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Stability of Icebergs and Period of Natural Oscillations in the Barents, Kara, and Laptev Seas

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The paper presents calculations of icebergs' stability criteria (metacentric height) based on iceberg towing experiments conducted in 2016–2017 in the Barents and Kara Seas. To ensure safety of marine operations during ice management in Arctic seas, it is essential to understand an iceberg's stability. Stable icebergs can be towed away from offshore facilities using standard vessels and procedures. Unstable icebergs create high risks and can easily capsize during the vessel's maneuvering and towing. As is known, an iceberg capsize event could lead to iceberg destruction into several pieces that can also damage offshore units. Especially dangerous are large icebergs that may capsize and damage the towing vessel.

NOMENCLATURE

b	Iceberg width (m)
b_{critical}	Critical width of an iceberg (m)
d	Average iceberg's draft (for tabular icebergs) (m)
$d_{\max}$	Maximum iceberg's draft (m)
g	Gravity acceleration (m/s^2)
h	Average iceberg's height (m)
$h_{\max}$	Maximum iceberg's height (m)
H_{met}	Metacentric height of an iceberg (m)
$J_{\max}$	Maximum iceberg's areal moment of inertia of the section at the waterline (m^4)
J_{OX}, J_{OY}	Iceberg's areal moment of inertia of the section relative to OX and OY at the waterline (m^4)
$J_{\text{waterline}}$ ($J_{\min}$)	Minimum iceberg's areal moment of inertia of the section at the waterline (m^4)
k	Coefficient of an iceberg's cross section reduction as a result of destruction
l	Iceberg length (m)
M	Iceberg's mass (thousands of tons)
M_a	Added mass (thousands of tons)
R_{met}	Metacentric radius of an iceberg (m)
$S_{\text{waterline}}$	Cross section of an iceberg at the waterline (m^2)
$S_{\text{waterline\_critical}}$	Critical cross section of an iceberg at the waterline (m^2)
T	Period of self-induced oscillations in a vertical plane (s)
$V_{\text{sub\_iceberg}}$	Volume of underwater part of an iceberg (m^3)
$V_{\text{total\_iceberg}}$	Total volume of an iceberg (m^3)
$V_{\text{up\_iceberg}}$	Volume of above-water part of an iceberg (m^3)
Z_{iceberg}	Vertical coordinate of the entire iceberg center of mass (from sea level) (m)
$Z_{\text{sub\_iceberg}}$	Vertical coordinate of the center of mass of the underwater part of an iceberg (from sea level) (m)
$Z_{\text{up\_iceberg}}$	Vertical coordinate of the center of mass of the above-water part of an iceberg (from sea level) (m)
ρ_i	Ice density (kg/m^3)
ρ_w	Seawater density (kg/m^3)

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KEY WORDS: Iceberg, towing, Arctic, Kara, Barents, ice, stability.