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REPORT OF THE 2ND WALRUS INTERNATIONAL TECHNICAL AND SCIENTIFIC (WITS) WORKSHOP

11-15 JANUARY 1993

WINNIPEG, MANITOBA, CANADA

edited

by

R.E.A. Stewart, P.R. Richard and B.E. Stewart

Central and Arctic Region

Department of Fisheries and Oceans

Winnipeg, Manitoba R3T 2N6

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PREFACE

Walruses are a staple in the diets and cultures of many northern people but walrus numbers have been reduced in most areas and walruses are exposed to a number of anthropogenic impacts. Several walrus stocks are shared by more than one nation. There is, therefore, an immediate need for carefully designed management and conservation programs based on the best scientific knowledge available. With this in mind, international biologists and resource users have gathered twice to discuss the problems facing walruses and possible solutions. The first meeting was in Seattle in March 1990. The second was in Winnipeg in January 1993. This report of the deliberations of the Winnipeg workshop on walrus biology is dedicated to the memory of Matthew Iya, who was an active participant at both meetings.

Matthew Iya, January 4, 1948 - February 8, 1993

Matthew Iya, Director of Natural Resources for Kawerak, Inc. (Nome, Alaska), passed away on February 8, 1993 in Alberquerque, New Mexico. Matthew was also the sole staff support to the Eskimo Walrus Commission and in that capacity, he attended both Walrus International Technical and Scientific Committee workshops.

Matthew was a strong advocate of co-management agreements between native user groups and American state and federal regulatory agencies for various species of fish and game, including walrus. He testified before the Boards of Fish and Game, the Federal Subsistence Boards, and in other fora as a consistent proponent of native subsistence lifestyle and self-regulation of subsistence resources such as walrus.

Recently, Matthew had taken the lead in preparing native communities to address the re-authorization of the US Marine Mammal Protection Act. He was committed to the issue of developing a management plan for the Pacific walrus in Alaska and worked with untiring devotion to this cause.

As a friend, teacher, and leader, Matthew touched the lives of many people that he knew and worked with. He exemplified the cultural values of his people in his sincere care and compassion for others and in his dedication to the issues in which he believed strongly. Matthew will be missed by his friends and colleagues in the walrus research and management community.

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The second meeting of the Walrus International Technical and Scientific (WITS) Committee was convened to continue to strengthen the communication links, coordination, and cooperative efforts among researchers, managers, and resource users of walruses (*Odobenus rosmarus*), fostered by the initial meeting in Seattle in 1990. Researchers from Norway, Greenland, USA, Netherlands, and Canada, and resource users from the USA and Canada discussed specific problems in carrying out research, managing, and conserving walruses throughout their range.

Range state reports from Norway, Greenland, USA, and Canada identified research and management accomplishments since the previous WITS meeting. In 1989, Norway initiated a major research program on the previously depleted walrus population in Svalbard and Franz Josef Land. Major haul-out areas in both regions have been located and surveyed, and preliminary satellite-linked tagging suggests exchange between Svalbard and Franz Josef Land. The population is now thought to number over 1 000 animals. Feeding behaviour is being examined using TDR's and divers are carrying out inventories of benthic prey.

Recent surveys in Greenland indicated a population in Central West Greenland of about 500 walruses. Simultaneous tests showed that line transect methods provided higher and more precise estimates of abundance. Satellite tracking of walruses in Central West Greenland, North West Greenland, and North East Greenland is continuing. Results of an analysis of age and reproductive parameters will be available soon. In 1993, recording and reporting the harvest of walruses became the responsibility of the individual hunter on a voluntary basis.

The USA carried out a fully integrated aerial survey with Russian researchers, covering the whole Pacific walrus range in 1990. Due to unusual ice conditions, the final estimate of approximately 200 000 is an underestimate and not directly comparable to previous estimates. New programs have been started to monitor and sample the harvest of walruses and a detailed management plan has been developed. These exercises have included and expanded the participation of native Alaskans in walrus management. Several terrestrial haul-out sites have been protected from fishing vessel activity and convictions have been won for illegally killing walruses and transgressing these protected areas. Contaminant analyses are continuing; cadmium levels are high and unchanged. In examining new methods for recording survey data and for stratifying surveys, American researchers found that 35 mm images can enhance counting ability but cannot replace the visual counts. Walrus distribution and numbers on haulouts correlate with some environmental variables but not well enough to permit survey stratification. Sensitivity analysis, which did not correct for walruses that are invisible to the surveyors, indicated that more than a dozen surveys over 60 y would be required to detect a 5% decline in population size. More research is required to correct for walruses unseen during surveys; results of satellite tracking may provide insights into the proportion of the population missed by surveys. Lab studies are continuing on previously collected material to assess biases in dietary studies, interpret biological events from the lines in teeth, and examine reproductive status and growth. Stock identification has been examined using mtDNA and nuclear DNA. Neither showed variation among Pacific walruses, but

geographic variation was detected in a small sample from Greenland. Studies of harvest levels and composition, hunter selectivity, loss rates, and the effects of ice breaking and of tourist activities are in various stages of completion.

In Canada, the recent signing of the Nunavut Land Claims Agreement will formalize the recommendations of northern people regarding walrus management and research. Current research in Foxe Basin is examining growth and reproduction. A sample of walruses from northern Quebec had high levels of ΣCHLOR and high Pb and Hg levels in the liver. Based on ^{13}C analysis, these walruses appear to have been eating seals. Continuing studies of acoustics and behaviour in the winter indicate that most calls of males are individually consistent and shared among other males at the Dundas Island polynia, but the songs are shortened in a consistent manner when females or vocal satellite males are present. Limits were established for the reliable use of surface codas as signature vocalizations. Surveys of walruses in Foxe Basin resulted in an estimate of about 5 000 for Foxe Basin, though a very large variance was associated with this estimate. A survey in northern Hudson Bay did not reveal a decline since similar surveys in 1976-77. Other current research in Canada includes studies on energetics, behaviour, contaminants, and parasitism.

Although not a range state, Netherlands is active in walrus research at the Harderwijk Dolphinarium. Research reported includes behavioural and anatomical analysis of sensory capabilities. The vibrissae are especially sensitive and can identify different shapes as small as 0.4 mm^2.

Nine working groups at the workshop considered specific topics in walrus biology and management. The working groups made recommendations on future research and management needs, and reported their discussions to all participants in plenary. Their reports presented here include these recommendations.

Most of the recommendations indicate the need for better techniques for collecting or interpreting data. For example, the annual nature of the lines in teeth, used to estimate age, needs to be verified. Methods for assessing reproductive states and contaminant assessment should be standardized. Explicit management goals are needed for some stocks. It was widely agreed that resource users should be more involved in setting these goals and in management and research in general. In some cases, this may mean diverting funds which are currently spent on other activities to improve information flow and ensure participation.

In a plenary session, participants discussed the future of WITS. WITS will continue as an independent group, concerned with the biology, management and conservation of walruses, to encourage and facilitate communication and cooperation among its members. An executive committee, comprised of the secretary and range state representatives, will be responsible for planning future meetings and coordinating responses for information directed to WITS.

Key words: walrus; *Odobenus rosmarus*; international meeting; ageing; census; population; biology; co-management; disturbance; telemetry; reproduction; management; research.

RÉSUMÉ

Stewart, R.E.A., P.R. Richard, and B.E. Stewart (ed.). 1993. Report of the 2nd Walrus International Technical and Scientific (WITS) Workshop, 11-15 January 1993, Winnipeg, Manitoba, Canada. Can. Tech. Rep. Fish. Aquat. Sci. 1940: viii + 91 p.

Cette deuxième réunion du Walrus International Technical (WITS) Committee, prévue lors de la première réunion à Seattle, en 1990, a eu lieu afin de poursuivre la consolidation des liens de communication et les initiatives de coordination et de collaboration parmi les chercheurs, les gestionnaires et les utilisateurs des ressources en morses (*Odobenus rosmarus*). Des chercheurs de la Norvège, du Groenland, des É.-U., des Pays-Bas et du Canada, ainsi que des utilisateurs de la ressource aux É.-U. et au Canada ont discuté de problèmes spécifiques en matière de recherches et concernant la gestion et la conservation des morses dans toute leur aire de distribution.

Des rapports de la Norvège, du Groenland, des É.-U. et du Canada, états faisant partie de l'aire de distribution des morses traitent des réalisations en recherche et en gestion depuis la première réunion du WITS. En 1989, la Norvège a entrepris un important programme de recherche sur la population de morses, réduite dans le passé, des îles du Svalbard et du Franz Josef Land. On a localisé et observé certaines échoueries et une étude préliminaire par émetteurs radio à liaison satellite laisse croire que l'espèce transite entre le Svalbard et le Franz Josef Land. On croit que la population compte maintenant plus de 1 000 individus. Des enregistreurs de profils de plongée ("TDR") sont utilisés pour étudier les habitudes alimentaires et des plongeurs inventorient les proies benthiques.

Des inventaires récents ont recensé dans le centre-ouest du Groenland une population de quelque 500 morses. Des études simultanées ont démontré que les méthodes par transect linéaire donnaient des estimations de nombres plus élevées et plus précises. On poursuit les suivis de morses par satellite dans le centre-ouest, le nord-ouest et le nord-est du Groenland. Les résultats d'une analyse de paramètres d'âge et de reproduction seront bientôt disponibles. À partir de 1993, chaque chasseur est devenu responsable d'enregistrer et de déclarer volontairement ses prises de morses.

Les É.-U. ont entrepris, en 1990, un inventaire aérien complètement intégré avec des chercheurs russes, couvrant toute l'aire de répartition du morse du Pacifique. À cause de conditions inhabituelles des glaces, l'estimation finale de 200 000 constitue une sous-évaluation qui ne se compare pas directement aux estimations préalables. De nouveaux programmes ont été amorcés pour observer et échantillonner les prises de morses et un plan de gestion détaillé a été mis sur pied. Ces initiatives ont incorporé les Autochtones de l'Alaska qui ont augmenté leur participation à la gestion du morse. Plusieurs échoueries ont été protégée contre les activités des bateaux de pêche et des causes ont été gagnées dans des cas de prises illégales de morses et de non-respect de zones protégées. L'analyse des polluants se poursuit; le taux de cadmium est élevé et ne change pas. En étudiant de nouvelles méthodes d'enregistrement de données et de stratification des inventaires, les chercheurs américains se sont aperçus que des images 35 mm amélioraient les décomptes mais elles ne peuvent pas remplaçer totalement le comptage visuel direct. Le nombre et la répartition des morses aux échoueries sont correlés à certaines variables environnementales, mais pas assez pour permettre une stratification des inventaires. De l'analyse statistique, qui n'a pas compensé pour les morses qui sont restés inaperçus à l'observateur, on a conclu qu'il faudrait plus d'une douzaine de relevés pendant les prochaines 60 années pour pouvoir déceler

une diminution de 5 % de la population. Il faut donc plus de recherches pour corriger les données biaisées par les morses manqués; les résultats des suivis par satellite peuvent donner quelques indices sur la proportion de la population qui échappe à l'observation. Les analyses de laboratoire se poursuivent avec les données déjà disponibles pour évaluer les erreurs dans les études des régimes alimentaires, pour interpréter les "événements biologiques" à partir des lignes des dents et pour étudier l'état reproductif et la croissance. L'identification des stocks a été effectuée grâce à l'ADN mitochondrial et l'ADN nucléaire. Ni l'un, ni l'autre n'ont démontré de variantes parmi les morses du Pacifique, mais on a trouvé des variations géographiques parmi un petit groupe-échantillon au Groenland. Les études de prises et de composition, de la sélectivité des chasseurs, le taux de perte, l'effet des brise-glaces et des activités touristiques en sont à différents stages de leur développement.

Au Canada, la signature récente de l'Accord sur les revendications territoriales du Nunavut rendra officielles les recommandations des peuples du Nord sur la recherche et la gestion concernant le morse. Des recherches en cours dans le bassin Foxe étudient la croissance et la reproduction. Un échantillonnage de morses du nord du Québec contenait de hauts niveaux de Σ-chlore, et un taux élevé de Pb et de Hg dans le foie. D'après une analyse au ^{13}C, ces morses semblent avoir mangé des phoques. Des études actuelles sur les sons et les comportements hivernaux indiquent que généralement les cris des mâles sont relativement invariables pour chaque individu et partagés entre mâles de la polynie de l'île de Dundas, mais les chants deviennent invariablement plus courts en présence de femelles ou du son de la voix de mâles voisins. Des limites ont été établies quant à la fiabilité de l'utilisation des codas de surface comme signatures sonores. Les inventaires de morses du bassin Foxe ont dénombré environ 5 000 individus, mais on considère que cet estimé comporte un taux de variabilité très élevé. Un inventaire du nord de la baie d'Hudson a permis de conclure qu'il n'y avait pas eu de déclin par rapport aux relevés semblables de 1976-1977. D'autres recherches en cours au Canada portent sur l'énergétique, le comportement, les contaminants et le parasitisme.

Même si les Pays-Bas ne font pas partie de l'aire de distribution du morse, la recherche sur cette espèce y est active au Dolphinarium de Harderwijk. Les recherches connues comprennent des analyses comportementales et anatomiques des capacités sensorielles. Les vibrisses sont particulièrement sensibles et peuvent reconnaître différentes formes aussi petites que 0,4 mm^2.

Neuf groupes de travail, à l'atelier, se sont penchés sur des aspects spécifiques de la biologie et de la gestion du morse. Les groupes de travail ont fait des recommandations quant aux besoins futurs de recherche et de gestion, et ils ont fait part de leurs discussions à tous les participants, lors de la plénière. Leurs rapports présentés ci-après contiennent ces recommandations.

La plupart des recommandations mentionnent la nécessité de meilleures techniques pour la cueillette et l'interprétation des données. Par exemple la méthode qui consiste à évaluer l'âge d'après l'incidence annuelle des lignes de croissance des dents doit être reconsidérée. Les méthodes d'étude des étapes de la reproduction et de la mesure des polluants devraient être normalisées. Il faut des objectifs explicites de gestion pour certains stocks. La majorité était d'accord sur le principe que les utilisateurs de la ressource devraient participer davantage à l'établissement de ces objectifs, ainsi qu'à la gestion et à la recherche en général. Dans certains cas, il se peut qu'il faille dériver des fonds habituellement engagés dans d'autres activités et ainsi améliorer l'acheminement de l'information et assurer la participation.

Lors d'une session plénière, les participants ont discuté de l'avenir du WITS. Le Comité du WITS continuera, en tant que groupe indépendant, à s'occuper de biologie, de gestion et de conservation des morses, à encourager et à faciliter la communication et la collaboration entre ses membres. Un comité exécutif, formé d'un secrétaire et de représentants des pays de distribution, sera responsable de la planification future des réunions et de la coordination des réponses aux demandes d'information que reçoit le WITS.

Mots clefs : morse; *Odobenus rosmarus*; réunion internationale; vieillissement; recensement; population; biologie; cogestion; dérangement; télémétrie; reproduction; gestion; recherche.

REPORTS OF RANGE STATE REPRESENTATIVES

NORWAY. I. Gjertz and Ø. Wiig.

Status of walrus research in Svalbard and Franz Josef Land in 1992. A Review.
(This is a summary of Appendix IV)

Walrus hunting started in Svalbard in 1604 and by the middle of the 19th century the stock showed a marked decrease. Walruses were on the verge of extirpation in Svalbard when they were protected totally in 1952. Hunting started in Franz Josef Land in 1865, again leading to near extirpation by 1956 when walruses there were protected. The original populations must have been large; over 10 000 were killed in Franz Josef Land over 40 years. There are now strong indications of a significant increase in walrus populations in both archipelagos.

Before 1989, little scientific information was available on the biology of the walrus in the western European arctic. The Norwegian Polar Research Institute (NP), a subsidiary of the Norwegian Ministry of the Environment, with the Norwegian Fisheries Research Council, started a major research effort in 1989.

DISTRIBUTION

Distribution of walruses in the area was examined through extensive literature searches (including trappers' diaries) and questionnaires about sightings at former haul-out sites. Walrus habitat has been mapped from information gathered by aircraft, ship, dinghy, and foot travel, noting the presence of former and current haul-out sites based on skeletal remains, drag marks, and hauled-out animals.

Svalbard

Four main areas were found: Hinlopenstretet and north to Moffen Island, southern Edgeøya and Tusenøyane, the northeast corner of Nordaustlandet including Storøya, and Kvitøya. Three smaller areas were found on the west coast of Spitsbergen. Initially walruses were abundant at Bjørnøya and along the west coast of Spitsbergen where they have started to reappear. They have not returned yet to Bjørnøya.

Franz Josef Land

Little information exists for this area because it was closed for almost half a century. However, the available information indicates that there are four haul-out areas: northeast, southeast, south, and northwest. Victoria Island, between Franz Josef Land and Svalbard, also is considered important.

Migrations

If walruses in Svalbard and Franz Josef Land are from a common stock, they must migrate. Some mention of such migrations was found in the literature, but they are not well documented and accounts are often contradictory. Satellite telemetry was used to determine

the distribution of walruses around Svalbard and to assess exchange with other areas.

Walruses were immobilized using an "Injector" darting gun and Zoletil, etorphine hydrochloride, cyprenorphine (diprenorphine HCl) or medetomedine HCl. Three different types of satellite transmitters were used. In 1989, 3 Telonics ST-3 platform terminal transmitters (PTTs) with 20 cm antennas were deployed. In 1990 and 1991, 25 ST-3s were deployed with 7 cm helical antennae. In 1992, 4 ST-3s and 2 ST-6s in titanium tubes were used. All units transmitted with 1W of power and had salt-water switches.

The PTTs were attached to the side of one tusk, with two 19 mm stainless steel bands. They were placed as far up on the tusk as possible without contacting the lip or vibrissae. In 1989 and 1990, epoxy glue was used between the transmitter and the tusk to prevent any leverage. In 1992, at Svalbard, epoxy glue was used and at Franz Josef Land, polyurethane was used.

Walruses that were immobilized were tagged with yellow Jumbo Rototags in both hind flippers if possible. Some were equipped with steel tusk-tags on the tusk that did not receive a PTT so they could be identified when swimming.

Preliminary results show that several of the walruses tagged at southeast Svalbard travelled to western Franz Josef Land and back, either to the tagging site or to other areas of Svalbard. Therefore, there is contact between Franz Josef land and Svalbard as well as between opposite ends of Svalbard, and the walruses in Svalbard and Franz Josef Land seem to belong to one population. Moreover, a walrus tagged by Born and Knutsen in Greenland was photographed at Moffen Island on the north coast of Svalbard in 1992.

Sexual Segregation

There are only a few observations of large numbers of females and calves on Svalbard. The observations suggest that the only area where females and calves are found in significant numbers is the extreme northeast part of the archipelago. The herds observed in other areas in summer are almost exclusively adult and immature males.

From about 1800, sealing vessels caught large numbers of walruses in Franz Josef Land, predominantly females and calves. Observations in 1990 and 1991 in Franz Josef Land revealed large numbers of females and calves in the south-central parts of the archipelago. Compared to herd composition at Svalbard, this suggests that there may be a close connection between the animals of these two neighboring archipelagos.

ABUNDANCE

Opportunistic Observations

Occasionally tourist, scientific, or governmental expeditions encounter herds of walruses. Such instances are reported to the conservation officers or to NP and provide useful information on walruses in Svalbard. In July 1984, the NP summer expedition found a herd of more than 500 walruses, including cows and calves, hauled out at Kvitøya. In 1985, 160 walruses, including cows and calves, were observed at Storøya and 200 were

seen at Kvitøya. In September 1987, dispersed groups of more than 500 cows and calves were located in the drift ice near Kvitøya.

Ground Surveys

Several ground surveys conducted in the Tusenøyane area annually since 1989 showed that virtually all the animals there were males of varying ages; only a few single cows with calves were seen. These surveys attempted to include all the haul-out sites in the area, but environmental conditions often prevented counting more than one or two islands in one day. The periods of ground surveys vary, but in total they span most of late June to September. Maximum counts vary among years from 165 to 340 walruses, indicating at least 200 walruses are in this area in summer.

Repeated observations of the same walruses and the return of tagged walruses to the tagging site in later years show that at least some walruses are site tenacious.

Aerial Surveys

Both opportunistic and planned aerial surveys were conducted to assess population size. Surveys concentrated on areas where walruses could be expected to be found, predominantly near-shore shallow water areas and present and former haul-out sites. Some former walrus hunting areas in the drift ice off northern and eastern Svalbard were also surveyed. A limited aerial survey was done in the remote Kvitøya area in late May 1992 to determine if this area might be a calving area but, despite favorable conditions, no walruses were seen.

Five hundred walruses were observed during helicopter surveys in 1992 at the important haul-out areas in Tusenøyane, Hinlopenstretet, and at Kvitøya, where some calves were seen. Helicopter surveys in the Edgeøya - Tusenøyane area in 1989 and 1992 produced maximum counts of 185 male walruses hauled out in 1989 and 275 in 1992. No calves were observed.

In September 1992, aerial surveys were conducted over all of Svalbard's coastline at least once, except for Hopen and Bjørnøya where unfavorable weather prevented the survey. We attempted to cover areas considered of special interest at least twice. A maximum of 270 walruses were counted in 1 day in 7 herds. No calves were seen. Two important walrus areas were not surveyed then due to bad weather but had a maximum of 73 and 67 walruses respectively when surveyed later. Cows and calves (4) were observed only on the drift ice at Kvitøya. Concurrent with these surveys in southeast Svalbard, over 100 walruses were reported in northwest Svalbard.

A minimum of 400 male walruses occur in Svalbard, excluding the Kvitøya area. The Kvitøya area has been the most important area for walruses in Svalbard this century and we assume that a considerable number of walruses also occur there; at least 500 females and young have been seen. The population of walruses belonging to the entire Svalbard area must be over 1 000 animals.

DIVING AND FEEDING

In 1986-1988, there was a conflict between the shellfish trawling fleet and the conservation authorities in Svalbard. Scallops (*Chlamys islandica*) were most abundant in and around the national park situated at the northwest corner of Spitsbergen, especially at the walrus sanctuary at Moffen Island. Trawlers were prohibited from entering the richest areas but they were active just outside the protected areas. Points of contention included whether scallops were walrus food and if this trawling was harmful to the walruses. Our research therefore attempted to map walrus feeding areas and identify the main prey species to prevent further such disputes.

Diving

The location of walrus feeding areas was determined using PTT positions and a time depth recorder (TDR) for dive information. The animals were immobilized a second time to recover the TDR. Location data were compared to information on walrus feeding from the same area, based on fecal samples, and on an inventory of benthic fauna in the area.

Four TDRs were recovered but only one was intact and provided about 2 weeks of dive records; 1 693 dives were made, averaging 19.6 m. There were 3 modes of dives: 3-4 m; approx. 20 m; and 55-70 m. Mean dive duration was 5.2 min. About 50% of the dives lasted 6-8 min. Dive duration was positively correlated with dive depth. Mean bottom time was 4.2 min. accounting for 81% of total dive time. Mean surface time (< 2m) was 1.5 min.

Walruses feed mainly on benthic invertebrates and we believe that continual diving to the same depths indicates foraging. The area where the TDR was deployed has water depths less than 100 m, less than 30 m right at the tagging site. The duration of feeding dives is probably a function of water depth and food abundance as well as the capability of the diver.

Feeding

Early results show diets around Svalbard are the same as in other areas. The dominant prey found was *Mya truncata* with a variety of different taxa and species being recorded, including ringed seal (*Phoca hispida*) and bearded seal (*Erignathus barbatus*).

Benthic Inventory

In 43 analyzed samples of benthic fauna, 117 species were found. Dominant in individual biomass were holothurians (*Cucumaria frondosa*) while the most constant species found was *Margarites groenlandicus* (78% presence). The estimated mean biomass was 400 g wet weight/m^2 but the distribution was patchy with rich sessile fauna in numerous patches and nearly deserted areas in between. No samples contained *Mya truncata* but numerous empty *Mya* shells were found by SCUBA divers. In the study area, the most likely walrus prey was *C. frondosa* with individual dry weights up to 80 g and up to 2.4 kg dry mass/m^2.

OTHER STUDIES

Former Population Structure

The age and sex structure of walrus remains from a well known slaughtering site dated 1851 were examined to assess changes in population structures in Svalbard over 1.5 centuries. Intact jaws with teeth at the slaughter sites were measured and a tooth was taken for age determination.

Tissue Samples

Samples for DNA analysis and studies of environmental pollutants have been taken both from immobilized walruses and from animals that were not immobilized. From immobilized animals, skin samples were collected using a 5 mm biopsy needle. Similar samples were obtained from non-immobilized walruses using a crossbow and arrows with heads modified as biopsy needles. Hair from moulting walruses was collected for analyses of pollutants.

Measurements and Weights

The following measurements were made on immobilized walruses when possible: zoological length (dorsal curvilinear length), standard length, half girth just behind the flipper, straight and curved lengths of both tusks from the gum to the tip, and circumference of both tusks at the gum. Attempts were made also to weigh immobilized walruses.

Physiology

An immobilized 960 kg male walrus was chemically restrained using a combination of medetomedine/ketamine for an experiment using tritium labeled water to assess body composition. Blood samples were taken before injection and every half hour for 5 hours.

PRELIMINARY CONCLUSION

When we started the walrus project in 1989, our main goal was to determine whether walruses in Svalbard were part of a population belonging to a larger geographical area and whether they undertook migrations between these areas or within them. We also wanted to estimate the size of the walrus population in Svalbard. Though we have not finished the project, we believe that we have demonstrated that the walruses in Svalbard and Franz Josef Land belong to one stock which may include the walruses in northeast Greenland. We found that walruses in Svalbard are site-faithful but that they travel between different parts of the archipelago. Our survey results indicate that there are at least 500 males in Svalbard in summer, suggesting that the population is probably twice this size. We expect that aerial surveys conducted in 1993 will increase this estimate.

GREENLAND/DENMARK. E. Born.

Report on research and management (1990-1992) of walruses in Greenland

RESEARCH

Since the last meeting of WITS in March 1990, the following research on walruses has been conducted by the Greenland Fisheries Research Institute (Greenland Home Rule). Other Institutes involved are given in parentheses.

1990

1) Attempt to immobilize walruses in the pack ice off Central West Greenland in April.
2) Aerial surveys in the same area at the same time.
3) Satellite tracking of male walruses in North East Greenland from August 1990 until March 1991.
4) Collection of biological samples from the Inuit's catch of walruses in North West and Central East Greenland.

1991

1) Aerial surveys off Central West Greenland in March.
2) Collection of data on total body weight and body composition of walruses in North West Greenland in May-June.
3) Attempt to immobilize walruses in the pack ice in the same area in June.
4) Analyses of ageing material and reproductive organs from approximately 400 walruses.
5) mtDNA and nuclear DNA studies together with US Fish and Wildlife Service.
6) Analyses of plutonium in tissues of walruses from North West and Central East Greenland (Institute of Nuclear Physics and Environmental Studies, Risø, Denmark).

1992

1) Analysis of various data completed.
2) Sequencing of mtDNA in one specimen of Atlantic walrus (Department of Genetics, University of Lund, Sweden).

MANAGEMENT

During the period, neither new management/hunting regulations have been introduced, nor have any new management schemes been implemented.

At present, the Greenland Home Rule Administration in Nuuk (Directorate for Fisheries, and Directorate for the Environment) is considering how to coordinate the management (and research) of Greenland walruses internationally either via, for example, the Canada-Greenland Joint Commission on Research and Management of Narwhals and Belugas and/or via North Atlantic Marine Mammal Commission (NAMMCO).

In Greenland, walrus catch statistics are very insufficient. On 1 January 1993, a new system of catch reporting was established. To obtain a new hunting licence, a hunter now reports (on a voluntary basis) his catch of various game (including walruses) during the previous year. There are, however, no measurements in this system to control or verify the accuracy of the reportings.

USA

Summary of walrus management and research in Alaska.

MANAGEMENT. D. Seagars and L. Lowry.

Population Survey of Pacific Walrus in the Bering and Chukchi Seas, 1990

Cooperative surveys of the Pacific walrus population have been conducted at 5 year intervals since 1975 under terms of the 1972 "Agreement on Cooperation in the Field of Environmental Protection", between the USA and the (former) USSR. The 1990 survey was the first fully integrated one. Biologists from both nations participated in pre-survey tests of methodology; the survey employed a common design (Gilbert et al. 1990); surveys originating in Russia and United States were flown concurrently; American biologists flew with the Russian team; data were immediately exchanged and cooperatively analyzed; and a report was prepared jointly (Gilbert et al. 1992). However, anomalous ice conditions during the survey period, when ice coverage approached recorded minima in the Chukchi Sea and East Siberian Sea, likely influenced walrus distribution and accounted for very low numbers of walruses in the pack ice. As a result, the joint survey produced a minimal estimate of the total population size (201 039) which is not comparable to estimates obtained from the previous joint surveys.

Harvest Monitoring

The US Fish and Wildlife Service (USFWS), assisted by the Eskimo Walrus Commission (EWC), conducted a harvest monitoring program in 6 western Alaska villages from 1980 until 1989. The monitoring program was not conducted in 1990 and 1991 due to lack of funds. The USFWS initiated a revised and more cooperative program in the spring of 1992 in four villages to monitor the level of harvest and to collect life history data (age, reproductive condition, contaminant, and other samples) to provide management agencies and hunting and conservation organizations with information about how the harvest might affect the walrus population. Key changes in the USFWS program included: 1) hiring and training native people to work as village monitors with USFWS biologists in the collection of data; 2) requesting native hunters to voluntarily provide samples (teeth, reproductive tracts) from all walruses harvested; and 3) committing the USFWS to analyze samples and to report results back to native users before the next harvest season so that hunters can use the information to make informed decisions about the level and structure of the upcoming harvest. Hunter participation in the first year was encouraging. Teeth were provided from about 50% of the non-calf harvest and reproductive tracts were collected from about 20% of the females taken in the villages monitored. The program will be continued in four villages in the 1993 season but funding for this work beyond 1993 is uncertain at this time.

Marking, Tagging, and Reporting Program

The USFWS continued to expand its Marking, Tagging, and Reporting Program (MTRP) for the skulls and pelts of sea otters (*Enhydra lutris*) and polar bears (*Ursus maritimus*), and the tusks of walruses harvested by native Alaskans. The regulations require that these parts be brought to a designated tagger within 30 days of the harvest and before they are converted into a traditional handicrafted item. The program is now fully implemented throughout Alaska with more than 95 individuals (many of whom are native) hired by the USFWS as taggers. This detailed information has been evaluated and a report is anticipated in 1993.

Management Planning

WITS-1 recommended that detailed long range management plans be prepared by range states for their respective walrus populations. The USFWS began work on such a plan in 1989. A Draft Management Plan for the Pacific Walrus was completed and made available January 15, 1993 for distribution and public comment. A cooperative approach to developing the plan was taken by working closely with representatives from the native hunting community, conservation organizations, industry, and other State and Federal agencies. In particular, the US Marine Mammal Commission and the EWC made important contributions facilitating its completion. Meetings were held in many coastal villages in northwestern Alaska and Anchorage to discuss the Plan. The Plan is expected to be revised, with the Final Management Plan being made available in late 1993.

Law Enforcement

The USFWS concluded a major law enforcement program in 1992 termed "Operation Whiteout" which resulted in 29 people being charged with violations (such as "wasteful take") of the Marine Mammal Protection Act and other laws. Twenty-five individuals were found guilty or pleaded guilty, and fines up to $5 000 and incarceration of up to 18 months in Federal prison were levied. Federal judges have stated that they believe these penalties will send a clear message that this type of illegal activity will not be tolerated. The USFWS law enforcement program is expected to continue to enforce actively laws that protect walruses and regulate walrus hunting practices.

Habitat Protection

The USFWS issued regulations authorizing the incidental taking of small numbers of walruses in the Chukchi Sea during exploratory activities for offshore oil and gas. These regulations provide protection to walruses through seasonal closures, reporting, and establishment of a scientific monitoring program. Similar regulations have been proposed for oil and gas activities in the Beaufort Sea; final regulations are expected to be issued in 1993.

In the summers of 1989-1991, Ebasco Environmental conducted aerial and shipboard surveys near a drill ship operation in the northeastern Chukchi Sea to investigate the effects of offshore exploratory oil drilling in summer on the distribution of walruses. They showed that walruses were not found within 1 km of ice-breakers that were moving or ice-breaking. Overall walrus distribution was more influenced by the distribution of the pack ice, and the responses of the walruses to the drilling and ice-breaking operation were "subtle, short term,

localized and/or confounded by other factors such as environmental conditions of walrus social behaviour."

Two issues have arisen since WITS-1 that may affect terrestrial walrus haulouts in Bristol Bay, Alaska. The first is the closure of areas around walrus haulouts to trawling for yellowfin sole (*Pleuronectes asper*). Because the number of walruses hauled out at Round Island declined in 1987 and 1988 with the development of this fishery in the area, a proposal was submitted to the North Pacific Fishery Management Council (NPFMC) for the establishment of buffer zones. As a result of NPFMC recommendations, the National Marine Fisheries Service (NMFS) published regulations closing the waters within 12 nautical miles (nm) of Round Island, the Twins, and Cape Peirce to yellowfin sole trawling from 1 April - 30 September for 1990 and 1991. NPFMC reviewed the need for fishery closures in 1991 and decided to continue the 12 nm seasonal no-trawl buffer around the three haul-out areas indefinitely. The NMFS renewed the regulations indefinitely but modified them to permit vessel transit through a 3 nm wide region within State coastal waters which extends into the northeastern section of the Round Island closure zone. The relationship between fishing effort, walrus numbers, and the effectiveness of the closures remains unclear with evaluation complicated by vessel use of the transit zone and minimal monitoring and behavioural data. The peak counts of hauled out walruses on Round Island were somewhat higher in 1990 and 1991 than in 1987-1988, but counts in 1992 were low again. Some vessels violated the regulations and fished within the closed zone in 1992. To date 10 cases have been prosecuted and penalties in excess of $800 000 and loss of fishing privileges have been levied.

The second issue is a proposal for subsistence hunting of walruses on Round Island. In 1991 residents of the village of Togiak requested a permit from the Alaska Board of Game to harvest 10 male walruses on Round Island in October. Although hunting by Alaskan natives for subsistence and handicraft purposes is not limited if the population is not depleted and the harvest is not wasteful, the State of Alaska has prevented hunting at Round Island indirectly by restricting access to the island since 1960 when it became part of a State Game Sanctuary. The Togiak proposal was considered by the State Board of Game in November 1991 but no decision was reached. During 1992, a task force appointed by the State considered this issue and made recommendations on how hunting should be conducted on Round Island, if it is permitted. The proposal was discussed again by the Board of Game in 1993, but no action was taken.

Contaminants Monitoring

The USFWS continued a 1981-1984 baseline study to monitor levels of heavy metals in tissues of Pacific walruses harvested in the spring by Alaskan natives. Analyses for metals and metalloids were conducted on 50 kidneys and 53 livers collected from 1986-1989 in Gambell, Savoonga, and Diomede. Mean cadmium concentrations were not significantly different than previously reported for walruses although they continued to exceed levels thought by the Environmental Protection Agency to interfere with organ function in domestic animals. Mean mercury concentrations were not significantly different than reported previously (Warburton and Seagars 1993).

Another 220 liver and kidney samples were taken from Pacific walruses during a 1991 USA-USSR research cruise. Analysis for heavy metals and metalloids is in progress, including, for the first time, methyl mercury. Relationships between contaminant levels and age, sex,

and female-calf pairs will be examined. Blubber samples from about 50 walruses also were collected during this cruise; these samples will be analyzed for a suite of hydrocarbons in 1993.

RESEARCH. S. Hills.

Estimation of Population Size

WITS-1 recommended research to improve counting systems and data recording, determine habitat parameters to improve survey design, improve counting on coastal haulouts, and to assess the potential for determining sex/age composition from photos and observations during spring surveys for Pacific walruses.

Videography. Walruses on ice are often very close together or on top of one another, making it difficult to distinguish individuals. The effectiveness of airborne visual imagery (High-8 video and 35 mm photography) to supplement or replace visual observations for counting walruses was evaluated by Douglas et al. (1991). The resolution of handheld 35 mm photography was superior to that of High-8 video but both were significantly lower than visual real-time estimates although the true number of walruses in the groups was not known. Douglas et al. (1991) recommended that 35 mm slides should be taken as a backup for the visual estimates, but that the imagery should not replace observer estimates.

Walrus distribution on ice haulouts by habitat type. Hills (1992) examined the distribution of walruses on ice in the northeastern Chukchi Sea during the 1975, 1980, and 1985 aerial surveys in relation to five habitat variables (ice cover, water depth, sediment type, degree of sorting of the bottom sediments, and water mass type). No combination of habitat variables examined consistently predicted the presence of walruses well, although in general walruses were less likely to be found over water deeper than 60 m, or in 7-8 oktas of ice. Thus, stratification of the coverage area for an aerial survey on the habitat variables examined would be of little help in reducing the variance of the population estimate. The ice cover data used in the analysis were recorded during the aerial surveys, not from satellite information. Scanning Multichannel Microwave Radiometer satellite ice observations and survey ice observations were compared and will be incorporated into the analysis of walrus distribution by habitat type (Rudnicky et al. unpubl. data). An alternate approach would be to categorize ice not only by ice cover, but also by some other functional classification such as that used by Burns et al. (1981).

Estimation of numbers on land haulouts. To develop methods to estimate better the numbers of walruses on land haulouts, daily counts of walruses on the beaches at Round Island, Cape Peirce, and Cape Seniavin (all in Bristol Bay, AK), in the summers of 1987-1991 were analyzed (Hills 1992). The number of walruses hauled out was related to wind speed, wind strength, temperature, tide state, and barometric pressure, using time series models. Generally, the number of walruses on the haulout was positively correlated with increasing barometric pressure, the rate of change of the tide, and wind direction that put the haulout beach in the lee, but no combination of environmental conditions was consistently highly correlated with peak haul-out days. During the 1975-1990 cooperative range-wide surveys, the Russians have counted walruses on terrestrial haulouts from aerial photographs but the photographs were not necessarily taken on peak haul-out days. The American haulouts were

counted by ground and aerial observers during a peak haul-out period within the survey time. The American method was more precise but neither method estimated the proportion of animals at sea and not available to be counted. Thus both methods underestimated totals by an unknown and unpredictable degree. In summer 1990, nine satellite transmitters were put on adult male walruses in Bristol Bay. Two main haul-out patterns were seen: the "classic" pattern of 2-4 days on the haulout followed by 7-10 days at sea, and the "daily" pattern of remaining in the area of the haulout with daily trips to sea.

Work is underway to compare the numbers of walruses counted from aerial or cliff-based photographs with the visual estimates by observers at the same haulout (L. Jemison, Togiak National Wildlife Refuge, pers. comm.).

Estimation of numbers on ice haulouts. The two main sources of the high variance in population estimates for Pacific walruses on ice are the distribution of walrus groups on the ice and the synchrony with which they haul out. That is, the walruses have a clumped distribution in both space and time. Data from satellite transmitters on individual walruses can provide information that can help to address both problems. Adult female walruses were tagged with PTTs in July 1988 (n=3), July 1989 (n=6), and April - May 1991 (n=6) in the Chukchi and Bering Seas. The 1988 and 1989 PTTs functioned for about a month and the animals stayed in the same general area where they were tagged (Hills unpubl. data). The 1991 PTTs, however, functioned through spring migration (Hills et al. 1991). Generally, the females moved northward as the ice receded, spending several weeks in the south central Chukchi Sea where the ice formed a relatively solid mass between 67-68°N. Two females were tagged one day apart near Nunivak Island in April. By late July they were in their summering areas: one near Wrangel Island and the other off the northwest coast of Alaska. Little analysis has been done yet on these data, other than plotting walrus locations on maps that show ice distribution derived from satellite-borne remote sensing (Douglas et al. 1992).

Evidence of trends in the Pacific walrus population. Since 1975, population estimates for Pacific walruses have been derived from rangewide aerial surveys and have large variances. Many changes in the aerial survey methods have been proposed and some have been tested. Given the variances that could reasonably be expected for population estimates from aerial surveys, can those estimates be used for trend information? A power analysis using Gerrodette's (1987, 1991) formulae showed that with a cv=0.6, probabilities of Type I and Type II errors of 0.1, and a survey interval of five years, 13 surveys over 60 years would be needed to detect a 5% decline in the population size (Hills 1992). Hills (1992) recommended that population estimates derived from aerial surveys of Pacific walruses should only be used to compare with the legally determined threshold number of "depletion" but not used as an indicator of trends in population size.

Comparison of Soviet and American census methods. Using data from the 1975, 1980, and 1985 range-wide aerial surveys, population estimates have been computed using both the American strip transect and the Soviet block estimate methods (Udevitz and Gilbert unpubl. data). The estimates are very different. No variance can be calculated using the Soviet method, and a conclusion was reached that researchers from both countries should use the American method. The manuscript is being revised after reviewer comments.

Alternative aerial survey designs. A suggested protocol for the 1990 range-wide aerial survey (Gilbert et al. 1990) recommended that Russians and Americans use the same survey

and analysis methods and incorporate adaptive sampling (Gilbert et al. 1990) and hand-held 35 mm photography. Simulations showed that adaptive sampling has the potential to reduce the variance of the population estimate by 60-90% when the sample size is increased by about 10% (McDonald and Erickson 1989). However, because of the anomalous ice conditions, walrus distribution, and logistical complexity, adaptive sampling was not used in the 1990 survey.

Haul-out Model. Gilbert has developed a model of haul-out behaviour of walruses. The predictions of the model will be compared with Hills' data on haul-out behaviour of both male and female walruses from satellite transmitters.

Synthetic Aperture Radar (SAR). Ground-truth data and SAR imagery were collected in summer 1992 for a pilot project by Alaska Fish and Wildlife Research Center to evaluate the ability of satellite-borne SAR to detect groups of walruses on land. The SAR images of northern Bristol Bay have not yet been processed for comparison with the daily counts of walruses hauled out on the beaches there. Unlike infrared detectors, radar is not blocked by clouds. SAR can be aircraft-borne, making it a potentially useful method for mapping large concentrations of walruses on ice.

Population Status

WITS-I recommended developing better means for using catch samples.

Samples from the harvest are being examined to assess feeding, reproductive history, and growth.

Feeding. G. Sheffield (a graduate student of F. Fay, University of Alaska, Fairbanks) is compiling all existing stomach content data for Pacific walruses and investigating better methods for evaluating stomach contents. The study is identifying and attempting to control for biases resulting from differential digestion. Artificial digestion of clams shows that after only 1-2 h, only feet and siphons remain from whole shucked clams. Previously it was thought that walruses ate just the feet and siphons (Fay 1982; Fisher et al. 1992; Vibe 1950). The work is to be completed in late 1994.

Fay et al. (unpubl. data) examined food consumption of captive walruses and found that intake is not constant throughout the year. Males fasted while adult non-lactating females reduced consumption during the breeding season. Females fasted around the time they gave birth and reduced intake during estrous. Females increased their intake by about 30% when they were pregnant and by about 40% when they were lactating.

Reproductive History. L. Lipton (a graduate student of F. Fay, University of Alaska, Fairbanks) is investigating the potential for determining the reproductive history of female walruses from tooth microstructure. Preliminary trials have been conducted with scanning electron microscopy, microprobe analysis, an optical imaging system, and different ways of cutting, polishing, and staining tooth sections.

Fay recently counted annuli in walrus teeth taken during the 1987 USA-USSR research cruise. The only collections of Pacific walrus teeth remaining to be examined are from animals taken during the 1991 USA-USSR research cruise, from 1988, 1989, 1992 and 1993 Alaskan

harvests, and some opportunistic samples, such as from beach-cast carcasses.

A handbook of standardized terms, procedures, and minimum information to be collected from walrus reproductive tracts is being produced by Hills and Fay. In conjunction with Fedoseev, Volokhov, and Burns, they are compiling all data from reproductive tracts for Pacific walruses, including those from Alaska village harvests and all USA-USSR research cruises. These will be reevaluated with respect to the standardized definitions and procedures. Analysis of the combined data has not yet begun.

Growth. Fay has length, weight, and age data from walruses collected on USA-USSR research cruises. Four different methods were used to measure the animals and he has the information to standardize the measurements. A manuscript is in preparation.

WITS-I recommended further development of non-intrusive monitoring methods.

Stock structure and population models are being studied.

Stock Structure. On the 1991 USA-USSR research cruise, 2 417 walruses in 154 groups were classified by sex and age (Hills et al. 1991). Near St. Lawrence Island, the average group size was 23.7, including many adult females and newborn calves (calves:adult female = 0.73:1). In contrast, in Anadyr Gulf the average group size was 16.7, mostly made up of adult females and older young with very few calves present (0.12:1 calves:adult female). Near Nunivak Island, average group size was 4.7 with a ratio of 0.38:1 calves:adult females. Hunters tend not to take females with newborn calves in the St. Lawrence Island area, as seen in the difference between the harvest (4 calves (7%) taken in harvest of 60 walruses) and the observed composition (407 calves (31%) in 1 302 animals classified). Sources of variance and bias have not been analyzed.

Population models. A population model was developed by Udevitz and Gilbert (unpubl. data), for sensitivity analysis of different life history parameters to guide the choice of indices used for long-term population monitoring. The authors describe the mathematics and general consequences of having fecundity vary with age in animals for which annual breeding is not possible. Other manuscripts evaluating the model's applicability to other species and the results of the sensitivity analysis will be drafted.

A back-calculating model is being developed by Eberhardt et al. (unpubl. data) to estimate the range of OSP for the Pacific walrus population.

Population Delineation

WITS-I recommended that Fay's craniological study be completed and published. The last major data-gathering effort for this study was completed in September-October 1992, with sampling of archived material from the extinct population from the Canadian maritime provinces. Some other populations are still poorly represented (e.g. East Greenland, Svalbard, Kara, and Laptev), but additional specimens apparently are not available. The data set is ready for analysis. Remaining to be completed is a large backlog of complementary data on tusk form and non-metrical characters that will be derived from photographs of skulls. These cannot be used in the analysis but will supplement the descriptions of the various populational units.

WITS-I recommended that studies of genetic structuring among walrus populations be initiated, beginning with the widely separated groups and expanding to all populations. To that end, mitochondrial DNA (mtDNA) in 10 tissue samples from walruses from three sites in Greenland (from E. Born) and 60 samples from walruses near the ice edge in the Chukchi Sea (from S. Hills) have been analyzed using PCR and restriction enzymes. The haplotypes of the Greenland samples are relatively distinct for each collection area, indicating little intermixing, but the Chukchi samples are not separable by collection locality, indicating much intermixing. The Greenland samples were distinct from the Chukchi samples. A paper describing the results has been drafted.

Hills, Cronin, and Fain (USFWS Forensics Laboratory, Ashland, OR) are investigating mtDNA and nuclear DNA in 70 walrus samples taken during a recent USA-USSR research cruise in four areas (Nunivak Island, Koryak coast, east of St. Lawrence Island, and northern Gulf of Anadyr). In addition, for two samples, approximately 300 base-pair portions of the mtDNA D-loop were sequenced. None of the analyses showed significant differentiation of genotypes by collection area. These results suggest that there is probably only one stock of Pacific walrus, or, if there are two stocks corresponding to the two main breeding concentrations, that they have not been separated long enough to show genetic differences. Many of the samples from the animals taken during the 1991 cruise have not been analyzed.

Effects of Human Activities

WITS-I recommended that data on age-sex composition of harvests of the Pacific walrus for the past 30 years be consolidated and published. The entire data set for Pacific walrus harvests (1930 to 1989) has been compiled by Fay and Burns and incorporated into a manuscript that will be published as a USFWS Marine Mammals Management Technical Report authored by Fay, Burns, and Bowlby.

WITS-I also recommended developing and implementing methods to quantify levels of struck and lost (unretrieved kill). All of the existing data on struck-and-lost rates in the Alaskan harvest have been compiled and analyzed by Fay with coauthors Burns, Stoker, and Grundy. The manuscript has been submitted for publication.

Beached carcass projects. In 1990 and 1991, Espinoza (USFWS Forensics Laboratory, Ashland, OR), in cooperation with USFWS Law Enforcement personnel, flew along the beaches of western Alaska to document the numbers, distribution, and condition of beached walrus carcasses. Many of the carcasses were headless, but whether the head was removed when the animal was killed on the ice or after the carcass washed up on the beach was not known. To distinguish between these possibilities, Espinoza experimented with cow bones, leaving them at sea, in the surf, and on the beach for various lengths of time, and concluded that it was possible to distinguish whether the head had been removed at sea or on the beach.

In a related project that may be published with the above study, beach-cast carcasses in Bristol Bay were studied in 1990-1992 by Jemison and Hills. The distribution, number, and condition of carcasses on the beaches of northern Bristol Bay were mapped during monthly aerial surveys. In addition, carcasses at Cape Peirce were marked and photographed to document the rate of carcass decomposition. The data have not yet been analyzed.

Heavy metals in walrus foods. High levels of cadmium and mercury have been found in liver and kidney tissues of Pacific walruses (Taylor et al. 1989; Warburton and Seagars 1993). To investigate the source of the metals, a pilot project was begun with Miles (USFWS, Patuxent Research Centre) to analyze metals in foods found in walrus stomachs. During the 1991 USA-USSR research cruise, Hills collected samples of *Serripes groenlandicus*, *Echiurus echiurus*, *Spisula polynyma*, and *Tellina* sp. from stomachs of walruses taken near Nunivak Island, AK, and off the Russian Koryak coast. Although the materials looked relatively undigested, many of the soft internal organs had been digested, which liklely biased the analysis. Only the *Mya* from the Koryak area had high levels of cadmium. A manuscript reporting the work has been drafted by Miles and Hills.

Effects of aircraft overflights. Data on the effect of aircraft overflights on walruses resting on ice were collected by Douglas and Gilbert in June 1989. Hessing, Jemison, and Hills have been collecting anecdotal information on the effects of overflights on walruses hauled out on land in Bristol Bay. The data have not been analyzed yet.

Effects of tourists on walruses on terrestrial haulouts. Hessing has been coordinating observations of walrus behaviour in response to boats and tourists at Round Island and Cape Peirce since 1988. The data have not been analyzed yet.

Other Work

Chemical immobilization of Pacific walruses. The results of immobilization attempts of Pacific walruses with Telazol (n=7), carfentanil (n=4), xylazine (n=4), and etorphine (n=66) were reported in a paper by Hills, Cornell, Jones, and Volokhov that has been submitted for publication.

Performance of satellite transmitters on Pacific walruses. The performance of 27 satellite transmitters (platform terminal transmitter, PTT) attached to the tusks of adult male (n=12) and female (n=15) walruses from August 1987 through May 1991 was analyzed and reported in a manuscript by Hills. Eleven different combinations of sampling program, housing design, and antenna type were tested. The PTTs transmitted from 2 to 256 days, giving 5 405 locations out of the 10 101 overpasses for which at least two messages were received. For the 206 satellite locations for which the true location of the walruses was known, 131 (63%) were within 2 km and 18 (8%) were >20 km away from the known location.

Data archiving. During some of the analyses outlined above, it became clear that there were mistakes and inaccuracies in some of the major data sets. As a result, Gilbert, Rudnicky, and Hills completely checked the data for both the Soviet and American portions of the 1975, 1980, and 1985 aerial surveys with the original data sheets (and voice tapes in several cases). Also, Jemison and Hills compiled all haul-out data for Round Island, Cape Peirce, and Cape Seniavin from the mid 1970's to the present, except for several years for which Taggart evidently has the only copy of the data. In several cases, especially at Cape Peirce, photographs existed to document the estimate and counts of walruses in the photos showed the estimates to be inaccurate. In some of the Round Island reports, no distinction had been made between counts of the entire island and counts of only the east side beaches, but the daily activity sheets of the personnel on the island were clear. In addition to the numbers of walruses, environmental conditions for each day were added to the data set

whenever possible. The corrected data sets are archived at the Alaska Fish and Wildlife Research Centre, Anchorage, AK.

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CANADA. P. Richard.

An overview of walrus distribution and abundance in Canadian waters appears in the report of the first WITS meeting (WITS-1) of March 1990. A brief review was presented at WITS-2 with a summary of the activities of Canadian managers and researchers since WITS-1.

WITS Secretary

For the last two years, Dr. Robert Campbell[1], has served as WITS Secretary, facilitating the exchange of information between range state representatives on new developments or issues relating to the world's walrus.

Management

Management of walruses in Canada has not changed since WITS-1 but the recent signing of the Nunavut Land Claim agreement between the eastern Canadian arctic Inuit and the Government of Canada means that a wildlife management board composed of Nunavut Inuit and federal government representatives will soon be created. In the future, this board will review information on the status of walrus stocks (and other species) and will make recommendations on walrus research and management.

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[1] Canadian CITES Administrator, Canadian Wildlife Service, Ottawa, Ontario, K1A 0H3; tel.: (819)953-1411; fax.: (819) 953-6283

The Nunavut Land Claim covers the Eastern Arctic Region and part of the Central Arctic Region of the Northwest Territories and has been negotiated over the last two decades. An agreement-in-principle was signed in April 1990; the final agreement was signed on January 1992 and is planned to be ratified in 1993. Under the agreement, local Hunters and Trappers Organizations (HTOs) known as Hunters and Trappers Associations (HTAs) in each community, will be officially responsible for day-to-day management and local allocation decisions. Regional Wildlife Organizations (RWOs), such as the Baffin Regional Hunters and Trappers Committee, consist of representatives from all local HTAs. The RWOs will make allocation decisions at the regional level.

The Nunavut Wildlife Management Board (NWMB) is a co-management organization defined under the terms of the land claim agreement. It is to consist of four representatives from the RWOs and four representatives from federal and territorial government departments. Among other responsibilities, the board will forward its decisions concerning all matters related to wildlife harvesting in the Nunavut area to the appropriate federal and territorial ministers.

Under the terms of the land claim agreement, the Minister of Fisheries and Oceans must accept and implement decisions of the NWMB, except when they conflict with the principles of conservation, the harvesting rights of others, the purpose and policies of parks, sanctuaries and conservation areas, or with public health and safety. The Minister may also reject decisions that are not supported by, or are not consistent with, the evidence available to the NWMB. The NWMB and its constituent RWOs will have considerable influence in shaping every aspect of management and conservation of Canadian walrus populations.

Research

Nine research projects on walrus ecology, physiology, contaminants, and population biology are presently in progress in Canada. Four more are at the proposal stage or are expected to start next year. [Addresses are given for those not listed in the WITS-2 list of participants (Appendix 1)]

Doug Evans, Peter Outridge (Department of Environmental Studies, Trent University), and Rob Stewart. Elemental structure of walrus teeth; analysis in progress. Trent University, Peterborough, ON, K9J 7B8. Telephone: (705) 748-1261.

Joel Garlich-Miller and Rob Stewart: Growth and reproduction in Foxe Basin; sample collection and analyses continuing.

Brendan Hickie (Trent University): Model of contaminant intake and metabolism in walruses; project proposal. Trent University, Peterborough, ON. K9J 7B8. Tel.: (705)748-1261, Fax (705)748-1569.

Beth Thomson (née Hiltz), Kathy Fisher, and Rob Stewart: Use of dietary manganese to determine assimilation efficiency of captive Pacific walruses. Food and faeces samples collected at Harderwijk Dolphinarium, Holland, by Kathy Fisher in 1988; analysis completed.

Stuart Innes: Readings of body surface temperature of walruses under varying environmental conditions on Foxe Basin pack ice in summer; coupled with behavioural observations; one field season completed.

_____ Development of a method for age structure from tusk length photogrammetry; unfunded project proposal.

_____ Age and gender of pre-history harvest from walrus hunter middens at Hall Beach raised beaches; two field seasons completed.

Derek Muir and Rob Stewart: Organic contaminant levels in Canadian walruses. Started two years ago; 30 samples of blubber analyzed throughout the eastern arctic and northern Quebec.

Stas Olpinsky (Makivik Research, Kuujjuaq): Development of rapid diagnosis of *Trichinella* sp. infection in walruses; project proposal. Makivik Coporation, Kuujjuaq, PQ, JOM ICO. Tel.: (819)964-2951, Fax: (819)964-2230.

Pierre Richard: Aerial surveys of walruses in Foxe basin and northern Hudson Bay, 1988-1990; paper in progress.

Becky Sjare (DFO, Saint John's): Social behaviour of walruses at a winter polynia in the Canadian high arctic; four field seasons, PhD Dissertation completed. Department of Fisheries and Oceans, Science Branch, P.O. Box 5667, Saint John's, NF, AIC 5X1. Tel.: (709) 772-4049, Fax: (709) 772-2156.

Rob Stewart and Erik Born: Satellite telemetry of high arctic walruses near Resolute; project started 1993.

Rudolph Wagemann and Rob Stewart: Heavy metal levels in Canadian walruses; ~60 animals sampled at five locations in the eastern arctic and northern Quebec; 1994. Concentrations of heavy metals and selenium in tissues and some foods of walrus (*Odobenus rosmarus rosmarus*) from the eastern Canadian arctic and sub-arctic, and associations between metals, age and gender. Can. J. Fish. Aquat. Sci. 51(2): In press.

REPORTS OF THE WORKING GROUPS

INTRODUCTION

These reports were drafted by the rapporteurs and chairs of the working groups but they represent the deliberations of various subgroups of experts and contain information and comments added in the plenary session. As such, they include the input of all participants so separate authorship[2] is not assigned. Names of working group chairs, rapporteurs, and participants are in Appendix II.

AGEING (Working Group 1)

The working group addressed the following topics:
- definition of terms
- general processing procedures
- validation studies
- a standardized reference collection
- seasonal correlates
- geographic and gender differences
- recommendations

Abbreviations

ADFG = Alaska Department of Fish and Game, Anchorage
FWI = Freshwater Institute, Fisheries and Oceans, Winnipeg
GFRI = Greenland Fisheries Research Institute, Copenhagen
GLG = growth layer group

Counts of GLGs (1 opaque layer followed by 1 translucent layer) are used rather than age to avoid confusion relating to the most recently formed line. Half a GLG can be reported without implying the season of birth; reporting half a year implies more precision than is available. The working group also agreed that counts of GLGs, which are believed to represent annual growth, are the best indicators of absolute age available. Counts of lines on claws have been examined for seals but are thought to be of limited use for walruses. GFRI has examined bacula for layered structures and found none. Closure of sutures was discussed for walruses, but it would produce only broad age categories.

Participants all followed a method similar to the one used at FWI. It is outlined here, with variations noted.

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[2] The working group reports may be cited in the following format: Working Group 1. 1993. Ageing, p. 20-23. *In* R.E.A. Stewart et al. (ed.). Report of the 2nd Walrus International Technical and Scientific (WITS) Workshop, 11-15 January 1993, Winnipeg, Manitoba, Canada. Can. Tech. Rep. Fish. Aquat. Sci. 1940: viii + 91 p.

Teeth are either removed individually by breaking the mandible with a hammer or back of a hatchet, or the whole lower jaw is removed. Teeth and jaws are frozen until further analysis. If teeth are removed in the lab, jaws are usually gently boiled to loosen the teeth before extraction with pliers or occasionally, chisels.

The tooth selected for ageing differs among labs. FWI and ADFG researchers use the lower canine in the belief that it erupts earlier than the other teeth which may have early lines worn off and that, being a larger tooth, lines will be more widely spaced, making counting easier. GFRI uses the second post-canine, believing that lines in a smaller tooth will be defined more clearly and will have fewer secondary lines. None of these assumptions has been tested and it was agreed that there is apt to be variation in GLG counts within a tooth row. Participants could not assess the direction or extent of this variation (Recommendation 1).

All labs use thin longitudinal sections taken from the middle of the tooth for ageing walruses. FWI has embedded teeth in epoxy and used a thin wafering saw with a motor-driven mechanical stage to produce sections about 0.3-0.5 mm thick. Other labs use hot glue and a hand powered mechanical stage with a smaller saw to produce sections about 0.5 mm thick. The epoxy embedding process is considerably slower than the hot glue technique.

Sections are stored in a mix of glycerine and alcohol (1:1), or glycerine, alcohol, and water (1:1:1). If samples are allowed to dry, the light transmitting nature of the annuli reverses, that is opaque lines in wet sections become translucent when dry. Wetting the section restores the original appearance. All labs examine the tooth sections wet, on stereo-microscopes with a combination of transmitted and reflected white light, and various light intensities.

In a lab exercise, the working group examined 3 sections of walrus teeth on a microscope. Participants all obtained virtually the same GLG count for each (±1 on counts of 14-20). For demonstration purposes, the working group also viewed sections on a video monitor attached to a stereo-microscope. This emphasized the need for readers to see the whole section to be able to see GLG patterns in different areas.

Most readers rely on supplementary information to assist counting GLGs (Recommendation 2). The thickness of cementum, measured about 2/3 of the distance up from the root tip, helps to identify young walrus (which may have several non-annual lines). The size of the pulp cavity provides similar information. Neither is useful in older animals. Most researchers record the date of kill but fewer are using it to examine seasonal changes in line formation. The mandible size and line-count and basal tusk circumference also provide supplementary data useful to readers. Data on reproduction and body size may also help but researchers must be aware of possible circularity. These sources of additional information are more useful in detecting over-estimates in age for young walruses (0-10 GLGs) than for old walruses (15+ GLGs). For example, an open pulp cavity and thin cementum are contrary to a count of 15 GLGs and would suggest a reading error. But, a closed pulp cavity and thick cementum is consistent with GLG counts of both 15 and 25. All relative age indicators are limited in this manner.

The working group discussed possible commercial sources for ageing walruses. In Europe, all porpoise ages are produced by a central lab. In the US, there is a commercial lab which appears cost-effective. Advantages of such an arrangement were thought to include

low cost and stability in readers. Disadvantages included loss of interpretive experience in the research labs, lack of knowledge of personnel turnover in the commercial lab, and problems of transboundary transport of marine mammal parts.

Aside from Fay's sample of 18 captive walruses, there have been no validation studies (Recommendation 3). Tetracycline could be used in captive walruses, although the working group was uncertain if lines form in captive walruses. Captive walruses do eat different amounts during the year and this may or may not mimic natural cycles. It may also be possible to inject a small number of wild walrus calves to be analysed on subsequent harvest. Micro-element analysis might reveal naturally incorporated elements which could be introduced in abundance to captive walruses as a more benign marker. It was noted that with current techniques, it is impossible to remove teeth from drugged walruses because the animals' jaws are firmly closed due to muscle tetany.

While not validation, it was noted that a reference collection, aged by a wide array of readers, would be useful as a standard against which new readers could be judged and experienced readers could do periodic checks (Recommendation 4). Such a collection could be augmented with known-age material as it becomes available, ultimately leading to validation.

All labs do replicate counts before assigning a final age estimate. The number of replicates varies from 2 to 5. Final age estimates for difficult sections may be made after detailed discussions among the readers. An analysis done at FWI indicated that such consensus taking produces the same final result as the central statistic (average, medial, mode) of many replicates (15 to 20). Consensus in this study was defined as a cv $\leq 10\%$ which allows some variation in older animals but none in young ones. It is important to record "confidence" in a final count for reference during subsequent use of the ages (Recommendation 5).

The working group discussed the seasonal correlates of annuli - a broad opaque layer is the first layer formed - but concluded that there were few quantitative data (Recommendation 6). A study has been started in the USA to examine seasonal and reproductive correlates of annuli formation. Studies to determine the elemental structure of the lines are being initiated (Trent University, FWI), trying to assess historical heavy metal exposure as recorded in annuli of marine mammals, including walruses. As part of this study, elemental composition will be determined. The finer resolution this technique offers over light microscopy may assist in determining the nature of the most recently formed line and address questions about seasonal deposition.

The working group discussed geographic and gender differences in the nature of GLGs. Geographic variation in clarity has been noted in beluga but has not been examined for walruses (Recommendation 7). Participants did not notice any obvious differences in the Pacific and Atlantic walrus teeth examined during the workshop.

Several researchers have noted that the lines in teeth of adult males are more clearly defined than in those of females and younger males. This was thought to be the result of more sharply defined seasonal shifts in the males. The working group did not speculate farther for wild walruses, but it was noted that in captive walruses, seasonal changes in appetite do occur and they are more pronounced in adult males. Teeth appear to wear down faster and the lines tend to merge more in females than in males (Recommendation 8).

RECOMMENDATIONS

Recommendations are presented in order of appearance in the text, not in any order of priority.

1. The variability in counts and the ease of reading among all teeth in an animal should be examined.

2. Readers should use all the information available to interpret difficult sections. Thus, data that should accompany the tooth include date of death, body size, tusk size, and gender. Data that should be recorded during ageing includes cementum thickness and size of the pulp cavity.

3. Validation is required. Teeth from known-age, captive walruses should be examined to see if there are annuli and if they match the known age. It is also possible to inject tetracycline into walruses at marine mammal parks to test the assumption of annual formation. There may be records available at places such as Sea World which would provide this information.

4. A reference collection should be developed. It could include a permanent collection held in one location, a photographic or video library of tooth sections, and a methods manual.

5. Readers should indicate the difficulty of determining a final GLG count. This could range from a cv for replicate readings through notes indicating that an estimate could only be obtained by consulting all the supplementary data available (tusk circumference, body size etc.), to a record that the section was impossible to read. These observations are important when using the age data in other analyses.

6. More information is required on the seasonal correlates of GLG formations. Useful sources of information are samples collected throughout the year and records on the nature (translucent-opaque, broad-narrow) of the last line, tetracycline marking of wild animals, and determination of the onset of cementogenesis. A sample of neonates is required. Data for other species should be reviewed.

7. Geographic or intra-stock variation in form and clarity of GLGs should be examined.

8. Gender variation in form and clarity of GLGs should be examined.

CENSUS (Working Group 2)

Assessment of walrus numbers is required by Pacific and Atlantic walrus managers to determine the effects of resource exploitation. The problem is: how do you census an animal that cannot be seen much of the time and inhabits a variable environment (pack ice)?

The working group addressed the following topics:

- counting techniques: new approaches
- walrus haulout/habitat relationships: is it possible to use habitat information to predict where walruses will haul out?
- sampling designs for cost efficiency
- corrections for walrus availability to observers: what proportion of the walruses are we seeing? what proportion is submerged, hidden from view or missed by observers?
- given their high cost and low effectiveness, are surveys worth doing at all?

The working group first listed all census (or counting) methods. These were divided in two categories: airborne and onsite methods.

AIRBORNE METHODS: POTENTIAL AND EXISTING

visual strip transect counts
visual line transect counts
black and white or colour photo strip transect counts
ultraviolet (UV) photography
infrared (IR) photography
forward-looking infrared (FLIR) strip transect thermal image indices from walrus groups
synthetic aperture radar (SAR) for detecting and indexing land haulouts

ONSITE METHODS: POTENTIAL AND EXISTING

visual ground counts or extrapolations
ground photo counts or extrapolations (time-lapse or staffed)
ground-truthing of airborne or orbital remote-sensing imagery

The working group discussed which of these methods are appropriate or useful for counting or estimating numbers of walruses in three environments: pack ice, open water, and land haulouts.

PACK ICE

A FLIR system flown at 3 000 m can detect walrus groups of 6+ hauled out on ice at ranges of about 10 km and over a strip about 5 km wide. Systematic FLIR surveys at high altitude can provide high coverage to detect walrus concentration areas prior to census flights. High density strata could therefore be delimited and covered more intensively than other parts of the census area. Such a stratified design would likely result in a reduction of sampling error of the overall estimate, as long as walrus numbers and distribution remained similar between the FLIR and the census surveys.

In visual surveys, the choice between line transect or strip transect depends on the behaviour of observers and their detection of walruses with distance. If detection diminishes

with distance, line transect is preferable to strip transect. There are cases when observers do not have a sloping detection function but they have a bi-modal one. Training of observers and determination of each observer's detection function before (and during) strip surveys are therefore highly recommended. Protocols for observer comparisons and for avoiding observer boredom or fatigue should also be used.

Photo strip transect surveys do not suffer from the problem of unequal detection across the strip but are very expensive in film cost and analysis. They may be practical only for small census areas.

OPEN WATER

Visual detection of walruses in water is poor (with vertical photos also, although not quite as bad) and open water surveys are not cost efficient. Working group participants concentrated on land and ice haulout surveys which, however variable, provide better indices of population size.

LAND HAULOUTS

Ground counts, ground photo counts (staffed or time-lapse photo), and aerial photo counts are appropriate methods depending on factors such as the circumstances, landscape etc. Statistics (mean, mode and variance) from a time series of counts throughout the season of occupation is preferred to single counts because walrus numbers at haulouts are highly variable and peak occurrences are difficult to predict.

Onsite visual or photo counts are preferred to aerial counts when there are vantage points over haulouts or counts can be made from boats. Time-lapse photography is an option for field camps but there are design problems and technical difficulties to overcome. Aerial surveys may be needed in inaccessible and inhospitable locations but the expense of acquiring a time series of counts in such a manner may be prohibitive.

SAMPLING DESIGNS

Stratification into high and low density strata is highly desirable to reduce sampling error to reduce estimate variance. Preliminary analysis suggests that spatial auto-correlation of Chukchi walrus density is weak even at small distances between samples ($\leq$ 2 km). High density strata may need to be surveyed at very high, even total, coverage to reduce sampling error.

Adaptive sampling used in pelagic trawl surveys is touted as a variance reduction technique but it remains to be thoroughly tested on walruses. It was tried once but conditions were so unusual that it had to be discontinued. Also, the amount of effort spent in any survey area is unpredictable and the completion of a survey is unpredictable. Planners cannot easily optimize survey effort.

WALRUS AVAILABILITY TO OBSERVERS

One set of data showed that in one year, 87% of instrumented walruses hauled out during peak haul-out times at Round Island. Similar data are available for pack ice haulout, but remain to be analyzed. Concurrent telemetry data are desirable to estimate the extent and variation of this visible proportion if survey counts are to be used as indices of population size.

There was some discussion, with no resolution, on how to correct for hidden animals (i.e. hidden by other walruses or by ice) or observer error.

Although it is apparent that survey methods are not very cost-effective for large areas like the Bering and Chukchi Seas, there are no alternative methods at present. The working group discussed whether surveys should be done at all in the Bering and Chukchi Seas at the cost of other research. After lengthy discussion, the working group remained undecided about the wisdom of abandoning surveys for the next decade.

RESEARCH RECOMMENDATIONS

1. Statistical analyses of the relationship between walrus density and ice characteristics should be continued with research focusing on new variables such as floe size and shape, the composition of different floe sizes in the pack, and ease of haulout on floes of different shape.

2. Research on the use of high altitude FLIR surveys to detect walrus concentration for the purpose of stratifying census areas should be continued.

3. Studies on walrus detectability with perpendicular distance should be done to determine which visual survey methods are most appropriate for pack ice surveys.

4. Protocols for training observers and reducing observer boredom or fatigue are needed.

5. Open water surveys should be avoided because of their low effectiveness.

6. Areas of high walrus density should be surveyed at high, even complete, coverage to diminish sampling error.

7. More telemetry studies are needed to determine the extent and variation of the proportion hauled out on pack ice and at land haulouts.

8. Analysis of behavioural and weather factors affecting the proportion of walruses hauled out on ice and at land haulouts is needed. Some Alaskan data are available for this type of analysis.

9. Experiments with SAR imagery to index walrus density at land haulouts and on pack ice are recommended.

POPULATION BIOLOGY (Working Group 3)

The topics proposed by the conveners were reviewed. To this list the working group added stock size(s), status, goals, and trend monitoring (e.g. dynamic response analysis). These additions were required by the range states, especially the USA because of their Marine Mammal Protection Act. Hence, topics discussed were:

- stock identity
- stock status and population goals
- productivity
- survival and mortality
- other indices
- population models
- recommendations

STOCK IDENTITY

The question discussed was "what do we need to define management stocks?". The provisional stocks were discussed. Genetic studies may be useful in resolving stock identities of walruses in Canada, Greenland, Northeast Atlantic, and Russia. Similar studies would be of interest with respect to the Bering and Chukchi Seas, but are not of high priority. The USA has some information on the genetic variability in this Bering-Chukchi stock. Combined with the satellite tagging information, it is consistent with the view that a single Bering-Chukchi stock exists. Greenland has some genomic (nuclear) DNA data indicating the presence of sub-populations.

The usefulness of tagging to delineate stocks was then discussed. This discussion included satellite tags and more traditional methods of marking animals. The usefulness of satellite tags is still limited by their working life. The longest transmission life of a satellite tag on a walrus is 256 days. Because of this working-life limitation, data from walruses do not reflect the whole annual range, nor do satellite tags give information on inter-year variation in movement. Ancillary long-term tagging associated with satellite tagging was recommended. Ø. Wiig described a tusk tag identification technique.

Satellite tagging is very useful in describing habitat use and limits of distribution. Satellite tagging has been used for this purpose in Greenland, Norway, and the USA. In Norway, the extension of the distribution also has had an impact on stock delineation. It was also thought that satellite tagging of walruses in Western Greenland and in Canada would be useful for stock identification, distribution, and habitat use. This is needed especially for possible internationally shared stocks.

The group discussed morphometric data for stock identification and concluded that standard length and growth data are not very useful compared with other techniques. The usefulness of non-metric methods such as foramina number and location was discussed. F. Fay should report on his findings at the next meeting, or we will see this work in published form by then.

The use of contaminants for stock identity was discussed. It was thought that studies of contaminant concentrations will likely continue in the range states. Trace metals in hard parts should be investigated as a feasibility study (at a limited level). The USA participants volunteered to investigate the technique on a limited number of teeth from range states.

STOCK STATUS AND POPULATION GOALS

Three different ways of setting population goals were discussed. These were the US Marine Mammal Protection Act, the Canadian conservation provision of land claims and supreme court decisions, and the designation of protected stocks by western Russia, Norway, and Greenland.

The population goals of the Marine Mammal Protection Act have not changed in 20 years and are not likely to change in the near future. The Marine Mammal Protection Act requires the population to be managed within the optimal sustainable population (OSP) range. Its goal is to maintain marine mammal stocks at population sizes between carrying capacity (K) and the maximum net productivity level (MNPL). While the USA has not definitively answered the question of the status of Bering-Chukchi walrus stock relative to OSP, it is thought that the available information is consistent with a stock above the lower bound of the OSP ranges (MNPL). The working group discussed Fay's observations about the condition indices from Bering-Chukchi walruses. These observations suggested that this population was near K.

The necessary goal of Canadian management is the maintenance of walrus stocks above the level that requires management actions to conserve the stocks (Sparrow decision). This court decision, and the wording of land claims legislation, permit management actions to allow depleted stocks to recover.

In Greenland, walruses are managed by the Greenland Home Rule (Ministry for the Environment, Ministry for Fisheries). Various regulations for the protection of walruses exist but do not apply to all areas of Greenland. Numbers and stock discreteness in the Baffin Bay-Davis Strait region are not known, but apparently walruses in Western Greenland are shared with Canada. Catch and losses are very poorly known in all areas. Walruses are protected in the National Park of North Arm East Greenland. Walruses found in Norwegian waters are protected. No representatives from Russia were present but since 1956, walruses in western Russia have been protected. Walruses in eastern Russia (a stock shared with the USA) are harvested commercially and for subsistence needs. Some of the walruses killed are used for fur farm food. Subsistence uses are regulated with quotas for each community and limited amounts can be sold. Uncertainty exists about future harvest levels and monitoring programs.

For exploited stocks of uncertain status and of relatively small size (such as those stocks in Canada and Western Greenland) information on their present status, as well as on exploitation, and a plan to allow recovery of depleted stocks should be developed.

PRODUCTIVITY

There is information on the Bering-Chukchi stock from samples of living animals, native harvests, and cooperative USA-USSR research cruises. There is evidence of good and poor years for females with respect to production and condition; however there is no information on the cause. Reproductive senescence has been observed in Pacific walruses, as well as the Foxe Basin stocks. Senescence may be a useful parameter to index population status with respect to relative population size. Longitudinal data on individual animals reproduction may be very useful for estimates of productivity. A study of terrestrial haulouts frequented by cows and calves would be useful and efforts should be made to identify such locations. Long term tags would be helpful for such a study.

Occupancy of new haul-out sites has been observed for Pacific walruses. Range extension may be of value for monitoring recovery of depleted stocks.

SURVIVAL AND MORTALITY

Long term tagging of individuals and long term projects to monitor tags would be needed to measure survival. There are no mortality estimates except for those implied in models.

Sources of mortality were discussed. Hunting is the easiest to document and may be the most important in Canadian and Western Greenland stocks. In the USA the hunt was monitored between 1980-1989 in four villages and then extrapolated to a state wide estimate. In 1990-1991 it was not done due to funding reasons but was started again in 1992. In addition to the harvest monitoring program in 1989, the US Fish and Wildlife Service started a program that required hunters to have their ivory tagged. This is state-wide and provides another source of harvest information. Animals without tusks are not reported. These two programs should give a good picture of the harvest and it is recommended that they be continued.

It is not known how the Russian hunt reporting will function. It was good in the past, but change is likely.

In Canada, hunt monitoring has been conducted in Igloolik and Hall Beach. This program is expanding. Under the Nunavut land claims agreement, harvest studies will be done during the implementation period.

No quotas exist for the catch of walruses in Greenland. Catch and loss figures are poorly known. Between 1988 and mid 1990, samples were collected from the catch of walruses in western Greenland to estimate (among other things) age and sex composition of the catch. Publication of results is in progress. On 1 January 1993, a new system of reporting catch of various wildlife - including walruses - was introduced in Greenland. To have a hunting licence renewed by the Home Rule authorities at the beginning of a new year, the hunter reports - on a voluntary basis - his catch of animals during the previous year. In this new system, there are no measures to determine accuracy of reporting.

Information on unretrieved kill has not been updated in the USA since the 1970's. This

should be done to evaluate the total number of animals killed. Similar data in all countries should be collected and evaluated.

Discussions were held on the sex ratio of the harvest. In Canada and Alaska a significant number of females are taken because calf meat is highly valued. In the USA hunters are encouraged to limit their hunt of female walruses. The female walruses are still needed for skin boats and food. Harvests of females from Canadian populations should be evaluated with respect to the impact of this harvest on the stocks. In many areas there is a tendency to harvest selectively for adult (large) animals. The effect of selective harvest of older age groups should be estimated.

Walruses are also killed by polar bears. I. Stirling is drafting a manuscript on this. Bears were photographed killing walruses on Wrangel Island during summer 1990. Anecdotal evidence is present for killer whale predation as well. It is unlikely that sufficient information can be gathered to estimate the amount of mortality from natural predators.

Disease factors were discussed. The USA has sent samples for antibody analysis for herpes distemper viruses. Serum samples should be taken when possible and properly archived for future work. No major walrus die-offs have been recorded, except for trauma induced deaths on terrestrial haulouts.

Rare occurrences of ice entrapped animals have been seen in Alaska and Chukotka.

OTHER INDICES

The USA has collected stomachs and has documented the diet of walruses. However it was thought that these represent a very biased sample. Sampling design and a lack of information on prey availability make interpretation difficult. A feasibility study is underway in the USA to investigate some possible corrections for these biases. Canada collected stomachs and the data are being published. It is extremely difficult to describe diet from stomach contents for protected stocks. Some discussions were held on monitoring the resources walruses feed on but no comprehensive assessment of walrus food resources is being carried out. It was not thought to be feasible. Other possible methods of indexing food availability were discussed. It was thought that haulout duration and other behaviour that can be measured by satellite tags may be useful in indexing food availability. Trophic level sensitive isotopes may also be of value as an index of relative population size.

POPULATION MODELS

Nothing about population models has been published since WITS-1. No information was presented on the requested trials of the Eberhardt model which is still under development. The Gilbert model, that is intended to evaluate biological indices and direct research goals, has reached manuscript stage, but was not presented.

Back calculation models for other stocks based on any available harvest data should be carried out to address the status of the stocks relative to initial population size as was previously recommended.

RECOMMENDATIONS

1. Contact Russians about their plans concerning the Bering-Chukchi stock. If the joint work is not going to continue then a source of information is lost.

2. Develop explicit population goals for stocks that are depleted but still being exploited (e.g. the Canadian and western Greenland stocks). Management plans that would result in increasing stocks would be appropriate.

3. Initiate adequate hunt monitoring for all hunted stocks. This includes estimation of the unretrieved kill. Age and gender of the harvested animals should be monitored continuously.

4. Evaluate the effect of selective harvest of females with calves (Canada) and of older age groups (i.e. large animals).

5. Assess stock identity based upon DNA analysis and other methods for some countries.

6. Collect serum to be archived for antibody analysis.

7. Carry out satellite tagging of Canadian and western Greenland stocks for stock identification and habitat use.

8. Consider long-term studies of individual female walruses on land haulouts, either by marking or natural marks, to determine the productivity of walruses.

9. Present information from the models.

HUNTER/BIOLOGIST COOPERATION (Working Group 4)

This was the first time this subject was discussed in its own working group. Discussions examined the relationship between resource users and collectors of scientific information.

Be they in English-speaking Alaska or in Inuktitut-speaking Canada, resource users usually find what biologists are saying confusing and difficult to understand. Much of the terminology used when explaining scientific methods is not easily understood and working through an interpreter can be frustrating and time consuming. It was noted that 25% of the conversation is missed or misinterpreted during meetings in the eastern Canadian arctic. When an interpreter is required at a meeting, the length of time to conduct a meeting is doubled. Although there are many qualified interpreters in the eastern Canadian arctic, they are not always available to translate at all meetings.

Cultural differences in the way biologists and resource users perceive things can cause misunderstandings and avoidable conflict. For example, biologists are usually species specific, whereas natives are multi-species orientated. Also, natives historically lived day by day with less emphasis on time and future perspectives, whereas biologists look towards the future

fate of a species, using statistical calculations and models. There are differences within the groups as well. A research scientist may have a different approach to a situation compared to a technician. Similarly, an elder from the eastern Canadian arctic would have a different perspectives than a young hunter from Alaska.

Both physical gestures and verbal behaviour can be unintentionally offending or intimidating. Biologists who are more aware of the "cultural taboos" could help to establish better working relationships. Our cultures are further apart than some realize.

Biologists must spend the time to develop a workable level of trust and credibility with the resource users. Too often biologists are seen as coming up, doing their studies with little or no consultation, and never being heard from again. Being forthright, honest, and communicative is the best way to overcome this. Some biologists make promises that they do not keep, making it difficult for others who want to do studies in the same area. Before a program begins the biologist should make sure that all the proper permits and permissions have been acquired.

In most cases there does not appear to be enough emphasis on traditional knowledge and biologists should make more of an effort to incorporate it into their decision making. Sometimes there is not sufficient time to discuss issues of mutual concern because biologists do not always have the time to adapt to local custom (e.g. talk over a cup of tea) where the resource user would feel more comfortable. Also, casual conversation is sometimes impossible in Canadian communities where most hunters or elders do not speak English and biologists do not speak Inuktitut. When biologists interact with natives, they sometimes have an attitude that they know more about the animals from reading books than the natives who have spent their entire lives living with the animals do.

Resource users may be reluctant to cooperate if they suspect the information may result in hunting restrictions. Some resource users feel that quotas are more detrimental to the people and the species than the absence of quotas. There are circumstances when a commercial or area quota system encourages hunters to harvest animals more quickly for fear the quota may be reached before they can hunt. Also, some hunters think that if a quota is not reached every year, it may be reduced in the future. Since they view themselves as having lived in harmony with the animals for generations, some resource users also feel quotas are insulting.

Communication and education were two words that kept recurring during the working group discussion. This was directed at both biologists and resource users, since much is unknown about each other. An effort must be made by both groups to increase the level of communication, especially when a biologist is working in the field.

Video tapes were identified for their potential for teaching resource users about scientific programs and results, as well as teaching biologists about northerners and how they interact with walruses. Having native-run film groups such as the Inuit Broadcasting Corporation film the activities of biological field programs would be better than filming by someone from the south. Local radio is a useful way to describe proposed work or the results to help people to understand the research. Quite often a "call-in" format fosters a good exchange of information.

Posters and simple fact sheets were thought to be useful but the working group agreed that using extensive text and graphs showing statistics was not best. Posters can be placed at strategic areas in the community where people would see them on a regular basis. Fact sheets were thought to be the least effective because they have the greatest potential to be thrown away without being seen.

Cooperative or co-management is becoming more common. Biologists and resource users should be partners in studies. Resource users can assume specific responsibilites and, with guidance, learn new approaches to enhance those responsibilities and improve inter-cultural liaison.

RECOMMENDATIONS

1. Develop better co-operative programs that will encourage and prepare young native people for biological management positions and restructure natural resources organizations to provide a number of entry-level positions for new native recruits.

2. Allocate some portion of operating budgets for environmental education programs even at the expense of a research program.

3. Establish, in each range state, cooperative or co-management regimes that will enable biologists and resource users to work together more effectively, to ensure that research and management activities are conducted in a useful and cooperative way.

4. All walrus-user organizations should accept the full responsibility for attending future WITS workshops. This would be a step towards them becoming full participants in the management of walruses. These walrus-user organizations should be responsible for securing the necessary funding for their travel, accommodatons, and interpreting costs while at a WITS workshop.

5. To improve their communication skills, biologists should learn the language and customs of the native resource users.

DISTURBANCES (Working Group 5)

POLLUTION

<u>Organochlorines</u>

PCBs are anthropogenic chemicals. In walruses, PCBs are found mainly in lipids (blubber). PCBs are of concern because of their potentially harmful effects on walrus reproduction, the walrus immune system, and human health through consumption of contaminated walruses.

Walruses typically contain low levels of organochlorines, except in seal-eating walruses. Hunters in Alaska indicate that seal-eating walruses are typically lone animals,

staying on the periphery of herds. Seal-eating walruses may be orphaned calves that did not learn from their mothers how to forage or they may have learned the behaviour from conspecifics. Seal-eaters can be identified by physical evidence or visual cues: blubber and skin of seals in their stomachs, yellow tusks, scars on mysticial pads, and dark faeces. The walruses are typically fat. Seal-eating walruses also have higher PCB levels than clam eaters because of the higher lipid content in seals. There will also be a difference in stable isotope ratios (^{15}N and ^{13}C) due to differences in the trophic level at which they feed.

Based on ^{13}C, PCB, and organochlorine pesticide residue analysis of tissue from walruses harvested near Inuujjuak (Muir 1992[3]; Wagemann et al. 1993, abstract this report), Muir concluded that these walruses are likely eating seals, not clams, as a predominant food source. The alternative hypothesis, which is considered to be highly unlikely, is that the high contaminant burden is due to exposure to local pollution.

Research Recommendations

1. Further analysis of the present samples; for instance, the samples from the Bering Sea, where there are seal-eaters, should be analyzed according to smaller sub-regions.
2. Coordination and standardization of methodology and laboratory analysis.
3. Studies of the physiological effect of PCBs on walruses.
4. Studies of the effects of walrus tissue PCBs on human consumers.

Radioactivity

Radioactive pollution by the Russians is of great concern due to the nuclear dumping site near Novaya Zemlya in the White Sea. Walruses are probably more sensitive to contamination because they are bottom feeders and may be good biological indicators of radio-active pollution.

Research Recommendations

1. Find out what has been dumped in Russia.
2. Start measurements of radioactivity.
3. Propose that AMAP (a joint program of all circumpolar countries) include monitoring radioactivity in walruses. AMAP is to produce a report in 1996 and the only arctic marine mammal monitored is the ringed seal. Walruses should be included because of their bottom-foraging.

Petrogenic Hydrocarbons

So far these seem to be of no concern because most hydrocarbons seem to be metabolized; however, physiological research is needed to verify this.

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[3] Muir, D. 1992. Spatial trends in organochlorines in Arctic ringed seal and walrus, p. 121-125. *In* Synopsis of research conducted under the 1991/92 Northern Contaminants Program. Environmental Studies Report No. 68. Indian and Northern Affairs Canada.

Research Recommendations

1. Study the effect of future oil exploration; a reference collection of "baseline" levels in walrus organs should be established by the circumpolar countries.

Heavy Metals

The main metals of concern are mercury, lead, and cadmium. Little information is available for walruses because only a few samples have been collected for heavy metal determination. In animals of the same sex and age, walruses show little variability in levels of heavy metals, suggesting walruses may be good biological indicators. It was noted that heavy metals are not always produced in the environment by human activity. High levels may occur naturally.

Research Recommendations

1. Systematically collect and measure heavy metals in bivalves eaten by walruses across the arctic to establish baseline levels.
2. Determine circumpolar variation of heavy metals in walrus tissues (small areas).
3. Determine especially methylmercury levels, since these have greatest effect on human consumers.
4. Collect tissue samples from all circumpolar countries and have them analyzed by at least two well qualified laboratories. Only a few laboratories in the world seem to be able to measure lead accurately.
5. Measure levels of metallothionein. This protein binds cadmium, reducing the metals toxicity. However, each organism makes its own metallothionein so walrus metallothionein does not protect human consumers.
6. Create a circumpolar reference collection of walrus tissues. When these tissues are stored in liquid nitrogen, they can also be used for biological investigation. Follow the existing NMFS model for collection, storage, and archiving.
7. Identify local age and sex differences in heavy metal tissue levels.
8. Determine female-calf relationships in heavy metal levels in tissues.
9. Determine the pathological effect of certain heavy metals in walruses.
10. Study the effect of walrus tissue heavy metals on human consumers.

DISTURBANCES

List of Disturbance Sources

Aquatic vessels
1. Fishing
2. Shipping - large, small
3. Icebreakers
4. Cruise ships
5. Support vessels for oil platforms
6. Motorized pleasure boats (private)
7. Seismic vessels
8. Canoes/kayaks

Semi aquatic
1. Drilling
2. Pumping
   (Includes support aircraft and vessels)

Airborne
1. Helicopters
2. Airplanes

On land mechanical noise
1. Snowmobiles (not in the USA)
2. ATVs (easy to control sources)

Land-based human activity
1. Hunters
2. Tourists
3. Researchers

Disturbances in Order of Most Concern

Degree of concern was determined by 1) effect, 2) frequency, 3) potential increase, and 4) difficulty to regulate.

1. Vessels
2. Aircraft
3. Humans on foot
4. Oil platforms (only the structures)
5. ATV, snowmobiles (not in Alaska)

Two Main Groups of Disturbances

Disturbances may impact on walruses in two ways. Physical disturbances to the environment, or habitat degradation, may have a detrimental effect through a reduction of the food supply, or may make a traditional haul-out site unavailable or undesirable to walruses.

The second mechanism by which disturbances may impact on walruses is through sensory systems. Sensory systems most likely to play a role in detection of a disturbance are: 1) hearing (underwater and in air), 2) olfaction (in air; smoke seems to have a great effect; masking of olfaction could restrict social communication or detection of predators), 3) vision (for small distances and moving objects), 4) mechanoreception (i.e. vibrations), and 5) gustation (e.g. pollution in water).

The relative impact of an underwater sound on walruses depends on many factors such as, 1) type of sound, 2) sound level, 3) age, 4) sex, 5) substrate, 6) weather, and 7) experience of walruses (e.g. historic/present hunting exposure). These factors encompass a large number of variables, making the prediction of impacts difficult.

Walruses probably are able to avoid many disturbances because they are related to negative actions of humans (e.g. killer whales are known to accompany fishing vessels but swim away when a whaling vessel arrives).

The effect of a disturbance on animals may elicit:

1. A fright response, ranging from lifting heads to moving away from the disturbance; the response may be temporary or permanent.

2. An interest response (i.e. curiosity); in walruses, satisfaction of curiosity can be a reward for the animals; in some cases, curiosity can have a negative effect as well.

Types of disturbance effects which will eventually have an impact on population dynamics are:

1. Trampling of calves during stampedes.
2. Insufficient rest to make demanding foraging journeys.
3. Insufficient suckling of calves which could reduce growth rate or increase disease.
4. Interference with feeding.
5. Expending too much energy on locomotion (fleeing towards the water, leaving transport ice floes during migration, etc.).
6. Increasing stress levels leading to immuno-depression or other physiological effects such as abortion.
7. Masking of communication and restriction of social interaction leading to reduced reproduction.
8. Impaired thermoregulation in pups if excess time is spent in cold water or on cold substrates instead of on or against conspecifics.

The likelihood of walruses habituating to a disturbance depends on 1) rate of introduction of the disturbance, 2) frequency of occurrence, and 3) meaning to the walruses from an evolutionary view point.

The response to disturbance is complex, depending on the nature of the disturbance, the psychological response, and the behavioural effect of that response. Moreover, the locality, local environment, and herd composition affect the final impact. Future rules and regulations should therefore include:

1. Local rules/regulations that can be based on a reasonable amount of scientific data (for instance Round Island).
2. Very conservative regulations for larger geographic areas.

CONCLUSION

Few studies have addressed disturbances of walruses. Some research recommendations:

1. Determine source sound pressure levels of underwater walrus vocalizations, using hydrophone arrays to locate the animals, to determine distances over which

walruses can communicate underwater.
2. Determine source sound pressure levels of walrus vocalizations in air (could be done in oceanaria).
3. Compile information on location of historic haul-out sites to determine whether any have been abandoned by historic disturbances.
4. Study the effect of hunting on females with calves.
5. Determine the in air/underwater hearing sensitivity of walruses to predict distances at which walruses may detect sound sources (and conspecific vocalizations).
6. Determine olfactory sensitivity.
7. Standardize the recording of anecdotal observations of disturbances by establishing standard protocol and observer effort (the latter to determine changes over time).
8. In local areas, measure noise profiles, and determine fluctuations in ambient noise levels (in air and underwater).

Potential disturbances that require immediate attention:

1. Ecotourism. This is a growing problem since there are either no regulations or, due to remoteness of areas, no law enforcement. A possible solution is for observers to accompany tourists to quantify the effect.
2. The proposed passage of cargo vessels through the high arctic from the Atlantic to the Pacific Ocean, north of Canada. Again, observers could be placed aboard these vessels if this is going to happen.

TELEMETRY (Working Group 6)

INFORMATION NEEDS

Stock Identity and Distribution

Telemetry is a useful tool for identifying walrus haul-out sites, local movements, migration routes, and connections between stocks. Presently, telemetry can provide accurate locations when walruses are on land or ice resting at the surface with the head out of the water. Current telemetric methods cannot give accurate locations while walruses are swimming, or follow animals through an entire year. Even when these limitations are overcome, data acquired are for a few individual animals and the movements of entire populations cannot be inferred.

Sub-Surface Behaviour

Walrus diving patterns registered by time-depth recorders (TDRs) or satellite transmitters (PTTs) can be related to feeding, travelling, or resting behaviour. Dive profiles, time at depth, maximum depth, time between dives etc., can be used to estimate activity budgets. To locate walrus feeding areas, data from diving patterns needs to be integrated with location estimates, submarine topography, benthic fauna in the area, and stomach temperature (lower temperature indicates ingestion). At present the inability to receive accurate locations from tagged walruses that are swimming and diving limits the use of sub-surface behaviour data to locate feeding areas.

Behaviour Relating to Surveys

Telemetry can be used to estimate the amount of time walruses spend on haulouts and in the water, and thus to estimate the proportion of walruses in a region that might be hauled out at a given time and season. However, only a few animals can be tagged for economic and practical reasons, so the variability in this method is likely to be high and information about the population imprecise. The level of accuracy will depend on the behaviour of the animals and the areas involved.

Useful information (e.g. presence/absence on haulout and short movements) for survey design and interpretation can also be obtained from very high frequency (VHF) tags and TDRs that are independent of PTTs. The best technique for collecting data would depend on the haul-out location and geography, and the ability to see tagged animals and recover TDRs.

If location data are collected over a long period, our overall understanding of walrus behaviour, hence information gathered from surveys, will improve.

Physiology

Activity and energy budgets are needed to address some research objectives for walruses. Parameters of interest are ambient temperatures of water and air, heart rate, stomach temperature, and different activity measurements. At present, physiological monitoring/telemetry packages are not well developed and walruses are not a good test animal. Equipment is now being developed to retrieve sensor data from tags using radio down-linking and remote release. The new generation of low earth-orbiting satellites will allow two way linkage between tags and satellites, allowing greater amounts of information to be transmitted. If these packages become readily available they could be a relatively inexpensive method of acquiring the necessary data.

EQUIPMENT NEEDS

Duration of Operation

Currently, the maximum duration of operation for a satellite transmitter attached to a walrus is about 256 days. A transmitter that works for more than a year is needed. Several battery options exist that should allow transmission for periods longer than one year if power consumption is minimized. When constructing a transmitter it is important to consider the battery life, power consumption of the different sensors in the pack, and duty cycle needed to obtain the necessary information.

Strength

A walrus can batter a transmitter until it physically breaks or the housing leaks chemicals which destroy the transmitter. Embedding the components of the transmitter in epoxy makes the transmitter physically stronger and prevents leakage. It is not possible to solid cast all types of transmitters, because of interference with signal transmission.

Antenna deformation or breakage has probably been the major cause of transmitter malfunction to date. The connection between the transmitter and the antenna needs to be strengthened or modified to bend, rather than break.

Reception

A transmitter attached to the tusk of a swimming walrus will not always come completely out of the water, thereby reducing the ability to determine accurate positions at sea. Currently, a saltwater switch is located on top of the transmitter, but by placing a salt water switch on the antenna or by using a pressure switch to prime the tag for transmission when a walrus comes close to the surface, signals could be transmitted faster when the antenna comes out of the water completely. If a pressure switch were to be used, then some energy would be wasted by transmitting signals when the antenna was still submerged.

Accuracy

Accuracy of location estimates may be affected by factors such as temperature change, oscillator shift, elevation change, the terrain of terrestrial haulouts, the number of days since deployment of the transmitter, distance to the satellite, and antenna type. From data supplied by ARGOS, Keating et al. (1991) predicted that 68% of the locations would be accurate within 226 m for LQ3 classifications, within 528 m for LQ2, and within 1 510 m for LQ1. It is not possible to determine whether an animal is on or off the land from position alone. A concurrent saltwater switch and temperature indicator would help to clarify that. When animals are in an area with sea ice, location alone cannot distinguish between an animal hauled out on the ice and one in the water.

RESEARCH RECOMMENDATIONS

Information needs include the locations of swimming walruses, amount of time spent in and out of the water, diving patterns, and physiological parameters. The following are research recommendations for the immediate future:

1. As is the case in all telemetry studies of marine mammals, the antenna system of the satellite transmitters is unable to provide quality reception at sea when the animal is swimming. Effort should be put into the development of a better antenna.

2. Immobilization of walruses for tagging is difficult because some drugs are not readily available and it is difficult to keep the animals sedated for more than 10 to 20 minutes. New immobilization agents and methods that are safer for the walruses and taggers need to be investigated.

3. Working conditions vary within and between range states. Research in satellite telemetry and immobilization has benefitted from the close cooperation of scientists from different range states. It is important to continue this cooperation.

LITERATURE CITED

KEATING, K.A., W.G. BREWSTER, and C.H. KEY. 1991. Satellite telemetry: performance of animal tracking systems. J. Wildl. Manage. 55: 160-171.

REPRODUCTION (Working Group 7)

This group discussed primarily the details of analysis of female reproductive tracts, and examined slides and specimen material from both Atlantic and Pacific walruses. There was little discussion of non-lethal ways to determine reproductive status, male reproduction, sampling bias, or statistical analysis, although all topics were recognized as important and were discussed in more detail in the plenary session.

OBJECTIVES OF REPRODUCTIVE TRACT ANALYSIS

Generally, analysis of reproductive tracts addresses such questions as: What is the average age at sexual maturity/ovulation/first reproduction, and has it changed over time? What proportion of the females (in the population or in various age classes) ovulate? What proportion implant? What proportion give birth? To answer those questions, usually individual females are examined and their current reproductive status determined (e.g. pregnant, post-partum). With less certainty, recent reproductive history can be inferred (e.g. birth the previous year). It is currently not possible to determine complete reproductive history for individuals that are beyond their first ovulation or first pregnancy (e.g. age at first reproduction, total number of calves borne).

DATA SETS

The working group summarized its knowledge of samples collected, associated data and state of analysis. Some data sets are represented by preserved material that is available for re-examination, others by detailed measurements of structures in the reproductive tracts, diagnosis of current reproductive state for individuals with no supporting measurements, or summary tables or graphs for an entire collection.

For Pacific walruses, F. Fay has collated the majority (perhaps all) of the reproductive tract data from various sources including those from the State of Alaska and the USFWS harvest monitoring, the USA-USSR research cruises, and Russian harvest ships. Most of the recent Russian data are from A. A. Kibal'chich and are primarily summary statistics rather than individual specimen information. Fay has kept the sample material (ovaries and placental scars) for many data sets (e.g. 1952-59 from St. Lawrence Island, 1980 and 1985 harvest monitoring samples, 1987 and 1991 USA-USSR research cruises). The USFWS (D. Seagars) harvest monitoring program will continue to collect reproductive tracts in 1993 and the future. No further USA-USSR research cruises are planned and no samples are collected during Russian harvest monitoring.

For Greenland walruses, female reproductive tracts were collected in 1978 (n=90), 1988, and 1990 (n=150) and have been analyzed macroscopically. Most were taken in May and June, some in fall, and a few in the winter.

The only Russian reproductive studies known to participants for Atlantic and Laptev walruses were from Chapskii (1936) and Popov (1960).

For Atlantic walruses, Mansfield's collection is thought to be lost. Samples stored at the FWI, Winnipeg, include: harvest samples from 13 walruses taken in northern Quebec in 1990-1992 and samples from 141 male walruses and 102 females that were taken in Foxe Basin in July-August 1983-4, 1987-8, and 1991-2. Harvest sampling will continue in 1993 in Foxe Basin and northern Quebec. Funding for further harvest sampling is not determined.

METHODS

The working group agreed on the protocols described below.

Field Collection and Preservation

Canadians have been collecting reproductive tracts (with the bladders attached), for descriptive morphology and to investigate anomalies in the cervix and vagina. For Greenland and Pacific walruses, the ovaries and the uterine horns to the cervix are collected. Collection of just the ovaries is not sufficient because placental scar information is necessary for interpreting ovarian structures. The material can be either frozen or fixed in 10% formalin (may be made with fresh or sea water), preferably in as flat a position as possible. Blastocysts and small embryos may decompose before the formalin penetrates, so if an implantation cavity is seen or pregnancy is suspected from the appearance of the ovary, the cavity or the upper portion of the lumen of the uterine horn should be injected with formalin.

USFWS and FWI examined some reproductive tracts that were frozen prior to fixation in formalin. These tracts were dark red-black and placental scars could be differentiated rarely by color, and usually by texture only. GFRI had not encountered similar problems, possibly because its samples had been removed quickly postmortem, thereby reducing the chance of the blood pooling. It was noted that some samples that had been frozen prior to fixation had rotted. Therefore, the group recommended that reproductive tracts be fixed in formalin as soon after the death of the animal as possible. If material is frozen before fixation, it should be placed in the formalin still frozen and allowed to thaw in the fixative. About a week after the material is put in formalin, the formalin should be changed and the material stored in formalin in a cool place until analysed.

The Russians usually excise the ovaries for preservation (marking the left one with a shallow knife cut) and record the color and length of placental scars in each uterine horn from the fresh uterus. In the Alaskan and Canadian harvest monitoring programs, usually the entire reproductive tract is preserved and placental scars are read on preserved material. The USA is investigating the comparability of the two methods. Preliminary data show that small/old scars are more likely to be missed when uteri are read fresh than when they are read preserved.

Examination of the Uterus

Material that has been fixed in formalin should be soaked for at least 24 h in water before examination to reduce vapours. Right and left ovaries and horns are determined by identifying the ventral side from the two broad ligaments on the uterine horns. At a minimum, the length of each uterine horn should be measured along the outside curve to where the two horns join and the width of the horn at the top of the curve should be measured to distinguish between animals that have never been pregnant in that horn (long, slender horn) and those that have been pregnant (shorter, thicker). The relative size of the horn also gives some information about how recently it was pregnant. Additional information includes: surface texture (smooth/rugose), colour, or state of vascularization. If a fetus is present, its location should be recorded as well as its crown-rump length, weight, and gender.

For Pacific walruses, the uterine horns are cut in half longitudinally, following the twists of the lumen, to look for placental scars. The number, length, color, and texture of scars found is recorded for each horn. The placental scars from the Alaskan spring 1985 harvest samples were categorized by scar size, texture, and color and four types of scars were distinguished, presumably from births in 1985, 1984, 1983, and 1982. The part of the uterus containing a scar(s) or an implantation cavity was excised and stored in 5% formalin with the ovaries from that animal for reference.

Greenland samples are cut across the top of the horn, the thickness of the endometrium is measured, and the relative vascularization (number of blood vessels: none, moderate, many) noted to determine whether the horn is active. The individual variability in the rate at which placental scars regress and heal may be too great to allow reliable detection of anything but a birth in the current year.

Examination of the Ovaries

The external appearance of the ovary should be described including any visible ovulation scars or visible corpora lutea (CLs). Each ovary should be trimmed of its bursa and serially sectioned into slices about 2 mm thick, leaving the slices attached at the base like a book. At GFRI, researchers measure each ovary in three dimensions and weigh it to relate ovary size and its growth to and the animal's maturation. A threshold occurs between juvenile and adult. The Canadians weigh each ovary. For walrus of the Kara Sea, Chapskii (1936) found that ovary weight and size were not reliable indices of age or maturity. For Pacific walruses, Fay and Burns (unpubl. data) also found that ovary weight and size was unrelated to either age or reproductive history, so weights and dimensions of the ovaries are no longer recorded.

For Pacific walruses, the size (measured in two dimensions) of all CLs and corpora albicantia (CAs), and the diameter of the largest vesicular follicle are recorded. In the past, CLs have been classified as "CL of new ovulation" or "CL of lactation", the latter being a CL in the first few months postpartum. The group recommended against names that imply function.

GFRI counts the number of follicles in two size classes ($1 <$ diameter < 5 mm and diameter ≥ 5mm), and measures the largest three dimensions of the largest follicle. The three follicle diameters and notes on the texture of the outer margin, the degree of vascularization,

the amount of connective tissue (none, moderate, much), and the diameter of the central cavity if it is present are recorded. The CAs are measured in three dimensions, and the largest diameter and a description of its form and site are noted.

For beluga collected between June and October in Canada, each CL was removed and weighed and assigned to one of four categories: CL (large, round, no obvious connective tissue or vascularization), CL regressing (less regular outline, some connective tissue and/or vascularization), luteal CAs (mostly connective tissue/scar tissue but pockets of luteal tissue present), CA (all white body with no evidence of luteal tissue). The terms "less", "some", and "mostly" were not quantified. A similar approach will be applied to walruses.

Interpretation and Diagnosis

Interpretation is required to diagnose the animal's reproductive status at the time of death and to infer the reproductive events of the previous few years. Interpretation of the structures seen in the uterus and ovaries depends on the time of year and area of collection, and often cannot be resolved without additional information such as the age of the animal, state of lactation, presence of a calf, or calf age. The levels of various reproductive hormones in the blood would be valuable as well, but information on them is available rarely.

If a CL is present but the animal was collected before the normal time of implantation (May-July, usually June in Pacific walruses), all that can be said is that an animal ovulated that spring unless the free blastocyst can be found in the uterus. From about July to the following spring, the presence of a fetus is obviously the criterion for pregnancy. If a large CL is found but there is no fetus or no recent, small placental scar, then the egg may not have been fertilized or the embryo may not have implanted. If a large CL is found and there is a recent placental scar but no fetus, then the embryo implanted but aborted.

Although the secretory functions of the CL are gradually taken over by the placenta before birth, the CL structure is maintained and is defined as a CL until birth when, by definition, it becomes a CA. The structure itself makes no such dramatic change. The process of involution of the structure and replacement of active yellow lutein with white connective tissue continues until well after birth. The amount of individual variability in the rate of regression of the CL, CA, and of placental scars makes inferences about the timing of birth or abortions difficult, although Fay has described the range of his observations very well. For example, in the 1985 harvest sample, based on the size of the placental scar, the size of the uterine horn in which the most recent scar was found, the state of the CL/CA, and the time of collection of the animal, 17 of 163 females were classified as "late abortion or very early birth". Clearly the distinction between these categories is important for population modeling. It was noted that abortion usually takes place in the first trimester, so unless there has been a stampede or other physical trauma that may result in stillbirths or premature labor, early births may be more likely. As the CA shrinks and completely changes to white connective tissue, its interpretation becomes more difficult. The group recommended counting and measuring CAs, but not using them for diagnosis of reproductive condition except as an indication of previous ovulation.

Pregnancy classes were developed for Canadian harp seals (*Phoca groenlandica*) that might prove useful for walruses:

Pregnancy class:
0: Juvenile, immature
1: CL present, uterus in "resting condition"
2: CL + swelling of uterine horn (implantation site)
3: CL + swelling of uterine horn + longitudinal folds of the endometrium smooth completely
4: all of previous criteria (no. 3) + fetus present
5: failed pregnancy - resorption or indication of abortion
6: mature but not pregnant - for walruses this would include females with involuting uteri, females lactating with a calf present, females with CA and a placental scar (i.e. past pregnancy)

The expected timing of reproductive events is clearly important for interpreting some structures but, for some areas and subpopulations, that information is not available. The variability of the timing and how that variability has changed with different population levels and in different areas cannot be assessed. The presence of a calf may be helpful, but genetic analysis of supposed mother-calf pairs of Pacific walruses taken in April-May 1991 showed that it can be very difficult to tell which calf belongs to which female. Similarly, interpretation of information on lactation can be difficult without histological examination: the presence of milk is clear, but the absence of milk may be because the calf has just suckled, especially if it is an old, large calf.

All participants recognized that there are many confusing aspects of walrus reproductive tracts. What appear as small CLs may be luteinized follicles. Small CAs may be missed between slices 2 mm thick, but because CAs are not used to count past pregnancies, perhaps it is not important. Ovulation scars on the tunic of the ovary are not necessarily always matched with a large CL, and sometimes two scars are found for one CL. Accessory CLs are found. No consensus was reached on a way to describe the amount of connective tissue and lutein as the CL changes into a CA. We did not discuss microscopic examination of ovarian, uterine or mammary tissues.

SAMPLING AND STATISTICS

Although it was recognized that there were many questions about statistical treatment of reproductive tract data, it was not discussed further except to make contacts for future communication and cooperation. The group mainly identified questions, caveats, problems, and potential biases.

Are reproductive rates density dependent and can changes in those rates be used as indices to population status? Is it possible to detect changes in reproductive rates at different population levels? What sampling scheme would be needed to detect changes in various reproductive parameters such as average age at first pregnancy? Is the difference between the average age at first ovulation and the average age at first pregnancy more informative than age at first ovulation alone? Various stages of mortality (e.g. the ratio of ovulations, implantation, births in the population) may be a good index of population status. The sampling scheme and time of collection must be planned in relation to the parameters of interest, e.g. spring collections will not indicate the proportion of females that are pregnant.

In Canada, walruses in different areas may have different synchrony of reproduction; there are anecdotal accounts of walruses being born at times other than April-June. More basic information is needed before a sampling strategy for monitoring reproductive status from reproductive tracts can be designed.

In most areas, the majority of reproductive tracts come from native hunters. In some areas (e.g. Canada, Gambell) hunters prefer to harvest mother/calf pairs, in other areas hunters prefer animals with large tusks. The hunter bias needs to be recognized and taken into account when sample data are used to generate reproductive rates and characterize populations.

Krylov et al. (unpubl. data) determined that some old females had been reproductively inactive for several years. Whether the female walruses might have eventually resumed activity is unknown; reproductive senescence is difficult to establish.

ALTERNATE METHODS TO ASSESS REPRODUCTIVE STATUS INFORMATION

It was recognized that directed scientific harvest of a magnitude that would give reasonable sample sizes was unlikely to be permitted for most populations. Hunter-contributed reproductive tracts are not a random sample, however, and the biases may not be known. Some populations are not being harvested. Therefore, non-lethal methods of determining at least some reproductive parameters are needed. The working group considered these briefly.

For individuals, reproductive hormone levels in blood, fat (from a biopsy) or urine may give current reproductive status, but need to be calibrated with samples from animals of known reproductive status (e.g. a captive or harvested animal). For some species, age and reproductive history can be determined from patterns in teeth, but extraction of a tooth from a living walrus under field conditions is highly unlikely.

For the population, sex-age composition counts have been suggested. In addition to problems with sampling and interpretation of the results, data from composition counts are not comparable to data from reproductive tracts. Rather than the proportion pregnant or those who have given birth, the counts are of the number of young that have survived from birth until the time of the count. Although the latter may be a more important number for our understanding of population dynamics, the data clearly are not equivalent.

For some animals such as caribou, polar bears, and elephant seals, females can be sighted for many years to get information on reproductive performance over time. That is not yet feasible for the majority of walrus populations because of the difficulty in relocating individuals. It may be possible for small populations with individually recognizable females.

RESEARCH RECOMMENDATIONS

The following research recommendations are not in order of priority.

1. Fay and Hills should complete their handbook for analysis of reproductive tracts and

include standardized terms and definitions, methods, and minimum data to be recorded about the animal (e.g. collection place and date, age, lactating, calf presence) and from the reproductive tract itself. Fay's 1982 definitions need to be expanded and illustrated for different times of the year.

2. More work needs to be done on lactation in walruses including: histology, the effect of loss of the calf, and differences in stages associated with calf age i.e. newborn to old calf.

3. CAs are presently used only to indicate that the female has ovulated. More work may show that additional inference is possible. Does a large CA result from a CL that supported a pregnancy? Is there any feedback from the physiological status of the female on the size or rate of change of the CA?

4. Similar research is required on CL development and regression.

5. Hormone levels in blood and in skin/blubber need to be determined for animals in different reproductive states. Skin/blubber samples can be collected much more easily than blood, but all need to be checked with animals of known reproductive status. Samples of blood and fat are availabe from wild walruses and samples of blood, urine and perhaps vaginal cells may be available from captive walruses.

6. Information is needed on the timing of reproductive events at different latitudes, in different areas for different populations. This should include samples throughout the year and natural history and observations of users. In particular, Canadians need to obtain reproductive material at other times of the year than July-August.

7. Biases in the existing data on reproductive tracts need to be recognized and future sampling should be designed to reduce biases.

8. Information is needed on the rate of involution of the uterus after birth, the rate of healing of placental scars, and the rate of change in CLs and CAs and the variability of those rates.

9. Non-lethal methods of collecting reproductive information (e.g. sex/age composition from aerial surveys and boat surveys) should be developed.

10. Reproductive organs of males should be collected throughout the year and from different areas to examine density dependent effects, the season of potency, age at physical (and perhaps social) maturity, and reproductive senescence.

11. All preserved reproductive tracts and reproductive tract data (as the original measurements and descriptions rather than cumulative diagnoses, if possible) should be located for all groups/populations.

12. After review of the draft working group report, Fay added the recommendation that more use be made of captive female walruses because their reproductive histories are known.

13. The group recommended increased communication with respect to all aspects of walrus reproduction but especially statistical treatment of reproductive data, interpretation of reproductive structures, sampling difficulties, and non-lethal sampling.

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MANAGEMENT (Working Group 8)

To start the discussion, an outline was presented based on the premise that we do not directly "manage" walruses. Wildlife management is the practice of influencing human behaviours that affect wildlife. The purpose of wildlife management, in this case walrus management, is to achieve a specific goal or goals. To be effective a management program or system needs to make and follow a well thought-out plan. In establishing such a course of action, we need to consider:

- What is the goal?
- For whom/what we are managing?
- On what time scale (long/short term)?
- How do we manage (regulations, cooperative management, co-management)?
- What are the critical issues and where are efforts going to be most effective?
- What are the priorities, how are they set?

It was assumed that there are two basic goals common to all walrus management regimes. These are: 1) to maintain the population at some predetermined level (this implies some degree of a long range perspective) and 2) to provide for some level of human use of the resource (e.g. harvest, incidental catch in fisheries, collection for public display, or for scientific purposes).

This working group focused on identifying how managers in various nations can influence human activities to achieve the goals of comprehensive walrus managment programs. The group thought it valuable to briefly review the system or structure for management for the different nations to identify the various management strategies.

USA

The Marine Mammal Protection Act (MMPA) sets both long and short term goals for management. The primary goal is to sustain populations within a range of optimal levels which, for walruses, has not yet been defined clearly. The MMPA established a moratorium on the "taking" (e.g. hunting, disturbance) of marine mammals except for specific conditions. Limited removals are authorized for specific types of incidental, accidental, or scientific taking, or collections for public display. The MMPA provides for harvest of walruses and other marine mammals by Alaskan natives provided the population is not depleted, the taking is for subsistence or handicraft purposes, and it is not wasteful. The MMPA limits sales of marine mammal parts to items that have been made into traditional handicrafts.

The responsibility for walrus management rests with the US Fish and Wildlife Service (USFWS), although management could be returned to the State of Alaska under specific conditions. Alaska successfully sought a return of management for walruses in 1976, but returned management to the USFWS in 1979. The USFWS works closely with the Eskimo Walrus Commission (EWC), a group of Alaskan natives representing hunters from most walrus hunting communities, as well as the State of Alaska and a number of other organizations. A formal cooperative working arrangement was implemented by a Memorandum of Agreement between the USFWS, the State, and the EWC in 1987. The Agreement focused on cooperation in communication, information exchange, data collection, scientific studies, education, law enforcement, and long range planning. The EWC plays an important advisory role and helps to promote important management programs benefiting native hunters. The Pacific Walrus Technical Committee is an advisory group made up of representatives from the USFWS, EWC, and the State of Alaska, that provides advice on walrus management issues. These recommendations are taken back to the respective organizations for their consideration.

The USFWS prefers to work cooperatively with user groups and other interested parties when reviewing proposed projects or activities. This cooperative approach is currently used for harvest management, and can be used as long as the Pacific walrus population remains above the depletion point. For other projects or activities, such as taking of walruses by oil and gas operations and removals for scientific research and public display, regulation or enforcement is involved. In these cases, the full authority of the MMPA's penalties serves to encourage compliance.

Critical Issues

The largest potential threat to the Pacific walrus population is the level of combined Alaskan and Russian harvest. Other concerns include visual and acoustic disturbance of walruses on haulouts, feeding areas, and in migratory corridors; habitat destruction due to oil and gas development, bottom trawling or dredging; and incidental take by fisheries.

Priorities

1. Develop a long range management plan (a recommendation of WITS-1). A Draft Management Plan has been completed and is now available for comment. The Final Plan is anticipated to be completed in 1994.

2. Develop a bilateral agreement between the USA and Russia for establishing joint management and research of the Pacific walrus population. Such an agreement should focus on ensuring conservation of the population through appropriate cooperative activities (e.g. surveys, harvest allocation and monitoring, habitat protection).

3. Monitor the level and structure of the Alaska native harvest and evaluate the population status. Thorough, long term programs need to be established. New, more accurate, population monitoring and assessment mechanisms need to be developed and implemented.

4. Native harvest is unregulated by the government until the walrus population reaches the depletion point. There is a need to provide more specific guidance on acceptable harvest levels to native hunters so the population will be maintained above the depletion point. The goals of the USFWS are to work toward a more cooperative and formalized system for developing this guidance and to ensure it is followed before the population is jeopardized. Some people and organizations have advocated changing the MMPA to implement some form of pre-depletion harvest management. It is widely accepted that whatever approach is taken, the only successful one will be one that involves native people in the decision-making and management processes.

5. The harvest must be conducted in a non-wasteful manner. Some individuals and groups have suggested that the MMPA be changed to provide for use of harvested animals in a more complete and efficient manner. This could reduce wasteful take. Enforcement actions have been taken on this issue; continued law enforcement is an essential element.

6. Minimize the effect of other human activities on walrus populations through continued cooperative and regulatory procedures. Considerable basic behavioural and habitat related data need to be acquired to permit effective mitigation of proposed human activities that may affect walruses.

CANADA[4]

Walrus management in Canada is conducted by the Department of Fisheries and Oceans (DFO) under the authority of the Fisheries Act of 1867. The act provides protection of all fisheries habitats, including those of walruses. As of February 1993, all marine mammals in Canada are covered by the Marine Mammal Regulations of the Fisheries Act. The Marine Mammal Regulations provide for the management of the species and control of the harvest. The regulations limit walrus hunting without a permit to the Indian and Inuit natives of Canada. A native hunter may take up to four walruses per year except in the settlements of Coral Harbour, Sanikiluaq, Arctic Bay, and Clyde River where catches are limited by annual community quotas (60, 10, 10, and 20 respectively). The walrus-hunting limitations were derived originally through negotiations with the appropriate communities of the Northwest Territories (NWT). Pending estimates of sustainable yield from walrus populations, they were based on estimates of subsistence needs of hunters and were aimed at limiting use to

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[4] Revised after the workshop to reflect legislative changes which occurred in February 1993.

subsistence hunting.

Non-native hunting is controlled by licences which can be issued to a person who wishes to obtain walruses for food for himself, his family, and his dogs. The Marine Mammal Regulations also establish conditions that should be met when hunting walruses. They state that reasonable effort must be taken to retrieve any animal killed or wounded during a hunt and that wastage of any parts suitable for food is prohibited.

Export of edible and non-edible walrus parts is controlled by the requirement of a DFO marine mammal transportation licence. International trade is controlled through the Convention on International Trade in Endangered Species (CITES). The walrus is listed on Appendix III of the Convention; therefore any person wishing to export walrus parts or derivatives from Canada must obtain an export permit from the Canadian CITES Administration at DFO.

The measures described above offer a minimal level of protection to walrus populations. They represent the status of walrus management prior to land claim settlements.

The Inuit Land Claim of the eastern arctic, negotiated between the Tungavik Federation of Nunavut and the Government of Canada, has a paramount importance in influencing the development of co-management of walruses in the Eastern Canadian Arctic Region. The Nunavut Land Claim covers the Eastern Arctic Region and part of the Central Arctic Region of the Northwest Territories and has been negotiated over the last two decades. The final agreement was legislated in 1993. Under the agreement, wildlife management, including walrus management, is conducted through a four tiered co-management process. The Nunavut Wildlife Management Board (NWMB) is the main decision-making organization. The NWMB delivers its decisions to Regional Wildlife Organizations (RWOs), such as the Baffin Regional Hunters and Trappers Committee, which makes regional allocation decisions. These decisions are passed on to local Hunters and Trappers Organizations (HTOs), extant in every community as Hunters and Trappers Associations (HTAs), which make local allocations. The NWMB also advises the appropriate federal and territorial ministers of its decisions.

The NWMBs precursor was the Nunavut Wildlife Management Advisory Board (NWMAB), which was created in 1989 and was composed of Inuit and government members. The NWMAB functioned as an interim co-management board so a working wildlife management system would be in place by the time the Nunavut Land Claim Agreement was legislated and the NWMB was created.

The NWMB is a co-management organization defined under the terms of the land claim agreement. It is to consist of four representatives from federal and territorial government departments and four representatives from the RWOs. The RWOs are made up of representatives of the HTAs, which in turn represent the local hunters. The NWMB, to be established possibly as early as November 1993, has a number of immediate tasks relating to walrus management (e.g. determining Inuit basic needs). In addition, the NWMB will be involved in: 1) establishing and allocating total allowable harvest, 2) approving conservation areas, management zones and management plans, 3) approving designation of stock status, 4) identifying and carrying out research, and 5) recommending on licences.

Under the terms of the land claim agreement, the Minister of Fisheries and Oceans must accept and implement decisions of the NWMB, except when they conflict with: 1) the principles of conservation, 2) the harvesting rights of others, 3) the purpose and policies of Parks, sanctuaries and conservation areas, or 4) with public health and safety. The Minister may also reject decisions that are not supported by, or are not consistent with, the evidence available to the NWMB.

The Northern Quebec Region does not belong to the Nunavut settlement area. Local organizations in northern Quebec villages involved in walrus hunting monitor the hunt and report their annual catch to DFO. DFO's goal for the Northern Quebec Region is to develop co-management plans for marine mammals through local organizations, but no walrus co-management plan is in place at this time. There are designated zones which are used by both Nunavut Inuit and northern Quebec Inuit. According to the Nunavut Land Claim Agreement, the management regime for these areas will be subject to further agreements between the Inuit of the two regions.

The fact that eastern Canadian walrus populations may be exploited both by eastern Canadian arctic Inuit and West Greenlanders is of obvious importance. Canada and Greenland are presently considering whether the walrus should be added to the list of species under consideration by the Canada/Greenland Joint Commission for the Conservation and Management of Narwhal and Beluga formed in 1989.

NORWAY

The Ministry of Fisheries (MOF) and Ministry of Environment (MOE) both deal with walruses. Through the Fisheries Act, walruses have been totally protected in all Norwegian territorial waters. Through the MOF, scientific research is highly regulated to prevent disturbance or death of walruses. Through the MOE, there are environmental regulations for Svalbard that create sanctuaries and restrict disturbance of walruses and other wildlife. In some sanctuary areas, no human access is allowed. There remain however, some problems with disturbance of important walrus feeding areas by commercial fishermen.

Norwegian law requires that Ministries proposing large scale developments, such as oil drilling, must prepare environmental assessments before a project commences. Hearings are conducted and the issue is decided by the Norwegian parliament. The potential for conflict of interest between resource developers preparing the assessments and the best interests of the potentially affected wildlife was noted.

There is a Norwegian/Soviet Fishery commission that deals with marine mammals, including walruses. The potential for incidental take is noted but these fisheries are apparently not monitored thoroughly.

There is no specific walrus management plan and no intention to draft one. A plan which is being developed for the management of tourism at Svalbard will propose mechanisms to protect wildlife and its habitat and programs to monitor the effectiveness of these restrictions. Management is hampered by the lack of information because there was very little research on walruses prior to 1989. Historically, marine mammal research was carried out by the Fisheries Research Institute where work is concentrated on those species that are

harvested. At present there is no intention to begin a harvest of walruses. The recently initiated walrus work is conducted through the MOE and MOF by the Polar Research Institute. The long range status of this program is uncertain.

GREENLAND

Walruses are managed by the Home Rule Ministry of Fisheries and the Ministry of Environment. There are regulations that vary by region. For example, walruses are protected within the NE National Park. The number of stocks is uncertain, although it is known that walruses found on the western side of Greenland are shared with Canada. Past harvest levels and loss rates are not known. There are no quotas on harvest, but there are regulations that restrict the methods of harvest. A new system of catch reporting is being introduced. Under this system, hunters must voluntarily report catches in order to get annual hunting licenses. Currently there are no plans to check on the accuracy of the information reported.

SUMMARY

The group briefly examined the critical issues or activities that affect walrus populations, recognizing that these had been discussed more thoroughly by another working group. It was noted that effects can be both direct and indirect:

1. Harvest.

2. Disturbance, habitat alteration, climate change.

3. Levels of contamination in walruses (animal health or impact on food quality).

4. International trade (illegal or legal; effects of lobbying by non-governmental organizations).

5. Parks and other nature reserves which can have positive or negative effects (e.g. protection of habitat but increased disturbance).

Management can influence human behaviour with respect to walruses through the following mechanisms:

1. Cooperative management efforts, shared information, and "gentle persuasion" (e.g. through recommendations to hunter groups or in review of required Environmental Assessments).

2. Formal co-management agreements (e.g. the Nunavut Wildlife Management Board).

3. Regulations (e.g. that limit harassment, or limit harvests). This includes hunter/trapper organization bylaws for local allocation.

4. Enforcement actions addressing both habitat and harvesting.

5. Use of the above mechanisms to limit access to or activities within habitat (e.g. area

controls on oil exploration, development, and transfer).

6. Cooperation with non-governmental organizations (NGOs). The effectiveness of these groups, both within nations and on international fora, should be recognized. There are constructive and less constructive roles of NGOs. The measure of this is largely dependent on the degree of emphasis these groups place on developing positions that have a basis in scientific fact.

7. Application of the Canadian environmental policy requiring no net loss of habitat productivity. Presumably trade-offs for potentially "lost habitat" could be made to gain protection for critical areas.

RECOMMENDATIONS

General

1. Sound goals and objectives for management, and/or a full management plan, should be developed for all stocks by all range states. Long range planning for research and management should be included. Management plans can be effective tools to acquire the long term resources necessary to conduct effective management research programs.

2. International agreements between range states sharing common stocks should be developed and implemented (a recommendation of WITS-1). International management plans should be developed for shared stocks as appropriate under these agreements.

3. Reliable basic biological information (population status and trends, harvest levels) should be collected to assess the effectiveness of various management measures. Without this information it becomes extremely difficult to determine if management measures are necessary, justified, or effective.

4. To improve their effectiveness, biologists and managers need to be trained in people management and negotiation. Specialized assistance should be acquired (through training or the addition of human dimension specialists to projects) when conducting studies of human behaviour (e.g. hunting methods, usage, loss rates). Cross-cultural training is necessary in many situations.

5. Effective programs must be designed and implemented to improve two way communication between resource users and managers/biologists (an endorsement of several of the educational recommendations identified in the Hunter/Biologist Cooperation Working Group).

6. Law enforcement activities should continue to play a role in management. Local authorities should play a greater role in enforcement, especially as co-management or cooperative management regimes are developed and implemented.

7. Subsistence hunter groups should be encouraged to participate in cooperative programs to monitor harvest levels. Voluntary reporting of harvest data and collection

of related biological samples should be encouraged. Such cooperative programs should be monitored to assess effectiveness. Hunting groups can more fully participate in management regimes by providing these data voluntarily. Such harvest monitoring regimes should be expanded or implemented where they do not now exist.

8. A future WITS working group should develop recommendations for universal goals, objectives, and principles for walrus management across range states. Such recommendations might be useful for discussions relating to international agreements.

9. The structure of management within several nations, reviewed by this workshop, should serve as background material for future management based workshops. However, future workshops should focus more on specific techniques and principles that are employed successfully to manage human behaviour for the achievement of management goals.

Range State Specific Recommendations

Canada

1. Implement fully operational co-management.

2. Management boards require information and DFO must be prepared to participate fully in the process. DFO should be responsive to the needs of the boards through the Arctic Fisheries Scientific Advisory Committee and other means.

3. NWMB must decide if it is a priority to develop a walrus management plan for the region. If it is so decided, the NWMB should lead in its development.

USA

1. Development and implementation of a more formal cooperative management regime is desirable in the USA. This may involve cooperative agreements, changes to law, or both. Several other changes to the MMPA may be desirable to ensure that cooperative management regimes prevent populations from becoming depleted. Taking a co-management approach toward marine mammal resources has received some support, but it has not been widely embraced by current management agencies.

INTERNATIONAL COORDINATION (Working Group 9)

The working group met to prepare statements regarding WITS' accomplishments since its creation at the March 1990 WITS-1 meeting. It also drafted recommendations for the future of WITS. These statements and recommendations were presented and discussed in a plenary session on the accomplishments and future of WITS. The results were as follows.

WITS: PAST, PRESENT, AND FUTURE

PAST

WITS has evolved to become the only multinational organization that provides for coordination of walrus research and conservation programs among the range states (Canada, Denmark for Greenland, Norway, Russia, and the USA). The initial impetus for range state coordination on walrus conservation was provided in 1987 when the government of the Netherlands proposed that the walrus be listed on Appendix II of the Convention on International Trade in Endangered Species (CITES). While this proposal was withdrawn before being voted on at the 6th Conference of the Parties to CITES, an agreement was made for the exchange of scientific information among range states. This informal arrangement was largely unsuccessful and did little to facilitate information exchange or to coordinate conservation programs. CITES was not the proper forum for efficient exchange of scientific information between walrus researchers and organizations engaged in studies and management of walruses.

Dr. Francis Fay of the University of Alaska began organizing a workshop on walruses in 1988. Originally conceived as an extension of the "Agreement Between the USA and the USSR in the Area of Environmental Protection", participation in the workshop was broadened to include representatives of all range states. As a result, the first "International Workshop on the Ecology and Management of Walrus Populations" was held in March 1990 in Seattle, Washington, USA. One of the principal accomplishments of the workshop was to establish and enhance communication and cooperation among scientists and managers dealing with walruses.

At the conclusion of the first international walrus workshop it was decided that a group should be formed to continue the efforts at communication among range state walrus programs. The result was the formation of the Walrus International Technical/Scientific Committee. Dr. Robert Campbell, Canadian Wildlife Service, (of the Department of Fisheries and Oceans at the time), was selected to serve as secretary of the WITS Committee. Since then, WITS and the office of the secretary have served to exchange information and coordinate activities relating to walruses, as well as to organize the second international walrus workshop. Range state governments have provided support for the walrus experts from their respective countries to participate in WITS activities. Thus, although CITES played a role in identifying the need for range state coordination on walrus issues, the WITS group that has evolved is independent of CITES.

PRESENT

WITS is an informal international forum including walrus researchers, managers, and resource users. It successfully promotes better communication among walrus workers through correspondence among the secretary of WITS, range state representatives and members, and through WITS workshops. These workshops foster contacts and cooperation between individual workers. WITS has now attained sufficient international profile to be asked to provide advice or endorsements on various activities related to walruses. However, WITS is still without a clear mandate, format, membership, or infrastructure which would permit it to act in the capacity now requested of it.

FUTURE

In a plenary session, all the participants at WITS-2 discussed the future of the group. Identified future objectives focus on how WITS can: 1) maintain its "grass-roots" nature emphasizing communications and cooperation, and develop the capability to 2) respond to requests, 3) disseminate information to non-members, 4) facilitate future WITS meetings, and to 5) increase its influence in areas of concern for walruses.

The approach adopted for meeting these goals is outlined here, in the form of statements of intent or mission statements. Objective 1) is best served by a continuation of current WITS activities. The first two mission statements formalize this activity. Meeting objectives 2)-5) requires some form of organization or secretariat. The third mission statement empowers an executive committee in WITS to: 1) investigate methods and consequences of formalizing the existence of WITS, 2) assess the interest and feasibility of being incorporated under an international agreement, and 3) explore the possibility of affiliating with a larger body already in existence.

Statement 1. WITS will continue as an independent group of people who are concerned with the study, management, and conservation of walruses.

All participants agreed that the best way walruses and walrus-related ecosystems can be understood and conserved is through discussions free of other biases and prejudices. Walruses, walrus habitat, and the walrus ecological communities, including human beings, are the sole concern of WITS, irrespective of the agendas of local, national, and international agencies. This independence is essential to the credibility of advice and information provided by WITS.

Statement 2. WITS will continue to encourage and facilitate communication and cooperation among researchers, managers, and resource users interested in the affairs of walruses.

The secretary and range state representatives will continue to form the main framework for this purpose. The secretary is responsible for monitoring existing or developing international agreements that affect walrus research and conservation. It was unanimously agreed that Dr. R. Campbell should continue as WITS secretary. The range state representatives are responsible for providing the secretary with information on <u>changes</u> in scientific knowledge, policy, regulations, and international agreements that affect walrus research and conservation. Individuals are responsible for maintaining contact at a personal level. Specifically, greater exchange among the scientific members and the resource users is required.

Cooperative research on shared or potentially shared stocks of walruses should be initiated, continued or intensified. Paralleling this, bilateral and multilateral agreements on research and conservation among range states sharing stocks should be negotiated.

Statement 3. The WITS secretary will chair an executive committee comprised of the secretary and range state representatives.

The naming of this committee allows the members to charge a specific internal group to perform certain duties. Tasks identified were:

- arrange the time and place of the next WITS workshop to be held in approximately 2 years.

- respond to requests made to WITS for information. Plenary meetings may respond to specific requests addressed to WITS if they may be dealt with expeditiously at a regular WITS workshop (Appendix VI - WITS-2 Responses to Specific Requests).

- investigate with the range state governments, governments' interest in developing an international agreement, similar to the Polar Bear agreement, to create an "official" mandate for WITS (Appendix VII - Letter Charging Secretary of WITS to Act Upon Recommendations).

- investigate the possibility, practicality, and costs/benefits of WITS becoming a sub-group of the IUCN Seal Specialist Group. When a complete information package is available, it will be reviewed by all WITS attendants (WITS-1 and WITS-2). The membership at large will review the material and decide whether this is an appropriate venue for WITS. If the response is favourable, the executive committee will act together to formalize the request to join IUCN (Appendix VIII).

- consider the definition of membership in WITS.

ACKNOWLEDGMENTS

The freely shared talents of a great number of capable people have made this workshop and report possible. J. Orr assumed the responsibility for organizing the logistics for this workshop. Many assistants from the Freshwater Institute, Department of Fisheries and Oceans, Winnipeg, worked diligently and efficiently, often "behind the scenes" to ensure that the meeting rooms were well prepared, the participants were well informed, copies were made on time, and that the out-of-town guests were made welcome and had transportation. H. Cleator, B. Dunn, M. Friesen, J. Garlich-Miller, B. Hyman, J. Orr, E. Thomson (née Hiltz), and P. Weaver were instrumental in these duties.

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The rapporteurs and chairs of the various working groups provided their reports on a timely basis and made the job of the editors substantially easier. B. Hyman patiently typed and tidied numerous drafts of the report with the capable assistance of K. DeCaigny. F. Fay and E. Miller provided thoughtful and constructive reviews of this report. Funds for the workshop were made available by the Director of Science, Department of Fisheries and Oceans, Central and Arctic Region, Winnipeg, Manitoba, and for the report by CITES Section, Canadian Wildlife Service, Hull, Quebec. We thank them all.

APPENDICES

APPENDIX I. LIST OF PARTICIPANTS

Born, Dr. Erik
Greenland Fisheries Research Institute
Tagensvej 135
DK-2200 Copenhagen DENMARK
Phone: 45 31 85 44 44 Fax: 45 35 82 18 50

Cleator, Ms. Holly
Department of Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba CANADA R3T 2N6
Phone: (204) 983-8975 Fax: (204) 984-2403

Cosens, Dr. Susan
Department of Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba CANADA R3T 2N6
Phone: (204) 983-8838 Fax: (204) 984-2403

Dueck, Mr. Larry
Department of Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba CANADA R3T 2N6
Phone: (204) 983-7795 Fax: (204) 984-2403

Dunn, Mr. Blair
Department of Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba CANADA R3T 2N6
Phone: (204) 984-2186 Fax: (204) 984-2402

Frankson, Mr. Darold
North Slope Borrow, Alaska USA
Phone: (907) 368-2798

Furgal, Mr. Chris
Department of Biology, University of Waterloo
Waterloo, Ontario CANADA N2L 3G1
Phone: (519) 885-6115 Fax: (519) 746-0614

Garlich-Miller, Mr. Joel
Department of Zoology,
University of Manitoba
c/o Freshwater Institute
501 University Crescent
Winnipeg, Manitoba CANADA R3T 2N6
Phone: (204) 983-3884 Fax: (204) 984-2403

Gjertz, Mr. Ian
Norwegian Polar Research Institute
9170 Longyearbyen
Svalbard NORWAY
Phone: 80 21121 Fax: 80 21559

Hessing, Ms. Polly
USFWS, Marine Mammals Management
4230 University Drive, Suite 310
Anchorage, Alaska 99508 USA
Phone: (907) 271-2394 Fax: (907) 271-2381

Hills, Dr. Susan
USFWS, Alaska Fish and Wildlife Research Centre
1011 East Tudor Road
Anchorage, Alaska 99503 USA
Phone: (907) 786-3686 Fax: (907) 786-3636

Holland-Bartels, Dr. Leslie
USFWS, Alaska Fish and Wildlife Research Centre
1011 East Tudor Road
Anchorage, Alaska 99503 USA
Phone: (907) 786-3312 Fax: (907) 786-3636

Innes, Dr. Stuart
Department of Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba CANADA R3T 2N6
Phone: (204) 983-5057 Fax: (204) 984-2403

Iya, Mr. Matthew (deceased Feb., 1993)
Eskimo Walrus Commission
c/o Kawerak, Inc.
P.O. Box 948
Nome, Alaska 99762 USA
Phone: (907) 443-5231 Fax: (907) 443-3708

Kastelein, Dr. Ron
Zeedierenpark, Harderwijk
Strandboulevard - Oost 1
3841 AB Harderwijk HOLLAND
Phone: (3410) 16041 Fax: (3410) 25888

Kovic, Mr. Ben
Nunavut Wildlife Management Advisory Board
Arviat, NWT CANADA X0C 0E0
Phone: (819) 857-2695 Fax: (819) 867-2990

Lowry, Mr. Lloyd
Alaska Department of Fish and Game
1300 College Road
Fairbanks, Alaska 99701-1599 USA
Phone: (907) 456-5156 Fax: (907) 452-6410

Moshenko, Mr. Robert
Department of Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba CANADA R3T 2N6
Phone: (204) 983-5160 Fax: (204) 984-2403

Muir, Dr. Derek
Department of Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba CANADA R3T 2N6
Phone: (204) 983-5168 Fax: (204) 984-2403

Nelson, Mr. Robert
Alaska Department of Fish and Game
Box 1148
Nome, Alaska 99762 USA
Phone: (907) 443-2271 Fax: (907) 443-5893

Orr, Mr. Jack
Department of Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba CANADA R3T 2N6
Phone: (204) 984-2187 Fax: (204) 984-2402

Pike, Mr. Dan
Department of Fisheries and Oceans
P.O. Box 358
Iqaluit, NWT CANADA R3T 2N6
Phone: (819) 979-6274 Fax: (819) 979-4539

Richard, Mr. Pierre
Department of Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba CANADA R3T 2N6
Phone: (204) 983-5130 Fax: (204) 984-2402

Seagars, Mr. Dana
USFWS, Marine Mammals Management
4230 University Drive, Suite 310
Anchorage, Alaska 99508 USA
Phone: (907) 271-2348 Fax: (907) 271-2381

Stewart, Ms. Barb
Department of Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba CANADA R3T 2N6
Phone: (204) 983-3884 Fax: (204) 984-2403

Stewart, Dr. Robert
Department of Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba CANADA R3T 2N6
Phone: (204) 983-5023 Fax: (204) 984-2403

Thomson (née Hiltz), Ms. Beth
Department of Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba CANADA R3T 2N6
Phone: (204) 983-5338 Fax: (204) 984-2403

Wagemann, Dr. Rudolph
Department of Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba CANADA R3T 2N6
Phone: (204) 983-5207 Fax: (204) 984-2403

Weaver, Ms. Patt
Department of Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba CANADA R3T 2N6
Phone: (204) 983-5280 Fax: (204) 984-2403

Wiig, Dr. Øystein
Norwegian Polar Research Institute
Postboks 158,
N-1330 Oslo, Lufthaven NORWAY
Phone: 212 3650 or 259 8701
Fax: 47 67 598750

APPENDIX II. WORKING GROUP MEMBERS

AGEING (WORKING GROUP 1)

Rob Stewart (Chair)
Joel Garlich-Miller
Ron Kastelein
Bob Nelson
Erik Born
Beth Thomson (née Hiltz) (Rapporteur)
Barb Stewart
Patt Weaver
Dan Pike

CENSUS (WORKING GROUP 2)

Pierre Richard (Chair)
Ian Gjertz
Ben Kovic
Jack Orr
Polly Hessing (Rapporteur)
Dana Seagars
Holly Cleator
Sue Hills

POPULATION BIOLOGY (WORKING GROUP 3)

Øystein Wiig (Chair)
Leslie Holland-Bartels
Lloyd Lowry
Stu Innes (Rapporteur)
Matthew Iya
Darold Frankson

HUNTER/BIOLOGIST COOPERATION (WORKING GROUP 4)

Jack Orr (Chair)
Bob Nelson
Joel Garlich-Miller
Ben Kovic
Robert Moshenko
Holly Cleator (Rapporteur)
Dan Pike
Blair Dunn
Dana Seagars
Darold Frankson

DISTURBANCES (WORKING GROUP 5)

Ron Kastelein (Chair and Rapporteur)
Derek Muir
Rudolph Wagemann
Matthew Iya
Susan Cosens
Polly Hessing
Larry Dueck

TELEMETRY (WORKING GROUP 6)

Ian Gjertz (Chair)
Sue Hills
Lloyd Lowry
Pierre Richard
Beth Thomson (née Hiltz) (Rapporteur)
Patt Weaver
Rob Stewart

REPRODUCTION (WORKING GROUP 7)

Sue Hills (Chair)
Joel Garlich-Miller
Barb Stewart
Ron Kastelein
Beth Thomson (née Hiltz) (Rapporteur)
Erik Born
Rob Stewart

MANAGEMENT (WORKING GROUP 8)

Dana Seagars (Chair)
Stu Innes
Susan Cosens
Bob Nelson
Darold Frankson
Ben Kovic
Dan Pike (Rapporteur)
Holly Cleator
Polly Hessing
Chris Furgal
Øystein Wigg
Jack Orr

INTERNATIONAL COORDINATION (WORKING GROUP 9)

Pierre Richard (Chair and Rapporteur)
Lloyd Lowry
Ian Gjertz

APPENDIX III. ABSTRACTS OF PAPERS PRESENTED

BORN, E.W., M.P. HEIDE-JØRGENSEN, AND R.A. DAVIS. 1993. AERIAL SURVEYS OF WALRUSES OFF CENTRAL WEST GREENLAND

In March and early April 1981-82 and 1990-91, systematic aerial surveys were flown over the walrus grounds off Central West Greenland between 66°15'N and 70°30'N and between the coast and 56°00'W. The purpose of the study was to determine distribution and abundance of walruses wintering in these areas. During the 1981-82 surveys, strip census methods were used, whereas the 1990-91 surveys relied upon the line transect method. A comparison of the 1981-82 and 1990-91 surveys based upon strip census data revealed no trends in distribution or abundance over the period. For the 1990-91 surveys, the estimates of abundance based upon line transects were on average 55% higher than the corresponding best estimates based on strip census technique. Conclusions of the study were that: 1) the line transect method was preferable to the strip census technique in that it gave higher and more precise estimates of abundance, and 2) the visible population of walruses in Central West Greenland is about 500.

GARLICH-MILLER, J., AND R.E.A. STEWART. 1993. GROWTH IN THE ATLANTIC WALRUS, Odobenus rosmarus rosmarus, OF FOXE BASIN, N.W.T., CANADA[1]

The relationship between body size and counts of cemental growth layer groups (GLGs) was investigated for the Atlantic walrus. Asymptotic growth equations were fit to length at age data collected from 107 male and 82 female walruses from Foxe Basin, N.W.T. The resulting growth model was characterized by sexual dimorphism in mature animals. For males, an asymptotic body length of 313 cm corresponded with 24 or more cemental GLGs. Female body length reached an asymptote of 273 cm after the formation of 18 GLGs. A significant sexual size dimorphism was reflected in the body weights of 14 mature walruses ($\geq$9 GLGs) also. The mean body weight of 9 mature males was 825.2 $\pm$ 130 kg, while the mean weight of 5 mature females was 584 $\pm$ 65 kg.

KASTELEIN, R.A., N.M. GERRITS, AND J.L. DUBBELDAM. 1991. THE ANATOMY OF THE WALRUS HEAD (Odobenus rosmarus) PART 2; DESCRIPTION OF THE MUSCLES AND OF THEIR ROLE IN FEEDING AND HAUL-OUT BEHAVIOUR

For examination of the walrus cranial muscles, one frozen head was cut into transverse sections that were photographed, and another was dissected. The location and attachment sites of the cranial muscles are described in great detail, along with the orientation of the muscle fibres. Photographs and line drawings are presented and functions are assigned to the muscles when possible. Most muscles are found to play a role in the movements of the vibrissae pads, which is of ecological importance for communication and food identification,

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[1] A preliminary report on research done in partial fulfilment of a M.Sc. in Zoology - J.G-M.

excavation, manipulation, and processing. Other large muscles are thought to be used in giving rigidity to the head when hauling out, and small specialized muscles close the sensory openings when walruses submerge. Live trained walruses were used to study the effects of the muscle movements externally.

KASTELEIN, R.A. et al.[2] *THE FUNCTION OF WALRUS SENSORY SYSTEMS IN THE DETECTION OF DISTURBANCES*

VISION

The walrus eye is small in comparison to that of other pinnipeds and the extrinsic eye muscles are well developed. The strong palpebral muscles can open the eyelids and probably protrude the eye by thickening during contraction. The protrusion and mobility of the eyes enlarges the monocular visual field. The recti muscles can roll the eyes to look laterally, dorsally or frontally. In the latter 2 positions, binocular vision, which is a requirement for stereoscopic vision, is a property which has not been tested yet but seems likely. Supraorbital processes are not found in the walrus, but for protection the eyes can be retracted deep into the orbital cavity and the lids can be closed by the strong *muscalaris orbicularis oculi.* Retraction of the eyeball deep into the orbital cavity may also keep the eye warm and functional. The thick layer of blood vessels between the sclera and the retina probably also has an important thermoregulatory function. Insulating fat-rich connective tissue and many blood vessels are found around the eye.

Under low light conditions, the pupil is a vertical oval; during moderate light conditions, keyhole-shaped, and during high light conditions, pinhole-shaped. A *tapetum lucidum* makes the eyes more light sensitive. Cones are found in the retina, suggesting colour vision. Based on behavioural observations, anatomical findings and histological investigation of the retina, visual acuity in walruses is judged to be less than in the other investigated pinnipeds and seems to be specialized for short range use underwater. The role of vision in social interactions, navigation, selection of haul-out areas, detection of predators, and foraging is discussed.

HEARING

A pilot free-field hearing study was carried out on Atlantic walruses which were hauled out at a beach on Svalbard, Norway. Five animals were exposed to two types of acoustic signals between 250 Hz and 4 kHz. The animals responded to signals with sound pressure levels of 10-20 dB above ambient noise levels, and it may be concluded that the hearing responses of walruses are similar to those of humans under similar environmental conditions. The experiment shows that it is possible to carry out rough audiometric tests in the field.

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[2] This presentation includes published and "in press" information:
Kastelein et al. 1990. Aquat. Mamm. 16(2): 78-87
Kastelein et al. 1988. Aquat. Mamm. 14(3): 123-133
Kastelein et al. 1993. Aquat. Mamm. 19(3). (In press)
Kastelein et al. 1993. Aquat. Mamm. 19(2). (In press)

An in-air hearing study under semi-laboratory conditions has been carried out using a psychophysical technique on one male Pacific walrus. The results do not agree with the day-to-day experiences at the park with the animal. The paper is presently being written.

TOUCH

The diet of walruses consists mainly of benthic invertebrates such as bivalves. In deep and murky water walruses probably detect and identify their prey with their vibrissae. This study investigated the sensitivity of walrus vibrissae.

A psychophysical test was used in which a blindfolded walrus had to identify circles and equilateral triangles with different surface areas. The animal was able to identify 3-mm-thick sets of shapes, down to a surface area of 0.4 cm^2. It mainly used the central mystacial vibrissae to make the final identification before responding. The smaller the shapes were, the more difficult the task became. As a result, the touch time (i.e. the time spent feeling each shape) increased as size decreased. The percentage of correct response improved during the test of a set of shapes. Tests including other shapes than triangles and circles revealed that the animal only searched for a sharp angle and did not interpret the objects by their entire contour.

The previously described psychophysical test showed that a blindfolded walrus could discriminate between circular and triangular objects which were mounted on a smooth background. The animal seemed to use its long lateral vibrissae to detect and locate the objects and its short central vibrissae for identification. Because walruses have to identify their prey in an heterogeneous substrate, the task was made more realistic by mounting the test-objects on a rough background. Even with this background, the animal was able to identify the 3-mm-thick circular and triangular objects down to a surface area of 0.4 cm^2.

To verify the different use of regions of the mystacium, the objects were offered in such a way that the animal had difficulty reaching the objects with its central vibrissae. The animal made a great effort to touch the objects with its short central vibrissae. The present study shows that the central vibrissae have more resolving power (mainly used for detection), and that the walrus is able to discount irrelevant signals.

TASTE

No studies have been done on the gustatory sensitivity of the walruses. Anecdotal information on animals at the Harderwijk Marine Mammal Park indicates that, at least for some substances known to be bad tasting (repulsive) for many terrestrial mammals, walruses show no aversion.

SMELL

According to anecdotal information of people who have encountered walruses in the wild (hunters and researchers) and people who work with walruses in zoological parks, olfaction in walruses is acute.

At the moment, a study is being carried out at the Harderwijk Marine Mammal Park to determine the olfactory sensitivity of the walruses. Problems encountered so far are the

saturation of the nose with the odour and the resulting drop in olfactory sensitivity in the following trials. Therefore, only a few trials per session can be performed, which makes the study very long and labour intensive.

CONCLUSION

Although most of sensory systems of the walrus have not yet been investigated thoroughly, a combination of the available scientific data and anecdotal observations indicate that anthropogenic disturbances are detected mainly by (in order of importance) the ears, the nose and the eyes. Mechanoreception and gustation probably play a much smaller role in the detection of anthropogenic disturbances.

Future research should focus on in-air and under water hearing sensitivity and on olfactory acuity, combined with field experiments to test the psychological effect of particular human activities.

RICHARD, P.R. 1993. SUMMER DISTRIBUTION AND ABUNDANCE OF WALRUSES IN NORTHERN HUDSON BAY, WESTERN HUDSON STRAIT, AND FOXE BASIN: 1988-1990

Walrus surveys were conducted during the summers of 1988-1990, in northern Hudson Bay, western Hudson Strait, Foxe Channel and northern Foxe Basin. They provided the first estimates for indexing the N Foxe Basin walrus population. Two systematic surveys gave similar mean estimates, circa 5 200+ walruses, but with very large variances. To reduce the variance, future surveys should either use a stratified design, an increased survey coverage or repeated surveys. Reconnaissance survey results in Foxe Channel suggest a seasonal movement into that area by mid-August or when ice conditions allow passage. Counts made at or near haulouts on N Hudson Bay islands are in the upper range of counts made in 1976-1977. The likelihood of a decline of that population in the last decade is therefore low, but more survey effort is needed to estimate the population trend more accurately. With the wide fluctuations in daily numbers at individual haulouts, daily counts at each land haulout throughout the haul-out season are probably the only practical way of monitoring a trend in this population.

THOMSON (NEE HILTZ), E.A., K.I. FISHER, AND R.E.A. STEWART. 1993. COMPARISON OF DIGESTIVE EFFICIENCIES OF PACIFIC WALRUSES (Odobenus rosmarus divergens) AS DETERMINED BY CHROMIC OXIDE ADDITION AND DIETARY MANGANESE

Dietary manganese has been identified as a possible inert marker in determining digestive efficiency of marine mammals. To test this hypothesis in captive Pacific walruses, we compared digestive efficiency determined by dietary manganese with that determined by the more traditional marker, chromic oxide. Digestive efficiencies of lipid, protein, dry matter, and energy were calculated for two adult and two immature walruses fed both herring (*Clupea harengus*) and clam (*Spisula* sp.) diets. There were significant differences between the mean digestive efficiencies for dry matter calculated from the two methods for walruses fed clam and herring diets but no significant differences between means for energy, lipid, and protein

for walruses on either diet. A linear relationship with a slope of one and an intercept of zero must exist between the two methods, if dietary manganese is valid for measuring digestive efficiency values. Energy, lipid, and protein digestive efficiencies from walruses fed herring were the only values that showed significant regressions between methods (F-test, $P \leq 0.05$). Of these, only the regression for lipid values had a significant r^2, explaining 53% of the variation. Only the protein regression had an intercept of zero and a slope of one. Dietary manganese is an inappropriate marker to determine digestive efficiency in Pacific walruses.

WAGEMANN, R., D.C.G. MUIR, AND R.E.A. STEWART. 1993. TRACE METAL AND ORGANIC CONTAMINANTS IN WALRUSES FROM THE CANADIAN ARCTIC AND NORTHERN QUEBEC

Organochlorine pesticide residues and PCBs were analyzed in blubber and heavy metals were analyzed in liver, kidney, and muscle of walruses from eastern Hudson Bay (Inuujjuaq, Akulivik), Foxe Basin (Igloolik, Hall Beach), and south Baffin Island (Loks Land). The animals were harvested between 1982-1990. Walruses from Inuujjuaq and Akulivik had anomalously high levels of ΣCHLOR in blubber (on average 3 300 and 3 510 ng/g wet wt, respectively), compared to Igloolik and Hall Beach animals (311-314 ng/g, wet wt). The concentrations of ΣDDT, ΣPCB and PCC were also anomalously high in animals from Inuujjuaq (26 600, 5 260, 758 ng/g wet wt, for ΣDDT, ΣPCB, and PCC respectively) compared to concentrations of the same compounds in Igloolik and Hall Beach animals (28-38, 192-206, 167-177 ng/g wet wt, respectively). Based on these results and ^{13}C analysis of tissues, the predominant food of these walruses may have been seals and not clams. Concentrations of lead and mercury in Inuujjuaq animals (8.0 and 0.58 μg/g dry wt. Pb and Hg in the liver, respectively) were approximately twice as high as in animals from Igloolik and Hall Beach. A small number of clams ($n=20$), from the vicinity of Igloolik, were analyzed for heavy metals. Metal concentrations in walrus tissues appeared to parallel, except cadmium, those in clam tissues. Cadmium was relatively high in liver and kidney of walruses, and the spatial trend was opposite to that for mercury and lead, decreasing toward the south. The cadmium concentration in the liver of animals from Igloolik and Hall Beach (on average 38 μg/g dry wt) was twice as high as in animals from Inuujjuaq. The cadmium concentrations in tissues of walruses from the more northerly locations (Igloolik, Hall Beach) were high compared also with those in other marine mammals. The results for walruses indicate unexpectedly high contamination with organochlorine pesticides, PCBs, lead, and mercury in animals from the southeastern part of Hudson Bay, relative to other locations in Hudson Bay and Foxe Basin, and in the case of organic compounds relative to other locations world wide. These results have implications for the assessment of human dietary exposure via consumption of walrus tissues.

APPENDIX IV. STATUS OF WALRUS RESEARCH IN SVALBARD AND FRANZ JOSEF LAND IN 1992. A REVIEW.

IAN GJERTZ AND ØYSTEIN WIIG

1. INTRODUCTION

In 1604, the first walrus (*Odobenus rosmarus*) hunt occurred in Svalbard (Poole 1604). This marked the beginning of the onslaught on the walrus population in this arctic archipelago. By the middle of the 19th century, the stocks showed clear signs of decrease (Lamont 1861). As hunting declined in the western parts of Svalbard, the sealers moved steadily eastwards in search of prey in the more inaccessable parts of the archipelago. This eventually led to the discovery of the neighboring Franz Josef Land archipelago in 1865 (Horn 1930). Centuries of walrus hunting finally caused the once vast herds to be on the verge of extinction in Svalbard (Norderhaug 1969), when they finally were given total protection in 1952 (Anonymous 1952). Walruses in Franz Josef Land were totally protected in 1956 (Øritsland 1973). It is difficult to assess the size of the original populations prior to hunting, but the Svalbard population must have been enormous (Reeves 1978). Gjertz et al. (1992) have shown that a minimum of ten thousand walruses were killed in Franz Josef Land over a 40 year period. Today, we finally have strong indications that there has been a significant increase in the walrus populations in both archipelagos.

Prior to 1989, little scientific information was gathered on the biology of the walruses in the western European arctic. What exists are basically reviews of observations of walruses and of former catch statistics (Tsalkin 1937, Norderhaug 1969, Lønø 1972, Øritsland 1973, Born 1984). The Norwegian Polar Research Institute (NP), being a subsidiary of the Norwegian Ministry of the Environment, has therefore, in cooperation with the Norwegian Fisheries Research Council, put major effort into obtaining basic scientific information on walruses in the European arctic. This effort has coincided with a similar effort by the Danish authorities in studying walruses in eastern Greenland. This joint effort provides new and very basic information on the biology of walruses in certain parts of a vast area stretching from eastern Greenland (approximately 20°W) to eastern Franz Josef Land (approximately 60°E).

The present paper is a review of the effort that the NP has put into studying walrus biology in Svalbard and Franz Josef Land (Fig. 1) during the period 1989-1992. Methods, results, and preliminary results are presented.

2. METHODS

2.1. Walrus observations and haul-out sites (see Gjertz and Wiig in press)

NP has Scandinavia's largest collection of polar literature. All books, trappers' diaries, sealing vessel logbooks, journals, and scientific literature concerning Svalbard and Franz Josef Land were searched for information on observations of walruses. Arktisk Forening's (Arctic Society, Tromsø) collection of trappers' diaries was searched similarily.

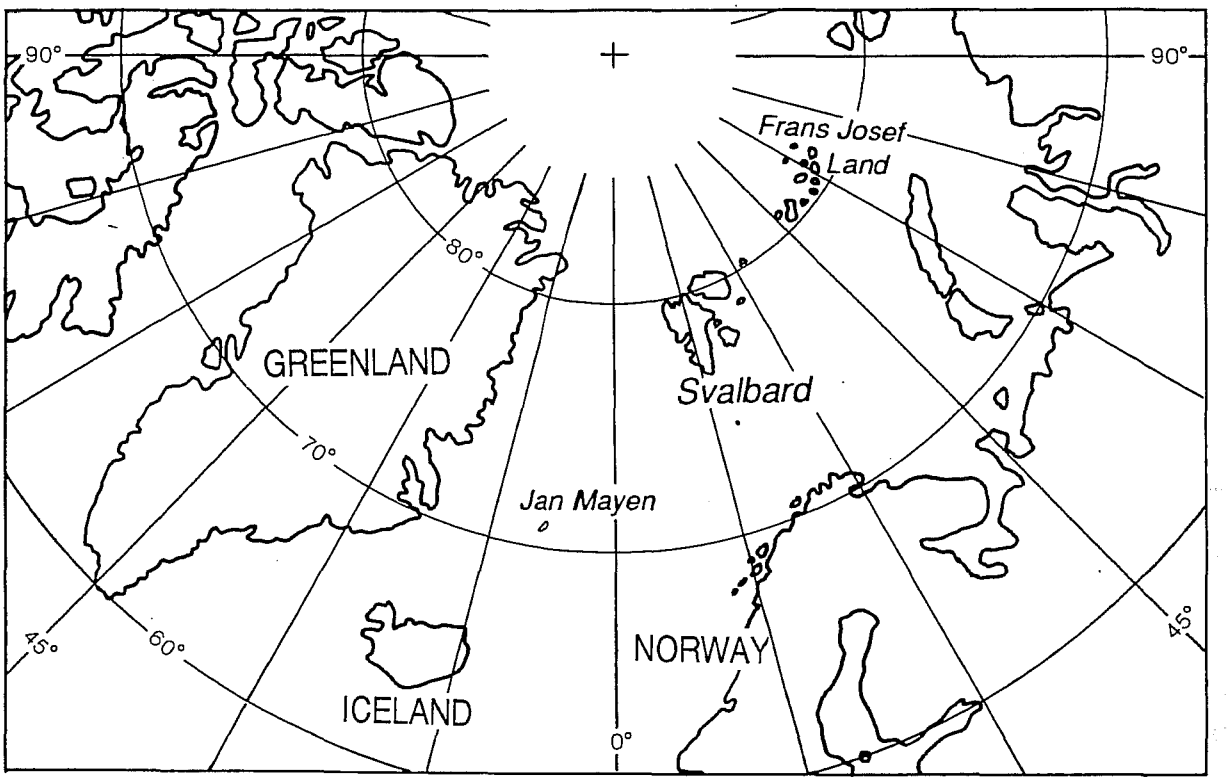

Figure 1. European Arctic and adjacent areas.

Most of Svalbard is uninhabited and, outside the summer season, coastal waters are travelled rarely by ships other than fishing vessels. A questionnaire, requesting information on walrus observations and offering a modest reward for such information, was sent to 92 Norwegian fishing vessels registered by the Norwegian Coast Guard as operating within Svalbard waters. In addition, advertisements were placed in Svalbard's local newspaper and in two different Norwegian newspapers for fishermen, requesting information on walrus observations.

Opportunistic interviews were conducted with residents of Svalbard and tourists, requesting information on walrus observations and the location of former haul-out sites. Similarily, interviews were conducted with members of Artisk Forening. These were retired sealers with considerable knowledge on Svalbard dating back to the 1920s. Walrus observations from the fauna data bases of Havforskningsinstituttet (Institute of Marine Research, Bergen), Sysselmannen (Governor of Svalbard), and Norwegian Polar Research Institute were put at our disposal. The two former provide opportunistic observations while the latter combines opportunistic observations, with walrus surveys.

The authors have spent considerable time mapping walrus habitat in Svalbard. Information has been gathered by aircraft, ship, dinghy, and foot travel. The presence of former haul-out sites, as well as haul-out sites now in use, were noted based on observations of skeletal remains, drag marks, and hauled-out animals.

2.2. Aerial surveys

Both opportunistic and planned surveys have been conducted. Three different types of aircraft have been used. These were predominantly an *Aerospatial AS 350 B* helicopter and a *Partenavia Spartacus* twin engin turboprop airplane. In addition Bell 212 helicopters were put at our disposal occasionally by Sysselmannen (Governor of Svalbard). Weather permitting, surveys were flown at altitudes of 1 000 feet, and speeds of approximately 100 knots with the AS 350 and 150 knots with the Spartacus. Planned surveys had two experienced observers in addition to the pilot. Opportunistic surveys usually had one experienced observer in addition to the pilot. The observers were equipped with binoculars, usually Swarowski 7x42, but other models and brands were used also. Herds of walruses were photographed with 35mm film (Fujichrome 400 ASA) using Nikkor 80-200 mm lenses. Walrus herds were counted by one observer while the other photographed the herd. Later the herd was counted on the photo and the results compared.

Surveys were concentrated in areas where walruses could be expected to be found. These were predominantly near-shore shallow water areas and present and former haul-out sites. However some former walrus hunting areas in the drift ice areas off northern and eastern Svalbard were also surveyed.

2.3. Former population structure

The age and sex structure of walrus remains were investigated from a well known slaughtering site dated 1851, to determine whether there have been any changes in population structure in Svalbard in the last one and a half centuries. The slaughter sites were searched for intact jaws with teeth remaining. The following measurements were taken: jaw length from the tip of the mandible to the line joining condyles; jaw breadth across the

condyles; mandible length; mandible height; ramus height, and ramus breadth. One tooth from each jaw was taken for age determination. Teeth were sectioned at the Institute of Marine Research, Bergen or at the Arctic Biological Station, St. Anne de Bellevue, Quebec. Tooth sections were read by experienced personel at the Institute of Marine Research or by the authors.

2.4. Immobilisation (see Griffiths et al. in press)

2.4.1 Darting sytem:

An "Injector" double-barrelled darting gun was used (Leif Martinsen, Norinject, Hølen, Norway) (see Øen 1982). One dart containing etorphine and one of cyprenorphine were loaded, the cyprenorphine being held in reserve in case the animal tried to enter the water before immobilization. Darts were usually shot from a range of about 20 m. Norinject darts (Leif Martinsen, Norinject, Hølen, Norway) used were designed to hold a maximum of one ml of fluid. Needles were 8 cm long with a neoprene collar at the tip to contain the pressurized drug (Øen 1990), thus the effective length of the needle was 5.5 cm.

2.4.2 Agents:

Zoletil was obtained in powder form (Laboratories Virbac B.PP., 13 06021 Nice, France) and mixed with sterile water to a final concentration of 250 mg/ml. Zoletil solution was injected at a dose rate of 2.0-2.5 mg/kg using a syringe system mounted on a jab-stick (Stirling and Sjare 1988).

Etorphine hydrochloride (HCl) was obtained as an aqueous solution of 9.8 mg/ml (C-Vet Ltd., Bury St. Edmunds, Suffolk, UK). The initial dose rate used was 5 mg (0.5 ml)/1 000 kg, based on the results of Born and Knutsen (1990). The drug was injected intramuscularly into the hip or shoulder. Darts were prepared in advance using a simplified system of two dosage levels. For smaller animals of around one tonne weight, darts containing 5 mg of drug were prepared, while for larger animals (to a maximum of 1.5 tonnes) 6.5 mg were used.

Cyprenorphine (diprenorphine HCl) (C-Vet Ltd., Bury St. Edmunds, Suffolk, UK), used to reverse the action of etorphine HCl, was obtained as an aqueous solution of 12 mg/ml. A single injection was given about ten minutes after the etorphine HCl injection at the rate of about 25 mg cyprenorphine for 10 mg etorphine HCl. Cyprenorphine was injected intramuscularly into the tongue, shoulder or hip or intravenously into the extradural vertebral venous sinus.

Medetomedine HCl (Farmos, Turku, Finland), and *ketamine* HCl (Nycomed Pharma A/S, Asker , Norway) were administered as an intramuscular injection (80 mg medetomedine and 1 000 mg of ketamine) to one 960 kg walrus to obtain long lasting chemical restraint in connection with a tritiated water experiment.

2.5. Satellite telemetry

Three different types of satellite transmitters were used. In 1989, three ST-3 platform terminal transmitters (PTTs) (Telonics, Arizona, USA) with 20-cm antennas constructed of multistranded stainless steel cable were attached (see Born and Knutsen 1992). In 1990 and

1991, 25 similar PTTs were deployed, each with a 7-cm-long helical antenna. In 1992, four such PTTs and two Wildlife Computer ST-6 PTTs were deployed. The ST-6 are somewhat smaller than the previous types and are housed in a titanium tube. All units transmit with an output of 1W and are equipped with external conductivity electrodes which serve as salt water switches. The transmitter, therefore, is shut down when submerged. A total of 34 PTTs have been deployed over four years.

In 1989, the duty cycle of the two transmitters was continous and had repetition rates of 70 seconds. In 1990 the duty cycles were also continuous, but the repetition rate was changed to 60 seconds. The PTTs deployed in 1991 were on a duty cycle of 18 hours on / 18 hours off, the repetition rate being 75 seconds. The transmitter deployed in Svalbard in 1992 had the same settings as those in 1991, while the transmitters deployed in Franz Josef Land had duty cycles of 6 hours on and 18 hours off, and a repetition rate of 45 seconds.

The transmitter was attached to the side of one tusk, somewhat latero-caudally using two 19 mm wide, 316-type stainless steel bands (Band-It, Houdaille, Denver, Colorado, USA) (Born and Knutsen 1992). The transmitter was placed as far up on the tusk as possible but low enough to ensure that it did not come in contact with the lip or vibrissae. In 1989 and 1990, epoxy glue was used between the transmitter and the tusk to prevent any leverage. This was also used in 1992 in Svalbard, while polyurethane (Sikaflex 11 FC) was used similarly in 1992 in Franz Josef Land.

2.6. Tagging

All walruses that were immobilized were tagged with yellow Jumbo Rototags. Tags were marked "Havforskning. Bergen, Norw". Each walrus was tagged in both hind flippers if possible.

Some walruses were equipped with steel tusk tags. These were placed on the tusk that did not receive a PTT. These steel tags consisted of two types. One was a 19 mm wide, 316-type stainless steel band (Band-it, Houdaille, Denver, Colorado, USA) tightened round the upper part of the tusk. The other consisted of a broader, colored, 1-mm- thick PVC band (Darvic, Weston Hyde Products Ltd., Hyde, Chesire, UK) fastened with a stainless steel band round the upper tusk. The object of these tusk bands is to recognize walruses that are observed while swimming as tagged or not.

2.7. Tissue samples

Samples for DNA analysis and studies of environmental pollutants have been taken both from immobilized walruses and from animals that were not immobilized. Several methods have been used.

From immobilized animals skin samples were collected using a 5 mm biopsy needle. Samples were either packed in aluminium foil and frozen or placed in a solution consisting of 20% DMSO, 0.1 M EDTA pH 8.0, and saturated with NaCl. Similar samples were obtained from non-immobilized walruses, using a crossbow and arrows with heads modified as biopsy needles. Hair from moulting walruses was collected for analysis of pollutants. The hair was placed in sterile plastic bags and kept cool and dry. Preliminary results indicate low levels of pollutants.

2.8. Measurements and weights

The following measurements were attempted from immobilized walruses: zoological length, standard length, half girth just behind the flipper, straight and curved lengths of both tusks, from the gumline to the tip of the tusk, and circumference of both tusks at the gumline. In addition, attempts were made to weigh immobilized walruses. The animal was rolled onto a steel framed net and weighed using a tripod, a dynamometer (PIAB 2 000 kg ± 10 kg) (PIAB Åkersberga, Sweden), and a hand powered winch.

2.9. Physiology (see Lydersen et al. 1992)

An immobilized 960 kg male walrus was chemically restrained with a combination of medetomedine/ketamine. Before injection of 20 ml Tritium labled water (HTO) of specific activity 6.98 10^6 Bq pr. ml. into the epidural vein, a blood sample was taken to determine the background level of HTO. Thereafter, 10 ml blood samples were taken from the plexus in the hind flippers approximately every half hour for 5 hours. All blood samples were stored frozen until analysed 8 weeks later. The water was vacuum distilled from frozen whole blood samples and 1 ml water was mixed with 10 ml Opti-flourine scintillation cocktail (Packard). Tritium activity was measured with a liquid scintillation counter (Packard Tri-Carb 4530). SD in the counts were ±1% and the quantitative detection limit was 1 Bq pr. ml.

2.10. Feeding and diving

An attempt was made to determine where walruses in the tagging area feed and at what depths. This was to be determined using a PTT for positions and a microprocessor controlled time depth recorder (TDR) for dive information. The animals had to be immobilized a second time to recover the TDR. This information was then to be compared to information on walruses feeding from the same area, primarily based on fecal samples (Gjertz and Wiig 1992). In addition a marine biological inventory of the benthic fauna in the area in question has been started.

Dry walrus scats (n = 14) were collected and searched for identifiable remains of prey. Each scat was weighed to the nearest gram, then broken up in water and decanted. All undigested parts were collected and animal remains identified as far as possible.

The TDR (see Wiig et al. 1992) was equipped with a salt water switch, pressure transducer, and a 256 Kbyte memory, and was housed in a 15 cm x 2.6 cm titanium tube (Type Mk3+, Wildlife Computers, Woodinville, WA 98072-7641, USA). The units were programmed to record depth at 10 second intervals with 1 m accuracy down to a depth of 250 m. Dive data were analyzed using Dive Analysis software (Wildlife Computers). Only dives of 2 m or deeper were considered. The TDRs were fastened to the tusks of five walruses that also received a PTT. The TDRs were fastened in a similar fashion as the PTT, using steel bands.

At six stations a dredge (1 m wide frame) with a 0.5 mm mesh size sack was used. Material collected was frozen at -18°C for biochemical analysis. In addition, three divers performed a total of 22 hours of SCUBA diving in the area. Divers collected quantitative samples, three frames from four different stations, using a 0.25 m^2 sized frame. In addition 22 underwater photos were made on one profile from 3-25 m depth. Triplicate Van Veen

samples were collected at two stations. Samples from 37 dredging stations were collected using a triangular (35-cm-sided) dredge with mesh size 0.5 cm and hauls varying from 100 m to 200 m, depending on local conditions. Dredging stations were selected using an echosounder to carry out dredging on uniform parts of the bottom. All material was preserved in 4% formaldehyde solution buffered with seawater.

3. RESULTS AND DISCUSSION

3.1. DISTRIBUTION

3.1.1. Svalbard

Based on the historical material and observations obtained in recent years, it has been possible to map the most important distribution areas of walruses in Svalbard (Fig. 2). Four main areas are evident (Fig. 3). These are around Hinlopenstretet, especially north to the small island of Moffen, the areas of southern Edgeøya and Tusenøyane, the northeast corner of Nordaustlandet including Storøya, and Kvitøya. Three smaller areas also are found on the west coast of Spitsbergen. From the beginning of the walrus harvest in Svalbard we know that walruses were very abundant at Bjørnøya and along the west coast of Spitsbergen. Walruses have started to recolonize these latter areas, but they have not yet returned to Bjørnøya (Gjertz and Wiig in press).

All known past and present haul-out sites in Svalbard, excluding Bjørnøya, are indicated in Figure 3. In some parts of the archipelago we still find walrus remains from the former hunt. It is fairly easy to distinguish between skeletal remains of slaughtered animals and remains of those that have died a natural death. The former usually have the front of the skull chopped off, or the premaxillary bone chopped open to remove the tusk. Due to the size and weight of a walrus it is unlikely that a hunter would move it up on shore if it was caught on ice or in the water. It is therefore safe to assume that large collections of walrus bones on land represent slaughter sites, and not animals caught elsewhere. The beach level in Svalbard is today fairly similar to that 400 years ago. The west coast of Spitsbergen is very stable, while the Edgeøya/Tusenøyane/Kong Karls Land area is rising slowly. Apart from factors such as erosion, sand drift and wave action, there are no physical reasons for the remains of walrus slaughter sites to disappear from Svalbards' beaches. We therefore believe that we have discovered a significant part of the haul-out sites in the archipelago.

3.1.2. Franz Josef Land

Little information exists from Franz Josef Land since it was a closed area for almost half a century. However, based on available information from the literature and from personal observations, we have illustrated the areas where walruses are most common (Fig. 4) (see also Gjertz et al. 1992). This seems to be in four different areas: in the northeast, the southeast, the south, and the northwest. Victoria Island situated between Franz Josef Land and Svalbard is not included in Figure 4, but must be considered an important area for walruses.

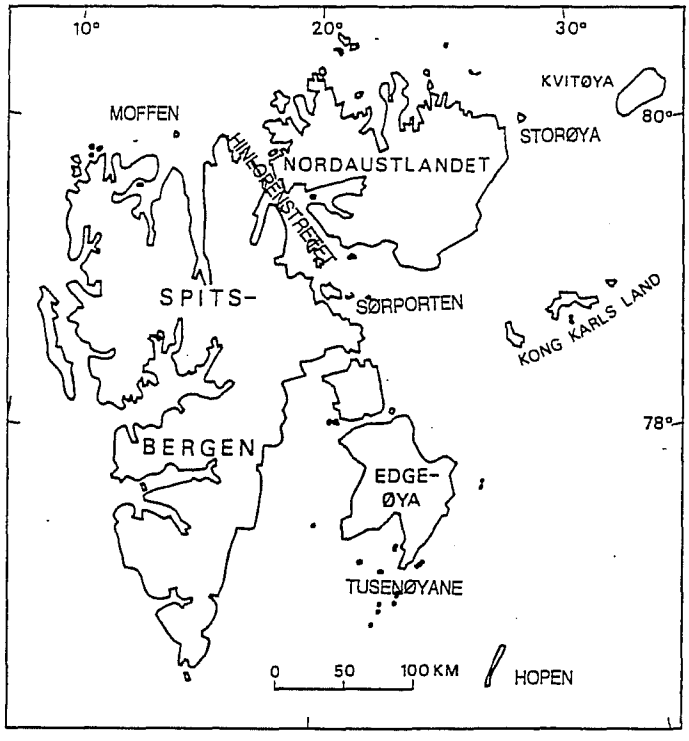

Figure 2. Svalbard, excluding Bjørnøya.

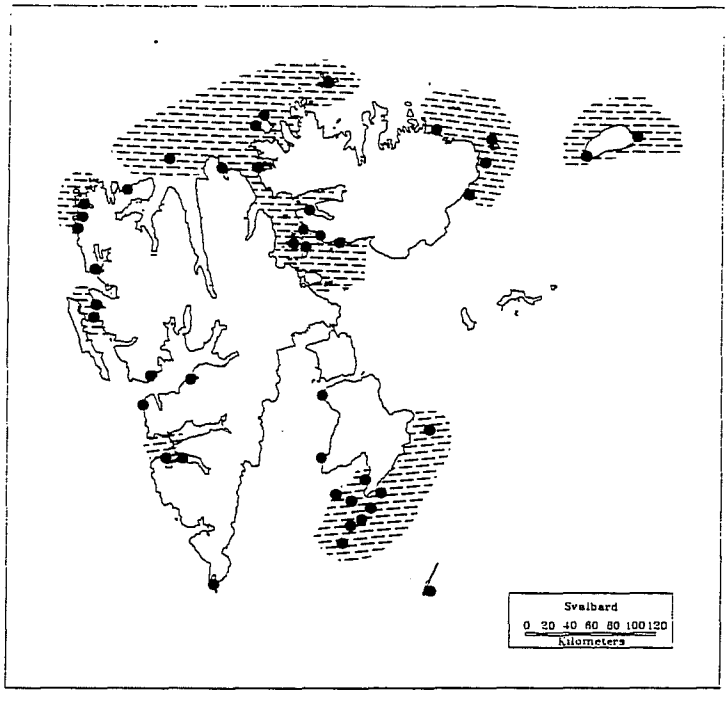

Figure 3. Svalbard, except Bjørnøya, indicating where walruses are most common (hatched). Haul-out sites, both former and present, are indicated by dark spots.

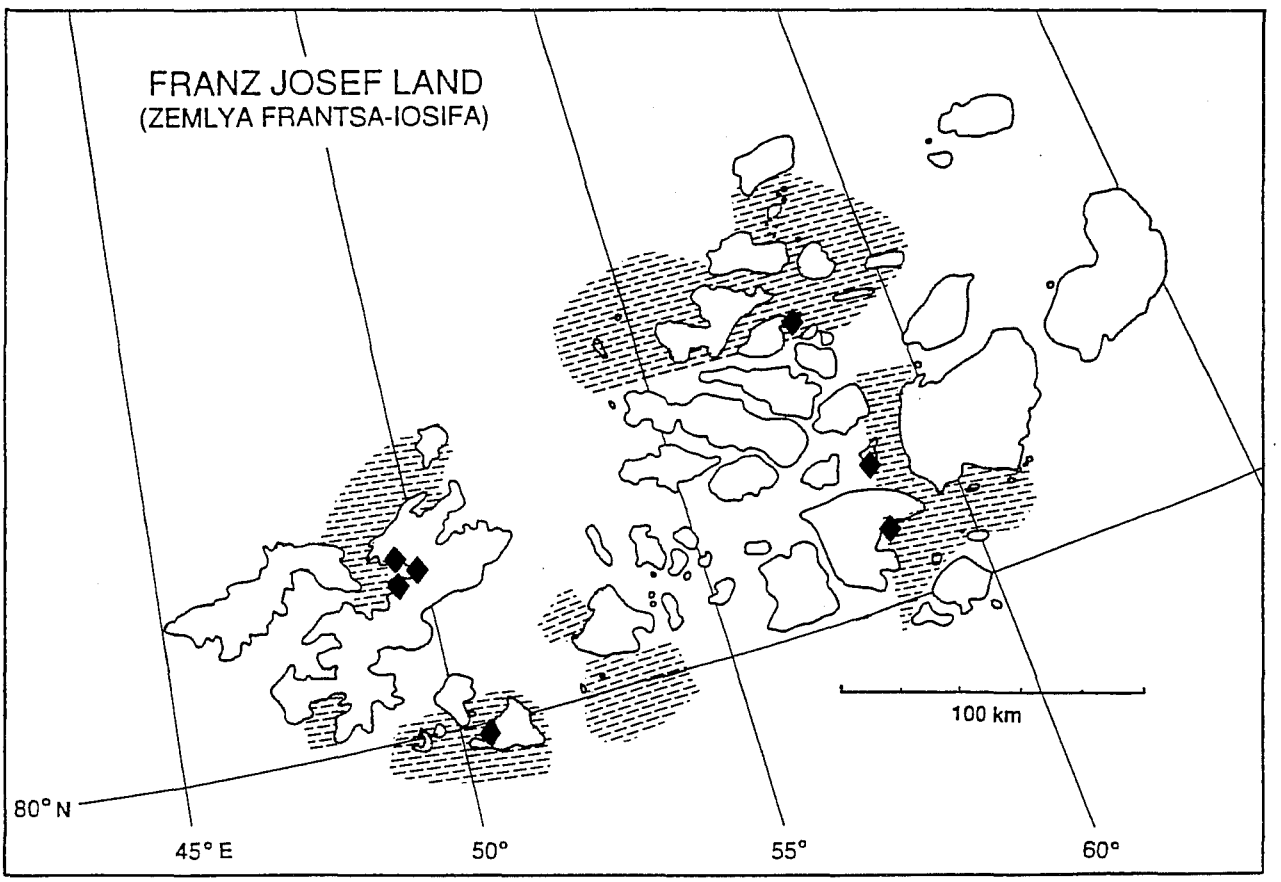

Figure 4. Franz Josef Land. Hatched areas indicate where walruses are most common. Dark spots indicate haut-out sites.

3.1.3. Migrations

If the walruses in Svalbard and Franz Josef Land are from one common stock then they will necessarily have to undertake migrations. Some mention of such migration is found in the literature, but it is not well documented. Lønø (1972) dismisses the idea of an annual migration between the northeasterly parts of Svalbard and Franz Josef Land. He shows, based on catch statistics, that even though walruses were exterminated in one area in Svalbard they could still be caught in other areas. He therefore suggests that the walrus population in Svalbard consisted of partially stationary groups which had some contact with each other. Born (1984) discusses the possibility of walruses wintering in polynias along the north coast of Nordaustlandet. He suggests that, since walruses are first observed at Moffen late in July, they must come from wintering grounds farther away than Nordaustlandet (e.g from Franz Josef Land). Occasional sightings by trappers indicate that at least some walruses are present in Svalbard during winter, and satellite telemetry has shown that some walruses are stationary at a polynia in Tusenøyane for up to nine months of the year, including the winter period.

One of the purposes with the satellite telemetry program was to attempt to determine the distribution of walruses within Svalbard and to find out whether these walruses swam to other geographical areas. At present our program is not finished but we see several important indications. Most of the walruses have been tagged in southeastern Svalbard. Several of these animals have made shorter trips to western Franz Josef Land and back to Svalbard, either back to the tagging site or to other areas (Fig. 5). A PTT ceased transmitting at the north coast of Svalbard, not far from Svalbard's best known haul-out site at Moffen. This shows that there is contact between Franz Josef Land and Svalbard, as well as between the far ends of Svalbard. Figure 6 depicts tracking of two different walruses. One was tagged on the west coast of Spitsbergen, swam up to Moffen and later down Hinlopenstretet between Spitsbergen and Nordaustlandet. This strengthens the indication derived from Figure 5, that walruses intermingle between different parts of Svalbard. Figure 6 further shows that a walrus tagged in eastern Franz Josef Land was tracked to Victoria Island, close to Kvitøya in Svalbard. Together the two figures indicate that the walruses in Svalbard and Franz Josef Land in fact belong to one population.

Born and Knutsen (1992) using satellite telemetry in northeast Greenland have shown that walrus bulls from this area disperse into the Fram Strait, but they found no indication of a connection between the walruses in northeast Greenland (Dove Bay) and Svalbard. Such a connection was proven in July 1992, however, when one walrus tagged by Born and Knutsen (1992) in Greenland was photographed at Moffen on the northern coast of Svalbard. This indicates a connection between the walruses in these two geographical areas.

According to Tsalkin (1937), walruses in Franz Josef Land and in the northern part of Novaya Zemlya may belong to one common stock. This was based on differences in age and sexes of walruses caught in these two areas. The distance between Franz Josef Land and Novaya Zemlya is comparable with that between Greenland and Svalbard, so walruses should therefore have little difficulty in making such a movement. If correct, this might even suggest a connection between walruses in Franz Josef Land and walruses in the Kara Sea and down to Pechora in northern Russia. However, present information concerning the distribution of walruses in these geographical areas is inadequate.

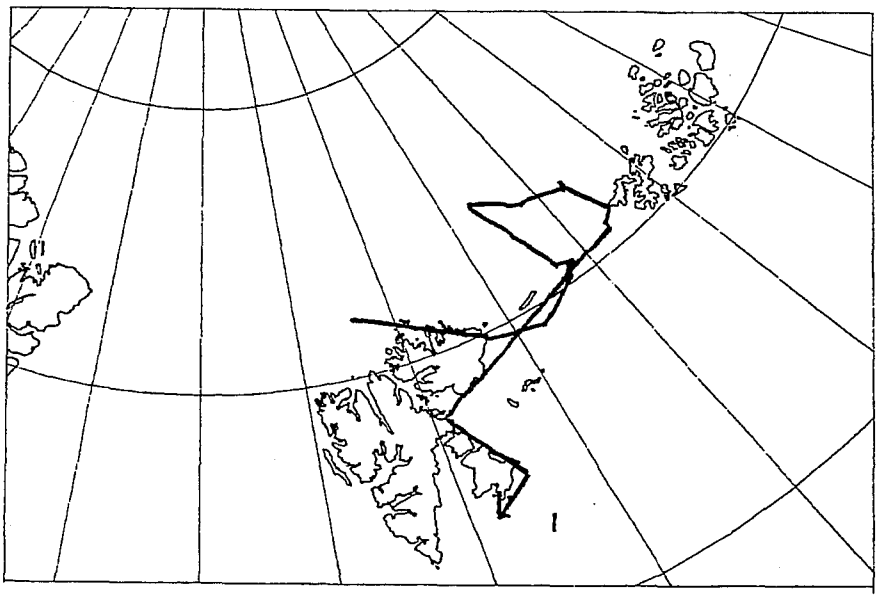

Figure 5. Walrus PTT tracks from Tusenøyane to Franz Josef Land and to northern Svalbard.

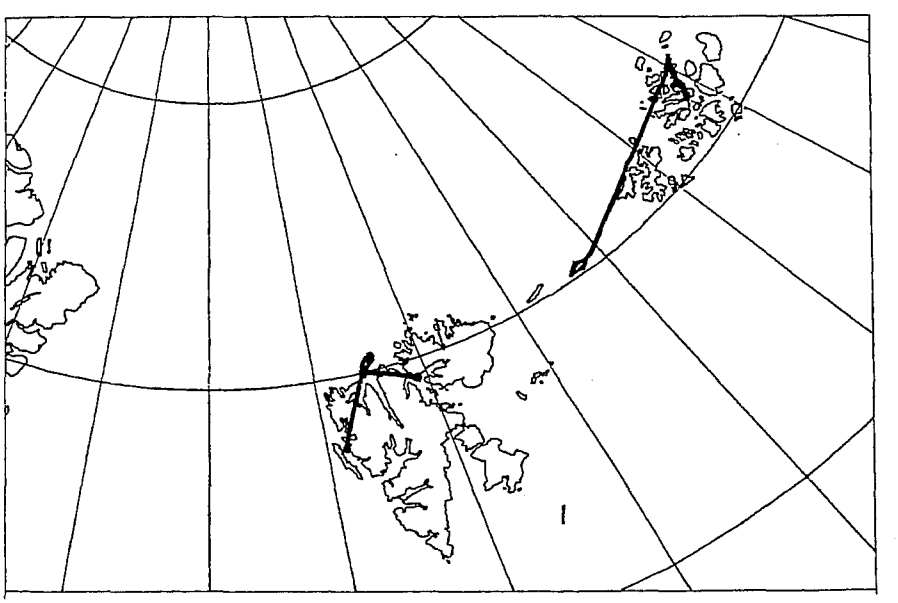

Figure 6. Walrus PTT tracks from western Spitsbergen to Hinlopenstretet, and from northeastern Franz Josef Land to Victoria Island.

3.1.4. Sexual segregation

Apart from some opportunistic observation in the 19th century and two observations from the 1980s, few observations of large numbers of females and calves are known from Svalbard. Our observations from Svalbard after 1982 indicate that the only area where females and calves are found in significant numbers is the extreme northeastern part of the archipelago. In August 1987, dispersed groups of females with calves, estimated to total more than 500 individuals, were seen at Kvitøya. The herds of walruses observed in other areas in summer are almost exclusivly males, both adults and immatures (see also Born 1984, Gjertz and Wiig in press). This is in accordance with observations from the early Svalbard literature.

We know that, from the turn of the last century, sealing vessels caught large numbers of walruses in Franz Josef Land (see Gjertz et al. 1992 for a review). These were predominantly females and calves. In 1990 and 1991, the authors undertook field trips to Franz Josef Land and found many females and calves in the south-central parts of this archipelago. Compared with our knowledge of the walruses in Svalbard this information suggests that there may be a close connection between the animals of these two neighboring archipelagos. Walruses are known to split up into male and female herds (Collett 1911). Chydenius (1865) writes from Svalbard that walrus cows and calves are found in other areas than the bulls, and that walrus hunters think the males travel in big herds out on the banks (i.e. shallow water far from land), while the females with calves habitually stay close to land and visit the fiords. It is possible therefore that the majority of walruses in Svalbard in summer are males from one common Svalbard - Franz Josef Land stock.

3.2. ABUNDANCE

3.2.1. Opportunistic observations

Occasionally expeditions, either tourist or scientific, or governmental patrols, may see herds of walruses. Such instances are reported to the conservation officers or to NP. These sightings provide vital information on walruses in Svalbard. In July 1984, the NP summer expedition in Svalbard came across a herd of more than 500 walruses hauled out at Kvitøya. This herd included cows and calves. In 1985, a similar expedition to the same area observed 160 walruses at Storøya, including cows and calves, and 200 more walruses at Kvitøya. In September 1987, one of the authors (ØW) came across dispersed groups of cows and calves totalling more than 500 animals in the drift ice near Kvitøya. Also, we have received a number of observations from different localities numbering from 40 to 100 animals in various parts of the archipelago in different years.

3.2.2. Ground surveys

Several ground surveys have been conducted in the Tusenøyane area each year from 1989 to 1992. These show that all the animals observed, with the exception of a few single cows with calves, were males of varying ages. These surveys have, when possible, covered all the known haul-out sites in the area, but weather and ice conditions have often prevented counting more than one or two islands in one day. The periods for our ground surveys vary, but in total they cover large parts of the period from late June until September. Therefore, results may vary within and between years. We counted a maximum of 192 animals in one

survey in July 1989 , 340 walruses in August 1990 , 165 walruses in August 1991, and 190 walruses in July 1992. This indicates that at least 200 walruses are found in this area in the summer.

The surveys have also shown that at least some of the walruses are site tenacious. One walrus, that had easily recognizable tusks was seen at the same haul-out sites three years in a row. One out of four walruses equipped with a PTT in 1990 was observed at the tagging locality in 1991 and in 1992 with the PTT intact. One out of nine walruses equipped with tusk tags in 1991 was observed at the same locality in 1992. These observations indicate that many individual walruses return to the same sites each year, or perhaps stay there all year.

3.2.3. Aerial surveys

An aerial survey was done in the remote Kvitøya area in late May 1992 to determine whether this might be a calving area. Despite favorable conditions, no walruses were seen.

In the period 6-12 August 1992, walrus surveys were conducted by helicopter in several of the important haul-out areas in Tusenøyane, Hinlopenstretet, and at Kvitøya. A total of 500 walruses were observed, including some calves observed at Kvitøya. It is possible that some of these walruses have moved between several haul-out sites, but considering the rather long distances involved, this probably does not involve many individuals.

In the period 1-11 September 1992, a total of 13 flights were conducted to all parts of Svalbard. These flights constituted 30 hours flying, and all of Svalbard's coastline, except for Hopen and Bjørnøya, was covered at least once. Attempts were made to cover areas of special interest at least twice. Unfavorable weather conditions and fog prevented the entire survey to be carried out as planned. A maximum of 270 walruses were counted in one day in a total of 7 herds. None of these herds contained calves. On this day, two important walrus areas were not surveyed due to fog and bad weather. When these areas were counted, they had a maximum of 73 and 67 walruses respectively. The only place where cows and calves were observed was on the drift ice at Kvitøya. Here at least four calves were observed on 4 September.

We have conducted several helicopter surveys in the Edgeøya - Tusenøyane area in 1989 and 1992. We then had the advantage of covering a limited area several times, while knowing exactly where to search for the animals. In July 1989, we counted a maximum of 185 male walruses hauled out in this area. In July 1992, we counted 275 male walruses hauled out. No calves were observed.

Further aerial surveys are planned for 1993. We hope to have access to another aircraft with a longer range, enabling us to cover all of Svalbard in one flight. Up to now this has not been possible.

When considering the abundance of walruses in Svalbard it is important to bear in mind that the animals observed seem to be predominantly males. In the same periods that we have been working in southeastern Svalbard, we have received reports of walrus herds in northwestern Svalbard numbering more than 100 animals. If we assume that the different

herds all behave like the ones in the southeast, i.e. that they are site tenacious, then we believe that at least 400 male walruses are found in Svalbard, excluding the Kvitøya area. The Kvitøya area has, based on sealing vessel logbooks and opportunistic observations, been the most important area for walruses in Svalbard in this century. We must therefore assume that a considerable number of walruses also are found there currently. In this area we know that at least 500 females and young have been seen. This area is visited rarely by observers and walruses are not seen regularly there. This suggests that they may be spread out in the remote ice areas east of Kvitøya or that they may wander back and forth between Franz Josef Land and Svalbard. If we assume that the sexual ratio among walruses in Svalbard is similar to that in other areas (i.e. 1:1) then the population of walruses belonging to the Svalbard area must be at least 1 000 animals.

3.2.4. Feeding

Presently only a preliminary study of walrus feeding has been published from Svalbard (Gjertz and Wiig 1992). This showed that walruses in this archipelago feed on basically the same prey as walruses in other areas. The dominant prey found was *Mya truncata.* A variety of other taxa and species have been recorded as prey in the Svalbard area. These include: *Buccinum* sp., *Saxicava rugosa, Cardium* sp., *Priapulus caudatus, Procellaria glacialis,* shrimps, crabs, polar cod (*Boreogadus saida*), eider duck (*Somateria mollissima*), ringed seal (*Phoca hispida*), and bearded seal (*Erignathus barbatus*). In Franz Josef Land, Tsalkin (1937) found *Cardium groenlandica* (= syn. *Serripes groenlandicus*) to be the most common walrus prey.

In 1986 to 1988, there was a conflict of interest between the shell-trawling fleet and the conservation authorities in Svalbard. Scallops (*Chlamys islandica*) were most abundant in and around the national park situated at the northwest corner of Spitsbergen, especially at the walrus sanctuary at the small island of Moffen. Trawlers were barred from entering the richest areas, but they were very active just outside the protected areas. There was at the time a big dispute over the possibility that scallops were walrus food and over the prospect that this trawling was harmful to the walruses (Gjertz 1988). To prevent further such disputes in other areas of Svalbard, we have been attempting to map walrus feeding grounds and determine what potential prey species dominate the benthic fauna in these areas. The PTT and TDR studies and the marine biological inventory are important parts of this work.

3.2.5. Diving

Five TDRs were deployed and we were able to get back four of these. Only one was intact, however, providing the first detailed data on a freely diving walrus (Wiig et al. 1992). This TDR gave data for the period 11:54:41 UCT on 20 July to 13:44:16 on 3 August. Four long dive periods were recorded, lasting a total of 190 hours or 57% of the time between deployment and recovery. A total of 1 693 dives were made. Mean dive depth was 19.6 m (SD = 14.2 m, range = 2-69 m). There were three modes of dives: 3-4 m, aproximately 20 m, and 55-70 m. Mean dive duration was 5.2 min (SD = 2.8 min, range = 0.2-12.7 min). About 50% of the dives lasted from 6-8 min. Dive duration was positively correlated with dive depth ($r = 0.74$, $P < 0.001$). Mean bottom time lasted for 4.2 min. (SD = 2.6 min, range = 0.0-11.3 min.) which accounts for 81% of total dive time. Mean surface time (< 2m) was 1.5 min (SD = 1.1 min, range = 0.2-21.1 min).

Walruses feed mainly on benthic invertebrates, so we believe that continual diving to the same depths indicates foraging behaviour. The area where the TDR was deployed is a shallow water area with depths less than 100 m. In the vicinity of the tagging site the depths are less than 30 m. The duration of feeding dives is probably a function of the water depth and abundance of food, as well as the capability of the diver (Fay 1982). The walrus spent longer times at the bottom during deep dives than in more shallow dives. Assuming that the abundance of prey is uniform, regardless of depth, then deeper dives are not necessarily more energy consuming for the walrus than shallower dives.

3.2.6. Marine biological inventory

In 43 analyzed samples of benthic fauna 117 species were found. The dominant type with regard to individual biomass was the holothurian *Cucumaria frondosa* (up to 3 700g wet weight/m^2), while the most constant species found was *Margarites groenlandicus* (78% presence). The estimated mean biomass in the area was 400 g wet weight per m^2, but the distribution was very patchy with rich sessile fauna in numerous patches and nearly deserted areas in between. No samples contained *Mya truncata* but numerous empty shells were found by SCUBA divers. In the study area the most likely walrus prey is *C. frondosa* with individual dry weights of up to 80 g and up to 2.4 kg dry mass per m^2.

3.3. PRELIMINARY CONCLUSION

When we started our walrus project in 1989, our main goal was to determine whether walruses in Svalbard were part of a population belonging to a larger geographical area, and whether walruses undertook migrations between these areas or within them. In addition, we wanted to estimate the size of the walrus population in Svalbard. Though we have not finished the project, we believe that we have proven that the walruses in Svalbard and Franz Josef Land belong to one common stock, which may include the walruses in northeastern Greenland as well. In addition, we found that walruses in Svalbard are site tenacious, but also that they travel between different parts of the archipelago. At present our survey results indicate that there are at least 500 males in Svalbard in summer, suggesting that the population is at least twice this size. We expect that aerial surveys conducted in 1993 will increase this estimate.

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APPENDIX V. THE VOCALIZATIONS AND BREEDING BEHAVIOUR OF ATLANTIC WALRUSES IN THE CENTRAL CANADIAN HIGH ARCTIC

BECKY SJARE[1] AND IAN STIRLING[2]

The singing behaviour of Atlantic walruses over-wintering at the Dundas Island polynia (76°09'N, 94°52'W) in the central Canadian high arctic was studied from 1981 to 1990. Since 1987, the scope of the study has been broadened to include social organization and breeding behaviour as well. We are currently in the final stages of writing up the results for the 1987-90 phase of the study. We are not involved in any new walruses projects presently but hope to return to the Dundas Island polynia in 1994 or 1995 and initiate a new study of vocalizations and breeding behaviour.

The general research objectives for the 1987-90 study were to: 1) describe the social organization, breeding behaviour and mating system of walruses over-wintering in the Dundas Island polynia, 2) examine the structural and temporal variability of walrus songs recorded under diverse environmental and social circumstances, 3) assess the individual variability of surface codas and determine whether they function as signature vocalizations (a surface coda is a loud, distinctively patterned series of knocks emitted during the surface portion of the song), and 4) document the number, distribution, and herd composition of walruses over-wintering in the Penny Strait region and consider the possible influences of sea ice conditions on walrus social organization and breeding behaviour.

SOCIAL ORGANIZATION AND BREEDING BEHAVIOUR

Walrus herds frequenting the Dundas Island polynia were composed of females and calves, lone adult females, juveniles of both sexes (4-8 yrs old), and young adult males (8-15 yrs old). Mean herd size varied between 10 and 20 walruses (range=3-45). In most cases females and calves made up at least 40% of a herd. All herds were accompanied by a large, mature, attending male that sang incessantly. He was the only male that participated in any breeding activity and the only male that sang continuously even though the younger male herd members were capable of doing so as well. As long as the younger males remained silent and did not attempt to contact the females, the attending male appeared to ignore them. It was evident that he strongly influenced their sexual and vocal behaviour. One attending male would associate with a herd for 1-5 days, then be replaced by another mature male. Only a few males in the polynia were able to establish themselves as an attending male (2/11 males in 1988 and 4/14 males in 1989). Of those males, one clearly monopolized access to females for a major portion of the breeding season. When an attending male lost or relinquished access to a herd, his subsequent activities usually were unknown. How difficult it was for

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[1] Department of Fisheries and Oceans, Science Branch, P.O. Box 5667, Saint John's, Newfoundland, A1C 5X1. Telephone: (709) 772-4049.

[2] Environment Canada. Canadian Wildlife Service, 5320-122 Street, Edmonton, Alberta, T6H 3S5. Telephone: (403) 435-7349.

a former attending male to regain the position also is unknown (only one herd takeover interaction has been observed).

Whenever a herd moved into the polynia, there were 1-5 satellite males stationed 50-300 m away from the herd. These lone males were either young adults or mature males capable of challenging the attending male. Some young adult males were always seen as silent herd members, others were predominantly vocal satellite males, and still others appeared to switch back and forth between the two roles. Mature satellite males rarely approached the herd or physically interacted with the attending male unless it was to challenge him. Females were never observed to leave the herd to consort with a satellite male or vice versa. When there were no herds in the polynia, lone males swam slowly around the polynia and the surrounding area, singing. Although they often sang from one location for several hours at a time, they did not defend parts of the polynia.

Based on the available data, the mating system of walruses breeding at the Dundas Island polynia most closely resembles a female defence system where the most dominant males control access to herds containing females. The importance of female choice in determining which males gain control of a herd is unknown. Females were difficult to identify and usually it was not possible to monitor their movements.

WALRUS SONGS

Underwater recordings of 23 mature, male walruses recorded in a number of different social situations confirmed that approximately 80% of their songs were individually consistent and shared among all males frequenting the polynia. The remaining songs were erratic in structure, not individually consistent, and not shared by all males. The basic structure and duration of the shared song types has not changed since 1981, but their frequency of occurrence has changed significantly from year to year. The occurrence and duration of shared song types also varied in response to: recording date, the presence of nearby females or silent males, the length of the male's singing bout, and the intensity of vocalizations of nearby satellite males. The presence of females and intensely vocalizing satellite males were the two most important factors influencing a male's song; singers significantly shortened their songs by consistently deleting specific segments. The basic structure of the shortened song was individually consistent and shared by all males that were recorded in those two particular behavioural situations. We routinely recorded and monitored males that sang continuously for 24 hours and have reliable data indicating that one male sang for 55 hours. The unconfirmed record for the longest, continuous singing bout is approximately 86 hours.

INDIVIDUAL RECOGNITION

Assessing whether or not surface codas may function as signature vocalizations was difficult, because we discovered that some males emitted two very distinct variations of their surface coda. In addition, the same factors that influenced the duration of their shared songs also influenced the duration and structure of their surface codas. However, if males that emitted two variations of surface codas were considered to be two individuals, and if surface codas were sampled from recordings made when males were engaged in a variety of social situations, then it was possible to distinguish individuals reliably on the basis of their surface

coda by using a discriminant function analysis. Unfortunately, when we tested whether or not the surface codas of an identified male recorded on different days, in different years, and under different social situations, varied enough to cause misclassification, problems arose. For a significant number of males, the variability of their surface codas during certain situations was great enough to cause them to be misclassified. It is important to note that we tested the most contrasting social situations and the most extreme recording dates; under typical field conditions, these circumstances would occur rarely. These results have established limits for the reliable use of surface codas as signature vocalizations but have not invalidated them. So far only surface codas have been studied in detail; there are several other distinctive series of knocks that may also contain signature information. If these vocalizations could be used in combination with surface codas, identification may be improved in the future. Surface codas are unreliable for identifying males younger than an estimated age of 10 years.

NUMBERS AND DISTRIBUTION OF OVER-WINTERING WALRUSES

Results of coastal reconnaissance surveys in the Penny Strait region of the Canadian high arctic are currently being analysed. We are particularly interested in this area because the walruses there have vocalizations surprisingly different from walruses at the Dundas Island polynia. Prior to this study it was thought there was a high proportion of young, sub-dominant males and non-breeding females in the Penny Strait area. Reduced levels of breeding activity was one possible explanation for the differences in the vocal behaviour. However, ground observations and aerial photography of the herds have indicated that there are substantial numbers of potentially breeding males present in the area. The possibility of dialects or geographically variable songs will have to be considered in the future. Data on the winter distributions and seasonal movements of walruses will be necessary to address these questions.

APPENDIX VI. WITS-2 RESPONSES TO SPECIFIC REQUESTS

At the WITS-2 meeting, several requests for advice or endorsement were tabled. They were discussed and responses formulated.

1. A request from A. Somov to F. Fay was redirected to WITS. A. Somov requested a summary of laws and regulations for protection and hunting of sea mammals, to assist him in revising Russian laws. F. Fay passed it to WITS with the understanding that a broader base of information would be more useful. WITS recommended that each range state representative prepare information on their regulations and submit it to the secretary who would collate it and send it to A. Somov.

2. E. Born, P. Richard, and R. Stewart drafted a proposal to have walruses included in the existing Joint (Canada/Greenland) Commission for Conservation of Narwhal and Beluga and asked WITS-2 if they would endorse it. WITS-2 endorsed it as consistent with its recommendation to foster bilateral and multilateral agreements among range states.

3. R. Kastelein asked if WITS could endorse research on underwater audiograms for the walruses he has in captivity at Harderwijk. Participants viewed such work favourably and noted it was a research recommendation of WG-5. In addition, R. Stewart, on behalf of WITS-2 will write the Harderwijk Aquarium, supporting the research.

APPENDIX VII. LETTER CHARGING SECRETARY OF WITS TO ACT UPON RECOMMENDATIONS

Dr. R. R. Campbell
Secretary, WITS
Canadian Wildlife Service
Ottawa, Ontario
K1A OH3

April 16, 1993

Dear Bob,

I have been a little tardy in discharging my duties as a co-convenor of WITS-2. I was asked to officially represent the wishes of WITS-2 to you.

First, the group unanimously accepted your offer to continue as secretary. Also unanimous were the statements of appreciation for your efforts in your first term and regrets that you were unable to attend this meeting.

Then we decided a number of things which are apt to make your second term even more interesting. We formalized the liaison and leadership provided by the secretary and range state representatives (RSR) by identifying you as an executive committee, and outlining duties for the exec. committee. RSRs are Ø. Wiig (Norway), E. Born (Greenland), P. Richard (Canada), D. Seagars (USA), G. Fedoseev and L. Popov (Russia).

Duties will be outlined in the WITS Workshop report but you will require details. In addition to what you have been doing, there are four main responsibilities identified: the next meeting, range state reports, a response to Dr. A. Somov, and affiliation.

1. Next Meeting. The executive committee will be responsible for arranging the time and place of WITS-3, although the host organization will tend to the actual arranging of the meeting. Dana Seagars indicated there was interest in the Fish and Wildlife Service in holding it in Alaska but that such thoughts are in a germinal stage. It was also noted that a workshop in Russia would ensure Russian attendance. Wherever they are held, WITS workshops should remain accessible to resource users. The secretary is responsible for instigating and monitoring discussions among RSRs at an appropriate time to facilitate the next meeting.

2. Range State Reports. RSRs will be responsible for informing you of changes in knowledge, policy, management or agreements that affect walrus. This may be as these changes take place, in which case you would pass the information on to WITS members, or they may be accumulated for a report at WITS meetings. The purpose of these decisions was to ensure a constant flow of important information while limiting the RSR reports to summaries of new information. The secretary is responsible for passing on information as it becomes available and requesting a report of new information to be delivered at the next WITS meeting.

3. Respond to Dr. A. Somov. Dr. Somov's request to Dr. Fay for a summary of laws and regulations for protection and hunting of sea mammals was discussed. WITS-2 recom-

mended that each range state representative prepare information on their regulations and submit it to the secretary who would collate it and send it to Dr. Somov.

4. Affiliation. We decided WITS may benefit from being officially sanctioned and we considered two main approaches. One would make WITS the vehicle of a new, formal international agreement. The other would attach WITS to an existing international organization. Members would like you, as secretary, to investigate the options, benefits and pitfalls of these two approaches and provide all WITS members with the details of your inquiries. The decision to proceed will be made by the whole group.

4a. International Agreement. In a way, this would make WITS a parallel to the Polar Bear Technical Committee, except the polar bear group arose out of an international agreement while WITS already exists without an agreement. Members have asked that you investigate, with range state governments, the governments' interest in developing such an umbrella agreement and reporting to WITS members the outcome of this investigation.

At the meeting, I asked Erik Born if he could send you a copy of the polar bear agreement to assist you, but his response was not recorded. He, Lloyd Lowry and Ian Stirling would be good people to talk to about this as they have experience dealing with the various organizations.

4b. IUCN. The Seal Specialist Group of IUCN was identified as a possible umbrella for WITS. We also considered affiliation with ICES and the Marine Mammal Society but thought IUCN most appropriate. It has acted on walrus concerns in the past and IUCN has several of these largely independent sub-groups.

Possible contacts are: Jacques Prescott, IUCN Canadian Representative, c/o Jardin Zoologique de Québec, 8191 ave du Zoo, Charlesbourg, QB, G1G 4G4 (418 622-0313, Fax 418 646-9239) and Peter Reijnders, Chair, IUCN Seal Specialist Group, Research Institute for Nature, P.O. Box 59, 1790 AB Benburg, Netherlands.

We realized that affiliation with either an international agreement or an existing international organization may impose certain restrictions of WITS. Some of the advantages are obvious: increase credibility, improved legitimacy in the eyes of our own governments, logistic (secretariat) support which may be available, but the negatives are less well known. Some discussions included the designation of membership (currently members of WITS are the participants of the first two WITS meetings and others sponsored by those participants), increased political demands, and obligations to IUCN that might conflict with WITS objectives.

Once again I would like to convey to you the appreciation of WITS members for your past efforts and offer of continued service.

Yours truly

Dr. Robert E. A. Stewart
Co-convener WITS-2
on behalf of WITS

APPENDIX VIII. THE WALRUS INTERNATIONAL TECHNICAL AND SCIENTIFIC (WITS) COMMITTEE PUBLICATION LIST

1. FAY, F.H., B.P. KELLY, AND B.A. FAY (ed.). 1990. The ecology and management of walrus populations. Report of an international workshop, 26-30 March 1990, Seattle, Washington, U.S.A. xii + 186 p. (Report PB91-100479 available from NTIS, 5285 Port Royal Road, Springfield, VA 22161, USA, for US $26.00 (USA requests) or US $50.00 (foreign requests)).

2. STEWART, B.E. (ed.). 1993. The Walrus International Technical and Scientific (WITS) Committee's bibliography on walrus, *Odobenus rosmarus* (L.), to January, 1993. Can. Tech. Rep. Fish. Aquat. Sci. 1923: iv + 191 p.

3. STEWART, R.E.A., P.R. RICHARD, and B.E. STEWART (ed.). Report of the 2nd Walrus Technical and Scientific (WITS) Workshop, 11-15 January 1993, Winnipeg, Manitoba, Canada. Can. Tech. Rep. Fish. Aquat. Sci. 1940: viii + 91 p.