NIWA
Taihoro Nukurangi

Application of the Key Biological Area (KBA) process to identify Key Ecological Areas

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Prepared by:
Phoebe Stewart-Sinclair
Carolyn Lundquist

For any information regarding this report please contact:

Phoebe Stewart-Sinclair
Quantitative marine ecologist
Marine ecology
+64 7 838 8367
phoebe.stewart@niwa.co.nz

National Institute of Water & Atmospheric Research Ltd
PO Box 11115
Hamilton 3251

Phone +64 7 856 7026

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	Reviewed by:	Matthew Bennion
	Formatting checked by:	Carole Evans
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Contents

Tables

Figures

Executive summary

Many marine habitats and ecosystems have been lost and degraded due to a variety of anthropogenic threats such as pollution, overfishing, sedimentation, and the impacts of climate change (e.g., ocean acidification and temperature rise). Marine Protected Areas (MPAs) are one tool often used to conserve marine areas and the biodiversity that inhabit them. Identification of areas to conserve that will provide the greatest benefit to biodiversity is an important process in conservation management.

In New Zealand, the KEA Ecological Areas (KEA) framework has been proposed as a methodology to identify important areas for protection and is based on the Convention on Biological Diversity's (CBD) criteria for Ecologically and Biologically Significant Areas (EBSAs). The KEA framework defines nine criteria under which a KEA could be proposed. These are 1) Vulnerability, fragility, sensitivity, or slow recovery; 2) Uniqueness/rarity/endemism; 3) Special importance for life history stages; 4) Importance for threatened / declining species and habitats; 5) Biological productivity; 6) Biological diversity; 7) Naturalness; 8) Ecological function; and 9) Ecosystem services.

The next step in developing this framework is to identify a clear-cut methodology for delineating areas that qualify as KEAs under each of the above criteria. The IUCN (International Union for Conservation of Nature) have recently published a similar framework, called the Key Biological Areas, which are sites that contribute significantly to global persistence of biodiversity. This framework defines thresholds for each criterion that could be used to delineate KEAs in the marine environment in New Zealand.

The Department of Conservation (DOC) contracted NIWA to assess how the IUCN's KBA criteria can be aligned with New Zealand's Key Ecological Area criteria and determine if KBA thresholds can be applied to KEA datasets as part of a delineation process. Specifically, the aim of this project was to align KBA criteria with KEA criteria and determine which KEA criteria fall outside of the KBA framework and may require additional work to develop thresholds. This project then constructed an outline of the delineation process to apply KBA criteria and thresholds to KEA criteria, and the feasibility of doing so with the datasets available.

This involved using a case study dataset for protected deep-water coral taxa to work through the process of KEA delineation using KBA thresholds for two criteria – 2 (Uniqueness/rarity/endemism) and 4 (Importance for threatened / declining species and habitats). This produced a series of maps showing the resulting draft KEAs for each coral taxa under the two criteria considered. For criterion 2, endemic coral taxa were considered (n=3), for which KEAs could be identified for two of the taxa. For criterion 4, twelve coral taxa were considered, which resulted in identification of 14 to 44 KEAs.

Future work should focus on defining thresholds for other KEA criteria, determining uncertainty surrounding current datasets, and developing further datasets that estimate the abundance of marine taxa. This work is a crucial first step in demonstrating how the KEA framework can be used to identify areas important for conservation of marine biodiversity in New Zealand.

1 Introduction

1.1 Background

The Department of Conservation (DOC) is required under the Conservation Act (1987)[1] to conserve New Zealand's biodiversity. In line with this, the DOC Climate Change Adaptation Action Plan[2] and Te Mana o Te Taiao - the Aotearoa New Zealand Biodiversity Strategy[3] were released in 2020. These documents aim to guide implementation of DOC work programmes and promote protection and restoration of species and ecosystems, including in marine and terrestrial ecosystems.

Marine ecosystems are under threat from anthropogenic stressors such as pollution, overfishing, sedimentation, and climate change (Halpernet al. 2008). As a result, many marine ecosystems have been lost or degraded, and protection is one approach to conserve biodiversity and provision of ecosystem services (Ramirez-Llodra et al. 2011). Marine Protected Areas (MPAs) are an important management tool and, when designed effectively and with appropriate enforcement, have had success in protection of marine biodiversity (Edgar et al. 2014, Halpern 2014). To maximise protection of biodiversity, identifying areas that will provide the greatest conservation returns is a crucial first step in planning which areas could be designated as MPAs. In New Zealand, the Marine Science Advisory Group (Fisheries New Zealand (FNZ), Ministry for the Environment (MfE) and DOC) selected marine ecological criteria for informing which areas should be prioritised for protection (Freeman et al. 2017). The Key Ecological Areas (KEA) framework describes nine criteria that can be used to define areas of high conservation value. The KEA criteria include: (1) Vulnerability, Fragility, Sensitivity or Slow Recovery; (2) Uniqueness / Rarity / Endemism; (3) Special Importance for Life History Stages; (4) Importance for Threatened / Declining Species and Habitats; (5) Biological Primary Productivity; (6) Biological Diversity; (7) Naturalness; (8) Ecological Function; and (9) Ecological Services (Freeman et al. 2017). The first seven KEA criteria are based on the Convention on Biological Diversity's "Ecologically and Biologically Significant Areas"[4] (Clark et al. 2014). The final two criteria (8 and 9) were included to incorporate ecological services in accordance with Aichi target 11[5] of at least 10% of coastal and marine areas conserved in systems of protected areas and other effective area-based conservation measures by 2020, especially areas of importance for biodiversity and ecosystem services. The draft Post-2020 Global Biodiversity Strategy[6] will include updated global biodiversity targets and will be discussed by governments in June 2022.

Prior DOC contracts to NIWA (Investigations no. 4735, 4757) have compiled a number of ecological datasets that could inform KEA criteria and assessed their robustness, uncertainty, and gaps (Stephenson et al. 2018, Lundquist et al. 2020). These datasets are an important resource, and the next step is to develop an approach for using this data to map KEAs. A repeatable, standardised, and transparent approach for determining KEAs at a site scale is important for streamlining the planning process and prioritising marine protected areas with the highest conservation importance.

Internationally, there are a number of frameworks similar to KEAs used to define and map areas that are important to protect for biological conservation (reviewed in Asaad et al. (2017)). These frameworks could potentially be adapted to map KEAs in New Zealand. For example, the IUCN (International Union for Conservation of Nature) have recently published a standardised approach for identifying important areas for biological conservation called Key Biological Areas (KBAs: IUCN

[1] https://www.legislation.govt.nz/act/public/1987/0065/latest/DLM103610.html
[2] https://www.doc.govt.nz/our-work/climate-change-and-conservation/adapting-to-climate-change/
[3] https://www.doc.govt.nz/nature/biodiversity/aotearoa-new-zealand-biodiversity-strategy/
[4] https://www.cbd.int/ebsa/about
[5] https://www.cbd.int/aichi-targets/target/11
[6] https://www.cbd.int/conferences/post2020

2016), that incorporates many of the components from prior frameworks and has criteria that overlap with New Zealand's Key Ecological Areas framework. KBAs are defined as sites that contribute significantly to global persistence of biodiversity (IUCN 2016).

The KBA framework has outlined thresholds for each criteria, which can be applied to various types of species- and ecosystem-level data (e.g., population size, species occupancy, suitable habitat, range, genetic diversity etc.: IUCN 2016). These criteria and thresholds could potentially be used as a method for demarcating KEAs within the marine environment in New Zealand. In addition, the KBA framework is recognised by international conventions such as the Convention on Biological Diversity and the Sustainable Development Goals (IUCN 2016). Worldwide, there are more than 16,000 KBAs, which are documented in the World Database of Key Biodiversity Areas[7] (WDKBA).

The KBA thresholds for species-based criteria are usually defined by the proportion of a population present at a site; however, when these data are not available, thresholds can be inferred with other measures. For example, the number of individuals of a species can be inferred from area-based data (e.g., range, estimated suitable habitat, area of occupancy etc.), where it is assumed that there is a relationship between these measures and population size (KBA Standards and Appeals Committee 2019). The New Zealand database of KEA datasets (Lundquist et al. 2020) is comprised of many biodiversity datasets, including > 600 raster modelled layers of habitat suitability of species and genera of cetaceans, fish, invertebrates, and macroalgae, and additional datasets that are provided as polygons or point records of locations of biogenic habitats, habitat ranges, and species' geographic range.

1.2 Aims and objectives

This project aims to determine whether KBA criteria are aligned with Key Ecological Area criteria in New Zealand's marine environment. If the criteria broadly align, this project will then outline the steps required to apply KBA thresholds to KEA datasets in order to identify KEAs, including any further information required for future KEA delineation.

Specifically, this project will:

- Map KBA criteria against KEA criteria and determine which KEA criteria (if any) fall outside of the KBA framework. If there are KEA criteria outside of the scope of KBA, identify additional work required or develop thresholds for these **(Section 2)**.
- Assess the feasibility of applying KBA thresholds to KEA datasets and identify any future work necessary to implement thresholds when there is not sufficient data available (**Section 3**).
- Construct an outline of the delineation process to apply KBA criteria and thresholds to KEA datasets, based on the "delineation procedures" in the KBA framework (IUCN, 2016). Identify any issues with this process (**Section 4**).
- Work through the delineation process using a case study from the KEA datasets as a proof of concept for the adapted delineation process (**Section 5**).

Ultimately, this work will build upon prior reports that assembled spatial datasets (Stephenson et al. 2018, Lundquist et al. 2020), and will demonstrate how to apply internationally recognised KBA

[7] https://www.keybiodiversityareas.org/

criteria and thresholds to define KEA boundaries in the New Zealand marine environment using existing KEA datasets.

2 KBA criteria vs KEA criteria

To map KBA criteria against KEA criteria we reviewed definitions of the KBA criteria presented by the IUCN (IUCN 2016) against definitions of KEA criteria developed by the MSAG (Freeman et al. 2016) and aligned criteria between systems where they had similar definitions. Our mapping exercise was then reviewed by members of the IUCN's KBA standards committee (Boyd, C., O'Brien, M., Edgar, G., personal communication, May 2022) and adjustments to the alignment made.

The KEA and KBA frameworks do overlap substantially (Table 2-1); however, there were some KEA criteria that had no equivalent criteria in the KBA framework. The KBA framework is more focused on threatened species and has less emphasis on criteria for ecological function, integrity, services, and naturalness, except with respect to threatened species. This is not unexpected as these criteria were adapted primarily from threshold criteria for assessing taxa for inclusion on the IUCN Red List[8]. The New Zealand national KEA criteria, in contrast, include a number of criteria that represent a more holistic, ecosystem-centric focus, that do not have an equivalent in the KBA framework (e.g., KEA Criterion 5 [Biological productivity], and Criterion 9 [Ecosystem services]) in addition to the species- (and habitat-) focused criteria (e.g., KEA Criterion 2 Special importance for life history stages).

[8] https://www.iucnredlist.org/

Table 2-1: KEA criteria paired with equivalent criteria in the KBA framework. Shaded boxes indicate where there are no equivalent criteria in the other framework.

KEA criterion	KEA criterion definition	KBA criterion	KBA criterion definition	Alignment strength
1: Vulnerability, fragility, sensitivity, or slow recovery	Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.	A2: Threatened ecosystem types	Sites qualifying as KBAs under criterion A2 hold a significant proportion of the global extent of an ecosystem type facing a high risk of collapse and so contribute to the global persistence of biodiversity at the ecosystem level.	Low
2: Uniqueness / rarity / endemism	Area contains either (i) unique ("the only one of its kind"), rare (occurs only in a few locations) or endemic species, populations or communities.	B1: Individual geographically restricted species	Sites qualifying as KBAs under criterion B1 hold a significant proportion of the global population size of a geographically restricted species and so contribute significantly to the global persistence of biodiversity at the genetic and species level.	High
		B2: Co-occurring geographically restricted species	Sites qualifying as KBAs under criterion B2 hold a significant proportion of the global population size of multiple restricted-range species, and so contribute significantly to the global persistence of biodiversity at the genetic and species level.	High
		B3: Geographically restricted assemblages	Sites qualifying as KBAs under criterion B3 hold assemblages of species within a taxonomic group that are globally restricted and so contribute significantly to the global persistence of biodiversity at the genetic, species and ecosystem levels.	High
	(ii) unique, rare or distinct, habitats or ecosystems; (iii) unique or unusual geomorphological or oceanography features.	B4: Geographically restricted ecosystem types	Sites qualifying as KBAs under criterion B4 hold a significant proportion of the global extent of a geographically restricted ecosystem type and so contribute significantly to the global persistence of biodiversity at the species and ecosystem level.	High

KEA criterion	KEA criterion definition	KBA criterion	KBA criterion definition	Alignment strength
3: Special importance for life history stages	Areas that are required for a population to survive and thrive.	D1: Demographic aggregations	Sites qualifying as KBAs under criterion D1 hold a significant proportion of the global population size of a species during one or more life history stages or processes, and so contribute significantly to the global persistence of biodiversity at the species level.	High
	Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.	D2: Ecological refugia	Sites qualifying as KBAs under criterion D2 hold a significant proportion of the global population size of a species during periods of environmental stress, and so contribute significantly to the global persistence of biodiversity at the species level.	Medium
	Area containing species, populations or communities with comparatively higher natural biological productivity.	D3: Recruitment sources	Sites qualifying as KBAs under criterion D3 are where a significant proportion of the global population size of a species is produced, and so contribute significantly to the global persistence of biodiversity at the species level.	High
4: Importance for threatened / declining species and habitats	Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.	A1: Threatened species	Sites qualifying as KBAs under criterion A1 hold a significant proportion of the global population size of a species facing a high risk of extinction and so contribute to the global persistence of biodiversity at genetic and species levels.	High
	Importance for threatened / declining species and habitats.	A2: Threatened ecosystem types	Sites qualifying as KBAs under criterion A2 hold a significant proportion of the global extent of an ecosystem type facing a high risk of collapse and so contribute to the global persistence of biodiversity at the ecosystem level.	High
5: Biological productivity	Area containing species, populations or communities with comparatively higher natural biological productivity.			

KEA criterion	KEA criterion definition	KBA criterion	KBA criterion definition	Alignment strength
6: Biological diversity	Area contains comparatively higher diversity of ecosystems, habitats, communities or species, or has higher genetic diversity.	E: Irreplaceability through quantitative analysis	Sites qualifying as KBAs under criterion E have very high irreplaceability for the global persistence of biodiversity as identified through a complementarity based quantitative analysis of irreplaceability.	Medium
7: Naturalness	Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.	C. Ecological Integrity	Sites qualifying as KBAs under criterion C hold wholly intact ecological communities with supporting large-scale ecological processes and so contribute significantly to the persistence of biodiversity at the ecosystem level.	Low
8: Ecological function	Area containing species or habitats that have comparatively higher contributions to supporting how ecosystems function.	C: Ecological integrity	Sites qualifying as KBAs under criterion C hold wholly intact ecological communities with supporting large-scale ecological processes and so contribute significantly to the global persistence of biodiversity at the ecosystem level.	Medium
9: Ecosystem services	Area containing diversity of ecosystem services; and/or areas of particular importance for ecosystem services.			

3 KBA criteria and thresholds

The KBA framework includes thresholds for each criteria that provide a clear methodology for determining if a site meets the requirements to be classed as a KBA (KBA Standards and Appeals Committee 2019). This section assesses the feasibility of applying these thresholds to the KEA datasets available and if not, how these thresholds could be adapted to identify KEAs in the New Zealand environment using the KBA methodology (Table 3-1).

Table 3-1: KBA criteria thresholds and examples in the New Zealand KEA database. KBA thresholds from IUCN (2016). IUCN Red List categories are indicated by CR = Critically endangered; EN = Endangered; VU = Vulnerable. Shaded boxes indicate where there are no equivalent criteria in the other framework.

KEA criterion	New Zealand example	KBA criterion	KBA criterion threshold
1: Vulnerability, fragility, sensitivity, or slow recovery.	Biogenic habitats, including bryozoan beds, sponge communities and coldwater corals. Low fecundity and, or high longevity (fish) species such as bramble sharks, hapuku, king tarakihi, orange roughy.		
2i: Unique ("the only one of its kind", rare (occurs only in a few locations) or endemic species, populations or communities.	Areas containing co-occurring geographically restricted species.	B1: Individual geographically restricted species.	Site regularly holds ≥10% of the global population size AND ≥10 reproductive units of a species.
		B2: Co-occurring geographically restricted species.	Site regularly holds ≥1% of the global population size of each of a number of restricted-range species in a taxonomic group, determined as either ≥2 species OR 0.02% of the global number of species in the taxonomic group, whichever is larger.
		B3: Geographically restricted assemblages.	a) Site regularly holds ≥0.5% of the global population size of each of a number of ecoregion-restricted species within a taxonomic group, determined as either ≥5 species OR 10% of the species restricted to the ecoregion, whichever is larger.

KEA criterion	New Zealand example	KBA criterion	KBA criterion threshold
			b) Site regularly holds ≥5 reproductive units of ≥5 bioregion-restricted species OR 30% of the bioregion-restricted species known from the country, whichever is larger, within a taxonomic group.
			c) Site regularly holds part of the globally most important 5% of occupied habitat for each of ≥5 species within a taxonomic group.
2ii) unique, rare or distinct, habitats or ecosystems.	Chenier banks; subtidal seagrass meadows.	B4: Geographically restricted ecosystem types.	Site holds ≥20% of the global extent of an ecosystem type.
2iii) unique or unusual geomorphological or oceanography features.	Hydrothermal vents; cold seeps.		
3: Special importance for life history stages.	Fish spawning or nursery grounds; seabird and pinniped breeding colonies; migratory corridors.	D1: Demographic aggregations.	a) Site predictably holds an aggregation representing ≥1% of the global population size of a species, over a season, and during one or more key stages of its life cycle.
			b) Site predictably holds a number of mature individuals that ranks the site among the largest 10 aggregations known for the species.
		D2: Ecological refugia.	Site supports ≥10% of the global population size of one or more species during periods of environmental stress, for which historical evidence shows that it has served as a refugium in the past and for which there is evidence to suggest it would continue to do so in the foreseeable future.
		D3: Recruitment sources.	Site predictably produces propagules, larvae, or juveniles that maintain ≥10% of the global population size of a species.

KEA criterion	New Zealand example	KBA criterion	KBA criterion threshold
4: Importance for threatened / declining species and habitats.	Estuaries with populations of threatened shorebirds; foraging areas for marine mammals and seabirds; pinniped haul-out sites.	A1: Threatened species.	a) Site regularly holds ≥0.5% of the global population size AND ≥5 reproductive units of a CR or EN species. b) Site regularly holds ≥1% of the global population size AND ≥10 reproductive units of a VU species. c) Site regularly holds ≥0.1% of the global population size AND ≥5 reproductive units of a species assessed as CR or EN due only to population size reduction in the past or present; d) Site regularly holds ≥0.2% of the global population size AND ≥10 reproductive units of a species assessed as VU due only to population size reduction in the past or present. e) Site regularly holds effectively the entire global population size of a CR or EN species.
		A2: Threatened ecosystem types.	a) Site holds ≥5% of the global extent of a globally CR or EN ecosystem type. b) Site holds ≥10% of the global extent of a globally VU ecosystem type.
5: Biological productivity.	Hydrothermal vents; frontal zones; areas of upwelling.		
6: Biological diversity.	Structurally complex communities such as deepwater sponge and coral communities; seamounts; areas with high diversity of fish and invertebrate species	E: Irreplaceability through quantitative analysis.	Site has a level of irreplaceability of ≥0.90 (on a 0–1 scale), measured by quantitative spatial analysis, and is characterised by the regular presence of species with ≥10 reproductive units known to occur (or ≥ 5 units for EN or CR species).

KEA criterion	New Zealand example	KBA criterion	KBA criterion threshold
7: Naturalness.	Remote areas; marine areas adjacent to protected terrestrial areas; areas not impacted by bottom trawling or invasive species.	C: Ecological integrity.	Site is one of ≤2 per ecoregion characterised by wholly intact ecological communities, comprising the composition and abundance of native species and their interactions.
8: Ecological function.	Soft sediment habitats containing high densities of bioturbators; areas of high functional trait diversity; areas with functionally important mesopelagic communities (including myctophids).	C: Ecological integrity.	Site is one of ≤2 per ecoregion characterised by wholly intact ecological communities, comprising the composition and abundance of native species and their interactions.
9: Ecosystem services.	Areas containing dense populations of filter-feeding invertebrates; areas important for seafood provisioning; areas important for supporting or regulating ecosystem services (e.g., areas of nutrient regeneration, biogenic habitat provision, carbon sequestration, sediment retention, gas balance, bioremediation of contaminants, storm protection) that underpin the delivery of provisioning or cultural ecosystem services.		

3.1 KEA criterion 1: Vulnerability, fragility, sensitivity, or slow recovery

KEA criteria 1 (Vulnerability, fragility, sensitivity, or slow recovery) applies to areas with a high proportion of sensitive habitats or species (Freeman et al. 2017). In the KBA framework there is no category that covers sensitive habitats/species; however, these may be implicit in threatened species (A1) or threatened ecosystem (A2) categories (see below) since sensitive species and habitats have a higher chance of being threatened or undergoing rapid decline (IUCN 2016). The threshold for these could be applied to sensitive habitats and species in the KEA database (Table 3-1). Examples include data compiled on sensitive habitats (e.g., calcareous tubeworm mounds), vulnerable marine ecosystems (e.g., reef-forming scleractinian corals) (Anderson et al. 2020), and vulnerable chondrichthyan species (Lundquist et al. 2020).

3.2 KEA criterion 2: Uniqueness/rarity/endemism

KEA criteria 2 refers to areas that i) contain rare (occurs only in a few locations) species, populations or communities, ii) contains unique, rare or distinct, habitats or ecosystems, or iii) contains unique or unusual geomorphological or oceanography features (Lundquist et al. 2020).

KEA criteria 2 (i) is a species-based index of importance and species-specific datasets in the KEA database contain occurrence records which can be used in lieu of absolute population size or abundance. The relationship between occurrence and population size or abundance is often unknown, and may be non-linear; however, occurrence models are often used as proxies in the absence of information on population size or abundance. Uncertainty layers are available for models of species occurrence in the KEA database, though uncertainty in these models is often associated with sampling effort, i.e., uncertainty where no observations are available to ground-truth models.

The equivalent criteria in the KBA framework are criterion B1 (Individual geographically restricted species), criterion B2 (Co-occurring geographically restricted species), criterion B3 (Geographically restricted assemblages), and criterion B4 (Geographically restricted ecosystem types).

3.2.1 Criterion B1: Individual geographically restricted species

Sites that qualify as KBAs under criterion B1 are defined as sites that regularly hold a large proportion of a geographically restricted species (IUCN, 2016). The threshold for qualifying as a KBA under criterion B1 is that a site regularly holds ≥10% of the global population size AND ≥10 reproductive units of a species. Having a restricted range is not a requirement of this criterion, as some species with large ranges can have sites with large numbers of individuals which can trigger a KBA (KBA Standards and Appeals Committee 2019). At these sites there can be a range of life stages and they are not just used for breeding or feeding (compare to criterion D1 below). Endemic species could also be considered geographically restricted as by definition they don’t occur outside of national boundaries.

3.2.2 Criterion B2: Co-occurring geographically restricted species

Similar to criterion B1, sites triggering a KBA under criterion B2 contain a large proportion of the population of range restricted species but differ in that a KBA under criterion B2 contains multiple range restricted species. The threshold for triggering a KBA under criterion B2 is that the site regularly holds ≥1% of the global population size of each of a number of restricted-range species in a taxonomic group (either ≥2 species or 0.02% of the global number of species in the taxonomic group) (KBA Standards and Appeals Committee 2019).

The species-based occurrence data available in the KEA database could be applied as in criterion B1 but in this example, multiple species within a taxon would be considered to determine if there are sites where more than one range restricted species co-occurs. Taxa where there are predictive models of habitat suitability for multiple species include cetaceans, seabirds, demersal fish, reef fish, benthic invertebrates, and macroalgae (Lundquist et al. 2020). There are also point records and polygon data for occurrences or ranges of shorebirds, seals, sea lions, and many other taxa for which habitat suitability models have not been constructed.

3.2.3 Criterion B3: Geographically restricted assemblages

Sites triggering a KBA under criterion B3 have an "assemblage" (>5 species) of geographically restricted species within a taxon (Table 3-1). Thresholds are defined for criterion B3 under the KBA framework as follows:

A. Site regularly holds ≥0.5% of the global population size of each of a number of ecoregion-restricted species within a taxonomic group, determined as either ≥5 species OR 10% of the species restricted to the ecoregion, whichever is larger.

B. Site regularly holds ≥5 reproductive units of ≥5 bioregion-restricted species OR 30% of the bioregion-restricted species known from the country, whichever is larger, within a taxonomic group.

C. Site regularly holds part of the globally most important 5% of occupied habitat for each of ≥5 species within a taxonomic group.

To identify sites under KBA B3 there would need to be data available on more than 5 species within a taxon. As with prior species-based KEA data, predictive models of habitat suitability have been spatially mapped, though estimates of population size or abundance are not available. Modelled data are available for demersal fish, reef fish, benthic invertebrates, and macroalgae (Lundquist et al. 2020). These data could be layered into species assemblages to identify where they overlap and potentially meet the KBA threshold.

3.2.4 Criterion B4: Geographically restricted ecosystem types

KEA criterion 2 (ii) refer to areas that contain "unique, rare or distinct, habitats or ecosystems" which is different from threatened ecosystems seen in the KBA framework. In the New Zealand Coastal Policy Statement under Policy 11, there are provisions to protect species and ecosystems that are not threatened but are naturally rare (Department of Conservation 2010).

Similarly, KEA criterion 2iii (Uniqueness/rarity/endemism) covers areas with unique or unusual geomorphological or oceanography features, for example hydrothermal vents and seeps (Lundquist, Stephenson et al. 2020). There is no directly comparable criterion in the KBA framework, but the most similar KBA criterion is B4 (Geographically restricted ecosystem types) which is characterised by sites holding a significant proportion of the global extent of a geographically restricted ecosystem type.

The data for geographically restricted ecosystem types in the KEA database include hydrothermal vents and cold seeps, and naturally rare and uncommon habitats such as Chenier Plains and other coastally rare habitats (Wiser et al. 2013). The equivalent criterion in the KBA framework is B4 (Geographically restricted ecosystem types).

KBA's are triggered under criterion B4 when sites hold geographically restricted ecosystem types (≥20% of the global extent of an ecosystem type). This threshold can be applied to ecosystems in the IUCN Red List of Ecosystems, and there are some ecosystem types in New Zealand that have been assessed under these criteria (Wiser et al. 2013).

3.3 KEA criterion 3: Special importance for life history stages

3.3.1 Criterion D1: sites important for species persistence

KEA criterion 3 (Special importance for life history stages) applies to areas that are required for a population to survive and thrive (Table 3-1). The KBA equivalent is criterion D1 which refers to sites that contain a large proportion of a species during one or more life stages, for example, breeding sites or migratory corridors. The thresholds for a KBA under criterion D1 are as follows:

A. Site predictably holds an aggregation representing ≥1% of the global population size of a species, over a season, and during one or more key stages of its life cycle.

B. Site predictably holds a number of mature individuals that ranks the site among the largest 10 aggregations known for the species.

In the KEA database, there are datasets available that were compiled for identification of regional council coastal plan schedules of "areas of significant conservation value" (ASCVs), which are often based on the importance for life history stages of birds or marine mammals (Lundquist et al. 2020). These data do not contain population size estimates but are spatial polygons or points that could be used to imply species occurrence. These areas, with nationally (i.e., seabird and marine mammal range maps and confidence intervals) and internationally (i.e., IBAs – Important Bird Areas, Birdlife International; RAMSAR internationally significant wetlands for migratory shorebirds) significant areas, can be utilised to identify areas to satisfy this criterion.

3.3.2 Criterion D2: sites important as ecological refugia

Sites that trigger a KBA under D2 (Ecological refugia) are important for species when environmental conditions are poor elsewhere. The threshold for KBAs under D2 are sites that support ≥10% of the global population size of one or more species during periods of environmental stress (IUCN 2016).

3.3.3 Criterion D3: sites important for species recruitment

The equivalent criteria in the KBA framework is D3 (recruitment sources), which are areas where a significant proportion of the global population size of a species is produced. The threshold for a KBA under D3 is a site that produces propagules, larvae, or juveniles that maintain ≥10% of the global population size of a species (IUCN 2016).

3.4 KEA criterion 4: Importance for threatened / declining species and habitats

3.4.1 Criterion A1: Threatened species

KEA Criterion 4 (Importance for threatened / declining species and habitats) applies to areas that contain habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species (Freeman et al. 2017).

The equivalent criterion in the KBA framework is criterion A1 (Table 3-1), referring to the presence of a significant proportion of the global population of a threatened species (IUCN 2016). Sites that are KBAs under criterion A1 are species-based (as opposed to ecosystem-based: IUCN, 2016). In the KBA framework, the thresholds for defining a KBA under A1 are set using IUCN Red List status (CR = critically endangered, EN = endangered, VU = vulnerable), population size and reproductive units as follows (Table 3-1):

A. Site regularly holds ≥0.5% of the global population size AND ≥5 reproductive units of a CR or EN species.

B. Site regularly holds ≥1% of the global population size AND ≥10 reproductive units of a VU species.

C. Site regularly holds ≥0.1% of the global population size AND ≥5 reproductive units of a species assessed as CR or EN due only to population size reduction in the past or present.

D. Site regularly holds ≥0.2% of the global population size AND ≥10 reproductive units of a species assessed as VU due only to population size reduction in the past or present.

E. Site regularly holds effectively the entire global population size of a CR or EN species (IUCN 2016).

Predictive models of habitat suitability were developed for four taxonomic groups (demersal fish, reef fish, benthic invertebrates and macroalgae) for the Key Ecological Areas database (Lundquist et al. 2020), and models for cetaceans and seabirds are available from aligned funding from FNZ (Stephenson et al. 2020). These models predict species occurrence as raster datasets and include uncertainty associated with predicted species occurrence (Lundquist et al. 2020). These modelled datasets do not include estimates of abundance; however, the area of occupancy could be used to infer population size to determine the proportion of a species' total population that occurs at a site. The uncertainty layers in the KEA database associated with species occurrence models could be used to prioritise sites, where sites with higher certainty of occupancy are prioritised over those with lower certainty. However, uncertainty is often correlated with sampling effort, i.e., the certainty of the models in predicting into unsampled space, thus excluding areas with high uncertainty could bias toward only prioritising areas that had been previously sampled, at the expense of areas of high suitability areas that have not yet been ground-truthed.

3.4.2 Criterion A2: Threatened ecosystem types

Sites that trigger KBAs under criterion A2 hold a significant proportion of a threatened ecosystem type (IUCN 2016) and because they are ecosystem-based the thresholds are measured by extent instead of species-level population abundance estimates.

In the KBA framework, criterion A2 is measured using the extent of an ecosystem type (Table 3-1):

A. Site holds ≥5% of the global extent of a globally CR or EN ecosystem type.

B. Site holds ≥10% of the global extent of a globally VU ecosystem type.

3.5 KEA criterion 5: Biological productivity

KEA criterion 5 (Biological productivity) are sites "containing species, populations or communities with comparatively higher natural biological productivity" (Freeman et al. 2017).

In the KEA database the data relating to criterion 5 is mostly mapped or ground-truthed distributions of primary producers (e.g., seagrass, kelp forests, algal meadows, and mangroves) (Lundquist et al. 2020). These data do not align with the KBA species-based thresholds for D3 and are instead ecosystem-based. However, these datasets could potentially be paired with species-level data to determine which areas are important as nursery grounds. Other datasets, such as marine reef fish records, that are currently applied to criterion 1 (Vulnerability, Fragility, Sensitivity or Slow Recovery) may be suitable for determining thresholds for biological productivity KBA/KEAs.

3.6 KEA criterion 6: Biological diversity

KEA criteria 6 (Biological diversity) applies to sites that contain comparatively higher diversity of ecosystems, habitats, communities, or species (Table 3-1). There is no directly comparable criterion in the KBA framework, but criterion E (Irreplaceability) might be applicable in some cases.

The irreplaceability criterion uses quantitative analysis of irreplaceability, where the threshold is for sites with an irreplaceability value of ≥0.90 (on a 0–1 scale). These sites are characterised by the regular presence of species with ≥10 reproductive units known to occur (or ≥ 5 units for EN or CR species: IUCN, 2016). There are spatial datasets in the KEA database for taxonomic groups that predict species richness based on stacked or summed species distribution layers (Lundquist et al. 2020), which could potentially be applied to irreplaceability thresholds under the KBA framework, though noting Irreplaceability also appears to be in alignment with ensuring representativeness of all aspects of biodiversity, whereas species richness would only represent areas of high alpha biodiversity. Alternatively, prioritisation scenarios based on existing species occurrence models could be performed using Zonation decision support software (e.g., Lundquist et al. (2021)) to determine high priority locations that assess both species richness and representation, informing irreplaceability of sites.

Sites triggering a KBA under criterion E (Irreplaceability) undergo “irreplaceability analysis” which is a model that determines if a site is important to biodiversity representation. Sites that are KBAs under this criterion are usually important in a network of complementary sites (i.e., increase connectivity: KBA Standards and Appeals Committee 2019). The threshold for a KBA under criterion E is sites with a level of irreplaceability of ≥0.90 (on a 0–1 scale), measured by quantitative spatial analysis, and is characterised by the regular presence of species with ≥10 reproductive units known to occur (or ≥ 5 units for EN or CR species). There is no directly comparable criterion under the KEA framework, but it is likely that “irreplaceable” sites exist in New Zealand. Spatial data on marine reserves or similar would help to identify where these KBAs may be located in New Zealand marine environment.

3.7 KEA criterion 7: Naturalness

In the KEA database, a range of datasets are available to represent naturalness. These include maps of bottom fishing footprint, commercial and recreational fishing areas, marine reserves, benthic protection areas, depth refuges from fishing impacts, and other use restrictions (Lundquist et al. 2020). While these datasets currently contain data on environmental stressors (or lack thereof) and are not suitable to apply to KBA thresholds, they could be overlaid with species level occurrence data to determine areas with minimal historical stressor impacts.

The semi-equivalent criteria in the KBA framework is criterion C (Ecological integrity) which can be triggered by undisturbed sites where the ecosystem is intact and fully-functioning (KBA Standards and Appeals Committee 2019). While there is some overlap between Naturalness and Ecological integrity criteria, the focus for Naturalness is more on absence of stressors than on ecological function. The threshold for a KBA under criterion C is a site that is one of ≤2 per ecoregion and is characterised by wholly intact ecological communities. An ecoregion is a large unit area that contains a distinct assemblage of natural communities and species, and these have been mapped for near-shore marine environments (Spalding et al. 2007).

3.8 KEA criterion 8: Ecological function

KEA criterion 8 (Ecological function) applies to habitats that have comparatively higher contributions to supporting ecosystem function (Table 3-1). As with KEA criterion 7, the semi-equivalent criteria in the KBA framework is criterion C (Ecological integrity). There are limited data layers within the KEA database that apply to criterion 8 (Lundquist et al. 2020) and perhaps not enough to determine KBA-based on the threshold for KBA criterion C. However, the sensitive habitat datasets used to inform KEA criterion 1 (Vulnerability, fragility, sensitivity, or slow recovery) may be applicable to KBA criterion C, because habitats such as bryozoan thickets or sponge gardens are indicative of healthy functioning ecosystems.

3.9 KEA criterion 9: Ecosystem services

Under the KEA framework, areas that are important for provision of ecosystem services are accounted for under criterion 9 (Ecosystem services) (Freeman et al. 2017). There is no directly comparable criterion in the KBA framework, however ecosystem services are tied to ecological integrity (KBA criterion C) and ecological function (KEA criterion 8) because ecosystems must be in good condition to function or provide ecosystem services. While there are no directly applicable datasets available, a proxy for ecosystem services could be developed using available datasets. For example, habitat maps (e.g., for mangrove habitats) and distance to populated areas could be used as an index for coastal protection services. Another example could be fish spawning areas, which provide nursery services and could be used as a proxy for fisheries production services.

4 KBA delineation process

The delineation process for identifying KBAs involves 5 steps: 1) assembling spatial datasets; 2) deriving the initial boundaries for the KEA based on the ecological data in the spatial datasets; 3) refine the initial boundaries to a manageable unit; 4) document delineation of KEA in a transparent way; and 5) consult with stakeholders (KBA Standards and Appeals Committee 2019). This process could be adapted to identify and map KEAs by using thresholds and data that is relevant at a national scale. Here, we apply the KBA delineation process to national KEA datasets, using national boundaries instead of global boundaries as the extent of distributions of species, habitats and ecosystems.

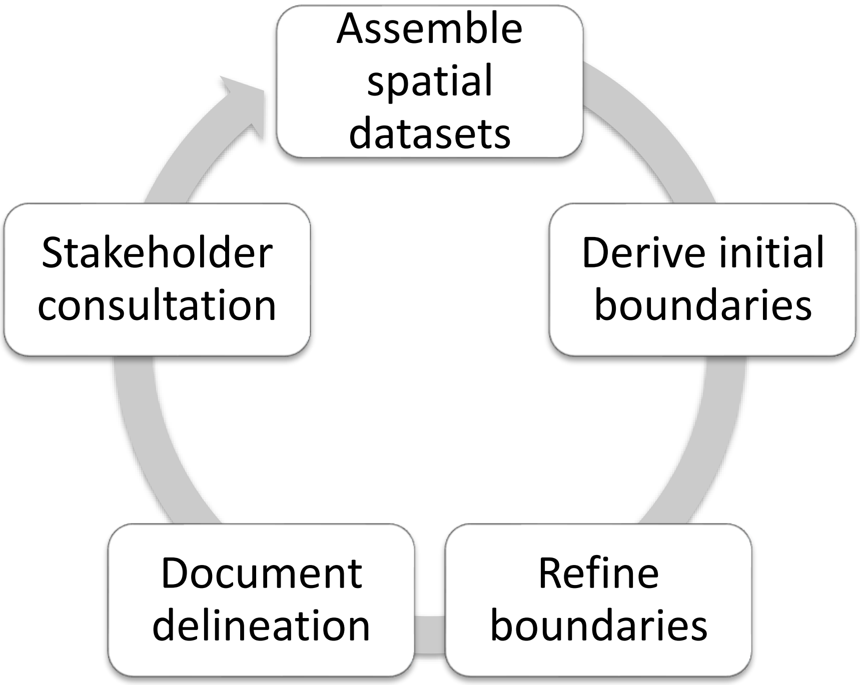

Figure 4-1: The iterative process for delineating KEA areas (IUCN 2016).

4.1 Assessment parameters

Most of the species based KBA criteria have thresholds that are defined by the number of mature individuals (Table 3-1). While direct estimates of individuals are preferred for determining KBA thresholds, other measures can be used to infer population size when these are absent. These include area of occupancy, extent of suitable habitat, range, number of localities, and distinct genetic diversity (IUCN 2016). The measure used to delineate a KBA should be based on the best available data, where the best data means that it is appropriate for the ecology of the species, and available means that measure has been reliably estimated at site and global scales (KBA Standards and Appeals Committee 2019).

Areal measures of distribution such as area of occupancy, extent of suitable habitat, range, and number of localities can be used as proxies for population size or abundance and should be prioritised from highest to lowest relevance to the parameter of interest. For example, area of occupancy is the area within the range of a species that is actually occupied and therefore has higher certainty of occurrence than range (KBA Standards and Appeals Committee 2019). However, area-based measures of assessing KBA sites are not reliable if a species is not evenly distributed across its range and an estimate of mature individuals is more appropriate to the ecology of the species (KBA Standards and Appeals Committee 2019). Area-based measures may also require temporal adjustment, e.g., for species with distributions that fluctuate significantly between seasons or years or for sites that are seasonally important for migratory species.

4.2 Assembling datasets

In the first step of the delineation process, spatial datasets are assembled. Datasets can include a range of different data types (e.g., point, polygons, or raster datasets). Species level data can include point records or localities (e.g., breeding or feeding areas), tracking data or habitat maps (KBA Standards and Appeals Committee 2019). Ecosystem level data can be boundaries of ecosystems/bioregions/ecoregions or existing areas of biodiversity importance. Datasets that inform management of any future KEAs, such as stakeholders, land tenure, human use (e.g., fishing areas) and infrastructure (e.g., ports) are also important for identifying existing and potential threats.

4.3 Deriving initial boundaries for KEAs based on ecological data

Once datasets have been assembled, the next step is to derive the initial boundaries for KEAs based on the ecological data. For example, an area that contains biodiversity elements (i.e., species or ecosystems) that fulfils the threshold for a criterion. These boundaries may be adjusted in the subsequent steps based on manageability (which could depend on size, access, tenure etc.).

4.4 Refining initial boundaries to yield practical boundaries

KEA delineation is not complete until boundary refinement has been considered to yield a manageable and defensible site or sites. This often means refining ecological boundaries with additional data (particularly where initial boundaries are informed by predictive modelling and ground-truthing is required to delineate defensible KEA sites) and following consultation with mana whenua, stakeholders and relevant knowledge holders (see Section 4.6).

4.5 Document delineation

After KEA boundaries have been assembled, the spatial files should be saved and stored, with transparent methodology for delineation outlined (as in the worked example of protected corals: see section 5).

4.6 Stakeholder and mana whenua consultation

The purpose of consultation with stakeholders or mana whenua following initial delineation of KBAs would be to ensure that values that are not able to be represented spatially or are unable to be included explicitly in steps 4.1 to 4.3 in Figure 4-1, are considered, such as mātauranga.

5 KEA delineation case study: protected deepwater corals

5.1 Species datasets

To assess the feasibility of using the KBA delineation process to define KEA areas in the New Zealand marine environment, we used protected coral taxa as a case study. The models for protected coral taxa produced habitat suitability index (HSI) that predicts species distribution within New Zealand waters (Anderson et al. 2020). The models use the relationship between occurrence records (point samples) and environmental variables to predict the probability of occurrence in areas that have not been sampled (Stephenson et al. 2021). The HSI data is available for the broader New Zealand region, which includes the New Zealand Exclusive Economic Zone (EEZ), the Territorial Sea (TS), and the Extended Continental Shelf (ECS). The cell size of data was 1 km^2, with a maximum depth of 2000 m (Anderson et al. 2020). While models were predicted to the coastline, shallow areas near the coast have lower accuracy since they required higher interpolation for some predictor variables. Layers are available that quantify the uncertainty (coefficient of variation) associated with modelled species occurrence, though they were not used in this exercise. All models had 'adequate' model evaluation scores. High habitat suitability was defined for this exercise as areas with an HSI value of >0.50, and these areas were used as an indicator for the range of each protected coral taxa. Modelled layers of abundance are not yet available for these deepwater corals in New Zealand.

5.2 Species

The New Zealand Threat Classification System (NZTCS) classes extant species into:

- Threatened: split into Nationally critical, Nationally endangered, Nationally vulnerable, and Nationally increasing),
- At Risk: split into Declining, Recovering, Relict, and Naturally uncommon), and
- Not Threatened.

The NZTCS Threatened category 'Nationally Critical' is equivalent to the IUCN category of 'Critically endangered', 'Nationally Endangered' is equivalent to the IUCN category of 'Endangered', and 'Nationally Vulnerable' is equivalent to the IUCN category of 'Vulnerable' (Townsend et al. 2008). Under the KBA framework, the thresholds applied to species-based criteria are based on the threat status of that species. While none of the coral taxa here are classed as threatened, they are protected in the New Zealand region under the Wildlife Act (1953) and are listed in Appendix II of the Convention on International Trade in Endangered Species (CITES)[9]. While protection under the Wildlife Act is not necessarily indicative of threat status, many of these species are under pressure from threats such as commercial fisheries (Anderson et al. 2020).

We assessed KEAs at species level for 12 taxa of protected corals: *Bathypathes* spp., *Corallium* spp., *Enallopsammia rostrata*, *Errina* spp., *Goniocorella dumosa*, *Keratoisis* and *Lepidisis* spp., *Leiopathes* spp., *Madrepora oculata*, *Paragorgia* spp., *Primnoa* spp., *Solenosmilia variabilis*, and *Stylaster* spp (Table 5-1). Of the 12 coral taxa here, seven are listed under the NZTCS as 'At risk (declining)', and five are listed as 'Data deficient' (nztcs.org.nz).

[9] https://cites.org/

In this worked example, we assessed KEAs in New Zealand at a national scale for KEA criterion 2 (Uniqueness/rarity/endemism) and criterion 4 (Importance for threatened / declining species and habitats).

Table 5-1: Taxonomy and threat status of 12 protected coral taxa in New Zealand.

Order	Taxon	Description	Endemicity	NZTCS threat status	NZTCS threat sub-status
Scleractinia	*Enallopsammia rostrata*	Reef-forming coral (stony corals).	Non-endemic	At risk	Declining
	Solenosmilia variabilis		Non-endemic	At risk	Declining
	Goniocorella dumosa		Non-endemic	At risk	Declining
	Madrepora oculata		Non-endemic	At risk	Declining
Alcyonacea	*Paragorgia* spp.	Bubblegum coral (tree-like)	Endemic	At risk	Declining
	Primnoa spp.	Primnoid sea-fans (tree-like)	Endemicity not specified	Data deficient	
	Corallium spp.	Precious coral	Endemic	At risk	Declining
	Keratoisis spp.	Bamboo corals (tree-like)	Endemicity not specified	At risk	Declining
	Lepidisis spp.		Endemic	At risk	Declining
Antipatharia	*Bathypathes* spp.	Black coral (tree-like)	Endemicity not specified	Data deficient	
	Leiopathes spp.		Endemicity not specified	Data deficient	
Anthoathecata	*Errina* spp.	Hydrocorals (small, hard)	Non-endemic	Data deficient	
	Stylaster spp.		Endemicity not specified	Data deficient	

5.3 KEA criterion 2: Uniqueness/rarity/endemism

To assess KEAs under criterion 2 (Uniqueness/rarity/endemism) in New Zealand, we applied the KBA thresholds and criterion B1 (Individual geographically restricted species) and criterion B2 (Co-occurring geographically restricted species) to endemic coral taxa in New Zealand. Of the 12 taxa considered here, three are endemic to New Zealand: *Corallium* spp., *Paragorgia* spp., and *Lepidisis* species. The model for *Lepidisis* spp. is a combined model with *Keratoisis* spp. which includes both endemic and non-endemic taxa. For illustrative purposes, here we treat the combined *Lepidisis*/*Keratoisis* occurrence model as endemic.

The threshold for triggering a KBA under criterion B1 is that a site regularly holds ≥10% of the global population size. The data available for coral taxa is a habitat suitability index, which is equivalent to the extent of suitable habitat measure outlined by the IUCN (KBA Standards and Appeals Committee 2019). As such, we defined KEAs under criterion 2 as sites that contain ≥10% of the total area of highly suitable habitat within New Zealand (Table 5-2).

Table 5-2: Area calculations to trigger KEA criterion 2 (Uniqueness/rarity/endemism). Total area of highly suitable habitat for endemic coral taxa, the area required to trigger a KEA under criteria 2 at ≥10% of the total area, and the number of sites within NZ that reach this threshold.

Coral taxon	Total area occupied (ha)	KEA 2 threshold (ha)	Number of KEA 2 sites identified
Corallium spp.	100 080 400	10 008 040	2
Paragorgia spp.	68 167 800	6 816 780	1
Lepidisis spp.	113 545 700	11 354 570	0

To delineate these, the total area of highly suitable habitat (HSI >0.50) was calculated for each taxon. For endemic species, we then defined sites with ≥10% of the total area of highly suitable habitat. These sites needed to be continuous to allow uninterrupted protection of species within the managed areas. We outlined two KEAs for *Corallium* spp. and one for *Paragorgia* spp. (Figure 5-1), but there was no continuous area that contained ≥10% of the highly suitable habitat of *Lepidisis* spp.

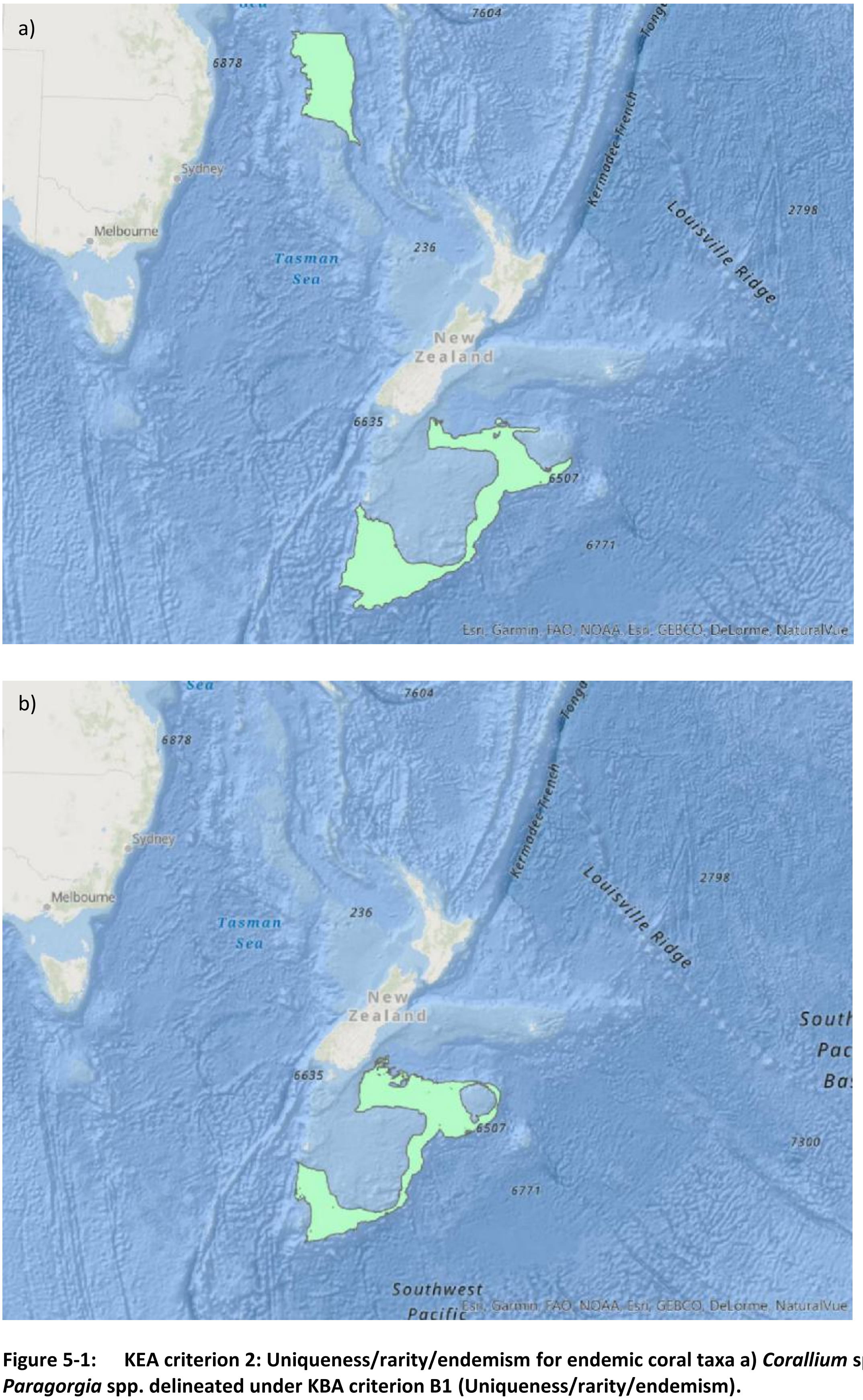

Figure 5-1: KEA criterion 2: Uniqueness/rarity/endemism for endemic coral taxa a) *Corallium* spp. and b) *Paragorgia* spp. delineated under KBA criterion B1 (Uniqueness/rarity/endemism).

Sites that meet the thresholds for multiple KEAs should be prioritised, so we determined if there were any overlapping KEAs under criterion B1, which would trigger a KEAs under KBA criterion B2 (Co-occurring geographically restricted species). To do this we overlapped the KEAs for *Corallium* spp. and *Paragorgia* spp. and outlined areas where they overlap, which results in the identification of one site under the criterion B2 threshold (Figure 5-2).

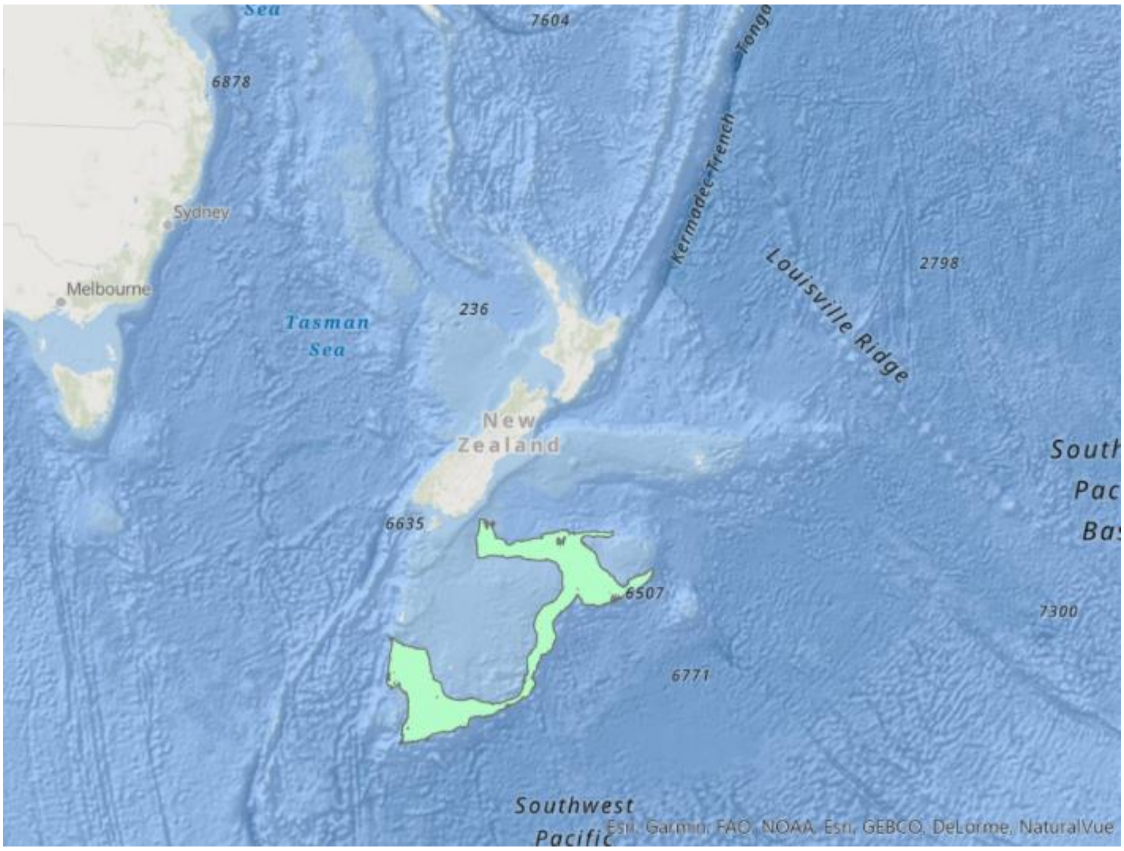

Figure 5-2: KEA criterion 2: Uniqueness/rarity/endemism for overlapping endemic coral taxa *Corallium* spp. and *Paragorgia* spp. delineated under KBA criterion B2 (Uniqueness/rarity/endemism).

5.4 KEA criterion 4: Importance for threatened / declining species and habitats: protected deepwater corals

To assess KEAs under criterion 4 (Importance for threatened / declining species and habitats) we applied the KBA threshold for criterion A1 for threatened species. We assumed that all coral taxa could be categorised as "declining" under the New Zealand Threat Classification System, where sites must regularly hold ≥0.2% of the global population size and ≥10 reproductive units of a species assessed as vulnerable (IUCN Red List VU) due only to population size reduction in the past or present (Table 3-1). Since we are using a habitat suitability measure that does not have estimates of population size, we applied a threshold of ≥0.2% of the total area of highly suitable habitat for each of the 12 coral taxa (Table 5-3). We were able to delineate large enough continuous areas of highly suitable habitat to trigger KEAs for every taxon (Figure 5-3).

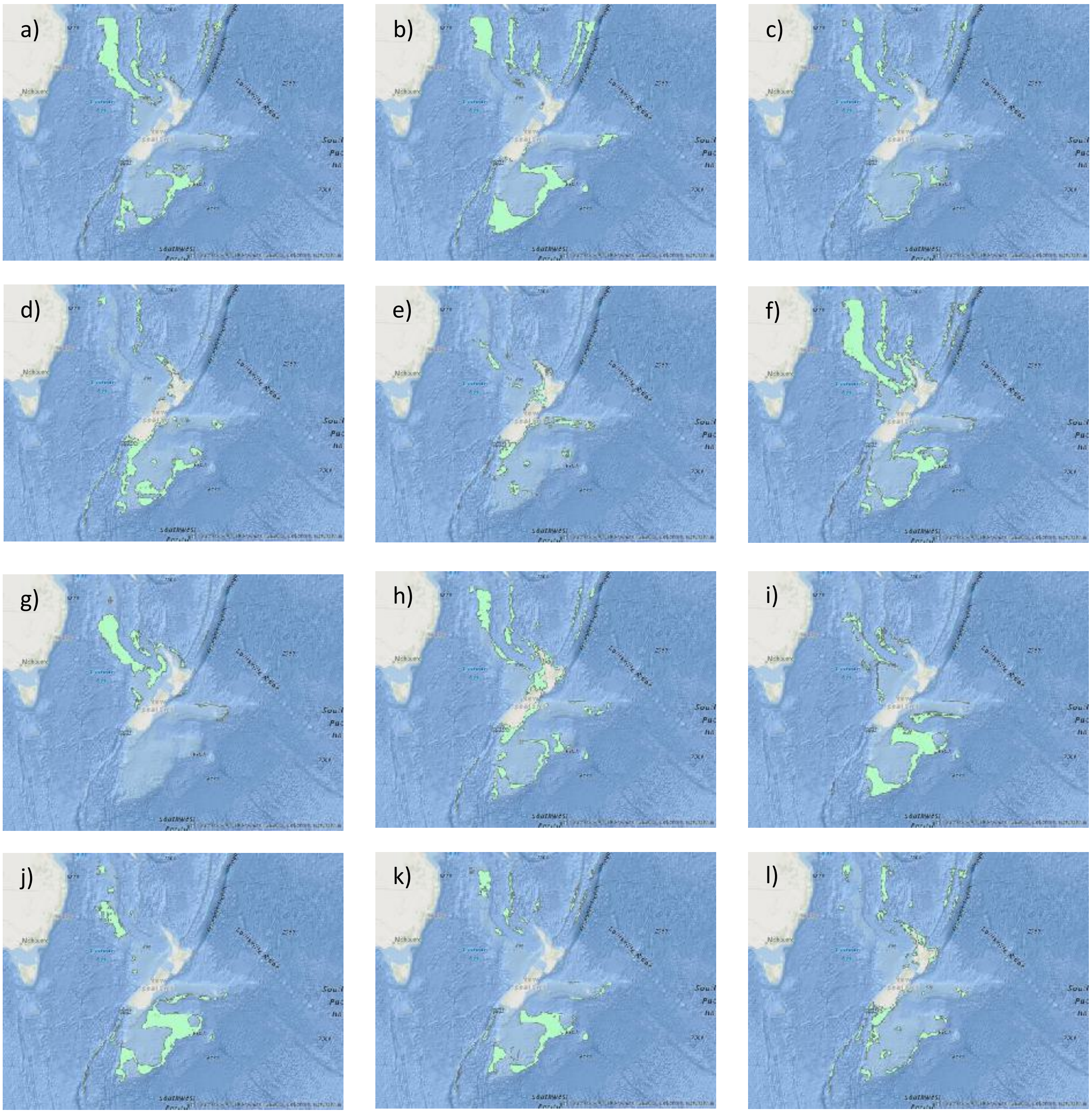

Figure 5-3: Potential KEAs delineated under KEA criteria 4 (Importance for threatened / declining species and habitats) for protected coral taxa: a) *Bathypathes* spp., b) *Corallium* spp., c) *Enallopsammia rostrata*, d) *Errina* spp., e) *Goniocorella dumosa*, f) *Keratoisis* and *Lepidisis* spp., g) *Leiopathes* spp., h) *Madrepora oculata*, i) *Paragorgia* spp., j) *Primnoa* spp., k) *Solenosmilia variabilis*, and l) *Stylaster* spp.

Table 5-3: Total area of highly suitable habitat for protected coral taxa and area needed to trigger a KEA under criteria 4 (Importance for threatened / declining species and habitats).

Coral taxon	Total highly suitable area (ha)	KEA trigger area (ha)	Number of KEA sites identified
Enallopsammia rostrata	48 759 700	97 519	42
Solenosmilia variabilis	60 311 000	120 622	30
Goniocorella dumosa	31 143 400	62 287	43
Madrepora oculata	74 339 000	148 678	44
Paragorgia spp.	68 167 800	136 336	21
Primnoa spp.	66 127 200	132 254	21
Corallium spp.	100 080 400	200 161	24
Keratoisis spp. and *Lepidisis* spp.	113 545 700	227 091	21
Bathypathes spp.	91 065 300	182 131	27
Leiopathes spp.	46 752 800	93 506	14
Errina spp.	54 055 600	108 111	34
Stylaster spp.	53 224 100	106 448	42

The number of KEAs triggered for each coral taxon ranged from 14 (for *Leiopathes* spp.) to 44 (*Madrepora oculata* [Table 5-3]). Should resources be insufficient to establish and manage KEAs for every taxon or all of the KEAs identified, sites that are KEAs for multiple species should be prioritised. Here, we overlaid KEA maps for all coral taxa to delineate areas where KEAs overlapped (i.e., “hotspots”). While some areas were only KEAs for one taxon, some KEAs were identified that satisfied criterion 4 for up to 11 taxa (Figure 5-4).

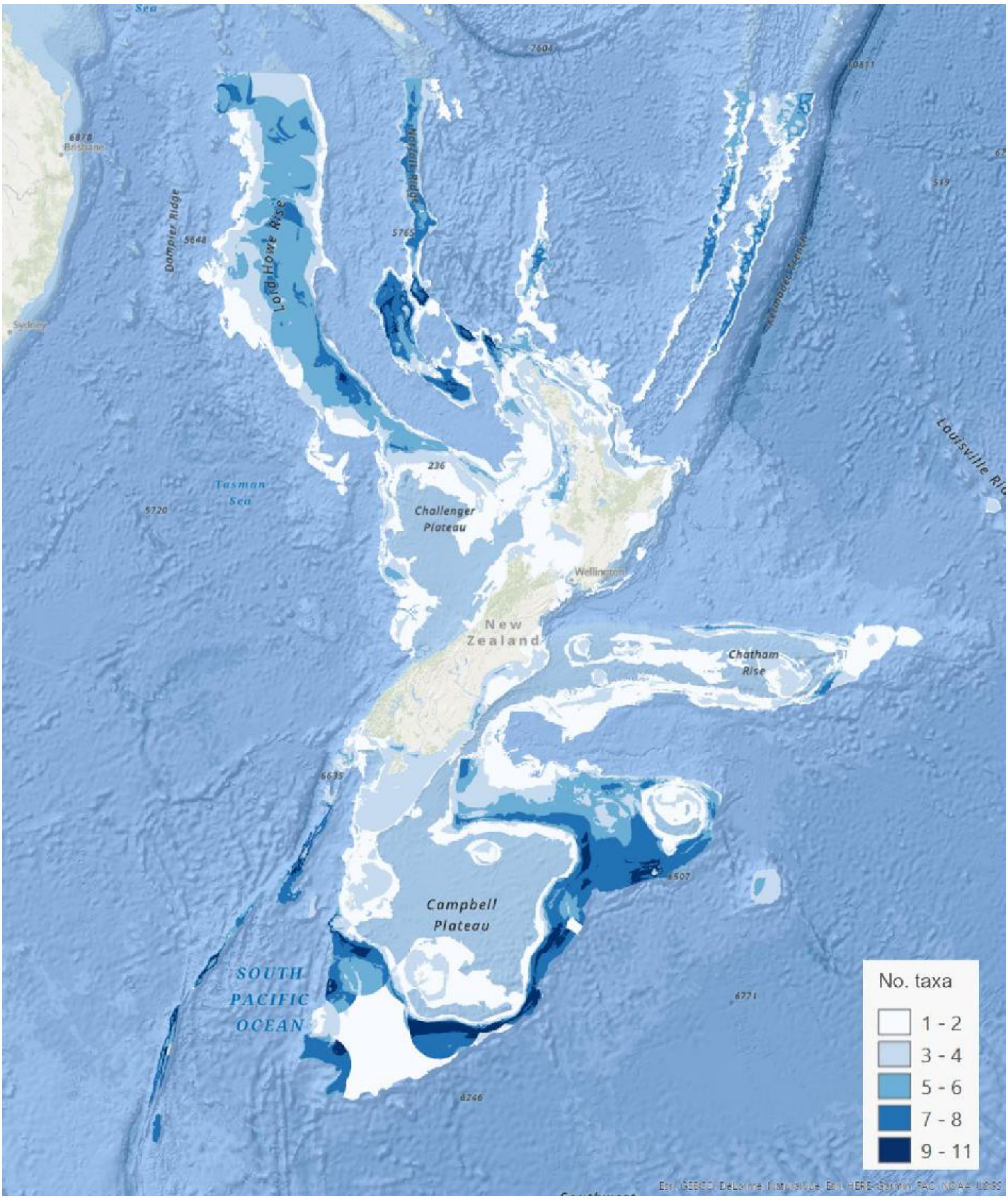

Figure 5-4: Areas of overlapping KEAs for 12 protected coral taxa, with dark blue indicating areas with up to 11 overlapping coral KEAs under criteria 4.

6 Discussion

6.1 Aims /overview

In this project we aimed to align KBA criteria and thresholds with KEA criteria in the New Zealand marine environment. This work involved using KEA databases to carry out the delineation process on a case study (protected deepwater corals). We produced a number of illustrative KEA areas delineated under two criteria (criteria 2 and 4) for different coral taxa. This methodology could be applied to other taxa to delineate KEAs within the marine environment.

6.2 Challenges with applying the criteria

There were some challenges in applying KBA criteria and thresholds to the KEA framework and data. In general, the KEA framework has a greater focus on ecosystem measures (e.g., Naturalness and Ecological function) while the KBA framework tends to be more species-centric or rare ecosystem focused, which is in line with the IUCN red lists for species and ecosystems. As a result, it is difficult to define thresholds for KEA criteria naturalness and ecological function (see section 'KBA criteria and thresholds' above).

KBA thresholds align in a more straightforward way to KEA criteria that are species-focused, such as importance for threatened species. However, most spatial databases for taxa within the KEA datasets use an estimation of occurrence (habitat suitability index - HSI), which is less ideal than abundance estimates because it gives no estimation of the density of organisms within an area. It is assumed here that a taxon will be present in areas with high habitat suitability and absent in areas of lower habitat suitability (with a threshold of HSI = 0.5).

Further, a key goal of delineating KBAs is to define areas that are practical for management. So smaller areas with high concentrations (e.g., ≥10% of the total population for geographically restricted taxa) of target organisms should be prioritised. However, when using occurrence data, large areas are delineated as areas with ≥10% of total occurrence would be large by definition. The minimum size for a KBA can be very large using these measures (see 'KEA delineation case study' above).

In contrast, for some areas with patchy occurrence (or patchily distributed areas of high habitat suitability), it can be difficult or impossible to identify contiguous areas that meet the thresholds defined above (e.g., ≥1% or ≥10% of total highly suitable habitat). This was not the case for our example of deepwater corals but may apply to rarer habitats such as shallow, soft sediment biogenic habitats (such as seagrasses or cockle beds).

If data on abundance were gathered for New Zealand marine taxa, these would need to be adapted for KBA abundance thresholds as the KBA framework applies to mature individuals, which are not always easily applicable to marine organisms. While this could be applied to animals such as seabirds, shorebirds and marine mammals where individuals of breeding age can be identified, it is not likely to be as applicable or possible to collect these data for other marine taxa (e.g., corals, bryozoans).

If more sample data become available, models of species abundance would be useful for identifying areas with high density, and this will be especially important for species/habitats that are patchily distributed or migratory. A good start would be compiling information of abundance for organisms where these data are already available – for example seabird and shorebirds (Engstrom 2008).

In order to develop this methodology in the future, there are a few data gaps that need to be filled or validated. In the absence of abundance data, an assessment of the uncertainty surrounding the current datasets is essential. The habitat suitability index models used in the worked example here are based off correlations between known occurrence and environmental variables. The HSI layers used in this illustrative analysis have model uncertainty layers associated with them, which measures the strength of the relationship between environmental variables and species occurrence. This uncertainty could be incorporated into the delineation process post-hoc by prioritising KEAs with higher certainty. Alternatively, a minimum level of certainty could be set to filter out KEAs with low certainty. However, setting a minimum level of certainty might be problematic for data deficient species which do not have many field observations of presence/abundance. For these species, it may be better to normalise (on a 0-1 scale) the level of uncertainty before setting a minimum level of certainty.

6.3 Priorities for future work

In this illustrative analysis, we applied the KBA framework to New Zealand datasets at a national level. KEAs identified at a national level cannot be ratified by the KBA committee, since this requires a global scale approach. However, a good approach may be to recognise KEAs as 'candidate' KBAs and reassess in the future if more data becomes available (KBA Standards and Appeals Committee 2019). Collection of more field data, in particular estimates of abundance, is an important priority for the future of delineation of KEAs in the New Zealand marine environment. The approach set out here is an important first step in determining thresholds and a delineation methodology for all KEA criteria, though we have only demonstrated the delineation process for two KEA criteria. Finalising the thresholds for all KEA criteria is outside the scope of this work but should be prioritised for future work. Identification of KEAs is a useful exercise to support management of New Zealand's marine resources and protection of vulnerable species and ecosystems.

7 Acknowledgements

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8 Glossary of abbreviations and terms

KEA	Key Ecological Areas
KBA	Key Biological Areas
IUCN	International Union for Conservation of Nature
NZTSC	New Zealand Threat Classification System

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