Watershed-to-Reef framework for southern Guam

USEPA Wetlands Program Development Grant

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https://www.uog.edu/ml/labs/houk.php

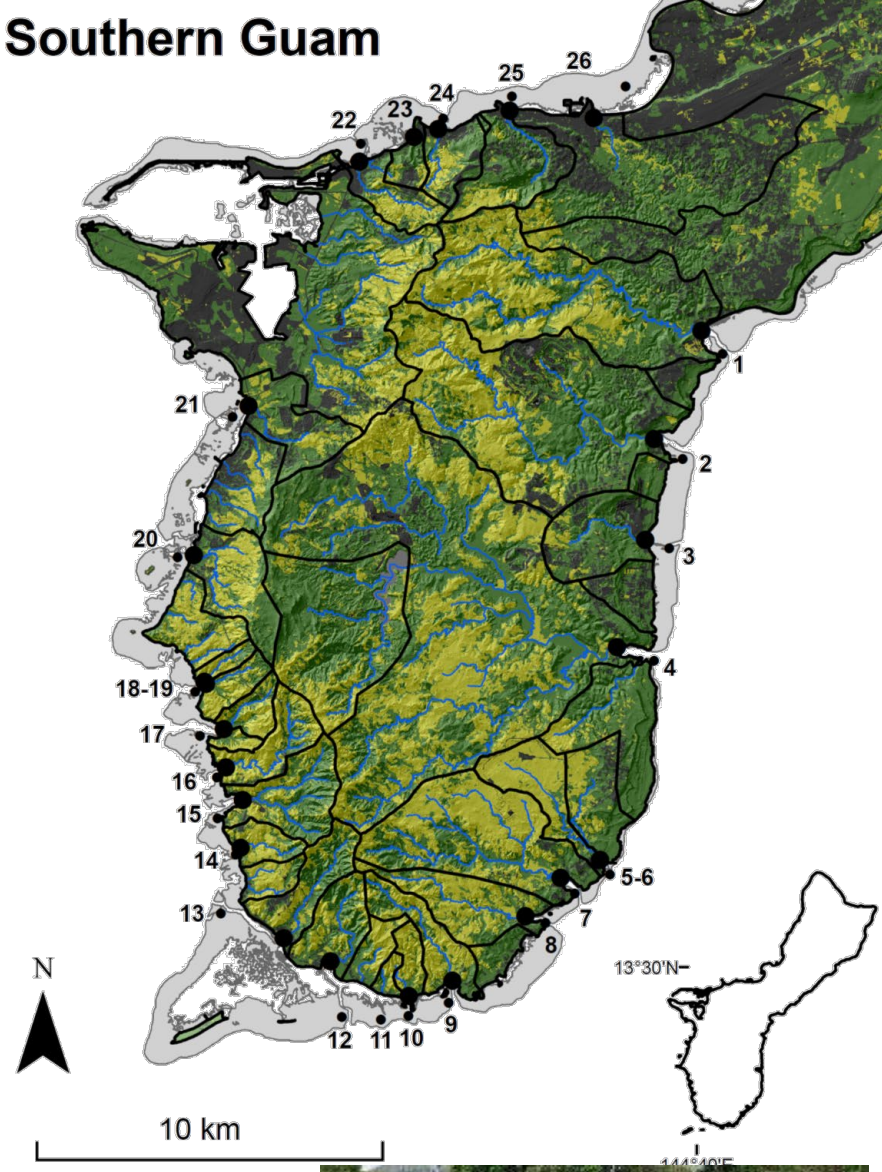
Objectives

- **Identify** and **characterize** watershed pollution and waterbodies
- Nutrient **criteria** for **water quality,** coral **reefs**, and nearshore **fisheries**
- Evaluate pollution, fishing pressure, and fisheries management (**MPA**) on reefs

Talofofo Bay photo by Tom Schils before and after rain event

Sampling design

- **26** watershed-river systems
  - Monthly, **383** samples across year
- Calibrated teams
  - Sample **simultaneously**
- **Nitrogen (DIN-NO3/NH4)**, orthophosphate, and suite of basic parameters
- Coral-reef surveys
  - Coral, benthic substrates, fish

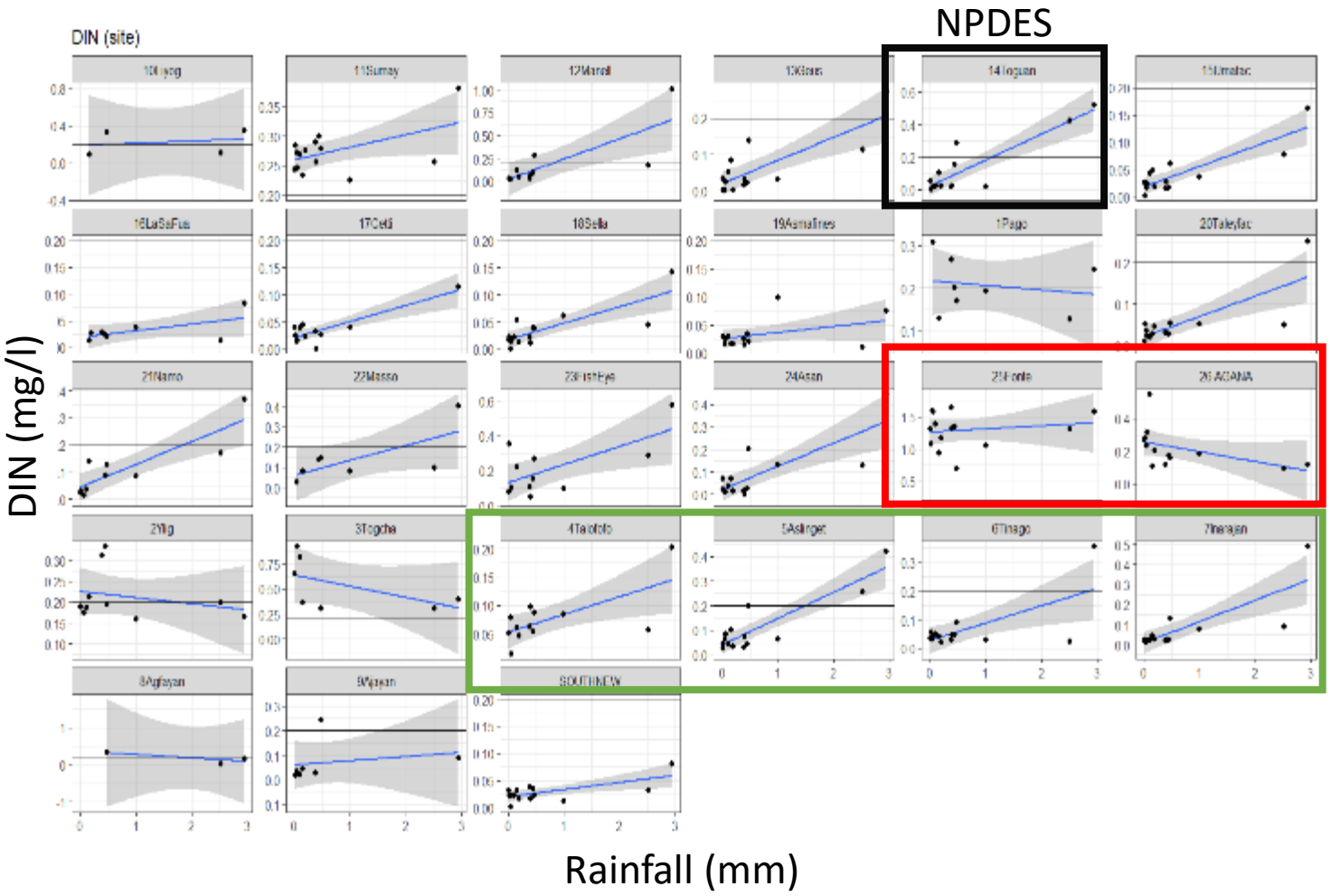


Goal 1: Characterize watershed pollution (DIN)

- Permitted NPDES DIN discharge
- Unclassified point-source pollution
- Non-point source pollution
  - septic, agriculture, urban, CAFO

Talofofo Bay photo by Tom Schils before and after rain event

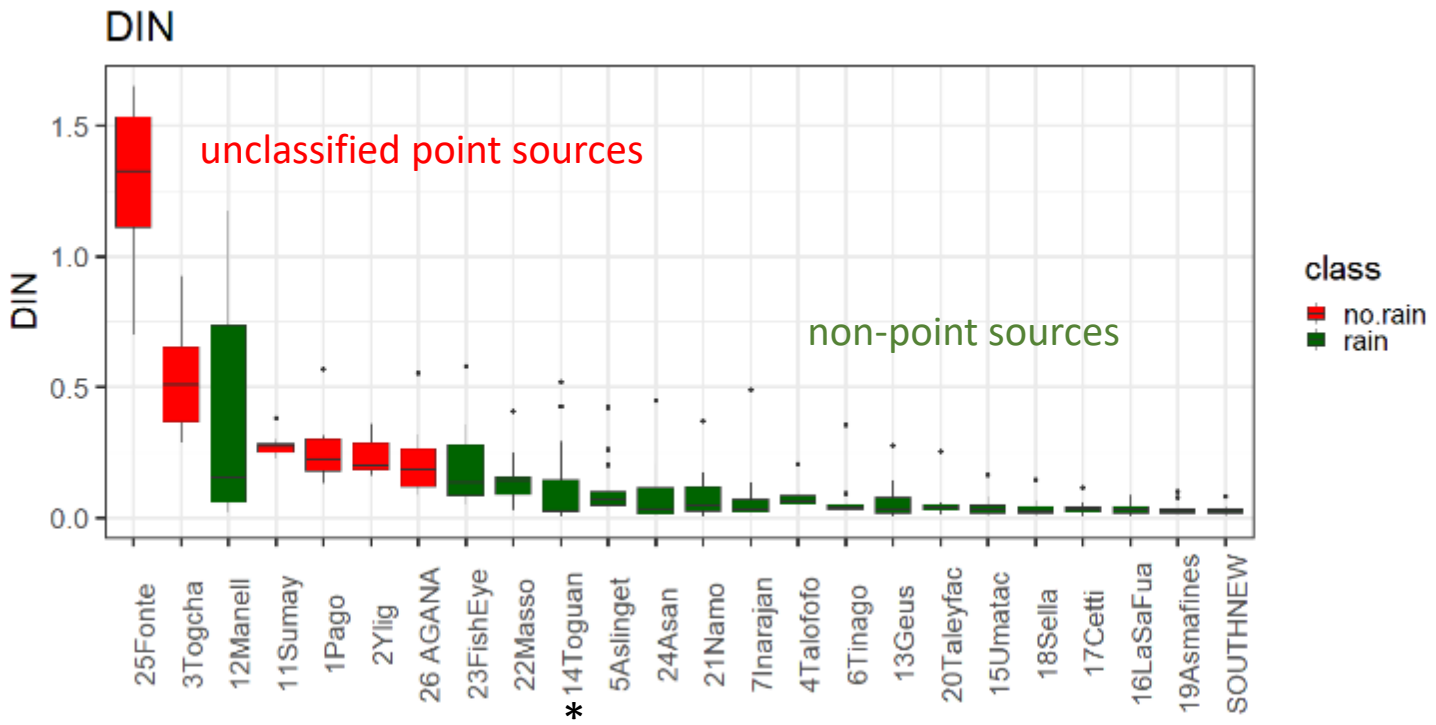
DIN ~ rainfall relationships

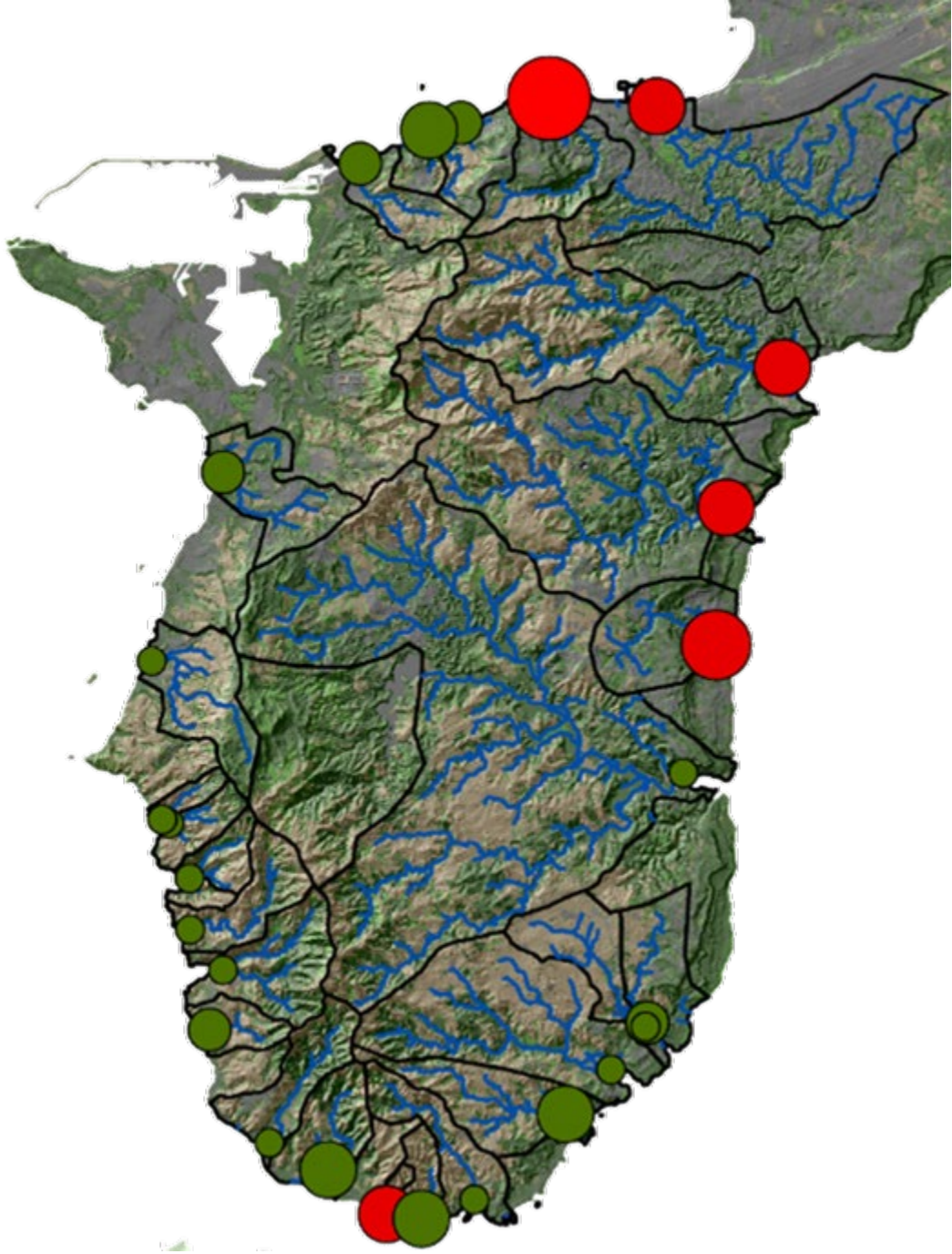


No or weak relationship with rainfall, high DIN - **point**

Relationship with rainfall, variable DIN – **nonpoint**

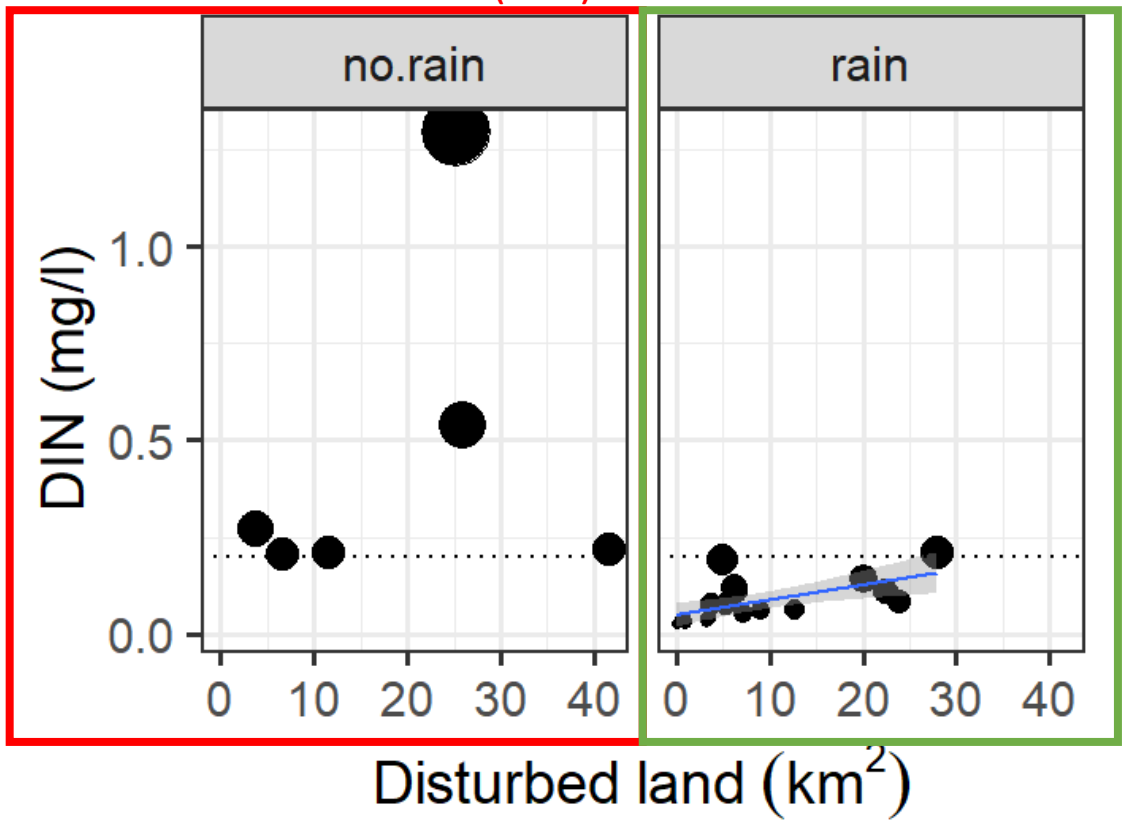
Spotlight on unclassified, suspected point sources



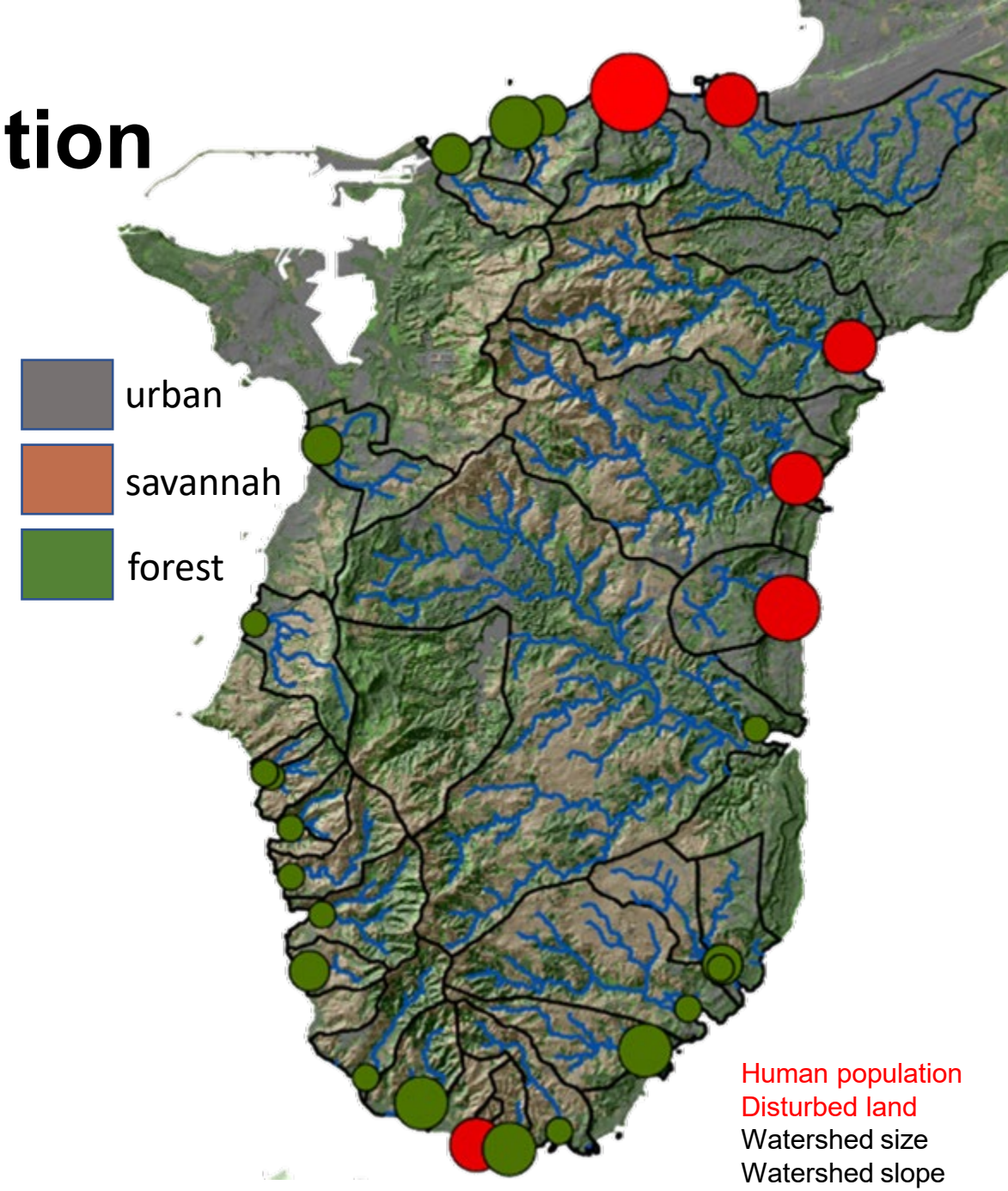


non-point versus point pollution

No or weak relation (n=6) Sites with rainfall relations (n=18)



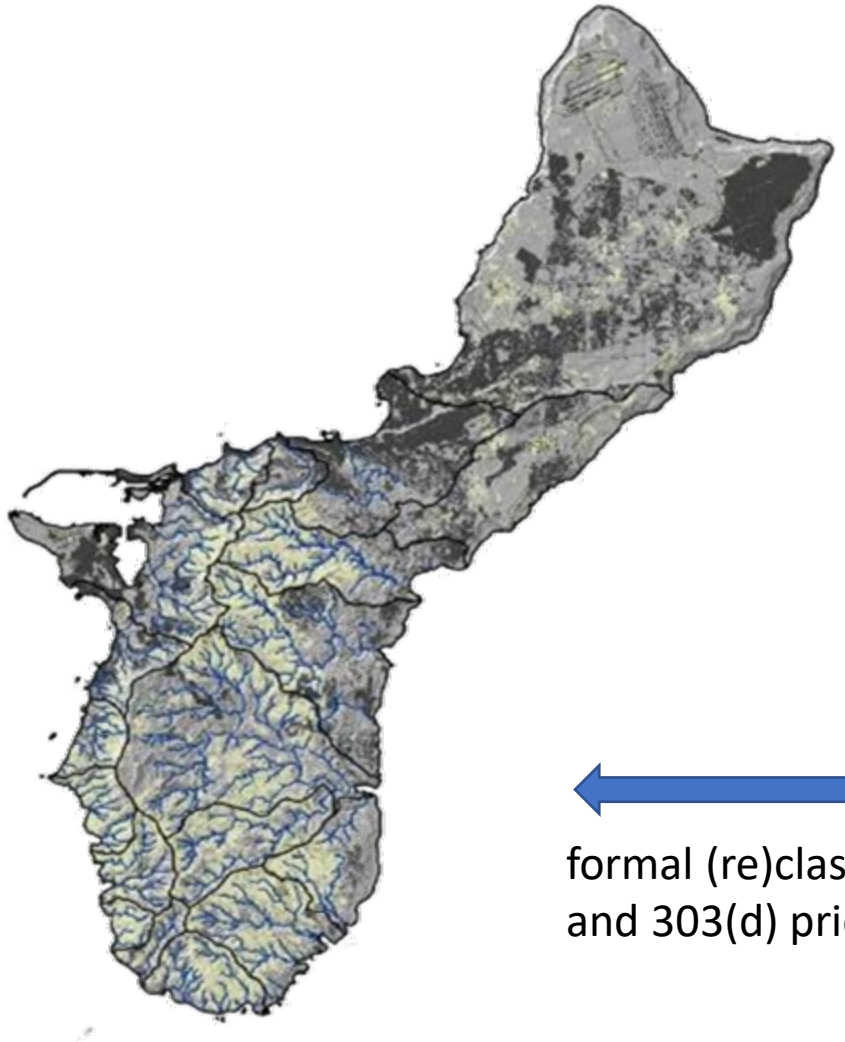
each data point = average of each site across the year

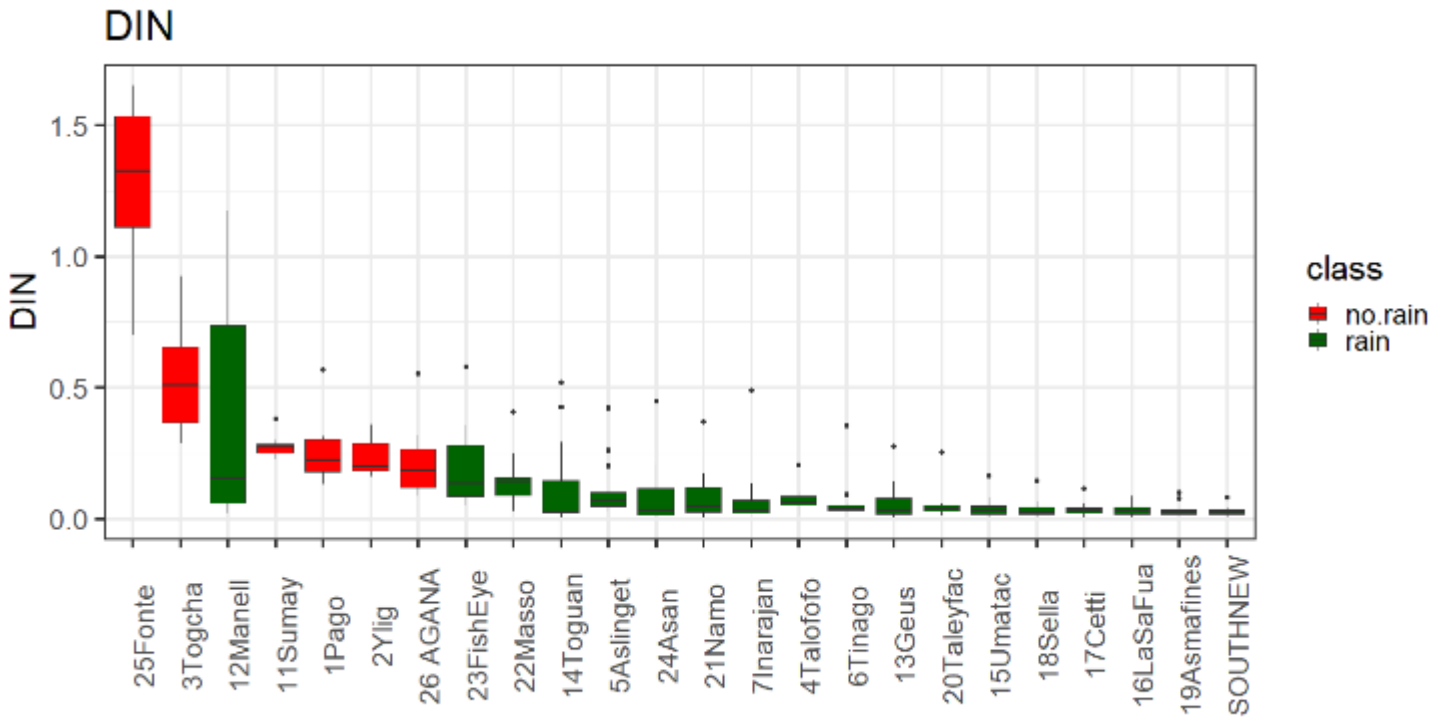


Human population
Disturbed land
Watershed size
Watershed slope

Outcomes of classification process

Classify and prioritize watersheds





formal (re)classifications and 303(d) priority

Class S2-3, high DIN, unclassified point-sources suspect, priority

Class S1, variable, often low DIN, non-point strategies

Part 2: DIN concentrations and water quality standards

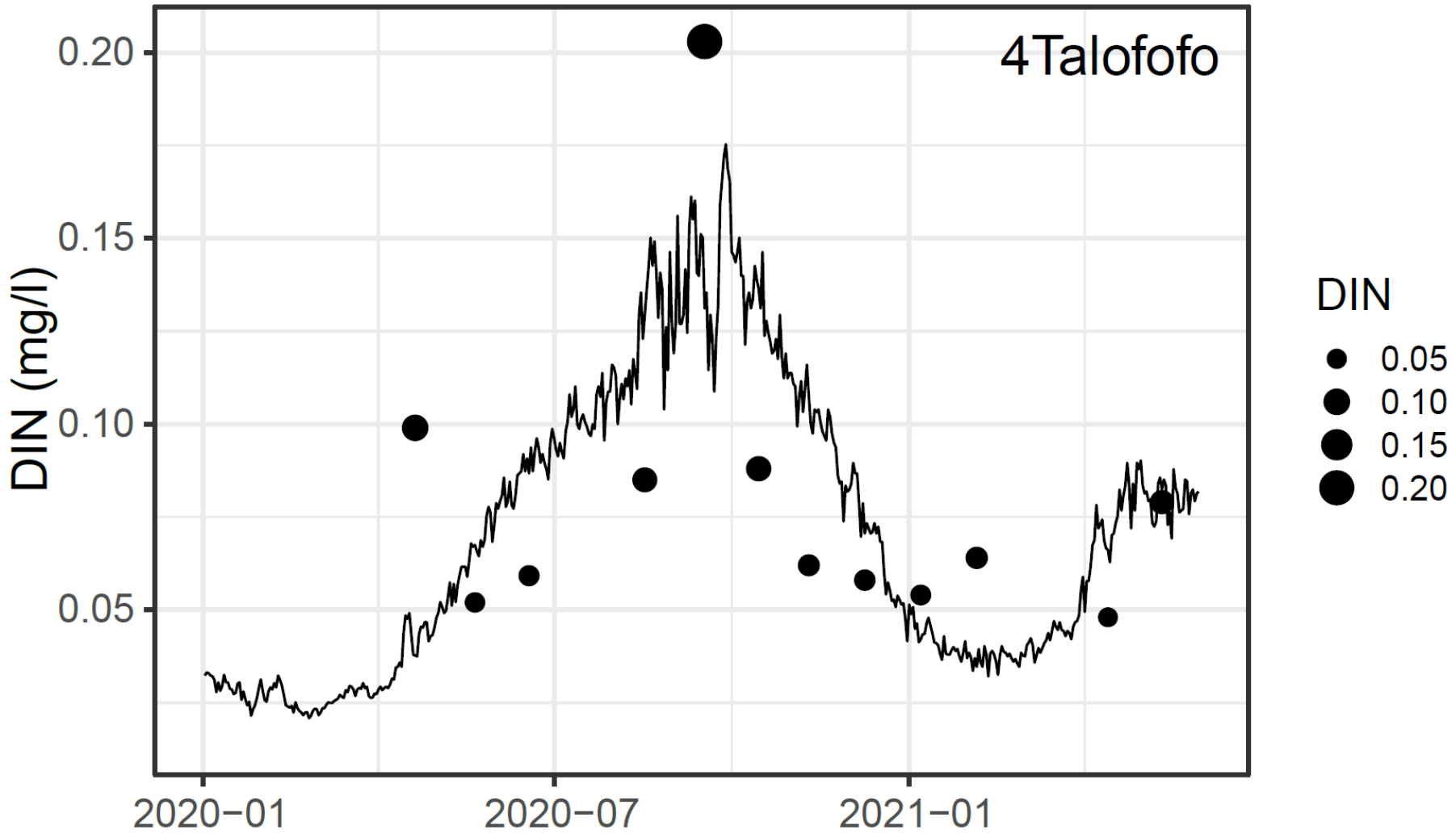
Statistical models to predict daily DIN (TMDL)

- Rain increase DIN?
  - Transport from watersheds
- Wind decrease DIN?
  - Flushing with waves
- Cooler SST/temp increase DIN?
  - Mineralization rates/process

Benefit of sampling design

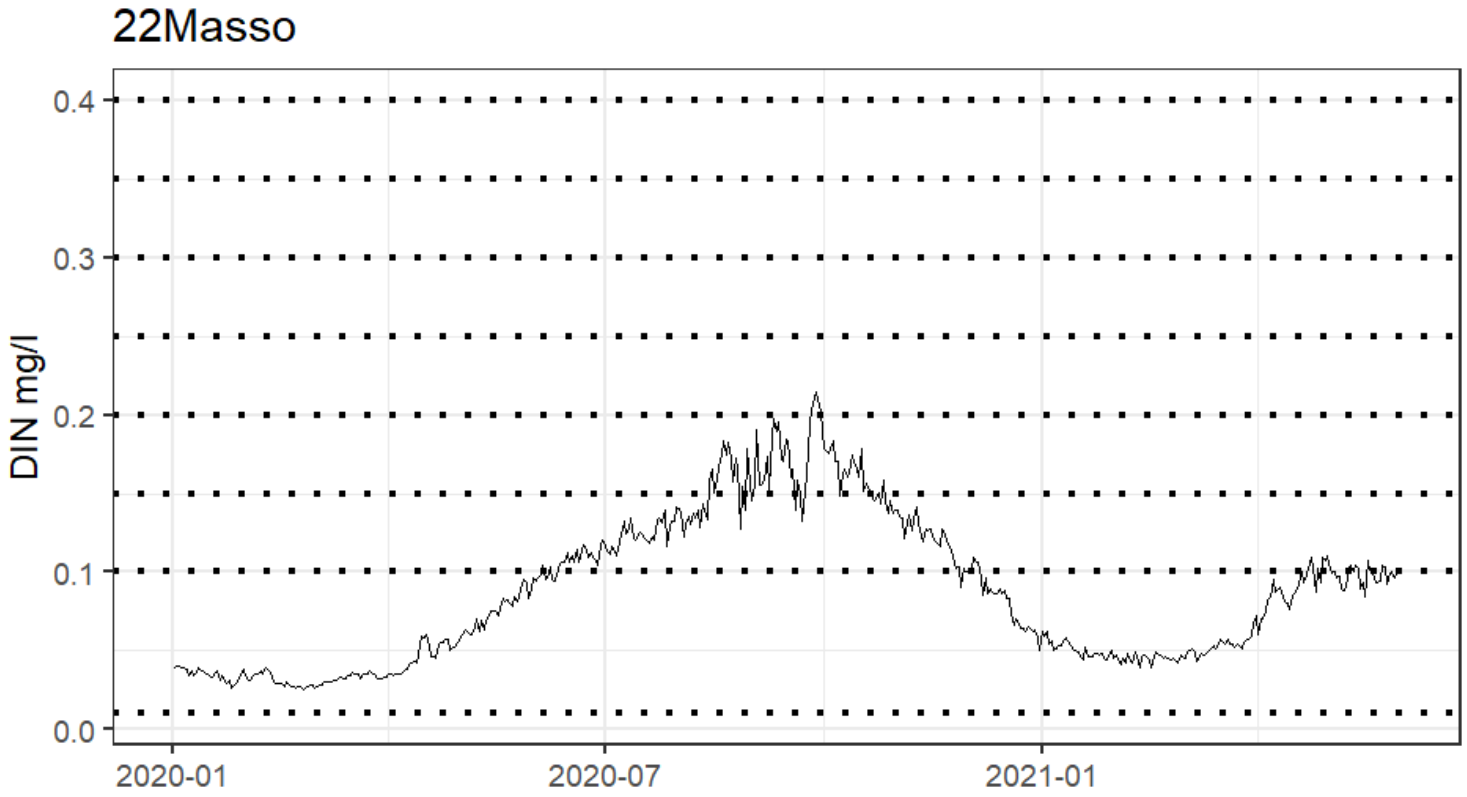
- Sites all sampled at the same time across year (n>300)

Dots – sample data**; line –** predicted daily concentration



Working with predictions to set standards

- What DIN will lead to 10%, 20%, and 30% exceedances?
- EPA guidance 10 to 30 % exceedance



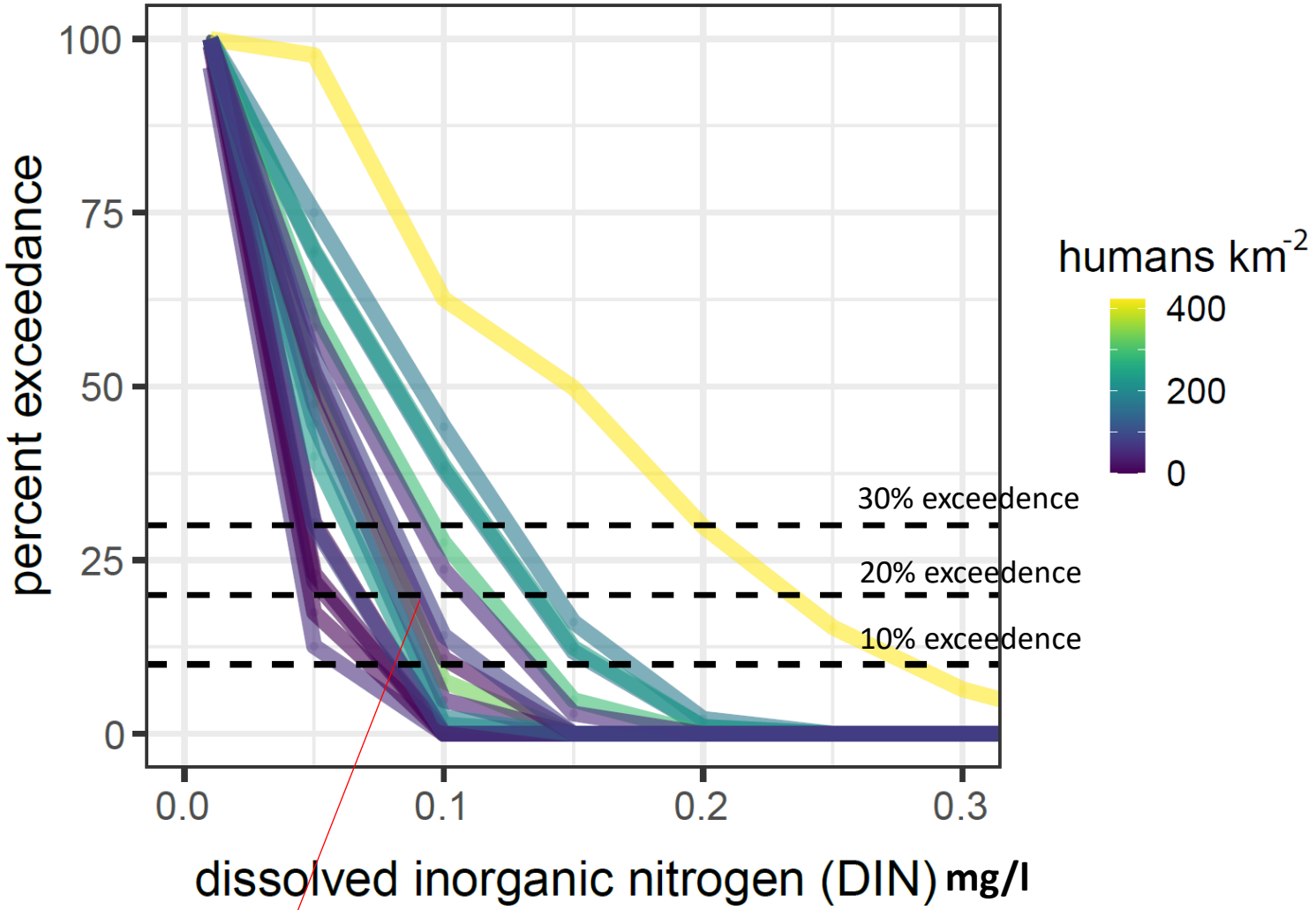
United States Environmental Protection Agency | Office of Water 4304 | EPA-822-B-01-003 October 2001

EPA **Nutrient Criteria Technical Guidance Manual**

Estuarine and Coastal Marine Waters

DIN thresholds

- Each line is a watershed

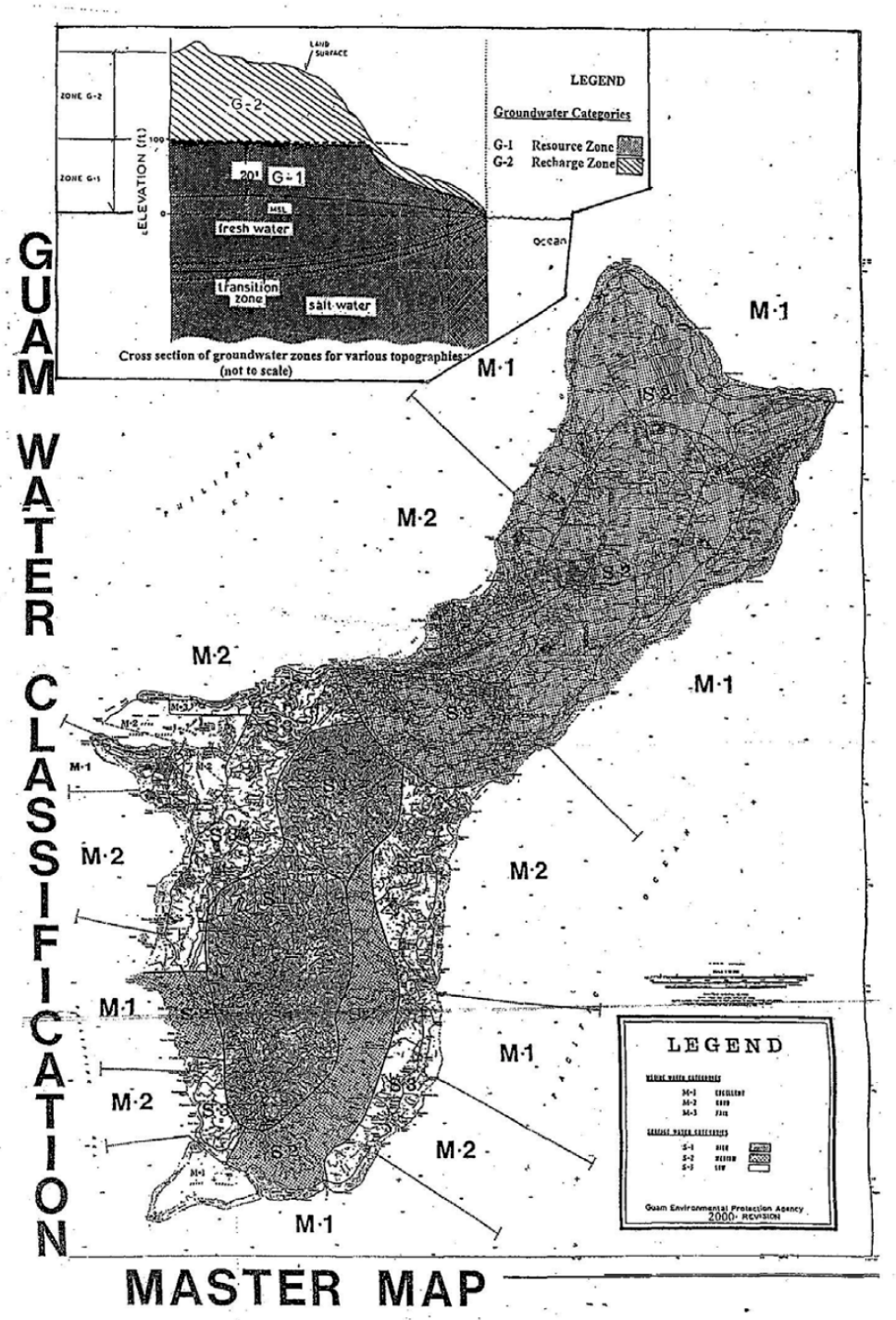


0.1 is a proposed criteria and threshold that aligned with low-moderate human presence

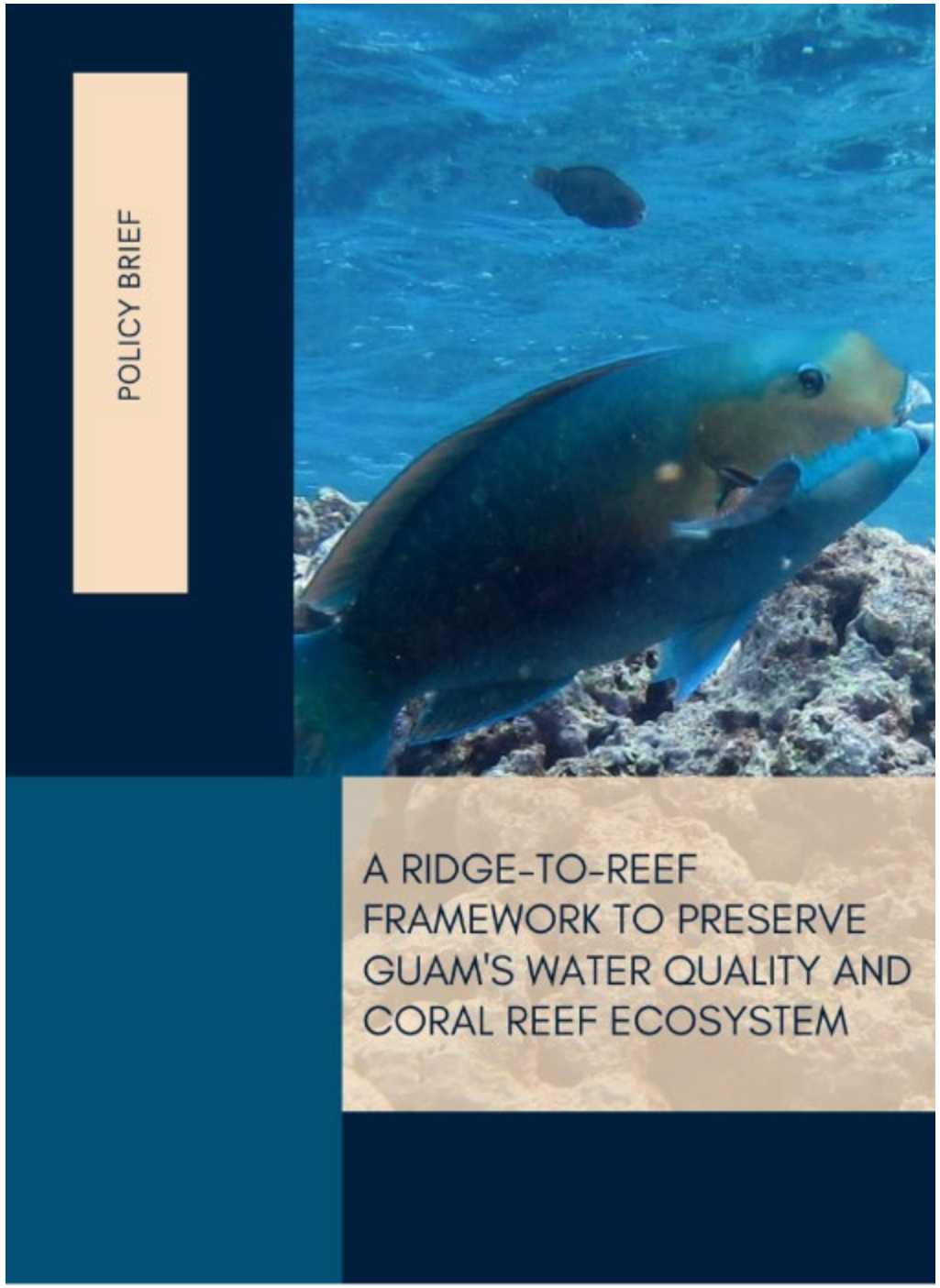
How compare to current Guam standards?

(3) Nutrients	Applicable to
(A) Phosphorus:	
Orthophosphate (P04-P) shall not exceed 0.025 mg/l	M-1, S-1
Orthophosphate (P04-P) shall exceed 0.05 mg/l	M-2, S-2
Orthophosphate (P04-P) shall not exceed 0.10 mg/l	M-3, S-3
(B) Nitrogen	
Nitrate-nitrogen (N03-N) shall not exceed 0.10 mg/l	M-1, S-1
Nitrate-nitrogen (N03-N) shall not exceed 0.20 mg/l	M-2, S-2
Nitrate-nitrogen (N03-N) shall not exceed 0.50 mg/l	M-3, S-3

Guam water quality standards (2015 to present)



Collaboration with Guam EPA and recently completed policy brief to support revised standards

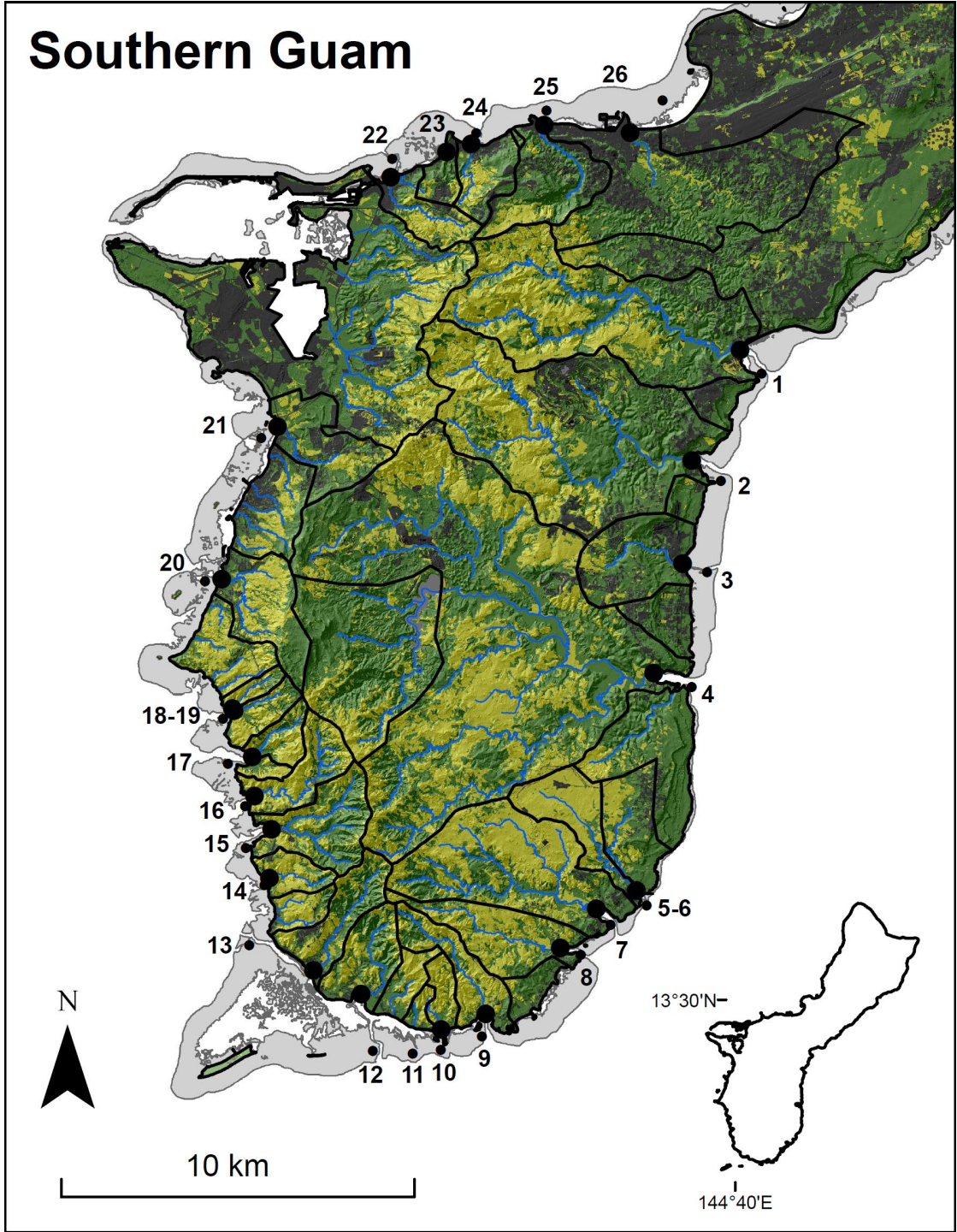


Part 3: Water quality, corals reefs, and fisheries

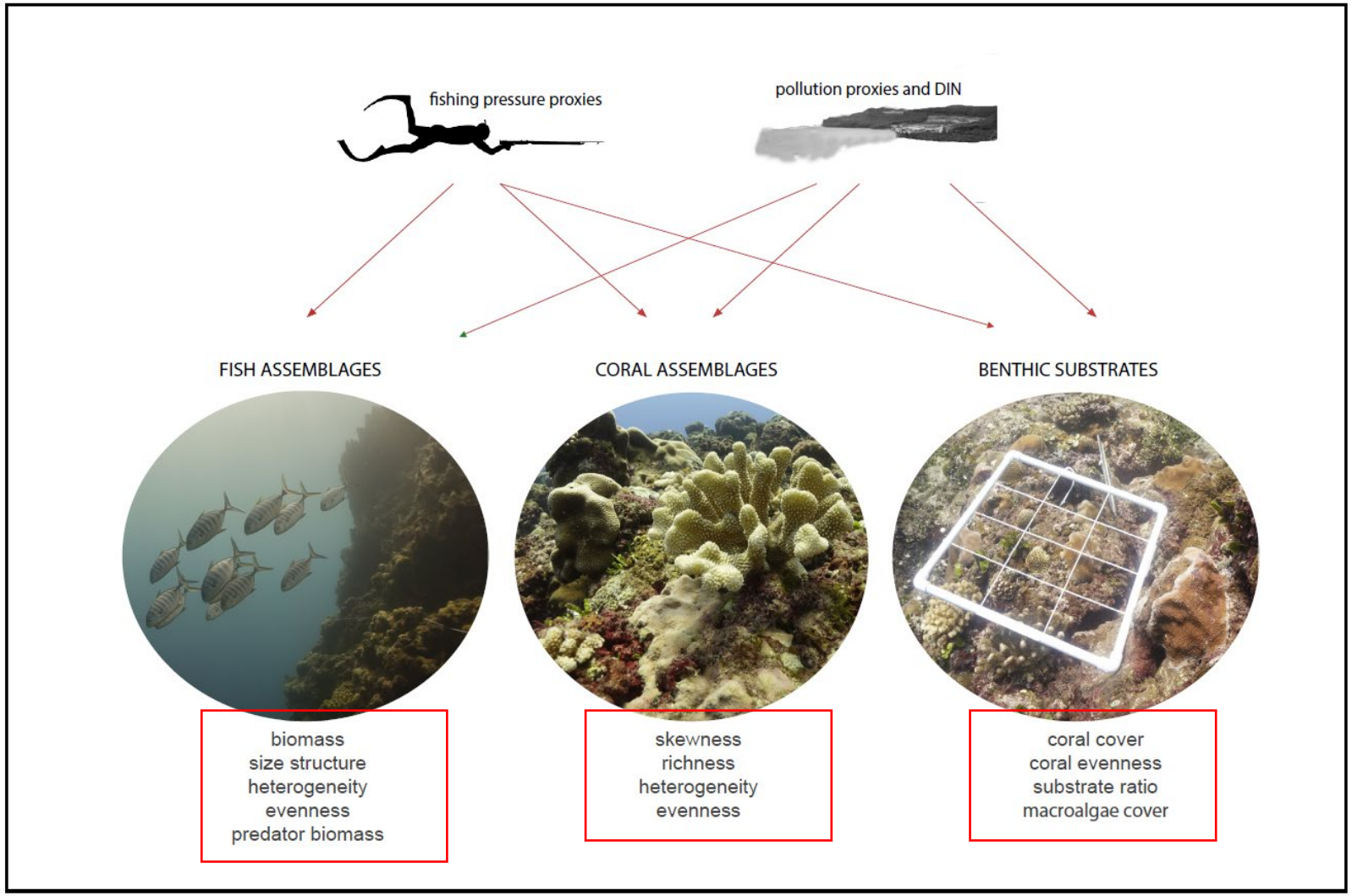
Does this DIN threshold make biological sense?

Biological data collection

sites at edge of channels



Approach – evaluate coral and fish assemblage condition, isolate upon impacts of stressors

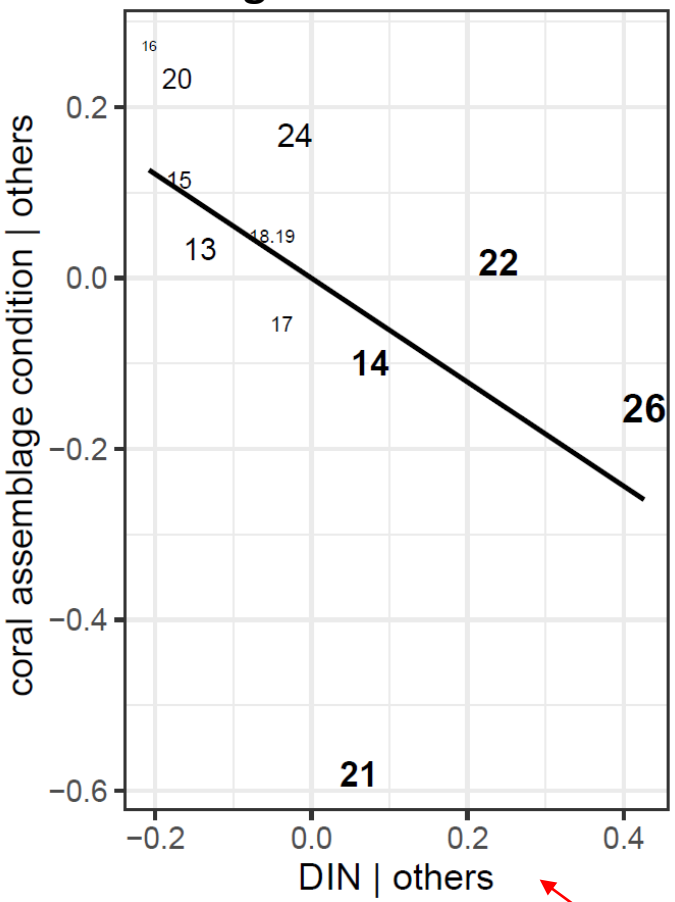


Ecological “condition” scores

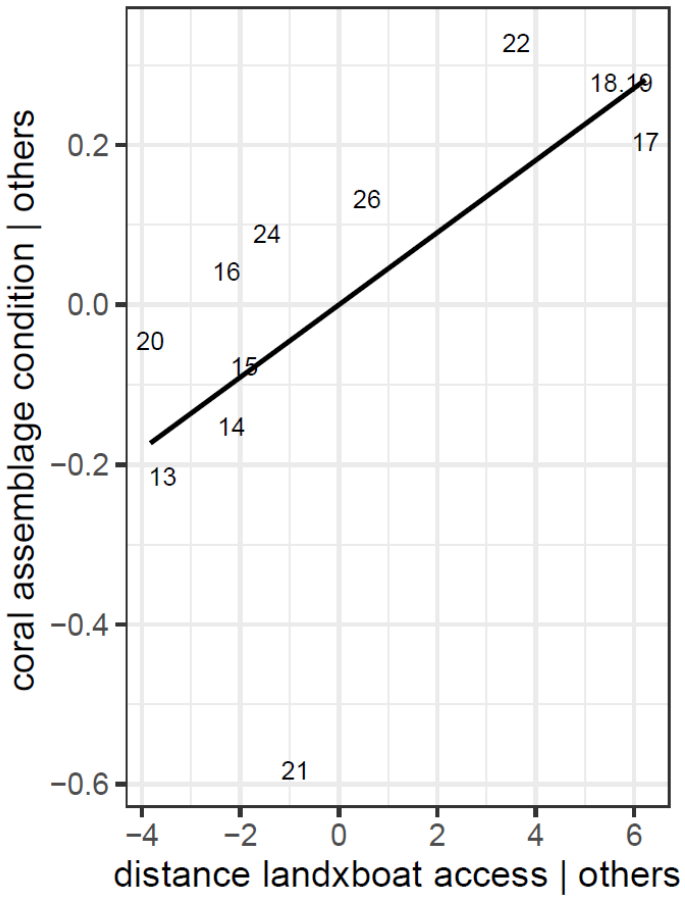
West Guam – coral condition

added variable regression plots

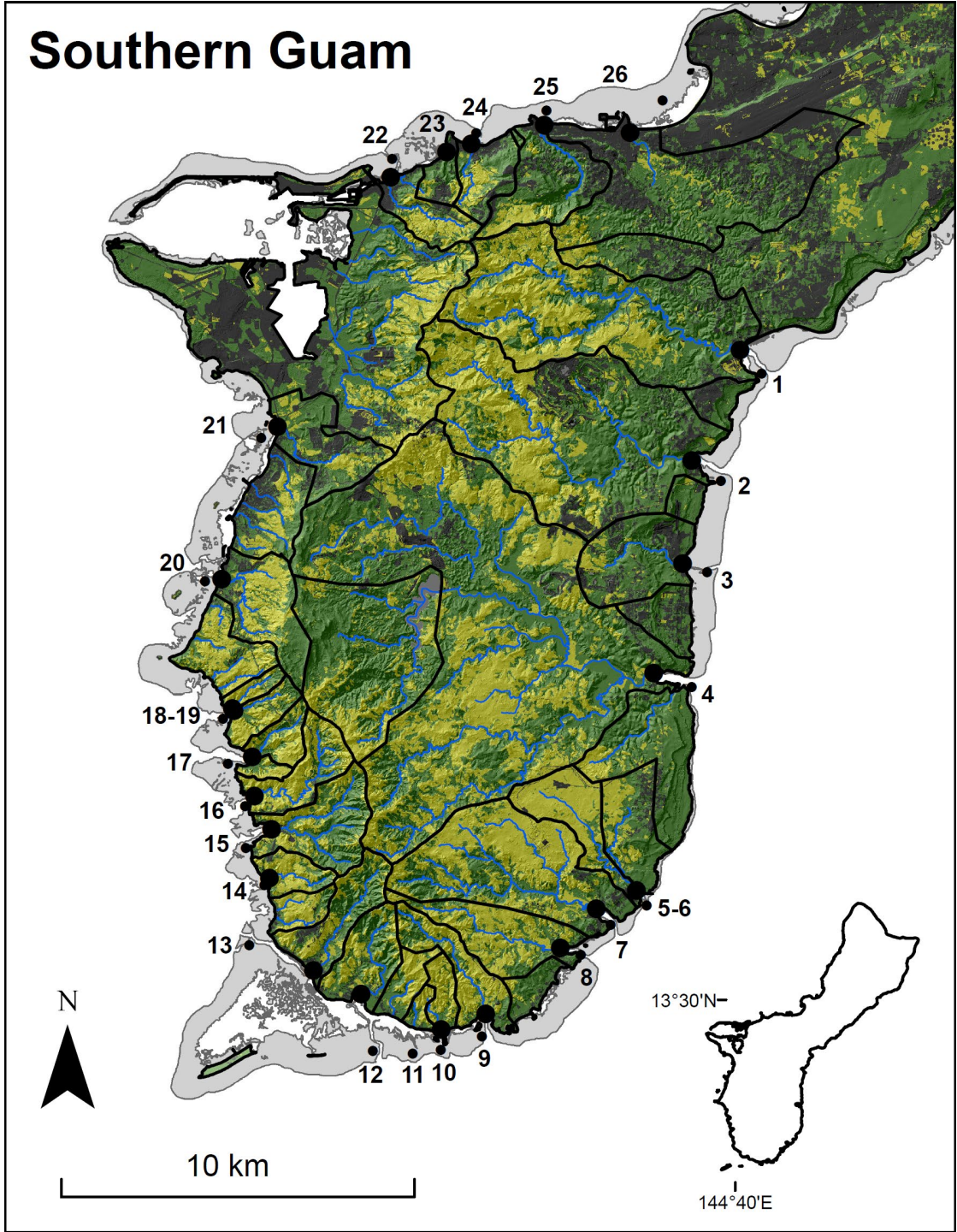
High DIN – low coral



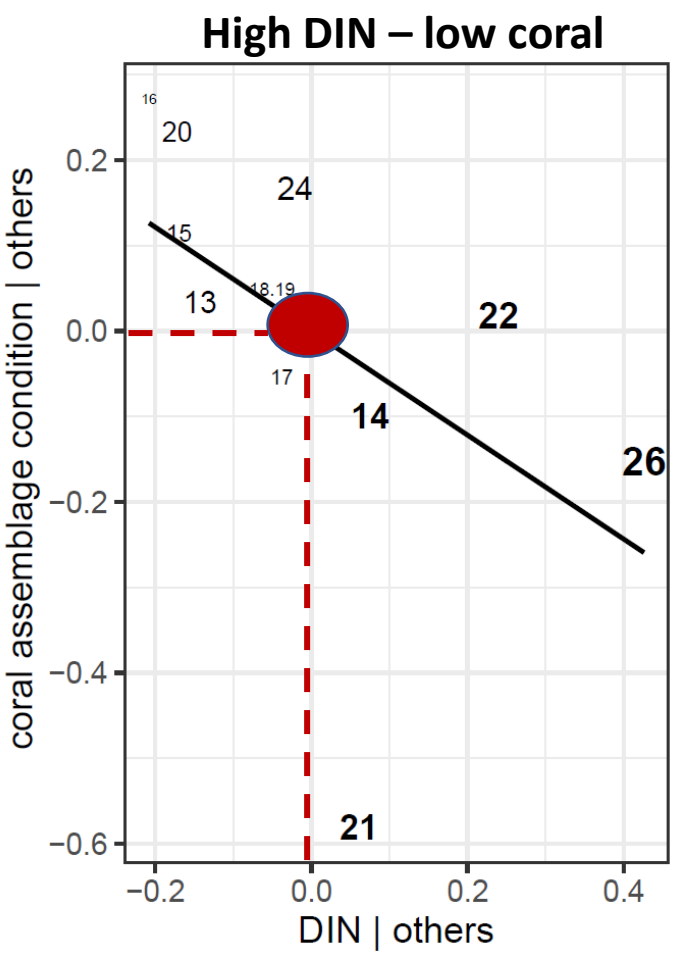
far from fishing access – high coral

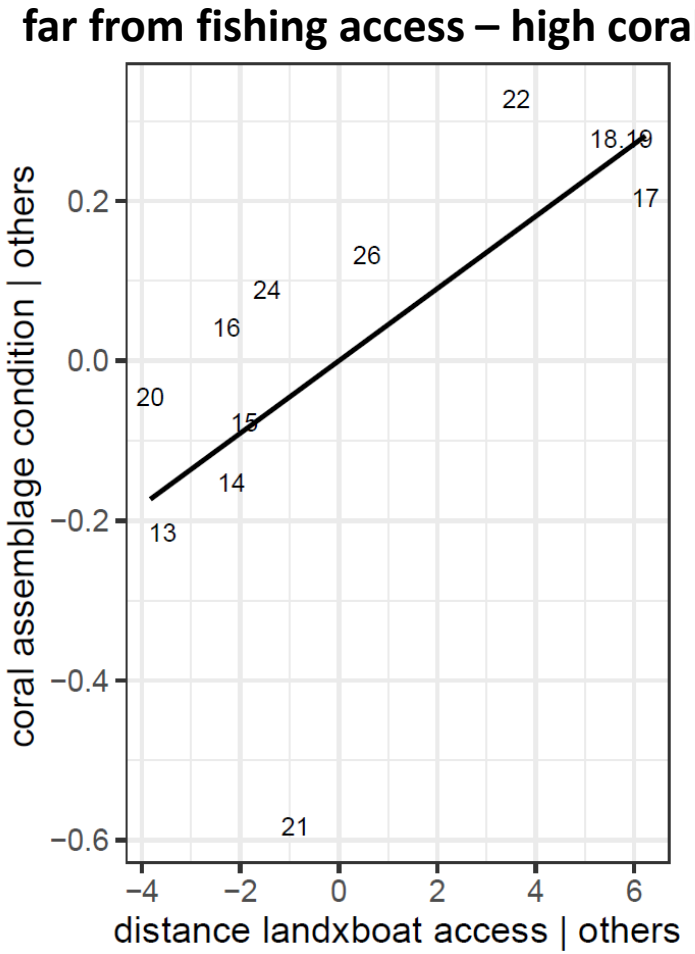


Coral assemblages ~ DIN + fishing access

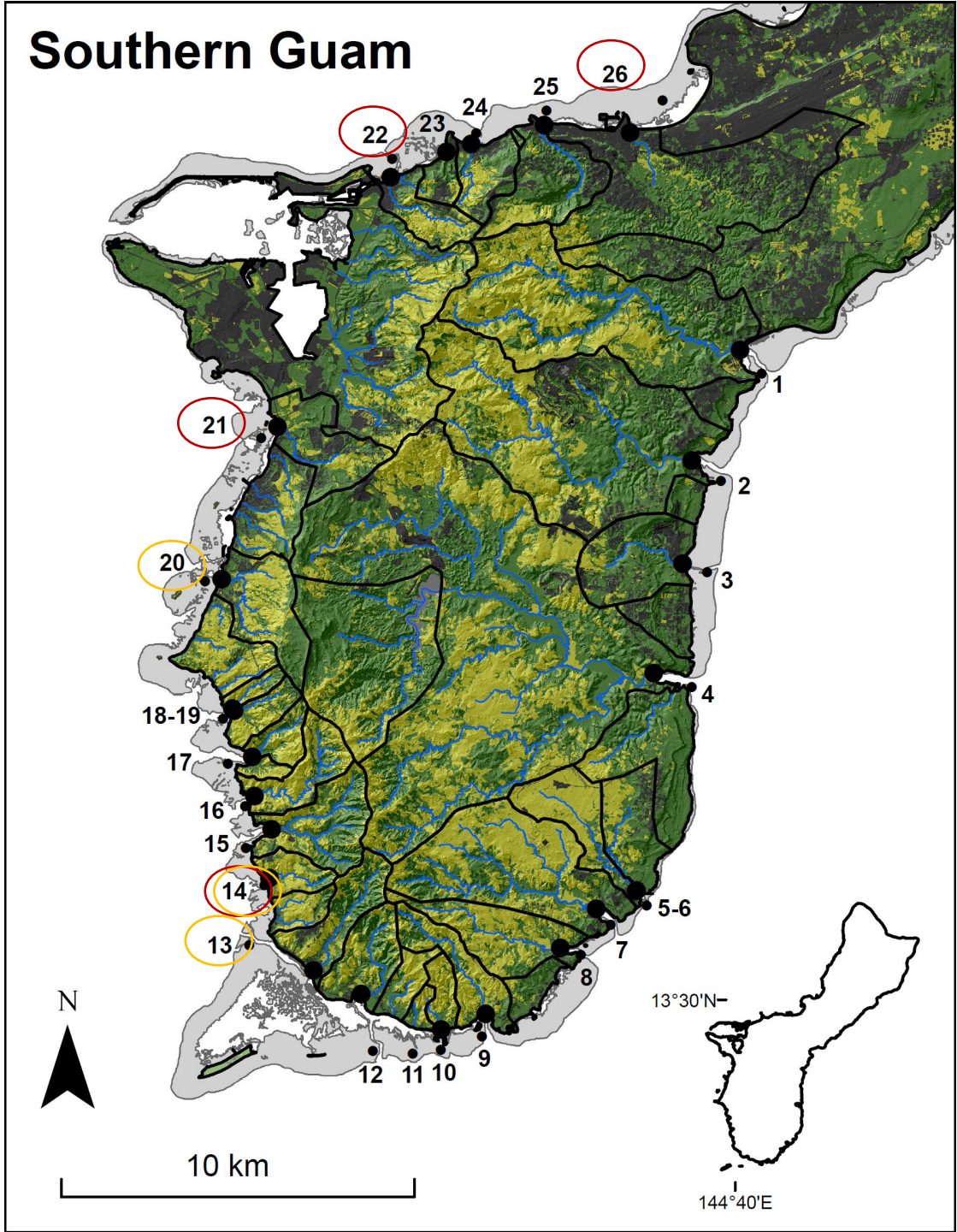


West Guam – coral condition





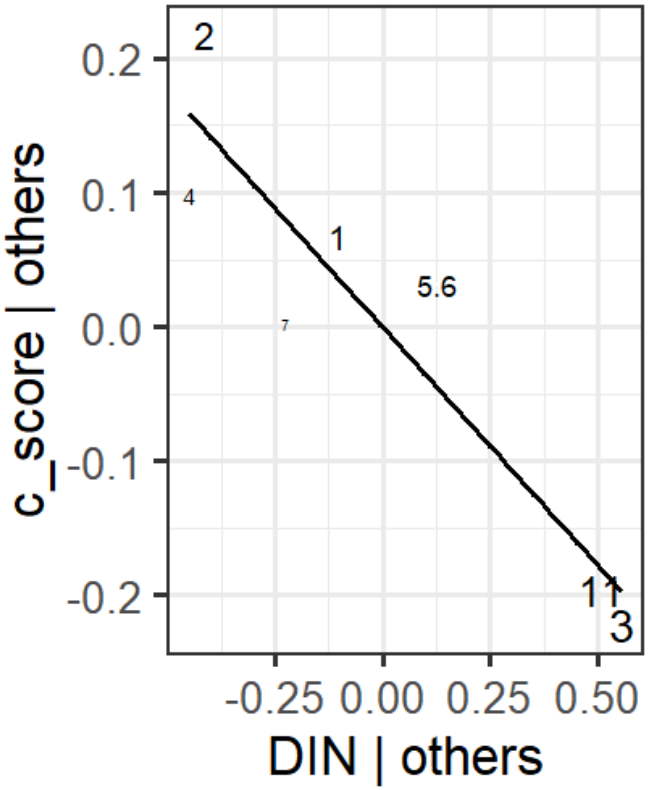
translates to 0.09 mg/l DIN, nearly identical to WQ approach



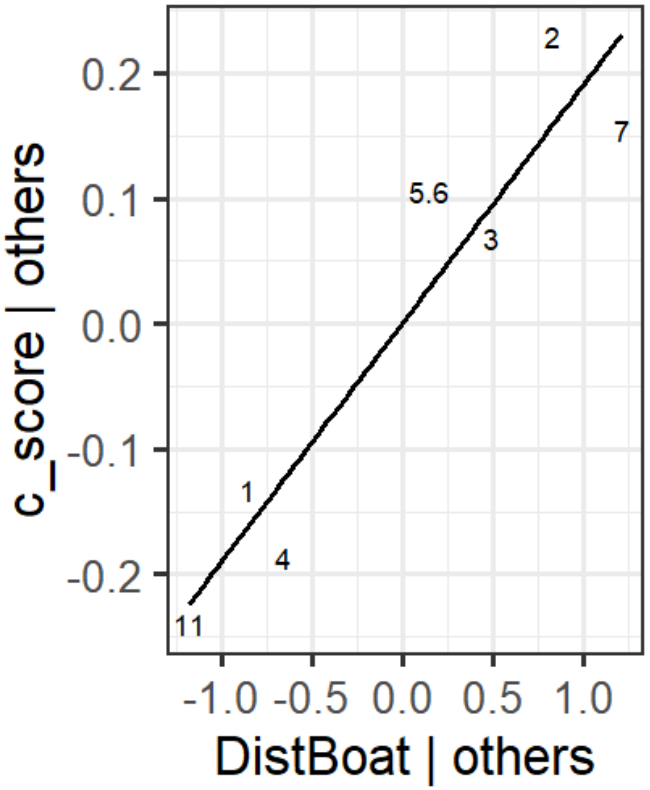
East Guam – coral condition

added variable regressions

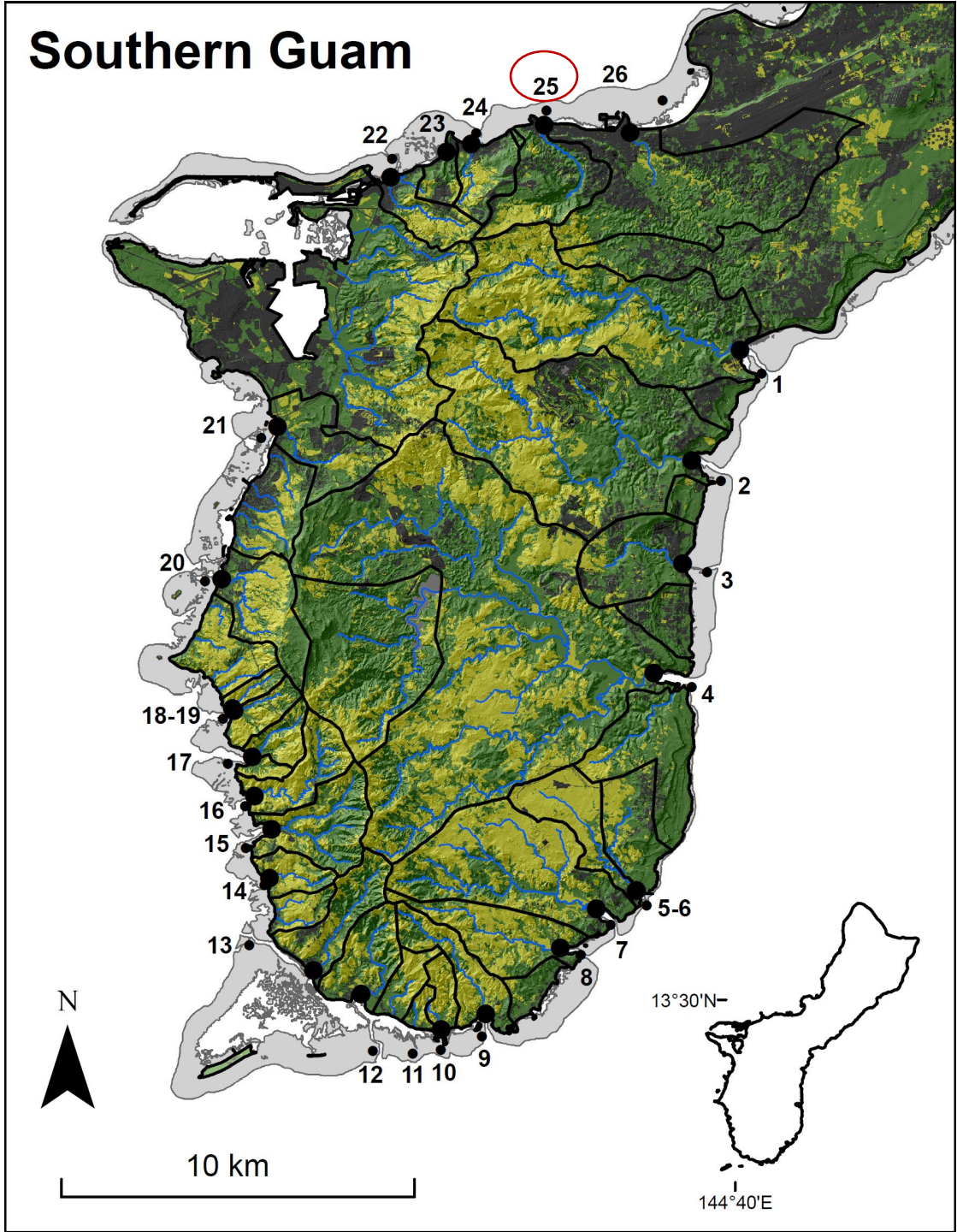
High DIN – low coral



far from fishing access – high coral



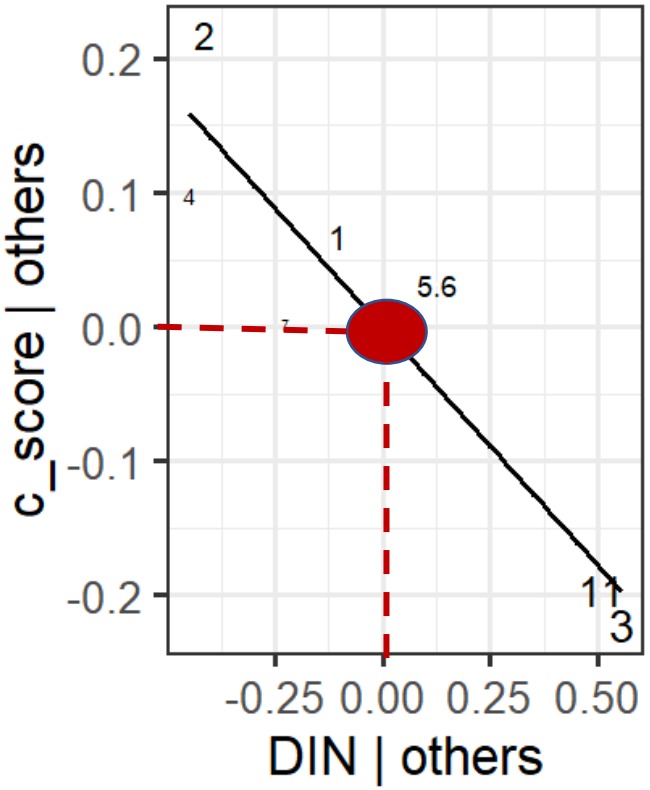
Coral assemblages ~ DIN + fishing access



East Guam – coral condition

added variable regressions

High DIN – low coral



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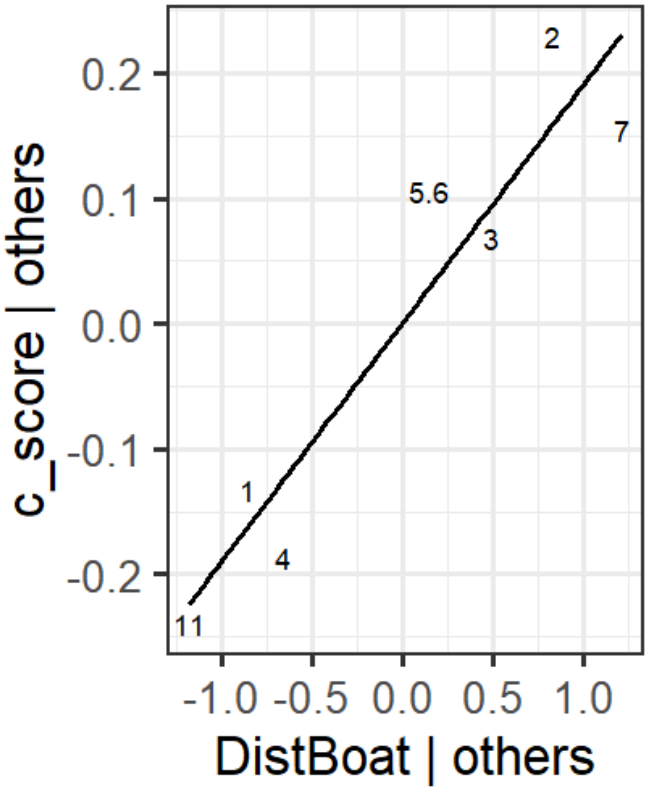
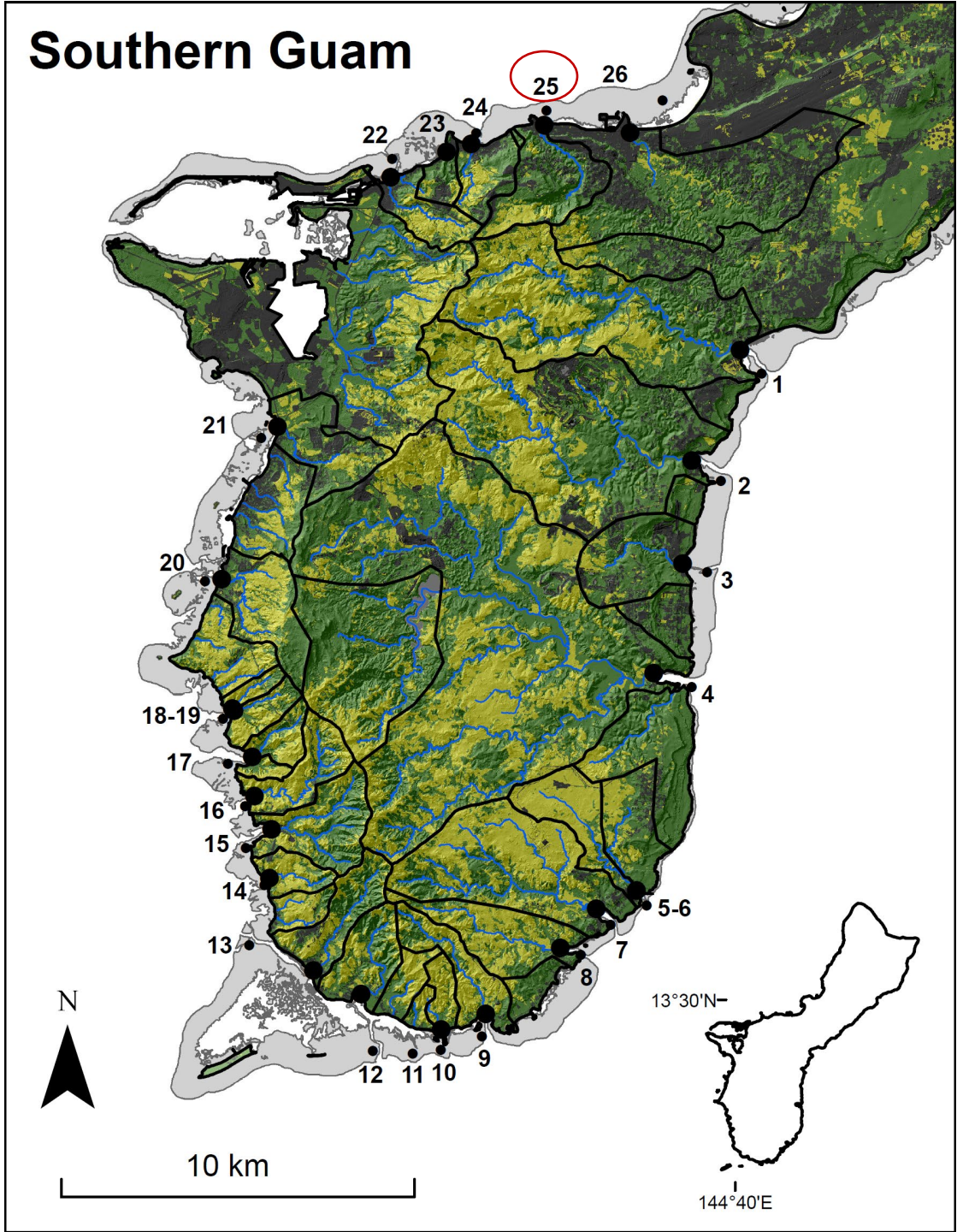


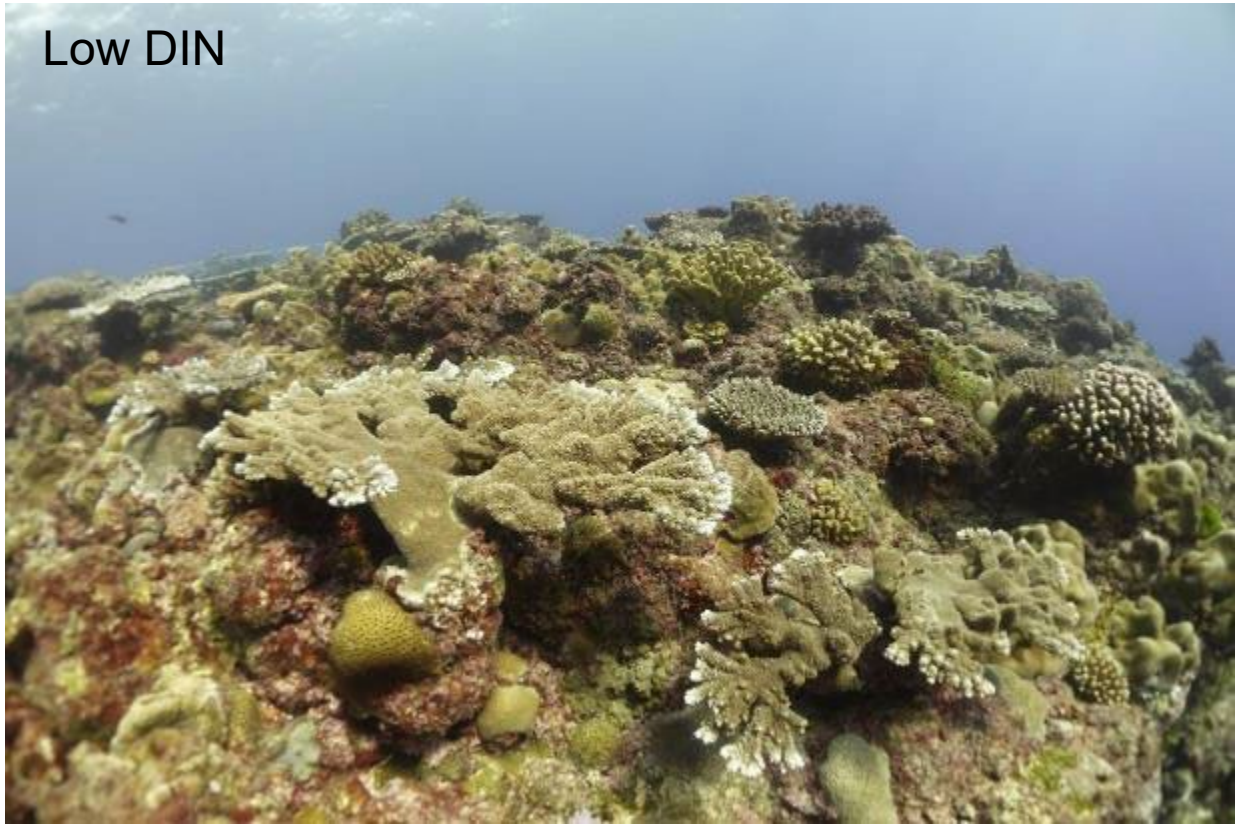
translates to 0.10 mg/l DIN, nearly identical to WQ approach



Biological summary of the ~0.1 mg/l threshold

- Impacts to corals
  - size structure, diversity, evenness
- Impact to benthic substrates
  - Increase algal substrates
  - Harder for corals to recover
- Increase fish biomass and size structure
  - DIN fuels fish, however, **homogenized** assemblages of weedy species

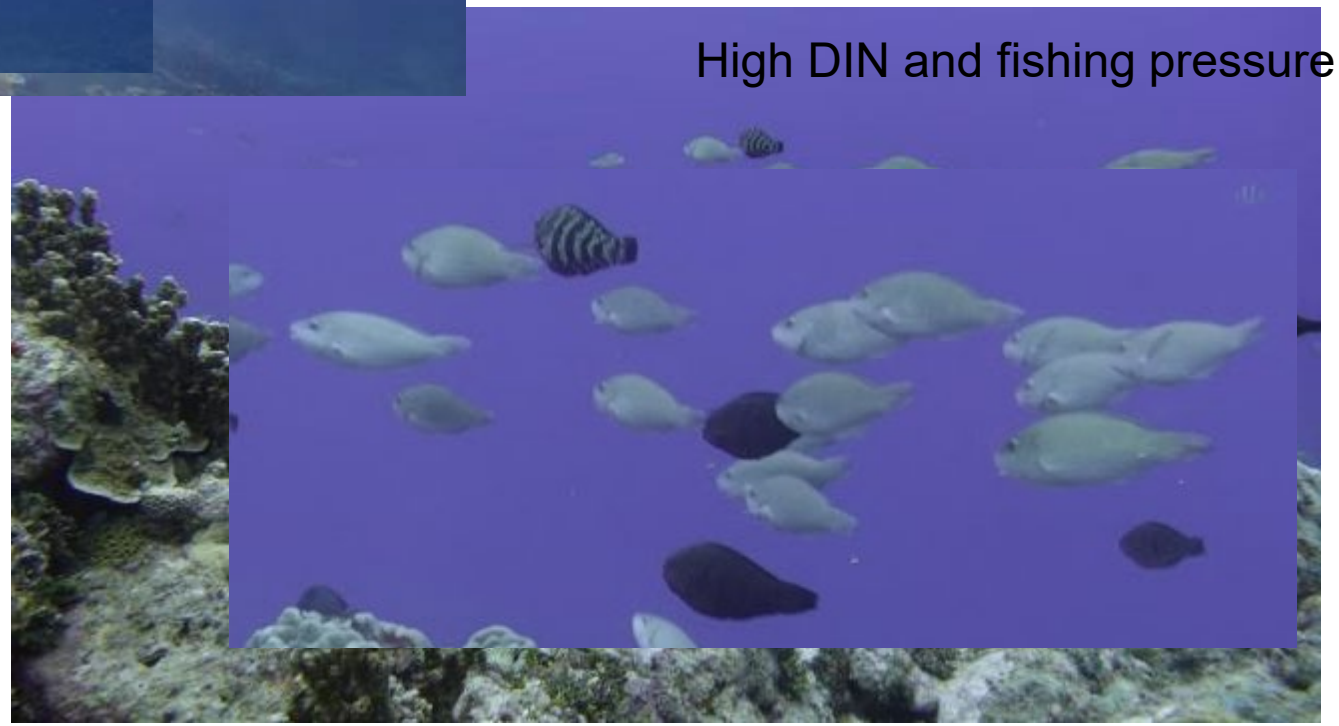
Talofofo Bay photo by Tom Schils before and after rain event



Reduced coral diversity
Reduced coral evenness
Increased opportunistic algae

Reduced coral diversity
Reduced coral evenness
Increased opportunistic algae


Low DIN and low fishing pressure


High DIN and fishing pressure

fishing pressure proxies

pollution proxies and DIN

relationships used to identify areas and priority metrics

DIN thresholds used to recommend thresholds (legislation)

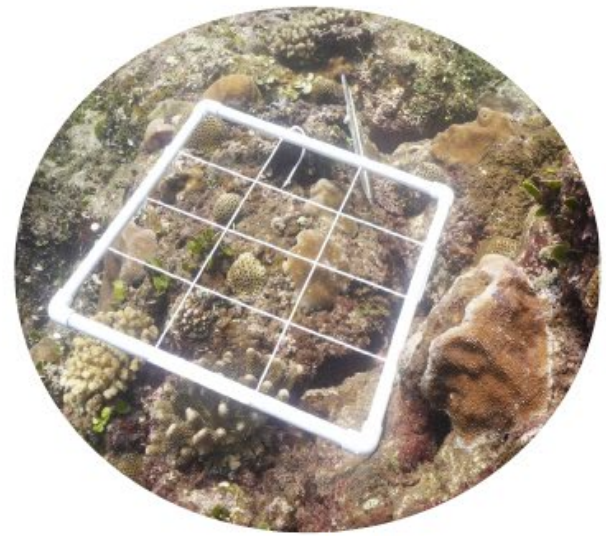
FISH ASSEMBLAGES

biomass
size structure
heterogeneity
evenness
predator biomass

CORAL ASSEMBLAGES

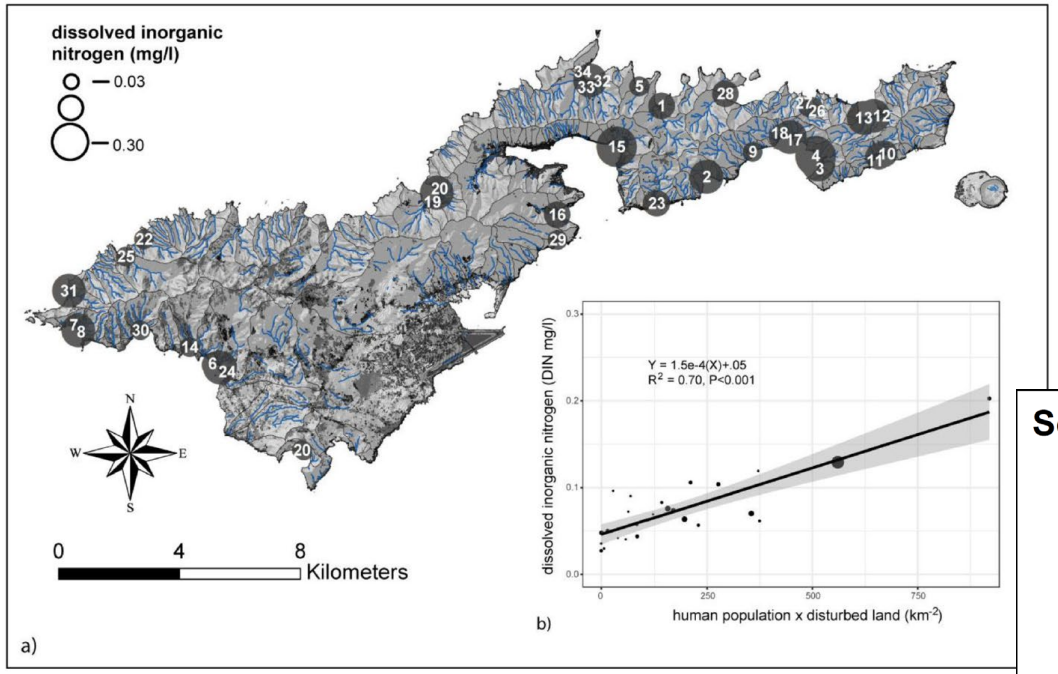
skewness
richness
heterogeneity
evenness

BENTHIC SUBSTRATES



coral cover
coral evenness
substrate ratio
macroalgae cover

Growing agreement across Pacific?



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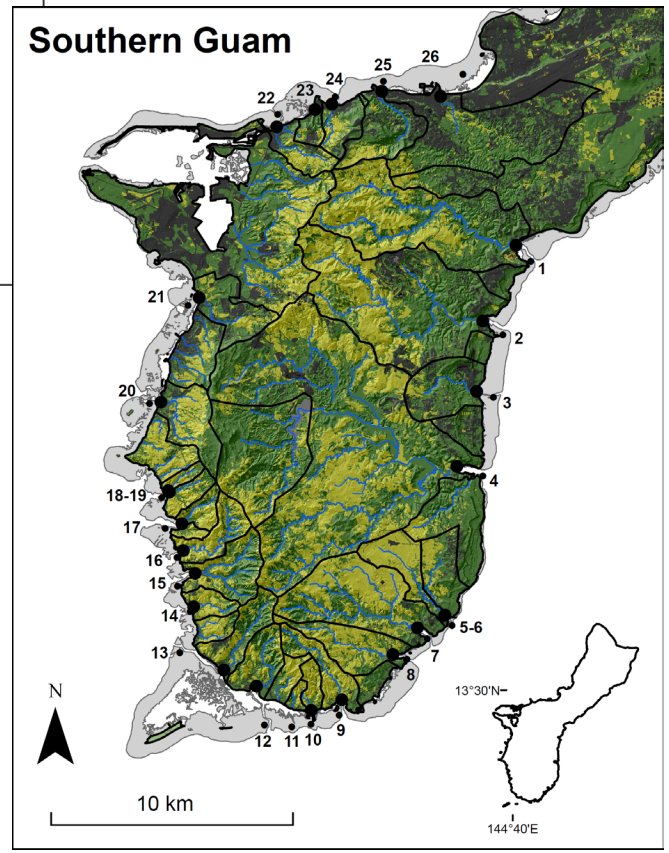

Nutrient thresholds to protect water quality, coral reefs, and nearshore fisheries

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Dissolved inorganic nitrogen
Fisheries

ABSTRACT

A ridge-to-reef framework was developed for 26 watersheds around Guam. Dissolved inorganic nitrogen (DIN) data were collected for one year at the base of streams while coral and fish surveys were conducted on adjacent reefs. Two independent analyses revealed a similar 0.10 mg/l DIN threshold beyond which negative impacts to

Si Yu’os Ma’ase and Thank You

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