Center for Independent Experts (CIE) Independent Peer Review Report of the Underwater Calculator (UWC) version 2.0

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Executive Summary

The **Underwater Calculator (UWC) version 2.0** is a useful tool for mitigation. Its principal goal is to accurately characterize the shock wave and its propagation from explosive removal of offshore structures (EROS) in order to predict the range to incidence of pre-determined risk criteria; i.e., to calculate the distance from source at which a given probable impact would be encountered by a submerged animal. The criteria for critical impacts are preset in accordance with NOAA/NMFS guidelines and therefore are an independent input variable in the representational value and performance assessment of the UWC2.

The scientific materials employed in the formulation and implementation of the **UWC2** are sufficient and representative of the state of knowledge for modeling underwater explosion effects. The major input variables of the UWC that are user controlled are charge weight, body mass of the species of concern, criteria for the zone of impact (e.g., dB values for energy flux density and psi), and structure type for the explosive placement. Both forward and backward projections are possible. The outputs of the UWC in both simulations provide the range at which the preset criteria are met or exceeded.

UWC2 is an outgrowth of simpler model that depended upon published data for open water blasts (Swisdak) and calculations based on near-field data coupled with the open water derived decay rates (Connor). All model data presume TNT derivative explosive charges.

UWC2 added to this composite empirical data from a Technical Assessment and Research (TAR) EROS project to assess peak pressure, impulse and energy flux density (EFD) for a number of pile configurations.

Strengths:

The main strength of the UWC2 is the flexibility of its inputs. UWC2 has incorporated user determined inputs for key variables affecting susceptibility to risk, including body mass, charge weight, and alternative scenarios. It also provides assessments for multiple shot scenarios.

Weaknesses:

Of greatest technical concern is the accuracy of the attenuation rates across the breadth of charge rates. In some cases, direct measures are known to be better predicted by the first version, UWC1, than UWC2. The relative strengths and weaknesses of each version need to be clarified so that reliable limits can be placed upon the applicability for each calculator.

At present, core outputs for UWC2 are focused on preset criteria of peak pressure distributions and energy flux density (EFD) corresponding to existing guidelines. While these guidelines are of value, they do not fully represent the parameters that are significant for a number of risks associated with explosive hazards, based on the available literature on blast impacts.

The model could gain value by incorporation of knowledge about broader demonstrated parameters related to mortality, injury, and hearing loss that go beyond the criteria that were tasked by the funders. While the current model, particularly in the backward calculation mode, displays distances for level B pressure and EFD, the value of the UWC2 would be greatly

enhanced through providing an option for user specified outputs, even if the options must be limited for the sake of practicality.

A second limitation is that the single input related to species is body mass. While this is a significant element for susceptibility to blast impacts, it also is insufficient to address other significant variations across species, particularly between reptiles and mammals. Therefore, anatomical features that relate to differences in potential severity of impacts between sea turtles and cetaceans are not addressed. Similarly, the UWC2 does not incorporate available hearing data and does not address the relation of blast spectra from different explosive sources to probable impacts. Consequently, there are limitations to both the immediate applicability and possibly to future relevance in its present form. These can however be overcome by capitalizing on the flexibility of its design through incorporation of species specific sensitivity data and expansion of impact criteria.

Background

Purpose and Structure of This Review: Biological Impact Relevance

This review is predicated on the assumption that the chief goal of the ***Underwater Calculator (UWC) version 2.0*** is to provide probable distances from an explosive event to several zones of risk for injury and hearing loss for turtles and mammals.

The review is provided from a biological perspective whether the basic measures calculated by the UWC reliably addresses the exposure criteria provided by NOAA/NMFS to estimate risk of injury, potential for hearing loss and substantive behavioral disturbance. In addition to assessing whether the UWC2 accurately provides distances or frontiers for distribution of hazardous zones delimited by the explicit NMFS criteria, the review addresses how the parameters as calculated and represented in UWC2 compare with other criteria for risks from underwater explosions and what limitations there may be on their interpretation and representation of such hazards.

This review is organized according to the stated Terms of Reference (TOR) provided in the Statement of Work (SOW). In order to provide background for the specific responses to the TOR and review conclusions, review assessments are preceded by the following background section on physiological elements of blast impacts, and where appropriate, with specific reference to data on turtles and cetaceans that are relevant to potential impacts from underwater blasts.

Marine Blast Impacts

Blast Trauma

At the extreme end, underwater explosions, whether buried or within the water column carry risks for organisms based on the precipitous release and propagation of energy from the source. Blast injuries generally result from a single exposure to a shock wave, either from the compressive phase with a few microseconds initial rise time to a massive pressure increase over ambient or from the rarefactive wave in which pressure drops significantly below ambient. Both of these extremes challenge the dynamic range and response tolerance of tissues and therefore have the capacity to produce lethal to sublethal injuries, directly (primary blast trauma) and indirectly (secondary and tertiary blast trauma). In water, secondary and tertiary effects are relatively rare, but primary blast trauma injuries can range from lethal to minor, paralleling those observed from in-air blasts with the same fundamental mechanisms. Key differences for turtles and marine mammals relate to their variations in air spaces, lung structure, anatomical planes (i.e., carapace, limb, and skull shapes) and major organ tissue material properties.

Blast injuries may be reparable or permanent according to the proximity to the source and tolerance of the tissues (generally related to the mass of the animal). The ear is considered the most pressure sensitive organ and therefore its susceptibility is the usual criterion for limits of risk for non-lethal impacts. Blast related auditory trauma and related hearing loss occurs primarily from precipitous over-extension of one or more ear components. These effects may range from severe (ruptures, fractures, hemorrhages) to mild (recoverable ear drum rupture, tinnitus, vertigo).

Hearing loss in nearfield exposure cases results commonly from an eruptive injury from the extreme pressure differentials and over-pressures from the shock wave; i.e., with the rarefactive wave of a nearby explosion, cerebrospinal fluid pressures increase and the inner ear window membranes blow out due to unsustainable pressure increases. Inner ear damage frequently coincides with fractures to the bony capsule of the ear or middle ear bones and rupture of the eardrum.

At increasing distance from the blast, primary blast injury impacts of the shock wave lessen and even though there is no overt tissue damage, mild damage with some permanent hearing loss occurs from a variety of mechanisms. In general, complex and fast-rise time sounds cause ruptures at lower overpressures than slow-rise time waveforms, and smaller mammals will be injured by lower pressures than larger animals. Thus, average body mass, a significant variable across age classes and species, is an important element to consider in predictive risk models. In addition to ear drum or other rupture injuries, inner ear tissues, notably the hair cells and basilar membrane, can sustain substantial and irrecoverable mechanical injuries. Such injuries result in traumatic permanent hearing loss. With increasing distance, these effects lessen, and impacts will be recoverable; i.e., temporary.

Energy flux density (EFD), with the UWC2 calculates, is one criterion that has been established, largely as a result of its use for mitigation measures in the Ship Shock Trials of the Winston Churchill. In this case, emphasis was placed on the relation of EFD to eardrum rupture, with most of the data based on in air and submerged terrestrial mammals. EFD has also been shown to relate to TTS in some captive cetacean studies. Of the animals tested to date, sheep and pig have ears anatomically closest to those of whales and seals. The data available for submerged and aquatic animals imply that lower pressures in water than in air induce exacerbated trauma (Myrick et al., 1989; see also summary in Richardson, et al. 1991). For submerged terrestrial mammals, lethal injuries have occurred at overpressures near 55 kPa (Yelverton, 1973, in Myrick, et *al.*, 1989; Richmond, *et al.*, 1989). In a study of Hydromex blasts in Lake Erie the overpressure limit for 100% mortality for fish was 30 kPa (Chamberlain, 1976), which is consistent with the observations in the necropsy reports of relatively massive fish losses (4,915) compared to the tens of turtles impacted in each of the observed explosions.

Hearing Loss

Hearing impacts may ultimately be as devastating as lethal impacts, even causing death ultimately through impaired foraging, predator detection, communication, and stress. Fitness can be further impaired by disrupting mating, abandonment of habitat, and inability of offspring to thrive. The potential for this type of extended or delayed impact is being addressed in a variety of ways, from direct observations, in some cases by experimental manipulation (Behavioral Response program and playback studies) and by modeling (PCAD program).

What is well documented for most mammals including marine species, but less so for turtles and reptiles in general is that hearing and hearing loss are related to a range of metrics. Briefly, the most common are as follows:

peak SPL – the maximum sound pressure level within specified frequency bands, commonly used for fast rise time, short duration, intense signals, such as impulse sounds.

rms SPL – root mean square SPL, which refers to the mean pressure over a defined duration, thus approximating the average received pressure as a function of time. This is the most commonly employed SPL for psychoacoustics.

SEL – sound exposure level, which represents total received energy integrated over time expressed as dB re 1 $\mu Pa^2 s$. It is the most common metric employed to represent cumulative effects.

To determine whether any one animal or species is subject to a noise induced hearing impact from any sound, regardless of source, requires understanding how its hearing abilities compare and can interact with that sound. IF a sound is within an animal's hearing range, and IF an exposure to that sound is loud enough and/or prolonged, the animal may sustain a loss of sensitivity is called a threshold shift. Not all noises will produce equivalent damage to all animals at any given exposure level; the extent and duration of a threshold shift depends upon the synergistic effect of several features, including how sensitive the subject is to the sound. For this reason, impacts are highly species specific. This is also the reason that much recent effort has been directed at devising weighting functions for marine mammals, although considerably more data per species are needed for definitive answers.

Hearing losses are recoverable (TTS - temporary threshold Shift) or permanent (PTS) primarily based on extent of *inner* ear response and recovery from the *received* spectra and *received* sound level. Rise time (i.e., whether impulsive) is a third significant feature. Inner ear damage location and severity are correlated with the power spectrum of the signal in relation to the sensitivity of the animal.

Unlike TTS which is highly species dependent, PTS onsets are more general; signal rise-time and duration of peak pressure are significant factors. Sharp rise-time signals, like those from explosions, have been shown to produce broad spectrum PTS at lower intensities than slow onset signals both in air and in water (Lipscomb, 1978; Kujawa and Liberman, 2009).

In summary, the following elements for threshold shifts are fairly consistent across all mammals:

1) Inner ear damage locations and severity correlate with the power spectrum ;
2) Intensity and duration can act synergistically to broaden the loss;
3) There is a critical limit beyond which shifts grow rapidly;
4) Continuous exposures over time induce asymptotic threshold shifts;
5) Impulse noise produces more profound effects than continuous noise at equivalent levels;

Turtle and Cetacean Hearing

For the purpose of this review, it is important to note differences in hearing of turtles vs. cetaceans.

A great deal of public and legislative concerns about marine sound impacts have focused explicitly on the effects of sonar and seismic sources on whales, and as a consequence, considerable information has been produced in the last decade on odontocete hearing. Briefly, it can be stated that odontocetes, and quite likely mysticetes, have fundamentally mammalian ear anatomies, but are well adapted to receive and process underwater sound (Tubelli et al, 2012). Odontocetes are known to have best sensitivities, in most species, to ultrasonics and are relatively insensitive to frequencies below 200 Hz. Mysticetes by contrast are thought, based largely on vocalizations, are thought to have hearing best adapted to mid to low and even infrasonic sounds. In addition to basic hearing, a good deal of effort has been devoted to TTS and other psychoacoustic studies of a wide range of marine mammals, and it is these data that largely drive the acoustic exposure regulations.

However, considering the endangered status of sea turtles, it is appropriate that there be a parallel and equal concern for acoustic and blast impacts on sea turtles. Relatively little is documented or understood about the hearing ability of any sea turtle species or their dependency on sound, passive or active, for survival cues. The original data on sea turtle hearing were largely anatomical and tested in air (Wever, 1978; Ridgway et al, 1969; Bartol et al, 1999). Some progress has been made through AEP audiograms in water for several age classes and species of sea turtle (Bartol and Ketten 2003). All turtles tested to date responded to sounds in the low frequency range, from 100 Hz to no greater than 1000 Hz, with the smallest turtles (hatchlings loggerheads) having a greater range of hearing and better high frequency sensitivity. None, however were broadly sensitive beyond low frequencies and all were relatively insensitive compared to mammalian ears.

In addition and relevant to this review, there are some interesting phenomena with respect to turtles and potential blast impacts. It has been noted that turtles can sustain higher peak pressures from blast sources without obvious impairment compared to odontocetes and that the relation of injury to body mass is not clearly consistent (Ketten et al 2003). These deviations from the expected norm have also been noted by Klima et al (1988) and may imply that a separate standard is required for turtles for both noise and blast impacts.

Terms of Reference: Review Key Points

1. Assess whether or not the UWC model sufficiently considers all relevant biological (e.g., animal distribution and movement) and physical variables (e.g., factors affecting sounds propagation) for decommissioning activities.

The scientific materials employed in the formulation and implementation of the ***Underwater Calculator (UWC) version 2.0*** were sufficient and representative of the state of knowledge for modeling underwater explosion effects although the core materials were focused primarily on the availability of comparative data for peak pressure distributions and were not fully representative of features that have been shown to be significant in blast effects and are outlined in the available literature on underwater anthropogenic impacts. This is not a shortcoming of the model per se as the parameters were set based on criteria determined by NOAA/NMFS and not by the author and chief architect of the model system, Dr. Peter Dzwilewski. The model could gain value by incorporation of knowledge about demonstrated parameters related to mortality, injury, and hearing loss outlined in the preceding background, particularly SEL, that go beyond the criteria that were tasked by the funders.

Strengths:

The UWC2 has incorporated flexibility in entry of multiple key variables affecting susceptibility to risk, notably body mass and charge weight, both of which dictate the spread and level of incident impact. UWC2 also provides a range of site specific structural options; e.g., the chief categories of conventional piles: Main Pile, Well Conductor, Caisson, etc. It is critical that these varying conditions and combinations of charge, buried depth, and casement characteristics be considered in parallel with the potential species of interest for mitigation and its physically relevant features such as body mass.

It is also a strength that the UWC provides forward/backward calculations, which increase its accuracy and applicability. The fact that it builds on algorithms from more data rich sources, including Swisdak and Connor, is a plus, although it could benefit as well from some in-air models, like that of Czaban.

Weaknesses:

There is no attempt apparent by the model to assess the potential effects, pro and con, on the probable impacts, of active animal responses, such as avoidance behavior, single vs group (pod) dynamics, local densities and distributions. Realistically, these are a substantial problem to model effectively and to date there has not been a comprehensive, successful, interactive model system for estimating multi-species, population level, impacts that is universally robust.

Concerning the physical variables, I defer to the commentaries of the other reviewers who are the appropriate experts to address the accuracy, completeness, and appropriateness of the data and assumptions employed.

Having said that, there is some concern that much is predicated on the accuracy and assumptions related to the use of the TAR data set. As the precise methodology of the analyses of that data set is not spelled out, it is difficult to assess whether the parameters are properly integrated. The data set is also somewhat limited (1-2 shots typically) in comparison to the more extensive per trial data for the Connor report (up to 12 each). There are also some potential inconsistencies between the TAR and Connor results that are not fully addressed.

2. Assess the underlying assumptions resulting from scientific uncertainty in estimating acoustic exposure for animals (with an emphasis on sea turtles, but also odontocetes) within the UWC model.

Strengths:

The criteria set by NMFS/NOAA (23 psi; 182 dB) are consistent with past studies outlined in the background section, driven primarily by data from odontocetes, as well as more recent data and modeling (Finneran and Jenkins, 2012) that seek to address multiple facets, including species sensitivities, nearfield primary shock wave effects, and the less traumatic but significant acoustic exposure effects on hearing. The criteria chosen by NMFS which are the determinants guiding the UWC2 outputs are not fully aligned with the criteria employed by other governmental agencies. Most notably, the level and peak pressure data employed here are something of a minimal but bridging set of values for turtles and odontocetes, whereas the Navy criteria (table 5, NUWC Tech Rpt 12,017A, 2013) provide multiple criteria according to source and target species (segregating turtles from mammals) as well as mass and depth, with differing criteria for onset of mortality, lung injury, etc. (n.b.: the Navy assume increasing risk with depth. This needs review in light of evidence that with compression, some tissues may become more resistant to injury). Thus, the specified parameters may be a necessary compromise based on inadequate species-specific data and efficiency. Under those assumptions and limitations, particularly the paucity of hearing data on turtles, the UWC2 fulfills its assigned task.

Weaknesses:

The main document providing the information on the basic architecture, inputs, and fixed parameters of UWC2 as well as supplemental material provided for review provides substantial detail on some aspects but does not provide detail on variables of the water column and how depth, substrate composition, and regional topography may affect the results and therefore the level of confidence in the outputs. It may be that these components are not possible to treat with fidelity in this model; that these items are not known for most cases and a single set of variables must be assumed; or that there are options for varying these parameters that have not been described.

One anomaly that needs clarification, qualification, and elaboration is the statement indicating that differences in below mud level (BML) burial depth is nearly insignificant. There are a number of possible explanations for that assumption but the data cited are sparse

Similarly, the paper provides some comments concerning the upward spread of energy for the shot and for the effect – and non-effect – of the depth of the charge below the sediment, but the description would have benefitted by far more detail on these points and explicitly on the final set of assumptions that went into the calculus of the model for each of the structural variants.

Lastly, there are large differences in the explosive weights across platforms. While this may reflect conventional usages, it requires some discussion and explanation of how these variations are interpreted and any possible effect or uncertainty this may introduce for the model simulations. Most important is that the input for charge weight is a single number. It is unclear in the case of multiple shots how the weight should be entered, as the total or some other variant, and how the sequencing of multiple shots is handled in contrast to a single equivalent weight charge. While compounding effects are a complex situation, it is an important variable to consider.

Another variable that is not specifically addressed is the depth of the water column and the assumed relative position of the peak radiation point for the shock wave across different pile types.

3. Assess the model validity in relation to field data collected by the PROP program for sea turtles and relevant scientific literature.

Weakness:

The model does not appear to benefit from the data collected by the PROP program that was presented for review in tandem with the UWC2 model. In addition to the seven data sets of observations of number of animals, there are data on the number of injured (lethal and non-lethal), stunned, and aberrant response animals as well as estimates of the number of impacted (floating) fishes and the localities and timing in some cases with respect to the shots. There has not been at evident attempt to analyze or incorporate the combined data on charge weight, number of shots, fish kills, and observed injury or deficiency in the turtle reports. These are potentially valuable data that may help address some issues about the susceptibility or resistance of turtles in comparison to marine mammals, especially odontocetes.

As noted in the background section, it may be appropriate to assess turtles separately, with different criteria from marine mammals, even though the data available are not definitive. As noted above, in several studies, including the 3 PROP necropsy reports, the list of injuries and their relation to body mass is not clearly consistent with expected results.

It is extremely rare to find major organ damage, such as blast lung or mesenteric hemorrhage, without at least moderate ear damage as well. In the PROP necropsies, this phenomenon was reported repeatedly. It has been suggested that sea turtles may have some protective elements for the brain and ear due to a reflective skull shape as well as significant material properties in the carapace (Bartol Moehn and Ketten 2007; Ketten et al, 2006, 2008). This may account for some of the anomalies in the PROP necropsy reports for turtles (see 08/08/2010; 08/20/2011; 07/18/2013) showing severe external and abdominal injuries but an absence of evident auditory damage may imply that a separate standard is required for turtles for both noise and blast impacts.

Cetaceans by contrast, despite their highly modified anatomy from that of terrestrial mammals, have essentially the same risk profile as most mammals, with the notation that the massiveness of some species may offer some protection in comparison to land counterparts.

Strength:

Considering variations in body mass, particularly the average body mass by species, one strength of the UWC2 is that body mass is an input variable and a significant element of accuracy in estimating risk. Given this level of flexibility, it may be worthwhile to consider adding an additional category to the input, which would be based on taxa, with some weighting for body parameters that relate to average mass and tissue densities and/or other salient features, such as potential protective mechanisms.

4. Assess whether or not the UWC meets the Environmental protection Agency's Council for Regulatory Monitoring (CREM) guidelines for model development.

Fundamentally, yes, the UWC meets the EPA's CREM guidelines. Please see the CREM section below for detailed comments.

1. UWC Model Implementation

Does the UWC model sufficiently consider all relevant physical variables in estimating acoustic exposure? Specifically, does the model:

i. Integrate the new in situ data correctly?

The TAR data as presented appear to have been well considered but there is some concern how the raw data were synthesized to provide input to the UWC, particularly in terms of the integration and averaging processes. The inclusion of the TAR data provides an important element of ground-truthing and therefore robustness to the model. However, an accurate assessment of the integration of the TAR data is beyond my area of expertise, and the reviews provided by the other experts should be considered as the definitive response.

ii. Accurately represent the acoustic impact zones from explosive use?

• Does (or can) the UWC model correctly consider the necessary parameters to estimate effects on sea turtles (and marine mammals) from exposure to explosives based on current scientific knowledge, such as:

i. Water, depth, size of target, size of explosives, location of charge (AML/BML)

The UWC, based on the information provided in discussions as well as in the paper provided does not provide sufficient information to assure that it provides a comprehensive and integrated representation of the listed variables. In particular, it relies upon the TAR data, which may be sufficient but a fuller explanation of the parameters and especially of the limitations of the applicability of those empirical data is needed to fully appreciate any limitations they impose on the UWC output.

ii. Habitat use and movement of species (e.g. on surface versus in water column)

In an ideal case, these elements would be beneficial but it must be stated that they are less likely to be major factors than body mass and sensitivities in the majority of species.

• How do the UWC model results compare to both field observations and the scientific literature in terms of zones of influence?

The UWC models for zones of influence are broadly consistent with other model outputs, given the same criteria for impacts are employed. The criteria for equivalent impact and for relevant species differ, however, across the various published and in press models. The model would benefit by reviewing the variability and their foundations in other model efforts and consider the possibility of incorporation of some of those parameters if appropriate.

• Does the UWC model consider the appropriate acoustic exposure metrics? How do the predictive outputs of the UWC model compare with the noise exposure guidelines developed by NMFS?

The model is consistent with the criteria set by NMFS. However, it is notable that SEL, which considers total received energy integrated over time is not considered in the model nor specified in the criteria, and this may be an important factor for time-integrated-squared-pressure data such as EFD, and given the possibility of multiple, sequenced shots.

- Comment on the strengths and weaknesses of the UWC modeling approach, and suggest possible improvements (both those that can be accomplished by implementing the current model differently and those that necessitate changes in the model)

An UWC modeling approach is both appropriate and conceptually well founded. Shock wave propagation modeling is a well-established and substantially documented field. Similarly, there is an extensive literature on the effects of blast in air and in water, from experimental, accidental, and intentional activities. The extensive body of literature that describes and analyses these cases provides a solid base for the UWC model.

The principal weakness for this case is the lack of explicit, controlled data for blast exposures in live turtles and marine mammals. These data are of course precluded given the endangered status of these animals as well as ethical concerns. There are, however, useful data from other species, from cadaveric experiments, and from incidental takes that can be employed usefully to inform model developments if used with the necessary caveats.

The principal recommendations are as follows:

- expand the model to incorporate more acoustic parameters known to be related to TTS
- add a zone for acoustically derived PTS for those species for which the progression from TTS is reasonably understood or estimated
- increase the sophistication of the propagation model
- increase the categories of risk and therefore the range of criteria

The majority of these suggestions are achievable because flexibility is a built in, significant attribute of the existing calculator and therefore should be exploited to provide substantial added value to the UWC2.

- Comment on whether any weaknesses in the UWC model would likely result in over/underestimates of take (and the degree, if possible)

Estimates of takes are largely dependent upon threshold criteria and how representational they are as opposed to the degree of conservatism (overestimate) or laxity (underestimate). Those are not a function of the UWC2 as the parameters are externally set.

CREM Guidelines

Have the principles of credible science been addressed during model development?

Yes

- Is the choice of model supported given the quantity and quality of available data?

The concept of employing a model is appropriate given the lack of explicit blast response data for any of the critical species.

• How closely does the model simulate the system (e.g., ecosystem and sound field) of interest?

There is insufficient information in the main paper on the UWC2 and additional materials to fully assess the accuracy of the propagation model underlying the simulations.

• How well does the model perform?

It provides zones of potential impact consistent with other similar underwater blast propagation algorithms, particularly for peak pressure distributions,

• Is the model capable of being updated with new data as it becomes available?

There is substantial flexibility in the inputs compared to some models. It is not possible to assess how complex or feasible it is to modify the foundation data nor to incorporate species-specific features such as hearing range and sensitivity differences.

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Appendix 1: Statement of Work

Underwater Calculator (UWC) version 2.0.

Background

The National Marine Fisheries Service (NMFS) is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NMFS science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards. (http://www.cio.noaa.gov/services_programs/pdfs/OMB_Peer_Review_Bulletin_m05-03.pdf).

Further information on the CIE program may be obtained from www.ciereviews.org.

Scope

The Bureau of Safety and Environmental Enforcement have developed a tool based on a model to predict the effects of underwater explosions used for the removal of oil and gas structures. The modeling tool is called the Underwater Calculator Version 2.0 (UWC). The UWC was developed through a federally-sponsored environmental study to measure sound pressures during explosive use and develop a mathematical model. The development of the UWC was sponsored by the Bureau of Safety and Environmental Enforcement (MMS Contract 0302P057572) which resulted in the report titled "*Shock Wave/Sound Propagation Modeling Results for Calculating Marine Protected Species Impact Zones During Explosive Removal of Offshore Structures*" (OCS Study 2003-059).

The study used field measurements to conduct numerical simulations of various explosive, target, sediment, and marine environments determining the level of energy coupled into the water. In addition, a separate federal-sponsored study calculated the exposures of marine mammals to explosives used for decommissioning in the Gulf of Mexico which are found in the report "*Explosive Removal Scenario Simulation Results – Final Report*" (MMS OCS study 2004-064).

The purpose of the UWC is to conduct assessments of projects using explosives to remove oil and gas structures and to predict the effects and mitigation needs for protected marine species, primarily marine mammals and sea turtles. The UWC needs to be based on sound scientific principals necessary to conduct environmental assessments under federal requirements (e.g., the Endangered Species Act, Marine Mammal Protection Act, and National Environmental Policy Act). The NMFS requires an independent peer review of the UWC to ensure that the data collection methods, analysis, principals of acoustics, and necessary physical and biological factors have been considered to provide a sound scientific model. The Terms of Reference (TORs) are below.

Requirements

NMFS requires three reviewers to conduct an impartial and independent peer review in accordance with the SOW, OMB Guidelines, and TORs below. The reviewers shall have the combined working knowledge and recent experience in the application of underwater acoustics (especially explosives), acoustic modeling, and sea turtle biology.

The underwater acoustician or physicist reviewer(s):

- shall have expertise and working experience with the physics and principals of the modeling of underwater explosives

- shall have relevant experience in the calculation and relationships of peak pressure, impulse, and energy flux density (EFD) as it relates to underwater shock waves caused by explosive use

The mathematical modeling reviewer(s):

- shall have expertise with underwater propagation of acoustic waves and modeling acoustic exposures of animals
- Experience with relevant acoustic modeling efforts dealing with impacts to marine protected species and NMFS acoustic criteria is desirable.

The sea turtle biologist and marine mammal reviewer(s):

- shall have experience with sea turtles (primarily) and marine mammal (secondarily) physiology and the effects of shock wave injury in marine animals
- shall have experience in sea turtle (primarily) and marine mammal (secondarily) habitat usage and behavioral ecology

Tasks for reviewers

- Review the following background materials and reports prior to conducting the review:

Primary Review Document Titles
1. ARA Final report – Water Shock Prediction for Explosive removal of Offshore Structures: Underwater Calculator (UWC) Version 2.0 Update based on Field Data
2. Underwater Calculator Version 2
3. Effect of Depth Below Mudline of Charge Placement During Explosive Removal of Offshore Structures (EROS)
4. Shock Wave/Sound Propagation Modeling Results for Calculating Marine Protected Species Impact Zones During Explosive Removal of Offshore Structures (OCS Study 2003-059)
5. Pressure Wave and Acoustic Properties Generated by the Explosive Removal of Offshore Structures in the Gulf of Mexico
Secondary Background Document Titles
5. Impacts of the Explosive Removal of Offshore Petroleum Platforms on Sea Turtles and Dolphins
6. Underwater Blast Effects from Explosive Severance of Offshore Platform Legs and Well Conductors

7. Underwater Blast Pressures from a Confined Rock Removal during the Miami Harbor Deepening Project
8. Determination of Acoustic Effects on Marine Mammals and Sea Turtles for the Atlantic Fleet Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement
9. The Environmental Effects of Underwater Explosions with Methods to Mitigate Impacts
10. NMFS PROP Reports and Necropsy Reports

Document	**Document Type**	**Number of Pages**
1. ARA Final report – Water Shock Prediction for Explosive removal of Offshore Structures: Underwater Calculator (UWC) Version 2.0 Update based on Field Data	PDF	35 pp
2. Underwater Calculator Version 2.0	Excel Spreadsheet	1 spreadsheet
3. Effect of Depth Below Mudline of Charge Placement During Explosive Removal of Offshore Structures (EROS)	PDF	71 pp
4. Shock Wave/Sound Propagation Modeling Results for Calculating Marine Protected Species Impact Zones During Explosive Removal of Offshore Structures (OCS Study 2003-059)	PDF	41 pp
5. Pressure Wave and Acoustic Properties Generated by the Explosive Removal of Offshore Structures in the Gulf of Mexico	PDF	72 pp
6. Impacts of the Explosive Removal of Offshore Petroleum Platforms on Sea Turtles and Dolphins	PDF	10 pp
7. Underwater Blast Effects from Explosive Severance of Offshore Platform Legs and Well Conductors	PDF	147 pp

Document	Document Type	Number of Pages
8. Underwater Blast Pressures from a Confinded Rock Removal during the Miami Harbor Deepening Project	PDF	12 pp
9. Determination of Acoustic Effects on Marine Mammals and Sea Turtles for the Atlantic Fleet Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement	PDF	109 pp
10. The Environmental Effects of Underwater Explosions with Methods to Mitigate Impacts	PDF	54 pp
11. NMFS PROP Reports and Necropsy Reports (7 incidents)	Excel Spreadsheets (7), Word (2), and PDF (2)	10 pp + 7 spreadsheets

- Participate in two, half-day webinars with NOAA, BSEE, and other personnel to discuss the technical aspects of the UWC, terms of reference, and related questions

- Conduct an independent peer review in accordance with the requirements specified in this SOW, OMB guidelines, and TORs, in adherence with the required formatting and content guidelines

Place of Performance

The place of performance shall be at the contractor's facilities.

Period of Performance

The period of performance shall be from the time of award through August 31, 2016. Each reviewer's duties shall not exceed 12 days to complete all required tasks.

Schedule of Milestones and Deliverables: The contractor shall complete the tasks and deliverables in accordance with the following schedule.

6/10/2016	Contractor selects and confirms reviewers
No later than 6/17/2016	Contractor provides the review documents to the reviewers
6/24 – 9/12/16	Each reviewer conducts an independent peer review as a desk review, including participating in two, half-day seminars
9/12/16	Contractor receives draft reports
9/14/16	Contractor submits final reports to the Government

Applicable Performance Standards

The acceptance of the contract deliverables shall be based on three performance standards:

(1) The reports shall be completed in accordance with the required formatting and content (2) The reports shall address each TOR as specified (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Travel

Since this is a desk review travel is neither required nor authorized for this contract. ODCs are not to exceed $500.00.

Restricted or Limited Use of Data

The contractors may be required to sign and adhere to a non-disclosure agreement.

Terms of Reference for the Peer Review

Underwater Calculator (UWC) version 2.0.

1. Assess whether or not the UWC model sufficiently considers all relevant biological (e.g., animal distribution and movement) and physical variables (e.g., factors affecting sounds propagation) for decommissioning activities.

2. Assess the underlying assumptions resulting from scientific uncertainty in estimating acoustic exposure for animals (with an emphasis on sea turtles, but also odontocetes) within the UWC model.

3. Assess the model validity in relation to field data collected by the PROP program for sea turtles and relevant scientific literature.

4. Assess whether or not the UWC meets the Environmental protection Agency's Council for Regulatory Monitoring (CREM) guidelines for model development.

1. <u>UWC Model Implementation</u>

- Does the UWC model sufficiently consider all relevant physical variables in estimating acoustic exposure? Specifically, does the model:
  - i. Integrate the new in situ data correctly?
  - ii. Accurately represent the acoustic impact zones from explosive use?
- Does (or can) the UWC model correctly consider the necessary parameters to estimate effects on sea turtles (and marine mammals) from exposure to explosives based on current scientific knowledge, such as:
  - i. Water, depth, size of target, size of explosives, location of charge (AML/BML)
  - ii. Habitat use and movement of species (e.g. on surface versus in water column)
- How do the UWC model results compare to both field observations and the scientific literature in terms of zones of influence?
- Does the UWC model consider the appropriate acoustic exposure metrics? How do the predictive outputs of the UWC model compare with the noise exposure guidelines developed by NMFS?
- Comment on the strengths and weaknesses of the UWC modeling approach, and suggest possible improvements (both those that can be accomplished by

implementing the current model differently and those that necessitate changes in the model)
- Comment on whether any weaknesses in the UWC model would likely result in over/underestimates of take (and the degree, if possible)

2. CREM Guidelines

The reviewers shall assess whether or not the UWC model meets the Environmental Protection Agency's CREM guidelines for model evaluation, which are summarized below. Some of the points listed below will have been addressed by the reviewers as part of their comments on Terms of Reference 1 and 2 above. Each reviewer shall ensure that clear answers are provided for the CREM guidelines, though extensive repetition of technical comments is not required.

- Have the principles of credible science been addressed during model development?
- Is the choice of model supported given the quantity and quality of available data?
- How closely does the model simulate the system (e.g., ecosystem and sound field) of interest?
- How well does the model perform?
- Is the model capable of being updated with new data as it becomes available?

Peer Review Report Requirements

1. The report must be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether or not the science reviewed is the best scientific information available.

2. The report must contain a background section, description of the individual reviewers' roles in the review activities, summary of findings for each TOR in which the weaknesses and strengths are described, and conclusions and recommendations in accordance with the TORs.

3. The report shall include the following appendices:

Appendix 1: Bibliography of materials provided for review

Appendix 2: A copy of this Statement of Work