National Science Challenges
SUSTAINABLE SEAS
Ko ngā moana whakauka

Ecological considerations for determining the size of an area for management actions

For regional council planners and scientists, and central government

Actions that consider both spatial and temporal scales tend to provide more effective and comprehensive management outcomes. For instance, when deciding the area of a marine spatial strategy, regional plan change or when setting consent conditions, management success is more likely if the stressors and responses are produced within the area. This roadmap focuses on the ecological reasons behind a choice of scale.

Determining fitness-for-purpose of a management area involves thinking about size and location.

1. Size – A management unit needs to be large enough to

a. Encompass one or more hydrodynamic units (eg arms within an estuary, bays enclosed by peninsulas)
b. If in a coastal area, include major freshwater inputs
c. Match the scale of the ecology. While this sounds simple, mismatches between the scale of the ecology and the size of management actions have frequently been highlighted as causing unintended consequences for both the ecological and the social system. The Challenge has researched this issue and produced a tool to assess management unit sizes against risk to management outcomes (see section below on spatial scaling decision tool).

Sizes set by considering points 1a, b, and c are likely to be smaller than those in legislation and policy, such as regional council boundaries, suggesting the need to create some nesting of management areas, with local areas managed within larger areas matching the scale of strategic plans/policies or reporting. Nesting is also likely to be needed to create successful maintenance of species that are differentially mobile across life stages.

2. Location – Relative to agency boundaries. While it makes sense from a local government view to locate management units solely in the area of their responsibility, there are some factors that mean that units overlapping with other areas would be more useful.

a. Activities that cross local government boundaries
b. Hydrodynamic dispersal that results in stressor footprints crossing boundaries
c. Ecological connectivity that results in ecological response footprints for activities (or stressors generated by them) taking place in one authorities' jurisdiction affecting another's jurisdiction.

While central government directives are not yet requiring such considerations, connecting management across jurisdictional boundaries is increasingly being required by Courts and Environmental Protection Agency decisions for example TTR (EEZ/CMA), Mangawhai Heads, ALIL consent case (freshwater/marine).

3. Location within agency boundaries

a. Preferably the location should encompass activity, stressor and response. However, this is not always possible. Ecological response areas may be disjunct, caused for example by nursery areas or spat production being separate from adult habitats. Thus, management may need to occur over linked, but physically separate, locations.

b. Locations are strongly linked to the ability to create successful management actions. For example, ecological health, degree and type of stressors, and environmental legacies all affect whether a specific management will achieve its desired outcomes. The Challenge has produced a series of guides for choosing locations to focus monitoring and management effort, the *recovery prioritisation tool* (see below) and Table 1 in An ecological principles-based approach to guide coastal environmental management.

Spatial and temporal dynamics of species

How species respond to management actions are dependent on several life history traits that detail the ability of the species to self-sustain a population within the area that management actions will occur, or to obtain new recruits from outside a managed area (eg adult daily use (home range), breeding, larval and nursery areas).

There are four simple questions that can help disentangle these factors

Do both adults and juveniles live in the area and do adults reproduce there? The size of the area will not prevent the management action being successful.

Are larvae or juveniles produced/living in the area, but adults are rarely seen? The size and location of the area is such that the management action is most likely to benefit other areas.

Are adults daily connectivity/home ranges within the area, but juveniles are rarely seen? The size and location of the area is such that the management action will only be temporarily successful with long-term success depending on the surrounding area continuing to be able to provide adults.

Or is the species not confined in any life stage to the area? The size of the management area is insufficient for successful management actions as individuals will rapidly disperse to other places.

It's not important to be certain about these answers – you can include maybe as an answer. However, if your group is aware that adults are not seen (or hardly ever seen) in the area, then question two should receive a 'yes'. Similarly, if you have not seen (or hardly ever seen) juveniles in the area then the answer to question three should be 'yes'.

It's also not necessary to answer these questions for all species but at least to record the areas and species that are known to locals and the ones that have been identified as being particularly important. Council scientists, NIWA, Cawthron Institute, university ecologists and museum specialists may also be helpful in knowing the generalities of many species' behaviours.

Spatial scaling decision tree tool

The marine environment is a mobile place. Although it seems that species living in or on the seafloor should at least be relatively fixed, many of these also are mobile at some stage in their life. Many functions and services are also not fixed in place due both to species mobility and the dispersive characteristic of water. This decision tree considers how large an area is needed to achieve outcomes from management actions.

Because there is usually more than one desired outcome, related to more than one species, function or service (F&S), the way we approach this is to compare size of the area with the spatial and temporal dynamics of the species or functions that underly the desired outcomes. From that we can assess the likely success (or otherwise) of actions taken in that area.Using the decision tree, different sized areas can be considered until management success is optimal.

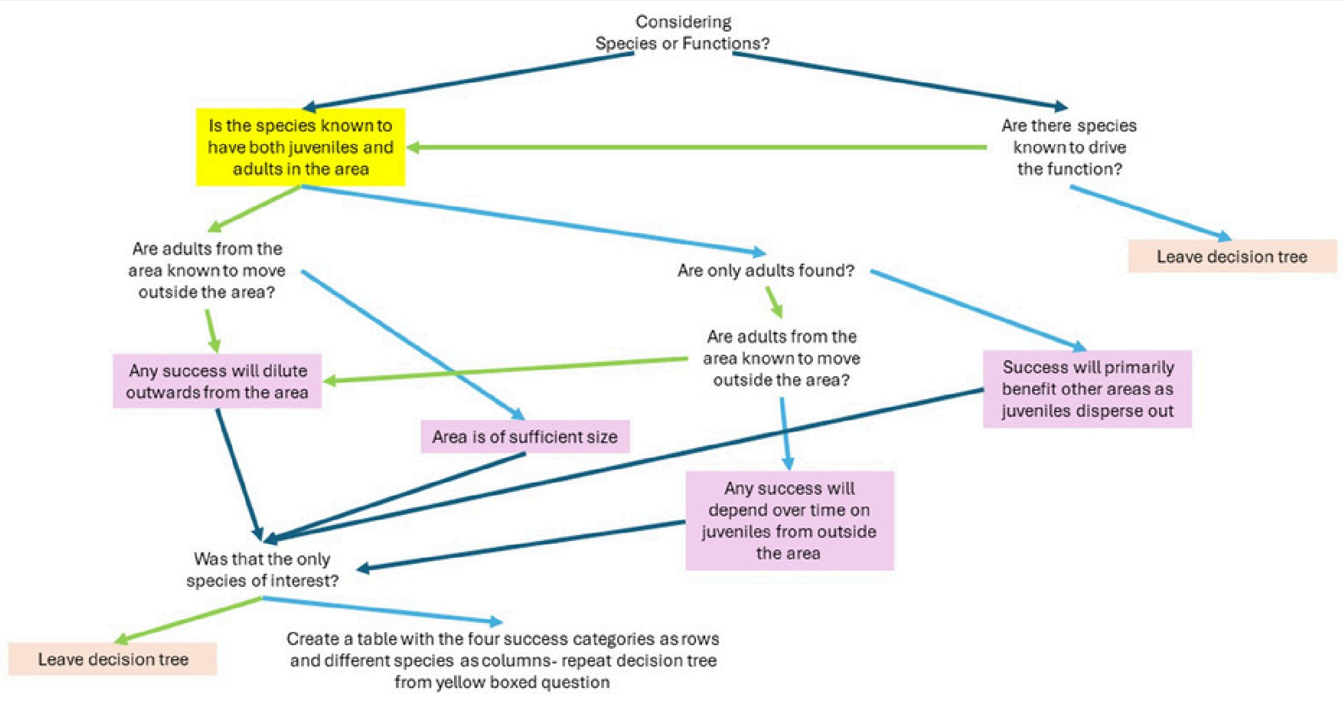

Figure 1: Spatial scaling decision tree

Example: Using the decision tree

If we started by considering 10 species that drive the sediment habitat provision, we assess for each of the 10 species which category it lies within.

Table for accumulating species											
Category	Percentage of species in category	Species 1	Sp 2	Sp 3	Sp 4	Sp 5	Sp 6	Sp 7	Sp 8	Sp 9	Sp 10
Area is of sufficient size	50%	1	1			1				1	1
Action will primarily benefit other areas as juveniles disperse outwards	10%						1				
Any success over time will depend on juveniles entering from other areas	20%			1					1		
Success would rapidly disperse outwards	20%				1			1			

Recovery prioritisation tool

This matrix is derived from a series of questions about species traits (mobility of different life stages, reproduction traits, juvenile-adult interactions and interactions with other species), distance to nearby patches of the species/habitat and surrounding landscape patterns in community composition and biodiversity. Below we give an example of how it has been used. In this case, the result of the series of questions (Table 2) is to identify the areas (labelled as sites in the table) for which habitat provisions will benefit from passive recovery, and those areas that require active intervention to restore.

Below: Hewitt J, Gladstone-Gallagher R, & Thrush S (2022). Disturbance-recovery dynamics inform seafloor management for recovery. Frontiers in Ecology and Environment. 20: 564-572.

Table 2. Example of prioritizing sites for passive recovery of a habitat-forming species, characterized by immobile adults and mobile juveniles (with the ability to travel up to 10 km)

	Stressor rank	× Degradation rank	× Species dispersion rank	= Site calculations*
rank = 1 (passive recovery possible)	At sites 1 to 3 & 10, primary stressor(s) removable and no environmental legacies	At sites 1, 4, and 7, the species has been maintained although reduced, no further prioritization required	At sites 2 & 6, juveniles already on site, recovery time driven by growth rates At sites 3 & 5, adults available on site, recovery time driven by frequency and duration of reproduction and growth rates	Site 1 = 1 × 1 = 1 Site 2 = 1 × 0.8 × 1 = 0.8 Site 4 = 0.8 × 1 = 0.8 Site 7 = 0.4 × 1 = 0.4 Site 3 = 1 × 0.4 × 1 = 0.4 Site 6 = 0.6 × 0.6 × 1 = 0.36 Site 5 = 0.8 × 0.2 × 1 = 0.16 Site 8 = 0.2 × 0.1 × 0.5 = 0.01 Site 10 = 1 × 0.1 × 0 = 0 Site 9 = 0.2 × 0 = 0 Site 11 = 0
1 > rank > 0 (passive recovery possible)	At sites 4 to 9, primary stressors reduceable: *4 & 5 > 6 > 7 > 8 & 9* *Sites 4 & 5 rank = 0.8* *Site 6 rank = 0.6* *Site 7 rank = 0.4* *Sites 8 & 9 rank = 0.2*	At sites 2 & 6, the species is sufficient in density but not size; site 2 has larger average size *Site 2 rank = 0.8* *Site 6 rank = 0.6* At sites 3 & 5, the species is sufficient in size but not density, no negative adult–juvenile interactions; density at site 3 is higher than site 5 *Site 3 rank = 0.4* *Site 5 rank = 0.2* At sites 8 & 10, no individuals remain, assign lowest rank (rank = 0.1)	At site 8, juveniles located 11 km away with a current flowing toward the site *Site 8 rank = 0.5*	
rank = 0 (passive recovery not possible)	At site 11, environmental conditions are now outside the range required for restoration objectives *Site 11 rank = 0*	At site 9, the species exhibits negative adult–juvenile interactions and is sufficient in size but not density *Site 9 rank = 0*	At site 10, juveniles are located 30 km away across a current *Site 10 rank = 0*	

Notes: *Sites are prioritized based on their scores, sorted in descending order (from top to bottom). Of the 11 sites, the three lowest-ranked sites (sites 9, 10, and 11) do not qualify for passive recovery.

Summary

When considering the size of an area for management, think through whether all stressors and the species and processes they affect can be taken into account. Doing so will help decide what sort of management effort is needed to restore what people value, and improve the likelihood outcomes are met.

Councils also need to consider socio-cultural scale and more guidance can be found in Scale dependencies and its influence on ecosystem-based management.