ROCKY REEF MONITORING PROGRAM

2024 - 2025 CAMPAIGN

INSTITUTE OF THE AMERICAS

CBMC
CENTRO PARA LA BIODIVERSIDAD MARINA Y LA CONSERVACIÓN, A.C.

SCRIPPS INSTITUTION OF OCEANOGRAPHY
UC San Diego

dataMares
www.datamares.org

PREPARED BY:

Eduardo León Solórzano
Centro para la Biodiversidad Marina y la Conservación A.C.

Fabio Favoretto
Marine Station, School of Biological & Marine Sciences
University of Plymouth

Octavio Aburto Oropeza
Scripps Institution of Oceanography

Catalina López-Sagástegui
Marine Research and Science Literacy Program
Institute of the Americas

DESIGN
dataMares

HOW TO CITE:
León Solórzano, E., F. Favoretto, O. Aburto-Oropeza. (2026). Rocky Reef Monitoring Program: 2024-2025 Campaign. Technical Report. Gulf of California Marine Program. 22 pp.

MARCH 2026
This report is a summary of research activities related to the rocky reef ecological monitoring program coordinated by the Gulf of California Marine Program. All data generated through this program are available upon request through dataMares or by contacting Catalina López-Sagástegui (clopez@ iamericas.org).

EXECUTIVE SUMMARY

Long-term ecological monitoring in the Gulf of California demonstrates accelerating structural changes in rocky reef ecosystems, primarily associated with ocean warming and habitat degradation. Analysis of the 1998–2025 time series confirms persistent regional variations in ecosystem condition; Loreto and Corredor support the highest fish biomass and species richness, while Santa Rosalía and San Basilio remain low. The presence of top predators distinguishes reefs with high ecological integrity, particularly within fully protected areas such as Cabo Pulmo. Conversely, several regions exhibit trophic truncation indicative of chronic fishing pressure.

Sea surface temperature records indicate a persistent warming trend and increasing frequency of marine heatwaves since 2014. Hypothesis testing using artificial intelligence methods identified a robust negative relationship between temperature and fish diversity, where reefs lost approximately 1.2 species for every 1°C increase in sea surface temperature. Sargasso forests have declined significantly over the past three decades, with mean biomass decreasing by nearly 30% and multiple sites experiencing total habitat loss. Leopard grouper biomass decreased by 79% at Saragsso sites, a result consistent with climate-driven recruitment model predictions and corroborated by evidence of recruitment failure. These data indicate that climate-driven habitat degradation is a primary driver of ecological change in Gulf of California reef ecosystems, with impacts comparable to fishing pressure.

INTRODUCTION

The Long-Term Ecological Monitoring (LTEM) program has documented ecological conditions in coastal ecosystems of the Gulf of California (GoC) since 1998. This collaborative effort has integrated an international team of scientists and students to monitor rocky reef communities and associated habitats and, over 27 consecutive years, has generated an extensive ecological dataset for the region. These data establish a foundation for understanding natural variability, detecting long-term ecological change, and evaluating the relative effects of local pressures and regional climate trends.

Rocky reefs in the GoC support diverse assemblages of fishes, invertebrates, and macroalgae that sustain ecological processes and regional fisheries. Long-term monitoring facilitates the evaluation of ecosystem status through indicators such as species richness, biomass, and trophic structure. These metrics provide complementary data on biodiversity, community composition, and ecosystem functioning, allowing for robust comparisons across spatial and temporal scales.

In recent years, the LTEM program has expanded its scope to include additional habitats critical to coastal food webs. Sargasso forests, which form dense seasonal canopies on shallow rocky reefs, provide essential nursery and feeding grounds for many reef-associated species. Surveys from the 1990s documented extensive Sargasso beds throughout the central and southern GoC. Revisiting these sites allows for direct comparisons spanning more than two decades, providing the data necessary to evaluate long-term changes in habitat extent and biomass.

Environmental conditions in the GoC are shifting rapidly. Long-term records of sea surface temperatures demonstrate a clear warming trend accompanied by frequent and intense marine heatwaves. These thermal anomalies alter species distributions, trophic interactions, and ecosystem stability, emerging as primary drivers of regional ecological change. Understanding biological responses to these environmental shifts requires consistent observations across multiple habitats and time scales.

The 2025 LTEM expedition was conducted between April and May across five regions and surveyed rocky reefs, rhodolith beds, and Sargasso forests using standardized field methods to ensure comparability with previous surveys. After the Sargasso expedition we also monitored reefs during October and November for our historical yearly monitoring. Assessments of fish, invertebrates, and benthic communities provided an integrated view of ecosystem conditions across habitats. By combining long-term monitoring data with historical comparisons and new analytical approaches, this report evaluates current ecosystem status and identifies emerging patterns of ecological change.

The LTEM program provides the scientific evidence required to evaluate conservation actions, interpret the effects of climate variability, and support ecosystem-based management. As environmental conditions continue to shift, sustained monitoring remains critical for understanding and protecting coastal ecosystems that support biodiversity and regional well-being.

2025 EXPEDITION OVERVIEW

The 2025 expedition took place from April 19 to May 7 aboard the M/V Storm, a 48 ft vessel with a capacity for 12 passengers plus 4 crew. This monitoring effort covered approximately 1,000 km over 18 days across five regions: La Paz, Corredor, Loreto, San Basilio, and Santa Rosalía (Figure 1). While the route was shorter than the 2023 expedition (~1,600 km over 30 days), it incorporated greater habitat diversity.

Historically, the LTEM focused on rocky reefs (Aburto-Oropeza et al., 2007); however, this campaign revisited sites with critical habitats such as Sargasso beds originally sampled in 1998 and 1999. This expanded sampling network enabled temporal comparisons of habitat status over a 26-year period.

The expedition included survey sites at 32 rocky reefs, 6 rhodolith beds, and 13 Sargasso forests where fish, invertebrates, and algal cover were assessed.

Surveyed locations included two marine protected areas: Espíritu Santo Archipelago Marine Zone National Park (PNZMAES) and Bahía de Loreto National Park (PNBL). Beyond evaluating the health of rocky reefs at the peak of winter productivity, the research team assessed the ecological condition, biomass, extent, and associated communities of Sargasso beds

ROCKY REEF MONITORING REGIONS AND SITES

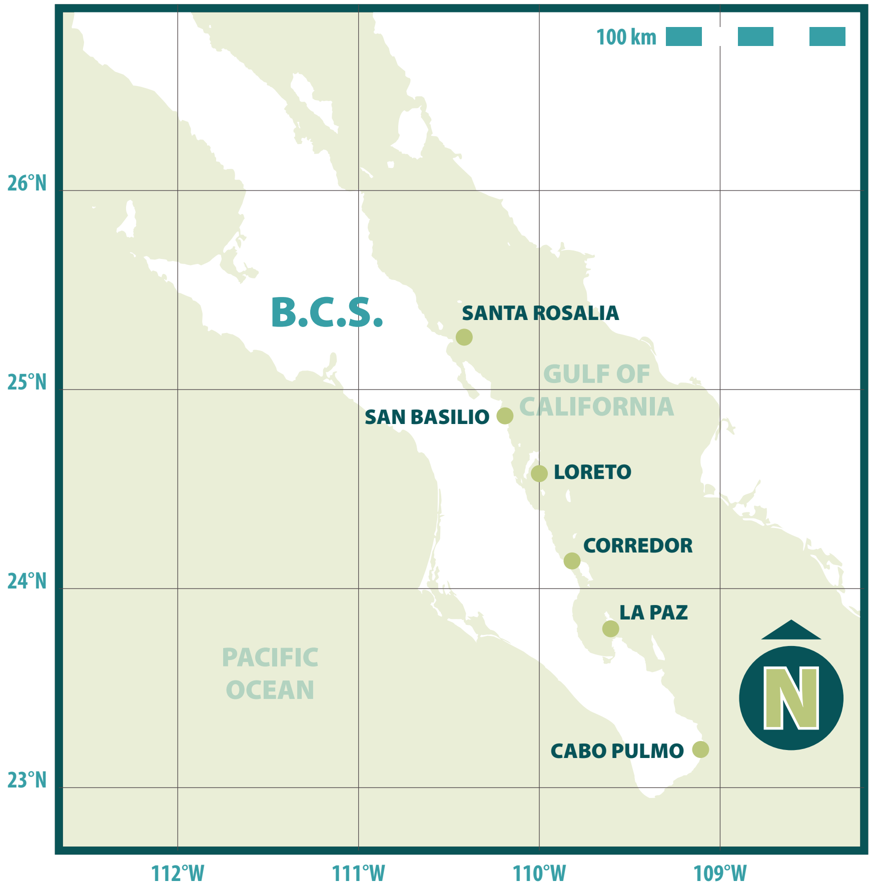


Figure 1. Rocky Reef monitoring regions and sites for the Spring–Fall 2025 campaign.

NUMBER OF ROCKY REEFS
47

NUMBER OF TRANSECTS
561

INVERTEBRATES
289

FISH
272

TOTAL AREA SURVEYED
2,750 m²

TOTAL TIME SPENT UNDERWATER
140 HOURS/SCIENTIST

CONTACT POINTS
23,247

INVERTEBRATE SPECIES
42

NUMBER OF SPECIES IDENTIFIED
217

INVERTEBRATES
95

FISH
122

NUMBER OF ORGANISMS COUNTED AND MEASURED
147,603

INVERTEBRATES
20,646

FISH
126,957

NEW COLLABORATIONS AND CAPACITY BUILDING

In 2025, the scientific team expanded through new collaborations with four academic groups from prominent marine research institutions in Mexico: the Marine Botany Laboratory at Universidad Autónoma de Baja California (UABC), the Plankton and Marine Ecology Laboratory at Centro Interdisciplinario de Ciencias Marinas (CICIMAR), the Environmental Science Bioengineering Laboratory at Universidad Autónoma de Baja California Sur (UABCS), and the Marine Botany Laboratory at Centro de Investigaciones Biológicas del Noroeste (CIBNOR).

The 2025 research team included 15 scientists, including two doctoral students and two master's students. These four students will utilize the data generated during the expedition and the historical datasets collected throughout the program's duration for their respective research. Additionally, they gained hands-on experience in field operations and data analysis under the guidance of expert researchers.

ROCKY REEF ECOSYSTEM HEALTH

Species richness, biomass, and relative biomass are utilized as complementary metrics to assess the ecological condition of rocky reefs in 2025. Richness reflects the total number of species recorded per region and serves as a direct indicator of taxonomic diversity (Figure 2). In the 2025 campaign, the central regions (Loreto and Corredor) exhibited the highest richness values, followed by La Paz, while Santa Rosalía and San Basilio showed the lowest values. Because diversity alone does not fully describe ecosystem status, functional metrics based on fish communities were incorporated.

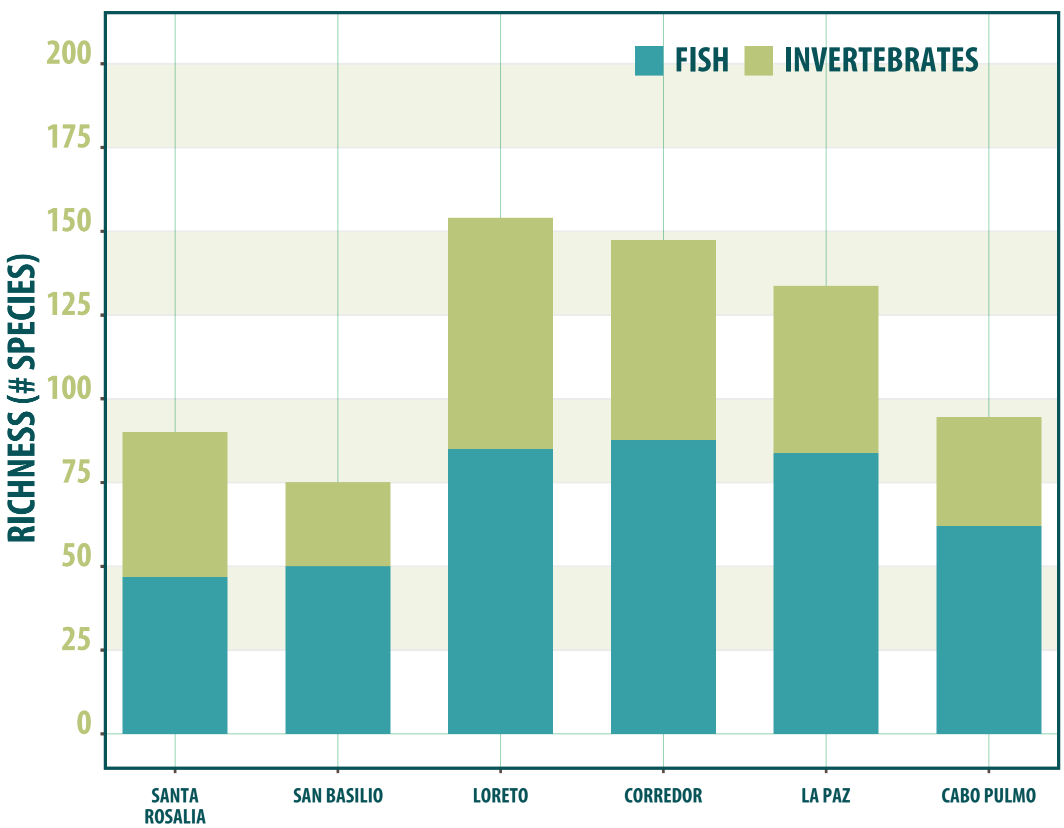


Figure 2. Species richness of fish and invertebrates observed during the Spring–Fall 2025 monitoring campaign.

Biomass (ton/ha) integrates abundance and body size, providing an estimate of total fish biomass (Figure 3). In 2025, Loreto, Corredor, and La Paz recorded the highest biomass values, whereas Santa Rosalía presented the lowest. Higher richness and biomass values suggest structurally complex and potentially more resilient communities; however, the internal distribution of biomass among trophic groups is essential for interpreting ecosystem functioning.

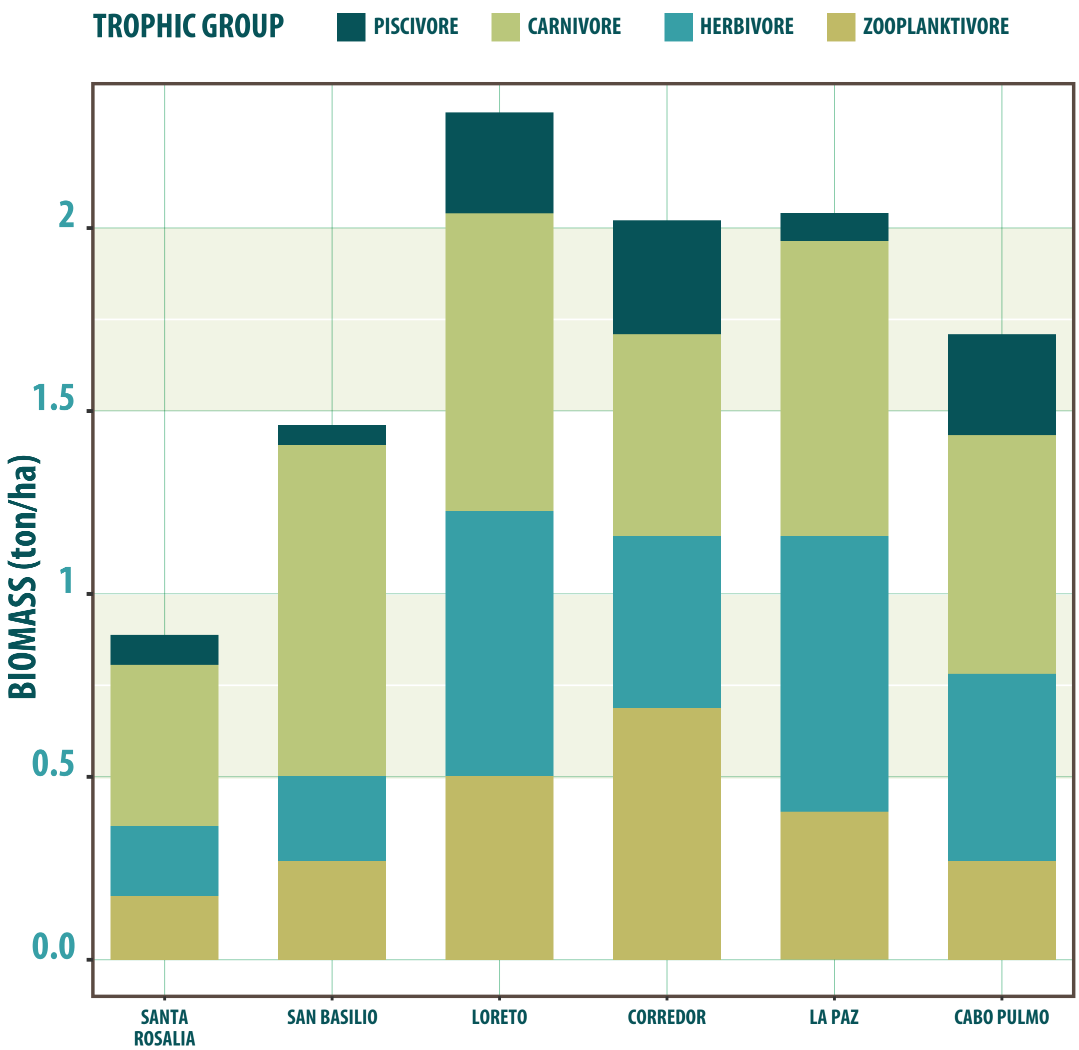


Figure 3. Average biomass (ton/ha) by fish trophic group across monitoring regions.

Relative biomass (%) facilitates the evaluation of trophic structure by comparing the contribution of piscivores, carnivores, herbivores, and zooplanktivores (Figure 4). In regions such as San Basilio and Santa Rosalía, carnivores dominate and piscivores are underrepresented, suggesting trophic truncation associated with fishing pressure. In contrast, Cabo Pulmo exhibited a higher relative proportion of top predators and a balanced distribution among functional groups, a pattern consistent with high ecological integrity (Aburto-Oropeza et al. 2011). The combination of these metrics allows for the quantification of diversity and biomass while enabling inferences regarding the degree of functionality and disturbance in monitored reefs.

Time-series data (1998–2025) allow for the evaluation of interannual changes in average fish biomass and the detection of responses to environmental drivers and local pressures (Figure 5). Loreto and La Paz show moderate variation over time, with periods of decline followed by partial recovery, suggesting dynamics influenced by both environmental variability and sustained fishing pressure. In Santa Rosalía and San Basilio, total biomass remains low and variable without a clear long-term increasing trend.

Corredor presents episodic peaks in biomass primarily associated with increases in zooplanktivores or temporary pulses of piscivores rather than sustained structural recovery. Conversely, Cabo Pulmo consistently records higher proportions of piscivores and elevated biomass events in recent years, a pattern consistent with its protected status. The time series indicates that while natural interannual fluctuations occur, the sustained presence of top predators remains the distinguishing feature of systems with lower fishing pressure and greater trophic integrity.

RELATIVE BIOMASS (%)

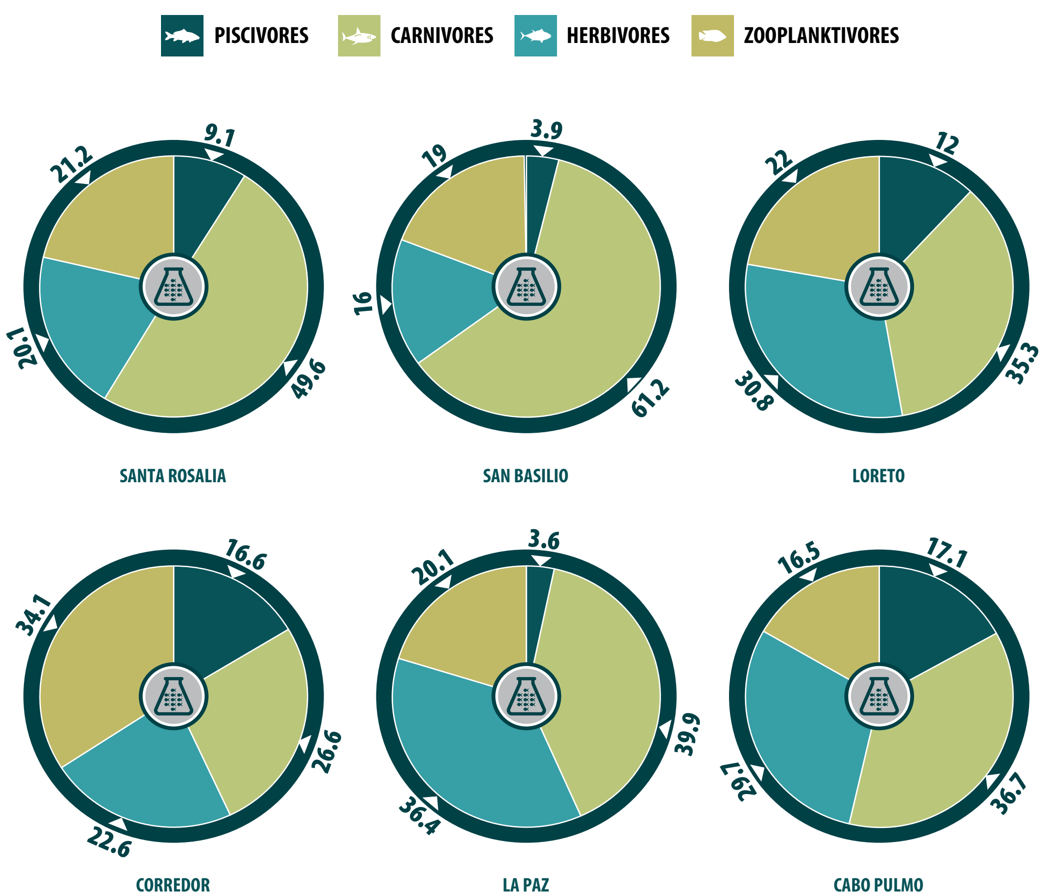


Figure 4. Relative biomass (percentage) by fish trophic group across monitoring regions during 2025.

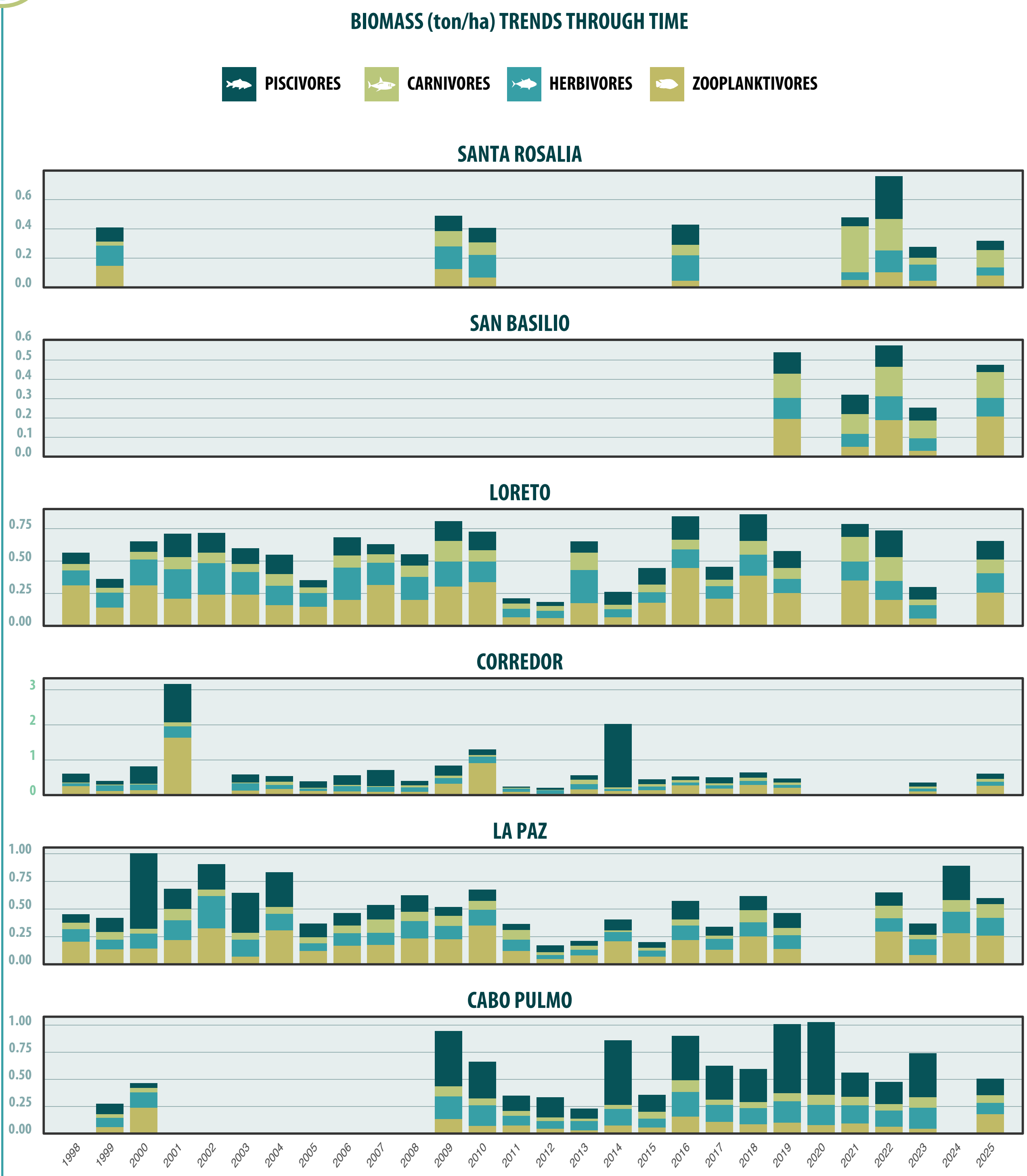


Figure 5. Time series of average biomass (ton/ha) by trophic group for monitored regions.

CLIMATE CHANGE AND ROCKY REEFS IN THE GULF OF CALIFORNIA

SEA SURFACE TEMPERATURE AND HEATWAVES

Decomposition of the Sea Surface Temperature (SST) time series by latitudinal degree reveals a general warming trend throughout the 1982–2025 period, superimposed on interannual variability (Figure 6). Lower latitudes consistently show higher temperatures and a pronounced warming signal in recent years, while higher latitudes maintain lower absolute values but exhibit a similar upward trajectory. Notable warm events, particularly in 1998, 2015–2016, and 2019, are evident across the gradient, reflecting regional-scale climatic drivers.

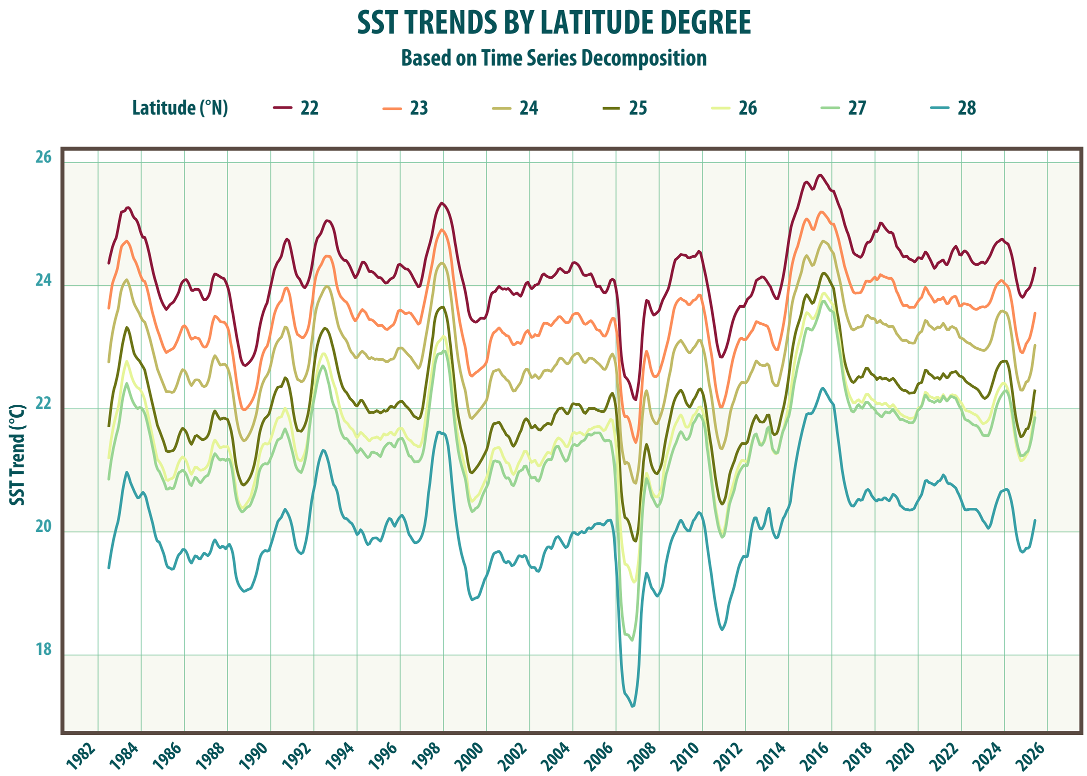


Figure 6. Time series of Sea Surface Temperature trends by latitudinal degree during the historical period (1982–2025).

The SST anomaly time series for the monitored region (23.3–27.5°N), calculated relative to the 1998–2011 baseline, shows interannual variability with a trend toward more frequent and intense warm anomalies over the last two decades (Figure 7). During early years of the series, cold anomalies predominated, whereas from the 2000s onward, particularly after 2014, a sustained increase in the magnitude and duration of warm events is observed.

Positive peaks associated with large-scale events, such as 2015–2016, exceed 2–3°C, reflect regional marine heatwave conditions. Although intermittent cold periods persist, the increased recurrence of positive anomalies in recent years suggests a shift toward a warmer thermal regime. This context is central to interpreting changes in richness, biomass, and trophic structure observed in 2025, as prolonged thermal anomalies modify species distributions, promote tropicalization processes, and alter the functional dynamics of rocky reefs.

SST ANOMALIES

Monitoring footprint: Cabo Pulmo to Santa Rosalia (23.3–27.5°N) | Baseline: 1998–2011

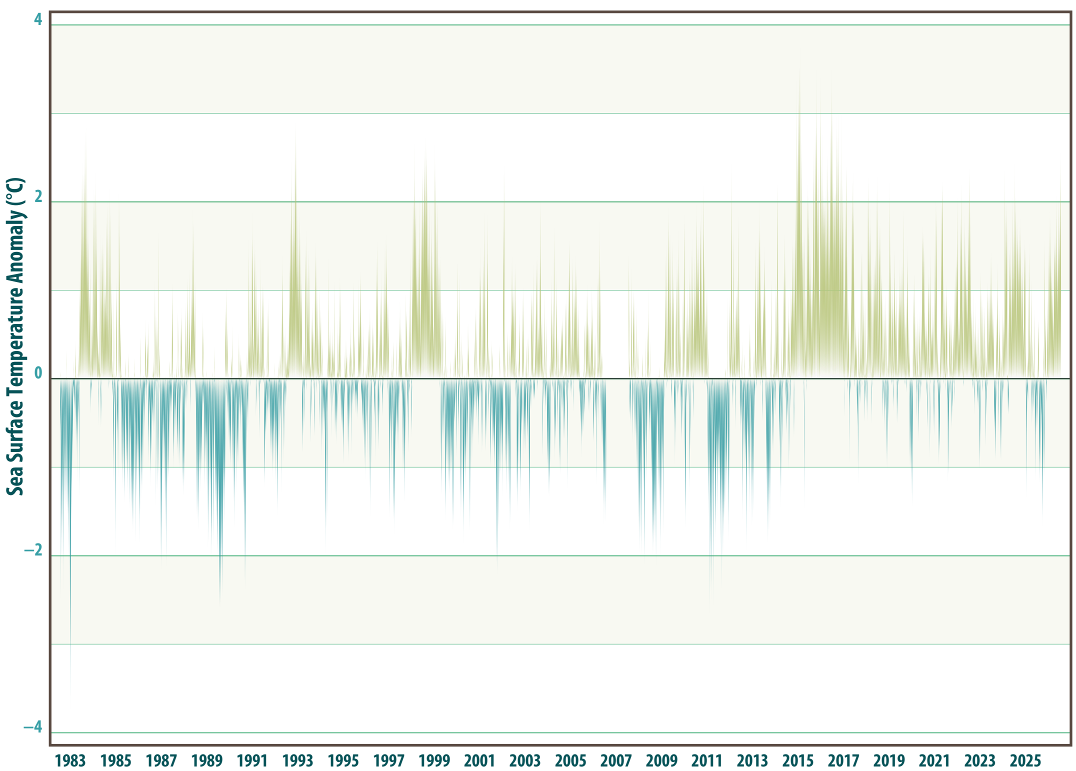


Figure 7. Sea Surface Temperature anomalies in the monitored region during the historical period (1982–2025).

Marine heatwaves (MHWs) are prolonged periods during which sea surface temperature exceeds the 90th percentile threshold of historical climatology, generating extreme thermal conditions that alter the structure and functioning of marine ecosystems (Wernberg et al., 2013). During 2025, MHW events were recorded across all monitored regions, particularly between late summer and fall, when observed temperatures consistently exceeded climatological thresholds (Figure 8). The intensity and duration of these events were evident in Santa Rosalía, San Basilio, Loreto, Corredor, La Paz, and Cabo Pulmo, indicating regionally synchronized thermal exposure.

These thermal anomalies drive shifts in species composition, favor warm-affinity organisms, and modify trophic interactions, contributing to tropicalization and biogeographic homogenization (Favoretto et al., 2022). The recurrence of warm events in 2025, combined with the long-term warming trend, indicates that rocky reefs in the GoC are experiencing an increasingly extreme thermal regime. Integrating this information with patterns of richness, biomass, and trophic structure is essential for interpreting ecological responses observed during the 2025 campaign within the broader context of climate change.

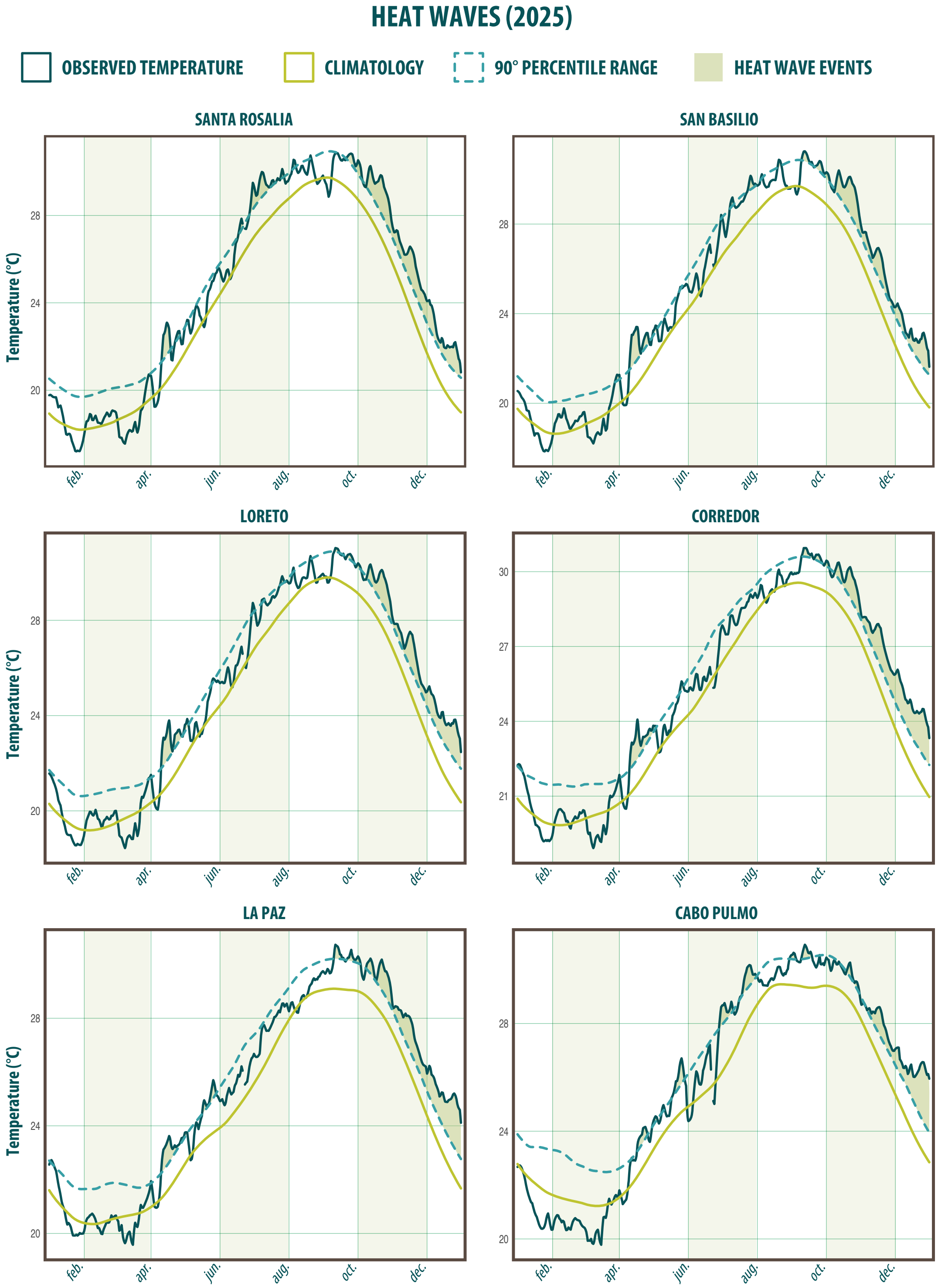


Figure 8. Marine heatwaves in the monitored regions during 2025.

SARGASSO BEDS AND THEIR SEASONAL DYNAMICS

The GoC is a center of diversity and biomass for the genus *Sargassum*. Early taxonomic expeditions in the 20th century described numerous species, initially reporting 15 new taxa, later consolidated to approximately ten based on morphological criteria (Andrade-Sorcia et al., 2014). Recent molecular analyses confirm that the GoC's Sargasso populations are distinct and largely endemic. At least six native species (Dawson, 1966) form the foundation of algal forests in the GoC: *S. herporhizum*, *S. horridum*, *S. johnstonii*, *S. lapazeanum*, *S. sinicola*, and the recently described *S. ulixei*.

These species colonize rocky reefs and hard substrates throughout the GoC, particularly in the central and southern regions where suitable habitat is extensive. In shallow subtidal zones, they attach to rock and form dense, canopy-forming beds that function as underwater algal forests. Surveys conducted in the 1990s documented extensive beds along the western GoC coast between 26–28°N, with additional records extending south to Bahía de La Paz (~24°N) and northward around central GoC islands (Pacheco-Ruíz et al., 1998). In contrast, the extreme northern GoC delta region lacks substantial Sargasso presence due to soft-bottom substrates and extreme environmental conditions, including high temperature, salinity, and turbidity.

Native GoC *Sargassum* species exhibit pronounced seasonal fluctuations in growth and biomass. Growth occurs during cooler months, with maximum development between late winter and spring, followed by reduced growth or partial senescence during warm summers (Pacheco-Ruíz et al. 1998). Fronds reach maximum length and weight in spring when water temperature is low and nutrient levels are high; growth is notably reduced by late summer as water becomes warm and stratified (Figure 9).

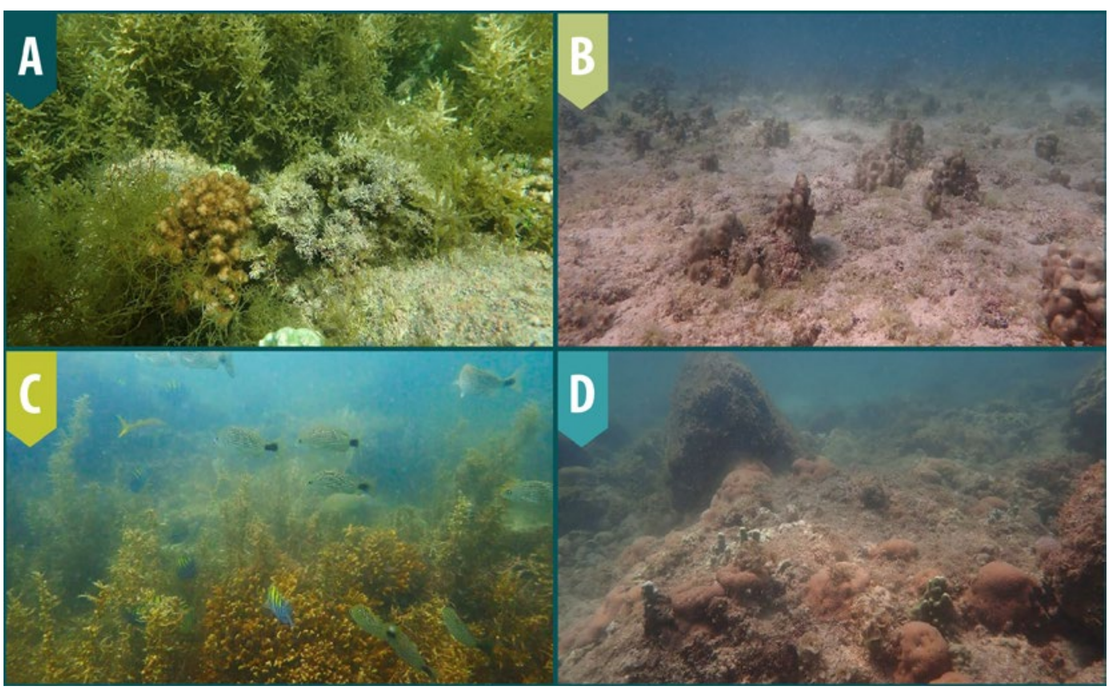


Figure 9. A, C) Sargasso forests grow on rocky reefs during the cold season; B, D) reefs where known Sargasso forests disappeared and now show dominant cover of stony corals and turf-algae.

LONG-TERM CHANGES & HABITAT LOSS

Sargasso populations in the GoC have undergone significant changes in distribution and abundance over the past three decades, driven by natural climate variability and recent warming trends (Casas-Valdez et al., 2016; Aburto-Oropeza et al., 2007). Surveys from the mid-1990s documented extensive, continuous Sargasso canopies along the western coast (Pacheco-Ruíz et al., 1998). By 2006, surveys revealed a smaller, fragmented beds. Although 72 distinct beds were mapped, none matched the spatial extent of those observed a decade earlier, and total canopy area had declined by approximately 45% relative to 1995. In Bahía de La Paz, the average frond length of *S. sinicola* was significantly shorter in 2006, suggesting increased environmental stress or reduced growing seasons. Because GoC Sargasso is not commercially harvested, these declines point to environmental rather than extractive causes.

In 2007, a climate-driven mechanism was proposed linking ENSO variability to leopard grouper (*Mycteroperca rosacea*) recruitment through its effects on Sargasso nursery habitat (Aburto-Oropeza et al., 2007). The model predicted that transitions from cool, productive La Niña conditions to warmer El Niño or neutral phases would reduce Sargasso biomass and, consequently, juvenile grouper recruitment. Using field surveys from 1999 (La Niña conditions) and 2025 (neutral ENSO conditions), together with 26 years of monitoring data, we provide a direct evaluation of this hypothesis. Across most surveyed sites, Sargasso biomass declined between 1999 and 2025 (Figure 10), with mean biomass decreasing from 4.4 kg/m^2 to 3.1 kg/m^2. Three sites experienced complete loss (-100%), and the dominant regional pattern reflects habitat degradation consistent with long-term warming trends.

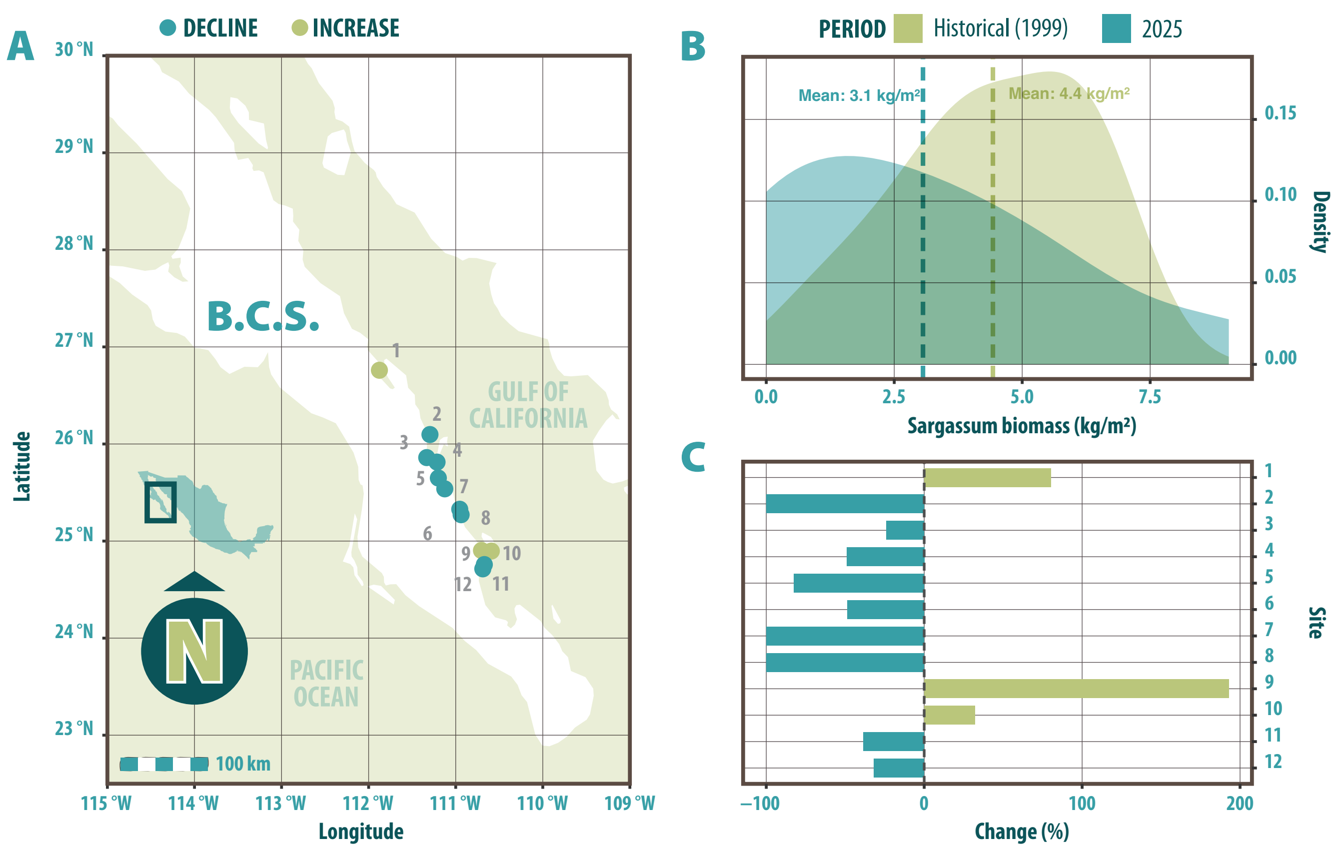


Figure 10. Study area and Sargasso biomass changes in the Gulf of California. (A) Survey sites colored by direction of change. (B) Density distributions of biomass comparison (1999 vs. 2025 surveys). (C) Site-level percent change.

CHANGES IN LEOPARD GROUPER RECRUITMENT PATTERNS

Leopard grouper biomass at Sargasso sites declined from 1.3 ton/ha at baseline to 0.28 ton/ha in the observed period—a 79% reduction (Figure 10B). The species was present in 100% of transects in 1999 but only 42% in 2025. The original model predicted a 77% decline based on the MEI transition; the observed 79% decline falls within the model's uncertainty bounds (95% CI: -88% to -60%), differing by only 1.1 percentage points from the central prediction. Results indicate that the climate-recruitment model explains 98% of the observed decline. This indicates that at these Sargasso habitat sites, the climate signal is sufficiently strong to overwhelm other potential drivers. The lack of adult groupers signifies a lack of population aging in addition to recruitment failure (Figure 11D), suggesting pressures on both ends of the population structure.

Changes in population size structure provide independent evidence of recruitment failure. At baseline, recruits (fish <25 cm) comprised 43% of the population; in the observed period, this proportion dropped to 16%, while sub-adults (25-40 cm) increased from 24% to 48%. This shift from a recruit-dominated to a sub-adult-dominated population is consistent with the model's mechanism: reduced Sargasso habitat limits successful settlement of juvenile groupers, leading to fewer young fish entering the population over time.

These findings provide empirical validation of a climate-habitat-recruitment model over a 26-year period. The close match between predicted and observed declines supports the mechanistic link between ENSO, Sargasso habitat, and grouper population dynamics. For conservation, these results suggest that protecting Sargasso nursery habitat is as critical as managing fishing pressure for leopard grouper populations. Climate-driven habitat loss can produce population declines comparable in magnitude to overfishing.

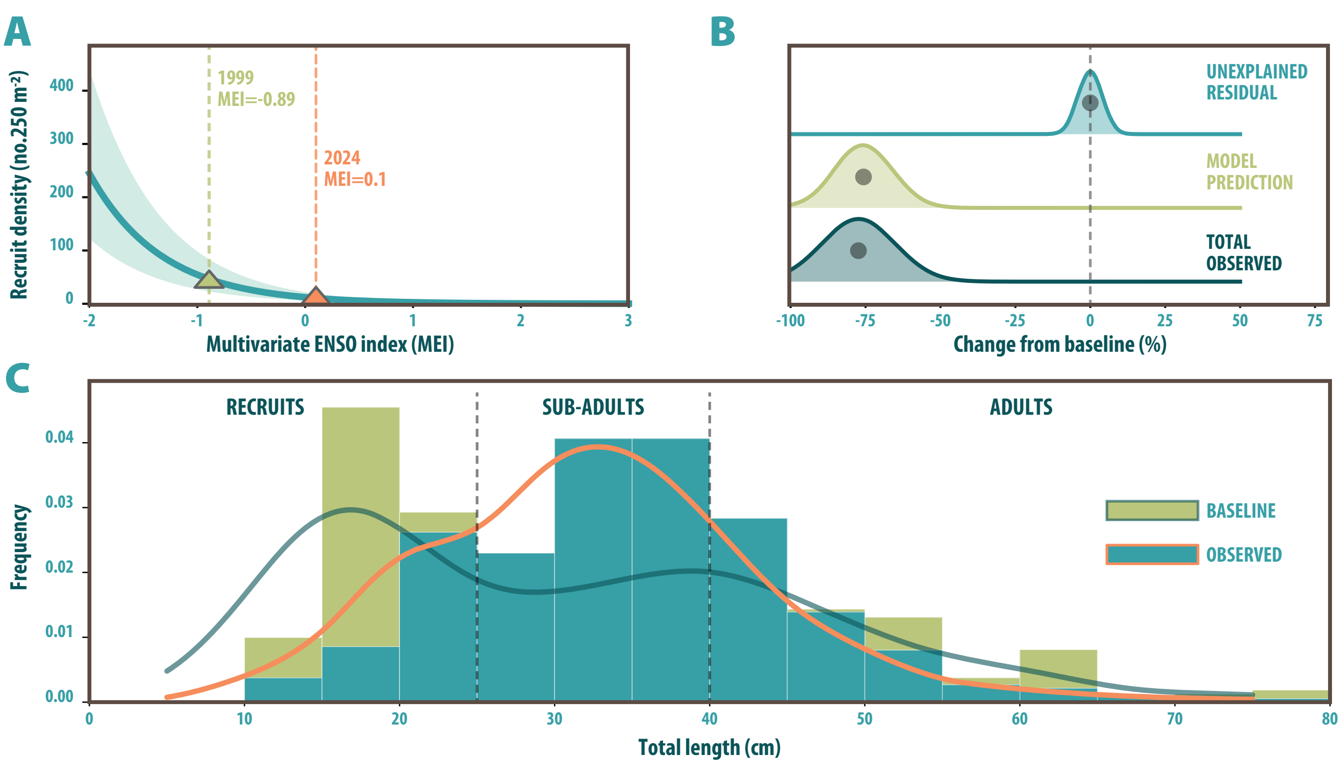


Figure 11. Model validation and population structure. (A) Recruitment model showing predicted leopard grouper density as a function of ENSO conditions; markers indicate 1999 and 2025 positions. (B) Bayesian decomposition showing that climate explains 98% of decline, with the unexplained residual centered on zero. (C) Size-frequency distributions showing the shift from recruit-dominated (baseline) to sub-adult-dominated (observed) population.

KEY FINDINGS

One of the clearest patterns detected by the AI-driven analysis is the relationship between ocean warming and fish diversity. Across the full dataset, higher sea surface temperatures were consistently associated with lower fish species richness. On average, reefs lost approximately 1.2 fish species for every 1°C increase in sea surface temperature. This relationship was statistically robust and observed across regions. As warming trends continue, reef fish communities are likely to experience progressive declines in diversity. Because fish diversity maintains ecological processes such as herbivory, predation, and nutrient cycling, continued warming may have cascading effects on ecosystem function.
A second major result challenges the "insurance hypothesis," which proposes that ecosystems with higher species richness are more resistant to environmental disturbance because functional redundancy allows species to compensate for the loss of others. Our analysis did not support this prediction. During the 2014–2016 marine heatwave, reefs with higher initial species richness experienced proportionally greater species losses than reefs with lower richness. This pattern occurred in both protected (Cabo Pulmo) and unprotected sites, suggesting that management status alone does not explain the observed vulnerability.

Several mechanisms may explain this pattern. Species-rich reefs may include a larger proportion of species living close to their upper thermal tolerance limits. High-diversity systems also tend to contain many rare species with small population sizes, increasing the probability of local extinction during stress events. Additionally, reefs with high richness may already operate near ecological carrying capacity, limiting their ability to absorb further disturbance. These findings indicate that biodiversity alone does not guarantee resilience under accelerating climate change.

If biodiverse reefs are more vulnerable to climate stress, conservation strategies require adjustment. Management plans should not assume that high-diversity areas are inherently more resilient; instead, these sites may require enhanced monitoring and targeted protection. This study underscores the value of long-term ecological monitoring, as the relationship between biodiversity and vulnerability became detectable only because the dataset spans multiple decades and includes extreme climate events.

LOOKING AHEAD: INCORPORATING ARTIFICIAL INTELLIGENCE TOOLS TO ADVANCE KNOWLEDGE AND UNDERSTANDING

A central component of our research is the implementation of an AI-based system called AutoDiscovery. This new tool is designed to generate, formalize, and evaluate scientific hypotheses using large ecological datasets. In contrast to traditional ecological studies that test a limited number of hypotheses, AutoDiscovery systematically translates ecological theory into formal predictions, generates multiple competing hypotheses, fits statistical models for each prediction, and compares model performance across alternatives.

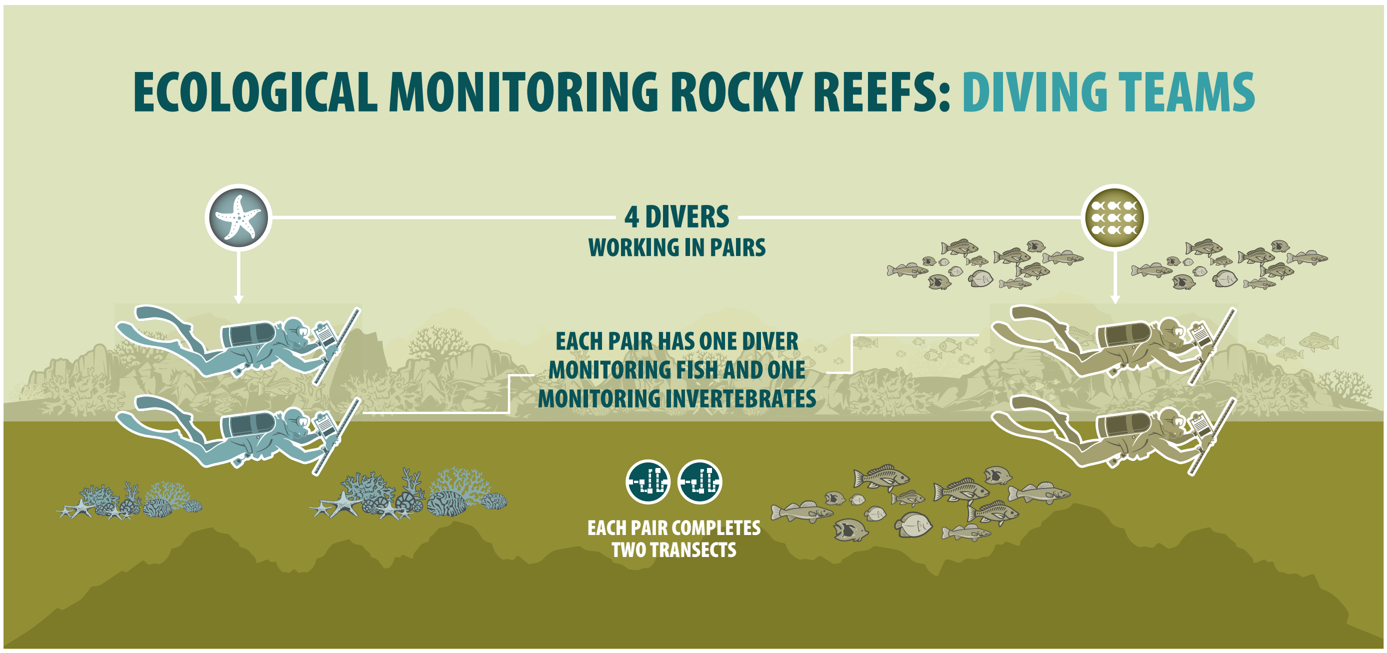
In an analytical exercise testing climate variability and reef protection effectiveness, Favoretto and Aburto-Oropeza evaluated nearly 100 ecological predictions simultaneously. This innovative approach reduces selection bias, allows structured comparison among competing explanations, and increases the likelihood of detecting both expected and unexpected patterns. By testing many hypotheses within the same dataset, AutoDiscovery provides a comprehensive and transparent evaluation of ecological theory.

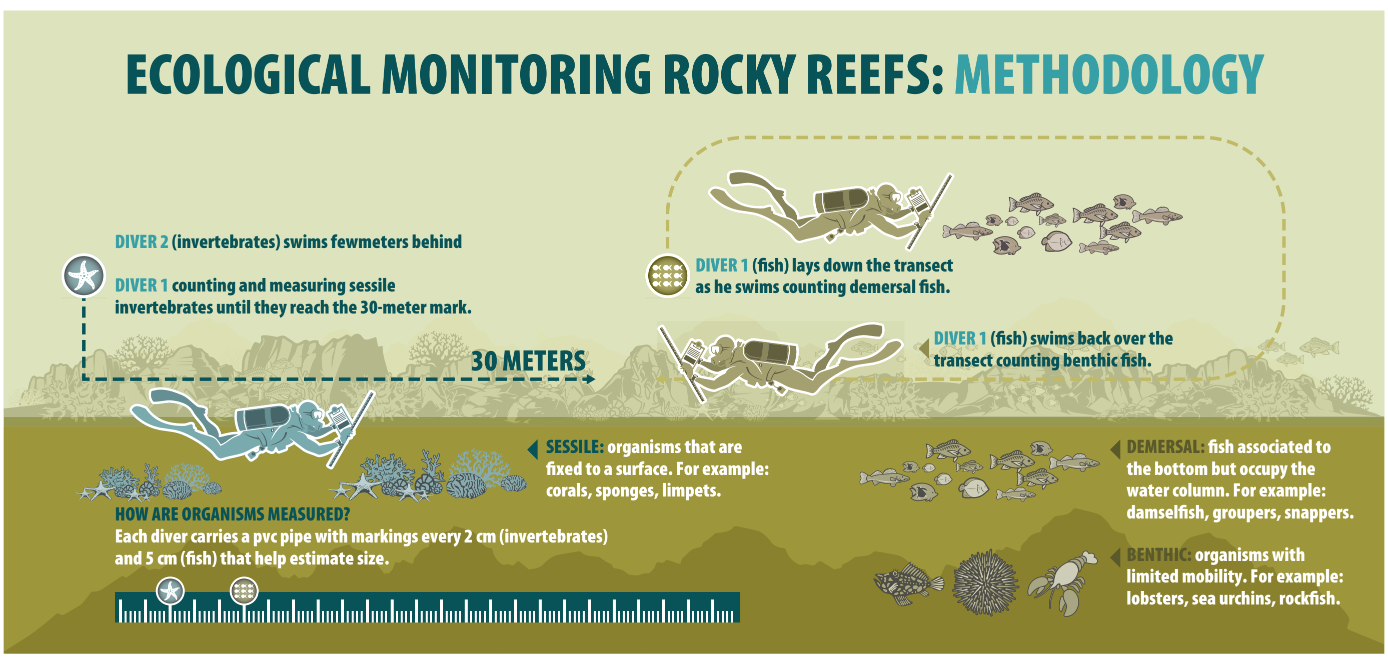
Details of this scientific exercise can be found here.

METHODS

Fish and Invertebrate Surveys

Rocky reef surveys followed standardized visual census methodology. At each site, SCUBA divers conducted underwater visual belt transects, with six replicate 50 × 5 m transects surveyed per location. Divers swam each transect at a constant speed (~15 min per transect), counting all fishes and estimating total length to the nearest cm for juveniles (<10 cm) and the nearest 5 cm for subadults and adults (>10 cm). All fish within 2.5 m of either side of the centerline were recorded (250 m^2 transect area). Surveys were conducted at consistent 5 m and 20 m depth contours. This methodology has been consistently applied since 1998, enabling direct temporal comparisons (Aburto-Oropeza et al. 2007).



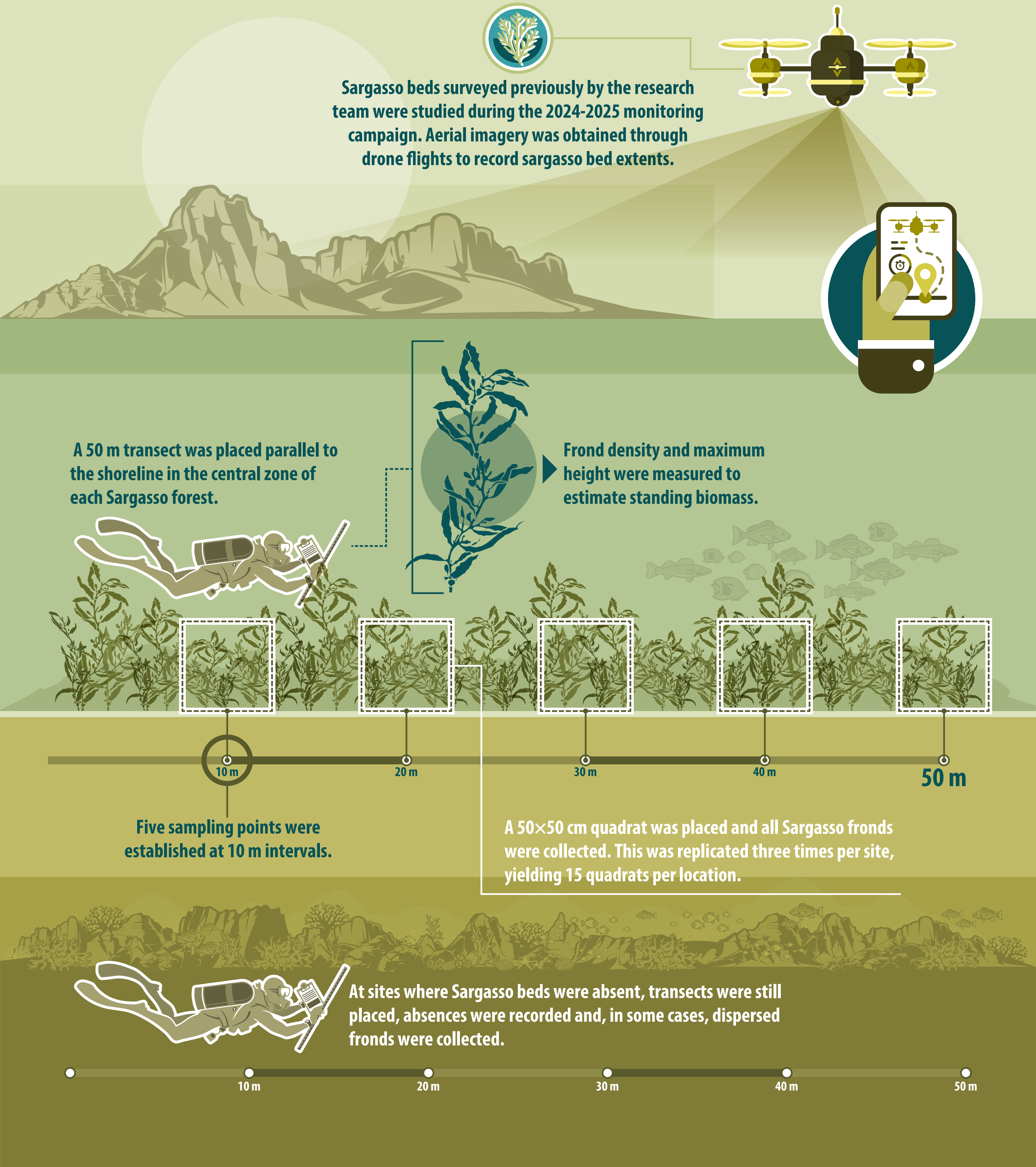


SARGASSO BIOMASS ASSESSMENT

Sargasso beds surveyed previously by the research team were studied during the 2024-2025 monitoring campaign. Aerial imagery was obtained through drone flights to record sargasso bed extents.

A 50 m transect was placed parallel to the shoreline in the central zone of each Sargasso forest.

Frond density and maximum height were measured to estimate standing biomass.



Five sampling points were established at 10 m intervals.

A 50×50 cm quadrat was placed and all Sargasso fronds were collected. This was replicated three times per site, yielding 15 quadrats per location.

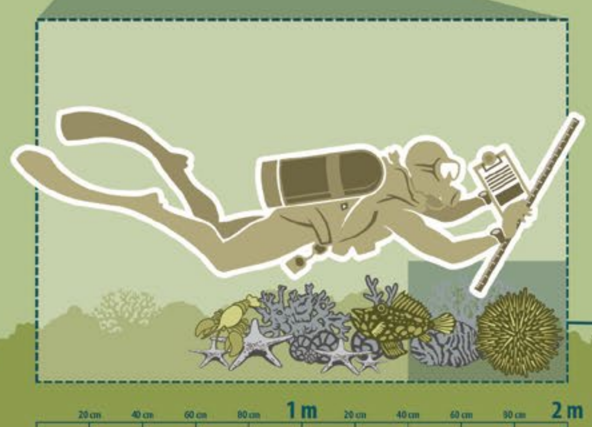
At sites where Sargasso beds were absent, transects were still placed, absences were recorded and, in some cases, dispersed fronds were collected.

BENTHIC COMMUNITY COMPOSITION

Benthic community composition was assessed using the Point Contact Uniform (PCU) method.

Along each 50 m transect, observers recorded the substrate type or organism present at 20 cm intervals, yielding 250 point observations per transect.

Surveys were conducted at two depth strata per reef:
20 m and 5 m depth.



Relative frequency of each benthic category was calculated as the proportion of points occupied, providing a standardized measure of percent cover for sessile invertebrates (corals, gorgonians, sponges, etc.) and macroalgae.

ACKNOWLEDGEMENTS

The rocky reef ecological monitoring 2025 campaign was supported by Alumbra Innovations Foundation, Builders Vision Philanthropy, the Mary G. Jameson Foundation, and Paul M. Angell Family Foundation. We extend our gratitude to the crew of the M/V Storm, whose professionalism and dedication were crucial to the success of the expedition. We also sincerely acknowledge and thank all individuals and partners who have supported and participated in this program throughout its 27 years.

Fieldwork and cruise logistics were coordinated by the Centro para la Biodiversidad Marina y la Conservación. Data analysis was led by Fabio Favoretto (University of Plymouth), Eduardo León Solórzano (CBMC), and Octavio Aburto-Oropeza (Scripps Institution of Oceanography). The Gulf of California Marine Program coordinates the binational team of scientists contributing to the research generated through this program.

REFERENCES

Aburto-Oropeza, O., Erisman, B., Galland, G.R., Mascareñas-Osorio, I., Sala, E., Ezcurra, E., 2011. Large Recovery of Fish Biomass in a No-Take Marine Reserve. PLoS ONE 6, e23601. https://doi.org/10.1371/journal.pone.0023601

Aburto-Oropeza, O., Sala, E., Paredes, G., Mendoza, A., & Ballesteros, E. (2007). Predictability of reef fish recruitment in a highly variable nursery habitat. Ecology, 88(9), 2220-2228.

Andrade-Sorcia, G., Riosmena-Rodriguez, R., Muniz-Salazar, R., Lopez-Vivas, J. M., Boo, G. H., Lee, K. M., & Boo, S. M. (2014). Morphological reassessment and molecular assessment of *Sargassum* (Fucales: Phaeophyceae) species from the Gulf of California, Mexico. Phytotaxa, 183(4), 201-223.

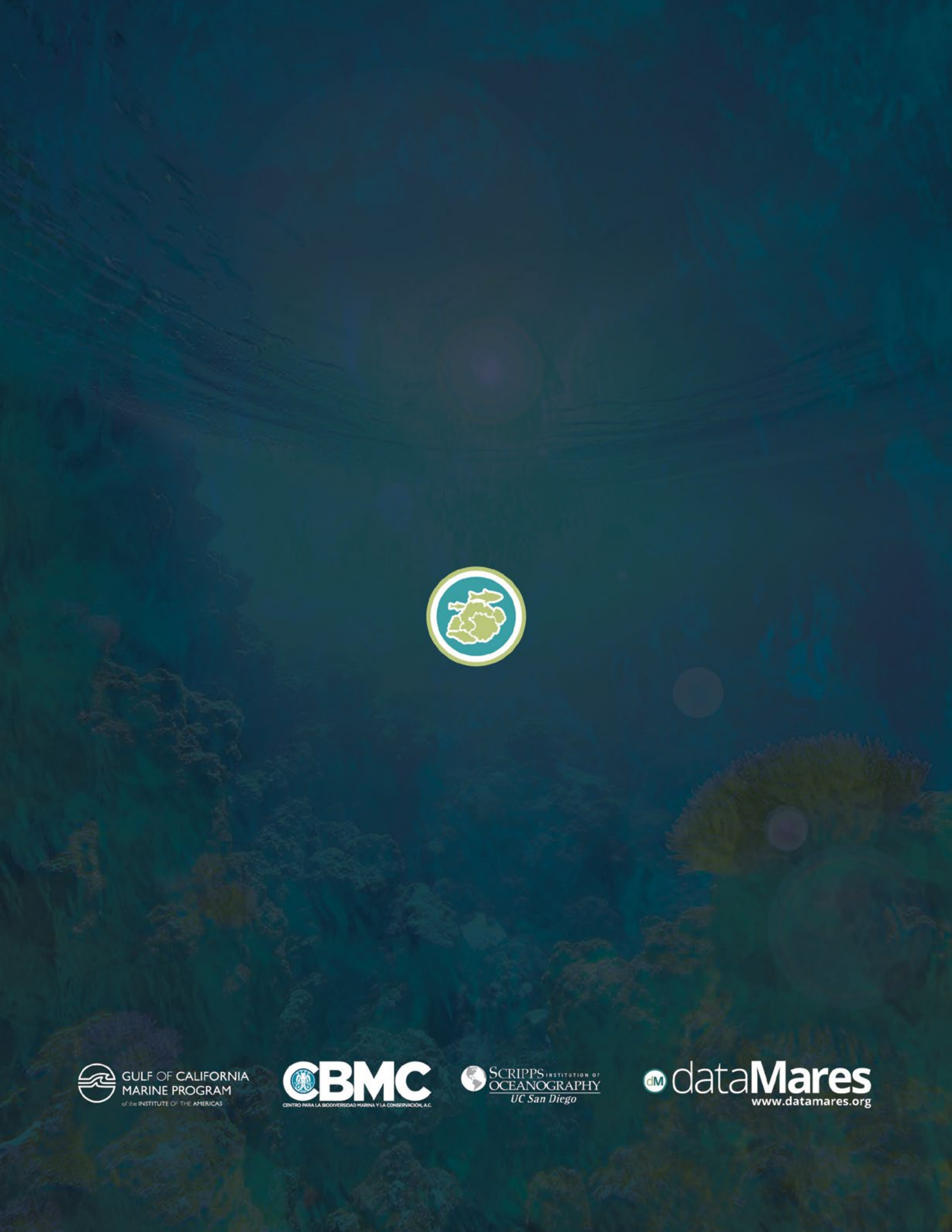
Casas-Valdez, M., Sánchez-Rodríguez, I., Serviere-Zaragoza, E., & Aguila-Ramírez, R. N. (2016). Temporal changes in the biomass and distribution of *Sargassum* beds along the southeastern coast of the Baja California Peninsula. Ciencias Marinas, 42(2), 99-109. https://doi.org/10.7773/cm.v42i2.2592

Dawson, E. Y. (1966). New records of marine algae from the Gulf of California. Journal of the Arizona Academy of Science, 4(2), 55-66. https://doi.org/10.2307/40022371

Favoretto, F., Sanchez, C., & Aburto-Oropeza, O. (2022). Warming and marine heatwaves tropicalize rocky reefs communities in the Gulf of California. *Progress in Oceanography*, 206, 102838.

Wernberg, T., et al. (2013). An extreme climatic event alters marine ecosystem structure in a global biodiversity hotspot. *Nature Climate Change*, 3(1), 78-82.

Pacheco-Ruíz, I., Zertuche-González, J. A., Chee-Barragán, A., & Blanco-Betancourt, R. (1998). Distribution and quantification of *Sargassum* beds along the west coast of the Gulf of California, Mexico. Botanica Marina, 41(1-6), 203-208. https://doi.org/10.1515/botm.1998.41.1-6.203



GULF OF CALIFORNIA MARINE PROGRAM
of the INSTITUTE OF THE AMERICAS

CBMC
CENTRO PARA LA BIODIVERSIDAD MARINA Y LA CONSERVACIÓN, A.C.

SCRIPPS INSTITUTION OF OCEANOGRAPHY
UC San Diego

dataMares
www.datamares.org