

Chapter 7 Swains Island

7.1 Geopolitical Context

Swains Island is the northernmost island in the Territory of American Samoa, situated 1228 km south of the equator and approximately 350 km north of Tutuila Island. Geologically, it is not a part of the Samoan hot-spot track, but part of the Tokelau volcanic chain. Swains is approximately 2.4 km in diameter, containing a 2.6-km² ring of highly vegetated sand and coral rising no more than 6 m above sea level, with a rain-fed lagoon of brackish water that is cut off from the ocean.

The island retains a relatively small population, with as many as 164 full-time residents on the island in the 1950s. Swains had seen a steady decline since then, with only 16 people reported in 1990. The island is currently inhabited by 30 people or less at any particular time, primarily in the northwest village of Taulaga, to retain private ownership by the Jennings family and as part of the Territory of American Samoa. An additional village in the southeast (Etaena) remains largely abandoned. It remains covered by a circle of coconut trees; however, it is not run as an active plantation. The population on Swains survives primarily by farming, specifically bananas, taro, breadfruit and papaya, and subsistence fishing.

7.2 Survey Effort

Physical and biological data have been collected around Swains since 2002 as part of the Pacific Islands Fisheries Science Center (PIFSC) Coral Reef Ecosystem Division’s (CRED’s) American Samoa Reef Assessment and Monitoring Program (ASRAMP). The extent and timeframe of these survey efforts are discussed below. To aid in the discussion of spatial patterns of ecological and oceanographic observations around the island throughout this chapter, four geographic regions are delineated in Figure 7.2a.

Benthic habitat mapping data were collected around Swains using acoustic multibeam survey methods, which completed mapping a total survey area of 256 km² during ASRAMP 2006. These data are further examined in Section 7.3: Benthic Habitat Mapping and Characterization.

Table 7.2a. Numbers, areas, and depths of REA and towed-diver surveys around Swains during ASRAMP 2002, 2004, and 2006.

Year	REA Surveys		Towed-diver Surveys		
	Number of Surveys	Mean Depth (m)	Number of Surveys	Survey Area (ha)	Mean Depth (m)
2002	10*	15.5 (SD 2.9)	9	23.1	10.3 (SD 4.9)
2004	8*	18.1 (SD 1.9)	14	26.5	12.5 (SD 6.9)
2006	8	14.5 (SD 0.6)	9	18.6	14.9 (SD 3.0)

* No coral disease surveys were conducted in 2002 and 2004.

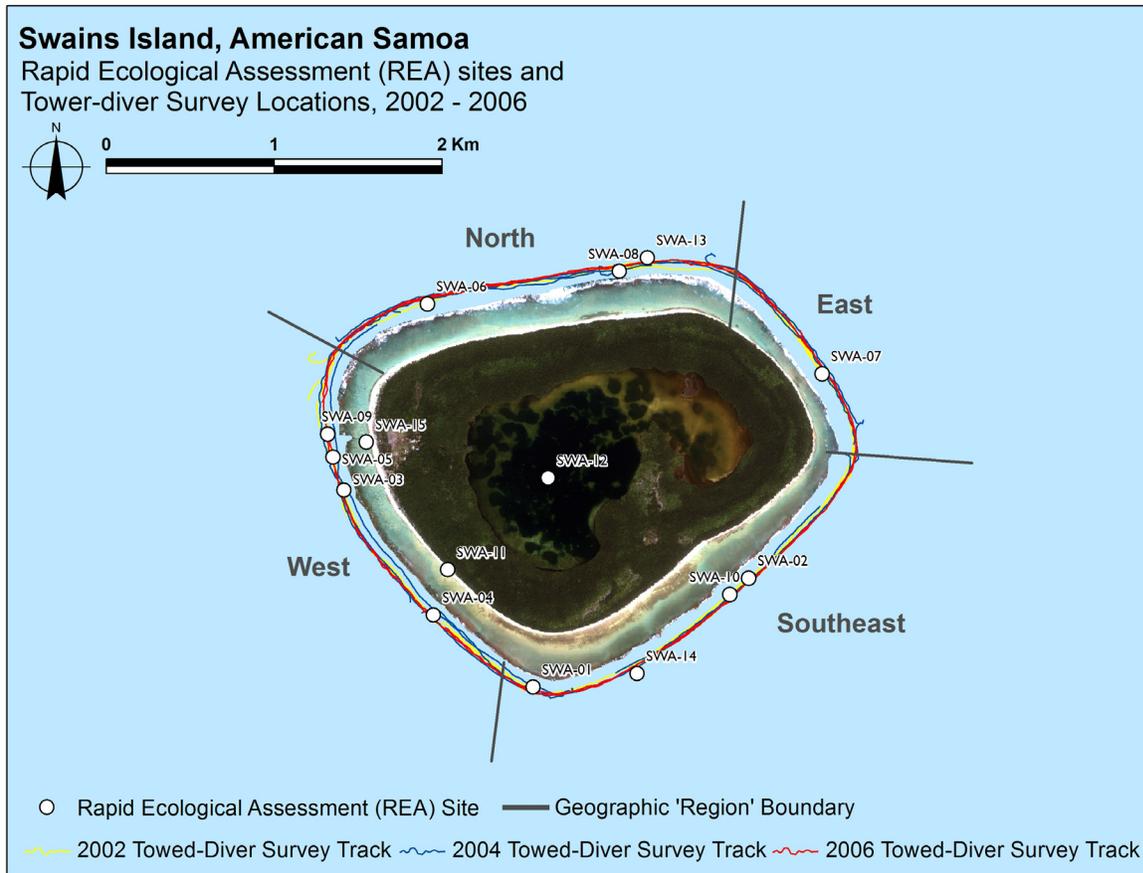


Figure 7.2a. Locations of REA and towed-diver surveys around Swains during ASRAMP 2002, 2004, and 2006. Four arbitrary geographic regions have been delineated to aid in discussion of spatial patterns.

Figure 7.2a shows the locations of Rapid Ecological Assessment (REA) and towed-diver survey efforts during ASRAMP 2002, 2004 and 2006. The number, mean depth, and area of these survey efforts are presented by year in Table 7.2a.

Depth ranges from towed-diver surveys are presented for each year in Figures 7.5.1b (2002), 7.5.1e (2004), and 7.5.1m (2006). Although the towed-diver survey methodology is aimed at following specific isobaths, the actual depths surveyed are often quite variable. These figures illustrate the depth variability observed during towed-diver surveys and should be referenced when further exploring the towed-diver datasets.

Spatial and temporal observations of key oceanographic and water quality parameters influencing reef conditions around Swains were collected using a diverse suite of long-term moored instrumentation packages and closely spaced conductivity, temperature, and depth (CTD) surveys of the vertical structure of the water column during ASRAMP 2002, 2004, and 2006 (see methods Chapter 2, Section 2.3: Oceanography and Water Quality). A summary of deployed instruments and collection activities is provided in Table 7.2b and are examined further in Section 7.4: Oceanography and Water Quality.

Table 7.2b. Numbers of oceanographic instrument deployments and shallow- and deep-water CTD casts around Swains during ASRAMP 2002, 2004, and 2006. Instrument types include ocean data platform (ODP) and subsurface temperature recorder (STR). Shallow-water CTD casts were conducted from the surface to a 30-m depth. Deep-water CTD casts were conducted from the surface to a 500-m depth. Deep-water CTD cast information is presented in Chapter 8: Archipelagic Comparisons.

Observation Type	2002	2004	2006
ODP	1	0	0
STR	0	1	3
Shallow-water CTD casts	19	29	27
Deep-water CTD casts	10	8	9

7.3 Benthic Habitat Mapping and Characterization

Benthic habitat mapping and characterization around Swains were conducted using acoustic multibeam sonar in depths between ~ 10 and ~ 3000 m. The shipboard Towed Optical Assessment Device (TOAD) could not be safely deployed around Swains because of the steep terrain and associated navigational concerns. Nearshore habitat mapping was conducted during towed-diver benthic surveys in depths between ~ 10 and 30 m.

7.3.1 Acoustic Mapping

Multibeam mapping was conducted around Swains in early 2006 (Fig. 7.3.1a). Continuous coverage was achieved in depths between ~ 10 and 3000 m. An additional noncontiguous swath was surveyed during deep-water acoustic Doppler current profiler transects that extended the bathymetric mapping to depths greater than 4000 m. TOAD optical surveys were not conducted around Swains because of the difficulty of maneuvering vessels close to this extremely steep seamount and limited areas within the depth range limitations of the TOAD optical equipment.

Multibeam mapping surveys show Swains to be a steep, conical emergent seamount/atoll with

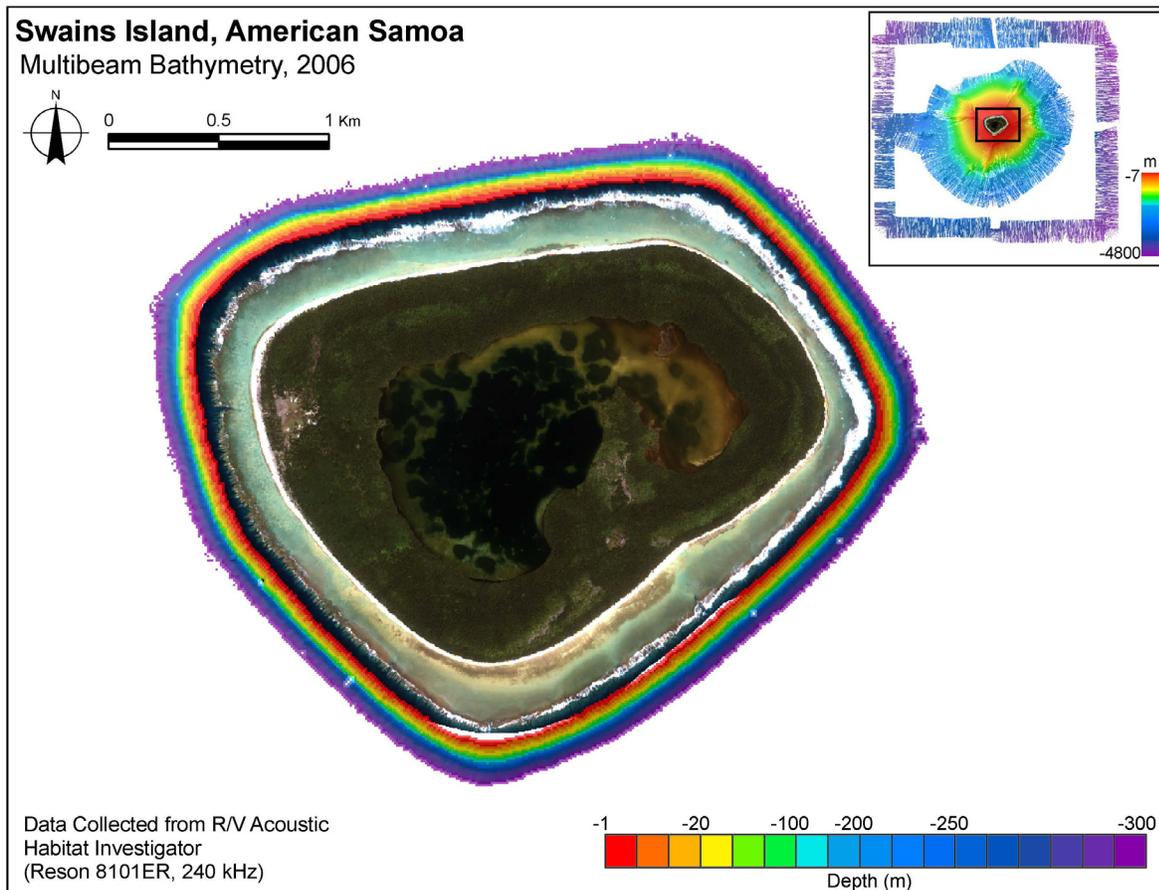


Figure 7.3.1a. Multibeam bathymetry acquisition around Swains was conducted between ~ 10 and ~ 4000 m in March 2006 from the National Oceanic and Atmospheric Administration (NOAA) Ship *Hi`ialakai* and the R/V *Acoustic Habitat Investigator (AHI)*. The island drops steeply on all sides to form an intact, conical volcanic pedestal.

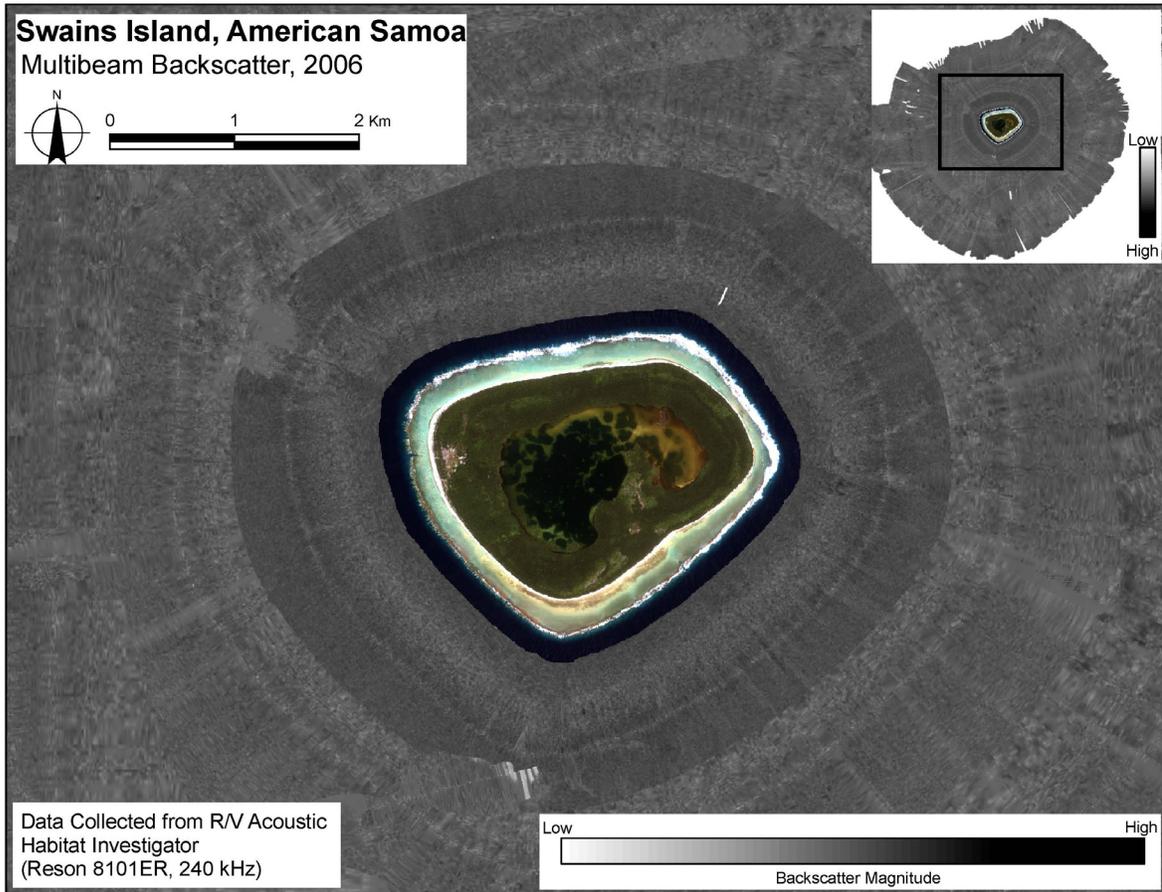


Figure 7.3.1b. Backscatter imagery was acquired in March 2006 during multibeam surveys around Swains from the NOAA Ship *Hi`ialakai* and the R/V *AHI*. Lighter shades represent low-intensity backscatter and likely indicate substrates that are acoustically absorbent and typically indicate unconsolidated sediment. Darker shades represent high-intensity backscatter and likely indicate consolidated hard-bottom and coral substrates.

rift zones that extend from each corner of the reef down to at least 3000 m. The bathymetry immediately adjacent to the exposed reef is very steep and shows no evidence of significant spur-and-groove structures. However spur-and-groove features are evident at some locations on the reef crest and shallow forereef. The sides of the seamount are relatively smooth and exhibit no signs of mass wasting. Based on the bathymetric data collected, it is apparent that reef communities around the island do not benefit from the protections provided by the insular shelves found at other islands in American Samoa.

Backscatter acquisition results from around Swains (Fig. 7.3.1b) showed a high-magnitude return surrounding the entire island. This result suggests that the seafloor surrounding Swains is composed of hard substrate. Towed-diver imagery and diver observations confirm that much of the benthos within the top 30 m of the water column is colonized by coral dominated communities.

7.3.2 Habitat Characterization

Towed-diver benthic survey observations around Swains from ASRAMP 2002, 2004, and 2006 were concatenated into mean spatial distributions (see Chapter 2, Section 2.2.3: Optical Validation Surveys) of the following benthic components: habitat complexity (Fig. 7.3.2a), percent cover of sand (Fig. 7.3.2b), hard substrate/pavement (Fig. 7.3.2c), rubble (Fig. 7.3.2d), and live coral (Fig. 7.3.2e). Since these habitat characterization maps represent different and complementary components of the same habitats, it is useful to analyze them in relation to one another as well as to the local watersheds and exposure to prevailing oceanographic conditions.

Habitat complexity was elevated on all coasts of the island, but appeared highest along the west region, specifically along the southwestern-facing shore of the atoll (Fig. 7.3.2a). Complexity was also elevated in the northeast along the dividing line between the north and east regions.

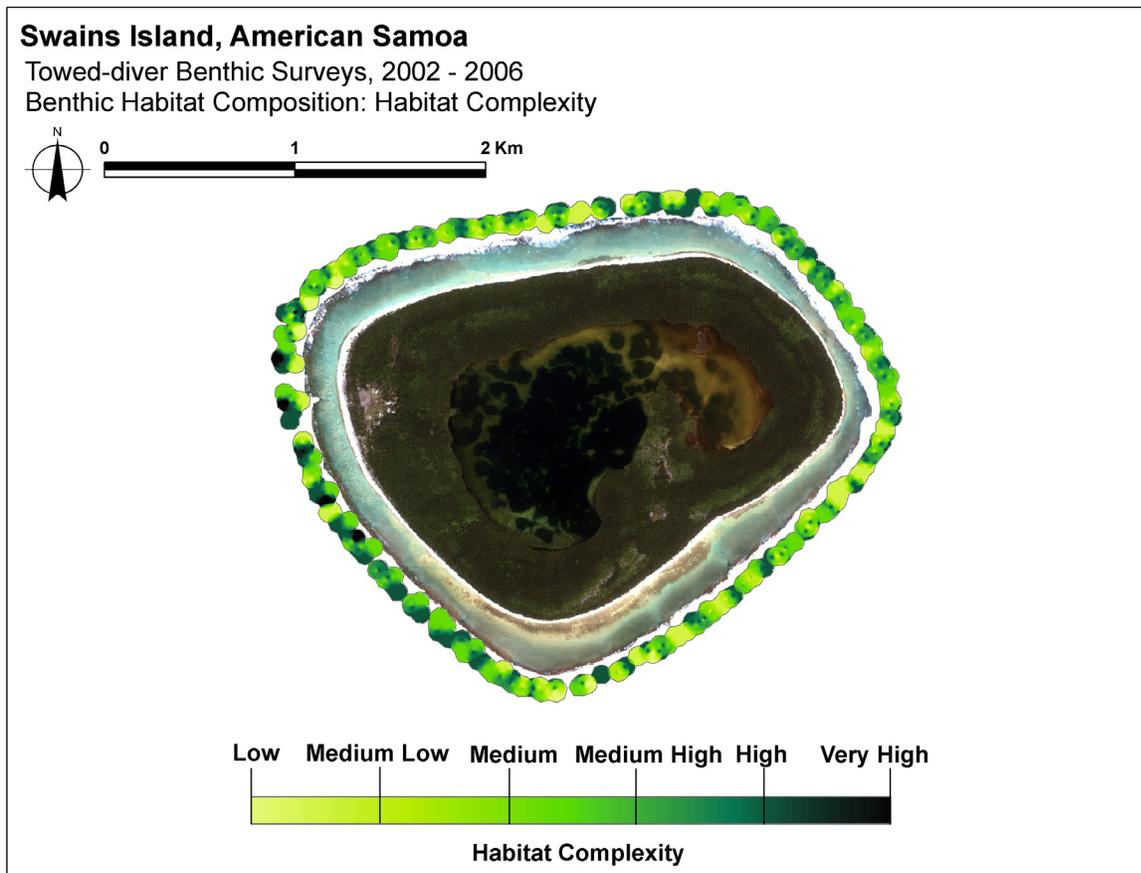


Figure 7.3.2a. Mean benthic habitat complexity concatenated from towed-diver survey observations around Swains during ASRAMP 2002, 2004, and 2006. Habitat complexity was subjectively rated by divers over 5-min ensembles (~ 200 m × 10 m) over a 6-point scale representing low (1), medium-low (2), medium (3), medium-high (4), high (5), and very high (6) topographic complexity. Yellow colors indicate low habitat complexity, and dark green colors indicate high habitat complexity.

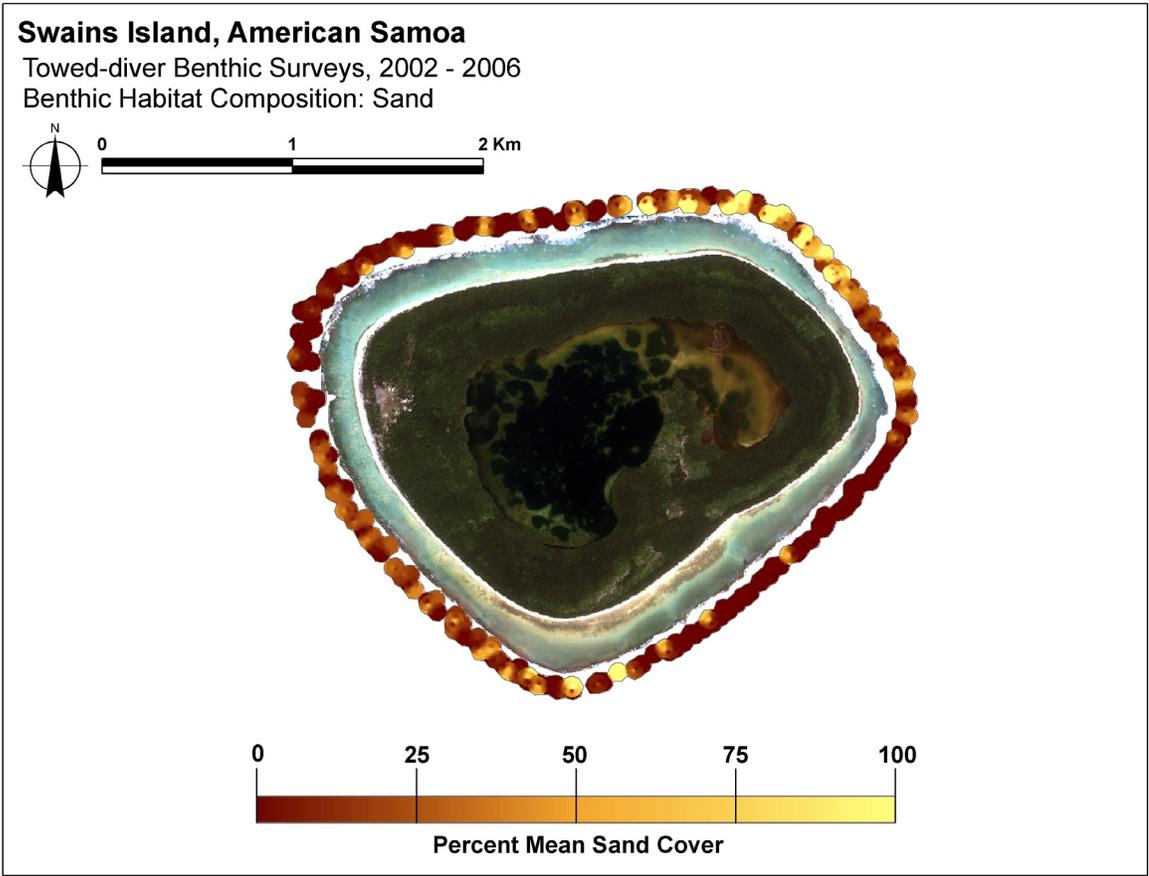


Figure 7.3.2b. Mean percent cover of sand concatenated from towed-diver habitat survey observations around Swains during ASRAMP 2002, 2004, and 2006. Sand composition was subjectively rated by divers over 5-min ensembles (~ 200 m × 10 m) over a 1–100% scale. Light shades indicate high percent cover of sand, and dark shades indicate low percent cover of sand.

True to Swains’ nature as a steep, conical seamount, towed-diver observations indicated low levels of sand, except for small scattered deposits located around the northeast corner of the island (Fig. 7.3.2b), indicative of steep spur-and-groove features along the forereef crest when coupled with moderate-to-high habitat complexity in the same region.

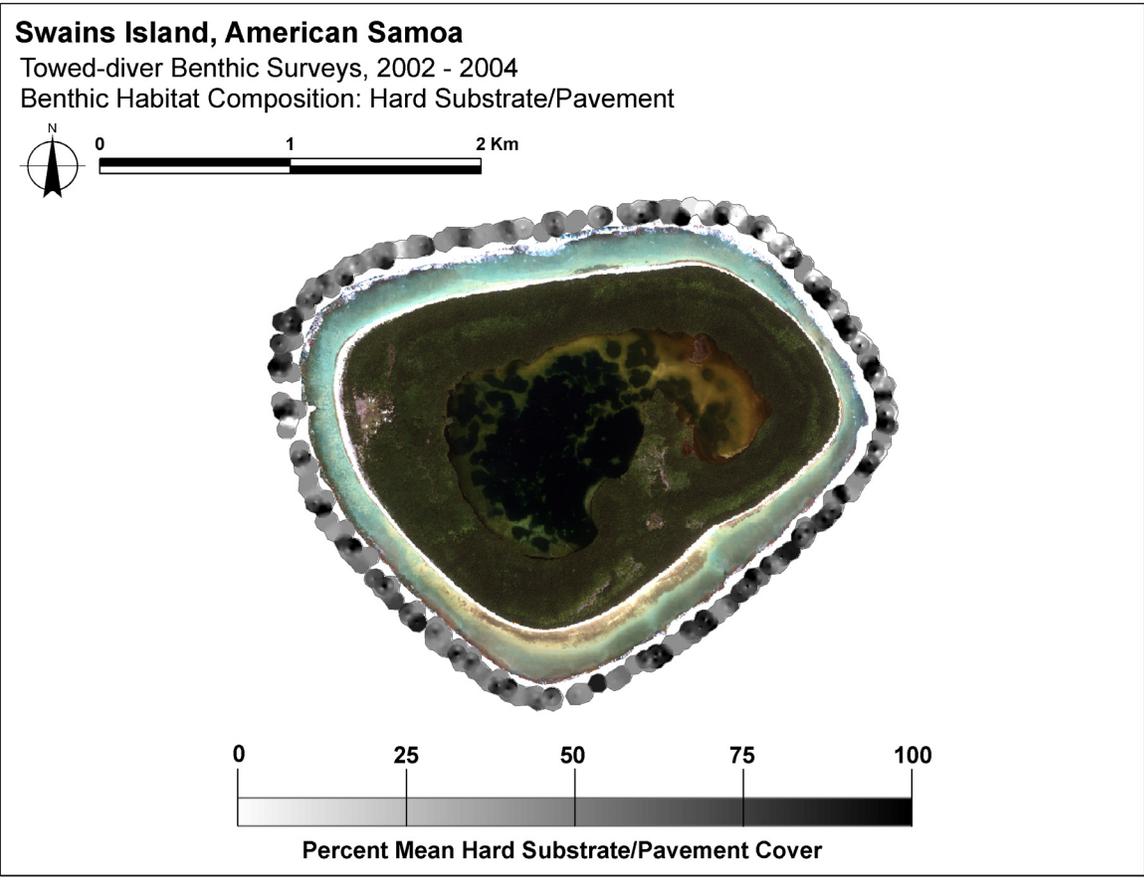


Figure 7.3.2c. Mean percent cover of hard substrate/pavement, concatenated from towed-diver survey observations around Swains during ASRAMP 2002 and 2004. Hard substrate/pavement composition was subjectively rated by divers over 5-min ensembles (~ 200 m × 10 m) on a 1–100% scale. Dark shades indicate high percent cover of hard substrate, and light shades indicate low percent cover of hard substrate.

Hard substrate/pavement composition appeared relatively uniform around the island, with slightly elevated cover along the windward east-facing coastline (Fig. 7.3.2c).

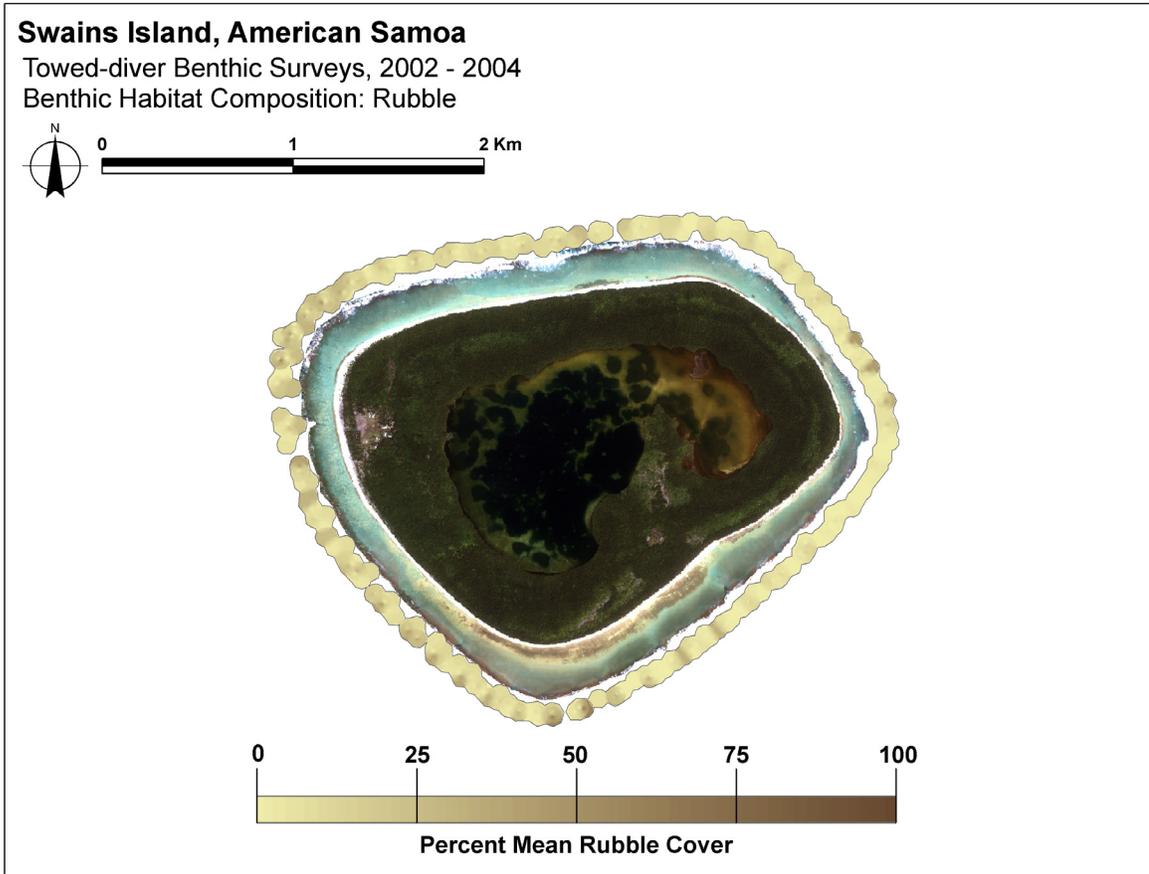


Figure 7.3.2d. Mean percent cover of coral rubble, concatenated from towed-diver survey observations around Swains during ASRAMP 2002 and 2004. Rubble composition was subjectively rated by divers over 5-min ensembles (~ 200 m × 10 m) on a 1–100% scale. Light shades indicate low percent cover of coral rubble, and dark shades indicate high percent cover of coral rubble.

Mean percent cover of coral rubble appeared highest around the northwest corner of the west region (Fig. 7.3.2d), which may have been biased higher than normal by inclusion of extensive coral fracturing and breakage observed during ASRAMP 2004 following the passage of Hurricane Heta. Additional patches of elevated coral rubble were recorded along the east corner and in the southeast region; these areas were widely scattered and localized (Fig. 7.3.2d).

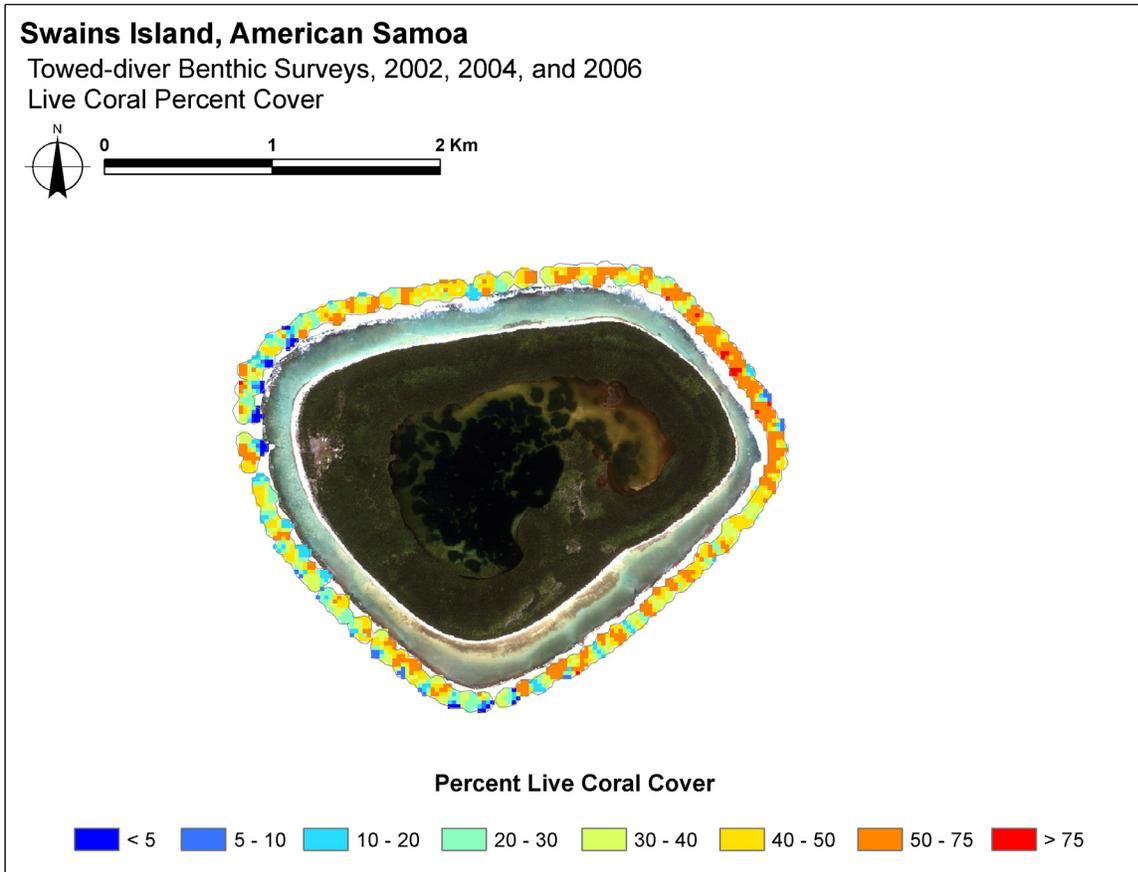


Figure 7.3.2c. Mean percent cover of live scleractinian (stony) coral, concatenated from towed-diver survey observations around Swains during ASRAMP 2002, 2004, and 2006. Live coral cover composition was subjectively rated by divers over 5-min ensembles (~ 200 m × 10 m) on a 1–100% scale. Blue colors indicate low percent cover of coral, and reddish colors indicate high percent cover of coral.

Mean percent cover of live scleractinian (stony) coral was exceptionally and consistently high around Swains compared with the other islands in American Samoa (Fig. 7.3.2e). Coral cover values were highest in the windward east region, with values ranging from 50% to 100%. Coral cover values were likewise high in the north and southeast regions, with values ranging from ~ 40% to ~ 75%. Though some high coral cover values were recorded in the west region, this side and the southwest corner had much more variable coral cover with values ranging from ~ 5% to ~ 75%. This formed an apparent gradient with the highest cover on the northeast, ranging down to the lowest cover on the southwest. Still, less cover was found on the corners of the island bracketing the southwestern side (Fig. 7.3.2e).

7.4 Oceanography and Water Quality

Oceanographic and water quality observations were collected in the waters surrounding Swains between 2002 and 2006. Instrumentation and equipment descriptions and locations, and a subset of results are discussed below. Specific details of deployments and additional data are presented in Appendix II, Table II. ii.

7.4.1 Hydrographic Data

2002 Spatial Surveys

During ASRAMP 2002, 19 shallow-water CTD casts were conducted between February 9 and 10 in nearshore waters around Swains and within the lagoon (Fig. 7.4.1a).

Data from these vertical profiles around the outside of the island show little variability in temperature, salinity, or density (Fig. 7.4.1b). The north side of the island in the north and east regions (A–C), and the eastern portion of the southeast region were marginally cooler (29.46° – 29.52° C) than the southern side of the island (29.54° – 29.56° C). However, salinity and density showed little vertical structure (well-mixed) or horizontal variability, with the exception of a single CTD at the northwest point where a low salinity tongue was observed throughout the water column. The reason for the lower salinity water is not clear, but the weak gradient of lowest salinity water near the bottom suggests the possibility of a subsurface

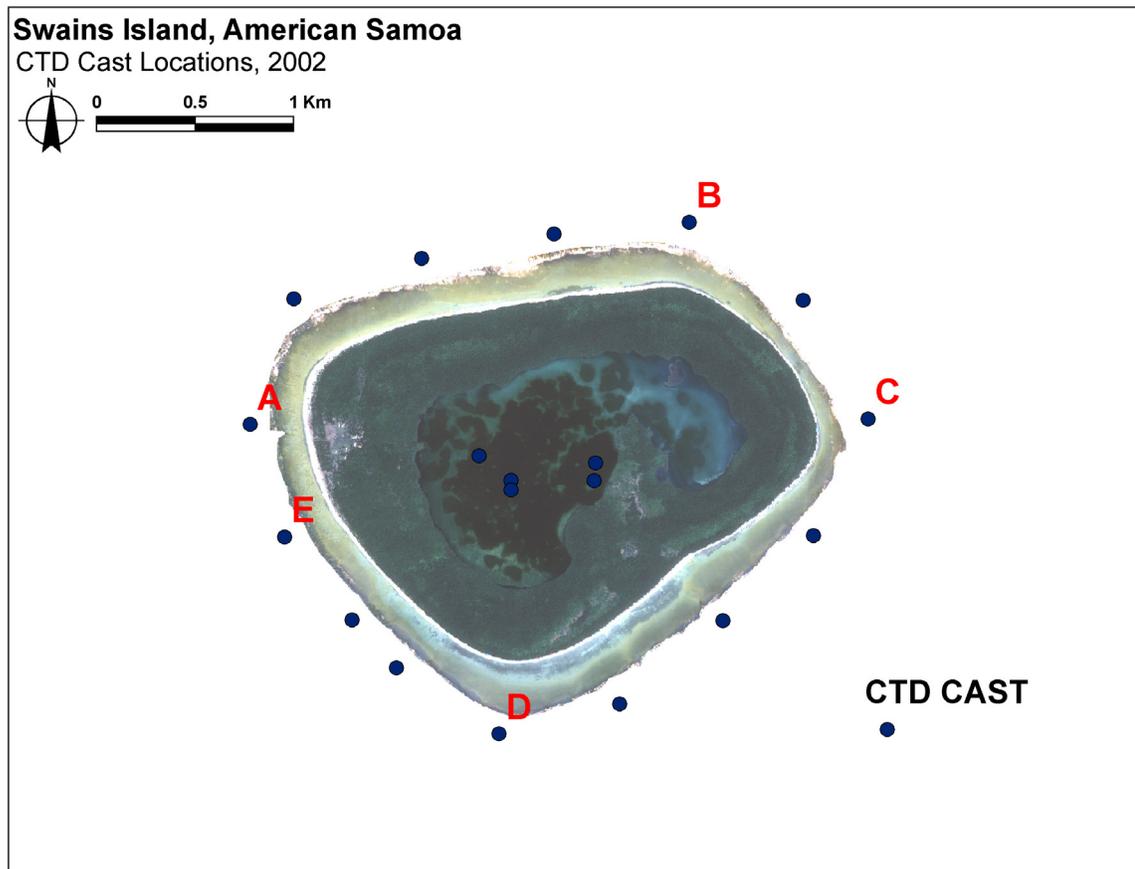


Figure 7.4.1a. Shallow-water CTD cast locations, shown as blue dots, expressed sequentially in a clockwise direction around Swains (A–E) during ASRAMP 2002, February 19–20.

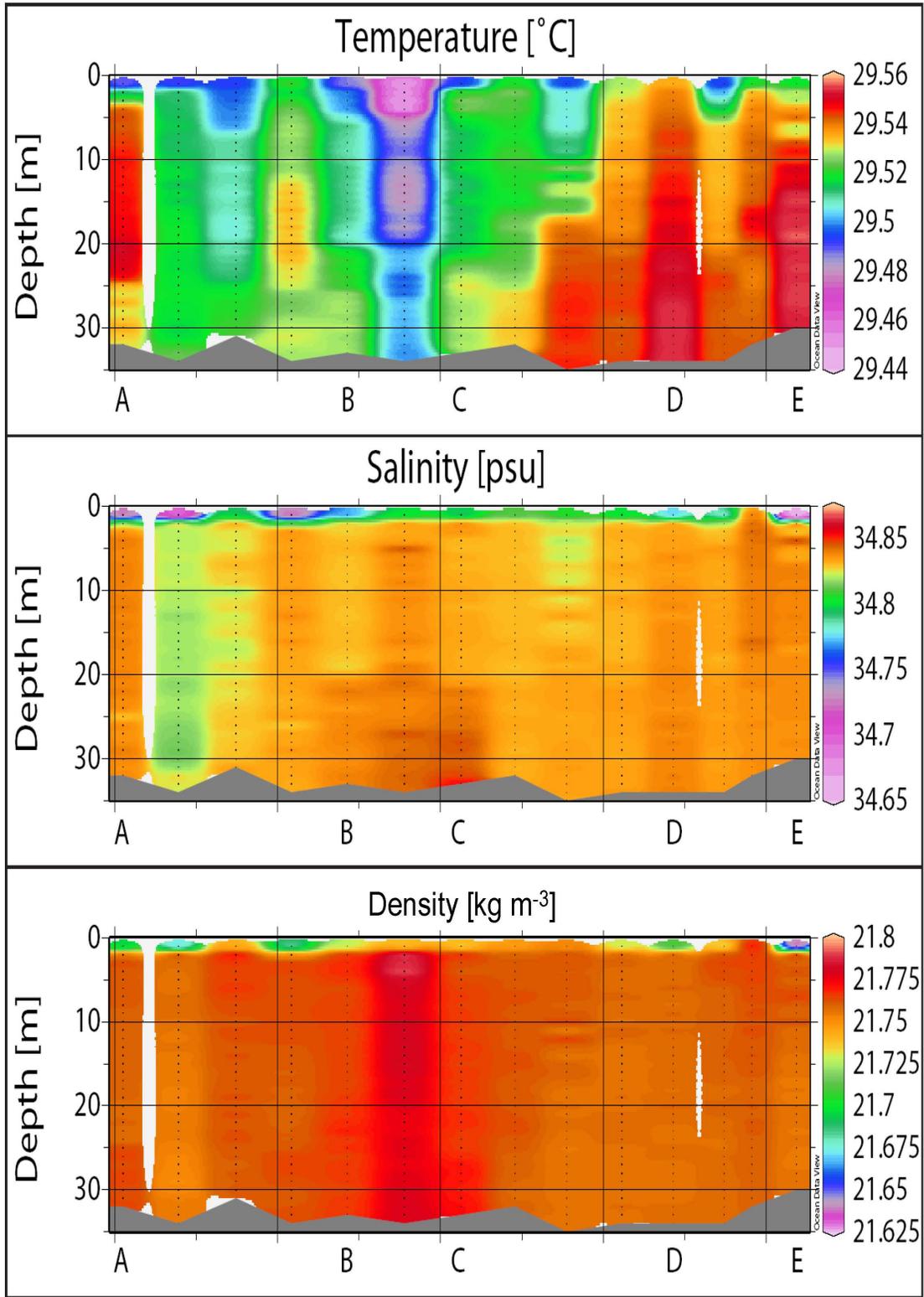


Figure 7.4.1b. Shallow-water CTD cast profiles to a 30-m depth around Swains during ASRAMP 2002, February 19–20, including temperature (°C), salinity (psu), and density (kg m⁻³). Profiles are shown sequentially in a clockwise direction around the island (A–E), as shown in Figure 7.4.1a.

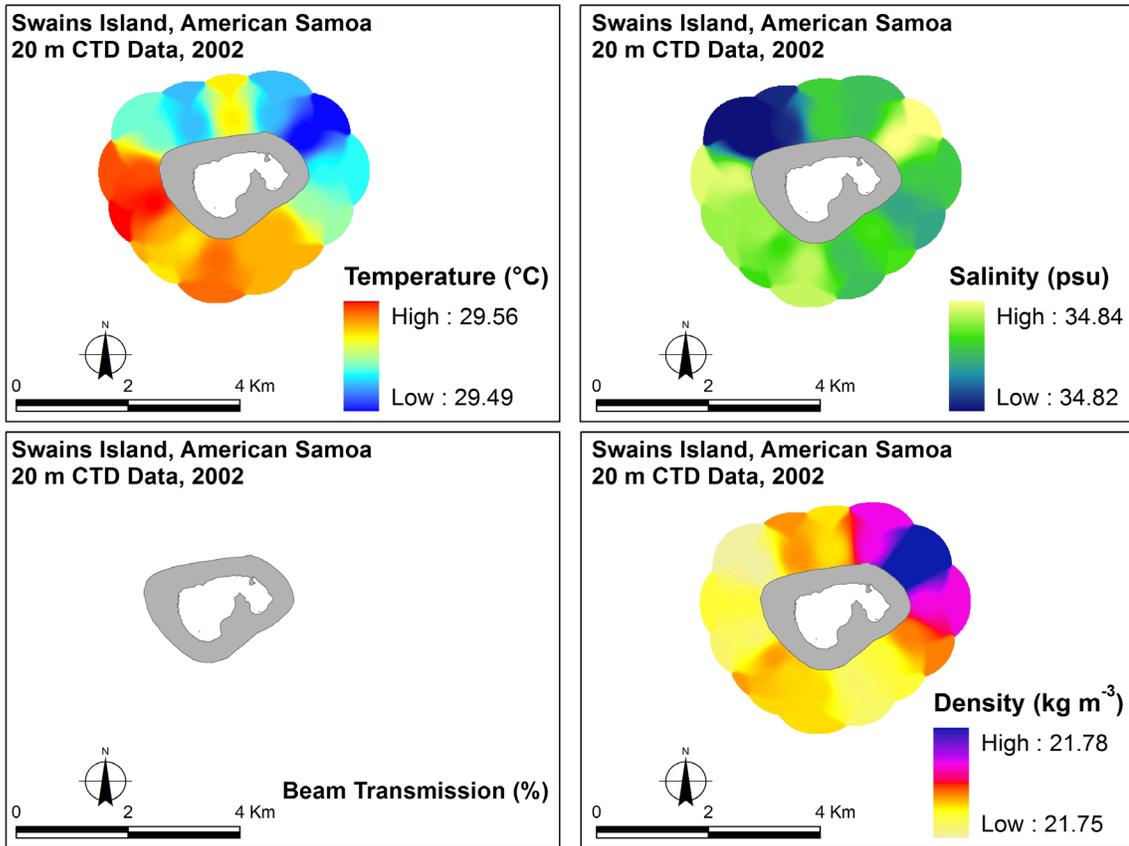


Figure 7.4.1c. Interpolated water temperature (top left), salinity (top right), and density (bottom right) at a 20-m depth derived from shallow-water CTD casts around Swains during ASRAMP 2002, February 19–20. Beam transmission data were not collected (bottom left).

freshwater spring at the northwest corner.

Analysis of the following physical water properties at a 20-m depth during this survey period (Fig. 7.4.1c) shows relatively little spatial variance or range in measured values: temperature (29.49°–29.56°C), salinity (34.82–34.84 psu), and density (21.75–21.78 kg m⁻³). Though gradients were small, general weak patterns were apparent. Waters at 20-m depths were warmer in the west and south regions and cooler in the north and northeast, where one CTD cast at the northeast corner recorded noticeably cooler temperature. The salinity minimum described at the northwest corner is strikingly apparent at the 20-m depth. The area to the northeast corner with cool water was also observed to have high salinity, resulting in a localized area of high density.

2004 Spatial Surveys

During ASRAMP 2004, 29 equally spaced shallow-water CTD casts were conducted in nearshore waters around Swains between February 15 and 18 (Fig. 7.4.1d). Data from these vertical profiles around the outside of the atoll showed limited variability in temperature, salinity, and density (Fig. 7.4.1e). Surface waters (0–5 m) in the north and east regions (A–C) and the eastern portion of the southeast region of the atoll were warmer by 0.2°–0.3°C than those on the south and west coast (C–E). The most significant feature observed was a lower temperature (29.7°C), higher salinity (34.8 psu), and higher density (21.55 kg m⁻³) body of bottom water (> 20 m) around the east side of the island (B–C). The west side of the island had a region of low salinity (34.6 psu) and transmittance (93.5%), with some evidence of stratification toward the south and west sides (D–E). Beam transmission levels were only slightly variable with the highest along the southeast shore (> 94%) and lowest along the west shore (~ 93%).

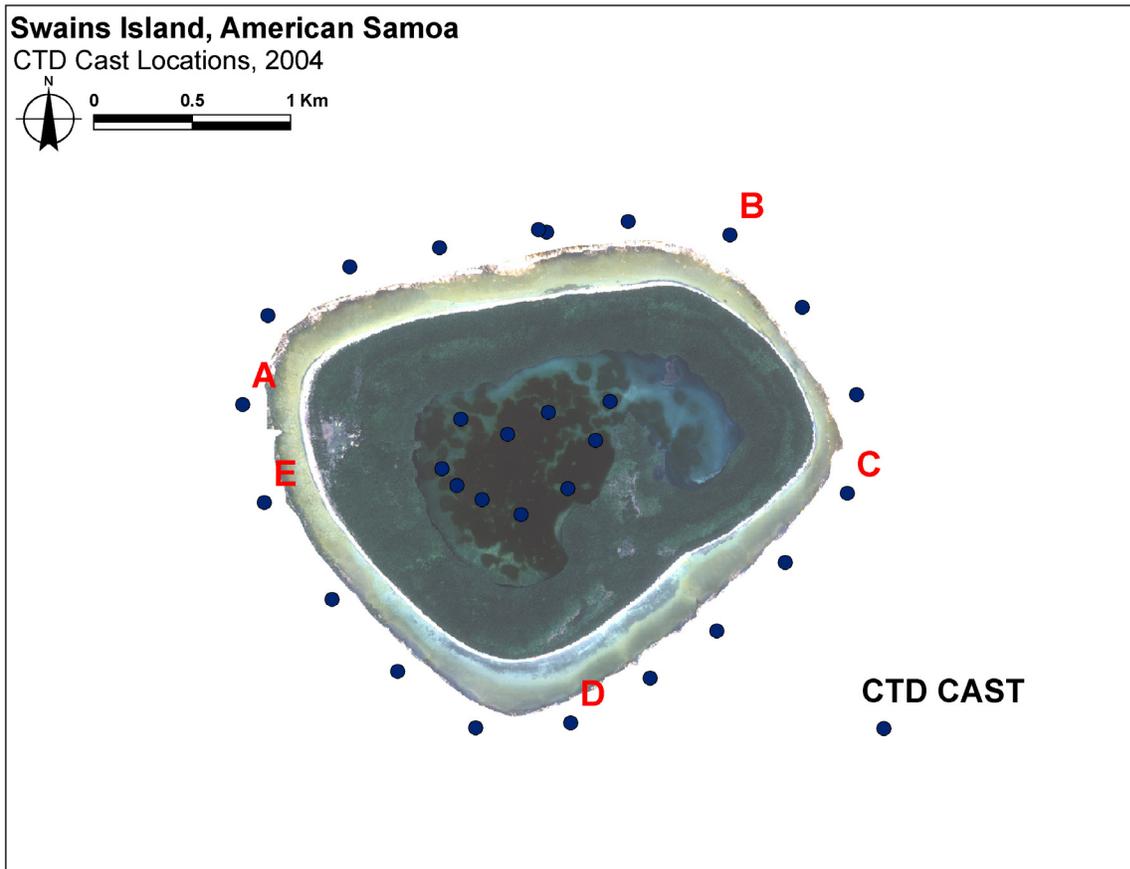


Figure 7.4.1d. Shallow-water CTD cast locations, shown as blue dots, expressed sequentially in a clockwise direction around Swains (A–E) during ASRAMP 2004, February 15–18. Notice 10 additional CTD locations within the brackish lake of the island.

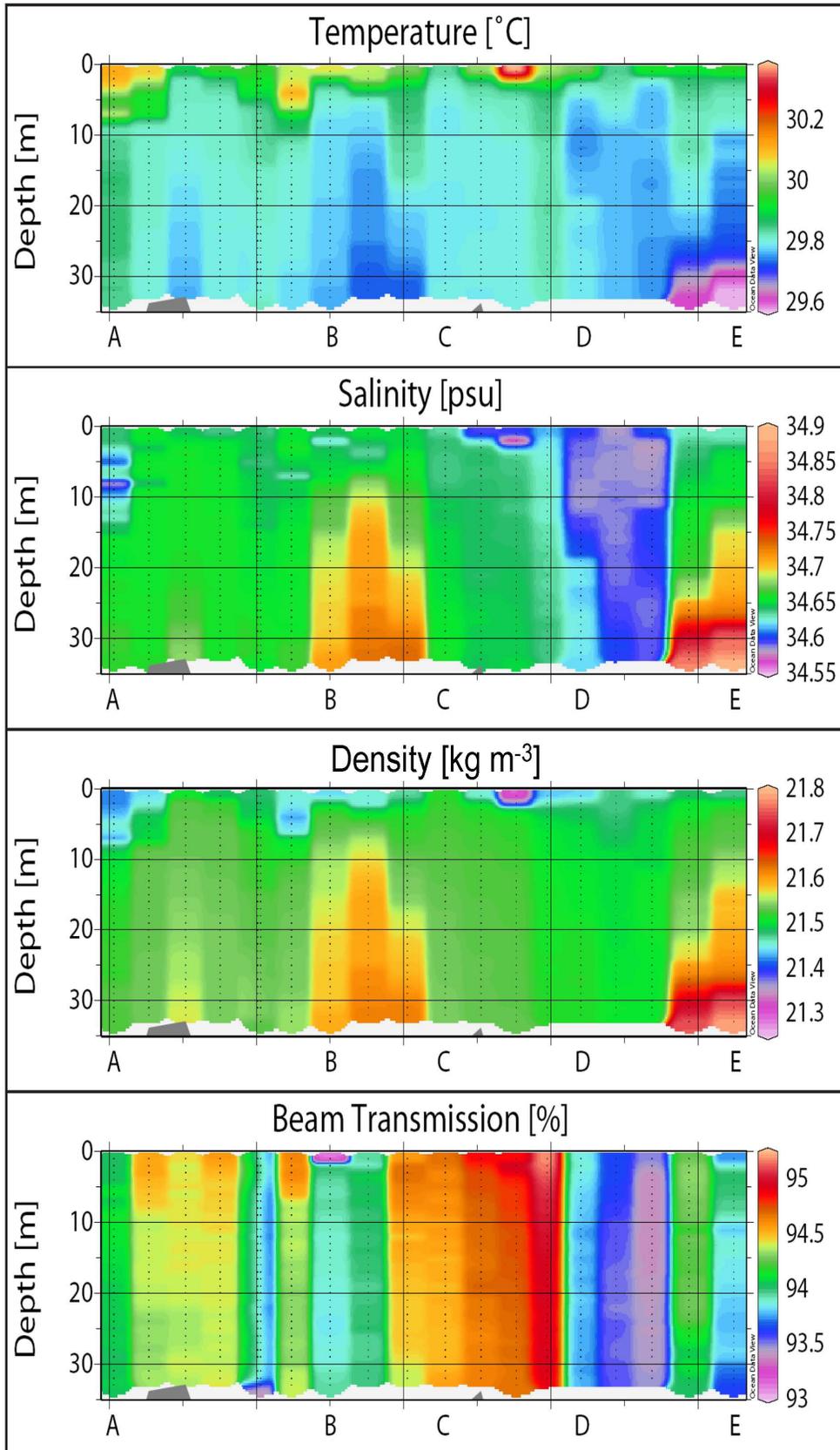


Figure 7.4.1e. Shallow-water CTD cast profiles to a 30-m depth around Swains during ASRAMP 2004, February 15–18, including temperature ($^{\circ}\text{C}$), salinity (psu), density (kg m^{-3}), and beam transmission (%). Profiles are shown sequentially in a clockwise direction around the island (A–E), as shown in Figure 7.4.1d.

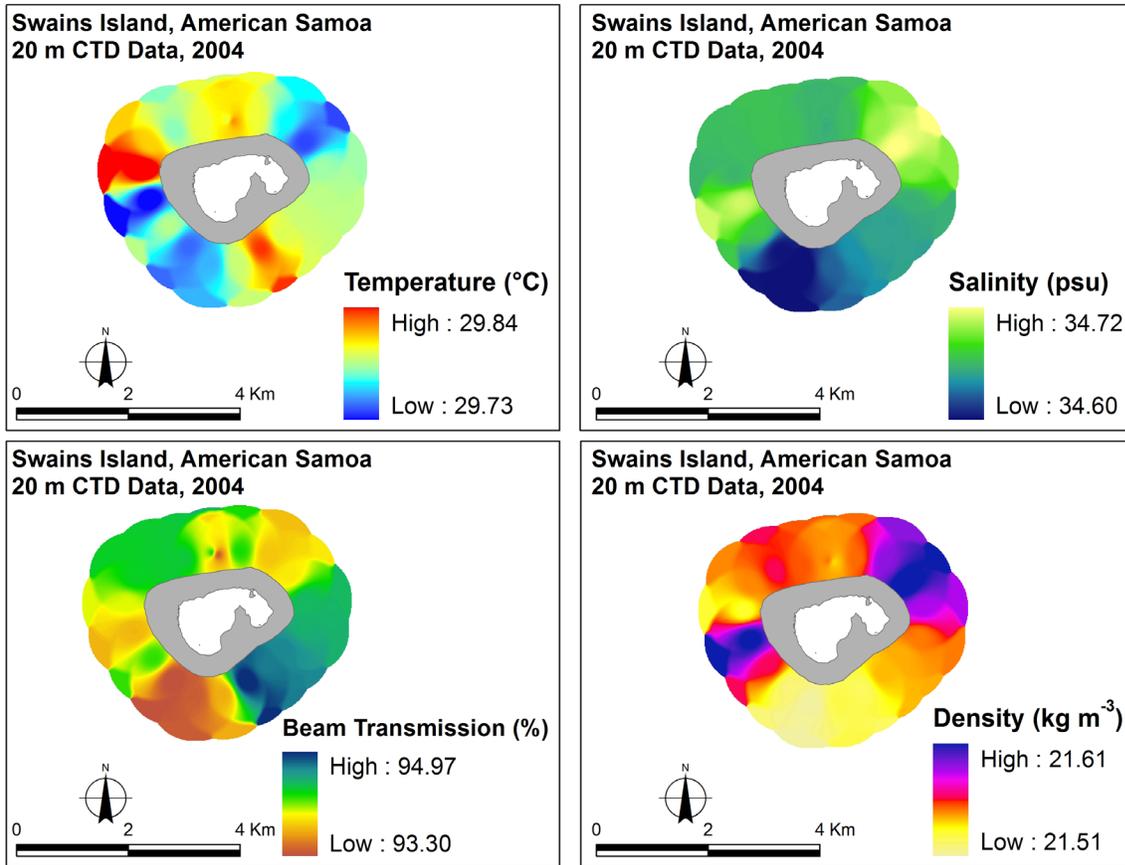


Figure 7.4.1f. Interpolated water temperature (top left), salinity (top right), beam transmission (bottom left) and density (bottom right) at a 20-m depth derived from shallow-water CTD casts around Swains during ASRAMP 2004, February 15–18.

Spatial patterns of physical water properties at 20-m depths around Swains during ASRAMP 2004 were observed, though differences were typically small (Fig. 7.4.1f). Ranges of key properties varied as follows: temperature (29.73°–29.84°C), salinity (34.60–34.72 psu), beam transmission (93.30–94.97%), and computed density (21.51–21.61 kg m⁻³). Alternating from relatively warm to cool to warm, the small temperature differences did not reveal any specific spatial pattern. For salinity, the most striking feature was an area of low salinity (34.6 psu) around the south point between the west and southeast regions. This area was also characterized by low beam transmission (high turbidity), which suggests possible weak seepage of lagoon waters into the nearshore environment.

2006 Spatial Surveys

During ASRAMP 2006, 27 CTD casts were conducted in nearshore waters around Swains between February 12 and 13 (Fig. 7.4.1g). Water samples were collected for nutrient analysis at 1-, 10-, 20-, and 30-m depths, where possible, at 11 of these shallow CTD sites. Dissolved inorganic carbon (DIC) samples were also collected at these locations.

Shallow-water CTD profiles from ASRAMP 2006 showed primarily well-mixed waters with little spatial variability in temperature, salinity or density around Swains (Fig. 7.4.1h). Temperatures on the east and southeast (B–D) regions were marginally higher than the north (A–B) and west (D–A) sides and were uniform with depth. Salinity, density and beam transmittance showed very little spatial or vertical variability around the island. The lagoon at Swains appeared to have little effect on the physical properties of the ocean outside the perimeter in 2006. This is caused by the lack of outflow from the inner lagoon to the ocean and to the low-lying geography, little vegetation, and no anthropogenic sources to affect rainfall runoff.

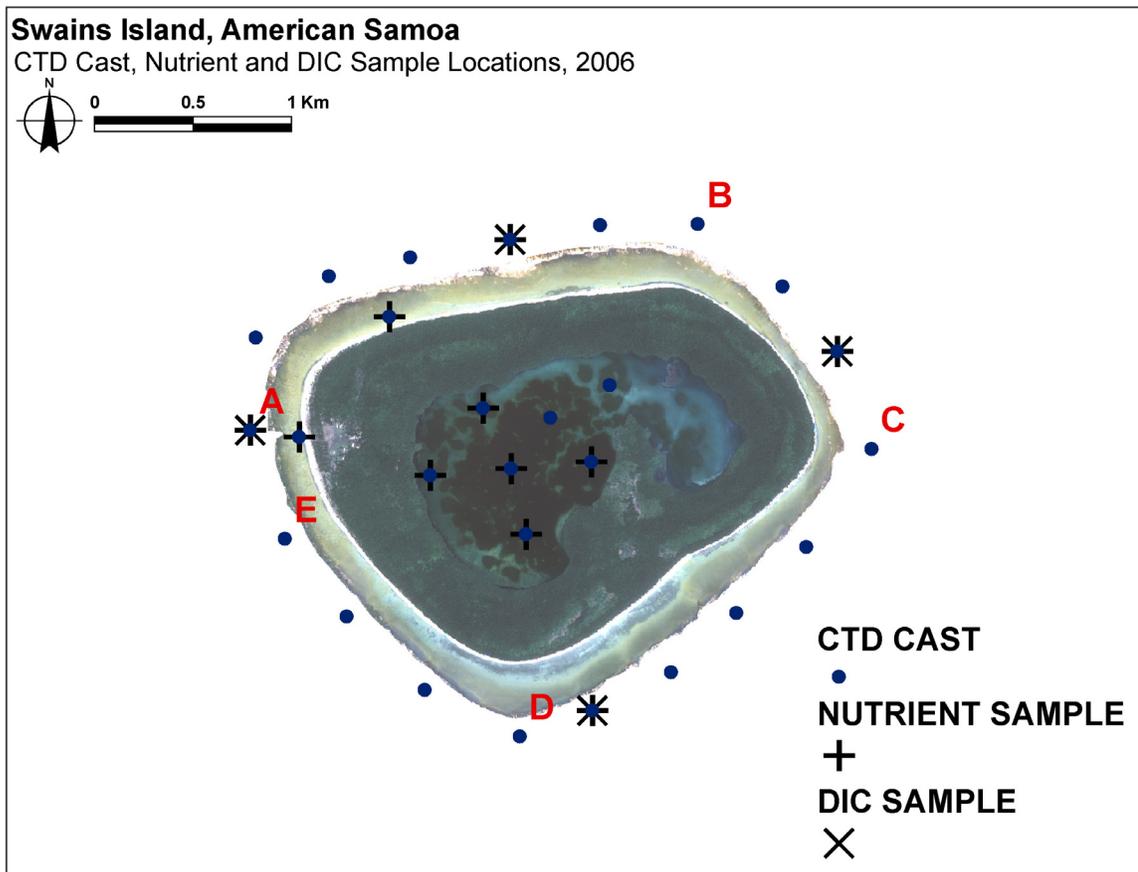


Figure 7.4.1g. Shallow-water CTD cast, nutrient and DIC water sample locations around Swains (A–E) during ASRAMP 2006, February 12–13.

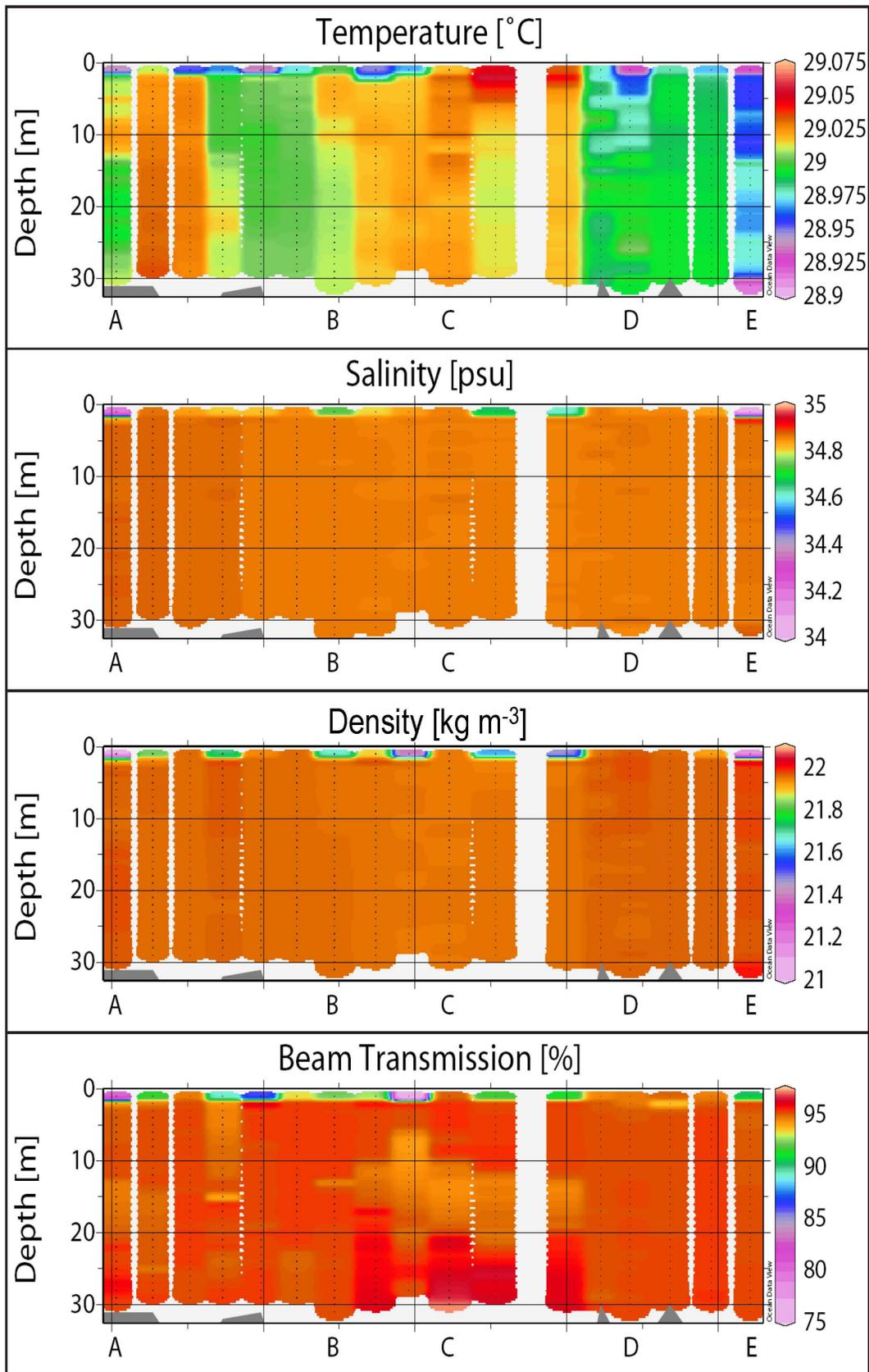


Figure 7.4.1h. Shallow-water CTD cast profiles to a 30-m depth around Swains during ASRAMP 2006, February 12–13, including temperature ($^{\circ}\text{C}$), salinity (psu), density (kg m^{-3}), and beam transmission (%). Profiles are shown sequentially in a clockwise direction around the island (A–E), as shown in Figure 7.4.1g.

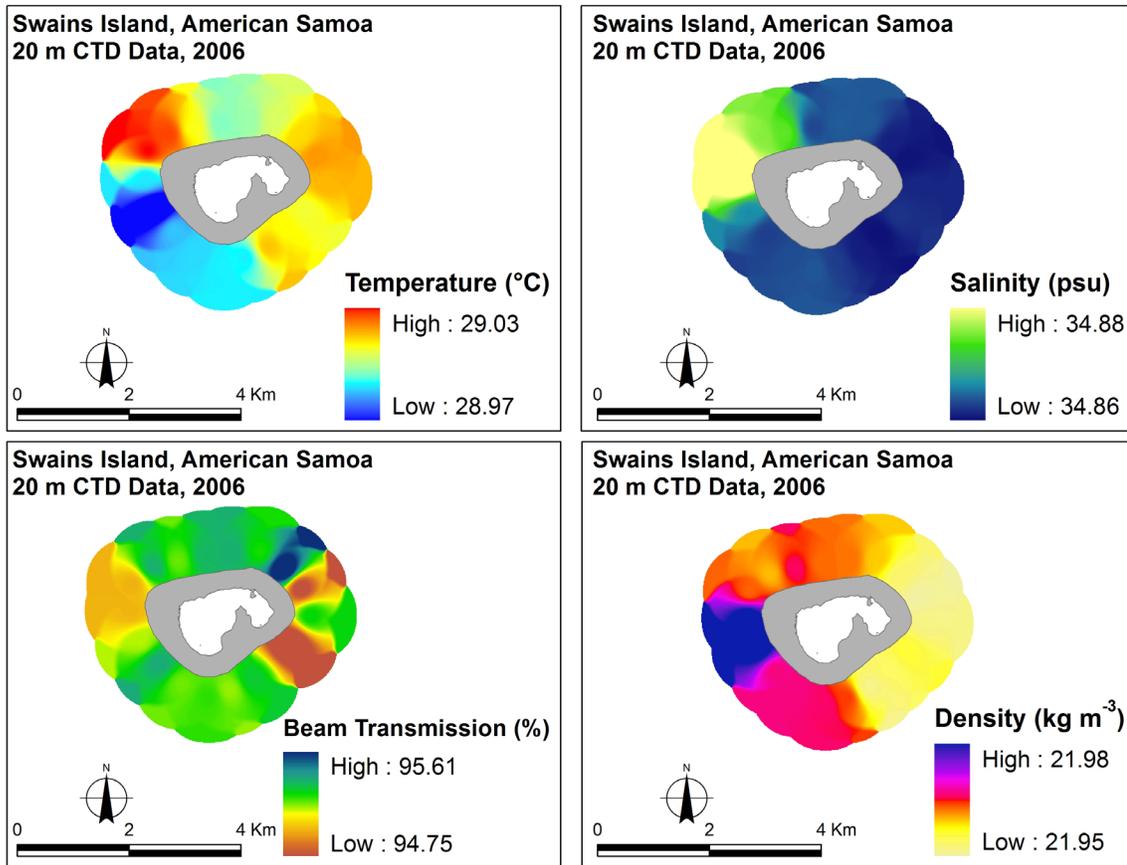


Figure 7.4.1i. Interpolated water temperature (top left), salinity (top right), beam transmission (bottom left), and density (bottom right) at a 20-m depth derived from shallow-water CTD casts around Swains during ASRAMP 2006, February 12–13.

Physical water properties at a 20-m depth around Swains showed limited, but noticeable, less discernable spatial patterns in the vertical sections (Fig. 7.4.1i). The actual spatial differences and ranges of the following properties around the island were small: temperature (28.97°–29.03°C), salinity (34.86–34.88 psu), beam transmission (94.75–95.61%), and density (21.95–21.98 kg m⁻³). The northwest corner of the island was observed to have a weak signal of increased temperature, salinity and density, and decreased beam transmission, possibly related to water discharge through the reef channel from the shallow reef flat surrounding the island.

Several spatial patterns of observed water quality properties at 20-m depths existed around Swains during ASRAMP 2006. Water quality analyses of the in situ samples collected at 20 m display the following ranges (Fig. 7.4.1j): chlorophyll-a, only 1 sample at 0.36 µg L⁻¹; phosphate (PO₄), 0.14–0.16 µM; silicate (SiO₂), 0.95–1.24 µM; and total nitrogen (N_{tot} = NO₃ + NO₂), 0.07–0.19 µM. Although the actual ranges in values were small, Swains exhibited higher PO₄ concentrations than the other islands in the archipelago, with the highest values falling on the east and west sides of the island. The measured nitrogen components also showed the greatest values from the sites sampled on the east and west sides of the island. Silicate, conversely, showed the greatest concentration on the south side of the island.

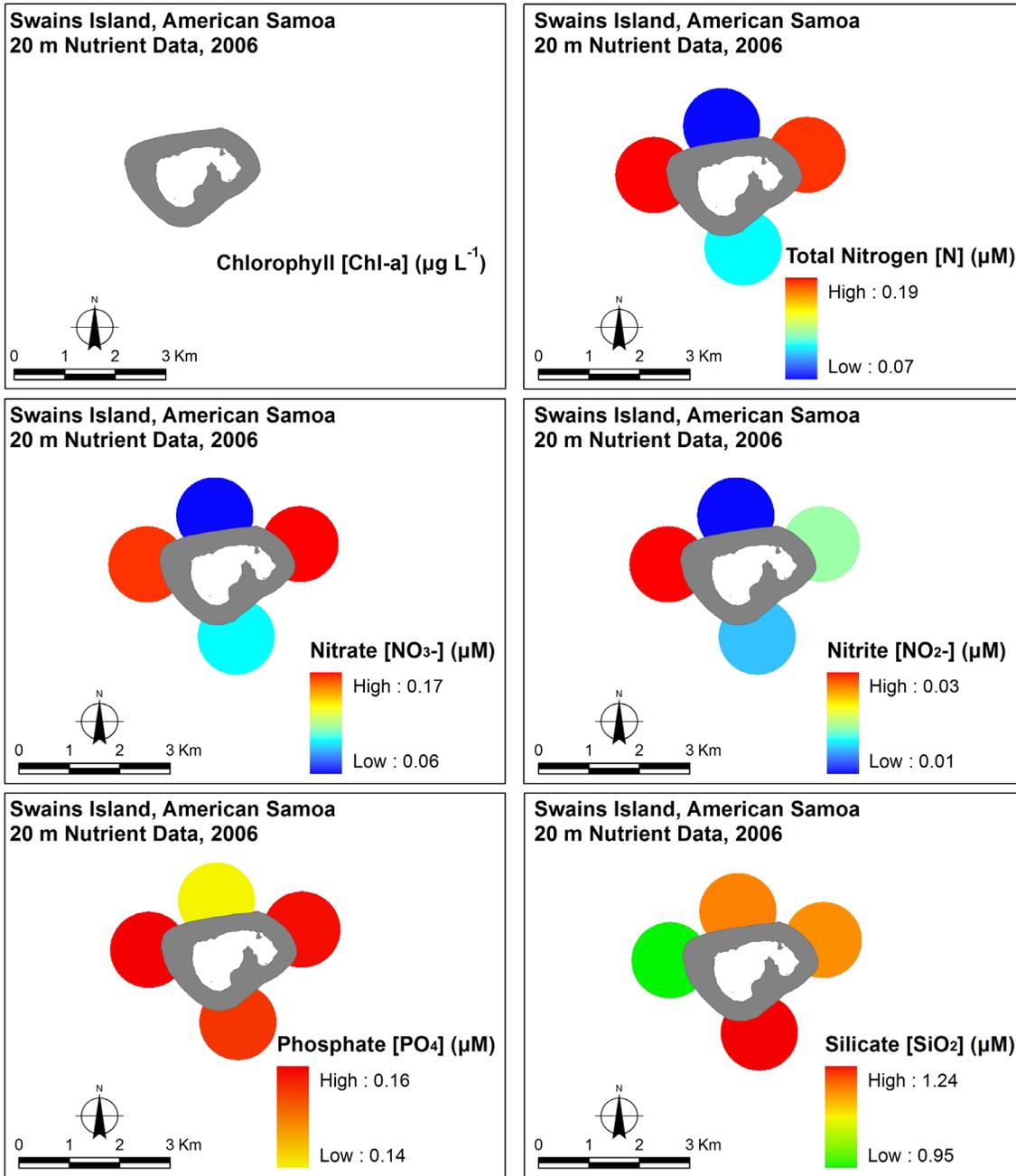


Figure 7.4.1j. Interpolated total nitrogen (top right), nitrate (middle left), nitrite (middle right), phosphate (bottom left) and silicate (bottom right) concentrations, at a 20-m depth derived from water samples collected in concert with shallow-water CTD casts around Swains during ASRAMP 2006, February 12–13. Chlorophyll-a interpolation is not included in this figure because there was only one data point for this parameter.

7.4.2 Temporal Comparison—Hydrographic Data

In each of the hydrographic survey periods of Swains, water properties and nutrient concentrations exhibited little spatial variability around the island. This is not a surprising result given the small size of the island; most small-scale processes, and certainly all large-scale oceanographic processes, would influence waters on all sides of the island. These results will act as a baseline from which to compare future oceanographic and water quality datasets.

7.4.3 Time Series Observations

A limited suite of moored instruments were deployed around Swains over the period between 2002 and 2006 to collect time series observations of key oceanographic properties influencing reef conditions (Fig. 7.4.3a). Deployment and retrieval dates are detailed in Appendix II, Table II. iv. Figure 7.4.3b shows a time series of in situ and remotely sensed sea surface temperature (SST) and modeled wave properties from January 2002 to April 2006.

Pathfinder SST and in situ temperature observations around Swains show strong seasonal variation with warmest temperatures ($\sim 30.5^{\circ}\text{C}$) observed during January–March and coolest temperatures ($\sim 28.5^{\circ}\text{C}$) in June–August (Fig. 7.4.3b, top panel). Pathfinder-derived SST and in situ temperature data showed similar variability; however, in situ observations were warmer (0° – 2.0°C) than those measured via satellite, particularly during austral winters. This trend is also consistent when comparing Pathfinder climatology with in situ observations.

One STR was deployed at Swains from 2004 to 2006 (Fig. 7.4.3a). The STR sensor showed 2° – 3°C temperature fluctuations caused by seasonal variability in addition to minimal ($< 1^{\circ}\text{C}$) diurnal temperature fluctuations during this time (Fig. 7.4.3c).

Modeled significant wave-height data for Swains revealed weak seasonal variability superimposed with episodic, cyclone-derived extreme wave events. Larger wave heights (~ 3 – 4 m) typically occurred during winter months compared to smaller wave heights (~ 2 m)

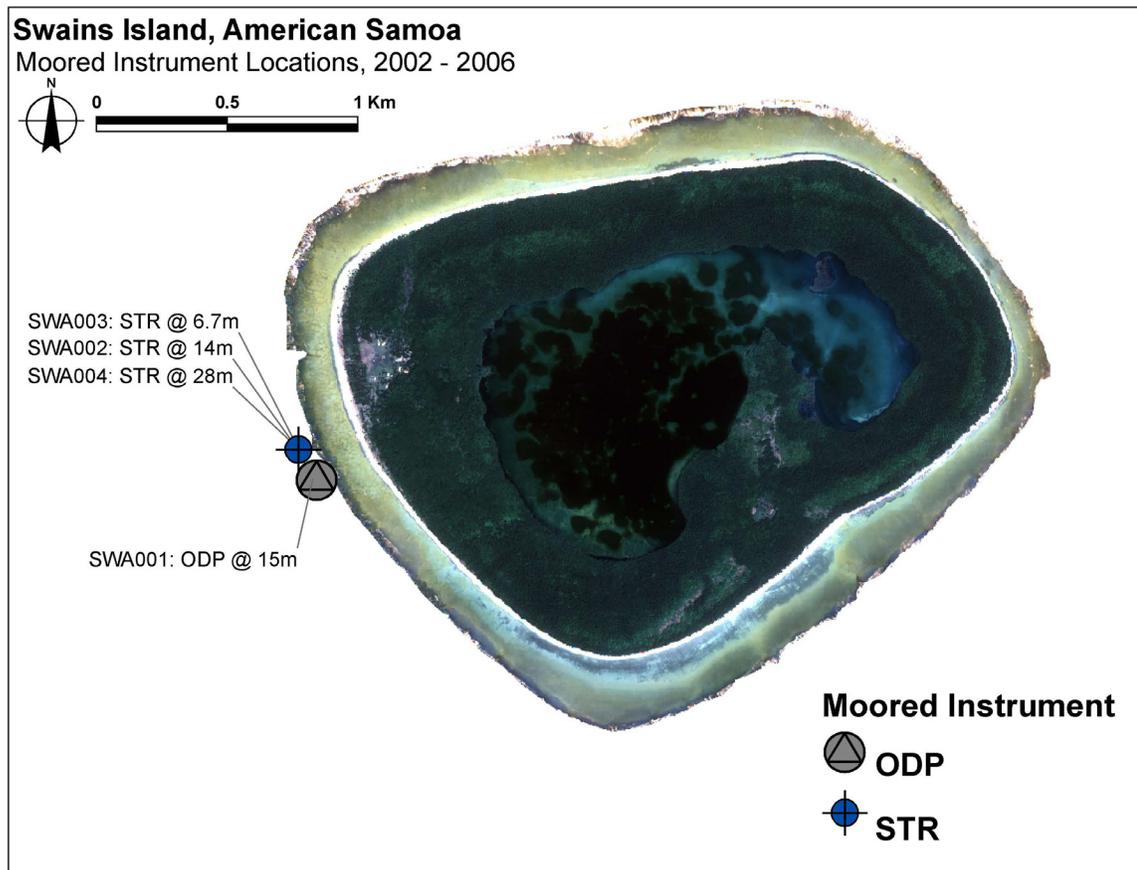


Figure 7.4.3a. Locations and types of oceanographic instrument moorings deployed around Swains between 2002 and 2006. Moored instrument types include ODP and STR.

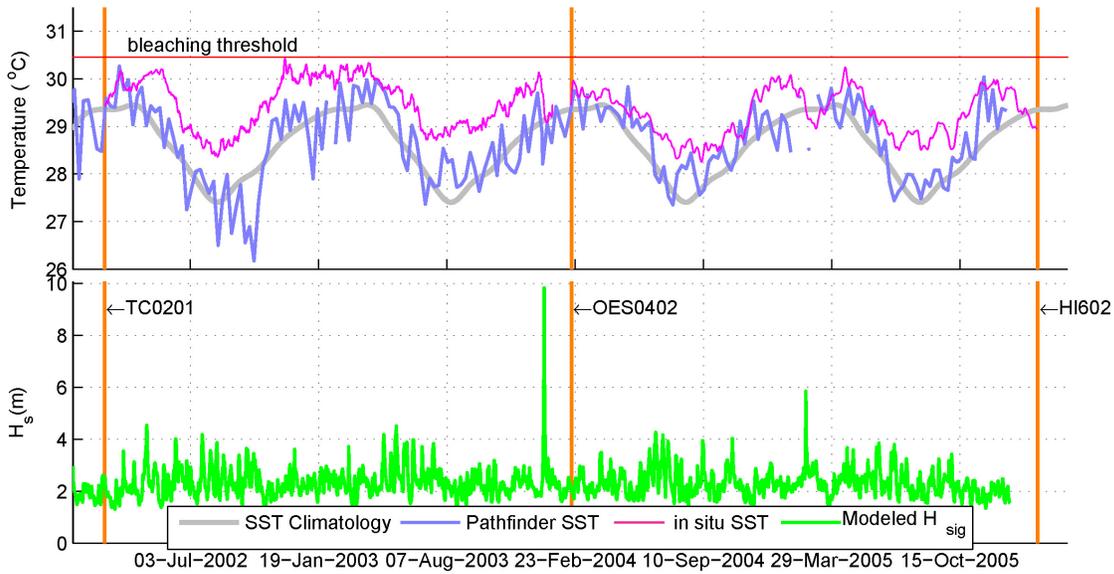


Figure 7.4.3b. SST and wave height time series around Swains between January 2002 and April 2006. Remotely sensed data (SST climatology and weekly Pathfinder-derived SST) and modeled significant wave-height data derived from Wave Watch III are overlaid with CRED in situ temperature observations from an ODP deployed at a 15-m depth at site SWA001, and an STR deployed at a 14-m depth at site SWA002 (locations shown in Fig. 7.4.3a). The horizontal red and vertical orange bars represent the bleaching threshold and the ASRAMP research cruise dates, respectively.

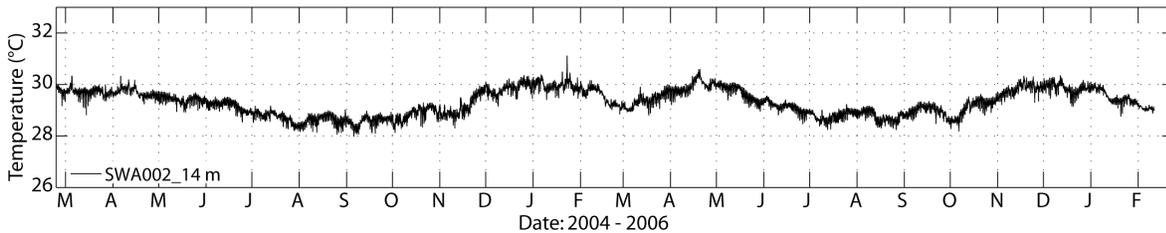


Figure 7.4.3c. Time series observations of temperature from March 2004 to February 2006 collected from an STR deployed at SWA002 at a 14-m depth at Swains. See Figure 7.4.3a for mooring locations.

during the summer months. Two extreme swell events were observed during the time series record. The first, in January 2004, was produced by Cyclone Heta and the second in February 2005 was produced by Cyclones Olaf and Percy (Fig. 7.4.3b, bottom panel).

7.5 Coral and Coral Disease

7.5.1 Coral Surveys

2002 Spatial Surveys

Nine towed-diver benthic surveys, with a mean depth of 10.3 m, were conducted around Swains during ASRAMP 2002. Individual towed-diver survey track depths ranged from 6 m (SD 2) to 23 m (SD 2; Fig. 7.5.1a). High live scleractinian (stony) coral cover characterized the benthic community surrounding Swains, with an island-wide mean of 60.0% (SE 4.6) live scleractinian (stony) coral cover (Fig. 7.5.1b). Dead coral percent cover observations were recorded as an independent component of the benthic community, with an island-wide mean of 4.0% (SE 0.8; Fig. 7.5.1c).

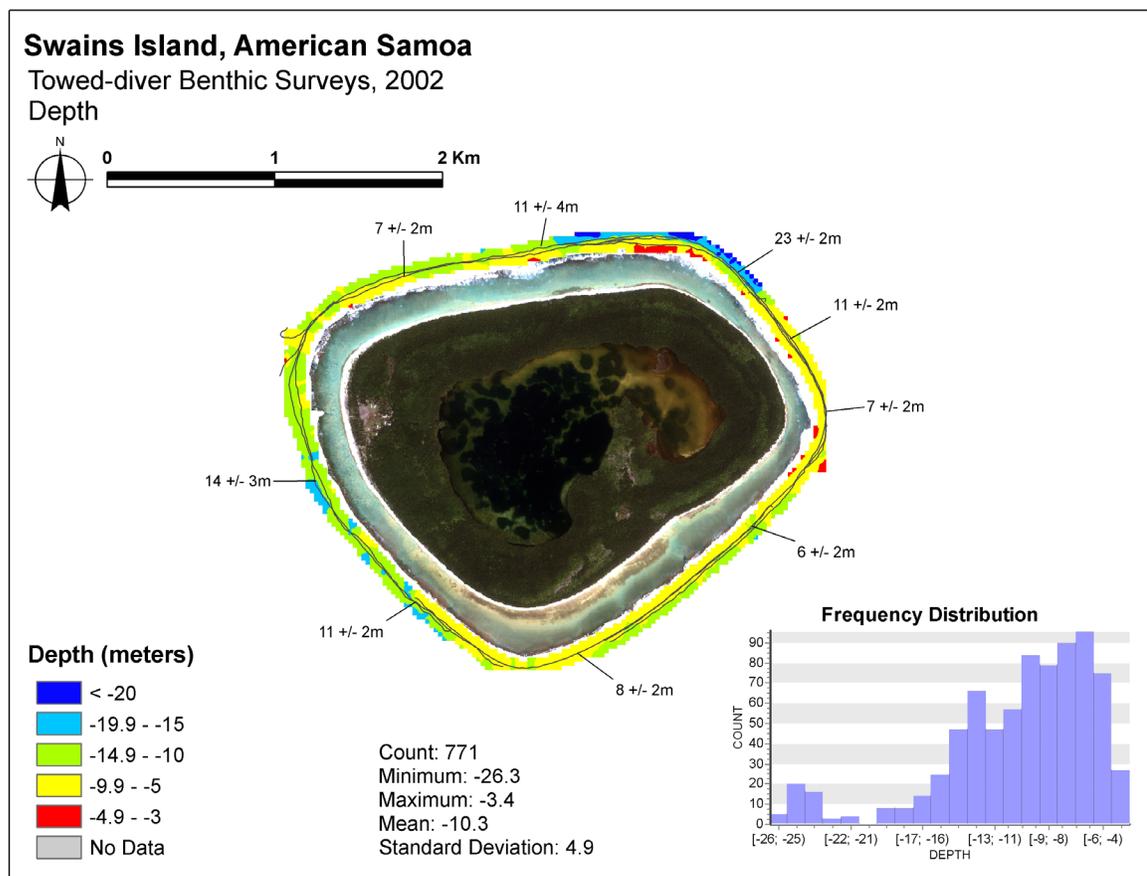


Figure 7.5.1a. Towed-diver survey tracks around Swains during ASRAMP 2002. Towed-diver survey tracks are color coded with mean depths for each 5-min segment. Mean depths and standard deviations for each towed-diver survey are shown in black text. Depth histogram and statistics (counts, minimum depth, maximum depth, mean, and standard deviation) from 30-sec depth recordings during towed-diver surveys are included.

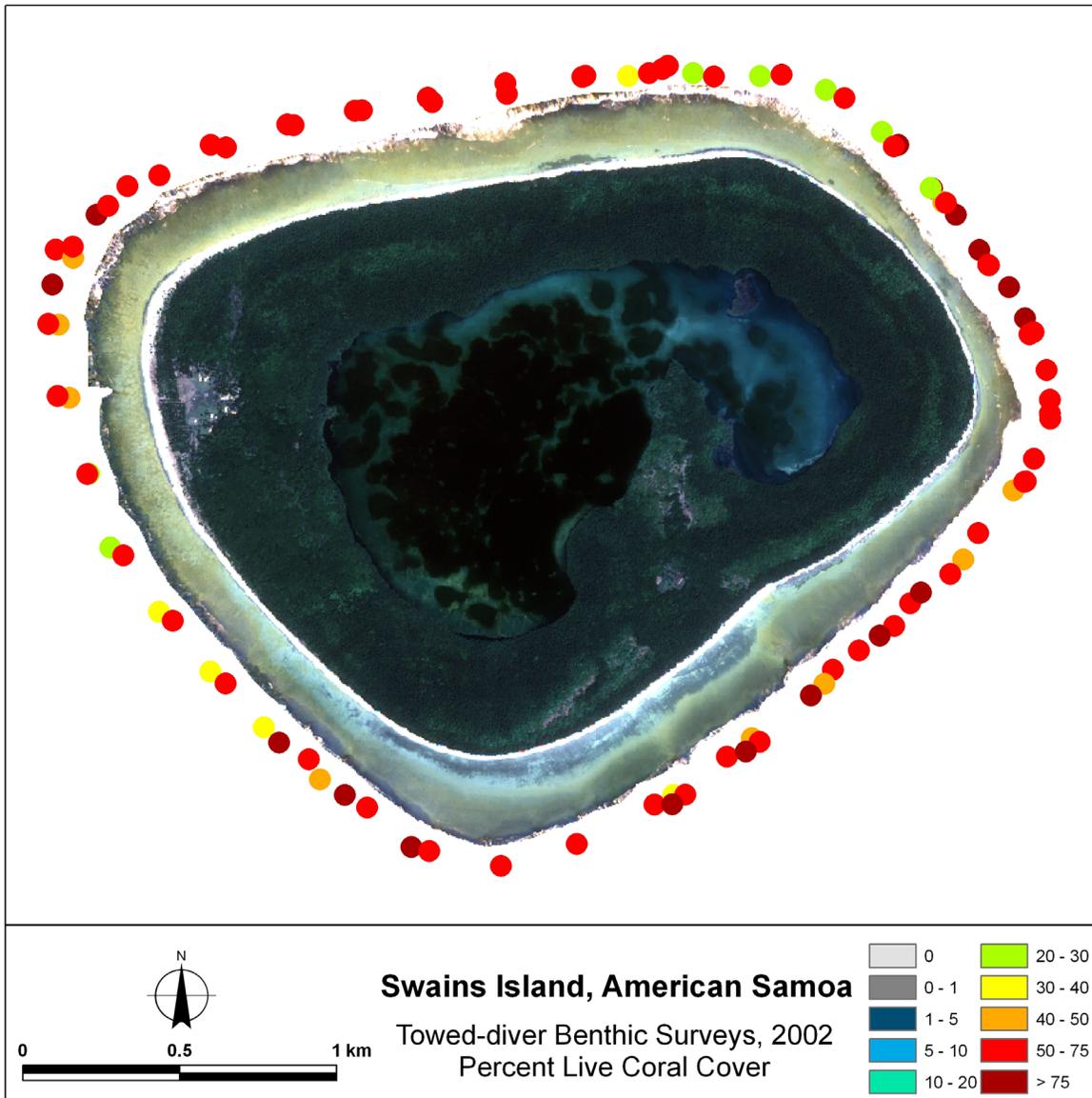


Figure 7.5.1b. Towed-diver benthic survey observations of live scleractinian (stony) coral cover around Swains during ASRAMP 2002. Each colored point represents an integrated estimate over a 5-min observation segment covering a survey swath of ~ 200 m × 10 m (~ 2000 m²). Symbol size represents the percent live coral cover on the benthic habitat. Note that coral cover was measured as a direct percentage of overall benthic cover in 2002. For more information, see Chapter 2, Section 2.4.2: Towed-diver Surveys.

High live coral cover typified the benthic community around Swains (Fig. 7.5.1b). However, specific hotspots of elevated live coral cover were observed during the 2002 towed-diver surveys. The northwest corner of the island, intersecting both the north and the west regions, was observed to have exceptionally high live coral cover (4 tow segments, mean: 73.8%). Other high coral cover areas included the east region (10 tow segments, mean: 71.8%) and the west region (6 tow segments, mean: 65.8%). Dead coral cover (Fig. 7.5.1c) was sporadically distributed around Swains, with increased levels observed in the west region (northwest corner of the island, 8 tow segments, mean: 8.9%) and in the north region (5 tow segments, mean: 6.6%).

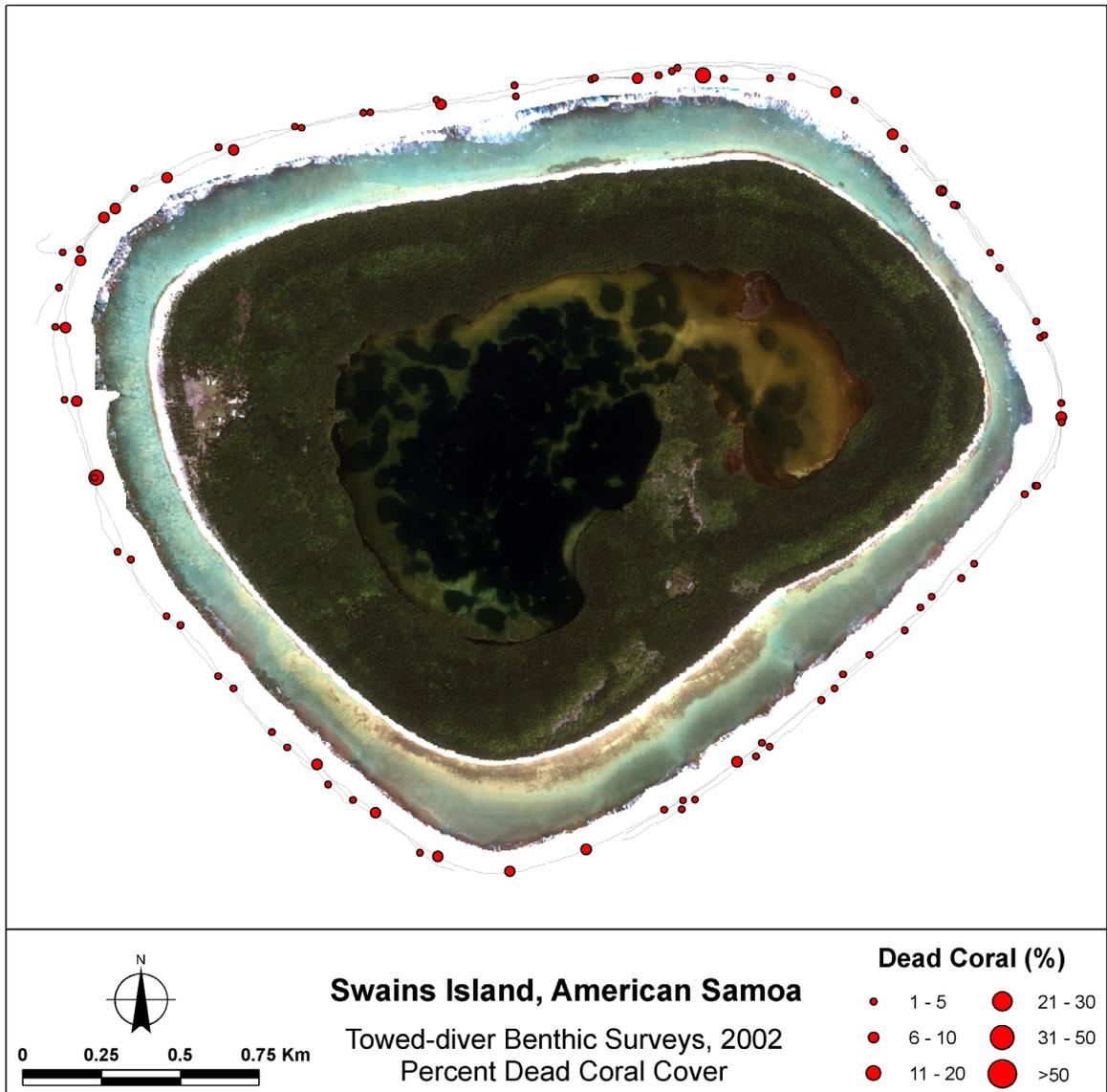


Figure 7.5.1c. Towed-diver benthic survey observations of dead coral cover around Swains during ASRAMP 2002. Each colored point represents an integrated estimate over a 5-min observation segment covering a survey swath of $\sim 200 \text{ m} \times 10 \text{ m}$ ($\sim 2000 \text{ m}^2$). Symbol size represents the percent of dead coral cover on the benthic habitat.

REA coral surveys during ASRAMP 2002 were the first surveys conducted in American Samoa by CRED. Although 15 sites were surveyed around Swains by a coral biologist, much of the focus of those surveys was to compile species inventories and explore different coral monitoring methodologies. Since the surveys were exploratory and qualitative in nature, no data are presented in this more quantitative report.

2004 Spatial Surveys

A total of 14 towed-diver benthic surveys were conducted around Swains during ASRAMP 2004. The mean towed-diver survey depth was 12.5 m, with individual towed-diver survey depths ranging from 5 m (SD 2) to 16 m (SD 8; Fig. 7.5.1d).

As a result of the numerous towed-diver survey tracks in 2004 and the shift to using dive computers instead of decompression tables, towed-diver surveys were intentionally conducted in three depth ranges (as reflected in the depth histogram in Fig. 7.5.1d): shallow (~ 5 m), mid-depths (~ 10–15 m), and deep (20–25 m).

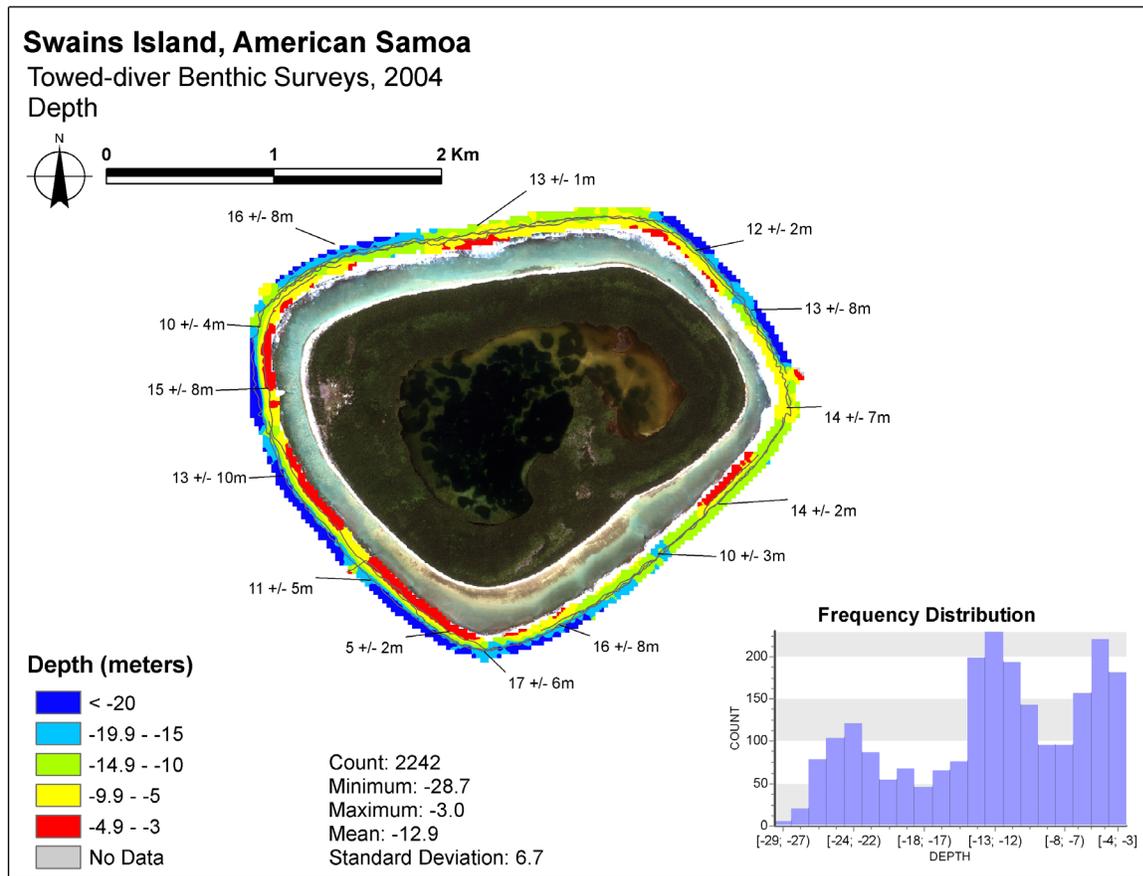


Figure 7.5.1d. Towed-diver survey tracks around Swains during ASRAMP 2004. Towed-diver survey tracks are color coded with mean depths for each 5-min segment. Mean depths and standard deviations for each towed-diver survey are shown in black text. Depth histogram and statistics (counts, minimum depth, maximum depth, mean, and standard deviation) from 30-sec depth recordings during towed-diver surveys are included.

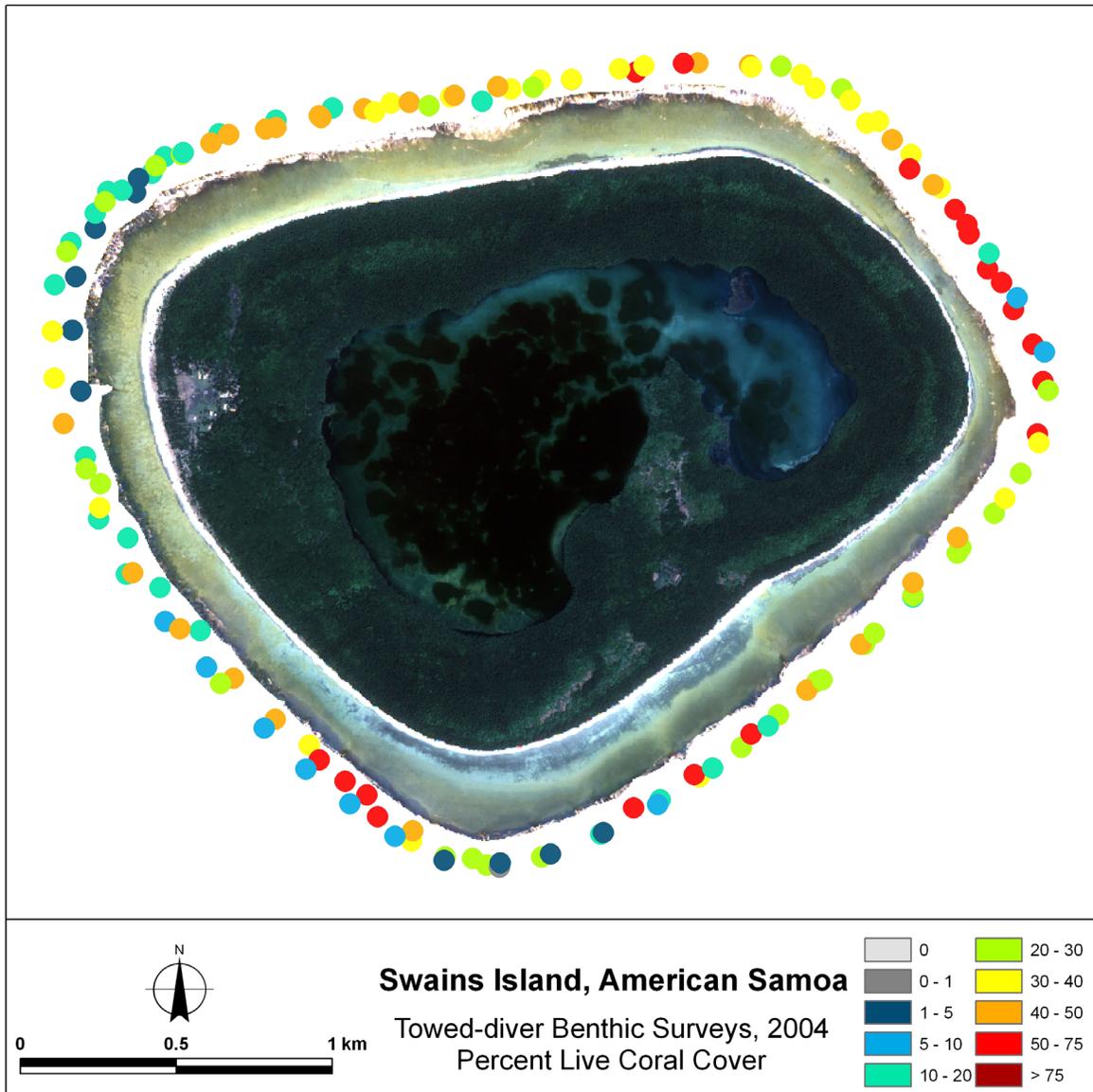


Figure 7.5.1e. Towed-diver benthic survey observations of live scleractinian (stony) coral cover around Swains during ASRAMP 2004. Each colored point represents an integrated estimate over a 5-min observation segment covering a survey swath of $\sim 200 \text{ m} \times 10 \text{ m}$ ($\sim 2000 \text{ m}^2$). Symbol size represents the percent live coral cover on the benthic habitat. For more information, see Chapter 2, Section 2.4.2: Towed-diver Surveys.

An island-wide mean percent cover of live scleractinian coral was 30.5% (SE 2.7; Fig. 7.5.1e). Coral cover was much more spatially variable during the 2004 surveys than observed during 2002. Areas of high coral cover were observed in the east region (16 tow segments, mean: 46.0%) and in the west region (5 tow segments, mean: 46.2%). Interestingly, the northwest corner, which had exceptionally high coral cover during 2002, and the southwest corner of Swains had the lowest observed live coral cover values during ASRAMP 2004, with values ranging from 1–5% to 20–30%.

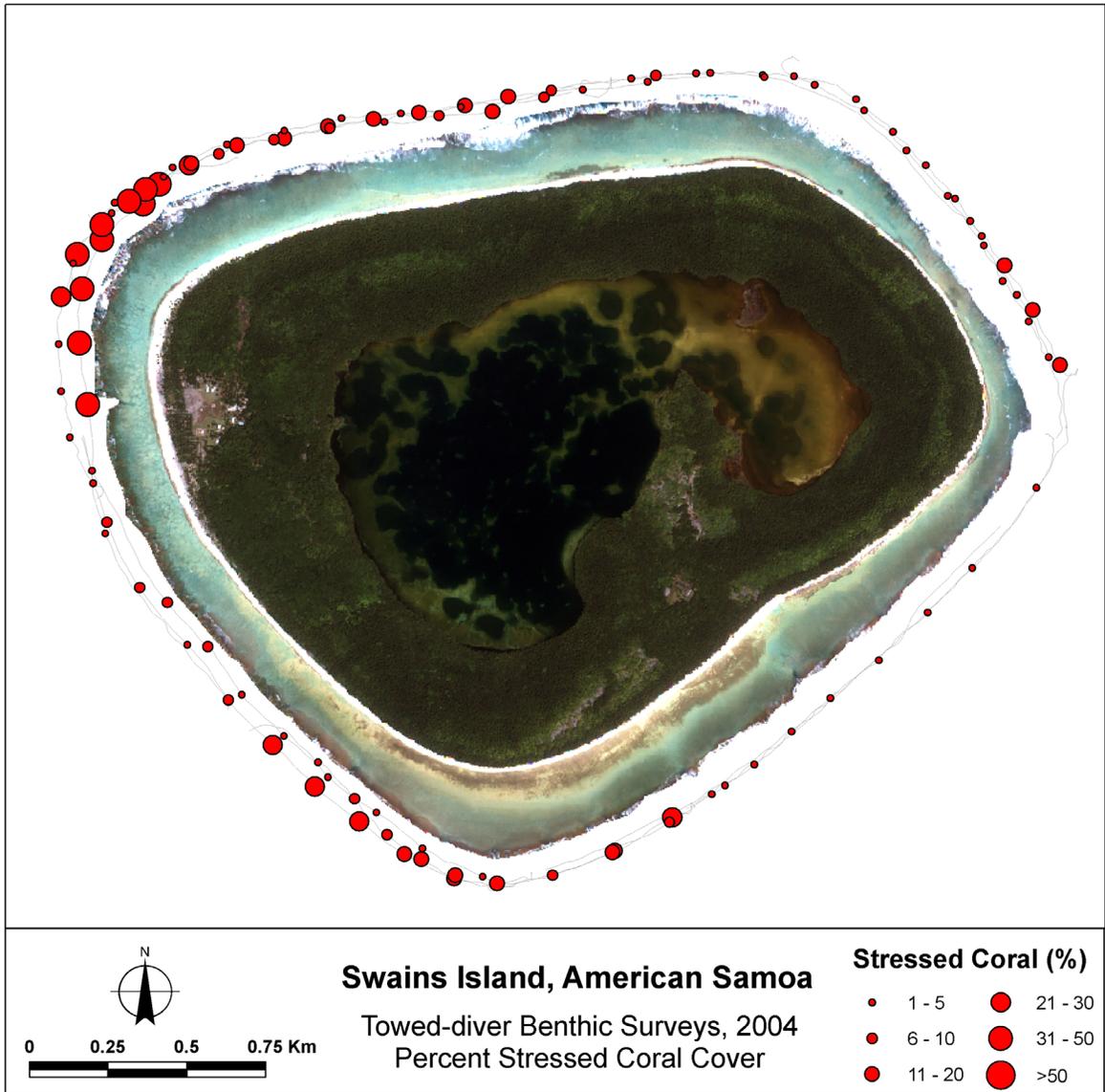


Figure 7.5.1f. Towed-diver benthic survey observations of stressed coral cover around Swains during ASRAMP 2004. Each colored point represents an integrated estimate over a 5-min observation segment covering a survey swath of ~ 200 m × 10 m (~ 2000 m²). Symbol size represents the percent of stressed coral cover of the total coral benthic coverage. Note that stressed coral cover was measured as a percentage of overall coral cover in 2004.

The island-wide mean of stressed coral, which was recorded as a subset value of percent live coral cover, was particularly high during ASRAMP 2004 (7.8% [SE 2.0]; Fig. 7.5.1f). High levels of stressed coral cover were observed in the west and north regions (most northwestern corner, 15 tow segments, mean: 30%). This clump of elevated coral stress was not associated with an area of high live coral cover in 2004, though this area had high observed coral cover during 2002 surveys. High coral stress was observed in the west and southeast regions, particularly the southern corner (13 tow segments, mean: 16.8%). Coral stress in this region was seen in the deeper tow segments, and similarly to the west/north region; these deeper sites with elevated coral stress had lower live coral percent cover. Results from 2004 indicated that coral stress on Swains was relatively independent of live coral percent cover and may be more directly associated with deeper coral communities. More importantly, the high levels of coral stress observed around Swains during 2004 most likely reflect significant coral breakage caused by Hurricane Heta 1 month prior to the

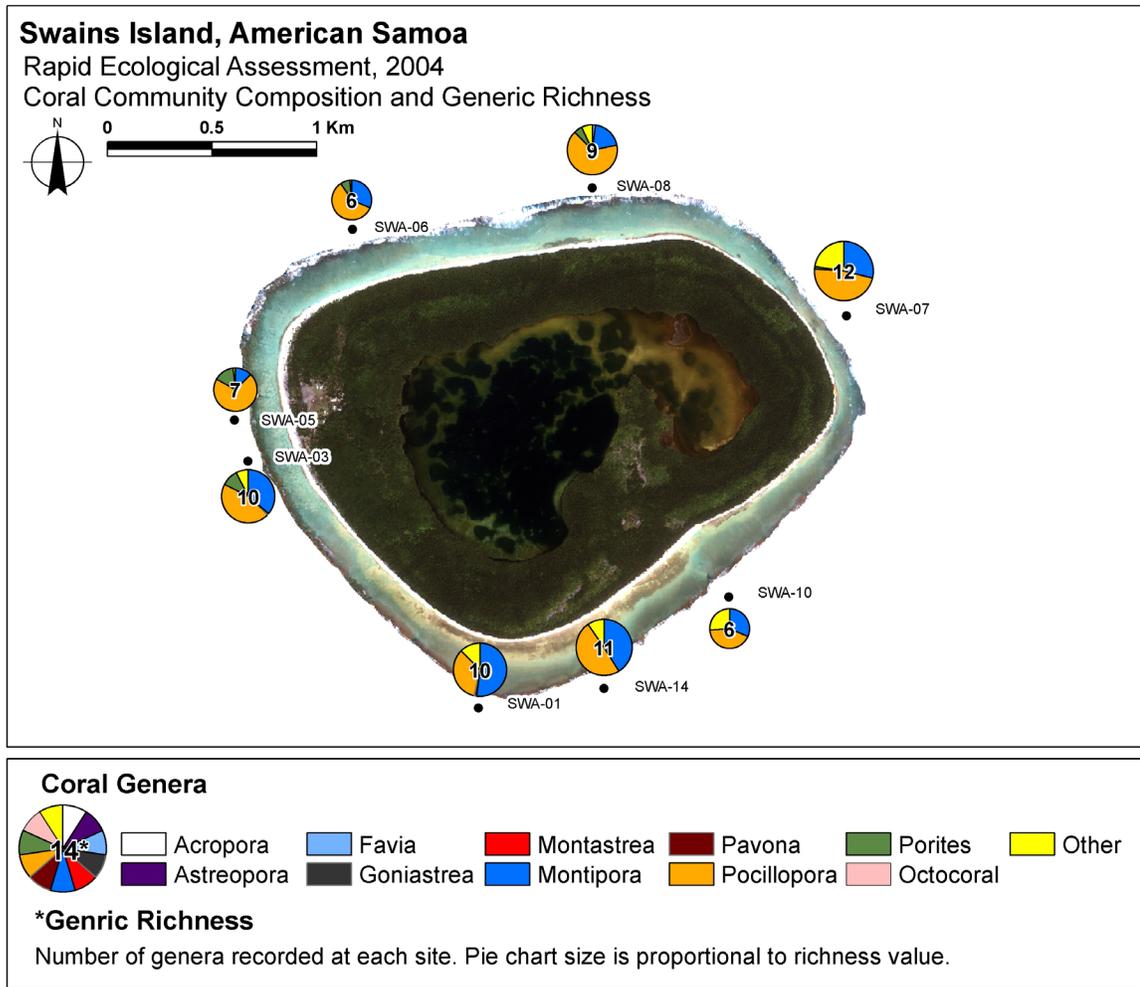


Figure 7.5.1g. Relative abundance of coral genera and generic richness from REA surveys around Swains during ASRAMP 2004. Percent relative abundance of key coral genera are indicated by color-coded portions of the pie charts. Size of the pie charts and black numbers in the center of the pie charts indicate the number of coral genera observed at each REA site.

surveys and a significant crown-of-thorns seastar (COTS) infestation that was observed at the time of these surveys, as described in Section 7.7.1: Benthic Macroinvertebrate Surveys.

Eight REA coral surveys were conducted around Swains during ASRAMP 2004. Coral communities at Swains were very similar across sites (Fig. 7.5.1g). Fifteen anthozoan and hydrozoan genera were observed, with members of the genera *Montipora* and *Pocillopora* dominating the coral fauna. Each genus contributed an island-wide mean of 31% (*Montipora*) and 51% (*Pocillopora*) to the total number of coral colonies recorded (Fig. 7.5.1g). *Porites* was more common at sites SWA-03, -05, -06, and -08 in the west and north regions (10% mean of the coral community), compared to less than 1% of the coral communities at the remaining sites around Swains. Generic richness of corals at Swains was relatively low (8.9 coral genera per site [SE 0.8]), ranging from 6 to 12 coral genera observed at each site (Fig. 7.5.1g). Site-specific data regarding the relative abundance of coral genera, by colony counts within belt transects, are available in Appendix III, Table III. vii.



Figure 7.5.1h. Coral communities at Swains are typified by shelving colonies of *Montipora*. (Photograph provided by NOAA PIFSC CRED; J. Kenyon, JIMAR)

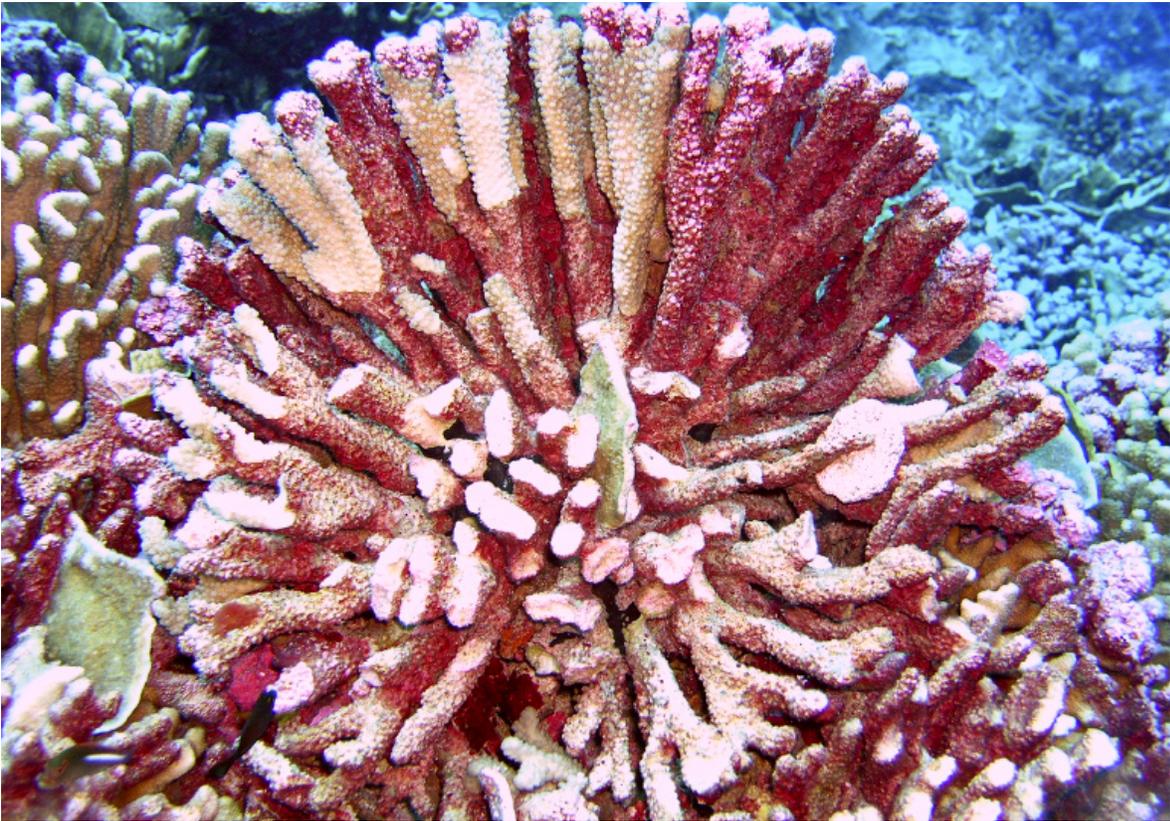


Figure 7.5.1i. Older dead portions of the *Pocillopora* colony are covered with coralline algae, but new damage in the form of storm-induced coral breakage was observed as well. (Photograph provided by NOAA PIFSC CRED; J. Kenyon, JIMAR)

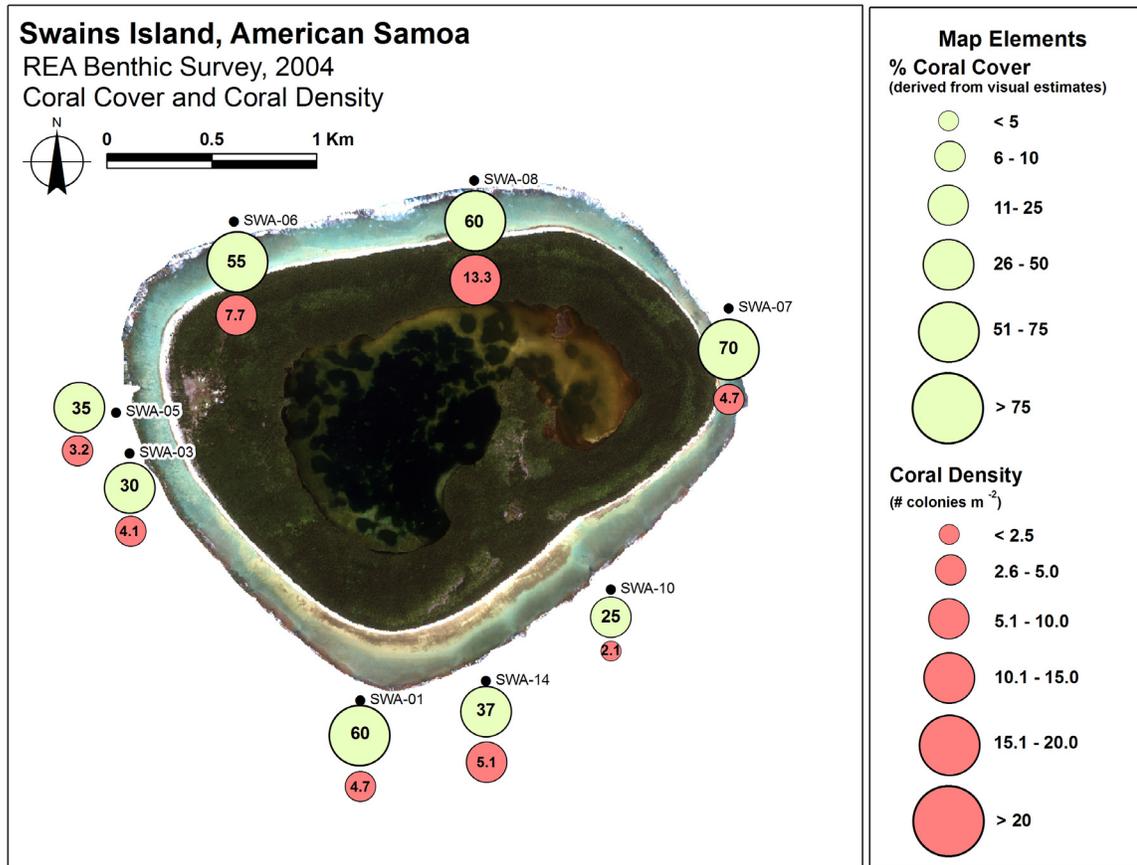


Figure 7.5.1j. Live scleractinian (stony) coral cover and coral colony density from REA surveys around Swains during ASRAMP 2004. The size of the symbol is proportional to the value of each parameter. It is important to note that coral percent cover was determined by qualitative visual estimates.

Figures 7.5.1h and 7.5.1i illustrate common *Montipora* and *Pocillopora* morphologies that typify the coral communities around Swains.

The mean percent live scleractinian (stony) coral cover (derived through visual estimates) observed during REA surveys at Swains was high, with an overall mean of 46.5% (SE 5.9; Fig. 7.5.1j). Coral cover was highest at sites SWA-06, -07, and -08 on the north and east region forereefs, ranging from 55% to 70%.

During ASRAMP 2004, a total of 3073 coral colonies were counted within a survey area of 642 m². Coral densities around Swains were variable (5.6 colonies m⁻² [SE 1.2]) with the highest coral densities observed at north region sites (Fig. 7.5.1j). High coral densities were observed at sites SWA-06 and -08, both off the north coast of Swains, with 7.7 colonies m⁻² and 13.3 colonies m⁻², respectively. The lowest coral density (2.1 colonies m⁻²) was recorded at SWA-10 in the southeast region.

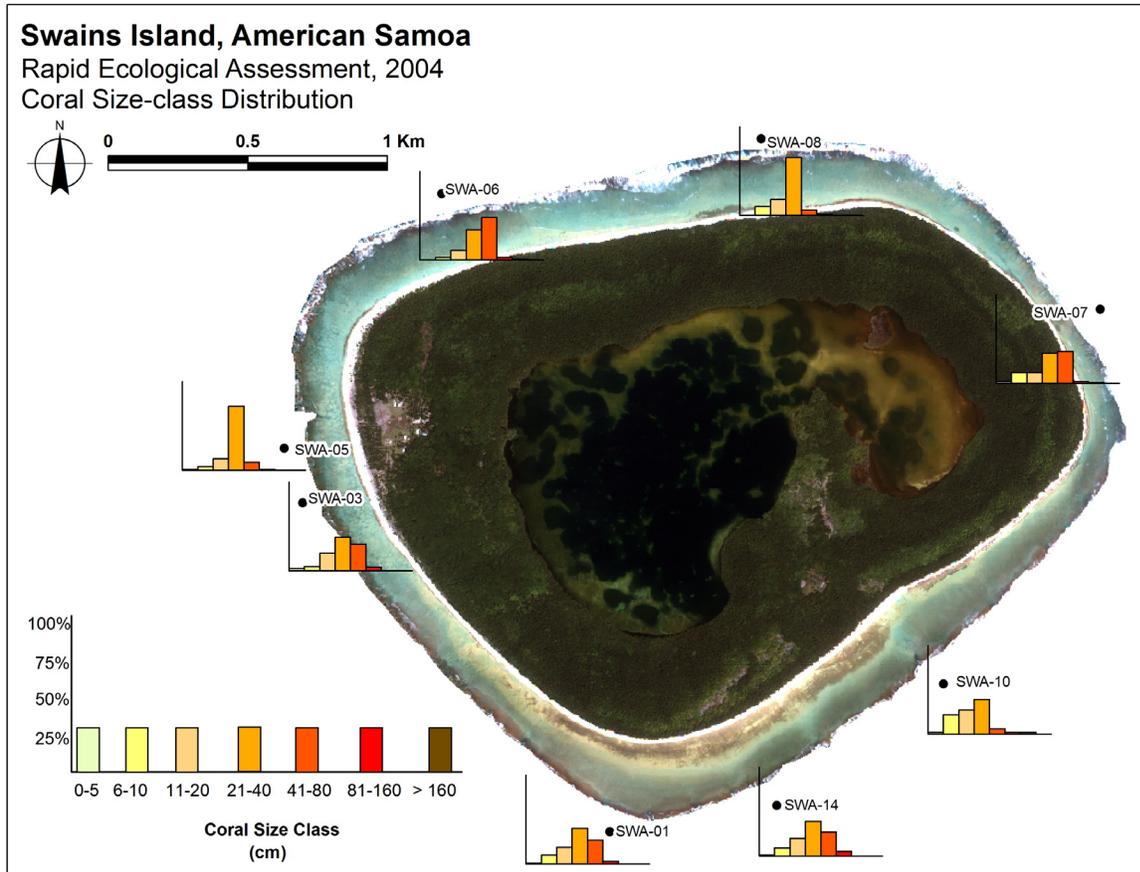


Figure 7.5.1k. Scleractinian coral size-class distribution around Swains from REA surveys during ASRAMP 2004. The height of the y-axis in each size-class chart represents 100%. The seven observed size classes (0–5, 6–10, 11–20, 21–40, 41–80, 81–160, and > 160 cm) are color coded in size frequency diagrams at each REA site.

Size-class distribution shows that 41.9% of coral colonies had maximum diameters between 20 and 40 cm (Fig. 7.5.1k) during ASRAMP 2004 surveys. Spatial patterns in coral size distributions were not apparent. Five of eight sites surveyed at Swains had more than 25% of corals with diameters larger than 40 cm (SWA-01, -03, -06, -07, -14). Corals with diameters less than 5 cm were uncommon at all sites around Swains.

2006 Spatial Surveys

Nine towed-diver benthic surveys were conducted around Swains during ASRAMP 2006, with a mean towed-diver survey depth of 12.7 m. Individual survey depths ranged from 10 m (SD 3) to 16 m (SD 3), and were fairly uniform around the island (Fig. 7.5.11). The island-wide mean of live scleractinian (stony) coral cover was 43.9% (SE 4.4; Fig. 7.5.1m). Stressed coral was also characterized during these surveys and was gathered as a subset percentage of live coral percent cover. The island-wide mean stressed coral cover was 1.9% (SE 0.4; Fig. 7.5.1n), substantially lower than observed during 2004.

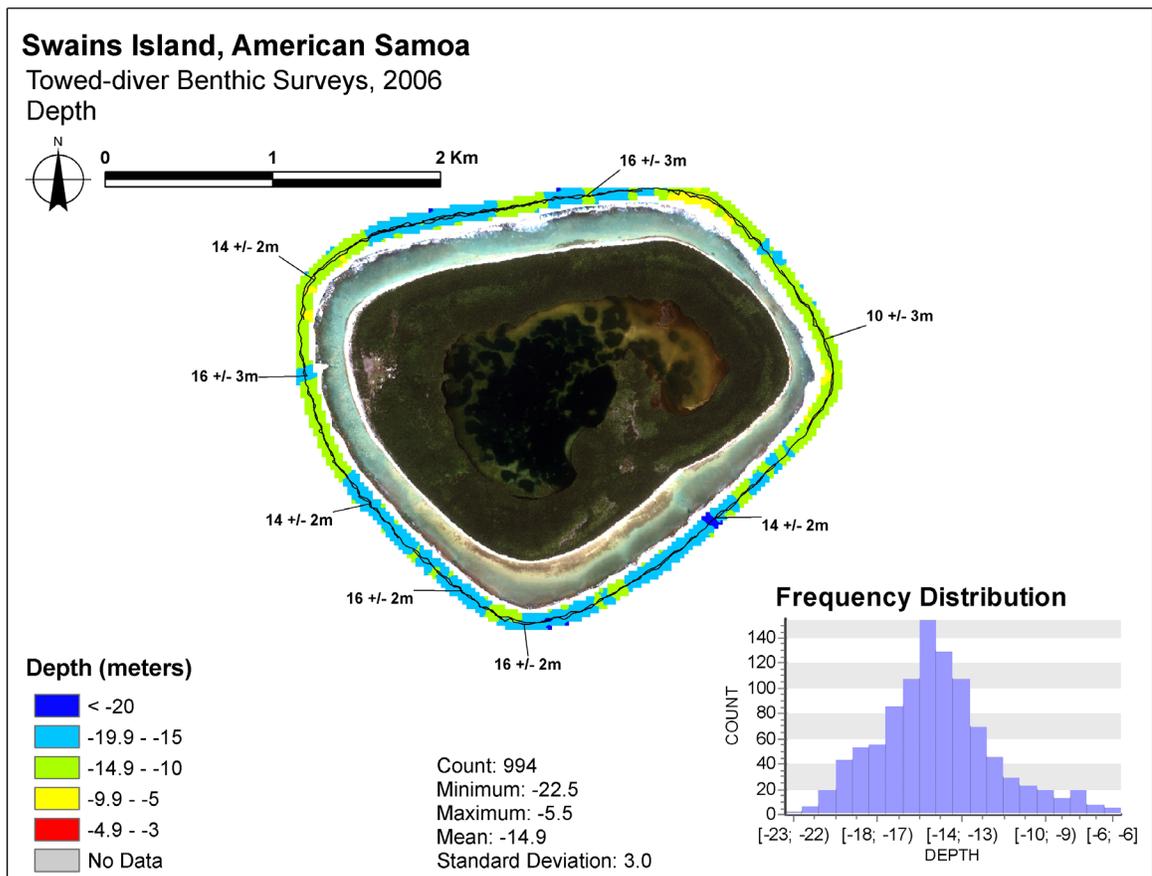


Figure 7.5.11. Towed-diver survey tracks around Swains during ASRAMP 2006. Towed-diver survey tracks are color coded with mean depths for each 5-min segment. Mean depths and standard deviations for each towed-diver survey are shown in black text. Depth histogram and statistics (counts, minimum depth, maximum depth, mean, and standard deviation) from 30-sec depth recordings during towed-diver surveys are included.

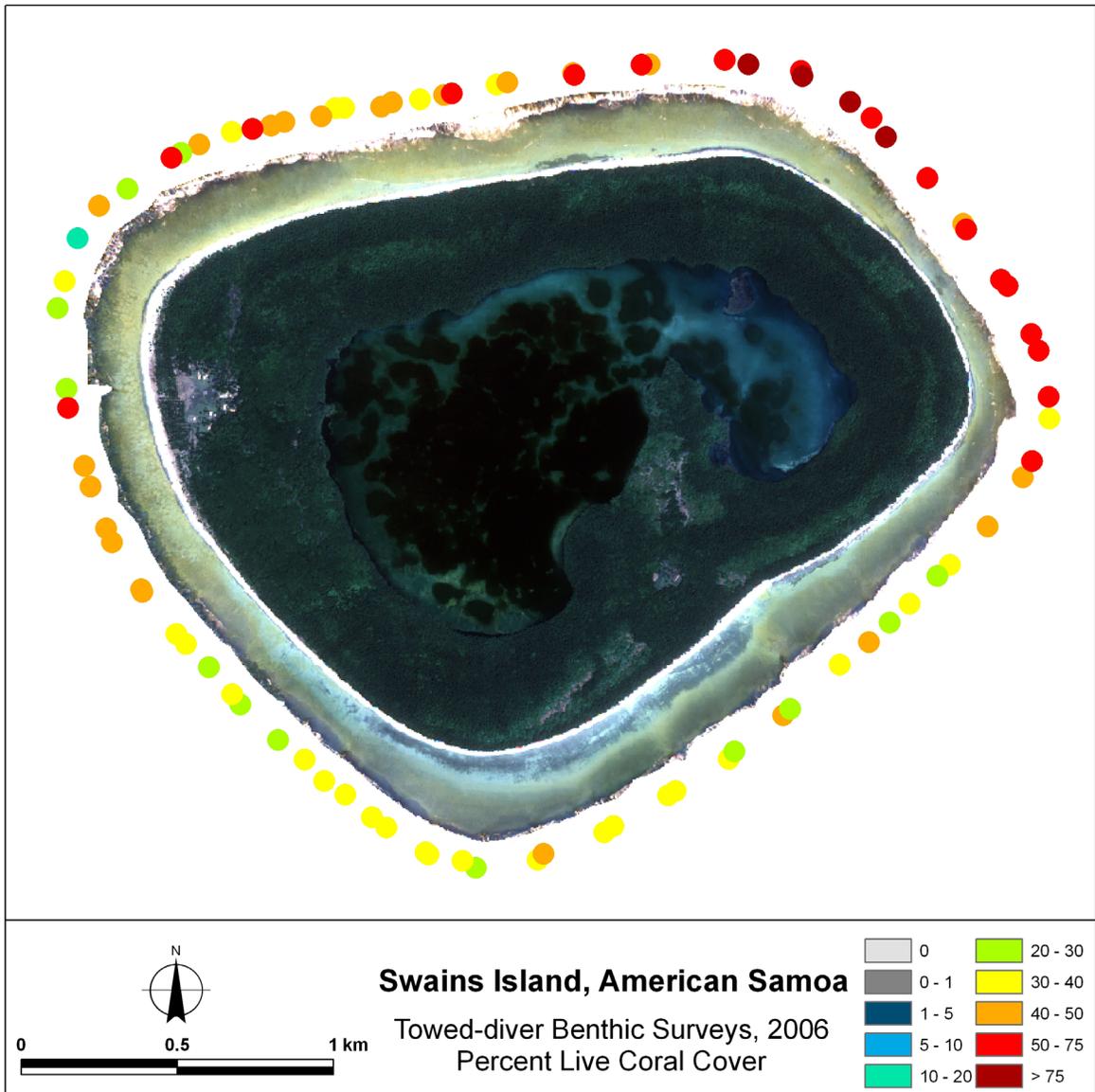


Figure 7.5.1m. Towed-diver benthic survey observations of live scleractinian (stony) coral cover around Swains during ASRAMP 2006. Each colored point represents an integrated estimate over a 5-min observation segment covering a survey swath of $\sim 200 \text{ m} \times 10 \text{ m}$ ($\sim 2000 \text{ m}^2$). Symbol size represents the percent live coral cover on the benthic habitat. See Chapter 2, Table 2.4.2b for more information on benthic towed-diver binning categories during ASRAMP 2006.

Exceptionally high live coral cover was observed in the east (northeastern corner) region of Swains (6 tow segments, mean: 79.5%). The tow segments were also some of the shallowest sites surveyed around Swains in 2006, suggesting that coral communities were stratified by depth around the island. Coral cover was moderately high (30–50%) around most of the remainder of the island. Stressed corals were low in abundance around Swains in 2006, with only one hotspot of stress observed in the west region (southernmost corner of the region, 5 tow segments, mean: 7%).

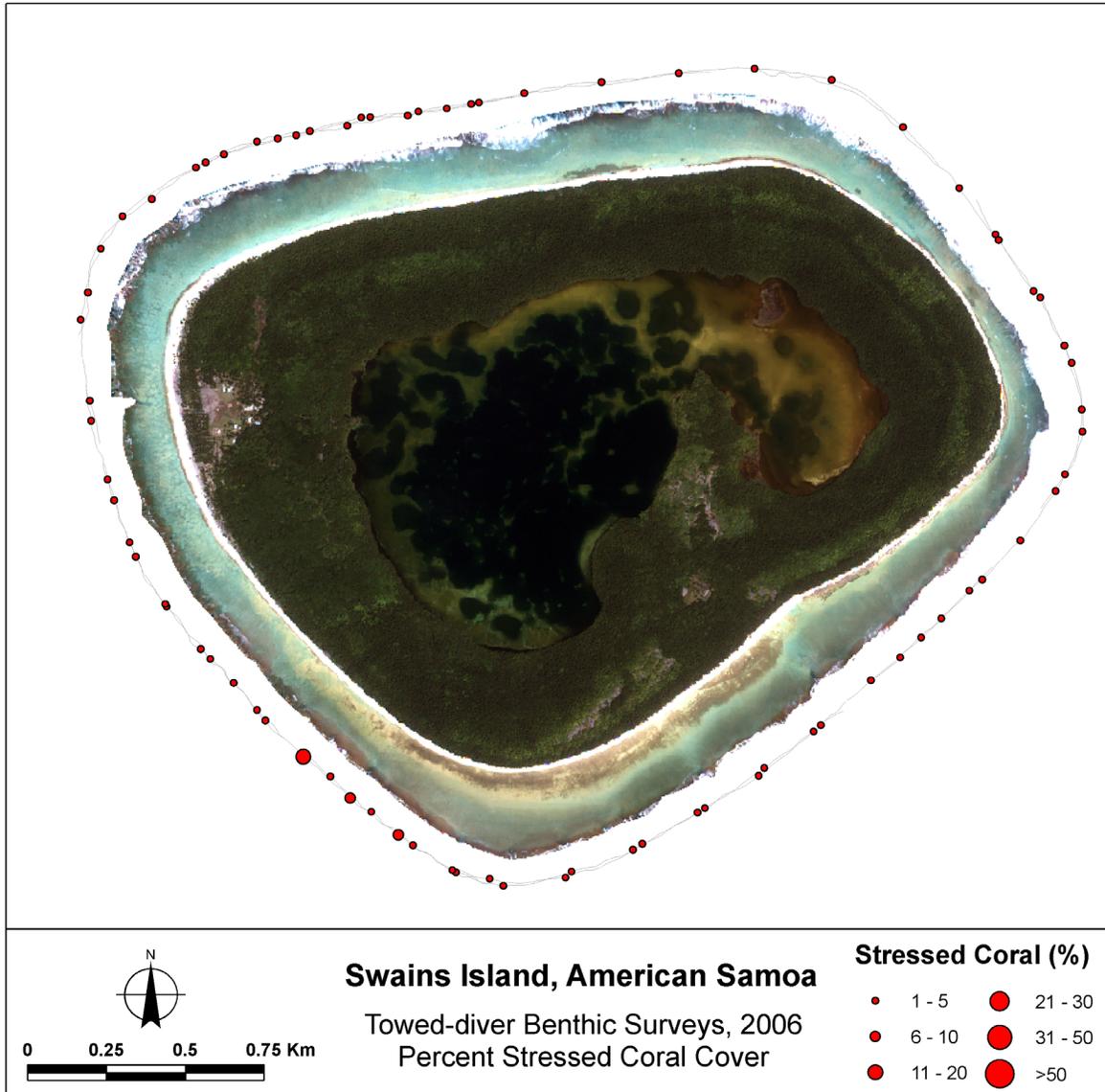


Figure 7.5.1n. Towed-diver benthic survey observations of stressed coral cover around Swains during ASRAMP 2006. Each colored point represents an integrated estimate over a 5-min observation segment covering a survey swath of ~ 200 m × 10 m (~ 2000 m²). Symbol size represents the percent of stressed coral cover of the total coral benthic coverage. See Chapter 2, Table 2.4.2b for more information on benthic towed-diver binning categories during ASRAMP 2006.

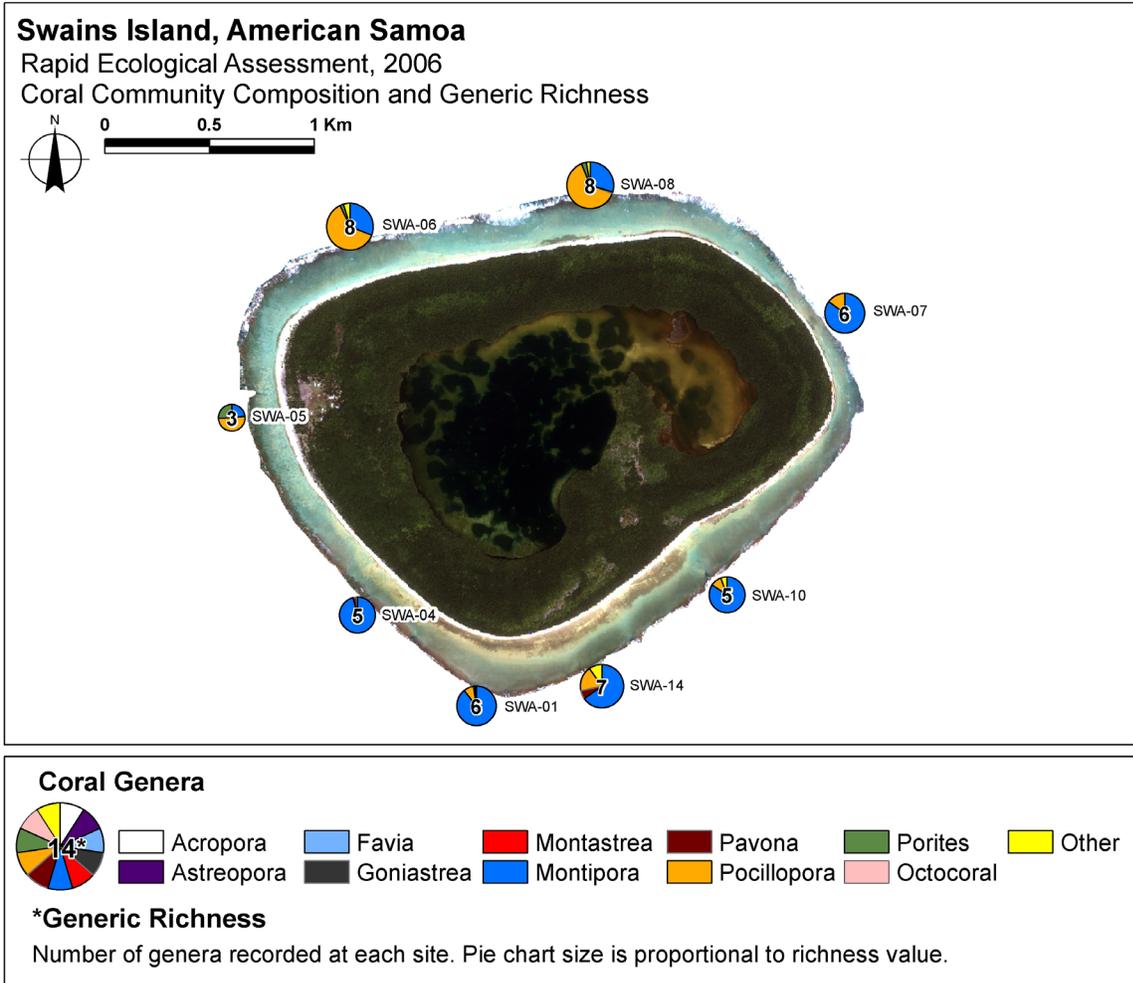


Figure 7.5.1o. Relative abundance of coral genera and generic richness from REA surveys around Swains during ASRAMP 2006. Percent relative abundance of key coral genera are indicated by color-coded portions of the pie charts. Size of pie charts and black numbers in the center of the pie charts indicate the number of coral genera observed at each REA site. Note that SWA-03 (surveyed in 2004) was not resurveyed but substituted with SWA-04 in 2006 to improve spatial coverage of survey sites.

Eight REA coral surveys were conducted around Swains during ASRAMP 2006. At least 12 genera of anthozoan and hydrozoan corals were reported around Swains (Fig. 7.5.1o). Members of the genera *Montipora* and *Pocillopora* dominated the coral fauna, and the community composition was quite different between northern and southern sites. *Montipora* dominated sites with southern exposures (SWA-01, -04, -07, -10, -14, mean: 83% of the coral community), while *Pocillopora* was common at northern sites (SWA-05, -06, -08, mean: 58% of the coral community). Generic richness of corals at Swains was relatively low at 6.0 coral genera per site (SE 0.6), with between 3 and 8 coral genera observed at each site. Site-specific data regarding the relative abundance of coral genera, by colony counts within belt transects, are available in Appendix III, Table III. viii.

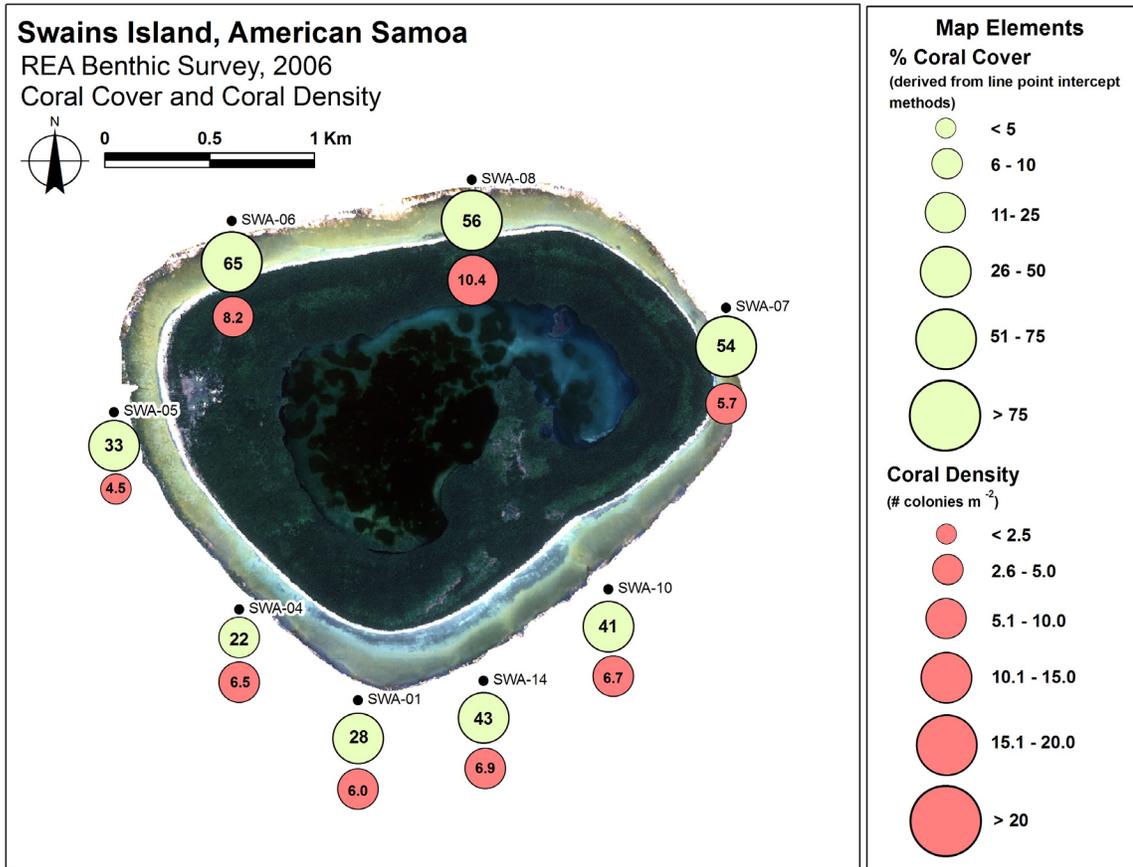


Figure 7.5.1p. Live scleractinian (stony) coral cover and coral colony density from REA surveys around Swains during ASRAMP 2006. The size of the symbol is proportional to the value of each parameter.

Island-wide mean percent scleractinian (stony) coral cover around Swains was relatively high, with an island-wide mean of 42.8% (SE 5.2). Coral cover was greatest at sites SWA-06, -07, and -08 on the north and east region forereefs and ranged from 54% to 65% (Fig. 7.5.1p). Relatively lower coral cover was reported at sites SWA-04 and -01 (22% and 28%, respectively) in the west region and south corner.

During ASRAMP 2006 surveys around Swains a total of 2739 coral colonies were counted within a total survey area of 400 m². Mean coral density between REA sites was variable with 6.9 colonies m⁻² (SE 0.6) reported. Relatively higher coral densities were recorded at sites in the north region, with 8.2 colonies m⁻² and 10.4 colonies m⁻² recorded at SWA-06 and -08, respectively (Fig. 7.5.1p).

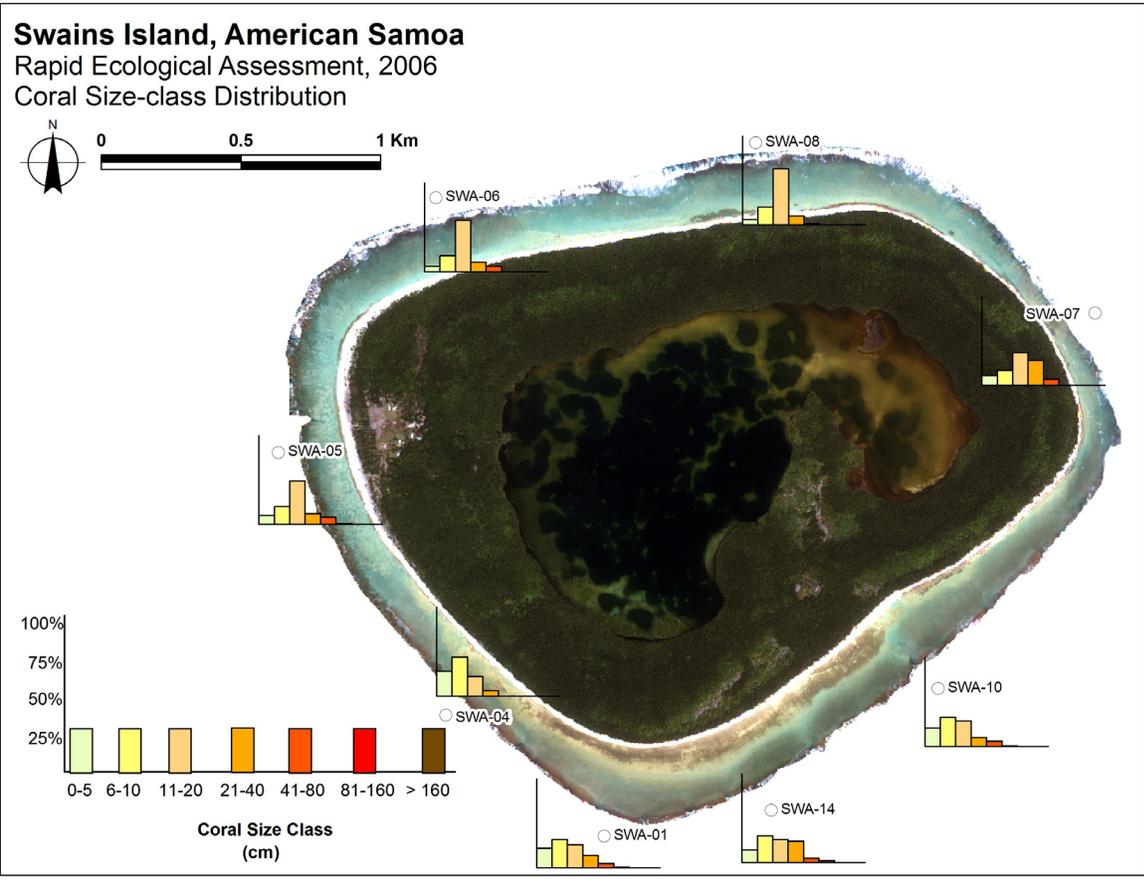


Figure 7.5.1q. Scleractinian coral size-class distribution around Swains from REA surveys during ASRAMP 2006. The height of the y-axis in each size-class chart represents 100%. The seven observed size classes (0–5, 6–10, 11–20, 21–40, 41–80, 81–160, and > 160 cm) are color coded in size frequency diagrams at each REA site.

During ASRAMP 2006, coral size-class distributions showed that 40.6% of coral colonies had maximum diameters between 10 and 20 cm (Fig. 7.5.1q). Small corals were common at Swains, with six out of eight sites having more than 10% of corals with diameters less than 5 cm. The only two sites that did not have abundant small corals were located off the north shore sites SWA-06 and -08. Corals larger than 40 cm were not common at any sites.

7.5.2 Coral Disease Surveys

2006 Spatial Surveys

Coral health and disease surveys covered a total survey area of 3200 m² around Swains during ASRAMP 2006, with 80 cases of coral disease, predation, and other lesions observed. Figure 7.5.2a illustrates the variability in prevalence of the different health states among sites. Coral diseases around Swains were uncommon, with only two of the eight sites surveyed containing disease. The estimated mean overall prevalence was 0.04% (SE 0.03; Fig. 7.5.2a), and all cases occurred at sites SWA-04 and -05, on the west region of the island. Growth anomalies totaled three cases, all on *Porites* spp. and in deeper water (16–18 m). In addition, lesions involving hyperpigmented irritations were also noted around Swains (two on *Porites* cf. *rus* and *P.* cf. *monticulosa*, and the other one on *Pocillopora eydouxi*). One case of mild bleaching was also observed at SWA-06.

Lesions attributable to *Acanthaster* and *Drupella* predation were quite abundant and common (Figs. 7.5.2a, 7.5.2b, and 7.5.2c). The estimated mean overall prevalence of predation was 0.33% (SE 0.05). Predation scars were the most numerous at SWA-01, where coral cover values were among the lowest reported for the island. SWA-06 exhibited the second greatest number of scars per area surveyed and also exhibited the highest percent of live coral cover for the entire island. Even though montiporid corals composed more than 66% of live coral cover, predation scars were more abundantly observed on *Pocillopora* (42%).

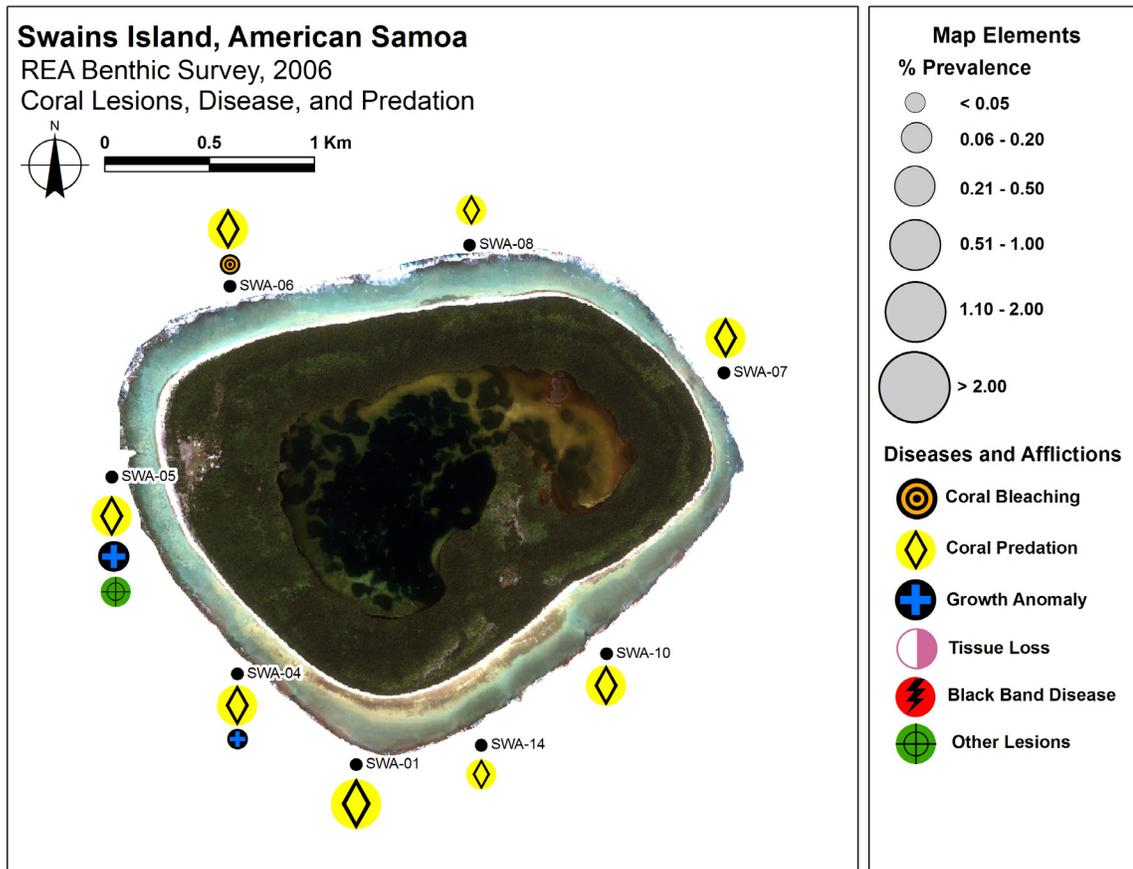


Figure 7.5.2a. Prevalence of predation, bleaching, growth anomalies, tissue loss, black band disease, and other lesions at Swains during ASRAMP 2006. Prevalence was calculated relative to the average colony density estimates and is indicated by the size of the respective symbols.

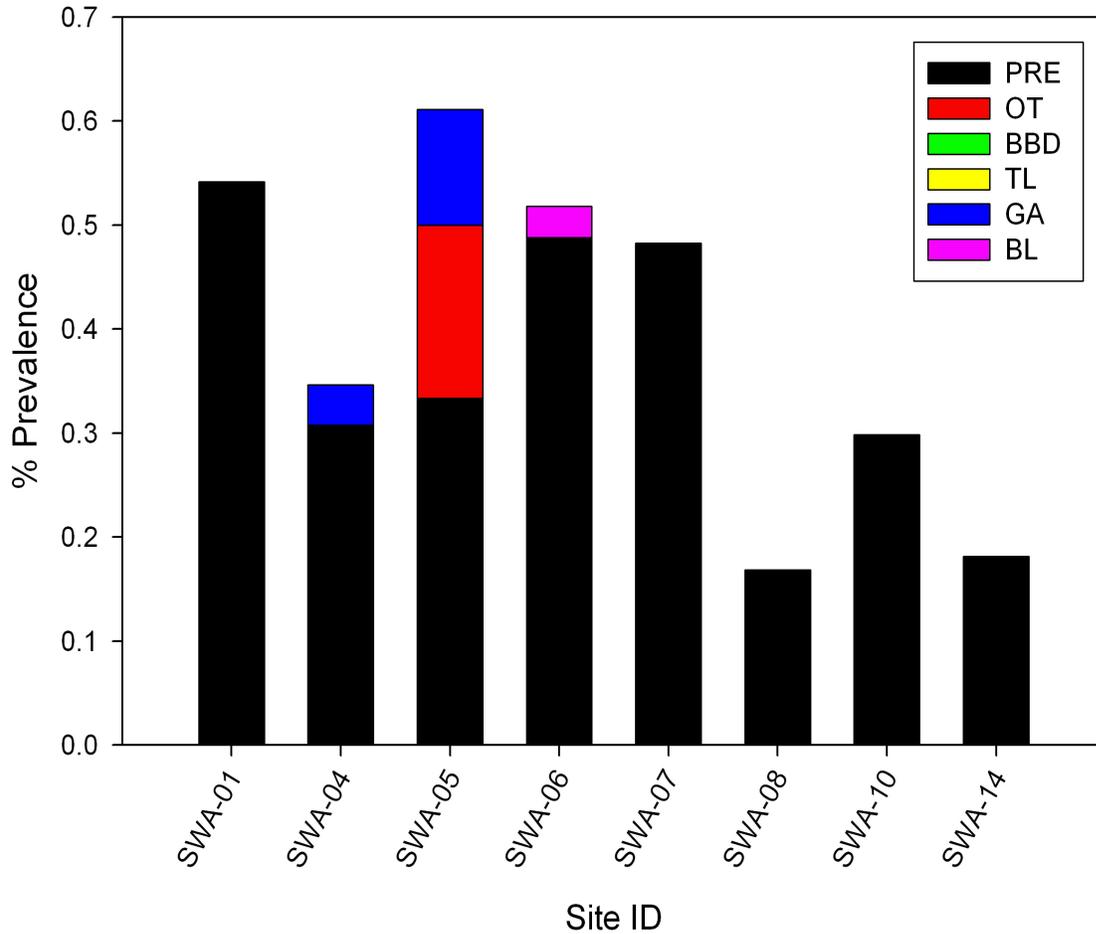


Figure 7.5.2b. Prevalence of predation, bleaching, growth anomalies, tissue loss, black band disease, and other lesions at Swains during ASRAMP 2006. Prevalence was calculated relative to the average colony density estimates. PRE—*Acanthaster* and/or *Drupella* predation; OT—other lesions, including hyperpigmented irritations; BBD—black band disease; TL—tissue loss; GA—skeletal growth anomalies; and BL—bleaching.



Figure 7.5.2c. Corallivore *Drupella* gastropods feeding on platy *Montipora* (left panel), and COTS (*Acanthaster planci*) feeding on *Montipora* sp. (right panel). (Photographs provided by NOAA PIFSC CRED; B. Vargas-Angel, JIMAR)

7.5.3 Temporal Comparison—Coral and Coral Disease

Very high live scleractinian coral cover observed during the towed-diver benthic surveys around Swains during the three ASRAMP cruises typified the reef ecosystem. The overall towed-diver island-wide mean percent cover of live coral ranged from a high of 60.0% (SE 4.6) in 2002 to a low of 30.5% (SE 2.7) in 2004, and then back up to 43.4% (SE 1.7) in 2006 (Fig. 7.5.3a). Moreover, island-wide mean percent cover of stressed coral was 7.8% in 2004 and 1.9% in 2006. Combined, these island-wide means for live coral cover and percent stressed coral may reflect a progression from a relatively unperturbed ecosystem in 2002 to an ecosystem affected by both Hurricane Heta and a COTS infestation in 2004 (see Section 7.7: Benthic Macroinvertebrates), followed by a partial recovery stage from the storm damage by Hurricane Heta, but continued perturbation by COTS in 2006. In either case, exceptionally high mean values of live coral cover have been consistently observed around Swains, particularly when compared with coral cover observations at most other sites surveyed around the United States-affiliated Pacific Islands as part of Pacific RAMP.

Island-wide live coral percent cover, as recorded by REA surveys, was very similar between 2004 (46.5% [SE 5.9]) and 2006 (42.8% [SE 5.2]; Fig. 7.5.3a). Although these values are similar, it is important to note the methods to estimate coral percent cover were different in 2004 (visual estimates) and 2006 (line point intercept technique). The highest REA coral cover values were observed in the north and east regions in both 2004 and 2006 (Figs. 7.5.1j and 7.5.1p). Sites SWA-06 and -08 on the north coast had very high live coral cover values in both 2004 (55% and 60%, respectively) and 2006 (65% and 56%, respectively). Site SWA-07 in the east region also had very high live coral in both 2004 (70%) and 2006 (54%). High coral cover at SWA-07 from REA results corroborated results obtained from towed-diver surveys.

Low generic diversity was observed around Swains, with 15 genera identified island wide in 2004 and 12 genera identified island wide in 2006. Per-site diversity was also low with 8.9 genera per site (SE 0.8) in 2004 and 6.0 genera per site (SE 0.6) in 2006 (Fig. 7.5.3b). *Montipora* and *Pocillopora* dominated the coral community in both 2004 and 2006. The data from 2006 shows a division within the distribution of coral genera, with the southeast, west, and east region sites dominated by *Montipora* (83% of the coral community) and north region sites (in addition to SWA-05 in the west region) dominated by *Pocillopora* (58% of the coral community; Fig. 7.5.1o).

Coral colony density increased slightly between 2004 (5.6 [SE 1.2]) and 2006 (6.9 [SE 0.6]; Fig. 7.5.3c). High colony density was directly associated with regions of high coral percent cover, as demonstrated by the north region sites SWA-06 and -08. Density at these two sites in 2004 was 7.7 colonies m⁻² (SWA-06) and 14.4 colonies m⁻² (SWA-08). In 2006, density at the same two sites was 8.2 colonies m⁻² (SWA-06) and 10.4 colonies m⁻² (SWA-08), respectively.

The majority of corals in 2006 had diameters between 10 and 20 cm, in contrast to observations in 2004 where the majority of corals had diameters between 20 and 40 cm (Fig. 7.5.3d). The difference in size-class distributions between the years may reflect one or several factors, including breakage from hurricane or other storm activity and interobserver variability.

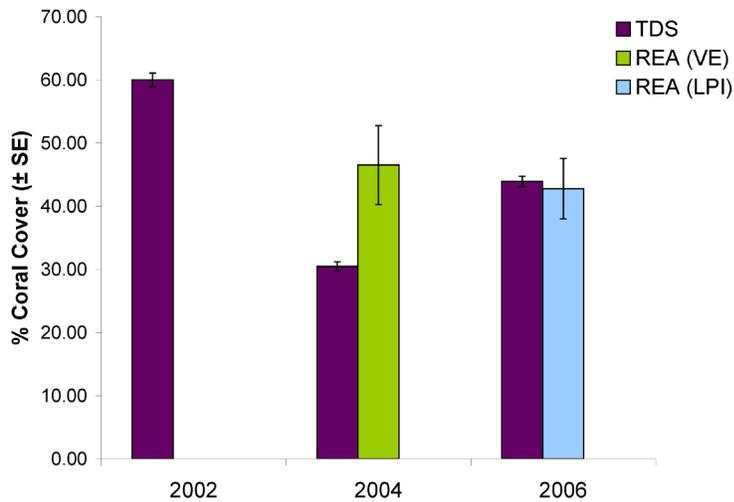


Figure 7.5.3a. Temporal comparison of mean percent live coral cover from REA surveys and towed-diver surveys around Swains during ASRAMP 2002, 2004, and 2006 surveys. The purple bars represent observations collected during towed-diver habitat surveys. The green bar represents REA data collected by visual estimates during REA surveys, and the blue bar represents data collected by the line point intercept technique during REA surveys. See Chapter 2, Section 2.4: Reef Benthic (Coral, Algae, Macroinvertebrate) and Fish Surveys for considerations when comparing the results of these methodologies.

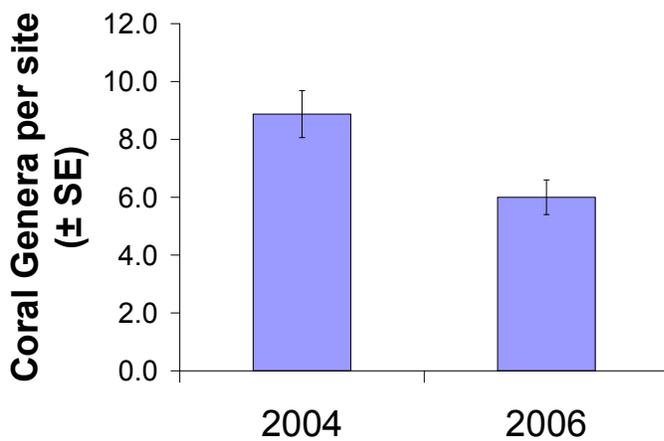


Figure 7.5.3b. Temporal comparison of mean values of coral genera per site around Swains during ASRAMP

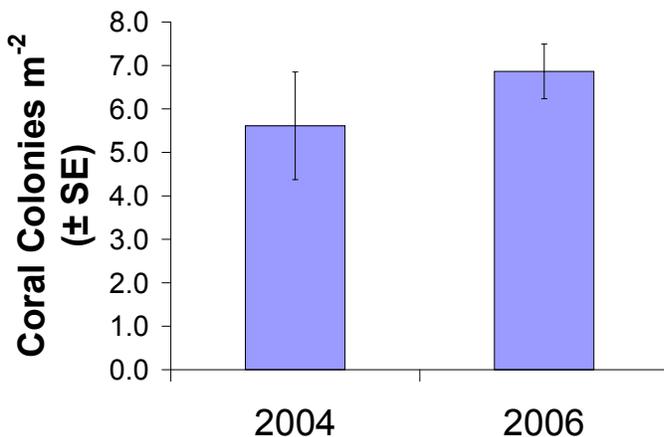


Figure 7.5.3c. Temporal comparison of mean coral colony density from REA surveys at sites around Swains during ASRAMP 2004 and 2006.

High coral cover on towed-diver surveys was not spatially linked with areas of high coral stress or dead coral percent cover, which indicates that other factors may have been responsible for the distribution of stressed or dead coral. Across the years of towed-diver surveys, the east region and the most southern tip of the west/southeast regions had the highest cover of live coral.

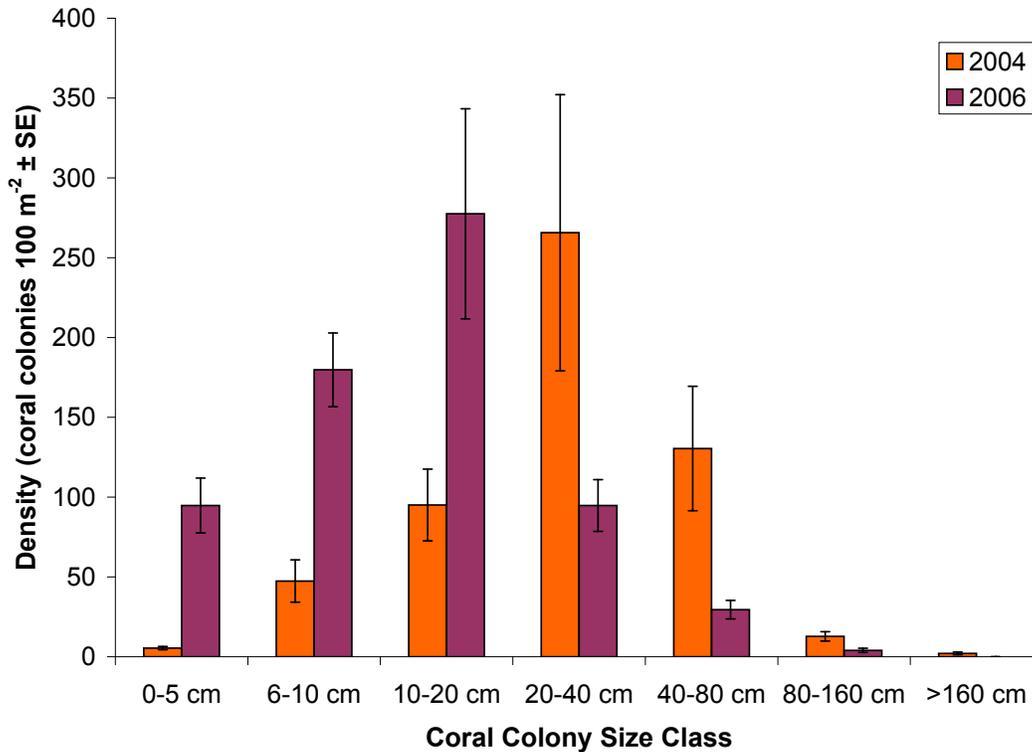


Figure 7.5.3d. Coral colony size-class mean density from REA surveys at sites around Swains during ASRAMP 2004 and 2006.

7.6 Algae

It is important to note when considering these results that turf algae, crustose coralline red algae, branched non-geniculate coralline red algae, and cyanophytes (blue-green algae) all need to be analyzed microscopically for proper taxonomic identification and therefore must be lumped into functional group categories in the field. Of these functional groups, turf algae are the most diverse with the possibility of up to 100 species occurring in a 10 cm² area. As well, macroalgae are large, fleshy, sometimes calcified entities that may be identifiable to genus or species in the field, but often require microscopic analysis to confirm taxonomic identities.

7.6.1 Algal Surveys

2002 Spatial Surveys

Nine towed-diver surveys were conducted around Swains during ASRAMP 2002, with fleshy macroalgae and crustose coralline red algae covering, on average, 32.7% of the benthic substrate. Mean fleshy macroalgal cover was 16.2% (SE 1.3), and mean crustose coralline algal cover was 16.5% (SE 0.7) of the benthic substrate (Fig. 7.6.1a). Highest percent cover of fleshy macroalgae was observed along the north and west shores of the island. Percent cover of crustose coralline

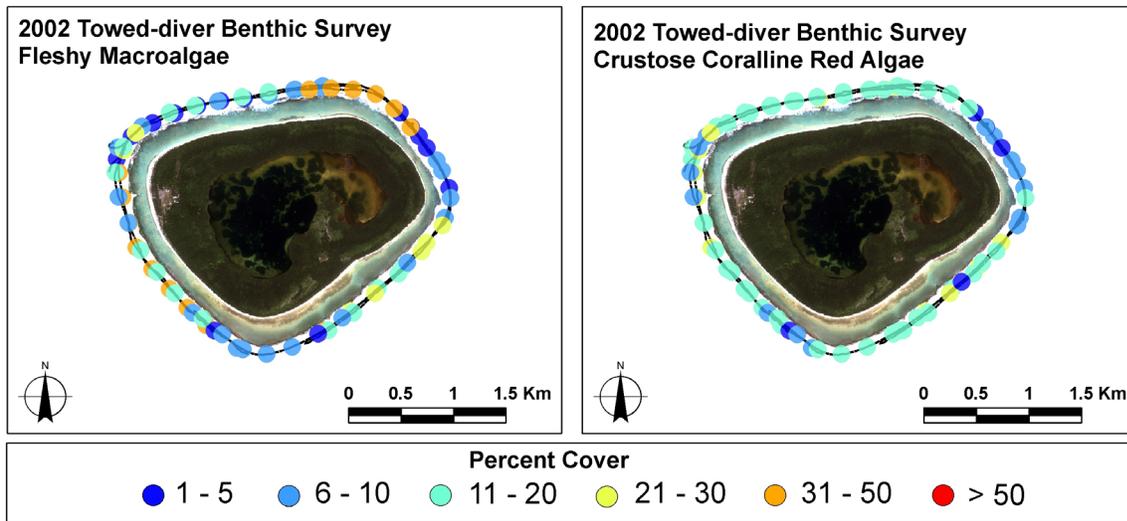


Figure 7.6.1a. Percent cover of fleshy macroalgae (including turf algae) and crustose coralline algae from towed-diver benthic surveys around Swains during ASRAMP 2002. Each colored point represents an integrated estimate over 5-min observation segments covering a survey swath of $\sim 200 \text{ m} \times 10 \text{ m}$ ($\sim 2000 \text{ m}^2$).

algae was fairly uniform around the perimeter of the island.

Qualitative REA algal surveys were conducted around Swains during ASRAMP 2002, and nine bags of algal voucher specimens were collected. These surveys provided baseline data used to design and scale the future methodology of algal REA surveys.

2004 Spatial Surveys

A total of 14 towed-diver benthic surveys around Swains during ASRAMP 2004 recorded a mean combined algal cover (including fleshy macroalgal, turf, and crustose coralline red algae) of 60.8% (Fig. 7.6.1b). Mean fleshy macroalgal cover (including turf) was 28.6% (SE 1.4), and mean crustose coralline algal cover was 32.2% (SE 0.9; Fig. 7.6.1b). Generally, higher cover of macroalgae was observed along the south coast than compared to other areas. Percent cover of crustose coralline algae was fairly uniform around the perimeter of the island.

During ASRAMP 2004, quantitative algal surveys were conducted at nine sites around Swains (Fig. 7.6.1c). A total of 10 macroalgal genera (4 green, 4 red, and 2 brown) and 4 additional algal functional groups (turf algae, crustose coralline red algae, branched non-geniculate coralline red algae, and cyanophytes) were observed in the field. Once completed, laboratory-based taxonomic identification of all algal species (including turf algae, epiphytes, and crustose coralline red algae) will greatly increase the known algal diversity. Crustose coralline red algal and turf algal functional groups (each containing numerous species) were the dominant algae found around Swains and observed in over 50% of sampled quadrats at 100% of sites.

Around Swains, the green alga *Rhipilia orientalis* was one of the dominant algal species found in high abundance at all sites assessed (Fig. 7.6.1c). *Microdictyon umbilicatum* (Vellay) Zanardini, a green algal species in the order Siphonocladales, was also in high abundance at most sites at Swains. Surprisingly, the calcified siphonous green algal genus, *Halimeda*, which is usually common in tropical marine environments, was relatively uncommon at most sites monitored around Swains, only being found in photoquadrats at one southern site (SWA-14). The green algal genus, *Dictyosphaeria*, was present in low abundance at most sites. Of interest, the green

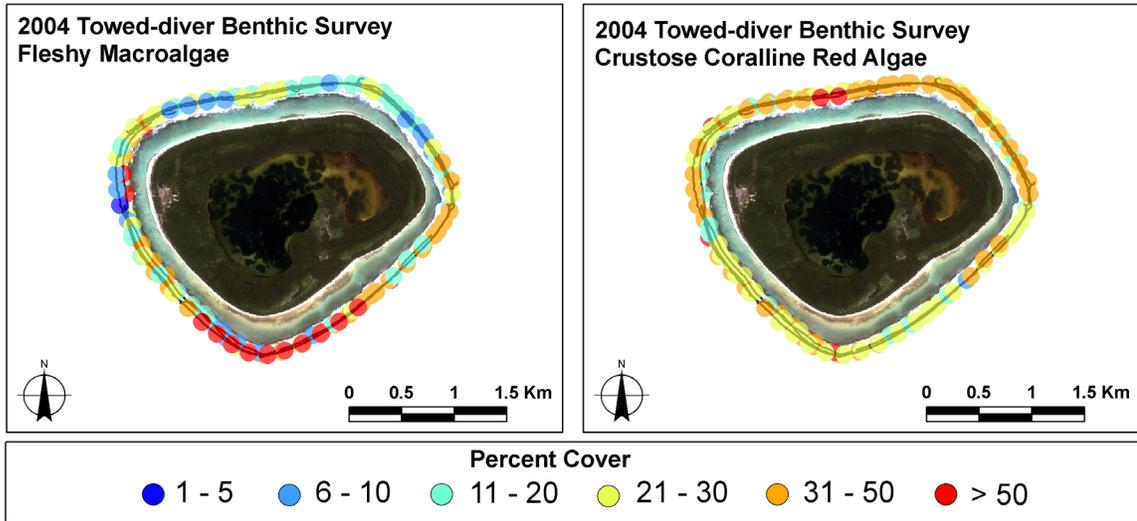


Figure 7.6.1b. Percent cover of fleshy macroalgae (including turf algae) and crustose coralline algae from towed-diver benthic surveys around Swains during ASRAMP 2004. Each colored point represents an integrated estimate over 5-min observation segments covering a survey swath of ~ 200 m × 10 m (~ 2000 m²).

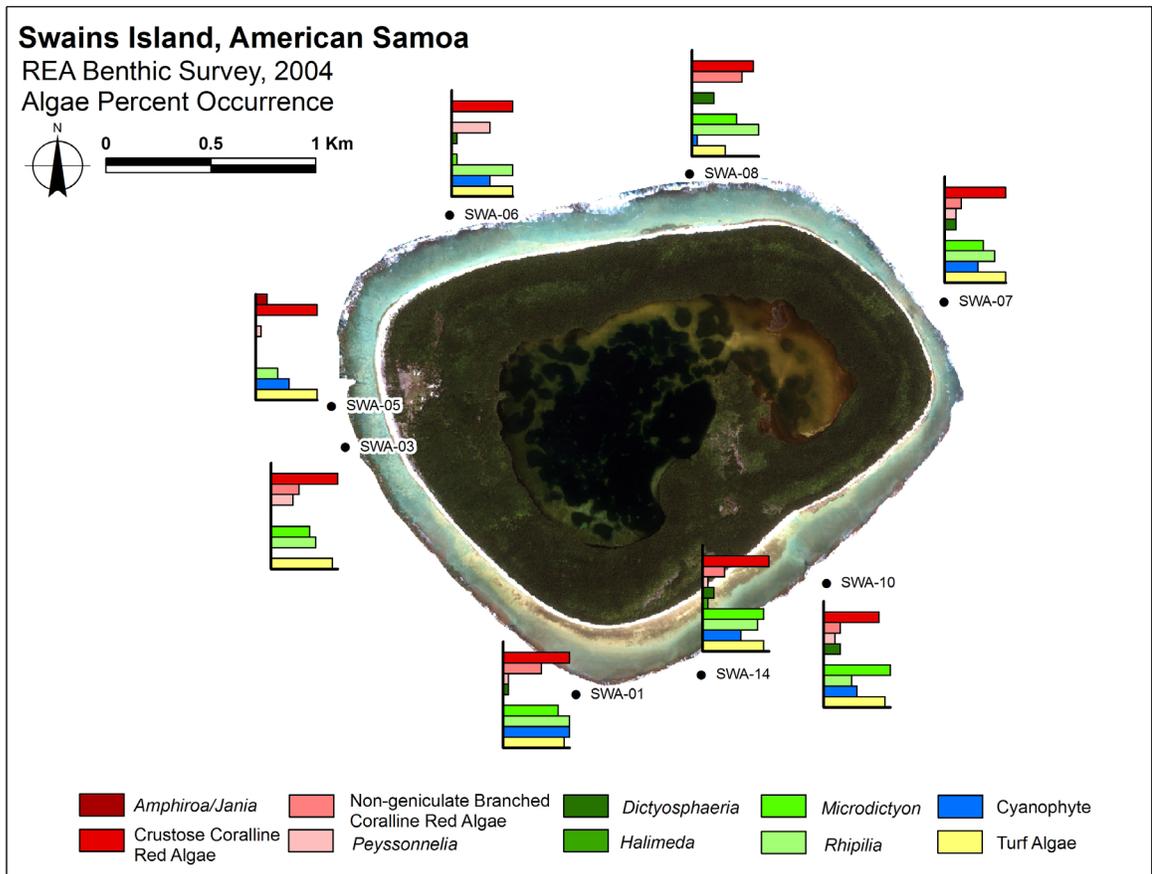


Figure 7.6.1c. Percent occurrence of select macroalgal genera and algal functional groups from REA surveys around Swains during ASRAMP 2004. Percent occurrence is equivalent to the percentage of photoquadrats in which an algal genus or functional group was observed. Length of x-axis denotes 100% occurrence.

alga *Caulerpa serrulata* was found during random collections made outside of quantitative photoquadrats and is a new record for Swains.

During ASRAMP 2004, some distributional trends were observed among macroalgal populations around Swains. The red algal genus, *Peyssonnelia*, was most abundant in photoquadrats at sites on the northwest corner of the island and was only observed in low abundance elsewhere. Alternatively, non-geniculate branched red algae were lacking from photoquadrats at northwestern sites but were fairly common at all other sites around the island. Sites on the west side of the island contained slightly lower algal species diversity than other areas.

2006 Spatial Surveys

A total of nine towed-diver surveys were conducted around Swains during ASRAMP 2006. Together, the mean cover of fleshy macroalgae (excluding turf) and crustose coralline algae made up 55.5% of the benthic substrate. Mean fleshy macroalgal cover was 36.1% (SE 1.8), and mean crustose coralline algal cover was 19.4% (SE 1.2; Fig. 7.6.1d). Macroalgal populations were greatest in the north region and were also elevated along southern-facing reefs. Crustose coralline algae were also of greatest abundance along the southern-facing reefs of Swains.

During ASRAMP 2006, quantitative algal surveys were conducted at eight sites around Swains, including seven of the eight sites surveyed in 2004 (Fig. 7.6.1e). A total of 11 macroalgal genera (7 green, 2 red, and 2 brown) and 3 additional algal functional groups (turf algae, crustose coralline red algae, and cyanophytes) were observed in the field. The diversity of crustose coralline red algal and turf algal functional groups (each of which contains numerous species) were the dominant algae found around Swains, being observed in over 50% of sampled quadrats at 71% and 57% of sites, respectively (Fig. 7.6.1e). The green algal genus *Rhipilia* was one of the dominant algal species found in high abundance at all sites. Surprisingly, the calcified siphonous green algal genus, *Halimeda*, which is usually common in tropical marine environments, was absent around Swains. *Microdictyon umbilicatum*, a green algal species in the order Siphonocladales, was common at northern, eastern, and southern sites around Swains. The northwestern side of the island exhibited the lowest algal diversity and abundance.

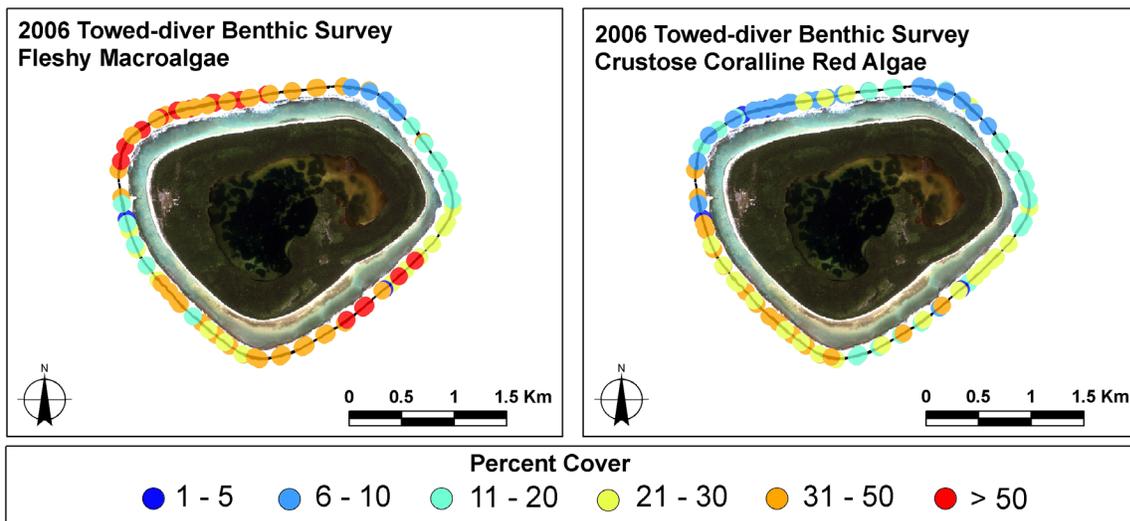


Figure 7.6.1d. Percent cover of fleshy macroalgae (including turf algae) and crustose coralline algae from towed-diver benthic surveys around Swains during ASRAMP 2006. Each colored point represents an integrated estimate over 5-min observation segments covering a survey swath of ~ 200 m × 10 m (~ 2000 m²).

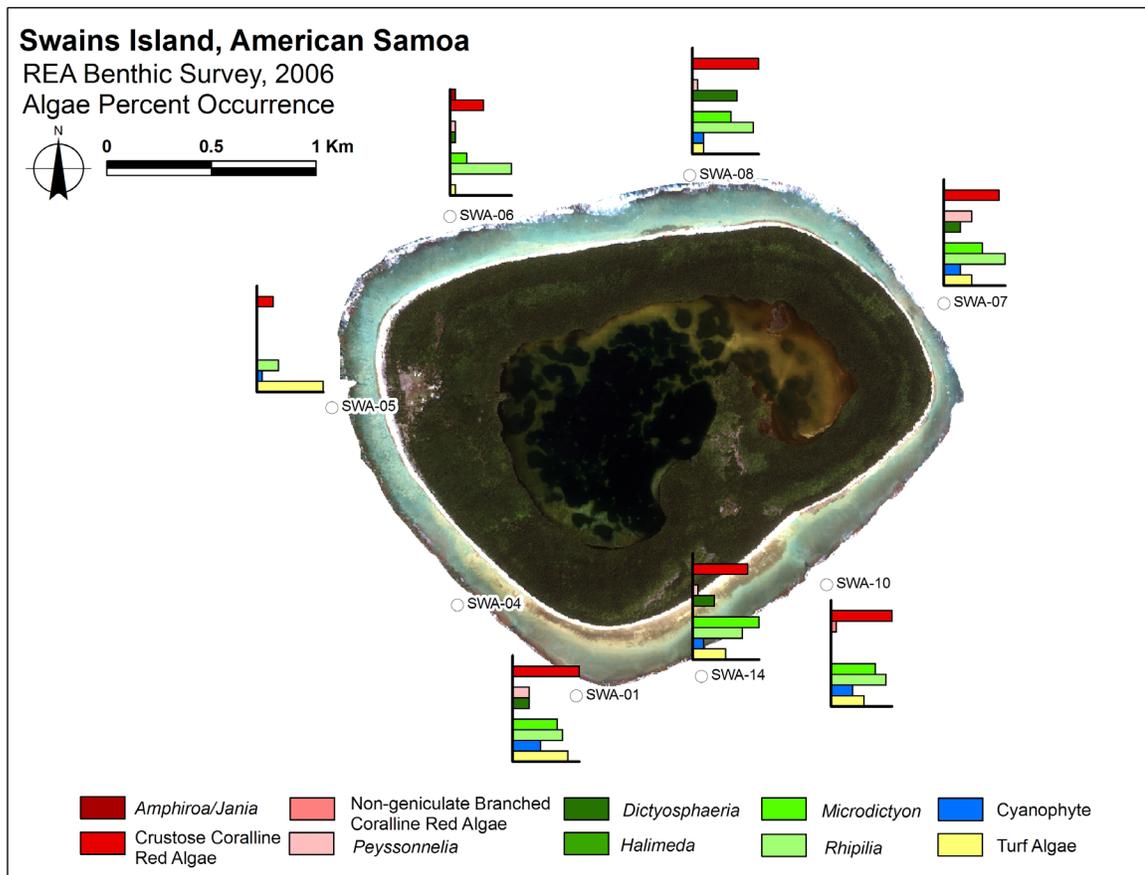


Figure 7.6.1e. Percent occurrence of select macroalgal genera and algal functional groups from REA surveys around Swains during ASRAMP 2006. Percent occurrence is equivalent to the percentage of photoquadrats in which an algal genus or functional group was observed. Length of x-axis denotes 100% occurrence.

7.6.2 Coralline Algal Disease Surveys

2006 Spatial Surveys

No coralline algal diseases or afflictions were observed at Swains in 2006.

7.6.3 Temporal Comparison—Algae

Temporal comparisons of both REA algal data and towed-diver benthic survey data are shown in Figures 7.6.3a and 7.6.3b, respectively. Algal populations around Swains were similar between ASRAMP 2004 and 2006. The number of macroalgal genera observed around Swains was similar for both years, with 10 and 11 genera recorded, respectively. The red calcified, geniculate genera *Amphiroa/Jania* were uncommon only occurring on the northwest corner of the atoll. The calcified green algal genus *Halimeda* was lacking from all photoquadrats sampled. No large cyanobacteria outbreaks or monotypic stands of invasive algae were discovered in 2004 or 2006.

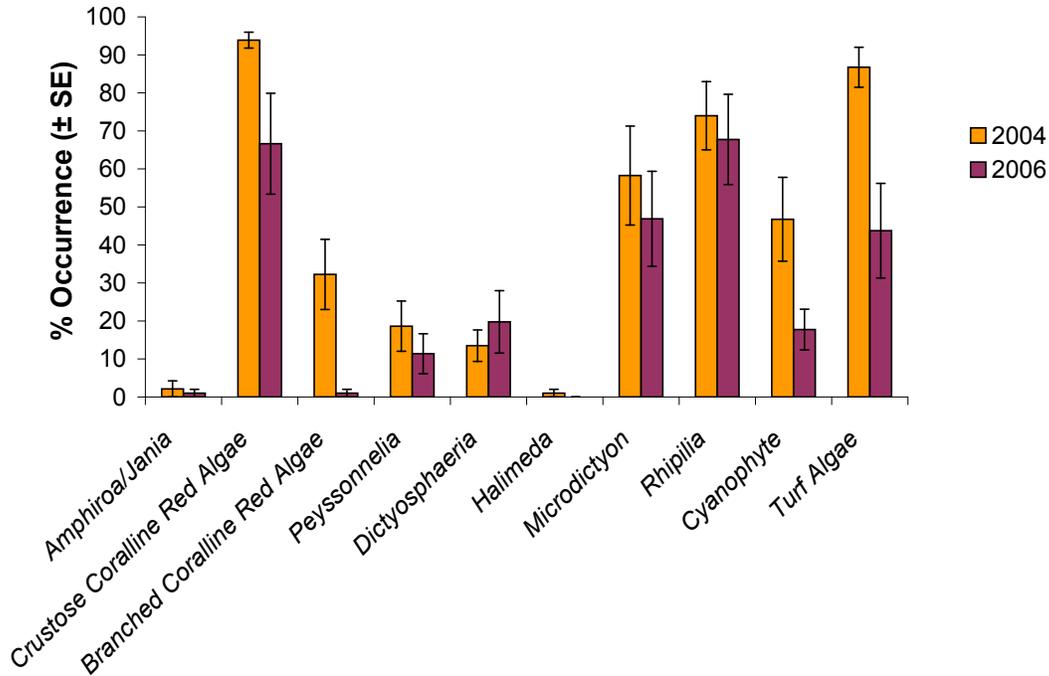


Figure 7.6.3a. Temporal comparison of REA algal genera and functional group percent occurrence around Swains between ASRAMP 2004 and 2006. See Chapter 2, Section 2.4: Reef Benthic (Coral, Algae, Macroinvertebrate) and Fish Surveys for considerations when comparing the results of these methodologies between years.

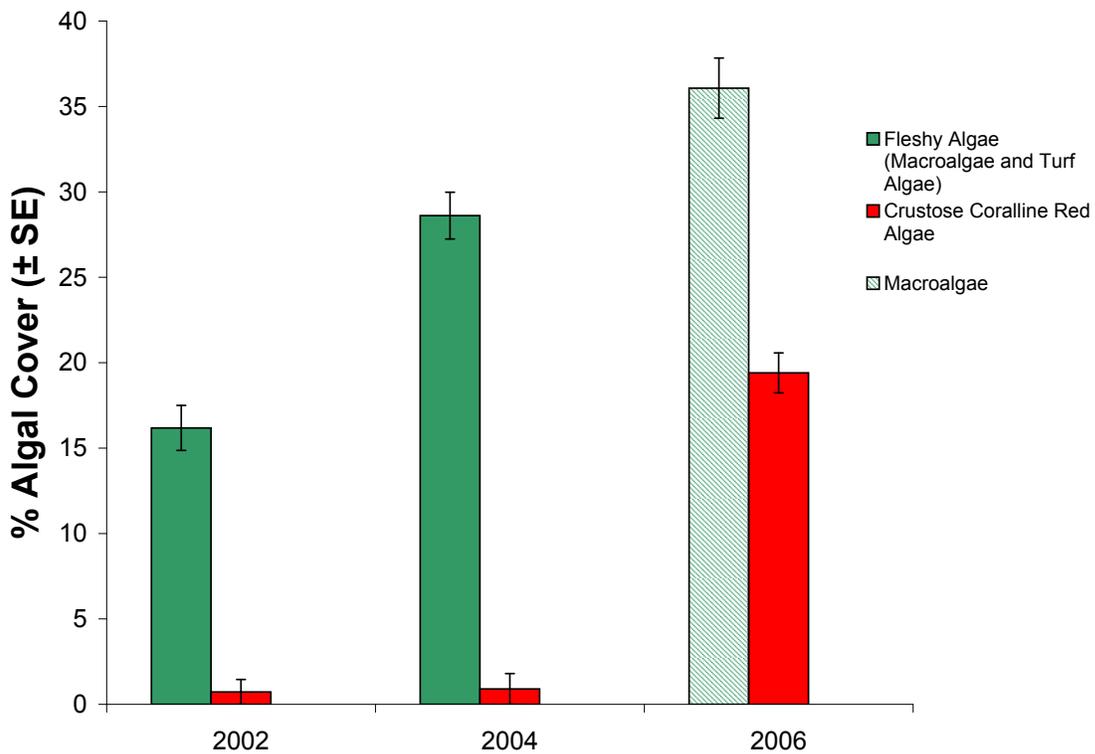


Figure 7.6.3b. Temporal comparison of towed-diver benthic survey algal percent cover results for fleshy crustose coralline and macroalgae for 2002, 2004, and 2006 ASRAMP surveys around Swains.

7.7 Benthic Macroinvertebrates

7.7.1 Benthic Macroinvertebrate Surveys

2002 Spatial Surveys

Towed-diver benthic macroinvertebrate surveys around Swains during ASRAMP 2002 found that COTS were commonly observed around the entire island with a mean density of 1.0 organisms ha^{-1}), but especially in the west, southeast, and north regions. No sea urchins or sea cucumbers were reported (Fig. 7.7.1a). Giant clam mean density was 0.4 organisms ha^{-1} , found along the north section of the island. As mentioned in the introduction (Chapter 1, Section 1.6: Limitations of Pacific RAMP), surveys in 2002 were limited by shipboard logistics and methods development that may have contributed to the paucity of macroinvertebrates observed in that year.

A total of 10 qualitative REA invertebrate surveys, focusing on general macroinvertebrate biodiversity, were conducted around Swains during ASRAMP 2002. These surveys provided baseline data used to design and scale the future methodology of macroinvertebrate REA surveys. No data are presented.

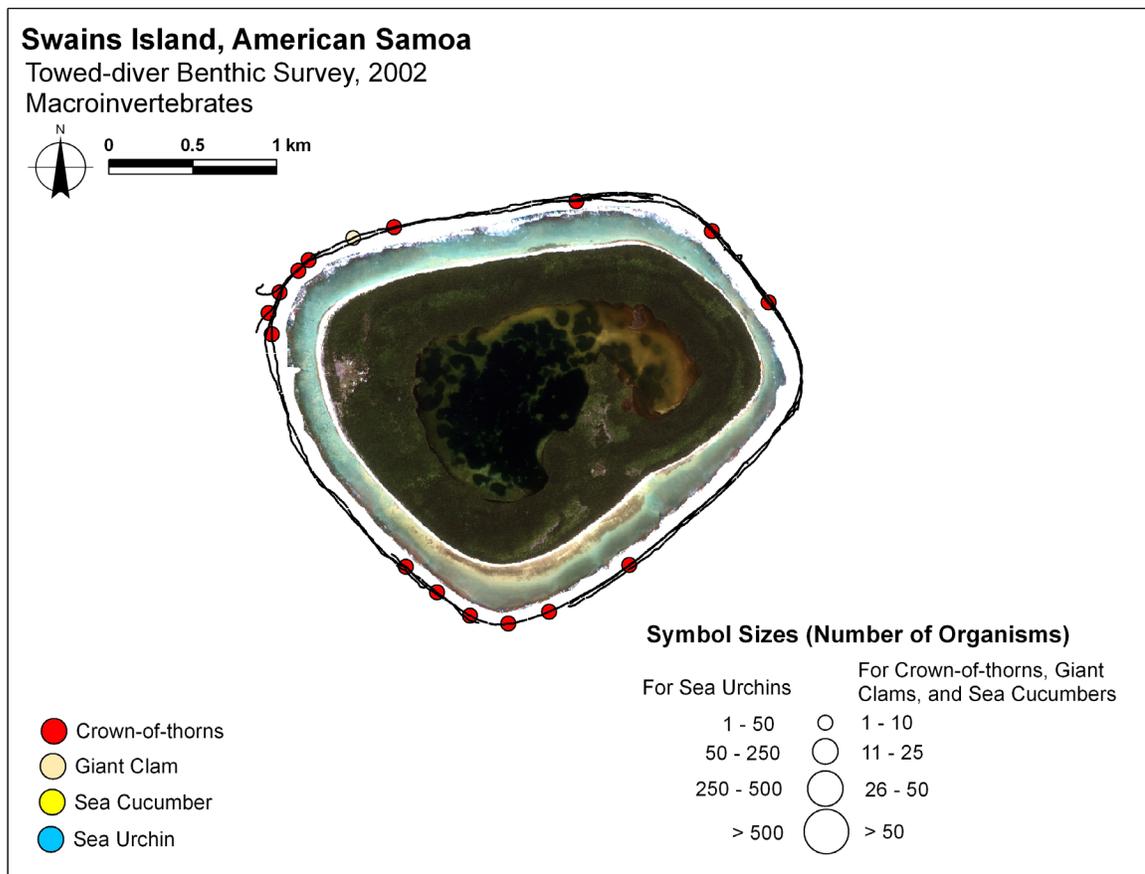


Figure 7.7.1a. Distribution of estimated population densities of COTS, giant clams, sea cucumbers, and sea urchins at Swains from towed-diver benthic surveys during ASRAMP 2002. Circle locations represent an integrated estimate over 5-min observation segments covering a survey swath of $\sim 200\text{ m} \times 10\text{ m}$ ($\sim 2000\text{ m}^2$). The sizes of the circles indicate the number of organisms counted or estimated in each $\sim 2000\text{ m}^2$ segment with one scale for COTS, giant clams, and sea cucumbers (1–10, 11–25, 26–50, and > 50) and another scale for sea urchins (1–50, 51–250, 251–500, and > 500).

2004 Spatial Surveys

Towed-diver benthic macroinvertebrate surveys around Swains during ASRAMP 2004 found few macroinvertebrates around Swains, with the exception of COTS (Fig. 7.7.1b). Only one giant clam was encountered during towed-diver surveys. Sea urchins (mean: 13.7 organisms ha⁻¹) and sea cucumbers (mean: 0.1 organisms ha⁻¹) were seen in very low densities around the island. A total of 91 COTS were observed around Swains (mean: 3.3 organisms ha⁻¹). The distribution of COTS was variable with a slightly higher concentration observed around the southern corner of the island.

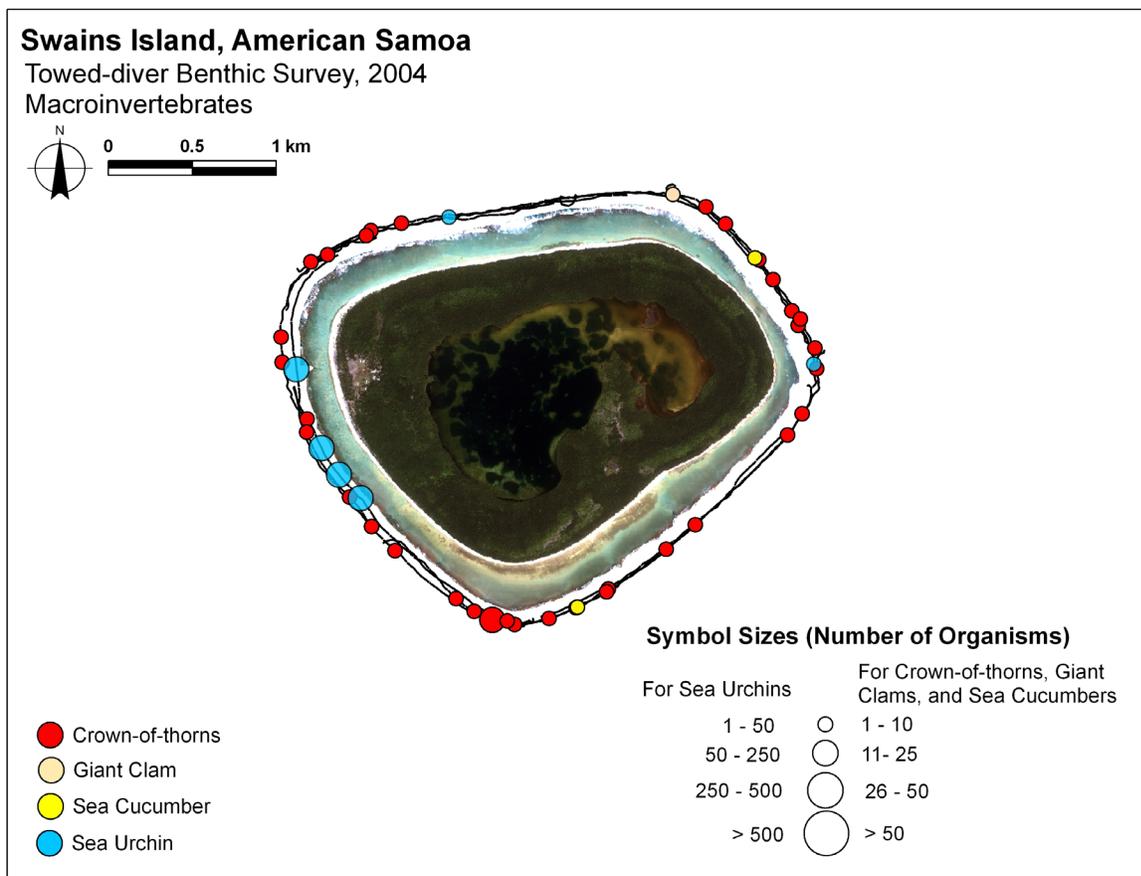


Figure 7.7.1b. Distribution of estimated population densities of COTS, giant clams, sea cucumbers, and sea urchins at Swains from towed-diver benthic surveys during ASRAMP 2004. Circle locations represent an integrated estimate over 5-min observation segments covering a survey swath of ~ 200 m × 10 m (~ 2000 m²). The sizes of the circles indicate the number of organisms counted or estimated in each ~ 2000 m² segment with one scale for COTS, giant clams, and sea cucumbers (1–10, 11–25, 26–50, and > 50) and another scale for sea urchins (1–50, 51–250, 251–500, and > 500).

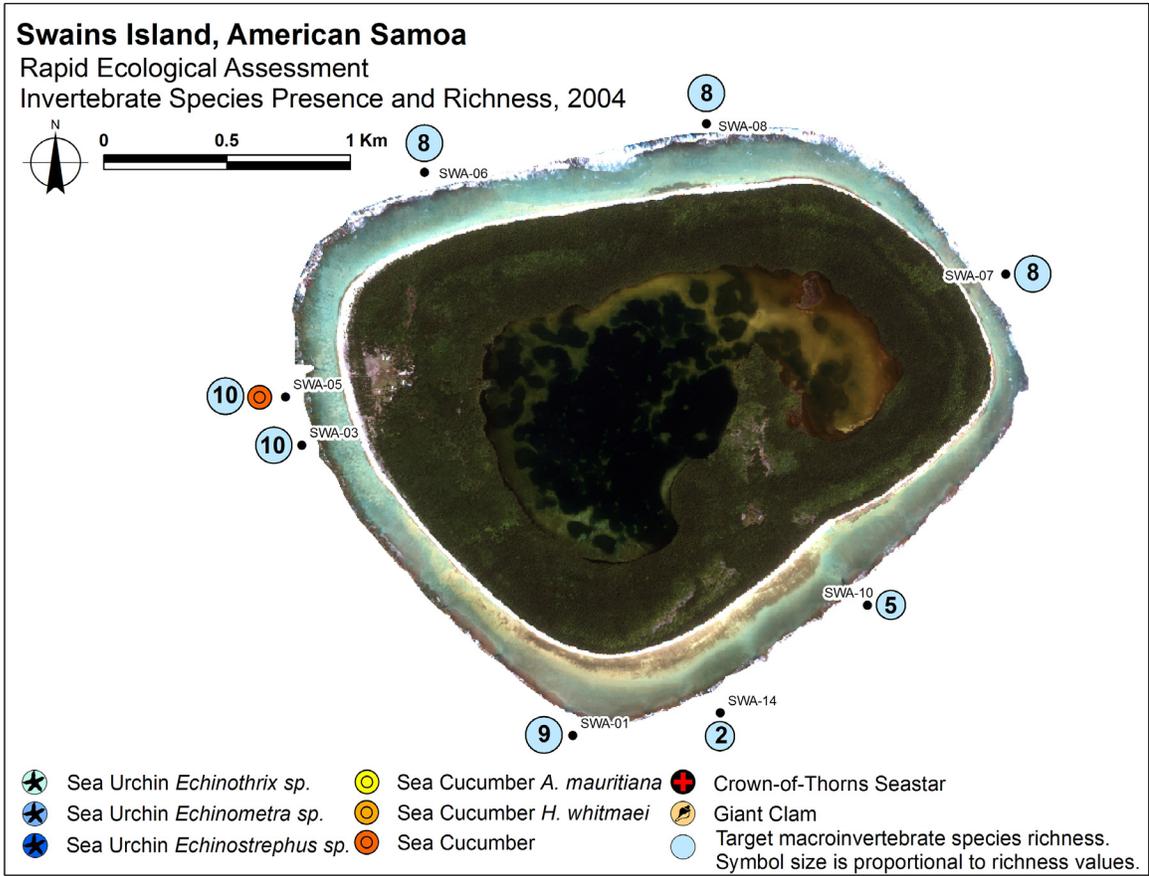


Figure 7.7.1c. Macroinvertebrate species richness, and target macroinvertebrate distribution at Swains from REA surveys during ASRAMP 2004. Size of light blue circles and values in circles indicate target species richness values for each REA site. Other symbols indicate the presence of specific target species.

During ASRAMP 2004, invertebrate species richness was relatively low at all REA sites around Swains, ranging from 2 species observed at SWA-14 to 10 species observed at SWA-05 and -03 (Fig. 7.7.1c). No giant clams or sea urchins were recorded, while only a single sea cucumber, *Thelonota ananas*, was observed (SWA-05). Unlike towed-diver surveys, no COTS were recorded at REA sites.

2006 Spatial Surveys

Towed-diver benthic macroinvertebrate surveys during ASRAMP 2006 found few macroinvertebrates around Swains, with the exception of COTS (Fig. 7.7.1d). Two sea cucumbers were observed within the west region of Swains, while no giant clams or sea urchins were encountered. A total of 88 COTS were observed around Swains in 2006 for a mean density of 4.9 organisms ha⁻¹. COTS were relatively common in the west and southeast coasts of Swains, but encounters were far less frequent during towed-diver surveys along the north and east regions.

During ASRAMP 2006, target invertebrates were almost completely absent from REA surveys around Swains (Fig. 7.7.1e). Two species of sea urchins, *Echinostrephus aciculatus* and *Echinometra mathei*, were present at one site each (SWA-05 and -14, respectively). COTS were observed at three sites, all along the west coast of Swains.

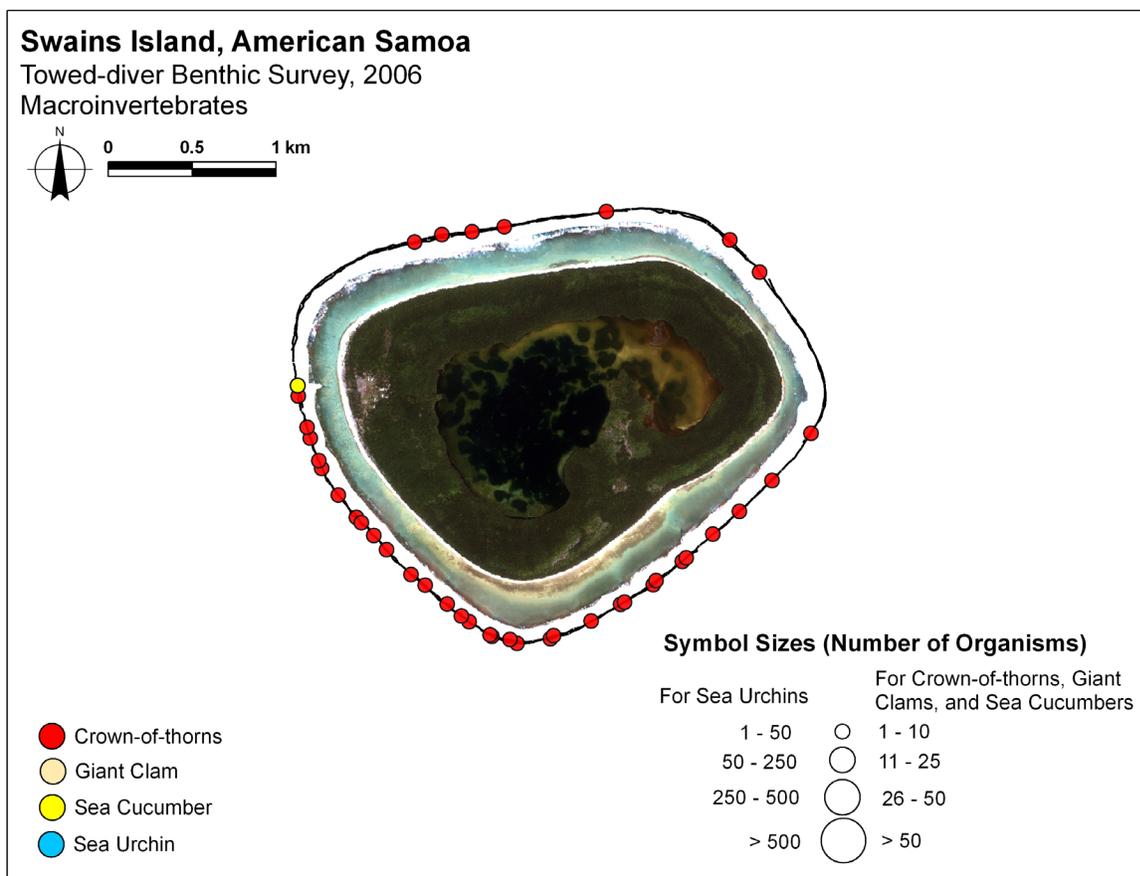


Figure 7.7.1d. Distribution of estimated population densities of COTS, giant clams, sea cucumbers, and sea urchins at Swains from towed-diver benthic surveys during ASRAMP 2006. Circle locations represent an integrated estimate over 5-min observation segments covering a survey swath of ~ 200 m × 10 m (~ 2000 m²). The sizes of the circles indicate the number of organisms counted or estimated in each ~ 2000 m² segment with one scale for COTS, giant clams, and sea cucumbers (1–10, 11–25, 26–50, and > 50) and another scale for sea urchins (1–50, 51–250, 251–500, and > 500).

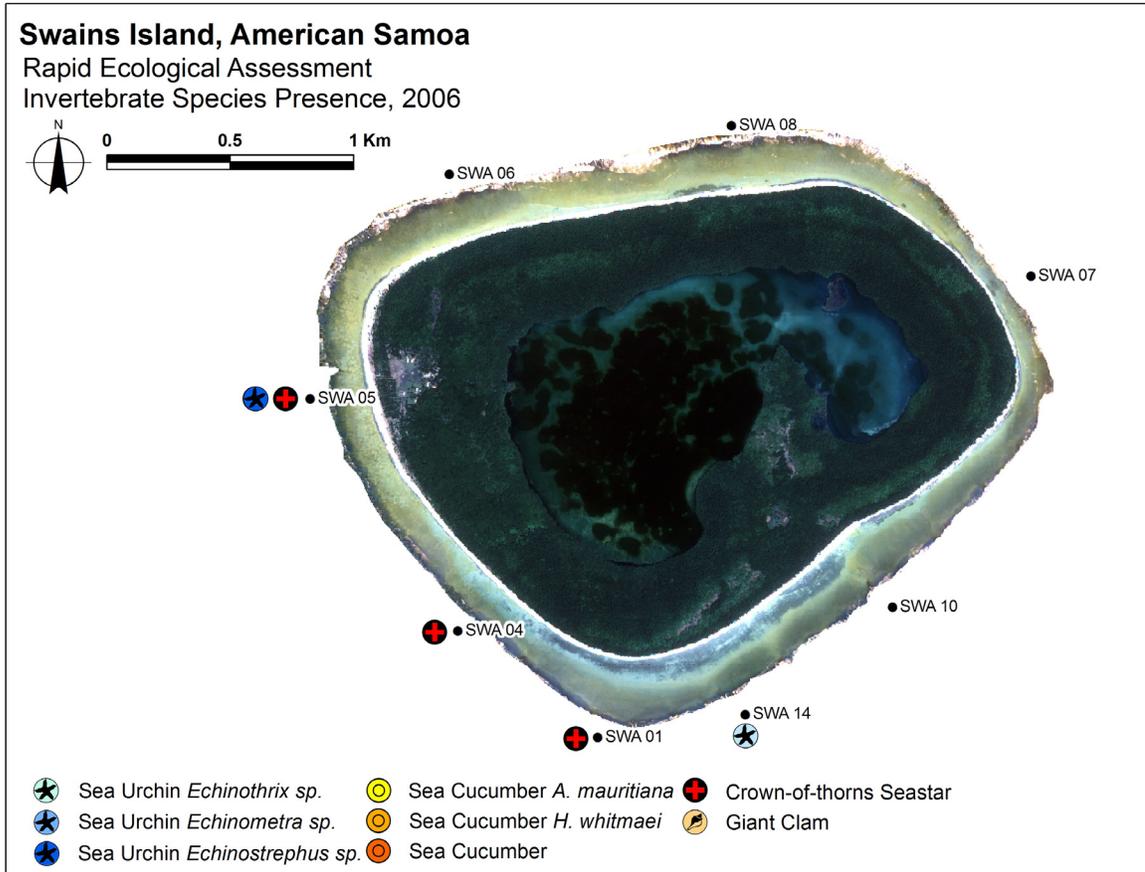


Figure 7.7.1e. Target macroinvertebrate distribution at Swains from REA surveys conducted during ASRAMP 2006.

7.7.2 Temporal Comparison—Benthic Macroinvertebrates

Temporal patterns of island-wide mean benthic macroinvertebrate density (# organisms m⁻²) around Swains from towed-diver benthic surveys during ASRAMP 2002, 2004 and 2006 are shown in Figures 7.7.2a (COTS), 7.7.2b (giant clams), 7.7.2c (sea cucumbers), and 7.7.2d (sea urchins). Towed-diver survey results show trends in density within each surveyed organism and between each sampling year.

With the exception of the COTS, macroinvertebrates were extremely rare around Swains during both 2004 and 2006 surveys. The average COTS sighting per hectare increased almost fivefold between 2002 and 2006, from 1 COTS ha⁻¹ in 2002 to 4.7 COTS ha⁻¹ in 2006 (Fig. 7.7.2a). Giant clams (*Tridacna* sp.) declined between 2002 and 2006, with no giant clams observed in 2006; the reason for this decline is unknown (Fig. 7.7.2b). Sea cucumbers and sea urchins were not seen in high densities in any years (Figs. 7.7.2c and 7.7.2d).

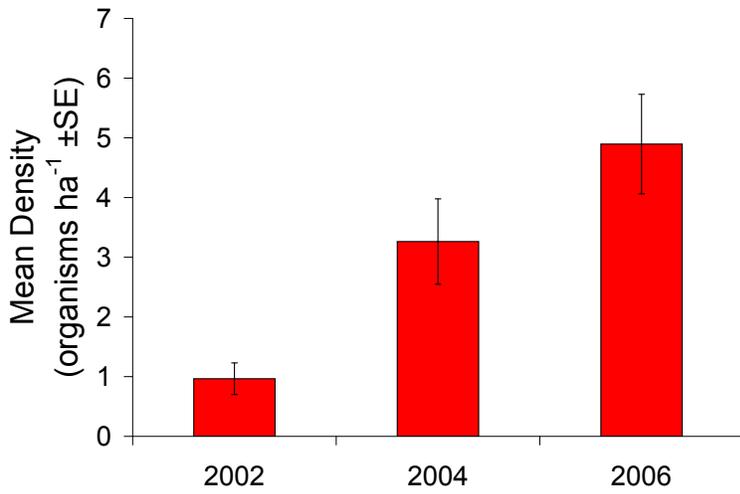


Figure 7.7.2a. Mean density of COTS at Swains from towed-diver surveys during ASRAMP 2002, 2004, and 2006.

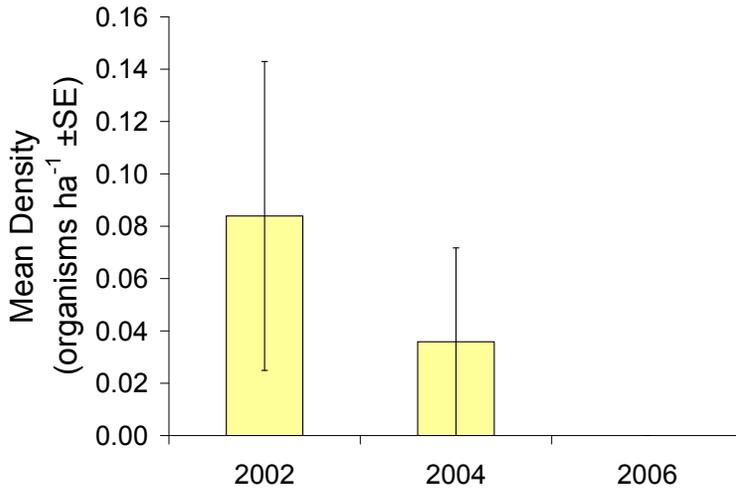


Figure 7.7.2b. Mean density of giant clams at Swains from towed-diver surveys during ASRAMP 2002, 2004, and 2006.

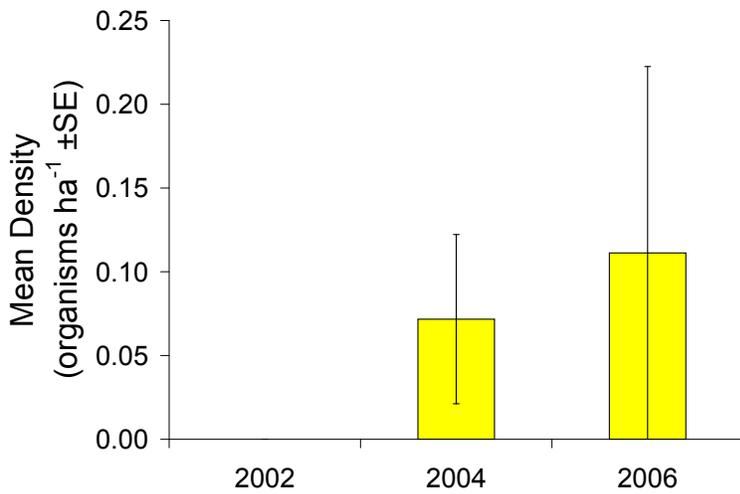


Figure 7.7.2c. Mean density of sea cucumber (holothuroids) at Swains from towed-diver surveys during ASRAMP 2002, 2004, and 2006.

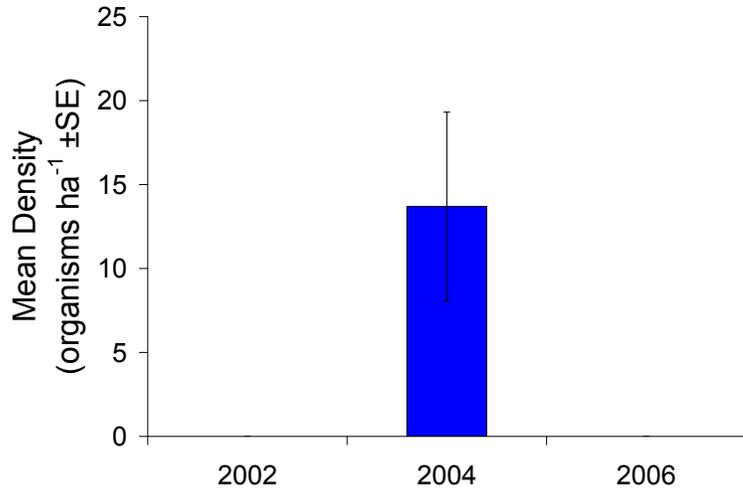


Figure 7.7.2d. Mean density of sea urchins (echinoids) at Swains from towed-diver surveys during ASRAMP 2002, 2004, and 2006.

7.8. Reef Fish

7.8.1 Reef Fish Surveys

2002 Spatial Surveys

Large fish (> 50 cm) biomass was relatively elevated and evenly distributed around Swains during ASRAMP 2002 (0.256 tons ha⁻¹ [SE 0.130]; Fig. 7.8.1a). Barracudas clearly dominated biomass, followed closely by lower biomass of jacks and snappers.

Sharks were most frequently sighted in the east and southeast regions and were represented by the grey reef shark (*Carcharhinus amblyrhynchos*) and the reef whitetip shark (*Triaenodon obesus*; Fig. 7.8.1a). Humphead wrasses (*Cheilinus undulatus*) were observed less frequently at various locations around the island. In addition, several large (> 1.5 m total length) dogtooth

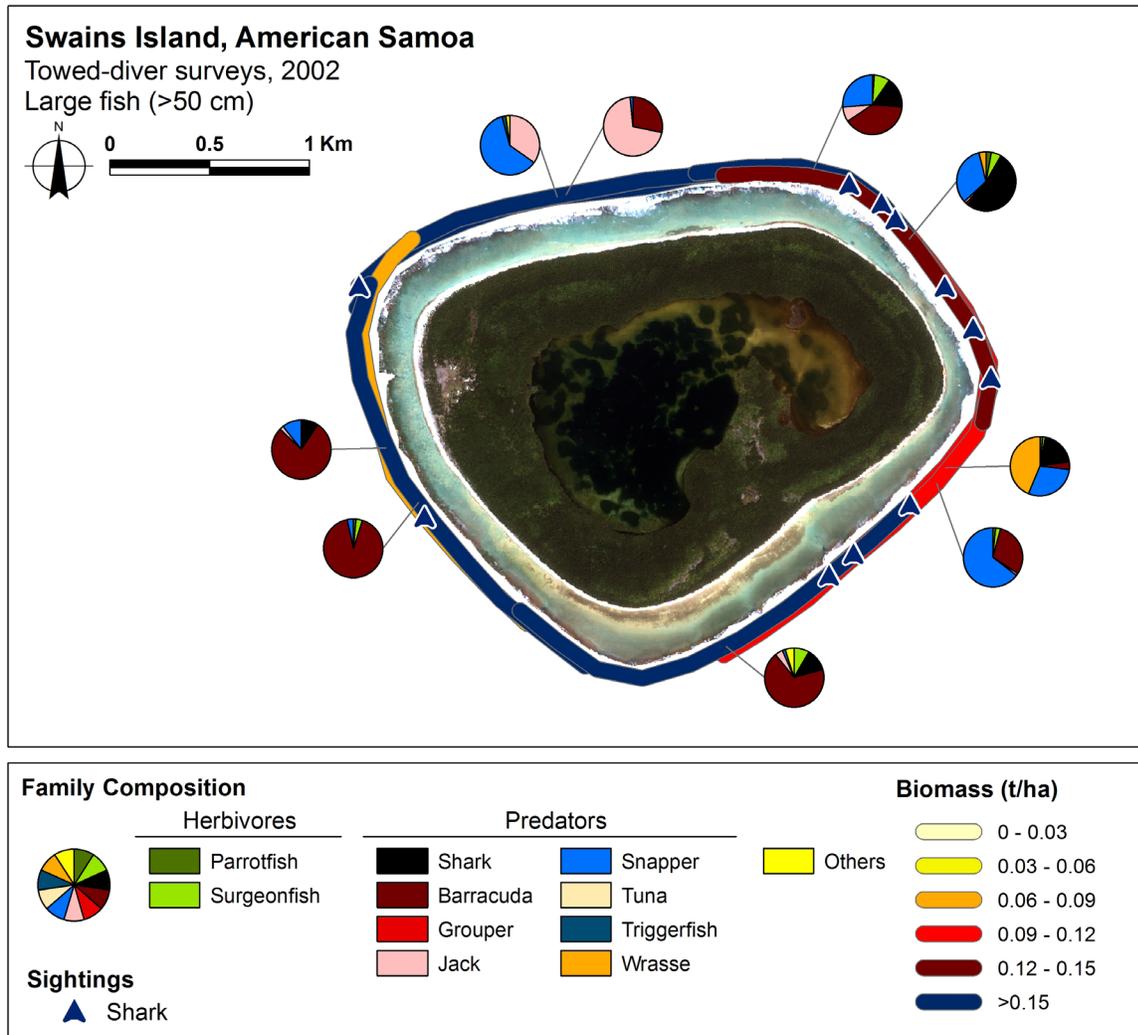


Figure 7.8.1a. Large fish biomass, family composition, and individual shark sightings at Swains recorded during ASRAMP 2002 towed-diver surveys. Large fish (length > 50 cm) biomass on each individual towed-diver survey is represented by the color of the survey track. Composition by trophic group is indicated by the family colors (green—mostly herbivores; other colors—mostly predators or mixed). Individual shark sightings, observed inside or outside the survey area, are represented by blue triangles.

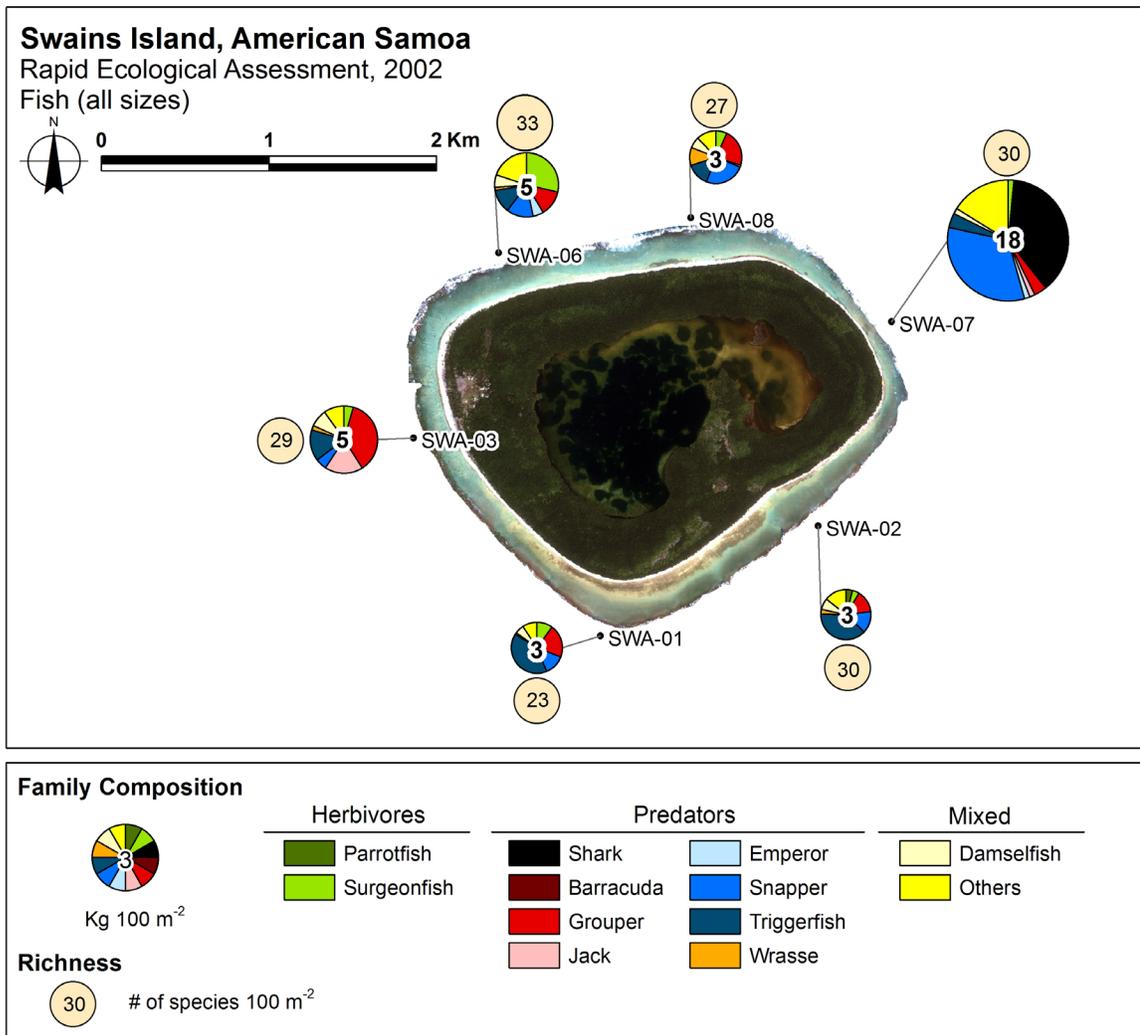


Figure 7.8.1b. Total fish biomass, family composition, and species richness of fishes at Swains recorded during ASRAMP 2002 REA belt-transect surveys. Total fish biomass (all species and size classes) is represented at each site by the size of the pie chart with the actual biomass value in the center (kg 100 m⁻²). Composition by trophic group is indicated by the family colors (green—mostly herbivores; other colors—mostly predators or mixed). Species richness at each REA site is indicated by numbers and the size of the beige circles.

tunas (*Gymnosarda unicolor*) and a school of approximately 100 blackfin barracudas (*Sphyrna genie*) were sighted.

Total fish biomass was similar at most sites around Swains during 2002 surveys (6.3 kg 100 m⁻² [SE 3.6]), except for site SWA-07 which had an elevated biomass related to a rare shark sighting on one transect (Fig. 7.8.1b). Predators, mainly snappers, groupers, and triggerfish, were the most abundant trophic group at all sites. The most common snapper and grouper were *Lutjanus bohar* and *Cephalopholis argus*, respectively. Herbivores were observed in relatively low abundance.

Species richness was approximately 30 fish species at each REA site and fairly consistent around the island (Fig. 7.8.1b).

2004 Spatial Surveys

Results from towed-diver surveys during ASRAMP 2004 showed that barracudas composed most of the large fish (> 50 cm total length) biomass around Swains, followed by snappers and jacks. The blacktongue unicornfish (Surgeonfish; *Naso hexacanthus*) was especially abundant. Distinct schools of more than 100 barracuda (*Sphyraena qenie*) and bigeye trevally (*Caranx sexfasciatus*) were again encountered. Overall, large fish biomass was very high around the island (0.164 tons ha⁻¹ [SE 0.102]), particularly in the north region (Fig. 7.8.1c).

Humphead wrasses (*Chelinus undulatus*) were seen in loose aggregations of up to 10 individuals (50 to > 150 cm total length), mostly in the west and east regions of the island. Behavior and densities suggest that this may be a resident spawning aggregation. In contrast to the abundance of other large fish taxa, shark sightings were relatively scarce (Fig. 7.8.1c).

During ASRAMP 2004, the overall fish biomass around Swains was around 29.3 kg 100 m⁻²

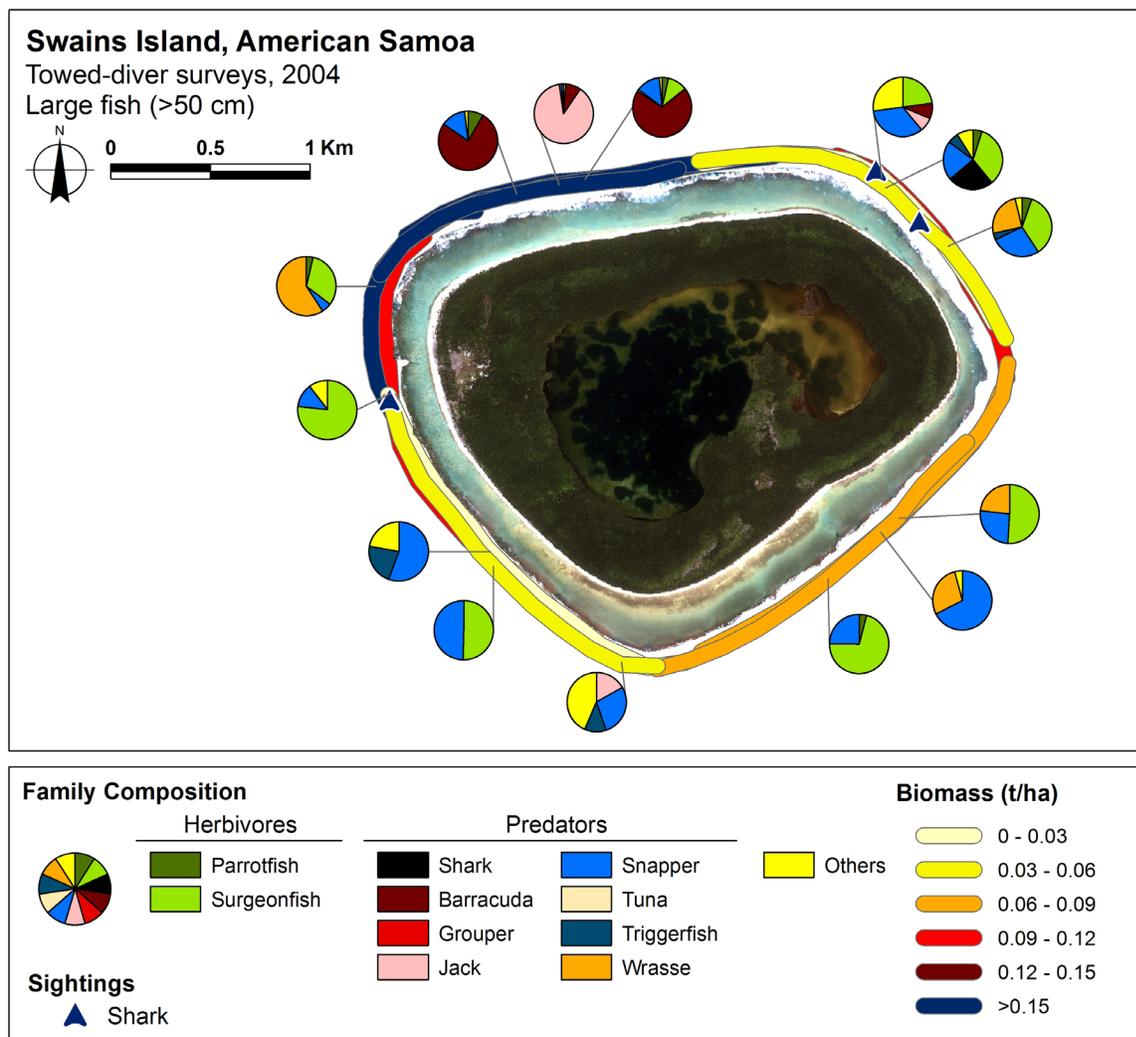


Figure 7.8.1c. Large fish biomass, family composition, and individual shark sightings at Swains recorded during ASRAMP 2004 towed-diver surveys. Large fish (length > 50 cm) biomass on each individual towed-diver survey is represented by the color of the survey track. Composition by trophic group is indicated by the family colors (green—mostly herbivores; other colors—mostly predators or mixed). Individual shark sightings, observed inside or outside the survey area, are represented by blue triangles.

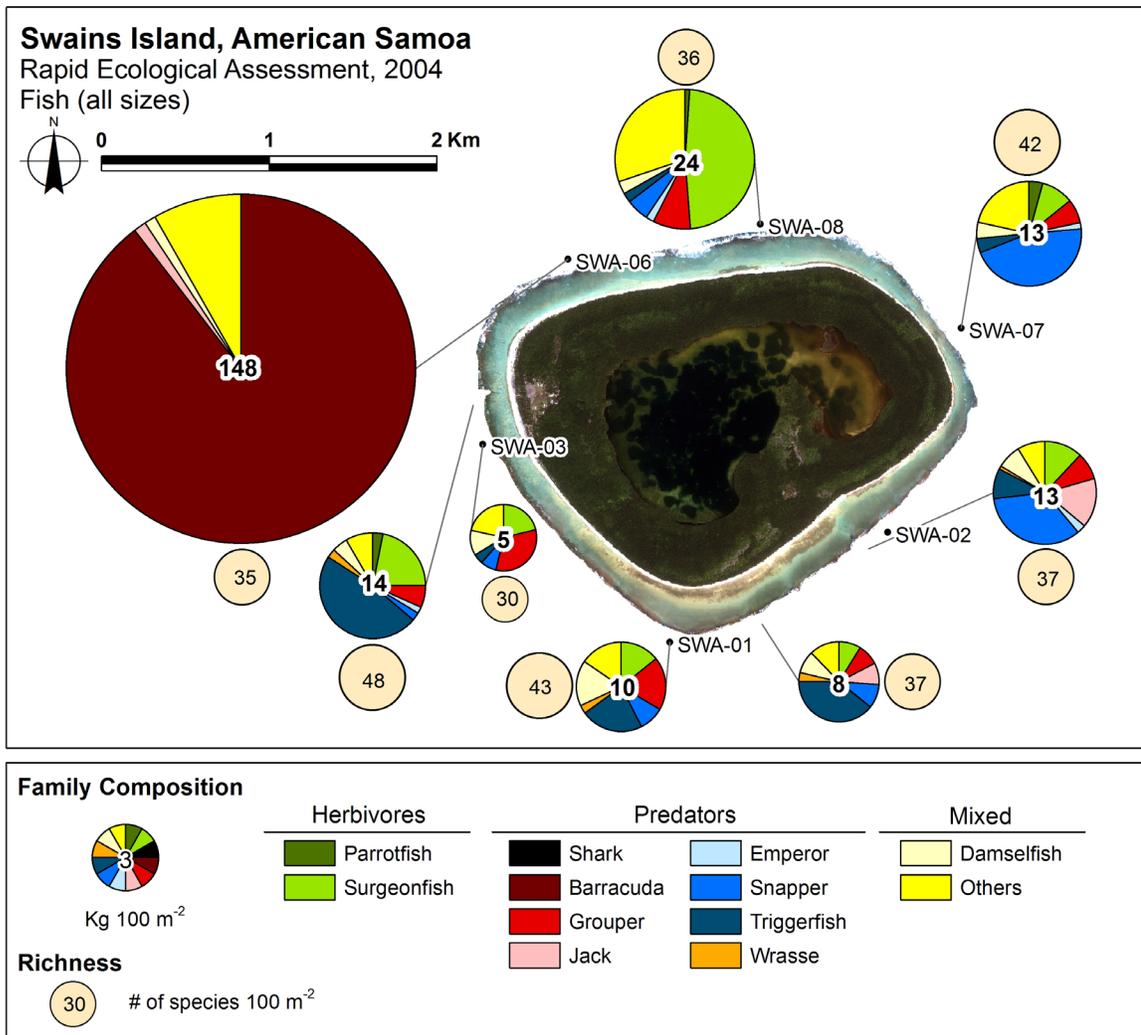


Figure 7.8.1d. Total fish biomass, family composition, and species richness of fishes around Swains recorded during ASRAMP 2004 REA belt-transect surveys. Total fish biomass (all species and size classes) is represented at each site by the size of the pie chart with the actual biomass value in the center. Composition by trophic group is indicated by the family colors (green—mostly herbivores; other colors—mostly predators or mixed). Species richness at each REA site is indicated by numbers and the size of the beige circles.

(SE 20.1); the greatest biomass was around the north region of the island (~ 86 kg 100 m⁻²; Fig. 7.8.1d). This observation remained constant even when the singular occurrence of a massive school of barracudas (*Sphyraena qenie*) encountered at site SWA-06 was removed from the analysis (~ 22 kg 100 m⁻²). Predators remained the dominant trophic group around the island (e.g., triggerfish, snappers, and groupers).

Medium-large fish (> 25 cm total length) biomass recorded during stationary point count surveys was dominated by snappers, followed by surgeonfish and groupers. Moderate levels were recorded for triggerfish, parrotfish, and jacks.

Species richness was slightly higher than in 2002 (~ 40 species 100 m⁻²) and was distributed evenly around Swains (Fig. 7.8.1d).

2006 Spatial Surveys

During ASRAMP 2006, the overall large fish (> 50 cm total length) biomass (all families pooled) was on average of 0.132 tons ha⁻¹ (SE 0.085; Fig. 7.8.1e). Similar to 2004, large fish biomass was mainly composed of jacks, barracudas, and sharks and was concentrated in the north and, to a lesser extent, south regions of the island.

A relatively high number of humthead wrasses were observed in 2006. Sharks were generally encountered in the north and south sections of the island during towed-diver surveys (Fig. 7.8.1e).

Similar to previous years, the total reef fish biomass during ASRAMP 2006 was highest in the north section of the island (~ 11 kg 100 m⁻²) caused by a large school of jacks (*Caranx sexfasciatus*; Fig. 7.8.1f). Overall total biomass was a relatively low 6.5 kg 100 m⁻² (SE 2.9).

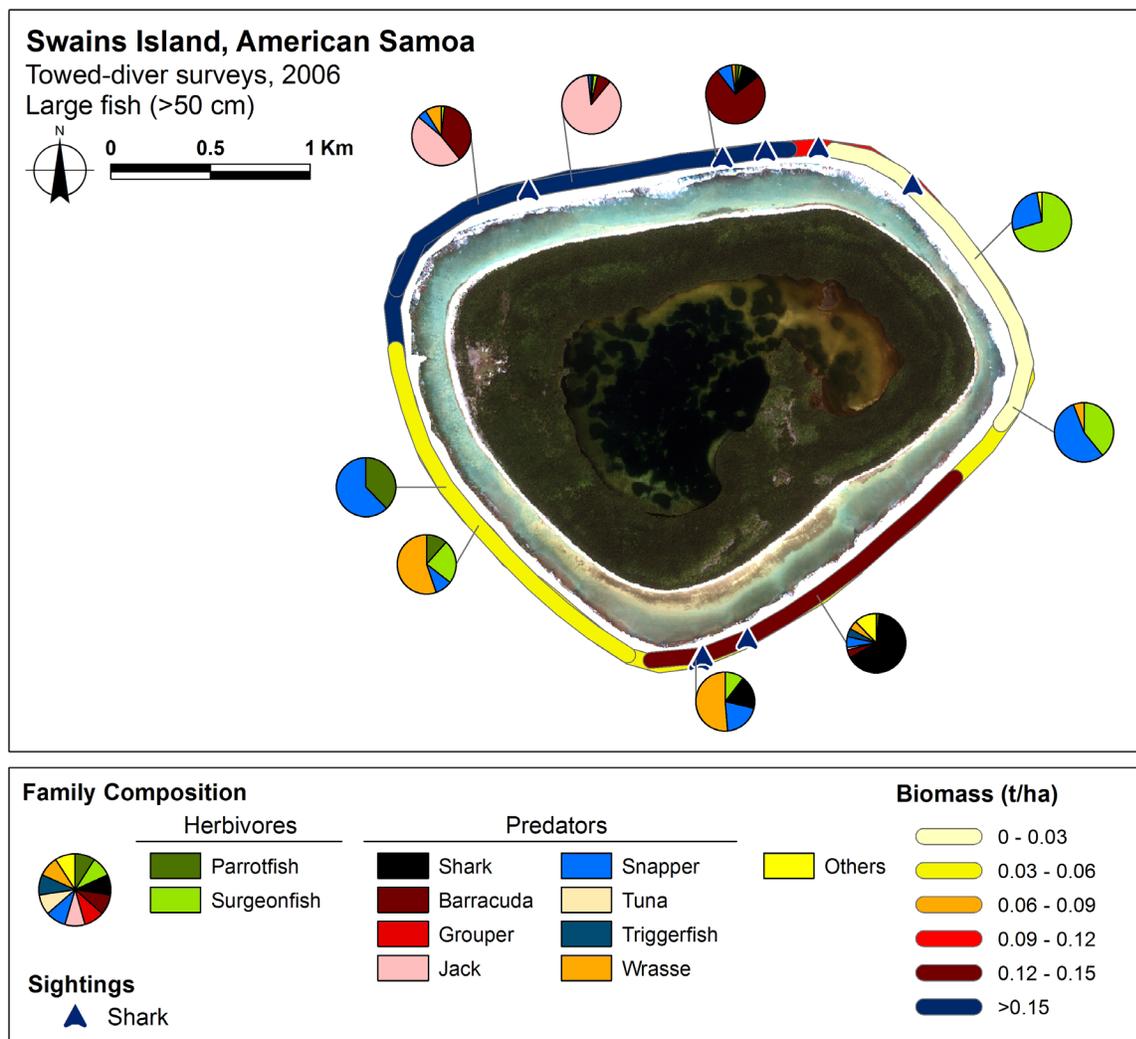


Figure 7.8.1e. Large fish biomass, family composition, and individual shark sightings around Swains recorded during ASRAMP 2006 towed-diver surveys. Large fish (length > 50 cm) biomass on each individual towed-diver survey is represented by the color of the survey track. Composition by trophic group is indicated by the family colors (green—mostly herbivores; other colors—mostly predators or mixed). Individual shark sightings, observed inside or outside the survey area, are represented by blue triangles.

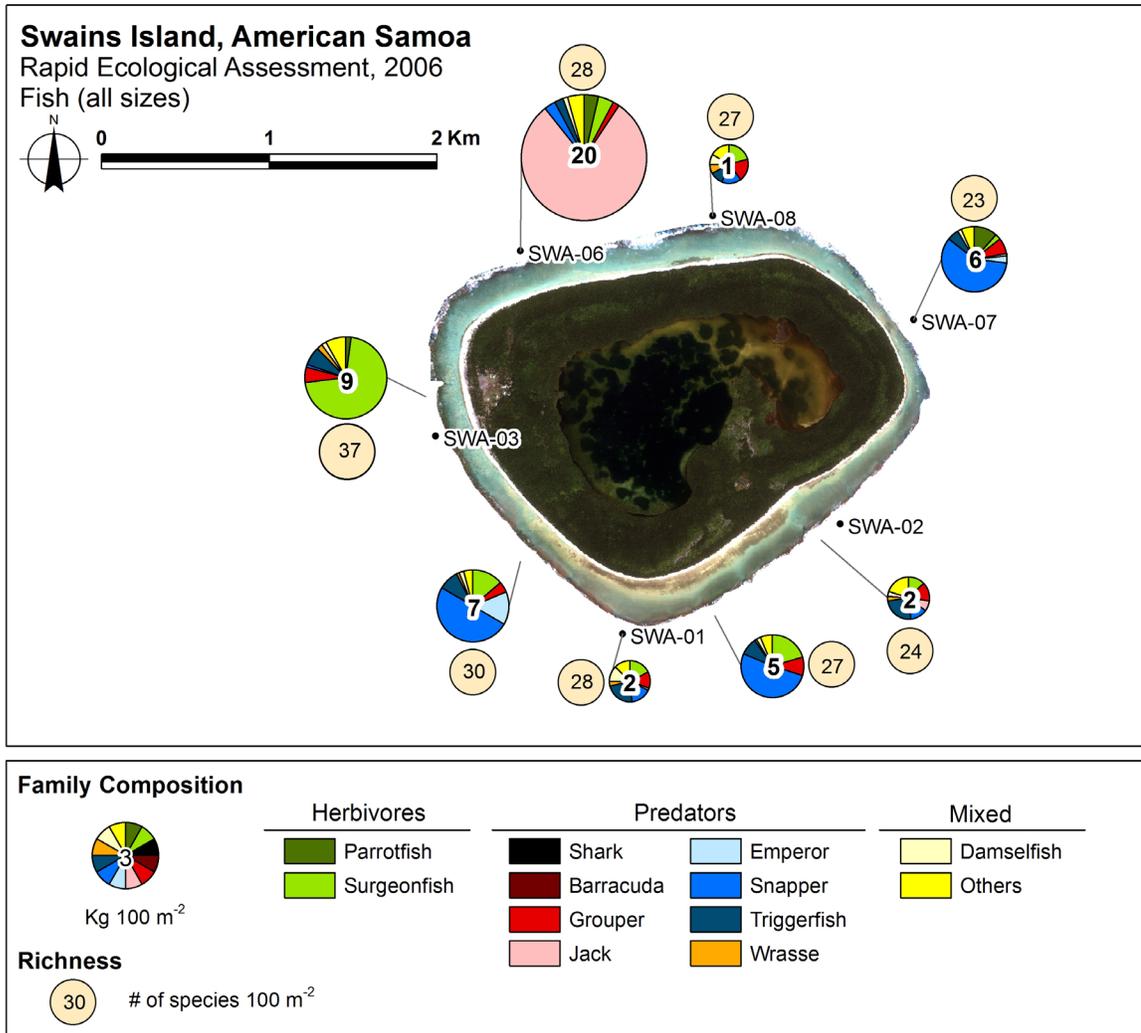


Figure 7.8.1f. Total fish biomass, family composition, and species richness of fishes around Swains recorded during ASRAMP 2006 REA belt-transect surveys. Total fish biomass (all species and size classes) is represented at each site by the size of the pie chart with the actual biomass value in the center. Composition by trophic group is indicated by the family colors (green—mostly herbivores; other colors—mostly predators or mixed). Species richness at each REA site is indicated by numbers and the size of the beige circles.

Snappers still represented the highest biomass of medium-large (> 25 cm total length) taxa around Swains, based on stationary point count surveys. Surgeonfish, wrasses (including several humpheads), grouper, and jacks (e.g., schools of rainbow runner, *Elegatis bipinnulata*) were also common. Parrotfish were rare around the island.

Fish species richness was slightly higher on the western side of the island (~ 30 species 100 m⁻²) compared to the eastern side (~ 25 species 100 m⁻²). In general, species richness was similar to 2002, which was lower than 2004 (Fig. 7.8.1f).

7.8.2 Temporal Comparison—Reef Fish

Total fish biomass distribution was variable among years, but this is mainly caused by the chance occurrence of very large schools at various sites (e.g., jacks, emperors, or barracudas). Swains was characterized by these large schools of predators and the general dominance of other predators

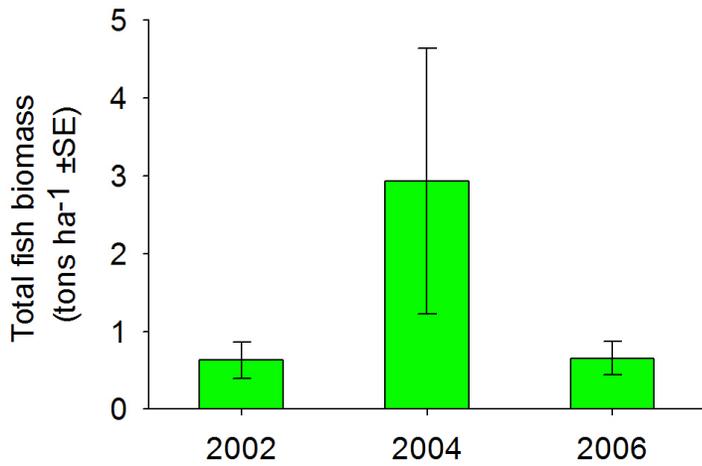


Figure 7.8.2a. Total fish biomass at Swains during ASRAMP 2002 (6 sites), 2004 (8 sites), and 2006 (8 sites) REA surveys.

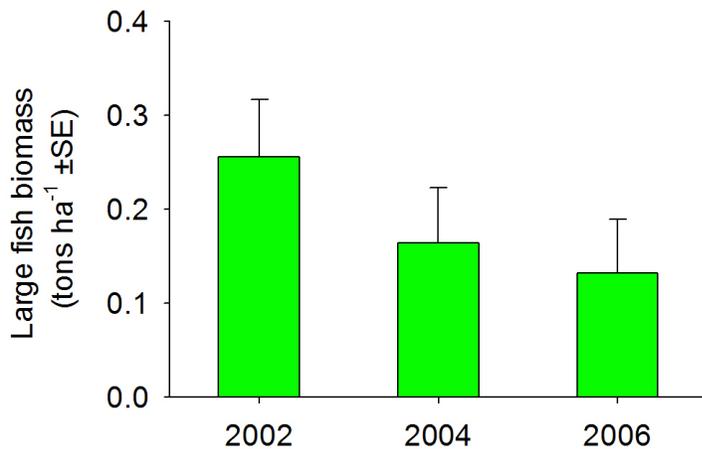


Figure 7.8.2b. Large fish biomass at Swains during ASRAMP 2002 (9 surveys), 2004 (14 surveys), and 2006 (9 surveys) towed-diver surveys.

at practically all sites in all years surveyed. This also explains the high interyear variability in total fish biomass (Fig. 7.8.2a). Overall fish biomass for the island was around 1.84 tons ha⁻¹ (SE 0.86).

Large fish biomass (> 50 cm total length) was high around the entire island but mainly concentrated in the northwest section. Large schools of barracudas and jacks were almost always encountered there. The bulk of the biomass was represented by barracudas, jacks, snappers, and sharks. Similar to Rose Atoll, large fish biomass around Swains appears to have decreased by half, from 0.256 tons ha⁻¹ in 2002 to 0.132 tons ha⁻¹ in 2006 (Fig. 7.8.2b). Overall, large fish biomass around Swains is around 0.184 tons ha⁻¹ (SE 0.105).

Sharks and humphead wrasses were frequently seen around the entire island. Shark species

commonly sighted were grey and whitetip reef sharks. No evidence of bumphead parrotfish populations have been observed around the island. Dogtooth tuna (*Gymnosarda unicolor*) were more common here than at any other island in American Samoa.

Fish diversity, measured as species richness, was mostly homogeneous around Swains (~ 32 species 100 m⁻²).

All the biomass per island means referenced in the above section can be found in Appendix IV, Table IV. i and Table IV. ii. Fish density per island means can also be found in Appendix IV, Table IV. iii and Table IV. iv.

7.9 Island Summary and Integration

Among the islands that make up American Samoa, Swains is the smallest in area (2.6 km²) and most distant in the archipelago, located about 350 km to the north of Tutuila. High-resolution bathymetry shows Swains as a steep, conical atoll with depths dropping off precipitously within close proximity to the island. Nearshore, the island is surrounded by a shallow (~ 1 m) reef flat from the shoreline to the reef crest, but lacks an insular shelf and is characterized by intermittent spur-and-groove features along the reef crest.

Habitat complexity was relatively high around all coasts of the island, but appeared highest along the west region, specifically along the southwestern-facing shore, and along the northeast side of the atoll near the dividing line between the north and east regions (Fig. 7.3.2a). Divers also noted small scattered deposits of sand in the northeast (Fig. 7.3.2b), which was indicative of spur-and-groove features along the forereef crest when coupled to habitat complexity observations (Fig. 7.3.2a), bathymetry (Fig. 7.3.1a), and backscatter intensity (Fig. 7.3.1b) in the same area.

Spatially, oceanographic conditions around Swains, because of its small size, geographic isolation, and lack of any prominent bathymetric features, were largely homogeneous at any given time as most small- and large-scale oceanographic processes influence waters on all sides of the island. Temporally, oceanographic conditions around Swains were principally dominated by seasonal variability with respect to temperature and wave heights (Figs. 7.4.1c, 7.4.1f, 7.4.1i, and 7.4.3b). The prevailing wave climate is shaped primarily by events originating from southeasterly directions. Episodic large swell (> 4 m) events derived from passing cyclones do occur, and in general, originate southeast of American Samoa and track northwest. As previously stated, the lagoon at Swains appeared to have little effect on the physical properties of the ocean outside the island perimeter. This is caused by the lack of outflow from the inner lagoon to the ocean and to the low-lying geography, limited vegetation, and lack of anthropogenic sources to affect nearshore nutrient loading during precipitation events.

Habitat complexity and the distribution and abundance of coral and invertebrate communities around Swains appear to be covariant. Habitat complexity, as observed by towed divers, was high along the north and west portions of the island, while the southeast side was characterized with low values (Fig. 7.3.2a). REA surveys recorded high values of mean coral cover and coral density also along the north and east (Figs. 7.5.1j and 7.5.1p, respectively), with the lowest values observed on the southeast side of the island. Towed-diver surveys also recorded high live coral cover (> 75%) on the east side of the island and the low cover (20–30%) at the southern and western points of the island (Fig. 7.3.2e). The high island-wide mean coral cover estimates from both REA and towed-diver surveys were somewhat exceptional when compared with most of

the other island and atolls surveyed as part of Pacific RAMP, suggesting that Swains is a unique ecosystem deserving thoughtful consideration for long-term management and conservation.

Coral size-class distribution at all REA sites was dominated by relatively small colonies; however, the 2006 surveys indicate a trend towards even smaller coral colonies on the southeast forereef (Figs. 7.5.1k and 7.5.1q). The relatively low habitat complexity and coral size and cover observed on the southeast side may be attributable in part to directional wave climatology of Swains, including the episodic large swell events that hit this region of the island.

Coral community composition in each of the survey years was principally composed of *Montipora* and *Pocillopora* spp., although a shift in abundance by site and location was observed. During the 2004 survey, *Pocillopora* was most common at all sites, while in 2006, *Montipora* was the most abundant at sites located on the southeast, east, and one site on the west side of Swains, while *Pocillopora* remained abundant to the north (Figs. 7.5.1g and 7.5.1o). Coral generic richness appeared more random in distribution, yet at all REA sites, richness decreased between the two survey periods. Coral diseases at Swains were uncommon, with diseases observed at only two of the eight sites surveyed (Fig. 7.5.2a).

Algal populations around Swains did not appear to be as covariant with habitat complexity, and they are slightly more evenly distributed relative to coral communities. In 2004, the green algal genera *Rhipilia* and *Microdictyon* were common at all sites around the island (Figs. 7.6.1c and 7.6.3a). The geniculate (branching) red coralline alga *Peyssonnelia*, however, was only observed at sites located on the north and west where the non-geniculate corallines were concurrently lacking. Algal diversity was slightly higher on the eastern side of the island compared to the west (Figs. 7.6.1c, 7.6.1e, and 7.6.3a).

Invertebrate species richness at all REA sites was low around Swains (Figs. 7.7.1c and 7.7.1e); however, invertebrate distributions during the 2004 survey exhibited similar spatial patterns as those observed in live coral and habitat complexity. The greatest numbers of invertebrate species were recorded at sites SWA-05 and -03 in the west region, and the lowest numbers were observed at site SWA-14 on the southeast side (Fig. 7.7.1c). Target invertebrates were nearly absent from REA surveys around Swains during 2006 (Fig. 7.7.1e). Invertebrate data collected by towed divers found the distribution of COTS to vary between years; abundance was high along the southern tip of the island (Fig. 7.7.1b) in 2004, while in 2006, COTS were far less frequent in the north region compared to the southeast, west, and east regions (Fig. 7.7.1d). In addition, towed-diver surveys around Swains found high values of stressed coral (7.8%) in 2004 (Fig. 7.5.1f). This corresponded with both a threefold increase in COTS between 2002 and 2004 and the nearby passage of Hurricane Heta the month prior to the ASRAMP 2004 surveys. An additional category 3 tropical cyclone (Percy), which produced 6-m wave heights, passed within close proximity (< 50 km) to Swains in 2005; however, significantly lower coral stress values were recorded in 2006 (1.9%; Fig. 7.5.1n) in comparison with 2004. It is very likely that a combination of known and unknown oceanographic and biological interactions contributed to the COTS population increase, which will likely be further examined during future ASRAMP deployments.

Similar to algal populations, fish populations around Swains appeared more evenly distributed relative to coral and macroinvertebrate communities. Total fish biomass was high overall, but varied between years (e.g., chance encounters of jack, emperor or barracuda schools on quantitative surveys; Figs. 7.8.1b, 7.8.1d, 7.8.1f, and 7.8.2a). Large fish biomass was characterized primarily by schools of predators (including barracudas, jacks, snappers and sharks) that dominated at

most sites around Swains and were concentrated on the northwest corner (Figs. 7.8.1a, 7.8.1c, 7.8.1e, and 7.8.2b). Species richness, a measure of diversity, was essentially uniform for fish populations around Swains.

Although it is difficult to adequately characterize the coral reef ecosystem of Swains with high spatial and temporal resolution from biennial surveys, the large amount of oceanographic, geological, and biological data collected during ASRAMP cruises since 2002 is sufficient to highlight many general ecosystem trends. Spatial patterns in habitat complexity and the distribution and abundance of corals and invertebrates appear well associated with the unidirectional nature of incoming wave energy. Consistent short period swell batters the southeastern shoreline of Swains, and although the specific nature of the physical-biological interactions requires further study, it appears the wave energy is reducing habitat complexity, reducing live coral growth, impinging upon coral densities and distribution, and affecting invertebrate distribution. Algae and fish distributions do not appear to have similar spatial variability or to be associated with the wave climatology data. Observed variability in the distribution and abundance of invertebrates, including COTS, and coral community composition and generic richness between ASRAMP cruises, was potentially caused by category 3 tropical Cyclone Percy that produced 6-m wave heights and passed within close proximity (< 50 km) to Swains in 2005. Integration of the ecosystem level components measured and observed around Swains between 2002 and 2006 yields a picture of a small isolated island, with no notable human population, minor terrigenous input, and little bathymetric variability, and whose biological components are highly subject to the ambient physical oceanographic conditions including the seasonally variable wave climatology.

SWAINS ISLAND