What it Means to "Maintain" Biodiversity in our Coastal Marine Environment




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INTRODUCTION

The Convention of Biological Diversity (CBD) is fundamental to protecting and maintaining life on Earth.

It arose out of the Rio Earth Summit in 1992. The global community affirmed the importance of biological diversity ("biodiversity") for its own intrinsic value and for humanity's sustainable use.

The CBD defined biodiversity (at art 2) as:

> *"[T]he variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and **the ecological complexes of which they are part**: this includes diversity within species, between species and of ecosystems." (bold added for emphasis)*

The Resource Management Act 1991 (RMA) and the *The New Zealand Biodiversity Strategy* (February 2000) (NZBS) have similar definitions, but the Fisheries Act 1996 omitted the ecological complexes component.

In part one, we identified that this inconsistency in statutory definitions is an important factor contributing to the unfolding biodiversity crisis in the marine environment.

In this article, we focus on the definition of ecological complexes, and their crucial importance in maintaining biodiversity and ecological function, which are inextricably linked.

This is because biodiversity is much broader than just the variety of life.

We also consider the importance and necessity of intact ecological complexes for safeguarding the life-supporting capacity of ecosystems, and the abundant services that healthy ecosystems provide.

This does not preclude use and development of biodiversity

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provided ecological functions, such as nutrient cycling, carbon sequestration, primary productivity, and habitat formation remain.

Many elements of biodiversity, but particularly elements of ecosystem function, are essential for resilience and adaptation to climate change, contaminants, and invasive species.

We take our analysis further by looking at the ecological definitions of maintain, restore, and enhance. This is because there has potentially been a misunderstanding and conflating of these terms in a planning context, which may be contributing to the ongoing decline of biodiversity.

Our aim in reframing these definitions is to see biodiversity become universally accepted as an essential contributor to the life-supporting capacity of ecosystems in achieving s 5(2) of the RMA.

We suggest it is necessary to move beyond the current predominant focus on protecting significant species and habitats (RMA, s 6(c)) as being sufficient to meet our biodiversity obligations.

We demonstrate this in the marine environment, where intact ecological complexes *between* significant habitats are essential to maintain biodiversity and ecosystem life-supporting capacity, given the connectivity of biological, chemical, and oceanographic processes in our seas.

ECOLOGICAL COMPLEXES

The RMA does not define ecological complex or ecosystem, nor does it define habitat. Ecosystem is included as part of the definition of environment, and is acknowledged as having "constituent parts, including people and communities" (RMA, s 2).

Intrinsic values of ecosystems are defined in the RMA as those aspects which have value in their own right, including biological and genetic diversity and the essential characteristics that determine an ecosystem's integrity, form, functioning, and resilience.

What is an ecosystem? The NZBS defines it as "[an] interacting system of living and non-living parts such as sunlight, air, water, minerals and nutrients" (at 138); and ecosystems can be small and ephemeral, or long-lived and large scale.

This is distinct from habitat, which the CBD defines as "the place or type of site where an organism or population naturally occurs" (art 2). Note that this definition does not preclude a habitat being defined by a structure-forming species such as a kelp forest or a shellfish bed.

The implication is that ecosystems are process-based in concept, so they do not intrinsically have specific geographic boundaries, whereas habitats generally do. Habitats can vary in size for different species; for example, blue whale habitat is oceanic in scale, whereas the New Zealand king shag habitat is distinctly geographic as it is endemic to Marlborough.

Clearly then the definition of biodiversity in the RMA is more encompassing than just the variety of life – it includes the diversity of ecosystems and their living and non-living components. In addition, the intrinsic values of a diversity of ecosystems include a human element, as well as the characteristics or processes that shape and maintain each ecosystem.

Section 5 of the RMA requires the life-supporting capacity of ecosystems to be safeguarded. Life-supporting capacity can be assessed by an understanding of the ecological complex component of biological diversity.

In the ecological literature, a consensus has emerged that ecological complexes are created by the actions of species or groups of species. These functions include nutrient cycling, sediment stabilisation, carbon sequestration, biomass production, bioturbation, and decomposition.

Some species in the marine environment can also form habitats for other species (see examples in Figure 1), from:

- living tissue (for example, kelp);
- exoskeletons (for example, horse mussels);
- secretions of calcium carbonate from colonial animals (for example, tubeworm reefs); and
- movement or feeding in the seabed (for example, burrows, holes, or mounds).

Clusters of these species provide establishment sites, refuges from predation, and feeding areas for different trophic levels from algae, marine invertebrates, and fish.

The ecological functions that these species provide go beyond merely providing resources for fisheries, as they are essential for the healthy functioning of ecosystems. Without these ecological complexes, there would be less diversity within and between species.

Biodiversity is therefore interdependent with, and integral to, ecological functioning, which results in different types of ecosystem services provided to nature and humans.

These include *provisioning* services, such as fish, shellfish and marine invertebrates (for example, sea cucumbers and kina) used or consumed by humans; and *regulating* services, such as shellfish beds filtering sediment from the water column, and sequestering carbon via primary production and the burial of carbon in marine sediments.

Figure 1: Examples of subtidal biogenic habitats in Marlborough.
Fish are circled in red where indistinct.

Sponges in high-current area Pelorus Sound (Photo: Danny Boulton);

Horse mussel bed in outer Sounds (Photo: NIWA)

Cobble habitat with anemones, outer Sounds (Photo: Rob Davidson);

Bryozoans, D'Urville Island (Photo: Rob Davidson)

Individual species are often important in delivering ecosystem functions. However, recent syntheses of multiple scientific studies show that biodiversity, as in the collective effect of multiple different species, influences and delivers multiple ecosystem functions.

The more diverse a biological community, generally the more stable ecosystem function is through time (Bradley J Cardinale and others "Biodiversity loss and its impact on humanity" (2012) 486 Nature 59).

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To encapsulate the importance of ecological complexes, we propose the following definition:

> *Interaction of species with their physical and chemical environment at densities that result in ecological functioning, including biogeochemical processes and habitat provision, that is necessary for safeguarding the life-supporting capacity of an ecosystem.*

We suggest this captures the processes that create the dynamic interactions between species and ecosystems, which together form a complex of ecological interactions and functions. This definition bridges the gap between habitats and ecosystems, makes clear the role of species in providing habitat, and does not duplicate either CBD definition (see Table 1 in the companion article).

We also suggest that ecological functioning created by different trophic levels of species provides ecosystems with their "essential characteristics", as referred to in the RMA definition of intrinsic values.

The last part of our definition reflects the interconnectedness of ecosystems between domains. For example, safeguarding the capacity of seabed ecosystems to sequester carbon by protecting them from physical disturbance assists in ameliorating the effects of rising carbon in the atmosphere.

This linkage between ecosystems is an example of "multi-scale functionality", as these interrelationships operate across time and at different spatial scales; and their importance is becoming increasingly recognised by scientists (Forest Isbell and others "Linking the influence and dependence of people on biodiversity across scales" (2017) 546 Nature 65).

This raises the question of the multi-scale and global consequences to carbon sequestration from repeated habitat damage to New Zealand's seabed ecological complexes over millions of hectares (Ministry for the Environment *Our Marine Environment 2016* (October 2016); and Steve Urlich "A national issue of international significance: seabed disturbance in our marine waters" (April 2017 RMJ 13).

MAINTAINING, RESTORING AND ENHANCING BIODIVERSITY

Maintenance of biodiversity requires protecting ecological complexes.

The biological traits that allow species to form habitats for others also frequently make them more sensitive to disturbances caused by human activities.

Biodiversity has declined in our marine environment as these biogenic habitat patches get reduced in size or eliminated over large areas, thereby reducing ecological functioning and diminishing the provision of multiple ecosystem services.

We have seen an apparent confusion about what "maintain" means in an ecological sense. We note that "maintain" has been interpreted by regulators as maintaining the status quo.

However, historical literature reviews and paleo-ecological research in New Zealand show that public perceptions of many marine ecosystems suffer from "sliding baselines", though sometimes changes in biodiversity are abrupt, not gradual.

We contend that "maintain" in an ecological sense must be about protecting ecological functioning over time.

Without this distinction "maintain" becomes the same as holding the ecosystem in a deteriorating, or a degraded, state. This is not consistent in our view with the RMA definition of biodiversity or safeguarding life-supporting capacity, nor does it meet international obligations and national policy.

Further, we suggest it is not ecologically meaningful to substitute the definition of "enhance" or "restore" for "maintain".

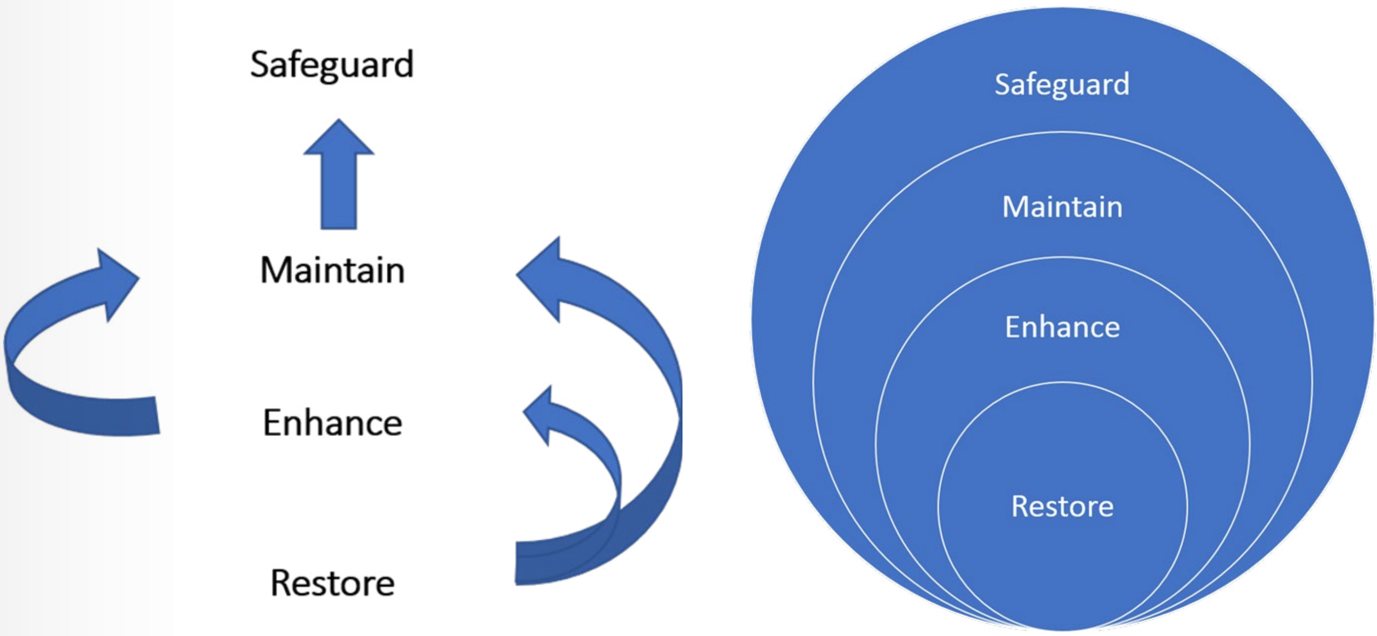
Table 1 shows that maintenance is about taking action to safeguard life-supporting capacity, and enhancement and restoration are two different approaches to returning to natural conditions.

This is a crucial distinction that requires regulators to take action to ameliorate or remove the effects of the stressors which have resulted in the conditions outlined in *Our Marine Environment*.

Table 1: Definitions of maintain, enhance and restore relevant to biodiversity from The New Shorter Oxford Dictionary 1993 and ecological definitions, along with applied examples.

Term	Dictionary Definition	Ecological Definition	Example 1	Example 2	Example 3
Maintain	To preserve or retain, cause to continue in being (a state of affairs, a condition, an activity, etc.); keep vigorous, effective, or unimpaired; to guard from loss or deterioration.	Take action to preserve or retain natural species diversity (including foundational species) from loss and keep the functioning of ecological complexes effective and unimpaired from deterioration.	Prevent habitat disturbance to intact mussel reefs at known specific sites.	Prevent habitat disturbance to soft sediment habitats to enable ecological functioning to recover at an ecosystem scale.	Implement more stringent rules on forest harvesting, earthworks, and replanting to reduce excess sedimentation into estuaries and enable ecological functioning to recover.
Enhance	To raise in degree, heighten, intensify (a quality, attribute, etc.).	Facilitate recruitment, coexistence and successional processes by stabilising ecological functioning through time.	Infilling of existing reefs and expansion from edges after action to maintain.	Expansion of biogenic species and succession to 3-dimensional complex structures.	Shellfish beds expand as storms flush out estuaries over time as sediment inputs reduce.
Restore	Bring back or re-establish; return something to a former condition or place.	Re-establish species or habitat by direct action.	Place live mussels on the seabed to create new reefs.	New habitats establish due to increased larval mass from intact & enhanced areas.	Replant saltmarsh and seagrass to replace lost habitat.

Figure 2: Graphical depictions of the hierarchical relationship between actions to meet our biodiversity obligations and safeguard life-supporting capacity of ecosystems.



This analysis puts maintaining biodiversity in its broadest sense as necessary for safeguarding life-supporting capacity of ecosystems. This relationship is depicted graphically in Figure 2.

We conclude that maintenance of biodiversity in the marine environment requires regulatory action to avoid, remedy or mitigate any adverse effect of human activity on species diversity, ecological complexes, and the essential characteristics of ecosystems. That is to say, taking action to ameliorate or remove the effects of the stressor has the consequence of maintaining biodiversity.

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DISTURBANCE, CONNECTIVITY AND RMA SECTION 6(C)

Repeated disturbance not only impacts on the resilience of ecosystems, it can also damage the form (i.e., structure), and degrade ecosystem functioning (Simon F Thrush and Paul K Dayton "Disturbance to marine benthic habitats by trawling and dredging: implications for marine biodiversity" (2002) 33 Annual Review of Ecology and Systematics 449).

This is now widely accepted in many situations: "There is now unequivocal evidence that biodiversity loss reduces the efficiency by which ecological communities capture biologically essential resources, produce biomass, decompose and recycle biologically essential nutrients." (Bradley J Cardinale and others "Biodiversity loss and its impact on humanity" (2012) 486 Nature 59).

The two most significant forms of disturbance in our coastal marine environment are sedimentation from land and marine activities; and physical habitat disturbance.

Sediment from land and marine activities reduces primary productivity and ecological functioning in three ways: (1) inhibiting light transmission through the water column, meaning there is less light available for seabed plants to photosynthesise; (2) reducing the capability of many species to feed effectively; and (3) falling onto the seabed.

Excessive sedimentation can smother seabed ecosystems, killing flora and fauna, and preventing exchanges of nutrients and oxygen between the seafloor and water components of the ecosystem (Simon F Thrush and others "Muddy waters: elevating sediment input to coastal and estuarine habitats" (2004) 2 Frontiers in Ecology and the Environment 299).

Biogenic-habitat forming species are particularly vulnerable to physical disturbance. Often these species are long-lived, slow growing and have poorly dispersing larvae making them susceptible to functional extinction with regard to their ability to provide habitat and ecosystem services.

When thinking about the consequences of disturbance to any one patch of habitat on the seafloor, it is necessary to also consider how different patches of habitat can be ecologically connected. This is essential if we seek to allow seafloor communities to recover between different types of disturbance events. This ecological connectivity can be very important for individual species and for biodiversity.

Many seafloor species reproduce by releasing sperm and eggs into the water, and for individuals at low density the probability of fertilization is low. For some species successful recruitment of post-larval life stages back to the seafloor requires mass settlement and again low densities limit the potential to create these large swarms of larvae in the water column.

In both circumstances we need to have sufficient habitat patches with high densities of adults to provide the necessary source of colonists.

As well as considering the ecological connectivity of individual species, research has shown that maintaining high biodiversity in some habitat patches enhances the recovery of disturbed patches within the region. As these high diversity source patches become increasingly isolated by disturbance their ability to play this role in rescuing disturbed patches decreases (Simon F Thrush and others "When small changes matter: the role of cross-scale interactions between habitat and ecological connectivity in recovery" (2013) 23 Ecological Applications 226).

When changes in the frequency and extent of disturbance outstrip the recovery potential of resident organisms, the selective loss of species contributes to habitat loss and fragmentation across the seafloor. This phenomenon highlights the importance of managing cumulative impacts on the seafloor, not only at habitats considered significant but across the Coastal Marine Area (CMA).

Policy 7(2) of the *New Zealand Coastal Policy Statement* (Department of Conservation, November 2010) directs councils to identify coastal processes, resources and values that are under threat or at significant risk from adverse cumulative effects; and manage those effects on biodiversity.

In our view, this requires managing disturbance across the CMA to safeguard ecological functioning as fundamental coastal processes. Policy 7(2) enables that to be done by spatial planning to set thresholds or specify acceptable limits to change to avoid activities causing cumulative effects.

We conclude that marine biodiversity will not be maintained if there is a sole focus on s 6(c) RMA sites to achieve our statutory requirements and policy objectives, and our international obligations.

We suggest that this is not a paradigm shift, rather an acknowledgment that the focus on s 6(c) RMA "protection of significant habitats" has represented a collective misunderstanding of biodiversity and how to maintain it.

In the common ownership of our seas, we believe it to be of fundamental importance to manage activities within and between significant sites to maintain biodiversity.

It is also through a clearer understanding of biodiversity, and what it means to maintain it, that regulatory agencies can be empowered to finally deliver on the spirit and promise of the Earth Summit.