2021

Interpreting Local Contexts and Identifying Top Threats for Solomon Islands

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OBJECTIVE

Local threats, when harming a reef, are an important priority for conservation and management, as mitigating these pressures (especially within climate refugia) can lead to better outcomes for coral reef health and the livelihoods and wellbeing of people who depend on these reefs. Mapping the variability of local threats to coral reefs can help prioritise where to monitor for impacts to reefs and where to invest conservation resources to protect the function and ecosystem services provided by healthy coral reefs.

In this analysis, we use global data layers to map three local threats across each of the Solomon Island Provinces: fishing pressure based on proximity to markets, local fishing pressure based on local human population, and sedimentation from land-based runoff (all described below). Given the limitations of globally available data layers, this analysis should be validated and complemented by local knowledge and, where available, local data layers. Most importantly, local threats are not always a threat, and can instead describe context. For example, at low levels of impact, each 'threat' may only be a local context and not a 'threat'. For example, local fishing provides livelihoods and food security for hundreds of millions of people while exploitative overfishing or destructive gear can be a threat.

IMPORTANT CAVEATS:

1. Local knowledge and validation is crucial.
2. Preliminary results are subject to change following scientific peer-review and the layers will be updated if required.

METHODS

MARKET DRIVEN FISHING PRESSURE

Threats due to fishing were measured as market gravity. The gravity concept draws on an analogy from Newton's Law of Gravitation and predicts that interactions between two places (e.g., cities) are positively related to their mass (i.e., population) and inversely related to the distance between them (Anderson 2011). Cinner et al. (2018) applied the gravity concept to coral reefs under the assumption that human interactions with a reef are a function of the population of a place divided by the

squared time it takes to travel to the reefs. Using travel time instead of linear distance accounts for the differences incurred by traveling over different surfaces, such as water, roads or tracks (Maire et al. 2016). High market gravity, measured as (number of people) / (hours of travel)^2, reduces fish biomass and the occurrence of top predators on coral reefs. We mapped gravity to the coral reef grid cells by calculating the mean value of market gravity of all the intersecting grid cells from Cinner et al.'s original layer.

LOCAL FISHING PRESSURE

As noted by Cinner et al. (2018), gravity values can be similar for places that have large populations but are far from the reefs (e.g., population = 15,000 people, travel time = 7 h, gravity = 306) as to those with small populations that are close to the reef (e.g., population = 300 people, travel time = 1 h, gravity = 300). We therefore also mapped the potential for fishing pressure based on population size alone, as an indicator for local fishing pressure unrelated to markets. We used the number of people living on the coast obtained from the population count layer v 4.11 for the year 2020 at a spatial resolution of 2.5 minutes of degree (about 5 km) from the Socioeconomic Data and Applications Center (SEDAC). Population counts were mapped to the grid cells by summing their values within a distance of 5km from the boundaries of each grid cells. We included population within 5 km distance on the basis of previous fisheries surveys undertaken by WCS in Western Province, which indicated that over 70% of the fishing effort (out of 571) was shore-based or short (less than 4 hours) boat-based trips where no fuel was used.

SEDIMENTATION

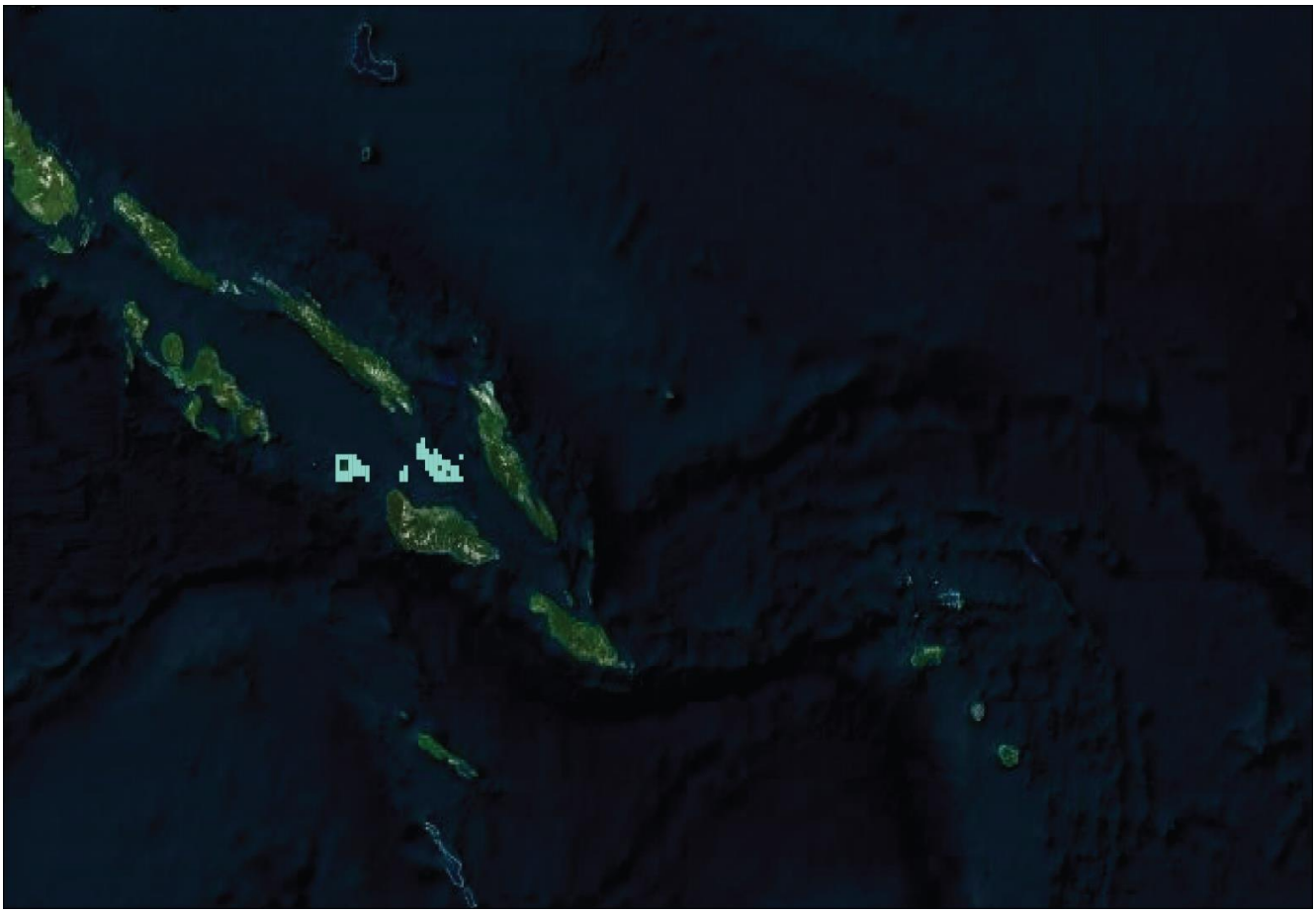
We combined two approaches for estimating sediment delivery to river mouths. For the first approach, we estimated sediment delivery using the Natural Capital Project's Integrated Valuation of Ecosystem Service Sediment Delivery Ratio (SDR) Model (InVEST SDR version 3.7.0) (Tallis & Polasky 2009; Hamel et al. 2015). Operating at the resolution of the land-cover input (250m), the SDR model calculates sediment yield by combining the revised universal soil loss equation (RUSLE) with a sediment delivery ratio (SDR) to quantify the amount of soil eroded for a given area that will travel to a stream pour-point (Hamel et al. 2015). The RUSLE approach uses five different environmental input factors: land cover and management factor (C-factor), rainfall-runoff erosivity (R-factor), slope length and steepness factor (LS-factor), soil erodibility (K-factor). Each of these layers plus global land cover data (from 2012) were taken from Borrelli et al. (2017). For the second approach, we used the SDR values from the Reefs at Risk analysis (Burke et al. 2011). While the calculations for these SDR values are more simplistic than the InVEST model, they account for sediment trapping potential of dams and mangroves, which InVEST does not.

The sediment exposure to adjacent reefs was modelled using a sediment plume model, written and run in R (version 3.5.3). The dispersal of potential sediment at each river mouth was modelled using a cost-path surface, where a decay function evenly distributes 0.5% of the initial potential sediment value to all adjacent cells, until either a threshold of 0.05% of the global maximum value or a distance of 80 km from the river mouth was reached (Halpern et al. 2008; Burke et al. 2011). The sediment plumes from each river mouth were then summed to provide a cumulative sediment exposure value, measured as tons of sediment / km^2. Finally, the sediment plumes for the two approaches were averaged.

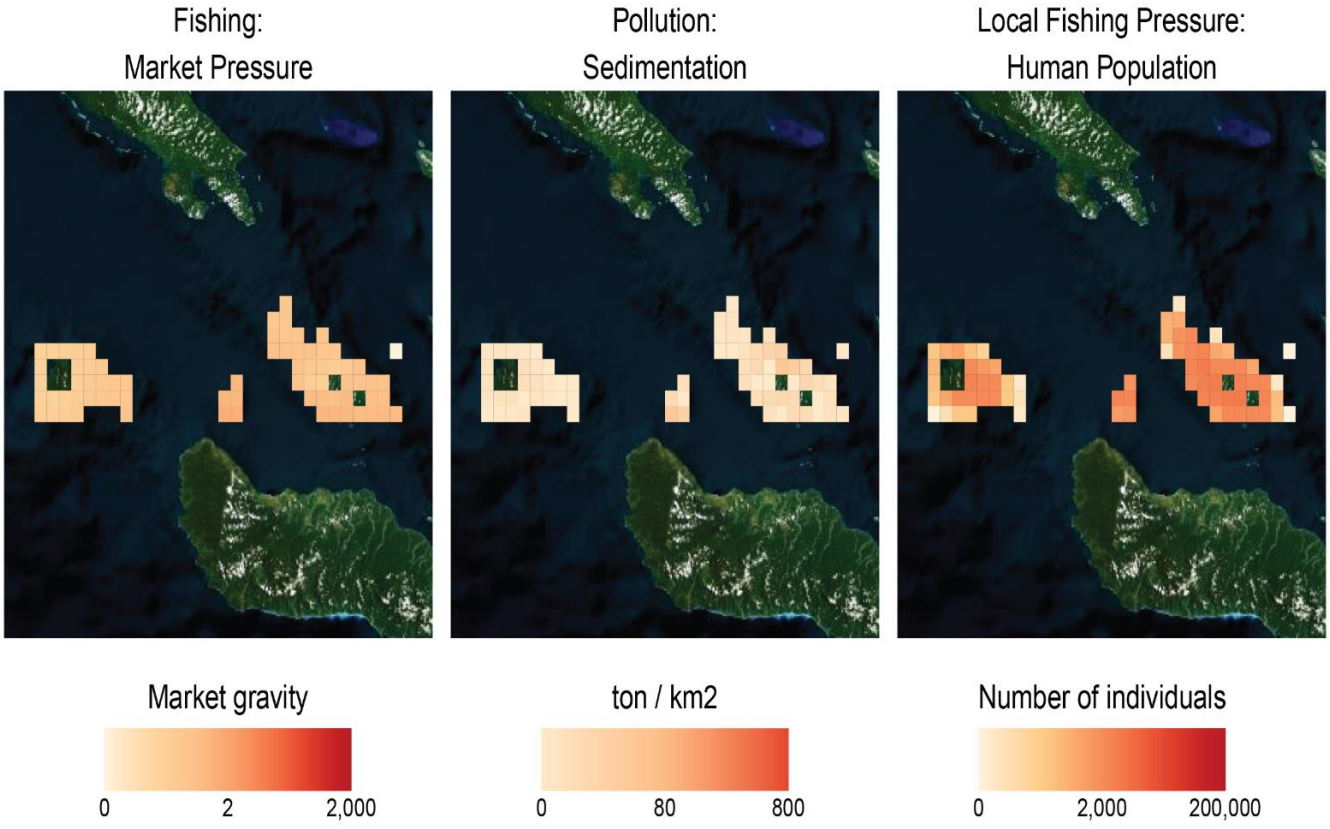
Because the land cover layer used for this analysis was from 2012, we also mapped deforestation rates for each Province since 2012, using data from Global Forest Watch (Hansen et al. 2013).

READING THE REPORT CARD

1. The first map in the report card shows you the location of the Province.

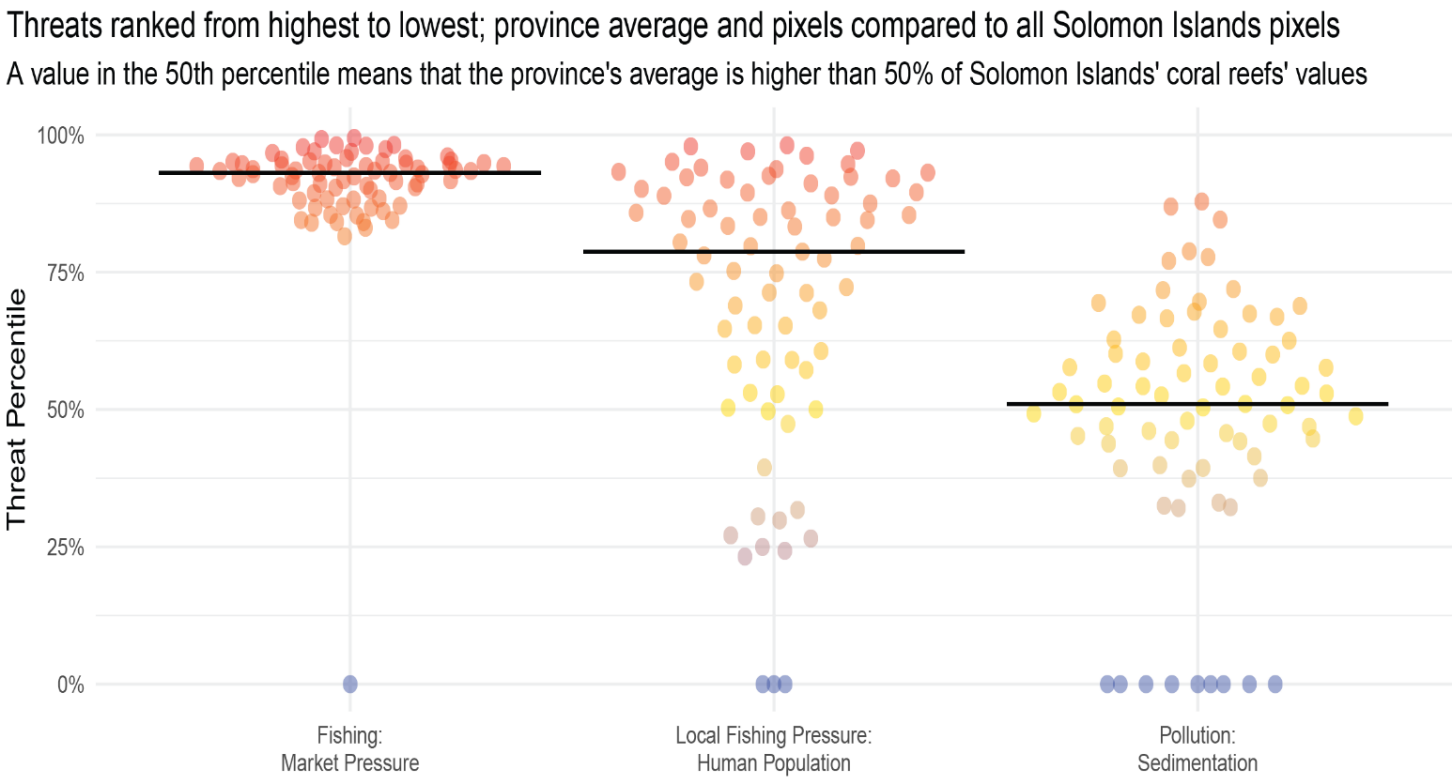


2. **Global Threat Indicators**. These are the detailed maps of the different threat variables. Each map shows you the variability of the threat across the specified Province (5 x 5 km pixels).

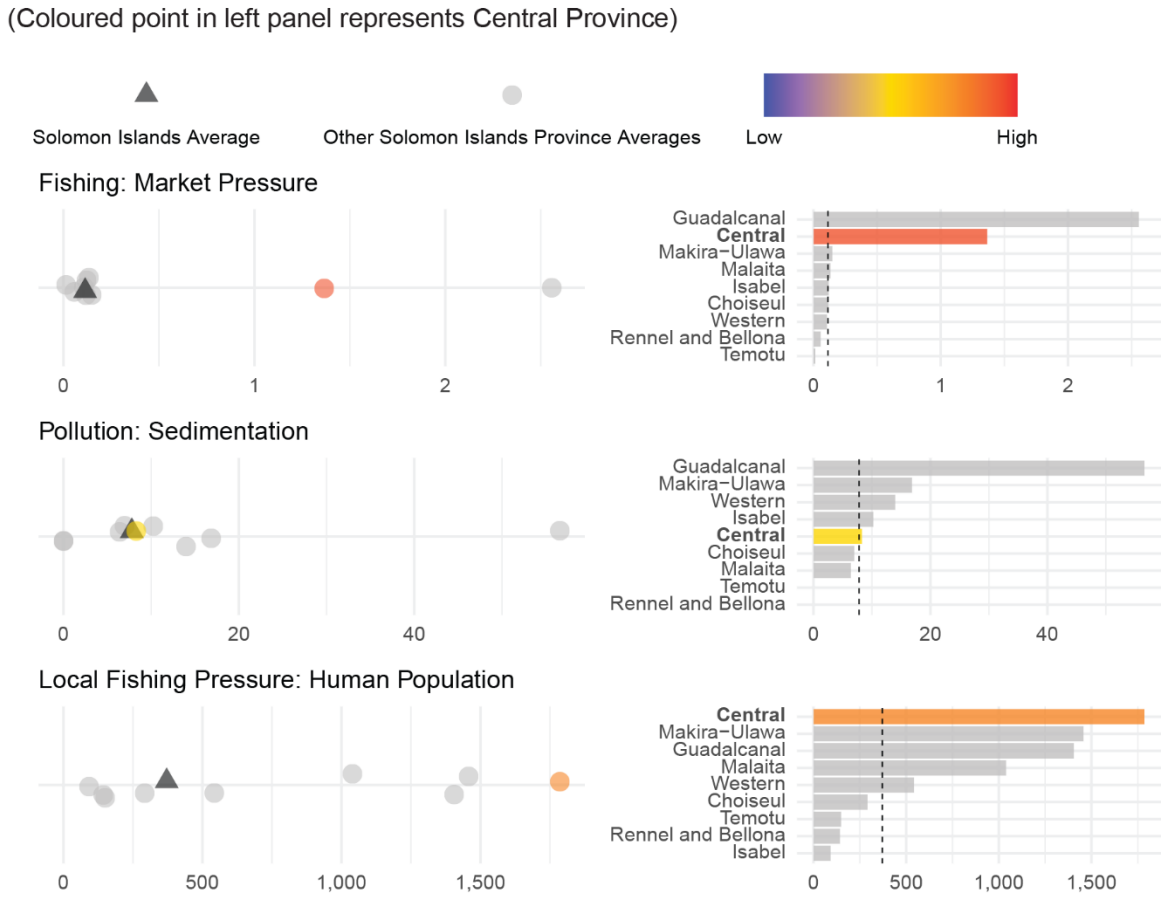


3. **Threat ranking.** This shows how each of the 5km x 5km pixels in a particular Province compares to all Solomon Island reef pixels. Values are shown in percentiles, where higher values represent higher pressure than other Solomon Island reefs. The black line is the average percentile for all the pixels within the Province.

In the example below, the average local fishing pressure variable for all the pixels in that Province (black line) is higher than ~75% of the market pressure values measured in all Solomon Island reefs. Each dot shows the value for one pixel, and together they show the variability of the values within the Province. In this example, while the average value of the Province might be higher than ~75% of local fishing pressure values measured on all Solomon Island reefs, local fishing pressure is highly variable within the Province, as shown by the spread of the dots.



4. **National context.** These graphs show the raw values of each variable (listed in the detailed maps above), and not as a percentile like the threat ranking graph. Here, you can see how the average Province value (colored dot) compares to the average values of other Provinces (grey dot) to provide a regional perspective. The dark grey triangle shows the Solomon Islands average, and allows you to compare the specific Province identified in each threat report card (coloured dot) and all Solomon Islands Provinces (grey dots) to the country average (dark grey triangle). The bar graphs on the right show the same information with each Province labelled.



RESULTS

PROVINCE THREATS

See additional report for threat report cards for each Province.

Table 1: top ranked threats for each province

Province	Top ranked threat
Central	Market driven fishing pressure
Choiseul	Market driven fishing pressure
Guadalcanal	Market driven fishing pressure
Isabel	Sedimentation
Makira-Ulawa	Local fishing pressure
Malaita	Local fishing pressure

Rennel and Bellona	Local fishing pressure
Temotu	Local fishing pressure
Western	Sedimentation

MARKET DRIVEN FISHING PRESSURE

Coral reefs in Guadalcanal faced the most market-based fishing pressure, with the Province average pressure being higher than ~95% of all Solomon Islands coral reefs (see attached threat report card and reference guide on how to interpret results below). Central Province reefs also faced high levels of market driven fishing pressure, with the Province average pressure being higher than ~90% of all Solomon Island coral reefs. Market driven fishing pressure was also the highest ranked threat for both Provinces.

LOCAL FISHING PRESSURE

Although local fishing pressure was not the top ranked threat within Central Province, when the total pressure from this threat was compared to all other Provinces, Central Province coral reefs faced the most local fishing pressure out of all the Provinces, with the average pressure from this threat being higher than over 75% of all Solomon Island coral reefs. However, unlike market driven pressure, which was consistently high across all Central Province reefs, there was much more variability in how much local fishing pressure there was at each reef (see Central Province threat report card). The Makira-Ulawa and Guadalcanal Provinces also experienced high levels of local fishing pressure, with the Province average for both being75% higher than all other Solomon Islands reefs. Similarly to Central Province, there was also a lot of variability in how much local fishing pressure there was within each Province.

SEDIMENTATION

Although within the Isabel and Western Provinces the top ranked threat was sedimentation, when compared to all other Provinces, the threat from sedimentation was highest in Guadalcanal, with the average pressure from this threat being greater than almost 90% of all Solomon Islands reefs. Makira-Ulawa Province experienced the second highest pressure from sedimentation when compared to all other Provinces, with the average pressure from this threat being higher than 60% of all reefs within Solomon Islands. However, within all Provinces (with the exception of Rennel and Bellona), the variability across reefs was high, with some reef areas experiencing high levels of sedimentation (see threat report cards).

Because the land cover map used in this analysis was from 2012, we also identified deforestation hotspots, which would indicate regions where the threat from sedimentation had increased over the last ten years.

Forest lost within each province since 2012

See Appendix 1 for maps of deforestation in each Province since 2012.

Table 2: area of forest lost within each Province since 2012

Province	Deforestation (ha)	Proportion of Province (Percent)
Central	1852	2.9
Choiseul	15338	5.2
Guadalcanal	27072	4.9
Isabel	13566	3.2
Makira-Ulawa	6550	2.0
Malaita	11012	2.4
Rennel and Bellona	877	1.2
Temotu	637	0.7
Western	30945	5.5

REFERENCES

Albuquerque, T.E., Loiola, M. Nunes, J. de A.C.C., Reis-Filho J.A., Sampaio, C.L.S. and A.O.H.C. Leduc. 2014. In situ effects of human disturbances on coral reef-fish assemblage structure: temporary and persisting changes are reflected as a result of intensive tourism, Marine and Freshwater Research 66: 23–32.

Anderson, J.E. 2011. The Gravity Model. Annual Review of Economics, 3, 133–160.

Borrelli, P., Robinson, D.A., Fleischer, L.R., Lugato, E., Ballabio, C., Alewell, C., Meusburger, K., Modugno, S., Schütt, B., Ferro, V., and V. Bagarello, V. 2017. An assessment of the global impact of 21st century land use change on soil erosion. Nature Communications 8: 1-13.

Burke, L., Reytar, K., Spalding, M., and A. Perry. 2011 Reefs at Risk Revisited. World Resources Institute, Washington, DC. https:// www.wri.org/publication/reefs-risk-revisited

Center for International Earth Science Information Network - CIESIN - Columbia University. 2016. Gridded Population of the World, Version 4 (GPWv4): Population Count. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi. org/10.7927/H4X63JVC

Cinner, J.E., Huchery, C., MacNeil, M.A., Graham, N.A.J., McClanahan, T.R., Maina, J., Maire, E., Kittinger, J.N., Hicks, C.C., Mora, C., Allison, E.H., D'Agata, S., Hoey, A., Feary, D.A., Crowder, L., Williams, I.D., Kulbicki, M., Vigliola, L., Wantiez, L., Edgar, G., Stuart-Smith, R.D., Sandin, S.A., Green, A.L., Hardt, M.J., Beger, M., Friedlander, A., Campbell, S.J., Holmes, K.E., Wilson, S.K., Brokovich, E., Brooks, A.J., Cruz-Motta, J.J., Booth, D.J., Chabanet, P., Gough, C., Tupper, M., Ferse, S.C.A., Sumaila, U.R. and D. Mouillot, D. 2016. Bright spots among the world's coral reefs. Nature 535: 416–419.

Cinner, J.E., Maire, E., Huchery, C., MacNeil, M.A., Graham, N.A.J., Mora, C., McClanahan, T.R., Barnes, M.L., Kittinger, J.N., Hicks, C.C., D'Agata, S., Hoey, A.S., Gurney, G.G., Feary, D.A., Williams, I.D., Kulbicki, M., Vigliola, L., Wantiez, L., Edgar, G.J., Stuart-Smith, R.D., Sandin, S.A., Green, A., Hardt, M.J., Beger, M., Friedlander, A.M., Wilson, S.K., Brokovich, E., Brooks, A.J., Cruz-Motta, J.J., Booth, D.J., Chabanet, P., Gough, C., Tupper, M., Ferse, S.C.A., Sumaila, U.R., Pardede, S. and D. Mouillot. 2018. Gravity of human impacts mediates coral reef conservation gains. PNAS: 201708001.

Halpern, B.S., Walbridge, S., Selkoe, K.A., Kappel, C.V., Micheli, F., D'Agrosa, C., Bruno, J.F., Casey, K.S., Ebert, C., Fox, H.E., Fujita, R., Heinemann, D., Lenihan, H.S., Madin, E.M.P., Perry, M.T., Selig, E.R., Spalding, M., Steneck, R. & Watson, R. (2008). A global map of human impact on marine ecosystems. *Science*, 319, 948–952.

Hamel P., Chaplin-Kramer R., Sim S., Mueller C. (2015) A new approach to modeling the sediment retention service (InVEST 3.0): Case study of the Cape Fear catchment, North Carolina, USA. *Science of The Total Environment* **524**, 166-177.

Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53. Data available on-line from: http://earthenginepartners.appspot.com/science-2013-global-forest.

Maire, E., Cinner, J., Velez, L., Huchery, C., Mora, C., Dagata, S., Vigliola, L., Wantiez, L., Kulbicki, M. and D. Mouillot. 2016. How accessible are coral reefs to people? A global assessment based on travel time. Ecology Letters 19: 351–360.

Tallis H., Polasky S. (2009) Mapping and Valuing Ecosystem Services as an Approach for Conservation and Natural-Resource Management. *Annals of the New York Academy of Sciences* **1162**, 265-283.

UNEP-WCMC, WorldFish Centre, WRI & TNC. 2010. Global distribution of warm-water coral reefs, compiled from multiple sources including the Millennium Coral Reef Mapping Project. version 1.3. includes contributions from IMaRS-USF and IRD (2005), IMaRS- USF (2005) and Spalding et al. (2001) http://data.unep-wcmc.org/datasets/1

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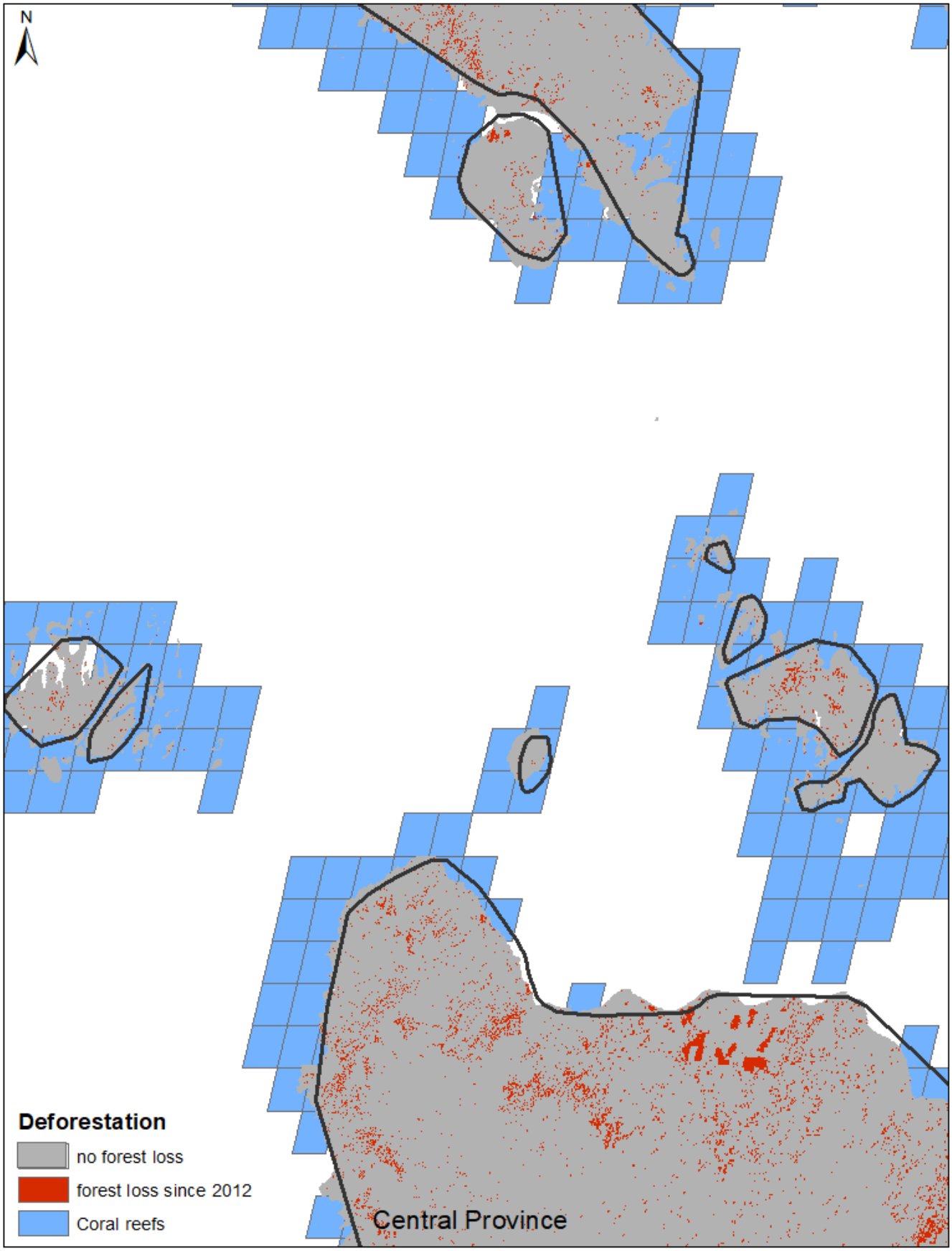
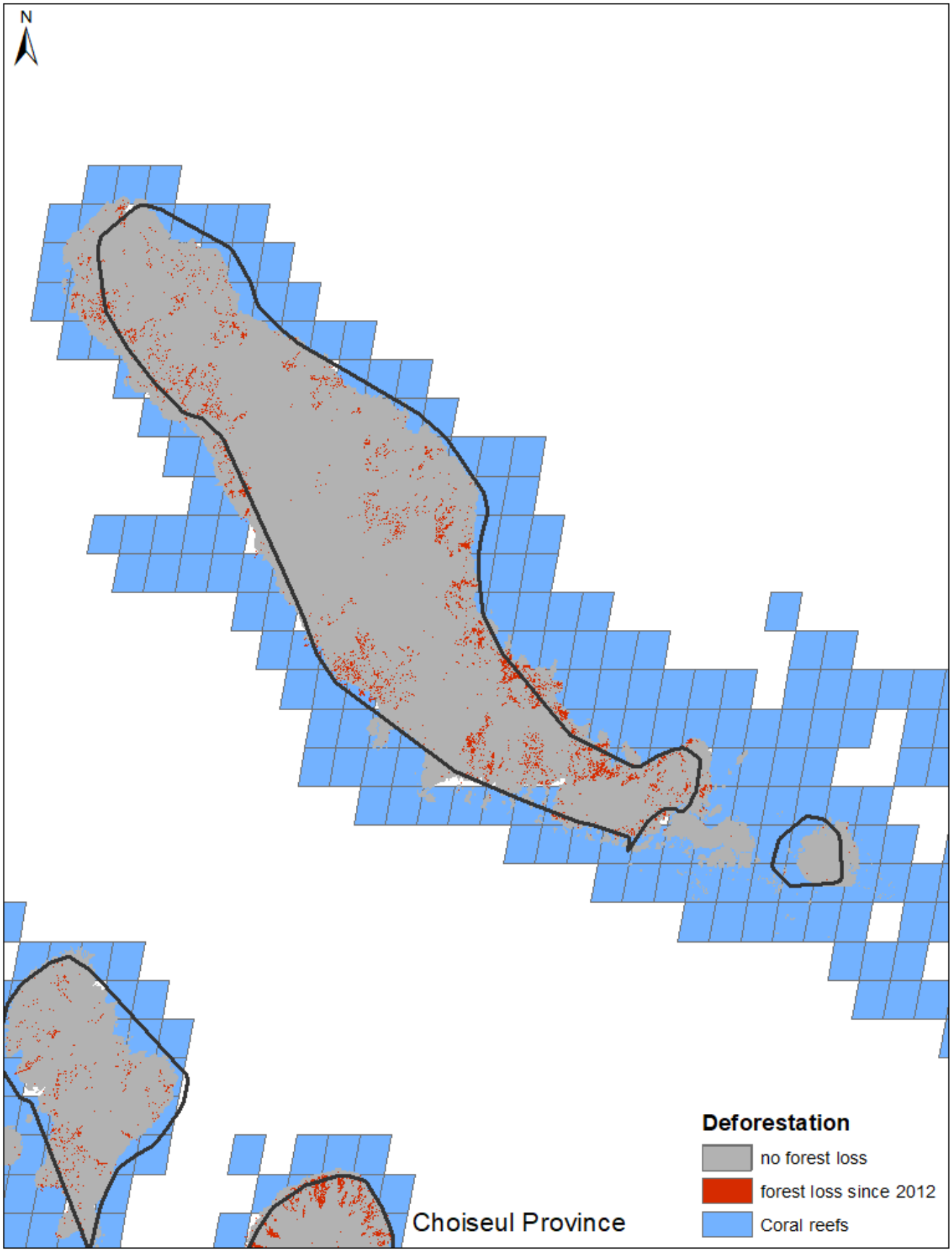
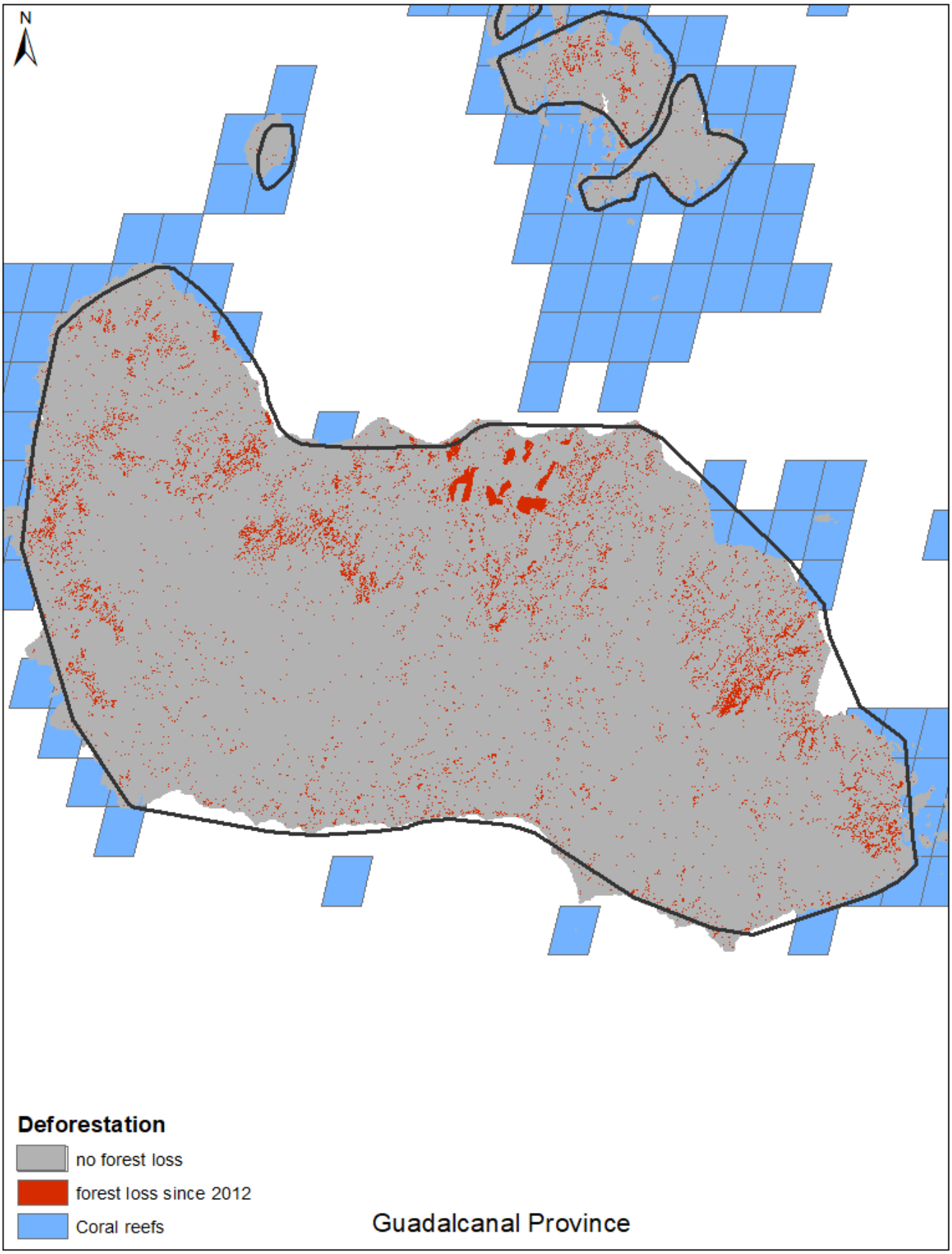
APPENDIX 1: DEFORESTATION IN EACH PROVINCE SINCE 2012




N
Deforestation
no forest loss
forest loss since 2012
Coral reefs
Choiseul Province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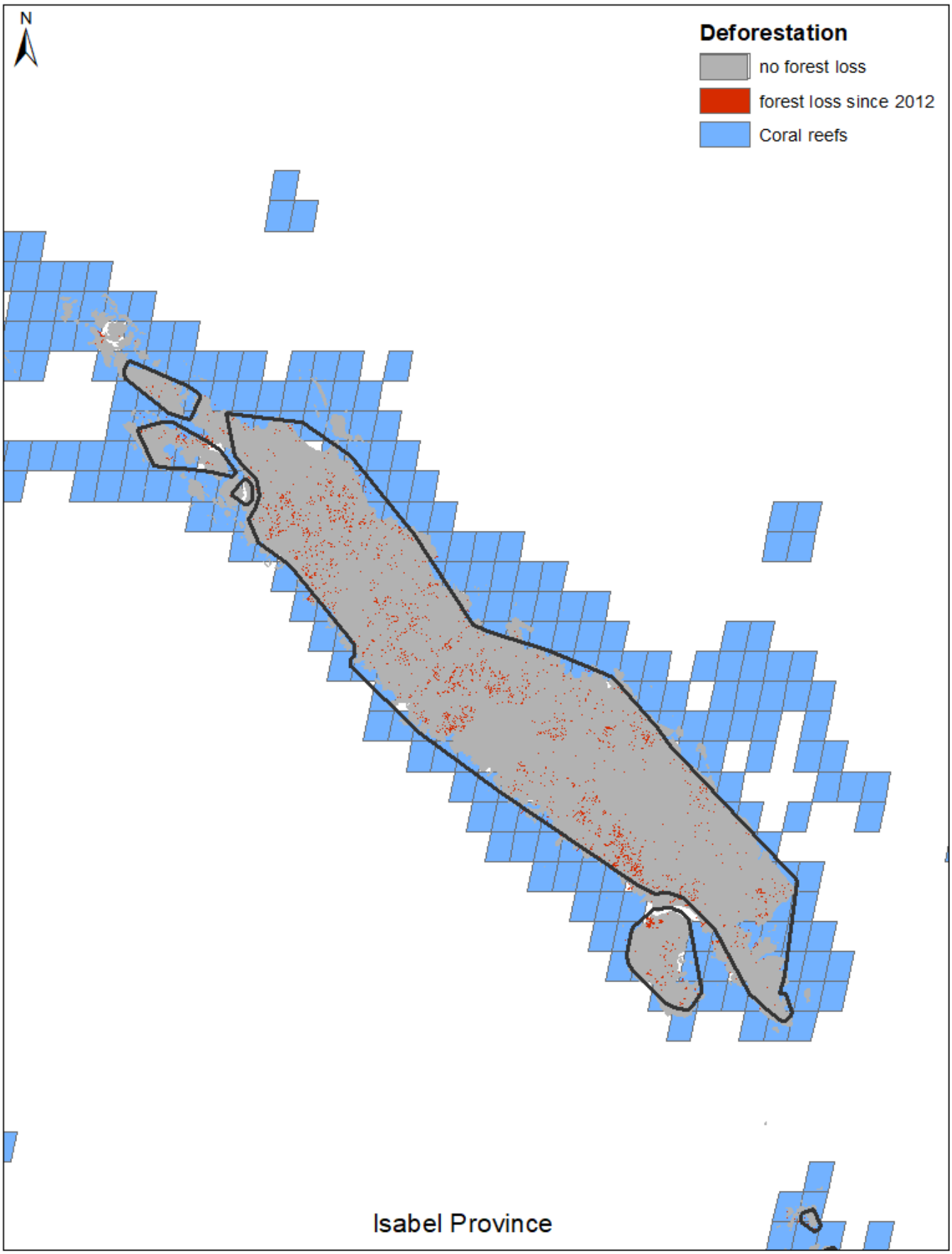
Deforestation
no forest loss
forest loss since 2012
Coral reefs
Guadalcanal Province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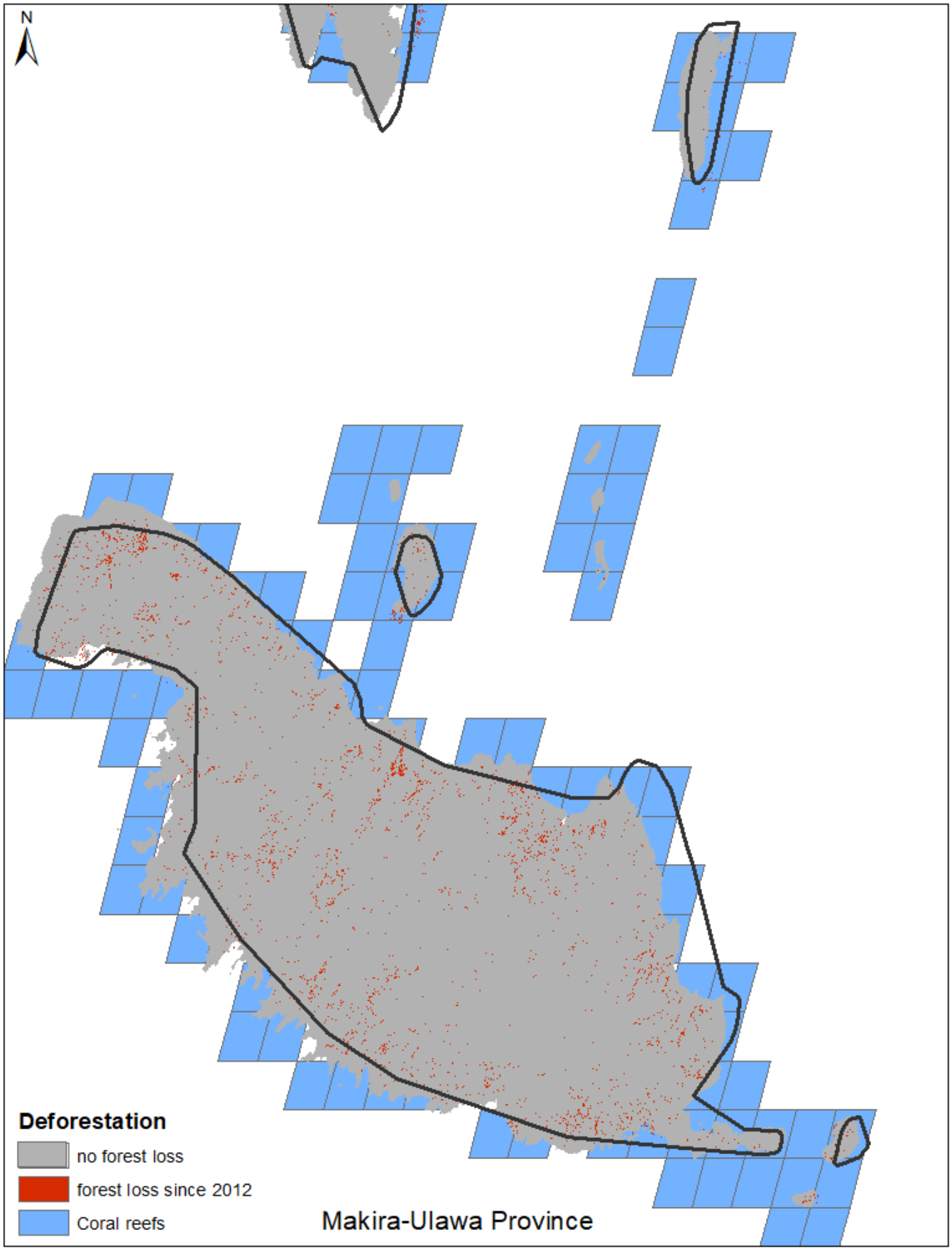
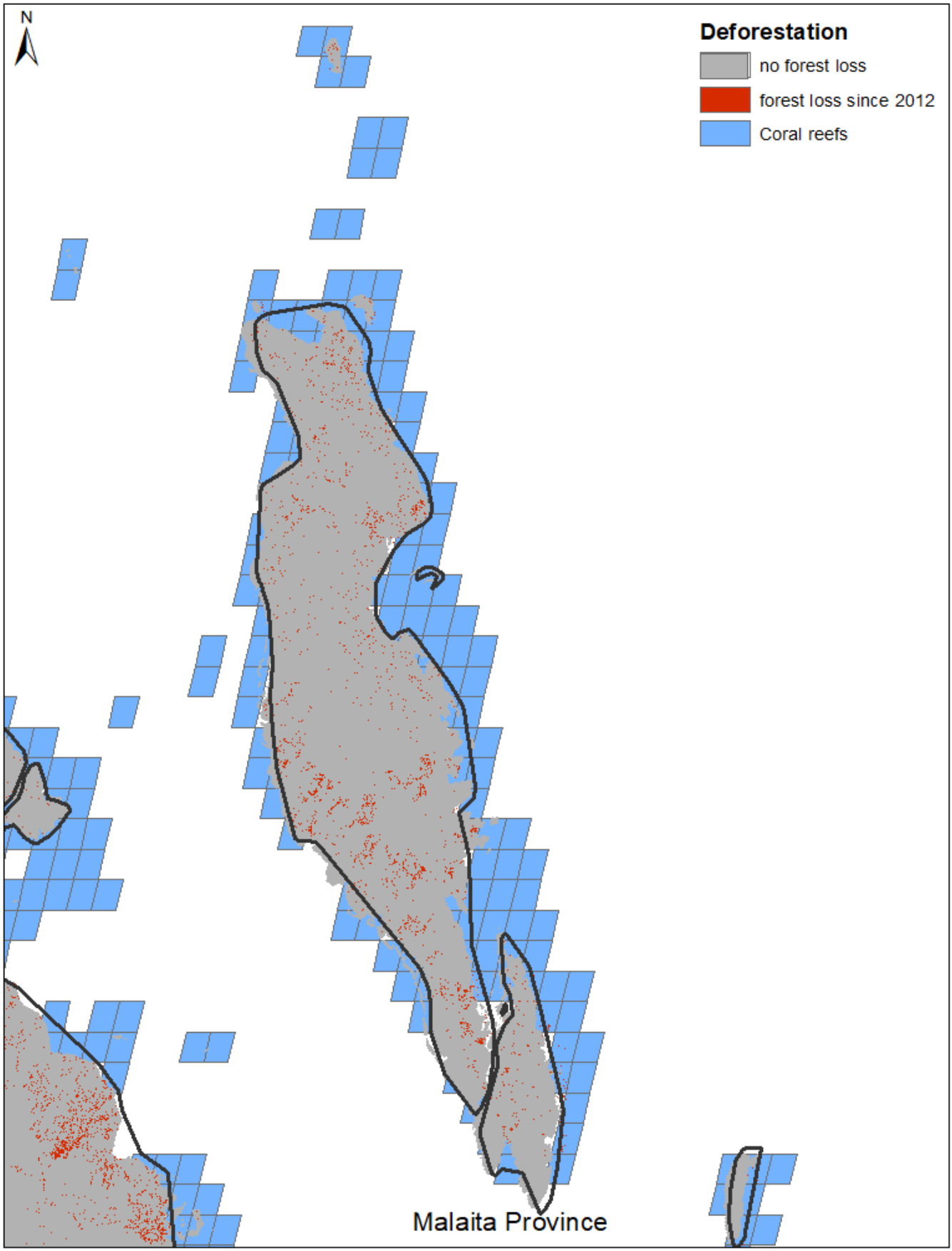
forest loss since 2012
Coral reefs
Isabel Province


N
Deforestation
no forest loss
forest loss since 2012
Coral reefs
Makira-Ulawa Province


N
Deforestation
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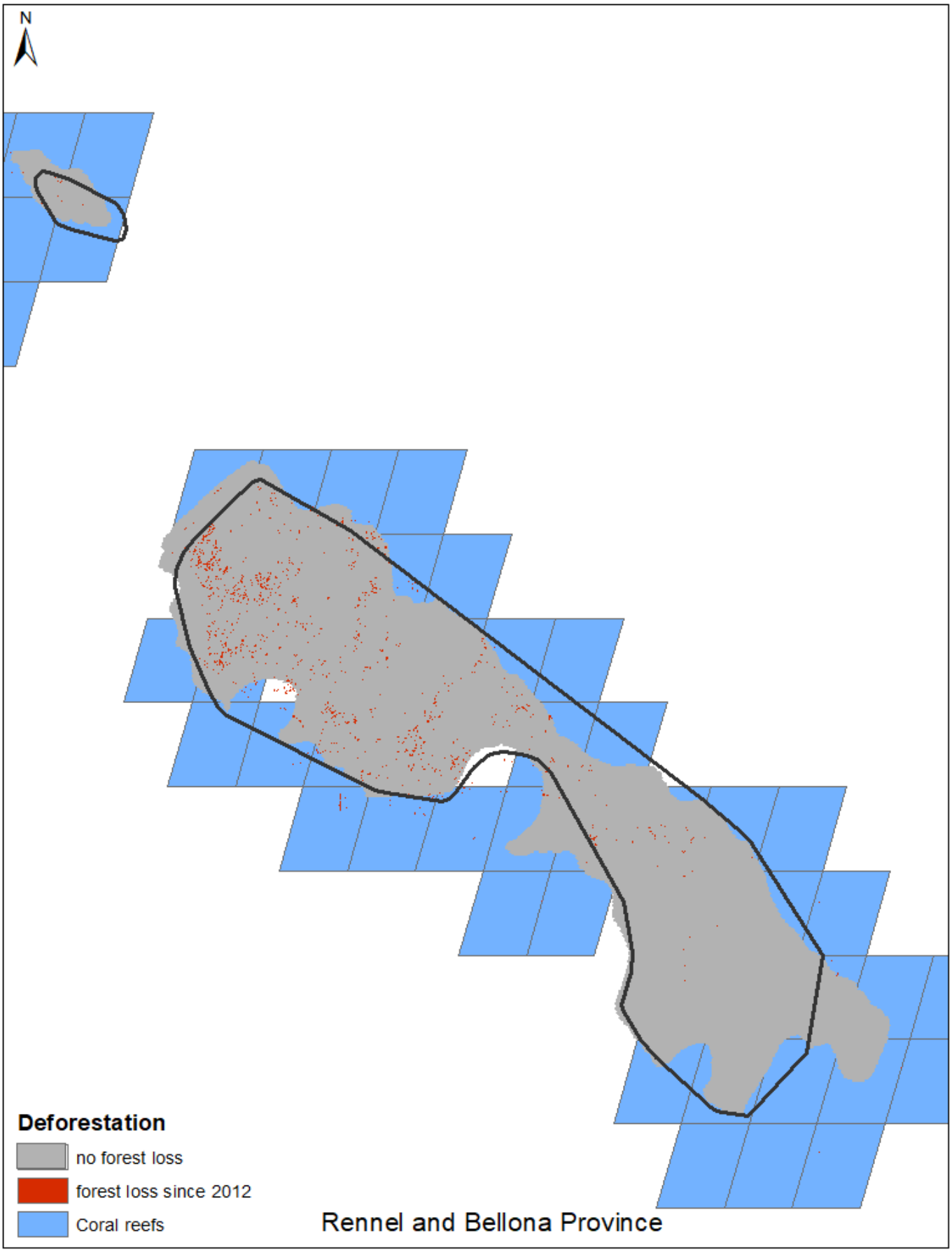
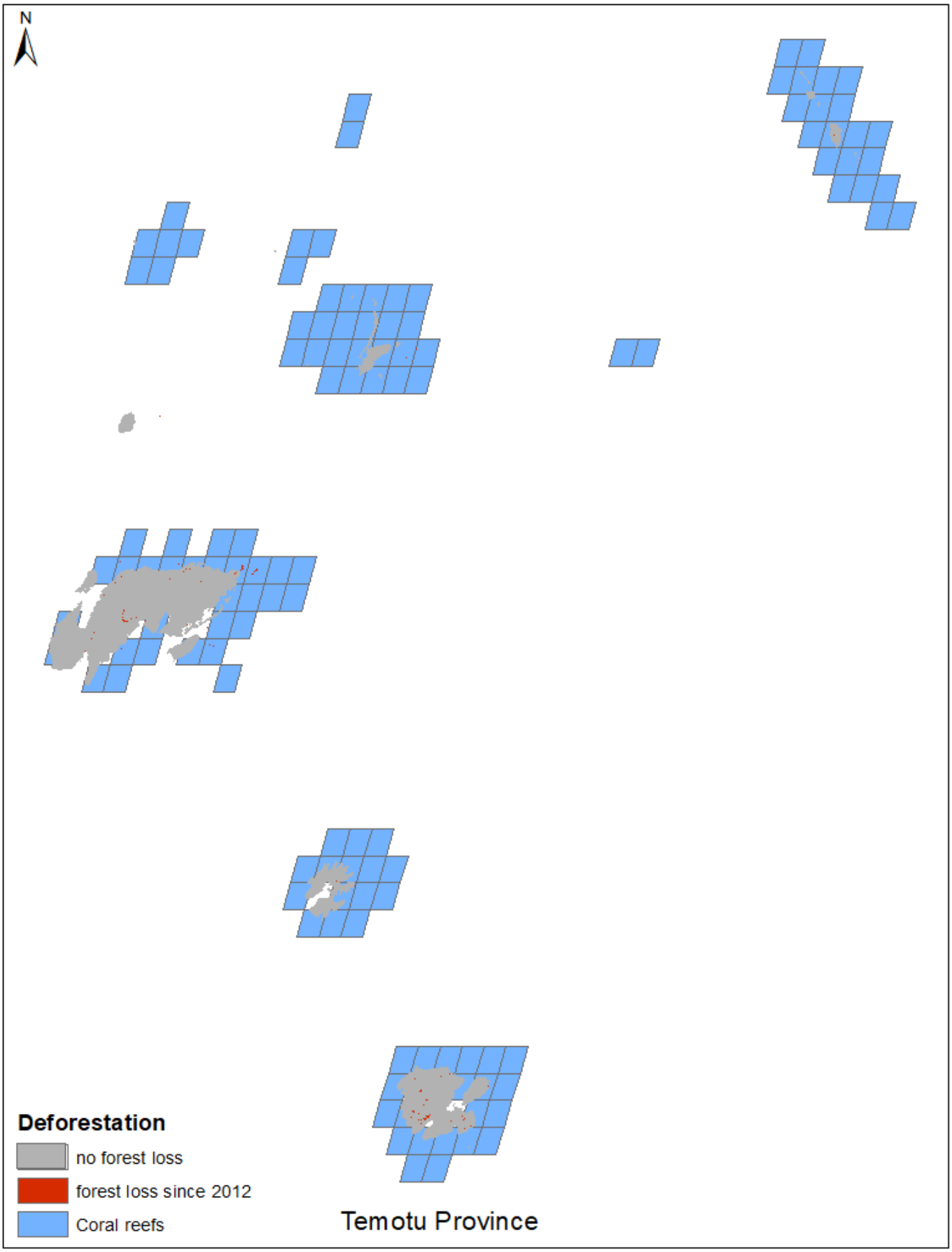
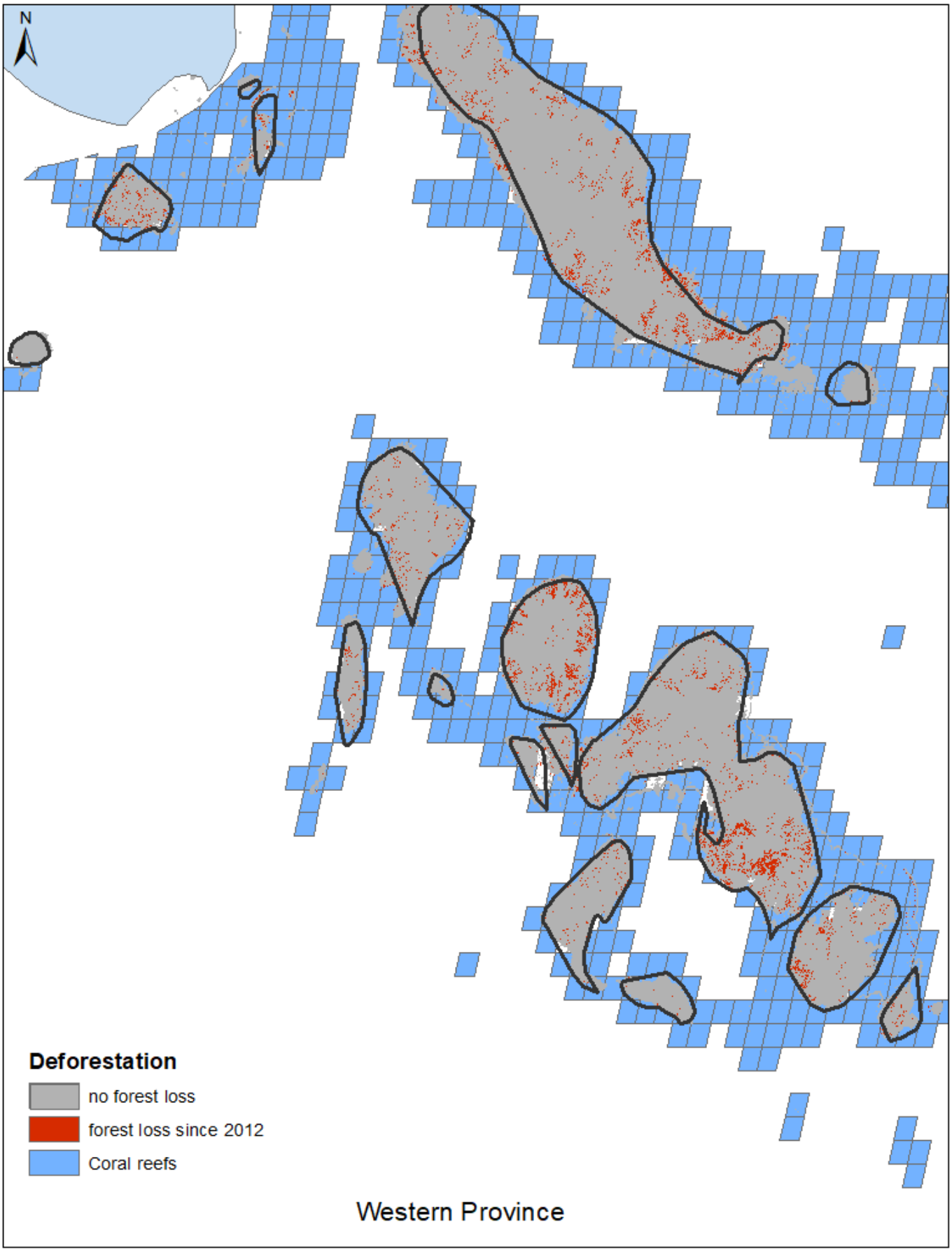
forest loss since 2012
Coral reefs
Malaita Province


N
Deforestation
no forest loss
forest loss since 2012
Coral reefs
Rennel and Bellona Province


N
Deforestation
no forest loss
forest loss since 2012
Coral reefs
Temotu Province


N
Deforestation
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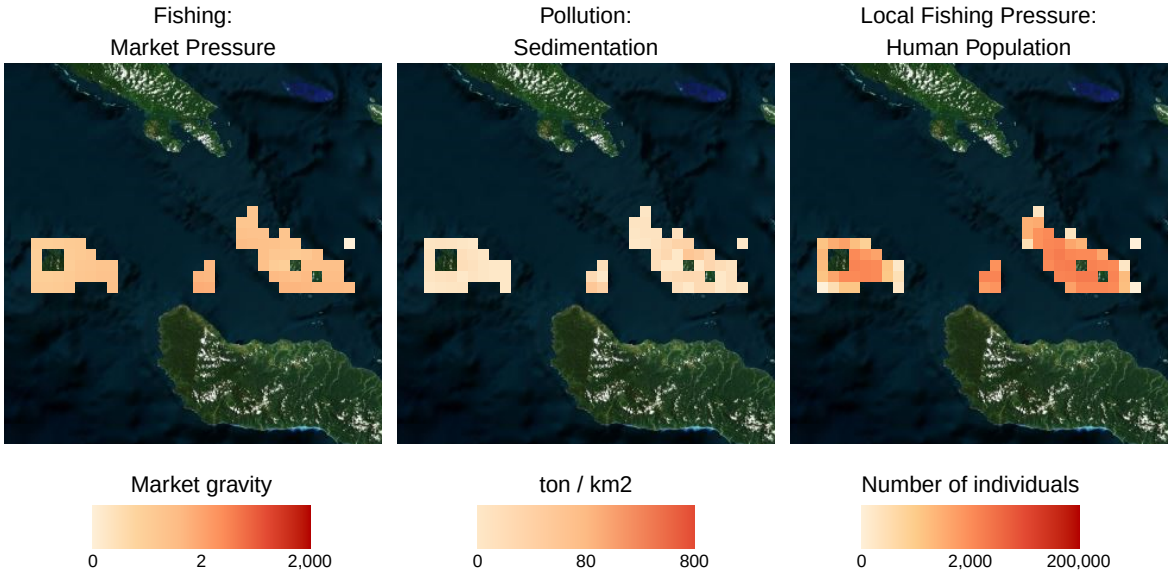
forest loss since 2012
Coral reefs
Western Province

Solomon Islands: Central Province

Global Threat Indicators



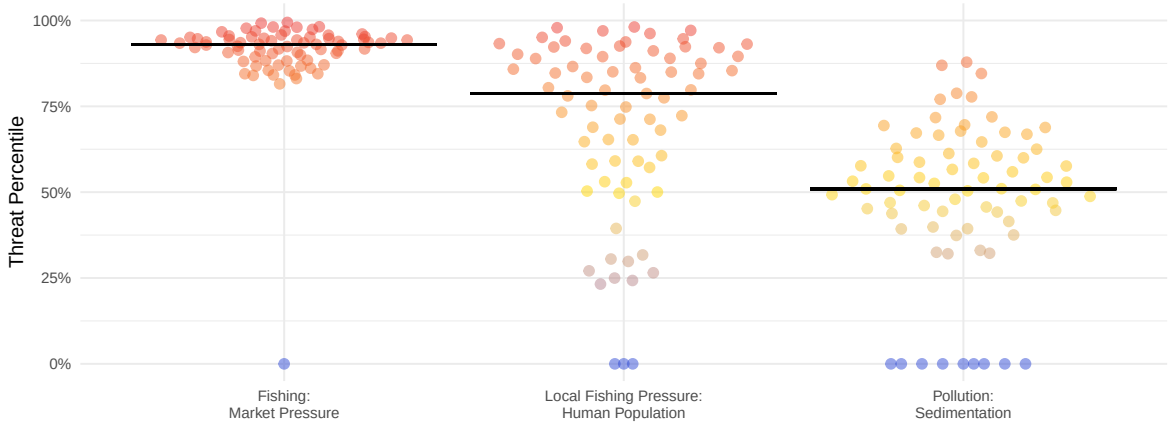
1) This is a mapping exercise that ranks a series of global data layers to understand the different contexts and/or threats of various reef locations. Local knowledge and validation is crucial.
2) Preliminary results are subject to change following scientific peer review; updated data layers can be found on https://programs.wcs.org/vibrantoceans/Map

Ranked Threats

1. Fishing: Market Pressure
2. Local Fishing Pressure: Human Population
3. Pollution: Sedimentation

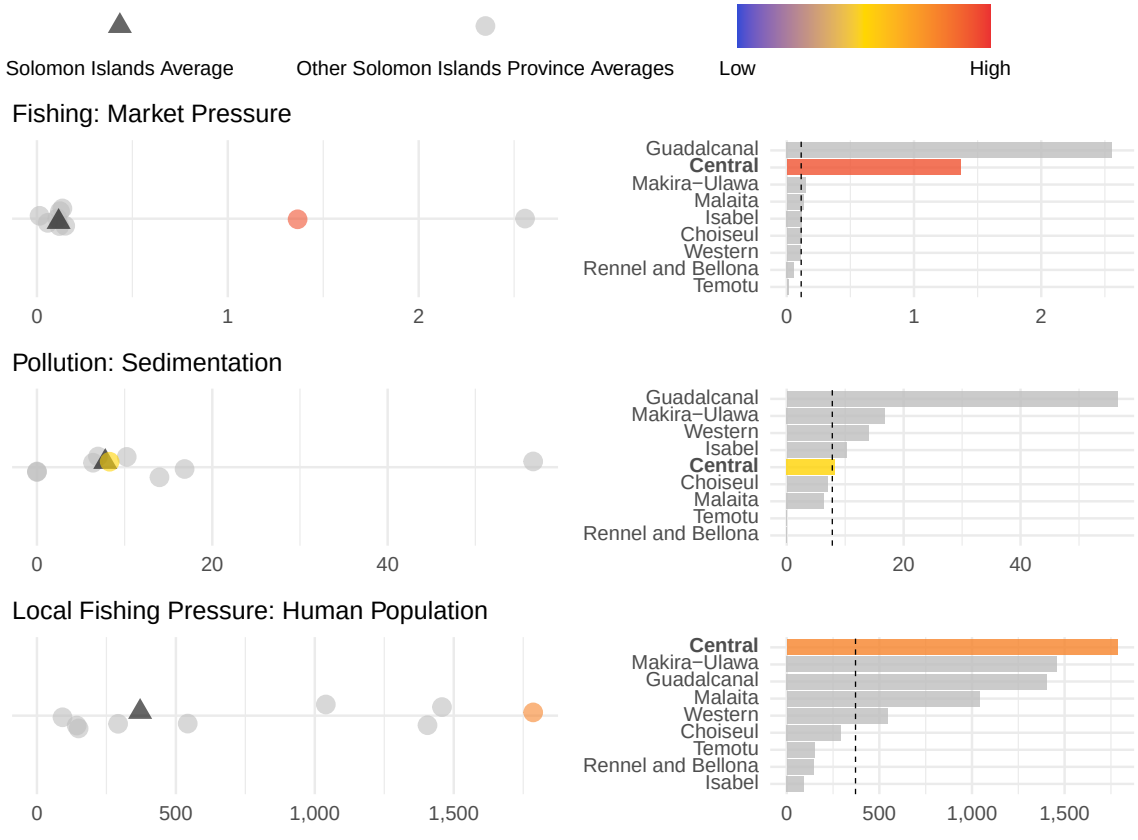
Threat Ranking

Threats ranked from highest to lowest; province average and pixels compared to all Solomon Islands pixels
A value in the 50th percentile means that the province's average is higher than 50% of Solomon Islands' coral reefs' values



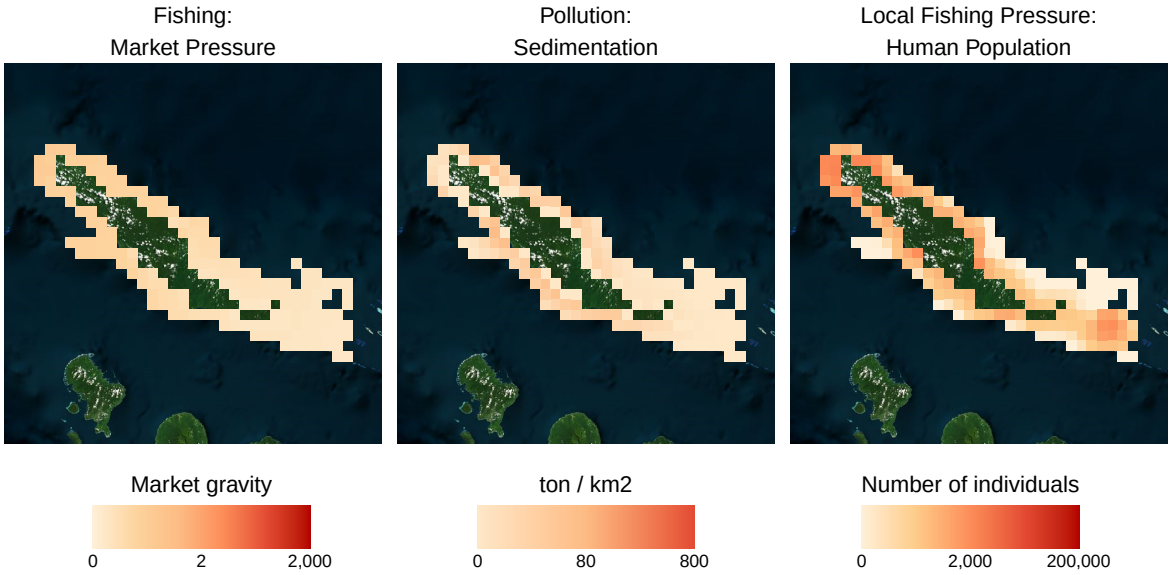
Context

(Coloured point in left panel represents Central Province)



Solomon Islands: Choiseul Province

Global Threat Indicators



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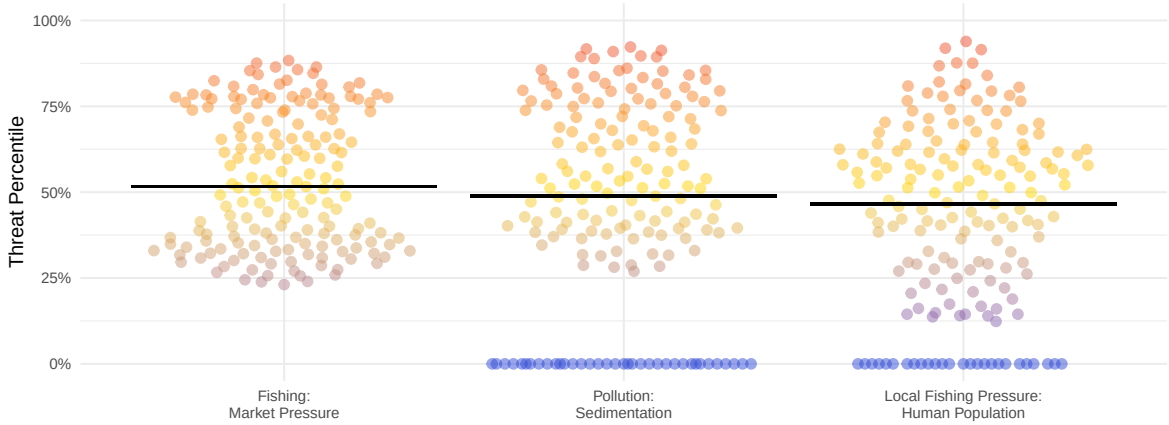
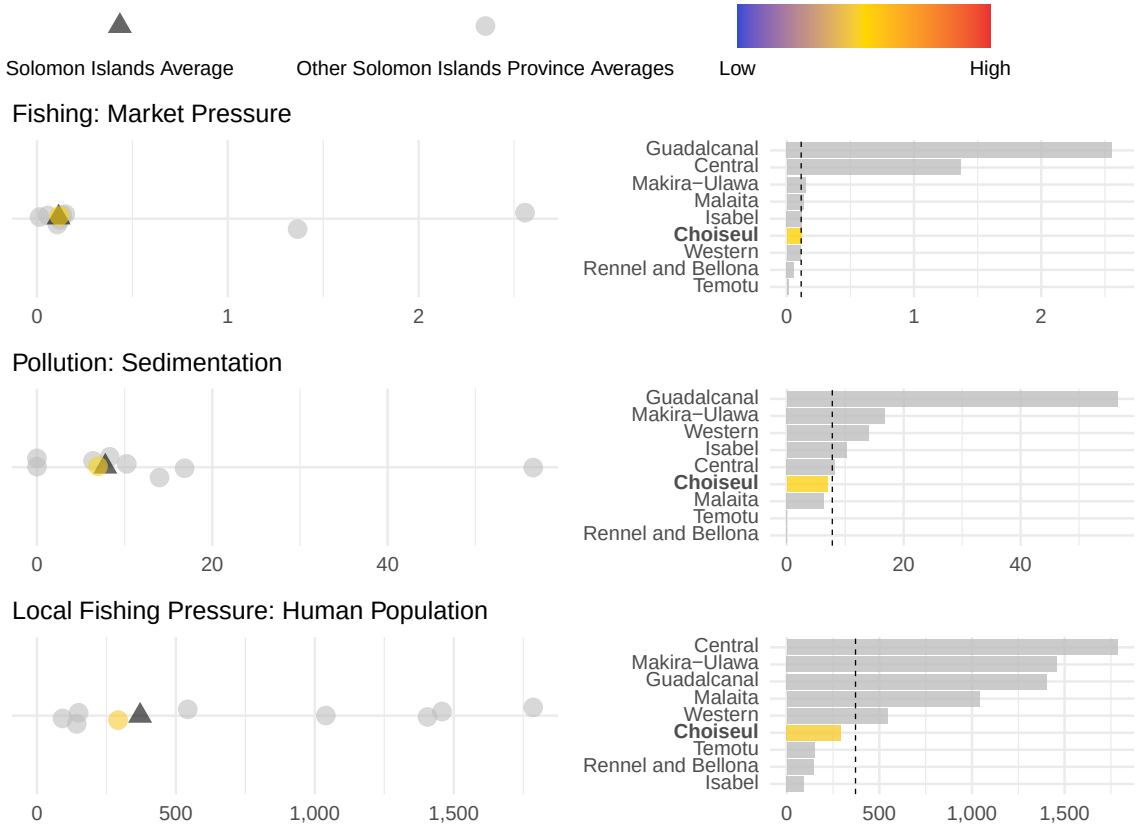


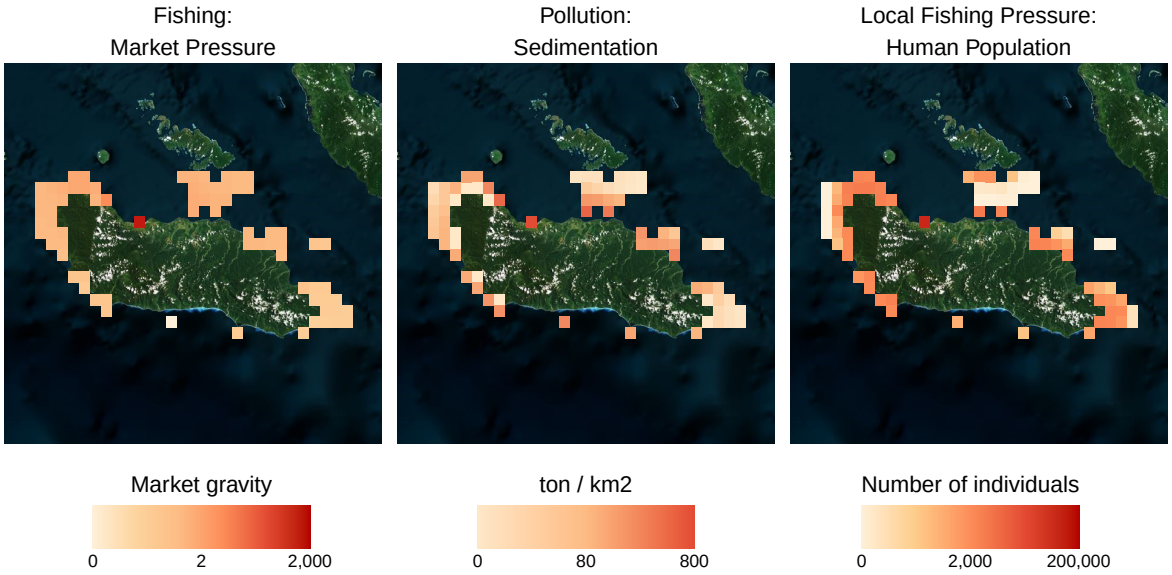
Context

(Coloured point in left panel represents Choiseul Province)



Solomon Islands: Guadalcanal Province

Global Threat Indicators



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3. Local Fishing Pressure: Human Population

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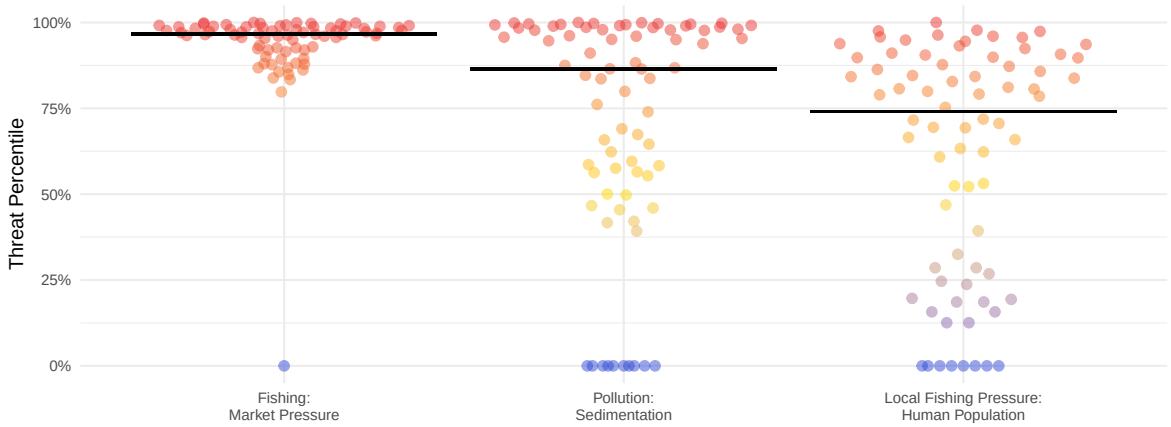
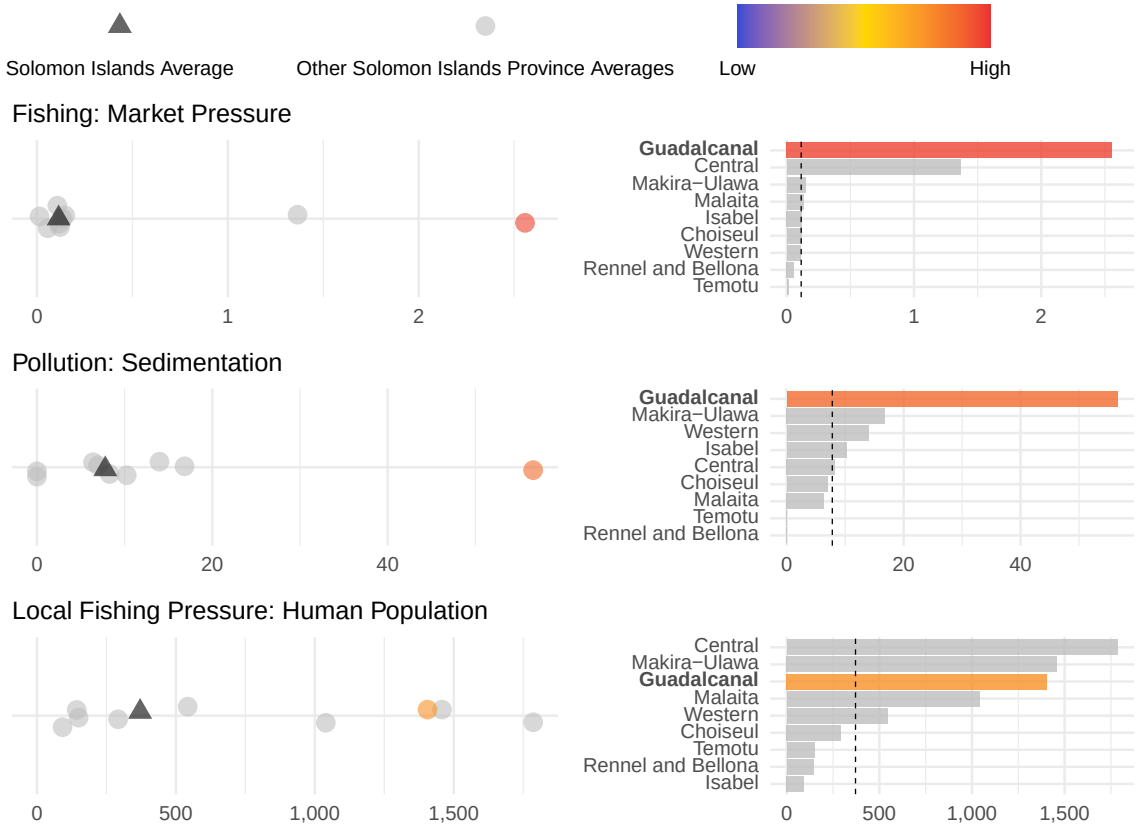
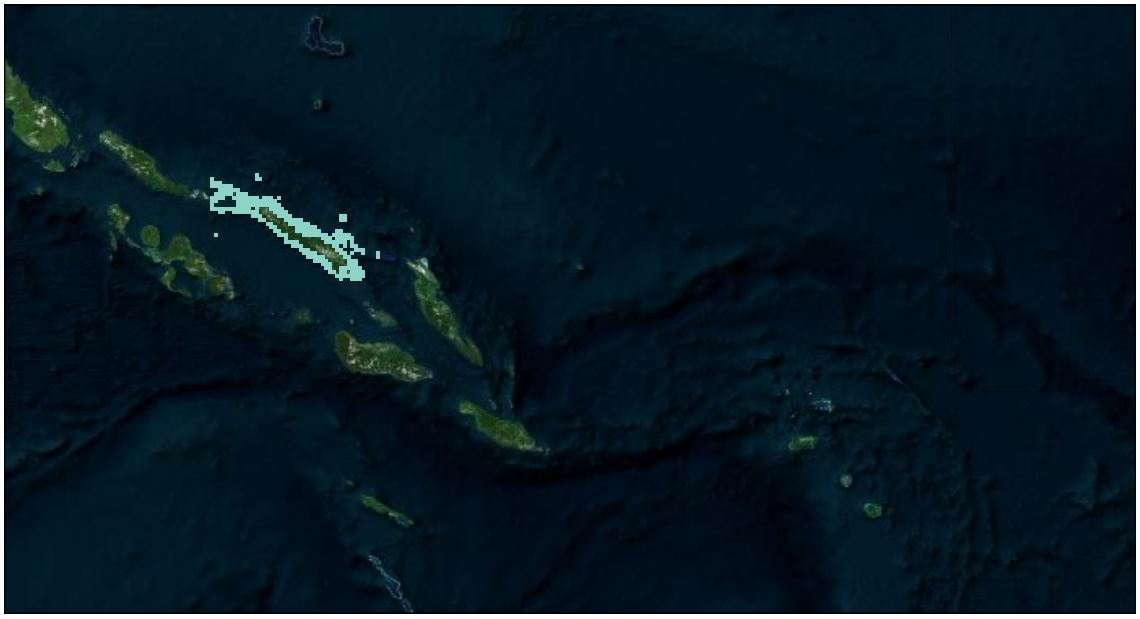


Context

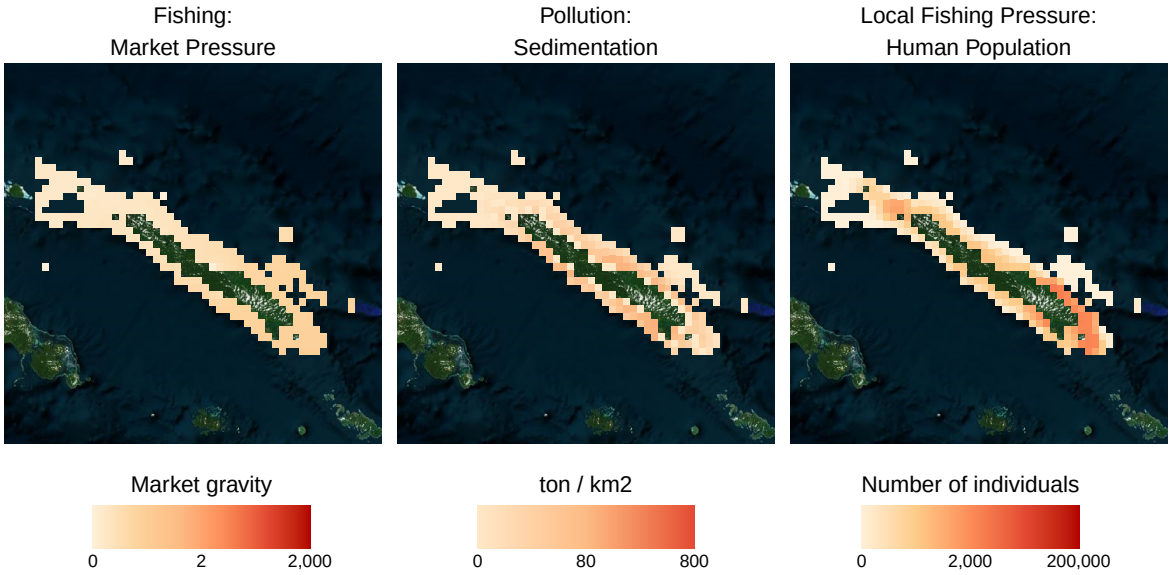
(Coloured point in left panel represents Guadalcanal Province)



Solomon Islands: Isabel Province



Global Threat Indicators



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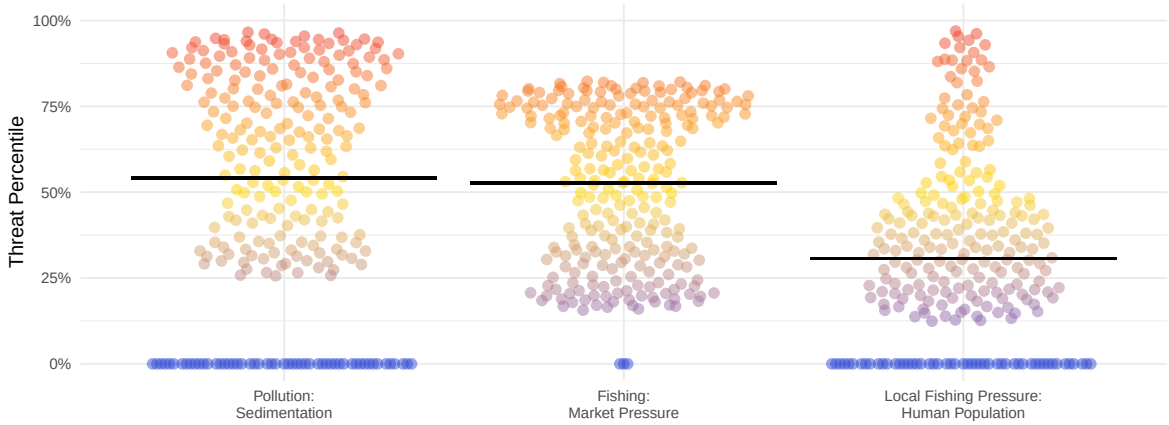
2) Preliminary results are subject to change following scientific peer review; updated data layers can be found on https://programs.wcs.org/vibrantoceans/Map

Ranked Threats

1. Pollution: Sedimentation
2. Fishing: Market Pressure
3. Local Fishing Pressure: Human Population

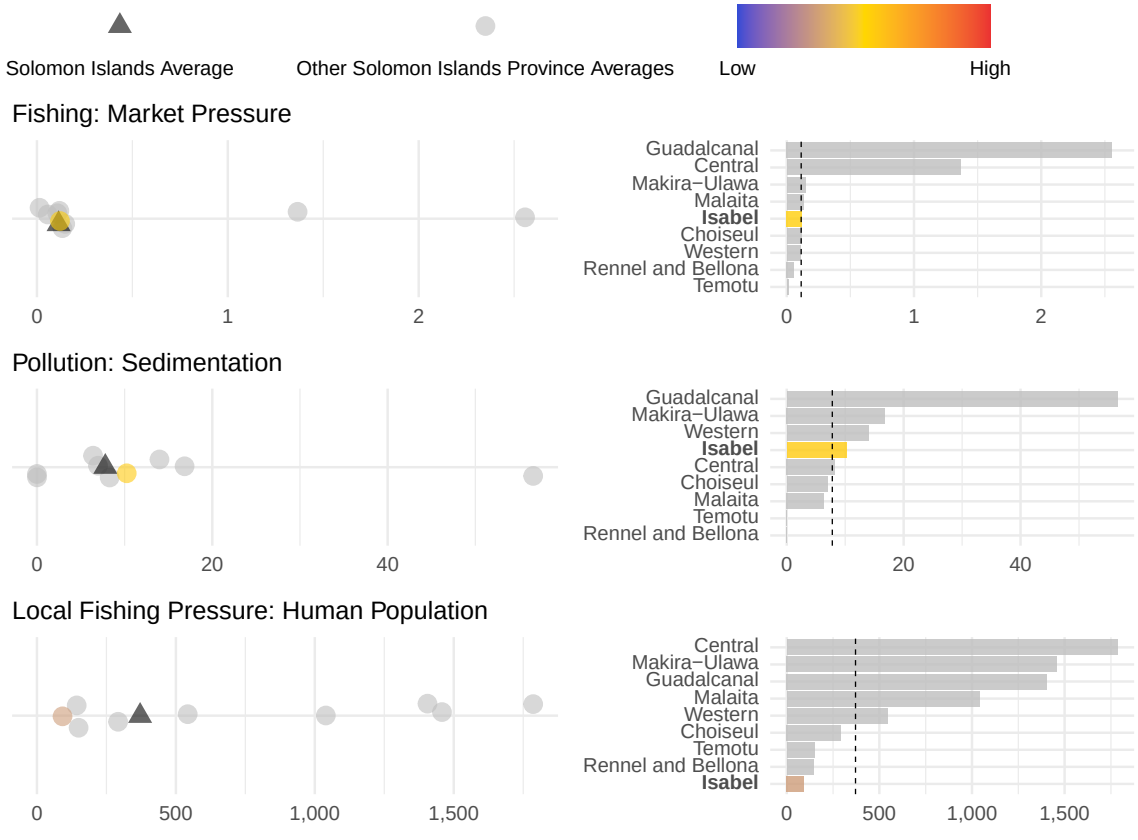
Threat Ranking

Threats ranked from highest to lowest; province average and pixels compared to all Solomon Islands pixels
A value in the 50th percentile means that the province's average is higher than 50% of Solomon Islands' coral reefs' values



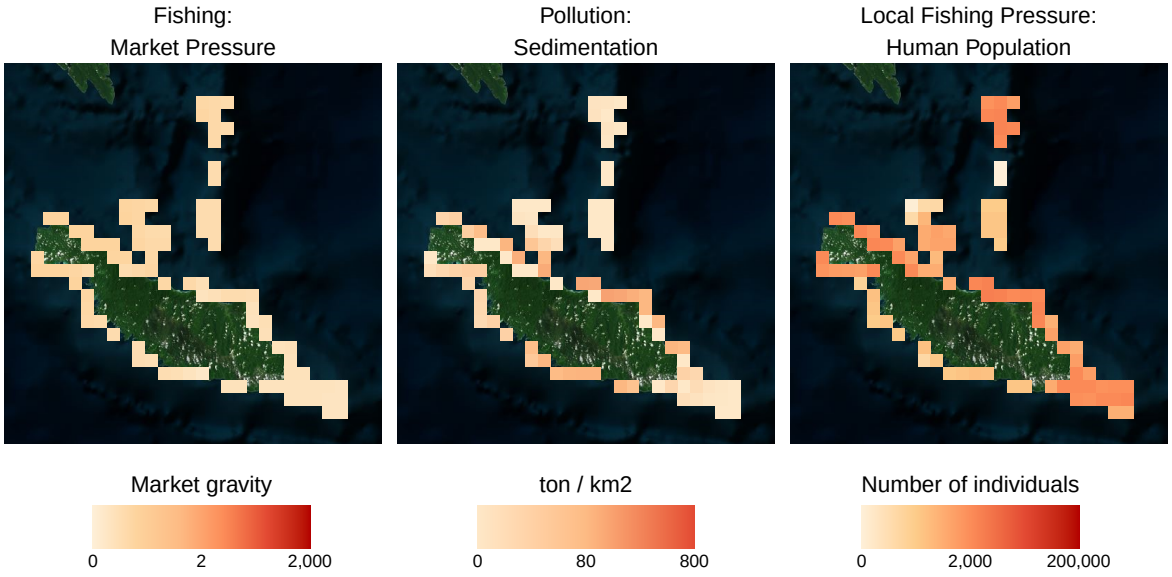
Context

(Coloured point in left panel represents Isabel Province)



Solomon Islands: Makira-Ulawa Province

Global Threat Indicators



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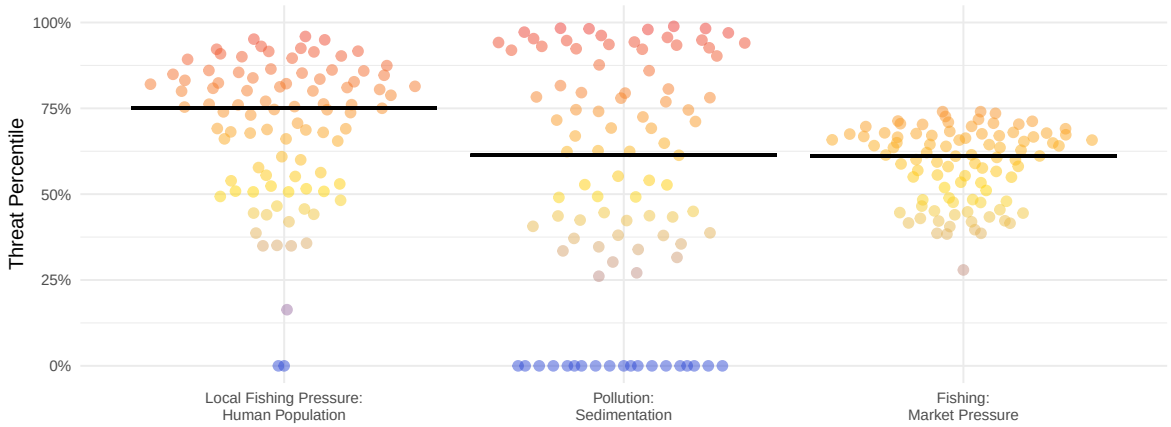
Ranked Threats

1. Local Fishing Pressure: Human Population
2. Pollution: Sedimentation
3. Fishing: Market Pressure

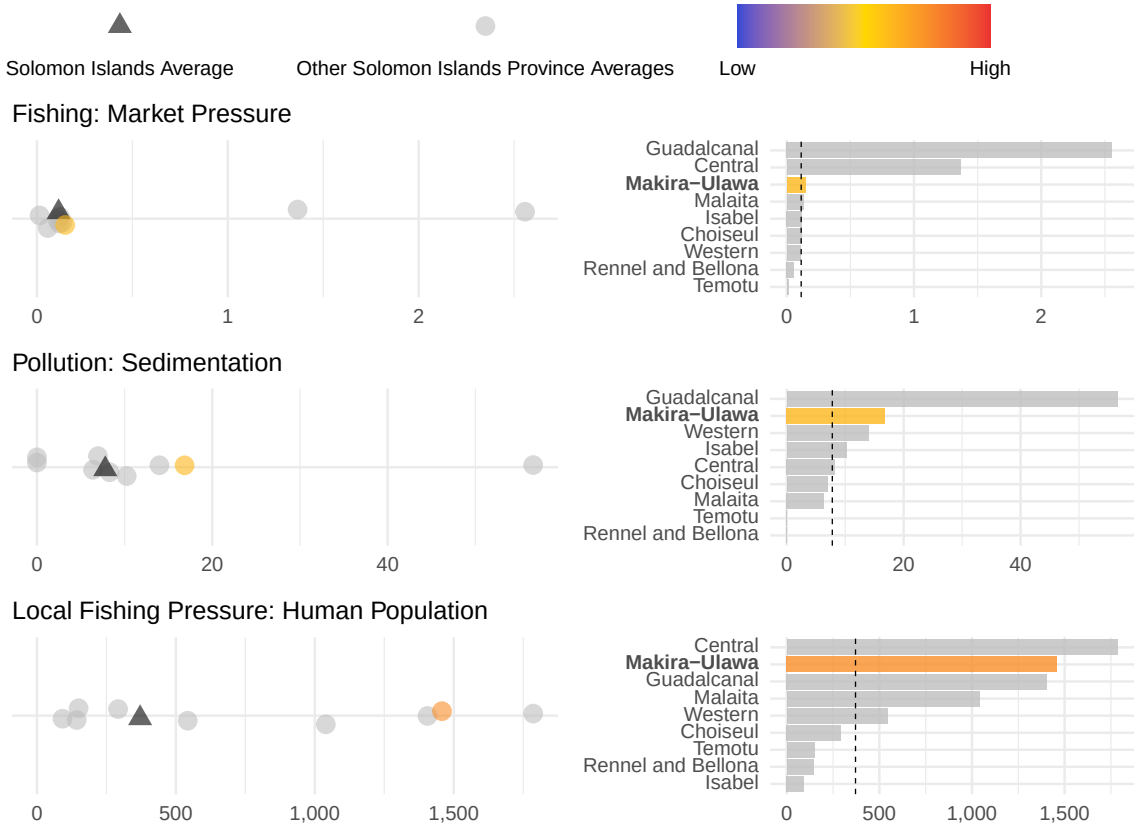
Threat Ranking

Threats ranked from highest to lowest; province average and pixels compared to all Solomon Islands pixels
A value in the 50th percentile means that the province's average is higher than 50% of Solomon Islands' coral reefs' values

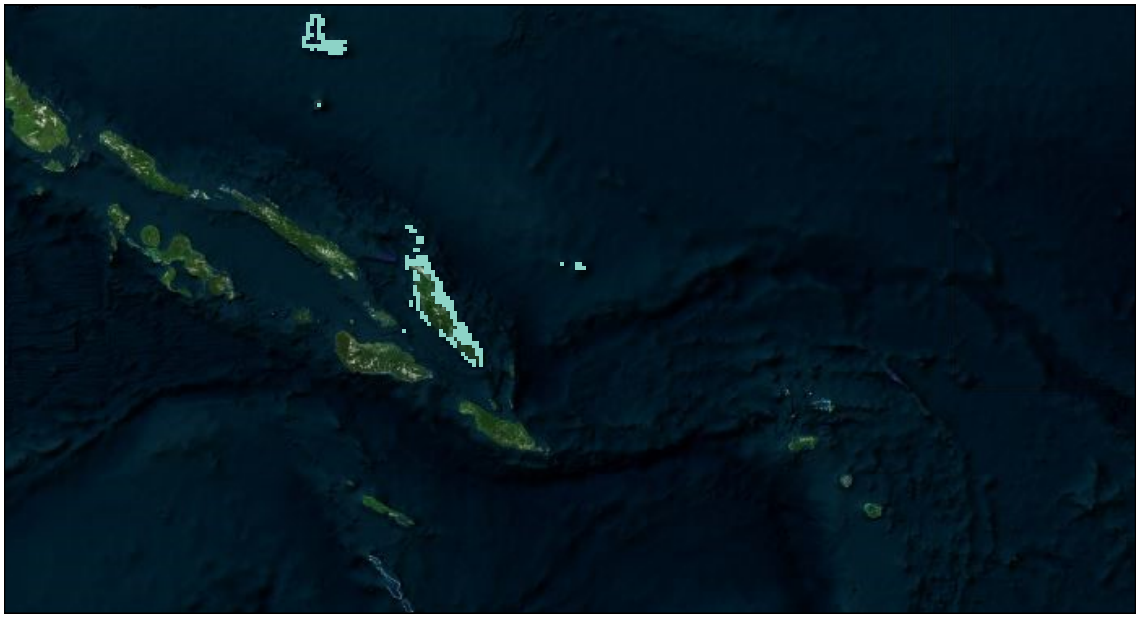


Context

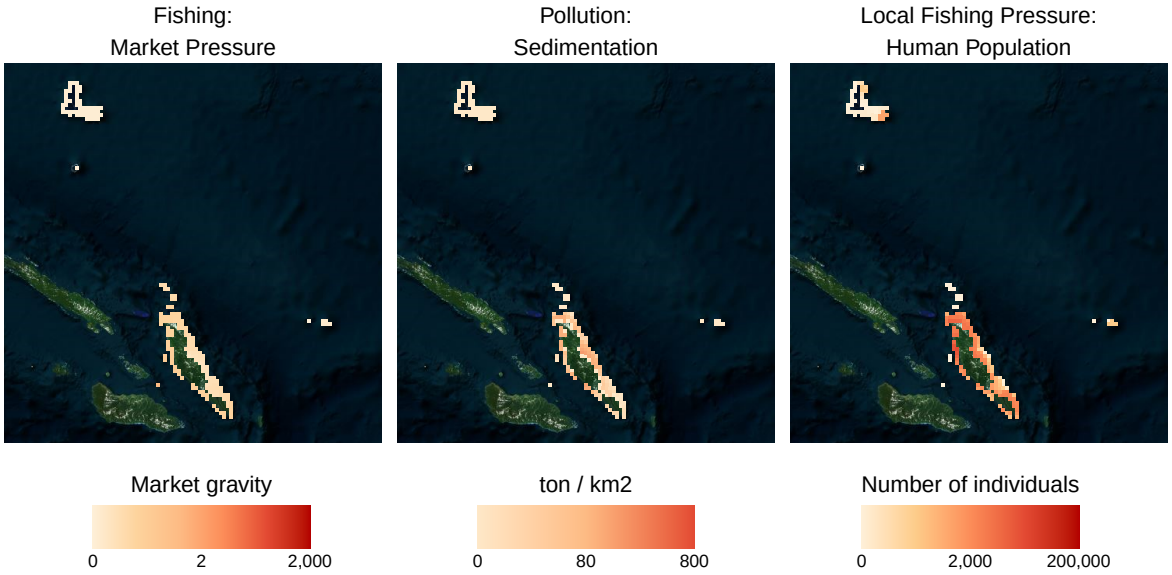
(Coloured point in left panel represents Makira-Ulawa Province)



Solomon Islands: Malaita Province



Global Threat Indicators



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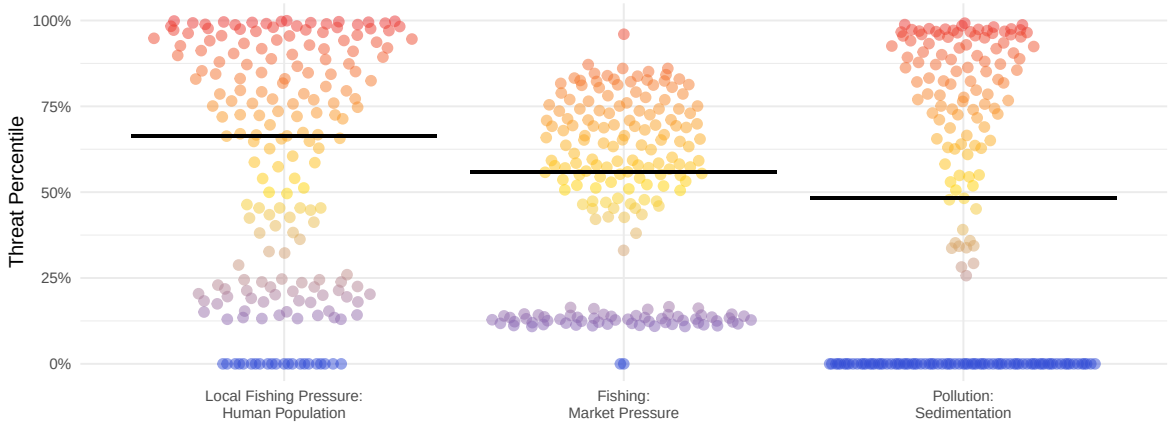
Ranked Threats

1. Local Fishing Pressure: Human Population
2. Fishing: Market Pressure
3. Pollution: Sedimentation

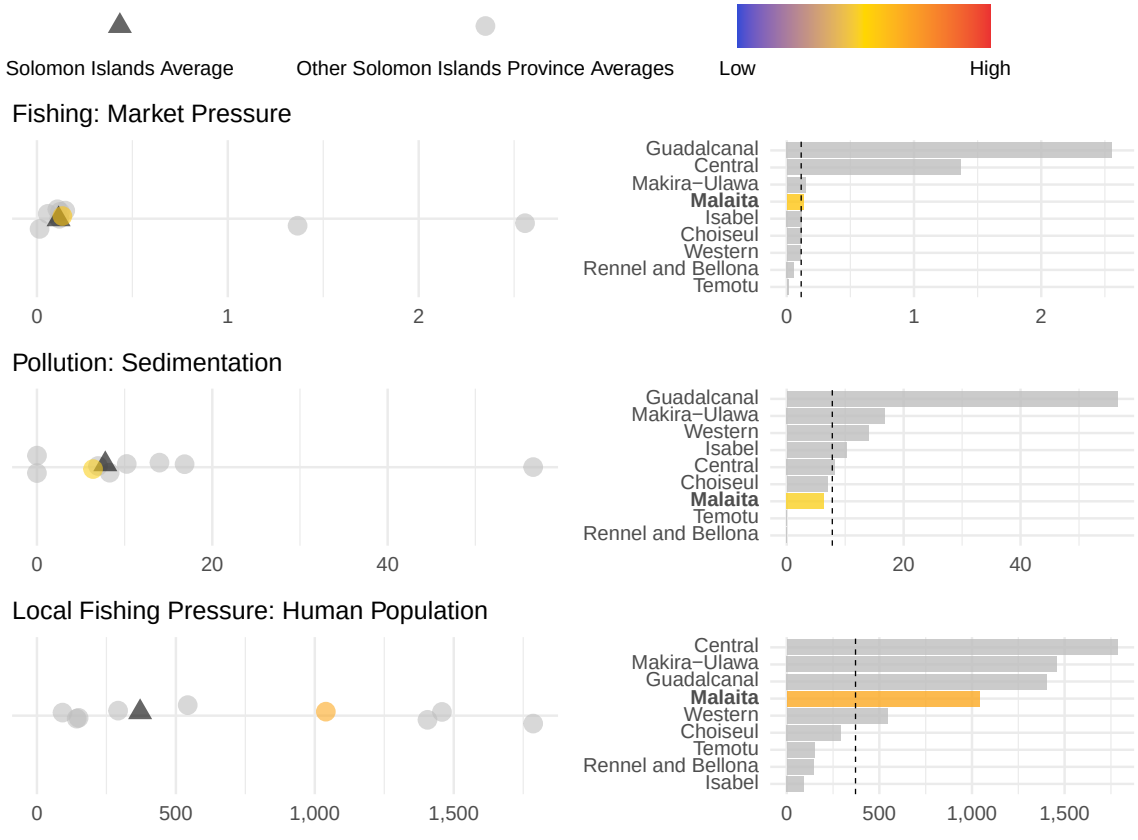
Threat Ranking

Threats ranked from highest to lowest; province average and pixels compared to all Solomon Islands pixels
A value in the 50th percentile means that the province's average is higher than 50% of Solomon Islands' coral reefs' values

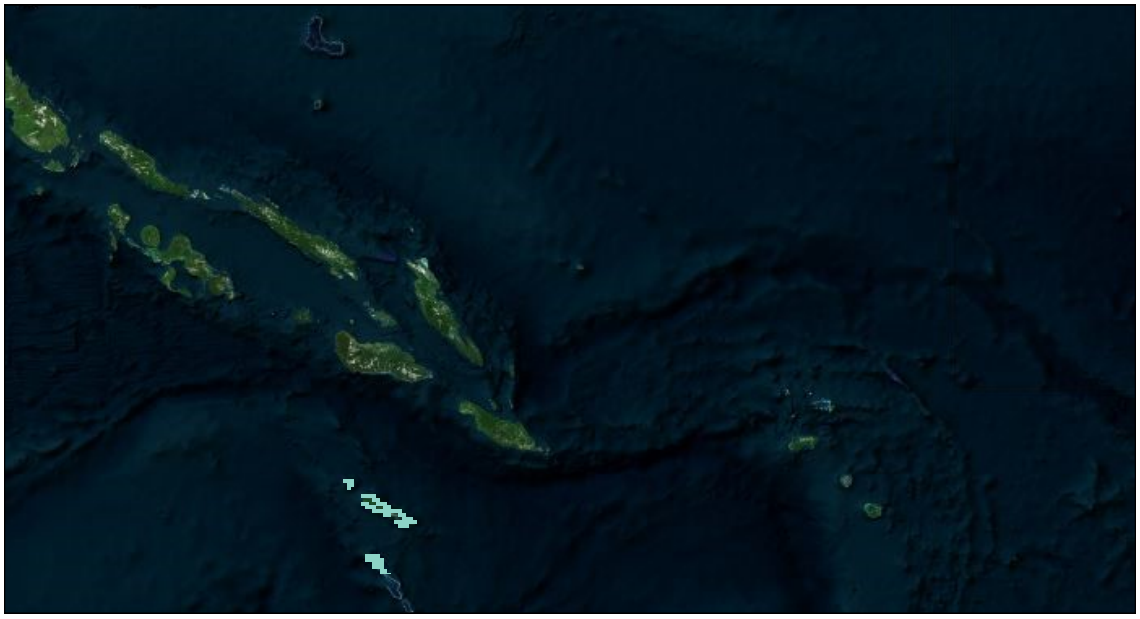


Context

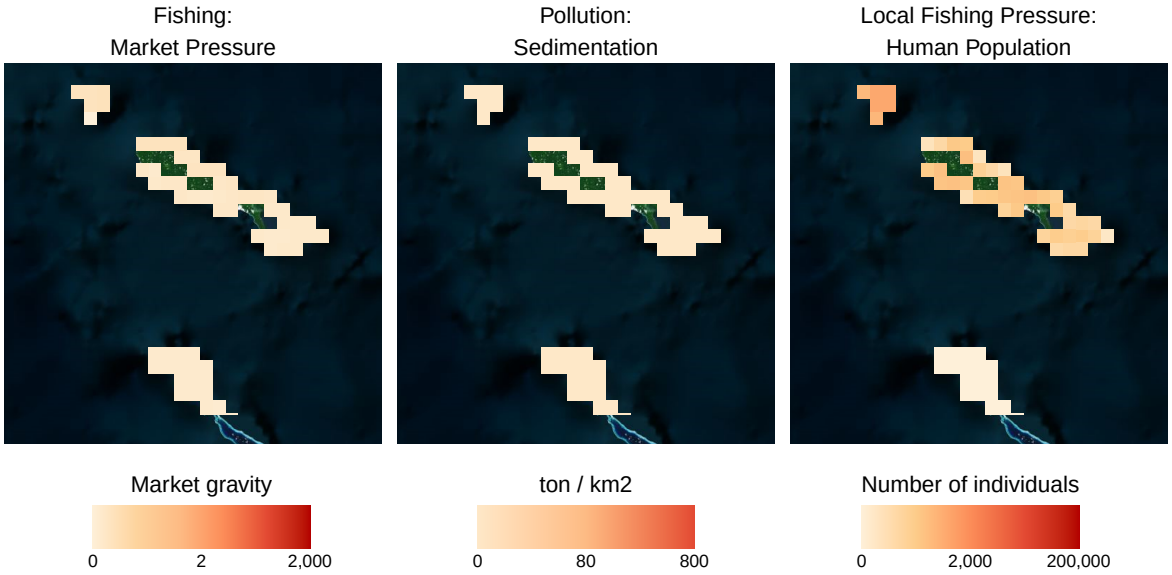
(Coloured point in left panel represents Malaita Province)



Solomon Islands: Rennel and Bellona Province



Global Threat Indicators



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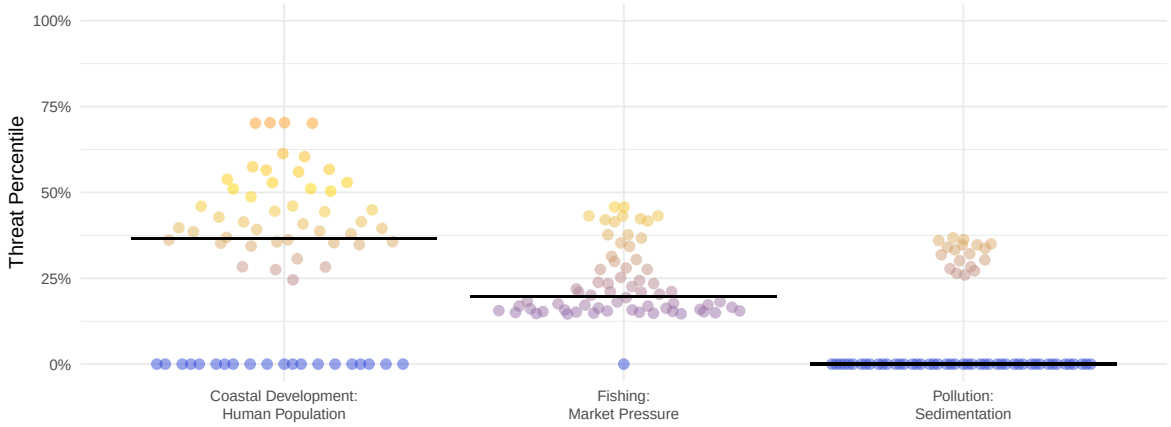
Ranked Threats

1. Coastal Development: Human Population
2. Fishing: Market Pressure
3. Pollution: Sedimentation

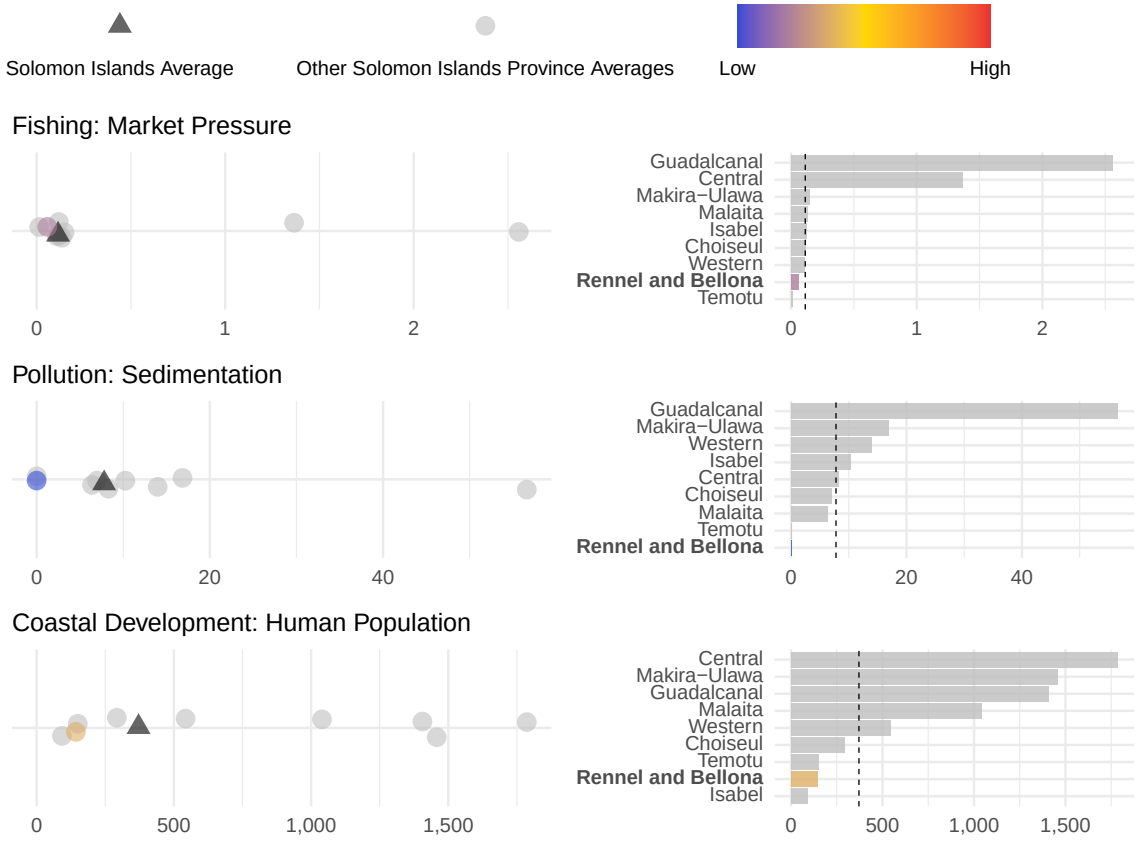
Threat Ranking

Threats ranked from highest to lowest; province average and pixels compared to all Solomon Islands pixels
A value in the 50th percentile means that the province's average is higher than 50% of Solomon Islands' coral reefs' values



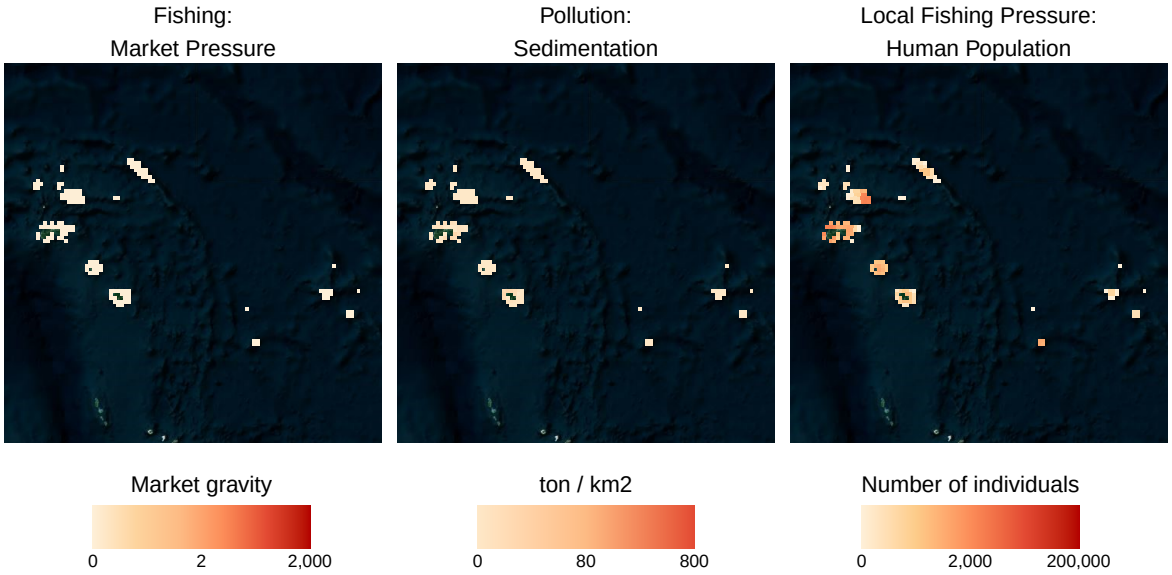
Context

(Coloured point in left panel represents Rennel and Bellona Province)



Solomon Islands: Temotu Province

Global Threat Indicators



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Ranked Threats

1. Local Fishing Pressure: Human Population
2. Pollution: Sedimentation
3. Fishing: Market Pressure

Threat Ranking

Threats ranked from highest to lowest; province average and pixels compared to all Solomon Islands pixels
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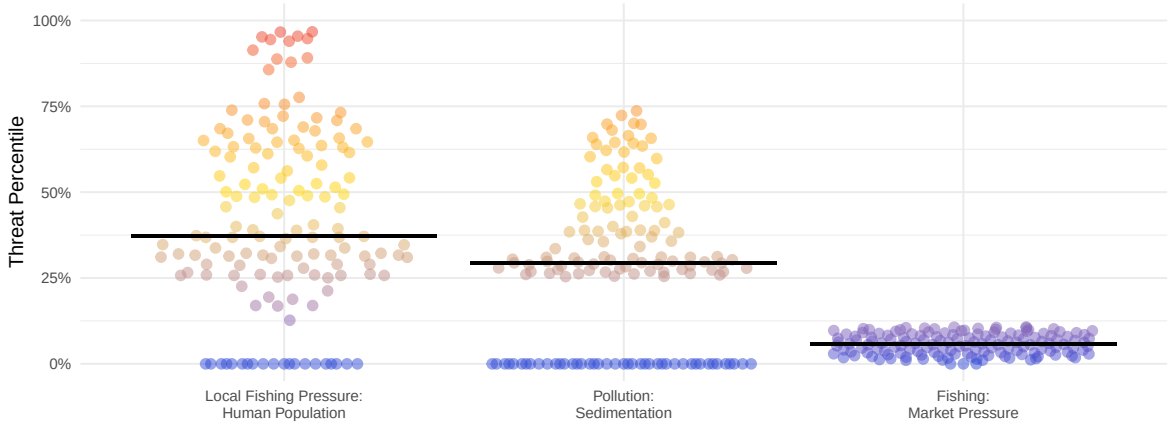
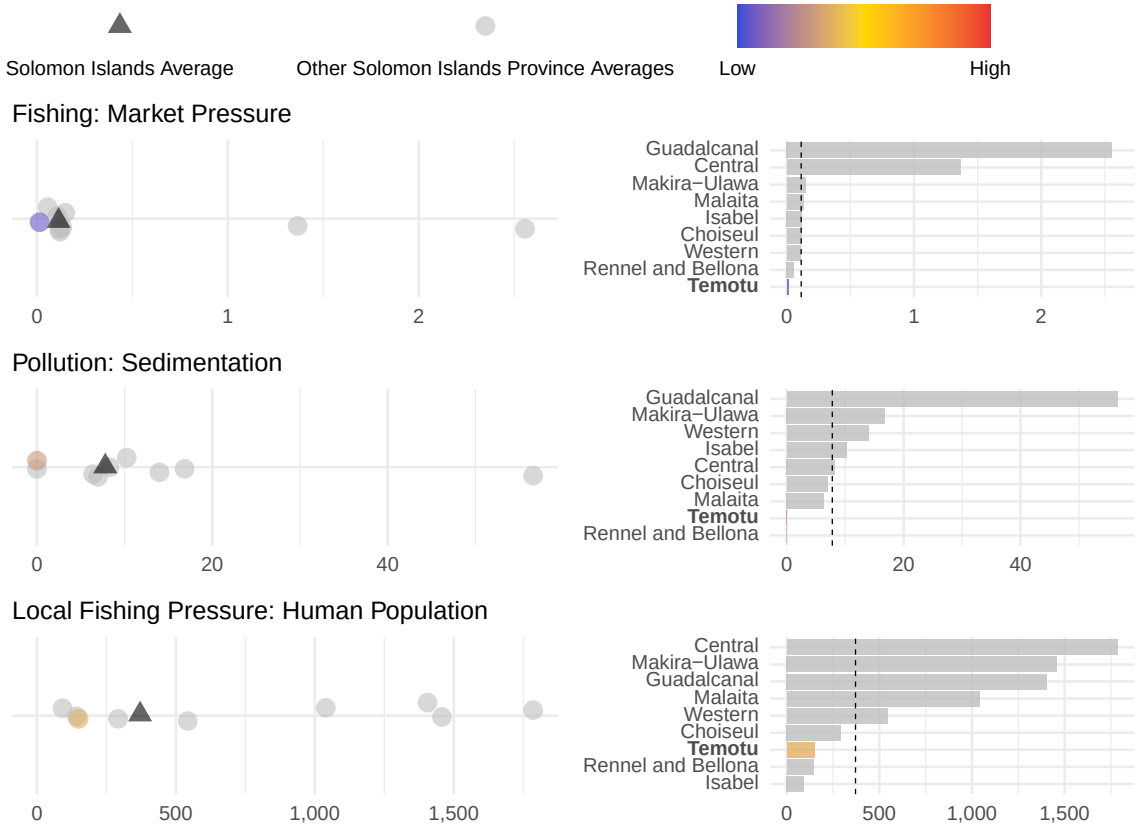


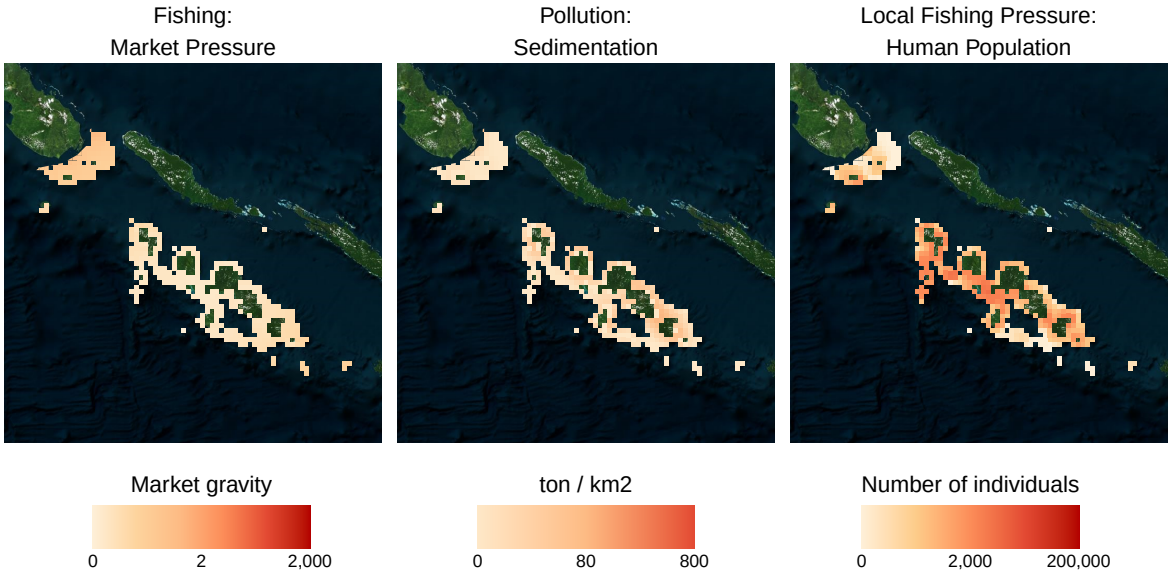
Context

(Coloured point in left panel represents Temotu Province)



Solomon Islands: Western Province

Global Threat Indicators



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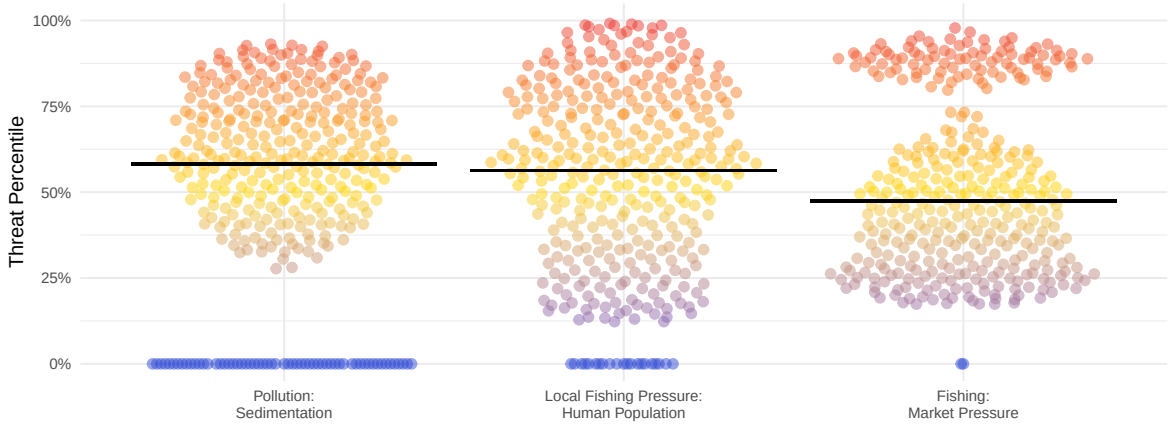
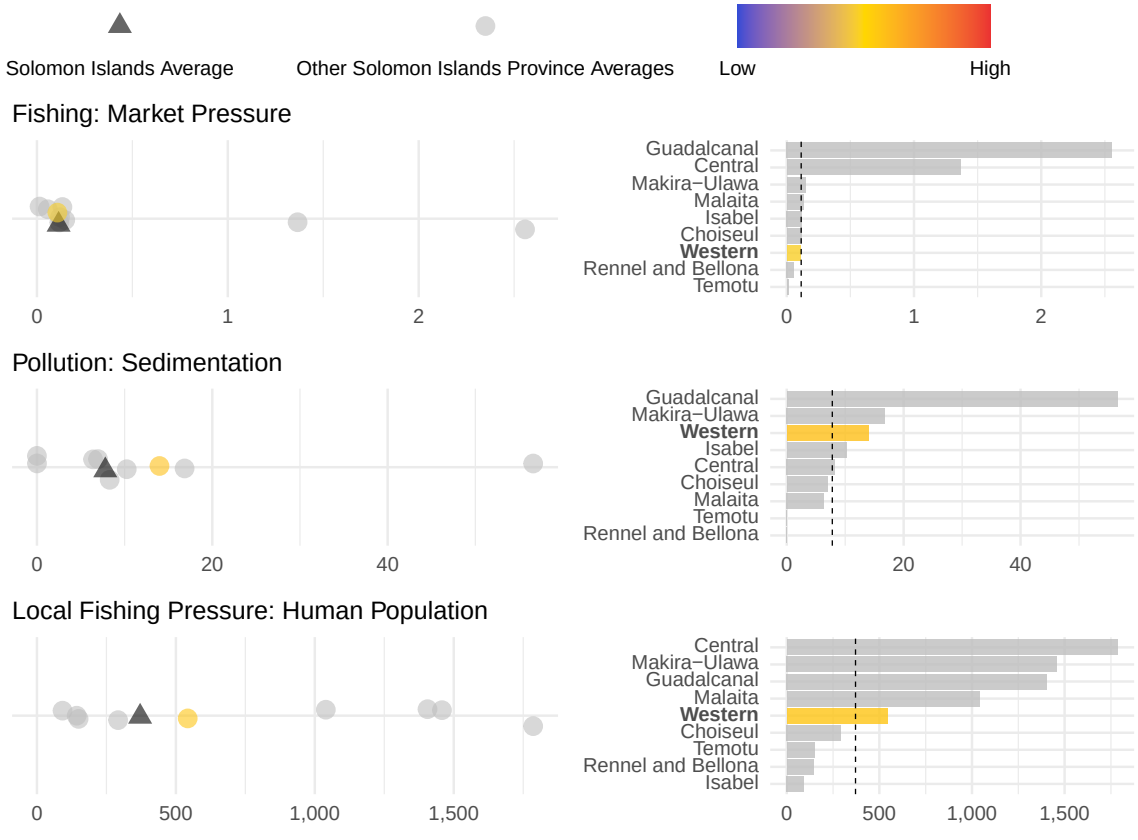
Ranked Threats

1. Pollution: Sedimentation
2. Local Fishing Pressure: Human Population
3. Fishing: Market Pressure

Threat Ranking

Threats ranked from highest to lowest; province average and pixels compared to all Solomon Islands pixels
A value in the 50th percentile means that the province's average is higher than 50% of Solomon Islands' coral reefs' values



Context

(Coloured point in left panel represents Western Province)