Marxan with Zones:

Explanation and Examples

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Based on materials developed by:

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Marxan with Zones

- Simulated annealing similar to Marxan, but...

- Can zone conservation areas with different levels of protection, or zone for multiple uses on land and sea

  - Multiple-zones (zone.dat)
  - Zone specific targets (zonetarget.dat)
  - Zone contributions to targets (zonecontrib.dat)

  - Multiple "costs" (revised pu.dat)
  - Different costs in different zones (zonecost.dat)
  - Zone interactions (zoneboundcost.dat)

- Same input files as Marxan plus a few more...

Example Applications

Marine
1. California (Klein 2009, Frontiers in Eco. And Env.)
2. Raja Ampat, Indonesia (Grantham, in prep.)
3. Philippines (Weeks 2010, Conservation Letters)
4. Australia (Segan, in prep. & Stewart, in prep.)

Terrestrial
1. East Kalimantan, Indonesia (Wilson 2009, Eco. Applications)
2. Berau, Indonesia (Venter, in prep.)
3. Gabon, Africa (Lee, in prep.)

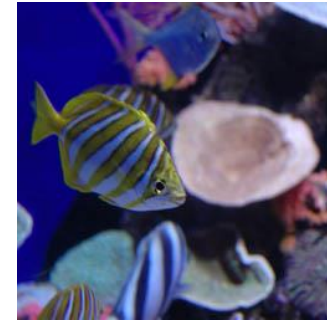# Example: Rottnest Island

Quokka (*Setonix brachyurus*)

Rottnest Island: Multiple-use Marine Park

Conservation of biodiversity

Non-extractive recreation

Recreational Fishing

Separate uses into zones:

Zone Name	Recreational Fishing	Non-extractive recreation
Multiple Use	✓	✓
Partial Protection	X	✓
High Protection	X	X

Rottnest Island Problem Definition

Allocate each planning unit to a zone while:

- Meeting zone feature targets
- Minimising all costs across zones
- Clumping the zones

Allocating to Zones: **Zone.dat**

Define Zones

- Number

- Name

- Activities allowed / prohibited

- Level of protection provided to features

zoneid	zonename
1	multiple_use
2	partial_protection
3	full_protection

zone.dat

Meeting Zone Feature Targets - Data

Not limited to one type of feature

- Biodiversity features

- Recreational features

- Socio-economic features

- Cultural features

- Any type of spatially defined feature!

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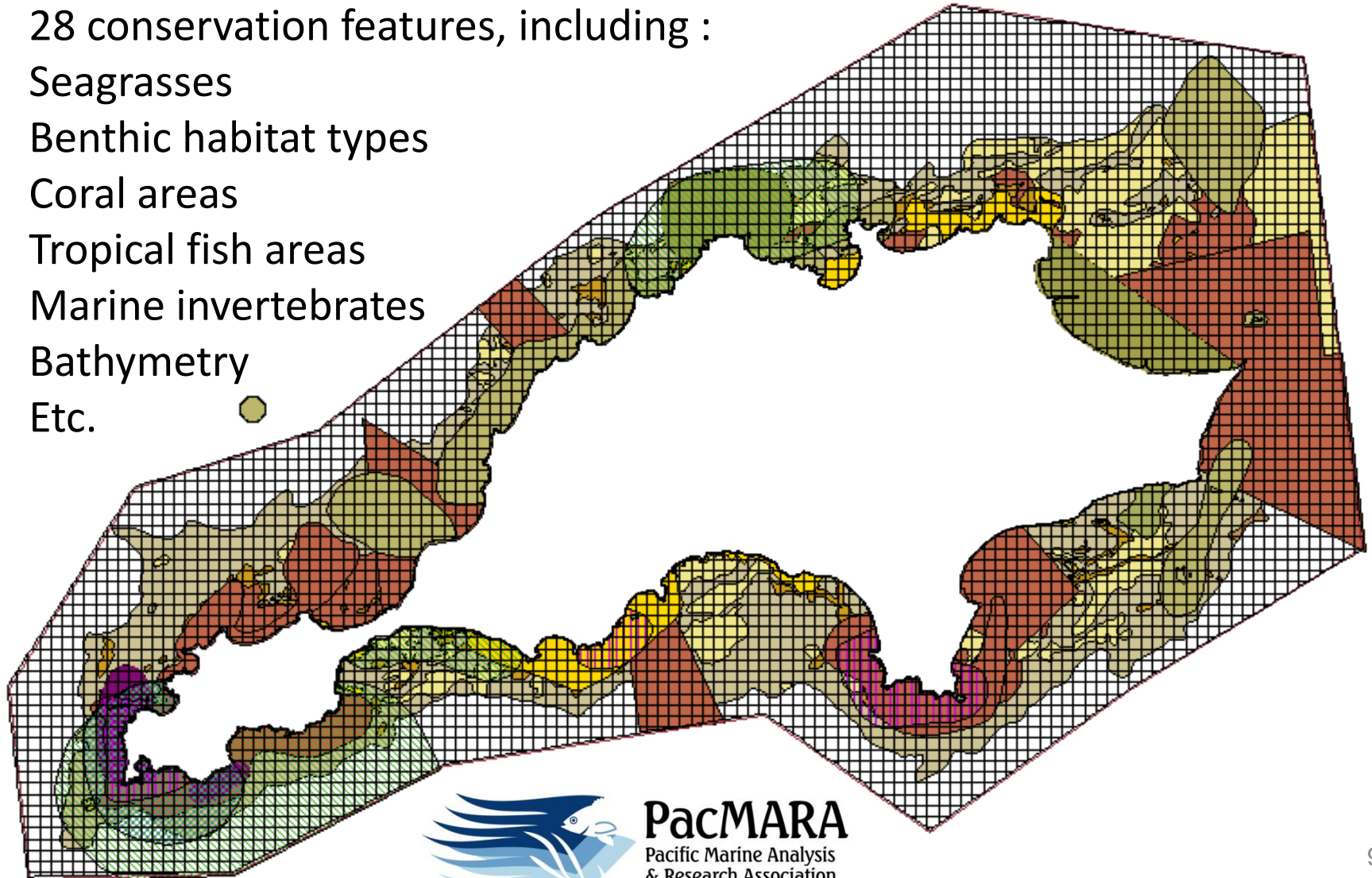28 conservation features, including :
Seagrasses
Benthic habitat types
Coral areas
Tropical fish areas
Marine invertebrates
Bathymetry
Etc.

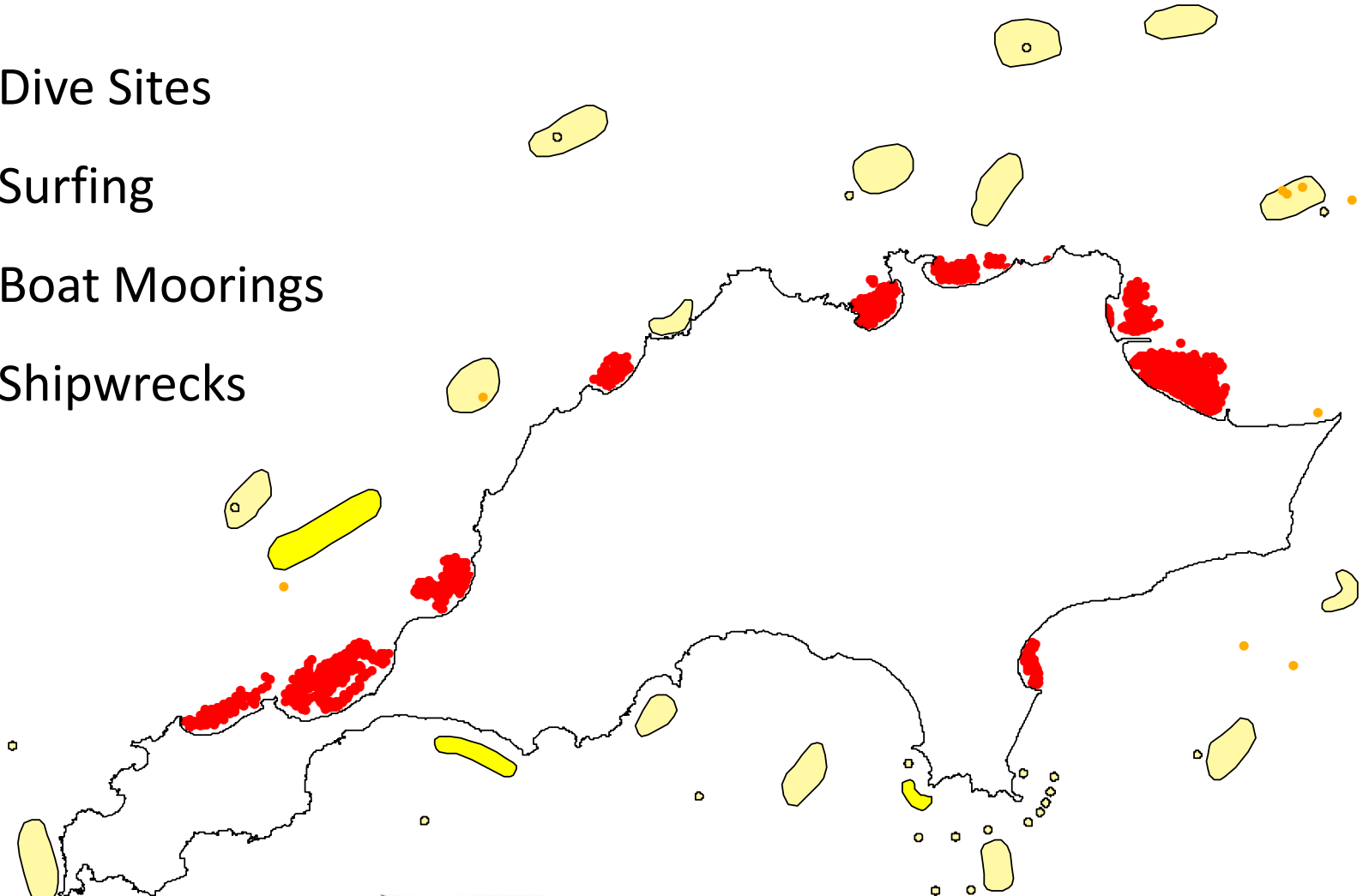
PacMARA
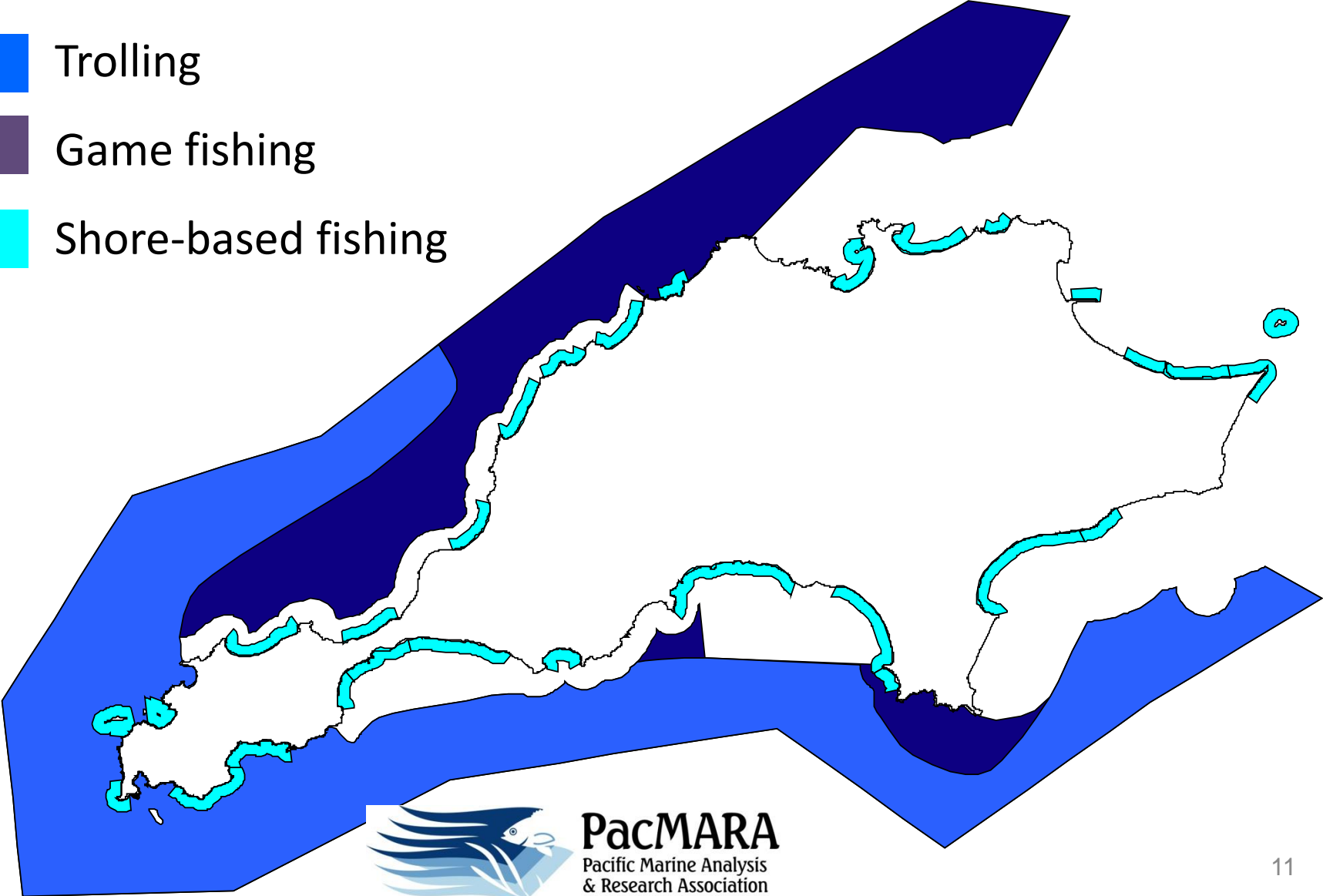Pacific Marine Analysis
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Meeting Zone Feature Targets - Recreational

Dive Sites

Surfing

Boat Moorings

Shipwrecks

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Meeting Zone Feature Targets - Fishing

Trolling

Game fishing

Shore-based fishing

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Meeting Zone Feature Targets

Puvsp.dat

How much of each feature in each *pu*?

- feature id (a.k.a *species*)

- *pu* id

- *amount*

For ALL features

```
species,pu,amount
52,1,0.15
53,1,0.15
52,2,0.48
53,2,0.48
52,3,0.35
53,3,0.35
52,4,0.21
53,4,0.21
52,5,0.05
53,5,0.05
52,6,0.04
53,6,0.04
52,7,0.53
53,7,0.53
32,8,0.02
52,8,0.98
53,8,0.98
32,9,0.38
52,9,1
53,9,1
32,10,0.55
52,10,1
53,10,1
32,11,0.44
52,11,1
53,11,1
32,12,0.15
52,12,1
53,12,1
52,13,0.91
53,13,0.91
52,14,0.75
```

puvspr.dat

Meeting Zone Feature Targets - Overall

feat.dat

- *id*

- *prop*

- *spf*

- *name*

For ALL feature types

id	prop	spf	name
25	0.4	20	REEF
26	0.4	20	REEFAWASH
27	0.4	20	SAND
28	0.4	20	ECHINODERM
29	0.5	20	SHIPWRECK
30	0.5	20	SURFING
31	0.5	20	MOORINGS
32	0.5	20	DIVESITES
33	0.5	20	TROLLING
34	0.5	20	KGW
35	0.5	20	DHUFISH
36	0.5	20	FLATHEAD
37	0.5	20	GARDIES
38	0.5	20	HERRING
39	0.5	20	MULLOWAY
40	0.5	20	SWHITING
41	0.5	20	SALMON
42	0.5	20	SAMSON

Conservation features

Non-extractive recreation features
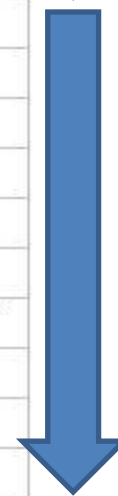
Recreational fishing features

spec.dat   *aka*   feat.dat

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Zone Feature Targets

- Zone specific targets for different feature types

Feature Type	Overall Target	Zone(s) Allowed	Zone - Target
Biodiversity	40%	High and Partial Protection	High Protection- 30% Partial- 10%
Non-extractive recreation	50%	Partial Protection and Multiple Use	Partial- 40% Multiple Use- 10%
Recreational fishing	50%	Multiple Use	Multiple Use- entire overall target

- Rigid - must be met in certain zone

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Defining Zone Feature Targets

zonetarget.dat

Zone-specific targets for different feature types

	Zone 1 multiple_use	Zone 2 partial_protection	Zone 3 full_protection
SEAGR_REEF	0	0.1	0.3
MOLLUSCS1	0	0.1	0.3
MOLLUSCS2	0	0.1	0.3
REEF	0	0.1	0.3
REEFAWASH	0	0.1	0.3
SAND	0	0.1	0.3
ECHINODERM	0	0.1	0.3
SHIPWRECK	0.1	0.4	0
SURFING	0.1	0.4	0
MOORINGS	0.1	0.4	0
DIVESITES	0.1	0.4	0
TROLLING	0.5	0	0
KGW	0.5	0	0
DHUFISH	0.5	0	0
FLATHEAD	0.5	0	0

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zonetarget.dat

Defining Zone Feature Targets - Zone Contribution – **zonecontrib.dat**

Example for conservation features:

- Full protection zone
  - Contributes at 100%
- Partial protection zone
  - Contributes at 50%
- Multiple Use zone
  - Does not contribute

More flexible - can be met across zones

	multiple_use	partial_protection	full_protection
SEAGR_REEF	0	0.5	1
MOLLUSCS1	0	0.5	1
MOLLUSCS2	0	0.5	1
REEF	0	0.5	1
REEFAWASH	0	0.5	1
SAND	0	0.5	1
ECHINODERM	0	0.5	1
SHIPWRECK	0.5	1	0
SURFING	0.5	1	0
MOORINGS	0.5	1	0
DIVESITES	0.5	1	0
TROLLING	1	0	0
KGW	1	0	0
DHUFISH	1	0	0
FLATHEAD	1	0	0
GARDIES	1	0	0
HERRING	1	0	0

zonecontrib.dat

Minimising Cost – **pu.dat**

pu id
ALL COSTS

id	SKIPPY	SPAMACK	SQUID	TAILOR	YELLKING	GAMEFISH	SHIPWRECK	SURFING	MOORINGS	DIVESITES
5607	0	0	0	0	0	1	0	0	0	0
5608	0	0	0	0	0	1	0	0	0	0.4
5609	0.56	0.56	0	0.56	0.56	1	0	0	0	0.26
5610	0.94	0.94	0	0.94	0.94	0.94	0	0	0	0
5611	0.27	0.27	0	0.27	0.27	1	0	0	0	0
5612	0	0	0	0	0	0.99	0	0	0	0
5613	0	0	0	0	0	0.89	0	0	0	0
5614	0	0	0	0	0	0.48	0	0	0	0
5615	0.26	0.26	0	0.26	0.26	0	0	0	0	0
5616	0.74	0.74	0	0.74	0.74	0	0	0	0	0
5617	0.97	0.97	0	0.97	0.97	0	0	0	0	0
5618	0.48	0.48	0	0.48	0.48	0	0	0	0	0
5619	0	0	0	0	0	0.14	0	0	0	0
5620	0	0	0	0	0	0.63	0	0	0	0
5621	0	0	0	0	0	1	0	0	0	0

pu.dat

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Minimising Cost – **zonecost.dat**

Cost applied to activities
not allowed /discouraged
in zone definition

- Different costs per zone

- Multiple costs per zone

- Zone-specific multiplier used
 to weight and sum costs

Zone boundary cost helps
further separate conflicting
uses or cluster compatible uses

	multiple_use	partial_protection	full_protection
TROLLING	0	10	10
KGW	0	10	10
DHUFISH	0	10	10
FLATHEAD	0	10	10
GARDIES	0	10	10
HERRING	0	10	10
MULLOWAY	0	10	10
SWHITING	0	10	10
SALMON	0	10	10
SAMSON	0	10	10
SANDPIKE	0	10	10
SILBREAM	0	10	10
SKIPPY	0	10	10
SPAMACK	0	10	10
SQUID	0	10	10
TAILOR	0	10	10
YELLKING	0	10	10
GAMEFISH	0	10	10
SHIPWRECK	5	0	10
SURFING	5	0	10
MOORINGS	5	0	10
DIVESITES	5	0	10

Zonecost.dat

Clumping Zones – **bound.dat**

Define boundaries
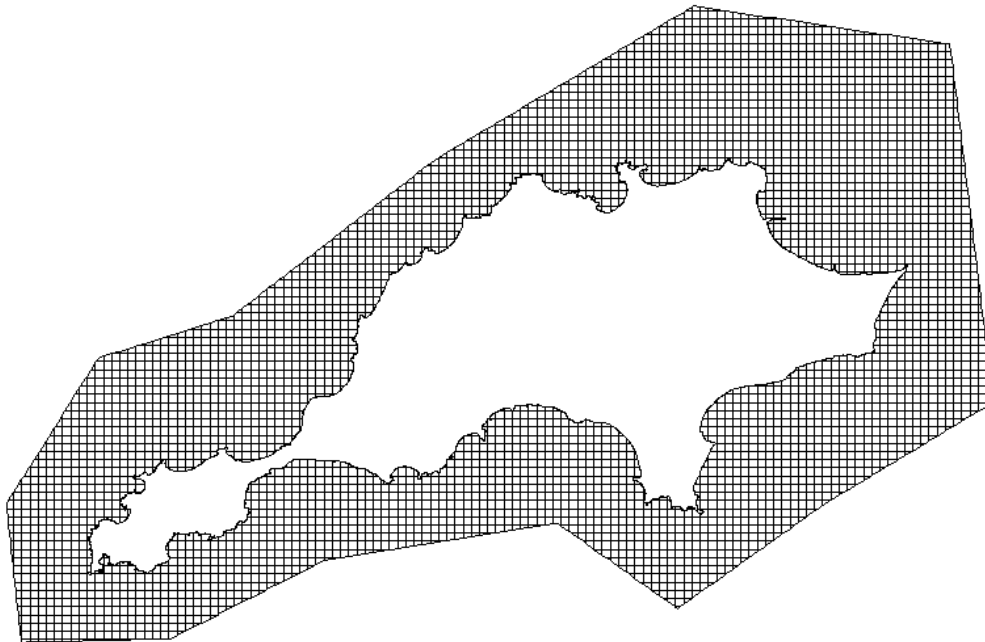

```
id1,id2,boundary
1,1,82.6972
1,2,42.2405
1,8,71.0955
2,2,104.244
2,3,42.656
2,9,100
3,3,101.106
3,4,27.7402
3,10,100
4,4,101.106
4,5,12.8245
4,11,100
5,5,86.9305
5,12,85.9794
6,6,45.8374
6,7,23.413
6,22,39.4068
7,7,116.319
7,8,82.8268
7,23,100
8,8,33.6213
8,9,100
8,24,100
9,10,100
9,25,100
10,11,100
10,26,100
11,12,100
11,27,100
12,12,14.1757
12,13,97.9087
12,28,100
13,13,101.106
13,14,82.993
13,29,100
14,14,101.106
```
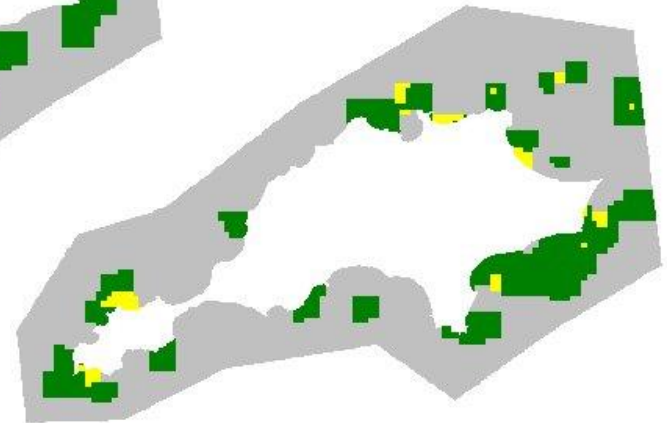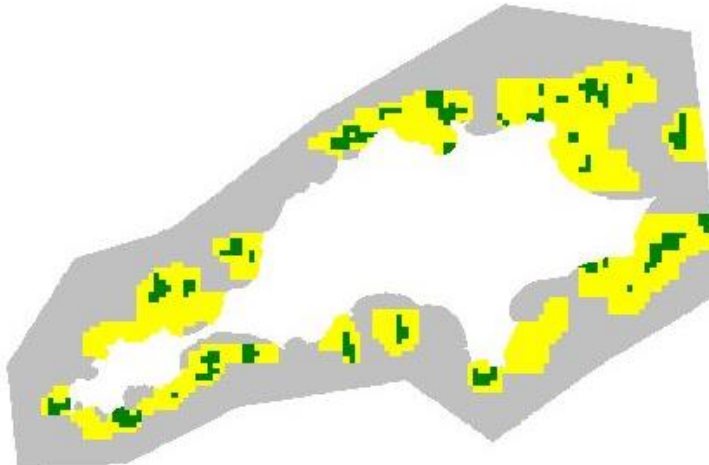
bound.dat

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Clumping Zones

Separate uses
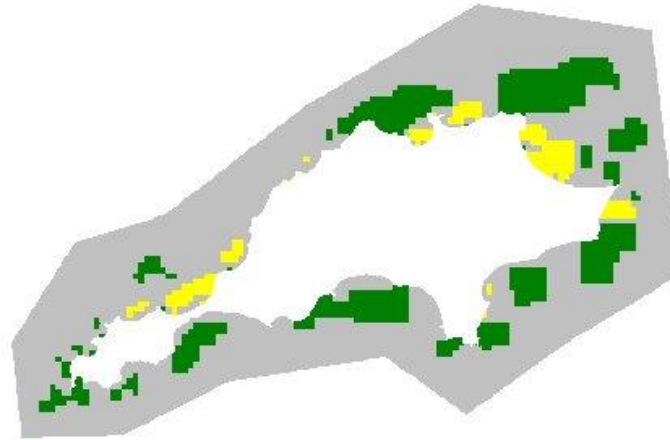
Cluster zones

Buffer zones

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Clumping Zones

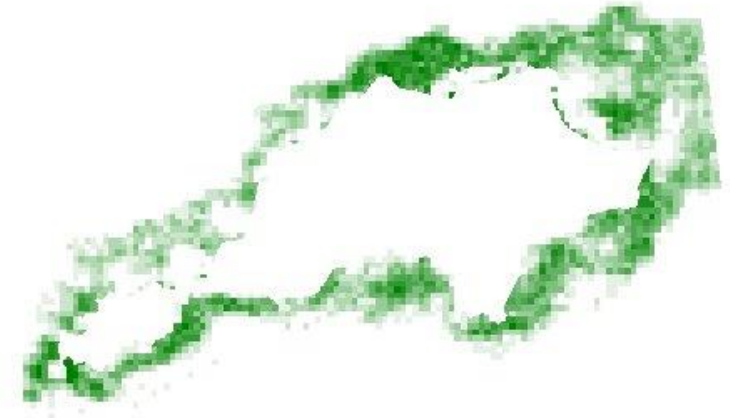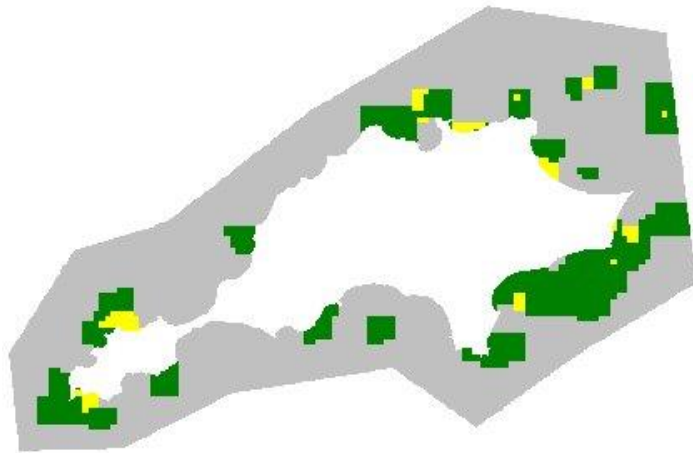|	multiple_use	partial_protection	full_protection
multiple_use	0	0.35	1
partial_protection	0.35	0	0.5
full_protection	1	0.5	0

zoneboundcost.dat
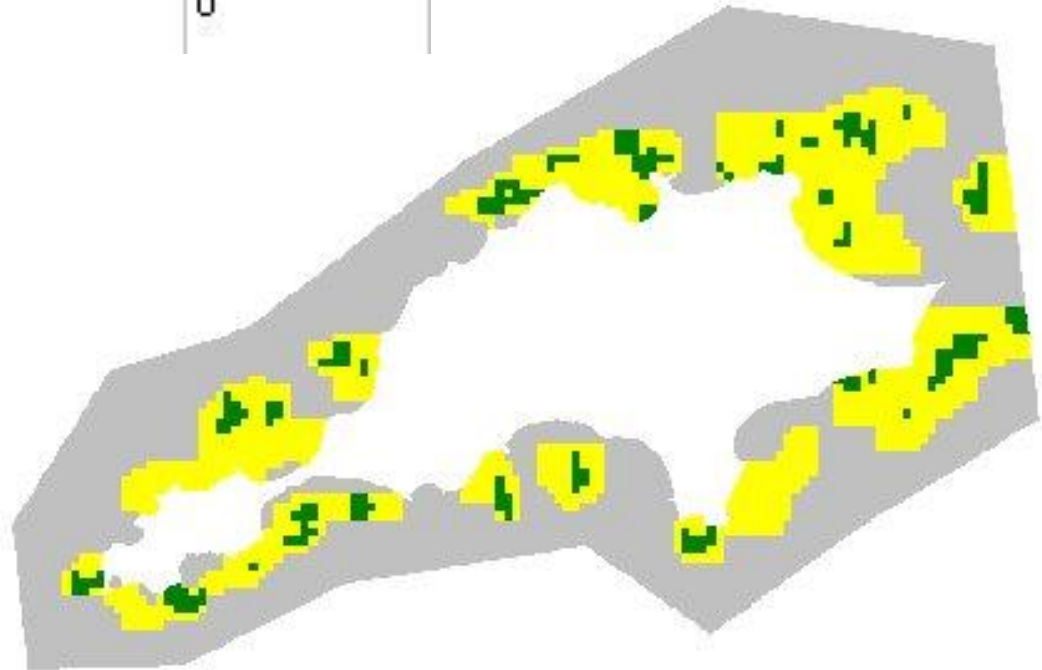
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Outputs of Marxan with Zones

Selection Frequency for each

Individual solutions

Missing value file for each solution

Summary file

Example: Zoning for Fisheries & Conservation

Socio-econ advantages with Zones for CA MLPA?

- Habitat and depth data, commercial fishing value

- 8 fisheries, 5 zones – fishing restrictions vary

- 2 scenarios with different zone-specific targets
 – Biodiversity feature %
  – Fisheries value %

Klein et al. 2009
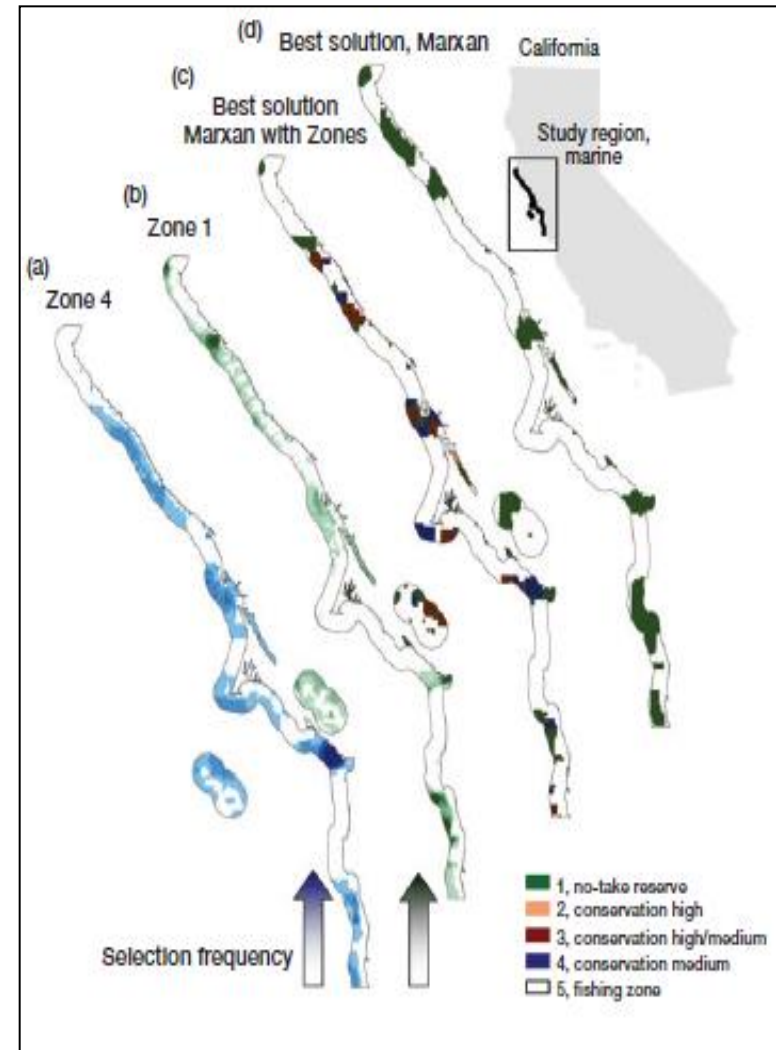
Zoning for Fisheries and Conservation

Zones	Marxan	Marxan with Zones	
		Conservation targets	Fishing targets
No-take reserve	30%	10%	No fishing allowed
Conservation area (high)			
Conservation area (high/medium)		30%	
Conservation area (medium)			
Fishing zone			

Klein et al. 2009

Zoning for Fisheries and Conservation

Klein et al. 2009
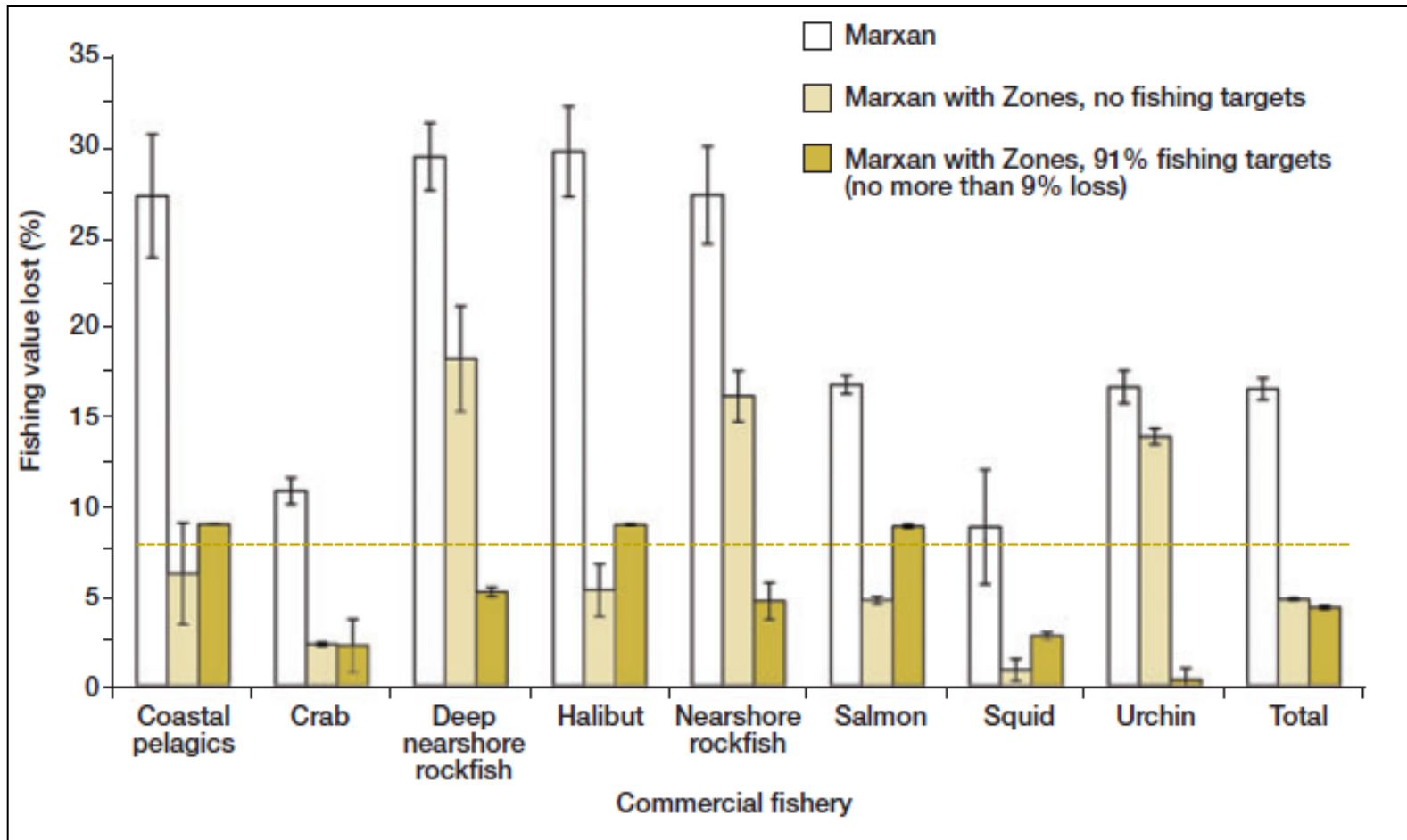
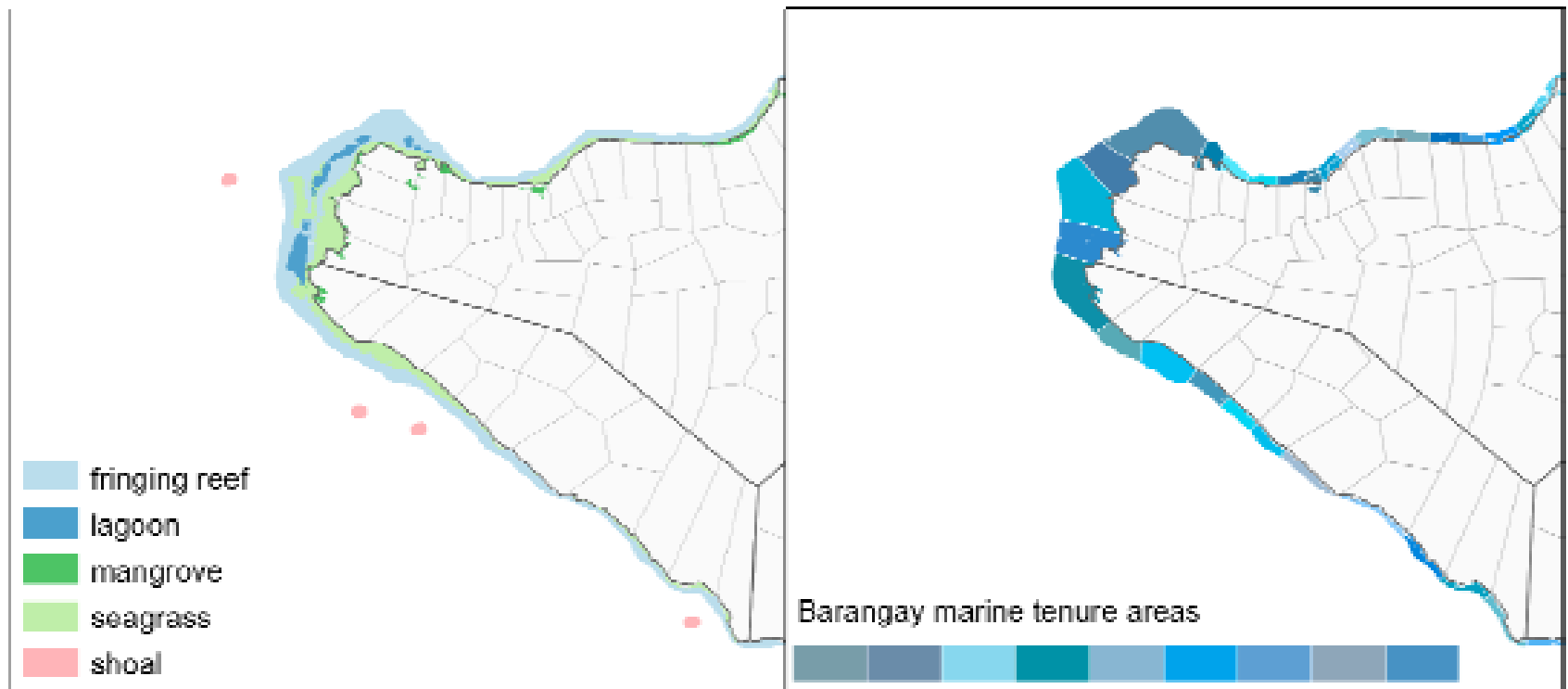# Incorporating local marine tenure in the design of MPA networks in the Philippines

- Siquijor island

- Population = 88,000

- 68 coastal communities
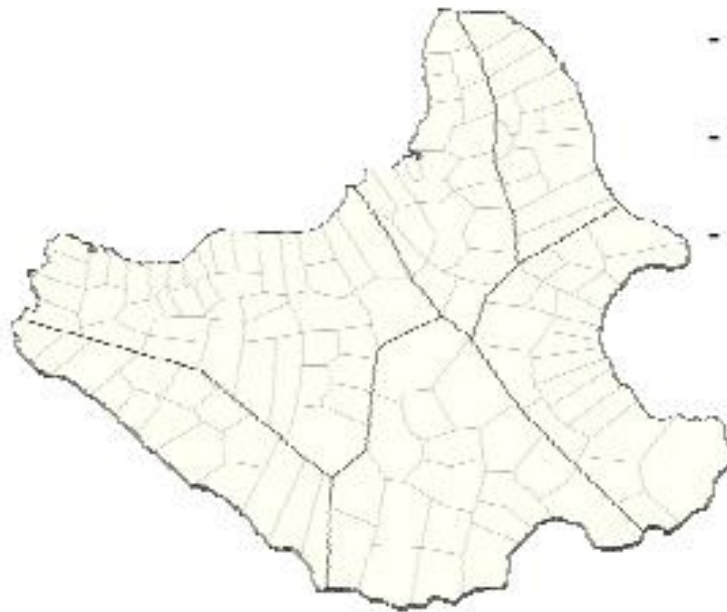
Barangay boundaries
Municipal boundaries

0 1 2 3 4 5   10   15 Kilometers

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fringing reef
lagoon
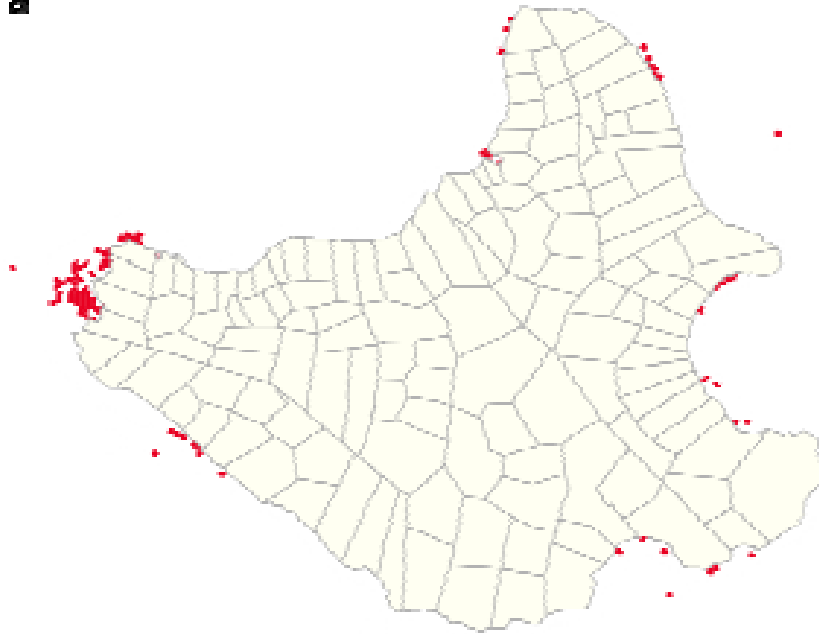mangrove
seagrass
shoal

Barangay marine tenure areas

- Marxan with Zones

- **Setting targets for socioeconomic activities**, rather than treating them as costs to be avoided may **better engage stakeholders**

- Biodiversity target = 10% of each habitat type **in MPAs**

- Fishery target = 80% fishing grounds associated with each coastal community **in areas open to fishing**
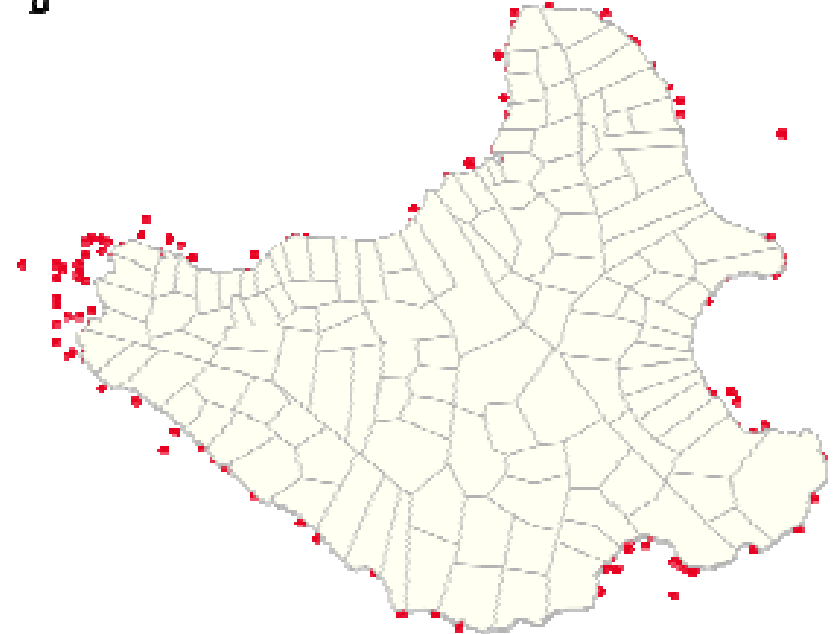
a

b

Minimising cost to small-scale fishers
as a single stakeholder group:
Some communities lose 80% of
fishing grounds

Setting fishery targets for each
community:
No community loses more than 13%
of fishing grounds

- Incorporating marine tenure boundaries **distributes the cost of MPA network implementation more equitably**

- But results in **more fragmented** MPA networks

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Conclusion

- Most conservation planning involves zoning

- Much more complex

- Better engage stakeholders

- Efficiently meet conservation objectives with less impact on socio-economic values

- Decision support, not decision maker

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