CRUISE REPORT[1]

VESSEL: *Hi'ialakai*, Cruise HI-07-01

CRUISE PERIOD: 19 April–9 May 2007

AREA OF OPERATION: Wake Atoll

TYPE OF OPERATION: Personnel from the Coral Reef Ecosystem Division (CRED), Pacific Island Fisheries Science Center (PIFSC), National Marine Fisheries Service (NMFS), NOAA, conducted coral reef assessment/monitoring and mapping studies in waters surrounding Wake Atoll.

ITINERARY:

19 April Start of cruise. Embarked Scott Ferguson (Chief Scientist), Brian Zgliczynski (REA- Fish), Marc Nadon, (REA – Fish), Paul Brown (REA – Fish), Jean Kenyon (REA – Corals), Bernardo Vargas Angel (REA – Corals), Elizabeth Keenan (REA – Invertebrates), Robert Tomasetti (REA – Algae), Bonnie DeJoseph (REA – Algae), Jason Helyer (REA – permanent transects), Benjamin Richards (Tow team – fish), Stephane Charette (Tow team – fish), Amy Hall (Tow team – benthic), Jacob Asher (Tow team – benthic), Noah Pomeroy (Oceanography), Frank Mancini (Oceanography), Oliver Vetter (Oceanography), James Bostick (Divemaster/Chamber Operator), Haiying Wang (Data Manager), Joyce Miller (Mapping). Departed Pearl Harbor at 0900. Conducted shipboard orientation meeting for all scientists. Conducted ship's fire and abandon ship drills. Conducted multibeam patch tests. After several unexplained power outages on the bridge, the uninterruptible power supply (UPS) supplying the bridge with power was determined to need new batteries. The ship remained in the vicinity of O'ahu overnight.

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[1]PIFSC Cruise Report CR-07-008
Issued 25 June 2007

20 - 28 April After new batteries were procured and installed in the UPS, the ship got underway for Wake Atoll at 1300. Conducted O2 administration and CPR training, baseline neurological examinations, survival at-sea training, diver emergency, and nighttime abandon ship drills. Scientists set up computer work stations and network and prepared field survey gear and equipment. Fish and benthic rapid ecological assessment (REA) teams met to discuss site selections, and tow and mooring teams met to discuss operations.

29 April Arrived at Wake Atoll at 1500 to begin field operations. Divers conducted an emergency dive drill, moving a disabled diver from the small boat (HI-1) to the recompression chamber. At 1700 shipboard mapping operations began with a conductivity-temperature-depth (CTD) cast to a depth of 250 m.

30 April Continued working at Wake Atoll. The ship continued mapping operations throughout the night collecting data around the atoll and in deeper water to the west and south. Small boat operations began at 0730 with a morning safety briefing, after which boats were deployed. The REA teams occupied three established sites on the western side of the atoll (WAK-12, WAK-8, and WAK-4). The towed-diver survey team conducted six tows. Ship's personnel transferred one 17-ft Avon inflatable into the lagoon with the invaluable assistance of shore personnel, truck, and trailer. Outside the lagoon the oceanography team conducted 11 shallow-water (30 m) CTD casts and 2 water quality profiles at a 30-m cast site during which 8 water samples were taken to be later analyzed for chlorophyll (4 samples) and nutrient (4 samples) content. Once the Avon was deployed in the lagoon, the oceanography team transferred to that boat and recovered and redeployed one sea surface temperature (SST) mooring, recovered and redployed one subsurface temperature recorder (STR) and deployed two new STRs, and deployed one ecological acoustic recorder (EAR). The *Acoustic Habitat Investigator (AHI)* mapped from 10- to 300-m depths around the south, west, and north sides of the atoll. Shipboard oceanographic operations, consisting of 250-m CTD casts in a line west of the atoll, began after all small boats were onboard.

1 May Continued working at Wake Atoll. The ship continued oceanographic operations during the night. Small boat operations began at 0730 with a morning safety briefing, after which boats were deployed. The REA teams occupied three established sites on the western side of the atoll (WAK-13, WAK-9, and WAK-6). The towed-diver survey team conducted six tows. Outside the lagoon, the oceanography team recovered 1 STR, deployed 2 STRs, and conducted 15 shallow-water (30 m) CTD casts and 2 water quality profiles at a 30-m cast site during which 8 water samples were taken to be later analyzed for chlorophyll

(four samples) and nutrient (four samples) content. In the lagoon the oceanography team recovered and redeployed one STR. The *AHI* mapped from 10- to 300-m depths around all sides of the atoll, completing the shallow water mapping operations at Wake. After all small boats were onboard, shipboard mapping operations began with a conductivity-temperature-depth (CTD) cast to a depth of 250 m and continued throughout the night.

2 May — Continued working at Wake Atoll. The ship continued mapping operations during the night. Small boat operations began at 0730 with a morning safety briefing, after which boats were deployed. The REA teams occupied three established sites on the western side of the atoll (WAK-14, WAK-1, and WAK-2). WAK-14 had strong currents, and not all divers were able to productively work under those conditions. The towed diver survey team conducted four tows. Outside the lagoon, the oceanography team recovered and redeployed two STRs and conducted two series of free dives using a portable EAR to monitor feeding bumphead parrotfish (*Bolbometopon muricatum*). Shipboard oceanographic operations, consisting of 250 m CTD casts in a line east of the atoll, began after all small boats were onboard.

3 May — Continued working at Wake Atoll. The ship continued oceanographic and mapping operations during the night. Small boat operations began at 0730 with a morning safety briefing, after which boats were deployed. The REA teams occupied three established sites on the western side of the atoll (WAK-7, WAK-5, and WAK-3). The towed-diver survey team conducted three tows. Outside the lagoon, the oceanography team conducted six series of free dives using a portable EAR to monitor feeding bumphead parrotfish (*Bolbometopon muricatum*). After all small boats were onboard, the ship departed Wake at 1700 bound for Santa Rosa Bank, south of Guam.

4 - 8 May — Continued transit to Santa Rosa Bank. Arrived near Santa Rosa Bank at 2300. Began nighttime mapping operations with a CTD cast.

9 May — Continued mapping operations until 0600. Deployed the 19-ft Safeboat with the oceanography team and recovered an Ocean Data Platform (ODP) in 20 m of water, leaving the anchor in place. Departed Santa Rosa Bank at 0745 and begin transit to Guam. Conducted post-cruise meeting. Arrived Apra Harbor in Guam. End of cruise.

Table 1: Cruise statistics for HI-07-01

	Wake Atoll	**Santa Rosa Bank, Guam**
Towed-diver Habitat/Fish Surveys	19	0
Combined tow lengths (km)	42.7	0
Fish Rapid Ecological Assessments	12	0
Benthic Rapid Ecological Assessments	12	0
Permanent Coral Transects Installed	23	0
Invertebrate collection dives	2	0
Wave and Tide Recorders (WTR) recovered	0	0
Wave and Tide Recorders (WTR) deployed	0	0
Ocean Data Platforms (ODP) recovered	0	1
Ocean Data Platforms (ODP) deployed	0	0
SST buoys recovered	1	0
SST buoys deployed	1	0
STRs recovered	5	0
STRs deployed	8	0
EARs deployed	1	0
Portable EAR dives	8	0
Shallow water sample profiles collected	4	0
Deepwater sample profiles collected	12	0
Deepwater CTDs (from *Hi`ialakai*)	14	1
Shallow water CTDs (oceanography team)	26	0
Shallow water CTDs (AHI)	2	0
Multibeam mapping (sq. km)	668	164
SCUBA dives	164	4

MISSIONS:

A. Conduct ecosystem monitoring of the species composition, abundance, percent cover, size distribution, and general health of the fish, corals, other invertebrates, and algae of the shallow water (<35 m) coral reef ecosystems of Wake Island.

B. Conduct benthic habitat mapping of the reefs and submerged banks surrounding Wake Island using ship-based and launch-based multibeam echosounders and underwater towed cameras.

C. Deploy an array of SST buoys, subsurface temperature recorders, and ecological acoustic recorders to allow remote long-term monitoring of oceanographic and environmental conditions affecting the coral reef ecosystem of Wake Island. Recover an ODP from Santa Rosa Bank south of Guam.

D. Collect water samples for analysis of nutrients and chlorophyll levels.

E. Conduct shipboard CTDs to a depth of 500 m, shallow water CTDs from small boats to a depth of ~30 m, and shipboard ADCP surveys around reef ecosystems to examine physical and biological linkages supporting and maintaining the atoll ecosystem.

F. Determine the existence of threats to the health of these coral reef resources from anthropogenic sources, including marine debris.

G. Collect ADCP data during all transits.

RESULTS:

A. Ecosystem monitoring of the species composition, abundance, percent cover, size distribution, and general health of the fish, corals, other invertebrates, and algae of the shallow water (<35 m) coral reef ecosystems at Wake Island was completed at 12 REA sites and 42.7 km of towed-diver survey transects.

B. Mapping from the *Hi'ialakai* and the survey launch R/V *AHI* resulted in the collection of high resolution multibeam bathymetry and backscatter imagery at Wake Atoll and Santa Rosa Bank. The waters surrounding Wake were completely mapped in depths ranging from 12 to 3000 m.

C. One SST buoy, one EAR, and eight STRs were deployed to allow remote long-term monitoring of oceanographic and environmental conditions affecting coral reef ecosystems of the Wake Atoll. One SST buoy and five STRs were recovered at Wake, and one ODP was recovered at Santa Rosa Bank.

D. Four shallow water and 12 deepwater stations were visited to collect water samples for analysis of nutrient and chlorophyll levels.

E. Fourteen shipboard CTDs to a depth of 500 m and 26 shallow water CTDs from small boats to a depth of ~30 m were completed.

F. The existence of threats to the health of these coral reef resources from anthropogenic sources, including marine debris were noted.

G. ADCP data were collected during all transits.

SCIENTIFIC PERSONNEL:

Scott Ferguson, Chief Scientist, Pacific Islands Fisheries Science Center (PIFSC), National Marine Fisheries Service (NMFS), Coral Reef Ecosystem Division (CRED)
Brian Zgliczynski, Research Biologist, PIFSC, NMFS, CRED
Marc Nadon, Marine Ecosystem Specialist, Joint Institute for Marine and Atmospheric Research (JIMAR), University of Hawaii (UH), Coral Reef Ecosystem Division (CRED)
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James Bostick, Divemaster/Chamber Operator, NMAO/NDC
Haiying Wang, Data Manager, JIMAR, UH, CRED
Joyce Miller, JIMAR, UH, CRED

DATA COLLECTED:

Fish REA numerical and biomass densities by species
Digital images of fish-habitat associations
Target REA macroinvertebrate counts
Macroinvertebrate voucher specimens
Algal voucher specimens
Coral voucher specimens
Coral REA numerical abundance and size class by genus
Digital still images of REA site characteristics
Digital still images of coral species
Digital video along transects at REA sites
Invertebrate voucher specimens
Algal REA field notes of species diversity and relative abundance
Digital images from algal photoquadrats
Quantitative towed diver surveys of large fish species (>50 cm TL)
Digital video surveys of habitat from towed-diver transects
Benthic composition estimations from towed-diver surveys
Macroinvertebrate counts from towed-diver surveys

Digital images of the benthic habitat from towed-diver surveys
Habitat lineation from towed-diver surveys
Shallow-deep conductivity, temperature and depth (CTD) profiles
Water samples to be tested for cholorophyll and nutrient content
Dissolved inorganic carbon from deepwater CTDs
Raw and processed multibeam digital data

(/s/Scott Ferguson)
Submitted by: ____
Scott Ferguson
Chief Scientist

(/s/David Kennedy)
Approved by: ____
David Kennedy
Program Manager
Coral Reef Conservation Program

Attachments

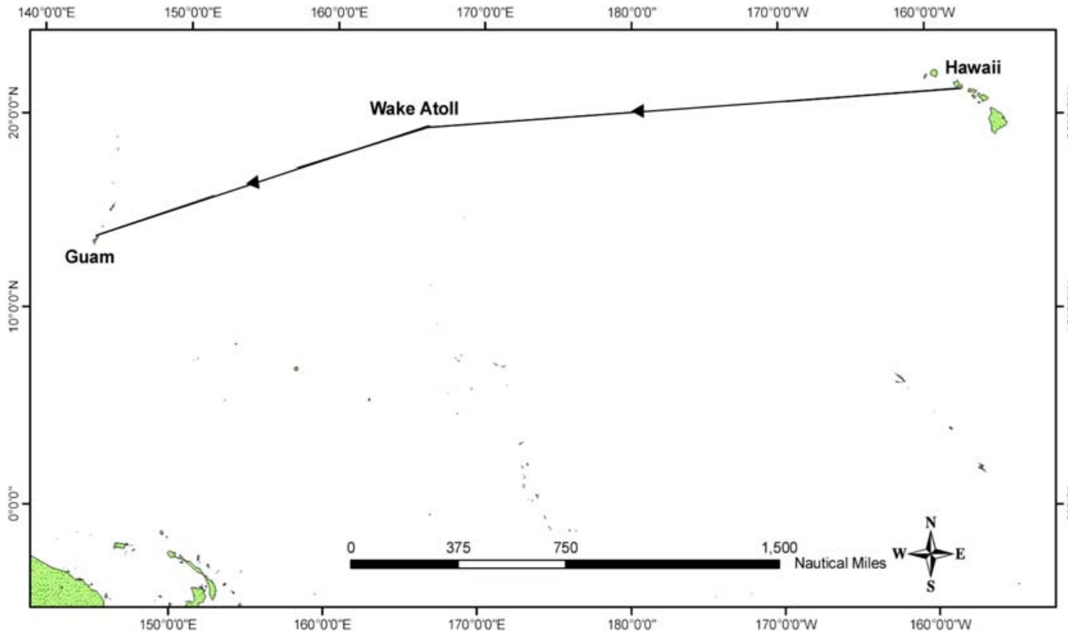


Figure 1.--NOAA ship *Hi'ialakai* cruise track to Wake Atoll, 19 April–9 May 2007.

Appendix A: Methods

A.1 Benthic Habitat Mapping Methods

(Joyce Miller, Scott Ferguson, Senior Survey Technician (SST) Jeremy Taylor)

System Descriptions

Multibeam mapping capability for cruise HI0701 included two shipboard multibeam echosounders (Kongsberg EM300 and EM3002D) and the Reson 8101ER multibeam aboard the 8-m launch R/V *Acoustic Habitat Investigator* (*AHI)*. Table A.1-1 provides an overview of the three multibeam sonars and their capabilities.

Table A.1-1. Sonar System Capabilities.

Sonar	Vessel	Freq. (kHz)	Depth range (m)	Beam size (deg)	Number of beams
EM300	*Hi'ialakai*	30	30-3000	1 ½ x 1 ½	135
EM3002D	*Hi'ialakai*	300	2-150	1 x 1	320-508
Reson 8101ER	*AHI*	240	2-250	1 ½ x 1 ½	101

In addition to the multibeam sonars, each vessel is equipped with an Applanix Position Orientation Sensor for Marine Vessels (POS/MV) vertical reference system, which provides timing, position, velocity pitch, roll, heave, and heading information for correction of motion in the multibeam data. Three different conductivity-temperature-depth (CTD) sensors were used to provide sound velocity profiles (SVPs) that are critical for proper correction of sound velocity errors associated with multibeam data.

All sensors on both vessels were interfaced to the SAIC ISS-2000 data acquisition and survey control system, which includes survey planning, data acquisition, and data processing capabilities.

During the 2006/2007 winter yard period, the main mast on the *Hi'ialakai* was replaced and the POS-MV antennae were relocated. These changes necessitated a recalibration of the multibeam system, including entry of new antennae offsets in the POS-MV software, performing a POS-MV GAMS calibration and running of patch tests. The GAMS calibration and EM300 patch tests were conducted on April 2-3, 2007, and the patch test for the EM3002D sonar were completed on April 19-20, 2007 to determine new bias parameters for entry into the EM300 and EM3002 software. These tests are documented in the *Hi'ialakai* Patch Test update, "Summary of April 2007 Patch Test Results: NOAA Ship *Hi'ialakai*: EM3002D and EM300 Multibeam Sonars."

Vessel offset and patch tests for the R/V *AHI* were also conducted with the cooperation of Office of Coast Survey representatives, Lt. Mark Van Waeas and Erin Campbell, Physical Scientist. These patch tests were performed during the week of March 12-16, 2007 in Honolulu in preparation for collaborative harbor charting surveys in the Commonwealth of the Northern Mariana Islands that are planned during HI0702. Two reports that document the R/V *AHI* tests are "Report on Vessel Offsets for R/V AHI (F2505)" and "Hydrographic Survey Readiness Review (F2505)."

Methods for acquisition and post processing
Prior to the cruise, data were assembled to provide a baseline for acquisition of multibeam data. These data included (1) IKONOS imagery; (2) predicted tides for station 1890000, Wake Island; and (3) preliminary survey plans. These data were integrated into the ISS-2000 software before the cruise. In addition, the available data were assembled and integrated into the Arc 9 Geographic Information System (GIS).

The ISS-2000 survey system is used on both the ship and the launch, enabling seamless sharing of data between the two vessels. The Generic Sensor Format (GSF), which is implemented in the ISS-2000 system, allows logging of multibeam data from a variety of multibeam sonars into a single, standardized format; the GSF also provides integrated metadata within the real-time multibeam files. In addition, the ISS-2000 creates digital message logs that allow full traceability of software and real-time events.

During system configuration, all vessel offsets are entered into either the POS/MV, the sonar, or into the ISS-2000. In addition, predicted tides are calculated for all tide zones to be surveyed and then recorded into the data in real time. Survey plans can be loaded into the real-time system on both vessels; coverage grids that are generated in real time during data acquisition can be viewed during planning, acquisition, and processing phases.

Sound Velocity Profiles (SVPs) are taken at the beginning of each 12-hour period of surveying on the ship and each 8-hour day of surveying on the *AHI* or as needed when the multibeam data indicate that a new SVP is needed. Standardized survey procedures, including a 2-minute warm up on deck and a 2-minute surface equilibration, are used on every cast. After the sound velocity cast is done, the data are downloaded with VelocWin software on the ship and with the SeaBird software on the launch. Sound velocity profiles are loaded using the ISS-2000 download utility; the downloaded profiles are sent to the two Kongsberg sonars on the ship and to the Reson sonar on the *AHI*, and the sound velocity information is logged as a part of the GSF. A real-time probe is used on the ship to monitor the surface sound velocity (SSV); if a difference between the SSV and the SVP at the surface is greater than 3 m/sec, an alarm is generated. The sonar on the *AHI* is less susceptible to SSV errors, and the daily casts are generally sufficient to correct for sound velocity. In all cases, the data are carefully monitored for sound velocity artifacts using the real-time displays.

During real-time operations, the ISS-2000 operator starts the ISS-2000 software, making sure to load the appropriate system configuration file. The System Control and Message windows are loaded at that time. The operator creates a dataset for the entire cruise that is named with the corresponding cruise delineator; *Hi'ialakai* and *AHI* data were logged into separate datasets (HI0701 and AHI0701) for file management purposes. After the dataset is created and all configurations are checked, "Start Survey" is selected and the Navigation Manager, Multibeam Manager, and Helm Display windows are opened. Text icons for all programs appear in the System Control window; the icons can be colored white, yellow, red, or green. White means that the program is selected but not activated; yellow means the program is activated but not logging; red means that there is a problem with the program; and green means that the program is operating and data are being logged. Files are automatically created for all multibeam sensors, for navigation inputs, for the POS/MV vertical reference, and for the messages generated by the system. Predicted tide files that can be used throughout 2006 were prepared before the cruise and were applied to the multibeam data in real time.

After the ISS-2000 Navigation Manager is started, a survey plan is chosen and one or more surveys are selected for execution. Tide zones, existing coverage grids, and navigational charts can be loaded into the display, if desired. The navigated ship icon appears on the screen. Survey lines are then selected from the survey file or made in real time and loaded into a Survey Schedule; lines can be selected in any order and their azimuth can be reversed; these lines appear on the screen when loaded into the schedule. When survey lines are being run in Survey Mode, the multibeam data is almost always logged (if logging is activated), but may be flagged as either "online" or "off-line." During transits, survey can be done in the "Underway Mode," but a flag must be set to not flag the off-line data during transits. If a coverage grid is loaded using the Coverage Monitor program and enabled for real-time logging, multibeam data are added to the coverage grid in real-time.

The Helm Display is also activated when the survey is started. This Helm Display appears both on the survey lab screens and on a screen on the bridge, and screen display parameters can be manipulated at either location. The same coverage grids, navigation charts, and survey lines selected in the Navigation Manager interface appear on the Helm Display as well; however, the display of these grids, charts, and lines can be turned on and off in the Helm Display independently of the Navigation Manager. The Helm Display can also be changed to different scales and color schemes than what is displayed on the Navigation Manager. The ISS-2000 feature, display of the coverage grids on the Helm Manager, enabled the bridge to steer lines in underway mode based upon existing coverage rather than always needing to create a formal survey line for the bridge to follow.

The Multibeam Manager is used to monitor the status of data files, to view and apply SVPs, and to view the multibeam bathymetry and backscatter data in real time. Many problems with the data can be detected immediately using feedback from these real-time displays. The Kongsberg SIS interfaces for the EM300 and the EM3002 are mounted above the two ISS-2000 screens, and other multibeam displays that provide different views of the data are available through SIS. Backscatter displays for all systems showed distinct and intriguing bottom types, but the ultimate quality of the data from the different sonars cannot be evaluated until data processing is complete.

During HI0701 aboard ship, multibeam data were collected primarily at night. The EM300 was used for depths between 100 m and 1500 m and the EM3002 was used for depths between 15 and 200 m.

The *AHI* was deployed during 2 days at Wake Island, and data collection was concentrated in depths between 10 and 300 m.

Aboard ship, data were logged to two disks simultaneously in real time. The ISS-2000 AutoArchive program, which copies the data to a third permanent archive disk was run as needed during post processing. The AHI0701 dataset was logged on the real-time computer in the launch, and a second copy of the data was manually made on a portable disk; the disk was then moved to the ship and connected to the shipboard computers, and the data were read to the permanent archive disk. A final copy of all data was made to the post-processing network disks, and data processing was done on only this copy of the data. The SABER data processing package, which provides full multibeam processing capability, was primarily used to manually edit the multibeam data in GSF, to plot tracklines, to update SVPs and tide data when necessary, and to create gridded data sets using the Pure File Magic (PFM) format that enables editing the integrated data set within the grid as well as reading any edits made in the grid back to the GSF multibeam files. CUBE, a recently implemented SABER software module that provides error estimates on the integrated data files and a more automated procedure for cleaning of the data set, was installed and tested with the new SABER version (3.11.4) installed on this cruise. Tape backups of all processed data were made one to two times per bank visited. The gridded data sets were converted to ASCII files for conversion to Arc raster grids. Map products were made as grids were created and added to the GIS product archive.

Backscatter data are logged as part of the GSF multibeam file and will be processed at PIBHMC after return to Honolulu.

A.2 Oceanography and Water Quality

(Oliver Vetter, Frank Mancini, Noah Pomeroy, SST Jeremy Taylor)

The Coral Reef Ecosystem Division (CRED) has been conducting oceanographic research throughout the Hawai’ian Archipelago and the U.S. remote Pacific

Territories since 2001. Research at Wake Atoll was first conducted in 2005. CRED's oceanographic investigations include in-situ surveys and the deployment and recovery of instrument platforms to monitor and assess important physical, chemical, and biological variables in the coral reef ecosystem. As a result of logistical constraints, visits to remote sites such as Wake Atoll are limited to short periods every 2 years. Long-term oceanographic monitoring is accomplished by way of moored instrument platforms that internally record data and/or telemeter data by satellite.

Knowledge of oceanographic conditions and water quality at Wake Atoll is fundamental to understanding the structure and function of coral reef ecosystem dynamics such as reef morphology, larvae distribution, productivity, species richness and diversity, growth rates, and overall ecosystem health.

The following in-situ oceanographic assessments were accomplished.

1. Shallow water (~30 m water depth) conductivity (salinity), temperature, and depth (CTD) profiles, including transmissometry (water clarity) measurements were conducted at regular intervals around Wake Atoll which provides information on small scale distributions of water masses, circulation, and local seawater chemistry changes (Table A.2-1).
2. Shallow water chlorophyll and nutrient samples were collected at 1-m, 10-m, 20-m, and 30-m water depths at the mid-point on each side of Wake Atoll. This links water quality with water masses and provides insight into localized nutrient enrichment and/or eutrophication.
3. Shipboard (> 500 m water depth) CTDs and acoustic Doppler current profiler (ADCP) transects were taken at a single latitude, traveling east and west from the latitudinal mid-point of Wake Atoll. This provides information on the oceanographic structure upstream and downstream of the atoll. Dissolved oxygen, chlorophyll, and nutrient samples were taken at each Shipboard CTD station (Table A.2-2).
4. Shipboard chlorophyll and nutrient samples taken at 3 m, 80 m, 100 m, 125 m, and 150 m at shipboard CTD locations east and west of Wake Atoll. This provides ground truth information for the CTD profiles as well as insight into local nutrient levels and local carbon cycles.
5. Continuous recording of surface and subsurface water temperatures as a function of depth during all towed-diver operations, provided a broad and diverse spatial and thermal sampling method. Refer to the Towed-Diver Habitat/Fish Survey Team Activity summary information.
6. A Portable Environmental Acoustic Recorder (PEAR) was used to calibrate the EAR within the lagoon, visually and acoustically recording the activity of the bumphead parrotfish (*Bolbometopon muricatum)* and the napoleon wrasse (*Cheilinus undulates)*. The PEAR device was used while free diving, rather than the noisier self-contained underwater breathing apparatus rigs to avoid

sound pollution and scaring the fish away. This survey was conducted on the south forereef of Wake Atoll and within the lagoon itself.

Long-term oceanographic monitoring was accomplished by deploying a variety of both internally recording and near real-time telemetered instrument platforms and oceanic drifters. For Wake Atoll these instruments included (Table A.2-3):

1. A Sea Surface Temperature (SST) Buoy was removed and replaced, the surface buoys measuring high-resolution water temperature. These buoys telemeter their data in near real time.
2. Subsurface Temperature Recorders (STRs) measure high-resolution subsurface temperatures. Five out of the six STRs deployed at Wake in 2005 were retrieved. A total of eight STRs were deployed in and around the atoll, including one on the SST anchor and one on the EAR instrument anchors.
3. An Environmental Acoustic Recorder (EAR) records sounds produced within the lagoon. This is specifically to monitor noises made by the bumphead parrotfish, which is abundant within the lagoon.
4. Moorings, shallow water CTDs, and water samples were collected from a small boat during daylight hours. Shipboard CTDs, ADCP transects, and shipboard water samples were collected during nighttime operations.

An Ocean Data Platform (ODP) was recovered on May 9 at Santa Rosa Banks, 50 km southwest of Guam. Results from this instrument will be discussed in the HI0702 cruise report.

Table A.2-1: Shallow water Oceanographic Sampling Summary

Site	CTD Sites	Water Sample Sites	Chlorophyll samples collected	Nutrient samples collected	Comments
Wake Atoll	26	4	15	15	CTDs and water samples were taken at the 30-m contour around the island. Due to the unusually steep gradient of the forereef, the 30-m contour was not always safely accessible. In these cases, the CTD was cast in deeper water.

Table A.2-2: Shipboard Oceanographic Sampling Summary

Site	CTD sites	Water sample sites	Chlorophyll samples collected	Nutrient samples collected	Comments
Wake Atoll	12	12	12	12	CTD profiles and concurrent water samples were obtained on linear transects taken along a single latitude, west and east of the atoll. These transects began 0.5 miles offshore and continued offshore, with CTD casts every 1 nmi for a total of six CTD casts each side. Chlorophyll and nutrient samples were collected during all CTD casts. ACDP data were collected along the CTD transect lines after the completion of all the CTD casts.

Table A.2-3: Oceanographic Moorings at Wake Atoll

Site	SST	STR	EAR	Comments
Wake Atoll	1	8	1	An SST buoy, an EAR, and an STR were deployed in the lagoon. The SST and EAR had STRs attached to their anchors. Five STRs were deployed in the forereef zone. One STR on the forereef from the 2005 deployment could not be found.

Note: All instrumentation numbers represent replacement deployments unless otherwise indicated in the comments column.

A.3 Rapid Ecological Assessment Methods

(Fish: Paul Brown, Marc Nadon, Brian Zgliczynski; Corals: Jean Kenyon; Coral Disease: Bernardo Vargas Angel; Algae:Robert Tomasetti and Bonnie DeJoseph; Invertebrates: Elizabeth Keenan)

The survey methodology used during HI-07-01 is the same as previous rapid ecological assessment (REA) surveys conducted by Coral Reef Ecosystem Division (CRED) cruises. At each REA site, three 25-m transect lines were laid out by the fish team, separated from each other by approximately 2–3 m. At most sites, transects were laid out at 13–15 m (40–45 ft) depth. REA methods for each specific discipline are as follows.

A.3.1 Fish

The REA fish team conducted three types of surveys at REA sites: Belt Transects (BLT), Stationary Point Counts (SPC), and Roving Diver Rapid Ecological Assessments (REA). BLTs were performed along three consecutive 25-m lines set along a single depth contour. As each line was set, two observers swam about 2 m apart along either side of the line, identifying to the lowest possible taxon, counting, and recording size classes for all fishes >20 cm total length (TL) within an area 4 m wide and 4 m high. At the end of each 25-m line, the divers turned around and returned along their respective sides of the line identifying, counting, and recording size classes of all fishes <20 cm TL within 2 m of their side of the line and 4 m off the bottom. The third fish team diver simultaneously conducted four SPCs at each REA site, generally ~15 m from the transect line. SPCs consist of the diver identifying, counting, and recording the size classes for all fishes >25 cm total length observed in a cylindrical volume 10 m in radius during a 5-minute period. Following and opportunistically during the BLT and SPC surveys, all three fish team divers recorded the presence of all fish species seen outside the transect area and outside the SPC counts. The fish REA team's species presence records are combined with fish species observed by other divers (benthic team, tow team, or oceanography team) to develop an island-wide record of all fishes observed. No collection efforts were made by the fish REA team during HI0701.

A.3.2 Algae

Standardized quantitative sampling methods for remote tropical Pacific islands were developed and published for marine algae (Preskitt *et al.*, 2004). To allow for vertical sampling in areas of high relief (walls), the method was modified slightly by Vroom *et al.* (in review, Coral Reefs) and entails photographing quadrats, collecting algal voucher specimens, creating in situ algal species lists, and ranking relative algal abundance. This modified "Preskitt method" has been used by CRED since 2003 in the Northwestern Hawaiian Islands, Guam/Mariana Islands, Pacific Remote Island Areas, and American Samoa.

Macroalgae were tentatively identified to genus (species-level when possible) in the field, and ranked abundance of algal genera was collected from 12 quadrats (0.18 m^2) at each site (1 being the most abundant, 2 being the next most abundant, etc., with 10 being the maximum number of genera found in a single quadrat). Six quadrats were located at random points along the first two transects (3 per transect), and six quadrats were located at points 3 m perpendicular from each random point, in the direction of shallower water. Additionally, samples of macroalgae present within each quadrat were collected as voucher specimens (Preskitt *et al.*, 2004) for microscopic analysis and species verification. A random swim at the end of each dive and between quadrats augmented macroalgal collections attained from quadrats and allowed cryptic species that predominantly occurred in shaded areas to be qualitatively recorded and collected. Because of difficulties with identification, algae that fell within the functional groups of turf, cyanophytes and crustose coralline algae were usually lumped into their respective categories. With the exception of 3 (of 12) sites that the primary phycologist was unable to dive, all ranked data were collected by the same individual to minimize the effects of observer bias. For the three sites in question, voucher specimens were collected for all genera within a quadrat and identified later by the primary phycologist.

A.3.3 Corals

At each site, the first two transect lines laid by the fish team served as the focal point for coral quantitative studies. Both transect lines were videotaped, including a 360^o pan at the beginning, middle, and end of each video survey. Then, working in the reverse direction along the transect lines, each coral whose center fell within one half meter of either side of the transect line was assigned to a species and one of seven size classes: 1-5 cm, 6-10 cm, 11-20 cm, 21-40 cm, 41-80 cm, 81-160 cm, and >160 cm based upon a visual estimate of the identification and long diameter of each coral. For all but a few sites, corals were completely censused along both lines, but in some cases, time was not sufficient to complete the census. In these latter cases, the length of the lines actually censused was recorded and used to establish corrections to allow for comparisons with coral census data from other sites. The above data were used to compile generic richness, frequency of corals (no. per m^2), total number of colonies per taxon, proportion of total by taxon, and to plot the size distribution of corals at each site. Lastly, a larger area outside the belt transects was examined according to the amount of time remaining for the occurrence of any additional taxa that did not occur within the belt transects.

A.3.3.1 Percent benthic cover

Only the first two, 25-m transect lines, previously laid out by the fish team, were surveyed for percent cover of benthic elements. Transect lines were previously labeled at 50-cm intervals. As the scientist swam along the transect lines, he inspected the benthic elements falling directly underneath each 50-cm mark on the transect line. Each such element was tallied and recorded to the lowest taxonomic level possible and then classified under the following scheme: live coral, dead coral, carbonate pavement, coral rubble, sand, rock, macroalgae, and other. These data are used to provide the basis for quantitative estimates of live coral cover, as well as percent cover of the divrese benthic and substrate components.

A.3.3.2. Coral health and disease assessment

At each site, using the first two transect lines laid by the fish team, an area of 3 m (depending on bottom time) on each side of the transect lines (approx. 300–400 m^2) was surveyed to document incidence of coral bleaching and/or disease. Within this survey area, each diseased/afflicted coral colony was identified to the lowest taxonomic level possible, and the following information was recorded: (1) colony size; (2) type of affliction (bleaching, skeletal growth anomaly, tissue loss/white syndrome, trematodiasis, necrosis, other: coral-algal interactions with pigmentation responses, and cyanobacterial infections); (3) area affected (percent live/dead); (4) severity of the affliction (based on the number of polyps affected and the possible effect on the overall ability of the colony to function normally; and ranked as follows mild: 1; moderate: 2; marked: 3; severe: 4; and acute: 5); and (5) photographic records and tissue samples were procured as needed. Tissue samples were catalogued and fixed in buffered, zinc-formalin solution for further histopathological analyses. The disease data together with coral colony densities estimated by the second coral biologist will be used to estimate disease prevalence; samples and photographs will be used to aid in further disease characterization.

A.3.4 Macroinvertebrates

Invertebrate biodiversity and abundance at Wake are only known through some limited surveys done on the south shore in 1998 and from the 2005 NOAA cruise. In 2005 the REA invertebrate diver was also responsible for assisting the coral diver and had somewhat different methods from what we employed in 2007.

The 2007 invertebrate surveys were conducted using belt transects and quadrats. The belt transect were 2 m wide and were performed along the first two transects laid out by the fish team, equaling two 50-m^2 transects per site. Species searched for along the belt transects include non-cryptic taxa of: zoanthids, anemones, echinoids, holothurians, crinoids, asteroids, urchins, bivalves (Tridacna, ark shells, spondylid and pearl oysters), large gastropods, cephalopods, and large crustaceans.

Five quadrat counts were conducted along each transect, for a total of 10 per site. A 0.5-m quadrat was used. The protocol called for the quadrat to be flipped once at each quadrat site, in order to expand the area surveyed to 1 m^2. During the first 2 days, logistics concerning placing of permanent transects cut the dives short and the quadrats were not flipped, and only 0.5 m^2 was surveyed per quadrat. Quadrats were placed randomly within a blocked design. One quadrat count was conducted within each 5-m segment of the 25-m transect. All non-cryptic taxa seen were recorded in the quadrat counts.

After the transect and quadrat counts were finished, a random swim was conducted if there was remaining time. Species seen during the random swim were added to a species list for the site.

A.3.5 Permanent Transect Installation
(Helyer, Keenan)

When monitoring temporal changes in coral reef communities, monitoring the same area of reef over time may improve the ability to detect changes in coral community parameters. During the HI0701 cruise, CRED installed permanent transect pins at REA stations on Wake Atoll.

At each REA station, noncorroding stainless still rods were hammered into the reef at 5-meter intervals along two 25-meter transects. A total of six pins were established at most transects with two 1-m long pins marking the beginning of each transect, followed by three 0.66-m long pins and finally one 1-m pin marking the end of each transect (Figure A.3.5-1). Afterwards marine epoxy (Powers Fasteners Power-Fast+) was applied at the base of each pin using a double-barreled applicator gun with a mixing tip in order to secure the pins to the substrate.

Following transect installation, a compass heading was recorded starting at the first transect pin of transect # 1 (GPS coordinate for site) and pointing towards the last transect pin of transect # 2. If the two transects did not point in the same general area, two compass headings were recorded, one for each transect. General notes on REA station features which may be useful for locating transects in the future, as well as pictures of transects, were taken depending on available dive time.

A GPS coordinate marking the site was taken from the surface, at the float tied to the bottom directly adjacent to the start of the first transect line. This was done either by maneuvering the boat up to the float (if live-boating) or swimming the GPS unit in a plastic bag to the float (if anchored).

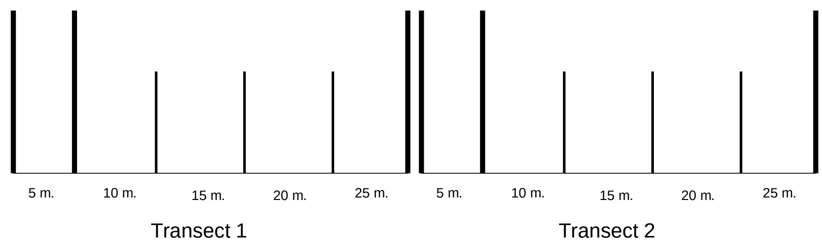


Figure A.3.5-1. Diagram of transect pin orientation. Transect pins are placed every 5 meters, with two larger 1-m pins marking the beginning of each transect, followed by three 0.66-m pins, and finally one larger 1-m pin marking the end of the transect.

A.4. Towed-diver Survey Team Methods

(Jacob Asher, Stephane Charette, Amy Hall, Benjamin Richards)

Shallow water habitats were surveyed using pairs of towed divers on towboards equipped with a downward high resolution digital still camera with dual strobes (benthic towboard) and forward-looking digital video camera (fish towboard) to quantify habitat composition and complexity and abundance and distribution of ecologically and economically important fish and macroinvertebrate taxa. The downward-looking camera was maintained 1-2 m off the bottom and was programmed to photograph benthic substrate every 15 seconds. The diver on the benthic towboard observed and recorded habitat composition (hard coral, stressed hard, soft coral, macroalgae, coralline algae, sand and rubble) and tallied conspicuous macroinvertebrates (crown-of-thorns starfish (COTS), urchins, sea cucumbers, and giant clams) along a 10-m swath. The diver on the fish towboard recorded fish greater than 50 cm total length along a 10-m swath in 5-minute segments for a total of 10 segments (50 minutes). Species of particular concern observed outside the survey swath were classified in presence/absence data recorded separately from the quantitative swath data. Tow surveys were between 1.51 km and 4.33 km in length with a mean of 2.28 km. Both towboards were instrumented with precision temperature and depth recorders (Seabird SBE39).

GPS positions, temperature, and depth were recorded every 5 s along each transect. The data were downloaded, processed, and presented in ArcGIS and overlaid on high resolution IKONOS imagery, NOAA chart data, and/or other spatial data layers.

Appendix B: Wake Atoll

B.1. Benthic Habitat Mapping

During HI-07-01, multibeam mapping surveys were conducted at Wake Island using the R/V *AHI*'s Reson 8101ER, and the *Hi'ialakai's* EM300 multibeam sonars. The *AHI* was deployed for 2 days and the *Hi'ialakai* surveyed for 2 nights and 1 day; total coverage at Wake Island was 668 sq. km in water depths ranging between 4 and 3890 m (Figure B.1-1). Features of interest at Wake Island include extensive mass wasting on all sides of the island, an extremely steep drop-off with slopes approaching 90 degrees at the northwest corner of the island, a relatively shallow (2000 m) elongated southeast rift zone, and a possible 200-m long shipwreck on the east side of the island at a depth of ~450 m.

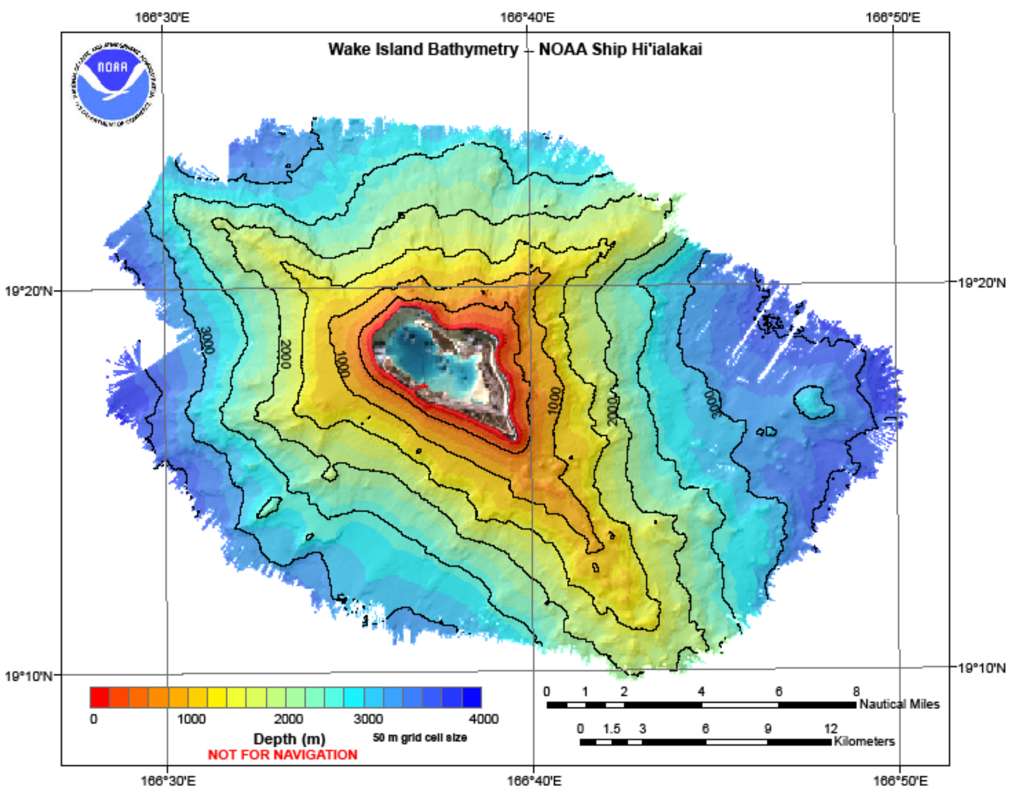


Figure B.1-1: Multibeam bathymetry displayed over IKONOS imagery (Space Imaging) from Wake Island.

Because of good sea and wind conditions, it was possible to get coverage into 10 m or shallower water depths on all sides of the island except for the east side, where we were only able to get into 15–20-m depths.   This multibeam coverage should overlap with much of the towed-diver survey coverage, which will allow comparison of habitat observations from the benthic and fish towed-diver data with multibeam bathymetry and backscatter and with other derivatives such as slope and rugosity.

A brief reconnaissance survey of the small boat harbor at Wake Island was also done. Preliminary mapping results are shown in Figure B.1-2.

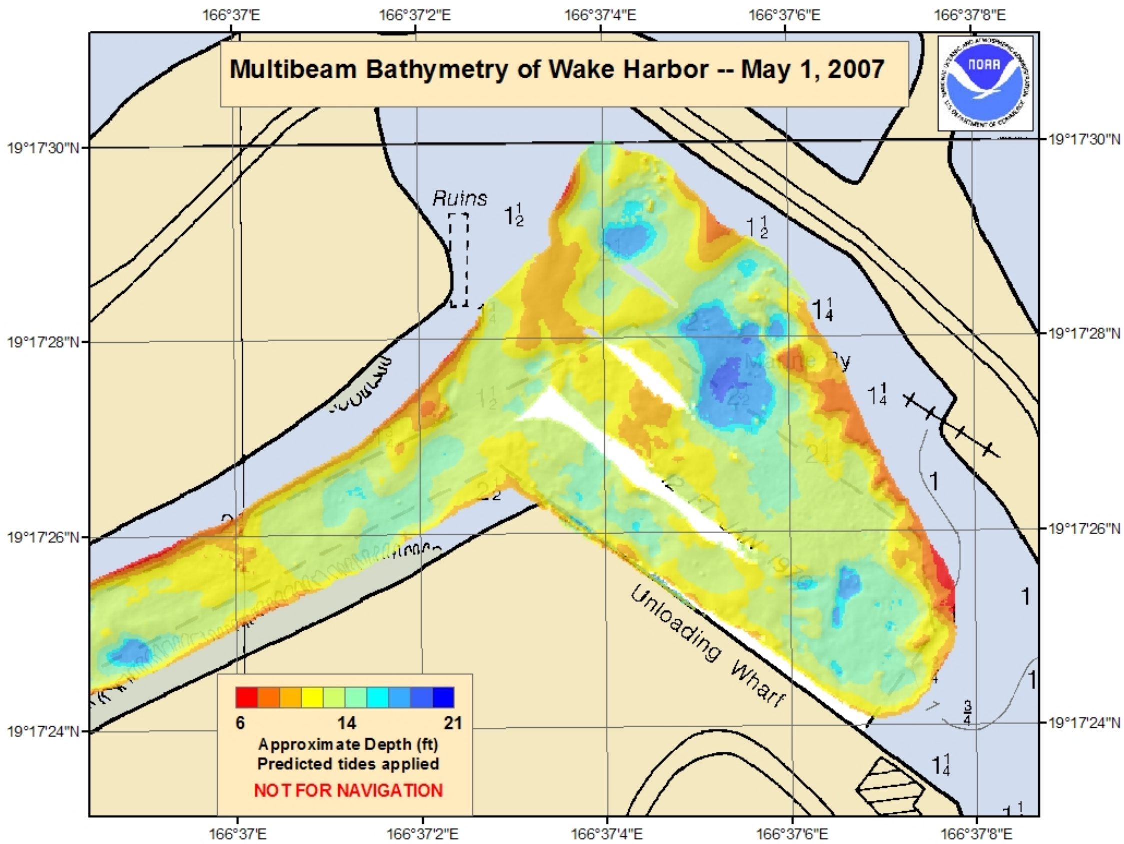


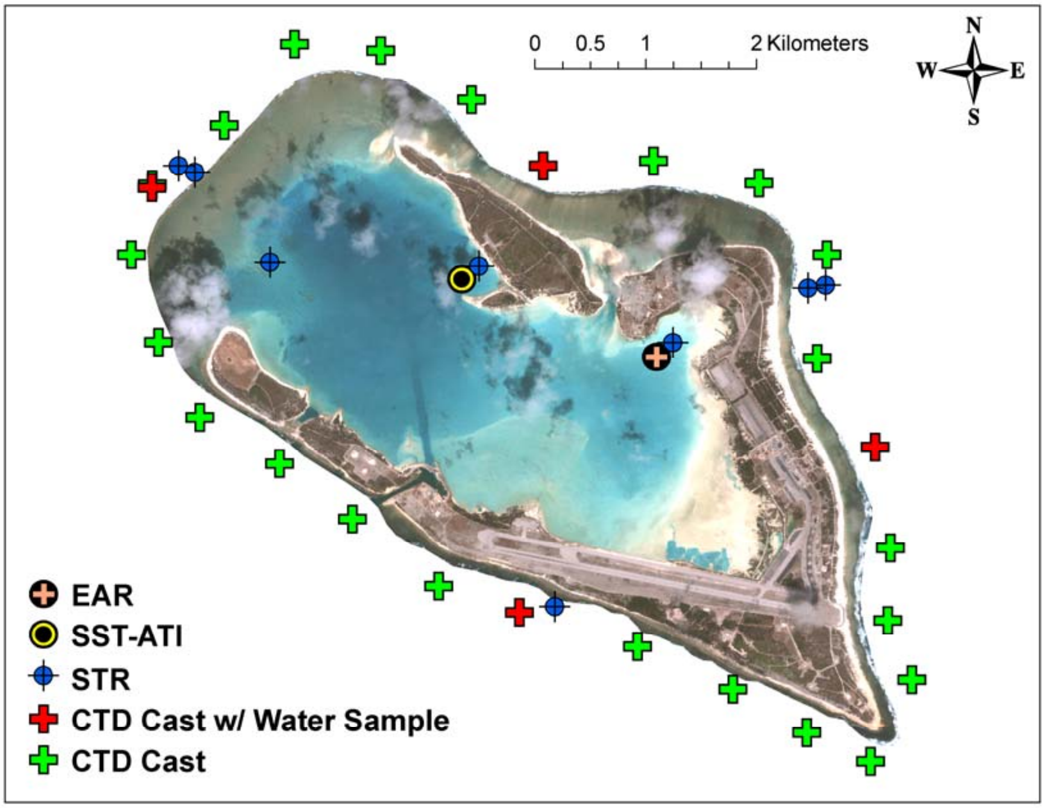
Figure B.1-2. Preliminary multibeam bathymetry of Wake Harbor.

B.2. Oceanography and Water Quality

Moorings recovered during HI0701 included five Subsurface Temperature Recorders (STRs) and a Sea Surface Temperature (SST) buoy (Figure B.2-1). All the STRs show very similar pattern and temperature ranges, with a clear annual fluctuation due to seasonal warming and cooling (Figure B.2-2). Warmest temperatures peaked at around 32 ^{0}C within the lagoon and 29 ^{0}C outside the lagoon and occurred during the summer months of July to October. Winter temperatures reached lows of 24 ^{0}C and occurred during November through June. Water temperature in the lagoon is significantly more affected by diurnal heating and cooling, and temperature fluctuations on this time scale are greater (2 - 3 ^{0}C) within the lagoon compared to those outside (< 0.5 ^{0}C).

The most significant event during this time series was a large temperature disturbance in August-September 2006. This temperature anomaly coincides with the arrival of Typhoon Ioke which made landfall at Wake Atoll on August 31, 2006.

Figure B.2-1. Position of Moorings at Wake Atoll



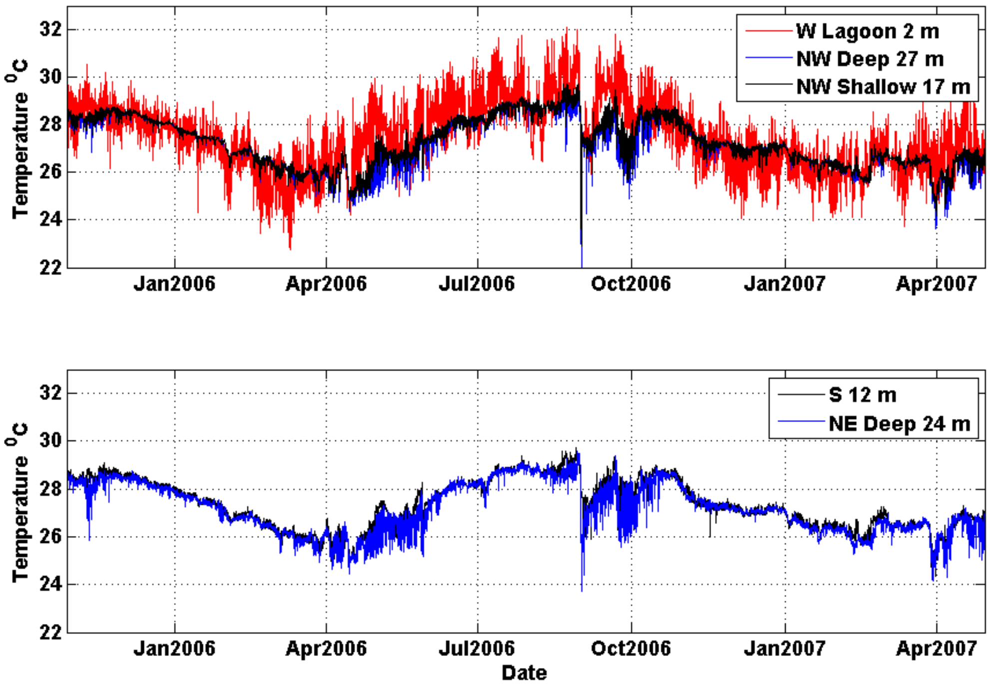
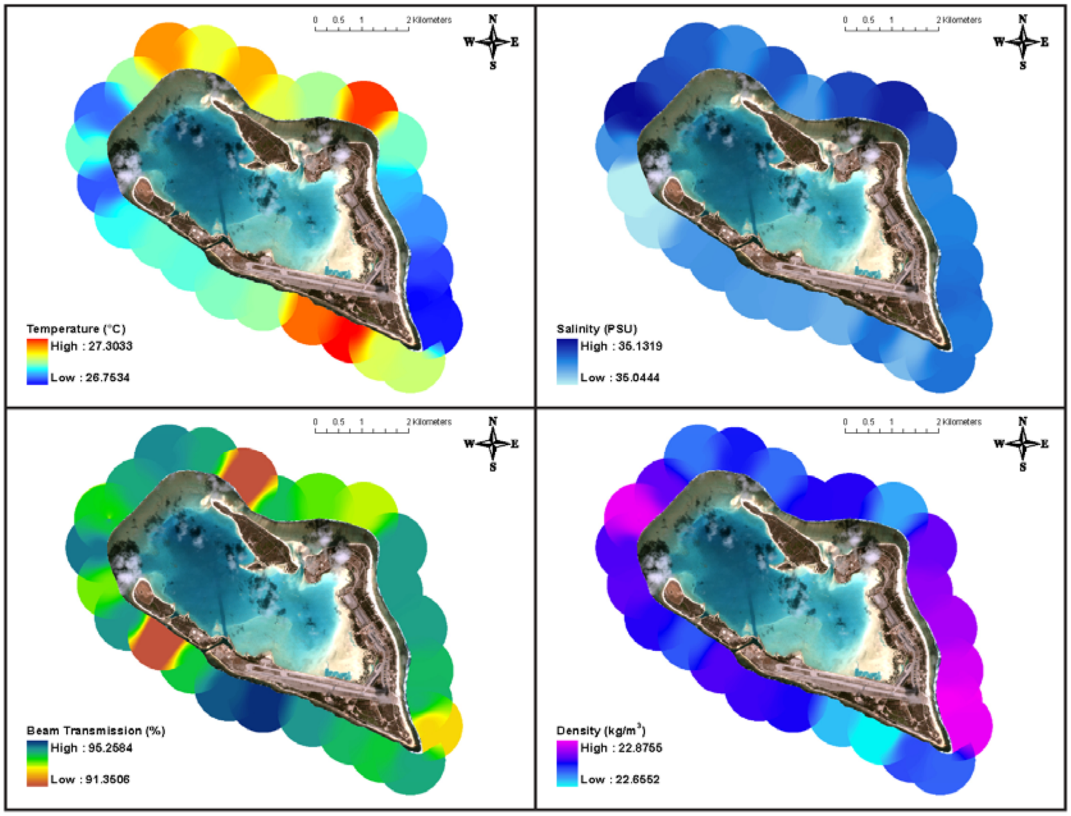


Figure B.2-2: Temperature Time-series from STR moorings at Wake Atoll.

Shallow water conductivity temperature and depth (CTD) casts were taken around the perimeter of Wake Atoll (Figures B.2-3 and B.2-4). Four water samples were taken, one on the north, south, east, and west sides of the atoll. Each water sample cast yielded a chlorophyll and nutrient sample from 1-m, 10-m, 20-m, and 30-m depths. Chlorophyll samples were filtered and nutrient samples were frozen at -30 ^{0} C for post-cruise analysis.

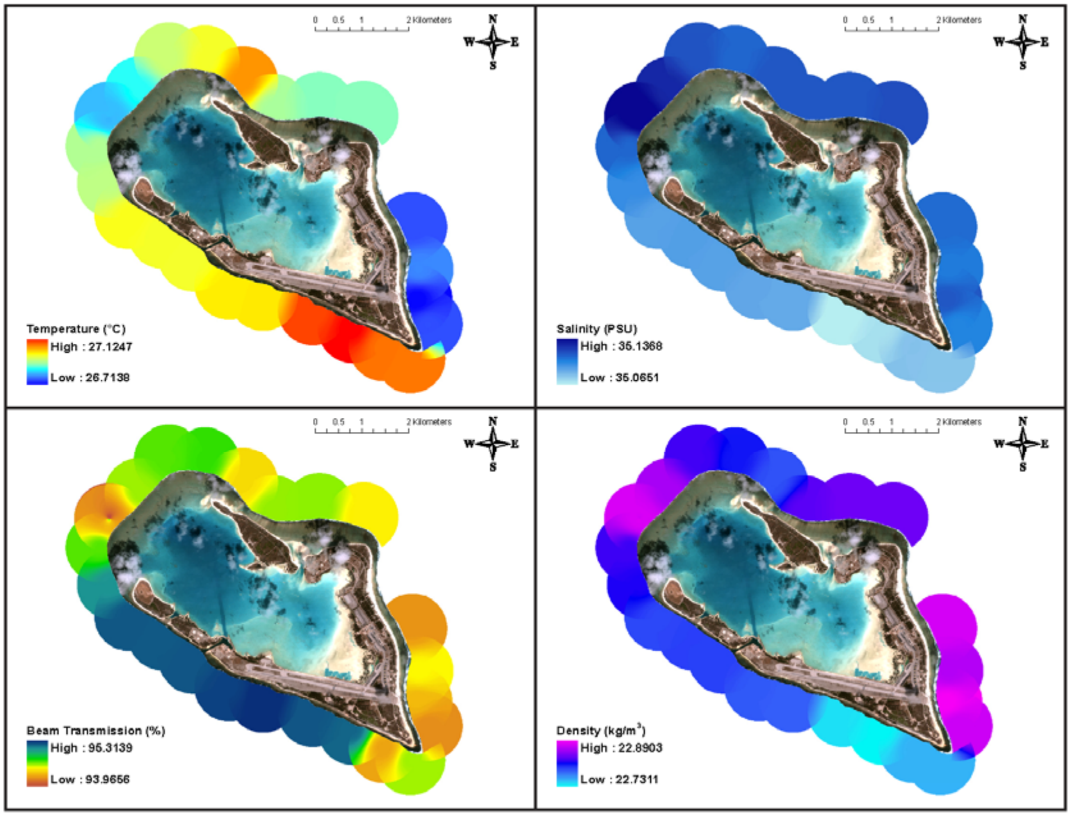
During field operations at Wake Atoll in 2007, significant spatial variation in temperature, salinity, transmissometry, and density, were apparent.
Waters at 1 m and 20 m were up to 0.4 ^{0} C and hence, more dense, along the eastern coast of the atoll compared with the warmer south and northern coasts. Along the southern coast of the atoll, waters at 20 m exhibited a west-east temperature gradient that increased toward the southeastern point of the island. This warm water mass in the south collides with the relatively cool waters of the eastern coast (Figure B 3 and B 4). The convergence of these water masses resulted in confused sea-state, high wave action, and strong currents that were consistently observed around the southeastern point of Wake Atoll.

Salinity and density were up to 0.7 PSU greater at both 1 m and 20 m at a sampling location immediately seaward of the lagoon opening compared to those areas away from the lagoon openings. This salinity peak is likely due to a hypersaline outflow from the lagoon. Lagoon waters are probably hypersaline because of various factors including: minimal water exchange with the open ocean, the presence of a desalinization plant within the lagoon, and the higher rate of evaporation in its shallow waters.



Interpolated water temperature (top left), salinity (top right), beam transmission (bottom left) and density (bottom right) at 1m depth derived from shallow water CTD casts around Wake Atoll during cruise HI0701, 29 April- 1 May, 2007.

Figure B.2-3: Water Properties from CTD casts at a 1-m Depth Contour.



Interpolated water temperature (top left), salinity (top right), beam transmission (bottom left) and density (bottom right) at 20m depth derived from shallow water CTD casts around Wake Atoll during cruise HI0701, 29 April- 1 May, 2007.

Figure B.2-4: Water Properties from CTD casts at a 20-m Depth Contour.

B.3 Rapid Ecological Assessment (REA) Site Descriptions

REA surveys were conducted at 12 forereef sites (Table B.3-1). These are the same 12 forereef sites that were surveyed in October 2005. Locations of all REA sites around Wake are shown in Figure B.3-1. The descriptions of each site are listed in the order they were occupied by the REA team.

Table B.3-1. Sites surveyed by REA team, HI0701, April-May 2007. Depths and temperatures are from Kenyon dive gauges.

Site #	Date	Latitude (N)		Longitude (E)		Transect Depth (m)	Max. depth (m)	Temp, ˚C
WAK-1	5/02/07	19	16.850	166	37.639	13.3-14.2	16.4	27.2
WAK-2	5/02/07	19	17.264	166	36.772	13.3-13.9	17.3	27.2
WAK-3	5/03/07	19	17.854	166	35.898	13.3-15.5	18.2	27.2
WAK-4	4/30/07	19	18.175	166	35.692	15.5-16.7	18.8	27.2
WAK-5	5/03/07	19	18.464	166	35.628	13.3	18.2	27.2
WAK-6	5/01/07	19	17.511	166	36.431	12.4-15.2	16.7	27.2
WAK-7	5/03/07	19	19.217	166	36.128	13.3-13.6	16.1	26.7
WAK-8	4/30/07	19	18.979	166	35.894	13.3-15.2	16.4	26.7
WAK-9	5/01/07	19	16.255	166	39.063	13.3-13.6	16.4	27.2
WAK-12	4/30/07	19	19.523	166	36.728	13.3-13.9	16.4	26.7
WAK-13	5/01/07	19	18.928	166	38.580	10.6-13.3	19.4	26.7
WAK-14	5/02/07	19	17.226	166	39.435	13.3-13.9	15.2	27.2

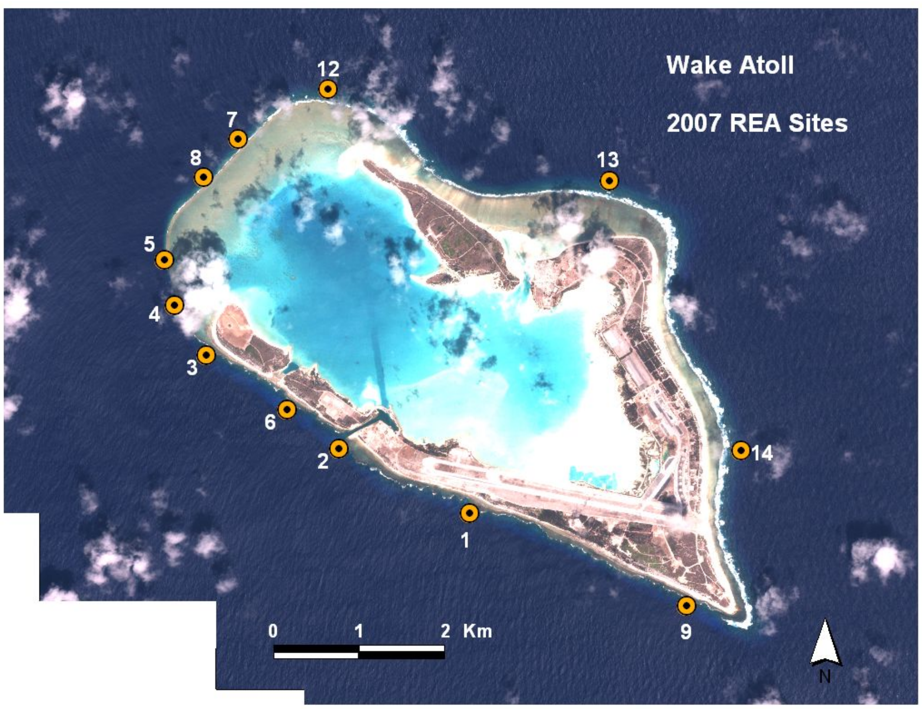


Figure B.3-1. Location of 2007 REA survey sites at Wake Atoll.

WAK-12
April 30, 2007
North-northwest forereef; depth range: 14–17 m; water temperature: 26.7ºC; Four permanent transects pins installed along the first transect. Benthic cover composed mainly of carbonate pavement (28%) and moderate coral cover (26.5%) with low crustose coralline algae cover (8%). Coral genera recorded within belt-transects included: thirteen genera of scleractinian corals, three octocoral genera (*Sinularia, Sarcophyton, Lobophytum*), and one hydrozoan genus (*Millepora* sp.). Two additional genera (*Scapophyllia, Symphyllia*) were seen outside the belt-transect survey area. Coral disease and health surveys reported one potential case of white syndrome on *Platygyra* and two cases of growth anomalies on *Astreopora*. Algal surveys reported fourteen species (11 genera) of algae, plus a diverse turf community. General survey of the reef showed *Caulerpa racemosa* var. *macrophysa* to be the most dominant algae and very common locally, but it was not recorded in most quadrats. Quadrats revealed exposed reef rock to be sporadically covered with the crustose coralline red algae, *Lobophora variegata*, and multiple turf and filamentous algal species (usually a mixture of Ulvophyceae, Phaeophyceae, and Rhodophyceae species). Macroinvertebrates were rare with only a few *Tridacna sp*. and *Spirobranchus giganteus* recorded.

WAK-8
April 30, 2007
West-northwest forereef; depth range: 13–16 m; water temperature: 26.7ºC; Nine permanent transect pins installed, six along the first transect and three along the second transect. Benthic cover composed mainly of carbonate pavement-turf (44%) with moderate coral (18.5%) and macroalgae (18.5%) cover. Coral genera recorded within belt-transects included: 14 genera of scleractinian corals and 3 octocoral genera (*Sinularia, Sarcophyton, Lobophytum*) with octocorals, *Favia, Goniastrea*, and *Pocillopora* numerically abundant corals. One additional genus (*Symphyllia*) was seen outside the belt-transect survey area. Coral disease and health surveys reported one case of tissue loss on *Goniastrea edwarsi* and one case of cyano-bacterial infection also on *Goniastrea edwarsi*. Algal surveys reported 17 species (15 genera), as well as a diverse turf-algae community. The algal community was very similar to WAK-12, with *Caulerpa racemosa* var. *macrophysa* the most dominant algae. With the exception of *Neomeris vanbosseae*, all species seen at WAK-12 were seen at WAK-8. Macroinvertebrates were limited with a few boring urchins, *Echinostrephus sp.*, *Sprirobranchus giganteus,* and one small *Porifera sp.*

WAK-4
April 30, 2007
West forereef; depth range: 13–16 m; water temperature: 27.2 ºC; Six permanent transect pins installed, three along the first transect and three along the second transect. Benthic cover composed mainly of carbonate pavement-turf (16%), macroalgae (27%), and moderate coral cover (27.5%). Coral genera recorded within belt-transects included: 11 genera of scleractinian corals with *Montipora* and *Pocillopora* corals numerically abundant. Coral disease and health surveys

reported several cases of predation on *Pocillopora* spp. and *Goniastrea edwarsi*. Algae surveys recorded six species (5 genera), as well as a diverse filamentous turf community. One new transect record was found: a fine *Portieria* sp. The macroinvertebrate community included a fair amount of sea cucumbers, *Holothuria edulis*, as well as several *Trapezia sp.*

<u>WAK-13</u>
<u>May 1, 2007</u>
North-northeast forereef; depth range: 11–13 m; water temperature: 26.7 ºC; Gradual reef slope. Six permanent transect pins installed, three along the first transect and three along the second transect. Benthic cover composed mainly of carbonate pavement-turf (50%) and relatively high coral cover (40.2%). Coral genera recorded within belt-transects included: 14 genera of scleractinian corals and 3 octocoral genera (*Sinularia, Sarcophyton, Lobophytum*) with encrusting *Montipora* corals numerically abundant and dominating the coral community. Coral disease and health surveys reported two cases of skeletal growth anomalies and two cases of patchy, focal bleaching were observed on colonies of *Porites* cf. *solida*. Algal surveys recorded 11 species (11 genera), as well as a diverse turf-algae community. *Caulerpa racemosa* var. *macrophysa* was less prominent than sites surveyed on April 30. New species recorded for transects were *Ganonema* cf. *farinosum* and *Liagora* sp. The macroinvertebrates community included several *Tridacna sp*., *Calcinus sp*., and *Echinostrephus* sea urchins as well as one *Echinometra mathaei.*

<u>WAK-9</u>
<u>May 1, 2007</u>
South-southeast forereef; depth range: 13–15 m; water temperature: 27.2 ºC; Moderate slope with coral bommies separated by channels of sand. Six permanent transect pins installed, three along the first transect and three along the second transect. Benthic cover composed mainly of coral rubble (40%) with moderate coral cover (17.6%). Coral genera recorded within belt-transects included: 13 genera of scleractinian corals and 1 octocoral genus (*Sinularia*). Coral disease and health surveys reported two cases of diffuse, mild bleaching detected on colonies of *Goniastrea edwarsi* and one case of patchy, focal bleaching on *Porites* cf *solida*. Several cases of coral-algal interaction were noted on *Pocillopora* sp. A total of seven algal species (7 genera) were recorded, as well as a diverse turf-algae community. *Caulerpa racemosa* var. *macrophysa* was less prominent than sites surveyed on April 30. A red algae (possibly *Acrosymphyton* cf. *taylorii*) was a new transect record not seen on previous dives. Sea cucumbers were abundant with high densities of *Holothuria edulis* as well as a few *Actinopyga mauritiana*.

<u>WAK-6</u>
<u>May 1, 2007</u>
South forereef; depth range: 13–16 m; water temperature: 27.2 ºC; Steep slope with numerous coral bommies interspersed by sand and a metal shipwreck seaward of transects. Six permanent transect pins installed, three along the first transect and

three along the second transect. Benthic cover consisted of moderately high coral cover (35%), carbonate pavement-turf (14%), and coral rubble (14%). Coral genera recorded within belt-transects included: 14 genera of scleractinian corals and 3 octocoral genera (*Sinularia, Sarcophyton, Lobophytum*) with encrusting *Montipora* numerically abundant. Coral disease and health surveys found no diseases or compromised health states at this site. A total of seven algal species (7 genera) were recorded, as well as a diverse turf-algae community. *Caulerpa racemosa* var. *macrophysa* was less prominent than sites surveyed on April 30. An unidentified red cyanobacterium from WAK-13 was common. Abundant sea cucumbers, *Holothuria edulis*, and the occasional *Opheocoma pica* and *Tridacna sp*. were the only macroinvertebrates recorded.

WAK-14
May 2, 2007
East forereef; depth range: 14–15 m; water temperature: 27.2 ºC; Strong current made it difficult to survey the area. Five permanent transect pins installed, three along the first transect and two along the second transect. Benthic cover was dominated by carbonate pavement-turf (50%) and relatively high coral cover (42%). No coral colony counts/size class/density data collected, as current and surge made collection of accurate data impossible. Coral disease assessment was abbreviated because of dive conditions; two cases of skeletal growth anomalies were detected on colonies of *Porites* cf. *solida*. A total of nine algae species (9 genera) were recorded, as well as a diverse turf-algae community and at least two cyanobacteria species. Invertebrate surveys were only conducted on the first transect, with rare sightings of the sea urchin, *Echinostrephus sp*. as well as several sightings of an unidentified opisthobranch.

WAK-1
May 2, 2007
South forereef; depth range: 11–13 m; water temperature: 27.2 ºC; Small, patch reef-like promontories separated by sand channels. Six permanent transect pins installed, three along the first transect and three along the second transect. Benthic cover composed mainly of carbonate pavement-turf (26%) and moderate coral cover (26%) with low macroalgae cover (9%). Coral genera recorded within belt-transects included: 13 genera of scleractinian corals and 1 octocoral genus (*Sinularia*) with *Montipora* and *Pocillopora* corals numerically abundant. Coral disease and health surveys found no diseases or compromised health states at this site although numerous senescing colonies of *Pocillopora* sp. overgrown with turf and macroalgae were observed. Algal surveys reported 14 algal species (8 genera), as well as a diverse crustose coralline and filamentous turf community. *Dictyota* cf. *pfaffii* was very common and a new transect record. A diverse assemblage of macroinvertebrates was observed with abundant sea cucumbers: numerous *Holothuria edulis,* as well a *Bohadshia argus* and a *Holothuria whitmaei.* Other macroinvertebrates seen include: *Tridacna sp, Opheocoma pica, Dardanus sanguinocarpus,* and *Linkia guildingi.*

WAK-2

May 2, 2007

South forereef; Depth range: 13–15 m; water temperature: 27.2 ºC; Patch reef-like promontories separated by sand channels with outstanding quantities of metallic debris scattered along the benthos. Six permanent transect pins installed, three along the first transect and three along the second transect. Benthic cover consisted mostly of turf algae- and cyanobacteria-colonized rock, metal, sand, and rubble which comprised over 80% of the benthic substrate. Relatively low coral cover (10.7%) was reported. Coral genera recorded along belt-transects include: 11 genera of scleractinian corals with 1 additional genus (*Leptastrea*) seen outside the belt survey area. Coral disease and health surveys found numerous cases of coral-cyanobacterial and -algal interactions on *Pocillopora* spp., but also on encrusting *Montipora* spp.; also numerous senescing colonies of *Pocillopora* spp. overgrown with turf-algae and macro-algae were observed. Two cases of patchy, multi-focal tissue fish predation were detected on *Montipora* cf. *grisea*, and one possible case of COTS predation (size and pattern of predation scar may be indicative of *Acanthaster planci*) was noted on an assemblage of *Porites-Acanthastrea-Pocillopora-Montipora*. A total of 13 algae species (13 genera) as well as a diverse turf-algae community were recorded. New transect records included a mucilagenous yellow cyanobacteria and a fine feathery brown cyanobacteria not seen on other dives, as well as the brown alga *Padina* sp. Considerable cyanobacterial overgrowth was seen covering the benthos, even epiphytic on *Liagora* sp., usually very slick and epiphyte free. The sea cucumber, *Holothiria edulis*, and sea star, *Linckia mutlifora,* were common while *Echinostrephus sp., Trapezia sp.,* and *Opheocoma pica*. were rare. A small *Didemnum* species was also seen.

WAK-7

May 3, 2007

West-northwest forereef; depth range: 12–13 m; water temperature: 26.7 ºC; Dive was shortened to allow REA team to visit Wake Island. Six permanent transect pins installed, three along the first transect and three along the second transect. Coral cover was 51%, the highest percent coral cover recorded for 2007. Carbonate pavement-turf was the next most common component of the benthos comprising over 20% of the benthic substrate. Coral genera recorded within belt-transects included: 17 genera of scleractinian corals and 3 octocoral genera (*Sinularia, Lobophytum, Sarcophyton*) making this the highest coral diversity site. Coral disease and health surveys were shortened because of time constrains but three cases of skeletal growth anomalies were observed; two on colonies of *Acropora* cf. *microclados*, and one on *Montipora* cf. *hoffmeisteri* were found. A total of 15 algae species (14 genera) were recorded in addition to a diverse turf-algae community. *Dictyota* cf. *pfaffii* was common as well as *Dictyota* cf. *dichotoma* (or similar morphological species). Six new transect records were found. Common macroinvertebrates include the boring urchin *Echinostrephus sp*., *Calcinus sp*., *Spirobranchus giganteus,* and the shrimp, *Alpheus deteropus,* evident by the presence of its burrows. Giant clams, *Tridacna sp*., were rare.

WAK-5

May 3, 2007

West-southwest; depth range: 13–15 m; water temperature: 27.2 ºC; Six permanent transect pins installed, three along the first transect and three along the second transect. Macroalgae (Caulerpa and Halimeda) comprised over 48% of benthic cover while coral cover was moderate (25.5%). Coral genera recorded with belt-transects included: 11 genera of scleractinian corals and 1 octocoral genus (*Sinularia*) with *Montipora* corals being abundant. Coral disease and health surveys found three cases of skeletal growth anomalies,, two on colonies of *Portites* cf. *solida* and one on *Montipora* cf. *hoffmeisteri*. A total of 11 algae species (8 genera) were recorded, with *Caulerpa racemosa* var. *macrophysa* the most common alga overall. While three *Dictyota* spp. were recorded, *Dictyota* cf. *pfaffii* was the most common, dominant on all smooth rock surfaces. No macroinvertebrates were found on either belt-transect, but several were seen in the adjacent survey area including: *Ophiocoma pica, Trapzia sp., Alpheus deteropus*, and a few individuals of the same unidentified opisthobranch as at WAK-14.

WAK-3

May 3, 2007

West-southwest forereef; depth range: 14–16 m; water temperature: 27.2 ºC; Six permanent transect pins installed, three along the first transect and three along the second transect. Carbonate pavement-turf and coral rubble comprised over 20% each of the benthic substrate. Coral cover was moderately high (33%). Coral genera recorded with belt-transects included: 12 genera of scleractinian corals with *Montipora* and *Pocillopora* corals numerically abundant and dominating the site. Coral disease and health surveys found one case of skeletal growth anomaly, and one case of algal irritation were noted on *Porites* cf. *solida.* A total of 16 algae species (13 genera), as well as a diverse turf-algae community, were recorded. *Dictyota* cf. *dichotoma* was the most common alga overall, with *D.* cf. *pfaffii* very rare (despite the proximity to WAK-5). A new transect record was a cyanobacterium resembling *Lyngbya majiscula*. While no other new records were found, *Portieria* sp. was the most common at this site compared to all other sites. It was still fairly rare, found mainly around the bases of coral bommies. The sea cucumber, *Holothuria edulis,* was common, as was *Ophiocoma pica*. Several other macroinvertebrate species were found in low numbers including *Linckia multifora, Tridacna sp.*, *Echinostrephus sp.*, *Trapezia sp*., and *Calcinus sp.* One sample of *Linckia multifora* was taken for genetic connectivity research.

B.3.1 Permanent Transect Installation

Permanent metal pins were installed at each REA transect, as described in section A.3.5. Table B.3.1-1 describes the characteristics of those installations. This information should be used in conjunction with the position and depth data in Table B.3-1.

Table B.3.1-1: Permanent transect installation notes

Site #	Tran-sect ID	Transect bearing, deg.	# of Pins	Notes
WAK-1	A	315	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel,
WAK-1	B	290	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel,
WAK-2	A	135	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel,
WAK-2	B	155	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel, Transect bisects the first two transect pins.
WAK-3	A	140	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel, Transect begins on patch reef, 2nd transect pin on patch reef adjacent to first.
WAK-3	B	130	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel, Transect begins 5 m. left from the end of 1st transect.
WAK-4	A	340	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel,
WAK-4	B	340	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel,
WAK-5	A	170	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel, Transect heading is 170 deg. to the 2nd transect pin, 180 deg. to final transect pin.
WAK-5	B	180	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel
WAK-6	A	90	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel, Transect begins on patch reef after end of first transect line.
WAK-6	B	160	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel, Transect begins on patch reef after end of first transect line.
WAK-7	A	30	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel
WAK-7	B	45	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel
WAK-8	A	240	6	Installed all 6 transect pins. Epoxy clogged, so unable to cement transects to reef.
WAK-8	B	225	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel,
WAK-9	A	280	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel, Transect begins and ends on coral bommie
WAK-9	B	280	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel, Transect begins and ends on coral bommie
WAK-12	A	280	4	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel, and one 2 ft. transect pin ~ 20 m.
WAK-13	A	265	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel,
WAK-13	B	270	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel,
WAK-14	A	180	3	Installed three 3 ft. transect pins at beginning, ~ 5, and end of transect reel,
WAK-14	B	180	2	Installed two 3 ft. transect pins at beginning and ~ 5, due to strong current

B.4. Benthic Environment

B.4.1. Algae

Quantitative algal surveys were conducted at 12 sites outside Wake Atoll (Table B.3-1). All sites were previously surveyed in 2005 and were forereef habitats within 150 m of shore or the northwestern reef flat. Time constraints prevented resurveys of 2005 lagoonal sites WAK-10 and WAK-11. The lagoon shore was qualitatively surveyed near Peale Island (north), with only two algae found. Quantitative sites were all situated in depths of highest coral growth, with shallow sites unsurveyed.

Wake Atoll has a large reef flat and it is expected that a diverse and different algal community will occur in shallower water and along the reef flat than observed during these mid-water surveys (13–20 m). In addition, a topographically complex spur-and-groove system was observed at site WAK-4, but was unsurveyed because it extended into shallow water towards the reef flat. In many sites, *Halimeda* spp. were major contributors to sand formation. Upwelling was observed at several sites near the northwestern reef flat towards Wilkes Island. Coral bleaching appeared common at site WAK-3. Several sites had strong currents and surge, and the dive at site WAK-14 was ended prematurely because several benthic survey teams had difficulty collecting meaningful data. Coral cover appeared very high at most sites, with topographically similar gently sloping forereef environments. Southern sites WAK-1 and WAK-2 consisted of coral bommies and outcroppings separated by relatively large patches of *Halimeda*-based sand.

Despite Typhoon Ioke passing directly over Wake Atoll in late August 2006, the only obviously disturbed site (from an algal community viewpoint) was site WAK-2. Cyanobacteria were overgrowing all substrates and even algae typically epiphyte-free (e.g., *Liagora* spp.). However, this site was near a dredged channel and also had large amounts of metallic debris in the water, and the disturbed nature was not considered a result of the Typhoon Ioke.

The most conspicuous algae at all sites were *Caulerpa racemosa* var. *macrophysa*, *Halimeda* sp., and *Dictyota* spp. (several luxuriant/foliose forms, with one resembling *Dictyota* cf. *dichotoma*). *Dictyota* cf. *pfaffii* was mostly found in regions of higher current near the northwest reef flat, clinging to all smooth rock faces and outcompeting *Lobophora variegata* and crustose coralline red algae where found. At all other sites, *Lobophora variegata* was very common. Crustose coralline red algae were present at most sites, but were generally small and relatively inconspicuous.

Tentatively, 28 species (25 genera) were found altogether: 9 species (7 genera) of green algae (Chlorophyceae), 12 species (12 genera) of red algae (Rhodophyceae), and 7 species (6 genera) of brown algae (Phaeophyceae). Also, multiple unidentified species of filamentous algae were grouped into the functional category of turf algae, and several species of cyanobacteria were found. Once microscopic examination of samples occurs, it is expected that epiphytes identified will increase the number of species collected substantially.

Tentative new records for the atoll (all require microscopic examination for confirmation) include *Acrosymphyton* cf. *taylorii*, *Caulerpa racemosa* var. *macrophysa*, *Derbesia marina*, *Dictyopteris* cf. *repens*, *Dictyosphaeria versluysii*, *Dictyota* cf. *pfaffii*, *Liagora* sp., *Lobophora variegata*, *Mesophyllum* cf. *funafutiense*, *Neomeris vanbosseae*, *Portieria* sp., possibly *Renouxia* sp., potentially *Rhipiliopsis* sp., *Sporolithon* sp., *Turbinaria conoides*, and an unknown gelatinous red alga. Given the number of tentative new records and multiple site-specific species, a much more thorough examination of Wake Atoll at more sites (including in shallow water and along the reef flat) is required to accurately portray the flora. The algal flora is still too inadequately surveyed to draw meaningful conclusions about differences in community structure between 2005 and 2007.

Table B.4.1-1: Algal taxa or functional groups recorded in photoquadrats at Wake Atoll. Italicized numbers indicate the percentage of photoquadrats in which an alga occurred. Bold numbers indicate an alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat. Asterisks indicate algal genera found during the random swim that were not present in photoquadrats. Sites WAK-4 and Lagoon were not surveyed quantitatively.

	WAK-1	WAK-2	WAK-3	WAK-5	WAK-6	WAK-7	WAK-8	WAK-9	WAK-12	WAK-13	WAK-14
GREEN ALGAE											
Avrainvillea cf. *amadelpha*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*20.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**5.0**	**0.0**	**0.0**	**0.0**	**0.0**
Caulerpa cf. *macrophysa/racemosa*	*0.0*	*0.0*	*	*66.7*	*33.3*	*41.7*	*60.0*	*8.3*	*14.3*	*	*0.0*
	0.0	**0.0**	*	**1.25**	**2.0**	**1.4**	**2.0**	**2.0**	**5.0**	*	**0.0**
Caulerpa serrulata var. *spiralis*	*25.0*	*16.7*	*8.3*	*8.3*	*25.0*	*8.3*	*20.0*	*	*14.3*	*8.3*	*12.5*
	3.0	**2.5**	**4.0**	**6.0**	**2.7**	**3.0**	**4.0**	*	**5.0**	**2.0**	**2.0**
Derbesia marina	*0.0*	*0.0*	*8.3*	*0.0*	*0.0*	*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**6.0**	**0.0**	**0.0**	*	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Dictyosphaeria versluysii	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*25.0*	*20.0*	*0.0*	*14.3*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**2.7**	**3.0**	**0.0**	**4.0**	**0.0**	**0.0**
Halimeda sp.	*58.3*	*16.7*	*66.7*	*91.7*	*58.3*	*83.3*	*100.0*	*58.3*	*57.1*	*58.3*	*87.5*
	2.4	**3.5**	**2.6**	**1.9**	**2.0**	**2.6**	**1.6**	**1.6**	**3.0**	**2.7**	**2.7**
Neomeris annulata	*8.3*	*16.7*	*33.3*	*8.3*	*0.0*	*0.0*	*40.0*	*16.7*	*57.1*	*50.0*	*25.0*
	4.0	**3.5**	**4.5**	**6.0**	**0.0**	**0.0**	**4.5**	**2.5**	**3.8**	**2.2**	**3.5**
Neomeris van-bosseae	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	*	**0.0**	**0.0**

	WAK-1	WAK-2	WAK-3	WAK-5	WAK-6	WAK-7	WAK-8	WAK-9	WAK-12	WAK-13	WAK-14
cf. *Rhipiliopsis*-like sp.	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*20.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.0**	**0.0**	**0.0**	**0.0**	**0.0**
RED ALGAE											
Acrosymphyton cf. *taylorii*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	*	**0.0**	**0.0**	**0.0**	**0.0**
Crustose coralline algae	*	*33.3*	*41.7*	*75.0*	*0.0*	*33.3*	*40.0*	*16.7*	*71.4*	*0.0*	*
	*	**2.0**	**4.2**	**4.3**	**0.0**	**2.3**	**1.5**	**3.0**	**1.4**	**0.0**	*
Dasya spp.	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	*	**0.0**	**0.0**
Ganonema cf. *farinosum*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*14.3*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3.0**	**0.0**	**0.0**
Hypnea spinella	*	*8.3*	*0.0*	*0.0*	*0.0*	*25.0*	*0.0*	*0.0*	*14.3*	*0.0*	*12.5*
	*	**1.0**	**0.0**	**0.0**	**0.0**	**4.3**	**0.0**	**0.0**	**4.0**	**0.0**	**3.0**
Jania spp.	*0.0*	*8.3*	*8.3*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**2.0**	**5.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Liagora spp.	*0.0*	*0.0*	*0.0*	*	*0.0*	*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	*	**0.0**	*	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Mesophyllum cf. *funafutiense*	*	*0.0*	*8.3*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	*	**0.0**	**5.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Portieria sp.	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*8.3*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**5.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
cf. *Renouxia*-like sp.	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	*	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Sporolithon sp.	*0.0*	*	*	*8.3*	*0.0*	*25.0*	*0.0*	*0.0*	*0.0*	*8.3*	*25.0*
	0.0	*	*	**4.0**	**0.0**	**4.0**	**0.0**	**0.0**	**0.0**	**1.0**	**2.5**
Unknown red gelatinous “ball”	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	*	**0.0**	**0.0**	**0.0**	**0.0**
BROWN ALGAE											
Dictyopteris cf. *repens*	*8.3*	*0.0*	*8.3*	*66.7*	*0.0*	*16.7*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	4.0	**0.0**	**5.0**	**3.6**	**0.0**	**3.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Dictyota spp. (luxuriant/upright)	*91.7*	*66.7*	*83.3*	*33.3*	*41.7*	*0.0*	*60.0*	*25.0*	*57.1*	*25.0*	*87.5*
	1.2	**2.8**	**1.1**	**3.0**	**2.6**	**0.0**	**2.7**	**2.3**	**3.8**	**2.7**	**1.4**
Dictyota cf. *pfaffii*	*33.3*	*16.7*	*66.7*	*83.3*	*16.7*	*83.3*	*60.0*	*33.3*	*57.1*	*25.0*	*12.5*
	3.5	**2.0**	**3.0**	**3.3**	**3.0**	**2.5**	**2.3**	**2.3**	**2.3**	**2.0**	**4.0**
Lobophora variegata	*25.0*	*8.3*	*8.3*	*16.7*	*0.0*	*0.0*	*0.0*	*16.7*	*0.0*	*0.0*	*0.0*
	3.7	**4.0**	**5.0**	**4.0**	**0.0**	**0.0**	**0.0**	**3.0**	**0.0**	**0.0**	**0.0**
Padina sp.	*0.0*	*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	*	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Turbinaria conoides	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*	*0.0*	*0.0*	*0.0*	*0.0*
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	*	**0.0**	**0.0**	**0.0**	**0.0**
Unknown orange crust	*8.3*	*0.0*	*8.3*	*66.7*	*0.0*	*16.7*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	4.0	**0.0**	**5.0**	**3.6**	**0.0**	**3.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

	WAK-1	WAK-2	WAK-3	WAK-5	WAK-6	WAK-7	WAK-8	WAK-9	WAK-12	WAK-13	WAK-14
FUNCTIONAL GROUPS											
Turf	*75.0*	*100.0*	*66.7*	*66.7*	*75.0*	*75.0*	*40.0*	*50.0*	*100.0*	*75.0*	*62.5*
	2.1	**1.3**	**2.1**	**2.5**	**1.2**	**1.9**	**5.0**	**1.2**	**1.3**	**1.6**	**1.8**
Blue-Green	*8.3*	*33.3*	*25.0*	*25.0*	*25.0*	*0.0*	*40.0*	*16.7*	*14.3*	*8.3*	*62.5*
	2.0	**1.3**	**4.0**	**4.3**	**3.0**	**0.0**	**4.5**	**1.0**	**5.0**	**1.0**	**1.8**

Table B.4.1-2: Putative algal species found at Wake Atoll. All sites were quantitatively analyzed except for the "Lagoon" site, in which a single specimen of Dictyota sp. was found washed up on the shore and cyanobacteria found on submerged sand. All specimens will require microscopic examination before species identifications can be confirmed. Epiphytes growing on macroalgae and turf community species will be identified in the lab. All specimens will be deposited at the B.P. Bishop Museum after analysis.

List of putative macroalgal species collected (one sample per site)	WAK-1	WAK-2	WAK-3	WAK-4	WAK-5	WAK-6	WAK-7	WAK-8	WAK-9	WAK-12	WAK-13	WAK-14	LAGOON
GREEN ALGAE													
Avrainvillea cf. *amadelpha*								X					
Caulerpa cf. *macrophysa/racemosa*			X	X	X	X	X	X	X	X	X		
Caulerpa serrulata var. *spiralis*	X	X	X		X	X	X	X	X	X	X	X	
Derbesia marina			X				X						
Dictyosphaeria versluysii							X	X		X			
Halimeda sp.	X	X	X	X	X	X	X	X	X	X	X	X	
Neomeris annulata	X	X	X		X			X	X	X	X	X	
Neomeris van-bosseae										X			
cf. *Rhipiliopsis*-like sp.								X					
RED ALGAE													
Acrosymphyton cf. *taylorii*								X					
Crustose coralline algae	X	X	X		X		X	X	X	X		X	
Dasya spp.										X			
Ganonema cf. *farinosum*			X								X		
Hypnea spinella		X								X			
Jania spp.	X	X					X			X		X	
Liagora spp.		X	X								X		
Mesophyllum cf. *funafutiense*					X		X						
Portieria sp.	X		X	X									
cf. *Renouxia*-like sp.							X						
Sporolithon sp.							X						
Unknown red gelatinous "ball"		X	X		X		X				X	X	
BROWN ALGAE													
Dictyopteris cf. *repens*				X						X			

List of putative macroalgal species collected (one sample per site)	WAK-1	WAK-2	WAK-3	WAK-4	WAK-5	WAK-6	WAK-7	WAK-8	WAK-9	WAK-12	WAK-13	WAK-14	LAGOON
Dictyota spp. (luxuriant/upright)	X	X	X	X	X	X		X	X	X	X	X	X
Dictyota cf. *pfaffii*	X		X		X		X						
Lobophora variegata	X	X	X		X	X	X	X	X	X	X	X	
Padina sp.		X											
Turbinaria conoides								X					
Unknown orange crust	X	X	X		X		X		X				
FUNCTIONAL GROUPS													
Turf	X	X	X	X	X	X	X	X	X	X	X	X	
Blue-Green	X	X	X		X	X		X	X	X	X	X	X

B.4.1.2 Benthic towed-diver surveys – Macroalgae

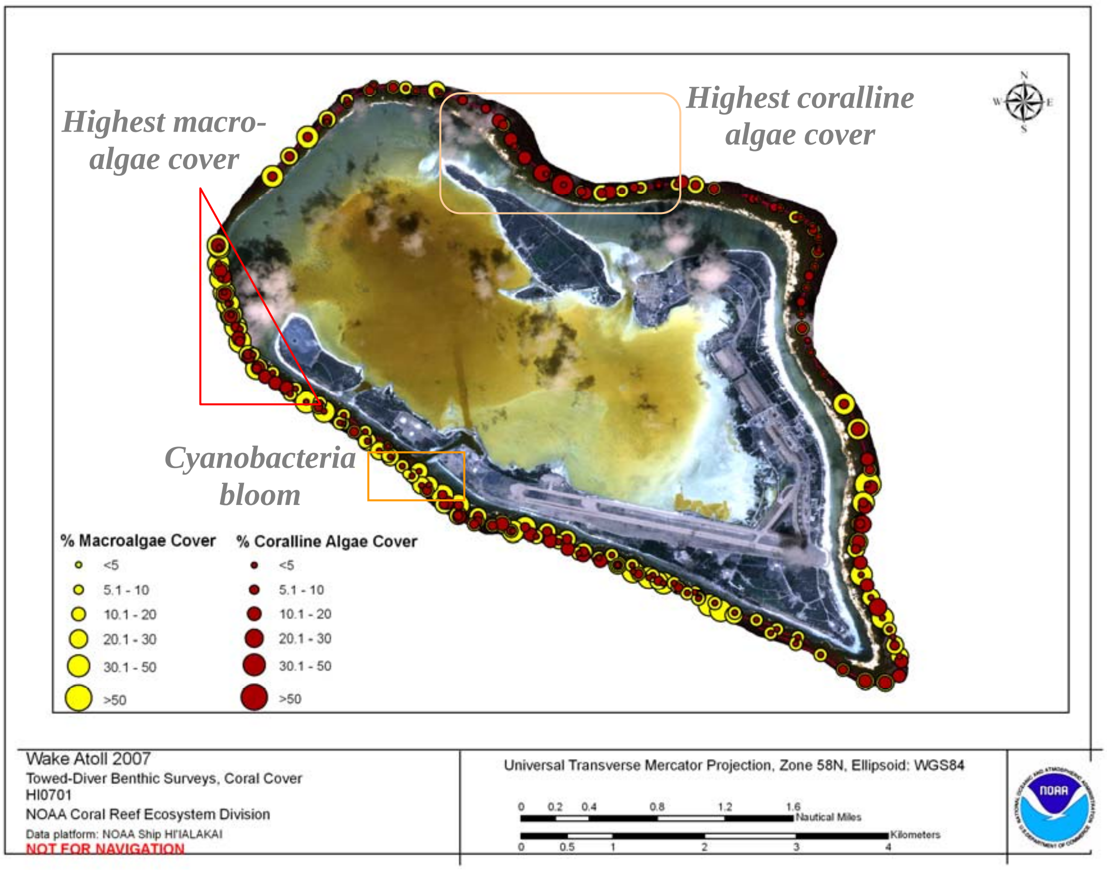


Figure B.4.1.2-1: Macroalgae and coralline algae cover around Wake (2007).

The island-wide average macroalgal cover was recorded at 19% (range 1.1 – 62.5%), while the coralline algae cover averaged 6% (range 0 - 30%). The highest macroalgae cover recorded during a single towed-dive was noted near the southwest (SW) corner of the atoll, passing the farthest (SW) corner of Wilkes

Island as the divers progressed to the northwest (average 36%, range 20.1 – 50%), while the highest coralline algae cover was recorded during the towed-diver survey along the northern forereef (average 17%, range 10.1 – 30%).

Several other observations were noted. These included:

- A cyanobacteria bloom along the southern forereef in the vicinity (east) of the harbor, in shallow water adjacent to the wreck of the RC Stoner;
- *Halimeda* was found island-wide;
- Large colonies of *Caulerpa racemosa* were found along the northern forereef.

<u>B.4.2. Corals</u>

REA surveys were conducted at 12 forereef sites (Table B.3-1). These are the same 12 forereef sites that were surveyed in October 2005. Locations of all REA sites around Wake are shown in Figure B.3-1. Only the line-intercept method for calculating benthic cover was conducted at WAK-12; other aspects of coral REA surveys could not be conducted at WAK-12 because excessive current and surge generated conditions inhospitable to recording reliable data.

B.4.2.1 Coral Populations

<u>Coral Diversity</u>

At least 46 new records of coral taxa were reported as a result of REA surveys conducted by Jean Kenyon and Victor Bonito in 2005. Since that time, many of these records have been confirmed by Gustav Pauley from photographs taken by Kenyon//Bonito, but tentative species identifications of the more challenging taxa (e.g., *Acropora, Montipora*) based on skeletal samples taken by Bonito still need to be confirmed. The species lists compiled from 2005 surveys, along with briefer coral species inventories recorded by Maragos (1979) and Molina (1998), provided a very useful basis for the surveys conducted by Kenyon and Vargas Angel in 2007. No additional taxa were reported in 2007.

<u>Population Parameters</u>

A total of 3274 cnidarian colonies were enumerated within belt transects covering 498 m^2 at Wake Atoll. The number of colonies enumerated and percentage of coral colonies represented by each taxon are shown in Table B.3.4.1-1.

Table 3.4.1-1. Number of cnidarians surveyed in belt transects at Wake Atoll forereef sites in 2007 and 2005. Taxa contributing more than 10% of the total number of coral colonies are in bold.				
	2007		2005	
Genus	# colonies	% of total	# colonies	% of total
Acanthastrea	311	9.5	168	8.9
Acropora	6	0.2	8	0.4
Astreopora	65	2.0	55	2.9
Cyphastrea	135	4.1	63	3.3
Echinopora	16	0.5	4	0.2
Favia	**483**	**14.8**	**333**	**17.7**
Favites	3	0.1	0	0.0
Fungia	5	0.2	1	0.1
Goniastrea	344	10.5	177	9.4
Leptastrea	9	0.3	9	0.3
Lobophytum	111	3.4	pooled as "octocorals"	
Millepora	6	0.2	0	0.0
Montastrea	162	4.9	69	3.7
Montipora	**626**	**19.1**	**327**	**17.3**
Pavona	37	1.1	15	0.8
Platygyra	17	0.5	10	0.5
Pocillopora	**590**	**18.0**	**363**	**19.2**
Porites	181	5.5	95	5.0
Psammocora	1	0.0	0	0.0
Sarcophtyton	38	1.2	pooled as "octocorals"	
Scapophyllia	2	0.1	0	0.0
Sinularia	122	3.7	pooled as "octocorals"	
Stylophora	4	0.1	0	0.0
TOTAL	3274	100.0	1886	
Area surveyed, m^2	498		400	
Density (colonies/m^2)	6.6		4.7	

Nineteen genera of scleractinian corals, 3 genera of octocorals (*Lobophytum*, *Sarcophyton*, *Sinularia*), and 1 hydrozoan genus (*Millepora*) were enumerated within belt transects encompassing 498 m^2. In terms of number of colonies represented within transect belts, *Favia*, *Goniastrea*, *Montipora*, and *Pocillopora* codominated the coral fauna at forereef sites. In 2005, octocorals were pooled during colony counts and accounted for 10.2% of colonies enumerated; in 2007 the three genera observed were enumerated separately, but collectively composed 8.3% of the coral fauna. The relative contribution of taxa to the coral fauna was highly similar to that observed in 2005 (Table 3.4.1-1), indicating the August 2006 typhoon at Wake did not have a selective pruning effect on the forereef coral composition at the depths surveyed (10.6–16.7 meters).

<u>Size Class Structure</u>

Size class distributions of all cnidarians enumerated within forereef belt transects at Wake Atoll in 2005 and 2007 are shown in Figure 3.4.1-1.

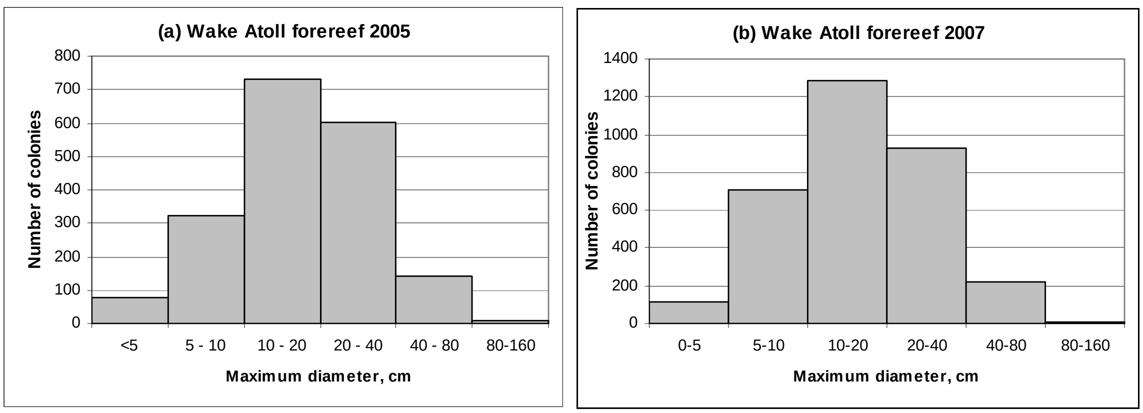


Figure 3.4.1-1. Size class distributions of cnidarians enumerated in forereef belt transects at Wake Atoll in 2005 and 2007.

Although a statistical test comparing the two distributions remains to be carried out (Kolmogorov-Smirnov two-sample test), visual inspection strongly suggests there is no difference between the two distributions. This is another line of evidence suggesting the August 2006 typhoon did not have a substantial effect on the forereef coral communities at the depths surveyed (10.6-16.7 meters) at Wake Atoll.

B.4.2.2 Percent Benthic Cover

Percent benthic cover surveys at Wake Atoll were conducted in concert with the fish, coral population, algae, and invertebrate REA surveys at 12 different sites selected in 2005. The line-intercept methodology quantified a total of 1,224 points along 500 m of forereef coral communities. Survey-transect depths ranged between 11 and 16 m for all reef locales visited. Patterns of intra-island variability in percent benthic cover, derived from the 12 independent REA surveys in 2007, are reflected in Figure B.3.4.2-1. Point-count surveys indicated that the mean percent live coral cover for all sites combined was intermediate: 29.7 ± 3.6% (mean ± SE). Coral cover in excess of 50% was encountered at site WAK-7 on the west-facing shore; in contrast lower percent coral cover (10.8%) was detected at WAK-2, in the vicinity of the dredged ship channel, adjacent to the wreck of the *RC Stoner*. Of the nearly 25 scleractinian genera observed at Wake Atoll (Jean Kenyon and Victor Bonito 2005 Coral REA), a total of 17 were enumerated along the point-count transects, with *Montipora* being the most numerically abundant (33.5 ± 4.1%), followed by *Porites* (20.1 ± 3.4%), and *Pocillopora* (18.3 ± 4.4%). Additional important coral genera enumerated along the point-intercept transects included: *Favia*, *Acanthastrea*, *Goniastrea*, and *Astreopora*. Figure B.3.4.2-2 illustrates the contribution of the different scleractinian genera to the total percent live coral cover.

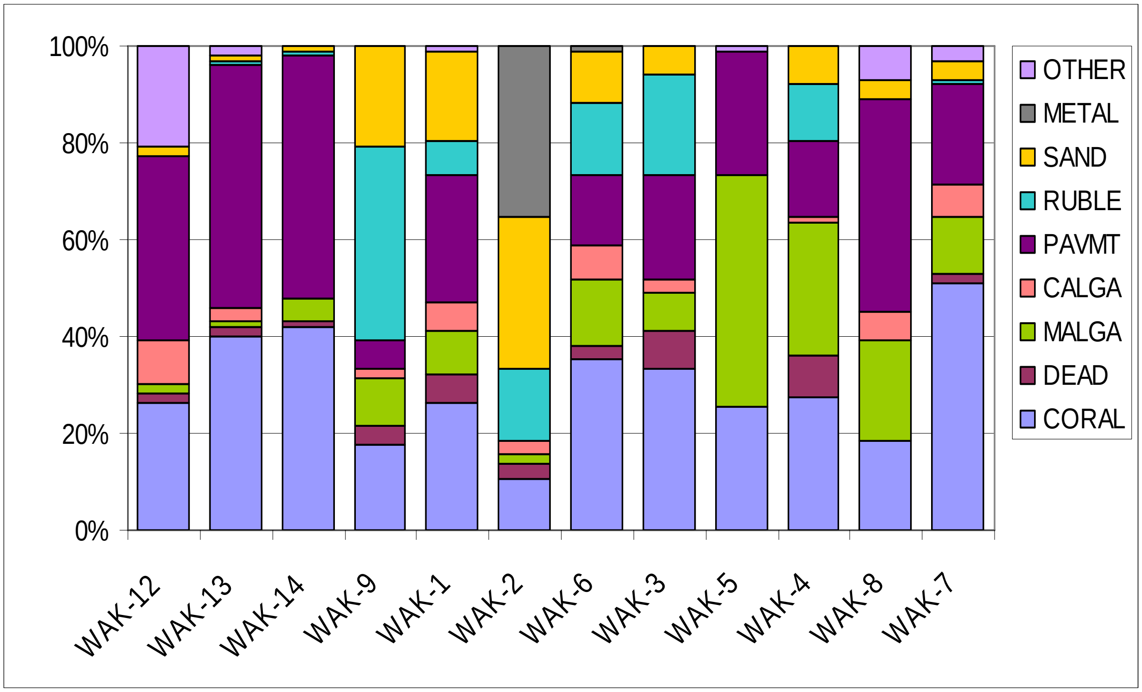


Figure B.3.4.2-1 Mean percent cover of selected benthic elements derived from 12 independent REA surveys at Wake Atoll, MAR-RAMP 2007. CORAL: live scleractinian and hydrozoan stony corals; DEAD: dead scleractinian and hydrozoan stony corals (including recent and old dead coral cover with turf-algae), MALGA: fleshy macroalgae; CALGA: crustose coralline algae; PVMT: carbonate pavement (including recent and old carbonate covered with turf-algae); RUBLE: coral rubble (including recent and old coral rubble covered with turf-algae); SAND: sand; METAL: corroding metallic debris; and OTHER: other sessile invertebrates including alcynoarian corals, echinoderms, sponges, tunicates, as well as cyanobacterial mats.

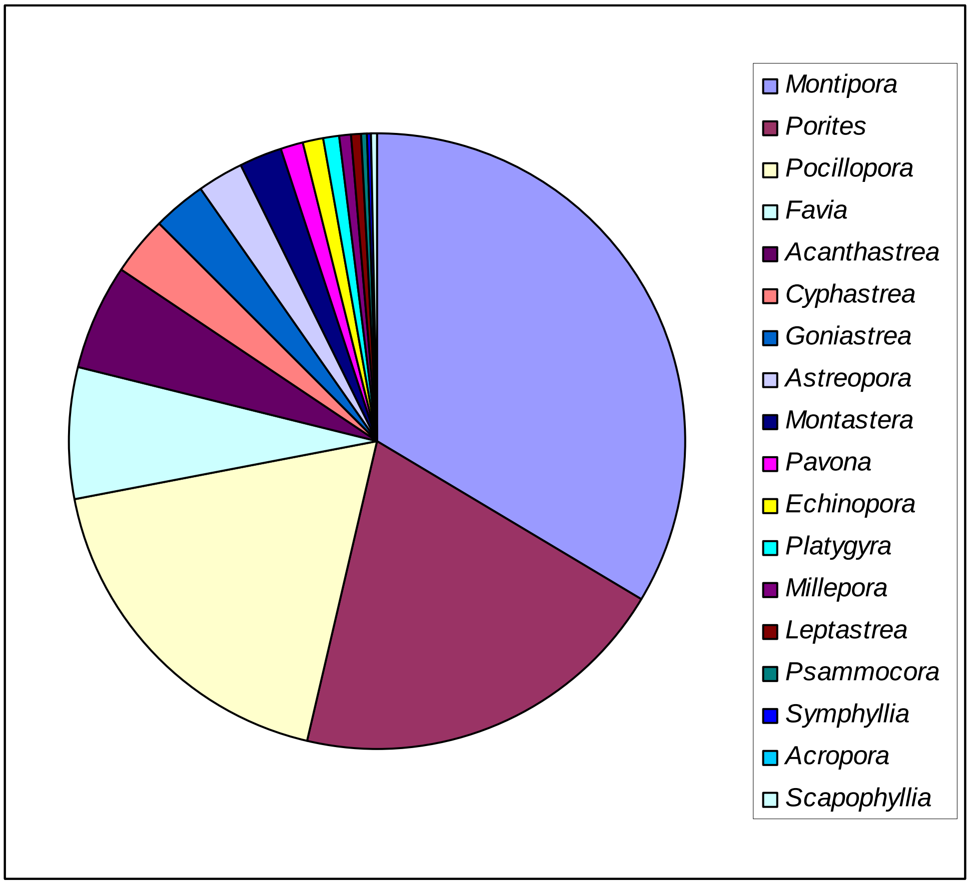


Figure B.4.2.2-2 Percent contribution of the different coral genera to the total live coral cover at Wake Atoll, MAR-RAMP 2007.

The quantitative data above documents important characteristics of the coral reef benthic assemblages, providing the opportunity to monitor for change in response to alterations in the reef environment. The category 5, Typhoon Ioke, hit the atoll in late August of 2006 as a category 5. An abridged comparison of percent live coral cover between the 2005 and 2007 is illustrated in Figure B.4.2.2-3. Sites WAK-12, -13, and -14 in the path of the storm exhibit the greatest changes in percent live coral cover since the last surveys in 2005. Our data indicate that these three sties have experienced, on average, changes in percent live coral cover of over 37%, compared to average changes of 2.7% for all the other sites combined. Given the strength of Typhoon Ioke, our REA surveys did not find the presence of evident signs of storm damage at sites WAK-12, -13, and -14, including dislodged or toppled colonies, and/or bottom scouring. A non-parametric Wilcoxon matched-pairs test indicated no statistically significant differences in percent coral cover for all sites combined based on the 2005 and 2007 data ($p > 0.05$).

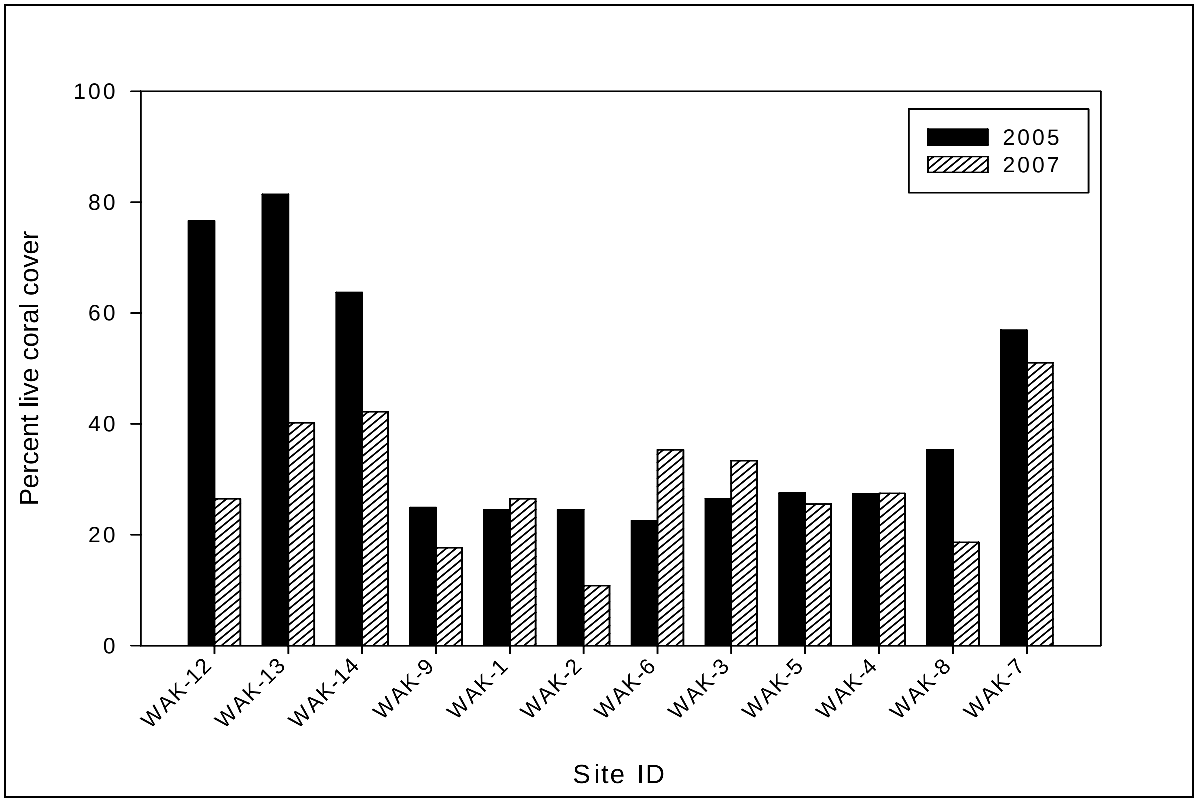


Figure B.4.2.2-3 Percent live coral cover for 12 REA sites at Wake Atoll contrasted for survey years 2005 and 2007.

B.4.2.3 Coral Disease

No prior records of coral disease occurrence are available for Wake Atoll because no disease surveys were conducted during REA activities in 2005. In 2007 the coral disease REA surveyed a total area of ~3125 m^2 at 12 different sites. Due to time constraints, only 75 m^2 were surveyed for disease at site WAK-7; also, strong currents allowed for disease surveys on 150 m^2 only at site WAK-14. A summary of disease occurrence is presented in Table B.4.2.3-1. Overall, occurrence was low, with a total of 24 cases within the total area surveyed (~ < 1 case/100 m^2 of reef area). Skeletal growth anomalies were the most abundant disease state (58% cases) followed by focal bleaching (21%). Among sites, WAK-13 on the north-facing shore exhibited the greatest occurrence of disease with over 20% of cases, compared to 8–9% for each of the other sites presenting disease. Disease conditions were registered on six different coral genera, with *Porites* exhibiting 50% of cases, followed by *Goinastrea* (21%), *Montipora* (8%), *Acropora* (8%), and *Astreopora* (8%). Of particular interest, was a case of tissue loss/white syndrome encountered on a colony of *Platygyra* cf. *daedalea*. Finally, a number of senescing colonies of *Pocillopora* spp. with partial mortality and macroalgal (mainly *Dictyota*) and cyanobacterial overgrowth were observed, particularly at sites WAK-2 and WAK-6.

Table B.4.2.3-1 Cumulative number of cases of disease conditions enumerated at each survey site at Wake Atoll during the 2007 RAMP cruise. BLE: focal bleaching; CYA: cyanobacterial infections; IRR: coral-algal interactions with pigmentation responses; SGA: skeletal growth anomaly; TLS: tissue loss/white syndrome. No disease conditions were observed at sites not listed herein. Total survey area ~3135 m^2.

Species	**Disease state**	**WAK-12**	**WAK-13**	**WAK-14**	**WAK-3**	**WAK-5**	**WAK-7**	**WAK-8**	**WAK-9**	**Grand Total**
Acropora cf. *microclados*	SGA						2			2
Astreopora	SGA	2								2
Goniastrea edwarsi	BLE								2	2
	CYA							1		1
	IRR							1		1
	TLS							1		1
Platygyra daedalea	TLS	1								1
Porites cf. *solida*	BLE		2							2
	IRR				1					1
	SGA		3	2	1	2				8
Porites lobata	BLE								1	1
Montipora cf. *hoffmeisteri*	SGA					1				1
Montipora cf. *grisea*	SGA						1			1
Grand Total		3	5	2	2	3	3	3	3	24

B.4.2.4 Benthic towed-diver surveys – Corals

The island-wide average hard coral cover was recorded at 13% (range 1.1–50%), with the average stressed coral averaging 4% (range 0.1–20%). The highest hard coral cover recorded during a single towed-dive was noted near the southwest (SW) corner of the atoll, passing the farthest (SW) corner of Wilkes Island as the divers progressed east (average 29%, range 20.1 – 40%; Fig. 3.2.4.1). The highest stressed coral recorded during a single towed-dive was noted during a subsequent tow, passing southern coast of forereef habitat south of Wilkes Island, heading west up to, and including, the habitat within the channel (average 10%, range 1.1 – 30%; Fig. 4.2.4-1).

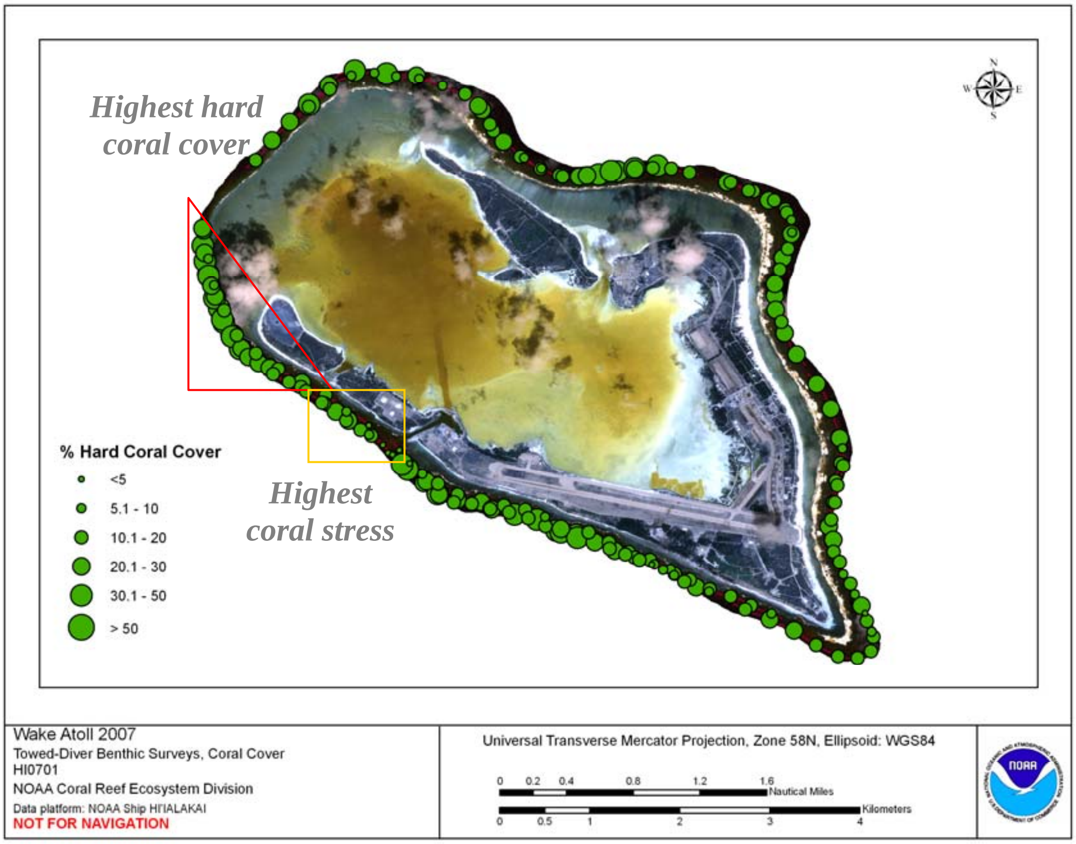


Figure 4.2.4-1: Hard coral cover around Wake (2007).

Divers noted discoloration of *pocillopora* species in many places along the southern forereef, with a typical presentation consisting of healthy tissue changing to affected tissue (pale/white) and associated algal growth over dead tissue. Whether this is attributed to normal senescence, an unknown pathogen, or other cause is not known.

Bite marks on corals were common and seen island-wide (especially visible on *porites* species). However, these did not appear to cause coral stress in surrounding tissues (Fig. 4.2.4-2).

Storm damage from the typhoon that struck Wake in August 2006 was much less than expected. Several large *porites lobata* coral heads were found broken along the eastern shoreline (Fig. 4.2.4-3), but the vast majority were intact and appeared healthy. Small clumps of vegetation (branches) were also noted at depths of 50–60 feet along the southeast side of Wake packed into small crevices. No other perceived storm damage was noted.

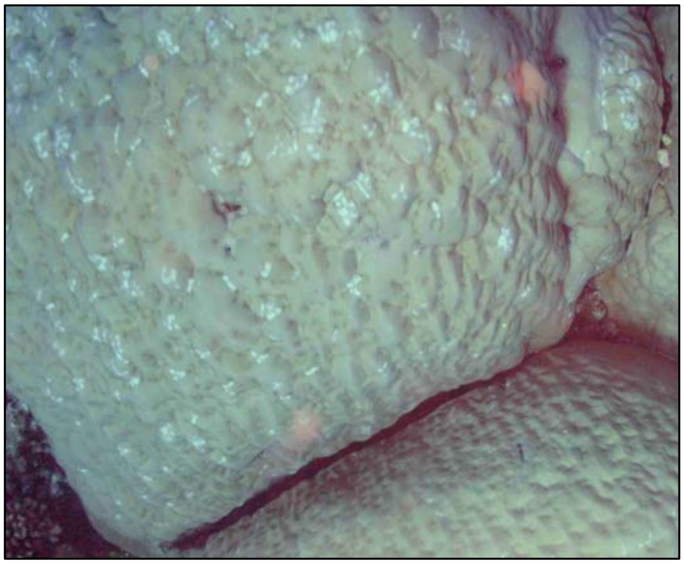


Figure 4.2.4-2: Coral bite marks.

Figure 4.2.4-3: Flipped *porites lobata*.

The island-wide average soft coral cover was recorded at 2% (range 0–40%), with the highest soft coral recorded along the northeastern tip of Peale Island heading southwest along the breakers (average 31%, range 20.1 – 40%; Fig. 4.2.4-4)

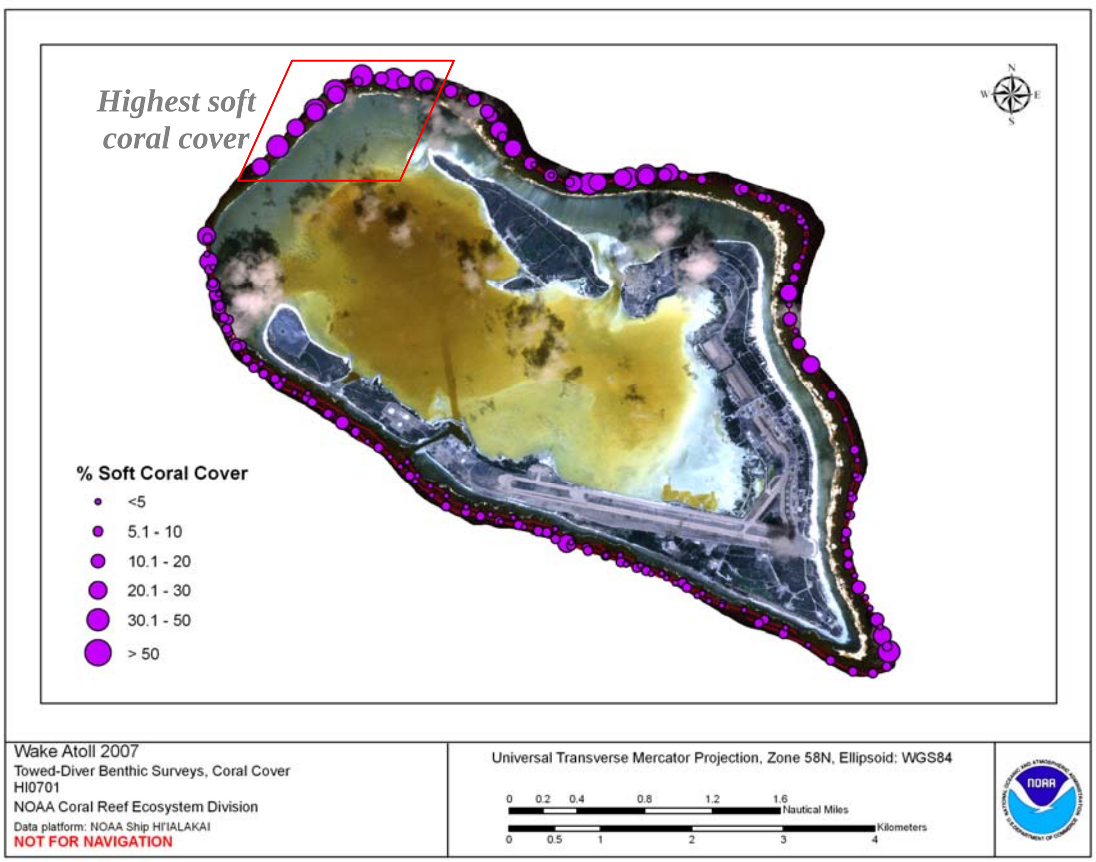


Figure 4.2.4-4: Soft coral cover around Wake (2007).

B.4.3 Macroinvertebrates

The REA sites surveyed were all on the outer reef this year, as the REA team deemed it more important to spend the limited time surveying the outer reef than spend the time getting into the lagoon, which tended to have limited reef habitat. The invertebrate records from all sites reflect only what was out on the reef, in sight. There was limited time for searching rubble, combined with the fact that there was limited rubble habitat at the sites. Actively searching the undersides of rubble would have yielded higher numbers of species and might be something that time is allotted for in the future. For this cruise, the objective for the invertebrate diver was to document any major changes in the benthic community that might have been associated with damage from the hurricane.

The only species that was abundant on the transects was *Holothuria edulis*, which was present at 6 of the 12 sites, these being the sites along the south side and the one site on the east side. The urchin, *Echinostrephus aciculatus*, was present at 8 of the 12 transects, but never in abundant numbers. *Tridacna sp*. were found on the transect in low densities at half of the sites, and they were spotted off transect at many of the others. The 2005 Wake cruise reported high densities of *Tridacna* in the lagoon. The lagoon was not resurveyed by the 2007 REA team, but there were reports and photos from the oceanography team of high densities of *Tridacna* in the lagoon again this year.

Invertebrate Taxa On Belt Transects	REA Site Numbers												
	1	12	13	14	2	3	4	5	6	7	8	9	Total
Actinopyga mauritiana												1	1
Bohadshia argus	1												1
Echinometra matthaii			1										1
Echinostrephus sp?											2		2
Echinostrephus aciculatus	1		5	1	2	2			1	5	2		19
Holothuria edulis	31				8	22	14		41			60	176
Holothuria whitmaei				1									1
Linckia multifora						1							1
Phyllidia sp.?	1												1
Spondylus sp.							1						1
Stichopus chloronotus						1							1
Tridacna sp.	1	3	2			1			1	3			11
Total	35	3	8	2	10	27	15		43	8	5	61	217

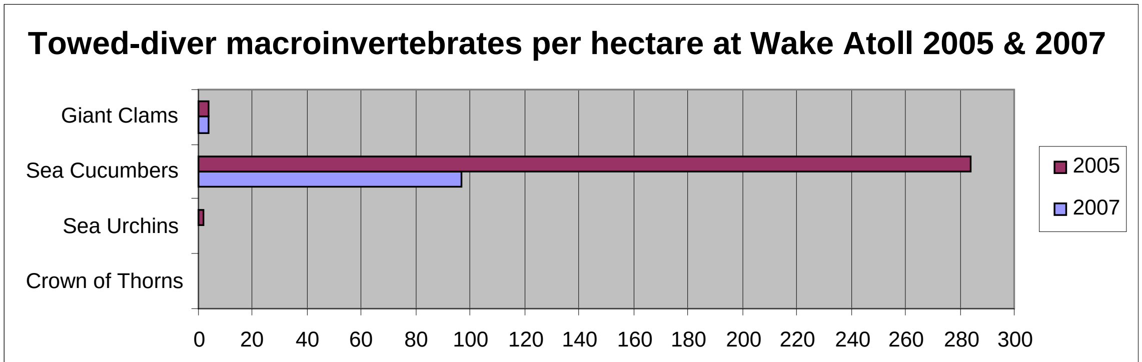
The most abundant taxa found in the quadrat surveys were the hermit crabs in the genus *Calcinus*. *Spirobranchus giganteus, Trapezia sp.*, and *Ophiocoma pica*, were also commonly seen, although they were not present in very high abundances at any one site.

Invertebrate Taxa In Quadrats	REA Site Numbers												
	1	12	13	14	2	3	4	5	6	7	8	9	Total
Alpheus sp.						1		3		8			12
Calcinus sp	4		1	1	2	3	4	2	6	8		7	37
Conus sp.												1	1
Cypraea sp.			1										1
Ophiocoma pica	1				2	6		4	1	1		2	17
Pedum sp.?												2	2
Unidentified Porifera											1		1
Spirobranchus giganteus		2	1	3		1				15	1		23
Trapezia sp.	2				2	4	1	4	1	1			15
Unidentified Opisthobranch								2					2
Unidentified Gastropod				1	1	1	1			1		1	5
Zanthid sp.?					1								1
Total	7	2	3	5	8	16	6	15	8	36	2	13	121

The finding in 2005 of a lack of certain components in the invert fauna, such as anemones, corallomorphs, large urchins (e.g., *Diadema*, *Echinothrix*), hydroids, lobsters and large crustaceans, crinoids, large asteroids, octopus, and ascideans and sponges, is again noted in 2007.

B.4.3.1 Benthic towed-diver surveys - Macroinvertebrates

Towed-diver benthic habitat and invertebrate surveys were conducted around the entire atoll, along with additional shallow tows conducted along the southern shore of Wake Island. No crown-of-thorns starfish were observed compared to only one observed in 2005. Only 27 sea urchins total were observed for all surveys with the majority on the southeastern corner of the island. The most abundant macroinvertebrate observed were sea cucumbers, with over 4,000 observed for the entire atoll and the majority along the southern coastline. Giant clams were sparse, with frequency ranging from 0 to 7 total for each tow. In 2005 there were more giant clams observed on shallower tows; there was no difference this year.



	Crown of Thorns	Sea Urchins	Sea Cucumbers	Giant Clams
2005	0.03	1.7	284.21	3.83
2007	0	0.633	96.484	3.891

Figure B.4.3.1-1 Towed-diver macroinvertebrate observations per Hectare for 2005 and 2007.

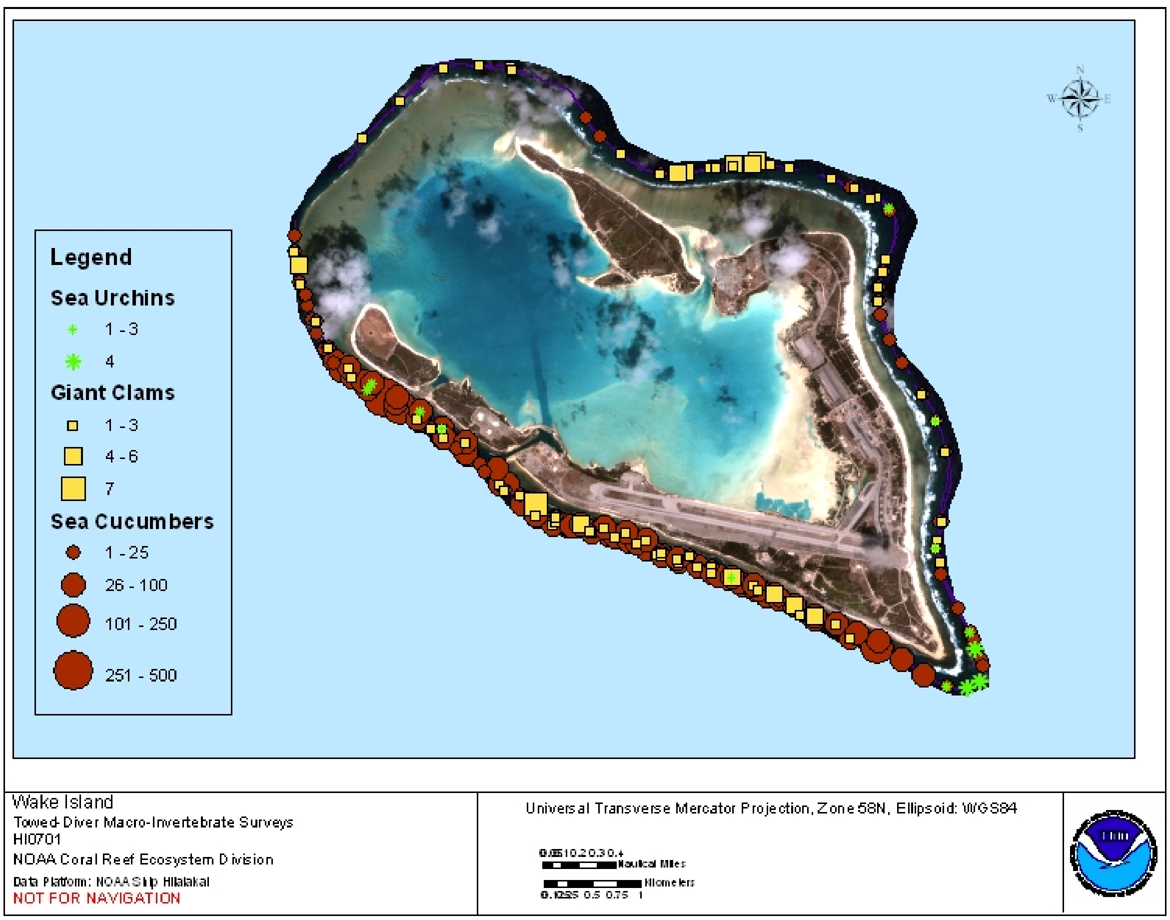


Figure B.4.3.1-2 Towed-diver macroinvertebrate observations for HI0701.

B.4.3.2 Invertebrate collections

Eighteen invertebrate samples were collected at Wake Atoll.

Species	**Observed**	**Collected**
Holothuria atra	Present	11
Linkia mulitifora	Present	7

B.5. Fish

B.5.1 REA Fish Surveys

Stationary Point Count (SPC) data
A total of 48 individual SPC surveys were conducted at 12 forereef sites around Wake Atoll. Divers enumerated 896 fishes representing 20 Families (67 spp.) during the survey period. Parrotfishes (Scaridae) were the most commonly observed Family with a numerical density of 1.6 fishes per m². Surgeonfishes (Acanthuridae) and Chubs (Kyphosidae) were also commonly observed during the SPCs yielding numerical densities of 1 and 1.4 fish per m², respectively. Notable observations included the IUCN Red Listed Napolean Wrasse (*Cheilinus undulatus*, *n* = 6) and Bumphead Parrotfish (*Bolbometopon muricatum*, *n* = 12). These species were commonly observed on every dive but were oftentimes observed outside the survey area (10 m).

Belt Transect (BLT) data
During the survey period, 36 belt transect surveys were conducted at 12 forereef sites around Wake Atoll. A total of 8,094 fishes representing 27 Families (136 spp.) were enumerated. Damselfishes (Pomacentridae) were the most commonly observed fishes with 275 fishes tallied per m². Surgeonfishes (Acanthuridae) and Wrasses (Labridae) were also commonly observed during the BLT surveys, yielding densities of 35 and 32 fishes per 100 m². Although not as abundant, herbivorous fish such as parrotfishes (Scaridae) and surgeonfishes (Acanthuridae) accounted for the largest portion of total fish biomass with 45% of the biomass (Fig. 5.1-1).

Overall observations
A total of 146 species representing 37 families of fishes were observed during the survey period by all divers. The medium to large fish biomass at Wake Atoll during the survey period was 0.40 tons/ha for the SPC surveys (Table 5.1-1), and the total fish biomass was 1.9 tons/ha for the Belt transect surveys (Table 5.1-2). These values are consistent with the biomass values observed during surveys conducted at Wake in 2005, suggesting that the fish communities were not impacted by the category 5 typhoon that struck Wake in August 2006.

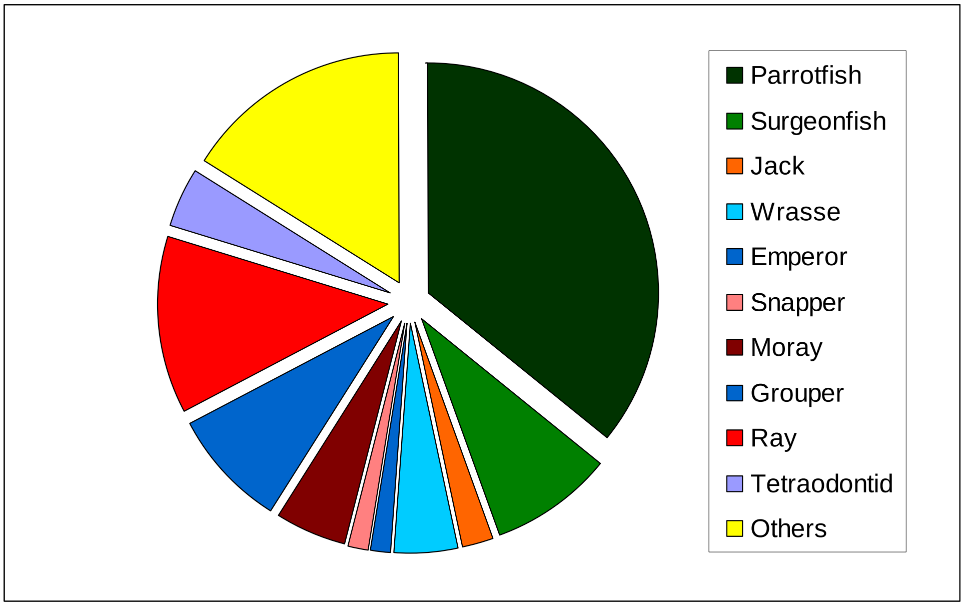


Figure 5.1-1 – Family composition of the total fish biomass (1.9 ton per hectare) around Wake Island.

Table 1. – Medium to large fish biomass (tail length >25cm) around Wake Island (ton per hectare).

Site	Total	Parrotfish	Surgeon	Trigger	Jack	Shark	Grouper	Wrasse	Emperor	Snapper	Chub	Others
WAK-1	0.04	0.0227	0.0000	0.0000	0.0000	0.0000	0.0000	0.0084	0.0000	0.0000	0.0029	0.0084
WAK-2	0.16	0.0167	0.0271	0.0000	0.0000	0.0000	0.0000	0.0797	0.0304	0.0000	0.0035	0.0051
WAK-3	0.17	0.0437	0.0220	0.0000	0.0604	0.0000	0.0056	0.0140	0.0187	0.0000	0.0035	0.0000
WAK-4	0.28	0.0973	0.0745	0.0000	0.0473	0.0000	0.0158	0.0142	0.0113	0.0070	0.0035	0.0055
WAK-5	0.69	0.3015	0.0534	0.0000	0.0121	0.0000	0.0226	0.1724	0.0000	0.0046	0.0150	0.1116
WAK-6	0.98	0.8231	0.0173	0.0071	0.0116	0.0000	0.0084	0.0209	0.0473	0.0017	0.0000	0.0469
WAK-7	0.60	0.2459	0.0402	0.0242	0.0172	0.1992	0.0109	0.0126	0.0041	0.0035	0.0144	0.0325
WAK-8	0.58	0.2002	0.0614	0.0120	0.0350	0.0000	0.0563	0.1376	0.0000	0.0090	0.0162	0.0517
WAK-9	0.47	0.1020	0.0155	0.0000	0.0030	0.1495	0.0075	0.1131	0.0000	0.0029	0.0103	0.0619
WAK-12	0.43	0.0607	0.0394	0.0060	0.0153	0.0000	0.0590	0.2225	0.0041	0.0119	0.0138	0.0000
WAK-13	0.23	0.0465	0.0221	0.0181	0.0293	0.0000	0.0123	0.0639	0.0041	0.0017	0.0167	0.0153
WAK-14	0.22	0.0396	0.0515	0.0277	0.0030	0.0000	0.0168	0.0198	0.0357	0.0027	0.0213	0.0000
Total	0.40	0.1667	0.0354	0.0079	0.0195	0.0291	0.0179	0.0733	0.0130	0.0037	0.0101	0.0282

Table 2. – Total fish biomass around Wake Island (ton per hectare)

Site	Total	Surgeonfish	Jack	Hawkfish	Soldier	Wrasse	Emperor	Snapper	Chub	Moray	Parrotfish	Grouper
WAK-1	0.7	0.0871	0.0064	0.0231	0.0430	0.1009	0.0343	0.0073	0.0198	0.0040	0.2224	0.0881
WAK-2	0.6	0.2107	0.0273	0.0225	0.0299	0.0983	0.0000	0.0000	0.0000	0.0000	0.1374	0.0000
WAK-3	2.0	0.2399	0.0000	0.0119	0.1914	0.0567	0.0455	0.0220	0.0313	0.0001	0.3229	0.5372
WAK-4	3.2	0.5869	0.0325	0.0319	0.0074	0.1083	0.0721	0.0689	0.0193	0.6918	1.0563	0.4541
WAK-5	3.0	0.1602	0.0675	0.0286	0.0245	0.0731	0.0093	0.0040	0.0584	0.4907	0.4317	0.0473
WAK-6	2.9	0.1213	0.0000	0.0276	0.0651	0.0526	0.0093	0.0364	0.0193	0.0000	2.3593	0.0199
WAK-7	1.0	0.1344	0.0000	0.0534	0.0172	0.0397	0.0093	0.0110	0.0284	0.0520	0.1775	0.1336
WAK-8	1.0	0.1654	0.0000	0.0277	0.0324	0.0547	0.0000	0.0536	0.0293	0.0000	0.2453	0.1973
WAK-9	3.7	0.0968	0.0268	0.0195	0.1803	0.0870	0.0334	0.0521	0.0782	0.0000	2.9633	0.1114
WAK-12	3.7	0.0981	0.3909	0.0305	0.0077	0.3085	0.1076	0.0453	0.1001	0.0000	0.3114	0.2410
WAK-13	1.0	0.0776	0.0000	0.0887	0.0425	0.0710	0.0087	0.0115	0.0349	0.0000	0.3884	0.1144
WAK-14	0.5	0.0983	0.0132	0.0191	0.0000	0.0270	0.0171	0.0000	0.0414	0.0000	0.1362	0.0889
Total	1.9	0.1731	0.0471	0.0320	0.0535	0.0898	0.0289	0.0260	0.0384	0.1032	0.7293	0.1694

B.5.2 Fish Towed-diver Surveys

At Wake Island, the towboard team conducted 19 tows totaling 42.66 kilometers in length and covering 42.66 hectares of ocean bottom. Mean survey length was 2.28 km and mean biomass of large fish (>50cmTL, all species spooled) was 2.33 t/ha. The two most abundant species by biomass were *Bolbometopon muricatum* and *Cheilinus undulatus*, followed by *Caranx sexfasciatus*, *Carcharhinus amblyrhynchos*, and *Aetobatus narinari*. Anecdotally, *Bolbometopon muricatum* appeared to be in highest abundance along the south coast of the island where large solitary adults were often encountered (Fig. 5.2-1). On the northern coast individuals were encountered rarely and only at the northwestern point of the island. Here smaller individuals were encountered in groups numbering from 5 to 18. *Cheilinus undulatus* were distributed a little more evenly around the island; however, the majority of the biomass was likewise aggregated along the southern coast. Observations were typically of solitary individuals a meter or more in length. Spawning behavior was observed in a school of *Caranx sexfasciatus* along the southern coast and in *Chlorurus microrhinos* at a site on the eastern coast. Looking at recently developed bathymetric maps, it appears that areas of high overall biomass correlate with areas of exaggerated seafloor slope. Formal spatial statistics will be employed to investigate this apparent correlation.

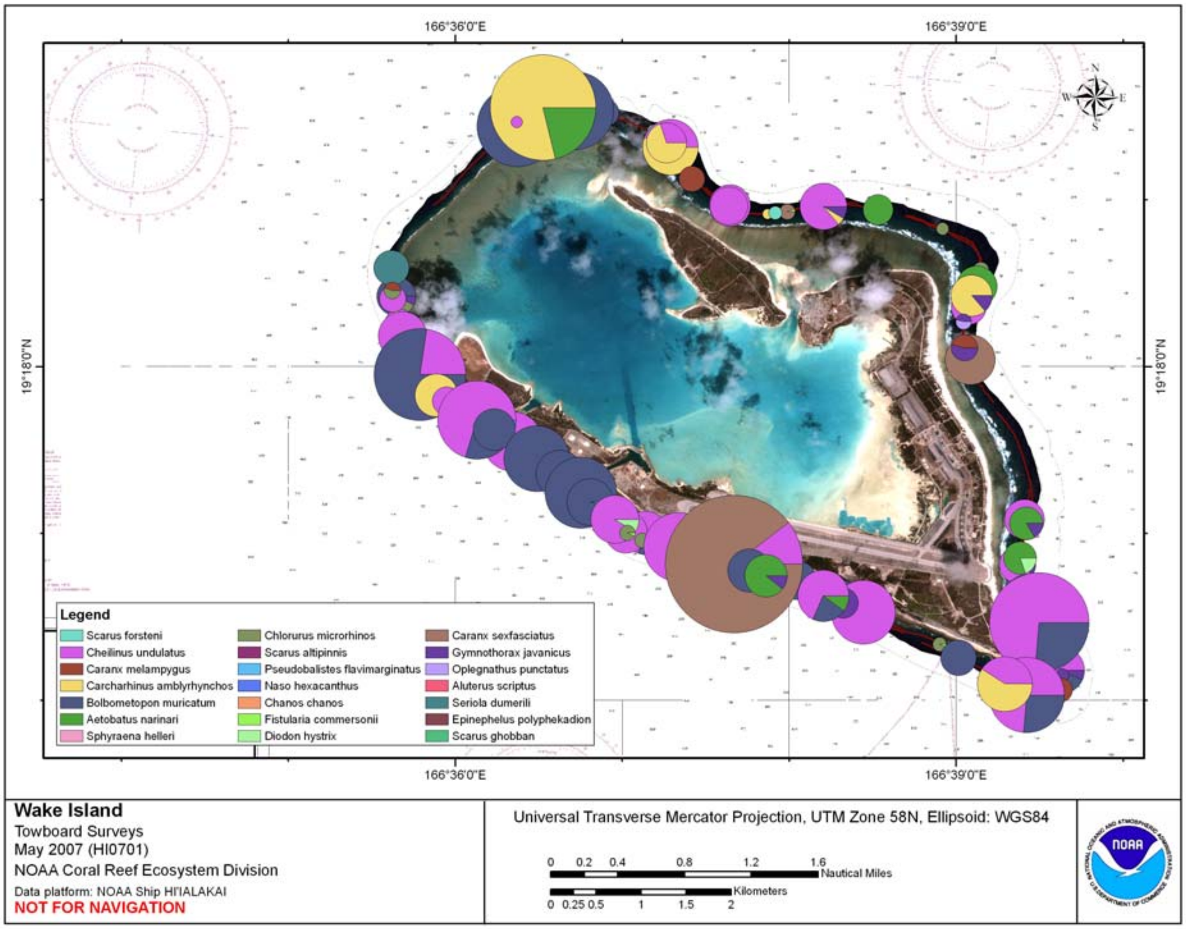


Figure 5.2-1. Distribution of Large Fish Biomass.