IMPROVING ENVIRONMENTAL IMPACT ASSESSMENTS USING LOCALISED FAUNA DATA

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ABSTRACT

The Environmental Risk Management Capability – Sonar (ERMC(S)) is the first operational software package that provides a comprehensive risk assessment of the potential impact of sonar usage on marine fauna. The estimates of fauna density used by the ERMC(S) software are derived from a global model of density as a function of habitat suitability. Whilst this approach provides a good basis for prediction of fauna densities, the accuracy of the model can be substantially improved by the inclusion of additional data collected in real-time at the location of the operation. Platforms often carry trained observers and/or acoustic detection equipment that can provide real-time observations of marine fauna. However, incorporating these observations into density predictions with statistical validity is not straightforward.

This paper will discuss possible techniques that could be employed to incorporate such real-time information to accurately predict the location of marine fauna within the surroundings both prior to and during an operation. Additionally, this paper will discuss how this data can be used to refine the ERMC(S) risk assessment and to evaluate whether such an approach would provide a more flexible, reliable and case-specific product.

INTRODUCTION

The effect of noise pollution on whales, dolphins and porpoises and other marine fauna is a topic of growing interest both scientifically and politically with an increasing number of concerned parties including the general public, news media and key decision makers. This interest has direct implications on how the use of sound in the marine environment is managed and is the subject of considerable discussion at both national and international levels.

The Environmental Risk Management Capability – (Sonar) ERMC(S) software tool has been developed by BAE Systems in collaboration with the Sea Mammal Research Unit (SMRU) and the Centre for Research into Ecological and Environmental Modelling (CREEM) at the University of St Andrews.

ERMC(S) can be used to inform decisions on the use of active sonars in the planning and operational stages of an activity. An example of the ERMC(S) HCI is shown in Figure 1. The application provides a robust, repeatable and transparent method to assess the potential environmental impact of sonar activity on both human divers and marine fauna. To assist in the management of this impact, ERMC(S) provides the user with advice on potential mitigation measures and supports a basis from which the user can continue to use active sonar, whilst complying with its policy and legislative obligations to protect the environment.

Whilst ERMC(S) has been developed to model the potential risk to marine fauna by active sonars, the product can be easily adapted to model the effect of other sources of noise pollution such as seismic surveys for hydrocarbon prospecting, shipping, offshore wind farms, pile driving and scientific research.

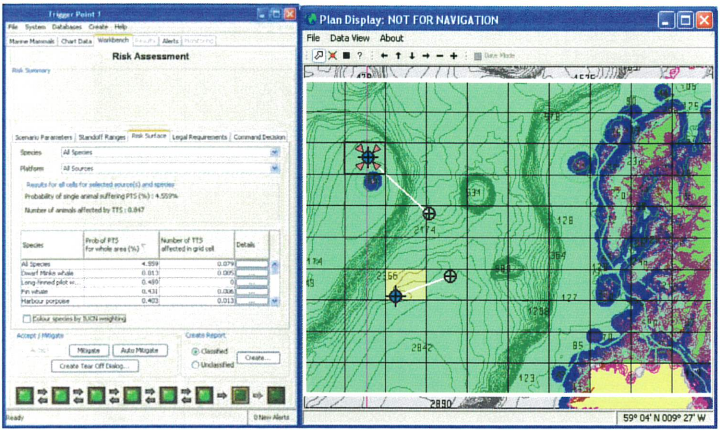

Figure 1 - ERMC(S) provides an automated solution for assessing the potential impact of underwater noise on marine fauna, allowing environmental risks to be quickly assessed and mitigated on-shore, or at sea, as the scenario changes.

MARINE MAMMAL DENSITY ESTIMATES

The existing approach to marine mammal density estimation within ERMC(S) uses a historical dataset that has been pre-processed using both historical and observed data to predict the number of animals in a given area. This dataset has been generated by the use of Relative Environmental Suitability (RES) functions to predict the worldwide distribution of all marine mammal species based on their preference for water depth, sea surface temperature and distance from the coast or ice edge [1].

Although this approach provides valuable information on the expected numbers of marine fauna within an area, it does however come with limitations. Due to the fact that the data was generated with historical environmental data, any localised environmental variations and the occurrence of environmental anomalies such as El Nino and La Nina events will not be taken into account. Such variability could severely affect the numbers of animals predicted to be present in the area and could result in either a positive or negative impact on the calculation of risk. To ensure that these fluctuations do not impact on the validity of the risk assessment, a more precautionary approach must be adopted to account for these unknowns. In fact, within ERMC(S), real-time observed environmental data is always used in preference to historical records for the accurate prediction of expected sound propagation through the encompassing water space.

Another limitation with the current approach to fauna density prediction is the resolution of the data. Currently the data is provided as a grid of 0.5° x 0.5° cells; whilst this is a useful resolution for assessing the distribution of fauna over a large area (too high a resolution will result in an increased waiting time when querying the dataset due to the large numbers involved), it does not provide enough resolution when assessing the distribution of fauna in a concentrated area such as that close to the sonar where the potential risk would be assumed to be higher. This approach will also limit the expected variability around areas of increased environmental change (for example, near a shelf break) as the animals will effectively be 'spread out' over the cells rather than concentrated in hotspots within cells.

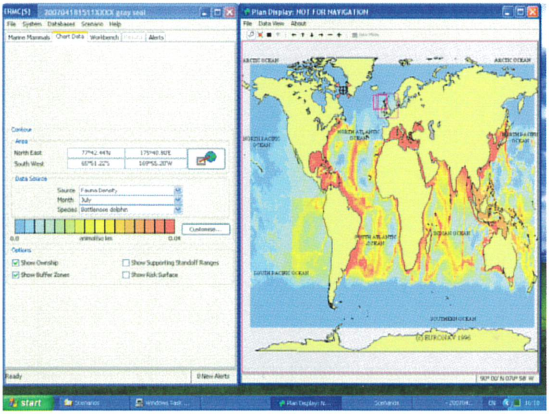

Figure 2 - The ERMC(S) database holds seasonal marine mammal density data at 1/2 degree resolution on a global scale

In addition to the above, the model also assumes an even distribution on fauna over the areas of habitat preference, so if the temperature, water depth and proximity to shore/ice edge correlates with the preferences of a certain species, it is expected that the species will be present in a ratio proportional to the size of the area and the total number of animals within the species (using known observations to weight data where possible). Although this is a good approximation and is satisfactory for the approach currently being undertaken, comparisons of the dataset against dedicated survey estimates of distribution in selected areas, where such estimates are available, have shown some discrepancies and a more precautionary approach has been adopted on the use of the results as a consequence. Also, as is typical in such analyses, uncertainty about the habitat preferences can vary widely between species due to disparity in the levels of knowledge on each genus.

Although we have discussed the potential pitfalls of historical fauna densities, it is essential to highlight the importance of this data when calculating the potential risk as this provides a baseline global dataset (albeit in some cases crude) from which an assessment can be made. As long as we 'know the unknowns' we can ensure that advice can be given which although errs on the side of caution, inevitably provides the user with a much clearer view of the potential impact and mitigation of their operations.

OBSERVED MARINE MAMMAL DATA

To attempt to mitigate the aforementioned problems associated with historical fauna densities, marine mammal observation data can be used to both validate and enhance the historical fauna datasets and provide real-time updating of estimates within the ERMC(S) system. Existing techniques which can be adopted for collecting marine mammal observations include (but are not limited to):

- Passive Acoustic Surveying
- Visual Surveying

For visual surveying, the techniques can vary from human observers to imaging solutions with built-in recognition algorithms and statistical analysis. Although a fully-automated system whereby a survey is undertaken and estimates of densities are produced automatically would be desirable, it is appreciated that a hybrid solution is the most achievable as the human element of the system can account for the expected uncertainties in characteristics in marine fauna. In this paper, we will examine further how aerial surveys of marine fauna can be integrated within the ERMC(S) system to improve its performance.

For all systems the accuracy of the identification of the observed marine mammal is crucial. Identification uncertainty varies greatly with the system adopted and the conditions in which the observation is made.

Another crucial aspect of observation data centers on the fact that nor all fauna in the vicinity are certain to be detected - if I haven't seen it – does that mean that it doesn't exist? It is unrealistic to expect an observation system (however sophisticated) to locate and accurately identify every marine mammal within the vicinity of the noise source – so the question of how we can use the information we do know to make inferences about that which we don't is central to reliable use of observation data.

Both the probability of detection and identification issues raise the important question of the utility of observed data compared to historical data. Hopefully, the next section will go someway to answer this.

AERIAL SURVEYS OF MARINE FAUNA

One method of visual survey is through aerial surveillance using either manned or unmanned aircraft with visual monitoring systems capable of detecting marine fauna under the surface of the water. Because marine mammals spend substantial time underwater the ability to detect them underwater provides substantially enhanced capability over visual counting by humans. Aerial surveying for marine mammal activity is an widely-used and accepted methodology for estimating animal density in a given area [2].

In addition to the obvious advantages of being able to detect and recognise marine fauna both above and below the surface, aerial surveys can be undertaken at a distance which ensures that the marine fauna they are tracking are not disturbed. This not only guarantees that species are not put at risk during this survey but also ensures that species' behavioural characteristics are not modified by the presence of the observer platform.

During an aerial survey, airborne imaging sensors such as electro-optic cameras and hyper spectral imaging systems are used to both detect and help identify marine fauna. The combination of these systems allows for detection and tracking range of up to 10 miles [3] (electro-optic cameras) and up to 20 metres [3] through the water column (hyper spectral imaging) at any time of day. This system provides obvious advantages over human observers as it is not reliant on the marine fauna surfacing in order to be recognised by visual observers. When surfacing, only a small part of the marine mammal may be visible which can make identification difficult; the hyper spectral imaging overcomes this as the full length of the marine mammal can be viewed.

The information collected by the airborne imaging sensors includes the fauna images, times and locations at which they were detected and tracked as well as data on search location (not seeing animals is also informative!). This information could easily be made available for use within ERMC(S) via cell or satellite phone data links. ERMC(S) would then be able to use this information to update the local marine mammal density estimates either on a temporary or permanent basis. The tracking of the marine fauna could also allow for the collection of information on the fauna's behavioural changes due to noise pollution and thus potentially allow for the update and validation of the fauna encyclopedic data held within the ERMC(S) system.

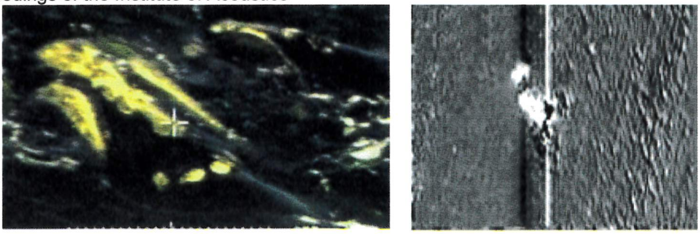

Figure 3 - Example of whale detections using an electro optic sensor (Left) and a hyper spectral sensor (Right). Taken from [3].

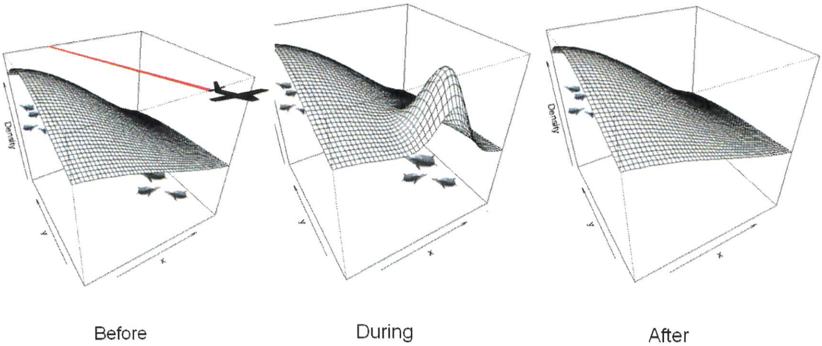

Figure 4 - Example of an ERMC(S) species density surface being temporarily modified following inputs from an aerial survey. "Before" represents the historical density surface within ERMC(S); "During" represents the surface updated in the light of detections of animals from the aircraft; "After" represents a return to the historical surface after sufficient time for the animals detected by the aircraft to disperse.

REFINING THE PRODUCT

As mentioned previously, information from the aerial surveys could be used to both validate and enhance the ERMC(S) fauna density datasets ensuring that the data within the system is up-to-date and accurate. This in turn will allow users to adopt a less precautionary approach to risk assessment and will therefore broaden the scope of their operational boundaries.

In addition to the update of the existing datasets, there is the potential for the use of the survey results in the real-time assessment of risk. The Statistical Algorithms For Estimating the Effect of Sonar Influence on Marine Megafauna (SAFESIMM) component of the ERMC(S) system calculates the potential impact on marine fauna of noise pollution. One element of these formulae is the assignment of marine fauna to starting locations with respect to their densities to ensure that a weighting is provided to those areas where marine fauna are highly concentrated. Using observed fauna data, this method can be further enhanced to put a greater emphasis on those areas where marine fauna have actually been observed by assigning a proportion of the population to these observed locations (this idea is illustrated in Figure 5).

A future development for the ERMC(S) system could be to combine the existing (and future) observation technologies into an integrated and networked capability which not only aids in the identification of marine fauna through both acoustic technologies and observation toolsets but allows these results to be fed directly into the risk calculations and the update of the existing data. Not only will this integration enhance the accuracy of the risk assessment but will also provide an improved set of predicted fauna densities which can be validated for future use.

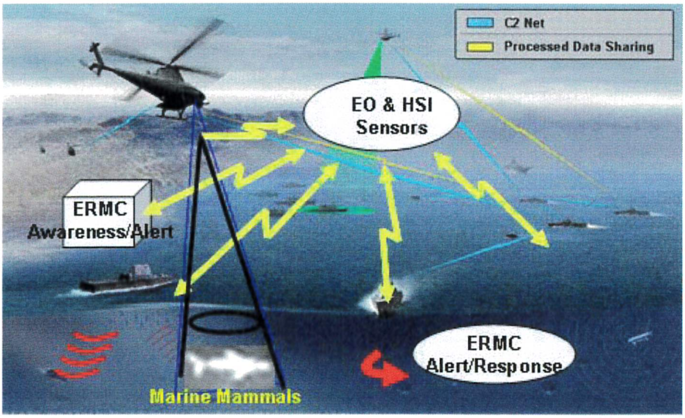

Figure 5 - Conceptual illustration of the ERMC(S) system being supplied with marine mammal observation data and supplying updated mitigation advice in real time.

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