Wave-induced mixing within a gravity-driven surface current

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An increasing awareness of environmental issues, coupled with a number of recent events, has focused considerable attention on the likely consequences of a large oil spill. If the impact of these accidental releases is to be minimises, the risk assessment and contingency planning must be based upon a sound understanding of the dispersion process. This is required to determine both the lateral spreading of the oil slick and the vertical mixing within the water column. Although a number of oil slick propagation models are available there are no existing solutions that adequately take into account the additional mixing associated with the wave climate. Indeed, it is widely believed that this uncertainty was responsible for the inability of the models applied to the Braer spillage (1993) to predict the extent of the oil contamination.

This thesis summarises work undertaken within the Department of Civil and Environmental Engineering at Imperial College. A new experimental facility has been developed to allow the formation of a surface gravity-driven current within a wave flume. This facility allows regular waves to be generated and superimposed onto the surface current. Concentration and velocity profiles are measured in the presence, and the absence of waves using instrumentation developed especially for this research project. In addition, photographic evidence of the wave-induced mixing wave recorded. The results of this experimental work have clearly shown that waves significantly increase the vertical mixing within the surface gravity-driven current. A physical explanation for this has been provided. By incorporating this understanding into an existing Gaussian patch model, it is possible to indicate likely changes in the lateral and vertical spreading of a hypothetical oil spill subject to significant wave action. Comparison between these results and the wave-induced far-field effects recently identified by Buick and Durrani (1998) allows the significance of the present results to be assessed.

To summarise, the experimental, theoretical and numerical work has enabled a better understanding of the addition near-surface mixing due to the wave climate, and has highlighted areas of further work in this complex mixing region. By incorporating this understanding into an existing oil spill model, an engineer will be able to predict spreading rate and therefore the impact of oils spills more accurately. This will allow resources and response strategy to be maximised so as to reduce the environmental impact.