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DFO’s National Marine Mammal Review Committee (NMMRC) met in Montreal from February 1 to 5 to address various issues on seals and whales from the Atlantic, Arctic and Pacific oceans. Thirty two participants discussed and evaluated research reports and provided specific advice on several topics. Three were invited experts from outside Canada while the others were from Canadian federal and provincial governments, the Fisheries Research Conservation Council, the Nunavut Wildlife Management Board, the Makivik Society, sealing communities and two private research groups (Groupe de Recherche et d'Éducation sur le Milieu Marin and International Marine Mammal Association). The agenda, list of participants and documents tabled at the meeting are presented in annexes I to III.

Current Information on the Status of the Harp Seal Population in Atlantic Canada

Catches and Age-composition of the harvest

Estimates of the total harvest of harp seals in the Northwest Atlantic are presented in WP 99/1. Harvests in Greenland, the Canadian Arctic and southern Canadian (Front[1] and Gulf [2]) areas were based upon catches reported to the Joint ICES/NAFO Working Group on Harp and Hooded Seals (Anon. 1999). Annual catches in southern Canadian areas have increased significantly from less than 65,000 for most years from 1983 through 1995 to over 240,000 between 1996 and 1998. Data obtained since this stock was last assessed in 1995 indicate that Greenland catches have increased significantly in recent years and, since 1975, have been higher than previously estimated. A change in the location of harvesting in Greenland has also been observed, particularly in Southwest Greenland where the number of harp seals taken has increased significantly.

Data on catches in Greenland for the 1952 - 1987 and 1993 – 1996 periods were available. Catches from 1988-92 and since 1996 were estimated by regressing the available catch data from 1975 to 1996 against year using a quadratic function. Based on this relationship, catches in 1998 were estimated to be approximately 84,000. The Committee noted that the form of the relationship assumed will affect the estimated 1997 and 1998 harvest levels. The impact of this assumption on these estimates should be explored and compared to the official statistics when they become available.

Based on the limited data from the Canadian Arctic prior to 1983, catches are considered to be relatively small. However, the number of harp seals taken in this area and the age structure should be determined.

Age composition of catches in southern Canadian waters since 1993 was estimated based on reported numbers of young taken and biological samples of seals one year of age and older (1+) taken from the commercial harvest and research samples (WP 99/1). These data indicate that the harvest consisted of approximately 40-50% pups in 1994 and 1995, but has increased to over 75% pups since 1996. Estimates of the age composition of seals harvested in Greenland were obtained from biological

[1] Front: pack-ice off N.E. Newfoundland and Labrador Coasts.
[2] Gulf: pack-ice in the Gulf of St. Lawrence.

samples collected in West Greenland between 1970 and 1993 (WP 99/2). Annual estimates were available for the period 1970-83, but the samples collected from 1984-93 were averaged to provide an estimate of the age structure of catches since the early 1980s. The data indicated a gradual decrease in the proportion of young of the year in the catch. Reports from hunters show a similar trend (Anon 1999).

The Committee noted that the sex ratio and age structure of seals taken in all components of the harvest should be determined. The components should be sampled in proportion to the size of the catches.

Unreported Mortality

The level of unreported mortality in harp seals during hunting in Canadian and Greenland waters is a growing concern. There are several sources of this mortality including seals that are killed and not recovered (struck and lost), seals caught as by-catch in fishing gear, and those taken for various products but not reported ('high-grading'). The current harp seal assessment model includes in its fitting procedure only reported kills i.e., unreported kills (mortality) are included in the composite estimate of the natural mortality parameter. Unreported mortality needs to be accounted for explicitly in harp seal stock assessments, but most of the available data are old, limited in geographical scope and highly variable. It is evident that more comprehensive data are required.

No data on levels of mortality resulting from by-catch or high grading (under-reporting) were presented although it was indicated that some information on levels of by-catch do exist. The Committee agreed that any existing data should be incorporated into the assessments if possible. Hunters present at the meeting felt that mortality due to high grading may have occurred in some years but this is no longer the case. A number of papers attempting to estimate potential levels of struck and lost were presented (WP 99/2,3,4).

Following a recommendation of an international workshop on interactions between harp seals and fisheries, held in St. John's, Newfoundland in 1997, Lavigne (WP 99/3) attempted to estimate total removals of Northwest Atlantic harp seals for the period 1994-1998. Estimating total removals for Northwest Atlantic harp seals is hindered by a lack of published data. While there is no doubt that some unreported kills occur, for example, as a result of "high grading," or as a result of incidental take in commercial fisheries, it is difficult to estimate the magnitude. Stuck and lost data do exist, however, for various hunts. WP 99/3 examined the available data to provide a basis for correcting landed catch data and to gain insights into the possible magnitude of total removals in recent years. Assuming loss rates of 1% for moulting seals taken on the ice (ragged-jackets), 50% for all seals taken in Greenland, and ranges of 10-25% for beaters and 20-50% for seals one year of age and older (1+) taken in Canada, preliminary calculations indicate that landed catches between 1994 and 1998 underestimate total removals by 19-89%. The amount depended largely on the relative sizes of the Greenland and Canadian hunts, and on the age structure of the catch. Lavigne (WP 99/3) concluded that total removal estimates could be improved if there were better catch data from northern harp seal hunts, both in Canada and West Greenland, better estimates of struck and lost rates for all seal hunts, and information on the extent of high grading and the size of incidental takes associated with various commercial fisheries in the Northwest Atlantic.

Winters (WP 99/4) also considered the problem of unreported mortalities associated with struck and loss rates of harp seals due to sinking from 1994 - 98. In general, fatness of adult harp seals increases during the heavy feeding period in winter, falls during the whelping and moulting season in March-April, and remains relatively low during the summer migration to Arctic waters. Thin seals tend to sink while fat seals tend to float. Thus, sinking losses are a function of three factors: a) the proportion of seals shot in the water, b) the proportion of those that have negative buoyancy, and c) the proportion of those seals with negative buoyancy that are retrieved because of the skill and tactics of the hunter. Based on data on blubber thickness, and assumptions about the proportion of seals taken in the water and retrieval rates, WP 99/4 estimated that sinking loss rates are in the range of 7 - 23.5%. This implies that current catches could be underestimated by a factor of 1.08-1.30. A best estimate of 8% sinking loss was derived for the current hunt based on conservative observer estimates of proportions shot on the ice and likely retrieval rates. (WP 99/5) estimated that about 1/2 of these losses are included in the natural mortality rate estimated by the current harp seal assessment model.

The Committee agreed that specifically accounting for mortalities associated with struck and lost is more informative than including them as part of an aggregate natural mortality. There was also considerable discussion about current struck and lost estimates for the Greenland hunt. The Committee was told that experienced hunters, who account for approximately half of the harvest in Greenland, appear to have relatively low loss rates (~10%). The rates of struck and lost by other hunters are unknown but may be much higher. Hunters from all regions at the meeting emphasised that it was to their best interest to minimise stuck and lost rates.

Sjare and Stenson (WP 99/5) presented a preliminary summary of recent struck and lost estimates collected by DFO Marine Mammal and Sea Watch Observer personnel off Newfoundland. The information was obtained from three main sources 1) longliners with DFO personnel aboard, 2) large vessels (>65ft.) chartered by DFO, and 3) longliners with Sea Watch Observers aboard. Most of the observations were made on 10 -14 day trips during the spring hunt with professional sealers.

There was a loss rate of 1.4% for beaters taken on the ice by longliners with DFO observers and a 0 - 2.0% loss rate for the Sea Watch longliners. The number of beaters shot in the water and not recovered was somewhat higher (3.2% based on DFO longliner data). Loss rates for 1+ aged seals shot on the ice from longliners varied between 1.3 - 11.1%. Loss rates for 1+ seals shot in the water were up to 50%. Sample sizes for all age classes of seals are still relatively small, particularly for seals shot in the water. The new information on beaters is similar to a 1977 estimate presented by Rowsell and the perception of experienced sealers present at the meeting. This study suggests that the 10% and 25% loss rate for beaters suggested in WP 99/3 might be too high. It also appears that the 20% loss rate for 1+ aged seals taken on the ice in WP 99/3 may be high as well. However, a 50% rate for older seals taken in the water may be appropriate until more information becomes available. Estimates of loss rates presented in WP 99/5 are comparable with some of the estimates in WP 99/4 which are based on seasonal changes in body condition.

Possible reasons for the high variability in estimated struck and lost rates were discussed. It was evident that the only way to reduce this variability is to collect more and better quality data. The question of Sea Watch Observer reliability and the effect of an observer on the activities of the hunters were also raised. These were valid concerns, but given the limited sources of data the Committee agreed that it would be unwise not to take advantage of the Program. Sjare and Stenson (WP 99/5) noted that the crew might be less influenced by the observers if they collect biological samples as well as struck and lost information. It was also noted that the recovery rates obtained from the large vessel data may be negatively biased since DFO personnel probably put more effort into looking for a struck seal than would a commercial seal hunter.

The Committee agreed that, for illustrative purposes, struck and lost rates of 5% for first year animals in the Front and Gulf, and up to 50% for other first year seals and all older animals should be used in calculations. However, there is an urgent need for more precise and accurate information on these rates[3].

Population trends

A time series of abundance estimates of harp seals (WP 99/6) was determined for the period 1960 to 1998 using estimates of pup production, pregnancy rates and age structure of the catch (WP 99/3). The two-parameter age structured population model described by Shelton et al. (1996) was fitted to six estimates of pup production under two different assumptions of pup mortality. In one model formulation pup mortality was assumed to be equal to that of seals one year of age and older (1+) while in the second, pup mortality rate was assumed to be 3 times the 1+ mortality rate. Replacement and sustainable yields were estimated using both model formulations under differing assumptions of the age structure of the harvest. The impact of assuming different levels of unreported mortality on population trends was also examined. The levels of unreported mortality assumed are given in Table 1.

[3] See footnote, Annex II.

Table 1. Assumed levels of unreported mortality (%). Prior to 1983 the level of unreported mortality among age class 0 in the Front and Gulf regions was assumed to be 1% for low, moderate and high runs.

Scenario	Harvest Area			
	Front and Gulf		Can. Arctic and Greenland	
	0	1+	0	1+
Reported Catch	0	0	0	0
Low	5	33	33	33
Moderate	5	40	50	50
High	25	50	50	50

Based upon the first model formulation and with no allowance for animals struck and lost, the total population was estimated to be approximately 5.51 million (95% C. I. 4.34 - 6.68) in 1998. Assuming higher pup mortality resulted in a slightly lower estimate of 5.28 million (Table 2). Under both models, the population was estimated to be growing at less than 0.5% per year. The 1999 replacement harvest was estimated to be approximately 407,000 animals under the assumption of constant mortality and 402,000 under the assumption of higher pup mortality.

Estimates of population size and instantaneous mortality were reduced if the catch was adjusted to account for struck and lost mortality (Table 2). Depending on the level of unreported mortality assumed the population has declined at 0.15 - 2% per year in recent years. Estimates of replacement yields were higher when unreported mortality was included, but this yield includes all removals (including animals struck and lost) and should be adjusted before it can be used to set Total Allowable Catches.

Table 2. Results of model runs assuming age-dependent mortality ($m_0=3m_{1+}$) and differing levels of unreported mortality. Estimates of replacement and sustainable yields were estimated assuming a catch consisting of 65% age class 0.

		Assumed levels of unreported catch		
	Reported	Low	Moderate	High
1998 Total Population	5,280,000	5,210,000	5,140,000	5,000,000
1998 Pup Production	795,000	786,000	779,000	772,000
Instantaneous mortality (M)				
1+	0.073	0.0649	0.0594	0.05688
Pup	0.219	0.1947	0.1783	0.1706
Growth rate (1998/1997)	1.0048	0.9985	0.9942	0.9830
Replacement Yield	402,000	448,000	478,000	497,000
Sustainable Yield	406,000	457,000	491,000	494,000

The Committee noted that there was still some confusion over how the pup production estimates used to fit the model were chosen. It was explained that these were the only available estimates that had been obtained from both the Front and Gulf in the same year, covered all known whelping patches and provided an estimate of variance.

Although the results of models assuming constant mortality over age classes are not significantly different from those which assume higher pup mortality, the Committee concluded that the latter assumption is more biologically realistic. Future efforts should focus on models incorporating age-dependent mortality, and which take explicit account of all known sources of mortality (including struck and lost, by-catch and unreported harvest). The Committee also noted that the accuracy of estimates of population abundance depend critically on the quality of the estimates of reproductive rates. It therefore recommended that more samples should be collected to improve the quality of these estimates.

The Committee recommended that the underlying model should be revised so that it can take into account all sources of uncertainty in the data (such as sampling error in the reproductive data), and so that it can incorporate as much of the available data as possible. The sensitivity of the model to assumptions about the pattern of age-dependent mortality should be investigated.

Density Dependence

Winters and Miller (WP 99/7) presented several long-term projections of harp seal population dynamics under alternative harvesting strategies. These projections were run using two models, one assuming a density dependent response in the reproductive rates in the population and a second assuming that the reproductive rates remain the same as those presented in Sjare et al. (1996). The density dependent response was modelled by linear regression of estimates of mean age of sexual maturity and pregnancy rates against population size lagged five and one year, respectively. Based on these relationships, it was concluded that there is a strong density dependent relationship in harp seals. Using this relationship, Winters and Miller estimated the maximum sustainable yield of harp seals in the Northwest Atlantic.

The results of the density dependent and density independent models differed significantly. With the density independent model, the replacement yield in 1999 was estimated to be 400,000. For the density dependent model this yield was unsustainable, and the maximum sustainable yield was estimated to be approximately 275,000 seals. This difference was due to the reproductive rates for recent years used in the two models. The density independent model assumes that current reproductive rates are the same as those estimated from samples collected off Newfoundland in 1990-94, while the density dependent model uses rates derived from the density dependent relationship. The latter are substantially different from the observed values (a higher age at first reproduction and a lower average pregnancy rate).

WP 99/8 raised a number of objections to the manner in which the density dependent relationship was determined. The linear relationships used would result in negative pregnancy rates at some population sizes; the relationships were highly dependent on the values for recent years; the underlying time series of abundance estimates has a discontinuity at a critical period which may have affected the observed relationships; and it was necessary to extrapolate well beyond the range of values used in the regression analysis to estimate current reproductive rates.

The Committee concluded that there was good evidence for density dependence in this population, but that there were substantial difficulties in estimating the form of the relationship. The most recent direct estimates of age at first reproduction and pregnancy rate are substantially different from those obtained via the regressions in WP 99/7. The direct estimates should be unbiased but they may have a large sampling error. The model estimates are not free of sampling error and are potentially biased. The Committee also noted that the current formulation of the harp seal population model (WP 99/6) does incorporate annual estimates of age specific reproductive rates which will reflect historical changes that may be due to density dependent responses.

The Committee agreed that reasonable short-term projections, up to about 5 years, may be possible using models of the kind described in WP 99/7 and WP 99/6, although this is predicated on the availability of accurate estimates of pregnancy rates. To estimate rates samples should be obtained from all areas to determine if there is differential migration of pregnant seals that could cause bias in the current sampling regime. Such short-term projections should be compared with the results of independent estimates of pup production (e.g. aerial surveys) carried out at regular intervals. Any disagreement could be the result of biased sampling or flaws in the underlying model, and this would have to be resolved before proceeding.

In exploited populations, it is necessary to monitor changes over time in parameters which can be measured with reasonable precision and which are sensitive to changes in abundance. In the case of harp seals the obvious parameters are pregnancy rate and pup production. Based on the 1994 aerial survey and pregnancy rate data, 5 million was a reasonable estimate for the size of the NW Atlantic harp seal population. However, since 1994 Canadian harp seal catches have increased dramatically, new (and much higher) estimates of the Greenland catch have become available, and we have begun to examine data that will help us estimate the struck and lost rate. Data from the 1999 survey of the population in the Gulf and Front will undoubtedly help to clarify and refine our ideas of what is occurring with the total population. But a risk analysis is really required if the results of this survey are to be applied effectively. This should take account of the known uncertainties in the basic model (Shelton et al. 1996) to generate probability distributions for predicted pup production in 1999 under a variety of scenarios, and for the likely effects of different TACs. Some indication of the general aims of management will make it easier to carry out this risk analysis (because fewer scenarios will need to be investigated), but we need to recognise that management objectives may change from year to year. To cope with this the model underlying the risk assessment should be relatively general and flexible. A more detailed underlying model can also be used to investigate the sensitivity of predictions to factors, such as age-specific survival rates and density dependence, which cannot be estimated directly. If predictions are sensitive to these factors, then additional research in these areas is clearly required.

Harwood suggested a process in which Risk Assessment can be applied to the Management of Renewable Resources. The steps included in such a procedure include:

- Establish an expert group of stakeholders and scientists to agree on the available information, the aims of management, and acceptable levels of risks for an issue.
- Use this group to draw up a list of potential management scenarios.
- Identify and integrate available information.
- Develop innovative statistical models of the underlying mechanisms and activities.
- Calibrate these models with the available data.
- Incorporate a range of uncertainties into the models and use them to assess the performance of different management options.
- Use the expert group to synthesise the results into a policy discussion document.

Recommendations:

1. A model assuming age-dependent mortality is more appropriate than one assuming that mortality is constant for all age groups.
2. To improve our understanding of population dynamics of Northwest Atlantic harp seals it is important to obtain annual estimates of size, age structure and sex ratios of the harvest (Greenland and Canada). Catch information should include estimates of the number of struck and lost for each of the hunting types.
3. Future development of the model should focus towards incorporating all sources of data and their associated uncertainties.
4. There should be an assessment of the risks associated with different management scenarios, taking account of all potential uncertainties. It noted that additional resources would be required to carry out this analysis.
5. As estimates of current reproductive rates are essential, current Canadian studies should be expanded and reproductive rates of seals sampled in Greenland and the Canadian Arctic should be determined.
6. Recognising the importance of aerial surveys in calibrating and validating the population model, the 1999 aerial survey should be supported. Periodic standardised surveys are essential.

Grey Seals on the Scotian Shelf and in the Gulf of St. Lawrence

The committee reviewed two working papers which provided pup production estimates for Sable Island in 1997 (WP 99/9), and for non-Sable Island colonies (Gulf) in 1996 and 1997 (WP 99/10). Both sets of estimates were based on the results of aerial surveys which had been corrected for pups which were absent at the time of the survey. The method used to make this correction was described briefly in WP 99/9, but not in sufficient detail to allow the Committee to evaluate it. It uses the number of pups in five different stage categories to estimate the proportion of pups born by the time of the survey. However, no estimate of the variance for the correction factor was provided. Experience in the UK has shown that the classification of individual pups into these stage categories could be difficult, and that the duration of the categories could vary from year to year and colony to colony. The Committee therefore recommended that the methodology be described in more detail and that an estimate of variance be provided. It also recommended that the sensitivity of the method to misclassification, variation in stage duration and when in the pupping season surveys were conducted be investigated. It was also noted that few pups in stage IV and none in stage V were recorded in the Gulf surveys. The sensitivity of the method to the absence of older pups should also be investigated.

Pup production on Sable Island was estimated to be 25,200 in 1997 (95% CLs 23,700-26,700) (WP 99/9). This estimate was then used with others to estimate that the annual rate of increase was 12.6 % (95% C.I. 12-13.4). However, the Committee noted that the basis for the estimates of pup production in 1989, 1990 and 1993 from aerial surveys used in this calculation needs to be better documented.

Gulf pup production was estimated to be 11,757 (6,789-16,8930) in 1996 and 7,426 (4,568-10,381) in 1997 (WP 99/10). The two estimates were not significantly different. Poor ice conditions were encountered in 1997, which may have lead to increased pup mortality. Using estimates of pup production from tagging experiments and aerial surveys between 1984 and 1997, it was estimated that this component of the population increased by 3.4% annually (95% C.I. 0-6.7) between 1984 and 1997.

WP 99/11 provided estimates of replacement yields calculated using a simple model which treated Sable Island and non-Sable Island grey seals separately. The calculated rate of increase and the upper and lower 95% confidence limits for Sable Island (12, 12.6. 13.4%) and the Gulf (0.0, 3.4 and 6.7%) were used to predict the populations' dynamics. These rates were achieved by varying adult and pup survival rates (subject to the constraint that pup survival<adult survival). The model incorporated information on age-specific reproductive rates, primarily from the Gulf, and documented removals. The stable age distribution in 1967 was calculated and this was projected forward taking account of recorded removals. For a harvest of 20% pups and 80% animals more than one-year old taken during the pupping season, the replacement yield for non-Sable Island animals varied between 0 and 6,300; for Sable Island it was >10,000 animals. The situation is more complicated if seals are taken outside the pupping season, because animals from the two breeding areas are believed to mix extensively. A precautionary approach, which avoids over-exploitation of Gulf seals, would use a replacement yield for animals from these sites alone and apply it to the entire Northwest Atlantic population. On this basis, a removal of around 2,000 animals of all ages outside the breeding season in 1999 will have little long term effect on either the entire population, or the Gulf component. This yield can be recalculated if more information on the distribution of animals from the two components outside the pupping season becomes available.

The Committee noted that the method currently used to estimate replacement yields for Northwest Atlantic harp seals (WP 99/6) could also be applied to grey seals. This would, provide confidence limits for the estimate of pup survival. During the meeting, Stenson carried out some of the necessary modifications and calculated provisional replacement yields for 1999. These were similar to those already obtained (e.g. a best estimate of around 2,000 all-age animals taken outside the pupping season).

Recommendations:

1. A more detailed description of the method used to convert pup estimates from the aerial surveys to total pup production is required. An estimate of the variance associated with the correction factor should be provided. The sensitivity of the stage model to variations in stage duration, miss-classification of pups, time during the pupping season, and missing stages should be investigated. The possibility of using different categories (e.g. suckling and non-suckling pups, only stages I and II) for the surveys of non-Sable Island seals should be investigated.
2. The basis for the estimates of pup production at Sable Island in 1989, 1990 and 1993 referred to in WP 99/9 should be documented.
3. The feasibility of using line transect surveys to estimate Gulf pup production should be investigated.
4. The Gulf component of the Northwest Atlantic population appears to experience highly variable pup mortality, because of variations in ice conditions. Currently, it is surveyed every 5-7 years, but the Committee recommends that it be surveyed more frequently to provide more precise estimates of trend.
5. The procedure currently used to estimate harp seal population size and replacement yields (WP 99/6) should be adapted for use on the grey seal population. An assessment of the risks associated with different management scenarios, along the lines recommended for harp seals, should be conducted.
6. A removal of around 2,000 animals of all ages outside the pupping season will have little long term effect on the Northwest Atlantic grey seal population, or on that component of the population which pups at sites other than Sable Island. A substantially higher removal could be taken during the pupping season, if harvesting is carried out predominantly on Sable Island. Outside of this period, more information on the distribution of the two components of the population is required before a harvest >2,000 animals should be considered.

Status of Harbour Seals in British Columbia

The committee reviewed available information on trends in abundance of harbour seals in British Columbia based on aerial surveys conducted during 1973-98 (WP 99/13). A correction factor to account for animals missed during surveys was derived based on an analysis of haulout patterns as determined by time-depth recorders. It was estimated that seal numbers in the Strait of Georgia were increasing exponentially at an annual rate of 11.9% (95% CI of 11.0-12.7%) during the 1970s and 80s. In the 1990s, however, the rate of increase began to slow and the population now appears to have stabilised. Abundance in the Strait of Georgia was estimated to have increased from 3,570 (95% CI of 2,480-4,650) when the first systematic surveys were conducted in 1973, to about 37,300 (95% CI of 28,200-46,300) during 1996-98. Similar trends were observed in other areas of British Columbia. Abundance was estimated at 54,500 (95% CI of 41,300-67,900) along that portion of the coast that has been surveyed. Extrapolations based on the densities observed in surveyed areas and on the relative distribution of historical kills indicate total harbour seal abundance in British Columbia may be on the order of 100,000. However, the committee advised that valid confidence limits could not be calculated for this estimate, and that potential sources of imprecision and bias needed to be documented.

Recommendations:

1. The author should explore various techniques such as re-sampling of existing survey data as a means of assessing the potential imprecision and bias in the extrapolated population estimates.
2. Unsurveyed areas, particularly the central and northern mainland coast should be surveyed. It was recommended that a randomised or systematic sampling component be incorporated into the survey design so that density estimates can be calculated prior to obtaining complete coverage.
3. Surveys should be continued to monitor harbour seal population trends. However, a more representative indication of overall trends could be obtained by allocating survey effort more broadly throughout British Columbia rather than surveying the entire Strait of Georgia biennially.

Canadian Papers to be Presented at NAMMCO[4]

This section summarises five papers prepared mainly by DFO scientists and submitted to the Committee for review before they were presented at NAMMCO in April 1999. Various recommendations from the Committee are included.

Stock Structure of Beluga (*Delphinapterus leucas*) Populations in the Arctic

Management of beluga stocks requires knowledge of stock differences and boundaries that can be integrated with other population information. Genetic information is becoming a valuable tool for recognising stock differences. WP 99/15 summarised the results of the analysis of tissue samples from more than 1200 beluga, with samples from Alaska to Greenland, collected between 1980 and the present. These samples come from several contributors, but primarily from native subsistence hunting. Four cases were presented in which results of genetic analyses were quite different. In some cases, populations of belugas could be distinguished by maternal haplotypes, and in other cases by patterns of similarities and differences in nuclear DNA. In yet other cases, genetic differences between belugas hunted by different communities were not evident, but other evidence (for example, contaminants, morphometrics) suggested they were different. North American waters were most likely recolonized from either two or three populations during and after the last glaciation, and some groups have been interbreeding at a slow rate since that time. Stocks may mix in wintering areas, on migration routes, and some animals are known to wander extensively. An important challenge for stock assessment scientists is to determine the population dynamics that could maintain these gradients and differences.

The stock identity of various beluga populations was also investigated using the concentrations of organochlorine contaminants in their blubber. In Southeast Baffin Island, several statistically significant univariate differences were found in beluga landed by hunters from Pangnirtung, Iqaluit and Kimmirut (WP 99/16). Canonical discriminant analysis was used to transform the data into variates that summarised differences between sampling locations. These variates were not dependent on sex or age of the beluga, as is often found in univariate analysis. The two possible canonical variates separated all three locations from each other and independently classified 146 of the 148 samples back to their sampling location. Combining locations and re-running the analysis did not alter this conclusion - locations still separated back to their sampling location. Thus there appears to be at least three separate stocks of beluga that are hunted in the Southeast Baffin Island area instead of the putative single stock previously used for management purposes.

The same approach was used to examine the stock relationships of beluga in Canada and Greenland (WP 99/17). Forty-nine compounds were summarised using canonical discriminant analysis into three composite variates. Based on these three variates it was possible to assign 94% (221 of 236) of the samples back to their sampling locations. The samples which were misclassified were between Sanikiluaq and Cumberland Sound, and between Western Hudson Bay and the Nastapoka River estuary. Examining smaller geographic subsamples did not improve the analysis due to small sample

[4] NAMMCO: North Atlantic Marine Mammal Commission.

sizes in some sampling locations. Differences between Grise Ford and West Greenland samples, between Sanikiluaq and Nastapoka River estuary, and between Cumberland Sound and Kimmirut require re-evaluation of the management stocks of beluga. A beluga stock can be defined by its migration path which brings it in contact with different hunting communities Based on this definition it was suggested that it is the cultural trait of migration path which is important in determining the stock.

Recommendations:
1. On the basis of WP 99/16 and WP 99/17, the precautionary approach should be used and the groups identified by organochlorine signatures be treated as separate stocks. 2. For the purposes of future presentations, a table comparing genetic and contaminants stocks should be prepared.

Population Estimates and Migration of Small Whales

The next paper in this series presented the results of a systematic survey of Baffin Bay beluga flown between July 31 - August 3, 1986, using line transect methods (WP 99/18). Two observers were used to determine the probability that whales were missed on the track line. The proportion of beluga at the surface was monitored using satellite-linked TDR transmitters deployed on 11 belugas. Both observers in the front and back seat saw 243 groups of whales, of which 111 were beluga and 122 were narwhal. Mean group size was 1.99 for beluga and 2.24 for narwhal. After correcting the numbers of beluga estimated offshore, beluga missed on the track line, the proportion of the time they spent on the surface, and double counting due to the migration between survey lines it was estimated that 28,499 (13,886 - 58,491) beluga were in the survey area. Narwhal counts, including those missed by front observers, produced an estimate of 14,240 (6,658 - 30,931). Observations of eight bowhead whales analysed as a strip survey provided an estimate of 104 bowhead (68-141). The database has been refined since these analyses. This will alter the number of duplicate sightings and thus the estimates of abundance.

The results of various studies of movements of beluga whales live-captured in Canadian waters and instrumented with satellite-linked radio-transmitters in Canadian Arctic waters were summarised in WP 99/20. Based on tracking data, it appears that the northern beluga whale stocks, the Beaufort Sea and Baffin Bay stocks, range more widely in summer than the stocks in Cumberland Sound, eastern Hudson Bay and western Hudson Bay. This behaviour probably biased the last estimate of the Beaufort Sea stock but not that of the Baffin Bay stock. The Cumberland Sound and two Hudson Bay stocks' summer ranges appear to have been covered adequately by surveys. Fall movements do not support the hypothesised migration routes of the Beaufort and Baffin Bay. The fall migration routes of southern stocks of belugas were not well documented. Several examples and references suggest that beluga whales spend roughly 40-60% of their time on average in surface water layers (≥ -4m to -10m) so roughly half can be seen by aerial survey observers.

The potential of photo ID for estimating population size and movement of narwhal along the ice edge was investigated by taking photographs from an ultralight aircraft in 1995 and 1996 in Admiralty Inlet (WP 99/21). These photographs were used to identify individuals based on natural marks and scars. Approximately 30 per cent of the narwhal had scars, and these were used to look for matches between days and years. No narwhal were re-sighted between days in 1995 but five were in 1996. One narwhal identified in 1995 was seen again in 1996. Several sources of heterogeneity in capture probability can produce bias in estimates of abundance derived from mark recapture studies. Impact of such heterogeneity should be investigated prior to a major study. This type of study could provide useful information on abundance and turnover rates, but long-term commitments are required. The Committee felt that there was not sufficient data to estimate the turnover rates.

General Recommendation for WP 99/15-21
All Canadian papers should be presented to NAMMCO, IWC and similar international meetings by one of their authors or, should none of them be able to attend, by other knowledgeable Canadian scientists.

Trends in the St. Lawrence Beluga Population

Kingsley (1998) reviewed the results of aerial surveys of beluga in the St Lawrence River made between 1973 and 1995. He corrected these various estimates for differences in survey design and concluded that, when the entire corrected time series was considered, there had been a significant increase in numbers. Michaud and Beland (WP 99/19) demonstrated that this analysis was sensitive to the corrections used: if a different set of correction factors was applied there was no significant trend in the abundance estimates. The committee could not reach any definitive conclusions about which correction factors were more valid. It was recommended that future trend analyses be based on standardised surveys flown since 1988.

WP 99/19 also examined how the growth rate of the population could affect the ability of different sampling regimes to detect a change in population size. If surveys using the 1992 protocol are conducted every 3 years, it will take 20 years to detect an annual change of 3% in population size and 40 years to detect a 1% annual change.

The Committee noted that although it is not possible to confirm that the population is increasing, none of the available time series provided evidence that the population is declining (the highest probability of a decline was < 25%). However, because the St. Lawrence population is small and geographically isolated, it is potentially vulnerable to the effects of a sudden reduction in numbers caused by a catastrophic event, such as an outbreak of an infectious disease. It therefore recommended that a population viability analysis should be carried out to assess the threats to which the population is likely to be exposed and their potential consequences. This information could then be used to establish the most appropriate interval between future aerial surveys.

Recommendations:
1. A population viability analysis should be conducted to examine the vulnerability of this population to large changes in abundance, and to determine the most appropriate interval between future aerial surveys. 2. Only the results of surveys conducted since 1988 should be used in any future trend analyses. Future surveys should use a similar protocol to that used since 1992. 3. Current long-term studies of individually recognisable animals are providing valuable information on reproductive rates and mortality rates. This information is useful for monitoring this population and should be supported.

Status Determination of Marine Mammals by COSEWIC[5]

The committee reviewed and discussed two draft COSEWIC reports. The first report (WP 99/12) reviewed the status of grey seals off the East coast of Canada. The committee concluded the report was generally accurate and provided the best available information for assessing this species, but required several minor revisions: 1) the information on the relationship between cod worm in seals and its prevalence in fish needs to be referenced; 2) the age-dependent reproductive rates need to be stated correctly; and 3) the population growth rates need to be updated to correspond with WP 99/11. The committee concurred with the author's recommendation that the status be designated as Not at Risk. It was recommended that a comment be inserted regarding the generally higher and more variable pup mortality rates of ice breeding grey seals, which would affect population trends.

The second report (WP 99/14) reviewed the status of harbour seals off the West Coast of Canada. The committee concluded the report was generally accurate and provided the best available information for assessing this subspecies, but required several minor revisions: 1) the historical reconstruction of population trends should not be included until it has been documented and peer-reviewed elsewhere; 2) the reference to maximum net productivity levels should be eliminated; and 3) the length of the manuscript should be reduced by eliminating unnecessary detail. The committee concurred with the author's recommendation that the status be designated as Not at Risk.

Following discussion of the two draft stock status reports presented (WP 99/12, WP 99/14), the Committee held a general discussion of the procedures used to develop COSEWIC status reports. The Committee expressed concern about the manner in which marine mammal status reports are currently solicited and reviewed. Examples of reports lacking important data, situations in which

[5] COSEWIC: Comittee on the Status of Endangered Wildlife in Canada.

scientific experts were not consulted prior to (or during) preparation of reports, and limited peer review of draft reports were discussed. The Committee felt that when reports are required, they should be solicited as widely as possible from the scientific community across Canada, especially from those directly involved with the species. Also, draft reports should undergo the comprehensive peer review possible and a transparent process implemented to ensure the reviews are properly incorporated.

Recommendations:

1. WP 99/12, after minor revision, be submitted to COSEWIC to serve as a basis for the evaluation of the status of grey seals on the east coast of Canada.
2. WP 99/14, after minor revision, be submitted to COSEWIC to serve as a basis for the evaluation of the status of harbour seals on the west coast of Canada.
3. Whenever possible, status reports be solicited widely from the scientific community across Canada to ensure reports are prepared by appropriate scientific experts.
4. The structure, review procedures and membership of COSEWIC Fish and Marine Mammal Subcommittee should be reviewed and if necessary modified to ensure comprehensive peer review of status reports.

References

Anonymous. 1999. Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals. ICES CM 1999/ACFM: 7.

Kingsley, M.C.S. 1998. Population index estimates for the St . Lawrence belugas, 1973-1995. Mar. Mamm. Sci. 14: 508-530.

Shelton, P.A., Stenson G.B., Sjare B. and Warren W.G. 1996. Model estimates of harp seal numbers-at-age for the Northwest Atlantic. NAFO Sci. Coun. Studies. 26: 1-14.

Sjare, B., Stenson G.B. and Warren W.G. 1996. Summary of female reproductive parameters in the Northwest Atlantic. NAFO Sci. Coun. Studies. 26: 41-46.

ANNEX I. Agenda

Review harp seal population model and new information on catches

- Updated Greenland catches.
- Estimates of struck and lost.

Grey seal abundance estimates and population status in Atlantic Canada

- Pup production estimates.
- Replacement yield.

Harbour seals in British Columbia

Recent research on small whales

- Structure of beluga populations.
- Population estimates (Baffin Bay beluga) and survey estimates (narwhal and bowhead whales) in the Canadian High Arctic.
- Population trends of St. Lawrence belugas.
- Distribution (use by narwhal of the ice-edge) and movement (of belugas of the Canadian Arctic)

Others

- COSEWIC population/stock status reports.

ANNEX II. List of participants[6]

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[6] Attendance varied throughout the meeting as a function of participants' expertise and availability. This report represents a consensus of all present at the time the final wording of a section was prepared. A preliminary version of the entire report was sent to all on this list and corrected based on the comments received. At the request of Dr. Lavigne it should be noted that he was absent when the text on harp seal "struck and lost" was finalized.

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ANNEX III. Working papers presented at the meeting. Research documents expected are indicated in bold.

WP 99/1. **Stenson, G.B., Sjare, B. and Wakeham, D. Catch-at-Age of Northwest Atlantic Harp Seals.**

WP 99/2. **Kapel, F.O. Age Composition in Greenland Catches of Harp Seals.**

WP 99/3. Lavigne, D.M. *In Press*. Estimating Total Kill of Northwest Atlantic Harp Seals, 1994-1998. Marine Mammal Science.

WP 99/4. Winters, G.H. A Simple Approach to Estimating Sinking Losses of Northwest Atlantic Harp Seals.

WP 99/5. **Sjare, B. and Stenson G.B. Comments on Struck and Loss Estimates for Harp Seals in the Northwest Atlantic.**

WP 99/6. **Stenson, G.B., Healey, B., Shelton, P.A. and Sjare, B. Recent Trends in the Population of the Northwest Atlantic Harp Seals, *Phoca groenlandica*.**

WP 99/7. Winters, G.H. and Miller D.S. 1998. A Simulation Model of the Response of Harp Seals to Alternative Harvesting Strategies. Report prepared for the Minister of Fisheries and Aquaculture, Government of Newfoundland and Labrador.

WP 99/8. Warren, W.G. Comments on the Winters and Miller Draft Report "A Simulation Model of the Response of Harp Seals to Alternative Harvesting Strategies".

WP 99/9. Bowen, W.D., Mohn, R. and McMillan, J. Grey Seal Pup Production on Sable Island: Sustained Exponential Growth of a Large Mammal Population.

WP 99/10. **Hammill, M.O., Gosselin, J.F., Stenson, G.B. and Sjare, B.J. Non-Sable Island Pup Production of the Northwest Atlantic Grey Seal in 1996 and 1997.**

WP 99/11. **Hammill, M.O. Replacement Yields of Northwest Atlantic Grey Seals (*Halichoerus grypus*).**

WP 99/12. Lesage, V. and Hammill, M.O. The Status of the Grey Seal (*Halichoerus grypus*) in the Northwest Atlantic.

WP 99/13. **Olesiuk, P.F. An Assessment of the Status of Harbour Seals (*Phoca vitulina*) in British Columbia.**

WP 99/14. Olesiuk, P.F. Status of the Pacific Harbour Seal (*Phoca vitulina richardsi*) in British Columbia.

WP 99/15. De March, B.G.E., Maiers, L.D. And Friesen, M.K. Genetic Differences among Canadian and Adjacent Beluga Whale Stocks as Determined by Mitochondrial DNA and 15 Nuclear DNA Microsatellite Loci.

WP 99/16. Innes S. and Stern G. Stock Identity of Beluga (*Delphinapterus leucas*) from Southeast Baffin Island Based on Multivariate Analysis of the Concentrations of Organochlorine Contaminants Found in their Blubber.

WP 99/17. Innes, S., Muir, D.C.G., Stewart, R.E.A., Dietz, R. and Heide-Jorgensen, M.P. Stock Identity of Beluga (*Delphinapterus leucas*) Based on Multivariate Analysis of the Concentrations of Organochlorine Contaminants Found in their Blubber.

WP 99/18. Innes, S., Cleator, H. and Richard. P.R. A Population Estimate for Baffin Bay Beluga (*Delphinapterus leucas*) and Survey Estimates for Narwhal and Bowhead Whales in the Canadian High Arctic.

WP 99/19. Michaud, R. and Beland, P. Looking for Trends in the Endangered St. Lawrence Beluga Population. A Critique of Kingsley, M.C.S. 1998. Population Index Estimates for the St. Lawrence Belugas, 1973-1995. Marine Mammal Science 14: 508-530.

WP 99/20. Richard. P.R. Summer and Autumn Movements of Belugas Across the Canadian Arctic.

WP 99/21. Innes, S., Williams, G., Qaunuq, S. and the Hunters and Trappers Organization of Arctic Bay. The Use of Fast-ice Edges and Cracks by Narwhal (*Monodon monoceros*) and Some Information on Population Structure and Struck and Lost but Lived Determined by Sighting-resighting of Individually Marked Narwhal.