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GUIDANCE FOR DEFINING ECOLOGICALLY APPROPRIATE SCALES OF ANALYSIS FOR MARINE BIODIVERSITY IN RELATION TO IFC PERFORMANCE STANDARD 6

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1.0

INTRODUCTION

"The scale of resolution chosen by ecologists is perhaps the most important decision in the research program, because it largely predetermines the questions, procedures, the observations, and the results..." (Dayton & Tegner, 1984).

Environmental and Social Safeguard Standards that are produced by International Finance Institutions (IFIs) provide an international best practice framework for the assessment of private and public sector development projects. The International Finance Corporation (IFC), a member of the World Bank Group, has developed Performance Standards to ensure that robust safeguards for managing environmental and social risks are met for projects that they fund. Other IFIs, such as the European Bank for Reconstruction and Development (EBRD), European Investment Bank (EIB), African Development Bank (AfDB) and the Inter-American Development Bank (IDB) also have similar environmental and social safeguard frameworks in place. The standards within these frameworks have been established to generally align, including where updates have been undertaken for some IFIs over recent years.

This document is focused on IFC Performance Standard 6 (PS 6) (IFC, 2012a) within the IFC framework. PS 6 sets out a framework for 'Biodiversity Conservation and Sustainable Management of Living Natural Resources'. PS 6 is supported by Guidance Note 6 (GN 6) (IFC, 2019). GN 6 provides comprehensive guidance on how to meet the requirements of PS 6, which includes the need to ensure that the ecologically appropriate scales for baseline studies, assessment and determining mitigation are applied. PS 6 and GN 6 provide a significant emphasis on the need to take forward landscape/ seascape approaches; and also to define **Ecologically Appropriate Areas of Analysis (EAAAs)** for critical habitat assessment. A core requirement of PS 6 is to ensure that project's undertake a comprehensive **Natural and Critical Habitat Assessment**, which is underpinned by the determination of biodiversity value at an ecologically relevant scale. To meet PS 6 requirements project studies must go beyond the project site and it's Area of Influence (AoI) – as defined within PS 6 and also Performance Standard 1 (PS 1) (IFC, 2012b). The main intent is to ensure that the context of biodiversity values are properly understood and that the potential consequences of a project are assessed across seascape areas, which include the consequence of broad-scale indirect project induced impacts. The area of analysis includes the consideration of areas where direct, indirect or cumulative effects will be observed (a project's AoI); and broader areas as necessary to identify outcomes for affected ecosystems or species populations. In the marine environment, this hierarchy of assessment scales should take broad-scale (including transboundary) ecosystem connectivity into account as a fundamental driver in the definition of ecologically appropriate scales.

Whilst GN 6 provides comprehensive steer on the need for biodiversity analysis at an ecologically appropriate scale that extends beyond a project site and its AoI, no detailed guidance is provided on how such areas may be defined, especially for the marine environment. Approaches taken by projects can vary, with possible misunderstanding of how to define the correct scale of analysis, including at times, a potential focus on a project's AoI. Although understanding the extent of the AoI is important for biodiversity risk assessment, this area does not always provide limits to the spatial extent for the analysis of biodiversity value and may not allow for interconnectivities to be determined, appropriate ranges and distributions to be defined and the importance of the biodiversity which may be affected by a project to be determined. In the first instance, PS 6 seeks to ensure that project studies take account of all of these factors in an approach that is driven by the understanding of ecological patterns and processes and not project impacts. Once biodiversity value has been defined at an ecologically appropriate scale then AoI can be used to define the potential direct, indirect and cumulative impacts on the biodiversity values that have been determined and quantified.

The application of evidence based approaches that accurately and objectively determine ecologically appropriate scales of analysis can be seen as a challenge in the marine environment and sometimes, there is uncertainty on how to interpret these requirements when addressing projects in the marine environment. This is often due to the conceptual and operational complexity of determining spatial areas of analysis for highly mobile species and the uncertainty over boundary delineation in the marine environment. Scale selection is further complicated by insufficient information on species' scale dependency, the identification of relevant cross-scale processes, land-sea interactions, ecosystem dynamics including transient features and organisms e.g. oceanic fronts, plankton patches, migrations, spawning events); and the need to address biodiversity across horizontal (neritic and oceanic) and vertical planes (with pelagic and benthic habitats). Scales et al. (2018) refer to the ocean exhibiting water masses separated by fluid gradients (ecoclines) or abrupt transitions (ecotones) (see Figure 1). This fluidity and some disparities in the spatial and temporal scales of processes and trophic components (e.g. short-lived marine planktonic algae versus longer lived terrestrial vascular plants as the dominant primary producers) is an important

1 For the purposes of implementation of PS 6, habitats are divided into modified, natural, and critical. Critical habitats are a subset of modified or natural habitats and are defined as areas with high biodiversity value, including habitat of importance to: (i) critically endangered and endangered species; (ii) endemic and restricted-range species; (iii) globally significant concentrations of migratory species and congregatory species; (iv) highly threatened and unique ecosystems; and (v) areas associated with key evolutionary processes.

difference between aquatic and terrestrial environments (Steele, 1989). In contrast to the transient structures in the water column, the seafloor terrain is characterised by more stable structural patterns such as geological formations and biogenic structure whereby some more obvious commonality exists between the challenges of assessing landscapes and seascapes. Assessments in the marine environment are also often hampered by data paucity that limit our understanding of baselines (Caldow et al., 2015).

IFC GN 6 provides some general guidance on approaches to address these issues through the emphasis on seascape analysis, the consideration of ecological connectivity and the definition of critical habitat to include areas of aggregation, recruitment and other features of importance to species and the ecological processes that support them (See notes GN53-GN59 in GN6). However, no comprehensive guidance on how to define different spatial scales of analyses are provided. Therefore, this document seeks to provide additional guidance to support the determination of ecologically appropriates scales of analysis in order to meet the requirements of PS 6 (and aligned IFI environmental and social risk frameworks). The focus of the guidance is on defining 'seascape' and EAAAs, including the relationship of these areas with a project's AoI.

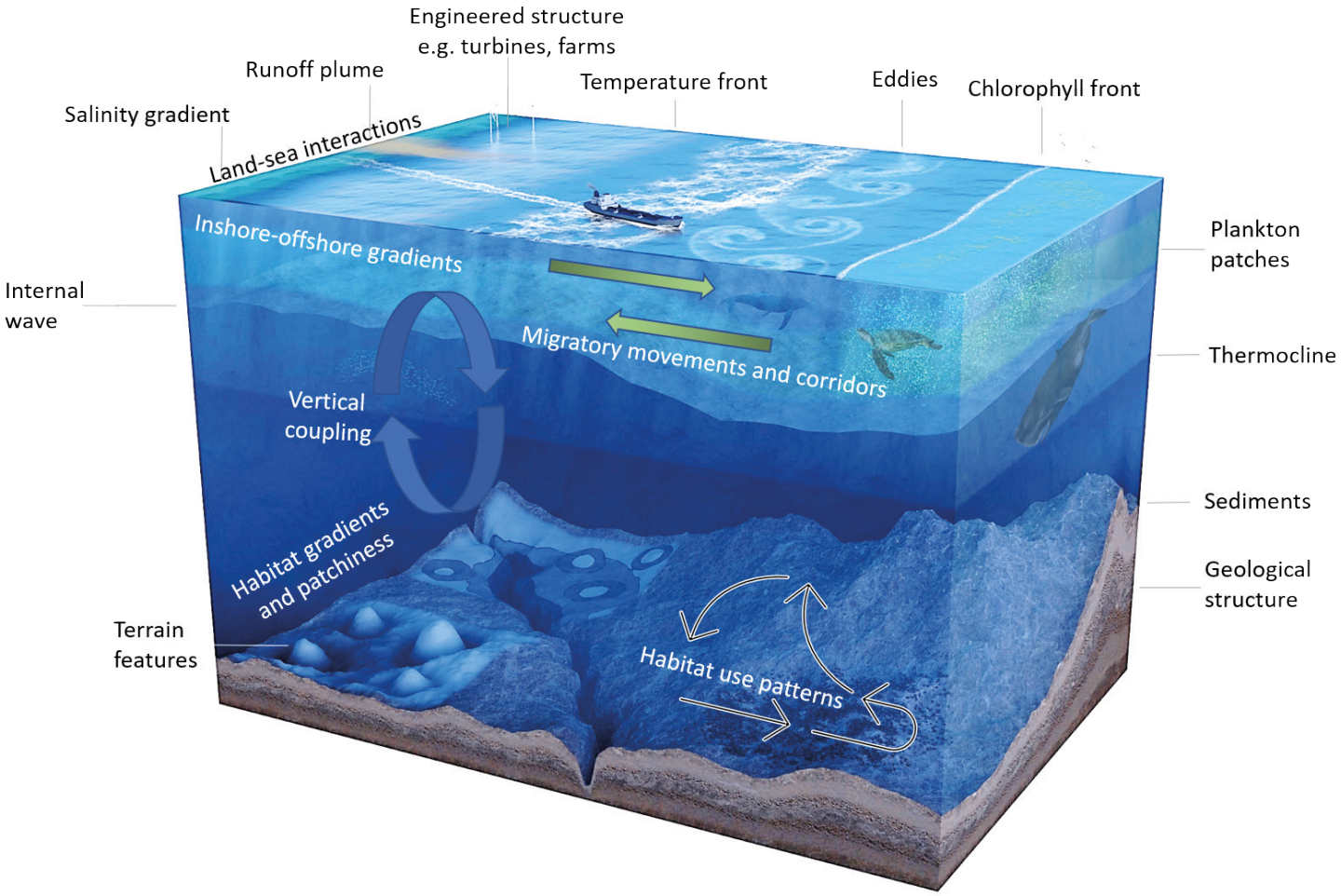

Figure 1. Examples of ecological patterns and processes that determine how seascapes function and respond to human activities. Source: Adapted from Pittman 2018, Seascape Ecology 1st Edition.

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2.0

SPATIAL SCALES FOR BIODIVERSITY ASSESSMENT

2.1 Overview

Defining ecologically appropriate spatial scales for biodiversity assessment depends on the values that are present and the ecological patterns and processes that sustain them including critical connectivity. In the marine environment these relationships operate across scales in time and space and can include complex processes at relatively broad scales (Levin, 1992). Individual species may be highly mobile and transient; and habitats may support many different functions across multiple species-specific life-cycles (Pittman & McAlpine, 2003; Dunn et al., 2019). Therefore, determining biodiversity value in the marine environment, at appropriate scale(s), generally requires a broad hierarchical understanding of habitat and species values and ecological functions. A basic tenet in ecological scaling is that animals will respond to their environment differently and at different scales and although some generality can exist the most influential scales tend to vary by life-stage. Identifying interconnectivities and the spatial and temporal scales at which these processes operate is particularly important when considering wide-ranging species; and there is a need to determine the types and locations of specific attributes and functions that are of importance to such species. It also requires an understanding of dynamic physical factors and processes that might influence the distributions of habitats and species, the integrity of ecosystems and the attributes that support broader ecological functions. For example, adult female green sea turtles are herbivorous with a critical dependence on seagrass and algae in shallow coastal waters, as well as nesting beaches at specific locations. They migrate between foraging and nesting sites sometimes travelling 100's of kilometres connecting distant waters to complete their life cycle. Such wide-ranging migrations connect intertidal, neritic[2] and deeper oceanic environments. Some animals will move vertically across pelagic[3] zones and connect surface waters to deep mesopelagic zones (e.g. deep diving marine mammals). Marine habitats for some seascape generalist species may be continuous across vast areas (e.g. for wide-ranging or deepwater pelagic shark species), with both local and far-field connectivity and complex links between ecosystem function and physical process (i.e. for different life-cycle functions). In contrast, for seascape specialists attributes that support important ecological functions may be confined to specific local features (e.g. coelacanth associations with specific seabed geomorphology). Many fish species in tropical coastal ecosystems use a mosaic of habitat types (i.e. mangrove, seagrass, coral reefs) as habitat steppingstones through the life cycle. These connected seascapes provide aggregated value for a wide range of species by providing refuge, foraging, breeding and nursery functions. Therefore, if the spatial scale of biodiversity analysis is inappropriate and is localised only to a project site or AoI, this will likely undermine the understanding of biodiversity values with regard to broader ranging species. Such a scale mismatch could result in considerable shortfalls in the assessment of critical habitat with potential for avoidable impacts to species and habitat. PS 6 therefore promotes an assessment that spans multiple scales in time and space where scales are selected using ecological rationale to understand biodiversity value and potential project risks.

The following sections set out the various scales of analysis that are required by PS 6 and provides introductory guidance on how these areas may be defined.

2 *The zone of shallow coastal waters on the continental shelf, typically consider as a zone in water depths of less than 200 m.*

3 *The entire water column of the ocean, which can be divided into sub-zones based on water depth. It includes the open waters of the neritic and deeper oceanic zones.*

2.2 The Different Spatial Scales of Analysis

With respect to the marine environment, the spatial scales that are considered within PS 6 are defined as follows:

- Project Area of Influence (AoI)
- Seascape
- Ecologically Appropriate Area of Analysis (EAAA)
- Processes and functions for wide-ranging species

A discussion of the different spatial scales of study and assessment is provided below.

2.2.1 Project Area of Influence (AoI)

As defined by paragraph 8 of PS 1, a project's AoI relates to the area where the Project and its Associated Facilities may lead to direct, indirect and cumulative impacts. This includes the footprint of the Project and those of Associated Facilities and also the broader zone of influence from all project and associated activities. In addition to PS 1 requirements, note GN5 of GN 6 states that the AoI should include supply chains (as required in paragraph 30 of PS 6); the project's proximity to areas of known biodiversity value or areas known to provide Ecosystem Services; the types of technology that will be used and efficiencies of the proposed equipment; and the project's potential to induce impacts by third parties via new access to remote areas. The AoI therefore incorporates direct[4] and indirect[5] impacts from a range of activities. Indeed, note GN15 states that a project must assess "*project-related direct, indirect and residual impacts on populations, species and ecosystems... identified in the baseline studies.*" Defining the AoI will require an understanding of the source of impact, the pathway to receptors and how this will affect marine biodiversity values both directly and indirectly.

Direct and indirect impacts can overlap in time and space. In the marine environment, the spatial relationship of direct and indirect impacts is complex due to ecosystem interconnectivity and also the variable spatial extent where impacts occur across different features. In the marine environment, information on the ecological connectivity between the Project's direct and indirect impacted areas and the wider seascape can contribute to defining the AoI (see below). For instance, impacts that occur in the localised project can affect species that are distributed more broadly across the seascape or that also use habitat outside of the impacted areas through wide-ranging movements and cascading ecological consequences through a species' population and via food webs. The need to consider the connectivity of marine ecological processes is a core requirement of PS 6. Indeed, Paragraph 6 states that for Natural and Critical Habitats "*the client should consider project-related impacts across the potentially affected landscape or seascape.*" The requirements of PS 6 seek to ensure that biodiversity assessments are undertaken that extend beyond the Project site and localised AoI where direct impacts may be most apparent; and seascape analysis is an essential component of the biodiversity assessment and provides a context for understanding broad patterns and ecological processes (see Section 2.2.2). Note GN17 reinforces this by stating that the assessment should consider all project-related impacts, especially with respect to connectivity outside the boundaries of the project site. Data paucity or uncertainties in determining the spatial extent of impacts may mean that it is appropriate to define the AoI for direct and indirect impacts at a broad scale to ensure that a precautionary approach is taken for the assessment. Indeed, note GN15 states that "where there is significant uncertainty, the client should take a conservative approach in ascertaining the significance of residual impacts." Where there are broad interconnectivities and uncertainty, and when determining impacts on critical habitat, there can be uncertainty on the extent

4 Impacts that are a direct result of project activities. These include the habitat and species mortality in the project footprint, discharges and sediment plumes affecting water quality, habitat smothering causing habitat loss, underwater sound generation causing injury or behavioural effects, artificial light emissions causing behavioural change, ship strike causing injury, introduction of alien invasive species increasing competition etc.

5 Impacts that are indirectly induced by project activities. These include associated ecological effects from water quality degradation, habitat loss and degradation leading to indirect effects on ecosystem functions for some associated fauna species (e.g. prey availability), increased fishing activity resulting from fish aggregation around artificial structures or in-migration of people, effects of species displacement on the occupancy of other habitat, altered predator-prey relationships with additional community alteration, direct effects on primary productivity leading to indirect effects on wider productivity (e.g. for fishes), wider spread of invasive alien species, edge effects from habitat fragmentation etc.

of impacts. In such circumstances it may be assumed that the boundary of the AoI extends to the boundaries of the EAAA for wide-ranging species as a precautionary approach (see Section 2.2.3.2). For wide-ranging species where it is not possible to clearly define an EAAA boundary (see Section 2.2.3.2), the AoI may considered in terms of the overlap with areas of importance for different life-cycle functions and the impact on maintaining population status may quantified on that basis.

Figure 2 provides an illustration of the various components of a Project's AoI with respect to considering a nested spatial hierarchy of potential impacts.

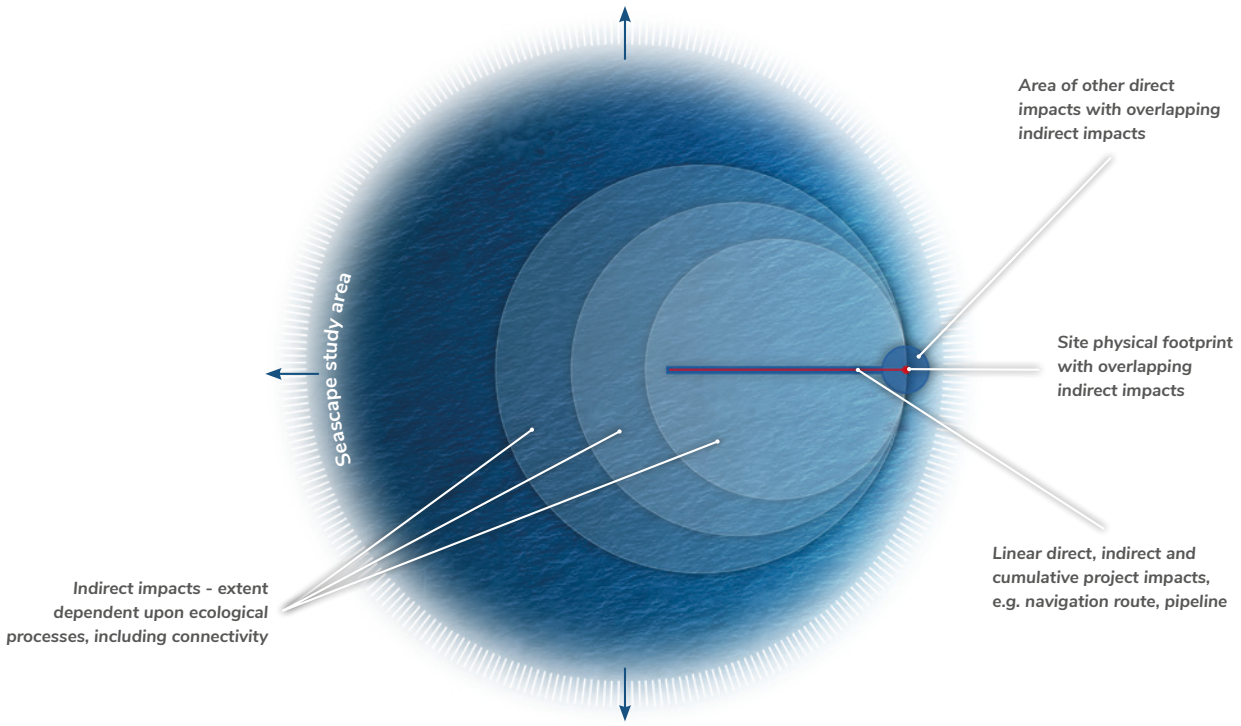


Figure 2. Spheres of influence comprising the AoI and wider seascape extending out from the actual project site and scaled through knowledge of connectivity of species and habitats.

2.2.2 Seascape

Note GN17 in GN 6 states that the seascape:

"...does not necessarily correspond to a predefined unit of geographical space. It is a broadly defined term that might correspond to an ecoregion, a biome, or any other ecologically significant unit of space on a regional level (that is, not site-specific). In some cases, the landscape/ seascape unit might be defined in terms of an administrative or territorial boundary or a particular zoned area within international waters."

Pittman (2018) defines seascapes as spatially heterogeneous and dynamic spaces that can be delineated at a wide range of scales in time and space. Spatial structure is typically represented as a mosaic of patches and spatial gradients. The composition and spatial configuration of a patch-mosaic will influence ecological function. The way in which seascape structure is represented will be fundamental to the types of analyses conducted, the tools required and to the subsequent understanding of ecological patterns and processes (Pittman, 2018). An important concept in scaling seascapes is the need to select spatial and temporal scales that are ecologically meaningful to species connectivity and other processes of interest. The seascape scale will therefore vary based on the attributes being considered and may not relate to a single defined unit of space, although structure may be defined using factors that create clear zonation of attributes and functions in the marine environment (Pitman, 2018). In addition to patchiness, the spatial seascape structure may be defined by understanding spatial gradients, including their dynamic variability, including physical influencing factors (e.g., depth, seabed morphology, hydrodynamic processes, salinity, temperature, nutrients etc) (Pitman et al., 2018). Connectivity is also a central concept for scaling seascape as it forms an understanding of the movement of animals and materials across the marine environment. The key concepts that help to determine seascape are considered in more detail in Section 4.

The main aim with respect to defining a project's seascape is to provide a study area that is sufficient to ensure that the full scope of biodiversity values and their ecological context are considered at an appropriate scale (see notes GN11, GN17, GN27 and GN61). As such, the determination of an appropriate seascape is essential to develop an appropriate level of baseline understanding, to identify all project-related impacts (see above), to undertake a robust Natural and Critical Habitat Assessment and to inform the development of appropriate and effective mitigation strategies, e.g. to define areas where offsets may be implemented to achieve No Net Loss or Net Gain.

There is no single way to define an appropriate seascape scale for marine biodiversity assessment. It requires a case-by-case approach, careful evaluation of the available data and flexibility and transparency in the data synthesis framework. Some of the different approaches that can be taken are explored below.

The structure and function of seascapes and the appropriate geographical extent of seascapes with regard to PS 6 are defined by interlinked ecological patterns and processes. Understanding the factors that determine the distributions and behaviour of these patterns and processes can help to define a seascape area and allow for ecologically meaningful boundaries to be drawn. However, an over-simplified approach may disregard important connectivity in the marine environment, such as the movements of wide-ranging species or those species that utilise geographically discrete habitats such as nearshore nursery habitat and offshore spawning sites at specific life history stages. In practice, the seascape is comprised of multiple units where different ecological processes occur, and these combine to form the structure and function of the seascape. The boundary of the seascape defines the broad ecological context for the habitat in which a project is located. In some instances, these boundaries can be estimated and mapped, but in other instances this may not be possible or could be misleading. One of the biggest challenges encountered is where static maps cannot sufficiently represent important spatial dynamics in features such as population distributions. Even where these areas are adequately mapped based on the majority of features, or to correlate to a clearly distinct seascape area, it may still be necessary to consider ecological patterns and processes beyond these limits, e.g. to understand the full distribution and connectivity of wide-ranging species (see Section 2.2.3.2). It is also important to realise that ecological relationships from one region may not always be reliably transferable to another area due to location-specific relationships or context dependency (Bradley et al., 2020).

Therefore, to define the spatial areas for assessing seascapes that are appropriate to the biodiversity values requires an understanding of multi-scale interconnected ecological patterns and processes. This approach has been advanced through the integrative and solution-focussed science of seascape ecology which applies landscape ecology concepts and techniques to the marine environment (Boström, 2011; Olds et al., 2016; Pittman, 2018). Seascape ecology recognises that a more complete understanding of seascape composition and spatial patterns relevant to species and habitats is achieved by also considering the surrounding context and connectivity. Understanding of spatial patterns and processes such as patches and edges, ecological functions and attributes, connectivity and how to apply expert judgement and precaution will be fundamental to drive the determination of appropriate seascape spatial limits.

It is possible that the species range will overlap with the spatial and temporal domains for other biodiversity values that are being considered and a single seascape boundary may be determined that incorporates all important attributes. Sometimes, wide-ranging species will be distributed across areas considerably broader than the project site and AoI. For wide-ranging species it may be necessary to establish spatially and temporally extended seascape boundaries that help to understand species specific life-cycle functions (e.g. movement to and from breeding or foraging or nursery areas), distributions (including at sub-population levels) and interconnectivities.

Figure 3 presents an illustration of the relationship of seascape and a project's AoI that takes account of different physical and ecological processes and interconnectivities.

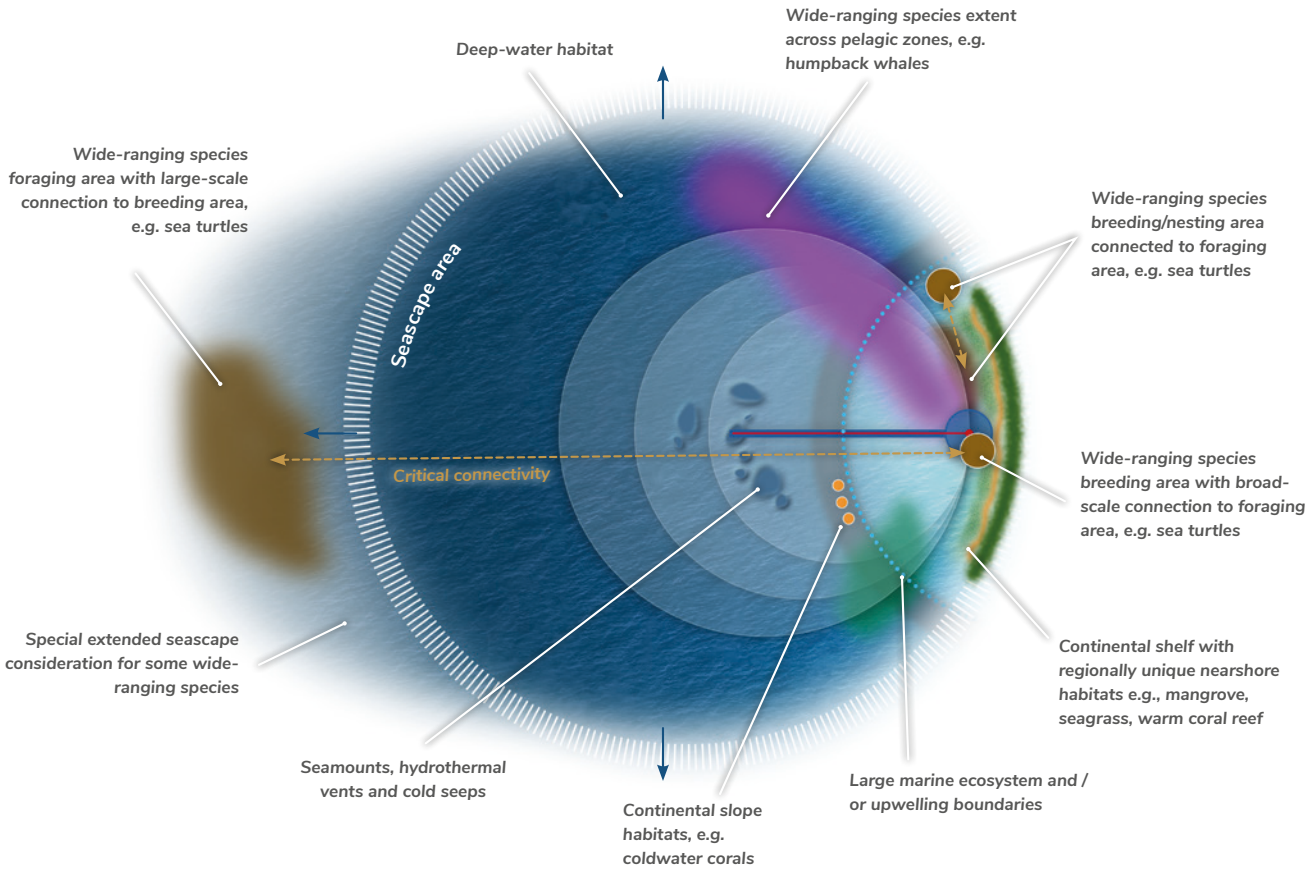


Figure 3. Illustration for defining seascape in a widely interconnected marine ecosystem

2.2.3 Defining Areas for Critical Habitat Assessment in a Seascape

Critical habitat assessment is completed for ecological units that are within the seascape. The main difference between the critical habitat assessment area and seascape definition is that the former provides a study area to define what areas should be assessed and the latter forms the assessment areas. How seascape and critical habitat areas are defined follows a similar approach with respect to undertaking ecological patterns and processes. What may differ between these areas is their scale and also critical habitat assessment areas need to be defined for each habitat and species. However, as already noted, in the marine environment, seascape determination can often require habitat- and species-specific consideration, especially for wide-ranging species. Also, in some instances, relatively large seascape units may be defined as critical habitat. There is therefore strong interdependency on the understanding of ecological processes in the seascape and the establishment of critical habitat assessment areas.

Defining seascape is the first step in determining appropriate ecological scales for critical habitat assessment. Once, ecology is understood in the seascape, there is a need to establish EAAAs for Criteria 1-4. EAAAs are delineated site boundaries within which critical habitat is assessed and defined. The scale of the EAAA needs to be ecologically justified; and should be sufficient to ensure effective conservation management of features being assessed. Critical habitat will be defined for the whole EAAA being assessed. In addition to this, there may also be a need to apply specific approaches for identifying critical habitat for some wide-ranging species where it is not possible or appropriate to define an EAAA. These differing approaches are discussed below, but in general, they relate to the inability to draw delineated site-based boundaries for some wide-ranging species. Assessment thresholds do not apply to Criterion 5: Key Evolutionary Processes; and the assessment under this Criterion normally requires a seascape understanding to determine key biophysical processes that will be spatial catalysts for evolutionary processes. Therefore, whilst GN 6 requires EAAAs to be established for critical habitat determination, critical habitat is not always limited to an EAAA, especially when site-based delineation is not ecologically justifiable.

Section 4 provides information on the driving and influencing factors for determining justifiable ecological areas for critical habitat assessment. These factors apply to both seascape study and definition of critical habitat determination. It is important to note that when defining critical habitat using EAAAs, the area of critical habitat defined for this whole area and not part it. There is therefore a direct consequence of the chosen scale of the EAAA on the extent of critical habitat; and the requirements of paragraphs 17-19 of PS 6 must be met for the conservation of critical habitat at this scale. This emphasises the need for critical habitat assessment to be undertaken at an ecologically appropriate scale.

2.2.3.1 Ecologically Appropriate Area of Analysis (EAAAs)

The definition of EAAAs requires a case-by-case assessment for **each** habitat and species being considered. As set out by note GN59 in GN 6 this requires the client to:

"...define the boundaries of this area, taking into account the distribution of species or ecosystems (within and sometimes extending beyond the project's area of influence) and the ecological patterns, processes, features, and functions that are necessary for maintaining them. These boundaries may include catchments, large rivers, or geological features...Critical habitats boundaries should be equivalent in scale to areas mapped for practical site-based conservation management activities...Where it can be shown that multiple values have largely overlapping ecological requirements and distributions, a common or aggregated area of critical habitat may be appropriate."

GN 6 is clear that the EAAA is not considered at the same scale as a project's AoI. In this regard, note GN60 states that:

The approximate location of a project and its area of influence should be considered when establishing an ecological area of analysis but the project type, its impacts and its mitigation strategy are irrelevant in carrying out Steps 1 through 3 (for critical habitat assessment). The definition of the critical habitat and the impacts of a particular project are two unrelated concepts. The definition of the critical habitat is based on the presence of high biodiversity values whether or not a project is to be undertaken in that habitat. Clients should not assert that they are not in critical habitat on the basis of the project's footprint or its impacts."

Note GN58 further iterates that critical habitat assessment must not focus solely on the project site or it's AoI. Further to this, note GN59 states that critical habitat should consider the distribution and connectivity of such features in the landscape/seascape and the ecological processes that support them.

In line with the seascape approach, GN 6 indicates that determination of EAAAs is driven by habitat and species-specific attributes and ecological processes. These aspects are also influenced by natural physical processes, and at times, human activities. A clear defensible rationale is provided to support the determination of EAAAs and often these areas are mapped so to define the boundary of critical habitats when criteria thresholds are met.

EAAAs need to be initially defined for each habitat and feature. However, it is possible that an aggregated EAAA boundary may be defined for individual habitats that may be grouped , i.e. clustering habitat patches, e.g. cold water coral habitats. Figure 4 shows how EAAAs may be defined on this basis. In this illustration multiple EAAAs have been defined in the seascape. This includes the spatial definition primarily based on unfragmented habitat patches, e.g. expanses of nearshore fringing reef or dense mangrove forest or distinct habitat patches (e.g. seamount, vents and seeps) . EAAAs are also defined where there are clear species/habitat associations, such as coelacanth connectivity to specific physical features (i.e. caves and overhangs). Where habitat shows a patchy distribution, these have been grouped to form a single boundary for assessment (e.g. coldwater coral reef at the edge of the continental shelf). Figure 4 also shows critical habitat assessment areas for migratory/congregatory species and this is discussed separately in Section 2.2.3.2.

Broader aggregated EAAAs may also be defined where there are multiple values that have largely overlapping requirements and distributions. These aggregate zones may be defined as being unique areas with specific habitat patches or mosaics providing common attributes for various species that have distributions only within this area or have clear connectivity to it, e.g., areas that are

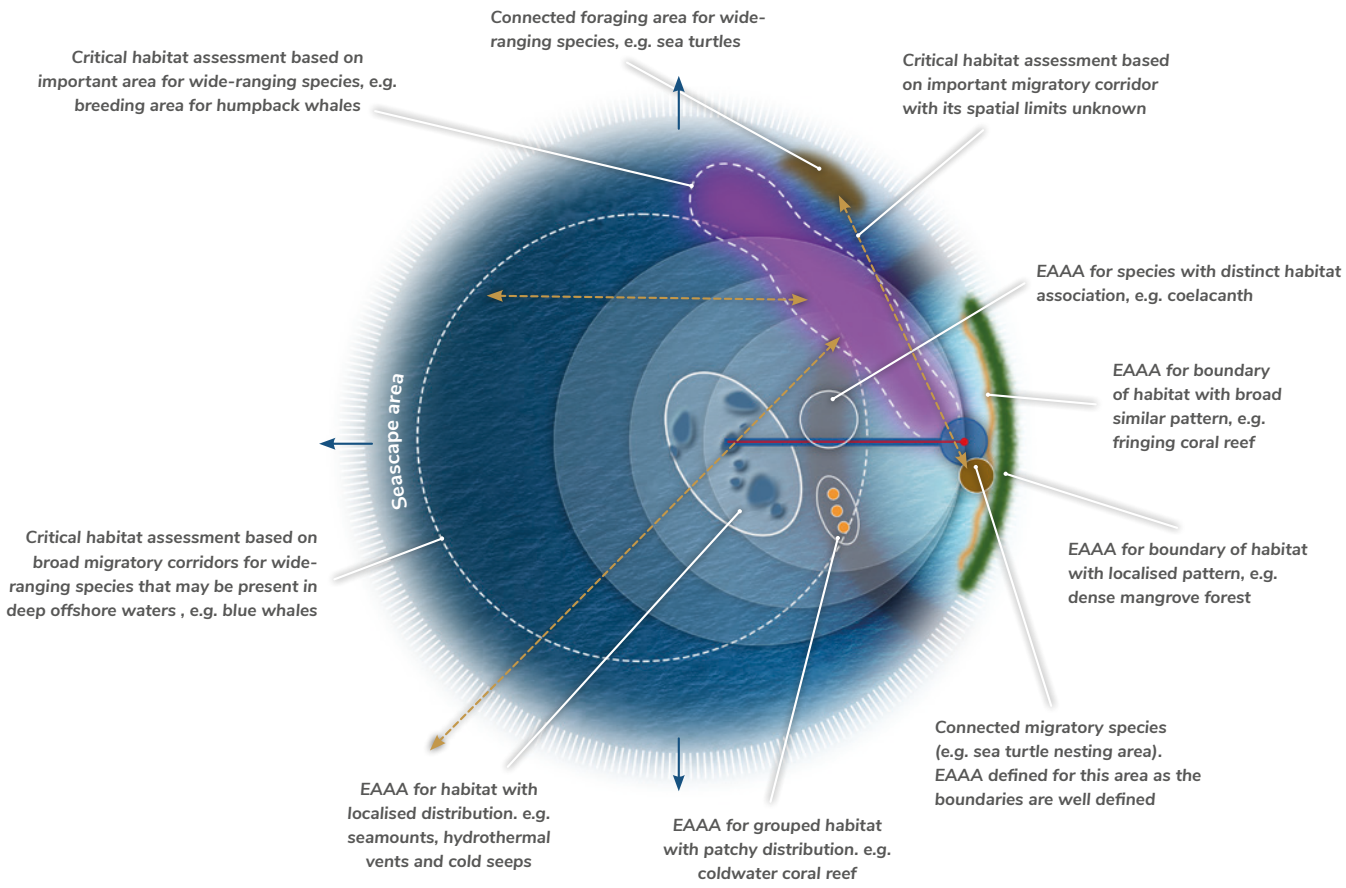


Figure 4. Illustration on defining individual EAAAs and the treatment of wide-ranging species, including the indicative zones for direct and indirect impacts shown in Figure 3

spatially defined using water depth and distance from shore which may provide biophysical zones for habitats and species. Figure 5 shows the broad zonation of EAAAs that aggregate ecological patterns and processes into distinct areas. In this example, EAAAs are primarily defined using physical parameters (e.g. water depth and distinct seabed morphology) that provides boundaries for some habitats. However, caution needs to be taken when developing such an approach to ensure that the critical habitat assessment takes account of ecologically connectivity across these zones, especially for wide-ranging species (see Section 2.2.3.2). Therefore, the establishment of broad zones in this way still requires EAAAs to still be considered for each species that may have overlapping ecological functions.

Although EAAAs will lie within the seascape area, it is also possible that broad seascape units and the EAAA may be indistinguishable. This may be true when EAAAs for individual species extend to an area that is equal to the seascape limits that have been defined, or where a broad seascape unit is considered unique (in terms of ecological patterns and processes) in comparison to other parts of the wider seascape study area, and where there are low levels of interconnectivity with wider areas. This is most likely to occur where there are unique physical conditions, clearly delineated habitat mosaics, high diversity and species with high site fidelity and no obvious dependency on external regions. Where significant data uncertainty exists, taking a precautionary approach may also require broad areas of assessment to be defined that encompass a geographically broad seascape assessment unit. Indeed, note GN58 states that:

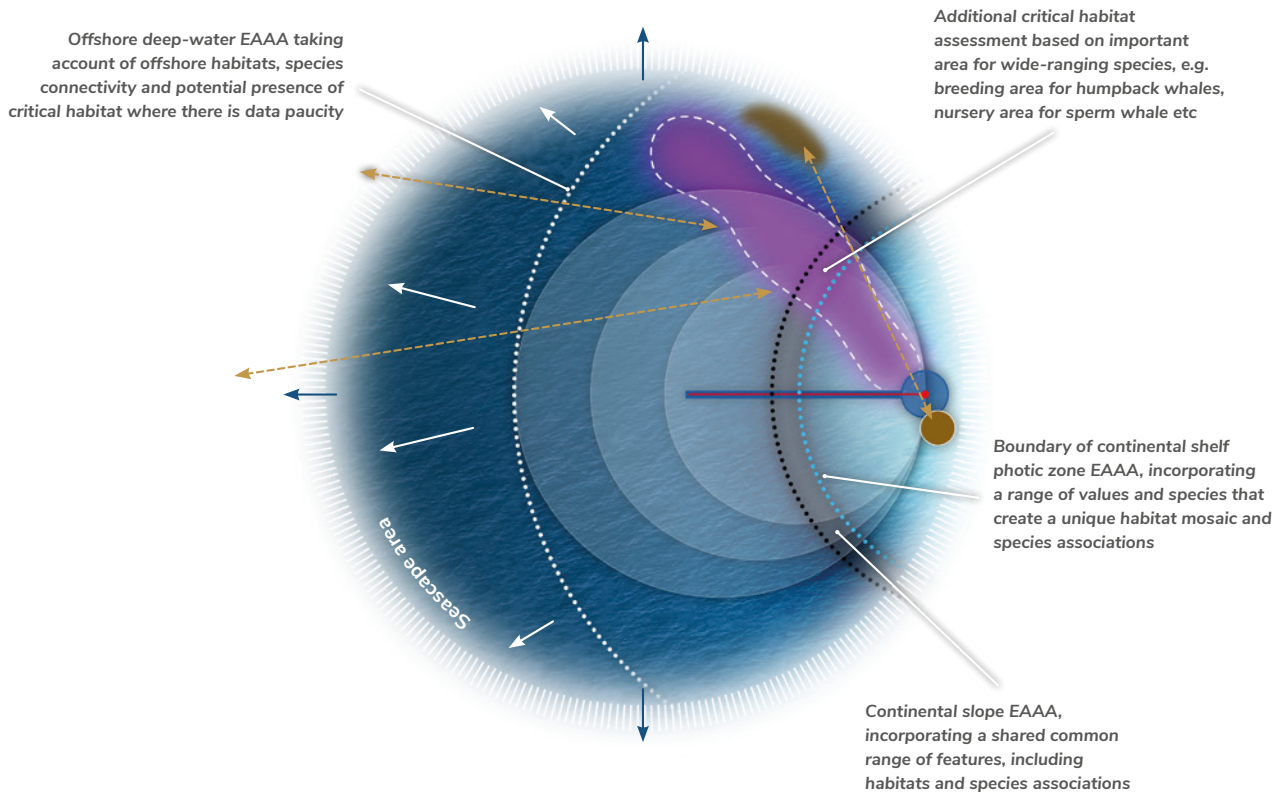


Figure 5. Illustration showing general aggregated EAAA zones and the treatment of wide-ranging species, including the indicative zones for direct and indirect impacts shown in Figure 3

Relatively broad landscape and seascape units might qualify as critical habitat. The scale of the critical habitat assessment depends on the biodiversity attributes particular to the habitat in question and the ecological patterns and processes required to maintain them... A critical habitat assessment therefore must not focus solely on the project site."

Figure 6 shows the definition of a broad single seascape unit as the boundary for the overall critical habitat assessment. In this example an aggregated EAAA has been defined for an overall area that shares common ecological processes and attributes that is distinct from other adjacent areas. The extent of assessment also encloses all impacts from project activities so that the consequence of the project on critical habitat can be fully assessed. Also, in this example there is limited or no broader ecological connectivity, which means that all attributes that need to be considered are enclosed within the assessment area.

EAAAs may overlap and incorporate boundaries for legally protected[6] and internationally recognised areas[7] or other areas that are identified for conservation management approaches. These areas may be used to help define EAAAs, but should not provide the spatial limits of EAAAs unless ecologically justified. Often these areas can be used to help define aggregated EAAAs encompassing multiple biodiversity values - as illustrated in Figures 5 and 6.

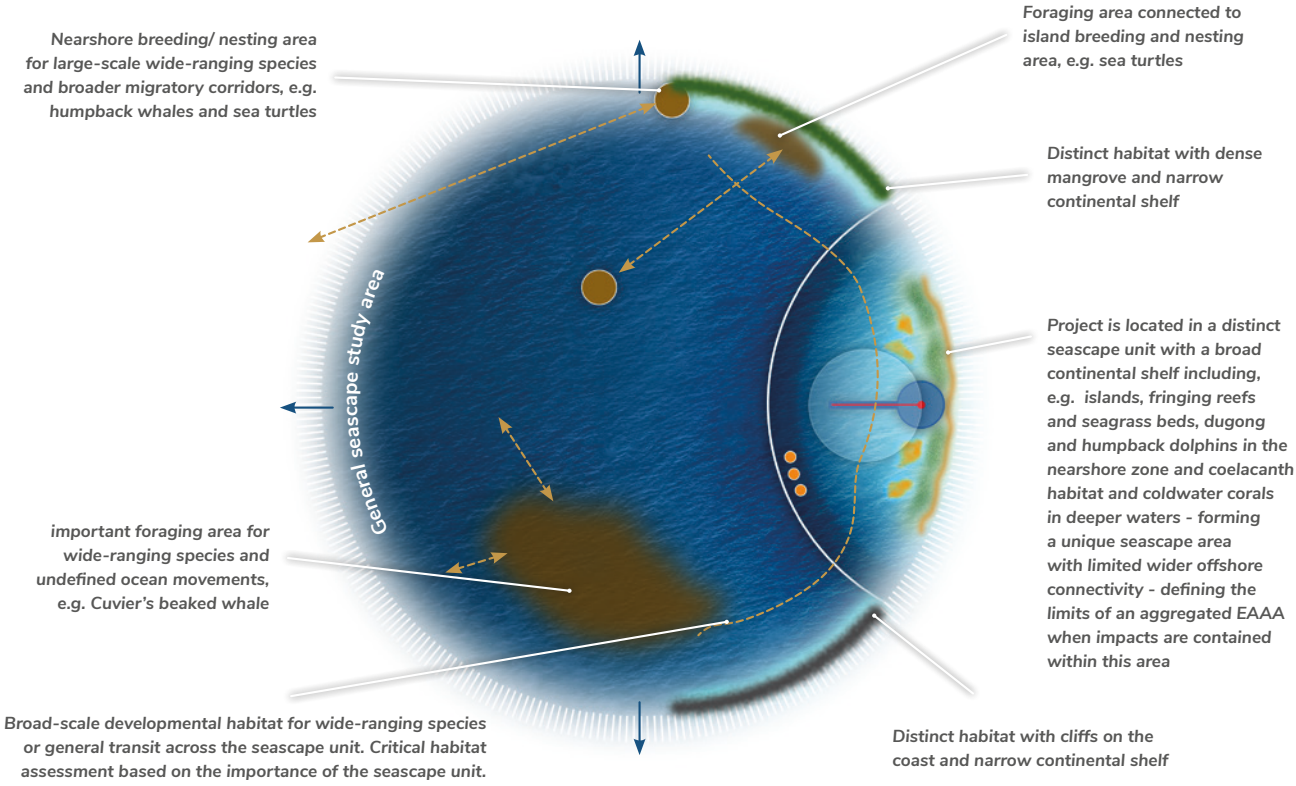


Figure 6. Illustration of a situation where a distinct seascape unit and an aggregated EAAA boundary are considered the same based on low connectivity and high levels of distinctiveness (when direct, indirect and cumulative impacts are also limited to this area)

6 As defined by GN 6: areas that meet the IUCN definition: "A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values." This includes areas proposed by governments for such designation.

7 As defined by GN 6: UNESCO Natural World Heritage Sites, UNESCO Man and the Biosphere Reserves, Key Biodiversity Areas, and wetlands designated under the Convention on Wetlands of International Importance (the Ramsar Convention).

2.2.3.2 Options for the Treatment of Wide-Ranging Species

Defining an area of analysis for wide-ranging species may be complex and requires understanding across a broad ecological scale. Wide-ranging species include those species that undertake migrations over ocean-basin scales through life-cycle development, breeding and for foraging. These movements are complex as they are species-specific and may differ across different populations. They also occur over a range of timescales and relate to specific biophysical conditions that support functions. For wide-ranging species, such as Endangered green sea turtles, a seascape assessment at the ecologically appropriate scale taking account of population distributions (including sub-populations) and important critical connectivity between ecological attributes (foraging and nesting beaches) is vital. The need to understand the appropriate seascape scale for wide-ranging species is a common issue that needs specific attention in the marine environment. Sometimes, species will be distributed across national jurisdictions, marine ecoregions and even global hemispheres (UNEP-WCMC, 2018). To understand such species at an ecologically appropriate scale, it is necessary to consider all attributes and functions across entire life-cycles. A seascape boundary that does not extend across such areas will ultimately lead to a weakness in the ecological evidence that informs the biodiversity assessment.

For some wide-ranging species, the determination of a delineated site-based assessment area may be difficult and it may not be possible to clearly define a distinct EAAA boundary. This may relate to habitat areas that are not spatially well defined or distinct or where low levels of information are available for individual species across their ranges. An example may be broad-scale developmental grounds for sea turtles. In such circumstances the assessment of critical habitat may be undertaken in line with note GN59, which states:

"For some wide-ranging species, critical habitat may be informed by areas of aggregation, recruitment, or other specific habitat features of importance to the species. In all cases, the critical habitat should consider the distribution and connectivity of such features in the landscape/seascape and the ecological processes that support them."

With respect to note GN59, for wide-ranging species where it is not possible to define a clear EAAA boundary or where there is insufficient data to undertake a quantified assessment against Criteria thresholds, then the critical habitat assessment should consider if critical features are present that are of importance to support and maintain populations (e.g., important breeding areas, nursery areas, blue corridors, foraging areas etc). For instance, if habitats are considered to be of global importance for Endangered or Critically Endangered species or other migratory/congregatory species then these are likely to be critical habitat. These areas may also comprise regional or national high priority conservation areas for wide-ranging species, and therefore, critical habitat may apply under Criterion 4. This type of assessment underscores the importance of appropriate seascape analysis to identify the areas that are considered to be critical for key ecological processes and populations. Ideally, conclusions should be informed with spatially explicit ecological knowledge including data such as maps of aggregation sites, foraging and breeding grounds, migratory routes, nursery areas, etc.). In the absence of animal movement data, the distribution of suitable habitat can also serve as a spatial proxy in the assessment. Scales et al. (2018) reported that identifying the preferred habitats of wide-ranging species and the routes taken between them (blue corridors) as an important step to defining pelagic seascapes. To achieve this requires spatially-explicit knowledge of species-habitat associations. Furthermore, Scales et al. (2018) also reported on the need to consider spontaneous reactions of individuals to dynamic biophysical conditions that may vary over time. The determination of critical habitat using non-delineated approaches require the use of expert judgement to help to define areas of importance to qualifying species and when defining critical habitat on this basis. GN 6 places considerable emphasis on the need to engage with experts for critical habitat assessment (see notes GN22 and GN58), including with individuals from IUCN Species Survival Commission Specialist Groups.

Figures 4 and 5 show how critical habitat assessment may be broadly defined for wide-ranging species based on the criticality of habitats in the seascape. Although for the purpose of illustration, these areas are mapped, it may not always be possible to draw lines and this is reflected in the broken lines around these areas. In these figures, critical habitat assessment is based on key functions, such as the identification of important foraging area or general

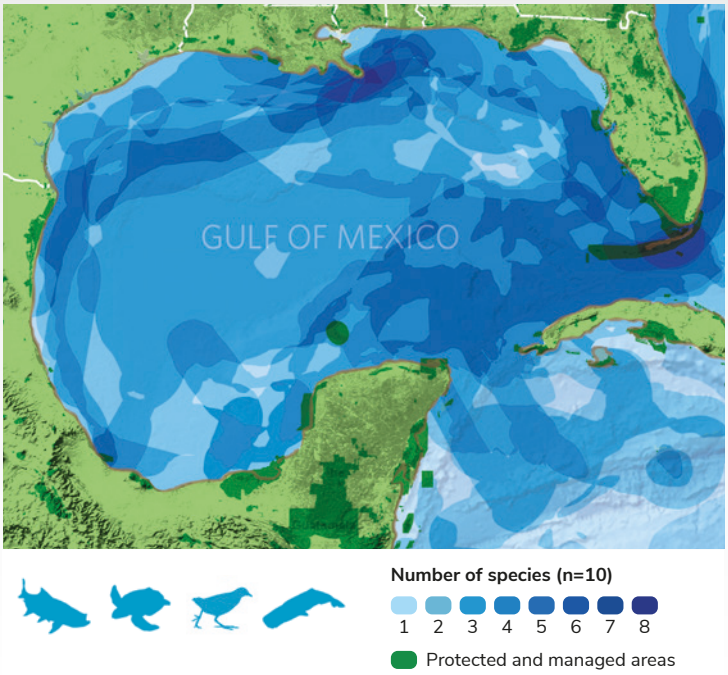
breeding and nursery areas. For these areas the critical habitat assessment could be undertaken on the basis of the importance of this habitat for the individual species being considered; and this requires consideration of broader areas of ecological connectivity across (and sometimes beyond) a seascape study area.

In some instances, it may be possible to clearly define EAAAs for wide-ranging migratory and congregatory species. This may relate to discrete areas where there are clear and distinct boundaries such as habitat structure or depth contours where important ecological functions such as breeding aggregation for a sub-population are known to occur. Again, the functions set out in GN59 may be used to define these areas. Where such areas exist and where data allows, critical habitat assessment boundaries may enclose these areas for assessment under relevant Criteria thresholds. For example existing site-based conservation management areas may be defined for wide-ranging species based on clear and distinct importance for species populations, e.g. congregation for breeding and calving of marine mammals or sea turtle nesting areas or fish spawning aggregation or seabird congregations at predictable times of the year. Where site-based approaches are used a seascape scale of understanding is again vital to provide justification related to critical habitat designation. Figures 4 and 5 show how clear EAAA boundaries may be identified for some wide-ranging species where predictable behaviours in a localised area, such as sea turtle nesting grounds or humpback whale breeding areas.

It may be necessary to consider a combination of approaches for the critical habitat assessment based on the functions and levels of certainty. It is possible that the assessment may need to consider connectivity between different areas being assessed and EAAAs could be grouped for an individual species. It is also possible that a clear quantifiable assessment is combined with expert judgement across different functions for the same species being considered.

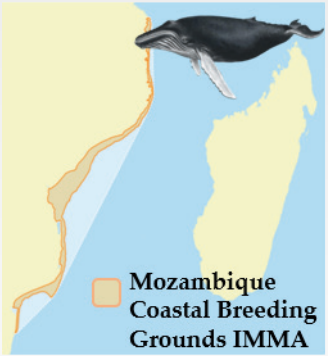
Box 1 **Considering critical ecological connectivity for multiple wide-ranging species**

In some areas of the world, marine movement corridors and critical habitat are being revealed through satellite and acoustic tracking data from multiple species. For example, to better incorporate the movements of large marine migratory species into conservation planning, The Nature Conservancy (Brenner et al., 2016) has compiled existing movement data from 10 marine migratory species (6 fish; 3 sea turtles; and 1 marine mammal) and identified feeding and reproductive aggregations and migratory movement corridors. This information also identified hotspot habitat (top 25% of all location points) for 26 migratory species. Overlaying key feeding and spawning locations across multiple species highlights that some areas are critical habitat for more than one species and that multi-species corridors exist in the Gulf of Mexico Large Marine Ecosystem.



Box 2 **Examples of site-based conservation management areas for wide-ranging species that will inform the development of spatial scales for critical habitat assessment – Important Marine Mammal Areas (IMMAs)**

Important Marine Mammal Areas (IMMAs) are internationally recognised areas that are defined as discrete portions of marine mammal habitat that have the potential to be mapped and managed for conservation. The criteria for identification of IMMAs includes vulnerability (species and population), distribution (important small resident population and aggregations), key life-cycle activities (reproductive areas, feeding areas and migration routes), and special attributes (distinctiveness and diversity). These criteria provide a mechanism to assess critical habitat status for wide-ranging species. Where data gaps exist the identification of IMMAs typically makes use of expert judgment and spatial modelling techniques. The scale of IMMAs varies with some large areas such as the Mozambique Coastal Breeding Grounds IMMA (80,936 km^2) or smaller areas such as the Kisite-Shimoni IMMA (726 km^2) designed to encompass the long-distance migrations of humpback whales (Megaptera novaeangliae) (breeding sub-stock C1). Satellite tracking, data from areas of breeding aggregations and expert knowledge have combined to define these IMMAs.), The information available helps to define breeding areas that are critical to the subpopulation that may be considered for critical habitat determination, including the definition of EAAAs. However, limited information is available on other areas that are important to population maintenance, such as precise information on migratory corridors, distribution ranges for each sub-stock and interconnectivity between sub-stocks (Cerchio et al., 2013); and these uncertainties also need consideration when determining critical habitat assessment areas.



2.2.4 Summary

A core requirement of PS 6 is to ensure that biodiversity assessment is driven by the understanding of ecological processes and attributes at an ecologically appropriate scale; and the conclusion on value is not only focused on the project site and where direct impacts may occur. This is to ensure that the full context of biodiversity value and potential risks are fully understood, robustly addressed and any risks managed for the effective conservation of biodiversity. The following provides a summary of key considerations:

- The AoI comprises the zone where direct and indirect impacts occur from the project and its Associated Facilities and where cumulative impacts occur.
- The extent of the AoI in the marine environment will need to consider ecological processes to take account of connectivity.
- Cumulative impacts should be assessed where direct and indirect impacts occur; and the extent of cumulative impacts is dependent upon the assessment of in-combination effects.
- The seascape extent is not defined by the AoI. It is defined by the broadscale ecological patterns and processes. Seascape analysis provides a broad study area for understanding of biodiversity value for the area in which a Project is located.
- The information gathered at the seascape scale is used to inform the definition of EAAAs for each habitat and species that needs to be assessed or to determine how some wide-ranging species should be considered based on important attributes and functions.

- The area for critical habitat assessment will lie within the seascape and could extend to overlay the seascape depending on what is considered ecologically appropriate for each habitat and species that is being considered. The extent of the EAAA is also therefore not spatially limited by the AoI but rather by the ecological attributes and processes that exist. Critical habitat is defined at the extent of the EAAA and not a part of it. However, an EAAA is not always defined for critical habitat determination and for some wide-ranging species critical habitat should be defined on the basis of the importance of habitats for supporting and maintaining their key functions and populations.

- When critical habitat is identified, impacts are considered in relation to the area of critical habitat. The overall extent of the project AoI may be within or extend beyond these areas for individual features.

- Where there is a high degree of connectivity or uncertainty in data, the AoI may be defined to the full extent of EAAAs to ensure that all potential direct and indirect project impacts on critical habitat are considered.

Figure 7 provides an illustration of how the different areas of concern for biodiversity assessment required by PS 6 may align.

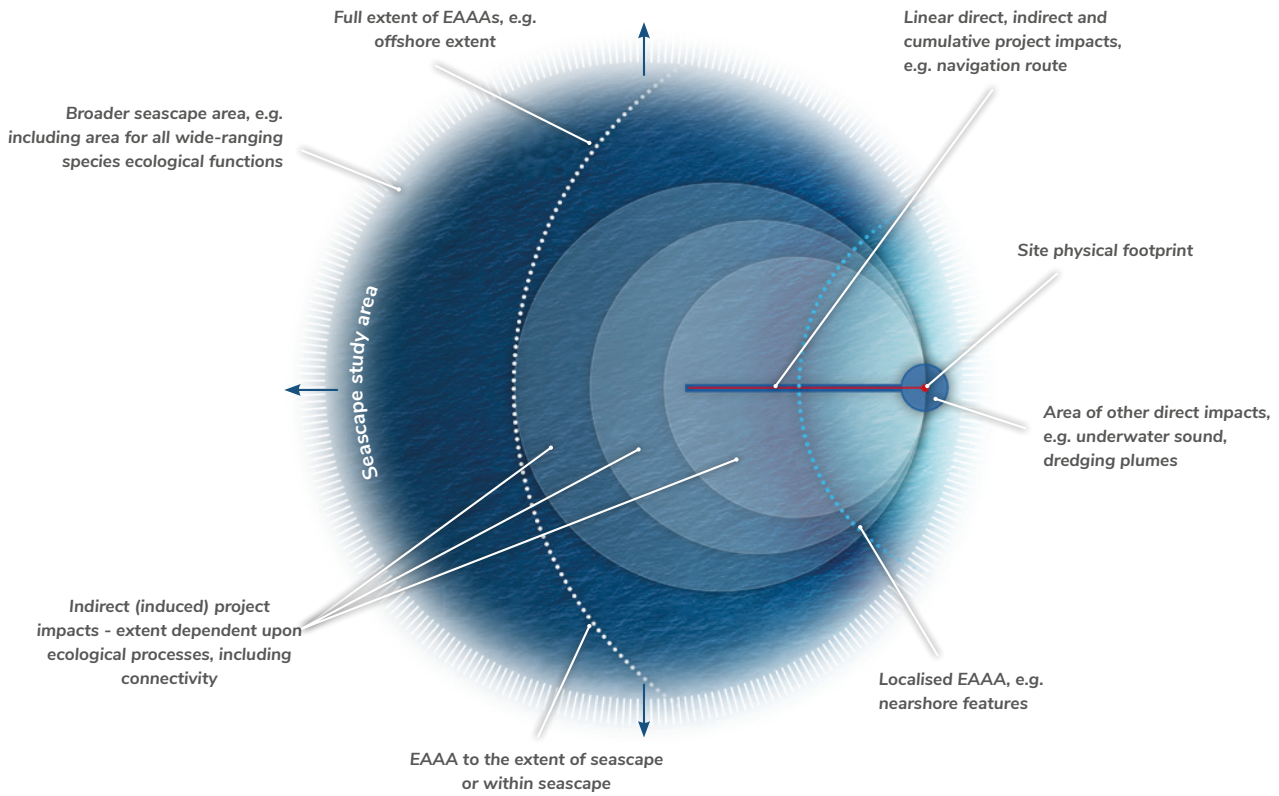


Figure 7. Combining the spatial areas for biodiversity assessment

2.3 Steps in defining spatial areas of analysis

Figure 8 show the assessment steps that should be undertaken to determine the appropriate scales of analysis to meet PS 6 requirements.

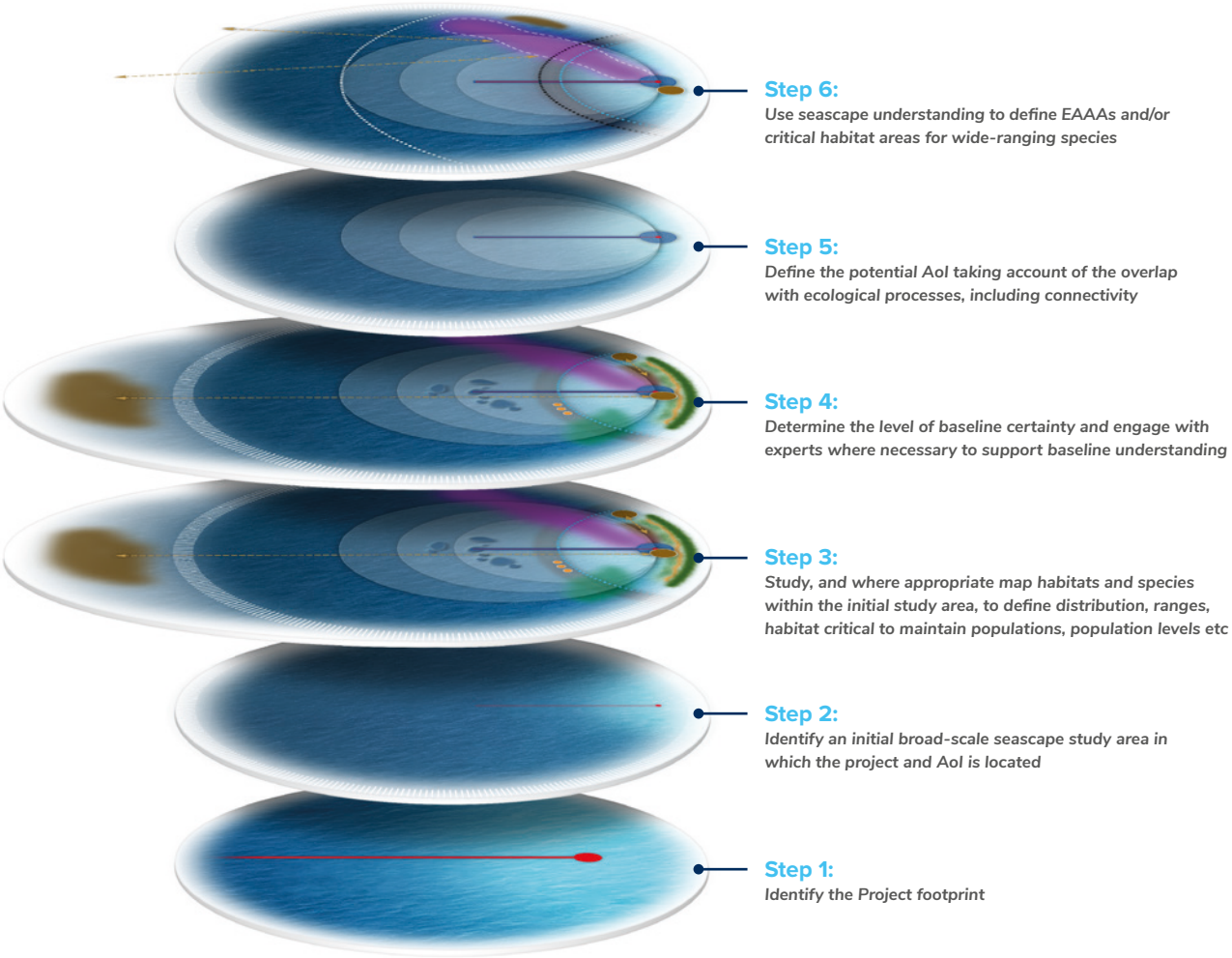


Figure 8. Steps in defining spatial areas of analysis

GUIDANCE FOR DEFINING ECOLOGICALLY APPROPRIATE SCALES OF ANALYSIS FOR MARINE BIODIVERSITY IN RELATION TO IFC PERFORMANCE STANDARD 6

3.0

BASELINE DATA AND MANAGING UNCERTAINTIES

3.1 Overview

The determination of seascape and areas for critical habitat assessment are dependent upon the comprehensiveness of baseline understanding across multiple spatial extents. PS 6 places considerable emphasis on the need for robust baseline understanding to inform the assessment biodiversity value and also potential project risks. Note GN9 states that requirements for the baseline study will vary depending on the nature and scale of the project. The type of studies required should therefore be proportionate to the Project risks on biodiversity. Where it is possible for a Project to have significant impacts on Natural or Critical Habitats, note GN9 of GN 6 requires that the understanding of baseline conditions be informed by field surveys over multiple seasons. As already noted, the determination of appropriate scales of analysis for marine biodiversity may include extensive areas. Therefore, it may not be possible to conduct field surveys across a seascape. This is addressed under note GN17, which states that taking a seascape perspective does not necessarily imply field data collection outside the project site. However, GN6 requires that baseline studies should include desktop assessment, including mapping exercises and consultation with regional specialists. The purpose of these studies is to help understand baseline conditions and also to define the appropriate areas of analysis.

Whilst baseline field surveys across a broad seascape area are not always required, the more information that is available, the more likely that a robust assessment using an appropriate scale of analysis will be achieved. The Multilateral Financing Institutions Biodiversity Working Group & Cross Sector Biodiversity Initiative (CBSI) have developed 'Good Practices for the Collection of Biodiversity Baseline Data' (Gullison et al., 2015). Hardner et al. (2015) provided information on how to develop baseline understanding for a project's AoI and also the need to consider biodiversity values across the landscape or seascape. The guidance provides a list of various spatial scales relevant to biodiversity, which includes the distribution of biodiversity values, ecological functions and migratory routes. In addition, the guidance states that where little is known about biodiversity, wider seascape surveys may be needed to help assess the significance of project impacts.

Whilst appropriate baseline studies can address gaps in knowledge this may not always be possible. Significant uncertainty will emerge in some data poor regions and where key species exhibit spatially complex distributions and where visual surveying is hampered by environmental conditions, such as light, depth, ice cover etc; or project development timeframes. Where uncertainties exist, a project will need to incorporate robust and transparent techniques to evaluate and address uncertainties in the baseline understanding. This is especially true for wide-ranging species where it may not be possible for a project to collect reliable baseline data across the seascape area. The note GN15 states that, where there is significant uncertainty, the client should take a conservative approach in ascertaining the significance of residual impacts. Whilst this point does not specifically relate to baseline, the ability to understand biodiversity values and potential impacts on it clearly depends critically on the adequacy of the baseline. Although undefined in GN 6, a likely interpretation of a 'conservative approach' is to apply the precautionary approach. The precautionary approach has been widely applied in global biodiversity policy such as Principle 15 of the Rio Declaration on Environment and Development (1992) and the Convention on Biological Diversity (COP Decision II/10 Conservation and Sustainable use of Marine and Coastal Biological Diversity). If there is uncertainty in baseline conditions it is important that the scale of analysis appropriately addresses any uncertainties

by using scientific judgement to form predictable conclusions as part of an informed risk-based approach. In the management of uncertainties, there is considerable need to ensure habitat- and species-specific expert input and for precautionary approaches to be adopted and documented to support judgements. In addition, a broad seascape approach will allow for predictable conclusions to be drawn. For instance, where data exists in one area this may be used to inform baseline understanding in another area with an understanding that uncertainty will remain due to the potential for ecological relationships to be context-dependent (Bradley et al. 2020). Uncertainty will also occur through the possibility that a critical habitat is present yet unknown with existing data.

The importance of selecting appropriate assessment scales cannot be underestimated for highly mobile and wide-ranging species, but also to help determine potential presence of habitats or species where it is unknown (for instance using data interpretation from elsewhere and surrogate approaches – see below). There are a range of techniques available to help manage uncertainties and these are explored in Section 3.2.

Box 3 **Useful sources of marine data for the development of study and assessment areas.**

Integrated Biodiversity Assessment Tool (IBAT): a web-based map and reporting tool that provides fast, easy and integration access to three of the world's most authoritative global biodiversity datasets, including the World Database on Protected Areas, the World Database of Key Biodiversity Areas; and the IUCN Red List of Threatened Species. IBAT is developed and maintained by the IBAT Alliance (IUCN, BirdLife International, UN Environment World Conservation Monitoring Centre (UNEP-WCMC), and Conservation International) with the aim to enable users to make informed decisions in policy and practice. IBAT was initially co-developed with World Bank Group specialists to support early implementation of Performance Standard 6. This remains one of the core applications of the tool but it is now also used in a range of circumstances and by a wide set of users including World Bank, Shell, Rainforest Trust, International Olympic Committee, General Motors, and the Cambridge Institute for Sustainability Leadership.

Global Biodiversity Information Facility (GBIF): A global database repository for species, including open access to mapping.

Ocean Data Viewer: Web based datasets on coastal and marine biodiversity developed by UNEP-WCMC.

Ocean Biodiversity Information System (OBIS): Global open access database for marine species.

AquaMaps: Global predictive mapping tool using modelling of the distribution of species using data from GBIF and OBIS.

State of the World's Sea Turtles (SWOT): Web based map and database for sea turtles, including nesting data, satellite telemetry data and species distributions.

Weatherdon et al. (2015) have written an excellent manual of marine and coastal datasets of biodiversity importance and this should be referred to for further reading on valuable data resources for marine biodiversity.

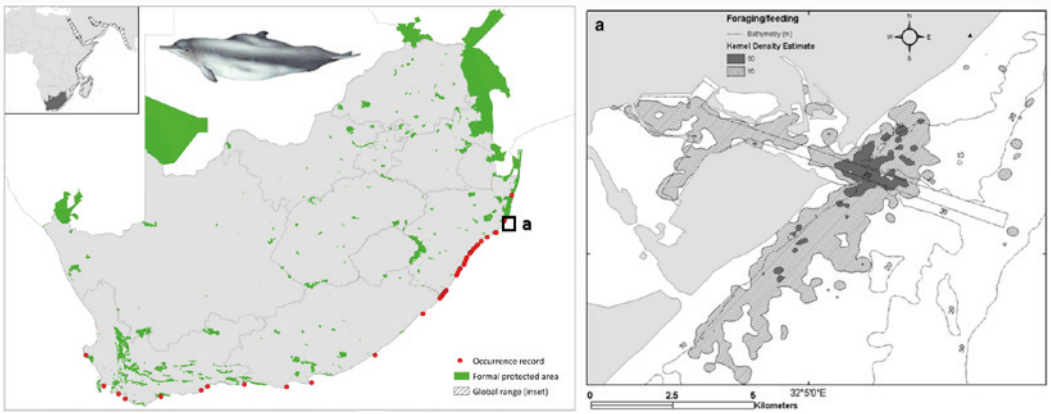
3.2 Methods and Tools for Managing Uncertainties

3.2.1 Predicting Presence using Habitat Preferences

In the absence of detailed information the general information on habitat preferences may be used to define suitable habitat, spatial limits related to movements offshore, connectivity to habitats that are known to be present or the identification of maximum potential ranges from where sightings have been made. Species distributions can be predicted even using a small number of sightings, the locations of sightings and existing ecological knowledge from other regions of the species range. Whilst some element of uncertainty will remain, this information can be used to help define an appropriate seascape for consideration using distribution models and a precautionary approach.

Box 4 **Sightings data enable the identification of habitat use at multiple spatial and temporal scales: Case study of the Indian Ocean humpback dolphin.**

The extent of occurrence and population estimates for the Endangered Indian Ocean humpback dolphin (*Sousa plumbea*) are limited at regional or global scales. Although regional biogeographic range has been estimated for the IUCN Red List assessment (Plön et al., 2016), the information is insufficient to adequately understand status, distribution and habitat requirements. Distributions likely reflects the existence of pockets of suitable habitat and possibly local extirpation and range reductions. In East Africa, for example, sightings data for *S. plumbea* suggests a small population with high uncertainty in geographical distributions, movement behaviour and population status (Braulik et al., 2015). This species is considered to be a feeding generalist foraging across a range of shallow (< 25 m) subtidal habitats, including reefs and seagrass beds and frequent protected bays and estuaries and also feeding in estuaries and mangroves (Braulik et al., 2017). In South Africa, Sharpe and Berggren (2018) show fine-scale habitat selection primarily driven by access to feeding grounds, such as the species' preference for rocky reef habitats. Their distribution likely reflects the existence of pockets of suitable habitat and possibly local extirpation and range reductions. Sightings and behavioural observations suggest that the population appear mostly to be composed of long-term residents that show high site fidelity with regular alongshore movements up to 150 km and fewer longer distance movements of up to 500 km (Vermeulen et al., 2018). Where intense behavioural observations have been used to categorise and map the ocean spaces associated with specific behavioural activities (see map a above) information can be used to identify critical habitat. For example, Keith et al. (2013) use kernel density techniques to map general (95%) and core activity (50%) spaces where dolphins were feeding. Therefore, where sightings have been recorded or presence is possible to predict, information can be used to define all suitable habitat for the species and to identify areas that may be of greatest importance for conservation. Rapid assessment protocols have been developed to rapidly and cost effectively generate basic information on distributions across broad geographical areas (e.g. Braulik et al. 2018).

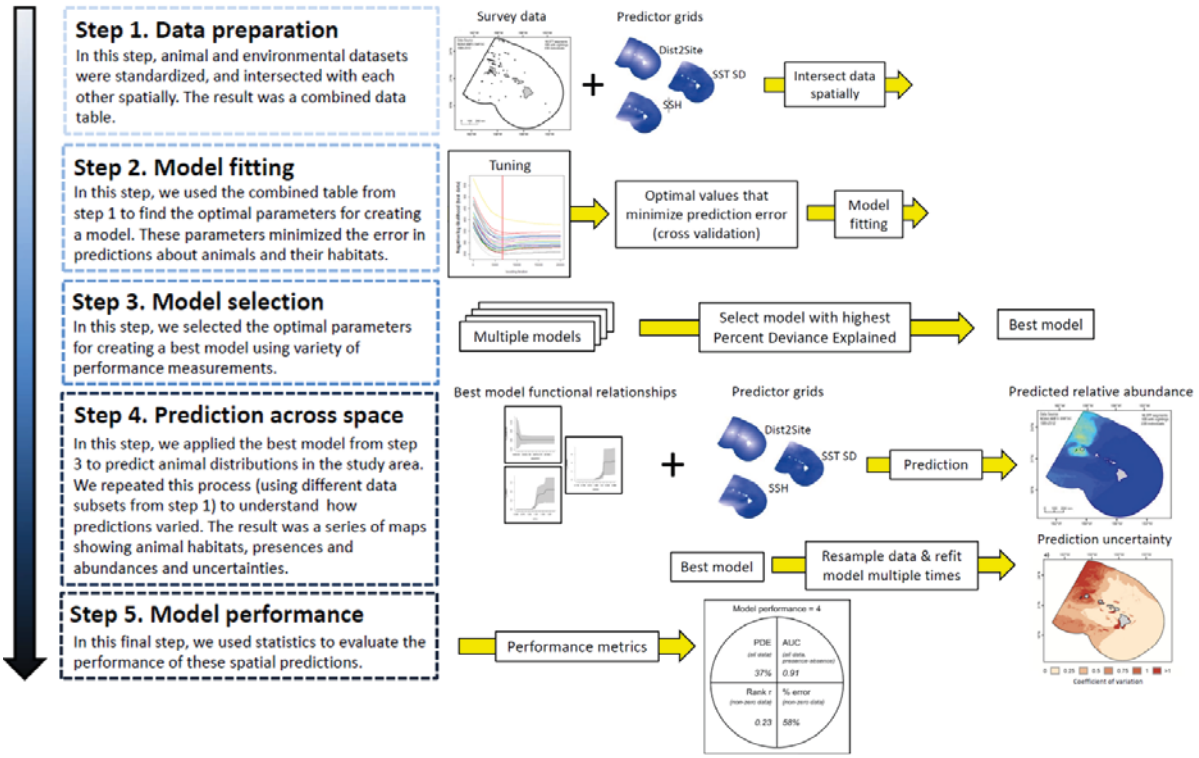


3.2.2 Predictive Mapping

Predictive mapping of biological distributions, sometimes referred to as species distribution modelling and ecological niche modelling, is now widely recognised as an effective analytical tool to address spatial information gaps (Elith & Leathwick et al., 2009). Reliable and cost-effective analytical techniques that integrate geostatistical modelling and machine-learning algorithms combined with geographical information systems (GIS), are increasingly being applied to model and predictively map environmental features and biological distributions (e.g. habitats, species, species diversity and assemblages) across broad geographical areas of the ocean (Caldow et al., 2015; Melo-Merino et al., 2020). These sophisticated modelling tools provide robust predictions even in data poor areas and are capable of more than gap filling since they also have the potential to provide new ecological insights through analyses of complex macroecological relationships. The model outputs can include predictive maps of potential critical habitat (Martin et al., 2014). Costa et al. (2018) provided a review of challenges that exist for mapping seascape where there are uncertainties and outline approaches to address such issues. Costa et al. (2018) also provided a conceptual framework and approaches for determining seascape patterns that is useful additional reading for defining seascape boundaries.

Box 5 **Example of predictive mapping to address knowledge gaps of endangered species distributions for marine spatial planning in the Main Hawaiian Islands (Pittman et al., 2016)**

To support spatial planning for offshore renewable energy in the Main Hawaiian Islands reliable information was required on marine species of conservation concern. NOAA Biogeography Branch applied a boosted generalized additive modelling framework (Pittman et al., 2016) to relate cetacean and seabird count data to a range of temporal and spatial environmental predictor variables. The model was robust to zero-inflated count data and aggregated animals typical with at-sea visual surveys. Estimated relationships were then used to predict the distributions of relative abundance of modelled species across the entire study area. Uncertainty in model predictions was estimated using a non-parametric bootstrapping framework.



3.2.3 Use of Spatial Proxies or Surrogate Variables

The development of reliable and cost-effective spatial predictive models has been aided by identification of useful surrogates or spatial proxies to represent complex spatial patterns that are difficult to map directly, such as species distributions and biological diversity patterns. Useful surrogate predictor variables have been found that can be either biotic or abiotic features providing they can be reliably mapped. Bathymetry is probably the single most useful predictor of marine biotic distributions due to its importance for marine ecological patterns and processes. For example, a change in depth is associated with a suite of complex environmental changes that may have abrupt threshold effects on a marine species distribution. As such, the change in habitat suitability can be well-represented by bathymetric change. In predictive models of habitat suitability for reef fish, higher species richness tends to be associated with higher topographic complexity – a metric that can be measured from seafloor bathymetry. Geographical context can also serve as a spatial proxy for unmeasurable parameters (Pittman & Brown, 2011; Mellin et al., 2011; Lindenmayer et al., 2015). For example, position metrics such as distance to shore, distance to shelf edge, and distance to river mouth have proved useful through interaction with other predictor variables because they can capture unobserved, unknown, or unmapped patterns such as inshore–offshore gradients in physical and chemical conditions and proximity to ecologically relevant features (e.g., nearshore nursery areas, shelf-edge spawning sites, freshwater outflow). In addition, the mapping of upwelling areas (using chlorophyll-a concentrations) can provide a proxy for wider ecosystem productivity and the seasonal aggregation of some species (e.g. marine mammals and seabirds).

Costa et al. (2018) and Scales et al. (2018) explore the use of proxies for seascape mapping, including geographic surrogates. They also reported on important limitations for the use of surrogates and that these should be treated with care. Costa et al. (2018) reported that these may only be used as a starting point for understanding how patterns in the seascape drive the distribution of habitats and species.

3.2.4 Use of Local Ecological Knowledge (LEK)

In some data poor situations it is becoming increasingly widespread to seek local ecological knowledge (LEK) to help improve ecological characterisations. For example, fishers usually have a much greater geographical knowledge of where the fish spawning aggregation sites are located, as well as the distributions of many species and habitats that may remain undocumented. LEK has also helped to gain a better understanding of seasonal dynamics and long-term trends in marine species populations including revealing undocumented critical habitats. There are many examples in the literature of local knowledge and citizen science data being used to identify priority sites, patterns of ecological connectivity and fish nursery areas (Berkström et al., 2019). For example, identifying important coral reefs with help from fishers and SCUBA divers' extensive local knowledge (Hamilton et al., 2012; Pittman et al., 2018). In addition, crowdsourced online digital images and communication on social media platforms are being used to address data gaps in marine species distributions (Noble et al., 2020). A recent study used underwater video and images posted online by SCUBA divers to map locations and assess human impacts to gorgonian forests in the Mediterranean (Di Camillo et al., 2018).

GUIDANCE FOR DEFINING ECOLOGICALLY APPROPRIATE SCALES OF ANALYSIS FOR MARINE BIODIVERSITY IN RELATION TO IFC PERFORMANCE STANDARD 6

4.0

DETERMINING ECOLOGICALLY APPROPRIATE SPATIAL AREAS OF ANALYSIS

This section provides a discussion of key considerations when defining spatial areas for analysis, including the determination of seascape and EAAAs.

4.1 Ecological Connectivity

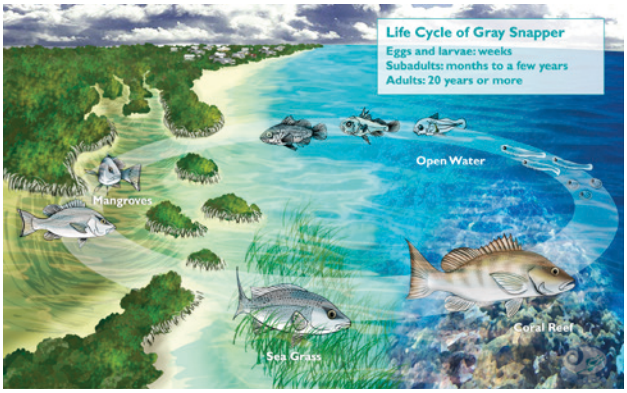
Ecological connectivity, the spatial movement of organisms and materials, is among the most important ecological processes in determining the distribution, persistence, and productivity of marine populations and functioning of ecosystems. Consequently, a wide variety of essential marine ecosystem services depend on ecological connectivity. To operationalise the term ecological connectivity for the post-2020 Global Biodiversity Framework, the Convention on the Conservation of Migratory Species of Wild Animals (CMS, 2020) defined ecological connectivity as "the unimpeded movement of species and the flow of natural processes that sustain life on Earth". The IUCN adopted the CMS definition and further defines ecological connectivity for species as "the movement of populations, individuals, genes, gametes and propagules between populations, communities and ecosystems, as well as that of non-living material from one location to another (Hilty et al., 2020). The importance of marine connectivity is underpinned by a rapidly growing global scientific evidence base catalysed by animal tracking technologies (Dunn et al., 2019). For shallow tropical marine ecosystems, Grober-Dunsmore et al. (2009) reported upon how connectivity has a profound consequence for the behaviour, growth, survival, and spatial distribution of marine species. This includes the connectivity of physical factors, but also the active movements across habitats (mosaics and patches) – such as daily foraging movements, tidal migrations, life-cycle behaviour (ontogeny), seasonal migrations, linkages of species with specific habitat types etc. For pelagic seascapes, Scales et al. (2018) reported on the presence of spatially structured patterns that occur across an array of interconnected scales that regulate marine biodiversity.

Three categories of connectivity have been defined: structural, potential and actual connectivity (Calabrese & Fagan, 2004).

- *Structural connectivity* is derived only from physical attributes of the seascape. For example, the spatial arrangement of habitat patches (sometimes referred to as configuration) can be used as a spatial proxy to infer connectivity without information on species dispersal ability.
- *Potential connectivity* integrates both the physical attributes of the seascape with limited information about dispersal ability. For example, sightings data can be linked to seascape features to model potential movement pathways.
- *Actual connectivity* (sometimes referred to as a type of functional connectivity) is the direct observation and measurement of individual movements through the seascape or landscape. This usually provides the most detailed information on movement behaviour and is typically generated from acoustic or satellite telemetry (Harcourt et al. 2019).

Each category has an associated suite of metrics and modelling techniques that differ in their data requirements, informational content and spatial scales of applications (Calabrese & Fagan, 2004; Saura & de la Fuente, 2017). In general, informational content and data demand increases from simple measures of structural connectivity using habitat maps to actual movement rates such as gained through radio and acoustic telemetry. These techniques can also be applied across the land-sea interface or from freshwater to marine waters (Fang et al., 2018).

In the absence of reliable data on actual connectivity, the interpretation of structural connectivity and to a lesser extent potential connectivity, will likely require management of uncertainties and use of precautionary approaches (see above). To understand connectivity, it is important to consider habitat- and species-specific scales. This means that the delineation of a seascape and EAAAs must also be considered at this scale so that appropriate structural boundaries for features of interest can be appropriately defined.



The gray snapper (Lutjanus griseus), like many tropical coastal fish, use multiple habitat types through their life cycle connecting mangroves, seagrass, seagrass, coral reefs and offshore waters. Art by Ryan Kleiner. Reproduced from www.piscoweb.org

4.2 Patches, Edges and Mosaics

The observable spatial patterns (patchiness, mosaics and terrain morphology) of both the seafloor and in the water can be used to define ecological meaningful spatial areas within the marine environment. Patches represent relatively discrete internally homogeneous features usually with well-defined edges (spatially defined) or periods in time (temporally defined) of relatively homogeneous conditions (Jackson et al., 2018). Where patches and edges form relevant structural and functional components of a seascape these patterns can also help to spatially determine EAAAs. A mosaic of patches may correspond with the determination of broad seascape study areas. Patches are dynamic at various scales and can be hierarchically structured (Jackson et al. 2018). Distinct edges often create edge effects where habitat suitability declines for some species and increases for others, or forms transition zones where biodiversity is greater (Bostrom et al., 2011). Edges may provide practicable boundaries for delineating EAAAs.

4.3 Influencing Factors

4.3.1 Physical Environment

Physical environmental factors are a driving force in the formation of the composition and spatial configuration of marine areas. Often, these factors can be used to help define specific zones that may provide limits to specific patterns and the boundaries for seascape and for the determination of EAAAs.

The habitats and species that are present in the marine environment are often driven by physical conditions that provide gradients and patchiness in habitat quality that influence growth, survival and reproductive success and also define natural limits. This may include bathymetry, seabed slope, extent of continental shelf zones, geology, photic zones, salinity, water temperature, oxygenation, substrate type, presence of unique topographic features; or relate to seasonal variations such as freshwater discharges (including seasonal), upwellings/chlorophyll fronts (areas of high productivity), oceanic fronts, currents, wave climates, and atmospheric conditions (e.g., monsoons and El Niño effects) etc. These areas may form distinct/unique components of a larger regional marine ecosystem zone (e.g., LME or ecoregion) or present more localised attributes that require unique consideration.

In line with the ecoregion and biome approach, seascape areas may be defined on the basis of shared specific biogeographical characteristics across large marine areas (Spalding et al., 2007; Kavanaugh et al., 2014). Sherman (1991) defined the concept of Large Marine Ecosystems (LMEs), which are extensive areas of ocean spaces of ≥ 200,000 km^2. These areas are partly defined by physical factors such as hydrography and bathymetry, which relate to productivity and trophically dependent populations. Scales et al. (2018) reported on the use of spatially explicit patterns of primary productivity to allow the classification of regions of the open ocean into broad-scale biogeographic provinces with their shape, size and structure primarily defined by circulation patterns. These areas may include endemic or restricted range or species ; and have common physical environmental conditions and ecological dynamics, including unique habitat and species mosaics or indicate where there is clear biophysical differentiation (i.e., areas of high primary productivity – seasonal or otherwise). However, the boundaries of some areas may be generally spatially

8 Flora and fauna species that exist only in one geographic region.

9 In GN 6 the term endemic is defined as restricted-range. Restricted range refers to a limited extent of occurrence (EOO). In For marine systems, restricted-range species are provisionally being considered those with an EOO of less than 100,000 km2

limited to neritic zones – e.g., LMEs. Where this is the case, these zones may only focus on specific biodiversity values; and may not be of primary importance to all features that may need to be assessed by a project. They will also not be defined on the basis of movements for wide-ranging species.

Often, where there is data paucity, some physical characteristics can provide a proxy understanding of biodiversity values based on habitat associations – i.e., the role of upwellings, fronts and eddies. These techniques are discussed in Section 5.

Box 6 **Example of physical influence on ecological attributes: Western Indian Ocean coelacanth**

The Western Indian Ocean coelacanth (*Latimeria chalumnae*) has a patchy known distribution from Kenya to South Africa, including Tanzania, Madagascar and the Comoro Islands. However, the understanding of distribution and population status for this species is limited by data paucity. Coelacanth rest in caves and overhangs during the day and feed across a broader range at night. During the day, coelacanth require shelter with limited water currents and water temperatures ranging from 15-20°C (Fricke et al., 1991; Fricke & Plante, 1998). During nocturnal feeding, coelacanths are generally thought to move into deeper waters (> 400 m), with the deepest observation at 698 m (Hissmann et al., 2000), where water temperatures may be as low as 12.2 – 13.1°C. However, coelacanth may move upward to depths with a maximum temperature of 22-23°C, which is regarded as their upper temperature threshold (Fricke & Hissmann, 2000). Fricke and Hissmann (2000) reported that in the Comoros, coelacanths spent most of their nocturnal feeding activities below their daytime cave and overhang shelters in relatively colder water. Only for about 8.2% of the time, they were located above their daytime habitat in warmer water. Coelacanths typically migrate 3-4 km per night, and individuals have not been observed more than 35 km from their home caves (Fricke et al., 1994; Hissmann et al., 2006). Coelacanth have a strong association with specific physical environmental attributes and behaviours that limit their distribution and ranges. Green et al. (2009) used criteria concerning depth and shelf morphology from known coelacanth habitats to identify locations of potential for suitable habitat. Data paucity requires a broad understanding of physical factors to determine the potential presence of these species supported by expert judgement. This information can be used to determine the extent of distribution in the seascape, but also to define EAAAs.

4.3.2 Environmental Degradation and Threats

An understanding of the exposure to stressors and cumulative threats from human activities that exist across the assessment scales will help to understand vulnerability for habitats and species, which in turn improves understanding of ecological attributes, processes and functions. Indeed, note GN14 states that:

"The client should provide an accurate account of threats, including regional level threats that are relevant to the project site and its area of influence. The client should describe any preexisting threats and the extent to which the project might exacerbate them."

Marine environments are often subject to a range of anthropogenic derived direct and indirect threats associated with, for example, ecosystem services, climate change (including increasing extreme events), shipping, land and sea-based sources of pollution, conversion of marine habitat to terrestrial land, noise and light pollution, ship collisions. In addition, threats from coastal erosion, storms, El Nino, heatwaves etc will also influence biodiversity value. Understanding such influences are, therefore, important to underpin the understanding of biodiversity value and may support the establishment of appropriate seascape boundaries and EAAAs based on threats that exist and vulnerabilities. Such assessment is a core requirement for Natural Habitat assessment, but it is also important for establishing EAAAs for Critical Habitat Assessment.

4.4 Offshore Boundaries

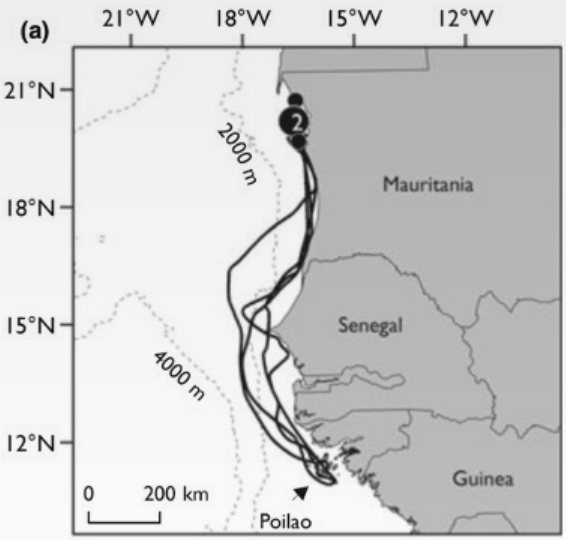
A common challenge when defining an appropriate seascape in the marine environment is the determination of offshore boundaries. In some areas, ecologically meaningful physical boundaries will exist that present appropriate limits to the offshore extent of an assessment area. Bathymetric contours, for example, a shelf edge can form natural boundaries to species movements and abrupt limits to habitat distributions. The shelf edge itself, however, can support critical habitat where oceanic fronts form and concentrate food for many species and where mass spawning aggregations are often located. Bathymetric data on seafloor terrain structure in deep water can be used to identify ecologically important features (Bouchet et al., 2015) such as coldwater coral areas, seamounts, ocean ridges, canyons, overhangs and cave systems, active seeps and vents; or where species behaviour is well understood (known water depth ranges and migratory corridors). Important foraging areas at the ocean surface have been identified using the density of ocean fronts and their biophysical characteristics (persistence, size, productivity and temperature) and these features have been considered as conservation priorities and potential focus areas for dynamic marine protected areas (Miller & Christodoulou, 2014; Scales et al., 2018). However, often, the extent and distribution of species may be uncertain due to data paucity, which often limits understanding and may require precautionary approaches to be adopted.

4.5 Geopolitical Boundaries

As already noted above, note GN17 of GN 6 states that in some cases, the seascape unit might be defined in terms of an administrative boundary or a particular zoned area within international waters. However, such approaches should only be taken forward in the marine environment where such boundaries encompass and capture all biodiversity values that may be affected by project activities. They must be driven from the perspective of providing an appropriate understanding of biodiversity value that may be presented within neritic and oceanic zones. Although rare, it is possible that in some instances, geopolitical boundaries may coincide with specific biogeographical features. For instance, sometimes administrative boundaries are delineated along distinct bathymetric contours or are aligned with continental shelf zones, which may correlate with particular values, i.e. features in the neritic and epipelagic[10] zones. These boundaries may, therefore, provide a function for creating a spatial boundary that adequately captures some biodiversity values that need to be considered. However, the extent of such areas may be limited in terms of their entire range for some individual species, especially wide-ranging species. Therefore, the use of geopolitical boundaries to define the seascape study area are often not appropriate in the marine environment, but may afford a function if they enclose all features of interest that need to be considered by a project. In general the use of geopolitical boundaries should be considered as a last resort in the absence of any other way of ecologically defining study areas.

Box 7 **Example of consideration of transboundary movements in scaling seascape: Sea turtle migrations in Northwest Africa**

Godley et al. (2010) have used satellite tagging techniques to determine the migration of green turtles in Northwest Africa. The focus of their study was to understand the movement of green turtles (*Chelonia mydas*) between breeding and non-breeding areas. Insights from their tagging studies have demonstrated the movement of sea turtles from their foraging sites in Mauritania in the Banq d'Arguin National Park to nesting grounds in the João Viera e Poilão National Marine Park in Guinea Bissau (see map below). As clearly demonstrated in this map of migration routes, the movement of green turtles and the scale of assessment required to understand key ecological attributes and important habitat functions needs to extend well beyond administrative boundaries. Therefore, in this instance, for green turtles, the seascape would need to extend to understand the ecological attributes and function that reflect distribution rather than be limited to the geopolitical boundaries of sovereign nations.



Post-nesting movements of four females tracked to their foraging sites in the Banq d'Arguin National Park (black dot 2) (Figure published in Godley et al., 2010). © 2010 The Authors. Journal compilation © 2010 British Ecological Society.

10 *The uppermost part of the oceanic zone that receives enough sunlight to allow photosynthesis.*

4.6 Conservation Management Areas

Protected and internationally recognised areas are also an important consideration – whether the project site is located in such areas or not. Such areas may define general seascape boundaries; but only if they are broad-scale and incorporate all biodiversity values of interest. However, in the marine environment, the boundaries of these areas will often not enclose all areas of biodiversity value or be representative of broader interconnectivities of species across their entire ranges, especially for wide-ranging species (see Box 7 where sea turtle behaviour extends far beyond individual National Park boundaries). Similarly, acoustic fish tracking in the Eastern Caribbean has determined that many reef fish are capable of moving across far greater spatial extents than the dimensions of the majority of coastal marine protected areas in the region resulting in fish spending considerable time outside of protected areas (Pittman et al. 2014). This scale mismatch between highly mobile species and static MPAs is widespread globally. These areas may only be representative of wider values in the seascape and enclose specific attributes that are of importance, where there has been significant research effort that defines their importance or have been subject to reduced influence from anthropogenic impacts. Therefore, the boundaries of these areas should not be used exclusively to define seascape areas. The information gathered for such areas may provide information on habitat and species presence that extend beyond; and may also provide an indication of wider interconnectivities – (e.g. sea turtle movements between important nesting and foraging areas). These areas may, however, provide a boundary of significance for certain biodiversity values, including specific functions and attributes and mosaics. They may provide appropriate areas for Natural and Critical Habitat Assessment, but they need to be considered carefully when defining boundaries for biodiversity assessment for all features, especially where there is broader interconnectivities for species and important ecosystem functions.

Box 8 **Example of marine internationally recognised areas - Ecologically or Biologically Significant Areas (EBSAs)**

EBSAs represent important marine areas that have been defined under a range of criteria (uniqueness and rarity, life-cycle functions, important for threatened and endangered species, vulnerability, productivity, diversity and naturalness). They can also relate to specific biophysical zones, including convergence zones and large current systems. EBSAs are designed to encompass most considerations for the assessment of biodiversity value for marine habitats and species (including wide-ranging species). EBSAs criteria broadly correspond to the Key Biodiversity Area (KBA) criteria but unlike KBAs do not have quantitative thresholds. Although EBSA also closely correspond to critical habitat criteria, a quantified assessment is often needed to determine critical habitat status. Similar to IMMAs, the geographical extent of EBSAs varies. Some EBSAs cover extensive areas, such as the Equatorial High-Productivity Zone, whilst others are more limited, such as Boa Vista Island in Cape Verde. The appropriateness of using EBSAs boundaries for seascape determination and also for critical habitat assessment will be dependent upon their scale, but also whether they capture all values and interconnectivities beyond these boundaries. For example, whilst the Boa Vista Island EBSA captures important nesting areas for the Endangered North East Atlantic loggerhead turtle (Caretta caretta) subpopulation, it does not cover all areas of importance across the life-cycle for this group (e.g. pelagic foraging and development areas or migration to coastal foraging grounds). Therefore, the determination of seascape for this subpopulation would require broader consideration and the assessment of critical habitat will be dependent upon a project's relationship to different life-cycle functions and important attributes (breeding, nesting, migrating, foraging etc).

4.7 Summary

Table 1 presents examples of important factors that should be considered when defining seascape, EAAAs, and when addressing critical habitat assessment for wide-ranging species. The factors in Table 1 should not be considered in isolation and a combined approach is often most appropriate.

Table 1. Key Factors for Determining Appropriate Scales of Analysis

Features		Factors
Influencing Factors	Physical Environment	• Physical parameters such as salinity, temperature, oxygenation etc • Topography and distinct bathymetric environments, including the extent and configuration of continental shelf, slopes, and abyssal planes – including interrelationships with other important attributes such as light penetration that influences vertical biological structuring • Presence of unique geological features, such as submerged caves, overhangs, seamounts and pockmarks, submarine canyons, vents etc • Spatially defined upwelling systems • Seabed composition, including coverage of hard and soft substrate and sediment type • Freshwater discharges and exchanges, including estuaries and nearshore mixing zones • Ecoclines and ecotones related to distinct physical dynamics • Upwelling zones • Currents, waves (local and oceanic), jets, eddies • Ocean-atmospheric system relationships
	Environmental degradation and threats	• Loss, disturbance, modification and fragmentation from anthropogenic activities (including alteration to physical conditions) • Environmental pollution (underwater sound, water quality and sediment quality) • Vulnerabilities

Features		Factors
Habitat and Species Values	Habitat attributes and functions	• Habitat type • Distribution and extent, including any identification of patches (including edges and their effects), matrix, mosaic, corridors etc. • Abundance and diversity • Contrast (with adjacent areas) • Dominance • Ecological function and species associations • Distinctiveness/uniqueness and rarity • Isolation/ fragmentation • Intactness • Maturity
	Species attributes and functions	• Known or potential presence • Distribution (local/ regional / global limits), including restricted range, endemism and wide-ranging status and also relationships to the vertical plane • Diversity • Productivity • Abundance, density and population status (including sub-populations) • Key life-cycle activities (e.g. breeding, spawning, nesting, calving and nursery zones, migrations including routes of movement (corridors), foraging areas, resting areas etc. • Habitat and physical environment associations and movements, including, e.g. across life-cycles, tides, and day-night changeovers etc.
Conservation management areas	Legally protected and internationally recognised areas	• Habitats and species of conservation value (see above) • Scale • Ecological attributes • Comparative value to other areas in the seascape • Connectivity of ecosystem functions within and outside of these areas • Habitat associations that may indicate presence of habitats and species outside of these areas • Threats and management objectives

5.0

CONCLUSIONS

The core requirement for defining the spatial scope of biodiversity assessment contained within PS 6 and GN 6 is that areas should be defined at an ecologically appropriate scale based on the values that may be affected by project activities.

Seascape assessment is an essential first step to ensure that all biodiversity values that may be connected to project activities are understood. Seascape can be defined on a number of scales and requires multiple considerations. Whilst approaches to large marine ecosystem delineations may inform the understanding of values in the seascape, they do not always contain the range of biodiversity values that need to be considered or address wider scale distribution. It is also possible that within these broad areas that unique habitat and species assemblages are present that allow for units within the seascape to be determined. Geopolitical boundaries are very rarely appropriate, but can be used for ease of mapping where there is confidence that all biodiversity values have been captured; and at times, may be of particular use for defining offshore oceanic boundaries. The definition of seascape can also be informed by the understanding of threats and also from the understanding of pre-existing conservation management areas. Where wide-ranging species are present, it is often necessary to consider species-specific seascape areas at a very broad-level and manage uncertainties associated with data paucity. Where these areas are very broad, they may be treated as a seascape extension. The seascape boundaries for wide-ranging species do not necessarily need to be mapped, especially where there is significant uncertainty and when doing so could lead to misrepresentation of values.

The definition of EAAAs and the understanding of important attributes for wide-ranging species is dependent upon robust seascape assessment. Of note, Critical Habitat Assessment should always be undertaken for each habitat and species; and consider ecological patterns and processes. Often, these factors may need to considered in combination and it is possible that aggregated areas of analysis can be defined where multiple values overlap.

Often, a key challenge for determining appropriate spatial scales of analysis relates to data paucity, especially where there are uncertainties. Where data paucity exists, it may be necessary for additional baseline data collection to improve understanding (where that is feasible); and appropriate expert input should always be used to inform the determination of the correct spatial scales for analysis and for precautionary approaches to be taken using a sound scientific risk-based approach. In most situations, it is important that a broad scale analysis is undertaken to avoid misunderstanding of potential values and also to understand the uncertainties that exist. Methods and tools are also available to support the assessment, as discussed in this report.

Delivering biodiversity assessment that fulfils the requirements of PS 6 at the appropriate scales of analysis for marine biodiversity is complex; and a simplistic reliance on pre-existing boundaries is unlikely to be suitable in most situations. Understanding where this complexity lies is important for driving robust approaches. If marine biodiversity values are considered in a context of ecological patterns and processes, including connectivity, and are informed by precautionary approaches and expert input, then developing a sound approach is very achievable.

GUIDANCE FOR DEFINING ECOLOGICALLY APPROPRIATE SCALES OF ANALYSIS FOR MARINE BIODIVERSITY IN RELATION TO IFC PERFORMANCE STANDARD 6

6.0

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