



Key Concepts in Marine Protected Area Design

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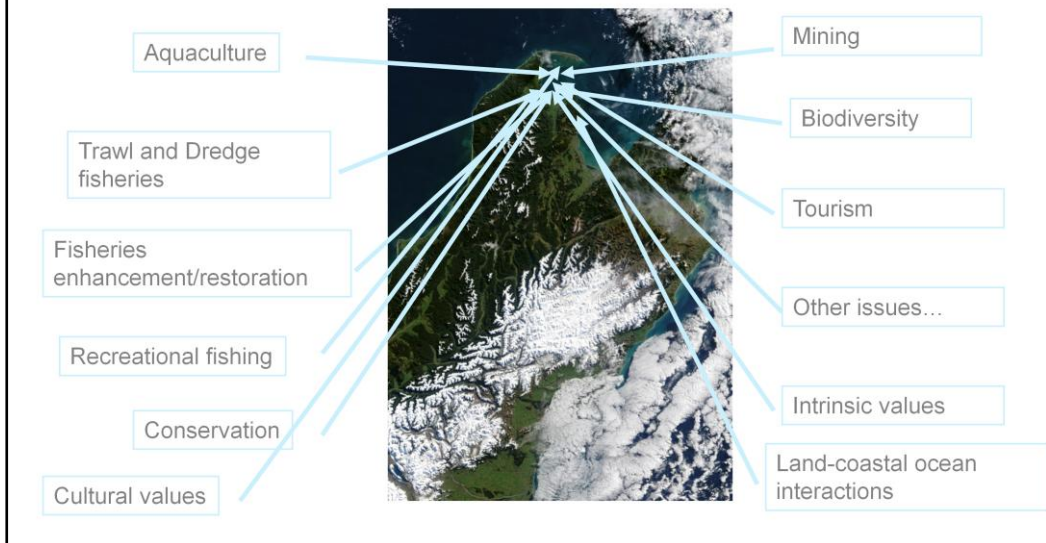


Outline:

- Key concepts for MPA design
- Scientific guidelines for MPA design
- Systematic Conservation Planning

Striking a balance between different resource uses

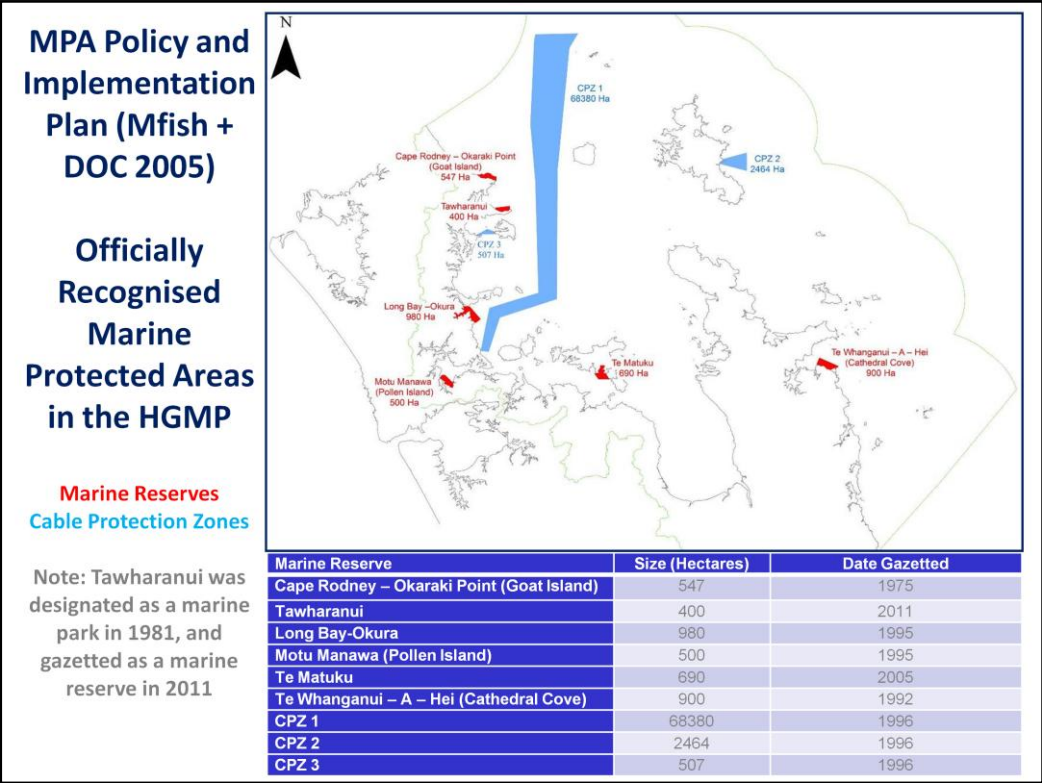
Cumulative effects occur through repeated stress or disturbance over particular space and time scales and because of the effects of multiple stressors



Intro- many impacts. MPAs can protect against only some of these.

Marine reserves are just one tool for marine and coastal protection

- In addition to marine reserves, measures to protect coastal and marine ecosystems are contained in the RMA (which deals with matters other than fisheries management and excludes the control of fisheries and many fishing impacts) and the Fisheries Act 1996 (which deals with fishing and fishing impacts).
- There are a range of measures under the Fisheries Act which can be used to provide protection for fisheries purposes. These include area closures, seasonal area closures, restrictions on certain fishing techniques, partial closures to certain commercial fishing, taiapure and mataitai.
- Marine mammal sanctuaries (Marine Mammals Protection Act 1978)



There are 6 no take marine reserves in HGMP, all of which are under 1000 ha. Cable Protection Zones are also legally MPAs under the MPA Policy and cover over 70,000 ha in the HGMP. They also cover a wider array of depths and exposures than the marine no take reserves which are shallow coastal areas.

Steps in marine spatial planning, including the design and implementation of MPAs

- Determine stakeholders involved
- Define the problem
- Define objectives (biodiversity, fishery enhancement, tourism, cultural, etc.)
- Define/map area to be protected with available information
- Determine set of options to maximize objectives and minimize conflict (software packages)
- Ensure resources for management and enforcement
- Ensure ongoing monitoring

There are many MPA objectives

(e.g. Jones 2002)

- protect rare and vulnerable habitats and species
- conserve a representative set of habitat types
- maintain and restore ecological function
- promote research and education
- establish harvest refugia
- control tourism and recreation
- promote integrated coastal management
- maintain aesthetic values
- maintain traditional values
- preserve cultural symbolic value of protected areas

Transition into general HGMP 'marine protected areas'. While MPA Policy is clear on what is and isn't MPA, the HGMP stakeholder group can identify different types of 'protection' that are fit for purpose – including conservation goals but also a range of other values. These may result in different types of protection. A marine mammal sanctuary could enact measures to protect against bycatch in fishing nets or ship collisions; places of high importance for rec fishing could have all other uses banned; places with diverse bottom habitats could have non-destructive fishing allowed but no bottom impacts (eg seamount closures with minimum depth above bottom). The key is to determine objectives for MPAs, and then have zoning rules accordingly. For biodiversity protection, if this is a HGMP goal, there are both national agreed standards for protection, and for 10% representation (at least at broad scales).

What is fit for purpose?

- The type of protection must be linked to reducing the impacts of activities on biodiversity
- If an area is not threatened by the activity of concern, then designating it as an MPA will not result in increased protection (e.g. >80% of NZ's Benthic Protection Areas are too deep for trawling, or were areas of low or no fishing effort)



Land-based impacts

- MPAs have no effect on land use
- Marine areas highly impacted by land-use (sediments, nutrients, other pollutants) need measures to protect against these impacts (e.g. RMA tools such as SEA-Ms, PMREs)



Land based impacts- MPAs that ban fishing have no effect on what is going on in adjacent land. There are other tools – eg RMA, Auckland council SEA-M – marine significant ecological areas, PMREs – priority marine receiving environments for the reduction of land-based impacts

Key concepts of MPA network design:

- **Comprehensive** – include full range of marine ecosystems at an appropriate scale within and across each bioregion
- **Representative** – reflect biodiversity of marine ecosystems in each bioregion
- **Adequate** – include level of protection to ensure ecological viability and integrity of species, populations, and communities
- **Vulnerable** habitats and species – include unique, rare, distinct, biogenic, spawning, nursery, critical habitat for threatened species
- **Replication** – insurance against chance events

ANZECC Guidelines (July 1999)

Site Selection Guidelines - Primary considerations

- **Protect the full range of marine habitats and ecosystems** – The MPA Policy calls for the protection of “the full range of marine habitats and ecosystems” as well as those which are rare, distinctive or internationally or nationally important.
- **Cultural use** – Consider information on traditional use, values, current economic value and Treaty settlement obligations.
- **Adverse impacts on users** – Where there are choices of several sites that would add a similar ecosystem or habitat to the protected area network if protected, the site(s) chosen should minimise adverse impacts on existing users and Treaty settlement obligations. Selection may also be guided by accessibility for management and enforcement requirements; and benefits such as educational, diving and tourism opportunities.
- **Social and economic interests** – When choosing among potential sites, information related to social and economic interests should be considered to minimise adverse impacts on existing users. Such information may include: current and potential use for the purposes of extraction or exploration, or contribution to economic or intrinsic value by virtue of its protection.

Some actual text from NZ MPA policy

Site Selection Guidelines - Secondary considerations

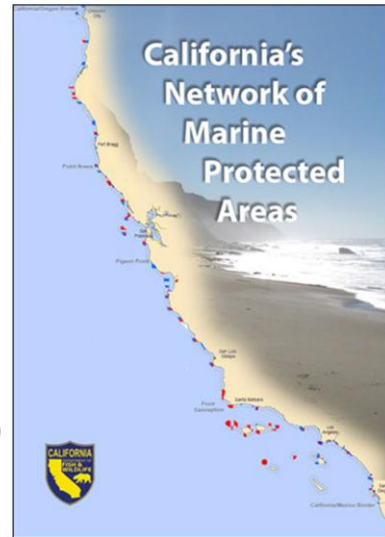
- **Number of protected areas** – The number of potential habitat and ecosystem types, defined by the classification and mapped within a biogeographic region, does not equate to the number of protected areas required to protect the full range of natural marine habitats and ecosystems. Multiple habitats should be protected within each protected area.
- **Have fewer larger (versus numerous smaller) protected areas** – It is beneficial to have fewer larger protected areas representative of more than one habitat or ecosystem than a large number of small protected areas.
- **Susceptibility to degradation** – Incorporate information on the location of, for example, coastal structures, dredging or dumping sites that potentially may impact on the integrity of the site.
- **Compatibility with adjacent land-use** – It is desirable to design protected area boundaries to align with other protected areas. This includes national parks on land and other protected waters, such as fish habitat. This allows opportunities for collaborative compliance efforts between agencies.
- **Replication** – Consideration should be given to whether the site provides replication of habitats and ecosystems in a biogeographic region.

MPA design rules of thumb

- **Protect whole habitats and ecosystems**
- **Size of protected areas** – protect fewer, larger areas rather than numerous smaller areas and minimise ‘edge effects’.
- **Maximise connectivity** - between habitats within individual MPAs and between MPAs within a network
- **Keep boundaries simple and aim for low boundary to area ratio**

How much?

- California MPA Network – 16% (6 types)
- GBRMPA – 33%
- Generally scientific theory suggests 10-40% for biodiversity goals; 20-50% for fishery sustainability



Size and replication

SIZE

- Channel Islands, California – goal 35 km²
- Great Barrier Reef – goal 20 km minimum dimension

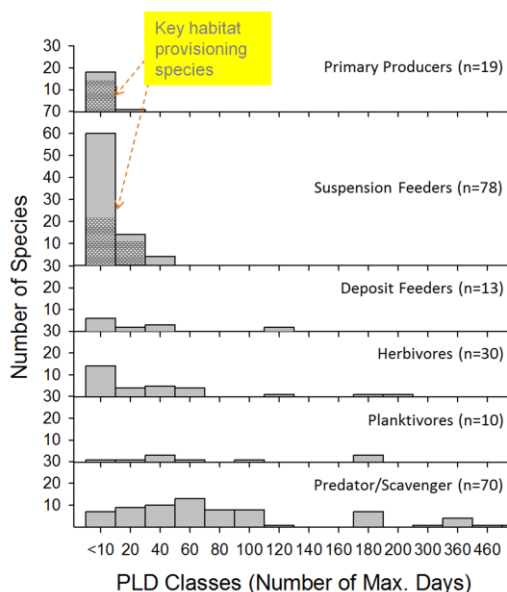
REPLICATION

- MPA Policy– each habitat should be represented within a no-take marine reserve and possibly a Type II MPA
- GBRMPA – at least 3 of each habitat

Spacing

Ranges of dispersal distances:

- marine algae, 1 m to 5 km
- invertebrates, 10 m to 1000 km
- fishes, 1 km to 1000 km
- Key habitat forming species, usually low dispersal



Unpublished data we have collected, figure by Tara Anderson at NIWA Nelson. Axis is pelagic larval duration – the shorter it is, the shorter they travel. Point out please that these are averaged across all Nztaxa for which we have dispersal info, and that these patterns are not different to other countries in a general sense. Eg Australia we share many species with Tasmania, Victoria, NSW. Also that particularly for soft sediments which are most of what we have in HGMP, 2/3 on average of soft species have limited or no planktonic dispersal. Majority of things in <10 days are minimal movement (10s of ms). Sorry do not have updated figure with 0 bin. But point is – spacing guidelines need to be adequate for what you are trying to protect. If big wide ranging tuna, this is a whole different story to protected the typical HGMP habitats and the whole complement of species in them (ie not just lobster and snapper)

Data-less management

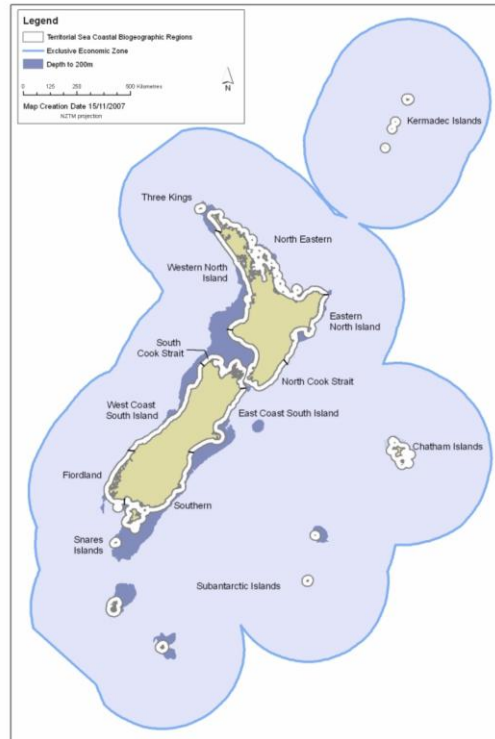
How to protect a system for which little quantitative information is available?

- Well informed decision-making is best but scientific data is often not available or has large gaps
- Options include: use of surrogates (e.g. physical correlates), expert consensus (Delphic), stake holder information and opinions, anecdotal information

Get them remembering that we do have enough info to make decisions. The MPA Policy gives a worst case physical surrogate approach, and use better biodiv info where you have it.

MPA Policy Coastal classification and mapping scheme:

Level 1. coastal biogeographic regions

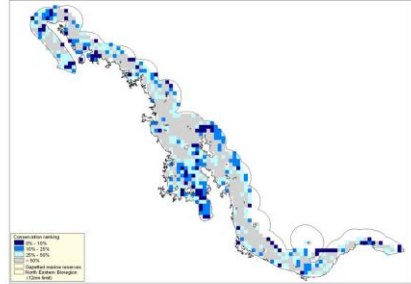


For territorial waters out to 12nm, NZ was divided into 14 bioregions. While the MPA policy states representation of 10%, the guidelines are broad here and in the NZBS commitment to the CBD, and it is assumed, but not mandated that this representation would be at both national and regional scales.

Level 2	Environment type	Estuarine		Marine						
Level 3	Depth	Intertidal	Subtidal	Intertidal			Shallow Subtidal			Deep Subtidal
				(MHWS – MLWS)			(MLWS – 30m)			(30m – 200m)
Level 4	Exposure	low	low	low	med	high	low	med	high	low
Level 5	Habitat type	Mud flat	Mud flat	Mud flat	Sandy beach	Sandy beach	Shallow mud	Shallow sand	Shallow sand	Deep mud
		Sand beach	Sand flat		Gravel beach	Gravel beach		Shallow gravel field	Shallow gravel field	Deep sand
		Gravel beach	Gravel field		Cobble beach	Cobble beach		Shallow cobble field	Shallow cobble field	Deep gravel field
		Cobble beach	Cobble field		Boulder beach	Boulder beach		Shallow boulder reef	Shallow boulder reef	Deep cobble field
		Boulder beach	Boulder reef		Rocky platform	Rocky platform		Shallow Rocky reef	Shallow Rocky reef	Deep boulder field
		Rocky platform	Rocky reef					Shallow Biogenic Reef	Shallow Biogenic Reef	Deep rocky reef
			Biogenic reef							Deep Biogenic reef

Systematic Conservation Planning (SCP) software

- Guide decisions about spatial management of marine seascapes in a systematic, transparent, repeatable way



- Use spatial planning to determine those areas that satisfy marine protection and stakeholder objectives

So once you put all your info together, what next? This is where we have software to help guide us in identifying the best bang for buck. SCP is the name for a number of software tools that have been used to support stakeholder forums such as the HGMSP.

Overall SCP tools do not give you the answer but they:

- allow detailed trade-off of costs and benefits
- evaluate existing MPAs and identify gaps in protection
- can be used to identify locations that provide limited biodiversity benefit

These tools do not give you the answer, but they can help to determine best trade-offs (ie they let you trade off biodiversity and resource use, and maximum one while minimising impacts on the other. You can also identify where best to go next, and also the relative value of different locations for biodiversity (or other) objectives.

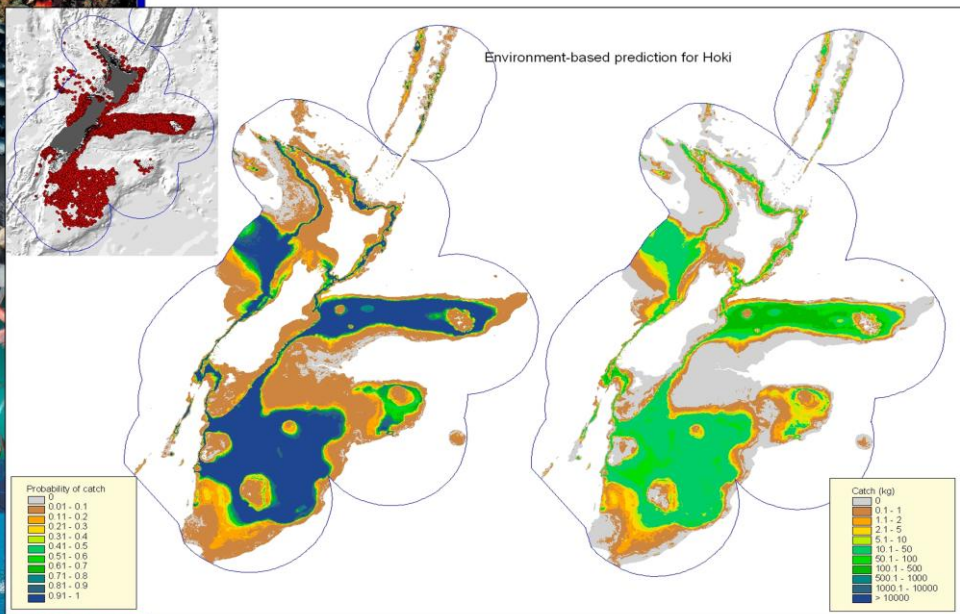


Leathwick et al. (2008)

What is an optimal MPA configuration for the New Zealand EEZ?

- Modelled the distributions of 96 demersal fish species from 21,400 research trawls
- Predicted across entire EEZ
- Analysed species distributions using Zonation to prioritise areas less than 2000 m depth
- Allows consideration of connectivity, varying species weights, costs, evaluation of existing reserves

Hoki...





Optimising MPA design & evaluation

Zonation

- a grid-based algorithm
- Based on specification of priorities & connectivity responses for biodiversity features rather than on setting conservation targets

Starts off assuming all cells protected

- Progressively removes cells with lowest conservation benefit
- Aims to protect core habitat for all species
- Highest value cells left until last
- Produces a nested prioritisation of all cells



Typical options in *Systematic Conservation Planning* software

- Weighting of species to reflect priority
e.g. increase protection accorded to endemics
- Taking account of connectivity
Recognises loss of value with fragmentation
- Use of spatially varying costs to adjust selection
e.g., fishing intensity
- Use of mask layers
exclusion of non-protectable areas
evaluation of the benefits of existing reserves



Trade-off scenarios

- ‘No cost’ – Basic Analysis, higher weight for endemics, species-specific connectivity, equal costs for all cell

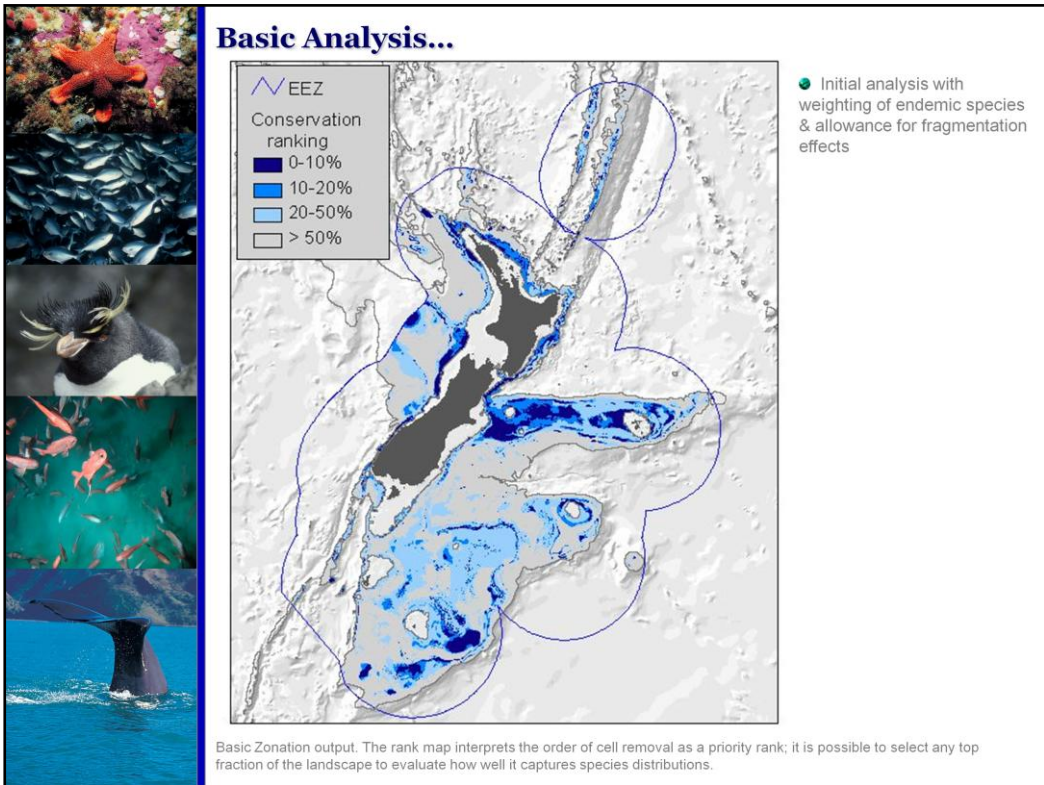
Sites selected solely on conservation value

- ‘Full cost’ – constrained by adding trawl intensity

based on c. 50,000 commercial trawls during 2005

- ‘BPA’ – evaluated the costs and benefits of “*Benthic Protected Areas*” proposed by fishing industry [and later implemented as proposed]

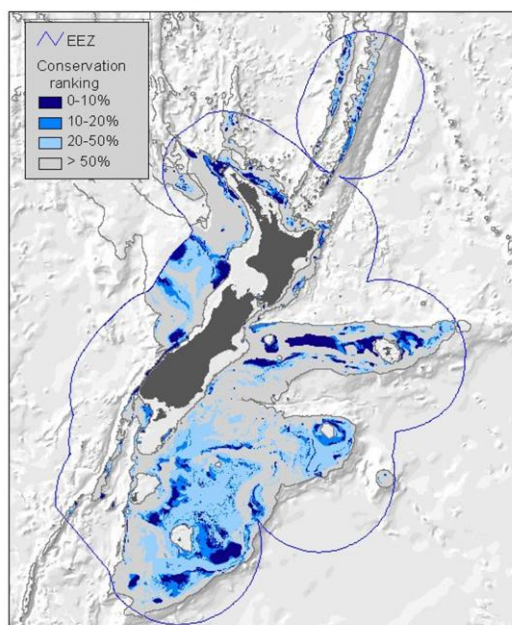
And here you can plot the bang for buck – so 10% of EEZ when chosen using this software can get you 27.4% of the biodiversity protected. 46.4% when you put aside 20%. Not bad.



Darkest blue is highest value, representative network.



Full Cost Analysis...



- Biases selection away from intensively fished areas, substantially reducing cost
- Only marginal loss of protection

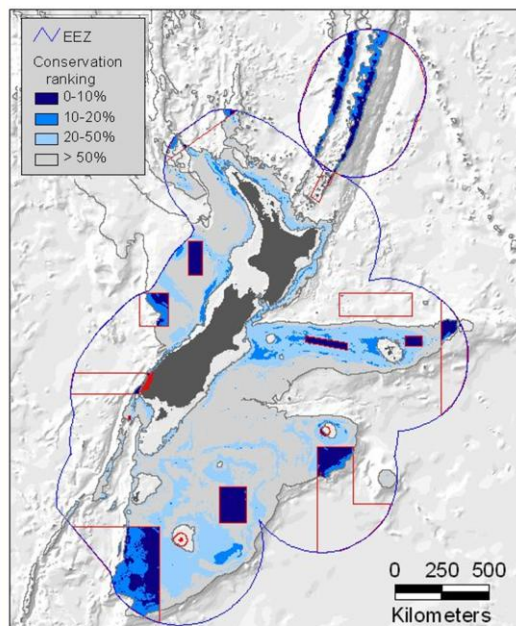
- 10% geographic protection gives 23.4% conservation benefit

- 20% geographic protection would increase this to 35.5%, with no additional loss of fishing opportunity

Cost constraint analysis using a fishing intensity layer to constrain site selection.



BPA Analysis...

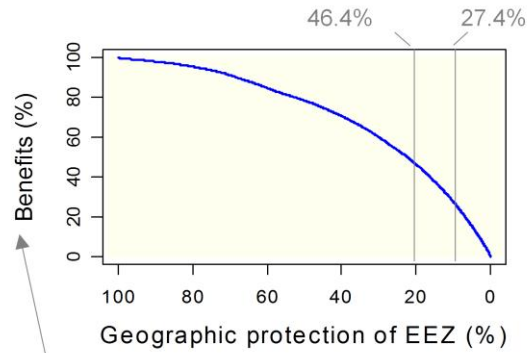


- Very low cost solution 0.2% loss of fishing opportunity
- Very low biodiversity protection – 8.4%
- An equivalent area based on our “Cost constraint” scenario would deliver average species protection of 31.4% at no cost

“BPA” analysis – cells falling within the Benthic protection areas (boundaries shown in red) were retained until all grid cells had been removed.



Basic Analysis...



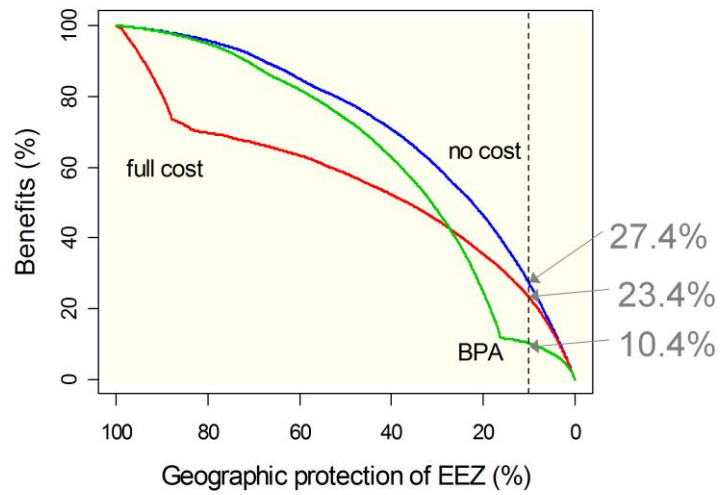
=The average protection of species distributional ranges

Basic Zonation output. The performance curves display the fraction of the distribution remaining for species at each level of landscape removal. The fractions covered for a species are influenced by their assigned weights, when the weight of one species is made ten times that of another species, the balance of the solution changes so that the fraction protected for the first species goes up at the expenses of decreased representation of other species.

And here you can plot the bang for buck – so 10% of EEZ when chosen using this software can get you 27.4% of the biodiversity protected. 46.4% when you put aside 20%. Not bad.

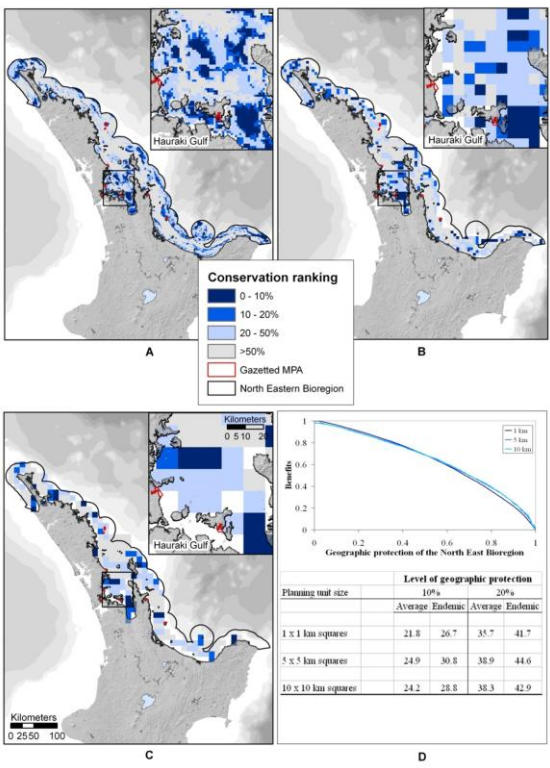


The conservation benefits...

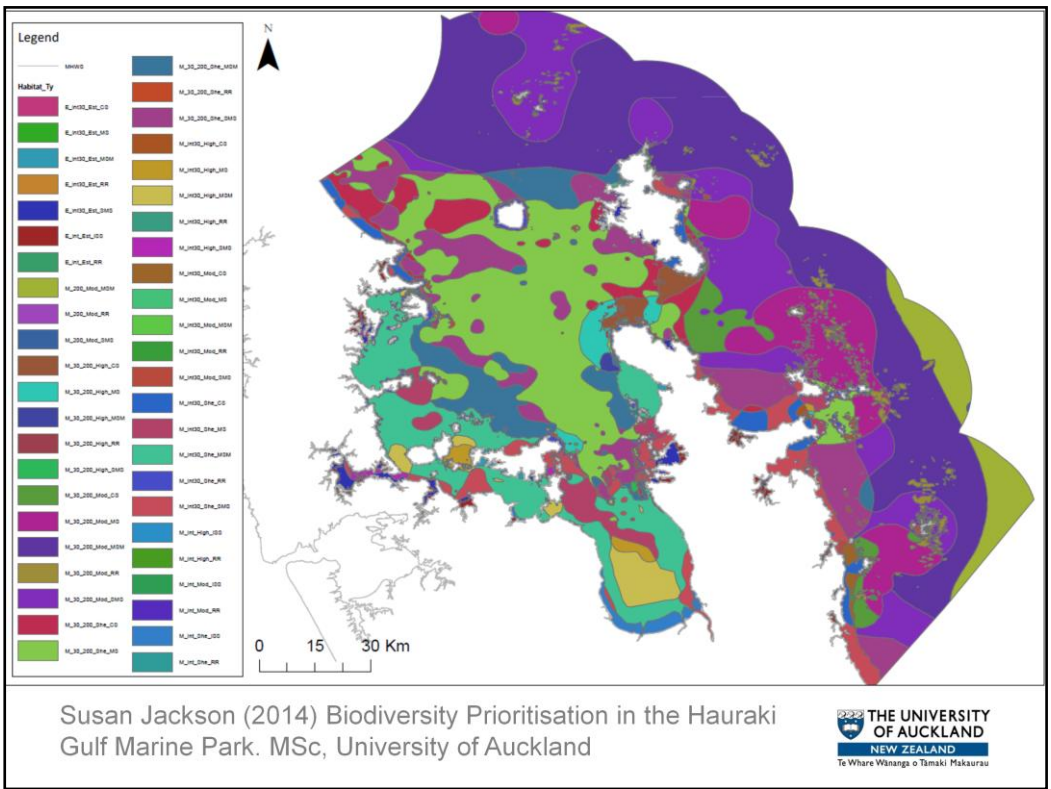


Mean conservation benefits as a function of geographic protection of waters of trawlable depth in the EEZ for 3 Zonation scenarios

Demersal and reef fish biodiversity hot spots identified using Zonation: effect of varying grid size from 1, 5 to 10 km



Another example from Northeast bioregion, this time with no cost included.

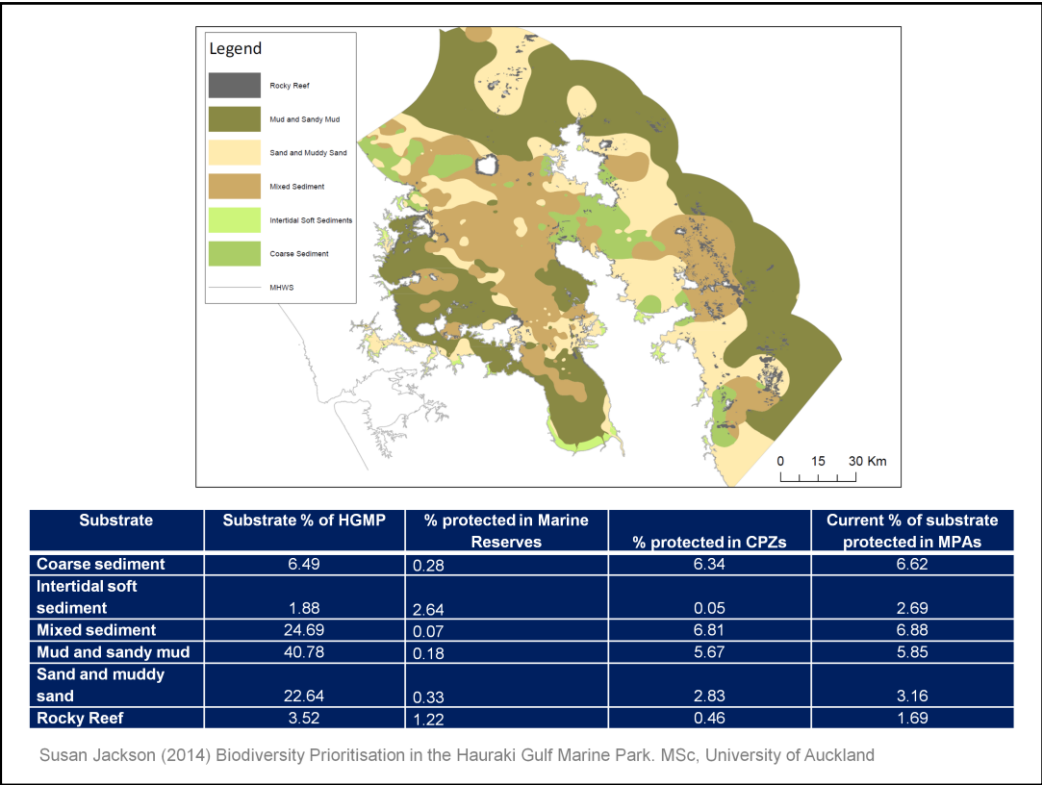


And here is Picasso- an adaptation of the MPA Policy physical habitat surrogates.

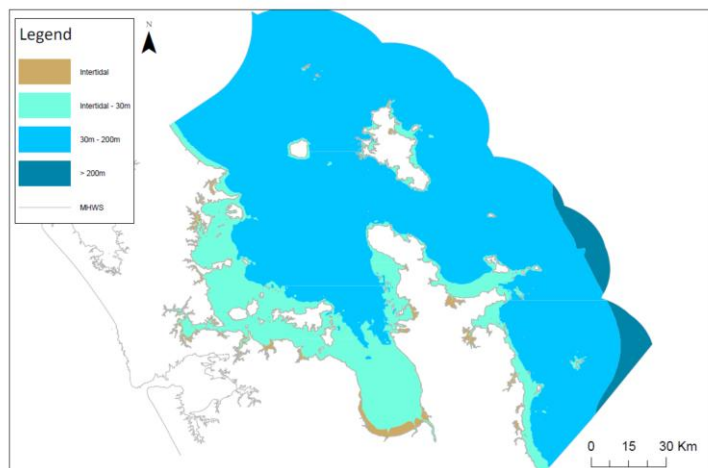
Habitat Type	Habitat % HGMP	% protected in MPAs	Habitat Type	Habitat % HGMP	% protected in MPAs
E_Int_Est_ISS	0.84	4.17	M_30_200_She_RR	0.31	0.42
E_Int_Est_RR	0.00	0.47	M_30_200_She_SMS	7.92	7.77
E_Int30_Est_CS	0.02	0.00	M_Int_High_ISS	0.01	0.00
E_Int30_Est_MS	0.02	0.00	M_Int_High_RR	0.00	0.00
E_Int30_Est_MSM	0.17	2.25	M_Int_Mod_ISS	0.00	0.00
E_Int30_Est_RR	0.05	0.23	M_Int_Mod_RR	0.00	0.00
E_Int30_Est_SMS	0.67	3.00	M_Int_She_ISS	1.04	1.72
M_200_Mod_MSM	3.40	0.00	M_Int_She_RR	0.09	1.75
M_200_Mod_RR	0.00	0.00	M_Int30_High_CS	0.08	0.00
M_200_Mod_SMS	0.01	0.00	M_Int30_High_MS	0.44	0.00
M_30_200_High_CS	0.70	0.00	M_Int30_High_MSM	1.52	1.57
M_30_200_High_MS	0.91	0.00	M_Int30_High_RR	0.10	0.00
M_30_200_High_MSM	0.11	0.00	M_Int30_High_SMS	0.16	0.00
M_30_200_High_RR	0.07	0.00	M_Int30_Mod_CS	0.22	0.00
M_30_200_High_SMS	0.06	0.00	M_Int30_Mod_MS	0.00	0.00
M_30_200_Mod_CS	1.67	2.05	M_Int30_Mod_MSM	0.01	0.00
M_30_200_Mod_MS	6.91	2.00	M_Int30_Mod_RR	0.14	0.00
M_30_200_Mod_MSM	23.81	7.38	M_Int30_Mod_SMS	0.09	0.00
M_30_200_Mod_RR	1.31	0.07	M_Int30_She_CS	1.22	2.82
M_30_200_Mod_SMS	10.62	0.25	M_Int30_She_MS	2.02	5.77
M_30_200_She_CS	2.59	13.97	M_Int30_She_MSM	7.55	5.23
M_30_200_She_MS	14.40	10.04	M_Int30_She_RR	1.43	3.91
M_30_200_She_MSM	4.21	4.94	M_Int30_She_SMS	3.10	1.69

Susan Jackson (2014) Biodiversity Prioritisation in the Hauraki Gulf Marine Park. MSc, University of Auckland

The Picasso habitat classes (e.g. M-30-200_she_MS; Marine, 30-200 depth, sheltered, Muddy Sand). Most important habitats in terms of % HGMP are shown in red. The key is point is that the key habitats aren't rock – they are soft sediment, deep habitats. Few are already above 10% protection, and most of this protection is in the CPZs. This gap analysis can be used to focus on what habitats are not yet well represented as MPAs.



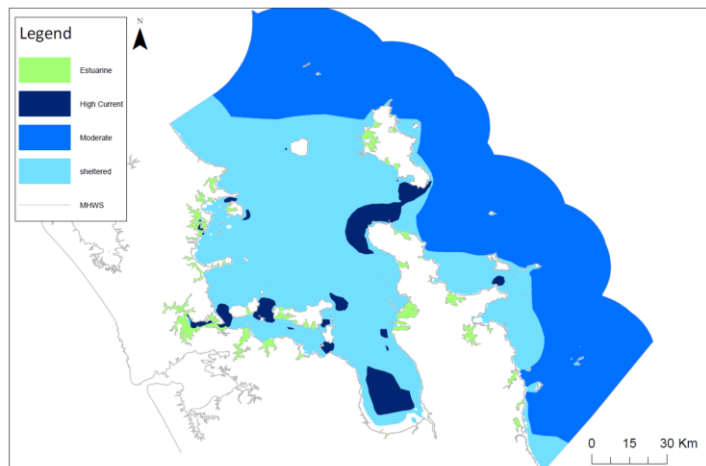
Gaps by sediment.



Depth	Depth % of HGMP	% protected in Marine Reserves	% protected in CPZs	Current % of depth protected in MPAs
Intertidal	1.98	2.58	0.05	2.74
Intertidal - 30m	19.02	1.16	2.53	3.69
30-200m	75.59	>0.01	6.07	6.07
> 200 +	3.41	0	0	0.00

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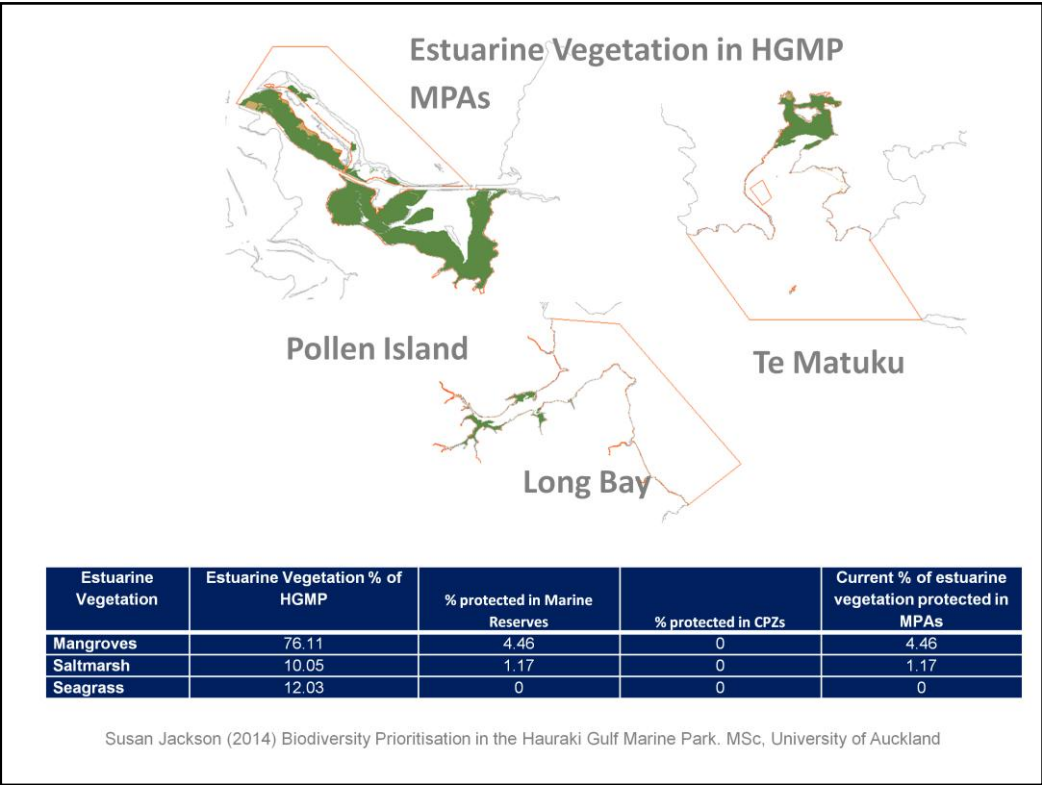
Gaps by depth



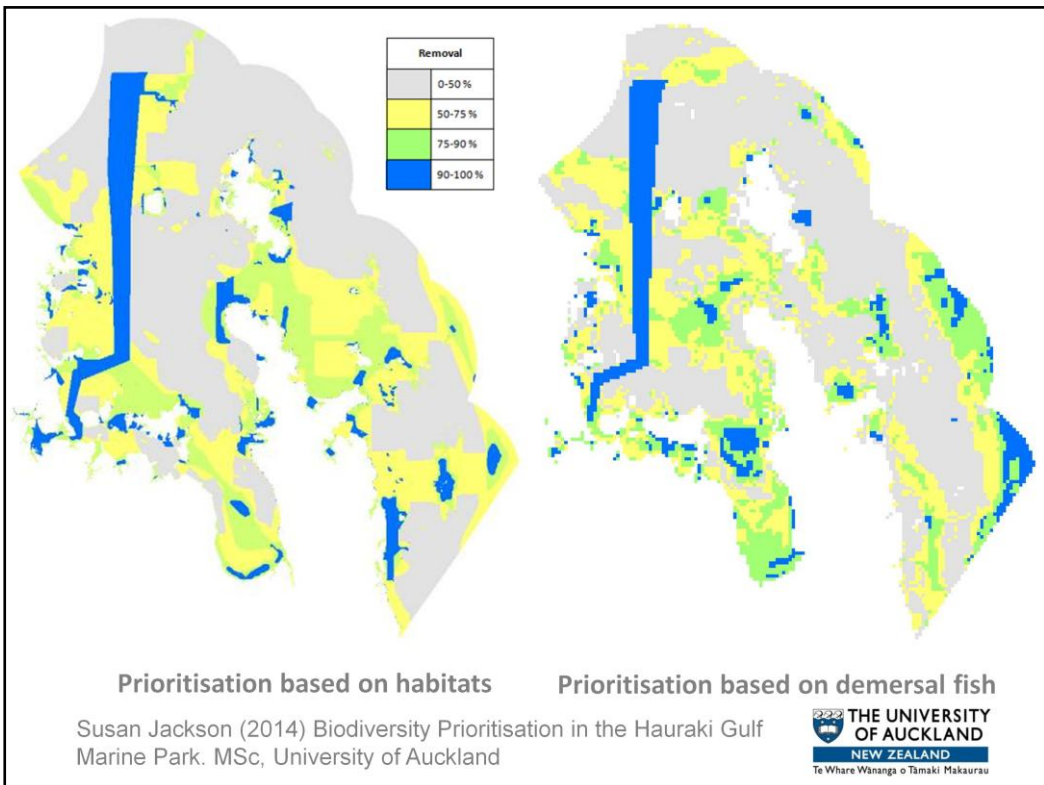
Exposure	Exposure % of HGMP	% protected in Marine Reserves	% protected in CPZs	Combined % protected
Sheltered	43.34	0.39	7.10	7.49
Estuarine	1.81	3.34	0	3.34
High Current	4.16	0	0.58	0.58
Moderate	48.20	0	4.06	4.06
Undefined	2.48	1.84	2.32	2.32

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Gaps by exposure



Gaps by vegetation



You can use tools like Zonation (here another example from Susan's thesis) to show where the hotspots are, here two scenarios run using habitats on the left, and demersal fish only on the right. WE have many data layers that can be used to inform the stakeholder groups objectives whether you want to focus on key species (Brydes), have multiple types of zones with different uses and impacts on biodiversity associated with each, and help inform goals whether these are biodiversity or economic. Happy to discuss further.

The managers dilemma: achieving a balance

Short-term, certain,
sectorial use

"Our conservation actions will be measured eventually, not by the extent of our protected area systems, but by the amount of short-term gain we were willing to forgo to accommodate other species."
Bob Pressey, 21 September 2012

Long-term, less
certain, multiple-
use





Tons of people that have supported HGMSP and datasets to inform it. And esp thanks Clinton!