Marine No Net Loss

A feasibility assessment of implementing no net loss of biodiversity in the sea

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UNEP WCMC

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Cover Photo
Sunlight falls on a sunstar underneath a canopy of a healthy kelp forest in Monterey Bay, California © Ethan Daniels

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ABNJ	Areas beyond national jurisdiction
APEI	Area of Particular Environmental Interest
BAU	Business as usual
BBOP	Business and Biodiversity Offsets Programme
CBD	Convention on Biological Diversity
CCC	California Coastal Commission
CCZ	Clarion-Clipperton Fracture Zone
CZMAI	Belize Coastal Zone Management Authority and Institute
DFO	Fisheries and Oceans Canada
DMC	Decision Making Committee
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EPBC	Environment Protection and Biodiversity Conservation Act
EU	European Union
EUNIS	European Nature Information System
FAD	Fish aggregation device
FAO	Food and Agriculture Organisation
GBRWHA	Great Barrier Reef World Heritage Area
HADD	Harmful alteration, disruption, and destruction
HEA	Habitat Equivalency Analysis
ICM	Integrated coastal management
ICMM	International Council on Mining and Metals
IEEP	Institute for European Environmental Policy
IFC	International Finance Corporation
IGEM	Inter-Governmental Environmental Meta-database
IMR	Impact Mitigation Regulation
INFOMAR	Integrated Mapping For the Sustainable Development of Ireland's Marine Resource
ISA	International Seabed Authority
IUCN	International Union for Conservation of Nature
MAREMAP	Marine Environmental Mapping Programme
MRC	Marine Review Committee
MSP	Marine Spatial Planning
NGO	Non-Governmental Organisation
NPI	Net positive impact
NSW	New South Wales
NZ EPA	Environmental Protection Authority of New Zealand
OBIS	Ocean Biogeographic Information System
ODV	Ocean Data Viewer
PS6	Performance Standard 6
RFMO	Regional Fisheries Management Organisation
SCE	Southern California Edison
SDM	Species distribution modelling
SFPA	Sustainable fishing partnership agreement
SONGS	San Onofre Nuclear Generating Station

UMAM	Uniform Mitigation Assessment Method
UN	United Nations
UNCLOS	UN Convention on the Law of the Sea
UNEP	United Nations Environment Programme
UNEP-WCMC	UNEP World Conservation Monitoring Centre
WAMSI	Western Australian Marine Science Institution

1 Executive Summary

The oceans are under threat; marine species populations declined by 49% between 1970 and 2012 (WWF, 2015). Anthropogenic pressures on the marine environment have increased over the past five years, with 66% of the high seas and 77% of areas within national jurisdiction showing increased human impact (Halpern *et al.*, 2015). On land, policy goals of no net loss, where project impacts on biodiversity are balanced by measures to avoid, minimise, restore, or offset those impacts, or net gain, where impacts are outweighed, have emerged as potential mechanisms to balance or outweigh negative development impacts on biodiversity.

This report, funded by the European Investment Bank (EIB), provides an initial high-level feasibility assessment of the potential for applying this concept to the marine environment. Desk based research combined with expert consultation was used to: (1) assess the impacts of each sector[1] on biodiversity, (2) examine potential mechanisms for preventative and remediative conservation interventions by habitat type, and (3) review current no net loss practice in the marine environment.

Current practice, even offsetting, is remarkably widespread, despite the lack of a rigorous assessment of the suitability of a no net loss approach for the marine realm. We conclude that while there are challenges to implementing marine no net loss, these are not above and beyond those faced on land. There are a growing range of innovative solutions in development and a wealth of research from the terrestrial realm from which to draw important lessons.

1.1 High level findings

- ***Many of the challenges in implementing no net loss are common between the sea and land***; for example, ensuring appropriate baselines, governance, stakeholder consultation, setting and monitoring appropriate metrics.
- ***Lessons learned from land can be adapted and applied in a marine context***; for example, habitat and species based metrics and methods to estimate habitat condition are transferrable to benthic habitats and some land based restoration activities can be applied in a marine context. Area based metrics are challenging to apply.
- ***Marine development projects face additional challenges to achieve no net loss of biodiversity but may also be more effective;*** the interconnected and dynamic nature of the marine environment, combined with data paucity makes it more difficult to set baselines, governance structures are complicated, restoration activities are technically challenging and costly and ability to correct mistakes limited (Ekstrom *et al.*, 2015). However, mitigating impacts may be quicker than in more stable environments.
- ***Examples of no net loss in the marine environment can be identified***; offsets are being developed despite the lack of a rigorous assessment of the suitability of a no net loss approach for the marine realm.
- ***The business case for avoidance of negative impacts on biodiversity will be stronger for marine projects and data are available to assist in identifying areas to avoid,*** as well as determining the viability of restoration activities. However, these are occasionally dispersed and difficult to extract.

[1] Offshore wind, deep sea mining, deep sea cabling, mariculture, and ports and harbours. Commercial fishing and oil and gas were not included, reflecting EIB's areas of interest.

1.2 Recommendations for further research

- ***Assess feasibility of no net loss across more sectors (fisheries, oil and gas, deep sea mining) and issues (ecosystem services)***. Better understanding is required of the feasibility of attaining no net loss for fisheries and extractives sectors given the interlinked nature of the marine environment and the opportunity of a cross-sector approach to mitigating impacts on biodiversity. As activities shift to deeper waters as a result of technological advances and resource competition, understanding their changing impacts and their implications for the feasiblity of attaining no net loss will be important.

- ***Address governance barriers to no net loss commitments.*** Investigate how the no net loss concept fits into marine spatial planning processes in national jurisdictions, and ocean governance in areas beyond national jurisdiction, to incentivise a reduction in impact of development in the marine environment. This will create a more certain operating environment for business decision making, facilitate understanding of indirect and cumulative impact, identify opportunities for cross sector collaboration and may enable more coordinated conservation planning.

- ***Address data paucity***. Access to robust and credible data is crucial for the design and implementation of no net loss commitments. Investment is required into marine data sets and decision making tools as such as the Ocean Data Viewer (ODV) to improve their completeness, robustness and accessibility to business decision makers. The report proposes the enhancement of a simple tool (Table 2, p15) that sign posts developers to key data sets and literature on mitigation.

- ***Build the evidence for effective mitigation of marine impacts.*** More research is needed to assess the lifetime impacts of the study sectors and possible strategies for mitigation of negative impacts from decommissioning and whether this can contribute to conservation goals as part of a commitment for no net loss. This could include examination of the positive contributions of marine development to, for example, reducing climate risk to biodiversity.

To conclude, the nature of the marine environment is such that, if no net loss is to be demonstrated for marine projects, there needs to be a shift away from the assumption of restorability and offset capability towards the original intention of terrestrial no net loss of the precautionary principle and emphasis of avoidance. Lessons can be learned from the application of no net loss on land, however, a number of knowledge gaps that must be addressed to enable no net loss to become a robust policy option for the marine environment.

2 Context

"The relative lack of knowledge about marine ecosystems suggests a more precautionary approach should be taken here than in the terrestrial environment"

Sub-Group on the Scope and Objectives of the EU No Net Loss Initiative of the Working Group on No Net Loss of Ecosystems and their Services

The oceans are under significant stress as a result of climate change-related impacts of ocean acidification, ultraviolet radiation, sea surface temperature changes and unsustainable fishing practices. Rising demands for renewable and non-renewable energy sources and food are likely to place increased pressure on the oceans through marine infrastructure development. A recent increase in no net loss commitments across public and private sector policies may offer opportunities to reduce these impacts. In the private sector, at least 32 companies have set company-wide no net loss or net positive impact commitments since 2001 (Rainey *et al.*, 2014). However, where these policies set out specific requirements for marine biodiversity, requirements for impact mitigation and compensation are generally limited. Impact mitigation legislation tends to be general in nature and applies to both the terrestrial and marine environments, failing to adequately reflect the different challenges presented by operating in the marine environment.

The European Union Birds and Habitats Directives, for example, include coastal and offshore habitats, applying generic requirements for biodiversity impact mitigation, including compensation, across both realms. In addition, in the case of governmental legislation, policies only refer to coastal and marine environments under national jurisdictions, and not in areas beyond national jurisdiction (ABNJ). Given the practical and political differences between operations in marine and terrestrial environments, there is a need for greater understanding of the specific challenges relating to accounting for, and mitigating, biodiversity losses and achieving no net loss in marine environments, including those in ABNJ. In the context of the rapidly expanding industrial exploitation and development of marine environments, this kind of policy support is very timely.

Both the assessment of impacts and the implementation of mitigation measures are challenging in the marine environment: impacts frequently occur at some distance from operations and may be experienced at multiple tiers within the three-dimensional complex of the oceans, making them difficult to identify and monitor. Compared to terrestrial ecosystems, marine ecosystems are often described as more highly connected and characterised by species with complex lifecycles that often demonstrate high density congregations, occupying different marine ecosystems for different life stages (e.g. for feeding, spawning/breeding, nesting/nurseries) (Dickie *et al.*, 2013). This expands the temporal and spatial vulnerability to impacts and may exacerbate impacts seen on land, making assessment and impact mitigation more difficult in the marine environment. Understanding of the state and function of some marine ecosystems is often lacking. This can make the implementation of restoration efforts particularly challenging. These issues are further compounded when operations occur in ABNJ where regulation is weaker, or even absent. In order to establish no net loss as a viable management goal in marine ecosystems, it is critical to identify situations where certain mitigation measures are likely to be appropriate or feasible and highlight the scientific knowledge, governance and conservation support needed to achieve this. As the developmental pressure on the marine environment increases, the need for this kind of assessment is becoming pressing.

2.1 Report objectives

Objectives:

1. To assess the feasibility of achieving no net loss in a range of marine ecosystems from coastal to the deep sea by:

    a. Reviewing mitigation potential (particularly restoration and protection activities) for key marine habitats.

    b. Identifying impacts of marine development on biodiversity and assessing opportunities and challenges for implementing offsets.

2. To review the practical, ecological and political factors associated with no net loss policies in different regions of the marine environment.

3. To review current practice in implementing no net loss policies in the marine environment and provide guidance to policy makers and practitioners.

Outcomes:

1. To provide a preliminary evidence base for the feasibility of no net loss in different marine ecosystems for effective decision-making by policy makers, companies and finance institutions

2. To support the development of effective no net loss policies, based on practical experience and political factors governing the marine realm.

This project brings together the expertise of UNEP-WCMC in marine biodiversity science and policy with offset design and implementation experience from external specialised practitioners in order to investigate the feasibility of achieving no net loss of biodiversity in marine ecosystems. The study utilises desk-based research combined with expert consultation. Taking a sample of key marine ecosystems from deep sea to coastal areas and focusing on five key marine sectors, offshore wind, ports and harbours, deep sea mining, mariculture, and cabling, this study examines the theory and practical experience of conservation science to assess the potential effectiveness of marine no net loss commitments. The study sectors were selected in consultation with the European Investment Bank as sectors of most interest to multilateral finance institutions. Commercial fishing was excluded from the scope of this report due to the lack of project financing the sector receives, and the complex and transboundary nature of its impacts. The oil and gas sector is also deemed to be out of scope, although it is referenced as there are transferable concepts to the focus sectors. The political context (and transboundary impacts) of operations and whether they occur in ABNJ are given consideration as these also pose significant challenges in terms of implementing active management solutions, monitoring and regulation. In order to further demonstrate the challenges and opportunities associated with marine no net loss, case studies of commercial activities taking place in marine environments are examined and lessons drawn from their experiences of designing and implementing approaches to achieve no net loss outcomes. This study is intended to help establish the science-based feasibility of no net loss policies and commitments in marine ecosystems. It represents an initial analysis of the issue to highlight areas for further work, and is not intended to be comprehensive, or act as guidance *per se*.

2.2 What is no net loss of biodiversity?

No net loss of biodiversity is inextricably linked with both net positive impact (NPI), sometimes referred to as 'net gain', and the often controversial idea of biodiversity offsetting. Both no net loss and NPI are biodiversity status goals for development projects, where biodiversity gains either negate (no net loss) or outweigh (NPI) negative project impacts.

Box 1: The mitigation hierarchy

> **"The sequence of actions to anticipate and avoid impacts on biodiversity and ecosystem services; and where avoidance is not possible, minimize; and, when impacts occur, rehabilitate or restore; and where significant residual impacts remain, offset"**
>
> **Cross Sector Biodiversity Initiative**
> (Ekstrom *et al.*, 2015)

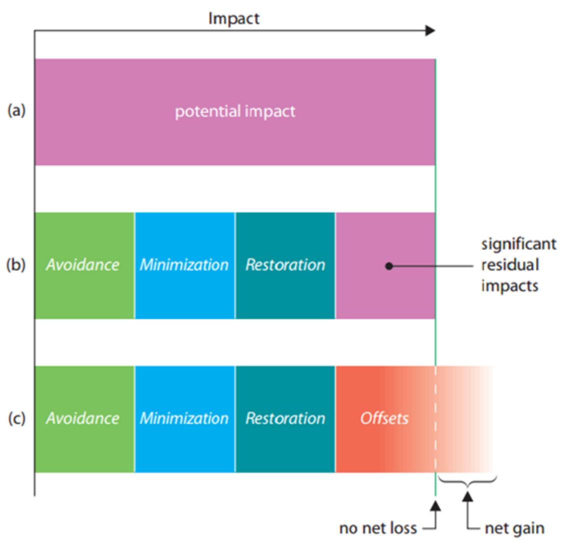

Figure 1: Schematic showing no net loss and net gain (Ekstrom *et al.*, 2015)

Defining and achieving an NPI goal is a "*precautionary way of ensuring an NNL* [no net loss] *outcome for biodiversity*" (Aima *et al.*, 2015).The Business and Biodiversity Offsets Programme (BBOP), a multi-stakeholder collaboration that develops best practice in following the mitigation hierarchy (Box 1), provides the following definition for no net loss:

> *"No net loss is a target for a development project in which the impacts on biodiversity caused by the project are balanced or outweighed by measures taken to avoid and minimise the project's impacts, to undertake on-site rehabilitation/restoration, and finally to offset the residual impacts, so that no overall biodiversity loss results."*
> (BBOP, 2012a)

The International Finance Corporation's (IFC) Performance Standard 6 (PS6) defines it as follows:

> *"The point at which project-related impacts on biodiversity are balanced by measures taken to avoid and minimize the project's impacts, to undertake on-site restoration and finally to offset significant residual impacts, if any, on an appropriate geographic scale (e.g., local, landscape-level, national, regional)."*
> (IFC, 2012)

The concept of no net loss (and net gain) can be seen in Figure 1.

2.3 Defining biodiversity value

Attaching a particular value to biodiversity for no net loss is a complex subject as it must incorporate both the ecological functional value of a feature, as well as the societal value affected stakeholders place on it (Gardner *et al.*, 2013). The conservation expectation for no net loss is for a project to replace all components of biodiversity as defined by the Convention on Biological Diversity (CBD): inter-community diversity, interspecific and intraspecific diversity. However, this may be unrealistic within project timeframes, especially given our incomplete understanding of ecosystem function, so best practice guidelines require developers to account for biodiversity features that are particularly valuable to people, or are of a particular ecological importance, through the use of surrogate metrics, detailed more in section 2.6.1 (BBOP, 2012b).

One good example of assigning a value to marine biodiversity was the recent global mapping of likely and potential marine critical habitat, as defined by the IFC (Martin *et al.*, 2015). The study concluded that there is currently a lack of reliable marine data and therefore existing data cannot be assumed to represent the full biodiversity value, but can be used for high-level early screening.

2.4 Origin of the no net loss concept

No net loss policy is implicitly based on the concept of the mitigation hierarchy, which has always been an important concept in various guises in conservation policy. It was arguably the U.S. wetland mitigation banking scheme that gave the concept profile and practical application in the context of spiralling wetland losses from development. Some estimates suggest that between 1780 and 1980 the lower 48 U.S. states lost on average 60 hectares per hour for the 200 year period (Dahl, 2000). No net loss of wetlands was implemented through the 1977 Clean Water Act.

2.5 Where is no net loss required? A summary of no net loss commitments

2.5.1 National legislation

Proceedings from the 3-4th June 2014 BBOP conference, To No Net Loss of Biodiversity and Beyond, indicate there could be 39 countries with mitigation or offset policies "in some form of development", with 21 more "developing policies" (BBOP, 2014). The Ecosystem Marketplace 2011 biodiversity markets update suggested there were 45 national or sub-national compensatory mitigation programs in existence and 27 in development (Madsen *et al.*, 2011). Examples include:

Australia is considered to be "*well-advanced*" in no net loss implementation, with biodiversity offset policies in place in each of its six States and two Territories. There is also a national policy. However, despite over a decade of implementation there are still significant concerns regarding the development and mitigation activities allowed under the policies (Maron *et al.*, 2015).
Canada implemented the *Fisheries Act*, which covers some marine environments (see Box 2 for more information).

The European Union (EU) is currently developing an overarching no net loss initiative, which builds on the compensatory requirements of the Birds, Habitats, and Environmental Liability Directives. Some participants of the Sub-Group on the Scope and Objectives of the [EU] No Net Loss Initiative suggested that any no net loss initiative should be restricted to terrestrial and freshwater environments, whereas others considered that it could be extended to the coastal and marine environments, as there were many parallels that could be drawn, e.g. between high energy environments like coastal and high altitude habitats, and the potential of 'functional re-creation' measures and averted loss offsets (European Commission, 2013).

In **France**, the mitigation hierarchy has been enshrined in environmental law since 1976. More recently, in 2012 and 2013, as a result of the introduction of the Birds, Habitats, and Environmental Liability Directives in 1979, 1992, and 2004 respectively, the French government published guidance on the mitigation hierarchy, with no net loss as an explicit goal (Quétier *et al.*, 2014).

Germany has had the *Eingriffsregelung* (Impact Mitigation Regulation in English, or IMR) since 1976. An Institute for European Environmental Policy (IEEP) report on the use of eco-accounts in Baden-Württemberg found that a diverse group of stakeholders evaluated the scheme as an efficient tool to achieve the EU no net loss principle (Mazza and Schiller, 2014).

The Netherlands created the platform *biodiversiteit, ecosystemen & economie* (Platform BEE) seeks to incorporate no net loss into the business strategies of Dutch companies and are investigating country-wide implementation.

In **South Africa**, especially the Western Cape, there are a number of provincial biodiversity offsets guidelines (Ekstrom *et al.*, 2013; BBOP, 2014), however "the emphasis is on adding priority habitats to the conservation estate, rather than on achieving 'no net loss' in the strictest sense" (Brownlie and Botha, 2009).

The UK implemented six two-year pilot schemes; report on this has been delayed and momentum towards a scheme has floundered in the face of severe public opposition. The Crown Estate commissioned two comprehensive reports on the feasibility of UK marine habitat banking and offsetting (Dickie *et al.*, 2013; Cook and Clay, 2013).

Box 2: Policy case study: the Fisheries Act in Canada

In 1976, Fisheries and Oceans Canada (DFO) enacted the habitat provisions of the *Fisheries Act*, a flagship environmental provision in Canada, to combat accelerated wetland losses and fish extinctions due to habitat alteration in the last century. DFO applied the principle of no net loss of productive capacity of fish habitat when it issued authorisations under Section 35(2) for a 'harmful alteration, disruption, and destruction' of fish habitat (HADD) caused by development activities.

Measuring no net loss of productive capacity

The selection of productive capacity as the measurement has been criticised as difficult to quantify and "*logically inoperable*" as it is an intrinsic potential property of the habitat, not easily predicted by its current state (Quigley and Harper, 2006). A 2005 study of 124 authorisations showed that only 10% of pre-impact assessments and 12% of post-construction monitoring moved beyond area-based metrics to estimate of productive capacity (Harper and Quigley, 2005).

Marine application

The *Fisheries Act* had a very broad remit, applying to estuarine, lacustrine, riparian and marine habitats. Of the 217 HADDs analysed in the 2005 study, 13 occurred in marine habitats. However, 4467m^2 less habitat was created than was impacted, far below the absolute minimum ratio of 1:1, and possibly indicating the difficulty in creating compensatory habitat in the marine realm (Harper and Quigley, 2005).

Efficacy of the Fisheries Act

Harper and Quigley conclude that fish habitat compensation under the *Fisheries Act* is "*strikingly similar*" to wetland no net loss in the U.S. under the *Clean Water Act*, of which one critic wrote "*the best current outcomes appear to be a slowing of the rate of biodiversity decline*" (Burgin, 2010); DFO does not keep adequate records of authorisations, compliance monitoring is too low, and there is no evaluation of compensatory mitigation projects. All of these need to be improved to evaluate progress towards the target of no net loss.

Changes to the Act

In 2012, the Canadian government altered the Act by removing reference to HADD, replacing this text with: "*No person shall carry on any work, undertaking or activity that results in serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery*". This focus on the use of fisheries, as opposed to fish habitat *per se*, came into force in late 2013, and has led to some scientists estimating that over 80% of the 71 wildlife species of freshwater fish at risk of extinction in Canada will not be covered by the revised legislation (Hutchings and Post, 2013).

2.5.2 Finance standards

More than 80 financial institutions have committed via the Equator Principles to IFC PS6: *Biodiversity Conservation and Sustainable Management of Living Natural Resources*. IFC PS6 requires that all projects in natural habitat implement mitigation measures that are designed to achieve no net loss of biodiversity, and those projects in critical habitat to achieve net gains for the biodiversity values for which the critical habitat was designated. The World Bank is in the process of updating its Environmental and Social Framework (development of third draft as of June 2016), which includes a commitment to no net loss in Environmental and Social Standard 6. A 2011 review of the biodiversity requirements of standards and certification schemes, conducted by UNEP-WCMC and the Secretariat of the Convention on Biological Diversity, found that four of the five finance standards reviewed contained reference to no net loss or net gain (Secretariat of the Convention on Biological Diversity, 2011).

2.5.3 Corporate policies

A 2014 study identified the extent of companies that had set a high-level policy of no net loss NPI as of 31st December 2011 (Rainey *et al.*, 2014). The study identified 32 companies, 41% of which were mining companies (aggregates, minerals, metals, and coal mining). 18 of the companies explicitly included a no net loss of, or NPI on biodiversity as opposed to a more generic environmental goal. The International Council on Mining and Metals (ICMM) reviewed their member's biodiversity management strategies and found that more than half "*have some form of commitment or aspiration to achieve no net loss or a net gain of biodiversity*" (Grigg *et al.*, 2014); the global oil and gas industry association for environmental and social issues, IPIECA, is currently examining the feasibility of a net positive approach for those issues. Although some companies, such as Rio Tinto, have had NPI commitments in place for some years, implementation is still a work in progress. Companies have been undertaking offsets as a result of legal requirements in some parts of the world for many years. However, in most cases such offsets have been terrestrial rather than marine. Companies, governments and NGOs are still working to determine how no net loss or NPI can best be accounted for to enable robust identification and quantification of impacts and thereby allow a credible application of the mitigation hierarchy.

2.6 Measuring biodiversity impacts

2.6.1 Metrics

Biodiversity metrics used to quantify no net loss policies can usually be categorised using seven broad typologies, or combinations of them (Rayment *et al.*, 2014; Tucker *et al.*, 2014).

Habitat area

Perhaps the simplest metric, area counts are only really appropriate for habitats of low biodiversity value, and they do not take into account changes in habitat condition. They are, however, extremely practical, with low transaction costs, and the data do exist to support broad habitat assessments, e.g. EUNIS habitats in the EU, a classification to harmonise the description and collection of habitat data across Europe, and the ongoing IUCN Red List of Ecosystems work.

Standard value

Standardising habitat area measurements goes some way to addressing concerns over the simplicity of simple area counts. Habitat areas can be multiplied by a given factor according to the ecological value of the habitat. This allows for 'trading up' of offsets, where an impacted area of less ecological value is replaced with an area of a higher value, but it also risks biodiversity losses where the reverse occurs as a result of poor biodiversity management strategies. Habitats' ecological values are usually based on a combination of expert judgement and policy guidance, which decreases the transparency of this type of assessment.

Habitat quality

Measurements of habitat quality can be used to assess project impacts that result in a change in habitat condition, e.g. an impact reducing a habitat from pristine to degraded. However, the data requirements for this are substantial, demanding a complex suite of indicators, a reliable understanding of the ecology, as well as habitat baselines against which to assess.

Species-focussed approaches

When measurements focus on species, they can give the impression of a clear, objective and transparent measure. Species-focussed metrics can often link with broader conservation goals, e.g. for endangered species. However, this type of approach requires complex species data and extensive field surveys with high costs. High costs can limit the quality of data practical, so species-focussed approaches can only really be used effectively when combined with other less expensive habitat measures.

Replacement costs

Replacement costs use estimates of the cost of replacing the lost biodiversity feature to inform how much should be paid in compensation. These are only appropriate for in-lieu fee systems, where costs of replacement are paid to third parties, and their use depends on whether the appropriate policy or legislation allows for in-lieu fee mitigation, e.g. wetlands no net loss in the U.S. Good data exist for management, creation and restoration costs, but these can vary considerably even within the same habitat.

2.7 Risk multipliers

Offsetting residual biodiversity impacts, after all other impacts have been avoided, minimised, and restored (Box 1), require practitioners to deal with a number of different factors. Offset multipliers, where a policy requires the offset of more than one biodiversity unit per unit impacted, are designed to address these. Offset multipliers can be used to deal with the achievement of conservation goals (so-called 'end-game' multipliers, where a multiplier is used to support no net loss or net gain); e.g. offsets for certain endangered species require larger offset ratios than for others, or to address social equity and distribution problems (Rayment *et al.*, 2014). Offset multipliers can also be used to address lack of good quality data, the inherent uncertainty of ecological restoration or creation, and the complications of temporary loss of habitat while the offset site is created (Gardner *et al.*, 2013; Pilgrim and Ekstrom, 2014; Tucker *et al.*, 2014). For a more detailed explanation of offset multipliers, please see Pilgrim and Ekstrom 2014.

Other studies have specified that no net loss can "*only be successful where the offset ratio is large*" (Pickett *et al.*, 2013); for example, the New South Wales (NSW) Policy and Guidelines for Fish Habitat Conservation and Management adopts this approach, requiring a multiplier of 2 to be applied to aquatic offsets.

3 Reviewing the science

Approaches to no net loss in the terrestrial realm are still being challenged and addressed, the marine environment amplifies many of the most pressing concerns. The interconnectivity and dynamic nature of the ocean, as well as the paucity of data for marine habitats and species, present a host of new challenges if no net loss is to be extended into coastal and international waters.

3.1 Differences between the marine environment and the terrestrial

In reports highlighting the differences between implementing no net loss in the marine and terrestrial environment (Cook and Clay, 2013; Dickie *et al.*, 2013; Institute of Chartered Engineers, 2013), it is often said that the marine environment is "*inter-connected, continuous and highly dynamic*" (Dickie *et al.*, 2013, p.17). However, this overlooks the fact that many impacts on land affect highly dynamic, interconnected habitats and species, e.g. migratory species like the endangered saiga antelope in Central Asia (Bull *et al.*, 2013), or temporary breeding congregations.

A report by the Institute of Chartered Engineers suggests some differences between terrestrial and coastal habitats which would impact on the feasibility of developing marine biodiversity offsets (Institute of Chartered Engineers, 2013), as well as avoidance, minimisation and restoration. It is suggested that, for marine habitats especially, it would take longer to create a functioning estuarine or near-shore habitat; or that marine coastal habitats are more distinct than terrestrial habitats (in the UK biodiversity offsetting guidance, no coastal habitat was classified as 'low' distinctiveness, with the majority classed as 'high'. 'Distinctiveness' is a collective measure of biodiversity and includes parameters such as species richness, diversity, rarity and the degree to which a habitat supports species rarely found in other habitats.). However, there is no indication that all marine environments would take longer to recover from impacts than on land. Estuarine habitats have been seen to recover in a matter of years (Farrugia *et al.*, 2011), whereas some terrestrial wetlands in the U.S. have still not recovered to pre-impact functioning (Turner *et al.*, 2001).

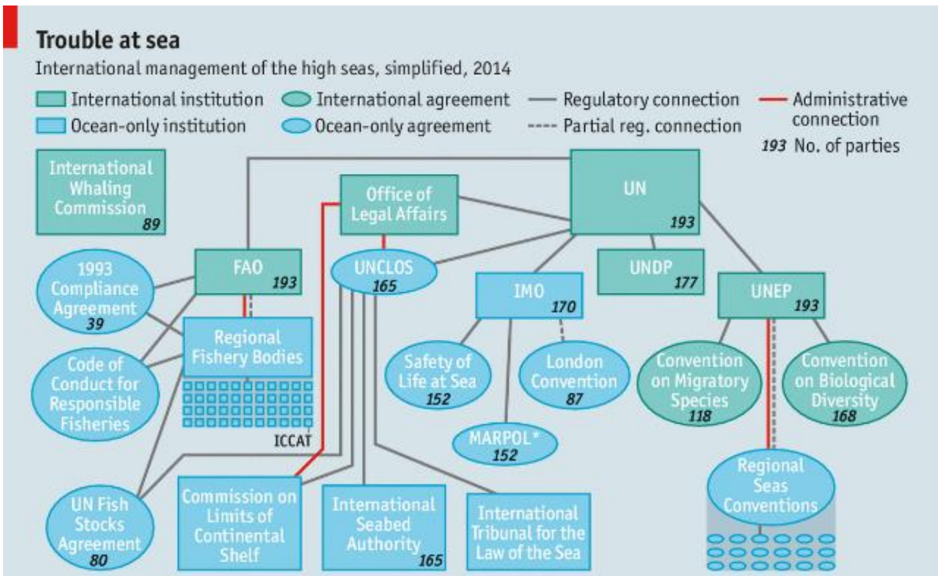

Figure 2: The complexity of the governance framework for ABNJ. Source: The Economist

This report argues that challenges of implementing no net loss in the marine environment cannot be considered novel to the concept and the existing challenges it faces on land. However, marine environments may see emphasis on some challenges over others: for example, the deep sea presents complex governance challenges (see Figure 2 on previous page for a 'simplified' governance framework of ABNJ).

3.2 Immediate challenges

3.2.1 Data paucity

The overriding challenge of implementing and achieving no net loss in the marine realm is the lack of data when compared to terrestrial ecosystems. A recent study, using data from the Ocean Biogeographic Information System (OBIS), demonstrated that the deep pelagic ocean is vastly under-represented when it comes to data availability; most data represent either shallow water or the seabed. Areas of ocean shallower than 200m in depth tend to have thousands of associated records, whereas areas over 6000m in depth generally have fewer than 10 records (see

Figure 3, where warmer colours represent more biodiversity data records) (Webb *et al.*, 2010).

3.2.2 Measuring baselines

Although few have yet been fully developed, it is broadly accepted that a successful no net loss initiative, whether at the project or landscape scale, requires an accurate biodiversity baseline against which to ascertain net losses and gains. This can either be set as a static baseline (as with dashed white line in Figure 1), or can be set as a business as usual (BAU) scenario, where biodiversity is expected to decline at a steady rate, as used in some Australia states (Maron *et al.*, 2015). In the case of the latter, for no net loss to be achieved, biodiversity needs to be restored to the level predicted by the BAU scenario, which will, by definition, be a lower value than was originally impacted.

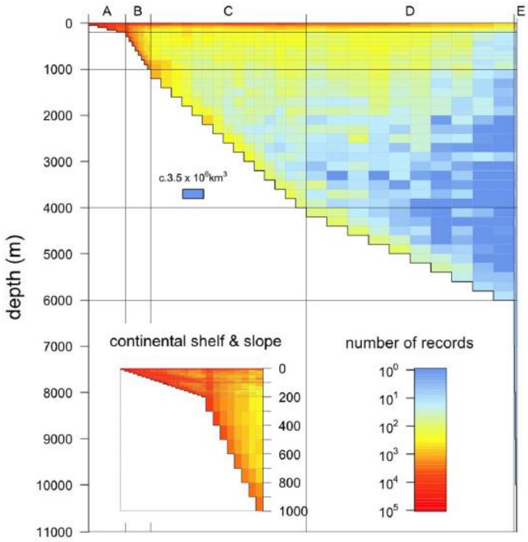

Figure 3: Global distribution within the water column of recorded marine biodiversity (Webb *et al.*, 2010)

There is a growing body of evidence for no net loss implementation in terrestrial environments that accurate baselines are critical to achieve no net loss (Bull *et al.*, 2014; Gordon *et al.*, 2015; Maron *et al.*, 2015). If baselines are not strictly informed by a robust evidence base, there is a chance that a BAU scenario that predicts too steep a decline can 'lock in' that decline: offset credits will be over-allocated so that a project or landscape achieves no net loss on paper, without the adequate real biodiversity gains to cover the original impacts.

The marine realm has traditionally struggled with what is called 'shifting baseline syndrome' (Pauly, 1995). This is where, instead of considering a baseline based on historical abundances, fisheries scientists use fish stocks at the start of their career as their frame of reference. Marine data paucity makes it significantly more difficult to set appropriate baselines or to investigate counterfactuals, scenarios against which the no net loss policy would be considered.

3.2.3 Hydrological connectivity

The ocean, especially the upper pelagic zones (water not near the shore or seabed; further divided into subdivisions, e.g. here epi-, meso-, and bathypelagic), are much more interconnected than the terrestrial realm. Ocean currents cycle nutrients globally, and regional connectivity underpins coastal fisheries, where known fish nurseries, such as the Waddenzee in The Netherlands, support commercial fishing at a regional scale.

This has important implications for no net loss calculations in the sea; project and seascape impacts can act at varying spatial scales, and in various pelagic zones in the marine environment. For example, mariculture infrastructure, although confined to the epipelagic zone, can have significant impacts on the benthos through increased detrital rain (fish faeces settling on the seafloor). Deep sea mining, with direct physical impacts confined to the geological feature on the seabed (benthos), can have significant impacts on the surrounding pelagic zone and benthos through the creation of sediment plumes that can smother sessile organisms and clog the feeding apparatus of others.

The hydrological connectivity of the seas also means that the scale at which we consider no net loss must also be analysed more closely. For example, an adequate supply of sediment is often considered critical to some marine habitats' viability so a conservation intervention outside of the project zone of influence on sediment flow may be enough to ensure habitat perpetuity (Institute of Chartered Engineers, 2013).

Consequently, marine no net loss must consider both indirect and cumulative impacts and their larger scale as carefully as on land, where they are recognised as problems but not always adequately addressed. Indirect impacts are impacts not resulting directly from project activities but through a complex impact pathway, and cumulative impacts are the combined impact of the assessed project and local past, present and future projects. A recent paper discussing the current situation for wind farm biodiversity offsets in Europe advises "*an urgent intensification of research on impacts* [and] *cumulative impacts*" (Vaissière *et al.*, 2014, p.16).

3.2.4 Dynamism

Exacerbating the issue of the hydrological connectivity of the ocean, the marine environment is also extremely dynamic. This is especially true for coastal habitats, where the process of coastal erosion has a large part to play, but, contrary to public perception, it is also true of some areas of the deep sea benthos. For example, in 1929, a magnitude 7.2 earthquake hit the continental slope off Newfoundland, causing a series of submarine landslides. These landslides produced currents that carried sand and mud to depths of over 4,500m, severing several deep sea cables. From the timing of the breaks, it was estimated that this deep sea current was moving at around 65km per hour; one of the first observations of how dynamic the deep sea can be (Carter *et al.*, 2009).

Marine species distributions also have defined seasonal and geographic patterns and are driven by environmental conditions, e.g. hydrodynamic regime. Many marine species have a planktonic life history stage, with their ultimate settlement very much dependent on the receiving habitat's recruitment levels, or how quickly that habitat accrues non-mobile species. For example, it has been found that the quickest communities to recover from significant aggregate dredging impacts most quickly are those adapted to highly dynamic environments (e.g. under high tidal stress), where opportunistic 'coloniser' species prevail; recovery in these environments occurs over months, as opposed to years for less dynamic environments where specialist species are more dominant (Hill *et al.*, 2011). This suggests that mitigating impacts in a highly dynamic marine environment may occur over a shorter timeframe than in more stable environments. Highly dynamic environments are also constantly changing due to the continual process of, for example, coastal erosion and intermittent flooding, meaning that like-for-like remediative action where a specific community state is targeted may be harder to implement in these environments (see, for example, salt marsh restoration in Box 3, where despite achieving the majority of community state targets, a prevalence of mud flat habitat is preventing the award of credit to the project).

3.2.5 *Inaccessibility*

Above all else, pursuing no net loss in the marine environment becomes increasingly difficult moving from coastal habitats, to near-shore shallow waters, to the deep sea. Surveying to collect the necessary data to inform decisions and remediative measures are technically challenging and costly in more remote marine environments like the deep sea. Estimates have put the costs of deep sea restoration at two to three orders of magnitude greater per hectare than restoration efforts in shallow-water marine systems (Van Dover *et al.*, 2014).

3.2.6 *High seas governance*

One of the most pressing issues for conducting no net loss in the marine realm is the lack of a comprehensive, cross-sector legal framework in which to operate in ABNJ. Current management of the high seas is extremely complex (Figure 2), and some argue that it is largely still based on 17th century principles of free and open access as opposed to sustainable use. This is in the process of being corrected through the global discussion regarding a potential UN Convention on the Law of the Sea (UNCLOS) Implementation Agreement. An agreement would provide legal protection for the sustainable use and conservation of biodiversity in ABNJ. Current UNCLOS implementation is both geographically (the regional seas conventions do not provide global coverage) and sectorally patchy (there is a lack of cooperation between Regional Fisheries Management Organisations–RFMOs–and environmental organisations).

The International Seabed Authority (ISA) has trusteeship over the seabed in ABNJ (see Figure 4 below). In the eastern Pacific Clarion-Clipperton Fracture Zone (CCZ), a region of the seabed with the highest known concentrations of high-grade polymetallic nodules, the ISA implemented the first deep sea regional environmental management plan (Wedding *et al.*, 2015). The plan divided the seafloor into mining concessions and Areas of Particular Environmental Interest (APEIs) following the precautionary approach set out by the common

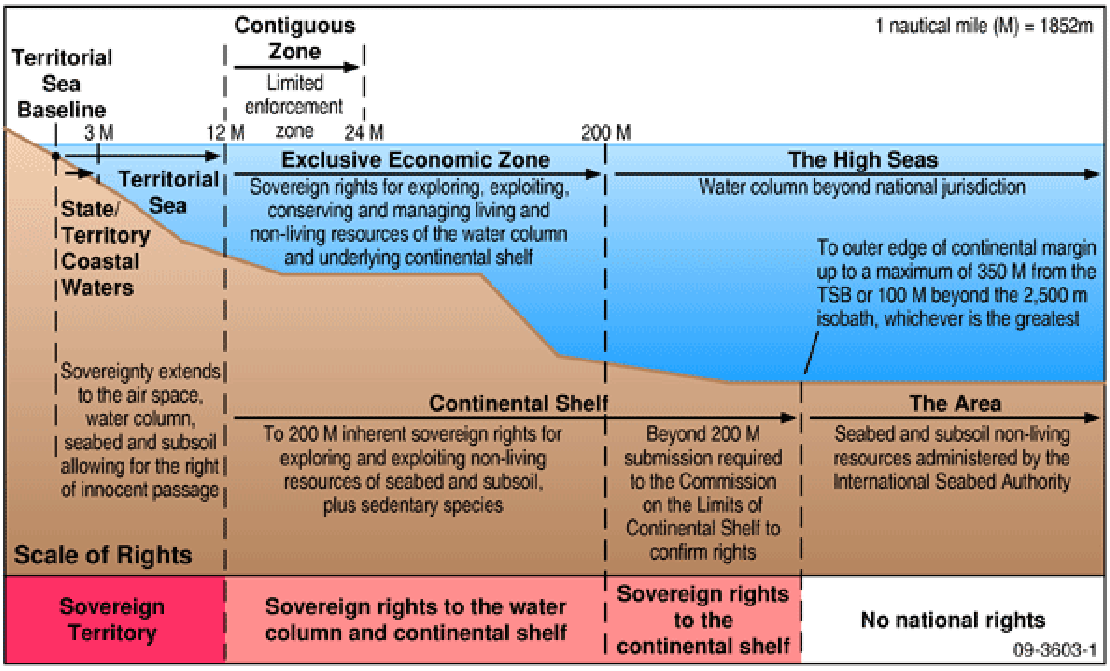

Figure 4: Maritime zones and rights under the 1982 United Nations Convention on the Law of the Sea (UNCLOS). Source: Australian Government

heritage of mankind principle of UNCLOS. The extension of regional initiatives (Rochette *et al.*, 2014) and the development of comprehensive legal principles (Houghton, 2014) have both been suggested as ways forward for the management of biodiversity in ABNJ. However, the current incomplete legal implementation under UNCLOS poses a difficult challenge for operating in ABNJ.

Although offshore wind farms have in some cases extended to around 80 miles from shore, e.g. Dogger Bank Creyke Beck in the UK Dogger Bank Zone, and there are suggestions that offshore mariculture within Exclusive Economic Zones (EEZs) has the potential to greatly increase if the 93 nations and territories currently practicing it intensify production (FAO, 2013), deep sea cabling and mining are the only two study sectors that currently operate in ABNJ. Of these two, deep sea mining has the far greater potential impact on deep sea biodiversity.

3.3 Measuring no net loss in the marine realm

3.3.1 Metrics

Due to the inherent interlinking and continuous nature of the marine environment, it is extremely difficult to delineate ecological boundaries in the marine realm, which makes no net loss, traditionally based on area measurements on land, challenging.

Two reports to the Crown Estate in the UK cover the practicalities of measuring no net loss in the marine environment in greater detail than can be afforded in this report. The first is a feasibility study of biodiversity offsetting and habitat banking in the UK (Cook and Clay, 2013), and the second is a scoping study for marine biodiversity offsetting (Dickie *et al.*, 2013).

Both Crown Estate reports cover possible metrics to support marine no net loss in excellent detail; Cook & Clay investigate the potential to transfer Defra's proposed area measurement for UK terrestrial use (since mothballed) to the marine realm using a conservative multiplier, whereas Dickie and colleagues investigate a broader range of possible metrics.

Transferring the metrics outlined in section 2.6.1, used frequently on land, has the potential to be adequate for benthic habitats, and Dickie and colleagues suggest a number of habitat and species-based metrics, as well as methods to estimate habitat condition. However, the pelagic environment poses a much bigger, if not insurmountable, challenge.

Another study, focusing on mandatory compensation measures in Florida, investigates the metrics used under a suite of regulations (Superfund Act, Oil Pollution Act, National Environment Policy Act, Clean Water Act, etc.): the Habitat Equivalency Analysis (HEA) and the Uniform Mitigation Assessment Method (UMAM), both based around habitat hectares calculations (Levrel *et al.*, 2012).

3.3.2 General impacts

This feasibility assessment focuses on five marine sectors: offshore wind farms, ports and harbours, telecoms/cabling, mariculture, and deep sea mining.

For all sectors it is important to assess full lifecycle project impacts, from the decision on where to place the infrastructure, right through to the decommissioning of the structure.

Marine sector projects can have multilevel impacts on the marine environment that are well-documented in the literature (Dickie *et al.*, 2013); impacts from ports and harbours (Grech *et al.*, 2013), mariculture (Price and Morris Jr, 2013; McCormack *et al.*, 2009), offshore wind (Bailey *et al.*, 2014), cable laying (Carter *et al.*, 2009), and deep sea mining (Ramirez-Llodra *et al.*, 2011; Boschen *et al.*, 2013) are summarised in Table 1. Some of these may be compensated for through traditional terrestrial metrics, such as the infrastructural footprint of a wind turbine and the removal of benthic habitat; however, others may need more innovative thinking, like changes in benthic habitat temperature, hydrodynamics and electromagnetism caused by the installation of seafloor cabling.

Table 1: Impacts of select marine sectors on biodiversity. Impacts are split between 'early stage' (surveys and construction) and 'late stage' (operation and decommissioning). Where a cell is orange, impacts were directly referenced in supporting literature; cells with hatched shading indicate where impacts were not explicitly mentioned but the authors presume there is likely an impact on

		Near shore industry								Deep water industry	
		Ports and harbours		Mariculture		Offshore wind		Cable laying		Deep sea mining	
	Distance from shore	Up to ~3 miles for some deep water ports		Near shore		Have been built 80 miles from UK shore		International waters (>200 nautical miles)		International waters (>200 nautical miles)	
	Depth	Dredging is usually to a maximum of 15 metres for Panamax ships		<100 metres		Usually <200 meters, with the potential for up to 900m for floating structures		No limit		Up to 5,000 metres	
Impact type	**Impact**	**Early stage**	**Late stage**	**Early stage**	**Late stage**	**Early stage**	**Late stage**	**Early stage**	**Late stage**	**Early stage**	**Late stage**
Habitat loss/degradation	Benthic habitat degradation	orange	orange	orange	orange	orange	orange	orange		orange	orange
	Benthic habitat loss	orange	orange	orange	orange	orange	orange	orange		orange	orange
	Pelagic habitat degradation	orange	orange	orange	orange	orange	orange			orange	orange
	Pelagic habitat loss	orange	orange	orange	orange	orange	orange			orange	orange
	Seabed erosion								orange		
	Coastal erosion		orange								
	Reduction in productivity, anaerobic/azoic conditions	hatched	hatched		orange	hatched	hatched				
Habitat disturbance	Habitat disturbance/turbulence	orange	orange	hatched	hatched	orange	orange	orange		orange	orange
	Disturbance current, sediment and temperature regimes		orange	hatched	hatched		hatched		orange		orange
	Electromagnetic disturbance						orange		orange		
	Increased vessel activity	orange	orange	hatched	hatched	orange	orange			orange	orange
Habitat avoidance	Habitat displacement	orange	orange	hatched	hatched	orange	orange			hatched	hatched
	Migration interference	hatched	hatched			orange	orange			hatched	hatched
Species mortality	Displacement fishing effort and conflict with fishing		hatched		orange		orange		orange		
	Bycatch/entanglement		orange		orange						
	Submergence	orange		hatched				orange		orange	
	Extinction rare/endemic species									orange	
Invasive species	Introduction of alien species from ballast and biofouling - pests, pathogens, competitors, predators	hatched	orange		orange	hatched	hatched			orange	orange
	Genetic dilution				orange						
Contaminants	Contamination from seabed sediment disturbance	orange	orange	hatched			hatched			hatched	
	Water pollution and bioaccumulation - oil, chemical, rubbish, waste, heavy metals, antibiotics	orange	orange		orange					orange	orange
	Air pollution and CO_2 emissions		orange								
	Over-fertilisation and eutrophication				orange						
Noise	Noise - above water	orange	orange	hatched	orange	orange	orange			orange	orange
	Noise - below water	orange	orange	hatched	orange	orange	orange	orange		orange	orange
Light	Light pollution - artificial lights	hatched	orange				hatched			orange	orange
	Water turbidity	orange	orange		orange			hatched		orange	orange
Collisions	Collisions (sea birds)						orange				
	Collisions (marine mammals)		orange								
Positive impacts	Habitat creation						orange		orange		
	Shelter/reserve				orange		orange		orange		
	Knowledge of poorly studied ecosystems									orange	
	Increasing productivity of nutrient poor areas				orange						

3.4 No net loss by habitat

As a result of the challenges mentioned in the previous sections, it may be easier to assess the feasibility of no net loss in the marine environment by specific habitat type, as opposed to national jurisdictions or under certain policy instruments. Table 2 below represents an initial analysis of the feasibility of no net loss for different marine habitat types. It assesses the potential for avoidance and restoration as representatives of both a preventative and remediative approach, and provides datasets or restoration examples where available. The next section will discuss current practice in more detail.

Table 2: Information to inform preventative and remediative interventions (avoidance and restoration) by habitat. Habitat classification as used by the IUCN Red List (2016) – Version 3.1. Global datasets for broad habitat types are shown, as well as examples of restoration from the academic and grey literature.

HABITAT	SPECIFIC DATASET Where available	EXAMPLES OF RESTORATION Where available
9 Marine Neritic		
9.1 Pelagic	Species distributions (Martin *et al.*, 2014)	
9.2 Subtidal Rock and Rocky Reefs 9.3 Subtidal Loose Rock/Pebble/Gravel 9.4 Subtidal Sandy 9.5 Subtidal Sandy-Mud 9.6 Subtidal Muddy		Restoration has proved successful in a short time span for subtidal muddy (Veríssimo *et al.*, 2012; Farrugia *et al.*, 2011), or see Gothenburg Harbour dredging (OSPAR Commission, 2009)
9.7 Macroalgal/Kelp		Restoration has been shown to be successful (Campbell *et al.*, 2014), but sites with continued human pressures can cause significant problems for re-establishment (Borja *et al.*, 2013); see also Box 3
9.8 Coral Reef	Global Distribution of Coral Reefs (2010); Global Distribution of Cold-water Corals (2005); Global Distributions of Habitat Suitability for Framework-Forming Cold-Water Corals (2011); Global Distribution of Habitat Suitability for Stony Corals on Seamounts (2009); Global Distributions of Habitat Suitability for Cold-Water Octocorals (2012)	Very dependent on the type of coral; e.g. for deep sea cold-water coral (Van Dover *et al.*, 2014), or warm-water coral (Ekstrom *et al.*, 2015), it has been shown to be extremely expensive to implement. Some studies also show poor survival rates (Bentivoglio, 2003)
9.9 Seagrass (submerged)	Global Distribution of Seagrasses (2005); Global Seagrass Species Richness (2003)	Very species-dependent: e.g. *Zostera sp.* show resilience, but *Posidonia oceanica* restoration is very difficult. Care must be taken not to over-harvest the donor seagrass community (Balestri and Lardicci, 2012)
9.10 Estuaries		One subtidal muddy estuary was shown to recover quickly after restoration efforts (Farrugia *et al.*, 2011)
10 Marine Oceanic		
10.1 Epipelagic (0-200m) 10.2 Mesopelagic (200-1,000m) 10.3 Bathypelagic (1,000-4,000m) 10.4 Abyssopelagic (4,000-6,000m)	Species distributions (Martin *et al.*, 2014)	
11 Marine Deep Ocean Floor (Benthic and Demersal)		

11.1 Continental Slope/Bathyl Zone (200-4,000m) 11.2 Abyssal Plain (4,000-6,000m) 11.3 Abyssal Mountain/Hills (4,000-6,000m) 11.4 Hadal/Deep Sea Trench (>6,000m)		
11.5 Seamount	Global Seamount Database (2011); Global Distribution of Seamounts and Knolls (2011); Seamounts Online: and Online Information System for Seamount Biology (2009)	One theoretical study suggests this is feasible but almost prohibitively expensive (Van Dover *et al.*, 2014); others suggest recovery could take "*several hundreds, or thousands of years, if at all*" (Roberts *et al.*, 2006). There is little empirical evidence either way.
11.6 Deep Sea Vents (Rifts/Seeps)	Global Distribution of Hydrothermal Vent Fields (2013); Global Distribution of Hydrothermal Vents (2010); Global Distribution of Cold Seeps (2010)	The same theoretical study suggested that this may be feasible as deep sea vent communities tend to be dominated by colonising species (Van Dover *et al.*, 2014), but again little empirical evidence.
12 Marine Intertidal		
12.1 Rocky Shoreline 12.2 Sandy Shoreline and/or Beaches, Sand Bars, Spits, etc. 12.3 Shingle and/or Pebble Shoreline and/or Beaches		Restoration of shoreline has long been a component of active coastal management
12.4 Mud Shoreline and Intertidal Mud Flats 12.5 Salt Marshes (Emergent Grasses)	Global Distribution of Saltmarsh (2013)	Feasible (see Box 3); also (Bakker *et al.*, 2002; Wolters *et al.*, 2005)
12.6 Tidepools		
12.7 Mangrove Submerged Roots	Global Distribution of Mangroves USGS (2011); World Atlas of Mangroves (2010); Global Distribution of Mangroves (1997)	Feasible (Ekstrom *et al.*, 2015; Bosire *et al.*, 2008)
13 Marine Coastal/Supratidal		
13.1 Sea Cliffs and Rocky Offshore Islands 13.2 Coastal Caves/Karst 13.3 Coastal Sand Dunes 13.4 Coastal Brackish/Saline Lagoons/Marine Lakes 13.5 Coastal Freshwater Lakes		
15 Artificial - Aquatic		
15.10 Karst and Other Subterranean Hydrological Systems [human-made] 15.11 Marine Anthropogenic Structures 15.12 Mariculture Cages 15.13 Mari/Brackish-culture Ponds		

4 Marine no net loss in practice

Despite the increased uptake of no net loss for terrestrial projects as a result of statutory requirements, voluntary standards, or voluntary commitments, and the potential to transfer this learning to the marine environment, there are very few examples of the concept of no net loss being applied to marine projects. The main reason for this appears to be the perception that marine projects very rarely have significant residual impacts, e.g. for wind farms (Vaissière *et al.*, 2014), despite widespread understanding that many unseen yet severe and highly dispersed impacts are taking place and that cumulative and indirect impacts are particularly significant in the marine environment.

4.1 Widening the net

As no net loss is in its infancy in the marine realm, a much wider set of project mitigation initiatives must be considered than just those specifically aiming for no net loss. Existing no net loss scoping studies often focus solely on the terminal aspects of the mitigation hierarchy (offsets) (Dickie *et al.*, 2013), or focus on a particular country (Cook and Clay, 2013). As the current evidence base is sparse, it is important to look for how a broad spectrum of current marine initiatives and sectors from isolated stages of the mitigation hierarchy can contribute to a project achieving defensible no net loss. For example, whilst the SONGS project case study (see Box 3, p23) is not specifically no net loss, the environmental permit details the need for "full mitigation" of the impacts in line with the Coastal Act 1976 Article 7 Section 30260 ("*adverse environmental effects* [of industrial expansions] *are mitigated to the maximum extent feasible*"), and includes examples of avoidance, minimisation, restoration and offsetting of impacts. As the Marine Review Committee (MRC) quantified species and habitat losses, the project can be thought of as no net loss.

The uncertain and data-poor environment of the ocean also emphasises the importance of adaptive management; as more information is made available on suggested minimisation activities, management measures must allow for change (Ekstrom *et al.*, 2015).

4.2 Examples of marine no net loss in practice

4.2.1 Avoidance

As for the terrestrial environment, the first stage of the mitigation hierarchy does not tend to be well documented in the wider literature for the marine realm. As avoidance will often be buried in lengthy Environmental Impact Assessments, or take place undocumented prior to the Environmental Impact Assessment (EIA), and depends almost entirely on the quality of data available which, as previously described, is a significant challenge for operating in the marine realm.

However, tools are being made available to make avoidance decisions easier for the private sector. Marine critical habitat was recently mapped to give an indication of habitats likely to trigger the IFC's definition and those that potentially could trigger it (delineated through a function of both confidence in the biodiversity data and alignment to IFC PS6 Critical Habitat criteria) (Martin *et al.*, 2015). Prioritisation initiatives like this have the potential to give an early indication of risk or biodiversity present until the data quality necessary to make more informed avoidance choices catches up with the pace of marine development.

A recent report aiming to strengthen the implementation of the mitigation hierarchy, especially avoidance, highlighted '*knowing what to avoid*', i.e. adequate data, as an enabling factor for effective avoidance and emphasises that the marine realm is "*particularly data poor*" (Hayes *et al.*, 2015). One of the case studies described, the Block Island Wind Farm (with associated cabling), details spatial avoidance of sensitive benthic communities, such as eelgrass and hard-bottom substrates, in its environmental report. Although the report goes on to describe the lack of data for the impacts of continuous noise on fish species or life stages, it suggests that enough habitat data are available to inform an evidenced best route for turbine and associated cabling placement (Tetra Tech EC INC., 2012).

However, as highlighted earlier in section 3.2.1, data paucity in the marine realm increases away from shore. This means that the largest data gaps are likely to be for those sectors and projects that operate in the high seas, e.g. deep sea mining; indeed, "*enormous data gaps*" was a repeated issue raised at a recent meeting of deep sea mining impact assessment experts[2] . Other sectors confined to EEZs or even within territorial waters are currently located where best available marine data resources for avoidance are present, e.g. the three examples of avoidance in a recent report, which focuses on the extractive industry (Ekstrom *et al.*, 2015).

4.2.2 Minimisation

Minimisation of impacts has increased concurrently with the availability of new technology, which is often cited as an enabling factor for mitigating harmful impacts, e.g. the use of soft start motors to minimise acoustic disturbance of marine mammals during seismic surveys. Soft start motors represent one aspect of potential minimisation options for the marine environment: reducing the scale of the impact; the other is reducing the sensitivity of the receptor, e.g. silt curtains that allow for sea water penetration only and prevent the smothering of coral reefs in coastal habitats and benthic communities in the deep sea but restrict sediment management.

4.2.3 Restoration

Supra-tidal coastal restoration is arguably very similar to some terrestrial restoration projects. Coastal habitats tend to be high energy environments, so riverine restoration (a high energy terrestrial environment) is comparable and has been widely studied, e.g. for Canada's no net loss legislation (see Box 2). However, even for these habitats it is easy to see the uncertainty associated with advancing to this stage of the mitigation hierarchy. For example, the SONGS nuclear energy expansion project, for which the monitoring elements of the environmental permit are still in place, failed to receive a wetland credit in 2014 due to a failure to provide sufficient salt marsh coverage compared to its restoration strategy. This is despite compliance with all other mandatory 'absolute' standards for the San Dieguito wetland (exotic species exclusion, topography, plant reproductive success) and a raft of 'relative' standards (e.g. water quality, bird densities, etc.). It is important to note that this example is largely demonstrative as it is not strictly restoration as a result of project activities, but like-for-unlike restoration to mitigate losses of fish in the bight[3].

The research into the practicalities of deep-sea ecological restoration is sparse. One theoretical study, investigating deep-sea semi-passive restoration (i.e. one initial management intervention, but none subsequently), highlights the possibility of seeding the heavily trawl-damaged Darwin Mounds, 900-1,200m below the surface off the coast of Scotland, with lab-grown specimens of the cold water coral *Lophelia pertusa*. It also describes a surprisingly resilient ecosystem surrounding a possible deep sea mining site 1,500m down in the Manus Basin, Papua New Guinea. The natural disturbance regime is relatively intense and the faunal assemblage present exhibits life history characteristics allowing for rapid colonisation. However, whilst the study concludes that terrestrial restoration principles "*can be applied to the deep sea*", it also emphasises that the cost

[2] Minutes available here: http://www.indeep-project.org/sites/indeep-project.org/f/document/EIA%20Workshop%20Report%20w appendices.pdf

[3] A curve or recess in the coastline, e.g. here, the Southern California Bight

of doing so, even semi-passively, would be "*expensive, likely two to three orders of magnitude more expensive than restoration undertaken in shallow-water ecosystems*" (Van Dover *et al.*, 2014).

4.2.4 Marine offsets

Given the apparent lack of robust no net loss frameworks for the marine environment or consistent implementation founded on robust scientific evidence, marine biodiversity offsets are already widely implemented in Australia (Richert *et al.*, 2015; Bos *et al.*, 2014; Dickie *et al.*, 2013; Cook and Clay, 2013; Vaissière *et al.*, 2014). Studies of the efficacy of marine offsets are "*scarce and patchy*" compared to the terrestrial realm (Levrel *et al.*, 2012), but they have been widely implemented in the Great Barrier Reef World Heritage Area (GBRWHA) since the introduction of enabling legislation, the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) (Bos *et al.*, 2014). Bos and colleagues provide a selection of five case studies in the GBRWHA 2010-2013. The first four examples stipulated for resource and financial support to prevent further loss of the impacted biodiversity features elsewhere and to support increased management and research of the GBRWHA by identifying stressors. Only the last identified case study required the implementation of a 'Marine Environment Offset Strategy'. However, an excerpt from the strategy does not mention explicitly accounting for residual biodiversity impacts, so any offsets cannot reasonably be thought of as no net loss accounting *per se*. The global push towards offsets is huge; as Bos and colleagues explain:

Figure 5: Mackerel gather under a jetty acting as a fish aggregation device

> *"We do not engage in the debate about whether offsets should be allowed. Rather, we assume that the current trend towards using offsets will continue, and investigate how to maximize the beneficial outcomes of these offsets while minimizing risks."*

One intervention that has received considerable attention in the literature is the creation, and efficacy, of artificial reefs (Bohnsack and Sutherland, 1985; Clark and Edwards, 1994; Carvalho *et al.*, 2013; Simon *et al.*, 2013; OSPAR Commission, 2009). It is also an intervention already widely used in marine development to mitigate impacts; for example, an artificial kelp reef is being created off the coast of California to mitigate impacts from the expansion of a nuclear power plant (see Box 3 for more detail), and the deepening of the Gothenburg Harbour in Sweden required the creation of artificial reefs in an adjacent protected area (OSPAR Commission, 2009).

4.2.5 Positive benefits of marine infrastructure

The premise of a no net loss approach is that positive biodiversity outcomes are needed to compensate for biodiversity losses. It also allows for positive biodiversity outcomes as a result of the project's construction *per se*. Adding artificial hard substrate in the marine realm has been argued, and sometimes proven to have, a positive impact on species richness and abundance. For offshore wind, the construction of near shore fixed and offshore floating turbines have shown similar effects to fish aggregation devices (FADs; see Figure 5), with positive impacts on benthic communities, demersal, non-commercial species of fish, and even commercial finfish (Fayram & de Risi 2007, Petersen & Malm 2006, Wilhelmsson 2006). The same is the case for seafloor cabling, which can often provide a hard substrate in a desert of soft substrate for the attachment of anemones (Actiniaria) (Carter *et al.*, 2009). However, the addition of a hard artificial substrate does need to be evaluated in the context of wider conservation goals; it will often be replacing soft bottom habitats and can lead to a higher probability of invasive species recruitment. On a project-by-project basis, the question must be asked whether we should value more the natural soft bottomed habitat, or the biodiversity shift associated with an introduced artificial substrate.

Where positive effects can be quantified, they could contribute towards a project-level goal of no net loss or net gain; further research can identify positive management interventions to encourage these effects and optimal design strategies.

A related benefit of some marine projects is the creation of no-take fishery zones. A comprehensive review of fish stock abundance studies in and out of fishing no-take zones proved their efficacy in increasing fish stocks of commercially attractive species (Koch *et al.*, 2009). Offshore wind farms, and to a certain extent marine cables, offer opportunities to work with local fishermen and conservation stakeholders to change fishery management in the area to address conflicts of space (loss of ground to marine renewables is often cited as significantly reducing fishing activity around offshore wind farms, Ashley et al. unpublished). Furthermore, a four year review of benthopelagic fish around a windfarm in the Belgian part of the North Sea found that although local production of cod stocks was occurring, this has not yet translated to regional production. The authors recommended excluding fishing activities within the windfarm until more data on fish stock production has been collected (Reubens *et al.*, 2014).

For other offshore windfarm designs, fishing activities are restricted for health and safety reasons, although those with more spaced wind turbines do allow some commercial fishing. Co-locating a marine protected area with an offshore windfarm in the Adriatic Sea has been suggested to help restock local Atlantic bluefin tuna stock (Fayram and de Risi, 2007), but its more widespread application is dependent on the fish species of interest and its habitat ecology regarding FADs. A similar study assessing the possible benefits of a cable protection zone in north eastern New Zealand's Hauraki Gulf found no difference inside and outside the cable protection zone (Shears and Usmar, 2006); it is thought that this could be because of the short study length (4 years), or illegal fishing (two of the cables showed typical bottom trawling displacement), but it could also show that the cable protection zone does not offer favourable conditions for marine biodiversity.

Box 3: Project case study: the San Onofre Nuclear Generating Station (SONGS), California

In 1974, what is now the California Coastal Commission (CCC) denied the expansion of SONGS Units 2 and 3. The following year, the CCC issued a coastal development permit to the operating company, Southern California Edison (SDE), with the condition of the creation of a Marine Review Committee (MRC) to monitor impacts of the Units and recommend mitigation measures. In 1991 and 1997, the CCC added the following four conditions as a result of MRC monitoring:

(1) Restoration of a southern California tidal wetland

Wetland creation is to compensate for Bight-wide losses of fish caused by the operation of SONGS Units 2 and 3: intake of seawater and subsequent temperature increase above ambient temperature kills fish eggs, larvae and immature fish. The Permit requires the **creation or substantial restoration** of at least 150 acres of wetlands in South California. As of the 2014 monitoring report, the designated mitigation area achieved four of five 'absolute standards' and could not therefore receive mitigation credit for 2014.

(2) Construction of an artificial reef

The creation of an artificial reef is to compensate for the loss of 179 acres of high density kelp bed caused by the rapid mixing of warm water efflux and the surrounding cooler seawater and subsequent sediment plume. The Permit requires the creation of an artificial reef large enough to sustain a 150 acres of medium to high density kelp bed. As of 2014, the reef had failed to gain mitigation credits for all six years of its existence on account of falling short of the 28 tons of fish biomass necessary to compensate for estimated fish losses at SONGS.

(3) Provision of funds for a marine fish hatchery

As part of the previous stipulation, the CCC added a requirement in 1993 for SCE to fund the construction of an experimental white sea bass hatchery; however, as this was deemed more experimental, the CCC did not assign mitigation credit to this condition.

(4) Installation of fish barrier devices

The MRC found that in the period 1983-1991, annual losses of fish in the cooling systems averaged 20 metric tons, on top of the larval and egg losses outlined in the first condition. The CCC required the reduction of fish impingement of 2 metric tons per year. One form of fish barrier device, the Fish Chase procedure, reduced fish impingement by 4.3 metric tons per year over the period 1992-1999.

5 Future directions

The marine environment is data-poor, impact-prone and extremely sensitive to chemical and physical change. In light of this, if no net loss is to be demonstrated for marine projects, there needs to be a radical shift away from the assumption of restorability and offset capability towards the original intention of terrestrial no net loss of the precautionary principle and emphasis on avoidance above all else. This can be supported by a more inclusive stakeholder process as ultimately, when there are few data on impacts and vulnerability, stakeholders have to decide what is important. When impacts truly are unavoidable, there is the opportunity to implement a limited number of innovative solutions to marine conservation that could potentially contribute to marine conservation gains.

5.1 Invoking the precautionary principle

The precautionary principle is one of the central tenets of conservation science, and should guide development decisions to choose not to proceed where the outcome is uncertain for biodiversity. The CBD defines it as follows: *"where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat"*. This can be applied to a new technology with unknown impacts on known marine ecology, or a known impact on unknown marine ecology. Where impacts cannot be quantified, no net loss cannot be demonstrated. The working group on no net loss for the EU admitted that "*there is still a large potential to improve avoidance and mitigation of impacts on marine biodiversity, for example through better marine spatial planning and better implementation of current legal obligations*" (European Commission, 2013).

As an example of the precautionary principle in action, there are real concerns about known and unknown impacts of the minerals rush to the high seas. In February 2015, the Environmental Protection Authority of New Zealand (NZ EPA) refused an application by Chatham Rock Phosphate Limited to mine phosphorite nodules on the Chatham Rise, citing inadequate impact mitigation: "*the destructive effects of the extraction process, coupled with the potentially significant impact of the deposition of sediment on areas adjacent to the mining blocks and on the wider marine ecosystem, could not be mitigated by any set of conditions or adaptive management regime that might be reasonably imposed.*"[4]

Further conclusions reached by the NZ EPA included:

- the assumption that mining would commence in parallel to the ground-truthing of seafloor coral predictive modelling preventing appropriate mitigation based on good data;
- lack of interventions to minimise impacts on vulnerable life cycles of benthic species;
- the refusal of the Decision Making Committee (DMC) to agree that the residual impacts on benthic habitat could be reversed.

5.2 Strengthening preventative measures

A recent report on implementation of the mitigation hierarchy in the extractive industries emphasised the important distinction between the first two stages of the mitigation hierarchy,

[4] EPA decision here: http://www.epa.govt.nz/eez/EEZ000006/EEZ000006_CRP%20Final%20Version%20of%20Decision.pdf

avoidance and minimisation, which are preventative, and the last two, restoration and offsetting, which are remediative (Ekstrom *et al.*, 2015).

There are concerns that the mitigation hierarchy is not being applied consistently across sectors and the globe (Hayes *et al.*, 2015), and that the later stages are considered before all avoidance and mitigation options have been exhausted; as one review of marine biodiversity offsets in the GBRWHA, a relatively mature offsets scheme, notes, *"too often, offsets for the GBRWHA are taken out of context and considered before the environmental impact assessment is complete"*, and recommends legislation for companies to document their exact adherence to the hierarchy (Bos *et al.*, 2014).

In order to be successful, no net loss needs to focus much more heavily on preventative rather than remediative actions, and the case for this appears to be stronger in the marine realm. Remediative measures in the marine environment are likely to encounter the following (Ekstrom *et al.*, 2015):

1. High technical, social, and political risks; e.g. for offsets, there is a vocal opposition to the use of biodiversity offsets as a 'licence to trash', an enabler of rapid, unwanted development, and alleged corporate 'greenwashing'.

2. Increasing uncertainty of costs, and risks of cost escalation; e.g. the estimated cost of deep sea hydrothermal vent restoration off the coast of Papua New Guinea is ~$740 M ha-1, compared to $0.1-$0.2 M h1 for shallow water restoration in San Francisco Bay (Van Dover *et al.*, 2014).

3. Increasing cost per unit of biodiversity.

4. Increasing requirements for external stakeholder engagement and specialist expertise.

5. Decreasing opportunity to correct mistakes.

6. Decreasing confidence and trust among key stakeholders; there is a wealth of scientific literature on the efficacy in practice of remediative measures, and these perceptions may be shared by the public (Quétier *et al.*, 2014; Gordon *et al.*, 2015; Maron *et al.*, 2015).

Thus, in the marine realm, it is even more important to understand the full implementation of the mitigation hierarchy, and to take on board reviews like Hayes and colleagues (Hayes *et al.*, 2015).

5.2.1 Early stakeholder engagement

In every guidance for achieving no net loss, there is rightly an emphasis on the importance of engaging a wide group of stakeholders as early as possible in the process and to continue this engagement and transparency throughout (Ekstrom *et al.*, 2015; Hayes *et al.*, 2015; IFC (International Finance Corporation), 2012; Gardner *et al.*, 2013). This is important in order to capture differing values attached to biodiversity by different actors/users.

Whilst stakeholder engagement may be easier for projects within EEZs, and follow a similar pattern to the terrestrial process, projects located in the high seas are completely different as they arguably have no (local) stakeholders with whom to engage. This may change with the introduction of a biodiversity convention for the high seas or the change in UNCLOS, but in the meantime broadened stakeholder engagement provides a good opportunity to collaborate with other marine industries like commercial fishing and shipping.

5.3 Improving conservation measures

Early stakeholder engagement and validation of the evidence is critical for evaluating conservation measure improvements to current marine conservation interventions that may improve the existing implementation failures and concerns (Bos *et al.*, 2014).

5.3.1 Artificial reef design

As mentioned in 4.2.4, the creation of artificial reefs as a mitigation measure is already widespread. However, traditional methods do not mirror the biological complexity of natural reefs, and some mitigation measures have even had a negative impact on biodiversity: when Gothenburg harbour was deepened to allow greater shipping traffic, some of the rocky material excavated was moved to a nearby site in order to mitigate for the removal of lobster habitat. While lobsters and some commercial species of fish, e.g. cod, were quick to recolonize the habitat, sedimentation caused by the construction of the habitat and the presence of sulphur bacteria had a negative impact on other local biodiversity (OSPAR Commission, 2009).

Reef Arabia, a team of reef experts in the Persian Gulf off Bahrain, have begun to use the 3D printing of 'coral' to encourage coral regrowth in an area devastated by overfishing. While it is in extremely early stages (the initiative has sunk 3,000 traditional concrete reef balls since March 2012, and has only recently considered the use of 3D printing of patented sandstone 'constructed reefs'[5]), the project scientists are hopeful that the inexpensive construction process, the inert nature of the sandstone mix, and the more natural, diverse structure of the reefs will provide a preferable habitat for a more diverse range of species than traditional concrete.

Widespread future application of this technology for artificial reefs could allow for more effective restoration and offsetting of benthic hard substrates; stakeholder engagement could assess whether it is acceptable for a given habitat in a given location, and future studies can provide the evidence base for whether the cost and temporal gains have a consequent positive effect on species recruitment.

5.3.2 Rigs to reefs

The recent economic downturn and the spiralling cost of decommissioning deep sea oil rigs have sparked a renewed interest in the 'rigs-to-reef' concept, where oil companies carry out a controlled sinking of parts of their offshore infrastructure (usually the topside) in order to provide artificial reef habitat for deep sea ecosystems. Whilst it has been suggested that this concept could have a positive impact on benthic biodiversity through increasing the overall area of what is essentially quite a rare benthic occurrence and for allowing reef connectivity (Macreadie *et al.*, 2011), the concept remains highly controversial (see Greenpeace's protest at the deep water disposal of the Brent Spar, where Greenpeace's temporary occupation of a Shell rig ultimately led to the company abandoning their rig-to-reef plan for decommissioning of that structure).

In light of this public refusal of the rigs to reef process, and amid allegations from some contracting parties that oil companies would use the concept to evade deep water disposal rules, OSPAR excluded all non-virgin materials (i.e. commercial waste) as acceptable construction materials for artificial reefs. Considering there are 220 production fields to be decommissioned in UK waters by 2025 (Jørgensen, 2012), and more than 7,500 rigs worldwide (Macreadie *et al.*, 2011), there are calls for OSPAR to reconsider this exclusion and move to the assessment of initiatives on a case-by-case basis. This is important as while there have been cases of successful translocation to the benthos, one study in the Gulf of Mexico has found that the addition of hard substrate alongside what is usually a desert of soft mud has increased the occurrence of ciguatera, a tropical disease that can affect humans if infected fish are ingested (Villareal *et al.*, 2007).

5.3.3 Financial incentives

Funding for marine biodiversity conservation is extremely stretched and is limiting the conservation gains that can be achieved (Bos *et al.*, 2015). To combat this, innovative financial mechanisms are being suggested to reduce the funding deficit. One such initiative is the development of 'blue bond standards' by the World Bank. This was discussed at length at the April 2014 Global Oceans Action Summit for

[5] News article: http://www.forbes.com/sites/ptc/2013/10/21/3d-printed-reef-restores-marine-life-in-the-persian-gulf-3/

Food Security and Blue Growth[6]. The positive effect of increased investment through the issuance of bonds can be seen in the tuna purse seine fisheries around the Pacific Islands that maximise the social, financial, and environmental returns[7].

The development of a blue bonds market could attract investment for marine conservation interventions in a similar manner to green bonds, where $35 billion in bonds were issued in 2014; representing a threefold increase year-on-year. Private sector development projects could issue bonds for increased effort conservation interventions. Increased interest in blue bonds could also provide benefits to for the collection of more robust marine data on which to make solid investor decisions, and the requirement to bring together different stakeholders.

However, at a workshop attended by environmental experts from many of the multilateral development banks and finance institutions in October 2015, the potential efficacy of blue bonds was questioned as a solution to marine conservation finance, largely on account of the difference between marine projects and those funded by the current green bonds initiative. It was suggested that the World Bank Pacific Islands Regional Oceanscape Program, which began in 2014 and runs to 2020, may provide the evidence to assess the marine application of bonds.

5.3.4 Reducing other impact pressures

A workshop held at UNEP-WCMC, convening experts in marine science and the no net loss approach, suggested that while the cumulative impact of marine infrastructure may not be known due to "*insufficient global data*" (Halpern *et al.*, 2015), the impact of other industries, especially extremely high volume commercial fishing and deep sea trawling, is well-documented. To this end, it was suggested that marine infrastructure sectors may be able to offset residual impacts with reductions in the impact of other industries, namely commercial fishing. Ideas to implement this included buying fishing concessions, e.g. in Mozambique, whose sustainable fishing partnership agreement (SFPA) with the EU expired January 2015, to allow fish stocks to recover to historic levels. However, a recent study of anthropogenic stressors on the marine environment highlighted that impacts from four of the five types of commercial fishing decreased in 70-80% of the ocean from 2008-2013, "*consistent with results suggesting global catch has stabilized or is declining in most parts of the ocean*" (Halpern *et al.*, 2015). The overall *increase* in cumulative impacts found by this study, as mentioned earlier, is driven mostly by changes in climate change stressors (sea surface temperature, ocean acidification, and ultraviolet radiation). Conservation International has taken a similar approach on land, where they financed two 'conservation concessions', bought as timber concessions, in Peru and Guyana (Ferraro and Kiss, 2002). However, there is little scientific evidence as to what the outcome of this has been for biodiversity conservation.

Another suggestion for cross-sector collaboration between the conservation and fishing sectors is the use of offsets to mitigate against the harmful bycatch of some commercial fishing practices. It is suggested that eradication of invasive mammals (e.g. rats and cats) on islands is a more cost-effective means of conserving target seabird species than bycatch reduction measures. The fishing sector could offset the most harmful practices with financial contributions to island mammal eradications (Wilcox and Donlan, 2007; Donlan and Wilcox, 2008). There is no reason why this suggested strategic partnership could not be extended to other sectors.

Strategic partnerships could also be created between marine infrastructure sectors and the fishing industry to share knowledge, collaborate and exchange the limited marine data available through cross-sector working groups.

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[6] Chair's Summary available here: http://www.fao.org/cofi/41010-0501970390bfbcde97d7082fb80f8da6.pdf

[7] Project summary: http://www.worldbank.org/projects/P151777?lang=en

5.4 Marine spatial planning

One possible mechanism of opening up helpful cross-sector dialogue is marine spatial planning. Marine spatial planning (MSP) "*is emerging as the dominant marine governance paradigm in much of the world*" (Fletcher *et al.*, 2013), and has been defined as:

"a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives"
(Ehler and Douvere, 2009)

One of the 'ecological goals' of MSP could be set to achieve no net loss for biodiversity in the area in which the MSP approach is being undertaken. However, it is possible that socio-economic goals take priority over environmental goals in trade-offs between the two.

An effective MSP approach maximises the quality and extent of the evidence base available, clarifies data gaps and uncertainty, and encourages full participation from stakeholders; all of which are barriers to the thorough implementation of a no net loss approach in the marine environment. For this reason, the advancement of the MSP approach can complement the development of a no net loss approach for biodiversity. These data improvements can be incredibly supportive to avoidance of biodiversity impacts, and can also help identify areas of degraded habitat where restoration or offset interventions may be most effective.

As one of the central tenets of MSP is the process of optimally allocating sea space for marine activities, it can provide a rigid framework in which to assess, design and implement co-location activities as described in section 4.2.5. Studies have proven the environmental and legal feasibility in country case studies, e.g. for England and the EU (Christie *et al.*, 2014), but that projects must be assessed on a case-by-case basis, and the scope and likelihood of co-location must be assessed at the earliest possible stage of development, preferably planning. This process would emphasise the proper implementation of the mitigation hierarchy when aiming for no net loss of biodiversity.

A good example of the MSP process complementing the development of marine no net loss policy can be seen in Belize, where the Belize Coastal Zone Management Authority and Institute (CZMAI) commissioned *The Marine and Coastal Biodiversity Offsets Framework for Belize* to guide the development of pilot projects to test the application of marine biodiversity offsets, in "*one of the first efforts to apply recent advances in offsetting theory and practice to a marine and coastal context*"[8] (Belize Coastal Zone Management Authority & Institute and Australia-Caribbean Coral Reef Collaboration, 2014).

5.5 Data availability

By far the biggest challenge to implementing no net loss in the marine realm is poor data availability when compared to the terrestrial environment. As mentioned in 3.2.1 and 3.2.2, data paucity constrains the measuring of impacts and conservation gains because no justifiable baseline can be set against which to measure.

In response to this, there are already a number of initiatives to combat data paucity at sea. Beyond the continued efforts of both independent scientific research and environmental impact assessments funded by the private sector, there are a number of initiatives to combat the lack of adequate marine biodiversity data.

The ODV[9] provides users easy access to a number of marine datasets to inform high-level decisions regarding the conservation of marine biodiversity, including the World Database on Protected Areas, raster data for some metrics of biodiversity (Shannon's and Hurlert's indices), and selected species distributions (e.g. the

[8] http://climateandreefs.org/biodiversity-offsets/
[9] data.unep-wcmc.org

Hawaiian monk seal). OBIS[10] provides a similar service, but allows for simple analysis of data.

ODV and OBIS provide high-level, global assessments of marine biodiversity, but do not provide data that can be used to query site-based assumptions. Project impact assessments represent a potentially huge repository of data concerning the marine environment. An initiative off the west coast of Australia, the Industry-Government Environmental Meta-database (IGEM), is a partnership between several oil and gas companies and the Western Australian Marine Science Institution (WAMSI). The initiative aims to collate metadata provided by member companies to inform regulatory processes, oil spill response measures, and research purposes. Data collection is expected to initially focus on mangroves, benthic habitats, demersal fish, nesting turtles, seabirds and shorebirds, megafauna, and sediment quality, with the platform itself available early 2016. National seafloor mapping initiatives are also proliferating, e.g. Marine Environmental Mapping Programme (MAREMAP) in the UK, Integrated Mapping for the Sustainable Development of Ireland's Marine Resource programme (INFORMAR) in Ireland, and MAREANO in Norway.

Finally, the *Manual of marine and coastal datasets of biodiversity importance* (Martin *et al.*, 2014) provides an overview of 78 datasets and/or databases and data portals of global biodiversity importance, as well as some of regional importance. An update, including an additional 50 datasets and 24 detailed metadata sheets, was released December 2015 (Weatherdon *et al.*, 2015). Both manuals also provides a discussion of challenges, gaps and limitations of marine data, before offering some solutions to these challenges.

One solution to current data gaps is to expand the use of species distribution modelling (SDM) techniques (Guisan and Thuiller, 2005), which use cheap-to-capture environmental predictors to model a particular species' likely distribution. AquaMaps, which holds standardised distribution maps for 17,300 species of fishes, marine mammals, and invertebrates, is an example of this (Kaschner *et al.*, 2014).

[10] http://www.iobis.org/

6 Conclusions and research recommendations

It is globally recognised that marine biodiversity is under threat (WWF, 2015; Halpern *et al.*, 2015; Tittensor *et al.*, 2014). It is therefore crucial that increased marine infrastructure development in response to rising energy and food demands does not add to the cocktail of stressors negatively impacting marine biodiversity. This feasibility assessment concludes that while there are a number of challenges to applying no net loss policies in the marine realm, there are a growing range of innovative solutions in development. In addition, there are opportunities to utilise the wealth of research that has been conducted into no net loss policies from which we can learn. This report has identified a number of gaps and possible further research areas.

6.1 Assess feasibility of no net loss across more sectors and issues

This report excluded the fisheries and extractive sectors, both of which are important players within the marine environment. Better understanding is required of the feasibility of attaining no net loss for those sectors given the interlinked nature of the marine environment.

6.1.1 Review sector impacts as they move further out to sea

Offshore wind floating turbine technology will allow the consideration of sites up to 700-900m in depth, deep water ports further out to sea are being seriously considered as ships become larger, and there is significant potential for mariculture to move to areas further offshore. As sectors shift into deeper waters, their impacts will also change. It is also likely, therefore, that the feasibility of attaining no net loss will also change. It will be important to assess how these changes individually and cumulatively may impact on marine biodiversity.

6.1.2 Deep sea mining

There is significant concern as to the potentially detrimental impacts on biodiversity of a rush to the deep sea for increasing mineral demands, exacerbated by weaker governance in ABNJ. The ISA have already granted 26 mining permits in international waters, laid out in a seabed plan patchwork of mining concessions and APEIs. Spatial analysis would be able to determine whether the current framework of seabed planning has captured the areas of highest benthic biodiversity in APEIs, or whether APEIs were an afterthought after concessions were decided. This information will be important to enable effective avoidance decisions to be made as a first step in any no net loss commitment.

6.1.3 Ecosystem services

This report has focussed on no net loss of biodiversity. However, it has been suggested that it may also be prudent to assess the feasibility of no net loss of biodiversity and ecosystem services, or the community benefits that humans derive from biodiversity. This may provide a more holistic framework with which to capture the many values of marine biodiversity and would require detailed consideration of the potential for no net loss commitments linked to fisheries.

6.1.4 No net loss within EEZs

The high level overview provided in this report gives a summary of the feasibility of no net loss from coastal waters to the deep sea. However, much more detailed research is needed into the specific challenges of no net loss within EEZs, where the concept could be more complicated than the deep sea due to excessive, complex governance and highly contested spaces. There has recently been some proposed methodologies, e.g. adapting UMAM and HEA (Bas *et al.*, 2016), but the authors highlight that "*in open water marine environments, offsetting are poorly implemented*".

6.1.5 Addressing land-based sources

Many marine problems have land-based problems, e.g. high nutrient input from a land-based source (Halpern *et al,* 2015), and one emerging challenge is how to deal with this within marine no net loss accounting. One approach that could incorporate the challenge is Integrated Coastal Management (ICM); research could focus on global case studies of ICM and how no net loss could be incorporated into each.

6.2 Addressing governance barriers to no net loss policies

6.2.1 No net loss in marine spatial planning

A more strategic, spatial planning approach will create a more certain operating environment for business decision making, facilitate understanding of indirect and cumulative impact, identify opportunities for cross sector collaboration and may enable more coordinated offset planning. Marine spatial planning is occurring globally, and provides the mechanism to effectively marry social, environmental and economic objectives for marine space. A recent survey identified 79 single MSP processes worldwide. Of these, only 30 have moved to the implementation stage, with fewer still implementing for more than five years (UNEP & GEF-STAP, 2014). As different MSP processes learn about implementation, there is an opportunity to investigate how the principle of no net loss can fit into these processes and incentivise a reduction in impact of development in the marine environment.

6.2.2 Support the revision of the governance of ABNJ

There is significant concern that the current UNCLOS framework does not sufficiently address the conservation and sustainable use of marine biodiversity in ABNJ. A two year process will begin in 2016 that will put forward a legal instrument under UNCLOS to address this shortcoming. There is an opportunity to support its revision to ensure the inclusion of a strong duty of care for biodiversity in ABNJ that is supported by best available data, thereby creating a clear operating framework for companies to undertake development in the marine environment.

6.3 Addressing data paucity

6.3.1 Make existing data more accessible to decision makers

Access to robust and credible data is crucial for the design and implementation of no net loss commitments. Efforts are ongoing to address this, including a recent paper that offers a global baseline for sea floor biodiversity (Woolley *et al.*, 2016), but more needs to be done to make this accessible to decision-makers.

Table 2 on page 15 draws together a list of data sets and scientific studies of restoration activities based on a brief literature review. This could be enhanced to provide a resource of robust biodiversity data for business decision makers, informing their investment decisions and the scope of future environmental impact assessments.

Alongside this, a number of tools are developing to collate marine data sets and make them accessible to governments, business and civil society e.g. ODV, marine critical habitat map (Martin *et al.*, 2015). Such tools require investment to increase their utility to the private sector.

6.3.2 Regionalisation of data

The 2015 update of the Manual of marine and coastal datasets of biodiversity importance will go some way to addressing significant data gaps, but global datasets always require collaboration with local data authorities to identify areas of regional importance or instances of better quality regional-scale data. There is an important opportunity to champion the regionalisation of marine biodiversity data: for example, the global map to aid screening of potential and likely critical habitat could be updated with a regional focus. The ODV is also moving towards incorporating more regional data. Access to more complete, detailed information will enable more informed decision making linked to, or prior to, EIA implementation facilitating adequate implementation of the avoidance stage of a no net loss commitment.

6.4 Building the evidence for effective mitigation

6.4.1 Decommissioning & end of life impacts

In the oil and gas sector, as an example, there are 220 oil production fields in the UK alone that require decommissioning by 2025, and 7,500 rigs worldwide. OSPAR's ban on the rigs-to-reef concept demonstrates the need for much more research into the potential biodiversity implications of leaving oil infrastructure in place and whether this can contribute to conservation goals as part of a commitment for no net loss. As offshore wind becomes a more important and widespread energy sector, this research can inform end of life strategies.

6.4.2 Future-proofing infrastructure from climate-related impacts

Human impacts have been shown to be increasing on the oceans irrespective of any contribution, positive or negative, from marine energy infrastructure development. In this respect, research could investigate the positive contribution increased remediative measures from marine development, spurred by the implementation of a rigorous no net loss framework, could make towards ecosystem-based resilience and climate change adaptation. This could assess the extent to which climate adaptation gains to biodiversity can contribute to a commitment to no net loss in the marine environment.

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