# 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.

BY

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In 1983, on the basis of a report suggesting that the population numbered 300-350 and was declining (Pippard 1985), the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assigned the status "Endangered" to the St. Lawrence Beluga population. Following this designation, a series of studies attempted to identify possible limiting factors and to monitor the evolution of the structure and size of the population**.**

These studies have shown that, in addition to small size, geographical isolation (Sergeant 1986), (Michaud *et al.* 1990), apparently reduced genetic variability (Patenaude *et al.* 1994) and restricted summer range (Michaud 1993), high contaminant burdens (Béland *et al.* 1993) and the threats from heavy marine traffic (Blane and Jaakson 1994, Lesage *et al.* 1999), place this population at increased risk (Lesage and Kingsley 1998). Consequently, all the above intrinsic and extrinsic factors have been identified as potential limiting factors for the recovery of the population (Bailey and Zinger 1995).

In 1995, a team of experts, the St. Lawrence Beluga Recovery Team, critically examined ten population surveys conducted between 1973 and 1992 (Bailey and Zinger 1995). The population abundance indices derived from these surveys ranged from 325 to 530. Unfortunately, over the years, repeated changes and major adjustments had been made to the survey design, and the resulting indices were not directly comparable. The Recovery Team concluded that they were not amenable to a trend analysis, though recognizing that the convergence of most abundance indices suggested that any change in population size over that period would have been very small (Bailey and Zinger 1995). Accordingly, the Recovery Team adopted a precautionary attitude, assumed the population to be stable, and recommended a number of actions likely to promote its recovery.

Recently, Kingsley (1998) reviewed the same series of surveys and used them for the purpose of a trend analysis, arguing that their results had been published as valid population estimates in peer-reviewed literature, and as such documented the evolution of scientific opinion. He applied several correction factors to the earlier population abundance indices (1973-1985) to make them as comparable as possible to his own most recent surveys carried out between 1988 and 1995 (Kingsley 1993, Kingsley 1996, Kingsley and Hammill 1991). The simple regression lines he ran through the original as well as the adjusted survey results, suggested an average increase of 14-24 belugas/yr since 1977 (Kingsley 1998). Kingsley (1998) concluded that the St. Lawrence beluga population had made some progress over the last two decades. He further suggested that beluga hunting in the 1970's consumed all the population potential for growth and that after hunting stopped in 1979, the St. Lawrence beluga population started increasing at near the maximum growth rate for the species, or 3%.

In this paper, we show that Kingsley's trend analysis was very sensitive to underlying assumption concerning the multiple adjustments made to earlier survey results. We argue, as did the St. Lawrence Beluga Recovery Team (Bailey and Zinger 1995), that results from surveys conducted before 1988 cannot be used to statistically assess the recent population trajectory. We then use a power analysis to estimate the number and frequency of annual surveys, following the design of the most recent and standard surveys (1988-1995), required to detect a significant trend in the population under different growth rate hypotheses.

## ADJUSTMENTS TO ORIGINAL POPULATION ABUNDANCE INDICES

Kingsley (1998) applied three classes of correction factors to the original population abundance indices. The first includes a series of straightforward and small adjustments (1.16% to 2.6%) to standardize calculations among surveys. According to the author, and we agree, these adjustments give little ground for discussion. The second class of correction factors were more significant (2.0% to 27%) and were aimed at correcting earlier surveys with incomplete coverage of the known range of the population. These latter adjustments were considered by the author, and we agree again, to be more « debatable ». The last class accounted for the effect of hunting that is believed by some authors (Laurin 1982, Pippard 1985) to have persisted until 1981, or 2 years after its official closing in 1979 through a ruling in the Canadian Fisheries Act. In the following, we review in detail the rationale behind Kingsley's second class of correction factor.

Surveys before 1988 limited their coverage to the central section of the summer range where the probability of finding belugas is high (Figure 1). Three surveys (1985-1988-1990) also omitted to cover the Saguenay fjord which is part of the normal summer range of the population. To adjust the results of surveys with incomplete coverage, Kingsley (1998) used the mean weighted proportion of the population observed outside the limits of less extensive surveys during the actual surveys that fully covered the summer range. Although these corrections seem straightforward, Kingsley (1998) made an inconsistent use of them. Three important decisions that he made, relative to these adjustments, significantly impacted his conclusion.

The first « debatable » decision concerned the corrections for the uncovered upstream and downstream portions of the beluga summer range (see Figure 1). For the upstream sector, a correction factor of 25% was applied to the 1977 abundance index and a 5% correction to the 1984 and 1985 indices. This is in very good agreement with the mean proportion of the total-counts of belugas also observed there (i.e. 26.8 and 5.2% ) during a series of 9 visual surveys flown between 1987 and 1992 to describe the beluga summer distribution (Michaud 1993). However, Kingsley (1998) did not then proceed with correcting for the downstream sector that had not been covered in these early surveys. This was in spite of the fact that belugas are regularly observed there during summer (Michaud 1993): the average proportions of belugas found by Michaud 's surveys below the downstream limit of the 1977, 1984 and 1985 surveys were respectively, 11.5%, 5.0% and 11.5%. Kingsley (1998) justified his decision on the basis that belugas tend to form few, and often only one, large aggregations in the downstream sector and that, therefore, if a concentrated group has been observed in that area, it is unlikely that there are more aggregations farther downstream. Although this is true in most surveys, large distinct aggregations (over 100 individuals) were observed both upstream and downstream of the 1985 survey limit during two of the 9 visual surveys conducted by Michaud (1993). The probability of finding aggregations of belugas in the downstream sector when large groups are also present in the central stratum is high enough to justify the use of a mean weighted correction factor for the uncovered downstream area, just as for the upstream area.

Kingsley's second « debatable » decision relates to adjustments for not surveying the Saguenay fjord. He applied a correction factor of 4.3%, derived from aerial distribution surveys (Michaud 1993), to the 1988 and 1990 surveys; however, he used a correction factor of 2% only for the 1985 survey. This latter decision was made on the basis that "about 10 whales" had been estimated by independent shore or water-based observers "near date of survey" (Kingsley 1998). Such reasoning is not warranted in view of the highly dynamic nature of the beluga distribution. During the summer of 1987, Michaud (1987) conducted pairs of surveys of the upstream area on four consecutive days. The number of belugas observed varied by as much as five-fold between days, and the observations on the first day could not be used to predict those on the next day (Michaud 1987). The same is true for the Saguenay, where the number of belugas seen on a given

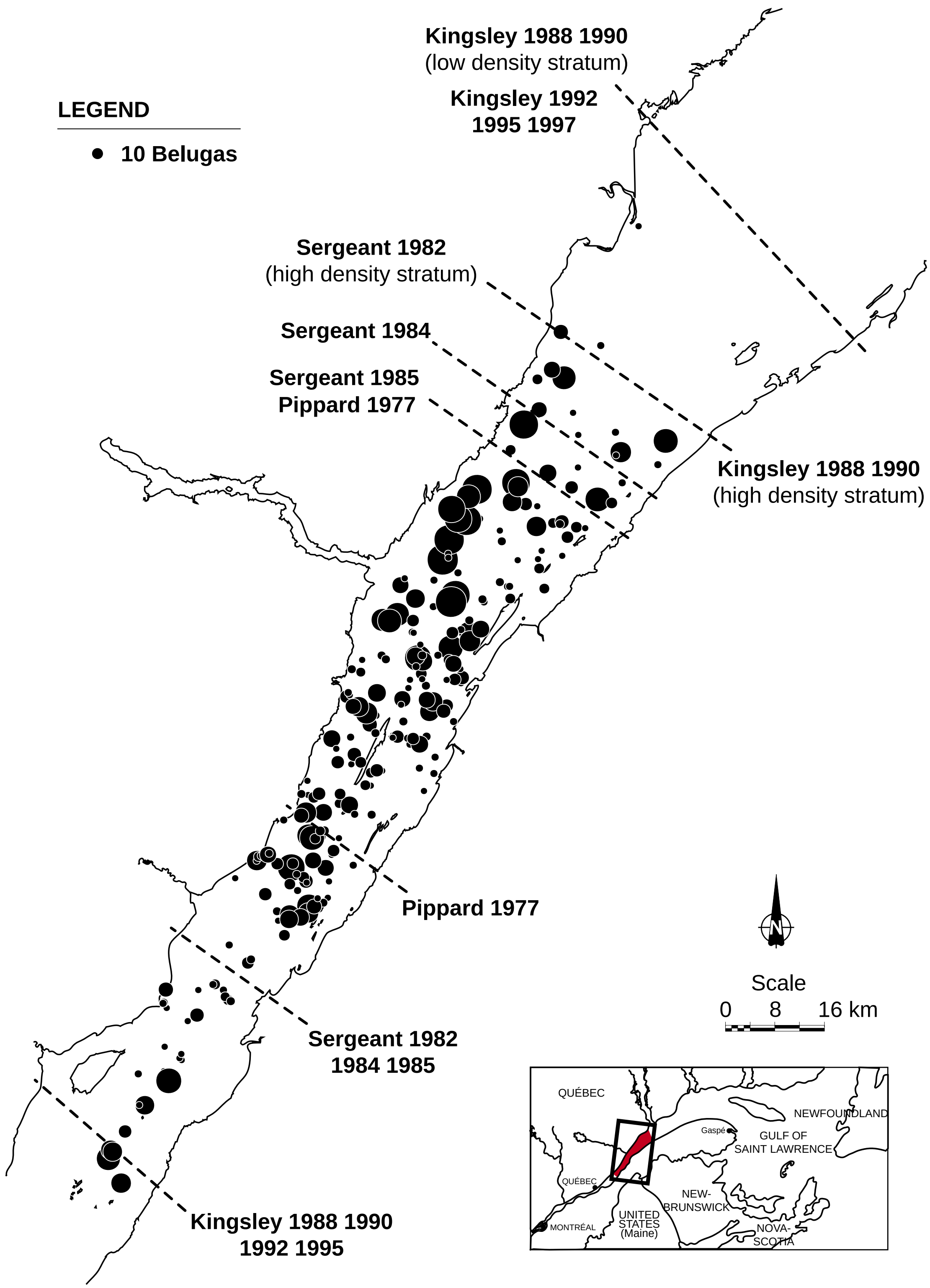


Figure 1. Distribution of belugas observed during 9 visual surveys flown between 1987 and 1992 (Michaud 1993a), showing the limits of all other surveys conducted between 1977 and 1997.

day is not correlated with the number seen on the preceding or following day (Michaud 1992, Chadenet 1997).

Finally, Kingsley (1998) decided not to apply any correction to Sergeant's 1982 visual survey. However, in that stratified survey, the central portion of the summer range was covered during one day, while the upstream and downstream areas were flown on a different day with an unspecified sampling regime. For the same reasons mentioned above, and because the sampling regimes of the upstream and downstream areas were not specified in Sergeant's original papers (Sergeant 1986, Sergeant and Hoek 1988), correction factors for uncovered areas should have been applied to the 1982 survey.

## RE-CORRECTED ABUNDANCE INDICES, TREND ANALYSES AND THEIR LIMITATIONS

We re-corrected the original population abundance indices using consistent correction factors for uncovered areas, while maintaining all other adjustments as in Kingsley (1998) (Table 1). Corrections for uncovered areas were based on Michaud's 9 total-count visual surveys (Michaud 1993). The re-corrected indices were calculated as follows:

$$I_i' = \frac{I_i + C_{std}}{(1 - C_{ui} - C_{di})} + C_{si}$$

where $I_i$ is the original index, $C_{std}$ is the standard adjustment suggested by Kingsley, $C_{ui}$ is the mean proportion of belugas counted in the estuary upstream of the limit of the ith survey, $C_{di}$ is the mean proportion of belugas counted in the estuary downstream of the limit of the ith survey**,** and $C_{si}$ is the mean proportion of belugas counted in the Saguenay fjord.

The rate of change estimated from a simple regression on the re-corrected indices, fitted by weighted least squares as suggested by Kingsley (1998), is 8.7 belugas/yr (SE = 7.1) over the period 1977 - 1995. Using only the six high-altitude photographic surveys of 1984 to 1995, it is 8.0 belugas/yr (SE = 12.1). At a mean population size of 575 to 600, these revised trends correspond to annual growth rates of 1.3 to 1.5%. The revised population trajectories are not significantly different from those predicted for a stable population ($p > .25$).

We agree with Kingsley (1998) that his trend analysis, as well as the revised version presented here, make numerous unverifiable assumptions about the historic range of the population and about a trend model. The variance between the conclusions obtained from Kingsley's regression and from the one presented here clearly illustrates the sensitivity of this analysis to underlying assumptions on which multiple alterations were made to earlier survey results. It supports the suggestion made by the St.Lawrence Beluga Recovery Team (Bailey and Zinger 1995) that these earlier survey results are not amenable to a statistically valid trend analysis.

Using only the most recent standardized surveys, carried out between 1988 and 1995, the estimated straight-line rate of change obtained (24.7 belugas/yr; SE =14.5) was not significantly different from zero (Kingsley 1998). Adding to the series the latest population survey flown in 1997 (681; SE = 91, Michael Kingsley, personnal communication), which was not included in Kingsley (1998), the estimated rate of change remains not significantly different from zero.

Kingsley (in Bailey and Zinger 1995) indicated that using the 1992 survey design at three year intervals, it would take 12 years to detect a 3% annual increase or decrease and up to 24 years for a 1% annual change. We recalculated the probabilities of detecting such changes under different

Table 1. Population abundance indices, revised correction factors and re-corrected indices for the St. Lawrence beluga population, 1977-1997. Correction factors and indices used by Kingsley (1998) that were at variance with those recalculated in the review are given in parentheses.

| Year | Original index estimate | Correction factors given as % (Kingsley's correction factors) | | | | | | Final corrected index |
|---|---|---|---|---|---|---|---|---|
| | | Standard adjustment | Weighting | Saguenay | Upstream area | Downstream area | Hunting | |
| 1977 | 325 | | | | 27.0 | 11.5 ( 0 ) | 48 | 480 (412) |
| 1982 | 512 | | | | 5.0 ( 0 ) | 0.1 ( 0 ) | | 540 (512) |
| 1984 | 431 | — 2.6 | | | 5.0 | 5.0 ( 0 ) | | 467 (441) |
| 1985 | 530 | — 2.6 | 9.0 | 5.1 (2.0) | 5.0 | 11.5 ( 0 ) | | 744 (601) |
| 1988 | 491 | 1.25 | | 5.1 (4.3) | | | | 524 (519) |
| 1990 | 607 | 1.25 | | 5.1 (4.3) | | | | 648 (641) |
| 1992 | 525 | 1.25 | | | | | | 532 |
| 1995 | 705 | 1.16 | | | | | | 713 |
| 1997 | 681 | 1.25 | | | | | | 689 |

Table 2. Number of years required to detect a significant trend in a population increasing at different annual rates of change with photographic aerial surveys estimates with a coefficient of variation of 14%.

| Annual rate of change | No. yr between surveys | effective % change / interval | No. surveys required | No yr to detection | Total % change at detection |
|---|---|---|---|---|---|
| 3% | 1 | 3 | 15 | 14 | 51 |
| | 2 | 6.1 | 10 | **18** | 70 |
| | 3 | 9.3 | 8 | 21 | 86 |
| 1% | 1 | 1 | 32 | 31 | 36 |
| | 2 | 2 | 20 | **38** | 46 |
| | 3 | 3 | 16 | 45 | 56 |

sampling regimes and different growth rate hypotheses, using Gerrodette (1987) general inequality model:

$$r^2 n^3 \geq 12CV^2 (z_{\alpha/2} + z_{\beta})^2$$

where *r* is the annual growth rate, *n* is the number of surveys, *CV* is the coefficient of variation of estimated population abundance indices, $z_{\alpha/2}$ is the one tailed probability of making Type 1 error and $z_{\beta}$ is the probability of making a Type 2 error. This power analysis indicated that under a sampling regime of one survey every two or three years, it would take 20 years, and not 12 years as previously reported, to detect a 3% annual change. It would take over 40 years, and not 24 years, to detect a 1% annual change (Table 2). This revised estimation of the power of the most recent population abundance indices to detect population growth emphasizes the conclusion reached by the St. Lawrence Beluga Recovery Committee in their 1996-1997 report: "it is scientifically too early and also contrary to the precautionary principle to conclude that the population is growing" (St. Lawrence Beluga Recovery Committee 1998).

## EPILOGUE

Questions of size and trends are critical issues in the evaluation of the status of a population (Campbell 1996, IUCN 1996). The consequences of accepting a false hypothesis in assessing trends in endangered population can be acute (Taylor and Gerrodette 1993). Neither Pippard's (1985) conclusion that the St. Lawrence beluga population was declining in the 1970's nor Kingsley's (1998) conclusion that the population has increased over the last two decades were supported by valid statistical demonstrations. Although it is impossible to verify if either Pippard or Kingsley accepted a false hypothesis, the consequences of their respective conclusions are dramatically different. Pippard's (1985) report on the status of the St. Lawrence beluga opened the door to an impressive scientific investigation (see Béland *et al.* 1993 for a review), the preparation of the first recovery plan for a Canadian marine mammal species (Bailey and Zinger 1995) and the creation of the first Canadian marine protected area, the Saguenay - St. Lawrence Marine Park. On the other hand, Kingsley's (1998) conclusion served as a central argument to suggest a change in the COSEWIC status of the St. Lawrence beluga population, from "Endangered" to "Threatened" (Lesage and Kingsley 1998). It also has been used by the fast growing St. Lawrence Estuary whale watching industry to argue for a relaxation of the voluntary ethic code that has excluded the beluga from the targetted species since 1986 (Gilbert and Parc Marin Saguenay—Saint-Laurent 1998).

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## LITERATURE CITED

BAILEY, R., AND N. ZINGER. 1995. St. Lawrence beluga recovery plan. World Wildlife Fund Canada, Toronto, and Department of Fisheries and Oceans, Mont-Joli. : 73 pp.

BÉLAND, P., S. DEGUISE, C. GIRARD, A. LAGACÉ, D. MARTINEAU, R. MICHAUD, D.C.G. MUIR, R.J. NORSTROM, É. PELLETIER, S. RAY, AND L.R. SHUGART. 1993. Toxic Compounds and Health and Reproductive Effects in St.Lawrence Beluga Whales. Journal of Great Lakes Research 19: 766-775.

BLANE, J.M., AND R. JAAKSON. 1994. The Impact of Ecotourism Boats on the St Lawrence Beluga Whales. Environmental Conservation 21: 267-269.

CAMPBELL, R. 1996. Rare and endangered fish and marine mammals of Canada: COSEWIC fish and marine mammal subcommittee status reports: X. Canadian Field-Naturalist 110: 454-461.

CHADENET, V. 1997. Fréquentation et bilan d'activité du béluga, *Delphinapterus leucas*,du Saint-Laurent dans la baie Sainte-Marguerite. Pages 75 p. Département de biologie. Université Laval, Québec.

ST. LAWRENCE BELUGA RECOVERY COMMITTEE. 1998. Implementation of the St. Lawrence beluga recovery plan: 1997-1997. World Wildlife Fund Canada, Toronto, and Department of Fisheries and Oceans, Mont-Joli. : 102 pp.

GERRODETTE, T. 1987. A power analysis for detecting trends. Ecology 68: 1364-1372.

GILBERT, M.C., AND PARC MARIN SAGUENAY—SAINT-LAURENT. 1998. Compte rendu de l'atelier de travail régional sur les activités d'observation en mer des mammifères marins, 25 et 26 mai 1998. Tadoussac (Québec) : 60 pp. + V annexes.

IUCN (INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE). 1996. 1996 IUCN Red list of threatened animals. IUCN, Gland, Suisse.

KINGSLEY, M.C.S. 1993. Census, trend, and status of the St. Lawrence beluga population in 1992. Canadian Technical Report of Fisheries and Aquatic Sciences 1938: vi + 17 pp. + Appendices.

KINGSLEY, M.C.S. 1996. Population index estimate for the belugas of the St. Lawrence in 1995. Canadian Technical Report of Fisheries and Aquatic Sciences 2117: vi + 42 pp.

KINGSLEY, M.C.S. 1998. Population index estimates for the St. Lawrence belugas, 1973-1995. Marine Mammal Science 14: 508-530.

KINGSLEY, M.C.S., AND M.O. HAMMILL. 1991. Photographic census surveys of the St. Lawrence beluga population, 1988 and 1990. Canadian Technical Report of Fisheries and Aquatic Sciences 1776: 19 pp.

LAURIN, J. 1982. La chasse aux bélugas, *Delphinapterus leucas*, du Saint-Laurent et statut actuel de la population. Carnet de zoologie (Société de zoologie de Québec) 42: 23-27.

LESAGE, V. AND M.C.S. KINGSLEY. 1998. Updated status of the St. Lawrence river population of the beluga, *Delphinapterus leucas.* Canadian Field-Naturalist 112 :98-114

LESAGE, V., C. BARRETTE, M.C.S. KINGSLEY, AND B. SJARE. 1999. The effect of vessel noise on the vocal behavior of belugas in the St. Lawrence river estuary, Canada. Marine Mammal Science 15: 65-84.

MICHAUD, R. 1987. Distribution du béluga, *Delphinapterus leucas*, dans la partie amont de l'estuaire du Saint-Laurent: secteur de l'Ile aux Coudres. Rapport final. INESL, Tadoussac, Québec. Contrat Hydro-Québec, région Montmonrency: 36 p. + Annexes + Cartes.

MICHAUD, R. 1992. Fréquentation de la Baie Sainte Marguerite par le béluga du Saint-Laurent. Rapport Final. INESL, Tadoussac, Qc. Contrat# FP707 1 5171, Pêches et Océans Canada, Québec: 34 p.

MICHAUD, R. 1993. Distribution estivale du béluga du Saint-Laurent; synthèse 1986 à 1992. Rapport Technique Canadien des Sciences Halieutiques et Aquatiques 1906: vi + 28 p.

MICHAUD, R., A. VÉZINA, N. RONDEAU, AND Y. VIGNEAULT. 1990. Annual distribution and preliminary characterization of beluga (*Delphinapterus leucas*) habitats in the St. Lawrence. Canadian Technical Report of Fisheries and Aquatic Sciences 1757E: v + 31 pp.

PATENAUDE, N.J., J.S. QUINN, P. BELAND, M. KINGSLEY, AND B.N. WHITE. 1994. Genetic variation of the St.Lawrence beluga whale population assessed by DNA fingerprinting. Molecular Ecology 3: 375-381.

PIPPARD, L. 1985. Status of the St. Lawrence River population of beluga, *Delphinapterus leucas*. Canadian Field-Naturalist 99: 438-450.

SERGEANT, D.E. 1986. Present status of white whales *Delphinapterus leucas* in the St. Lawrence Estuary. Le Naturaliste Canadien 113: 61-81.

SERGEANT, D.E., AND W. HOEK. 1988. An update of the status of white whales *Delphinapterus leucas* in the Saint Lawrence Estuary, Canada. Biological Conservation 45: 287-302.

TAYLOR, B.L., AND T. GERRODETTE. 1993. The uses of statistical power analysis in conservation biology: the vaquita and the northern spotted owl. Conservation Biology 7: 489-500.

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# Proceeding of the
# National Marine Mammal Review Committee
# Montreal, Quebec

**February 1- 5, 1999**

Dr. Jacques A. Gagné
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Canada

# REPORT OF THE NATIONAL MARINE MAMMAL REVIEW COMMITTEE
# MONTREAL, QUEBEC, FEBRUARY 1-5, 1999

DFO's National Marine Mammal Review Committee (NMMRC) met in Montreal from February 1-5 to address various issues on seals and whales from the Atlantic, Arctic and Pacific oceans. Three international experts joined twenty nine other participants from Canadian federal and provincial governments, the Fisheries Research Conservation Council, the Nunavut Wildlife Management Board, the Makivik Society, the sealing industry and two private research groups (Groupe de Recherche et d'Éducation sur le Milieu Marin and International Marine Mammal Association) to discuss and evaluate research reports and provide specific advice on several topics.

## Trends in the St. Lawrence Beluga Population

Kingsley (1998. Population index estimates for the St . Lawrence belugas, 1973-1995. Mar. Mamm. Sci. 14:508-530) reviewed the results of aerial surveys of beluga in the St Lawrence River made between 1973 and 1995. He corrected these 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 standardized 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.