

A clownfish (*Amphiprion chrysopterus*)
hiding inside a bubbletip anemone
// Joe Lepore

Blue Prosperity Fiji

2023 Ocean Science Expedition

FINAL SCIENCE REPORT

2026 REVISED VERSION



FIJI GOVERNMENT



BLUE
PROSPERITY
FIJI

VAITT
INSTITUTE



SCRIPPS INSTITUTION OF
OCEANOGRAPHY

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Aerial view of a coastline in Cakaudrove Province
// Andy Estep



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Science divers at work:
Arthur Sokimi (top),
Leone Vokai (middle),
Ulamila Matairakula (bottom)
// Joe Lepore

LIST OF KEY TERMS

In alphabetical order

Acropora: A genus of fast-growing, reef-building corals commonly found on Pacific reefs. *Acropora* species exhibit a wide range of growth forms, such as branching, tabular, and bushy morphologies, which contribute significantly to the reef's three-dimensional structure. These corals are especially important for creating complex habitats for fish and invertebrates, but are highly susceptible to bleaching and storm damage.

Anthropogenic stressors: Human activities that can harm natural ecosystems, such as pollution, overfishing, or land development.

Baseline data: Initial information collected to serve as a reference for future comparisons and monitoring.

Belt transect: A survey method where researchers record all organisms found within a specific strip of area along a line.

Benthic community composition (or benthic cover): The makeup of organisms and materials covering the seafloor, such as corals, algae, sand, or rubble.

Crustose Coralline Algae (CCA): Hard, encrusting red algae important for reef building and coral larval settlement.

Crown-of-Thorns Seastar (COTS): A large coral-eating starfish that can cause major damage to reefs during population outbreaks.

Coral bleaching: A stress response in corals, often due to high water temperatures, that causes them to expel the algae living in their tissues and turn white.

Coral cover: The percentage of the reef covered by live hard coral.

Coral diversity: The number of different coral species or genera present on a reef.

Coral genera: Taxonomic groupings of corals (e.g., *Acropora*, *Porites*, and *Pocillopora*).

Coral recruitment: The settlement and growth of juvenile corals on a reef, critical for reef regeneration.

Coral species: The most specific level of coral classification, referring to individual types of corals that share the same physical traits, genetic makeup, and ecological role. Each species belongs to a broader genus (e.g., *Acropora millepora* is a species within the genus *Acropora*).

Customary Fishing Rights Areas (CFRA): This is a nearshore marine area, offshore island or reef, where a specific indigenous Fijian group holds traditional, hereditary fishing rights rather than complete ownership. These areas are based on historically recognized customary fishing grounds and are officially registered by the iTaukei Land and Fisheries Commission following a legal process undertaken in accordance with the Fisheries Act, 1941. There are 410 registered i Qoliqoli in Fiji, that generally extend from the foreshore to the fringing reef and total approximately 30,011.09 km². The Fisheries Act recognises and protects these rights, although the State retains underlying ownership of the waters. See also: i Qoliqoli.

Customary Fishing Rights Owners (CFRO): This is the group typically a Yavusa (tribe) and sometimes a Mataqali (clan), both a subdivision of the iTaukei people that has been legally determined by the iTaukei Fisheries Commission to be the rightful communal "owner" of the fishing rights within a CFRA.

Cyanobacterial bloom: A rapid accumulation of cyanobacteria in the marine environment. While cyanobacteria can provide important ecosystem functions, such as nitrogen fixation and sediment stabilization that support reef growth, blooms can become harmful when thick mats form. These mats may smother corals, block sunlight, release toxins, and disrupt reef recovery. Not all blooms are harmful, but persistent overgrowth often signals ecological imbalance, such as nutrient enrichment or loss of key grazers.

δ¹⁵N: A measurement of nitrogen isotopes used to infer the source of nitrogen in marine environments, such as whether it comes from agricultural runoff, sewage or natural sources.

Detritivores: Animals, such as sea cucumbers, that eat dead plants and animals.



Close-up view of gorgonian soft coral
// Gilles Siu

LIST OF KEY TERMS (CONT.)

In alphabetical order

Exclusive Economic Zone (EEZ): A sea zone extending up to 200 nautical miles from the coastal baseline, within which a country has special rights to marine resources.

Endangered species: Species that are at very high risk of extinction in the near future.

Fish biomass: The total weight of fish present in a given area, often measured in kilograms per hectare.

Fish density: The number of fish per unit area, often measured in individuals per hectare.

Fleshy macroalgae: Large, soft seaweeds that are important primary producers on coral reefs, converting sunlight into energy, supporting the marine food webs, and providing habitat for marine life. However, when they grow too much, often due to changes in nutrients or herbivore populations, they can compete with corals for space and light.

Foreereef: The seaward side of a reef, typically exposed to open ocean conditions.

Fringing reef: A reef located directly along the shore of an island or continent.

i Qoliqoli: Customary marine areas managed by local Fijian communities and traditionally governed by chiefs. See also: Customary Fishing Rights Area (CFRA).

Juvenile corals: Young corals usually under 5 cm in diameter; measured as a sign of reef recovery and regeneration.

Live rock: Pieces of coral or reef limestone that have naturally broken off and are colonized by living marine organisms like algae, bacteria, and invertebrates.

Locally-Managed Marine Area network (LMMA): In Fiji, LMMA refers to Locally Managed Marine Areas, which combine traditional rules, like tabu, to declare modern conservation areas. These areas are part of the broader Fiji Locally Managed Marine Area Network (FLMMA), which promotes the sustainable use of marine resources.

Macroinvertebrates: Large invertebrates such as sea cucumbers, clams, crabs, and octopuses, important for reef ecology and fisheries.

Marine Conservation Agreement (MCA): A legal contract between a conservation organisation and customary fishing rights owners where the community agrees to manage their marine area in exchange for benefits.

Marine tenure: Customary or legal rights over specific marine areas, typically managed by indigenous communities and chiefs in Fiji.

Marine Protected Area (MPA): According to the International Union for Conservation of Nature (IUCN), a Marine Protected Area is “a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.”

A variety of hard corals at Tuvana-i-Colo atoll in Lau Province
// Gilles Siu

LIST OF KEY TERMS (CONT.)

In alphabetical order

Marine Spatial Planning: A process used to plan the use, development and protection of coastal and offshore marine areas. It is a public, stakeholder-driven and science-based process that uses spatial information about natural resources and human uses to determine the best uses of an ocean space through a comprehensive management plan.

Mosaic plot (or photo mosaic): A 3D photo-mapped plot created using thousands of overlapping reef photos, used for detailed analysis of reef structure and organisms.

Overfishing: Harvesting fish at rates faster than the rate at which the populations can naturally replenish.

Photoquadrat: A quadrat (a defined area, often square or rectangular) that is photographed for later analysis of the species or other features

present within it. It is a method used in ecological surveys, particularly in habitats like coral reefs, to assess and document the composition and abundance of organisms or other elements within a specific area.

Planktivores: Animals that feed on plankton; a dominant fish trophic group in Fijian waters.

Point cloud: A 3D digital representation of the reef surface created from overlapping photographs.

Rugosity: A measure often used to describe the physical complexity or roughness of reef habitats, particularly for benthic organisms (those living on the seafloor). Higher rugosity (more irregular surfaces) typically provides more diverse habitats and shelter for a wider range of species. For example, coral reefs with high rugosity offer more attachment sites for corals and provide hiding places for fish.

Panoramic view of a reef in Lau Province
// Gilles Siu

LIST OF KEY TERMS (CONT.)

In alphabetical order

Rugosity ratio: A numerical value representing the ratio of surface length to linear distance, with higher values indicating more complex reef structures.

Sewage pollution: Contamination of marine environments by untreated sewage, detectable through $\delta^{15}\text{N}$ values.

Stable isotope: Atoms of the same element with different numbers of neutrons, used to trace nutrient sources in marine ecosystems.

Trophic group: Classification of organisms based on what they eat (e.g., herbivores, carnivores, planktivores).

Tabu area: A traditional, temporary closure of a fishing area declared by a chief. This is a customary tool, not a formal legal designation, but the government recognises the right of

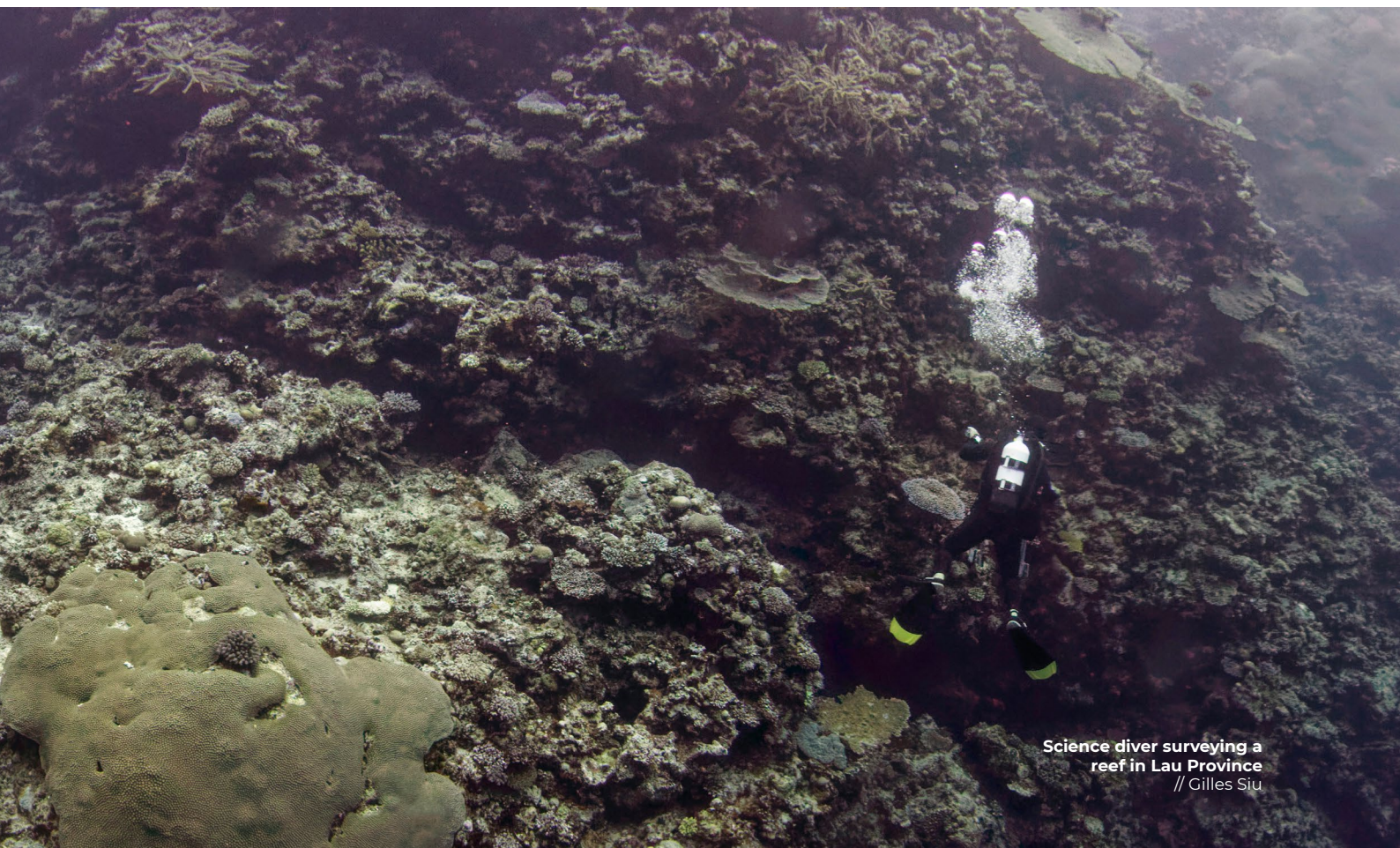
communities to declare one within their i Qoliqoli. A key point is that as an informal “customary” tool, these only effectively apply to members of the same CFRA/i Qoliqoli, unless the tabu area (no-take area) is incorporated as a condition in any fishing licence issued by the Ministry of Fisheries. If a tabu area is a fishing licence condition, then it can be enforced under fisheries legislation against the holder of the fishing licence.

Top predators: Large predatory fish, like groupers or snappers, that sit at the top of the food web.

Transect: A fixed path along which surveys are conducted to measure ecological variables.

Turf algae: Short, dense algae that resemble a lawn and often dominate degraded reef habitats.

Vulnerable species: Species facing a high risk of becoming endangered.



Science diver surveying a
reef in Lau Province
// Gilles Siu

FOREWORD

(ENGLISH)

Our ocean is our life. For generations, Fijians have looked to the sea for food, protection, and prosperity.

Fiji's coral reefs are the heartbeat of our ocean, rich in biodiversity, deeply woven into our culture, and essential to our food security and economy. They protect our shores, support our fisheries, and sustain our people. These living resources face significant threats from overfishing, unsustainable development, and climate change, yet they remain resilient and full of potential.

To care for our most precious resources, we must first understand them. That is why I am honoured to share the results of the Blue Prosperity Fiji Ocean Science Expedition, the largest underwater study to ever take place in Fiji's waters. This study represents a comprehensive snapshot of coral reef health that will guide our Government and our communities as stewards of our ocean.

Over nine weeks in 2023, scientists studied 270 coral reefs across Fiji to gather data about coral reefs, fishes, invertebrates, and water quality. This remarkable achievement was led by the Government, in partnership with the Waitt Institute through Blue Prosperity Fiji, with the support and collaboration of i Qoliqoli owners, local communities, Fijian NGOs, and local and international scientists. Our communities opened their waters and shared their wisdom. This effort would not have been possible without their blessing and deep knowledge of the sea.

The findings presented in this report will directly inform the Government's efforts to sustainably manage our marine resources and fully protect at least 30% of our ocean.

This information will be crucial in developing a comprehensive Marine Spatial Plan, strengthening our fisheries management, and fostering the sustainable growth of a Blue Economy, thereby creating new economic pathways for our communities.

It is vital that this report be shared widely and discussed openly so that we can learn about the life beneath the waves and band together to sustain the ocean as it has sustained us. That requires all of us, the Government, communities, and every Fijian, to act on what we have learned.

While this report shows that our ocean faces serious challenges, it also shows that we have the power to change course if we respond now. This represents a significant step forward in our journey to protect our ocean. Let us embrace the science from the expedition and use it as a call to action to honour our heritage, safeguard our resources, and ensure a healthy ocean, thriving communities, and a brighter future for generations to come.

Hon. Alitia Bainivalu
Minister for Fisheries
and Forestry
Republic of Fiji





A Blue-green damselfish (*Pomacentrus callainus*) and two swallowtail pullers (*Chromis ternatensis*) swimming over a leather coral at Moala Island in Lau Province
// Gilles Siu

I VAKAMACALA TAUMADA (ITAUKEI)

Na waitui e tiki ni noda bula. Mai na nodra gauna na nodai tubutubu ka yacovi keda, na waitui e okati mei vurevure ni keda kakana kei nai yau, me i sasabai, kai vurevure ni bula sautu.

Na veicakau e Viti e rawa ni okati se vakatauvatani me uto ni noda wasawasa, na veika bula era tu kina, na noda i vakarau kei na veiwekani, vurevure ni keda kei na noda i yau, kei na noda bula vakailavo. Era maroroya na noda vei matasawa, tiki ni noda i qoligoli ka vukei ira na noda ena nodra bula. Na veika bula kece qo era sa tekivu vakaleqai ka sotava na leqa ka vu mai na kena sa qolivi vakasivia nai qoligoli, na veisautaki kei na vakacacani ni vanua kei na waitui ka vu mai na veivakatorocaketaki sega ni vakasamataki se caka vakavinaka kei na veisau ni draki, ia era se tiko dei ka tu vinaka tu eso na cakau kara na rawa ni yavu ni veivakacokotaki e rawa ni sagai.

Ke da vinakata me da taqomaka ka maroroya na noda i yau talei qo, na cakau, e dodonu me da na kila taumada na veika kece baleti ira. Sai koya qo na vuna au marautaka kina meu vakaraitaka ka wasea na macala sei

tukutuku ea kumuni mai na Blue Prosperity Fiji Ocean Science Expedition, na vakadidike levu taudua me vakayacori ena wasawasa nei Viti. Na vakadidike oqo e na vakaraitaka vakavinaka vei keda nai tuvaki dina duadua ni noda vei cakau me dusimaka kina Matanitu kei na noda vei vanua ka noda i tavi me da yadrava ka cakacakataka na maroroi ni noda waitui kei na veika bula era tu kina.

E na loma ni ciwa na macawa ena yabaki 2023, era a vakadidike kina na kena dau ena 270 na tiki ni veicakau e Viti, ka ra kumuna mai kina nai tukutuku baleta na veicakau, na ika, na sasalu kei nai tuvaki ni waitui. Na cakacaka levu qo, e a liutaka na Matanitu e Viti, ka rau a cakacaka vata kina kei Waitt Institute, ka rau tiki ni Blue Prosperity Fiji, ka ra a veitokoni kina na leweni vanua ena veiyasana e Viti, ko ira na vei matai Soqoqo Sega ni Vaka Matanitutaki kei ira na dau ni vakadidike e Viti kei ira na gole mai vanua tani. Era a veitokoni nai taukei ni vei qoligoli ena noda vanua ena nodra vakadonua ka marautaka na vakadidike ni nodra veicakau ka ra talanoataka ka wasea na nodra kila titobu baleta na nodra i qoligoli.

Na macala sei tukutuku ka kumuni mai na vakadidike ka tiki tiko ni ripote oqo, ena vakayagataka na Matanitu me yavutaka kina na kena sagai me vakayagataki vakayalomatua na i qoliqoli kei na waitui taucoko ena noda Viti raraba kei na kena maroroi ka vakatabui e 30 na pasede ni waitui. Na i tukutuku e a kumuni ena vakadidike oqo ena bibi ka yaga sara vakalevu ena kena biuvata e dua nai tuvatuva se Marine Spatial Plan, na vakaqacacotaki ni kena vakayagataki vakavuku na noda i qoliqoli kei na kena tokoni ka vakabibitaki na tarai cake kei na kena vakayagataki vakayalomatua nai vurevure ni bula vaka i lavo e yavutaki ena vakayagataki ni waitui se na Blue Economy, me rawa ni buli ka tarai cake kina eso nai vurevure ni bula vakai lavo ena noda vei tikotiko.

Sa bibi sara me vakaraitaki ka wasei yani vakaraba i levu ka veitalanoa vakalevu na ripote oqo me da rawa ni vulica kina na veika bula era tu ena noda vei qoliqoli ka da qai duavata ena noda maroroya na noda i qoliqoli baleta ni a dau maroroi keda voli mai. Sa ka bibi kina kivei keda kece sara kei ira na noda kawa, na Matanitu, na vei tikotiko kece sara kei keda yadua me da duavata ka cakacakataka na veika dina e da sa vulica ka kila.

Dina ga ni sa dusia tiko vei keda na ripote mai na dikevi ni noda vei cakau oqo e vuqa sara na tikina e bolei keda vakalevu, esa vakaraitaka tale tiko ga ni tu vei keda na kila, nai naki kei nai gu me da vakavinakataka cake kina na noda i sema kina noda i qoliqoli kevaka e da sa tekivu taka sara ga qo na veisautaka na noda i walewale ni vakayagataka na noda i qoliqoli. Oqo sa na dua na kalawa levu e noda saga me da taqomaka, maroroya ka vakayagataka vakavuku na waitui kei na noda veicakau ka rau tiki ni noda i qoliqoli. Au sureti kemuni me da ciqoma nai tukutuku mai na vakadidike ena noda veicakau oqo ka vakayagataka me yavutaki kina na noda cakacakataka na kena rokovi na noda i yaubula, maroroi ka vakayagataki vakayalomatua na noda i qoliqoli kei na waitui me yavu ni kena tarai cake na noda veitikotiko, na vuvala kei na nodra bulagoci ka vakarautaki vakavinaka na noda kawa ena veisiga ni mataka.

Hon. Alitia Bainivalu

Minister for Fisheries and Forestry,
Republic of Fiji



**Aerial view of Nairai Island
in Lomaiviti Province**
// Andy Estep

EXECUTIVE SUMMARY

(ENGLISH)

The Government of Fiji, in partnership with the Waitt Institute through Blue Prosperity Fiji and Scripps Institution of Oceanography, carried out the **largest coral reef survey in the nation's history**.

From May to August 2023, scientists **collected data from 269 sites across 13 Provinces** to establish a baseline of the health of Fiji's reefs. These results will guide future decisions on marine protection and sustainable management of the country's ocean resources.

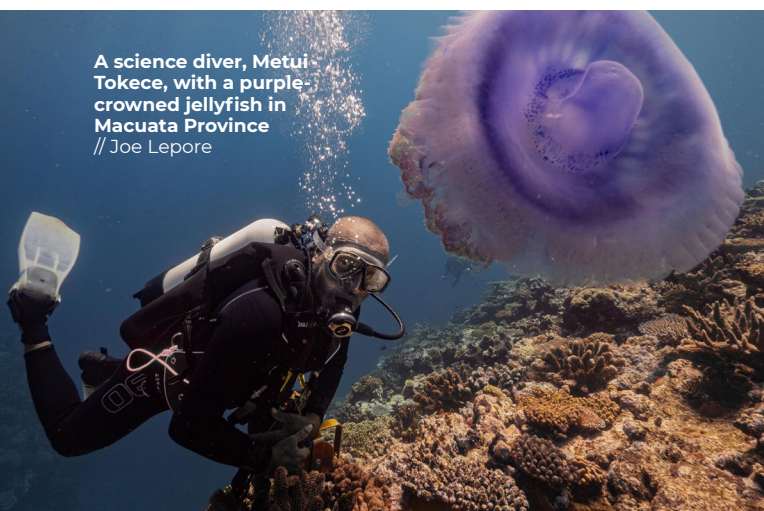


A darkfin chromis (*Pycnochromis atripes*) at Moala Island in Lau Province (top) & Zoanthids, a type of soft coral, in Ba Province (bottom)
// Gilles Siu & Joe Lepore

Before the expedition, more than 100 Customary Fishing Rights Owners (CFRO) and communities were consulted to grant permission for the survey of their traditional fishing grounds.

Overall, Fiji's reefs show both strength and vulnerability. They host rich marine life and show a strong capacity to recover, but they face ongoing pressures from overfishing, climate change, and other threats. Acting now to protect them can help ensure they remain viable and productive ecosystems for future generations.

A science diver, Metui Tokece, with a purple-crowned jellyfish in Macuata Province
// Joe Lepore



REEF FISH

Fiji's reefs are home to an impressive variety of fishes, with 547 different species recorded during the surveys.

Fish were found in high numbers, with an average of more than 45,000 in every hectare surveyed. The total weight of fish was also high, averaging 2,573.6 kilograms per hectare. **Both the number of fish and the total weight were higher** than those recorded in similar studies in Vanuatu and Samoa. **The most common type of fish were planktivores**, which feed on tiny plants and animals drifting in the water. **Sharks and top predators, such as snappers, were seen in every Province**, but in much smaller numbers compared to other kinds of fishes.



Two clownfish (*Amphiprion chrysopterus*) swimming over a bubbletip anemone in Lau Province
// Gilles Siu

CORAL COVER

Live coral cover across surveyed sites averaged 19.7%, comparable to levels observed in other nearby Pacific Island nations but lower than some South Pacific regional averages.



The impacts of severe cyclones, including Cyclone Winston in 2016, and past bleaching events are likely contributors to this moderate coral cover. Despite this, coral diversity was relatively high, with 60 genera recorded. An average of 11 juvenile corals per square meter was recorded, a recruitment rate considered high for an inhabited Pacific Island nation. **This suggests that Fiji's reefs have a strong natural capacity for recovery if chronic stressors such as climate change are reduced.**

Reef structural complexity was also high, with an average rugosity of 1.8 across all Provinces. **Such complex reef structures provide critical habitat** for fish and invertebrates, and are particularly important for supporting populations of larger, commercially and ecologically important fish species.

MACROINVERTEBRATES

The survey recorded a wide variety of macroinvertebrate species, but some commercially valuable species were found in only a few locations.

Because this study only reports where species were present or absent and not their exact numbers, these **findings suggest but do not confirm that their populations may be low**. In total, 85 species were recorded, including 16 species of bivalves, two cephalopods, one crinoid, one crustacean, 36 gastropods, 18 sea cucumbers, and eight sea stars. Interestingly, **no sea urchins were recorded** within survey transects around Vanua Levu, although a few were observed outside survey areas, indicating that they are present but not abundant.

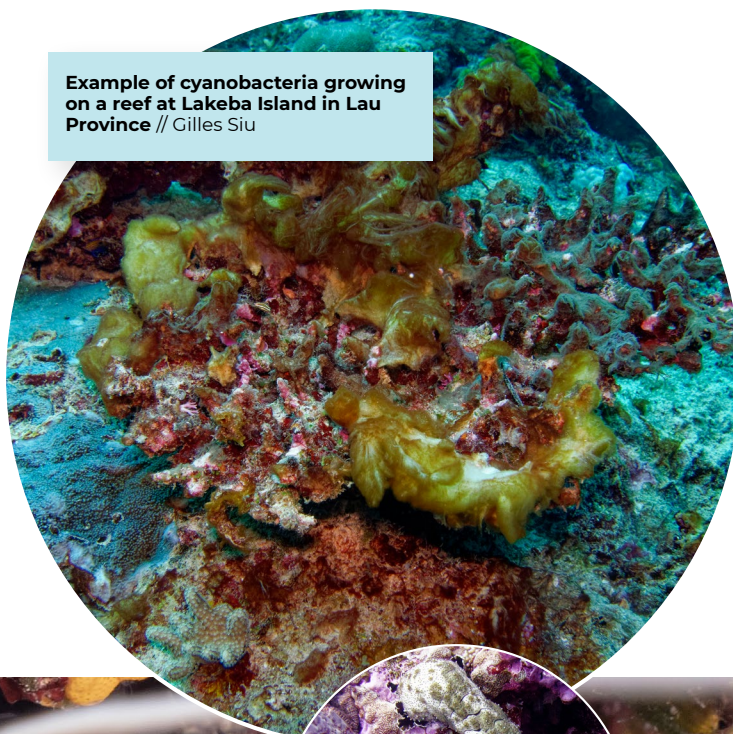
Macroinvertebrate numbers could not be fully assessed due to methodological issues; however, for **sea cucumbers**, available evidence suggests that populations of several species are likely very low. **Crown-of-thorns sea stars (COTS)** were found in about half of the Provinces surveyed, but there were no signs of large outbreaks, suggesting they are currently at normal background levels. **Lobsters and octopus** were moderately common, recorded in eight and five of the 13 Provinces surveyed respectively.

CYANOBACTERIA

Cyanobacteria were present at many survey sites, averaging 4.4% cover across all Provinces.

Cyanobacterial mats are becoming increasingly common on coral reefs in Fiji and throughout the Pacific. While cyanobacteria play various roles in reef ecosystems, the thick mats that were observed in many locations during this study have the **potential to smother and kill corals**, as well as prevent new corals from settling and growing.

Example of cyanobacteria growing on a reef at Lakeba Island in Lau Province // Gilles Siu



A sea cucumber (*Pearsonothuria graeffei*) found at Ono Island in Lau Province (above) & a Lobster (*Panulirus versicolor*) in Lomaiviti Province (bottom) // Gilles Siu & Joe Lepore



WATER QUALITY



There were no signs of sewage pollution on the outer reef at 10 metres depth, although conditions are likely different closer to shore where land-based impacts are typically more pronounced.

Fiji's long-standing tradition of customary governance by Customary Fishing Rights Owners (CFROs), including the practice of establishing tabu areas, offers a powerful foundation for marine conservation and sustainable fisheries management. **When paired with Marine Spatial Planning efforts, Fiji is well-positioned to strengthen its resilience against threats.** By weaving together traditional knowledge and science, Fiji can safeguard its coral reef ecosystems and the livelihoods they support for generations to come.



Two-stripe damselfish (*Dascyllus reticulatus*) swimming over *Acropora* coral in the Dawasamu region of Tailevu Province
// Gilles Siu

SUMMARY

269

dive sites surveyed

547

fish species recorded

19.7%

average live coral cover

85

species of macroinvertebrates recorded

4.4%

cover of cyanobacteria

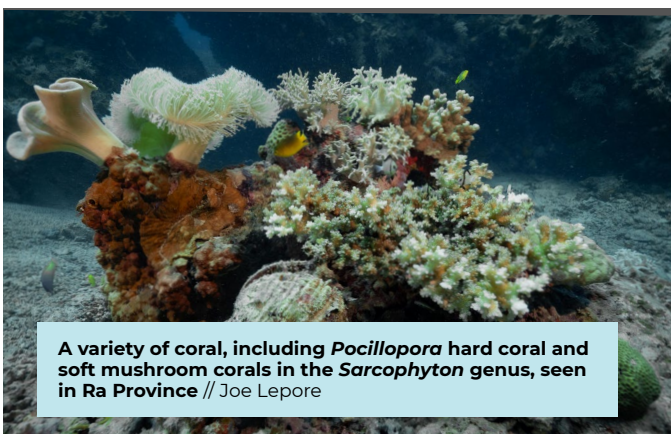
No

signs of sewage pollution at 10m depth

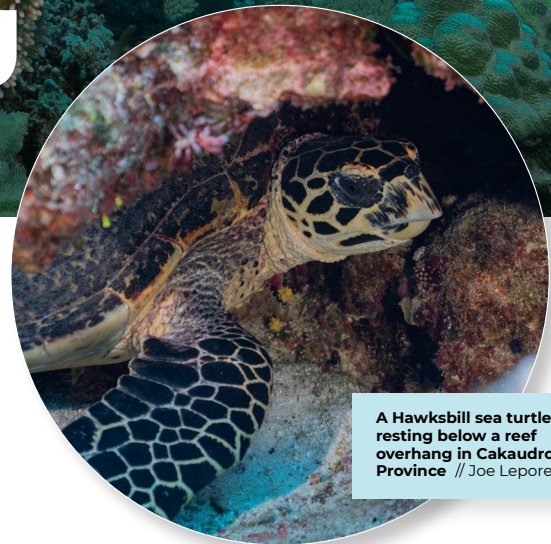
NA VAKALELEKA NI TUKUTUKU (ITAUKEI)

Na Blue Prosperity Fiji, na sasaga e liutaka na Matanitu ko Viti, ka veitokoni tiko kina na Waitt Institute kei na Scripps Institution of Oceanography, e a qarava ena yabaki 2023 na vakadikevi ni wasawasa levu duadua me qai caka e Viti.

Mai na vula ko Me ki na Okosita, era a kumuna kina na dau vakadidike nai tukutuku mai na 269 na tikini cakau ena loma ni 13 na Yasana mei vakaraitaki ni tuvaki ni veicakau e Viti. Nai tukutuku ka kumuni ena i dusidusi kina veivakataulewa se digiidigi mena caka se tauci ena veigauna mai muri me baleta na maroroi, taqomaki kei na kena vakayagataki vakayalomatua na i yaubula ni wasawasa nei Viti.



A variety of coral, including *Pocillopora* hard coral and soft mushroom corals in the *Sarcophyton* genus, seen in Ra Province // Joe Lepore



A Hawksbill sea turtle resting below a reef overhang in Cakaudrove Province // Joe Lepore

Ni bera ni tekivutaki na vakadidike, e a qaravi taumada na kena kerei na veivakadonui vakavanua mai vei ira e sivita ni 100 nai taukei ni i qoliqoli e Viti. Era a solia na nodra veivakadonui kei na veitokoni ko ira kece sara nai taukei ni i qoliqoli.

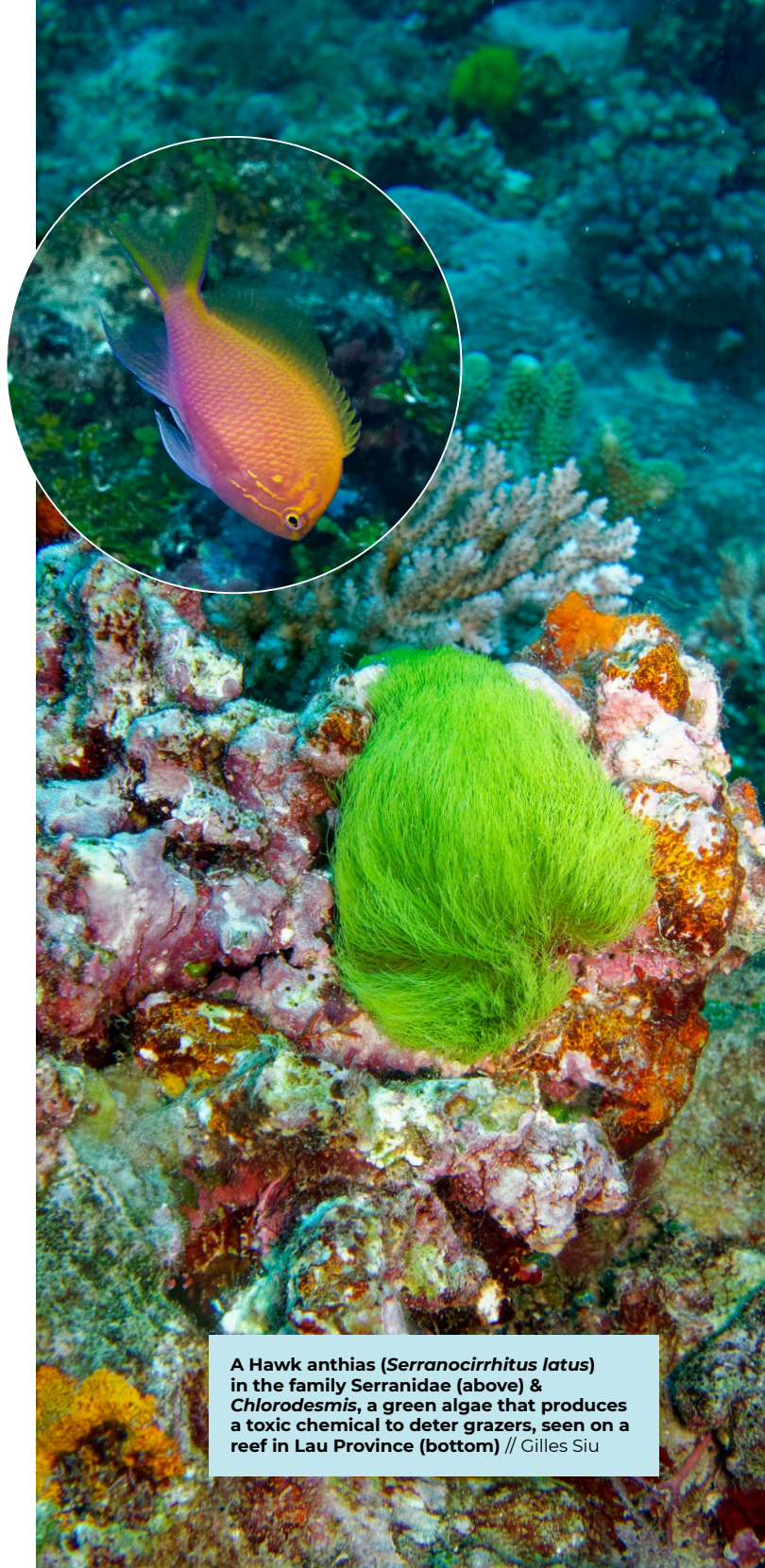
Wasoma ni dau lairai vata ena veicakau e Viti na kena e tu vinaka ka bulabula kei na kena ka sa leqa tu se sa vakacacani. Na veicakau era sautu tu ena veika bula era na rawa ni dau vakacokotaki ira, ia e dau vakaleqa na veivakacokotaki se na kena vakalesui nai tuvaki vinaka ni cakau na kedra dau qolivi sivia, na draki veisau kei na leqa tale eso me vaka na levu ni deni qele kei na veimataqali benu e yauta yani na dave kina veicakau. Ke da sa yalovata qo me da taqomaka na noda veicakau, ena rawa ni vinaka tiko ga na kedra i tuvaki ka da na dau sotava na veika e da vinakata koi keda nikua kei ira na noda kawa era na muri keda mai.

Ika ni Cakau

Na veicakau e Viti e nodra i tikotiko e vuqa sara na veimataqali ika me vaka na 547 na kena veimataqali kara sa vakaivolaitaki ena vakadidike oqo. E a laurai e vuqa sara na veimataqali ika, ka vakatauvatani ni tiko e sivia ni 45,000 na ika ena vei eketea yadua e a vakadikevi. Na levu na kedra bibi na ika ka i vakaraitaki ni kedra lelevu (biomas) e rauta ni 2,573.6 na kilokaramu ena vei eketea. Nai wiliwili ni ika kei na kedra bibi erau levu cake mai na veika e a kune ena vakadidike ka qaravi mai Vanuatu kei Samoa. Ena vei mataqali ika, e levu duadua na planktivores, na ika era kania na co ni waitui, vutia kei na lumi kei na manumanu lalai ka ra ciri voli e wai. Na qio kei na ika era dau kania na vei ika tale eso (top predators) me vaka na sabutu, kawakawa, kei na damu, era a laurai ena vei Yasana kece, ia e lailai sara na kedra i wiliwili ke vakatauvatani kei na levu kei nai wiliwili ni veimataqali ika tale eso.

Vanua e Bula Kina na Lase

E tu na lase bula ena 19.7% ni vanua e a vakadikevi, ka rawa ni vatauvatani kei na i vakatagedegede mai na veivanua era veivolekati kaya ena Pasifika, ia era lailai sobu mai na so na i vakatautauvata (average) mai na veimatanitu ena Ceva ni Pasifika. Na revurevu ni cagilaba kaukauwa me vakataki Cyclone Winston ena 2016 kei na veigauna edau katakata sivia kina na waitui ka dau vakamatea na lase e kilakasamitaki ni vakavuna na kena sega ni bula vinaka na lase ena so na vanua. Dina ga ni tu eso na vanua vakaoqo, na veimataqali lase e kune e levu sara, wili kina na 60 na kena veiwasewase (genera) era sa vakaivolataki tu. A i vakatautauvata ni 11 na lase lalai (juvenile corals) e ra kune ena loma ni vei yadua na mita vakarivirivi, ka okati me i vakatagedegede vinaka ena dua na vanua era tawana na lewe ni vanua ena Pasifika. E vakaraitaka oqo ni veicakau e Viti e se ra rawa tiko ni vakacokotaki ira tale kevaka e vakalailaitaki na veika era rawa ni vakaleqa na bula vinaka ni lase me vaka na draki veisau.



A Hawk anthias (*Serranocirrhitus latus*) in the family Serranidae (above) & *Chlorodesmis*, a green algae that produces a toxic chemical to deter grazers, seen on a reef in Lau Province (bottom) // Gilles Siu

Totoka nai tuvaki ni cakau ke ra verevereya, rewarewa ka basobasoga baleta na i tuvaki ni cakau vaka oqo e na levu kina vanua me ra vakavale kina na ika kei na manumanu lalai ni wasawasa (reef rugosity). Na vei cakau kece ena vei Yasana e Viti era yacova nai vakatautauvata ni tuvaki ni cakau e 1.8. ka bibi ena kedra taqomaki na ika lelevu e yaga ena bula vakailavo kei na taqomaki ni veika bula.

Sasalu

E vuqa na veimataqali sasalu e a kumuni na kedra i tukutuku ena vakadidike. E levu na sasalu e a kunei, ka so vei ira era sau levu sara, ia era a kunei walega ena vica nai qoliqoli. E sega ni vakabibitaki ena kumuni tukutuku oqo na kedra levu se lailai na sasalu ka ni a tauri walega nai tukutuku ni nodra kunei ka sega na kedra lelevu. A sega talega ni tauri nai wiliwili ni sasalu baleta e so na leqa a sotavi e na vakayagataki vakadodonu ni walewale ni wiliwili.

Eso na sasalu era vakayagataki me i vurevure ni i lavo kei na bisinisi era sa kune ga ena so na vanua lelevu. Na veika e kune e vakaraitaka (ia e sega ni vakadeitaka) ni sa lailai sara tiko na kedra i wiliwili na sasalu.

E 85 na mataqali manumanu e volai tukutukutaki, okati kina e 16 na vasua, kai (bivalves); 2 na kuita, kuita nu (cephalopods), dua na (crinoid), dua na

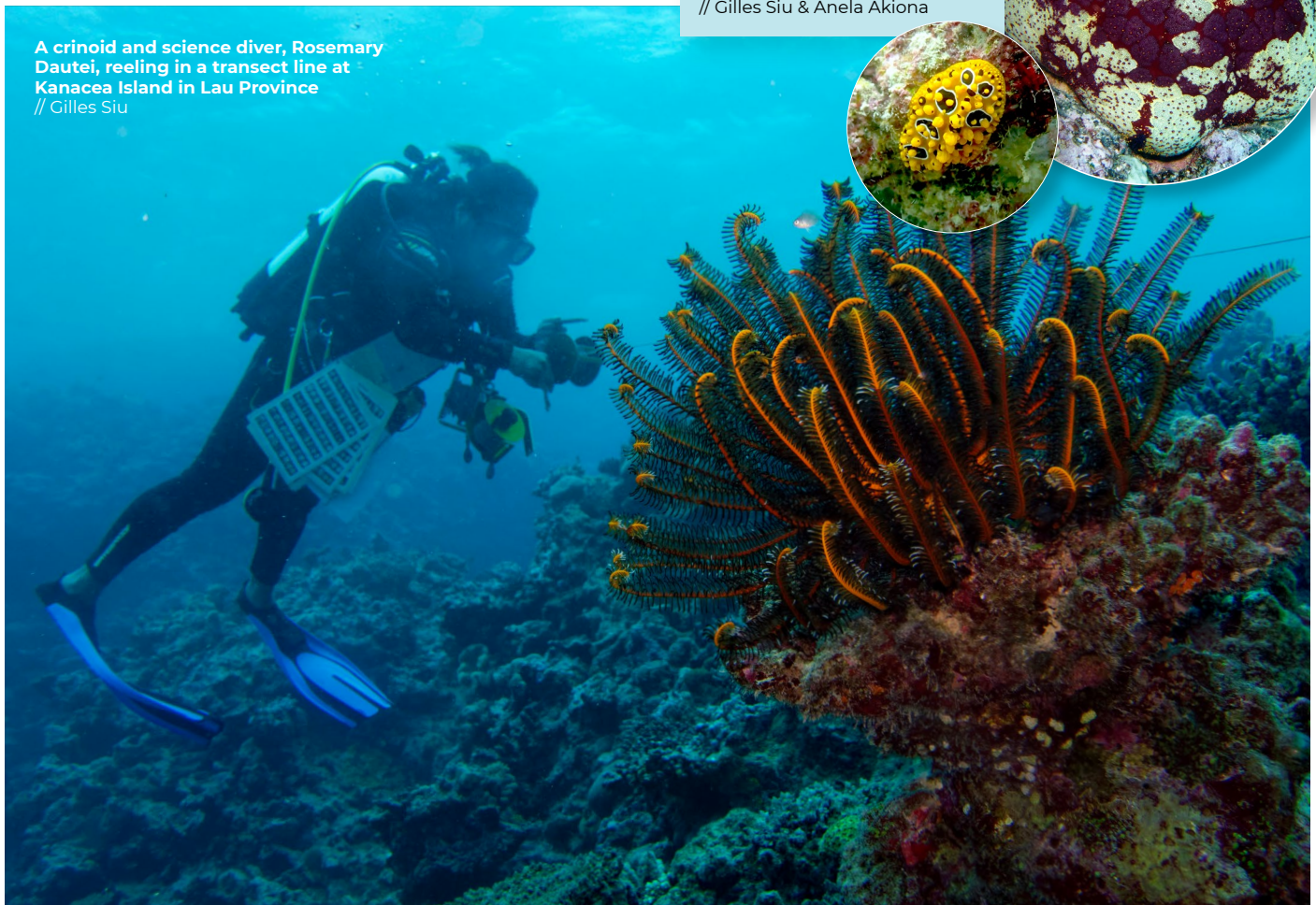
crustacean, 36 na gastropods, 18 na dri (sea cucumbers) kei na 8 na davui ni wasawasa (sea stars).

E a sega ni kune e dua na cawaki (sea urchin) ena vakadidike e Vanua Levu, ia e kune ga eso e tautuba ni veivanua e vakadidike, ka vakaraitaka ni ra tiko. ia e sega ni levu.

Na i wiliwili ni sasalu oqo e sega ni rawa ni vakatautauvatataki vakadodonu baleta na leqa ena i vakarau ni vakadidike ka caka; ia na dri (sea cucumbers), na i vakatakilakila e vakaraitaka ni ra lailai sara eso na mataqali. Na davui daukana bula (Crown-of-thorns sea star, COTS) era kune ena veimama ni Yasana e ra a vakadidike, ia e sega ni kune na nodra tubu vakasivia (outbreaks) na bula, ka vakaraitaka ni rau veiraurau tiko na bula kei na kedra i kata. Na urau (lobsters) kei na kuita (octopus) e rau kunei ena walu kei na lima na Yasana era a vakadikevi.

A cushion sea star (*Cladonia* *novaeguineae*) in Lau (right) & a dorid nudibranch (*Phyllidia* *ocellata*) in Ba Province (left)
// Gilles Siu & Anela Akiona

A crinoid and science diver, Rosemary Dautei, reeling in a transect line at Kanacea Island in Lau Province
// Gilles Siu



Cyanobacteria

E kune na cyanobacteria ena levu na vanua e caka kina na vakadidike, ka vakatautauvataki ni ra kune ena 4.4% ni vanua ena vei Yasana kece. Na veivanua e tu kina na cyanobacteria (cyanobacterial mats) e laurai vakalevu ena veicakau e Viti ka vakina e na Pasifika taucoko. Dina ni vuqa nai tavi ni cyanobacteria ena veicakau, na kedra vavaku me vaka e sa kunei ena levu na vanua ena vakadididike oqo, era rawa ni ra vakalatilati se vakamate ira na lase, ka vakadredretaka na nodra vakatikori ka tubu na lase vovou.

Some *Porites* coral seen at the Coral Coast in Nadroga-Navosa Province

School of fusiliers, including three-stripe fusilier (*Pterocaesio trilineata*), blue and gold fusilier (*Caesio caerulaurea*), & ruddy fusilier (*Pterocaesio pisang*) at Vanua Balavu in Lau Province // Gilles Siu

Water Quality

E sega ni kunei na i vakatakilakila ni kena vakaleqai na wai mai na benu ni vale lailai ena taudaku ni veicakau ka 10 na mita na titobu ni wai, ia e nanumi ni na rawa ni laurai na veileqa oqori ena veivanua voleka ki matasawa baleta ni dau vakilai kina vakalevu na revurevu ni veika e caka tiko e vanua mamaca.

Rau ni veiliutaki vakavanua ni i Qoliqoli, ka okati kina na kena tuvai na vanua tabu, e vakarautaka na ivakarau kaukauwa me maroroi kina na wasawasa kei na qoli vakadodonu. Kevaka e semati kei na ituvatuva ni Marine Spatial Planning, e sa tu vinaka kina o Viti me vakaukauwataka na nona tudei ni vakaraitaka ki na veivakararawataki. Ena kena sema vata na kilaka vakavanua kei na vakasaenisi, ena rawa ni maroroi kina o Viti na kaukamea kei na wasawasa me baleta na veitabana kei na bula vakavanua ni veitabagauna mai muri.

Na vakayagataki ni qoliqoli kara vakataulewa kina nai taukei ni qoliqoli ka ra rawa ni vakadonua na vakatabui ni so na tiki ni nodrai qoliqoli e rawa ni yavu ni kena vakabibitaki na maroroi ni yaubula kei na kedra vakayagataki vakavuku. Na kedrau semati ka vakayagataki vata na nodra dodonu nai taukei ni qoliqoli mera vakayagataki na Marine Spatial Planning e na rawa ni yaga vakalevu sara vei Viti ena kena vakaqacotaki na sagai ni wali se i sasabai kina vei dredre e da namaka ni da na sotava. Ke rawa vei Viti me vakayagataka vata na nodra kila na noda qase kei na veika e da sa vukica mai na vakadidike baleta na noda i yaubula, sa na rawa vei Viti me vakavinakataka na nona veicakau kei na nodra i vurevure ni bula na leweni vanua ena gauna qo kei na veitaba tamata era na muri mai.

INTRODUCTION



GEOLOGY & DEMOGRAPHICS

Fiji is an island nation in the South Pacific comprising 332 islands and 522 islets, with a land area greater than 18,000 km² and an Exclusive Economic Zone (EEZ) exceeding 1.2 million km² (Chandra 2011, Mangubhai et al. 2019, Mangubhai et al. 2025). The country has both volcanic high islands and coralline limestone low islands that support extensive reef systems (Lovell & Sykes 2008, Jones 2009, Bruckner et al. 2016). Fiji hosts over 1,000 coral reefs of diverse types, including fringing, platform pinnacle, submerged, ribbon, barrier, and atoll reefs (Mangubhai et al. 2019, Mangubhai et al. 2025). **Fringing and barrier reefs are particularly well developed in Fiji**, including Cakaulevu (also known as the Great Sea Reef), which is the third largest barrier reef in the world at 370 km long (Cumming et al. 2002a, Jenkins 2004, Lovell & Sykes 2008, Ellison & Fiu 2010, Andradi-Brown et al. 2022). **Fijian reefs have been shown to have high biodiversity**; its reefs are home to over 2,340 species, including over 200 species of coral and approximately 1,200 species of reef fish (Jenkins 2004, Prasad 2010, Chandra 2011, Andradi-Brown et al. 2022, Mangubhai et al. 2025). Biodiversity estimates for some parts of

the country indicate comparable biodiversity to known biodiversity hotspots such as Indonesia and Papua New Guinea (Jupiter & Egli 2011).

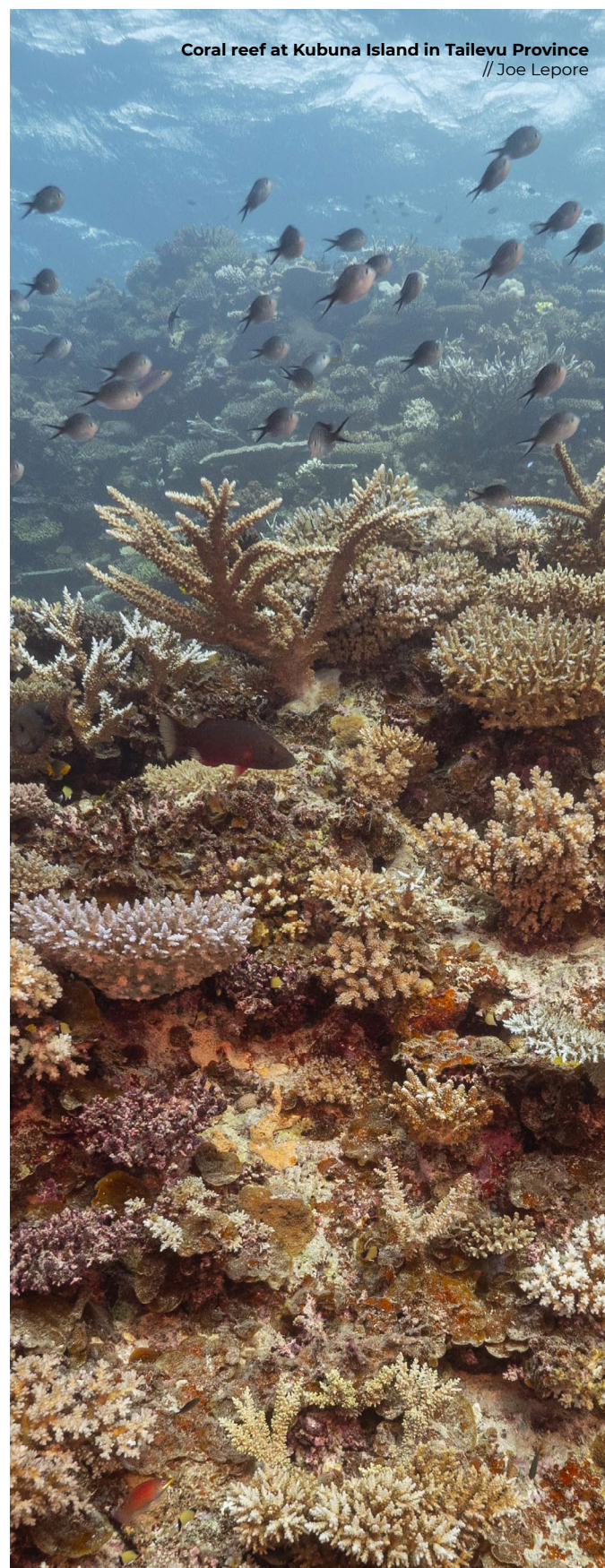
Of Fiji's 332 islands, approximately 100 are inhabited (Teh et al. 2009, Hastings et al. 2012). As of the 2017 census, the total population of Fiji was 884,887, with approximately 81% of the population based on the main island of Viti Levu, and another 15% on Vanua Levu (Fiji Bureau of Statistics 2017). About 63% of the population is iTaukei (Indigenous Fijian), and 33% is Indo-Fijian (Fiji Bureau of Statistics 2017). The capital city of Suva, on Viti Levu, is the largest urban center in the South Pacific outside of Australia and New Zealand (Lal et al. 2018). Outside of the main population centers, much of Fiji is rural, with 40-50% of the population living in rural areas and 6% of the total population depending fully on subsistence for their livelihoods (Hastings et al. 2012, Fiji Bureau of Statistics 2017, Dacks et al. 2018). **In total, approximately half of all Fijians live within 5 km of a coral reef** (Mangubhai et al. 2025). **Of rural Fijians, 80% live within 5 km of the coast and depend heavily on reefs for protein** (Jenkins 2004). In addition to fisheries, reefs are important for supporting the country's tourism industry, which is the country's largest overseas income generator (Cumming et al. 2002a, Mangubhai 2016).

Fiji is divided into several sectors based on administrative and traditional tenure systems that have implications for marine governance. Administratively, the country is divided into 14 Provinces, which are grouped into four administrative Divisions: Western, Northern, Central and Eastern. Additionally, iTaukei ownership of the majority of land (approximately 90%) and customary marine tenure or usage rights are legally recognized in Fiji, customary land and marine tenure is legally recognized in Fiji, and **410 Customary Fishing Rights Areas (CFRA) (traditional tenure areas, also known as i Qoliqoli) are present across the country** totaling approximately 30,011.09 km² (Tuqiri 2009, Mills et al. 2011, Hastings et al. 2012, Gillett et al. 2014, Prince et al. 2020). CFRA boundaries generally extend from the foreshore to the outer reef and are fished by single or multiple villages, with access granted by the local Chief and Customary Fishing Rights Owners (CFRO) (Dacks 2018).

A key feature of Fiji's system is the dual legal and governance system over fisheries management in CFRAs. **While all fishing grounds are vested in the State, Fiji law recognizes the exclusive rights of communities to fish in their traditional fishing grounds** within their respective CFRA. This system separates the state's underlying ownership from the communities' use rights for inshore waters. For example, the State, through the Fisheries Act, holds the legal management rights to the CFRA (Sloan & Chand 2016).

This also means there is open access for subsistence fishing by customary landowners, and Fiji law recognizes the exclusive rights of communities to fish in their traditional fishing grounds within their respective CFRA (Hunt 1999, Tuqiri 2009, Chandra 2011, Dacks 2018, Fache & Breckwoldt 2018, Mangubhai et al. 2025). Though not legally recognized, customary management over CFRAs is widespread throughout Fiji and is practiced in most rural areas across the country (Dacks 2018). This customary management has often been implemented with support from organisations like the Fiji Locally Managed Marine Area (FLMMA) Network. They implement traditional management tools, such as declaring informal no-take zones known as tabu areas. While these tabu areas are not legally binding on outsiders, the State's permit and licensing system,

which requires non-customary commercial fishers to seek permission from CFRO, provides a mechanism for exclusion. This shared system means that effective fisheries management initiatives must involve both the government and the communities.



REEF HEALTH & THREATS

In contrast to many other Pacific Island nations, where data on coral reef health is sparse, Fiji's reefs have been comparably well studied.

The existence of notable universities such as the University of the South Pacific (USP), strong community leadership, and widespread non-governmental organisation (NGO) presence in Fiji has resulted in several community-, region-, and seascape-level coral reef assessments across the country. In aggregate, these studies give an idea of reef health across the various regions of Fiji at different points in time. However, due to the large geographic extent of the country and the number of independent groups conducting surveys, **no nationwide surveys at a single point in time exist, and various survey methods have been used, making comparisons between different regions difficult.** Similarly, habitat types (e.g., forereef, lagoon, backreef) vary between studies, further complicating comparisons. Nevertheless, the information that exists allows for a general understanding of the state of Fiji's reefs over the past few decades.

Estimates of coral cover within Fiji vary over space and time. A survey conducted on Cakaulevu (Great Sea Reef) in 2019 found mean coral cover across the region to be 34%, with a high in Bua at 45% and a low in Nadroga-Navosa at 23% (Andradi-Brown et al. 2022). A 2017 survey of the Lau Seascape found a range of hard coral cover between 20.2% to 34.3%, and recorded 281 distinct coral species (Meo et al. 2021). **An analysis of data from 12 different datasets from 650 monitoring sites between 1997-2023 estimated nationwide coral cover of around 34% (Mangubhai et al. 2025).** This analysis also found relatively stable coral cover over this period, with **slight reductions in coral cover immediately following disturbances followed by rapid recovery.**

Crustose coralline algae (CCA) and macroalgae both also showed relatively stable percent cover (approximately 10% and 7%, respectively) over the 25-year period (Mangubhai et al. 2025). However, it should be noted that the majority of the datasets used for this analysis had only one year's worth of data, and different methods were used to collect benthic cover estimates between datasets. Similarly, habitat type was not constrained, and estimates presented show crosshabitat means.

Nama (*Caulerpa racemosa*), also known as sea grapes, growing in Ono-i-Lau
// Gilles Siu

Example of Crustose Coralline Algae (CCA) seen at Tuvana-i-Colo in Lau Province // Gilles Siu



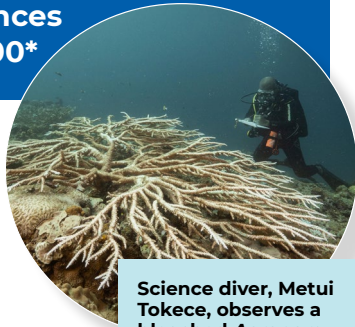
CCA (CRUSTOSE CORALLINE ALGAE): Hard, encrusting red algae important for reef building and coral larval settlement

TIMELINE

Major Acute Disturbances on Fiji Reefs since 2000*

2000

Bleaching event
~64% of corals bleached, 10-80% coral mortality



Science diver, Metui Tokece, observes a bleached *Acropora* coral in Cakaudrove
// Joe Lepore

2002

Bleaching event
Widespread coral mortality

2004 - 2008

Crown-of-Thorns sea star (COTS) outbreaks in Mamanuca Group
High mortality of *Acropora* corals

2006

Bleaching event
Low to moderate bleaching, no evidence of widespread mortality

2016

Bleaching event & Cyclone Winston

- Cyclone cooled sea surface temperatures, minimising adverse effect of bleaching
- Widespread damage of coral reefs
- Shipwreck in Ovalau

2018

Shipwreck in Toga in Rewa Province

2019

Bleaching event (March - April)
Bleaching of up to 40% in March-April, but low mortality due to a drop in sea surface temperatures in May - June

2020

Cyclone Harold (April)

- Category 4
- Localized damaged to reefs

Cyclone Yasa (December)

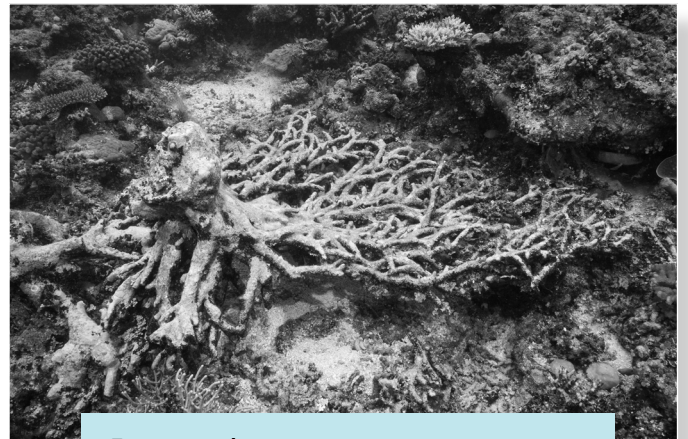
- Category 4
- Localized damaged to reefs

2022

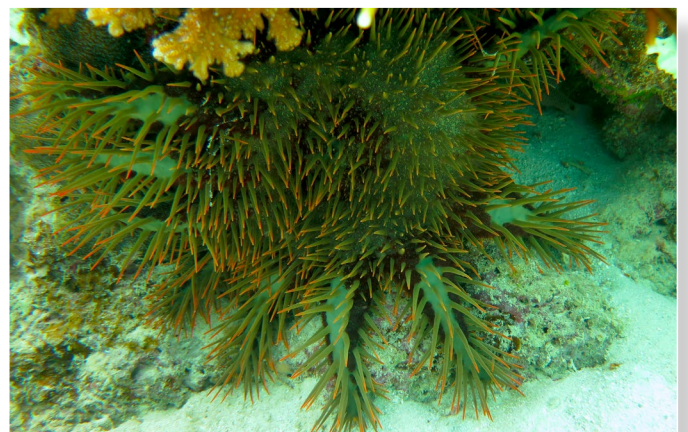
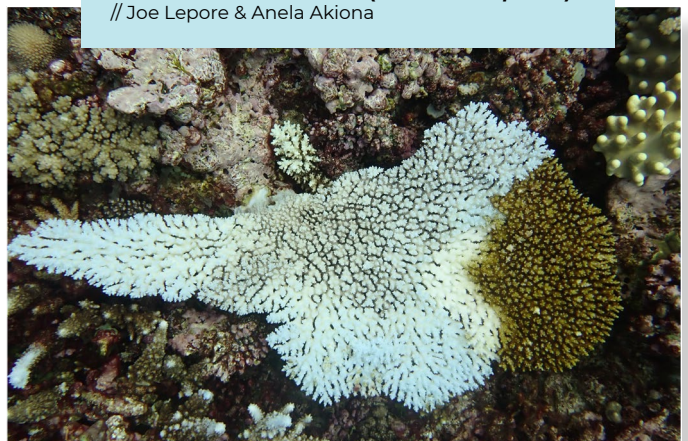
Hunga Tonga-Hunga
Ha'apai eruption & tsunami

2020 - 2025

- Regular outbreaks of COTS in Beqa
- Outbreaks of COTS in Yasawa Group and Vomo Island



From top to bottom:
- A healthy colony of *Acropora* stony coral in Ra,
- An overturned dead colony of *Acropora* (occurs during storms and swell events) in Cakaudrove,
- Signs of coral bleaching in Kadavu Province, &
- Crown-of-Thorns seastar (*Acanthaster planci*)
// Joe Lepore & Anela Akiona



*List is not comprehensive; Minor, regional, or local scale disturbances not included in this list.

Prior to the reports referenced above, the most recent estimates of coral cover came from surveys conducted following Cyclone Winston.

This cyclone, one of the most destructive on record in the Southern Hemisphere, passed through Fiji in February 2016 and caused **significant damage to reefs around the country**, with up to 90% coral cover loss at some sites (Mangubhai 2016, Miller et al. 2018, Nand et al. 2020, Price et al. 2021, Mangubhai et al. 2025). At the time the cyclone made landfall, a coral bleaching event was underway across the country; however, the storm cooled sea surface temperatures, alleviating bleaching stress in areas less affected by storm damage (Mangubhai 2016, Goberdhan & Kininmonth 2021, Mangubhai et al. 2025). Damage to reefs was severe, with a relative loss of 54% hard coral cover in affected regions (Ford et al. in press). In Lomaiviti, one of the hardest hit Provinces of the country, coral cover ranged from 0-53%, with a mean of 25.7% at popular dive sites in the Vatu-i-Ra passage (Mangubhai 2016), and a mean of 8.4% at sites that are not commonly visited by tourists (Nand et al. 2019). In Lau, where cyclone damage was less concentrated, estimates of hard coral cover during this time period ranged from 9.1-27.9%, with a mean of 21.4% (Miller et al. 2018). For comparison, when Lau's reefs were surveyed in 2013, prior to the cyclone, mean coral cover was estimated at 36% (Bruckner et al. 2016). Concurrent with coral decline, increases in filamentous benthic algae were observed (Price et al. 2021). **Reef structural complexity (rugosity) decreased substantially at exposed sites** following Winston, though due to the patchiness of impacts, fish community composition remained mostly unchanged, with the exception of obligate corallivores (Price et al. 2021). However, **substantial recovery and reassembly at impacted sites had been documented by 2020, likely facilitated in part by healthy fish communities in these areas** (Mangubhai et al. 2025, Ford et al. in press). Since Winston, two category 4 cyclones, Yasa and Harold, have hit Fiji and resulted in localised damage to reefs (Mangubhai et al. 2025).

In total, 29 cyclones with sustained winds of greater than 100km/h passed within 100 km distance of Fijian coral reefs between 1980-2023, indicating that cyclones are a persistent stressor to reefs in Fiji (Mangubhai et al. 2025).

In addition to cyclones, several global and local phenomena threaten the health of Fiji's reefs.

Coral bleaching, though somewhat alleviated by Cyclone Winston in 2016, has occurred throughout Fiji multiple times in the past few decades, and is expected to increase in frequency and severity as global sea surface temperatures rise (Sulu et al. 2002). **While Fiji was largely unaffected by the worldwide mass bleaching event of 1998, the country experienced widespread bleaching in 2000**, which affected reefs throughout most of the country (Cumming et al. 2002b, Obura & Mangubhai 2003, Lovell et al. 2004, Lovell & Sykes 2008, Mangubhai et al. 2025). **Considered the worst on record, it is estimated that 64% of corals in Fiji bleached during this event**, and 10-80% of corals experienced mortality, with some sites losing 80-99% of *Acropora*, one of the dominant reef taxa in Fiji (Cumming et al. 2002a, Cumming et al. 2002b, Sulu et al. 2002, Sykes 2007, Lovell & Sykes 2008, Sykes & Morris 2009, Ellison & Fiu 2010).



ACROPORA: A genus of fast-growing, reef-building corals commonly found on Pacific reefs. These corals are especially important for creating complex habitats for fish and invertebrates, but are highly susceptible to bleaching and storm damage.



Two-stripe damselfish (*Dascyllus reticulatus*) swimming above a partially bleached *Acropora* coral
// Anela Akiona



Partially bleached *Lobophyllia* coral, Cakaudrove Province (left) & Pink anemonefish (*Amphiprion perideraion*) in a bleached anemone in Kubuna (right)
// Joe Lepore & Anela Akiona

Fiji experienced a second bleaching event in 2002, but reefs recovered quickly from the back-to-back events, with coral cover approaching pre-bleaching levels (~40-45%) by 2007 (Sulu et al. 2002, Lovell et al. 2004, Sykes 2007, Lovell & Sykes 2008, Sykes & Morris 2009). While *Acropora* corals were most affected by these disturbances, they soon recovered, and coral diversity was found to be higher following the disturbances (Sykes 2007, Sykes & Lovell 2009, Sykes & Morris 2009). During this period, fine scale structural complexity (rugosity) decreased on reefs (Wilson et al. 2010), possibly due in part to the loss of *Acropora*. Following these larger events, smaller, more localised bleaching events were recorded in Fiji between 2002-2006, without evidence of widespread mortality (Sykes 2007, Mangubhai et al. 2025). A survey of Lau Province in 2017 found no evidence of bleaching related mortality associated with the 2016 global bleaching event (Meo et al. 2021). Bleaching of up to 40% in some parts of the country was recorded in March-April 2019, but by May-June of that year, sea surface temperatures had dropped and most corals had recovered (Mangubhai et al. 2025). In general, **Fiji's reefs have shown high resilience to bleaching related disturbances**, and the lack of major bleaching impacts may be partly explained by the fact that the warmest months coincide with cyclone season, often working to reduce temperature stress to corals (Mangubhai et al. 2025).

In addition to coral bleaching and cyclones, a number of local threats affect Fiji's reefs, such as **overfishing, eutrophication, siltation, and predation by crown-of-thorns seastars (COTS)** (Cumming et al. 2002a, Obura & Mangubhai 2003, Lovell et al. 2004, Sykes & Lovell 2009, Sykes & Morris 2009, Tuqiri 2009, Ellison & Fiu 2010). In urban and heavily touristed areas, such as Suva and the Coral Coast, **sewage pollution, land reclamation, and lack of proper waste disposal have led to decreased water quality and sedimentation** (Cumming et al. 2002a, Mosley & Aalbersberg 2003, Maata & Singh 2008, Ellison & Fiu 2010, Tamata & Morrison 2012, Hastings et al. 2015, Lal et al. 2018, Goberdhan & Kininmonth 2021). **Runoff and siltation from agriculture** and mining have also been found to negatively affect Fiji's reefs (Morrison & Naqasima 1999, Hoffmann 2002, Jenkins 2004, Sykes & Morris 2009, Hastings et al. 2015). **COTS outbreaks** have been documented periodically in Fiji since the 1960s, though oral histories with elder fishers indicate outbreaks likely occurred previously as well (Zann et al. 1990, Cumming et al. 2002a, Ellison & Fiu 2010). Baseline densities of COTS are typically low, but during outbreaks, densities of hundreds or even thousands have been found in localised areas, causing extensive damage to the reef (Hoffmann 2002, Sykes & Morris 2009). While the cause of COTS outbreaks is debated, anecdotal reports note that several outbreaks have occurred on overfished reefs across Fiji (Jennings 1998, Ellison & Fiu 2010).

REEF FISH FISHERIES

Fishing is a culturally, domestically, and economically important activity in Fiji. **Fisheries is the third largest natural resource sector in the country** (Tuqiri 2009). While data collection on inshore fisheries has historically been lacking in Fiji, it is clear that small-scale inshore coral reef fisheries are critically important to the nation's economy and food security (Teh et al. 2009, Tuqiri 2009, Gillett et al. 2014). **By some estimates, 96% of rural Fijian households engage in fishing in some capacity, and for 33%, fishing is one of the three top income sources** (Dacks et al. 2018). Small-scale, domestic inshore fisheries provide food for about 50% of rural households and contribute over \$48 million to the national economy each year (Teh et al. 2009, Eastwood et al. 2016). It is estimated that the direct economic value of coastal commercial and domestic subsistence fisheries in Fiji is approximately eight times greater than that of offshore fisheries, and that **coastal fisheries produce greater than 16 times the amount of fish for local consumption than those based offshore** (Gillett et al. 2014). While estimates of the number of domestic subsistence fishers vary significantly, even on the low end, it is estimated that there are greater than **23 times as many artisanal and subsistence fishers than offshore fishers in Fiji** (Gillett et al. 2014).

This high dependence on inshore fisheries places pressure on the coral reef ecosystems that support them, and highlights the importance of having healthy reef ecosystems. Many of Fiji's inshore reefs are considered moderately or heavily fished, and there is evidence of overfishing for highly targeted taxa (Cumming et al. 2002a,

Obura & Mangubhai 2003, Jenkins 2004, Lovell et al. 2004, Sykes 2007, Sykes & Morris 2009, Tuqiri 2009, Ellison & Fiu 2010, Gillett et al. 2014, Dacks et al. 2018, Fache & Pauwels 2022). In recent decades, **increasing urbanisation and higher numbers of Fijians in full time employment has led to escalating demands for fish and an associated rise in fish prices**, which has led many fishers to increase fishing pressure to maximise profits (Jennings & Polunin 1996). Traditionally, nearshore Fijian fisheries target a wide range of species (Jones 2009), but the **recognition of fish as a monetarily important resource has led to a shift in effort towards more valuable species**, such as snappers, groupers, emperors, parrotfish, and unicornfish, placing excessive pressure on these taxa (Jennings & Polunin 1996). In addition, technological advances such as a switch from outrigger canoes to outboard powered vessels has led to increased catch efficiency, placing further pressure on reef fish fisheries (Kuster et al. 2005). While hand lines are the most common fishing gear employed in rural areas, **more destructive and efficient fishing methods are also sometimes employed**, including night-time spearfishing, gillnets, and in some cases, poison or dynamite fishing (Rawlinson et al. 1995, Jennings & Polunin 1996, Matthews et al. 1998, Morrison & Naqasima 1999, Sykes & Morris 2009, Teh et al. 2009, Tuqiri 2009, Ellison & Fiu 2010, Dacks et al. 2018, Fache & Breckwoldt 2018, Prince et al. 2020). As a result, large, targeted food fish such as groupers, sweetlips, emperors, parrotfish and wrasses have become smaller and more scarce, and some large, prized species such as the bumphead parrotfish (*Bolometopon muricatum*) have been threatened with local extinction in parts of the country (Cumming et al. 2002a, Jenkins 2004, Sykes & Morris 2009, Cakacaka 2010, Gillett et al. 2014, Fache & Pauwels 2022).

A photograph showing a variety of reef fish laid out on a white tiled surface at a fish market. The fish include several large, bright orange-red snappers, a large blue and white striped fish, and several smaller, darker fish. Some fish are still in their original packaging or have blue string tied around them.

A variety of reef fish for sale at the fish market in Suva, Fiji
// James Sloan

The effects of overfishing can be seen in ecological and socio-economic data from across the country. A 2019 survey of the Great Sea Reef (GSR) found generally **low fish abundance and biomass across the region**, with a decline of 33% in abundance and of 80% in biomass of key fisheries families from surveys conducted in the early 2000s (Andradi-Brown et al. 2022). A survey across Lau Province conducted in 2013 found fish size distributions skewed towards smaller fish, indicating high fishing pressure (Bruckner et al. 2016). Similarly, fish in Kadavu were scarce and small when surveyed in the early 2000s, with a scarcity of preferred food fish, to the point that fishers from Suva had abandoned the area as a secondary fishing ground due to loss of economically viable stocks (Obura & Mangubhai 2003). Following a transition to motorised vessels, fishers on Ono-i-Lau experienced a 27% decrease in annual fish landings due to increased fishing pressure on their reefs (Kuster et al. 2005). One analysis determined that, **based on projected population growth, Fiji may not be able to meet its future food needs without effective fisheries management** (Gillett et al. 2014).

INVERTEBRATE AND AQUARIUM FISHERIES

In addition to reef fish, invertebrates form an important part of nearshore fisheries in Fiji. It is estimated that invertebrates account for up to 72% of artisanal catches by weight and almost 50% of subsistence catches around Viti Levu (Rawlinson et al. 1995, Teh et al. 2009). Fiji's coastal invertebrate fishery includes over 50 species (Mangubhai et al. 2019), and several invertebrates and other marine products are collected for export, including sea cucumber (*bêche-de-mer*), trochus, live rock and coral products (Chandra 2011, Gillett et al. 2014). Other commonly harvested taxa include giant clams, sea urchins, lobsters, crabs, triton snails, pearl oysters and cephalopods such as octopus (Matthews et al. 1998, Sykes & Morris 2009, Gillett et al. 2014, Mangubhai et al. 2019).

Sea cucumbers have been harvested and traded in Fiji for over a century (Teh et al. 2009) and are likely to be the **country's single most valuable coastal fishery** (export value of FJD \$16.5 million in 2005) (Gillett et al. 2014). Twenty-seven species of sea cucumber are present in Fiji, 20 of which are commercially important (Pakoa et al. 2013). **Sea cucumbers are important for regulating sediment health on coral reefs, and their removal can reduce the capacity of sediments to buffer pulses of organic matter, reducing the function and productivity of reef ecosystems** (Lee et al. 2018). Due to export demand, fishers fetch high prices for sea cucumbers (Jennings & Polunin 1996, Morrison & Naqasima 1999), and this, combined with the sedentary and easy-to-catch nature of these organisms, makes sea cucumber fishing an attractive prospect for income generation.

As is common in the *bêche-de-mer* trade, the sea cucumber fishery in Fiji has followed a boom and bust cycle, where stocks are fished intensively until densities are no longer viable, and long resting periods are required to build them back up to fishable levels (Teh et al. 2009, Jupiter et al. 2013, Gillett et al. 2014). Continuous exploitation has led to low densities and smaller sizes of most species (Teh et al. 2009, Gillett et al. 2014).



For most commercially targeted species, densities are far below reference densities for healthy populations, and sea cucumbers in Fiji are smaller than average for the Pacific region (Jupiter et al. 2013, Pakoa et al. 2013, Gillett et al. 2014). In an effort to maintain catch volumes despite declining populations, fishers have resorted to unsustainable and dangerous fishing practices, such as the use of sea cucumber “bombs” (weighted lines with hooks) and UBA (underwater breathing apparatus, including hookah and SCUBA) to catch more individuals and access deeper populations (Morrison & Naqasima 1999, Jupiter et al. 2013). The use of UBA, though banned, is of particular concern as it has resulted in the deaths of several fishers across the country (Morrison & Naqasima 1999, Sykes & Morris 2009, Jupiter et al. 2013, Pakoa et al. 2013).

Other important invertebrate fisheries, such as giant clams and trochus, have also seen the effects of overharvesting. Giant clams are a traditional delicacy in Fiji, and have been harvested for subsistence and commercial use (Lewis et al. 1988, Matthews et al. 1998, Kuster et al. 2005, Sykes & Morris 2009, Miller et al. 2018). Until the late 1970s, giant clam stocks were not considered depleted, and Fiji had the highest stocks of *Tridacna derasa* outside of the Great Barrier Reef (Lewis et al. 1988). However, by 1984-1988, clams had been harvested beyond sustainable levels, and *Tridacna gigas* had likely been fished to extinction in Fiji (Teh et al. 2009). In recent years, *Hippopus hippopus* has also been fished to local extinction, and stocks of the once abundant *T. derasa* are considered overfished (Kuster et al. 2005, Ellison & Fiu 2010, Gillett et al. 2014). Even in rural areas, local fishing pressure has reduced clam stocks on inhabited islands, though nearby uninhabited islands tend to have higher population densities (Morrison & Naqasima 1999, Jones 2009). Some villages and tourism operators have implemented management measures, such as Marine Protected Areas or tabu zones, and others have created clam nurseries or reintroduced clams to their reefs in an effort to enhance stocks, but results have been slow and variable (Lewis et al. 1988, Morrison & Naqasima 1999, Sykes & Reddy 2018, Andradi-Brown et al. 2022, Fache & Pauwels 2022). Trochus, a gastropod snail whose shell is used for button making, is an export commodity that generates supplemental income for many coastal households in some

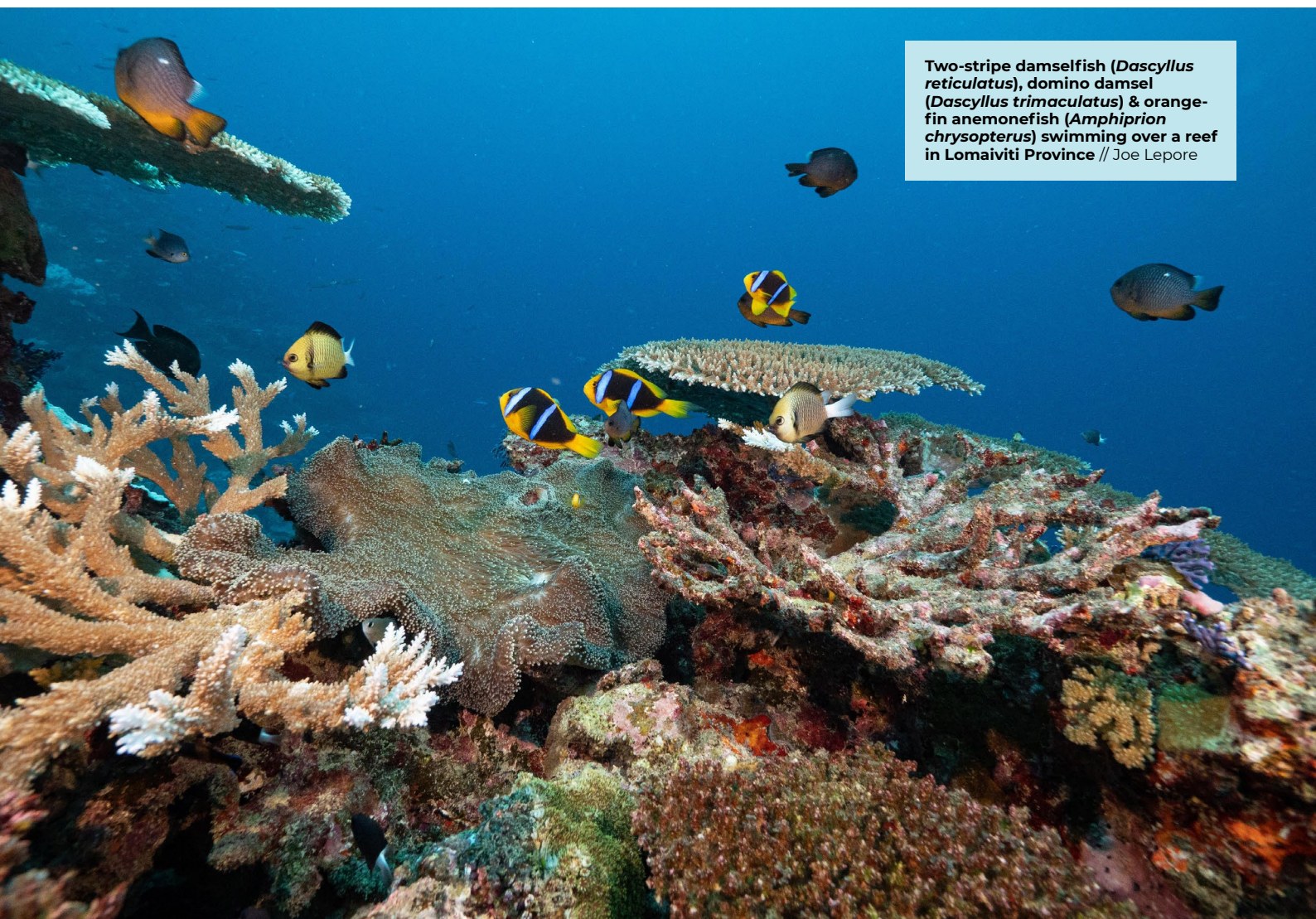
parts of Fiji (Teh et al. 2009). In the early 1990s, Fiji contributed 15% of the worldwide trochus harvest at 271 tonnes, but catch declined steadily to 153 tonnes by 2001 (Teh et al. 2009). It is believed that overfishing of trochus has continued to contribute to a decline of this resource through to the present day.



A giant clam and anemonefish (*Amphiprion barberi*) in Tailevu Province (above) & a trochus in the Great Sea Reef in Nadroga-Navosa Province (bottom)
// Joe Lepore & Andy Estep

Sea urchins are important for maintaining reef health, and are also an important fishery species. Many sea urchins are herbivorous, removing algae from reefs and creating open space for corals to settle and grow (Ogden & Lobel 1978, PHAMA 2018). The collector urchin, *Tripneustes gratilla* (locally known as cawaki) is an important domestic fisheries resource, as well (Coppard & Campbell 2005, PHAMA 2018, Nalasi et al. 2024). Cawaki are harvested for their gonads, which are sold domestically at markets (Nalasi et al. 2024). Women are the primary harvesters of cawaki, and this fishery represents an important livelihood for coastal women in Fiji (PHAMA 2018, Nalasi et al. 2024). While a previous report found cawaki densities to be sufficient to support local markets, it was determined densities were too low to support an export fishery, and that additional management of stocks would be required to achieve this goal (PHAMA 2018).

In addition, Fiji supports an aquarium fishery focused on corals, invertebrates, reef fish, live rock and live sand (Cumming et al. 2002a). **Fiji is one of the world's largest exporters of live reef products for the aquarium trade** (Cumming et al. 2002a, Sulu et al. 2002), providing 5% of aquarium fish and 4% of live corals to the global market (Teh et al. 2009). In 2004, Fiji exported 169,143 live aquarium fish (Sykes & Morris 2009), **mostly butterflyfish, damselfish, and angelfish** (Teh et al. 2009). During the same period, Fiji exported 161,927 pieces of hard and soft coral and 1.36 million pieces of live rock as part of the aquarium trade (Sykes & Morris 2009). Corals have also been harvested for use in septic systems, for medical use, and for the curio trade (Cumming et al. 2002a). While there is concern about the sustainability of harvesting corals and live rock for the aquarium industry, an assessment of the impacts of this practice concluded that the reduction in coral cover due to coral harvesting was minimal (Lovell & Morris 2009).



Two-stripe damselfish (*Dascyllus reticulatus*), domino damselfish (*Dascyllus trimaculatus*) & orange-fin anemonefish (*Amphiprion chrysopterus*) swimming over a reef in Lomaiviti Province // Joe Lepore

MARINE RESOURCE MANAGEMENT AND GOVERNANCE

Despite the importance of nearshore fisheries to Fiji's economy and food security, much of the national regulatory effort in the country has been focused on offshore fisheries (Gillett et al. 2014, Fache & Breckwoldt 2018). For many years, no dedicated coastal fisheries group existed within the Ministry of Fisheries and Forestry (MoFF) and resources for data collection were limited, making assessments of the efficacy of management initiatives difficult to determine (Gillett et al. 2014). The limited government resources devoted to nearshore fisheries tended to focus on development and increasing production, rather than managing overfishing (Tuqiri 2009, Chandra 2011, Gillett et al. 2014). Beginning in 2002, the Coastal Fisheries Program (CFP) had the responsibility for monitoring, control and surveillance of coastal fisheries (Prince et al. 2020). In 2017, a new Inshore Fisheries Management Division was established to take over these responsibilities, though staffing remains low (Prince et al. 2020).



There is no single, overarching legislative act that governs marine conservation. However, Fiji's legal framework does include several acts that provide for sustainable use and conservation of Fiji's marine areas and resources:

- **The Climate Change Act, 2021 (CC Act)** establishes a framework for ocean governance and gives the relevant Minister the power to implement regulations and policies for "conservation and restoration of all of Fiji's maritime areas and coastal environments". This includes measures for the "sustainable management of oceans and reducing anthropogenic stresses on marine and coastal ecosystems".
- **Both the Offshore Fisheries Management Act, 2012 (OFMA) and the Fisheries Act, 1941 (FA)** enable the designation of **Marine Protected Areas (MPAs)** to control or restrict fishing effort in a lawfully designated area. The OFMA allows the Ministry of Fisheries to designate MPAs through secondary legislation for fisheries management purposes.
- **The Environment Management Act, 2005 (EMA)** requires an Environmental Impact Assessment (EIA) for any development proposal in Fiji's marine environment and also controls pollution in marine environments.
- **The Maritime Safety Authority of Fiji Act, 2009** also controls marine pollution.
- **The Marine Spaces Act, 1977** authorises the Minister responsible for Foreign Affairs to issue regulations that prescribe measures for the protection and preservation of the marine environment of Fiji's EEZ.

The Fisheries Act does not mention resource management except where it refers to the protection of customary rights (Veitayaki et al. 2003). While the Ministry of Fisheries and Forestry is able to issue fishing licenses to commercial fishers and set limits on gear types and allowable fish sizes, **a lack of resources for enforcement means that awareness of these regulations is low and unlicensed and illegal fishing still occur in many areas** (Hunt 1999, Teh et al. 2009, Chandra 2011, Korovulavula 2016, Prince et al. 2020).



Community leader showing
Mangrove oysters, a source
of income and food along the
Rewa River system
// Shayna Brody



In response, a complex network of coastal marine management strategies has been developed and employed in Fiji. Communities that hold customary fishing rights utilise **traditional ecological knowledge (TEK) to inform the implement or declare tabu areas**, where harvesting of certain marine taxa is limited based on the communities' needs (Fache & Breckwoldt 2018). MPAs where fishing is permanently prohibited are also implemented in cases where biodiversity conservation is prioritised for long-term benefit over supporting short-term food supply (Cakacaka et al. 2010, Jupiter & Egli 2011, Fache & Breckwoldt 2018). **A network of Locally-Managed Marine Areas (LMMAs)** has taken root across Fiji, bringing communities, NGOs and other partners together to develop management strategies (Teh et al. 2009, Hastings et al. 2012). In some cases, **Marine Conservation Agreements (MCAs)** have been developed between communities and industry partners, such as tourism operators, in which economic incentives are delivered in exchange for one or more parties committing to or refraining from certain actions within a marine area (Sykes et al. 2018, Mangubhai et al. 2020, Andradi-Brown et al. 2022). MCAs may include explicit economic incentives to resource owners, or supply broader benefits, such as sustainable marine resources or employment in the tourism sector (Mangubhai et al. 2020). Together, these strategies fill many of the coastal marine management roles across the country; however, the **decentralised and bespoke nature of many of these arrangements means that reef management across Fiji can in some cases be varied and inconsistent.**

Given the intensive nearshore fishing pressure and the limits on staffing in the central government, **customary rights holders are important partners** in the management of coastal fisheries in Fiji (Hunt 1999, Prince et al. 2020, Andradi-Brown et al. 2022). Customary fisheries management in Fiji relies heavily on TEK and is typically based on customary systems that regulate access to and use of marine resources, including the concept of tabu areas (Fache & Breckwoldt 2018). **Tabu areas** are sections of reef within a CFRA, where restrictions are placed on the harvesting of marine resources. They may be temporary or permanent, and are often opened for special occasions at the discretion of the local chief (Fache & Pauwels 2022). While customary marine management practices have eroded somewhat, particularly in more urbanised parts of the country (Matthews et al. 1998, Hunt 1999, Teh et al. 2009), some studies have shown that traditional management practices tend to be more effective and have higher compliance than those put forth by the central government (Jennings & Polunin 1996, Hoffmann 2002). For example, the government allows for the appointment of honorary fish wardens to enforce fishing regulations such as licensing (Chandra 2011, Prince et al. 2020); however, these have tended to be less effective at reducing non-compliance than community managed tabus (Sykes & Reddy 2009, Tuqiri 2009, Fache & Breckwoldt 2018).

In response to the deterioration of inshore fisheries and the erosion of traditional marine management practices in Fiji, the concept of LMMAs has become popular in the past few decades (Teh et al. 2009, Jupiter & Egli 2011, Hastings et al. 2012). **An LMMA is a well defined or designated area of coastal water, actively managed by resource-owning residential groups**, often with support of the government and other partner organisations (Hastings et al. 2012, Fache & Breckwoldt 2018). LMMAs **typically include a tabu area** where all or some extraction of marine resources is prohibited (Hastings et al. 2015). In addition, LMMAs may include additional initiatives, such as COTS removal, coral culturing, replanting mangroves, creating licensing systems, and banning specific fishing gear, such as underwater spearfishing and gillnets (Veitayaki et al. 2003). Fiji Locally Managed Marine Area network (FLMMA) was previously the organising

body that supported LMMA development in Fiji, and assumed a large part of coastal fisheries management in the country (Hastings et al. 2015, Fache & Breckwoldt 2018). Since its inception in 2000-2001 (Veitayaki et al. 2003, Sykes & Morris 2009, Hastings et al. 2015), FLMMA worked closely with communities to develop LMMAs that fit their needs and were aimed at achieving their resource management goals (Lovell et al. 2004, Veitayaki et al. 2007). In addition to FLMMA, more than 20 non-governmental organisations (NGOs) have been involved in coastal fisheries in Fiji, with many supporting communities in the development, maintenance and monitoring of their LMMAs (Gillett et al. 2014, Hastings et al. 2015). The LMMA network has grown rapidly within Fiji, beginning with one LMMA in 1997 and reaching >150 by 2011, managed by about 400 communities and covering an area of >10,000 km² (Mills et al. 2011, Fache & Breckwoldt 2018).



A topside view of a mangrove habitat along the Rewa River
// Shayna Brody

MONITORING AND ENFORCEMENT

Monitoring of LMMAs and other managed areas varies in regularity and methodology (Hastings et al. 2015), so gaining a holistic understanding of the effects of these measures is difficult. However, several studies have documented success stories related to each style of management intervention.

A survey of sea cucumbers within and outside of tabu areas in Lau showed significantly higher abundances inside of tabu areas (Jupiter et al. 2013). Another study surveyed tabu areas on the Coral Coast, and found that **reefs within the tabu areas had 260-280% more coral** and only 5-25% as much macroalgae as non-tabu areas. The reefs within the tabu areas also had higher numbers of **coral recruits**, and more diverse fish assemblages with greater biomass and higher numbers of herbivores (Bonaldo et al. 2017). A survey of three large, district-wide no take areas (part of an MCA) and 17 tabu areas in Kubulau District found **higher reef fish biomass (>1000kg/ha) within tabu areas** on naturally productive reefs close to villages and in one large, long-term permanent closure distant from fishing pressure (Jupiter & Egli 2011). **However, enforcement of tabu and other managed areas is variable, and poaching is known to happen**, often negating any positive effects of tabu closures (Veitayaki et al. 2007, Sykes & Morris 2009, Sykes & Reddy 2009, Korovulavula 2016, Fache & Breckwoldt 2018, Fache & Pauwels 2022). **Tabu areas within visual distance of villages are easier to patrol and have been shown to have higher fish biomass** as they are easier to enforce. Conversely, in cases where the success of management actions in a managed area has been publicised, noncompliance has

been shown to increase, leading to reduced reef fish biomass (Jupiter & Egli 2011). In general, the most common drivers of non-compliance in community managed marine areas are a) reduced perceived legitimacy of local rules and rule-makers, b) economic incentives to break rules, such as market access or lack of other income, and c) weak enforcement, or low perceptions of risk due to rule breaking (Rohe et al. 2017).

LMMAs have shown successes since the first was instituted in 1997 in Ucunivanua village on Viti Levu, in which a 24 hectare no-take zone was established to successfully increase the population of ark shells in the area (Fache & Breckwoldt 2018). No-take zones within LMMAs in Navakavu and Waitabu have increased biomass of fishes within their boundaries by 40% or more, but have not resulted in noticeable spillover effects or differences in benthic cover (Hastings et al. 2015). LMMAs have also demonstrated **increased socio-economic benefits**, even when ecological effects are not detected; LMMA users tend to have higher marine-related income and more diversified livelihoods than non-LMMA users, and have stronger environmental awareness and perceptions of non-monetary benefits of marine ecosystems (Hastings et al. 2015). While poaching within LMMAs and resourcing enforcement is an issue, LMMA users are more likely to know the rules and regulations and be involved in decision making than non-LMMA users (Hastings et al. 2015). However, strong involvement of NGOs in the LMMA development process has led to the perception in some communities that their LMMAs are “owned” by the NGO, minimising the communities’ feeling of ownership and making it easier for them to trade their LMMAs for material goods when the opportunities arise (Hastings et al. 2015, Fache & Breckwoldt 2018).



CORAL RECRUITMENT:
The settlement and growth of juvenile corals on a reef, critical for reef regeneration.

An example of a juvenile *Acropora* coral found in Cakaudrove Province

In 2003, the Fijian Government initiated a feasibility study for a system of marine reserves and concluded that 20-30% of waters should be set aside in traditionally managed no-take areas (Drew & Barber 2012). In 2005 at the Barbados Plan of Action meeting in Mauritius, the Government of Fiji made a commitment to effectively manage at least 30% of inshore marine areas by 2020 (Sykes & Morris 2009, Mills et al. 2011). In a 2007 National Biodiversity Strategy and Action Plan produced by the Department of Environment, the government estimated that a large part of this commitment would be met through government support of FLMMA (Sykes & Morris 2009). However, while at the time, FLMMA contributed a significant amount towards coastal marine management in Fiji (Hastings et al. 2015, Fache & Breckwoldt 2018), an assessment in 2011 concluded that under business as usual scenarios, FLMMA efforts alone would not be sufficient to meet this commitment (Mills et al. 2011).



A science diver, Andy Estep, conducting fish surveys in Kanacea, Lau Province
// Gilles Siu

STUDY MOTIVATION

While Fiji's reefs have been well studied compared to other Pacific Island nations, **research to date has been somewhat disjointed in space, time and methodology**, limiting the ability to compare between studies or make confident assessments of reef health across the entire country. The studies that exist focus on different reef habitats, in localised regions, at different points in time, and employ varied methodologies for similar metrics. While on their own, the assessments of Fiji's reef communities to date are extremely valuable, when taken in aggregate, they paint a murky picture of national reef status and variability between regions.

To fill this gap, the Government of Fiji, in collaboration with the Waitt Institute through Blue Prosperity Fiji, and the Scripps Institution of Oceanography, conducted a nationwide Ocean Science Expedition aimed at collecting baseline data on reef health across the country. **The data collected in this survey span the full geographic extent of Fiji** (with the exception of Rotuma, Ceva-i-Ra, and Southern Kadavu, which were surveyed by other organisations), **focus on standardised habitats, and utilise consistent methodology** with the goal of creating a holistic understanding of regional variability in reef health across the country. **This survey was the most geographically extensive, standardised reef assessment conducted in Fiji in modern history**, and provides data on the health of benthic, fish and invertebrate communities and water quality across 13 of Fiji's Provinces. The data collected during this survey will serve to fill in gaps in understanding reef health in Fiji and to support decision-making for future coral reef management initiatives.



A banded sea krait (*Laticauda colubrina*) swimming over the reef with a science diver, Amy Lee-Walton, surveying the dive site in Lomaiviti Province
// Joe Lepore

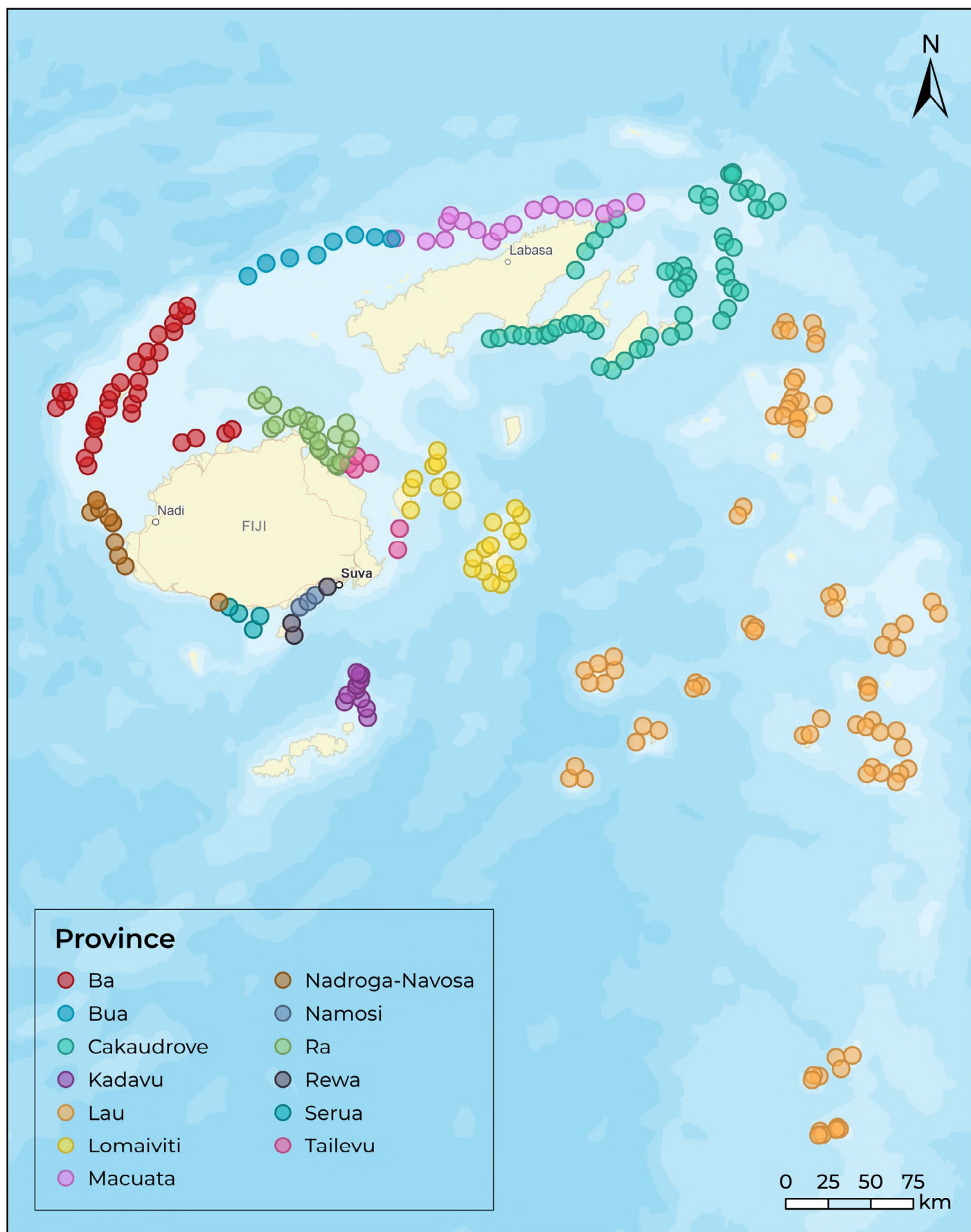
SURVEY METHODOLOGY

The data presented in this report were collected during a field expedition undertaken from May-August 2023.

The expedition was broken up into three 3-week long legs, for nine total weeks of surveys. During the expedition, researchers conducted surveys of reef fish populations, benthic coral reef communities, marine macroinvertebrates, and water quality parameters. Across the country, **269 sites were surveyed**, covering Viti Levu, Vanua Levu, the Lau group, and the southern and central islands (Map 1).

A detailed summary of survey methods can be found in Appendix 1, and a summary of the sites surveyed as well as the corresponding metadata can be found in Appendix 2.

MAP 1: Map of survey sites. Sites are colored by Province.



Survey areas were chosen strategically, considering ecological factors, relevance to ongoing monitoring, and potential to visit areas that have not yet been surveyed in previous studies. Sites were selected near both inhabited and uninhabited islands to support broader data collection on coral reef ecosystems and potential human impacts. All sites were located on the forereef at 10m depth. Efforts were made to ensure that sites were at least 2 km apart from each other to avoid pseudoreplication. Sites that had not previously been surveyed in previous studies were purposefully chosen in order to provide complementary information that may facilitate a more complete understanding of spatial trends and differences within regions. Weather and operating considerations were incorporated into the final dive site selection, and not all areas initially scoped were surveyed due to weather conditions and other circumstances. Note that only the northern half of Kadavu was included in the survey, and that Rotuma and Ceva-i-Ra were not surveyed.

Prior to conducting surveys, the Blue Prosperity Fiji team worked with government agencies to **engage over 100 traditional communities and obtain permission from Customary Fishing Rights Owners (CFRO) through a formal consultation process** guided by free, prior, and informed consent (FPIC). Following sevusevu ceremonies, communities were informed of the expedition's goals and granted access by signing FPIC forms.



Community consultations in Tailevu (left), Ba (right), Kadavu Provinces (bottom)

A science diver, Aporosa Nalasi, using the photoquadrat method to survey a reef at Moala Island in Lau Province // Gilles Siu



At each site, the following indicators of reef health were surveyed:

- reef fish abundance, diversity, and biomass;
- benthic community composition, including percent cover and diversity of benthic taxa;
- the abundance of juvenile corals (coral recruitment);
- reef rugosity (structural complexity); and
- the presence and diversity of benthic macroinvertebrates.

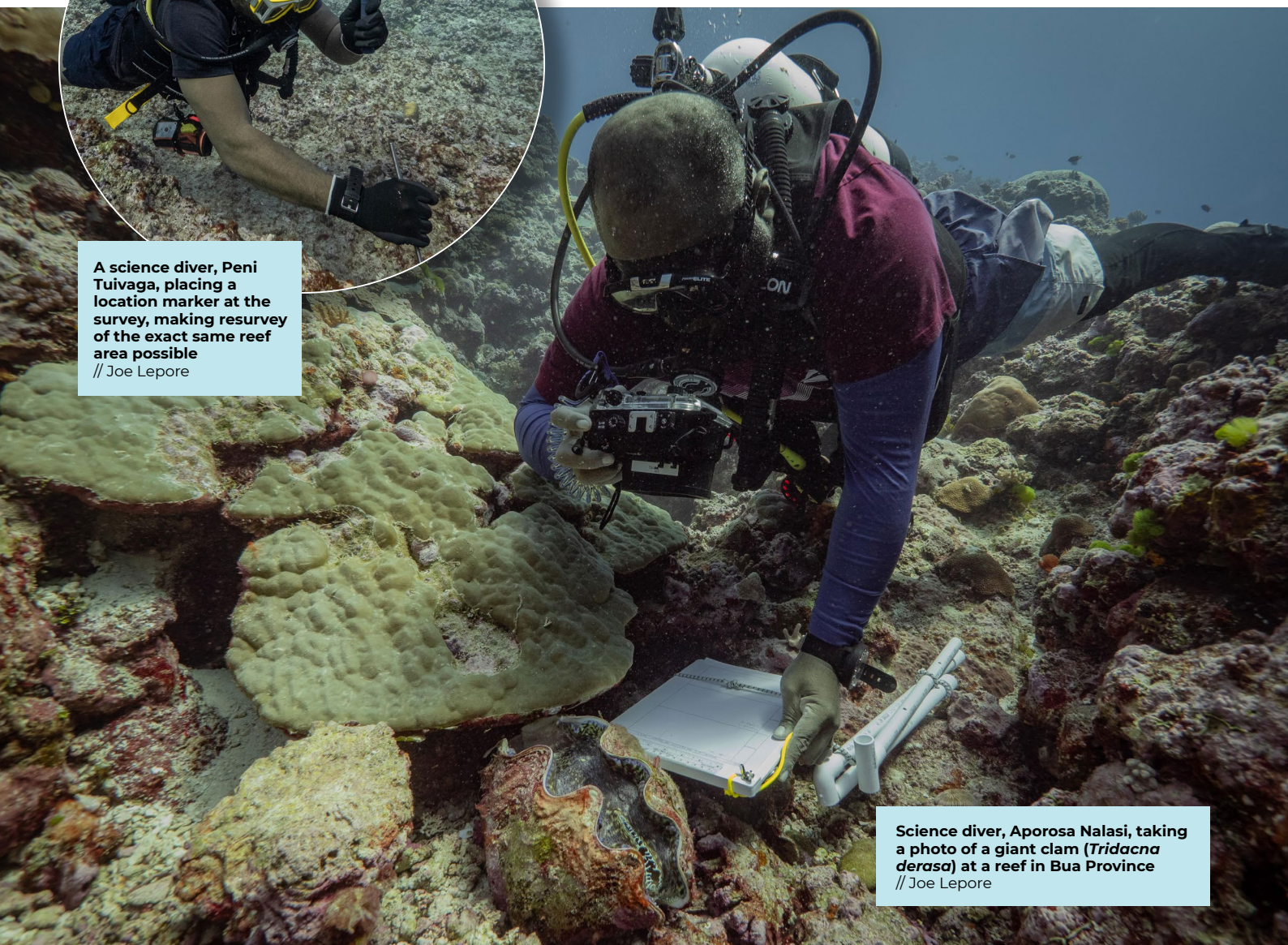
Algal samples were collected at each site to be utilised for stable isotope analysis, which provides information on the origin of nutrients at the collection sites.

Survey methods were designed to collect comprehensive data for each indicator, and in some cases to gather specific information regarding species of ecological and/or economic significance. All surveys were undertaken at a depth of 10 meters, and sites with continuous or nearly continuous hard bottom were prioritised, where possible, in order to minimize variability in community composition between sites. A brief summary of the survey methods used can be found in Table 1, and full methods can be found in Appendix 1. In some cases, not all surveys could be completed at each site; Appendix 2 lists the sites surveyed and the surveys conducted at each.

Temperature loggers were deployed at a subset of sites for collection at a later date. No temperature data is included in this report. A summary of sites where temperature loggers were deployed can be found in Appendix 2.



A science diver, Peni Tuivaga, placing a location marker at the survey, making resurvey of the exact same reef area possible
// Joe Lepore



Science diver, Aporosa Nalasi, taking a photo of a giant clam (*Tridacna derasa*) at a reef in Bua Province
// Joe Lepore

TABLE 1: Summary of key metrics, units, and methods used to measure the key indicators of reef health.

KEY METRIC	DEFINITIONS	UNITS	METHOD	SIGNIFICANCE TO REEF HEALTH
Reef fish density, diversity, biomass	Density: Number of reef fish per unit area Diversity: Number of different species of reef fish Biomass: Total weight of reef fish in a certain area	Density: Individuals/ha Diversity: Number of species recorded Biomass: kg/ha	Belt transect surveys Three transects: 25m x 8m + 25m x 4m	Healthy reefs are able to support diverse, abundant fish communities, as well as higher fish biomass. Overfished reefs will tend to have lower biomass and diversity. Herbivores promote reef health by removing macroalgae and creating space for coral recruitment.
Benthic community composition	What makes up the sea floor	Percent cover	Photo-quadrats Three 25 m transects, 13-15 images per	Corals are the building blocks of coral reefs, so higher coral cover is indicative of healthier reefs. Too much algae can crowd out corals and reduce reef health.
Juvenile coral density	Number of young, newly settled corals (1-5cm diameter) on a reef	Individuals/ m ²	Large-area imagery 10m x 10m	Young corals indicate the reef is growing and recovering well. More juveniles suggest better chances for long-term reef health.
Reef rugosity	A number that shows the structural complexity of the reef (how rough or smooth the reef is)	Rugosity ratio (ratio of surface distance [measured at 10 cm intervals]/ linear distance)	Large-area imagery 10m x 10m	More complex (higher rugosity) reefs provide more habitat for important coral reef species, such as fish and invertebrates.
Macroinvertebrate presence, diversity and size frequency distribution	Presence/absence: Whether a species was observed in a certain location Diversity: Number of different species of macroinvertebrates Size frequency distribution: A chart showing how big or small animals are in a group.	Diversity: Number of species recorded	Belt transect surveys Three transects: 25m x 4m	Macroinvertebrates such as herbivorous urchins can clear reefs of macroalgae. Other invertebrates, such as sea cucumbers, crustaceans, and bivalves are important food/ fisheries resources.
Water quality	Source of nutrients delivered to a reef (e.g., sewage pollution, agriculture, atmospheric/natural sources)	Stable isotope ratio (‰)	Stable isotope ($\delta^{15}\text{N}$) approaches n=3 samples/ site	Poor water quality can stress reefs by causing macroalgal blooms, promoting coral disease, increasing bioerosion, etc.

RESULTS

While efforts were made to sample each Province as extensively as possible, sample sizes and distribution of sites was not even across all Provinces. Some Provinces had fewer survey sites due to the size of the Province relative to others. Additionally, some areas within Provinces were not surveyed either due to unsafe diving conditions or because they had been previously surveyed by other groups. A list of specific considerations for Provinces with low sample sizes or uneven site distributions can be found in Appendix 3. These considerations should be taken into account when interpreting the results presented here.

All results are presented as Province-level means with standard error (SE), unless otherwise specified. Standard error is a measure of variance, or uncertainty, in an estimate.

Note that sample size varied widely between Provinces, which in some cases may lead to higher estimates of variance for less intensively sampled Provinces. Provinces with lower sample sizes are therefore less likely to produce an accurate estimate of the true mean. All sites surveyed were located at 10 m depth on the forereef. A summary of all Province level data, including the sample size for each Province, can be found in Table 2.

REEF FISH

In total, 547 species of reef fish could be identified to the species level during the surveys (Appendix 4). In addition, 35 genus- or family-level entries were recorded, in cases where fish could not be reliably identified to the species level. *Ctenochaetus striatus* was the most widely distributed species, occurring at 256 of the 269 sites where fish surveys took place. This species also had the highest mean biomass of any species surveyed (216.4 kg/ha) while *Pycnochromis margaritifer* had the highest mean density of any species (3,192.7 individuals/ha). Labridae (wrasses) was the most speciose family, with 83 confirmed species (not including species in the subfamily Scarinae (parrotfishes, nested within Labridae), which are reported separately in this report; with scarids included, the total number of confirmed labrid species increases to 113).



Striated surgeonfish (*Ctenochaetus striatus*) at Cakau Vucovu in Cakaudrove (left) & in Lau Province (right) // Gilles Siu

Overall mean fish density was 45,508.2 individuals/ha (± 1665.3 SE; Figure 1, Map 2). Tailevu (n=6 sites surveyed) had the highest mean fish density ($69,475.0 \pm 1253.6$ SE) while Namosi and Nadroga-Navosa had the lowest ($28,022.2 \pm 517.8$ SE and $28,181.1 \pm 335.9$ SE, respectively).

Planktivores were the most abundant **trophic group** in all Provinces except Bua and Namosi, where **lower carnivores** had the highest mean densities. While **top predators** and sharks were present in all Provinces, densities were low compared to other trophic groups. Macuata had the highest densities for both, with a mean density of 552.9 top predators/ha (± 218.6 SE) and 26.5 sharks/ha (± 6.6 SE). Macuata also had the highest mean herbivore density (15,929.4 individuals/ha $\pm 1,923.8$ SE), while Tailevu had the highest planktivore and lower carnivore densities ($45,091.7$ individuals/ha $\pm 12,833.6$ SE and $17,463.9$ individuals/ha $\pm 2,239.7$ SE, respectively).

Total mean reef fish biomass was 2,573.6 kg/ha (± 130.2 SE; Figure 2, Map 3). Macuata had the highest biomass by far (6,832.0 kg/ha ± 69.8 SE; Figure 3), and the highest biomass in each trophic

category except for sharks, which was highest in Serua (540.3 kg/ha ± 375.1 SE, Map 4). Herbivore biomass in Macuata ($2,008.4$ kg/ha ± 246.7 SE) was almost twice that of the next highest Provinces, Cakaudrove and Kadavu, which had mean biomass values of 1190.2 kg/ha (± 125.4 SE) and 1188.0 kg/ha (± 155.5 SE), respectively (Map 5). Similarly, mean lower carnivore biomass in Macuata was $1,907.5$ kg/ha (± 527.0 SE), while the next highest value, in Serua, was 986.1 kg/ha (± 314.2 SE). While Macuata did have the highest mean planktivore biomass ($1,610.6$ kg/ha ± 373.5 SE), the difference between the two largest values was not as great as for other trophic groups, as Kadavu had a mean value of $1,258.7$ kg/ha (± 466.6 SE) in this trophic group. However, the range between the largest and smallest value in this group was large, with a mean planktivore biomass of only 112.0 kg/ha (± 37.0 SE) in Bua. Despite having the lowest planktivore biomass, though, Bua had the second-highest mean top predator biomass (449.8 kg/ha ± 289.8 SE), following Macuata, which had the highest biomass of top predators (800.9 kg/ha ± 383.1 SE, Map 6).

A Honeycomb grouper (*Ephinephalus merra*) perched in a dead *Acropora* coral in Macuata Province
// Joe Lepore

School of Bluestreak fusilier (*Pterocaesio tile*), a planktivore, in Lau Province // Gilles Siu

Bicolor chromis (*Pycnochromis margaritifer*) at Cicia Island, Lau

TROPHIC GROUP:
Classification of organisms based on what they eat

PLANKTIVORES:
Animals that feed on plankton

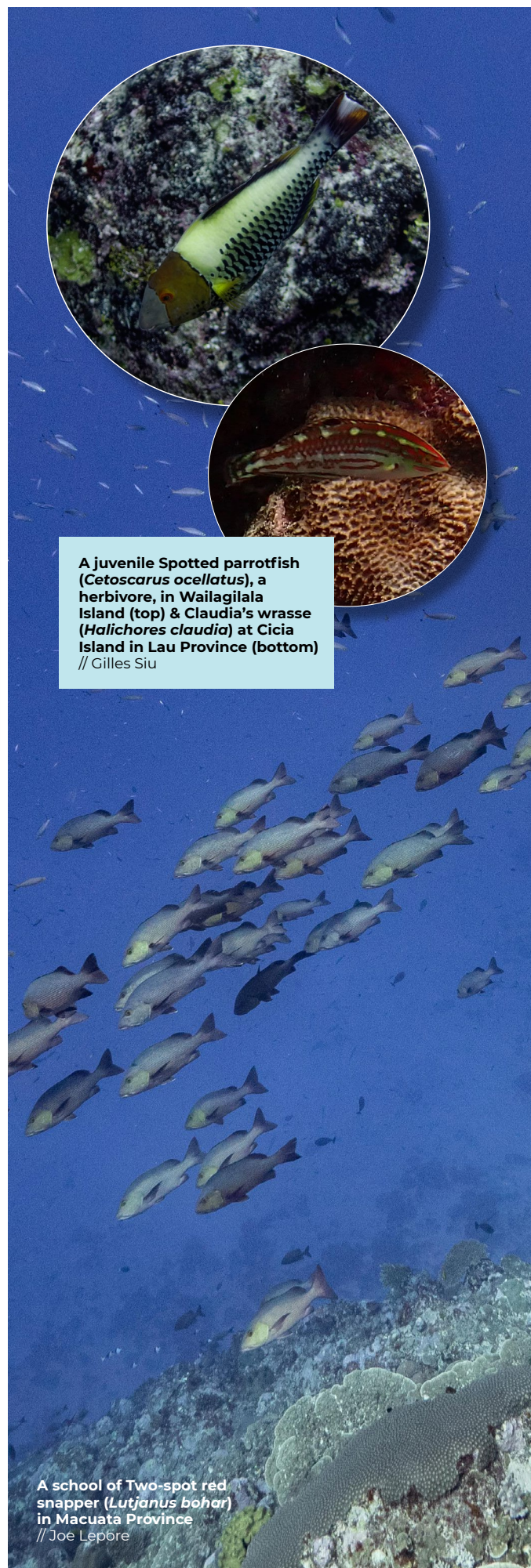
TOP PREDATORS:
Large predatory fish, like groupers or snappers, that sit at the top of the food web

Despite having the highest fish density, Tailevu had the fifth lowest overall mean biomass, indicating that fish tend to be smaller on average in this Province. Conversely, the large difference in biomass between Macuata and the rest of the Provinces, compared with the relatively low range of density values, indicates that fish in this Province tended to be much larger than in other Provinces. Within the Eastern Division, mean fish densities were very similar between Provinces, but biomass differed, indicating differences in fish size between these three Provinces; fish were larger in Kadavu and smaller in Lau. Similarly, in the Western Division, Ra had low biomass relative to density, suggesting that fish tend to be smaller in Ra than in Ba or Nadroga-Navosa.



A Bleeker's parrotfish (*Chlorurus bleekeri*) at Dawasamu region of Tailevu Province

Acanthurids (surgeonfish) contributed the most to the overall biomass of any fish family, followed by caesionids (fusiliers) and scarids (parrotfishes; Figure 4). Acanthurid and lutjanid (snapper) biomass values were particularly high in Macuata (1,821.1 kg/ha $\pm$ 79.5 SE and 1,721.9 kg/ha $\pm$ 242.1 SE, respectively). These values far exceed the next highest estimates for both families, with the second highest acanthurid biomass in Cakaudrove at 834.8 kg/ha ($\pm$ 25.8 SE), and the next highest lutjanid biomass in Serua at 436.6 kg/ha ($\pm$ 100.0 SE). Macuata also had particularly high lethriniid (emperor) biomass with a mean of 230.5 kg/ha ($\pm$ 42.1 SE), compared with the next highest value, in Serua, at 89.0 kg/ha ($\pm$ 28.0 SE). However, Macuata did not have the highest biomass values for all families. Caesionids had highest mean biomass values in Kadavu (972.9 kg/ha $\pm$ 282.4 SE) and and labrids (wrasses, excluding parrotfishes) had the highest mean biomass in Bua (342.8 kg/ha $\pm$ 73.7 SE, respectively). Serua had the highest scarid and carcharhinid (requiem shark) biomass (631.8 kg/ha $\pm$ 29.0 SE, 540.3 kg/ha $\pm$ 345.5 SE, respectively), and Tailevu had the highest mean pomacentrid (damselfish) biomass, at 335.4 kg/ha ($\pm$ 14.0 SE).



A juvenile Spotted parrotfish (*Cetoscarus ocellatus*), a herbivore, in Wailagilala Island (top) & Claudia's wrasse (*Halichoeres claudia*) at Cicia Island in Lau Province (bottom)
// Gilles Siu

A school of Two-spot red snapper (*Lutjanus bohar*) in Macuata Province
// Joe Lepore

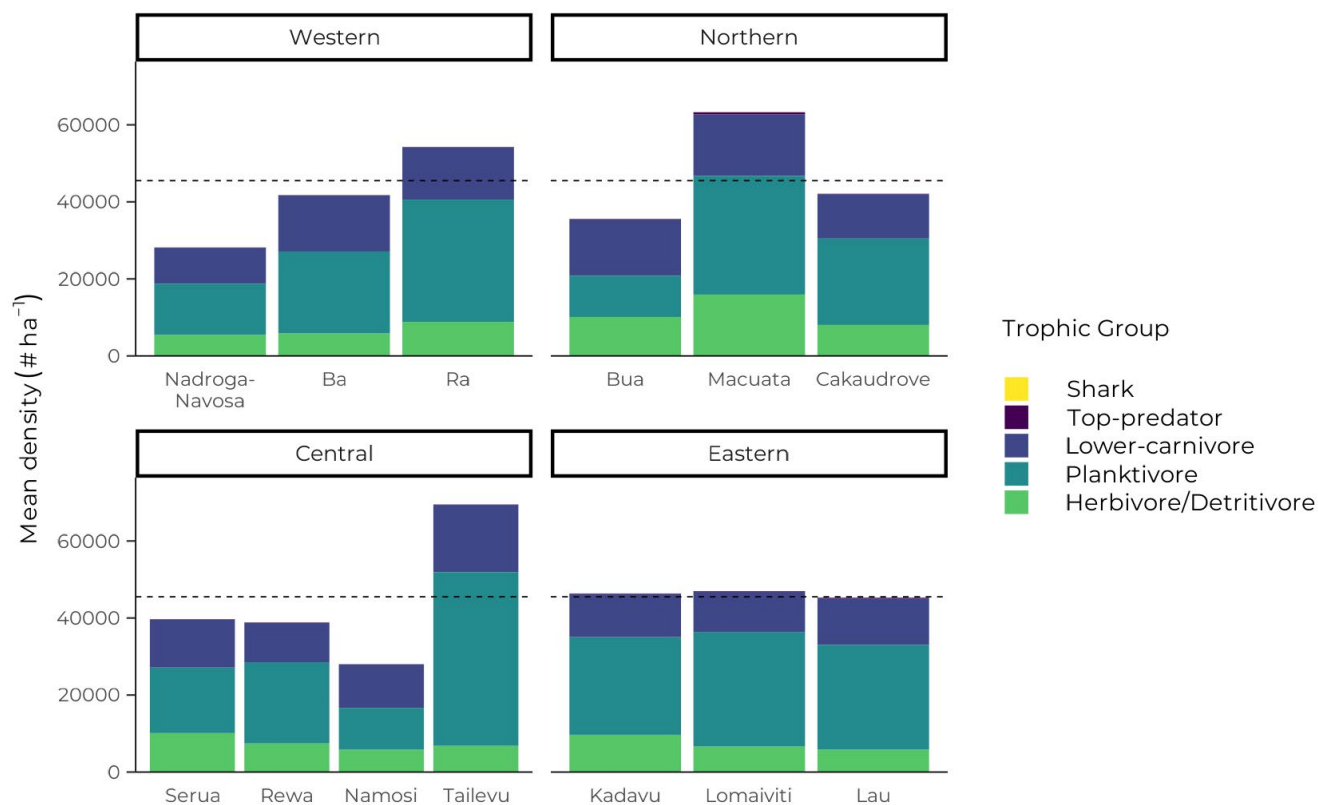
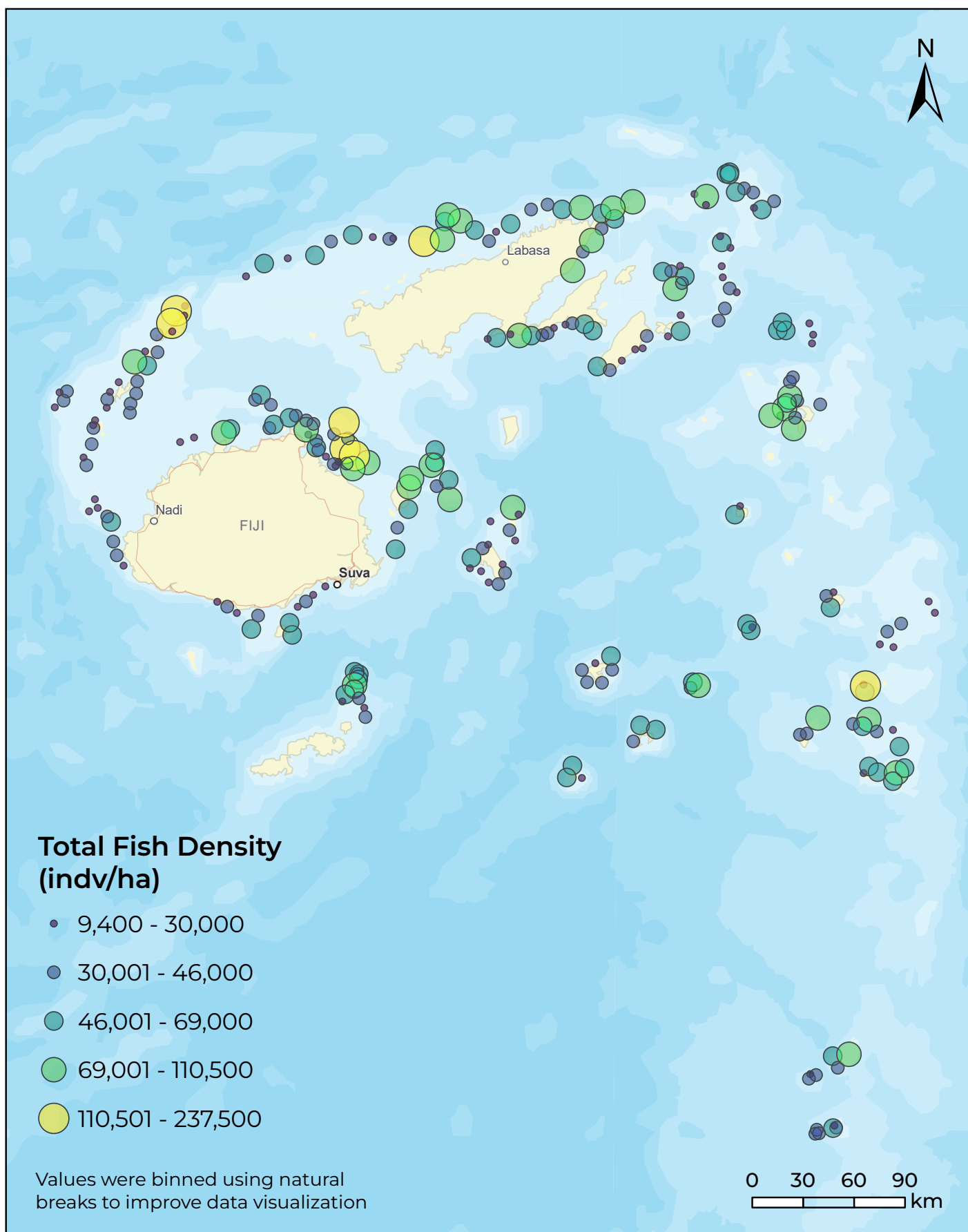


FIGURE 1: Mean fish density at each Province surveyed, by trophic group. The horizontal dashed line represents the overall mean fish density across Provinces. Provinces are grouped by Division for ease of interpretation. Shark and top predator densities were low, so these categories are difficult to see in the figure.

A school of yellow and blueback fusilier (*Caesio teres*) in Lau Province
// Gilles Siu



MAP 2: Mean fish density at survey sites across Fiji.



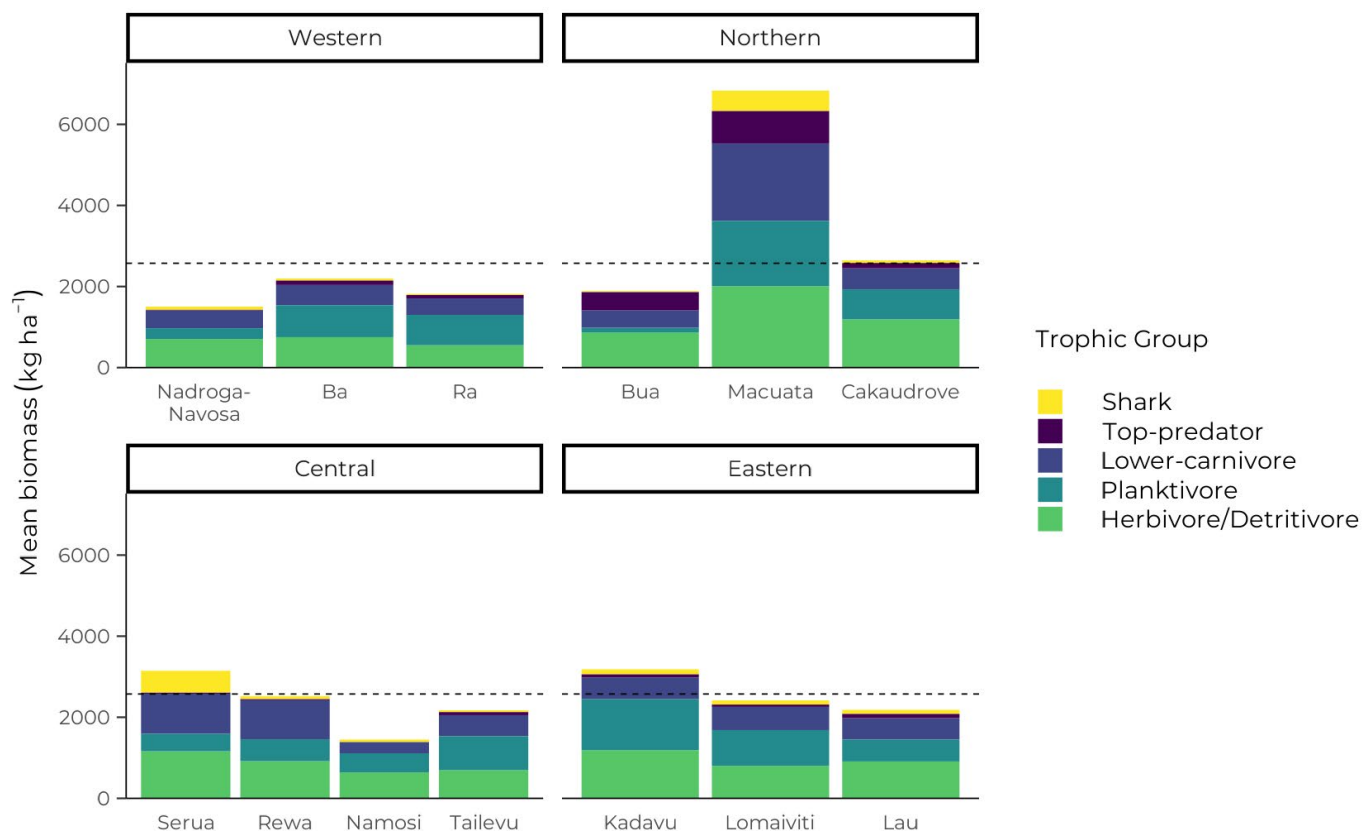


FIGURE 2: Mean fish biomass at each Province surveyed, by trophic group. The horizontal dashed line represents the overall mean fish biomass across Provinces. Provinces are grouped by Division for ease of interpretation.

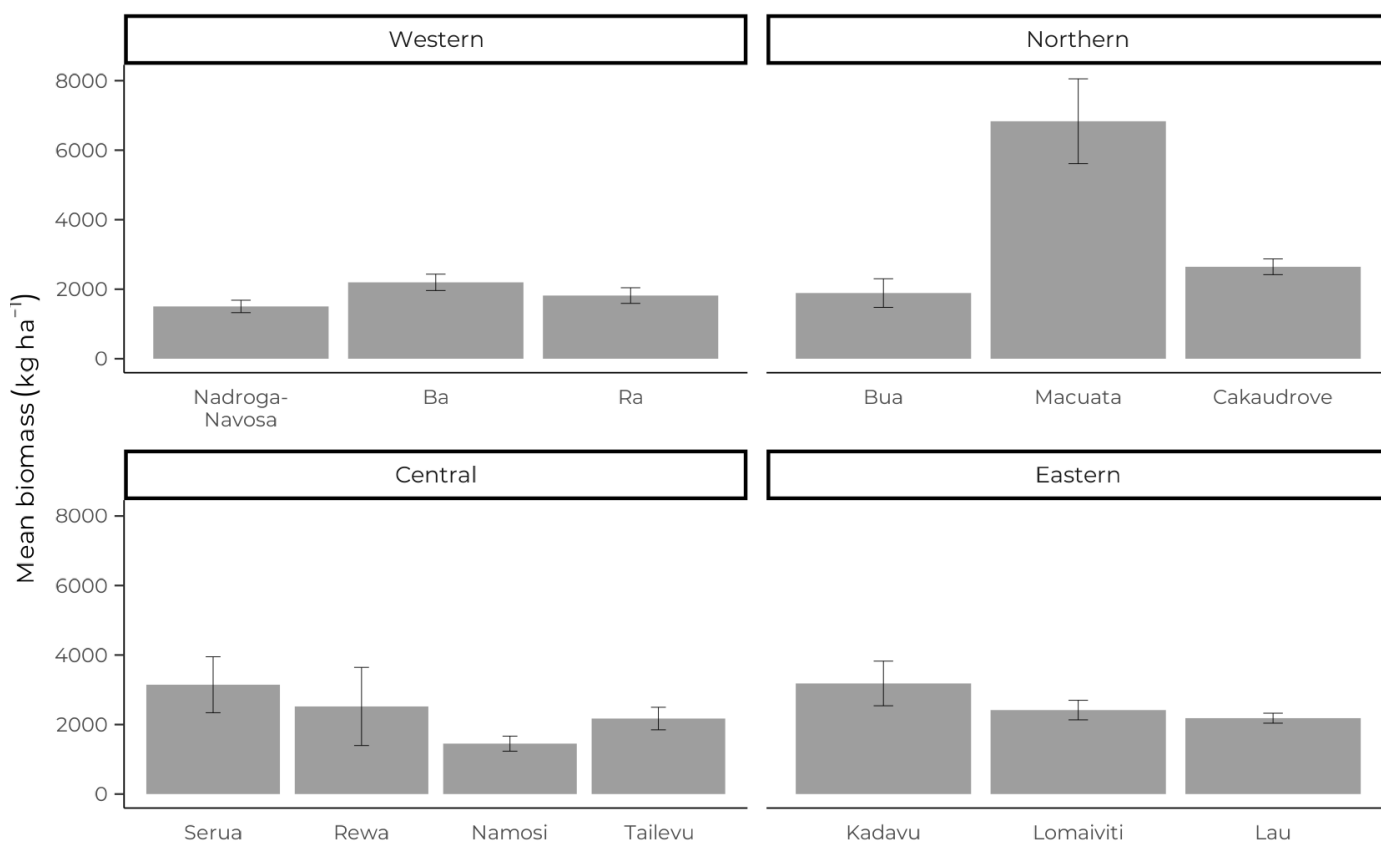
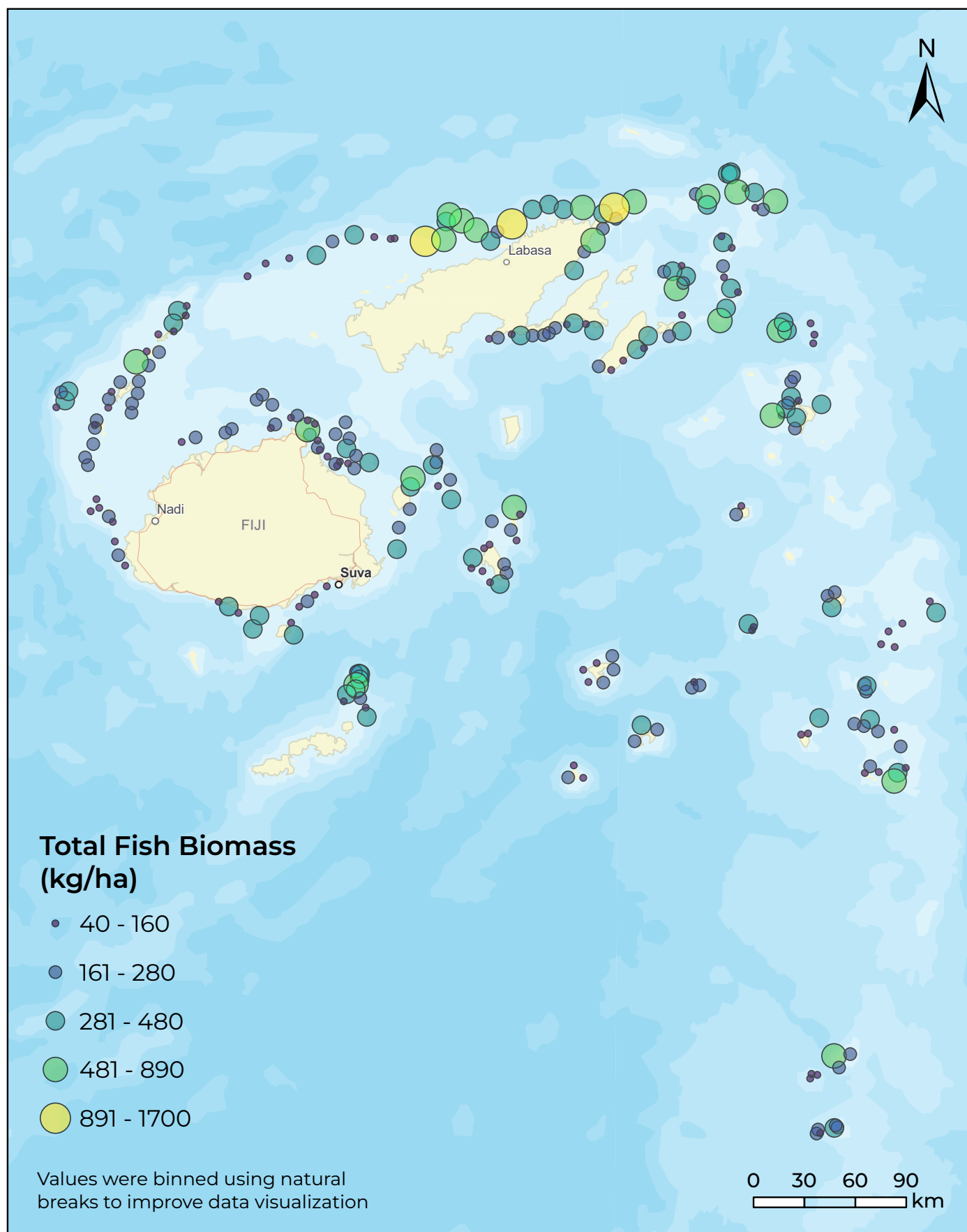
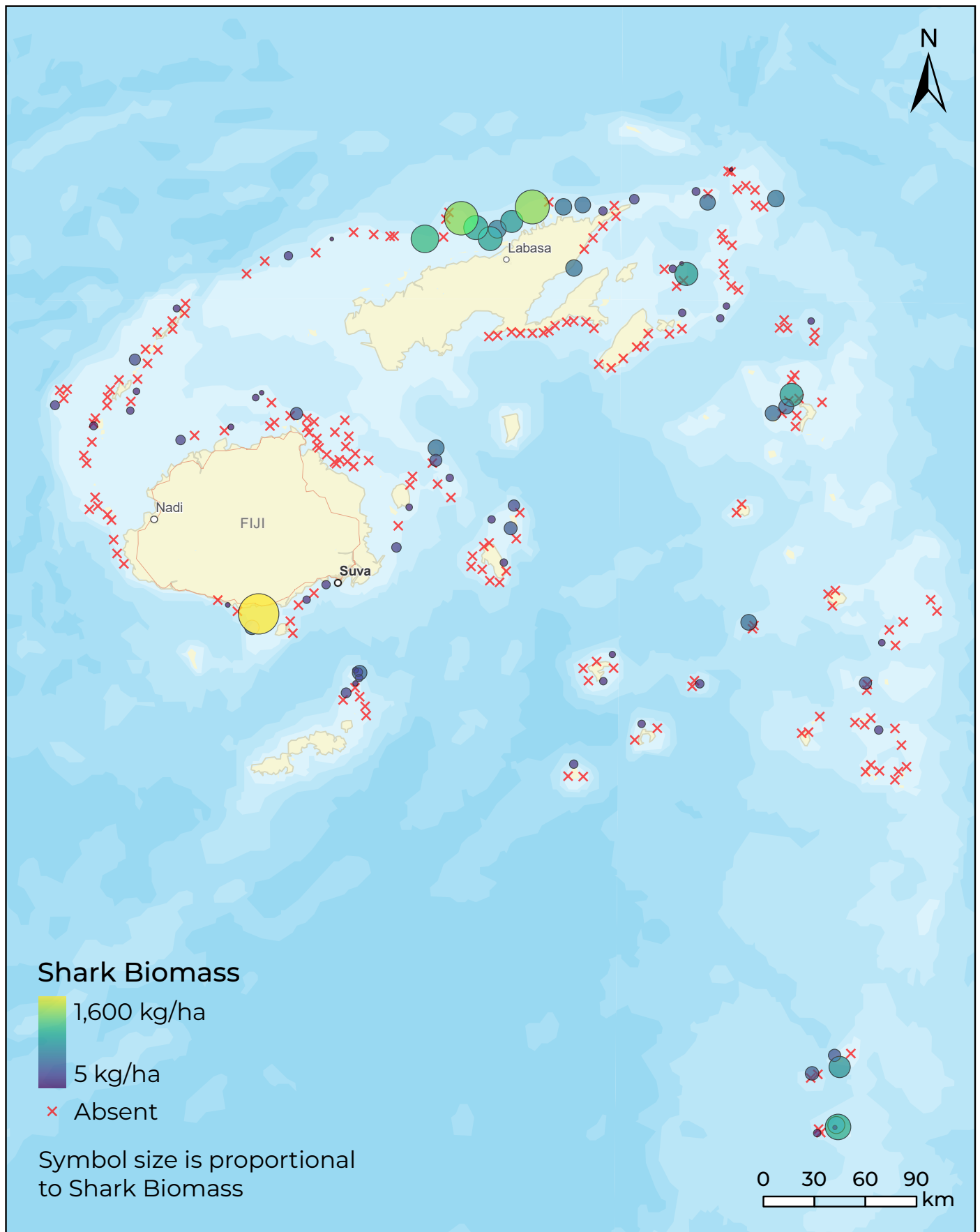


FIGURE 3: Mean fish biomass at each Province surveyed. Error bars represent standard error. Provinces are grouped by Division for ease of interpretation.

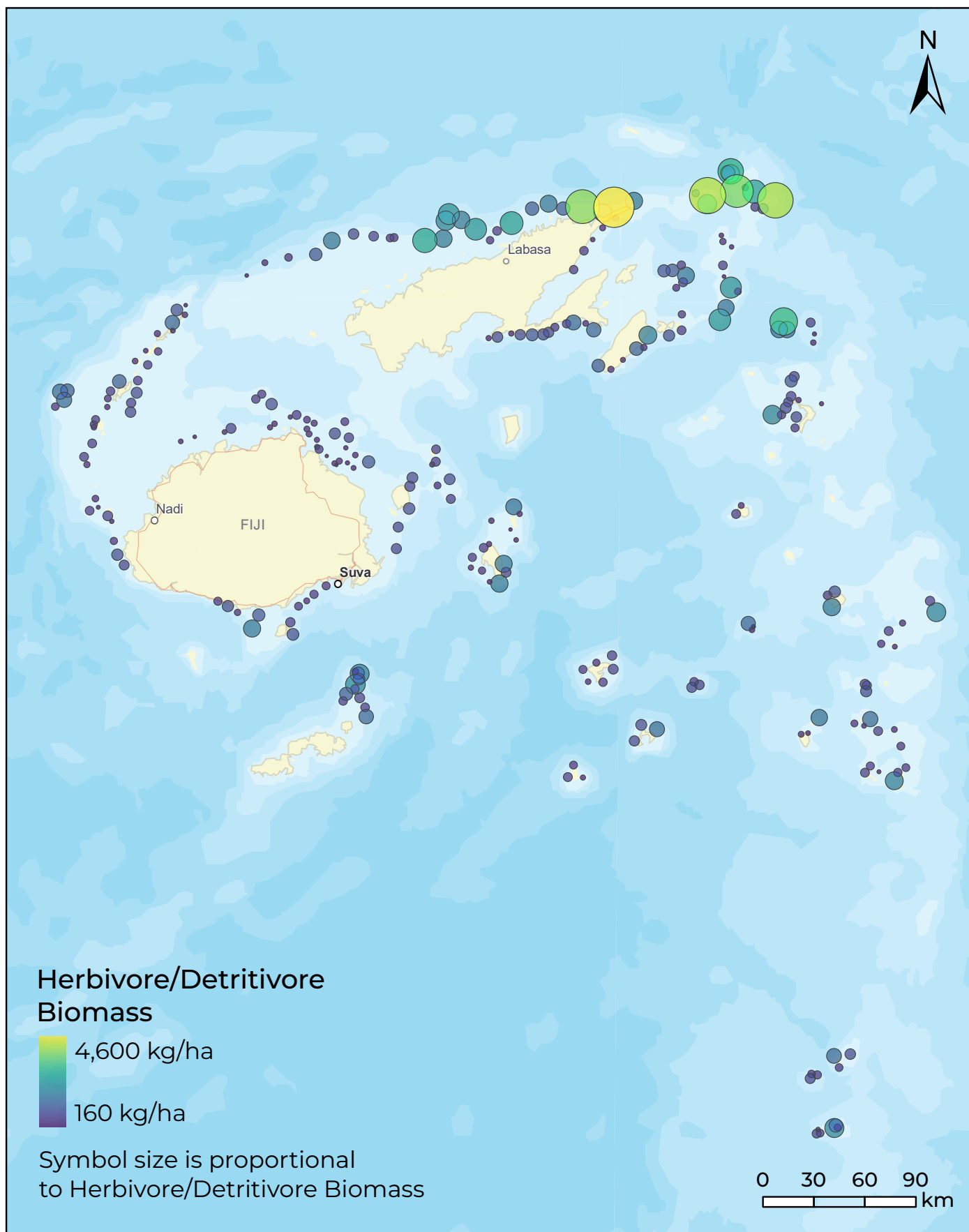
MAP 3: Mean fish biomass at survey sites across Fiji.



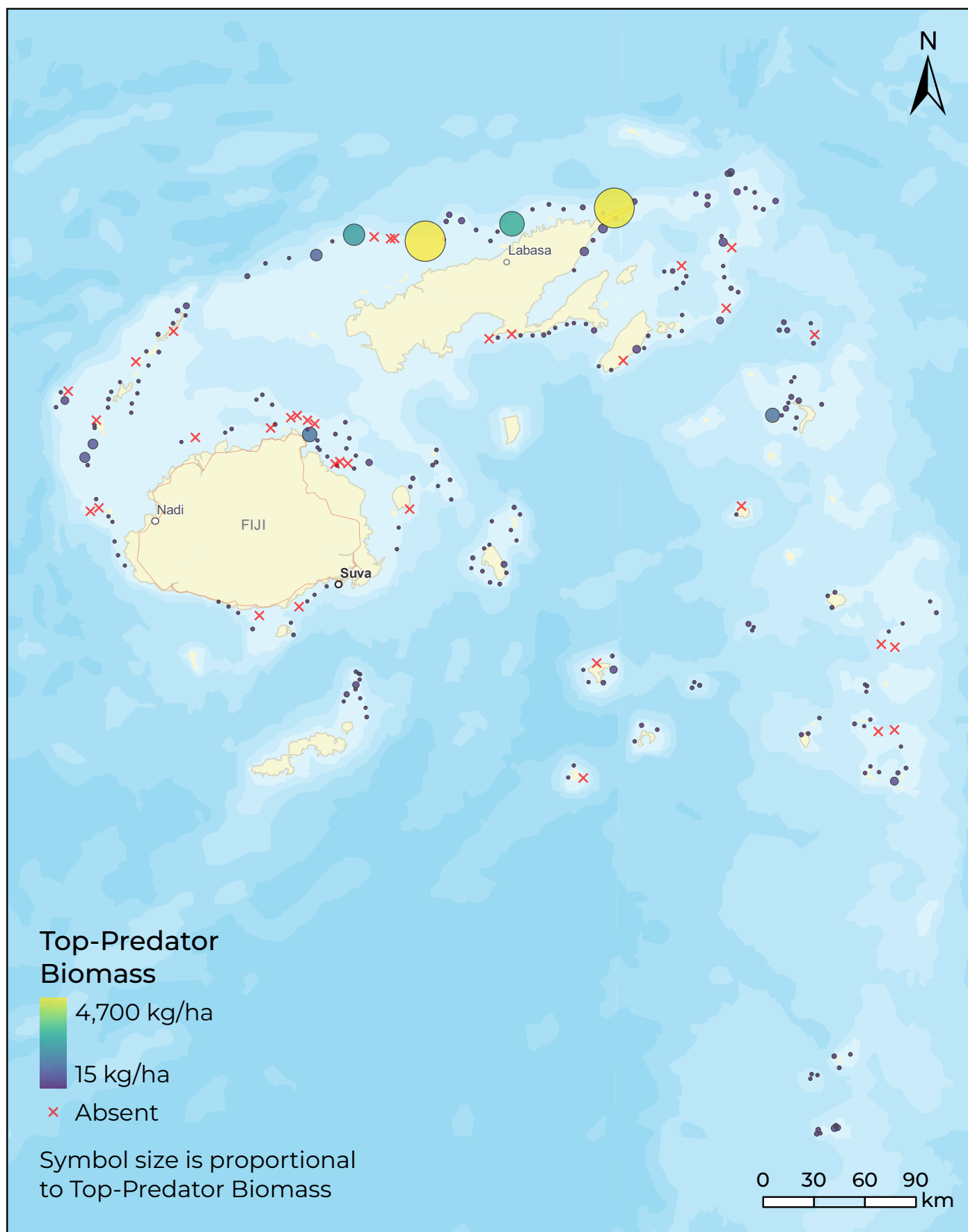
MAP 4: Mean shark biomass at survey sites across Fiji.



MAP 5: Mean biomass of herbivorous and detritivorous fish at survey sites across Fiji. Herbivores feed primarily on algae and seaweed, and detritivores consume decaying organic material.



MAP 6: Mean top-predator fish biomass at survey sites across Fiji.



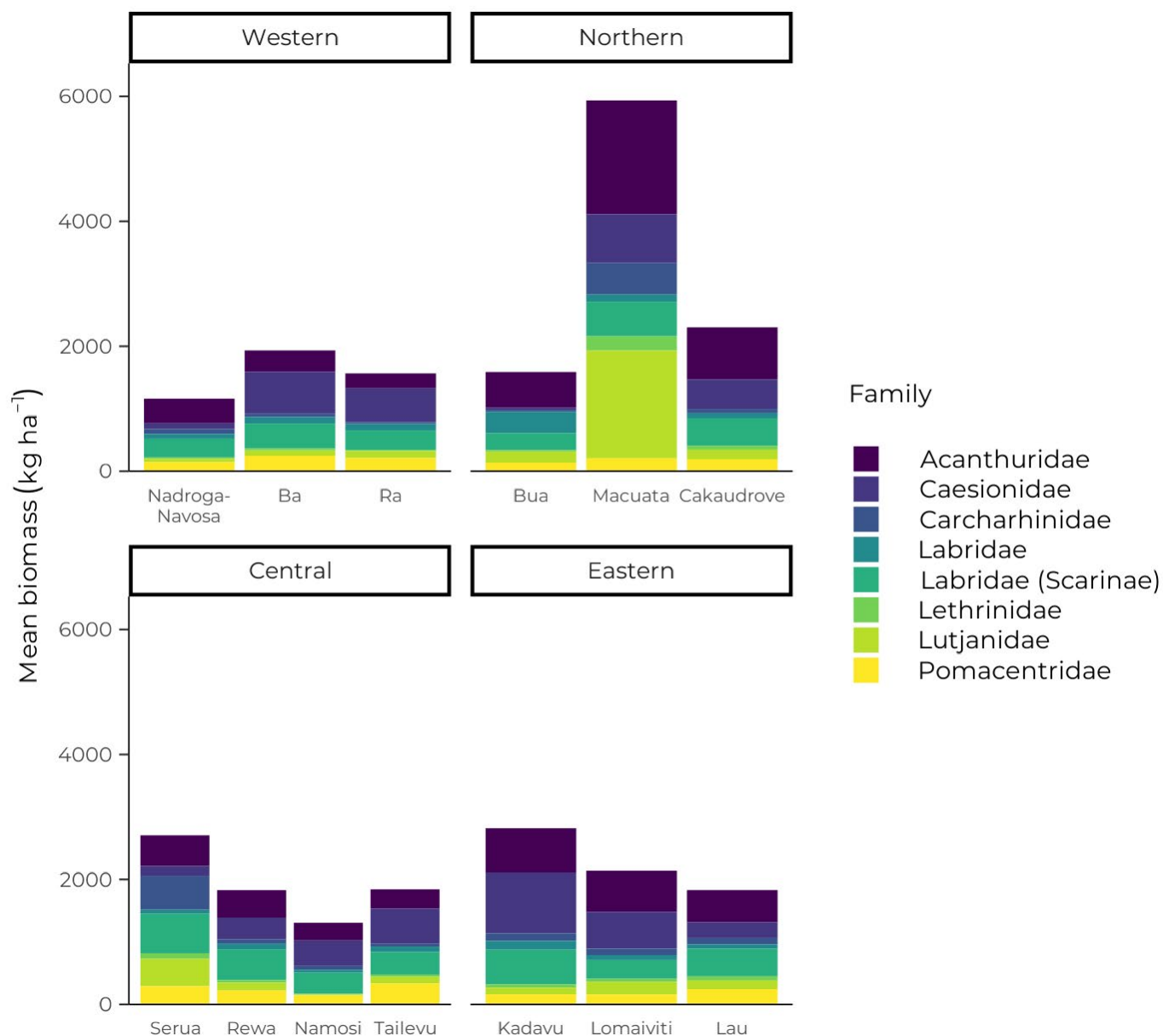


FIGURE 4: Mean biomass of the fish families with the highest mean biomass by province. Note that the subfamily Scarinae is listed separately from Labridae in order to highlight the contribution of parrotfishes to mean biomass. Provinces are listed from north to south on the x-axis.



A redstreaked blenny (*Cirripectes stigmaticus*) at Ogea Levu Island in Lau Province // Gilles Siu

BENTHIC COVER

Overall mean coral cover across Fiji was 19.7% (± 0.7 SE, Map 7). **Turf algae** made up the highest proportion of benthic cover, with a country-wide mean of 38.5% (± 1.0 SE). **CCA** cover was 16.1% (± 0.7 SE), and calcified macroalgae cover was (8.5% ± 0.4 SE). **Fleshy macroalgae** cover was low at 2.9% (± 0.3 SE), but **cyanobacteria** cover was higher, with a mean cover of 4.4% (± 0.3 SE) across all Provinces. Cyanobacteria is reported separately from macroalgae here due to its notable prevalence at some sites.

Namosi Province had the highest coral cover (34.0% ± 9.5 SE; Figure 5, Figure 6). This was also the only Province in which turf did not make up the highest proportion of cover, though it was roughly equal to coral cover (33.7% ± 6.2 SE). However, it is important to note that **only three sites were surveyed in Namosi Province**, and the standard error indicates high levels of variability between sites. It appears that this pattern is being driven mainly by site NAV_21, which had a mean coral cover of 49.9%.

Bua Province had the lowest coral cover on average (8.9% ± 1.8 SE). However, it was **among the Provinces with the highest CCA cover** (22.3% ± 4.3 SE), along with Serua (25.0% ± 1.0 SE) and Lau (24.6% ± 1.5 SE). Turf algae cover was highest in Nadroga-Navosa (61.7% ± 4.5 SE) and lowest in Ba (30.6% ± 2.0 SE). Fleshy macroalgae cover was highest in Tailevu (9.8% ± 3.3 SE) and Ra (9.3% ± 1.9 SE) and lowest in Kadavu (0.5% ± 0.1 SE). Despite having the lowest macroalgae cover, however, Kadavu had the highest cover of cyanobacteria, with a mean of 9.3% (± 1.5 SE). Cyanobacteria was also prevalent in Ba (8.1% ± 1.3 SE) and to a lesser extent, in Lomaiviti (4.9% ± 1.0 SE), Cakaudrove (4.9% ± 0.7 SE), Lau (3.8% ± 0.5 SE) and Rewa (3.4% ± 1.5 SE).

TURF ALGAE: Short, dense algae that resemble a lawn and often dominate degraded reef habitats

FLESHY MACROALGAE: Large, soft-bodied seaweeds that are important primary producers and typically grow attached to the ocean floor; when they grow too much, however, they can compete with corals for space and light

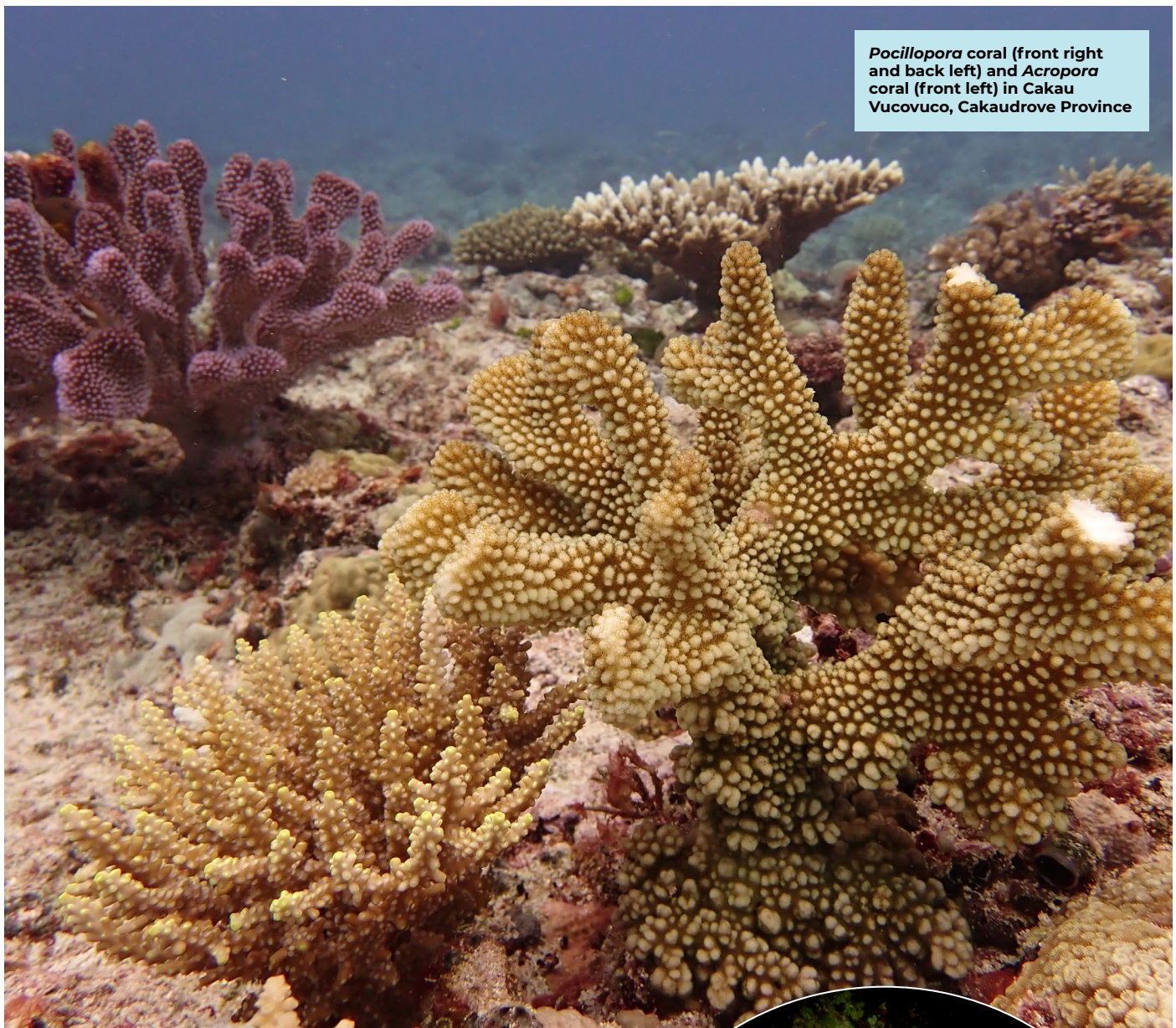
Degraded reef with dead corals covered in cyanobacteria and dominated by turf algae in Kanacea Island, Lau Province
// Gilles Siu

Cyanobacteria overgrowing *Acropora* coral in Cakaudrove Province // Andy Estep

CYANOBACTERIAL BLOOM: While cyanobacteria can provide important ecosystem functions, when thick mats (or blooms) form, they can smother corals, block sunlight, release toxins, and disrupt reef recovery.



Dictyota (brown fleshy algae) around a calibration tile from Beqa & Yanuca in Rewa Province



Pocillopora coral (front right and back left) and *Acropora* coral (front left) in Cakau Vucovuco, Cakaudrove Province

Acropora was the most common coral genus, with a mean cover of 6.1% (± 0.4 SE). ***Porites*** and ***Pocillopora*** were the next most common, with mean cover of 3.2% ± 0.2 SE and 2.8% ± 0.2 SE, respectively. In total, 56 genera of hard corals were recorded in the photoquadrat surveys (Appendix 5).

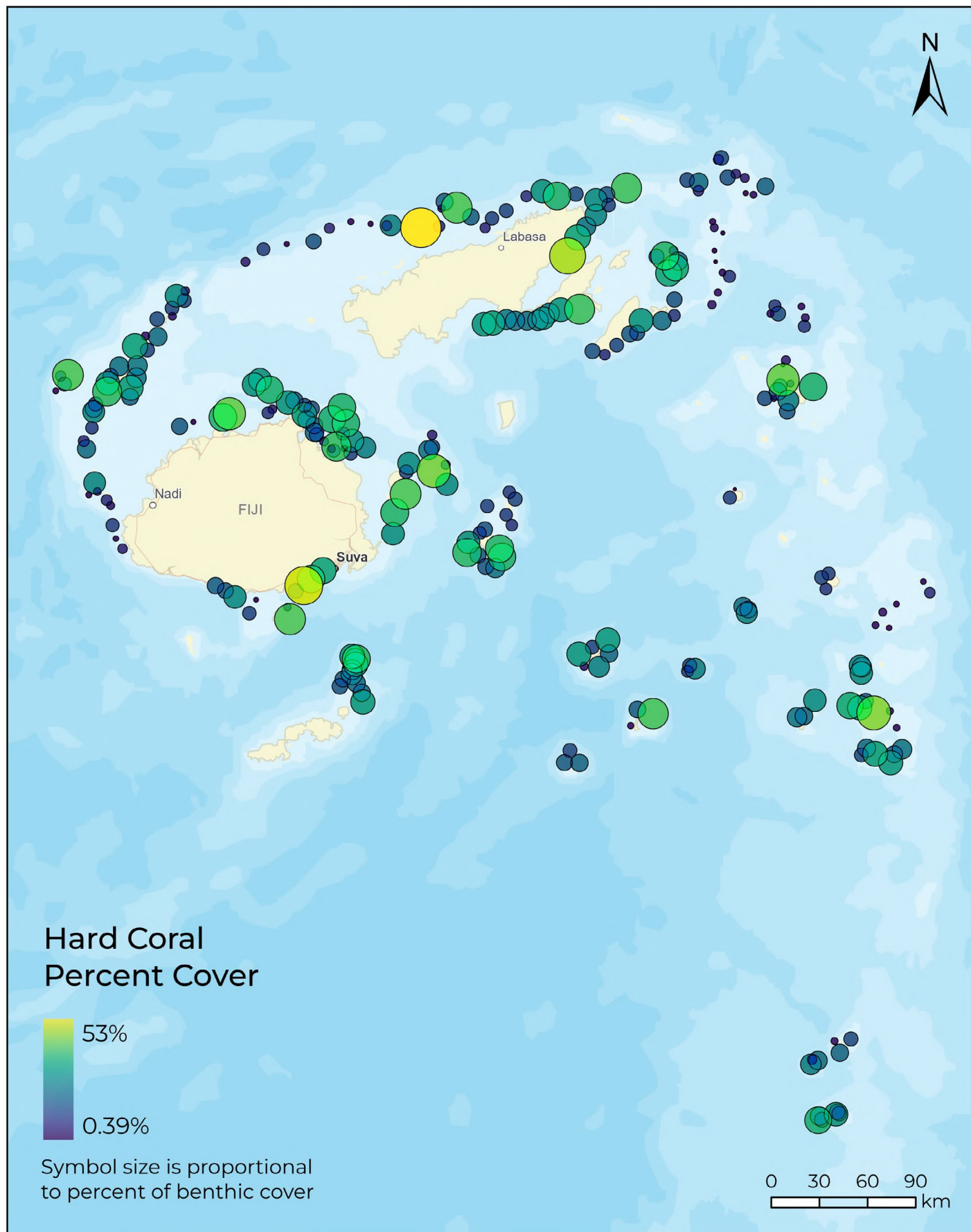
Namosi and Tailevu had particularly high *Acropora* cover (16.6% ± 7.5 SE and 11.2% ± 2.6 SE, respectively; Figure 7). *Porites* was the most common genus in Rewa and Macuata (10.5% ± 4.4 SE and 5.9% ± 1.9 SE, respectively). Some Provinces had relatively high cover of rarer genera compared to others; for example, *Diploastrea* was highest in Ba (2.9% ± 0.6 SE) and Kadavu (2.4% ± 1.3 SE), and *Goniastrea* was highest in Macuata (1.5% ± 0.3 SE).



Porites coral seen in Ba Province (top) & an example of branching *Porites* coral at Cakau Galu, Cakaudrove Province (bottom)



MAP 7: Mean percent of the seafloor covered by living hard corals at survey sites across Fiji. Hard corals contribute to reef building and create complex habitats for fish and other organisms.



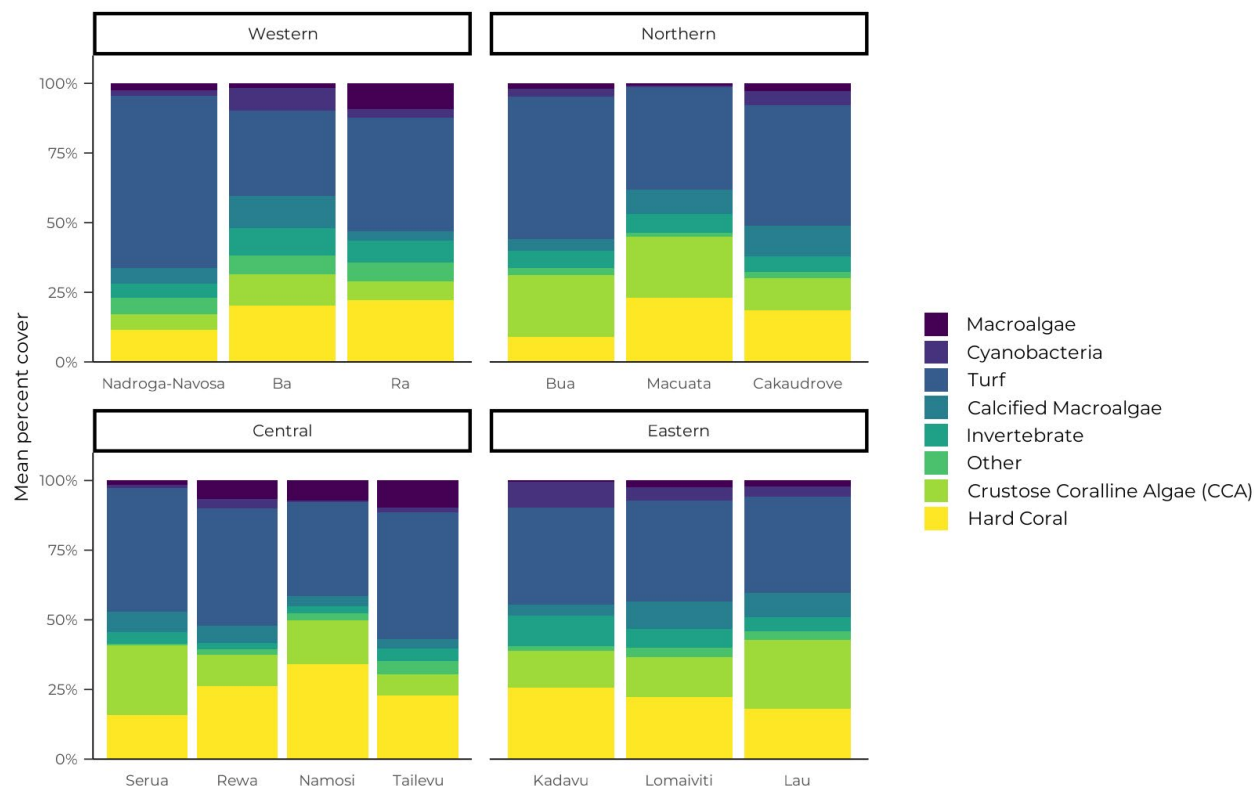


FIGURE 5: Mean percent cover of main benthic functional groups at each Province. Provinces are grouped by Division for ease of interpretation.

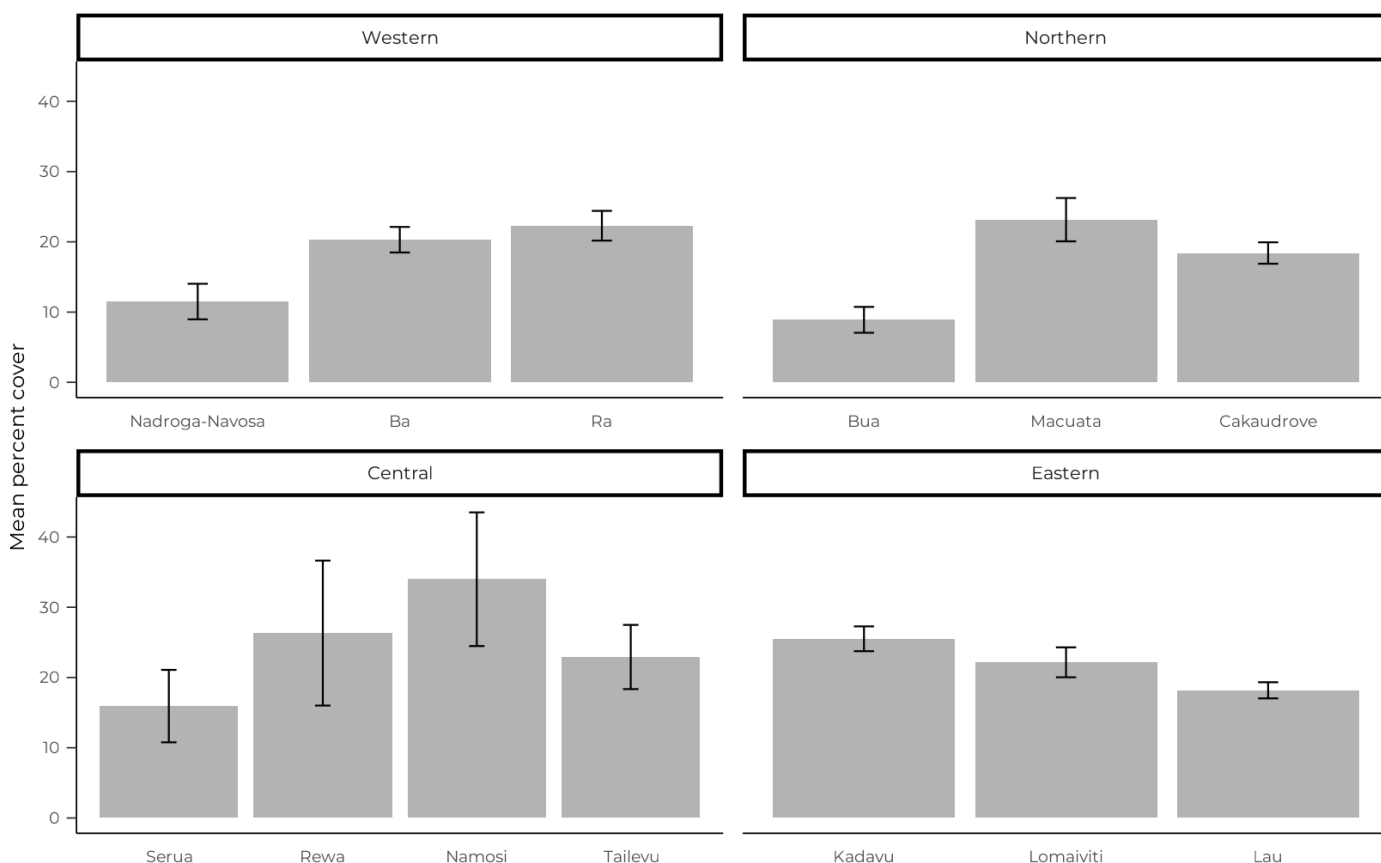


FIGURE 6: Mean percent cover of hard corals at each Province. Provinces are grouped by Division for ease of interpretation.

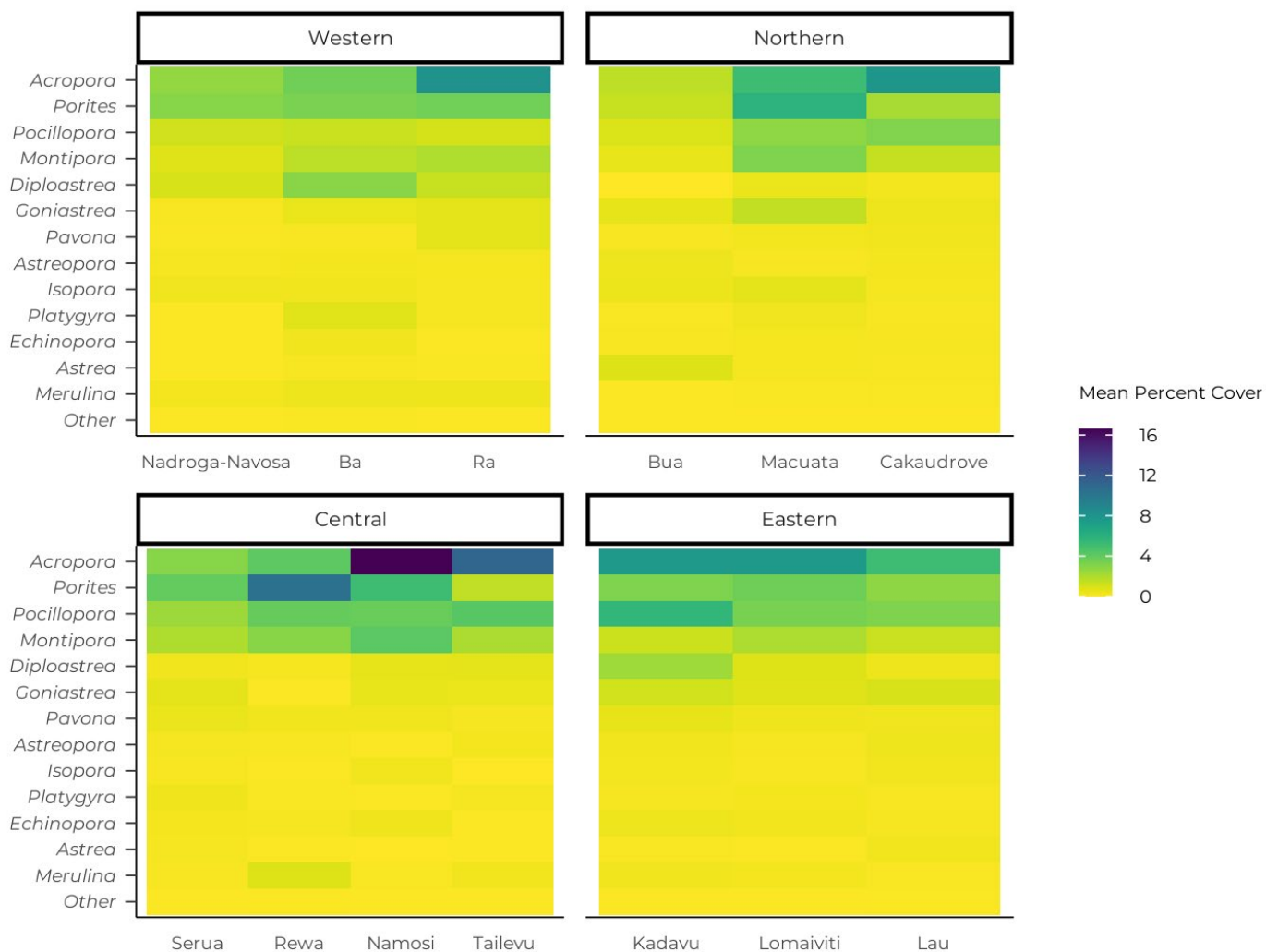


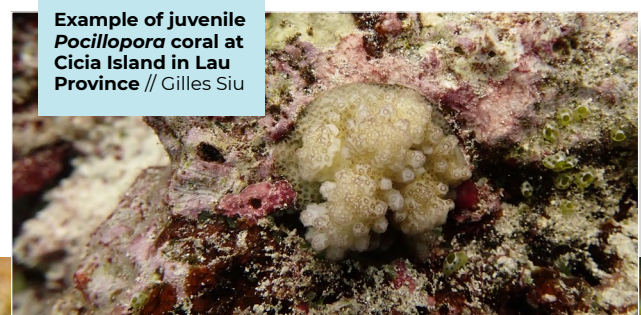
FIGURE 7: Heatmap of the mean percent cover of most abundant coral genera at each Province. Coral genera are ranked in order of overall abundance. All coral genera with an overall mean percent cover <0.2% were grouped into “Other.” Provinces are grouped by Division for ease of interpretation.

CORAL RECRUITMENT

Average juvenile coral density across Fiji was 11.0 individuals/m² ($\pm$ 0.4 SE, Map 8). Lau Province had the highest mean juvenile coral density at 15.1 individuals/m² ($\pm$ 0.8 SE), while Namosi had the lowest (3.1 individuals/m² $\pm$ 0.6 SE; Figure 8). Recruitment was lowest in Rewa and Namosi; however, it should be noted that sampling effort was lowest in these Provinces, with only three sites surveyed in each. Conversely, Lau Province had the highest number of sites surveyed.

Juvenile coral density did not always correlate with sampling intensity, however. For example, Bua had high mean recruitment (11.9 individuals/m² $\pm$ 1.7 SE) despite having a relatively low sample size (n=9 sites), whereas Cakaudrove Province had lower recruit density (8.6 individuals/m² $\pm$ 0.7 SE) but high sampling effort (n=52 sites).

***Acropora*, *Pocillopora*, and *Porites* were the three most common genera** identified in juvenile coral surveys, respectively (Figure 9). The highest density of any one genus was *Acropora* in Kadavu (3.9 individuals/m² $\pm$ 0.7 SE). Interestingly, *Pocillopora*, the second most commonly seen juvenile coral genus, was not recorded in Namosi, along with several other commonly seen genera; however, it should be noted that this Province had a low sample size. In total 43 genera of coral juveniles were recorded (Appendix 5).



Example of juvenile *Pocillopora* coral at Cicia Island in Lau Province // Gilles Siu



Example of juvenile *Acropora* coral from Lau Province // Gilles Siu

Examples of juvenile *Acropora* coral seen at Cakau Vucovuco in Cakaudrove Province

MAP 8: Mean density of juvenile corals (1-5 cm in diameter) observed at survey sites across Fiji.

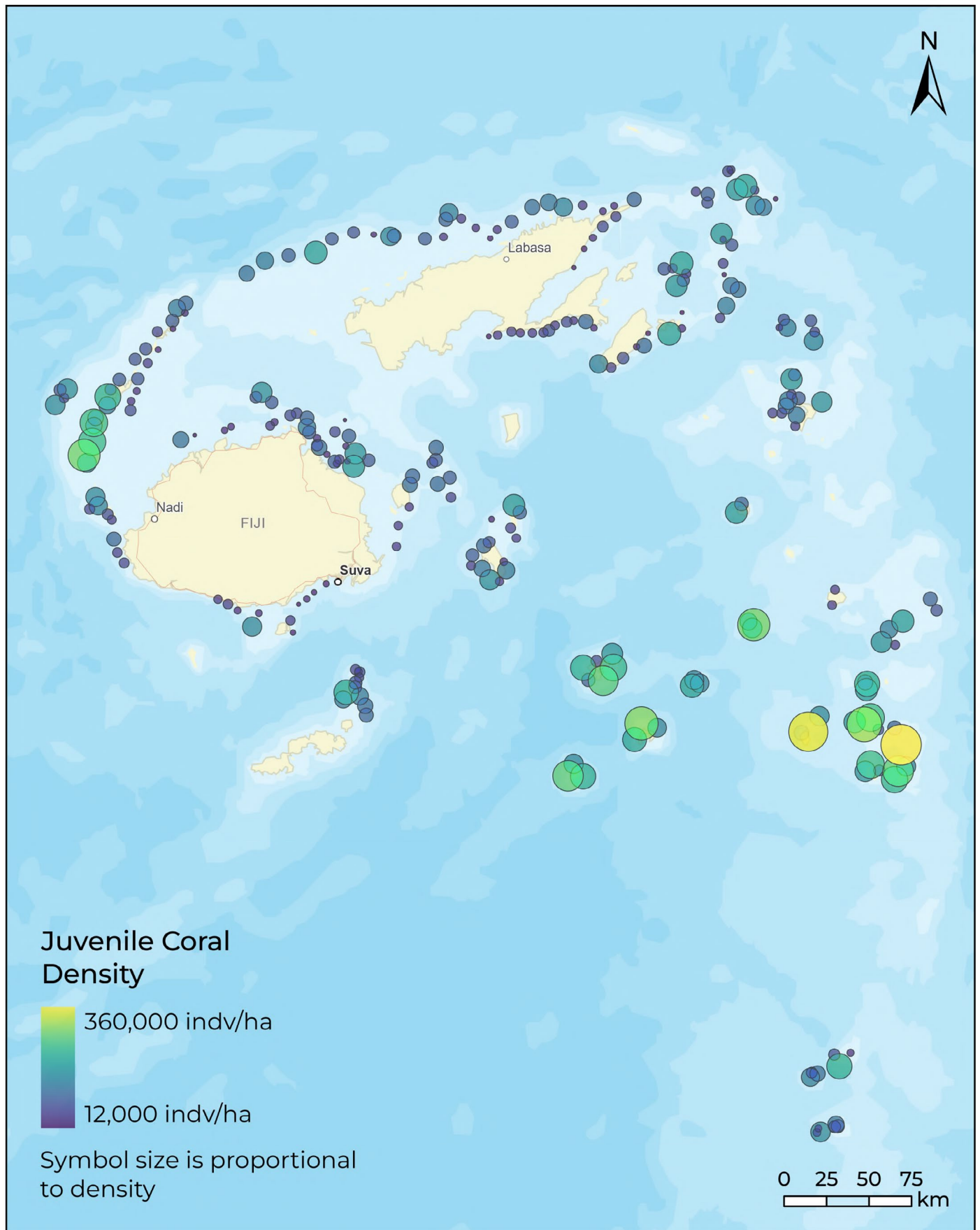


FIGURE 8:
Mean density of juvenile corals at each Province surveyed. Bold horizontal lines represent the median value for each Province. Provinces are grouped by Division for ease of interpretation.

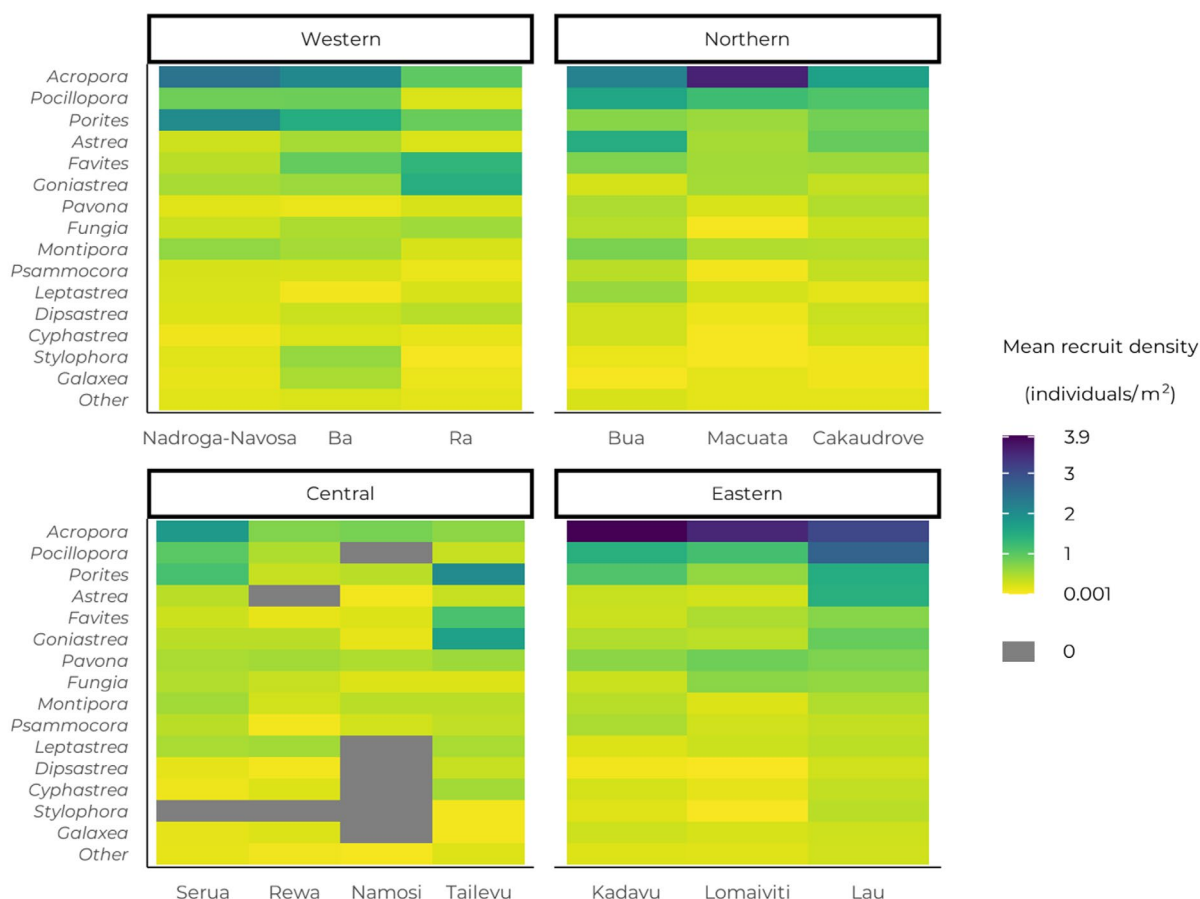
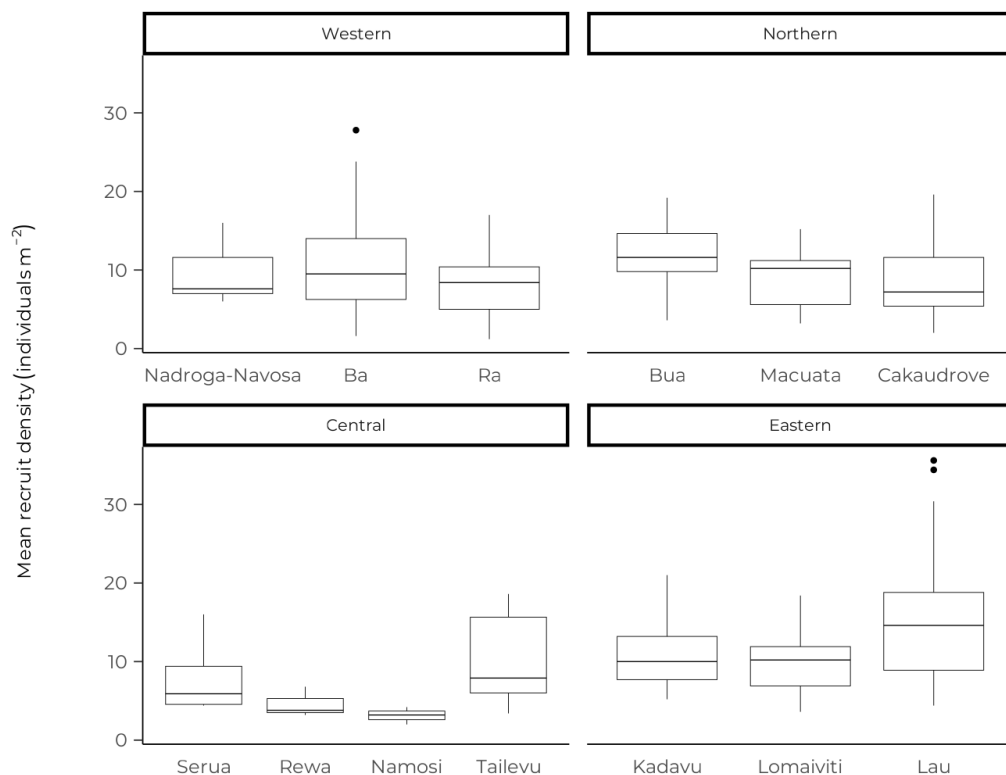


FIGURE 9: Heatmap of the mean juvenile coral density of the most abundant coral genera at each Province. Grey cells represent instances where the genus was not present at the corresponding Province. Coral genera are ranked in order of overall abundance. All coral genera with an overall mean juvenile coral density <0.2 individuals/ m^2 were grouped into “Other”. Provinces are grouped by Division for ease of interpretation.

RUGOSITY

Overall mean rugosity across all Provinces was 1.8 (± 0.02 SE). **Ra and Tailevu had the highest** mean rugosity ratios, at 2.0 (± 0.06 SE) and (± 0.09 SE), respectively (Figure 10). **Rugosity was lowest in Bua**, with a mean of 1.4 (± 0.05 SE). At the island level, Kabara had the highest mean rugosity (2.2 ± 0.07 SE) and Qelelevu had the lowest, at 1.4 (± 0.06 SE). **No obvious latitudinal or longitudinal patterns were observed.**

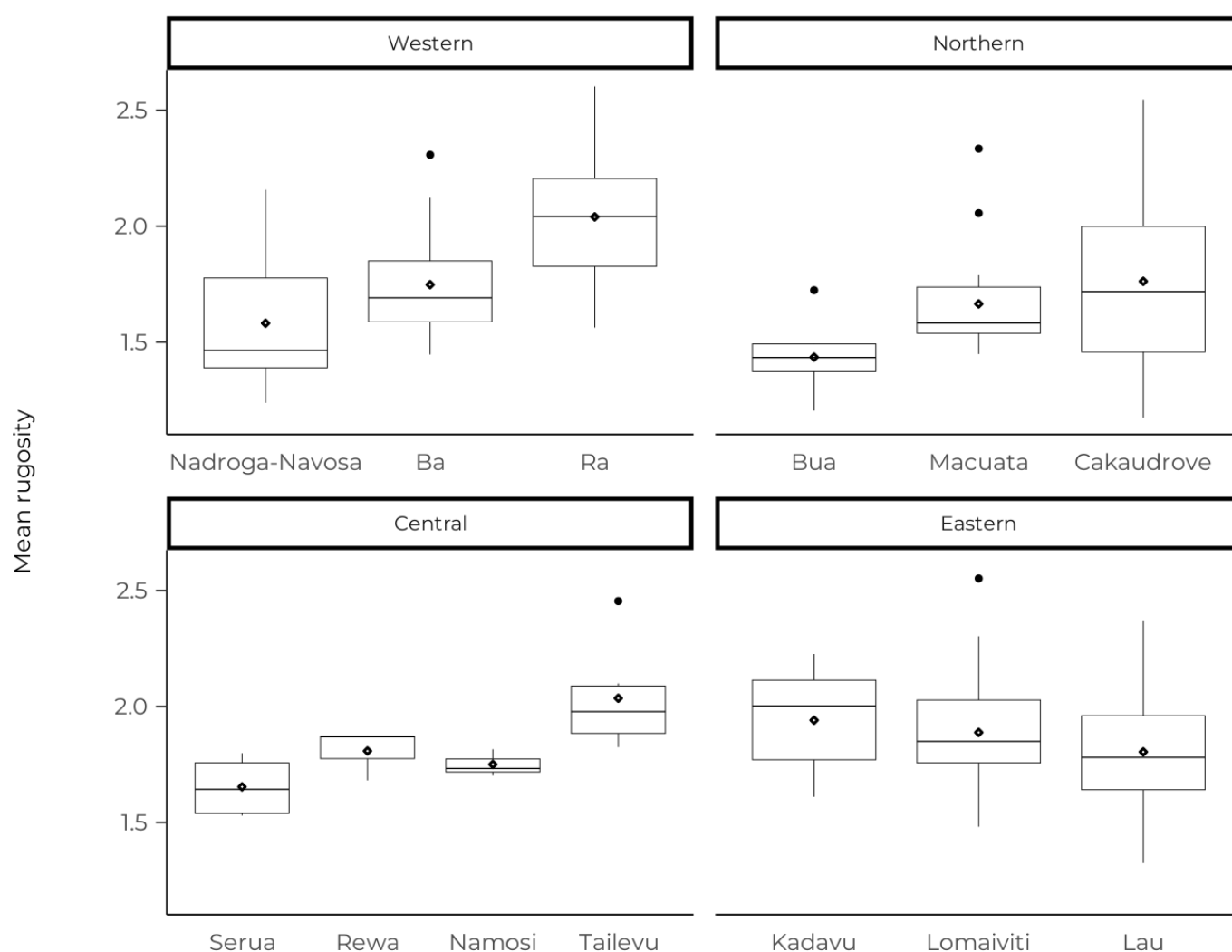


FIGURE 10:

Mean rugosity at each Province surveyed. Bold horizontal lines represent the median value at each island, and diamonds represent the mean. Provinces are grouped by Division for ease of interpretation.

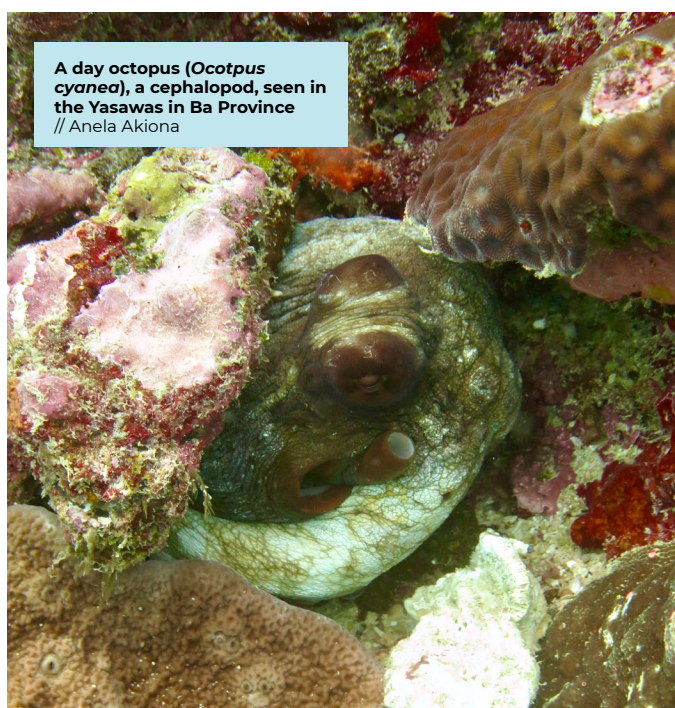
MACROINVERTEBRATES

In total, **76 species of macroinvertebrates were recorded and identified**, and an additional 9 species were recorded that could not be identified to the species level (Appendix 6). **Including these unidentified species, the surveys recorded:**

- 16 species of **bivalves**,
- 2 species of **cephalopod**,
- 1 species of **crinoid**,
- 1 **crustacean** species,
- 36 species of **gastropod**,
- 18 **sea cucumber** species,
- 8 **sea star** species, and
- 3 species of **sea urchin**.

However, only commercially and ecologically important species are included in the subsequent analysis for this report.

Due to methodological issues with belt transect surveys, density could not be accurately calculated from the data collected. Instead, presence/absence of ecologically and commercially important macroinvertebrates in each Province is presented here. Note that this analysis only includes species that were noted within the belt transects, and does not include off-transect observations. Sizes were recorded for a subset of species and have been used to construct size-frequency distributions.



A day octopus (*Ocotpus cyanea*), a cephalopod, seen in the Yasawas in Ba Province
// Anela Akiona



An Amberfish sea cucumber (*Thelanota anax*) in Ba Province
// Joe Lepore

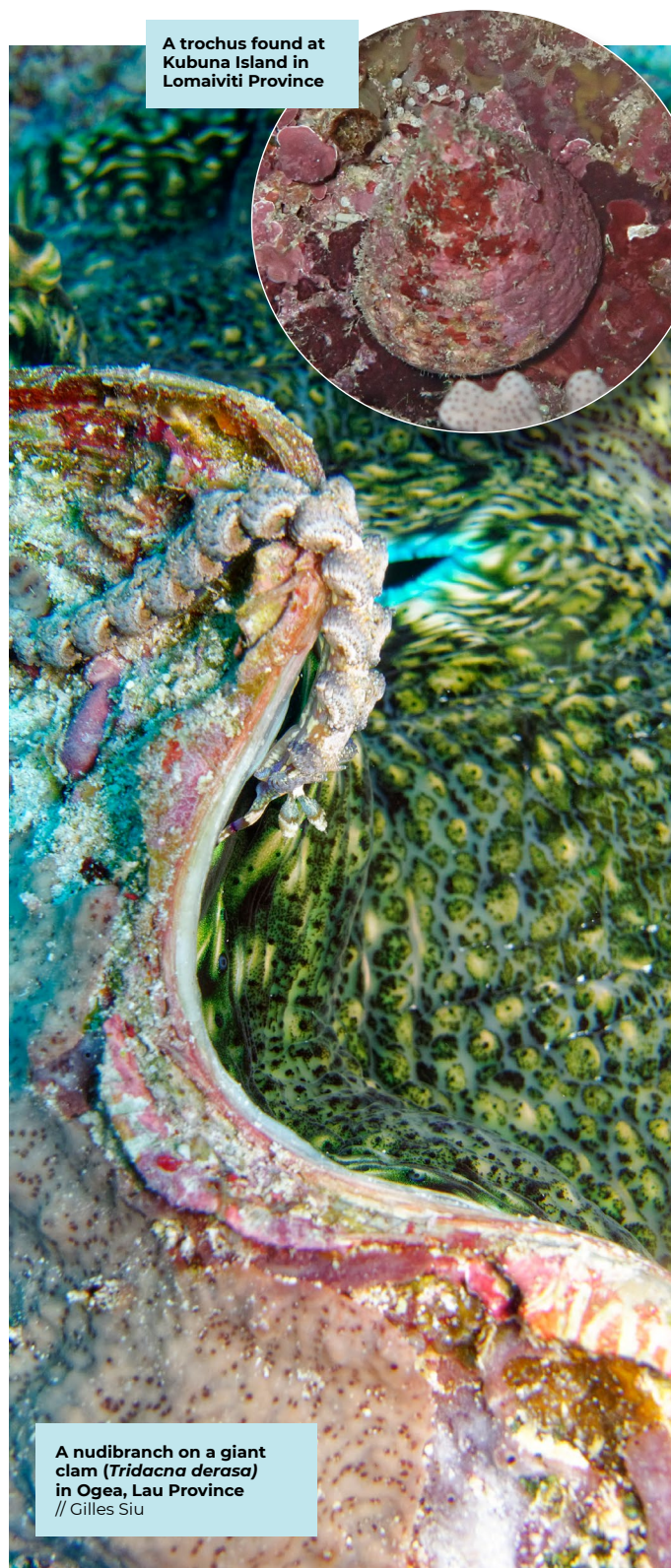
Eighteen species of sea cucumber were recorded in belt transect surveys (Map 9). Of those, six species were recorded only in one Province each. *Actinopyga echinites*, *Actinopyga lecanora*, and *Actinopyga palauensis* were all only seen in Lau. *Actinopyga miliaris* was found only in Lomaiviti, *Stichopus hermannii* was found in Cakaudrove, and *Stichopus vastus* was found in Ba. *Pearsonothuria graeffei* was the most widely distributed sea cucumber species, and the only species found in all 13 Provinces. Lau had the most diverse sea cucumber populations, with 11 species found in this Province. In contrast, Rewa and Serua only had two species each (*P. graeffei* and *Thelanota anax* in Rewa, *P. graeffei* and *Stichopus chloronotus* in Serua). However, sampling intensity was very different between these Provinces, with 77 sites surveyed in Lau and only four and three sites in Serua and Rewa, respectively. Of the 18 species recorded, only 9 species were abundant enough to form meaningful size-frequency distributions (Figure 11). Of these, *Bohadschia argus* and *T. anax* had high numbers of very small individuals and a number of larger individuals, but fewer instances in mid-range sizes. *S. chloronotus*, *Holothuria atra* and *P. graeffei* had distributions skewed towards smaller individuals, but without the lack of medium specimens. The remaining species had relatively balanced size-frequency distributions.

Trochus (*Rochia nilotica*), was present in all Provinces except Nadroga-Navosa, Serua, Rewa and Namosi (Map 10). The majority of trochus were in the middle range of sizes, from 6 cm- 12 cm (basal diameter) (Figure 12). The green snail *Turbo marmoratus* was less widely distributed, and was only present in Bua, Macuata, Cakaudrove and Lau. *Charonia tritonis*, known as Triton's trumpet or giant triton snail, is one of the few known predators of the corallivorous crown-of-thorns sea star (COTS; *Acanthaster planci*), and was found in Cakaudrove and Lau.

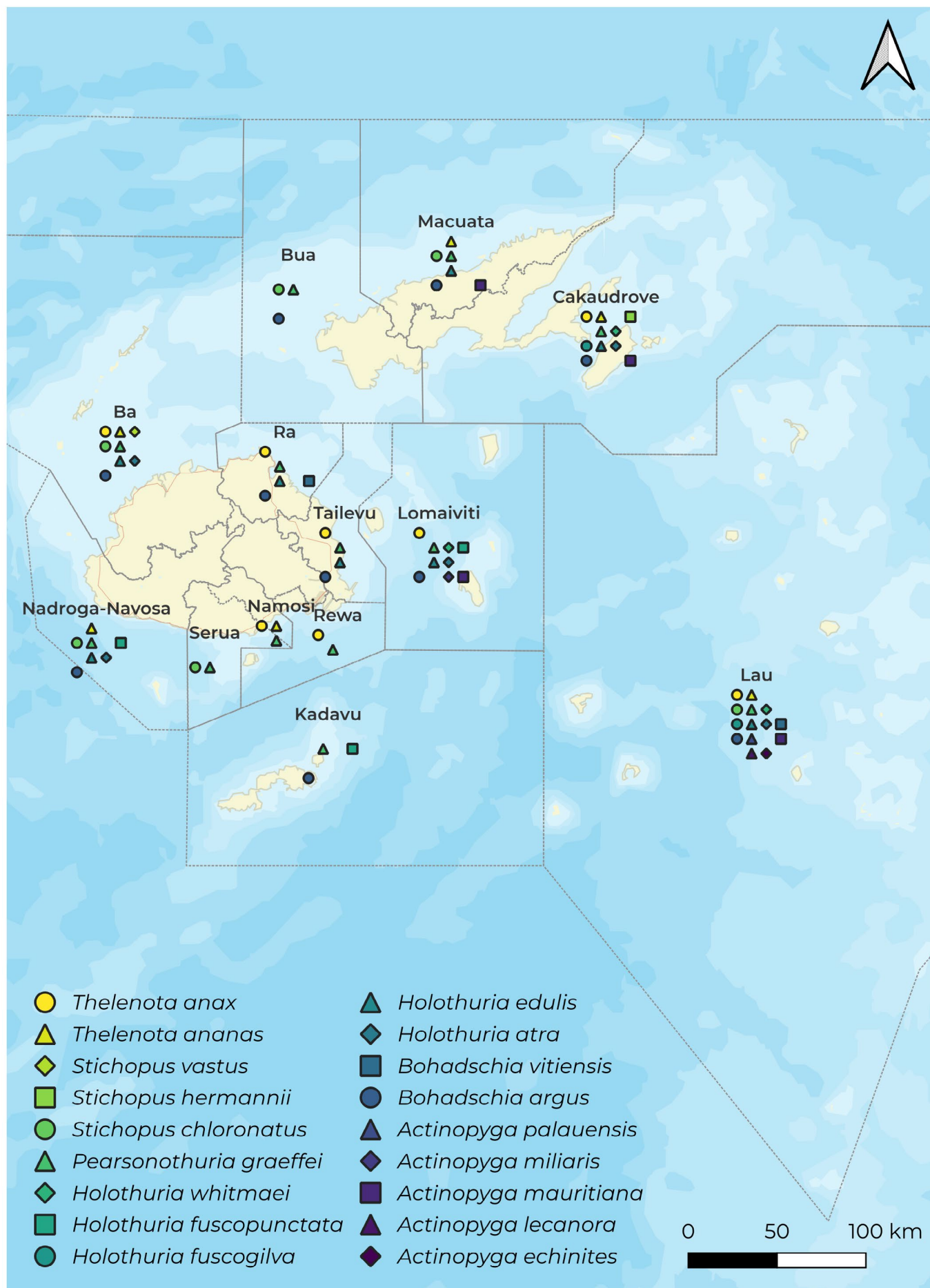
Six species of giant clam were found in the surveys (Map 11). *Tridacna crocea* was found in Ba, Ra, Tailevu and Lau. *Tridacna derasa* and *Tridacna squamosa* were more widely distributed, with both found in all but three Provinces (Nadroga-Navosa, Serua and Namosi for *T. derasa*, and Nadroga-Navosa, Rewa and Namosi for *T. squamosa*). *Tridacna gigas* and *Tridacna mbalavuana* were the least widely distributed species of clam, occurring at three Provinces (Nadroga-Navosa, Kadavu and Lau) and one Province (Lau), respectively. Conversely, *Tridacna maxima* was found in all 13 Provinces surveyed. Lau had the highest diversity of clams, with all six species present in this Province. Namosi was the least diverse, with only *T. maxima* present. *T. gigas* and *T. mbalavuana* were not abundant enough to construct meaningful size-frequency distributions (Figure 13). However, the remaining four species of clam showed size-frequency distributions that covered the full range of sizes for each species. Anomalous sizes (greater than the known largest size for each species) were removed from the analysis.

***Diadema setosum* was the most widely distributed sea urchin species**, but was completely absent in the three Provinces of Vanua Levu (Bua, Macuata, Cakaudrove; Map 12). In fact, no sea urchins were recorded in the belt transects in these Provinces; however, surveyors at these sites noted seeing instances of *Tripneustes gratilla*, *D. setosum*, and *Echinothrix calamaris* off-transect. So while urchins are present, they are likely present in very low densities. *Echinostrephus aciculatus* was recorded in Ba and Ra, and *Echinometra mathaei* was found only in Lau.

COTS (*A. planci*) were present in Nadroga-Navosa, Cakaudrove, Serua, Rewa, Lomaiviti, and Lau (Map 13). The cushion star *Culcita novaeguineae*, which is also corallivorous but is less voracious than COTS, was found only in Lau. The lobster *Panulirus versicolor* was found in eight of the 13 Provinces surveyed (Nadroga-Navosa, Ba, Ra, Bua, Macuata, Cakaudrove, Serua and Lau; Map 14). Octopus were recorded in Bua, Macuata, Cakaudrove, Lomaiviti, and Lau (Map 15).



MAP 9: Map of sea cucumber species present in each Province surveyed. Note that only presence is plotted and an absence of a symbol indicates a true zero, rather than an absence of data.



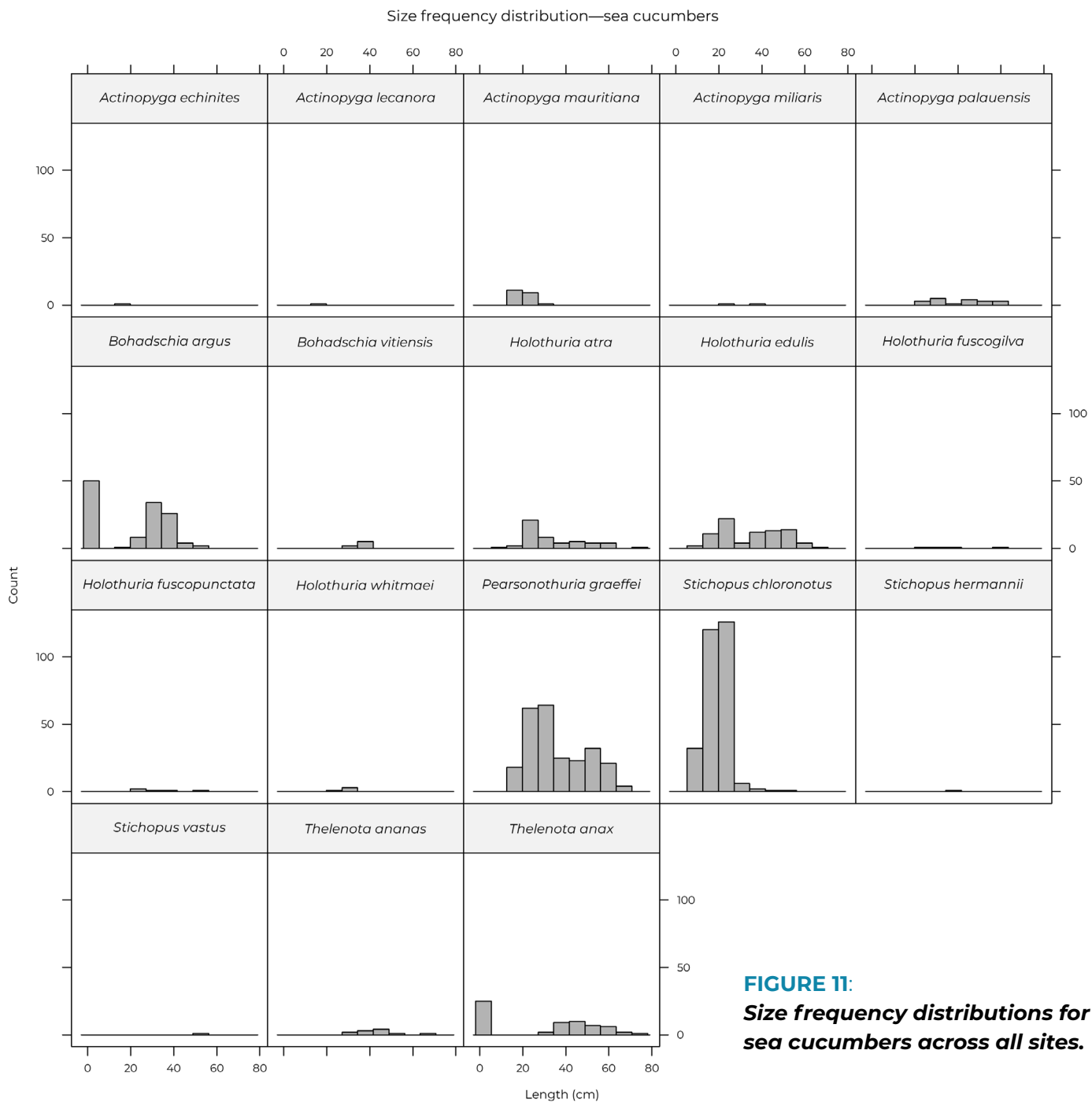
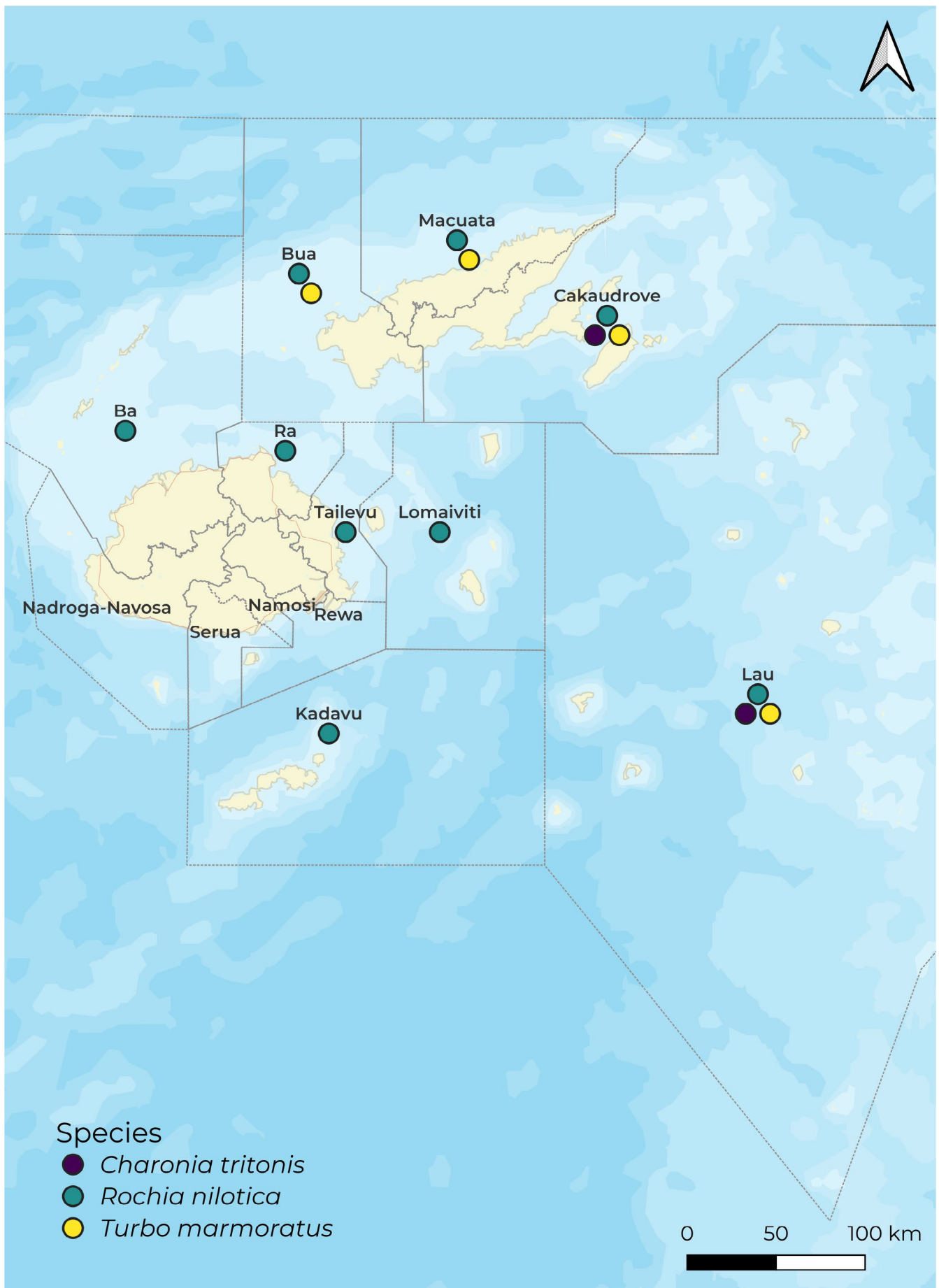


FIGURE 11:
Size frequency distributions for sea cucumbers across all sites.



MAP 10: Map of ecologically and commercially important gastropod species present in each Province surveyed. Note that only presence is plotted and an absence of a symbol indicates a true zero, rather than an absence of data.



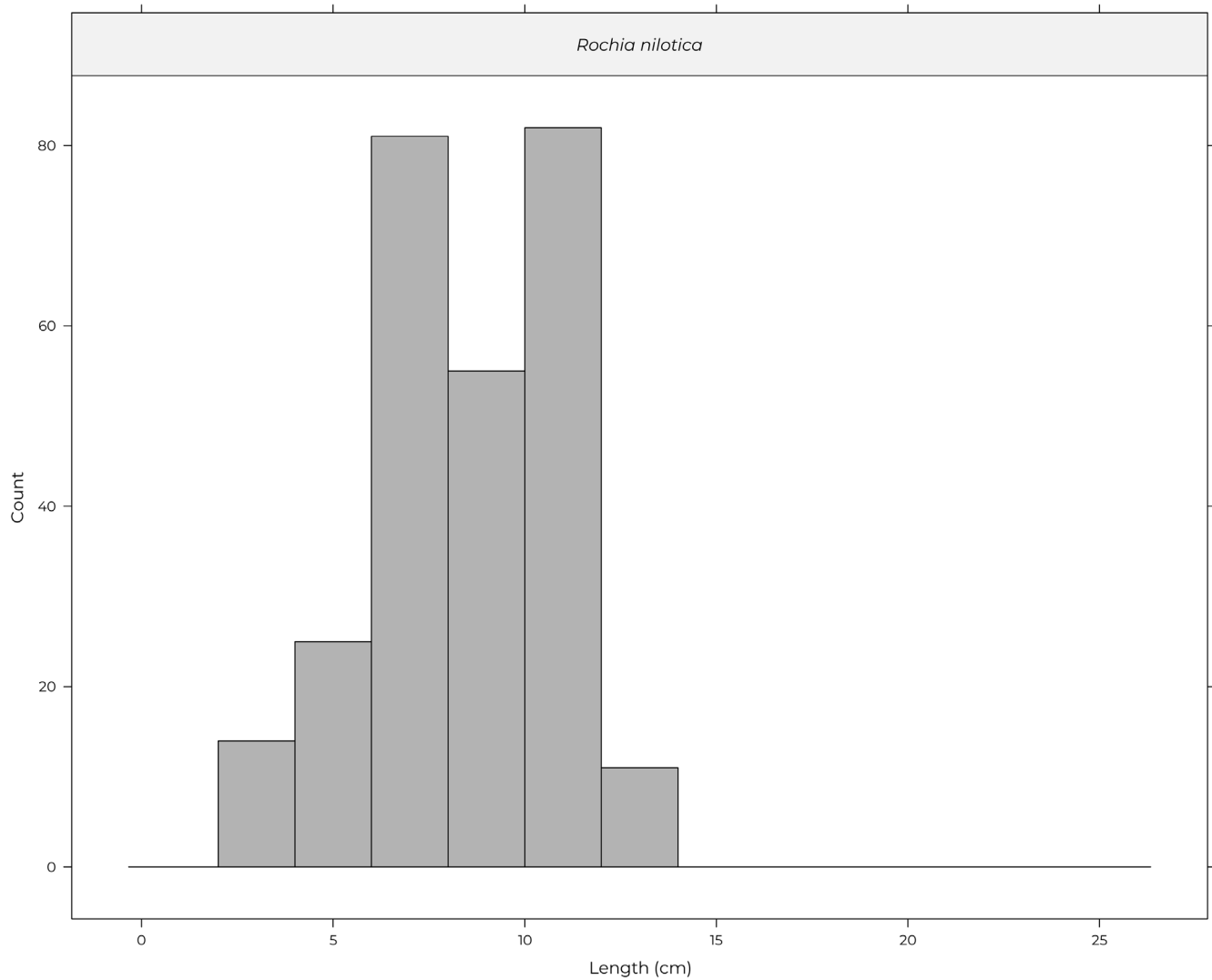
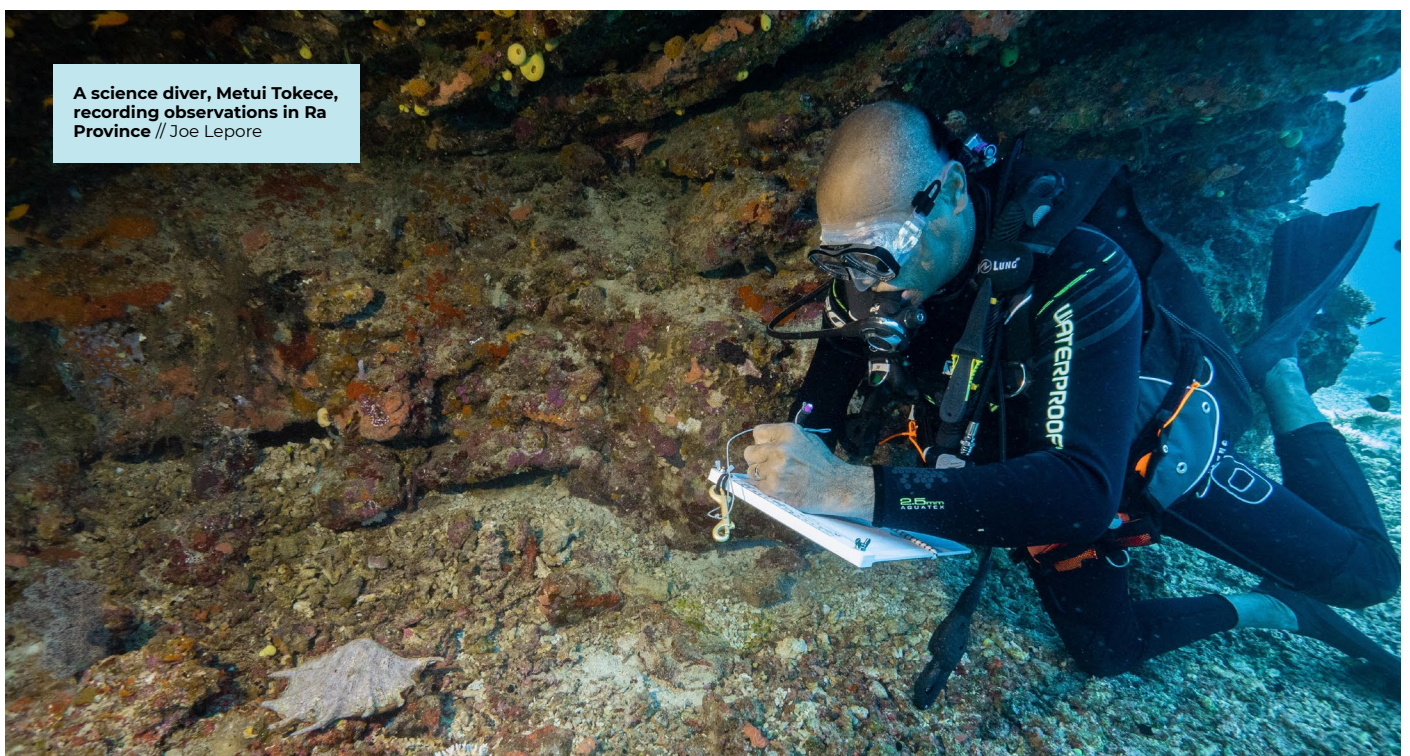
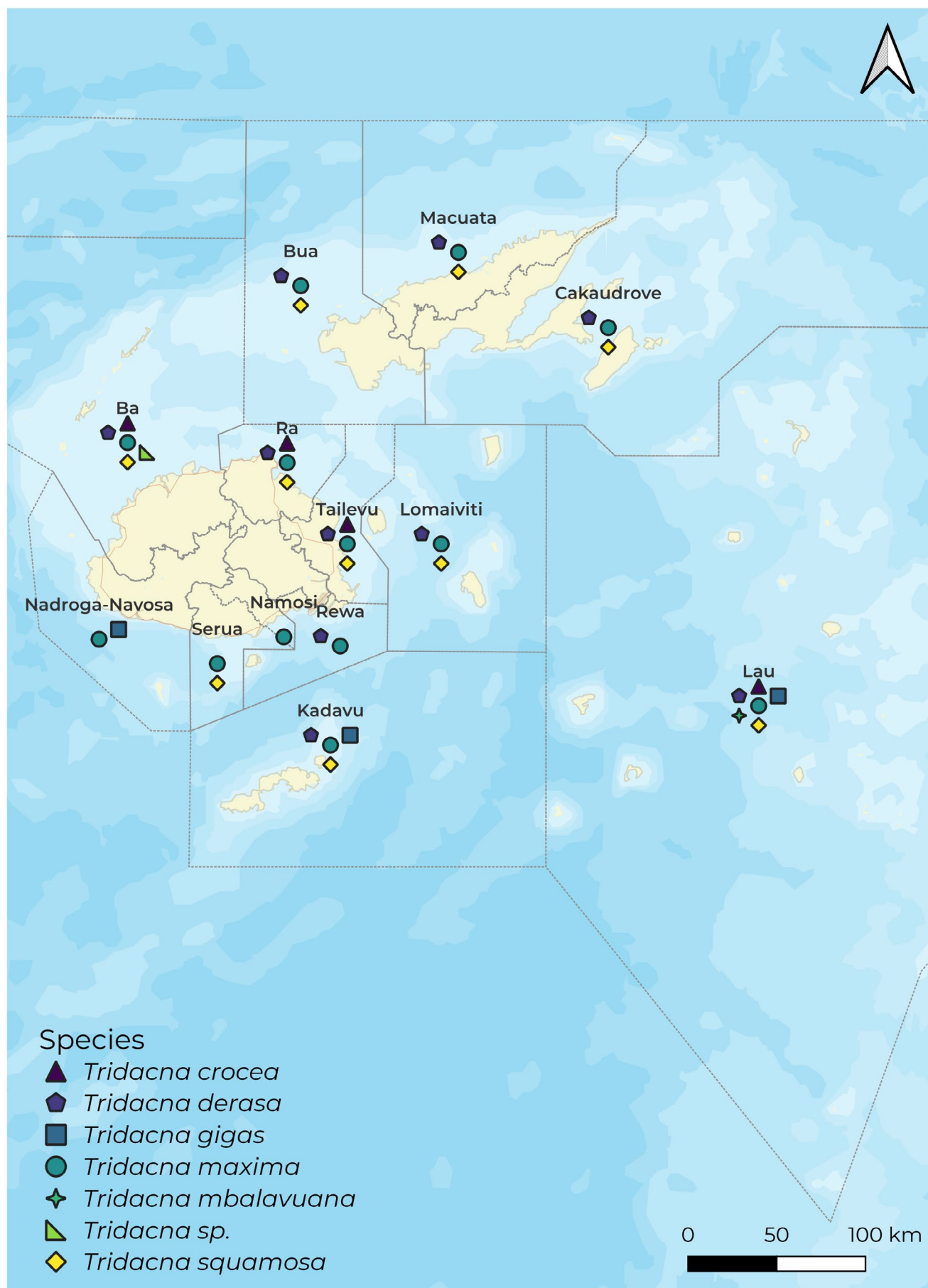


FIGURE 12: Size frequency distribution for trochus across all sites.



MAP 11: Map of giant clam species present in each Province surveyed. Note that only presence is plotted and an absence of a symbol indicates a true zero, rather than an absence of data.



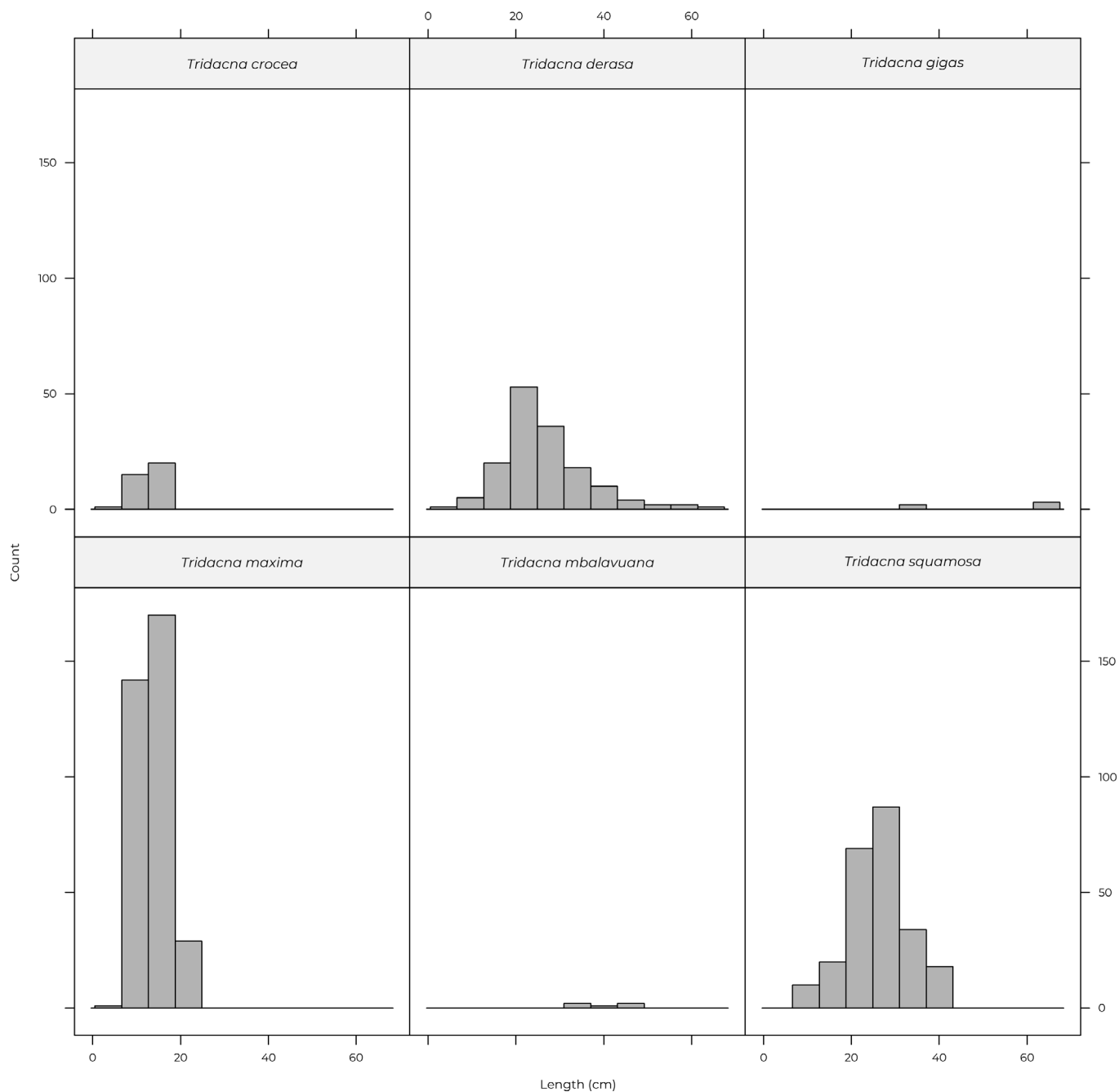
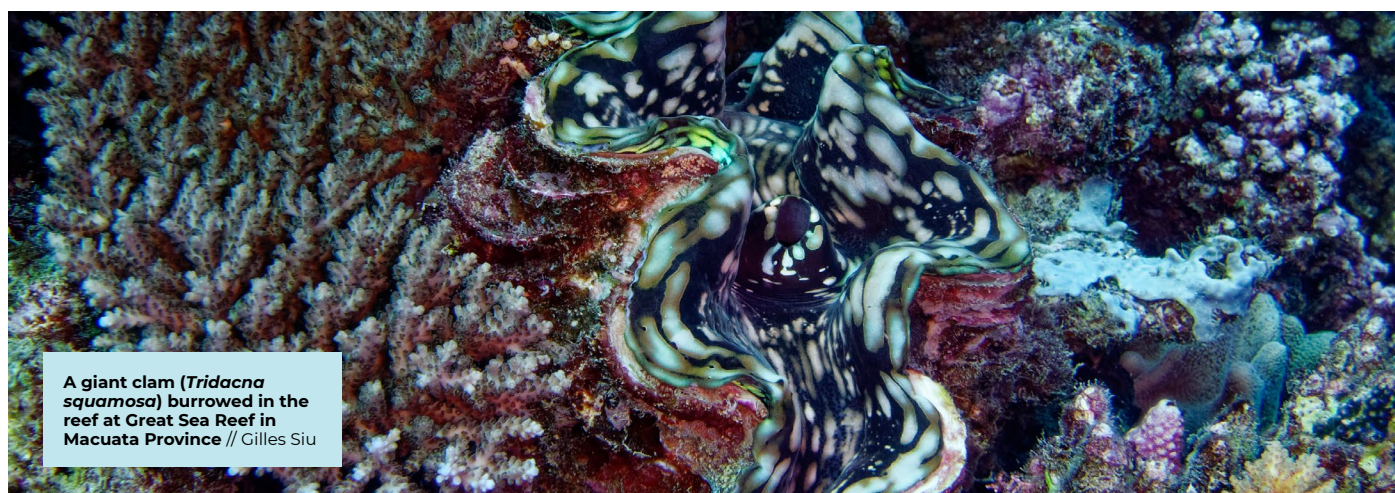
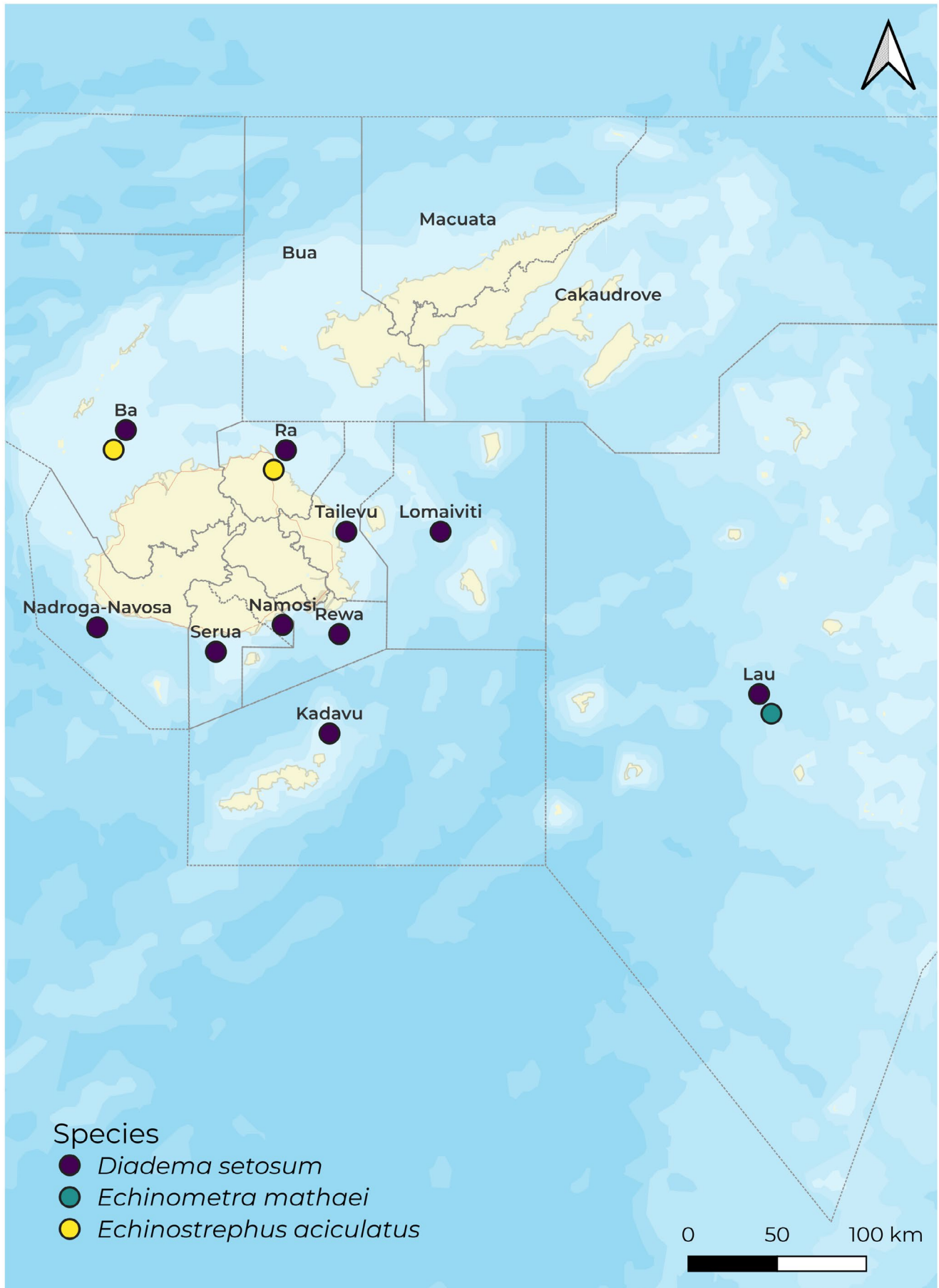


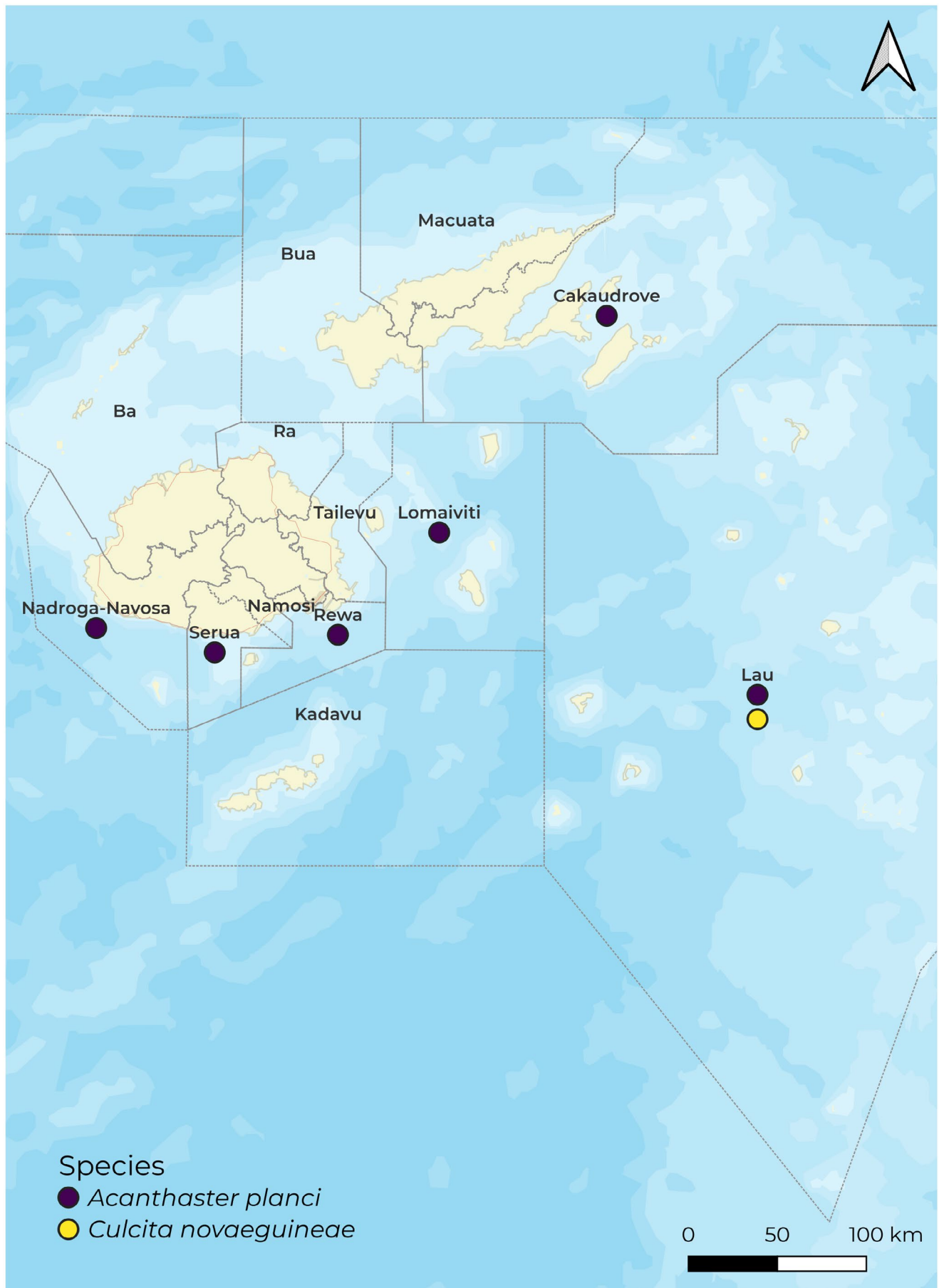
FIGURE 13: Size frequency distributions for giant clams all sites.



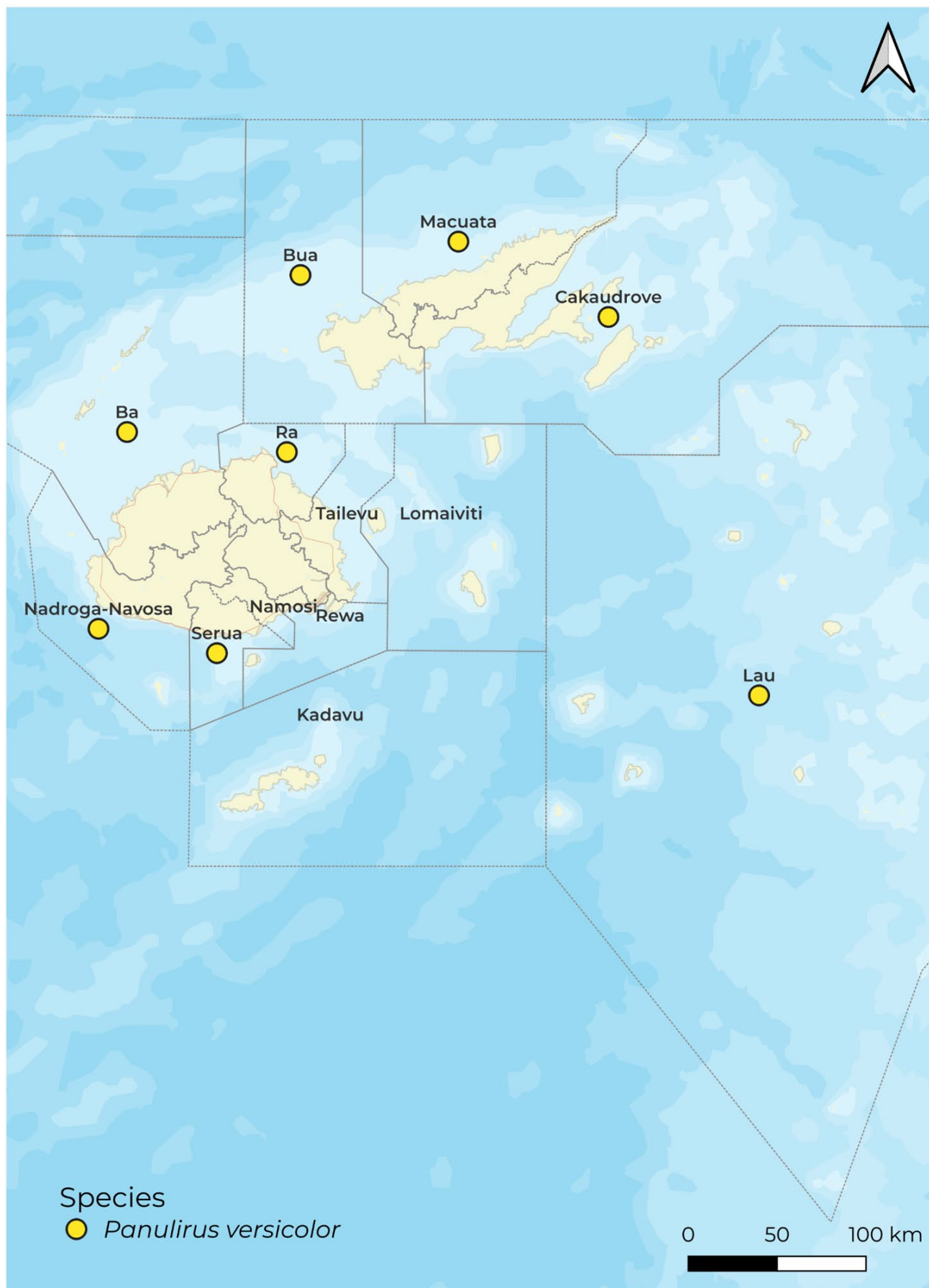
MAP 12: Map of sea urchin species present in each Province surveyed. Note that only presence is plotted and an absence of a symbol indicates a true zero, rather than an absence of data.



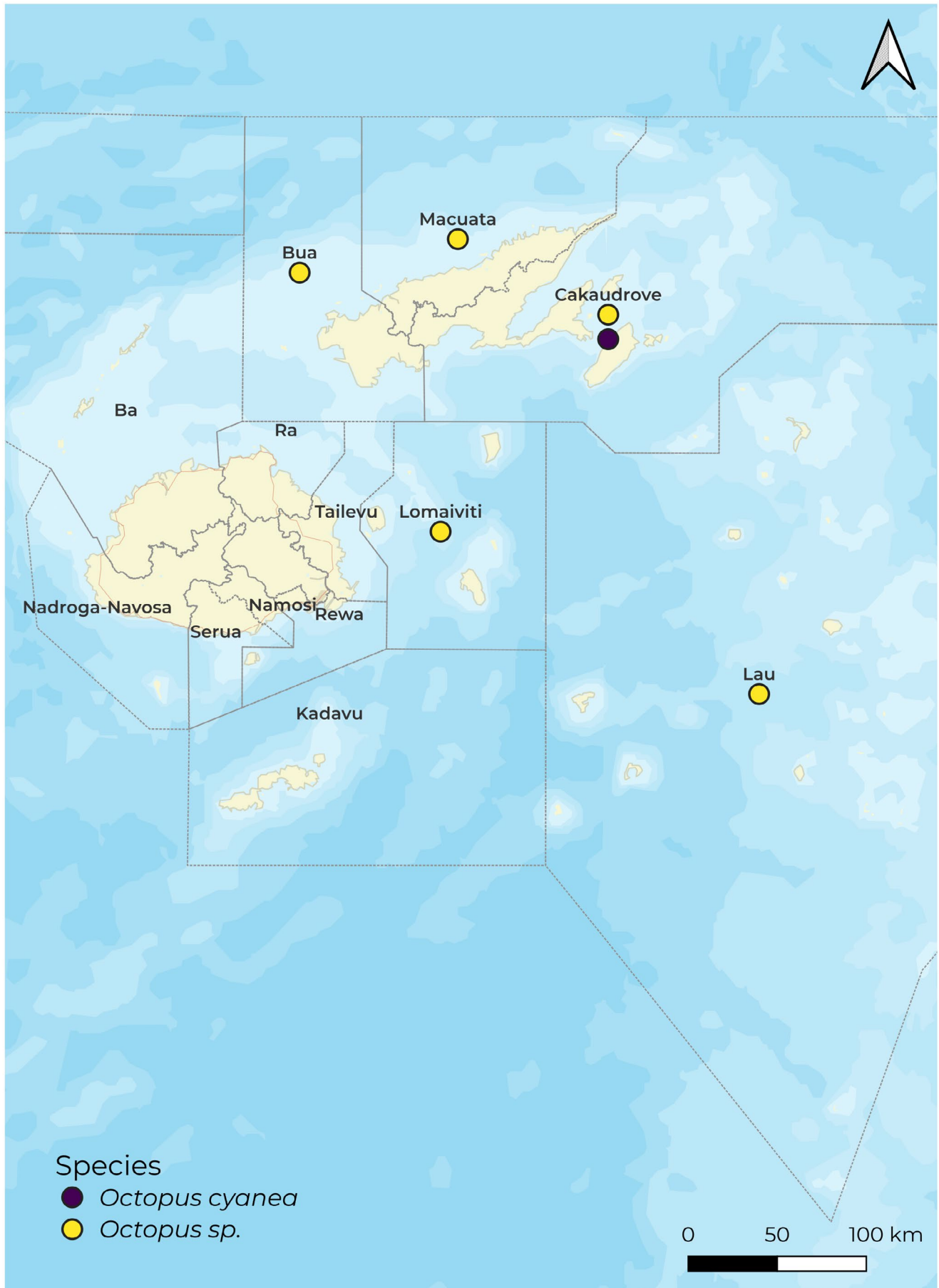
MAP 13: Map of sea star species present in each Province surveyed. Note that only presence is plotted and an absence of a symbol indicates a true zero, rather than an absence of data.



MAP 14: Map of lobsters present in each Province surveyed. Note that only presence is plotted and an absence of a symbol indicates a true zero, rather than an absence of data.



MAP 15: Map of octopus species present in each Province surveyed. Note that only presence is plotted and an absence of a symbol indicates a true zero, rather than an absence of data.



WATER QUALITY

Stable isotope data ($\delta^{15}\text{N}$) was extracted from dried samples of calcified green algae (*Halimeda spp.* when present, *Tydemania expeditionis* otherwise). See Appendix 2 for sites where algal samples were collected. **Low $\delta^{15}\text{N}$ values (0‰ to 4‰) tend to represent natural atmospheric sources of nitrogen, while higher values (7‰ to 38‰) indicate sewage pollution** (Dailer et al. 2010). Interpretation of agricultural (fertilizer) inputs of nitrogen are typically context-dependent, as these values overlap with those for atmospheric nitrogen (-4 to 4‰) (Dailer et al. 2010).

Mean $\delta^{15}\text{N}$ was low across all Provinces, with a maximum in Bua at only 1.7‰ (± 0.2 SE; Figure 14). Kadavu had the lowest mean value of all Provinces, at 0.7‰ (± 0.2 SE). No obvious geographic patterns in $\delta^{15}\text{N}$ were observed, and there did not appear to be any patterns related to population density or degree of urbanisation between Provinces.

Halimeda spp. growing in Gau, Lomaiviti Province, a calcifying macroalgae collected to identify point sources of sewage and agricultural pollution
// Andy Estep

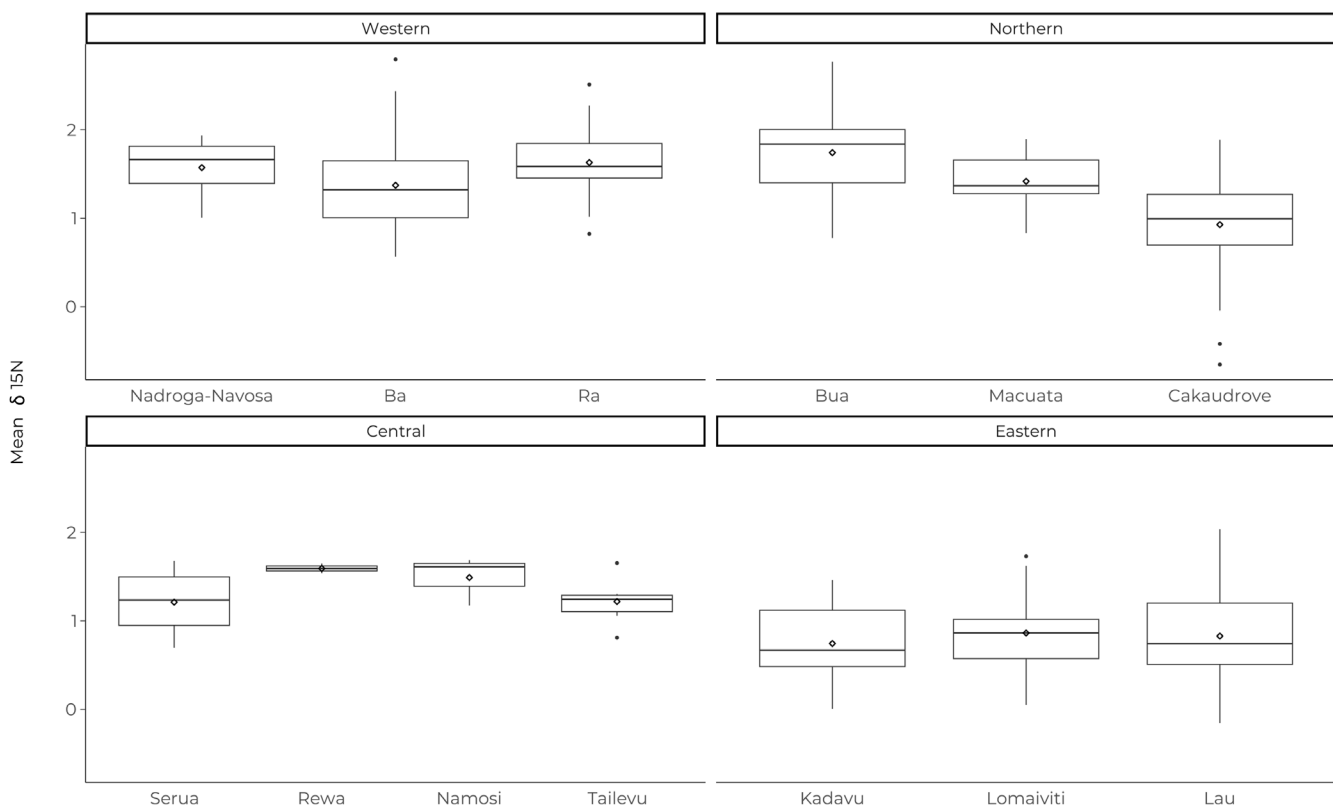
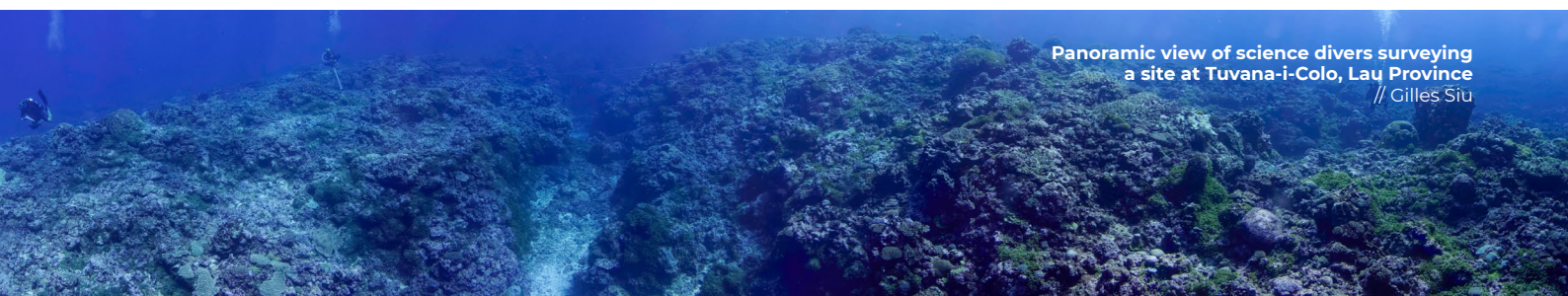


FIGURE 14:

Mean $\delta^{15}\text{N}$ at each Province surveyed. Bold horizontal lines represent the median value at each island, and diamonds represent the mean. Provinces are grouped by Division for ease of interpretation.



Panoramic view of science divers surveying a site at Tuvana-i-Colo, Lau Province
// Gilles Siu

PROVINCIAL SUMMARIES

Province-level means for the main reporting metrics described above are summarized in Table 2.

TABLE 2: Province-level sample sizes, means, and associated standard errors for major reporting metrics across all surveys.

REEF HEALTH INDICATOR	UNIT	FIJI TOTAL	TROPHIC GROUPS	BA 32 SITES 326 FISH SPECIES	BUA 8 SITES 172 FISH SPECIES	CAKAUDROVE 53 SITES 370 FISH SPECIES	KADAVU 11 SITES 251 FISH SPECIES	LAU 76 SITES 373 FISH SPECIES
				MEAN ± SE	MEAN ± SE	MEAN ± SE	MEAN ± SE	MEAN ± SE
Fish	Density (individuals/ha)	45,510 ± 1665.3 SE	Sharks	4.7 ± 1.5	4.2 ± 2.7	4.1 ± 1.2	19.7 ± 10.3	7.2 ± 1.7
			Top-Predators	60.4 ± 12.8	108.3 ± 68.7	120.4 ± 17.9	97 ± 17	177.6 ± 46.7
			Lower-carnivores	14578.6 ± 1444.1	14622.9 ± 224.2	11519.1 ± 649	11253 ± 1006.7	12079.4 ± 531.2
			Planktivores	21262.5 ± 4284.7	10731.3 ± 1860.4	22418.8 ± 2397.9	25359.1 ± 4260.6	27175.7 ± 2407.4
			Herbivores	5857.8 ± 510.7	10108.3 ± 1389.5	8050 ± 649.2	9672.7 ± 1223.9	5842.5 ± 235.6
			Biomass (g/ha)	2,573.6 ± 130.2 SE				
Benthic Cover (calcifiers)	Hard Coral Cover (%)	19.7 ± 0.7 SE	Sharks	51.6 ± 17.2	29.4 ± 27.6	65.1 ± 24.2	124.4 ± 47.7	100.8 ± 24.8
			Top-Predators	108.8 ± 39.3	449.8 ± 289.8	130.3 ± 25.6	74.6 ± 39.7	103.3 ± 21.4
			Lower-carnivores	489.9 ± 43.3	430.3 ± 73.5	519.9 ± 47.4	537 ± 72.8	528.6 ± 46.9
			Planktivores	788.3 ± 220.8	112.0 ± 36.9	739.6 ± 142.5	1258.7 ± 466.6	539.5 ± 70.1
			Herbivores	750.1 ± 71	868.6 ± 171.3	1190.2 ± 125.4	1187.8 ± 155.5	909.7 ± 59.4
Benthic Cover (non-calcifiers)	Cyanobacteria (%)	4.4 ± 0.3 SE		20.3 ± 1.8	8.9 ± 1.8	18.4 ± 1.5	25.5 ± 1.8	18.2 ± 1.2
				11.7 ± 1.3	4.2 ± 0.6	11.0 ± 1.1	3.9 ± 0.5	8.7 ± 0.7
				11.0 ± 1.3	22.3 ± 4.3	11.8 ± 1.0	13.3 ± 1.8	24.6 ± 1.5
				8.1 ± 1.3	2.8 ± 0.8	4.9 ± 0.7	9.3 ± 2.3	3.9 ± 0.5
Juvenile Corals	Density (individuals/m²)	11.0 ± 0.4 SE		9.7 ± 1.1	6.0 ± 2.3	5.5 ± 0.7	11.0 ± 3.0	5.1 ± 0.4
				1.7 ± 0.5	2.0 ± 0.8	2.9 ± 0.5	0.5 ± 0.1	2.0 ± 0.4
				6.9 ± 2.0	2.6 ± 1.1	2.2 ± 0.5	1.9 ± 1.4	3.0 ± 0.5
				30.6 ± 2.0	51.2 ± 6.6	43.4 ± 2.3	34.7 ± 3.3	34.6 ± 2.0
Rugosity	Mean Rugosity (no units)	1.8 ± 0.02 SE		1.7 ± 0.04	1.4 ± 0.05	1.8 ± 0.05	1.9 ± 0.07	1.8 ± 0.03
Water Quality	Mean δ¹⁵N (‰)	1.1 (± 0.04 SE)		1.4 ± 0.1	1.7 ± 0.2	0.9 ± 0.08	0.7 ± 0.2	0.8 ± 0.06

PROVINCIAL SUMMARIES (continued)

TABLE 2. Province-level sample sizes, means, and associated standard errors for major reporting metrics across all surveys.

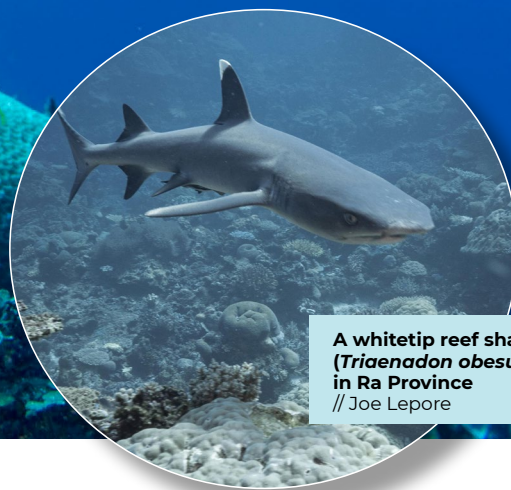
REEF HEALTH INDICATOR	UNIT	FIJI TOTAL	TROPHIC GROUPS	LOMAIVITI 23 SITES 310 FISH SPECIES	MACUATA 17 SITES 287 FISH SPECIES	NADROGA-NAVOSA 11 SITES 260 FISH SPECIES	NAMOSI 3 SITES 127 FISH SPECIES	RA 22 SITES 264 FISH SPECIES
				MEAN ± SE	MEAN ± SE	MEAN ± SE	MEAN ± SE	MEAN ± SE
Fish	Density (individuals/ha)	45,510 ± 1665.3 SE	Sharks	8.7 ± 2.9	26.5 ± 6.6	6.1 ± 6.1	5.6 ± 5.6	3.0 ± 1.8
			Top-Predators	151.4 ± 23.3	553.0 ± 218.5	69.7 ± 19.6	33.3 ± 19.2	122.7 ± 53.3
			Lower-carnivores	10441.3 ± 692.1	15955.9 ± 1496.3	9334.1 ± 556	11316.7 ± 905.7	13543.9 ± 933
			Planktivores	29750.0 ± 4881.2	30833.3 ± 5641.8	13306.8 ± 2661.2	11316.7 ± 905.7	31737.9 ± 10219.4
			Herbivores	6638.4 ± 906.9	15929.4 ± 1923.8	5464.4 ± 695.9	5822.2 ± 1197.7	8846.2 ± 648.6
	Biomass (g/ha)	2,572 ± 130.2 SE	Sharks	103.7 ± 35.0	504.5 ± 117.6	79.6 ± 79.6	59.9 ± 59.9	26.4 ± 18.5
			Top-Predators	56.7 ± 15.3	800.9 ± 383.0	15.1 ± 4.9	0.6 ± 0.3	84.9 ± 63.3
			Lower-carnivores	572.3 ± 113.9	1907.5 ± 527.0	439.2 ± 69.9	278.6 ± 34.8	407.3 ± 38.5
			Planktivores	881.8 ± 178.5	1610.6 ± 373.5	265 ± 72.9	472.2 ± 241.1	746.9 ± 211.3
			Herbivores	801.9 ± 21.4	2008.4 ± 246.7	705.6 ± 80.4	639.8 ± 84.9	551.8 ± 57.9
Benthic Cover (calcifiers)	Hard Coral Cover (%)	19.7 ± 0.7 SE		22.2 ± 2.1	23.2 ± 3.1	11.5 ± 2.5	34.0 ± 9.5	22.3 ± 2.1
	Calcified Macroalgae (%)	8.5 ± 0.4 SE		10.0 ± 1.2	8.5 ± 1.4	5.7 ± 2.9	3.8 ± 0.6	3.2 ± 0.7
Benthic Cover (non-calcifiers)	CCA (%)	16.1 ± 0.7 SE		14.6 ± 1.7	21.7 ± 2.4	5.7 ± 1.8	16.0 ± 5.0	6.7 ± 1.2
	Cyanobacteria (%)	4.4 ± 0.3 SE		4.9 ± 1.0	0.7 ± 0.2	2.2 ± 0.7	0.5 ± 0.3	2.9 ± 0.9
	Invertebrate (%)	6.4 ± 0.3 SE		6.7 ± 1.0	6.7 ± 1.3	5.0 ± 1.2	2.4 ± 0.5	8.0 ± 1.3
	Macroalgae (%)	2.9 ± 0.3 SE		2.3 ± 1.2	0.8 ± 0.2	2.4 ± 1.6	7.2 ± 3.2	9.3 ± 1.9
	Other (%)	3.6 ± 0.4 SE		3.2 ± 1.0	1.6 ± 0.7	5.8 ± 2.0	2.6 ± 2.3	6.7 ± 1.9
Juvenile Corals	Turf (%)	36.5 ± 1.0 SE		36.1 ± 3.5	36.8 ± 4.1	61.7 ± 4.5	33.7 ± 6.2	41.0 ± 2.5
	Density (individuals/m²)	11.0 ± 0.4 SE		9.9 ± 0.8	8.9 ± 1.0	9.5 ± 1.3	3.1 ± 0.6	8.3 ± 0.8
Rugosity	Mean Rugosity (no units)	1.8 ± 0.02 SE		1.9 ± 0.06	1.7 ± 0.06	1.6 ± 0.1	1.8 ± 0.03	2.0 ± 0.06
Water Quality	Mean δ¹⁵N (‰)	11 (± 0.04 SE)		0.9 ± 0.1	1.4 ± 0.08	1.6 ± 0.09	1.49 ± 0.2	1.6 ± 0.1

PROVINCIAL SUMMARIES (continued)

TABLE 2. Province-level sample sizes, means, and associated standard errors for major reporting metrics across all surveys.

REEF HEALTH INDICATOR	UNIT	FIDI TOTAL	TROPHIC GROUPS	REWA 3 SITES 148 FISH SPECIES	SERUA 4 SITES 184 FISH SPECIES	TAILEVU 6 SITES 207 FISH SPECIES
				MEAN ± SE	MEAN ± SE	MEAN ± SE
Fish	Density (individuals/ha)	45,510 ± 1665.3 SE	Sharks	5.6 ± 5.6	20.8 ± 8.0	2.8 ± 2.8
			Top-Predators	111.1 ± 22.2	91.7 ± 51.6	88.9 ± 33.8
			Lower-carnivores	10222.2 ± 773.7	12491.7 ± 2169.6	17463.9 ± 2239.7
			Planktivores	21083.3 ± 10426.4	17016.7 ± 6034.2	45091.7 ± 12883.6
			Herbivores	7433.3 ± 1493.9	10108.3 ± 1912.2	6827.8 ± 902.2
	Biomass (g/ha)	2,572 ± 130.2 SE	Sharks	74.2 ± 74.2	540.3 ± 375.1	45.2 ± 45.2
			Top-Predators	25.6 ± 17.5	24.2 ± 18	76.1 ± 63.5
			Lower-carnivores	962.9 ± 657.4	986.1 ± 314.2	518.2 ± 46.6
			Planktivores	540.5 ± 376.0	428.3 ± 158.5	835.5 ± 242.3
			Herbivores	917.3 ± 131.4	1162 ± 263.5	697.5 ± 163.5
Benthic Cover (calcifiers)	Hard Coral Cover (%)	19.7 ± 0.7 SE		26.3 ± 10.3	15.9 ± 5.2	22.9 ± 4.6
	Calcified Macroalgae (%)	8.5 ± 0.4 SE		6.4 ± 2.2	7.1 ± 1.4	3.5 ± 1.6
	CCA (%)	16.1 ± 0.7 SE		11.1 ± 3.7	25.0 ± 1.0	7.5 ± 2.9
Benthic Cover (non-calcifiers)	Cyanobacteria (%)	4.4 ± 0.3 SE		3.4 ± 1.5	1.2 ± 0.3	1.5 ± 0.5
	Invertebrate (%)	6.4 ± 0.3 SE		2.0 ± 0.6	4.4 ± 0.8	4.6 ± 2.2
	Macroalgae (%)	2.9 ± 0.3 SE		6.6 ± 4.3	1.5 ± 0.3	9.8 ± 3.3
	Other (%)	3.6 ± 0.4 SE		2.1 ± 1.4	0.4 ± 0.2	4.6 ± 3.0
Juvenile Corals	Turf (%)	38.5 ± 1.0 SE		42.1 ± 5.7	44.5 ± 6.0	45.4 ± 7.4
	Density (individuals/m²)	11.0 ± 0.4 SE		4.6 ± 1.1	8.0 ± 2.7	10.2 ± 2.6
Rugosity	Mean Rugosity (no units)	1.8 ± 0.02 SE		1.8 ± 0.06	1.7 ± 0.07	2.0 ± 0.09
Water Quality	Mean δ ¹⁵ N (‰)	1.1 (± 0.04 SE)		1.6 ± 0.06	1.2 ± 0.2	1.2 ± 0.1

DISCUSSION



A whitetip reef shark
(*Triaenodon obesus*)
in Ra Province
// Joe Lepore

REEF FISH

In total, 547 fish species were recorded in the surveys. In addition, 35 genus- or family-level entries were recorded, in cases where fish could not be reliably identified to the species level. A previous biodiversity survey in Lau found 527 fish species (Meo et al. 2017), suggesting that the present study agrees with previous research. Mean fish density across the country was 45,508.2 individuals/ha and mean biomass was 2,573.6 kg/ha. These values are higher than found in directly comparable studies in Vanuatu (mean density $\approx$ 37,000 individuals/ha, mean biomass $\approx$ 1,519 kg/ha) and Samoa (mean density $\approx$ 22,000 individuals/ha, mean biomass $\approx$ 888 kg/ha) (Government of Samoa 2024, Government of the Republic of Vanuatu & Blue Prosperity Vanuatu 2025).

Consistent with recent surveys (e.g., Meo et al. 2021, Andradi-Brown et al. 2022), shark and top predator densities were extremely low across the country. Comparable belt transect surveys at islands in the Southern Line Islands (Kingman and Palmyra) found shark densities of 50-170 individuals/ha (as calculated from biomass reported in Sandin et al. 2008; Nadon et al. 2012), while provincial means in Fiji ranged from 2.8 individuals/ha in Tailevu to 26.5 individuals/ha

in Macuata. The same surveys found a mean shark biomass of 3290 kg/ha for the Southern Line Islands (Sandin et al. 2008), whereas shark biomass in this study ranged from 26.4 kg/ha in Ra to 540.3 kg/ha in Serua. This suggests that in most parts of the country, where top predators and sharks are present, they are both scarce and small, likely indicating widespread overfishing of predatory fish species across Fiji.

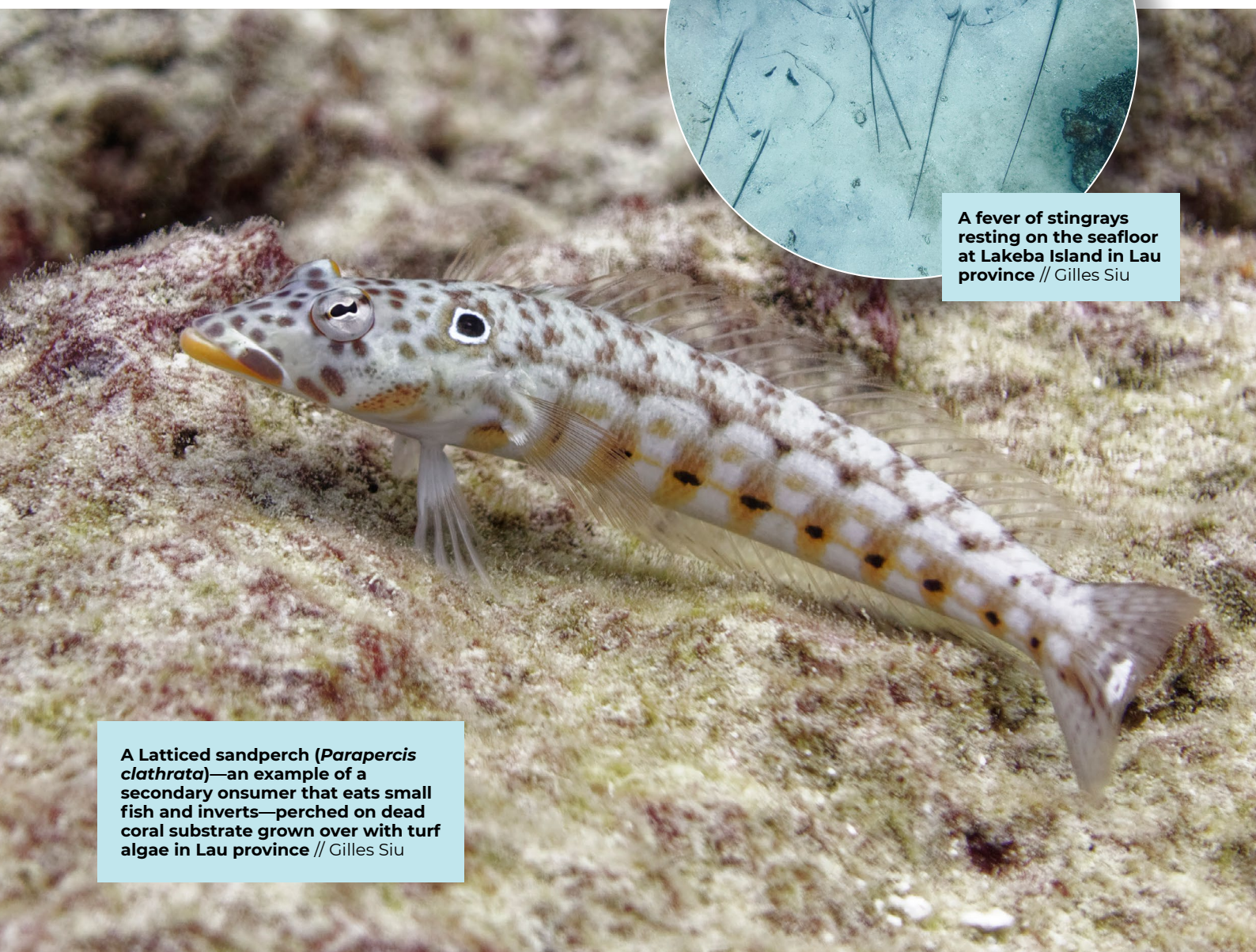
Acanthurids (surgeonfish) made up the largest proportion of the overall fish biomass, though this pattern was not always true at the provincial level. Acanthurids made up the largest proportion of biomass in the three Provinces of Vanua Levu (Bua, Macuata, and Cakaudrove) as well as Nadroga-Navosa, Lomaiviti and Lau. However, in Ba, Kadavu, Namosi, Ra and Tailevu, caesionids (fusiliers) had the highest biomass of any fish family, and in Serua and Rewa, scarids (parrotfish) dominated. In general, predatory fish families contributed less to overall biomass, except in Macuata and, to a lesser extent, Serua, where lutjanids (snappers) made up a significant proportion. **Pomacentrids (damselfish), though typically very small bodied (<10 cm), still contributed a sizable proportion of biomass in each Province**, indicating that this family was particularly abundant across the country.

Despite having comparable fish densities, Macuata stood out as having particularly high fish biomass compared to other Provinces. This trend appears to be exaggerated by three sites (GSR_76, GSR_83, and GSR_90) in which several schools of large fish, including snappers, surgeonfish, and fusiliers, were recorded (Map 3). Notably, GSR_90 also had the highest coral cover of any site surveyed, at 53.5% (Map 7). However, the remaining sites within this Province did tend to have slightly higher biomass than in many other Provinces, so the pattern is not wholly driven by these outliers, and suggests that fish may be larger on average in Macuata than in other Provinces. This is in contrast to a recent study of the GSR, which found low mean biomass (462 kg/ha) of target fish families (Andradi-Brown et al. 2022). Potential reasons for this difference are discussed in the Considerations section, below.

Though Macuata had much higher biomass than all other Provinces, fish density in Macuata was comparable to Ra and lower than Tailevu. However, these two Provinces had relatively low biomass compared to all Provinces, indicating that fish in Ra and Tailevu are abundant, but small. Fish densities within the three Provinces in the Eastern Division were similar, but biomass in Kadavu was noticeably higher than in Lomaiviti or Lau, indicating that fish are larger on average in this Province. Macuata represents an extreme version of this pattern, in which fish in this Province were much bigger on average than in any other Province.



A fever of stingrays resting on the seafloor at Lakeba Island in Lau province // Gilles Siu



A Latticed sandperch (*Parapercis clathrata*)—an example of a secondary consumer that eats small fish and inverts—perched on dead coral substrate grown over with turf algae in Lau province // Gilles Siu

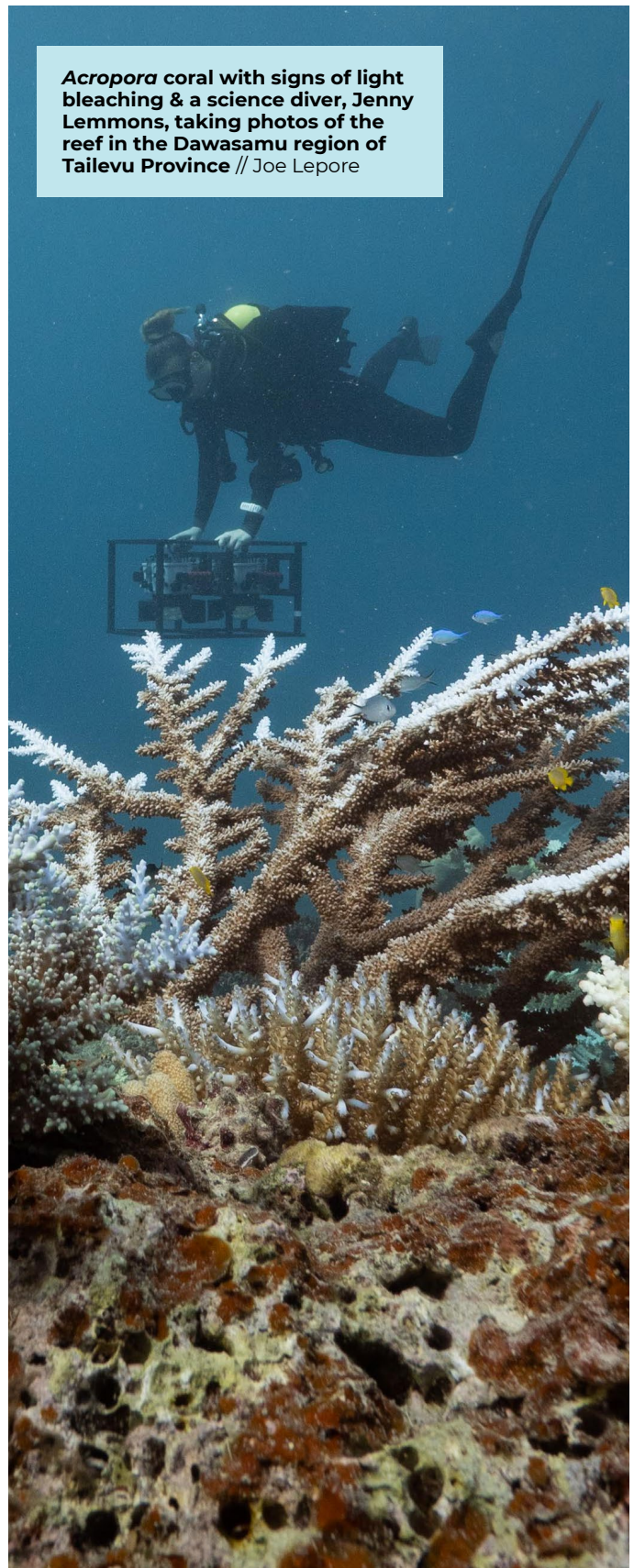
HARD CORAL

Overall mean coral cover was 19.7%. This is similar to other nearby Pacific Island nations; directly comparable surveys from Vanuatu in 2023 and Samoa in 2022 showed mean coral cover estimates of 19.8% and 20.9%, respectively (Government of Samoa 2024, Government of the Republic of Vanuatu & Blue Prosperity Vanuatu 2025). **However, these estimates are lower than some reported averages for the wider South Pacific, estimated by different studies as 25.6%** (Mortiz et al. 2018) and 36% (Carlton et al. 2021). It must be noted, though, that these Pacific-wide surveys occurred prior to the 2016 global bleaching event; therefore, current averages may differ. **The current estimate is also lower than some regional and aggregated estimates previously reported for Fiji.** Recent surveys and analyses have returned estimates of 34% coral cover, both as a nationwide average and for Cakaulevu (Great Sea Reef) (Andradi-Brown 2022, Mangubhai et al. 2025). Similarly, Lau was estimated to have a mean coral cover of 36% in 2013 (Bruckner et al. 2016), although estimates from five islands in Northern Lau following Cyclone Winston were closer to the current estimate at 21.4% (Miller et al. 2018), and by 2017, it ranged from 20.2%-34.3% (Meo et al. 2021). It is likely that the inclusion of more heavily populated regions of the country as well as less developed reef systems in this survey may account in part for the lower mean coral cover estimate.

Province-level mean coral cover ranged between 8.9% in Bua and 34% in Namosi. It should be noted, however, that only three sites were surveyed in Namosi, and one in particular (NAV_21) had particularly high coral cover and another had above-average coral cover, bringing up the mean value in this Province. **Additional surveys in Namosi would help assess whether this estimate of coral cover is representative of the entire Province or whether it is an artifact of a few exceptional sites.**

Despite moderate mean coral cover, coral diversity was relatively high, with a total of 60 genera recorded across the benthic photoquadrat and coral recruitment surveys (note, 56 genera were recorded in photoquadrats and 43 genera were recorded in juvenile coral

surveys, but due to a lack of complete overlap between the genera in the two surveys, the total number comes out to more than either survey on its own. See Appendix 4 for a full list). This number is on par with previous surveys, which found 59 distinct genera in coral diversity surveys in Lau (Meo et al. 2021).



ALGAE AND CYANOBACTERIA

Turf algae made up the highest proportion of benthic cover on average (38.5%), while CCA averaged 16.1%. **There did not appear to be a relationship between coral cover and turf algae or CCA cover.** For example, Nadroga-Navosa had relatively low coral cover, the lowest CCA cover, but the highest cover of turf, while Bua and Serua both had similarly low coral cover, but two of the highest mean CCA cover values and less turf on average.

While often grouped with fleshy macroalgae in benthic assessments (Ford et al. 2018), **cyanobacteria is reported separately in this study due to its notable presence across many of the survey sites.** Benthic cyanobacterial mats are becoming increasingly common on coral reefs, and are known to occur throughout Fiji (Ford et al. 2021). Cyanobacteria cover was highest in Kadavu, with a mean of 9.3% cover. Ba also had particularly high cyanobacteria cover, with a mean of 8.1%. These estimates are on par with the highest estimates of fleshy macroalgae cover observed in the study, at Tailevu (9.8%) and Ra (9.3%). Cyanobacterial blooms have been noted

previously in Lau, and it is **hypothesised that in some cases their proliferation may be due in part to overexploitation of sea cucumbers** (Bruckner et al. 2016, Meo et al. 2021).

Cyanobacteria perform many varied functions on coral reefs, but thick mats as observed in many locations in this study have the potential to overgrow and kill corals and inhibit coral recruitment (Ritson-Williams et al. 2005, Charpy et al. 2012, Ford et al. 2021). Possible drivers of increased cyanobacteria cover include **climate change, reduced water quality, iron input, and reductions in key consumer and ecosystem engineer species** (Ford et al. 2018). Cyanobacteria are often prominent on declining reefs, and can form noxious blooms due to changes in nutrient availability and increased solar radiation (Charpy et al. 2012, Ford et al. 2018). Benthic cyanobacteria contain toxins that make them a poor and unpreferred food source for many grazers, reducing herbivory rates and limiting the reef community's ability to manage cyanobacteria growth once established (Charpy et al. 2012, Ford et al. 2018, Ford et al. 2021). Therefore, **it may be prudent to continue monitoring cyanobacteria levels in Provinces where it was abundant, and consider management efforts to minimize conditions conducive to cyanobacterial blooms.**



Science diver, Aporosa Ledua, with a transect line and algae samples collected from the reef
// Joe Lepore

JUVENILE CORALS

Coral recruitment was relatively high for an inhabited Pacific Island nation, with an average of 11.0 individuals/m². Again, this is comparable to recent surveys in Vanuatu, where mean juvenile coral density was 10.7 individuals/m² (Government of the Republic of Vanuatu & Blue Prosperity Vanuatu 2025). **Directly comparable surveys in Samoa and Tonga found much lower juvenile coral densities** (5.7 and 6.2 individuals/m², respectively; Vava'u Ocean Initiative 2023, Government of Samoa 2024). On Heron Island in Australia, juvenile coral density was 3.8 individuals/m² (Doropoulos et al. 2015), while reefs in Palau were found to have an average of 6.3 juveniles/m² at 10 m depth (Gouezo et al. 2020). However, **more remote locations have been found to have much higher rates of recruitment**; for example, reefs at Palmyra Atoll had an average of 59.5 juveniles/m² (Roth & Knowlton 2009). **While overall mean densities were high, variability between Provinces was substantial**, with mean densities ranging from 3.1 individuals/m² in Namosi to 15.1 individuals/m² in Lau. It should be noted, though, that sample sizes varied widely between Provinces; for example, only three sites were surveyed in Namosi, while 77 were surveyed in Lau. Patterns of juvenile coral diversity were less regular than found in the photoquadrat surveys; while *Acropora*, *Porites*, *Pocillopora* and *Montipora* were consistently the most common genera in photoquadrats, the dominant juvenile coral genera varied from province to province.



Juvenile *Pocillopora* coral at Cicia Island



A science diver, Apolosi Cokanasiga, surveying a site in Ra Province using the photoquadrat method, swimming next to a bommie, which are isolated coral formations
// Joe Lepore

RUGOSITY

Rugosity was high, with an average value of 1.8 across all Provinces. **High structural complexity on reefs is often associated with increased habitat** for fish and other reef organisms, and reefs with higher rugosity may be capable of supporting populations of larger fish (Nemeth & Appeldoorn 2009; Harborne et al. 2012). In some cases, rugosity appeared to be correlated with coral cover, such as in Bua, where mean rugosity and coral cover were both the lowest of all Provinces. However, Ra and Tailevu, which had the highest rugosity estimates, had moderate coral cover, indicating that **larger scale structure may be driving some of the highest rugosity values**. Indeed, many of the 10 m forereef locations surveyed were composed of a series of large bommies, rather than a continuous sloping reef. In cases where the 3D mosaic plots were located on a bommie that was less than 10 m x 10 m in size, rugosity measurements included the vertical sides of the bommie, increasing the rugosity ratio. This is likely the case at Kabara, which had the highest mean rugosity of any island region, and the sites surveyed consisted of small bommie reefs.

INVERTEBRATES

Eighty-five species of macroinvertebrates were recorded in the belt transect surveys, including nine that could not be identified to the species level. Including these unidentified species, the surveys recorded 16 species of **bivalves**, two species of **cephalopod**, one species of **crinoid**, one **crustacean** species, 36 species of **gastropod**, 18 **sea cucumber** species, eight **sea star** species, and three species of **sea urchin**.

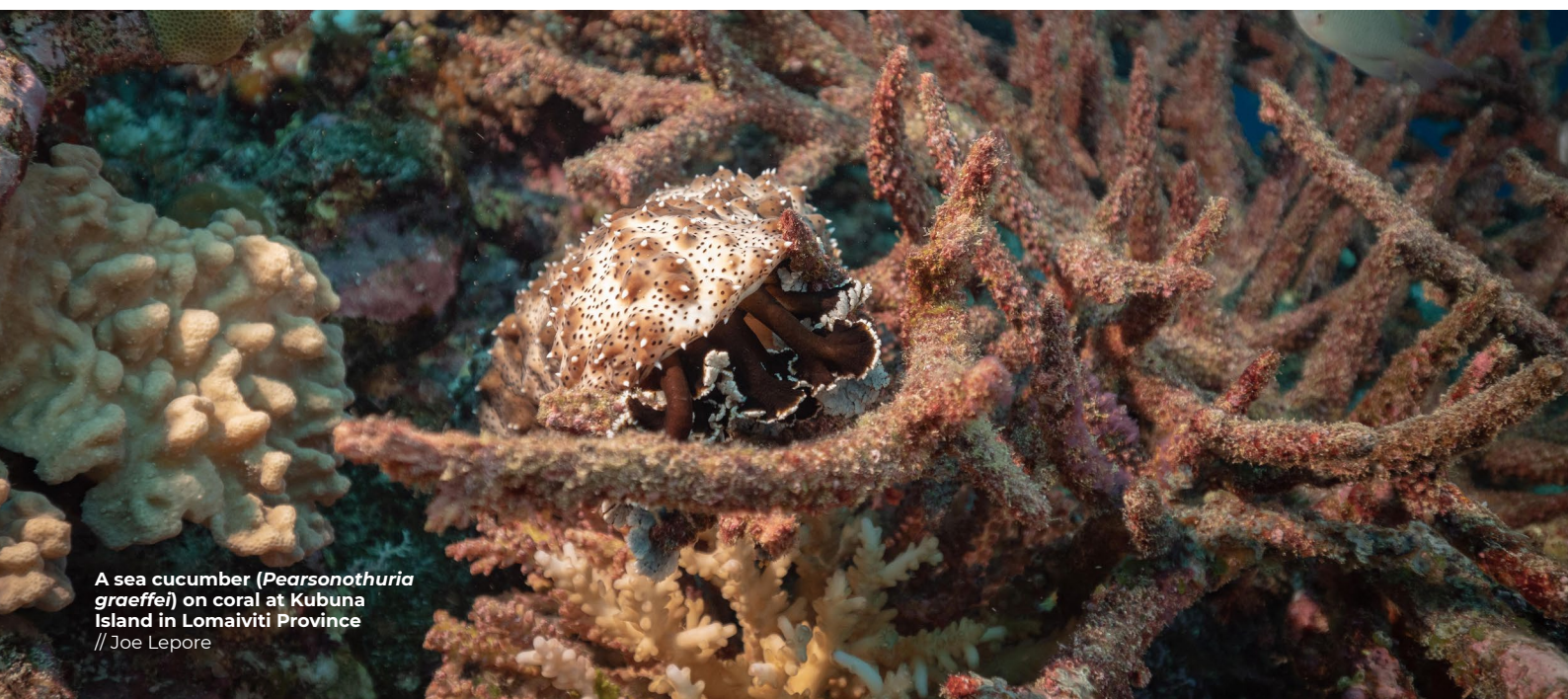
SEA CUCUMBERS

Of the 27 sea cucumber species present in Fiji (Pakoa et al. 2013), 18 were recorded in this survey. This is on par with a previous survey of six Provinces (Bua, Cakaudrove, Macuata, Lau, Lomaiviti and Kadavu) which found 19 species present (Pakoa et al. 2013), and a recent survey of Lau that recorded 15 species (Meo et al. 2021). Three of the species surveyed are considered to have low fisheries value, nine are considered of medium value, five are high value, and one (*Holothuria fuscogлива*) is considered to have very high value (Pakoa et al. 2013). Four species (*A. echinites*, *Actinopyga mauritiana*, *A. miliaris*, and *S. hermannii*) are classified as Vulnerable by the IUCN Red List, while two species (*Holothuria whitmaei* and *T. ananas*) are classified as Endangered (IUCN 2025). While sea cucumber densities could not be reported due to methodological issues, six of the species

were found in only one Province each, and only nine species were abundant enough to form meaningful size frequency distributions, indicating that densities for several species were likely very low. Several previous studies have noted low sea cucumber densities across Fiji, indicating that bêche-de-mer fisheries are overexploited (Teh et al. 2009, Sykes & Morris 2009, Jupiter et al. 2013, Pakoa et al. 2013, Gillett et al. 2014, Bruckner et al. 2016, Miller et al. 2018, Nand et al. 2019, Meo et al. 2021). While Lau had the highest sea cucumber diversity of any Province, this was also the most heavily sampled Province, with 77 sites in total. Conversely, only two species each were found in Serua and Rewa, two of the Provinces with the lowest sampling intensity, suggesting that effort is likely correlated with species diversity to some degree.

TROCHUS

While trochus is an important export commodity in parts of Fiji, participation in this fishery is generally lower than for sea cucumbers (Teh et al. 2009), and less is known about the state of trochus stocks across the country. In this survey, trochus was moderately distributed, with individuals recorded in nine of the thirteen Provinces. However, three of the Provinces where trochus was not present (Serua, Rewa and Namosi) had low sample size, with only three or four sites surveyed in each. Of the trochus that were surveyed, the majority were in the mid-range of sizes (6-12 cm basal diameter).



A sea cucumber (*Pearsonothuria graeffei*) on coral at Kubuna Island in Lomaiviti Province
// Joe Lepore



A giant clam
(*Tridacna derasa*)
at Bua Province
// Joe Lepore

GIANT CLAMS

Six species of giant clam were found in the surveys. *T. gigas*, which had once been declared extinct in Fiji since the 1970s (Lewis et al. 1988, Teh et al. 2009, Ellison & Fiu 2010, Gillett et al. 2014, Bermudes & Rarawa 2018), was found in three Provinces. This species has been reintroduced to Fiji and is actively cultured as a mariculture species at a hatchery in Makogai (Bermudes & Rarawa 2018). Stocks of *T. derasa* were also previously identified as depauperate (Kuster et al. 2005, Gillett et al. 2014), but this was one of the most widely distributed species in the survey, occurring in all but three Provinces. Prior to the 1980s, Fiji was home to the highest stocks of *T. derasa* outside of the Great Barrier Reef (Lewis et al. 1988). While additional assessments would be required to understand the densities of *T. derasa* in the locations where it is present, its extensive distribution is a positive sign. *T. maxima* was the most widespread species, occurring in all 13 Provinces. This is consistent with previous studies that have indicated *T. maxima* as the most common species of giant clam in Fiji (Lewis et al. 1988). Again, Lau had the highest diversity and Namosi was the least diverse, likely due in part to an imbalance in sample size between these Provinces.

SEA URCHINS

Interestingly, no sea urchins were recorded in belt transects in any of the Provinces around Vanua Levu, but they were seen outside of the transect. Surveyors in these Provinces noted seeing instances of several urchin species, including *T. gratilla* (cawaki), *D. setosum*, and *E. calamaris* outside of the belt transects at low densities, indicating that urchins are present, but not abundant, in this region. *D. setosum* was the most widely distributed sea urchin species, while *E. aciculatus* and *E. mathaei* were rare. This is in contrast to a previous study that found that *E. mathaei* was the most common urchin found, though it is possible that the 10 m forereefs surveyed in this study were not the preferred habitat for this species (Coppard & Campbell 2005). The same study also found that *D. setosum* increased in densities shoreward from the forereef due to increased crevice size in the coral bommie zone inshore (Coppard & Campbell 2005), again suggesting that the area surveyed is not the preferred habitat for this species. The collector urchin, cawaki (*T. gratilla*), which is consumed locally in Fiji (Coppard & Campbell 2005, PHAMA 2018, Nalasi et al. 2024), was not recorded in any of the belt transects. Further surveys in known sea urchin habitats would give a more holistic view of the status of sea urchin populations in Fiji.



A Crown-of-Thorns seastar
(*Acanthaster planci*) seen
at Kubuna Island in Tailevu
Province // Anela Akiona

SEA STARS, LOBSTERS & OCTOPUS

COTS were recorded in approximately half of the Provinces surveyed. Although density data could not be presented, there were no reports of dense aggregations at any point during the expedition, suggesting that COTS are likely currently at background densities across the sites surveyed. **Lobsters and octopus** were moderately distributed, appearing in eight and five of the thirteen Provinces surveyed, respectively.

WATER QUALITY

The stable isotope ratio of nitrogen ($^{15}\text{N}:^{14}\text{N}$, expressed as $\delta^{15}\text{N}$), can be used to trace the source of nutrients on a reef (Dailer et al. 2010; Dailer et al. 2012). Typically, natural (atmospheric/oceanic) sources of nitrogen, as well as nitrogen from agricultural runoff, have low $\delta^{15}\text{N}$ values ranging from 0‰ to 4‰ and -4‰ to 4‰, respectively, while sewage tends to have values greater than 7‰ (Dailer et al. 2010; Dailer et al. 2012).

Mean $\delta^{15}\text{N}$ was consistently low across all Provinces, ranging from 0.7‰ in Kadavu to 1.7‰ in Bua. The results indicate that there is no evidence of sewage pollution on 10 m forereefs in any of the Provinces. Even Provinces that are home to large population centers, such as Rewa, had mean $\delta^{15}\text{N}$ values far below what would be expected of sewage runoff, despite previous reports of poor water quality near Suva (Maata & Singh 2008, Lal et al. 2017). While in rural areas, the signals found in this study are likely representative of the true runoff from land. **In urban areas, it is likely that any land-based pollution may have**

been diluted by the time it reached 10 m on the forereef; further testing closer to shore and within lagoons would be needed to get a more accurate picture of true sewage runoff in these areas. However, regardless of potential pollution in shallower, lagoonal sites, sewage was not detected or determined to have an influence on any study sites throughout Fiji.

It is possible, however, that agricultural runoff may be an influence on some of the reefs in this study. The $\delta^{15}\text{N}$ values representative of agricultural runoff (-4‰ to 4‰) overlap with those for atmospheric nitrogen (0‰ to 4‰), so interpretation of results in this range are often context dependent and require knowledge of land use practices near sites and/or additional assessments to determine the true source of nitrogen. However, a small number of negative values in certain Provinces (such as Cakaudrove and Lau) indicate that agricultural runoff is likely at some sites in these Provinces.



An Eschmeyer's scorpionfish (*Scorpaenopsis eschmeyerii*) in Cakaudrove Province (circle) & a school of barracuda (*Sphyraena helleri*) in Macuata Province (bottom) // Joe Lepore

CONSIDERATIONS

Fiji's coral reefs have been extensively studied, and the existing literature gives a strong overview of the large-scale patterns in reef health over time. However, due to the extensive geographic area of the country, and the number of different organisations conducting coral reef assessments, these research efforts have been geographically, temporally, and methodologically fragmented, making comparisons between studies and regions difficult. This study aims to fill this gap by providing a survey of Fiji's reefs across the full extent of the country (save for Rotuma, Kadavu (partial survey), and Ceva-i-Ra) at a single time point, in order to provide a baseline view of the current state of Fiji's reefs. Standardisation of survey methods and habitats was prioritised in order to ensure comparability between regions. In this way, direct comparisons between Provinces can be made for the first time, and managers will have access to a nationwide view of reef health to prioritise effective reef management initiatives.

While the benefits of this standardised approach are numerous, differences between the design of this survey and previous studies means that comparisons can be difficult for several reasons. While the differences in these studies do not invalidate their respective merits, it does mean that caution should be taken when constructing trends or identifying patterns between different surveys.

METHODOLOGY

Different methods for assessing the same metrics can often produce varying results. For example, this survey used photoquadrats to assess benthic cover, while point intercept transects (PIT) have been previously used in many assessments of Fiji's reefs. These two methods have been demonstrated to produce different estimates of coral cover. One comparative study of different benthic survey methods showed that PIT surveys estimated significantly higher percent coral cover than other methods, and consistently overestimated coral cover compared to photoquadrats, sometimes returning estimates twice as high as photographic methods (Jokiel et al. 2015). Some surveys use similar methods but

focus on different taxa; for example, this survey included all fish families in the assessment, whereas other surveys have commonly restricted their target species list to families that are commercially, societally, or ecologically important.

HABITATS SURVEYED

Fiji's reef system is widespread and heterogeneous, and different habitats are known to host different fish, benthic and invertebrate assemblages. To control for this, only 10 m forereef habitats were included in this study. However, inshore reefs are often preferentially selected for coral reef assessments, as they are easier to access and more likely to be impacted by human activities. Coral cover has been shown to vary widely in different reef habitats; for example, one study found that nearshore reefs on the Great Barrier Reef had twice the coral cover of mid- and outer-shelf reefs (Morgan et al. 2016). Similarly, habitat has a strong influence on reef fish biomass, as demonstrated by another study from the Great Barrier Reef which estimated parrotfish biomass on exposed outer shelf sites as three times greater than in other habitat zones (Gust et al. 2001). Reef habitat significantly affects fish community composition (Jankowski et al. 2015), which will also affect overall biomass estimates, particularly when only certain fish families are included in surveys.

VARIABILITY IN BIOLOGY

Regardless of methods used or habitats surveyed, natural variability will always result in differing estimates when assessing reef health in situ. Even if the exact same methods are used at the same site, estimates of benthic cover and fish communities are likely to differ. Reef ecosystems are dynamic and constantly changing. Patchy species distributions, variation in transect placement, seasonality, and time of day can all affect survey results, especially for mobile taxa such as fish. For example, the presence of a few large schools of fish within the survey area can dramatically impact fish biomass; however, if surveys are conducted at a different time or on a different day, it is possible that these schools would not cross through the surveyors' belt transects, leading to significantly different estimates for the same site.

RECOMMENDATIONS

Recommendations are ranked in order of importance.

Create standardised guidelines for coral reef assessments.

While Fiji's reefs are well studied, most coral reef assessments have used different survey methodologies, making comparisons between regions and time points difficult. Many different organisations within Fiji have interest in conducting coral reef surveys (e.g., government, universities, NGOs, community groups), however their motivations for doing so may differ slightly, necessitating variations in survey design. To accommodate the need for standardisation while still accommodating flexibility in experimental design, it is recommended that a set of guidelines for coral reef assessments be developed. These guidelines would provide technical support for decision making when planning an assessment, such as guidance on site selection, survey methodology, and data analysis, but would not be prescriptive, allowing each organisation to tailor surveys to their needs. In this way, members of the coral reef community in Fiji can work together to ensure consistent and comparable data collection while still achieving their individual goals.

Focus on prioritised and strategic capacity building to equip Fiji with the skills, tools and financial resources necessary to complete this work independently.

In order for future monitoring initiatives to be sustainable, it is important that Fiji have the capacity to complete the work independently. Therefore, working to establish the necessary technical expertise, infrastructure, and funding resources needed to support this type of work in the future is key. To ensure the appropriate investments in capacity building, clear goals

and priorities should be outlined, which support the needs of the country of Fiji. Skills, tools and resources to prioritise include:

- Finance - Operational funding
- Cross Ministry Process Approval - Channels of approval outlined for quicker turnaround time
- Cross Ministry Coordination and Communication - Brokered coordination, strategic planning, alignment, and transparency
- Technical Capacity
 - Ensure staff have proper certifications (e.g., diving certifications)
 - Ensure staff have access to appropriate software, methodology, and other administrative needs
 - Standardised data collection techniques
- Equipment - Internet connectivity in the field, etc.
- Centralized Data Repository - including access, updates and version archiving

Establish a bi-directional national data-sharing framework and a common access point to enhance the accessibility, security, and utility of Fiji's ecological research data.

This system would connect ministry databases with NGO and academic repositories, building on Cabinet's recent endorsement of a national Marine Scientific Research (MSR) approval process, which emphasises cross-ministry coordination and data management for MSR activities. A unified access point would facilitate timely sharing of critical datasets, promote the adoption of common standards, and integrate existing platforms, strengthening Fiji's commitments to coordinated ocean governance and evidence-based decision-making. This repository would create a pathway and storage location for data from NGOs and academic sources within the government, allowing for transparency and clear data sharing between organisations.

A leopard shark (*Stegostoma tigrinum*) at Wailagilala in Lau Province // Gilles Siu



RECOMMENDATIONS (CONTINUED)

Expand the range of this survey to include unsurveyed islands and coasts, additional depth strata and habitat types.

While efforts were made to ensure that data generated in this study covered the full extent of the country, not all islands were able to be included, and surveys were constrained to leeward coasts to ensure safe diving conditions. In addition, weather precluded safe diving in some parts of the country, and Rotuma could not be surveyed due to its remoteness from the main islands. Conducting additional surveys in the areas not included in this study would help create a more holistic understanding of the state of Fiji's reefs, and would provide useful information to the communities located in these unsurveyed areas.

In addition, only forereef sites at 10 m depth were surveyed. However, coral reef communities vary widely between different depth strata, and reefs at different depths are affected differently by anthropogenic and physical forces such as fishing and temperature fluctuations. Similarly, reef communities vary widely between different habitats, with forereefs serving different ecological functions and comprising different species assemblages than lagoons, back reefs, and other reef habitats. Different habitats are also utilised differently by coastal communities, and thus may see different pressures despite being in close geographic proximity. Expanding this survey effort to include additional depth strata and habitat types will help create a more comprehensive understanding of coral reef health and function across the country, and may help identify locations for additional management (e.g., areas exposed to high fishing pressure, areas of particular ecological significance, etc.).

Plan to resurvey existing sites over time. All sites surveyed in this study were marked with a GPS point and a permanent marker, making resurvey of the exact same reef area possible. While the data presented in this

study represent a snapshot of reef condition at a given point in time, resurveying sites allows for an understanding of trends and changes over time. These data are useful in understanding the effects of human pressures, climate change, and management actions on reefs, and can help inform future management initiatives. If possible, future resurveys should follow the methodology outlined in this study in order to produce directly comparable results between time points and locations.

Collect temperature loggers to help understand nearshore temperature dynamics over time.

Temperature loggers were deployed at a subset of sites across the country, and set to collect measurements at 45 minute intervals. At this rate of data collection, the loggers have sufficient battery life to collect data for several years (>5 years). Once collected, the data from these loggers can help understand temperature dynamics over various temporal (days, months, years) and geographic (site, island, Province) scales. In concert with survey data, these temperature data can be used to shed light on reef dynamics, such as coral bleaching, algal cover, fish recruitment, etc.

Conduct additional invertebrate surveys, targeting preferred habitats for commercially important species.

While macroinvertebrates were surveyed in this study, the 10 m forereefs targeted by this survey are not necessarily the preferred habitat of the most commercially or ecologically important species. Some taxa, such as sea cucumbers or trochus, prefer shallower inshore habitats such as reef flats or lagoons. Therefore, the distributions presented in this report are likely an underestimate of the full ranges of these species. Additionally, density could not be reported in this survey due to methodological issues with data collection. Clarifying methods to allow for the calculation of density will provide an additional layer of information that will help support appropriate management of these important organisms.

APPENDICES

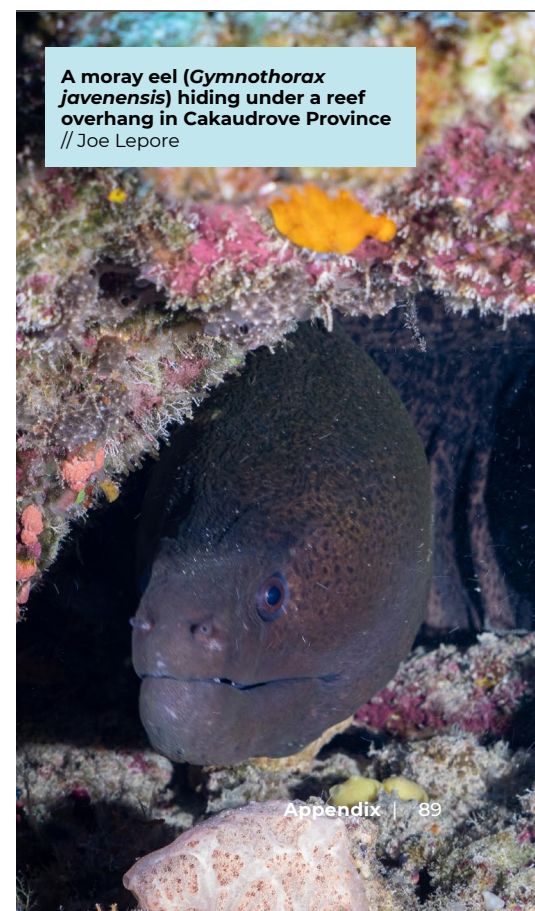
Appendix 1

METHODOLOGY

SITE SELECTION

Survey areas were chosen strategically, considering ecological significance, relevance to ongoing monitoring, and potential to visit areas that have not yet been surveyed in previous studies. Sites were selected near both inhabited and uninhabited islands to support broader data collection on coral reef ecosystems and potential human impacts. All sites were located on the forereef at 10 m depth. Efforts were made to ensure that sites were at least 2 km apart from each other to avoid pseudoreplication. Sites that had not previously been surveyed in previous studies were purposefully chosen in order to provide complementary information that may facilitate a more complete understanding of spatial trends and differences within regions. Weather and operating considerations were incorporated into the final dive site selection, and not all areas initially scoped were able to be surveyed due to weather.

While efforts were made to collect all data streams at each site, in some cases conditions prevented a subset of surveys from being completed. Appendix 2 identifies which surveys were conducted at each site surveyed. All available data from each survey type were used in the analysis.



A moray eel (*Gymnothorax javanensis*) hiding under a reef overhang in Cakaudrove Province
// Joe Lepore

FISH

Underwater visual census approaches in the form of belt transect methods were used to enumerate the density, size structure, biomass and species composition of the reef fish assemblage at each reef. At each site, divers laid out three 25 m transect lines along the reef, identifying and estimating the length of all fishes to the nearest 5 cm size class along each transect. Fish abundance estimates were made by means of two passes for each 25m transect: on the outward swim, the divers surveyed an 8 m width (200m² area) for individuals >20 cm total length (TL), and on the return swim, a 4 m width (100m² area) was surveyed for species ≤20 cm TL. All fish were identified to the species level where possible.

Following the original publication of the report, the fish species list was revised based on known distributions of the species recorded in the survey. Fish species distributions were confirmed using FishBase, species identification books, and consultations with local experts. Entries originally included on the species list that were determined to be out of range were examined and corrections were made based on the outcome of the quality control process. In cases where the correct species name could be confidently identified, the entry(ies) was changed; if the correct species name could not be reliably determined, then the entry was recorded to the genus or family level.

Trophic groupings for each fish species surveyed were assigned using the best available information from FishBase and the published literature. Biomass was estimated using the length-weight equation $W = aL^b$, where W is the weight of the fish in grams, L is the total length of the fish in cm, a is the species-specific scaling coefficient, and b is a species-specific shape parameter related to body shape. a and b values were selected using Akiona et al. (2025).

BENTHIC COVER

Benthic cover was estimated using photoquadrats taken of the benthos at each site. Following the completion of each fish belt transect survey, **divers collected photoquadrat images along the same transect line, taking photos every 2 m, for a total of 13-15 photos per transect.** A monopod was attached to each

camera to ensure that photos were taken from a fixed distance and covered the same area of the benthos (approximately 0.72m² per photo).

Photoquadrat images from the expedition were analyzed using the image analysis software ReefCloud (AIMS 2024), which projects 25 random points onto each image. The taxon under each randomly generated point was identified to the lowest taxonomic level possible in order to determine percent cover of each taxon. Photoquadrat analysis was undertaken by a group of analysts based out of the University of the South Pacific in Suva, Fiji.

Following initial annotation by the USP analysts, quality control procedures were conducted by the Sandin Lab at the Scripps Institution of Oceanography to ensure data accuracy. Three random images from each transect ($n=9$ images per site) were checked for accuracy. If the accuracy of these images was found to be $\geq 90\%$, no further quality control measures were undertaken. If the accuracy of these images was $<90\%$, then all images from the site were checked and corrected.

CORAL RECRUITMENT

Coral juveniles were identified using large-area imagery techniques. At each site, a **10 m x 10 m plot** was selected to be surveyed using this method. To capture the imagery, a diver swam a specialized camera rig containing two Nikon D780 SLR cameras set to different focal lengths (24 mm and 60 mm) in a double lawnmower pattern (Figure 15) approximately 1.5m above the reef at each site. As the diver slowly swam the plot, the cameras took photographs of the benthos each second, creating a set of approximately 3000 photos of each plot, all with high overlap between adjacent images, which can be stitched together to form a 3D model.

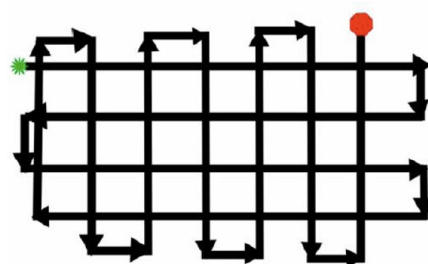


FIGURE 15: Schematic of diver survey pattern to collect images of mosaic plot.

3D models of each plot are reconstructed using the commercially available Structure from Motion (SfM) based software Agisoft Metashape to fuse raw imagery from the 24 mm camera to create 3D point clouds. These point clouds can then be analyzed using a specially developed software, Viscore, allowing data to be extracted from the models. Viscore allows for the visualization of the 3D model and raw imagery, as well as the ability to measure reef features to mm-scale resolution (Figure 16).

For the juvenile coral analysis, a 10 m x 10 m area was defined on each photomosaic, and 1m x 1m quadrats were drawn inside this area. Five randomly selected quadrats were analyzed per model. Within each quadrat, the raw imagery used to build the mosaic was searched, and all coral juveniles less than 5 cm in maximum diameter were identified to the lowest taxonomic level possible.

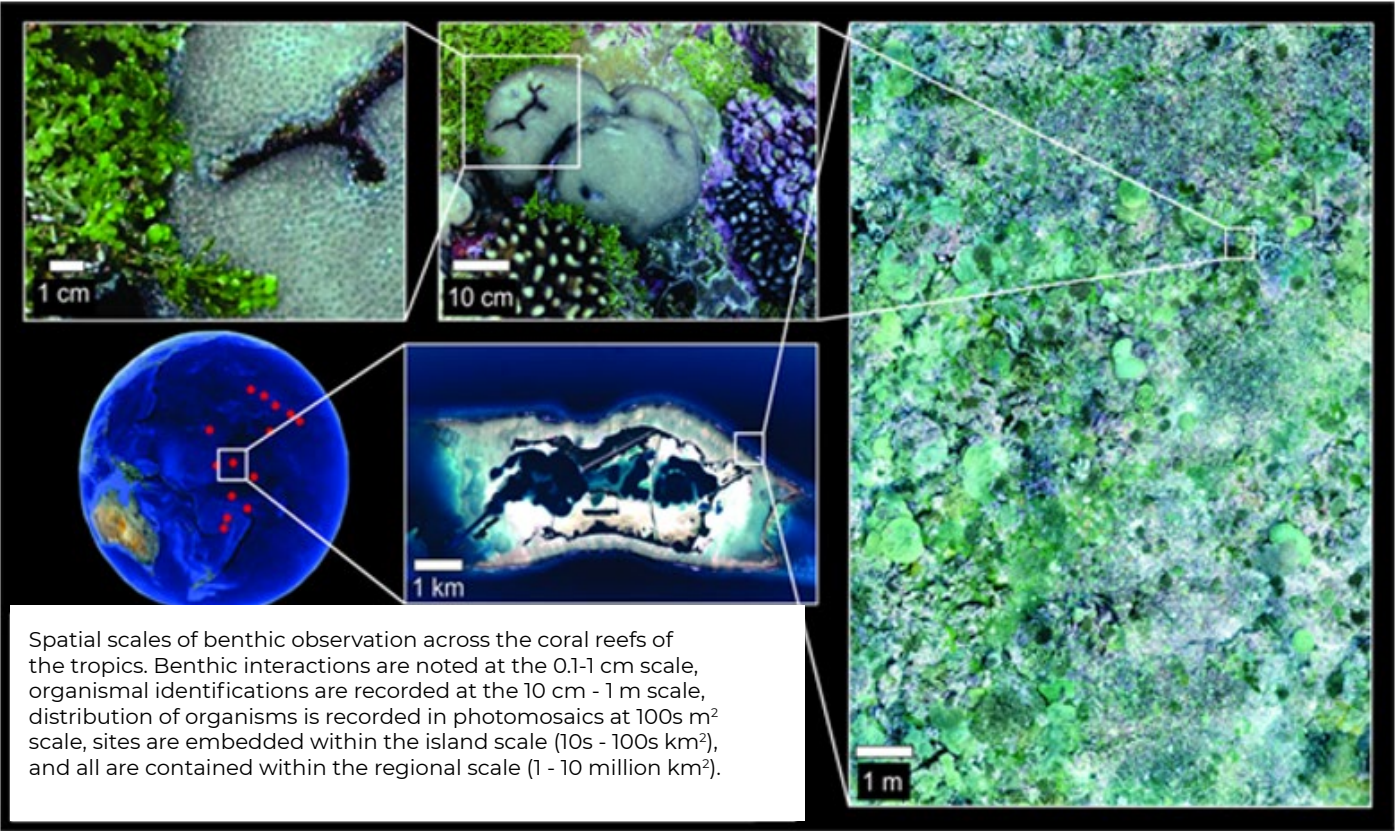


FIGURE 16:
Schematic showing the different scales of resolution afforded by the large-area imagery methodology.

RUGOSITY

Rugosity data were collected from the 3D models described above using a simulated point gauge approach (McCormick 1994). In Viscore, a 10 m x 10 m area was defined on each mosaic. Point clouds that had noticeable noise (i.e., errant points floating above the reef surface) were cleaned up using Viscore's point confidence function prior to collecting rugosity measurements. Within this area, 100 parallel transects spaced 10 cm apart were sampled in an alongshore direction across the model. Along each transect, depths were sampled every 10 cm following the contours of the reef from a top-down perspective. The length of each transect following the depth contours was divided by the linear length of the transect (in this case, 10 m) to calculate the rugosity ratio for each transect. The rugosity ratios for all 100 transects were then averaged to produce a mean rugosity value for each site. A ratio of 1 indicates a completely flat reef, with increasing values indicating more complex reefs.

MACROINVERTEBRATES

Estimates of key macro-invertebrate species were made using modified transect methodologies as outlined by the Global Coral Reef Monitoring Network (GCRMN; Hill & Wilkinson 2004). To summarise, at each site a diver estimated the number of macro-invertebrates found along the three 25 m transects used for fish and photoquadrat surveys. For each survey, a 4 m wide swath was inspected for invertebrates, yielding a 100m² survey area for each transect. Certain economically and ecologically important invertebrates were measured along their longest axis or widest diameter. Due to methodological issues with data collection, density estimates could not be reported. However, data quality was high enough to confidently report presence/absence. Size data were used to construct size frequency distributions for relevant species. A full list of invertebrate species recorded in the belt transect surveys is listed in Appendix 6, while only select economically and ecologically important invertebrates are reported in the text.

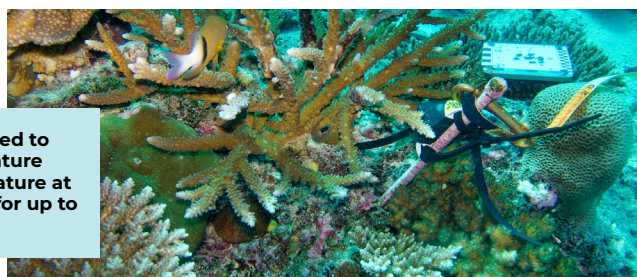
WATER QUALITY

Stable isotope ($\delta^{13}\text{C}$ – $\delta^{15}\text{N}$) approaches were used to assess water quality across Fiji. These water quality assessments were made by collecting five samples of the calcified macroalga *Halimeda* spp. along the three transects at each site. In some cases, where algal cover was low or if *Halimeda* was not present at a site, samples of *Tydemania expeditionis* were collected instead, as previous studies have shown similar values for these two taxa (e.g., Noo Raajje 2025). If less than five samples of either taxa were present at a site, fewer samples were collected. For each site, three replicate samples (where available) were randomly selected for stable isotope analysis. See Appendix 2 for a list of sites where algae samples were collected.

Samples were first rinsed with fresh water, dried in a salad spinner to remove excess water, and dried overnight in a food dehydrator. Samples were wrapped in aluminum foil packets for storage and transport. Once in the lab, samples were rinsed with deionized water and decalcified for 24 hours in a 5% HCl solution. Samples were then triple rinsed with deionized water and placed in a food dehydrator to dry for 48 hours. Dried samples were then ground into a fine powder using a Wig-L-Bug amalgamator, and 2.5mg ($\pm$ 0.5mg) of each sample was packed into foil for analysis. Samples were analysed using mass spectrometry at the UC Davis Stable Isotope Facility for $\delta^{15}\text{N}$, total N, $\delta^{13}\text{C}$ and total C.

TEMPERATURE LOGGERS

At a subset of sites (Appendix 2), a temperature logger (Onset HOBO Tidbit MX) was deployed at 10 m depth, on one of the stainless-steel stakes used to mark the large area imagery plots. Loggers were wrapped in electrical tape to prevent fouling and were set to record measurements every 45 minutes. Loggers will be collected for analysis at a later date.



A temperature logger fixed to a relocation pin; temperature loggers collect a temperature at depth every 45 minutes for up to five years // Gilles Siu

Appendix 2

SITE METADATA

Site metadata for all sites surveyed. Codes for “Data Collected” are as follows: B=benthic photoquadrats, F=fish, M=mosaic, I=invertebrates, A=algae collected, T=temperature logger installed. Temperature loggers were only installed at a subset of sites.

Notes on sites with irregular or missing data:

- **Sites with no algae data:** in some cases, neither *Halimeda* spp. or *T. expeditionis* were present at a given site. In this case, no algae was collected at that site.
- **Sites with missing latitude/longitude:** rough dive conditions precluded the ability to collect accurate coordinates for two sites
- **Sites with missing benthic photoquadrats or mosaic data:** camera malfunctions or rough diving conditions prevented collection of benthic imagery at some sites.
- **Sites with missing invertebrate data:** rough diving conditions and misplaced data sheets prevented data collection/data entry in some cases.
- **Site VBA_62:** this site was selected for the deployment of an array of temperature loggers at different depths, to understand temperature variability across depth gradients. Temperature loggers were deployed at this site, but no other data were collected. No data from this site is included in this report.

PROVINCE	STATION ID	LATITUDE	LONGITUDE	DATA COLLECTED
Ba	BAP_68	-17.31434	177.8477	B, F, M, I, A, T
Ba	BAP_69	-17.33373	177.81165	B, F, M, I
Ba	BAP_71	-17.35831	177.64646	B, F, M, I, A, T
Ba	YAS_76	-17.05722	177.33369	B, F, M, I, A
Ba	YAS_78	-16.97422	177.38927	B, F, M, I, A, T
Ba	YAS_80	-16.90305	177.44698	B, F, M, I, A
Ba	YAS_75	-16.65821	177.60089	B, F, M, I, A, T
Ba	YAS_77	-16.70928	177.59589	B, F, M, I, A
Ba	YAS_79	-16.79335	177.52917	B, F, M, I, A
Ba	YAS_82	-16.68346	177.55212	B, F, M, I, A
Ba	YAS_84	-16.75018	177.52666	B, F, M, I, A, T
Ba	YAS_86	-16.8083	177.44353	B, F, M, I, A
Ba	YAS_81	-16.89881	177.37878	B, F, M, I, A
Ba	YAS_83	-16.9535	177.31967	B, F, M, I, A, T
Ba	YAS_85	-17.06114	177.23137	B, F, M, I, A
Ba	YAS_88	-17.12195	177.32721	B, F, M, I, A
Ba	YAS_90	-17.17556	177.29575	B, F, M, I, A, T
Ba	YAS_92	-17.2244	177.29222	B, F, M, I, A

PROVINCE	STATION ID	LATITUDE	LONGITUDE	DATA COLLECTED
Ba	YAS_87	-17.11257	177.18245	B, F, M, I, A
Ba	YAS_89	-17.15139	177.16711	B, F, M, I, A, T
Ba	YAS_91	-17.19638	177.16371	B, F, M, I, A
Ba	YAS_93	-17.26271	177.09869	B, F, M, I, A
Ba	YAS_95	-17.28877	177.08846	B, F, M, I, A, T
Ba	YAS_97	-17.30348	177.08894	B, F, M, I, A
Ba	YAS_96	-17.46018	177.03302	B, F, M, I, A, T
Ba	YAS_98	-17.50155	177.04837	B, F, M, I, A
Ba	YAS_94	-17.38953	177.07867	B, F, M, I, A
Ba	YAS_100	-17.15662	176.92543	B, F, M, I, A
Ba	YAS_102	-17.11282	176.90356	B, F, M, I, A, T
Ba	YAS_99	-17.10743	176.94452	B, F, M, I, A
Ba	YAS_101	-17.19202	176.87627	B, F, M, I, A, T
Bua	GSR_92	-16.304397	178.728345	B, F, M, I, A
Bua	GSR_93	-16.294574	178.637896	B, F, M, I, A, T
Bua	GSR_94	-16.282893	178.527207	B, F, M, I, A
Bua	GSR_95	-16.317888	178.40739	B, F, M, I, A
Bua	GSR_96	-16.391033	178.318863	B, F, M, I, A
Bua	GSR_97	-16.406587	178.168648	B, F, M, I, A
Bua	GSR_98	-16.434217	178.0384	B, F, M, I, A, T
Bua	GSR_99	-16.501884	177.93797	B, F, M, I, A, T
Cakaudrove	CVU_59	-16.116644	-179.52756	B, F, M, I, A
Cakaudrove	CVU_61	-16.071946	-179.525743	B, F, M, I, A, T
Cakaudrove	CVU_63	-16.059484	-179.591335	B, F, M, I, A
Cakaudrove	CKE_22	-16.829642	179.321164	B, F, M, I, A
Cakaudrove	CKE_23	-16.835856	179.272514	B, F, M, I, A
Cakaudrove	CKE_24	-16.817357	179.446588	B, F, M, I, A
Cakaudrove	CKE_25	-16.810965	179.397342	B, F, M, I, A, T
Cakaudrove	CKE_26	-16.814845	179.574348	B, F, M, I, A, T
Cakaudrove	CKE_27	-16.817606	179.512912	B, F, M, I, A
Cakaudrove	CKE_28	-16.776637	179.637786	B, F, M, I, A
Cakaudrove	CKE_29	-16.803779	179.603568	B, F, M, I, A
Cakaudrove	CKE_30	-16.750964	179.740481	B, F, M, I, A
Cakaudrove	CKE_31	-16.758166	179.701979	B, F, M, I, A, T
Cakaudrove	CKE_32	-16.789316	179.852249	B, F, M, I, A, T
Cakaudrove	CKE_33	-16.755506	179.807429	B, F, M, I, A
Cakaudrove	LAU_41	-16.81701	-179.73163	B, F, M, I, A
Cakaudrove	LAU_43	-16.788882	-179.662656	B, F, M, I, A, T
Cakaudrove	LAU_45	-16.704114	-179.661956	B, F, M, I, A
Cakaudrove	NAT_70	-16.369429	179.796118	B, F, M, I, A
Cakaudrove	NAT_71	-16.469923	179.740174	B, F, M, I, A, T
Cakaudrove	NAT_72	-16.247141	179.898201	B, F, M, I, A
Cakaudrove	NAT_73	-16.309679	179.844063	B, F, M, I, A, T
Cakaudrove	NAT_75	-16.194051	179.969765	B, F, M, I, A
Cakaudrove	NUK_40	-16.731256	-179.452154	B, F, M, I, A
Cakaudrove	NUK_42	-16.666224	-179.418741	B, F, M, I, A, T
Cakaudrove	NUK_44	-16.579915	-179.354032	B, F, M, I, A
Cakaudrove	NUK_46	-16.559645	-179.3933	B, F, M, I, A
Cakaudrove	NUK_47	-16.343345	-179.391169	B, F, M, I, A
Cakaudrove	NUK_48	-16.501065	-179.43146	B, F, M, I, A
Cakaudrove	NUK_49	-16.314997	-179.439123	B, F, M, I, A
Cakaudrove	NUK_50	-16.441741	-179.437914	B, F, M, I, A, T
Cakaudrove	NUK_51	-16.28247	-179.447999	B, F, M, I, A, T

PROVINCE	STATION ID	LATITUDE	LONGITUDE	DATA COLLECTED
Cakaudrove	QEL_54	-16.048651	-179.268243	B, F, M, I, A
Cakaudrove	QEL_55	-16.093449	-179.152735	B, F, M, I, A
Cakaudrove	QEL_56	-16.046457	-179.364735	B, F, M, I, A
Cakaudrove	QEL_57	-16.026919	-179.318529	B, F, M, I, A, T
Cakaudrove	TAV_34	-16.998985	179.948554	B, F, M, I, A
Cakaudrove	TAV_35	-16.979929	179.879409	B, F, M, I, A, T
Cakaudrove	TAV_36	-16.887912	-179.911655	B, F, M, I, A
Cakaudrove	TAV_37	-16.948155	-179.985438	B, F, M, I, A
Cakaudrove	TAV_38	-16.816029	-179.848559	B, F, M, I, A, T
Cakaudrove	TAV_39	-16.881609	-179.870401	B, F, M, I, A
Cakaudrove	VET_58	-15.953522	-179.40046	F, M, I, A, T
Cakaudrove	VET_60	-15.9417	-179.399675	B, F, M, I, A
Cakaudrove	VET_62	-15.949944	-179.416153	B, F, M, I, A
Cakaudrove	YAN_64	-16.442213	-179.666916	B, F, M, I, A
Cakaudrove	YAN_65	-16.562977	-179.69424	B, F, M, I, A
Cakaudrove	YAN_66	-16.47066	-179.71598	B, F, M, I, A
Cakaudrove	YAN_67	-16.53332	-179.65669	B, F, M, I, A, T
Cakaudrove	YAN_68	-16.4736	-179.762484	B, F, M, I, A, T
Cakaudrove	YAN_69	-16.497727	-179.64087	B, F, M, I, A
Kadavu	GAR_22	-18.72757	178.48286	B, F, M, I, A
Kadavu	GAR_24	-18.70082	178.53249	B, F, M, I, A, T
Kadavu	GAR_26	-18.7488	178.55838	B, F, M, I, A
Kadavu	GAR_23	-18.76539	178.46597	B, F, M, I, A
Kadavu	GAR_25	-18.84851	178.5946	B, F, M, I, A
Kadavu	GAR_27	-18.79938	178.58839	B, F, M, I, A, T
Kadavu	NAR_28	-18.67747	178.53458	B, F, M, I, A
Kadavu	NAR_30	-18.62082	178.55821	B, F, M, I, A
Kadavu	NAR_29	-18.64927	178.55496	B, F, M, I, A
Kadavu	NAR_31	-18.61768	178.55096	B, F, M, I, A
Kadavu	NAR_33	-18.60782	178.53481	B, F, M, I, A, T
Lau	BUK_38	-18.21069	-178.26907	B, F, M, I, A, T
Lau	BUK_40	-18.26997	-178.23314	B, F, M, I, A
Lau	BUK_42	-18.33026	-178.41978	B, F, M, I, A
Lau	CAK_67	-16.74098	-178.95139	B, F, M, I, A, T
Lau	CAK_69	-16.80128	-178.92949	B, F, M, I, A
Lau	CAK_71	-16.84729	-178.93518	B, F, M, I, A
Lau	CIC_47	-17.71689	-179.32396	B, F, M, I, A, T
Lau	CIC_45	-17.76227	-179.35187	B, F, M, I, A
Lau	FUL_27	-19.09193	-178.58725	B, F, M, I, A
Lau	FUL_25	-19.12782	-178.61662	B, F, M, I, A
Lau	FUL_29	-19.12187	-178.53857	B, F, M, I, A, T
Lau	KNC_65	-17.23257	-179.10614	B, F, M, I, A, T
Lau	KNC_64	-17.2326	-179.15691	B, F, M, I, A
Lau	KNC_66	-17.19551	-179.08298	B, F, M, I, A
Lau	KIB_61	-17.02892	-179.03851	B, F, M, I, A, T
Lau	KIB_63	-17.05246	-179.05493	B, F, M, I, A
Lau	KOM_36	-18.65747	-178.62415	B, F, M, I, A, T
Lau	KOM_34	-18.69527	-178.61658	B, F, M, I, A
Lau	KOM_32	-18.66477	-178.61336	B, F, M, I, A
Lau	KBA_20	-18.92854	-178.97575	B, F, M, I, A
Lau	KBA_22	-18.9221	-178.93759	B, F, M, I, A, T
Lau	LAK_51	-18.16923	-178.79906	B, F, M, I, A, T
Lau	LAK_53	-18.25069	-178.81454	B, F, M, I, A

PROVINCE	STATION ID	LATITUDE	LONGITUDE	DATA COLLECTED
Lau	MAT_83	-19.10372	179.75352	B, F, M, I, A, T
Lau	MAT_81	-19.16961	179.80682	B, F, M, I, A
Lau	MAT_84	-19.16765	179.7225	B, F, M, I, A
Lau	MOA_02	-18.66235	179.91568	B, F, M, I, A, T
Lau	MOA_04	-18.59266	179.97221	B, F, M, I, A
Lau	MOA_06	-18.52027	179.96497	B, F, M, I, A
Lau	MOA_05	-18.55868	179.87791	B, F, M, I, T
Lau	MOA_01	-18.65985	179.83273	B, F, M, I, A
Lau	MOA_03	-18.59506	179.80341	B, F, M, I, A
Lau	NAM_23	-18.84313	-178.59174	B, F, M, I, A, T
Lau	NAM_19	-18.86733	-178.67957	B, F, M, I, A
Lau	NAM_21	-18.87884	-178.62573	B, F, M, I, A
Lau	NTU_75	-18.65585	-179.57674	B, F, M, I, A, T
Lau	NTU_77	-18.68587	-179.58904	B, F, M, I, A
Lau	NTU_78	-18.67229	-179.54669	B, F, M, I, A
Lau	OGA_30	-19.09775	-178.38841	B, F, M, I, A, T
Lau	OGA_26	-19.16849	-178.45219	B, F, M, I, A
Lau	OGA_28	-19.12393	-178.43291	B, F, M, I, A
Lau	ONE_41	-18.37384	-178.49632	B, F, M, I, A, T
Lau	ONE_39	-18.44229	-178.53677	B, F, M, I, A
Lau	ONE_37	-18.45631	-178.46077	B, F, M, I, A
Lau	ONO_14	-20.69574	-178.73648	B, F, M, I, A
Lau	ONO_18	-20.62341	-178.67453	B, F, M, I, A
Lau	ONO_16	-20.63442	-178.76616	B, F, M, I, A, T
Lau	TOT_79	-18.97314	-179.90686	B, F, M, I, A
Lau	TOT_80	-18.88754	-179.86909	B, F, M, I, A, T
Lau	TOT_82	-18.90983	-179.78131	B, F, M, I, A
Lau	TUC_08	-21.01705	-178.75786	B, F, M, I, A
Lau	TUC_12	-21.01384	-178.74026	B, F, M, I, A, T
Lau	TUC_10	-21.00386	-178.75027	B, F, M, I, A
Lau	TUR_09	-21.0269	-178.84984	B, F, M, I, A, T
Lau	TUR_11	-21.04546	-178.83702	B, F, M, I, A
Lau	TUR_07	-21.04823	-178.85774	B, F, M, I, A
Lau	VBA_59	-17.13386	-179.0545	B, F, M, I, A
Lau	VBA_55	-17.17147	-178.88589	B, F, M, I, A, T
Lau	VBA_57	-17.15333	-179.01309	B, F, M, I, A
Lau	VBA_56	-17.30148	-179.03108	B, F, M, I, A, T
Lau	VBA_58	-17.24355	-179.02422	B, F, M, I, A
Lau	VBA_60	-17.16555	-179.07025	B, F, M, I, A
Lau	VBA_62	-17.24331	-179.02538	T
Lau	VVA_73	-18.35976	-179.24855	B, F, M, I, A
Lau	VVA_74	-18.34336	-179.27802	B, F, M, I, A, T
Lau	VVA_76	-18.37707	-179.257	B, F, M, I, A
Lau	VUQ_24	-18.83876	-178.87619	B, F, M, I, A
Lau	VUO_17	-20.73647	-178.85881	B, F, M, I, A
Lau	VUO_13	-20.7562	-178.8987	B, F, M, I, A
Lau	VUO_15	-20.73169	-178.89171	B, F, M, I, A, T
Lau	WAI_68	-16.7373	-179.10005	B, F, M, I, A, T
Lau	WAI_72	-16.7793	-179.1248	B, F, M, I, A
Lau	WAI_70	-16.77972	-179.08115	B, F, M, I, A
Lau	YAG_31	-18.90576	-178.5466	B, F, M, I, A
Lau	YAG_35	-18.98407	-178.41852	B, F, M, I, A
Lau	YAG_33	-18.89607	-178.45621	B, F, M, I, A, T

PROVINCE	STATION ID	LATITUDE	LONGITUDE	DATA COLLECTED
Lomaiviti	GAU_01	-18.001618	179.185126	B, F, M, I, A
Lomaiviti	GAU_02	-17.950579	179.24813	B, F, M, I, A
Lomaiviti	GAU_03	-17.931016	179.277588	B, F, M, I
Lomaiviti	GAU_04	-18.072022	179.239116	B, F, M, I, A
Lomaiviti	GAU_05	-18.056321	179.177503	B, F, M, A, T
Lomaiviti	GAU_06	-18.140407	179.33595	B, F, M, I, A
Lomaiviti	GAU_07	-18.131588	179.281802	B, F, M, I, A
Lomaiviti	GAU_08	-18.035325	179.35918	B, F, M, I, A, T
Lomaiviti	GAU_09	-18.080611	179.372724	B, F, M, I, A
Lomaiviti	KUB_40	-17.74263	178.83377	B, F, M, I, A, T
Lomaiviti	KUB_42	-17.57892	178.85187	B, F, M, I, A
Lomaiviti	KUB_41	-17.6241	178.83762	B, F, M, I, A
Lomaiviti	MAK_18	-17.493261	178.981329	B, F, M, I, A
Lomaiviti	MAK_20	-17.427437	178.982427	B, F, M, I, A, T
Lomaiviti	MAK_21	-17.508316	178.961414	B, F, M, I, A
Lomaiviti	NAI_10	-17.732437	179.414191	B, F, M, I, A
Lomaiviti	NAI_11	-17.769751	179.44692	B, F, M, I, A, T
Lomaiviti	NAI_12	-17.806596	179.290593	B, F, M, I, A, T
Lomaiviti	NAI_13	-17.908285	179.428127	B, F, M, I, A
Lomaiviti	NAI_15	-17.853063	179.396488	B, F, M, I, A
Lomaiviti	WAA_16	-17.586518	179.058345	B, F, M, I, A
Lomaiviti	WAA_17	-17.691077	179.06498	B, F, M, I, A
Lomaiviti	WAA_19	-17.619769	178.991171	B, F, M, I, A, T
Macuata	GSR_74	-16.102689	-179.930135	B, F, M, I, A, T
Macuata	GSR_76	-16.137334	179.96006	B, F, M, I, A
Macuata	GSR_77	-16.145437	179.680747	B, F, M, I, A
Macuata	GSR_78	-16.166111	179.898238	B, F, M, I, A
Macuata	GSR_79	-16.120056	179.60004	B, F, M, I, A
Macuata	GSR_80	-16.134882	179.78665	B, F, M, I, A, T
Macuata	GSR_81	-16.146581	179.509774	B, F, M, I, A, T
Macuata	GSR_82	-16.257198	179.199468	B, F, M, I, A
Macuata	GSR_83	-16.223817	179.396946	B, F, M, I, A
Macuata	GSR_84	-16.207882	179.119454	B, F, M, I, A
Macuata	GSR_85	-16.26569	179.317148	B, F, M, I, A, T
Macuata	GSR_86	-16.176644	179.051599	B, F, M, I, A, T
Macuata	GSR_87	-16.315463	179.278827	B, F, M, I, A
Macuata	GSR_88	-16.21224	179.03454	B, F, M, I, A
Macuata	GSR_89	-16.30743	179.021851	B, F, M, I, A
Macuata	GSR_90	-16.317282	178.919623	B, F, M, I, A, T
Macuata	GSR_91	-16.301777	178.750353	B, F, M, I, A
Nadroga-Navosa	COC_04	-17.98194	177.2128	B, F, M, I
Nadroga-Navosa	COC_03	-17.90865	177.19412	B, F, M, I, A
Nadroga-Navosa	COC_05	-18.03719	177.25012	B, F, M, I, A
Nadroga-Navosa	COC_11	-18.23294	177.7702	B, F, M, I, A
Nadroga-Navosa	GSR_01	-17.74676	177.06113	B, F, M, I
Nadroga-Navosa	GSR_08	-17.68272	177.09383	B, F, M, I, T
Nadroga-Navosa	GSR_10	-17.77493	177.16142	B, F, M, I, A
Nadroga-Navosa	GSR_07	-17.72912	177.10896	B, F, M, I, A
Nadroga-Navosa	GSR_09	-17.80406	177.18332	B, F, M, I, A, T
Nadroga-Navosa	COC_06	NA	NA	B, F, I
Nadroga-Navosa	GSR_02	NA	NA	F
Namosi	NAV_17	-18.19803	178.30472	B, F, M, I, A
Namosi	NAV_20	-18.26122	178.21846	B, F, M, I, A, T
Namosi	NAV_21	-18.23274	178.26421	B, F, M, I, A

PROVINCE	STATION ID	LATITUDE	LONGITUDE	DATA COLLECTED
Ra	BAP_60	-17.34544	178.2798	B, F, M, I, A
Ra	BAP_61	-17.31913	178.26773	B, F, M, I, A, T
Ra	BAP_62	-17.2883	178.30811	B, F, M, I, A
Ra	BAP_63	-17.26968	178.26826	B, F, M, I, A
Ra	BAP_65	-17.25533	178.17567	B, F, M, I, A, T
Ra	BAP_67	-17.30992	178.06381	B, F, M, I, A
Ra	BAP_64	-17.24423	178.21094	B, F, M, I, A
Ra	BAP_66	-17.29084	178.08858	B, F, M, I, A
Ra	BAP_73	-17.38201	177.5691	B, F, M, I, A
Ra	BAP_70	-17.18612	178.07278	B, F, M, I, A
Ra	BAP_72	-17.13317	178.01855	B, F, M, I, A, T
Ra	BAP_74	-17.15899	177.98559	B, F, M, I, A
Ra	DAW_48	-17.49005	178.44644	B, F, M, I, A
Ra	DAW_50	-17.50212	178.42033	B, F, M, I, A, T
Ra	DAW_49	-17.5111	178.43085	B, F, M, I, A
Ra	DAW_54	-17.28048	178.47775	B, F, M, I, A, T
Ra	DAW_52	-17.3657	178.49976	B, F, M, I, A
Ra	DAW_56	-17.34346	178.42241	B, F, M, I, A
Ra	DAW_51	-17.41963	178.483	B, F, M, I, A
Ra	DAW_55	-17.42693	178.33485	B, F, M, I, A
Ra	DAW_57	-17.46278	178.3774	B, F, M, I, A
Ra	DAW_58	-17.41434	178.32373	B, F, M, I, A, T
Ra	DAW_59	-17.37686	178.3232	B, F, M, I, A
Rewa	BAY_16	-18.37878	177.95943	B, F, M, I, A
Rewa	BAY_18	-18.41065	178.18687	B, F, M, I, A, T
Rewa	NAV_19	-18.15312	178.37222	B, F, M, I, A
Serua	BAY_15	-18.34633	178.17274	B, F, M, I, A, T
Serua	COC_12	-18.2588	177.82565	B, F, M, I, A
Serua	COC_14	-18.30724	177.99712	B, F, M, I, A
Serua	COC_13	-18.29281	177.879	B, F, M, I, A
Tailevu	DAW_46	-17.49963	178.49188	B, F, M, I, A
Tailevu	DAW_45	-17.52651	178.52589	B, F, M, I, A
Tailevu	DAW_47	-17.45817	178.53557	B, F, M, I, A, T
Tailevu	KUB_37	-17.9558	178.76302	B, F, M, I, A
Tailevu	KUB_44	-17.4946	178.60928	B, F, M, I, A
Tailevu	KUB_39	-17.84116	178.77304	B, F, M, I, A, T

Appendix 3

PROVINCIAL SAMPLING CONSIDERATIONS

Sample size and considerations for Provinces with low sample size or uneven site distributions. These considerations should be taken into account when interpreting the results for these Provinces.

PROVINCE	SAMPLE SIZE	CONSIDERATIONS
BUA	8	Uneven survey distribution: sites in Vatu-i-Ra Seascape not surveyed, only GSR forereef surveyed
KADAVU	11	Uneven survey distribution: only north east Kadavu surveyed
NADROGA-NAVOSA	11	Uneven survey distribution: Coral Coast and Vatulele largely unsurveyed
NAMOSI	3	Low sample size
REWA	3	Uneven survey distribution; low sample size
SERUA	4	Uneven survey distribution; low sample size
TAILEVU	6	Uneven survey distribution: coastal forereefs largely unsurveyed

Appendix 4

FISH BELT TRANSECT SUMMARY DATA

Full list of fish species surveyed during the belt transect surveys.

DACOR (Dominant, Abundant, Common, Occasional, Rare) classifications are as follows:

D=observed at $\geq 75\%$ of sites (201-269 sites),
 A=observed at 50-74% of sites (148-200 sites),
 C=observed at 25-49% of sites (67-147 sites),
 O=observed at 10-24% of sites (27-66 sites), &
 R=observed at $<10\%$ of sites (0-26 sites).

Entries highlighted in bold are genus- or family-level entries, for cases in which a fish could not be reliably identified to the species level. These entries are not included in the total count of distinct species reported in the text.

Family	Species	Mean density (individuals per ha)	Mean biomass (kg per ha)	Number of sites	DACOR
Acanthuridae	Acanthuridae species	5.0186	1.2333	3	R
	<i>Acanthurus achilles</i>	1.4250	0.4200	4	R
	<i>Acanthurus albipectoralis</i>	26.1462	6.7970	38	O
	<i>Acanthurus auranticavus</i>	0.4957	0.2623	2	R
	<i>Acanthurus bariene</i>	0.5266	0.1612	2	R
	<i>Acanthurus blochii</i>	60.4089	23.7820	91	C
	<i>Acanthurus dussumieri</i>	2.8501	1.0079	6	R
	<i>Acanthurus guttatus</i>	2.9740	0.8631	10	R
	<i>Acanthurus leucocheilus</i>	0.0620	0.0231	1	R
	<i>Acanthurus leucopareius</i>	6.1958	1.0782	2	R
	<i>Acanthurus lineatus</i>	286.3737	48.6273	145	C
	<i>Acanthurus mata</i>	16.3569	7.5093	27	O
	<i>Acanthurus nigricans</i>	217.0384	25.0200	99	C
	<i>Acanthurus nigricauda</i>	27.5713	6.5083	66	O
	<i>Acanthurus nigrofuscus</i>	620.0655	41.0326	204	D
	<i>Acanthurus nigros</i>	8.2404	1.0800	8	R
	<i>Acanthurus nubilus</i>	0.1859	0.0453	1	R
	<i>Acanthurus olivaceus</i>	41.7596	9.2755	40	O
	<i>Acanthurus pyroferus</i>	40.4585	5.1459	89	C
	<i>Acanthurus thompsoni</i>	65.6134	6.1771	56	O
	<i>Acanthurus triostegus</i>	9.6654	0.9568	10	R
	<i>Acanthurus xanthopterus</i>	0.8674	0.6963	6	R
	<i>Ctenochaetus binotatus</i>	410.8426	21.0662	179	A

Family	Species	Mean density (individuals per ha)	Mean biomass (kg per ha)	Number of sites	DACOR
Acanthuridae (continued)	<i>Ctenochaetus cyanocheilus</i>	138.1483	13.5812	103	C
	<i>Ctenochaetus striatus</i>	1605.4740	216.4293	256	D
	<i>Ctenochaetus tominiensis</i>	1.6109	0.2127	4	R
	<i>Naso annulatus</i>	0.9913	0.8123	5	R
	<i>Naso brachycentron</i>	0.3717	0.4188	2	R
	<i>Naso brevirostris</i>	50.3098	18.3528	85	C
	<i>Naso caesi</i>	15.8612	9.0605	24	R
	<i>Naso hexacanthus</i>	52.6642	57.6933	52	O
	<i>Naso lituratus</i>	116.0382	34.5492	191	A
	Naso species	0.7435	0.1925	3	R
	<i>Naso tonganus</i>	8.8600	21.6137	21	R
	<i>Naso unicornis</i>	19.0830	13.2864	50	O
	<i>Naso vlamingii</i>	12.7323	5.3569	39	O
	<i>Paracanthurus hepatus</i>	4.2751	0.3481	6	R
	<i>Zebrasoma scopas</i>	313.9405	20.4377	180	A
	<i>Zebrasoma velifer</i>	28.8414	4.9748	67	C
	<i>Zebrasoma scopas</i>	313.9405204	20.43770393	180	A
	<i>Zebrasoma velifer</i>	28.84138786	4.974846973	67	C
Aetobatidae	<i>Aetobatus ocellatus</i>	0.2478	5.3290	3	R
Apogonidae	Apogon species	6.1958	0.0371	13	R
	<i>Cheilodipterus artus</i>	1.1152	0.0578	5	R
	<i>Cheilodipterus isostigmus</i>	8.2404	0.0908	14	R
	<i>Cheilodipterus macrodon</i>	1.8587	0.1657	8	R
	<i>Cheilodipterus quinquelineatus</i>	0.1239	0.0015	1	R
	<i>Nectamia luxuria</i>	0.1239	0.0026	1	R
	<i>Nectamia savayensis</i>	0.4957	0.0409	1	R
	<i>Ostorhinchus angustatus</i>	3.0359	0.4858	4	R
	<i>Ostorhinchus apogonoides</i>	0.0620	0.0234	1	R
	Ostorhinchus species	0.3717	0.0008	1	R
	<i>Ostorhinchus taeniophorus</i>	0.6196	0.0354	3	R
	<i>Pristiapogon exostigma</i>	1.3631	0.0475	3	R
	<i>Pristiapogon fraenatus</i>	0.1239	0.0075	1	R
	<i>Pristiapogon kallopterus</i>	0.2478	0.0150	2	R
	<i>Pristicon trimaculatus</i>	0.2478	0.0088	1	R
	<i>Siphamia jebbi</i>	0.2478	0.0043	1	R
	<i>Siphamia tubifer</i>	0.7435	0.1070	1	R
Aulostomidae	<i>Aulostomus chinensis</i>	2.8501	0.2640	34	O
Balistidae	<i>Balistapus undulatus</i>	45.3355	7.5040	182	A
	<i>Balistoides conspicillum</i>	2.4783	1.7882	25	R
	<i>Balistoides viridescens</i>	10.8736	17.5547	83	C
	<i>Melichthys niger</i>	13.5688	6.4026	47	O

Family	Species	Mean density (individuals per ha)	Mean biomass (kg per ha)	Number of sites	DACOR
Balistidae (continued)	<i>Melichthys vidua</i>	19.0211	6.2217	62	O
	<i>Odonus niger</i>	22.1809	2.6080	6	R
	<i>Pseudobalistes flavimarginatus</i>	0.5576	0.8282	8	R
	<i>Pseudobalistes fuscus</i>	0.2478	0.2383	1	R
	<i>Rhinecanthus lunula</i>	1.1772	0.1448	9	R
	<i>Rhinecanthus rectangulus</i>	0.0620	0.0139	1	R
	<i>Sufflamen bursa</i>	26.0223	2.9875	93	C
	<i>Sufflamen chrysopterum</i>	9.5415	1.1715	37	O
	<i>Sufflamen fraenatum</i>	2.4783	0.8806	12	R
Blenniidae	<i>Aspidontus dussumieri</i>	0.7435	0.0075	1	R
	<i>Aspidontus taeniatus</i>	1.1152	0.0112	8	R
	<i>Atrosalarias fuscus</i>	8.4263	0.1338	10	R
	<i>Blenniella chrysospilos</i>	0.1239	0.0001	1	R
	<i>Cirripectes chelomatus</i>	8.0545	0.0979	23	R
	<i>Cirripectes imitator</i>	0.2478	0.0084	2	R
	Cirripectes species	32.0765	0.3585	88	C
	<i>Cirripectes springeri</i>	0.9913	0.0114	5	R
	<i>Cirripectes stigmaticus</i>	26.5180	0.3488	51	O
	<i>Cirripectes variolosus</i>	0.1239	0.0023	1	R
	<i>Crossosalarias macrospilus</i>	0.3717	0.0045	3	R
	<i>Ecsenius bicolor</i>	1.8587	0.0034	11	R
	<i>Ecsenius fijiensis</i>	0.3717	0.0022	3	R
	<i>Ecsenius fourmanoiri</i>	0.6196	0.0010	5	R
	Ecsenius species	0.2478	0.0003	1	R
	<i>Exallias brevis</i>	0.9913	0.0150	6	R
	<i>Helcogramma striata</i>	0.2478	0.0003	1	R
	<i>Meiacanthus bundoon</i>	7.5589	0.0559	25	R
	<i>Meiacanthus oualanensis</i>	20.5700	0.0927	65	O
	Meiacanthus species	1.1152	0.0028	6	R
	<i>Plagiotremus flavus</i>	8.9042	0.0092	35	O
	<i>Plagiotremus laudandus</i>	0.9913	0.0047	4	R
	<i>Plagiotremus rhinorhynchos</i>	0.4957	0.0029	4	R
	<i>Plagiotremus tapeinosoma</i>	8.7980	0.0263	28	O
Caesionidae	<i>Caesio caeruleaurea</i>	1142.8130	134.2271	102	C
	<i>Caesio lunaris</i>	92.3792	19.7775	25	R
	Caesio species	86.3693	8.3822	5	R
	<i>Caesio teres</i>	404.8947	75.3854	52	C
	<i>Gymnocaesio gymnoptera</i>	95.1673	3.7017	5	R
	<i>Pterocaesio digramma</i>	115.3656	5.8991	28	O
	<i>Pterocaesio lativittata</i>	4.9566	0.5517	1	R
	<i>Pterocaesio marri</i>	99.1946	8.4426	14	R

Family	Species	Mean density (individuals per ha)	Mean biomass (kg per ha)	Number of sites	DACOR
Caesionidae (continued)	<i>Pterocaesio pisang</i>	2903.7790	97.0630	90	C
	<i>Pterocaesio tile</i>	631.3507	59.0016	72	C
	<i>Pterocaesio trilineata</i>	1212.3300	43.7289	59	O
Carangidae	<i>Atule mate</i>	0.1859	0.0500	2	R
	Carangidae species	2.1685	0.4587	5	R
	<i>Caranx ignobilis</i>	0.2478	4.3829	4	R
	<i>Caranx melampygus</i>	4.2751	6.4311	28	O
	<i>Caranx sexfasciatus</i>	12.5155	3.5413	2	R
	<i>Craterognathus plagiotænia</i>	2.7261	1.0133	16	R
	<i>Decapterus macarellus</i>	9.1698	0.9303	6	R
	Decapterus species	1.3631	0.0783	2	R
	<i>Elagatis bipinnulata</i>	3.1599	1.7022	8	R
	<i>Ferdauia ferdau</i>	0.4957	0.1623	4	R
	<i>Naucrates ductor</i>	0.1239	0.0028	1	R
	<i>Scomberoides lysan</i>	0.5576	0.2540	4	R
	<i>Seriola dumerili</i>	0.3717	0.0340	1	R
Carcharhinidae	<i>Carcharhinus albimarginatus</i>	0.0620	5.7079	1	R
	<i>Carcharhinus amblyrhynchos</i>	0.6815	15.4709	8	R
	<i>Carcharhinus melanopterus</i>	0.2478	3.4302	3	R
	<i>Triaenodon obesus</i>	6.7534	85.4931	74	C
Chaetodontidae	<i>Chaetodon auriga</i>	8.5502	0.6179	25	R
	<i>Chaetodon baronessa</i>	85.6258	2.4406	118	C
	<i>Chaetodon bennetti</i>	3.3457	0.2839	17	R
	<i>Chaetodon citrinellus</i>	36.9269	1.0060	95	C
	<i>Chaetodon ephippium</i>	22.9067	3.3543	77	C
	<i>Chaetodon flavirostris</i>	0.9294	0.1908	5	R
	<i>Chaetodon kleinii</i>	35.9356	1.0700	64	O
	<i>Chaetodon lineolatus</i>	4.0892	0.4953	12	R
	<i>Chaetodon lunula</i>	15.8612	0.6207	36	O
	<i>Chaetodon lunulatus</i>	47.0880	1.9469	106	C
	<i>Chaetodon melannotus</i>	7.2491	1.1308	14	R
	<i>Chaetodon mertensii</i>	16.9765	0.8738	45	O
	<i>Chaetodon ornatissimus</i>	6.0719	0.5148	17	R
	<i>Chaetodon pelewensis</i>	128.6245	3.9877	187	A
	<i>Chaetodon plebeius</i>	11.8959	0.3327	37	O
	<i>Chaetodon quadrimaculatus</i>	0.4957	0.0475	3	R
	<i>Chaetodon rafflesii</i>	14.7283	0.8563	34	O
	<i>Chaetodon reticulatus</i>	21.4374	2.4747	61	O
	<i>Chaetodon semeion</i>	1.8587	0.1549	7	R
	Chaetodon species	72.2429	0.5479	6	R
	<i>Chaetodon speculum</i>	5.3903	0.1765	3	R

Family	Species	Mean density (individuals per ha)	Mean biomass (kg per ha)	Number of sites	DACOR
Chaetodontidae (continued)	<i>Chaetodon trifascialis</i>	18.7113	0.5844	51	O
	<i>Chaetodon ulietensis</i>	26.9782	0.9533	63	O
	<i>Chaetodon unimaculatus</i>	6.8154	0.5891	24	R
	<i>Chaetodon vagabundus</i>	24.5353	1.5009	73	C
	<i>Forcipiger flavissimus</i>	35.0682	1.4731	92	C
	<i>Forcipiger longirostris</i>	9.5061	0.6720	34	O
	<i>Hemitaurichthys polylepis</i>	106.3197	6.9197	31	O
	<i>Heniochus acuminatus</i>	4.0096	0.6785	18	R
	<i>Heniochus chrysostomus</i>	33.0501	5.3080	97	C
	<i>Heniochus monoceros</i>	7.4261	2.2074	36	O
	<i>Heniochus singularius</i>	7.1252	2.4479	27	O
	<i>Heniochus varius</i>	32.8023	5.2509	99	C
Chanidae	<i>Chanos chanos</i>	0.3717	0.0185	1	R
Cirrhitidae	<i>Cirrhitichthys falco</i>	19.5433	0.2862	71	C
	<i>Cirrhitichthys oxycephalus</i>	2.6022	0.0054	2	R
	<i>Neocirrhites armatus</i>	1.3631	0.0088	8	R
	<i>Paracirrhites arcatus</i>	185.1036	3.0330	168	A
	<i>Paracirrhites forsteri</i>	28.0050	1.0985	107	C
	<i>Paracirrhites hemistictus</i>	6.6915	0.5624	24	R
Dasyatidae	<i>Taeniura lymma</i>	0.0620	1.6494	1	R
Echeneidae	<i>Echeneis naucrates</i>	1.6729	0.1211	14	R
Ephippidae	<i>Platax orbicularis</i>	1.2392	3.5481	8	R
	<i>Platax teira</i>	0.1239	0.3074	2	R
Fistularidae	<i>Fistularia commersonii</i>	0.3098	0.1681	5	R
Gobiidae	<i>Amblyeleotris fasciata</i>	4.5229	0.0517	4	R
	<i>Amblyeleotris guttata</i>	0.6196	0.0010	4	R
	Amblyeleotris species	0.9913	0.0107	1	R
	<i>Amblyeleotris steinitzi</i>	0.3717	0.0006	1	R
	<i>Amblygobius phalaena</i>	0.3717	0.0147	1	R
	<i>Ctenogobiops aurocingulus</i>	0.2478	0.0013	2	R
	Ctenogobiops species	0.4957	0.0129	1	R
	<i>Eviota teresae</i>	0.1239	0.0000	1	R
	<i>Exyrias belissimus</i>	0.2478	0.0130	2	R
	<i>Koumansetta rainfordi</i>	14.6221	0.0259	28	O
	<i>Trimma nasa</i>	8.0545	0.0101	3	R
	<i>Valenciennea puellaris</i>	0.2478	0.0059	1	R
	<i>Valenciennea strigata</i>	9.7893	0.1292	14	R

Family	Species	Mean density (individuals per ha)	Mean biomass (kg per ha)	Number of sites	DACOR
Haemulidae	<i>Plectorhinchus chaetodonoides</i>	1.2082	1.5806	11	R
	<i>Plectorhinchus gibbosus</i>	0.5576	0.1522	2	R
	<i>Plectorhinchus lessonii</i>	0.3098	0.1249	2	R
	<i>Plectorhinchus picus</i>	0.1859	0.0712	2	R
	<i>Plectorhinchus vittatus</i>	2.9120	2.4964	24	R
Holocentridae	<i>Myripristis adusta</i>	12.3296	2.3665	11	R
	<i>Myripristis amaena</i>	2.7261	0.4089	4	R
	<i>Myripristis berndti</i>	64.1264	8.5992	75	C
	<i>Myripristis botche</i>	3.0979	0.2608	1	R
	<i>Myripristis chryseres</i>	3.7175	0.6417	1	R
	<i>Myripristis hexagona</i>	0.3717	0.0743	1	R
	<i>Myripristis kuntzei</i>	140.2992	12.1442	112	C
	<i>Myripristis murdjan</i>	6.3197	0.7814	17	R
	<i>Myripristis pralinia</i>	0.4957	0.1206	3	R
	Myripristis species	2.1597	0.2898	13	R
	<i>Myripristis violacea</i>	52.3987	7.2719	63	O
	<i>Myripristis vittata</i>	15.9763	0.9521	24	R
	<i>Neoniphon argenteus</i>	0.7435	0.0168	4	R
	<i>Neoniphon aurolineatus</i>	0.2478	0.0131	1	R
	<i>Neoniphon opercularis</i>	4.1512	0.5396	17	R
	<i>Neoniphon sammara</i>	32.4659	3.5521	53	O
	Neoniphon species	0.6196	0.0958	2	R
	<i>Sargocentron caudimaculatum</i>	105.3107	9.7098	112	C
	<i>Sargocentron cornutum</i>	0.6196	0.0332	1	R
	<i>Sargocentron diadema</i>	1.2392	0.0621	6	R
	<i>Sargocentron ittodai</i>	0.7435	0.0476	3	R
	<i>Sargocentron melanospilos</i>	0.4957	0.0599	3	R
	<i>Sargocentron microstoma</i>	2.4783	0.1992	5	R
	<i>Sargocentron spiniferum</i>	17.6580	5.1658	67	C
	<i>Sargocentron tiere</i>	1.3011	0.1824	4	R
	<i>Sargocentron violaceum</i>	3.1244	0.2834	8	R
Kyphosidae	<i>Kyphosus bigibbus</i>	0.1239	0.1440	1	R
	<i>Kyphosus cinerascens</i>	2.2305	0.9008	8	R
	Kyphosus species	1.5489	1.0599	10	R
	<i>Kyphosus vaigiensis</i>	0.1859	0.1352	2	R
Labridae	<i>Anampses caeruleopunctatus</i>	3.5936	0.3150	25	R
	<i>Anampses geographicus</i>	0.1239	0.0121	1	R
	<i>Anampses melanurus</i>	2.3544	0.0761	8	R
	<i>Anampses meleagrides</i>	7.1871	0.1328	24	R
	<i>Anampses neoguinaicus</i>	35.1921	1.2157	91	C
	Anampses species	2.4164	0.1776	8	R

Family	Species	Mean density (individuals per ha)	Mean biomass (kg per ha)	Number of sites	DACOR
Labridae (continued)	<i>Anampses twistii</i>	19.7026	0.5652	73	C
	<i>Bodianus anthioides</i>	0.6196	0.0576	5	R
	<i>Bodianus axillaris</i>	36.6702	2.3245	127	C
	<i>Bodianus dictynna</i>	0.6196	0.0329	4	R
	<i>Bodianus loxozonus</i>	17.7200	4.5745	83	C
	<i>Bodianus mesothorax</i>	13.3652	0.7399	55	O
	<i>Bodianus perditio</i>	0.1239	0.2786	2	R
	<i>Cheilinus chlorourus</i>	23.1722	1.9837	71	C
	<i>Cheilinus fasciatus</i>	18.9901	3.0359	73	C
	<i>Cheilinus oxycephalus</i>	15.4895	0.3639	74	C
	<i>Cheilinus trilobatus</i>	21.4064	3.2799	87	C
	<i>Cheilinus undulatus</i>	2.1066	17.9832	16	R
	<i>Cheilio inermis</i>	0.1859	0.0126	3	R
	<i>Choerodon jordani</i>	0.2478	0.0304	2	R
	<i>Cirrhilabrus exquisitus</i>	64.1884	0.1350	39	O
	<i>Cirrhilabrus punctatus</i>	352.2924	2.5444	123	C
	<i>Cirrhilabrus scottorum</i>	32.4659	0.3410	10	R
	Cirrhilabrus species	0.1239	0.0014	1	R
	<i>Coris aygula</i>	2.9740	1.7828	31	O
	<i>Coris batuensis</i>	10.5328	0.2548	23	R
	<i>Coris dorsomacula</i>	2.0446	0.0476	8	R
	<i>Coris gaimard</i>	13.4758	1.7011	74	C
	Coris species	1.0533	0.0206	3	R
	<i>Epibulus brevis</i>	0.7435	0.1035	6	R
	<i>Epibulus insidiator</i>	25.2080	5.3695	111	C
	<i>Gomphosus varius</i>	210.7364	4.0131	227	D
	<i>Halichoeres argus</i>	0.9913	0.0123	3	R
	<i>Halichoeres biocellatus</i>	133.4661	1.7245	183	A
	<i>Halichoeres claudia</i>	29.9257	0.4681	64	O
	<i>Halichoeres hartzfeldii</i>	0.2478	0.0157	1	R
	<i>Halichoeres hortulanus</i>	97.0614	5.8445	198	A
	<i>Halichoeres margaritaceus</i>	4.0892	0.0344	6	R
	<i>Halichoeres marginatus</i>	7.7890	0.1680	27	O
	<i>Halichoeres melanurus</i>	4.2131	0.0414	12	R
	<i>Halichoeres melasmapomus</i>	0.5576	0.0333	3	R
	<i>Halichoeres ornatissimus</i>	0.7435	0.0206	2	R
	<i>Halichoeres prosopeion</i>	50.1239	1.1221	58	O
	<i>Halichoeres richmondi</i>	1.5489	0.0836	7	R
	<i>Halichoeres scapularis</i>	1.4870	0.0552	3	R
	Halichoeres species	14.3742	0.0900	10	R
	<i>Halichoeres trimaculatus</i>	1.3631	0.0420	5	R

Family	Species	Mean density (individuals per ha)	Mean biomass (kg per ha)	Number of sites	DACOR
Labridae (continued)	<i>Hemigymnus fasciatus</i>	18.8662	2.8341	101	C
	<i>Hemigymnus melapterus</i>	9.7274	3.5244	68	C
	<i>Hologymnosus doliatus</i>	0.4957	0.0961	5	R
	<i>Labrichthys unilineatus</i>	22.8448	0.5155	64	O
	<i>Labroides bicolor</i>	47.8138	0.4193	118	C
	<i>Labroides dimidiatus</i>	92.3703	0.5851	197	A
	<i>Labroides rubrolabiatus</i>	4.8327	0.0360	21	R
	Labroides species	0.1239	0.0012	1	R
	<i>Labropsis australis</i>	19.4548	0.2671	52	O
	<i>Labropsis xanthonota</i>	12.7279	0.1615	55	O
	<i>Macropharyngodon meleagris</i>	25.3054	0.2761	79	C
	<i>Macropharyngodon negrosensis</i>	3.2218	0.0453	14	R
	<i>Novaculichthys taeniourus</i>	2.4783	0.3923	13	R
	<i>Oxycheilinus arenatus</i>	0.4957	0.0034	2	R
	<i>Oxycheilinus bimaculatus</i>	0.1239	0.0017	1	R
	<i>Oxycheilinus digramma</i>	73.7918	4.5256	180	A
	<i>Oxycheilinus orientalis</i>	6.2577	0.2742	29	O
	<i>Oxycheilinus unifasciatus</i>	8.0545	1.1734	52	O
	<i>Pseudocheilinus evanidus</i>	56.7534	0.2848	88	C
	<i>Pseudocheilinus hexataenia</i>	250.9559	0.5215	210	D
	<i>Pseudocheilinus octotaenia</i>	39.0335	0.3611	82	C
	<i>Pseudocheilinus tetrataenia</i>	0.9913	0.0014	4	R
	<i>Pseudocoris aurantiofasciata</i>	0.1239	0.0057	1	R
	<i>Pseudocoris yamashiroi</i>	14.6221	0.2845	9	R
	<i>Pseudodax moluccanus</i>	2.8501	0.5145	18	R
	<i>Pseudojuloides splendens</i>	0.2478	0.0036	2	R
	<i>Pteragogus cryptus</i>	0.2478	0.0039	2	R
	<i>Pteragogus turdus</i>	0.1239	0.0020	1	R
	<i>Stethojulis bandanensis</i>	18.1979	0.2898	70	C
	<i>Stethojulis notialis</i>	0.3717	0.0093	2	R
	<i>Stethojulis strigiventer</i>	5.0805	0.2585	5	R
	<i>Stethojulis trilineata</i>	0.8674	0.0376	5	R
	<i>Thalassoma amblycephalum</i>	263.1970	1.0598	77	C
	<i>Thalassoma hardwicke</i>	50.7435	1.2527	103	C
	<i>Thalassoma lunare</i>	141.9455	4.6218	103	C
	<i>Thalassoma lutescens</i>	176.6242	5.0041	166	A
	<i>Thalassoma nigrofasciatum</i>	66.7906	1.5412	55	O
	<i>Thalassoma purpureum</i>	0.2478	0.0106	1	R
	<i>Thalassoma quinquevittatum</i>	39.2813	0.3349	45	O
	Thalassoma species	0.7435	0.0078	2	R
	<i>Thalassoma trilobatum</i>	2.4783	0.2185	2	R

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Labridae (Scarinae)	<i>Bolbometopon muricatum</i>	0.0620	0.5704	1	R
	<i>Calotomus carolinus</i>	1.7348	0.6339	18	R
	<i>Cetoscarus ocellatus</i>	14.6044	8.0867	88	C
	<i>Chlorurus bleekeri</i>	226.2878	41.6732	121	C
	<i>Chlorurus frontalis</i>	5.5762	0.0833	2	R
	<i>Chlorurus japanensis</i>	27.4075	9.2421	87	C
	<i>Chlorurus microrhinos</i>	48.4820	34.1020	108	C
	<i>Chlorurus species</i>	11.1524	0.2920	4	R
	<i>Chlorurus spilurus</i>	386.0019	75.7535	233	D
	<i>Hipposcarus longiceps</i>	53.2838	46.9076	95	C
	<i>Leptoscarus vaigiensis</i>	0.1239	0.0398	1	R
	<i>Scarus altipinnis</i>	50.8055	25.2681	105	C
	<i>Scarus chameleon</i>	8.1076	2.5037	55	O
	<i>Scarus dimidiatus</i>	4.2131	0.9443	14	R
	<i>Scarus festivus</i>	0.9913	0.4738	4	R
	<i>Scarus flavipectoralis</i>	0.1239	0.0164	1	R
	<i>Scarus forsteni</i>	30.8860	13.4793	101	C
	<i>Scarus frenatus</i>	26.7658	9.3142	107	C
	<i>Scarus fuscocaudalis</i>	0.3717	0.0244	1	R
	<i>Scarus ghobban</i>	22.4288	6.8939	75	C
	<i>Scarus globiceps</i>	14.6840	6.5558	73	C
	<i>Scarus longipinnis</i>	2.4783	2.2039	19	R
	<i>Scarus niger</i>	165.0248	38.3224	197	A
	<i>Scarus oviceps</i>	11.8340	6.0079	65	O
	<i>Scarus prasiognathos</i>	0.1859	0.1041	1	R
	<i>Scarus psittacus</i>	79.0051	12.6438	131	C
	<i>Scarus quoyi</i>	1.3631	0.4340	3	R
	<i>Scarus rivulatus</i>	18.8972	6.7911	52	O
	<i>Scarus rubroviolaceus</i>	22.5527	19.6539	91	C
	<i>Scarus schlegeli</i>	165.2770	37.1323	222	D
	<i>Scarus species</i>	25.4780	3.6190	39	O
	<i>Scarus spinus</i>	16.1091	4.9047	80	C
Lethrinidae	<i>Gnathodentex aureolineatus</i>	91.3259	14.6952	46	O
	<i>Gymnocranius euanus</i>	0.0620	0.0895	1	R
	<i>Gymnocranius microdon</i>	0.6196	0.4424	1	R
	<i>Lethrinus amboinensis</i>	0.1859	0.0270	2	R
	<i>Lethrinus atkinsoni</i>	0.2478	0.3338	2	R
	<i>Lethrinus erythracanthus</i>	0.7435	0.6613	7	R
	<i>Lethrinus harak</i>	0.8674	0.1758	5	R
	<i>Lethrinus lentjan</i>	0.5886	0.2191	3	R
	<i>Lethrinus obsoletus</i>	0.7745	0.3445	9	R
	<i>Lethrinus olivaceus</i>	0.3717	0.3916	5	R

Family	Species	Mean density (individuals per ha)	Mean biomass (kg per ha)	Number of sites	DACOR
Lethrinidae (continued)	<i>Lethrinus rubrioperculatus</i>	0.4957	0.1345	3	R
	<i>Lethrinus species</i>	0.3098	0.0835	4	R
	<i>Lethrinus xanthochilus</i>	1.5489	0.3762	8	R
	<i>Monotaxis grandoculis</i>	44.5477	24.5282	104	C
	<i>Monotaxis heterodon</i>	73.5086	19.2575	158	A
Lutjanidae	<i>Aphareus furca</i>	14.8079	4.8829	88	C
	<i>Aphareus rutilans</i>	0.0620	0.0163	1	R
	<i>Aprion virescens</i>	2.7261	7.0122	29	O
	<i>Lutjanus argentimaculatus</i>	2.7881	6.8942	3	R
	<i>Lutjanus biguttatus</i>	16.2949	1.4311	16	R
	<i>Lutjanus bohar</i>	48.0793	61.1447	116	C
	<i>Lutjanus ehrenbergii</i>	2.7261	0.5902	6	R
	<i>Lutjanus fulviflamma</i>	0.7435	0.1411	3	R
	<i>Lutjanus fulvus</i>	8.3024	4.4383	24	R
	<i>Lutjanus gibbus</i>	144.2379	54.4705	130	C
	<i>Lutjanus kasmira</i>	60.3470	9.9390	58	O
	<i>Lutjanus lutjanus</i>	2.4164	0.3756	6	R
	<i>Lutjanus monostigma</i>	10.5771	7.1737	54	O
	<i>Lutjanus quinquelineatus</i>	17.6580	3.1207	18	R
	<i>Lutjanus rivulatus</i>	2.8810	5.2449	11	R
	<i>Lutjanus rufolineatus</i>	0.0929	0.0888	1	R
	<i>Lutjanus semicinctus</i>	14.0025	3.9045	81	C
	Lutjanus species	0.5576	0.0705	2	R
	<i>Lutjanus timoriensis</i>	0.3717	0.0101	1	R
	<i>Macolor macularis</i>	19.5167	20.4987	48	O
	<i>Macolor niger</i>	19.9504	21.0433	61	O
	Macolor species	12.5775	24.3063	3	R
	<i>Paracaesio sordida</i>	0.3717	0.1444	1	R
Malacanthidae	<i>Malacanthus brevirostris</i>	0.5576	0.0492	2	R
	<i>Malacanthus latovittatus</i>	0.0620	0.0126	1	R
Microdesmidae	<i>Nemateleotris magnifica</i>	41.7596	0.0794	75	C
	<i>Ptereleotris evides</i>	54.6468	0.3758	62	O
	<i>Ptereleotris heteroptera</i>	0.2478	0.0067	1	R
	<i>Ptereleotris zebra</i>	6.0719	0.0695	5	R
Monacanthidae	<i>Aluterus scriptus</i>	5.8240	0.2988	4	R
	<i>Amanes scopas</i>	0.9913	0.0503	5	R
	<i>Cantherhines dumerilii</i>	2.7261	0.9594	21	R
	<i>Cantherhines pardalis</i>	2.7261	0.3235	23	R
	<i>Oxymonacanthus longirostris</i>	10.0195	0.1275	27	O
	<i>Paraluteres prionurus</i>	0.2478	0.0003	2	R
	<i>Pervagor janthinosoma</i>	1.3631	0.0427	8	R

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Mullidae	<i>Mulloidichthys flavolineatus</i>	6.3197	0.7109	9	R
	<i>Mulloidichthys pfluegeri</i>	1.9827	0.0811	2	R
	<i>Mulloidichthys species</i>	0.9913	0.1269	2	R
	<i>Mulloidichthys vanicolensis</i>	29.0582	5.3937	20	R
	<i>Parupeneus barberinoides</i>	7.9306	0.6212	22	R
	<i>Parupeneus barberinus</i>	14.6840	2.1951	75	C
	<i>Parupeneus ciliatus</i>	0.1239	0.0476	2	R
	<i>Parupeneus crassilabris</i>	42.5031	7.9087	106	C
	<i>Parupeneus cyclostomus</i>	22.3933	4.1468	108	C
	<i>Parupeneus heptacanthus</i>	0.8055	0.1575	2	R
	<i>Parupeneus indicus</i>	3.6555	1.4202	10	R
	<i>Parupeneus multifasciatus</i>	107.6120	7.2696	207	D
Muraenidae	<i>Gymnothorax javanicus</i>	0.8674	3.0208	12	R
	<i>Gymnothorax meleagris</i>	0.3098	0.2261	5	R
Nemipteridae	<i>Pentapodus aureofasciatus</i>	0.4957	0.0413	2	R
	<i>Scolopsis bilineata</i>	56.5056	5.1172	85	C
	<i>Scolopsis lineata</i>	0.6196	0.1481	1	R
	<i>Scolopsis temporalis</i>	0.2478	0.0419	2	R
	<i>Scolopsis trilineata</i>	0.1859	0.0318	1	R
Ostraciidae	<i>Ostracion cubicum</i>	1.1772	0.3728	10	R
	<i>Ostracion meleagris</i>	0.9913	0.0794	7	R
	<i>Ostracion solorensis</i>	1.7348	0.1189	13	R
Pempheridae	<i>Pempheris oualensis</i>	7.4969	0.6364	19	R
	<i>Pempheris vanicolensis</i>	2.1066	0.0867	5	R
Pinguipedidae	<i>Parapercis clathrata</i>	7.2491	0.6208	35	O
	<i>Parapercis millepunctata</i>	0.1239	0.0014	1	R
	Parapercis species	0.2478	0.0014	2	R
	<i>Parapercis xanthogramma</i>	5.8860	0.3351	27	O
Polynemidae	<i>Polydactylus microstoma</i>	35.5638	0.3979	16	R
Pomacanthidae	<i>Apolemichthys trimaculatus</i>	1.3941	0.1446	7	R
	<i>Centropyge bicolor</i>	54.6468	2.0390	76	C
	<i>Centropyge bispinosa</i>	390.1044	9.8116	217	D
	<i>Centropyge deborae</i>	7.1871	0.1239	20	R
	<i>Centropyge flavissima</i>	188.7856	5.6901	212	D
	<i>Centropyge heraldi</i>	8.9219	0.3240	18	R
	<i>Centropyge loriculus</i>	0.2478	0.0074	1	R
	<i>Genicanthus melanospilos</i>	1.1152	0.0846	4	R
	<i>Genicanthus watanabei</i>	1.1152	0.0967	3	R
	<i>Paracentropyge multifasciata</i>	4.0892	0.2679	9	R
	<i>Pomacanthus imperator</i>	3.2218	2.2157	34	O
	<i>Pomacanthus semicirculatus</i>	5.5143	2.2528	27	O

Family	Species	Mean density (individuals per ha)	Mean biomass (kg per ha)	Number of sites	DACOR
Pomacanthidae (continued)	<i>Pygoplites diacanthus</i>	42.2154	6.5492	141	C
Pomacentridae	<i>Abudefduf septemfasciatus</i>	1.8587	0.4021	2	R
	<i>Abudefduf sexfasciatus</i>	125.7125	4.9215	44	O
	<i>Abudefduf sordidus</i>	0.4337	0.6220	1	R
	<i>Abudefduf vaigiensis</i>	6.0542	0.1939	10	R
	<i>Acanthochromis polyacanthus</i>	1.3631	0.1075	2	R
	<i>Amblyglyphidodon aureus</i>	77.8191	1.5418	47	O
	<i>Amblyglyphidodon curacao</i>	46.0347	1.5757	25	R
	<i>Amblyglyphidodon orbicularis</i>	220.9418	7.3245	62	O
	<i>Amphiprion barberi</i>	9.5415	0.2125	15	R
	<i>Amphiprion chrysopterus</i>	16.7286	0.9303	54	O
	<i>Amphiprion clarkii</i>	5.4523	0.1446	21	R
	<i>Amphiprion perideraion</i>	16.7286	0.2670	25	R
	<i>Azurina lepidolepis</i>	138.9095	0.7234	25	R
	<i>Chromis alpha</i>	46.2825	0.6415	45	O
	<i>Chromis analis</i>	2.7261	0.0473	2	R
	<i>Chromis atripectoralis</i>	525.2965	3.9030	92	C
	<i>Chromis chrysur</i>	58.9839	4.2791	22	R
	<i>Chromis ternatensis</i>	2035.6700	13.3509	136	C
	<i>Chromis viridis</i>	229.5273	1.0329	72	C
	<i>Chromis weberi</i>	152.4164	1.1616	60	O
	<i>Chromis xanthochira</i>	3.3457	0.0253	3	R
	<i>Chromis xanthura</i>	453.0182	6.3429	151	A
	<i>Chrysiptera biocellata</i>	0.8674	0.0242	1	R
	<i>Chrysiptera glauca</i>	0.7435	0.0007	2	R
	<i>Chrysiptera starcki</i>	2.8501	0.0025	1	R
	<i>Chrysiptera talboti</i>	799.0264	1.9476	133	C
	<i>Chrysiptera taupou</i>	288.6883	0.8278	119	C
	<i>Dascyllus aruanus</i>	137.2986	0.8420	21	R
	<i>Dascyllus reticulatus</i>	1416.5340	11.8461	159	A
	<i>Dascyllus trimaculatus</i>	214.6221	6.9891	125	C
	<i>Lepidozygus tapeinosoma</i>	17.3482	0.2160	2	R
	<i>Neoglyphidodon carlsoni</i>	57.1252	1.1477	36	O
	<i>Neopomacentrus filamentosus</i>	2.3544	0.0369	3	R
	<i>Neopomacentrus metallicus</i>	8.0545	0.0909	4	R
	<i>Plectroglyphidodon dickii</i>	239.8876	3.7731	129	C
	<i>Plectroglyphidodon fasciolatus</i>	246.5923	5.3280	109	C
	<i>Plectroglyphidodon johnstonianus</i>	80.2974	1.1045	104	C
	<i>Plectroglyphidodon leucozonus</i>	0.2169	0.1962	2	R
	Plectroglyphidodon species	0.2478	0.0007	1	R
	Pomacentridae species	192.8129	2.6324	20	R

Family	Species	Mean density (individuals per ha)	Mean biomass (kg per ha)	Number of sites	DACOR
Pomacentridae (continued)	<i>Pomacentrus adelus</i>	11.4003	0.1548	11	R
	<i>Pomacentrus amboinensis</i>	8.4263	0.0292	3	R
	<i>Pomacentrus bankanensis</i>	182.7757	2.1606	29	O
	<i>Pomacentrus brachialis</i>	55.1425	0.2950	31	O
	<i>Pomacentrus callainus</i>	1120.8360	13.0895	179	A
	<i>Pomacentrus coelestis</i>	466.5339	1.7263	68	C
	<i>Pomacentrus flavioculus</i>	703.1156	13.4763	208	D
	<i>Pomacentrus imitator</i>	21.2516	0.4536	15	R
	<i>Pomacentrus lepidogenys</i>	2.2305	0.0069	1	R
	<i>Pomacentrus maafu</i>	449.3804	2.0233	55	O
	<i>Pomacentrus microspilus</i>	69.6406	0.7112	36	O
	<i>Pomacentrus moluccensis</i>	446.0967	0.7353	64	O
	<i>Pomacentrus nigriradiatus</i>	32.4659	0.6232	24	R
	<i>Pomacentrus nigromarginatus</i>	75.4647	2.0161	40	O
	<i>Pomacentrus pavo</i>	2.4783	0.1193	1	R
	<i>Pomacentrus spilotoceps</i>	56.8773	0.2910	26	R
	<i>Pomacentrus vaiuli</i>	2890.3790	35.4293	251	D
	<i>Pomachromis richardsoni</i>	80.8550	0.1323	36	O
	<i>Pycnochromis acares</i>	280.6691	0.4925	53	O
	<i>Pycnochromis agilis</i>	19.4548	0.0581	17	R
	<i>Pycnochromis amboinensis</i>	577.1995	5.7251	93	O
	<i>Pycnochromis atripes</i>	1799.0710	5.0414	134	C
	<i>Pycnochromis caudalis</i>	6.1958	0.0501	3	R
	<i>Pycnochromis iomelas</i>	2191.6360	6.8278	184	A
	<i>Pycnochromis leucurus</i>	58.4882	0.1183	4	R
	<i>Pycnochromis margaritifer</i>	3192.6980	8.4653	205	D
	<i>Pycnochromis retrofasciatus</i>	663.2147	3.3258	81	C
	<i>Pycnochromis vanderbilti</i>	947.3358	1.6897	59	O
	<i>Stegastes albifasciatus</i>	0.1239	0.0116	1	R
	<i>Stegastes lacrymatus</i>	1105.6820	19.8734	225	D
	<i>Stegastes nigricans</i>	7.9306	0.5111	8	R
Priacanthidae	<i>Priacanthus blochii</i>	3.0979	0.1245	1	R
	<i>Priacanthus hamrur</i>	0.5576	0.1030	4	R
Pseudochromidae	<i>Cypho purpurascens</i>	0.3717	0.0032	3	R
Scombridae	<i>Grammatorcynus bilineatus</i>	0.1859	0.7686	2	R
	<i>Gymnosarda unicolor</i>	0.8055	4.0506	10	R
	<i>Rastrelliger kanagurta</i>	21.0037	5.4991	8	R
	<i>Scomberomorus commerson</i>	0.6196	0.9849	5	R
Scorpaenidae	<i>Caracanthus maculatus</i>	0.3717	0.0014	3	R
	<i>Caracanthus unipinna</i>	5.2045	0.0240	11	R
	<i>Pterois radiata</i>	0.1239	0.0143	1	R

Family	Species	Mean density (individuals per ha)	Mean biomass (kg per ha)	Number of sites	DACOR
Priacanthidae	<i>Priacanthus blochii</i>	3.097893432	0.1245169631	1	R
	<i>Priacanthus hamrur</i>	0.5576208178	0.1029937679	4	R
Pseudochromidae	<i>Cypho purpurascens</i>	0.3717472119	0.003226556771	3	R
Scombridae	<i>Grammatorcynus bilineatus</i>	0.1858736059	0.7685618907	2	R
	<i>Gymnosarda unicolor</i>	0.8054522924	4.050584883	10	R
	<i>Rastrelliger kanagurta</i>	21.00371747	5.499065268	8	R
	<i>Scomberomorus commerson</i>	0.6195786865	0.9849045079	5	R
Scorpaenidae	<i>Caracanthus maculatus</i>	0.3717	0.0014	3	R
	<i>Caracanthus unipinna</i>	5.2045	0.0240	11	R
	<i>Pterois radiata</i>	0.1239	0.0143	1	R
	<i>Scorpaenopsis eschmeyer</i>	0.1239	0.0111	1	R
	<i>Scorpaenopsis oxycephalus</i>	0.0620	0.0782	1	R
	<i>Sebastapistes tinkhami</i>	0.1239	0.0022	1	R
Serranidae	<i>Aethaloperca rogaa</i>	0.1859	0.1352	3	R
	<i>Anyperodon leucogrammicus</i>	0.4337	0.1342	6	R
	<i>Belonoperca chabanaudi</i>	2.4164	0.1123	18	R
	<i>Cephalopholis argus</i>	13.3519	6.1375	86	C
	<i>Cephalopholis leopardus</i>	5.8240	0.2039	23	R
	<i>Cephalopholis miniata</i>	1.1772	0.2019	8	R
	<i>Cephalopholis species</i>	2.3544	0.3442	2	R
	<i>Cephalopholis spiloparaea</i>	1.7348	0.0740	4	R
	<i>Cephalopholis urodeta</i>	154.8548	13.7384	178	A
	<i>Epinephelus areolatus</i>	0.0620	0.0359	1	R
	<i>Epinephelus coeruleopunctatus</i>	0.9294	1.1338	11	R
	<i>Epinephelus corallicola</i>	0.0620	0.0476	1	R
	<i>Epinephelus fasciatus</i>	0.3098	0.0462	2	R
	<i>Epinephelus fuscoguttatus</i>	0.1239	0.1096	2	R
	<i>Epinephelus hexagonatus</i>	0.4337	0.0825	5	R
	<i>Epinephelus howlandi</i>	1.4250	0.6459	17	R
	<i>Epinephelus macrospilos</i>	1.3631	0.6016	13	R
	<i>Epinephelus malabaricus</i>	0.3098	0.2838	2	R
	<i>Epinephelus melanostigma</i>	0.2478	0.0130	1	R
	<i>Epinephelus merra</i>	4.2131	0.5095	26	R
	<i>Epinephelus ongus</i>	0.8674	0.1063	4	R
	<i>Epinephelus polyphekadion</i>	1.7968	1.4576	20	R
	<i>Epinephelus species</i>	0.2478	0.1708	3	R
	<i>Epinephelus spilotoceps</i>	0.0620	0.0440	1	R
	<i>Epinephelus tauvina</i>	0.1239	0.1277	2	R
	<i>Gracila albomarginata</i>	0.5576	0.1865	6	R
	<i>Grammistes sexlineatus</i>	0.3717	0.0045	1	R
	<i>Plectropomus areolatus</i>	2.2924	5.0912	18	R

Family	Species	Mean density (individuals per ha)	Mean biomass (kg per ha)	Number of sites	DACOR
Serranidae (continued)	<i>Plectropomus laevis</i>	2.4164	5.5538	22	R
	<i>Plectropomus leopardus</i>	0.7435	0.2565	8	R
	<i>Pseudanthias cooperi</i>	3.0979	0.0365	2	R
	<i>Pseudanthias pascalus</i>	200.8674	1.5700	32	O
	<i>Pseudanthias squamipinnis</i>	427.7571	2.0366	36	O
	<i>Serranocirrhitus latus</i>	77.1995	0.5093	24	R
	<i>Variola albimarginata</i>	0.4957	0.2550	6	R
	<i>Variola louti</i>	4.1512	3.4389	42	O
Siganidae	<i>Siganus argenteus</i>	17.28625	2.998712	30	O
	<i>Siganus doliatus</i>	20.07435	3.454939	48	O
	<i>Siganus guttatus</i>	1.1772	0.287582	5	R
	<i>Siganus lineatus</i>	1.239157	0.190349	2	R
	<i>Siganus puellus</i>	0.86741	0.096214	1	R
	<i>Siganus punctatissimus</i>	9.107807	3.853966	47	O
	<i>Siganus punctatus</i>	12.08178	2.20822	46	O
	Siganus species	3.097893	0.555605	6	R
	<i>Siganus spinus</i>	2.726146	0.326844	7	R
	<i>Siganus uspi</i>	14.05559	2.539208	48	O
	<i>Siganus vermiculatus</i>	0.247831	0.063653	1	R
	<i>Siganus virgatus</i>	0.86741	0.073647	1	R
Sphyraenidae	<i>Sphyraena barracuda</i>	0.1859	1.7766	3	R
	<i>Sphyraena flavicauda</i>	0.0620	0.0377	1	R
	<i>Sphyraena jello</i>	0.9913	3.7134	1	R
	<i>Sphyraena putnamae</i>	1.8587	0.2115	1	R
Synanceiidae	<i>Synanceia verrucosa</i>	0.0620	0.0780	1	R
Synodontidae	<i>Saurida nebulosa</i>	0.1239	0.0038	1	R
	<i>Synodus binotatus</i>	2.1066	0.1365	13	R
	<i>Synodus dermatogenys</i>	0.3717	0.0053	3	R
	<i>Synodus jaculum</i>	0.9913	0.0582	6	R
	<i>Synodus variegatus</i>	0.7435	0.0178	5	R
Tetraodontidae	<i>Arothron hispidus</i>	0.061958	0.027984	1	R
	<i>Arothron mappa</i>	0.061958	0.189037	1	R
	<i>Arothron meleagris</i>	0.185874	0.083952	2	R
	<i>Arothron nigropunctatus</i>	4.894672	1.479123	38	O
	<i>Arothron stellatus</i>	0.309789	1.399626	4	R
	<i>Canthigaster bennetti</i>	0.247831	0.038908	1	R
	<i>Canthigaster janthinoptera</i>	0.247831	0.003386	2	R
	<i>Canthigaster solandri</i>	0.743494	0.017141	5	R
	<i>Canthigaster species</i>	0.123916	0.000493	1	R
	<i>Canthigaster valentini</i>	1.115242	0.050755	6	R
Zanclidae	<i>Zanclus cornutus</i>	32.96159	5.471527	91	C

Appendix 5

CORAL DIVERSITY

Full list of coral genera recorded in the photoquadrat and coral recruit surveys.

GENUS	PHOTOQUADRATS	RECRUITS
<i>Acanthastrea</i>	X	X
<i>Acropora</i>	X	X
<i>Anacropora</i>	X	
<i>Astrea</i>	X	X
<i>Astreopora</i>	X	X
<i>Cantharellus</i>		X
<i>Caulastrea</i>	X	X
<i>Coeloseris</i>	X	
<i>Ctenactis</i>	X	X
<i>Cycloseris</i>	X	X
<i>Cyphastrea</i>	X	X
<i>Diploastrea</i>	X	X
<i>Dipsastrea</i>	X	X
<i>Duncanopsammia</i>	X	
<i>Echinomorpha</i>	X	X
<i>Echinopora</i>	X	X
<i>Echinophyllia</i>	X	X
<i>Euphyllia</i>	X	X
<i>Favites</i>	X	X
<i>Fungia</i>	X	X
<i>Galaxea</i>	X	X
<i>Gardineroseris</i>	X	X
<i>Goniastrea</i>	X	X
<i>Goniopora</i>	X	
<i>Halomitra</i>	X	
<i>Heliofungia</i>	X	
<i>Herpolithia</i>	X	X
<i>Homophyllia</i>	X	
<i>Hydnophora</i>	X	X
<i>Isopora</i>	X	X

GENUS	PHOTOQUADRATS	RECRUITS
<i>Leptastrea</i>	X	X
<i>Leptoria</i>	X	X
<i>Leptoseris</i>	X	X
<i>Lithophyllon</i>		X
<i>Lobactis</i>	X	
<i>Lobophyllia</i>	X	X
<i>Merulina</i>	X	X
<i>Montipora</i>	X	X
<i>Mycedium</i>	X	X
<i>Oulophyllia</i>	X	
<i>Oxypora</i>	X	
<i>Pachyseris</i>	X	X
<i>Pavona</i>	X	X
<i>Pectinia</i>	X	
<i>Platygyra</i>	X	X
<i>Plerogyra</i>		X
<i>Plesiastrea</i>	X	
<i>Pocillopora</i>	X	X
<i>Podobacia</i>	X	
<i>Polyphyllia</i>	X	
<i>Porites</i>	X	X
<i>Psammocora</i>	X	X
<i>Sandalolitha</i>	X	X
<i>Seriatopora</i>	X	X
<i>Stylocoeniella</i>	X	
<i>Stylophora</i>	X	X
<i>Trachyphyllia</i>	X	
<i>Tubastrea</i>		X
<i>Turbinaria</i>	X	X
<i>Zoopilus</i>	X	

Appendix 6

INVERTEBRATE DIVERSITY

Full list of invertebrate species recorded in belt transect surveys.

SCIENTIFIC NAME	ORGANISM TYPE
<i>Anadara sp.</i>	Bivalve
<i>Atrina vexillum</i>	Bivalve
<i>Chlamys sp.</i>	Bivalve
<i>Pinctada imbricata</i>	Bivalve
<i>Pinctada margaritifera</i>	Bivalve
<i>Pinctada maxima</i>	Bivalve
<i>Pteria penguin</i>	Bivalve
<i>Spondylus squamosus</i>	Bivalve
<i>Tridacna crocea</i>	Bivalve
<i>Tridacna derasa</i>	Bivalve
<i>Tridacna gigas</i>	Bivalve
<i>Tridacna maxima</i>	Bivalve
<i>Tridacna mbalavuana</i>	Bivalve
<i>Tridacna squamosa</i>	Bivalve
<i>Tridacna sp.</i>	Bivalve
<i>Vasticardium elongatum</i>	Bivalve
<i>Octopus cyanea</i>	Cephalopod
<i>Octopus sp.</i>	Cephalopod
<i>Comaster sp</i>	Crinoid
<i>Panulirus versicolor</i>	Crustacean
<i>Astralium rhodostomum</i>	Gastropod
<i>Cerithium nodulosum</i>	Gastropod
<i>Charonia tritonis</i>	Gastropod
<i>Conus ammiralis</i>	Gastropod
<i>Conus leopardus</i>	Gastropod
<i>Conus litteratus</i>	Gastropod
<i>Conomurex luhuanus</i>	Gastropod
<i>Conus miles</i>	Gastropod
<i>Conus vexillum</i>	Gastropod
<i>Cypraea scurra</i>	Gastropod

SCIENTIFIC NAME	ORGANISM TYPE
<i>Cypraea tigris</i>	Gastropod
<i>Dendropoma maximum</i>	Gastropod
<i>Filifusus filamentosus</i>	Gastropod
<i>Lambis lambis</i>	Gastropod
<i>Lambis truncata</i>	Gastropod
<i>Oliva caerulea</i>	Gastropod
<i>Oliva miniacea</i>	Gastropod
<i>Oxymeris maculata</i>	Gastropod
<i>Pleuroploca sp.</i>	Gastropod
<i>Reishia armigera</i>	Gastropod
<i>Rochia nilotica</i>	Gastropod
<i>Sinustrombus latissimus</i>	Gastropod
<i>Strombus alatus</i>	Gastropod
<i>Strombus chrysostomus</i>	Gastropod
<i>Strombus sinuatus</i>	Gastropod
<i>Strombus sp.</i>	Gastropod
<i>Tectus fenestratus</i>	Gastropod
<i>Tectus pyramis</i>	Gastropod
<i>Thetystrombus latus</i>	Gastropod
<i>Thais tuberosa</i>	Gastropod
<i>Trochus maculatus</i>	Gastropod
<i>Turbo crasus</i>	Gastropod
<i>Turbo marmoratus</i>	Gastropod
<i>Turbo petholatus</i>	Gastropod
<i>Vasum ceramicum</i>	Gastropod
<i>Vasum turbinellus</i>	Gastropod
<i>Actinopyga echinites</i>	Sea cucumber
<i>Actinopyga lecanora</i>	Sea cucumber
<i>Actinopyga mauritiana</i>	Sea cucumber
<i>Actinopyga miliaris</i>	Sea cucumber
<i>Actinopyga palauensis</i>	Sea cucumber
<i>Bohadschia argus</i>	Sea cucumber
<i>Bohadschia vitiensis</i>	Sea cucumber
<i>Holothuria atra</i>	Sea cucumber
<i>Holothuria edulis</i>	Sea cucumber
<i>Holothuria fuscopunctata</i>	Sea cucumber
<i>Holothuria fuscogilva</i>	Sea cucumber
<i>Holothuria nobilis</i>	Sea cucumber
<i>Holothuria whitmaei</i>	Sea cucumber
<i>Pearsonothuria graeffei</i>	Sea cucumber

SCIENTIFIC NAME	ORGANISM TYPE
<i>Stichopus chloronatus</i>	Sea cucumber
<i>Stichopus hermannii</i>	Sea cucumber
<i>Stichopus vastus</i>	Sea cucumber
<i>Thelenota ananas</i>	Sea cucumber
<i>Thelenota anax</i>	Sea cucumber
<i>Acanthaster planci</i>	Sea star
<i>Choriaster granulatus</i>	Sea star
<i>Culcita novaeguineae</i>	Sea star
<i>Linckia laevigata</i>	Sea star
<i>Linckia multifora</i>	Sea star
<i>Linckia sp.</i>	Sea star
<i>Nardoa novaecaledoniae</i>	Sea star
<i>Ophiothrix sp.</i>	Sea star
<i>Diadema setosum</i>	Urchin
<i>Echinostrephus aciculatus</i>	Urchin
<i>Echinometra mathaei</i>	Urchin

Appendix 7

DATA INVENTORY

An inventory of data produced from the expedition.

A = Visit blueprosperityfiji.org/expedition for links to these data.

B = Visit blueprosperityfiji.org/expedition for instructions on requesting these data.

DATA	CONTENT	ACCESS POINTS
Metadata	Survey site locations, dates, data collected	A
Daily Ship Logs	Notes and maps documenting the expedition as it occurred	A
Underwater Photo Selects	Photos from divers taken during the expedition	A
Drone Footage Selects	Drone footage taken during the expedition	A
Fish	Fish transect survey data	B
Benthic Cover	Photoquadrat survey images and processed data	B
Macroinvertebrates	Macroinvertebrate transect survey data	B
Water Quality	Stable isotope results	B
Temperature Loggers	Deployment locations. Note: loggers remain deployed at the time of this report	B
Large Area Imaging 3D Coral Reef Models	Survey images and model files	B
Coral Recruitment	Juvenile coral observations derived from models	B
Rugosity	Rugosity data derived from models	B
Coral Reef Fly-through Videos	Videos examining 3D coral reef models from a selection of survey sites	A
SeaSketch Platform	Interactive maps showing expedition data	A
Coral Reef Orthophotomosaics	Flat, high resolution images of the coral reef models	A

Appendix 8

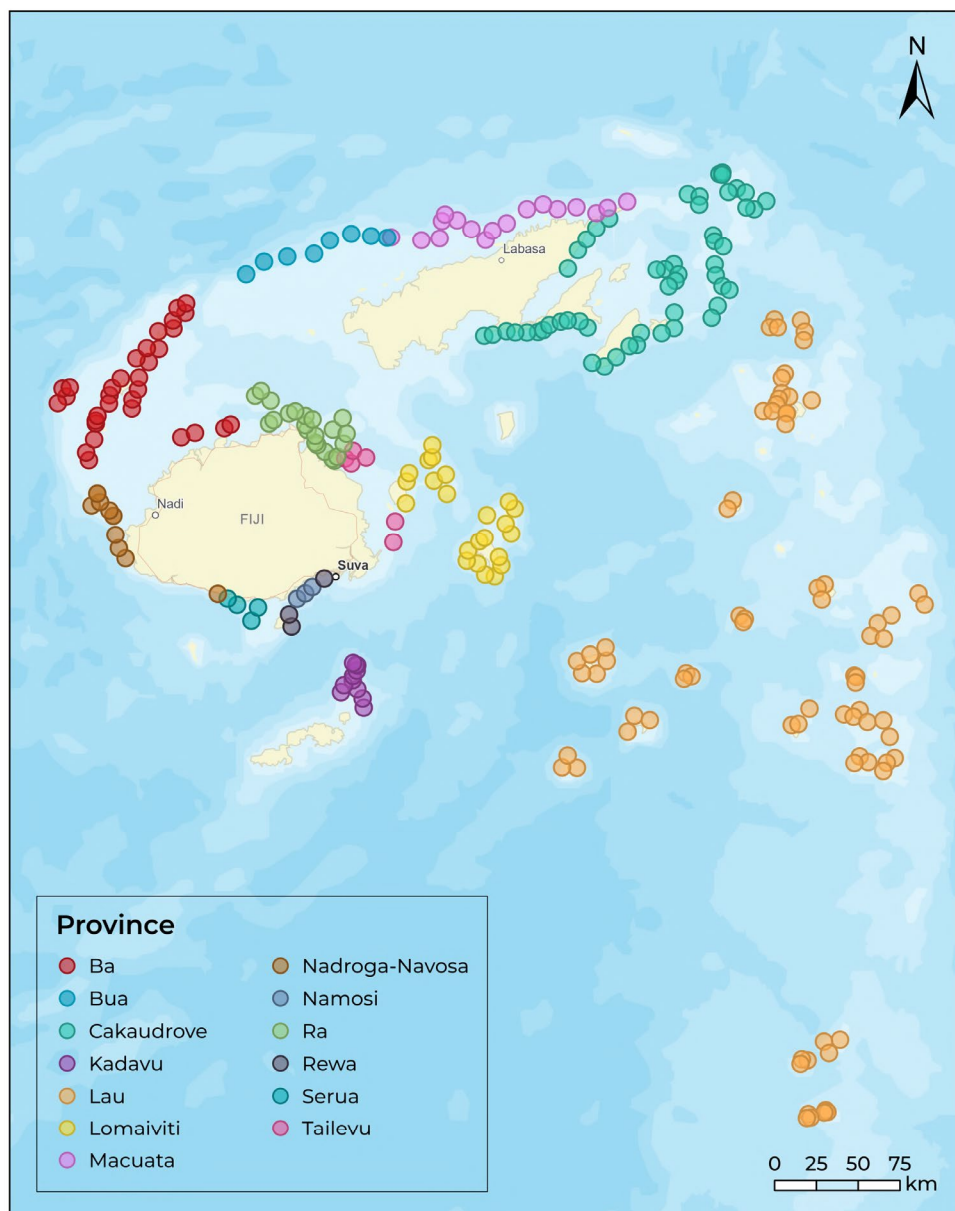
MAP BOOK

The Map Book includes maps created with data from the 2023 Expedition, providing visual references to help readers understand spatial patterns in Fiji's marine environment. The maps contain survey site-level data presented at a national and provincial scale.

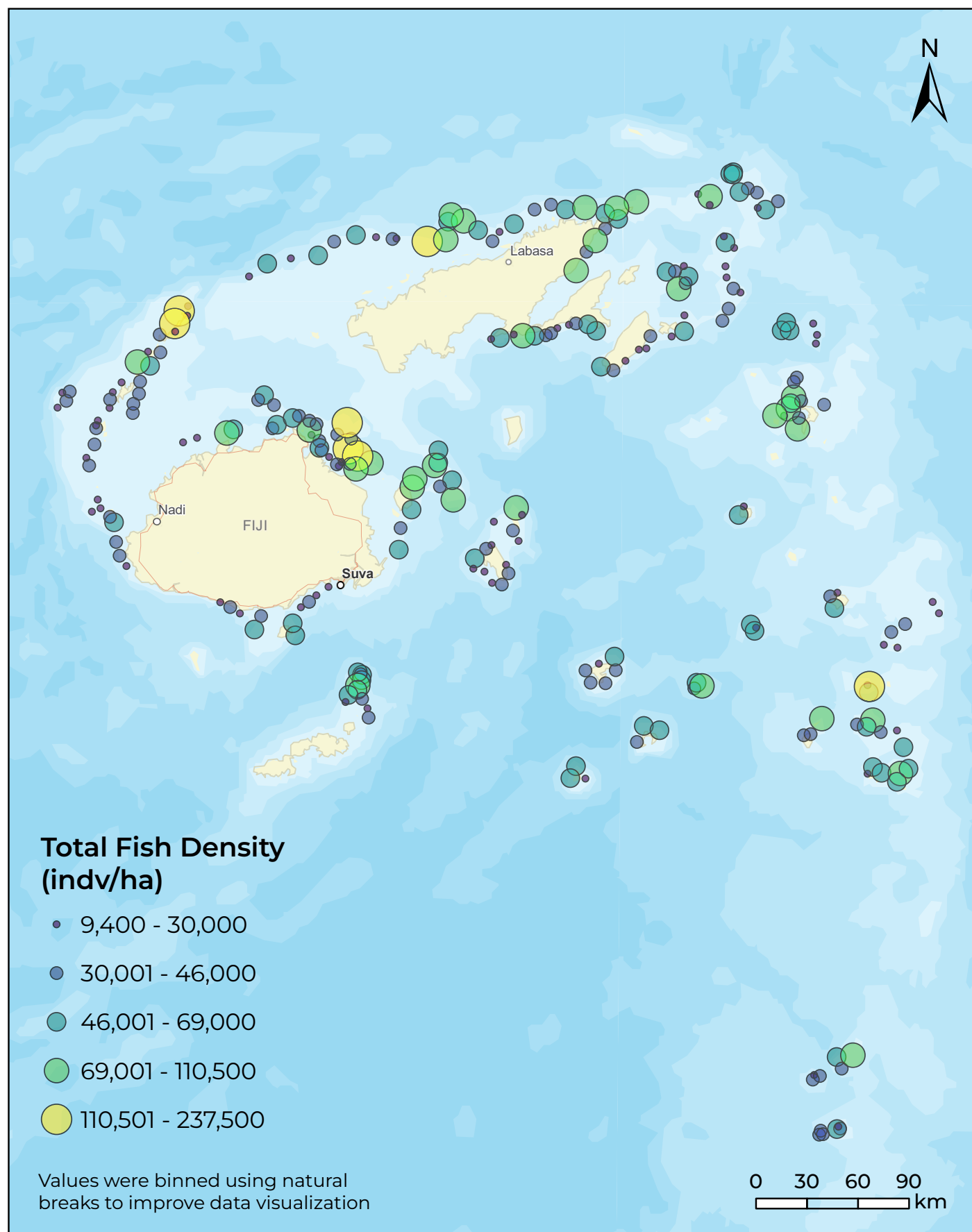
By mapping these variables, the Map Book helps identify areas with certain ecological characteristics and analyse relationships between different environmental factors, offering a tool to support Fiji's Marine Spatial Planning and conservation goals.

These datasets can also be viewed online at www.seasketch.org/fiji/app.

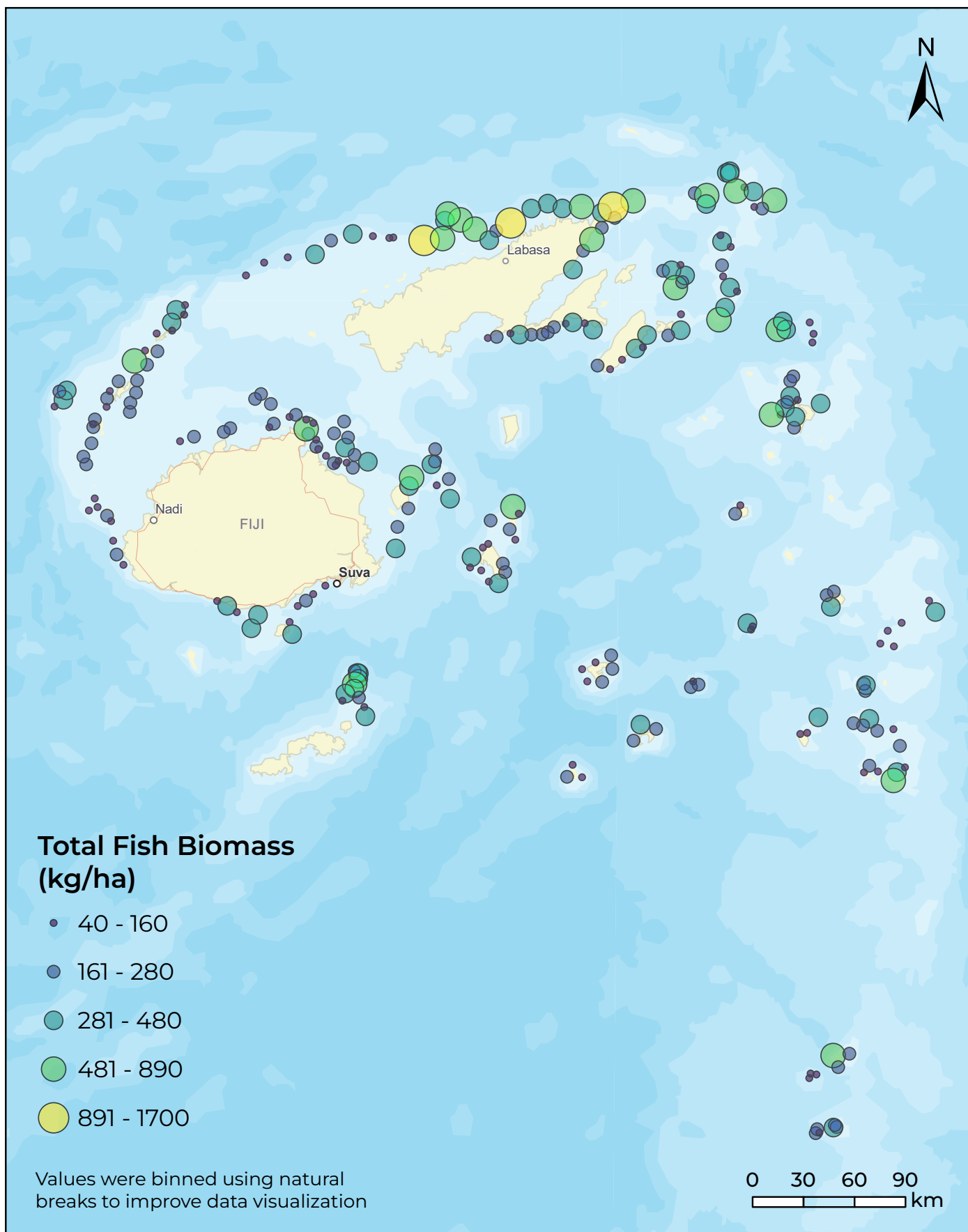
MAP 1: Map of survey sites. Sites are colored by Province.



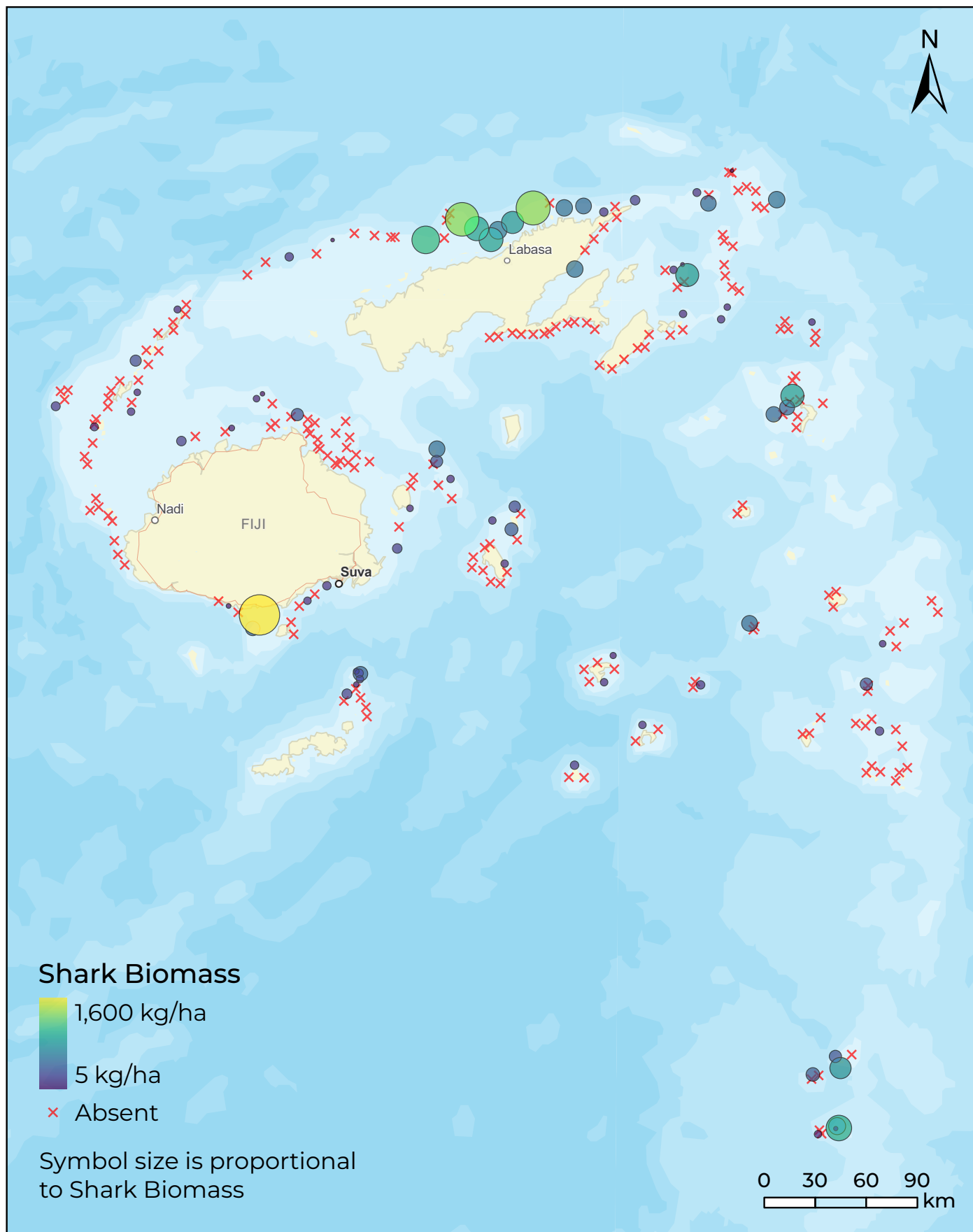
MAP 2: Mean fish density at survey sites across Fiji.



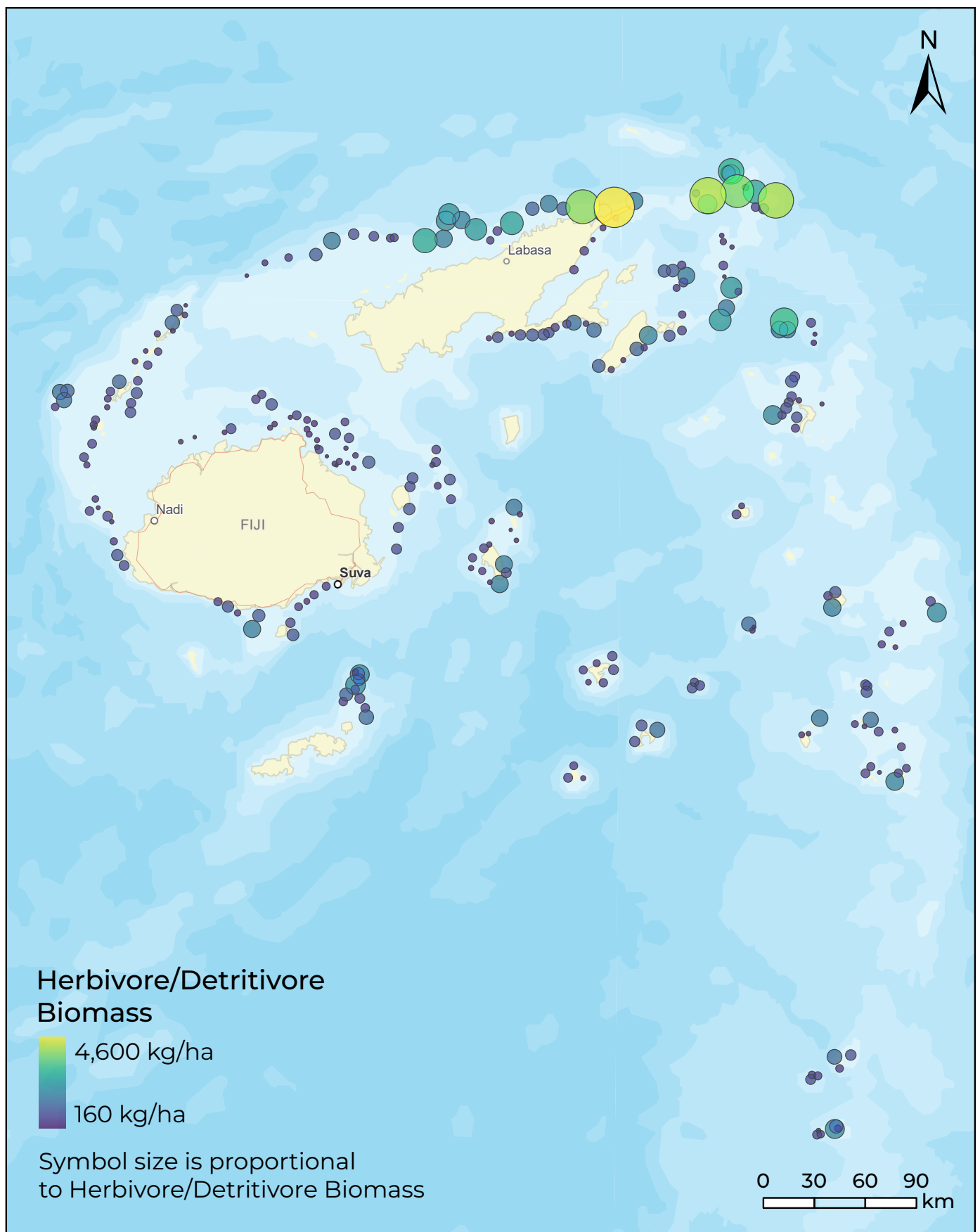
MAP 3: Mean fish biomass at survey sites across Fiji.



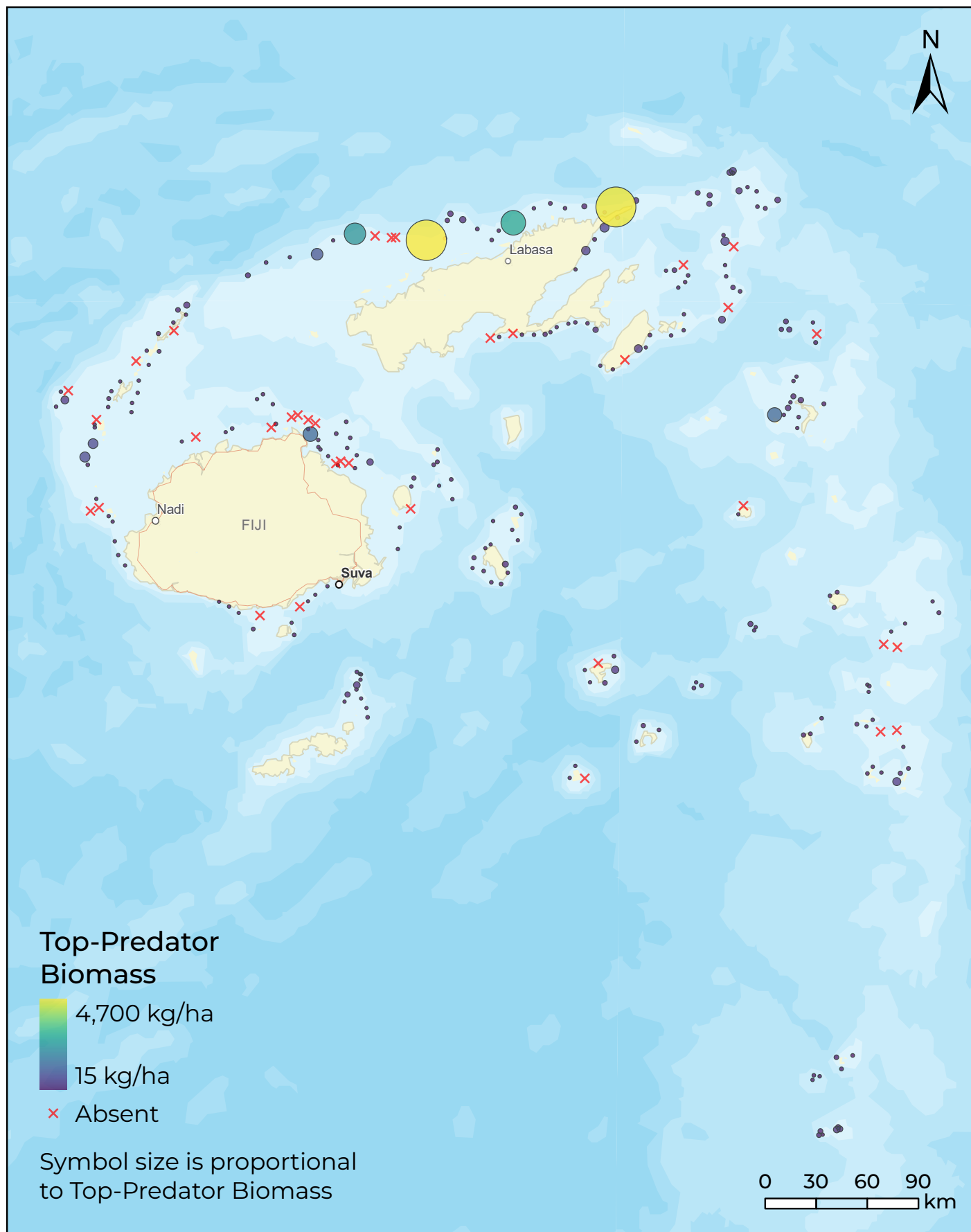
MAP 4: Mean shark biomass at survey sites across Fiji.



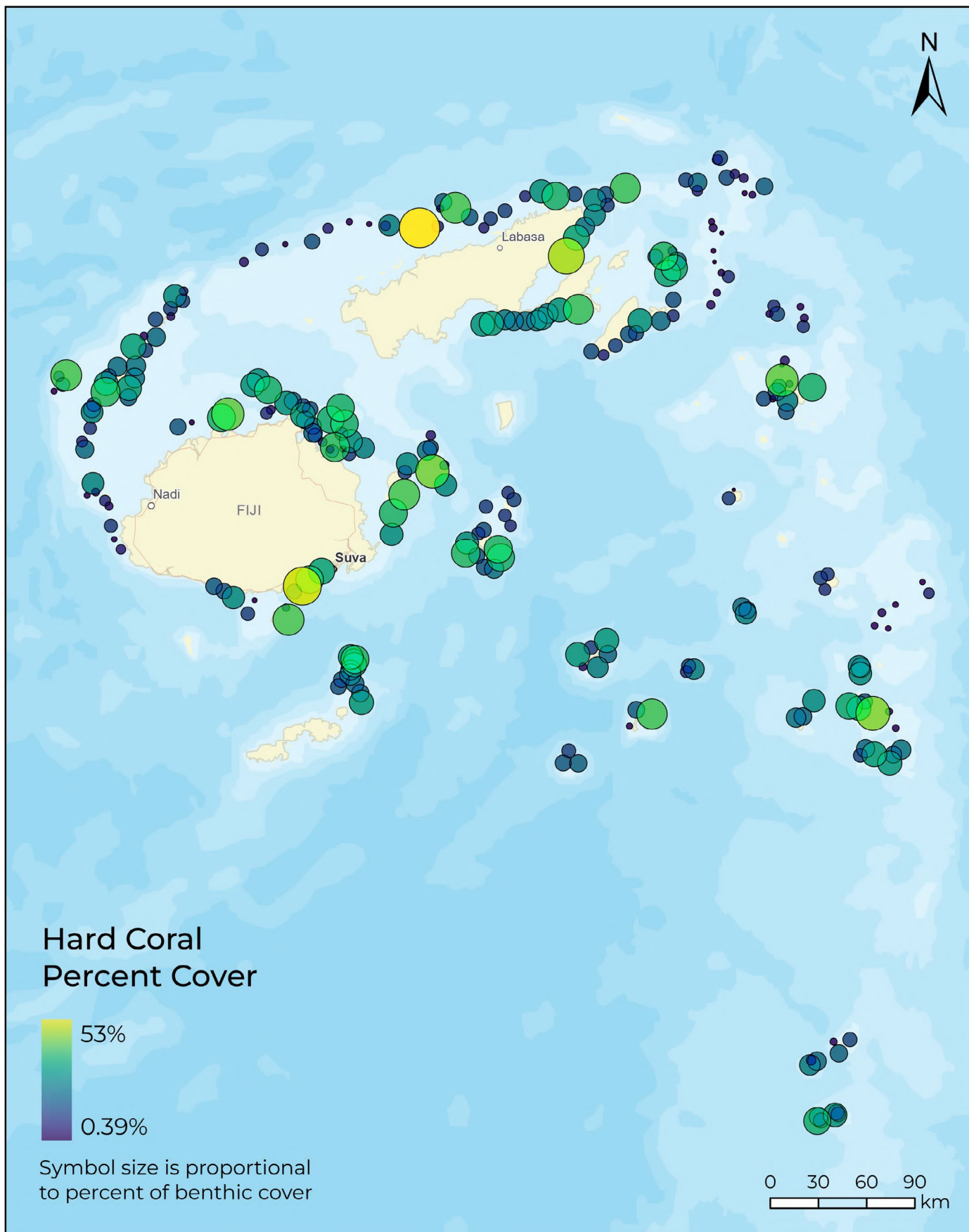
MAP 5: Mean biomass of herbivorous and detritivorous fish at survey sites across Fiji. Herbivores feed primarily on algae and seaweed, and detritivores consume decaying organic material.



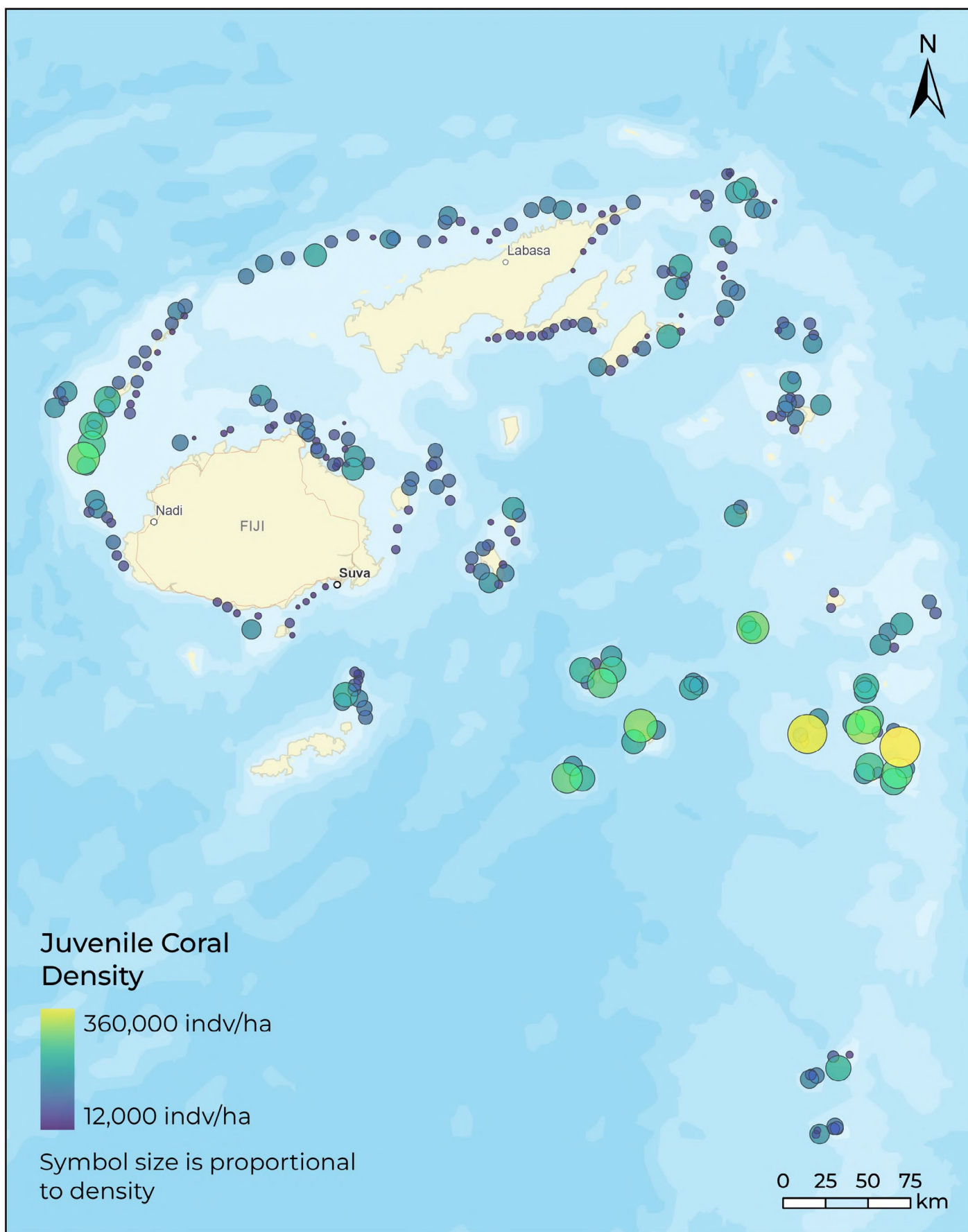
MAP 6: Mean top-predator fish biomass at survey sites across Fiji.



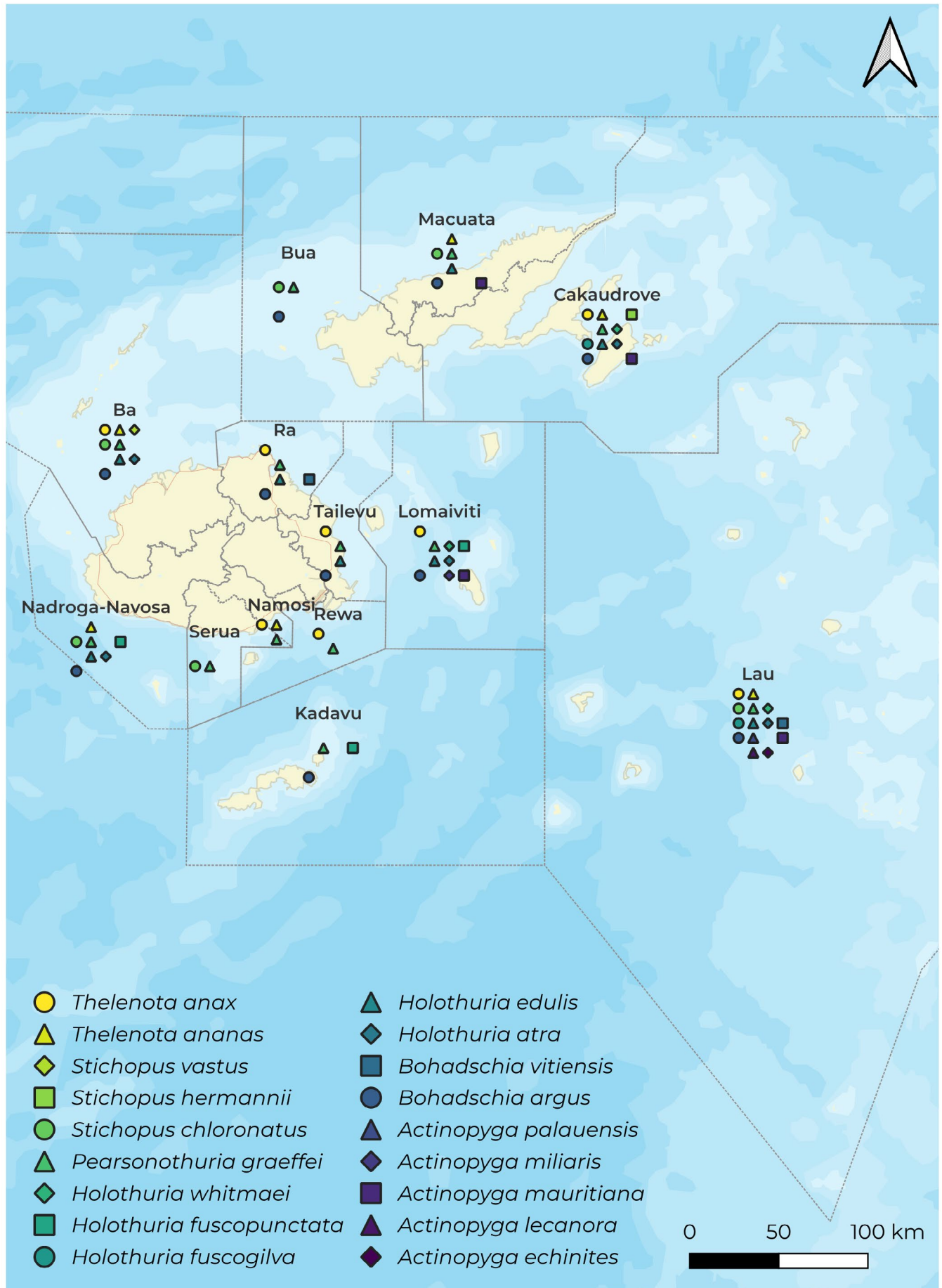
MAP 7: Mean percent of the seafloor covered by living hard corals at survey sites across Fiji. Hard corals contribute to reef building and create complex habitats for fish and other organisms.



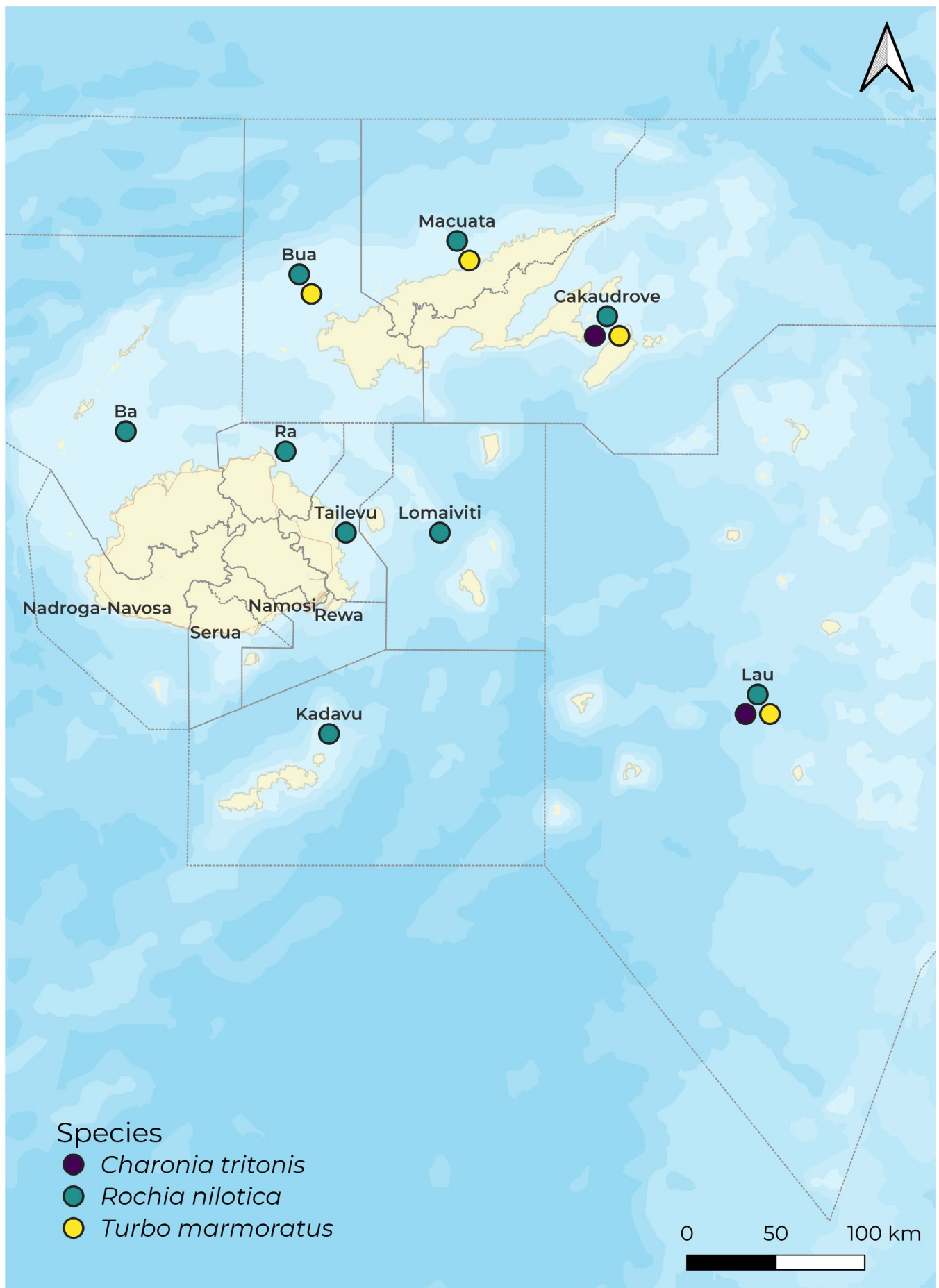
MAP 8: Mean density of juvenile corals (typically 1-5 cm in diameter) observed at survey sites across Fiji.



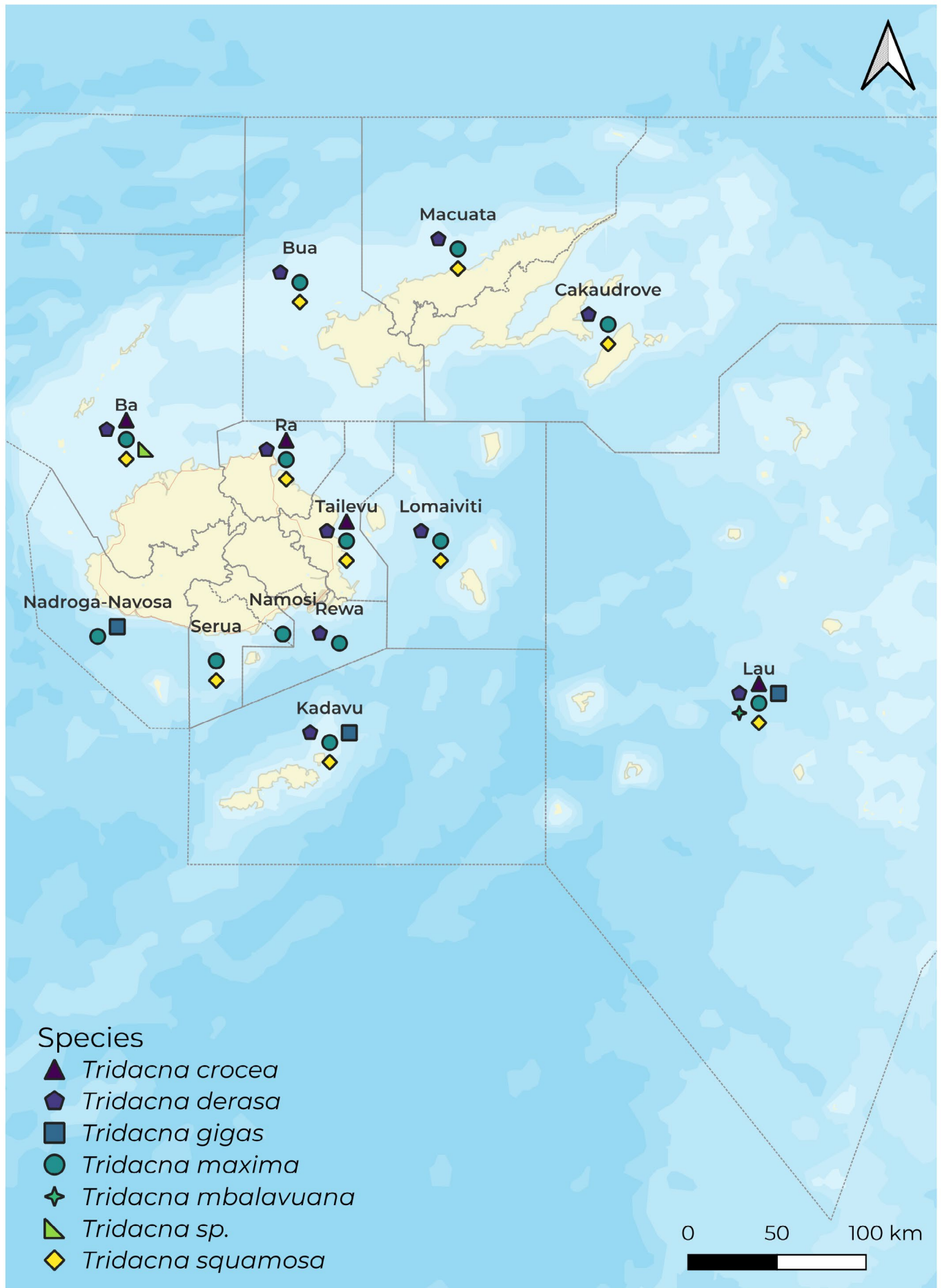
MAP 9: Map of sea cucumber species present in each Province surveyed. Note that only presence is plotted and an absence of a symbol indicates a true zero, rather than NA.



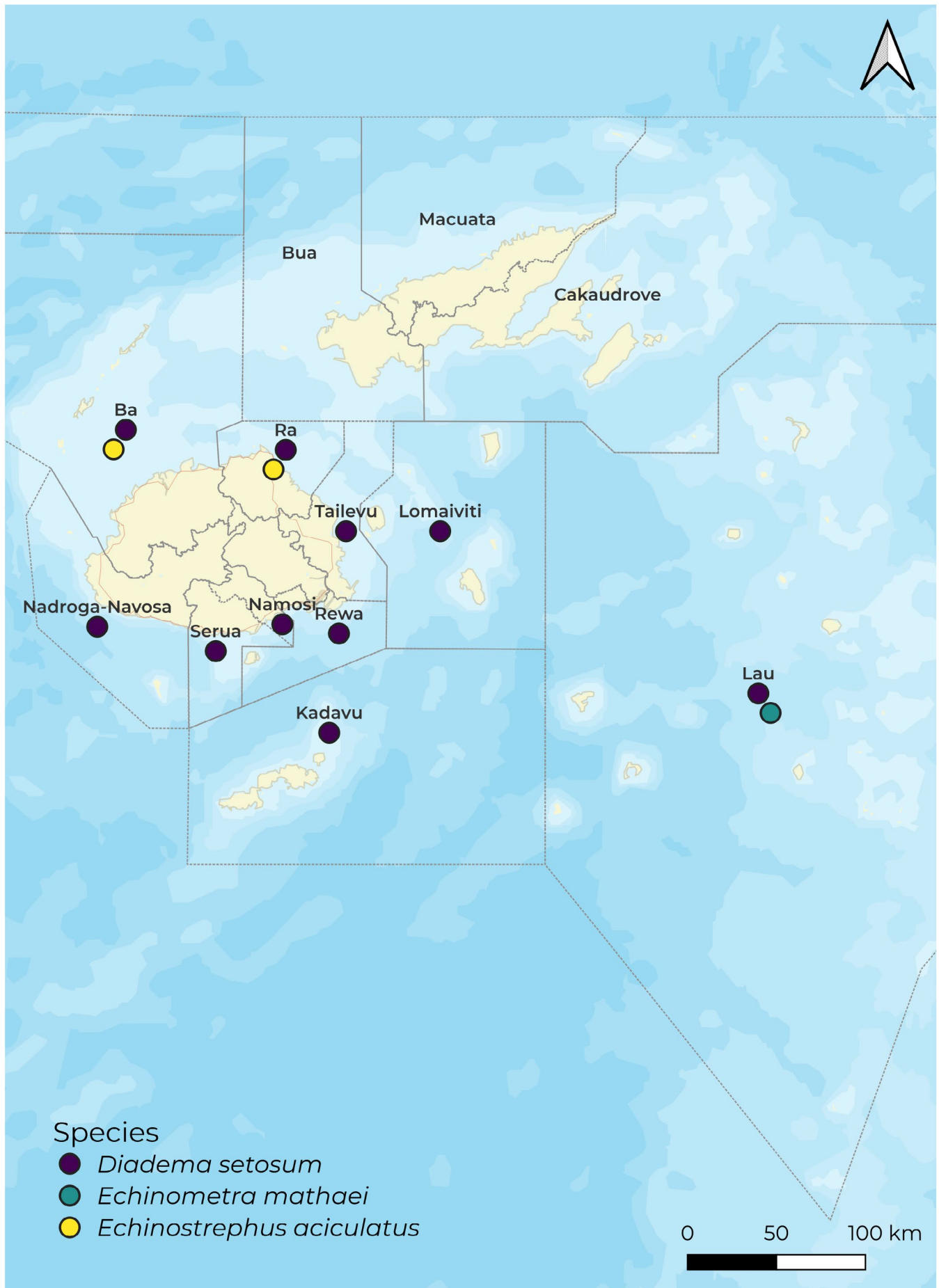
MAP 10: Map of ecologically and commercially important gastropod species present in each Province surveyed. Note that only presence is plotted and an absence of a symbol indicates a true zero, rather than NA.



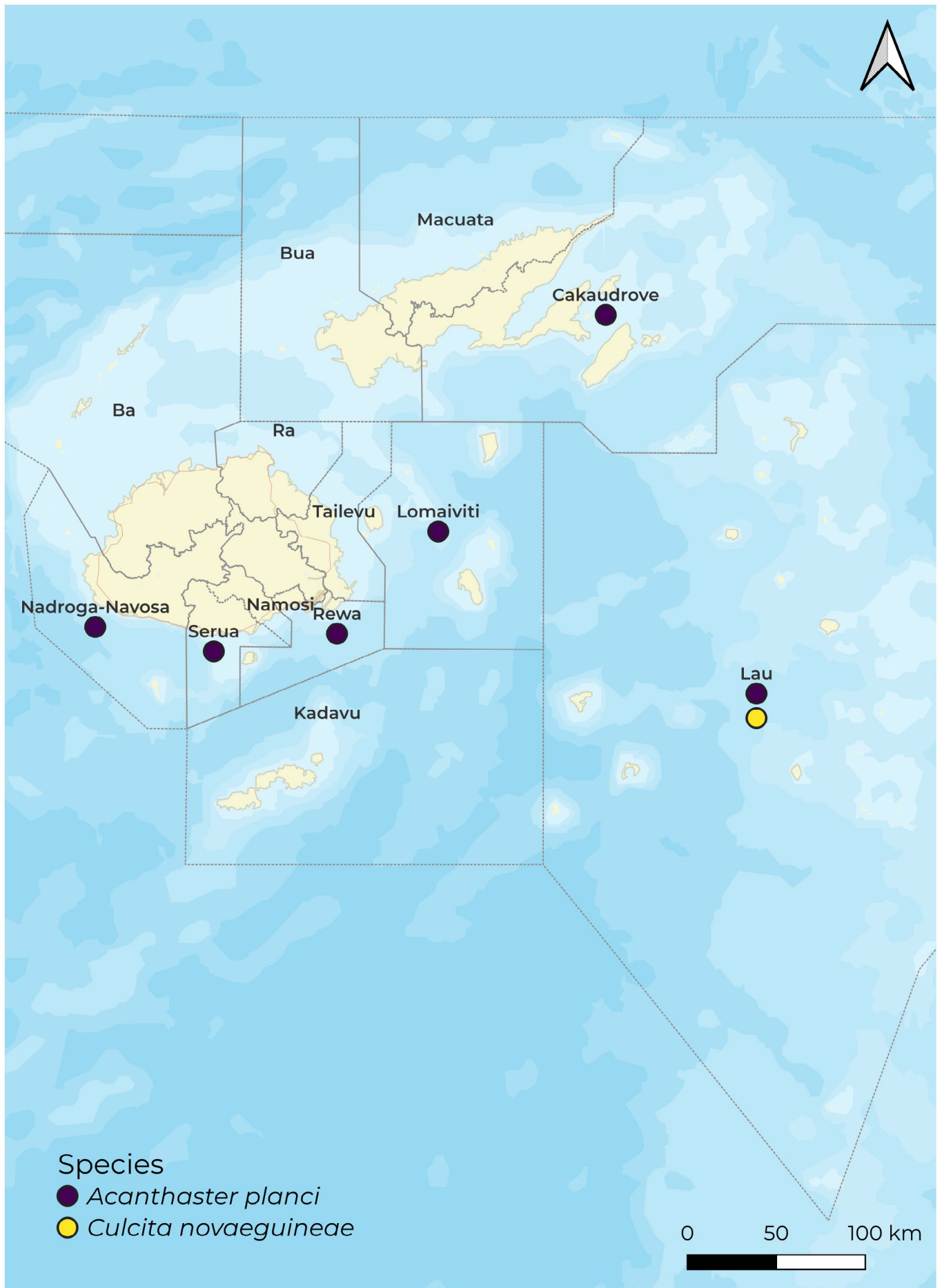
MAP 11: Map of giant clam species present in each Province surveyed. Note that only presence is plotted and an absence of a symbol indicates a true zero, rather than NA.



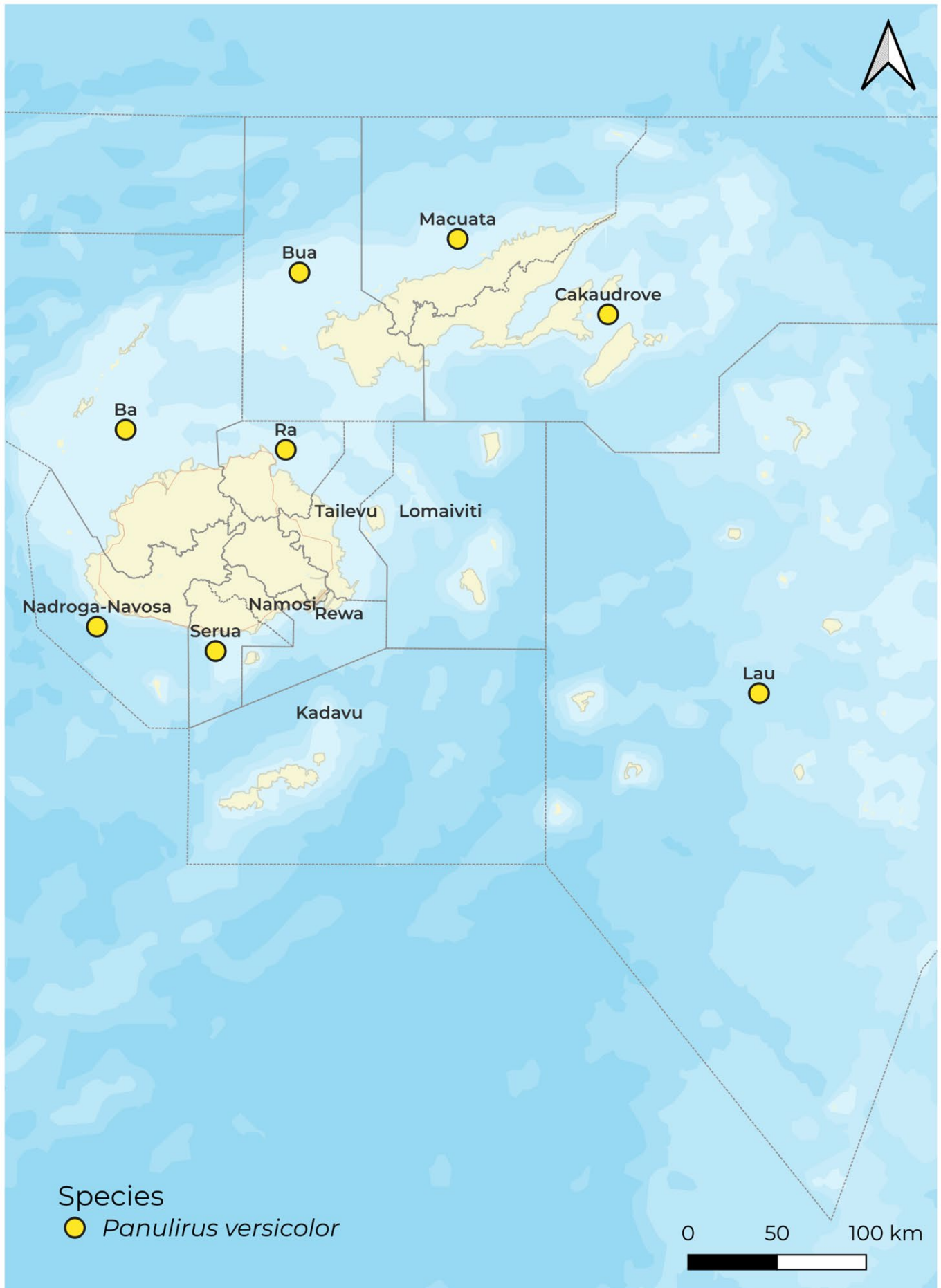
MAP 12: Map of sea urchin species present in each Province surveyed. Note that only presence is plotted and an absence of a symbol indicates a true zero, rather than NA.



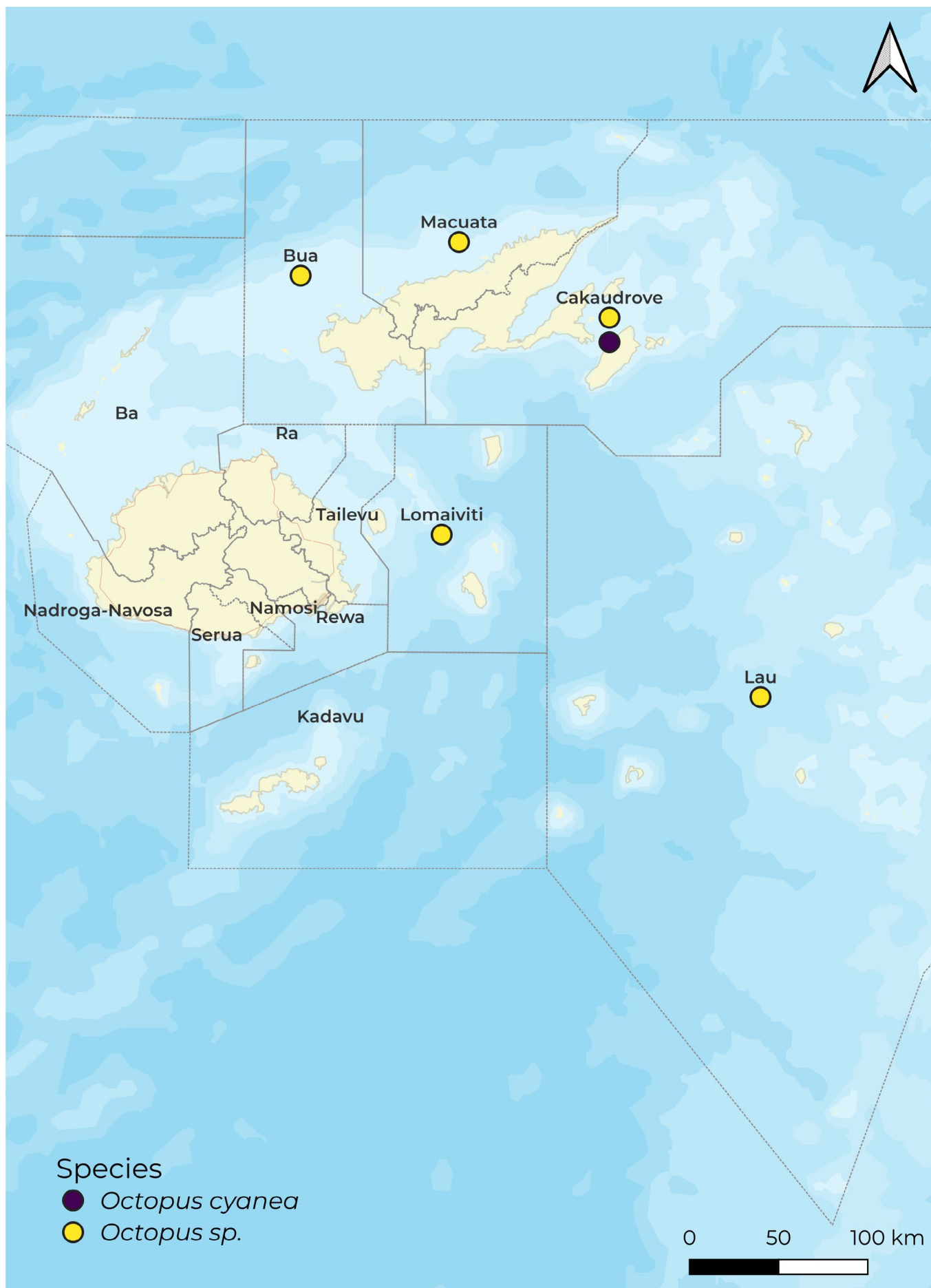
MAP 13: Map of sea star species present in each Province surveyed. Note that only presence is plotted and an absence of a symbol indicates a true zero, rather than NA.



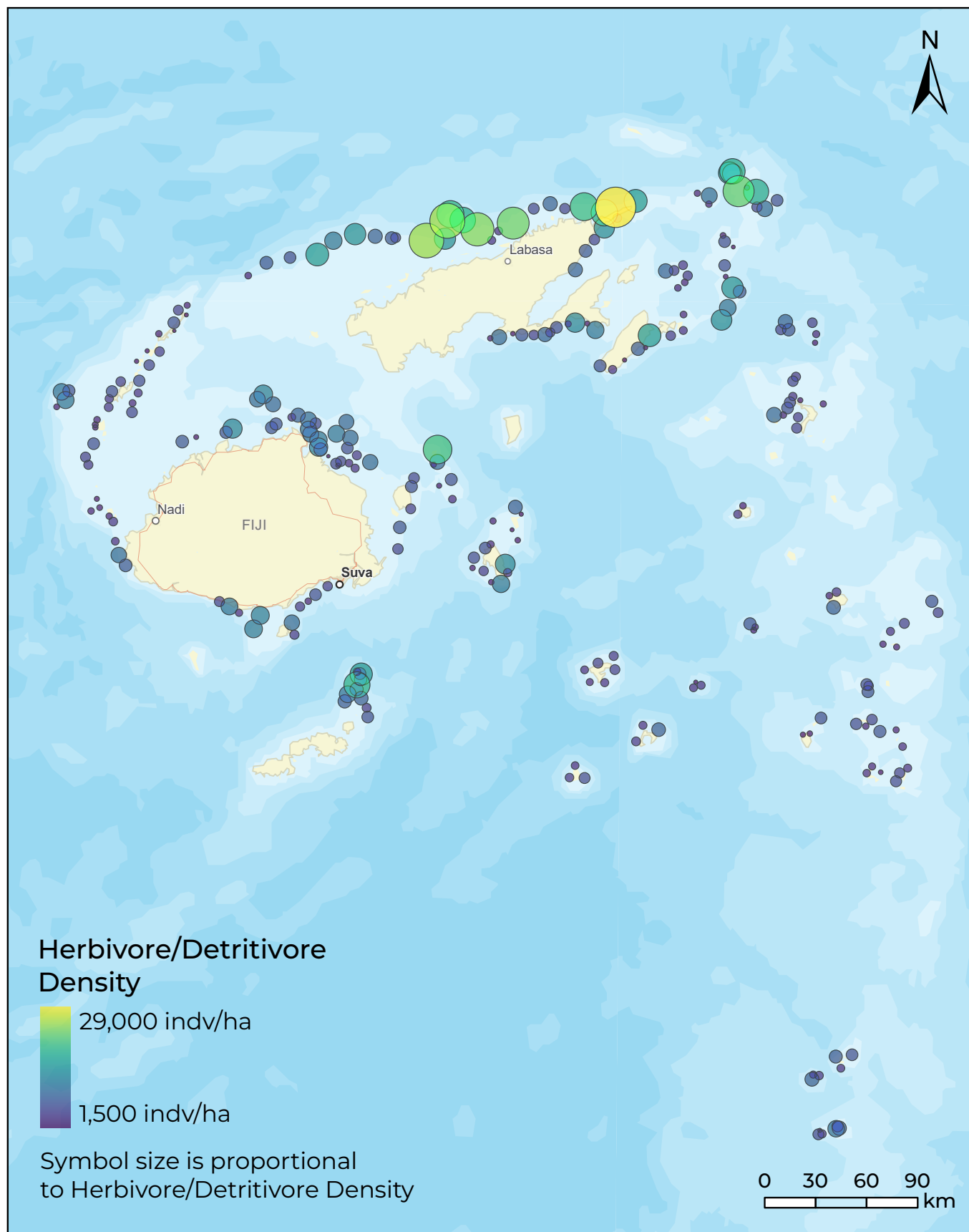
MAP 14: Map of lobsters present in each Province surveyed. Note that only presence is plotted and an absence of a symbol indicates a true zero, rather than NA.



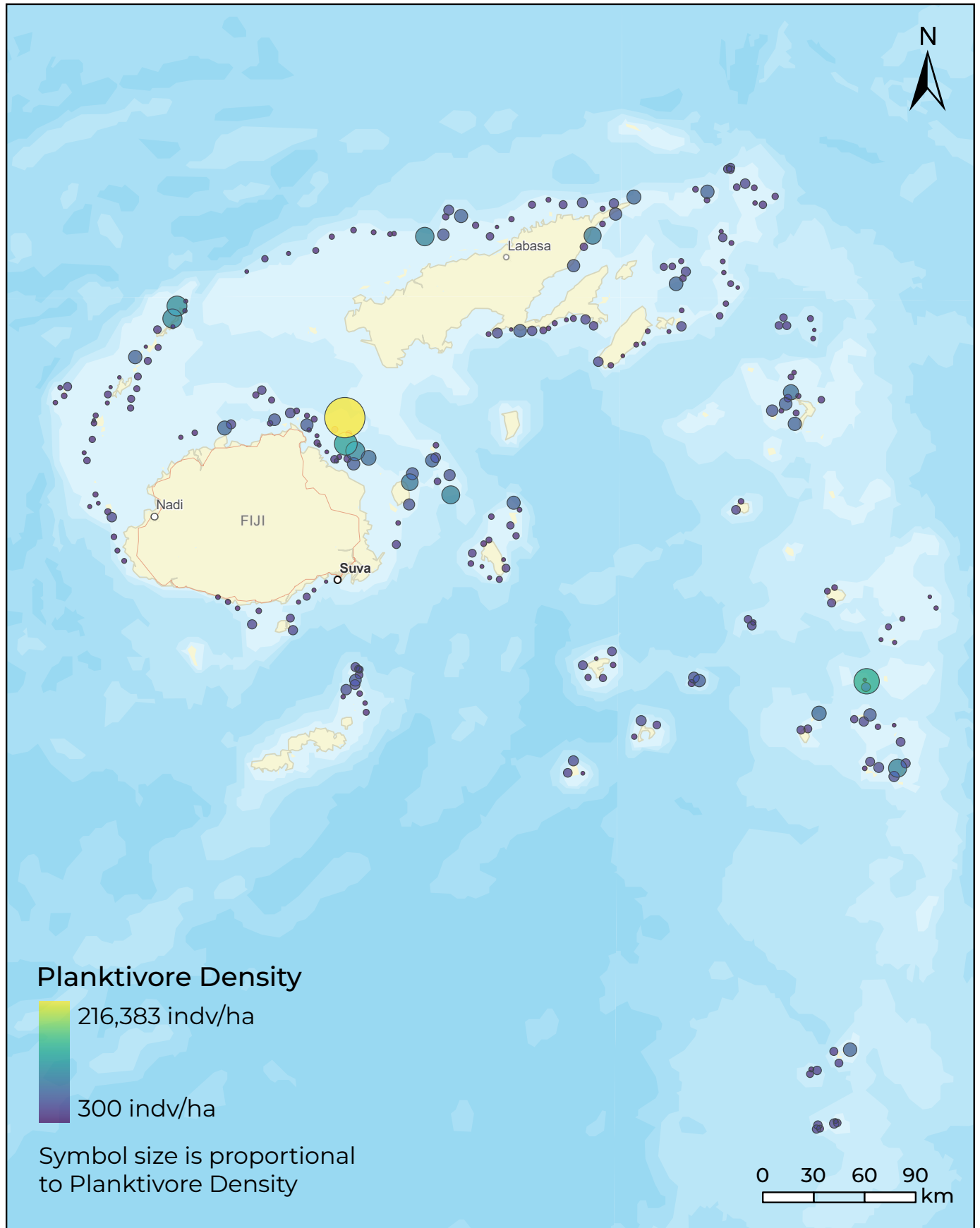
MAP 15: Map of octopus species present in each Province surveyed. Note that only presence is plotted and an absence of a symbol indicates a true zero, rather than NA.



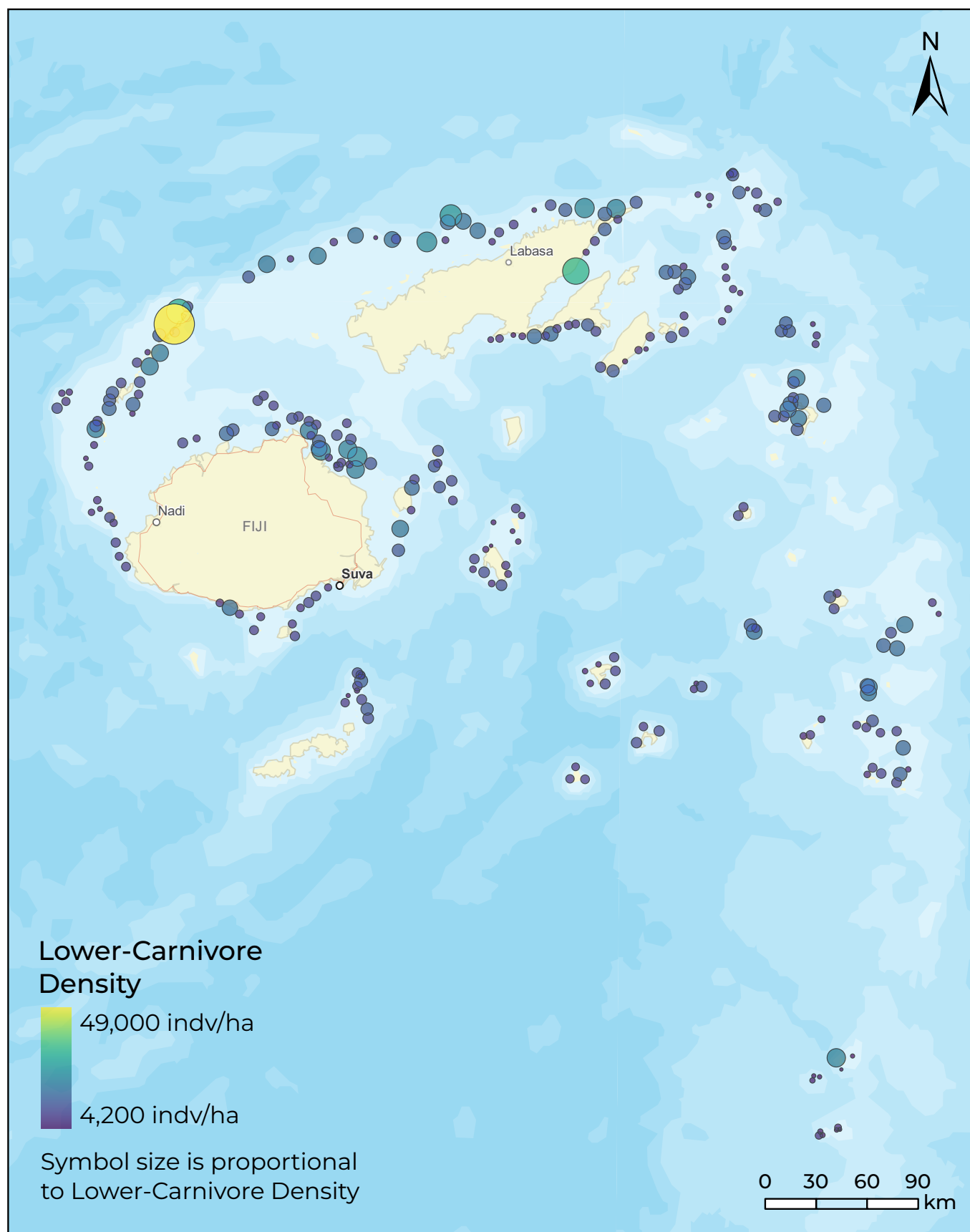
MAP 16: Mean density of herbivorous and detritivorous fish at survey sites across Fiji. Herbivores feed primarily on algae and seaweed, and detritivores consume decaying organic material.



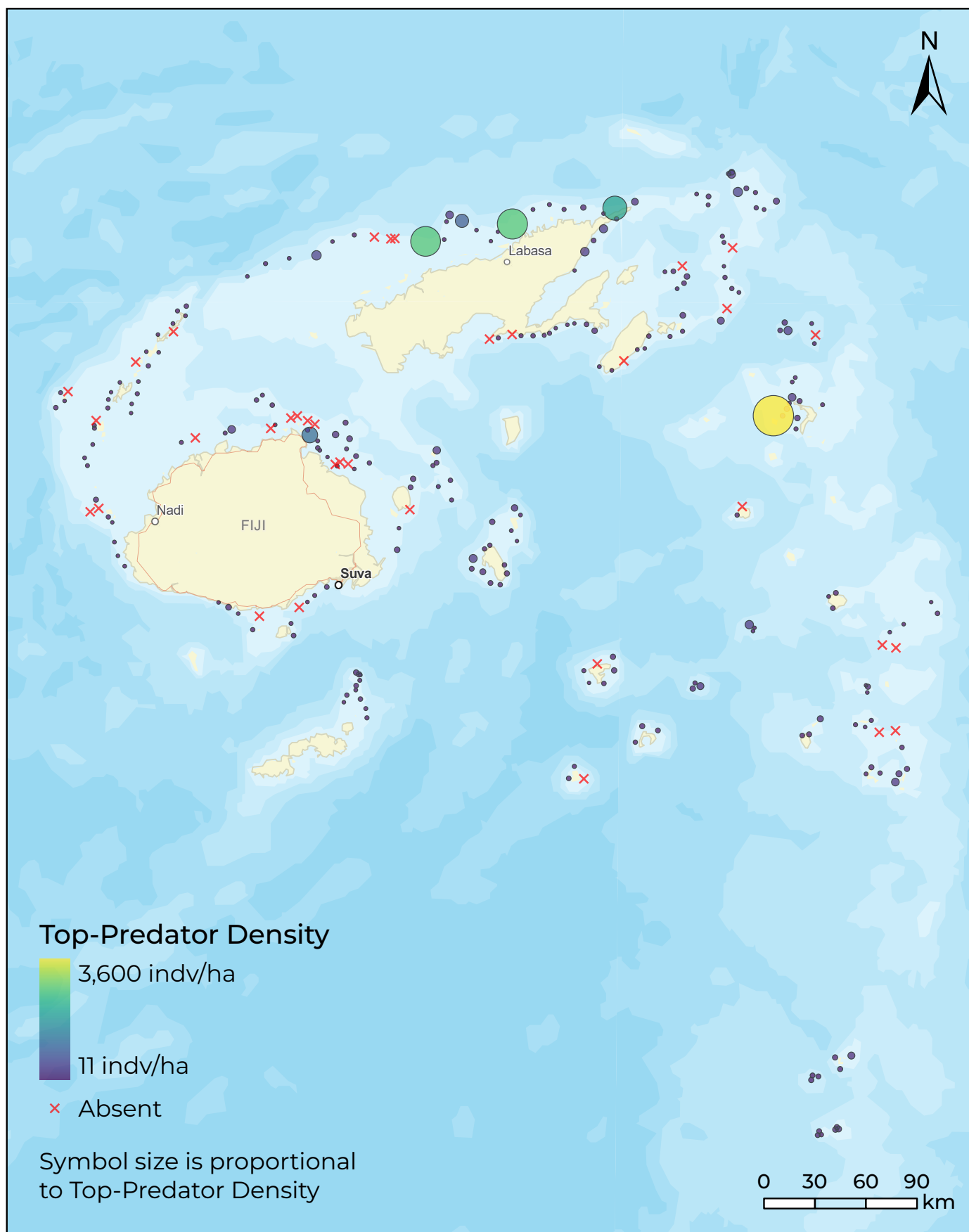
MAP 17: Mean density of planktivorous fish at survey sites across Fiji. Planktivores feed primarily on plankton.



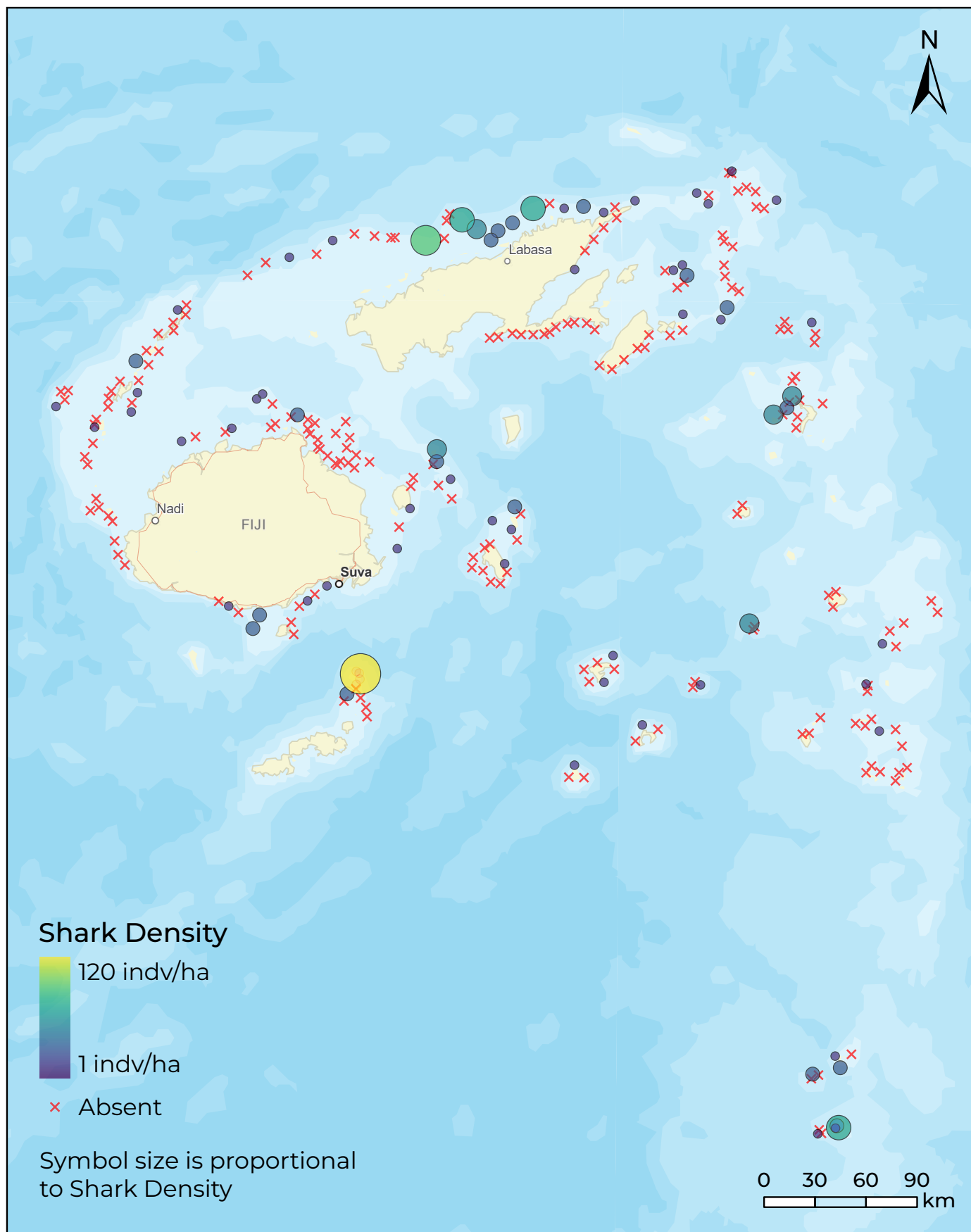
MAP 18: Mean density of lower-carnivore fish at survey sites across Fiji.



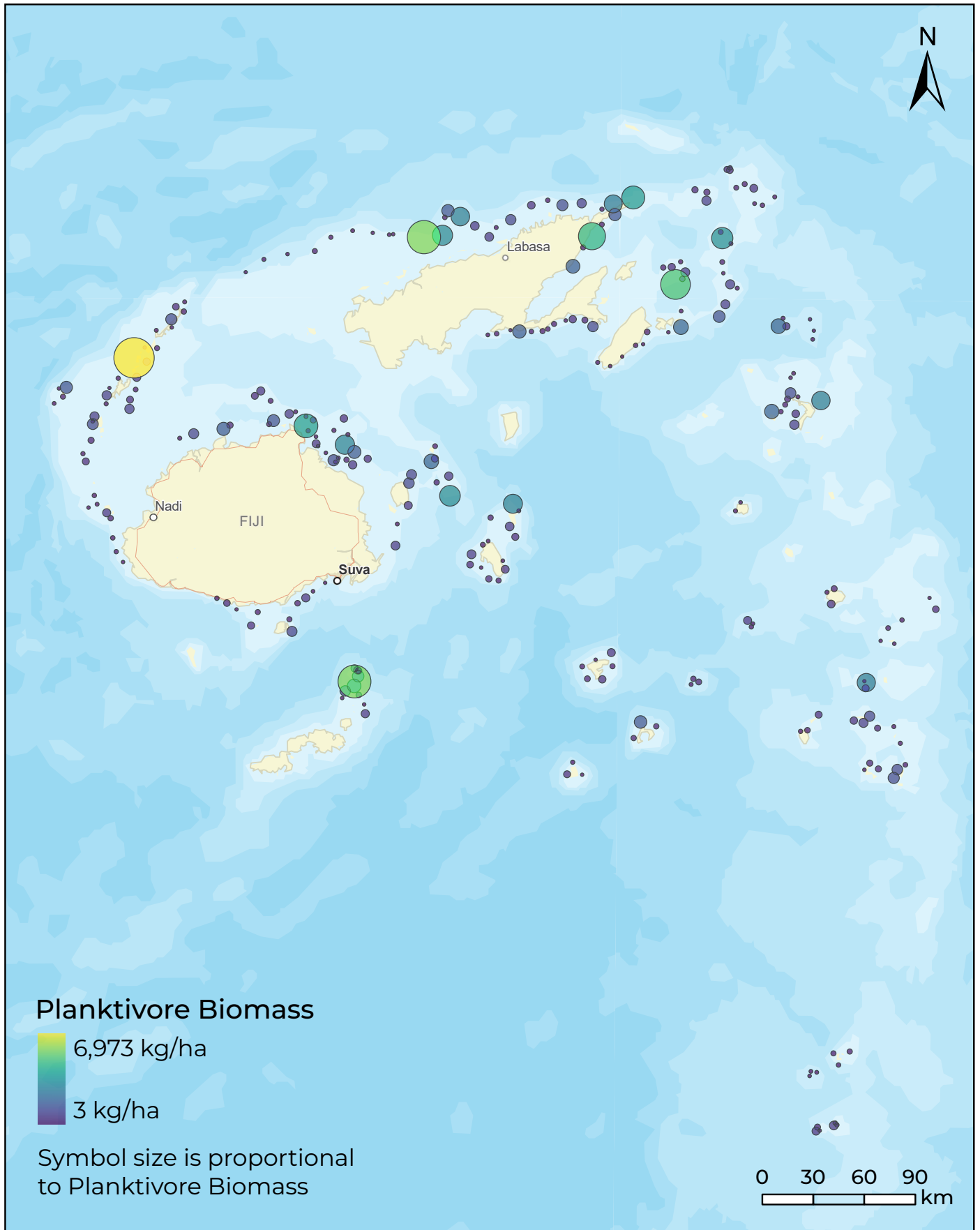
MAP 19: Mean density of top-predator fish at survey sites across Fiji.



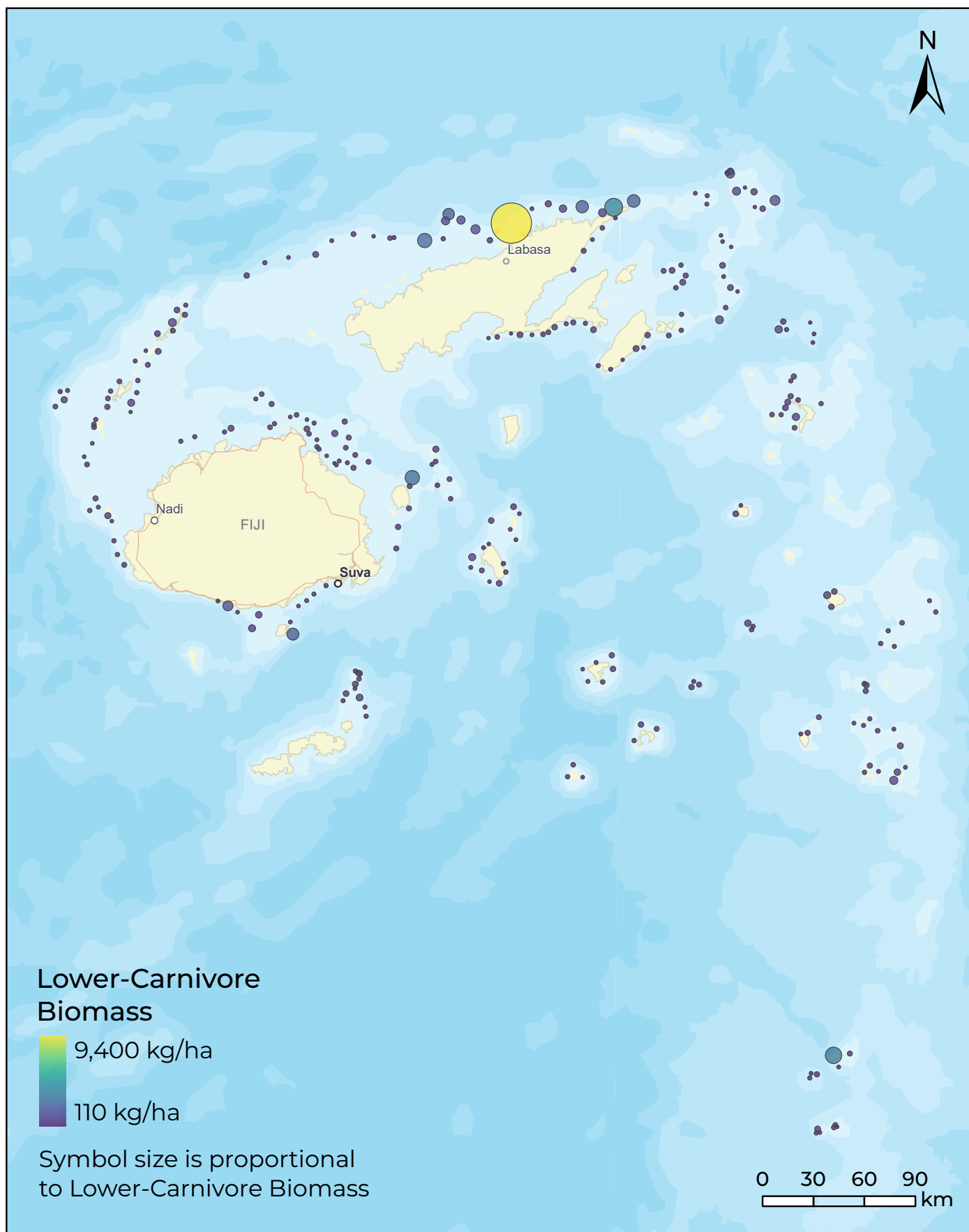
MAP 20: Mean density of sharks at survey sites across Fiji.



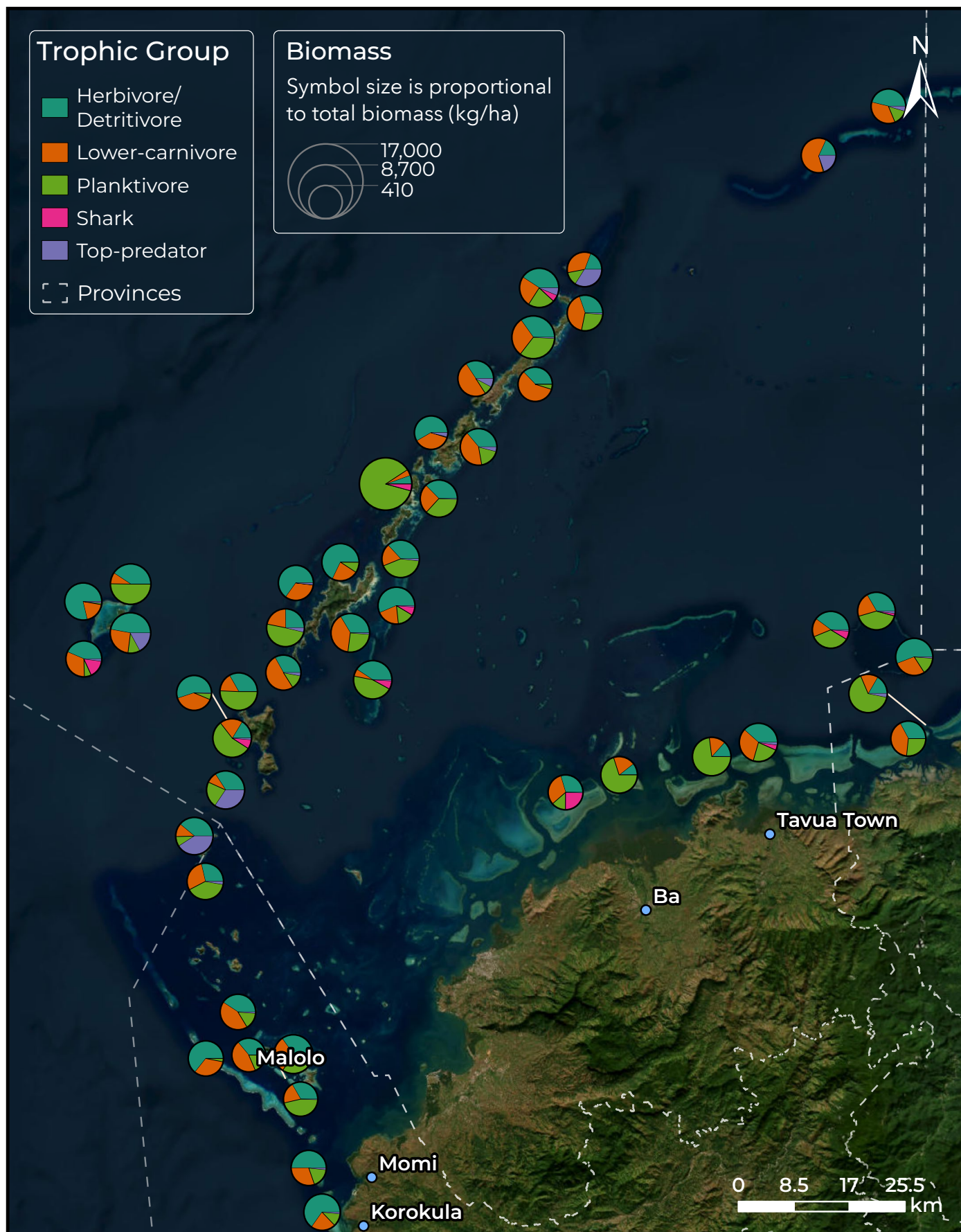
MAP 21: Mean planktivorous fish biomass at survey sites across Fiji. Planktivores feed primarily on plankton.



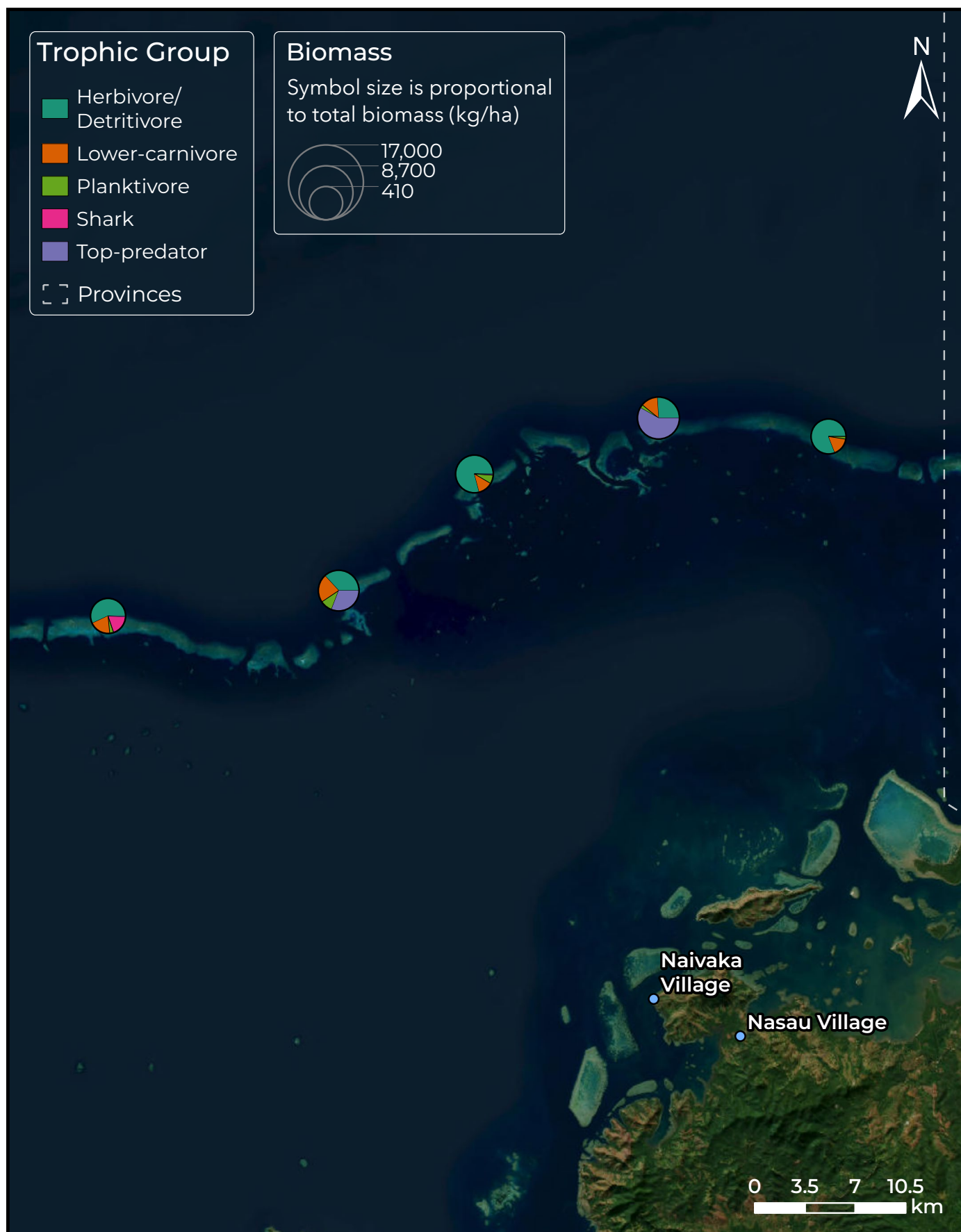
MAP 22: Mean lower-carnivore fish biomass at survey sites across Fiji.



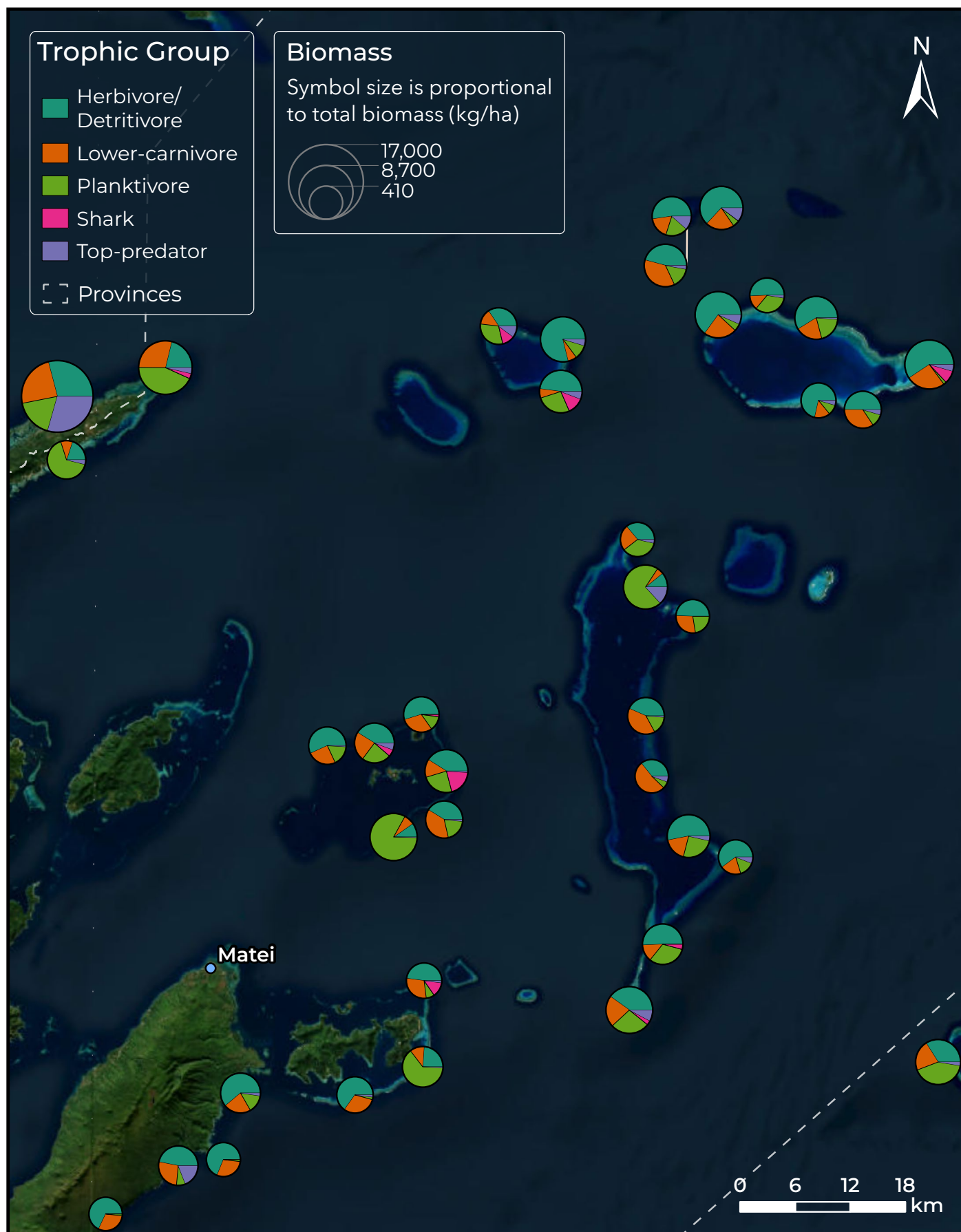
MAP 23: Mean fish biomass by trophic group at each survey site — Ba Province.



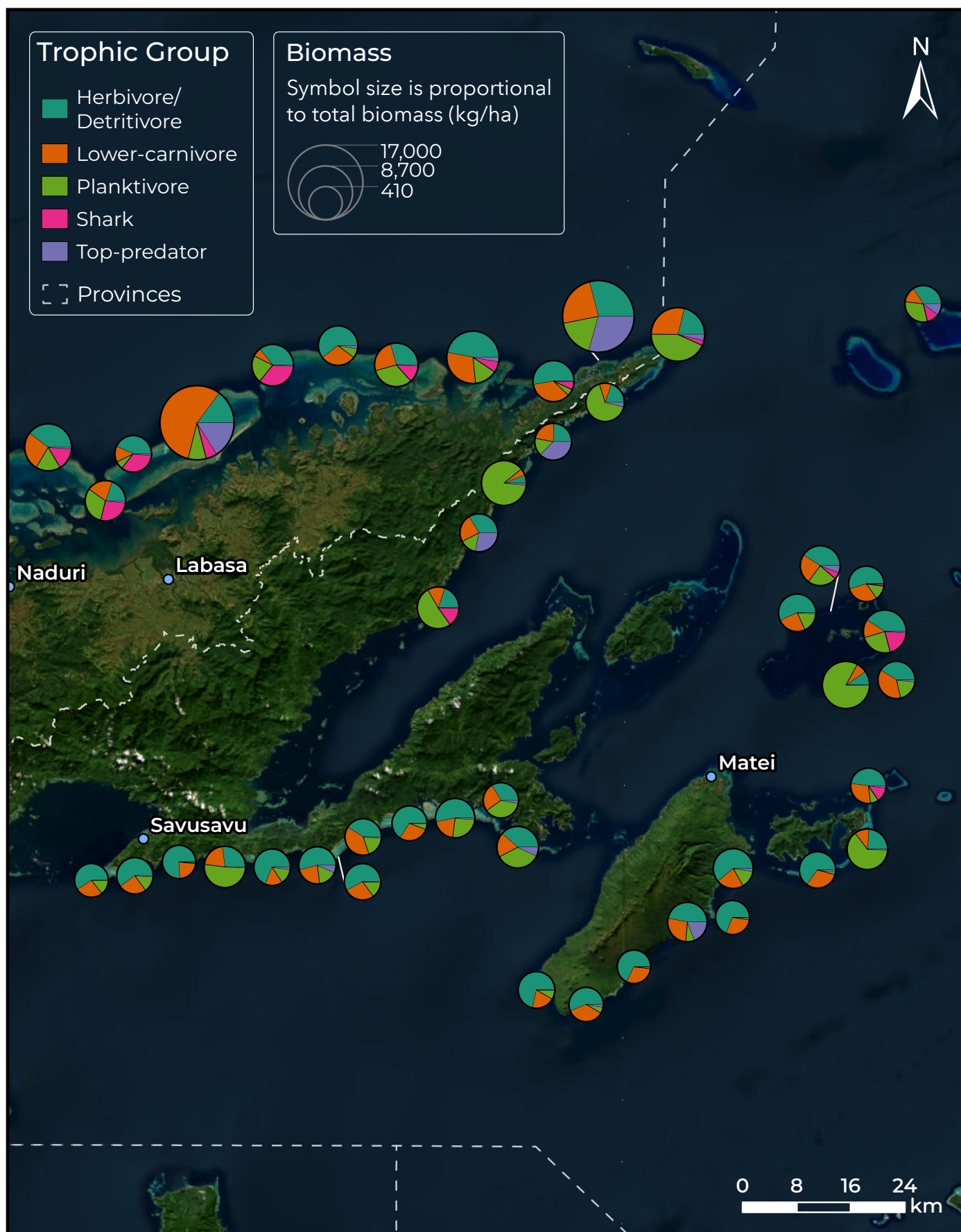
MAP 24: Mean fish biomass by trophic group at each survey site — Buva Province.



MAP 25: Mean fish biomass by trophic group at each survey site — Cakaudrove Province (East).



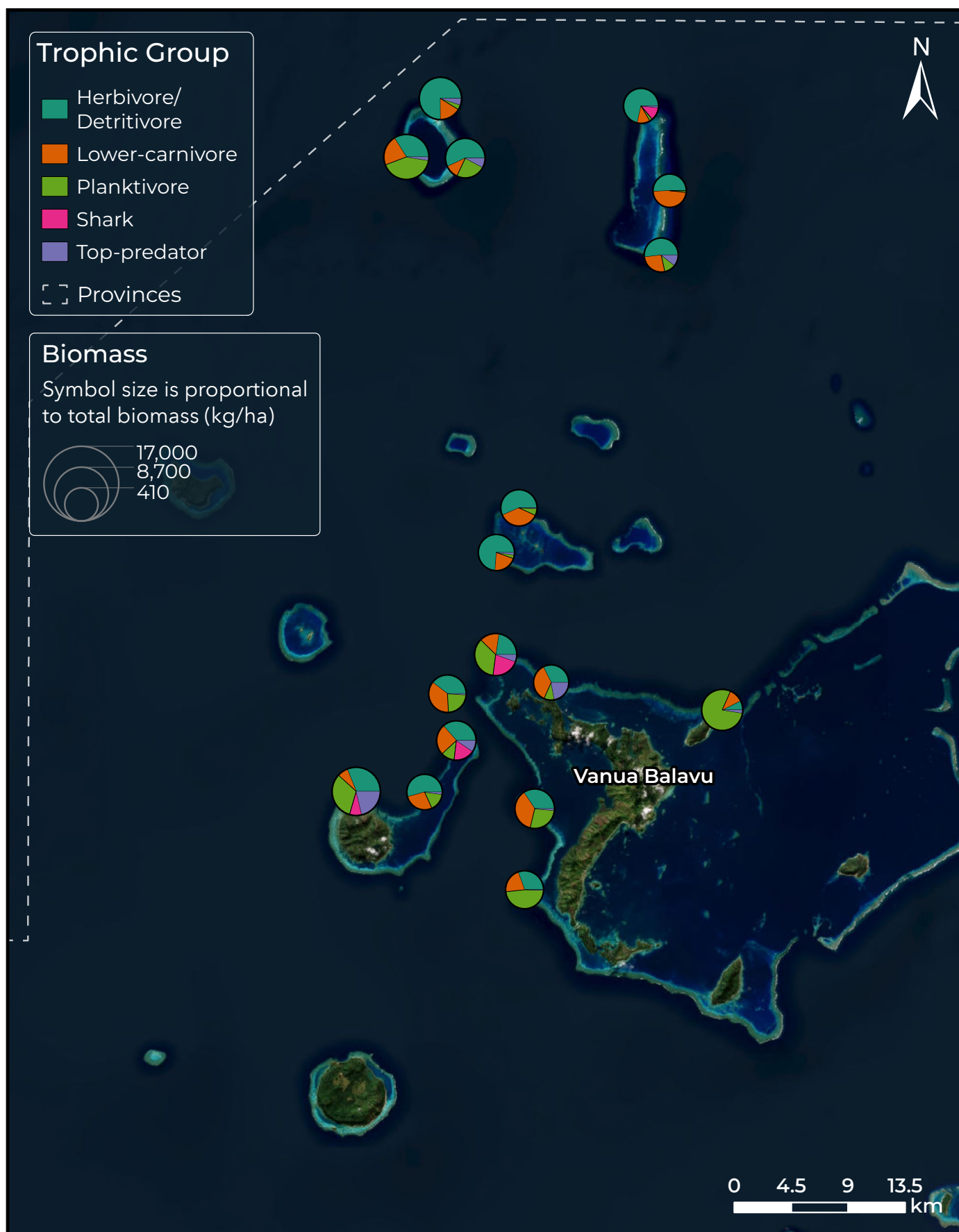
MAP 26: Mean fish biomass by trophic group at each survey site — Cakaudrove Province (West).



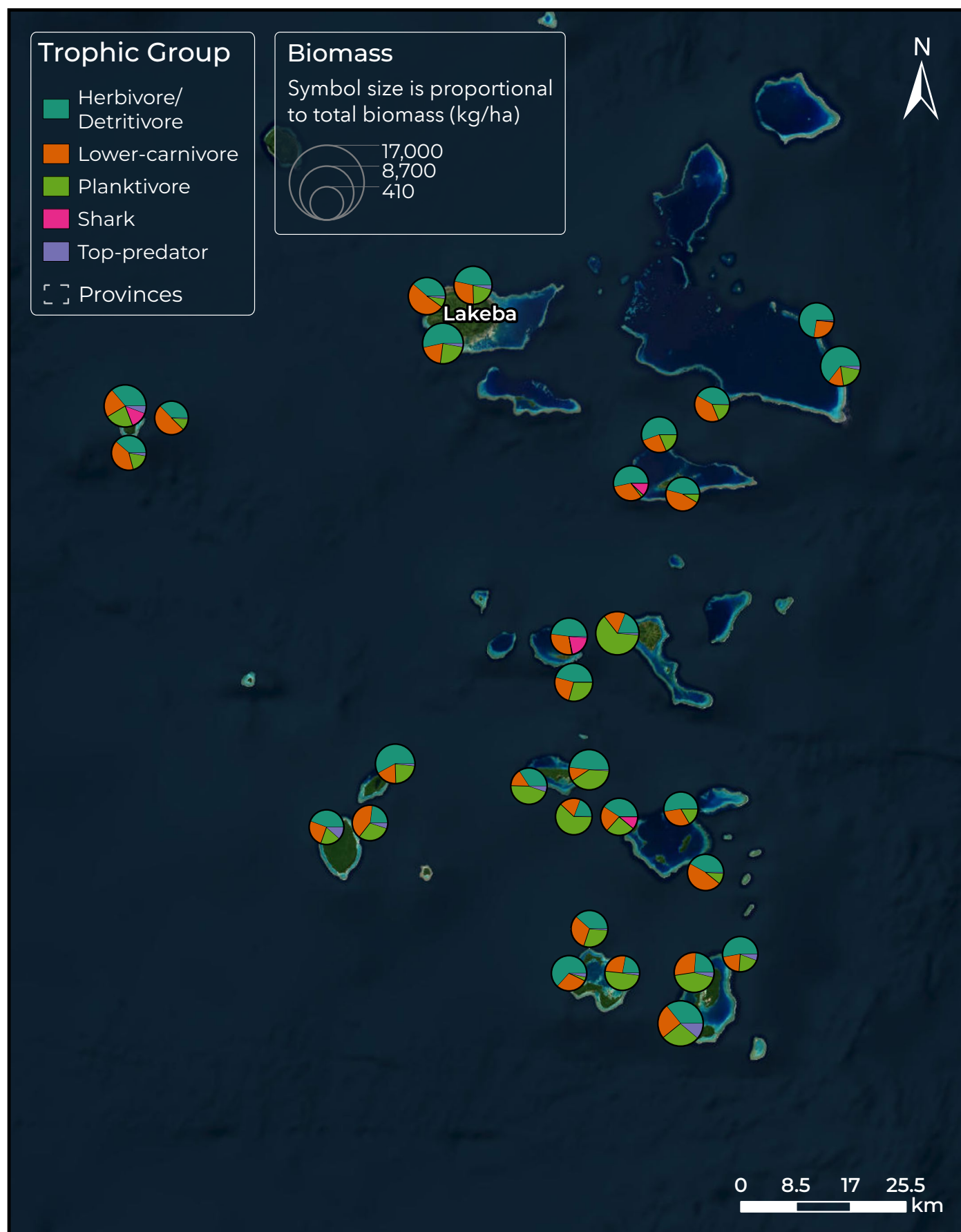
MAP 27: Mean fish biomass by trophic group at each survey site — Kadavu Province.



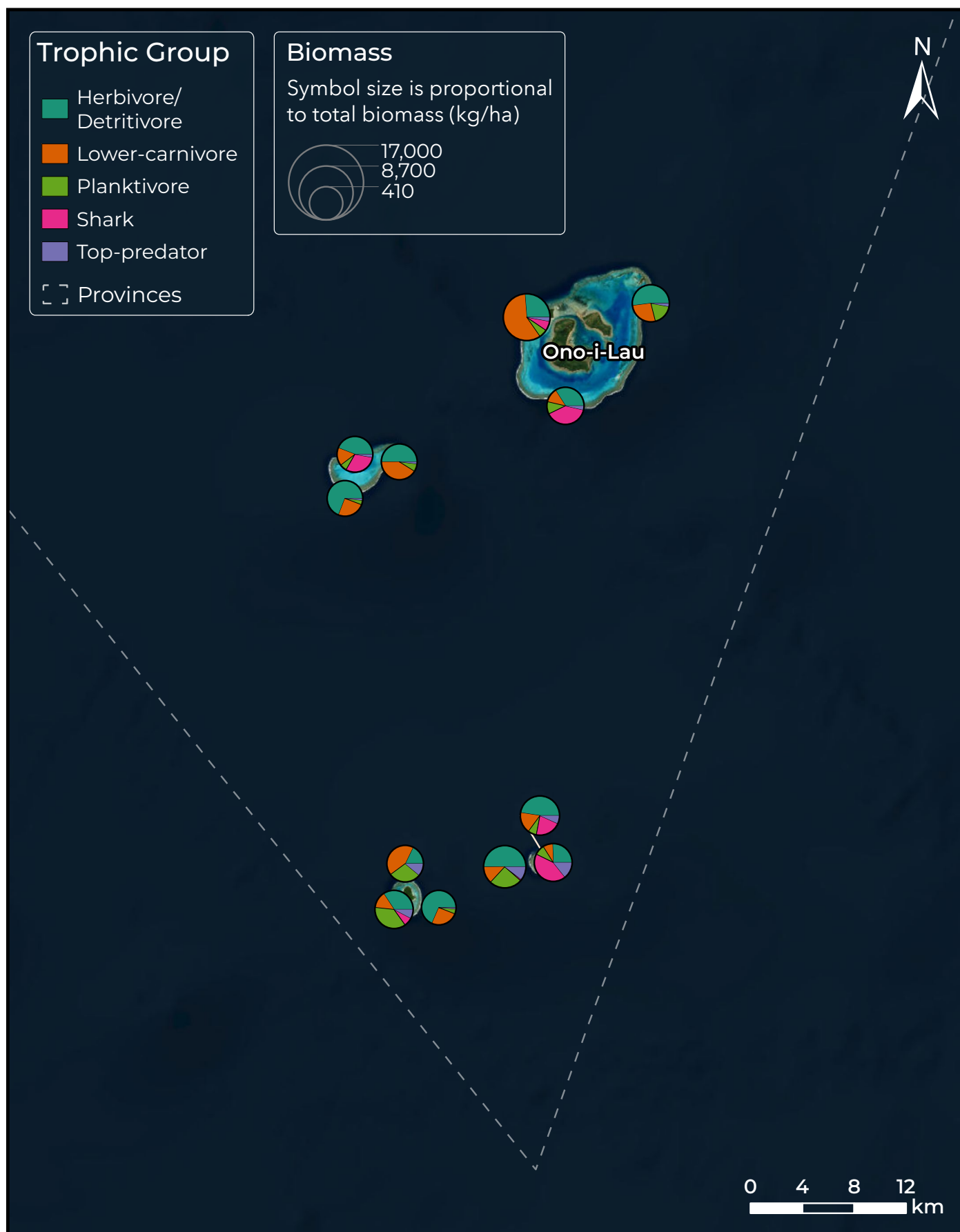
MAP 28: Mean fish biomass by trophic group at each survey site — Lau Province (North).



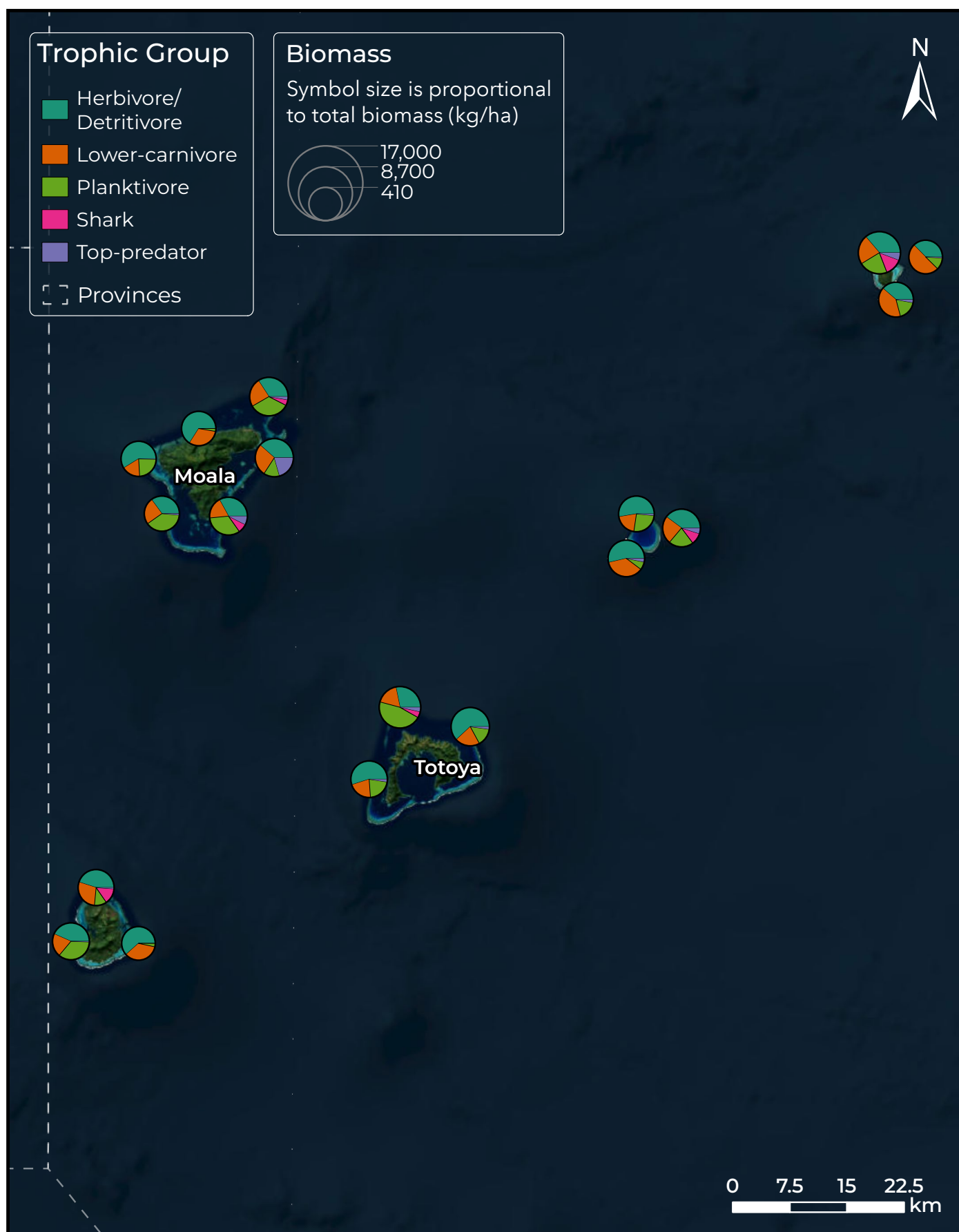
MAP 29: Mean fish biomass by trophic group at each survey site — Lau Province (East).



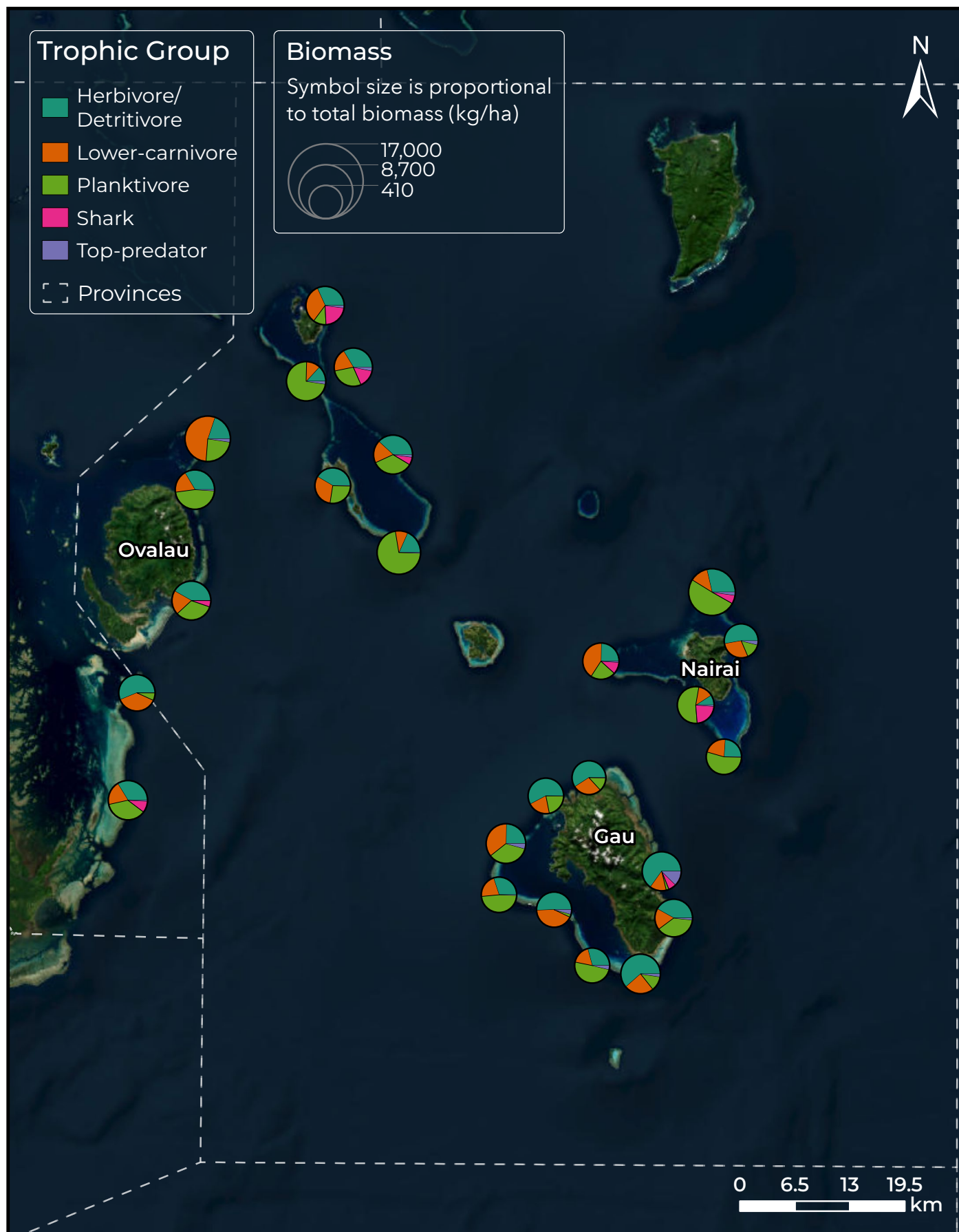
MAP 30: Mean fish biomass by trophic group at each survey site — Lau Province (South).



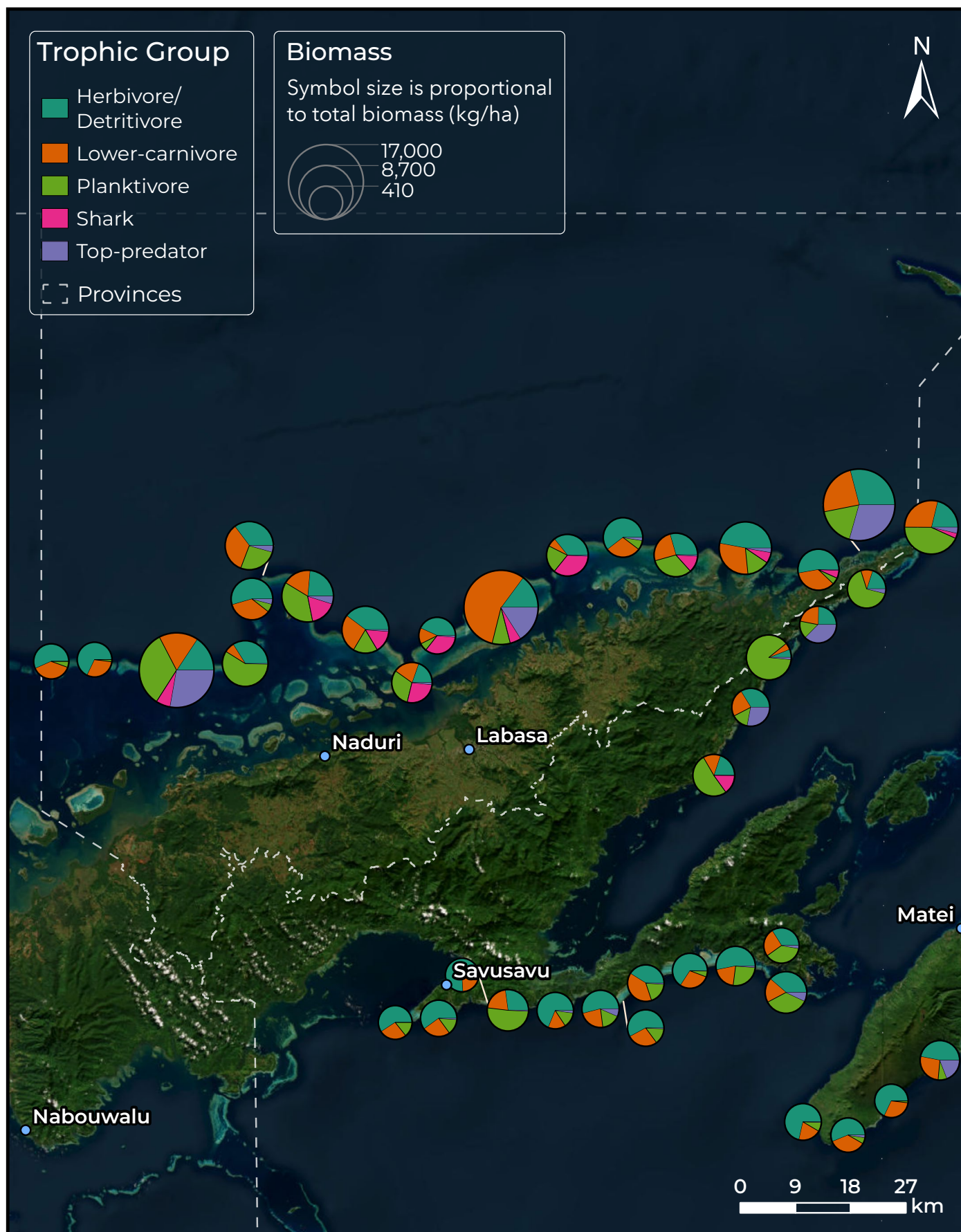
MAP 31: Mean fish biomass by trophic group at each survey site — Lau Province (West).



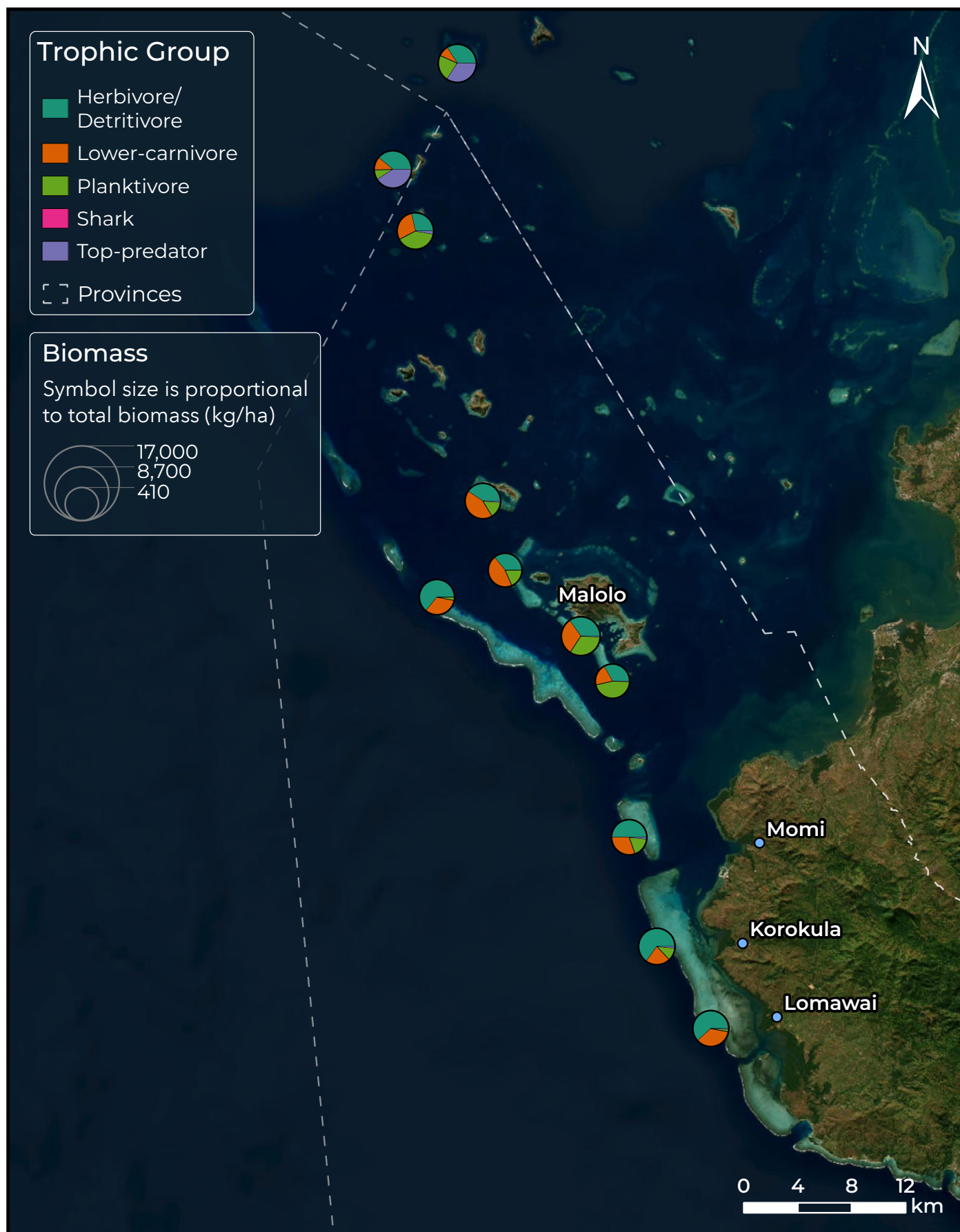
MAP 32: Mean fish biomass by trophic group at each survey site — Lomaiviti Province.



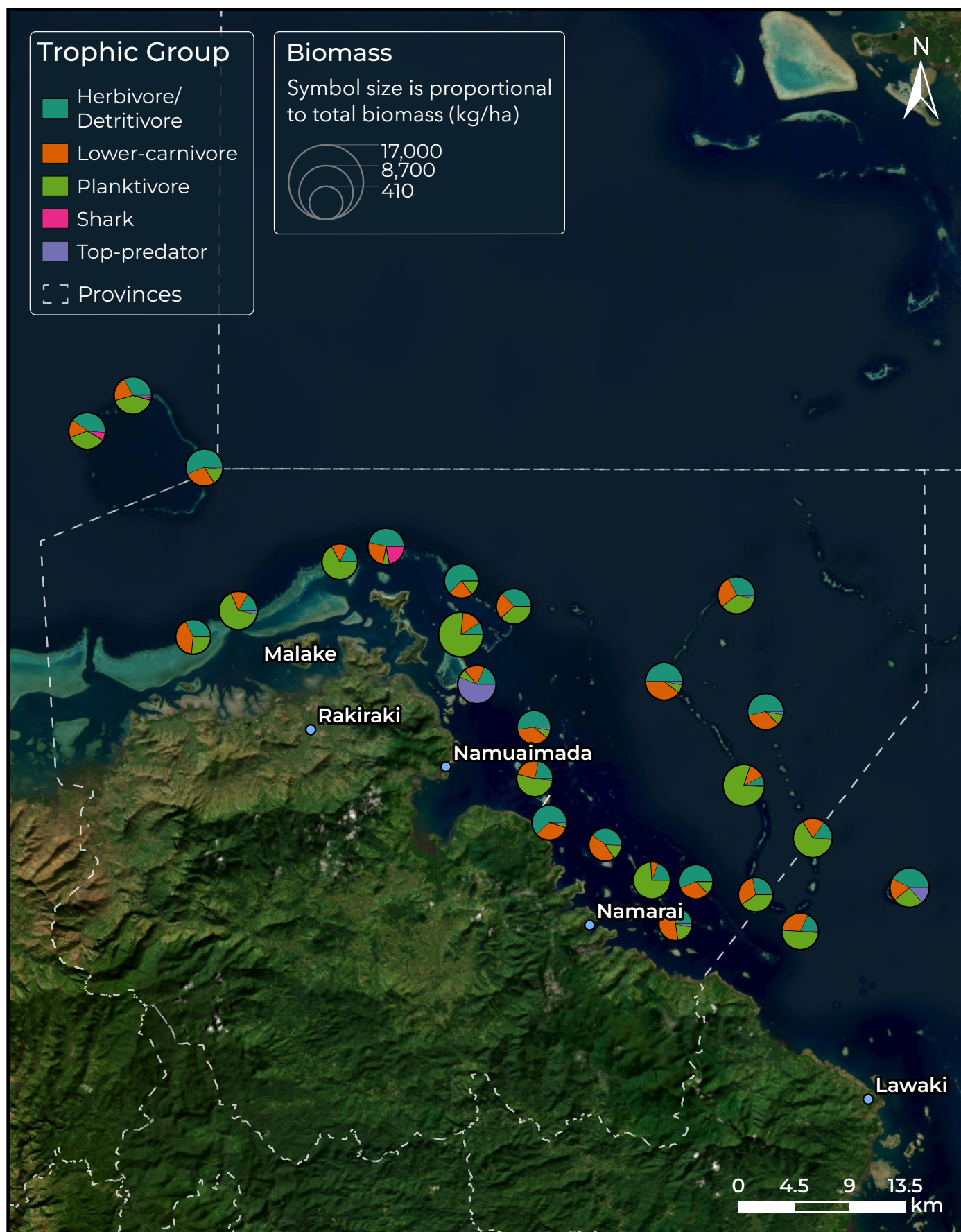
MAP 33: Mean fish biomass by trophic group at each survey site — Macuata Province.



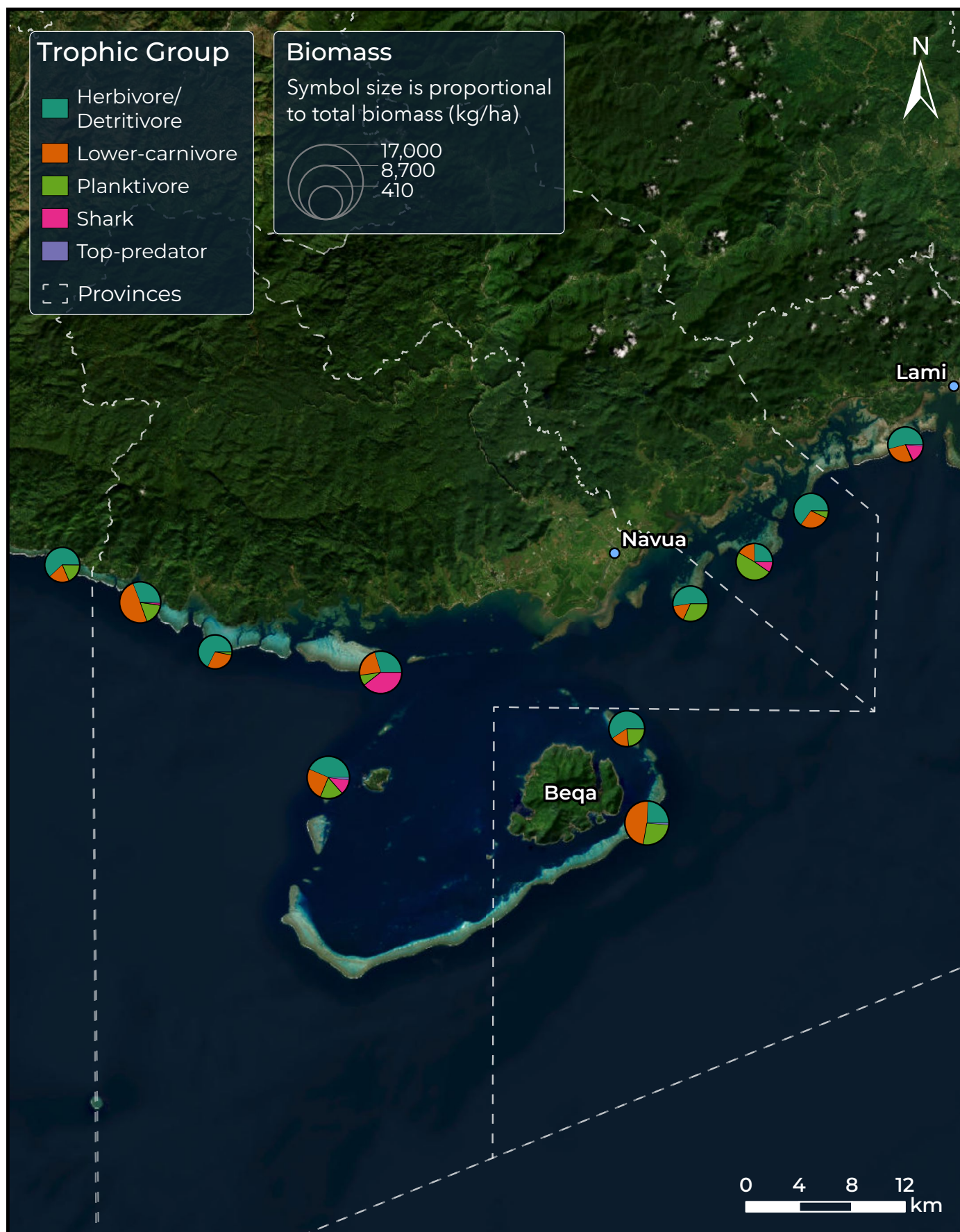
MAP 34: Mean fish biomass by trophic group at each survey site — Nadroga-Navosa Province.



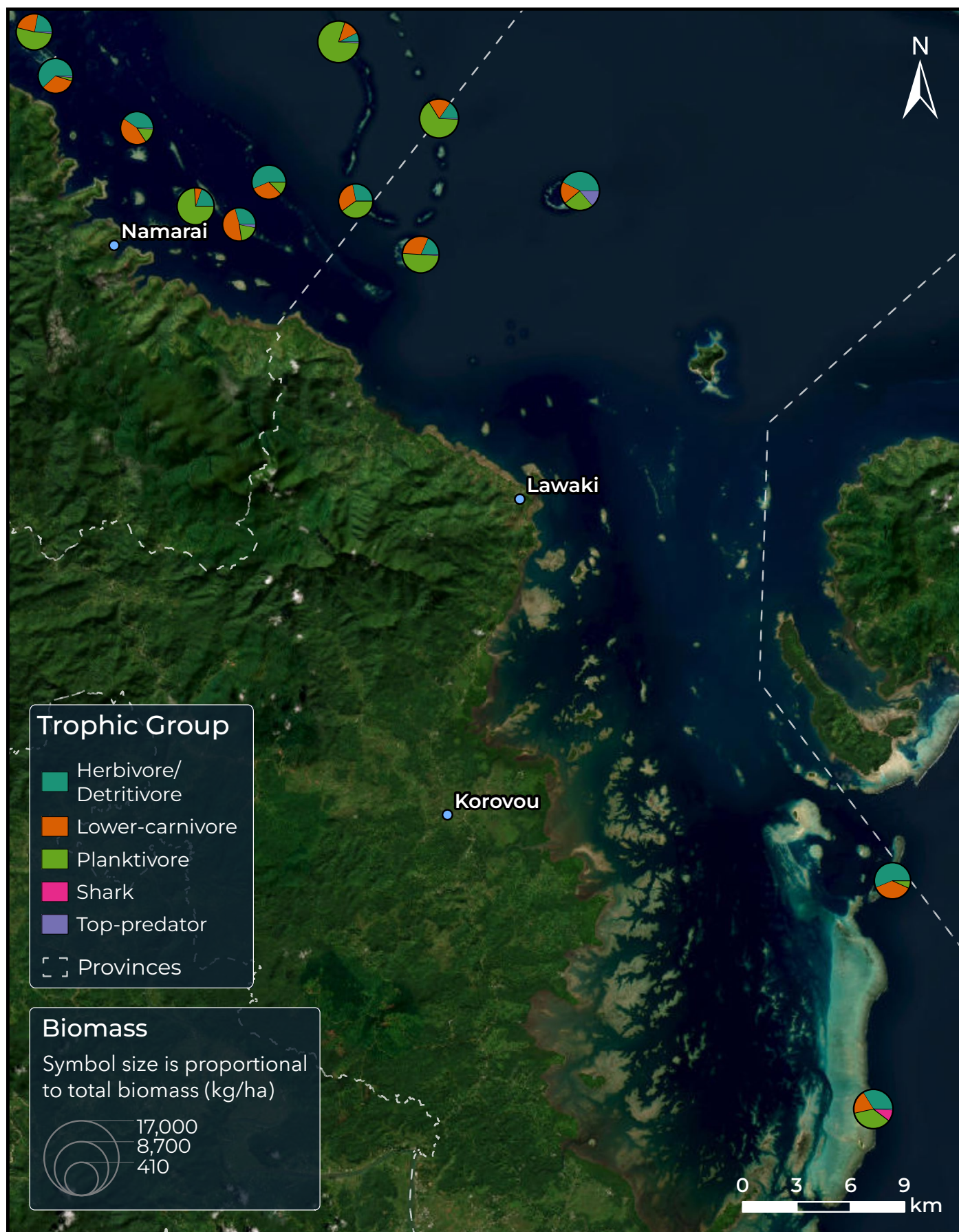
MAP 35: Mean fish biomass by trophic group at each survey site — Ra Province.



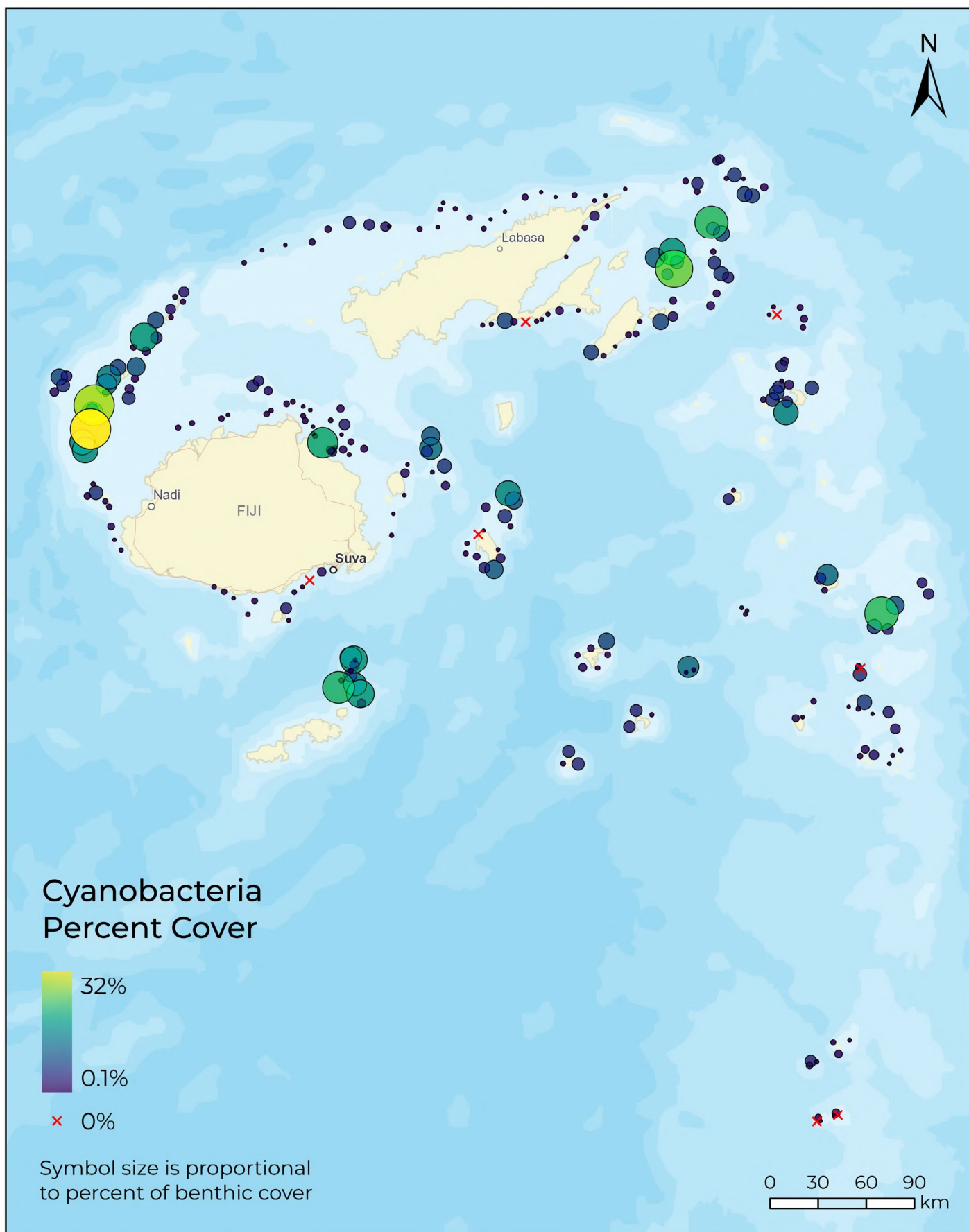
MAP 36: Mean fish biomass by trophic group at each survey site — Serua, Namosi & Rewa Provinces.



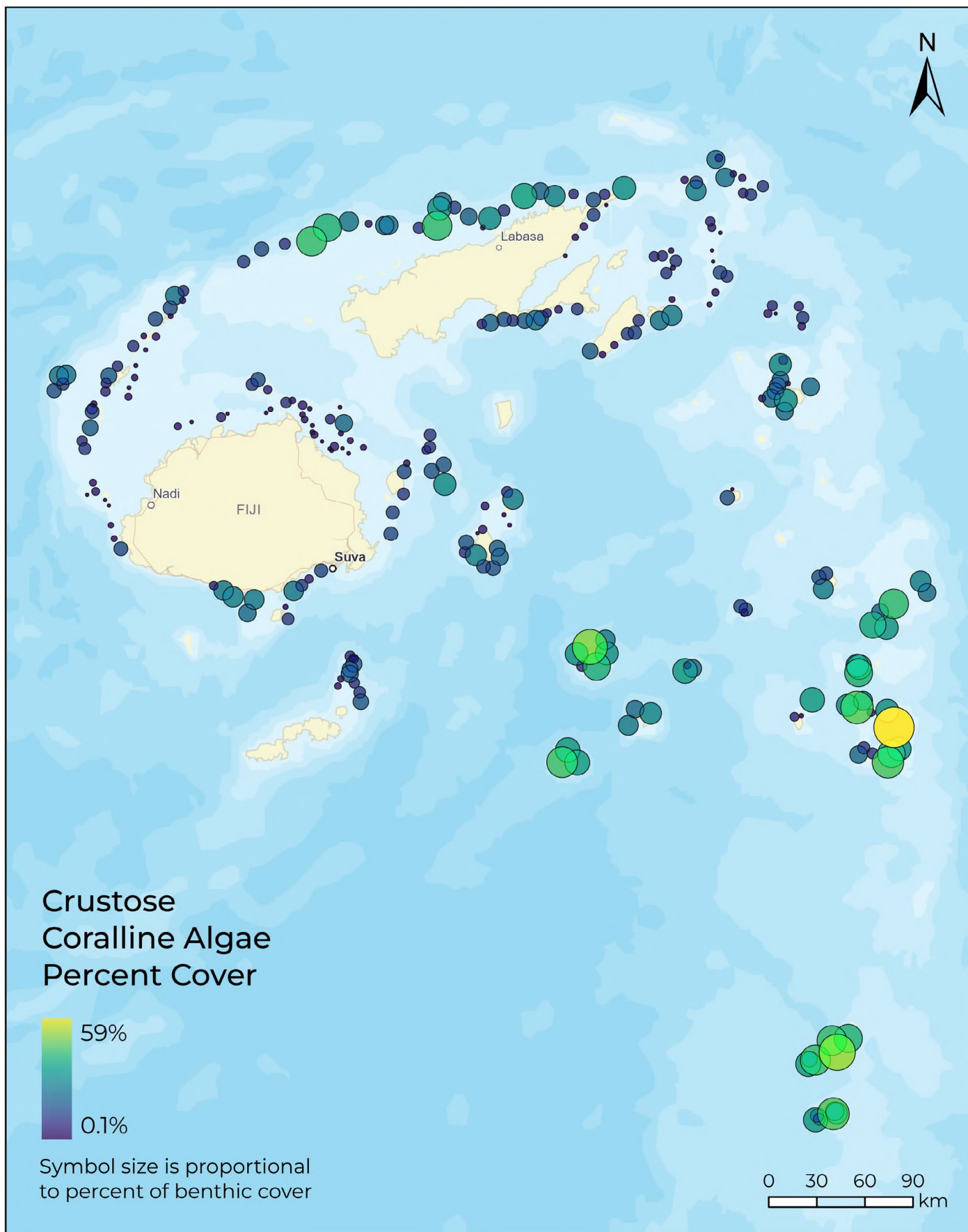
MAP 37: Mean fish biomass by trophic group at each survey site — Tailevu Province.



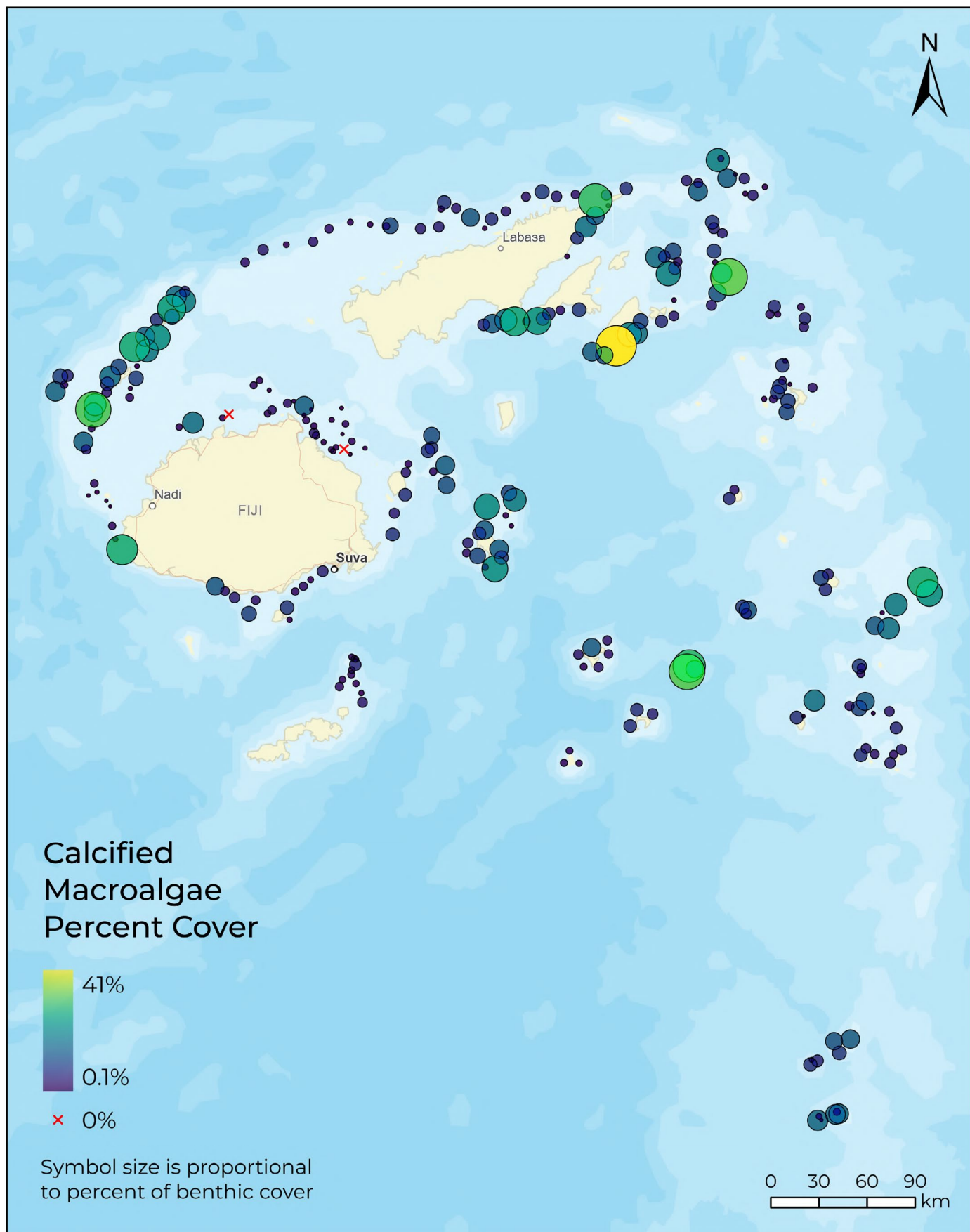
MAP 38: Mean percent of the seafloor covered by cyanobacteria at survey sites across Fiji.



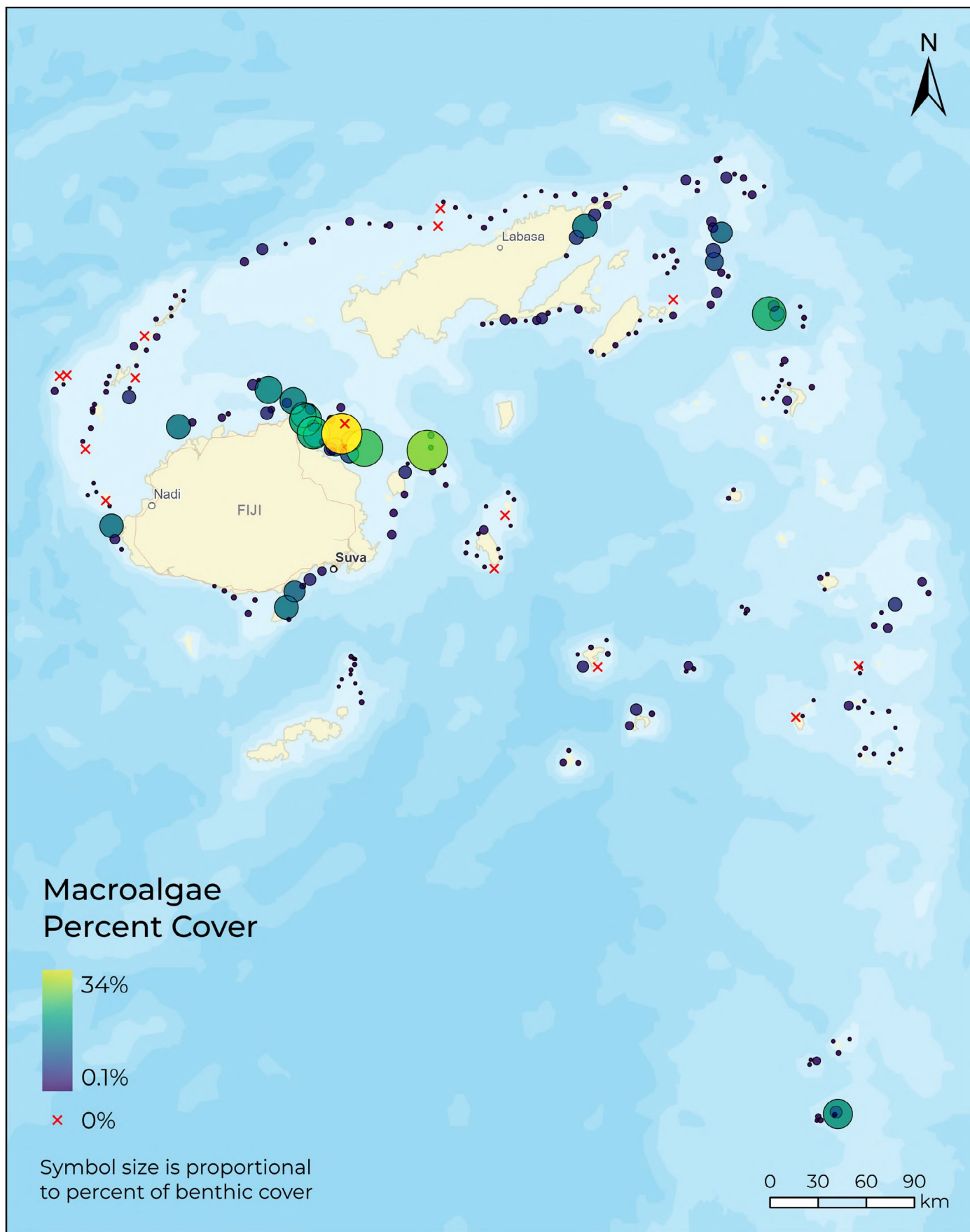
MAP 39: Mean percent of the seafloor covered by crustose coralline algae (CCA) at survey sites across Fiji. CCA is a hard, encrusting red algae that helps stabilize reefs and promote coral settlement.



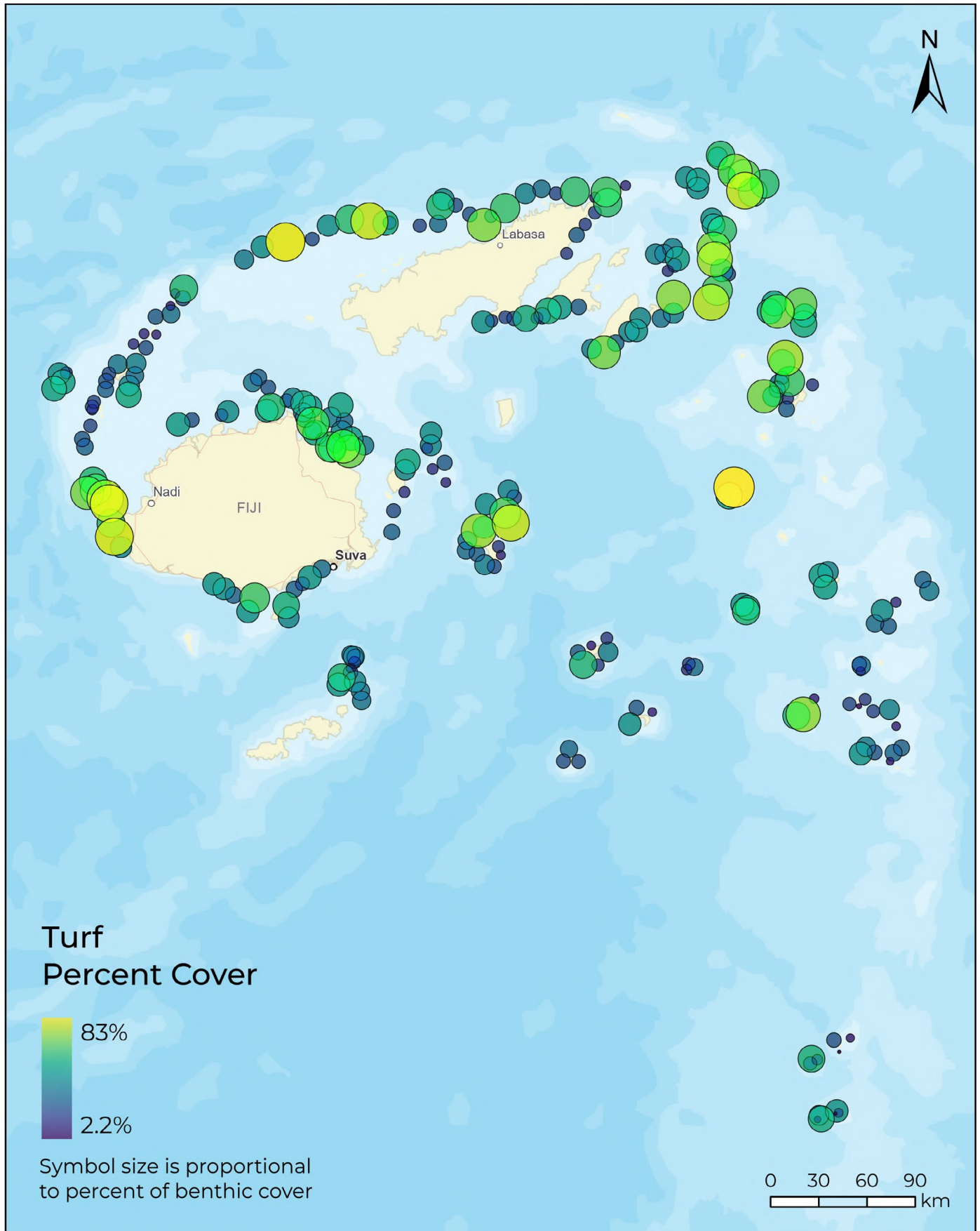
MAP 40: Mean percent of the seafloor covered by calcified macroalgae at survey sites across Fiji. Calcified macroalgae help stabilize reefs and contribute to reef building.



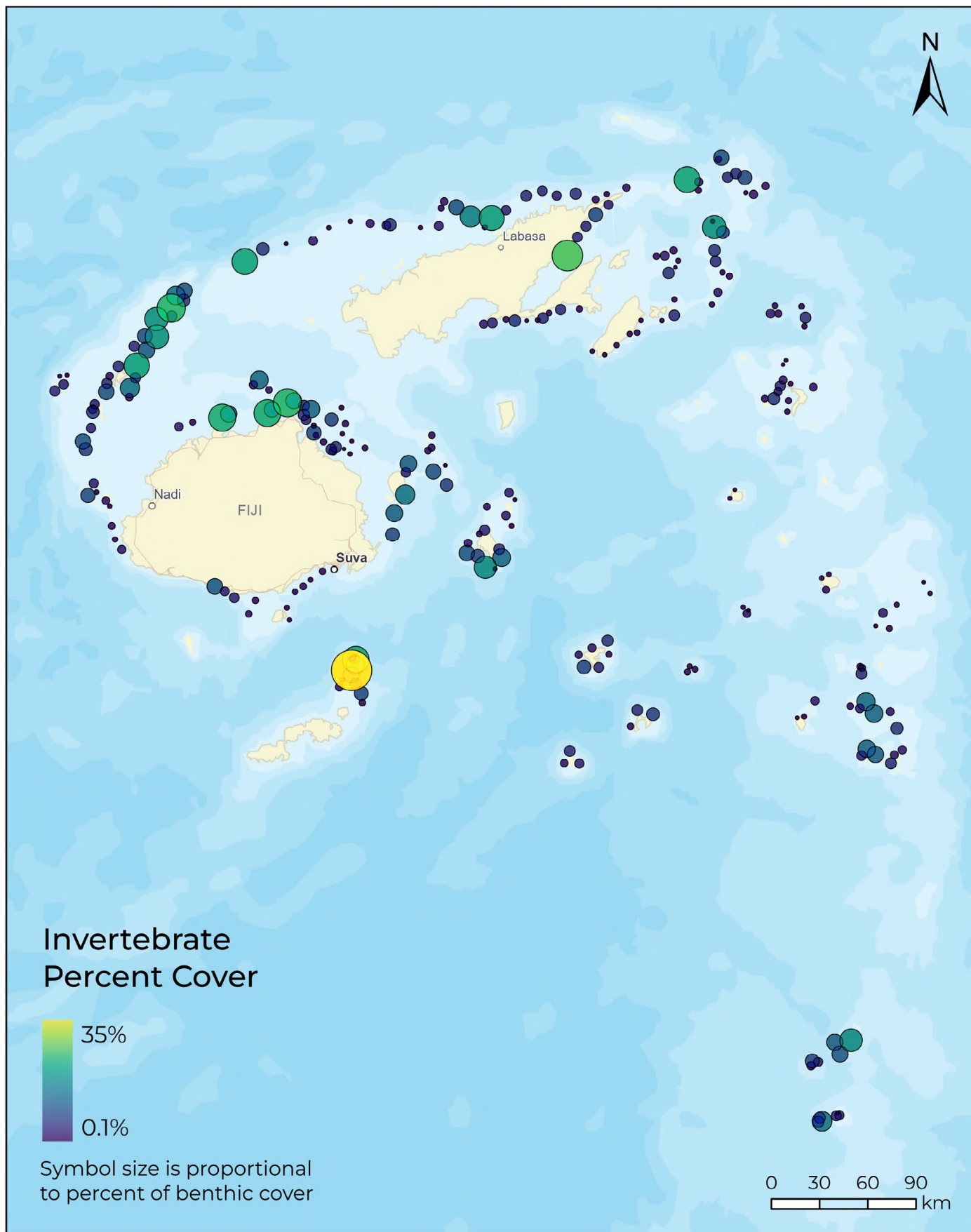
MAP 41: Mean percent of the seafloor covered by macroalgae at survey sites across Fiji. Macroalgae are soft-bodied seaweeds that typically grow attached to the ocean floor.



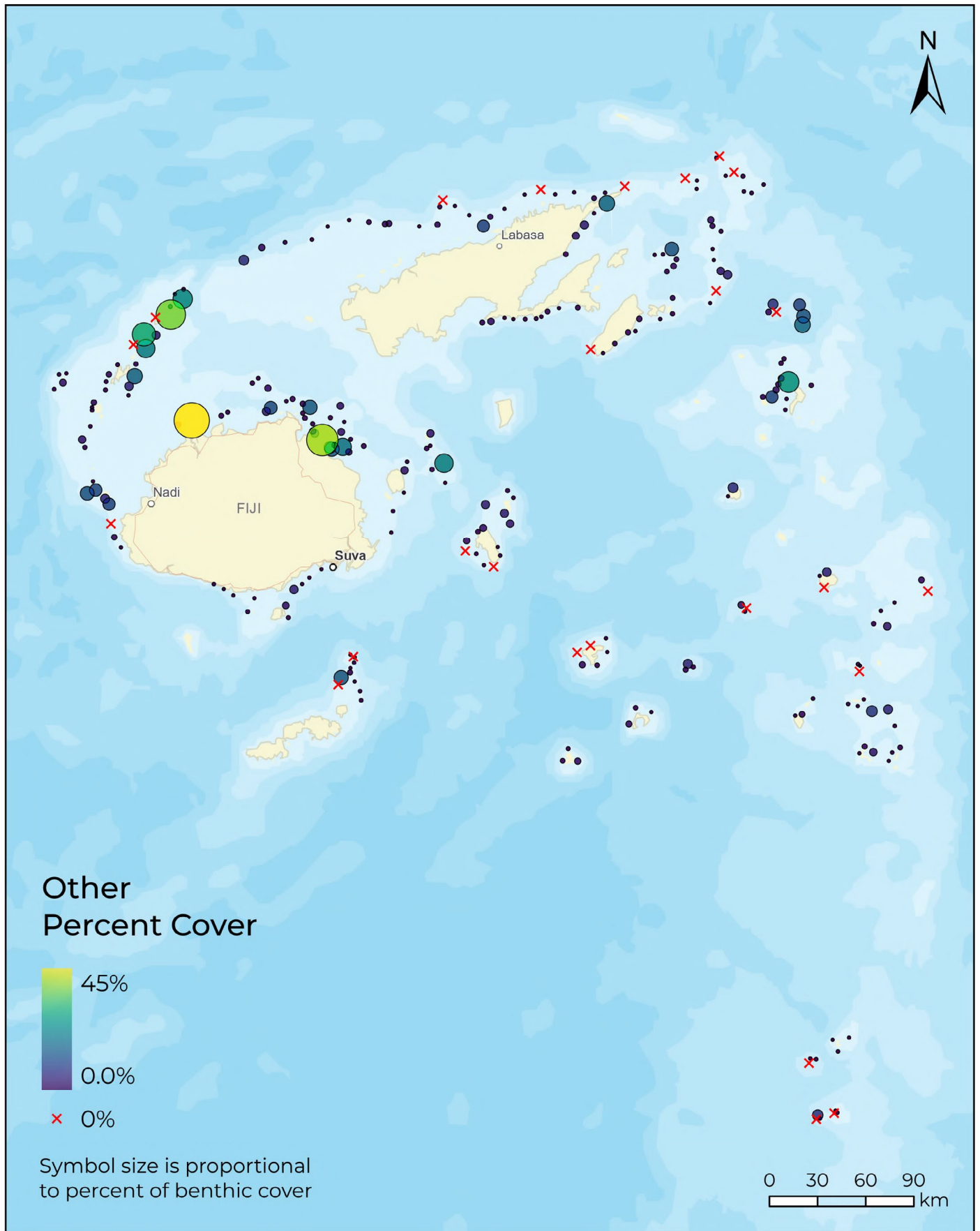
MAP 42: Mean percent of the seafloor covered by turf algae at survey sites across Fiji. Turf algae is short, filamentous / fuzzy seaweed that grows like grass on the reef.



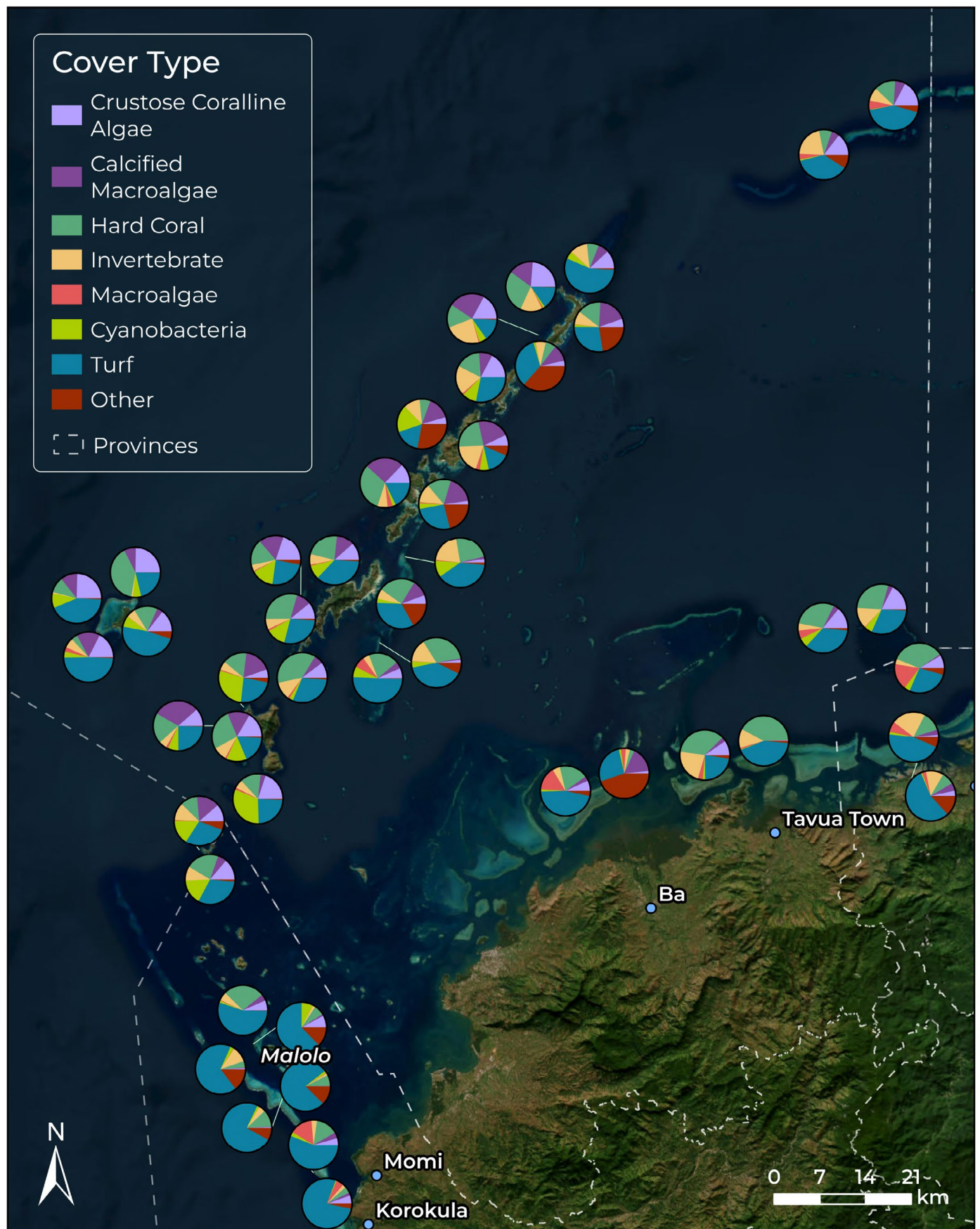
MAP 43: Mean percent of the seafloor covered by invertebrates like sponges at survey sites across Fiji.



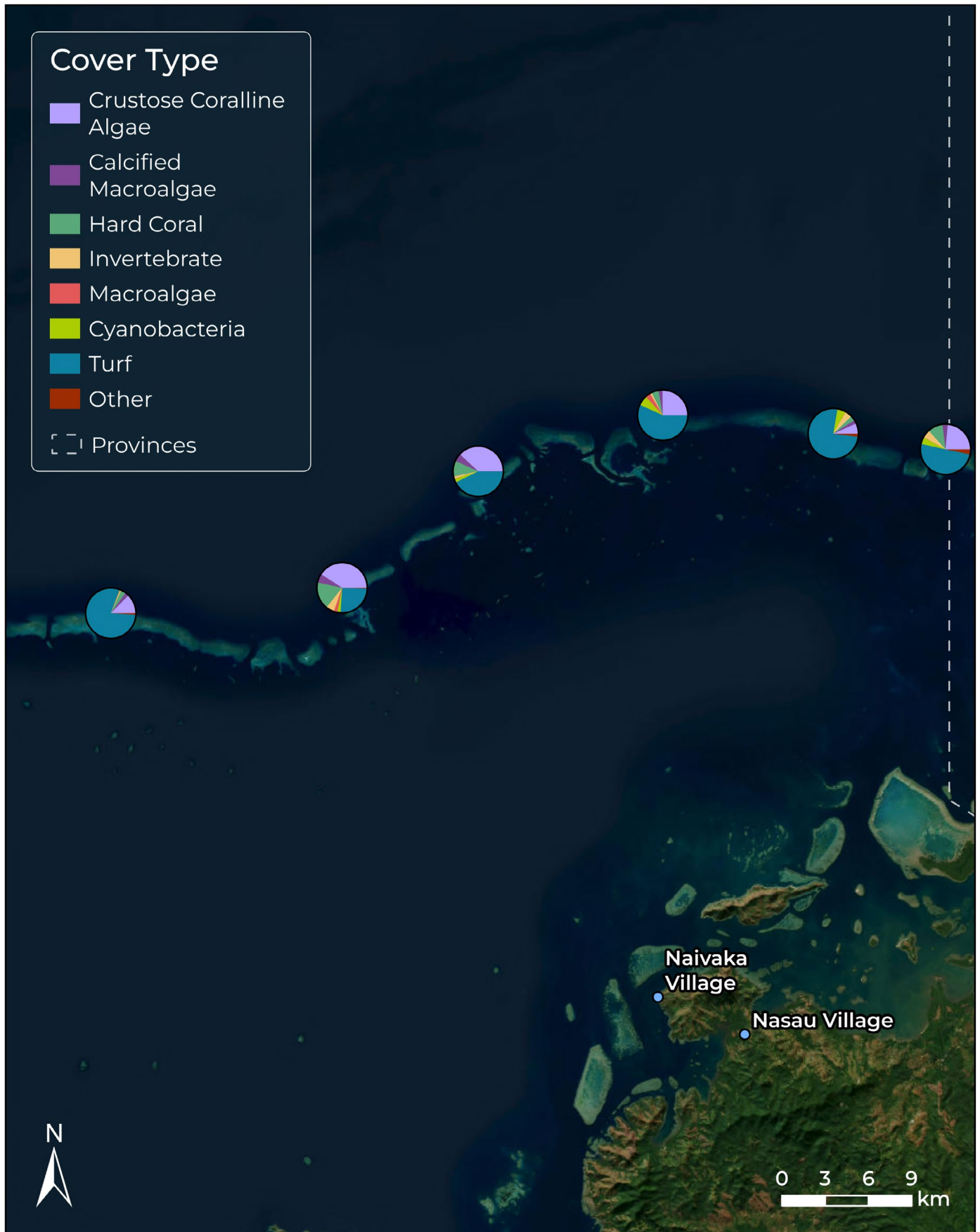
MAP 44: Mean percent of the seafloor covered by other substrates (e.g., sand, basalt, etc.) at survey sites across Fiji.



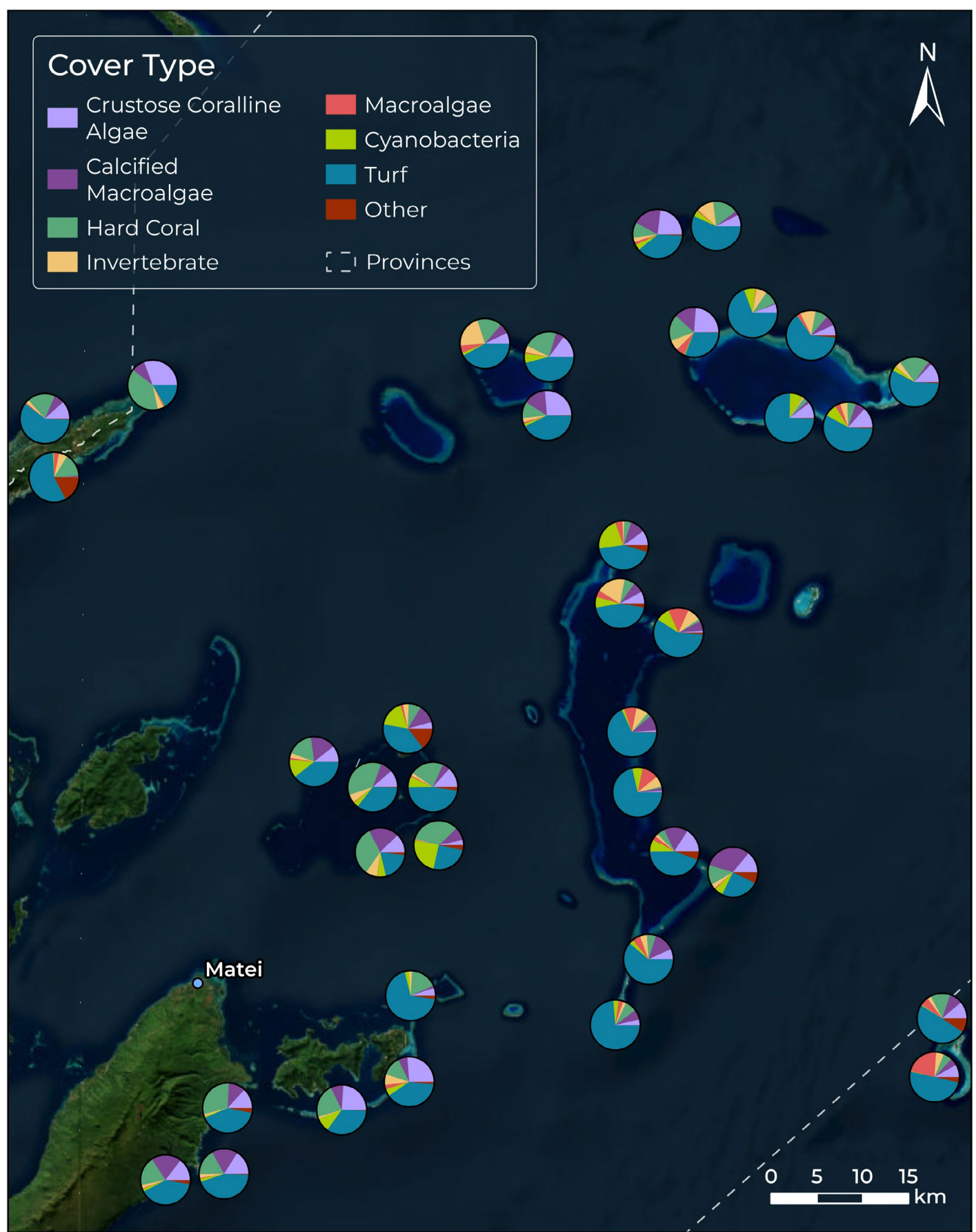
MAP 45: Relative portion of the seafloor covered by all benthic cover types. “Other” includes nonliving substrates such as sand, basalt, etc. — Ba Province.



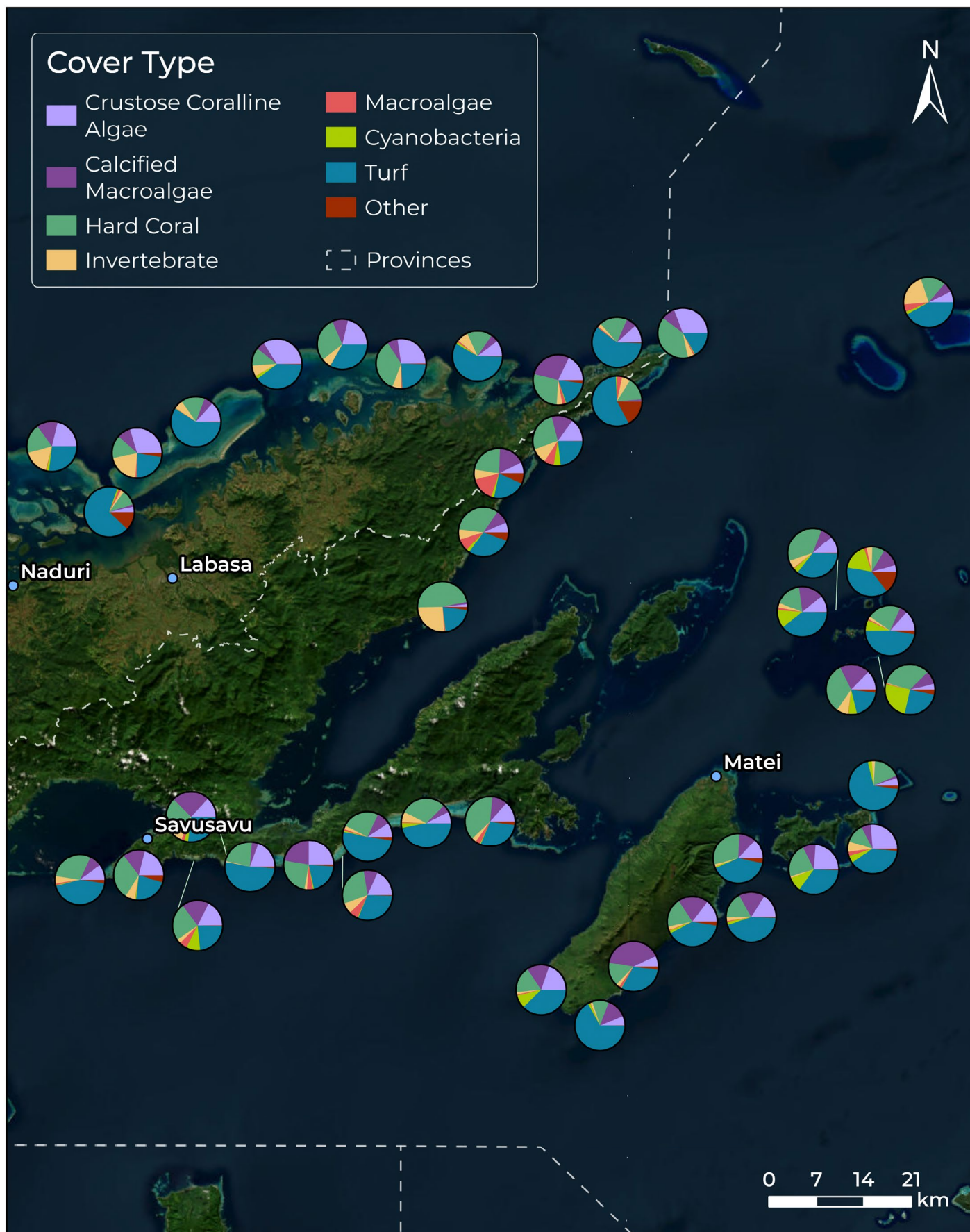
MAP 46: Relative portion of the seafloor covered by all benthic cover types. “Other” includes nonliving substrates such as sand, basalt, etc. — Bua Province.



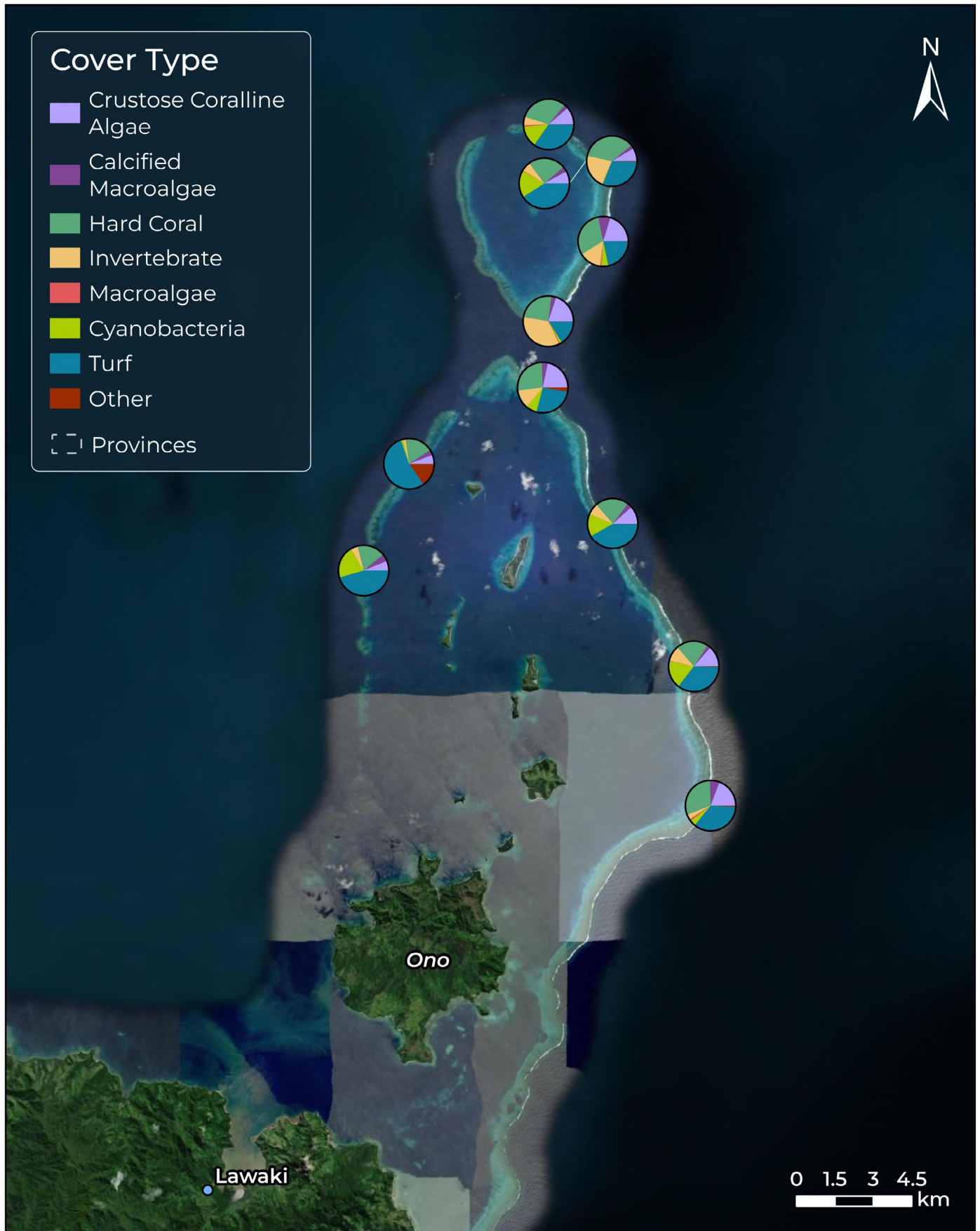
MAP 47: Relative portion of the seafloor covered by all benthic cover types. “Other” includes nonliving substrates such as sand, basalt, etc. — Cakaudrove Province (East).



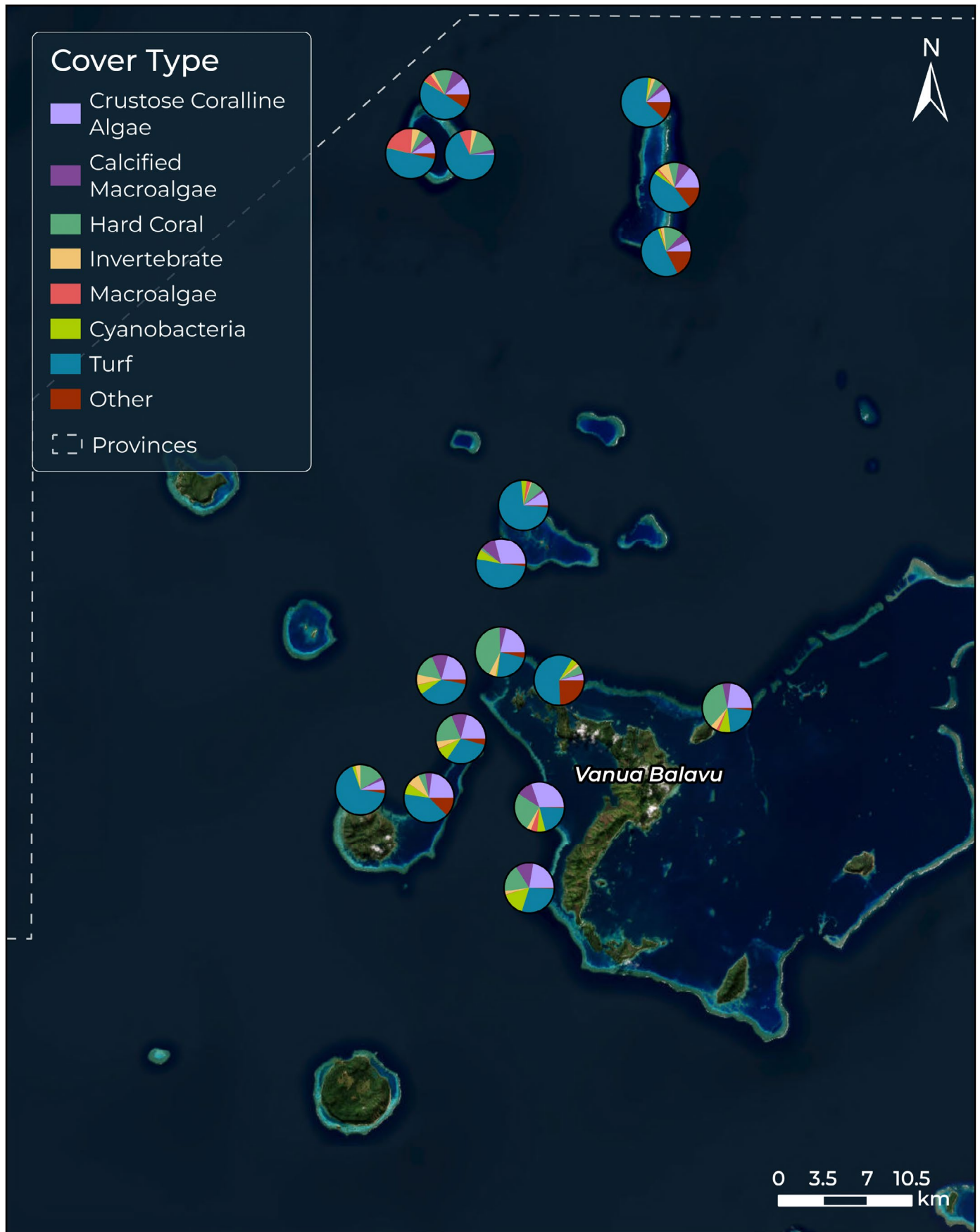
MAP 48: Relative portion of the seafloor covered by all benthic cover types. “Other” includes nonliving substrates such as sand, basalt, etc. — Cakaudrove Province (West).



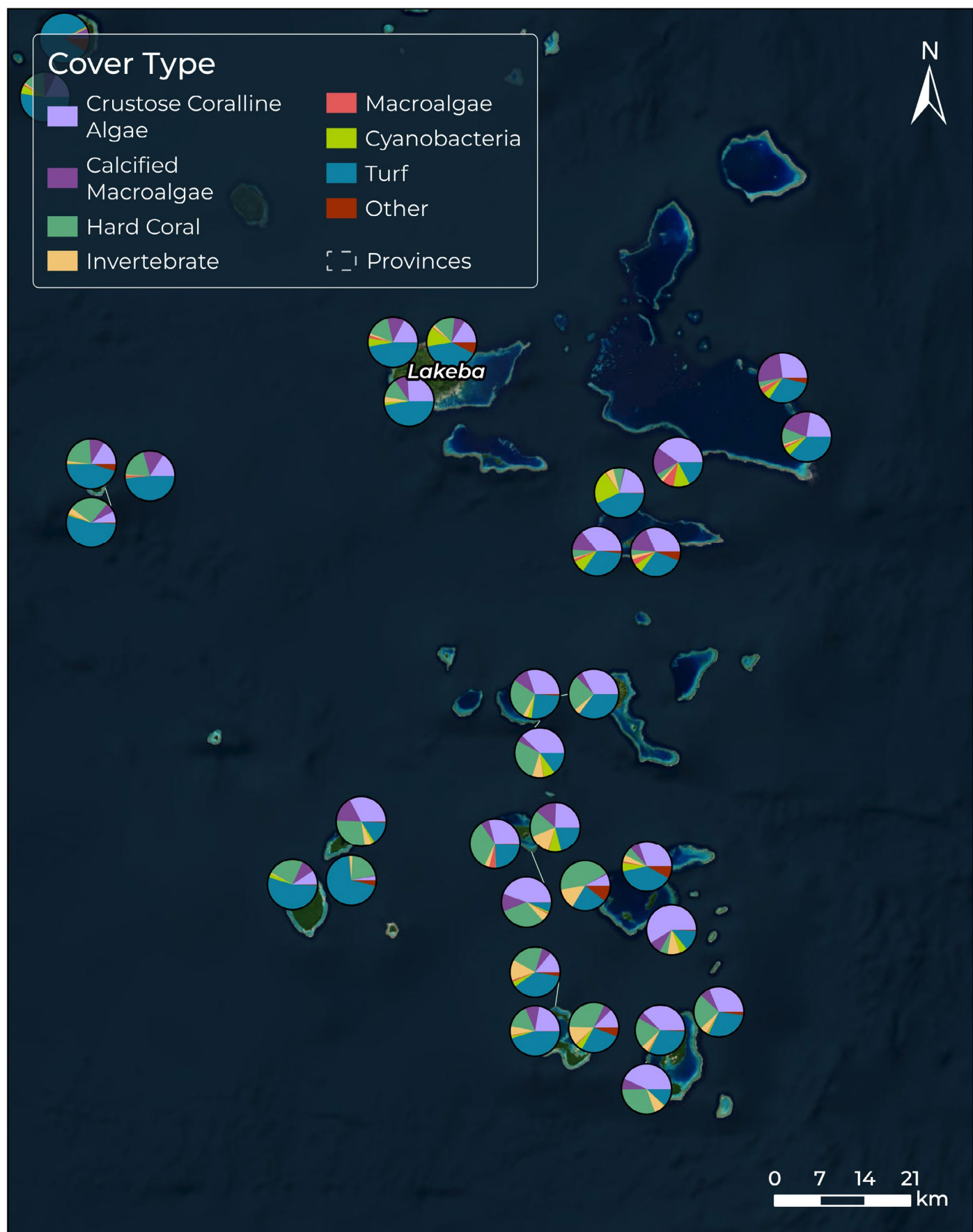
MAP 49: Relative portion of the seafloor covered by all benthic cover types. “Other” includes nonliving substrates such as sand, basalt, etc. — Kadavu Province.



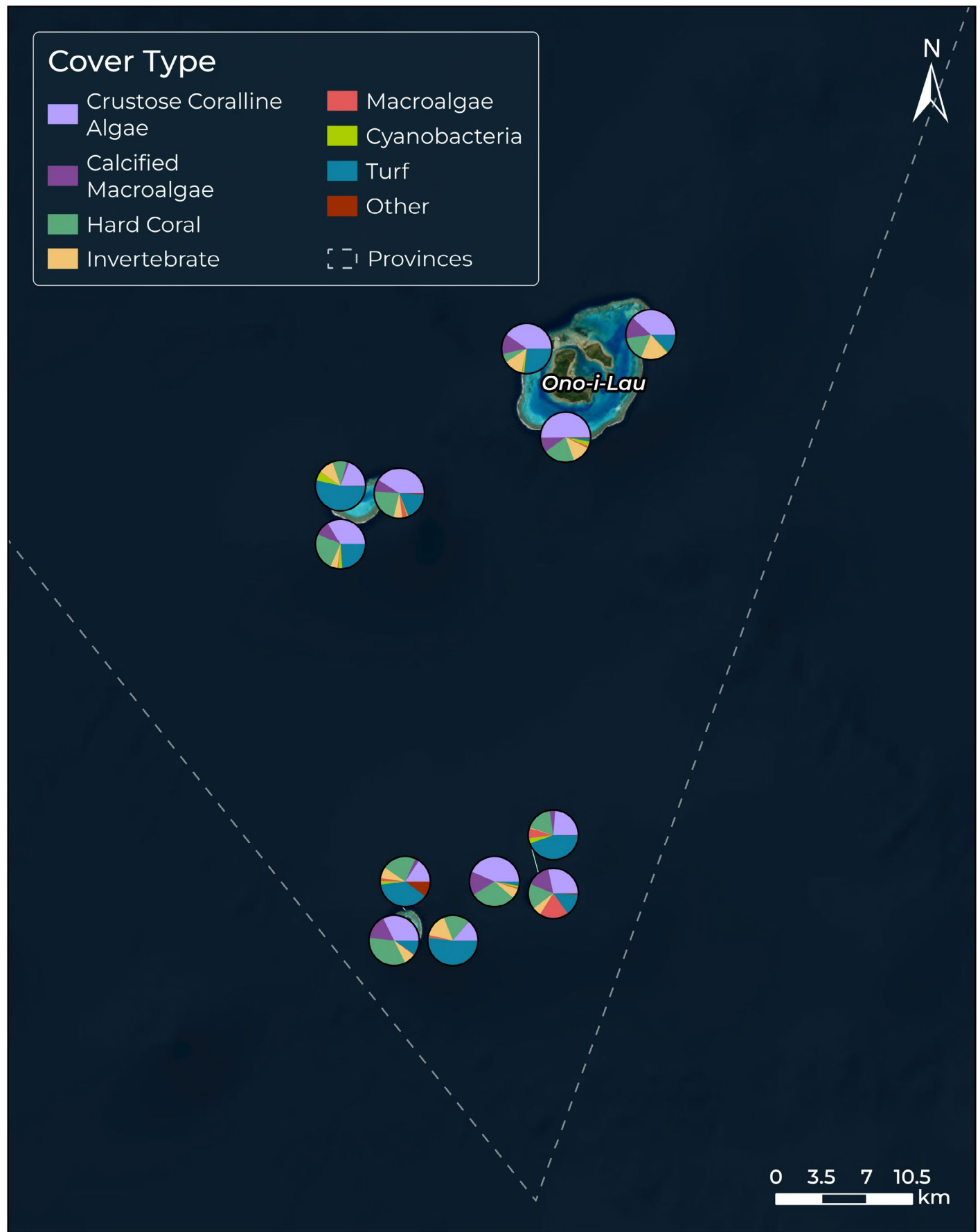
MAP 50: Relative portion of the seafloor covered by all benthic cover types. “Other” includes nonliving substrates such as sand, basalt, etc. — Lau Province (North).



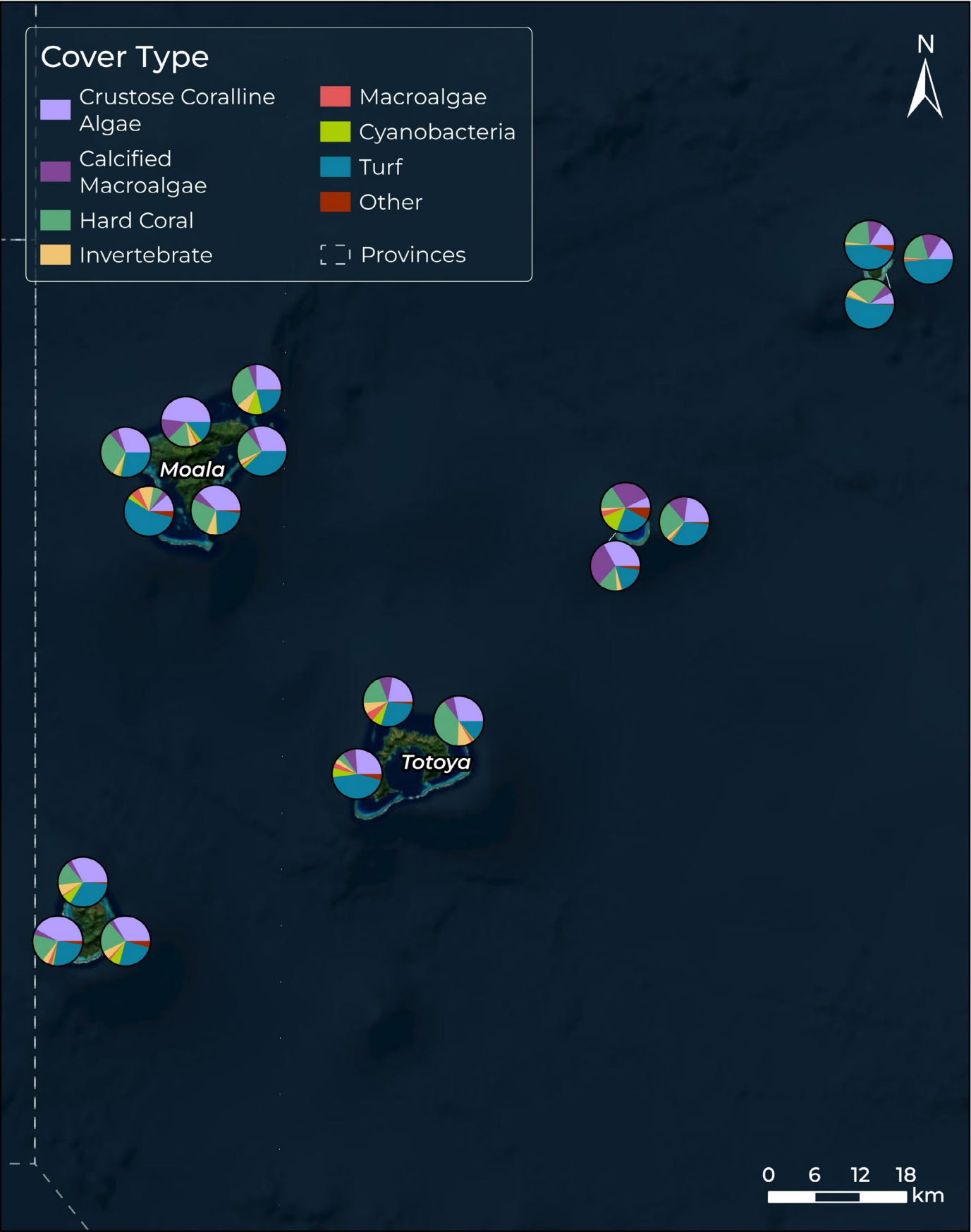
MAP 51: Relative portion of the seafloor covered by all benthic cover types. “Other” includes nonliving substrates such as sand, basalt, etc. — Lau Province (East).



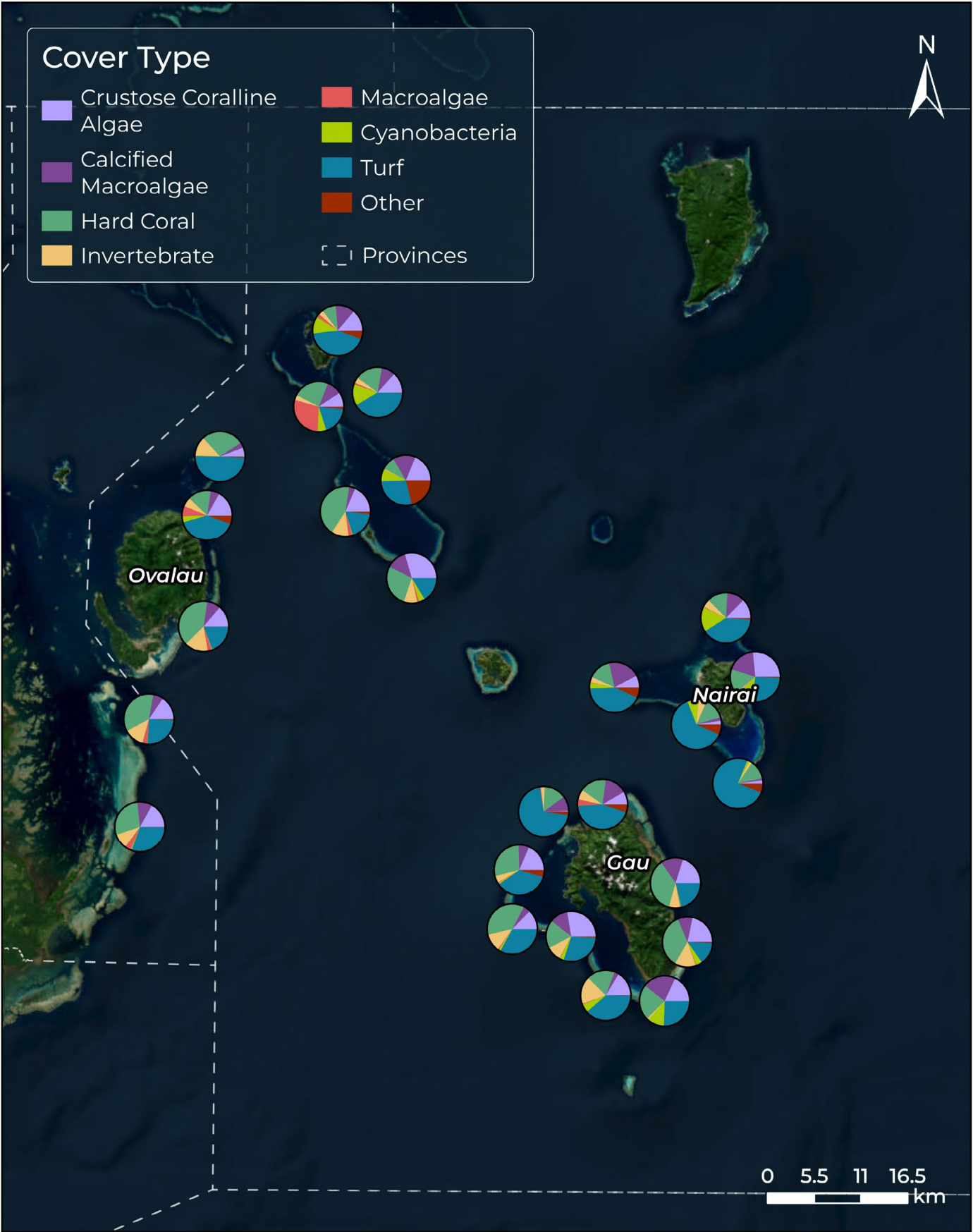
MAP 52: Relative portion of the seafloor covered by all benthic cover types. “Other” includes nonliving substrates such as sand, basalt, etc. — Lau Province (South).



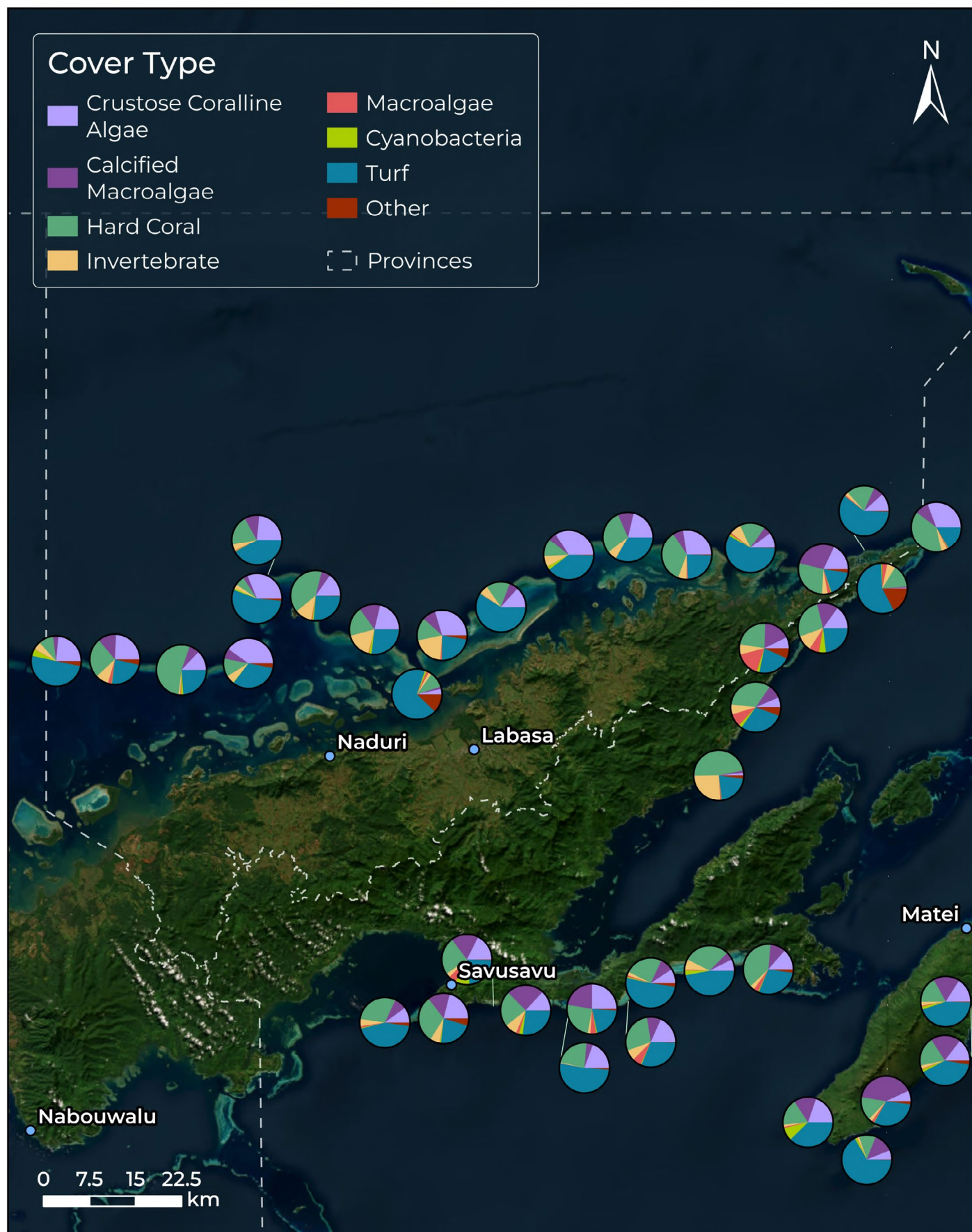
MAP 53: Relative portion of the seafloor covered by all benthic cover types. “Other” includes nonliving substrates such as sand, basalt, etc. — Lau Province (West).



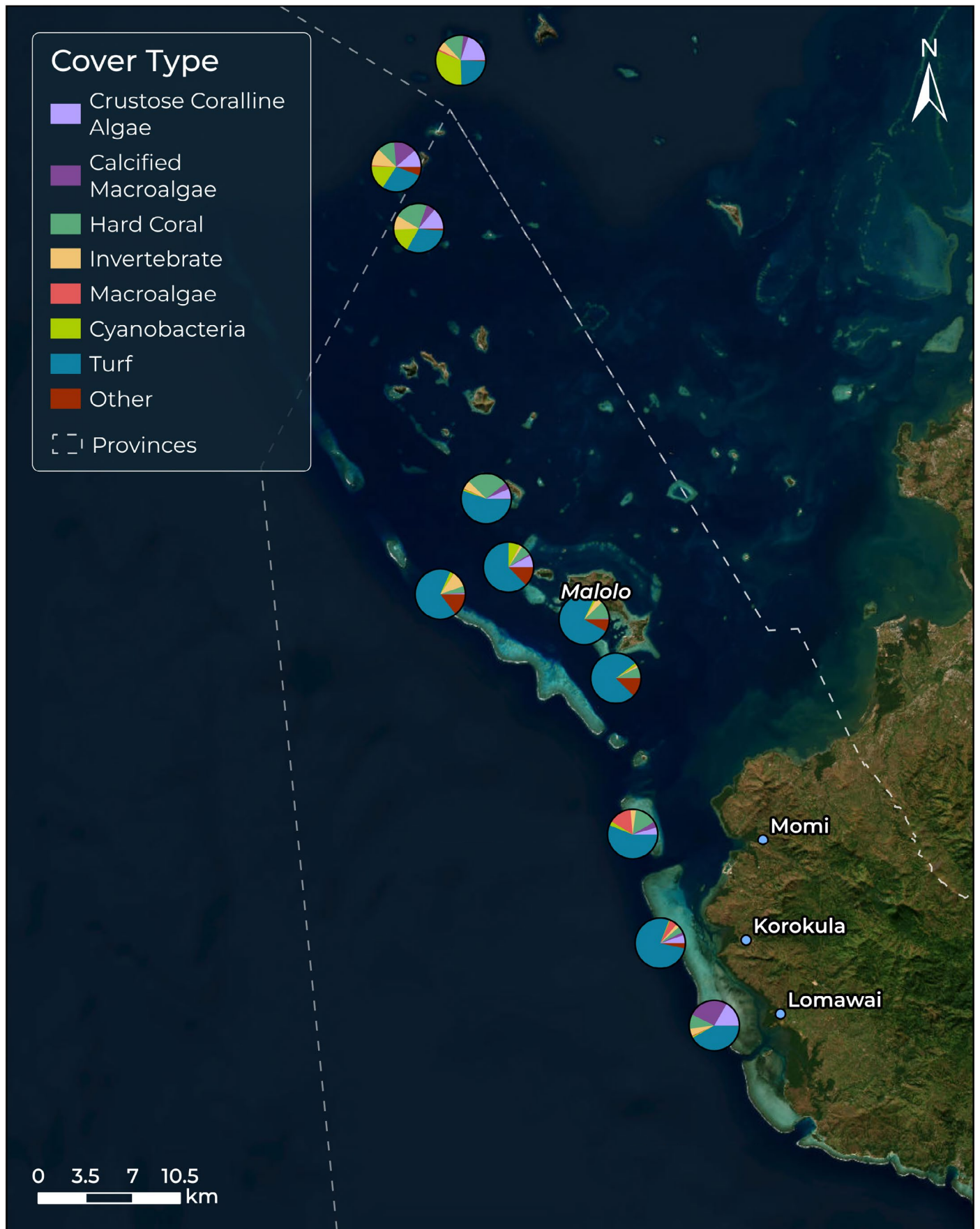
MAP 54: Relative portion of the seafloor covered by all benthic cover types. “Other” includes nonliving substrates such as sand, basalt, etc. — Lomaiviti Province.



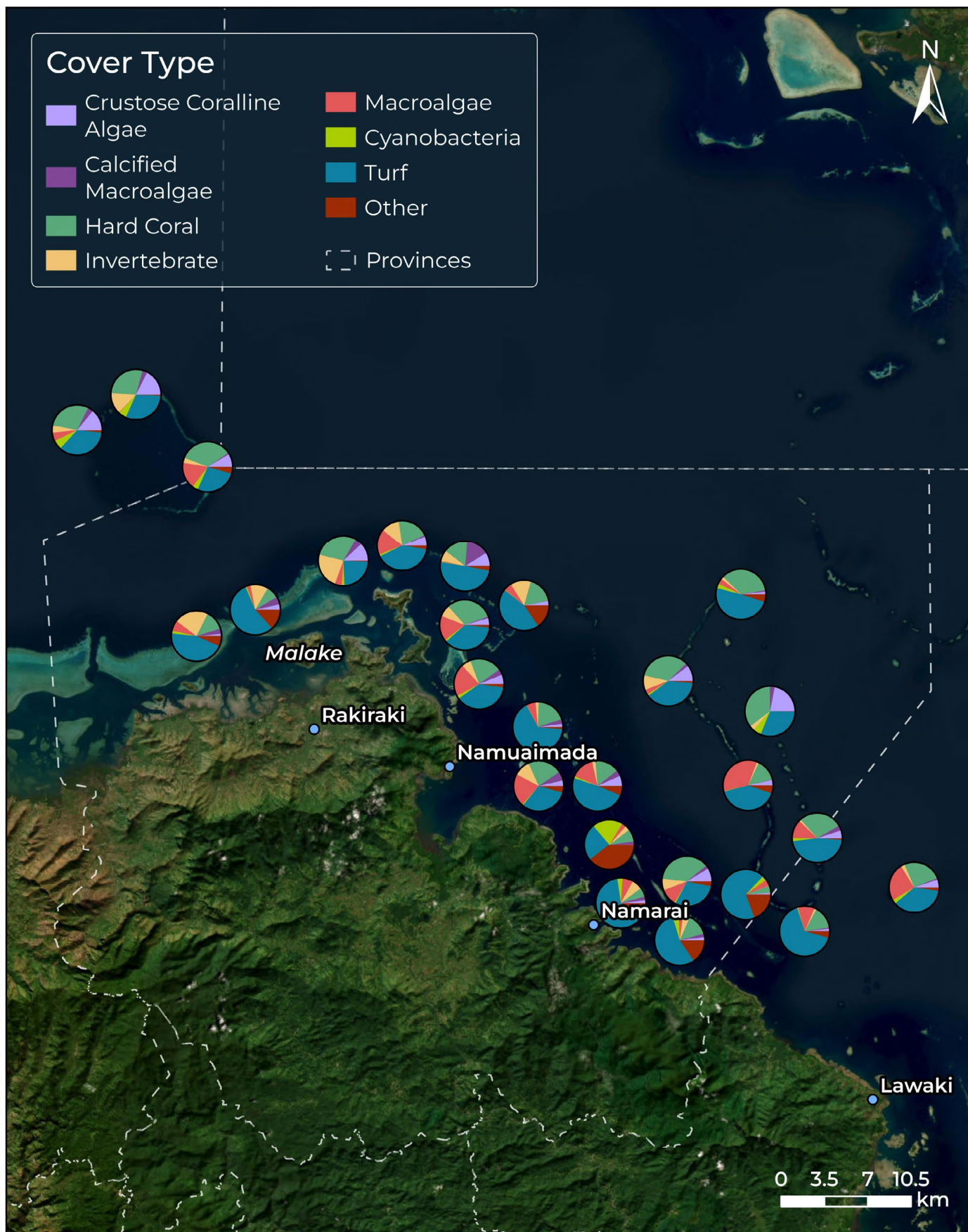
MAP 55: Relative portion of the seafloor covered by all benthic cover types. “Other” includes nonliving substrates such as sand, basalt, etc. — Macuata Province.



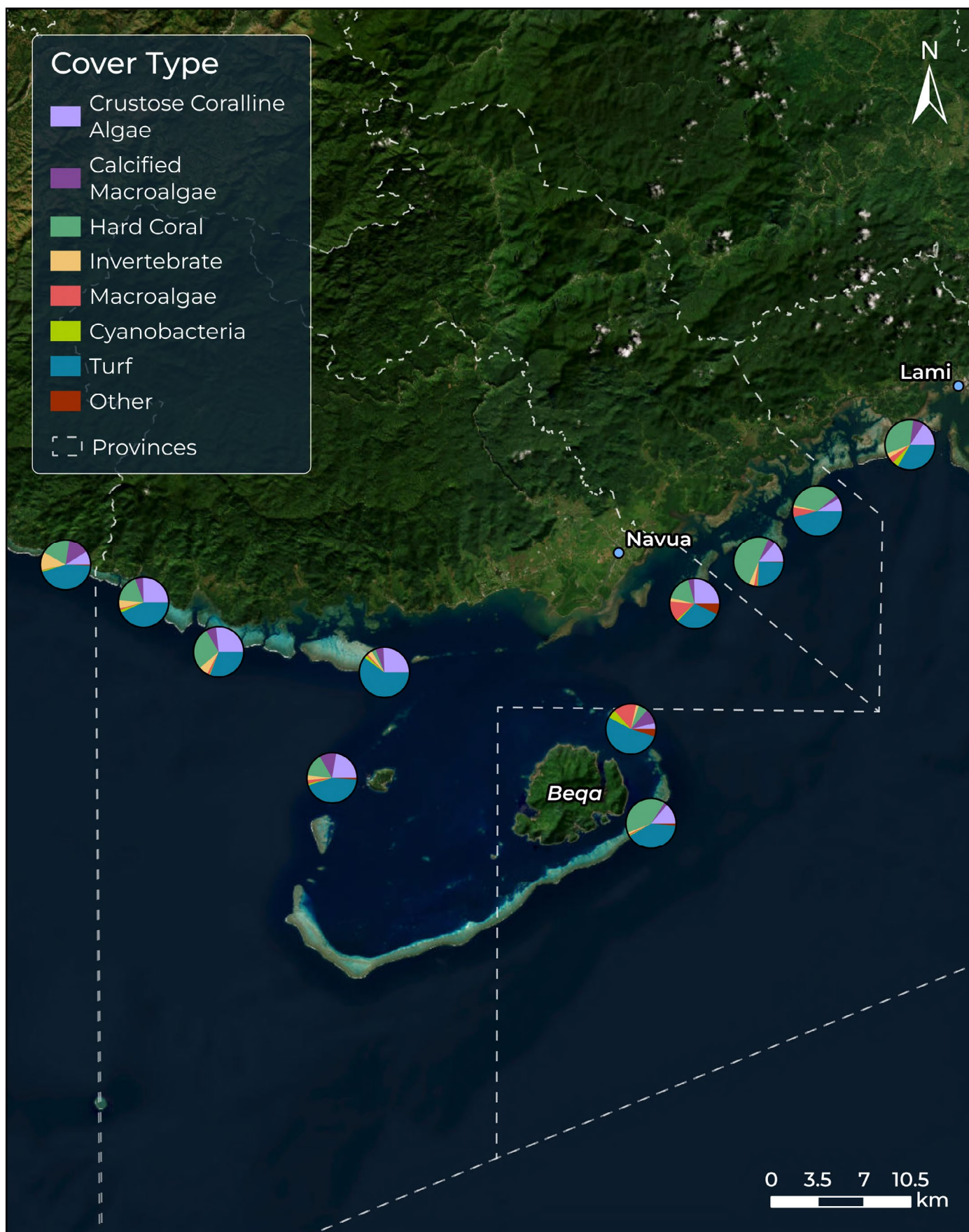
MAP 56: Relative portion of the seafloor covered by all benthic cover types. “Other” includes nonliving substrates such as sand, basalt, etc. — Nadroga-Navosa Province.



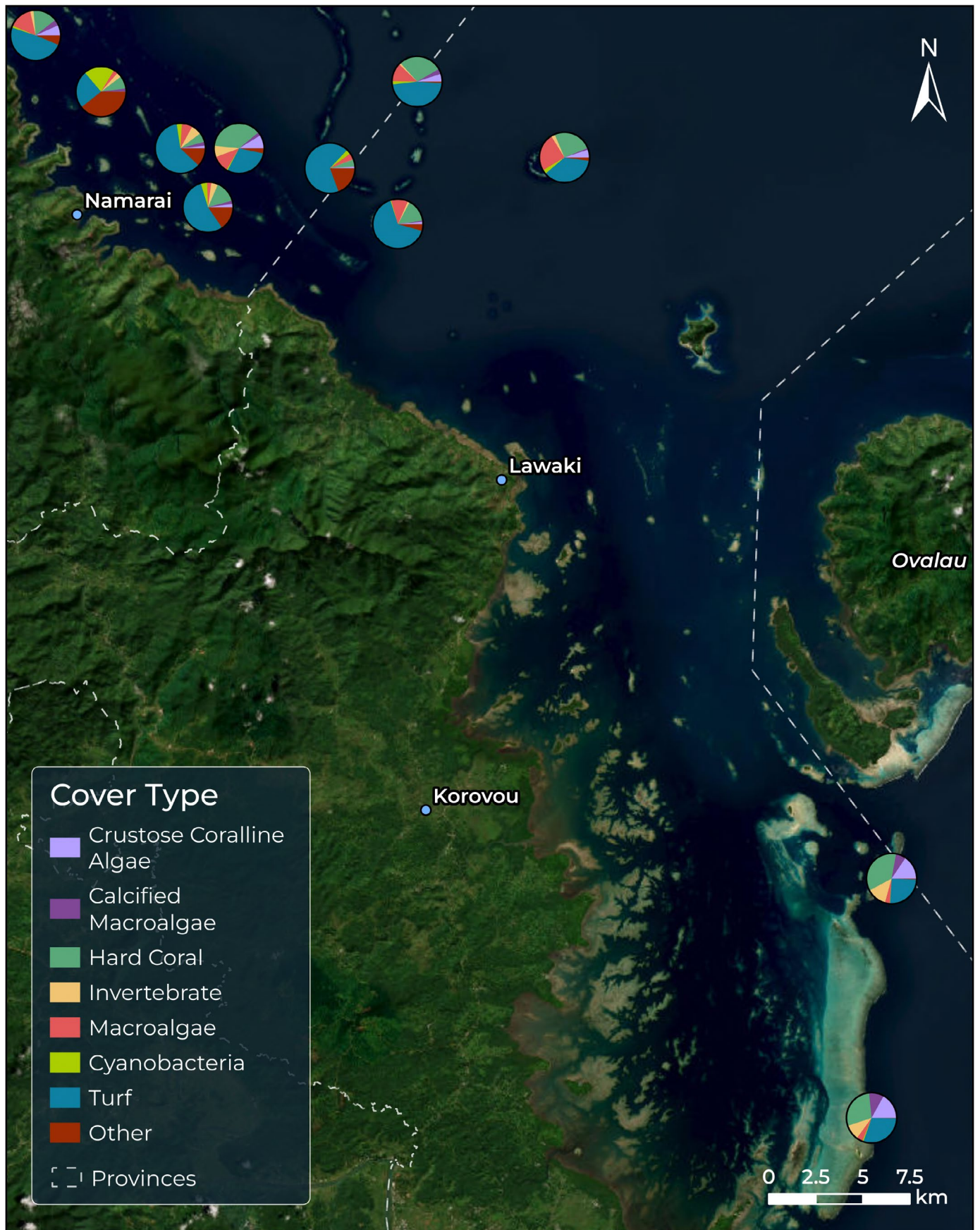
MAP 57: Relative portion of the seafloor covered by all benthic cover types. “Other” includes nonliving substrates such as sand, basalt, etc. — Ra Province.



MAP 58: Relative portion of the seafloor covered by all benthic cover types. “Other” includes nonliving substrates such as sand, basalt, etc. — Serua, Namosi & Rewa Provinces.



MAP 59: Relative portion of the seafloor covered by all benthic cover types. “Other” includes nonliving substrates such as sand, basalt, etc. — Tailevu Province.



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