Status Assessment of the Cook Inlet Belugas:
Chairman's Summary Report

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I. Executive Summary

The status assessment depends mainly on survey and harvest data, which represent the best available science. Harvest data are, however, imprecise. Survey methods have been specially developed and should be more thoroughly presented in the assessment. Estimates of extinction risk would be sensitive to a possible trend in detection rates in surveys and this possibility should be investigated. Data on population structure and on vital rates are not available.

Biological knowledge of belugas is adequately reviewed, both in general and for Cook Inlet. Better review of knowledge and management experience in respect specifically of depleted populations of the species in other jurisdictions would be useful.

A stochastic model, fitted to the past data by Bayesian methods, is used to project the population forward. This is an appropriate analytical method. Given the available data, the model has been built at an appropriate level of complexity and is a good compromise between realism and simplicity. The only age-structuring is a fixed age at which females start to bear calves; otherwise, birth- and death-rates are constant. Births and deaths are modelled as simple independent binomial draws. There are provisions for density dependence, Allee effects, and fixed predation levels. The forward projection and estimation of extinction risk have covered a reasonable spectrum of scenarios.

However, the fit of the model to the data is in some respects questionable. Since 1999, survey estimates decline faster than the fitted population trajectories. The survey estimates since hunting was stopped should be analysed without the earlier data, at least with simple regression analyses if not with a complete population model. The behaviour of the model in fitting to survey data with different levels of variability has not been explored, although this may affect the future variability of population projections and the estimates of extinction risk. The development of prior distributions for modelled vital rates and their connection to the tabulated values from the literature should be better explained, and a better presentation, and explanation, of posterior distributions is necessary. The reporting of model fit and function contains little information on whether posterior distributions are constrained by priors, or what it means if they are. The effect of including age-specific mortality in the model should be investigated.

The analysis methods are in general valid. However, extinction-risk estimates of this kind are based on long-term extrapolations from relatively short data series and assume that vital rates will, for decades or centuries, stay the same as their averages over the recent past. This assumption may not hold; it, and its significance, needs to be clearly stated. The tabulated estimates of extinction risk probably give qualitatively valid comparisons between different scenarios, but are unlikely to be quantitatively exact.

The status review concludes on the basis of present knowledge and recent data that the population faces a significant risk of extinction. This conclusion is supported by the scientific information presented.

II. Terms of Reference

1. Evaluate whether the adequacy, appropriateness, and application of data used in the assessment represents the best available science.

The data used in the assessment comprise survey and harvest data, and represent the best available science. Data on population structure and on population-dynamics parameters such as birth- and death-rates are not available, and are needed; efforts should be made to get such data. Harvest data, which regrettably are imprecise, may be influential in the model fit and the forward projections. Data on numbers have been acquired through specially developed survey methods, which, as this data are crucial, should be more thoroughly presented in the assessment document. Estimates of extinction risk would be sensitive to any possible trend in detection rates in surveys and this possibility should be investigated.

2. Evaluate whether the adequacy, appropriateness, and application of analytical methods and modeling represents the best available science.

A stochastic model, fitted to the best available past data, and used to project the population forward, is an appropriate analytical method with potential for identifying sensitivity of results to different features of the data. The use of Bayesian methods for fitting the model is appropriate and represents good science.

3. Do the biological data, population data, model structure and assumptions, and the analysis methods applied to the extinction risk assessment represent the best available data and methodology for sound science?

The model has a level of complexity appropriate to the available data and has drawn on an appropriate set of past data. The forward projection and estimation of extinction risk have covered a reasonable spectrum of scenarios. The fit of the model to the data, in some respects questionable, has not been adequately investigated. The estimates of numbers collected since hunting was stopped should be analysed without the earlier data, at least with simple regression analyses if not with a complete population model.

4. Does the status review provide an adequate assessment of the current knowledge regarding the biology of belugas in general and the Cook Inlet beluga population in particular? Comment on the strengths and weakness of the status review in regard to this question.

The review of the biological knowledge is adequate for Cook Inlet belugas and for beluga biology in general. Better review of knowledge and management experience in respect specifically of depleted populations of the species in other jurisdictions would be useful. It should be more clearly explained how the tabulated collection of published vital-rate values is connected with and used in the modelling, extinction-risk estimation, and assessment.

5. Do the population models adequately represent the processes within the population? Comment on the strengths and weakness of the models in regard to this question.

The population models are a satisfactory compromise between realism and simplicity. The only age-structuring is a fixed age at which females start to bear calves; otherwise, birth- and death-rate are constant. There exists no age-structure data for this population and no data on vital rates either. The behaviour of the model in fitting to survey data with different levels of variability has not been explored, although this may affect the future variability of population projections and the estimates of extinction risk. The development of prior distributions for modelled vital rates and their connection to the tabulation of published values should be better explained, and a better presentation, and explanation, of posterior distributions is necessary. There is no, or very little, information on whether any posterior distributions are being constrained by priors, or what it means if they are. The effect of including age-specific mortality in the model should be investigated.

6. Are the analysis methods valid and sufficient to estimate the extinction risk? Comment on the strengths and weakness of the analysis methods in regard to this question.

The analysis methods are in general valid. However, the estimates of extinction risk are conditional on an unstated assumption that the state of the population—i.e. environmental conditions and average birth- and death-rates—will remain for decades or centuries the same as for the most recent 23 years. This may not hold. Uncertainty of prediction of this kind is not included in the forward projections and it is difficult to see how it could be. The tabulated estimates of extinction risk probably give qualitatively valid comparisons between different scenarios, for example of predation level, but for longer-term predictions are unlikely to be more than indicative at the quantitative level.

7. Are the conclusions of the status review supported by the scientific information presented?

The status review concludes, by quantitatively extrapolating data from the most recent 23 years on the basis of present knowledge, that the population faces a significant risk of extinction. This conclusion is supported by the scientific information presented.

III. Peer Review Findings

With respect to whether the Cook Inlet population is a ‘Distinct Population Segment’, the panel agreed that the data and analyses represent the best available science and that the conclusions of the assessment, vis a vis that the Cook Inlet population is indeed a DPS, are well supported by the scientific findings.

The part of the assessment that is concerned with the status of this distinct population, and the reviewers’ comments on it, is considered below.

<u>Data. (ToR 1)</u>

The data used in the status assessment were considered to represent the best available science. This population is for both logistic and conservation reasons inaccessible and direct data on population structure, longevity, birth-rates whether age-specific or not, in fact on any life-history parameter, are unavailable. This lack of data hinders scientific status assessment.

The population modelling represents a method of extrapolating the survey and harvest series forward in time. The reliability of its conclusions depends on the quality of the input data from harvests and surveys.

The harvest data are important for two reasons: firstly, when taken together with the trend in survey estimates from 1994 through 1998 the data inform on the underlying population dynamics; and secondly the harvest is expected to have altered population structure, owing to heavy adult harvests, and so to have affected population dynamics even after hunting was closed. The harvest data from 1994 to 1998 used in the assessment include estimates of the annual numbers landed, imprecise estimates of loss rates, information that only adults were taken, and a single-sample estimate of the sex and age structure. All are used in the model, some as guides in defining prior distributions of corresponding parameters. Although the data are highly uncertain they nevertheless represents the best available science, but closer monitoring of the harvest might have helped the current assessment.

The survey data series is crucial to the assessment. It comes from annual total-count aerial surveys, and it consists of total numbers, with corrections applied for unseen animals. Correction factors have been obtained from several sources. The methods have been developed over several years for this particular population, and these represent the best available science. However, the development of the surveys might have been associated with increasing expertise and a trend (upward) in detection rates that might camouflage a population decline. The survey data are important and should be presented as a part of the assessment report, with an exposition of the underlying methods, the derivation of the visibility corrections, and a discussion of the potential for bias due to a trend in detection ability.

Regrettably, the aerial survey data do not at the moment provide usable data on population structure, and it is recommended that effort is put into using the survey records, which include video recordings, to provide information on population structure, particularly a lower bound on birth rate. Information on population structure can show whether unfavourable population dynamics are to be blamed on poor reproductive success or elevated mortality, and without such knowledge it will be difficult to formulate recovery plans.

Other population-dynamic data available to the assessment included counts of beach-cast carcasses and a tabulation of published vital-rate values for this species. Age at first birth was a structural parameter in the model, but other values were used only to set bounds on prior distributions for the Bayesian population modelling. Although the data and their use were considered to represent the best available science, neither the data, nor the use, were well explained and some misunderstanding arose even among the review panel. The text discussion of the tabulated collection of parameter values should be expanded, with an analysis of their mutual consistency, and a clear presentation of the model’s key input parameters and associated data.

The panel also considered that the mapping of the progressive reduction of the area in Cook Inlet used by the belugas was significant and informative and could be included more prominently in the status review.

Modelling and Analysis (ToR 2 & 3)

The future evolution of the population, including the risk of extinction, was estimated quantitatively with a stochastic age- and sex-structured model of the dynamics of a generic beluga population. There was one age-class for each sub-adult year, and one for all adults. The population dynamics were driven chiefly by 3 parameters: female age at first birth; birth-rate of adult females; and death-rate (modelled as uniform). Stochastic behaviour in the model chiefly came from applying birth- and death-rates as binomial trials, respectively to the adult females and to the whole population. Age at first birth was entered as a structural constant, but birth- and death-rates were stochastically estimated by fitting to the past harvest and survey data. The modelling of the harvest included parameters for loss rate and sex ratio, which were also estimated by fitting to the data. The model was fitted by Bayesian methods. The population was projected forward using the same stochastic processes, with birth- and death-rate parameters assumed constant at their estimated values.

The model could also provide for density-dependent reduction in net growth rate—carrying capacity being set as a fixed value—Allee effects at low numbers, predation as a constant number of animals taken yearly, and stochastic catastrophic mortality events.

The model represented the population dynamic processes in a beluga population with a degree of fidelity appropriate to the paucity of data, and is considered to be best available science. A stochastic model, fitted by Bayesian methods, was considered appropriate. Its predictions that the population was at risk of extinction were incontrovertible. Nonetheless the assessment report too simply presented the quantitative results of the model runs, and further analyses, as well as more thorough presentation of the model's characteristics, would be appropriate. The fit of the model to the data was questionable, and in particular the modelled population trajectories did not match the steepness of the downward trend in survey numbers from 1999 to 2006. The survey data since 1999 should be analysed separately.

Another, differently structured model, using a more flexible modelling of Allee effects, that took the stochastic estimates of population growth rate generated by the first model's fit to the data and used them to project the population forward in time produced similar results. It also found that the population was at risk of extinction.

Review of Knowledge (ToR 4)

The review of current knowledge of Cook Inlet belugas represented the best available science, and the tabulation of published values of life history parameters was thorough. However, the connection between the table of published values and the inputs to the population modelling was not clear.

The survey series should be presented as an integral part of the assessment document, with a review of its methods, in more detail.

The descriptions and maps of the contracting range of the population are so compelling as evidence of population decline that they should be included in the assessment report.

Other jurisdictions, notably Canada, also have depleted populations of belugas that they are trying to recover. Some reference to those might be appropriate; data on population structure relevant to the Cook Inlet assessment might be available from studies of those populations.

Model Representation (ToR 5)

Overall, the fitted model is a good compromise between simplicity and realism. The level of age-structuring is minimal, and birth- and death-rates are modelled as independent binomial draws.

Variability in population dynamics might affect extinction risk. The modelling of births and deaths as simple binomial processes apparently resulted in posterior distributions for the governing birth- and death-rate parameters that were weighted toward low values of both, producing population dynamics with low turnover and, therefore, low variability. This could have been due the lack of age-specific survival; or alternatively low-variability population dynamics might fit best to the survey series, which has very low scatter about its trend. (The latter possibility is supported by some simple analyses.) Better understanding of the behaviour of this model formulation in fitting to data series with different levels of variability would help resolve this issue.

Extinction Risk (ToR 6)

To the extent that extinction risk *can* be satisfactorily estimated by extrapolating the recent past over long time horizons, the status assessment is satisfactory. However, the key assumption, that environmental conditions will remain unchanged in the future, which is modelled as an assumption that birth- and death-rates will continue for decades or centuries to have the values estimated from the past 23 years' data, limits the validity of forward predictions and estimates of extinction risk. Uncertainty of knowledge and uncertainty of realisation are included, but uncertainty of prediction is not. This key assumption, and its significance, ought to be clearly stated. The modelling approach is useful for comparing levels of risk under different future scenarios, but the tabulated probabilities of extinction should be regarded as only indicative, and very much so at longer time horizons. Emphasis should mainly be placed on the shorter-term forecasts.

Conclusions (ToR 7)

The assessment concludes that the recent trajectory of the Cook Inlet population does not conform to that expected for a depleted, but otherwise healthy, beluga population, which would be expected to grow at 2–8% a year. On the contrary, the assessment concludes that the population is unlikely to be growing at all and is facing a significant risk of extinction. The review panel concurs with these conclusions. However, the tabulated risks of extinction, although they probably make valid qualitative comparisons between different scenarios, should not be seen as valid, at the quantitative level, for the longer time horizons.

IV. Further Analyses and Evaluations

The construction of trial values for the population-dynamics parameters was not clear, perhaps partly because the procedure is somewhat involved: a value for the population growth rate is drawn from a prior distribution, then a value for the death rate is drawn from a prior that is conditional on the growth rate. Birth-rate is then estimated from growth rate and death rate through the Lotka equation, and the birth-rate and death-rate that are then used as key parameters in the modelling. The relationship between this process and the presented tabulation of published values of population-dynamics parameters was obscure. An additional table should be included to present the key input parameters and the data used in generating their priors, with figures showing posterior distributions.

The fit of the model to the data caused concern. The overall fit between population trajectories and survey data should be investigated. The fitted population trajectories appear to decline faster than the survey series between 1994 and 1999, but more slowly since 1999: the rate of change in the survey series since the hunt was closed (a decrease of about 4% a year) is barely within the posterior distribution of the population rate of change from the Bayesian fit of the complete model. The harvest data may be having too much influence, given the uncertainties associated with it. An additional analysis based only on the survey series from 1999 through 2006 should be carried out and its results presented.

It was not clear that alteration of the population age structure by the heavy harvests in 1994–1998 would have been properly allowed for in modelling population dynamics after 1998. Including in the assessment a graphic showing changes in simple age-structure statistics with time could allay this concern.

The sensitivity of the model to including some simple form of age-specific variation in death rate should be explored. Possibilities include a simple Siler-type exponential function or making juvenile mortality a multiple of adult mortality.

IV. Additional Comments

There were no additional comments. The review panel thanks Rod Hobbs, Kim Shelden, and Paul Wade for their hospitality during the review, and for their helpfulness in making presentations of data and methods and in getting background documents.

V. Recommendations

Present the survey data as a part of the assessment report, with an exposition of underlying methods, the derivation of the visibility corrections, and a discussion of the potential for bias due to trend in detection ability;

Use the survey records, which include video records, to provide information on population structure, particularly a lower bound on birth rate;

Discuss the tabulated collection of published vital-rate values; analyse their mutual consistency; and present the model's key input parameters and associated data;

Include the progressive reduction of the area in Cook Inlet used by the belugas in the status review;

Analyse separately the survey data since 1999;

Refer to recovery of depleted beluga populations in other jurisdictions, and enquire after availability of population structure data from studies on them;

Investigate the influence of variability in data series on the estimation of turnover rates in population models;

State clearly the assumption that environmental conditions will remain unchanged over the projection horizon.

VI. Reviewer Statements

The present report gives a fair summary of four independent reviewer reports, separately submitted to CIE, based on document review, presentations and panel discussions.