May 1st, 10:30 AM - 12:00 PM

Spatio-temporal dynamics of Marbled Murrelet hotspots during nesting in nearshore waters along the Washington to California coast

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Nest site abundance and quality

Nest predators, disease

Pollution, oil spills, gill-nets, disease

Oceanographic conditions

Production of young

Prey abundance and distribution

Recruitment

Adult survival

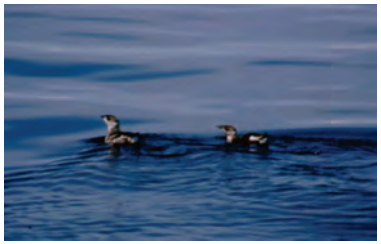
Distribution and movement

Population status and trend

Assessing relative influence of marine and forest habitat attributes

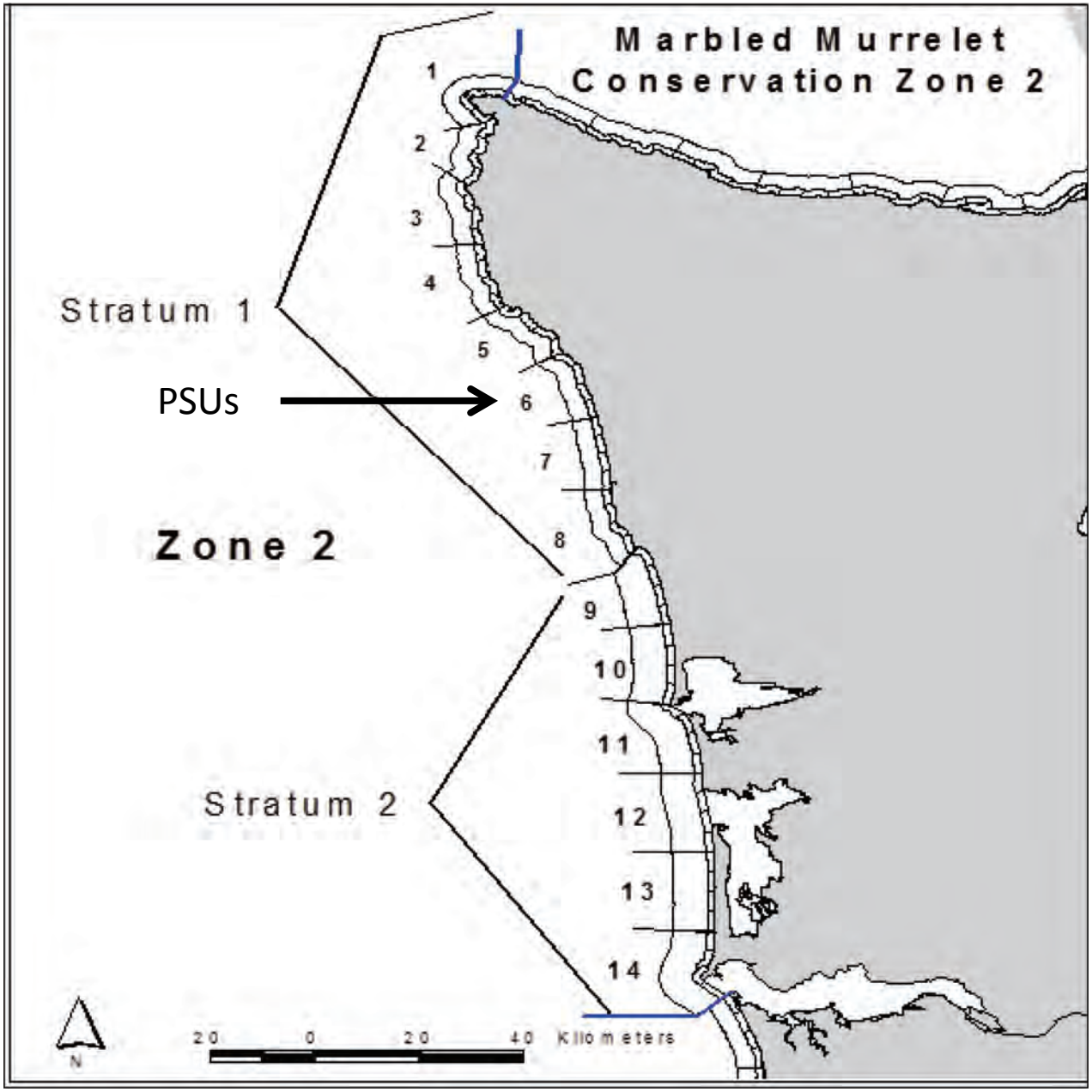
- Document spatial and temporal distribution of marbled murrelets in WA, OR, CA
- Estimate amount and trend of nesting habitat
- Estimate amount and trend of foraging habitat
- Assess relative contributions of marine and terrestrial factors to predict spatial and temporal distribution of murrelets

Murrelet Range in WA, OR, CA



- 6 Conservation Zones (Recovery Plan)
- We survey zones 1 to 5

An Example of Primary Sample Unit (PSU) Layout

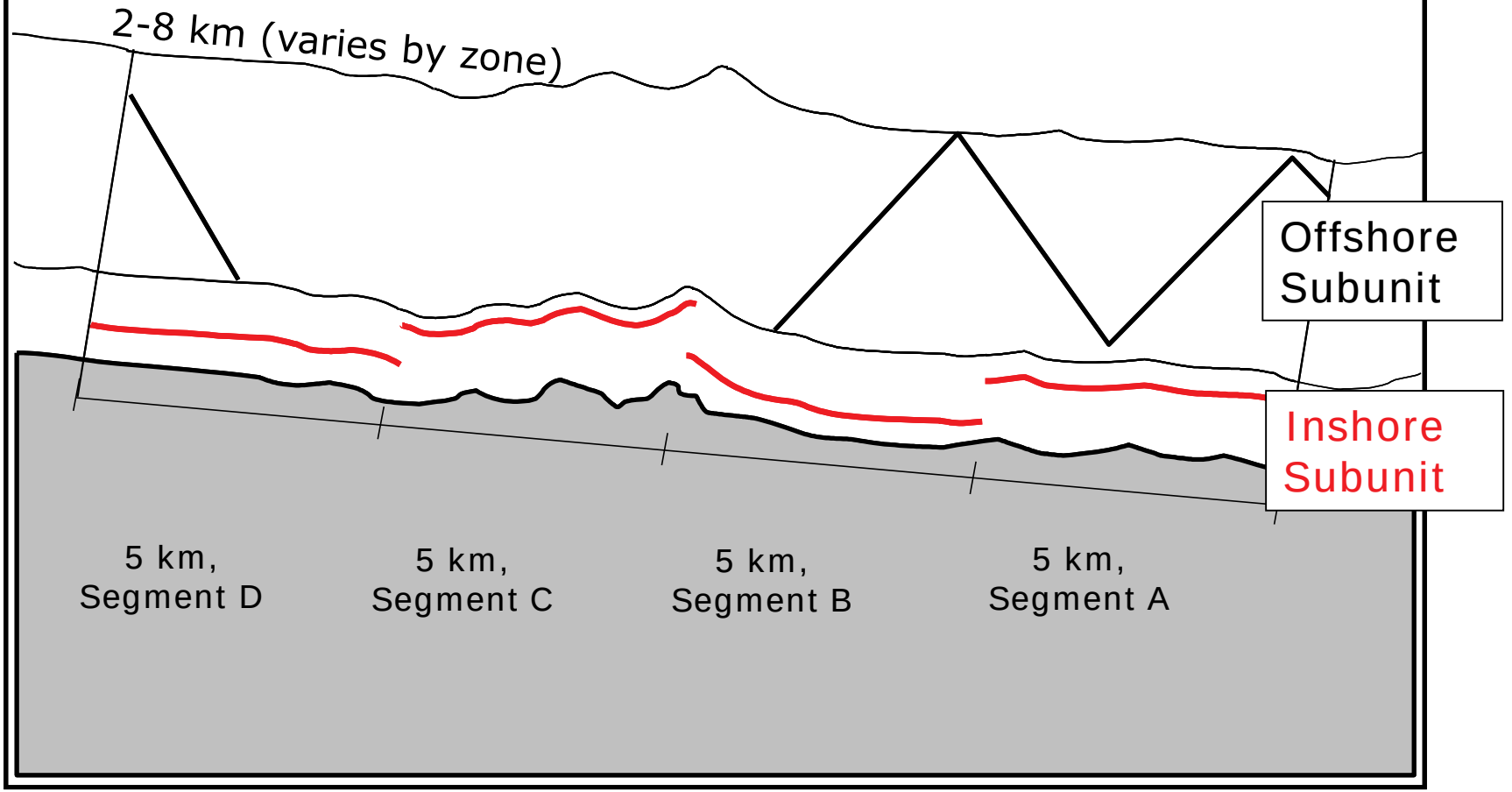


Sampling within a PSU

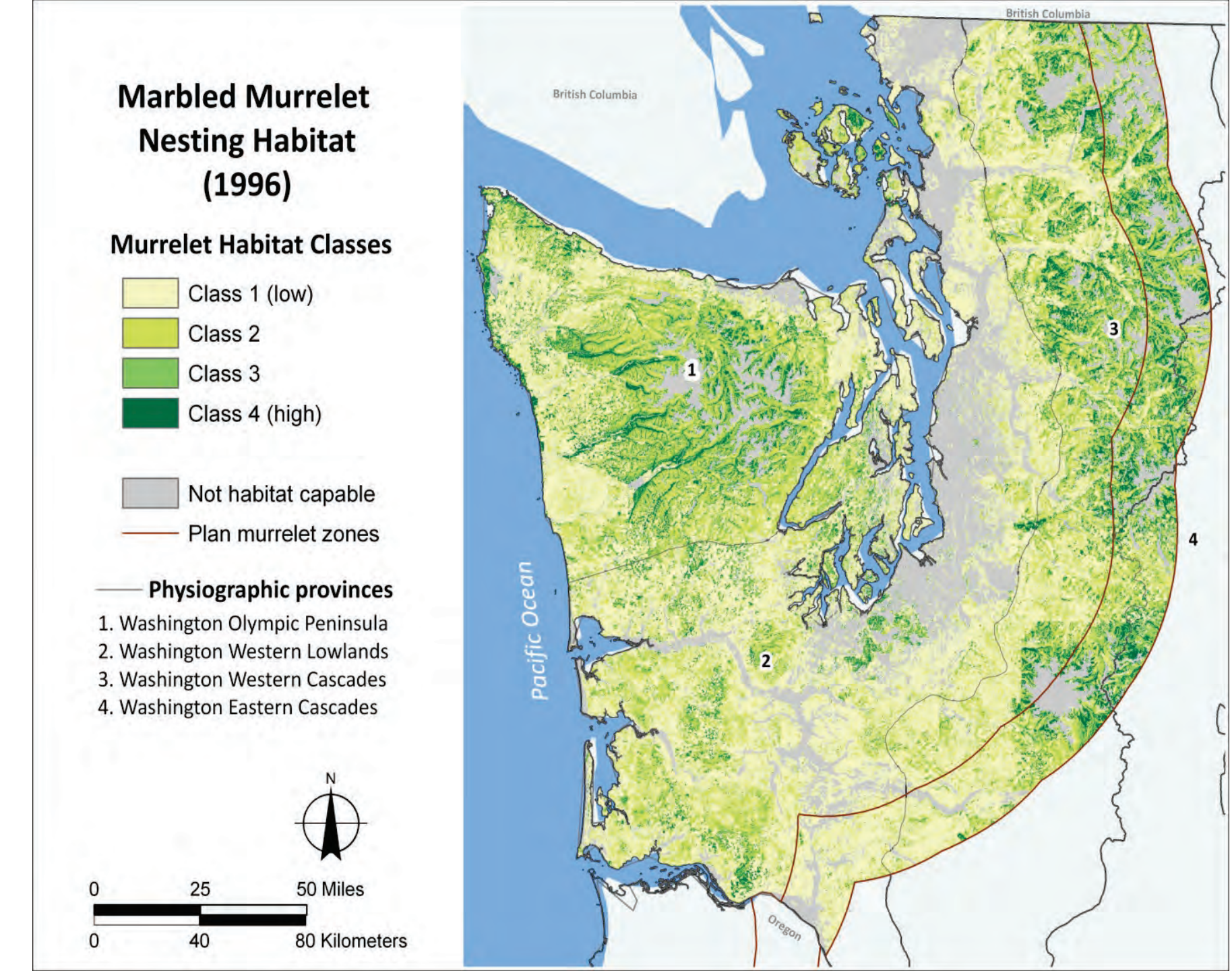
Each sample:

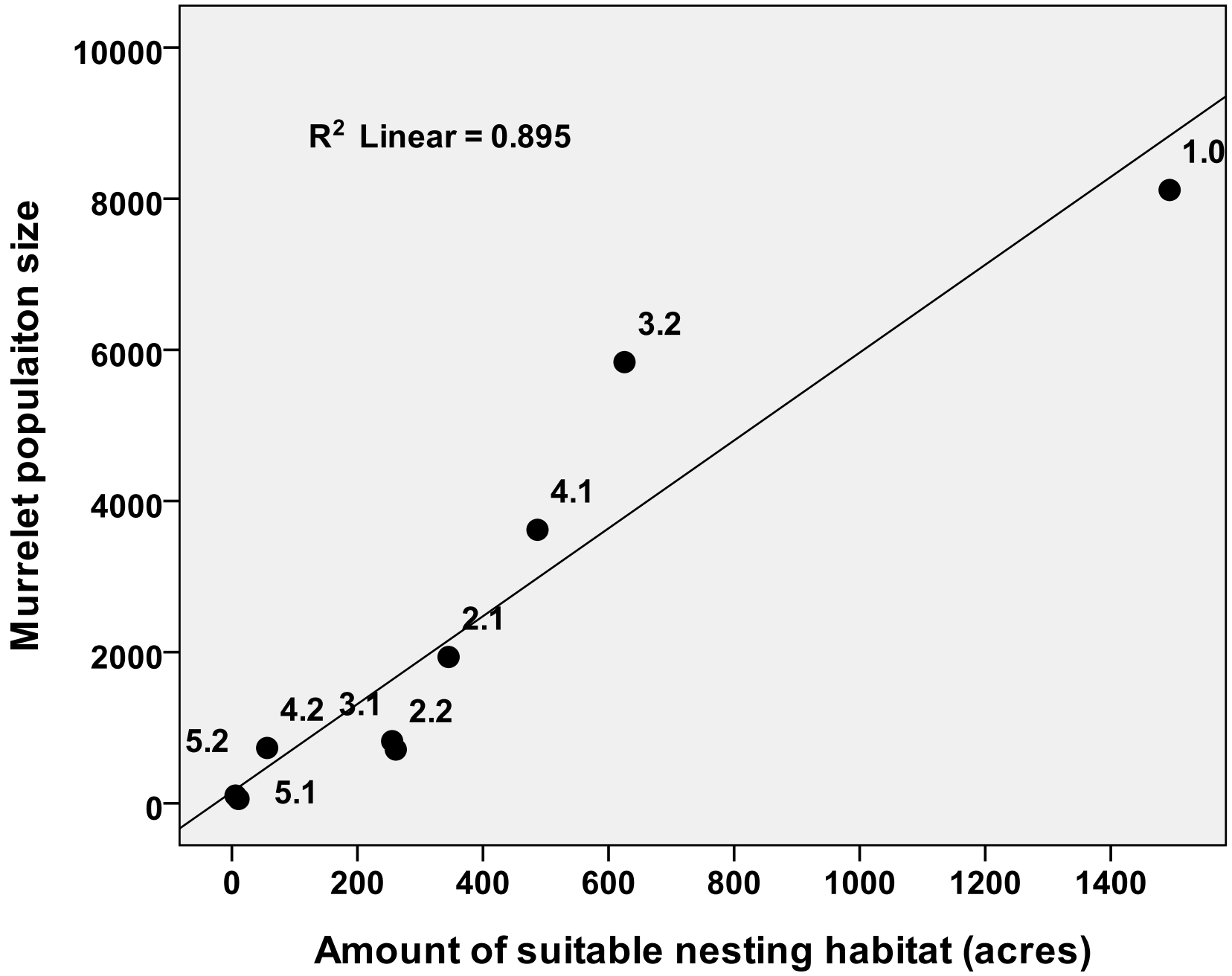
4 inshore segments

1 offshore segment (zigzag)

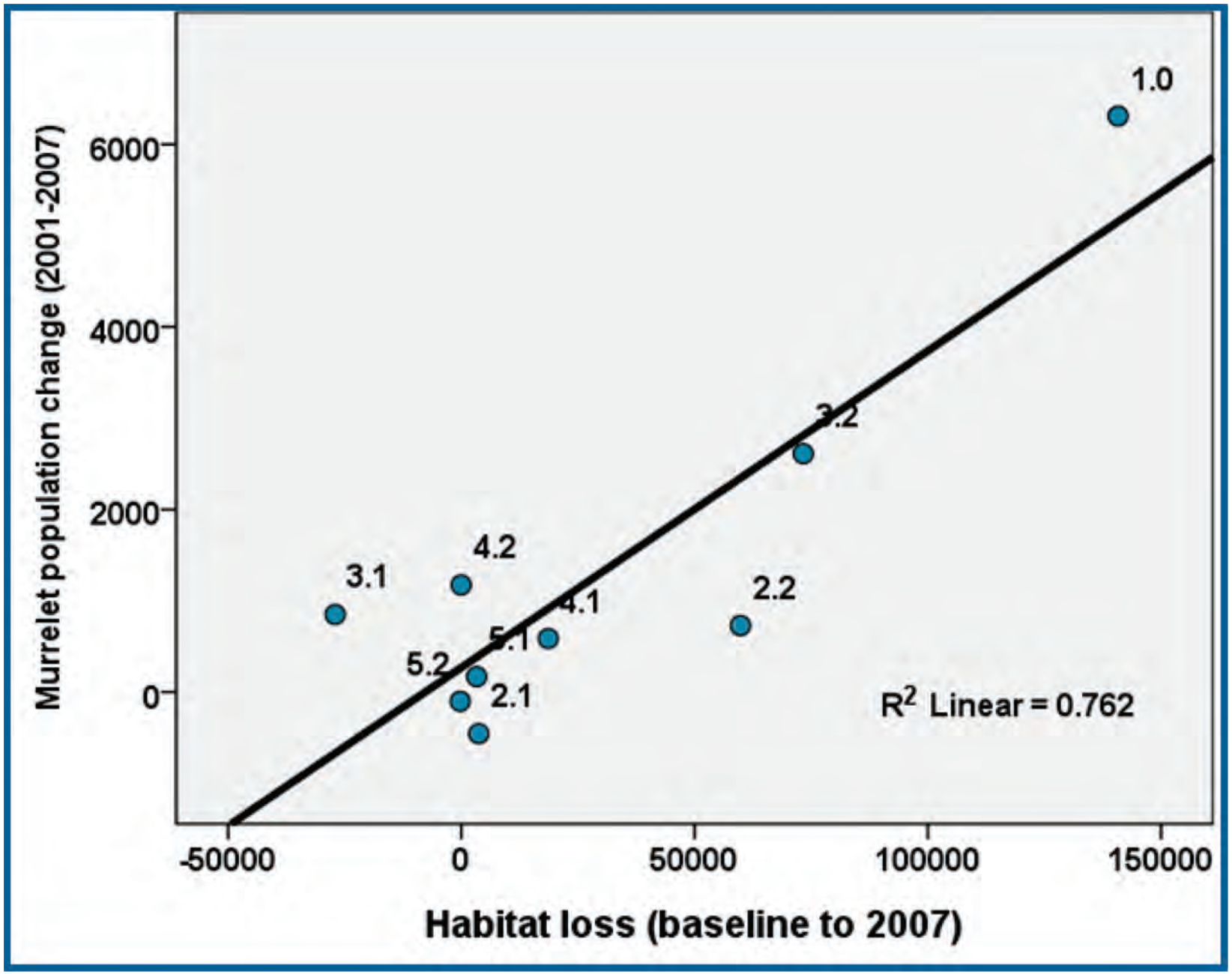


Marbled Murrelet Nesting Habitat (1996)




R^2 Linear = 0.895
Murrelet populaiton size
Amount of suitable nesting habitat (acres)
10000
8000
6000
4000
2000
0
0
200
400
600
800
1000
1200
1400
1.0
3.2
4.1
2.1
4.2
3.1
2.2
5.2
5.1

Murrelet population decline is related to loss of habitat



Model details

Observational data

3954 observations (annual counts of a PSU segment)
Years: 2000-2012
Months: May-July

Covariates (21 in initial model, plus autoregression term)

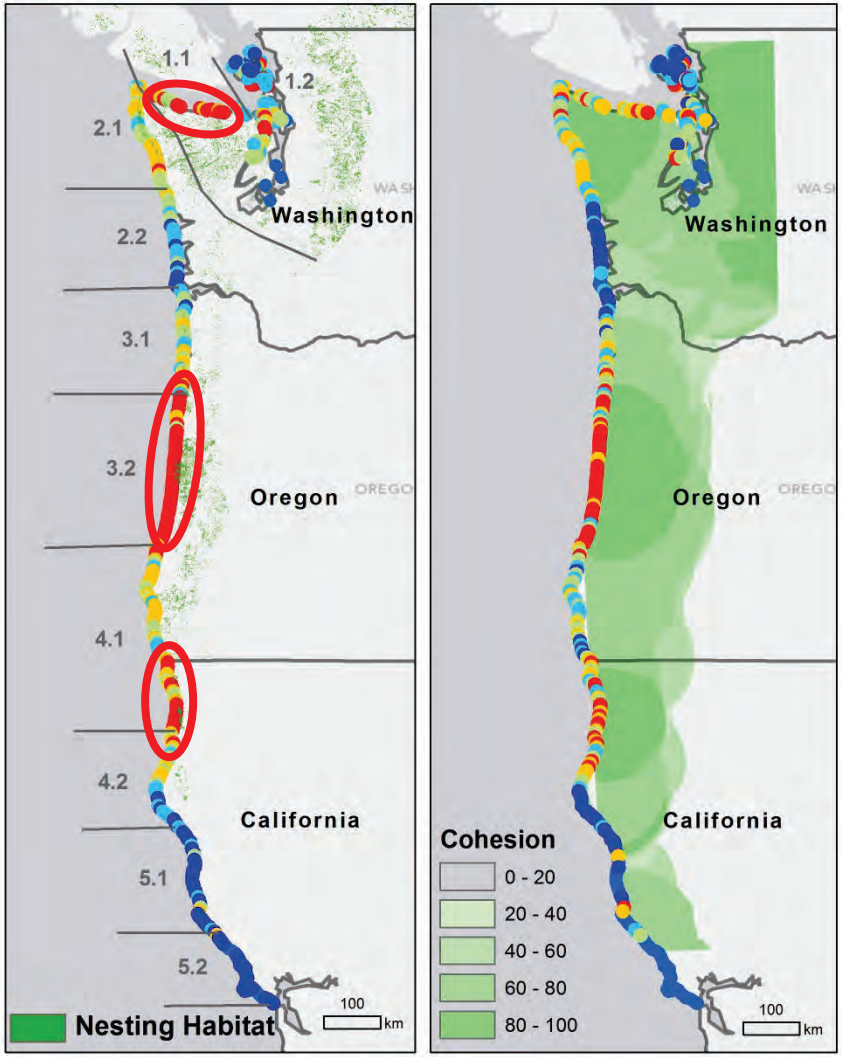
8 temporal covariates
7 spatial covariates
6 spatial and temporal covariates
1 autoregression term

Boosted Regression Tree (implemented via GBM package in R)

Response: mean of replicated PSU segment counts
Family: poisson
Learning rate: 0.01 (weight of each new tree to model fit)
Bag fraction: 0.5 (half the data is used to train the model)
Tree complexity: 5
Crossvalidation folds: 5

Model Covariates

Spatial	Temporal	Spatiotemporal
Distance to Major River	Biological Transition Day	Nesting Habitat (80 km)
Distance to Shore	Spring Physical Transition Day	Nesting Habitat Cohesion
Shoreline Type	Upwelling Anomaly	Summer SST
Mean Depth w/in 10 km	Upwelling Season Duration	Winter SST
Foraging Area w/in 10 km	Winter Oceanic El Nino Index	Summer Chlorophyll A
Marine Human Footprint	Summer Oceanic El Nino Index	Winter Chlorophyll A
Terrestrial Human Footprint	Winter PDO Index	
Residuals Autocorrelation	Summer PDO Index	



Mean Density (birds/km2)

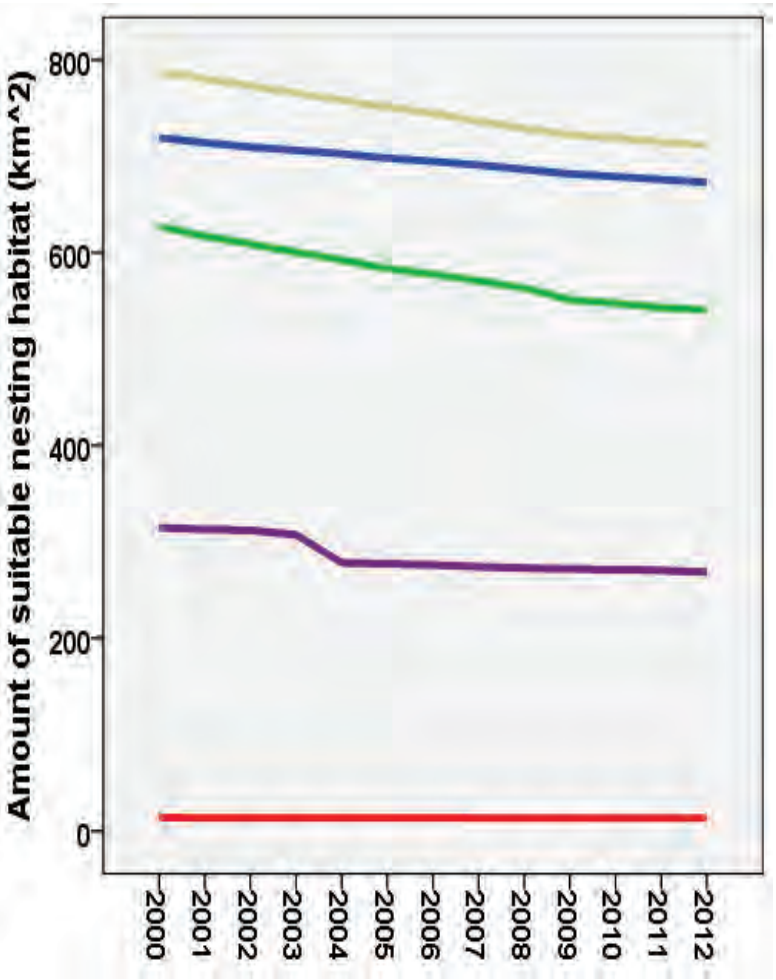
- 0.0 - 0.1
- 0.2 - 0.8
- 0.9 - 2.4
- 2.5 - 8.5
- 8.6 - 51.7

Coefficient of Variation

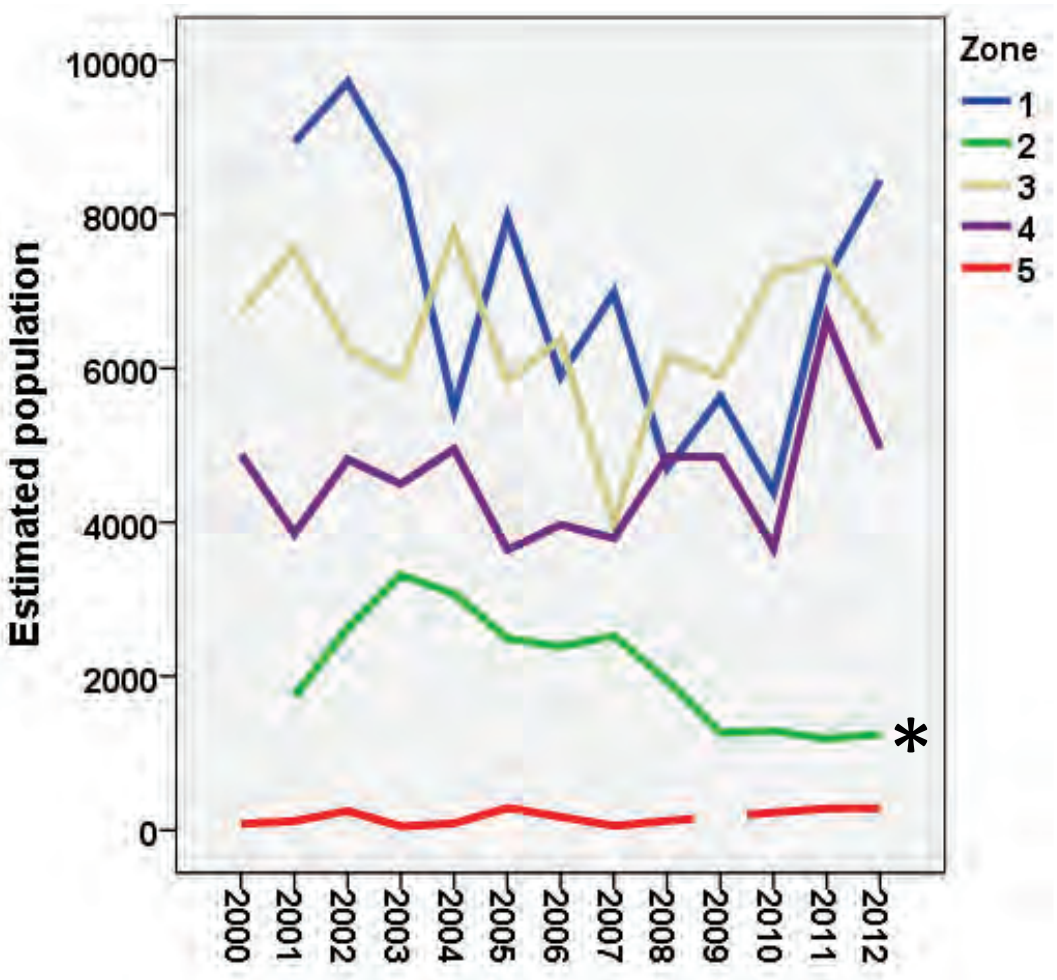
- 41.6 - 87.6
- 87.7 - 111.3
- 111.4 - 148.2
- 148.3 - 214.4
- 214.5 - 360.6

Spatial and temporal variation by Zone

Amount of nesting habitat

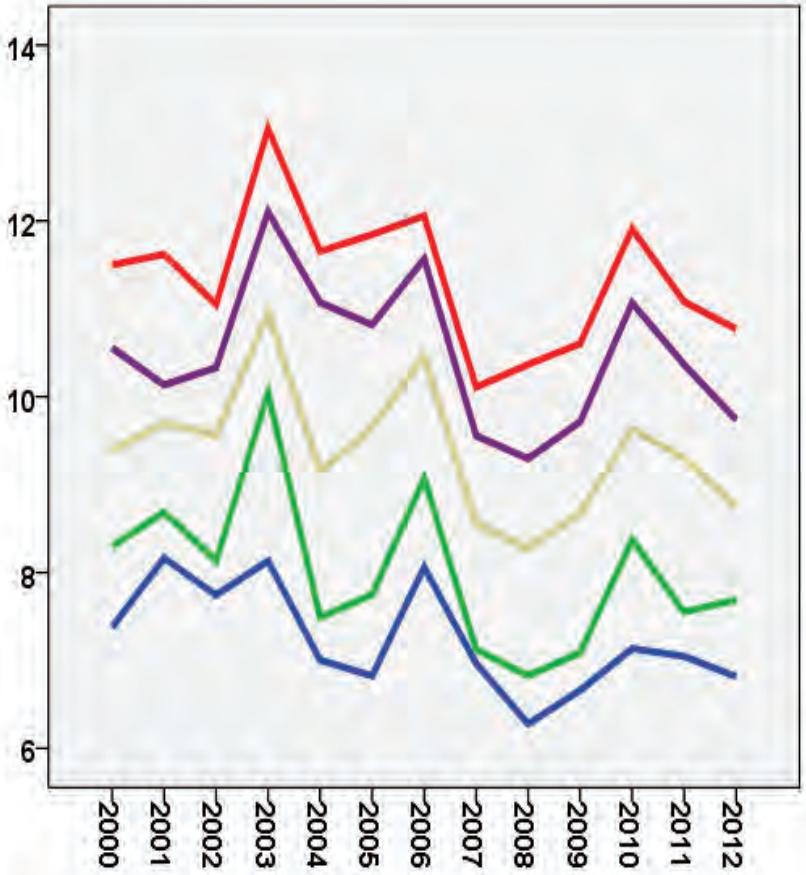


Murrelet population size

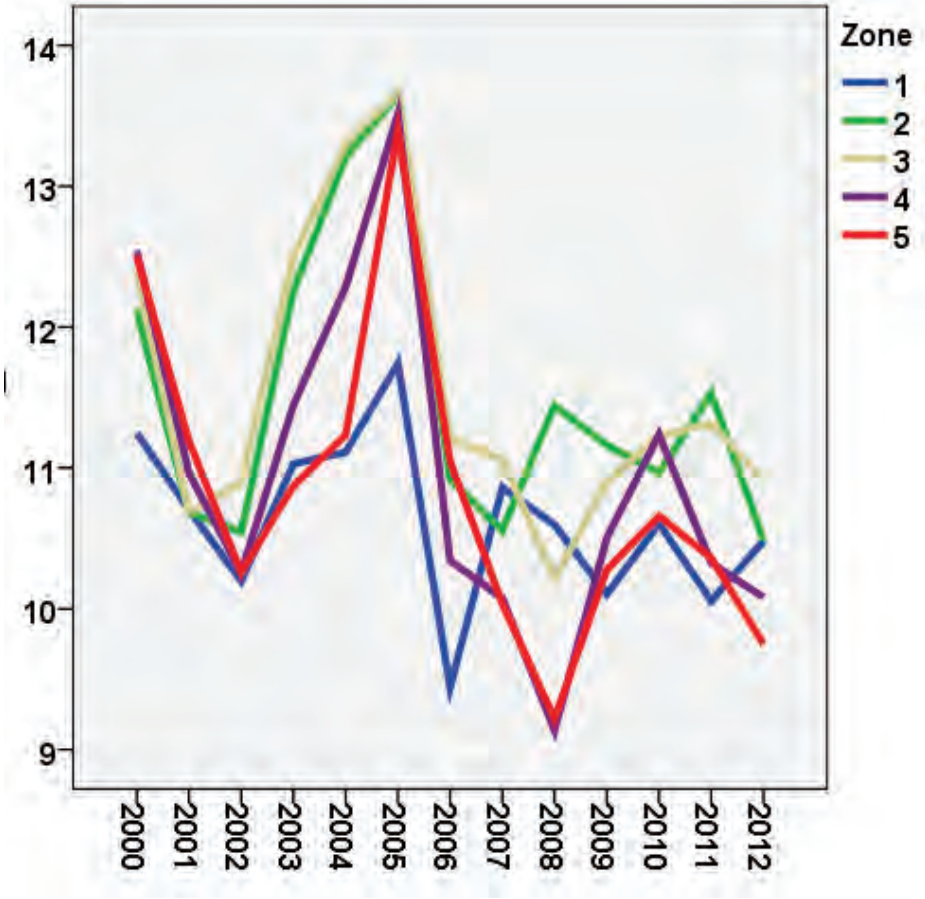


Sea surface temperature (°C)

Winter

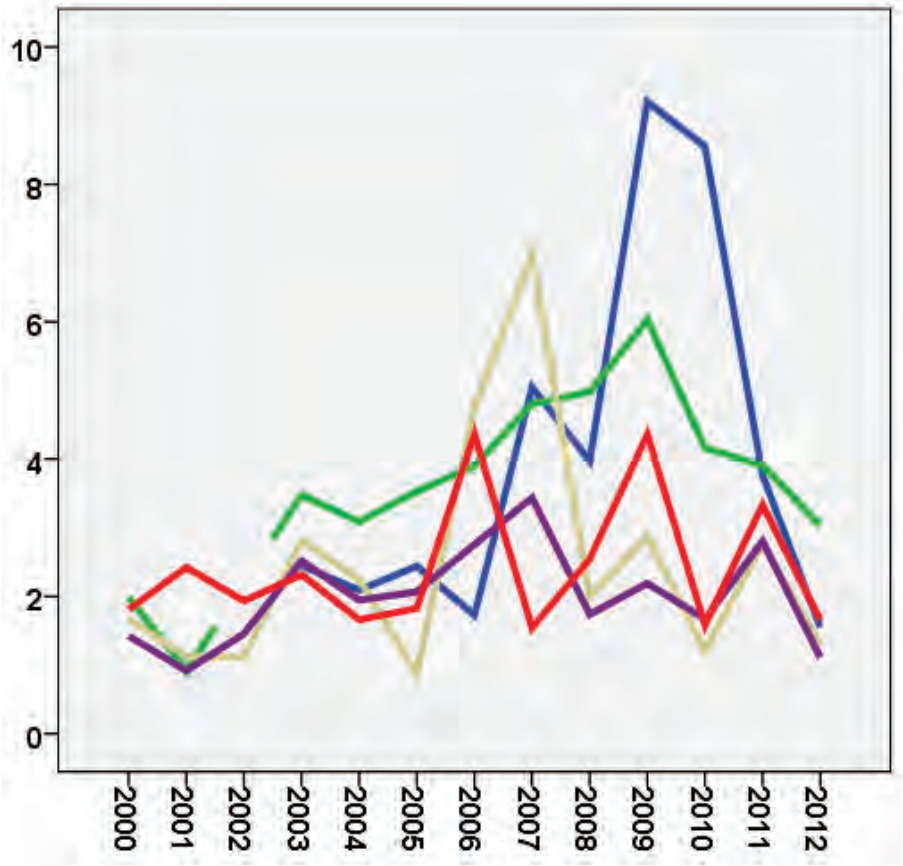


Summer

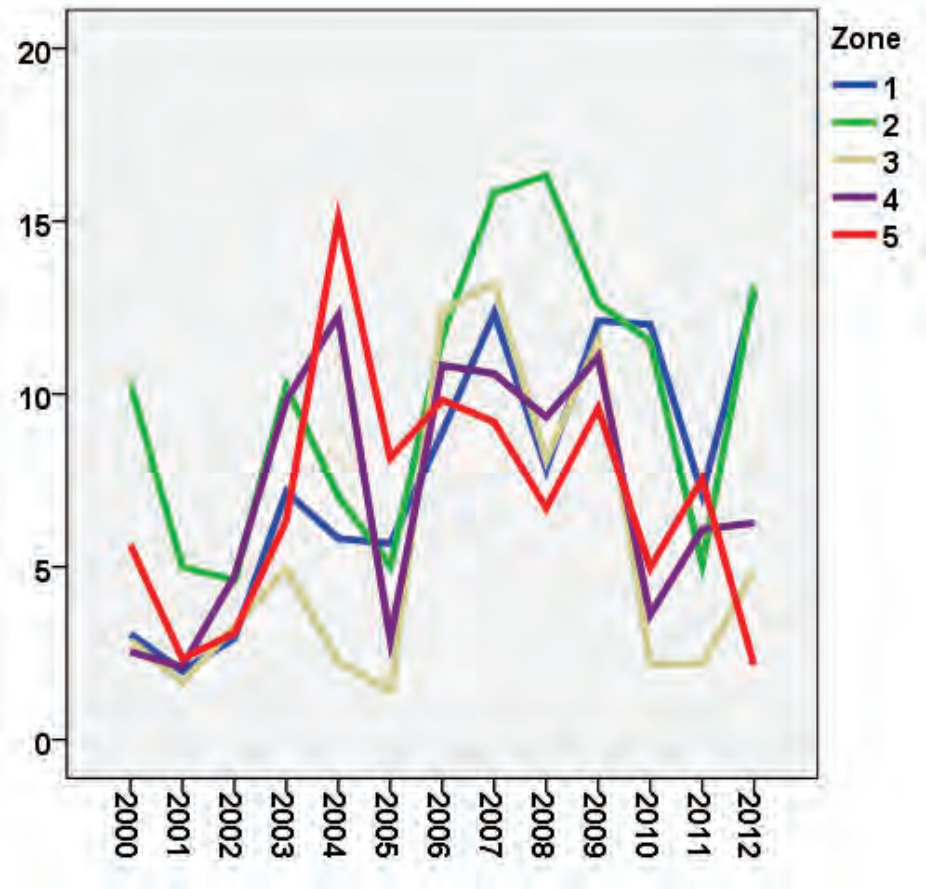


Chlorophyll A (mg/m^3)

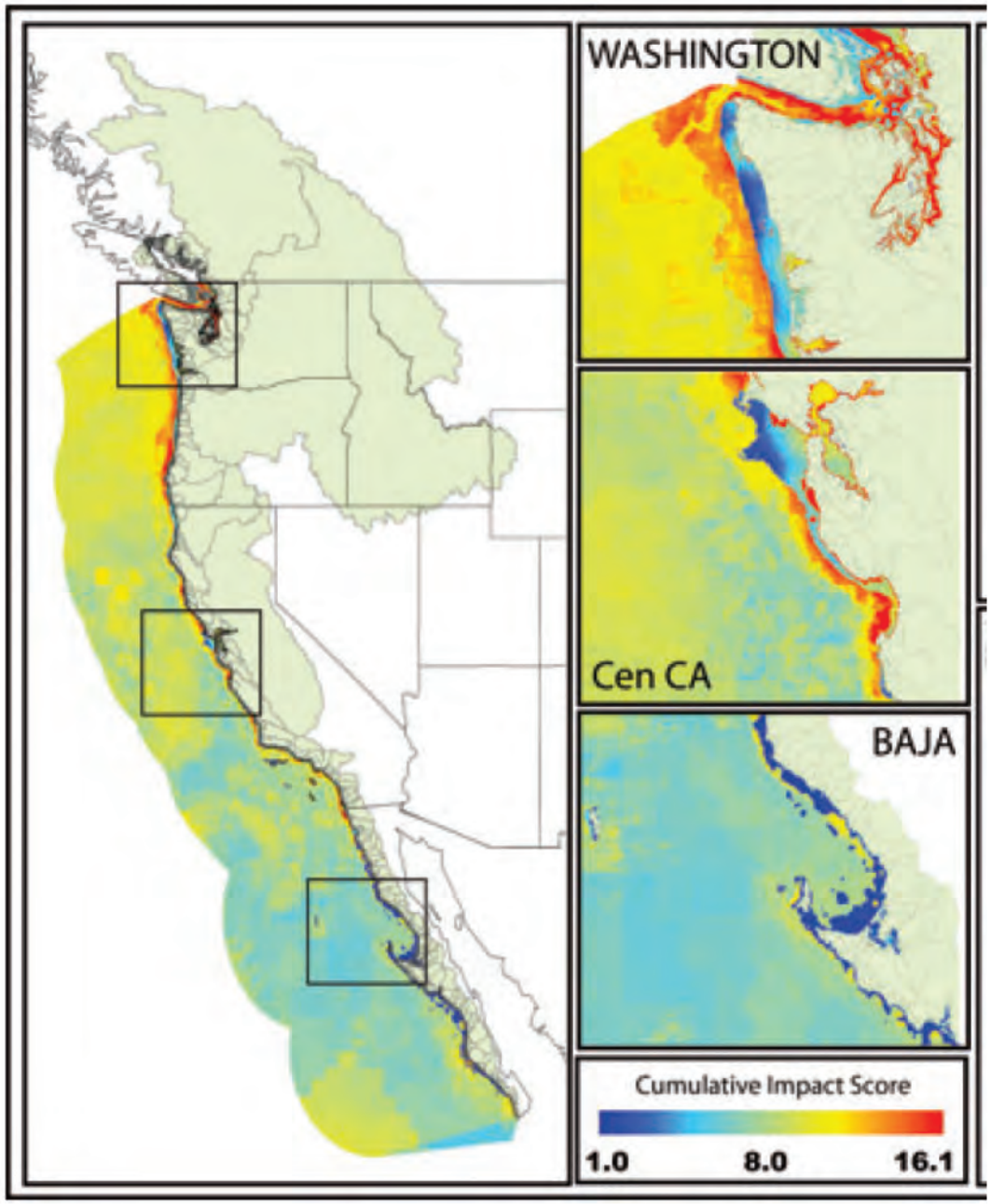
Winter

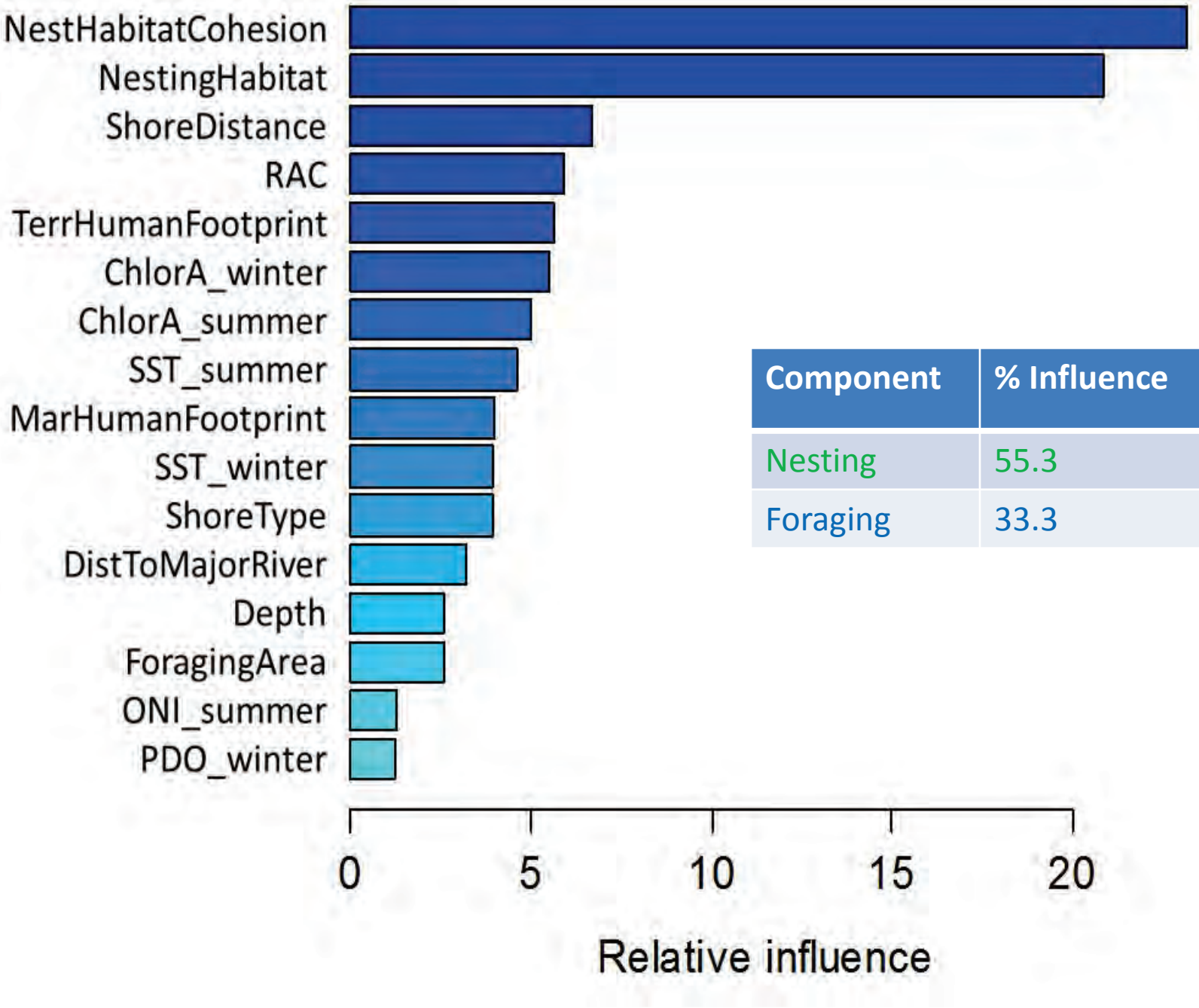


Summer



Marine Human Footprint (Halpern et al. 2009)

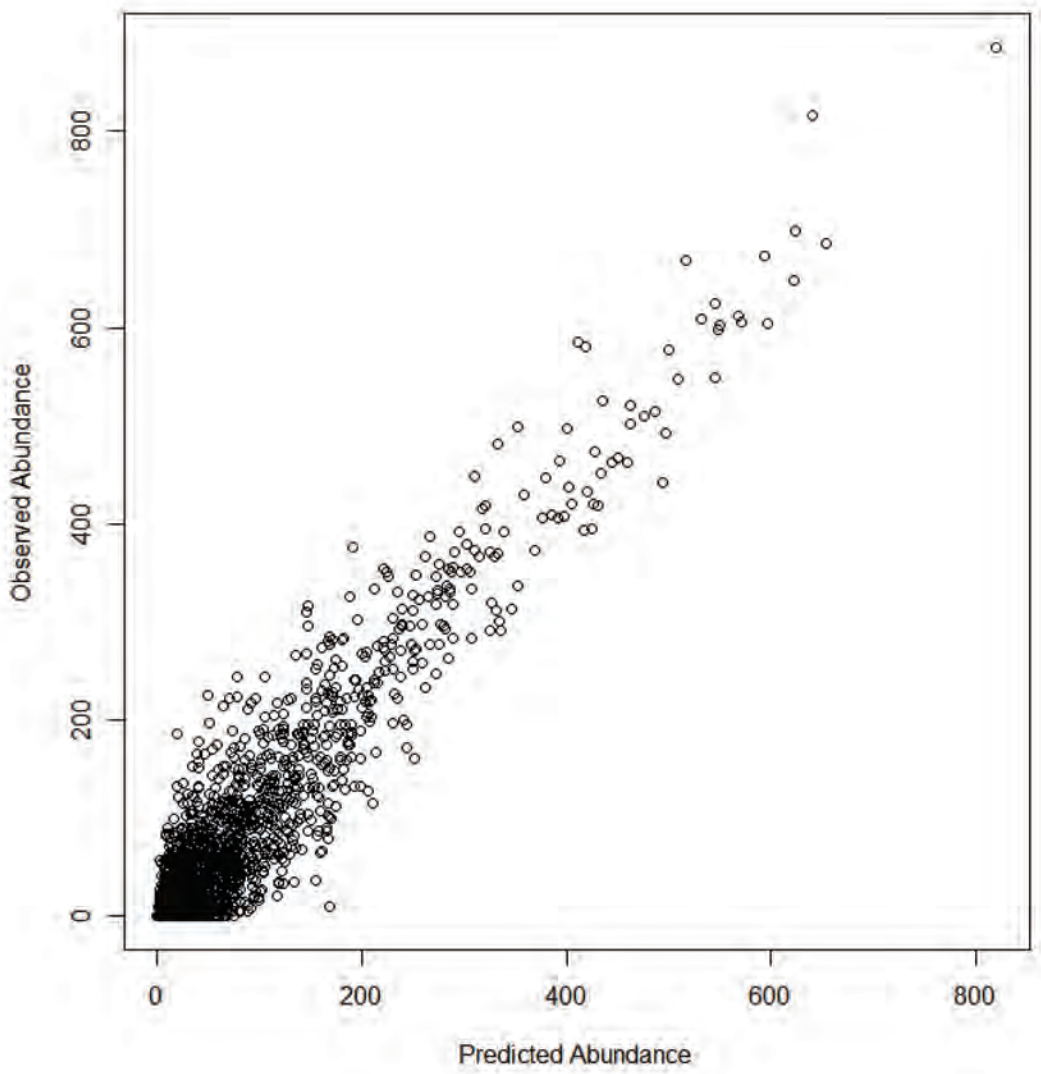




Component	% Influence
Nesting	55.3
Foraging	33.3

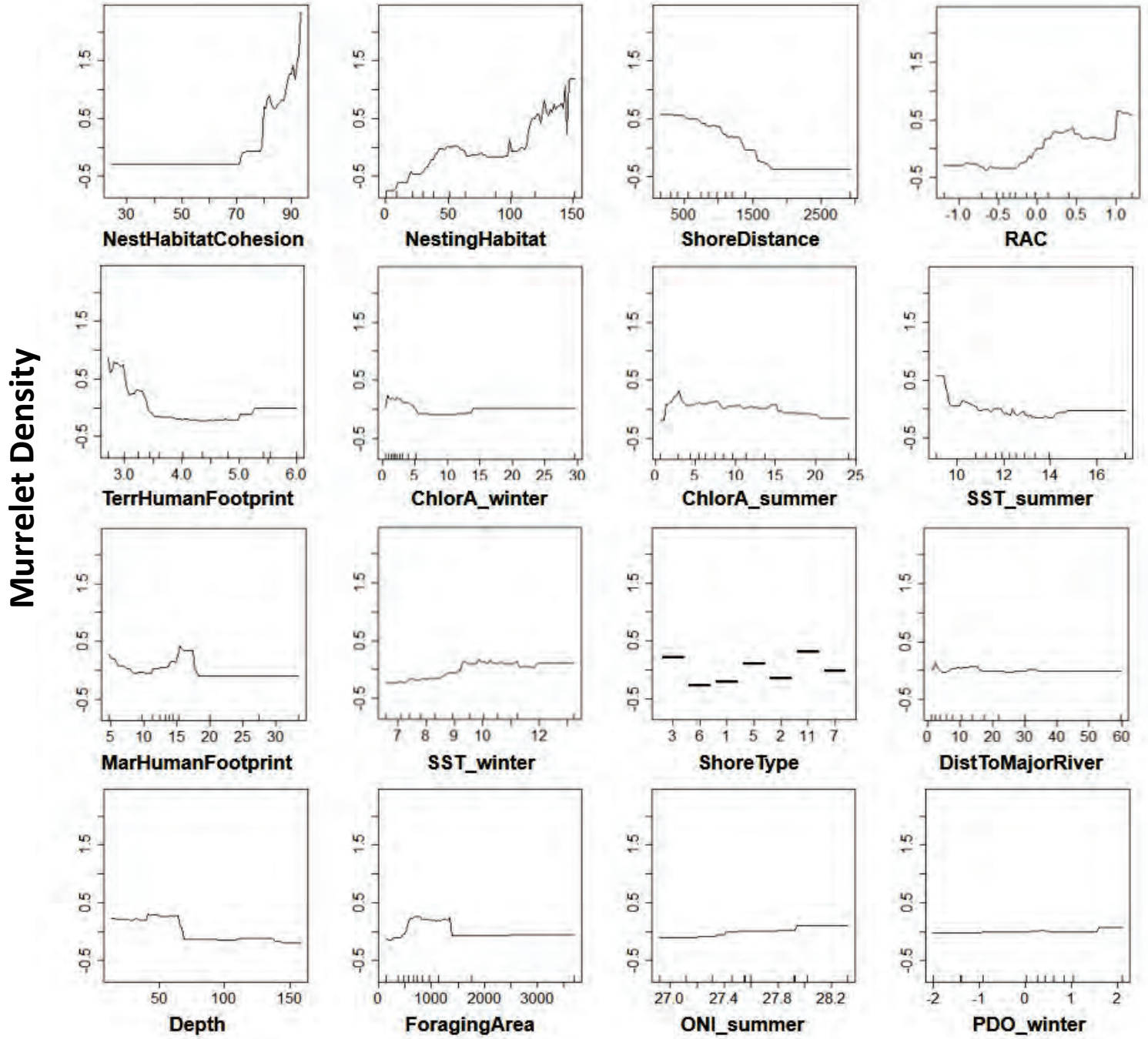
Predictive performance

Most parsimonious model

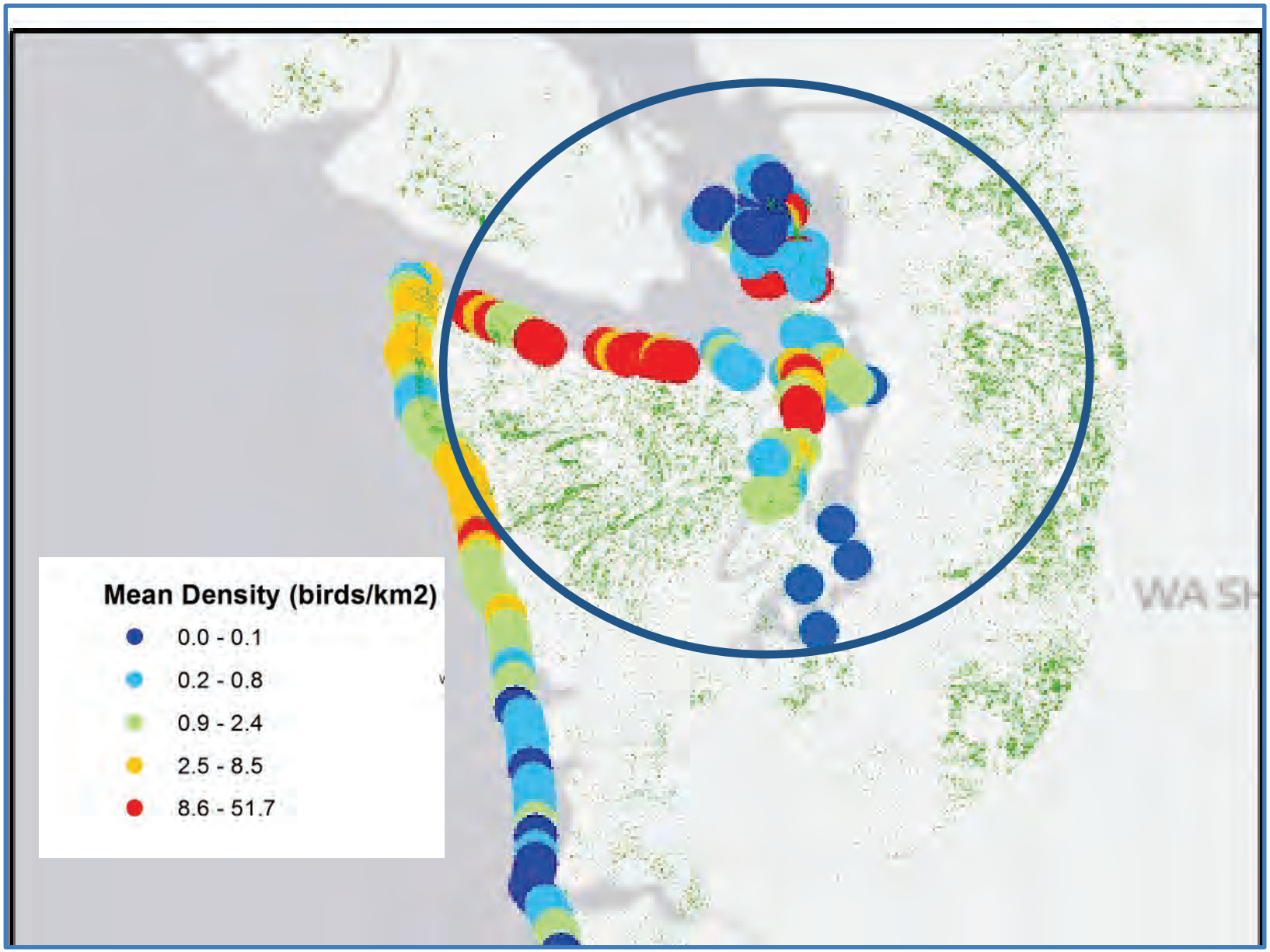


% Deviance explained – 82.7%

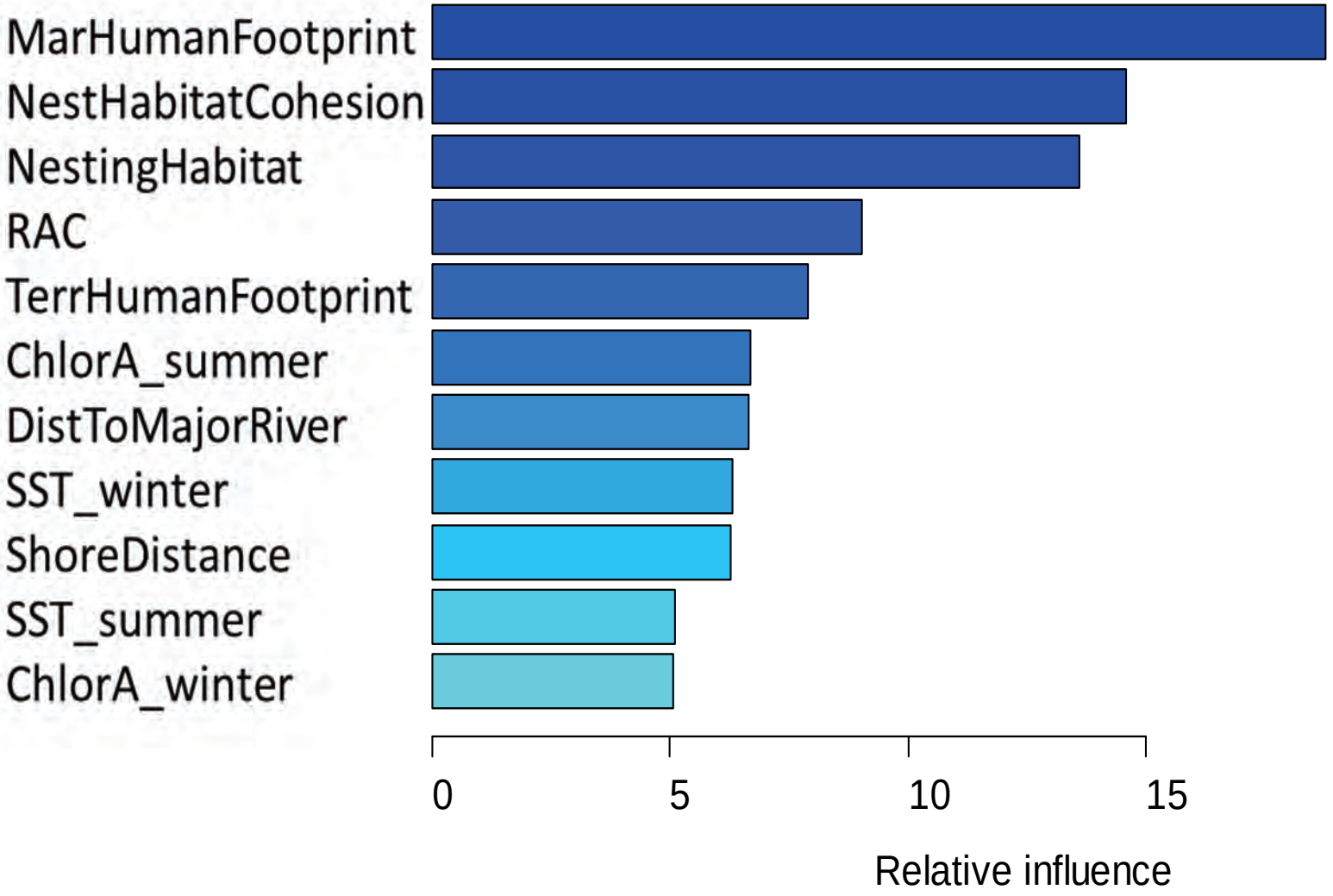
% Deviance explained (crossvalidated) – 63.3%


Murrelet Density
NestHabitatCohesion
NestingHabitat
ShoreDistance
RAC
TerrHumanFootprint
ChlorA_winter
ChlorA_summer
SST_summer
MarHumanFootprint
SST_winter
ShoreType
DistToMajorRiver
Depth
ForagingArea
ONI_summer
PDO_winter

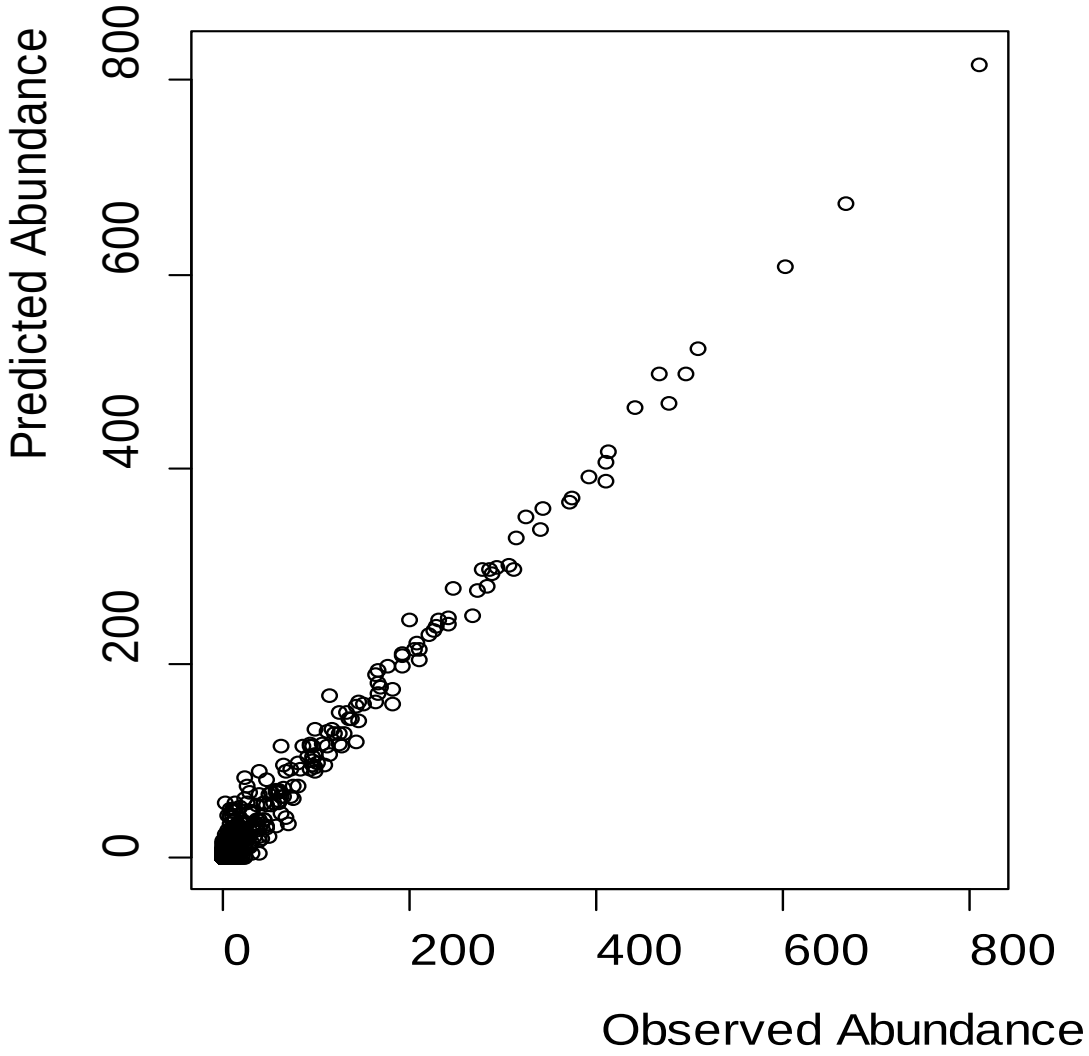
Samples in Zone 1 (southern Salish Sea)



Zone 1 – southern Salish Sea



Zone 1 – southern Salish Sea



% Deviance explained – 93%

% Deviance explained (crossvalidated) – 72%

Summary

- Spatial distribution of nesting habitat is strongest predictor of murrelet distribution during breeding season
- Marine covariates contribute to prediction to a lesser degree along coast
- Marine human footprint is strongest contributor in Salish Sea
- Murrelet hotspots are therefore best predicted by the amount and pattern of adjacent nesting habitat
- **BUT** - we need to look at non-breeding (winter) distribution
- **AND** - as prey data become available, models may improve

For more information

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