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Strategies for creating a kelp forest restoration and protection target

This document details a variety of strategies for creating a global kelp forest restoration and protection target. Full details for each approach are contained in the accompanying appendix.

Summary

The summary table provides low-very high scenario outputs for the different methods (methods 1 – 5). A short description of each method follows the summary table.

Capacity: Ability to do restoration

Requirement: Need to do restoration

			Target value M ha			
Method	**Overview**	**Capacity or requirement**	**Low**	**Med**	**High**	**Very high**
1	Percent of observed or modelled kelp extent	Requirement	0.01	0.5	2	18
2	50 year baseline	Requirement	7	10	14	276
2	20 year baseline	Requirement	1	1.5	2	82
3	Linear growth in restoration capacity	Capacity	0.25	0.7	22	188
4	Percent of observed kelp extent estimation	Requirement	0.05	0.5	1.3	2.6
5	Budget available and cost of restoration	Capacity	2	4	9	37
	Average (M ha)		1.72	2.87	8.38	100.60

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Method 1

What if we try to restore a certain fraction of the known kelp forest cover?

Kelp distribution

Blue cells refer to values within the range of measured kelp distribution. These are likely underestimates. They also exclude Arctic kelp forest distribution which is extensive but may not be available for restoration.

Green cells refer to values within the range of modelled kelp *potential* habitat. These are likely overestimates and include kelp forest in areas which may be unlikely to be restored (e.g., extremely remote or deep).

		Fraction of kelp distribution					
		0.01	**0.02**	**0.05**	**0.075**	**0.1**	**0.3**
Kelp distribution (M ha)	**1**	0.01	0.02	0.05	0.075	0.1	0.3
	5	0.05	0.1	0.25	0.375	0.5	1.5
	10	0.1	0.2	0.5	0.75	1	3
	50	0.5	1	2.5	3.75	5	15
	100	1	2	5	7.5	10	30
	150	1.5	3	7.5	11.25	15	45
	180	1.8	3.6	9	13.5	18	54

Method 2

Given current rates of decline (Krumhansl et al. 2016) and current estimates of kelp distribution, how much kelp would we need to restore to reach a 10-50 year baseline?

Estimated rate of decline: 1.8%

		Average of modelled distributions	Eger et al. 2023	Pesseradona et al. 2023 (Unpublished)
	Current distribution (M ha)	191.56	4.93	11.91
Reference year	2010	37.42	0.96	2.33
	2000	82.14	2.11	5.11
	1990	135.61	3.49	8.43
	1980	199.51	5.13	12.40
	1970	275.89	7.10	17.15

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50 year baseline

7 – 275 million hectares to restore

Method 3

How much kelp can we restore if we assume a linear growth in the capacity to do restoration? For example, if we can restore 10,000 hectares a year in 2020 and the ability grows by 5% a year, how much kelp can we restore by 2040.

Current restored kelp area (ha)
15000

	M ha potential							
Growth in restoration ability per year (%)	100	60	40	20	10	5	2.5	1
2030	7.67	1.69	0.74	0.31	0.20	0.17	0.15	0.14
2040	7864.08	188.79	22.31	2.24	0.70	0.39	0.30	0.25

1% growth per year by 2040: 0.25 million hectares

10% growth per year by 2040: 0.70 million hectares

40% growth per year by 2040: 22.31 million hectares

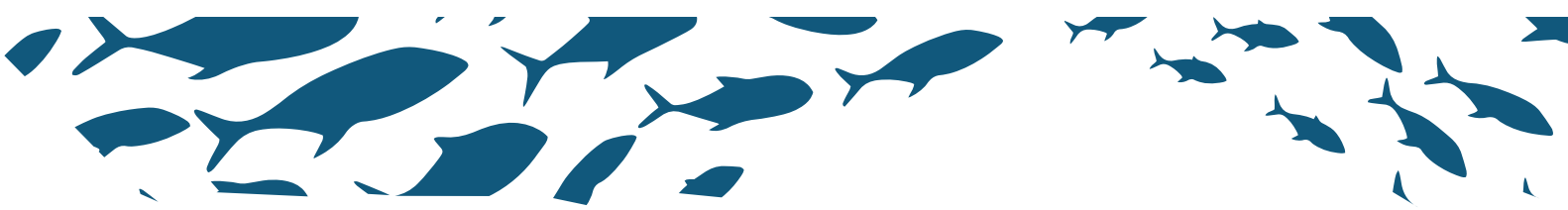
100% growth per year (doubling) by 2040: 7,864 million hectares

Method 4

What if we try to restore a certain fraction of the estimated kelp forest cover?

This approach uses a global model of rocky habitat cover and estimated kelp forest percent coverage.

Global potential kelp habitat (rocky seafloor): 42.47 million hectares



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Kelp cover %	Estimated kelp area (M ha)	Percent of global distribution to restore	0.05	0.1	0.2	0.3
0.025	1.06		0.05	0.11	0.21	0.32
0.05	2.12		0.11	0.21	0.42	0.64
0.075	3.19		0.16	0.32	0.64	0.96
0.1	4.25		0.21	0.42	0.85	1.27
0.125	5.31		0.27	0.53	1.06	1.59
0.15	6.37		0.32	0.64	1.27	1.91
0.2	8.49		0.42	0.85	1.70	2.55

Method 5

Given the GDP of countries with kelp forests, percent spending on marine biodiversity and conservation, and costs of restoration, how much area could we afford to restore by 2040?

		M ha				
	Cost of restoration/protection (M USD/ Ha)	0.01	0.02	0.04	0.06	0.08
Fraction GDP spent	Budget Available for restoration and protection (M USD)					
0.0002	8,326	14.99	7.49	3.75	2.50	1.87
0.0003	12,489	22.48	11.24	5.62	3.75	2.81
0.0004	16,651	29.97	14.99	7.49	5.00	3.75
0.0005	20,814	37.47	18.73	9.37	6.24	4.68

Approaches to determining global kelp extent

Species distribution models, niche suitability models: These models predict kelp habitat cover by using the relationship between the known locations of kelp forests and the environmental variables (temperature, salinity, etc.) at those locations. These predictions are bounded by the cell or resolution size of the data. They do not give the true area of kelp habitat but rather the area where the environmental conditions are appropriate for kelp habitat. In other words, this approach produces the potential, not the realized niche. As a result, these models are overestimates of true global kelp cover.

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Survey data: These data are collected using a variety of observation methods, satellite, aerial, diver surveys, autonomous vehicles, etc. They are constrained by the physical area surveyed and are underestimates of the true kelp area.

Modelled rocky reef: This approach uses a model to estimate the area of rocky reef on a country-by-country basis. We then combine the area of rocky reef with a range of kelp cover percentages to provide estimates of the global kelp forest cover.