

SUSTAINABLE
SEAS

Ko ngā moana
whakauka

Scale dependencies and its influence on EBM

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December 2022



**Report for Sustainable Seas National Science Challenge project *Scale and EBM*,
(Project 4.4)**

Authors

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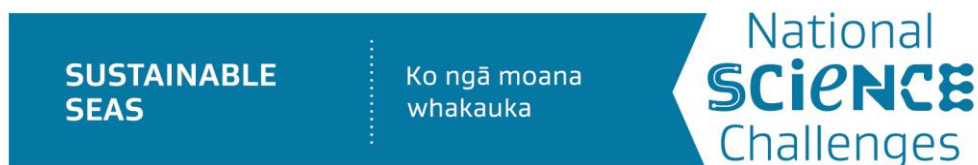
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Date of publication

December 2022

For more information on this project, visit: <https://www.sustainableseaschallenge.co.nz/our-research/scale-ebm/>



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About the Sustainable Seas National Science Challenge

Our vision is for Aotearoa New Zealand to have healthy marine ecosystems that provide value for all New Zealanders. We have 75 research projects that bring together around 250 scientists, social scientists, economists, and experts in mātauranga Māori and policy from across Aotearoa New Zealand. We are one of 11 National Science Challenges, funded by the Ministry of Business, Innovation & Employment.

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Disclaimer

Every effort has been made to ensure that the information contained in this report is as accurate as possible. However, the nature of the survey leaves room for interpretation and we acknowledge its subjective nature. This report has been developed and funded as part of the Sustainable Seas – National Science Challenge project 'Scale and EBM' and is produced for guidance of the Scale and EBM project and synthesis work in Sustainable Seas National Science Challenge.

Contents

Executive summary.....	1
List of Figures.....	2
List of Tables.....	3
1. Introduction.....	4
2. Approach.....	5
3. Overview participants.....	8
4. Environmental variability and ecological responses.....	9
5. Social, cultural (VM), and organisational scales.....	13
6. Business and innovation scales.....	15
7. Relevance of scale in tool development.....	19
8. Scale influences on values and risk practices.....	23
9. Scale dependencies aiding/hindering EBM.....	24

Executive summary

Ecosystem Based Management (EBM) is a dynamic process, and requires a good understanding of the system across a range of disciplines and scales over which it operates. Issues of scale are often recognised for individual disciplines (e.g. ecology, human geography, law, policy, planning) highlighting scale-mismatches and the need to transcend scale boundaries in space and time. However, scale-dependencies will impact decision-making processes in EBM and its chance of success, and requires a multi-disciplinary understanding of how EBM may be achieved across a variety of scales, which is currently lacking. Within the Sustainable Seas – National Science Challenge, some projects explicitly recognise scale-dependencies whereas other do not. This report therefore summarises and categorises the scales at which existing projects were conducted, the tools they produce(d), how scale might impact risk/value practices, and how it may aid or hinder the implementation of EBM in Aotearoa New Zealand.

The ecological, socio-cultural, organisational, and economic scales over which projects operate(d) were identified and categorised to identify scale patterns and knowledge gaps that have not yet been addressed in the Challenge. Ecological scales tend to cluster on larger spatial and temporal scales (local to national and years plus), especially for phase II projects. Overall, Phase I projects generally worked over single temporal or spatial scales whereas Phase II projects are covering wider ranges in space and time. Consideration of cultural scales has increased with 53% of Phase I and 95% of Phase II participants mentioned cultural aspects, including Māori organisational scales, to their research, however not all identified specific levels of interest. We found a strong emphasis on local spatial scales, long (multi-generational or whakapapa) time scales, as well as more applied (tikanga) insights, and social scales often identified involving Iwi and Hapū. For social scales, local, business, and international communities were identified. Finally, economic scales were strongly clustered on local spatial scales and longer temporal (annual – century) scales over which businesses operate.

The relevance of scale in tool development within the Challenge was considered, according to the categorisation described above. For each research theme, the type of approach (e.g. model, framework/guidelines, management plans, etc.) and the spatial, organisational, and temporal scales over which they can operate were identified. The flow and links between these scale categories were illustrated to highlight which connections were abundant, and which might be missing. For Phase I projects frameworks and guidelines were the dominant approach identified at local-national spatial scales. Phase II had a more even balance between approaches and covered a wide range of spatial, temporal, and organisational scales.

Scale impacts on risk/value practices were identified and responses often focussed on business or cultural categories, individually or in combination. For example, the perceptions of risk and values change when shifting a business mindset from short to long term strategies. Furthermore, projects acknowledged the risk of inaction. There was a strong cultural (and social) aspect related to the temporal scales associated with risk/value practices, probably related to the long-term and intergenerational mindset in Te Ao Māori, and values (e.g. kaitiakitanga) that are embedded within environmental ethical obligations. Finally, project leaders identified ways in which scale can aid or hinder the implementation of EBM. Main barriers identified include the mismatch in space (national vs. local/regional) and/or time (short vs. long-term thinking). Mismatches in jurisdictional boundaries also create barriers, which may be further complicated by institutional fragmentation and siloed agencies. Knowledge on scale can aid EBM by identifying meaningful spatial scales for operation (e.g. for restoration) and a better consideration of context. Both environmental and cultural disciplines highlighted that a better understanding of cumulative stressor effects across scales using Western science and Mātauranga Māori can aid EBM.

List of Figures

Figure 1. Survey responses for the Sustainable Seas projects – Phase I (left) and Phase II (right). Inner circles identify theme/programme groups and outer circle for project widths relate to the number of response (e.g. one or two per project). Projects with no responses for Phase II are shown in grey and * indicate projects that had not started before commencing the survey or started recently..... 8

Figure 2. Frequency of spatial (A) and temporal (B) scales under investigation in Phase I (left) and II (right) projects focused on environmental variability and ecological responses 10

Figure 3. Spatial and temporal scales of environmental variability and ecological responses of Phase I research projects. Spatial scales (m) are represented horizontally and temporal scales (s) vertically. Secondary horizontal and vertical axes aid the interpretation of the spatial and temporal scale categories. The position of projects, based on survey responses, were indicated in the combined spatial/temporal space and colour coded per theme. 11

Figure 4. Spatial and temporal scales of environmental variability and ecological responses of Phase II research projects. Spatial scales (m) are represented horizontally and temporal scales (s) vertically. Secondary horizontal and vertical axes aid the interpretation of the spatial and temporal scale categories. The position of projects, based on survey responses, were indicated in the combined spatial/temporal space and colour coded per theme. 12

Figure 5. Frequency of cultural (A), social (B), and institutional (C) scales under investigation in Phase I (left) and II (right) projects..... 14

Figure 6. Frequency of spatial (A) and temporal (B) scales under investigation in Phase I (left) and II (right) projects focused on business, economic, and investment activities..... 16

Figure 7. Spatial and temporal scales of business, economic, and investment activities in Phase I research projects. Spatial scales (m) are represented horizontally and temporal scales (s) vertically. Secondary horizontal and vertical axes aid the interpretation of the spatial and temporal scale categories. The position of projects, based on survey responses, were indicated in the combined spatial/temporal space and colour coded per theme. 17

Figure 8. Spatial and temporal scales of business, economic, and investment activities in Phase II research projects. Spatial scales (m) are represented horizontally and temporal scales (s) vertically. Secondary horizontal and vertical axes aid the interpretation of the spatial and temporal scale categories. The position of projects, based on survey responses, were indicated in the combined spatial/temporal space and colour coded per theme. 18

Figure 9. Frequency of the approaches used (A), and the spatial (B), organizational (C) and temporal (D) scales under investigation in Phase I (Red) and II (blue) projects..... 20

Figure 10. Scales at which tools operate within Phase I projects..... 21

List of Tables

Table 1. Categorisation of levels for ecological, socio/cultural, organisational and economic scales 7

Table A1. Summary of projects from Sustainable Seas – Phase II and the response type: i) Participant, ii) Leadership team, iii) Resources, iv) Not included (NA)**Error! Bookmark not defined.**

Table A2. Summary of projects from Sustainable Seas – Phase I and the response type: i) Participant, ii) Leadership team, iii) Resources, iv) Not included (NA)**Error! Bookmark not defined.**

1. Introduction

The Sustainable Seas National Science challenge focusses on the holistic ways to manage marine environments through the implementation of Ecosystem Based Management (EBM). EBM is a dynamic process, focussed on understanding and managing ecosystems across a range of organisational, spatial and temporal scales. Despite the importance of scale, only rarely are scale-dependencies in different disciplines and the interactions between them explicitly stated and brought into play as affecting both the decision-making process and its success. While some research in the Challenge explicitly focusses on producing results for different scales, other research does not, leaving gaps in our ability to fully understand how EBM can be achieved across a variety of scales.

The concept of scale is of importance in many different disciplines, including ecology (and environmental variability), human geography (including social and cultural systems and place), as well as law, policy and planning. Studies of ecological heterogeneity in space and/or time have highlighted that the (short) scales of observations and experiments do not necessarily match the (large) scale of environmental problems and management. Socially, people experience or interact with the environment at different scales and have different abilities to psychologically transcend barriers of space and time. Furthermore, cultural differences in the scales at which people experience and perceive environmental issues exist. Within Te Ao Māori, concepts of scale exist, such as atua, whakapapa, waka, ki uta ki tai, wāhi tūpuna, wāhi tapu, and often draw on experiences from the past through intergenerational knowledge. Scales can affect policy and planning through differences in spatial scale (e.g. national vs. local/regional scale policies/plans) and timeframe over which they operate and may not match with other disciplines.

Here, we aimed to identify the existing knowledge of scale dependencies through a review of existing Sustainable Seas projects from Phase I and II and the outputs they produce(d). We further aimed to identify how scales interact to aid or hinder the implementation of EBM, the impacts on risk and value practices, and the barriers identified in work completed to date within the challenge.

2. Approach

To identify the existing knowledge of scale dependencies from Sustainable Seas projects, a survey was circulated to Phase I and Phase II project (co-) leaders. The survey aimed to collect information on which ecological, socio-cultural, organisational and business scales the project's objectives are tested, how these scales interact to aid/hinder actions and solutions, the type of information needed/used and the barriers identified. Survey questions were provided in an open format so as to allow participants to identify the aspects of scale applicable to their project, and participants were instructed to focus on the sections of relevance to their project. The survey consisted of the following questions:

1. What are the spatial and temporal scales of environmental variability and ecological responses involved in your project?
2. What are the organisational scales your objectives and co-development partners are working over (e.g. local, national, mātauranga Māori and kaitiaki-driven organisational scales and/or spatial and temporal economic strategy scales and so forth)?
 - a. Does your project involve social and cultural scales that are not incorporated in the organisational scales question? If so, what are they?
3. What are the space and time scales of business and investment activities (or other economic factors) involved in your project?
4. If you are producing tools, guidelines or models do these have specific spatial, temporal or organisation scales over which they would operate? Please elaborate
5. Has your project investigated values and/or risk practices when presented with different space and time scales?
 - a. If so do you think (or are you finding) that values or perceptions of risk change with differing scaled information?
6. How do these scales interact to aid/hinder actions and solutions to EBM and/or what are the barriers identified?

Surveys were sent to project (co-) leaders in May 2022. Phase I consisted of 40 projects from 8 programmes and Phase II of 35 projects from 7 themes. Since Phase I has finished, not all original co-leaders remained involved in the challenge. Where no answers from Phase I projects were obtained, the Challenge Leadership Team was asked to provide insight into unanswered projects or resources on the Challenge website were used to gain insights into the remaining projects.

Question 1 to 3 capture the scales for ecological (Q1), socio-cultural/institutional (Q2), and business (Q3) disciplines. Responses to these 3 questions were analysed by categorising scales for space (mm to international), time (sec to long-term/century), and/or organisational levels (social, cultural, institutional levels) (Table 1). Responses were captured at project level but were also grouped by theme to observe patterns within and between themes. The frequency of each level for the different categories were compared between Phase I and Phase II projects to observe shifts in scales. We note that not all participants identified all scales for each question and the frequency with which levels were identified were not necessarily paired. For ecological and business scales, the spatial and temporal scales were linked where possible to identify clusters in space/time and how this might shift between challenge phases. Finally, we acknowledge that not all answers are readily categorised and highlight specific answers or responses that fall outside these categories and provide examples to illustrate and include these considerations.

These patterns were then used to identify in what way scales impact tools generated within the challenge (Q4). Here, tools refer more broadly to the 'approaches or resources that support the implementation of EBM', including guidelines and frameworks, numerical and conceptual models, and management plans. We note that some participants did not distinguish tools (e.g. talking about 'mapping tools'), hence 'tools' was kept as a category on the approach list for Q4. Flow diagrams were used to illustrate the connections between approaches identified by participants and the spatial, temporal, and organisational scales over which they can operate. These were studied at theme level and were used to illustrate the range of scales covered. Responses to Q5, related to value and/or risk practices, were analysed qualitatively where we quote responses. Finally, project leaders identify how scale may aid or hinder EBM and if any barriers were identified at the ecological, social/cultural, or business levels (Q6). Here we aimed to highlight key responses, when similar barriers or solutions were identified by multiple participants, and/or from multiple disciplines.

Table 1. Categorisation of levels for ecological, socio/cultural, organisational and economic scales

Discipline	Scale	Level
Ecological & Economic	Spatial	mm
		m
		km
		Local
		Regional
		National
		Global
	Temporal	Second
		Minute
		Hour
		Day
		Week
		Month
		Season
		Annual
		Years
		Decade
Century/Intergenerational		
Cultural	Spatial	Local
		Regional
		National
	Temporal	Multigenerational
		Whakapapa
		Tikanga
	Social	Whanau
		Hapu
		Iwi
Social	Community	Local
		International
		Business
Institutional	Spatial	Local
		Regional
		National
	Council	District council
		Regional council
		National government
	Other	Agencies
		Co-management forums
		Pan-iwi collectives

3. Overview participants

Survey responses were obtained from 20 project (co-) leaders from Phase II projects and an additional 11 (co-) leaders from Phase I projects. For Phase II, the 20 responses covered 21 projects as some participants are (co-) leaders for multiple projects. For Phase I, 27 projects were answered on behalf by the challenge leadership team, and 2 projects by resources (e.g. summaries, reports, presentations, etc.) available from the challenge website. This resulted in a 100% and 60% cover of projects from Phase I and II respectively (Figure 1). Although the overall cover for Phase II was lower, responses were available for each theme and covered between 50 and 100% of projects within the theme (Figure 1).

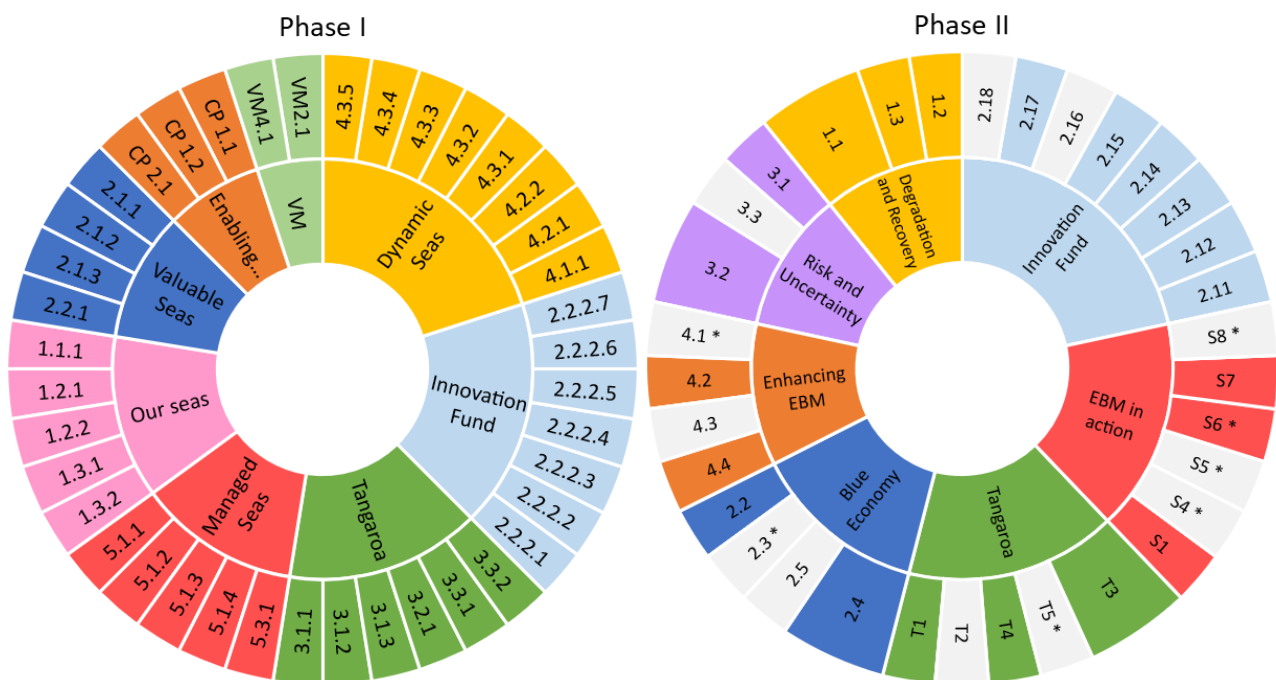


Figure 1. Survey responses for the Sustainable Seas projects – Phase I (left) and Phase II (right). Inner circles identify theme/programme groups and outer circle for project widths relate to the number of response (e.g. one or two per project). Projects with no responses for Phase II are shown in grey and * indicate projects that had not started before commencing the survey or started recently.

4. Environmental variability and ecological responses

In response to the first question “What are the spatial and temporal scales of environmental variability and ecological responses involved in your project?”, 65% of Phase I and 86% of Phase II participants identified scales of interest in their research project. For the remaining 35% and 14%, ecological scales were not identified. The answers from participants were scored along a spectrum of spatial (mm to global) and temporal (seconds to century) scales. Note that the ‘century’ category was used to represent responses such as ancestral and intergenerational knowledge. In many cases, participants identified more than one spatial or temporal scale, with up to 5 spatial scales and 8 temporal scales identified per project.

Histograms of the frequencies of spatial and temporal scales (Figure 2) illustrate that both Phase I and Phase II research projects had a strong focus on local (10’s km) and regional (100’s km) spatial scales. Furthermore, Phase I projects gave more emphasis to scales of km’s compared to Phase II. Phase II projects focused on longer time scales especially for annual to century (intergenerational) temporal scales. In Phase I, a mix of temporal scales were found, including shorter time scales (hours – seasons).

When looking at spatial and temporal scales in combination (Figure 3 & 4), Phase I and Phase II projects show clear clustering of ecological/environmental research in space and time. We note not all projects provided information on both spatial and temporal scales, these projects are displayed along the top and left axis. Phase I research showed more projects worked at one or two spatial or temporal scale combination, with only few projects working over wider spatial and temporal ranges. Phase II research, on the other hand, shows a clustering of projects at larger spatial and temporal scales, covering wider spatial and temporal ranges. Few responses from Phase II researchers indicated they studied ecological variability at smaller spatial and temporal scales.

In Phase II, temporal scales from Tangaroa and other projects focussed on research by Māori-for Māori (e.g. including some innovation fund projects) illustrate the intergenerational nature, often adopted at local-regional scale (see also social scale section below). Of additional interest, responses for Māori-based and led research projects (e.g. Tangaroa: Ngā Tohu o te Ao and Te Tahuhu Matatau, Innovation fund: Whakaika te Moana) illustrated concepts of scale existing within Te Ao Māori, expressed as ‘ki uta ki tai’ and the connection from mātāpuna (source) to wahapū (estuary) in their research.

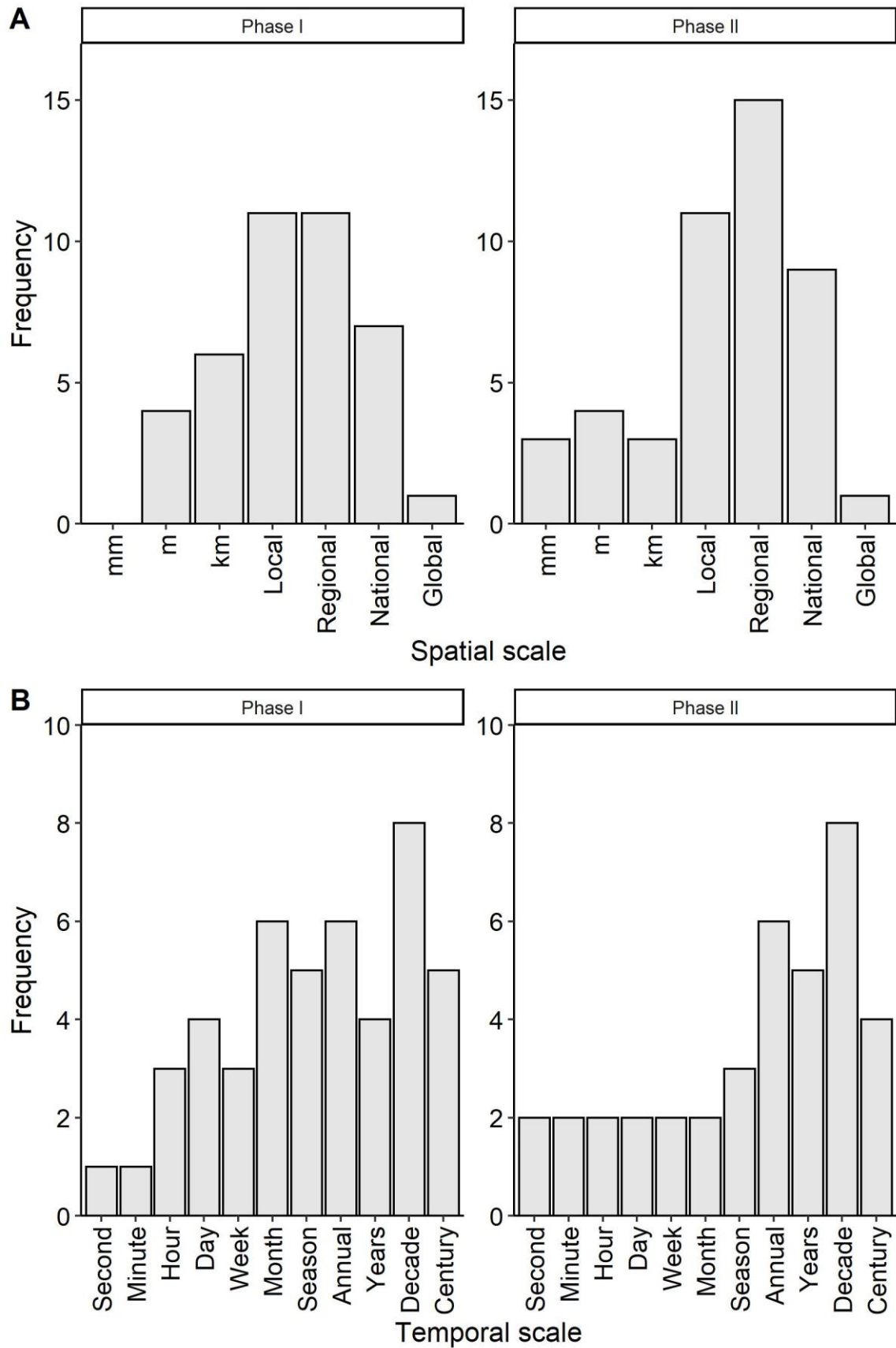


Figure 2. Frequency of spatial (A) and temporal (B) scales under investigation in Phase I (left) and II (right) projects focused on environmental variability and ecological responses.

**Spatial and temporal scales of environmental variability and ecological responses
Phase I**

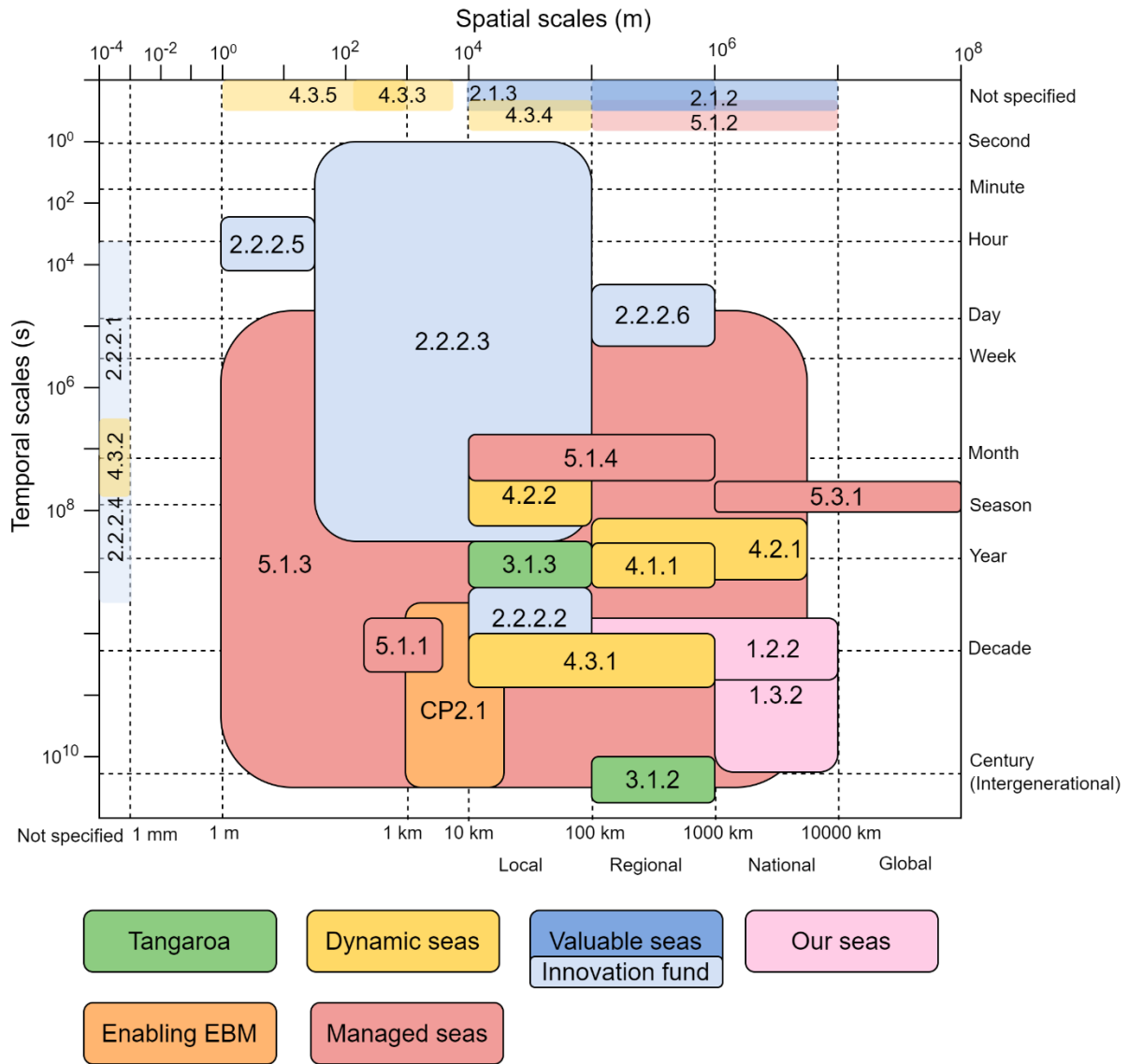


Figure 3. Spatial and temporal scales of environmental variability and ecological responses of Phase I research projects. Spatial scales (m) are represented horizontally and temporal scales (s) vertically. Secondary horizontal and vertical axes aid the interpretation of the spatial and temporal scale categories. The position of projects, based on survey responses, were indicated in the combined spatial/temporal space and colour coded per theme.

**Spatial and temporal scales of environmental variability and ecological responses
Phase II**

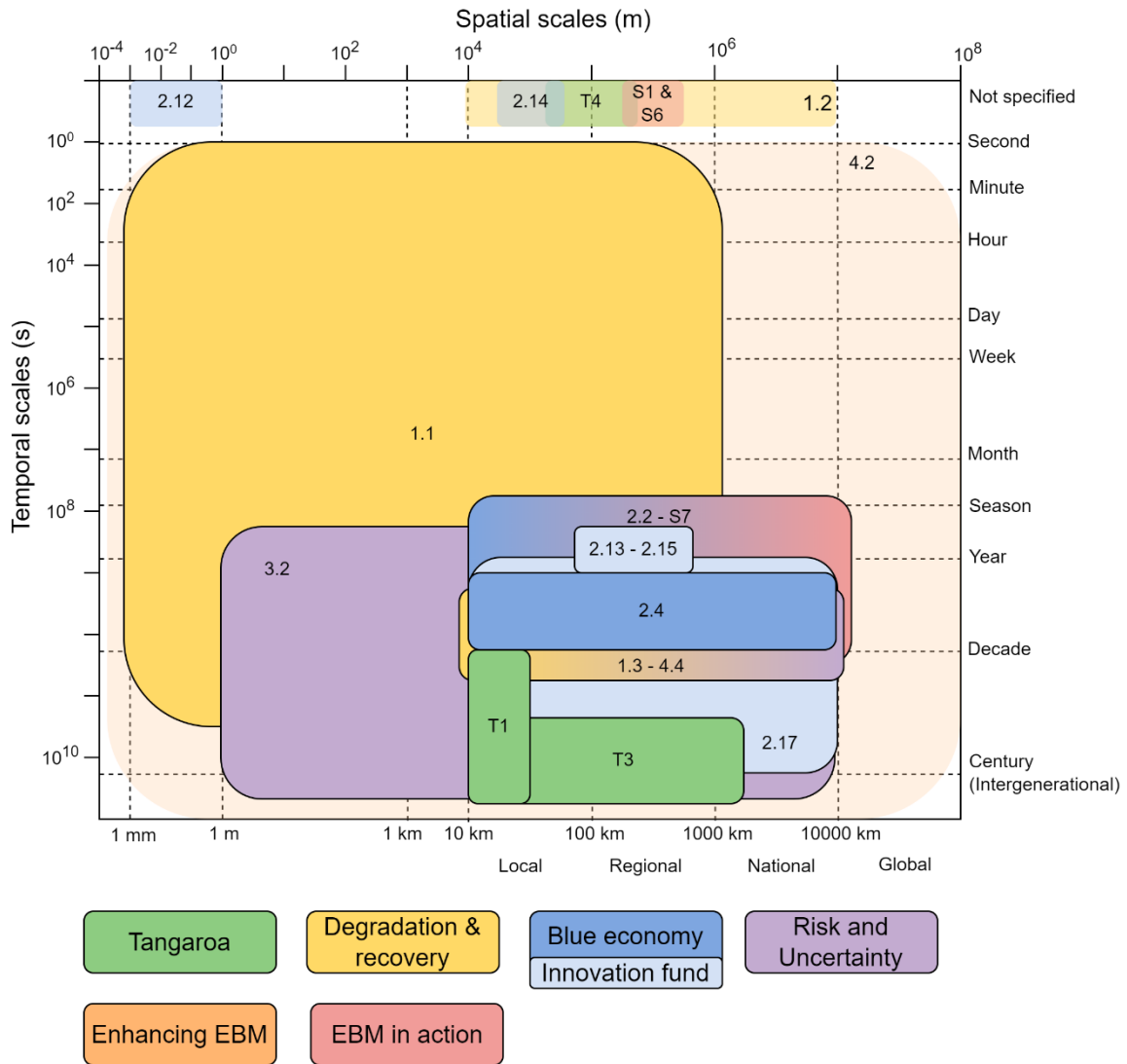


Figure 4. Spatial and temporal scales of environmental variability and ecological responses of Phase II research projects. Spatial scales (m) are represented horizontally and temporal scales (s) vertically. Secondary horizontal and vertical axes aid the interpretation of the spatial and temporal scale categories. The position of projects, based on survey responses, were indicated in the combined spatial/temporal space and colour coded per theme.

5. Social, cultural (VM), and organisational scales

The second question asked participants ‘What are the organisational scales your objectives and co-development partners are working over (e.g. local, national, mātauranga Māori and kaitiaki-driven organisational scales and/or spatial and temporal economic strategy scales and so forth)?’. Three components of participants responses were identified, including the cultural (Vision Mātauranga; VM), organisational, and social scales of interest. Overall, 78% of Phase I and 95% of Phase II participants identified at least one scale of interest.

For the cultural (VM) scale, we found that 53% of Phase I and 95% of Phase II participants mentioned VM scales to their research, however not all identified specific levels of interest. From these responses 76% (Phase II) and 45% (Phase I) of participants further specified scales which were split based on spatial (local, regional, national), temporal (Multi-generational, Whakapapa/ long-term, or Tikanga/applied), or social (Whanau, Hapū, Iwi) levels (Table 1). For both Phase I and Phase II, we found local to be the highest scoring spatial scale, followed by national, then regional (Figure 5A). Both Phases include long (multi-generational or whakapapa) time scales, as well as more applied (tikanga) insights (especially in Phase I). Phase I participants highlighted both ‘hapu’ and ‘iwi’ frequently, whereas Phase II participants most often identified ‘iwi’ as social scale. Pan-iwi collectives (iwi corporate and political collectives) were identified in some cases but are covered as part of the Institutional and Co-development partner part of this question.

Fewer community scales (that were not linked to cultural scales) were identified in our survey. These included social scales targeting local, international and business communities. For Phase I, 35% of projects identified one of these community scales, and 29% for Phase II projects. Phase I identified business community more often (Figure 5B), see section 6 on business and innovation scales.

Finally, institutional scales were identified, including levels related to spatial scale as well as the councils or other organisations they were involved with. 58% of Phase I and 76% of Phase II participants identified at least one institutional scale of interest in their project. Spatial scales were identified as local, regional or national in survey responses, with a high frequency of all 3 identified in Phase I and Phase II (Figure 5C). Government levels included district and regional councils as well as national government, with regional councils most often identified as co-development partners. Finally, several other organisations were mentioned, like agencies (e.g. DoC, MPI, EPA), co-management forums, and pan-iwi collectives, with high frequency of agencies as partners in Phase I.

We note that two projects in Phase II identified ‘all’ socio/cultural/institutional scales and confirmed after showing the final list of categories. These include responses from project 3.1 on perceptions of risk and uncertainty (from a social processes perspective), and project 4.2 on policy and legislation for EBM.

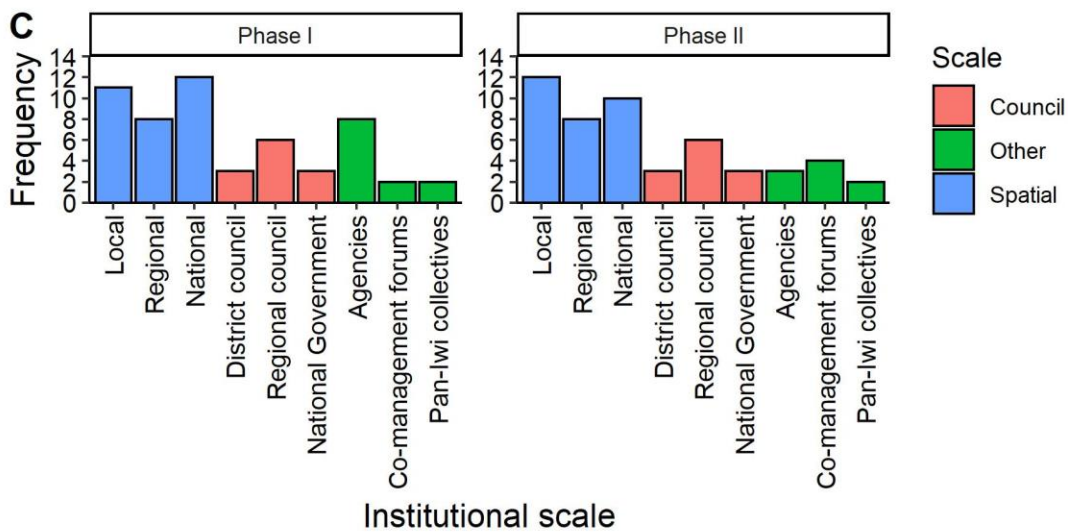
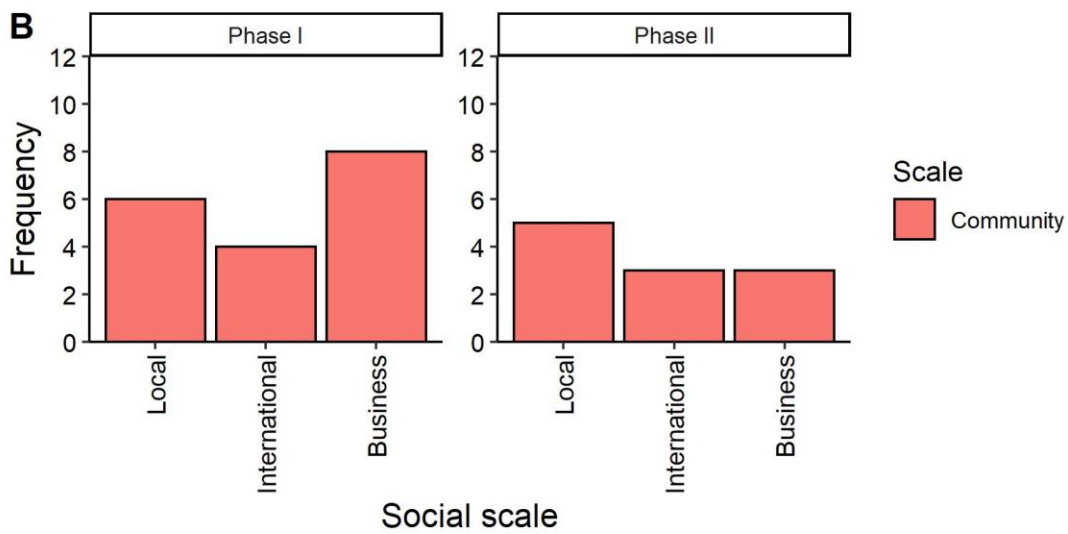
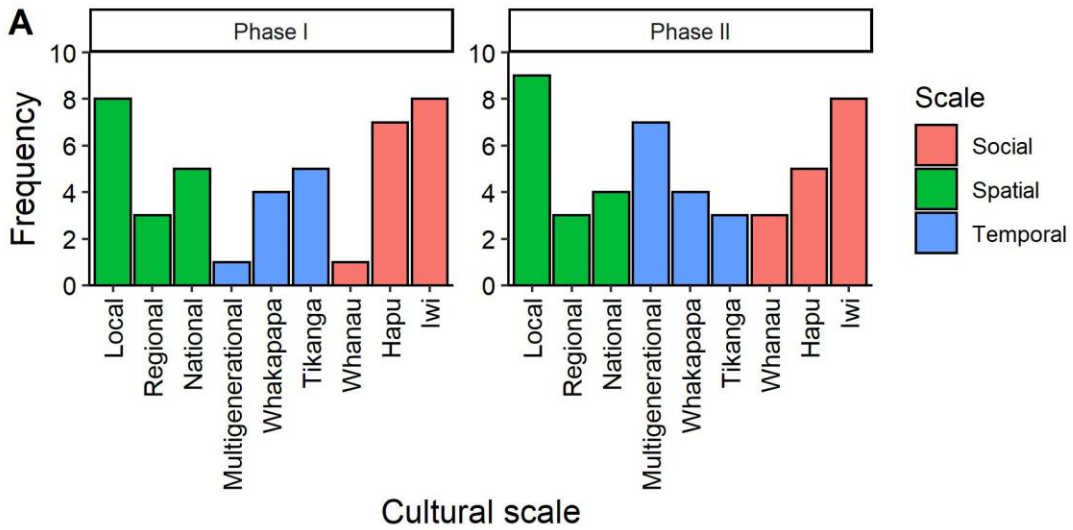


Figure 5. Frequency of cultural (A), social (B), and institutional (C) scales under investigation in Phase I (left) and II (right) projects.

6. Business and innovation scales

In response to the question 'What are the space and time scales of business and investment activities (or other economic factors) involved in your project?' participants from 43% (Phase I) and 52% (Phase II) identified spatial or temporal scales of interest. For both Phases, more than half the responses came from the blue economy/valuable seas and innovation fund programs. This result is as expected, given the focus of these projects on economic factors. Like section 4, spatial and temporal scales of interest were categorised from millimetres to global scale, and seconds to century.

Looking at the frequency of spatial (Figure 6A) and temporal (Figure 6B) scales of business and innovation activity, we saw that Phase I and II both have a strong focus on local scales. In comparison, Phase II had more emphasis on regional and national scale business/innovation initiatives, with some interest in global/international scales. For example, the 'Growing marine ecotourism' project had a mostly regional business application, but also has a strong focus on international scale due to the nature of the tourism sector. Temporally there was a strong focus on longer time scales for Phase I, especially annual to century/intergenerational time scales. In Phase II, few identified temporal scales for business, either at a multi-year scale or intergenerational (century) focus. We acknowledge that business scales do not operate over small spatial and temporal scales (e.g. below 'local' spatial scales and annual temporal scales), due to the nature of business activity. The few scores we did get for these levels came, for example, from projects that defined 'all' scales and confirmed these after seeing the final list of categories as displayed below.

When looking at the spatial and temporal scales combined, we note that only few projects identified both scales, as shown along the top or left axes of Figures 7 and 8. For Phase I, many projects only identified long-term temporal time scales. Similar for Phase II, not all projects identified both spatial and temporal scales. For both Phases, most projects that did identify both showed clustering of projects at larger spatial and temporal scales, covering wider spatial and temporal ranges.

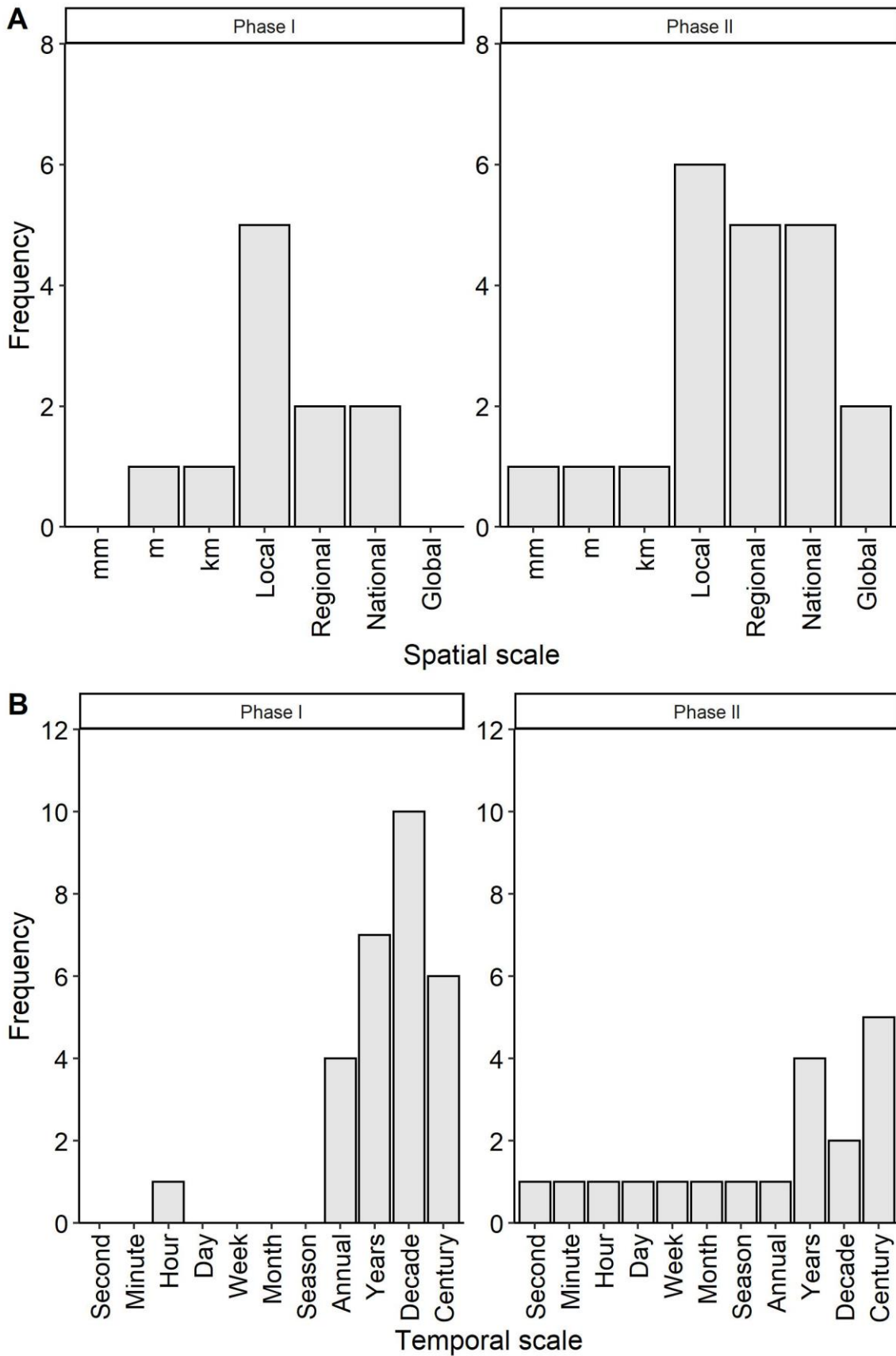


Figure 6. Frequency of spatial (A) and temporal (B) scales under investigation in Phase I (left) and II (right) projects focused on business, economic, and investment activities.

Spatial and temporal scales of business, economic and investment activities Phase I

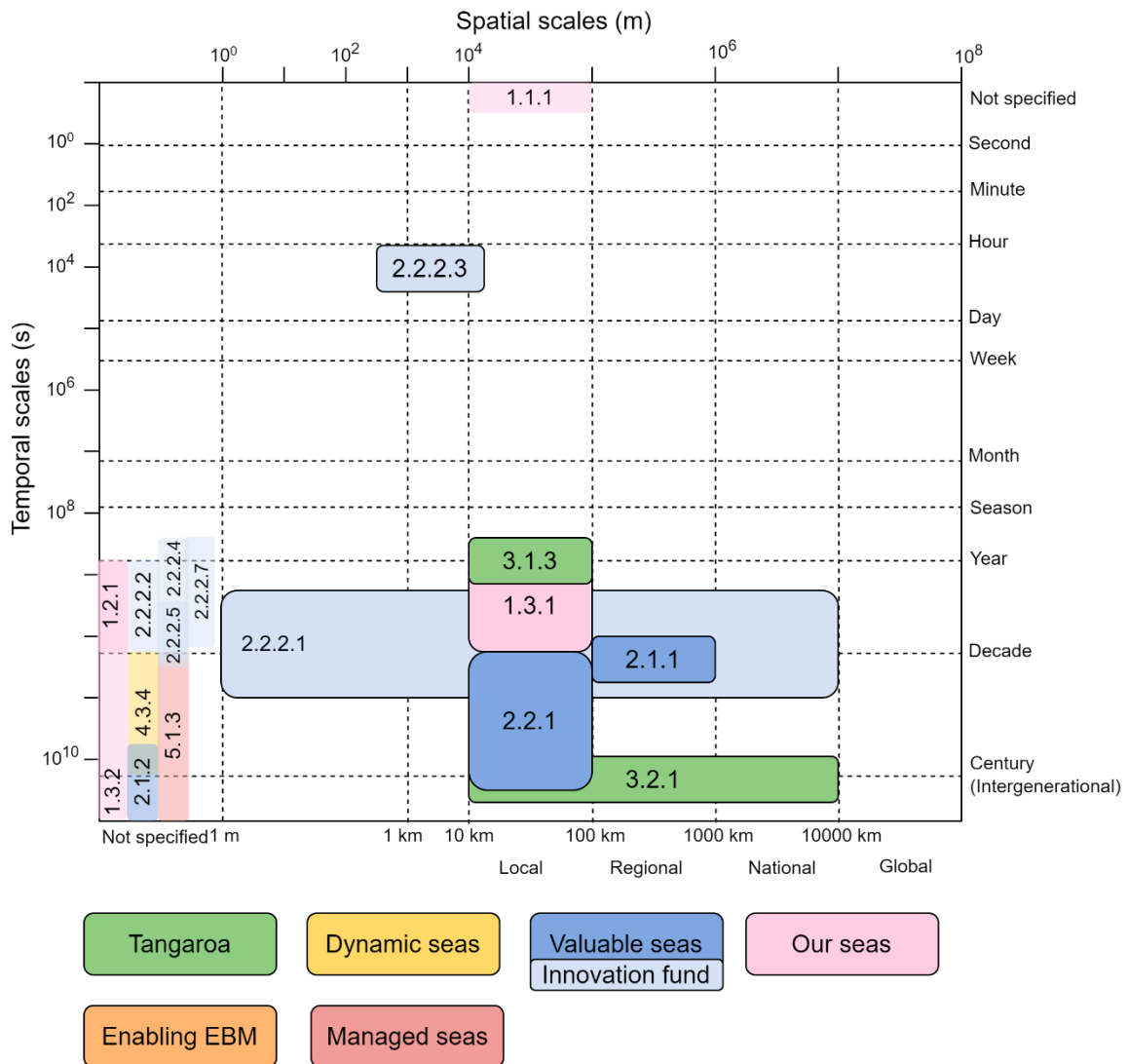


Figure 7. Spatial and temporal scales of business, economic, and investment activities in Phase I research projects. Spatial scales (m) are represented horizontally and temporal scales (s) vertically. Secondary horizontal and vertical axes aid the interpretation of the spatial and temporal scale categories. The position of projects, based on survey responses, were indicated in the combined spatial/temporal space and colour coded per theme.

**Spatial and temporal scales of business, economic and investment activities
Phase II**

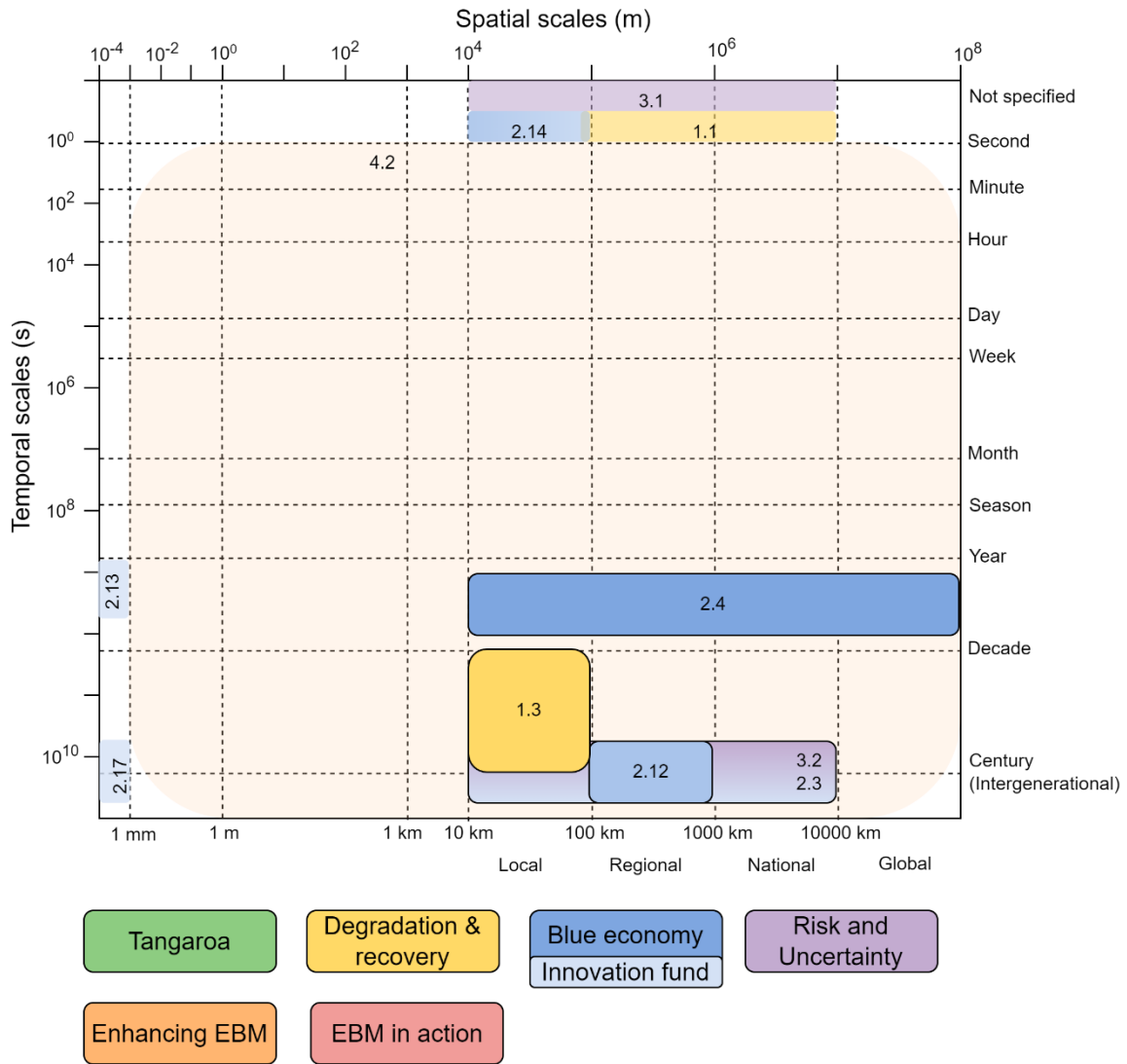


Figure 8. Spatial and temporal scales of business, economic, and investment activities in Phase II research projects. Spatial scales (m) are represented horizontally and temporal scales (s) vertically. Secondary horizontal and vertical axes aid the interpretation of the spatial and temporal scale categories. The position of projects, based on survey responses, were indicated in the combined spatial/temporal space and colour coded per theme.

7. Relevance of scale in tool development

We asked participants if they produced tools, guidelines or models in their projects, and if so, if they had any specific spatial, temporal or organisational scales over which they operate. For Phase I, 73% of projects identified tools that were produced for their project, with 31 tools identified in total. Likewise, for Phase II, 85% of projects indicated tools were produced as part of their project, with 27 tools identified in total. Projects could identify more than one tool, which was often the case especially in Phase II responses. We noted that responses varied widely in level of detail provided, with some elaborate answers identifying all scales for multiple tools within the projects, whereas others only indicated tools were produced. This can skew the results to those more detailed responses, which should be acknowledged when interpreting the results.

For each project, we identified what approach was used, distinguishing between Tools (if not further specified, e.g. mapping tool), Guidelines and frameworks, Models, and Management plans. These were then followed by the spatial, temporal, or organisational scales identified with similar categories to those identified in sections 4 to 6. Most responses for both Phases covered frameworks/guidelines, tools, and models, with no or fewer responses for management plans (Figure 9). We note the peak for frameworks in Phase I. Most spatial scales operated on the local to national scale for both Phases, but some smaller scales were identified for Phase I (meters – kilometres) and international scale. These were not identified for Phase II. Organisational scales included cultural organisational scales (whanau, hapū, iwi), pan-iwi collectives, the wider community, agencies, and government organisations (Figure 9C). Likewise, several temporal scales were covered in both Phases, with an emphasis on the longer time scales for Phase II. We included ‘static’ models that indicated they did not cover temporal dependencies in the models. Spatial scales were identified for most approaches, but organisational and temporal scales were covered more rarely.

The flow between the connections for approaches, spatial, organisational, and temporal scales is visualised in Figures 10 and 11. These figures help identify flows and links between categories, which connections are abundant, and which might be missing. The width of connections showed the number of times each was identified in the survey. Note that the incoming and outgoing numbers to nodes was not balanced as multiple scales could be identified from the same project, e.g. when tools worked over a wider range. For Phase I (Figure 10), we see that for the ‘Our Seas’ and ‘Tangaroa’ themes these programs operated mostly on larger (local-national) spatial scales, which were covered proportionally less by other approaches. Models and tools covered a variety of spatial and temporal scales. Phase II covered local to national spatial scales (Figure 11).

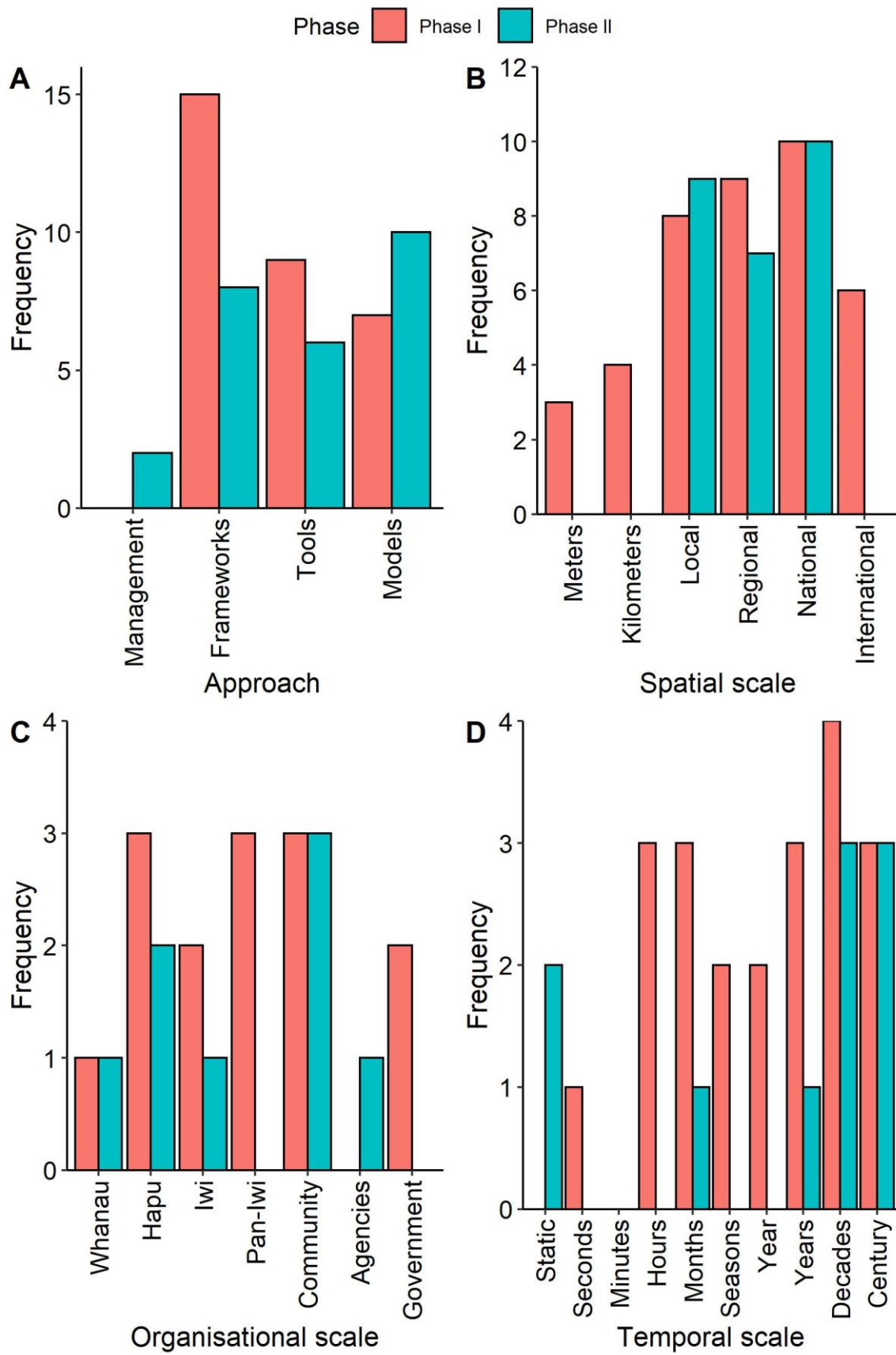


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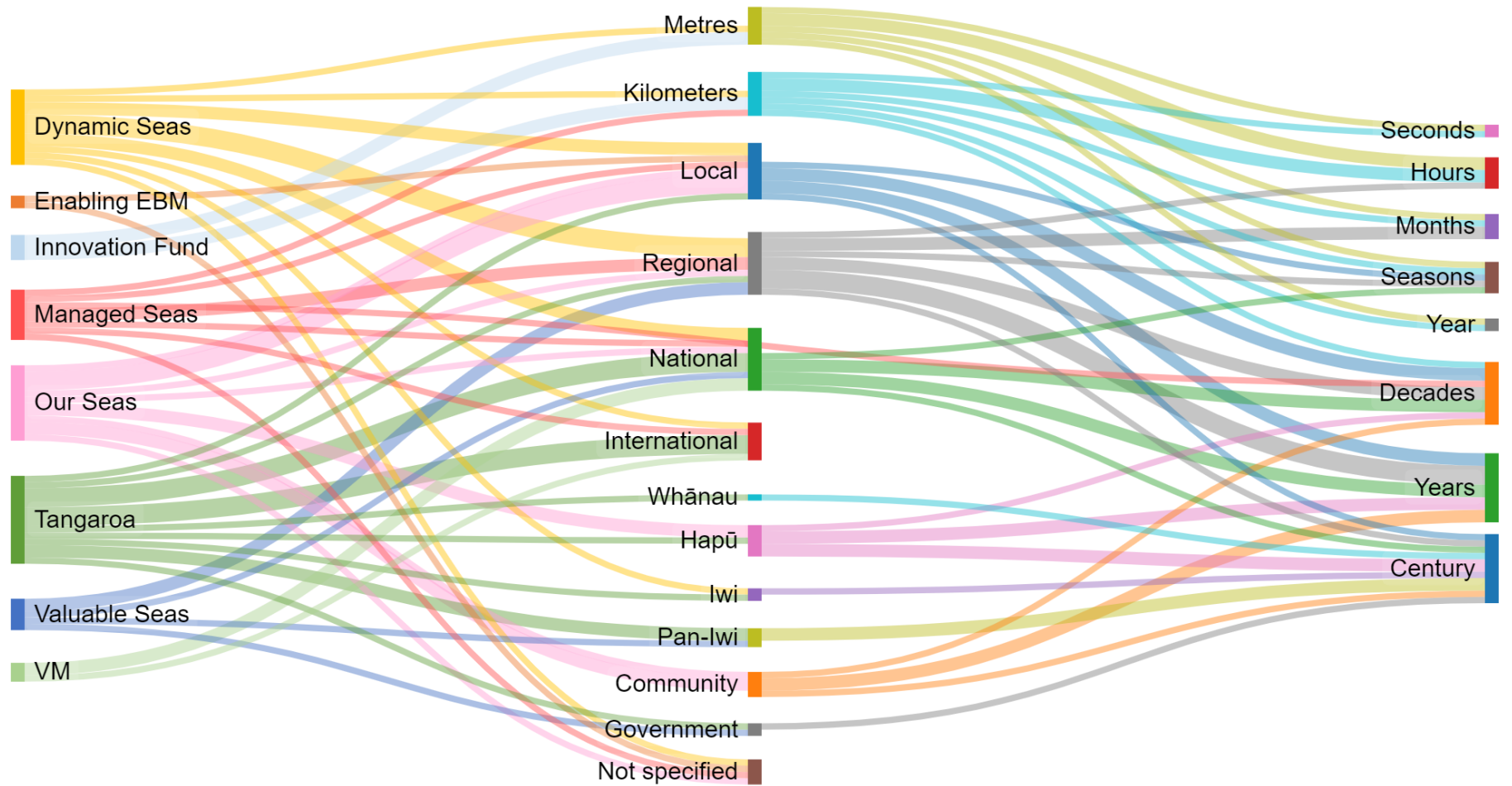


Figure 10. Scales at which tools operate within Phase I projects.

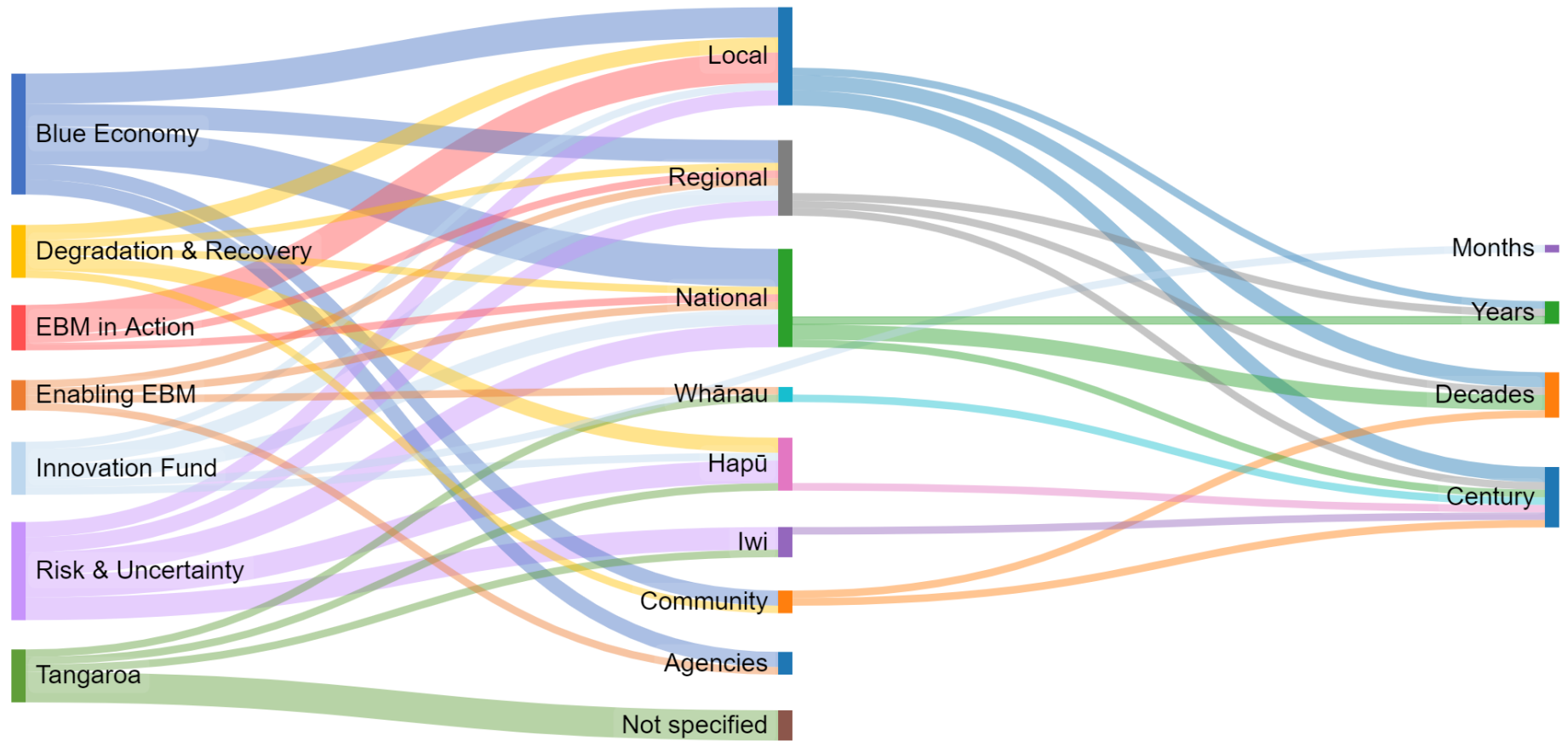


Figure 11. Scales at which tools operate within Phase II projects.

8. Scale influences on values and risk practices

For the question 'Did your project investigate values and/or risk practices when presented with different space and time scales? If so, do you think (or did you find) that values or perceptions of risk change with differing scaled information?' 37% of Phase I participants indicated their research looked at values (n= 11) and/or risk (n= 13) practices, of which 10 responses described the evaluated scales. Likewise, for Phase II projects 57% studies values (n=8) and/or risk (n=3) practices, of which 7 participants identified scale dependencies. Below we describe and quote the type of responses when risk and value was considered, described or evaluated in relation to scale.

For projects in Phase I and II that identified either risk or value in their projects, responses highlighted the different scales affecting cultural, environmental, and political risks from the different categories (ecological/social/cultural/organisational/business), as well as societal values. A large proportion of responses focussed on risk and/or values related to business or cultural categories, or their combination. For example, multiple responses identified that the perceptions of risk and values change when shifting a business mindset from short-term (high flow, low value economy) to long term (low flow, high value economy) strategies. Some responses also acknowledged the risk of inaction. There was a strong cultural (and social) aspect related to these temporal scales as well, given the long-term/intergenerational mindset in Te Ao Māori, which can result in "more awareness of risk to their capital from long-term environmental and political risks". This further relates to values (e.g. kaitiakitanga) that are embedded within environmental ethical obligations.

Further related to cultural aspects, a response indicated that "Larger companies often engage with interest groups and organisations rather than individuals or local communities. Māori generally prefer to use social licence concepts based on Māori values and tikanga." We note the response that "From a Māori world view there are no boundaries around scale. There are local nuances, e.g. the way tikanga is applied may differ slightly between local spaces, but not really the same scale boundaries as western science. Some of the tools in our current system (the way the legal/policy frameworks divide up the ocean and the rights/interest division cause different opinions at different scales). Local scale interest differs from national scale interest."

For community engagement, a response indicated it tends to be easier to identify values and risk at local scales. When engaging with children through education programs, this often leads to identification of different types of risk. Community engagement is likewise an essential component in a bottom-up approach to restorative economic activities, which should consider uncertainty and probability of success and risk of failure. Another set of responses focussed on organisational scales, for example focussed on how cumulative effects could (negatively) affect values or how restoration/ conservation priorities may change with temporal and spatial scales, comparing regionally balanced vs. national considerations. Finally, one of the projects identified gaps in our understanding of risk as we are "lacking wider knowledge of the social, cultural, economic, and political dimensions of risk and uncertainty". These gaps were specifically addressed in Phase II and covered perceptions of risk and uncertainty from social and cultural angles through worldview, discipline, and positionality (an individual's identity and experiences). "Scale likely operates through positionality but only in that the closer (or more affected) you are to a problem and its impacts the more concerned you will be with detailed information and understanding the risk."

9. Scale dependencies aiding/hindering EBM

Finally, participants were asked ‘How did these scales interact to aid/hinder actions and solutions to EBM and/or what were the barriers identified?’. 55% of Phase I and 57% of Phase II participants answered this question, identifying aspects of their research that aids and/or hinders (barriers) EBM. For both Phases, more participants identified barriers of scale to further EBM (i.e. 13 and 10 projects than solutions (7 and 4 projects; Phase I and II respectively). We note that the wording of responses sometimes classed a similar response in the barrier or solution category, but capturing the same aspect (e.g. ‘non-inclusive language’ as a barrier vs. ‘language choices that are empowering’ as a solution). Below we describe and quote the main barriers identified for Phases, followed by solutions to EBM related to scale.

Some of the main barriers identified for scale to further EBM include the spatial mismatch between national and local/regional scales. This barrier was identified by different disciplines, including environmental/ecological, cultural, institutional/legislative, and economic/business. Related to this barrier is the barrier identified for environmental and institutional disciplines that highlighted the mismatch between artificial jurisdictional boundaries and environmental effects that often transcend these jurisdictional boundaries. In addition, institutional fragmentation and siloed agencies further complicate the scale of jurisdictional boundaries. Multiple responses from Phase I and II highlighted the mismatches in temporal scales, including the short-term thinking (economic/political) vs. long-term processes (ecological) and focus (Te Ao Māori). Furthermore, ecological and cultural legacy effects can form a barrier to EBM if not considered in consent processes, planning, or policies. This ties in with “willingness” and “inertia” in management systems and among Co-Development Partners (CDP) to act on evidence and the difficulty in translating this into planning processes. Research from cultural disciplines further emphasise barriers from a Te Ao Māori perspective that include e.g. ignorance of practices/perspectives, informed consent and meaningful engagement.

Scale related findings from Sustainable Seas research projects have also provided insights that can aid the implementation of EBM in New Zealand. Solutions to EBM from spatial scales include, for example:

- Gaining a better understanding between local and national scales, which has highlighted the importance of context.
- Insights for ecosystem restoration have highlighted the need to work at meaningful scales, by focussing on integrated networks of many restoration projects as opposed to current fragmented and short-term projects.
- Both environmental and cultural disciplines highlighted that a better understanding of cumulative stressor effects from Western science and Mātauranga Māori can provide solutions for EBM.
- Likewise, for temporal scales, some projects focussing on near real-time environmental forecasting suggested this as an aid to better use of resources, although this appeared limited to short timeframes in certain industry contexts (e.g. forecasting contaminant effects to identify best times to harvest shellfish (aquaculture) and beach closures). Over longer time frames forecasting options might be less applicable and limited by relevance of appropriate measures from an EBM perspective.
- Historical/past knowledge, practices and perspectives were highlighted as important to move forward, and can aid in collective ownership of past events and move towards resilience and future preparedness.

- From social and cultural perspectives, solutions come from language choices that are empowering, promote inclusive discourse, create space for a common vision and multiple perspectives. These further highlight the need to work with youth, as they are the future. Multiple projects within Sustainable Seas have engaged with children through education and (community) outreach, thereby creating early engagement.
- Finally, at the institutional and legislative level, solutions can come from more efficient navigation through bureaucratic structures and greater integration/collaboration across agencies.