Development and Implementation of a Coral Health Assessment Tool for St. John, USVI

by

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B.S., Civil Engineering (2001)

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Submitted to the Department of Civil and Environmental Engineering
in Partial Fulfillment of the Requirements of the Degree of
Master of Engineering in Civil and Environmental Engineering

at the

Massachusetts Institute of Technology

June 2007

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ABSTRACT

Coral health in St. John, US Virgin Islands, has shown tremendous declines in recent years, with more than 50% declines in live coral cover. As one component of a group project to assess the possible impacts of anthropogenic development on coral health, a Coral Health Assessment Tool (CHAT) was developed using Microsoft Access ® and used to assess coral health in four bays in St. John.

The tool builds on data management techniques that are currently employed by the National Park Service in St. John. The CHAT includes an Access form-based user interface that allows for random image selection and iterative analysis of still images that have been extracted from video of coral conditions. The database is dynamically linked to Microsoft Excel ® Pivot Table outputs that provide users with extensive data manipulation and exploration capabilities. The CHAT is constructed to allow extensibility and customization by developers and users. While this implementation of CHAT was specific to St. John, the tool's structure lends itself to further development and implementation in coral reef assessment programs worldwide.

The health assessment employed a multi-parameter index, allowing bays to be ranked by relative coral health. This index combined multiple coral health factors, including percent cover, percent healthy, and others to create a single numerical score for each bay. Combined with the conclusions of other group members, results of the health assessment generally indicate that coral health is adversely affected by development.

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EXECUTIVE SUMMARY

This thesis, produced as a portion of a group project studying the effects of nitrogen and sediment loading on coral health in St. John, USVI, included the development of a Coral Health Assessment Tool (CHAT) that allows users to perform coral health assessments and a Coral Health Index (CHI) that quantifies coral health.

The CHAT builds on data management techniques that are currently employed by the National Park Service in St. John by integrating data management, image viewing, and data analysis capabilities into a single software package. It was developed as a Microsoft Access database and includes a form-based user interface that allows for random image selection and iterative analysis of still images that have been extracted from video of coral conditions. The primary CHAT user interface form is shown as Figure 1.1-1 and was built to maximize data entry efficiency, while the supporting table and query structure was constructed to ensure accurate data storage and reporting. The database is dynamically linked to Microsoft Excel Pivot Table outputs that provide users with extensive data manipulation and exploration capabilities. As well, the CHAT can either store or be dynamically linked to images in various electronic formats. The CHAT is constructed to allow expansion and customization if it is used in future coral health assessment applications.

The coral health assessment was based on 34 total digital video transects collected in Fish, Leinster, Reef, and Round Bays in January 2007. More than 1000 still images were extracted from the video transects, and a portion of these were randomly selected for assessment using the CHAT. Subsequently, coral identification and health assessment was performed at twelve discrete locations on each image. By combining the data collected from image analysis with a multi-parameter index (CHI), the four bays were assigned relative coral health scores. The CHI combined multiple coral health factors, including percent cover, percent healthy, and others to create a single numerical score for each bay. Results of the health assessment indicate that coral health is greater in Leinster and Round Bays than in Fish and Reef Bays. These results, when reviewed with the work of other Coral Solutions team members, generally indicate that coral health is adversely affected by development. An expanded discussion of this correlation can be found in the Coral Solutions group report (Coral Solutions, 2007).

Future development related to the CHAT could include customization for specific user needs, such as development of additional Pivot Table outputs, modified data entry forms, or changes to the underlying data structure. Additional forms that allow users to interact with the CHAT without needing to make manual table updates would shield the user from inadvertent data changes. Because the CHAT was constructed to allow for expansion and customization, many further improvements could be made with relative ease.

Overall, an objective coral health index was developed and used to assess coral health in St. John. The CHAT tool enabled the author to effectively compile and evaluate data and ultimately deduce meaningful conclusions about coral health based on numerous parameters. While this implementation of the CHAT was specific to St. John, the tool's structure lends itself to further development and implementation in coral reef assessment programs worldwide.

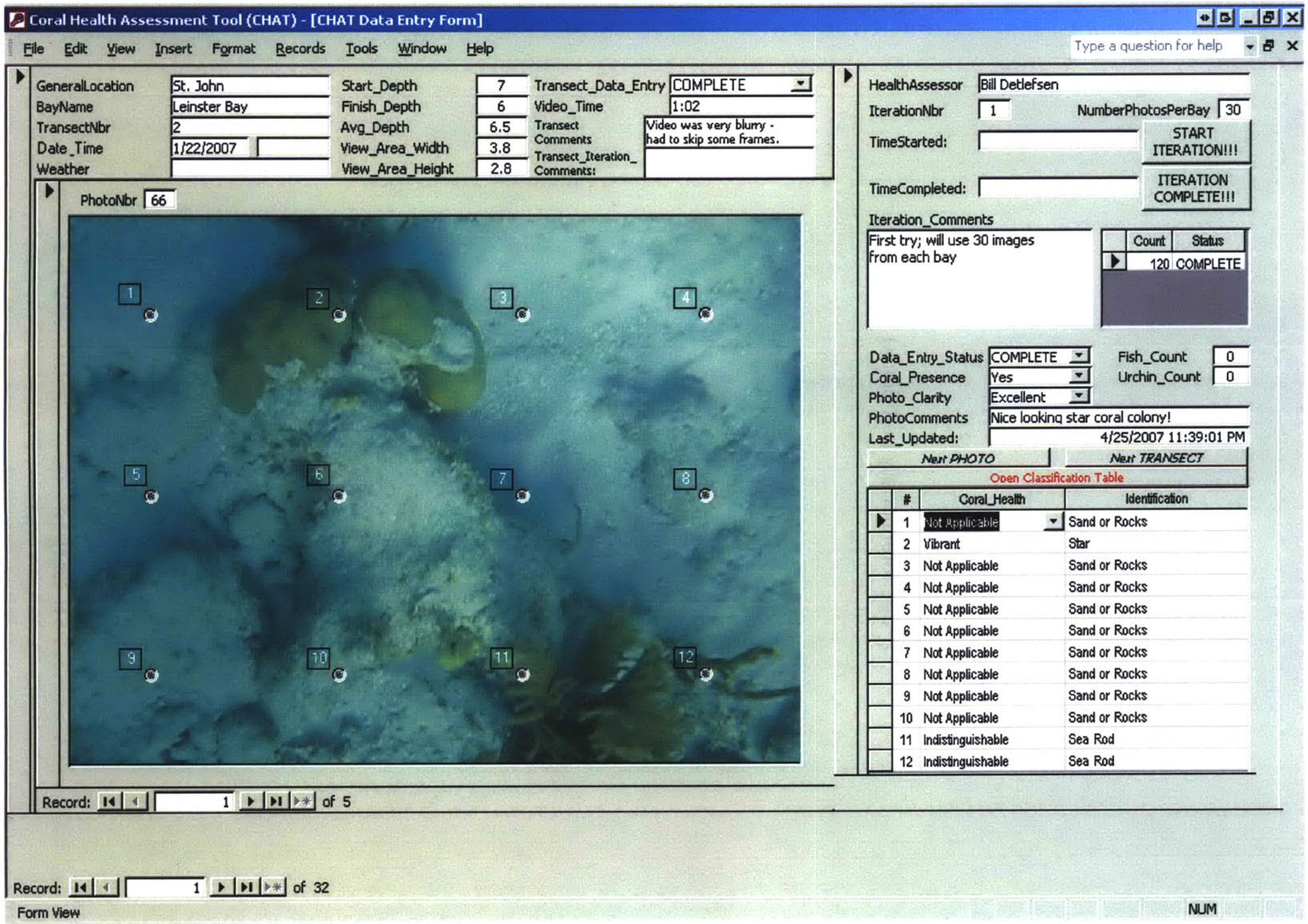

Figure 1.1-1 – Primary CHAT User Interface

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1 INTRODUCTION & BACKGROUND

1.1 PROJECT BACKGROUND

Tremendous losses of coral colonies have been observed in St. John, U.S. Virgin Islands (USVI) in recent years, coincidental with increased land development and tourism on the island. St. John is not alone, as the scientific community acknowledges that coral reefs throughout the world have significantly decayed due to human activity in the past decades (Downs et al. 2005). In response, the United Nations declared 1997 "International Year of the Reef", and in 1998 President Bill Clinton established the *U.S. Coral Reef Task Force* to "better preserve and protect coral reef ecosystems" (U.S. Coral Reef Task Force (USCRTF) 2006).

In response to the coral declines, in January 2007, four MIT students, Helen McCreery, Alfred Navato, Jeffrey Walker, and William Detlefsen, the author, traveled to St. John, USVI, to study the possible impacts of land development on coral health. Throughout this thesis, this group of four students will be referred to as 'Coral Solutions', the name given the fictitious consulting company they formed. The other three students focused specifically on sediment and nitrogen loading and transport to bays due to development, while the author developed a Coral Health Assessment Tool (CHAT) and used it to perform a subsequent health assessment. This thesis will refer to the work of other Coral Solutions members, as well as the overall group report summarizing the findings of all members. Portions of Section 1 of this document were co-written with other Coral Solutions members and also exist in varying forms in their individual theses.

Land development, the construction of roads, houses, buildings, and infrastructure, often causes changes in hydrologic conditions and consequently increases sediment runoff. Particularly in regions of steep terrain that are close to bays, the sediment runoff can reach the bays. Also associated with land development, septic systems, use of fertilizers, and other factors can increase the amount of nitrogen that reaches bays.

As such, the overall group goal was to study the effects of development, via sediment and nitrogen loading, on coral health. To do this, a clear view of the existing health conditions was necessary to understand possible correlations. While long-term coral health monitoring over a period of years would have been preferable to assess changes in health conditions, Coral

Solutions was limited to only one trip to St. John. As such, this health assessment provides a 'snapshot' of health conditions as they were observed in January 2007.

While in St. John, Coral Solutions performed various field work related to different aspects of the overall group project, including recording video of existing coral conditions, collecting rainwater runoff samples, collecting water samples for suspended solids and nitrogen analysis, and performing other tasks. The primary field work related to this thesis was the collection of video of coral health conditions, which was subsequently analyzed upon return to MIT.

1.2 Research Goals and Ties to Existing Research

There are two driving goals for this thesis. The first goal is the completion of a coral health assessment that can be related to the nitrogen and sediment research performed by other members of Coral Solutions. The second major goal is the development of an integrated, portable health assessment system that can be easily customized or expanded based on user needs. The author hopes that people who perform coral health assessment using videographic methods, and in particular the National Park Service employees who perform coral health assessment in St. John, will embrace this tool, or components thereof, for their own work.

Videographic methods, discussed further in Section 1.7, are currently used in a range of coral monitoring programs. However, as described in Section 1.7, various coral health monitoring programs exist worldwide and are often very different in terms of methods, use of health indicators, and other aspects. However, to the author's knowledge, there are no standardized software packages available for coral health assessment, data management, and reporting that are tailored specifically to the needs of those performing coral monitoring.

Many of the general methods employed in this thesis, as well as the software applications that are utilized, are currently used by the National Park Service in St. John. As such, this thesis does not propose completely new methods of coral health assessment, but instead builds on currently practiced methods. The author intentionally used similar software for development to allow compatibility between his work and that which is currently in use by the National Park Service, and he believes that the integrated approach presented in this thesis may offer an improved approach to data collection, management, and reporting.

1.3 Geography and Climate

Because coral health can be greatly influenced by environmental conditions, it is important to understand the regional setting, climate, and seasonal variations where corals live. While they are found in many regions of the world, corals are generally found only in tropical and sub-tropical areas, the latter of which describes St. John.

The physical location of the USVI is significant for coral health, particularly because water temperatures can be influenced by warm water transported from the west via ocean currents. The islands are located about 80 km east of Puerto Rico in the northeastern region of the Caribbean Sea (18° 20' N 64° 50' W) (Figure 1.3-1). The USVI are a territory of the United States and encompass three main islands—St. John, St. Thomas, and St. Croix—in addition to a number of smaller uninhabited islands (Figure 1.3-1). The total territorial area is 1910 km^2 of which 346 km^2 is land surface bounded by 188 km of coastline (Seitzinger 1988).

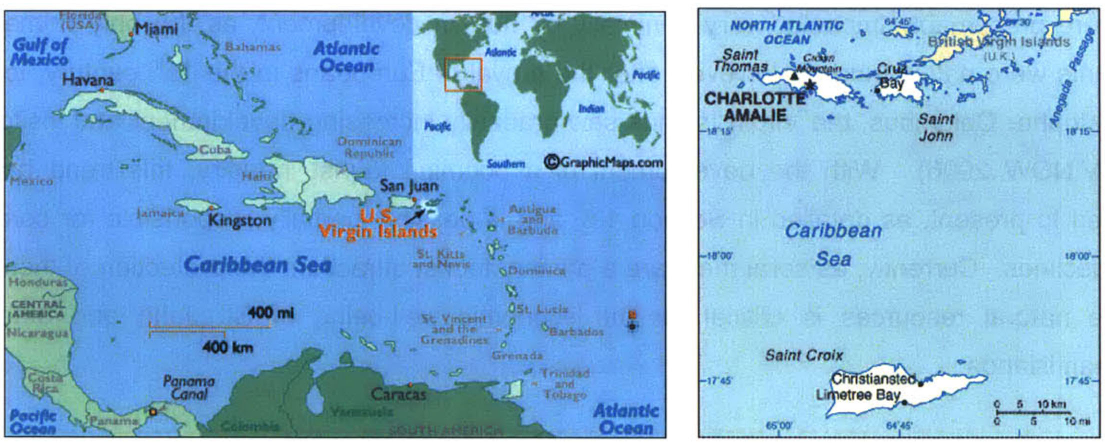

Figure 1.3-1 – Regional and local maps of the US Virgin Islands;
from (World Atlas 2007)

The climate in this region is subtropical and generally stable with monthly-average mean air temperatures ranging from 24 to 28°C (76 to 82°F) throughout the year (Southeast Regional Climate Center 2005). Daily air temperature fluctuations are fairly low, as the monthly-average daily maxima and minima range from 3 to 5°C (5 to 9°F) around daily means (Southeast Regional Climate Center 2005). Average coastal water temperature variations are also relatively low, generally ranging from 25 to 28°C (77 to 84°F) (Department of Planning and Natural Resources 1980). Total annual precipitation averages about 1,140 mm (45 inches) with the rainiest months occurring during the hurricane season, roughly August through November, with precipitation generally occurring as storms of short duration. (Southeast Regional Climate Center 2005)

Due to their latitude and proximity to the Gulf Stream, the USVI are subject to frequent tropical storms and hurricanes. Large storm events can cause significant reef damage as well as high intensity rainfall, which can cause flooding and very high sediment loading rates to coastal waters (Jeffrey et al. 2005). While there have not been any major hurricanes in this region in recent years, increased water temperatures have been recorded due to the lack of major storm activity, most notably in 2005, as discussed in Section 1.7.5.

1.4 History and Economy of St. John

Due to their slow growth rates, coral reefs have taken hundreds to thousands of years to develop to their current size (HUBBARD et al. 2005). During much of that time, the reefs in St. John were presumably impacted very minimally by human development, as the only human inhabitants were native tribes. However, after the arrival of Europeans in the 15th century, led by Christopher Columbus, the Virgin Islands saw gradually increasing development and visitor traffic (VINOW 2006). With the development of a booming tourist industry, this trend has continued to present, as detailed in Section 1.5, and is possibly partially responsible for coral health declines. Currently, as coral reefs are a primary tourist attraction, the protection of these valuable natural resources is critical for the economic well-being of St. John and other Caribbean islands.

While it may be today, coral was not always a primary draw for visitors to St. John. Following its initial exploration by Europeans, the island proved to be an excellent location for cultivation of tobacco, sugar and cotton. By the mid-17th century, the native island populations had been decimated by Europeans, who began to establish permanent settlements and plantations. Although the islands were occupied by a number of European countries, the Danish eventually assumed complete ownership of the islands, where slave labor was employed until its use was abolished in 1848 (VINOW 2006).

Throughout the 19th century, sugar was the primary export of the island. As the years passed, demand for sugar began to decrease and sugar production became less and less profitable. Poor housing conditions led to widespread sickness and a decline in the population. Costs of maintaining the islands led the Danish government to try to sell the islands in 1867 and 1906, but political and national concerns prevented the transaction. The United States eventually purchased the three islands of St. Croix, St. John and St. Thomas for $25 million in 1917 as a military positioning tactic during WWI (VINOW 2006).

Although change was slow, tourism began to grow after World War II with the construction of resorts on the islands. In 1952, Laurance Rockefeller purchased a huge portion of the island of St. John and began constructing roads, and installing water pipes and electrical infrastructure to create a luxury campground. Over the following decades, the islands emerged as one of the most popular vacation destinations worldwide, with correspondingly high levels of development (VINOW 2006).

Today, tourism is the main industry on the USVI with approximately 80% of the economy specializing in the service-related industries (Lexdon Business Library 2006). The Gross Territorial Product (GTP) has steadily increased by about 6% annually to 2.6 billion in 2004 (USVI Bureau of Economic Research 2005). Between 1996 and 2000, the number of visitors to the three islands increased dramatically by 35% to 2.4 million annually, 85% of which visited the two smaller islands—St. Thomas and St. John (Eastern Caribbean Center 2002). To support the increased tourist traffic, population has increased at a lesser rate: approximately 23% increase between 1990 and 2005 (Mills et al. 2006). Tourists are attracted to many things on St. John, but the beautiful beaches and easily accessible coral reefs are among the strongest attractions.

1.5 Development of St. John

Because the Virgin Islands are a major tourist destination, the level of habitation and anthropogenic development are generally greater than islands focused on other revenue sources. In the context of this thesis, the term 'development' refers to any type of large, man-made structure such as a building, road, or dock that may directly or indirectly enhance or alter sediment or nitrogen transport to bays. Compared to the other islands of the USVI, St. John has far fewer developments due to the presence Virgin Islands National Park, which covers more than half the area of the island. Even so, there are still many developments on the island that can potentially affect the coral reefs. In general, there is development throughout much of the island, centered in two major areas. However, the presence of a large national park limits the extent of development in some regions. Development of St. John is covered in greater depth in the Coral Solutions group report.

The two regions that contain the most development on St. John are Cruz Bay and Coral Bay, with the majority of the population at Cruz Bay. Cruz Bay is the main harbor, servicing cruise ships, and is the location of the majority of businesses on the island. A wastewater treatment facility is located at Cruz Bay and most buildings within the Cruz Bay district are connected via a sewer system. The treatment plant uses secondary treatment and discharges the effluent approximately one mile from the coast. Coral Bay is developed to a lesser degree, does not support cruise ships, and does not have a wastewater treatment plant.

Outside of Cruz and Coral Bays, individual homes and two major resorts, Caneel Bay and the Westin Resort, account for the majority of the development. Homes are located throughout the island with the exception of the central and southern regions that are part of the National Park and contain a few buildings. All homes are connected to the electrical grid, but few houses outside of Cruz Bay are connected to the water distribution or sanitary system. Instead, many residents purchase delivered water or utilize rain collection systems for their water supply and employ individual septic systems.

Offsetting some of the developed areas, over half of St. John is designated a national park, thus limiting development within park boundaries (Uhler 2007). The Virgin Islands National Park was established on August 2, 1956, and initially protected over half of the island (9,485 out of the 12,500 acres of St. John). In 1962, the park was expanded to include 5,650 submerged acres to protect the coral reefs around the island. Today, the park encompasses 14,689 acres of island and submerged areas and is one of the major tourism sites on the island (Uhler 2007).

Within the park and elsewhere, transportation on the island is generally via truck or car on paved roads, concentrated on the eastern side of the island. Two roads (North Shore Road and Centerline Road) connect Cruz Bay to Coral Bay. Because of the relief on the island, large portions of the hills have to be carved out in order to construct the roads. Many of the roads are paved, but a significant portion, particularly in residential areas, remain unpaved.

1.6 BACKGROUND OF CORAL REEFS

Like many ecosystems, the coral reef ecosystems that support an entire industry in St. John are very fragile, and they are easily disrupted by external influences. When assessing whether development, via nitrogen loading and sedimentation, may be impacting coral reefs, it is important to have a clear understanding of exactly what corals are, how they live, and how they are affected by stressors. Because different coral species may exhibit different responses to stressors, it is particularly important during a coral health assessment to understand how to identify corals. Finally, an understanding of current research on how development may be linked to coral health declines provides a context for this research. For further information, particularly regarding coral stressors and sediment and nitrogen loading, the reader may refer to the Coral Solutions group project report.

1.6.1 ECOLOGY AND BIOLOGY OF CORAL REEFS

Reef-building, or hermatypic, corals are animals that resemble sea anemone and build carbonate shells, known as coralline cups, to protect and support their internal organs (Figure 1.6-1). As corals die, these carbonate shells are left behind, forming spatially complex reef structures that provide niche habitats for the wide diversity of organisms that comprise the food web. The formation of these structures is driven by the growth and erosion of coral skeletons.

Throughout most of its lifecycle, the coral remains attached to a fixed substrate, usually the reef itself. When a coral dies, its skeleton remains and physical disturbances such as wave impacts and burrowing by organisms known as 'bioeroders' break the skeleton into smaller and smaller pieces. Over time, these small pieces of calcium carbonate accumulate on the reef surface resulting in growth of the reef substrate. Numerous species of encrusting algae also contribute to the formation of a reef structure by depositing thin sheets of limestone. These free-living algae can account for 17-40% of total carbonate deposition (Mann 2000). Other species of non-encrusting algae including small, filamentous forms are often found in reef ecosystems and form the short algal turf which is a key food supply for herbivores (Gleason 1998).

A coral's shell is open-ended allowing the head of the coral, known as the polyp, to emerge and feed on free-floating planktonic animals from the surrounding water. Within the tentacles of these polyps reside symbiotic, single-celled dinoflagellate algae called zooxanthellae, which are mainly of the genus *Symbiodinium*. These algae produce organic carbon by photosynthesis which they supply to their host coral in exchange for dissolved carbon dioxide and nutrients (Mann 2000).

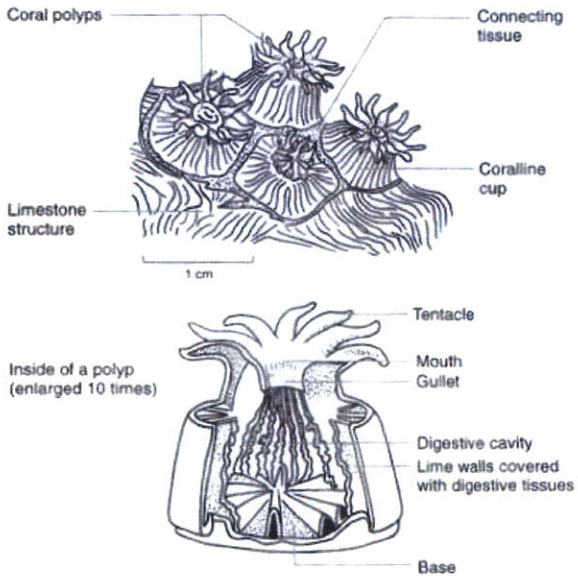

Figure 1.6-1 – Anatomy of coral polyps;
from Mann (2000).

Coral reefs are some of the most productive and diverse ecosystems in the world. The mean aerial rate of net primary productivity, or flux of carbon from the atmosphere into plant matter, is higher than any other type of ecosystem, including tropical rain forests (Geyer 1997). These high rates of productivity are due in part to a highly efficient cycling of nutrients and energy through a complex food web.

While they are extremely productive ecosystems, coral reefs are typically located in oligotrophic, or nutrient-poor, marine environments and thus rely heavily on efficient nutrient cycling within the ecosystem to maintain their high rates of productivity (Smith 1984). A highly complex food web ensures the uptake and cycling of all available nutrients. The interactions between trophic levels may have significant impacts on the composition of the reef building community. For example, there is evidence that the abundance of herbivores may control the colonization of macroalgae on coral substrate (Belliveau and Paul 2002).

Coral reef formation is highly sensitive to temperature and generally requires mean annual water temperatures of at least 18°C (64°F) (Mann 2000). This sensitivity confines reefs to the tropical and subtropical regions between the Tropics of Cancer and Capricorn. Since reefs depend on the growth of photosynthesizing organisms at the base of the food web, these ecosystems exist in relatively shallow regions such as continental shelves, island coastlines and atolls where light is able to penetrate through the entire water column. The three major types of coral reefs are fringing reefs, barrier reefs and atoll reefs (Figure 1.6-2). Fringing reefs occur near the coastline of continents or islands; barrier reefs are located further from shore and form lagoons between the reefs and the mainland; atoll reefs develop on atolls which are isolated and submerged land masses resulting from the subsidence of a former island. The coral reefs around St. John are primarily fringing and are found close to shore around most of the island (Drayton et al. 2004).

In addition to the stony reef building corals, other groups of corals include lace corals, fire corals, and soft corals (Humann and DeLoach 2002). Discussed further in Section 1.6.2, these corals are physiologically different than the corals that deposit calcium carbonate to produce massive reef structures, but they are still very important within the coral reef ecosystem.

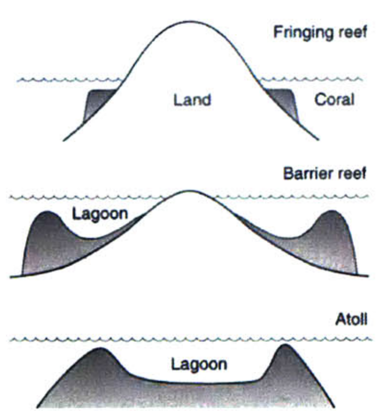

Figure 1.6-2 – Major types of coral reefs;
from Mann (2000)

1.6.2 CORAL TAXONOMY

To clearly understand the state of coral health, it is important for a coral health assessor to understand what he/she is identifying. For this reason, it is valuable to understand the classification of corals.

Biological taxonomy generally describes the science and practice of classification of living organisms and provides an accurate, precise means of uniquely identifying creatures within a classification hierarchy, based on many physical characteristics. In the seven levels of scientific classification, the kingdom is the most broad and wide-encompassing classification, while the species is the most specific. From most general to most specific, the scientific classification groups are: kingdom, phylum, class, order, family, genus, and species.

Corals are members of the Cnidaria phylum, but they are further classified by scientists using the remaining scientific classification groups. Most scientists agree on coral classifications to the genus level, however, species identification can become extremely complex at the species level, often requiring DNA analysis (Humann and DeLoach 2002). For the casual observer of coral however, these differences are relatively imperceptible. Instead of using this complex classification and naming schema, non-scientists often group corals into broad categories by easily identified features. When doing so, corals are often referred to by common names based on physical description that do not incorporate their scientific classification. While the use of common names can simplify discussion of organisms, it can also introduce ambiguity in identification, as common names are less precise than scientific names. However, common names allow non-experts to identify organisms to a useful level of classification.

Paul Humann and Ned DeLoach categorize all corals into four 'Commonly Recognized Groups' in *Reef Coral Identification* (Humann and DeLoach 2002). These groups, along with a brief explanation of each, are summarized below. These descriptions generally do not include scientific names, and for ease of identification, this thesis typically refers to corals only by common names.

- <u>Stony Corals</u>

  Stony corals are the primary reef-building organisms. As described in Section 1.6.1, they secrete calcium carbonate to form protection for their soft bodies. As the corals die, the stony protective structure is left behind, forming the stony reef.

General types of stony corals include staghorn, mustard hill, finger, elkhorn, star, and brain corals. Of particular note, *montastraea annularis*, or star coral, is known to be the most abundant reef-building coral in St. John (Jeffrey et al. 2005).

- <u>Soft Corals</u>

  Soft corals, or corals without a rigid skeleton, are commonly called 'octocorals'. The term 'soft coral' explicitly refers to the family Nephtheidae, however, it is commonly used to refer to all octocorals and will be used as such in this paper.

  In general, soft corals are attached to rigid substrate by the base of a branching stem. Branching patterns can vary greatly, therefore soft corals can take many different shapes. Common soft corals are sea rods, sea fans, and sea whips.

- <u>Hydrocorals</u>

  Hydrocorals are often mistaken for stony corals, as they also secrete calcium to produce skeletons (Humann and DeLoach 2002). However, the polyp structure of hydrocorals is different than that of stony corals, and thus they are classified in a different taxonomic group. Nonetheless, the hard deposits of hydrocorals can aid in reef building.

  Hydrocorals are further classified as Fire or Lace corals. Fire corals are known for the stinging sensation that is produced when touched with bare skin. The three basic structures of fire corals are blade, branching, and box corals.

- <u>Black Corals</u>

  Black corals are typically found in very deep waters, although some species are found within SCUBA diving depths. The polyps of these corals secrete protein material that is deposited in concentric layers, similar to those observed in trees (Humann and DeLoach 2002). The material, usually black, becomes very hard and provides a structure for the corals.

  In contrast to stony corals, black coral polyps do not create protective shells in which to dwell. Instead, they live on, not in, the underlying structure.

1.6.3 CORAL STRESSORS AND BLEACHING

When many tourists travel to Caribbean locations, they expect to see colorful, vibrant coral reefs. Instead, they are often greeted with 'bleached' coral, or coral that has lost its pigmentation. Bleaching is actually a coral's response to stress, but it is just one of the many threats that coral colonies face, as global climate change, increased ship traffic and groundings, disease, water quality degradation, and other things threaten coral health in St. John and elsewhere. In this section, the well-known 'bleaching' response of coral is discussed, as well as the threats primarily investigated by Coral Solutions, nitrogen and sediment loading. An expanded discussion of coral stressors can be found in the Coral Solutions group report.

1.6.3.1 Bleaching

Bleaching occurs when coral are under prolonged or acute episodes of stress, which can be caused by a variety of factors. This loss of color is an indication that the coral have expelled the symbiotic zooxanthellae algae that live within their polyps. Without zooxanthellae, only the calcium carbonate shells of the coral are visible, giving them a white appearance (Figure 1.6-3). If the stress is short-lived, coral are capable of repopulating their zooxanthellae colonies. However, if the zooxanthellae do not recover, the coral will be unable to survive from the loss of this symbiotic relationship. Although the biochemical processes by which the coral expel their zooxanthellae are not well understood, some speculate that under stressful conditions the symbiosis becomes less beneficial for one or both species (Brown 1997). Expulsion of zooxanthellae is not the only possible cause of coral bleaching; any loss of the symbiotic algae, including death, will result in the loss of pigmentation and is therefore considered bleaching.

Figure 1.6-3 – Comparison of healthy (left) and bleached (right) coral;
from (Great Barrier Reef Marine Park Authority; Seaman)

Many stressors can cause coral bleaching, including changes in turbidity, pH, or salinity (Jeffrey et al. 2005). However, perhaps the most widespread threat to coral reefs is rising seawater temperature due to global climate change (Jeffrey et al. 2005). Research has repeatedly shown that rising temperature can cause massive, episodic coral bleaching and death (Edmunds 2004; Knowlton 2001). Some evidence suggests that in addition to coral bleaching, climate change may have other potentially significant impacts on reef ecosystems. Although a gradual rise in sea temperature may not cause a bleaching event, it may still change the ecology of the reef (Edmunds 2004). Under a new temperature condition, different coral species will dominate and reef diversity may suffer. Edmunds (2004) suggests that higher temperatures may allow coral that produce small, simple colonies to outcompete coral that build large, complex skeletons. Although rising sea temperatures pose a clear threat to the coral reefs on St. John, the focus of work by Coral Solutions is on local rather than global stressors.

1.6.3.2 Sedimentation

One of the most direct impacts of coastal development on coral reefs, an area of investigation by Coral Solutions, is through increases in the transport of sediment from the land surface to coastal waters. During construction of new developments, large amounts of soil are typically excavated and relocated to form level foundations. This loose soil is highly susceptible to being transported during rain events, particularly during those of high intensity, such as hurricanes.

High sedimentation rates can cause stress and even death of coral in a number of ways. The most direct mechanism is for the sediment to simply bury the coral, effectively restricting access to free-floating phytoplankton, the main food source for coral, and to light, which is needed for survival of the zooxanthellae (Bothner et al. 2006). However, sediment may affect coral well before loading rates reach this stage.

Sedimentation causes an increase in turbidity, which in turn reduces light penetration through the water column. As a result, less light reaches the photosynthesizing zooxanthellae that live symbiotically with the coral. Additionally, in most cases, increases in sediment loads are associated with increases in nutrient loads leading in eutrophication.

A study on the effect of chronic stress from sediment load on coral reefs in Singapore found that coral cover decreased by about 50% over the past three decades (Dikou and van Woesik 2006). While some of the coral still survive, the dominant species are typically found in much deeper, more naturally turbid waters; the ecology of the reef has therefore changed as a result of the sediment stress.

1.6.3.3 Eutrophication Due to Nitrogen Loading

Another significant threat to coral reefs is eutrophication, occurring when the rate of primary production becomes sufficiently high such that it is detrimental to the system. Eutrophic conditions are caused by excessive nutrient enrichment, particularly due to an influx of nitrogen in marine systems. Eutrophication is having significant impacts on aquatic ecosystems worldwide by causing oxygen depletion, loss of biodiversity, increased frequency of harmful algal blooms and alterations in species composition (Scavia and Bricker 2006). Proliferation of algae from nutrient addition increases the turbidity of the water column and decreases light penetration to benthic primary producers such as seagrasses or corals, a similar effect as increased sediment loads.

The functioning of any ecosystem depends on the supply of organic biomass from primary producers, such as plants and algae. These organisms convert inorganic carbon, usually carbon dioxide, to organic carbon using biochemical carbon fixation pathways such as photosynthesis. In order to build new biomass from inorganic carbon sources, producers need nutrients such as nitrogen, phosphorous, sulfur and calcium. The amounts of each nutrient needed per unit of carbon fixed vary by organism. Terrestrial primary producers generally require much more carbon than aquatic producers due to greater carbon-rich structural content such as wood. Average element ratios exist for various ecosystems, including, perhaps most famously, the Redfield molar ratio for marine systems: 106 C:16 N:1 P (Redfield 1958). Generally, the ratios of elements in the environment differ from those in primary producer biomass. If one element is scarcer than other required elements relative to the stoichiometric ratio of the producer biomass then growth will be limited by the availability of that element. The element is thus referred to as a limiting nutrient.

The two most common limiting nutrients in aquatic ecosystems are phosphorous and nitrogen (Smith 1984). Phosphorous was recognized as the limiting nutrient in freshwater ecosystems during the 1970's. However, the scientific community did not accept nitrogen as the limiting nutrient in marine ecosystems, until the 1980's. (Howarth and Marino 2006; Smith 1984). The addition of the nutrient that is limiting to an ecosystem stimulates growth rates of primary producers more than the addition of any other nutrient. Therefore, the enrichment of marine ecosystems with nitrogen tends to boost primary production.

Typically, the enrichment of limiting nutrients causes high growth rates of suspended- and macro-algae (Duarte 1995). In eutrophic conditions, competition between algae and other primary producers usually results in a shift from dominance by one type of primary producer to another type such as from seagrasses to macro-algae (Duarte 1995). However, coral reef ecosystems are particularly unique compared to other aquatic ecosystems due to their high rates of primary production, significant biodiversity, and close proximity to oligotrophic (nutrient-poor) ocean water. These characteristics result in less well-understood dynamics regarding shifts caused by nutrient enrichment.

Nutrient enrichment has been shown to cause replacement of small filamentous algae turfs with large filamentous and macrophytic algae (Lapointe 1997). However, there is great debate in the literature over the cause-and-effect relationship between nutrient enrichment and shifts between these two types of benthic communities (Szmant 2002).

Some studies have shown that corals are not necessarily competitively inferior to algae in nutrient uptake. In one review, only 7 of 57 papers (12%) on the competition between coral and algae focused on direct experimental evidence of this interaction with the rest being theoretically-based (McCook et al. 2001). It is possible that algal proliferation may instead be a consequence rather than a cause of coral death as new substrate is made available for algae to inhabit by the death of coral.

One of the most ambitious field experiments to date on nutrient enrichment is the Effect of Nutrient Enrichment on Coral Reefs (ENCORE) in the Great Barrier Reef (Koop et al. 2001). Four treatments of nutrients (control with no nutrient addition, nitrogen addition only, phosphorous addition only, and both nitrogen and phosphorous addition) were applied in triplicate to twelve individual coral reefs and a number of biological responses were assessed. The researchers concluded that reef organisms were indeed affected by nutrient enrichment, though the impacts were not severe. The only direct effects of nutrients on coral reefs were on the reproductive success of corals and the ability to regenerate after disturbance. A number of studies also highlight the importance of other factors in controlling algae proliferation in coral reefs, especially herbivory (Szmant 2002).

The observed changes of coral reefs due to nutrient enrichment is a classic ecological problem of bottom-up versus top-down controls (Littler et al. 2006). Bottom-up control refers to the effects of nutrient enrichment on the base of the food web while top-down is control of the food web by the higher trophic levels, such as herbivores. One study showed that the level of herbivory had a much greater impact on the density and growth of seaweed recruits than did nutrient enrichment (Diaz-Pulido and McCook 2003).

Littler and Littler (1984) proposed a conceptual model relating nutrient variability and herbivory to the type of benthic community. The model states that in pristine conditions, where grazing is intense and nutrients are relatively unavailable, corals will dominate the reef. If nutrient availability increases but grazing remains intense then coralline and encrusting algae, which are capable of coral reef building, will dominate. If herbivory decreases then algal turf will dominate with low nutrient availability and fleshy macro-algae, typically the most degraded state, will exist with high nutrient availability. The results of this model are confirmed by the studies comparing herbivory with nutrient availability mentioned earlier (Belliveau and Paul 2002; Diaz-Pulido and McCook 2003; Szmant 2002).

1.6.3.4 Disease and Other Risks

In addition to the risks discussed in Sections 1.6.3.1 through 1.6.3.3, corals face attack by a variety of diseases and physical damage. Disease has recently become a particularly severe problem in the Caribbean, the most devastating of which has been white band disease (Drayton et al. 2004) (Figure 1.6-4). White band disease is characterized mainly by a visible white band that proceeds through living coral leaving behind bleached remains. Black band disease (Figure 1.6-4) and white plague (not pictured) have also reduced healthy coral cover.

The causes of coral diseases is still being debated, but recent studies suggest a link between an increase in coral disease and an increase in the severity of African dust storms, which may be related to global climate change (Weir-Brush et al. 2004). Other studies suggest that rates of coral disease may be related to sewage outflow (Kaczmarsky et al. 2005). Although the causes of these diseases are not fully known, it has been observed that disease can be particularly devastating to coral colonies already weakened by bleaching (Miller 2007).

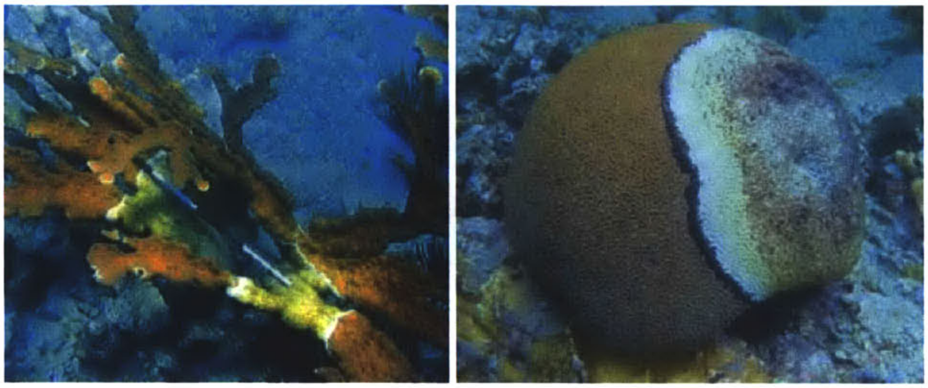

Figure 1.6-4 – White Band Disease (left); Black Band Disease (right)
from (Jeffrey et al. 2005)

Physical damage of coral can occur due to hurricanes, collisions with anchors or boats, or even by physical contact with tourists. Since reefs develop at very slow rates, recovery from physical damage, or any coral death, typically occurs over very long time scales—hundreds of years for a large, well-established reef. Given the frequency of tropical storms and hurricanes in the Caribbean, the reefs in this area are particularly prone to damage from storm events.

1.6.4 Impact of Development on Coral Reefs

One of the primary concerns about the gradual urbanization of coastal watersheds is its impact on sediment and nutrient loading rates. As discussed in Sections 1.6.3.2 and 1.6.3.3, increasing these inputs to coral ecosystems can have a negative impact on coral health. The effect of developments on the land surface is that it replaces vegetation coverage with impervious surfaces. Vegetation holds soil in place through its roots that brace the soil and hold water. It is also an important sink for nutrients. Impervious surfaces have the opposite effect of vegetation by preventing water from percolating into the ground, thereby increasing the volume of runoff during storms. Increasing runoff flow carries greater sediment and nutrients into the bays. Roads, especially unpaved ones that have no stormwater capture system, contribute greatly to sediment loading rates within watersheds.

Many studies have expressed serious concern over the impact of coastal developments on coral reefs. Approximately 58 percent of coral reefs in the Caribbean are threatened by human activity (UNEP 2006). These threats are the result of an increase in tourism over the past fifty years, which has lead to the construction of more developments to attract and house more visitors. This construction requires that large portions of the ground must be cleared of vegetation and excavated. In St. John, the excavated material is often deposited in ravines that can flood during large storms and release highly turbid water into the bays. Construction on St. John has a greater impact on sediment loading because of the slopes on the island. The island has many high-grade slopes that must be excavated into flat slopes to allow construction of buildings or roads. As the cut into the hill widens, a greater proportion of soil has to be excavated due to the triangular shape of the cut; doubling the width of road quadruples the amount of earth needed to be removed. Reducing the sizes of roads and buildings substantially reduces the amount of soil needed to be excavated.

From a nitrogen loading perspective, wastewater effluents from water treatment facilities and septic tanks contain high concentrations of nutrients which can lead to excess nutrient loading and eventual eutrophication of bays (UNEP 2006). While the wastewater treatment facility on St. John disposes its effluent a mile offshore of the island away from the bays, septic tanks are the primary effluent treatment system for the majority of homes on the island. Effluent from septic tanks is released below the ground and disperses into the soil, traveling with groundwater flow. If the groundwater containing effluent reaches a 'seepage face', or area where groundwater exits the soil matrix and enters a water body such as a bay, effluent could be introduced to the bay. As the population increases on the island, more waste is produced, thus increasing the possibility of effluent discharge to bays.

1.7 Reef Monitoring

In St. John, current coral reef monitoring is performed by a team of specialists. Declines in health are readily apparent, as their results have shown up to 90% decline in elkhorn coral over the past 15-25 years, and a drop in live coral cover from 65% to 43% between 1997 to 2001 (Jeffrey et al. 2004, 2005). Current monitoring results are discussed further in Section 1.7.5.

However, St. John is not only location where coral health is monitored. Internationally, there has been growing concern, particularly in the last decade, regarding coral health degradation. As mentioned in Section 1.1, the *U.S. Coral Reef Task Force* was established in 1998, and 1997 was declared "International Year of the Reef". Due in part to this added visibility, many coral health monitoring programs have been implemented around the globe.

As coral health decays, it is extremely important to understand how and why changes occur, so that if possible, measures can be implemented to preserve coral. When considering different monitoring methods, it is important to differentiate between quantitative and qualitative assessments; quantitative assessments use numerical measures associated with coral health, while qualitative are generally based on an impression a person may have of coral health, but are not necessary associated with a numerical value. As discussed in Section 1.7.1, quantitative measures provide researchers with much more information.

Equally important as choosing quantitative methods, health parameter selection is critical to ensure that researchers are in fact measuring the proper indicators of coral health. However, as presented in Section 1.7.2, even after health parameters are chosen, it is often valuable to create an 'index', or single numerical score, that integrates many parameters into a single numerical value. A coral health index (CHI) was developed and used in this thesis.

When methods have been chosen, implementation of comprehensive monitoring programs is necessary. Worldwide, a variety of monitoring programs exist, as discussed in Section 1.7.3, and they employ many different methods.

1.7.1 Necessity of Quantitative Coral Reef Monitoring Programs

Because of the vast array of threats facing coral populations, their populations have declined worldwide, particularly within the past two to three decades (JEFFREY et al. 2004). However, the lack of overall consistency in monitoring methods and protocols means that data from different sites or periods of time are rarely directly comparable. As such, it is difficult for researchers to draw far-reaching conclusions about changes in coral health. To further complicate the issues, while there have been many indications that coral reefs are declining in health and abundance, identification of these trends has been generally qualitative; observed, but not based on measured quantities. (Downs et al. 2005). These issues underscore the need for quantitative, versus qualitative, monitoring of coral health, preferably with standardized parameters and methods.

The general lack of historical quantitative data is clear; because organized coral monitoring programs were not in place decades ago, anecdotal, qualitative assessments based on the observations of coastal residents often provide the most accessible history of reef conditions as they existed historically (Drayton et al. 2004). While valuable, these historic data are inferior to quantitative data for many reasons.

Quantitative, standardized coral ecosystem health metrics are most valuable to researchers, in part because they allow for the assessment of cause and effect relationships between human stressors and coral ecosystems (Jameson et al. 2001). Data collected using these metrics allows comparability between spatial areas and across time, allowing researchers to test hypotheses about causes of coral declines. Aside from their purely scientific value, these quantitative data can also help coral advocates gain political acceptance. Currently, policy makers generally lack comparable, quantitative data that would allow them to understand the true condition of coral reefs and put forth strong arguments for policy change (Jameson et al. 2001). As a result, they may be less proactive in setting standards for conservation or pollution prevention. In general, understanding coral conditions and which human activities are detrimental to the health of coral reefs allows coastal managers to implement strategies that mitigate damaging effects.

To foster development of quantitatively comparable monitoring programs, Jameson et al. (2001) have proposed the development of a universal coral reef 'Index of Biotic Integrity' (IBI) that would integrate various parameters into a single meaningful index to assess and compare coral health worldwide. The production of such an index, if universally applied, would allow comparison of coral health over time and in different geographic areas by the same metrics.

Overall, it is clear that there is a necessity for quantitative reef monitoring, both on global and local scale. While local programs may not coincide with the IBI that Jameson proposes, they may provide site-specific data that the IBI would not. There are number of programs set up to monitor coral health around the world, discussed in Section 1.7.3. Private organizations, such as Reef Check, and government agencies, such as the National Oceanic & Atmospheric Administration, monitor coral health using several different methods.

1.7.2 Health Assessment Parameter Selection

After an organization has decided to implement a quantitative monitoring program, the selection of proper parameters for measurement is very important. Often, as in this thesis, monitoring programs use coral cover, relative abundance of species, and other easily quantified parameters to assign a degree of health. Limited by the amount of field work performed in a single site visit to St. John, the author used a relatively basic health assessment parameter selection process, as further described in Section 5.1. Because a great portion of this thesis focused on the development of a health assessment tool (CHAT) instead of parameter selection, this thesis should be considered a scoping study for the latter. However, if more comprehensive health assessments are performed in the future, they could possibly benefit from incorporation of biological factors researched by Jameson, et al.(1998)(2001), discussed below.

While programs such as Reef Check and others have evaluated the conditions of coral reefs and collected raw data on coral health, Jameson and colleagues have conducted significant research on the development of coral health assessment strategies that can be normalized worldwide, focusing on biological criteria (Jameson et al. 1998; Jameson et al. 2001). They seek to develop a numerical index that incorporates specific biological indicators (bioindicators) that change in a predictable fashion in response to changes in water quality, sediment influx, nutrient availability, and other ecosystem characteristics. Defined by Jameson, a bioindicator is an organism or group of organisms whose change in abundance or health may be quantified in response to environmental changes. While these researchers aim to create a health index that can be used globally, their methodology is applicable to the creation of a health index on a smaller scale, such as in St. John and the other USVI.

The monitoring of bioindicators has several advantages over simple water quality monitoring of coral ecosystems. These benefits include: 1) the fact that bioindicators only consider pollutants that are available for biological uptake, 2) they can indicate biological impacts when chemical concentrations may be below detectable limits, and 3) they may aid researchers in determining if a contaminant's effects may be enhanced or decreased by the presence of another contaminant (Jameson et al. 2001).

Combining the quantitative observations of a number of bioindicators into an overall coral health index would be helpful for comparing different reefs and would allow information to be easily conveyed to the public and regulators. In order to create a coral health index, researchers must select bioindicators and other factors that can be combined into a single value that accurately and consistently describes the health of coral reefs. Because indices such as this condense information from many variables into one single value, they have been criticized for this loss of information. Nevertheless, the individual metrics, such as percent coral cover, may also be compared in addition to the overall index (Jameson et al. 2001).

Selection of proper parameters is critical when creating an overall index. Monitoring programs have collected information on a wide array of environmental conditions and bioindicators, which are only useful if they can be related to overall coral health. The true health of a coral reef ecosystem may be misinterpreted if improper indicators are used in the overall coral health index. The complexity of interactions and diversity of organisms in coral reef ecosystems makes it difficult to select the most relevant indicators. Several studies have demonstrated that even if coral reefs have been degraded by severe environmental changes, a coral health index is not always able to show such a quantitative response (Jameson et al. 1998). The failure of a coral health index is likely due to the fact that the monitoring program did not employ the proper bioindicators. Therefore, it is extremely important to choose proper bioindicators for development of an overall coral health indicator.

Jameson and colleagues considered different combinations of biological attributes that could be used to develop a coral health index. For an entire coral community, the richness (lack of disease) and abundance of specific coral, amphipod, and fish species are the major components of an overall index. For example, if a particular species that is highly sensitive to a pollutant is abundant in a specific area, one could infer that the area is relatively free of that pollutant. Conversely, an abundance of pollutant-tolerant species may indicate that other species populations have suffered because of the pollutant's presence.

Various other proposed monitoring methods exist (Jameson et al. 2001). Coral skeleton growth rates could provide community level health information, indicating overall growth of a coral population. Monitoring accumulation of contaminants such as heavy metals in coral skeletons could also provide information of contaminant presence. An index could incorporate factors such as anchor damage, parasites, and disease as they may be observed in individual organisms. By looking at individual organisms, changes in condition may be observed before they are detected on a larger scale. The metabolic activity and rate of reproduction of specific coral species could be assessed as well, and the loss of zooxanthellae and proliferation of disease may also be important indicators.

Meesters et al. (2002) found that the ratio of RNA to DNA may indicate metabolic functioning growth rates of reef building corals. While the results of this study indicate that the RNA/DNA ratio may be a viable indicator of metabolic activity and health of coral, this method requires destructive harvesting and expensive laboratory procedures.

Many of the parameters described above are difficult to measure for numerous reasons including the length of time necessary to measure growth rates of the coral skeleton, the costs of complex chemical and biological analyses associated with reproduction and bio-accumulation assessments, and the need to harvest coral biomass for analysis. Richness and abundance bioindicators, such as the percentage of corals that are healthy and percent coral cover, were the most readily accessible and quantifiable parameters for developing an effective coral health assessment for this study, as discussed in Section 4.2.

1.7.3 Existing Monitoring Programs and Methods

While a comprehensive discussion of all coral health monitoring programs is not practical for this thesis, a brief overview of some of the major health monitoring programs and methods are presented in this section.

1.7.3.1 Reef Check

Founded in 1996 and based at the Institute of the Environment at the University of California at Los Angeles, Reef Check is a volunteer organization that operates in over 80 countries and territories worldwide (Shuman 2006). 'Reef Check' also refers to the monitoring protocol that the organization employs; worldwide it is more widely used than any other monitoring methodology (Hodgson et al. 2004). Reef Check's success has been magnified by its relative simplicity, ease of implementation, and use of volunteers. Reef Check scientists train volunteers to perform surveys using a standardized methodology that includes collection of data in four main areas (Hodgson and Liebeler 2002):

- Site description including various environmental conditions, such as location, anthropogenic influences, weather, etc.
- Fish counts (abundance and diversity)
- Invertebrate counts
- Substrate surveys (including percentage of seabed covered by live and dead coral)

Reef Check volunteers use standardized checklists for recording this data along 20-meter transects while SCUBA diving (Hodgson and Liebeler 2002). This methodology tracks specific indicator organisms that were chosen to provide information specifically related to overfishing, damage by boats, and souvenir collection. For example, in the Atlantic region, indicator organisms such as the Nassau grouper, a sport-fish, and flamingo tongue corals, collected as souvenirs, provide information about the effects of overfishing and souvenir collection (Hodgson and Liebeler 2002). The data are then transferred from the field checklists to electronic files that are entered into a central database maintained by Reef Check and their partner ReefBase, a central repository of information relating to coral health worldwide.

These data were analyzed by Hodgeson to create a Coral Reef Health Index (CRHI) using six groups of indicator organisms. The CRHI showed a correlation between reef health and human activities such as fishing, but health effects due to other factors, such as sedimentation, were not considered (Hodgson 1999). Also, percentage of living coral cover was only one of the six indicators used to ascertain the reef health; three fish species, lobster, and urchins comprised the others. Therefore, coral reef ecosystem health as a whole was the focus, as opposed to a focus specifically on corals.

From the perspective of practical implementation, Reef Check is relatively manageable, yet still requires surveyors to have access to SCUBA equipment. This factor eliminates any potential volunteers that may only have access to snorkeling equipment. As well, it requires volunteers to record data while underwater, which can be a time-consuming process.

Overall, Reef Check has been useful for assessing coral health conditions, but it generally focuses on changes caused by physical human influences such as overfishing, while not necessarily addressing coral health declines caused by environmental changes such as water temperature, pollution, or other factors. However, the general assessment structure and methodology of Reef Check provides a valuable framework for understanding and quantifying coral health. To the author's knowledge, the local monitoring program discussed in Section 1.7.4 is the only formal monitoring program in St. John, thus Reef Check data were not sought for inclusion in this thesis.

1.7.3.2 NOAA Coral Health & Monitoring Program

The Coral Health and Monitoring Program (CHAMP) administered by the U.S. National Oceanic & Atmospheric Administration (NOAA) focuses on meteorological and oceanographic data as related to coral health (The National Oceanic and Atmospheric Administration 2006). As a part of the program, a number of remote stations have been installed at various locations to measure certain parameters of interest including air and sea temperatures, salinity, wind direction and speed, barometric pressure, and incoming radiation available for photosynthesis, among others. With these datasets experts better understand the conditions under which coral bleaching events occur and can use models to predict future events.

Data provided by CHAMP are invaluable for monitoring coral degradation on a macro-scale. However, in assessing specific coral health conditions as they may relate to the particular impact of nitrogen and sediment, the information is not directly applicable. As such, the author did not seek data from CHAMP for inclusion in this thesis.

1.7.3.3 Other Monitoring Programs

Numerous other programs exist throughout the world to monitor the health of coral reefs including the Caribbean Coastal Marine Productivity Program (CARICOMP), Atlantic and Gulf Rapid Reef Assessment (AGRRA), and Florida Keys Coral Reef Monitoring Program (CRMP), among others (Downs et al. 2005).

While they often have differing protocols, many of these programs assess percentage of coral cover, fish populations, and other reef characteristics. Unfortunately, while they record coral conditions, most of these programs have not been effective in addressing, identifying, or quantifying the factors that lead to reef deterioration (Downs et al. 2005).

1.7.3.4 Field Methods Used by Monitoring Programs

A variety of field methods exist for collecting data about the health of coral reefs. These methods vary in level of difficulty, accuracy, cost, and amount of equipment necessary. Aspects of different methods can be combined with one another to create techniques that best suit a given monitoring goal. Table 1.7-1, summarized from Rogers et al. (1994), provides a brief comparison of some common methods, describe in further detail below.

Table 1.7-1 – Comparison of Field Methods

Summarized from (Rogers et al. 1994)

Method	Benefits or Strengths	Limitations or Weaknesses
Manta Tow Survey	Large areal coverage Relatively rapid assessment. No need for expensive SCUBA gear.	If not performed with video or photography, no permanent visual record of coral health.
Quadrat	Quadrat itself is inexpensive. Relatively easy to replicate survey.	Need for SCUBA gear. Slight risk of damage to reef.
Chain Transect	Measures all surface areas below a given transect line.	Increased risk of damage to reef due to physical contact. Not possible to use for elkhorn/staghorn coral due to high vertical relief. Impossible to replicate location of chain exactly. Requires high level of skill.
Photographic	Permanent visual record of coral health. Can be combined with other methods.	Can be time consuming. For high quality images, SCUBA equipment most likely necessary.
Video	Same as Photographic Method benefits. Aditionally, more rapid than photographic method.	Same as Photographic Method, though more rapid. Additionally, video must be decomposed to still images for assessment. Image resolution will be less than photographic methods.

When performing a manta tow survey, a snorkeler is towed behind a small motorboat while holding a plywood diving plane upon which data sheets are stored. The boat driver maneuvers the boat above the areas of coral cover, stopping periodically to allow the observer to record data, such as percent coral cover (Rogers et al. 1994). The method and recorded parameters are influenced by the level of aptitude of the observer, depth of coral, water quality conditions, and other factors. While this method allows surveyors to cover large areas of reef, the relative quality of the data is much less than that attained via other methods. This method is similar to the method employed by Coral Solutions, describe in Section 2.3, in that Coral Solutions team members were snorkeling on the water surface.

Unlike the manta tow survey, which is performed from the water surface, the quadrat method is typically performed by SCUBA divers. A 'quadrat' is typically a rectangular or square unit which provides a framework within which to sample or count target organisms. An outer frame of a quadrat can be assembled from various materials, the most common being PVC pipe. For coral monitoring purposes, these frames are typically ½ m^2 to 1 m^2 in area (Rogers et al. 1994). Within the frame, string or another material is used to create a grid, thereby increasing the number of discrete 'sampling units' within the quadrat. The quadrat is placed above the region to be sampled and the surveyor records what is present within each sampling unit, such as

coral, invertebrates, or benthos. From these records, the surveyor can calculate the percentage of coral cover and abundance of various species. The quadrat method can be combined with photographic or video methods, allowing analysis in an office setting (Rogers et al. 1994).
Like the quadrat method, the chain transect method is typically used by SCUBA divers and consists of using lightweight chains to delineate transects over reef areas. Benthic substrates lying directly beneath the chain are cataloged to assess percent cover of each substrate type (Rogers and Miller 2006). This method requires the use of SCUBA gear to allow the surveyor close proximity of the coral, and is potentially damaging due to the physical contact of the chain with the coral.

The Reef Check methodology suggests the use of a fiberglass measuring tape instead of a chain in its protocol, but the transect methodology is similar. However, instead of recording only what lies beneath the transect line, Reef Check methods require surveyors to record what is observed along a 'belt transect', that is, within a certain lateral distance of the measuring tape (Hodgson et al. 2004).

Video or photographic methods can be combined with any of the methods previously discussed, and can be used to collect coral health data that can be analyzed at a later date, preserving coral health data long after a survey is completed. The use of video or photography have many benefits: time in the field is minimized, surveyors have increased access to taxonomic reference material to identify specie after returning to an office, assessment by different people is possible, and photos and video provide permanent records of reef conditions at given points in time.

However, photo and video have limitations in that the surveyor is limited to the data that are captured in the video or on the still image; he/she cannot physically change the camera angle or field conditions to provide a closer look at something of interest. Instead, the surveyor is limited to electronic manipulation of photos to increase understanding. As well, photo and video methods are limited by image clarity and resolution. Still photos allow much higher resolution than video (up to 9 megapixels or more); however, a surveyor cannot effectively survey the large amount of coral area that he/she could using video. Using commonly available digital video equipment, the highest pixel resolution is generally 640 x 480, corresponding to merely 0.3 megapixel still images. However, if the camera is in relative proximity to the image target, this level of resolution can provide enough meaningful data.

1.7.4 Local Monitoring in St. John, USVI

Formal monitoring of coral reefs on St. John is conducted by the South Florida / Caribbean Network Inventory and Monitoring Program (SFCN) and is administered by the U.S. National Park Service (National Park Service 2006). Staffed by two full-time employees, the program uses video surveys taken while SCUBA diving to collect information on coral health using visual indicators. The video surveys are manually analyzed using photo manipulation software and a Microsoft Access database.

1.7.4.1 Field, Videographic, and Data Analysis Methods

Led by biologist Jeff Miller of the National Park Service, surveyors use SCUBA diving equipment and digital cameras housed in waterproof cases. The following description is based on information provided by Miller (2007). Along 20m transects, at a distance of approximately 40 cm from the coral, the surveyor records video. The surveyor moves at a relatively slow rate of approximately 10 meters per five minutes, allowing for the best quality video. However, because of the available equipment, the video resolution is currently limited to 640 pixels x 480 pixels.

The video is subsequently broken into non-overlapping images with the help of video editing software. However, due to the diverse nature of coral reefs and the large amount of vertical relief in these structures, the process remains labor intensive.

The still images are stored in bitmap format to preserve all digital image information in 24-bit resolution, and each photo is named using a convention that uniquely identifies the photo by date, bay, transect, and photo number. Next, a WinBatch® macro is run, incorporating a random number function from MS Excel and image manipulation by Adobe Photoshop. Through this method, each photo is 'auto-adjusted' to improve quality and ten randomly placed 'indicator squares' are placed on each photograph. The reason behind random placement is discussed further in Section 1.7.4.2. At this point, the image is stored as a .JPEG file, thus reducing file size, but also losing some image file information. This 'image file information' refers strictly to the digital information that relates to the colors, contrast, etc. of the individual photos; not the information about what is present in each photo, such as coral or urchins. This is the only time during the process that a .JPEG is saved, as subsequent saves of a .JPEG result in further degradation of the digital file.

Analysis of photos is performed manually by SFCN staff, using Adobe Photoshop for viewing and manipulating images and a MS Access database to store the corresponding data. The two programs are generally run side-by-side on a single desktop PC. Viewing the images in Photoshop allows the surveyor to manipulate image colors, contrast, or other aspects to better understand exactly what each photo depicts.

For each random point, the surveyor quantifies what is directly inside each 'indicator square', focusing on the benthic structure, even if the point is directly on a non-stationary organism, such as a sea urchin. Surveyors quantify benthic invertebrates, fish, and other indicator organisms, but are primarily interested in what *lies underneath* these organisms. If the identified object is a coral, a health value is assigned.

Corals, fish, and other organisms are identified to a high degree of taxonomic specificity, as are coral health conditions. However, the author is not fully aware of the method of health condition assessment. Subsequently, SFCN staff members use these data to calculate percent of live coral cover, create species diversity indices, and gain overall understanding of the state of coral health.

When photo analysis is complete, in order to view the data summary, SFCN personnel must wait for NPS database personnel to generate reports or are forced to manually copy and paste data into MS Excel. This is a time consuming process and its improvement was a primary design goal during the CHAT development.

1.7.4.2 Statistical Considerations

In order to avoid conscious or unconscious bias in sampling, thus skewing results, it is important for surveyors to employ random sampling methods. Intuitively, the word 'random' implies the 'purely haphazard and unbiased collection of measurements', however, it is often difficult for samplers to conduct themselves in a completely unbiased manner (Bailey 1995). Unknowingly, it is common for a surveyor to be preferentially drawn to areas that are visually interesting, where very vibrant or terribly degraded coral exist, while they may downplay other regions.

In choosing coral monitoring transects, the SCFN monitoring team employs random numbers and a GPS transceiver that functions underwater. By using random coordinates to begin and end transects, the team ensures that possible transect locations have an equal opportunity to be chosen for sampling (Miller 2007).

While analyzing still images, a similar method of randomness is employed. As previously mentioned, an unconscious bias can skew results. While using videography and still images, such a bias would exist if a videographer consistently recorded images with the primary coral mass in the center of the frame. If random sampling locations on the still images were not used, it is likely that the true extent of coral cover could be over- or under-represented. Therefore, for each photo, a Microsoft Excel function creates ten sets of random coordinates, each of which corresponds to a sampling location on a photo. In this way, it is assured that the sampling randomized.

1.7.5 Local Monitoring Results: Current Coral Health in St. John, USVI

Coral monitoring has shown that St. John and the other Virgin Islands have not escaped declines in coral health. In the U.S. Virgin Islands, living coral cover less than 20% of the bottom of most reefs, whereas twenty-five years ago, living coral covered more than 40% (Jeffrey et al. 2005; Ray 2007). Healthy elkhorn coral, an important reef building coral, have seen declines of up to 90% at some sites within the past 15-25 years due to disease (JEFFREY et al. 2004). Coral bleaching has been observed in the USVI since 1987, and possibly before (Boulon 2007).

Relatively recently, live coral cover in the USVI was observed to have dropped from approximately 65% in 1997 to 43% in 2001 along monitoring transects (Jeffrey et al. 2005). During 1998-1999, the entire Caribbean experienced very high surface temperatures. Not surprisingly, the high temperatures in 1998 were coincidental with a large bleaching event (Miller and Patterson 2005). In 2003-2004, over a mere 18 month period, 17% of monitored elkhorn coral died, while 74% were observed to be diseased (Jeffrey et al. 2005).

Within only the past two years, rates of coral decline have increased even more. From the end of 2005 through the beginning of 2006, a three-month seawater warming event in the Caribbean lead to a severe bleaching event (Miller et al. 2006). Record-setting temperatures were recorded at depths in excess of 80 feet, and researchers postulate that even after the warm temperatures subsided, coral were weakened and therefore unable to fend off subsequent 'white plague' disease, discussed in Section 1.6.3.4. While local scientists are still quantifying the damage, early estimates indicate the loss of up to 50-80% of living coral cover on St. John, from this event alone (Boulon 2007).

Bleaching and disease continue to be major threats to coral in the Virgin Islands. Overall, it is clear that the increased stress over the past decades has caused a marked decline in coral cover and coral health on St. John, and in the Caribbean at large.

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2 *Research Approach*

2.1 Experimental Design

The development of a tool for health assessment and its use for performance of a health assessment was the primary goal of this thesis, but it is only one component of the larger group project. From a group perspective, Coral Solutions' goal was to determine the effect of human development of St. John on the health of coral, with an emphasis on sedimentation and nitrogen loading. To do this, one necessary component was a health assessment of coral in various bays.

To investigate the effects of development, Coral Solutions measured coral health and sediment and nitrogen loading rates in multiple bays, including those with little human development on nearby land, and those that are heavily developed. Other factors that may influence coral health, such as water temperatures, were not measured or otherwise accounted for in this study. A comparison of coral health in the two types of bays provided an indication as to whether human development plays a local role in coral health; for example, if a developed bay has coral that are significantly less healthy, or has significantly less coral, one could say that development may have a negative effect on coral. Likewise, if the two types of bays have no significant difference in coral health, one cannot say that development affects coral, at least on local level. A comparison of sedimentation and nitrogen loading rates in the bays provided an indication as to whether these loading rates play a role in coral degradation.

Another potentially important factor that may differentiate coral health in different bays, especially with respect to nitrogen and sediment loading, is watershed size. Compared with a small watershed, a large watershed will produce more runoff, and more sediment. Given the same development density, it will also produce more nitrogen loading.

The study focused on four bays on St. John: one developed and one undeveloped with small watersheds, and one developed and one undeveloped with large watersheds. Specific details related to development of each watershed can be found in Navato (2007). This allowed examination of the relationships between human development on the island and watershed size with the health of coral reefs in the bays. Four specific bays were chosen based on the level of development, presence of coral reefs and watershed size. Out of the bays with small watersheds, Coral Solutions chose to investigate Leinster Bay, which is undeveloped, and Round Bay, which is developed. Out of the bays with large watersheds, Coral Solutions investigated Reef Bay, which is undeveloped, and Fish Bay, which has one of the most developed watersheds on St. John. Figure 2.1-1 shows the location of each bay.

Figure 2.1-1 – Aerial photograph with site locations.
A: Reef Bay; B: Round Bay; C: Leinster Bay; D: Fish Bay.

2.2 Research Activities

Detailed in Figure 2.2-1and Figure 2.2-2, various research activities were conducted by Coral Solutions team members, starting with bay selection and proceeding through final data analysis. Steps related to nitrogen and sediment loading and analysis are not included in this thesis, but can be found in the individual theses of other Coral Solutions group members and in the group report.

In general, following bay selection, field visits were performed to record video transects, during which certain field parameters, including time and location were recorded. While still in St. John, the author decomposed the transect videos into non-overlapping still images and began development of the CHAT. The CHAT was subsequently developed using five development 'spirals', discussed in Section 3, leading to image analysis and final conclusions regarding coral health.

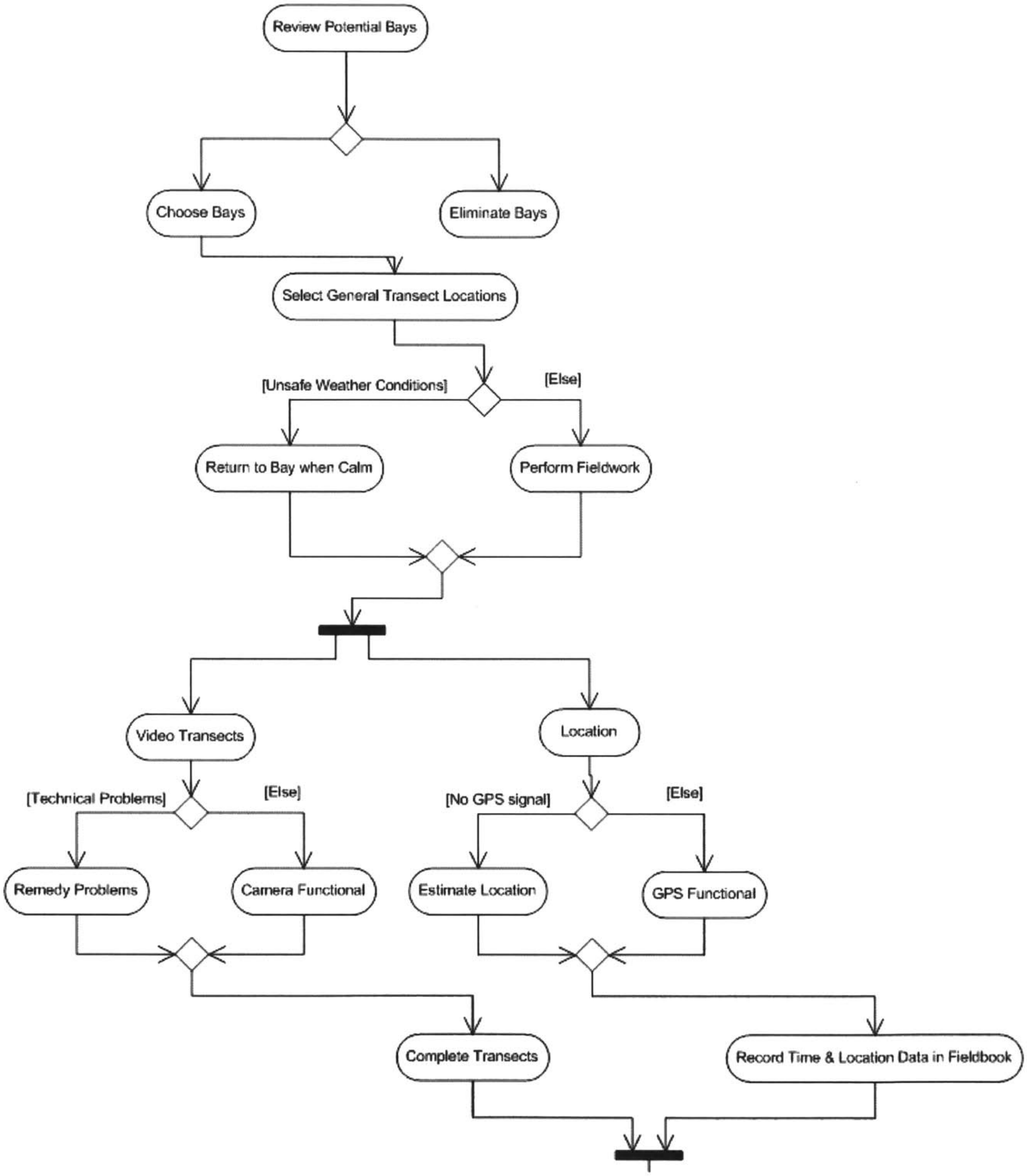

Figure 2.2-1 – Activity Diagram

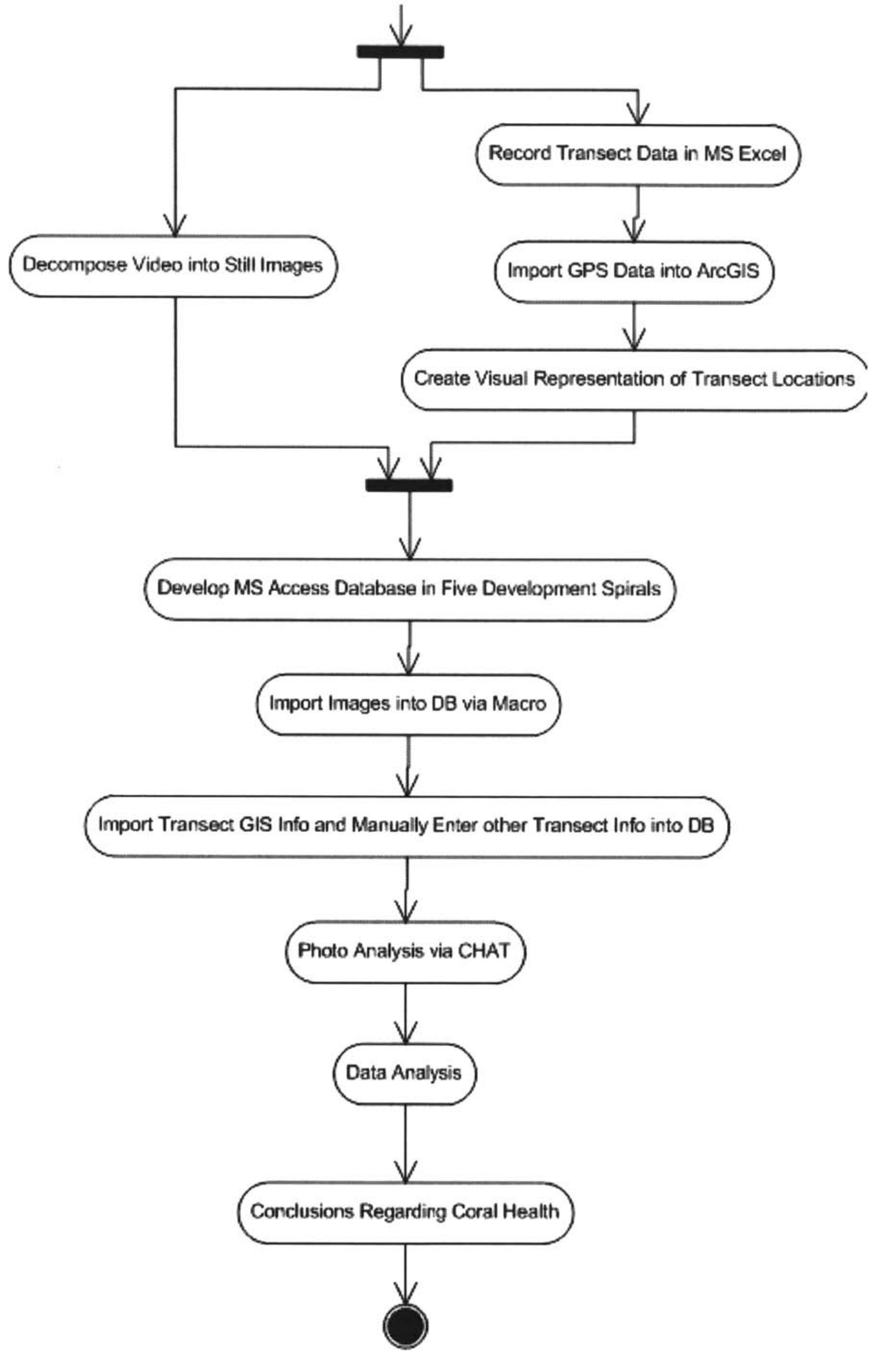

Figure 2.2-2 – Activity Diagram (cont.)

2.3 Field Methods

For the health assessment, Coral Solutions collected video transects while snorkeling. Two team members snorkeled, while two team members paddled in a kayak to provide support and record location and depth data. While this method did not offer the visual clarity of other methods that allow a surveyor to get physically closer to the coral, it was determined to be the best possible surveying solution considering all limitations.

Many methods were initially considered for coral health data collection, including all those discussed in Section 1.7.3.4. However, many of these methods were excluded because of the requisite equipment, safety considerations, or other concerns. Because the author and team members did not have access to nor had proper permits to use a motorized boat, the manta tow survey was excluded. As well, any method employing SCUBA diving was excluded as an investigatory option because of the high associated cost and because team members were not safety certified. Because SCUBA was not an option and due to permit restrictions against physically contacting coral, the chain transect was excluded.

Having eliminated all SCUBA-related methods, Coral Solutions was relegated to swimming on the water surface and using snorkeling equipment to view coral conditions. After taking initial video while snorkeling, it was apparent that the video method would be most appropriate for recording coral conditions over large areas. Manually writing down all data in the field would have been slow and difficult because of the need for underwater writing, and would not provide permanent record of coral conditions for assessment at a later date. The use of a quadrat photographed along transects was considered, but proved impractical due to safety considerations. To test the quadrat method, Coral Solution team members would alternately swim underwater to within approximately 18 inches of the benthic surface and swim with the quadrat, while another tea member recorded video. This method was slow, physically exhausting, and added little value to the video.

2.3.1 Video Transect Details

In the four selected bays, Coral Solutions team members identified general areas of coral cover using geographic information systems (GIS) benthic cover maps (Center for Coastal Monitoring and Assessment 2007). Within the areas identified as having coral cover, team members collected video transects. To the extent practicable, Coral Solutions chose transect locations randomly within the known coral-covered regions of the bays. Coral Solutions did not attempt to quantify the total coral coverage within each bay.

Depth was recorded at the beginning and end of each transect and estimated using a calibrated depth measurement tool, accurate within one foot. However, due to the bathymetry of reef structures, the depth along transects was often highly variable. GPS coordinates were recorded for many transects, however, due to equipment failures, coordinates were not recorded for all transects. For those transects where GPS coordinates were not recorded, a sketch was made or notes were taken to roughly identify the transect location.

Transects were generally between 50-150 feet long and are shown in Figure 2.3-3 through Figure 2.3-4 . Coordinates, length, and other details of each transect are listed in Appendix F.

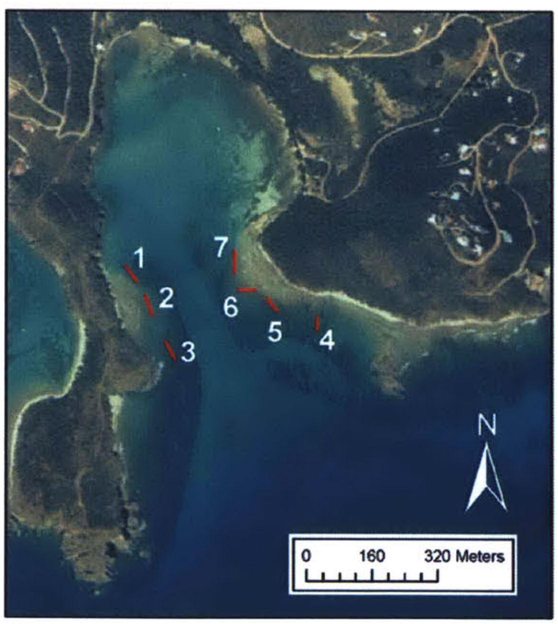

Figure 2.3-1 – Fish Bay Transect Locations

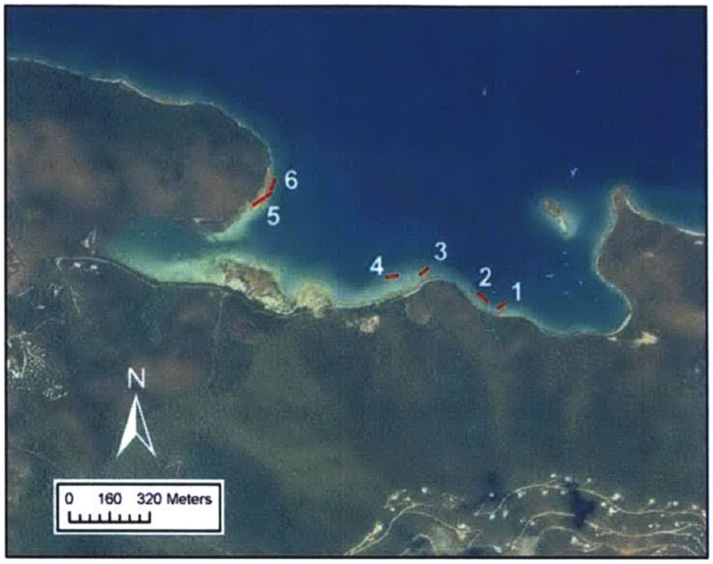

Figure 2.3-2 – Leinster Bay Transect Locations

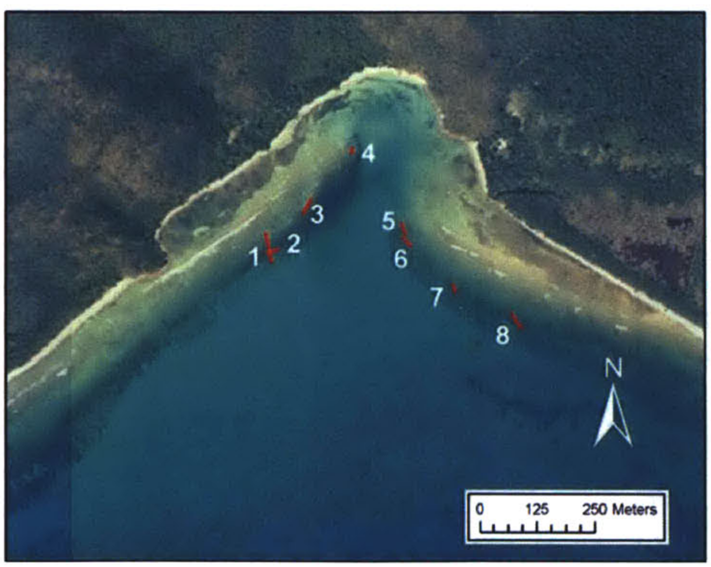

Figure 2.3-3 – Reef Bay Transect Locations

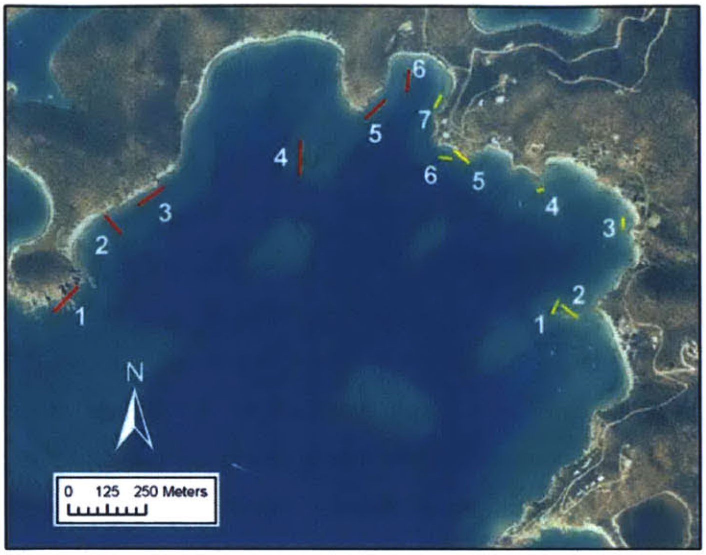

Figure 2.3-4 – Round Bay Transect Locations

2.3.2 EQUIPMENT

Coral Solutions employed commonly available equipment to perform the survey. This equipment is listed below.

- Canon SD450 camera; video recorded at high resolution (640x480) at 30 frames per second.
- Waterproof camera case – Canon-specific.
- Two person Malibu-Two ® kayak and paddles.
- Mask, snorkel, fins.
- Depth measurement device, consisting of a calibrated rope with a weighted end.
- Quadrat – while not ultimately used in health assessment, an initial attempt was made to use a quadrat.
- Garmin GPS – Etrex®.

2.3.3 METHOD LIMITATIONS

Coral Solutions encountered limitations of the chosen field methods, primarily due to safety concerns. Coral Solutions team members were unable to survey areas of coral cover that were more than approximately 300 feet from the shore or in otherwise overly exposed regions of the bays. Surveying in shallow areas was dangerous to surveyors due to large waves, possible collisions with hard coral reefs and sea urchins, and other hazards.

Relatively calm weather conditions were generally observed in the early mornings, with wind and wave action increasing in the afternoons. As a result, Coral Solutions attempted to collect most transect data in the early morning as a safety consideration. However, this practice in some ways compromised the quality of the video, as lighting conditions were not optimal until approximately mid-day. As a result, some video was taken in low-light conditions, which reduces clarity and contrast. Because transects were taken while snorkeling on the surface of the water, video quality is directly related to water depth; deeper water generally means poorer video quality.

The length and number of transects taken during events was limited by physical endurance of team members. The use of a man-powered craft also limited the speed with which Coral Solutions could travel between survey areas. During data collection, surveyors would swim and paddle the kayak for over two hours at a time. As a safety precaution, data collection was terminated when team members became physically exhausted. When necessary, Coral Solutions returned to the same bay to continue data collection at a later date. The reliability of transect location data was not verified, as Coral Solutions did not attempt to replicate any specific transects.

2.4 Video Decomposition

Still images were extracted from video using *ImageGrab3.0a En* software, licensed as freeware and available at http://paul.glagla.free.fr/index_en.htm. Video transects were broken into non-overlapping images of the benthic surface to be analyzed individually.

Initially, the same software was used to extracted overlapping images of the benthic surface that were subsequently merged using *Adobe Photoshop 5.0* using the *Photomerge* function. The resulting image was a visual estimation of the benthic surface along the transect line. However, due to the high degree of vertical relief of the bottom and motion of swimmer due to wave motion, there were significant variations in perspective while viewing the same object in different photos. As a result, the photos could not be merged without some amount of visual data loss.

As well, an efficient, standardized method of data analysis was not readily apparent. For these reasons, the method of combining still images into a single transect image was not chosen.

2.4.1 Factors Affecting Still Image Quality

While all transect videos were recorded using approximately the same field methods, video and still image quality varied greatly. This was due to many factors, including:

- Swimming speed; faster swimming blurred video.
- Wave frequency/amplitude; increased wave frequency and amplitude blurred video.
- Depth; increased depth decreased image quality.
- Light penetration due to water quality parameters such as turbidity; increased turbidity decreased image quality.
- Weather conditions, ie bright sunlight, overcast, etc.
- Time of day; lighting conditions generally favorable near mid-day.

Depth calibration was performed by filming a known length of PVC pipe in known water depths. Using the same length of pipe and two known depths, a linear relationship was derived, correlating water depth to viewable image height and width. Because a project-specific calibration will be needed for any implementation of this method, this derivation is not included in this thesis.

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3 CORAL HEALTH ASSESSMENT TOOL (CHAT) DEVELOPMENT

In order for Coral Solutions to understand if sediment and nitrogen were impacting coral health, it was necessary to understand the condition of coral in different bays. To gain this understanding, a significant amount of information regarding health in each bay was necessary. As discussed in Section 2.3, video transects were recorded to gather this information. However, even before still image analysis was begun, it was necessary to organize and store a considerable amount of data, including transect time, location, weather, and other factors. Subsequently, a total of 34 transects were decomposed into over 1000 still images, each of which the author planned to analyze each image at twelve discrete locations. Faced with storing significantly more than 12,000 discrete data points, the author developed a project-specific Microsoft Access (Access) database, the CHAT. This section begins with an overview of database development and presents specific aspects of CHAT. Significant design and operation documentation can be found in the appendices.

3.1 INTRODUCTION TO DATABASE DEVELOPMENT

When faced with storing and manipulating large quantities of data, people have various electronic options. Often, data are stored in spreadsheets, created in Microsoft Excel (Excel) or other software. While spreadsheets are extremely useful, they can become cumbersome when storing large amounts of data, especially when variables have complex relationships. This format can lead to data duplication, and as a result introduce potential sources of error. As well, Excel is limited to a maximum of 65,536 rows and 256 columns.

Under these circumstances, it is often favorable to utilize a relational database to store data in a more effective and efficient manner. Various database software packages are commercially available, ranging from very basic systems to extremely complex, custom-built data management systems. Microsoft Access (Access) is a readily available, relatively robust, and reasonably priced software option that contains a powerful data entry form development tool. While software packages such as Microsoft SQL Server provide significantly more functionality, they are much more difficult to implement and configure. Because the CHAT is designed for relatively simple implementation, configuration, and use by non-technical users, Access was chosen as the database software.

In a database, data is stored in tables, organized in columns and rows. Columns, or fields, correspond to a single characteristic of an object, such as a coral's health (Donald 2002). Data populating these columns are stored in rows as 'records'. A record corresponds to one row of data within a table.

Databases consist of interconnected, related tables, tied to one another by keys, a common field or fields. These connections allow various types of relationships between data; for example, a coral researcher may record unique position coordinates for a favorite coral colony. These coordinates correspond to only one colony, and the colony has only one set of coordinates; this is a one-to-one relationship. The researcher could also record all the dates he visited a specific bay. It is possible that he visited the same bay on many days; a one-to-many relationship. Many-to-many relationships are also possible, as well as enforcement of rules (cardinality) that governs relationships. Relationships can be imposed by physical constraints, developer design, or both.

Because of these relationships, properly structured, or normalized, databases can efficiently store data without repetition. For example, even if a researcher visits the same bay on many occasions, he only needs to store the name of that bay once in a 'bay information' table, while he records many corresponding dates in a 'dates' table. Because of its lack of repetition, a normalized data structure allows information to be easily updated and maintained accurately, as it eliminates potentially conflicting values of the same data point.

Database structure allows users to extract meaningful data from the database by use of queries. Structured Query Language (SQL) is the means by which a user can query the database. In Access, a Query Builder provides a Graphical User Interface (GUI) that allows relatively easy construction of SQL queries. As well, Access allows the development of forms that allow simple user interaction with underlying DB tables.

3.2 Development Process

A developer has various choices for structuring the software development process. To meet development goals and time deadlines, it is important for the developer to choose an appropriate model. For this reason, the 'spiral model' was adopted, allowing for the creation of a functional health assessment tool that can be further refined in the future.

The spiral model is well structured and guarantees a working product in a relatively short period of time, although it may not be fully refined or polished. As described in *Rapid Development*, the spiral software development model consists of increasingly spirals of development of a software component (McConnell 1996). The term 'spiral' refers to a software component starting out very small, as if towards the center of a spiral, and gradually 'spiraling' outwards until it is a much larger and more robust system. In this model, spiral builds on the previous and includes components of requirement identification, design, development, and testing (McConnell 1996). This model was chosen because it guarantees a viable product at the end of each development spiral and allows for further refinement if time constraints permit.

The CHAT Access database development was completed in approximately five spirals of development, the first of which was initiated while in St. John. By using this method, a basic working prototype was completed in a relatively short period of time. Subsequently, troubleshooting of this prototype revealed important design changes that would not have been readily apparent if other development models were implemented.

The first development spiral was essentially the 'scoping study' for development of this tool and consisted of an unrefined initial data model and table structure within MS Access and a preliminary data entry form. This development phase was generally exploratory in nature. In this phase, the data entry form included drop-down menus located at each of the twelve points on the photo, allowing entry of identification and health information. The CHAT was initially populated with some photos and partial data that related to each transect, such as video length, GPS coordinates, and others. In this spiral, the underlying data structure was treated as secondary, with the primary focus on the user interface.

The second spiral of development built upon the first, but included an in-depth analysis of data structure and normalization. The CHAT was entirely rebuilt and many useless fields in tables were eliminated, depth, viewable area, and transect clarity fields were incorporated into the user interface, and the data structure was normalized. As well, controls were implemented to reduced user error. These controls included locking certain fields against editing and removing drop-down selection on some fields. .

The third spiral of development included incorporating standardized naming conventions, an improved user interface, query and reporting capabilities. As well, the data-entry form was refined, including improved tab order and addition of the data entry status field.

The fourth development spiral included refinement of table structure, addition of a unique index for each table using an Autonumber data-type field, and implementation of randomized image selection for 'subsampling' of the total images stored in the database.

The fifth and final spiral included further refinement of the user interface, query, and table structures, as well as inclusion of 'Welcome' and 'Iteration Details' forms. In addition, the primary data entry form was fully redesigned.

3.3 Requirements

When developing software, it is very important to initially define and continuously refine system requirements to ensure a final product that meets user needs. For the CHAT, the target users are those interested in assessing the health of coral reefs. To this end, the tool was designed to be relatively accessible to all users, and not tailored to the MS Access or database expert. It is expected that typically a person assessing coral health will have a much greater understanding of marine biology than database structure. Section 3.3 outlines the key design requirements of the CHAT.

3.3.1 Deployment Diagram

The Deployment Diagram, Figure 3.3-1, documents the interactions between various objects during the data acquisition and health assessment process. To fulfill health assessment requirements, the CHAT was developed to support this data collection process. Other design requirements fall into broad categories and are detailed in the remainder of Section 3.3.

In general, while in the field, data were recorded in a field notebook and using a camera. Subsequently, the field notebook information was transferred to a MS Excel spreadsheet, from which it was imported into ArcGIS 9.0 and the CHAT. Because the general locations of bays and transects were known to Coral Solutions, only transect number and coordinates were imported into ArcGIS 9.0. The video was decomposed into still images that were loaded into the CHAT. Ultimately, images were analyzed using the analysis form within the CHAT and data was assessed using MS Excel Pivot Tables.

3.3.2 Interface Requirements

In order for the CHAT to be effectively used by a wide range of users, the user interface is a critical component. The interface was designed to be intuitive, user friendly, and most importantly, provide an accurate method for recording data.

Users should not have to view or understand underlying data tables to accomplish health assessment. As such, the CHAT was designed to shield users from complex data structures or queries. As well, users should only be able to access components of the system that are necessary for their tasks. Different levels of user privileges were not incorporated for this CHAT implementation, however, they would be very helpful if the tool were used on a larger scale. While administrator privileges can be given to some users, restricting privileges of others can make the users' experience less complex, as well as protect the database from technical errors.

The CHAT was designed to provide a summary of data for each picture, as it is useful for a user to review all data for a photo at one time. In order to increase the speed of processing large amounts of data, the interface was designed to minimize keystrokes. To allow image manipulation by users, the CHAT enables users to open images in a program of their choice to modify properties such as brightness or contrast. As well, the tool was designed so that users will not accidentally update or delete records.

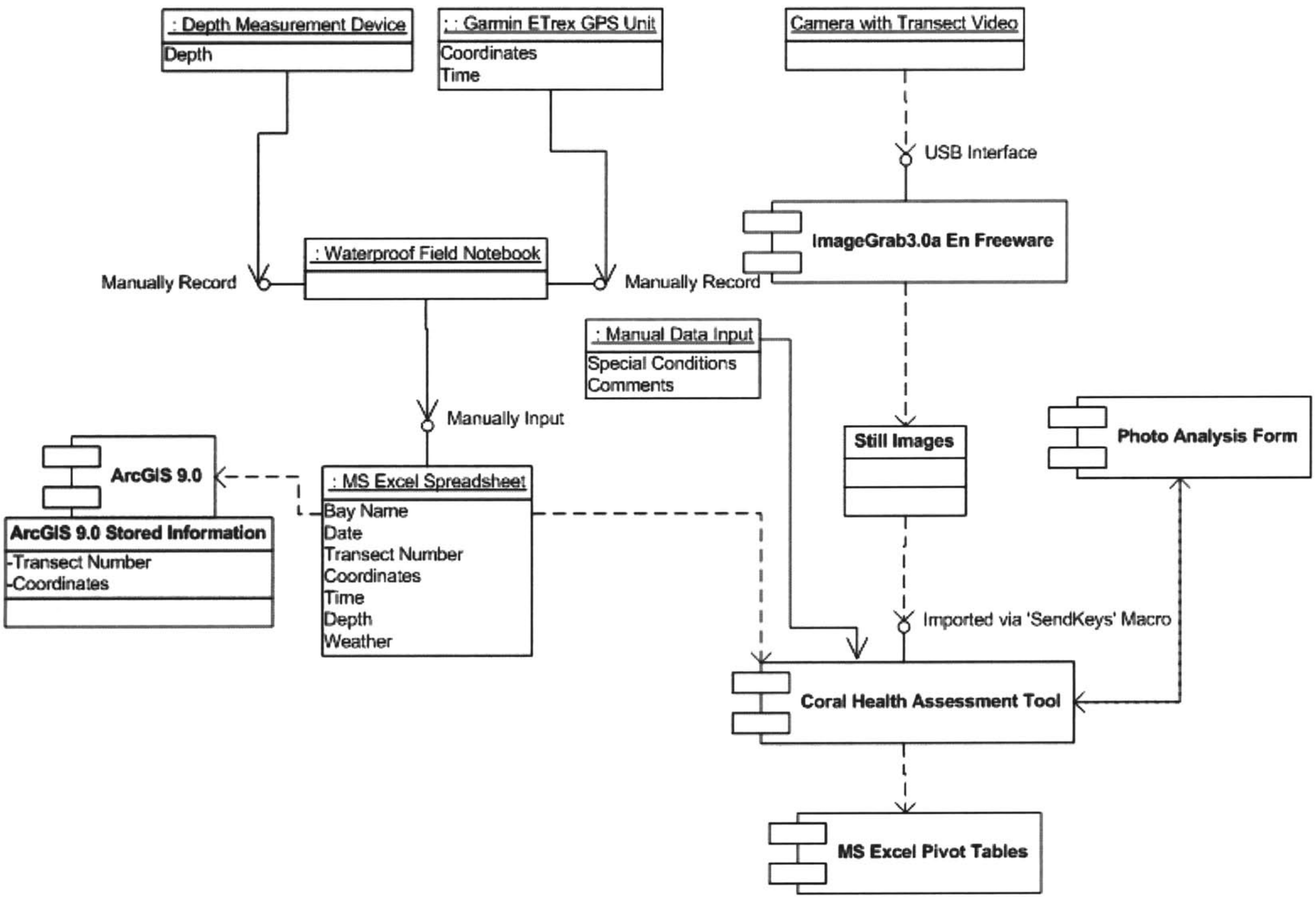


Figure 3.3-1 – Deployment Diagram

3.3.3 Analysis and 'Iteration' Requirements

The CHAT was designed to allow for extensive data analysis, including comparison of coral health between bays, how health assessment may be related to image clarity, amount of healthy vs. unhealthy coral, percent cover, species diversity, and other components. Data analysis should be dynamic and the user should be able to define the comparison criteria. To accomplish this, static reporting was not employed.

When faced with a large number of images for assessment, it is possible that a user would be interested in subsampling the total number of images, and the CHAT was built to support this functionality. By randomly choosing and assessing a subsample of all available images, the user can obtain meaningful coral health data without the need for assessment of all collected images.

Coupled with random image subsampling, iterative analysis allows a user to perform health assessments by randomly subsampling a set of images multiple times, providing the user multiple subsamples. As further discussed in Section 3.4.3.2 and 4.1, an 'Iteration', or assessment of a randomly selected group of images by a user, allows a user to increase the total number of photo assessments by performing subsequent Iterations. Iterative analysis also allows multiple people to review the same images and compare their respective assessment, thus allowing quality assurance/quality control (QA/QC) of identification and health value assignment.

3.3.4 System Requirements

From a hardware and software system perspective, the CHAT needed to be easily installed and configured by users with moderate computer knowledge and should utilize common software and hardware.

The CHAT was designed to be essentially 'self-contained', that is having all data should be stored in only a few easily accessed files or directories. In the implementation of the CHAT for this thesis, all files were stored within the Access database itself. However, in future implementations, if files are linked to image files in different directories, this should be made apparent to the user.

In order to make the CHAT usable, small file size is an important consideration. Image files should be compressed to a reasonable degree such that image quality is not compromised, but necessary storage space is greatly reduced. This topic is further discussed in Section 3.6.2.

Hardware such as a large monitor and computer with a faster processor and upgraded memory will make this tool run more efficiently. Within MS Access, forms cannot be automatically resized to fit different screen resolutions; therefore, all development was performed at a very common screen resolution, 1024x768, to maximize hardware compatibility.

3.3.5 Data Structure and Table Population Requirements

In order for the collected data to be utilized efficiently by users, the data must be queriable, that is one must be able to run queries to extract data given specific parameters. To accomplish this, the data must be normalized, or without repetition of data components, as repetition can lead to errors as the database is expanded. The data structure should be extensible, or designed so that its capabilities can be expanded or modified by users, so that users can customize the tool to their specific needs. The CHAT was designed to meet all of these requirements, as further discussed in Section 3.6.1.

The data structure must support the importation of image files or linking of image files. Because the CHAT was built after the collection of video transects and subsequent still image extraction, the total number of transects and number of photos in each transect were known. As a result, SQL was used to pre-populate tables with the appropriate number of records. After the proper number of records were already in the various tables, it was much easier to use macros to import the Bitmap image files. Following these pre-populations, some fields were locked so as to minimize chances of accidental user updates.

If used for subsequent health assessments, such pre-population may not be feasible or expeditious. As such, a different manner of photo importation would need to be developed.

3.4 DATABASE COMPONENTS

The CHAT is comprised of various components within Access that work together to provide an integrated tool to users. The primary user interface, built from Access forms, allows users to easily view and manipulate data, which is stored in a complex table structure. Relationships exist between tables, meaning that the data the tables store have some sort of affiliation. Queries serve a variety of functions within the database, and they provide data output to Microsoft Excel Pivot Tables. Overall, these components integrate to create a user-friendly health assessment tool.

3.4.1 FORMS USER INTERFACE

The user interface consists of a Welcome Form, an Iteration Entry Form and subform, and the Primary Data Entry Form and subforms. When the database is first opened, the user is greeted with a 'Welcome' form, from which he/she can choose to enter/view Iteration data or go directly to the form for performing a coral health assessment. All form details, including field types and definitions, are listed in Appendix D.

While some manual table updates are necessary to enter information such as Location or Bay names, all coral health assessment using CHAT is performed using a Microsoft Access Forms interface. This structure is beneficial, as it shields the user from direct interaction with tables, thus increasing overall data integrity and chances of accidental updates/additions/deletions of data. In all forms, primary keys of tables are hidden from the user, allowing future key changes that will be transparent to users. Each form is populated by a dedicated query, describe in Appendix E.

3.4.1.1 Welcome Form

The Welcome Form (Figure 3.4-1)is a very basic form that greets the user and allows navigation to the Iteration Entry Form or directly to the Primary Data Entry Form by clicking on the respective command buttons.

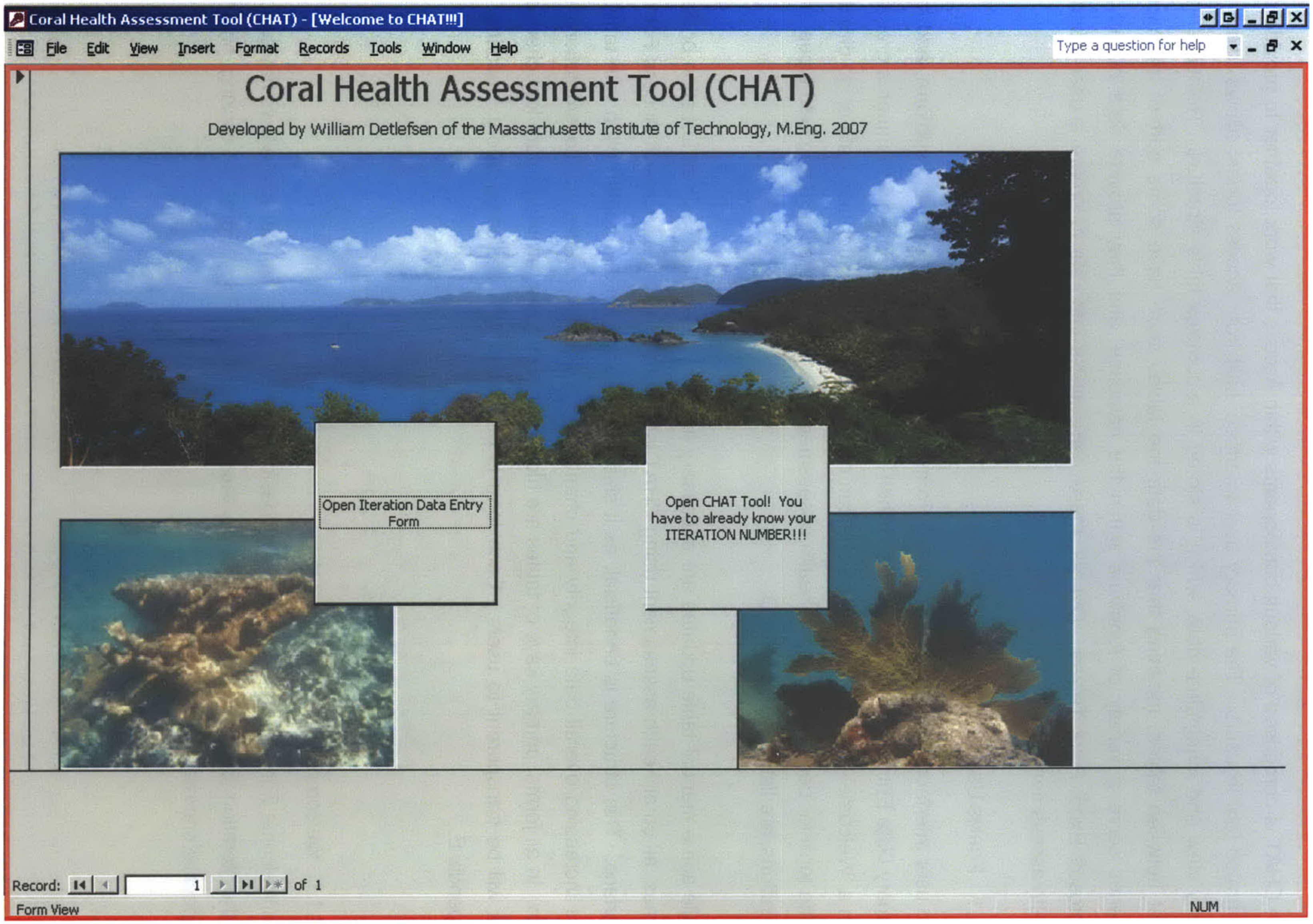


Figure 3.4-1 – Welcome Form (frm_WELCOME_SCREEN)

3.4.1.2 Iteration Entry & Subform

The Iteration Entry and Iteration Entry Subforms, Figure 3.4-2, allow users to enter new Iteration information or update Iteration information for those iterations that are not in a 'COMPLETE' status. The Iteration Entry form allows user input, but the Subform is strictly read-only to display Iteration data. Once an Iteration is listed as 'COMPLETE', it can no longer be edited using this form.

The Iteration Entry form features three command buttons. The first, 'Add this Iteration Data to the Iteration Table', inserts the data to the Iterations table and requeries the subform such that the new Iteration appears immediately in the Subform.

The 'Append Records for this New Iteration' button runs macros that append records to a table to enable random image selection, select random images, and append records to other tables that will ultimately be updated by the user during the coral health assessment. This process is detailed in Appendix G. This step must be performed before the user can enter data using the Primary Data Entry Form for any given Iteration.

The 'Use CHAT to Enter Some Coral Health Data!' button prompts the user for the Iteration Number and opens the Primary Data Entry Form.

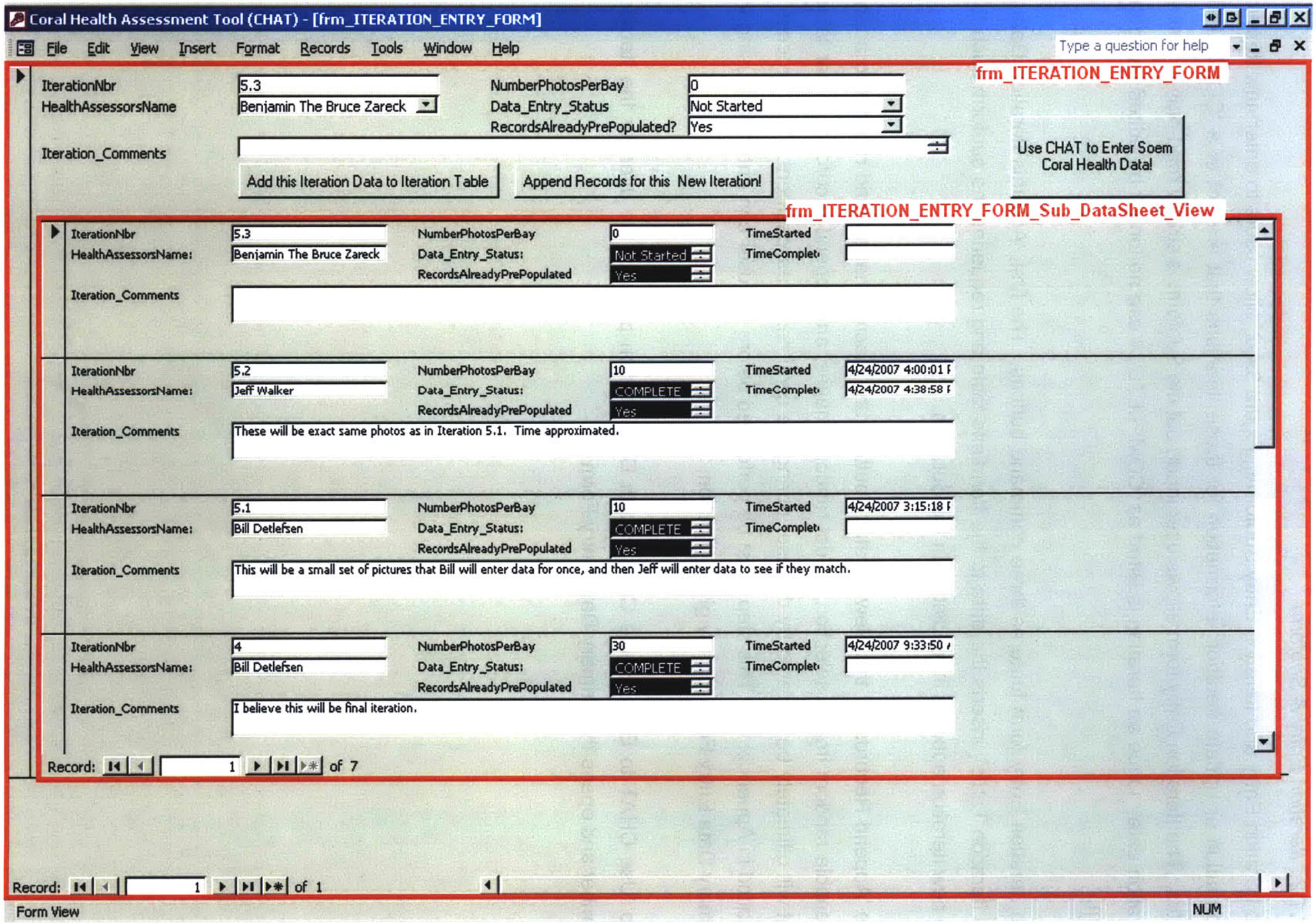


Figure 3.4-2 – Iteration Entry Form (frm_ITERATION_ENTRY_FORM)

3.4.1.3 Primary Data Entry Form & Subforms.

The Primary Data Entry Form, 'frm_CHAT_DATA_ENTRY_FORM', and its subforms, Figure 3.4-3, are the most important user interface within the CHAT database. From this form and its subforms, a user can update/input coral health identification and health data.

The main form includes information regarding the location, bay, transect, depth, and other parameters. Other than the Transect_Data_Entry_Status and Transect_Iteration_Comments, all fields are locked, as the data populating those fields was gathered when the transect was recorded, and thus should remain static.

The subform 'frm_Subform_Photos' displays the .BMP image that is stored in the database. This subform is read-only.

The subform 'frm_Subform_Photos_Iterations' displays data about the Iteration and photo, as well as contains two subforms. It includes buttons to update the start/finish time of the iteration, allows comments, records information about the photo including fish and urchin counts, and records the data entry status of the Photo-Iteration (e.g. 'In-Progress).

The subform 'frm_Subform_EntryStatus' provides an up-to-date status of the number of photos that have been assessed or remain to be assessed within the current Iteration. For example in the example shown in Figure 3.4-3, all 120 Photos included in the Iteration have already been assessed and assigned a 'COMPLETE' status.

The subform 'frm_Subform_Photos_Iterations_Points' is the subform that enables users to input actual identification and coral health information. Figure 3.4-4 and Figure 3.4-5 show how these values are populated by the user.

Navigation and date/time updates within the Primary Data Entry Form and Subforms is accomplished by the use of macros. These are detailed in Section 3.4.5.

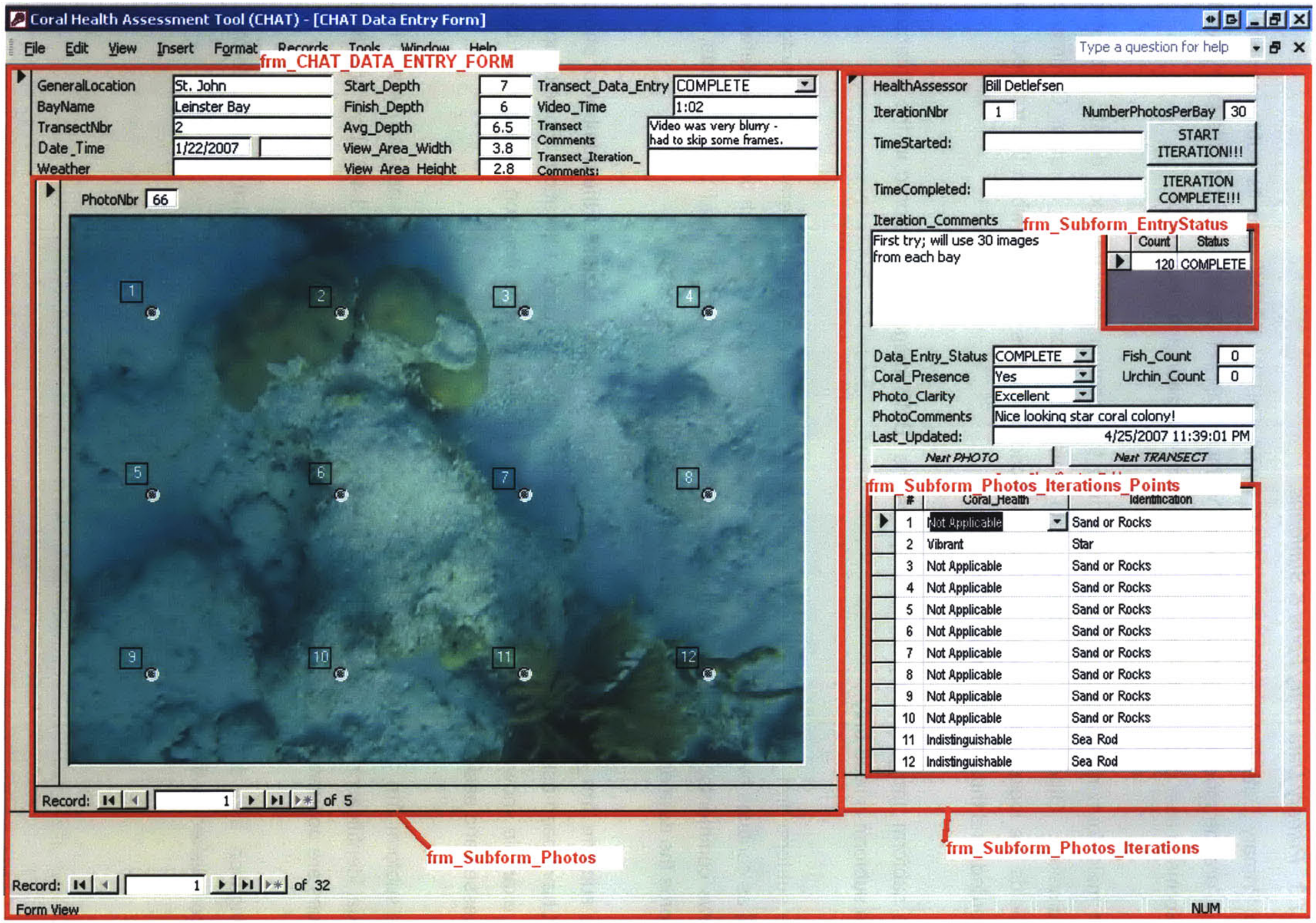


Figure 3.4-3 – Primary Data Entry Form (frm_CHAT_DATA_ENTRY_FORM)

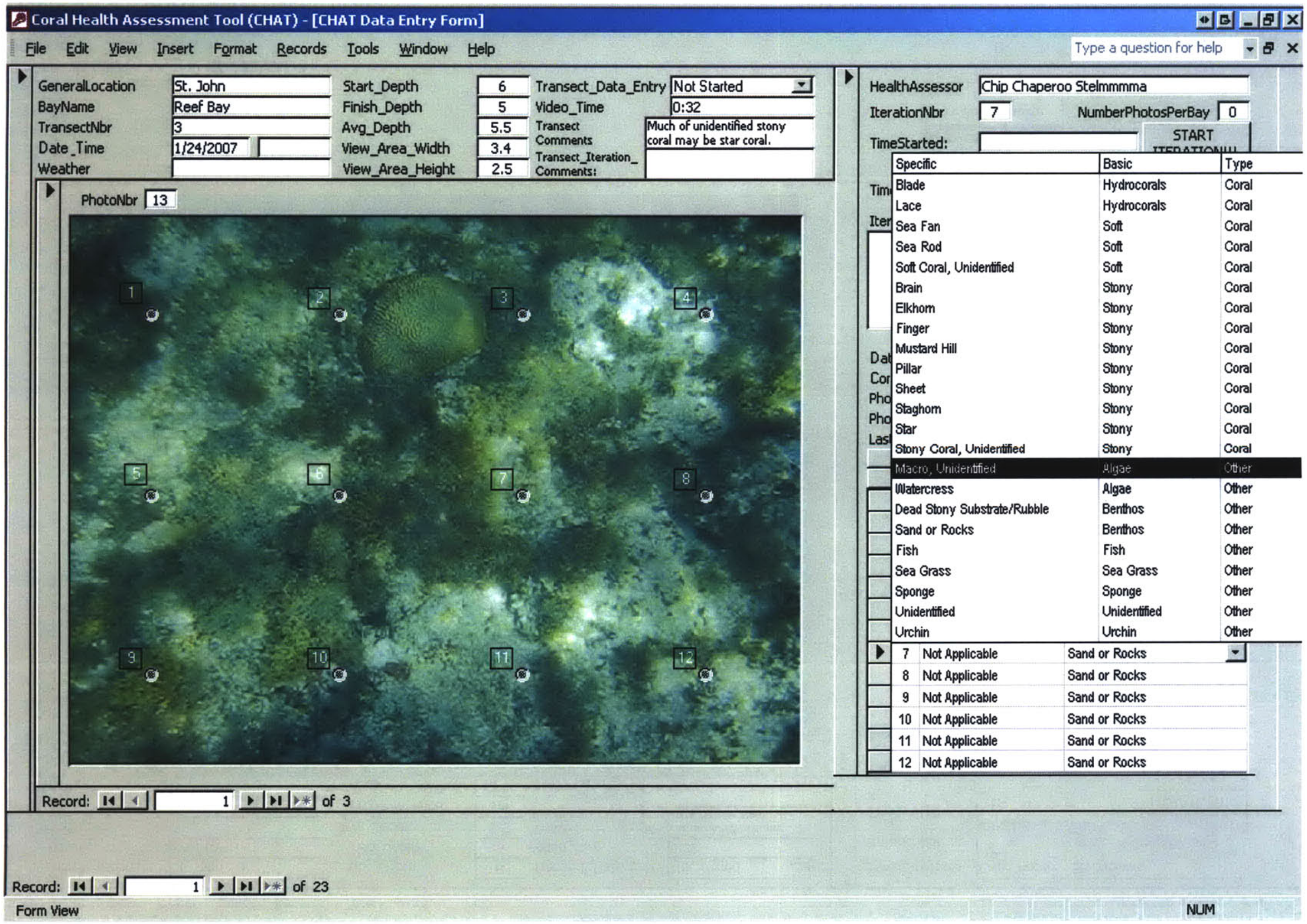


Figure 3.4-4 – CHAT Identification Menu

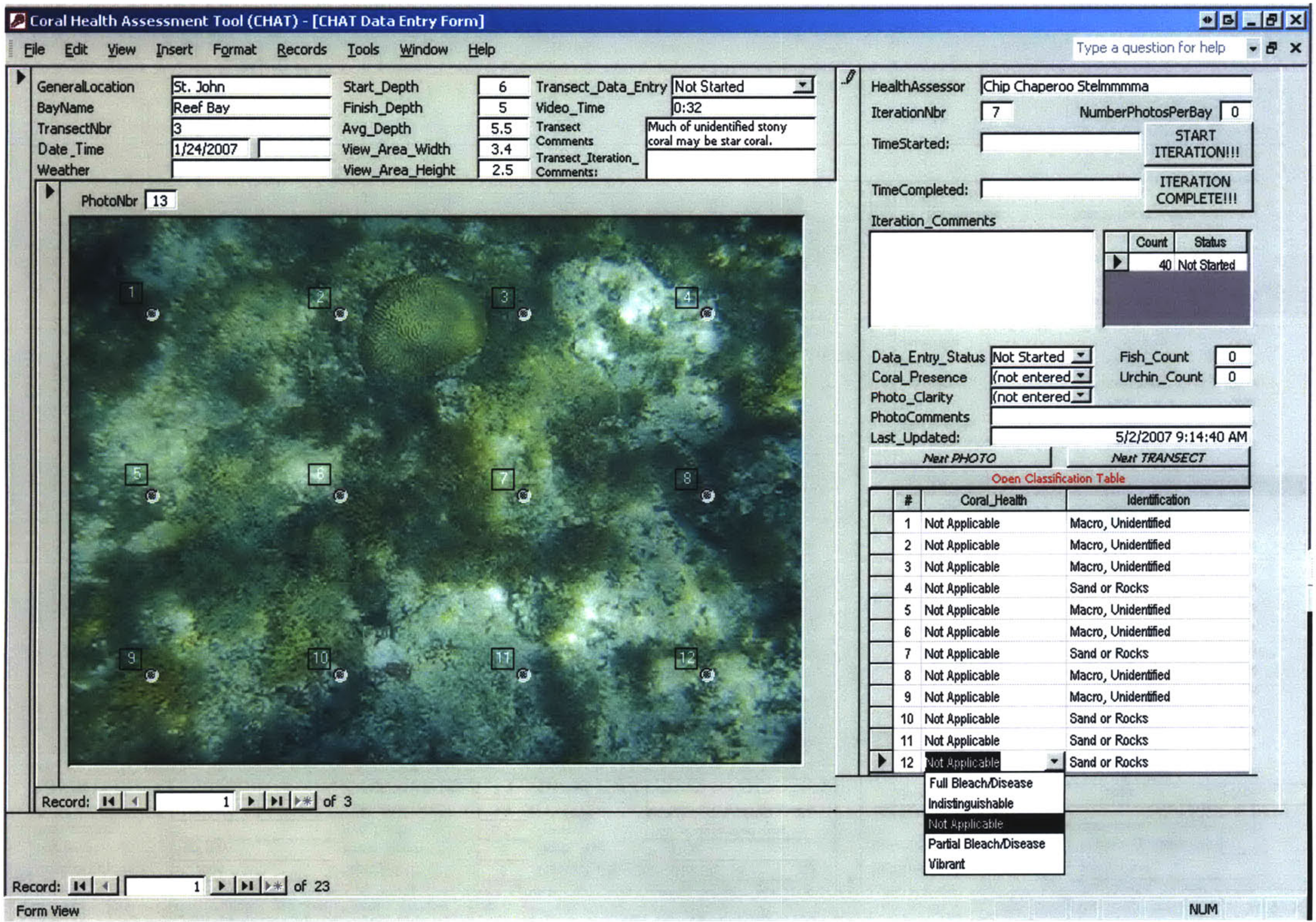


Figure 3.4-5 – CHAT Coral Health Menu

3.4.2 TABLES

As discussed in Section 3.1, databases utilize tables to store data in an organized manner. Tables within the CHAT database tables are classified into one of three general categories based on their primary function. Transaction tables store the primary information regarding field data collection and all subsequent data related to image analysis. Validation, or 'lookup', tables restrict fields within the transaction tables to lists of valid values. Classification tables, essentially validation tables, store the biological classification structure in a three-tiered system. These three types of tables are detailed in the proceeding sections.

3.4.2.1 Transaction Tables

The CHAT database includes eleven transaction tables that store all data related to the field collection of data and subsequent analysis using CHAT, or user 'transactions'. For a typical user, these tables should only be updated using the Forms described in Section 3.4.1.

Transaction tables are listed in Table 3.4-1 and described in detail, including all column definitions, in Appendix B. An example of a transaction table, tbl_Events, is shown as Figure 3.4-6.

Table 3.4-1 – Transaction Tables

Transaction Tables	
tbl_General_Locations	Stores all information regarding general sampling location.
tbl_Bays	Stores all bay information.
tbl_Events	Stores all event information.
tbl_Transects	Stores transect details.
tbl_Photos	Stores image details.
tbl_Photos_Iterations	Intermediate table in many-to-many relationship between tbl_Photos and tbl_Iterations. When photos are assessed, this table stores user-input assessment information.
tbl_Photos_Iterations_Points	Stores all actual coral ID and health data for points identified.
tbl_GPS_Data	Stores Global Positioning System data collected while in field.
tbl_Iterations	Stores Iteration information. An Iteration consists of a user randomly selecting and assessing images.
tbl_IterationsRandomNbrs	Stores random numbers that are used for random photo selection. Updated with Append query for each Iteration.
tbl_Transect_Iterations	Intermediate table in many-to-many relationship between tbl_Transects and tbl_Iterations. It is appended when a new iteration is started and includes a transect-iteration for any transect which includes any photo that was assessed in the corresponding it

3.4.2.2 Validation

The database includes nine validation, or lookup tables that provide valid values for drop-down selection options.

These tables are manually maintained to input valid values available for selection via the CHAT Analysis Form and would typically not be accessed directly by a person performing coral health assessment.

These tables are listed in Table 3.4-2 and described in detail, including all column definitions, in Appendix B. An example of a validation table, tbl_Valid_Coral_Health_Values, is shown as Figure 3.4-7**Error! Reference source not found.**.

Table 3.4-2 – Validation Tables

Validation Tables	
tbl_ValidPointNbrs	Stores valid identification point numbers for point location on images.
tbl_Valid_Clarity_Values	Stores valid image clarity values.
tbl_Valid_Coral_Health_Assessors	Stores information about valid users, or 'Coral Health Assessors'.
tbl_Valid_Coral_Health_Values	Stores valid values of coral health, such as 'Vibrant'.
tbl_Valid_Coral_Presence_Values	Stores valid coral presence values, such as 'Yes'.
tbl_Valid_Data_Entry_Status	Stores information regarding data entry status.
tbl_Valid_GPS_Data_Point_Types	Stores transect location descriptors, such as start or finish of a transect.
tbl_Valid_Yes_No_ComboBox	Simply provides Yes/No selection for a ComboBox.
tbl_CurrentIterationSingleRowTable	Single row table used to store the current iteration number. Updated following user prompt for current iteration number. Used in joins to populate forms.

3.4.2.3 Classification

The classification tables store all information related to identification of coral, fish, benthic structures, or anything a user may observe in an image. The three-tiered classification structure allows for increasingly specific identification of coral or other objects. The structure utilizes inheritance, meaning that all members of a child table inherit certain properties from the parent table.

These tables are listed in Table 3.4-3 and described in detail, including all column definitions, in Appendix B. An example of the expanded classification tables is shown as

Table 3.4-3 – Classification Tables

Classification Tables	
tbl_0_Type	Stores most broad identification description, such as 'Coral'.
tbl_1_Basic	Stores more specific identification description, such as 'Stony Coral'.
tbl_2_Specific	Stores most specific identification description, such as 'Stony Brain Coral'.

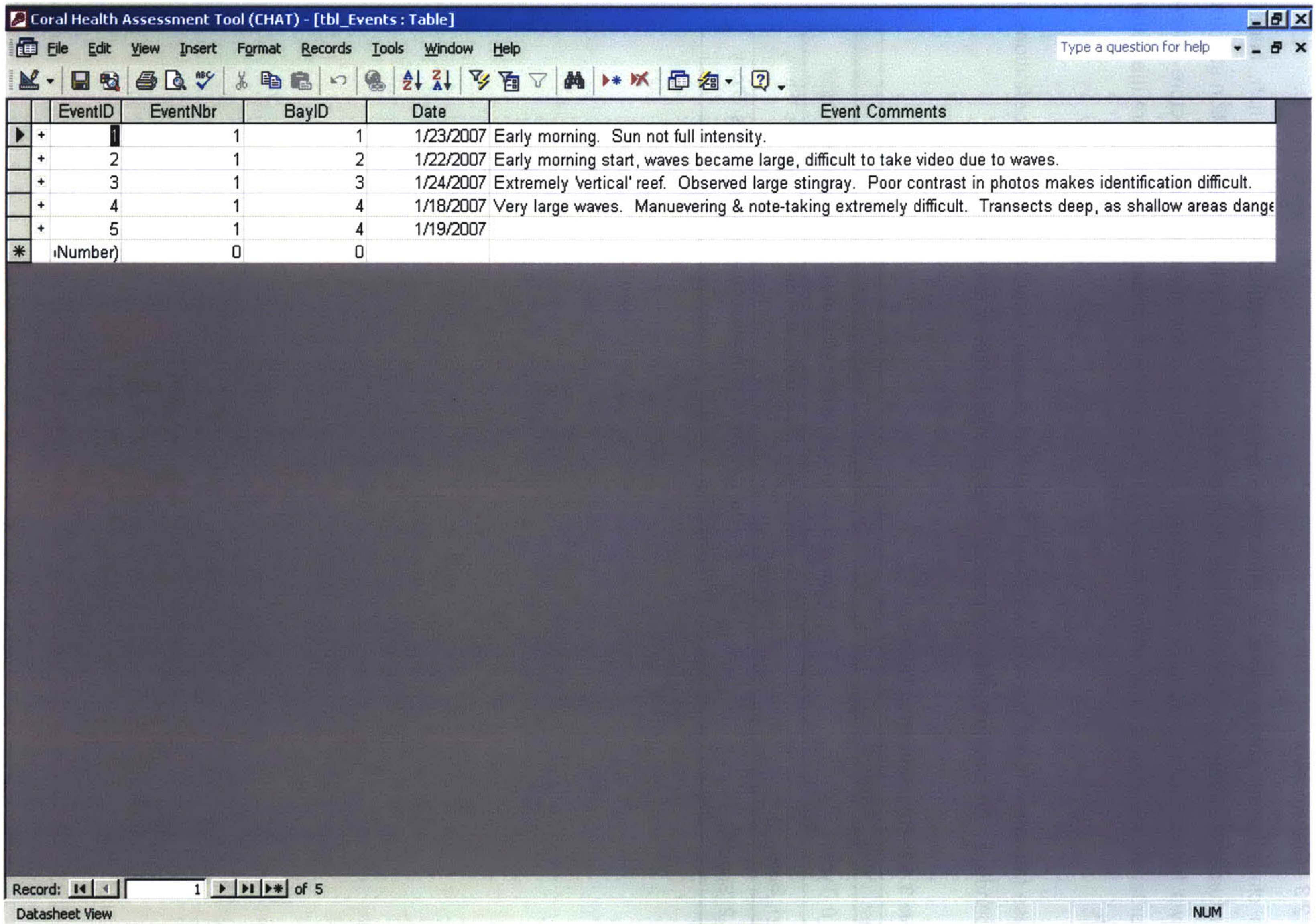


Figure 3.4-6 – Example Transaction Table – tbl_Events

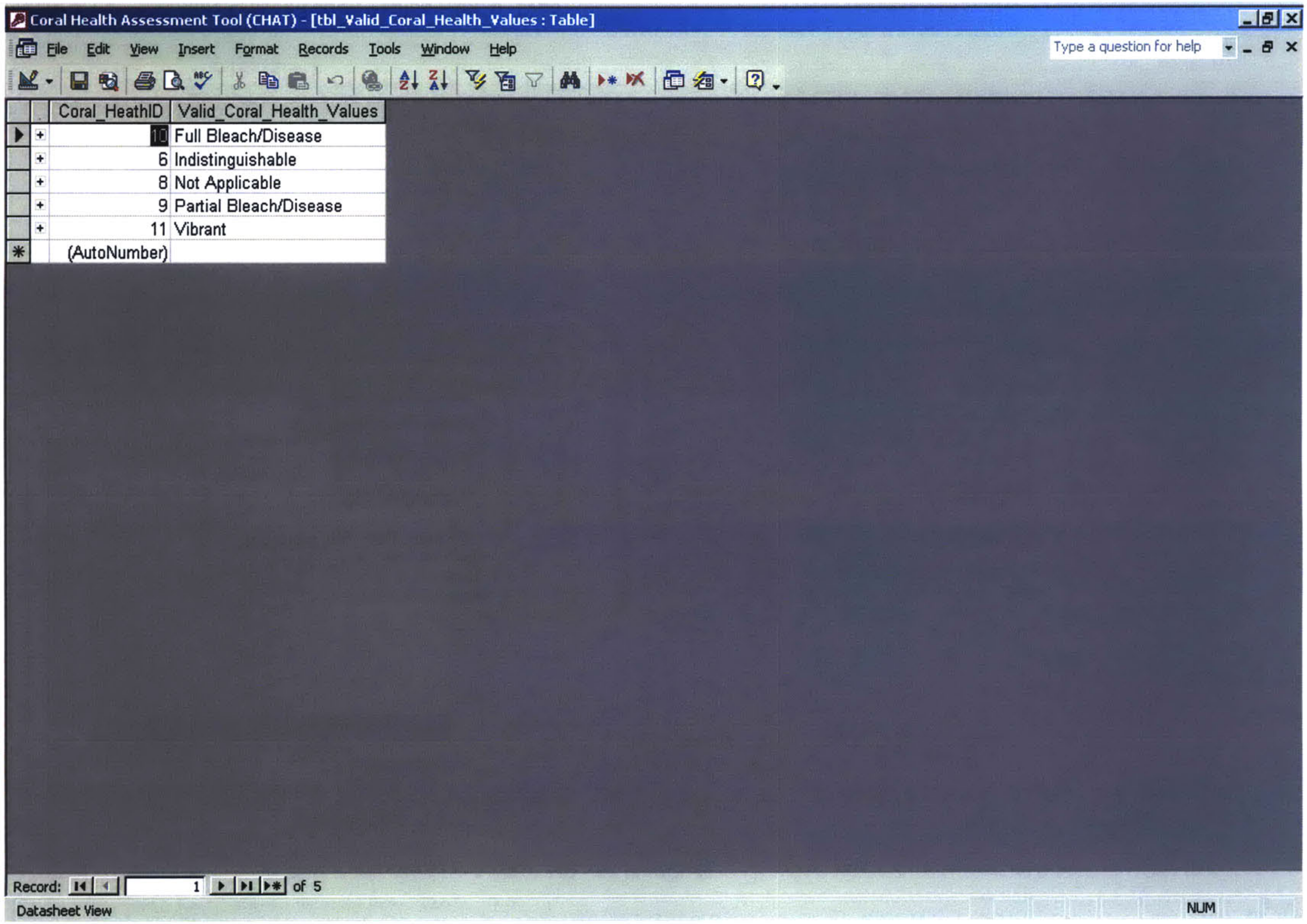


Figure 3.4-7 – Example Validation Table – tbl_Valid_Coral_Health_Values

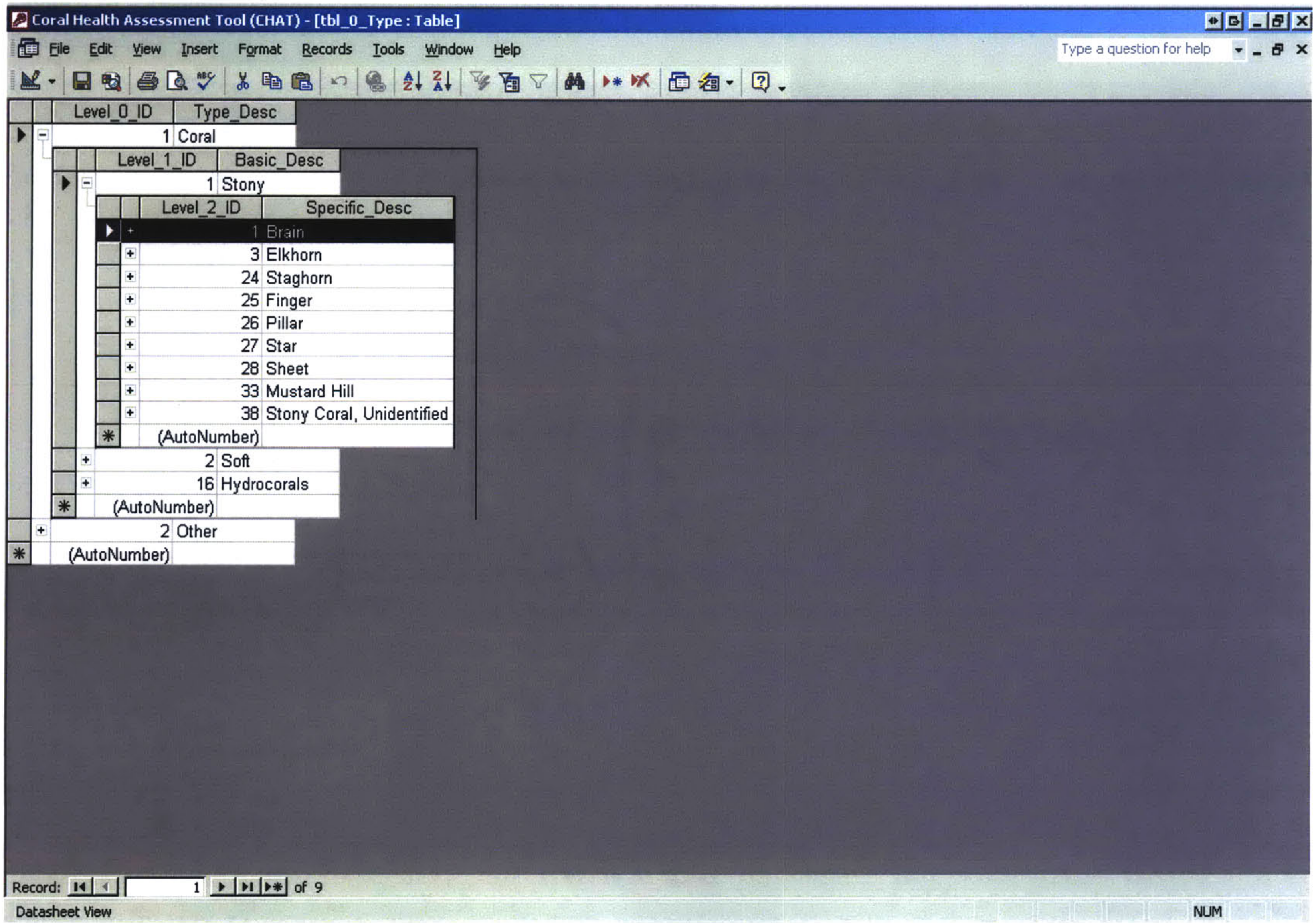


Figure 3.4-8 – Example Classification Tables – tbl_0_Type

3.4.3 DATAMODEL / ENTITY RELATIONSHIPS

A relational database is defined by the existence of relationships between data tables, and the CHAT database employs relationships that are most easily understood when grouped by their purpose. Loosely defined for the purposes of this report, 'physical relationships' within the database are those that are generally defined by a physical constraint. 'Procedural relationships' are those relationships that are imposed by a developer to maintain a certain process or processes. 'Validation relationships' provide validation for transaction tables, thus eliminating the chance that a user would enter an invalid value into a form field.

The three basic relationship types are discussed in the following sections, while the Entity Relationship Diagram (ERD), Figure 3.4-9, visually depicts all relationships. The numbered relationships in the ERD are described in detail in Appendix C.

3.4.3.1 Physical Relationships

Physical relationships exist between many entities within the CHAT database. For the software developer, these relationships are generally less flexible than procedural or validation relationships.

- General Locations, such as St. John, USVI, can have many Bays, such as Reef and Fish. However, each Bay is located in only one General Location.
- In each Bay, many Events can occur, with each Event defined by a discrete visit to a bay. Each Event occurs in only one Bay.
- More than one Event can occur on the same day, at the same or different Bays.
- During each Event, people record one or multiple video Transects. Each Transect is associated with only one Event.
- Each Transect can have multiple GPS Data Points, as at least two points are needed to define the most basic Transect, a straight line. Each GPS Data Point is associated with only one Transect.

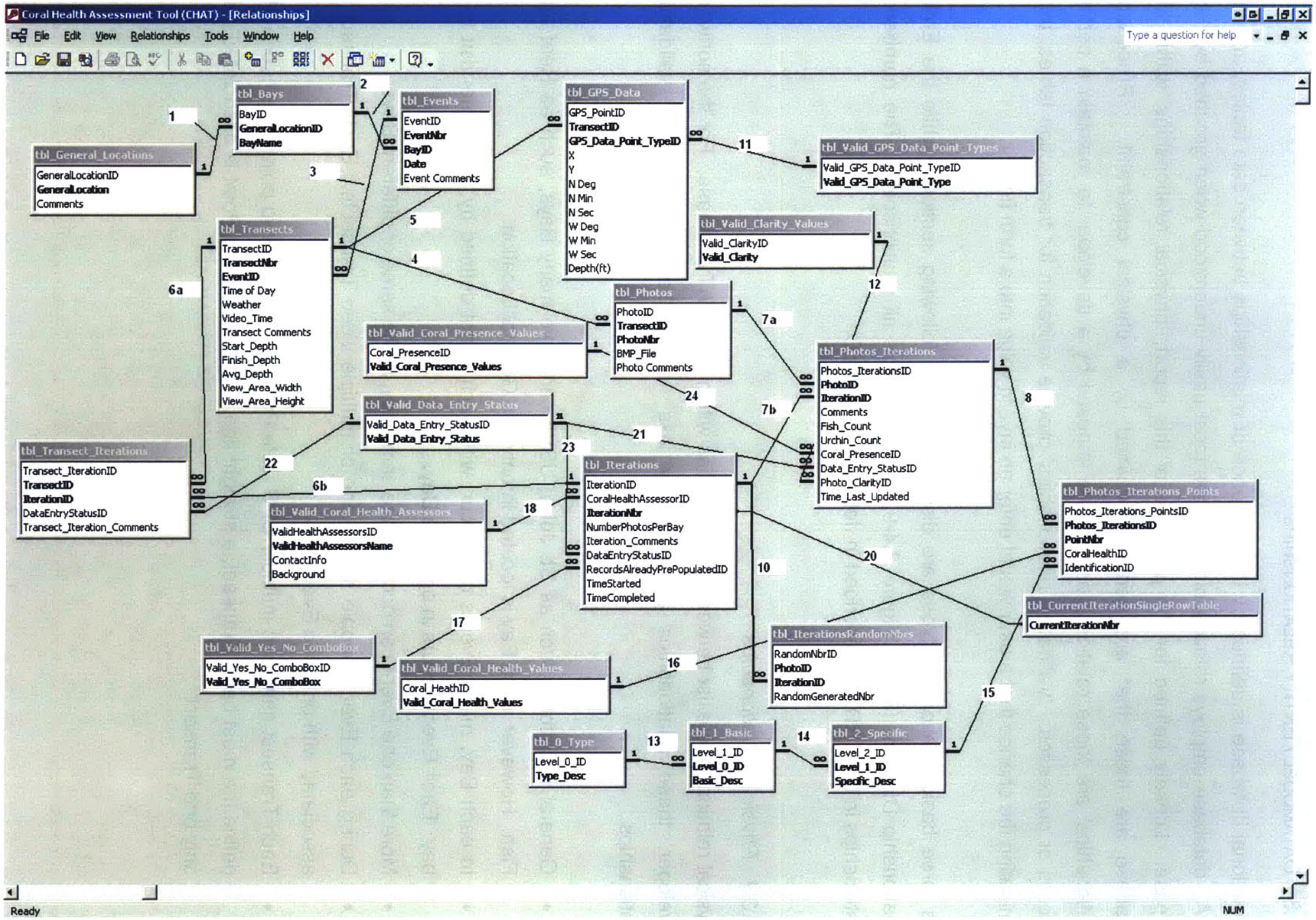


Figure 3.4-9 – Entity Relationship Diagram

- From each Transect, there are many Photos that are extracted. However, each Photo is associated with only one Transect.
- In each Photo, there are exactly 12 data Points for which the user identifies the underlying component and assigns a coral health value if the data Point is located on coral. Each discrete Point is associated with only one Photo.
- For the three levels of classification, each parent value can have many child values, such as the parent 'Coral' and children 'Soft' and 'Stony'.

3.4.3.2 Procedural Relationships

In order to allow for effective Photo assessment, relationships are necessary to control the assessment process. As discussed in Section 3.3.3, when faced with a large number of images for assessment, it is possible that a user would be interested in subsampling the total number of images and/or analyzing the images in an iterative manner. To enable this functionality, both random selection and data storage for iterative analysis are necessary.

The table tbl_Iterations stores data related to an 'Iteration', or an assessment of images by a user. Because Photos (and therefore the Transects to which they belong) could be selected for inclusion in many Iterations, various many-to-many relationships exist. All tables that include 'Iterations' in their title are involved in storing data that is related to iterative assessment.

To allow random image selection during each Iteration, a randomly generated number corresponding to each Photo is stored in the table tbl_IterationsRandomNbrs. These random numbers are subsequently sorted to provide random selection of Photos, which are then included in the table tbl_Photos_Iterations.

3.4.3.3 Validation Relationships

All relationships that involve a table with 'Valid' in the name indicate a validation relationship. These relationships enforce the use of valid values in other tables. For example, if Joe Michaels is not a ValidCoralHealthAssessor in the table tbl_Valid_Coral_Health_Assessors, it is impossible for Joe Michaels to perform an Iteration. Classification relationships can be considered validation-type relationships.

3.4.4 QUERIES

Structured Query Language (SQL) queries constructed using the Access Query Builder tool are the primary method for batch table updates, data display, and data mining within the CHAT database.

After users collect new video and transect data in the field and load this information into the CHAT, append queries populate the linked tables with corresponding rows. Update queries are used to update default coral identification and health values with values that may have already been entered, as well as to specify the current Iteration number.

Select queries provide the data that is displayed in all user entry forms. When a user updates a field on a form, the query updates the underlying tables. Select queries are also linked to all Pivot Table outputs.

Temporary SQL queries were used throughout the development process to understand the status of data entry and to validate the output of the permanent queries. As well, queries were used for initial data population, such as pre-populating the CHAT with known information, such as exactly 12 points per photo, numbered 1-12.

All queries are detailed in Appendix E.

3.4.5 MACROS

Macros were employed to enable CHAT navigation between and within forms, as well as to import image files into the database. As the image importation macros were SendKeys statements that were machine-specific, they are not included in this documentation. All other macros and descriptions are listed in Appendix G.

3.5 DATA OUTPUT & MANIPULATION

The main reporting tools of the CHAT are five Microsoft Excel Pivot Tables. These particular Pivot Tables are based on SQL Select queries, tied directly to the CHAT database, and provide a user with the same information as a cross-tab query within Access. However, the structure of the Pivot Table allows the user extensive data manipulation capabilities.

Pivot Tables allow users to summarize vast quantities of data, using counts or summation of records. Users can drag-and-drop different data fields into different regions of the Pivot Tables, thus summing, counting, and grouping data in many different configurations. An added benefit of the use of Pivot Tables is that they are completely external to the DB, so that users cannot accidentally update records within the database. The purpose of each Pivot Table is detailed in Table 3.5-1.

Table 3.5-1 – Pivot Table Purposes

Pivot Table Name	Purpose
Pivot_1	Summary of coral classification and health data
Pivot_2	Summary of fish and urchin counts; photo clarity summary.
Pivot_3	Provides data entry status of Iterations.
Pivot_4	Summarized the number of distinct photos analzyed.
Pivot_5	Provides the total photos summarized by transect.

Pivot Table outputs were used to generate almost all tables contained in this thesis and its appendices. To illustrate the flexibility of this reporting tool, three different Pivot Table configurations of Pivot 1 are shown as Table 3.5-2 - Table 3.5-4. All of these tables were generated from the same Pivot Table with just a few mouse clicks. The displayed data relates to the 30 images selected from Leinster Bay for analysis Iteration 1. The total number of analyzed points = 12*30 = 360 points.

As seen in Table 3.5-2, the information is grouped by increasingly specific levels of coral identification. However, if a user was less interested in the breakdown of corals by specific descriptions and more interested in which coral species accounted for certain coral health descriptions, such as 'Vibrant', Table 3.5-3 would provide this information. Finally, if a user was completely disinterested in coral descriptions and only wanted to know the amount of points that fell into each coral health category, he/she could look to Table 3.5-4.

Table 3.5-2 – Pivot 1 – Grouped by Specific Coral Desc.

GeneralL	St. John
BayName	Leinster Bay

					Data	
Type	Basic	Specific_Desc	Coral_Health	Iteration	Number	Percent
Coral	Hydrocorals	Blade	Partial Bleach/Disease	1	2	0.56%
			Vibrant	1	1	0.28%
	Soft	Sea Fan	Indistinguishable	1	8	2.22%
		Sea Rod			16	4.44%
		Soft Coral, Unidentified	Indistinguishable	1	5	1.39%
	Stony	Brain	Partial Bleach/Disease	1	1	0.28%
		Mustard Hill	Vibrant	1	3	0.83%
		Star	Partial Bleach/Disease	1	1	0.28%
			Vibrant	1	2	0.56%
		Stony Coral, Unidentified	Full Bleach/Disease	1	5	1.39%
			Indistinguishable	1	2	0.56%
			Partial Bleach/Disease	1	16	4.44%
			Vibrant	1	6	1.67%
Coral Total					68	18.89%
Other	Algae	Macro, Unidentified			2	0.56%
	Benthos	Sand or Rocks			252	70.00%
		Dead Stony Substrate/Rubble			24	6.67%
	Unidentified	Unidentified			14	3.89%
Other Total					292	81.11%
Grand Total					360	100%

Table 3.5-3 – Pivot 1 – Grouped by Coral Health

GeneralL	St. John
BayName	Leinster Bay

					Data	
Type	Coral_Health	Basic	Specific_Desc	Iteration	Number	Percent
Coral	Full Bleach/Disease	Stony	Stony Coral, Unidentified	1	5	1.39%
	Indistinguishable	Soft	Sea Fan	1	8	2.22%
			Sea Rod		16	4.44%
			Soft Coral, Unidentified	1	5	1.39%
		Stony	Stony Coral, Unidentified	1	2	0.56%
	Partial Bleach/Disease	Hydrocorals	Blade	1	2	0.56%
		Stony	Brain	1	1	0.28%
			Star	1	1	0.28%
			Stony Coral, Unidentified	1	16	4.44%
	Vibrant	Hydrocorals	Blade	1	1	0.28%
		Stony	Mustard Hill	1	3	0.83%
			Star	1	2	0.56%
			Stony Coral, Unidentified	1	6	1.67%
Coral Total					68	18.89%
Other	Indistinguishable	Benthos	Sand or Rocks		1	0.28%
	Not Applicable	Algae	Macro, Unidentified		2	0.56%
		Benthos	Sand or Rocks		251	69.72%
			Dead Stony Substrate/Rubble		24	6.67%
		Unidentified	Unidentified		14	3.89%
Other Total					292	81.11%
Grand Total					360	100%

Table 3.5-4 – Pivot 1 – Grouped by Coral Health – Collapsed

GeneralL	St. John
BayName	Leinster Bay

			Data	
Type	Coral_Health	Iteration	Number	Percent
Coral	Full Bleach/Disease	1	5	1.39%
	Indistinguishable	1	31	8.61%
	Partial Bleach/Disease	1	20	5.56%
	Vibrant	1	12	3.33%
Coral Total			68	18.89%
Other	Indistinguishable	1	1	0.28%
	Not Applicable	1	291	80.83%
Other Total			292	81.11%
Grand Total			360	100%

3.6 Additional Database Development Considerations

3.6.1 Data Normalization and Key Selection

The database table structure was generally designed using a modified Third Normal Form (3NF) structure. This data normalization standard states that repeating groups, redundant data that is dependent on only a portion of a key, and columns that are not dependent on the key be removed to separate tables (Anonymous 2005). The use of this normalization protocol greatly enhances the data integrity of the database, as well as allowing greater extensibility without the need for retrofitting.

Exceptions to the 3NF exist in the tbl_GPS_Data and tbl_Transects, where coordinate, depth, and viewable area values are both repeated and interdependent. These violations are known to the developer and would be remedied if further expansion of CHAT were undertaken.

Key selection for tables was generally driven by physical constraints, while a unique Autonumber index was also added to each table, thus enabling much simplified joins. As a result, each row in each table has two unique identifiers; the primary key, often a composite of two or more fields, and the 'ID' field, a unique index.

For example, in table tbl_General_Locations, a location is defined (key) by the text field GeneralLocation (e.g., St. John). However, the location 'St. John' can also be uniquely identified by its GeneralLocationID, an Autonumber field. In this way, when the relationship between tbl_General_Locations and tbl_Bays is created, the key field GeneralLocation, does not need to be included in tbl_Bays. Instead, the unique index, GeneralLocationID is used to create the relationship. Similarly, when tbl_Bays is involved in a relationship with tbl_Events, the only field that needs to be joined between the two tables is the BayID. In this way, the need to include composite keys in child tables is eliminated.

3.6.2 Electronic Image Formats

In general, software developers must be mindful of hardware limitations. Particularly when developing a software solution that involves the storage of image files, it is important to consider compressible file formats that may reduce the need for tremendous amounts of hard drive storage space.

In this implementation of the CHAT, images were embedded in the database as Bitmap files, thus retaining excellent image quality, but creating a database that is approximately 1GB due to storage of 1000+ photos. In order for this tool to be useful in the future, image size would need to be greatly reduced, and images would likely need to be linked to the database instead of embedded. After significant investigation, the author was unable to store or link to compressed format images, just as .jpeg, due to an apparent lack of native support within access for compressed formats.

However, while it was not used for the health assessment performed during this project, the author successfully used the ActiveX control DBPix2.0, available at http://www.ammara.com/dbpix/access.html, to enable external linking of compressed image file formats. As well, this control allows a user to zoom on the image. At the time of publication, this control seems to be the most feasible option for combining a compressed image format with the database functionality of the CHAT.

3.6.3 STANDARDIZATION

To the extent practical, tables, queries, and other database objects within the DB follow the Leszynski/Reddick Guidelines for Microsoft Access, as published on the Microsoft Developer Network (MSDN). Use of these standardized naming conventions will allow future developers to better understand and build upon the current database (Leszynski and Reddick 1994). The conventions employed in development of the CHAT are shown in Table 3.6-1.

Table 3.6-1 – Database Naming Conventions

Object	Tag	Example
Table	tbl	tbl_General_Locations
Table (validation)	tbl_Valid	tbl_Valid_Clarity_Values
Query	qry	qry_FORMS_Subform_Photos
Form	frm	frm_Classification
Macro	mcr	mcr_MAXIMIZE_window

Note: Standards modified from Microsoft Developer Network at: http://msdn.microsoft.com/archive/default.asp?url=/archive/en-us/dnaraccess/html/msdn_20naming.asp

3.6.4 QUALITY ASSURANCE / QUALITY CONTROL

Throughout the development process, quality assurance / quality control (QA/QC) was performed by using validation queries to verify that the information being provided by the main reporting tools, the Pivot Tables, is indeed correct.

However, these queries and output results are not included in this document. If further development of the CHAT is performed, QA/QC documentation should be prepared.

4 *IMAGE ANALYSIS USING CHAT*

4.1 ITERATIONS AND RANDOM SAMPLING

While Coral Solutions was in St. John in January 2007, the team collected 34 video transects in four different bays. When decomposed into still images, these videos corresponded to over 1000 still images.

Because of the large number of images that were collected, it became apparent that analyzing all images was not feasible due to constrained time and resources. Thus, as discussed in Section 3.3.3, it was determined that a subsample of the collected images would be used in the health assessment. To do this, random selection functionality was built into the CHAT, and four Iterations of health assessment, numbered 1-4, were performed. For each Iteration, from each of the four bays, 30 randomly chosen images were selected for assessment. Thus, a total of 120 distinct images were analyzed in each of the four iterations. However, because images that were chosen in a previous iteration were still eligible to be chosen for subsequent iterations, some photos were chosen in more than one iteration; thus there were less than 480 (4*120) distinct images analyzed.

While video transects were recorded in each of the four bays, the number of transects and still images extracted from each transect varied widely. As shown in Appendix F, Fish, Leinster, and Reef Bays were visited on only one day, while transects were collected on two different days at Round Bay. As a result, a total of 13 transects were recorded in Round Bay, while only 6-8 transects were recorded in each of the other bays.

When still photo extraction was performed, the number of images extracted per transect was highly variable, due to the physical length of each transect, depth, and time-length of video. As a result, each bay has a different number of still images. Fish Bay, with a total of only 149 images has the least, while Reef Bay, with 387 total images has the most.

When coral health assessments were performed using these photos, in Iterations 1-4, 30 distinct images were selected from each bay, regardless of the number of total images that were available for each bay. However, the images were selected 'with replacement', that is, even if an image had been selected in a previous Iteration, it was still eligible to be randomly chosen in a later Iteration. As such, due to the relatively low number of images available for selection in some bays, some images were selected in more than one iteration. As shown in Appendix F, in all cases, the number of distinct images assessed is less than the total number of photo-assessments, indicating that some images were assessed multiple times.

4.2 Classification and Health Assessment Methods

4.2.1 Photo Clarity

The photo clarity classifications that were used during this implementation of the CHAT are described below.

- Excellent – clear, sharp resolution. Allows positive identification of whether or not the image contains a coral colony and a specific identification.
- Moderate – Image clarity is slightly less than excellent, but may still allow user to make a specific identification. Most images were classified as 'Moderate' clarity.
- Poor – Image provides user with information, but image quality may be poor due to blurs or other factors. Generally allows user to identify if coral is present, but does not allow a specific identification.
- Useless – Extremely blurry image, with overall poor quality and poor contrast. Allows almost no identification of coral or other components. Often due to depth or water tubidity.

4.2.2 Identification

Coral or benthic structure identification was performed using a three tiered classification structure. The most basic classification was 'Type', which differentiated between coral and anything that was not coral. The next classifications were 'Basic' and 'Specific', which further detailed the identification. The classification structure is shown in Figure 4.2-1.

Due to the vast quantity of points that were not located on coral, all identification and coral health values default to the value 'Sand or Rocks' and 'Not Applicable', respectively. Difficulties in classification were encountered when differentiating between 'Sand or Rocks', 'Dead Stony Substrate', and 'Fully Bleached' coral. In general, a structured was assigned the value 'Sand or

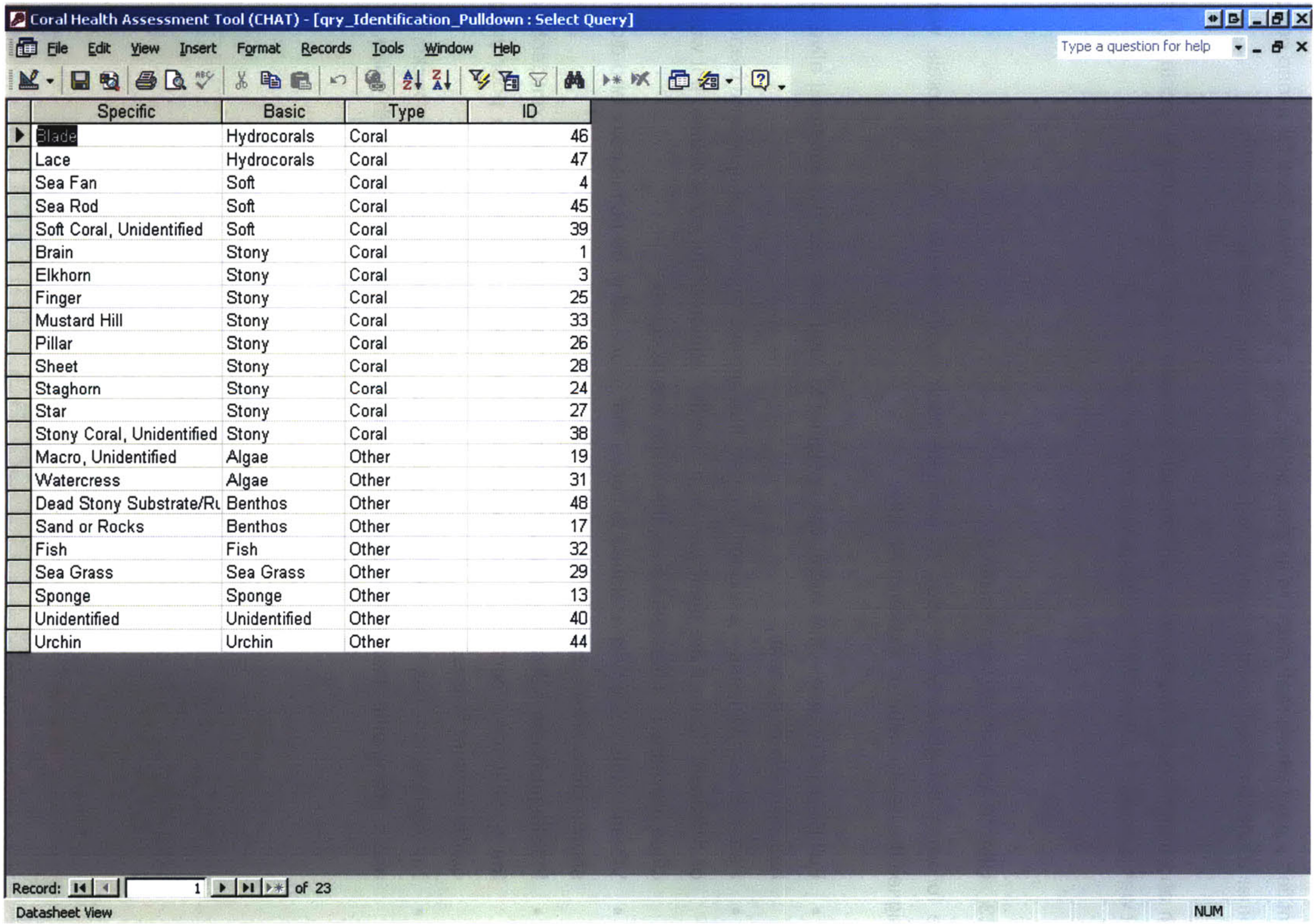
Rocks' if it was clearly not stony substrate. 'Dead Stony Substrate' was assigned if the point identified a point where reef structure existed, but appeared to have been dead for a long period of time. 'Fully Bleached' coral referred to regions where coral appeared to be alive.

Fish and urchin counts were performed for each analyzed image. Every visible urchin or fish that was partially or fully within the image was counted once.

4.2.3 Health Assessment Categories

The following categories were used to evaluate each coral's health. All soft corals were assigned the health value of 'Indistinguishable'.

- Full Bleach/Disease – this value was assigned to coral colonies that appeared alive but had very little or no color.
- Partial Bleach/Disease – assigned to corals that showed regions that appeared bleached or diseased. Even if the point was on a 'healthy' portion of the coral colony, if it was in close proximity to a bleached area, this value was assigned.
- Vibrant – this value was assigned to corals that appeared to be rich in color and did not show regions of bleaching.
- Indistinguishable – this health value was assigned when the assessor was confident that the point defined coral, but was unable to distinguish the health due to poor image quality or other factors.
- Not Applicable – this term refers to anything that is not coral. Macro algae, rocks, fish, and anything other than stony corals or hydrocorals were assigned this health value.



Specific	Basic	Type	ID
Blade	Hydrocorals	Coral	46
Lace	Hydrocorals	Coral	47
Sea Fan	Soft	Coral	4
Sea Rod	Soft	Coral	45
Soft Coral, Unidentified	Soft	Coral	39
Brain	Stony	Coral	1
Elkhorn	Stony	Coral	3
Finger	Stony	Coral	25
Mustard Hill	Stony	Coral	33
Pillar	Stony	Coral	26
Sheet	Stony	Coral	28
Staghorn	Stony	Coral	24
Star	Stony	Coral	27
Stony Coral, Unidentified	Stony	Coral	38
Macro, Unidentified	Algae	Other	19
Watercress	Algae	Other	31
Dead Stony Substrate/Ru	Benthos	Other	48
Sand or Rocks	Benthos	Other	17
Fish	Fish	Other	32
Sea Grass	Sea Grass	Other	29
Sponge	Sponge	Other	13
Unidentified	Unidentified	Other	40
Urchin	Urchin	Other	44

Figure 4.2-1 – Classification Structure

5 *RESULTS AND ANALYSIS*

5.1 ASSESSMENT METRICS AND SCORING STRUCTURE

As discussed in Section 1.7.2, it is very difficult for researchers to truly understand the state of coral health if they do not consider multiple parameters or indicators of coral health. As such, the author developed a Coral Health Index (CHI) comprised of seven equally weighted health metrics, or properties by which coral health is measured. The metrics were selected from those that were most readily available from the videographic methods used.

For each of the seven metrics, summarized in Table 5.1-1, a total score of 100 was distributed amongst the four bays on a weighted basis. In this scoring system, a high score indicates a high coral health relative to the other bays. Each metric measures a slightly different aspect of coral health than do other metrics. Scoring is discussed further in Section 5.2, where Table 5.2-1 provides the weighted scoring information for each bay.

A brief discussion of each metric and its corresponding results is contained in this section. Table 5.1-2 details the specific results for each metric, and Figure 5.1-1 and Figure 5.1-2 depict this information graphically. Supporting data for all metrics can be found in Appendix A.

Table 5.1-1 – Metric Descriptions

Metric Number	Description	Importance
1	Percent of Stony and Hydrocorals Vibrant	Indicates health of the current reef-building population
2	Percent of Coral Living	Provides information about living coral compared with that coral that is already dead.
3	Percent Soft Coral Cover	Soft coral cover is an important aspect of coral reefs.
4	Percent Algae Free	High levels of eutrophication and algal cover indicate a poor environment for coral growth. As such, high percentages of algae-free areas indicate positive environments for coral.
5	Coral Species Count	A high level of species diversity can indicate a healthy reef environment.
6	Total Fish Count	An abudance of fish indicates a health reef.
7	Urchin Count	The presence of urchins is postively linked to coral health, as they graze on algal, thus reducing algal cover.

- Metric 1

  The percentage of living stony and hydrocorals that were classified as 'Vibrant' was used as a measure of the health of the coral colonies that have not already died. Results show that Reef Bay had the highest percentage of Vibrant coral at 35%, while Fish Bay had the lowest percentage at 17%. Leinster and Round Bays had similar scores for this metric, at 24% and 26% respectively.

- Metric 2

  While Metric 1 provides an understanding of how healthy the living coral is, Metric 2 provides information related to what portion of coral is still living. This is an important measure of coral health, because if only a small portion of coral is still alive, the overall coral health of the bay may be poor.

  In Metric 2, Round Bay was observed to have the highest percentage of living coral, at 89%. However, due to the large number of points on photos that were classified as 'Unidentified' and relatively low number of positively identified corals, it is possible that is value is artificially high. However, overall, Leinster and Round Bays showed significantly higher scores than Fish and Reef Bays in this metric.

- Metric 3

  While it does not contribute to reef formation, soft coral cover is an important component of the reef ecosystem. The highest level of soft coral cover was 8%, observed in Round Bay, followed closely by 7% cover in Leinster Bay. Fish Bay had the least soft coral cover, at only 1%.

- Metric 4

  As discussed in Section 1.6.3.3, high levels of algal cover within bays is a sign of eutrophication, a danger to corals. Conversely, a high percentage of algae-free regions can be taken to be the most oligotrphic, indicating a positive environment for corals.

  Leinster Bay was observed to be the most oligotrophic bay at 99% algae-free, while Reef Bay displayed the lowest level of algae-free cover.

- Metric 5

  Metric 5, number of observed species, was relatively constant for all the bays, with a minimum of eight in Fish and Leinster Bays and a maximum of ten in Round Bay.

- Metric 6

  Fish counts between the bays was highly variable, with Leinster Bay, at a count of 64, showing drastically more fish than any of the other bays. However, it should be noted that these counts are often greatly increased by a school of fish observed in just a few photos.

- Metric 7

  Like fish counts, total urchin counts were highly variable, with 60 urchins observed in Round Bay and zero observed in Fish and Reef Bays.

Table 5.1-2 – Metric Results Summary

Bay Name	Metric 1 - % Vibrant	Metric 2 - % Living	Metric 3 - % Soft Coral Cover	Metric 4 - % Algae Free	Metric 5 - # Observed Coral Species	Metric 6 - Total Fish Count	Metric 7 - Total Urchin Count
Fish	17%	27%	1%	77%	8	12	0
Leinster	24%	51%	7%	99%	8	64	14
Reef	35%	29%	3%	57%	9	8	0
Round	26%	89%	8%	95%	10	16	60

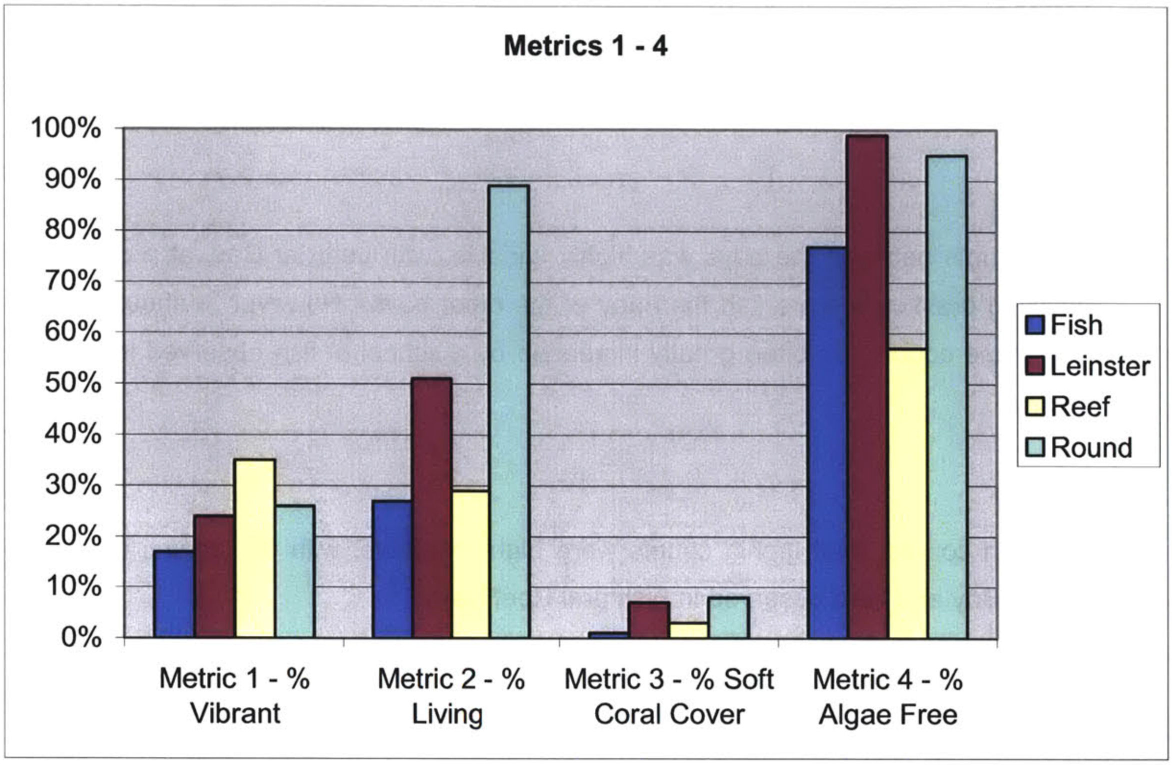


Figure 5.1-1 – Metrics 1 – 4 Results

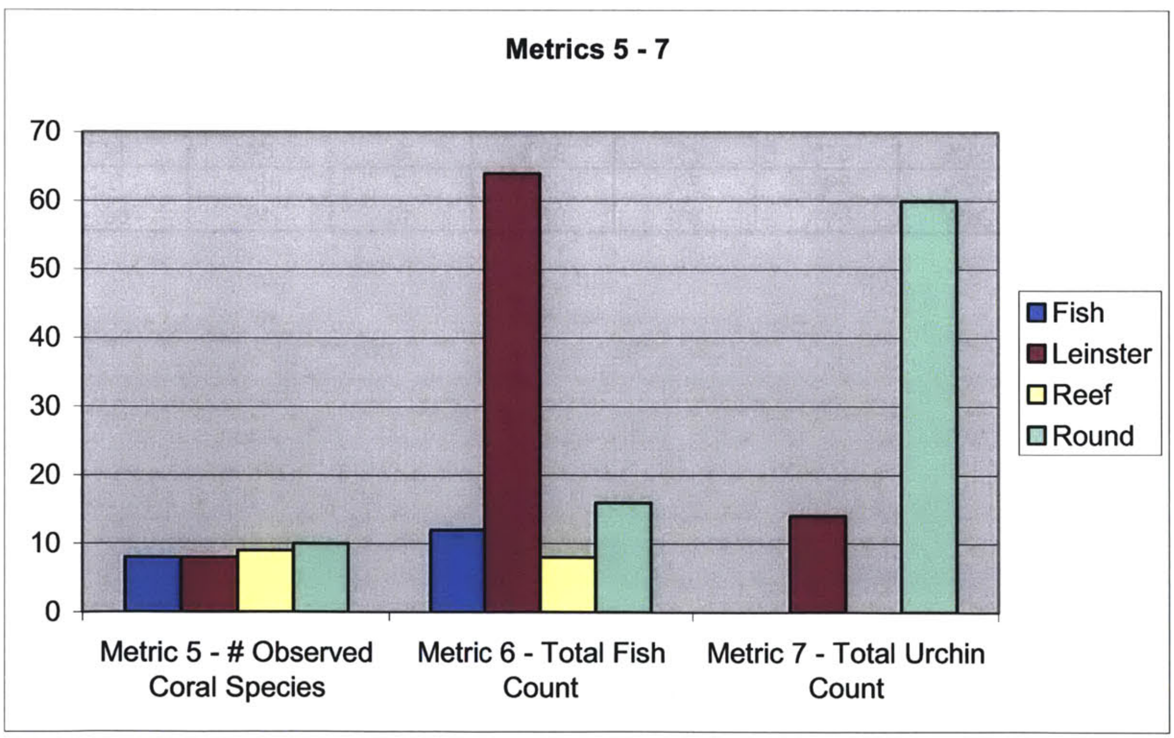


Figure 5.1-2 – Metrics 5 – 7 Results

5.2 Overall Results and Discussion

The overall coral health assessment results are presented in Table 5.2-1. These scores are proportional to the metric values shown in Table 5.1-2 and are normalized such that each metric is equally weighted. Overall, the total score for each bay is interpreted as its relative coral health. These scores show that Round and Leinster Bays exhibit a significantly higher level of overall coral health than the other two bays, with scores of 268 and 222 respectively. Fish Bay shows the least coral health, with a score of 94.

During the analysis, risk factors existed that may have influenced results. Coral health assessments were based on video transects recorded in each bay, still images extracted from the video transects, and health assessment primarily performed by the author. Approximately one third of all images reviewed were assigned a clarity value of 'Poor' or 'Useless'. As a result, the data derived from these images may not be as accurate as that derived from images of 'Excellent' clarity. To the extent practicable, transect locations were chosen in an unbiased manner. However, use of randomly generated GPS coordinates for transect locations could have further reduce bias. Finally, while performing photo assessment using the CHAT, the author encountered some difficulties in taxonomic identification.

Final results as they relate to development via sediment and nitrogen loading are discussed in depth in the Coral Solutions group report (Coral Solutions, 2007). However, in general, when reviewed with sedimentation and nitrogen loading research results, coral health results indicate that coral health is adversely affected by development.

Table 5.2-1 – Overall Coral Health Scoring Summary

Bay Name	Metric 1 Score	Metric 2 Score	Metric 3 Score	Metric 4 Score	Metric 5 Score	Metric 6 Score	Metric 7 Score	Total Score for Bay
Fish	17	14	5	23	23	12	0	**94**
Leinster	24	26	37	30	23	64	19	**222**
Reef	34	15	16	17	26	8	0	**116**
Round	25	45	42	29	29	16	81	**268**

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6 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

This thesis, produced as a portion of a group project studying the effects of nitrogen and sediment loading on coral health in St. John, USVI, included the development of a coral health index (CHI) that quantifies coral health and a coral health assessment tool (CHAT) that allows users to perform coral health assessments.

The health assessment, based on still images extracted from video of coral, employed a multi-parameter index, allowing Fish, Leinster, Reef, and Round Bays to be ranked by relative coral health. This index combined multiple coral health factors, including percent cover, percent healthy, and others to create a single numerical score for each bay. Results of the health assessment, when reviewed with the work of other Coral Solutions team members, generally indicate that coral health is adversely affected by development. An expanded discussion of this correlation can be found in the Coral Solutions group report (Coral Solutions, 2007).

The assessment tool (CHAT) builds on data management techniques that are currently employed by the National Park Service in St. John. CHAT includes an MS Access forms user interface that allows for random image selection and iterative analysis of still images that have been extracted from video of coral conditions. The database is dynamically linked to MS Excel Pivot Table outputs that provide users with extensive data manipulation and exploration capabilities. The database is constructed to allow extensibility and customization if it is used in future coral health assessment applications.

Overall, an objective coral health index was developed and used to assess coral health in St. John. The CHAT tool enabled the author to effectively compile and evaluate data and ultimately deduce meaningful conclusions about coral health based on numerous parameters. While this implementation of CHAT was specific to St. John, the tool's structure lends itself to further development and implementation in coral reef assessment programs worldwide.

6.2 Recommendations for Future Research/Improvement

From the perspective of coral health assessment on St. John, there are numerous ways that the results presented in this thesis could be improved. These include:

- Long term monitoring, performed over the period of years, would provide valuable data related to changing coral conditions.
- Use of SCUBA equipment would allow the collection of much higher quality video or still images, allowing for more accurate health assessments.
- Additional research on biological health indicators would provide a more accurate view of coral health.

From a software perspective, the CHAT could be improved in various ways. In the next spiral of development, the following improvements would enhance the CHAT's effectiveness.

- All database components, including form fields, should comply with standardized naming conventions.
- Additional pivot table output could be generated to provide increased understanding of data.
- The issue of linking to external .JPEG images should be explored further, particularly with the use of DBPix2.0 software.
- A 'Help' file specific to the CHAT should be generated, accessible from within the CHAT.
- The CHAT could be developed with added extensibility such that users could very easily customize and use it.
- All 'hard-coded' values, those that are not populated via a user prompt, such as the number of randomly selected photos, should be changed to dynamic population.
- Some functionality could be streamlined with the use of Visual Basic programming, as opposed to the current programming in SQL.
- Additional user forms should be added, allowing a user to input a new coral health assessor, bay, GPS data, and other items. Overall, forms should be available so that a user could update or append to virtually all data within the database without the risk of inadvertently overwriting or deleting data.
- It would be extremely valuable for future CHAT developers to conduct an extensive survey of people who perform coral health assessments. In this way, developers could tailor the CHAT to specific user needs.

- The video decomposition process as performed by Coral Solutions was extremely time consuming and labor intensive. It would be valuable to automate this procedure using forms and a standardized naming structure.
- If the CHAT were implemented on a large scale, generation of an internet web-interface could be helpful.

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Appendix A HEALTH ASSESSMENT RANKING DATA

TABLE OF CONTENTS

METRIC 1 – PERCENT VIBRANT OF ALL STONY AND HYDROCORALS

Metric 1 – Fish Bay

METRIC 1 - Coral Health of All Stony and Hydrocorals Observed

GeneralLocation: St. John
BayName: Fish Bay

Type_Desc	Coral_Health	Basic_Desc	Iteration Number 1 Nbr of Pts.	2 Nbr of Pts.	3 Nbr of Pts.	4 Nbr of Pts.	Total Nbr of Pts.	Total %
Coral	Full Bleach/Disease	Stony	2	1	6	4	13	19%
	Indistinguishable	Stony	1	7	7	2	17	24%
	Partial Bleach/Disease	Hydrocorals	0	0	3	0	3	4%
		Stony	7	3	9	6	25	36%
	Vibrant	Stony	2	3	4	3	12	17%
Coral Total			12	14	29	15	70	100%
Grand Total			12	14	29	15	70	100%

% Vibrant of All Stony and Hydrocorals **17%**

Metric 1 – Leinster Bay

METRIC 1 - Coral Health of All Stony and Hydrocorals Observed

GeneralLocation: St. John
BayName: Leinster Bay

Type_Desc	Coral_Health	Basic_Desc	Iteration Number 1 Nbr of Pts.	2 Nbr of Pts.	3 Nbr of Pts.	4 Nbr of Pts.	Total Nbr of Pts.	Total %
Coral	Full Bleach/Disease	Stony	5	10	5	11	31	23%
	Indistinguishable	Stony	2	2	0	1	5	4%
	Partial Bleach/Disease	Hydrocorals	2	0	0	1	3	2%
		Stony	18	13	20	13	64	47%
	Vibrant	Hydrocorals	1	0	0	1	2	1%
		Stony	11	1	13	6	31	23%
Coral Total			39	26	38	33	136	100%
Grand Total			39	26	38	33	136	100%

% Vibrant of Stony and Hydrocorals **24%**

Metric 1 – Reef Bay

METRIC 1 - Coral Health of All Stony and Hydrocorals Observed								
GeneralLocation	St. John							
BayName	Reef Bay							
			Iteration Number				Total Nbr of Pts.	Total %
			1	2	3	4		
Type_Desc	Coral_Health	Basic_Desc	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.		
Coral	Full Bleach/Disease	Stony	0	0	3	2	5	14%
	Indistinguishable	Hydrocorals	0	1	0	0	1	3%
		Stony	2	1	0	0	3	8%
	Partial Bleach/Disease	Hydrocorals	1	0	0	0	1	3%
		Stony	7	1	2	4	14	38%
	Vibrant	Hydrocorals	0	0	1	0	1	3%
		Stony	1	3	3	5	12	32%
Coral Total			11	6	9	11	37	100%
Grand Total			11	6	9	11	37	100%
% Vibrant of Stony and Hydrocorals		**35%**						

Metric 1 – Round Bay

METRIC 1 - Coral Health of All Stony and Hydrocorals Observed								
GeneralLocation	St. John							
BayName	Round Bay							
			Iteration Number				Total Nbr of Pts.	Total %
			1	2	3	4		
Type_Desc	Coral_Health	Basic_Desc	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.		
Coral	Full Bleach/Disease	Hydrocorals	0	1	0	0	1	1%
		Stony	2	4	0	8	14	9%
	Indistinguishable	Hydrocorals	1	0	0	0	1	1%
		Stony	11	13	8	9	41	26%
	Partial Bleach/Disease	Hydrocorals	1	3	1	1	6	4%
		Stony	18	9	20	9	56	35%
	Vibrant	Hydrocorals	1	3	0	1	5	3%
		Stony	11	6	9	10	36	23%
Coral Total			45	39	38	38	160	100%
Grand Total			45	39	38	38	160	100%
% Vibrant of Stony and Hydrocorals		**26%**						

METRIC 2 – PERCENT OF STONY AND HYDROCORALS LIVING

Metric 2 – Fish Bay

METRIC 2 - Percent of Stony and Hydrocorals Living

Location St. John
BayName Fish Bay

			Iteration Number				Total Nbr of Pts.	Total %
			1	2	3	4		
Type_Desc	Basic_Desc	Specific_Desc	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.		
Coral	Hydrocorals	Blade	0	0	3	0	3	1%
	Stony	Brain	0	0	1	0	1	0%
		Elkhorn	0	0	2	5	7	3%
		Star	2	2	5	0	9	3%
		Stony Coral, Unidentified	10	12	18	10	50	19%
Stony and Hydrocoral Total			12	14	29	15	70	27%
Other	Benthos	Dead Stony Substrate/Rubble	63	49	26	56	194	73%
Other Total			63	49	26	56	194	73%
Grand Total			75	63	55	71	264	100%

Metric 2 – Leinster Bay

METRIC 2 - Percent of Stony and Hydrocorals Living

Location St. John
BayName Leinster Bay

			Iteration Number				Total Nbr of Pts.	Total %
			1	2	3	4		
Type_Desc	Basic_Desc	Specific_Desc	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.		
Coral	Hydrocorals	Blade	3	0	0	2	5	2%
	Stony	Brain	1	0	0	0	1	0%
		Mustard Hill	3	0	5	3	11	4%
		Star	3	14	14	20	51	19%
		Stony Coral, Unidentified	29	12	19	8	68	25%
Stony and Hydrocoral Total			39	26	38	33	136	51%
Other	Benthos	Dead Stony Substrate/Rubble	24	13	51	45	133	49%
Other Total			24	13	51	45	133	49%
Grand Total			63	39	89	78	269	100%

Metric 2 – Reef Bay

METRIC 2 - Percent of Stony and Hydrocorals Living								
Location	St. John							
BayName	Reef Bay							
			Iteration Number				Total Nbr of Pts.	Total %
			1	2	3	4		
Type_Desc	Basic_Desc	Specific_Desc	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.		
Coral	Hydrocorals	Blade	1	1	1	0	3	2%
	Stony	Brain	2	2	2	1	7	6%
		Elkhorn	3	0	0	3	6	5%
		Mustard Hill	0	1	0	1	2	2%
		Star	0	0	0	1	1	1%
		Stony Coral, Unidentified	5	2	6	5	18	14%
Coral Total			11	6	9	11	37	29%
Other	Benthos	Dead Stony Substrate/Rubble	15	36	29	9	89	71%
Other Total			15	36	29	9	89	71%
Grand Total			26	42	38	20	126	100%

Metric 2 – Round Bay

METRIC 2 - Percent of Stony and Hydrocorals Living								
Location	St. John							
BayName	Round Bay							
			Iteration Number				Total Nbr of Pts.	Total %
			1	2	3	4		
Type_Desc	Basic_Desc	Specific_Desc	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.		
Coral	Hydrocorals	Blade	3	7	0	1	11	6%
		Lace	0	0	1	1	2	1%
	Stony	Elkhorn	0	0	0	1	1	1%
		Mustard Hill	6	4	4	3	17	9%
		Star	6	8	2	0	16	9%
		Stony Coral, Unidentified	30	20	29	32	111	62%
		Finger	0	0	2	0	2	1%
Coral Total			45	39	38	38	160	89%
Other	Benthos	Dead Stony Substrate/Rubble	2	3	6	9	20	11%
Other Total			2	3	6	9	20	11%
Grand Total			47	42	44	47	180	100%

METRICS 3 & 4 – SOFT CORAL COVER AND PERCENT ALGAE FREE

Metrics 3 & 4 – Fish Bay

METRICS 3 & 4 - Soft Coral Cover & Percent Algae Free, respectively.							
Location	St. John						
BayName	Fish Bay						
		Iteration Number				Total Nbr of Pts.	Total %
		1	2	3	4		
Type_Desc	Basic_Desc	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.		
Coral	Hydrocorals	0	0	3	0	3	0%
	Soft	4	2	2	4	12	1%
	Stony	12	14	26	15	67	5%
Coral Total		16	16	31	19	82	6%
Other	Algae	91	82	71	81	325	23%
	Benthos	202	230	218	218	868	60%
	Fish	2	0	0	2	4	0%
	Unidentified	49	32	40	40	161	11%
Other Total		344	344	329	341	1358	94%
Grand Total		360	360	360	360	1440	100%
	% Algae Free						77%

Metrics 3 & 4 – Leinster Bay

METRICS 3 & 4 - Soft Coral Cover & Percent Algae Free, respectively.							
Location	St. John						
BayName	Leinster Bay						
		Iteration Number				Total Nbr of Pts.	Total %
		1	2	3	4		
Type_Desc	Basic_Desc	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.		
Coral	Hydrocorals	3	0	0	2	5	0%
	Soft	29	18	24	27	98	7%
	Stony	36	26	38	31	131	9%
Coral Total		68	44	62	60	234	16%
Other	Algae	2	5	0	2	9	1%
	Benthos	276	282	287	283	1128	78%
	Sponge	0	2	1	0	3	0%
	Urchin	0	1	0	1	2	0%
	Unidentified	14	26	10	14	64	4%
Other Total		292	316	298	300	1206	84%
Grand Total		360	360	360	360	1440	100%
	% Algae Free						99%

Metrics 3 & 4 – Reef Bay

METRICS 3 & 4 - Soft Coral Cover & Percent Algae Free, respectively.							
Location	St. John						
BayName	Reef Bay						
		Iteration Number				Total Nbr of Pts.	Total %
		1	2	3	4		
Type_Desc	Basic_Desc	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.		
Coral	Hydrocorals	1	1	1	0	3	0%
	Soft	13	13	12	12	50	3%
	Stony	10	5	8	11	34	2%
Coral Total		24	19	21	23	87	6%
Other	Algae	150	150	158	158	616	43%
	Benthos	145	150	152	154	601	42%
	Fish	1	0	0	0	1	0%
	Unidentified	40	41	29	25	135	9%
Other Total		336	341	339	337	1353	94%
Grand Total		360	360	360	360	1440	100%
	% Algae Free						57%

Metrics 3 & 4 – Round Bay

METRICS 3 & 4 - Soft Coral Cover & Percent Algae Free, respectively.							
Location	St. John						
BayName	Round Bay						
		Iteration Number				Total Nbr of Pts.	Total %
		1	2	3	4		
Type_Desc	Basic_Desc	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.	Nbr of Pts.		
Coral	Hydrocorals	3	7	1	2	13	1%
	Soft	24	31	50	13	118	8%
	Stony	42	32	37	36	147	10%
Coral Total		69	70	88	51	278	19%
Other	Algae	20	18	18	17	73	5%
	Benthos	202	202	183	242	829	58%
	Sponge	1	0	2	1	4	0%
	Urchin	2	1	4	4	11	1%
	Unidentified	66	69	65	45	245	17%
Other Total		291	290	272	309	1162	81%
Grand Total		360	360	360	360	1440	100%
	% Algae Free						95%

Metric 5 – Species Counts

Metric 5 – Fish Bay

METRIC 5 - Observed Coral Species Count						
Location	St. John					
BayName	Fish Bay					
			Iteration Number			
			1	2	3	4
Type_Desc	Basic_Desc	Specific_Desc	Observed	Observed	Observed	Observed
Coral	Hydrocorals	Blade			X	
	Soft	Sea Fan	X	X	X	X
		Sea Rod				X
		Soft Coral, Unidentified	X			
	Stony	Brain			X	
		Elkhorn			X	X
		Star	X	X	X	
		Stony Coral, Unidentified	X	X	X	X
Total Number of Observed Species (including 'Unidentified')						**8**

Metric 5 – Leinster Bay

METRIC 5 - Observed Coral Species Count						
Location	St. John					
BayName	Leinster Bay					
			Iteration Number			
			1	2	3	4
Type_Desc	Basic_Desc	Specific_Desc	Observed	Observed	Observed	Observed
Coral	Hydrocorals	Blade	X			X
	Soft	Sea Fan	X	X	X	X
		Sea Rod	X	X	X	X
		Soft Coral, Unidentified	X		X	X
	Stony	Brain	X			
		Mustard Hill	X		X	X
		Star	X	X	X	X
		Stony Coral, Unidentified	X	X	X	X
Total Number of Observed Species (including 'Unidentified')						**8**

Metric 5 – Reef Bay

METRIC 5 - Observed Coral Species Count						
Location	St. John					
BayName	Reef Bay					
			Iteration Number			
			1	2	3	4
Type_Desc	Basic_Desc	Specific_Desc	Observed	Observed	Observed	Observed
Coral	Hydrocorals	Blade	X	X	X	
	Soft	Sea Fan	X	X	X	X
		Sea Rod		X	X	
		Soft Coral, Unidentified			X	X
	Stony	Brain	X	X	X	X
		Elkhorn	X			X
		Mustard Hill		X		X
		Star				X
		Stony Coral, Unidentified	X	X	X	X
Total Number of Observed Species (including 'Unidentified')						**9**

Metric 5 – Round Bay

METRIC 5 - Observed Coral Species Count						
Location	St. John					
BayName	Round Bay					
			Iteration Number			
			1	2	3	4
Type_Desc	Basic_Desc	Specific_Desc	Observed	Observed	Observed	Observed
Coral	Hydrocorals	Blade	X	X		X
		Lace			X	X
	Soft	Sea Fan	X	X	X	X
		Sea Rod	X	X	X	X
		Soft Coral, Unidentified	X	X	X	X
	Stony	Elkhorn				X
		Mustard Hill	X	X	X	X
		Star	X	X	X	
		Stony Coral, Unidentified	X	X	X	X
		Finger			X	
Total Number of Observed Species (including 'Unidentified')						**10**

Metrics 6 & 7 – Total Fish and Urchin Counts

Metrics 6 & 7 – Fish Bay

METRICS 6 & 7 - Total Fish and Urchin Counts										
Location	St. John									
BayName	Fish Bay									
	Iteration Number									
	1		2		3		4		Total	Total
Transect Number	Fish Count	Urchin Count	Fish Count	Urchin Count	Fish Count	Urchin Count	Fish Count	Urchin Count	Fish Count	Urchin Count
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	4	0	0	0	1	0	5	0	10	0
4	0	0	0	0	0	0	0	0	0	0
5	1	0	0	0	0	0	1	0	2	0
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
Grand Total	5	0	0	0	1	0	6	0	12	0

Metrics 6 & 7 – Leinster Bay

METRICS 6 & 7 - Total Fish and Urchin Counts										
Location	St. John									
BayName	Leinster Bay									
	Iteration Number									
	1		2		3		4		Total	Total
Transect Number	Fish Count	Urchin Count	Fish Count	Urchin Count	Fish Count	Urchin Count	Fish Count	Urchin Count	Fish Count	Urchin Count
1	0	0	0	1	0	0			0	1
2	0	0	5	0	2	0	4	0	11	0
3	0	0	0	0	0	0	0	0	0	0
4	40	9	0	0	0	0	12	4	52	13
5	0	0	1	0	0	0	0	0	1	0
6	0	0	0	0	0	0	0	0	0	0
Grand Total	40	9	6	1	2	0	16	4	64	14

Metrics 6 & 7 – Reef Bay

METRICS 6 & 7 - Total Fish and Urchin Counts										
Location	St. John									
BayName	Reef Bay									
	Iteration Number									
	1		2		3		4		Total	Total
Transect Number	Fish Count	Urchin Count	Fish Count	Urchin Count	Fish Count	Urchin Count	Fish Count	Urchin Count	Fish Count	Urchin Count
1	0	0	0	0	0	0	0	0	0	0
2	2	0	1	0	1	0	0	0	4	0
3	1	0	0	0	0	0	1	0	2	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	1	0	0	0	0	0	1	0
6	0	0	0	0	0	0	0	0	0	0
7	1	0	0	0	0	0	0	0	1	0
8	0	0	0	0	0	0	0	0	0	0
Grand Total	4	0	2	0	1	0	1	0	8	0

Metrics 6 & 7 – Round Bay

METRICS 6 & 7 - Total Fish and Urchin Counts										
Location	St. John									
BayName	Round Bay									
	Iteration Number									
	1		2		3		4		Total	Total
Transect Number	Fish Count	Urchin Count	Fish Count	Urchin Count	Fish Count	Urchin Count	Fish Count	Urchin Count	Fish Count	Urchin Count
1	0	7	0	0	0	0	0	0	0	7
2	0	0	0	0	0	1	0	0	0	1
3	0	4	2	0	2	10	0	11	4	25
4	1	2	0	4	1	2	1	0	3	8
5	1	0	7	0	1	3	0	16	9	19
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
Grand Total	2	13	9	4	4	16	1	27	16	60

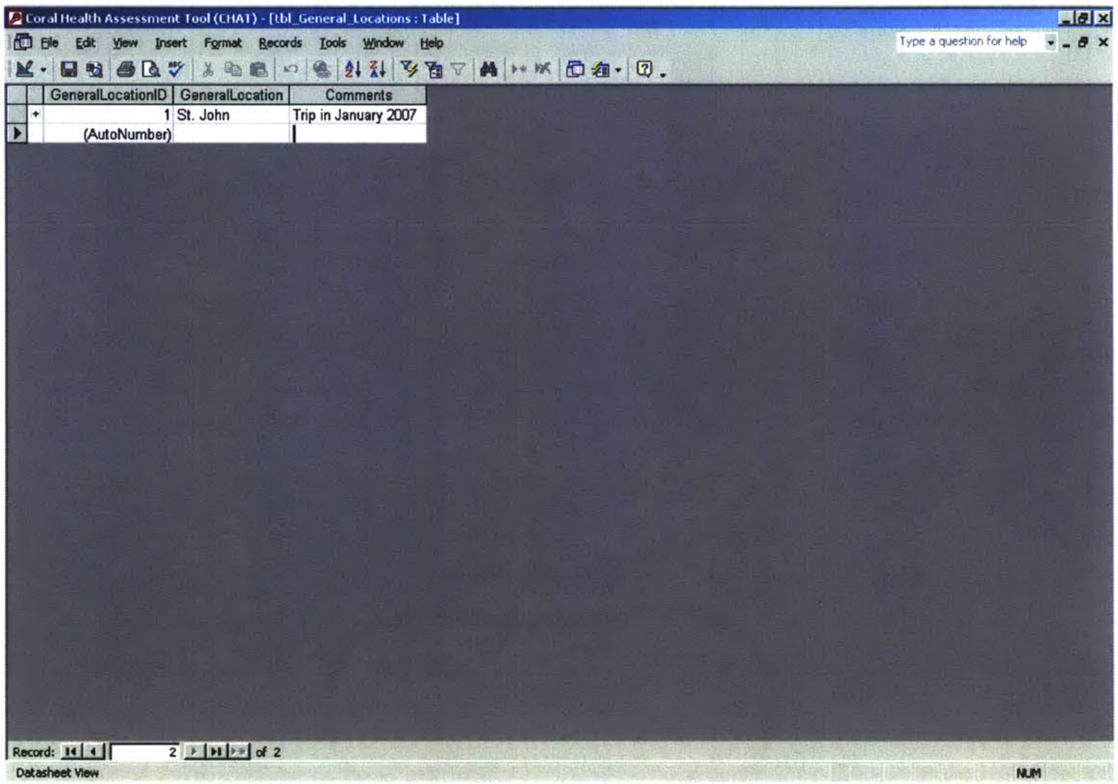
Appendix B DATABASE TABLE DETAILS

APPENDIX B TABLE OF CONTENTS

TRANSACTION TABLES

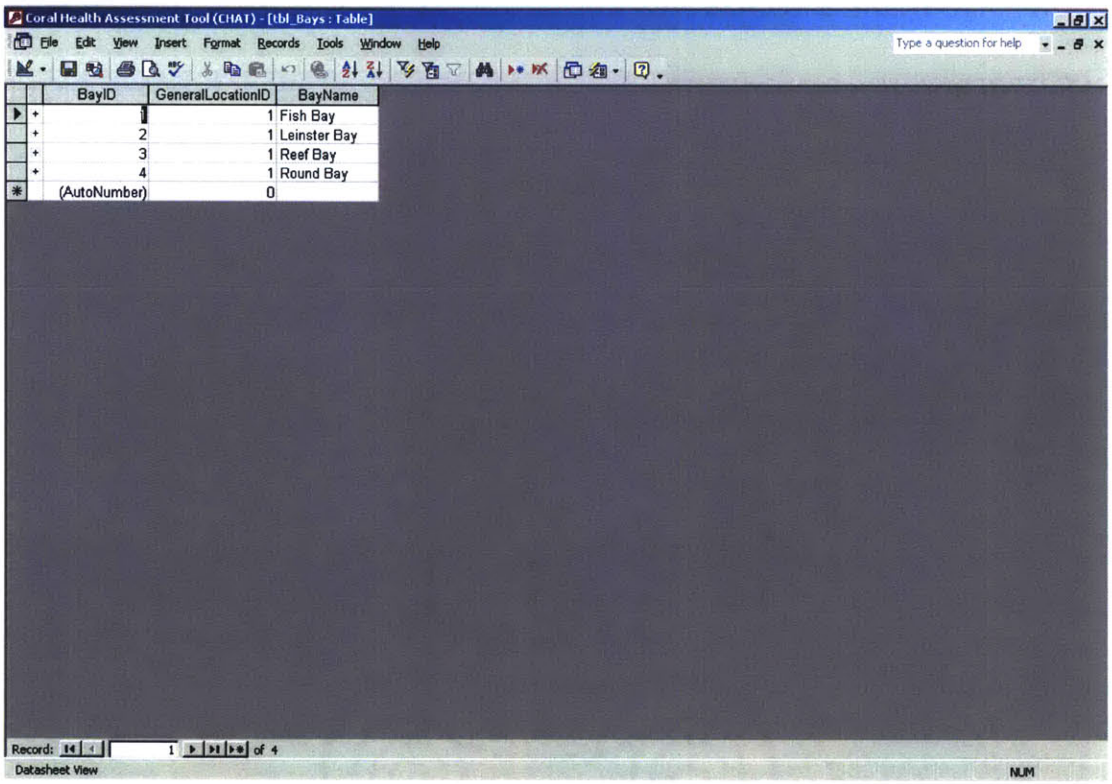
tbl_General_Locations

Table Name	tbl_General_Locations				
Table Comments	Stores all information regarding general sampling location.				
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
GeneralLocationID	Autonumber	X			X
GeneralLocation	Text	X	Location, such as St. John, USVI	X	X
Comment	Memo				



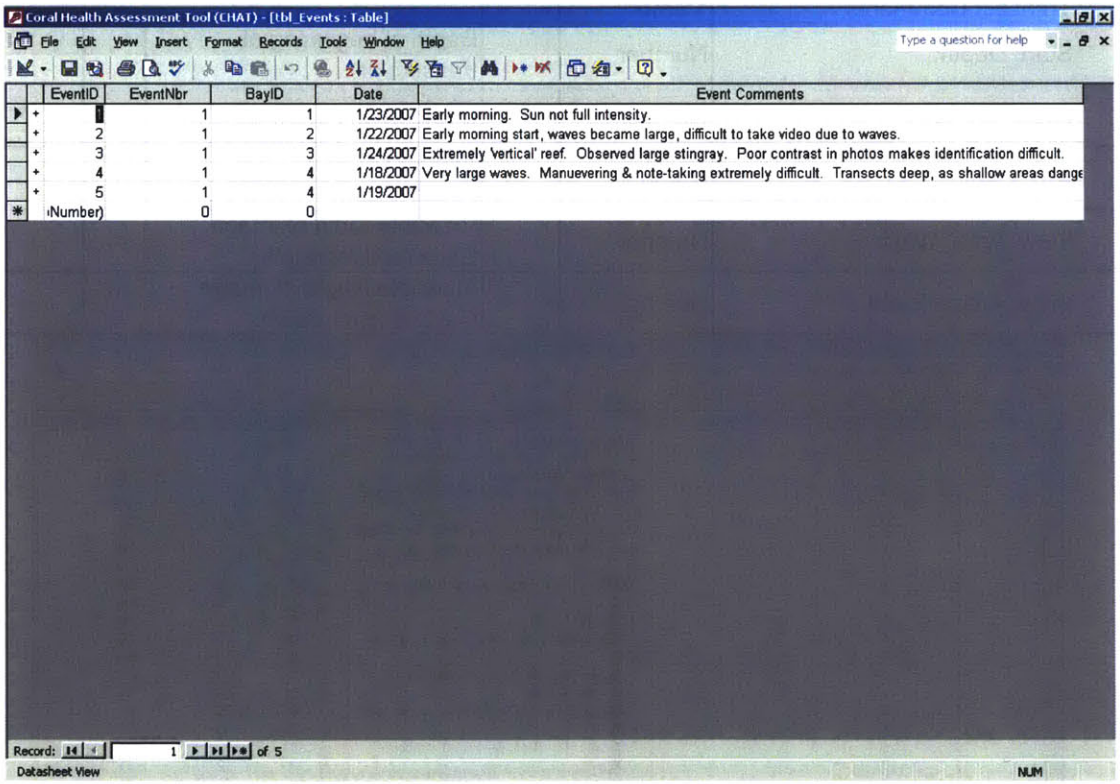
tbl_Bays

Table Name	tbl_Bays				
Table Comments	Stores all bay information.				
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
BayID	Autonumber	X			X
GeneralLocationID	Number	X		X	X
BayName	Text	X	Bay name		



tbl_Events

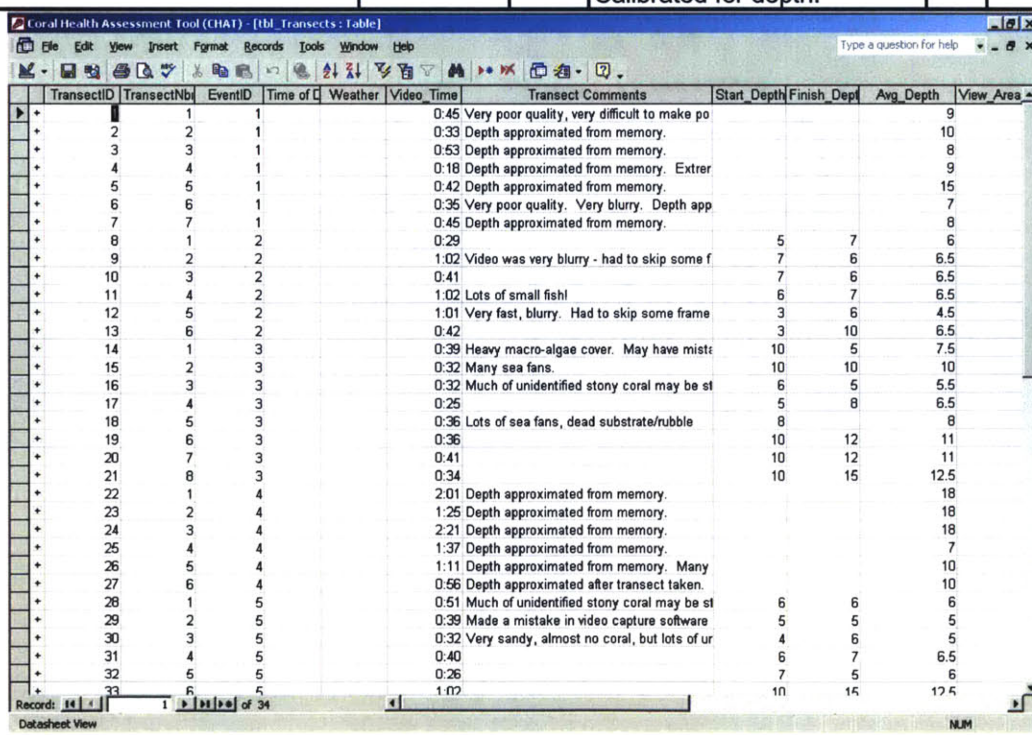
Table Name	tbl_Events				
Table Comments	Stores all event information.				
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
EventID	Autonumber	X			X
EventNbr	Number	X	The number of the event on any given day, e.g., EventNbr's 1 & 2 on 3/23/2007.	X	X
BayID	Number	X			
Date	Date/Time	X			
Event Comments	Memo				



EventID	EventNbr	BayID	Date	Event Comments
1	1	1	1/23/2007	Early morning. Sun not full intensity.
2	1	2	1/22/2007	Early morning start, waves became large, difficult to take video due to waves.
3	1	3	1/24/2007	Extremely 'vertical' reef. Observed large stingray. Poor contrast in photos makes identification difficult.
4	1	4	1/18/2007	Very large waves. Manuevering & note-taking extremely difficult. Transects deep, as shallow areas dange
5	1	4	1/19/2007	
(Number)	0	0		

tbl_Transects

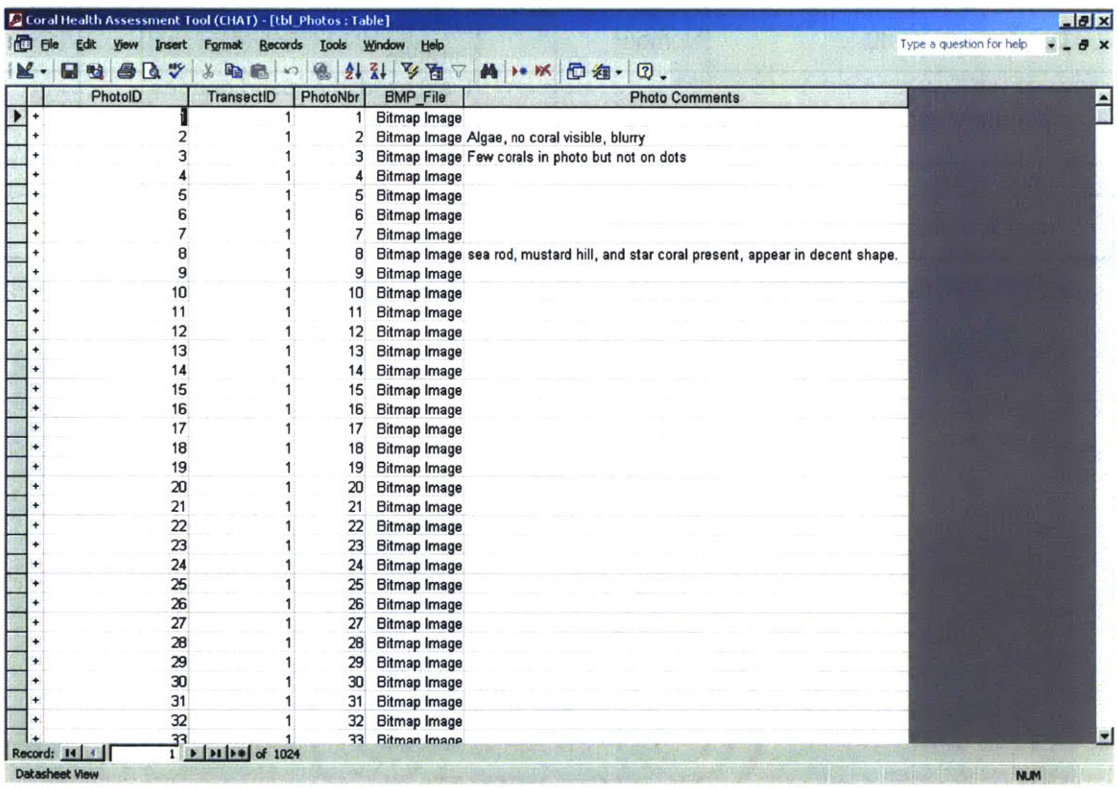
Table Name	tbl_Transects				
Table Comments	Stores transect details.				
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
TransectID	Autonumber	X			X
TransectNbr	Number	X	Numbers assigned to transects, e.g., on a given day, transect numbers may range from 1-10	X	X
EventID	Number	X			
Time of Day	Date/Time		Time at which video transect was recorded		
Weather	Text				
Video_Time	Date/Time		Length of video in mm:ss format.		
Transect Comments	Memo				
Start_Depth	Number		Depth at beginning of transect (ft).		
Finish_Depth	Number		Depth at end of transect (ft).		
Avg_Depth	Number		Average of Start_ and Finish_Depth.		
View_Area_Width	Number		Viewable width of image. Calibrated for depth.		
View_Area_Height	Number		Viewable height of image. Calibrated for depth.		



TransectID	TransectNbr	EventID	Time of D	Weather	Video_Time	Transect Comments	Start_Depth	Finish_Dept	Avg_Depth	View_Area
1	1	1			0:45	Very poor quality, very difficult to make po			9	
2	2	1			0:33	Depth approximated from memory.			10	
3	3	1			0:53	Depth approximated from memory.			8	
4	4	1			0:18	Depth approximated from memory. Extrer			9	
5	5	1			0:42	Depth approximated from memory.			15	
6	6	1			0:35	Very poor quality. Very blurry. Depth app			7	
7	7	1			0:45	Depth approximated from memory.			8	
8	1	2			0:29		5	7	6	
9	2	2			1:02	Video was very blurry - had to skip some f	7	6	6.5	
10	3	2			0:41		7	6	6.5	
11	4	2			1:02	Lots of small fish!	6	7	6.5	
12	5	2			1:01	Very fast, blurry. Had to skip some frame	3	6	4.5	
13	6	2			0:42		3	10	6.5	
14	1	3			0:39	Heavy macro-algae cover. May have mist	10	5	7.5	
15	2	3			0:32	Many sea fans.	10	10	10	
16	3	3			0:32	Much of unidentified stony coral may be st	6	5	5.5	
17	4	3			0:25		5	8	6.5	
18	5	3			0:36	Lots of sea fans, dead substrate/rubble	8		8	
19	6	3			0:36		10	12	11	
20	7	3			0:41		10	12	11	
21	8	3			0:34		10	15	12.5	
22	1	4			2:01	Depth approximated from memory.			18	
23	2	4			1:25	Depth approximated from memory.			18	
24	3	4			2:21	Depth approximated from memory.			18	
25	4	4			1:37	Depth approximated from memory.			7	
26	5	4			1:11	Depth approximated from memory. Many			10	
27	6	4			0:56	Depth approximated after transect taken.			10	
28	1	5			0:51	Much of unidentified stony coral may be st	6	6	6	
29	2	5			0:39	Made a mistake in video capture software	5	5	5	
30	3	5			0:32	Very sandy, almost no coral, but lots of ur	4	6	5	
31	4	5			0:40		6	7	6.5	
32	5	5			0:26		7	5	6	
33	6	5			1:02		10	15	12.5	

tbl_Photos

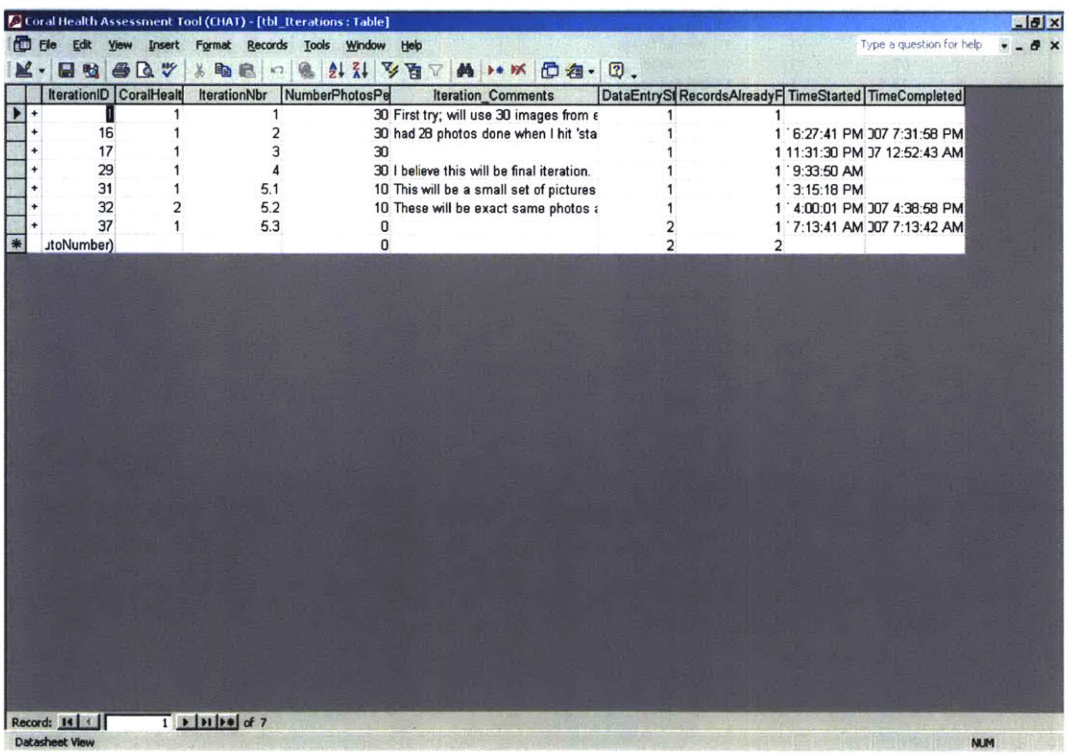
Table Name	tbl_Photos				
Table Comments	Stores image details.				
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
PhotoID	Autonumber	X			X
TransectID	Number	X			
PhotoNbr	Number	X	Numbers assigned to still images/photos that are extracted from video transect, e.g. PhotoNbr 1-33 for a given transect.	X	X
BMP_File	OLE Object		Stores the bitmap image embedded within the database.		
Photo_Comments	Memo				



PhotoID	TransectID	PhotoNbr	BMP_File	Photo Comments
1	1	1	Bitmap Image	
2	1	2	Bitmap Image	Algae, no coral visible, blurry
3	1	3	Bitmap Image	Few corals in photo but not on dots
4	1	4	Bitmap Image	
5	1	5	Bitmap Image	
6	1	6	Bitmap Image	
7	1	7	Bitmap Image	
8	1	8	Bitmap Image	sea rod, mustard hill, and star coral present, appear in decent shape.
9	1	9	Bitmap Image	
10	1	10	Bitmap Image	
11	1	11	Bitmap Image	
12	1	12	Bitmap Image	
13	1	13	Bitmap Image	
14	1	14	Bitmap Image	
15	1	15	Bitmap Image	
16	1	16	Bitmap Image	
17	1	17	Bitmap Image	
18	1	18	Bitmap Image	
19	1	19	Bitmap Image	
20	1	20	Bitmap Image	
21	1	21	Bitmap Image	
22	1	22	Bitmap Image	
23	1	23	Bitmap Image	
24	1	24	Bitmap Image	
25	1	25	Bitmap Image	
26	1	26	Bitmap Image	
27	1	27	Bitmap Image	
28	1	28	Bitmap Image	
29	1	29	Bitmap Image	
30	1	30	Bitmap Image	
31	1	31	Bitmap Image	
32	1	32	Bitmap Image	
33	1	33	Bitmap Image	

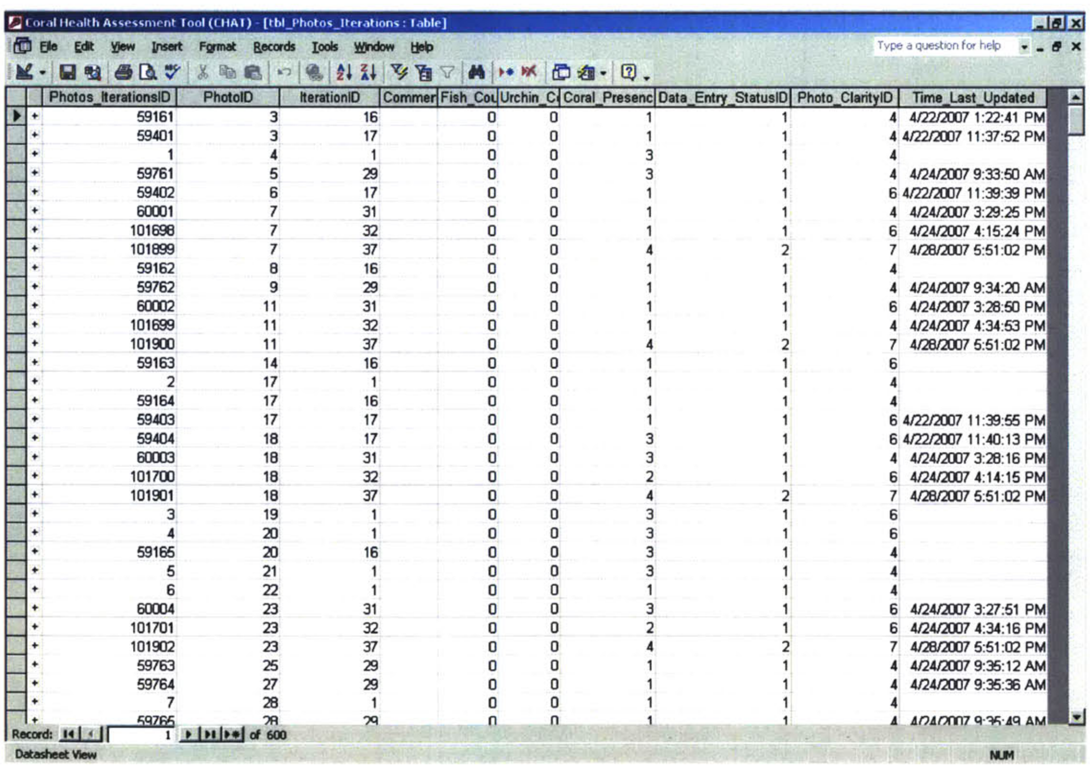
tbl_Iterations

Table Name	tbl_Iterations				
Table Comments	Stores Iteration information. An Iteration consists of a user				
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
IterationID	Autonumber	X			X
CoralHealthAssessorID	Number	X			
IterationNbr	Number	X	User-defined number to define the iteration number. Can be integer, or like 5.1, 5.2 to indicate iterations that are associated with one another.	X	X
NumberPhotosPerBay	Number		User-entered number of images that will be selected from each bay for analysis.		
Iteration_Comments	Memo				
DataEntryStatusID	Number		Data entry status for the iteration		
RecordsAlreadyPrePopulatedID	Number	X	Field used in Append queries that append records for new iterations.		
TimeStarted	Date/Time		Date/Time iteration started.		
TimeCompleted	Date/Time		Date/Time iteration completed.		



tbl_Photos_Iterations

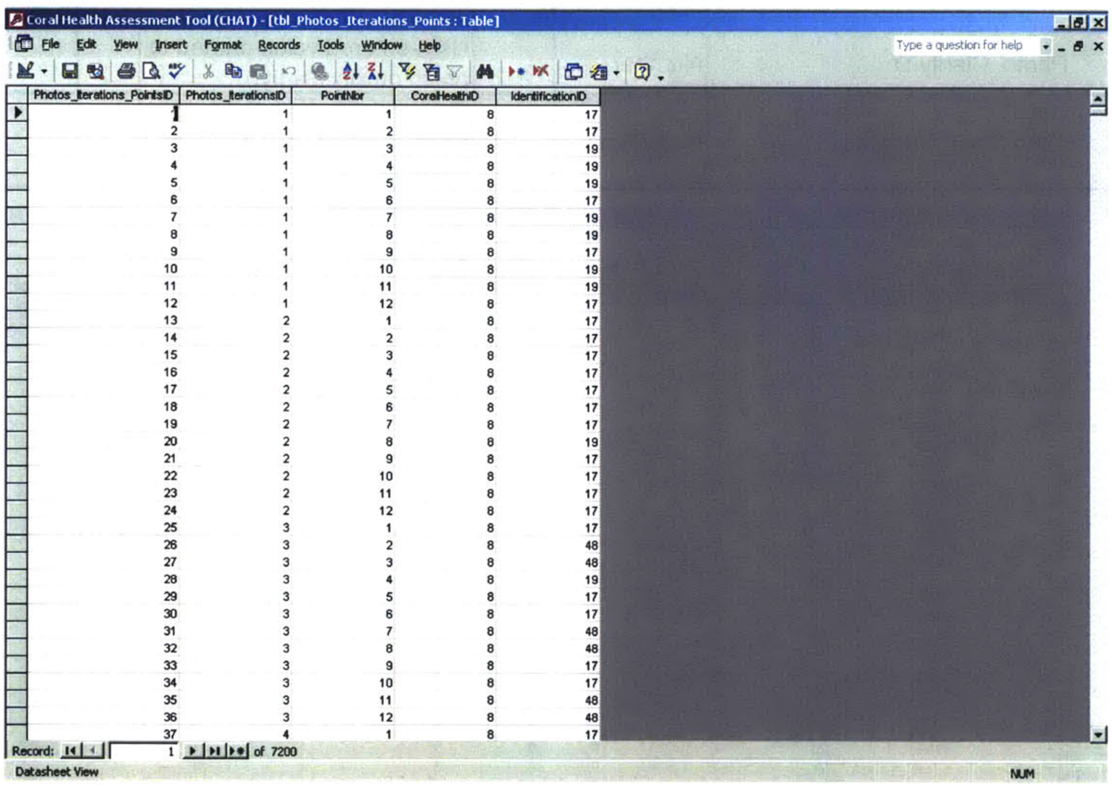
Table Name	tbl_Photos_Iterations				
Table Comments	Intermediate table in many-to-many relationship between				
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
Photos_IterationsID	Autonumber	X			
PhotoID	Number	X		X	X
IterationID	Number	X			
Comments	Text				
Fish_Count	Number		Total number of fish or portions thereof visible within the photo		
Urchin_Count	Number		Total number of urchins or portions thereof visible within the photo		
Coral_PresenceID	Number		Whether or not the user identified the presence of coral within the image.		
Data_Entry_StatusID	Number		Stores user's data-entry status for each photo-iteration.		
Photo_ClarityID	Number		User-entered value related to photo quality/clarity.		
Time_Last_Updated	Date/Time		Automatically updated field; updates when user clicks or changes certain fields.		



Photos_IterationsID	PhotoID	IterationID	Commer	Fish_Cou	Urchin_C	Coral_Presenc	Data_Entry_StatusID	Photo_ClarityID	Time_Last_Updated
59161	3	16		0	0	1	1	4	4/22/2007 1:22:41 PM
59401	3	17		0	0	1	1	4	4/22/2007 11:37:52 PM
1	4	1		0	0	3	1	4	
59761	5	29		0	0	3	1	4	4/24/2007 9:33:50 AM
59402	6	17		0	0	1	1	6	4/22/2007 11:39:39 PM
60001	7	31		0	0	1	1	4	4/24/2007 3:29:25 PM
101698	7	32		0	0	1	1	6	4/24/2007 4:15:24 PM
101899	7	37		0	0	4	2	7	4/28/2007 5:51:02 PM
59162	8	16		0	0	1	1	4	
59762	9	29		0	0	1	1	4	4/24/2007 9:34:20 AM
60002	11	31		0	0	1	1	6	4/24/2007 3:28:50 PM
101699	11	32		0	0	1	1	4	4/24/2007 4:34:53 PM
101900	11	37		0	0	4	2	7	4/28/2007 5:51:02 PM
59163	14	16		0	0	1	1	6	
2	17	1		0	0	1	1	4	
59164	17	16		0	0	1	1	4	
59403	17	17		0	0	1	1	6	4/22/2007 11:39:55 PM
59404	18	17		0	0	3	1	6	4/22/2007 11:40:13 PM
60003	18	31		0	0	3	1	4	4/24/2007 3:28:16 PM
101700	18	32		0	0	2	1	6	4/24/2007 4:14:15 PM
101901	18	37		0	0	4	2	7	4/28/2007 5:51:02 PM
3	19	1		0	0	3	1	6	
4	20	1		0	0	3	1	6	
59165	20	16		0	0	3	1	4	
5	21	1		0	0	3	1	4	
6	22	1		0	0	1	1	4	
60004	23	31		0	0	3	1	6	4/24/2007 3:27:51 PM
101701	23	32		0	0	2	1	6	4/24/2007 4:34:16 PM
101902	23	37		0	0	4	2	7	4/28/2007 5:51:02 PM
59763	25	29		0	0	1	1	4	4/24/2007 9:35:12 AM
59764	27	29		0	0	1	1	4	4/24/2007 9:35:36 AM
7	28	1		0	0	1	1	4	
59765	28	29		0	0	1	1	4	4/24/2007 9:35:49 AM

tbl_Photos_Iterations_Points

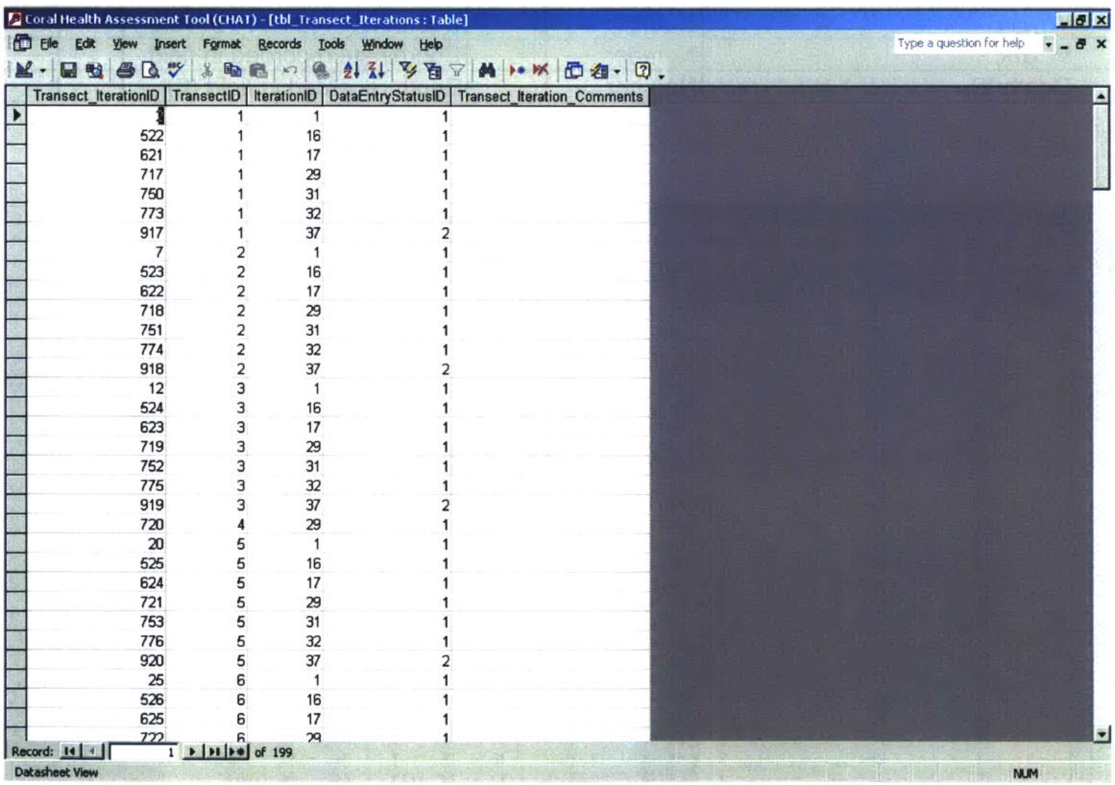
Table Name	tbl_Photos_Iterations_Points				
Table Comments	Stores all actual coral ID and health data for points identified.				
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
Photos_Iterations_PointsID	Autonumber	X			X
Photos_IterationsID	Number	X		X	X
PointNbr	Number	X	The point number as shown on the frm_Subform_Photos Subform. In this implementation, integers 1-12.		
CoralHealthID	Number	X	User-entered value defining coral health if point defines coral.		
IdentificationID	Number	X	User-entered value defining identification at point.		



Photos_Iterations_PointsID	Photos_IterationsID	PointNbr	CoralHealthID	IdentificationID
1	1	1	8	17
2	1	2	8	17
3	1	3	8	19
4	1	4	8	19
5	1	5	8	19
6	1	6	8	17
7	1	7	8	19
8	1	8	8	19
9	1	9	8	17
10	1	10	8	19
11	1	11	8	19
12	1	12	8	17
13	2	1	8	17
14	2	2	8	17
15	2	3	8	17
16	2	4	8	17
17	2	5	8	17
18	2	6	8	17
19	2	7	8	17
20	2	8	8	19
21	2	9	8	17
22	2	10	8	17
23	2	11	8	17
24	2	12	8	17
25	3	1	8	17
26	3	2	8	48
27	3	3	8	48
28	3	4	8	19
29	3	5	8	17
30	3	6	8	17
31	3	7	8	48
32	3	8	8	48
33	3	9	8	17
34	3	10	8	17
35	3	11	8	48
36	3	12	8	48
37	4	1	8	17

Tbl_Transect_Iterations

Table Name	tbl_Transect_Iterations				
Table Comments	Intermediate table in many-to-many relationship between				
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
Transect_IterationID	Autonumber	X			X
TransectID	Number	X		X	X
IterationID	Number	X			
DataEntryStatusID	Number		Data entry status for the transect-iteration. Viewable on frm_CHAT_DATA_ENTRY_FORM form.		
Transect_Iteration_Comments	Memo				



Transect_IterationID	TransectID	IterationID	DataEntryStatusID	Transect_Iteration_Comments
1	1	1	1	
522	1	16	1	
621	1	17	1	
717	1	29	1	
750	1	31	1	
773	1	32	1	
917	1	37	2	
7	2	1	1	
523	2	16	1	
622	2	17	1	
718	2	29	1	
751	2	31	1	
774	2	32	1	
918	2	37	2	
12	3	1	1	
524	3	16	1	
623	3	17	1	
719	3	29	1	
752	3	31	1	
775	3	32	1	
919	3	37	2	
720	4	29	1	
20	5	1	1	
525	5	16	1	
624	5	17	1	
721	5	29	1	
753	5	31	1	
776	5	32	1	
920	5	37	2	
25	6	1	1	
526	6	16	1	
625	6	17	1	
722	6	29	1	

tbl_GPS_Data

Table Name	tbl_GPS_Data				
Table Comments	Stores Global Positioning System data collected while in field.				
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
GPS_PointID	Autonumber	X			X
TransectID	Number	X		X	X
GPS_Data_Point_TypeID	Number	X	Correspondes to 'Start' or 'Finish' of Transect		
X	Number		X-coordinate used in ArcGIS		
Y	Number		Y-coordinate used in ArcGIS		
N Deg	Number		Coordinate recorded in field		
N Min	Number		Coordinate recorded in field		
N Sec	Number		Coordinate recorded in field		
W Deg	Number		Coordinate recorded in field		
W Min	Number		Coordinate recorded in field		
W Sec	Number		Coordinate recorded in field		
Depth(ft)	Number		Depth recorded in field (ft)		

Coral Health Assessment Tool (CHAT) - [tbl_GPS_Data : Table]

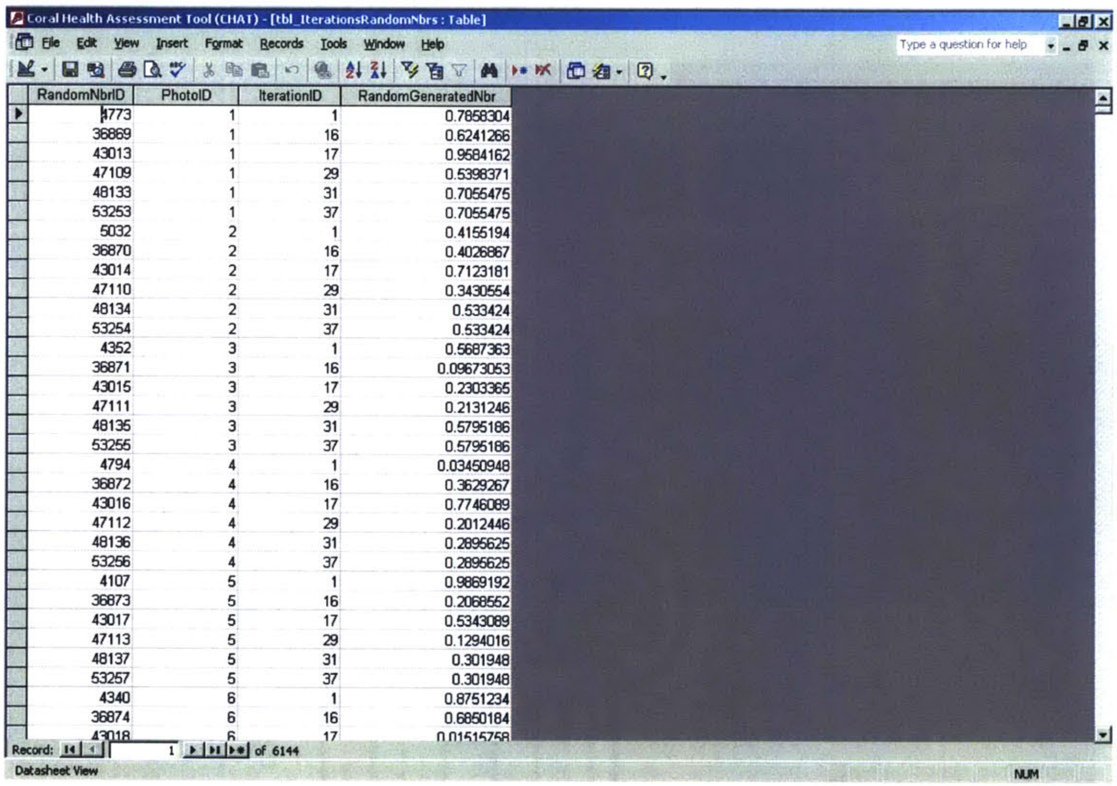
GPS_PointID	TransectID	GPS_Data_Point_TypeID	X	Y	N Deg	N Min	N Sec	W Deg	W Min	W Sec	Depth(ft)
2	8	1	-64.724722	18.363583	18	21	48.9	64	43	29	5
1	8	2	-64.724916	18.363444	18	21	48.4	64	43	29.7	7
4	9	1	-64.725361	18.363666	18	21	49.2	64	43	31.3	7
3	9	2	-64.725694	18.363972	18	21	50.3	64	43	32.5	6
6	10	1	-64.727555	18.364861	18	21	53.5	64	43	39.2	7
5	10	2	-64.727833	18.364666	18	21	52.8	64	43	40.2	6
8	11	1	-64.728666	18.364611	18	21	52.6	64	43	43.2	6
7	11	2	-64.729083	18.364555	18	21	52.4	64	43	44.7	7
10	12	1	-64.733972	18.367194	18	22	1.9	64	44	2.3	3
9	12	2	-64.733333	18.367611	18	22	3.4	64	44	0	6
12	13	1	-64.733194	18.368111	18	22	5.2	64	43	59.5	10
11	13	2	-64.733338	18.36775	18	22	3.9	64	44	0	3
14	14	1	-64.749666	18.320722	18	19	14.6	64	44	58.8	10
13	14	2	-64.749777	18.321277	18	19	16.6	64	44	59.2	5
16	15	1	-64.74975	18.320888	18	19	15.2	64	44	59.1	10
15	15	2	-64.749527	18.320972	18	19	15.5	64	44	58.3	10
18	16	1	-64.749055	18.321666	18	19	18	64	44	56.6	6
17	16	2	-64.748888	18.321944	18	19	19	64	44	56	5
20	17	1	-64.748111	18.322833	18	19	22.2	64	44	53.2	5
19	17	2	-64.748083	18.322944	18	19	22.6	64	44	53.1	8
22	18	1	-64.747138	18.321472	18	19	17.3	64	44	49.7	8
21	18	2	-64.747055	18.32125	18	19	16.5	64	44	49.4	
24	19	1	-64.747111	18.321194	18	19	16.3	64	44	49.6	10
23	19	2	-64.746944	18.321027	18	19	15.7	64	44	49	12
26	20	1	-64.746138	18.320305	18	19	13.1	64	44	46.1	10
25	20	2	-64.746083	18.320138	18	19	12.5	64	44	45.9	12
28	21	1	-64.744972	18.319722	18	19	11	64	44	41.9	10
27	21	2	-64.744777	18.319444	18	19	10	64	44	41.2	15
30	28	1	-64.676666	18.339027	18	20	20.5	64	40	36	6
29	28	2	-64.6765	18.339388	18	20	21.8	64	40	35.4	6
32	29	1	-64.676361	18.33925	18	20	21.3	64	40	34.9	5
31	29	2	-64.675888	18.338916	18	20	20.1	64	40	33.2	5
34	30	1	-64.674527	18.341555	18	20	29.6	64	40	28.3	4

Record: 1 of 42

Datasheet View

tbl_IterationsRandomNbrs

Table Name	tbl_IterationsRandomNbrs				
Table Comments	Stores random numbers that are used for random photo selection.				
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
RandomNbrID	Autonumber	X			X
PhotoID	Number	X		X	X
IterationID	Number	X			
RandomGeneratedNbr	Number	X	Randomly generated number		

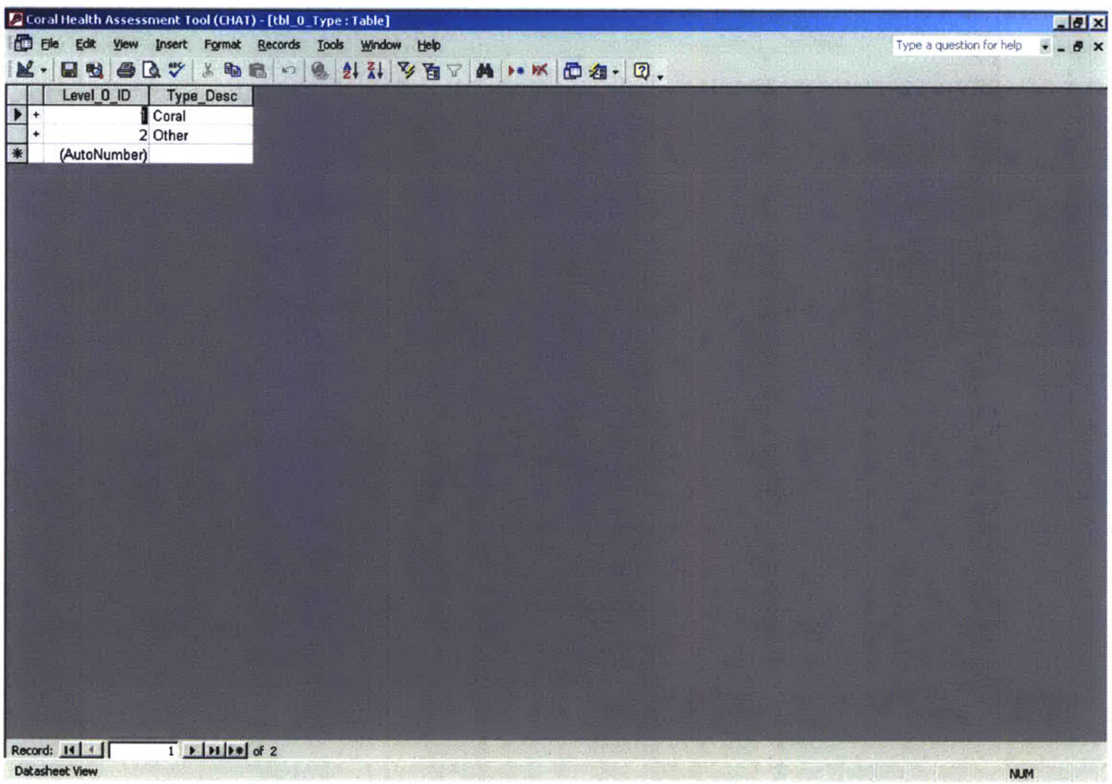


RandomNbrID	PhotoID	IterationID	RandomGeneratedNbr
4773	1	1	0.7858304
36869	1	16	0.6241266
43013	1	17	0.9584162
47109	1	29	0.5398371
48133	1	31	0.7055475
53253	1	37	0.7055475
5032	2	1	0.4155194
36870	2	16	0.4026867
43014	2	17	0.7123181
47110	2	29	0.3430554
48134	2	31	0.533424
53254	2	37	0.533424
4352	3	1	0.5687363
36871	3	16	0.09673053
43015	3	17	0.2303365
47111	3	29	0.2131246
48135	3	31	0.5795186
53255	3	37	0.5795186
4794	4	1	0.03450948
36872	4	16	0.3629267
43016	4	17	0.7746089
47112	4	29	0.2012446
48136	4	31	0.2895625
53256	4	37	0.2895625
4107	5	1	0.9869192
36873	5	16	0.2068552
43017	5	17	0.5343089
47113	5	29	0.1294016
48137	5	31	0.301948
53257	5	37	0.301948
4340	6	1	0.8751234
36874	6	16	0.6850184
43018	6	17	0.01515758

CLASSIFICATION TABLES

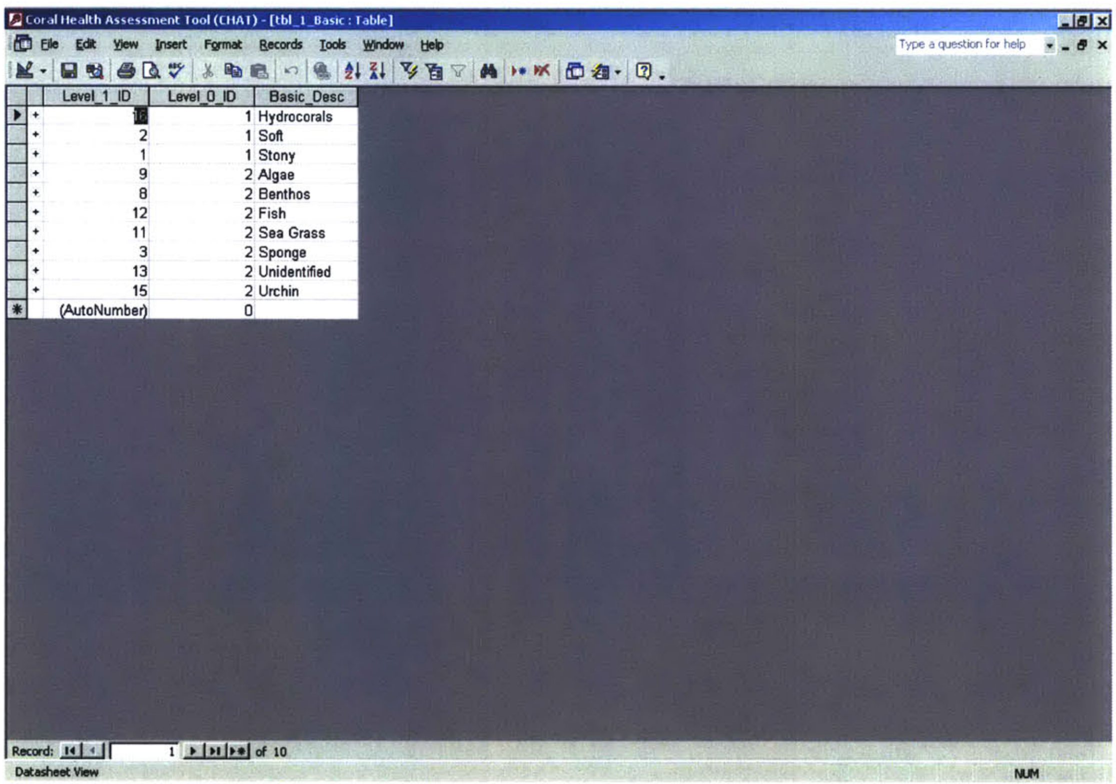
tbl_0_Type

Table Name	tbl_0_Type				
Table Comments	Stores most broad identification description.				
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
Level_0_ID	AutoNumber	X			X
Type_Desc	Text	X	Most broad description of a point, such as 'Coral' or 'Other'	X	X



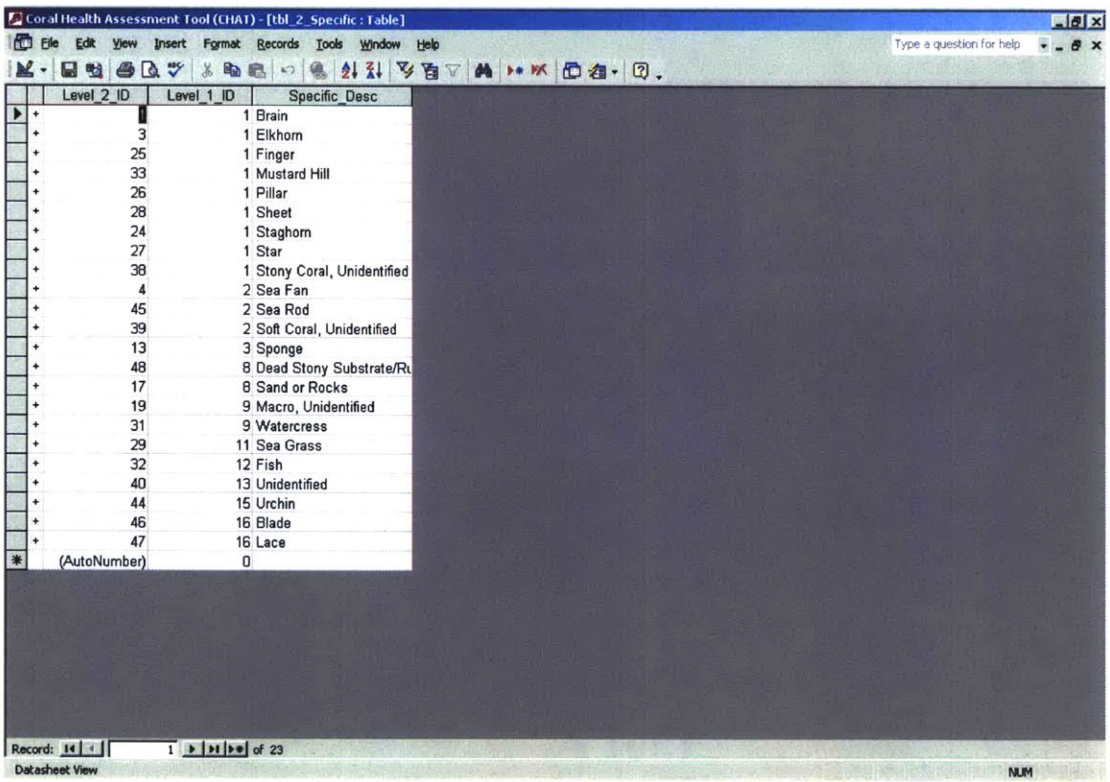
tbl_1_Basic

Table Name	tbl_1_Basic				
Table Comments	Stores more specific identification description.				
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
Level_1_ID	AutoNumber	X			X
Level_0_ID	Number	X	Links to tbl_0_Type	X	X
Basic_Desc	Text	X	More specific description of a point, such as 'Stony' or 'Soft' Corals		



tbl_2_Specific

Table Name	tbl_2_Specific				
Table Comments	Stores most specific identification description.				
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
Level_2_ID	AutoNumber	X			X
Level_1_ID	Number	X	Links to tbl_1_Basic		
Specific_Desc	Text	X	Most specific description of a point, such as 'Brain' or 'Elkhorn' Stony Corals	X	X



Coral Health Assessment Tool (CHAT) - [tbl_2_Specific : Table]

Level_2_ID	Level_1_ID	Specific_Desc
1	1	Brain
3	1	Elkhorn
25	1	Finger
33	1	Mustard Hill
26	1	Pillar
28	1	Sheet
24	1	Staghorn
27	1	Star
38	1	Stony Coral, Unidentified
4	2	Sea Fan
45	2	Sea Rod
39	2	Soft Coral, Unidentified
13	3	Sponge
48	8	Dead Stony Substrate/Ru
17	8	Sand or Rocks
19	9	Macro, Unidentified
31	9	Watercress
29	11	Sea Grass
32	12	Fish
40	13	Unidentified
44	15	Urchin
46	16	Blade
47	16	Lace
(AutoNumber)	0	

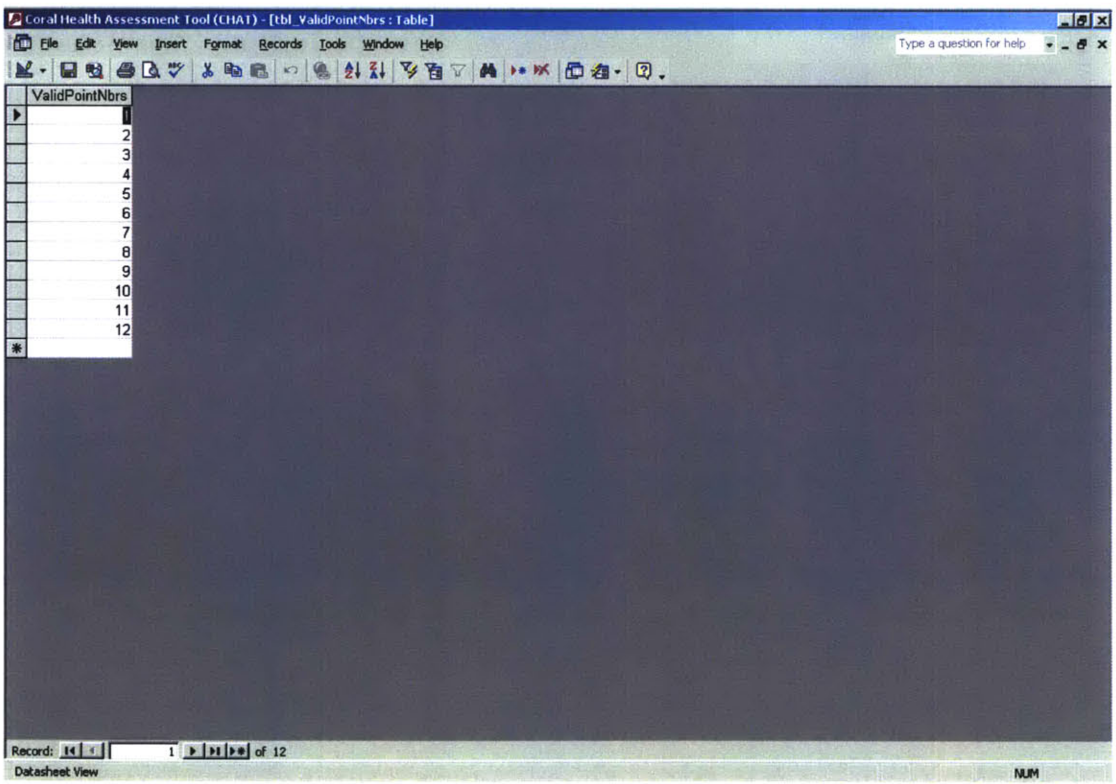
Record: 1 of 23

Datasheet View

VALIDATION TABLES

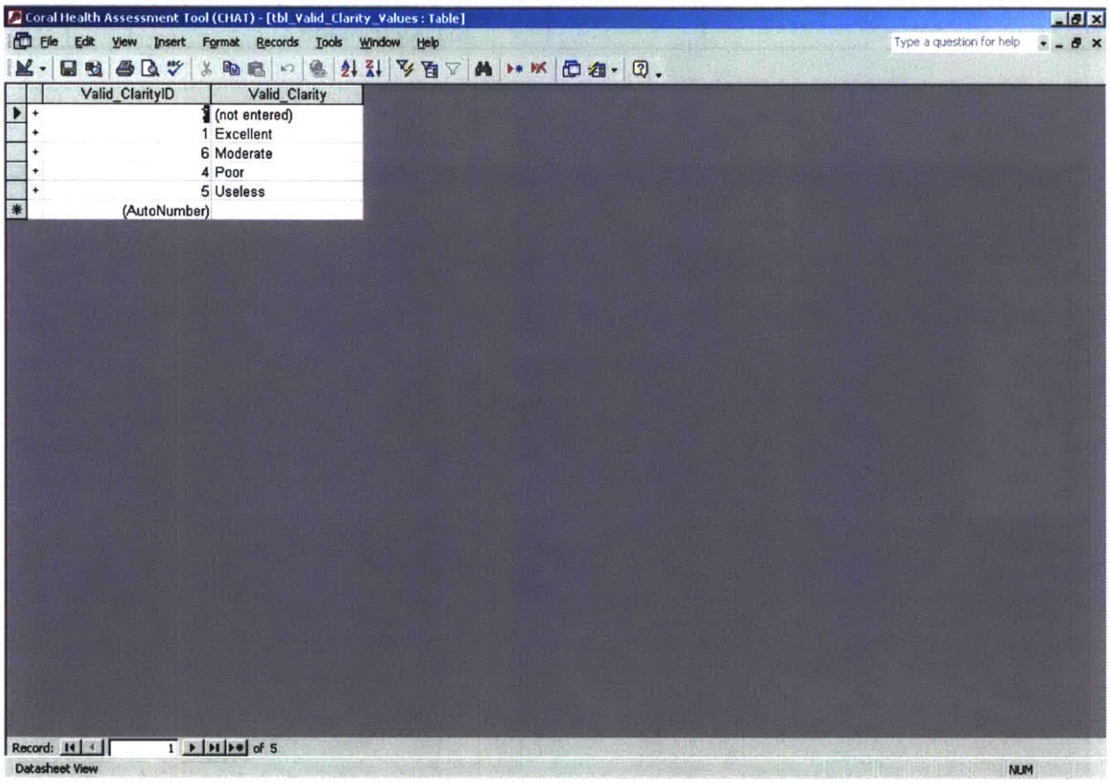
tbl_ValidPointNbrs

Table Name	tbl_ValidPointNbrs				
Table Comments					
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
ValidPointNbrs	Number	X	Used in join to populate the tbl_Photos_Iterations_Points table; in this case, it contains values 1-12 for points 1-12 on each image	X	X



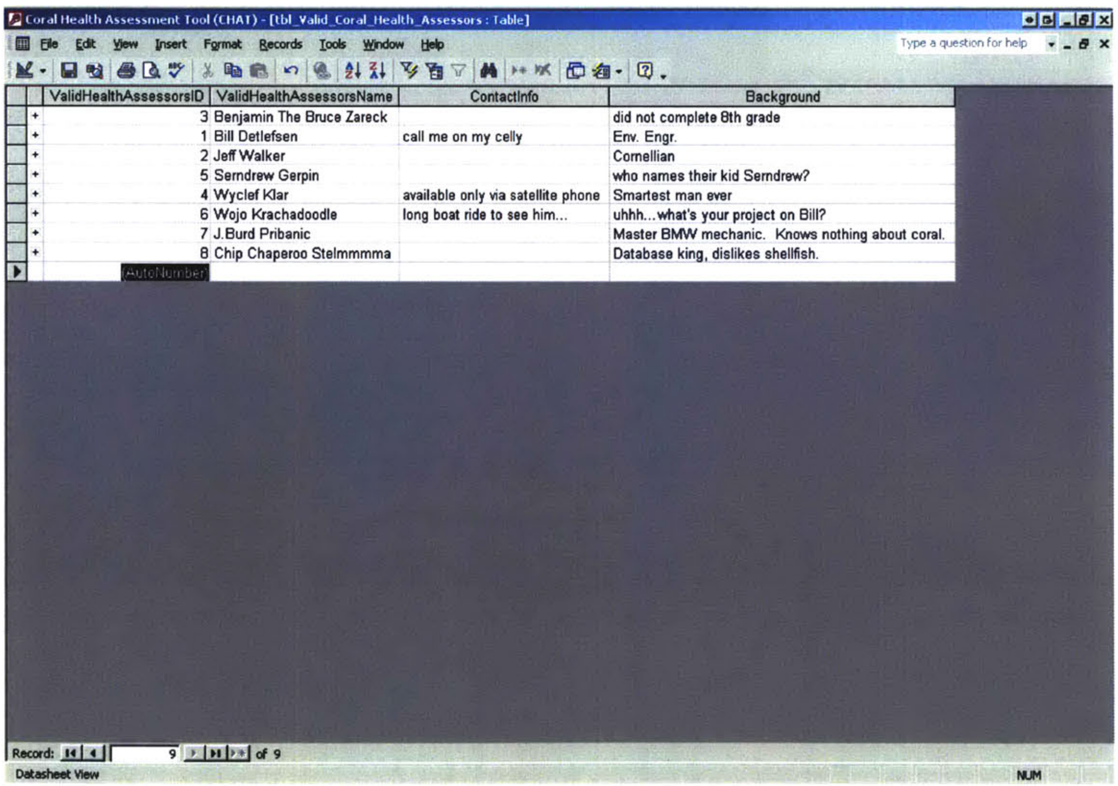
tbl_Valid_Clarity_Values

Table Name	tbl_Valid_Clarity_Values				
Table Comments					
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
Valid_ClarityID	AutoNumber	X	Unique index		X
Valid_Clarity	Text	X	Clarity description, such as 'Excellent'	X	X



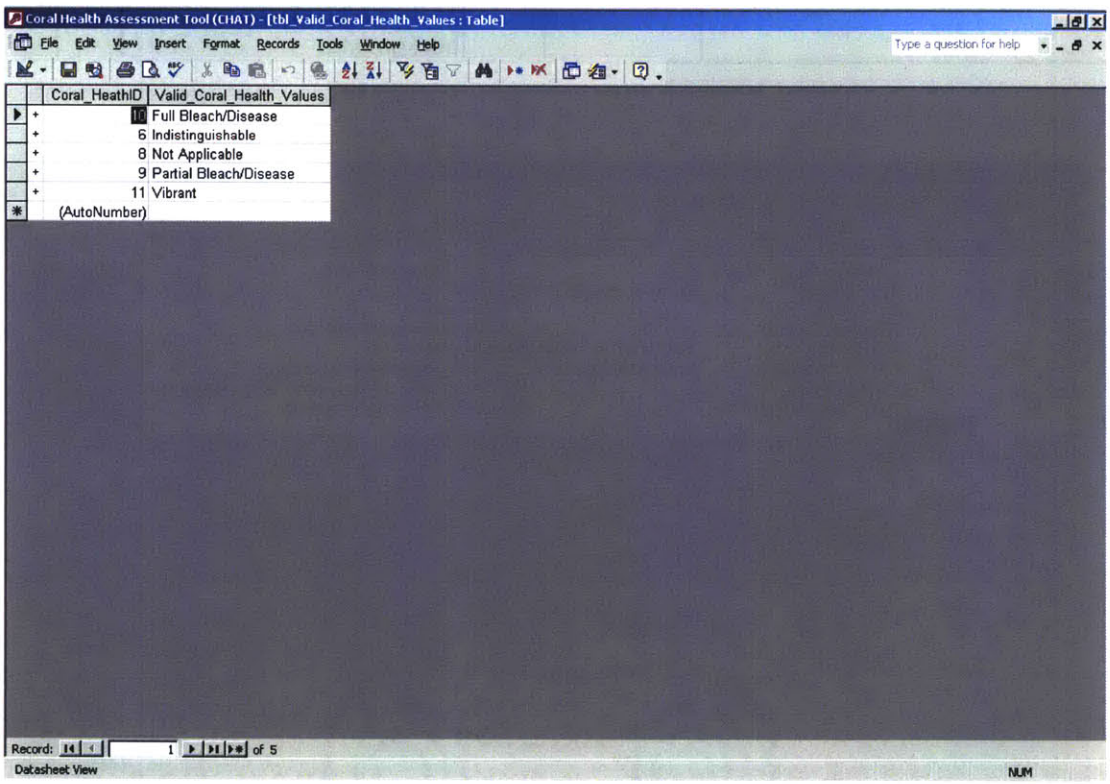
tbl_Valid_Coral_Health_Assessors

Table Name	**tbl_Valid_Coral_Health_Assessors**				
Table Comments					
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
ValidHealthAssessorsID	AutoNumber	X	Unique index		X
ValidHealthAssessorsName	Text	X	Name of possible users ('coral health assessors')	X	X
ContactInfo	Memo		Stores contact information for users.		
Background	Memo		Stores background information about users, such as their educational background.		



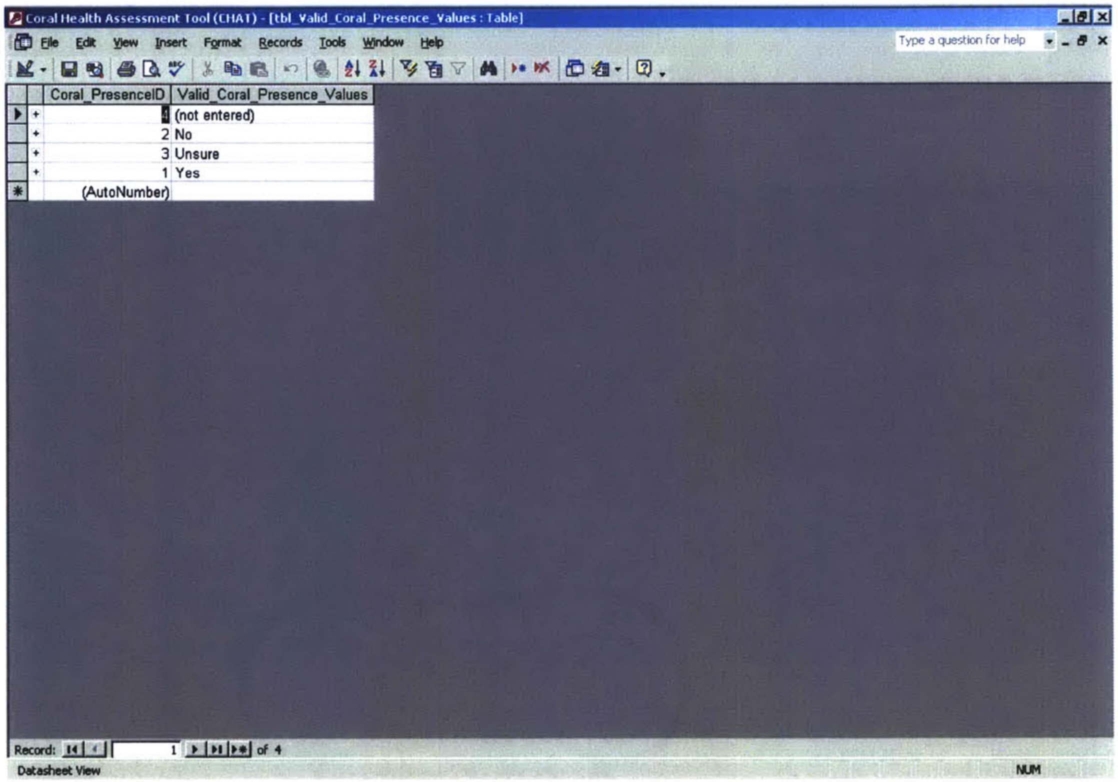
tbl_Valid_Coral_Health_Values

Table Name	tbl_Valid_Coral_Health_Values				
Table Comments					
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
Coral_HeathID	AutoNumber	X	Unique index		X
Valid_Coral_Health_Values	Text	X	Health values, such as 'Vibrant' or 'Partially Bleached or Diseased'	X	X



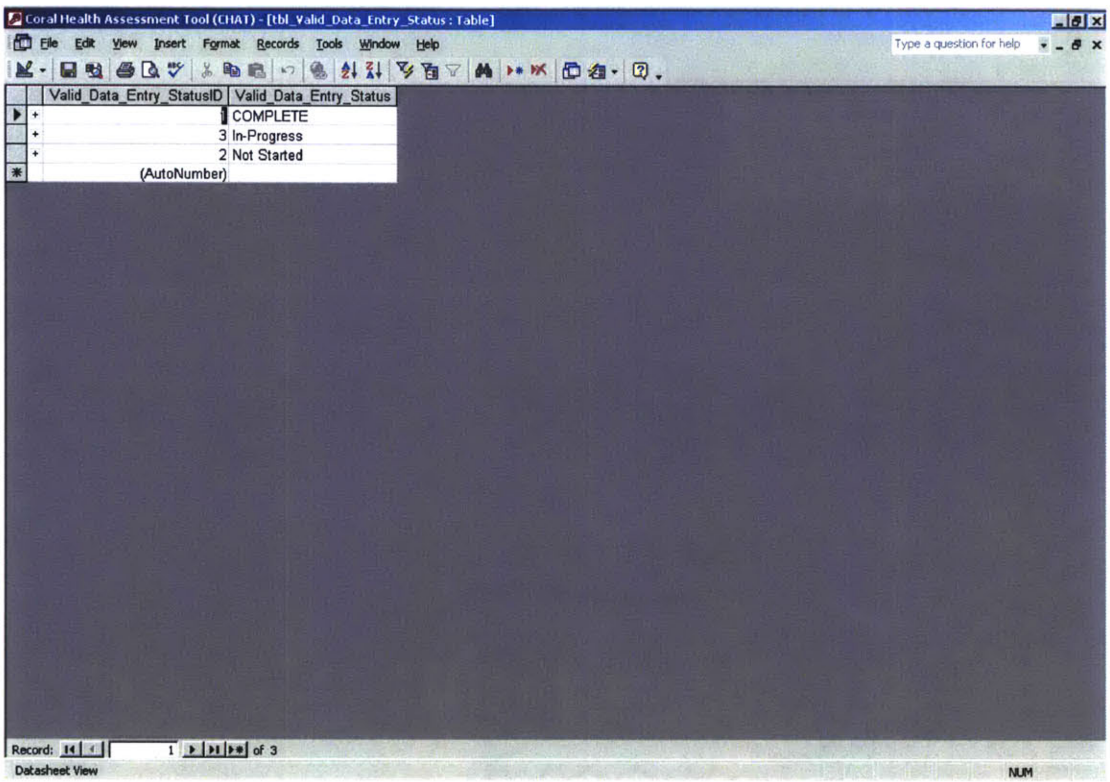
tbl_Valid_Coral_Presence_Values

Table Name	tbl_Valid_Coral_Presence_Values				
Table Comments					
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
Coral_PresenceID	AutoNumber	X	Unique index		X
Valid_Coral_Presence_Values	Text	X	Coral presence values, such as 'Yes' or 'Unsure'	X	X



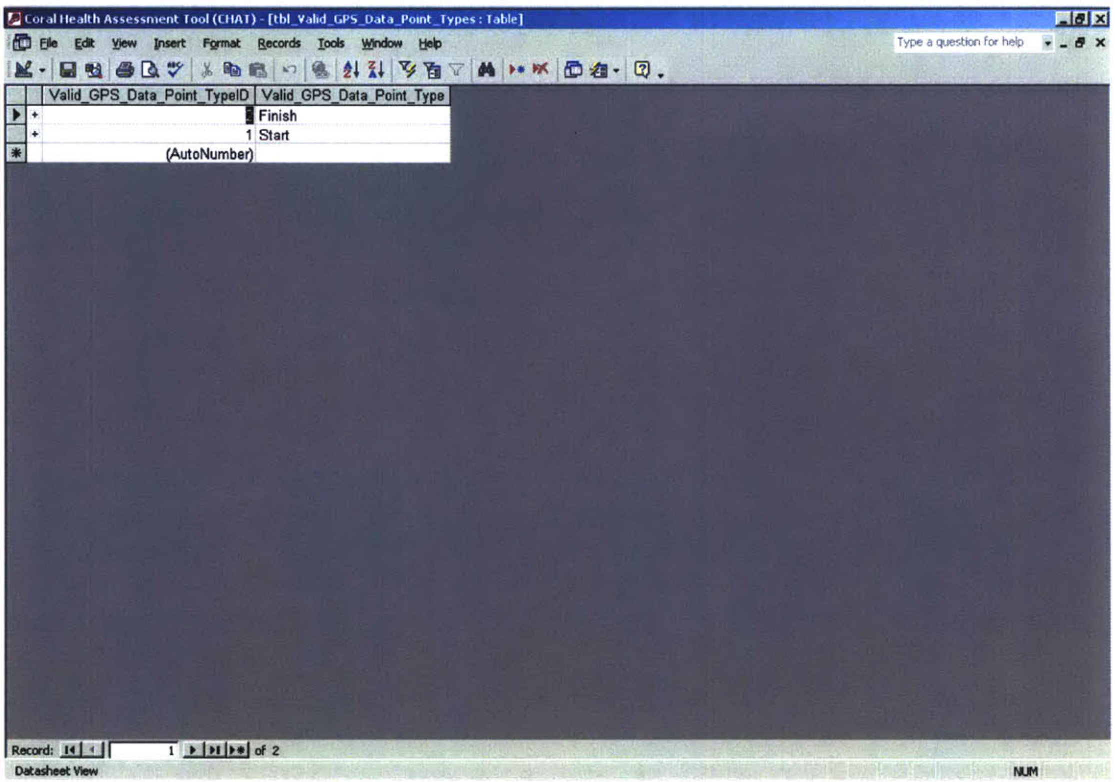
tbl_Valid_Data_Entry_Status

Table Name	tbl_Valid_Data_Entry_Status				
Table Comments					
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
Valid_Data_Entry_StatusID	AutoNumber	X	Unique index		X
Valid_Data_Entry_Status	Text	X	Data entry status, such as 'COMPLETE'	X	X



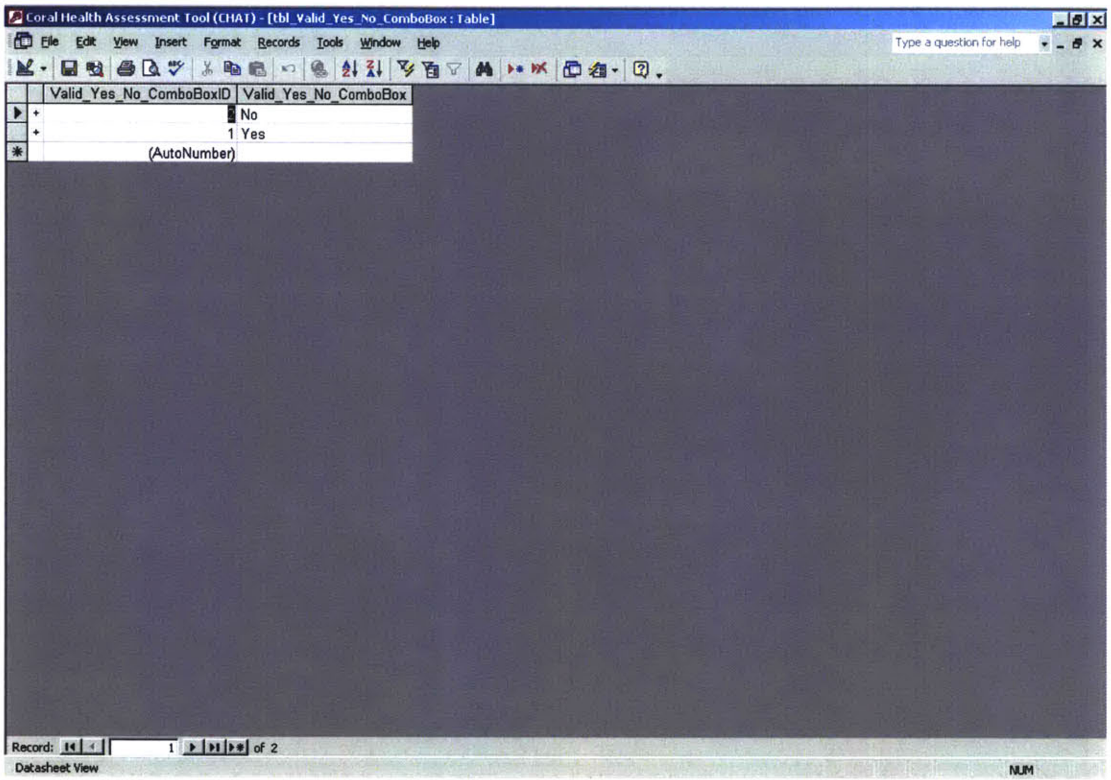
tbl_Valid_GPS_Data_Point_Types

Table Name	tbl_Valid_GPS_Data_Point_Types				
Table Comments					
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
Valid_GPS_Data_Point_TypeID	AutoNumber	X	Unique index		X
Valid_GPS_Data_Point_Type	Text	X	GPS point descriptor, such as 'Start' or 'Finish' of a transect	X	X



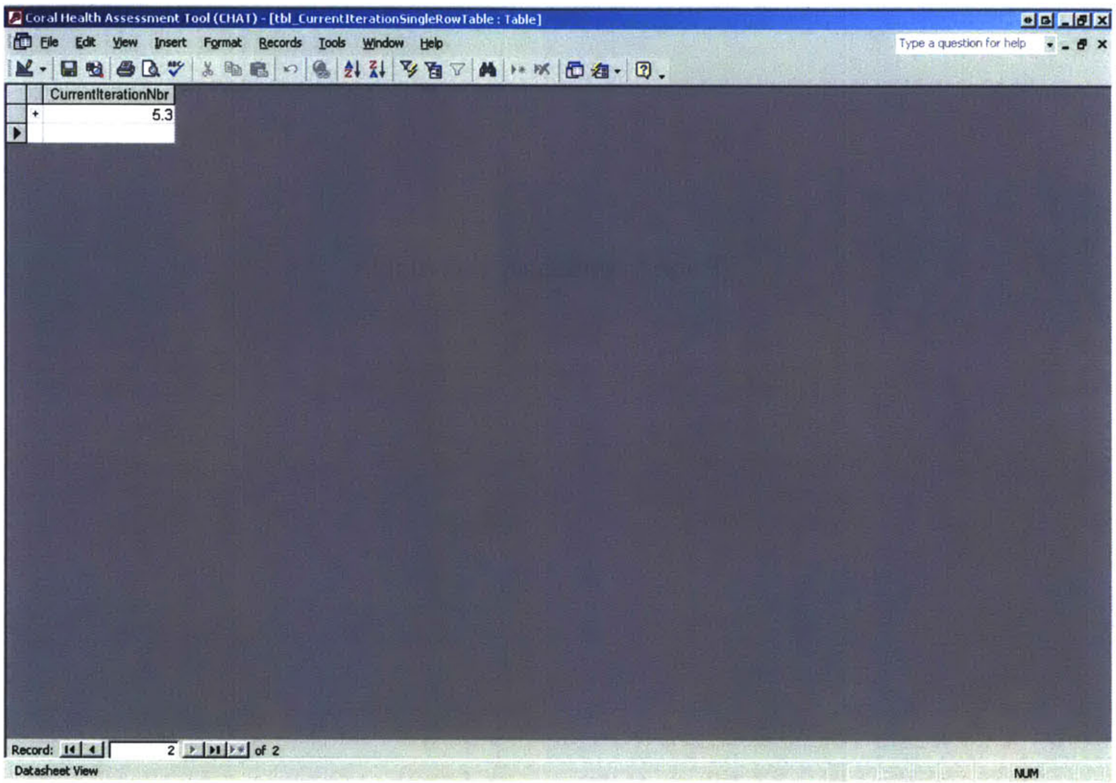
tbl_Valid_Yes_No_ComboBox

Table Name	tbl_Valid_Yes_No_ComboBox				
Table Comments					
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
Valid_Yes_No_ComboBoxID	AutoNumber	X	Unique index		X
Valid_Yes_No_ComboBox	Text	X	Stores values 'Yes' and 'No' for	X	X



tbl_CurrentIterationSingleRowTable

Table Name	tbl_CurrentIterationSingleRowTable				
Table Comments					
Fields (Columns)	Data Type	Req'd	Description / Comments	Key	Unique Index
CurrentIterationNbr	Number	X		X	X



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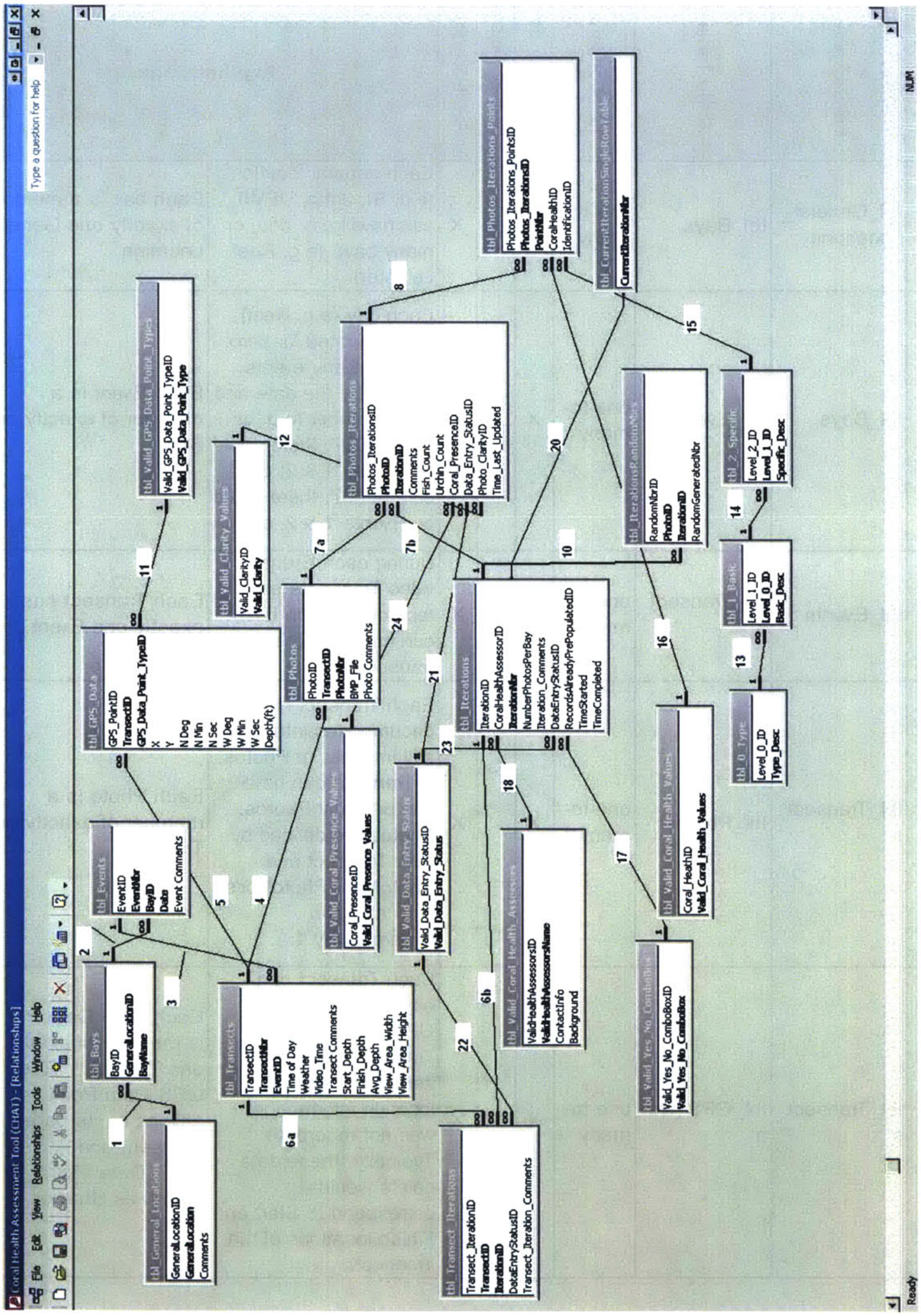
Appendix C DATABASE RELATIONSHIP DETAILS – COVER PAGE

APPENDIX C TABLE OF CONTENTS

ENTITY RELATIONSHIP DIAGRAM



Relationship Details

Relationship Nbr	Parent Table	Child Table	Relationship	Cascade Update	Cascade Delete	Ref. Integrity	Explanations	
1	tbl_General_ Locations	tbl_Bays	one-to-many	X		X	Each general location (e.g. St. John, USVI) can have zero, one, or many bays (e.g. Reef, Leinster).	Each bay is a member of exactly one General Location
2	tbl_Bays	tbl_Events	one-to-many	X		X	Each bay (e.g. Reef) can be visited for zero, one, or many events, defined by the date and event number (e.g. on 05/23/2007, there could be Events 1 & 2; on 06/21/2007, there could be Events 1 & 2, etc.).	Each Event is a member of exactly one Bay.
3	tbl_Events	tbl_Transects	one-to-many	X		X	During each Event, video Transects are recorded. Each Event can have one or many transects.	Each Transect has exactly one Event.
4	tbl_Transects	tbl_Photos	one-to-many	X		X	Each Transect is decomposed into many still images, or Photos. A Transect can have one or many Photos. Photos are defined by their Transect and PhotoNbr. PhotoNbr's start at 1 and increment by 1.	Each Photo is a member of exactly on Transect.
5	tbl_Transects	tbl_GPS_Data	one-to-many	X		X	Each Transect can have zero or many GPS Data Points (a Transect would have zero data points if location information was not recorded). Typically, these data points would correspond to Start and Finish locations of the Transect.	Each GPS Data Point is member of exatly one Transect. Each GPS Data Point is defined by its parent Transect and GPS_Data_Point_Type, such as Start or Finish.

RELATIONSHIP DETAILS (CONTINUED)

Relationship Nbr	Parent Table	Child Table	Relationship	Cascade Update	Cascade Delete	Ref. Integrity	Explanations	
6a	tbl_Transects	tbl_Transect_Iterations	one-to-many	X	X	X	Transects and Iterations are involved in a many-to-many relationship, therefore, the intermediate table tbl_Transect_Iterations is necessary. Some Photos from each Transect may be analyzed in many Iterations. Also, each Iteration may analyze Photos from	
6b	tbl_Iterations	tbl_Transect_Iterations	one-to-many	X	X	X		
7a	tbl_Photos	tbl_Photos_Iterations	one-to-many	X	X	X	Photos and Iterations are involved in a many-to-many relationship, therefore, the intermediate table tbl_Photos_Iterations is necessary. Each photo can be reviewed in many Iterations. Also, each Iteration contains many photos.	
7b	tbl_Iterations	tbl_Photos_Iterations	one-to-many	X	X	X		
8	tbl_Photos_Iterations	tbl_Photos_Iterations_Points	one-to-many	X		X	Each Photo_Iteration can have one or many points. In this implementation, each Photo_Iteration has exactly 12 points.	Each Photo_Iteration_Point is a member of exactly one Photo_Iteration

RELATIONSHIP DETAILS (CONTINUED)

Relationship Nbr	Parent Table	Child Table	Relationship	Cascade Update	Cascade Delete	Ref. Integrity	Explanations	
10	tbl_Iterations	tbl_IterationsRandomNbrs	one-to-many	X	X	X	For each Iteration, random numbers are assigned to every PhotoID. Therefore, each Iteration has many IterationRandomNbr's. It is from tbl_IterationsRandomNbr that random photos are chosen for inclusion in tbl_Photo_Iterations.	Each IterationRandomNbr is a member of exactly one Iteration.
11	tbl_Valid_GPS_Data_Point_Types	tbl_GPS_Data	one-to-many	X		X	Validation relationship.	Each row in tbl_GPS_Data has exactly one GPS_Data_Point_Type
12	tbl_Valid_Clarity_Values	tbl_Photo_Iterations	one-to-many	X		X	Validation relationship. Each Transect has exactly one Clarity, however many Transects can have the same Clarity, e.g. 'Excellent'.	Each row in tbl_Photo_Iterations has exactly one Clarity_Value
13	tbl_0_Type	tbl_1_Basic	one-to-many	X	X	X	Coral classification relationships. Three total classification levels. tbl_0_Type is most general Type classification (e.g. 'Coral' or 'Not Coral'), tbl_1_Basic is a basic classification (e.g. 'Stony' or 'Soft'), and tbl_2_Specific maintains the most specific descriptions (e.g. 'Brain Coral').	
14	tbl_1_Basic	tbl_2_Specific	one-to-many	X	X	X		

RELATIONSHIP DETAILS (CONTINUED)

Relationship Nbr	Parent Table	Child Table	Relationship	Cascade Update	Cascade Delete	Ref. Integrity	Explanations	
15	tbl_2_Specific	tbl_Photos_Iterations_Points	one-to-many	X		X	Validation relationship. Each Level_2 description (e.g. 'Brain Coral') can occur at many Photo_Iteration_Points.	Each Photo_Iteration_Point has exactly one Identification, e.g. 'Brain Coral'
16	tbl_Valid_Coral_Health_Values	tbl_Photos_Iterations_Points	one-to-many	X		X	Validation relationship. Each Coral Health Value (e.g. 'Vibrant') can occur at many Photo_Iteration_Points.	Each Photo_Iteration_Point has exactly one Coral Health Value, e.g. 'Vibrant' or 'Indistinguishable'.
17	tbl_Valid_Yes_No_ComboBox	tbl_Iterations	one-to-many	X		X	Validation relationship. tbl_Valid_Yes_No_ComboBox stores values 'Yes' and 'No' to indicate whether or not records have already been appended to pertinent tables for a new iteration.	Each Iteration has exactly one value of Yes_No_ComboBox; either 'Yes' or 'No'.
18	tbl_Valid_Coral_Health_Assessors	tbl_Iterations	one-to-many	X		X	Validation relationship. Each Coral Health Assessor can perform many Iterations.	Each Iteration is performed by exactly one Coral Health Assessor.
20	tbl_Iterations	tbl_CurrentIterationSingleRowTable	one-to-one				User interface relationship. tbl_CurrentIterationSingleRowTable is updated via prompt to user defining current Iteration. Queries are subsequently performed using Current Iteration Number.	Does not maintain referential integrity, as tbl_CurrentIterationSingleRowTable is a one row table.

RELATIONSHIP DETAILS (CONTINUED)

Relationship Nbr	Parent Table	Child Table	Relationship	Cascade Update	Cascade Delete	Ref. Integrity	Explanations	
21	tbl_Valid_Data_Entry_Status	tbl_Iterations						
22	tbl_Valid_Data_Entry_Status	tbl_Transect_Iterations	one-to-many	X		X	Validation relationship. Provides Status values such as 'COMPLETE'.	
23	tbl_Valid_Data_Entry_Status	tbl_Photos_Iterations						
24	tbl_Valid_Coral_Presence_Values	tbl_Photos_Iterations	one-to-many	X		X	Validation relationship. Provides Coral Presence values such as 'Yes' or 'Unsure'.	

Appendix D DATABASE FORM DETAILS

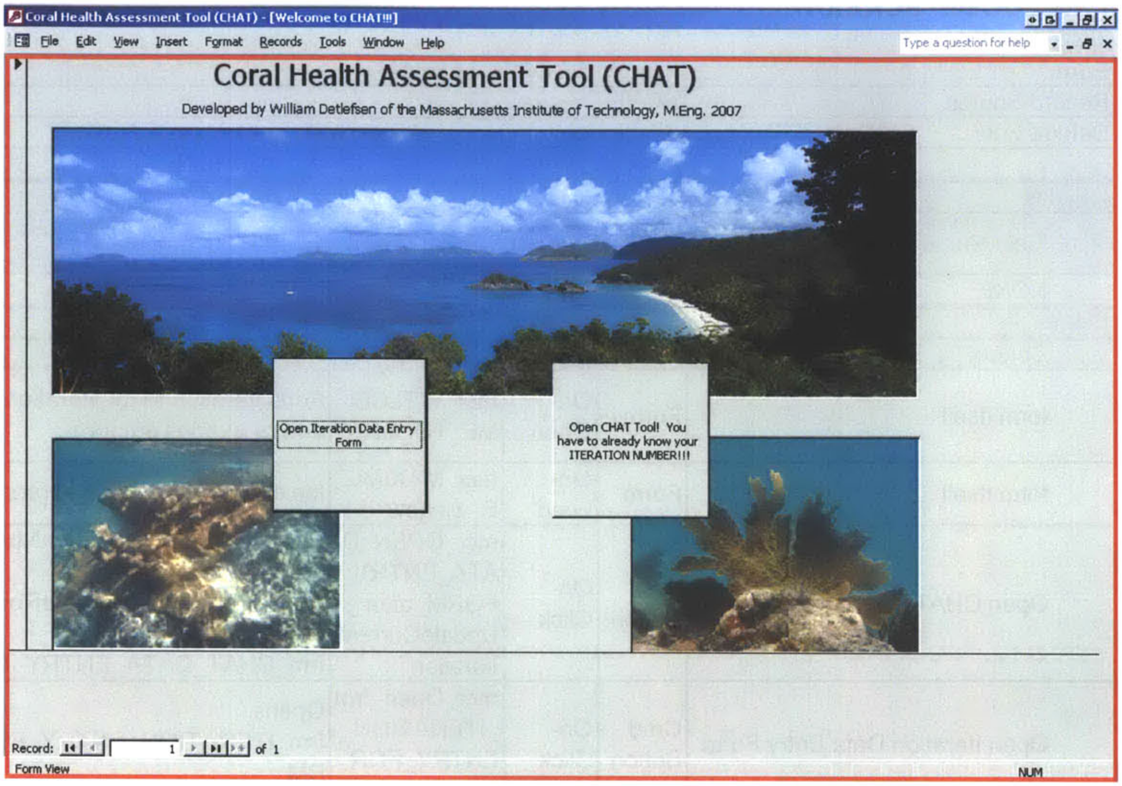
APPENDIX D TABLE OF CONTENTS

WELCOME SCREEN

frm_WELCOME_SCREEN

Form	frm_WELCOME_SCREEN				
Record Source	NONE				
Default view	Single Form				
Fields					
Field Name	Type	Locked	Linked Table	Bound Column	ComboBox Source
NONE					
Events					
Control	Type	Active	Event	Description	
form itself	Form	On-Open	mcr_WELCOME_TO_CHAT	Adds Iteration to tbl_Iterations and re-queries subform.	
form itself	Form	On-Load	mcr_MAXIMIZE_window	Maximizes form to full screen	
Open CHAT Tool! You have to a	Cmd Button	On-Click	mcr_OPEN_DATA_ENTRY_FORM_after_UpdateCurrentIteration	Prompts user for IterationNbr, updates tbl_CurrentIterationSingleRowTable, and opens frm_CHAT_DATA_ENTRY_F	
Open Iteration Data Entry Form	Cmd Button	On-Click	mcr_Open_frm_ITERATION_ENTRY_FORM	Opens frm_ITERATION_ENTRY_FORM	
NOTES:					
User Welcome Screen					

frm_WELCOME_SCREEN (cont.)

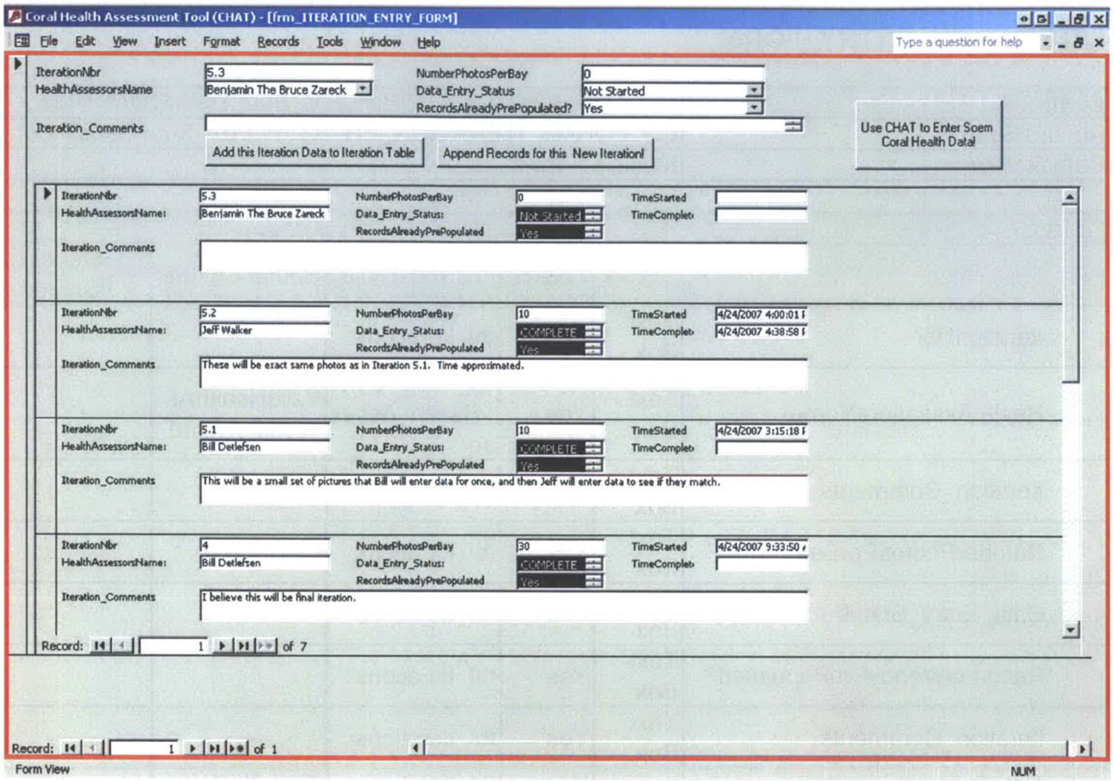


ITERATION ENTRY FORM

frm_ITERATION_ENTRY_FORM

Form	frm_ITERATION_ENTRY_FORM_Sub_DataSheet_View				
Record Source	qry_FORMS_ITERATION_ENTRY_FORM_Sub_DataSheet_Vi				
Default view	Multiple Forms				
Fields					
Field Name	Type	Locked	Linked Table	Bound Column	ComboBox Source
IterationNbr	Text Box	Yes	tbl_Iterations		
HealthAssessorsName	Text Box	Yes	tbl_Valid_Coral_Health_Assessors	ValidHealthAssessorsName	
Iteration_Comments	Text Box	Yes	tbl_Iterations		
NumberPhotosPerBay	Text Box	Yes	tbl_Iterations		
Data_Entry_Status	Text Box	Yes	tbl_Iterations		
RecordsAlreadyPrePopulated?	Text Box	Yes	tbl_Iterations		
Iteration_Comments	Text Box	Yes	tbl_Iterations		
TimeStarted		Yes	tbl_Iterations	TimeStarted	
TimeCompleted		Yes	tbl_Iterations	TimeCompleted	
Events					
Control	Type	Active	Event	Description	
Add this Iteration Data to Iteratio	Cmd Button	On-Click	mcr_frm_ITERATION_ENTRY_FORM_NextIterationRecord	Adds Iteration to tbl_Iterations and re-queries subform.	
Append Records for this New Ite	Cmd Button	On-Click	MCR_1_AppendRecordsForNewIteration	Prompts user for IterationNbr; appends all records to allow user to complete health assessment by running macro MCR_1_AppendRecordsForNewIteration	
Use CHAT to Enter Some Coral	Cmd Button	On-Click	mcr_OPEN_DATA_ENTRY_FORM_after_UpdateCurrentIteration	Opens frm_CHAT_DATA_ENTRY_FORM	
NOTES:					
Strictly allows user to view all iterations. Once an Iteration is set to status 'COMPLETE', it will only appear in this form view (not in frm_ITERATION_ENTRY_FORM)					

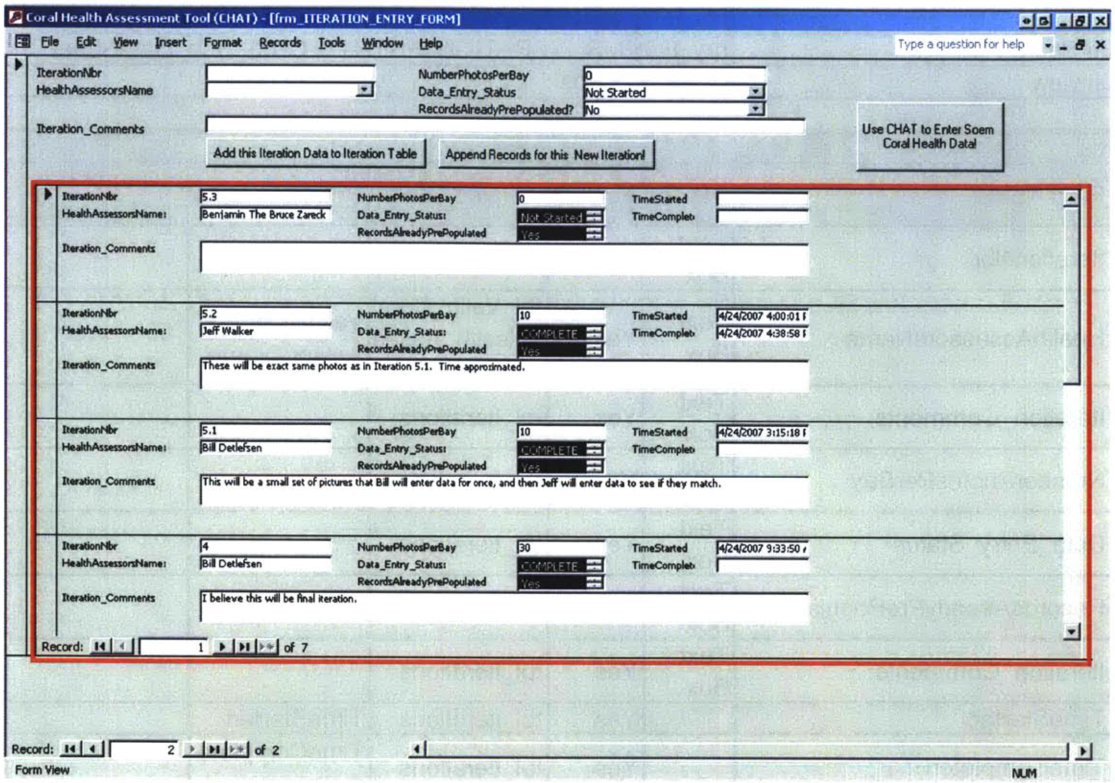
frm_ITERATION_ENTRY_FORM (cont.)



frm_ITERATION_ENTRY_FORM_Sub_DataSheet_View

Form	frm_ITERATION_ENTRY_FORM_Sub_DataSheet_View				
Record Source	qry_FORMS_ITERATION_ENTRY_FORM_Sub_DataSheet_Vi				
Default view	Multiple Forms				
Fields					
Field Name	Type	Locked	Linked Table	Bound Column	ComboBox Source
IterationNbr	Text Box	Yes	tbl_Iterations		
HealthAssessorsName	Text Box	Yes	tbl_Valid_Coral_Health_Assessors	ValidHealthAssessorsName	
Iteration_Comments	Text Box	Yes	tbl_Iterations		
NumberPhotosPerBay	Text Box	Yes	tbl_Iterations		
Data_Entry_Status	Text Box	Yes	tbl_Iterations		
RecordsAlreadyPrePopulated?	Text Box	Yes	tbl_Iterations		
Iteration_Comments	Text Box	Yes	tbl_Iterations		
TimeStarted		Yes	tbl_Iterations	TimeStarted	
TimeCompleted		Yes	tbl_Iterations	TimeCompleted	
Events					
Control	Type	Active	Event	Description	
Add this Iteration Data to Iteratio	Cmd Button	On-Click	mcr_frm_ITERATION_ENTRY_FORM_NextIterationRecord	Adds Iteration to tbl_Iterations and re-queries subform.	
Append Records for this New Ite	Cmd Button	On-Click	MCR_1_AppendRecordsForNewIteration	Prompts user for IterationNbr; appends all records to allow user to complete health	
Use CHAT to Enter Some Coral	Cmd Button	On-Click	mcr_OPEN_DATA_ENTRY_FORM_after_UpdateCurrentIteration	Opens frm_CHAT_DATA_ENTRY_FORM	
NOTES:					
Strictly allows user to view all iterations. Once an Iteration is set to status 'COMPLETE', it will only appear in this form view (not in frm_ITERATION_ENTRY_FORM)					

frm_ITERATION_ENTRY_FORM_Sub_DataSheet_View (cont.)

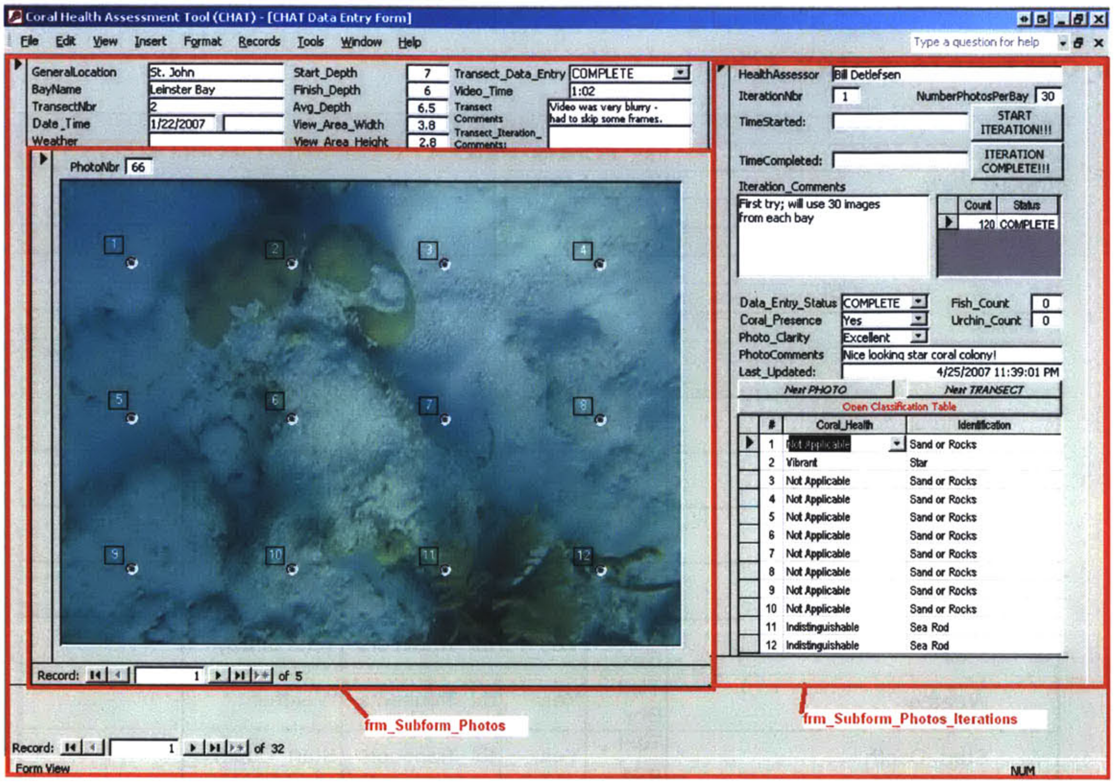


CHAT DATA ENTRY FORM

frm_CHAT_DATA_ENTRY_FORM

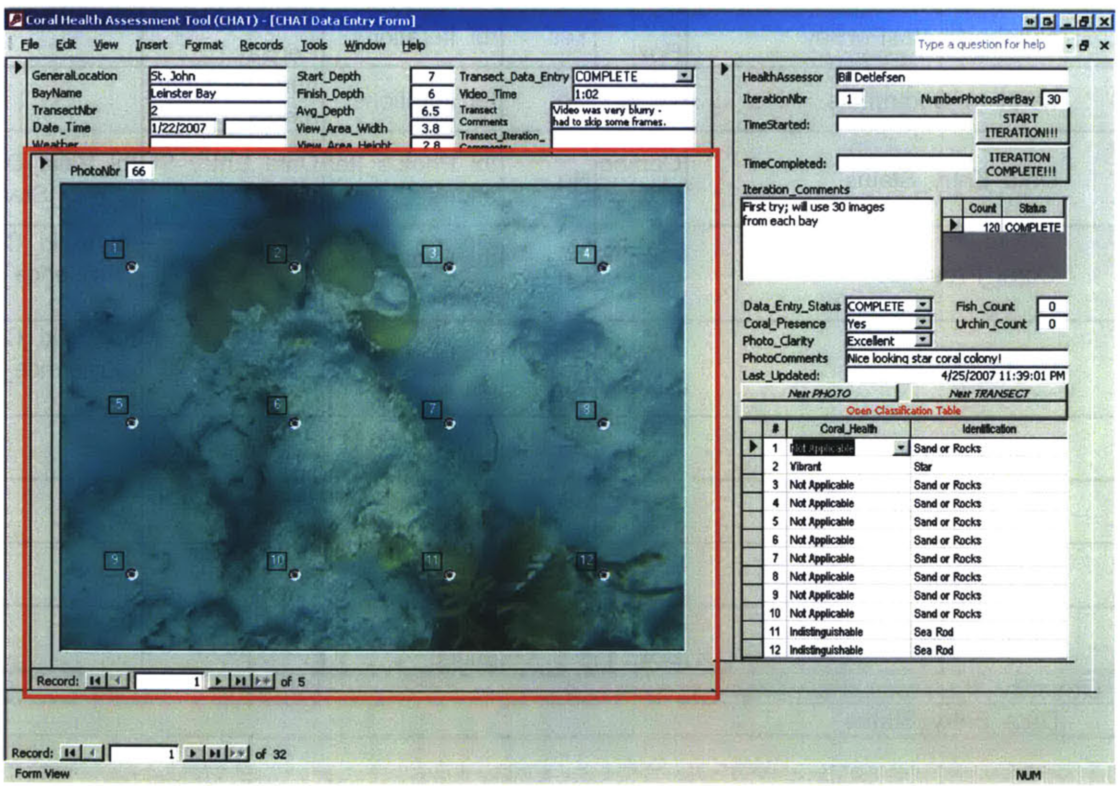
Form	frm_CHAT_DATA_ENTRY_FORM				
Record Source	qry_FORMS_frm_CHAT_DATA_ENTRY_FORM_MAIN_QRY				
Default View	Single Form				
Subforms					
frm_Subform_Photos					
frm_Subform_Photos_Iterations					
Fields					
Field Name	Type	Locked	Linked Table	Bound Column	ComboBox Source
GeneralLocation	Text Box	Yes	tbl_General_Locations	GeneralLocation	
TransectNbr	Text Box	Yes	tbl_Transects	TransectNbr	
BayName	Text Box	Yes	tbl_Bays	BayName	
Date	Text Box	Yes	tbl_Events	Date	
Time	Text Box	Yes	tbl_Transects	Time of Day	
Weather	Text Box	Yes	tbl_Transects	Weather	
Start_Depth	Text Box	Yes	tbl_Transects	Start_Depth	
Finish_Depth	Text Box	Yes	tbl_Transects	Finish_Depth	
Avg_Depth	Text Box	Yes	tbl_Transects	Avg_Depth	
View_Area_Width	Text Box	Yes	tbl_Transects	View_Area_Width	
View_Area_Height	Text Box	Yes	tbl_Transects	View_Area_Height	
Transect_Data_Entry	Combo Box	No	tbl_Transect_Iterations	DataEntryStatusID	tbl_Valid_Data_Entry_Status
Video_Time	Text Box	Yes	tbl_Transects	Video_Time	
Transect_Comments	Text Box	Yes	tbl_Transects	Transect Comments	
Transect_Iterations_Comments	Text Box	No	tbl_Transect_Iterations	Transect_Iteration_Comments	
Order By					
Transect_Data_Entry					
Events					
Control	Type	Active	Event	Description	
form itself	Form	on-current	mcr_MAXIMIZE_window	Maximizes form to full screen	
form itself	Form	on-open	mcr_MAXIMIZE_window	Maximizes form to full screen	
NOTES:					
Main data entry form. Almost all fields are locked to prevent user from changing pre-populated data.					

frm_CHAT_DATA_ENTRY_FORM (cont.)



frm_Subform_Photos

Form	frm_Subform_Photos				
Record Source	qry_FORMS_Subform_Photos				
Default view	Single Form				
Fields					
Field Name	Type	Locked	Linked Table	Bound Column	ComboBox Source
Data_Entry_StatusID	Text Box	Yes	tbl_Photos_Iterations	Data_Entry_StatusID	
BMP_File	Text Box	Yes	tbl_Photos	BMP_File	
Order By					
Data_Entry_StatusID					
NOTES:					
Data_Entry_StatusID field is not visible while displayed as Subform in main form. Data_Entry_StatusID is only present to order images; user is shown images that have not been analyzed first.					



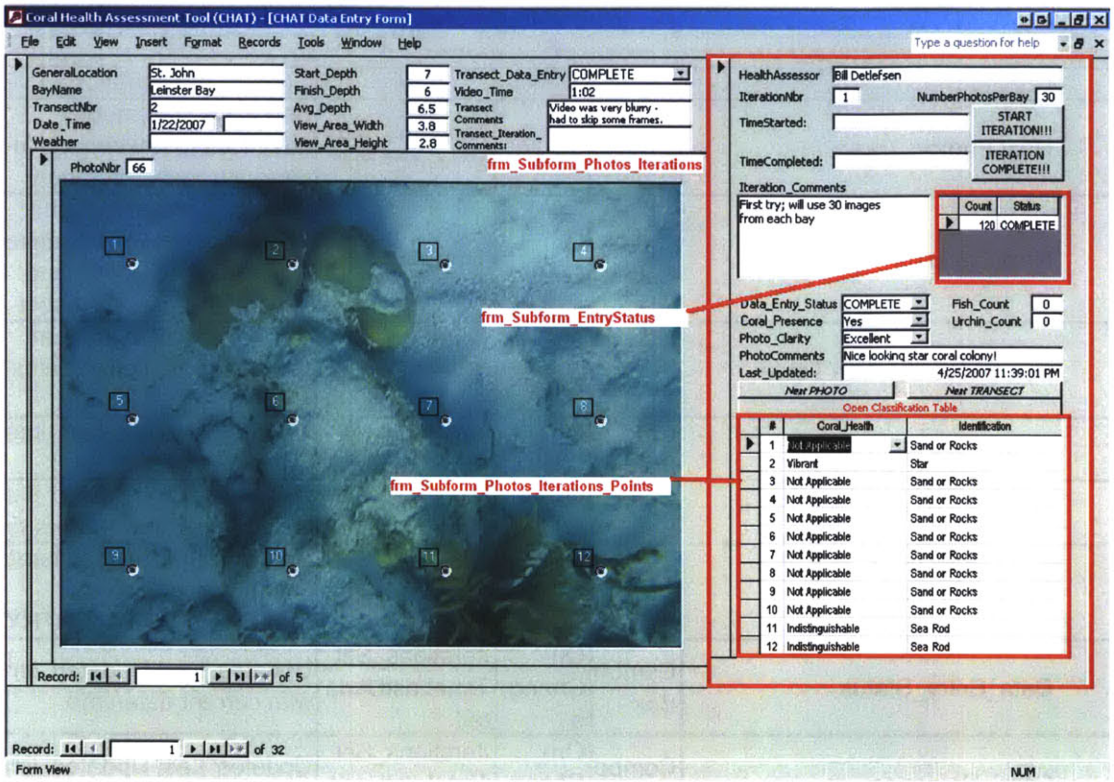
frm_Subform_Photos_Iterations

Form	frm_Subform_Photos_Iterations				
Record Source	qry_FORMS_Subform_Photos_Iterations				
Default view	Single Form				
Subforms					
frm_Subform_Photos_Iterations_Points					
frm_Subform_EntryStatus					
Fields					
Field Name	Type	Locked	Linked Table	Bound Column	ComboBox Source
HealthAssessor	Text Box	Yes	tbl_Valid_Coral_Health_Assessors		
IterationNbr	Text Box	Yes	tbl_Iterations	IterationNbr	
TimeStarted	Text Box	No	tbl_Iterations	TimeStarted	
TimeCompleted	Text Box	No	tbl_Iterations	TimeCompleted	
NumberPhotosPerBay	Text Box	Yes	tbl_Iterations	NumberPhotosPerBay	
Iteration_Comments	Text Box	No	tbl_Iterations	Iteration_Comments	
Data_Entry_Status	Combo Box	No	tbl_Photos_Iterations	Data_Entry_StatusID	tbl_Valid_Data_Entry_Status
Coral_Presence	Combo Box	No	tbl_Photos_Iterations	Coral_PresenceID	tbl_Valid_Coral_Presence_Values
Photo_Clarity	Combo Box	No	tbl_Photos_Iterations	Photo_ClarityID	tbl_Valid_Coral_Presence_Values
PhotoComments	Text Box	No	tbl_Photos_Iterations	Comments	
Last_Updated:	Text Box	Yes	tbl_Photos_Iterations	Time_Last_Updated	
Fish_Count	Text Box	No	tbl_Photos_Iterations	Fish_Count	
Urchin_Count	Text Box	No	tbl_Photos_Iterations	Urchin_Count	
Order By					
Data_Entry_Status					

frm_Subform_Photos_Iterations (cont.)

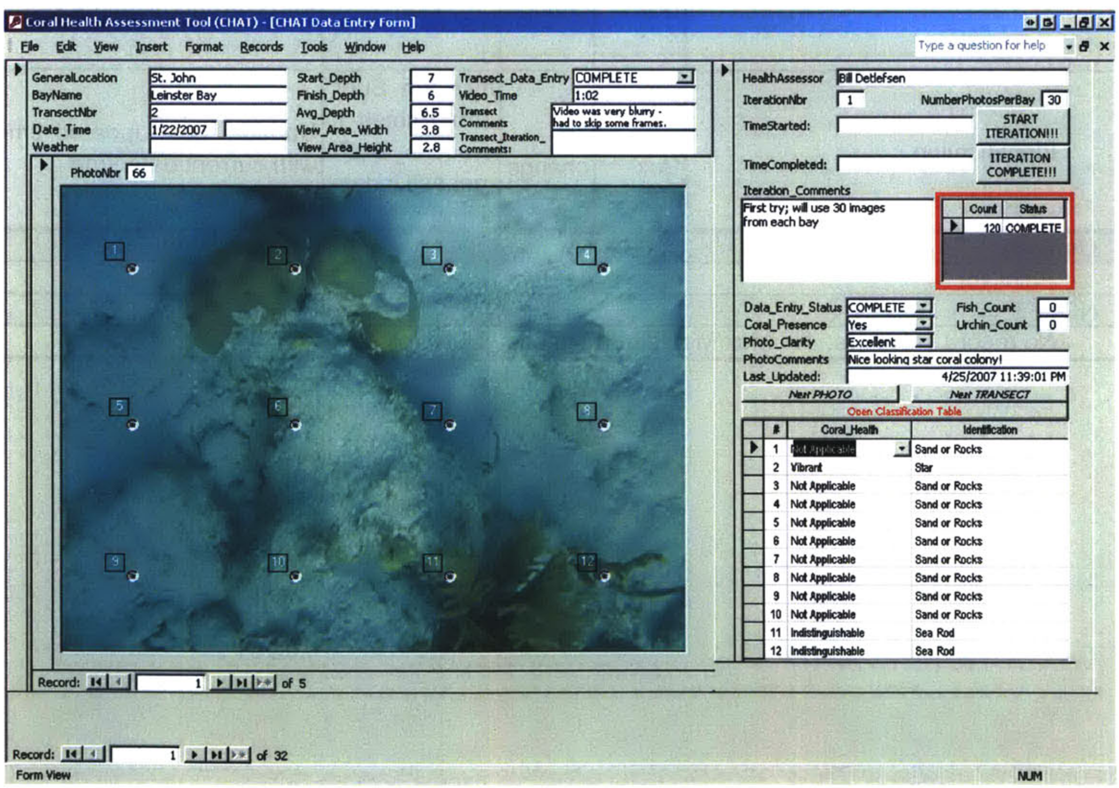
Form	frm_Subform_Photos_Iterations			
Events				
Control	Type	Active	Event	Description
Next Photo	Cmd Button	On-Click	Iterations_MoveToNextPhoto	Sendkeys statement; advances to next image in current transect-iteration
Next Transect	Cmd Button	On-Click	Iterations_SetTransectStatusCompleteNext	Sendkeys statement and update; sets current transect-iteration as complete and advances to next transect-
Open Classification Table	Cmd Button	On-Click	Iterations_OpenClassificationForm	Opens classification form frm_Classification in datasheet view
START ITERATION!!!	Cmd Button	On-Click	Iterations_SetSartTime	Updates iteration start time with current time
ITERATION COMPLETE!!!	Cmd Button	On-Click	Iterations_SetFinishTime	Updates 'Last Updated' field with current time - refers to the
Data_Entry_Status	Text Box	On-Exit	Iterations_SetTransectStatusInProgress	Sets current transect-iteration to 'In Progress' on frm_CHAT_DATA_ENTRY_F
Data_Entry_Status	Combo Box	On-Change	Iterations_SetTimeLastUpdated	Updates 'Last Updated' time with current date/time
Coral_Presence	Combo Box	On-Change	Iterations_SetTimeLastUpdated	Updates 'Last Updated' time with current date/time
Photo_Clarity	Combo Box	On-Change	Iterations_SetTimeLastUpdated	Updates 'Last Updated' time with current date/time
PhotoComments	Text Box	On-Change	Iterations_SetTimeLastUpdated	Updates 'Last Updated' time with current date/time
Fish_Count	Text Box	On-Change	Iterations_SetTimeLastUpdated	Updates 'Last Updated' time with current date/time
Urchin_Count	Text Box	On-Change	Iterations_SetTimeLastUpdated	Updates 'Last Updated' time with current date/time
NOTES:				
All macros are listed with shortened names. All macros listed have 'mcr_frm_Subform_Photos_Iterations_' prefix No record selectors. No Max/Min record buttons. No scroll bars.				

frm_Subform_Photos_Iterations (cont.)



frm_Subform_EntryStatus

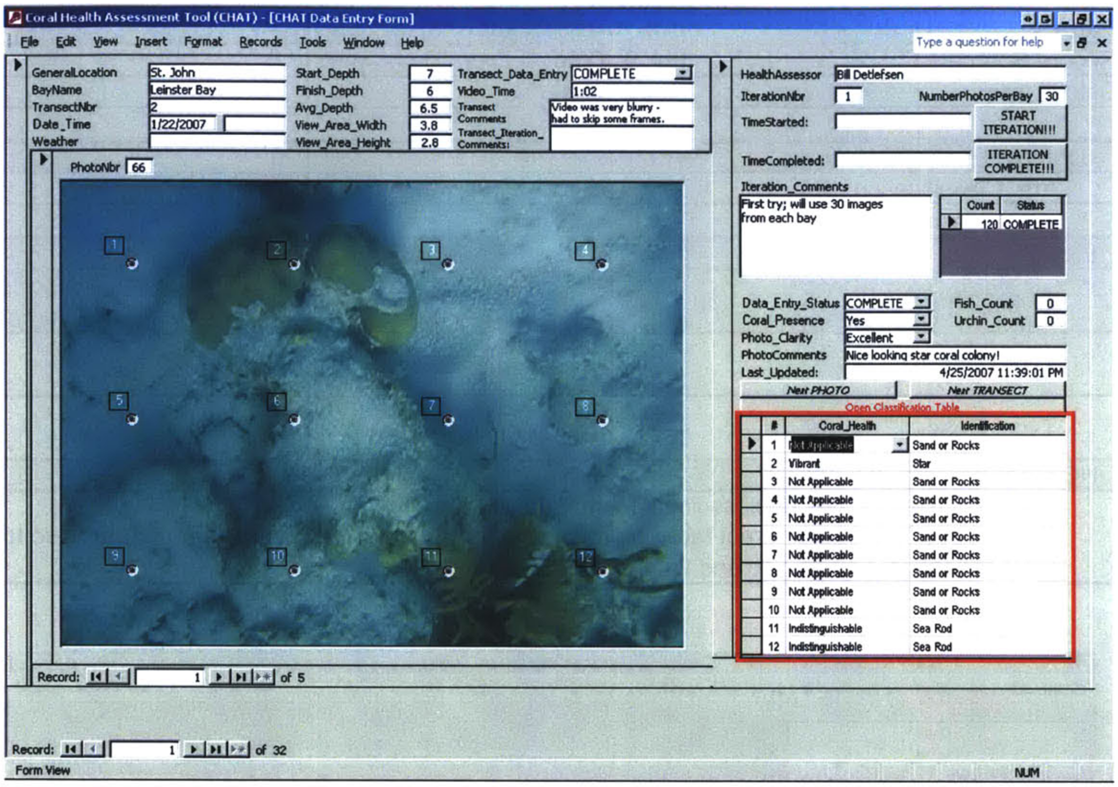
Form	frm_Subform_EntryStatus				
Record Source	qry_FORMS_Subform_Entry_Status				
Default view	Datasheet				
Fields					
Field Name	Type	Locked	Linked Table	Bound Column	ComboBox Source
Count	Text Box	Yes	zqry_Photo_Iterations_CountOfPhotosNOTCOMPLETEPerIteration	Count	
Status	Text Box	Yes	zqry_Photo_Iterations_CountOfPhotosNOTCOMPLETEPerIteration	Status	
NOTES:					
No record selectors. No Max/Min record buttons. No scroll bars.					



frm_Subform_Photos_Iteration_Points

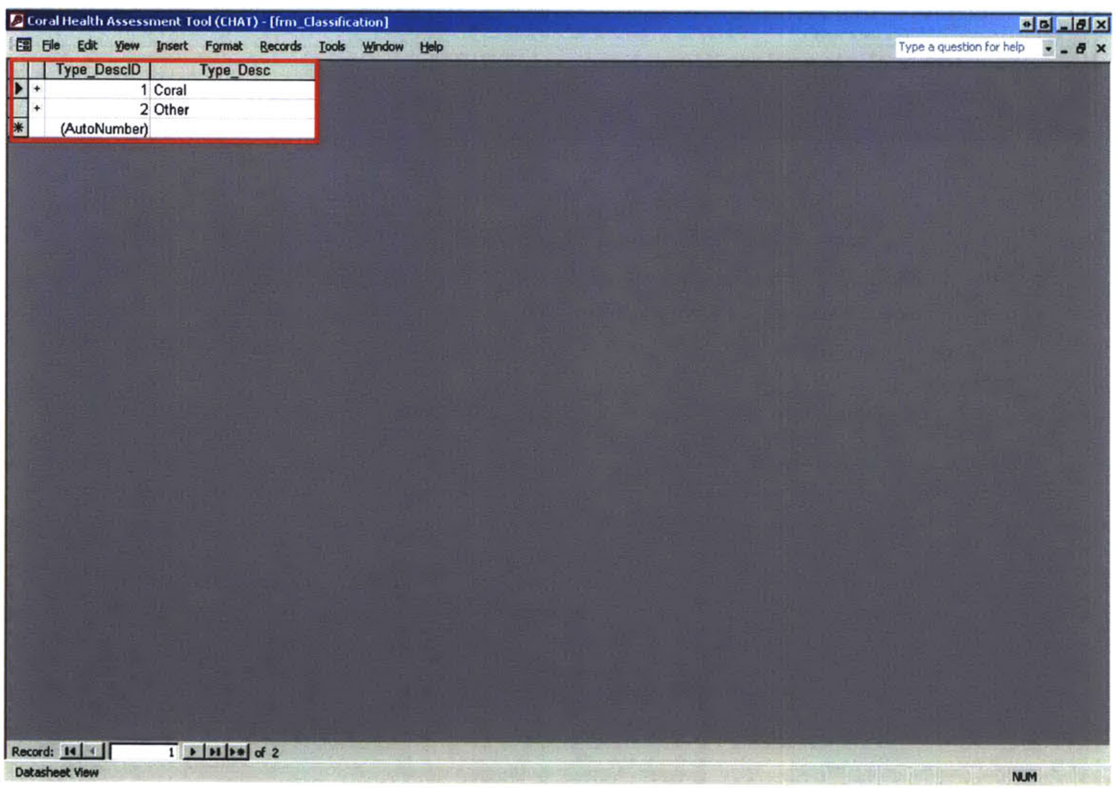
Form	frm_Subform_Photos_Iterations_Points				
Record Source	qry_FORMS_Subform_Photos_Iterations_Points				
Default view	Datasheet				
Fields					
Field Name	Type	Locked	Linked Table	Bound Column	ComboBox Source
PointNbr	Text Box	Yes	tbl_Photos_Iterations_Points	PointNbr	
Coral_Health	Text Box	No	tbl_Photos_Iterations_Points	CoralHealthID	tbl_Valid_Coral_Health_Values
Identification	Text Box	No	tbl_Photos_Iterations_Points	IdentificationID	qry_Identification_Pulldown
Events					
Control	Type	Active	Event	Description	
Coral_Health	Combo Box	on-change	mcr_frm_Subform_Photos_Iterations_SetTimeLastUpdated	Updates 'Last Updated' time with current date/time	
Identification	Combo Box	on-change	mcr_frm_Subform_Photos_Iterations_SetTimeLastUpdated	Updates 'Last Updated' time with current date/time	
Order By					
PointNbr					
NOTES:					
No record selectors. No Max/Min record buttons. No scroll bars.					

frm_Subform_Photos_Iteration_Points (cont.)



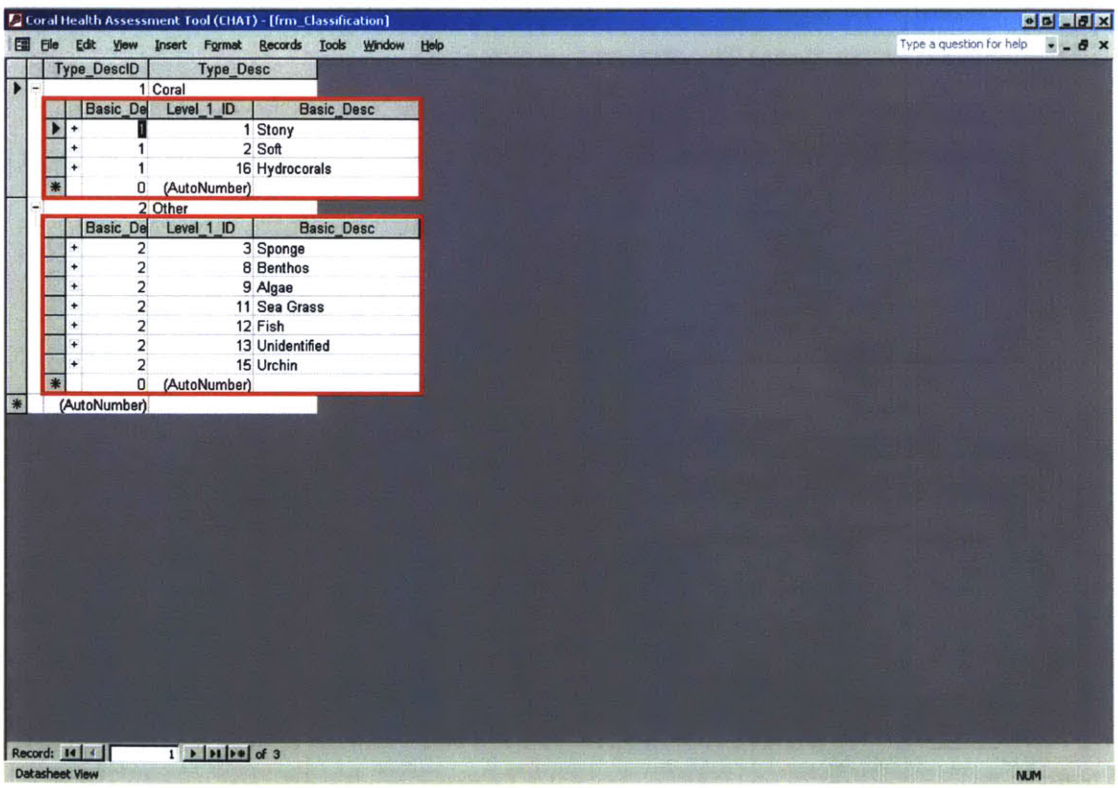
frm_Classification

Form	frm_Classification				
Record Source	tbl_0_Type				
Default view	Datasheet				
Subforms					
frm_Classification_Sub_1					
frm_Classification_Sub_2					
Fields					
Field Name	Type	Locked	Linked Table	Bound Column	ComboBox Source
Type_DescID	Text Box	No	tbl_0_Type	Level_0_ID	
Type_Desc	Text Box	No	tbl_0_Type	Type_Desc	
NOTES:					
Used for user updates of classification structure. Form is used instead of direct table interation to guard against accidental data updates due to link between tbl_2_Specific and tbl_Photos_Iterations_Points					



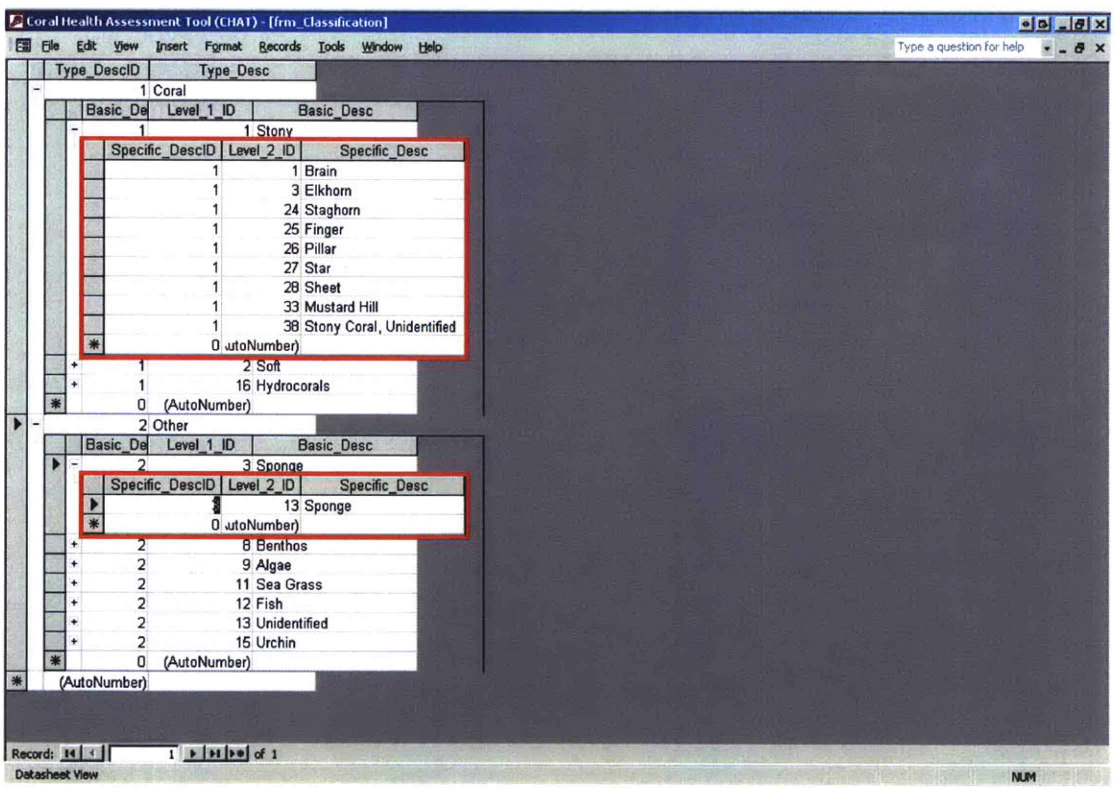
frm_Classification_Sub_1

Form	frm_Classification_Sub_1				
Record Source	tbl_1_Basic				
Default view	Datasheet				
Subforms					
frm_Classification_Sub_2					
Fields					
Field Name	Type	Locked	Linked Table	Bound Column	ComboBox Source
Basic_DescID	Text Box	No	tbl_1_Basic	Level_0_ID	
Level_1_ID	Text Box	No	tbl_1_Basic	Level_1_ID	
Basic_Desc	Text Box	No	tbl_1_Basic	Basic_Desc	
NOTES:					



frm_Classification_Sub_2

Form	frm_Classification_Sub_2				
Record Source	tbl_2_Specific				
Default view	Datasheet				
Subforms					
frm_Classification_Sub_2					
Fields					
Field Name	Type	Locked	Linked Table	Bound Column	ComboBox Source
Specific_DescID	Text Box	No	tbl_2_Specific	Level_1_ID	
Level_2_ID	Text Box	No	tbl_2_Specific	Level_2_ID	
Specific_Desc	Text Box	No	tbl_2_Specific	Specific_Desc	
NOTES:					



Appendix E DATABASE QUERY DETAILS

APPENDIX E TABLE OF CONTENTS

DATABASE QUERY SUMMARY

Query Summary

Query Name	Query Type	Description / Comments
qry_append_1_IterationsRandomNbrs	Append	Appends rows to tbl_IterationsRandomNbrs; assigns a random number to each PhotoID so that random selection can be performed.
qry_append_1_IterationsRandomNbrs_Sub_UpdatePrePopulatedStatus	Update	Sub-query to qry_append_1_IterationsRandomNbrs
qry_append_2_Photo_Iterations	Append	Appends rows to tbl_Photo_Iterations with randomly selected PhotoID's
qry_append_2_Sub_1_PhotoID_UnionQuery	Union	Union query that combines randomly selected PhotoID's from Fish, Leinster, Reef, and Round Bays.
qry_append_2_Sub_2_PhotoID_Fish	Select	For the user-entered IterationNbr, selects the top 'X' rows (in this code, X=10 rows. For Iterations 1-4, x=30 was used) of PhotoID's where BayName = Fish
qry_append_2_Sub_2_PhotoID_Leinster	Select	For the user-entered IterationNbr, selects the top 'X' rows (in this code, X=10 rows. For Iterations 1-4, x=30 was used) of PhotoID's where BayName = Leinster
qry_append_2_Sub_2_PhotoID_Reef	Select	For the user-entered IterationNbr, selects the top 'X' rows (in this code, X=10 rows. For Iterations 1-4, x=30 was used) of PhotoID's where BayName = Reef
qry_append_2_Sub_2_PhotoID_Round	Select	For the user-entered IterationNbr, selects the top 'X' rows (in this code, X=10 rows. For Iterations 1-4, x=30 was used) of PhotoID's where BayName = Round
qry_append_3_Photos_Iterations_Points	Append	Appends rows to tbl_Photos_Iteration_Points for all PhotoIterationID's that were selected for the Iteration. In this implementation, 12 rows were appended for each PhotoIterationID.
qry_append_4_Transect_Iterations	Append	Appends rows to tbl_Transect_Iterations for Transects that contain Photos that have been included in an Iteration.
qry_FORMS_frm_CHAT_DATA_ENTRY_FORM_MAIN_QRY	Select	Select query for frm_CHAT_DATA_ENTRY_FORM_MAIN_QRY

Query Summary (cont.)

Query Name	Query Type	Description / Comments
qry_FORMS_ITERATION_ENTRY_FORM	Select	Select query for frm_ITERATION_ENTRY_FORM
qry_FORMS_ITERATION_ENTRY_FORM_Sub_DataSheet_View	Select	Select query for frm_ITERATION_ENTRY_FORM_Sub_DataSheet_View
qry_FORMS_Subform_Entry_Status	Select	Select query for frm_Subform_EntryStatus
qry_FORMS_Subform_Photos	Select	Select query for frm_Subform_Photos
qry_FORMS_Subform_Photos_Iterations	Select	Select query for frm_Subform_Photos_Iterations
qry_FORMS_Subform_Photos_Iterations_Points	Select	Select query for frm_Subform_Photos_Iterations_Points
qry_Identification_Pulldown	Select	Populates Identification Pulldown menu in frm_Subform_Photos_Iterations_Points
qry_PIVOT_1_CORAL_ID_AND_HEALTH	Select	Linked to Pivot Table 1
qry_PIVOT_2_PHOTOCOUNT	Select	Linked to Pivot Table 2
qry_PIVOT_2_Sub_PhotoCount	Select	Sub-query to qry_PIVOT_2_PHOTOCOUNT
qry_PIVOT_3_Data_Entry_Status	Select	Linked to Pivot Table Pivot 3
qry_PIVOT_4_DistinctPhotoCount	Select	Linked to Pivot Table Pivot 4; specifically provides output for QA/QC Iterations 5.1 & 5.2 in this case.
qry_PIVOT_4_DistinctPhotoCount1	Select	Linked to Pivot Table Pivot 4; specifically provides output for Iterations 1-4 in this case.
qry_PIVOT_5_TotalPhotosPerTransect	Select	Linked to Pivot Table Pivot 5
qry_update_1_Photos_Iterations_Points	Update	Allows user to update default values in new Iterations with points that may have already been entered in previous Iterations. Prompts user for Source and Destination Iterations.
qry_update_1_Sub_1_Source_Data_Points	Select	Sub-query for qry_update_1_Photos_Iterations_Points
qry_update_CurrentIterationSingleRowTable	Update	Prompts user for current IterationNbr and updates table. Table is subsequently used in joins to display only records related to the current Iteration.
zqry_Photo_Iterations_CountOfPhotosNOTCOMPLETEPerIteration	Select	Used to populate frm_Subform_EntryStatus
zqry_Photo_Iterations_CountOfPhotosPerIteration	Select	Used to populate frm_Subform_EntryStatus
zz_qry_Append_Duplicate_Iteration_PhotoIDs	Append	Appends duplicate points so that users can duplicate the exact same iteration; this query was used to duplicate Iteration 5.1 to Iteration 5.2.
zz_qry_Append_Duplicate_Iteration_PhotoIDs_Sub	Select	Sub-query to zz_qry_Append_Duplicate_Iteration_PhotoIDs

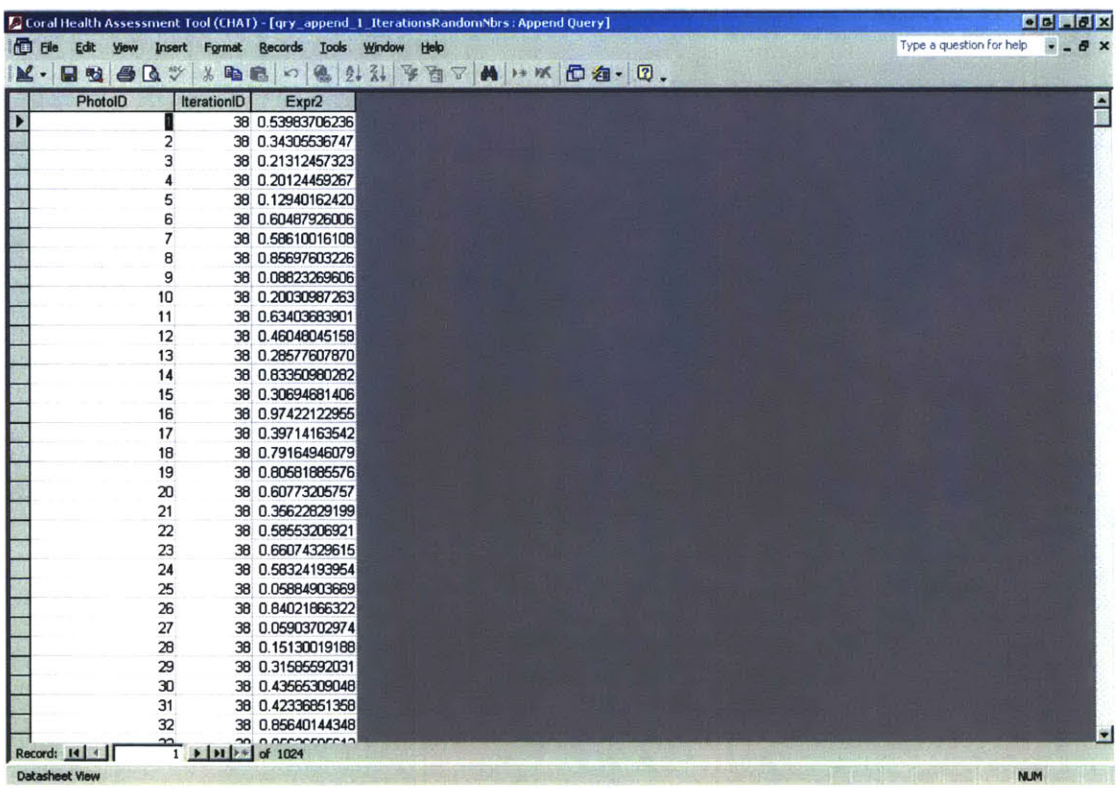
DATABASE QUERY DETAILS

qry_append_1_IterationsRandomNbrs

Query Name	Query Type	Description / Comments
qry_append_1_IterationsRandomNbrs	Append	Appends rows to tbl_IterationsRandomNbrs; assigns a random number to each PhotoID so that random selection can be performed.

SQL Code

```
INSERT INTO tbl_IterationsRandomNbrs ( PhotoID, IterationID, RandomGeneratedNbr )
SELECT DISTINCTROW tbl_Photos.PhotoID, tbl_Iterations.IterationID, Rnd(tbl_Photos.PhotoID) AS
Expr2
FROM tbl_Photos, tbl_Valid_Yes_No_ComboBox INNER JOIN tbl_Iterations ON
tbl_Valid_Yes_No_ComboBox.Valid_Yes_No_ComboBoxID =
tbl_Iterations.RecordsAlreadyPrePopulatedID
WHERE (((tbl_Valid_Yes_No_ComboBox.Valid_Yes_No_ComboBox)="No"));
```



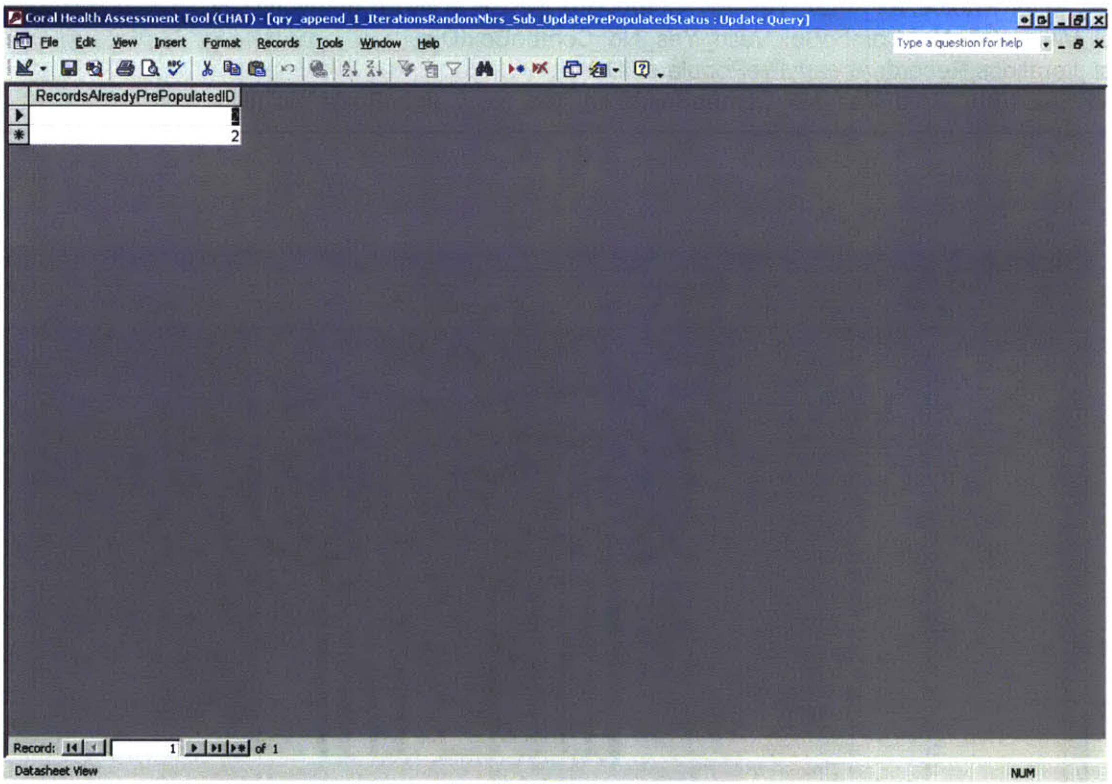
PhotoID	IterationID	Expr2
1	38	0.53983706236
2	38	0.34305536747
3	38	0.21312457323
4	38	0.20124459267
5	38	0.12940162420
6	38	0.60487926006
7	38	0.58610016108
8	38	0.85697603226
9	38	0.08823269606
10	38	0.20030987263
11	38	0.63403683901
12	38	0.46048045158
13	38	0.28577607870
14	38	0.83350980282
15	38	0.30694681406
16	38	0.97422122955
17	38	0.39714163542
18	38	0.79164946079
19	38	0.80581885576
20	38	0.60773205757
21	38	0.35622829199
22	38	0.58553206921
23	38	0.66074329615
24	38	0.58324193954
25	38	0.05884903669
26	38	0.84021866322
27	38	0.05903702974
28	38	0.15130019188
29	38	0.31585592031
30	38	0.43565309048
31	38	0.42336851358
32	38	0.85640144348

qry_append_1_IterationsRandomNbrs_Sub_UpdatePrePopulatedStatus

Query Name	Query Type	Description / Comments
qry_append_1_IterationsRandomNbrs_Sub_UpdatePrePopulatedStatus	Update	Sub-query to qry_append_1_IterationsRandomNbrs

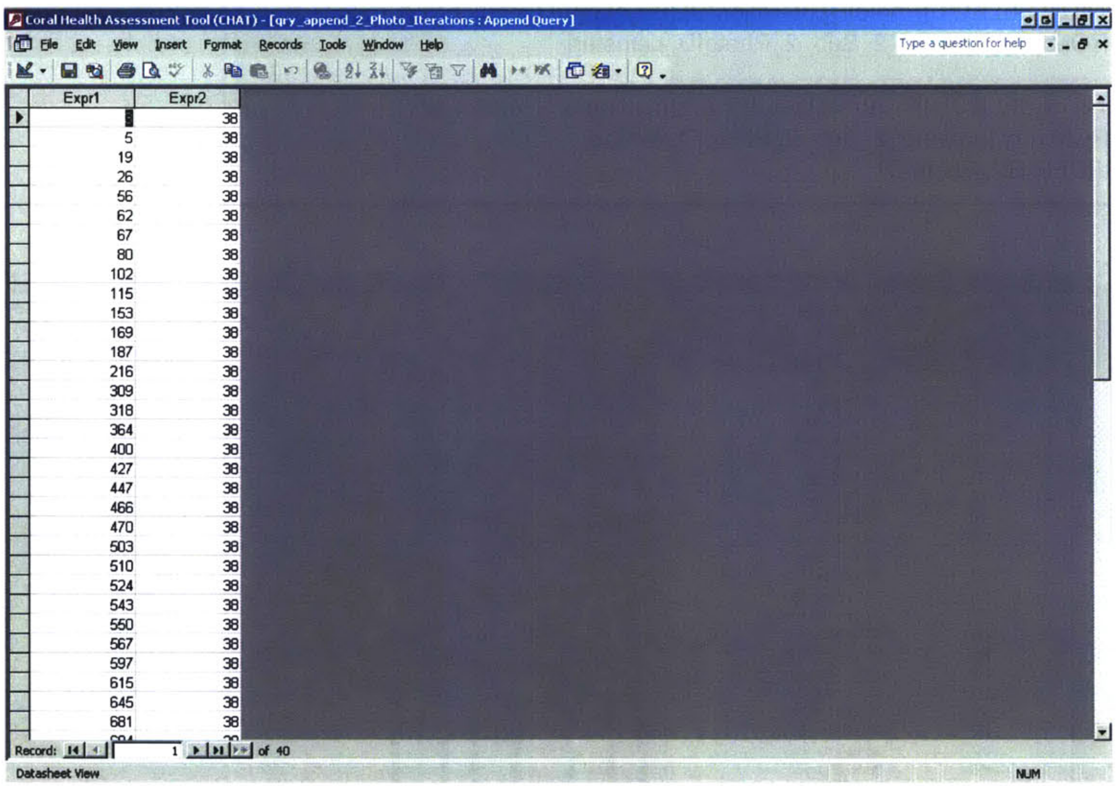
SQL Code

```
UPDATE DISTINCTROW tbl_Photos, tbl_Iterations SET
tbl_Iterations.RecordsAlreadyPrePopulatedID = 1
WHERE (((tbl_Iterations.RecordsAlreadyPrePopulatedID)<>1));
```



qry_append_2_Photo_Iterations

Query Name	Query Type	Description / Comments
qry_append_2_Photo_Iterations	Append	Appends rows to tbl_Photo_Iterations with randomly selected PhotoID's
SQL Code		
INSERT INTO tbl_Photos_Iterations (PhotoID, IterationID) SELECT DISTINCTROW qry_append_2_Sub_1_PhotoID_UnionQuery.PhotoID AS Expr1, qry_append_2_Sub_1_PhotoID_UnionQuery.IterationID AS Expr2 FROM qry_append_2_Sub_1_PhotoID_UnionQuery, tbl_Photos_Iterations;		



qry_append_2_Sub_1_PhotoID_UnionQuery

Query Name	Query Type	Description / Comments
qry_append_2_Sub_1_PhotoID_UnionQuery	Union	Union query that combines randomly selected PhotoID's from Fish, Leinster, Reef, and Round Bays.

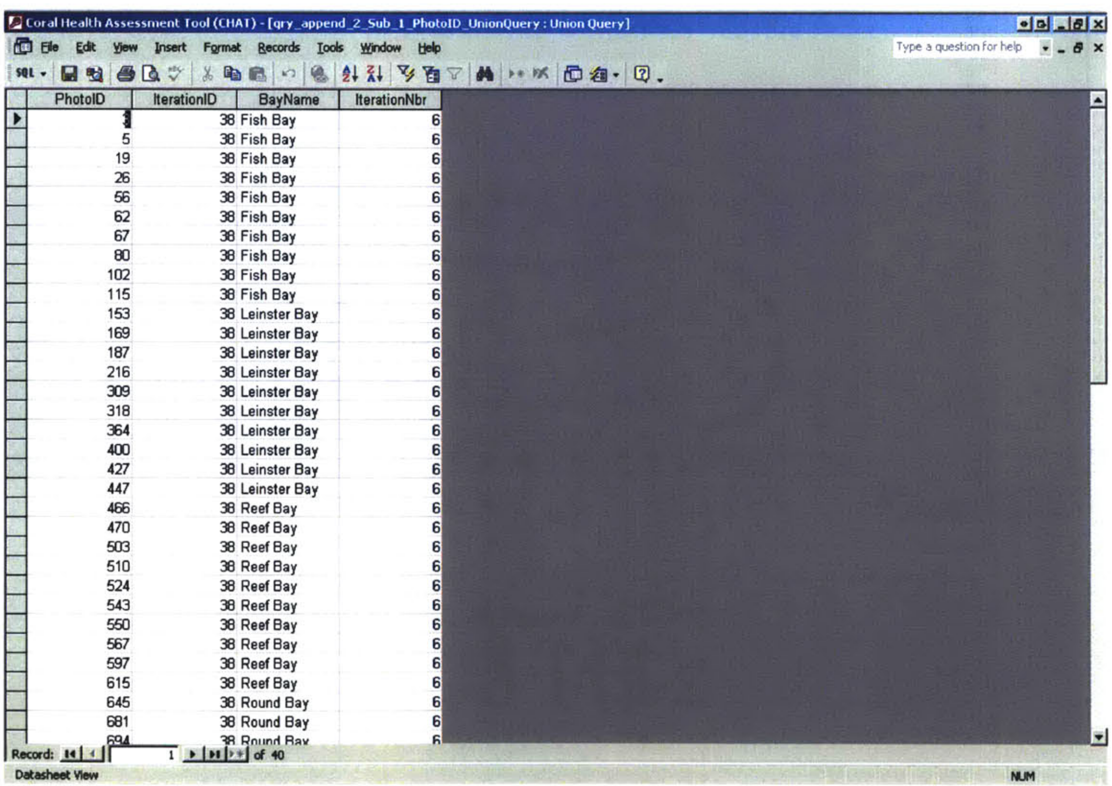
SQL Code

```
.SELECT [PhotoID],[IterationID],[BayName],[IterationNbr]
FROM [qry_append_2_Sub_2_PhotoID_Fish]

UNION SELECT [PhotoID],[IterationID],[BayName],[IterationNbr]
FROM [qry_append_2_Sub_2_PhotoID_Reef]

UNION SELECT [PhotoID],[IterationID],[BayName],[IterationNbr]
FROM [qry_append_2_Sub_2_PhotoID_Leinster]

UNION SELECT [PhotoID],[IterationID],[BayName],[IterationNbr]
FROM [qry_append_2_Sub_2_PhotoID_Round]
ORDER BY [PhotoID];
```



PhotoID	IterationID	BayName	IterationNbr
3	38	Fish Bay	6
5	38	Fish Bay	6
19	38	Fish Bay	6
26	38	Fish Bay	6
56	38	Fish Bay	6
62	38	Fish Bay	6
67	38	Fish Bay	6
80	38	Fish Bay	6
102	38	Fish Bay	6
115	38	Fish Bay	6
153	38	Leinster Bay	6
169	38	Leinster Bay	6
187	38	Leinster Bay	6
216	38	Leinster Bay	6
309	38	Leinster Bay	6
318	38	Leinster Bay	6
364	38	Leinster Bay	6
400	38	Leinster Bay	6
427	38	Leinster Bay	6
447	38	Leinster Bay	6
466	38	Reef Bay	6
470	38	Reef Bay	6
503	38	Reef Bay	6
510	38	Reef Bay	6
524	38	Reef Bay	6
543	38	Reef Bay	6
550	38	Reef Bay	6
567	38	Reef Bay	6
597	38	Reef Bay	6
615	38	Reef Bay	6
645	38	Round Bay	6
681	38	Round Bay	6
694	38	Round Bay	6

Record: 1 of 40

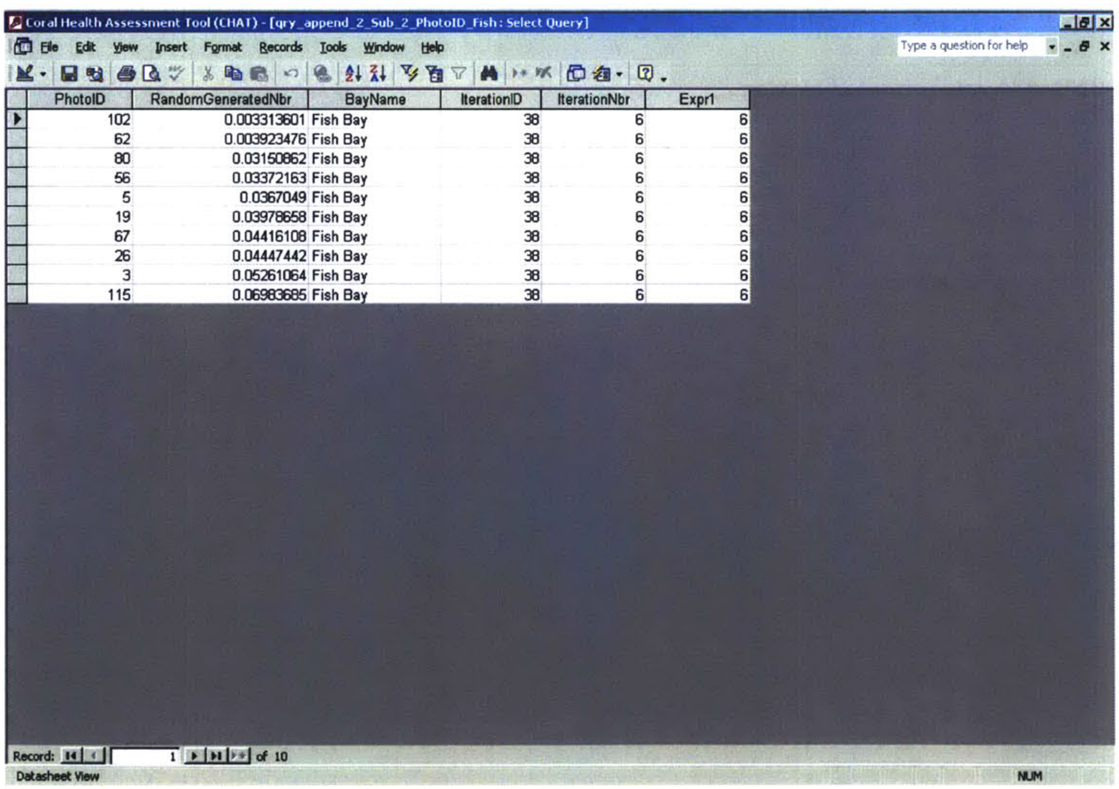
Datasheet View NUM

qry_append_2_Sub_2_PhotoID_Fish

Query Name	Query Type	Description / Comments
qry_append_2_Sub_2_PhotoID_Fish	Select	For the user-entered IterationNbr, selects the top 'X' rows (in this code, X=10 rows. For Iterations 1-4, x=30 was used) of PhotoID's where BayName = Fish

SQL Code

```
SELECT DISTINCT TOP 10 tbl_IterationsRandomNbrs.PhotoID,
tbl_IterationsRandomNbrs.RandomGeneratedNbr, tbl_Bays.BayName,
tbl_IterationsRandomNbrs.IterationID, tbl_Iterations.IterationNbr, [UserEnteredIterationNbr] AS Expr1
FROM ((tbl_Bays INNER JOIN tbl_Events ON tbl_Bays.BayID = tbl_Events.BayID) INNER JOIN
tbl_Transects ON tbl_Events.EventID = tbl_Transects.EventID) INNER JOIN (tbl_Iterations INNER
JOIN (tbl_Photos INNER JOIN tbl_IterationsRandomNbrs ON tbl_Photos.PhotoID =
tbl_IterationsRandomNbrs.PhotoID) ON tbl_Iterations.IterationID =
tbl_IterationsRandomNbrs.IterationID) ON tbl_Transects.TransectID = tbl_Photos.TransectID
WHERE (((tbl_Bays.BayName)="Fish Bay") AND
((tbl_Iterations.IterationNbr)=[UserEnteredIterationNbr]))
ORDER BY tbl_IterationsRandomNbrs.RandomGeneratedNbr;
```



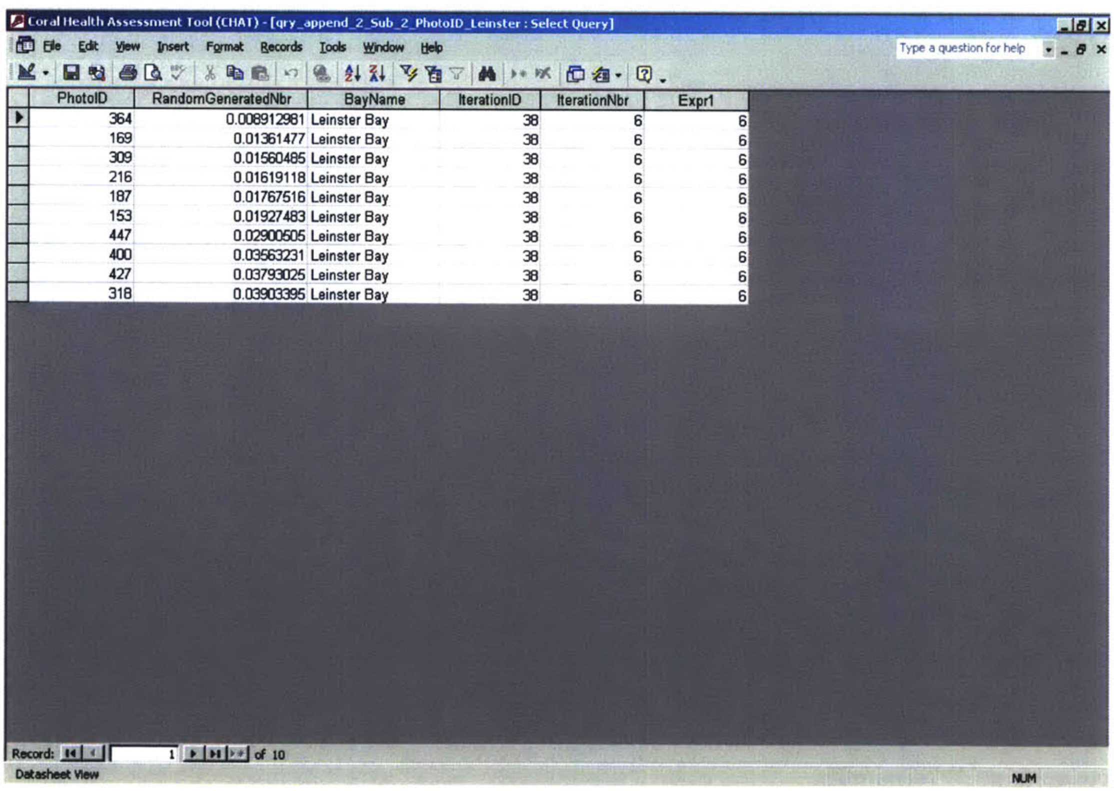
PhotoID	RandomGeneratedNbr	BayName	IterationID	IterationNbr	Expr1
102	0.003313601	Fish Bay	38	6	6
62	0.003923476	Fish Bay	38	6	6
80	0.03150862	Fish Bay	38	6	6
56	0.03372163	Fish Bay	38	6	6
5	0.0367049	Fish Bay	38	6	6
19	0.03978658	Fish Bay	38	6	6
67	0.04416108	Fish Bay	38	6	6
26	0.04447442	Fish Bay	38	6	6
3	0.05261064	Fish Bay	38	6	6
115	0.06983685	Fish Bay	38	6	6

qry_append_2_Sub_2_PhotoID_Leinster

Query Name	Query Type	Description / Comments
qry_append_2_Sub_2_PhotoID_Leinster	Select	For the user-entered IterationNbr, selects the top 'X' rows (in this code, X=10 rows. For Iterations 1-4, x=30 was used) of PhotoID's where BayName = Leinster

SQL Code

```
SELECT DISTINCT TOP 10 tbl_IterationsRandomNbrs.PhotoID,
tbl_IterationsRandomNbrs.RandomGeneratedNbr, tbl_Bays.BayName,
tbl_IterationsRandomNbrs.IterationID, tbl_Iterations.IterationNbr, [UserEnteredIterationNbr] AS Expr1
FROM ((tbl_Bays INNER JOIN tbl_Events ON tbl_Bays.BayID = tbl_Events.BayID) INNER JOIN
tbl_Transects ON tbl_Events.EventID = tbl_Transects.EventID) INNER JOIN (tbl_Iterations INNER
JOIN (tbl_Photos INNER JOIN tbl_IterationsRandomNbrs ON tbl_Photos.PhotoID =
tbl_IterationsRandomNbrs.PhotoID) ON tbl_Iterations.IterationID =
tbl_IterationsRandomNbrs.IterationID) ON tbl_Transects.TransectID = tbl_Photos.TransectID
WHERE (((tbl_Bays.BayName)="Leinster Bay") AND
((tbl_Iterations.IterationNbr)=[UserEnteredIterationNbr]))
ORDER BY tbl_IterationsRandomNbrs.RandomGeneratedNbr;
```



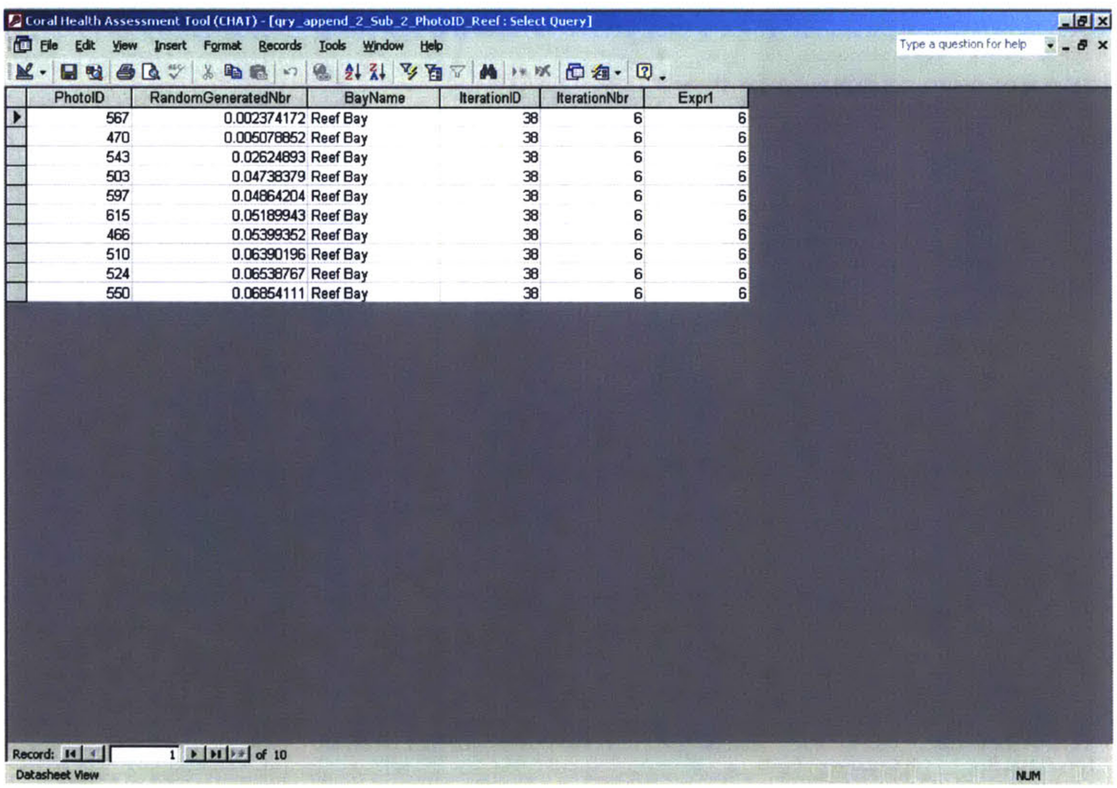
PhotoID	RandomGeneratedNbr	BayName	IterationID	IterationNbr	Expr1
364	0.008912981	Leinster Bay	38	6	6
169	0.01361477	Leinster Bay	38	6	6
309	0.01560485	Leinster Bay	38	6	6
216	0.01619118	Leinster Bay	38	6	6
187	0.01767516	Leinster Bay	38	6	6
153	0.01927483	Leinster Bay	38	6	6
447	0.02900505	Leinster Bay	38	6	6
400	0.03563231	Leinster Bay	38	6	6
427	0.03793025	Leinster Bay	38	6	6
318	0.03903395	Leinster Bay	38	6	6

qry_append_2_Sub_2_PhotoID_Reef

Query Name	Query Type	Description / Comments
qry_append_2_Sub_2_PhotoID_Reef	Select	For the user-entered IterationNbr, selects the top 'X' rows (in this code, X=10 rows. For Iterations 1-4, x=30 was used) of PhotoID's where BayName = Reef

SQL Code

```
SELECT DISTINCT TOP 10 tbl_IterationsRandomNbrs.PhotoID,
tbl_IterationsRandomNbrs.RandomGeneratedNbr, tbl_Bays.BayName,
tbl_IterationsRandomNbrs.IterationID, tbl_Iterations.IterationNbr, [UserEnteredIterationNbr] AS Expr1
FROM ((tbl_Bays INNER JOIN tbl_Events ON tbl_Bays.BayID = tbl_Events.BayID) INNER JOIN
tbl_Transects ON tbl_Events.EventID = tbl_Transects.EventID) INNER JOIN (tbl_Iterations INNER
JOIN (tbl_Photos INNER JOIN tbl_IterationsRandomNbrs ON tbl_Photos.PhotoID =
tbl_IterationsRandomNbrs.PhotoID) ON tbl_Iterations.IterationID =
tbl_IterationsRandomNbrs.IterationID) ON tbl_Transects.TransectID = tbl_Photos.TransectID
WHERE (((tbl_Bays.BayName)="Reef Bay") AND
((tbl_Iterations.IterationNbr)=[UserEnteredIterationNbr]))
ORDER BY tbl_IterationsRandomNbrs.RandomGeneratedNbr;
```



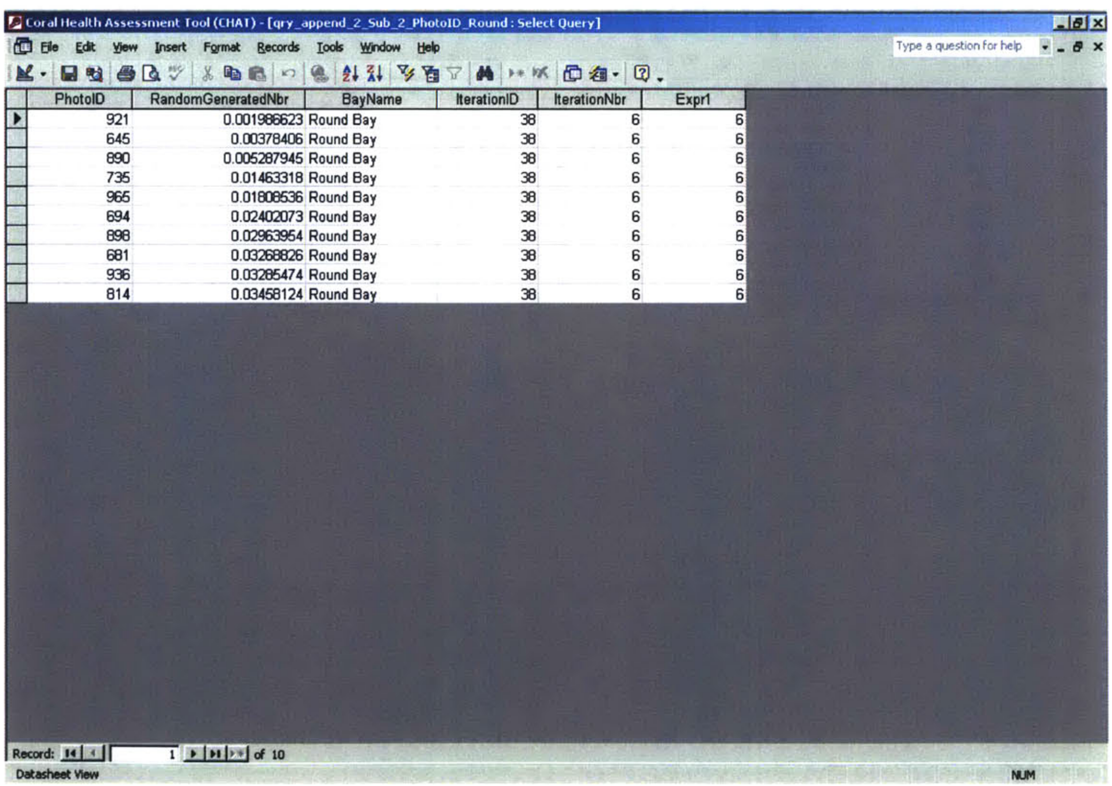
PhotoID	RandomGeneratedNbr	BayName	IterationID	IterationNbr	Expr1
567	0.002374172	Reef Bay	38	6	6
470	0.005078852	Reef Bay	38	6	6
543	0.02624893	Reef Bay	38	6	6
503	0.04738379	Reef Bay	38	6	6
597	0.04864204	Reef Bay	38	6	6
615	0.05189943	Reef Bay	38	6	6
466	0.05399352	Reef Bay	38	6	6
510	0.06390196	Reef Bay	38	6	6
524	0.06538767	Reef Bay	38	6	6
550	0.06854111	Reef Bay	38	6	6

qry_append_2_Sub_2_PhotoID_Round

Query Name	Query Type	Description / Comments
qry_append_2_Sub_2_PhotoID_Round	Select	For the user-entered IterationNbr, selects the top 'X' rows (in this code, X=10 rows. For Iterations 1-4, x=30 was used) of PhotoID's where BayName = Round

SQL Code

```
SELECT DISTINCT TOP 10 tbl_IterationsRandomNbrs.PhotoID,
tbl_IterationsRandomNbrs.RandomGeneratedNbr, tbl_Bays.BayName,
tbl_IterationsRandomNbrs.IterationID, tbl_Iterations.IterationNbr, [UserEnteredIterationNbr] AS Expr1
FROM ((tbl_Bays INNER JOIN tbl_Events ON tbl_Bays.BayID = tbl_Events.BayID) INNER JOIN
tbl_Transects ON tbl_Events.EventID = tbl_Transects.EventID) INNER JOIN (tbl_Iterations INNER
JOIN (tbl_Photos INNER JOIN tbl_IterationsRandomNbrs ON tbl_Photos.PhotoID =
tbl_IterationsRandomNbrs.PhotoID) ON tbl_Iterations.IterationID =
tbl_IterationsRandomNbrs.IterationID) ON tbl_Transects.TransectID = tbl_Photos.TransectID
WHERE (((tbl_Bays.BayName)="Round Bay") AND
((tbl_Iterations.IterationNbr)=[UserEnteredIterationNbr]))
ORDER BY tbl_IterationsRandomNbrs.RandomGeneratedNbr;
```



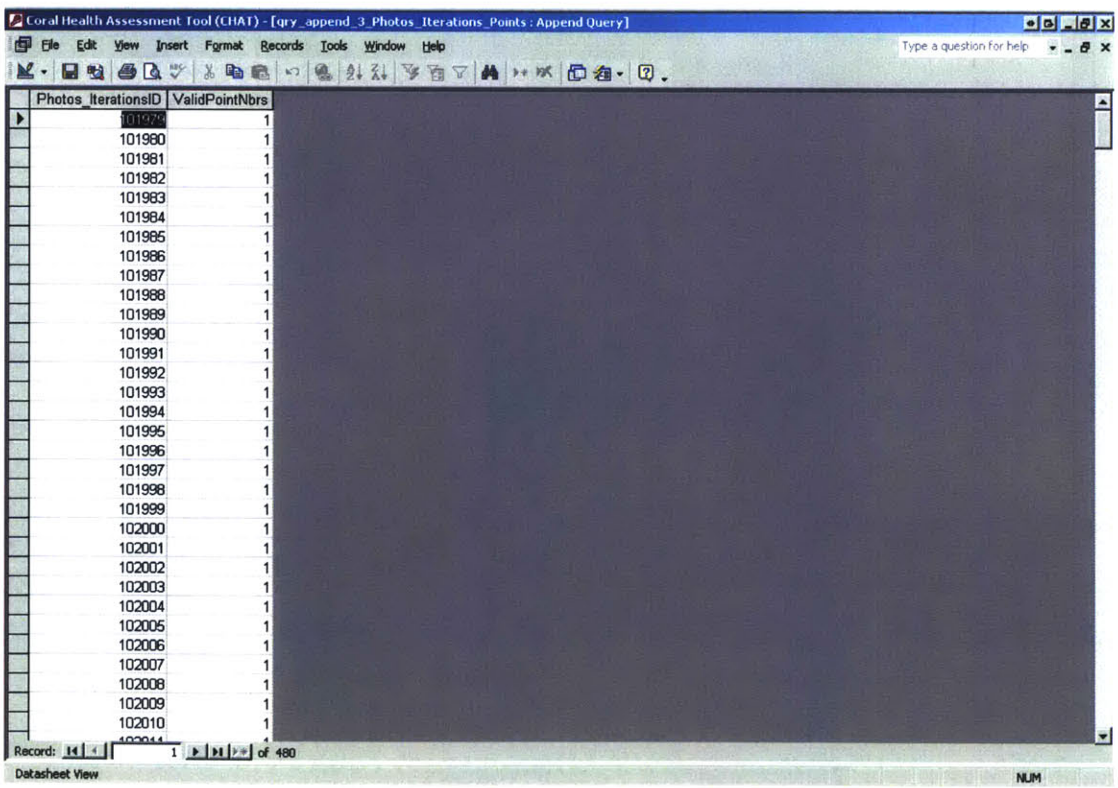
PhotoID	RandomGeneratedNbr	BayName	IterationID	IterationNbr	Expr1
921	0.001986623	Round Bay	38	6	6
645	0.00378406	Round Bay	38	6	6
890	0.005287945	Round Bay	38	6	6
735	0.01463318	Round Bay	38	6	6
965	0.01808536	Round Bay	38	6	6
694	0.02402073	Round Bay	38	6	6
898	0.02963954	Round Bay	38	6	6
681	0.03268826	Round Bay	38	6	6
936	0.03285474	Round Bay	38	6	6
814	0.03458124	Round Bay	38	6	6

qry_append_3_Photos_Iterations_Points

Query Name	Query Type	Description / Comments
qry_append_3_Photos_Iterations_Points	Append	Appends rows to tbl_Photos_Iteration_Points for all PhotoIterationID's that were selected for the Iteration. In this implementation, 12 rows were appended for each PhotoIterationID.

SQL Code

```
INSERT INTO tbl_Photos_Iterations_Points ( Photos_IterationsID, PointNbr )
SELECT DISTINCTROW tbl_Photos_Iterations.Photos_IterationsID, tbl_ValidPointNbrs.ValidPointNbrs
FROM tbl_ValidPointNbrs, tbl_Iterations INNER JOIN tbl_Photos_Iterations ON
tbl_Iterations.IterationID = tbl_Photos_Iterations.IterationID
WHERE (((tbl_Iterations.IterationNbr)=[UserEnteredIterationNbr]));
```



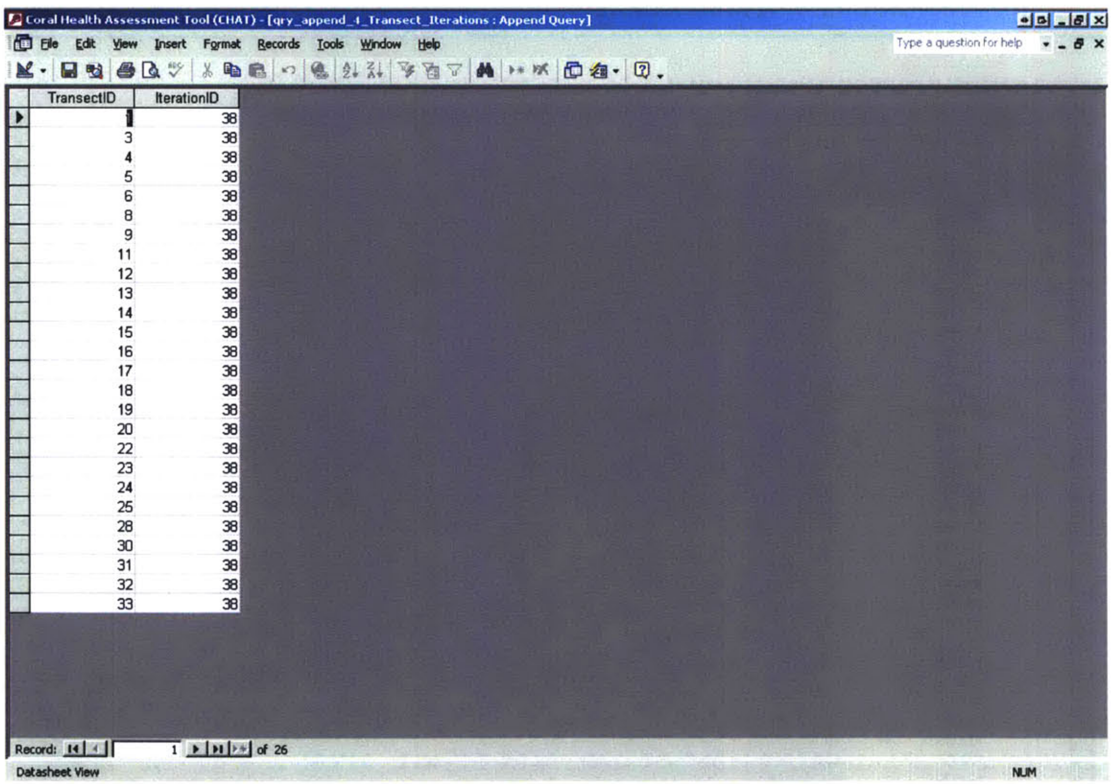
Photos_IterationsID	ValidPointNbrs
101979	1
101980	1
101981	1
101982	1
101983	1
101984	1
101985	1
101986	1
101987	1
101988	1
101989	1
101990	1
101991	1
101992	1
101993	1
101994	1
101995	1
101996	1
101997	1
101998	1
101999	1
102000	1
102001	1
102002	1
102003	1
102004	1
102005	1
102006	1
102007	1
102008	1
102009	1
102010	1

qry_append_4_Transect_Iterations

Query Name	Query Type	Description / Comments
qry_append_4_Transect_Iterations	Append	Appends rows to tbl_Transect_Iterations for Transects that contain Photos that have been included in an Iteration.

SQL Code

```
INSERT INTO tbl_Transect_Iterations ( TransectID, IterationID )
SELECT DISTINCT tbl_Photos.TransectID, tbl_Photos_Iterations.IterationID
FROM tbl_Photos INNER JOIN (tbl_Iterations INNER JOIN tbl_Photos_Iterations ON
tbl_Iterations.IterationID = tbl_Photos_Iterations.IterationID) ON tbl_Photos.PhotoID =
tbl_Photos_Iterations.PhotoID
WHERE (((tbl_Iterations.IterationNbr)=[UserEnteredIterationNbr]));
```



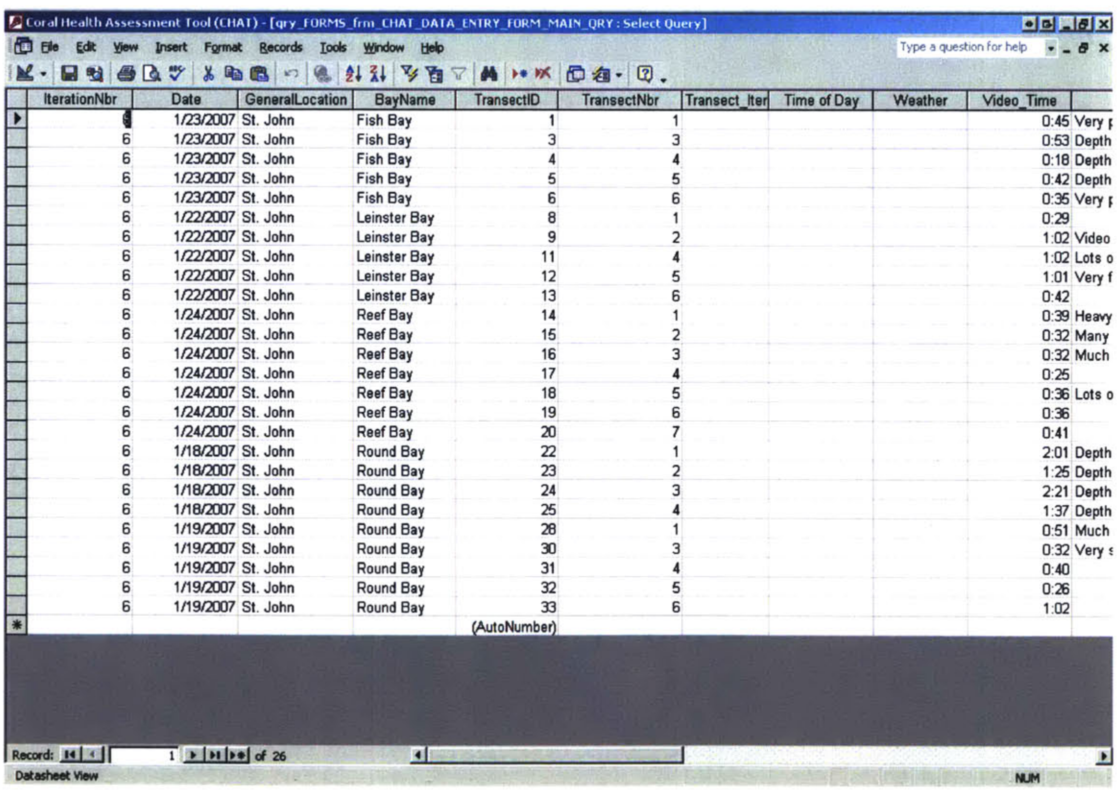
TransectID	IterationID
1	38
3	38
4	38
5	38
6	38
8	38
9	38
11	38
12	38
13	38
14	38
15	38
16	38
17	38
18	38
19	38
20	38
22	38
23	38
24	38
25	38
28	38
30	38
31	38
32	38
33	38

qry_FORMS_frm_CHAT_DATA_ENTRY_FORM_MAIN_QRY

Query Name	Query Type	Description / Comments
qry_FORMS_frm_CHAT_DATA_ENTRY_FORM_MAIN_QRY	Select	Select query for frm_CHAT_DATA_ENTRY_FORM_MAIN_QRY

SQL Code

```
SELECT tbl_Iterations.IterationNbr, tbl_Events.Date, tbl_General_Locations.GeneralLocation,
tbl_Bays.BayName, tbl_Transects.TransectID, tbl_Transects.TransectNbr,
tbl_Transect_Iterations.Transect_Iteration_Comments, tbl_Transects.[Time of Day],
tbl_Transects.Weather, tbl_Transects.Video_Time, tbl_Transects.[Transect Comments],
tbl_Transects.Start_Depth, tbl_Transects.Finish_Depth, tbl_Transects.Avg_Depth,
tbl_Transects.View_Area_Width, tbl_Transects.View_Area_Height,
tbl_Transect_Iterations.DataEntryStatusID
FROM (tbl_General_Locations INNER JOIN ((tbl_Bays INNER JOIN tbl_Events ON tbl_Bays.BayID =
tbl_Events.BayID) INNER JOIN tbl_Transects ON tbl_Events.EventID = tbl_Transects.EventID) ON
tbl_General_Locations.GeneralLocationID = tbl_Bays.GeneralLocationID) INNER JOIN ((tbl_Iterations
INNER JOIN tbl_CurrentIterationSingleRowTable ON tbl_Iterations.IterationNbr =
tbl_CurrentIterationSingleRowTable.CurrentIterationNbr) INNER JOIN tbl_Transect_Iterations ON
tbl_Iterations.IterationID = tbl_Transect_Iterations.IterationID) ON tbl_Transects.TransectID =
tbl_Transect_Iterations.TransectID;
```



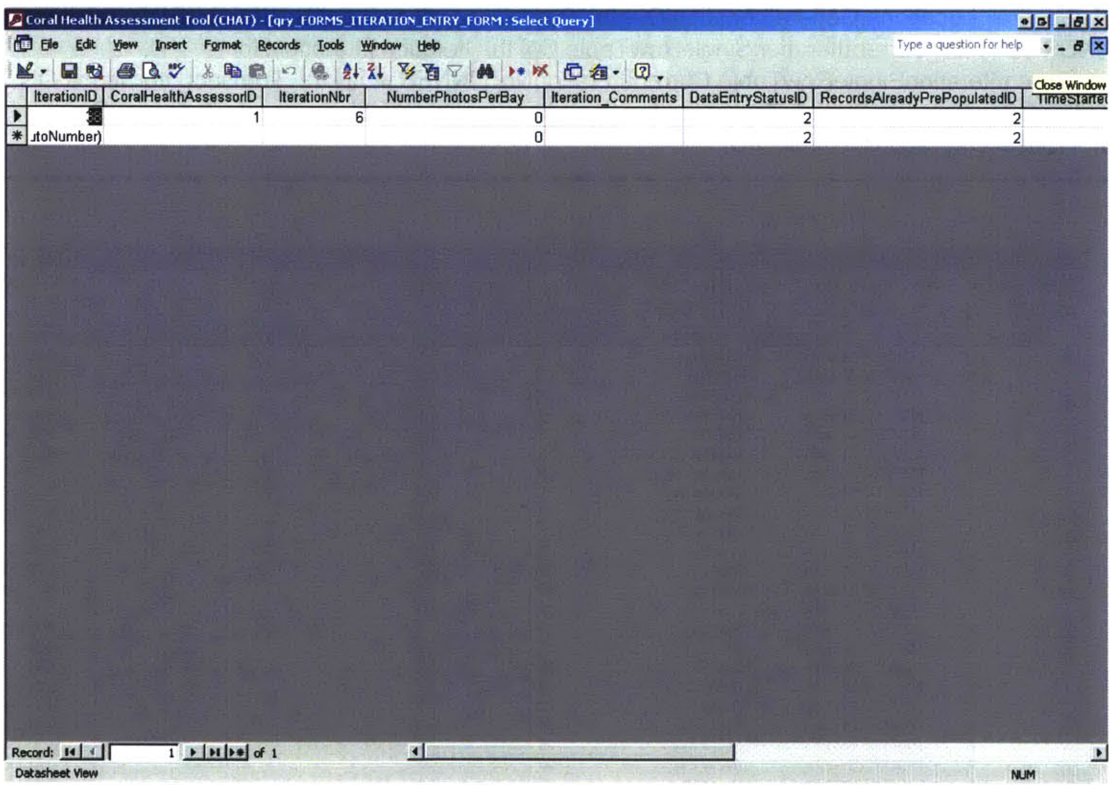
IterationNbr	Date	GeneralLocation	BayName	TransectID	TransectNbr	Transect_Iter	Time of Day	Weather	Video_Time	
6	1/23/2007	St. John	Fish Bay	1	1				0:45	Very p
6	1/23/2007	St. John	Fish Bay	3	3				0:53	Depth
6	1/23/2007	St. John	Fish Bay	4	4				0:18	Depth
6	1/23/2007	St. John	Fish Bay	5	5				0:42	Depth
6	1/23/2007	St. John	Fish Bay	6	6				0:35	Very p
6	1/22/2007	St. John	Leinster Bay	8	1				0:29	
6	1/22/2007	St. John	Leinster Bay	9	2				1:02	Video
6	1/22/2007	St. John	Leinster Bay	11	4				1:02	Lots o
6	1/22/2007	St. John	Leinster Bay	12	5				1:01	Very f
6	1/22/2007	St. John	Leinster Bay	13	6				0:42	
6	1/24/2007	St. John	Reef Bay	14	1				0:39	Heavy
6	1/24/2007	St. John	Reef Bay	15	2				0:32	Many
6	1/24/2007	St. John	Reef Bay	16	3				0:32	Much
6	1/24/2007	St. John	Reef Bay	17	4				0:25	
6	1/24/2007	St. John	Reef Bay	18	5				0:36	Lots o
6	1/24/2007	St. John	Reef Bay	19	6				0:36	
6	1/24/2007	St. John	Reef Bay	20	7				0:41	
6	1/18/2007	St. John	Round Bay	22	1				2:01	Depth
6	1/18/2007	St. John	Round Bay	23	2				1:25	Depth
6	1/18/2007	St. John	Round Bay	24	3				2:21	Depth
6	1/18/2007	St. John	Round Bay	25	4				1:37	Depth
6	1/19/2007	St. John	Round Bay	28	1				0:51	Much
6	1/19/2007	St. John	Round Bay	30	3				0:32	Very s
6	1/19/2007	St. John	Round Bay	31	4				0:40	
6	1/19/2007	St. John	Round Bay	32	5				0:26	
6	1/19/2007	St. John	Round Bay	33	6				1:02	
				(AutoNumber)						

qry_FORMS_ITERATION_ENTRY_FORM

Query Name	Query Type	Description / Comments
qry_FORMS_ITERATION_ENTRY_FORM	Select	Select query for frm_ITERATION_ENTRY_FORM

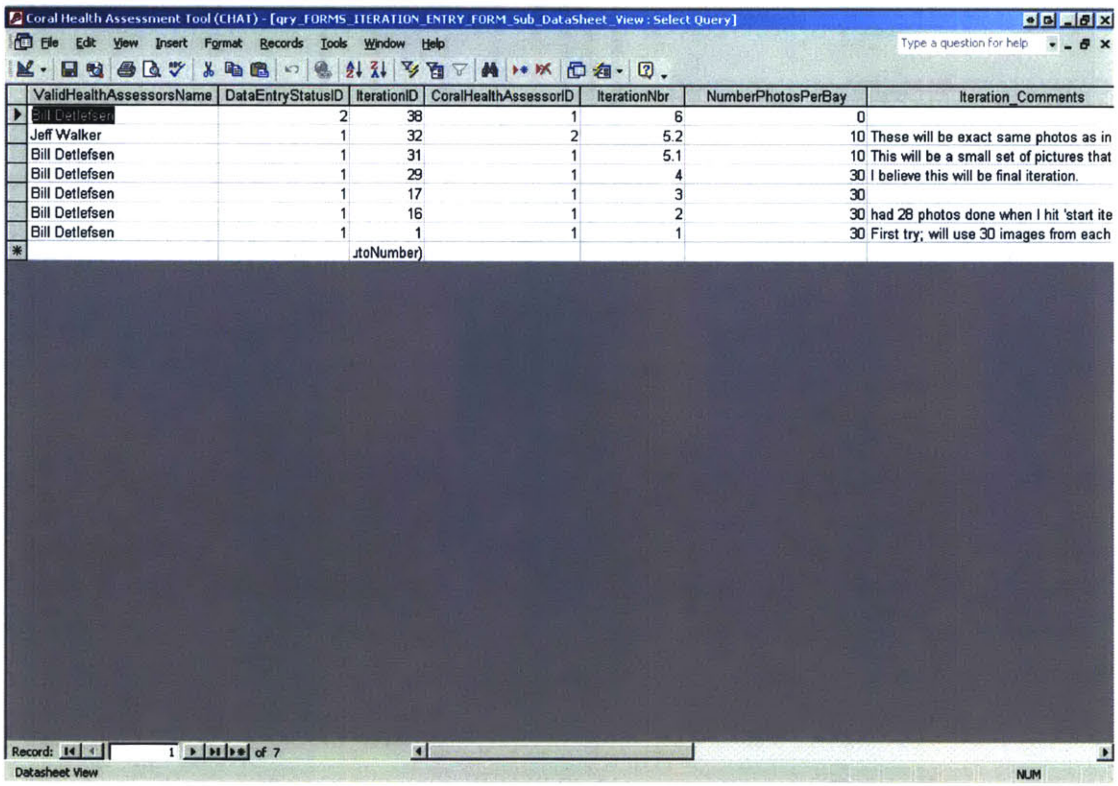
SQL Code

```
SELECT tbl_Iterations.IterationID, tbl_Iterations.CoralHealthAssessorID, tbl_Iterations.IterationNbr,
tbl_Iterations.NumberPhotosPerBay, tbl_Iterations.Iteration_Comments,
tbl_Iterations.DataEntryStatusID, tbl_Iterations.RecordsAlreadyPrePopulatedID,
tbl_Iterations.TimeStarted, tbl_Iterations.TimeCompleted
FROM tbl_Iterations
WHERE (((tbl_Iterations.DataEntryStatusID)<>1));
```



qry_FORMS_ITERATION_ENTRY_FORM_Sub_DataSheet_View

Query Name	Query Type	Description / Comments
qry_FORMS_ITERATION_ENTRY_FORM_Sub_DataSheet_View	Select	Select query for frm_ITERATION_ENTRY_FORM_Sub_DataSheet_View
SQL Code		
SELECT tbl_Valid_Coral_Health_Assessors.ValidHealthAssessorsName, tbl_Iterations.DataEntryStatusID, tbl_Iterations.IterationID, tbl_Iterations.CoralHealthAssessorID, tbl_Iterations.IterationNbr, tbl_Iterations.NumberPhotosPerBay, tbl_Iterations.Iteration_Comments, tbl_Iterations.RecordsAlreadyPrePopulatedID, tbl_Iterations.TimeStarted, tbl_Iterations.TimeCompleted FROM tbl_Valid_Coral_Health_Assessors INNER JOIN tbl_Iterations ON tbl_Valid_Coral_Health_Assessors.ValidHealthAssessorsID = tbl_Iterations.CoralHealthAssessorID ORDER BY tbl_Iterations.IterationNbr DESC;		



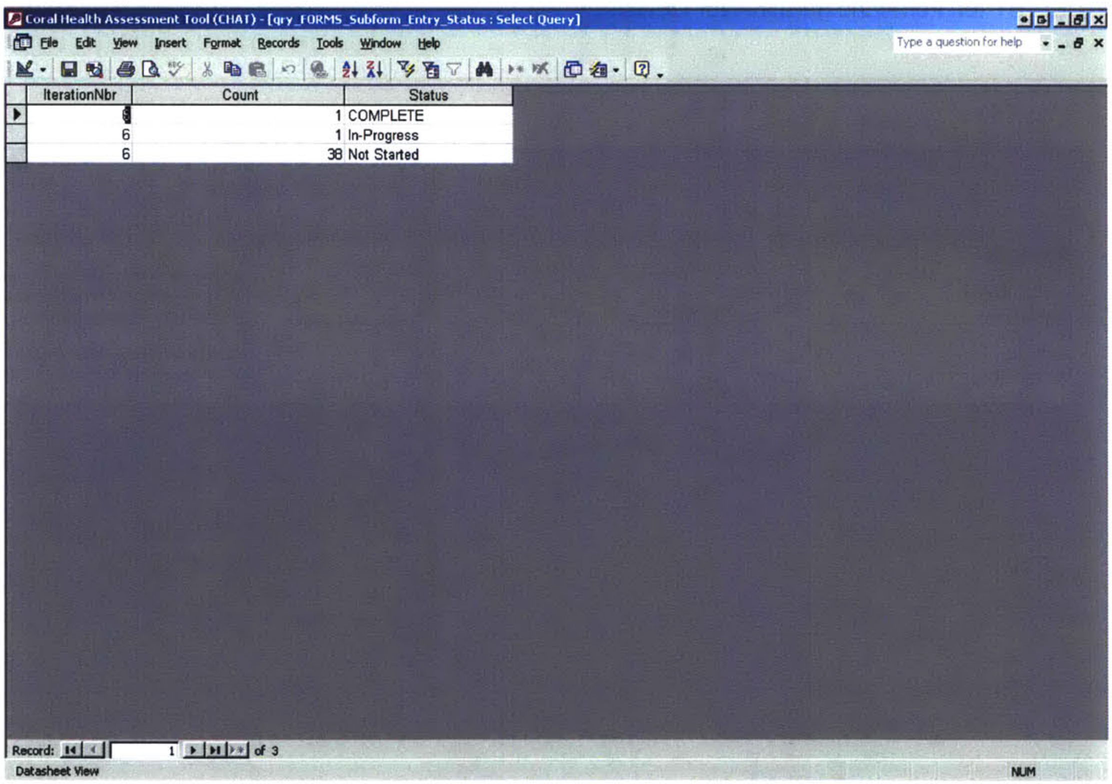
ValidHealthAssessorsName	DataEntryStatusID	IterationID	CoralHealthAssessorID	IterationNbr	NumberPhotosPerBay	Iteration_Comments
Bill Detlefsen	2	38	1	6	0	
Jeff Walker	1	32	2	5.2	10	These will be exact same photos as in
Bill Detlefsen	1	31	1	5.1	10	This will be a small set of pictures that
Bill Detlefsen	1	29	1	4	30	I believe this will be final iteration.
Bill Detlefsen	1	17	1	3	30	
Bill Detlefsen	1	16	1	2	30	had 28 photos done when I hit 'start ite
Bill Detlefsen	1	1	1	1	30	First try; will use 30 images from each
		utoNumber)				

qry_FORMS_Subform_Entry_Status

Query Name	Query Type	Description / Comments
qry_FORMS_Subform_Entry_Status	Select	Select query for frm_Subform_EntryStatus

SQL Code

```
SELECT qry_Photo_Iterations_CountOfPhotosNOTCOMPLETEPerIteration.IterationNbr,
qry_Photo_Iterations_CountOfPhotosNOTCOMPLETEPerIteration.Count,
qry_Photo_Iterations_CountOfPhotosNOTCOMPLETEPerIteration.Status
FROM tbl_CurrentIterationSingleRowTable INNER JOIN
qry_Photo_Iterations_CountOfPhotosNOTCOMPLETEPerIteration ON
tbl_CurrentIterationSingleRowTable.CurrentIterationNbr =
qry_Photo_Iterations_CountOfPhotosNOTCOMPLETEPerIteration.IterationNbr;
```

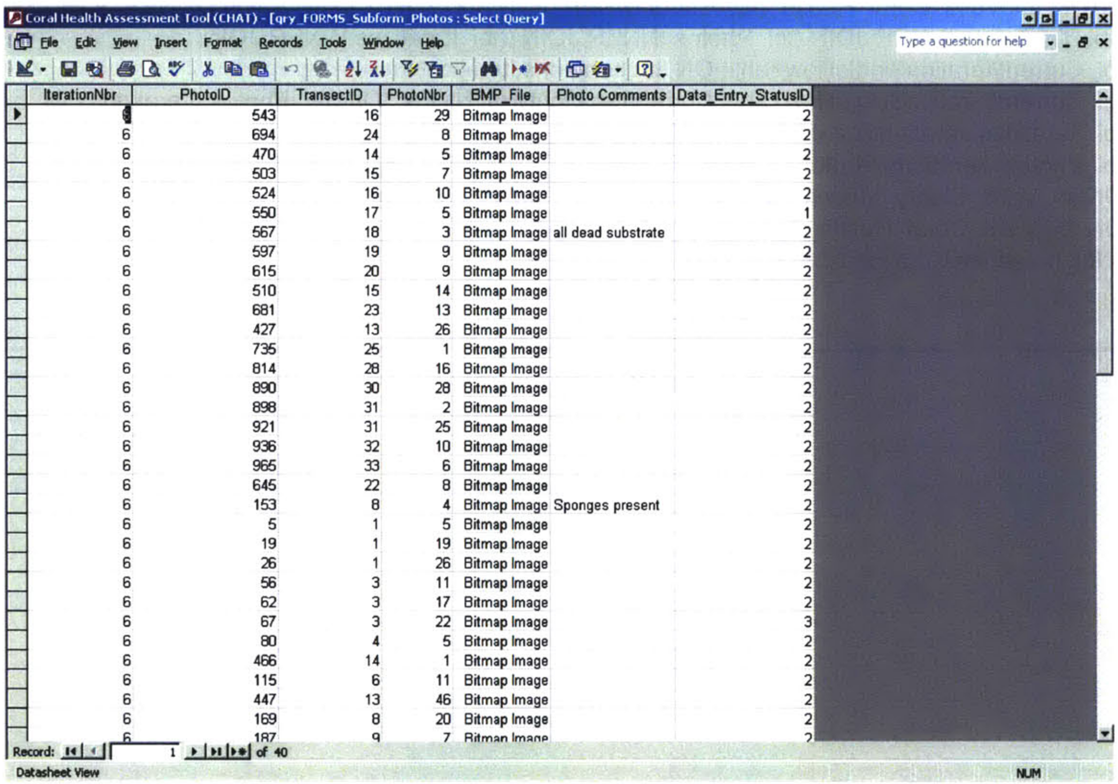


qry_FORMS_Subform_Photos

Query Name	Query Type	Description / Comments
qry_FORMS_Subform_Photos	Select	Select query for frm_Subform_Photos

SQL Code

```
SELECT tbl_Iterations.IterationNbr, tbl_Photos.PhotoID, tbl_Photos.TransectID, tbl_Photos.PhotoNbr,
tbl_Photos.BMP_File, tbl_Photos.[Photo Comments], tbl_Photos_Iterations.Data_Entry_StatusID
FROM tbl_Photos INNER JOIN ((tbl_Iterations INNER JOIN tbl_CurrentIterationSingleRowTable ON
tbl_Iterations.IterationNbr = tbl_CurrentIterationSingleRowTable.CurrentIterationNbr) INNER JOIN
tbl_Photos_Iterations ON tbl_Iterations.IterationID = tbl_Photos_Iterations.IterationID) ON
tbl_Photos.PhotoID = tbl_Photos_Iterations.PhotoID;
```



IterationNbr	PhotoID	TransectID	PhotoNbr	BMP_File	Photo Comments	Data_Entry_StatusID
6	543	16	29	Bitmap Image		2
6	694	24	8	Bitmap Image		2
6	470	14	5	Bitmap Image		2
6	503	15	7	Bitmap Image		2
6	524	16	10	Bitmap Image		2
6	550	17	5	Bitmap Image		1
6	567	18	3	Bitmap Image	all dead substrate	2
6	597	19	9	Bitmap Image		2
6	615	20	9	Bitmap Image		2
6	510	15	14	Bitmap Image		2
6	681	23	13	Bitmap Image		2
6	427	13	26	Bitmap Image		2
6	735	25	1	Bitmap Image		2
6	814	28	16	Bitmap Image		2
6	890	30	28	Bitmap Image		2
6	898	31	2	Bitmap Image		2
6	921	31	25	Bitmap Image		2
6	936	32	10	Bitmap Image		2
6	965	33	6	Bitmap Image		2
6	645	22	8	Bitmap Image		2
6	153	8	4	Bitmap Image	Sponges present	2
6	5	1	5	Bitmap Image		2
6	19	1	19	Bitmap Image		2
6	26	1	26	Bitmap Image		2
6	56	3	11	Bitmap Image		2
6	62	3	17	Bitmap Image		2
6	67	3	22	Bitmap Image		3
6	80	4	5	Bitmap Image		2
6	466	14	1	Bitmap Image		2
6	115	6	11	Bitmap Image		2
6	447	13	46	Bitmap Image		2
6	169	8	20	Bitmap Image		2
6	187	9	7	Bitmap Image		2

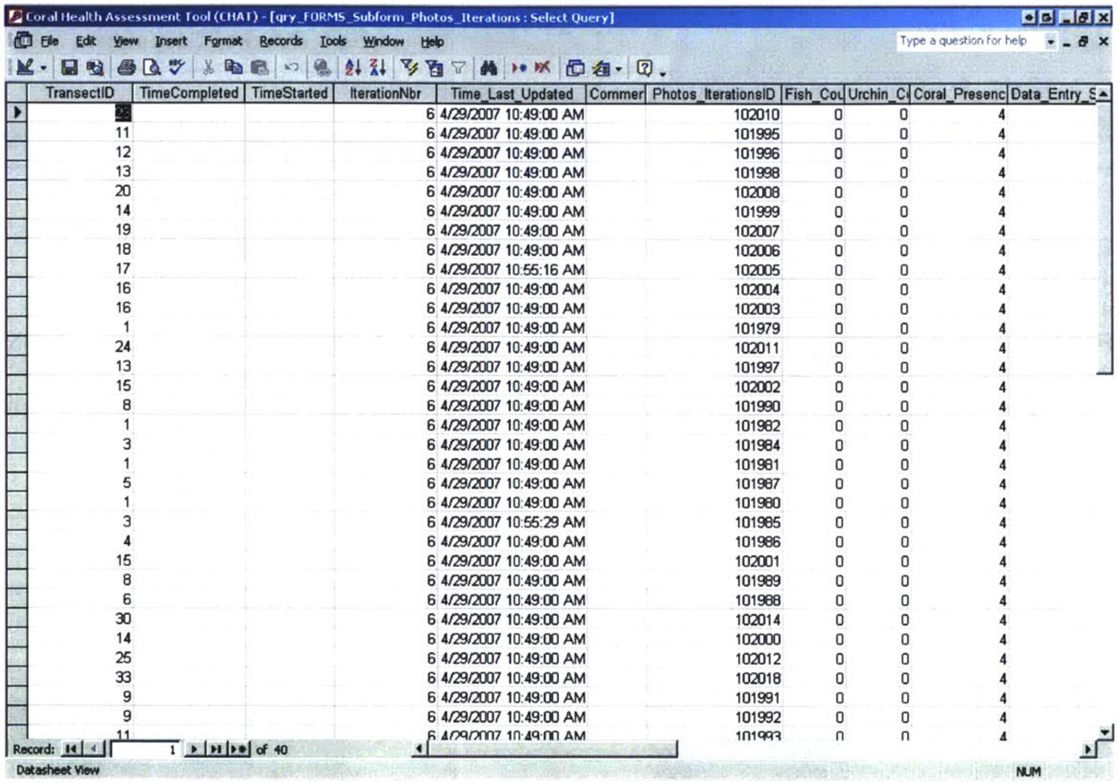
qry_FORMS_Subform_Photos_Iterations

Query Name	Query Type	Description / Comments
qry_FORMS_Subform_Photos_Iterations	Select	Select query for frm_Subform_Photos_Iterations

SQL Code

```
SELECT tbl_Transects.TransectID, tbl_Iterations.TimeCompleted, tbl_Iterations.TimeStarted,
tbl_Iterations.IterationNbr, tbl_Photos_Iterations.Time_Last_Updated, tbl_Photos_Iterations.Comments,
tbl_Photos_Iterations.Photos_IterationsID, tbl_Photos_Iterations.Fish_Count,
tbl_Photos_Iterations.Urchin_Count, tbl_Photos_Iterations.Coral_PresenceID,
tbl_Photos_Iterations.Data_Entry_StatusID, tbl_Iterations.NumberPhotosPerBay,
tbl_Iterations.Iteration_Comments, tbl_Photos_Iterations.PhotoID, tbl_Photos_Iterations.IterationID,
tbl_Valid_Coral_Health_Assessors.ValidHealthAssessorsName, tbl_Photos_Iterations.Photo_ClarityID
FROM tbl_Valid_Coral_Health_Assessors INNER JOIN (tbl_Valid_Clarity_Values INNER JOIN
(tbl_Transects INNER JOIN (tbl_Photos INNER JOIN ((tbl_Iterations INNER JOIN
tbl_CurrentIterationSingleRowTable ON tbl_Iterations.IterationNbr =
tbl_CurrentIterationSingleRowTable.CurrentIterationNbr) INNER JOIN tbl_Photos_Iterations ON
tbl_Iterations.IterationID = tbl_Photos_Iterations.IterationID) ON tbl_Photos.PhotoID =
tbl_Photos_Iterations.PhotoID) ON tbl_Transects.TransectID = tbl_Photos.TransectID)
ON tbl_Valid_Clarity_Values.Valid_ClarityID = tbl_Photos_Iterations.Photo_ClarityID)
ON tbl_Valid_Coral_Health_Assessors.ValidHealthAssessorsID
= tbl_Iterations.CoralHealthAssessorID;
```

qry_FORMS_Subform_Photos_Iterations (cont.)



Coral Health Assessment Tool (CHAT) - [qry_FORMS_Subform_Photos_Iterations : Select Query]

TransectID	TimeCompleted	TimeStarted	IterationNbr	Time_Last_Updated	Commer	Photos_IterationsID	Fish_Cou	Urchin_C	Coral_Presenc	Data_Entry_S
[illegible]			6	4/29/2007 10:49:00 AM		102010	0	0	4	
11			6	4/29/2007 10:49:00 AM		101995	0	0	4	
12			6	4/29/2007 10:49:00 AM		101996	0	0	4	
13			6	4/29/2007 10:49:00 AM		101998	0	0	4	
20			6	4/29/2007 10:49:00 AM		102008	0	0	4	
14			6	4/29/2007 10:49:00 AM		101999	0	0	4	
19			6	4/29/2007 10:49:00 AM		102007	0	0	4	
18			6	4/29/2007 10:49:00 AM		102006	0	0	4	
17			6	4/29/2007 10:55:16 AM		102005	0	0	4	
16			6	4/29/2007 10:49:00 AM		102004	0	0	4	
16			6	4/29/2007 10:49:00 AM		102003	0	0	4	
1			6	4/29/2007 10:49:00 AM		101979	0	0	4	
24			6	4/29/2007 10:49:00 AM		102011	0	0	4	
13			6	4/29/2007 10:49:00 AM		101997	0	0	4	
15			6	4/29/2007 10:49:00 AM		102002	0	0	4	
8			6	4/29/2007 10:49:00 AM		101990	0	0	4	
1			6	4/29/2007 10:49:00 AM		101982	0	0	4	
3			6	4/29/2007 10:49:00 AM		101984	0	0	4	
1			6	4/29/2007 10:49:00 AM		101981	0	0	4	
5			6	4/29/2007 10:49:00 AM		101987	0	0	4	
1			6	4/29/2007 10:49:00 AM		101980	0	0	4	
3			6	4/29/2007 10:55:29 AM		101985	0	0	4	
4			6	4/29/2007 10:49:00 AM		101986	0	0	4	
15			6	4/29/2007 10:49:00 AM		102001	0	0	4	
8			6	4/29/2007 10:49:00 AM		101989	0	0	4	
6			6	4/29/2007 10:49:00 AM		101988	0	0	4	
30			6	4/29/2007 10:49:00 AM		102014	0	0	4	
14			6	4/29/2007 10:49:00 AM		102000	0	0	4	
25			6	4/29/2007 10:49:00 AM		102012	0	0	4	
33			6	4/29/2007 10:49:00 AM		102018	0	0	4	
9			6	4/29/2007 10:49:00 AM		101991	0	0	4	
9			6	4/29/2007 10:49:00 AM		101992	0	0	4	
11			6	4/29/2007 10:49:00 AM		101993	0	0	4	

Record: 1 of 40

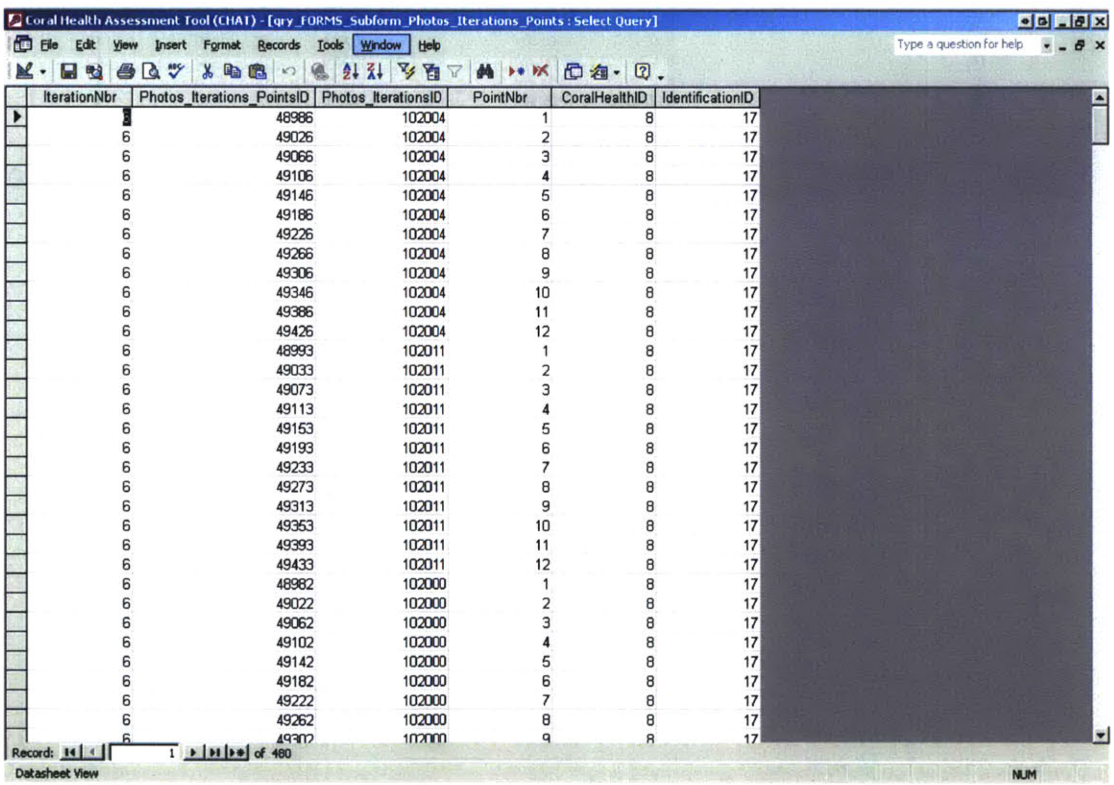
Datasheet View

qry_FORMS_Subform_Photos_Iterations_Points

Query Name	Query Type	Description / Comments
qry_FORMS_Subform_Photos_Iterations_Points	Select	Select query for frm_Subform_Photos_Iterations_Points

SQL Code

```
SELECT tbl_Iterations.IterationNbr, tbl_Photos_Iterations_Points.Photos_Iterations_PointsID,
tbl_Photos_Iterations_Points.Photos_IterationsID, tbl_Photos_Iterations_Points.PointNbr,
tbl_Photos_Iterations_Points.CoralHealthID, tbl_Photos_Iterations_Points.IdentificationID
FROM ((tbl_Iterations INNER JOIN tbl_CurrentIterationSingleRowTable ON tbl_Iterations.IterationNbr =
tbl_CurrentIterationSingleRowTable.CurrentIterationNbr) INNER JOIN tbl_Photos_Iterations ON
tbl_Iterations.IterationID = tbl_Photos_Iterations.IterationID) INNER JOIN tbl_Photos_Iterations_Points
ON tbl_Photos_Iterations.Photos_IterationsID = tbl_Photos_Iterations_Points.Photos_IterationsID;
```



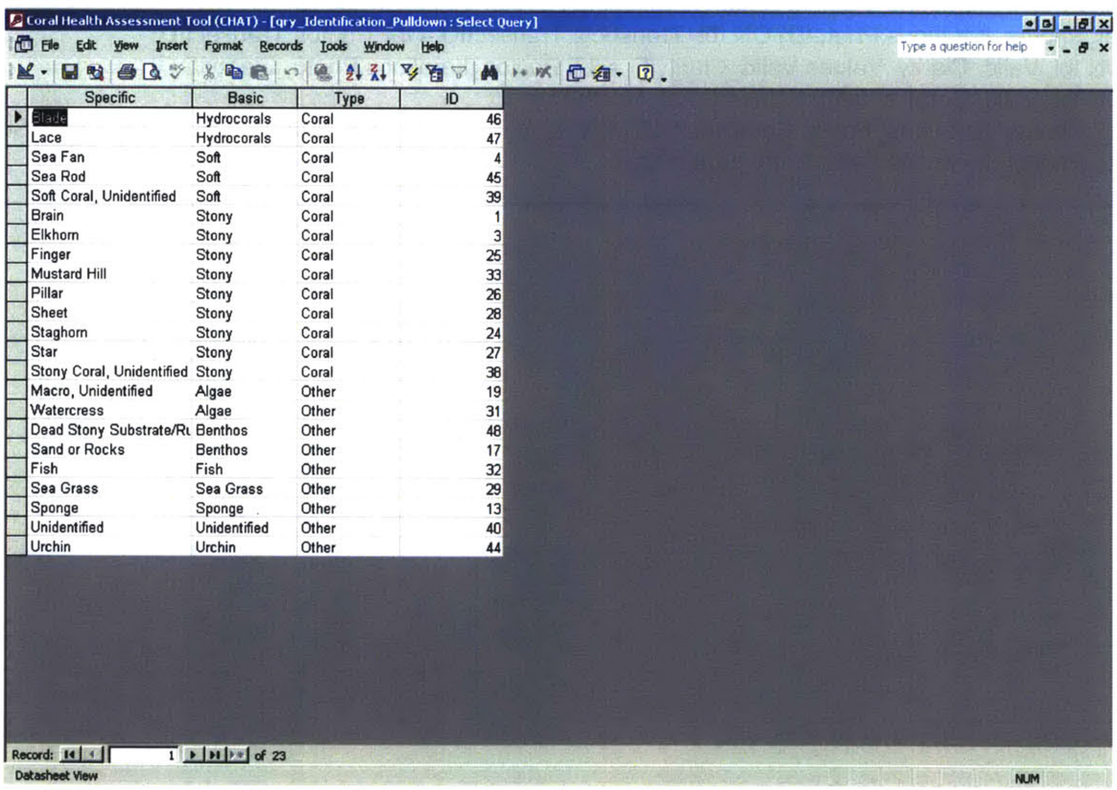
IterationNbr	Photos_Iterations_PointsID	Photos_IterationsID	PointNbr	CoralHealthID	IdentificationID
6	48986	102004	1	8	17
6	49026	102004	2	8	17
6	49066	102004	3	8	17
6	49106	102004	4	8	17
6	49146	102004	5	8	17
6	49186	102004	6	8	17
6	49226	102004	7	8	17
6	49266	102004	8	8	17
6	49306	102004	9	8	17
6	49346	102004	10	8	17
6	49386	102004	11	8	17
6	49426	102004	12	8	17
6	48993	102011	1	8	17
6	49033	102011	2	8	17
6	49073	102011	3	8	17
6	49113	102011	4	8	17
6	49153	102011	5	8	17
6	49193	102011	6	8	17
6	49233	102011	7	8	17
6	49273	102011	8	8	17
6	49313	102011	9	8	17
6	49353	102011	10	8	17
6	49393	102011	11	8	17
6	49433	102011	12	8	17
6	48982	102000	1	8	17
6	49022	102000	2	8	17
6	49062	102000	3	8	17
6	49102	102000	4	8	17
6	49142	102000	5	8	17
6	49182	102000	6	8	17
6	49222	102000	7	8	17
6	49262	102000	8	8	17
6	49302	102000	9	8	17

qry_Identification_Pulldown

Query Name	Query Type	Description / Comments
qry_Identification_Pulldown	Select	Populates Identification Pulldown menu in frm_Subform_Photos_Iterations_Points

SQL Code

```
SELECT tbl_2_Specific.Specific_Desc AS Specific, tbl_1_Basic.Basic_Desc AS Basic,
tbl_0_Type.Type_Desc AS Type, tbl_2_Specific.Level_2_ID AS ID
FROM (tbl_0_Type INNER JOIN tbl_1_Basic ON tbl_0_Type.Level_0_ID=tbl_1_Basic.Level_0_ID)
INNER JOIN tbl_2_Specific ON tbl_1_Basic.Level_1_ID=tbl_2_Specific.Level_1_ID
GROUP BY tbl_2_Specific.Specific_Desc, tbl_1_Basic.Basic_Desc, tbl_0_Type.Type_Desc,
tbl_2_Specific.Level_2_ID
ORDER BY tbl_0_Type.Type_Desc, tbl_1_Basic.Basic_Desc, tbl_2_Specific.Specific_Desc,
tbl_2_Specific.Level_2_ID;
```



Specific	Basic	Type	ID
Blade	Hydrocorals	Coral	46
Lace	Hydrocorals	Coral	47
Sea Fan	Soft	Coral	4
Sea Rod	Soft	Coral	45
Soft Coral, Unidentified	Soft	Coral	39
Brain	Stony	Coral	1
Elkhorn	Stony	Coral	3
Finger	Stony	Coral	25
Mustard Hill	Stony	Coral	33
Pillar	Stony	Coral	26
Sheet	Stony	Coral	28
Staghorn	Stony	Coral	24
Star	Stony	Coral	27
Stony Coral, Unidentified	Stony	Coral	38
Macro, Unidentified	Algae	Other	19
Watercress	Algae	Other	31
Dead Stony Substrate/Rı	Benthos	Other	48
Sand or Rocks	Benthos	Other	17
Fish	Fish	Other	32
Sea Grass	Sea Grass	Other	29
Sponge	Sponge	Other	13
Unidentified	Unidentified	Other	40
Urchin	Urchin	Other	44

qry_PIVOT_1_CORAL_ID_AND_HEALTH

Query Name	Query Type	Description / Comments
qry_PIVOT_1_CORAL_ID_AND_HEALTH	Select	Linked to Pivot Table 1

SQL Code

```
SELECT tbl_General_Locations.GeneralLocation,
tbl_Valid_Data_Entry_Status.Valid_Data_Entry_Status, tbl_Bays.BayName, tbl_Transects.TransectNbr,
tbl_Iterations.IterationNbr, tbl_Valid_Clarity_Values.Valid_Clarity AS Photo_Clarity,
tbl_Transects.Avg_Depth, tbl_0_Type.Type_Desc, tbl_1_Basic.Basic_Desc,
tbl_2_Specific.Specific_Desc, tbl_Valid_Coral_Health_Values.Valid_Coral_Health_Values AS
Coral_Health, tbl_Photos_Iterations_Points.PointNbr AS Point
FROM tbl_Valid_Data_Entry_Status INNER JOIN (tbl_Valid_Coral_Health_Values INNER JOIN
(tbl_Valid_Clarity_Values INNER JOIN ((tbl_General_Locations INNER JOIN ((tbl_Bays INNER JOIN
tbl_Events ON tbl_Bays.BayID = tbl_Events.BayID) INNER JOIN tbl_Transects ON tbl_Events.EventID
= tbl_Transects.EventID) ON tbl_General_Locations.GeneralLocationID = tbl_Bays.GeneralLocationID)
INNER JOIN (tbl_Photos INNER JOIN ((tbl_Iterations INNER JOIN tbl_Photos_Iterations ON
tbl_Iterations.IterationID = tbl_Photos_Iterations.IterationID)
INNER JOIN (((tbl_0_Type INNER JOIN tbl_1_Basic ON tbl_0_Type.Level_0_ID =
tbl_1_Basic.Level_0_ID) INNER JOIN tbl_2_Specific ON tbl_1_Basic.Level_1_ID = tbl_2_Specific.Level
tbl_Photos_Iterations_Points.Photos_IterationsID) ON tbl_Photos.PhotoID =
tbl_Photos_Iterations.PhotoID) ON tbl_Transects.TransectID = tbl_Photos.TransectID)
ON tbl_Valid_Clarity_Values.Valid_ClarityID = tbl_Photos_Iterations.Photo_ClarityID)
ON tbl_Valid_Coral_Health_Values.Coral_HeathID =
tbl_Photos_Iterations_Points.CoralHealthID) ON tbl_Valid_Data_Entry_Status.Valid_Data_Entry_Status
tbl_Photos_Iterations.Data_Entry_StatusID;
```

qry_PIVOT_1_CORAL_ID_AND_HEALTH (cont.)

Coral Health Assessment Tool (CHAT) - [qry_PIVOT_1_CORAL_ID_AND_HEALTH : Select Query]

GeneralLocation	Valid_Data_Entry_Status	BayName	TransectNbr	IterationNbr	Photo_Clarity	Avg_Depth	Type_Desc	Basic_Desc	Specific_Desc
St. John	COMPLETE	Round Bay	5	1	Moderate	6	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Round Bay	5	1	Moderate	6	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Round Bay	5	1	Moderate	6	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Round Bay	5	1	Moderate	6	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Round Bay	5	1	Moderate	6	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Round Bay	5	1	Moderate	6	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Round Bay	5	1	Moderate	6	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Round Bay	5	1	Moderate	6	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Round Bay	5	1	Moderate	6	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Round Bay	5	1	Moderate	6	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Round Bay	5	1	Moderate	6	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Round Bay	5	1	Moderate	6	Coral	Stony	Mustard Hill
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Algae	Macro, Unidentified
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Algae	Macro, Unidentified
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Coral	Stony	Mustard Hill
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Algae	Macro, Unidentified
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Algae	Macro, Unidentified
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Algae	Macro, Unidentified
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Algae	Macro, Unidentified
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Algae	Macro, Unidentified
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Algae	Macro, Unidentified
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Algae	Macro, Unidentified
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Benthos	Sand or Rocks
St. John	COMPLETE	Reef Bay	3	2	Moderate	5.5	Other	Benthos	Sand or Rocks

Record: 1 of 7200

Datasheet View

qry_PIVOT_2_PHOTOCOUNT

Query Name	Query Type	Description / Comments
qry_PIVOT_2_PHOTOCOUNT	Select	Linked to Pivot Table 2

SQL Code

```
SELECT DISTINCTROW tbl_General_Locations.GeneralLocation, tbl_Bays.BayName,
tbl_Iterations.IterationNbr, tbl_Transects.TransectNbr, tbl_Events.Date,
qry_PIVOT_2_Sub_PhotoCount.Photo_ClarityID, qry_PIVOT_2_Sub_PhotoCount.PhotoCount,
qry_PIVOT_2_Sub_PhotoCount.Sum_of_Fish_Count,
qry_PIVOT_2_Sub_PhotoCount.Sum_of_Urchin_Count, qry_PIVOT_2_Sub_PhotoCount.Valid_Clarity
FROM tbl_Photos INNER JOIN ((tbl_General_Locations INNER JOIN ((tbl_Bays INNER JOIN
tbl_Events ON tbl_Bays.BayID = tbl_Events.BayID) INNER JOIN
(tbl_Transects INNER JOIN (tbl_Iterations INNER JOIN qry_PIVOT_2_Sub_PhotoCount ON
tbl_Iterations.IterationID =
qry_PIVOT_2_Sub_PhotoCount.IterationID) ON tbl_Transects.TransectID =
qry_PIVOT_2_Sub_PhotoCount.TransectID) ON tbl_Events.EventID =
tbl_Transects.EventID) ON tbl_General_Locations.GeneralLocationID = tbl_Bays.GeneralLocationID)
INNER JOIN tbl_Photos_Iterations ON
tbl_Iterations.IterationID = tbl_Photos_Iterations.IterationID) ON (tbl_Transects.TransectID =
tbl_Photos.TransectID) AND (tbl_Photos.PhotoID =
tbl_Photos_Iterations.PhotoID)
GROUP BY tbl_General_Locations.GeneralLocation, tbl_Bays.BayName,
tbl_Iterations.IterationNbr, tbl_Transects.TransectNbr, tbl_Events.Date,
qry_PIVOT_2_Sub_PhotoCount.Photo_ClarityID, qry_PIVOT_2_Sub_PhotoCount.PhotoCount,
qry_PIVOT_2_Sub_PhotoCount.Sum_of_Fish_Count, qry_PIVOT_2_Sub_PhotoCount.Sum_of_Urchin_
qry_PIVOT_2_Sub_PhotoCount.Valid_Clarity;
```

qry_PIVOT_2_PHOTOCOUNT (cont.)

Coral Health Assessment Tool (CHAT) - [qry_PIVOT_2_PHOTOCOUNT : Select Query]

GeneralLocation	BayName	IterationNbr	TransectNbr	Date	Photo_ClarityID	PhotoCount	Sum_of_Fish_Count	Sum_of_Urchin_Count	Valid_(
St. John	Fish Bay	1	1	1/23/2007	4	7	0	0	Poor
St. John	Fish Bay	1	1	1/23/2007	6	2	0	0	Moderate
St. John	Fish Bay	1	2	1/23/2007	4	1	0	0	Poor
St. John	Fish Bay	1	2	1/23/2007	5	1	0	0	Useless
St. John	Fish Bay	1	3	1/23/2007	4	3	4	0	Poor
St. John	Fish Bay	1	3	1/23/2007	6	3	0	0	Moderate
St. John	Fish Bay	1	5	1/23/2007	4	2	0	0	Poor
St. John	Fish Bay	1	5	1/23/2007	5	1	0	0	Useless
St. John	Fish Bay	1	5	1/23/2007	6	2	1	0	Moderate
St. John	Fish Bay	1	6	1/23/2007	4	2	0	0	Poor
St. John	Fish Bay	1	6	1/23/2007	5	1	0	0	Useless
St. John	Fish Bay	1	7	1/23/2007	4	5	0	0	Poor
St. John	Fish Bay	2	1	1/23/2007	4	4	0	0	Poor
St. John	Fish Bay	2	1	1/23/2007	5	1	0	0	Useless
St. John	Fish Bay	2	1	1/23/2007	6	1	0	0	Moderate
St. John	Fish Bay	2	2	1/23/2007	4	1	0	0	Poor
St. John	Fish Bay	2	2	1/23/2007	5	1	0	0	Useless
St. John	Fish Bay	2	2	1/23/2007	6	2	0	0	Moderate
St. John	Fish Bay	2	3	1/23/2007	4	3	0	0	Poor
St. John	Fish Bay	2	3	1/23/2007	6	4	0	0	Moderate
St. John	Fish Bay	2	5	1/23/2007	4	1	0	0	Poor
St. John	Fish Bay	2	6	1/23/2007	4	6	0	0	Poor
St. John	Fish Bay	2	7	1/23/2007	4	3	0	0	Poor
St. John	Fish Bay	2	7	1/23/2007	5	1	0	0	Useless
St. John	Fish Bay	2	7	1/23/2007	6	2	0	0	Moderate
St. John	Fish Bay	3	1	1/23/2007	4	1	0	0	Poor
St. John	Fish Bay	3	1	1/23/2007	6	4	0	0	Moderate
St. John	Fish Bay	3	2	1/23/2007	4	2	0	0	Poor
St. John	Fish Bay	3	3	1/23/2007	4	3	0	0	Poor
St. John	Fish Bay	3	3	1/23/2007	6	4	1	0	Moderate
St. John	Fish Bay	3	5	1/23/2007	1	1	0	0	Excellent
St. John	Fish Bay	3	5	1/23/2007	4	2	0	0	Poor
St. John	Fish Bay	3	5	1/23/2007	5	2	0	0	Useless

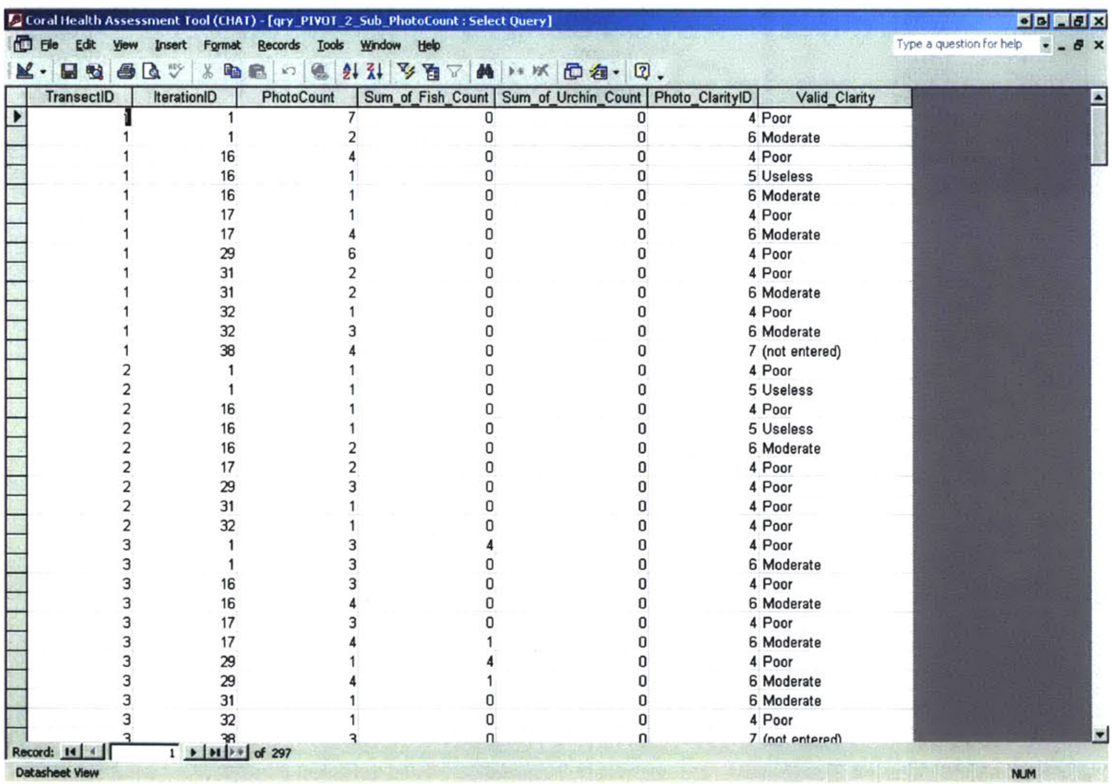
Record: 1 of 297

Datasheet View

qry_PIVOT_2_Sub_PhotoCount

Query Name	Query Type	Description / Comments
qry_PIVOT_2_Sub_PhotoCount	Select	Sub-query to qry_PIVOT_2_PHOTOCOUNT
SQL Code		

```
SELECT tbl_Photos.TransectID, tbl_Photos_Iterations.IterationID, Count(tbl_Photos.PhotoID) AS
PhotoCount, Sum(tbl_Photos_Iterations.Fish_Count) AS Sum_of_Fish_Count,
Sum(tbl_Photos_Iterations.Urchin_Count) AS Sum_of_Urchin_Count,
tbl_Photos_Iterations.Photo_ClarityID, tbl_Valid_Clarity_Values.Valid_Clarity
FROM tbl_Valid_Clarity_Values INNER JOIN (tbl_Photos INNER JOIN tbl_Photos_Iterations ON
tbl_Photos.PhotoID = tbl_Photos_Iterations.PhotoID) ON tbl_Valid_Clarity_Values.Valid_ClarityID =
tbl_Photos_Iterations.Photo_ClarityID
GROUP BY tbl_Photos.TransectID, tbl_Photos_Iterations.IterationID,
tbl_Photos_Iterations.Photo_ClarityID, tbl_Valid_Clarity_Values.Valid_Clarity;
```

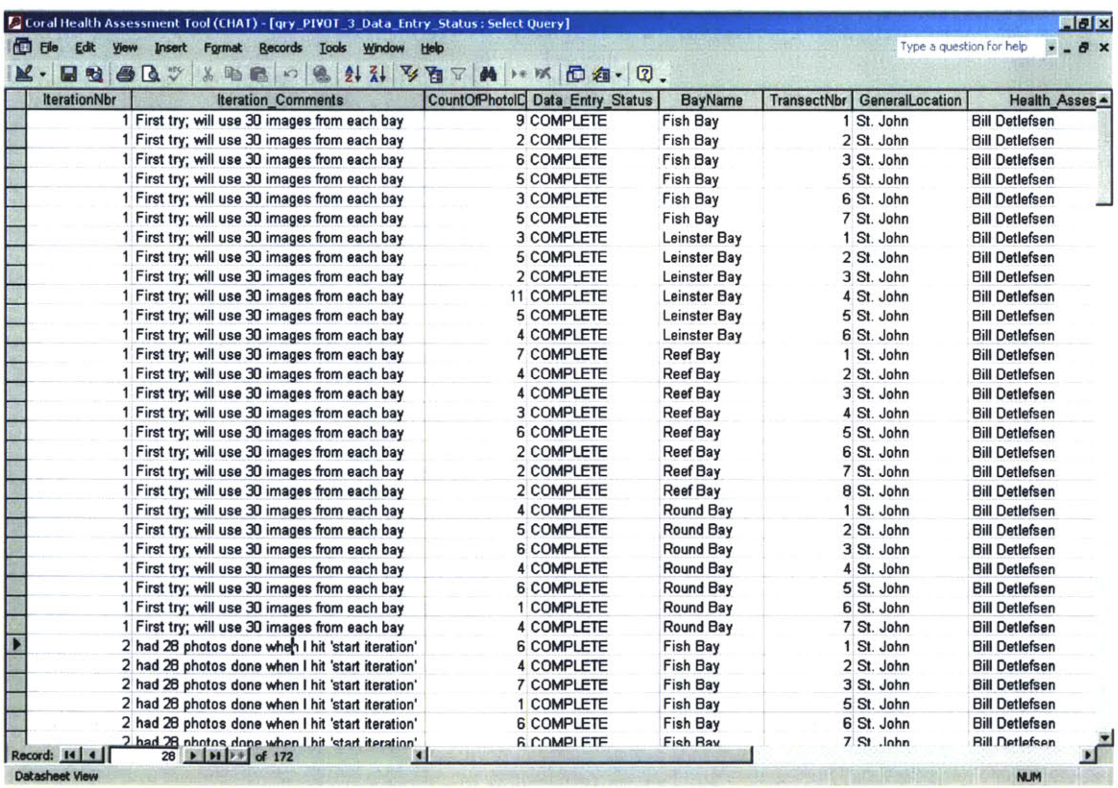


TransectID	IterationID	PhotoCount	Sum_of_Fish_Count	Sum_of_Urchin_Count	Photo_ClarityID	Valid_Clarity
1	1	7	0	0	4	Poor
1	1	2	0	0	6	Moderate
1	16	4	0	0	4	Poor
1	16	1	0	0	5	Useless
1	16	1	0	0	6	Moderate
1	17	1	0	0	4	Poor
1	17	4	0	0	6	Moderate
1	29	6	0	0	4	Poor
1	31	2	0	0	4	Poor
1	31	2	0	0	6	Moderate
1	32	1	0	0	4	Poor
1	32	3	0	0	6	Moderate
1	38	4	0	0	7	(not entered)
2	1	1	0	0	4	Poor
2	1	1	0	0	5	Useless
2	16	1	0	0	4	Poor
2	16	1	0	0	5	Useless
2	16	2	0	0	6	Moderate
2	17	2	0	0	4	Poor
2	29	3	0	0	4	Poor
2	31	1	0	0	4	Poor
2	32	1	0	0	4	Poor
3	1	3	4	0	4	Poor
3	1	3	0	0	6	Moderate
3	16	3	0	0	4	Poor
3	16	4	0	0	6	Moderate
3	17	3	0	0	4	Poor
3	17	4	1	0	6	Moderate
3	29	1	4	0	4	Poor
3	29	4	1	0	6	Moderate
3	31	1	0	0	6	Moderate
3	32	1	0	0	4	Poor
3	38	3	0	0	7	(not entered)

qry_PIVOT_3_Data_Entry_Status

Query Name	Query Type	Description / Comments
qry_PIVOT_3_Data_Entry_Status	Select	Linked to Pivot Table Pivot 3
SQL Code		

```
SELECT tbl_Iterations.IterationNbr, tbl_Iterations.Iteration_Comments,
Count(tbl_Photos_Iterations.PhotoID) AS CountOfPhotoID,
tbl_Valid_Data_Entry_Status.Valid_Data_Entry_Status AS Data_Entry_Status, tbl_Bays.BayName,
tbl_Transects.TransectNbr, tbl_General_Locations.GeneralLocation,
tbl_Valid_Coral_Health_Assessors.ValidHealthAssessorsName AS Health_Assessor
FROM tbl_Valid_Data_Entry_Status INNER JOIN (tbl_Valid_Coral_Health_Assessors INNER JOIN
((tbl_General_Locations INNER JOIN ((tbl_Bays INNER JOIN tbl_Events ON tbl_Bays.BayID =
tbl_Events.BayID) INNER JOIN tbl_Transects ON tbl_Events.EventID = tbl_Transects.EventID) ON
tbl_General_Locations.GeneralLocationID = tbl_Bays.GeneralLocationID) INNER JOIN (tbl_Photos
INNER JOIN (tbl_Iterations INNER JOIN tbl_Photos_Iterations ON tbl_Iterations.IterationID =
tbl_Photos_Iterations.IterationID) ON tbl_Photos.PhotoID = tbl_Photos_Iterations.PhotoID) ON
tbl_Transects.TransectID = tbl_Photos.TransectID) ON
tbl_Valid_Coral_Health_Assessors.ValidHealthAssessorsID = tbl_Iterations.CoralHealthAssessorID)
ON tbl_Valid_Data_Entry_Status.Valid_Data_Entry_StatusID = tbl_Photos_Iterations.Data_Entry_Status
GROUP BY tbl_Iterations.IterationNbr, tbl_Iterations.Iteration_Comments, tbl_Valid_Data_Entry_Status.
```



Coral Health Assessment Tool (CHAT) - [qry_PIVOT_3_Data_Entry_Status : Select Query]

IterationNbr	Iteration_Comments	CountOfPhotoID	Data_Entry_Status	BayName	TransectNbr	GeneralLocation	Health_Asses
1	First try; will use 30 images from each bay	9	COMPLETE	Fish Bay	1	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	2	COMPLETE	Fish Bay	2	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	6	COMPLETE	Fish Bay	3	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	5	COMPLETE	Fish Bay	5	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	3	COMPLETE	Fish Bay	6	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	5	COMPLETE	Fish Bay	7	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	3	COMPLETE	Leinster Bay	1	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	5	COMPLETE	Leinster Bay	2	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	2	COMPLETE	Leinster Bay	3	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	11	COMPLETE	Leinster Bay	4	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	5	COMPLETE	Leinster Bay	5	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	4	COMPLETE	Leinster Bay	6	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	7	COMPLETE	Reef Bay	1	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	4	COMPLETE	Reef Bay	2	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	4	COMPLETE	Reef Bay	3	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	3	COMPLETE	Reef Bay	4	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	6	COMPLETE	Reef Bay	5	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	2	COMPLETE	Reef Bay	6	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	2	COMPLETE	Reef Bay	7	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	2	COMPLETE	Reef Bay	8	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	4	COMPLETE	Round Bay	1	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	5	COMPLETE	Round Bay	2	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	6	COMPLETE	Round Bay	3	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	4	COMPLETE	Round Bay	4	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	6	COMPLETE	Round Bay	5	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	1	COMPLETE	Round Bay	6	St. John	Bill Detlefsen
1	First try; will use 30 images from each bay	4	COMPLETE	Round Bay	7	St. John	Bill Detlefsen
2	had 28 photos done when I hit 'start iteration'	6	COMPLETE	Fish Bay	1	St. John	Bill Detlefsen
2	had 28 photos done when I hit 'start iteration'	4	COMPLETE	Fish Bay	2	St. John	Bill Detlefsen
2	had 28 photos done when I hit 'start iteration'	7	COMPLETE	Fish Bay	3	St. John	Bill Detlefsen
2	had 28 photos done when I hit 'start iteration'	1	COMPLETE	Fish Bay	5	St. John	Bill Detlefsen
2	had 28 photos done when I hit 'start iteration'	6	COMPLETE	Fish Bay	6	St. John	Bill Detlefsen
2	had 28 photos done when I hit 'start iteration'	6	COMPLETE	Fish Bay	7	St. John	Bill Detlefsen

Record: 28 of 172

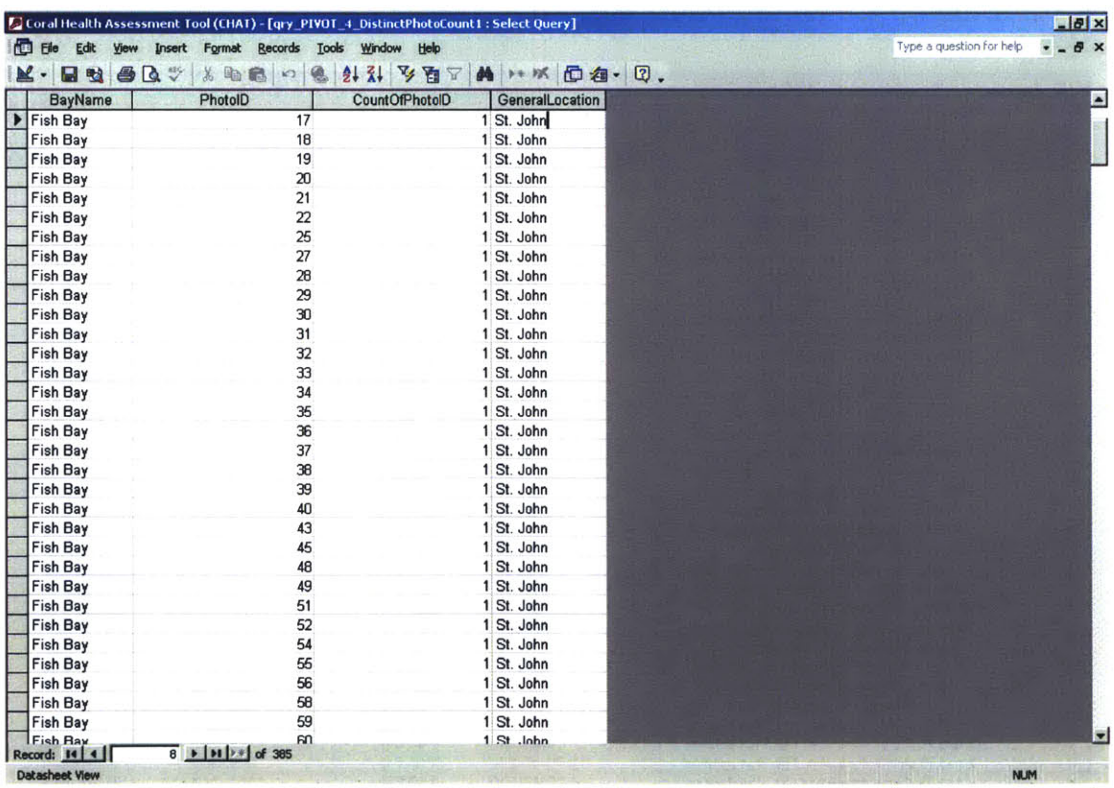
Datasheet View

qry_PIVOT_4_DistinctPhotoCount1

Query Name	Query Type	Description / Comments
qry_PIVOT_4_DistinctPhotoCount1	Select	Linked to Pivot Table Pivot 4; specifically provides output for Iterations 1-4 in this case.

SQL Code

```
SELECT DISTINCT tbl_Bays.BayName, tbl_Photos.PhotoID, Count(tbl_Photos_Iterations.PhotoID) AS
CountOfPhotoID, tbl_General_Locations.GeneralLocation
FROM (tbl_General_Locations INNER JOIN ((tbl_Bays INNER JOIN tbl_Events ON tbl_Bays.BayID =
tbl_Events.BayID) INNER JOIN tbl_Transects ON tbl_Events.EventID = tbl_Transects.EventID) ON
tbl_General_Locations.GeneralLocationID = tbl_Bays.GeneralLocationID) INNER JOIN (tbl_Photos
INNER JOIN (tbl_Iterations INNER JOIN tbl_Photos_Iterations ON tbl_Iterations.IterationID =
tbl_Photos_Iterations.IterationID) ON tbl_Photos.PhotoID = tbl_Photos_Iterations.PhotoID) ON
tbl_Transects.TransectID = tbl_Photos.TransectID
GROUP BY tbl_Bays.BayName, tbl_Photos.PhotoID, tbl_General_Locations.GeneralLocation,
tbl_Iterations.IterationNbr
HAVING (((tbl_Iterations.IterationNbr) In (1,2,3,4)));
```



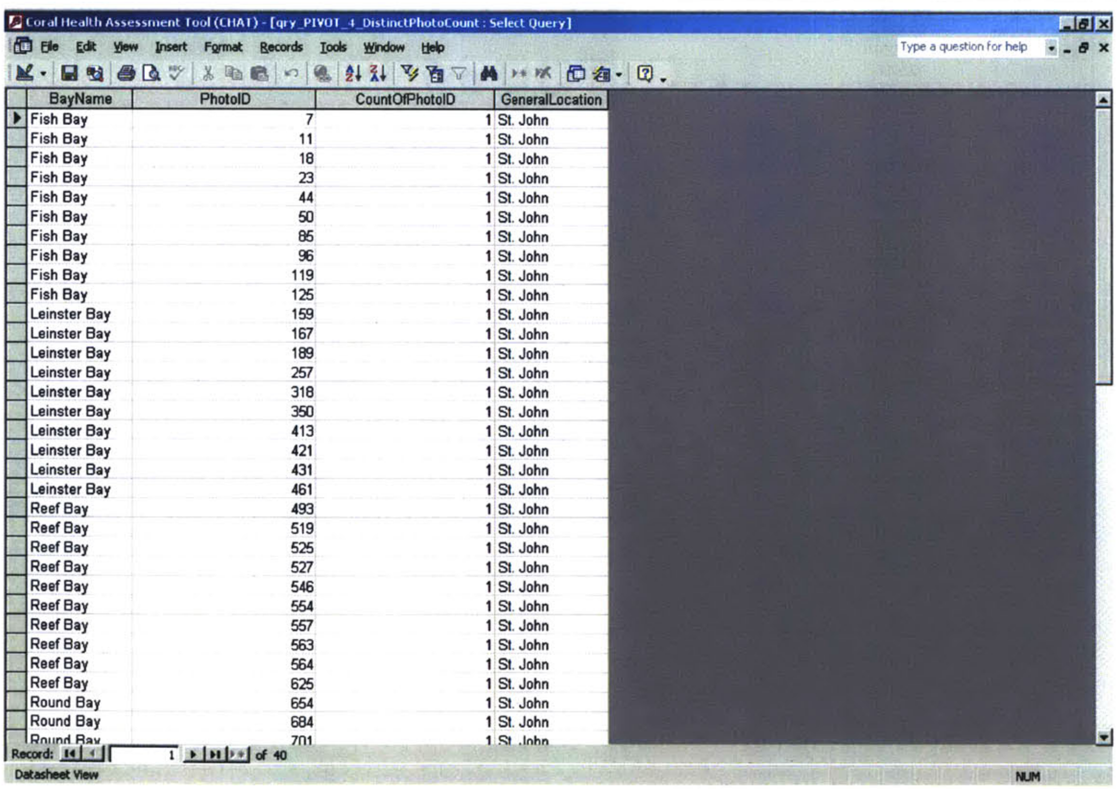
BayName	PhotoID	CountOfPhotoID	GeneralLocation
Fish Bay	17	1	St. John
Fish Bay	18	1	St. John
Fish Bay	19	1	St. John
Fish Bay	20	1	St. John
Fish Bay	21	1	St. John
Fish Bay	22	1	St. John
Fish Bay	25	1	St. John
Fish Bay	27	1	St. John
Fish Bay	28	1	St. John
Fish Bay	29	1	St. John
Fish Bay	30	1	St. John
Fish Bay	31	1	St. John
Fish Bay	32	1	St. John
Fish Bay	33	1	St. John
Fish Bay	34	1	St. John
Fish Bay	35	1	St. John
Fish Bay	36	1	St. John
Fish Bay	37	1	St. John
Fish Bay	38	1	St. John
Fish Bay	39	1	St. John
Fish Bay	40	1	St. John
Fish Bay	43	1	St. John
Fish Bay	45	1	St. John
Fish Bay	48	1	St. John
Fish Bay	49	1	St. John
Fish Bay	51	1	St. John
Fish Bay	52	1	St. John
Fish Bay	54	1	St. John
Fish Bay	55	1	St. John
Fish Bay	56	1	St. John
Fish Bay	58	1	St. John
Fish Bay	59	1	St. John
Fish Bay	60	1	St. John

qry_PIVOT_4_DistinctPhotoCount

Query Name	Query Type	Description / Comments
qry_PIVOT_4_DistinctPhotoCount	Select	Linked to Pivot Table Pivot 4; specifically provides output for QA/QC Iterations 5.1 & 5.2 in this case.

SQL Code

```
SELECT DISTINCT tbl_Bays.BayName, tbl_Photos.PhotoID, Count(tbl_Photos_Iterations.PhotoID) AS
CountOfPhotoID, tbl_General_Locations.GeneralLocation
FROM (tbl_General_Locations INNER JOIN ((tbl_Bays INNER JOIN tbl_Events ON tbl_Bays.BayID =
tbl_Events.BayID) INNER JOIN tbl_Transects ON tbl_Events.EventID = tbl_Transects.EventID) ON
tbl_General_Locations.GeneralLocationID = tbl_Bays.GeneralLocationID) INNER JOIN (tbl_Photos
INNER JOIN (tbl_Iterations INNER JOIN tbl_Photos_Iterations ON tbl_Iterations.IterationID =
tbl_Photos_Iterations.IterationID) ON tbl_Photos.PhotoID = tbl_Photos_Iterations.PhotoID) ON
tbl_Transects.TransectID = tbl_Photos.TransectID
GROUP BY tbl_Bays.BayName, tbl_Photos.PhotoID, tbl_General_Locations.GeneralLocation,
tbl_Iterations.IterationNbr
HAVING (((tbl_Iterations.IterationNbr) In (5.1,5.2)));
```



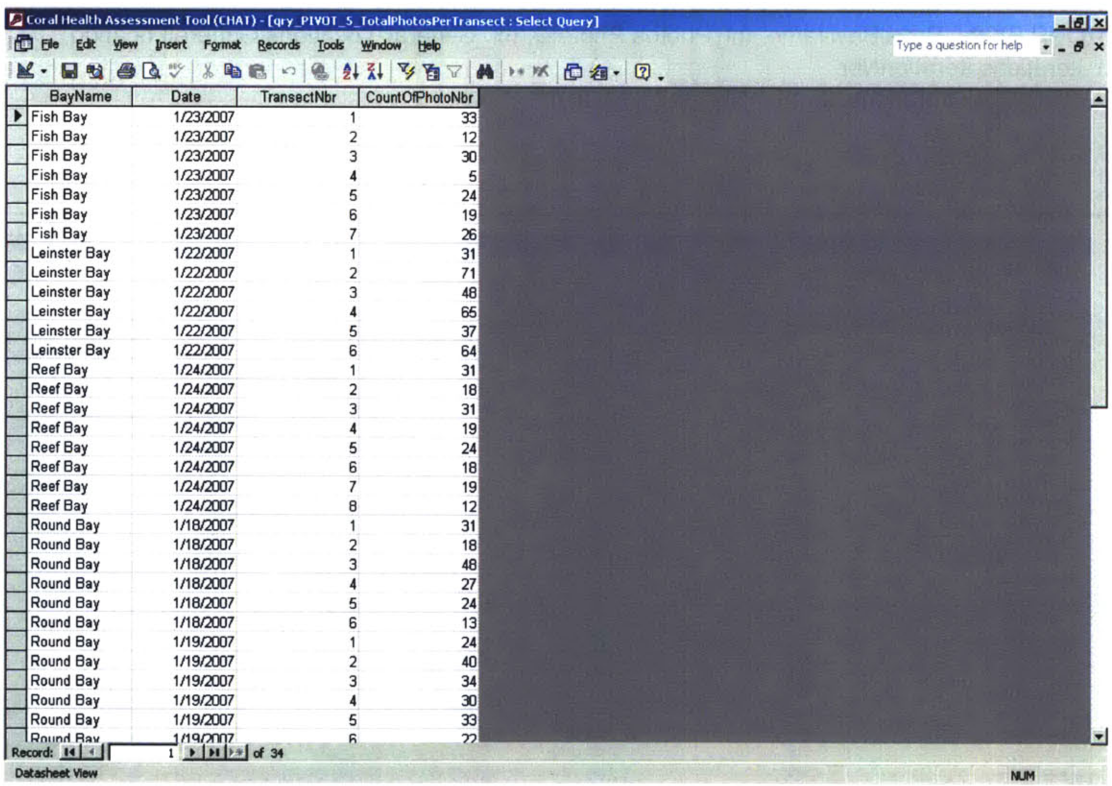
BayName	PhotoID	CountOfPhotoID	GeneralLocation
Fish Bay	7	1	St. John
Fish Bay	11	1	St. John
Fish Bay	18	1	St. John
Fish Bay	23	1	St. John
Fish Bay	44	1	St. John
Fish Bay	50	1	St. John
Fish Bay	85	1	St. John
Fish Bay	96	1	St. John
Fish Bay	119	1	St. John
Fish Bay	125	1	St. John
Leinster Bay	159	1	St. John
Leinster Bay	167	1	St. John
Leinster Bay	189	1	St. John
Leinster Bay	257	1	St. John
Leinster Bay	318	1	St. John
Leinster Bay	350	1	St. John
Leinster Bay	413	1	St. John
Leinster Bay	421	1	St. John
Leinster Bay	431	1	St. John
Leinster Bay	461	1	St. John
Reef Bay	493	1	St. John
Reef Bay	519	1	St. John
Reef Bay	525	1	St. John
Reef Bay	527	1	St. John
Reef Bay	546	1	St. John
Reef Bay	554	1	St. John
Reef Bay	557	1	St. John
Reef Bay	563	1	St. John
Reef Bay	564	1	St. John
Reef Bay	625	1	St. John
Round Bay	654	1	St. John
Round Bay	684	1	St. John
Round Bay	701	1	St. John

qry_PIVOT_5_TotalPhotosPerTransect

Query Name	Query Type	Description / Comments
qry_PIVOT_5_TotalPhotosPerTransect	Select	Linked to Pivot Table Pivot 5

SQL Code

```
SELECT tbl_Bays.BayName, tbl_Events.Date, tbl_Transects.TransectNbr, Count(tbl_Photos.PhotoNbr)
AS CountOfPhotoNbr
FROM ((tbl_Bays INNER JOIN tbl_Events ON tbl_Bays.BayID = tbl_Events.BayID) INNER JOIN
tbl_Transects ON tbl_Events.EventID = tbl_Transects.EventID) INNER JOIN tbl_Photos ON
tbl_Transects.TransectID = tbl_Photos.TransectID
GROUP BY tbl_Bays.BayName, tbl_Events.Date, tbl_Transects.TransectNbr;
```



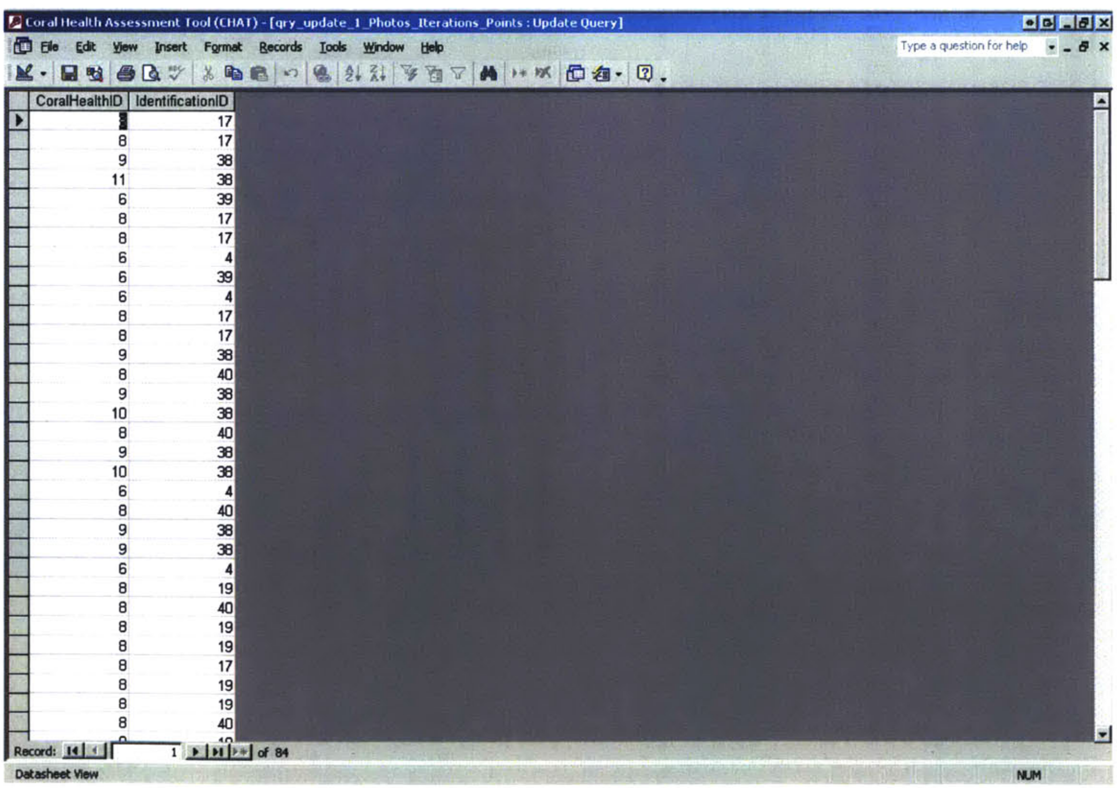
BayName	Date	TransectNbr	CountOfPhotoNbr
Fish Bay	1/23/2007	1	33
Fish Bay	1/23/2007	2	12
Fish Bay	1/23/2007	3	30
Fish Bay	1/23/2007	4	5
Fish Bay	1/23/2007	5	24
Fish Bay	1/23/2007	6	19
Fish Bay	1/23/2007	7	26
Leinster Bay	1/22/2007	1	31
Leinster Bay	1/22/2007	2	71
Leinster Bay	1/22/2007	3	48
Leinster Bay	1/22/2007	4	65
Leinster Bay	1/22/2007	5	37
Leinster Bay	1/22/2007	6	64
Reef Bay	1/24/2007	1	31
Reef Bay	1/24/2007	2	18
Reef Bay	1/24/2007	3	31
Reef Bay	1/24/2007	4	19
Reef Bay	1/24/2007	5	24
Reef Bay	1/24/2007	6	18
Reef Bay	1/24/2007	7	19
Reef Bay	1/24/2007	8	12
Round Bay	1/18/2007	1	31
Round Bay	1/18/2007	2	18
Round Bay	1/18/2007	3	48
Round Bay	1/18/2007	4	27
Round Bay	1/18/2007	5	24
Round Bay	1/18/2007	6	13
Round Bay	1/19/2007	1	24
Round Bay	1/19/2007	2	40
Round Bay	1/19/2007	3	34
Round Bay	1/19/2007	4	30
Round Bay	1/19/2007	5	33
Round Bay	1/19/2007	6	22

qry_update_1_Photos_Iterations_Points

Query Name	Query Type	Description / Comments
qry_update_1_Photos_Iterations_Points	Update	Allows user to update default values in new Iterations with points that may have already been entered in previous Iterations. Prompts user for Source and Destination Iterations.

SQL Code

```
UPDATE tbl_Iterations INNER JOIN ((qry_update_1_Sub_1_Source_Data_Points INNER JOIN
tbl_Photos_Iterations_Points ON qry_update_1_Sub_1_Source_Data_Points.PointNbr =
tbl_Photos_Iterations_Points.PointNbr) INNER JOIN tbl_Photos_Iterations ON
(tbl_Photos_Iterations.Photos_IterationsID = tbl_Photos_Iterations_Points.Photos_IterationsID) AND
(qry_update_1_Sub_1_Source_Data_Points.PhotoID = tbl_Photos_Iterations.PhotoID)) ON
tbl_Iterations.IterationID = tbl_Photos_Iterations.IterationID SET
tbl_Photos_Iterations_Points.CoralHealthID =
qry_update_1_Sub_1_Source_Data_Points.CoralHealthID,
tbl_Photos_Iterations_Points.IdentificationID =
qry_update_1_Sub_1_Source_Data_Points.IdentificationID
WHERE
(((tbl_Iterations.IterationNbr)=[DESTINATION_Iteration_Number_to_Update_DONT_SCREW_THIS_U
P]));
```



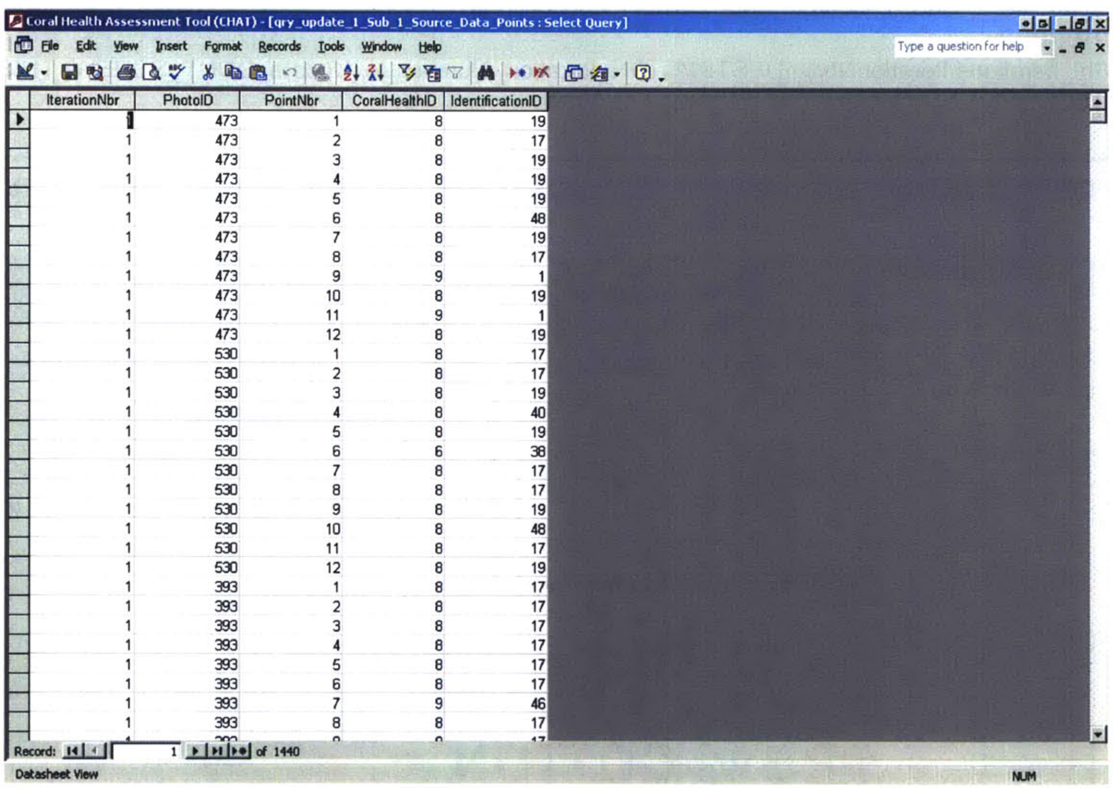
CoralHealthID	IdentificationID
8	17
8	17
9	38
11	38
6	39
8	17
8	17
6	4
6	39
6	4
8	17
8	17
9	38
8	40
9	38
10	38
8	40
9	38
10	38
6	4
8	40
9	38
9	38
6	4
8	19
8	40
8	19
8	19
8	17
8	19
8	19
8	40

qry_update_1_Sub_1_Source_Data_Points

Query Name	Query Type	Description / Comments
qry_update_1_Sub_1_Source_Data_Points	Select	Sub-query for qry_update_1_Photos_Iterations_Points

SQL Code

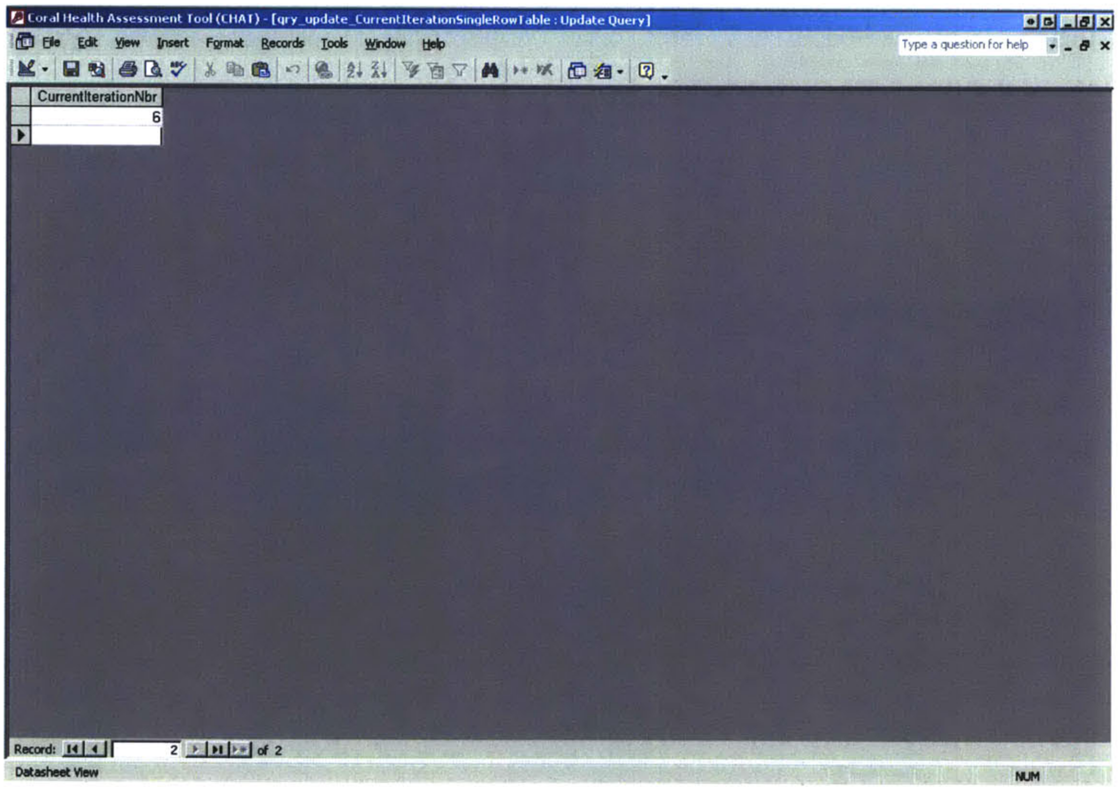
```
SELECT tbl_Iterations.IterationNbr, tbl_Photos_Iterations.PhotoID,
tbl_Photos_Iterations_Points.PointNbr, tbl_Photos_Iterations_Points.CoralHealthID,
tbl_Photos_Iterations_Points.IdentificationID
FROM (tbl_Iterations INNER JOIN tbl_Photos_Iterations ON tbl_Iterations.IterationID =
tbl_Photos_Iterations.IterationID) INNER JOIN tbl_Photos_Iterations_Points ON
tbl_Photos_Iterations.Photos_IterationsID = tbl_Photos_Iterations_Points.Photos_IterationsID
WHERE
(((tbl_Iterations.IterationNbr)=[SOURCE_Iteration_Number_to_Update_DONT_SCREW_THIS_UP]));
```



IterationNbr	PhotoID	PointNbr	CoralHealthID	IdentificationID
1	473	1	8	19
1	473	2	8	17
1	473	3	8	19
1	473	4	8	19
1	473	5	8	19
1	473	6	8	48
1	473	7	8	19
1	473	8	8	17
1	473	9	9	1
1	473	10	8	19
1	473	11	9	1
1	473	12	8	19
1	530	1	8	17
1	530	2	8	17
1	530	3	8	19
1	530	4	8	40
1	530	5	8	19
1	530	6	6	38
1	530	7	8	17
1	530	8	8	17
1	530	9	8	19
1	530	10	8	48
1	530	11	8	17
1	530	12	8	19
1	393	1	8	17
1	393	2	8	17
1	393	3	8	17
1	393	4	8	17
1	393	5	8	17
1	393	6	8	17
1	393	7	9	46
1	393	8	8	17

qry_update_CurrentIterationSingleRowTable

Query Name	Query Type	Description / Comments
qry_update_CurrentIterationSingleRowTable	Update	Prompts user for current IterationNbr and updates table. Table is subsequently used in joins to display only records related to the current Iteration.
SQL Code		
UPDATE tbl_CurrentIterationSingleRowTable SET tbl_CurrentIterationSingleRowTable.CurrentIterationNbr = [IterationNumber];		

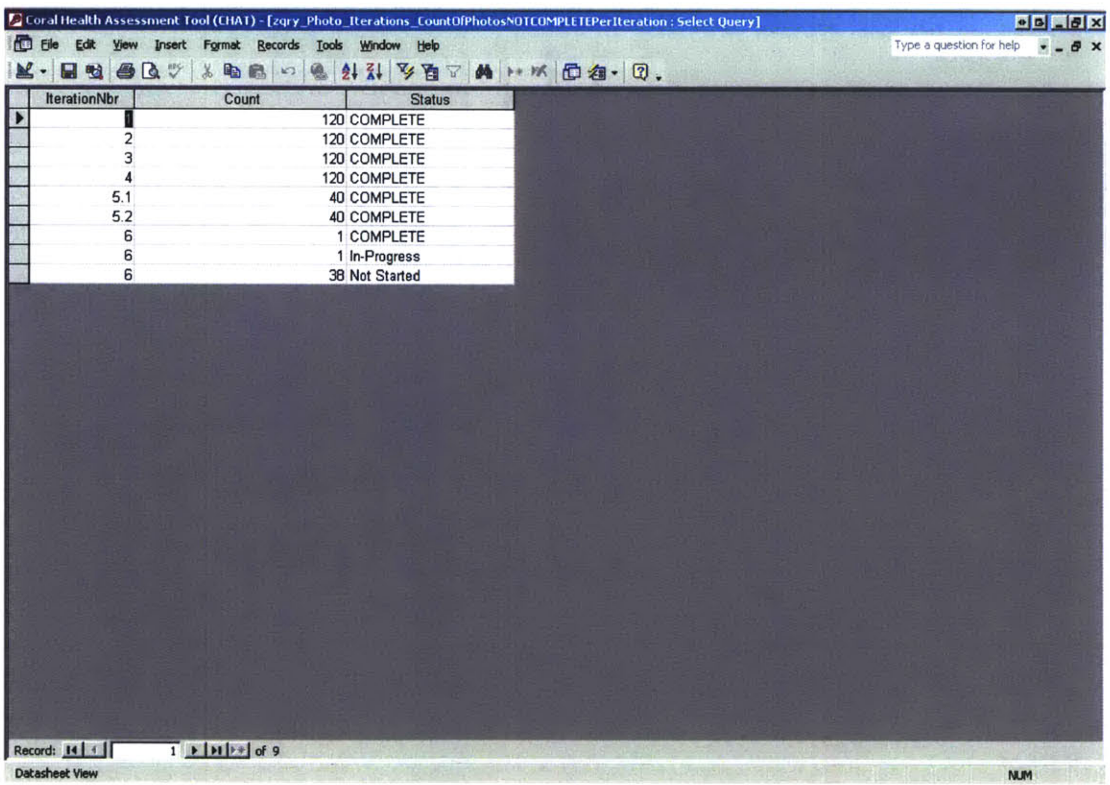


zqry_Photo_Iterations_CountOfPhotosNOTCOMPETEPerIteration

Query Name	Query Type	Description / Comments
zqry_Photo_Iterations_CountOfPhotosNOTCOMPLETEPerIteration	Select	Used to populate frm_Subform_EntryStatus

SQL Code

```
SELECT tbl_Iterations.IterationNbr, Count(tbl_Photos_Iterations.PhotoID) AS [Count],
tbl_Valid_Data_Entry_Status.Valid_Data_Entry_Status AS Status
FROM tbl_Valid_Data_Entry_Status INNER JOIN (tbl_Iterations INNER JOIN tbl_Photos_Iterations ON
tbl_Iterations.IterationID = tbl_Photos_Iterations.IterationID) ON
tbl_Valid_Data_Entry_Status.Valid_Data_Entry_StatusID = tbl_Photos_Iterations.Data_Entry_StatusID
GROUP BY tbl_Iterations.IterationNbr, tbl_Valid_Data_Entry_Status.Valid_Data_Entry_Status;
```



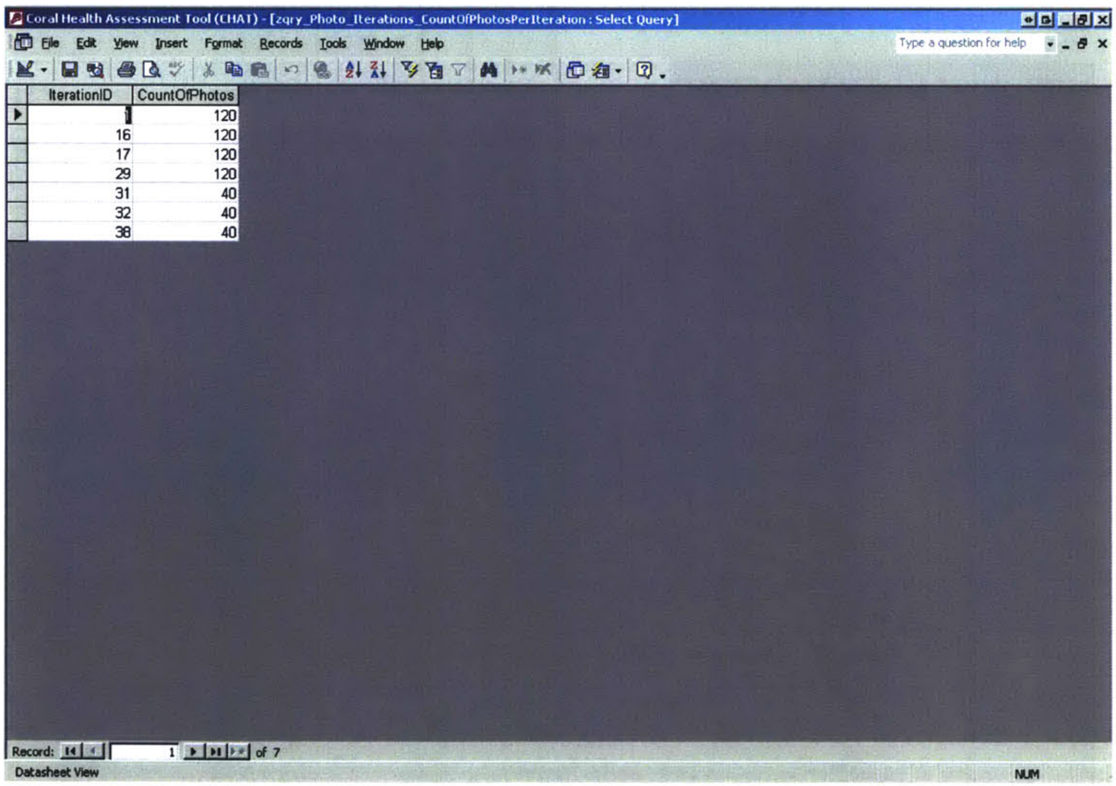
IterationNbr	Count	Status
1	120	COMPLETE
2	120	COMPLETE
3	120	COMPLETE
4	120	COMPLETE
5.1	40	COMPLETE
5.2	40	COMPLETE
6	1	COMPLETE
6	1	In-Progress
6	38	Not Started

zqry_Photo_Iterations_CountOfPhotosPerIteration

Query Name	Query Type	Description / Comments
zqry_Photo_Iterations_CountOfPhotosPerIteration	Select	Used to populate frm_Subform_EntryStatus

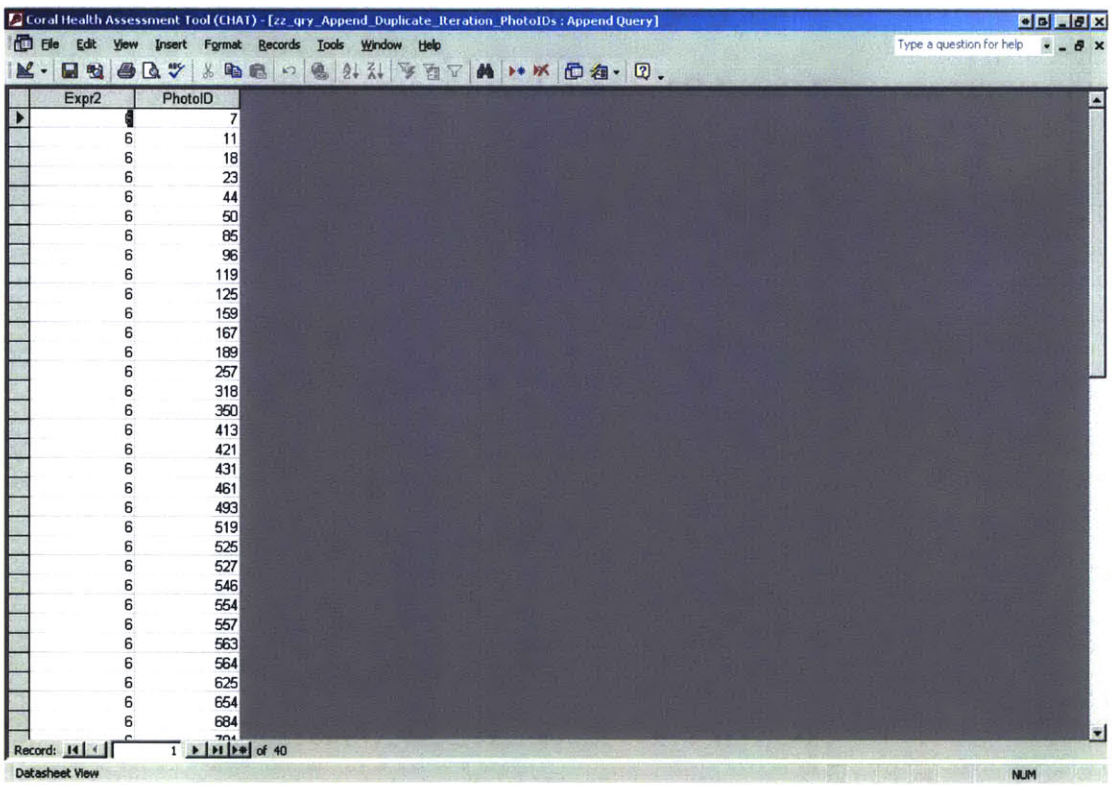
SQL Code

```
SELECT tbl_Photos_Iterations.IterationID, Count(tbl_Photos_Iterations.PhotoID) AS CountOfPhotos
FROM tbl_Photos_Iterations
GROUP BY tbl_Photos_Iterations.IterationID
ORDER BY tbl_Photos_Iterations.IterationID;
```



zz_qry_Append_Duplicate_Iteration_PhotoIDs

Query Name	Query Type	Description / Comments
zz_qry_Append_Duplicate_Iteration_PhotoIDs	Append	Appends duplicate points so that users can duplicate the exact same iteration; this query was used to duplicate Iteration 5.1 to Iteration 5.2.
SQL Code		
INSERT INTO tbl_Photos_Iterations (IterationID, PhotoID) SELECT [UserEnteredIterationID] AS Expr2, zz_qry_Append_Duplicate_Iteration_PhotoIDs_Sub.PhotoID FROM zz_qry_Append_Duplicate_Iteration_PhotoIDs_Sub;		



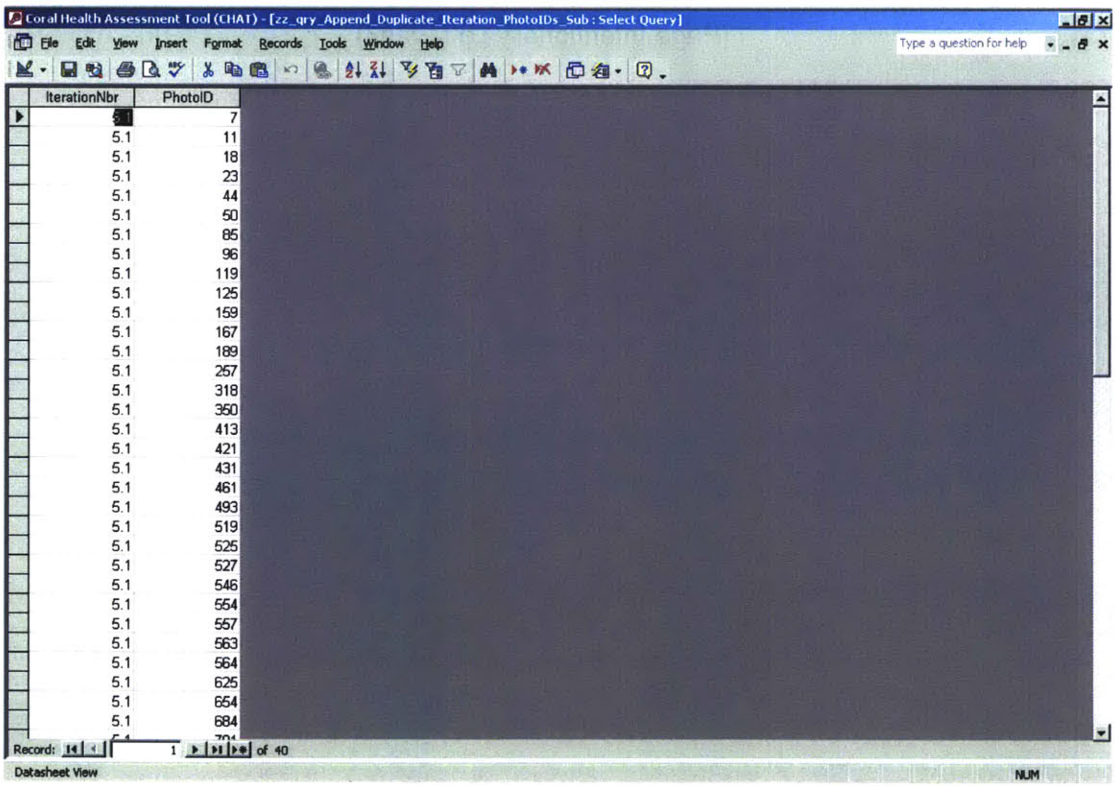
Expr2	PhotoID
6	7
6	11
6	18
6	23
6	44
6	50
6	85
6	96
6	119
6	125
6	159
6	167
6	189
6	257
6	318
6	350
6	413
6	421
6	431
6	461
6	493
6	519
6	525
6	527
6	546
6	554
6	557
6	563
6	564
6	625
6	654
6	684

zz_qry_Append_Duplicate_Iteration_PhotoIDs_Sub

Query Name	Query Type	Description / Comments
zz_qry_Append_Duplicate_Iteration_PhotoIDs_Sub	Select	Sub-query to zz_qry_Append_Duplicate_Iteration_PhotoIDs

SQL Code

```
SELECT tbl_Iterations.IterationNbr, tbl_Photos_Iterations.PhotoID
FROM tbl_Iterations INNER JOIN tbl_Photos_Iterations ON tbl_Iterations.IterationID =
tbl_Photos_Iterations.IterationID
WHERE (((tbl_Iterations.IterationNbr)=5.1));
```



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Appendix F TRANSECT LOCATION AND PHOTO DETAILS

APPENDIX F TABLE OF CONTENTS

TRANSECT GPS LOCATION DATA

Transect GPS Coordinates and Depths

Bay Name	Date	Transect Number	Start / Finish	X	Y	N DEG	N MIN	N SEC	W DEG	W MIN	W SEC	Depth	Notes
Fish	1/23/2007	1	Start			18	18	55.8	64	45	52.0	9	***
			Finish			18	18	57.0	64	45	52.7	9	***
		2	Start			18	18	59.3	64	45	53.8	10	***
			Finish			18	19	0.7	64	45	54.3	10	***
		3	Start			18	19	1.8	64	45	55.0	8	***
			Finish			18	19	3.0	64	45	55.8	8	***
		4	Start			18	18	58.1	64	45	41.0	9	***
			Finish			18	18	59.0	64	45	41.0	9	***
		5	Start			18	18	59.5	64	45	44.1	15	***
			Finish			18	19	0.5	64	45	44.9	15	***
		6	Start			18	19	1.2	64	45	45.8	7	***
			Finish			18	19	1.2	64	45	47.0	7	***
		7	Start			18	19	2.5	64	45	47.4	8	***
			Finish			18	19	4.3	64	45	47.4	8	***
Leinster	1/22/2007	1	Start	-64.7247	18.3636	18	21	48.9	64	43	29.0	5	
			Finish	-64.7249	18.3634	18	21	48.4	64	43	29.7	7	
		2	Start	-64.7254	18.3637	18	21	49.2	64	43	31.3	7	
			Finish	-64.7257	18.364	18	21	50.3	64	43	32.5	6	
		3	Start	-64.7276	18.3649	18	21	53.5	64	43	39.2	7	
			Finish	-64.7278	18.3647	18	21	52.8	64	43	40.2	6	
		4	Start	-64.7287	18.3646	18	21	52.6	64	43	43.2	6	
			Finish	-64.7291	18.3646	18	21	52.4	64	43	44.7	7	
		5	Start	-64.7340	18.3672	18	22	1.9	64	44	2.3	3	
			Finish	-64.7333	18.3676	18	22	3.4	64	44	0.0	6	
		6	Start	-64.7332	18.3681	18	22	5.2	64	43	59.5	10	
			Finish	-64.7333	18.3678	18	22	3.9	64	44	0.0	3	
Reef	1/24/2007	1	Start	-64.7497	18.3207	18	19	14.6	64	44	58.8	10	
			Finish	-64.7498	18.3213	18	19	16.6	64	44	59.2	5	
		2	Start	-64.7498	18.3209	18	19	15.2	64	44	59.1	10	
			Finish	-64.7495	18.321	18	19	15.5	64	44	58.3	10	
		3	Start	-64.7491	18.3217	18	19	18.0	64	44	56.6	6	
			Finish	-64.7489	18.3219	18	19	19.0	64	44	56.0	5	
		4	Start	-64.7481	18.3228	18	19	22.2	64	44	53.2	5	
			Finish	-64.7481	18.3229	18	19	22.6	64	44	53.1	8	
		5	Start	-64.7471	18.3215	18	19	17.3	64	44	49.7	8	
			Finish	-64.7471	18.3213	18	19	16.5	64	44	49.4		
		6	Start	-64.7471	18.3212	18	19	16.3	64	44	49.6	10	
			Finish	-64.7469	18.321	18	19	15.7	64	44	49.0	12	
		7	Start	-64.7461	18.3203	18	19	13.1	64	44	46.1	10	
			Finish	-64.7461	18.3201	18	19	12.5	64	44	45.9	12	
		8	Start	-64.7450	18.3197	18	19	11.0	64	44	41.9	10	
			Finish	-64.7448	18.3194	18	19	10.0	64	44	41.2	15	

Transect GPS Coordinates and Depths (cont.)

Bay Name	Date	Transect Number	Start / Finish	X	Y	N DEG	N MIN	N SEC	W DEG	W MIN	W SEC	Depth	Notes
Round	1/18/2007	1	Start			18	20	20.5	64	41	28.9	18	***
			Finish			18	20	23.1	64	41	26.4	18	***
		2	Start			18	20	29.0	64	41	21.8	18	***
			Finish			18	20	30.8	64	41	19.9	18	***
		3	Start			18	20	32.0	64	41	19.9	18	***
			Finish			18	20	33.8	64	41	17.3	18	***
		4	Start			18	20	35.3	64	41	3.2	7	***
			Finish			18	20	38.8	64	41	2.9	7	***
		5	Start			18	20	41.2	64	40	56.0	10	***
			Finish			18	20	43.2	64	40	54.0	10	***
		6	Start			18	20	44.1	64	40	51.6	10	***
			Finish			18	20	46.4	64	40	51.4	10	***
Round	1/19/2007	1	Start	-64.6767	18.339	18	20	20.5	64	40	36.0	6	
			Finish	-64.6765	18.3394	18	20	21.8	64	40	35.4	6	
		2	Start	-64.6764	18.3393	18	20	21.3	64	40	34.9	5	
			Finish	-64.6759	18.3389	18	20	20.1	64	40	33.2	5	
		3	Start	-64.6745	18.3416	18	20	29.6	64	40	28.3	4	
			Finish	-64.6745	18.3418	18	20	30.6	64	40	28.3	6	
		4	Start	-64.6769	18.3427	18	20	33.7	64	40	37.0	6	
			Finish	-64.6771	18.3427	18	20	33.6	64	40	37.5	7	
		5	Start	-64.6791	18.3435	18	20	36.6	64	40	44.9	7	
			Finish	-64.6796	18.3438	18	20	37.8	64	40	46.4	5	
		6	Start	-64.6797	18.3436	18	20	37.0	64	40	46.8	10	
			Finish	-64.6800	18.3436	18	20	37.1	64	40	48.1	15	
		7	Start	-64.6802	18.3451	18	20	42.5	64	40	48.6	6	
			Finish	-64.6800	18.3455	18	20	43.8	64	40	47.9	5	

*** Location estimated using GIS following data collection in field. No GPS data logged while in field.

PHOTO DETAILS

Number of Photos per Transect – Fish Bay

Number of Photos per Transect		
Location	St. John	
BayName	Fish Bay	
Date	Transect Number	Total
1/23/2007	1	33
	2	12
	3	30
	4	5
	5	24
	6	19
	7	26
1/23/2007 Total		149
Grand Total		149

Number of Photos per Transect – Leinster Bay

Number of Photos per Transect		
Location	St. John	
BayName	Leinster Bay	
Date	Transect Number	Total
1/22/2007	1	31
	2	71
	3	48
	4	65
	5	37
	6	64
1/22/2007 Total		316
Grand Total		316

Number of Photos per Transect – Reef Bay

Number of Photos per Transect		
Location	St. John	
BayName	Reef Bay	
Date	Transect Number	Total
1/24/2007	1	31
	2	18
	3	31
	4	19
	5	24
	6	18
	7	19
	8	12
1/24/2007 Total		172
Grand Total		172

Number of Photos per Transect – Round Bay

Number of Photos per Transect		
Location	St. John	
BayName	Round Bay	
Date	Transect Number	Total
1/18/2007	1	31
	2	18
	3	48
	4	27
	5	24
	6	13
1/18/2007 Total		161
1/19/2007	1	24
	2	40
	3	34
	4	30
	5	33
	6	22
	7	43
1/19/2007 Total		226
Grand Total		387

Photo Clarity of Analzyed Photos by Transect and Iteration – Fish Bay

Photo Clarity of Analzyed Photos by Transect and Iteration						
Location	St. John					
BayName	Fish Bay					
		Iteration Number				Grand Total
Transect Number	Clarity	1	2	3	4	
1	Moderate	2	1	4	0	7
	Poor	7	4	1	6	18
	Useless	0	1	0	0	1
2	Moderate	0	2	0	0	2
	Poor	1	1	2	3	7
	Useless	1	1	0	0	2
3	Moderate	3	4	4	4	15
	Poor	3	3	3	1	10
4	Poor	0	0	0	1	1
5	Excellent	0	0	1	0	1
	Moderate	2	0	1	1	4
	Poor	2	1	2	5	10
	Useless	1	0	2	0	3
6	Moderate	0	0	0	1	1
	Poor	2	6	5	4	17
	Useless	1	0	0	0	1
7	Moderate	0	2	2	3	7
	Poor	5	3	2	1	11
	Useless	0	1	1	0	2
Grand Total		30	30	30	30	120

Photo Clarity of Analzyed Photos by Transect and Iteration – Leinster Bay

Photo Clarity of Analzyed Photos by Transect and Iteration						
Location	St. John					
BayName	Leinster Bay					
		Iteration Number				Grand Total
Transect Number	Clarity	1	2	3	4	
1	Excellent	0	0	2	0	2
	Moderate	3	2	0	0	5
	Poor	0	0	1	0	1
2	Excellent	0	0	7	1	8
	Moderate	2	6	4	5	17
	Poor	3	2	0	3	8
3	Excellent	0	0	3	6	9
	Moderate	2	10	1	1	14
4	Excellent	9	0	3	5	17
	Moderate	2	2	0	0	4
5	Excellent	0	1	1	2	4
	Moderate	3	0	1	1	5
	Poor	2	1	0	0	3
	Useless	0	1	0	0	1
6	Excellent	0	0	6	5	11
	Moderate	3	5	1	1	10
	Poor	1	0	0	0	1
Grand Total		30	30	30	30	120

Photo Clarity of Analzyed Photos by Transect and Iteration – Reef Bay

Photo Clarity of Analzyed Photos by Transect and Iteration						
Location	St. John					
BayName	Reef Bay					
		Iteration Number				Grand Total
Transect Number	Clarity	1	2	3	4	
1	Moderate	6	3	5	6	20
	Poor	1	1	0	1	3
2	Excellent	0	1	2	2	5
	Moderate	4	2	1	3	10
3	Excellent	0	0	2	2	4
	Moderate	3	5	2	4	14
	Poor	1	0	1	0	2
4	Excellent	0	0	1	1	2
	Moderate	0	2	1	1	4
	Poor	3	1	0	0	4
5	Excellent	0	0	4	0	4
	Moderate	4	4	1	4	13
	Poor	2	1	0	0	3
6	Excellent	0	1	2	1	4
	Moderate	2	2	3	1	8
	Poor	0	1	1	1	3
7	Moderate	2	3	1	0	6
	Poor	0	0	1	2	3
8	Moderate	1	1	0	1	3
	Poor	1	2	2	0	5
Grand Total		30	30	30	30	120

Photo Clarity of Analzyed Photos by Transect and Iteration – Round Bay

Photo Clarity of Analzyed Photos by Transect and Iteration						
Location	St. John					
BayName	Round Bay					
		Iteration Number				Grand Total
Transect Number	Clarity	1	2	3	4	
1	Excellent	0	1	1	1	3
	Moderate	2	0	1	0	3
	Poor	1	2	2	1	6
	Useless	1	2	1	0	4
2	Excellent	0	1	1	0	2
	Moderate	3	2	3	2	10
	Useless	2	3	1	1	7
3	Excellent	0	0	2	3	5
	Moderate	3	1	4	2	10
	Poor	0	5	4	2	11
	Useless	3	0	0	0	3
4	Excellent	2	1	2	1	6
	Moderate	0	1	0	0	1
	Poor	1	1	0	1	3
	Useless	1	0	0	1	2
5	Excellent	1	0	1	7	9
	Moderate	5	4	2	0	11
	Poor	0	3	1	1	5
6	Poor	0	2	1	4	7
	Useless	1	0	0	0	1
7	Excellent	0	0	1	2	3
	Moderate	4	1	2	1	8
Grand Total		30	30	30	30	120

Number of Distinct Photos Assessed and Photo-Assessments for Iterations 1 – 4

BayName	Number of Distinct Photos Assessed	Total Number of Photo Assessments	Total Number of Photos in Bay
Fish Bay	89	120	149
Leinster Bay	105	120	316
Reef Bay	94	120	172
Round Bay	97	120	387
Grand Total	385	480	1024

NOTES: For Iterations 1-4
For each Iteration 1-4, 30 distinct photos were chosen from each bay.

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Appendix G TRANSECT LOCATION AND PHOTO DETAILS

APPENDIX F TABLE OF CONTENTS

MACRO DETAILS

Macro Details	
Macro Name	**Action**
MCR_1_AppendRecordsForNewIteration	Appends all necessary records for a new iteration. Sets PrePopulatedStatus to 'Yes' so that a future Append query does not attempt to re-append these same records a second time. Runs queries: qry_append_1_IterationsRandomNbrs, qry_append_2_Photo_Iterations, qry_append_3_Photos_Iterations_Points, qry_append_4_Transect_Iterations, qry_append_1_IterationsRandomNbrs_Sub_UpdatePrePopulatedStatus
mcr_frm_ITERATION_ENTRY_FORM_NewIterationRecord	Sets Iteration to a new record on-open of frm_ITERATION_ENTRY_FORM.
mcr_frm_ITERATION_ENTRY_FORM_NextIterationRecord	Moves to next Iteration record on frm_ITERATION_ENTRY_FORM.
mcr_frm_Subform_Photos_Iterations_MoveToNextPhoto	Form navigation on frm_ITERATION_ENTRY_FORM and subforms.
mcr_frm_Subform_Photos_Iterations_OpenClassificationForm	Opens frm_Classification
mcr_frm_Subform_Photos_Iterations_SetFinishTime	Sets values of TimeCompleted for Iteration to current data/time.
mcr_frm_Subform_Photos_Iterations_SetSartTime	Sets values of TimeStarted for Iteration to current data/time.
mcr_frm_Subform_Photos_Iterations_SetTimeLastUpdated	Sets value of Last_Updated for Photo-Iteration to current date/time.
mcr_frm_Subform_Photos_Iterations_SetTransectStatusCompleteNext	Send keys statement for form navigation and and set value of TransectStatus to Complete.
mcr_frm_Subform_Photos_Iterations_SetTransectStatusInProgress	Send keys statement for form navigation and and set value of TransectStatus to InProgress.
mcr_MAXIMIZE_window	Maxmizes form in window.
mcr_OPEN_DATA_ENTRY_FORM_after_UpdateCurrentIteration	Updates current iteration to user entered IterationNbr. Opens frm_CHAT_DATA_ENTRY_FORM with records for entered current Iteration.
mcr_Open_frm_ITERATION_ENTRY_FORM	Opens frm_ITERATION_ENTRY_FORM; initiated from frm_WELCOME_SCREEN or frm_ITERATION_ENTRY_FORM
mcr_WELCOME_TO_CHAT	Message box to user at CHAT opening.