Agenda Item 4.7 Review of New Information on Threats to Small Cetaceans

Emerging Issues

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Practical management of cumulative anthropogenic impacts with working marine examples

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Conservation Biology

Essay

Practical management of cumulative anthropogenic impacts with working marine examples

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Abstract: *Human pressure on the environment is expanding and intensifying, especially in coastal and offshore areas. Major contributors to this are the current push for offshore renewable energy sources, which are thought of as environmentally friendly sources of power, as well as the continued demand for petroleum. Human disturbances, including the noise almost ubiquitously associated with human activity, are likely to increase the incidence, magnitude, and duration of adverse effects on marine life, including stress responses. Stress responses have the potential to induce fitness consequences for individuals, which add to more obvious directed takes (e.g., hunting or fishing) to increase the overall population-level impact. To meet the requirements of marine spatial planning and ecosystem-based management, many efforts are ongoing to quantify the cumulative impacts of all human actions on marine species or populations. Meanwhile, regulators face the challenge of managing these accumulating and interacting impacts with limited scientific guidance. We believe there is scientific support for capping the level of impact for (at a minimum) populations in decline or with unknown statuses. This cap on impact can be facilitated through implementation of regular application cycles for project authorization or improved programmatic and aggregated impact assessments that simultaneously consider multiple projects. Cross-company collaborations and a better incorporation of uncertainty into decision making could also help limit, if not reduce, cumulative impacts of multiple human activities. These simple management steps may also form the basis of a rudimentary form of marine spatial planning and could be used in support of future ecosystem-based management efforts.*

Keywords: cumulative impact assessment, marine, noise, offshore wind farm, renewable energy, seismic survey

Ejemplos Funcionales del Manejo Práctico del Impacto Acumulativo en la Conservación de Mamíferos Marinos

Resumen: *La presión humana sobre el ambiente se está expandiendo e intensificando, especialmente en las áreas costeras y de litoral. Los principales contribuyentes a esto son el impulso para tener fuentes de energía renovable en el litoral, las cuales se consideran como fuentes de energía amigables con el ambiente, y la demanda continua de petróleo. La perturbación humana, incluido el ruido que se asocia globalmente con la actividad humana, probablemente aumente la incidencia, magnitud y duración de los efectos adversos sobre la vida marina, incluyendo a las respuestas de estrés. Estas respuestas tienen el potencial de inducir consecuencias de adaptación para los individuos, lo que se añade a problemas más obvios y directos (es decir, la caza o la pesca) que incrementan impacto general a nivel de población. Para cumplir con los requerimientos de planeación espacial marina y manejo con base en ecosistemas, actualmente se llevan a cabo muchos esfuerzos para cuantificar los impactos acumulativos de todas las acciones humanas sobre las especies o poblaciones marinas. Mientras tanto, los reguladores enfrentan el reto de manejar con poca guía científica estos impactos que interactúan y son acumulables. Creemos que hay apoyo científico para nivelar (a un mínimo) el nivel de impacto para las poblaciones en declinación o con estados desconocidos. Esta nivelación puede facilitarse por medio de la implementación de ciclos regulares de aplicación para la autorización de proyectos o evaluaciones de impacto programadas y agregadas que consideren simultáneamente proyectos*

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Paper submitted April 16, 2014; revised manuscript accepted August 11, 2014.

Conservation Biology, Volume 29, No. 2, 333–340

DOI: 10.1111/cobi.12425

múltiples. La colaboración entre compañías y una mejor incorporación de la incertidumbre al proceso de toma de decisiones también puede ayudar a limitar, sino es que a reducir, los impactos acumulativos de múltiples actividades humana. Estos pasos sencillos de manejo también pueden formar la base de una forma rudimentaria de planeación espacial marina y puede usarse como apoyo para esfuerzos futuros de manejo basado en ecosistemas.

Palabras Clave: censo sísmico, energía renovable, evaluación de impacto acumulativo, granja eólica de litoral, marino, ruido

Introduction

In the marine environment, human activity takes many forms, including commercial shipping, oil and gas exploration and extraction, dredging, fishing, hunting, and construction of, for example, bridges and wind farms. These actions introduce numerous threats and pressures into marine ecosystems, from physical disturbance to chemical and noise pollution. Lawmakers around the world acknowledge the collective impact of human activity on the environment by requiring that managers undertake cumulative impact assessments (CIAs) before authorizing many activities.

This process is not simple. It involves more than merely adding up the total impact of all activities because interactions may lead to a greater (or lesser) overall impact. Although effective quantitative tools are being developed to help managers undertake thorough CIAs, these are not yet widely available. This has left managers with little guidance in the interim. Despite this, they must continue to make decisions regarding additional actions that will add to the number and types of anthropogenic pressures present in the environment, such as the development of new offshore energy sources (mineral and renewable) and the increased human presence in the opening Arctic. Complicating matters further, climatic changes are likely to be altering ecosystem properties (such as temperature and primary productivity) and thus the distribution and quality of habitat for wildlife (e.g., MacLeod 2009; Kaschner et al. 2011).

Ecosystem-based management and marine spatial planning may offer solutions. However, full implementation of these data-hungry processes may also require political paradigm shifts (Slocombe 1998). Consequently, political inaction typically occurs while scientific studies are undertaken to fill data gaps. We believe that, despite the various complexities and unknowns, several scientifically supported management actions can be immediately taken to limit and reduce the cumulative impact of human activities on the environment. Here, we sought to provide a brief outline of the problem of cumulative impacts and offer general suggestions for management actions that could be quickly implemented under disparate legal frameworks to reduce the total impact of human activity. We focused specifically on marine mammals and noise due to our particular expertise in this area and because these species have heightened protection in many parts of the world. Furthermore, as (typically) top predators, their populations may reflect environmental degradation faster than others (e.g., they are keystone and sentinel species [Bowen 1997; Sergio et al. 2008]). We do not provide specific implementation details because these will vary between countries and legal frameworks. Accordingly, much of the guidance we offer can also be applied to terrestrial ecosystems.

Cumulative Impacts and Their Management

Impacts on marine mammals can be categorized as directed take, incidental take, injury, and disturbance. Directed takes include subsistence hunting; commercial and scientific whaling; and killings to prevent damage to property (e.g., fishing gear), in self-defense, or due to perceived competition with fisheries. Incidental takes may also occur; they result from ship strikes, bycatch, and other human–animal interactions (e.g., exposure to underwater detonations). Surviving these events can result in injuries. Injury may also result from high-level noise exposure or toxic loading and bioaccumulation. Disturbance arises in various ways, including attempts by wildlife to avoid human activities and the obscuring of sounds of interest, known as masking, that can still occur at lower level noise exposures.

Indirect fitness impacts may also exist. Some of these are reasonably well understood and generally accepted by scientists and managers, such as those related to reduced prey availability that may result, for example, from overfishing (Moore 2013). However, scientific understanding of other indirect fitness impacts is in its infancy, including those arising from disturbance and minor injuries. For example, under certain conditions, disturbance can have important energetic consequences (e.g., Williams et al. 2006*a*) or cause behavioral reactions associated with potentially disproportionate physiological responses, including fear and alarm responses (e.g., Beale & Monaghan 2004*b*; Götz & Janik 2011). Similarly, levels of blood cortisol, the main mammalian stress hormone, have been shown to be affected by noise exposure in captive beluga whales (*Delphinapterus leucas*) and bottlenose dolphins (*Tursiops truncatus*) (Romano et al. 2004). Increased fecal cortisol levels were also seen in

North Atlantic right whales (*Eubalaena glacialis*), most likely in relation to exposure to shipping noise (Rolland et al. 2012). Fear and stress responses can, in other species, including humans, have far-reaching fitness implications, such as increased mortality risk and reduced reproductive output (e.g., Passchier-Vermeer & Passchier 2000; Beale & Monaghan 2004*a*; Preisser et al. 2005; Clark & Stansfeld 2007). Maternal exposure at certain times in pregnancy and lactation may even lead to cross-generational impacts (see Romero 2004; Romero & Butler 2007).

Lethal impacts aggregate in an additive manner in terms of a simple body count, although actual total mortality likely exceeds observed totals (Laist 1996; Williams et al. 2011; Peltier et al. 2012). In contrast, nonlethal impacts influence the behavior and fitness of animals in disparate ways that can interact. For example, each impact may contribute to the overall stress response and psychological state (e.g., cognitive bias) of the animal (e.g., Wright et al. 2007*a*, 2007*b*). Additionally, certain impacts may combine in nonlinear ways (e.g., Crain et al. 2008) or lead to emergent consequences that would not be present otherwise. For instance, marine mammals are exposed to numerous contaminants, many of which are stored in their blubber. However, at times of need, such as during pregnancy, lactation, or starvation, they metabolize this stored fat, unwittingly dosing themselves (or their offspring) with the contaminants at susceptible times (e.g., Routti et al. 2010; Sonne 2010). Similarly, exposures to novel sounds can lead to maladaptive behavioral responses that may place individuals at greater risk of interaction with other human activities (e.g., Nowacek et al. 2004). Anthropogenic noise may also distract cetaceans, making them less likely to detect fishing nets and more susceptible to bycatch (Wright et al. 2013).

New tools under development may help unravel these interactions and assess their consequences and the overall impact of multiple threat exposures. One example of such tools is the population consequences of disturbance (PCoD) model framework (e.g., New et al. 2013). Another is the more conceptual stepped impact model outlined by participants at a 2009 workshop on the subject (Wright 2009). None of the proposed new tools are functional for generalized management uses and all require considerable data, which is also not yet available in many cases.

Thus, a need exists for practical guidance for mitigating and minimizing cumulative impacts from multiple human activities that can be applied in the disparate legal frameworks for management actions around the world. Accordingly, we present a set of ideas that can be generalized for use across management frameworks. Although the extent of benefit remains unquantified, all the following can improve, or at least reduce the worsening of, the situation for species or populations in the face of growing exposure to human activities. We hope these options will help managers of various human activities meet their legislative mandates while more detailed management tools are being developed.

Minimizing Exposure

Exposure of wildlife to human activities at lower rates (e.g., incidence and duty cycles) and levels (e.g., toxic concentrations and noise levels) inherently has less impact than exposure at higher rates and levels. Early planning and environmental impact assessment (EIA) can reduce the exposure of a given species or at least the exposure of particularly sensitive individuals during sensitive periods if total avoidance cannot be achieved. This early planning approach may be particularly useful for selecting locations for wind farms, given the relatively high-impact construction periods and likely comparatively low-impact operations (IWC SC 2012; Petruny et al. 2014). Although such ideas are controversial, sitting navigation-inhibiting wind farms in areas seasonally inhabited by animals may offer a development-friendly way to separate marine mammals from more persistent threats (Petruny et al. 2014), including shipping noise, ship strikes, and the risk of oil spills (e.g., Williams et al. 2009; Williams & O'Hara 2010). Wind farms and other permanent structures may also prevent trawling, potentially leading to higher food concentrations and therefore serving to some extent as protected areas. To minimize impacts from any activity (no matter how transient) to the maximum extent possible, potential consequences that extend beyond the physical location of that activity, such as the drifting of an oil spill or the overall acoustic footprint (e.g., Wright et al. 2011), must be considered.

Impact from disturbance cannot be assessed merely by monitoring behavioral reactions because individuals perceived to be nonresponsive may be more compromised than those who respond early and quickly; may be reacting in unobserved ways; may be unable or unwilling to react; or may have learned to be more tolerant of the disturbance. Consequently, these so-called nonresponsive animals may ultimately be subjected to higher levels of disturbance and thus be more affected than animals reacting in an overt manner (e.g., Beale & Monaghan 2004*b*; Williams et al. 2006*a*; Wright & Kuczaj 2007; Bejder et al. 2009).

Management Cycles

One of the simplest ways for managers to improve assessments of, and thus more efficiently limit, the cumulative impacts of numerous projects is to review them collectively and well in advance of the proposed activities so that they can be revised if necessary. This can be achieved very effectively by instituting management cycles, wherein proposals for human activity in any given management area must be submitted by a specific deadline so they can all be considered simultaneously. Although it could be argued that such cycles are detrimental to those proposing the activities (e.g., industry) because they restrict flexibility, precedent does exist. For example, the licensing body for offshore oil and gas exploration and production in Greenland (the Bureau of Minerals and Petroleum) has instituted an annual application cycle for seismic surveys in the Greenlandic Economic Exclusive Zone. Similarly, the U.S. National Marine Fisheries Service set an application deadline for all researchers planning research on Steller sea lions (*Eumetopias jubatus*) to allow assessment of aggregate impacts in the Steller Sea Lion and Northern Fur Seal Research: Final Programmatic Environmental Impact Statement (NMFS 2007).

Beyond facilitating CIAs, management cycles also make it possible for management agencies to request that companies intending to submit applications cooperate to produce one aggregated EIA among them, or at least to provide a joint overview of the locations and extent of activities and their potential impacts. For example, companies planning seismic surveys in overlapping areas of the Greenland EEZ are obliged to produce a single noise exposure model (Kyhn et al. 2011; see also http://www.bmp.gl/petroleum/approval-of-activities/offshore). Such requirements not only facilitate CIA, but also save management agencies time and resources reviewing (or producing themselves) numerous management documents. Side-by-side comparisons of proposals and mitigations also give regulators a mechanism to ensure that the best available technology and practices are planned for use by all companies. Additionally, collective assessments and models might benefit industry in terms of reduced EIA production costs.

We thus highly recommend the use of management cycles for all regulated human activities in the marine environment. Simultaneous project consideration may be of particular use in assessing and facilitating the rapid development of offshore renewable energies currently underway in Europe, in planning stages in the United States, and likely to spread elsewhere.

Cross-Company Collaboration

Cross-company collaboration has benefits for CIAs beyond integrated exposure modeling. Overall impact is not directly proportional to the number of projects in an area (e.g., 4 similar projects do not simply have 4 times the impact of a single project). Thus, the combined effects of multiple projects cannot be effectively evaluated on a linear scale. Instead quantitative models (or at least qualitative assessments) accounting for different aspects of all proposed projects may better evaluate individual and cumulative environmental risks. By combining all potential impacts in a single assessment early in the planning process, industry itself can reflect on and prioritize different potential mitigation actions. This would allow them to reduce likely cumulative effects before submitting applications to the regulators, rather than face specific mitigation demands at a later point in the application process. Such collaborations may therefore give industry a new element of freedom in the planning stages, in addition to making CIAs easier for management. However, such collaboration is only likely to arise if joint application deadlines are well in advance of project schedules.

Regardless of management cycles, regulators, or even industry, can still implement cross-company mitigation measures for activities occurring in one area at the same time. For example, short periods without activity (e.g., silence) could, if beneficial, be established within the combined period of activity. Alternatively, access to specific areas could be controlled to limit the intensity of local impacts. In this way important habitats might be left undisturbed to provide mobile animals refuge, perhaps at the price of a longer presence in the wider region (e.g., sequential rather than concurrent seismic survey to limit peak noise levels). Several presumptions underlie the effectiveness of such area-based mitigation: different parts of the region are equally important to the species of interest (or the combined fauna of the ecosystem, depending on the management goal); animals perceive the disturbance as a threat and respond appropriately by avoidance (Beale 2007); and animals willingly move from one part of their habitat to another. Crucially, these presumptions are not always found to be true in reality (e.g., Lusseau 2003; Beale 2007; Lusseau & Bejder 2007). Accordingly, great caution is required in the widespread application of avoidance-based mitigations in general.

In contrast, one mitigation measure that would work to reduce cross-company impacts in any situation is a requirement at either the leasing or permitting stages that all seismic survey data be made public. Although this would be unpopular with corporations due to perceived proprietary rights to information regarding public areas, this would eliminate the need for duplicative surveys by competitive companies and thus reduce overall impacts.

Zero-Sum Management

Regardless of the use of management cycles, environmental damage could be limited if the current level of impact from human activities was considered the maximum allowable (i.e., additional activity would not be permitted until impacts were reduced). This type of zero-sum management means that no additional impact can be added to a population or region and that impacts of any new activity must be offset by a reduction in impacts from ongoing activities. Zero-sum management may be especially useful or even necessary for declining populations, which by definition are already overtaxed by the combination of all human activities and natural events, meaning additional impacts can only make the situation worse. However, given that such continuing population declines are typically due to current impact levels, a reduction in overall impact to some point below current levels may be required to ultimately prevent extinction.

It would also be appropriate to consider data-deficient populations to be in decline to meet generally precautionary management standards. Similar accommodations 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). Here zero-sum management should prevent slowing of recoveries. Finally, zero-sum management could also be applied to more healthy populations facing multiple threats to avoid sending them into decline, which might occur if impact assessments or applied mitigation measures are incorrect or inefficient. Zero-sum management of relatively healthy populations would also limit the potential for dangerous synergies to emerge, especially given the many changes expected under climate change.

Such a management regime has the advantage that it inherently must consider and account for the current level of fishing and other established human activities in the area. Likewise, it will also provide constant incentive for industries to reduce their environmental impacts. For example, industries planning expansion in a region would need to reduce the impact of each existing project if additional projects are to be allowed (all else being equal). Similarly, developing techniques with lower impacts would reduce the needs of managers to curtail industry activities to offset impacts from another stakeholder entering the area. However, it is important that measures be implemented to offset long-term operation and maintenance impacts arising from the presence of offshore facilities, in addition to measures to limit the often larger impacts associated with construction and decommissioning phases.

The creation of a commercial cap-and-trade system for authorized takes (lethal or nonlethal) would be one way to achieve a zero-sum management structure for wildlife populations. Regardless of how it is achieved, zero-sum management of a population might require a reduction in existing directed takes (e.g., hunting) or in the scale of activities that have incidental impacts (e.g., fishing to reduce bycatch) because these reductions would inarguably also reduce cumulative impacts. It also follows that a large reduction is better than a small reduction, which in turn is better than no reduction at all.

Another possible tool would be the implementation of fallow (and by implication also sacrificial) years for certain, or all, activities to allow for undisturbed reproduction of the population of concern. It may be that at least 2 consecutive fallow years are required to encompass an entire reproductive period in some species, from mating through birth and early development to weaning. However, this approach may not be sufficient for maintaining species subject to directed lethal takes, such as fish stocks (Williams et al. 2006*b*). Finally, zero-sum management might encourage baseline monitoring and controlled impact studies prior to planning new activities in an area, which would improve the allocation of impact levels among the various industries.

In a hypothetical example, several wind farm projects are planned for a coastal area where marine mammals already face continuous commercial fishing and dredging. There are 3 potential zero-sum management options. First, severely reduce or ban fishing and dredging throughout the area during construction. Second, allow fishing and dredging to take place in the region, but only within a given radius from the current construction site, where that radius is based on noise exposure levels from the construction (assuming marine mammals will avoid the area with noise exposure above a given noise level). Third, reduce the level of fishing on a permanent basis and limiting dredging and wind farm construction to every third year. The first option would directly offset fishing and dredging against wind farm construction. The second measure would produce nearby areas without disturbances, thereby minimizing the overall exposed area. The third measure primarily protects the area from noise exposure for 2 out of every 3 years. However, this option also offsets the ongoing impacts of wind farm access and operation through a reduction in the ongoing fisheries impact to the ecosystem (both in terms of bycatch and effects on prey abundance).

One potential issue with the second option is that it relies heavily on the untested presumption that marine mammals will avoid areas with certain levels of sound exposures. Regardless, it remains expected that densities in the exposed area will be lower than elsewhere (Tougaard et al. 2009; Wright 2014).

Uncertainty Built into Thresholds

One issue related to zero-sum management is the need to accept that the extent of any impact is likely underestimated, regardless of how it is measured (e.g., Wobeser 1994). Thus, any take limits set exactly to the calculated maximum number of takes sustainable for a given population will almost certainly result in impacts that are not sustainable. This is a particular problem for marine mammals because large uncertainties result from our limited ability to observe impacts on these animals, even in terms of simply counting dead bodies (Laist 1996; Williams et al. 2011; Peltier et al. 2012). Similarly, a nonlethal impact onset threshold will likely either under- or overestimate the level of impact for a given individual due to natural variation. Furthermore, basing such thresholds on population mean values is inappropriate because it results in 50% of the population being overexposed.

The need for integrating uncertainty into management has been realized and directly incorporated into the calculation of the maximum number of allowable marine mammal bycatch takes for fisheries, known as the potential biological removal (PBR) in the United States (Wade 1998; Taylor et al. 2000). This integration is achieved by multiplying the minimum (not best) population estimate by half of the maximum theoretical population growth rate to calculate the number of animals that could be removed while maintaining a sustainable population (Taylor & Wade 2000). The result is then multiplied by an adjustment factor (known as a recovery factor) ranging from 0.1 to 1.0 based on the perceived level of risk to the population and data availability and coverage. Such precautionary mechanisms transparently limit the allowable level of mortality (in this case from fisheries bycatch) to a lower level than would be calculated using the best estimates alone. Accordingly, even if PBR is reached, the level of take is, in theory, almost certain to be low enough to still allow growth in any otherwise healthy population.

Although this may not be true, given the issues with observing takes (e.g., Williams et al. [2011] estimated that actual mortality from the BP Deep Horizon spill was 50 times greater than the observed levels), the concept itself has merit. This is especially true if nonlethal takes from other industries (NRC 2005, but note Wright 2006) and changes to carrying capacity (see Moore 2013) can be incorporated into the calculation. Quantitative methods for incorporating uncertainty into targets, rather than limits or thresholds, for fishing quotas has also been proposed for, but not yet incorporated into, management (e.g., Caddy & McGarvey 1996; Prager et al. 2003). In contrast, many other thresholds, such as those related to exposure to noise, have been based on best estimates with no accounting for either natural variation or uncertainty in observing, identifying, assessing, and quantifying responses. In this case and in the face of incomplete knowledge, it may be prudent to use, for example, 50% of the energy contained in the level of sound at the lower confidence interval for the onset of temporary threshold shift (TTS) in hearing as the official threshold for inception of TTS in any given species. Although not ensuring certainty, such an adjustment would increase the likelihood that even thresholds based on relatively small sample sizes will be low enough to be representative of the most sensitive individuals.

Facilitating Future Management

Management agencies should require, at a very minimum, that those undertaking development projects collect data to determine the extent to which the ecosystem will be altered (e.g., acoustic, chemical introductions, habitat loss, etc.) and, to the greatest extent possible, the likely resulting impacts (preferably over the long term). Determination of effects may require that basic biological research be undertaken prior to the activity. Publication of the data, in one form or another, should also be required to allow for public dissemination of the results and to facilitate inclusion of the information into subsequent management decisions and EIAs. This can be considered part of a long-term process to assess and reduce cumulative human impacts. One limited example of this is the Greenlandic requirement for seismic survey companies to validate their noise models through in-field measures and report the results to the authorities (Kyhn et al. 2011).

Summary

It is possible to manage cumulative impacts, at least to some extent, in the absence of full information on a population, the extent of a population's exposure to human activities, or the nature and magnitude of the consequences for the population of that exposure. An example of how this could be achieved even under the complicated U.S. legal structure is outlined in Supporting Information.

In particular, we strongly recommend that immediate management action be taken to cap and preferably reduce the level of take for any species currently known to be in decline or with an unknown population status. We consider the application cycle to be one very useful tool for achieving this goal because it may also foster cross-company cooperation at all stages of their projects, from application and aggregated impact assessment to project completion and impact monitoring. This type of system has already been successfully implemented by at least one authority and it offers many benefits to both ecosystems and their custodian managers. There are also some benefits to industry through the sharing of EIA costs, reduced uncertainty in the management regime, fewer delays related to assessment of cumulative impacts by regulators, etc. However, many of the other measures we presented to minimize cumulative human impacts on species or the environment should work under any management framework.

Although some of the above-mentioned management options may not be popular with all interest groups, they represent options that will unarguably reduce, or at least limit, 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 use them must thus be seen as a politically based decision and not a scientifically based one. Finally, the above-mentioned steps may in combination form a rudimentary marine spatial planning structure, which could be further developed and extended to become part of a wider ecosystem-based management plan in the future.

Acknowledgments

We thank J. Tougaard, A. Mosbech, S. Young, and 2 anonymous reviewers for their input on earlier versions of this manuscript. This manuscript was produced without funding, although expenses to present these concepts at an International Whaling Commission Scientific Committee meeting by A.J.W. were partially covered by OceanCare.

Supporting Information

An example of how to manage cumulative impacts in the absence of full information on the biology of a population, the extent of a population's exposure to human activities, and the nature and magnitude of the consequences for the exposed population is available on-line (Appendix S1). The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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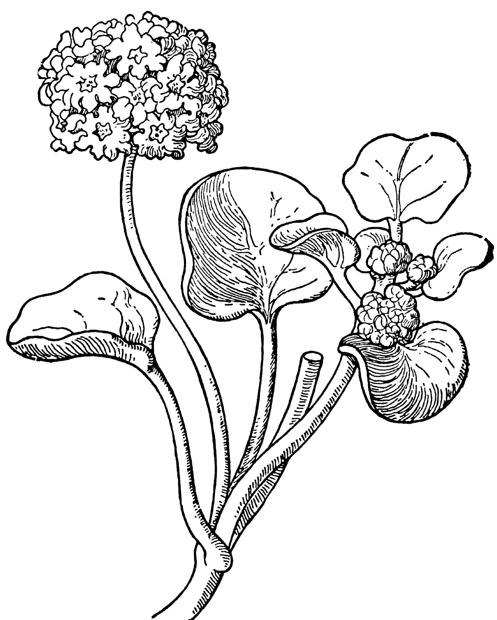

Practical management of cumulative anthropogenic impacts with working marine examples – Supplemental Material

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FLIGHTS OF FANTASY?

It might be argued that management cycles, zero-sum management and many of the specific approaches discussed in the main paper (Wright & Kyhn, 2014) are unrealistic, especially in complicated legal frameworks, such as that found in the US, where legislation is mixed across federal, state and local levels. In fact, we believe that the contrary is true, at least in that particular case. We submit that all the necessary legislative tools are already in place in the US to implement many of the above mechanisms.

The core of this is the fact that, with the notable exception of fisheries, all entities seeking to conduct an activity that may impact marine mammal (or other threatened or endangered species) must apply for authorisation for impacts (in terms of the number of individuals, called 'takes'), or risk legal repercussions if impacts actually occur (under the Marine Mammal Protection Act, MMPA 1972, and the Endangered Species Act, ESA 1973). The act of take authorisation is a federal action that initiates the US National Environmental Policy Act (NEPA 1969), and therefore usually requires preparation of an environmental assessment or environmental impact statement, including an assessment of cumulative impacts (NEPA 1969). Authorisations have a lifetime of a maximum five years, meaning that impact assessment under the MMPA-NEPA combination already has a cyclical nature.

The same agencies (U.S. National Marine Fisheries Service and the U.S. Fish and Wildlife Service) that are obliged to conduct environmental impact assessments (EIAs) and cumulative impact assessments (CIAs) under NEPA are also mandated to take steps to ensure recovery of listed species under the ESA. They are also required to assess the status and extent of fishing-related mortalities for marine mammal populations before recalculating PBR annually (within Stock Assessment Reports) under the MMPA. This can be done because, while fisheries enjoy an exemption from such authorisation under the MMPA (provided certain conditions are met), they instead have (among other things) a requirement to report marine mammal bycatch to the afore-mentioned agencies. If the potential biological removal (PBR) is exceeded, take reduction teams must be put together to come up with take reduction plans outlining actions to bring incidental bycatch below PBR once again and ultimately to a rate of zero. Any regulatory process (resulting from this or other origins) for enacting no-take marine protected areas or establishing annual fishing quotas are also federal actions that also requires impact assessment under NEPA.

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Accordingly, the results of CIAs under NEPA could easily be fed back into the assessments of status. They could also be considered when setting the level of take 'available' to other activities, with a maximum (the zero-sum line) of PBR, even if a formal incorporation of sub-lethal impacts into the calculation is not yet undertaken. It can be argued that only fisheries should be able to legally exceed PBR temporarily under the MMPA, without detrimental effects on the ability of a population to reach or maintain its optimum sustainable population.

In comparison to the legislative machinery already in place, only relatively small changes would be needed to institute a zero-management policy. Firstly, take reduction teams would be needed whenever PBR is exceeded, regardless of the source. Next, sub-lethal impacts would need to be included in the calculation of PBR. Finally, if a formal management cycle is not put into place, it would be necessary to allow for PBR to be temporarily exceeded if a new industry wishes to take action in an area, only on the condition that reductions to the levels of take authorised to existing industries take place in their next 'natural' assessment cycle. The necessary public scoping period under NEPA would give existing industries the opportunity to discuss these reductions. Additionally, the entry of a new industry into an area could also be interpreted as 'significant new information', which is a legislative trigger for revisiting affected EIAs under NEPA.

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