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Estimating Design Currents During Joint Eddy-TRWs and Joint Eddy-Hurricanes

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Abstract

While the Industry has been aware of TRWs (Topographic Rossby Waves) for several years, they have been assumed to occur solely on their own. Recent observations summarized in this paper suggest that in fact a warm-core eddy or associated features often affects a site at the same time as a strong TRW. It remains uncertain whether this is a cause-and-effect or a random occurrence. When the profile from an eddy and a TRW are combined, the result is an onerous case for riser design in an important new production region of the Gulf. While there is insufficient data to support a published design profile, our paper does offer some thought-provoking evidence that TRWs and eddies should be considered to occur jointly.

As for the joint eddy-hurricane event, the Industry has typically treated it by either arguing that the event was too rare to be considered or by linearly superimposing the eddy-only and hurricane-only currents from moderate events. As the Industry has moved into the ultra-deep waters of the Gulf where eddies are more persistent, our analysis suggests joint events occur every few years. In addition, recent research shows there is a strong nonlinear enhancement of the subsurface currents during the joint event. Both these factors mean that the previous approaches to estimating the eddy-hurricane event can be unconservative. We suggest a method for calculating the joint event and show that at a site in the deepwater west-central Gulf, the joint eddy-hurricane condition is quite strong.

Introduction

There are three known processes that can generate strong currents in the deepwater Gulf: hurricanes, the Loop and associated eddies¹, and TRWs (Topographic Rossby Waves). Metocean design criteria have typically neglected joint events though some like (1) have accounted for the joint eddy-hurricane.

The probability of a joint event will generally depend on the frequency of occurrence of the contributing processes, the expected durations, and whether one process can trigger the other.

The frequency of occurrence is affected by the spatial range of the individual process and this differs considerably among the three processes. Hurricanes are fairly uniformly distributed in the oil-producing regions of the U.S. Gulf and affect a site roughly every 5 years, (2). Eddies affect a site about once a year and are concentrated in two regions as depicted in Fig. 1. TRWs are found within only a few km of the Sigsbee Escarpment² shown in Fig. 1. A site can see several strong TRWs within the span of a few weeks every year, (3).

Another important factor affecting the frequency of a joint event is the duration of the process. Hurricanes generate strong currents for a few hours per year while strong TRWs affect a site for perhaps 1-2 weeks per year. Eddies are the most persistent, affecting sites for weeks per year. The cyclones and meanders that form along the front of warm-core eddies typically affect a site for roughly a week but new ones are frequently regenerated.

Finally there is the issue of cause-and-effect (dependence) between the processes. As will be shown later, there is some evidence that strong TRWs may be caused by local warm-core eddies or associated meanders or cold-core frontal eddies. In contrast there is no evidence that an eddy can generate a hurricane (though it might affect the hurricanes intensity, see (4)) or that a hurricane could suddenly create an eddy at a site.

¹The term “eddies” is used in this paper as a generic term which includes warm-core eddies and the Loop. From an engineering standpoint, these features are basically the same.

² While the Sigsbee Escarpment occupies a small portion of the Gulf there are many new and important production sites found there, e.g. Chevron’s Jack-St. Malo and Bigfoot, BP’s Atlantis, and Shell’s Stones.