the Nunavut Walrus Working Group	Nunavut Wildlife Management Board (NWMB)
Blair Dunn	Marine Mammal Research Technician	DFO Science, Central and Arctic Region
Steve Ferguson	Research Scientist	DFO Science, Central and Arctic Region
Maha Ghazal	A/Manager, Fisheries and Sealing, Marine Mammal Advisor	Government of Nunavut
Gregor Gilbert	Senior RDD Coordinator	Makivik Corporation
Mike Hammill	Section Head - Marine Mammals, Representing DFO Nunavik walrus	DFO Science, Quebec Region
Jeff Higdon (day 1 only)	Senior Scientist and Head	Higdon Wildlife Consulting
Chadwick Jay	Research Ecologist, Alaska Science Center, Anchorage, Alaska. Representing Alaska Pacific walrus	U.S. Geological Survey
Joe Justus (day 1 only)	Regional Senior Fisheries and Aquaculture Management Officer	DFO Fisheries Management, Central and Arctic Region
Brandon Laforest	Senior Specialist, Arctic Species and Ecosystems, Nunavut	World Wildlife Fund (WWF) Canada
Sheena Majewski	Research Biologist	DFO Science, Pacific Region
Marianne Marcoux	Research Scientist	DFO Science, Central and Arctic Region
Allison McPhee	Central and Arctic Region walrus lead, co-chair Nunavut Walrus Working Group	DFO Fisheries Management, Central and Arctic Region
Jason Mikki	Coordinator	Qikiqtaaluk Wildlife Board (QWB)
Robert Moshenko	Board Member	NMRWB
Manasie Naullaq	QWB Executive, Co-chair Nunavut Walrus Working Group	Qikiqtaaluk Wildlife Board (QWB)
Lianne Postma	Molecular Genetics Biologist, Meeting Chair	DFO Science, Central and Arctic Region

Garry Stenson	Research Scientist and Section Head, Marine Mammals, Representing Atlantic Region pinnipeds	DFO Science, Newfoundland Region
Sam Stephenson	Species at Risk Biologist	DFO Species at Risk Program, Central and Arctic Region
Bruce Stewart	Senior Scientist and Head	Arctic Biological Consultants
Rob Stewart	Senior DFO Research Scientist (Retired)	Sila Consultants
Denise Tenkula	Molecular Genetics Biologist, rapporteur	DFO Science, Central and Arctic Region
Fernando Ugarte (FU) * present day 1 via teleconference	Head of Department of Birds and Mammals	Greenland Institute of Natural Resources, Nuuk, Greenland
Rob Young (day 1 only)	Division Manager, Arctic Aquatic Research Division	DFO Science, Central and Arctic Region
David Yurkowski	Post-Doctoral Fellow	DFO Science, Central and Arctic Region

APPENDIX 2. TERMS OF REFERENCE[1]

Five-year research plan for walrus in the Canadian Arctic
Central and Arctic Regional Science Meeting
9:00 a.m. to 4:30 p.m. (Central Daylight Time) on 26 and 27 April 2016

Chair: Lianne Postma

Context

There are seven walrus stocks (6 management units) in the eastern Canadian Arctic (Map 1). Increasing national and international attention regarding how Canada is managing walrus stocks requires the Department to be able to demonstrate a sustainable harvest or take appropriate actions if current harvesting is deemed unsustainable. Walrus are a challenging species to enumerate owing to their aggregated distribution and correlated haulout behavior resulting in highly variable proportion of animals hauled out at a time.

Walruses have a comparatively narrow ecological niche and are generally thought to require: 1) large areas of shallow water (80 m or less) with suitable bottom substrate to support a productive bivalve community, 2) reliable open water over rich feeding areas, particularly in winter when access to many feeding areas is limited due to ice cover, and 3) the presence of haul-out areas in close proximity to feeding areas.

In Canada, walruses are primarily harvested for subsistence purposes, although some communities engage in a limited and regulated sports hunt. The walrus fishery is co-managed in accordance with Land Claim Agreements and the *Fisheries Act* and its regulations. The Committee on Species of Endangered Wildlife in Canada (COSEWIC) has assessed Atlantic walrus as ‘Special Concern’ (COSEWIC 2006). They are also listed under Appendix III of the Convention on International Trade in Endangered Species (CITES), which means that a permit from the Canadian CITES authorities is required to export walrus parts from Canada.

Fisheries management efforts are guided by Sustainable Fisheries Framework policies that seek to incorporate precautionary and ecosystem approaches into fisheries management decisions to ensure continued health and productivity of Canada’s fisheries and healthy fish stocks, while protecting biodiversity and fisheries habitat.

[1] As provided by DFO.

Objectives

The objective of the meeting is to bring together walrus researchers and management practitioners to identify data gaps and information needs, and develop a five-year research plan to help inform management and policy decisions for the conservation of walrus and their habitats to ensure long-term sustainability. In particular, key objectives include:

1. Review management objectives and priorities;
2. Overview of current walrus research initiatives (Alaska, Canada, Greenland);
3. Review research approaches;
4. Identify information gaps; and
5. Prioritize research needs and establish a five-year implementation plan.

Expected publications

The expected publication is a working paper that identifies current walrus research activities and approaches, prioritizes the research gaps to be addressed, and outlines the research plan required to provide for the long-term conservation and sustainable use of Canada's walrus fishery. This regional Science peer review meeting will generate a report that summarizes the discussions of the participants. It will be published in the Technical Report Series and available on the DFO library website. Following the meeting the working paper will be revised, if necessary, to reflect the meeting discussions.

Participation

DFO does not currently have a dedicated walrus research program and personnel with field experience are limited in order to plan and direct research efforts. Therefore, we are having a meeting with participation by other DFO regions and international experts representing Alaska and Greenland to plan a walrus science research program that delivers walrus management advice. DFO Science and Fisheries Management sectors both regionally and nationally, the Nunavut Wildlife Management Board, Nunavut Tunngavik Inc., Government of Nunavut, U.S. Geological Survey, Nunavik Marine Regional Wildlife Board, Makivik, international walrus experts (Alaska and Greenland) and general knowledge holders (e.g., hunters, elders, academia, consultants, retirees) are invited to this meeting.

Map 1. Atlantic walrus stocks/stock units in the eastern Canadian Arctic.

APPENDIX 3. MEETING AGENDA[2]

AGENDA: 26-27 April 2016 Freshwater Institute, 501 University Crescent, Winnipeg MB

RATIONALE

Purpose of Event: Active participation to discuss and plan Atlantic walrus research in the Canadian Arctic region based on available techniques for fisheries stock assessment. Results will be recorded in a Technical Report that details what is needed over the next 5 years to advance the management and conservation of walruses in Canada. The information will be used to develop a research plan to deliver science advice for management while also conducting ecosystem research for large-scale conservation.

Benefit to DFO: Develop 5-year research plan for walrus in the Canadian Arctic relevant for Canadian management goals and international conservation requirements.

Participant Justification: DFO does not currently have a dedicated walrus research program and personnel with field experience are limited. Therefore, a meeting with participation by Canadian and international knowledge holders will plan a walrus science program that delivers walrus management advice. Also, invited are our co-management partners, NWMB, GN, NTI, Makivik, NMRWB as well as DFO Fisheries Management personnel to represent interests from various groups.

PARTICIPANTS See Appendix 1.

DAY ONE

9:00 AM – 9:30 AM (1/2 HOUR)

Introductory Remarks (R. Young, 5 minutes)

Introductions and agenda (Roundtable, 5 minutes)

Background and Terms of Reference (Blanchfield/Ferguson – 20 minutes)

9:30 AM – 10:00 AM (1/2 HOUR)

Management and Conservation (DFO/COSEWIC/SARA/CITES) – A. McPhee – 25 mins

10:00 AM – 10:30 AM (1/2 HOUR)

[2] As provided by DFO

Break

10:30 AM – 12:00 AM (1.5 HOUR)

Project Presentations [Edited to reflect sequence changes]

- Alaska research – C. Jay – 45 mins
- Canada research – P. Blanchfield – 15 mins
- TEK – A. McPhee – 15 mins
- Nunavimmiut Knowledge and Science – K.Breton-Honeyman – 15 mins

12:00 AM – 1:00 PM (1.0 HOUR)

Lunch - order in

1:00 PM – 3:00 PM (2 HOURS)

Research Approaches

- Biopsy sampling – B. Dunn – 15 mins
- Genetic Mark-Recapture – L. Postma – 15 mins
- Aerial surveys – M. Hammill – 15 mins
- Greenland research –F. Ugarte – 30 mins
- Remote imagery – R. Stewart – 15 mins
- Telemetry – C. Jay – 15 mins
- Others (Discussion) – 15 mins

3:00 PM – 3:15 PM

Break

3:15 PM - 4:45 PM (1.5 HOUR)

- ➢ Develop a template (information needed) for the drafting of the research plan (e.g. identify priorities, planned activities, general timelines etc…).
- ➢ Plan tomorrow's break-out groups (2-3 groups), determine appropriate topics for discussion, clarify objectives.

Evening Events

Dinner out together for those available

DAY TWO

9:00 AM – 10:30 AM (1.5 HOURS)

- Review of Day 1: Recap what was discussed previous day and add any other thoughts, ideas people may have thought of overnight.
- Review tasks to be accomplished by breakout groups.
- Discussions in breakout groups.

10:30 AM – 11:00 AM (1/2 HOUR)

Break

11:00 AM – 12:00 AM (1 HOUR)

- Review of previous breakout group discussions, modify approach as needed.
- Round 2 of breakout group discussions.

12:00 AM – 1:00 PM (1 HOUR)

Lunch – order in

1:00 PM – 3:00 PM (2.0 HOURS)

- Larger group review of breakout group summaries.
- Larger group identify gaps and future challenges.
- Resourcing analysis including assessment of financial and human resources required and collaboration and funding opportunities.

3:00 PM – 3:15 PM

Break

3:15 PM - 4:30 PM (1.25 HOURS)

- Bring together all products and continue discussion in context of developing a research plan with consensus points.
- Review of preliminary outline/draft of a research plan and instructions for what should be reflected in meeting report. Provide direction for contractors.
- Plan for next steps – finalizing plan, communicating plan, and writing funding proposals.

Meeting adjourned – Thanks for everyone's contribution!

APPENDIX 4 A-L. PRESENTATIONS

Appendix 4A. DFO walrus research planning meeting introduction (Paul Blanchfield, DFO Winnipeg).

Slide 1

2

Rationale

- DFO does not currently have a dedicated walrus research program
- seeking advice to plan a walrus science research program
- participants include:
  - international walrus experts and general knowledge holders (e.g., hunters, elders, academia, government, consultants, retirees)
  - DFO Science and Fisheries Management
  - Nunavut Wildlife Management Board, Nunavut Tunngavik Inc., Government of Nunavut, Nunavik Marine Regional Wildlife Board, Makivik

3

Meeting Objectives

bring together walrus researchers and management practitioners to:

- identify data gaps and information needs
- develop a 5 year research plan
  - inform management and policy decisions for the conservation of walrus and their habitats to ensure long-term sustainability

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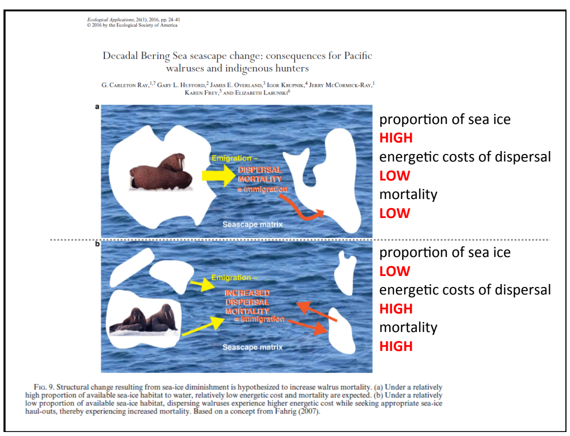

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Meeting Objectives

1. Review management objectives and priorities
2. Overview of current walrus research initiatives (Alaska, Greenland, Canada)
3. Review research approaches
4. Identify information gaps
5. Prioritize research needs and establish a 5 year implementation plan

Appendix 4A continued.

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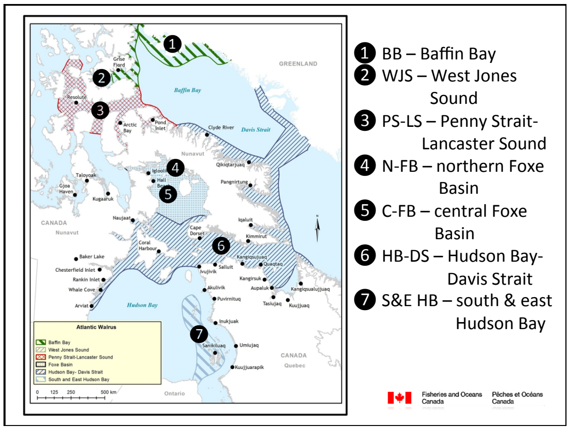

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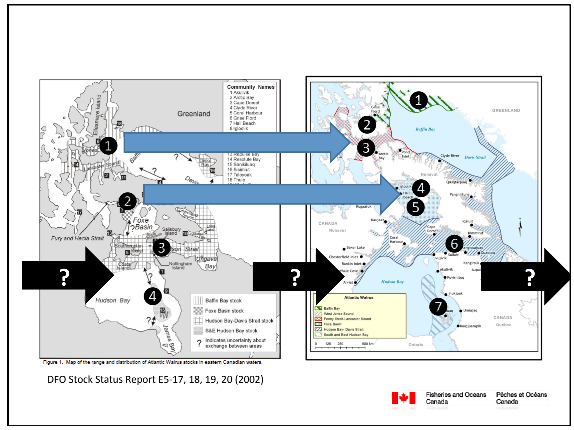

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Appendix 4B. Walrus management in Nunavut (Allison McPhee, DFO, Winnipeg).

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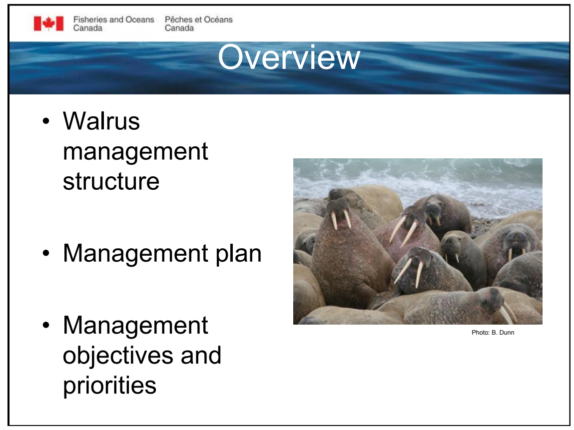

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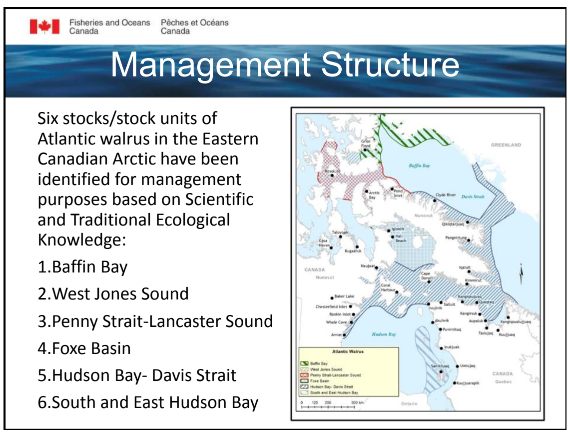

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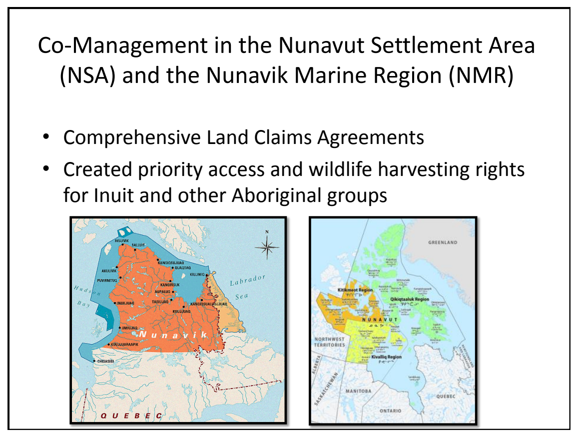

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Changes to Walrus Management

- Increased national and international interest in how the walrus fishery is managed.
- Demonstrate sustainable harvesting.
- Strengthen walrus co-management consistent with NLCA/NILCA wildlife harvesting and management provisions.
- Incorporate best available scientific and Inuit knowledge.

8

Fisheries and Oceans Canada Pêches et Océans Canada

Walrus Working Groups- Nunavut

- Anticipating the collection of science information, in 2007 DFO established Walrus Working Groups to start the development of an Integrated Fisheries Management Plan (IFMP) for Walrus.

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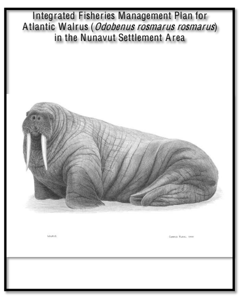
Fisheries and Oceans Canada Pêches et Océans Canada

IFMP

- Developed through an adaptive co-management process;
- 10 Walrus Working Group meetings;
- 2 separate rounds of community consultations with high Arctic and Foxe Basin communities
- Final IFMP currently going through a written hearing process
- Decision anticipated in June 2016


Integrated Fisheries Management Plan for Atlantic Walrus (*Odobenus rosmarus rosmarus*) in the Nunavut Settlement Area

10

Fisheries and Oceans Canada Pêches et Océans Canada

IFMP

- Includes the best available information on the species biology, abundance, distribution, governance, traditional knowledge and management issues.
- It will be used to provide direction in the sustainable management of walrus in the NSA.

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Fisheries and Oceans Canada Pêches et Océans Canada

Management Issues

- **Abundance Estimates/ Stock Status Updates**: The conservation of walrus requires a detailed understanding of their population size, spatial distribution and demographic trends.
- **Sustainable Harvest Levels**: Ensure the conservation of walrus and that the harvesting of walrus is sustainable.
- **Struck and Lost Rates:** Determining appropriate struck and lost rates are required in order to estimate sustainable harvest levels.
- **Hunter Training/ Reducing Loss Rates**: This would include training on the best harvesting techniques, when and where to harvest, hunter safety, preparation and preservation of meat, and how to minimize struck and lost rates.
- **Monitoring and Reporting**: Timely, accurate reporting of walrus harvesting is essential.
- **Sport Hunt** : Develop by-laws or guidelines that would identify the community rules or best management practices for the sport hunt.

12

Fisheries and Oceans Canada Pêches et Océans Canada

Management Issues

- **Abundance Estimates/ Stock Status Updates**: The conservation of walrus requires a detailed understanding of their population size, spatial distribution and demographic trends.
- **Sustainable Harvest Levels**: Ensure the conservation of walrus and that the harvesting of walrus is sustainable.
- **Struck and Lost Rates:** Determining appropriate struck and lost rates are required in order to estimate sustainable harvest levels.
- **Hunter Training/ Reducing Loss Rates**: This would include training on the best harvesting techniques, when and where to harvest, hunter safety, preparation and preservation of meat, and how to minimize struck and lost rates.
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- **Sport Hunt** : Develop by-laws or guidelines that would identify the community rules or best management practices for the sport hunt.

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Fisheries and Oceans Canada / Pêches et Océans Canada

Management Issues

- **Ship Traffic/Development/ Tourism**: There are a number of potential impacts and threats from increased development and shipping activities
- **Food Safety**: Outbreaks of trichinosis.
- **Shared Stocks**:
  - *Within Canada*: (Nunavut and Nunavik)
  - *Greenland*
- **Oceans and Habitat Considerations**: e.g. Marine Protected Areas (MPA); Ecological and Biologically Significant Areas (EBSA)
- **COSEWIC; SARA; CITES**:

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Fisheries and Oceans Canada / Pêches et Océans Canada

Management Issues

- **Ship Traffic/Development/ Tourism**: There are a number of potential impacts and threats from increased development and shipping activities
- **Food Safety**: Outbreaks of trichinosis.
- **Shared Stocks**:
  - *Within Canada*: (Nunavut and Nunavik)
  - *Greenland*
- **Oceans and Habitat Considerations**: e.g. Marine Protected Areas (MPA); Ecological and Biologically Significant Areas (EBSA)
- **COSEWIC; SARA; CITES**:

15

Fisheries and Oceans Canada / Pêches et Océans Canada

Traditional Knowledge

Important element for all identified management objectives. Includes consideration for:

- research design and implementation
- communication materials to inform on research methods, activities and results

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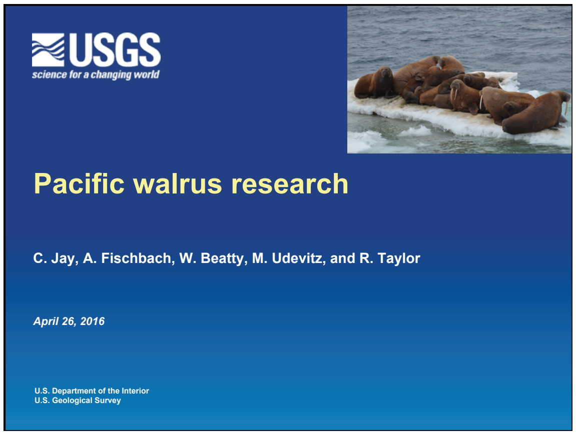
Fisheries and Oceans Canada / Pêches et Océans Canada

Key Management Issues

- Population abundance estimates for remaining stocks (SE Hudson Bay, HBDS)
- Sustainable harvest level recommendations
- Updated stock status (high Arctic stocks)
- Stock delineation (high Arctic stocks (shared with Greenland), HBDS (shared NV/NU and Greenland) and SEHB (shared NU/NV)

Appendix 4C. Pacific walrus research (Chad Jay, USGS, Alaska).

Slide 1



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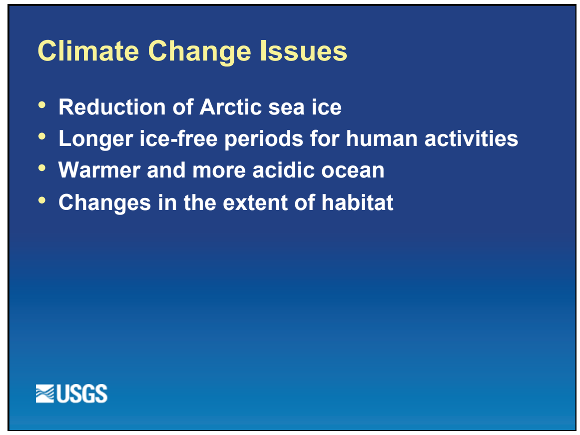

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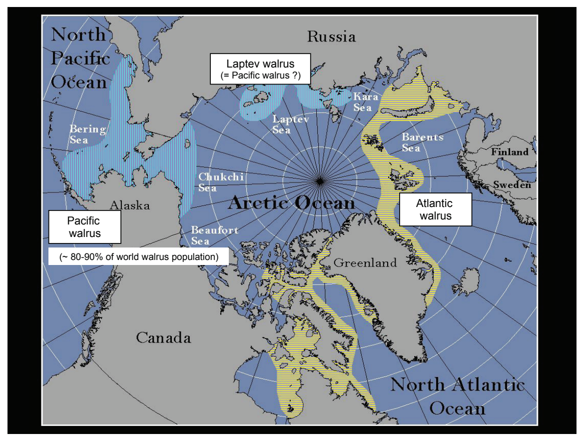

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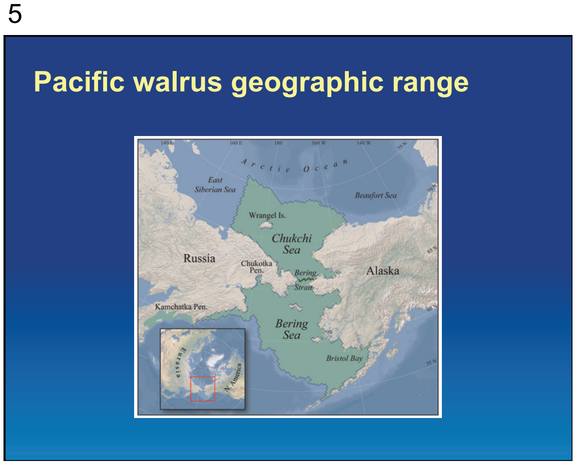

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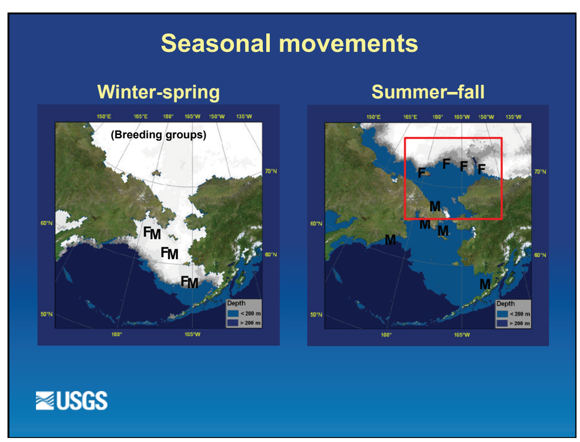

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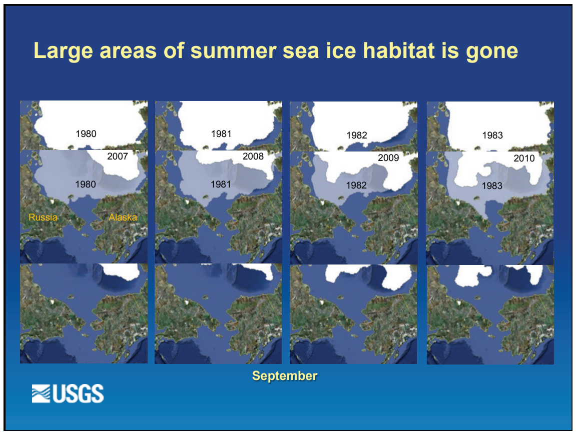

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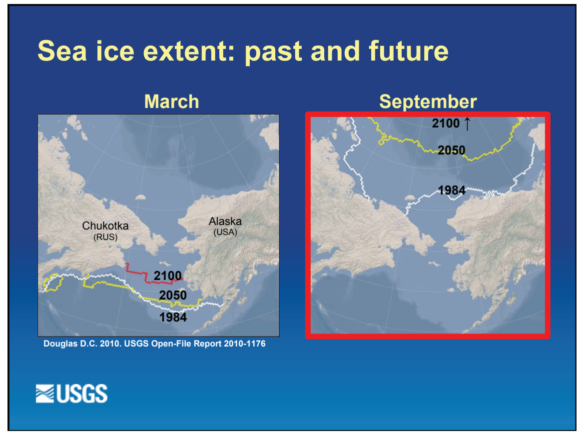

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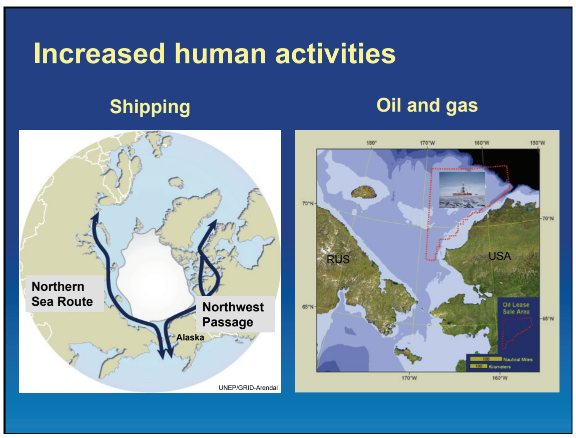

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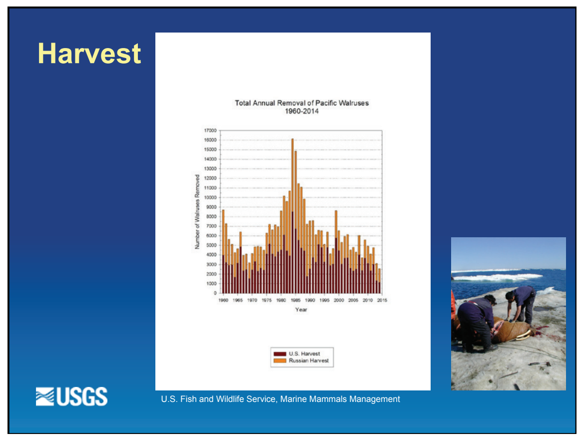

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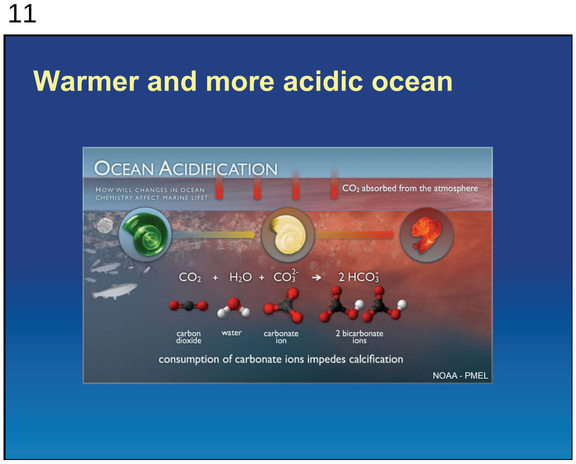

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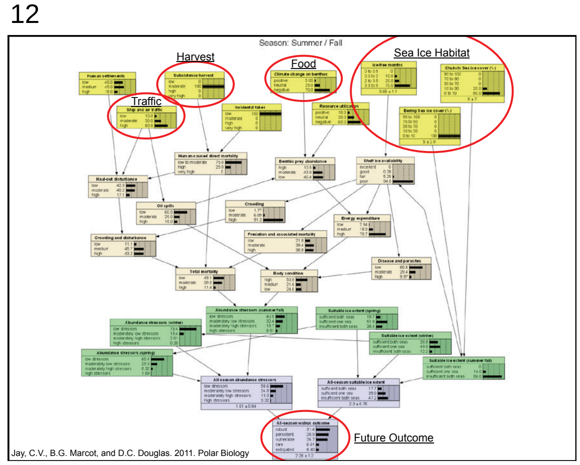

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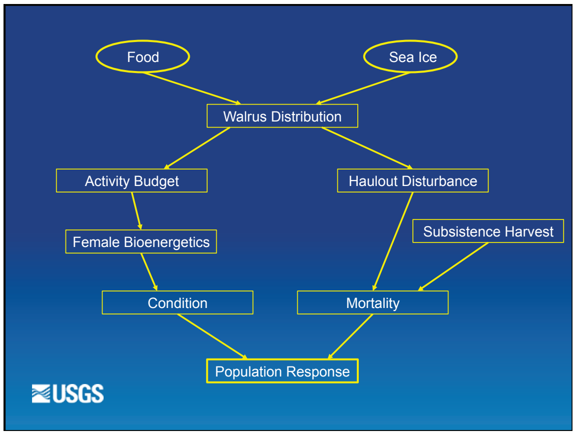

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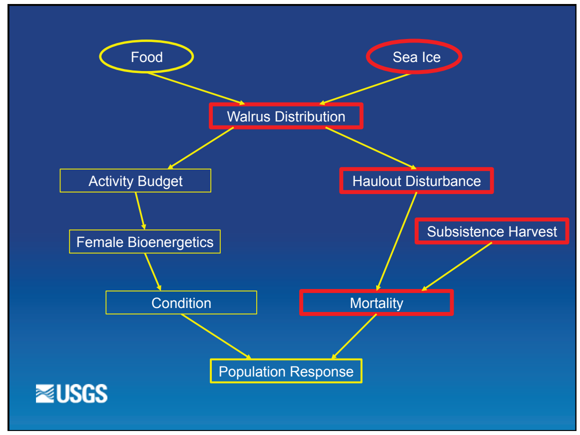

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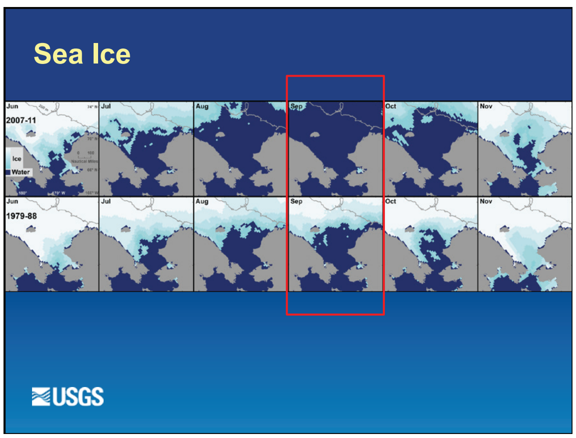

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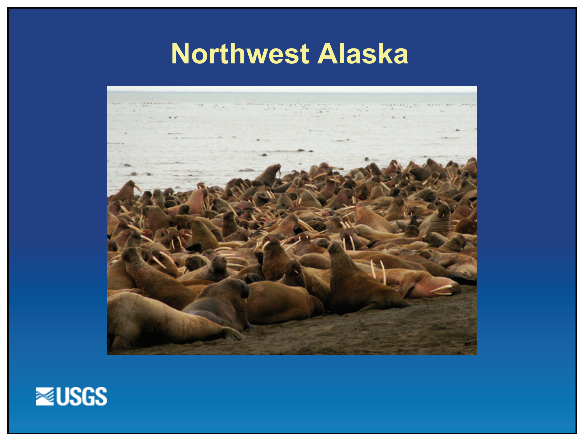

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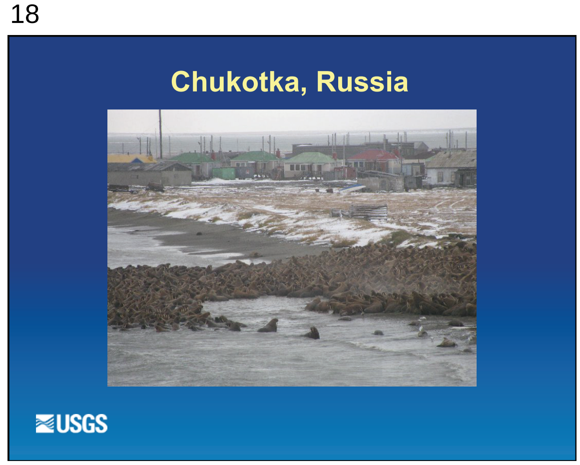

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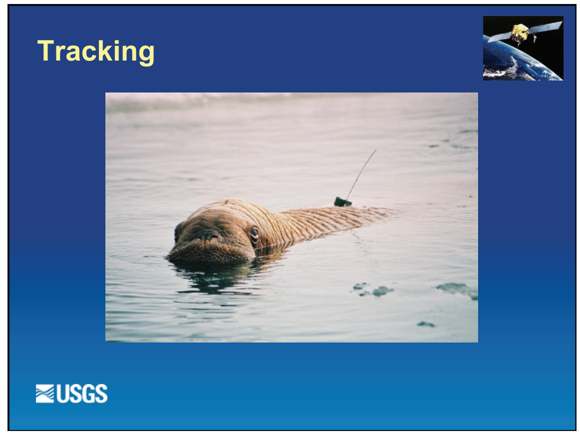

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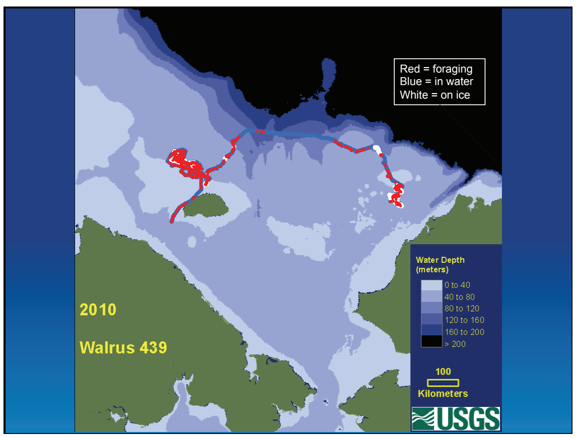

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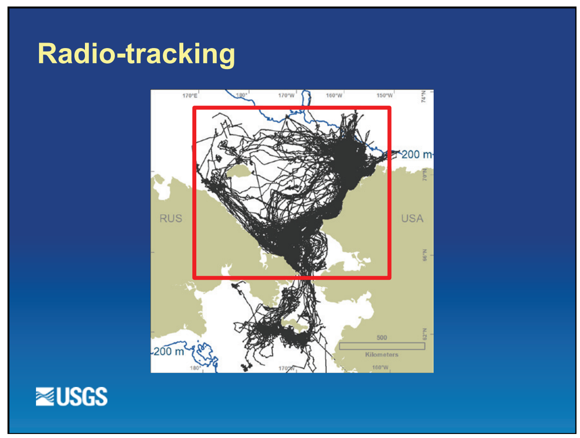

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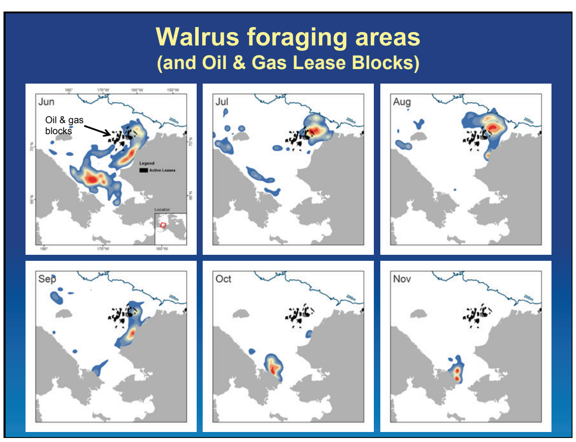

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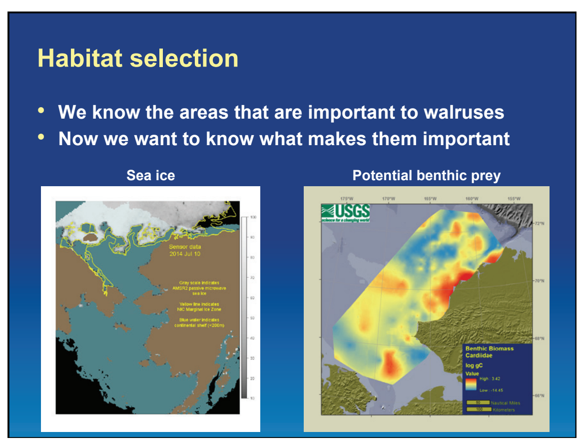

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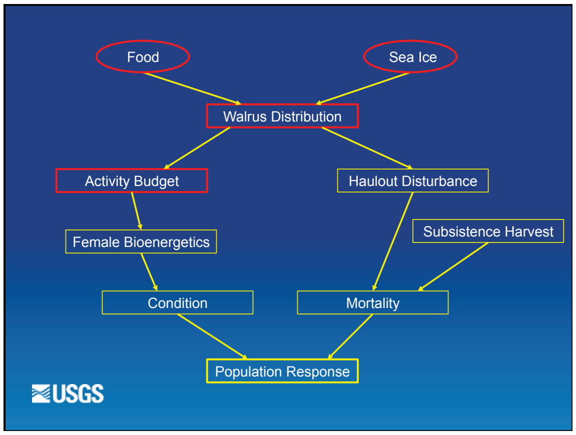

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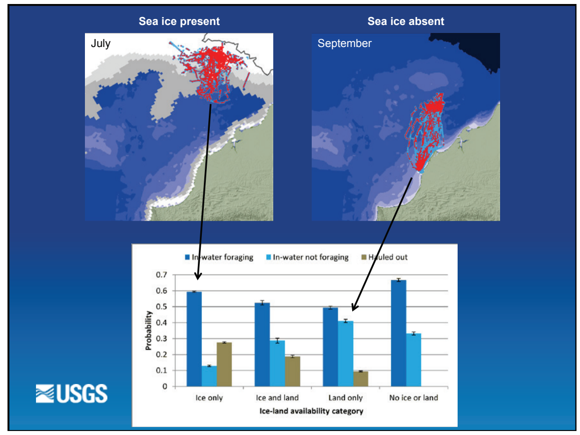

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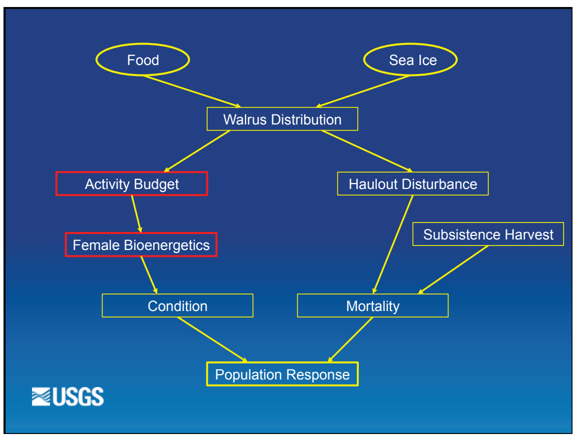

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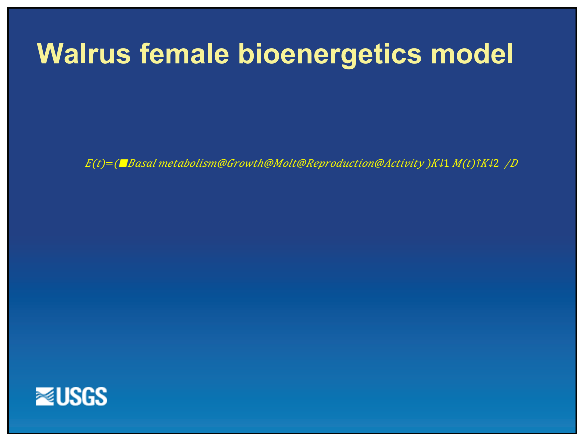

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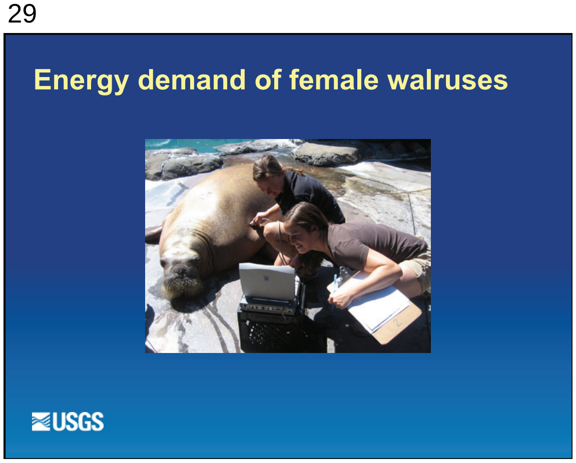

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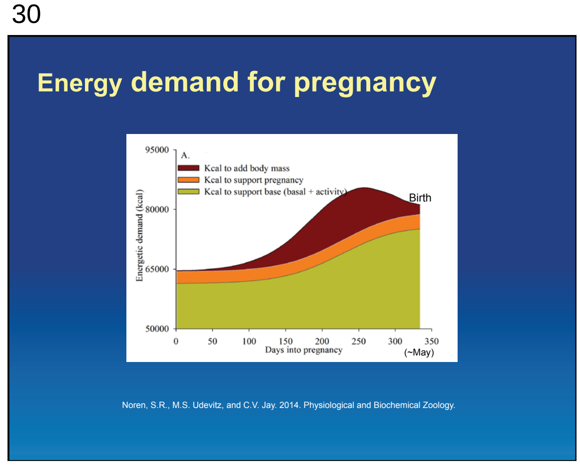

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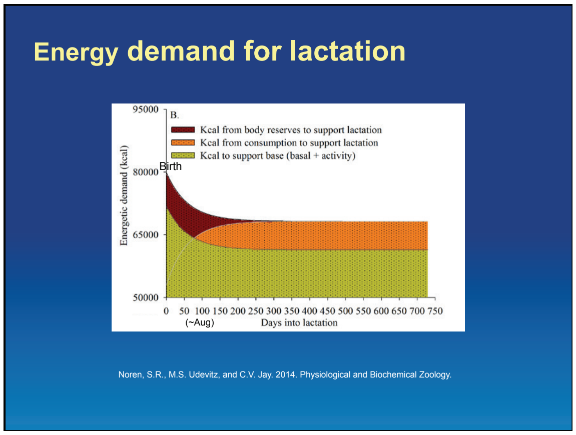

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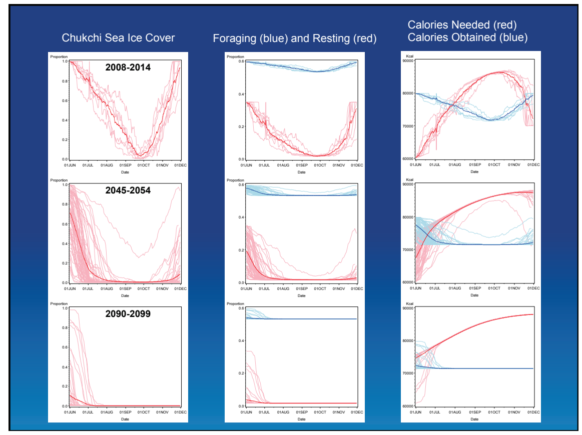

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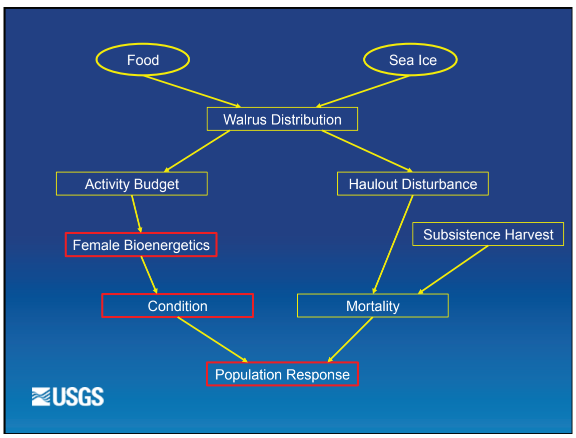

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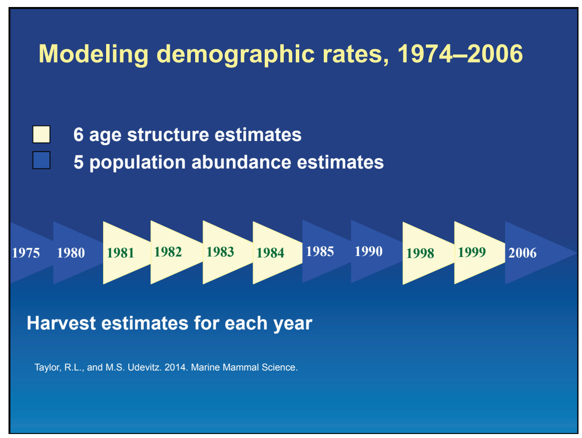

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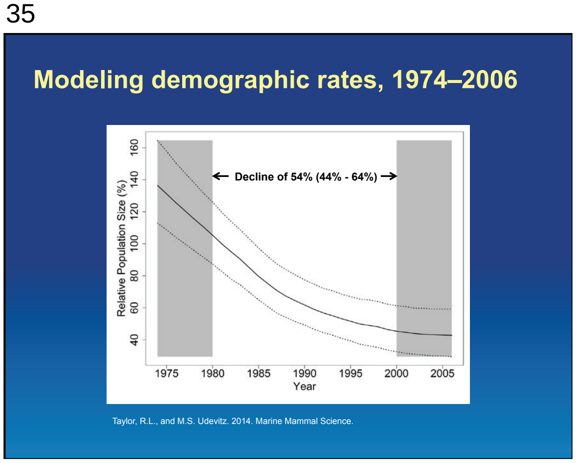

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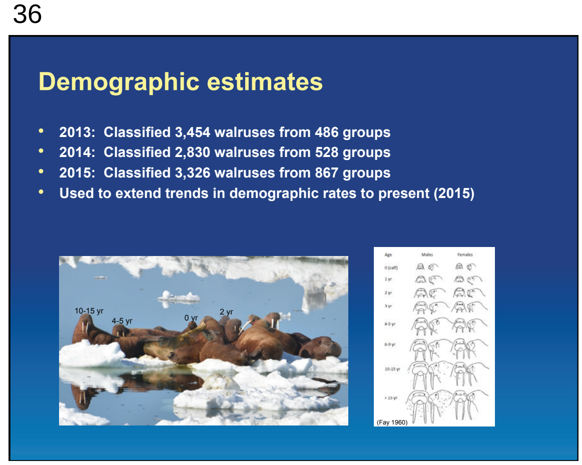

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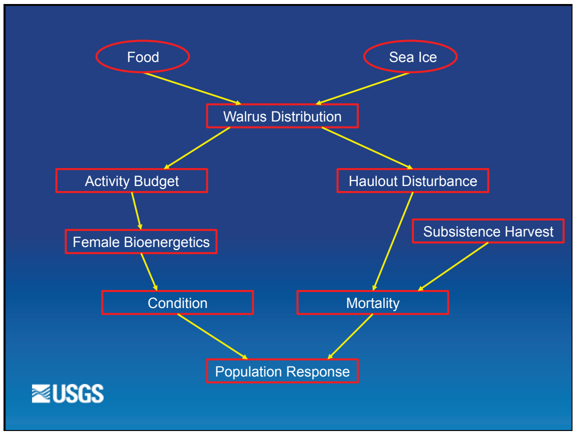

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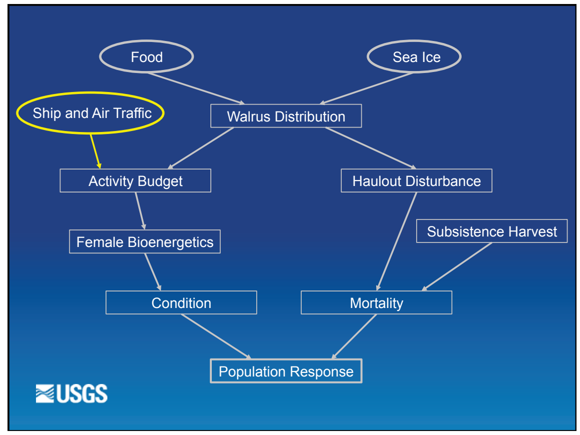

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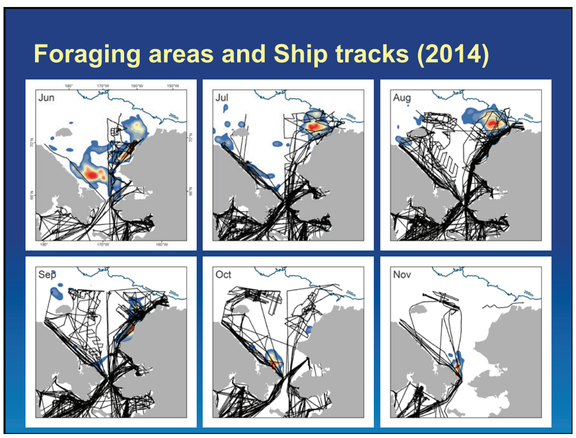

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Appendix 4D. Canadian walrus research (Paul Blanchfield, DFO, Winnipeg).

Slide 1

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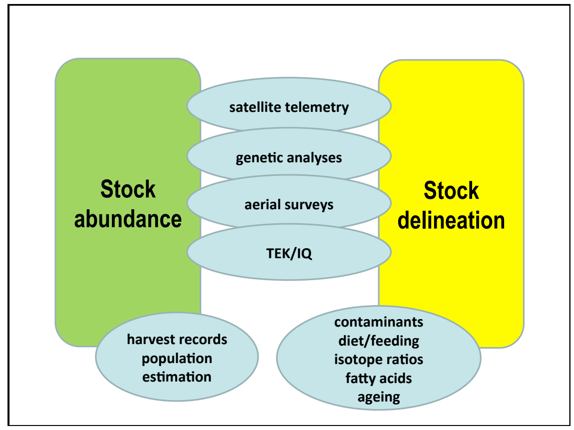

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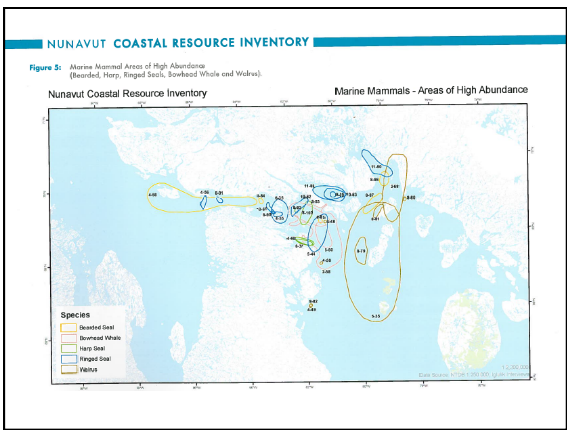

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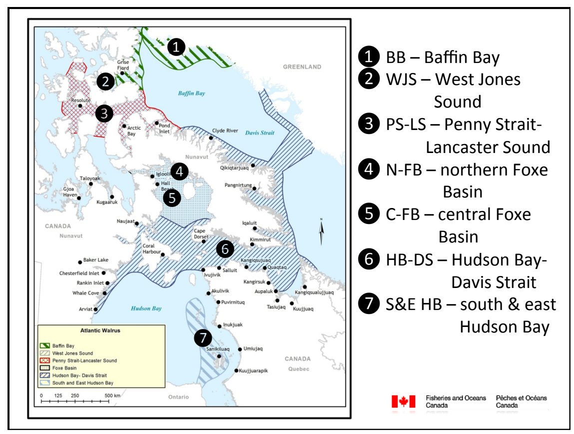

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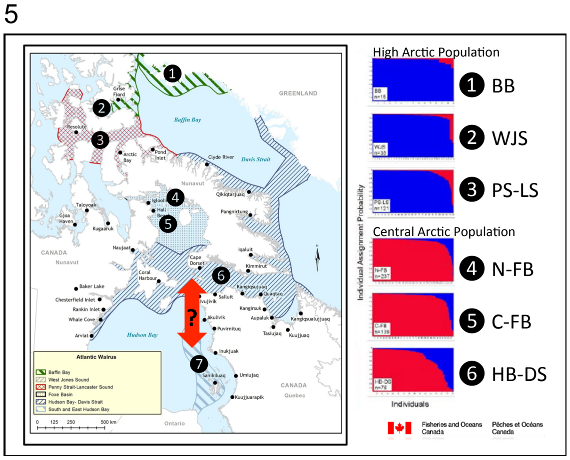

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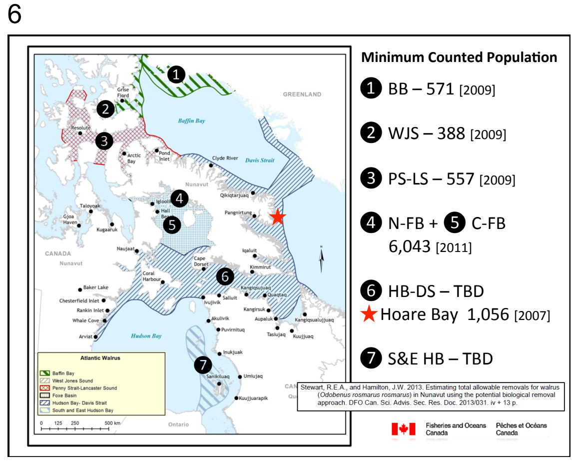


Appendix 4D continued.

7

❶ count walrus on land
- aerial surveys
- photos

➕

❷ account for walrus at sea
- satellite telemetry

=

❸ population estimate

⬇

❹ calculate Total Allowable Harvest (TAH)

⬅

❺ calculate Total Allowable Landed Catch (TALC) to account for known losses

8

❶ count walrus on land
- aerial surveys
- photos

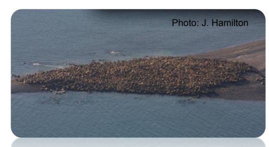
- **August and September 2010 & 2011**

9

❶ count walrus on land
- aerial surveys
- photos

10

❶ count walrus on land
- aerial surveys
- photos



Year	#Walrus Counted on Land
2010	3,861 (2,409)
2011	6,033 (1,117 - 4,484)

11

❶ count walrus on land
- aerial surveys
- photos

➕

❷ account for walrus at sea
- satellite telemetry

=

❸ population estimate

⬇

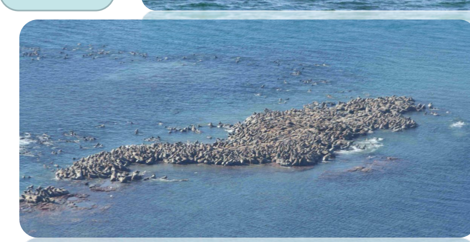
❹ calculate Total Allowable Harvest (TAH)

⬅

❺ calculate Total Allowable Landed Catch (TALC) to account for known losses

12

❷ account for walrus at sea
- satellite telemetry



Appendix 4D continued.

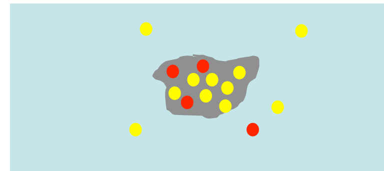
13

❷ account for walrus at sea
- satellite telemetry

- determine proportion of walrus at sea from literature values (Adjustment #1)
- collect survey-specific data prior to aerial surveys (Adjustment #2)
  - 11 walrus tagged in 2010
  - 23 walrus tagged in 2011

14

❷ account for walrus at sea
- satellite telemetry



Adjustment #1
- 6 studies
- 70 walrus tagged
  - 74% of walrus on land

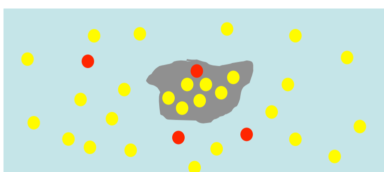
MCP$_{HO}$/0.74

Table 1. Maximum proportions of satellite tagged walrus hauled out concurrently. Variance for each proportion (p) is the binomial variance (p(1-p)/(n-1) for small samples (Zar 1999). SD = Standard Deviation

Location/ season	Year	Number of tags (dry/total)	Maximum proportion hauled out (SD)	Source
Alaska/ summer	1990	5/6	0.833 (0.17)	Hills 1992
Svalbard/ August	2003 2004	6/9 9/11	0.667 (0.17) 0.818 (0.12)	Lydersen *et al.* 2008, C. Lydersen pers. comm. 2011
Alaska/April	2004 2006	8/12 17/24	0.667 (0.14) 0.708 (0.10)	Udevitz *et al.* 2009, M. Udevitz pers. comm. 2011
NE Greenland/ August	2009	7/8	0.875 (0.13)	Born, unpubl. data
Weighted average		0.743 (52/70)		
Variance SD CV		0.0028 0.053 0.07		

15

❷ account for walrus at sea
- satellite telemetry



- walrus abundance estimates are greater using Adjustment #2

MCP$_{HO}$/%tags dry

Adjustment #2

Year	#active transmitters	%Walrus on land
2010	8	38%
2011	12	25%

16

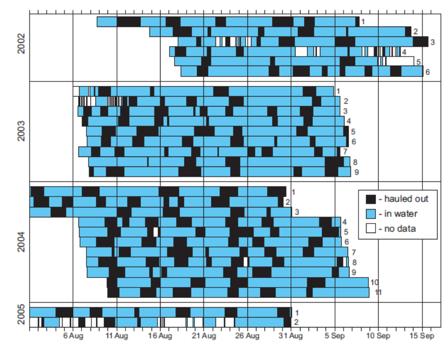


FIG. 3. Haul-out chronologies for 28 walrus data sets based on information from satellite relay data loggers (SRDLs) deployed on the tusks of the animals in August 2002 to 2004. For SRDLs that transmitted for more than one year (walruses 1, 2, and 3 in 2004, and 1 and 2 in 2005), we included haul-out information from the first 30 days of deployment, starting 24 h after drugging, in addition to haul-out data from the 30 first days of August the following year. The figure illustrates that within each year, walruses that were tagged at the same time tend to be hauled out (and thus also at sea) at the same time more frequently than would be expected by chance.

Lydersen et al. 2008 Arctic

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❶ count walrus on land
- aerial surveys
- photos

\+

❷ account for walrus at sea
- satellite telemetry

=

❸ population estimate

Year	#Walrus on Land	#Walrus at Sea	Total # Walrus
2010	2,409	4,071	**6,480**
2011	4,484	8,968	**13,452**

18

❶ count walrus on land
- aerial surveys
- photos

\+

❷ account for walrus at sea
- satellite telemetry

=

❸ population estimate

↓

❹ calculate Total Allowable Harvest (TAH)

←

❺ calculate Total Allowable Landed Catch (TALC) to account for known losses

Appendix 4D continued.

19

❹ calculate Total Allowable Harvest (TAH)

- Potential Biological Removal (PBR) method
- adopted by DFO Science for marine mammal species that are considered "data-poor" (e.g. narwhal, beluga and bowhead)
- estimate of the maximum number of animals that can be removed without depleting a stock/population, or allowing the stock to grow

20

❹ calculate Total Allowable Harvest (TAH)

$$PBR = N_{min} \times \tfrac{1}{2} R_{max} \times F_R$$

N_{min} = estimate of minimum population size
R_{max} = maximum reproduction rate (0.07)
F_R = recovery factor (0.5)

21

❹ calculate Total Allowable Harvest (TAH)

Year	Total # Walrus	N_{min}	PBR
2010	6,480	4,756	**83**
2011	13,452	9,510	**166**

22

❶ count walrus on land
- aerial surveys
- photos

+

❷ account for walrus at sea
- satellite telemetry

=

❸ population estimate

↓

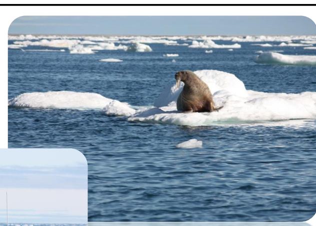
❹ calculate Total Allowable Harvest (TAH)

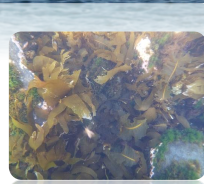
←

❺ calculate Total Allowable Landed Catch (TALC) to account for known losses

23

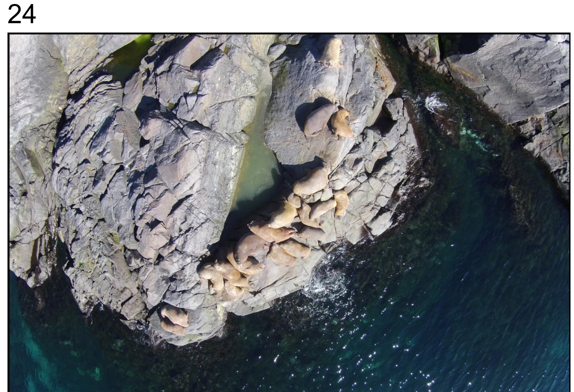
Where to from here?





Fisheries and Oceans Canada Pêches et Océans Canada

24

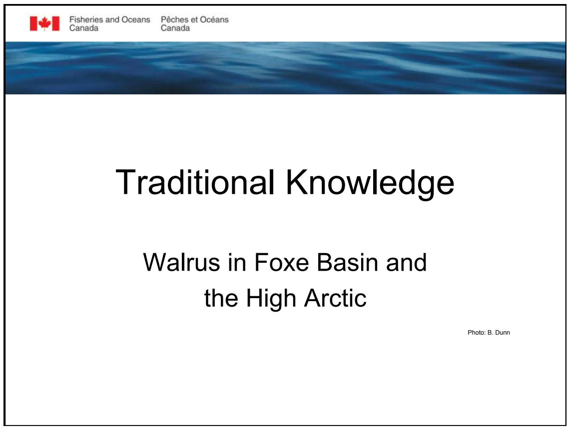


Drone survey of haulout on Walrus Island, NU
P. Blanchfield & A. Chapelsky, August 2015

Fisheries and Oceans Canada Pêches et Océans Canada

Appendix 4E. Traditional knowledge of walrus in Foxe Basin and the High Arctic (Allison McPhee, DFO, Winnipeg).

Slide 1



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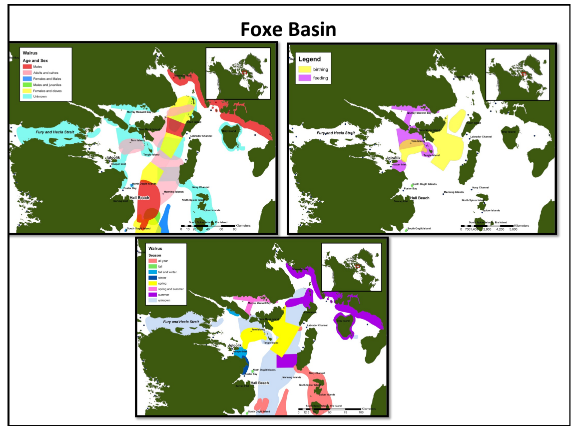

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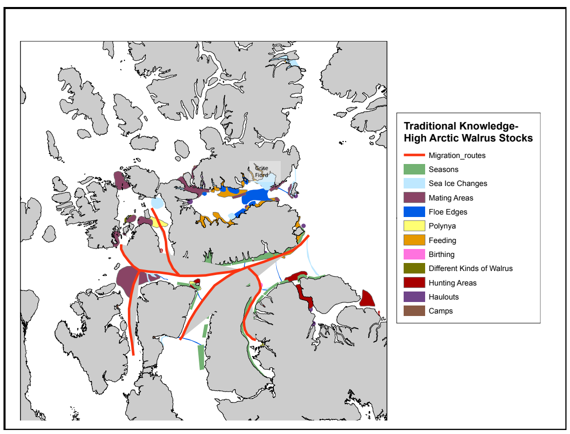

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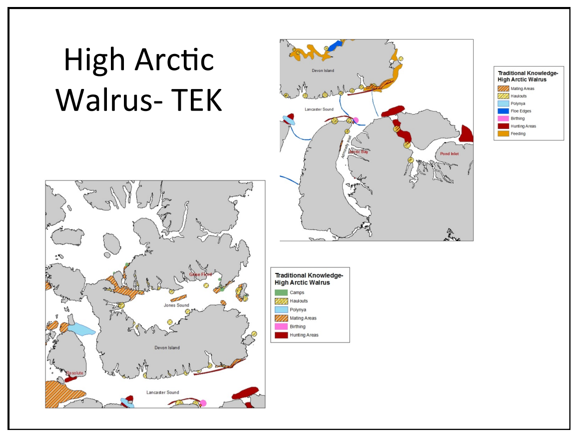

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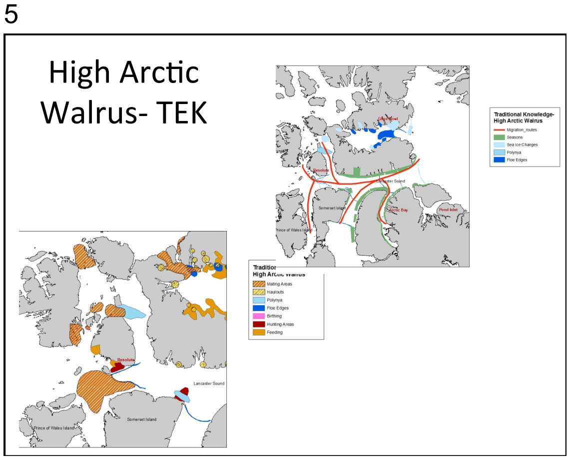

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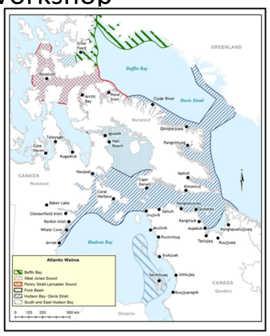
Appendix 4E continued.

7

Walrus Traditional Knowledge 2-Day Workshop

- Walrus knowledge holders from key communities in Hudson Bay-Hudson Strait area of Nunavut and co-management organizations;
- Share scientific and local traditional knowledge of walrus, including biology, habit uses, local changes in the environment, hunting practices and techniques, and walrus management.



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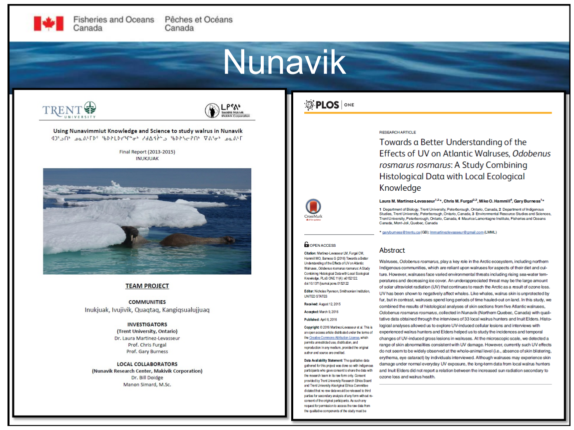
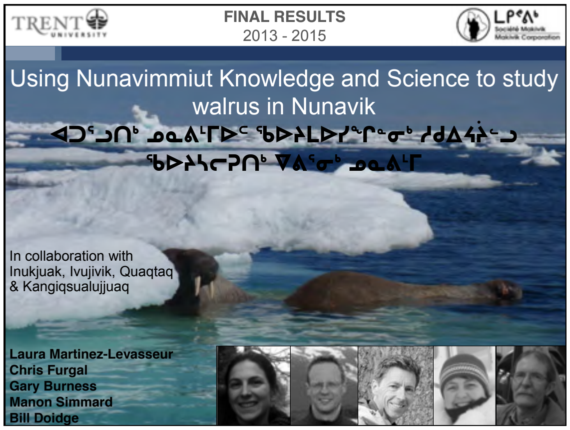


Appendix 4F. Using Nunavimmiut knowledge and science to study walrus in Nunavik (Kaitlin Breton-Honeyman, NMRWB).

Slide 1



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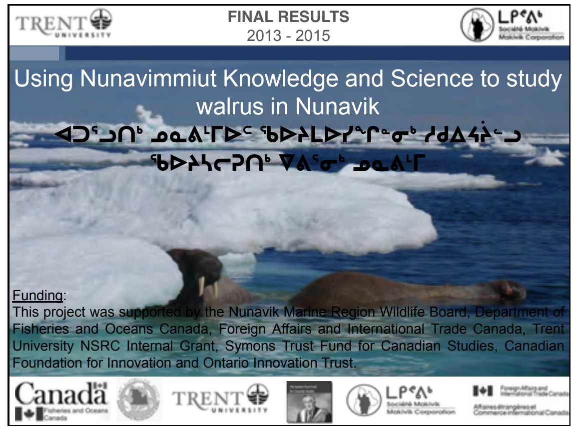

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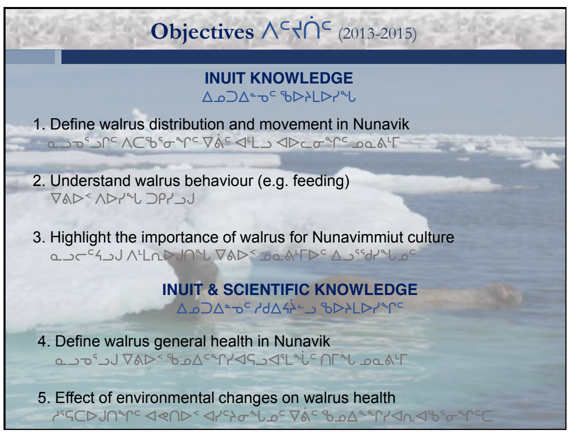

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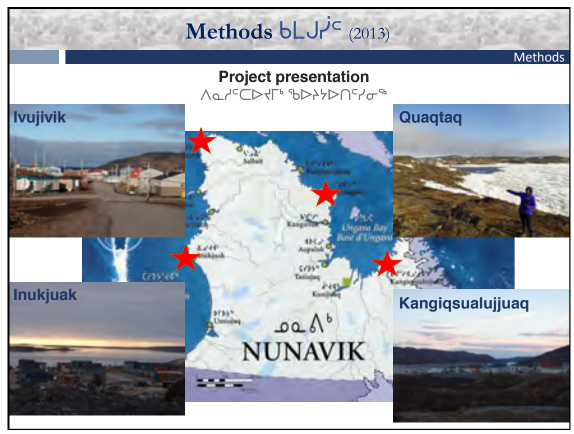

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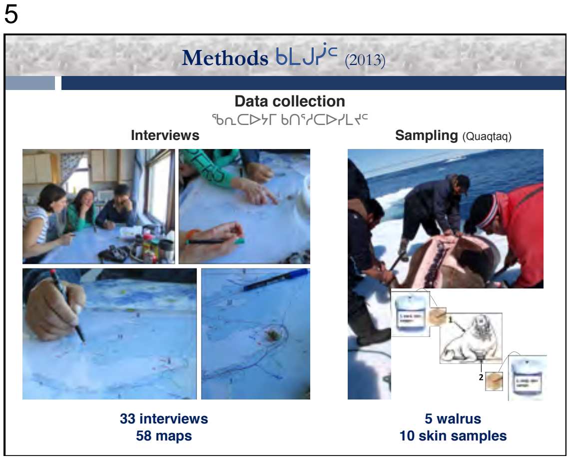

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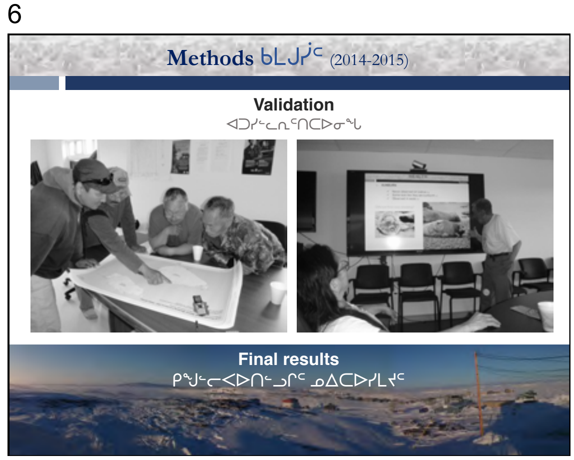

Appendix 4F continued.

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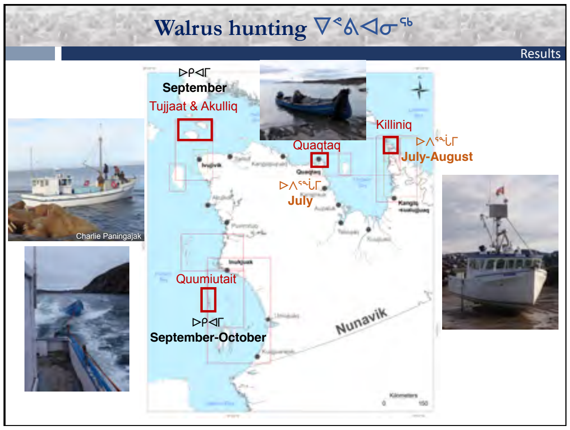

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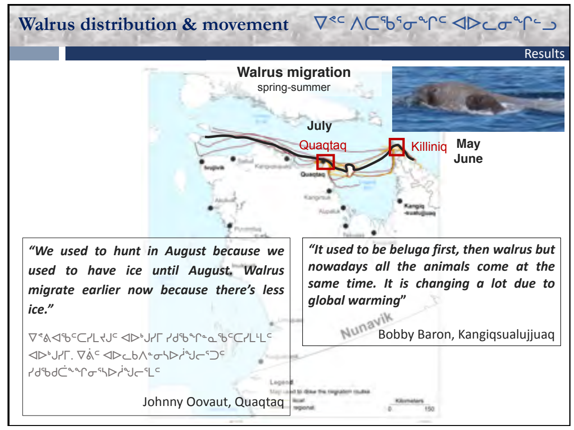

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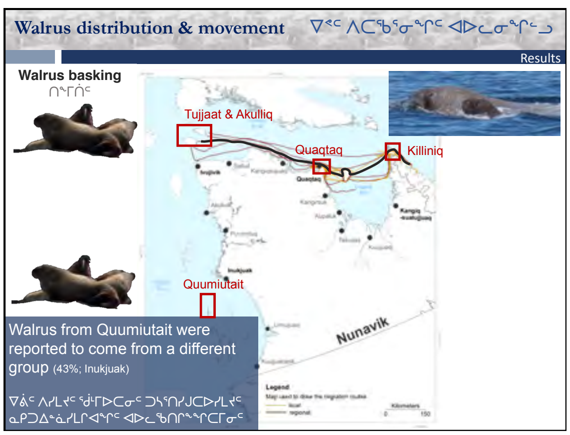

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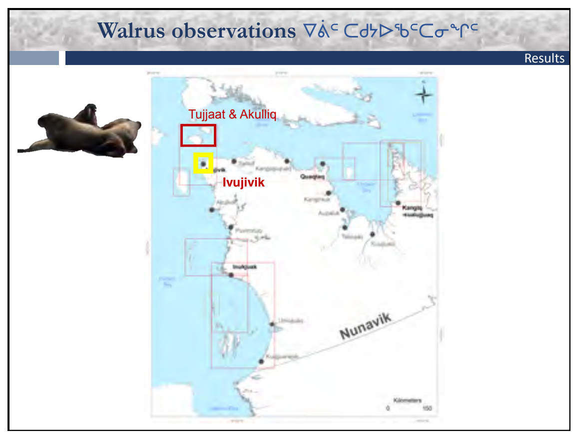

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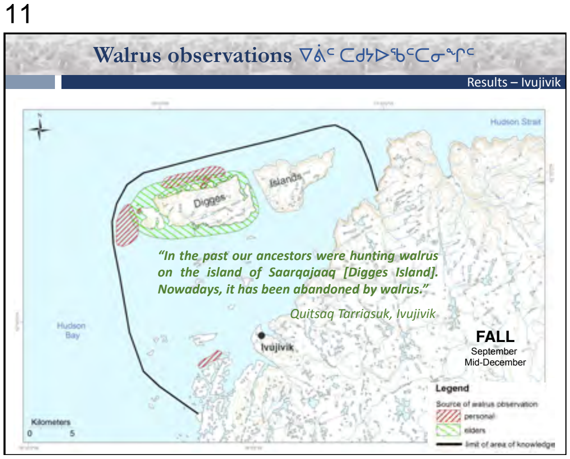

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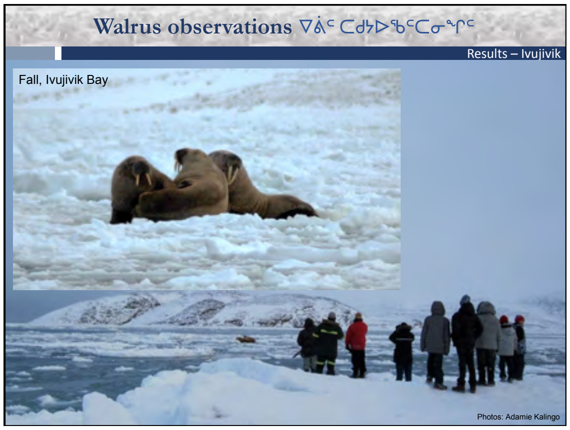

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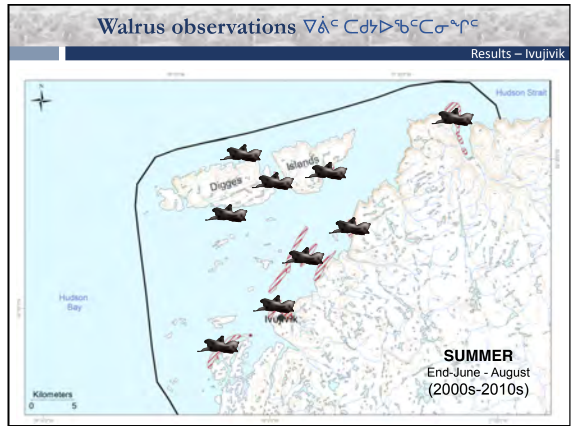

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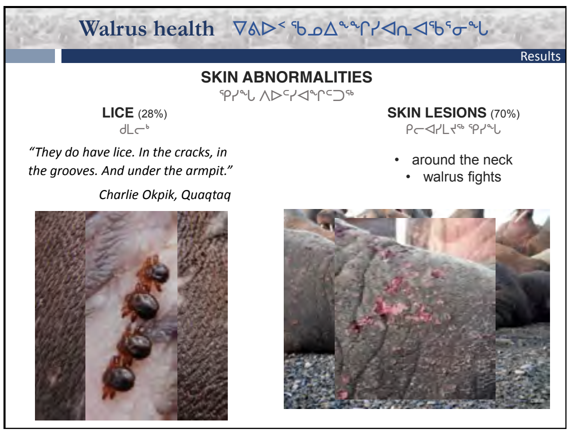

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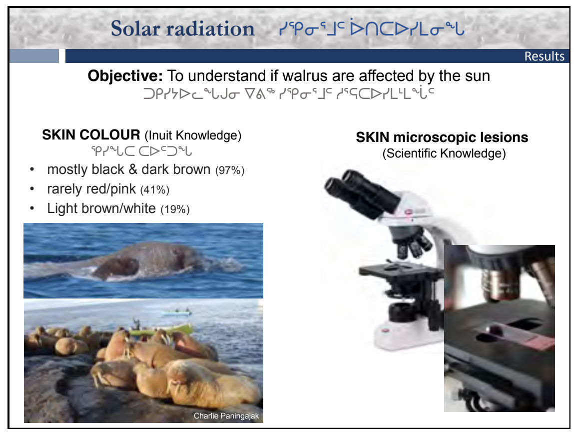

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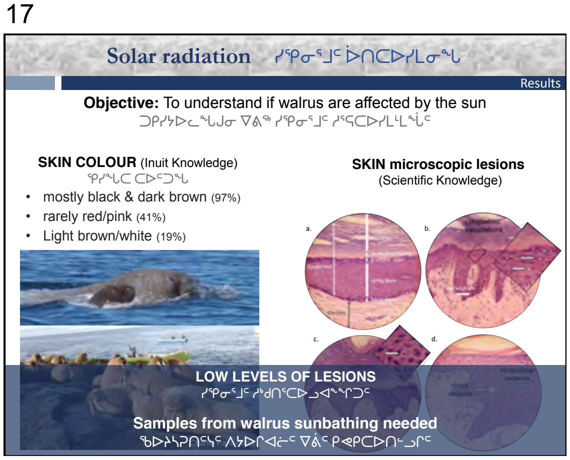

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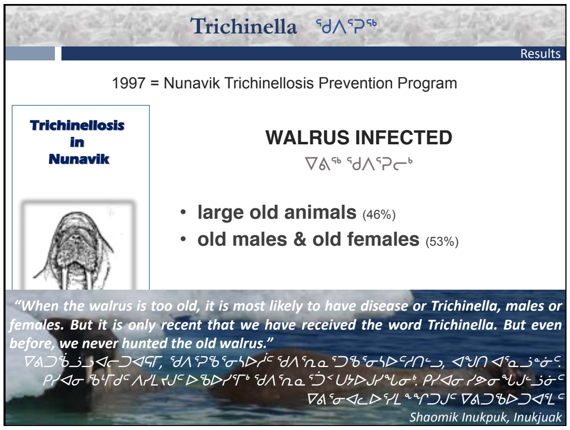

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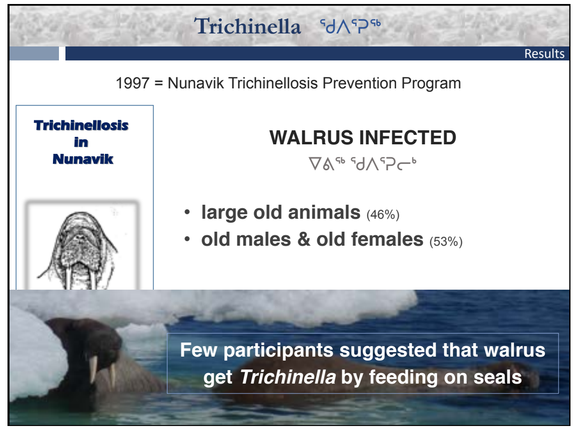

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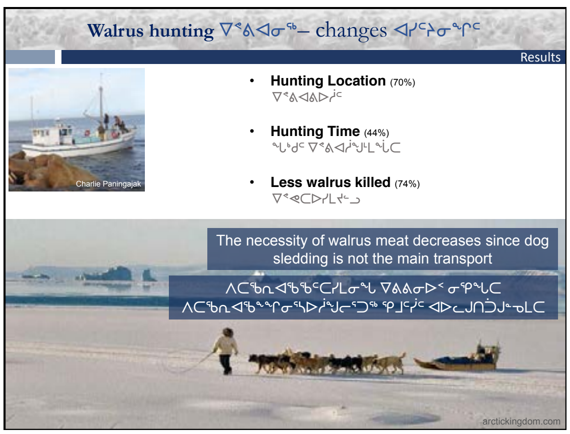

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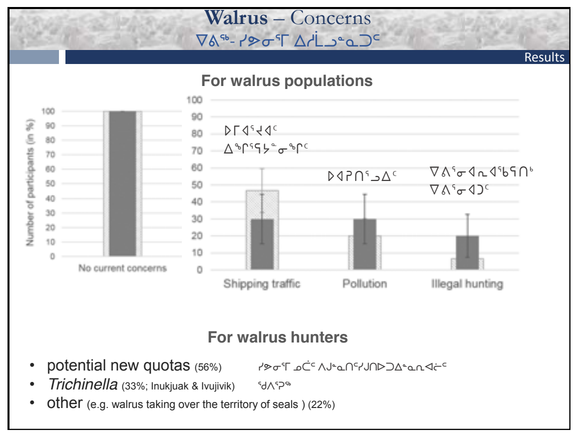

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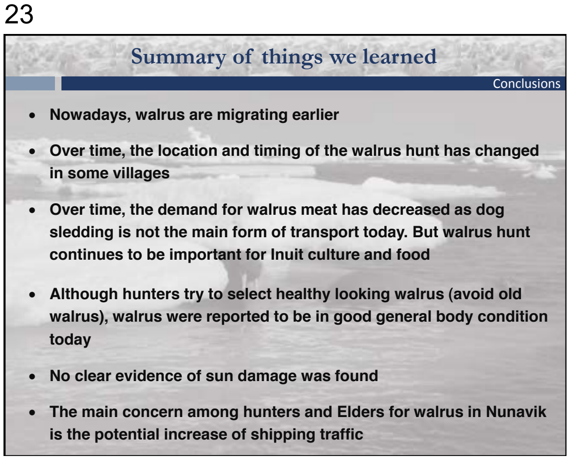

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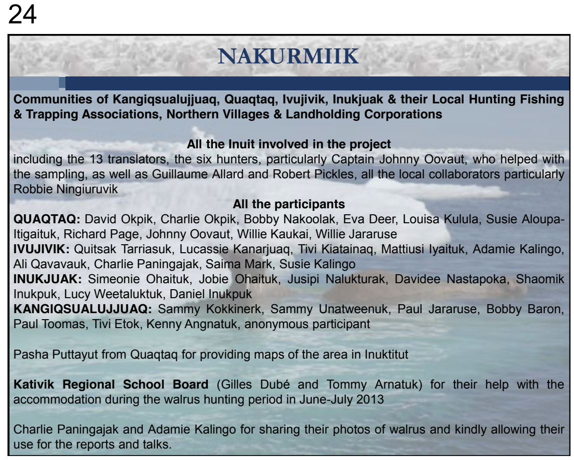
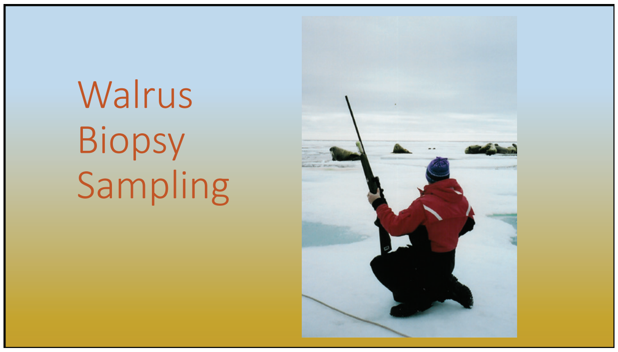


Appendix 4G. Walrus biopsy sampling (Blair Dunn, DFO, Winnipeg).

Slide 1



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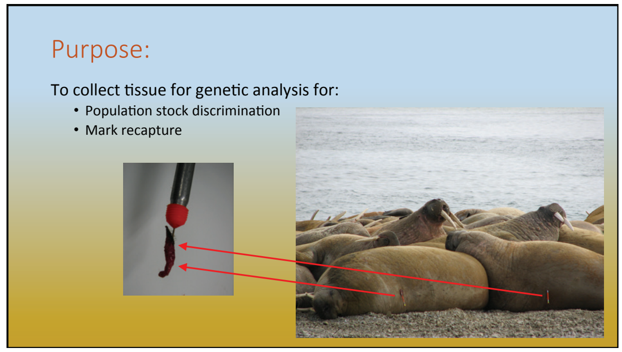

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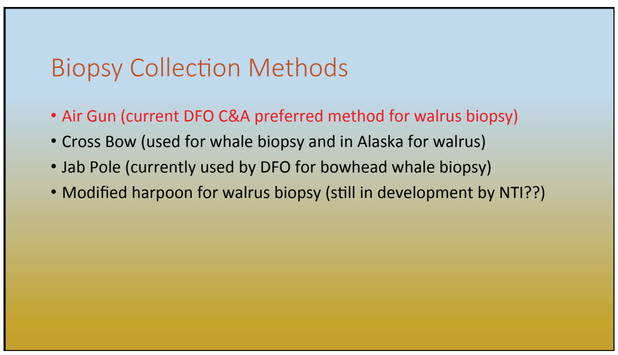

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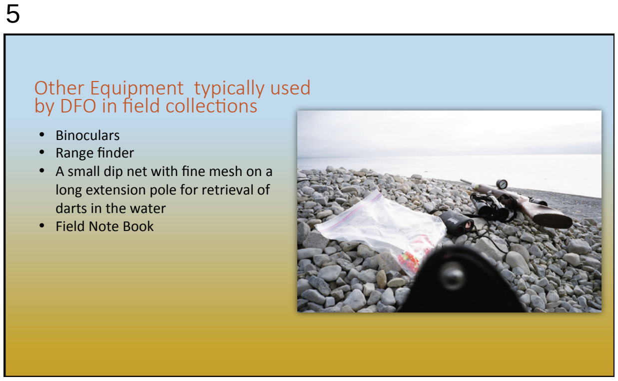

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Appendix 4G continued.

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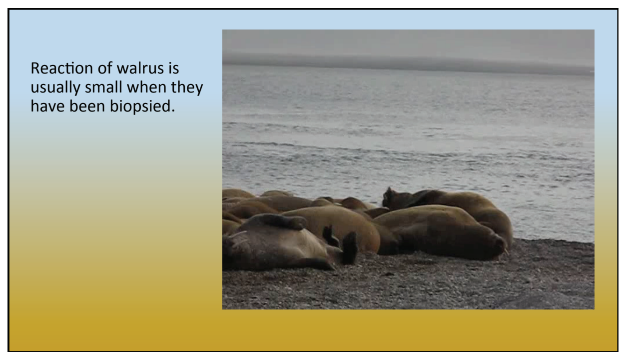

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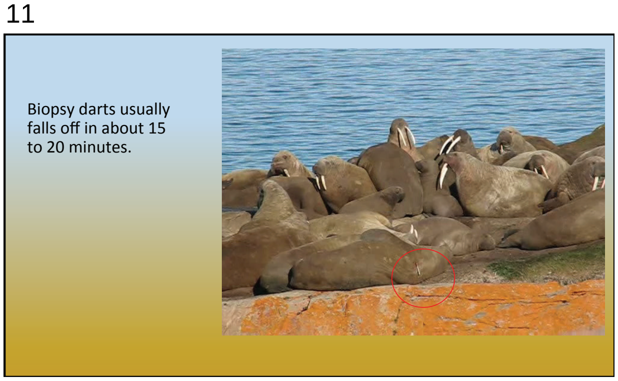

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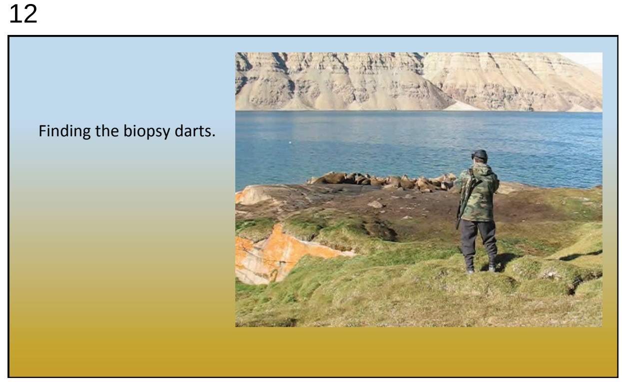

Appendix 4G continued.

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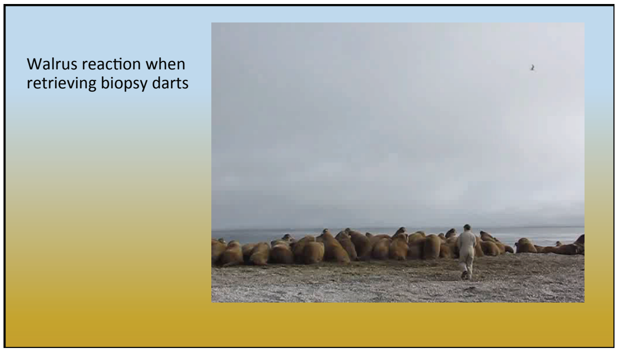

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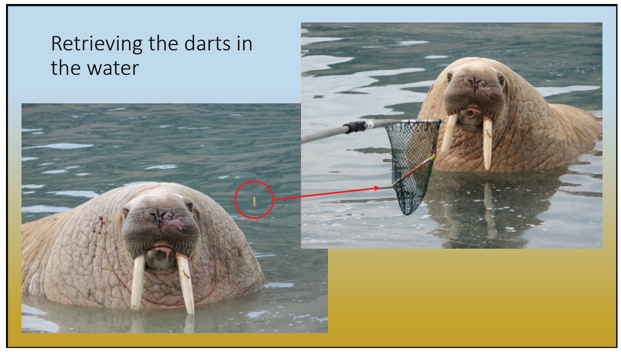

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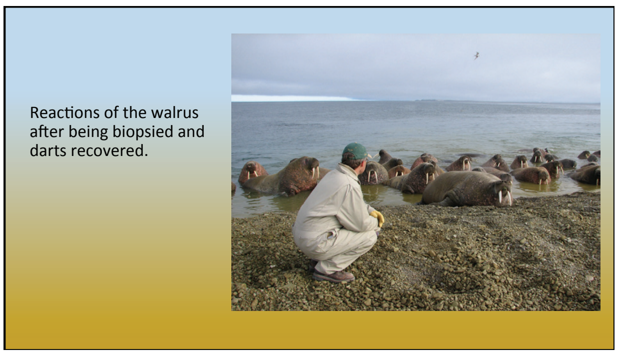

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Appendix 4G continued.

19

Situations when we don't try to collect biopsies.

20

Samples and data collected

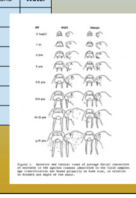
21

The data collected

Walrus Biopsy Collection Data Sheet

Date:			Community:	Resolute / High Arctic / Jones Sound
Sampler:			Location:	

Sample ID	Vial No.	Dart No.	GPS Location		Sex	Age Class	Time of Day	Sampled on		
			Latitude	Longitude				Ice	Land	Water
ARHA2006 -			N	W						
ARHA2006 -										
ARHA2006 -										
ARHA2006 -										
ARHA2006 -										
ARHA2006 -										



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Biopsy and other sample collections

- 2003 to 2011 – 400 biopsies
  - ~75 from Foxe Basin area
  - ~325 from the High Arctic (i.e. Lancaster and Jones Sound area)
- 1981 to 2009 – 416 samples from Nunavut subsistence hunts
  - Primarily the Foxe Basin area
    - 118 Hall Beach
    - 214 Igloolik

23

Walrus samples collected from the subsistence hunt in Nunavut – 1981 to 2009

Year	Cape Dorset	Coral Harbour	Grise Fiord	Hall Beach	Igloolik	Iqaluit	Pangnirtung	Pond Inlet	Repulse Bay	Resolute	Total
1981					4						**4**
1982					26						**26**
1983					45			1			**46**
1984						31					**31**
1985					1	1					**2**
1987					33						**33**
1988				20	28						**48**
1992				14	6						**20**
1993				7	15						**22**
1996			9	19	32						**60**
1997		16									**16**
1998	4	4	3						6	1	**18**
2000				12			2				**14**
2001				1							**1**
2004				14							**14**
2007			1	6	5						**12**
2008			5	4	7						**16**
2009				21	12						**33**
Total	**4**	**20**	**18**	**118**	**214**	**32**	**2**	**1**	**6**	**1**	**416**

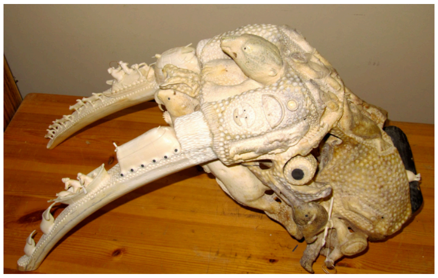
24

Questions??

Appendix 4H. Genetic capture - mark - recapture for Canadian Atlantic walrus stock deliniation and abundance estimation (Lianne Postma, DFO, Winnipeg).

Slide 1

Genetic Capture-Mark-Recapture (gCMR) for Canadian Atlantic Walrus stock delineation and abundance estimation



Lianne Postma (DFO, Winnipeg) and Tim Frasier (St. Mary's University, Halifax)

2

Mark-recapture methods are well established for estimating the abundance of wildlife populations:

marking or tagging is used to uniquely identify individuals in successive capture samples, and mark-recapture models use information on the recapture rate to estimate population size.

With technological advances, photographic identification using natural markings and/or genetic characterization of individuals have increased the utility and application of the mark-recapture approach.

3

Year	Location	# of Samples
various	Atlantic	16
1998	Cape Dorset	6
1997	Coral Harbour	13
1997	Coral Harbour	3
1998	Coral Harbour	4
1999	Coral Harbour	4
2012	Coral Harbour	1
2004	Goose fiord	2
1991	Fox Basin	50
1996	Grise Fiord	9
1998	Grise Fiord	2
1999	Grise Fiord	6
2007	Grise Fiord	1
2008	Grise Fiord	4
1988	Hall Beach	19
1992	Hall Beach	29
1993	Hall Beach	14
1996	Hall Beach	26
2000	Hall Beach	12
2004	Hall Beach	15
2007	Hall Beach	7
2008	Hall Beach	4
2009	Hall Beach	21
2003	High Arctic	11
2004	High Arctic	27
2005	High Arctic	9
2006	High Arctic	66
2007	High Arctic	50
1983	Igloolik	29
1984	Igloolik	40
1987	Igloolik	16
1988	Igloolik	20
1991	Igloolik	16
1992	Igloolik	27
1993	Igloolik	22
1996	Igloolik	26
2004	Igloolik	46
2005	Igloolik	42
2007	Igloolik	5
2008	Igloolik	7
2009	Igloolik	11
2012?	Iqaluit	1
2013	Iqaluit	15
2004	Norfolk Inlet	1
1984	Pangnirtung	3
1999	Pangnirtung	2
2007	Pangnirtung	80
1983	Pond Inlet	1
1999	Pond Inlet	1
1998	Repulse Bay	6
1992	Resolute	5
1993	Resolute	9
1996	Resolute	4
1998	Resolute	1
2010	Arctic Bay	1

NAMMCO SCIENTIFIC PUBLICATIONS *Online Early Version*

Microsatellite assessment of walrus (*Odobenus rosmarus rosmarus*) stocks in Canada

Aaron BA Shafer[1], Corey S Davis[1], David W Coltman[1], and Robert EA Stewart[2]*

[1]*Department of Biological Sciences, University of Alberta, Edmonton, Alberta, T6G 2E9, Canada*
[2]*Fisheries and Oceans Canada, Freshwater Institute, 501 University Crescent, Winnipeg, Manitoba, R3T 2N6, Canada*

**Corresponding Author*

Used data from 623 samples

ABSTRACT

Walruses in Canada are currently subdivided into seven stocks based on summering areas; Western Jones Sound (WJS), Baffin Bay (BB), Penny Strait-Lancaster Sound (PS-LS), North Foxe Basin (N-FB), Central Foxe Basin (C-FB), Hudson Bay Davis Strait (HB-DS) and Southern and Eastern Hudson Bay (SE-HB). In this study, walrus were sampled from six of the seven stocks (SE-HB samples were not available) and genotyped at 10

Currently, we have approximately 850 walrus samples in the genetics tissue archives (harvested and biopsies).

4

Biopsy Darts and Walrus Population Monitoring

The U.S. Fish and Wildlife Service, in collaboration with the Alaska Department of Fish and Game, Native subsistence hunters, and Russian scientists, is testing the feasibility of genetic mark-recapture methods to provide accurate estimates of population size, survival rates, and productivity for Pacific walruses. The process involves collecting skin samples from walruses with a biopsy punch fitted to a dart (pictured above) and fired from a crossbow. Researchers sample walruses on ice floes in the Bering and Chukchi Seas in the spring by approaching walruses to within 20 meters with small skiffs. Darts are sometimes lost to the ice during the process and can float up on area beaches. In 2013 and 2014 we successfully collected 3,500 samples from live walruses in the Bering and Chukchi Seas. This is a long-term project and will be carried out for several years. ***If you have questions or find lost darts please contact Patrick Lemons at the U.S. Fish and Wildlife Service, Marine Mammals Management, 1011 E. Tudor Road, Anchorage, AK 99503 or call 907-786-3800 or 1-800-362-5148.***

5

One important requirement in mark-recapture studies, regardless of which method of identification is used, is ensuring that the study area provides adequate opportunities for "capturing" all individuals within the study population.

For species with wide distributions and substantial heterogeneity in habitat use patterns (such as Atlantic walrus), it may not be possible to obtain adequate coverage of all sites.

In such cases, abundance estimation needs appropriate corrections during the analytical stages of the study.

NEED A BETTER MODEL

6

We have been developing the gCMR methods to estimate bowhead population abundance and have been investigating the potential of using similar methods for walrus.

1. Modify/improve current model to be able to estimate the total number of missing individuals (marked and unmarked), and combine this information with data from sample sites to result in one estimate of total abundance for the population of interest. **SOUNDS SIMPLE BUT IS VERY COMPLICATED**….
2. "Test" the model with existing genetics data for Canadian walrus.
3. Use simulations to test the effect of sampling effort on the precision of abundance estimates using the model.

Appendix 4H continued.

7

1. **THE MODEL**

The model performs quite well and is suitable for general implementation.

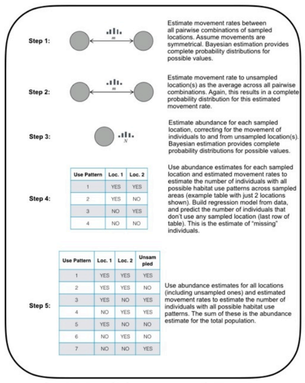


Figure 1. Illustration and brief description of the main steps of the model.

8

2. Use the existing genetic data for Canadian walrus to see what the model produces as an abundance estimate…

Location	Count
BB	15
C_FB	139
HB_DS	69
N_FB	237
PS_LS	128
WJS	35

A. Queried data to identify locations sampled and the count of individuals sampled in each location.

	PS_LS	WJS
PS_LS	6	0
WJS	0	1

B. Identified "recaptures" (genetic duplicates). Data was not suitable to estimate abundance for any location using the new model.

C. However, used a simplified version of the model (that assumed a "closed" population model) to estimate abundance for PS-LS.

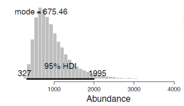


Figure 5. Abundance estimate for PS_LS population. Shown is the mode and 95% highest density interval for the posterior probability for the number of individuals.

Estimated between 661 and 727 walrus for PS-LS based on 2009 aerial survey (DFO 2013)

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3. What kind of sampling effort do we need to use for the model to estimate abundance with reasonable confidence?

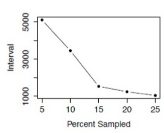

Figure 2. Range of abundance estimates (difference between upper and lower 95% HDI values) obtained for total abundance when 5, 10, 15, 20, and 25% of the individuals from each location are sampled.

A good goal would be to try to sample ~15% of the population on different occasions ("marking" and "recapture" periods) ideally within as short a time frame as possible.

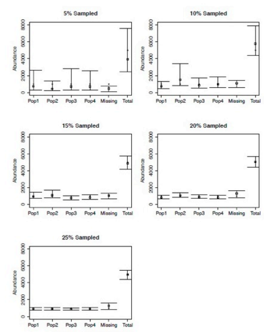

Figure 3. Abundance estimates and associated 95% HDIs for each simulated scenario testing the effects of sampling effort. Actual values are shown in black circles. Here "Missing" refers to the number of individuals in the unsampled location(s).

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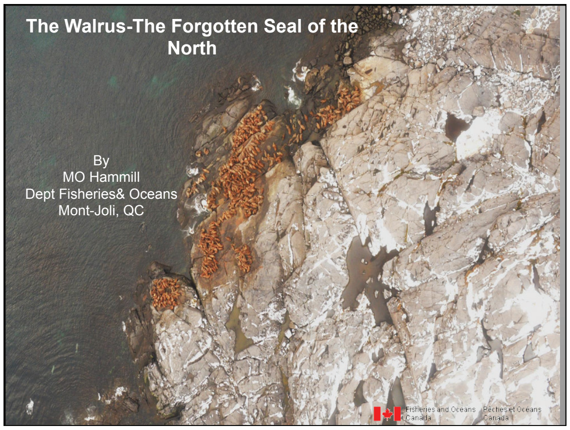
Thank you for your attention!

Appendix 4I. Walrus abundance: aerial surveys (Mike Hammill, DFO, Mont-Joli).

Slide 1



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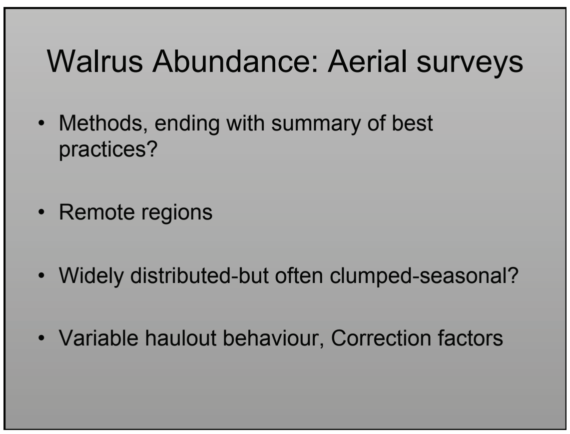

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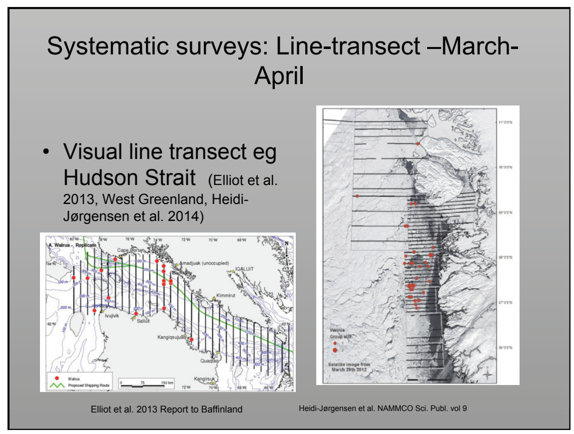

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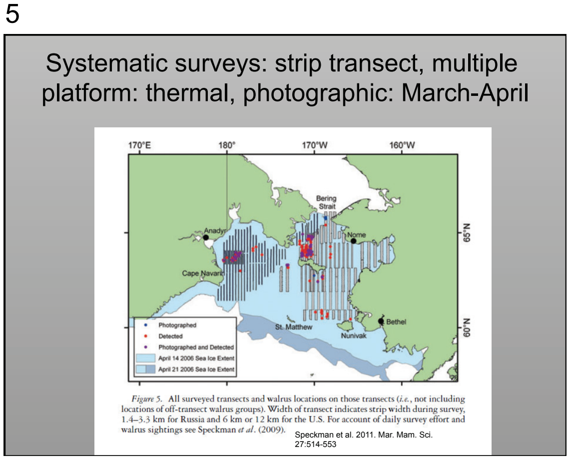

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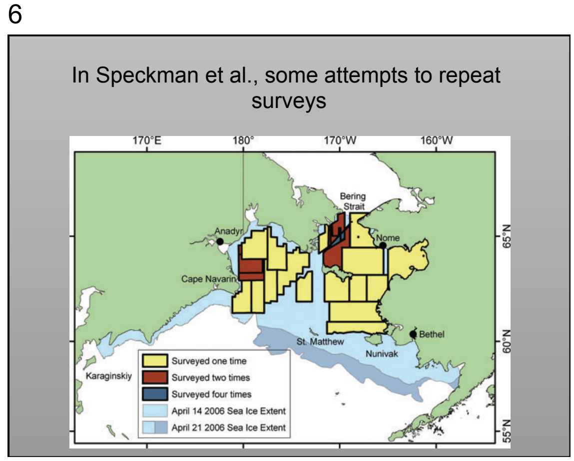

Appendix 4I continued.

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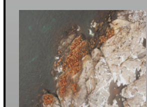
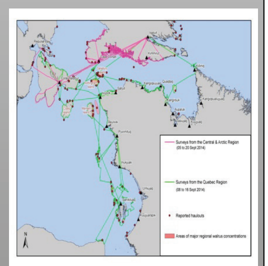
Coastal surveys

- Ice-free period
- Visual, photographic
- Extensive consultation to know where to look





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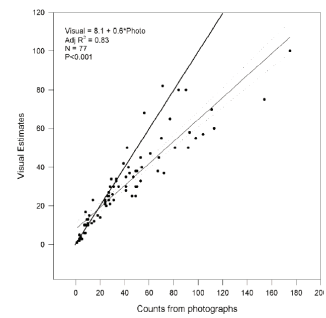


Fig. 3. a) Visual estimates of the number of walruses present from counts during the aerial survey compared to the number counted in aerial photo-graphs taken during the survey and counted later. The thin line is the fitted regression, the dashed line the 95% confidence interval and the heavy line denotes the theoretical 1:1 correspondence.

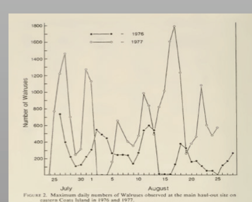
Stewart et al. 2014. NAMMCO No 9

9

Variable haulout numbers

(Mansfield and St. Aubin 1991. Cdn Fld-Nat. 95-100)

- Numbers hauling out are variable
- Movement between haulout sites? Random? Directed?
- % hauling out-are they hauled out elsewhere or in water?



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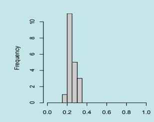
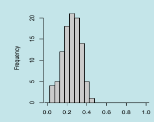
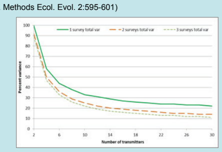
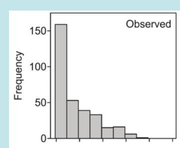
Analyses

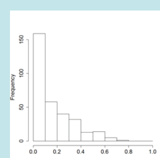
(Doniol-Valcroze et al. 2016 CSAS, but see Martin et al. 2011. Methods Ecol. Evol. 2:595-601)











Variability in haulout proportion from Udevitz et al. 2009 (left), variability in haulout behaviour assuming beta-binomial, with correlation =0.2, instead of binomial

11

Summary: Best Practices

- Understanding of walrus distribution-more important for coastal approach, since it is a count-don't want to miss important haulout sites
- If possible don't rely only on visual
- Haulout is quite variable-need to know more on movement between haulouts, proportion hauling out
- Satellite telemetry?
- Repeated counts

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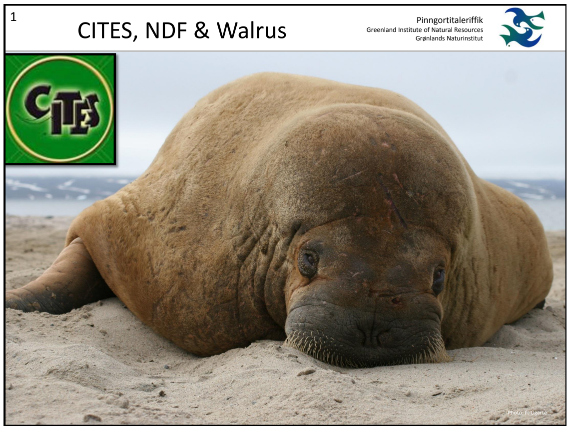
Appendix 4J. Walrus management and research in Greenland (Fernando Ugarte, GINR, Nuuk, Greenland).

Slide 1



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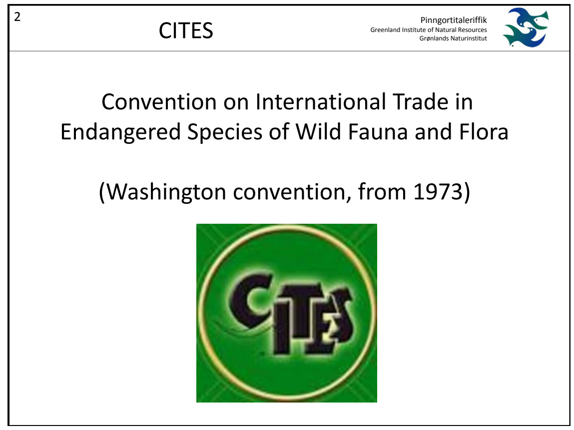

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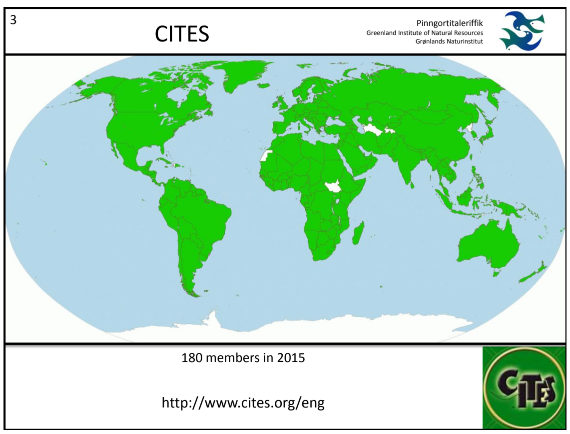

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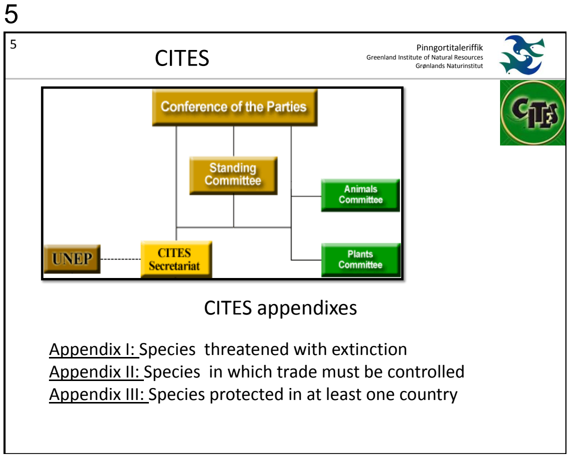

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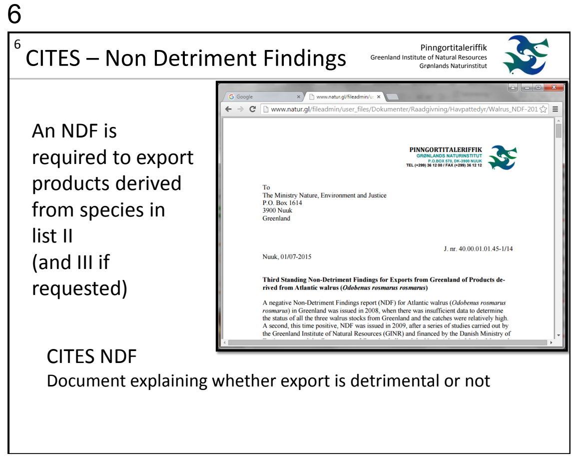

Appendix 4J continued.

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7 Non Detriment Findings

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CITES NDF

http://www.natur.gl

A positive NDF can be issued if export is not detrimental.

In Greenland, positive NDF is possible only if it can be documented that harvest is sustainable

8

8 Non Detriment Findings

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Narwhal: ~~2006 (negative), 2009 (positive),~~ 2016 (negative)
Beluga: 2007 & 2016 (positive)
Walrus: ~~2007 (negative), 2011 (positive), 2015 (positive),~~ 2016 (negative)
Polar bear: 2007 & 2016 (negative),
Harbour porpoise: 2016 (negative)
Pilot whale: 2016 (negative)
White beaked dolphin: 2016 (negative)
Killer whale: 2016 (negative)
West Greenland minke whale: 2016 (positive)

CITES NDF

http://www.natur.gl

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9 Non Detriment Findings 2016

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Green = Positive NDF   Red = Negative NDF

Minke whale West GL	**Narwhal**	**Beluga**
Other small whales (Harbour porpoise, pilot whale, white beaked dolphin and killer whale)	**Walrus**	**Polar bear**

In the NDF for 2016, catches (and losses) are compared to the advice for 7 stocks of narwhals, 2 of belugas, 3 of walruses and 4 of polar bears (16 tables)

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Walrus NDF 2016

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Management

- Executive order 2006
  - Quotas (2007)
  - Transport (no skidoos)
  - Protection of calves, females (except BB) and haul out places
  - Harpoon before shooting
  - Hunting season
- Quotas according to 3 years management plans
- Inspection by wildlife officers (except BB)

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Hunting

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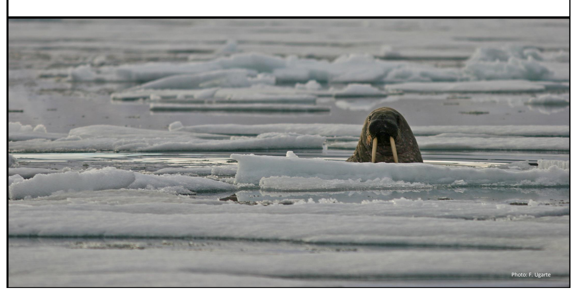
- Davis Strait: boat
- Northern Baffin Bay: Ice edge and boat



Appendix 4J continued.

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Hunting

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Assumed struck and loss

- 15 % in Davis Strait (NAMMCO & APNN)
- 15 % in Northern Baffin Bay (NAMMCO), or 3% (APNN)
- 5 % for West Greenland (Born *et al* subm)

14

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Research

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- Satellite telemetry
  - Movements / stock identity
  - Calibration of aerial surveys
- DNA analyses
  - Stock identity
  - Sex distribution of the catch
- Aerial surveys
  - Abundance & distribution
- Interview survey
  - Catch
  - Climate
- Catch statistics

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Research

- Satellite telemetry
  - Movements / stock identity
  - Calibration of aerial surveys
- Equipment and methods developed in collaboration with hunters

16

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Research

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Appendix 4J continued.

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19 **Research**

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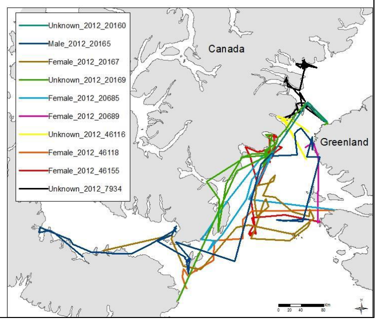
Grønlands Naturinstitut



The track line of 10 walruses instrumented with satellite transmitters in 2012.

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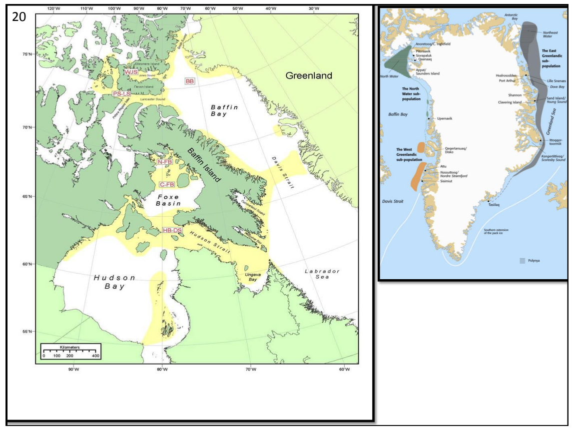

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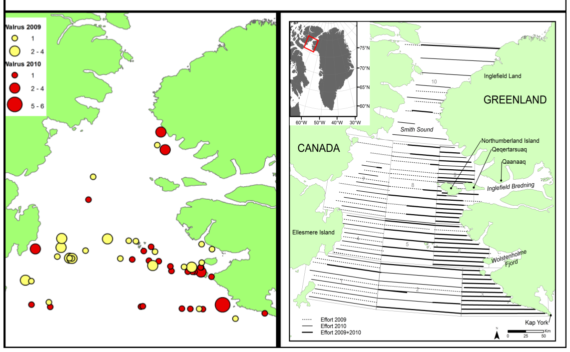
Research



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Aerial surveys

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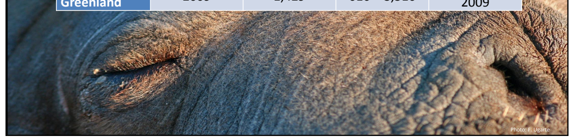
Area/stock	Year of survey	Estimate	95 % CI	Reference
West Greenland, winter	2006	1,105	610-2,002	Heide-Jørgensen et al. 2013a
	2008	1,137	468-2,758	
	2012	1,408	922-2,150	
Baffin Bay (North Water polynya)	2009	1,238	856-1,791	Heide-Jørgensen et al. 2013b
	2010	1,759	1,008-3,070	
	2014	2,434	1,428-4,150	Heide-Jørgensen et al. In sub
East Greenland	2009	1,429	616 – 3,316	Born et al. 2009



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Catches & advise

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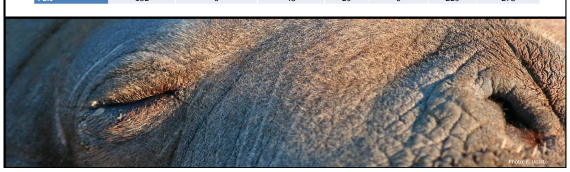
Stocks shared with Canada

Qaanaaq (Baffin Bay)	Reported catches	Unreported catches	Catches in Canada	15 % S&L	Other kills	Total	Advice
2013	65	0	7	11	0	83	68
2014	67	0	7	11	0	85	68
2015	74	0	7	12	0	93	93
i alt	206	0	21	34	0	261	229

Davis Strait	Reported catches	Unreported catches	Catches in Canada	15 % S&L	Other kills	Total	Advice
2013	47	0	16	9	0	72	89
2014	52	0	16	10	0	78	89
2015	53	0	16	10	0	79	100
i alt	152	0	48	29	0	229	278



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Catches & advise

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East Greenland

East Greenland	Reported catches	Unreported catches	15 % S&L	Other kills	Total	Advice
2013	8	0	1	0	9	20
2014	8	3*	1	0	12	20
2015	4	0	0	0	4	20
i alt	20	3	2	0	25	60

Appendix 4J continued.

25

Conclusion

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- The stocks of walrus in Davis Strait is depleted but increasing catches are sustainable
- In East Greenland, the stock has reached carrying capacity and catches are sustainable
- In Baffin Bay, removals may be higher than advised and therefore it is uncertain whether catches are sustainable
- Therfore, it can not be concluded that international trade does not have a negative effect in the populations of walruses in Greenland and this is a *negative NDF*.

26

Uncertainty

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- Quota in Qaanaaq is high compared to the advice
- Uncertain struck and lost rate
- Catch is higher than advice, if NAMMCO's S&L rate is used
- Catch is within the advice if one of the lower S&L rates suggested by interviews with hunters is used

27

Trade

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The main motivation for hunting walrus in Qaanaaq is to provide food for sledge dogs and people, rather than export

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Qujanaq

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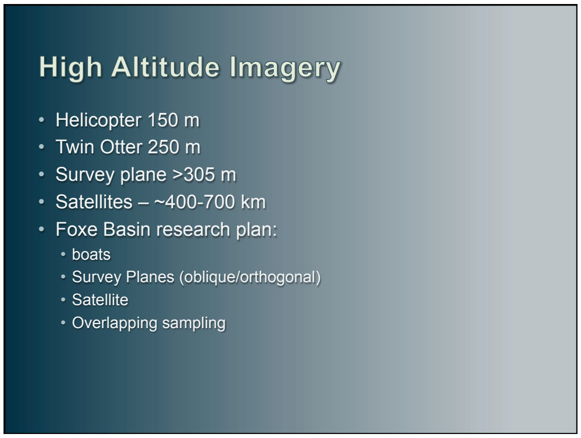
Appendix 4K. High altitude imagery (Rob Stewart, DFO Winnipeg (retired)).

Slide 1



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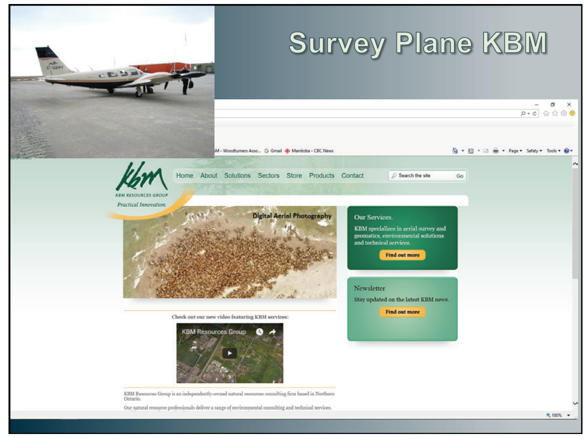

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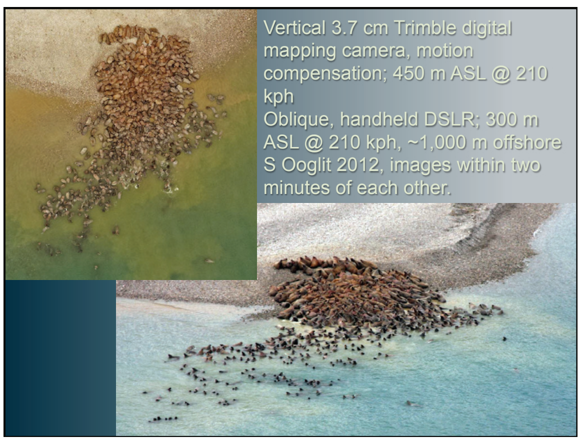

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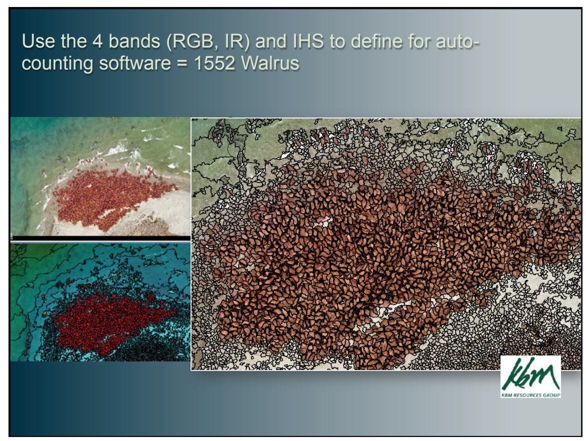

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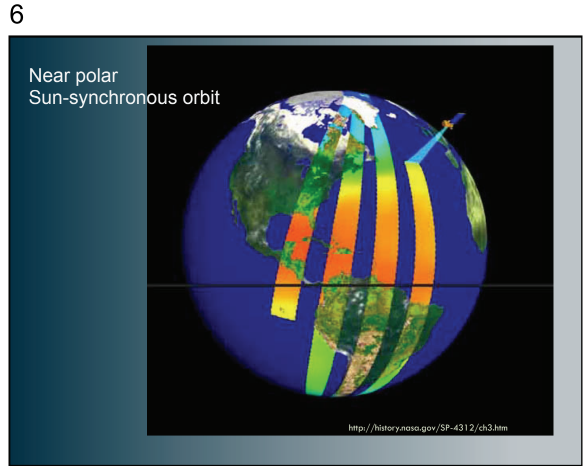

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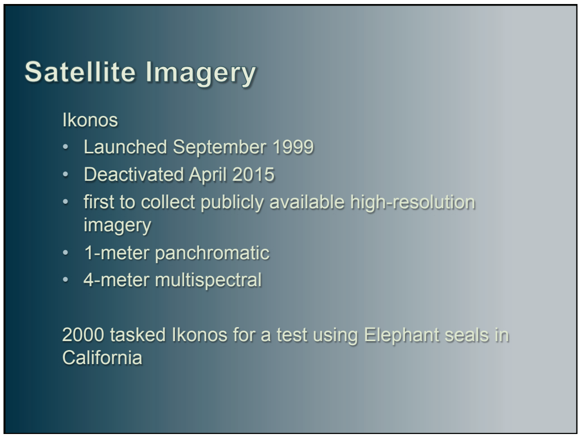

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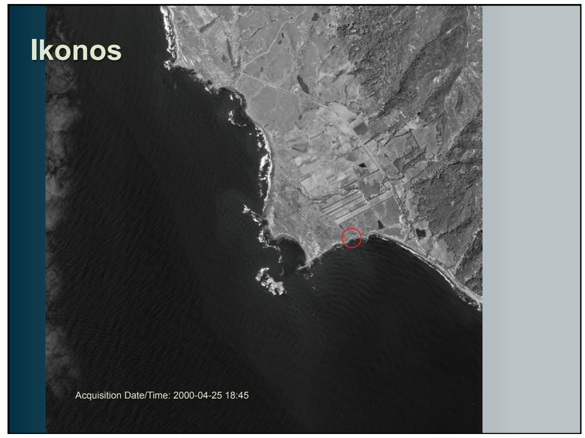

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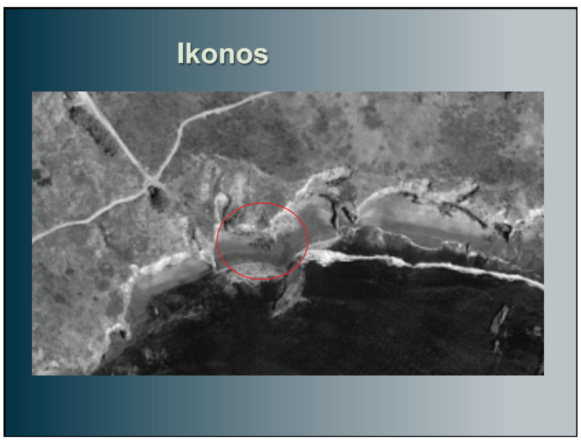

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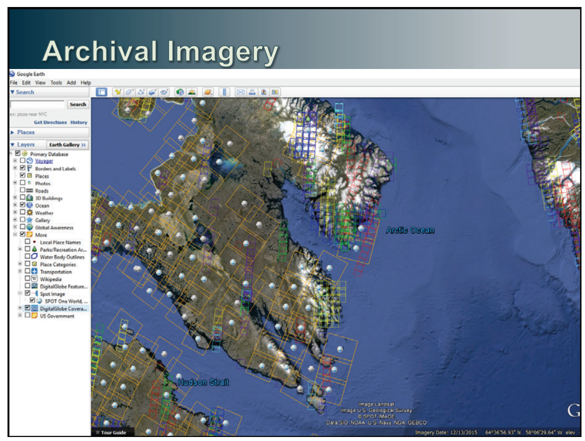

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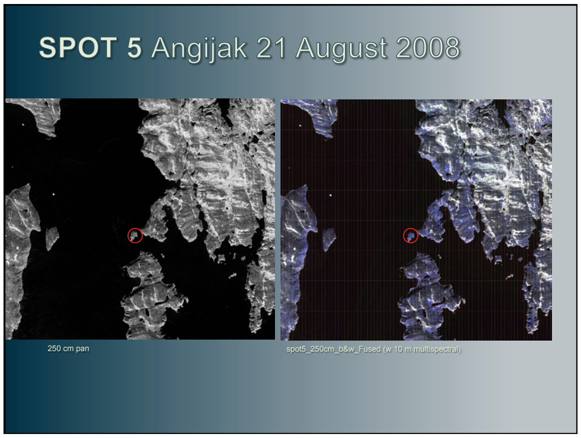

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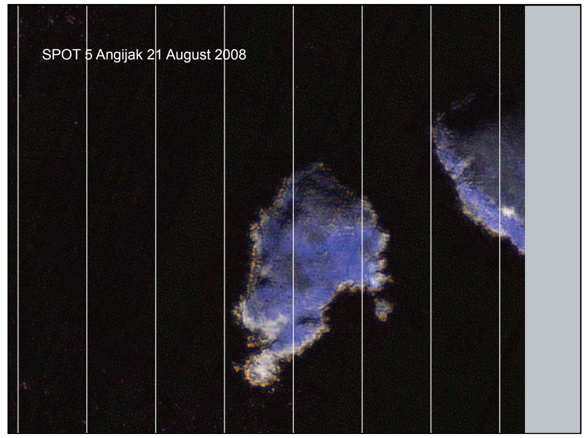

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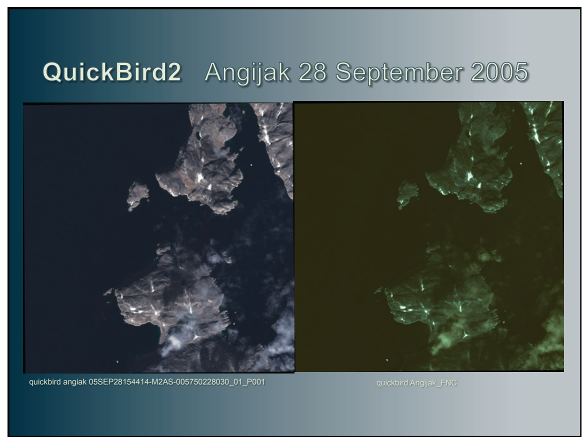

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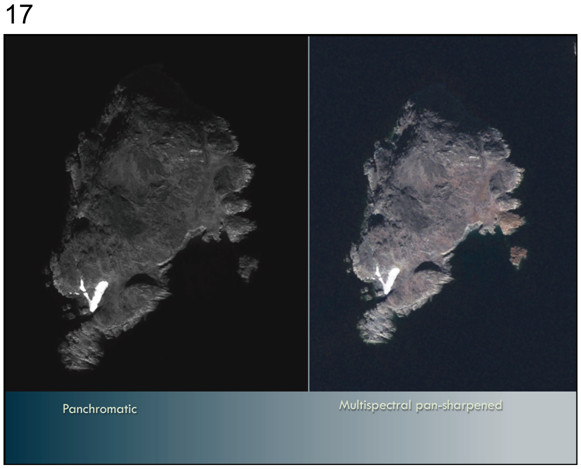

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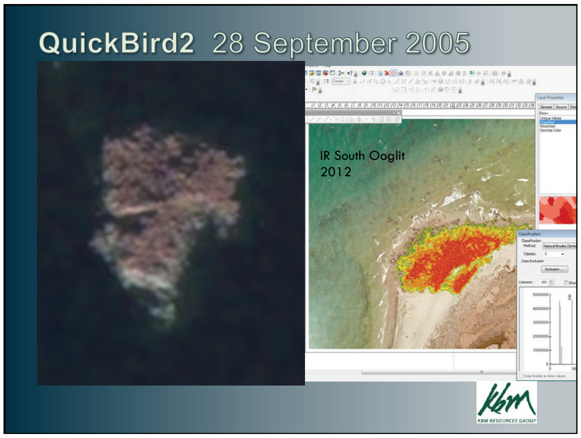

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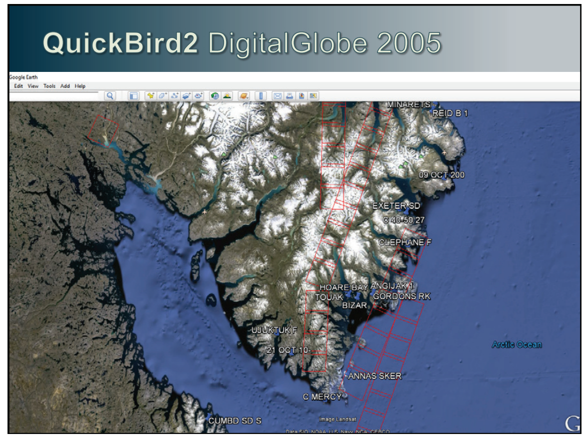

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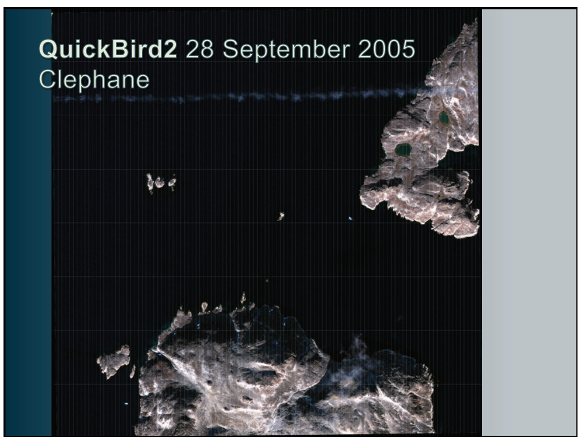

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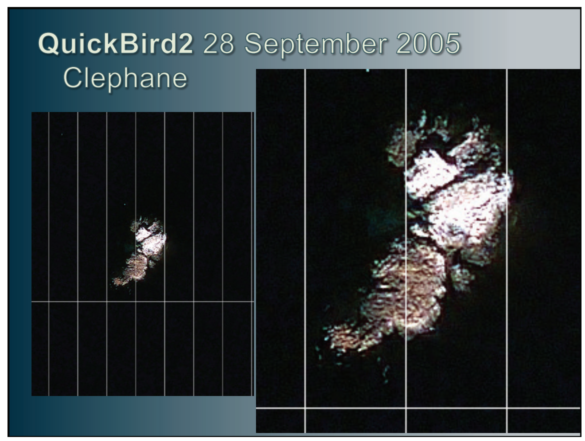

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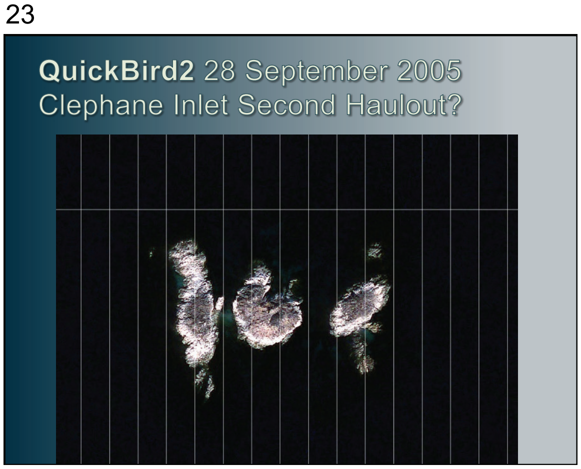

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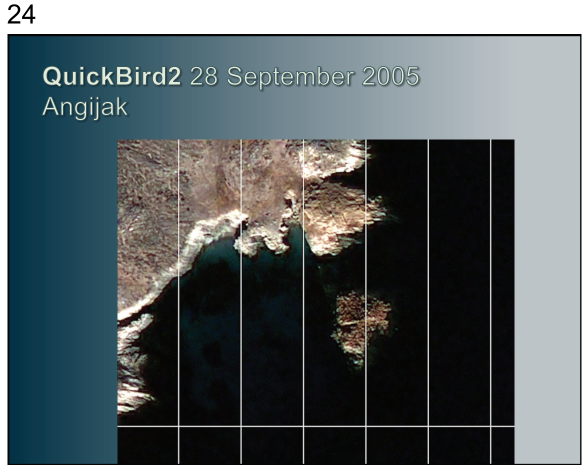

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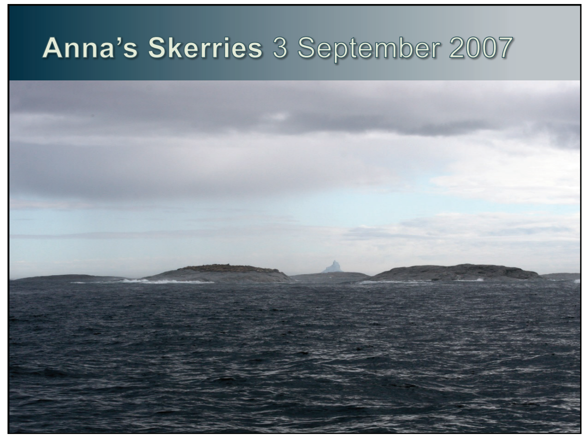

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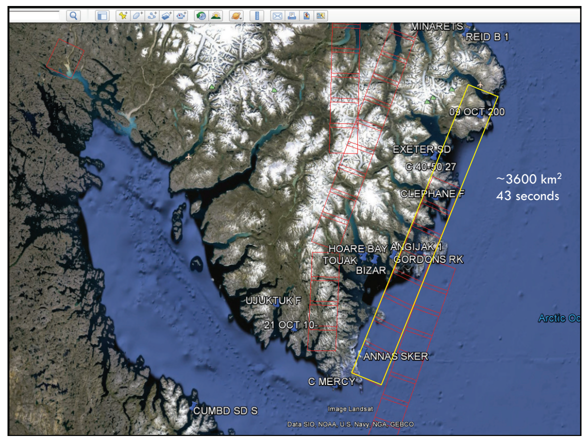

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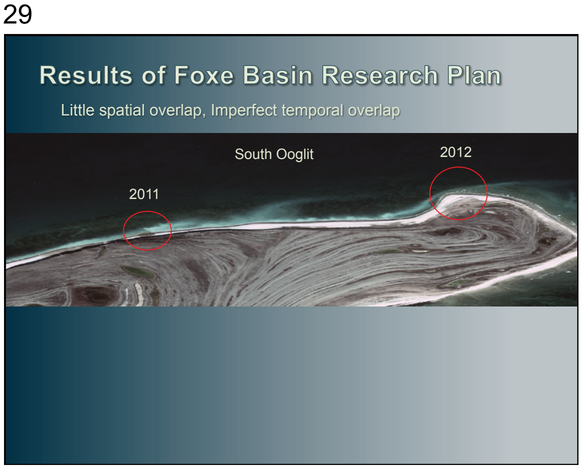

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Appendix 4K continued.

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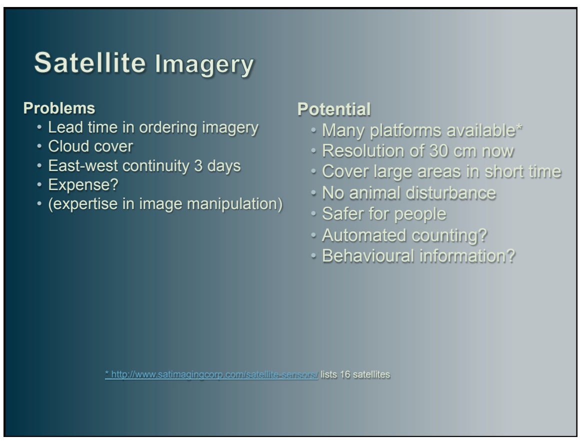

Appendix 4L. Remotely-deployed satellite radio-tags (Chad Jay, USGS, Alaska).

Slide 1

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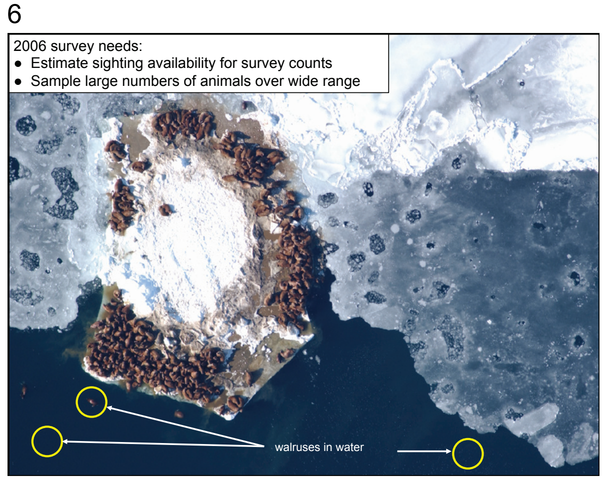

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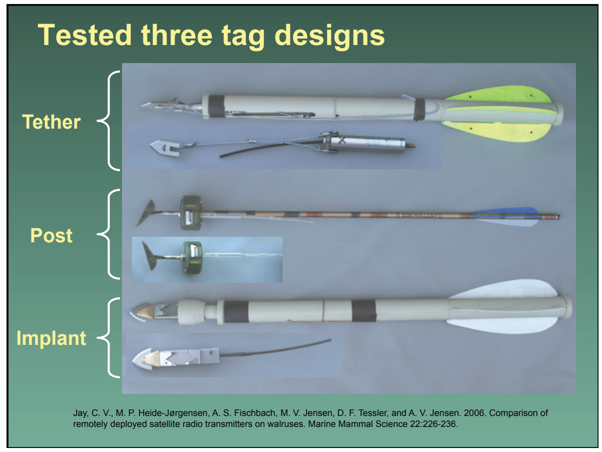

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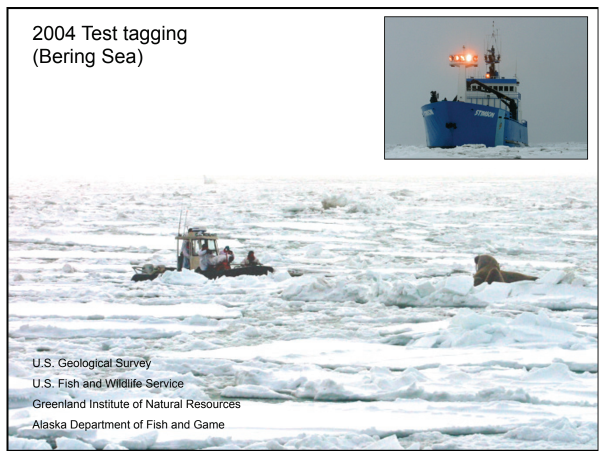

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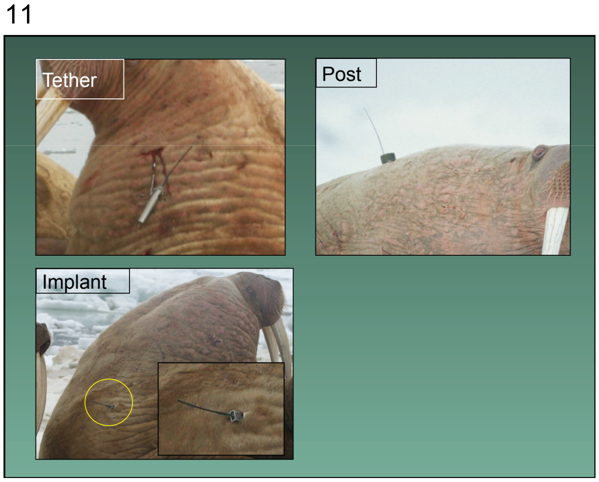

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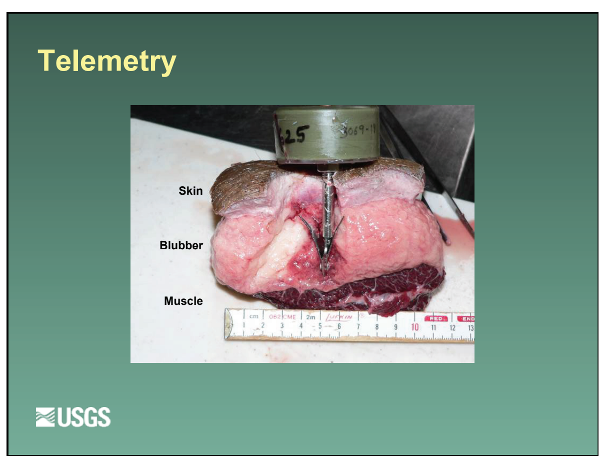

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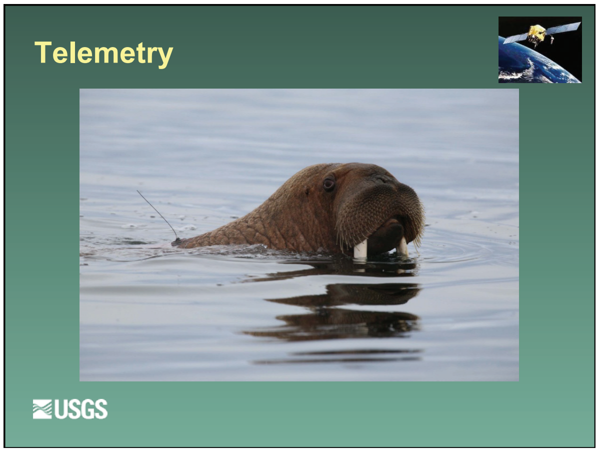

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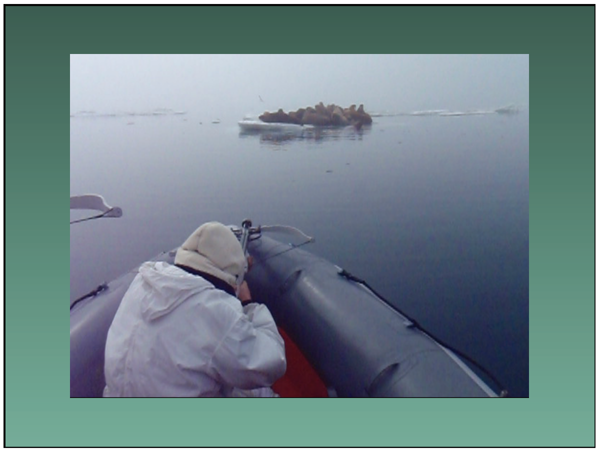

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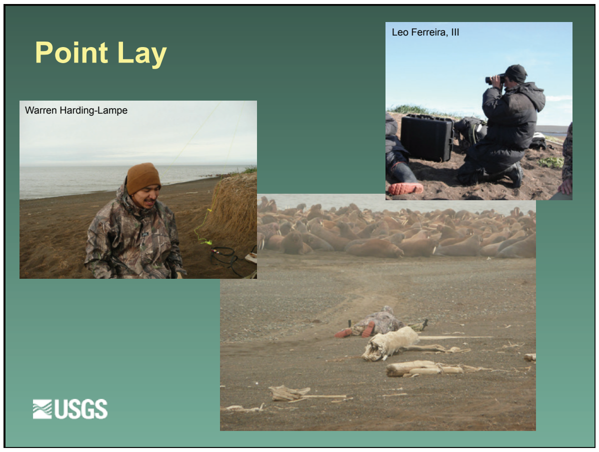

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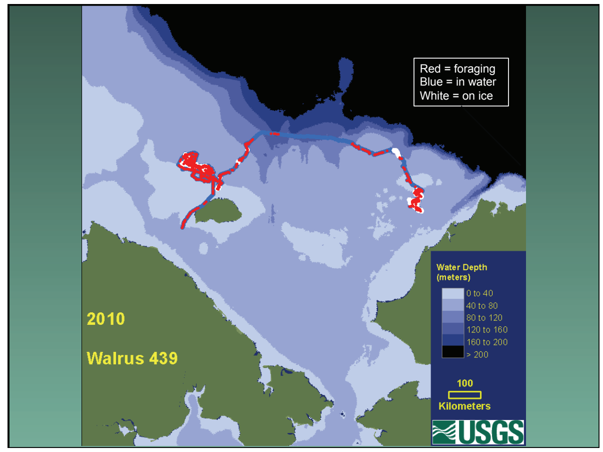

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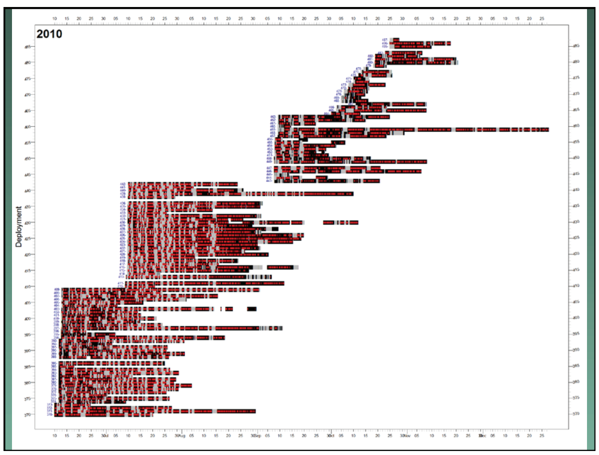

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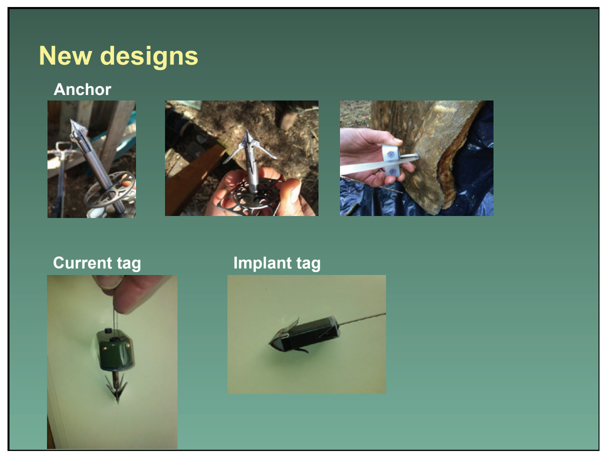

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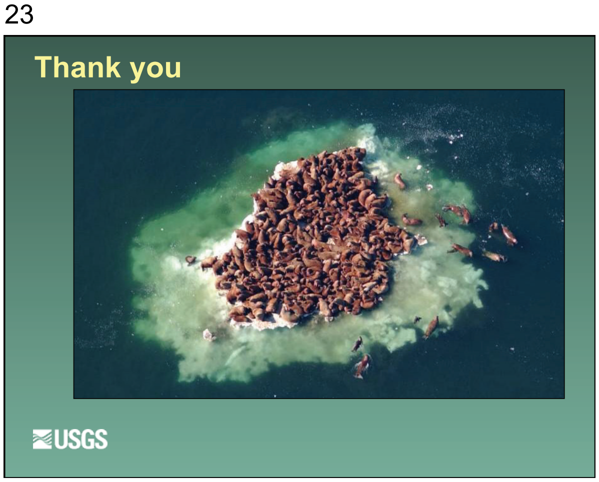

APPENDIX 5. BREAKOUT SESSIONS

Appendix 5. Development of a 5-year science plan for walrus: breakout sessions (Lianne Postma, DFO, Wiinnipeg).

Slide 1

Development of a 5-year Science Plan for Walrus

Breakout Sessions

Objective: The breakout sessions will help identify the **data gaps**, **information needs**, **possible protocols**, and **timelines** for key walrus research themes in order to develop a robust 5-year plan.

2

1.5 Hours/Session

Each group will consider two themes per session

Considerations:

- Identify main issues
- Identify knowledge gaps
- Possible strategies and approaches
- Identify existing data sources
- Identify resources and/or expertise required
- Identify partners/collaborators
- Prioritize
- Identify the timeline

3

Breakout groups

- 1. Abundance
- 2. Population biology
- 3. Management science
- 4. Stressors
- 5. Distribution
- 6. Ecosystems

4

1. Abundance

- Methods (e.g., aerial surveys, gCMR, photo-id, TEK)
- Availability and perception bias
- Frequency (trend analysis)

5

2. Population Biology

- Knowledge related to biological characteristics/ demographics of the stocks, e.g.:
  - Sex/age structure
  - Mortality
  - Recruitment
  - Fecundity
- Condition
- Health
- TEK

6

3. Management Science

- Limit Reference Points PA
- Potential Biological Removal (PBR)
- Population Modelling
- Allocation framework (inter-jurasdictional)
- Frequency of assessments (trends)
- Harvest statistics (e.g., S/L)
- TEK, community-based monitoring, catch effort
- Lands claim agreements

Appendix 5 continued.

7

4. Threats/Stressors

- Shipping, mining, noise, climate change, oil and gas development, fisheries interactions, invasive science
- Cumulative impacts
- Gap analysis
- Data collection, monitoring (baseline, effects)
- TEK

8

5. Distribution and movements

- Telemetry (fidelity, seasonal, haul-out behaviour, foraging etc.)
- Stock discrimination (markers), connectivity
- Genetics
- TEK
- Inter-jurisdictional
- Bioenergetics

9

6. Ecosystems and Habitat

- Improve understanding of primary and secondary productivity.
- Improve understanding of environmental changes (e.g. climate change).
- Important/critical habitats (features, processes)
- TEK
- Food web, foraging, modeling, mapping, physical oceanography
- Marine protected areas

10

3 Groups

Group 1:
- List participants

Group 2:
- List participants

Group 2:
- List participants

11

Template

Session Theme	
Main Issues	
Prioritization	Ranking and rationale
Knowledge Gaps	
Possible/ Recommended Strategies and/or approaches	

12

Existing Data Sources	
Resources and/or Expertise Required	
Partners/ collaborators	
Timeline