Marine biodiversity offsets: Pragmatic approaches toward better conservation outcomes

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Abstract
Increasing exploitation of marine natural resources and expansion of energy infrastructure, shipping, and aquaculture across the oceans are placing increased pressure on marine life. Biodiversity offsets, as the last stage of the mitigation hierarchy, provide an opportunity to promote a more sustainable basis for development by addressing residual impacts and achieving “no net loss” for biodiversity. Despite debate around their effectiveness, biodiversity offsets are seeing increasing application on land but remain a rarely used tool in the marine environment. We assess how offsets can be applied in the marine environment to achieve better biodiversity outcomes, and identify implications for conservation policy and practice. For instance, spatial conservation planning provides opportunities to move away from a siloed, project-by-project, approach by pooling offsets on a regional scale. There are real differences between marine and terrestrial environments in relation to ecology, connectivity, data availability, management options, and impact perception, and marine offsets are therefore often regarded as challenging. However, fundamental offset principles, types, and approaches apply equally on land and at sea. Marine biodiversity offset approaches can build on the experience of terrestrial offsets but can also innovate to help achieve biodiversity gains and contribute toward global and national biodiversity targets.

KEYWORDS
biodiversity offsets, blue growth, marine environment, mitigation hierarchy, no net loss, sustainable development

1 INTRODUCTION
Coastal and marine-based industrial development, including exploration for oil and gas and minerals, renewable energy, shipping, and aquaculture development, is expanding rapidly and has potential for huge future growth (OECD, 2016). However, these developments are placing increasing pressure on natural resources. Increased stress resulting in deterioration of biodiversity is evident in over three quarters of marine areas under national jurisdictions and nearly two thirds of all oceanic systems (Halpern et al., 2015). Only 13.2% (~55 million km²) of the world’s ocean can now be considered largely free of human impacts (Jones et al., 2018).

In response, standards and policies around biodiversity risk management continue to develop within industry and through finance lender requirements such as International Finance...
Corporation (IFC)’s Performance Standard 6 (Rainey et al., 2015). Application of the mitigation hierarchy to avoid, minimize, restore, and—as a last resort—offset impacts is central to many of these policies (CSBI, 2015). Existing and emerging national mitigation policies also increasingly recognize the potential of marine biodiversity offsets to address residual impacts even if their application has been limited to date (Niner, Milligan, Jones, & Styan, 2017a; Shumway, Watson, Saunders, & Maron, 2018).

Offsets are actions designed to compensate for significant residual adverse biodiversity impacts arising from project development by providing measurable conservation gains that persist at least as long as projected impacts (IFC, 2012). Offsets can take the form of positive management interventions such as restoration of degraded habitat, or enhanced protection of an existing site, averting the loss of biodiversity where there is an imminent or projected loss of habitats or species. Biodiversity offsets are distinguished from other types of conservation or compensation because they are based on explicit assessment of biodiversity losses and gains, usually at matched impact and offset sites (ICMM & IUCN, 2013). Supporting actions such as awareness raising, environmental education, research, and capacity building are often fundamental for long-term offset success but are typically not considered offsets in themselves.

There are a number of widely agreed, fundamental criteria to apply when assessing the feasibility and appropriate use of offsets (e.g., IUCN, 2016; Pilgrim & Ekstrom, 2014). Offsets need to be comparable (a fair exchange for the biodiversity lost; also referred to as “equivalence”), additional (over and above what would have happened without the offset), lasting (in place for at least as long as impacts), and within limits (some impacts are not offsettable). In all cases, offsets should only be considered once all feasible steps have been taken to avoid, minimize, and restore impacts through rigorous application of the mitigation hierarchy.

Offsets remain contentious and their long-term effectiveness debated (May, Hobbs, & Valentine, 2017). Studies of the efficacy of marine offsets in particular are scarce and patchy compared to those for freshwater and terrestrial ecosystems (Bos, Pressey, & Stoeckl, 2014; Jacob, Pioch, & Thorin, 2016; Levrel, Pioch, & Spieler, 2012; Vaissière, Levrel, Pioch, & Carlier, 2014). Although Niner et al. (2017a) identified six countries with marine offset policies and many more considering them, there was little evidence of policy implementation to date. This may be attributable to a number of factors, including real or perceived implementation difficulty, paucity of data to inform management, complexity of monitoring and enforcement, and a limited understanding of impacts (OECD, 2016; Shumway et al., 2018). Negative public perceptions toward offshore windfarms, for example, arise mainly as a result of aesthetic concerns rather than their environmental impacts below the surface (Vaissière et al., 2014).

On land, the application of offsets appears little diminished by challenges in their implementation (zu Ermgassen et al., 2019) and uncertainty over their effectiveness (Gardner et al., 2013). Current trends show an increased uptake of offsets by governments, developers, and lenders, as a consequence of setting “no net loss” or similar requirements (Bull & Strange, 2018; Global Inventory of Biodiversity Offset Policies [GIBOP]1; Rainey et al., 2015). Offsets will in all likelihood be required to support sustainable marine development as part of the “blue economy” (Bennett et al., 2019). Close to 4% (c. 13 million km²) of marine and coastal areas are recognized for their high potential biodiversity value (Martin et al., 2015) and development in many of these areas would require application of offsets under existing or emerging government policies and lender safeguards.

Earlier reviews have outlined the challenges involved in undertaking marine offsets (Bos et al., 2014; Jacob et al., 2016; Levrel et al., 2012; Niner, Milligan, Jones, & Styan, 2017b; Shumway et al., 2018; Vaissière et al., 2014). Here, we look at how to address these challenges (assessing where terrestrial approaches can be applied in the marine context), identify the opportunities for undertaking different types of marine offsets, and outline the implications for conservation policy and practice.

## 2 | KEY CONSIDERATIONS FOR APPLYING MARINE OFFSETS

The perceived challenges of implementing marine offsets relate to some key differences between marine and terrestrial environments. Below we summarize the differences identified in earlier reviews (see above for references) and further examine their implications.

### 2.1 | Dynamic and diffuse environment

The highly dynamic and diffuse nature of the marine environment typically requires sampling across much broader spatial and temporal scales than on land, often far beyond the direct project area. This can also make it difficult to distinguish impacts and offset gains from background noise (e.g., pollution and sedimentation inflows, land runoff, etc.). As noted by Lindeboom, Degraer, Dannheim, Gill, and Wilhelmsson (2015), assessing cumulative impacts from multiple windfarm developments remains a major challenge that applies equally to other marine sectors.

1. [https://portals.iucn.org/offsetpolicy/](https://portals.iucn.org/offsetpolicy/)
2.2 | Extensive connectivity

Marine connectivity also has implications for effective offset implementation. Area-based offset interventions can be particularly problematic as it may be difficult to quantify offset gains across the large spatial and temporal scales needed to encompass a species’ ecology and life history. Offsets for wide-ranging marine species, which are often threatened across their range, could therefore require “mobile offsets” that aim to tackle a number of impacts at different seasons in order to be effective. On land, offsets are typically implemented within an area with more clearly defined ecological or political boundaries. It should be noted that, although marine threats rarely impact terrestrial biodiversity, onshore developments can have significant impacts on marine life through, for example, increasing land-based sediment run-off into the sea. In order to be effective therefore, offsets close to shore will have to account for and address both marine and land-based threats to biodiversity.

2.3 | Data gaps

Accurate and up-to-date biodiversity data are essential to understanding biodiversity impacts and measuring offset gains (Bull, Milner-Gulland, Suttle, & Singh, 2014; Maron, Bull, Evans, & Gordon, 2015). A baseline and an appropriate counterfactual (i.e., what would have happened in the absence of the project) are needed in order to measure both project losses and offset gains to determine whether no net loss can be realized (Gurney, Pressey, Cinner, Pollnac, & Campbell, 2015; Mascia et al., 2017). This is particularly challenging in a context where reliable biodiversity data are often limited (Mora, Tittensor, & Myers, 2008; Webb, Berghe, & O’Dor, 2010) and where there remains a significant under-representation of marine species (less than 15% of all the species assessed on the IUCN Red List; IUCN Barometer for life, 2019).2

2.4 | Governance regimes

The absence of clear governance arrangements in areas beyond national jurisdiction makes it difficult to attribute responsibility over impacts and implement offsets (Freestone, Johnson, Ardon, Morrison, & Unger, 2014; Rochette et al., 2014; Shumway et al., 2018). Marine infrastructure such as cables and pipelines often spans areas with different legal regimes. Offsets associated with impacts to these sites may therefore require engagement and approval from a range of authorities with differing regulations and policies. Even in areas subject to national jurisdiction, many countries with limited resources and/or weak governance already struggle to

2 https://www.iucnredlist.org/about/barometer-of-life.

2.5 | Perception of impacts

Finally, marine impacts tend to occur largely beneath the surface and outside of the public eye. It has been argued that this “out of sight, out of mind” issue goes some way toward explaining the low public expectation for offset application in marine renewable energy development (Kermagoret, Levrel, Carlier, & Ponsero, 2016; Vaissière et al., 2014). Lotze, Guest, O’Leary, Tuda, and Wallace (2018) identified a mismatch between public and expert perception of the key threats to the marine environment, with biodiversity loss ranking lower with the general public. The concept of “Social License to Operate” encapsulates the business case for management of reputational risks including demonstration of no net loss for biodiversity (Richert, Rogers, & Burton, 2015). Increasing the public’s awareness of marine biodiversity impacts is therefore key to ensuring there is adequate accounting for impacts and offsets.

3 | PROSPECTS FOR ADDRESSING RESIDUAL IMPACTS THROUGH MARINE OFFSETS

These challenges notwithstanding, there is no fundamental conceptual difference between marine and terrestrial offsets and the same principles and methods of design and implementation apply (IUCN, 2016; Pilgrim & Ekstrom, 2014). As on land, appropriate marine offsets are likely to include site-based actions, aimed at averting future threats or remediating past ones (e.g., through habitat rehabilitation) or policy-based actions, targeted at changing sectoral policy and practice. Table 1 provides some examples of different types of marine offset application.

3.1 | Opportunities for averted loss-type offsets

Averted loss-type offsets may be particularly relevant to marine ecosystems. Only 7.3% of the world’s oceans are currently under some form of protection compared to 15% on land (UNEP-WCMC, IUCN & NGS, 2018), far below the global conservation target of 10%. The relatively slow pace of establishing marine protected areas and limited resources to support their effective management in many countries (Gill et al., 2017) mean there is a good case to be made for marine offsets being additional to existing efforts. Offsets could also help reduce the rate of seascape-scale biodiversity loss by contributing to specific national or regional biodiversity protected targets, providing a clear and transparent basis for compensation (Simmonds et al., 2019).
**Table 1** Example approaches to marine offsets. Links and references are provided to case study examples. Otherwise examples are theoretical.

| Offset type        | Examples                                                                                                                                                                                                 |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| **Averted loss**   | - Supporting the establishment and management of coastal and marine protected areas (e.g., Rotterdam’s port expansion and Saint–Brieuc offshore windfarm).   |
|                    | - Removing threats to sensitive species impacted by a project (e.g., Rio Tinto’s Amrun project strategy to offset impacts to sea turtles by managing nest predation by feral pigs). |
|                    | - Supporting local communities to improve marine resource management.                                                                                                                                      |
|                    | - Implementing upstream pollution and sedimentation controls to improve water quality for coastal ecosystems.                                                                                              |
| **Restoration**    | - **Active restoration:**                                                                                                                                                                                  |
|                    |  - transplanting mangrove, seagrass, and coral stock from healthy to degraded ecosystems such as was undertaken in the Gulf of Aqaba in Jordan for coral colonies (Koth, 2016).                   |
|                    |  - wetland restoration to compensate for fish and kelp habitat loss from the San Onofre nuclear power plant in southern California.                                                                     |
|                    | - **Passive restoration:** Creation of suitable hard substrates for resettlement of corals as was undertaken for the Dampier port upgrade in Australia (Blakeway, Byers, Stoddart, & Rossendell, 2013) and reef creation to compensate for fish and kelp habitat loss from the San Onofre nuclear power plant in southern California. |
| **Policy based**   | - Supporting uptake of turtle excluder devices in net fisheries to reduce marine turtle bycatch.                                                                                                           |
|                    | - Changing longline fishing practices (including gear type, night setting, temporary closures, etc.) to reduce bycatch of sharks and dolphins.                                                             |
|                    | - Establishing and enforcing seasonal “no take” zones on the high seas to support sustainable fisheries.                                                                                                |
|                    | - Compensatory mitigation measures, such as addressing impacts to seabirds from fisheries bycatch by controlling invasive rodents on islands with important seabird colonies.                        |
|                    | - Addressing impacts to coastal marine ecosystems by addressing land-based pollution sources.                                                                                                               |

Further, many marine wilderness areas, recognized globally for their high biodiversity value, remain unprotected and thus provide potentially suitable offset sites where existing or predicted threats can be averted (Jones et al., 2018). Using a simple overlay of marine protected areas with likely and potential Critical Habitat, we found that nearly half of areas of high biodiversity significance are currently not receiving any formal protection (Figure 1). These could provide appropriate offset receiving sites. Marine Key Biodiversity Areas also provide developers and governments with a useful means of identifying suitable offset sites and contributing toward conservation targets in the absence of national-level marine spatial plans.

![Areas of “likely” and “potential” Critical Habitat located within and outside protected areas. Critical Habitat based on International Finance Corporation’s definition in Performance Standard 6. Definitions of Likely and Potential Habitat from Martin et al. (2015). Values presented in million square kilometers and as a percentage of the total area of Likely and Potential Critical Habitat](https://portals.iucn.org/offsetpolicy/)

However, linking averted loss offsets to conservation targets carries the risk of cost-shifting, where governments avoid investment to meet their stated commitments (Maron et al., 2015; Pilgrim & Bennun, 2014). Also, implementing averted loss offsets alone results in overall biodiversity loss at seascape scale; restoration offsets will also be needed where jurisdictional targets are for no net loss or net gain (Simmonds et al., 2019). Further, special attention should be paid to avoid merely shifting impacts from the offset site to other locations (Shumway et al., 2018). Such issues of “leakage” have been very well documented in the case of no-take fishing zones (Halpern, Gaines, & Warner, 2004).

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*Further information:*  
1. [www.maassvlakte2.com/kennisbank/nature_compensation.pdf](http://www.maassvlakte2.com/kennisbank/nature_compensation.pdf)  
2. [https://www.riotinto.com/documents/Amrun_Reports_and_Publications_Feral_Pig_Management_Offset_Strategy.pdf](https://www.riotinto.com/documents/Amrun_Reports_and_Publications_Feral_Pig_Management_Offset_Strategy.pdf)  
3. [http://marinemitigation.msi.ucsb.edu/mitigation_projects/wetland/index.html](http://marinemitigation.msi.ucsb.edu/mitigation_projects/wetland/index.html)
FIGURE 2 Potential for undertaking restoration offsets for different marine ecosystems, based on the approximate timescale required and feasibility (feasibility represents a function of costs and success). Among the extensive literature providing elements on restoration feasibility and timescale, we can cite Bayraktarov et al. (2016), Edwards & Gomez (2007), Jacob, Buffard, et al. (2018), Van Dover et al. (2014), and Zhao et al. (2016).

3.2 Opportunities for restoration offsets

Ecological restoration is increasingly seen as a means to compensate for impacts to biodiversity as a result of development projects (Maron et al., 2012). However, it is a process that presents challenges and considerable uncertainty, both for terrestrial and marine offsets (Curran, Hellweg, & Beck, 2014; Moreno-Mateos, Power, Comín, & Yockteng, 2012). Marine restoration is typically expensive, uncertain, and often unrealistic within the timescales of large-scale development projects (Bayraktarov et al., 2016). Further, there remain only a limited number of successful case studies to learn from and few tried and tested techniques that can be widely applied (Jacob, Buffard, Pioch, & Thorin, 2018). Figure 2 summarizes the potential for undertaking restoration offsets for different marine ecosystems.

On land, rehabilitation of degraded ecosystems such as rainforests is often slow and uncertain (e.g., Cole, Bhagwat, & Willis, 2014). The interconnectivity of marine ecosystems means that, where threats are successfully removed, recovery may sometimes be more rapid and successful (Jones & Schmitz, 2009). Most of the existing marine restoration literature concerns ecosystem engineers such as kelp, coral, and biogenic reefs (Jacob, Buffard, et al., 2018). In sufficient quantities, these structuring species can support restoration of ecosystem functioning (Elliott, Burdon, Hemingway, & Apitz, 2007). Nevertheless, there are limits to what can be restored. Restoration offsets to slow-growing and sensitive deep-sea systems such as cold-water corals and hydrothermal vent communities, for example, are unlikely to be feasible due to unrealistic costs and timescales (Niner et al., 2018; Van Dover et al., 2017).

3.3 Opportunities for policy-based offsets

Policy-based offsets aim to avert biodiversity loss by supporting changes in policy or practice that have a positive impact on target biodiversity. They have seen little application to date but offer innovative approaches to realize gains. This applies particularly to migratory or wide-ranging species that face a multitude of varying threats across their range. Offset interventions that aim to address one or more of these threats can, in theory, be used to address project-related impacts.

For example, project impacts to sea turtles could be offset through policy-based interventions that increase uptake of turtle excluder devices on industrial fishing fleets. Similarly, interventions that support eradication of invasive rodents on islands with seabird nesting colonies could be used to compensate for their bycatch within the fisheries sector (Milner-Gulland et al., 2018; Squires & Garcia, 2018). Although contentious, such distant offsets could help deliver better conservation outcomes and serve as an interim solution in the absence of more effective measures to tackle the root cause (Pascoe, Wilcox, & Donlan, 2011).

The high connectivity between land and coastal marine systems, often viewed as a challenge, also provides opportunities for offset interventions targeted at land-based threats. Although uncertainties and time lags need to be accounted for, policy-based interventions aimed at reducing land-based pollution by promoting better agricultural or waste management policies and practices could be used as a means to reduce threats to downstream coral reefs and seagrasses and offset development impacts (Bell, 2016). Although attributing impacts with land-based sources can be challenging, models can help predict impacts and potential gains that can be realized (Delevaux et al., 2018; Rude et al., 2016). Such a mechanism is already recognized within Australia’s Environmental Offset Policy and Guidelines, which permits offset actions that reduce sediment runoff and improve water quality as a means to offset impacts to the Great Barrier Reef World Heritage Area (Dutson et al., 2015).

In Table 2, we review some of the challenges and opportunities of implementing various marine offset actions in relation to the central offset design principles of additionality, longevity, equivalence, and limits.
Summary of key challenges and opportunities for implementing marine offsets based on key offset principles

| Opportunities                  | Longevity                     | Equivalence                                      | Limits to offsetting |
|--------------------------------|-------------------------------|--------------------------------------------------|----------------------|
| Opportunity to increase        | Provision of insurances       | Opportunities for equivalence at a wider          | The diffuse and      |
| representation of threatened   | through biodiversity          | geographic scale and                            | interconnected nature |
| biodiversity within marine     | banking or in-lieu fees, as   | across borders, such as                         | of marine ecosystems  |
| protected areas.               | currently being applied to    | averting losses to                              | mean natural recovery |
| Opportunities to enhance        | coastal wetlands in the       | wide-ranging seabirds                           | is often feasible     |
| management effectiveness of    | United States.               | along their flyway.                             | where threats are     |
| many existing “paper parks.”   | In territorial seas, states’ | Innovative approaches for                       | removed.             |
| Opportunities to tackle        | jurisdiction could be         | achieving equivalence through policy-based      |                      |
| impacts poorly addressed        | viewed as an asset to         | offsets.                                       |                      |
| by sectoral policies (e.g.,    | ensure long-lasting           | Opportunities for trading up                     |                      |
| impacts of fisheries).         | measures.                    | ecosystems of lower                            |                      |
|                                | Reinforcing community         | conservation priority for                       |                      |
|                                | tenure of marine              | highly threatened ecosystems (e.g., pelagic      |                      |
|                                | resources can help ensure     | for coastal waters,                            |                      |
|                                | long-term protection.        | sand-dominated habitats for intertidal mudflats. |                      |

| Challenges/constraints         | Risk of re-opening            | Restoration feasibility for                      | Many countries lack   |
|--------------------------------| protected area offset sites   | highly complex and/or                          | effective marine      |
|                                | back to exploitation as a     | slow-growing systems is low.                    | spatial management    |
|                                | result of public and/or       | Habitat condition and                          | plans making it       |
|                                | industry pressure.           | counterfactual scenario                         | difficult to determine|
|                                | Relatively high costs of     | often difficult and                            | where offsets are      |
|                                | marine monitoring and         | expensive to assess                            | acceptable.           |
|                                | enforcement can threaten the | reliably.                                       |                      |
|                                | long-term protection          | Risk of overestimating                         | Restoration cannot    |
|                                | of offset sites.             | offset gains, particularly                      | be achieved within     |
|                                | Difficult to ensure lasting   | for restoration offsets.                       | realistic timeframes   |
|                                | protection where there is no  |                                              | for many marine       |
|                                | clear ownership (e.g., for    |                                              | ecosystems and is      |
|                                | the high seas).              |                                              | prohibitively costly.  |
|                                | Offset sites are more prone  |                                              |                      |
|                                | to exploitation by foreign   |                                              | Complex, slow-growing |
|                                | actors such as illegal       |                                              | deep-sea systems such  |
|                                | fishing.                     |                                              | as cold-water coral    |
|                                |                               |                                              | reefs and vent        |
|                                |                               |                                              | communities cannot     |
|                                |                               |                                              | easily be offset.      |

*This applies to some extent: “even in the absence of disturbance,” as mentioned by Elliott, Burdon, Hemingway, and Apitz (2007), the “gradual changing of conditions (e.g., nutrient loading, climate change, and habitat fragmentation) may exceed threshold levels, resulting in an abrupt system response (Kaiser, Atrill, Jennings, Thomas, & Barnes, 2011; The Resilience Alliance, 2002).”

4 | ADDRESSING CHALLENGES

4.1 | Applying lessons learnt from land

Lessons learned from implementing offsets on land can also inform marine offset approaches. For instance, approaches to offset impacts to wide-ranging species on land would also be effective for many wide-ranging marine species. As an example, offsets targeting the Mongolian Khulan (*Equus hemionus hemionus*) in the Gobi Desert included the protection and restoration of large areas of rangeland habitat in combination with measures to address exploitation and fragmentation impacts. Similar measures could be applied to, for example, sea turtles through a mixture of measures including protection of nesting beaches and by promoting policies to reduce bycatch, light pollution, and nest predation by feral animals.

Ecosystems with unique species composition are often difficult to offset as there may not be ecologically equivalent sites elsewhere (Pilgrim et al., 2013). For example, offsets for
hydropower projects may have to rely on averting losses by withdrawal or preclusion of potential or planned development from other parts of the same watershed. This was the case for the Reventazón Hydropower Plant in Costa Rica, for which an agreement was made to exclude future hydropower development on the ecologically comparable Parismina River.\(^8\) Similarly, restoration-type offsets for deep-sea mining are unlikely to be feasible (Niner et al., 2018), whereas averting losses may only be possible for adjacent sites with similar species composition (Van Dover et al., 2017). Preclusion of these sites from future development may therefore be the only option. This implies an acceptance of further loss, until an agreed lower limit target is reached beyond which further exploitation of these sites is no longer tolerated (Simmonds et al., 2019).

Methodologies to assess losses and gains can usefully be applied to marine ecosystems with some adaptation (Chiavacci and Pindili, 2018; Gamarra, Lassoie, & Milder, 2018). Examples include the Rapid Assessment Methods (RAM) for wetlands (Fennessy, Jacobs, & Kentula, 2007) and the Habitat Equivalency Analysis (HEA), which can be applied to both terrestrial and coastal marine habitats (Dunford, Ginn, & Desvouges, 2004). Some methods for marine biodiversity already build on terrestrial systems such as those developed for wetlands (Bas, Jacob, Hay, Pioch, & Thorin, 2016). In most cases, loss–gain calculations will face similar challenges in marine as for terrestrial application, including identification of appropriate indicators, suitable timescales and counterfactuals, and accounting for uncertainty.

There are also parallels between policy-based offsets on land, which are similar to environmental measures developed within sectoral policy (such as the Common Agricultural Policy in Europe encouraging best practice among farmers, e.g., adaptation of land pasture calendar), and marine offsets that support environmental measures targeting fisheries (e.g., marine debris collection measures developed within the Common Fisheries Policy in Europe). In all cases, it is important to ensure that offsets are in addition to and do not replace existing environmental commitments.

Measures to reduce offset risk including the use of offset multipliers, bet-hedging, insurance/bonds, and the production of offset gains before impacts through conservation banks all apply equally to the terrestrial and marine environment (Bekessy et al., 2010; Moilanen et al., 2009; Pilgrim & Ekstrom, 2014). This is illustrated in the U.S. Wetland Offset system, which requires wetland offsets (including for coastal and shallow marine systems) through an in-lieu fee or mitigation banking system.

4.2 Working with limited data and addressing gaps

The availability of suitable data is often considered a limiting factor for marine impact assessment including offset calculations (Jacob et al., 2016). However, a number of existing biodiversity data platforms can be used to inform early assessment including the Integrated Biodiversity Assessment Tool\(^9\) (IBAT), the Ocean Data Viewer,\(^10\) the Ocean Biogeographic Information System\(^11\) (OBIS), and the Global Fishing Watch.\(^12\) Such information sources are essential for understanding biodiversity risk and informing decision-making, including around offsetability, often before there are opportunities to undertake surveys.

The use of physical proxies including geomorphological features such as seamounts and ridges can provide a reliable indicator for the presence of some sensitive benthic communities. Similarly, abiotic factors such as temperature, salinity, and turbidity are relatively simple and cheap to measure and provide a good indication for the presence or absence of threatened biodiversity likely to require offsets (McArthur et al., 2010). Species Distribution Modelling techniques can provide pragmatic and cost-effective approaches to help to address spatial and temporal data gaps (Franklin, 2010; Rengstorf, Yesson, Brown, & Grehan, 2013).

Marine developers can play a meaningful role in contributing to biodiversity information while improving their reputational standing. In Norway, for example, biodiversity information gathered by development projects is made widely available and easily accessible to society through online databases.\(^13\) Development projects are known to generate a voluminous “gray” literature that is often undervalued (Jacob, Buffard, et al., 2018). Examples include seismic and seafloor mapping surveys, which can help identify biodiversity features such as deep-sea communities. A proportion of offsets funding could then be used to strengthen national biodiversity databanks (see SADC, 2015 for the extractive industry).

4.3 Improving governance and social perception

Governance in the marine environment is complex and presents a challenge for the implementation of offsets. Marine offset application has suffered from this general lack of governance at sea—characterized by fragmented regulation systems for the use of marine resources, and related rights,

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8 See https://www.thebiodiversityconsultancy.com/wp-content/uploads/2015/10/Hydro2016_The-Biodiversity-Consultancy.pdf.

9 www.ibatforbusiness.org.

10 http://data.unep-wcmc.org/.

11 https://obis.org.

12 https://globalfishingwatch.org/map/.

13 https://www.gbif.org/article/2gnrlnYXNKiuWCoOqi8gQG/mobilization-of-biodiversity-data-from-the-private-sector.
decision-making rules, and processes not suited for spatiotemporal biophysical systems (Young et al., 2007). In developing countries with high local dependence on coastal resources, enforcement of existing fisheries and protected area laws can be extremely challenging (Islam et al., 2017; Pomeroy, Parks, Mrakovich, & LaMonica, 2016; Sjöstedt & Sundström, 2015). The costs of enforcement will therefore need to be accounted for in offset design and implementation.

Better implementation of marine offsets goes hand in hand with improved national governance in the marine environment including better regulation of fisheries, marine spatial planning, and of course clear mitigation and offset policies. Global trends since the early 2000s show that oceanic governance has gained much importance in the international agenda, both within territorial waters and the high seas (Campbell et al., 2016), representing an opportunity for the implementation of marine offsets with a strong regulatory structure, clearly defined responsibilities, transparent processes, early and ongoing stakeholder engagement, and with clear conservation targets to contribute to.

In areas beyond national jurisdiction, current negotiations following the convocation of United Nations General Assembly are attempting to formulate an internationally binding instrument for the governance of the high seas (Tiller, De Santo, Mendenhall, & Nyman, 2019). This may include provisions for spatial planning (e.g., protected areas), increased regulation of economic activities, the use of biological resources, and assessment of environmental impacts (Tiller et al., 2019). These are improvements that could support effective implementation of offset mechanisms in the high seas. Several entities exist to help manage high seas activities and impacts. The UN Convention the Law of the Sea (UNCLOS) stipulates that the International Seabed Authority has jurisdiction over nonliving resources of the seabed, the International Maritime Organization controls aspects of shipping, security, and pollution, and regional fisheries management organizations (RFMOs) help regulate regional fisheries (Freestone, 2009). Better utilization of these existing instruments and collaboration between them may also help improve governance and create an environment that facilitates effective offsetting.

Multiple uses occur across the marine environment and thus numerous stakeholders can be involved in the management of a zone. Development planning including identification of offset receiving sites can benefit from Marine Spatial Planning exercises at appropriate national or regional levels (Douvere, 2008). Such planning can help identify appropriate offset receiving sites for but also priority sites for conservation and thus no-go for developments. Such planning needs to adequately account for specificities of the marine realm, such as ecological processes occurring at larger spatial–temporal scales and its three-dimensional character. In turn, this will also help characterize and manage the cumulative impacts from numerous diffuse pressures and prevent leakage of impacts to other areas.

Governing can also be improved and made more efficient by moving away from the project-by-project approach to offsetting and pooling offsets on a regional scale into aggregated offsets. An aggregated offset approach in the marine environment could draw on current systems developed for offsetting in the United States such as in-lieu fees, conservation banking, or habitat banking systems (Bayon, Carroll, & Fox, 2012; Saltzman & Ruhl, 2006). In the case of the Southern California Wetlands Recovery Project (SCWRP), the development of an in-lieu fee mitigation program has been viewed as an opportunity to pool contributions from multiple developments into consolidated offsets that can improve ecological outcomes, use scientific and technical resources more efficiently, reduce uncertainty, and better achieve regulatory requirements, compared to a fragmented, project-by-project approach to offsetting (Draft ILF, 2016). In Guinea, aggregated approaches to offsets are being developed to address cumulative impacts on chimpanzees from several mining projects (Kormos et al., 2014). Similar approaches could be used to secure, for instance, a single large marine protected area supporting sensitive marine biodiversity as an offset for the combined impacts of multiple offshore oil and gas developments.

Broader and earlier engagement of public and private interest groups in marine development planning can be an effective way to improve stakeholders’ perception and understanding of marine impacts and thus the importance of offsets to deliver better conservation outcomes. In California, for example, the involvement of a broad range of stakeholders beyond government agencies and including NGOs, developers, and academia was identified as a key element for effective marine offset schemes (Jacob, Thorin, & Pioch, 2018). “Community benefit” measures (Bristow, Cowell, & Munday, 2012) are typically used to enhance social acceptance of marine developments and/or to achieve environmental justice (Kermagoret, Levrel, & Carlier, 2014). Additional measures to address the “out of sight, out of mind” issue and increase marine environmental awareness could include environmental education, citizen science exercises.

### 4.4 Conclusions: Implications for conservation practice and policy

Given the oceans’ huge potential for future economic development, industrial pressures in the marine realm are only likely to intensify. There is an important role for biodiversity offsets, as a component of good mitigation practice, to help ensure that biodiversity impacts are not simply overlooked or ignored, and to drive greater attention to avoidance, minimization, and

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14 [https://scwrp.org/](https://scwrp.org/).
restoration (Pascoe, Cannard, & Steven, 2019). Real or perceived differences between the marine and terrestrial realms in ecology, impacts, information availability, governance, and conservation costs have so far discouraged the application of marine offsets. The limited implementation to date represents a challenge but also an opportunity to apply the learnings from terrestrial offsets and to innovate to suit the marine realm.

What are the implications for conservation policy and practice? First, there is the need for robust marine spatial conservation planning, at a regional scale, linked to the regulatory requirements for offsets. Identifying priority conservation and/or restoration areas informs avoidance (reducing the need for offsets) and can help streamline project assessment and permitting processes, reducing uncertainty and costs to developers. Spatial conservation planning also provides real opportunities to move away from a siloed project-by-project approach for the design of offsets. Offsets that contribute to broader ecosystem dynamics and address issues shared on a regional scale can be pooled for better efficiency of implementation (reduced transaction costs for planning, implementation, enforcement, and monitoring) and improved biodiversity outcomes. Policy-focused offsets are also likely to be more effective when resources and interventions are pooled across projects. Such offsets may best be viewed as pilot interventions to catalyze change, initiating a transition toward more sustainable practice that must then be picked up and consolidated within the concerned sector.

Practice at the project level also needs to evolve, in particular regarding Environmental Impact Assessments. Marine impact assessment needs to be undertaken at spatial and temporal scales that are broad enough to account for the ecological characteristics of the marine environment. It is also important that project-level impact assessment links to better evaluation of cumulative impacts at a wider scale, in particular considering the land–sea interface for projects close to the shore. Practically, this can be integrated with spatial conservation planning through wider application of Strategic Environmental Assessment approaches.

A broad, integrated approach to planning and impact assessment will also enable offsets to move beyond project-specific goals of no net loss/net gain and contribute explicitly to achieving jurisdictional biodiversity targets (Simmonds et al., 2019). This requires policy decisions both on the broader goals and on the extent to which regulated sectors (i.e., those required to compensate for residual biodiversity losses) should contribute to achieving these. An emphasis on restoration offsets will be needed where current biodiversity levels are below or at target, as averted loss offsets alone cannot achieve no net loss or net gain at a seascape scale (Simmonds et al., 2019).

Permitting authorities can support improvement of the information base through requiring developers to share assessment and monitoring data. This by itself is unlikely to resolve the current gaps in data, however. Proper characterization of impacts, baselines, and counterfactuals will rely on robust monitoring encompassing large spatial and temporal scales that are likely beyond the scope of individual projects. For instance, in Europe, this could be achieved via implementation of the Marine Strategy Framework Directive, aimed at better protecting the marine environment, which establishes a monitoring program for the ongoing assessment and the regular update of 11 Descriptors (linked to ecosystem components, anthropogenic pressures, and impacts) used to define the Good Environmental Status (Zampoukas et al., 2012). There is scope to make better use of modeling to interpret bathymetric data and other abiotic proxies, and for new technologies to support collection of large volumes of data at reduced costs (e.g., use of ocean gliders, remotely operated or autonomous underwater vehicles, see White et al., 2020). The collection and management of biodiversity-related marine monitoring data require ongoing support and coordination. Regulators and financiers can help improve the information base by requiring that a small proportion of offset budgets is devoted to supporting national marine biodiversity databanks.

Although the higher cost of monitoring and enforcement of marine mitigation measures including offsets should be budgeted appropriately within project scoping, improved national ocean governance initiatives and inclusion of local stakeholders, especially in developing countries, are fundamental to the effective long-term success of any conservation actions. Public engagement and the involvement of all relevant stakeholders through participatory processes are also critical within marine developments to generate awareness about project impacts and support for its mitigation approach, including through the application of offsets. In particular, identifying limits to what can be offset could also be better discussed through consultative processes. In cases where impacts cannot be offset, such as is the case for deep-sea mining, acceptable limits may need to be based on societal agreement (Bennett, 2019). Such public engagement should be anchored to broader processes linked to ocean governance initiated at larger scale (regional and national). Beyond national jurisdiction, the design of an internationally binding instrument for the governance of the high seas is crucial for framing future development activities.

As the final step within the mitigation hierarchy, offsets should always be the last resort for mitigation, used only after all feasible options to avoid, minimize, and restore biodiversity have been applied. Despite this, offsets are an important tool to promote ecological sustainability and improve biodiversity outcomes of development in the marine environment. The development of effective mitigation and offset mechanisms must go hand in hand with addressing challenges currently faced by marine conservation policies. This means moving beyond the Environmental Impact
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