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Approaches To Find Iceberg Collision Risks for Fixed Offshore Platforms

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ABSTRACT

This study concentrates on simple concepts for the mathematical modelling of the probability of an iceberg hitting a fixed offshore structure in regions like the Northern Barents Sea. It illustrates the sensitivity of the estimate to various physical assumptions. The study indicates that iceberg collision risks for fixed offshore structures are significant. The paper gives concepts for the description and estimation of iceberg production and the spatial distribution of iceberg trajectories.

PETROLEUM ACTIVITIES IN ARCTIC WATERS

There is virtually no experience with the use of fixed platforms in Arctic waters at depths allowing large icebergs to float freely without grounding. For large icebergs this may require water depths of 100 m or more. High estimates of iceberg collision likelihoods will determine the layout and costs of such platforms. That may well be the case in the Northern Barents Sea region. This paper discusses how to estimate the probability of an iceberg collision with a fixed platform in this region. The paper indicates that collisions with large icebergs in this region almost certainly will occur during the platform's life.

The perspectives for collision risk assessment are different for government agencies, oil or insurance companies. A trivial example is that an agency usually not explicitly includes in its analyses the most unfavourable, low-probability events that may lead to bankruptcy — the game-over-event. A mandatory disaster insurance coverage will, however, impose a wider perspective.

Low estimates of risks may have, for example, the favourable consequence that the insurance premiums will be low. Therefore collision risk estimates should be as objective, standardised and general as possible. Objective and standardised general approaches may also promote efficient reporting for operator's management. The purpose of this paper is to clarify certain key concepts and show that it is possible to make reasonably accurate and consistent estimates of iceberg collision risks. The paper gives some simplified and illustrative case studies. It also indicates some ideas for relevant data collection, which of course must be based on insight into the physics of the problem.

The main purpose of this paper is to show how far we can get by simple physical assumptions. The foundation of the methods is entirely academic, involving spatial statistics, random sets, and fractal geometry as developed by Matheron (1975), Mandelbrot (1983) and others. These ideas were applied in the present context in a doctoral thesis at the Norwegian Institute of Technology by Korsnes (1991). We may regard iceberg paths as random sets within the theory of Matheron (1975), who provides theoretical foundations for quantitative techniques and modelling. We want to stress the usefulness of the pure mathematical origin of this work, though it may be given a pure applied point of view. Nothing is more practical than good theory.

This paper is based on a quantitative statistical description of:

- Iceberg production
- Large-scale model of iceberg paths
- Small-scale model of iceberg paths

STATISTICAL DESCRIPTION OF ICEBERG PRODUCTION

A collection of icebergs is often described by its number-size distribution:

$$N(s) = \text{number of icebergs larger than } s \qquad (1)$$

where s represents iceberg size defined, for example, as iceberg volume or diameter. There are indications that certain general laws exist concerning the shape of the number-size curves for long-term production of icebergs. The following simple relationship may be suggested:

$$N(s) \cong c \cdot s^{-D} \qquad (2)$$

Roughly speaking this means that the relative frequency of small and large bergs is retained regardless of what is considered a large berg. In other words there will always be 2^D times as many icebergs when the size is halved, regardless of where one starts. Nature often exhibits such self-similarity or scale invariance. Examples are size of meteors, craters on the moon, natural lakes and islands (Mandelbrot, 1983).

Fig. 1 shows an example of an iceberg's population (given in red by image processing) close to its site of production. The image is a subscene of a Landsat TM image channel 4 (optical) covering 30 km times 30 km southeast of Zemlja Vil'čeka, Franz Josef Land, September 6, 1992. Fig. 2 shows the estimate of the number volume relation for this iceberg population. Field verification (Vinje et al., 1992) shows that most of these icebergs have horizontal surface and are calved by floating ice sheets (tabular icebergs) with a characteristic freeboard h of about 14 m. The climate at the production site seems to control this characteristic

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