Chapter 7
Conclusions

The climate system is very complex and its mechanism is still not fully understood, however, observed and projected climate changes indicate that changes in met-ocean conditions can be expected. This will impact on ship and offshore structural design.

The results presented by IPCC (2007), 2012 are strongly dependent on an adopted scenario for emissions and concentration of CO_2 and are affected by various types of uncertainties which need further investigation.

This review has identified that there is an agreed increase in significant wave height from the middle of the twentieth century to the early twenty first century in the northern hemisphere winter in high latitudes in the north Atlantic and the north Pacific. There has been a decrease in more southerly latitudes of the northern hemisphere. The increase of the 99-percentile significant wave height has been observed to be up to 0.5 % per year (Young et al. 2011). However, if the record is extended back to late nineteenth century the picture changes, as studies show that storminess and wave heights in late nineteenth/early twentieth century were about the same as near the end of the twentieth century. Thus, it is unclear if the increase observed during the last 4–5 decades is caused by anthropogenic climate change or just manifestation of long-term natural variability.

The review has also identified that the future is likely to bring regional increases in the wind speeds and wave heights, more pronounced for the extremes than for the means. The increases of the 20-year return period of SWH or the highest storms in 20–30 years intervals are generally in the range 0.5–1.0 m in the North and Norwegian Seas, immediately west of the British Isles, off the northwest of Africa, around 30°N from the east coast of the United states to 50°W and in the Pacific between 25°N and 40°N and from the west coast of the United States to 170°W. However, increases up 18 % for the 99th percentile SHW have been reported for the southern North Sea by Grabemann and Weisse (2008). There are indications that the increase in extreme wave heights may reach more than 10 % above present day extremes in some areas. The projections are influenced by choice of climate model, emission scenario and downscaling method for waves. The uncertainty of the estimated increases is of the same order as the estimates.

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Although the uncertainties in future projections of extreme wind speed and wave heights are less known than for surface temperature and precipitation they should not be ignored when impacts of climate change on design and operation of ship and offshore structures are considered.

In light of the findings summed up above the potential impacts of climate change on the tanker design has been investigated. The study indicates that observed and projected changes in wave climate will have large effects on tanker design practice. The presented examples show that in order to maintain the safety level the steel weight of the deck for net scantlings should be increased by 5–8 % if the extreme SWH increases by 1 m.

This calls for investigations of the necessary increase in partial safety factor(s) and/or revised specification of the characteristic wave bending.

An approach combining continuously new information about climate change and extreme weather events and relevant uncertainties in current design practice of ship and offshore structures is proposed. To be able to design for climate change statistical extreme value analysis, as currently used in the met-ocean community, has to be upgraded to take into account for the non-stationary character of current climate. This needs to include both anthropogenic climate change trends and natural variability cycles.

In the case of climate change leading to more extreme weather, rules for tankers would need revisions in order to maintain the structural reliability level. This could be done either by revising the IACS formula for the characteristic wave bending moment or by increasing the partial safety factor for the wave bending moment. Alternatively, one could consider introducing direct calculation of the characteristic wave bending moment and apply the environmental model corresponding to the climate change in this calculation. This has not been done in the present study.

Further studies are called for to describe and quantify potential implications of climate change on safe design and operations of ship and offshore structures as well as related economic consequences before firm conclusions are reached regarding possible updates of Classification Societies Rules and Offshore Standards.

The industry should continue to develop decision support systems which need to be associated with proper warning criteria to extreme weather events. However, for some phenomena, e.g. rogue waves, there is still a need for a better understanding of the actual phenomena, particularly met-ocean conditions when rogue waves occurred.

References

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