Practical cumulative impact management

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ABSTRACT

Mounting development of coastal and offshore areas is expanding and intensifying the human pressure on the marine environment. Major contributors to this are the current push for offshore renewable energy sources as more climate-friendly sources of power are sought and the continuation of demand for petroleum. Human disturbance, including the noise almost ubiquitously associated human activity, is likely to increase the incidence, magnitude and duration of adverse effects on marine life, including stress responses. These have the potential to induce fitness consequences for individuals, which in turn can lead to consequences at the population level. This is all in addition to more defined impacts of human activities, such as bycatch or directed hunting. While efforts are on-going to quantify the cumulative impacts of the aggregate of human actions on marine species or populations, regulators face the challenge of managing these accumulating and interacting impacts with little scientific guidance. However, we consider that the introduction of a regular cycle for applications for project authorisation provides a management structure that offers an opportunity to address cumulative impacts in the interim, while data collection moves forward. Here we discuss a number of management options available in such a framework (and some beyond) that would help limit, if not reduce, cumulative impacts of multiple human activities on marine species. These simple management steps may also form the basis of a rudimentary form of marine spatial planning and could be used in support of wider ecosystem-based management.

Keywords: Conservation, Stress, Noise.

INTRODUCTION

Mounting human development of coastal and offshore regions is altering the marine environment in a number of ways. These diverse activities, including commercial shipping, oil and gas exploration and extraction, dredging, fishing, hunting and the building of bridges, windfarms and constructions, bring a variety of threats and pressures into marine ecosystems, ranging from physical disturbance to chemical pollution, as well as noise pollution. For marine mammals, these impacts notably include 'directed takes' (including subsistence hunting, commercial and scientific whaling and killings to prevent damage to property, e.g., fishing gear, self-defence or due to perceived competition with fisheries), 'incidental takes' (such as resulting from ship-strikes and bycatch), toxic loading (including bioaccumulation of PCBs), reduced foraging options (through reduced prey availability as a consequence of fisheries activity, potential alterations of food webs, or other factors) and noise exposure (including behavioural avoidance and masking).

Most recently, interest in developing offshore renewable energy sources promises to bring additional and, in some cases, new pressures into the marine environment. With regards to cetaceans and other marine mammals, these new developments will bring increased noise exposure, both during construction and operation, and possibly also increased entanglement and impact risks (with particular consideration of anchoring systems and turbines respectively).

In addition to the more direct impacts, human disturbance in general has also been demonstrated to have important energetic consequences (e.g., Williams et al., 2006), as well as to cause behaviourally-disconnected physiological responses in various species, including through fear and/or alarm responses (e.g., Beale and Monaghan, 2004a; Götz and Janik, 2011). Noise exposure in particular has been shown to affect levels of cortisol, the main mammalian stress hormone, in one study involving captive beluga and bottlenose dolphins (Romano et al., 2004). Noise has also been implicated more recently in increasing cortisol levels in a wild cetacean (Rosalind et al., 2012). From research in other species, including humans, it can be seen that indirect impacts arising from fear and stress responses can have far-reaching fitness implications, such as increased mortality risk and reduced reproductive output (e.g., Beale and Monaghan, 2004a, 2004b; Clark and Stansfeld, 2007; Passchier-Vermeer and Passchier-Vermeer, 2000; Preisser et al., 2004; see also discussion in MMC 2007; Wright et al., 2007a, 2007b and references therein). In mammals, cross-generational impacts can also be induced through maternal exposure at certain times in pregnancy and lactation (see Romero, 2004; Romero and Butler, 2007).

Due to the myriad human impacts on the marine environment, including the large potential for the damaging consequences of aggregated chronic stress responses, managers in many parts of the world are now trying to deal with the spectre of cumulative impacts. Accordingly, a number of new tools are being proposed and developed to help assess the overall impact of multiple threat exposures (e.g., the Population Consequences of Acoustic Disturbance, PCAD, model: NRC 2005; the stepped impact models discussed in Wright, 2011, etc.). However, none of these are yet available as management tools and all currently require considerable data, which is not yet available in many cases. Despite this, managers in various parts of the world are mandated to find some way to identify, quantify and ultimately mitigate these cumulative impacts.

In this paper, we offer some suggestions for management actions that could be implemented to mitigate and minimise cumulative impacts from multiple human activities. Some may have been discussed or presented elsewhere previously and we seek no credit for the formation of the following ideas. We merely seek to present them collectively. All can improve, or at least reduce the worsening of, the situation for species or populations in the face of growing exposure to human activities, although the precise extent of benefits from the various options may be unquantified. Although many of the following suggestions can be applied to any human activity, we specifically consider the development of offshore renewable energy capacity. However, we hope that these options may help managers of various human activities meet their legislative mandates while more detailed management tools are developed.

MANAGEMENT CYCLES

One of the simplest ways for managers to assess the cumulative impact of a number of projects is to review them at the same time well in advance of the proposed activities. This can be achieved very effectively by instituting management cycles, where applications for proposed human activity in a given management area must be submitted by a specific deadline so that they can all be considered simultaneously. While it could be argued that this type of management framework is detrimental to those proposing the activities (e.g., industry) as it restricts their flexibility, it is not unprecedented. For example, the Greenland Bureau of Minerals and Petroleum, which is the licensing body for offshore oil and gas exploration and production, has put an annual application cycle into place for seismic surveys in the Greenlandic economic exclusive zone (EEZ) area.

Not only does this type of management cycle present managers with the opportunity to begin to address cumulative impacts by assessing multiple proposed projects simultaneously, but it also has other benefits. For example, it is also possible for management agencies to request that companies intending to submit applications for project approvals co-operate to produce one comprehensive environmental impact assessment (EIA) between them or at least by cooperating on the chapters regarding the locations and extent of activities and their potential impacts. For example, several companies could build a joint noise exposure model of the combined activities (as was suggested by the National Centre for Environment and Energy, Aarhus University and now enforced in the approval cycle for seismic surveys in the Greenlandic EEZ (see Kyhn et al., 2011 and also http://www.bmp.gl/petroleum/approval-of-activities/offshore). Collaboration could also be mandated for conducting impact studies or more widespread monitoring. This not only clearly outlines the total proposed additional impact to the region, but also saves the management agency time and resources reviewing (or producing themselves) numerous management documents. We thus highly recommend the use of management cycles for major human activities in the marine environment, including not only oil and gas exploration and extraction, but also the construction of renewable energy installations. In particular, simultaneous project consideration may be of particular use in assessing and facilitating the rapid development of offshore renewable energies currently underway in Europe and likely to spread elsewhere. It should also provide regulators with a mechanism for simultaneously comparing proposed mitigation from different applicants to ensure that best available technology and practise are used by all companies.

MINIMISING EXPOSURE

Although not a new concept, we consider it again worth-while to note that lower exposure rates and levels are inherently less impactful than higher ones. Thus, early planning (and EIA) can facilitate avoiding exposure of particularly sensitive marine species when possible, avoid exposure of sensitive individuals or at sensitive time periods when total avoidance cannot be achieved or, at the very least, minimise exposure. This may be particularly of use in selecting the location of renewable energy installations, as well as the scheduling of high-impact construction periods currently required for windfarms. (It should be noted that due consideration must still be given to the acoustic footprint of the activity to avoid impacts entirely, rather than simply its physical location, see Wright et al., 2011.)

Also noted elsewhere previously, the impact from exposure cannot be assessed through the monitoring of behavioural reactions as non-responsive individuals may be: (1) already more compromised than those who react freely; (2) reacting in unobserved ways; (3) unable or unwilling to react; or (4) have learned to be tolerant of the disturbance. As a consequence these individuals may ultimately be subjected to higher rates of levels of disturbance and thus suffer a greater impact than those reacting in an overt manner (e.g., Beale and Monaghan, 2004b; Williams et al., 2006; see also discussion of habituation and tolerance in Bejder et al., 2009; Wright and Kuczaj, 2007; Wright et al., 2007a, 2007b).

CROSS-COMPANY COLLABORATION

As alluded to above, management cycles may be used to facilitate cross-company collaboration and evaluation. This may be embodied in various forms, but perhaps one of the most useful is the creation of joint exposure models in EIAs for all disturbing projects in the area (noise, fishing, dredging, etc.). Effects of individual projects cannot be effectively evaluated on a linear scale, where the increase in potential effects is directly proportional to the number of projects in an area in (e.g., the environmental impacts of the presence of four similar projects is directly equivalent to four times the impact of a single project). Instead quantitative models (or at least qualitative assessments) taking account of different aspects of all the proposed projects may better combine and highlight the individual and cumulative risks for the environment. By combining all the impacts in one model the industry itself can reflect on and prioritise different potential mitigation actions to reduce cumulative effects before submitting the EIA, rather than being enforced with specific mitigation demands by regulators at a later point in the application process. This methodology may therefore add a new element of freedom into the industry’s planning stage, in addition to making it easier for the management to assess the cumulative effects. This approach can only be applied by first enforcing a joint application deadline well in advance of the projects, making it possible for the industry to prepare the model.

Similarly, cross-company mitigation measures can also be implemented. For example, this allows the institution of periods without activity (e.g., silence) if required. Likewise, concurrent area access to different parts of an area can also be achieved (e.g., taking turns to seismic survey in an area to reduce external noise and allow for lower source levels), while simultaneously ensuring that other areas of important habitat are left undisturbed so that animals may then always find refuge. It should, however, be noted that there are several assumptions underlying the effectiveness of this joint mitigation: (1) that the different parts of an area are of equal importance to the species of interest (or to the fauna in the ecosystem in general, depending on the management goal), (2) that animals will perceive the disturbance as a threat and respond appropriately by avoidance (see Beale, 2007); and (3) that animals are willing to move from one part of the habitat to another (see Lusseau, 2003; Lusseau and Bejder, 2007).

ZERO-SUM MANAGEMENT

It is possible to consider the current level of impact from human activities to be the maximum that shall be allowed. This type of ‘zero-sum’ management means that no additional impact can be added to a population or region and that the impact of any new activity must be offset with a reduction in the impact from on-going activities. Zero-sum management may be especially useful (or even necessary) for declining populations, which by definition can be assumed to already be over-taxed, meaning that any additional impact can only deteriorate the situation further.

It would also be appropriate here to consider data deficient populations to also be in decline to meet typical precautionary management standards. Furthermore, similar consideration should be given to small remnant populations that are not yet ‘recovered’ from the extensive impacts of earlier human activities (e.g., many mysticetes and other intensely hunted populations). In this case, zero-sum management will prevent their recovery from being slowed to a rate lower than it is currently. Finally, zero-sum management could also be applied to more healthy populations facing multiple threats to avoid sending them into decline, which would be entirely possible if impact assessments or applied mitigation measures are incorrect or inefficient. Zero-sum management of more healthy populations would also limit the potential for the emergence of dangerous synergisms, especially in the face of the many changes expected with a changing climate.

Such a management regime has the advantage that it inherently must consider and account for the current level of fishing and other currently established human activities in the area. Likewise, it will provide constant incentive, especially in expanding industries, to reduce their impact on the environment to reduce any constraints upon them by the introduction of other industries or projects.

In order to achieve a zero-sum management structure for wildlife populations, some combination of the following (and probably also other) measures could be used.

1) A reduction in the level of any existing directed take in the population. This will not reduce the impacts of any new human disruption, but will instead ensure a higher survival rate in the population in general. Consequently, even if full extent of this mitigation measure is unknown, there will undoubtedly be more animals remaining in the population after the reductions than would otherwise have been. Likewise, larger reductions in directed takes will reduce the overall cumulative impacts of the combined old and new actions more than smaller ones.
2) A reduction in the levels of other activities that have incidental impacts on the population of concern, such as fishing (e.g., to reduce bycatch) or other construction or development (e.g., to reduce total noise exposure and/or habitat loss). Although this may be especially important during high-disturbance periods (e.g., construction of a windfarm), it would also be appropriate to offset long-term operation and maintenance impacts. As above, large reduction better than small reduction, better than no reduction.
3) The implementation of 'fallow' (and by implication also 'sacrificial') years for certain, or all activities, to allow for undisturbed reproductive cycles for the population of concern between high-disturbance periods. It may be that paired fallow years are required to encompass an entire reproductive period, from conception to birth and early development.
4) An increased requirement for undertaking baseline monitoring and controlled impact studies prior to permitting new activities in an area, which would assist in the allocation of authorised levels of impact to the various industries and activities.

A hypothetical example related to marine mammals could be a coastal area with the continuously on-going commercial fishing and dredging, where co-occurring applications for windfarm construction have been submitted. Potential mitigation measures could be to: (1) severely reduce or ban fishing and dredging at the time of the windfarm construction throughout the area; (2) allow fishing and dredging to take place *within* a given radius from the construction site, where that radius is based on noise exposure levels from the construction (assuming that marine mammals will avoid the area with noise exposure above a given noise level anyway); or (3) reduce the level of fishing on a permanent basis and limit dredging and windfarm construction to every third year. The first option would directly offset fishing and dredging against windfarm construction (only), the second measure will result in nearby areas without disturbances, thereby minimising the size of the overall exposed area and the third possibility institutes years protected from noise while offsetting the impacts of this (and continuing windfarm access and operation) against a reduction in fisheries impact to the ecosystem (including both prey abundance and bycatch).

FACILITATING FUTURE MANAGEMENT

Management agencies should require, at a very minimum, that those undertaking development projects collect data to determine the extent of the exposure resulting from their project (e.g., the amount of acoustic output, habitat loss or modification, chemical introduction, etc.) and, to the greatest extent possible, the consequences of their actions for the populations or habitats of interest. The latter may also require that basic biological research is undertaken initially. Publication of the data, in one form or another, should also be required to allow for public dissemination of the results as well as facilitate inclusion of the information into subsequent management decisions. This can be considered part of a long-term process to assess and reduce cumulative impacts on marine ecosystems, especially if monitoring occurs before, during and after any short-term disruptions, or is on-going for an extended period through the operation of new facilities.

CONCLUSIONS

We consider it possible to manage cumulative impacts, at least to some extent, in the absence of full information regarding the population, the extent of exposure to human activities, or the extent of the consequences of that exposure. One very useful tool for this is the application cycle, which can then be utilised to foster cross-company cooperation at all stages of their projects, from application and impact assessment to project completion and impact monitoring. This type of system offers many benefits to both the regulators and the ecosystems they are responsible for and has already been successfully implemented by at least one management body. There are also some benefits to industry as well, through the sharing of EIA costs, etc. In addition to this framework shift, additional measures are available to minimise cumulative human impact on marine species or the environment. Despite the fact that some of the above-mentioned management options may not be popular with all interest groups, they represent options that will unarguably reduce overall cumulative impact in one way or another. There is no scientific support for their lack of use, especially in the management of declining, data-deficient and substantially reduced populations. Failure to utilise them must thus be seen as a politically-based decision and not a scientifically-based one. Finally, the abovementioned steps may well form a basic marine spatial planning structure, which could be further developed and extended to become part of a wider ecosystem-based management.

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