The Impacts of Seismic Exploration and International Law

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Executive Summary

1. The exploration of the ocean for the valuable elements of nature, is an activity which has been occurring for many decades and can be expected to exponentially increase in the future. The primary method utilised in this exploration is with seismic surveys.
2. These surveys appear to have impacts upon multiple species of the marine environment. The full extent of these impacts is a matter of debate. Whilst this debate is beginning to be resolved by the international bodies that deal with cetaceans, the same cannot be said for other marine species, especially fish.
3. The most appropriate body to start on the resolution of these questions is the Council of Fisheries (COFI) of the Food and Agriculture Organisation. This work needs to be done in the same way that COFI supports other studies into pollutants that impact upon the marine environment, and fisheries in particular.
4. Without this work being completed, the international regulation of seismic pollution, with specific regard to its impact on fisheries, is unlikely to proceed.
5. Once the scientific issues have been resolved, the question of which institution to regulate this type of pollution comes to the forefront. Under the guidance of the United Nations Convention on the Law of the Sea (UNCLOS), it is clear that this answer falls into two parts.
6. The first part deals with marine pollution caused in areas beyond sovereign control. This type of pollution will have to be managed by the International Seabed Authority of the United Nations. However, given the multifarious nature of noise pollution, it is likely that a number of other bodies will also need to be directly involved in the regulation of seismic noise pollution in areas beyond sovereign control. The COFI is one of these bodies.
7. The second part deals with marine pollution caused in areas within sovereign control. The way that this can be dealt with is either via a dedicated treaty to the topic or via agreed guidelines. Under the guidance of the UNCLOS, whilst the first option has evolved under the oversight of the International Maritime Organization, the latter has evolved under the guidance of the United Nations Environment Programme (UNEP). Given the nature of this problem, it is likely that UNEP is better suited to this task. However, given the multifarious nature of noise pollution, it is likely that a number of other bodies will also need to be directly involved. The COFI is one of these bodies.
8. However, before this task can be undertaken with regard to areas which are either under sovereign control, or not, it is essential that the COFI provides the evidence, and with it, the momentum, by which one of the defining pollution issues of the 21st century can be resolved.

Therefore, it is recommended that in accordance with earlier COFI precedents on pollution of the marine environment and fisheries in particular, that the COFI should recommend the adoption of a scoping study to identify the key issues on noise pollution and fisheries and initiate a discussion on how the fishing industry can adapt to noise pollution. In addition, the FAO should take a lead in informing fishers and policy makers about the likely consequences of seismic noise pollution for fisheries.

1. Introduction

The exploration of the ocean for the valuable elements of nature, be they oil and gas reserves or marine minerals, is an activity which has been occurring for many decades. The scale and methods of this activity have increased rapidly in recent years, and this can be expected to expand even more in coming decades as the exploitation of these resources becomes increasingly attractive in economic terms. The difficulty is that the primary method utilised in this exploration is with seismic surveys. These surveys appear to have impacts upon multiple species of the marine environment. However, the full extent of these impacts is a matter of debate. Whilst this debate is beginning to be resolved by the international bodies that deal with cetaceans, the same cannot be said for other marine species, especially fish. The most appropriate body to start on the resolution of these questions is the Council of Fisheries of the Food and Agriculture Organisation.

Once the scientific issues have been resolved, the question of which institution to manage this problem comes into play. Under the guidance of the United Nations Convention on the Law of the Sea, it is clear that this answer falls into two parts. The first part deals with marine pollution caused in areas beyond sovereign control. This type of pollution will have to be managed by the International Seabed Authority of the United Nations. The second part deals with marine pollution caused in areas within sovereign control. The way that this can be dealt with is either via a dedicated treaty to the topic or via agreed guidelines. Whilst the first option has evolved under the oversight of the International Maritime Organization, the latter has evolved under the guidance of the United Nations Environment Programme (UNEP). Given the nature of this problem, it is likely that UNEP is better suited to this task.

Once this task has been taken up, the broad principles that are necessary to control seismic noise pollution can be brought into play. These principles are already in existence. The foremost principle is mitigation, not abolition, of this source of pollution. This principle can be adduced by the high value that the law of the sea places on both marine exploration and the protection of the environment. Specific supplemental principles that are already common include, *inter alia*, identification of species and areas to be protected, and for areas which are not protected but still hold protected species, buffer zones, visual identification and rules for slow starts and changes of direction. Although these broad principles are already in existence there is considerable variation in the way that each principle may be applied. These variations will be best reconciled via a global instrument.

2. Seismic Noise

Noise pollution is one of the emerging conservation issues of the 21st century. Although methodologies for the assessment of the environmental burdens and their impacts are difficult in all fields, this area is especially difficult with noise pollution, and particular forms of noise pollution such as low-frequency. Due to such difficulties, until recently there was little international scientific agreement even on the methodologies for estimating some forms of noise pollution and its impacts on humans, let alone non-human species. Nevertheless, it is estimated that as of 2007 an estimated 113 million Europeans have been exposed to noise levels high enough to cause serious health problems. In some instances, even prolonged noise levels at low frequencies may have large impacts. Noise pollution can also produce detrimental impacts on non-human animals. The most observable effect of noise on wild animals appears to be behavioural. Many animals learn to differentiate among acoustic stimuli and to adapt and live with different types of noise pollution while others have gone in the opposite direction and have shown strong sensitivities to noise pollution.[1] This has been particularly well studied with regards to birds which, as has been known for decades, may have unique sensitivities. For example, in 1950 it was shown that adult condors were very sensitive to noise and abandoned their nests when disturbed by blasting sonic booms or even traffic noise.[2] Since then, additional recorded (albeit subtle) changes showed that some bird species have either changed their singing patterns to compete with other noise, or the times when they sing, such as at night. Some birds, unable to compete with other noise sources, especially those species reliant on their song, have seen their pairing success rates fall by up to 15 percent.[3]

The impact of excessive noise is also recognised in aquatic environments. In the case of the latter, the impacts are often unknown and have become the source of increasing public disquiet.[4] A large part of this disquiet is due to the nature of the oceans and the way in which noise behaves differently to the way it does on land and air. Although the ocean is relatively opaque to light, it is relatively transparent to sound. Background, or ambient, noise occurs in all oceans and seas. Natural geophysical sources include wind-generated waves, earthquakes, precipitation, and cracking ice. Natural biological sounds include whale songs, dolphin clicks, and fish vocalisations. Anthropogenic sounds are generated by a variety of activities, including commercial shipping, geophysical surveys, oil drilling and production, dredging and construction, sonar systems and oceanographic research. Intentional sounds are produced for an explicit purpose, such as seismic surveying. Depending on the conditions of depth, temperature, salinity and surface and bottom conditions, sound can travel four times faster in water than in air.

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1 Hopkins, C. (1979). 'Effects of Noise on Wildlife'. 29 *Bioscience* 547. See also World Health Organization (2000). *Methodology for Assessment of the Environmental Burden of Disease*, (WHO, Geneva). 3–18.
2 Anthony, A. (1959). 'Noise Stress in Laboratory Rodents'. 31 *J. Acoust. Soc. Am.* 11, 1437.
3 See Potash, L. (1972). 'A Signal Detection Problem and Possible Solution in Japanese Quail'. 18 *Animal Behaviour* 7.
4 MacDougall, D. (2003). 'Offshore Seismic and Fisheries and Environmental Issues: How Can They Be Reconciled?'. 26 *Dalhousie Law Journal* 470-90.

Thus, depending on the variability of conditions, sound velocity reaches speeds of up to 1600 m/s in seawater as compared with 350 m/s in air. Moreover, transmission loss in water is much lower. Thus, noises can be heard at great distances. Thus, in some instance, it makes no difference in terms of impact if noise is heard 450 metres from the source, or 12 kilometres from the source.[5]

These considerations have direct relationship with some noise-emitting technologies utilised in the ocean, such as reflection seismology (or seismic reflection). This is a method of exploration geophysics that uses the principles of seismology to estimate the properties of the Earth's subsurface from reflected seismic waves. This method requires a controlled seismic source of energy, such as dynamite, seismic vibrator or a specialised airgun. The source most often used in geophysical surveying in the ocean is the seismic airgun. Airguns are generally used in clusters, and fired at regular intervals, up to six times per minute. The airguns release compressed air to generate the seismic signals at regular intervals, typically each 25 metres the vessel moves. Each time an airgun is fired it releases a bubble of compressed air. The sound pulse is directed down into the various geological layers in the subsurface. However, despite its downward aim, it also ends up being radiated in horizontal directions.

The back-scattered signals are registered by several groups of hydrophones mounted in cables towed behind the ship. The three possible methods that utilise this technology are known as 2-D, 3-D and 4-D. In 2-D operations, a single seismic cable or streamer is towed behind the survey vessel, together with a single sound source. This method is generally used today in frontier exploration areas, to produce a general understanding of the area's geological structure. A 3-D survey covers a specific area, generally with known geological targets. Simplistically, 3-D acquisition is the acquisition of many 2-D lines closely spaced over the area. 3-D surveys can take many months to complete. 4-D surveys, or so called 'Time Lapse' surveys, are 3-D surveys that are repeated over the same geographical area, but at different times. 4-D surveys are being used regularly on established fields to monitor fluid (oil and gas) movement during the field's production phase.[6]

In terms of decibels (dB), seismic airgun arrays have maximum noise levels at source in the 200 to 250 dB range. By comparison, open ocean ambient (normal) ocean noise ranges between 74 and 100 dBs, whilst supertankers moving at speeds of 20 to 23 knots generate noise in the 190-200 dB range. Additional tools known as 'sparkers' and/or 'boomers' are high frequency devices

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5 Brahic, C. (2008). 'Hearing the Carbon Jolt Loud and Clear'. *New Scientist* Sep 27, 10. Madsen P., et al. (2006). 'Quantitative Measures of Air-Gun Pulses Recorded on Sperm Whales Using Acoustic Tags'. 120 *J. Acoust. Soc. Am.* 2366–79.

6 See, generally, Caldwell, J. (2000). 'A Brief Overview of Seismic Airgun-Arrays'. 19(8) *The Leading Edge* 892–902. Dragoset, W. (1990). 'Airgun Array Specs: A Tutorial'. *Geophysics* 24–32. Parkes, G. & Hatton, L. (1986). *The Marine Seismic Source*. (Kluwer Academic Publishers, The Netherlands).

that are generally used to determine shallow features in sediments. Typical source levels from these tools are around 204 - 220 dB.[7]

By noting the time it takes for a reflection to arrive at a receiver, it is possible to estimate the depth of the feature that generated the reflection. In this way, reflection seismology is similar to sonar and echolocation. First and foremost, marine seismic surveys are central to the oil and gas industry, and have contributed substantially to the discovery and definition of new hydrocarbon reservoirs, as well as playing an integral role in defining the extent and directing the depletion of existing reservoirs. Seismic surveys are also used to gather data for governmental needs, such as mapping the continental shelf of countries, so they can apply for extensions to their Exclusive Economic Zones. In some instances, the use of such tools is nearly constant. For example, the Gulf of Mexico has the highest level of oil and gas exploration in the world, averaging about 25 offshore oil exploration crews in operation, conducting over 900 seismic surveys each year (in addition to the drilling over 100 oil wells). Other areas of particularly high seismic activitity include the North Sea, Nigeria, Brazil, Malaysia, Indonesia, India, the northwestern coast of Australia and Sakhalin Island (Russia).[8]

The early predecessors of seismic technologies were operative in the early 1920s. Although the technology of exploration activities has improved exponentially in the past few decades, the basic principles for acquiring seismic data have remained the same. Although the principles are the same, the technology has become much more advanced (in terms of the way the signals are read) and powerful (in terms of the way the signals are generated). For example, modern seismic signals, especially when generated at a lower frequency (within the 20 to 50 Hz bandwidth) may be received thousands of kilometres away from the source if spread in a sound channel.[9] Nevertheless, these developments remain a type of improvement on the earlier methods. That is, airguns only replaced the use of explosives as a sound source in the 1960s, with resultant reduced, short-term, damage to biodiversity. In time, completely different technological advances may eclipse the current airgun seismic methods, or refinements and efficiencies of the existing technologies may mean that more can be accomplished with much lower decibels of sound. Although some current seismic methods utilised in terrestrial environments do away with the unnecessary noise emissions, the same cannot be said for marine environments. In time,

7 DeRuiter, S., et al. (2006). 'Modeling Acoustic Propagation of Airgun Array Pulses'. 120 *J. Acoust. Soc. Am.* 4100–14. Bain, D.E., et al. (2006). 'Long-range Effects of Airgun Noise on Marine Mammals: Responses as a Function of Received Sound Level and Distance'. IWC-SC/58E35.

8 Hildebrand, J. (2009). 'Anthropogenic and Natural Sources of Ambient Noise in the Ocean'. 395 *Marine Ecology Progress Series* 5–20.

9 Nieukirk, S.L., et al. (2004). 'Low-Frequency Whale and Seismic Airgun Sounds Recorded from the Mid-Atlantic Ocean'. 115(4) J. Acoust. Soc. Am. 1832–43. Gedamke, J. (2010). 'Initial Quantification of Low Frequency Masking Potential of a Seismic Survey'. SC/62/E12.

technological developments which eclipse current methods are quite possible. It is, however, unlikely to be in the short term.[10]

3. The Impacts Upon Marine Species

The first study of the impact of ocean noise on marine biodiversity was conducted in 1971.[11] In the four decades since this point, a large collection of ad-hoc studies of the impacts of seismic noise on fish, and especially marine mammals, has been generated. The strong interest in the relationship between seismic noise and marine mammals is because the acoustic output of underwater seismic energy at relatively low frequencies of 10 to 200 Hz, overlaps extensively with the low frequency sound produced by baleen whales in the 12 to 500 Hz bandwidth. In general, this research has been conducted to test the generally accepted hypothesis that intense underwater sounds have the potential to induce a range of effects on marine mammals. Within these studies, the ranges of effects have spanned from negligible to fatal. At the fatal end , a few cases of beaked whale strandings appear to have coincided with seismic surveys. Indeed, the stranding of two Cuvier's beaked whales in the Gulf of California in 2002 coincided with seismic reflections. Likewise, three seismic surveys conducted off Brazil in 2002 may have been responsible for an increase in the stranding rate of adult humpback whales.[12] However, as it currently stands, there is no conclusive evidence of a link between sounds of seismic surveys and the direct mortality of any marine mammals. There is, however, a substantial amount of research which suggests that seismic surveys do create behavioural responses (in terms of avoidance reactions, such as change in abundance, change in direction, change in speed, as well as change in blow interval and dive time) abandonment of habitat and/or 'masking' or the obscuring of natural sounds. Such reactions are evident with a number of marine species including some (but by no means all) types of seals.[13] Similar behavioural changes in reaction to seismic noise are evident in some whale species, namely grey, bowhead, blue, sei and minke. Some species, like fin, appear to stop vocalisation across areas up to 10,000 nautical miles whilst seismic surveys are ongoing. Impacts upon the communication of some species, such as blue whales, which are

10 For a view of some of the options in this area, see Weilgart, L. (ed). *Alternative Technologies to Seismic Airgun Surveys for Oil and Gas Exploration and Their Potential for Reducing Impacts on Marine Mammals*. (Foundation for the Sea, Darmstadt).
11 See Payne, R. (1971). 'Orientation by Means of Long Range Acoustic Signaling in Baleen Whales'. 188 *Annual New York Academy of Sciences* 110–141.
12 Parsons, E. et al. (2007). 'The Conservation of British Cetaceans: A Review of Threats and Protections'. 13 *Journal of International Wildlife Law and Policy* 29–33. Nieukirk, S. (2004). 'Low Frequency Whale and Seismic Airgun Sounds Recorded in the Mid-Atlantic Ocean'. 115 *J. Acoust. Soc. Am.* 1832–1843. Malakoff, D (2002). Suit Ties Whale Deaths to Research Cruise. Science 298. Palacios. D., et al.. 2004. Cetacean Remains and Strandings in the Galápagos Islands, 1923-2003. 3(2) *Latin American Journal of Aquatic Mammals* 127–150. Mulqueen, E. (2000). 'Whale Strandings Due to Seismic Activity'. *The Irish Times* May 6, A2.
13 Kastelein, R.A. (2006). The Influence of Underwater Data Transmission Sounds on the Displacement Behaviour of Captive Harbour Seals'. 61 *Marine Environmental Research* 19–39. Bain, D., et al. (2006). Long-range Effects of Airgun Noise on Marine Mammals: Responses as a Function of Received Sound Level and Distance. IWC-SC/58E35.

known to emit sound in order to communicate over hundreds of miles, have also been observed.[14]

Despite the above findings, depending on the scale and proximity of the noise, some species such as male (unlike females) humpbacks, and some sperm whales reflect evidence of relative toleration of seismic sources.[15] Questions of whether biologically significant impacts of seismic surveys (following strong mitigation techniques) on highly endangered western grey whales have actually occurred have also been asked.[16] Mixed implications of reactions have been recorded for some small cetaceans, although, depending on the sound levels and proximity, some temporary avoidance behaviours are evident.[17]

Studies investigating sound-induced effects on the less charismatic species of the ocean, as well as being less numerous, are also variable. Nevertheless, preliminary evidence suggests behavioural responses among some species, such as turtles, including rising to the surface and altered swimming patterns, may be elicited with exposure to seismic signals. Evidence of strong behavioural reactions from squid (such as firing their ink sac, and possibly even stranding) to airgun sounds has also been demonstrated with squid showing an increase in alarm responses to seismic noise sources above 156 dB (rms).[18]

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14 OSPAR (2009). *Assessment of the Environmental Impact of Underwater Noise* (OSPAR Commission, Paris, Publication Number 436/2009) pp.34–36. Weilgart L.S. (2007) 'The Impacts of Anthropogenic Ocean Noise on Cetaceans and Implications for Management'. 85 *Canadian Journal of Zoology* 1091–1116. Clark, C., et al (2006). 'Considering the Temporal and Spatial Scales of Noise Exposures from Seismic Surveys on Baleen Whales'. Paper SC/58/E9. Richardson, W., et al. (1995). *Marine Mammals and Noise*. (Academic Press, California) pp.74–82. Myrberg, A. (1990). 'The Effects of Manmade Noise on the Behaviour of Marine Animals.' 16 Environment International. 575–86. Richardson, W. (1986). ' Reaction of Bowhead Whales to Seismic Exploration in the Canadian Beaufort Sea'. 79(4) *J. Acoust. Soc. Am.* 1117–28.

15 Koski, W., et al. (2009). 'An Update on Feeding by Bowhead Whales Near an Offshore Seismic Survey in the Central Beaufort Sea'. Paper SC/61/BRG3. Miller, P., et al. (2009). 'Using At-sea Experiments to Study the Effects of Airguns on the Foraging Behavior of Sperm Whales in the Gulf of Mexico'. 56 *Deep-Sea Research* 1168–81. Weir, C.R. (2008). 'Overt responses of humpback Whales, Sperm whales and Atlantic Spotted Dolphins to Seismic Exploration off Angola'. 34 *Aquatic Mammals* 71–83, 349–354. Wright A., et al. (2007) 'Do Marine Mammals Experience Stress Related to Anthropogenic Noise?' 20 *International Journal of Comparative Psychology* 274–316. Gordon, J, et al. (2006). 'An Investigation of Sperm Whale Headings and Surface Behaviour Before, During and After Seismic Line Changes in the Gulf of Mexico'. IWC SC/58/E45. Boebel, O., et al. (2005). 'Risks Posed to the Antarctic Marine Environment by Acoustic Instruments: A Structural Analysis'. 17(4) *Antarctic Science* 533–40. Madsen, P.T. (2005). 'Marine Mammals and Noise: Problems with Root Mean Square Sound Pressure Levels for Transients'. 117(6) *J. Acoust. Soc. Am*. 3952–57. Gordon, J., et al. (2004). 'The Effects of Seismic Surveys on Marine Mammals'. 37 *Marine Technology Society Journal*16–34. Madsen P.T., et al (2002). 'Male Sperm Whale Behaviour During Exposures to Distant Seismic Survey Pulses'. 28 (3) *Aquatic Mammals* 231–40. McCauley, R., et al. (1998) 'The Response of Humpback Whales to Offshore Seismic Survey Noise: Preliminary Results'. APPEA Journal 692–707.

16 Johnson S., et al. (2007) A Western Gray Whale Mitigation and Monitoring Program for a 3-D Seismic Survey, Sakhalin Island, Russia'. 134 *Environmental Monitoring and Assessment* 1–19. Yazvenko S.B., et al. (2007). 'Distribution and Abundance of Western Gray Whales During a Seismic Survey near Sakhalin Island, Russia'. 134 *Environmental Monitoring and Assessment* 45–73, 93–106. Gailey G., et al. (2007). 'Abundance, Behaviour, and Movement Patterns of Western Gray Whales in Relation to a 3-D Seismic Survey, Northeast Sakhalin Island, Russia'. 134 *Environmental Monitoring and Assessment* 75–91. Rutenko A.N., et al. (2007).'Calibrating and Monitoring the Western Gray Whale Mitigation Zone and Estimating Acoustic Transmission During a 3D Seismic Survey, Sakhalin Island, Russia'. 134 *Environmental Monitoring and Assessment* 21–44.

17 Lucke K., et al. (2008). 'Testing the Acoustic Tolerance of Harbour Porpoise Hearing for Impulsive Sounds'. 17 *Bioacoustics* 329–31. Stone C.J., et al. (2006). 'The Effects of Seismic Airguns on Cetaceans in UK Waters'. 8 *Journal of Cetacean Research and Management* 255–63.

18 Guerra, A., et al. (2004). 'A Review of Records of Giant Squid in the North-eastern Atlantic and Severe Injuries After Acoustic Exploration'. ICES Annual Science Conference. Paper CC: 29, ICES-Annual Science Conference. MacKenzie, D.

Very few studies have investigated the effects of anthropogenic sound on fish behaviour. Nothing is known about the long terms effects nor the cumulative effects of sound exposure on fish. Rather, what little is known relates to short term impacts in experimental settings. From this limited scholarship it appears that some species of fish, which are subject to a variety of different hearing systems and differences in physical conditions, appear to also be impacted upon by seismic surveys. Most fish species hear noise sounds from below 50 Hz up to 500 to 1500 Hz. A small number of species can detect sounds over 3 kHz, but this is very rare and only a few species can detect sounds over 100 kHz. If undue noise overlaps with the species' hearing band, especially if the noise is repeated and at at close range, extreme damage may result. Beyond such immediate impacts, there is added uncertainty with regards to behavioural results. This uncertainty relates to whether fish freeze and stay in place, are deafened (either permanently or temporarily), or try to flee an area. In terms of the last option, it appears that between 40 to 80% of some species of fish, such as cod, haddock, rockfish, herring, sand eel and blue whiting, will leave an area (for at least five days), within a radius of up to 25 miles, when exposed to seismic noise. This may be doubly problematic if fish that are on their way to the spawning grounds are exposed to this type of noise, or if they are exposed to the noise during the actual spawning, as the effects may have an impact on the fish's spawning success and thereby the recruitment.[19] Finally, there is a severe lack of data regarding the effects of sound on developing eggs and larvae. Nevertheless, evidence in this area suggests that many fish species in their early life stages are vulnerable. The survival rate of eggs and larvae of a number of fish species, when exposed to sound levels of 120 dB or above reflect statistically significant decreases. Some

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(2004). 'Seismic Surveys May Kill Giant Squid'. *New Scientist* September 22, 7. MacKenzie, D. (2004). 'Seismic Surveys Blamed for Giant Squid Deaths'. *New Scientist* October 2, 15.

19 Popper, A. (2009). 'The Effects of Human Generated Noise on Fish'. 4 *Integrative Zoology*. 43–52. Popper, A. (2006). 'The Effects of Anthropogenic Noise on Fish'. 28 *Fisheries* 24–31. . ICES Advisory Committee on Ecosystems (2005). 'Report of the Ad-hoc Group on the Impacts of Sonar on Cetaceans and Fish' (AGISC). ICES CM 2005/ACE:06 (2nd edn). Popper, A., et al. (2005). 'Effects of Exposure to Seismic Airgun Use on Hearing of Three Fish Species'. 117(6) *J. Acoust. Soc. Am*. 3958–71. Popper, A.N., et al. (2005). 'Effects of Low Frequency Active Sonar on Fish' 117 *J. Acoust. Soc. Am.* 2440. Popper, A.N., et al. (2004). 'Anthropogenic Sound: Effects on the Behavior and Physiology of Fishes' 37(4) *Marine Technology Soc. J.* 35–40. Hassel, A., et al. (2004). 'Influence of Seismic Shooting on the Lesser Sand Eel' 61 *ICES Journal of Marine Science* 1165–73. Smith, M., et al. (2003). 'Noise-induced Stress Response and Hearing Loss in Goldfish. The Journal of Experimental Biology. 207. Popper, A. (2003). 'Effects of Anthropogenic Sounds on Fishes'. 28(1) *Fisheries*24–31. Fewtrell, J., et al. (2003). 'High Intensity Anthropogenic Sound Damages Fish Ears'. 113(1) *J. Acoust. Soc. Am*. 638. McCauley, R. (2003). 'High Intensity Anthropogenic Sound Damages Fish Ears'. 113(1) *J. Acoust. Soc. Am.*. 631–42. Engas, A., et al. (1996). 'Effects of Seismic Shooting on Local Abundance and Catch Rates of Cod and Haddock'. 53 *Canadian Journal of Fish Aquatic Science*2238–49. Knudsen, F., et al. (1994). 'Avoidance Responses to Low Frequency Sound in Downstream Migrating Atlantic Salmon'. 45 *Journal of Fish Biology* 227. Pearson, W., et al. (1992). 'Effects of Sound from a Geophysical Survey Device on Behaviour of Captive Rockfish'. 49 (7) *Can. J. Fish. Aquat. Sci*. 1343–56. Skalski, J. R., et al. (1992). 'Effects of Sounds From a Geophysical Survey Device on Catch-per-unit-effort in a Hook-andLine Fishery for Rockfish'. 49 *Canadian Journal of Fisheries and Aquatic Sciences* 1357–65. Lagardere, J. (1982). 'The Effects of Noise on the Growth and Reproduction of Crangon Crangon'. 71 *Marine Biology*177. Blaxter, J., et al. (1981). 'Sound and Startle Response in Herring Shoals'. 61 *J. Mar. Biol.Ass. U.K.* 851–79. Knudsen, F.R, et al. (1992). 'Awareness Reactions and Avoidance Responses to Sound in Juvenile Atlantic Salmon'. 40 *Journal of Fish Biology* 523–34.

species, reflect a loss of around 0.3% per survey. Thus, in theory, the more surveys, the more loss. However, such contentions have been challenged.[20]

4. The Gaps in the Scientific Knowledge and the Call for Action

Against a background of such evidence, in 2010, the Secretariat of the Convention on Biological Diversity (CBD), in cooperation with governments, and relevant organisations, was instructed to compile and synthesise available scientific information on anthropogenic underwater noise and its impacts on marine and coastal biodiversity and habitats, for consideration at a future meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) as well as other relevant organisations prior to the eleventh meeting of the Conference of the Parties.[21]

The difficulty with this instruction from the CBD, is that despite the rapidly growing national, regional and international interest in oceanic noise pollution, there are a large number of scientific uncertainties with regard to the impacts of oceanic noise pollution upon the marine environment, which need to be addressed before internationally comprehensive policies can be implemented. This is particularly important, as the international law which governs the seas (the United Nations Convention on the Law of the Sea, UNCLOS) is clear that any standards developed to confront the problems of marine pollution, either individually or through the competent international organisations, must be based upon robust, publically available, scientific assessments and monitoring, which reveal the nature and extent of pollution, exposure to it, and its pathways, risks and remedies.[22]

The specific problem in the context of noise pollution of the oceans is that in addition to numerous academic studies, generic research gaps in this area of noise pollution and its impact on the marine environment have been identified by a number of national, regional and international bodies. In this regard, the International Council for the Exploration of the Sea (ICES)[23] and the 1994,[24] 2000[25], 2003[26] and 2005[27] reports of National Research Council (NRC)

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20 Blaxter, J., et al. (1985). 'The Development of Startle Responses in Herring Larvae'. 65 *J. Mar. Biol. Ass., U.K.* 737-50. Banner, A. (1973). 'Effects of Noise on Eggs and Larvae of Two Estuarine Fishes'. *Transactions of the American Fisheries Society* 134–36. Kostyuchenko, L.P. (1973). 'Effects of Elastic Waves Generated in Marine Seismic Prospecting of Fish Eggs in the Black Sea'. 9(5) *The Hydrobiology Journal* 45–48.

21 Decision X/13 (2010). New and Emerging Issues, paragraph 2(b). Note also Decision X/29 (2010) on Marine and Coastal Biodiversity, paragraph 12.

22 UNCLOS. Articles 200, 201, 204, 205 and 206.

23 Tasker, M., et al (2010). *The Marine Strategy Framework Directive: Task Group 11, Underwater Noise and Other Forms of Energy*. (ICES, Paris), pp.33–36. ICES Advisory Committee on Ecosystems (2005). *Report of the Ad-hoc Group on the Impacts of Sonar on Cetaceans and Fish* (AGISC). ICES CM 2005/ACE:06 (2nd Edn), pp.12–-23,47–49.

24 National Research Council(1994). *Low-Frequency Sound and Marine Mammals: Current Knowledge and Research Needs*. (National Research Council, Washington).

25 National Research Council (2000). *Marine Mammals and Low-Frequency Sound: Progress Since 1994*. (National Research Council, Washington).

26 National Research Council. (2003). *Potential Impacts of Ambient Noise in the Ocean on Marine Mammals* (National Academies Press, Washington)

27 National Research Council (2005). *Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Biologically Significant Effects*. (National Academies Press, Washington).

of the United States are notable.[28] Similar calls highlighting the scientific gaps in this area have been made by the specialist cetacean organisations that operate within international law, namely, the International Whaling Commission (IWC),[29] the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS)[30] and the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS).[31]

The overall difficulty that all of the above bodies have recognised is that behaviour of sound in the marine environment is complex. To begin to resolve some of these difficulties, the first step has to be for the creation and agreement of robust and transferable baseline data and analytical structures. Once agreed methodological frameworks are in place that can be consistently and comprehensively applied, the real research can begin. In this regard, much more needs to be known about the marine environment, and in particular, the key habitats (especially in terms of location of breeding, feeding and migration routes) of the species likely to be impacted upon by marine pollution. Finally, and perhaps most importantly, there is a lack of data for most oceanic species on the effects of sound on behaviour (including communication, foraging, migration, reproduction and predator avoidance), the biological significance (population-level effects) of these changes including long-term cumulative effects and synergisms with non-acoustic stressors. The scientific gaps are particularly acute when trying to establish when noise impacts become 'biologically significant'. That is, when would the noise induce long-term abandonment of an area important for feeding, breeding or rearing the young, leading to a reduction in fecundity, carrying capacity, or both. The primary question of what level is 'biologically significant' has not been resolved. The 2005 NRC report, added that, when trying to ascertain what were biologically significant impacts upon marine mammals from ocean noise, 'there was a consensus that we are a decade away or more away from having the data and understanding of the transfer functions needed to turn such a conceptual model into a functional, implementable tool'.[32]

Due to the gaps in the scientific understanding of a problem which may have large impacts upon the marine environment, there have been repeated official calls since the 1985 Marine Mammals:

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28 For other official reports, note the Marine Mammal Commission (2007). *Marine Mammals and Noise: A Sound Approach to Research and Management: A Report to Congress from the Marine Mammal Commission*. (MMC, Washington), pp.iii-iv. United States Commission on Ocean Policy (2005). *Ocean Blueprint for the 21st Century*. (National Technical Information Service, Washington), pp.315–16. Department of Fisheries and Oceans Canada (2004). *Review of Scientific Information on Impacts of Seismic Sound on Fish, Invertebrates, Marine Turtles and Marine Mammals* (DFO Canadian Science Advisory Secretariat. Habitat Status Report 2004/002).

29 Report of the Scientific Committee of the IWC. IWC/62/Rep 1.52. Also, IWC/56/Rep 1.Section 12.2.5.

30 See Resolution 2.16 (2004). 'Assessment And Impact Assessment Of Man-Made Noise'.

31 See Section 3 of Resolution No. 5. 'Effects of Noise and of Vessels. *Proceedings of the Fourth Meeting of the Parties to the ASCOBANs Convention*. (Esbjerg, 2003).

32 ICES Advisory Committee on Ecosystems (2005). Report of the Ad-hoc Group on the Impacts of Sonar on Cetaceans and Fish (AGISC). ICES CM 2005/ACE:06 (2nd Edn). , at 2, 10–13, 15–17, 36–38, National Research Council. (2005), at 3, 4. National Research Council. (2000), at 3,59; National Research Council. (2003), at 4–6.

Global Plan of Action from the United Nations Environment Programme to study this problem.[33] In coming decades these calls have become amplified. For example, the ICES was clear that 'as this is an international problem, there may be benefits to an international research effort'.[34] Likewise, the Scientific Committee of the IWC has recommended, *inter alia*, 'the integration and coordination of international research projects to study and describe acoustic ecologies' and the establishment of working groups to study specific scientific questions in this area.[35] In addition, the ACCOBAMs Parties have urged the 'facilitat[ion] of national and international researches' on a number of noise related scientific problems.[36] The European Parliament[37] and the United States have also both endorsed this approach. In particular, the latter, following recommendations by the NRC[38] has 'encouraged an international approach to advance scientific understanding of this issue and to promote science-based means of addressing adverse effects'.[39] A very similar call has also been evident within the United Nations since 2005, since when the General Assembly has annually recognised that noise is 'a potential threat to living marine organisms' and has affirmed 'the importance of sound scientific studies in addressing this matter, and *encourages* further research, studies and consideration of the impacts of ocean noise on marine living resources'.[40] In 2010, the General Assembly went further, and encouraged further studies in this area to be done by the Food and Agricultural Organization (FAO).[41]

5. The Committee on Fisheries (COFI).

Whilst the regional and international scientific investigations into the effects of seismic noise pollution upon cetaceans are already well under way within the bodies that have primacy in this area, namely the IWC, ASCOBANS and ACCOBAMS, the same cannot be said for other, non-cetacean, marine species.

The international body which needs to take the lead in the scientific investigation of the impact of noise pollution upon the marine environment, and fisheries in particular, is the Committee on Fisheries (COFI). The COFI is a subsidiary body of the Council of the Food and Agricultural Organization of the United Nations. It was established in 1965 and has consistently strived to secure the long-term sustainable development and utilisation of the world's fisheries (and aquaculture). The COFI is the only global inter-governmental forum where major international

33 UNEP (1985). *Marine Mammals Global Plan of Action*. (Regional Seas Programme, Number 55), p.17.
34 ICES Advisory Committee on Ecosystems (2005), p. 47.
35 Report of the Scientific Committee of the International Whaling Commission (2004), Section 12.2.5.
36 Resolution 2.16 (2004). 'Assessment And Impact Assessment Of Man-Made Noise'.
37 European Parliament Resolution on the Environmental Effects of High-Intensity Active Naval Sonars (2004). B6-0089/2004., Paragraph 5.
38 National Research Council (2000) at. 4, 7. National Research Council. (2003). Potential Impacts, at 7 and 11.
39 IUCN. Third Conservation Congress (2004, Thailand). RESWCC3.068. Resolution on 'Undersea Noise Pollution'. Congress reference: CGR3.RES053.Rev.1. Statement, attached to the end of the resolution.
40 This quote is from paragraph 186 of the 2010 Oceans Resolution: A/RES/65/37. For the earlier recognition of the same point, see paragraph 162 of the 2009 A/RES/64/71; paragraph 141 of the 2008 A/RES/63/111; paragraph 120 of the 2007 A/RES/62/215; paragraph 107 of the 2006 A/RES/61/222 and, paragraph 84 of the 2005 A/RES/60/30.
41 Paragraph 127 of the 2010 A/RES/65/38.

fisheries problems and issues are examined and recommendations addressed to governments, regional fishery bodies and a multitude of non-governmental organisations. These examinations occur as the COFI reviews the programmes of work of the FAO in the field of fisheries, conducts periodic general reviews of fishery problems of an international character and appraises such problems and their possible solutions.

This work is done in a supplementary way to existing international and regional laws and governing bodies which tend to be at the forefront of all related issues in this area. As such, the COFI is somewhat of a catalyst, from which studies, guidelines, plans of action and blueprints for conventions on matters related to fisheries evolve. This is especially so when the matters go directly to fishing practices impacting upon fisheries. Their foremost success in this area has been the FAO Code of Conduct for Responsible Fisheries.[42] This success is supplemented by the FAO International Plans of Action (IPOAs), which have been developed to deal with key thematic problems. The IPOAs are voluntary instruments, which reflect a soft form of international agreement, elaborated within the framework of the Code of Conduct for Responsible Fisheries. Four IPOAs have been developed to date. These cover the incidental catch of seabirds,[43] the conservation and management of sharks,[44] fishing capacity,[45] and illegal, unregulated and unreported fishing.[46] Guidelines on Deep Sea Species and Habitats[47] and bycatch[48] are also notable, as is their work on fisheries compliance issues. In this regard, their Compliance Agreement[49] and Model Scheme on Port Measures to Combat Illegal, Unreported and Unregulated Fishing[50] are particularly notable.[51]

All of the work of the COFI pertains to issues of which they can claim some control. That is, they do not seek primacy in any areas that are not directly related to the management of fisheries. This is not to suggest that they abstain from these areas they are not directly involved with if the acts of these areas have an impact on fisheries. Rather, they seek to supplement these areas, in a

42 FAO. The Code of Conduct for Responsible Fisheries. For an overview of this, see Hosch, G. (2009). 'An Analysis of the Implementation and Impact of the FAO Code of Conduct for Responsible Fisheries since 1995'. *FAO Fisheries and Aquaculture Circular* No. 1038. (FAO, Rome.).

43 FAO (1999). 'International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries'. Technical Note, Section 5. COFI (2009). 'Progress in the Implementation of the Code of Conduct for Responsible Fisheries', Related International Plans of Action and Strategy, 3.

44 'The International Plan of Action for the Conservation and Management of Sharks'. (FAO, Rome).

45 'The International Plan of Action for the Management of Fishing Capacity'. (FAO, Rome).

46 'The International Plan of Action to Prevent, Deter and Eliminate Illegal, Unregulated and Unreported Fishing'. (FAO, Rome).

47 FAO (2008). 'Technical Consultation on International Guidelines for the Management of Deep-Sea Fisheries in the High Seas'. *Fisheries and Aquaculture Report* No 881 (FAO, Rome). COFI (2009). 'Management of Deep Sea Fisheries in the High Seas'. COFI/2009/5/Rev.1.1.

48 Note, the bycatch ones were evolving at the time of writing. COFI (2009). 'Progress in the Implementation of the Code of Conduct for Responsible Fisheries', Related International Plans of Action and Strategy, 5. COFI (2009). 'Review of the 28th Session of the Committee of Fisheries'. FIEL/R902, Paragraph 72.

49 The 1993 Agreement to Promote Compliance With International Conservation and Management of Fishing Vessels on the High Seas.

50 'FAO Model Scheme on Port Measures to Combat Illegal, Unreported and Unregulated Fishing'. (FAO, Rome, 2007).

51 COFI (2007). Report of the 27th Session, p. xii.

supportive way, with the provision of information that may be of direct relevance to the other forums where the issues have precedence. For example, with the topic of climate change, the COFI, in 2009, suggested that that the FAO should adopt a scoping study to identify the key issues on climate change and fisheries and initiate a discussion on how the fishing industry can adapt to climate change. It was also recommended that the FAO take a lead in informing fishers and policy makers about the likely consequences of climate change for fisheries.[52] This exact same logic should apply to seismic noise pollution. That is, the FAO should adopt a scoping study to identify the key issues on noise pollution and fisheries and initiate a discussion on how the fishing industry can adapt to noise pollution. In addition, the FAO should take a lead in informing fishers and policy makers about the likely consequences of seismic noise pollution for fisheries. This analysis, collection and dissemination of information pertaining to the impact of seismic noise upon the marine environment, and fisheries in particular, is the fundamental step that is essential to be completed, before the international regulation of seismic noise can proceed.

6. The International Regulation of Seismic Noise

Despite the coalescing of the principles necessary to effectively regulate seismic noise pollution, there is no coalescing of the necessary institutional governance frameworks through which they can be regulated. Accordingly, it is falling to individual, species focused, conventions, which have offered guidelines (as noted above) to their signatories, along with calls for any seismic emissions occurring under their auspices, to be controlled. This approach is evident in regimes such as the Convention on Migratory Species,[53] the International Whaling Commission,[54] the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area[55] and the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas.[56] The European Parliament, while also issuing recommendations to control particular types of noise pollution, has called for the creation of a 'Multinational Task Force to develop international agreements regulating noise levels in the world's oceans, with a view to regulating and limiting the adverse impact of anthropogenic sonars on marine mammals and fish'.[57] Whilst all of these calls for potential regional and/or international regulation of seismic noise are a logical consequence of the development of prima facie evidence that a substantial problem may exist in this area, what is not logical is where this regional and/or international regulation should be placed, as there is no pre-existing international arrangement to deal with this type of pollutants.

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52 COFI (2009). 'Report of the 28th Session of the Committee of Fisheries'. FIEL/R902, Paragraph 84. Also, COFI (2009). 'Climate Change and Fisheries and Aquaculture'. COFI/2009/8.

53 Resolution 9.19. (2008). 'Adverse Anthropogenic Marine/Ocean Noise Impacts On Cetaceans and Other Biota'.

54 Resolution 1 (2004). 'The Western North Pacific Gray Whale'. IWC 56th Report, 2005, 66. Resolution 3 (2005). 'The Western North Pacific Gray Whale'. IWC/57/25.

55 Resolution 4.17. 'Guidelines to Address the Impact of Anthropocentric Noise on Cetaceans in the ACCOBAMS Area'. Also, Resolution 2.16. (2004). 'Assessment and Impact Assessment Of Man-Made Noise'.

56 Resolution No. 2 (2009). 'The Adverse Effects of Underwater Noise on Marine Mammals during Offshore Construction Activities for Renewable Energy Production'. Also, Resolution 5 (2003). 'Effects of Noise and of Vessels'.

57 'European Parliament Resolution on the Environmental Effects of High-Intensity Active Naval Sonars'. (2004). B6-0089/2004, Paragraph 6.

Although the COFI should be at the forefront of the scientific analysis of the impacts of noise pollution on the marine environment, and clearly be involved in the regulation of such noise pollution, the COFI is not the international body by which the regulation should evolve. Rather, this regulation has to develop out of the broad principles of the binding United Nations Convention on the Law of the Sea (UNCLOS), moreover, the UNCLOS provides the broad principles on how this should happen.

Section five of the UNCLOS deals with the International Rules and National Legislation to Prevent, Reduce and Control Pollution of the Marine Environment. This section sets down all of the fundamental rules from which pollution of the marine environment is dealt with, and the international community has responded accordingly. The recurring theme in all of these areas is that in addition to individual State responsibility to control their pollution of the marine environment, States should be working through appropriate competent regional and/or international organisations (if they exist) or establishing such organisations via diplomatic conference to global and regional rules, standards and recommended practices and procedures to prevent, reduce and control pollution of the marine environment. In three areas, the particular problems are dealt with via specific independent conventions whereby the Parties deal, in detail, with the specific pollutant. Thus, the areas of marine pollution which are identified by the UNCLOS, dealing with pollution by dumping[58] and pollution by vessels[59] are dealt with under the auspice of the International Maritime Organization. In the area of marine dumping, this has been dealt via the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes[60] and Other Matter and the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter.[61] The area of marine pollution has been dealt with under the International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978, and the associated annexes.[62] The third area, pollution from or through the atmosphere[63] is dealt with, indirectly, through the respective regimes on climatic change, ozone depletion and air pollution.[64]

A different, somewhat softer approach is evident with pollution of the ocean from land-based sources. The obligations on States to control this, especially through international organisations for the development of global rules, was clear within the UNCLOS.[65] However, rather than form a global instrument on the topic, the international community has dealt with the issue via the United Nations Environment Programme and their 1985 Guidelines for the Protection of the Marine Environment Against Pollution from Land-Based Sources,[66] and the successor document,

58 UNCLOS, article 210.
59 UNCLOS, article 211.
60 The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. 26 UST 2403.
61 The Protocol to the London Dumping Convention. 36 ILM (1997), 7.
62 Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships. 17 ILM (1978), 1546.
63 UNCLOS, article 212.
64 See Gillespie, A. (2006). *Climate Change, Ozone Depletion and Air Pollution: Legal Commentaries With Science and Policy Considerations*. (Nijoff, The Netherlands), chapters 10 to 15.
65 UNCLOS, article 207.
66 '1985 Montreal Guidelines for the Protection of the Marine Environment Against Pollution from Land-Based Sources'.

the 1995 Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities[67] (which was updated in 2001 and 2006).[68]

The last two areas of potential pollution sources within the UNCLOS that may need some control are those with regards to pollution coming from within 'the Area' and pollution from seabed activities subject to national jurisdiction.[69]

'The Area' is the place beyond the Exclusive Economic Zone and/or the continental shelf. The vast majority of the world's oceans exist in this space. All States and competent international organisations have the right, in conformity with the provisions of UNCLOS on the international seabed, to conduct marine scientific research in the Area[70] and/or the water column (the water between the surface and the bottom of the ocean) beyond the Exclusive Economic Zone.[71] In many regards, this research is encouraged as it is the hope of the Parties to the UNCLOS that this Area, the common heritage of mankind,[72] will be equitably developed.[73] Although all States are encouraged to utilise the opportunities that were created, the exploration and exploitation within the Area, is to be 'organized, carried out and controlled by the Authority on behalf of mankind as a whole'.[74]

With such activities in the Area, necessary measures to ensure effective protection for the marine environment and natural resources of the Area from 'harmful effects which may arise from such activities' must be adopted by the Authority.[75] In this regard, it is expected that international rules, regulations and procedures will be established in accordance with the UNCLOS to prevent, reduce and control pollution of the marine environment from activities in the Area. States which are also pursuing activities in the Area, are expected to also adopt supplementary rules to prevent, reduce and control pollution of the marine environment from activities in the Area undertaken by vessels, installations, structures and other devices flying their flag.[76] This focus is fully consistent with the strong emphasis the UNCLOS places upon cooperation and harmonised policies on a global basis and, as appropriate, on a regional basis, directly or through competent international organisations for the protection and preservation of the marine environment.[77]

The body which deals with the Area is the International Seabed Authority. Since its establishment in 1994, in all of its activities related to the administration and regulation of deep-seabed activities, the Authority has made environmental protection one of its considerations. This consideration is most evident with regard to the exploration and potential exploitation of the

67 'The Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities'. A/51/116 Annex II. Available from UNEP. 1995 6 YBIEL245.

68 The 2006 Intergovernmental Review Meeting on the Implementation of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities. Second Session. 2006, October 23. UNEP/GPA/IGR.2/7.

69 UNCLOS, article 208.

70 UNCLOS, article 256.

71 UNCLOS, article 257.

72 UNCLOS, article 136.

73 UNCLOS, article 150.

74 UNCLOS, article 153.

75 UNCLOS, article 145.

76 UNCLOS, article 209. Note also article 208.

77 UNCLOS, article 194 (1), 197 and 208 (5).

key marine minerals that exist beyond national territories, namely, polymetallic nodules, cobalt rich crusts and polymetallic massive sulphides. As it currently stands, this activity is in its infancy, in terms of exploration and exploitation. Nevertheless, it is clear that the prospecting and exploration for these marine minerals are similar in many ways to other oceanographic research, though with a focus on potential exploitation. Thus, although explorers for these marine minerals have refined and modified many procedures to fit their particular goals, their basic methods and backgrounds stem directly from the well-developed disciplines of geological, physical and biological oceanography, as commonly represented by seismic surveys. These techniques are initially employed to find the best mine sites and to map their extent. It is likely that these techniques will also have implications in terms of noise pollution. However, due to the restricted focus of the Authority at this point of history, only a small amount of jurisprudence on the protection of the environment exists. In this regard, in 2000, the Authority adopted its first rules in this area, with their Regulations on Prospecting and Exploration for Polymetallic Nodules, as part of their overall, and evolving, Mining Code.[78] In 2010, these regulations were joined by those covering polymetallic sulphides, and the hope is that in 2011 they will be joined by regulations for cobalt rich crusts. These regulations are binding on all entities that have contracted with the Authority to explore the Area for these minerals and have been followed since then by all of the contractors with the Authority.[79] The overall difficulty in this area is that although environmental considerations are a clear part of the consent process, noise is currently not part of their considerations. As such, if the goal of dealing with seismic noise *beyond* national jurisdictions is accepted, the International Seabed Authority is the first port of call.

If the goal is of dealing with seismic pollution generated from areas *within* national jurisdictions, the first port of call is the UNCLOS. The final area where the UNCLOS provides a pointer in dealing with pollution of the marine environment of significance, is with pollution from seabed activities subject to national jurisdiction.[80] It is under this realm that most seismic noise pollution is currently created, yet as it stands, . there are no specific international treaties, standards or laws that specifically address this topic.[81] Accordingly, it is necessary to return to the guidance of the UNCLOS as to how this area can be progressed. The starting point is the principle that coastal States are obliged to enact laws and regulations to prevent, reduce and control pollution of the marine environment arising from or in connection with seabed activities subject to their jurisdiction pursuant to the rules on exclusive economic zones and the continental shelf.[82] These rules, which should be harmonised, at the appropriate regional level, and be dealt with 'through competent international organizations or diplomatic conference' from which 'global and regional rules, standards and recommended practices and procedures to prevent, reduce and control pollution of the marine environment' should be developed.[83] Following from the precedents noted above, this may be via a specialised convention or more generic guidelines, such as those adopted through the United Nations Environment Programme for Land Based Pollution of the Marine Environment. It is likely that this route, via the UNEP, is the best approach, as a stepping

78 See the Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area (2000). (ISA, Jamaica).

79 International Seabed Authority (2004). *The Protection of the Seabed*. (ISA, Jamaica), pp.2–5.

80 UNCLOS, article 208.

81 Scott, K. (2004). 'The International Regulation of Undersea Noise'. 53 *International and Comparative Law Quarterly* 287–324. McCarthy, E. (2001). 'The International Regulation of Transboundary Pollutants: The Emerging Challenge of Ocean Noise'. 6 *Ocean and Coastal Law Journal* 257, 260.

82 UNCLOS, article 208 (1).

83 UNCLOS, article 208 (5).

stone, until further evidence is adduced to see if a dedicated convention is needed in this area. This is especially so if a wider based instrument is opted for, which covers other sources of noise pollution of the marine environment which need regulation, in addition to seismic sources.

7. The Mitigation Principles of Seismic Pollution

In the case of seismic pollution both within, or beyond, national boundaries, the principles to be applied in mitigation are relatively well developed and can be adduced from both the UNCLOS and existing State practice in this area. Both areas point to the same overall approach, namely, the mitigation – not the abolition – of the activity. The importance of mitigation, not abolition, within the UNCLOS is drawn out of somewhat of a paradox within the UNCLOS. The UNCLOS covers a remarkable array of topics. However, part of the problem of this wide diversity is that sometimes these topics do not always, prima facie, sit easily together. This imbalance is apparent with the right to conduct scientific research (of which seismic surveys clearly are) and the obligations to prevent pollution (of which resultant noise emissions are apparent).

On the one hand, the protection and preservation of the marine environment is a key part of the UNCLOS. The broad rule is that States shall take, individually or jointly as appropriate, 'all measures consistent with [the UNCLOS] that are necessary to prevent, reduce and control pollution of the marine environment (especially when dealing with activities that cause pollution beyond their own territory)[84] from any source, using for this purpose the best practicable means at their disposal and in accordance with their capabilities'.[85] Pollution, as defined within the UNCLOS includes, *inter alia*, 'the introduction by man, directly or indirectly, of ... energy into the marine environment'[86] clearly covers noise emissions. This coverage may also be inferred by the general directive for 'all'[87] sources of pollution of the marine environment to be 'minimize[d] to the fullest possible extent'.

On the other hand, the 'right' of States to conduct marine scientific research[88] is also an important part of the UNCLOS. All States and competent international organisations are expected to, individually and/or collectively, promote, facilitate and cooperate in scientific research of the oceans in general[89] and specifically within the scope of the Area (related to exploration and exploitation of the seabed beyond the Exclusive Economic Zone).[90] However, in both cases, this is not an absolute right. The general principle for such research in the context of this discussion, is that it must be conducted in compliance with all relevant regulations including 'those for the protection and preservation of the marine environment'.[91] Actions in contravention of the UNCLOS in respect of marine scientific research conducted by other States, or by

84 UNCLOS, article 194 (2).
85 UNCLOS, article 194 (1).
86 UNCLOS, article 1 (4).
87 UNCLOS, article 194 (3).
88 UNCLOS, article 238.
89 UNCLOS, articles 239, 242, 243, 244 and 255.
90 UNCLOS, article 143.
91 UNCLOS,article 240 (d).

competent international organisations, which damage the marine environment are expected to incur liability.[92]

When dealing with marine scientific research within the areas that are under the authority of the Coastal State, the UNCLOS is clear that Coastal States, in the exercise of their sovereignty, 'have the exclusive right to regulate, authorize and conduct marine scientific research in their territorial sea' (the belt of water that extends 12 nautical miles from the low tide mark). As such, marine scientific research in the territorial sea can be conducted only with the express consent of, and conditions if appropriate, set forth by the Coastal State.[93] Within the Exclusive Economic Zone and on the continental shelf, the same rule applies, with the consent of the coastal State to conduct such research being uppermost.[94] However, under normal circumstances, it is assumed that the Coastal State will consent to marine scientific research carried out by other States or competent international organisations (who must provide full information about their intended scientific projects)[95] in the EEZ or on their continental shelf, if the object is 'exclusively for peaceful purposes and in order to increase scientific knowledge of the marine environment for the benefit of all mankind'.[96] However, Coastal States may make their consent to such research conditional,[97] or may refuse the project in full. The consent may be refused if the research is of direct significance for the exploration and exploitation of natural resources, whether living or non-living[98] or, in the only indirect reference to noise pollution in the UNCLOS, uses explosives (which were the preferred method of seismic testing before the popularity of airguns).[99] In terms of possible mitigation options that may be considered within the area of scientific research, the UNCLOS recognises the idea of, *inter alia*, safety zones[100]and warning signals.[101]

Although the UNCLOS gave some broad indications of what methods may be utilised to help mitigate the impacts of seismic noise pollution, the real options in this area only began to develop nearly a decade after the UNCLOS was concluded. Since this point, a clear range of options to mitigate the impacts of seismic noise have developed, from which broad considerations can now be adduced from a few regional guidelines and a much broader collection of national standards.[102] In many regards, these are positive developments, as most of these responses are congregating around the same eight considerations. The difficulty is that

92 UNCLOS,article 263.
93 UNCLOS, article 245.
94 UNCLOS, article 246 (1) and (2).
95 UNCLOS, article 248.
96 UNCLOS, article 246 (3).
97 UNCLOS, article 249. Note also article 253 for the possibility of suspension if conditions are breached.
98 UNCLOS, article 246 (1).
99 UNCLOS, article 246 (2).
100 UNCLOS, article 260.
101 UNCLOS, article 262.
102 For a discussion of these, see Blue Planet Marine (2010). 'Review of Seismic Guidelines and Reference Document: Discussion Paper Prepared for Department of Conservation'. Document Reference No. BPM-10-DOC-DP-v1.0. (BPM, Canberra). OSPAR (2009). *Overview of the Impacts of Anthropogenic Underwater Sound in the Marine Environment*. (OSPAR, Paris), p.1419. OSPAR Commission (2009). *Assessment of the Environmental Impact of Underwater Noise*. (OPSAR, Biodiversity Series, Paris), pp.4, 5, 24–25. Weir, C., et al. (2007). 'Comparative Review of the Regional Marine Mammal Mitigation Guidelines Implemented During Industrial Seismic Surveys'. 10 *Journal of Wildlife Law and Policy* 1–16. Castellote, M. (2007). 'General Review of Protocols and Guidelines for Minimizing Acoustic Disturbance to Marine Mammals from Seismic Surveys'. 10 *Journal of International Wildlife Law and Policy* 273–88. McCauley, R., et al. (2006). 'Marine Seismic Mitigation Measures'. IWC SC/58/E44. Joint Nature Conservation Committee (2004). *Guidelines for Minimising Acoustic Disturbance to Marine Mammals from Seismic Surveys*. (JNCC, Aberdeen).

there is a multitude of different ways to apply the same eight considerations. Accordingly, one of the primary tasks of any international and/or regional body that was tasked to create regulation in this area, would be to reach agreement on exactly how each principle would be applied.

The first agreed principle in this area is that there should be guidelines to mitigate against the potentially harmful impacts of seismic noise. The debate is whether they should be voluntary or mandatory. The second principle is that species which are threatened by seismic noise pollution should be protected from such noise. The first question in this area is, which are these species: are they whales, marine mammals, fish, other marine species, or those which are endangered or/and juvenile? The second question is how seriously this obligation is taken at the beginning, namely, are environmental impact assessments prior to activities being undertaken? For example, within the United Kingdom, it is a legal requirement that new oil and gas developments cannot proceed until an environmental impact assessment has taken place.

The third principle, building on the second, is that the best way to secure the protection of threatened species is via ensuring that certain areas are prohibited to seismic surveys. The basis of this principle is that the most effective mitigation measures are geographical and seasonal restrictions which completely avoid the ensonification of the habitats where protected species feed, breed and/or migrate. In regard to this, some countries, such as Brazil and Australia, have placed certain marine protected areas ‘off limits’ for any seismic testing at any time. Other countries, such as Norway, have imposed seasonal restrictions on seismic surveys, which may be imposed in specific areas or included in license conditions. Thus, prior to each seismic survey the Norwegian Institute of Marine Research must do a biological evaluation and recommendation. The questions around the third principle are due to the fact that marine protected areas are vastly underrepresented locally, regionally and globally. As such, in most instances, it is likely that an area will not be declared categorically ‘off limits’. Accordingly, pre-survey identification may help locate particular habitats where listed species may be expected to be present, and caution is necessary. The options in this area are whether pre-survey identification work (in areas where there are no marine protected areas) is required before a survey is undertaken or not.

Given that there are very few permanent protected areas whereby seismic testing is completely prohibited, the more common way to regulate the activity is via the fourth principle, which is the creation of temporary buffer or safety zones around seismic operations. These are frequently defined as circular areas which remain around a sound source. If protected animals are located in the buffer zone, the operations cease until the animal exits the area. Animals outside this zone are presumed not to be exposed to harmful levels of sound. The first question in this area is the radius of buffer/safety zones. Some countries adopt relatively small buffer zones of 500 metres whilst others adopt buffer zones of up to 4 kilometres for critically endangered species. The second questions concern the amount of time required for the shut-down and the geographical range of the shut-down zones (with precedents also ranging from 500 metres to four kilometres).

For buffer zones to effectively work, a fifth principle is recognised. Specifically, although some species of animals which are impacted upon by seismic noise are usually not visible above the water and are thus difficult to detect (such as beaked whales), it is still necessary to have visual surveillance of the buffer zones by specialist marine mammal observers. These observers scan the zone before and during the period of the survey. The questions with regards to observers pertain to their training, independence, application (in terms of timing), placement (some countries require aerial as well as vessel platforms for observers) and the numbers of observers required per survey. The size of the buffer zone may also necessitate additional observers on support vessels, so that a greater range of view is achieved. For example, in the case of the critically endangered western grey whale which was resident off Sakhalin Island, Russia, two observers were present on the seismic vessel and these people were supplemented by two support vessels, which each contained 3 observers. One support vessel was positioned 4 kilometres shoreward (and closer to the gray whale feeding area) of the seismic vessel to provide better visual coverage of the 4 kilometre exclusion zone and to help define the 4 kilometre edge of the zone. The second support vessel was positioned near the seismic vessel. Further questions relate to times of low visibility, especially at night. That is, whilst most nations require continuous visual observation during daylight hours, the same rule is not always applied in times of poor visibility or at night. In these situations, the ideal (although not all species are vocal or make detectable noise) is supplemental acoustic monitoring, as well as radar and infrared scanning. The questions in this situation is whether seismic surveys can be done in periods of low visibility at all, and if they are permitted, whether acoustic monitoring is required? Some countries, like Australia, only allow operations in low visibility if acoustic monitoring is utilised, *and* only if three or fewer whale-instigated remedial actions have occurred in the previous 24 hours.

The sixth principle is that seismic operations should start slowly so that animals can leave the area before the operations reach capacity. This principle is known as ‘soft starts’ or ‘ramp ups’. The aim of soft start or ramp-up is the gradual increase in sound from an array (either by starting from a single gun and adding elements sequentially, or by gradually increasing the power output). The soft start is designed to give animals the opportunity to leave the survey area before ‘operational’ sound levels are reached. The questions in this area are twofold. First, for how long a soft start should be employed, with most guidelines ranging between 20 to 60 minutes before full power is reached and a survey line commenced. Second, is a soft-start/ramp-up required for a change of direction of surveying? The difficulty here is there is evidence that under some circumstances the practice of firing a single gun during a line turn may in fact be an attractant to some marine species and therefore not a deterrent. As such, some countries require a complete shut down before a change of direction, appropriate surveys, and then a soft-start/ramp up technique.

The seventh principle is that seismic noise operations should aim to use the minimum of noise necessary to successfully achieve their work. The background to this is that seismic survey processes can be fine tuned in a number of ways. These include the targeting of airguns, the timing of the surveys and their frequency and duration. In particular, surveys should not be unnecessarily repeated and concurrent operations should be avoided. One of the most notable options that is being used by some (but not all) countries with regards to the overall limits in noise is the setting of limits on source levels used during seismic surveys, and/or requesting the use of lowest practicable power levels, so as to avoid unnecessarily high emissions of noise. In some instances, the limits are actually imposed. For example, with Sakhalin Island a maximum 163 dB re 1μPa received sound level (the limit which 90% of the whales were believed to tolerate before leaving the area) was applied.

The eighth principle is that all seismic operations should have a careful reporting of their activities. Thus, most nations identify the need for accurate and complete reporting (sightings forms and summary report) within reasonable timeframes. The questions in this area pertain to whether reports are required, what the reports should contain, and whether this information should be placed in centralised, transparent, databases which reveal all sightings from all seismic surveys.

8. Conclusion

The exploration of the ocean for the valuable elements of nature, be they oil and gas reserves or marine minerals, is an activity which has been occurring for many decades. However, both the scale and methods of this activity have increased rapidly in recent years, and can be expected to expand even more in coming decades as the exploitation of these resources becomes increasingly attractive in economic terms. The difficulty is that the primary method utilised in this exploration is seismic surveys. These surveys, which are effective at mapping the potential of the various elements beneath the ocean, may also be effective at having detrimental impacts upon many species within the ocean. Prima facie evidence would suggest that this is likely with a number of marine mammals, and possible with a number of fish species. However, the full extent of these impacts is a matter of debate, and in need of resolution at the appropriate international levels. Whilst questions of cetaceans and noise pollution are already being resolved by bodies such as the International Whaling Commission and the cetacean Agreements of the Convention on Migratory Species, the only body that can answer these questions for fish – the Committee on Fisheries of the Food and Agriculture Organisation of the United Nations – has yet to engage in this area.

Once the scientific issues have been resolved, the question of which institution to manage this problem comes into play. Under the guidance of the United Nations Convention on the Law of the Sea, it is clear that this answer falls into two parts. The first part deals with marine pollution caused in areas beyond sovereign control. This type of pollution will have to be managed by the International Seabed Authority of the United Nations. However, at the moment, the Seabed Authority has shown no interest in this area. This will need to be rectified in the future. The second part deals with marine pollution caused in areas within sovereign control. In accordance with the UNCLOS, the way that this can be dealt with is either via a dedicated treaty to the topic (such as with marine pollution from vessels), or via agreed guidelines which can be reviewed at appropriate intervals (such as with marine pollution from land based sources). Whilst the first option has evolved largely under the tutelage of the International Maritime Organization, the latter has evolved under the guidance of the United Nations Environment Programme. Given the nature of this problem, and the respective mandates of both the IMO and UNEP, it is likely that UNEP is better suited to this task, although this may have to be a cooperative endeavour with other organisations.

The broad principles that need to be applied to mitigate seismic noise pollution, either inside or outside of areas of common control, are already in existence. The foremost principle is mitigation, not abolition, of this source of pollution. This principle can be adduced by the high value that the law of the sea places on both marine exploration and the protection of the environment. Specific supplemental principles that are already common include, *inter alia*, identification of species and areas to be protected, and for areas which are not protected but still hold protected species, buffer zones, visual identification and rules for slow starts and changes of direction. Although these broad principles are already in existence there is considerable variation in the way that each principle may be applied. These variations can only be reconciled if a global instrument is created from which the recognition of the problem could be achieved, and common positions and understandings could be undertaken.