



Marine Fish Monitoring Protocol

Pacific Islands Network (Version 1.0)

Natural Resource Report NPS/PACN/NRR—2011/421



ON THE COVER

Pacific Redfin Butterflyfish (*Chaetodon lunulatus*) feeding on a coral colony in War in the Pacific National Historical Park.
Photograph: NPS

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March 2011

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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Please cite this publication as:

Brown, E., J. Beets, P. Brown, P. Craig, A. Friedlander, T. Jones, K. Kozar, M. Capone, L. Kramer, and L. Basch 2011. Marine fish monitoring protocol: Pacific Islands Network (Version 1.0). Natural Resource Report NPS/PACN/NRR—2011/421. National Park Service, Fort Collins, Colorado.

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Executive Summary

Fish are a major component of the coral reef ecosystem, potentially numbering 500 – 1,100 species in Pacific Islands Network (PACN) parks depending on geographic location (Allen et al. 2003, Randall 2005, Randall 2007). This highly diverse assemblage of carnivores, planktivores, herbivores and detritivores serve a variety of ecological functions that affect ecosystem structure, productivity, and sustainability (e.g., Sale 1991, Hixon 1997). Fish assemblages or selected species can also act as indicators of general reef health and provide a warning of environmental stress and potential ecosystem change (e.g., Friedlander and DeMartini 2002). Additionally, fish within the parks are harvested in traditional, subsistence, artisanal, and recreational fisheries (e.g., Craig et al. 2008) which may affect the species composition, abundance and size of targeted species. Fishing is increasingly being recognized as the principal threat to Pacific coral reefs and other marine ecosystems worldwide (e.g., Dayton 1998, Friedlander and DeMartini 2002, Birkeland 2004, Hutchings and Reynolds 2004). In this respect, it is highly probable that most of the Pacific Islands parks can be categorized as “impaired” to “seriously impaired” in terms of their fish communities. Marine Fish ranked 11th in priority as a network Vital Sign. While the harvest of fish is addressed in a separate complementary (fisheries-dependent) protocol, data collected through the Marine Fish Protocol will contribute to the overall understanding by providing an in-water (fisheries-independent) assessment of the size and numerical density of daytime, non-cryptic species within park waters. Monitoring efforts will be conducted concurrently with Water Quality and Benthic Marine Community Vital Signs to maximize data interpretation value.

Long-term changes in the numerical density and biomass of fish assemblages can often be correlated with specific stressors or drivers. For example, a decline in size and numerical density of target species is often associated with overfishing. Reef fish diversity and biomass also correlate with the structural complexity of reef habitats so changes in habitat topography can alter the fish assemblage at various spatial scales. Moreover, many reef fishes are either large apex predators or major herbivores whose trends in numerical density can have ecologically and statistically significant impacts on coral reef ecosystems and the dynamics of major system components; e.g., declines in herbivorous fishes could result in increased growth and benthic cover of native or invasive algae which can out-compete and overgrow corals, leading to associated declines in coral health, reef structure, and ecosystem resiliency.

The Marine Fish Monitoring Protocol will be implemented initially in four parks: Kaloko-Honokohau National Historical Park (KAHO), Kalaupapa National Historical Park (KALA), National Park of American Samoa (NPSA), and War in the Pacific National Historical Park (WAPA), and will address one primary monitoring question: What are long-term trends in the numerical density, biomass, and size of reef fishes? The primary objective is to annually determine the density, biomass, and size of daytime, non-cryptic reef fishes at sites randomly selected on hard substrata in an isobath between the 10 and 20 meter depths (selected for ecologic and safety reasons).

The methodology to monitor coral reef fish has been actively developed over the past 25 years, resulting in several commonly used survey techniques (e.g., Bohnsack and Bannerot 1986, Rogers et al. 1994, English et al. 1997, Samoilys 1997, Sweatman et al. 1998, Atlantic and Gulf

Rapid Reef Assessment 2000, Hill and Wilkinson 2004). The primary technique adapted for this protocol consists of a visual count and size estimation of fish by trained scientific divers along underwater belt transects. This non-destructive technique focuses on one major component of the coral reef fish community—the diurnal or day-active fish species that are highly visible due to their typically bright coloration and generally large size. While the small, cryptic or nocturnal species contribute to biodiversity and may be of ecological or management importance, the additional effort and time required to sample nocturnal and cryptic fish is not usually feasible with available resources. The visual estimate of fish size is an important component of these surveys for several reasons. First, lengths allow a conversion from fish numbers to biomass by using established length-weight relationships. Second, lengths are often a useful indicator of fishing pressure or population dynamics, e.g., a trend of decreasing sizes may indicate overfishing, or recruitment year classes. Third, there is a strong positive correlation between fish size and fecundity (reproductive potential) which, along with recruitment success, is important in assessing ecological services provided by park fish stocks.

A split panel field sampling design will be implemented for monitoring, with 30 randomly selected sites sampled annually in each park. Fifteen of the sites will be fixed (permanent) and revisited annually. The remaining sites will be randomly selected each year and will not be revisited. This sampling regime represents the maximum sustainable effort given current logistic and fiscal realities. Initially, this sampling design should have statistical power with a 33% chance of detecting a 50% relative change in total fish species richness over 10 years, a 23% chance to detect a 50% relative change in total fish density over 10 years, and a 22% chance to detect a 50% relative change in total fish biomass over 10 years. The statistical power is anticipated to increase over time to an estimated 80% chance of detecting a 25% change, resulting from the ability to conduct parameter corrections based on temporally repeated analyses. Spatial analysis of fish assemblage data will utilize standard univariate (e.g., general linear models) and multivariate (e.g., multidimensional scaling) procedures to examine the influence of factors (e.g., management regime, topographical complexity, benthic cover, etc.) structuring fish communities (e.g., Friedlander et al. 2003). Temporal data sets will utilize repeated measures ANOVA and regression analysis to detect changes in the fish assemblages. Trend analysis using route regression or period mean regression will be employed when analyzing fish data sets with other data sets (e.g., benthic marine community and water quality parameters) that are co-located and may be sampled at different frequencies.

Personnel requirements for implementing this Vital Sign monitoring identify a team approach from a variety of organizational levels. Individual park staff provide in-park coordination for field efforts and initial reporting, while the National Park Service Lead (NPS Lead) provides coordination across parks to optimize consistency in implementation and data collection, is the primary park liaison to ensure that this Vital Sign continues to address park management needs, ensures database management, and oversees the implementation, analyses, and reporting for the protocol. The Biological Technicians in each park facilitate implementation of this Vital Sign and are responsible for pre- and post- season preparations, field work within each park, and conducting the bulk of initial data management, quality assurance, and analysis. PACN and park-based staff help facilitate Vital Sign operations, ensure database management, conduct detailed status and trend analyses and reporting, and provide other co-located reporting and operational assistance at a network and national level.

The complete Marine Fish Protocol consists of this narrative with appendices and Standard Operating Procedures (SOPs). A complete list of SOPs is found in Appendix J. Any changes in this narrative will be logged in the Revision Log found in Appendix A.

Acknowledgements

This Vital Sign monitoring protocol and associated Standard Operating Procedures (SOPs) were prepared with assistance from the Hawaii-Pacific Islands Cooperative Ecosystems Studies Unit (HPI-CESU) University of Hawaii at Manoa and the NPS Pacific Islands Coral Reef Program (PICRP).

Background and Objectives

In the National Park Service (NPS), coral reefs within a park's legislated boundary fall under the protections granted by the National Park Service Organic Act (1916), the National Park System Resource Protection Act (16 U.S.C. § 19jj), and the Redwoods Act (1978). The National Park Service has been directed by Congress, via the National Park Omnibus Management Act (1998), to conduct science based management. The Natural Resource Challenge (NRC), initiated in 1999 under the auspices of the Omnibus Act (1998), is an action plan for preserving natural resources throughout the NPS system. The Coral Reef Conservation Act in 2000 created the U.S. Coral Reef Task Force and directed the Departments of Commerce and the Departments of Interior to improve understanding, preservation, and restoration of coral reef ecosystems, while promoting wise management and sustainable use of these valuable marine resources. As a result of these actions, the NPS Inventory and Monitoring (I&M) Program was developed.

NPS established 32 I&M networks across the nation which encompassed 270 national parks. Each network is comprised of NPS units that share geographical and natural resource characteristics, allowing these parks to share financial resources and expertise (National Park Service 2006a). The Inventory and Monitoring Program's first objective was to complete basic inventories of natural resources in all parks. This information formed the baseline for long-term monitoring efforts. Monitoring programs were built around measuring critical parameters (Vital Signs) within each network in order to gauge ecosystem health. The information gained by monitoring will be used for natural resource management decision-making. As defined by the NPS, Vital Signs are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. This subset of monitored resources and processes is part of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations..., including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources..." (National Park Service Organic Act of 1916). Major challenges addressed in the NRC pertinent to the marine environment include native and endangered species, non-native species, environmental stewardship, and water quality. The Vital Signs monitoring plan address these issues and this protocol focuses on some of these topics in relation to fish communities.

Chapter One of the PACN Monitoring Plan (HaySmith et al. 2005) outlines 33 general monitoring objectives for the network. The Marine Fish Vital Sign will provide information to address eight of these objectives (Table 1.1). This information will provide a more complete picture of the factors that influence the marine fish community.

Table 1.1. General monitoring objectives of the Marine Fish Monitoring Protocol that apply to other Vital Signs of the PACN I&M Program.

Level 1	Level 2	General monitoring objectives
Biological Integrity	Invasive Species	Use monitoring data for early detection and predictive modeling of incipient invasive species.
Biological Integrity	Invasive Species	Document changes in established populations of invasive species, including response to treatment.
Biological Integrity	Focal Species or Communities	Determine trends in composition, structure, and function of populations of selected focal species within the parks.
Biological Integrity	Focal Species or Communities	Determine trends in composition, structure, and function of populations of selected focal communities within the parks.
Biological Integrity	At-risk Biota	Determine trends in populations of threatened, endangered, and at-risk species within parks.
Ecosystem Patterns and Processes	Landscape Dynamics	Determine spatial and temporal patterns and changes in marine benthic cover and community distribution.
Ecosystem Patterns and Processes	Landscape Dynamics	Determine spatial and temporal patterns in marine use and effects on park resources.
Ecosystem Patterns and Processes	Extreme Disturbance Events	Track extreme disturbance events in parks.

Long-term monitoring is a repeated information-gathering effort to better understand changes in ecosystems (Likens 1988, Magnuson 1990, Rogers et al. 1994). Monitoring may serve as an "early warning system" to detect declining trends (as well as positive changes) in species or population viability and ecosystem integrity, ideally before irreversible change or loss occurs (Wiersma 1984, Davis 1989). The nature of the observed changes can guide managers to probable causes and suggest further investigations ultimately providing necessary information to support best management decisions and actions (White and Bratton 1980, Croze 1982, Jones 1986, Davis 1989, Quinn and van Riper 1990). In cases where natural systems in or near parks have been so highly altered that natural ecological processes no longer function properly, managers can use information from monitoring to understand how the altered systems operate, in order to determine the most effective approach(es) for restoration of systems and/or natural processes.

To design an effective monitoring program, a substantial base of information is necessary. Baseline information includes inventories of species and habitats, and measurements of natural variability (both spatial and temporal) for the monitoring variables of interest. Currently, little baseline information exists for marine systems in the PACN national parks, and while species inventories are available in some cases and some information on spatial and temporal variability exists—comprehensive measures of natural spatial and temporal variability for all PACN parks are lacking. Fortunately, this important information can be collected as part of a monitoring program. The development of the Marine Fish Monitoring Protocol is therefore designed to be an adaptive monitoring program, amendable as new data become available and as situations may change at any park. It is anticipated that the first few years of monitoring will serve as a pilot study to refine logistical, statistical, and financial issues.

The Vital Signs selected by NPS have been carefully chosen to be valuable indicators of coral reef health, are sufficiently sensitive to undergo change, and can be easily measured with, in many cases, comparatively small measurement error relative to levels of natural variability. The Vital Sign selection process is described in Chapter 3 of the PACN Vital Signs Monitoring Plan (HaySmith et al. 2005).

Setting

The marine fish communities in the PACN parks are comprised of a diverse assemblage of organisms consisting of near-shore or shallow-water fish species with diurnal, nocturnal, and crepuscular diel activities. More than 1,100 coral reef fish including sharks, eels, groupers, cardinalfish, jacks, snappers, butterflyfish, angelfish, damselfish, parrotfish, and surgeonfish can be found in the rich coral reef ecosystems of American Samoa, Guam, and Hawaii (Wass 1984, Allen et al. 2003, Randall 2005, Randall 2007). Due to logistical, methodological and funding constraints, monitoring this vital sign will focus on diurnal non-cryptic fish species. If future needs arise or funding becomes available, other aspects of the fish community can be monitored.

Marine fish are a vital resource to the indigenous peoples of the PACN parks. They provide nutrition, economic gain, and cultural ties to their heritage. However, throughout the Pacific, coral reef ecosystems are threatened by a variety of anthropogenic and natural stressors including overfishing, habitat loss, and environmental changes (Smith and Buddemeier 1992, Wilkinson 2002). While island societies have historically subsisted on fish protein, recent technological advances in fishing tackle have decimated what were once active and productive local fisheries (Wilkinson 2004). Throughout the Pacific, recent quantitative assessments have clearly shown a decline in standing fish biomass and a shift in fish communities (e.g. Friedlander and DeMartini 2002). This research has shown that over wide areas of the Pacific, marine fish resources are highly exploited and that many stocks are “overfished”. Of great concern recently are the lack of large apex predators on many reefs and the associated shifts in ecosystem species composition. The length and complexity of food webs has shortened, affecting the resiliency and prospects for sustainability for the future. Many target species, for example Giant grouper (*Epinephelus lanceolatus*), Humphead wrasse (*Cheilinus undulatus*), Bumphead parrotfish (*Bulbometopon muricatum*), and many species of sharks including Grey reef (*Carcharhinus amblyrhynchos*) and Blacktip reef (*Carcharhinus melanopterus*) have become rare in the Pacific.

Because of their importance ecologically, culturally and economically, it is critical that the PACN parks have scientifically rigorous data on the current health and long-term trends of the marine fish communities within their boundaries. In most Pacific parks, coral reefs form an important component of the ecosystem which has been compared to tropical rainforests in terms of high species diversity and complexity of interactions (Connell 1978, Birkeland 1997). Within these ecosystems, marine fish are one of the most visible resources and certainly the most exploited. The United Nations Environment Programme (UNEP) has proposed coral reefs as a worldwide indicator ecosystem for global climate change (Spalding et al. 2001). For these reasons, the PACN nominated marine fish as the #11 Vital Sign and subsequently selected it for implementation of long-term ecological monitoring. The Marine Fish Vital Sign is closely linked with the Benthic Marine Community Vital Sign which is ranked second.

Benthic Marine Community, Water Quality, and Marine Fish Monitoring will be co-located and co-visited to maximize logistics and to examine comparisons of interrelated monitoring data sets.

The integration of information across datasets forms a more holistic understanding of community condition over time that is useful for management. The interrelationship of coral reefs, their physical and chemical environment, and the associated fish community will provide additional explanatory power to marine Vital Signs. Data from the Water Quality Monitoring Protocol will be useful for interpreting changes in the benthic community as they relate to climate change and anthropogenic impacts. For example, composition and rates of surface flow from upland watersheds can help clarify patterns observed in adjacent marine communities. Other PACN Vital Signs that can potentially provide valuable information in parks with marine monitoring where these Vital Signs are also implemented, include Groundwater Dynamics, Erosion and Deposition, Climate, Landscape Dynamics, and Freshwater Animals: Stream Communities Vital Signs. Correlations among these variables will not establish causal links but can focus further research to examine the relationship between material transport and the downstream biota.

The responses of marine fish to a variety of ecological and anthropogenic drivers have been well studied, and reliable predictions can often be made. For example, removal of apex predators often leads to a shift in fish community structure and an accompanying shift in habitat (Friedlander et al. 2007). Although ecological monitoring is capable of documenting changes in community components as well as likely agents of change, monitoring alone cannot discern cause-effect relationships (Halpern et al. 2006). This relationship requires further investigation using targeted research to establish cause (e.g., HaySmith et al. 2005, Halpern et al. 2006). As a result of monitoring, managers and researchers can formulate adaptive management strategies accordingly.

System of Interest

The system of interest for this Vital Sign monitoring protocol is the nearshore coral reef fish community between 10 – 20 m depth, encompassing primarily diurnal non-cryptic fish species. While this protocol focuses on the daytime active fish, we recognize the importance of nocturnal and crepuscular fish on the ecology and overall function of the ecosystem, such as soldierfish, squirrelfish, cardinalfish, eels, and sharks. These fishes serve vital functions for the marine ecosystems within the PACN. Furthermore, we recognize that many fish species predominate only certain depth strata on the reef and that this protocol, because of its scope and limitation of resources, will exclude certain species, such as those fish which occupy the surf zone as well as deep water fishes. Appendix H (Stephens and Daniel 2006) and the Marine Workgroup Overview of Appendix E (Daniel and Minton 2006) in the PACN monitoring plan (HaySmith et al. 2005) provides more detail on other systems found in the network.

Marine fish are diverse and form complex communities, and are important components in reef ecosystems in PACN parks. Marine fish are one of the most abundant and certainly one of the most visible aspects to any coral reef community. They provide food for many organisms during various life history stages as well as serving as predators to cull populations of other organisms. They clear the reef of algae so that corals may thrive and are not overgrown, they fill nearly every ecological niche and in some way shape the dynamics of the coral reef communities in which they live.

One of the most conspicuous aspects of coral reef fish are the various trophic groups found in close proximity to each other. Fish from different phylogenetic backgrounds often serve similar

ecological role in the environment, while others which are closely related may occupy widely disparate niches. For example, the family Acanthuridae has fishes which are open water planktonivores (*Acanthurus thompsonii*), territorial herbivores (*Acanthurus lineatus*), schooling herbivores (*Acanthurus guttatus*), and (Randall 2005, Allen et al. 2003). These trophic groups are defined by the environment and at the same time help to define the community structure of the reef. A reef with considerable upwelling will have a very different fish assemblage than one which is flat and has extensive sand zones.

Reef zonation has been well studied in the Pacific Islands (Maragos 1972, Dollar 1982, Randall and Myers 1983). This zonation results in very distinct fish assemblages often with representatives of each trophic group. A shallow surf zone and a 20 m deep reef slope each have apex predators and herbivores, but they are rarely the same species. Commonly observed zones include the reef flat, the reef crest, the reef slope or forereef, and the deep forereef or pelagic zone (Odum and Odum 1955, Dollar 1982, Done 1983, Huston 1985, Littler et al. 1989, Kendall et al. 2001, Coyne et al. 2003). The reef flat zone is generally characterized by shallow water (less than 2 m), high light exposure, and moderate wave energy. This zone is dominated by algal grazers (e.g. *Chrysiptera glauca* and *Siganus argenteus*) and small piscivorous fish (e.g. *Epinephelus hexagonatus* and *Strongylura incisa*). The reef crest is characterized by high light exposure and generally high wave energy, depending upon orientation to predominant wave origin. This zone is characterized by schooling herbivores like *Acanthurus guttatus* and the somewhat cryptic *Blenniella chrysopilos*. The reef crest may have constant swell exposure on windward or exposed shores. Water depth is generally shallower than 10 m, with the actual reef crest often exposed at low tide.

For this protocol, it is in the reef slope, in the 10 – 20 m zones, that we see the widest array of fish species representing nearly every family and every trophic group. Compared to zones closer to shore, the reef slope is typically characterized by higher species diversity (Karlson 1999). At depths greater than 10 m (bottom limit varies based on the reef but rarely exceeds 40 m), the forereef has high light penetration and relatively moderate wave energy. Among the PACN parks these geomorphological and biological characteristics will vary along with the anthropogenic stressors so the primary focus will be on temporal comparisons of the various metrics within a park.

Of particular ecological importance to the PACN parks are the apex predators. Worldwide, large apex predators have been on the decline with many, including sharks, disappearing at alarming rates (Worm et al. 2006). These (typically) large predators are important to the reef because their absence can cause dramatic shifts in the species composition and dominant taxa of a reef. Reefs which were once dominated by coral are often unrecognizable with the removal of apex predators.

Threats and Concerns

The coral reef fish community is severely affected by a series of anthropogenic events as well as natural stressors. These influences are sometimes species-specific as in targeted fishing for a certain species or more broad scale such as general fishing pressure for multi-species and leaching of terrestrial pollutants into the coral reef habitat affecting entire ecosystems. In this section, we discuss some of the prevalent issues in the PACN. Many of the stressors on the

marine environment have a terrestrial origin, and most are associated with human activity (Bruckner et al. 2005).

On Pacific Islands, population densities are often highest near the coast, resulting in considerable human use with concomitant impact on marine resources (Waddell 2005, Craig et al. 2008). Coral reefs occur at the bottom of watersheds and are subject to multiple threats from both land-use practices in the adjacent watersheds and easy land-based access to exploitable marine resources (Waddell 2005, Wilkinson 2000, Jokiel & Cox 1996). While resource use is often zoned and enforced on land, marine zoning is rare or limited, and many activities are conducted in a lightly or entirely unregulated manner (Bruckner et al. 2005, Waddell 2005, Wilkinson 2000). In PACN parks, coral reef resources are found in shallow nearshore coastal waters, exposing them to a wide range of natural and anthropogenic threats.

Nearly all parks have land management issues either within park units or in surrounding watersheds that result in terrestrial runoff. Runoff-associated issues (e.g., sediments, nutrients, contaminants, and freshwater inputs) have been identified as one of the most significant threats to Pacific marine habitats (Birkeland 1997, Fabricius 2005, Porter et al. 2005). Land-derived sediments, generally a result of runoff, can often be accompanied by inputs of nutrients or pollutants. Nutrient loading into the marine environment often results in an increase in growth and reproduction of phytoplankton and macroalgae (Done 1992, McCook et al. 2001, Smith et al. 2004). Algae, in the presence of high nutrients, can bloom out of control and lead to “red tides” and mass mortality of fish from the reduction of available dissolved oxygen, especially in protected or confined bodies of water (e.g. Cheevaporn and Menasveta 2003). This can also be a significant source of fish poisoning for humans as some of these algae blooms can produce toxins which bio-accumulate in the fish, making them more and more toxic until they eventually become a human health hazard (Heymann 2004).

Climatic stressors are also prevalent across the Pacific Island National Parks. These include ENSO events (El Niño/Southern Oscillation), storms (e.g., seasonal sea conditions, tropical cyclones) and global climate change. While most of these “natural” events are outside management capabilities of the NPS, their effects on the marine ecosystem must be taken into account when attempting to monitor other stressors. The distinction between natural and anthropogenic agents of change is an important consideration when managing park ecosystems for ecological integrity, but difficult to differentiate. Many Pacific Island ecosystems have co-evolved with disturbance from tropical cyclones and volcanic activity. In the absence of anthropogenic influence, these ecosystems undergo natural succession when affected by a natural disturbance regime. However, very few Pacific Island ecosystems are now unaffected by human activity or invasive species which may severely compromise natural ecosystem succession (Brown 1997, Bruckner et al. 2005).

Climate change and in particular its impact on fish habitats are potential threats to PACN parks (Hughes et al. 2003, Graham 2007). As water temperatures increase the amount of available dissolved oxygen decreases leading to areas which can become anoxic and cause mass mortality (Diaz 2001). Furthermore, the effects of bleaching on corals directly relates to some fish as the corals provide obligate habitats and/or food (Graham 2007). If increased sea surface temperatures kill off corals, then the accompanying habitat loss will directly affect some fish and

indirectly impact nearly all the others.

The magnitude of invasive species as a significant marine stressor is currently unknown in most Pacific National Parks, but the seriousness of this threat is well demonstrated by several highly visible and costly cases in Hawaii (Carlton 2001). Efforts should be placed on collecting baseline data on the identity and distribution of marine invasive species and on their early control or eradication.

Natural and Anthropogenic Stressors

Nearshore coral reef fish are subject to many natural and anthropogenic threats and stressors, which can be chemical (e.g. pollution), biological (e.g. invasive species), or geo-physical (e.g. seismic or extreme weather events). Ecosystem responses may vary by degree and consequence depending on a number of factors. These responses are by no means definitive or comprehensive but serve as guidelines for interpretation of observations. The degree and consequence of ecosystem responses may also be affected if there are multiple stressors acting synergistically or sequentially. For example, if a natural event such as a hurricane devastates a reef system within a park, the recovery of that reef might be delayed or never occur due to chronic anthropogenic stressors (i.e. fishing pressure) that are compounding the damage from the hurricane.

While there are a number of ways to illustrate the role of fish in coral reef ecosystems, a threats-based approach focuses on the stressors most likely to affect fish populations in the foreseeable future. These include both natural stressors (hurricanes) and anthropogenic factors (global warming, land-based pollution, fishing pressure). Table 1.2 shows the relationships of the stressors to four Vital Signs that are associated with each other: Benthic Marine Community, Marine Fish, Fish Harvest, and Water Quality. Together, these Vital Signs will monitor changes in fish numerical density, habitat condition and harvest.

Parks Where Protocol Implemented

This Vital Sign monitoring protocol will be implemented, initially, at four parks, Kaloko-Honokohau National Historical Park (KAHO), Kalaupapa National Historical Park (KALA), National Park of American Samoa (NPSA), and War in the Pacific National Historical Park (WAPA) (Table 1.3). All permits and permissions (Appendix C) will be obtained in advance for all federal, state, and territory agencies and from local villages or communities, where appropriate.

Table 1.2. The relationship of some potential natural and anthropogenic stressors to the Marine Fish, Benthic Marine Community, Water Quality, and Fisheries Harvest Vital Signs. This is not an exhaustive list, but rather a list of some of the potential impacts from some stressors.

Stressors		Potential Impacts			
		Fish Abundance <i>Marine Fish Vital Sign</i>	Habitat <i>Benthic Marine Communities Vital Sign</i>	Environmental Condition <i>Water Quality Vital Sign</i>	Fish Harvest <i>Fish Harvest Vital Sign</i>
Natural	Storms	localized decreases in fish abundance of certain species, potential for introduced species	coral damage, reef structure loss	localized increased turbidity, sedimentation, debris, bacterial count, nutrient	localized decrease in catch
Anthropogenic	Global Climate Change	shifts in dominant species, loss of species, decreases in overall fish abundance	coral bleaching, coral diseases, coral death, reef structure erosion, reef degradation, reef loss, increases in algal coverage	increasing ocean temperatures, sea level rise, increased storm activity, increasing erosion, sedimentation, and deposition, and decreasing pH	shifts in harvest amount for differing species, generalized decreases in fish catch
	Land-Based Pollution (Siltation, nutrients, etc.)	shifts in dominant species, loss of species, decreases in overall fish abundance	coral bleaching, coral diseases, coral death, reef degradation, increases in algal coverage	localized increased turbidity, sedimentation, debris, bacterial count, nutrient	localized shifts in harvest species
	Fishing Pressure	decreases in target species abundance, size and distributions, shifts in dominant species, increases in fish disease, decreases in overall fish abundance	coral damage, coral loss, increase in algal cover	localized nutrient and chemical pollution increases, increased sedimentation	decrease in fish size, catch and catch per unit effort, shifts in harvest species

Table 1.3. Parks where this protocol will be initially implemented.

Park	Abbreviation	Location
Kaloko-Honokohau National Historical Park	KAHO	Island of Hawaii, State of Hawaii
Kalaupapa National Historical Park	KALA	Island of Molokai, State of Hawaii
National Park of American Samoa	NPSA	Island of Tutuila, Territory of American Samoa
War in the Pacific National Historical Park	WAPA	Island of Guam, Territory of Guam

Kaloko-Honokohau National Historical Park

KAHO has numerous marine resources including extensive coral formations, threatened and endangered sea turtles and turtle nesting beaches, humpback whales, and spinner dolphins. Large ancient Hawaiian fishponds are both a natural and cultural resource. The coral reefs located in KAHO are an important resource because the island is geologically young and reefs, especially in Kona, are typically less extensive than elsewhere in the state. This park is one of three National Park units in Hawaii to include marine habitat. Significant coral growth is located in the

waters adjacent to parklands, in Honokohau Bay, Alula Bay and offshore of Kaloko Pond, as well as within the northern legislative boundary offshore of Kohanaiki Development.

The State of Hawaii owns and administers the submerged lands below the high tide line within 4.8 km of all coastline within the state. Consequently, the jurisdiction falls under the Department of Land and Natural Resources within the state government. Pelagic resources are also under state control. The Park has official title to marine waters extending offshore of the park but no real management authority over fishers.

Recently, several significant threats have been identified for the marine resources at KAHŌ. Honokohau Harbor and its associated fuel and maintenance facilities interrupt the south boundary of the park (the park owns a small shoreline parcel south of the harbor) and there is considerable concern about up-slope land-based developments. A county wastewater treatment plant discharges treated effluent within 2 km upslope of the harbor and KAHŌ boundaries. This area also contains a county landfill that accepts cars and appliances. The lands to the north of the park are currently being developed as a resort consisting of a golf course and 500 luxury housing units, with a coastal public park. Just across the eastern boundary, marked by Queen Kaahumanu Highway, lies a rock quarry, equipment storage area, gasoline station, and a business district that is under steady expansion. In 2002, the area around the quarry was rezoned from “conservation” to “urban”, adding 0.42 km² to the light industrial development upslope of the park. Aquarium fish collecting is significant in Hawaii, particularly along the Kona coast where approximately fifty permits have been issued and just over 100 target species are sought (West Hawaii Aquarium Project; Tissot and Hallacher 2003). Overfishing and habitat alteration (e.g., coral mortality) due to hurricanes and climate change impacts are also concerns.

Kalaupapa National Historical Park

KALA is located on the north shore of the island of Molokai, encompassing a wide variety of habitats from submerged marine resources to lowland coastal, mesic, and rainforest habitats as well as three offshore islands. The park preserves and interprets the Kalaupapa settlement and Hansen’s disease patients; as a result visitation by the public is limited. Significant marine resources include the presence of threatened and endangered species (monk seal, humpback whale, green sea turtle), and high wave energy coral reef communities, including marine intertidal and fish resources. Some species of hermatypic corals occur at KALA; however, prevailing oceanographic conditions appear to prevent coral reef formation. The intertidal areas consist of exposed basalt benches, low and high cliffs, basalt boulder and cobble beaches, sand beaches and numerous tidepools that provide habitat for juvenile fish species. Upland development, including sedimentation and other runoff-associated issues (mostly along southern shores of the island), overfishing (including from commercial fishing vessels) have all been indicated as significant anthropogenic factors affecting KALA.

The National Park of American Samoa

NPSA has three park units which are located on three different islands (Tutuila, Ofu, and Tau) separated by approximately 11 - 113 km. Each park unit has a marine component which includes fringing reef habitat from nearshore to deepwater representing reef zones from backreef lagoon to reef slope. As a result, all of the approximately 900 species of fish found in American Samoa can be found within the parks’ boundaries. Tutuila is the largest island (136 km²) and supports 96% of the territory’s population of 65,000 (in 2005). The seaward boundary is 400 m offshore

of park units where waters are about 45 m deep. The Ofu Island unit is primarily a marine unit and much of this area is backreef lagoon habitat. Extensive research efforts in the past have identified over 250 species of hard coral, many of which have been found to have significant resiliency to warm waters and coral bleaching. The island of Tau has a significant portion (over 50%) of the land area dedicated to the park. Most of the marine resources are found along the south shore of the island where the forereef quickly drops to over 60 m.

Significant anthropogenic stressors are currently affecting NPSA. Most notably is the apparent overfishing which has reduced the numbers of large fish and apex predators to unsustainable levels (Craig and Green 2006). Other reef species are also actively fished, though a recent territorial law prohibiting the use of SCUBA while night spearfishing seems to be benefiting the territory's fish populations. Habitat alteration (e.g., coral mortality) due to climate change impacts and hurricanes have had significant impacts and the ever present illegal dumping of trash and pollutants has degraded parts of the islands especially on Tutuila (mostly outside of the park on the south side and in Pago Pago Harbor).

War in the Pacific National Historical Park

WAPA consists of seven non-contiguous units of beaches, adjacent offshore lands, and inland areas on the central west coast of Guam that were important to the World War II invasion (1944). The two marine units, Agat and Asan, have extensive marine resources bounded by fringing reefs almost 100 m offshore, including coral reefs, reef flats and seagrass beds. Overfishing and lack of coral recruitment due to erosion/sedimentation resulting from poor land practices have been identified as threats to the marine resources.

Vital Sign Objectives

Most successful monitoring programs have been developed around specific questions and objectives (National Park Service 2006b). These objectives are specific statements that provide additional focus about the purpose or desired outcome of the monitoring program and should be consistent and justifiable with current scientific knowledge (National Park Service 2006b). It should be noted that some successful monitoring programs have been initiated and continued by a few persistent individuals (e.g., Connell et al. 1997, Coles and Brown 2007). In this protocol, two types of objectives are presented: Monitoring Objectives and Sampling Objectives.

Monitoring Questions and Objectives

An effective set of monitoring objectives should meet the test of being realistic, specific, and measurable (National Park Service 2006b). The marine fish vital sign will address the following question and general objective:

Question: For coral reef fishes, what are the long-term trends in the numerical density, biomass, and size of reef fishes?

Objective: Annually determine the density, biomass and size of reef fishes at sites randomly selected on hard substrata in an isobath between the 10 and 20 m depths.

Note that this objective focuses on the day-active component of the coral reef fish fauna rather than cryptic or nocturnal species. While the latter contribute to biodiversity and may be of ecological or management importance, the additional effort and time required to sample cryptic and nocturnal fish is not usually feasible with available resources. Similarly, this protocol targets

the 10 to 20 m depth zone thereby limiting biological extrapolation to shallower and deeper portions of the marine parks.

Sampling Objective

Sampling objectives are usually written as companion objectives to management or monitoring objectives. Sampling (or statistical) objectives specify target levels of precision, power, acceptable Type I and II error rates, and magnitude of change we are hoping to detect.

The parameters of interest vary across space and time, and as such, no single design can provide maximum statistical precision, power, or acceptable error rates for all parameters simultaneously. Therefore, the design was developed to maximize the statistical power of the fish numerical density, with some consideration to fish biomass because both parameters were identified by the PACN as high priorities. Our sampling objective for this Vital Sign protocol follows:

Key System Components and Indicators

Desired conditions:

Fish are a major component of the coral reef ecosystem, potentially numbering 500 – 1,100 species in PACN parks depending on geographic location (Myers 1999). This highly diverse assemblage of carnivores, planktonivores, herbivores and detritovores serve a variety of ecological functions that affect ecosystem structure, processes, productivity and sustainability (e.g., Sale 1991, Hixon 1997). Ideal conditions for coral reef fish across the PACN vary from park to park due, in part, to the diversity of habitats and geomorphological structures. For example, areas with large sand flats will be more productive for rays, razorfish, tilefish, and flounders, while areas with high coral cover are more suited to populations of filefish, parrotfish, butterflyfish, and other coral grazers. The complexity of the coral reef ecosystem provides a great diversity of niches and microhabitats for various species and therefore no one area can be said to be ideal for all species. This protocol, however, is co-located with the Benthic Marine Community Monitoring Protocol to correlate fish assemblage characteristics with associated habitat variables and to efficiently utilize limited sampling resources. The sampling frame chosen for that protocol, (hard bottom substrate within 10 – 20 m depth,) will likely yield the widest array of marine fish species which can be sampled within one habitat type. Therefore, within this sampling frame, the desired condition for healthy reefs will be the presence of no or few invasive species, a full complement of ecological guilds (e.g., presence of apex predators and herbivores that have not been overfished), stable population dynamics, adequate settlement with subsequent recruitment of fish larvae among native species, and low stress on individuals resulting from good environmental conditions (Waddell 2005).

The indicators selected for this Vital Sign are relatively easy to measure and provide information on the state (healthy or degraded) of the system. These indicators include fish density (density is a relative measure of abundance and the terms may be used interchangeably throughout the protocol), fish length, biomass, and community composition.

Fish density:

Fish counts are the basic method of assessing relative changes in population abundance for marine fish. Sources of variation, however, affect fish counts including fish behavior, taxonomic diversity, and diver training. For example, some species avoid the diver, others are curious and attracted to the diver (Kulbicki 1998). A typical sampling approach is to first count the larger,

mobile species that flee, then count the smaller, resident fish (Coral Reef Ecosystem Division 2009). There is a high diversity of fishes in the Pacific parks, particularly in Guam and American Samoa where there are ~1000 species. Considerable skill is needed to be competent in species identification and tallying numbers, thus there is the potential bias due to observer identification skills. Because we are focusing on day-active species rather than cryptic or nocturnal species, the identification task is more manageable. Size of transect/plot area, observer's swimming speed, depth of transect, etc. can also affect results (Colvocoresses and Acosta 2007).

Fish Length:

A visual estimate of fish size is an important component of these surveys for several reasons. First, lengths allow a conversion from fish numbers to biomass by using established length-weight relationships. Second, lengths are often a useful indicator of fishing pressure or population dynamics, e.g., a trend of decreasing sizes may indicate overfishing, or recruitment year classes. Third, there is a strong positive correlation between fish size and fecundity (reproductive potential) which, along with recruitment success, is important in assessing ecological services provided by park fish stocks. Observers will undergo periodic training and testing to reduce sampling biases and estimate fish sizes to an acceptable degree of precision (Williams et al. 2006). With training divers can be expected to have an accuracy of less than two centimeters (Friedlander et al. 2003).

Biomass:

Biomass is a standard companion measurement to fish density. It is derived by estimating fish lengths (visually) and then converting those size estimates into a weight via length-weight relationships (Kulbicki et al. 1993). Biomass standing stock provides another metric for assessing fishing pressure and the efficacy of management activities (Friedlander et al., 2007).

Community composition:

Fish assemblages or selected species can also act as indicators of general reef health and provide a warning of environmental stress and potential ecosystem change (e.g., Friedlander and DeMartini 2002). Additionally, fish within the parks are harvested in traditional, subsistence, artisanal and recreational fisheries (e.g., Craig et al., 2008) which may affect the species composition, abundance and size of targeted species. Fishing is increasingly recognized as a principal threat to Pacific coral reefs and other marine ecosystems worldwide (Dayton 1998, Friedlander and DeMartini 2002, Birkeland 2004, Hutchings and Reynolds 2004). In this respect, it is highly probable that all of the Pacific Islands parks can be categorized as "impaired" in terms of their fish communities. While the harvest of fish will be addressed in a separate, complementary (fisheries-dependent) monitoring protocol, data collected here will contribute to the overall analyses of trends in marine fish resources by providing an in-water (fisheries-independent) assessment of the numerical density, size and biomass of harvested species within park waters.

Long-term changes in the numerical density and biomass of fish assemblages can often be correlated with specific stressors or drivers. For example, a decline in size and numerical density of harvested species is often associated with overfishing. Reef fish diversity and biomass also correlate with the structural complexity of reef habitats; a declining trend in habitat complexity is known to be associated with declines in the fish community (Friedlander and Parrish 1998). Moreover, large apex predators or major herbivores can have ecologically significant impacts on

coral reef ecosystems and the dynamics of major system components. For example, declines in herbivorous fishes could result in increased growth and benthic cover of native or invasive algae which can out-compete and overgrow corals, leading to associated declines in coral health, reef structure and ecosystem resiliency (Hughes et al. 2007).

Potential PACN Managerial Influence

By understanding the ecological stressors affecting marine fish, and obtaining trend information by monitoring key Vital Signs, NPS managers can target potential problem areas that can be addressed through their managerial influence, both within and external to park jurisdictional boundaries (Figure 1.1). Stressors originating within or near park boundaries may be addressed through direct management action; stressors originating outside park boundaries may need to be addressed through indirect means, such as influencing other jurisdictional agencies and decision makers (e.g., through partnerships or submitting comments on proposed development activities). Stressors within parks that are prominent agents of change with multiple linkages, affecting the entire ecosystem, and within the managerial sphere of influence, may be considered a high priority. Park management may attempt to address these high priority stressors with the limited resources available, while prominent agents of change outside the managerial sphere of influence may only be able to be monitored for their effects at least in the short term.

One powerful management strategy to address stressors on marine fish communities is to utilize thresholds or trigger points from fisheries independent monitoring data. When thresholds are exceeded then management action is initiated within that park. The importance of each of these thresholds will depend on the conservation focus of each individual park and the confidence (i.e., statistical power) in the detection level for that metric. Given that statistical power is low for fish data, the most typical threshold will center on a 50% relative decline for the particular metric of interest (e.g. species richness, number/density, and size). For example, if a park is focused on biodiversity conservation, then a relative decline in fish species richness of 50% might trigger a management action. If a park is more interested in fishery resources conservation then a 50% relative decline in fish density and size might initiate a shift in management strategy.

Management actions can be spatially oriented to address stressors such as overfishing since conventional measures like seasonal closures and bag limits have been largely unsuccessful (Cooke and Cowx 2006, Friedlander et al. 2007). For example, if heavy fishing pressure within the park is the primary stressor then a closure of a vulnerable area identified by the monitoring data might be warranted. Management activities can also be focused on activities that target the primary stressor both inside and outside of the park boundaries. If a stressor such as sedimentation from poor land use practices is negatively impacting the fish community then correcting the drainage in the watershed might promote recovery of the fish assemblage. The actual management action will vary depending on the legal authority of the park, location and severity of the stressor, and the strength of partnerships inside and outside of the park.

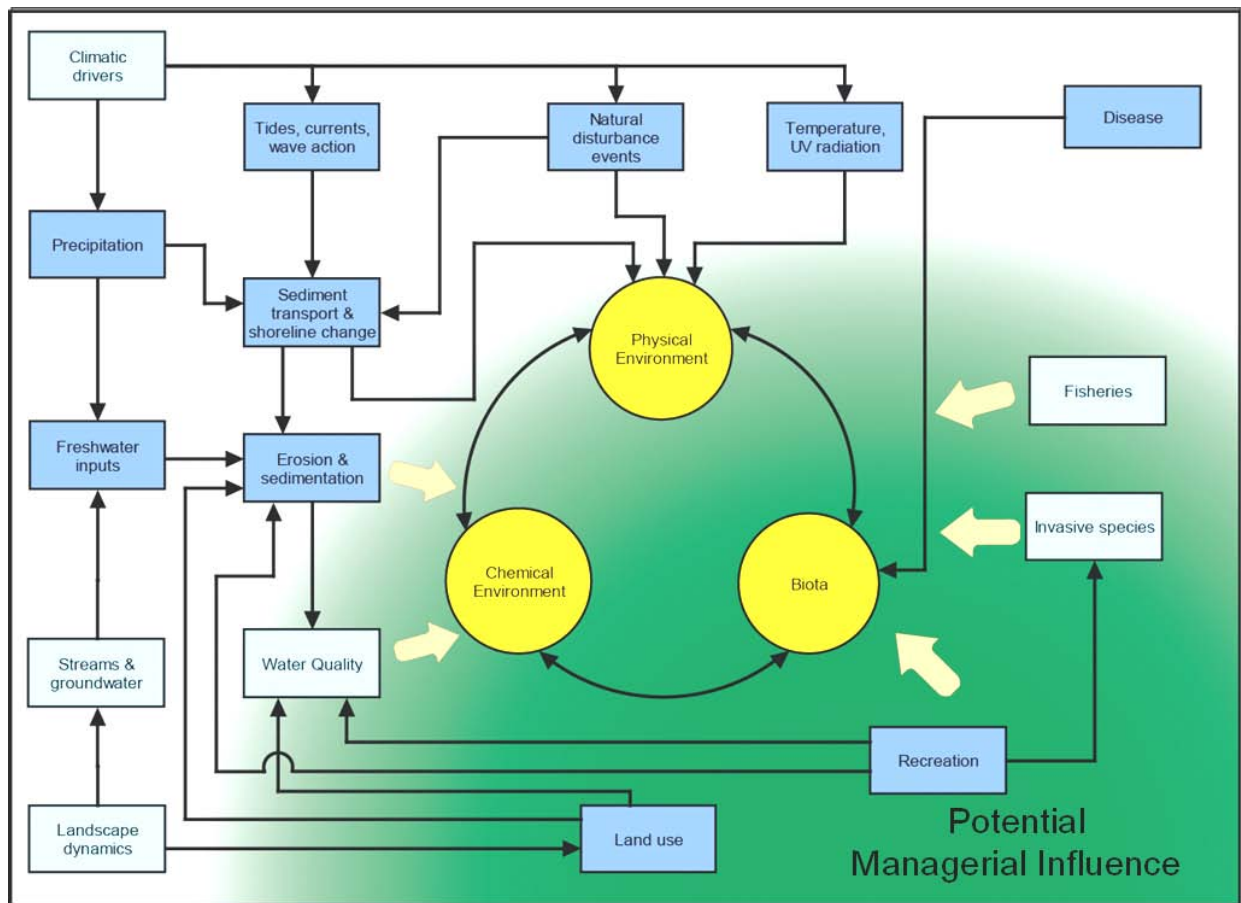


Figure 1.1. Some stressors of nearshore marine ecosystems of PACN parks are under the NPS sphere of managerial influence, while other stressors lie outside this sphere and may prove more difficult to manage directly. Areas generally within the parks managerial sphere (green) may be managed through direct NPS action. Areas outside of the NPS management sphere (white) could potentially be managed by influencing other management agencies and decision makers outside of park jurisdictional boundaries. Rectangles indicate prominent agents of change and circles represent major components of the ecosystem. Light blue rectangles are other PACN vital signs. Large pink arrows link agents of change to the entire ecosystem, including biotic, physical, and chemical components. The dark green area indicates those agents of change or resources that can be potentially managed by NPS (Brown et al. 2007).

Other Monitoring Efforts Past and Present

Widely used, well-tested, peer-reviewed, published, and implemented protocols exist for monitoring all components of this Vital Sign. For example, I&M methods have been developed at Virgin Islands National Park (VIIS) by NPS and USGS for tropical Caribbean coral reef fish. Other existing protocols have been implemented by the National Oceanic and Atmospheric Administration (NOAA), Hawaii Coral Reef Initiative (HCRI), Australian Institute of Marine Sciences/Great Barrier Reef Marine Park Authority, and many others (Table 1.4).

Table 1.4 Summary of other monitoring programs for coral reef or fish communities.

Organization	Description	References
Australian Institute of Marine Science (AIMS)	Monitoring Great Barrier Reef fish & coral communities	http://www.aims.gov.au/pages/research/research-groups/rg-conservation-biodiversity-01-teams-d.html
Atlantic & Gulf Rapid Reef Assessment (AGRRA)	International collaboration to examine condition of Caribbean reefs: corals, algae & fishes	http://www.agrra.org/method/methodhome.html
NPS I&M South Florida Caribbean Network & USGS Southeast Ecological Science Center	Monitor coral reef invertebrate & fish communities	http://www.nature.nps.gov/im/units/sfcn/benthic.cfm http://cars.er.usgs.gov/Coral_Reef_Ecology/Coral_Monitoring_Kit/coral_monitoring_kit.html
NOAA Center for Coastal Monitoring & Assessment Biogeography Program	Develops tools & applications to interpret relationships of species & their surrounding environment	http://ccma.nos.noaa.gov/about/biogeography/
Commonwealth of the Northern Mariana Islands Inter-Agency Marine Monitoring Team (MMT)	Multi-agency effort to monitor coral reef health throughout the Mariana Islands	http://www.cnmicoralreef.net/monitoring.htm
Hawaii Coral Reef Assessment & Monitoring Program (CRAMP)	Developed network of monitoring sites throughout Hawaii for coral and fish species	Rogers et al. 1994, Miller and Rogers 2002
State of Hawaii, Division of Aquatic Resources (DAR)	Long-term monitoring of benthic and fish communities in Maui County. Partnership with CRAMP	Jokiel et al. 2001, 2004; Friedlander et al. 2005
West Hawaii Aquarium Project (WHAP)	Analyzing impacts of aquarium fish collecting on west coast Hawaii Is. Data include fish densities, recruitment, coral/benthic cover, & rugosity	Tissot & Hallacher 2003, Tissot et al. 2004, http://coralreefnetwork.com/kona/overview.htm
Department of Marine & Wildlife Resources (DMWR), American Samoan Government	Monitor distribution, densities & condition of coral, fish, Crown-of-thorns surveys & giant clams	Green 1996, Mundy 1996, Fisk & Birkeland 2002, Green 2002, Craig et al. 2008
Fagatele Bay National Marine Sanctuary, Tutuila Island, American Samoa	Long-term monitoring of benthic community, including coral identification, percent cover & fish numerical density	Birkeland et al 2004

Many marine monitoring programs have lacked statistical rigor and, as a result, have low power to detect ecological change (Brown et al. 2004). The monitoring design proposed in this protocol has been developed to have a sufficient statistical power to detect meaningful change. The methods employed in this protocol, however, obtain similar metrics (e.g., fish numerical density) to most other monitoring programs, especially those operating in the Pacific Ocean. Therefore, valid comparisons can still be made over space and time not only within and among parks but also at larger spatial scales.

The marine fish communities in each park have been inventoried and monitored over the past twenty years to a highly variable degree. Each park also differs greatly in the numbers and diversity of species present within park boundaries and with their given states or territories.

At WAPA the diversity of marine fish is higher than any other PACN park. The coral reef fish fauna in the Mariana Islands numbers at least 1019 species (Myers & Donaldson 2003), many of which occur nowhere else in the National Park System. Focal fish species are not well known in the marine environment at Agat and Asan and further studies are needed to determine specific genera and/or species to monitor. Fish surveys, almost exclusively of daytime-active species, have been conducted around Guam over the years. Main sources include Eldredge et al. (1977), Amesbury (1978), Chernin et al. (1977), and US Army Corp of Engineers (1981). Many of these early studies were biological resource baselines for environmental impact statements and documented species richness and numerical density. In these studies, biomass was not derived but Gawel (1977) did estimate fish lengths.

Recently, fewer larger fish have been observed in nearshore waters across Guam (Paulay et al. 2001); therefore, monitoring programs have been initiated by Division of Aquatic and Wildlife Resources (DAWR) (Gutierrez 2003), University of Guam Marine Laboratory (UOGML), and by the US Navy at Orote and Haputo (Amesbury et al. 2001). NOAA initiated the Marianas Archipelago Reef Assessment and Monitoring Program (MARAMP) in 2003, to be repeated biennially. Several techniques were used such as Rapid Ecological Assessment techniques to document species diversity, Stationary Point Counts to estimate densities of larger (>25 cm), mobile species, belt transects to estimate densities of small, abundant fish, and towed-diver/video surveys to estimate densities of larger (>50 cm) wide-ranging fish (Porter et al. 2005). Sites within the Agat Bay unit in the park were surveyed in 2005 by NOAA using similar techniques (Burdick et al. 2008).

The coral reef fish fauna in the NPSA is nearly as diverse as WAPA with more than 900 species (Wass 1984). Only a few marine endemic species are thought to exist due to widespread dispersal of their pelagic larvae. The few possible endemics may be found to occur elsewhere but their small cryptic nature may have contributed to their only being found on Tutuila. Fish surveys, almost exclusively of daytime-active species and with at least one site in the park include Green and Hunter (1998), Green (2002), Hunter et al. (1993), Whaylon and Fenner (2005), CRED (2009). Outside of the park a long-term but intermittent monitoring program in Fagatele Bay National Marine Sanctuary has been done by Birkeland et al. (1987, 1994, 2004) and Green et al. (1999). Miscellaneous fish studies throughout the territory include Green and Mundy (1995), Craig (1996, 1998), Craig et al. (1997), and Page (1998).

At KAHO there is a significant amount of historical knowledge relating the marine resources in the Park. Parrish et al. (1990) conducted an extensive study documenting marine fish and invertebrate species within the park boundaries. While this was an in depth study of the KAHO specific biota, marine fauna and resource utilization descriptions and maps for west Hawaii Island were developed in 1981 (Nolan and Cheney). Fish and invertebrate inventories have been conducted specifically along the Kona shoreline by Bailey-Brock and Brock (1974). Additionally, biological surveys of the marine waters off of the Old Kona Airport (Hawaii Division of Aquatic Resources 1978) and Wawahiwaa Point (Nolan 1978) nearby to KAHO shores have been conducted.

Researchers have well documented the ecology of the nearshore marine communities of West Hawaii (Doty 1968, Doty 1969, Kimmerer and Durban 1975, Cheney et al. 1977, Kay et al.

1977) yielding excellent information necessary to understand the historical ecological picture of west Hawaii Island prior to the significant growth and development that began in the late 1990s. Prior to the sharp rise in development, Bienfang (1980) and Brock (1980) both conducted impact studies of development on the coastal and brackish water resources on the Harbor directly adjacent to KAHO. Peterson and Orr (2004) conducted a more recent study of marine resource utilization by native Hawaiians for KAHO to better inform Park management of the natural resources and cultural values of the park.

A quantitative study conducted by the U.S. Army Corp of Engineers (1983) repeated five surveys for fish, corals, and invertebrates over 8 years, beginning in 1971, yielding significant information about repeat surveys over time in west Hawaii. The West Hawaii Aquarium program (WHAP) has been conducting studies focused on aquarium trade fish and the value of marine protected areas (Tissot et al. 2004). Data collected include fish densities, recruitment patterns, percent coral cover, diversity, distribution, and the complexity of the three dimensional habitat (rugosity). Most recently, Beets et al. (2006) surveyed fish assemblage characteristics throughout the park along with comparison surveys at three other national parks—Puukohola Heiau National Historic Site (PUHE), Puuhonua o Honaunau National Historical Park (PUHO), and KALA.

The main source of information on fish assemblages at KALA is from (Beets et al. 2006). Data on species richness, numerical density, biomass, and diversity was used to document fish habitat utilization patterns within the park boundaries. Recently, Coles et al. (2008) surveyed the offshore islands in and around the park for unique fish species, numerical density levels, biomass, and diversity. Reef Environmental Education Foundation (REEF) (www.reef.org) also has two sites on the north coast that provides species checklist information.

Sampling Design

Background

Marine fishes are an ecologically vital and charismatic assemblage in marine ecosystems. They are essential for proper ecosystem function, because of the important ecological processes they engage in. Additionally, people enjoy fishes while snorkeling and diving recreationally, particularly to observe in clear, tropical waters. Coral reef fishes are also harvested in subsistence and recreational fisheries. Therefore, marine fishes have been identified as high priority ‘vital signs’ for monitoring programs.

A number of sampling methods and monitoring protocols for marine fishes are described and in use throughout the world. Many commonly used monitoring methods, however, may need modification in the sampling design to address differences in habitat and/or monitoring objectives at the scale of PACN parks. For example, coral reef ecosystems within the Pacific are inherently variable over multiple scales in space and time within and among parks, and are markedly different from Atlantic-Caribbean coral reef systems. Pacific reefs typically have a greater diversity of coral habitats (Spalding et al. 2001) and species assemblages (Longhurst and Pauly 1987, Veron 2000) than reefs in the Caribbean. In addition, Pacific reefs have more extensively developed reef structures (Longhurst and Pauly 1987) shaped by a greater diversity of environmental factors. In terms of sampling scale, many monitoring programs (e.g. Great Barrier Reef Monitoring Program) focus their effort at the level of a site (spatial scale 100 m). In contrast, the sampling design for the marine fish communities in the PACN parks is tailored to provide inference at the larger spatial scale of kilometers. Consequently, methods are not perfectly interchangeable between programs and oceans.

A comprehensive review of these methods along with thorough testing and evaluation of sampling designs was necessary to achieve the program’s goal of developing protocols that are adaptive, yet rigorous scientifically and statistically. Variability may often be greater spatially than temporally, unless the reefs have been exposed to catastrophic disturbance, such as from a tropical cyclone (Beets and Friedlander 2003, Friedlander and Beets 2008). Given these conditions, a split panel sampling design allows for increased spatial sampling while simultaneously examining multiple temporal scales and permitting broader ecological and statistical inference beyond that provided by fixed or permanent sampling locations alone (Skalski 2005).

The purpose of this chapter is to outline the factors considered in selecting the sampling design, outline the basic parameters, evaluate existing data sets, and discuss aspects of the sampling design. Based on various constraints, available data, discussions with NPS marine scientists, PACN staff, and contract statisticians, the sampling design for the Marine Fish Vital Signs monitoring will consist of 15 randomly selected permanent (fixed) 25 x 5 m transect locations and an equal number of random non-fixed locations that are not re-visited. The 30 transects per park will be sampled annually and analyzed for species richness, fish density, and biomass. The sampling frame will be within the 10 – 20 m depth stratum on hard bottom substrate.

General Considerations

This protocol was developed to evaluate three different parameters: (1) fish species richness; (2) fish density; and (3) fish biomass. These parameters vary across space and time, and as such, no single design can provide maximum statistical power for all three parameters simultaneously. Therefore, the design was developed to optimize the statistical power of these three parameters, since these parameters were identified by the PACN as high priorities. Statistical power for parameters of interest will be determined after three years of sampling. Statistical robustness and scientific rigor, however, are not the only criteria that need to be considered in the selection of the sampling design. Additional criteria included:

Maximizing personnel safety. Conducting work in the marine environment presents special challenges and hazards. The safety of field personnel is a critical consideration in the selection process. For example, shallow water habitats (less than 10 m) can be dangerous to survey in many areas due to strong wave action.

Spatial coverage. Sufficient spatial coverage throughout parks that provides broad inference beyond the permanent transect locations.

Logistical constraints. The design limits the number of sites visited each year. Each park has a limited window of time when field activities can be safely conducted, usually during the park's summer months, restricting the number of sites that can be completed in this time frame.

Fiscal constraints. Working in the marine environment is expensive, requiring specialized equipment and highly trained staff. Field work for this protocol will be conducted by in-park coral reef dive scientists associated with the Pacific Islands Coral Reef Program (PICRP) and PCRIP-trained PACN personnel (see Chapter 6). Fiscal constraints within this program, which affect staffing levels and equipment availability, restrict the number of monitoring transect locations that can be visited each year.

Sampling efficiency. Co-location and co-visitation with other marine protocols (e.g. Benthic Marine Community and Water Quality) are desirable to maximize field effort and strengthen correlations among various ecological parameters.

Basic Parameters

Target Population

The target populations are the suite of non-cryptic diurnal fish species, occurring in the depth zone between the 10 – 20 m isobaths on hard bottom substrates.

Sampling Frame

The sampling frame includes all fore-reef slope, hard bottom communities between 10 and 20 m depths within the parks' legislated boundaries and adjacent coastal areas that may impact (or be impacted by) the park (e.g., Figure 2.1). Adjacent coastal areas extend to the edges of the watershed in which the park lies. Selection of the 10 – 20 m depth sampling zone was based on

safety, logistical and cost considerations. Many areas outside this sampling area (depth zone) are too hazardous to sample (e.g., shallow water zones) or too deep to safely and feasibly conduct sampling within the available scuba bottom time limits. The sampling frames for each park covered in this protocol are presented in Appendix D.

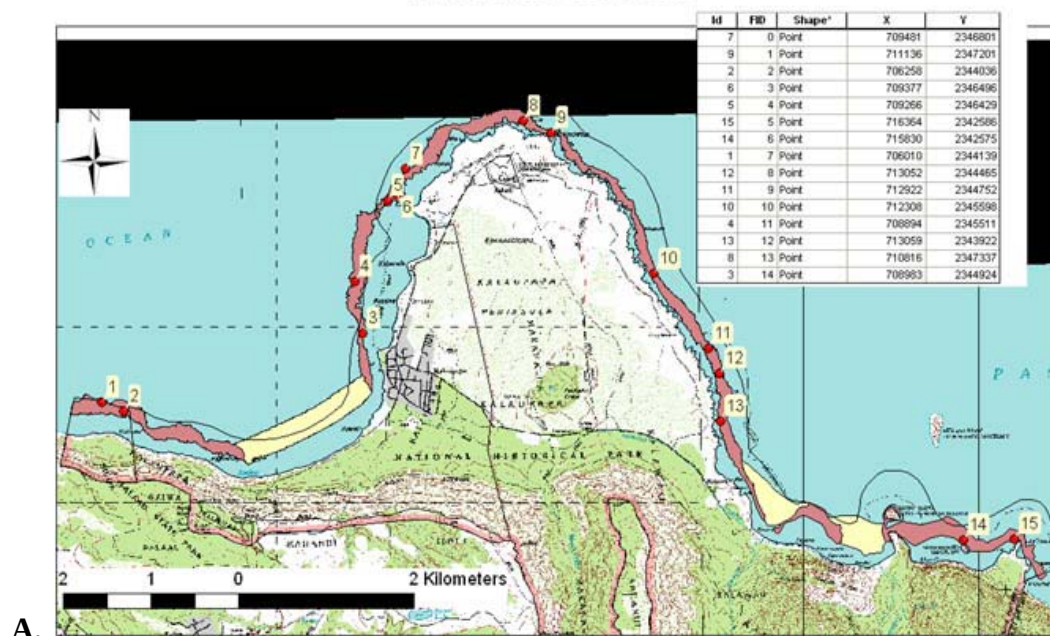
Sampling Unit

The fundamental sampling unit for monitoring of the Marine Fish Vital Sign is the strip, or belt, transect (Brock, 1954) of specified dimensions. The most commonly used transect dimensions in Hawaii and much of the tropics is 4 – 5 m width x 25 m length (e.g. Friedlander et al. 2007), which was selected based on previous multiple parameter studies (e.g. Mapstone and Ayling 1998, Williams et al. 2004). Previous studies (e.g. Fowler 1987) have shown that transect dimensions influence visual survey results. Mapstone and Ayling (1998) found that estimated densities for selected butterflyfishes (Chaetodontidae) were higher on narrower (4 m vs. 12 m and 20 m width) and shorter (20 m vs. 60 m and 100 m length) transects compared to wider and longer transects. Smaller fishes (e.g. Labridae and Pomacentridae) counted on small transects (1 – 4 m x 10 – 30 m), however, were not influenced by transect width or length (Mapstone and Ayling 1998). They attributed these results to larger transects being less intensively searched than smaller transects and consequently underestimating fish densities. Williams et al. (2004) noted similar findings with transect width and also documented the suitability of transects when compared to stationary point counts. Based on the literature results and the desire to compare PACN results with previous studies (e.g. Friedlander et al. 2003, Friedlander and DeMartini 2002), a 5 m width x 25 m length single pass belt transect was selected as the sampling unit in Hawaii and a 4 m width x 25 m length dual pass belt transect (2 m width on the return pass) was selected as the sampling unit in American Samoa and Guam). Although these methods are somewhat different they were selected based on inherent differences in diversity among locations and on the desire to compare data generated by NPS monitoring with the best available data from other reef areas in the region. A second consideration was placing NPS reef areas on a continuum of other reefs in the region that would be meaningful in assessing their status.

The transect method was selected among other methods because: 1) the method provides density data on most non-cryptic taxonomic and trophic groups of all sizes, 2) one diver accompanied by a safety diver trailing behind can safely collect data on fishes, 3) transects of similar dimensions can be co-located with the Benthic Marine Community Vital Sign monitoring and sampled simultaneously, 4) training is not difficult, and 5) the transect method is commonly used by numerous government and non-government monitoring projects, allowing for valid statistical comparisons. Transects of various dimensions are used for specific purposes, such as for large pelagic fishes (Thresher and Gunn 1986) and small juvenile benthic fishes (DeMartini and Anderson 2007). Sampling unit dimensions should be selected based on 1) monitoring project goals and objectives, 2) parameters selected, and 3) a sampling unit study of the resources and locations included in the monitoring program. Other visual monitoring methods have been incorporated in monitoring programs used by NPS and other federal agencies and should be considered for specific objectives. The stationary point count method (Bohnsack and Bannerot 1986) is commonly used in Florida and Caribbean and has been demonstrated effective for stock assessments (Williams et al. 2004). Monitoring for biodiversity parameters, such as species richness, may be more accurately sampled using transect methods, as has been demonstrated in Virgin Islands National Park (Virgin Islands National Park unpublished report). Method

accuracy and precision will vary among resources, parameters, and locations. For a more detailed account of this monitoring methodology, see SOP #7 “Conducting Marine Fish Surveys”.

KALA Fixed Transects



KALA Temporary Transects 2006

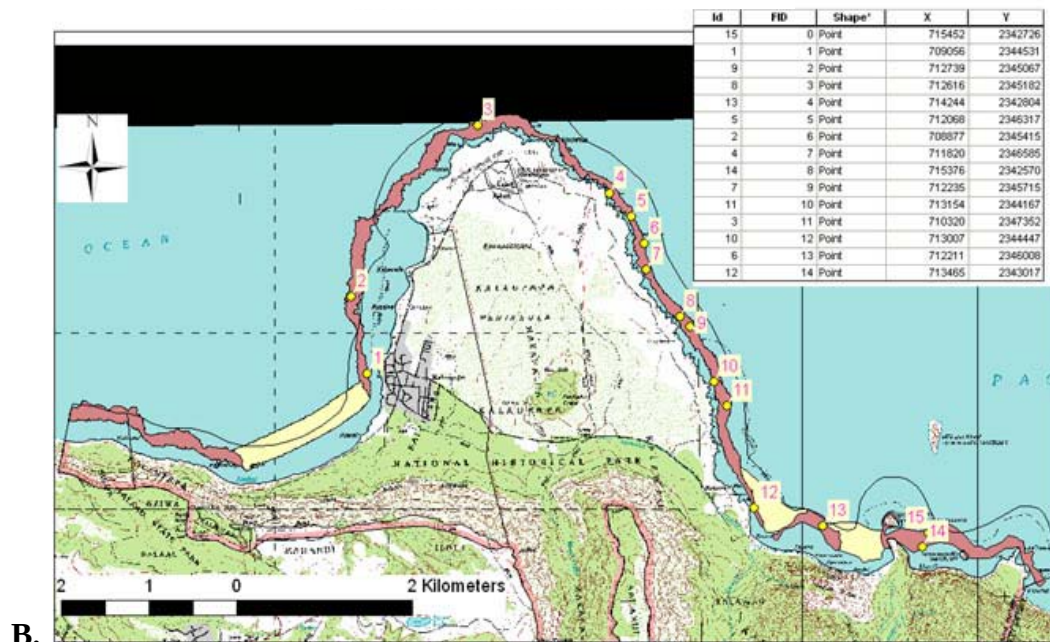


Figure 2.1. The sampling frame for KALA displaying 15 randomly selected fixed sites (A) and 15 randomly selected temporary sites (B) sampled in the first year. Temporary sites are never revisited (NOAA benthic habitat maps, watershed boundaries and bathymetry data are used to define the sampling frame).

Statistical Evaluation of Existing Data Sets

Annual Precision

Precision in the estimates of variables is affected by multiple sources of variation, including spatial and temporal variation. Increasing precision is obtained by increasing replication within the largest component of variation. Equation 2.1 shows precision of the estimate (E) as a function of variability in a typical sample design with multiple transects at a given site. Precision in estimating fish assemblage characteristics (e.g. fish density) at each of the parks is affected by three sources of variability:

at the level of site - Coefficient of Variation₁ (CV₁)

at the level of transect within a site - Coefficient of Variation₂ (CV₂)

at the level of measurement error - Coefficient of Variation₃ (CV₃)

Annual precision is estimated using Equation 2.1.

$$E = Z_{1-\alpha/2} \sqrt{\frac{(1-f_1)CV_1^2}{n} + \frac{(1-f_2)CV_2^2}{nm} + \frac{(1-f_3)CV_3^2}{nmk}} \quad (2.1) \text{ (From Skalski, 2005)}$$

Where:

f_1 = fraction of area sampled by sites (Assume that $1-f_1 = 1$ for the sampled area within a park)

f_2 = fraction of area sampled by transects within a site (Assume that $1-f_2 = 1$)

f_3 = fraction of area sampled by transects repeated for measurement error (Assume that $1-f_3 = 1$)

n = number of sites within the area of interest (e.g. within park boundaries)

m = number of transects per site

k = number of transects repeated for measurement error

and,

$Z_{1-\alpha/2}$ = distribution value for selected confidence interval

Existing estimates of expected variation

The number and species of marine fishes at a given site on Pacific coral reefs can vary significantly. Variability increases with habitat heterogeneity, substrate (structural) complexity, and large densities of small, schooling species, particularly those with highly dispersed groups. The following example uses data from Hawaii to estimate the variance components for species richness, numerical density, and biomass density, but the procedure is applicable to any PACN park. The results indicated that the Coefficient of Variation (CV) was highest among sites for species richness and numerical density and highest among transects within a site for biomass (Table 2.1). Biomass had the highest CV values among the fish assemblage characteristics for the three variability components.

Table 2.1. Coefficient of Variation (CV) among sites, within sites/between transects, and within transects for species richness, numerical density, and biomass density. (Data obtained from Hanalei Bay, Hawaii data [Friedlander and Brown 2006])

Type of Variability	Species Richness	Density	Biomass
Among Sites (CV_1)	0.29	0.61	0.75
Among Transects within a site (CV_2)	0.28	0.50	0.79
Within Transects – Measurement Error (CV_3)	0.15	0.25	0.38

For the purposes of this protocol we used the parameters listed below.

$Z_{1-\alpha/2} = 1.96$ = distribution value for “95% of the time”

$n = 30$ = number of sites within a park to coincide with the benthic protocol

$m = 1$ = number of transects within a site

$k = 1$ = number of transects repeated for measurement error.

These sample sizes are based on previous sampling designs (e.g. Friedlander et al. 2007) and what parks can feasibly survey due to logistical and financial constraints. In addition, the sample size corresponded to the number of samples utilized for the co-located Benthic Marine Community and Water Quality Monitoring Protocols.

Using Equation 2.1, and the CV values from Table 2.1, the annual relative precision of marine fish species richness was $\pm 30.4\%$, 95% of the time (Note that this protocol only has 1 transect at a site rather than a more typical sampling design with multiple transects at a site. Consequently, we had to use the CV values in the table above to determine the precision of the current protocol, otherwise the CV_2 value would be zero for transects within a site). Marine fish numerical density and biomass were more highly variable spatially, temporally, and taxonomically than species richness, with lower annual relative precision of $\pm 41.7\%$ and $\pm 49.6\%$ respectively, 95% of the time. Numerous factors influence marine fish density and biomass (e.g., larval supply, currents, fishing pressure, habitat, water motion, toxic chemicals, predation, and space availability). As a result, variation in marine fish assemblages is incompletely understood. However, analytical results indicated that a significant source of error for measuring fish assemblages was in the measurement itself (Table 2.1). These calculations suggest that precision can be increased by maximizing replication at the highest source of variation which is among sites within a park (n). Future analyses of data derived from park monitoring using this protocol will allow for evaluation of the sources of variation for each park and protocol modification.

Proportion of Fixed Versus Random Panels (Transects)

The goal of this monitoring effort is to detect change over time in fish assemblage characteristics with sufficient statistical power at targeted detection level (See section on Targeted Detection Level). The split panel design selected for this protocol maximizes the spatial replication while reducing the within site effort using a combination of fixed and rotating panels to maximize

power. The optimal proportion of fixed to rotating panels can be estimated from the correlation (r) between years within sites [Equation (2.2)].

$$\text{Proportion of fixed to random sites} = \frac{\sqrt{1-r^2}}{1+\sqrt{1-r^2}} \quad (2.2) \text{ (From Skalski, 2005)}$$

With greater correlation between years, fewer fixed panels are needed.

Marine fish species richness at sites is correlated from year to year, ranging from 0.41 for a given family (Acanthuridae) to 0.79 for the entire surveyed assemblage (Table 2.2). Using Equation 2.2, the proportion of fixed to random sites can range from 38% to 48% for various levels of resolution in fish species richness. Fish density has a lower inter-annual correlation of 0.62 for herbivores to 0.76 for secondary consumers resulting in a proportion of fixed to random sites between 39% and 44%. Finally, total fish biomass has the lowest inter-annual correlation (0.68) for the entire surveyed assemblage. Therefore, a proportion of 42% of the sampled sites would need to be fixed for biomass estimates. Given this wide range of inter-annual correlations for various fish assemblage characteristics and the desire to correlate the fish data with other protocol variables (e.g. Benthic Marine Community and Water Quality Monitoring protocols) that are co-located and co-visited, a conservative design has been selected in which 50% of the panels are fixed and the remaining, rotating panels are visited only once before replacement.

Table 2.2. Average inter-annual correlation (p) and the resulting proportion of fixed versus random sites for different fish assemblage characteristics (Total, Family level, and Trophic level. Data obtained from Friedlander and Brown [2006] at Hanalei, Hawaii and Friedlander and Hunter [2003] at Christmas Island).

Characteristic	R	Proportion of Fixed Sites
Total Species Richness	0.792	0.38
Total Density	0.699	0.42
Total Biomass	0.680	0.42
Acanthuridae species richness	0.412	0.48
Labridae species richness	0.574	0.45
Herbivore density	0.620	0.44
Secondary consumer density	0.764	0.39

Statistical Power Estimation and Sample Size

Statistical power estimations were calculated using available fish monitoring datasets with a sample size of n = 30 transects within a park. This is the sample size utilized in the co-located and co-visited Benthic Marine Community and Water Quality Monitoring Protocols. The equations and tables used in the power analysis were from Skalski (2005) and assembled in a spreadsheet that is provided to each park for their own power calculations. Based on these analyses, this sample size is, at a minimum, sufficient to have a 33% chance of detecting a 50% relative change in total fish species richness over 10 years, a 23% chance to detect a 50% relative change in total fish density over 10 years, and a 22% chance to detect a 50% relative change in total fish biomass over 10 years (Table 2.3). The power estimates for the density of fishes in trophic guilds were generally lower than for pooled density data (Table 2.4). When only adult fishes were analyzed, lower power estimates were obtained for assemblage parameters than for the entire assemblage (adults and juveniles combined).

Power analysis of density data at the family level (Table 2.5) and species level (Table 2.6) demonstrated similar values to those obtained at the assemblage and trophic levels, but with a few greater values for selected taxa. Greater power estimates were obtained for the density of a few common families with greater frequency of occurrence (e.g., wrasses [Labridae] and butterflyfishes [Chaetodontidae]) and a few common species. Although most species with greater power values were infrequently harvested species, a few species with large power values (e.g., *Ctenochaetus strigosus* and *Parupeneus multifasciatus*) are harvested species. Future analyses should evaluate additional parameters for consideration of program evaluation and monitoring modifications.

It is recognized that the current sample size yields low statistical power for the fish assemblage characteristics, but several factors need to be considered. First, this sample size corresponds to the number of samples utilized for the co-located and co-visited Benthic Marine Community and Water Quality Monitoring Protocols. This desirable approach not only increases sampling efficiency but also provides stronger ecological correlations with the other data sets. Second, statistical power was estimated using different sampling designs than what is currently proposed, with fewer fixed sites and no temporary sites. Power is expected to be higher in the proposed design because 50% of the sample sites will be re-surveyed annually, allowing for the refinement of parameter estimates using multiple years of data (e.g., increased parameter precision). These methods have been used to significantly increase statistical power in other monitoring programs (Skalski 2005). The true power of this design will be revisited after 3 to 5 years of consecutive sampling, and the sample sizes may be adjusted accordingly. Third, the data used in the analyses were collected from sites with higher habitat heterogeneity than what is expected within the restricted strata selected for the PACN parks. In the other studies (e.g. Friedlander and Brown 2006), sites were selected based on different habitat types and depths. Finally, logistical constraints, including staffing and budget considerations dictated what each park could feasibly sample in a year. Perhaps, sample size could be increased in the future if park resources were enhanced with more staff and equipment.

Table 2.3. Statistical power for a 1-tailed F distribution at $\alpha = 0.05$ and $\alpha = 0.10$ for detecting relative changes of 10%, 25%, and 50% after 5 and 10 years for total fish assemblage characteristics. Sample size was 20 fixed transects. Values were calculated using fish data collected by A. Friedlander for Hawaii (Friedlander and Brown 2006). The detection level selected for this protocol is highlighted in bold.

Species Richness			$\alpha = 0.05$		$\alpha = 0.10$		
Year	Mean	Variance	Relative Percent Change (%)	5 years	10 years	5 years	10 years
1993	19.90	72.62	10	0.102	0.106	0.204	0.208
1994	20.90	60.20	25	0.115	0.133	0.224	0.246
1999	19.55	41.42	50	0.159	0.227	0.290	0.326
2003	22.80	54.69					
2004	21.95	74.68					
2005	19.55	62.89					

Density			$\alpha = 0.05$		$\alpha = 0.10$		
Year	Mean	Variance	Relative Percent Change (%)	5 years	10 years	5 years	10 years
1993	114.65	16399.40	10	0.043	0.056	0.086	0.110
1994	139.20	29838.17	25	0.102	0.106	0.204	0.208
1999	147.25	13180.51	50	0.110	0.121	0.215	0.230
2003	190.00	26900.42					
2004	112.00	5685.05					
2005	94.20	3897.43					

Biomass			$\alpha = 0.05$		$\alpha = 0.10$		
Year	Mean	Variance	Relative Percent Change (%)	5 years	10 years	5 years	10 years
1993	0.93	1.69	10	0.034	0.044	0.068	0.087
1994	1.11	3.41	25	0.085	0.103	0.169	0.205
1999	1.23	1.72	50	0.106	0.113	0.210	0.219
2003	1.29	1.66					
2004	1.37	1.85					
2005	0.99	1.02					

Table 2.4. Statistical power for a 1-tailed F distribution at $\alpha = 0.05$ and $\alpha = 0.10$ for detecting relative changes in fish density of 10%, 25%, and 50% after 5 and 10 years at the trophic level. Sample size was 20 fixed transects. Values were calculated using fish data collected by Alan Friedlander for Hawaii (Friedlander and Brown. 2006).

Herbivores			$\alpha = 0.05$			$\alpha = 0.10$	
Year	Mean	Variance	Relative % Change (%)	5 years	10 years	5 years	10 years
1993	34.90	938.41	10	0.025	0.032	0.050	0.063
1994	66.05	24097.94	25	0.062	0.080	0.124	0.159
1999	39.65	1113.08	50	0.103	0.108	0.205	0.211
2003	42.90	483.04					
2004	37.30	569.27					
2005	27.80	411.33					

Secondary Consumers			$\alpha = 0.05$		$\alpha = 0.10$		
Year	Mean	Variance	Relative %Change (%)	5 years	10 years	5 years	10 years
1993	55.6	6066.78	10	0.034	0.043	0.067	0.086
1994	55.85	4071.82	25	0.085	0.103	0.168	0.205
1999	81.85	9299.50	50	0.106	0.113	0.210	0.218
2003	75.65	8389.82					
2004	55.15	3494.03					
2005	45.15	1668.98					

Planktivores			$\alpha = 0.05$			$\alpha = 0.10$	
Year	Mean	Variance	Relative % Change (%)	5 years	10 years	5 years	10 years
1993	20.75	924.20	10	0.027	0.034	0.053	0.068
1994	14.35	265.19	25	0.066	0.086	0.132	0.170
1999	22.05	680.26	50	0.104	0.109	0.206	0.212
2003	68.05	8291.73					
2004	14.9	457.04					
2005	18.3	295.38					

Piscivores			$\alpha = 0.05$			$\alpha = 0.10$	
Year	Mean	Variance	Relative % Change (%)	5 years	10 years	5 years	10 years
1993	3.40	26.67	10	0.037	0.048	0.074	0.095
1994	2.95	6.16	25	0.093	0.104	0.186	0.206
1999	3.70	11.48	50	0.107	0.116	0.212	0.223
2003	3.40	21.20					
2004	4.65	14.13					
2005	2.95	8.16					

Table 2.5. Statistical power for a 1-tailed F distribution at $\alpha = 0.05$ and $\alpha = 0.10$ for detecting relative changes in fish density of 10%, 25%, and 50% after 5 and 10 years at the family level. Sample size was 20 fixed transects. Values were calculated using fish data collected by Alan Friedlander for Hawaii (Friedlander and Brown 2006).

Labridae (wrasses)			$\alpha = 0.05$		$\alpha = 0.10$		
Year	Mean	Variance	Relative% Change (%)	5 years	10 years	5 years	10 years
1993	22.60	11.17	10	<0.1021	<0.1029	<0.2033	<0.2040
1994	22.40	14.43	25	0.107	0.116	0.212	0.223
1999	20.55	6.70	50	0.129	0.162	0.244	0.285
2003	17.05	9.94					
2004	11.70	7.97					
2005	15.75	10.35					

Chaetodontidae(butterflyfishes)			$\alpha = 0.05$			$\alpha = 0.10$	
Year	Mean	Variance	Relative% Change (%)	5 years	10 years	5 years	10 years
1993	3.10	3.21	10	<0.1021	<0.1029	<0.2033	<0.2040
1994	1.85	1.87	25	0.103	0.106	0.204	0.209
1999	2.00	1.78	50	0.111	0.123	0.217	0.232
2003	4.05	2.82					
2004	4.25	3.49					
2005	2.85	3.17					

Pomacentridae (damselfishes)			$\alpha = 0.05$		$\alpha = 0.10$		
Year	Mean	Variance	Relative % Change (%)	5 years	10 years	5 years	10 years
1993	23.25	28.09	10	<0.1021	<0.1029	<0.2033	<0.2040
1994	19.20	19.51	25	<0.1021	<0.1029	<0.2033	<0.2040
1999	23.50	27.73	50	0.105	0.109	0.207	0.213
2003	40.60	59.09					
2004	9.05	19.34					
2005	13.40	14.47					

Acanthuridae,(surgeonfishes)			$\alpha = 0.05$		$\alpha = 0.10$		
Year	Mean	Variance	Relative % Change (%)	5 years	10 years	5 years	10 years
1993	25.75	24.92	10	<0.1021	<0.1029	<0.2033	<0.2040
1994	54.50	151.67	25	<0.1021	<0.1029	<0.2033	<0.2040
1999	30.05	24.73	50	0.103	0.106	0.204	0.209
2003	40.10	20.07					
2004	36.50	22.68					
2005	26.35	18.62					

Table 2.6. Statistical power for a 1-tailed F distribution at $\alpha = 0.05$ and $\alpha = 0.10$ for detecting relative changes in fish density of 10%, 25%, and 50% after 5 and 10 years at the species level. Sample size was 20 fixed transects. Values from 1993 to 2004 were calculated using fish data collected by Alan Friedlander for Hawaii (Friedlander and Brown. 2006).

<i>Thalassoma duperrey</i> Saddle wrasse			$\alpha = 0.05$			$\alpha = 0.10$	
Year	Mean	Variance	Relative % Change (%)	5 years	10 years	5 years	10 years
1993	29.00	374.21	10	0.058	0.075	0.116	0.149
1994	27.30	462.75	25	0.105	0.110	0.208	0.214
1999	13.10	41.46	50	0.118	0.139	0.227	0.253
2003	10.00	52.63					
2004	6.70	37.48					

<i>Acanthurus nigrofuscus</i> Brown surgeonfish			$\alpha = 0.05$			$\alpha = 0.10$	
Year	Mean	Variance	Relative% Change (%)	5 years	10 years	5 years	10 years
1993	15.75	258.72	10	0.043	0.056	0.086	0.110
1994	12.45	193.73	25	0.102	0.106	0.204	0.208
1999	5.75	22.09	50	0.110	0.121	0.215	0.230
2003	13.5	69.74					
2004	7.2	22.80					

<i>Ctenochaetus strigosus</i> Goldeye surgeonfish			$\alpha = 0.05$			$\alpha = 0.10$	
Year	Mean	Variance	Relative % Change (%)	5 years	10 years	5 years	10 years
1993	14.65	481.82	10	0.028	0.036	0.055	0.071
1994	12.55	265.00	25	0.070	0.090	0.139	0.178
1999	7.4	88.88	50	0.104	0.109	0.207	0.213
2003	6.5	30.58					
2004	3.75	27.99					

<i>Parupeneus multifasciatus</i> Manybar goatfish			$\alpha = 0.05$			$\alpha = 0.10$	
Year	Mean	Variance	Relative % Change (%)	5 years	10 years	5 years	10 years
1993	3.1	5.94	10	0.025	0.032	0.050	0.064
1994	4.45	15.31	25	0.062	0.080	0.124	0.159
1999	1.3	13.26	50	0.104	0.108	0.206	0.211
2003	1.35	14.64					
2004	0.15	14.26					

Statistical Considerations for Decreasing Variance and Increasing Power

Given that the statistical power in the above tables is low, there are several statistical approaches that can decrease the variance components and ultimately increase power. These methods include using a covariate, pooling or stratification, utilizing a split panel design, and modeling the error structure using a gamma distribution instead of a normal distribution.

Covariate

For fish data, examples of covariates include coral cover and rugosity. Rugosity in particular has been shown to explain most of the variation in fish density and biomass in Hawaii (Friedlander et al. 2003). The covariate can either be used in the statistical analysis to control for the variation of the response variable or a new dependent variable can be utilized such as the ratio of density to rugosity. For example, using the ratio of fish assemblage characteristics to rugosity reduced the variance to mean ratio 32 to 33% for biomass and species richness respectively (Table 2.7). The variance to mean ratio for density remain unchanged.

Table 2.7. Comparison of means, variances, and variance to mean ratios for species richness, density, and biomass to the ratios of each of these parameters divided by the rugosity. SR = species richness, Den = Density, Biom = Biomass, and Rug = Rugosity. Values were calculated using fish data collected by Alan Friedlander within KALA (Beets et al. 2006).

Statistic	Species Richness	Density	Biomass	Rugosity	SR/Rug	Den/Rug	Biom/Rug
Mean	23.15	124.11	12950.52	1.52	15.58	86.41	8468.87
Variance	45.87	2898.41	96784949.93	0.11	20.76	2027.34	43341490.62
Variance/Mean	1.98	23.35	7473.44	0.07	1.33	23.46	5117.74

The primary caveats to this approach are twofold. First, the relationship between the initial response variable and the covariate may change with time. For example, if fish density changes but the rugosity stays the same then the variance may actually increase over time. Second, the relationship may remain strong over time but actually mask changes in the initial response variable. Thus, the covariate and ultimately the ratio would be a poor predictor of trends. For example, if density declined due to some anthropogenic activity (e.g. fishing) but the few remaining fish selected areas of high rugosity then the ratio would remain relatively constant compared to prior years, but the density would have declined.

Pooling or stratification

Pooling/stratification can be done taxonomically or spatially. Ideally, this technique should be done *a priori* but levels of pooling or stratification are unknown for many of the parks. For example, benthic habitat maps do not exist for all of the parks so stratifying by habitat would be difficult. Consequently, pooling or stratification is often performed post hoc as in the taxonomic example above with fish families (Table 2.5). Taxonomic pooling can also take place when taxa exhibit extremely localized high abundances and/or are not deemed to be of significant managerial importance. Statistical power may be improved in this situation without significant information loss by removing those taxa from the analyses, pooling just the specified relevant management taxa. As an example of habitat pooling, the Virgin Islands National Park selected sites *a priori* by a tightly defined habitat type that only included the lower forereef area. The

higher statistical power of the fish assemblage characteristics, compared to the Hanalei data with more diverse habitat types (Table 2.3), is depicted in Table 2.8.

Table 2.8. Statistical power for a 1-tailed F distribution at $\alpha = 0.05$ and $\alpha = 0.10$ for detecting relative changes of 10%, 25%, and 50% after 5 and 10 years for total fish assemblage characteristics. Sample size was 18 fixed transects. Values were calculated using fish data collected by Alan Friedlander and Jim Beets for the U.S. Virgin Islands (Beets and Friedlander 2003).

Species Richness Relative Percent Change (%)	$\alpha = 0.05$		$\alpha = 0.10$	
	5 years	10 years	5 years	10 years
10	0.121	0.145	0.232	0.262
25	0.230	0.362	0.382	0.524
50	0.519	0.816	0.721	0.912

Density Relative Percent Change (%)	$\alpha = 0.05$		$\alpha = 0.10$	
	5 years	10 years	5 years	10 years
10	0.105	0.111	0.208	0.215
25	0.130	0.166	0.247	0.290
50	0.217	0.346	0.371	0.506

Biomass Relative Percent Change (%)	$\alpha = 0.05$		$\alpha = 0.10$	
	5 years	10 years	5 years	10 years
10	<0.102	<0.103	<0.203	<0.204
25	<0.102	<0.103	<0.203	<0.204
50	0.105	0.112	0.208	0.216

Spatial stratification such as wave exposure categories could also be performed post-hoc as new environmental data sets become available. Another approach to post-hoc stratification is to parse out sites with high variance and analyze separately. This could be done with both fixed and temporary sites. It is advisable, however, to continue analyzing the entire suite of sites for at least five years to provide baseline levels for comparison.

Split panel design

The split panel design was developed to improve prior year estimates for both the mean and variance (Skalski 2005). In essence, the fixed sites are used for estimating trends and the annual temporary sites selected from the remainder of the population are used for estimating status. After the first year, the repeated measures of the population mean coupled with the status estimate from the temporary sites provides information to improve the prior year's estimate. Using regression analysis and the sequence of equations (25 – 38) outlined in Skalski (2005), one can adjust the prior year estimate. An Excel spreadsheet has been developed to perform these calculations and is available from the Project Lead. Using the Hanalei species richness data, note

that the adjusted year 1 estimator reduced the variance from 3.63 in year 1 to 3.23 in year 2 or 11% (Table 2.9).

Table 2.9. Adjusted year 1 estimates for species richness mean and variance using a sample size of 10 fixed transects and 10 random transects. Values were calculated using fish data collected by Alan Friedlander for Hawaii (Friedlander and Brown 2006) and equations in Skalski (2005).

Statistic	Year 1 original data	Year 2 original data	Year 1 adjusted estimate
Mean	19.90	20.90	20.41
Variance	3.63	3.01	3.23

The increase in power for the one year was minimal and averaged 0.4 ± 0.1 SE % (Table 2.10). It is anticipated, however, that over time the lower annual variance will improve overall power of the method.

Table 2.10. Comparison of statistical power between the original species richness data in year 1 and the adjusted statistical power for a 1-tailed F distribution at $\alpha = 0.05$ and $\alpha = 0.10$ for detecting relative changes of 10%, 25%, and 50% after 5 and 10 years for total fish assemblage characteristics. Sample size was 20 transects (10 fixed and 10 random). Values were calculated using fish data collected by Alan Friedlander for Hawaii (Friedlander and Brown 2006).

Original Species Richness Relative Percent Change (%)	$\alpha = 0.05$		$\alpha = 0.10$	
	5 years	10 years	5 years	10 years
10	0.145	0.197	0.269	0.330
25	0.355	0.599	0.548	0.752
50	0.999	0.981	0.999	0.995

Adjusted Species Richness Relative Percent Change (%)	$\alpha = 0.05$		$\alpha = 0.10$	
	5 years	10 years	5 years	10 years
10	0.146	0.199	0.271	0.333
25	0.361	0.609	0.555	0.761
50	0.999	0.985	0.999	0.996

Modeling the Error Structure using a Gamma Distribution

Typically, the error structure of fish data does not follow a normal distribution used in conventional statistical procedures. Consequently, modeling the error using a gamma distribution within a generalized linear model (GLZ) should produce a better fit to the GLZ. In the example below, fish density data from two years was analyzed using a two-way ANOVA GLZ with year and transect as categorical factors and density as the dependent factor. The two way design (data = year + transect) without the interaction term tested whether the mean from one year to the next differed, controlling for consistent variation among locations on a transect.

The results indicated that the model structure using a normal distribution with link identity function was not a good fit for the data due to the large deviance and scaled deviance values

(Table 2.11). The gamma distribution with both the link identity and log identity functions modeled the error better. In addition, the log identity function also increased the Wald statistic and improved the probability of detecting a trend in the density data.

Table 2.11. Statistical output from a two way ANOVA Generalized Linear Model using several types of distribution and link functions to model the error structure of the fish density data. Values were calculated using fish data collected by Alan Friedlander for Hawaii (Friedlander and Brown 2006).

Normal Distribution - Link Identity			
	df	Wald Stat.	p
Intercept	1	98.104	0.000
Year	1	0.918	0.338
Goodness of Fit	df	Stat.	Stat/df
Deviance	19	262741.50	13828.50
Scaled Deviance	19	40.00	2.11
Pearson Chi ²	19	262741.50	13828.50
Scaled P. Chi ²	19	40.00	2.11
Loglikelihood		-232.60	

Gamma Distribution - Link Identity			
	df	Wald Stat.	p
Intercept	1	256.760	0.000
Year	1	0.842	0.359
Goodness of Fit	df	Stat.	Stat/df
Deviance	19	3.23	0.17
Scaled Deviance	19	40.53	2.13
Pearson Chi ²	19	2.68	0.14
Scaled P. Chi ²	19	33.66	1.77
Loglikelihood		-181.42	

Gamma Distribution - Link LOG			
	df	Wald Stat.	p
Intercept	1	10001.400	0.000
Year	1	1.820	0.178
Goodness of Fit	df	Stat.	Stat/df
Deviance	19	3.15	0.17
Scaled Deviance	19	40.52	2.13
Pearson Chi ²	19	2.69	0.14
Scaled P. Chi ²	19	34.66	1.82
Loglikelihood		-180.89	

Methodological Considerations for Decreasing Variance and Increasing Power

Another consideration for reducing variance is ensuring adequate training of observers to reduce measurement error. Measurement error, however, is usually minimal compared to other sources of variation (Friedlander et al. 2003) and as noted in the precision section, the highest variation existed at the park level. Training of observers is covered in SOP #2 Training Observers.

Increasing sample size is one of the most useful sampling design methods to lower the variance. Sample size analysis of the Kalaupapa fish data (Beets et al. 2006) using the Bros and Cowell (1987) technique, indicated that 8 –13 samples were needed to detect differences among

transects for species richness, 9 – 13 for density, and 18 – 20 for biomass. The proposed sampling design will use 30 transects so the sample size appears to be sufficient to detect spatial patterns within the park. In contrast, the power to detect changes in fish assemblage parameters over time was poor using 20 transects (Tables 2.3 – 2.6). Even modeling sample sizes up to 40 transects produced insignificant increases in temporal power. These results suggest that fish assemblage characteristics are highly variable within a park so power to detect differences spatially is high. Temporally, however, this high variation results in low power to detect trends.

If an alternative method or modification to the current method is proposed then both methods need to be conducted concurrently for a minimum period of 3 years to evaluate and validate the alternative. In addition, the simultaneous use of both methods will be needed to develop correction factors.

Targeted Detection Level

Based on the analysis of the existing data sets and incorporating logistical and fiscal constraints, the targeted detection level for any of the marine fish assemblage characteristics is $\pm 50\%$ of the baseline mean for the monitoring parameters, expressed as a relative measurement of change after 10 years. For example, if total species richness within a park averaged 24 species, our targeted detection level is change of ± 12 species in absolute number (50% relative). This is based on sampling 30 sites (n) each year, with each site consisting of a single transect (m) and replicated only once annually (k).

Rationale for Sampling Design

Several different spatial and temporal sampling designs were considered for this protocol. Spatial designs for establishing sampling stations included simple random sample, systematic sample (grid), stratified random sample, cluster sample, and Generalized Random Tessellation Stratified (GRTS) (DeBacker et al. 2005). Each of these spatial designs has advantages and disadvantages. The PACN Marine Fish Vital Sign protocol has chosen the simple random sample for the following reasons:

- 1) This is the simplest strategy to setup and implement within a Geographic Information System (GIS).
- 2) This strategy ensures that every portion of the sampling frame has an equal probability of being selected. Many of the PACN parks have marine areas that are relatively unknown (e.g., KALA); therefore it would be difficult to stratify or cluster sampling units based on known habitats, geomorphologic structures, or organism distribution patterns.
- 3) The GRTS system, while appealing, is complicated to implement without contracted statisticians (DeBacker et al. 2005). Limited resources within the PACN preclude use of this approach.

Temporal designs considered in this protocol included sites always revisited, sites never revisited, rotating panels with sites sampled on x consecutive occasions, and split panels which partitions sites into two or more revisit designs (McDonald 2003). Again, each approach has

strengths and weaknesses. The PACN Marine Fish protocol has selected the split panel design for the following reasons:

- 1) A split panel sampling design allows for increased spatial sampling while simultaneously examining multiple temporal scales and permitting broader ecological and statistical inference beyond that provided by fixed or permanent sampling locations alone (Skalski 2005).
- 2) Sampling a new set of sites annually minimizes the bias in status estimates.
- 3) Leaving fixed stations within the design is useful for several reasons. First, the majority of the historical data uses fixed sampling locations so spatial comparisons will be simpler. Second, after the initial random setup, the fixed stations should be easier to resample, thus reducing preparation time and ultimately costs to generate the random grid for subsequent site measurements (Green and Smith 1997). Third, utilizing exclusively randomized sampling without fixed stations makes it difficult to detect change in fish parameters if change occurs dramatically over time; random design measures inherent spatial variation at each sampling period, which adds variance associated with spatial heterogeneity rather than changes or patterns that are time-related (Green and Smith 1997). Fourth, fixed stations can provide additional information in variance structure that is difficult to obtain with random stations (e.g., Connell et al. 1997). Fifth, the fixed stations can be used to update prior estimates through time series calculations (Skalski 1990). Finally, interpreting results from fixed stations is much easier for the general public and resource managers to comprehend than using a straight randomized sampling design.

Establishing Sampling Sites (Spatial Design)

Sample Site Selection Process

To determine the location of the sampling sites for monitoring, spatial coordinates for potential sampling sites will be randomly generated *a priori* in a GIS program (e.g., ArcMap[®] 9.2) using benthic habitat characterization maps. Sampling sites must be between depths of 10 and 20 m, have a hard substrate bottom, and be large enough in area to survey the 25 m transect. If additional depths or strata are considered, refer to subsequent section: **Important Considerations; Addition of Monitoring Strata.**

Sample unit selection will continue until enough sites meeting the criteria have been selected for that sampling year. Randomly selected alternative transect locations will also be generated in case the initial location is unsuitable with respect to benthic habitat type. Full details can be found in SOP # 6 “Selecting Sampling Transect Locations” but a brief narrative is provided below.

Each year, in addition to the 15 points selected for fixed sites, 15 points (plus five additional points for alternative transect locations, if needed) will be generated and sampled. These points will follow the same selection criteria as outlined above. If the generated random points have

been used previously for either fixed or temporary transects then an alternative transect location will be used. When all sites are selected, they should be ordered according to proximity of the transect locations to each other, minimizing travel time. Before starting field work, the site coordinates and transect location numbers should be entered into a Global Positioning System (GPS) (See SOP #4 “Using GARMIN® Global Positioning System Units”). Fixed sites should have the letter F as a prefix to the transect location number. Temporary sites should have the letter T as a prefix to the transect location number.

Establishing Fixed Study Sites

A marine fish monitoring transect location includes two permanent steel pins to mark the start and end points of a transect location. Completing this can be accomplished on one dive with two trained divers. The following is a brief narrative of the procedure. A more detailed description is provided in SOP #6 “Selecting Sampling Transect Locations.”

One permanent transect will be installed at each fixed monitoring transect location. Stainless steel, threaded rod stock will be used as transect marking pins in non-living hard substrate. Other programs have developed methods to install transects without the use of permanent pins; however, these are not feasible for the PACN parks because of environmental conditions (e.g., high wave energy) and the necessity that transects be easily revisited and highly reproducible. Refer to equipment list for installing transect pins in Table S6.2 found in SOP#6: “Selecting Sampling Transect Locations”.

Once the transect area is located using a GPS, a threaded stainless steel pin (See SOP #5: “Pre-Dive Equipment Preparation” and SOP #6 “Selecting and Marking Subtidal Sites”) will be installed in solid substrate with epoxy. One cable tie will be installed around the rod to denote the start pin. The trailing end of the cable tie will be left intact to facilitate relocation. Divers will stretch a fiberglass transect tape along an isobath and install the end pin at the 25 m mark, as was done at the start (0 m) pin. Two cable ties around the rod will denote the end pin. If relocating the end pin will be difficult then the divers could install shorter threaded rods every 5 m. Installing the additional pins between the end pins is not recommended, however, because this procedure detracts from the aesthetic beauty of each park. Note that the temporary transects will not have permanent pins to mark the start and end points.

Non-Fixed Study Sites

Fifteen randomly selected, non-fixed study sites, will be visited each year. Because these sites will not be re-visited annually, the method for conducting a fish survey at non-fixed sites (SOP#7) will be conducted. Temporary transects will be co-located and co-visited with the 15 Benthic Marine Community monitoring surveys by conducting benthic monitoring immediately following the Marine Fish surveys along the same transect. Transects will be installed and measured as described in detail in SOP#6: “Selecting Sampling Transect Locations.” To ensure that sampling is conducted without replacement, it is advisable to randomly select 15 points annually for a minimum of 5 years. Then evaluate each point to make sure that there is a minimum buffer between points of 50 m for all current and previous 25 m transects.

Transect Set-up and Spatial Summary

Figure 2.3 depicts a typical fixed transect setup with the end marker pins. Ideally, the fixed fish transects will be co-located with the Benthic Marine Community Monitoring transects. Therefore, the entire setup would include coral recruitment arrays and tagged coral colonies as shown in the figure. Table 2.12 summarizes the spatial sampling effort for an entire park for a given year.

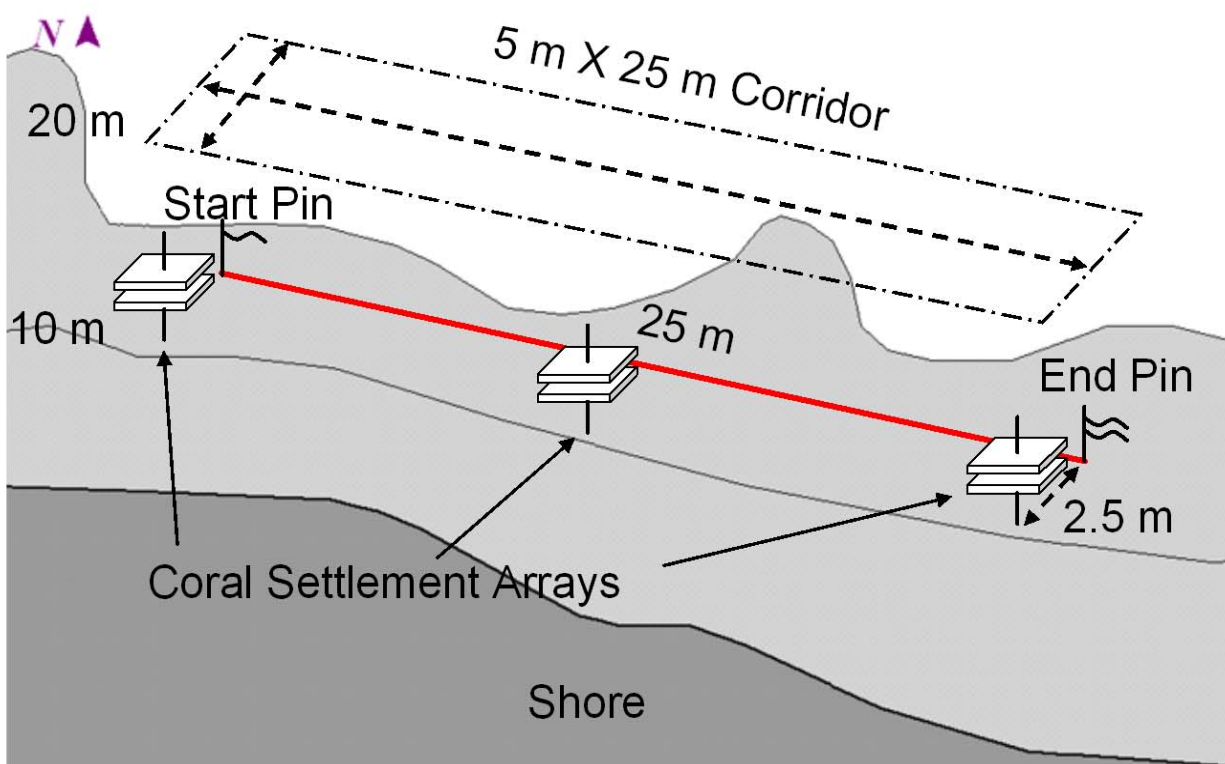


Figure 2.3. Graphical depiction of a typical fixed transect setup with one 25 m transect line and a superimposed 5 m X 25 m corridor for conducting the fish survey. Also included are three coral settlement arrays that would be present on the co-Benthic Marine Community Monitoring transect.

Table 2.12. Total number of sampling units surveyed on an annual basis within each park

Sampling Unit	Variable(s)	Sample Size (N)	Units
Fixed fish transect	Species richness	15	#
	Density	15	# per species
	Size	15	cm per individual
Temporary fish transect	Species richness	15	#
	Density	15	# per species
	Size	15	cm per individual

Sampling Frequency (Temporal Design) Panel Description

Sampling all sites annually would greatly limit the level of spatial coverage, and the breadth of ecological and statistical inference that could be achieved. Consequently, a split panel design will be used to maximize spatial sampling and the breadth of inference by increasing the number of sites monitored. For example, after the first five years, monitoring 30 sites annually with 15 fixed (permanent) sites and a second set of 15 randomly determined temporary sites, the total number of sites surveyed would be 90 (Table 2.13). Temporary sites (rotating panels) will not be revisited, but all sampling sites for Marine Fish Monitoring will be co-located and co-visited with protocols for monitoring the Benthic Marine Community and Water Quality.

Sampling size is based on current staffing and fiscal constraints (see above). At the present time, the PACN parks can sample up to 30 sites per year in each of the four PACN parks with established coral reef programs (PICRP). This level of replication will be evaluated as data are collected in the 3 – 5 years following implementation of the monitoring program, and modified as needed.

Table 2.13. The panel survey schedule for the mixed panel design with 15 fixed/permanent panels and 15 temporary/rotating panels.

Panel	Year				
	1	2	3	4	5
1-15	X	X	X	X	X
15-30	X				
31-45		X			
46-60			X		
61-75				X	
76-90					X

The current sampling design has been based on consideration of safety issues, logistical limitations, financial constraints, analyses of sample data sets for the principal monitoring parameters, and consultations among statisticians and experienced benthic marine ecologists. The PACN parks, however, currently lack adequate coral reef fish assemblage parameter data on spatial and temporal variation within each park to develop a final sampling design. This requires collecting, analyzing, and interpreting several years of data. The design for this monitoring plan has been developed with the best available data, but it is anticipated that modifications within an adaptive sampling design framework will be necessary as implementation proceeds. It is critical to this monitoring program that the collected data be analyzed annually, and that the results will be used to adaptively “fine-tune” the design to optimize effort, statistical power, and inference. It is also anticipated that the statistical power of this design will increase over the values estimated here from previous designs.

Important Considerations; Addition of Monitoring Strata

Numerous considerations should be considered during development and subsequent modifications of monitoring projects. Methods will be improved and the monitoring frame will be modified, particularly following periodic monitoring project evaluations. Method revisions must be validated and calibrated usually requiring simultaneous monitoring with existing methods.

Additional strata may also be identified for incorporation into the monitoring project. Additional depth zones, environmental types, or management units would represent new strata that require careful integration into a monitoring project and protocol modification/approval. Individual parks or NPS units may identify a stratum for integration into a monitoring project, however, such additions should be carefully reviewed and considered to avoid loss of power for parameters in the existing monitoring project.

Managers are usually very concerned with specific resources and locations with significant features (impressive reefs) or high diversity ('Biodiversity Hotspots'). Such resources may not be adequately represented in an initial monitoring project and should be incorporated as 'a new stratum' in the protocol design. Such resources may require 'Special Project' status to derive sound scientific data for management evaluation and action, particularly when acute or pulse events arise (e.g., disease or mortality events). Resource managers and scientists should be knowledgeable of their resources and monitoring programs for effective use of and required modifications to this protocol.

Field Methods

The ability to reliably detect differences in resources over time or among sites is only assured if data are gathered in a consistent and well-documented manner (Beard et al. 1999). The field methods section is intended to ensure consistent methodology and repeatability in light of changing personnel. Those aspects of field methodology that are repeated in different locations or by different personnel are written in the form of a standard operating procedure (SOP). SOPs are detailed written instructions intended to ensure uniformity and consistency of a given procedure within the protocol. SOPs need to be easy to read and implement. For more information on specific field details, please see SOPs #1 – #8 and SOP #10 (Appendix J provides a complete listing of SOPs).

Field Season Preparations, Field Schedule and Equipment Setup

Before beginning the field season, personnel should review this entire protocol, including all of the SOPs and recommended references listed at the end of this document. Permitting applications and compliance forms (Appendix C) need to be completed. The staff should pay special attention to the tasks described in SOP #1 “Before the Field Season” and SOP #2 “Training Observers.” Training sessions using simulated sampling sites along with field checkout dives should be scheduled several weeks before the field season commences. Team leaders should ensure that observers undergo periodic training and testing to avoid sampling biases and estimate fish abundance and sizes to an acceptable degree of precision (Williams et al. 2006). Equipment and supplies listed in SOP #1 should be organized and made ready for the field season, and copies of the field data forms found in Appendix F “List of Field Data forms” should be made on waterproof paper (e.g., Xerox never tear paper). In addition, maps of the sampling area (Appendix D) for that year along with the associated transect coordinates should be printed out and laminated for the field work.

Sampling dates should be scheduled and logistics organized well before the start of each field season. For parks located in the northern hemisphere, the field season might begin in April and May whereas in the southern hemisphere, where seasons are reversed, this would be in October or November. However, flexibility is needed in scheduling sampling trips because of unpredictable weather, ocean conditions, and staff workloads. See SOP #1 “Before the Field Season” for details on chronological timing of logistics.

Conducting the Field Surveys

Sampling Methods

Marine fish surveys will occur during the park’s respective summer months. Summer season for KAHŌ, KALA, and WAPA will be from June through August. Summer survey months for NPSA are December through April. To complete the annual fish surveys it takes approximately 8 – 10 days of field work per park. A total of approximately 30 days should be allocated to complete one field season for all of the co-located marine work (e.g. deployment and retrieval of coral settlement tiles, benthic surveys, and water quality sampling). Surveys will be conducted only in weather/sea conditions that are safe for field work. Fish surveys can be accomplished with a minimum of two observers. Three staff or more are recommended, as two observers are needed underwater while a third person would remain at the surface as the safety diver.

Surveys conducted within one field season will consist of 30 study sites located within each park's sampling frame. The study sites are randomly selected using ArcMap® with 15 sites that are sampled yearly (permanent sites already established under the Benthic Marine Community Vital Signs protocol), and 15 that are randomly selected anew each year. The permanent sites are randomly selected at the onset and marked with stainless steel pins. These sites are relocated annually using a GPS unit. Refer to SOP #4 "Using GARMIN® Global Positioning System (GPS) Units" and SOP #6 "Selecting and Marking Subtidal Sampling Transect Locations" for navigation between sampling sites and site establishment instructions, respectively. The randomly selected temporary sites are never revisited and therefore are not permanently marked. Study sites will be accessed on water by small boats outfitted with outboard motors. For details on preparation for field surveys, see SOP #5 "Pre-Dive Equipment Preparation."

At each study site one 25 m transect will be positioned parallel to the reef crest along a constant depth contour between 10 and 20 m on hard substrate. Once a site is located, observers descend below water and lay a transect line, enumerating fish as the line is deployed. On the initial pass only fishes >20 cm will be counted within a 4 m wide by 4 m high corridor (400 m³). On the return pass, fishes <20 cm will be recorded within a 2 m wide by 4 m high corridor (200 m³). The amount of time spent in the water will be standardized but may vary somewhat depending on how speciose the fish assemblage is at each sampling site. For example, with the more depauperate fauna at KAHO and KALA, only one pass is required and all fish are enumerated and sized within the corridor. The transect dimensions are also expanded slightly to 25 m length X 5 m width for comparisons with other studies conducted in Hawaii.

Fish density

Within each transect, all species of fish encountered will be counted regardless of diel activity pattern (nocturnal, crepuscular, diurnal), habitat (pelagics, nearshore, deepwater), or habitat niche (reef associated, sand flat, surf zone, etc.). Due to the higher biodiversity at NPSA and WAPA, sizes will be partitioned by pass with fishes >20 cm counted on the initial pass and fishes <20 cm recorded on the return pass. By collecting all fish sightings on transect, a better representation of the fish community can be established. Some of these groups may be excluded from the subsequent data analysis (i.e. nocturnal fish counted on transect could be excluded because of obvious underestimation of abundance). These non-destructive techniques focus on a major component of the coral reef fish community, the diurnal or day-active fish species that are highly visible due to their typically bright coloration, generally large size, and good visibility underwater. It is recognized that this approach does not adequately document cryptic fishes (which might require time-consuming or destructive sampling) or nocturnal fishes (because of increased logistical and safety concerns involved in night time SCUBA work).

Fish length

Fish lengths will be estimated in water by the diver to the closest centimeter. Friedlander et al. (2003) found that, with practice, trained observers had an accuracy of less than 1 cm in estimating total fish lengths. Observer's accuracy at estimating fish sizes must be periodically inter-calibrated to avoid sampling biases. A visual estimate of fish size is an important component of these surveys because it allows biomass calculations, is a useful indicator of

fishing pressure, and fish size is a good predictor of reproductive potential. For this protocol, total length is used instead of standard length.

Biomass

Length estimates of fishes are converted to biomass using the following length-mass relationship derived for each species: $\text{Mass} = a * (\text{Standard Length})^b$ where a and b are species-specific constants for the allometric growth equation, standard length (SL) is in millimeters, and mass is in grams (Kulbicki et al. 1993, Friedlander et al. 2003). Total length is converted to standard length by multiplying standard length by total length-fitting parameters obtained from FishBase (www.fishbase.org). Length–mass fitting parameters are available for 150 species commonly observed on visual fish transects in Hawaii (Hawaii Cooperative Fishery Research Unit, unpublished data). This is supplemented with information from other published and Web-based sources. In the cases where length–mass information does not exist for a given species, the parameters from similar bodied congeners are used. All biomass estimates are converted to metric tons per square kilometer (Mg/km²) to facilitate comparisons with other studies worldwide.

Community composition

Species presence/absence data will be collected after completion of the survey transects to give a broader perspective of the fish assemblages present at the study sites but may not have been represented on the transect. This information is collected for all fish species seen during the complete dive. Sizes are not recorded except for species of special management concern such as sharks and humphead wrasse. These data are not included in the data analysis.

Survey Effort and Time Allocation

Annually, the entire field survey effort is expected to take 2 weeks. During a survey, a team of two divers will conduct fish counts with length estimations and photograph the benthos and measure rugosity as part of the co-located/co-visited Benthic Marine Community Protocol transect. The community composition (or species presence data) measurement will take place during the same dive immediately after completing the second pass along the transect to do fish counts. The time required to complete all of these tasks will be approximately 40 to 50 minutes. The initial establishment of the fixed sites adds approximately 10 minutes to the total survey time.

For more details on survey effort and time allocation, refer to Chapter 6 “Operational Requirements” and SOPs #6 “Selecting and Marking Subtidal Sampling Transect Locations.”

After the Field Season

General equipment maintenance tasks need to be completed at the end of the field season. General post field season logistics and tasks are described in SOP #16 “After the Field Season.” All gear and equipment will need to be rinsed and those pieces in need of repair or maintenance will be identified at this point. A service schedule will be prepared so that gear is ready for the next field season. Maintenance required for the boat, boat trailer, motor and dive gear may be park-specific and observers will need to refer to park-specific or manufacturer documents.

Data Handling, Analysis, and Reporting

Data handling, analysis, and reporting are treated as three interrelated steps in managing Marine Fish Monitoring information. Additional details and context for this chapter may be found in the [PACN Data Management Plan](#) (Dicus 2006), which describes the overall information management strategy for the network. The [PACN website](#) also contains guidance documents on various information management topics (e.g., report development, GIS development, and GPS use).

Project Information Management Overview

Project information management may be best understood as an ongoing or cyclic process, as shown in Figure 4.1. Specific information management tasks for this project and their timing are described in Appendix G: Project Task List. Readers may also refer to each respective chapter section below for additional guidance and instructions.

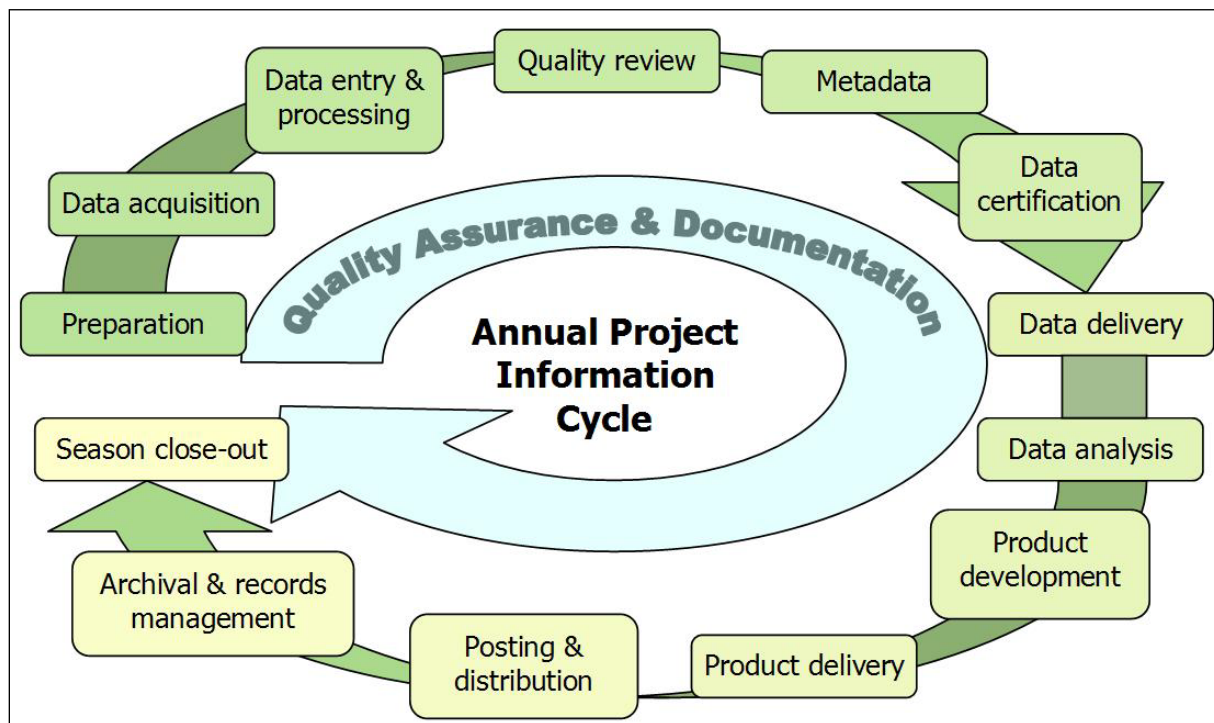


Figure 4.1. Idealized flow diagram of the cyclical stages of project information management, from preparation to season close-out. Note that quality assurance and documentation are thematic and not limited to any particular stage.

The stages of this cycle are described in greater depth in later sections of this chapter, but can be briefly summarized as follows:

- 1) *Preparation* – Training, logistics planning, print forms and maps
- 2) *Data acquisition* – Field trips to acquire data
- 3) *Data entry & processing* – Data entry and uploads into the working copy of the database, GPS data processing, etc.
- 4) *Quality review* – Data are reviewed for quality and logical consistency

- 5) *Metadata* – Documentation of the year’s data collection and results of the quality review.
- 6) *Data certification* – Data are certified as complete for the period of record.
- 7) *Data delivery* – Certified data and metadata are delivered for archival and uploaded to the master project database.
- 8) *Data analysis* – Data are summarized and analyzed.
- 9) *Product development* – Reports, maps, and other products are developed.
- 10) *Product delivery* – Deliver reports and other products for posting and archival.
- 11) *Posting & distribution* – Distribute products as planned and/or post to NPS clearinghouses.
- 12) *Archival & records management* – Review analog and digital files for retention (or destruction) according to [NPS Director’s Order 19](#). Retained files are renamed and stored as needed.
- 13) *Season close-out* – Review and document needed improvements to project procedures or infrastructure, complete administrative reports, and develop work plans for the coming season.

Preparations for Information Management

Set up project workspace

A section of the networked file server at each host park is reserved for this project, and access permissions are established so that project staff members have access to needed files within this workspace. Prior to each season, the Project Lead should make sure that network accounts are established for each new staff member, and that the Data Manager is notified to ensure access to the project workspace and databases. Additional details may be found in SOP #9: Workspace Setup and Project Records Management.

GPS loading and preparation

The GIS Specialist and Project Lead should work together to ensure that target coordinates and data dictionaries are loaded into the GPS units prior to the onset of field work, and that GPS download software is available and ready for use. Additional details on GPS use and GPS data handling may be found in SOP #4: Using Garmin® GPS units, and on the [PACN website](#).

Implement working database copy

Prior to the field season, the Data Manager will implement a copy of the working database and ensure proper access on the part of the project staff. Refer to Overview for Database Design for additional information about the database design and implementation strategy.

Overview of database design

PACN data management staff designed customized relational database applications to store and manipulate the data associated with this project. Marine Fish components (e.g. tables, queries, etc.) have been added to the Benthic Marine Community database since data for both protocols will be collected at the same sampling sites during the same sampling events. The design of the Benthic Marine Community Monitoring database follows the hierarchical data table organization of the [Natural Resource Database Template](#), the standard for the NPS I&M Program (see the data dictionary and other documentation in Appendix F: Database Documentation). The PACN data

management staff is responsible for development and maintenance of the database, including customization of data summarization and export routines.

The database is divided into two components – one for entering, editing and error-checking data for the current season (i.e., the “working database copy”), and another that contains the complete set of certified data for the monitoring project (i.e., the “master project database”). A functional comparison of these two components is provided in Table 4.1.

Table 4.1. Functional comparison of the master project database and the working database.

Project database functions and capabilities	Working database	Master database
Software platform for back-end data	MS Access®	MS SQL Server® or MS Access®
Contains full list of sampling locations and taxa	X	X
Portable for remote data entry	X	
Forms for entering and editing current year data	X	
Quality assurance and data validation tools	X	X
Preliminary data summarization capabilities	X	
Full analysis, summarization and export tools		X
Pre-formatted report output		X
Contains certified data for all observation years		X
Limited editing capabilities, edits are logged		X
Full automated backups and transaction logging		X

Each of these components is based on an identical underlying data structure (tables, fields and relationships, as documented in Appendix F: Database Documentation). The working database is implemented in Microsoft Access® to permit greater flexibility when implementing on computers with limited or unreliable network access. Eventually, we would like to have the master database be implemented in Microsoft SQL Server® in order to take advantage of the backup and transaction logging capabilities of this enterprise database software.

Both components have an associated front-end database application (“user interface” with forms, queries, etc.) implemented in Microsoft Access®. The working database application has separate screens for data entry, data review, and quality validation tools. The master database application contains the analysis and summarization tools, including pre-formatted report output and exports to other software (e.g., for analysis and graphics production). This front-end application arrangement allows for modification and update of the user interface with no disruption to data entry continuity (i.e., an improved front-end file can be distributed to data entry staff, who link it to the back-end file, discard the out-dated front-end file, and proceed with their data entry work). Under this arrangement, data entry staff has no need to open the back-end file, thereby reducing the risk of improper deletions or other inadvertent data loss occurring within the protocol-specific data tables. In addition, a multi-user environment can be accommodated by storing the back-end file on a server available to all users via a computer network.

During the field season, the project crew will be provided with their own copy of a working database into which they enter, process, and quality-check data for the current season (refer to the next section and SOP #12: Data Entry and Verification). Once data for the field season have been certified they will be uploaded into the master database, which is then used to inform all reporting and analysis. This upload process is performed by the Data Manager, using a series of pre-built append queries.

Data Acquisition

Data will be acquired during the field season, which spans the spring through the fall. Each park will be visited once during the field season for a duration of about 2 weeks. Field observations and position data will be collected during each field tour. Data forms should be reviewed after data collection each day to look for errors. If errors are discovered, changes to the data form will be made according to the instructions in SOP 10: Field Form Handling.

The data acquisition phase and the data entry and processing, quality review, and metadata phases are occurring simultaneously for Marine Fish Monitoring. After each tour of a park during the field season, data entry and processing, quality review, and metadata procedures will be conducted for that tour. This will occur before data acquisition starts for the next park's tour.

Data Entry and Processing

The functional components for data entry into the working database are described in SOP #12: Data Entry and Verification. Each data entry form is patterned after the structure of the field form, and has built-in quality assurance components such as pick lists and validation rules to test for missing data or illogical combinations. Although the database permits users to view the raw data tables and other database objects, users are strongly encouraged only to use these pre-built forms as a way of ensuring the maximum level of quality assurance.

Regular data backups

Upon opening the working database, the user will be prompted to make a backup of the underlying data (see SOP #12: Data Entry and Verification). It is recommended that this be done on a regular basis – perhaps every day that new data are entered – to save time in case of mistakes or database file corruption. These periodic backup files should be compressed to save drive space, and may be deleted once enough subsequent backups are made. All such backups may be deleted after the data have passed the quality review and been certified.

Data verification

Analyses performed to detect ecological trends or patterns require data that are recorded properly and have acceptable precision and minimal bias. Poor quality data can limit detection of subtle changes in ecosystem patterns and processes, and may lead to incorrect conclusions. Quality assurance/quality control (QA/QC) procedures applied to ecological data include four procedural activities, ranging from simple to sophisticated, and inexpensive to costly:

- 1) Defining and enforcing standards for electronic formats, locally defined codes, measurement units, and metadata
- 2) Checking for unusual or unreasonable patterns in data
- 3) Checking for comparability of values between data sets
- 4) Assessing overall data quality

To the greatest extent possible, the Benthic Marine Community database application which includes the Marine Fish data incorporates QA/QC strategies involving the first activity (defining and enforcing standards). The database design and the allowable value ranges assigned to individual fields within the data tables help to minimize the potential for data entry errors and/or the transcription of erroneously recorded data. The other activities are integrated in the validation

phase (see Data Quality Review and SOP #13: Data Quality Review and Certification for more details).

Field form handling procedures

As the field data forms are part of the permanent record for project data, they should be handled in a way that preserves their future interpretability and information content. To minimize the possibility of data loss, hardcopy data forms and field notebooks should be stored in a well organized fashion in a secure location, with photocopies or duplicates stored in a separate location (e.g., on the PACN data server). Refer to SOP #10: Field Form Handling for more details.

Image handling procedures

Photographic images should also be handled and processed with care. Refer to SOP #11: Managing Photographic Images for details on how to handle and manage these files.

GPS data procedures

The following general procedures should be followed for GPS data (see SOP #4: Using Garmin[®] GPS units and Appendix H: Project Task List):

- 1) GPS data should be downloaded by the field crew from the units at the end of each field trip and stored in the project workspace (see SOP #9: Workspace Setup and Project Records Management).
- 2) Raw files should be sent in a timely manner to the GIS Specialist for processing and correction.
- 3) The GIS Specialist will process the raw GPS data and store the processed data in the project workspace.
- 4) The GIS Specialist will upload corrected coordinate information into the database and create any GIS data sets.

The technicians and park biologists should periodically review the processed GPS data to make sure that any problems are identified early on.

Quality Review

After the data have been entered and processed, they need to be reviewed by the Project Lead for quality, completeness, and logical consistency. The working database application facilitates this process with queries that check for data integrity, data outliers missing values, and illogical values. The Project Lead may then fix these problems and document the fixes. Not all errors and inconsistencies can be fixed, in which case a description of the resulting errors and why edits were not made is then documented and included in the metadata and certification report (see Metadata Procedures and Data Certification and Delivery, and SOP #13: Data Quality Review and Certification).

Data edits after certification

Due to the high volume of data changes and/or corrections during data entry, it is not efficient to log all changes until after data are certified and uploaded into the master database. Prior to

certification, daily backups of the working database provide a crude means of restoring data to the previous day's state. After certification, all data edits in the master database are tracked in an edit log (refer to Appendix G: Database Documentation) so that future data users will be aware of changes made after certification. In case future users need to restore data to the certified version, we also retain a separate, read-only copy of the original, certified data for each year in the PACN Digital Library (refer to SOP #16: Product Delivery Specifications).

Geospatial data

The Project Lead and GIS Specialist may work together to review the surveyed coordinates and other geospatial data for accuracy. The purpose of this joint review is to make sure that geospatial data are complete and reasonably accurate, and also to determine which coordinates will be used for subsequent mapping and field work.

Metadata

Data documentation is a critical step toward ensuring that data sets are usable for their intended purposes well into the future. This involves the development of metadata, which can be defined as structured information about the content, quality, condition, and other characteristics of a given data set, both tabular and spatial. Additionally, metadata provide the means to catalog and search among data sets, thus making them available to a broad range of potential data users. Metadata for all PACN monitoring data will conform to Federal Geographic Data Committee (FGDC) guidelines and will contain all components of supporting information such that the data may be confidently manipulated, analyzed, and synthesized.

At the conclusion of the field season (according to the schedule in Appendix G: Project Task List), the Project Lead will be responsible for providing a completed, up-to-date metadata interview form to the Data Manager. The Data Manager and GIS Specialist will facilitate metadata development by creating and parsing metadata records from the information in the interview form, and by posting such records to national clearinghouses. Refer to SOP #14: Metadata Development for specific instructions.

Data Certification and Delivery

Data certification is a benchmark in the project information management process that indicates that: 1) the data are complete for the period of record; 2) they have undergone and passed the quality assurance checks (Quality Review); and 3) that they are appropriately documented and in a condition for archiving, posting and distribution as appropriate. Certification is not intended to imply that the data are completely free of errors or inconsistencies which may or may not have been detected during quality assurance reviews.

To ensure that only quality data are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. The Marine Ecologist in each Park is primarily responsible for ensuring completion of a PACN Project Data Certification Form for the data acquired in their park, available on the PACN website. This brief form should be submitted with the certified data according to the timeline in Appendix G: Project Task List. Refer to SOP #13: Data Quality Review and Certification and SOP #16: Product Delivery Specifications for specific instructions.

Data Analysis

Note: Refer to Appendix G: Project Task List for the specific analysis tasks and their timing, and to SOP #18: Data Analysis and Reporting for a more detailed description of analytical procedures. Recommendations for data summaries and statistical analyses are provided in the SOP with a univariate example for fish species richness. The example illustrates step by step procedures in a statistical program (e.g. *STATISTICA*® 8.0) for the three levels of analysis (Unit, Landscape, and Trend Assessment). A multivariate figure is also provided to show an additional approach to data presentation.

Product Development

Refer to Appendix G: Project Task List and SOP #16: Product Delivery Specifications for the complete schedule for project reports and other deliverables and the people responsible for them.

Report content

A summary report will be produced annually, with a more detailed report produced every five years. The annual report will include:

- 1) Executive summary with superintendent briefing table.
- 2) Brief methods listing sampling locations, survey dates, site coordinates, personnel, and data variables collected.
- 3) GIS maps by park showing spatial patterns of each of the variables.
- 4) Identify any data quality concerns and/or deviations from protocols that affect data quality and interpretability.

Detailed reporting guidelines and table structures are provided in SOP #18: Data Analysis and Reporting.

A more in-depth trend analysis report will be produced every five years. In addition to the above, the five-year report will also include:

- 1) GIS maps for park showing temporal patterns of each of the variables.
- 2) Statistical results of spatial patterns and temporal trends displayed either in tables or graphs. This section will be by park as well as variables among parks.
- 3) Evaluation of statistical power and confidence in results.
- 4) Discussion on interpretation of results. Focus will be on status and trends in distribution and numerical density of vital signs within a park and among parks.
- 5) Place network results within the larger context of Marine Fish population changes throughout the Pacific.
- 6) Evaluate operational aspects of the monitoring program, such as whether any sampling locations need to be eliminated or moved due to access problems, whether the sampling period remains appropriate (the optimal sampling season could conceivably change over time in response to climate change), etc.
- 7) Recommended management actions.

Note: Many of the reports listed in table S18.3 in SOP #18 can be viewed as sections that will be integrated into the larger annual and five year reports.

Standard report format

Annual reports will use the [Natural Resource Report](#) template, and trend analysis and other peer-reviewed technical reports will use the [Natural Resource Technical Report](#) template. These pre-formatted Microsoft Word® templates and documentation of the NPS publication standards are available at: <http://www.nature.nps.gov/publications/NRPM/index.cfm>.

Review products for sensitive information

Certain project information related to the specific locations of rare or threatened taxa may meet criteria for protection and as such should not be shared outside NPS except where a written confidentiality agreement is in place prior to sharing. Before preparing data in any format for sharing outside NPS – including presentations, reports, and publications – the Project Lead should refer to the guidance in SOP #15: Sensitive Information Procedures. Certain information that may convey specific locations of sensitive resources may need to be screened or redacted from public versions of products prior to release.

Product Delivery, Posting and Distribution

Refer to SOP #16: Product Delivery Specifications for the complete schedule for project deliverables, the people responsible for them and detailed instructions on how to deliver final products. Upon delivery, products will be posted to NPS websites and clearinghouses (e.g., NatureBib, NPSpecies, NPS Data Store) as appropriate (refer to SOP #17: Product Posting and Distribution for more information).

Holding period for project data

To permit sufficient time for priority in publication, certified project data will be held upon delivery for two years after it was originally collected. After the two year period has elapsed, all certified, non-sensitive data will be posted to the NPS Data Store. Note that this hold only applies to raw data and not to metadata, reports or other products which are posted to NPS clearinghouses immediately after being received and processed.

Special procedures for sensitive information

Products that have been identified upon submission by the Project Lead and/or park biologists as containing sensitive information will either be revised into a form that does not disclose the locations of sensitive resources, or withheld from posting and distribution. When requests for the unedited version of products are made by the NPS, by another federal agency, or by another partner organization (e.g., a research scientist at a university), the unedited product (e.g., the full data set that includes protected information) may only be shared after a confidentiality agreement is established between NPS and the other organization. Refer to SOP #15: Sensitive Information Procedures for more information.

All official Freedom of Information Act (FOIA) requests will be handled according to NPS policy. The Project Lead will work with the Data Manager and the park FOIA representative(s) of the park(s) for which the request applies.

Archival and Records Management

All project files should be reviewed, cleaned up, and organized by the Project Lead on a regular basis (e.g., annually in January). Decisions on what to retain and what to destroy should be made following guidelines stipulated in [NPS Director's Order 19](#), which provides a schedule indicating

the amount of time that the various kinds of records should be retained. Refer to SOP #9: Workspace Setup and Project Records Management.

Season Close-out

After the conclusion of the field season, the Project Lead, Data Manager, and GIS Specialist should meet to discuss the recent field season, and to document any needed changes to the field sampling protocols, the working database application, or to any of the SOPs associated with the protocol. Refer to the section on Data Entry and Verification for additional close-out procedures not specifically related to project information management.

Personnel Requirements and Training

Roles and Responsibilities

The Marine Fish Protocol will be implemented using a Project Lead (PL), an I&M Marine Ecologist (IMME), existing NPS staff, a centralized Marine Biological Technician (MBT), an I&M Data Manager (IMDM), and study design consultants.

Appendix H to this protocol narrative identifies past and current names and contact information of various personnel.

Project Lead (PL)

The PL will oversee planning, field logistics, data collection, data entry, data verification, data analysis, final report preparation and dissemination. The PL will delegate each park's annual field program coordination to the respective park's marine ecologist but will provide occasional evaluation and consultation. The PL will ensure that data has been managed and archived appropriately, meeting I&M program standards. The PL will also communicate budget, Vital Sign, and program needs to the PACN Program Manager and park staff. The PL will be responsible for I&M programmatic reporting as well as annual trend analysis and reporting, building upon park-based status reports.

The PL will coordinate periodic programmatic reviews of this Vital Sign to ensure the applicability of the protocol and data for park management needs. The PL will be responsible for changes to the protocol design in cooperation with Network and Park staff. In addition to the responsibilities outlined above, the PL assists the park's marine staff with tracking schedules and deadlines to help ensure all relevant park-based tasks are completed in a timely manner. The PL is the primary point of contact should questions/comments arise regarding the protocol and resulting products.

I&M Marine Ecologist (IMME)

The IMME will review effort in each park and help ensure that operations and results are consistent across parks, and meet the guidelines outlined in this protocol. The IMME will communicate with the PACN Program Manager and PL on budget issues and reporting requirements (e.g., protocol review reports and conference attendance). The IMME will provide guidance to the PL and MBT on the protocol and overall coral reef program support to each of the parks in the PACN in which this Vital Sign is implemented. Guidance and support will be in the form of scientific expertise, review of protocol products, logistics support, and identification of research projects to augment existing monitoring.

Marine Biological Technicians (MBTs)

The NPS - MBTs will be stationed in each of the four parks under the supervision of the park marine ecologist with guidance from the PL. These term appointments are not full time positions for marine work, but rather spread among 3 FTEs for all aquatic related work. There will be two FTE's: half FTE in WAPA, half FTE in NPSA, half FTE in KALA, and half FTE in KAHO with a HAVO based full FTE focusing on freshwater work and providing assistance to other MBTs as required. Duties for all MBTs will encompass all aquatic related work in their area. This approach will reduce the travel budget significantly.

The MBT in each park will be responsible for pre- and post-field season preparations within each park where this Vital Sign monitoring is being conducted to assist with on-site field monitoring (typically two to three weeks of in-park field support for each park). This would enable the technician to maintain familiarity with species and conditions found in each park. The primary responsibilities will be field data collection, data entry, data management, and equipment management. The technicians will work with the PL and IMDM to merge each park's data into a final verified database. Initial preparation of analysis log files (see SOP #10 "Data Analysis and Reporting") will be prepared under the direction of the PL and IMDM. Assistance with report preparation will also be provided as directed by the PL and park marine ecologists.

Park-Based NPS Staff

Existing NPS marine resource staff, including ecologists and technicians, will work with the MBT to implement field data collection, data entry, data management, and equipment management.

Park staff will also work with the PL to schedule field data collection. Park-based staff will prepare annual reports on park resource status with support from the PL.

I&M Data Manager

The IMDM will provide guidance and, assistance with data management, archiving, adaptive database design, database maintenance, database integration, and data distribution. The PACN Data Manager will not be responsible for day-to-day activities required to implement this protocol, but will review the data and database-related practices of the PL, park-based marine resources staff, and the MBT to ensure they meet programmatic and Vital Sign standards and needs.

Study Design Consultants

The consultants will provide guidance and assistance with study design and statistical validity of the methodology in cooperation with the PL, IMME, and park-based NPS Marine Ecologists. The consultants will statistically evaluate historical data sets, submit a draft for a suitable sampling design, and review monitoring data from the first few years to refine the protocol.

Qualifications and Training

All technical staff will be trained in and responsible for being familiar with all relevant SOPs and the database. Annual training and recertification is required for NPS dive certification and Department of Interior motorboat operator certificate as outlined in SOP #2 "Training Observers." Prior to the start of each field season, all participating field personnel must refresh their methodologic and taxonomic skills by reviewing SOP #2 "Training Observers."

Each position demands a certain level of competency in background knowledge, skills, and abilities. The PL position requires a graduate degree or equivalent experience in related discipline(s) (e.g., benthic marine ecology, coral reef biology, oceanography, fisheries), taxonomic experience in the field, experience as a working scientific diver, and data analysis experience. The park-based ecologists should have similar experience and expertise that enables them to assist with all aspects of the program.

The MBT requires, at a minimum a bachelor's degree and experience in related discipline(s) (e.g., biological sciences, marine ecology, oceanography). This position must remain capable of underwater field taxonomic identifications, data collection, data management, post-processing, basic data analysis (e.g., statistical software familiarity, data summarization), and equipment maintenance. Due to the strong SCUBA diving emphasis of these positions, NPS will aim to recruit active and experienced SCUBA divers who dive regularly throughout the year. Consequently, training and recalibration will be with comfortable divers who know the local reef assemblages well.

Operational Requirements

The “Operational requirements” chapter outlines preparatory work necessary before monitoring occurs (pre-monitoring documents), annual workloads and field schedule, facility and equipment needs, start-up costs, and annual budgets. A considerable savings in time, effort and cost occurs because Marine Fish sampling sites are co-located and co-visited with the Benthic Marine Community and Water Quality Protocols. A single dive team will usually conduct all three protocols on the same dive.

Pre-Monitoring Documents

Requisite preparations for annual monitoring activities are summarized in SOP #1 “Before the Field Season.” At minimum, the PL, Park Marine Ecologists, and MBT should review all SOPs, the associated database, and other products prior to annual monitoring activities. As needed, the protocol narrative, appendices, SOPs, and databases shall be updated prior to initiating field-based monitoring efforts.

Annual Workload and Field Schedule

Fish surveys will be conducted each year at KAHO, KALA, NPSA, and WAPA. The preferred field sampling window is during the (boreal or austral) summer months at all parks. Inclement weather, personnel workloads, or other factors may preclude the scheduling of certain sampling to specific annual dates (e.g., to encompass the peak coral spawning periods at each park). To limit sources of inter-annual variability, a three-month window will be adopted, when monitoring may occur at each park. Table 6.1 outlines an annual schedule of programmatic and monitoring related activities for this Vital Sign.

Facilities and Equipment

The PL, IMME, and existing park-based staff will have all facility and equipment needs met by their respective host park or office. Facility support, office space, and supply requirements for the MBT are outlined below, with budget considerations detailed in the Annual Budget section (Table 6.2).

Equipment and supply needs are outlined in SOP #1 “Before the Field Season” and SOP #5 “Pre-Dive Equipment Preparation.” Other than personal equipment for the MBT, items such as vehicles, boats, trailers, gas, dive gear, SCUBA tanks and air, and Vital Sign-specific field equipment (consumable and durable) will be provided by the park where monitoring is occurring, or from an I&M equipment pool.

Table 6.1. Annual (fiscal year) schedule of monitoring activity benchmarks with responsible individual(s) identified. This schedule is identical to that presented in the Benthic Marine Community Protocol.

Month	Preparation & Maintenance	Responsible Party
Oct.	Finalize budget for fiscal year. Begin equipment purchases	PL and park marine ecologists
Oct.	Plan summer monitoring and permitting/compliance for NPSA	PL, IMME, and NPSA park ecologists
Jan.-Mar.	Field monitoring in NPSA (Oct. – Mar. for coral settlement)	NPSA marine ecologist, park staff, and MBTs, PL as necessary
Mar.	Complete WAPA, KALA, and KAHO data entry and initial data management (NPSA data entry and initial management is post-austral summer or March)	PL and MBT
Mar.	Plan summer monitoring and permitting/compliance in WAPA, KALA, and KAHO	PL, IMME, and KAHO, KALA and WAPA park marine ecologists
Apr.	Re-evaluate budget status for fiscal year	PL and park marine ecologists
Apr.	Mid-year equipment evaluation	PL, MBT, and park marine ecologists
May	Initial annual data analysis (depending on NPSA timing, NPSA data may be from previous year)	PL and MBT
Jun.	Complete NPSA data entry and initial data management	MBT
Jun. – Aug.	Field monitoring in WAPA, KALA and KAHO (Apr. – Oct. for coral settlement)	Park staff, MBTs, and PL as necessary
Sep.	Close out year-end budget and finalize equipment purchases for previous fiscal year	PL and park marine ecologists
Sep.	Complete annual reporting (protocol summary and annual analysis may be completed earlier; this is the annual deadline for the previous calendar year)	PL and park marine ecologists
Sep.	End of the year equipment evaluation	PL, MBTs, and park marine ecologists
Sep. (or as needed)	Training/safety needs evaluation for PL, MBT, and park-based staff	PL, MBTs, and park staff

Office space and equipment for the MBT will be provided by the host parks and at Hawaii Volcanoes National Park (HAVO) on Hawaii Island during training visits. The office space and task-related equipment items include desk, chair, computer, software, digital camera, peripherals, and miscellaneous supplies.

Park staff will be responsible for their own office space, laboratory space, and supplies as well as providing for the MBT during on-site visits. These items include a computer workstation, internet access, bench space, microscope, wet-sink, and limited chemical use.

Start-up Costs

Because the fish and benthic protocols are inter-connected, a combined budget is appropriate for these budget sections.

Start-up costs are identified separately from annual monitoring and maintenance expenses. In general, start-up costs are not anticipated to be substantial, as costs for this Vital Sign are shared with the Benthic Marine Community Protocol, and build upon existing Pacific Islands Coral Reef Program (PICRP) infrastructure at each park. Also, most annual expenses are personnel, training, and travel-related, and are thus recurring fixed costs.

Approximately \$1,000 per park in field monitoring supplies (transect marking, rugosity chain, and other miscellaneous supplies) and fish identification guides are anticipated. These supplies will be provided using park-based PICRP funds as long as these funds are available.

For the MBT, approximately \$12,000 in start-up costs are anticipated and include dive gear, training, computer equipment, office material, and recruitment costs (Table 6.2). These start-up costs assume existing office space, durable equipment, and consumable supplies are already in place. Note that these costs would be shared with the Benthic Marine Community Protocol. Subsequent new hires for the benthic technician position will incur startup costs of approximately \$8,500.

Initial protocol development will be in collaboration with the Hawaii-Pacific Islands Cooperative Ecosystems Studies Unit. Implementation of this Vital Sign will largely be the responsibility of NPS staff with assistance from various partners and cooperators.

Table 6.2. Start up costs for the Vital Sign Marine Biological Technician for the combined Marine Fish and Benthic Marine Community Protocols.

Start up costs	PACN
Dive equipment	\$2,500
Training and certification	\$3,000
Computer and software	\$3,500
Position rating and recruitment	\$3,000
TOTAL	\$12,000

Annual Budget

Annual expense estimates for the Marine Fish Vital Sign are outlined in Table 6.3. These expenses are based on a single annual field season in each park, using the MBT during an intensive 2 – 3 week window, and existing park-based staff for all additional field work (approximately two additional weeks). As this protocol, sample design, field visit schedule, safety issues and other considerations evolve, this budget will need refining. In addition, these estimates are based on 2008 general pay schedules with expected annual increases.

These expenses are dedicated for implementation of this monitoring protocol, and are outlined in detail by park or office contribution. These include salary (with COLA and benefits), travel, computer and office supplies, office space, personal equipment, and mandatory training and certification expenses related to maintaining dive and boating certifications. Approximately 25%

of the MBT's time will be devoted to this vital sign, the remainder to the Benthic Marine Community Protocol.

For the PL and park-based staff, existing PICRP base funds will be used to support personnel, equipment, supplies, travel, and training expenses with the exception of some PACN-related travel costs. The expenses directly related to this protocol and the Benthic Marine Community Protocol are identified in Table 6.3. This includes all costs associated with boat use and SCUBA supplies, as well as field monitoring supplies such as rugosity chains, fish models for estimating lengths underwater, and cameras. Given the benthic substrate heterogeneity among parks, monitoring transects may need to be installed and maintained using a combination of inexpensive (hand sledge hammer) and costly equipment (underwater drills to be maintained and shared among parks). It is the responsibility of the park, with assistance from the MBT, to insure that all appropriate compliance and permitting has been completed prior to the start of each field season.

The total PACN I&M contribution will be \$121,400 or 32% of the annual budget for this protocol (Table 6.3). PACN data management time and costs will initially be higher (~25% FTE, \$22,700) during the first year of database development. Costs, however, are expected to decrease after the first year because much of the database structure has been borrowed from existing databases (e.g., NOAA Fish Habitat Utilization Study) and the fish database is integrated into the PACN I&M Benthic Marine Protocol database. In addition, some capacity exists within PICRP to assist in database development, further reducing costs. Once the database is operational then it is estimated that data management costs will be approximately 25 – 30% of the annual PACN budget for this protocol.

Costs associated with existing NPS PICRP staff are not requested from PACN, as these positions and their responsibilities already exist without this Vital Sign work. Should this collaboration not be available in the future, additional expenses must be anticipated. Additional partnerships and collaborators will be pursued regardless, to further the mission of NPS, the I&M program, PICRP Parks, and partners.

Table 6.3. Annual implementation expenses for the combined Marine Fish and Benthic Marine Community Vital Signs.

Categories	PACN I&M	HAVO	WAPA	NPSA	KALA*	KAHO	TOTAL
Salaries							
Marine Biological Technician Salary (GS-7, step 3, 100% FTE, 2008 pay schedule with 25% COLA and 33% benefits) X 2 (0.5 NPSA, 0.5 WAPA, & 1.0 Hawaii)	\$109,660	\$0	\$0	\$0	\$0	\$0	\$109,660
PACN I&M Marine Ecologist 0.30 FTE (GS-13, step 5, 100% FTE, 2008 pay schedule with 25% COLA and 33% benefits)	\$0	\$38,800	\$0	\$0	\$0	\$0	\$38,800
Park-based support 0.20 FTE (Park Lead [GS-11, step 5] and 1 Biological Technician [GS-7, step 5] for 5 pay periods/year [100% FTE] with 25% COLA, 25% hazard and 33% benefits)	\$0	\$0	\$31,800	\$31,800	\$68,000	\$31,800	\$163,400
PACN I&M Data Manager 0.07 FTE (GS-11, step 5, 100% FTE, 2008 pay schedule with 25% COLA and 33% benefits)	\$6,400	\$0	\$0	\$0	\$0	\$0	\$6,400
Travel							
Bio-Tech Travel: WAPA training	\$4,000	\$0	\$0	\$0	\$0	\$0	\$4,000
Bio-Tech Travel: NPSA training	\$4,000	\$0	\$0	\$0	\$0	\$0	\$4,000
PL Travel (Park implementation, meetings, etc.)	\$32,000	\$0	\$0	\$0	\$0	\$0	\$32,000
Equipment & Supplies							
Bio-Tech laptop computer hardware and office supplies	\$2,000	\$0	\$0	\$0	\$0	\$0	\$2,000
Bio-Tech computer software	\$500	\$0	\$0	\$0	\$0	\$0	\$500
Bio-Tech personal field equipment	\$500	\$0	\$0	\$0	\$0	\$0	\$500
Park-based Equipment and Supplies (e.g. boat, fuel, trailer, vehicle, survey, safety, and personal equipment)	\$0	\$0	\$8,000	\$8,000	\$8,000	\$8,000	\$32,000
Other							
Bio-Tech mandatory training and certifications	\$1,000	\$0	\$0	\$0	\$0	\$0	\$1,000
Compliance and permits	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Museum collection management	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Park-based personnel mandatory training and certifications	\$0	\$1,500	\$1,500	\$1,500	\$1,500	\$1,500	\$7,500
TOTAL	\$160,060	\$40,300	\$41,300	\$41,300	\$77,500	\$41,300	\$401,760

*KALA Park Lead is PL so 0.60 FTE

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Appendix A. Narrative Revision Log

Only changes in the narrative will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Appendix B. Personnel Names and Contact Information

This appendix to the protocol narrative identifies past and current names and contact information of various personnel identified in Chapter 5. Titles of positions are based on those in Chapter 5. Current personnel are listed in Table B.1. As personnel change, new names will be added and individual tables added for each position.

Table Field Definitions

Name

Name of individual holding position. If no individual is assigned for a time period, designate as “Vacant”. If a responsibility is delegated, such as the I&M Data Manager delegates the role to a subordinate, identify the individual to whom responsibility is delegated. The most recent/present individual with this responsibility is always listed first, followed in reverse chronological order by predecessors.

Start Date

Initial date the named individual assumed this responsibility. Note, only a single, contiguous time period is referenced for each table row. If one individual assumes the same role for multiple non-contiguous time periods, each period of time shall be referenced in a separate table row.

End Date

Terminal date the named individual relinquished or was relieved of this responsibility.

Role

Formal or Acting: Boolean response indicating if this responsibility was assigned as part of standard job duties (formal), or assigned in a temporary capacity and temporary time period while other arrangements were being made (acting).

Physical Duty Station Address

Mailing address.

Park Administratively Assigned

Park or office where named individual is formally stationed.

Job Title

Official Office of Personnel Management type, including grade, if appropriate.

Email

Email address used.

Phone

Phone number used.

Table B.1. Current individuals holding positions listed in Chapter 5.

	Project Lead	Marine Bio-logical Tech	KAHO	KALA	NPSA	NPSA	WAPA	PACN Marine Ecologist	PACN Data Manager
Name	Eric Brown	Vacant	Sallie Beavers	Eric Brown	Peter Craig	Tim Clark	Vacant	Tahzay Jones	Kelly Kozar
Start Date	01 July 2006		01 July 2006	01 July 2006	01 July 2006	02 May 2010		01 July 2006	01 July 2007
End Date	Present		Present	Present	Present			Present	Present
Role	Formal		Formal	Formal	Formal	Formal	Formal	Formal	Formal
Physical Duty Station Address	PO Box 2222, Kalaupapa, HI 96742		73-4786 Kanalani St. Suite #14 Kailua-Kona, HI 96740	PO Box 2222, Kalaupapa, HI 96742	Pago Plaza Pago Pago, American Samoa 96799	Pago Plaza Pago Pago, American Samoa 96799	460 North Marine Drive, Maintenance Facility, Piti, Guam 96915	PO Box 52, 1 Crater Rim Drive, Q22, Hawaii National Park, HI 96718	PO Box 52, 1 Crater Rim Drive, Q16, Hawaii National Park, HI 96718
Park Assigned	KALA		KAHO	KALA	NPSA	NPSA	WAPA	PACN	PACN
Job Title	Marine Ecologist		Marine Ecologist	Marine Ecologist	Ecologist	Marine Ecologist	Marine Ecologist	PACN Aquatic Ecologist	PACN Data Manager
Email	eric_brown@nps.gov		sallie_beavers@nps.gov	eric_brown@nps.gov	peter_craig@nps.gov	tim_clark@nps.gov		tahzay_jones@nps.gov	kelly_kozar@nps.gov
Phone	808-567-6802 x1502		808-329-6881 x220	808-567-6802 x1502	684-633-7082	684-633-7082 x33	671-477-7278 x1010	808-985-6188	808-985-6186

Table B.2 Historical record of individuals holding Project Lead position.

	PL #1	PL #2
Name	Eric Brown	Tahzay Jones
Start Date	01 July 2006	1 Oct 2010
End Date	1 Oct 2010	Present
Role	Formal	Formal
Physical Duty Station Address	PO Box 2222, Kalaupapa, HI 96742	PO Box 52 Hawaii National Park, HI 96718
Park Assigned	KALA	HAVO
Job Title	Marine ecologist	Aquatic ecologist
Email	eric_brown@nps.gov	tahzay_jones@nps.gov
Phone	808-567-6802 x1502	808-985-6188

Appendix C. Permits and Permission

Various research permits and environmental compliance procedures are required to implement this monitoring. As this protocol is implemented, the PL (or designee) in cooperation with NPS park leads will proceed through project compliance as appropriate for each park according to federal as well as state/commonwealth/territory guidelines (Table C.1). The PLs in cooperation with the PACN Aquatic Ecologist (or PACN staff designee) will ensure full compliance with all existing and future regulations. All permitting will be reviewed (if permit type applicable) by each park's person(s) responsible for National Environmental Protection Act (NEPA), Section 106 of the National Historic Preservation Act, Section 7 of the Endangered Species Act, Park research permits, and approved by cultural resource staff. The PACN aquatic ecologist (or PACN staff designee) will be responsible for ensuring appropriate park permitting contacts are notified. Some specific permits required and identified by this protocol follow with descriptions.

Submerged Cultural Resources

When implementing and conducting this protocol, observers will look out for any submerged cultural resources and will report this information to park cultural resources staff as best as can.

Federal Permitting

NPS

NPS research permits will be obtained, in advance of any field activities, for each park where monitoring occurs. Permits will be evaluated on an annual basis, or other timeframe as stipulated in the permit itself. The research permit review process also includes NEPA compliance documentation, as discussed further below. The PL (or designee) in cooperation with NPS park leads will maintain all appropriate documentation.

US Army Corps of Engineers

US Army Corps permits may be required, where permanent markers are installed (such as rebar marking transects). Any permits will be obtained based on consultation with the US Army Corps. Should permits be required, they will be evaluated on an annual basis, or other timeframe as stipulated in the permit itself. The PL (or designee) in cooperation with NPS park leads will maintain all appropriate documentation.

NEPA

At present, under the National Environmental Policy Act, we anticipate that this protocol falls under a Categorical Exclusion (CE) where “a category of actions which do not individually or cumulatively have a significant effect ...and for which, therefore, neither an environmental assessment nor an environmental impact statement is required” (40 CFR 1508.4). Under Directors Order 12 a CE (or CX) is “an action with no measurable environmental impact which is described in one of the categorical exclusion lists in section 3.3 or 3.4 and for which no exceptional circumstances (section 3.5) exist.” NEPA compliance review and documentation will occur as part of the NPS research permitting process.

State, Territorial, and Commonwealth Permitting

State of Hawaii

Department of Land and Natural Resources, The Division of Aquatic Resources issues permits, including ones for scientific research (<http://www.state.hi.us/dlnr/dar/licenses.htm>).

Territory of Guam

MPA and Live Rock permits will be required from the Department of Agriculture, Division of Aquatics and Wildlife Resources located at 163 Dairy Road, Mangilao, Guam 96913.
Phone: (671) 735-3955 and Fax: (671) 734-6569.

And Submerged Lands Permits are required from the Bureau of Land Management

Territory of American Samoa

The territory requires a permit through the Department of Marine and Wildlife Resources.

Village permission should be obtained by personally contacting the village mayor to describe what the study is about, prior to initiating any work according to park cultural resource staff guidelines.

Table C.1. Permits and Compliance by Park.

Permit	WAPA	NPSA	KALA	KAHO
Park Research Permit	X	X	X	X
NEPA	X	X	X	X
Section 7	?	?	?	?
Section 106	N/A	N/A	?	?
Army Corp Engineers	X	N/A	N/A	N/A
State of Hawaii	N/A	N/A	X	X
Territory of Guam	X	N/A	N/A	N/A
American Samoa Territory	N/A	X	N/A	N/A
Village permission	N/A	X	N/A	N/A

Appendix D. Sampling Frame

The following draft maps are examples of what park sampling frames will be like, once the fixed sites and temporary sampling sites are selected. These maps will be updated once these sites are determined and established.

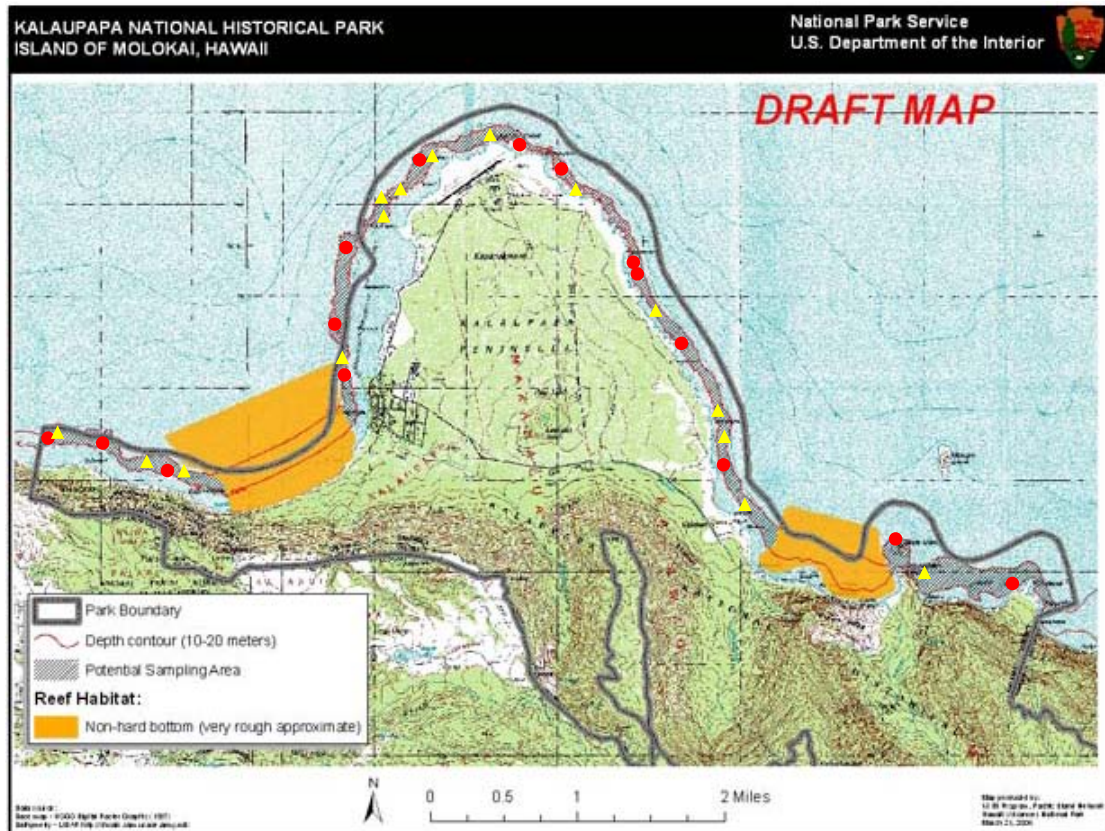


Figure D.1. The sampling frame for KALA with 15 randomly selected fixed sites () and 15 temporary sites (); the latter will be sampled in the first year then replaced by 15 new randomly selected sites each subsequent year. Note, the sampling area has been extended beyond park boundaries in some areas to include the hard bottom habitat within the 10 – 20 m depth contour that is influenced by the watershed within or upslope of the park.

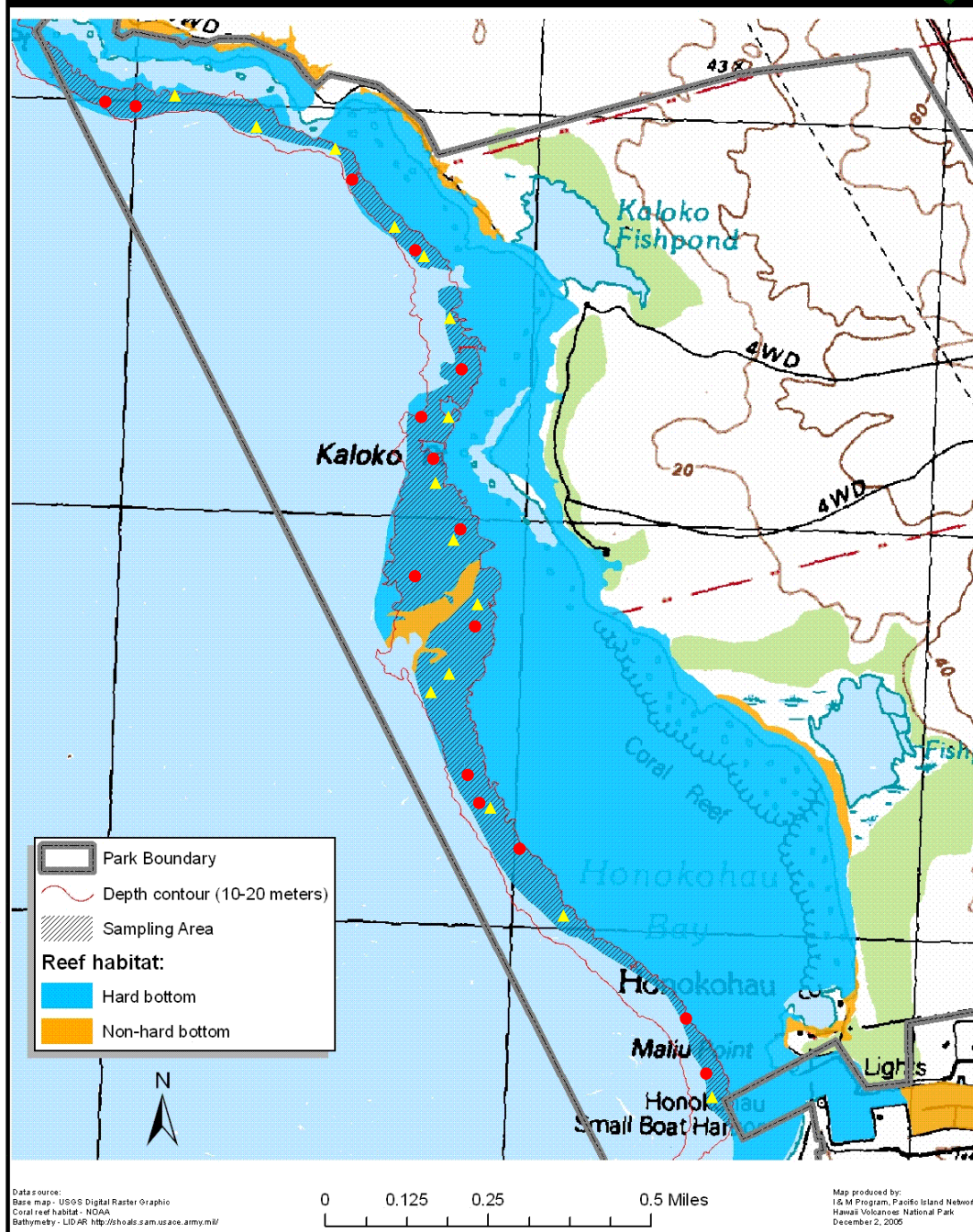


Figure D. 2. The sampling frame for KAHO with 15 randomly selected fixed sites (●) and 15 temporary sites (▲); the latter will be sampled in the first year then replaced by 15 new randomly selected sites each subsequent year. Note, the sampling area has been extended beyond park boundaries in some areas to include the hard bottom habitat within the 10 – 20 m depth contour that is influenced by the watershed within or upslope of the park.

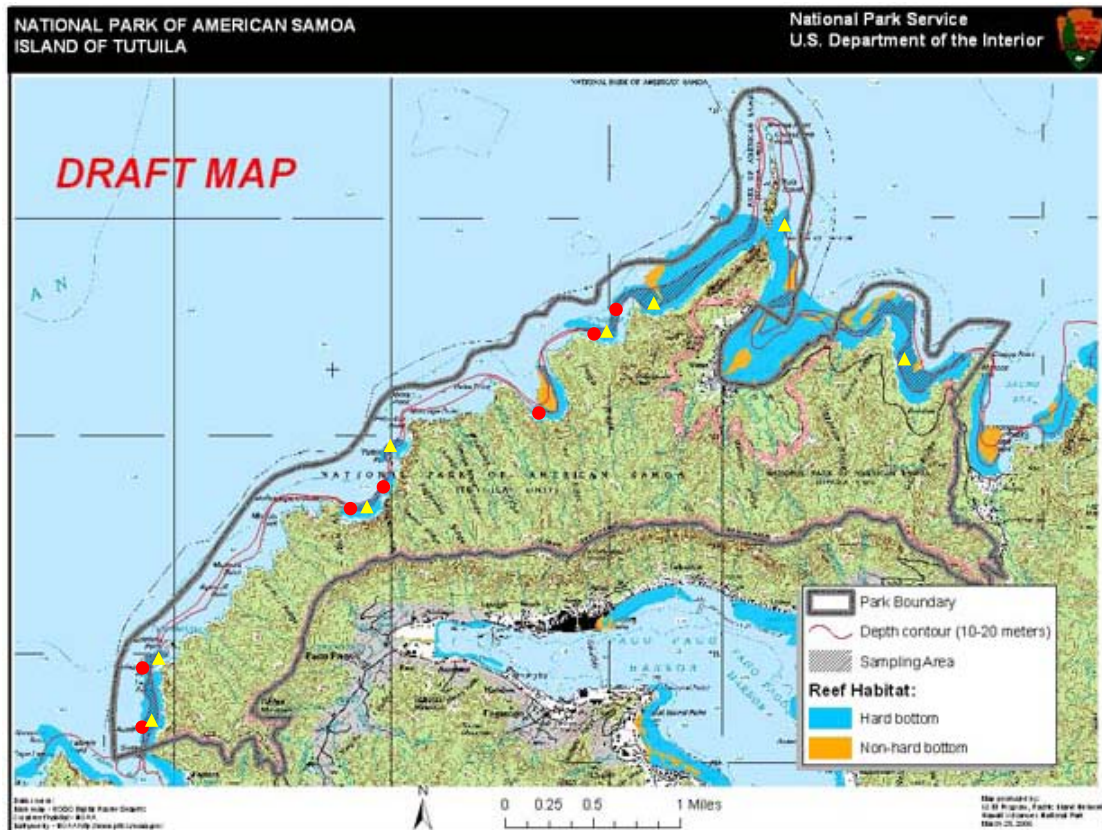


Figure D.3. Sampling frame for NPSA, Tutuila Island unit displaying randomly selected fixed sites (●) and temporary sites (▼); the latter will be sampled in the first year then replaced by new randomly selected sites each subsequent year.



Figure D.4. Sampling frame for NPSA, Ofu Island Unit displaying randomly selected fixed sites (●) and temporary sites (▲); the latter will be sampled in the first year then replaced by new randomly selected sites each subsequent year. Note the sampling area has been extended beyond park boundaries in some areas to include the hard bottom habitat within the 10 – 20 m depth contour that is influenced by the watershed within or upslope of the park.



Figure D.5. Sampling frame for NPSA, Tau Island Unit displaying randomly selected fixed sites (●) and temporary sites (▲); the latter will be sampled in the first year then replaced by new randomly selected sites each subsequent year. Note, the sampling area has been extended beyond park boundaries in some areas to include the hard bottom habitat within the 10 – 20 m depth contour that is influenced by the watershed within or upslope of the park.

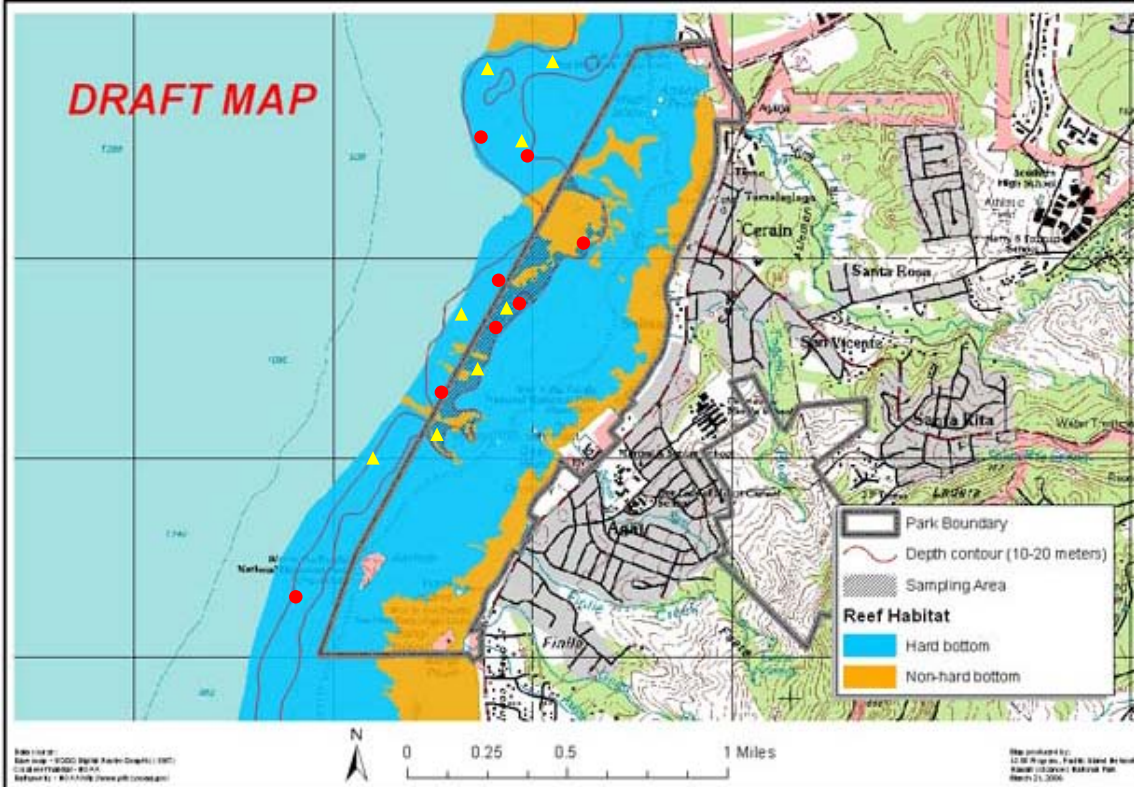
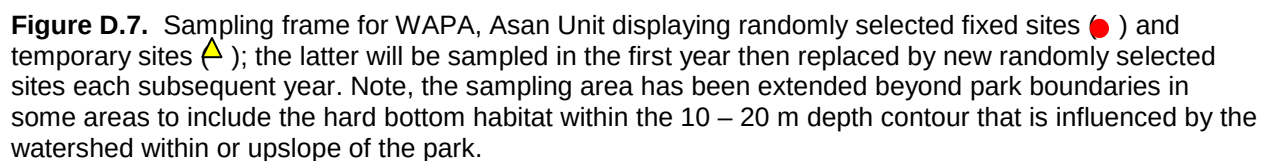


Figure D.6. Sampling frame for WAPA, Agat unit displaying randomly selected fixed sites (●) and temporary sites (▲); the latter will be sampled in the first year then replaced by new randomly selected sites each subsequent year. Note, the sampling area has been extended beyond park boundaries in some areas to include the hard bottom habitat within the 10 – 20 m depth contour that is influenced by the watershed within or upslope of the park.



Appendix E. List of Field Data Forms

Table E.1. List of data forms necessary for the Marine Fish Monitoring Vital Sign protocol.

Dataform	SOP #	Notes
Marine Fish Survey Form	SOP 7: Conducting marine fish surveys, (Table S7.1)	Datasheets should be customized for the fish assemblage in each park.

Appendix F. Benthic Marine Community and Marine Fish Database Documentation

Data Model

Marine monitoring at the PACN presently consists of four separate protocols: Benthic Marine Community, Marine Fishes, Water Quality, and Fish Harvest. Two monitoring protocols, Benthic Marine Community and Marine Fishes, will be co-located, with data managed within one database and data management framework. Combining the data for these two protocols is essential for effective analysis and interpretation. Although this Appendix focuses on the Marine Fish Protocol, the underlying structure of the Benthic Marine Community database will be reviewed because it is the overarching database for both protocols.

The Benthic Marine Community database employs a front-end/back-end configuration in which the user interface (e.g. forms, queries, modules, macros, and reports) resides in the front-end file (benthic_marine_FE_v1.0.mdb) and is linked to a back-end file (benthic_marine_BE_v1.0.mdb) which holds the data tables. The front-end user interface includes a back-end linking utility that allows the user to control this link. This front-end/back-end configuration allows for continual improvements to the user interface without requiring duplication or modification of the underlying data tables. Figure 1 shows the relationships among the primary tables in the database. The database structure is based on the National Park Service Natural Resources Database Template Version 3. The table “tbl_Sites” contains the park name and any descriptions, notes, etc. Linked to this table is “tbl_locations” which includes location information about the transect sampling units. The linked table “tbl_events” records each sampling event and includes the date. This allows for easy repeat entry where multiple dates are tied to the same locations or transects. The actual sampling data is maintained in the tbl_Fish which is linked to events. Several sub-tables link from these data tables and contain more detailed information.

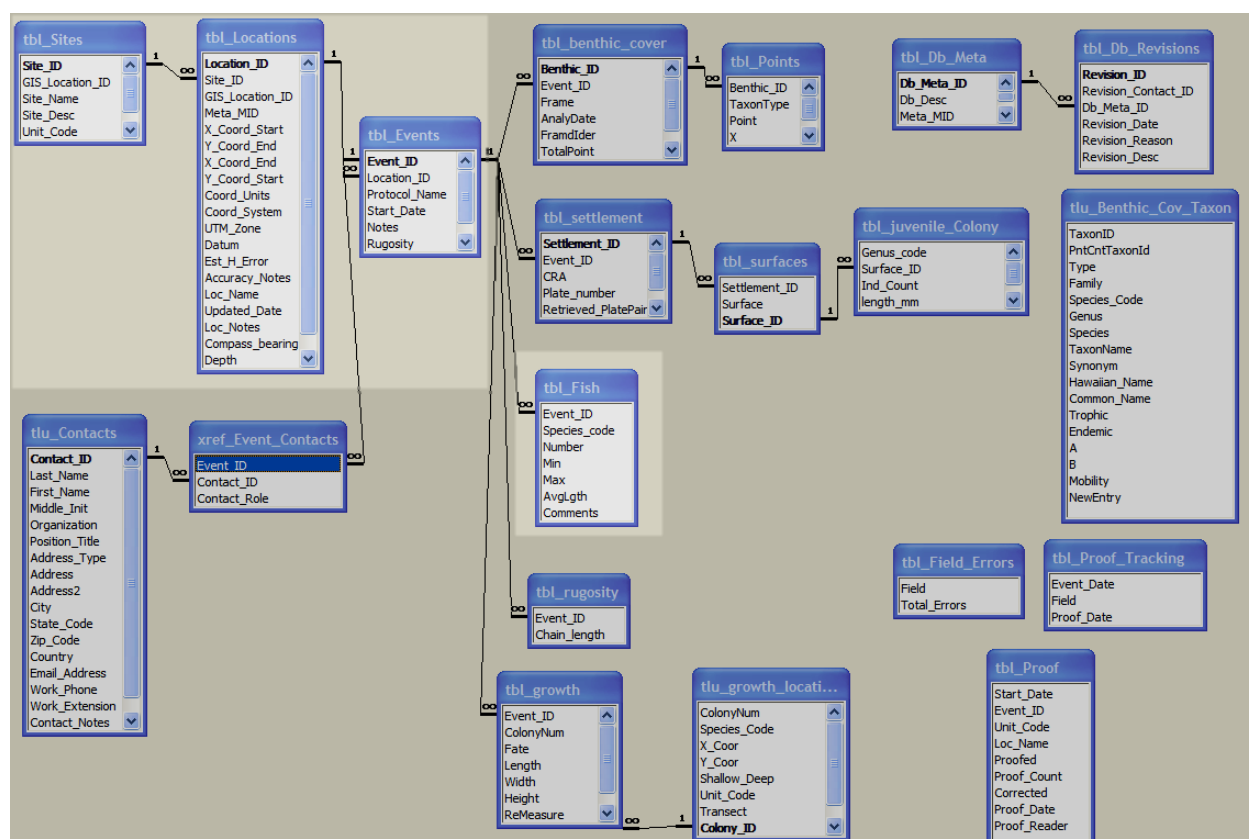


Figure F.1. Data Model for the Benthic Marine Community database. There are four main data tables associated with the Marine Fish Protocol. They are structured spatially (tbl_Sites, tbl_Locations), temporally (tbl_Events), and statistically (tbl_Fish).

Documentation of Database Tables

Table: *tbl_Sites*

Description: Primary table that stores data about the broader location, which in this case is the park. There is one record for each park.

Field Name	Field Type	Size	Field Description
Site_ID	ReplicationID	16	Site identifier
GIS_Location_ID	ReplicationID	16	Link to GIS feature, equivalent to NPS_Location_ID
Site_Name	Text	100	Unique name for a site
Site_Desc	Text	255	Description for a site
Unit_Code	Text	12	4-letter Park, Monument or Network code
Site_Notes	Memo	NA	General notes on the site

Table: tbl_Locations

Description: Standardized table for storing information about the sampling location. In this case the location is each transect. Contains UTM coordinates for start and end of transects, as well as other spatial details such as UTM zone and datum. There is one record for each transect.

Field Name	Field Type	Size	Field Description
Location_ID	ReplicationID	16	Location identifier
Site_ID	ReplicationID	16	Link to tbl_Sites
GIS_Location_ID	ReplicationID	16	Link to GIS feature, equivalent to NPS_Location_ID
Meta_MID	ReplicationID	16	Link to NR-GIS Metadata Database
X_Coord_Start	Double	8	UTM X (easting) of transect start
Y_Coord_Start	Double	8	UTM Y (northing) of transect start
X_Coord_End	Double	8	UTM X (easting) of transect end
Y_Coord_End	Double	8	UTM Y (northing) of transect end
Coord_Units	Double	8	Coordinate distance units
Coord_System	Double	8	Coordinate system
UTM_Zone	Double	8	UTM Zone
Datum	Double	8	Datum of mapping ellipsoid
Est_H_Error	Double	8	Estimated horizontal accuracy
Accuracy_Notes	Memo	NA	Positional accuracy notes
Loc_Name	Text	4	Name of the location (F [fixed] or T[temporary] + Transect Number)
Updated_Date	Date/Time	10	Date of entry or last change
Loc_Notes	Memo	NA	General notes on the location
Compass_bearing	Single	4	Bearing of transect from starting point
Loc_Type	Text	50	Notes whether the transect is fixed or temporary
Depth	Double	8	Depth at start of transect.

Table: tbl_Events

Description: Standardized table containing information about each sampling event. There is one record for each sampling event.

Field Name	Field Type	Size	Field Description
Event_ID	ReplicationID	16	Sampling event ID code
Location_ID	ReplicationID	16	Link to tbl_Locations
Protocol_Name	Text	100	Protocol version used in this sampling event
Start_Date	Date/Time	8	Sampling Date (Format dd/mm/yy)
Notes	Memo	NA	Any notes for this sampling event
Rugosity	Yes/No	1	Indicates if rugosity was measured in this sampling event
Data_Enterer	Text	50	Person who entered this event data

Table: *tbl_Fish*

Description: Table for storing information on fish numerical density and size. Data for this table will be imported initially from a Microsoft Excel[®] data file used for data entry and later imported directly into the database.

Field Name	Field Type	Size	Field Description
Event_ID	ReplicationID	16	Field data table row identifier
Species_code	Text	50	Four letter code used to identify each fish species
Number	Long Integer	4	Number of fish of this species seen individually or in a group
Min	Double	10	Minimum total length in centimeters of fish in group
Max	Double	10	Maximum total length in centimeters of fish in group
AvgLgth	Double	10	Average total length in centimeters of fish in group
Comments	Text	50	Notes regarding species identification or enumeration

For associated Benthic Marine Community database tables see SOP #11: Data Management in the Benthic Marine Community Protocol.

Table: *tlu_Contacts*

Description: Lookup table for observers and data enterers.

Field Name	Field Type	Size	Field Description
Contact_ID	ReplicationID	16	Contact identifier
Last_Name	Text	50	Last name
First_Name	Text	50	First name
Middle_Init	Text	4	Middle initial
Organization	Text	50	Organization or employer
Position_title	Text	50	Title or position description
Address_type	Text	50	Address (mailing, physical, both)
Address	Text	50	Street Address
Address2	Text	50	Address line 2, suite, apartment number
City	Text	50	City or town
State_Code	Text	8	State or province
Zip_Code	Text	50	Zip code (postal)
Country	Text	50	Country
Email_Address	Text	50	E-mail address
Work_phone	Text	50	Phone number
Work_extension	Text	50	Phone extension
Contact_notes	Memo	NA	Contact notes, if any

Table: xref_Event_Contacts

Description: Cross-reference table that links tbl_Events to tlu_Contacts. This keeps track of which contact is connected to each event, and the role of the contact.

Field Name	Field Type	Size	Field Description
Event_ID	ReplicationID	16	Link to tbl_Events
Contact_ID	ReplicationID	16	Link to tlu_Contacts
Contact_Role	Text	50	The contact's role in the survey

Table: tlu_Benthic_Cov_Taxon_fish

Description: This lookup table will be used to verify imported fish species, derive biomass estimates and augment the data summarization and reporting.

Field Name	Field Type	Size	Field Description
TaxonID	Integer	2	Taxon ID Code
PntCntTaxonId	Integer	2	Taxon ID Code for Point Counts
Type	Text	255	Taxon Type
Family	Text	255	Family Name
Species_Code	Text	255	4-letter species code
Genus	Text	255	Genus Name
Species	Text	255	Species Name
TaxonName	Text	255	Taxon Name (Genus and Species)
Synonym	Text	255	Synonym Name
Hawaiian_Name	Text	255	Hawaiian Name
Common_Name	Text	255	Common Name
Trophic	Text	10	Fish trophic guild: primary, secondary, and apex
Endemic	Text	2	Endemic codes: E (Endemic), I (Indigenous), and X (Introduced)
A	Double	8	Fish length-weight fitting parameter for allometric growth equation
B	Double	8	Fish length-weight fitting parameter for allometric growth equation
Mobility	Text	2	Fish mobility guild: S1 (Semi-vagile 1 – 10 m), S2 (Semi-vagile 2 – 100 m), T (Transient), R (Resident)
NewEntry	Boolean	1	Whether this is a new entry (yes or no)

Table: tbl_Db_Meta

Description: Database description and links to I&M metadata tools.

Field Name	Field Type	Size	Field Description
DB_Meta_ID	ReplicationID	16	Local primary key
Db_Desc	Memo	NA	Description of database purpose
Meta_MID	ReplicationID	16	Link to NR-GIS Metadata Database
X_DSC_GUID	ReplicationID	16	Link to I&M Dataset Catalog desktop metadata tool

Table: tbl_Db_Revisions

Description: Database revision history data.

Field Name	Field Type	Size	Field Description
Revision_ID	Text	50	Database revision (version) number or code
Revision_Contact_ID	ReplicationID	16	Link to tlu_Contacts
DB_Meta_ID	ReplicationID	16	Link to tbl_DB_Meta
Revision_Date	Date/Time	8	Database revision date
Revision_Reason	Memo	NA	Reason for the database revision
Revision_Desc	Memo	NA	Revision description

Table: tbl_Proof

Description: Table that stores information on which records have been proofed, and of those, which records have been corrected.

Field Name	Field Type	Size	Field Description
Corrected	Boolean	1	Was record corrected for errors (Y/N)?
Event_ID	Other	16	Unique event record identifier
Loc_Name	Text	50	Name of transect
Proof_Count	Long Integer	4	How many times the records were proofed
Proof_Date	Date/Time	8	Date record was proofed
Proof_Reader	Text	50	Who proofed the record
Proofed	Text	3	Was record proofed (Y/N)?
Start_Date	Date/Time	8	Sampling event date
Unit_Code	Text	4	4 letter unit code of park

Table: tbl_Proof_Tracking

Description: Table that keeps a tally of which fields were corrected for errors and for which date. Used to populate tbl_Field_Data and generate reports.

Field Name	Field Type	Size	Field Description
Event_Date	Date/Time	8	Sampling event date
Field	Text	50	Field in table that was corrected for errors
Proof_Date	Date/Time	8	Date the record was proofed

Table: tbl_Field_Errors

Description: Stores the total number of errors per field. Data stored is temporary, and deleted after each calculation of total of field errors; used to populated report.

Field Name	Field Type	Size	Field Description
Field	Text	50	Field in table that was corrected for errors
Total_Errors	Long Integer	4	Total number of errors made in the field

Documentation of Database Queries

This SOP will be updated to reflect changes in queries. Queries associated with the Benthic Marine Community data are covered in SOP # 11 Data Management of that protocol.

Queries for forms

These queries are used as form sources.

Query: qfrm_Data_Gateway

Description: List of sample locations and associated sampling events

Query Type: Select

SQL: SELECT tbl_Sites.Site_ID, tbl_Sites.Unit_Code, tbl_Locations.Loc_Type, tbl_Locations.Location_ID, tbl_Locations.Loc_Name, tbl_Events.Start_Date, Year([start_date]) AS Sample_year, tbl_Events.Event_ID, tbl_Locations.Updated_Date, tbl_Events.Protocol_Name, tbl_Locations.Loc_Type FROM tbl_Sites INNER JOIN (tbl_Locations INNER JOIN tbl_Events ON tbl_Locations.Location_ID = tbl_Events.Location_ID) ON tbl_Sites.Site_ID = tbl_Locations.Site_ID ORDER BY Year([start_date]) DESC;

Query: qfrm_DataEntry

Description: Data entry form record sources

Query Type: Select

SQL: SELECT tbl_Events.* FROM tbl_Events;

Queries for importing CSV files

A series of update and append queries were created to import fish data from Microsoft Excel[®] in the correct format. These include the following:

Query: qry_Check_Fish_Species

Description: Checks to make sure data being imported matches species that exist in the database

Query Type: Select

SQL: SELECT tbl_Sites.Unit_Code, tbl_Locations.Loc_Name, tbl_Events.Start_Date, tlu_Benthic_Cov_Taxon_fish.Species_Code, tlu_Benthic_Cov_Taxon_fish.TaxonName, tbl_Fish.Number, tbl_Fish.AvgLgth FROM tbl_Sites INNER JOIN (tbl_Locations INNER JOIN (tbl_Events INNER JOIN (tbl_Fish LEFT JOIN tlu_Benthic_Cov_Taxon_fish ON tbl_Fish.Species_code = tlu_Benthic_Cov_Taxon_fish.Species_Code) ON tbl_Events.Event_ID = tbl_Fish.Event_ID) ON tbl_Locations.Location_ID = tbl_Events.Location_ID) ON tbl_Sites.Site_ID = tbl_Locations.Site_ID WHERE (((tlu_Benthic_Cov_Taxon_fish.Species_Code) Is Null));

Queries for proofing data

Query: qry_Field_Errors

Description: Provides details about errors that were corrected during the proofing process

Query Type: Select

SQL: SELECT tbl_Proof_Tracking.Event_Date, tbl_Proof_Tracking.Field, Count(tbl_Proof_Tracking.Field) AS Total_Errors FROM tbl_Proof_Tracking GROUP BY tbl_Proof_Tracking.Event_Date, tbl_Proof_Tracking.Field;

Query: qry_Proof_Changes

Description: Source for frm_Proof. Lists records randomly chosen for proofing- tracks proofing efforts and if errors were corrected.

Query Type: Select

SQL: SELECT qry_Proof.Start_Date, tbl_Proof.Event_ID, qry_Proof.Unit_Code, qry_Proof.Loc_Name, tbl_Proof.Proofed, tbl_Proof.Corrected, qry_Proof.Loc_Type FROM tbl_Proof INNER JOIN qry_Proof ON tbl_Proof.Event_ID = qry_Proof.Event_ID

Query: qry_Proof

Description: Lists all sampling events and includes park and location. This is used to look for duplicate entries in qry_Proof_Changes and qry_Proof_Record_Count.

Query Type: Select

SQL: SELECT tbl_Sites.Unit_Code, tbl_Locations.Loc_Name, tbl_Events.Start_Date, tbl_Events.Event_ID, tbl_Locations.Loc_Type FROM tbl_Sites INNER JOIN (tbl_Locations INNER JOIN tbl_Events ON tbl_Locations.Location_ID = tbl_Events.Location_ID) ON tbl_Sites.Site_ID = tbl_Locations.Site_ID ORDER BY tbl_Events.Start_Date;

Query: qry_Proof_Record_Count

Description: Lists where record has been proofed more than one time so that duplicate entries in tbl_Proof can be deleted.

Query Type: Select

SQL: SELECT tbl_Proof.Event_ID, Count(tbl_Proof.Event_ID) AS Number_of_Records FROM tbl_Proof INNER JOIN qry_Proof ON tbl_Proof.Event_ID = qry_Proof.Event_ID GROUP BY tbl_Proof.Event_ID HAVING (((Count(tbl_Proof.Event_ID))>1));

Queries for summary and analysis

A series of queries were created to provide summaries (e.g. fish biomass by species). These include the following queries:

Query: qry_Final_Data

Description: Collates fish data from several tables and computes biomass for each observation.

Query Type: Select

SQL: SELECT tbl_Events.Start_Date AS [Date], tbl_Sites.Island, tbl_Sites.Unit_Code AS Park, tbl_Locations.Management, tbl_Locations.Habitat, Left([First_Name],1) & Left([Middle_Init],1) & Left([Last_Name],1) AS Obsr, tbl_Locations.Location_ID, tbl_Locations.Loc_Name AS Transect, tbl_Locations.X_Coord_Start, tbl_Locations.Y_Coord_Start, tbl_Fish.Species_code AS Species, tlu_Benthic_Cov_Taxon_fish.Target_Species, tbl_Fish.Number, tbl_Fish.Min, tbl_Fish.Max, tbl_Fish.AvgLgth, tlu_size_class.size_freq, tlu_size_class.size_class, tlu_Benthic_Cov_Taxon_fish.[TL TO SL_FL], ([AvgLgth]*10)*[TL TO SL_FL] AS LEN_MM, tlu_Benthic_Cov_Taxon_fish.A, tlu_Benthic_Cov_Taxon_fish.B, tlu_Benthic_Cov_Taxon_fish.Trophic, tlu_Benthic_Cov_Taxon_fish.Consumer, [A]*[LEN_MM]^[B]*[Number] AS BIOMASS, tlu_Benthic_Cov_Taxon_fish.Family, tlu_Benthic_Cov_Taxon_fish.Endemic, ([BIOMASS]*0.8)/10000 AS bio_tha, ([Number]*0.8)*100 AS num_ha FROM tlu_Contacts INNER JOIN (tbl_Sites INNER JOIN (tbl_Locations INNER JOIN ((tbl_Events INNER JOIN ((tbl_Fish INNER JOIN tlu_size_class ON tbl_Fish.AvgLgth =

tlu_size_class.size_freq) INNER JOIN tlu_Benthic_Cov_Taxon_fish ON tbl_Fish.Species_code = tlu_Benthic_Cov_Taxon_fish.Species_Code) ON tbl_Events.Event_ID = tbl_Fish.Event_ID) INNER JOIN xref_Event_Contacts ON tbl_Events.Event_ID = xref_Event_Contacts.Event_ID) ON tbl_Locations.Location_ID = tbl_Events.Location_ID) ON tbl_Sites.Site_ID = tbl_Locations.Site_ID) ON tlu_Contacts.Contact_ID = xref_Event_Contacts.Contact_ID;

Query: qry_Species_Grouped_by_Transect

Description: Number and biomass of each species on a transect within a park.

Query Type: Select

SQL: SELECT qry_Final_Data.Date, qry_Final_Data.Island, qry_Final_Data.Park, qry_Final_Data.Obsr, qry_Final_Data.Location_ID, qry_Final_Data.Transect, qry_Final_Data.X_Coord_Start, qry_Final_Data.Y_Coord_Start, qry_Final_Data.Species, qry_Final_Data.Trophic, qry_Final_Data.Consumer, qry_Final_Data.Target_Species, Sum(qry_Final_Data.Number) AS SumOfNumber, Sum(qry_Final_Data.BIOMASS) AS SumOfBIOMASS, IIf([SumOfNumber]=0,0,[SumOfNumber]*Log([SumOfNumber])) AS FiLofFi, Sum(qry_Final_Data.bio_tha) AS bio_tha, Sum(qry_Final_Data.num_ha) AS SumOfnum_ha, [SumOfnum_ha]/1000 AS [num_ha x 1000] FROM qry_Final_Data GROUP BY qry_Final_Data.Date, qry_Final_Data.Island, qry_Final_Data.Park, qry_Final_Data.Obsr, qry_Final_Data.Location_ID, qry_Final_Data.Transect, qry_Final_Data.X_Coord_Start, qry_Final_Data.Y_Coord_Start, qry_Final_Data.Species, qry_Final_Data.Trophic, qry_Final_Data.Consumer, qry_Final_Data.Target_Species;

Query: qry_Summary_Stats_by_Transect

Description: Species richness, number, biomass, diversity, and evenness for each transect by year.

Query Type: Select

SQL: SELECT qry_Species_Grouped_by_Transect.Island, qry_Species_Grouped_by_Transect.Park, qry_Species_Grouped_by_Transect.Location_ID, qry_Species_Grouped_by_Transect.Transect, qry_Species_Grouped_by_Transect.Date, First(qry_Species_Grouped_by_Transect.X_Coord_Start) AS FirstOfX_Coord_Start, First(qry_Species_Grouped_by_Transect.Y_Coord_Start) AS FirstOfY_Coord_Start, Count(qry_Species_Grouped_by_Transect.Species) AS CountOfSpecies, Sum(qry_Species_Grouped_by_Transect.SumOfNumber) AS SumOfSumOfNumber, Sum(qry_Species_Grouped_by_Transect.SumOfBIOMASS) AS SumOfSumOfBIOMASS, Sum(qry_Species_Grouped_by_Transect.FiLofFi) AS SumOfFiLofFi, [SumOfSumOfNumber]*0.8*100/1000 AS [Num_ha x (1000)], ([SumOfSumOfBIOMASS]*0.8)/10000 AS bio_t_ha, IIf([SumOfSumOfNumber]=0,0,([SumOfSumOfNumber]*(Log([SumOfSumOfNumber]))-[SumOfFiLofFi])/[SumOfSumOfNumber]) AS Div, IIf([Div]=0,0,[Div]/Log([CountOfSPECIES])) AS Even FROM qry_Species_Grouped_by_Transect GROUP BY qry_Species_Grouped_by_Transect.Island, qry_Species_Grouped_by_Transect.Park, qry_Species_Grouped_by_Transect.Location_ID, qry_Species_Grouped_by_Transect.Transect, qry_Species_Grouped_by_Transect.Date;

Query: qxtb_Trophic_Comps_x_Habitat

Description: Trophic summary by habitat for each transect within a park

Query Type: Crosstab

SQL: TRANSFORM Sum(qry_Species_Grouped_by_Transect.bio_tha) AS SumOfbio_tha
SELECT qry_Species_Grouped_by_Transect.Island, qry_Species_Grouped_by_Transect.Park,
qry_Species_Grouped_by_Transect.Transect, tbl_Locations.Habitat,
qry_Species_Grouped_by_Transect.Date FROM qry_Species_Grouped_by_Transect INNER
JOIN tbl_Locations ON qry_Species_Grouped_by_Transect.Location_ID =
tbl_Locations.Location_ID GROUP BY qry_Species_Grouped_by_Transect.Island,
qry_Species_Grouped_by_Transect.Park, qry_Species_Grouped_by_Transect.Transect,
tbl_Locations.Habitat, qry_Species_Grouped_by_Transect.Date PIVOT
qry_Species_Grouped_by_Transect.Consumer;

Query: qry_Family_x_Park_x_Transect

Description: Displays family level data on species richness, number, biomass, diversity, and evenness for each transect within a park.

Query Type: Select

SQL: SELECT qry_Species_Grouped_by_Transect.Island,
qry_Species_Grouped_by_Transect.Park, qry_Species_Grouped_by_Transect.Transect,
First(qry_Species_Grouped_by_Transect.X_Coord_Start) AS FirstOfX_Coord_Start,
First(qry_Species_Grouped_by_Transect.Y_Coord_Start) AS FirstOfY_Coord_Start,
tlu_Benthic_Cov_Taxon_fish.Family, Count(qry_Species_Grouped_by_Transect.Species) AS
CountOfSpecies, Sum(qry_Species_Grouped_by_Transect.SumOfNumber) AS
SumOfSumOfNumber, Sum(qry_Species_Grouped_by_Transect.SumOfBIOMASS) AS
SumOfSumOfBIOMASS, Sum(qry_Species_Grouped_by_Transect.FiLofFi) AS SumOfFiLofFi,
[SumOfSumOfNumber]*0.8*100/1000 AS [Num_ha x (1000)],
([SumOfSumOfBIOMASS]*0.8)/10000 AS bio_t_ha,
IIf([SumOfSumOfNumber]=0,0,([SumOfSumOfNumber]*(Log([SumOfSumOfNumber]))-
[SumOfFiLofFi])/[SumOfSumOfNumber]) AS Div,
IIf([Div]=0,0,[Div]/Log([CountOfSPECIES])) AS Even,
IIf([SumOfSumOfNumber]=0,0,[CountOfSPECIES]) AS Species_0
FROM qry_Species_Grouped_by_Transect INNER JOIN tlu_Benthic_Cov_Taxon_fish ON
qry_Species_Grouped_by_Transect.Species = tlu_Benthic_Cov_Taxon_fish.Species_Code
GROUP BY qry_Species_Grouped_by_Transect.Island,
qry_Species_Grouped_by_Transect.Park, qry_Species_Grouped_by_Transect.Transect,
tlu_Benthic_Cov_Taxon_fish.Family;

Query: qxtb_Species_Matrix_x_Number

Description: Multivariate matrix of species numerical density (number) by transect within a park

Query Type: Crosstab

SQL: TRANSFORM Sum(qry_Final_Data.num_ha) AS SumOfnum_ha
SELECT qry_Final_Data.Island, qry_Final_Data.Park, qry_Final_Data.Transect,
qry_Final_Data.Date, qry_Final_Data.Management, qry_Final_Data.Habitat
FROM qry_Final_Data GROUP BY qry_Final_Data.Island, qry_Final_Data.Park,
qry_Final_Data.Transect, qry_Final_Data.Date, qry_Final_Data.Management,
qry_Final_Data.Habitat PIVOT qry_Final_Data.Species;

Query: qxtb_Species_Matrix_x_Biomass

Description: Multivariate matrix of species biomass by transect within a park

Query Type: Crosstab

SQL: TRANSFORM Sum(qry_Final_Data.bio_tha) AS SumOfbio_tha
SELECT qry_Final_Data.Island, qry_Final_Data.Park, qry_Final_Data.Transect,
qry_Final_Data.Date, qry_Final_Data.Management, qry_Final_Data.Habitat
FROM qry_Final_Data GROUP BY qry_Final_Data.Island, qry_Final_Data.Park,
qry_Final_Data.Transect, qry_Final_Data.Date, qry_Final_Data.Management,
qry_Final_Data.Habitat PIVOT qry_Final_Data.Species;

Query: qry_Size_Spec_Mgmt

Description: Generates a size frequency distribution for different size categories of fish

Query Type: Select

SQL: SELECT qry_Final_Data.Park, Sum(qry_Final_Data.Number) AS SumOfNumber,
Sum(qry_Final_Data.BIOMASS) AS SumOfBIOMASS, qry_Final_Data.size_class,
qry_Final_Data.Habitat FROM qry_Final_Data GROUP BY qry_Final_Data.Park,
qry_Final_Data.size_class, qry_Final_Data.Habitat HAVING
((qry_Final_Data.Habitat)<>"ucs");

Query: qry_SurveysDone

Description: Shows which transects have been sampled.

Query Type: Select

SQL: SELECT tbl_Sites.Unit_Code, tbl_Locations.Loc_Type, tbl_Locations.Loc_Name,
Right([Start_Date],4) AS [Year], tbl_Events.Start_Date AS [Survey Date],
First(tbl_benthic_cover.FramdIdler) AS Analyzer FROM tbl_Sites INNER JOIN (tbl_Locations
INNER JOIN (tbl_Events INNER JOIN tbl_benthic_cover ON tbl_Events.Event_ID =
tbl_benthic_cover.Event_ID) ON tbl_Locations.Location_ID = tbl_Events.Location_ID) ON
tbl_Sites.Site_ID = tbl_Locations.Site_ID GROUP BY tbl_Sites.Unit_Code,
tbl_Locations.Loc_Type, tbl_Locations.Loc_Name, Right([Start_Date],4),
tbl_Events.Start_Date;

Appendix G. Project Task List

Table G.1. This table identifies each task by project stage, indicates who is responsible, and establishes the timing over two years for its execution. Protocol sections and SOPs are referred to as appropriate.

Project Stage	Task Description	Responsibility	Timing
Preparation – Administration	Initiate announcements for seasonal technician positions, begin hiring	Project Lead	Jan.
	Notify Data Manager and GIS Specialist of needs for the coming season (field maps, GPS support, training)	Project Lead	by Dec. 1
	Meet (or conference call) to recap past field season, discuss the upcoming field season, and document any needed changes to field sampling protocols or the working database	Project Lead, Park Biologists, Data Manager, and GIS Specialist	Jan.
	Ensure all project compliance needs are completed for the coming season	Park Biologists	Jan.-Feb.
	Inform GIS Specialist and Data Manager of specific needs for upcoming field season	Project Lead	by Mar. 31
	Ensure that project workspace is ready for use and GPS download software is loaded at each park	Project Lead, Data Manager, and GIS Specialist	by Apr. 30
	Implement working database copy	Data Manager	by May 1
	Initiate computer access and key requests (may need park-specific dates)	Park Biologists	May
	Provide field crew email addresses and user logins to Data Manager	Park Biologists	May
	Provide database/GPS training as needed	Data Manager and GIS Specialist	May
Preparation – Field Work	Provide itinerary and names of field crew to Park Biologists	Project Lead	1 month prior to visit
	Examination and certification of field observer qualifications.	Park Biologists and Park Dive Officer	1 month prior to visit
	Plan schedule and logistics, including ordering any needed equipment and supplies	Project Lead and Park Biologists	2 months prior to visit
	Generate field navigation reports, roster of sample points and coordinates from the database	Project Lead and Technicians	1 month prior to visit
	Prepare and print field maps	Project Lead and Technicians	2 weeks prior to visit
	Update and load data dictionary, background maps, and target coordinates into GPS units	GIS Specialist	1 week prior to visit
	Train field crew in sampling protocols and safety	Project Lead	1 week prior to and first day of visit
Data Acquisition	Collect field observations and position data during field trips	Technicians	Spring to Fall
	Review data forms after each day	Technicians	daily
	Check in with Park Biologist	Technicians	after each tour
	De-brief crew on operations, field methods, gear needs	Technicians and Park Marine Ecologists	after each tour
Data Entry & Processing	Download GPS data and email files to GIS Specialist for correction	Technicians	after each tour
	Download and process digital images	Technicians	after each tour
	Enter data into working copy of the database	Technicians	after each tour
	Verification of accurate transcription as data are entered	Technicians	after each tour

Project Stage	Task Description	Responsibility	Timing
	Correct GPS data and send screen capture to technicians and Project Lead for review	GIS Specialist	after each tour
	Periodic review of GPS location data and database entries for completeness and accuracy	Technicians	bi-monthly
	Merge, correct, and export GPS data. Upload processed and verified coordinates to database	GIS Specialist	2 months after each tour
Product Development	Update annotated park dive log	Project Lead and Technicians	after each tour
Quality Review	Quality review and data validation using database tools	Project Lead	1 month after each tour
	Prepare coordinate summaries and/or GIS layers and data sets as needed for spatial data review	GIS Specialist	2 months after each tour
	Joint quality review of GIS data, determine best coordinates for subsequent mapping and field work	Project Lead and GIS Specialist	2 months after each tour
Metadata	Identify any sensitive information contained in the data set	Project Lead	2 months after each tour
	Update project metadata records	Project Lead	2 months after each tour
The following tasks will commence in January after completion of field work in the prior year.			
Data Certification & Delivery	Certify the season's data and complete the certification report	Park Marine Ecologists	Jan.
	Deliver certification report, certified data, digital photographs, and updated metadata to Data Manager	Park Marine Ecologists	Feb.
	Upload certified data into master project database, store data files in PACN Digital Library ¹	Data Manager	Feb.
	Notify Project Lead of uploaded data ready for analysis and reporting	Data Manager	Feb.
	Update project GIS data sets, layers and associated metadata records	GIS Specialist	Feb.
	Finalize and parse metadata records, store in PACN Digital Library ¹	Data Manager and GIS Specialist	by Mar. 15
Data Analysis Note: The tasks in this section occur every 5 years.	Conduct data analysis – See SOP # 18 “Data Analysis and Reporting”	Data Analyst	Mar.
Reporting & Product Development	Export automated summary queries and reports from database	Data Analyst	Feb.-Mar.
	Produce park-wide and transect-specific map output for archives	GIS Specialist	Feb.-Mar.
	Generate report-quality map output for reports	GIS Specialist	Feb.-Mar.
	Acquire the proper report template from the NPS website , create annual report	Data Analyst and Project Lead	Feb.-Apr.
	Screen all reports and data products for sensitive information	Project Lead	Feb.-Apr.
	Prepare draft report and distribute to Park Biologists for preliminary review	Project Lead	by Apr. 1
Product Delivery	Submit draft I&M report to I&M Marine Ecologist and Program Manager for review	Project Lead	by Apr. 30

Project Stage	Task Description	Responsibility	Timing
	Review report for formatting and completeness, notify Project Lead of approval or need for changes	I&M Marine Ecologist	May.
	Upload completed report to PACN Digital Library ¹ submissions folder, notify Data Manager	Project Lead	upon approval
	Deliver other products according to the delivery schedule and instructions	Project Lead	Upon completion
	Product check-in	Data Manager	upon receipt
Posting & Distribution	Submit metadata to NPS Data Store ²	Data Manager	by Mar.
	Create NatureBib ³ record, post reports to NPS clearinghouse	Data Manager	upon receipt
	Update NPSpecies ⁴ records according to data observations	Data Manager	Jan.-Mar.
	Submit certified data and GIS data sets to NPS Data Store ²	Data Manager	Jun. (after 2-year hold)
Archival & Records Management	Store finished products in PACN Digital Library ¹	Data Manager	upon receipt
	Review, clean up and store and/or dispose of project files according to NPS Director's Order #19 ⁵	Project Lead	Jan.
Season Close-out	Inventory equipment and supplies	Project Lead and Park Biologists	by Aug.
	Conference call to discuss recent field season (close out); discuss who needs to do what to get data ready for analysis	Project Lead, Park Biologists, Data Manager, and GIS specialist	by Oct.
	Discuss and document needed changes to analysis and reporting procedures	Project Lead, Park Biologists, and Data Manager	by Dec.

¹ The PACN Digital Library is a hierarchical digital filing system stored on the PACN file server. Network users have read-only access to these files, except where information sensitivity may preclude general access.

² NPS Data Store is a clearinghouse for natural resource data and metadata (<http://science.nature.nps.gov/nrddata>). Only non-sensitive information is posted to NPS Data Store. Refer to the protocol section on sensitive information for details.

³ NatureBib is the NPS bibliographic database (<http://www.nature.nps.gov/nrbib/index.htm>). This application has the capability of storing and providing public access to image data (e.g., PDF files) associated with each record.

⁴ NPSpecies is the NPS database and application for maintaining park-specific species lists and observation data (<http://science.nature.nps.gov/im/apps/npspp/index.htm>).

⁵ NPS Director's Order 19 provides a schedule indicating the amount of time that the various kinds of records should be retained. Available at: <http://data2.itc.nps.gov/npspolicy/DOrders.cfm>

Appendix H. Roles and Responsibilities

Table H.1. Roles and responsibilities of project participants.

Role	Responsibilities	Name / Position
Project Lead (NPS Lead)	- Project oversight and administration of field work - Project operations and implementation - Certify each season's data for quality and completeness - Conduct data analysis - Complete reports, metadata, and other products according to schedule - Assist in training field crews	Eric Brown, Marine Ecologist, KALA
I&M Marine Ecologist	- Track project objectives, budget, requirements, and progress toward project objectives - Facilitate communications between NPS and cooperator(s) - Coordinate and ratify changes to protocol - Assist in performing data summaries and analysis, assist interpretation and report preparation - Review annual reports and other project deliverables for completeness and compliance with Inventory and Monitoring Program specifications - Maintain and archive project records	Tahzay Jones, Aquatic Ecologist, HAVO
Field Lead (Technicians)	- Train and ensure safety of field crew - Plan and execute field visits - Acquire and maintain field equipment - Oversee data collection and entry, verify accurate data transcription into database - Update annotated park dive logs	Field Biologist (These duties can be filled by Project Lead and Park Biologists)
Technicians	Collect, record, enter and verify data	Technicians
Data Manager	- Consultant on data management activities - Facilitate check-in, review and posting of data, metadata, reports, and other products to national databases and clearinghouses according to schedule - Maintain and update database application - Provide database training as needed	Kelly Kozar, Data Manager, HAVO
GIS Specialist	- Consultant on spatial data collection, GPS use, and spatial analysis techniques - Facilitate spatial data development and map output generation - Work with Project Lead and Data Analyst to analyze spatial data and develop metadata for spatial data products - Primary steward of GIS data and products	Ben McMillan, GIS Specialist, HAVO
PACN Program Manager	Review annual reports for completeness and compliance with I&M standards and expectations	Greg Kudray, Program Manager, HAVO
Park Biologists	- Facilitate logistics planning and coordination - Ensure project compliance with park requirements - Review reports, data and other project deliverables	Park Wildlife Biologists and Resource Managers
Park Curator	- Receive and catalogue voucher specimens - Receive and archive copies of annual reports, analysis reports, and other publications - Facilitate archival of other project records (e.g., original field forms, etc.)	Park Curators and Collections Managers at HAVO

Appendix I. Benthic Marine Monitoring Database User Guide

Abstract

This document will lead the user through the data entry process for data collected for Benthic Marine Community and Marine Fish Monitoring.

File Name

Benthic_User_Guide.doc

Recommended Citation

National Park Service. 2006. Benthic Marine Monitoring Database. Version 1.0 documentation. Inventory and Monitoring Program, Hawaii National Park, HI. 24 pg.

Introduction

The Benthic Marine Community Monitoring database is the main storage location for all data related to the Benthic Marine Community and Marine Fish Protocol. Two types of data entry occur here—first is the import of files for benthic cover and second is manual data entry for rugosity, growth, settlement, and marine fish.

Database files will be distributed to individual parks at the beginning of the field season to facilitate prompt data entry and edits by park staff. At the end of the field season, files will be submitted to the PACN data management staff for consolidation into the master database file.

Installing the Benthic Marine Community Monitoring Database

The user can copy and paste both front and back end database files to a park server that has automatic backups. If some parks lack these resources, store the files on a local computer and employ a backup strategy. The database application contains a back up component, which is accessed from the main application switchboard form that opens automatically when the application starts (see “Back Up Data” below). This component can be programmed to automatically ask the user to create a back up when the database is opened for a data entry session. This will ensure that the initial data starting point can be recovered should irreversible errors or problems occur during the data entry session. Back-up copies are used for the current field season only and will not be archived. The database files should be stored in the appropriate I&M project folder (recommended directory structure: benthic_marine/database/backups).

To facilitate data entry, the front end file should be copied to a local workstation. Opening and using the front-end on the network ‘bloats’ the database file and makes it run more slowly. Once copied, users will need to re-link the databases (see “Connect Data Tables” below).

Starting the Benthic Marine Community Monitoring Database

Double-click on benthic_FE_v1.0.mdb to start the application.

Features of the Application Startup Form

The startup form is the entry point for the application, and therefore the first thing users will usually see when opening the application.

Double-clicking “Pacific Islands Network” at the top left of the form will open the web site for the Network. Double-clicking the NPS Arrowhead or the title National Park Service at the top right of the form will open a browser and navigate to the National Park Service web site (www.nps.gov).

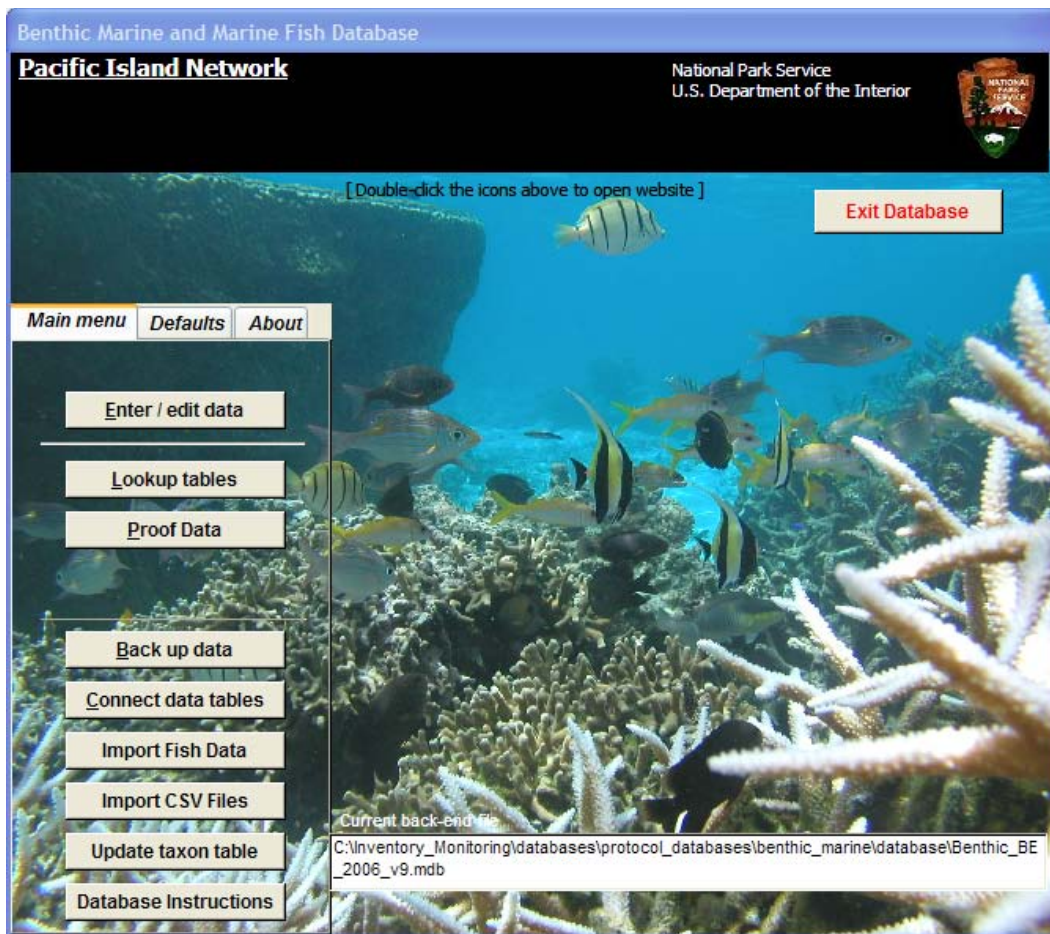
Also at the top right of the form is an exit button which can be used to close the application.

A tabbed menu resides at the lower left corner of the form. It contains tabs for the main menu, application defaults, and information about the application. Each of the tabs will be examined in more detail in the sections that follow.

At the bottom center-right of the form is a box that displays the current location of the data file to which the application is linked.

Main Menu

The main menu of the application is what users will see when the application is started. It provides buttons for entering/editing data, managing lookup tables, proofing data, viewing the database window, backing up data, connecting data tables, importing CSV files, updating the taxon table, and built-in database instructions.



Main Menu

Enter/Edit Data

Clicking the Enter / Edit data button will open the Data Gateway form. From there click “Add New Record” to add a record in the Main Data Form.

Main Data Form

The Main Data form is used to select a park, transect type, and transect, as well as to enter event information, enter information about the people who participated in the sampling event, and enter some of the protocol-specific information.

Parks and transects that were previously entered can be selected from a drop-down list; new parks and transects can be entered by clicking on **Add New Park** or **Add New Transect** (see below- “Sites Form” and “Locations Form”).

Event information entered here includes:

- Sampling Date
- Rugosity (if checked, the rugosity form opens (see below- “Rugosity Form”))
- Data Enterer
- Event Notes

Information about people who participated in the sampling event can be entered in the *Observers* box. Contacts can be selected from the drop-down list. If a new contact needs to be entered, click the **Add Data Enterer/Observer** button to open the Contacts Form (see below).

The screenshot shows the 'Main Data Form' window for 'Marine Benthic Monitoring'. The interface includes a top navigation bar with buttons for 'Add New Record', 'Park' (with a dropdown), 'Add New Park', 'Edit Park Information', 'View/Edit Records', 'Fixed/Temporary' (with a dropdown), 'Transect' (with a dropdown), 'Add New Transect', 'Edit Transect', and 'Close Form'. Below this is the 'Sampling Events' section, which contains fields for 'Sampling Date (mm/dd/yy:)', 'Notes:', 'Observer(s):', 'Role:', 'Data Enterer:', and 'Was rugosity measured?'. There are also buttons for 'Add Data Enterer/Observer', 'Delete Event', and 'View Data'. A tabbed interface at the bottom shows 'Benthic Cover' as the active tab, with other tabs for 'Settlement', 'Growth', and 'Fish'. The 'Benthic Cover' tab contains a large blue area for data entry, with fields for 'Frame:', 'Analysis Date:', 'Frame Identifier:', 'Disease:', 'Taxon ID Code:', 'Point: X:', and 'Y:'. At the bottom of the form, there are record navigation controls showing 'Record: 1 of 1'.

Main Data Form

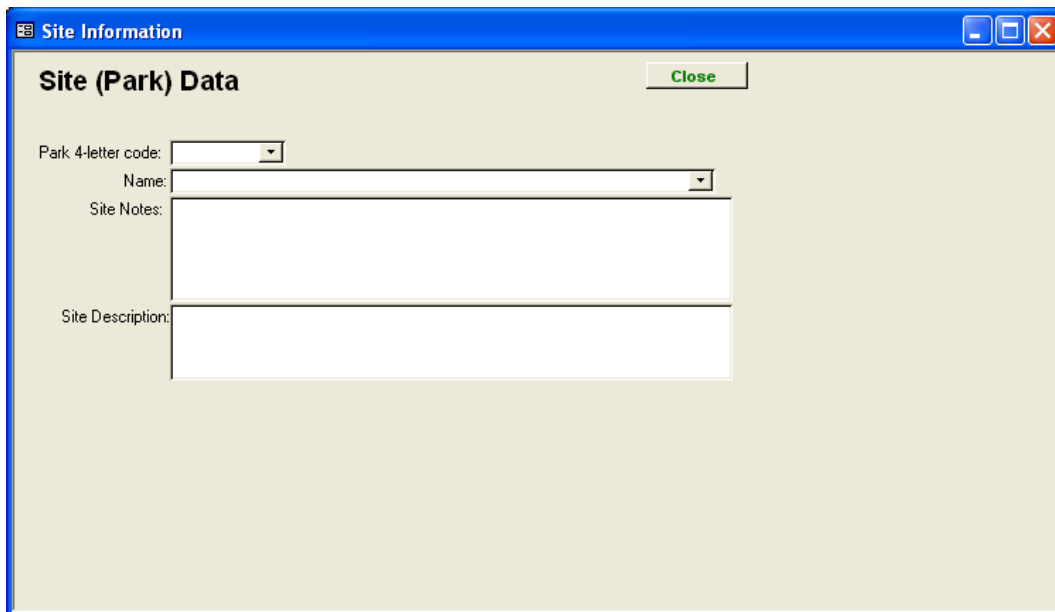
Data to be entered depends on type of transect—Fixed vs. Temporary. For Temporary transects, data collection only occurs for benthic cover, and therefore only the *Benthic Cover* tab is visible. Four tabs exist for Fixed transects: *Benthic Cover*, *Settlement*, *Growth*, and *Fish*. For both transect types, no data entry occurs into the *Benthic Cover* tab- this data is imported from a function through the Startup Form (see “Import CSV Files” below).

Sites Form

If the *Park* drop-down list on the Main Data Form does not include the park you need, click on the **Add New Park** button. This will open the Sites Form. This form is used to enter park information for a sampling location. Likewise, you can click on the **Edit Park Information** button (from the Main Data Form) if you need to update site information. The Sites form is used to enter site information which can be used to group locations. Values entered here include:

- NPS Unit (4-letter code)
- Site Name
- Site Description
- Site Notes
- GIS Location ID- currently not in use

The Site ID value, which uniquely identifies a site, is automatically generated by the application.

The image shows a screenshot of a software window titled "Site Information". The window has a blue title bar with standard Windows window controls (minimize, maximize, close) on the right. Inside the window, the main area has a light beige background. At the top left of the main area, the text "Site (Park) Data" is displayed. To its right is a green "Close" button. Below the title, there are four input fields: "Park 4-letter code:" with a small dropdown arrow, "Name:" with a larger dropdown arrow, "Site Notes:" with a large text area, and "Site Description:" with a large text area. The form is designed for entering site-specific information.

Sites Form

Locations Form

If the *Transect* drop-down list on the Main Data Form does not include the transect you need, click on the **Add New Transect** button. This will open the Locations Form. The Locations Form

is used to enter transect information. Likewise, you can click on the **Edit Transect** button (from the Main Data Form) if you need to update transect information. Values entered here include:

- Transect
- Transect Type
- Compass Bearing
- Depth
- Start and End X & Y Coordinates, Coordinate Units, and Coordinate System
- UTM Zone and Datum
- Estimated Horizontal Error & Accuracy Notes
- GIS Location ID & Meta MID (a link to the NPS Data Store) - these two fields are currently not being used.
- Notes

The Location ID value, which uniquely identifies a location, is automatically generated by the application.

The screenshot shows a software window titled "Location Information" with standard Windows window controls (minimize, maximize, close) in the top right corner. Inside the window, the "Transect Information" section is highlighted with a blue header. Below the header, a note reads: "Only use this if a transect is not in the existing drop-down list". The form contains several input fields: "Transect:" and "Type:" at the top; "Compass Bearing:" below "Transect:"; "Depth:" with a unit "(m)" to its right; "Start Transect" and "End Transect" sections, each containing "UTM X:" and "UTM Y:" fields; "Coordinate Units:" with a dropdown menu showing "meters"; "Coordinate System:" with a dropdown menu showing "UTM"; "UTM Zone:" and "Datum:" fields; "Estimated Horizontal Error" field; "Accuracy Notes:" field; and a large "Notes:" field at the bottom. On the right side of the form, there are two buttons: "Close Form" (highlighted in green) and "Delete Record".

Locations Form

Rugosity Form

Rugosity is not measured at every sampling event. If it is measured, check the box next to *Was rugosity measured?* on the Main Data Form. This opens the rugosity form.

Rugosity Form

Only enter the *Chain length*. *Rugosity* is immediately calculated, based on a 25 m transect.

Settlement Form

This form displays data about coral settlement into settlement plates. (Reminder—settlement data is only collected on Fixed transects).

Settlement Subform

Settlement plates are attached to CRAs, which are placed at specific distances along and from the transect. First select the *CRA* number (1, 2, or 3). Enter the *plate number* that is associated with this *CRA*. Enter the date the plate was retrieved in the *Retrieved Plate* box. *Duration* is automatically calculated.

In the darker blue area to the right, chose a *Plate Surface*. To the right of this, list all the species and numbers in the subform. Click on **Next Surface** and go through all the surfaces and enter species for all sides of the plates until complete.

If retrieving plates from more than one *CRA*, click on **Add Another Settlement Record** until data for all plates for that transect have been entered.

Growth Form

This form displays data about coral growth.

Colony Number:	Fate:	Length:	Width:	Height:	Re-measure?	
						View Permanent Info Delete Record

Record: of 1

Growth Subform

Enter the Colony Number. If the Colony Number has not previously been entered, the following form will open. Enter the Colony Number information in this form. You must enter data in all the fields.

Permanent Colony Info			
Species Code:	X Coordinate:	Y Coordinate:	Shallow or Deep:

Colony Form

After entering the Colony Number information, the remaining growth information, Fate, Length, Width, Height, and Re-measure, can be filled in. To view past records for the colony, click “View Permanent Info”. A subform below the coral growth subform will be populated with the relevant data.

Colony Number:	Fate:	Length:	Width:	Height:	Re-measure?		
10	Initial	12	12		No	View Permanent Info	Delete Record
						View Permanent Info	Delete Record

Record: ◀ ▶ 1 ▶ ▶ ▶ of 1

Species Code:	X Coordinate:	Y Coordinate:	Shallow or Deep:	
Apan	20	1.2	Deep	Save Record

Growth Subform with Colony History

Marine Fish Form

This form displays information on fish detected during the sampling event.

Species Code:	Avg. Length:	Min:	Max:	Number:	Comments:	
ACDU						Delete Record
*						Delete Record

Marine Fish Subform

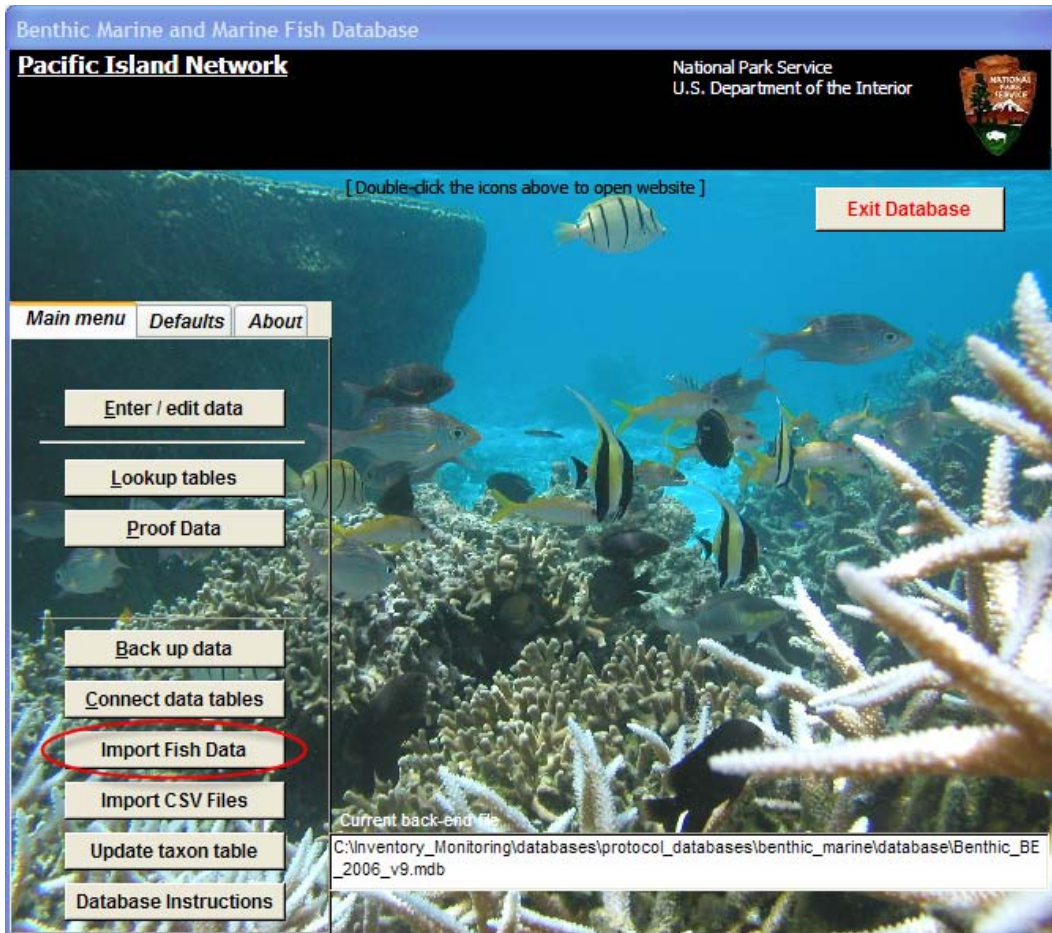
Marine fish are counted along the transect. Enter the species found, the average length, the minimum and maximum length, the number of fish, and any comments in this subform.

Importing Fish Data

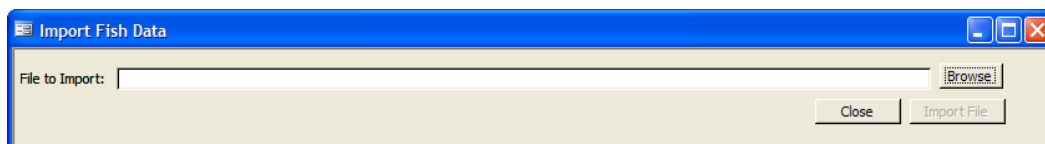
Alternatively, fish data may be imported from an Excel spreadsheet. In order for the import process to work, the header rows in the Excel spreadsheet **must be exactly** the headings shown below. Date is the sampling event date, Island is the island name, Location is the four letter Park code, Station Type is either Temporary or Fixed, Transect# is the transect number, and Species is the four letter species code. Depth, Number, Min, Max and AvgLgth are numbers.

Date	Island	Location	Depth (m)	Obsr	Station Type	Transect#	Species	Number	Min (cm)	Max (cm)	AvgLgth
------	--------	----------	-----------	------	--------------	-----------	---------	--------	----------	----------	---------

To import fish data, click “Import Fish Data” on the Main Switchboard.



The dialog box below will open. Click “Browse” to select the file to import. Once you have selected the file, click “Import File”



The import function will look for any existing sampling events for the locations of the fish data being imported. If the sampling event already exists, data will be imported and linked to that sampling event. If no sampling event exists, a sampling event will be created, and the data will be linked to the new sampling event.

The import function will also perform a check to ensure that the transects and species codes being imported already exist in the database. If they do not, a message will tell you which transects and species codes are not in the database, and the import function will end before importing any fish data. Make the changes to the database or spreadsheet, and retry the import process.

If fish data was imported successfully, a message box will notify you. To modify or check fish data, click on the sampling event (Visit Date; see below) for the transect from the Data Gateway Form.

Data Gateway Form

This form displays location and event information for each record, and is designed to help the user determine which record to edit/view. This form will open when “Enter/edit data” is clicked on the Main Swithboard. To access this form from the Main Data form, click “View/Edit Records”. By default, the Data Gateway form starts off with a filter (a criteria that limits which records are displayed) for the default park that was selected on the Application Defaults form.

Sample Data Gateway - List of data that have been entered

* Double-click on the field label to change sort order. Double-click on a Location Name to open the Locations form for that record or a Visit Date to open the Data Entry form for that record.

Filters
 Park: KALA Transect: Year: Visit Date: Filter Is On Clear Filters

Unit*	Transect*	Transect Type*	Year*	Visit date*	Entered/updated*
KALA	1	Fixed	2006	02 Aug 2006	
KALA	1	Temporary	2006	08 Aug 2006	
KALA	2	Temporary	2006	24 Jul 2006	

Data Gateway Form

Additional filters for *Transect*, *Year*, and *Visit Date* can be set by selecting from the drop-down lists at the top of the form in the Filters box. Filters can be removed by clicking the toggle button that says “Filter Is On”. It will toggle up and say “Filter Is Off” when the filter is removed. When the filter is removed, all records will be displayed. To clear all filters and turn the filter off, click “Clear Filters”. Optionally, a specific filter can be removed by deleting the text that is currently displayed in one of the filter controls.

In addition to filters, there are sorting options for the records on the Data Gateway form. Double-clicking any of the column headings will cause the records to be sorted in ascending order by that column value. The column heading will change to a bold italic format to indicate that it is the column being used to determine sort order. If the same column is double-clicked a second time, the records will be sorted in descending order by that column value.

Double-clicking a *Visit Date* will open the Main Data Form (includes Event data) for that particular record. If an Event record has not been added for a particular location, when that blank Visit Date is double-clicked, a new Data Entry record will be opened.

To add a new data entry record, click the Add a new record button at the top of the Data Gateway form.

Contacts Form

The Contacts form is used to enter details about individuals who participate in data gathering for the protocol and who enter information in the database. This form can be opened from the Main Data Form. Values entered here include:

- First Name, Middle Initial, Last Name
- Organization
- Position/title

- Work Phone and Extension
- Email Address
- Address Information, including Address Type, Street Address, City, State, Zip Code, and Country
- Notes

Previously entered addresses can be selected from the Address 1 drop-down list, and the associated Street Address, City, State, Zip, and Country values will automatically be filled in. The Organization and Position/Title drop-down lists will also allow selection from previously entered values or new entries.

Contact Information Form

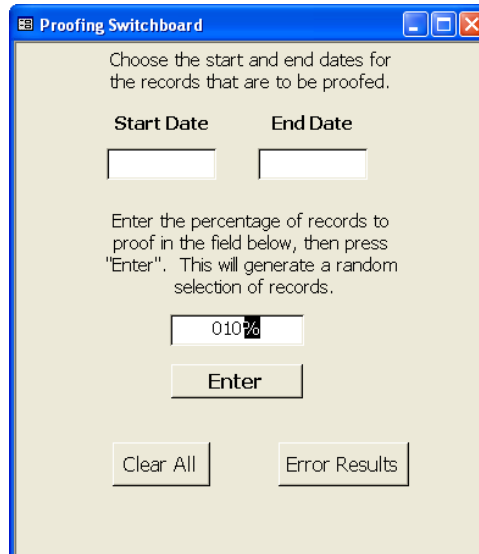
Lookup Tables

Clicking the Lookup tables button will open the form for managing lookup tables. On the Other lookup tables tab, lookup tables can be selected from the Tables drop-down list. The values in the lookup table will be displayed in a datasheet below the drop-down list. If the table is listed as “Editable” in the drop-down list, then records can be edited, deleted, or added in the datasheet.

Contact_ID	Last_Name	First_Name	Middle_Init	Organization	Position_Title	Address	Address	Address2	City	State_Code	Zip
04D168	Beavers	Sallie		NPS	Marine Ecologist						
3B7FF5148	Craig	Peter		NPS	Marine Ecologist						
755D87BC	Basch	Larry		NPS	Ecologist/Science Advisor						
59F51F58C	Brown	Eric		NPS	Marine Ecologist						

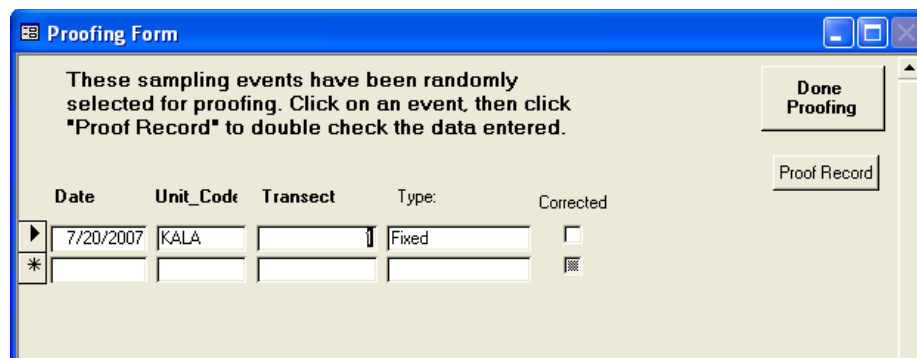
Proof Data

When you click on this button, the Proofing Switchboard will open.



The Proofing Switchboard dialog box has a blue title bar with the text "Proofing Switchboard". Inside, it says "Choose the start and end dates for the records that are to be proofed." Below this are two text boxes labeled "Start Date" and "End Date". Further down, it says "Enter the percentage of records to proof in the field below, then press 'Enter'. This will generate a random selection of records." Below this text is a text box containing "010%". At the bottom are three buttons: "Enter", "Clear All", and "Error Results".

Enter *Start Date* and *End Date*. If you don't enter a date, it will automatically select the earliest and latest dates entered into the database, respectively. Then enter the percent of samples you want randomly sampled (usually 10%) and click **Enter**. This will open the Proofing Form.



The Proofing Form dialog box has a blue title bar with the text "Proofing Form". Inside, it says "These sampling events have been randomly selected for proofing. Click on an event, then click 'Proof Record' to double check the data entered." Below this text is a table with columns: Date, Unit_Code, Transect, Type, and Corrected. The first row shows a date of 7/20/2007, Unit_Code of KALA, and Type of Fixed. The second row is empty. To the right of the table are two buttons: "Done Proofing" and "Proof Record".

	Date	Unit_Code	Transect	Type	Corrected
▶	7/20/2007	KALA		Fixed	☐
*					☐

Select the record you want to proof, and click on **Proof Record**. This will open the record in the Main Data Form. If any errors are found, they should be corrected here. When finished, click on **Close Form**. If errors were corrected, the *Corrected* box is now checked on the Proofing Form. Proof all records until complete. Then click on **Done Proofing**. This will take you back to the Proofing Switchboard. Click on **Error Results** to open the Proofing Results Form.

Again, you may enter dates. Click on **% of Records with Errors** to see your error rate. If the error rate is greater than 10%, you will be instructed to error check all records. Click on **Field Errors** to see a report of which errors were most frequently corrected.

Field Errors

Field	Total Errors	Percent of Total Field Errors
Data_Enterer	1	50%
Rugosity	1	50%
Grand Total	2	

View db Window

Clicking the **View db window** button will display the Microsoft Access® database window, which lists all of the tables, queries, forms, reports, pages, macros, and modules in the application. It is recommended that you exercise caution when working with objects directly in the database window. To hide the database window once you have opened it, make sure it is selected and select Window > Hide from the menu at the top of the application.

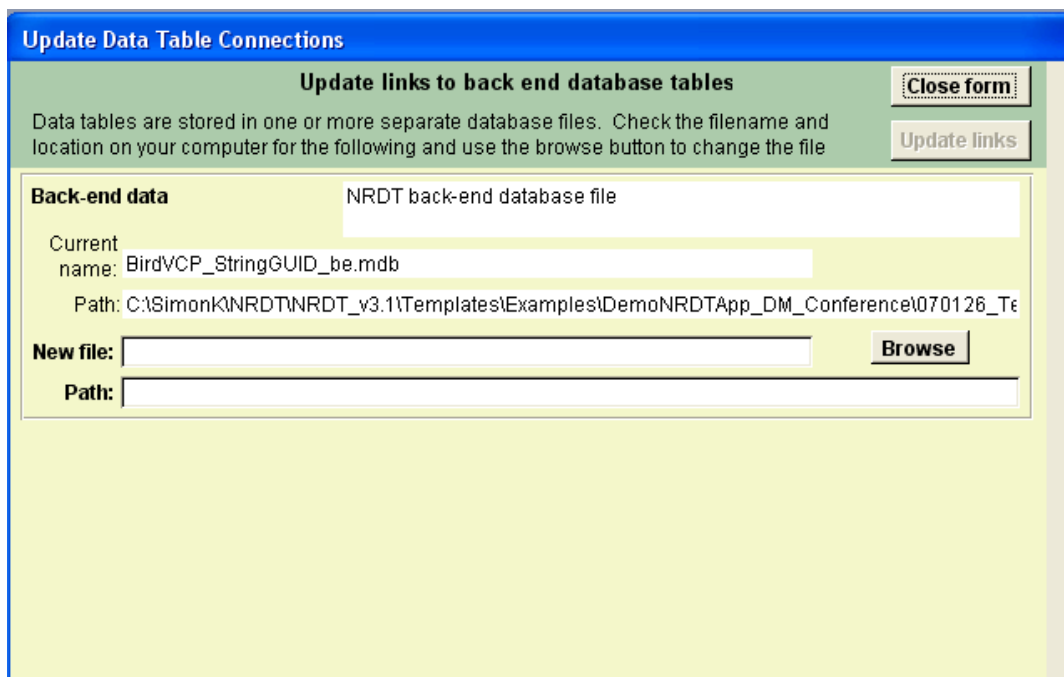
Back Up Data

Clicking the **Back up data** button will pop up a Yes/No box asking if you would like to make a backup copy of the data. If you select Yes, you will be prompted to select a folder in which to place the backup copy, which has a default name of *marine_benthic_FE_v.1.0_yyyymmdd_hhmm.mdb*. You can rename the file if you would prefer a different name. Clicking the Save button creates the backup file and displays a success message.

Connect Data Tables

The application has a separate front-end (user interface) and back-end (data tables). In order for the application to work properly, the front-end file must be connected to the correct back-end file.

Clicking the **Connect data tables** button opens the Update Data Table Connections Form, which can be used to establish the link from the front-end to the back-end.

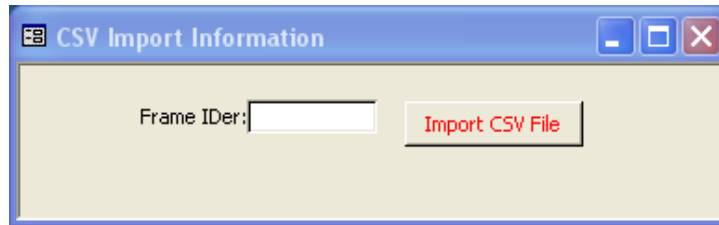


Update Data Table Connections Form

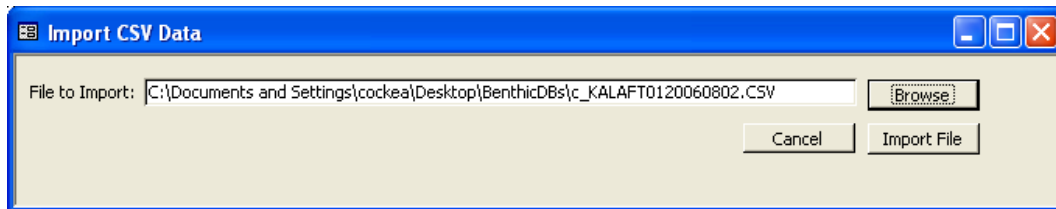
For each back-end file linked to the front-end, a record will be displayed on the Update Data Table Connections form. The name, path, and file name of the current back-end file are displayed. To change the back-end file connection, click the **Browse** button, select a new back-end file, and click the **Open** button. You will be returned to the Update Data Table Connections form and the New file and Path text boxes will be filled in. To make the new connection, click the **Update links** button. If the connection is made, a success message will be shown and you will be returned to the main menu.

Import CSV Files

CSV files are imported so that they don't need to be entered manually. These files are exported from the software package PhotoGrid (<http://www.photogrid.netfirms.com> [Last accessed 26March2007]) and include data for species identified in photos. On clicking the **Import CSV Files** button, the CSV Import Information Form opens. The user needs to enter the initials of the person who identified the species in PhotoGrid.



Once entered and the user has clicked on **Import CSV File**, the Import CSV Data Form opens.



Click **Browse** and navigate to the file to be imported. Then click on **Import File**. A message will appear when the data has been successfully updated. If the file does not contain exactly 51 records, an error message will appear to fix the CSV file.

Update Taxon Table

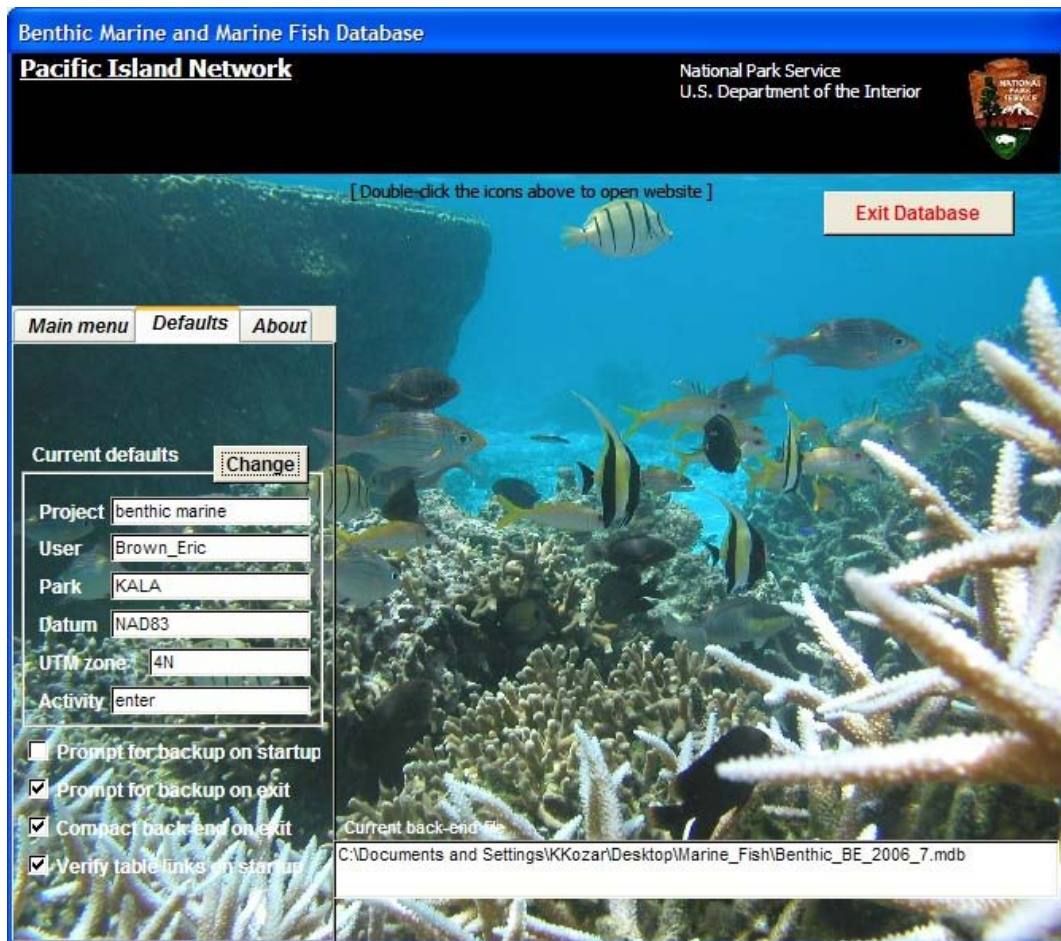
The taxonomy table that some fields draw upon will occasionally need to be updated. Clicking this button will open the Add/Edit Taxon form, where users can easily make updates to the table.

Database Instruction

When clicked, this opens a form with basic database instructions, so that they can be included within the database and not only as a separate document.

Defaults

The Defaults menu provides feedback on the current default values, and check boxes for automatic backups on startup, backups on exit, data file compaction on backup, and link verification on startup.



Defaults

Current Defaults

The current defaults section of the Defaults menu displays values that will automatically be filled in for the following fields when new records are added:

- Project
- User
- Park
- Datum
- UTM Zone
- Activity

To change *Project*, you should contact the developer of the application (see the About menu in the next section), since this is set when the application is created.

To change *User*, *Park*, *Datum*, or *UTM Zone*, click the Change button to bring up the Defaults form. Each value can be selected from a drop-down list. If you are unable to find a *User*, click the **New user** button to add a new one (see the Contact Information Form section of this document for more information). When you have finished entering default values, click the **OK** button to return to the Default menu.

The screenshot shows a dialog box titled "Set application default values". It has a blue header bar. Inside, there are several input fields: "User" (a text box with a dropdown arrow), "Park" (a text box with a dropdown arrow), "Datum" (a text box with a dropdown arrow), "UTM Zone" (a text box with a dropdown arrow), "Project" (a text box), and "Activity" (a text box with the text "enter" next to it). There are two buttons: "OK" in the top right and "New user" to the right of the "Datum" field.

Application Default Form

Automatic Backups

The application can be set to automatically prompt for backups every time it is started and/or every time it is closed using the **Exit** button on the main form. Making backups before and after data entry sessions is a good habit to get into, in case of database corruption or data entry mistakes. Backups can also be run manually by clicking the **Back up data** button on the Main menu.

Compact Back-End on Exit

Compaction is a process whereby Microsoft Access[®] optimizes the organization of the file, making it smaller and quicker to access data. If you check the option to Compact back-end on exit (recommended), the application will compact the data file that is linked to the front-end when the application is closed using the **Exit** button on the main form.

Verify Table Links on Startup

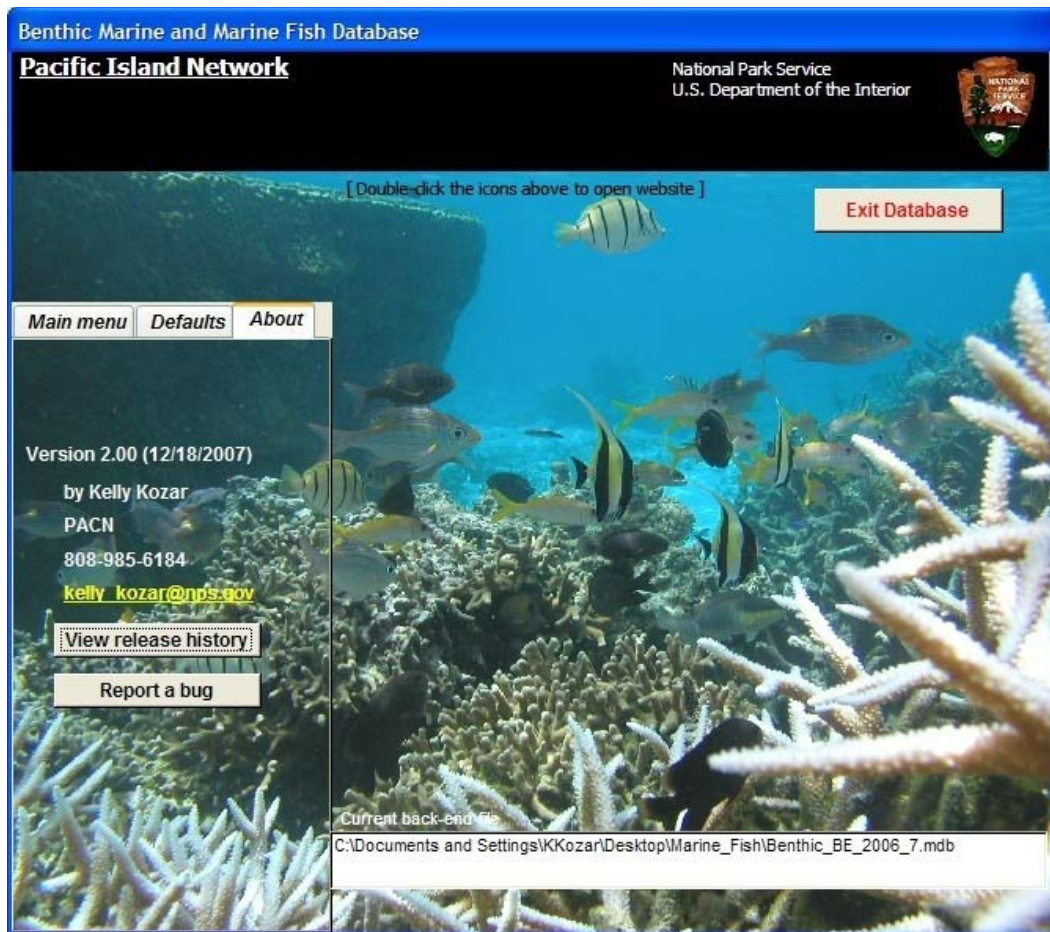
The application is structured with a front-end (user interface) and a back-end (data tables). In order for the application to work properly, the front-end must be linked to the tables in the back-end. If this check box is checked (recommended), the link to the back-end file(s) will be checked when the application is started.

About Menu

The About menu presents information about the application, including:

- Version number
- Application author
- Author organization
- Author phone
- Author email (click to email)

Buttons for viewing release history and reporting bugs are also provided on the About menu.



About

Release History

Clicking the **View release history** button opens the Application Releases form. This form provides information about all of the different versions of the application that have been released. It is filled in by the application developer before the application is distributed and is therefore read-only.

Included in the Application Releases form are title, version, and release information about the application, information about the author of the application, and bug information.

Report a Bug

Clicking the **Report a bug** button will prompt the user to contact the application developer with the details of the bug. Developer contact information is located above the Report a bug button.

The following information is useful when reporting a bug:

- application name
- application version
- name of the form/report you were on when the bug happened
- action, if any, you took right before the bug occurred
- screen capture of any error messages

Application Releases	
Release ID	20070307101607-705547511.577606
Database title	Benthic Marine Monitoring Database
Version number	1.00
Release date	3/7/2007
File name	Benthic_FE_72.mdb
Release by	Allison Snyder
Author phone	808-985-6186
Author email	allison_snyder@nps.gov
Author org code	PACN
Author org. name	Pacific Island Network
Release notes	
Known bugs	
Bug ID	20070328125134-705547511.5776
Report date	3/28/2007
Found by	Brown, Eric
Reported by	Brown, Eric
Report details	"Delete Event" button not working.
Fix date	3/30/2007
Fixed by	Snyder, Allison
Fix details	Fixed button- working properly now.
Record: 1 of 1	

Application Releases Form

Appendix J. List of Associated SOPS

Important Note: The Marine Fish Monitoring Protocol consists of this Protocol Narrative (Chapters 1 through 6 and Appendices A-J) and the following Standard Operating Procedures in Appendix K:

SOP 1:	Before the field season
SOP 2:	Training observers
SOP 3:	Safety protocol
SOP 4:	Using GARMIN® Global Positioning System (GPS) Units
SOP 5:	Pre-dive equipment preparation
SOP 6:	Selecting and marking subtidal sampling transect locations
SOP 7:	Conducting fish surveys
SOP 8:	Post-dive procedures and equipment maintenance
SOP 9:	Workspace setup and project records management
SOP 10:	Field form handling
SOP 11:	Managing photographic images
SOP 12:	Data entry and verification
SOP 13:	Data quality review and certification
SOP 14:	Metadata development
SOP 15:	Sensitive information procedures
SOP 16:	Product delivery specifications
SOP 17:	Product posting and distribution
SOP 18:	Data analysis and reporting
SOP 19:	After the field season
SOP 20:	Revisions to the protocol

Important Note: The complete Marine Fish Monitoring Protocol consists of this document (Protocol Narrative: Chapters 1 through 6, Appendices A-J) and Appendix K—Standard Operating Procedures for the Marine Fish Monitoring Vital Sign Protocol. Within the narrative, we explain project rationale and other objectives to be met by the monitoring program. The SOPs include specific instructions for conducting the Marine Fish monitoring.

APPENDIX K: Standard Operating Procedures (SOPs) for the Marine Fish Monitoring Vital Sign Protocol

Pacific Islands Network

Important Note: The complete Marine Fish Monitoring Protocol consists of Appendix K—Standard Operating Procedures (SOPs) for the Marine Fish Monitoring Vital Sign Protocol and the Protocol Narrative (Chapters 1 through 6, Appendices A – J). Within the narrative we explain the project rationale and other objectives to be met by the monitoring program. The SOPs include specific instructions for conducting the Marine Fish Monitoring.

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Appendix K. SOP #1: Before the Field Season

Revision Log

Only changes in this specific Standard Operating Procedure (SOP) will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

Prior to the field season each year, usually beginning in early spring, observers are required to review the entire Marine Fish Protocol, including all SOPs listed in the protocol. This SOP outlines the annual steps to prepare for a field season ensuring the availability of proper equipment prior to the start of monitoring. More detailed descriptions of specific monitoring tasks are given in the SOPs for training observers (SOP #2), outlining safety procedures (SOP #3), using the GPS (SOP #4), preparing for a dive (SOP #5), selecting transect locations (SOP #6), and conducting the surveys (SOPs #7).

A master equipment list for the entire Marine Fish Protocol can be found in Appendix S1.a of this SOP. The master equipment list should be updated simultaneously if any SOP associated with or containing gear lists is revised. A list of equipment required to complete the tasks specified in this SOP has been provided in Appendix S1.b.

General Preparation and Review

Notebooks and Dive Logs

Notebooks and dive logs from previous surveys need to be reviewed to identify unique events that may be encountered in the current field season. A field notebook for the current survey year should be prepared with columns indicating sampling schedule, observer names, field hours, and unique occurrences. These fields may influence how the data are interpreted and reported. Survey reports are based on information recorded in field notebooks; therefore it is imperative these are clearly organized for ease of field note entry.

Compile Species Lists

A list of fish species from previous surveys in a park or local area should be compiled from the existing database and reference manuals to identify fish that have a probability of being recorded. Prior knowledge of fish species most likely to be encountered in a park will aid divers in species identification. Copies of this list should be updated and carried into the field as quick references in helping to identify fish species.

Load Waypoints

Waypoints for each Marine Fish transect (co-located with Benthic Marine Community transects) must be loaded onto the Global Positioning System (GPS) unit prior to the start of the field season. Waypoints are the X and Y coordinates for each transect start point and are used to navigate to sampling locations. SOP #6 “Selecting and Marking Subtidal Transect Locations” contains instructions for generating transect locations in latitude and longitude for each of the PACN parks with their associated Universal Transverse Mercator (UTM) grid coordinates and SOP #4 “Using GARMIN Global Positioning System (GPS) Units” contains instructions on loading transect locations into the GPS unit.

Prepare Compass Headings

A complimentary list of compass headings and depths should be compiled or updated in advance of the field season for each fixed transect within a park (see SOP #6 “Selecting and Marking Subtidal Sampling Transect Locations”). Paper copies of these compass headings and depths, in addition to the GIS/GPS version, should be carried into the field to ensure that each fixed transect is located at the same point and surveyed as in previous years.

Scheduling Field Work

Sampling Dates

Sampling dates should be scheduled and logistics organized well before the start of each field season. In the northern hemisphere, fish surveys can be conducted after the first full week of May until the end of September to coincide with diminished wave activity. In the southern hemisphere, surveys can be scheduled after the first full week of November until the end of April. It is preferable to sample at approximately the same time each year (± 1 month) and as early in time as possible at a given park. Inclement weather, rough sea conditions, or personnel workloads may preclude the scheduling of sampling events to specific annual dates. Ideally, the Marine Fish monitoring needs to be scheduled at a time period that (± 1 month) coincides as close in time as possible with other marine protocols (e.g., Benthic Marine Community) to examine any correlations with other data sets.

Crew

Monitoring efforts within each PACN park require a two to four person crew. Ideally, three people are needed to sample and one to serve as a boat operator/safety diver. Parks may possess site-specific safety requirements, SOP #3 “Safety Protocol” should be reviewed by all personnel prior to entering the field.

Timing and Co-location

Two to four fish transects should be scheduled for completion each field day (30 total transects annually). Thus, at least 8 – 15 field days per park will be needed to complete the field portion of this protocol. To maximize efficiency, this protocol can be completed simultaneously with the

PACN Benthic Marine Community Protocol. Once transects are set-up, if fish and benthic monitoring are conducted on the same day, the field work for the PACN Marine Fish Protocol must be completed first to prevent disturbance to fish and bias in data.

Organizing Supplies and Equipment

Review Equipment Lists

The marine ecologist at each park ensures that all equipment and supplies listed in the tables of Appendix S1.a of this SOP have been compiled, organized, and made ready for the field season at least two months in advance. Advance preparation allows time to make needed repairs and order equipment.

Field Data Forms

Copies of the field data forms (see specific SOPs for each anticipated task) must be made on waterproof paper with waterproof photocopies or printer ink (e.g., Xerox laser/copier; never-tear paper, not rite-in-rain).

Reference Manuals

Suggested reference manuals to facilitate identification of organisms encountered in fish surveys for each park should be available to pertinent staff (Table S1.1).

Table S1.1. Suggested reference materials by region and park.

Region and Park	Reference
American Samoa (NPSA)	Randall, J. 2005. Reef and shore fishes of the South Pacific. Univ. Hawaii Press, Honolulu, Hawaii. Allen, G. et al. 2003. Reef fish identification, tropical Pacific. New World Publ., Jacksonville, Florida. Myers, R. 1999. Micronesian reef fishes. Coral Graphics, Guam. Randall, J. et al. 1997. Fishes of the Great Barrier Reef and Coral Sea. Univ. Hawaii Press, Honolulu, Hawaii. Michael, S. 2001. Reef fishes, Vol. 1 - 5, T.F.H. Publications, New Jersey
Guam/CNMI (WAPA)	Myers, R. 1999. Micronesian reef fishes. Coral Graphics, Guam. Allen, G. et al. 2003. Reef fish identification, tropical Pacific. New World Publ., Jacksonville, Florida. Randall, J. et al. 1997. Fishes of the Great Barrier Reef and Coral Sea. Univ. Hawaii Press, Honolulu, Hawaii. Randall, J. 2005. Reef and shore fishes of the South Pacific. Univ. Hawaii Press, Honolulu, Hawaii. Michael, S. 2001. Reef fishes, Vol. 1 - 5, T.F.H. Publications, New Jersey
Hawaii (KALA & KAHO)	Randall, J. 1996. Shore fishes of Hawaii. Natural World Press. Vida, Oregon. Hoover, J. 1993. Hawaii's fishes, a guide for snorkelers, divers and aquarists. Mutual Publishing. Honolulu, Hawaii. Michael, S. 2001. Reef fishes, Vol. 1-5, T.F.H. Publications, New Jersey

Camera Gear

Camera gear will occasionally be used to aid identification of fishes observed. This method of identification is highly valuable especially for people with less identification experience; however, this method should only be utilized if it will not disrupt the further collection of data (i.e. not scaring other would-be surveyed fish).

Boat, Motor and Trailer

Boat, trailer, and motor servicing should be independently verified for each park for field operation. Ensure that this required preparation has been done in accordance with the Department of Interior (DOI) Motorboat Operator Manual and park specific SOPs (Table S1.2). Park-specific SOPs can be obtained from the Park Dive Officer or the certified motorboat operator at each park. Marine Fish Protocol SOP #11 “After the Field Season” also outlines the required post-field season maintenance for each.

Table S1.2. Equipment list for operating motor boats. This equipment list refers to SOP #1 “Before the Field Season.” Specific equipment required based on vessel length is listed in MOCC (2006)¹.

Equipment (#/quantity)	Vendor Source	Preparation & Maintenance
MOCC (2006) ¹	DOI course in Honolulu or at a park	Ensure that this equipment is available
DAN O2 kit	DAN 800-446-2671	Ensure that this equipment is available
Dive flag	Local dive store	Ensure that this equipment is available
Flares	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Survival kit (with contents list)	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Extra water	Local hardware store	Ensure that this equipment is available
PFDs for each person	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Spare parts kit	West Marine, 808-845-9900 or website	Ensure that this equipment is available
EPIRB	West Marine, 808-845-9900 or website	Ensure that this equipment is available
First aid kit	Local drug store	Ensure that this equipment is available
VHF and park radio or cell phone	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Water intake “rabbit ears”	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Water hose	Local hardware store	Ensure that this equipment is available
Battery	Local auto parts store	Ensure that this equipment is available
Battery charger	Local auto parts store	Ensure that this equipment is available
Fuel tanks	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Fuel filter	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Outboard motor leg oil	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Impeller	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Mooring lines	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Anchor, chain, and line	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Bilge pump	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Fire extinguisher	Local hardware store	Ensure that this equipment is available
Compass	West Marine, 808-845-9900 or website	Ensure that this equipment is available
GPS/plotter	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Depth finder	West Marine, 808-845-9900 or website	Ensure that this equipment is available

¹ Department of Interior (2006). Motorboat operator certification course, student manual.

Dive Gear

Prior to the start of the field season all dive gear should be checked, serviced, and tested as required by Resource Manual #4 – Diving Management (RM-4). Verify that required inspections and maintenance were completed for the gear in Table S1.3.

Table S1.3. SCUBA gear requiring periodic inspection and maintenance.

Equipment	Certification or Required Service
Air cylinders	VIP certification (annually), check o-rings, hydrostatic testing for expired cylinders (once every 5 years)
Regulators	Annual Service
Buoyancy compensator devices (BCDs)	Annual Service

Transect Lines

New transect lines should be purchased or old transect lines reconditioned for conducting the fish survey as described in SOP #5 “Pre-Dive Equipment Preparation”. Tables S1.4a-g are the Master equipment list for gear preparation for the Marine Fish Protocol.

Table S1.4a. Equipment list for installing permanent transect marking pins. This equipment list refers to SOP #6 “Selecting and Marking Subtidal Sampling Transect Locations”.

Equipment (#/quantity)	Vendor Source	Preparation and Maintenance
1 cm (3/8") X 40 cm (16") threaded stainless steel rod (2+)/transect	Local hardware store, Fastening Specialty 800-327-8364	More pins may be necessary if conditions warrant
Z-spar [®] or Powerfast [®] epoxy (1 ea.)	West Marine, 808-845-9900 or website	Ensure that 1 gallon of A&B (Z-Spar [®]) or 1 tube (Powerfast [®]) is available
Mesh bag (1)	Local dive store	Ensure that this equipment is available
Tupperware [®] containers for Z-spar [®] (2)	Local supermarket	One for each part of (A&B) of Z-spar [®] compound; Ensure that this equipment is available
2 or 5 lb. sledge hammer (2)	Local hardware store	One for back up; Ensure this equipment is available
30 m transect line (2)	Forestry Suppliers 601-354-3565 or website	Labeled at 50 cm intervals; see SOP #1 “Before the Field Season”
Coordinates, depths, compass headings, and/or maps of transect locations	Generated within each park	See SOP #6 “Selecting and Marking Subtidal Sampling Transect Locations”
GPS (1)	West Marine, 808-845-9900 or website	See SOP #4 “Using GARMIN [®] Global Positioning System (GPS) Units”
Transparent waterproof container for GPS (1)	West Marine, 808-845-9900 or website	Ensure that this equipment is available
U/W compass (1)	Local dive store	Ensure that this equipment is available
Surface float marker (2)	Local dive store	One for back-up; Ensure that this equipment is available
U/W slate with pencil (2)	Local dive store	Ensure that this equipment is available
U/W lights (2)	Local dive store	Ensure that this equipment is available
U/W light rechargeable batteries (2 sets)	Local dive store	Ensure that this equipment is available
Scuba gear	Local dive store	See SOP #5 “Pre-Dive Equipment Preparation”

Table S1.4b. Equipment list for conducting marine fish surveys. This equipment list refers to SOP #5 “Pre-Dive Equipment Preparation” and SOP #7 “Conducting Marine Fish Surveys.”

Equipment (#/quantity)	Vendor Source	Preparation & Maintenance
30 m transect line	Forestry Suppliers 601-354-3565 or website	Labeled at 50 cm intervals, see SOP #1 “Before the Field Season”
Coordinates, depths, compass headings, and/or maps of transect locations	Generated within each park	Ensure that this equipment is available; See SOP #6 “Selecting and Marking Subtidal Sampling Transect Locations”
GPS (1)	West Marine, 808- 845-9900 or website	Ensure in working order; See SOP #4 “Using GARMIN® Global Positioning System (GPS) Units”
Transparent waterproof container for GPS (1)	West Marine, 808- 845-9900 or website	Ensure that this equipment is available
U/W compass (1)	Local dive store	Ensure that this equipment is available
Surface float marker (2)	Local dive store	One for back-up; Ensure that this equipment is available
U/W slate with pencil (2)	Local dive store	Ensure that this equipment is available
U/W field data forms	Local dive store	See SOP #7 “Conducting Marine Benthic Cover and Rugosity Surveys”
U/W lights (2)	Local dive store	Ensure equipment is in working order
U/W light rechargeable batteries (2 sets)	Local dive store	Ensure equipment has sufficient power
Pelican® case to store equipment (e.g. GPS) on boat.	West Marine, 808- 845-9900 or website	Ensure that this equipment is available
SCUBA gear	Local dive store	See SOP #5 “Pre-Dive Equipment Preparation” and SOP #11 “After the Field Season”
Boat, motor, and trailer	GSA vendor	See SOP #5 “Pre-Dive Equipment Preparation” and SOP #11 “After the Field Season”

Table S1.4c. Equipment list for conducting diving activities. This equipment list refers to SOP #5 “Pre-Dive Equipment Preparation”. All of these equipments can be obtained from a local dive shop.

Equipment (#/quantity)	Preparation & Maintenance
Air cylinders	Verify hydro and VIP, fill with compressed air or NITROX. See SOP #16 “After the Field Season”
Fins	Ensure that this equipment is available
Booties	Ensure that this equipment is available
Wetsuit	Ensure that this equipment is available
Hooded vest (optional)	Ensure that this equipment is available
Weights	Ensure that this equipment is available
Belt/integrated weight container	Ensure that this equipment is available
BC	Verify annual service. See SOP #16 “After the Field Season”
Regulator	Verify annual service. See SOP #16 “After the Field Season”
Mask & Snorkel	Ensure that this equipment is available
Dive computer	Ensure that this equipment is available
Thermometer	Ensure that this equipment is available
Compass	Ensure that this equipment is available
Knife, dive tool, or shears	Ensure that this equipment is available
Rescue “sausage” (international orange)	Ensure that this equipment is available
Whistle or surface noise maker	Ensure that this equipment is available
Underwater noise maker (e.g., subduck, knife)	Ensure that this equipment is available
Save a dive kit	Ensure that this equipment is available
Spare gear (mask, fin, snorkel, straps, other as needed)	Ensure that this equipment is available
Brass clips--attached to BCD, gear bags, or equipment (e.g., camera housing, hammers)	Ensure that this equipment is available
Dive bag for boat work	Ensure that this equipment is available
Bucket for shore work	Ensure that this equipment is available

Table S1.4d. Equipment list for operating motor boats.

Equipment (#/quantity)	Vendor Source	Preparation & Maintenance
MOCC (2006)	DOI course in Honolulu or at a park	Ensure that this equipment is available
DAN O2 kit	DAN 800-446-2671	Ensure that this equipment is available
Dive flag	Local dive store	Ensure that this equipment is available
Flares	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Survival kit (with contents list)	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Extra water	Local hardware store	Ensure that this equipment is available
PFDs for each person	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Spare parts kit	West Marine, 808-845-9900 or website	Ensure that this equipment is available
EPIRB	West Marine, 808-845-9900 or website	Ensure that this equipment is available
First aid kit	Local drug store	Ensure that this equipment is available
VHF and park radio or cell phone	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Water intake "rabbit ears"	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Water hose	Local hardware store	Ensure that this equipment is available
Battery	Local auto parts store	Ensure that this equipment is available
Battery charger	Local auto parts store	Ensure that this equipment is available
Fuel tanks	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Fuel filter	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Outboard motor leg oil	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Impeller	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Mooring lines	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Anchor, chain, and line	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Bilge pump	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Fire extinguisher	Local hardware store	Ensure that this equipment is available
Compass	West Marine, 808-845-9900 or website	Ensure that this equipment is available
GPS/plotter	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Depth finder	West Marine, 808-845-9900 or website	Ensure that this equipment is available

Table S1.4e. Equipment list for permanent pin maintenance, as needed.

Equipment (#/quantity)	Vendor Source	Preparation & Maintenance
Pins (threaded stainless steel rod)	Local hardware store, Fastening Specialty 800-327-8364	Ensure that this equipment is available
Z-spar [®] (or other 2-part marine epoxy)	West Marine, 808-845-9900 or website	Ensure that this equipment is available
Mesh bag	Local dive store	Ensure that this equipment is available
Tupperware [®] containers	Local supermarket	Ensure that this equipment is available
Sledge hammer	Local hardware store	Ensure that this equipment is available
Slate	Local dive store	Ensure that this equipment is available

Table S1.4f. Equipment list for tools and repair, as needed.

Equipment (#/quantity)	Vendor Source	Preparation & Maintenance
Fin and mask straps	Local dive store	Ensure that this equipment is available
O-rings	Local dive store	Ensure that this equipment is available
Electrical tape	Local hardware store	Ensure that this equipment is available
Duct tape	Local hardware store	Ensure that this equipment is available
Pliers	Local hardware store	Ensure that this equipment is available
Wire cutters	Local hardware store	Ensure that this equipment is available
Cable ties	Local hardware store	Ensure that this equipment is available
Snorkel keepers	Local dive store	Ensure that this equipment is available
Multimeter	Local hardware store	Ensure that this equipment is available
Allen & crescent wrenches for regulator repair	Local hardware store	Ensure that this equipment is available
O-ring pick	Local hardware store	Ensure that this equipment is available
Multi purpose tool (e.g., Leatherman [®])	Local hardware store	Ensure that this equipment is available

Table S1.4g. Equipment list for paperwork needed to complete any of the surveys in this protocol.

Equipment (#/quantity)	Source	Preparation & Maintenance
Permits	NPS and Local Gov.	Ensure that this equipment is available
Log book for documenting dives and accomplishments.	Local dive store	Ensure that this equipment is available
Charts and grid layouts	NOAA	Ensure that this equipment is available
Call local marine enforcement agency as appropriate	DOCARE 808-984-8110 in Hawaii	Ensure that this equipment is available
Pencils	Local supermarket	Ensure that this equipment is available
Pens	Local supermarket	Ensure that this equipment is available
Eraser	Local supermarket	Ensure that this equipment is available
Permanent marker	Local supermarket	Ensure that this equipment is available

Appendix K. SOP #2: Training Observers

Revision Log

Only changes in this specific Standard Operating Procedure will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This Standard Operating Procedure outlines the requirements and training procedures that field staff and office analysts should follow. All field personnel should: (1) have NPS bluecard diving certification; (2) DOI motorboat operator certification; (3) know how to identify PACN regional marine fish species; (4) know how to accurately visually determine the size of marine fish; (5) know how to operate survey gear such as transect lines and GPS units, and (5) know basic computer software such as Microsoft Word[®], Microsoft Excel[®], and *STATISTICA*[®]. Office personnel need to know: (1) data management principles, infrastructure, and practices associated with this Vital Sign; (2) relevant marine fish species; (3) SOPs associated with field data collection practices; (4) sound statistical background for analyses, and (5) analysis and reporting principles outlined in the SOPs associated with this protocol. The use of products identified in this protocol does not imply endorsement, effectiveness, or warranty by NPS.

A master equipment list for the entire Marine Fish Vital Sign Monitoring Protocol can be found in Appendix S1.a of SOP #1 “Before the Field Season.” The master equipment list should be updated simultaneously if any SOP requiring an equipment list is revised.

Field Personnel Requirements

NPS Operational Leadership Course

All NPS personnel should take the operational leadership course. This is typically a one day course that can be conducted within each park or at a central location. Contact your supervisor for the next available class.

NPS Blue Card Certification

An essential component for conducting the underwater Marine Fish surveys is that divers maintain current NPS bluecard certification or have approved diving reciprocity. Divers from some outside organizations (e.g., AAUS, NOAA) may take part in diving operations provided they have obtained a letter of reciprocity (LOR) from their Dive Safety Officer (DSO) and this LOR has been approved by the Park Dive Officer (PDO) prior to diving within that specific park.

All SCUBA divers must adhere to the requirements outlined in NPS Reference Manual #4 “Dive Management” (RM-4) and the Dive Safety Manual specific to their park of origin. All SCUBA divers must be familiar with reference materials required for NPS bluecard certification (Table S2.1).

Table S2.1. References required for dive certification, including location where permanent copies can be located.

Reference	Location
Open Water Certification Manual for nationally recognized dive training organization (e.g., PADI, NAUI)	I&M Library
NPS RM-4 (complete manual)	I&M Library
Dive Safety Manual specific to each park	Available at each park

All field SCUBA diving personnel must spend time diving prior to the field season to obtain/maintain proficiency in buoyancy control. Divers with good buoyancy control underwater will have less trouble transporting gear, deploying and retrieving equipment, and surveying fish along a transect line. In addition, they will be less apt to damage the substrate during surveys.

NPS Motorboat Operator Certification

All employees who will operate motorboats must pass the DOI motorboat operator course prior to conducting field operations. Exceptions may be granted for personnel operating a boat under the supervision of a DOI motorboat operator instructor. All motorboat operators must be familiar with reference materials required of a DOI motorboat operator (Table S2.2).

Table S2.2. Reference materials required for DOI motorboat operator.

Reference	Location
DOI Motorboat Operator Certification Course (MOCC) Manual (DOI DM 485, Chapter 22)	I&M Library
Maloney, E.S., and C.F. Chapman. 1996. Chapman Piloting: Seamanship & Small Boat Handling, 62 nd ed. William Morrow and Company.	I&M Library

Fish Identification Procedure

Field and office personnel must be familiar with the fish species specific to each PACN park (see Table S1.1 in SOP #1 “Before the Field Season”). Field personnel conducting fish surveys must pass a fish identification exam by correctly identifying at least 95% of the fish in digital images (minimum 300 images) from the park where analysis will occur (or network, if the staff member will be identifying fish for multiple parks). Observers should be familiar with all pertinent reference materials for marine fish identification (Table S2.3).

Table S2.3. Reference materials for fish identification.

Reference	Location
Allen, G., Steene, R., and Humann, P. 2003. Reef Fish Identification Tropical Pacific. New World Publications, Jacksonville, FL.	I&M Library – hard copy
Lieske, E.W. and Myers, R. 1999. Coral Reef Fishes: Caribbean, Indian Ocean, and Pacific Ocean; including the Red Sea. Princeton University Press, Princeton, NJ.	I&M Library – hard copy
Myers, R. 1999. Micronesian Reef Fishes: A Field Guide for Divers and Aquarists. Coral Graphics, Barrigada, Guam.	I&M Library – hard copy
Randall, J. 1999. Shore Fishes of Hawaii. University of Hawaii Press, Honolulu, HI.	I&M Library – hard copy
Randall, J. 2005. Reef and Shore Fishes of the South Pacific: New Caledonia to Tahiti and the Pitcairn Islands. University of Hawaii Press, Honolulu, HI.	I&M Library – hard copy

Fish Size Determination

Field personnel conducting fish surveys must annually pass a fish size assessment examination in addition to the fish identification examination. Field personnel will swim a 25 m transect and determine the length of 20 plastic-laminated fish models ranging in size from 5 – 30 cm (models will represent various morphologies). Fish models will be haphazardly attached to a weighted line that runs parallel to the transect. Field personnel estimates for model length must be accurate to within 10% of model fish lengths. Fish models will be rearranged after each test, and field personnel will repeat size estimate exam until observer accuracy meets the SOP requirement.

Table S2.4. Size determination reference materials.

Reference	Location
Friedlander, A.M, Brown, E.K., Jokiel, P.L., Smith, W.R., and Rodgers, K.S. 2003. Effects of habitat, wave exposure, and marine protected area status on coral reef fish assemblages in the Hawaiian archipelago. Coral Reefs 22:291-305.	I&M Library – hard copy

Transect Lines Deployment

Field personnel need to be familiar with the deployment of transect lines underwater by first deploying and spooling the lines on land. Once accomplished, they will proceed to practice deployment skills underwater while maintaining good buoyancy control. Keep in mind that some transect lines are weighted so buoyancy will change substantially while laying and spooling the line.

GPS Operation

Field personnel need to know how to operate the GPS to navigate to various waypoints. See SOP #4 “Using GARMIN® Global Positioning System (GPS) Units” and practice using the unit before heading out into the field.

Reference materials related to operating survey gear can be found in Table S2.5.

Table S2.5. Survey gear reference materials.

Reference	Location
Coyer, J., and J.D. Witman. 1990. The underwater catalog: A guide to methods in underwater research. Shoals Marine Laboratory, Cornell University and New York Sea Grant, Ithaca, New York, USA.	I&M Library – hard copy
English, S., C. Wilkinson, and V. Baker. 1994. Survey manual for tropical marine resources. Australian Institute of Marine Science, Townsville, Australia.	I&M Library – hard copy
Rogers, C.S., G. Garrison, R. Grober, Z-M Hillis, and M.A. Franke. 1994. Coral reef monitoring manual for the Caribbean and Western Atlantic. National Park Service, US Virgin Islands, USA.	I&M Library – digital ;and http://cars.er.usgs.gov/Monitoring_Manual.pdf (accessed 26 May 2006)

Computer Software

All field and office personnel should be familiar with using Microsoft Word® and Microsoft Excel® Programs. Reference materials for operating computer software are listed in Table S2.6.

Table S2.6. Computer software references.

Reference	Location
Microsoft Word® manual or third party manual	I&M library; and: http://office.microsoft.com/en-us/assistance/default.aspx (accessed 26 May 2006)
Microsoft Excel® manual or third party manual	I&M Library; and http://office.microsoft.com/en-us/assistance/default.aspx (accessed 26 May 2006)

PACN Monitoring Plan

All office personnel involved in the fish monitoring program will need to be familiar with the PACN monitoring plan. The complete monitoring plan will be posted at: <http://www1.nature.nps.gov/im/units/pacn/monitoring/index.htm> (accessed 30 May 2006). All office personnel will be familiar with the Marine Fish Community Monitoring Protocol, all chapters and all SOPs.

Data Management Principles, Infrastructure, and Practices

PACN: All office personnel will be familiar with the PACN I&M Program, infrastructure and practices. All office personnel will be required to read and be familiar with the PACN data management principles and infrastructure which can be found in Chapter 6, Data Management Plan of the PACN Monitoring Plan.

Marine Fish Monitoring Protocol: The chapters and SOPs associated with data management include: Chapter 4 “Data Handling, Analysis and Reporting,” SOP #10 “Data Management.”

SOPs Associated with Field Data Collection Practices

All office personnel will need to be familiar with all chapters and SOPs associated with field data collection and methods. Chapters and SOPs related to these practices and procedures include

Chapter 3 “Field Methods,” SOP #6 “Selecting and Marking Subtidal Sampling Transect Location,” SOP #7 “Conducting Marine Fish Surveys.”

All office personnel will need to participate in at least one (1) on-site field visit during actual monitoring; even if they are only boat-based while divers conduct field data collection activities.

Statistical Background for Analyses

All office personnel will be familiar with Microsoft Office[®], and in particular, Microsoft Word[®], Microsoft Excel[®], and the statistical package, *STATISTICA*[®] 7.0. Reference material for operating computer software is listed in Table S2.7.

All personnel involved in this protocol will need to review the manual for *STATISTICA*[®] 7.0, the Statistical Software used for data analysis with the Benthic Marine Community Protocol. More information on data analysis can be found in SOP #10 “Data Analysis and Reporting.”

Table S2.7. Reference material for operating computer software.

Reference	Location
Microsoft Word [®] manual or third party manual	I&M library; and: http://office.microsoft.com/en-us/assistance/default.aspx (accessed 26 May 2006)
Microsoft Excel [®] manual or third party manual	I&M Library; and visit: http://office.microsoft.com/en-us/assistance/default.aspx (accessed 26 May 2006)
<i>STATISTICA</i> [®] 7.0 instructional manual	

Analysis and Reporting Principles

All personnel involved in this protocol will be required to read and be familiar with the chapters and SOPs in the PACN Monitoring Plan associated with analysis and reporting. In particular, use Chapter 4 “Data Analysis and Reporting.”

All personnel involved in this protocol will be required to read and understand all chapters and SOPs associated with analysis and reporting in the Marine Fish Community Protocol. In particular, personnel will need to be familiar with Chapter 4 “Data Handling, Analysis, and Reporting,” and SOP # 10 “Data Analysis and Reporting.” Furthermore, personnel will need to be familiar with PACN and this Vital Sign’s reporting needs and audiences both for the network and each park.

Appendix K. SOP #3: Safety Protocol

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This SOP explains the safety protocol for the Marine Fish Vital Sign Monitoring Protocol and associated SOPs for PACN. This document outlines safety considerations for conducting any aspect of the protocol. All observers should be familiar with this SOP in order to identify and use the most current procedures and ensure optimum safety.

A master equipment list for the entire Marine Fish Vital Sign Monitoring Protocol can be found in Appendix 1.a of SOP #1: “Before the Field Preparations.” The master equipment list should be updated simultaneously if any SOP requiring an equipment list is revised.

General Preparation and Review

Prior to conducting field work, observers are required to review this entire Marine Fish Protocol, including all SOPs listed in this protocol. In particular, all participants should be thoroughly familiar with the NPS Occupational Safety and Health Policies, SCUBA, and watercraft manuals, various environmental and chemical safety guidelines, procedures outlined in SOP #2: “Training Technicians,” as well as the various equipment lists in SOP #1: “Before the Field Preparations.”

The USGS National Field Manual (<http://water.usgs.gov/owq/FieldManual/Chap9/content.html>) is another recommended reference for safety procedures. Table 3.1 provides a partial list of reference material and websites with information on specific safety topics.

Table S3.1 List of documents and websites for safety requirements and guidelines related to conducting the marine fish communities monitoring protocol.

Safety Topic	Guidance	Website
Safety policies, regulations and requirements	DRAFT NPS RM 50B Occupational Safety & Health Program Safety Smart! USGS National Field Manual Section 9.1 29 CFR, Part 1960, "Elements for Federal Employee Occupational Safety and Health Programs," Subpart C Departmental Manual (DM), Part 485, "Safety and Health Handbook," Chapter 4	http://inside.nps.gov/waso/custommenu.cfm?lv=2&prg=46&id=5898 http://safetysmarts.smis.doi.gov/ http://water.usgs.gov/owq/FieldManual/Chap9/A9.1.html
Safety training guidelines	SMIS Training Materials DOI Office of Occupational Health and Safety 29 CFR, Part 1960, "Elements for Federal Employee Occupational Safety and Health Programs," Subpart H Departmental Manual (DM), Part 485, "Safety and Health Handbook," Chapter 13	https://www.smis.doi.gov/SMISReference/homepage.htm http://www.doi.gov/ohs/index.html
SCUBA safety	NPS Reference Manual 4 Diving Management SCUBA certification materials (PADI, NAUI, SSI, YMCA)	http://inside.nps.gov/waso/custommenu.cfm?lv=3&prg=533&id=1137
Boating safety	NPS Reference Manual 50B, Section 9.0 Watercraft Safety DOI Motorboat Operator Certification Course (MOCC)	http://inside.nps.gov/waso/custommenu.cfm?lv=3&prg=704&id=2863
Transportation	NPS Reference Manual 50B, Section 6.0 Motor Vehicles USGS National Field Manual Section 9.3 State, Territory, and Commonwealth traffic laws	http://www.inside.nps.gov/waso/custommenu.cfm?lv=3&prg=704&id=2860 http://water.usgs.gov/owq/FieldManual/Chap9/A9.3.html
Inclement weather and water activities	USGS National Field Manual Section 9.4 National Weather Service	http://water.usgs.gov/owq/FieldManual/Chap9/A9.4.html http://www.prh.noaa.gov
Environmental conditions	USGS National Field Manual Section 9.8 1992. USDHHS. CDC. HIOSH. "Working in Hot Environments"	http://water.usgs.gov/owq/FieldManual/Chap9/A9.8.html
Contaminated water	NPS Reference Manual 83D1 Bathing Beaches Recreational Waters USGS National Field Manual Section 9.7	http://www.nps.gov/public_health/inter/info/rms/rm83d1.pdf http://www.nps.gov/public_health/inter/rec_water/rw.htm http://water.usgs.gov/owq/FieldManual/Chap9/A9.7.html

Safety Topic	Guidance	Website
	EPA	http://www.epa.gov/OST/beaches/
Animals and disease vectors	NPS Reference Manual 83G Vectorborne and Zoonotic Diseases USGS National Field Manual Section 9.9	http://www.nps.gov/public_health/inter/info/rms/rm83g.pdf http://water.usgs.gov/owq/FieldManual/Chap9/content.html
Divers/Boat Operators	Reference Manual 4 Diving Management	http://inside.nps.gov/waso/custommenu.cfm?lv=3&prg=533&id=1137

Safety is “the condition of averting or not causing injury, danger, or loss” (Lane and Fay 1997). As a Federal employee, partner, or cooperator, you are required to know and follow safety policies and requirements documented in Reference Manual 50 B Occupational Safety and Health Program (<http://inside.nps.gov/waso/custommenu.cfm?lv=2&prg=46&id=5898>). For divers and boat operators, Reference Manual 4 Diving Management (RM-4 located at <http://inside.nps.gov/waso/custommenu.cfm?lv=3&prg=533&id=1137>) and Reference Manual 9 Watercraft Safety (<http://inside.nps.gov/waso/custommenu.cfm?lv=3&prg=704&id=2863>) should be followed accordingly. In addition, individual parks also have park specific safety procedures, and operational protocols. This SOP recommends that these and all other available reference materials be used to address the topics below.

Safety Policies, Regulations and Requirements

All individuals participating in activities related to this Vital Sign must adhere to applicable safety policies, regulations, and requirements outlined in RM 50 B Occupational Safety and Health Program. This includes both field and office activities and applies equally to NPS staff, cooperators, partners, volunteers, and others. The applicable policies, regulations, and requirements of each participating agency should be compiled and reviewed each year as part of this SOP. Ensure that all field personnel obtain First Aid, CPR training, and Oxygen Administration. This is also highly recommended for office personnel. Supervisory staff should ensure that all field staff are well trained in the safety guidelines and policies outlined below.

SCUBA Diving

Unique safety hazards of using scuba are detailed in RM-4 (<http://inside.nps.gov/waso/custommenu.cfm?lv=3&prg=533&id=1137>). Each diver must adhere to the guidelines required by the NPS Diving program and follow the safety requirements specific to each park. Park-specific Diving Safety Manuals are on file at each park and should also be made available and reviewed before field work. All SCUBA is conducted at the discretion of the PDO, who has final approval of all SCUBA activity within his/her park. The PDO should be consulted prior to the start of field activities for assistance with park-specific requirements or safety issues. Recommended maintenance procedures for SCUBA equipment can also be found in RM-4 and SOP #5 “Pre-dive Equipment Preparation.”

It is important when planning logistics to ensure that aircraft flights will not take place until 24 hours following any diving activity regardless of the length of the dive. Additionally, altitude dive tables or corrections on the dive computers must be used when returning home requires travel above 305 m in elevation. This is particularly important for dive operations in KAHO

where many houses in Kailua-Kona, HI are above 305 m. Additionally, divers operating in KAHO and returning to the Hilo/Volcano, HI area must be aware that the lowest altitude route from KAHO to the Hilo side of the island slightly exceeds 610 m and requires traveling along the Hamakua coast. For operations in KALA, the trail height is approximately 518 m in elevation and requires strenuous hiking; it is therefore recommended that this route not be used for 24 hours following diving operations.

Transportation

Safety considerations for vehicles used to reach sampling sites should be considered for each park and field location. It is very important to inspect the vehicle before going into the field. Ensure that safety equipment required for the scheduled activity is stowed securely in the vehicle. During driving to and from sampling areas, it is particularly important to consider issues such as night-time driving, fatigue, storms, road flooding, driving in unfamiliar areas, and remote areas where large animals may be crossing the road. Additional details regarding transportation safety procedures and policies are listed in NPS Reference Manual 50B Section 6.0 Motor Vehicles (<http://www.inside.nps.gov/waso/custommenu.cfm?lv=3&prg=704&id=2860>) and the USGS National Field Manual Section 9.3 (<http://water.usgs.gov/owq/FieldManual/Chap9/A9.3.html>).

In some cases, this protocol may require the transportation of a trailered vessel. Vehicles towing boat trailers should only be operated by individuals who have completed the DOI MOCC. All small boat operations must be conducted by DOI MOCC certified operators and must follow the operational and safety guidelines detailed in the NPS Reference Manual 9 “Watercraft Safety” (<http://inside.nps.gov/waso/custommenu.cfm?lv=3&prg=704&id=2863>) in addition to park-specific guidelines. In some cases, approval to operate motorboats may be granted to individuals holding comparable or greater certifications (e.g. US Coast Guard Captain’s License), but this is at the discretion of the Park Safety Officer and/or PDO.

Equipment

All equipment is potentially hazardous. It is the responsibility of the individuals participating in the field operations to understand and address all equipment issues that potentially pertain to field operations. In particular, SCUBA diving gear must be serviced a minimum of annually to be compliant with PWR diving safety operations. Compressed air is always potentially hazardous and it is the responsibility of the diver to ensure, to the best of their ability, the compressed air being used for the diving operations is suitable and safe. Any air that tastes or smells tainted is immediate grounds for the cancelling of the dive with that tank. Tank and diving gear are heavy and when combined with environmental conditions can pose hazards while donning or doffing gear. Assistance will always be provided as necessary to ensure the safety of all individuals on the vessel. Dive computers may fail. The PACN recommends a second backup dive computer for all diving operations. If computers fail at depth, appropriate measures should be taken to reduce the possibility of decompression injury. These measures can be found in each park’s diving safety manual.

Table S3.2. List of basic field survival equipment for the Marine Fish Protocol.

Equipment (#/quantity)	Preparation & Maintenance
Water	Ensure that the proper quantities are available.
Food (lunch)	Ensure that the proper quantities are available.
First Aid Kit	Keep stocked (see SOP #3: Safety Protocol)
Sunscreen (non-toxic)	Ensure that the proper quantities are available.
Insect repellant (non-toxic)	Ensure that the proper quantities are available.
Sunglasses	Ensure that this equipment is available.
Personal items	Ensure this equipment is available.

Weather

Sampling during inclement weather is of particular concern in the aquatic environments. Wave swells and surge are always a serious factor to consider in any diving operations. Weather can change rapidly on the ocean, creating hazardous conditions in a relatively short time period. Prior to departure, it is the responsibility of all personnel to be aware of the appropriate local weather, tide, and current forecast for the day and to decide whether sampling should commence. Consult the USGS National Field Manual Section 9.4

(<http://water.usgs.gov/owq/FieldManual/Chap9/A9.4.html>) for more weather related safety considerations. Also review Reference Manual 9 “Watercraft Safety” and Reference Manual 4 “Diving Management” (<http://inside.nps.gov/waso/custommenu.cfm?lv=3&prg=533&id=1137>) for additional information regarding inclement weather.

Sampling should be conducted during periods of mild wind, and small ocean swell. If thunder is heard or lightning seen while boating, sampling will be suspended and personnel should return to shore for at least 30 minutes. Do not stay on the water during a lightning storm. During intense rainfall events, visibility may drop and appropriate precautions should be taken to ensure that the boat does not ground. High wind and swells can cause gear, and equipment to be tossed or roll about the vessel potentially injuring personnel or creating walking hazards. Additionally, high wind and swell conditions can cause personnel to lose balance and fall. At any point during sampling, any personnel involved have the right and responsibility to abort a sampling trip if hazardous conditions develop.

Environmental Conditions

Individual parks have occupant emergency plans which cover safety procedures for medical emergencies, earthquakes, floods, fires, Tsunamis, and bomb threats. Be familiar with the procedures and emergency contact numbers of your duty station park as well as other parks you may visit during field sampling activities. Overall, be aware of your environment, use common sense, do not exceed your limits (for example, operation of equipment; lifting heavy objects and equipment; physical tolerance to exertion, heat, and cold), and trust your instincts (Lane and Fay 1997). The USGS National Field Manual Section 9.8 (<http://water.usgs.gov/owq/FieldManual/Chap9/A9.8.html>) covers environmental hazards in more detail.

The marine environment presents unique environmental hazards. Extended hours in the water breathing compressed gas can cause hypothermia and dehydration, which increase the likelihood of Decompression Sickness. Open boats expose crews to intense tropical sunlight, wind, and rain. Prolonged exposure to sun and sunlight reflected from the water can produce potentially serious health hazards including sunburns, skin cancer, and eye damage. Eye protection

(preferable polarized with UV A and UV B filters) and sunscreen should always be worn on exposed skin while conducting boating and diving operations. Special care needs to be taken to protect field personnel from injuries as well as dehydration and exposure in these environments. Table S3.2 provides a list of recommended items to be taken to the field.

Chemical and Material Safety Considerations

All chemicals should be handled and stored according to the recommendations found in the Material Safety and Data Sheet (MSDS) provided by the supplier. Chemicals likely to be encountered on the boat include, but are not limited to, gasoline and lubricating oil. All persons using or exposed to hazardous substances must be fully informed of the properties and potential hazards of the material in use as well as proper handling and disposal procedures. Park staff should always be consulted about local considerations when handling any chemicals of concern. Chemical users should also consult the park-specific Chemical Hygiene Plan. Other chemical handling procedures can be found in the USGS National Field Manual Section 9.6 (<http://water.usgs.gov/owq/FieldManual/Chap9/A9.6.html>).

Contaminated Water

Waterborne pathogens that may survive or be transmitted in seawater include *Enterococci* and *Staphylococci* bacteria. Never consume seawater. Areas being sampled may be contaminated with pathogens or harmful chemicals. Current known water quality issues in the PACN are outlined in Appendix I: Water Quality Report of the PACN Monitoring Plan. Consuming untreated or unfiltered freshwater may result in the contraction of bacterial diseases or parasites (i.e. *Leptospirosis*, *Giardia*.) In particular, keep hands away from nose, ears and mouth and wash hands thoroughly before eating. If no soap and water are available, use of an antibacterial hand cleanser is highly recommended after handling equipment. Consult NPS Reference Manual 83D1 Bathing Beaches (http://www.nps.gov/public_health/inter/info/rms/rm83d1.pdf) and the USGS National Field Manual Section 9.7 (<http://water.usgs.gov/owq/FieldManual/Chap9/A9.7.html>) for complete recommended safety procedures concerning contaminated water.

Animal Hazards and Disease Vectors

Any open cut has a high likelihood of becoming infected and all cuts should be carefully tended and monitored. While traveling to field stations in the PACN, some terrestrial hazards are applicable. Terrestrial areas of the PACN are relatively free of pests, although the brown tree snake is a concern on Guam. Mosquitoes, possible vectors, are likely to be encountered in the freshwater and brackish water environments. Personnel should also be aware of spiders and other insects that can bite or sting. Of particular medical concern are the black widow spider and the brown violin spider. Though bites are not common, if they occur, personnel should seek immediate medical attention (Kuwaye, 2002).

Hazardous marine life, including jellyfish, scorpion fish, cone snails, and large fish, can sting or bite, and some of these conditions can be life threatening (Thomas and Scott 1997). Corals can scrape and/or cut and care should be taken to avoid contact with the bottom. Appropriate first aid should be administered and professional medical attention sought if necessary. It is the responsibility of all personnel to be familiar with the local hazardous flora and fauna and to understand the appropriate treatment methods.

Field Trip Preparations and Emergency Contacts

Basic planning is required before each field sampling event. A large component of the planning effort involves gathering safety information and documenting all aspects of field sampling trip plans in advance. All field personnel should complete an Emergency Contact Form (Appendix 3.a) and a Medical Information Form (Appendix 3.b) prior to conducting field work. A trip plan must be completed. One copy should be left at the office, and additional copies should be given to the park safety officer and field personnel involved in the trip. Weather and marine forecasts should be obtained prior to departure. Upon completion of the field work it is imperative that personnel check in with the park safety officer at the specified time noted on the plan.

It is the responsibility of all personnel to ensure that the appropriate safety equipment is present and in working condition. Examples of safety equipment checklists are provided below (Appendix 3.c). These lists should be customized according to the specific field conditions and the needs of personnel. Additional safety equipment may be required at some parks, and the Park Safety Officer and PDO must be consulted prior to commencing sampling activities. No sampling activities will be conducted without all necessary safety equipment present and in proper working condition.

Emergency Procedures

In the event of an emergency, the first action is ALWAYS to take care of the injured person and seek help. If a dive injury is suspected, follow the dive injury plan outlined by the park DSO for the appropriate park. Once feasible and appropriate, with help on the way or when the situation is under control, the team leader or crew member should contact, or have someone else contact, the supervisor to inform them of the incident. The person that sustained the injury, or (if necessary) another team member who was witness to the accident must fill out report forms as soon as feasibly possible. The forms are available online on The United States Department of the Interior Safety Management Information System (SMIS) at (<https://www.smis.doi.gov/>). This website contains online accident reports and other documentation to be filled out by the injured crew member, witnesses, and supervisor. These documents must be completed as soon as possible, no later than 24 hours from the time of the accident.

Table S3.3. Emergency Contact Form (modified from USGS National Field Manual, Ch. A9).

Emergency Contact Form Employee Name: Personal contacts Name: Phone (home) (work): Name: Phone (home) (work): PACN contacts: WAPA: NPSA: KALA: KAHO: Local emergency contacts (or call 911): Hospital / Phone: Address: Walk-in clinic / Phone: Address: Police: Fire: Utility: Health Information Centers: Center Disease Control: Information Hotline: Fax: Disease Directory: Other:

Table S3.4. Medical information form for office personnel (modified from USGS National Field Manual, CH. A9).

Medical Information for Office Personnel Employee Name: Home Phone: Treatment preference: Medical: other: Doctor Name: Phone: Other Emergency Contact: Name: Phone: Relevant Medical History: Allergies & Medical Conditions: Allergies: Conditions: Medications: Current: To avoid: Special Instructions:
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Table S3.5. Example of standard safety checklist.

Standard Safety Checklist	
Item:	Check:
Climatic and UV protection	
Boots	_____
Fluids (e.g., water, electrolyte drink)	_____
Hat, wide-brimmed	_____
Insect repellent (unscented)	_____
Rain gear	_____
Sunglasses	_____
Sunscreen	_____
Antibacterial soap or hand lotion	_____
Temperature-modifying clothing	_____
Items for Vehicles	
Vests and jackets w/reflective protection	_____
First aid kit (see below)	_____
Flares	_____
Fire extinguisher	_____
Flashlight	_____
Tool kit	_____
Reflector triangles	_____
Chemical Protection and Storage	
Chemical spill kit	_____
Personal Protective Equipment (eye wear, gloves, apron, close-toed shoes)	_____
Eye wash kit (replace old/expired solution)	_____
Material Safety Data Sheets (MSDS)	_____
Chemical reagents (stored appropriately)	_____
Flammable solvents (stored appropriately)	_____
Pressurized gases (stored appropriately)	_____
First Aid and Protective Equipment	
Complete change of clothes (stored dry)	_____
Fire extinguisher (safely secured)	_____
First aid kit and manual (ensure full/updated)	_____
Orange reflective vest	_____
Communications	
Cellular phone/communication equipment	_____
Field folder (see below)	_____
Digital Radios	_____
Field Folder:	
Maps	_____
Medical facility numbers/location	_____

Standard Safety Checklist	
Item:	Check:
Emergency contact numbers	_____
Miscellaneous Equipment	
Bungie cords (to secure loose articles)	_____
District flood plan (most current)	_____
Flagging	_____
Flares	_____
Flashlight (include batteries)	_____
Safety cones	_____
Tool kit	_____
USGS TWRI Book 9 Chapter A9	_____
Climatic and UV protection	
Boots	_____
Fluids (e.g., water, electrolyte drink)	_____
Hat, wide-brimmed	_____
Insect repellent (unscented)	_____
Rain gear	_____
Sunglasses	_____
Sunscreen	_____
Antibacterial soap or hand lotion	_____
Temperature-modifying clothing	_____
Items for Vehicles & Boats	
Vests and jackets w/reflective protection	_____
First aid kit (see below)	_____
Flares	_____
Chemical Protection and Storage	
Chemical spill kit	_____
Eye wash kit (replace old/expired solution)	_____
Material Safety Data Sheets (MSDS)	_____
Chemical reagents (stored appropriately)	_____
Flammable solvents (stored appropriately)	_____
Pressurized gases (stored appropriately)	_____
First Aid and Protective Equipment	
Complete change of clothes (stored dry)	_____
Fire extinguisher (safely secured)	_____
First aid kit and manual (ensure full/updated)	_____
Orange reflective vest	_____
Communications	
Cellular phone/communication equipment	_____
Field folder (see below)	_____

Standard Safety Checklist	
Item:	Check:
Field Folder:	
Maps	_____
Medical facility numbers/location	_____
Emergency contact numbers	_____
Miscellaneous Equipment	
Bungie cords (to secure loose articles)	_____
District flood plan (most current)	_____
Flagging	_____
Flares	_____
Flashlight (include batteries)	_____
Safety cones	_____
Tool kit	_____
USGS TWRI Book 9 Chapter A9	_____

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- U.S. Geological Survey, variously dated, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1-A9. Online. (<http://water.usgs.gov/owq/FieldManual/>) Accessed 14 June 2010.

Appendix K. SOP #4: Using GARMIN® Global Positioning System (GPS) Units

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This Standard Operating Procedure explains how to use an autonomous, non-differential Garmin® (or similar unit) GPS receiver and GPS transfer software. This protocol may be used for any Garmin® GPS that can average a waypoint and store tracklogs. The GPS transfer process uses DNRGarmin® Version 5.1.1. and GIS software.

A master equipment list for the entire Marine Fish Vital Sign Monitoring Protocol can be found in Appendix S1.a of SOP #1 “Before the Field Season.” The master equipment list should be updated simultaneously if any SOP requiring an equipment list is revised.

Garmin GPS Pre-Field Preparation

Step by step procedures:

- 1) Read and remain familiar with GPS user manual, hardware, and software.
- 2) Load freshly charged batteries and have extra, charged sets available. Extra rechargeable batteries should be placed in a water tight “dry bag” or a re-sealable plastic bag and stored in an enclosed space or sealed container on the boat.
- 3) Initialize and download a fresh almanac into a Garmin® if more than one week has passed since last use or if the GPS unit has moved more than a straight-line distance of 240 km. Downloading the almanac takes roughly 20 minutes in open areas - away from buildings, canopy, and obstructions.

- 4) Delete old waypoints and tracks from memory (but download beforehand and save data elsewhere if appropriate).
- 5) Turn off active tracklog. Set “Tracklog” to the preferred collection method (“Time” is recommended) and an appropriate logging rate for the data collection (“5 seconds” is recommended for most walking collection, but keep in mind the total storage capacity of the GPS).
- 6) Ensure Simulator Mode is *not* ON when collecting data.
- 7) If necessary, transfer data (e.g., background maps) to the GPS unit using DNR Garmin[®] software. See below for DNR Garmin[®] instructions.
- 8) Set Time and Date on the GPS Unit (note that no PACN parks use daylight savings time, rather the entire PACN is always in ‘standard’ time).
- 9) Make sure that “Interface Protocol” is set to Garmin.
- 10) Make sure that WAAS is enabled.
- 11) Set the Coordinate System (UTM or LAT/LONG) and Datum to ensure compatibility with any written coordinates you may need to navigate to or map. Recommended settings for UTM are in Table S4.1.

Table 4.1. Coordinate system and datum for PACN.

Island	Datum	Projection
Hawaii	NAD83	UTM zone_5N
Maui	NAD83	UTM zone_4N
Molokai	NAD83	UTM zone_4N
Oahu	NAD83	UTM zone_4N
Guam	WGS84	UTM zone_55N
Saipan	WGS84	UTM zone_55N
American Samoa (all islands)	WGS84	UTM zone_2S

- 12) Set Heading to Magnetic or True. If set to True, ensure compass has same declination.
- 13) If needed, use Trimble Planning[®] Software to ensure best time of day for GPS data collection.
- 14) Prior to use in the field, ensure the GPS has been placed in a “dry bag” with a recently dried desiccant pack.

GPS Transfer Software (DNR Garmin®)

Step by step procedures:

- 1) Uninstall any previous versions of DNRGarmin®
- 2) As of Spring 2006, download and install Version 5.1.1 to any computer that will receive GPS data from the Garmin®. DNRGarmin® can be downloaded from the State of Minnesota Department of Natural Resources <http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html> (accessed 05 July 2006).
- 3) In DNRGarmin®, set projection to ensure compatibility with data stored in GIS (Table S4.2).

Table S4.2. Projection settings for islands in PACN

Island	ESRI (or EPSG) POSC code	Datum	Projection
Hawaii	26905	NAD83	UTM zone_5N
Maui	26904	NAD83	UTM zone_4N
Molokai	26904	NAD83	UTM zone_4N
Oahu	26904	NAD83	UTM zone_4N
Guam	32602	WGS84	UTM zone_55N
Saipan	32602	WGS84	UTM zone_55N
American Samoa (all islands)	32775	WGS84	UTM zone_2S

- 4) In ESRI ArcMap®, ensure that the Data Frames are set to the appropriate projection. Datum and projections are in the third and fourth columns, respectively, of Table S4.2.

Field GPS Data Collection

Data collection is not anticipated to be a frequent task. Initially, actual data collection locations will need to be documented, relative to sample design specifications. Other data collection needs are not anticipated.

Step by step procedures:

- 1) Hold GPS unit or antenna at or above your head. Use an external antenna if needed to free hands.
- 2) Electronically store all data (waypoints and tracks). Manually write down a position coordinates for backup.
- 3) Note that a Garmin® will collect data no matter what the GPS positioning quality is, so you will need to monitor the GPS Satellite Page continuously for anomalies and accuracy. Collect only when “3D GPS” or “3D Differential” is shown. Do not collect data in 2D unless absolutely necessary. 2D Differential should not be used either.

- 4) Collect waypoints in “Averaged Position” mode. To ensure greatest accuracy possibly, either (1) collect a minimum of 10 points per location, or (2) collect points for a minimum of 20 minutes at that site. Depth from the boat sounder can also be recorded if conducting benthic habitat surveys for mapping purposes. Otherwise, use dive computers to record depth when diving at a waypoint.
- 5) TrackLogs
 - a. Use “Stop when Full” or “Fill” Record Mode to prevent overwriting TrackLog points when Active TrackLog becomes full.
 - b. Begin collecting Active TrackLog when you know where you need to go and immediately begin moving when TrackLog begins collecting.
 - c. Stop Active TrackLog when stopped.
 - d. Always stop Active TrackLog when nearing the beginning point of a polygon area you want closed. A line between your last track point and the initial point will automatically be generated in order to close the polygon.
 - e. Always turn Active TrackLog to OFF when finished collecting.
 - f. NEVER ‘store’ or ‘save’ an active Tracklog unless you need to save space, rather choose to ‘stop’ an active TrackLog. Garmin III+ receivers remove the ActiveTrack, while newer Garmin models merely make a copy of the Active Track. In any case, saved tracklogs degrade original data, whereas a ‘stopped’ TrackLog retains data quality.

Office Downloads and Management

Step by step procedures:

- 1) Connect GPS to PC with cable and place GPS in Simulator Mode
- 2) Check that TrackLog is OFF! Again, do not save Track!
- 3) Open DNRGarmin[®] from the desktop (for ArcGIS[®] users) or from within ArcView[®] by loading the extension.
- 4) Check Projection in DNRGarmin[®] one more time. This will define the projection the GPS file will be stored in.
- 5) Download waypoints and Tracks and save to Shapefile (if in ArcGIS[®]) or if saving a shapefile from the desktop DNR Garmin[®], save to projected shapefile. Use naming conventions as below.
 - a. See SOP 12a “Data Management” to identify the folder location and hierarchy where this file is to be saved.
 - b. The file-naming convention is to indicate the GPSModel, type of data (waypoint or Tracks), projection and datum, and date (YYYYMMDD) separated by an underscore (_). For example, a set of waypoints collected with a Garmin GPS76c, using UTM and WGS84 as the projection and

datum, on Christmas Day 2005, would be named
“GPS76c_waypt_UTMWGS84_20051225”.

- c. If additional notes about GPS collection exist, such as data collected in ‘2D’ mode; create a simple text file with an identical filename in the same location which contains this information, with a .txt filename extension.
- 6) Delete all waypoints and tracks for the next mapping mission.
- 7) Turn off the GPS and disconnect cables, returning equipment to its proper storage location.
- 8) Recharge batteries if appropriate

Options to Consider

Improve Accuracy: An external beacon, such as the Thales MobileMapper Beacon[®], for Differential GPS will improve the accuracy of your GPS location. Averaging will improve your GPS locations, if and only if, the satellite geometry improves during point collection. Otherwise, averaging can sometimes result in a less accurate position.

Appendix K: SOP #5: Pre-Dive Equipment Preparation

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This SOP provides directions for daily equipment preparation including: Marine Fish survey equipment; diving equipment; and boating equipment. See SOP # 1 “Before the Field Season” for further instruction on the preparation of the equipment and supplies needed prior to the start of each field season.

A master equipment list for the entire Marine Fish Monitoring Protocol can be found in Appendix S1.a of SOP #1 “Before the Field Season.” The master equipment list should be updated simultaneously if SOP #1 is revised. A list of equipment required to complete the tasks specified in this SOP has been provided in Appendix S5.a.

Marine Fish Survey Equipment Preparation

This section details the equipment which should be gathered and checked out prior to conducting fish surveys.

Step by step procedures:

- 1) Gather all SCUBA gear as described in the section below on “Dive equipment preparation.” Verify that there are enough full air cylinders available for the planned number of divers and dives.
- 2) Verify that the boat has adequate fuel and all boating safety equipment and supplies are available as described in the section below “Boat preparation.”
- 3) Pack a transect line.

- 4) List the compass headings, depth, and coordinates and carry a waterproof map of the transect locations.
- 5) Ensure that a GPS unit with waterproof housing is available and in working order. Pack extra batteries as necessary.
- 6) Prepare the underwater slate, pencils, and the required number of field data forms to complete the planned transects.

Dive Equipment Preparation

SCUBA diving equipment must be maintained according to Reference Manual #4 – Diving Management (RM-4), as well as according to manufacturer and park specific guidelines appearing in each park’s Dive Safety Manual. Care and maintenance of dive equipment is also detailed in SOP #11 “After the Field Season.” It is imperative that all dive gear is inspected before each use. See Appendix S5.a for a complete equipment list for conducting diving activities.

Step by step procedures:

- 1) Ensure SCUBA cylinders are full and there are enough for the planned number of dives and divers. Typically, one tank is sufficient for one diver to complete two transects. If necessary, fill tanks as per park specifications.
- 2) Check to ensure all appropriate personal and dive safety equipment is present and in proper working condition before departing for the field. See Reference Manual #4 – Diving Management (RM-4), SOP #2: “Training Observers” and SOP #3: “Safety Protocol.”

Boat Preparation

Boat, trailer, and motor servicing should be independently done and verified for each park where field operations will occur well in advance of field operations. Ensure that this required preparation has been done in accordance with the DOI Motorboat Operator Certification Course Manual and park specific guidelines. Park-specific guidelines can be obtained from the PDO or the certified motorboat operator(s) at each park. Care and maintenance of the boat, motor, and trailer is also detailed in SOP #11 “After the Field Season.”

Step by step procedures:

- 1) Ensure that there are adequate fuel and oil supplies for the planned activities.
- 2) Verify that all required safety equipment is aboard and in proper working condition. A list of this equipment is available in SOP #11 “After the Field Season” and in the DOI Motorboat Operator Certification Course Manual.
- 3) Submit a daily dive plan for each day of diving. This form is found in each park’s Dive Safety Manual and includes information on dive locations, number of dives, personnel on board, and emergency contact information.

Tables S5.1a and b are the gear list for equipment needed in SOP #5: Pre-Dive Equipment Preparation. Note that a master gear list is located in SOP #1: Before the Field Season.

Table S5.1a. Equipment list for conducting Marine Fish surveys.

Equipment (#/quantity)	Preparation & Maintenance
30 m transect line	See SOP #1 "Before the Field Season"
Coordinates, depths, compass headings, and maps of transect locations	Ensure that this equipment is available; See SOP #6 "Selecting and Marking Subtidal Sampling Transect Locations"
GPS	Ensure in working order; See SOP #4 "Using GARMIN® Global Positioning System (GPS) Units"
Clear waterproof container for GPS	Ensure that this equipment is available
U/W compass	Ensure that this equipment is available
Surface float marker	Ensure that this equipment is available
U/W slate with pencils	Ensure that this equipment is available
U/W field data forms	See SOP #7 "Conducting Fish Surveys"
Boat, motor, and trailer	See section on "Boat Preparation" in SOP #5 "Pre-Dive Equipment Preparation" and SOP #11 "After the Field Season"
SCUBA gear	See section on "Dive Equipment Preparation" in SOP #5 "Pre-Dive Equipment Preparation" and SOP #11 "After the Field Season", and table below: "Equipment list for conducting diving activities"

Table S5.1b. Equipment list for conducting diving activities.

Equipment (#/quantity)	Preparation & Maintenance
Air cylinders	Verify hydro, VIP and airfill. See SOP # 16 "After the Field Season"
Fins	Ensure that this equipment is available
Booties	Ensure that this equipment is available
Wetsuit (2)	Ensure that this equipment is available
Weights	Ensure that this equipment is available
Belt/integrated weight pouches	Ensure that this equipment is available
BC	Verify annual service. See SOP #16 "After the Field Season"
Regulator	Verify annual service. See SOP #16 "After the Field Season"
Mask & Snorkel	Ensure that this equipment is available
Dive computer	Ensure that this equipment is available
Thermometer	Ensure that this equipment is available
Compass	Ensure that this equipment is available
Dive bag for boat work	Ensure that this equipment is available

Appendix K. SOP #6: Selecting and Marking Subtidal Transect Locations

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This SOP describes how to select and mark subtidal transect locations. Marine Fish monitoring transect locations consist of a transect 25 m in length that is co-located with the Benthic Marine Community Protocol. Transect width and monitoring procedures are covered in SOP #7.

A master equipment list for the entire Marine Fish Vital Sign Monitoring Protocol can be found in Appendix S1.a of SOP #1 “Before the Field Season.” The master equipment list should be updated simultaneously if this SOP is revised. A list of equipment required to complete the tasks specified in this SOP has been provided in Appendix S6.a in this SOP.

Selecting Transect Locations

Locations for transects will be randomly selected within ArcMap[®] 9.2 using the criteria outlined below. Randomly selected alternative transect locations will also be generated in case the initial location is unsuitable with respect to benthic habitat type, area, or possesses conditions that make it unsafe to work. The following steps will be done prior to conducting any field work.

Generating Random Points for Fixed Transect Start Pins within ArcMap®

Step by step procedures:

- 1) Open ArcMap® on your computer.
- 2) Open park specific project file and associated layers which should include a map of the park, the park unit(s) boundaries, benthic habitats, and isobaths.
- 3) Criteria for generating points are as follows:
 - a. Within park boundaries plus adjacent coastal areas that may impact (or be impacted by) the park. Adjacent coastal areas extend to the edges of the watershed(s) in which the park lies.
 - b. Within 10 to 20 m depth contours
 - c. On hard substrate (basalt or limestone, or coral reef) that has been predetermined from the benthic habitat map.
- 4) Generate 30 points with X and Y coordinates that fall within depth contours and on hard substrate, using the following procedures.
 - a. Select the benthic contours shape file.
 - b. Create a polygon or raster file within the 10 m to 20 m depth contour. This can be done by right clicking on the contour shape file and selecting “Open Attribute Table”. Note this file must be the original point file (e.g., Lidar data file) and not a line file that has been interpolated from a point file.
 - c. Then select the “Options” button in the lower right hand corner of the window and choose “Select by Attributes” from the pull down menu. In the “Select by Attributes” dialog box enter in the query to select the appropriate depth contours (See example query phrase in Figure S6.1).

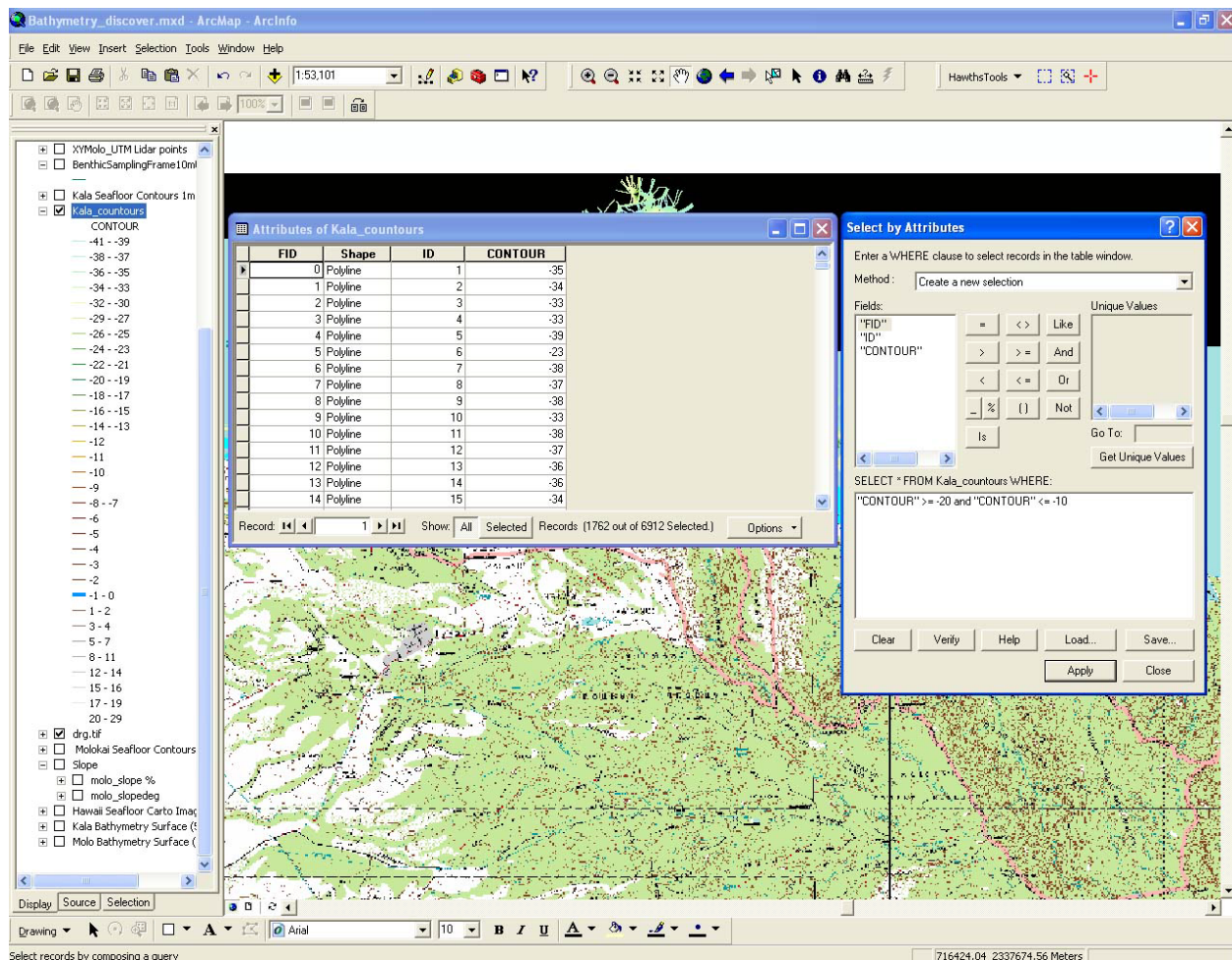


Figure S6.1. Sample screen display for selecting depth contours within a shape file in ArcMap® 9.2.

- d. Select this new layer and load the Hawth's tools from the View-Toolbar menu. Hawth's tools is a free extension that can be downloaded from <http://www.spatialecology.com/htools/download.php> (accessed 05 July 2006).
- e. Under the Hawth's Tools down arrow button, select the "Sampling Tools-Generate Random Points" option.
- f. Within the dialog box, select the polygon or raster file, check the "Prevent points from being located in the NODATA cells" box, enter 30 points within the "Generate this number of random points" box, and specify the output filename (Figure S6.2). It should be noted, that some parks (e.g. WAPA, KAHŌ) have sites with existing data sets and these sites will be included in the sampling frame to extend the historical perspective. The sites must meet the basic criteria (i.e. hard bottom, 10 – 20 m depth) to be incorporated into the sampling frame. Therefore, simply subtract the number of historical sites from the total number of new points generated. For example, if three historical sites will be used in the sampling frame then simply generate 27 new points for consideration.

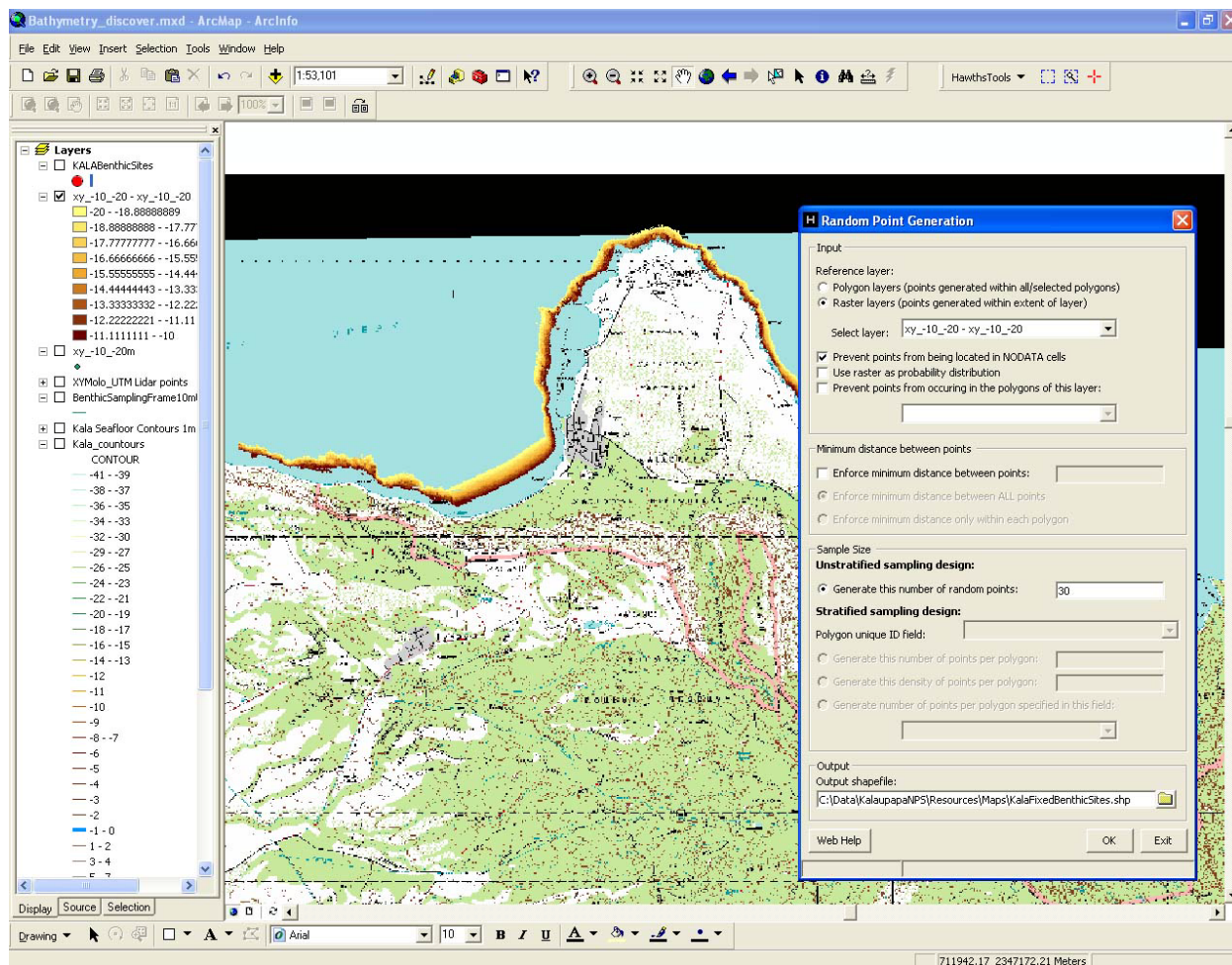


Figure S6.2. Sample screen display for generating 30 random points within a shape file using the Hawth's Tools extension in ArcMap® 9.0 .

- g. Once the points have been displayed then use the Hawth's tools "Table Tools – Add XY to Table (points)" to create X and Y values for each of the random points within the newly created output shape file. Select the Point layer to identify the shape file and label the X and Y Fields within the Add new fields radio button.
- 5) Randomly select 15 of the 30 points that will be fixed and sampled annually beginning in year 1. The other 15 points will be used as alternative locations should any of the first 15 points be deemed unsuitable (e.g., sand instead of hard substrate) during the field installation. Random selection can be done using the Excel "RANDBETWEEN" function or simply picking points out of a hat. For example, in Excel assign the 30 points to 30 cells and label them sequentially from 1 to 30 in another column. Then in a third column highlight 30 cells and enter the formula =Randbetween(1,30). Select the point whose number is generated in the first 15 cells.
- 6) Establish a Microsoft Excel® file to record all XY coordinate pairs for transect start points that are used correlatively over time, starting with year one. When new random

points are generated, compare these against existing point coordinates to assure that no point coordinates are re-used.

Generating Random Points for Temporary Transect Start Pins within ARC Map

Step by step procedures:

- 1) Annually generate 15 points (plus fifteen additional points for alternative transect locations, if needed) that will be sampled during that year using the same procedure as above (“Generating random points for fixed transect start pins within ArcMap®”).
- 2) Each year a new set of random points will be generated and sampled.
- 3) If the generated random points have been used previously for either fixed or temporary transects (see Step 6 above) then automatically use the alternative transect locations. In subsequent years you may have to generate more than 30 points to ensure that the random point coordinates have not been used for previous transect start points.

Printing Coordinates

Step by Step Procedures:

- 1) Print 15 random points for fixed transect locations:
 - a. Print out X and Y coordinates for the 15 primary fixed transect start points as successively numbered points in a list. To maximize efficiency in the field, the list should be ordered according to proximity of the transect locations to each other. Clearly label the list so that the primary points are not confused with the alternative points printed out in Step 2.
 - b. Print the GIS map(s) showing the transect start points relative to each other.
 - c. Laminate (two-sided: map on one side, list on the other) for field use.
 - d. Coordinates should be in both Universal Transverse Mercator Geographic Coordinate System (UTM) and Latitude and Longitude (hddd’mm.mmm’) formats.
- 2) Print 15 random points for alternative fixed transect locations.
 - a. Print out X and Y coordinates for the 15 alternative sites as successively numbered points in a list. Clearly label the list so that the alternative points are not confused with the primary points printed out in Step 1.
 - b. Print the GIS map(s) showing the transect start points relative to each other. Include all 30 points for fixed transects. This will allow field personnel to better plan their dives if an alternative site needs to be used.
 - c. Laminate (two-sided: map on one side, list on the other) for field use.
 - d. Coordinates should be in both UTM and Latitude and Longitude (hddd’mm.mmm’) formats.
- 3) Repeat steps 1 and 2 using points for temporary transect locations.

- 4) Enter X and Y coordinates, with transect start location number into GPS (See SOP #4).
 - a. Fixed sites should have the letter F as a prefix to the transect location number.
 - b. Temporary sites should have the letter T as a prefix to the transect location number. Use consecutive T#s prefixes (T06001, T07001, T08001...) across years (2006, 2007, 2008...) to facilitate identification of temporary points.
 - c. Waypoints for each benthic transect within a park are stored in the park's annual copy of the marine database and the main database which resides on the I&M share drive (i.e., "I" drive) of the PACN data server. Once a year the main database is updated with the waypoints from each park by the Marine Biological Technician.

Establishing Fixed Study Sites

These procedures detail establishing permanent transects that are 25 m in length.

Before Entering the Field

Step by Step Procedures:

- 1) Collect the equipment necessary to complete all tasks that will be conducted (Appendix S6.a). Cut pins and other mounting rods to required lengths. As noted in SOP #1 "Before the Field Season.", transect pins should be approximately 0.40 m long and CSA mounting rods should be at least 0.50 m long.
- 2) Ensure all random points have been generated, printed, and downloaded into the GPS.
- 3) Copy relevant forms to plastic coated paper for in-water use. Forms for CSA installation and tagging corals are needed in-water.

Navigating to Selected Sites

Step by Step Procedures:

- 1) Using a GPS unit in which the random transect location points are already stored, navigate by boat, or surface swim, to the location using the GPS's navigation feature. If surface swimming, put the GPS in a transparent waterproof container attached to a surface float such as an inner tube with dive flag and a line with a bottom weight to be set at the transect start point (see SOP #4 "Using Garmin Global Positioning System (GPS) Units" for information on using GPS).
- 2) When approaching the random point, assess the area for safety. If the point is not a location that is safe to dive or anchor the boat, discard the point and adopt one of the alternative points. Move on to the next location. Repeat steps 1 and 2 until a random point is found that is determined to be safe for field work.

- 3) When within approximately 3 m of the site, carefully but quickly lower a surface float marker or Pelican[®] surface float with a bottom weight (~ 1 kg) so that it comes to rest as close as possible to transect start/terminus pin location.
- 4) Allow the boat to drift a short distance off the site before lowering and setting the anchor, or tying boat's bow line to a mooring buoy (if available near the site).
- 5) Always attempt to lower the anchor into a nearby sand or non-colonized rock or boulder patch. If no sand or rock patch is available, attempt to lower anchor so that it does not impact live coral or other live benthic organisms. If a permanent mooring buoy-line is available nearby, use it to securely tie off boat's bow line. Then, locate the deployed surface float by taking a compass bearing to it.
- 6) Using mask, fins, and snorkel, determine the bottom substrate composition. If the bottom is unconsolidated material (e.g., sand) or too small of an area of contiguous hard bottom, discard the location and adopt an alternative random point to replace it. Collect the float and move on to the next point. Repeat until a site with appropriate safety and bottom characteristics is located.

Installing Permanent Transect Marking Pins

The following protocol steps assume that divers have successfully navigated to and selected the fixed transect site and that it meets all suitability criteria for transect placement. Care must be taken when initially installing transect locating pins. One permanent transect will be installed at each monitoring transect location. Threaded stainless steel rod stock will be used as transect marking pins in non-living hard substrate. Other studies have developed methods to install transects without the use of permanent pins (e.g., large cable ties, marker floats). These methods are not feasible for the PACN parks because of environmental conditions and the necessity that transects be easily revisited and highly reproducible. In particular, large wave disturbances such as typhoons require that markers have a low cross-sectional area to reduce drag, do not physically degrade (e.g., cable ties), and are anchored deep enough in the substrate to survive substantial habitat disturbance. Refer to the equipment list needed to install permanent transect marking pins in Appendix S6.a.

Step by Step Procedures:

- 1) Upon descent, examine both possible transect direction along the isobath to ensure that at least one section contains a 25 m length of contiguous habitat. If neither direction meets this criterion then resurface and select one of the alternative points.
- 2) When a point is determined to be suitable, starting at the weight on the bottom of the float marker, install a threaded stainless steel pin into solid substrate by hammering the pin into a crack or crevice with a two or five pound sledgehammer. Alternatively, an appropriate diameter hole is drilled into solid hard bottom (basalt, limestone or dead coral) using a rock or masonry drill bit in an underwater drill. Permanently epoxy the pin into a vertical position using a suitable fast-setting two-part marine epoxy, such as Powerfast[®] or Z-Spar[®]. Powerfast[®] is packaged in dual "caulking" or syringe-like tubes, to mix epoxy parts and minimize epoxy handling. Z-Spar comes in separate metal containers which need to be transferred to plastic containers for

underwater use. Latex gloves should always be worn when handling epoxy. Place an appropriate amount of epoxy in the hole (about one hand-full), then press rod into hole, tapping it gently with a hammer to set pin. If needed, apply epoxy around the base of the installed pin. The start and end pins of the transect should extend at least 10 cm above the bottom.

- 3) Install one cable tie around the rod to denote the start pin. Leave the trailing end of the cable tie intact to facilitate relocation.
- 4) Randomly select a possible transect direction along the isobath unless only one direction contains contiguous habitat. One can do something like spinning a knife handle to determine the direction. Take a compass bearing corresponding to the depth of the pin along the isobath (using a wrist or diving console mounted underwater compass with side sighting capability), and record the bearing on an underwater slate. If the bottom is of uniform depth, the compass bearing should be run parallel to shore. Care must be taken to keep compass away from stainless steel pins or any other ferrous metals, including any dive gear and tools.
- 5) Use a fiberglass transect tape marked in meters to measure the initial transect length. The transect tape should have a loop and small brass clip at the 0 m end and a loop and small brass clip on the handle. Loop and secure the 0 m end of the tape to the start pin. Two divers then swim the compass bearing along the isobath slightly above the bottom, one maintaining the bearing and the second holding the tape allowing it to feed out freely. The latter diver should look back at the tape often to ensure that it remains straight and taut. The divers should swim along the depth contour following the selected, or predetermined, random compass heading.
- 6) Once the appropriate 25 m distance has been swum, the diver handling the tape should stop and slightly stretch the tape again so that it is tight along the bottom.
- 7) Temporarily secure it on the bottom (e.g., to a temporary stake, rock or dead coral head).
- 8) The diver that swam the compass bearing should turn 180 degrees and swim back along the transect to check transect orientation, placement along the isobath, and tautness. If necessary, orientation or placement should be corrected to match the compass heading and isobath.
- 9) The two divers should then install the end pin at the 25 m mark, as was done at the start (0 m) pin.
- 10) Install two cable ties around the rod to denote the end pin. Leave the trailing end of the cable ties intact to facilitate relocation.
- 11) If relocating the end pin will be difficult (e.g., site typically has poor visibility) then divers can also install shorter threaded rods every 5 m between end pins, ensuring the tape remains taut as they work. The pins should be installed as above, except that no

more than 10 cm of the threaded rods should extend above the substrate. Install the additional pins between the end pins only if necessary, because this procedure may detract from the underwater aesthetic beauty of each park.

- 12) The transect tape is reeled up after all pins are installed. Once epoxy is set and monitoring commences, the 0 m tape end is looped or clipped to the start pin, the tape looped once around either the intermediate pins or natural anchor points, and then looped or clipped to the end pin. Clipping or looping the meter tape will ensure that the transect tape is taut and will not move around during high surge conditions. The tape must be taut, or future measurements along the transects will have poor precision and reproducibility.
- 13) If surge is a problem then an alternative approach is to use a 35 to 40 m ¼" diameter leaded line that is deployed between the end pins. This line is marked at every meter and laid along the bottom during photoquadrat sampling.
- 14) Note: the temporary transects will not have permanent pins to mark the start and end points. Follow and repeat Step 1 for each transect. Instead of attaching transect tape to pins, temporarily attach tape ends to non-living natural anchors or temporary pins on the bottom. Continue with Steps 4 to 8.

Table S6.1. Equipment necessary to install fixed transect locations with permanent marking pins.

Equipment (#/quantity)	Preparation and Maintenance
1 cm (3/8") X 40 cm (16") threaded stainless steel rod (2+)	More pins may be necessary if conditions warrant
Z-spar [®] or Powerfast [®] epoxy (1 ea.)	Ensure that 1 gallon of A&B (Z-Spar [®]) or several tube (Powerfast [®]) available
Mesh bag (1)	Ensure that this equipment is available
Tupperware [®] containers for Z-spar (2)	One for each Z-spar [®] compound; Ensure that this equipment is available
2 or 5 lb. sledge hammer (2)	One for back up; Ensure this equipment is available
30 m transect line (2)	Labeled at 50 cm intervals; see SOP #1 "Before the Field Season"
Coordinates, depths, compass headings, or maps of transect locations	See SOP #6 "Selecting and Marking Subtidal Sampling Transect Locations"
GPS (1)	See SOP #4 "Using GARMIN [®] Global Positioning System (GPS) Units"
Transparent waterproof container for GPS (1)	Ensure that this equipment is available
U/W compass (1)	Ensure that this equipment is available
Surface float marker (2)	One for back-up; Ensure that this equipment is available
U/W slate with pencils (2)	Ensure that this equipment is available
U/W lights (2)	Ensure that this equipment is available
U/W light batteries (2 sets)	Ensure that this equipment is available
SCUBA gear	See SOP #5 "Pre-Dive Equipment Preparation"
Boat, motor, trailer, and associated gear	See SOP #5 "Pre-Dive Equipment Preparation"

Appendix K. SOP # 7: Conducting Marine Fish Surveys

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This SOP explains how to conduct Marine Fish surveys to quantify species richness, fish abundance, and estimate total length to derive biomass. The SOP assumes that a monitoring site has been previously established as outlined in SOP#6 “Selecting and Marking Subtidal Sampling Transect Locations” and will detail relocating the monitoring site, laying out the transect line, and performing the fish survey. This SOP is designed to be completed by a single diver with the co-located Benthic Marine Community protocol diver serving as a buddy. Any dive equipment mentioned in this SOP is intended to be used as a guideline only and use of this equipment, while shown to be effective, is not intended as an endorsement of any particular manufacturer or model.

General Procedure

The amount of time needed to complete a survey is approximately 15 – 20 minutes along a 25 m transect in ideal conditions making one to two passes along the transect. The number of passes is dependent on the survey region and the richness of the fish assemblage. With more depauperate fauna such as Hawaii only one pass is required. At NPSA and WAPA two passes are necessary to survey the greater number of fish species. All safety precautions will be followed as outlined in SOP#3 “Safety Protocol.”

Equipment

For a complete list of equipment needed to carry out this procedure, refer to Table S1.4a – S1.4g in SOP#1: “Before the field season.” Observers will want to ensure that all equipment is ready prior to the scheduled survey dive day. For more detailed information on protocol prior to dive day, please see SOP#5: “Pre-dive gear preparations.”

An example of a datasheet used for this protocol can be found in Appendix A.

Relocating the monitoring site

Step by step procedures:

- 1) Navigate by boat, or surface swim to a transect start point using a GPS unit which has the transect start point stored as a Waypoint. If surface swimming, put the GPS in a transparent waterproof container attached to a surface float (e.g. inner tube with dive flag) that has a line and a bottom weight to attach at the transect start point (see SOP#4: “Using Garmin® GPS units” for information on using a GPS).
- 2) Approximately 3 m from the site, carefully but quickly lower a surface float marker or Pelican® surface float from the boat with a bottom weight (~ 1 kg) so that it comes to rest as close as possible to the transect start pin.
- 3) Allow the boat to drift a short distance off the site before lowering and setting the anchor, or tying the boat’s bow line to a mooring buoy (if available near the site). In some situations such as remote locations, it may be better to live boat the survey with one crew member remaining on board throughout the dive.
- 4) Always attempt to lower the anchor into a sand or un-colonized rock patch. If no sand or rock patch is available, attempt to lower the anchor so that it does not impact live coral or other live benthic organisms. Then, locate the deployed surface float by taking a compass bearing to it.
- 5) Check to ensure that all dive gear is in working order and that the primary and secondary regulators as well as power inflation devices are working correctly. This procedure also ensures that the divers’ air is turned on.
- 6) Check to make sure that a transect tape and datasheets are in hand before entering the water or that other personnel are available to hand these items safely to the diver.
- 7) Put on dive gear and enter the water.
- 8) Retake a compass bearing to the surface float if needed. Swim to the float and descend down the line.
- 9) Once on the bottom, have the benthic diver reposition the boat anchor so that the chain and line are secure and does not damage coral or other live organisms.

Locate transect pin and conduct fish survey at permanent sites

Step by step procedures:

- 1) Both divers begin a systematic search for the transect start pin and if necessary move the bottom float marker to the vicinity of the transect start pin.
- 2) Secure the brass clip end of the transect line/tape around the start pin.

- 3) Once the transect line is secured, take the known compass bearing to the end point of the transect, pulling the transect line out as you swim ensuring to keep the line as taut as possible.
- 4) For NPSA and WAPA the fish diver progresses down the transect at a constant speed and enumerates, to the lowest possible taxon, all fish **greater than** 20 cm total length. Total length (TL) of each fish is also estimated to the nearest centimeter.
- 5) On this first pass of the fish survey, **the corridor** for fish considered “on the transect” is 4 m wide and 4 m high but is visualized out to the end of the transect. Any fish outside this corridor is not included in the survey, though large or interesting fish should be noted.
- 6) Nomenclature should follow Randall (2005) for NPSA, Meyer (1999) for WAPA, and Randall (2007) for KAHO and KALA.
- 7) Once at the end of the transect loop the line around the end pin twice so that it does not slip and loosen. The transect should now be installed such that the line is straight, suspended just above the bottom and taut over its entire length. This should reflect a runtime of approximately 5 – 8 minutes.
- 8) Turn and start the second pass of the survey by returning along the now laid transect line. On this section only fish **less than** 20 cm are counted and sized. The corridor is also reduced to 2 m wide and 4 m high. Again, note any large or noteworthy fish, but do not include them in the data. This section should take approximately 10—12 minutes, giving you a runtime to complete the survey of 15 – 20 minutes.
- 9) For more detail on the sampling design rationale, see Chapter 2 and Brainard et al. (2007).
- 10) For the more depauperate fauna at KAHO and KALA, the transect dimensions are 25 m length X 5 m width. Only one pass is required and all fish are enumerated and sized within the corridor.

Locate transect pin and conduct fish survey at random sites

Step by step procedures:

- 1) Upon arriving at the random site, randomly determine the compass bearing of the transect that is parallel to the shoreline. This can be done on the boat or at the surface prior to beginning the dive. Typically there are only 2 possible bearings along a depth contour but this can be adjusted slightly when the divers descend down the float line and scan for homogeneous habitat along with the direction of the substrate contour.
- 2) Navigate to the random site and drop a surface float marker or have the divers disembark from the boat directly above the site.
- 3) Descend and once on the bottom, locate the bottom marker.

- 4) Since no pins will be found at this transect location, tie one end of the transect line securely around a dead coral colony or piece of rubble. The tie-off location will be the first available piece of dead coral or rubble along the selected compass bearing of the transect.
- 5) Once the line is secured, swim the known compass bearing enumerating and sizing fish as before (see above) until 25 m of transect lines has been released. Pull the line taut and extend out several additional meters. Holding the tape taut, find a dead coral colony or piece of rubble suitable to tie off the line. Loop the line around the rubble twice so that it does not slip, causing it to loosen. Tie off securely. The transect should now be installed such that the line is straight, suspended just above the bottom and taut over its entire length.
- 6) Return along the transect documenting fish species and sizes as noted above in the permanent sites section.
- 7) In the case of KAHO and KALA, one pass is sufficient so once the fish diver has completed their survey then the benthic diver can commence their work.

General considerations for fish surveys:

- 1) All fish should be counted only if they are completely within the boundaries of the transect.
- 2) Fish should be sized individually but with large schools the number of individuals in a range of sizes will suffice.
- 3) On the initial pass there is no maximum fish size, although very large fish (i.e. greater than 2 m) should be highlighted as they may confound the overall data.
- 4) On the return pass there is no minimum fish size because it is important to document new recruits. However, 3 cm may be the practical limit so minimum size will be revisited after several years of data collection.
- 5) Always try to look ahead for wary fish that may depart quickly from the area, but be careful that fish beyond the transect are not being surveyed.
- 6) Be careful to note if fish leave the area, so that they are not double-counted if they return.
- 7) On the return pass for smaller fish, try to look into cracks, crevices, and corals to look for smaller, wary, and cryptic species.
- 8) On both sections of the survey swim fish should be identified to the species level. If species level is not possible try to identify to the lowest taxon possible and take a photograph of the specimen if practical and only if doing so will not disrupt further data collection.

- 9) Since each park has different fish assemblages, individual parks should customize the dataform for data collection based on the most prevalent species encountered. Doing so speeds data collection and ensures less time is spent looking down on the dataform.

Literature Cited

- Brainard et al. 2007. Coral reef monitoring report. 2002 – 2006. NOAA—Coral Reef Ecosystem Division.
- Myers, Robert F. 1999. Micronesian Reef Fishes: A Comprehensive Guide to the Coral Reef Fishes of Micronesia. Coral Graphics. Barrigada, Guam.
- Randall John. 2005. Reef and Shore Fishes of the South Pacific: New Caledonia to Tahiti and the Pitcairn Islands. University of Hawaii Press, Honolulu, Hawaii.
- Randall John. 2007. Reef and Shore Fishes of the Hawaiian Islands. University of Hawaii Sea Grant College Program, Honolulu, Hawaii.

Table S7.1. Marine Fish Survey Form. Example KALA/KAHO datasheet for collection of marine fish data. Datasheets should be customized for the fish assemblage in each park. The same datasheet format can be used for NPSA and WAPA.

Location Time	Transect Depth	Obs.	Date	Transect Depth	Obs.
Fis com/A ch					
Ceph argu					
Lutj kash					
Cirr fasc					
Cirr pinn					
Para arcu					
Para fost					
Mull flav					
Mull vani					
Paru bifa					
Paru cycl					
Paru mult					
Kyph sp					
Chae mult					
Chae ornat					
Chae quad					
Chae trif					
Chae unim					
Forc flav					
Plec impa					
Plec john					
Steg fasc					
Abud abdo					
Chro oval					
Chro hanu					
Chro vand					
Cori venu					
Hali orna					
Labr phth					
Macr geof					
Gomp vari					
Stet balt					
Thal ball					
Thal dupe					
Chlo pers					
Scar psit					
Scar rubr					
Chlo sord					
Cirr vand					
Acan bloc					
Acan leuc					
Acan nigrof					
Acan oliv					
Acan trio					
Cten stri					
Naso litu					
Zebr flav					
Meli nige					
Meli vidu					
Rhin rect					
Suff burs					
Cant dume					
Cant amb					
Cant jact					

Appendix K: SOP # 8: Post Dive Procedures and Equipment Maintenance

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This Standard Operating Procedure covers post dive equipment maintenance for SCUBA gear and associated equipment.

Post-Dive Instructions for Equipment Cleaning and Maintenance

Step by step procedures:

- 1) Following each field day, all equipment must be rinsed with freshwater. Seawater left on the equipment for an extended period of time will reduce the operational life of the equipment. For reference, a SCUBA equipment list can be found in Appendix S5.a. of SOP#5 “Pre-Dive Equipment Preparation”.
- 2) Ensure that electronic gear and other sensitive equipment such as regulators get rinsed quickly to reduce damage from salt crystallization.
- 3) Rinse all SCUBA gear including the inner bladder of the buoyancy compensators devices (BCD). The more that buoyancy is manipulated underwater the more seawater can enter a BCD.
- 4) Rinse boat (if removed from the water), trailer, and vehicle. Apply WD-40[®] or other lubricant such as Corrosion Block[®] to moving parts on the trailer (e.g., winch) and boat engine. Rinse the engine.
- 5) Rinse each data sheet with fresh water. Then, dry data sheets.
- 6) Rinse all other gear used each day.

- 7) Once dry, all equipment should be stored until needed again. If this is the final dive of the season, see SOP#19: “After the Field Season” for additional steps required when storing equipment.

Complete Dive Log

Each diver must log dive information as required by Resource Manual #4 (RM-4) and submit the log to the Park Dive Officer at the end of each calendar year.

Post-Dive Instructions for Handling Datasheets

Step by step procedures:

- 1) Once data sheets are dry, Photocopy all data sheets and store in a labeled three ring binder showing year and type of data.
- 2) Archive original data sheets according to SOP#9: “Workspace Setup and Project Records Management” guidelines.
- 3) At this step, data for each type of survey should then be treated according to further instruction found its respective data management SOP. For general data archiving and entry see SOP#9: “Workspace Setup and Project Records Management”.

Appendix K. SOP #9: Workspace Setup and Project Records Management

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This Standard Operating Procedure document describes how to set up a project workspace on one's computer, and describes the PACN Digital Library which is used for archival of finished Marine Fish Monitoring products.

Set-up Project Workspace

A section of the networked file server at each host park is reserved for this project, and access permissions are established so that project staff members have access to needed files within this workspace. If network connections are slow, a workspace should be established on project staff computers. Prior to each season, the Project Lead should make sure that network accounts are established for each new staff member, and that the Data Manager is notified to ensure access to the project workspace and databases. It is the responsibility of the Project Lead or designee(s) to ensure that data entry and edits occur in a single database file, and that multiple copies of the database are not created and stored in other locations on the server, or on staff computers.

The recommended file structure within this workspace is shown in Figure S9.1. Certain folders – especially those for GPS data and images – should be retained in separate folders for each calendar year (Figure S9.1). This will make it easier to identify and move these files to the project archives at the end of each season (see Chapter 4: Season Close-out).

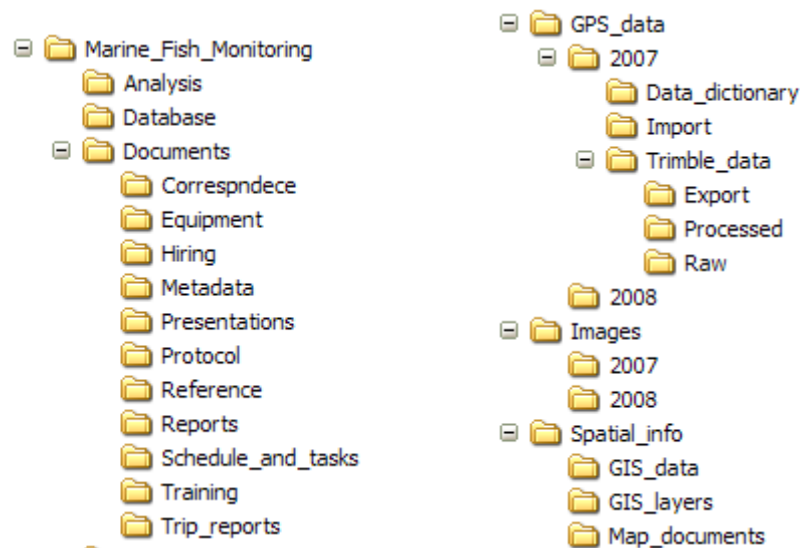


Figure S9.1. Recommended file structure for project workspace.

Each major subfolder is described as follows:

Analysis: Contains working files associated with data analysis.

Database: Contains the working database file for the season. The master database for the project is stored in the PACN Digital Library.

Documents: Contains subfolders to categorize documents as needed for various stages of project implementation.

GPS data: Contains GPS data dictionaries, and raw and processed GPS data files. Note that this folder contains subfolders to arrange files by year.

Images: For storing images associated with the project (refer to SOP #11: Managing Photographic Images). Note that this folder contains subfolders to arrange files by year.

Spatial info: Contains files related to visualizing and interacting with GIS data.

GIS data: New working shapefiles and geodatabases specific to the project.

GIS layers: Pointer files to centralized GIS base themes.

Map documents: Map composition files (.mxd).

Naming Conventions

Folder Naming Standards

In all cases, folder names should follow these guidelines:

- 1) No spaces or special characters in the folder name.
- 2) Use the underbar (“_”) character to separate words in folder names.
- 3) Try to limit folder names to 20 characters or fewer.
- 4) Dates should be formatted as YYYYMMDD.

File Naming Standards

In all cases, file names should follow these guidelines:

- 1) No spaces or special characters in the file name.
- 2) Use the underbar (“_”) character to separate file name components.
- 3) Try to limit file names to 30 characters or fewer, up to a maximum of 50 characters.
- 4) Dates should be formatted as YYYYMMDD.
- 5) Correspondence files should be named as YYYYMMDD_AuthorName_subject.ext.

Archival and Records Management

All project files should be reviewed, cleaned up and organized by the Project Lead on a regular basis (e.g., annually in January). Decisions on what to retain and what to destroy should be made following guidelines stipulated in NPS Director’s Order 19

(<http://www.nps.gov/refdesk/DOrders/DOrder19.html> Accessed 16 Aug. 2007), which provides a schedule indicating the amount of time that the various kinds of records should be retained.

Although many of the files for this project may be scheduled for permanent retention, it is important to isolate and protect these important files and not lose them in the midst of a large, disordered array of miscellaneous project files. Because this is a long-term monitoring project, good records management practices are critical for ensuring the continuity of project information. Files will be more useful to others if they are well organized, well named, and stored in a common format. In addition, it is important that files containing sensitive information be stored in a manner that will enable quick identification. Refer to SOP #15: Sensitive Information Procedures for more information.

To help ensure safe and organized electronic file management, PACN has implemented a system for archived data products called the PACN Digital Library, which is a hierarchical digital filing system stored on the PACN file servers. The typical arrangement is by project, then by year to facilitate easy access. Network users have read-only access to these files, except where information sensitivity may preclude general access. Data sensitivity will be reviewed by the PACN I&M management team because of recent changes to the Freedom of Information Act on data transparency. Explanations for why data are withheld will be clearly presented. Submission of certified products occurs in the PACN Digital Library by uploading the certified products in the “Submissions” folder and notifying the Data Manager.

As digital products are delivered for long-term storage according to the schedule in SOP #16: Product Delivery Specifications, they will be catalogued in the PACN project tracking database and filed within the PACN Digital Library by the Data Manager. The master versions of all digital files relating to the Marine Fish Protocol are stored within the PACN Digital Library, with regular file back-ups accomplished automatically. Presently, the master protocol files include the

protocol narrative, the SOPs, and the Marine Fish database files. Analog (non-digital) materials are to be handled according to current practices of the individual park collections.

Archived Data Maintenance

Any editing of archived data is accomplished jointly by the Project Lead or designee and PACN Data Manager. Prior to any major changes of a dataset, a copy is stored with the appropriate version number to allow for tracking of changes over time. Likewise, any time a revision of the protocol requires a revision to the database, a complete copy of the database will be made and stored in an archive directory. In addition to this copy in its native database format, all tables will be archived in a comma-delimited ASCII format that is platform-independent by using the Access_to_ascii.mdb utility developed by the Central Alaska Network.

Versioning of archived datasets is handled by adding a three digit number to the file name, with the first version being numbered 001 (e.g., marine_fish_be_2008_validated_v001, for the first version of a back-end data file validated by the Project Lead and data manager at the end of the 2008 field season). Each additional version is assigned a sequentially higher number. Frequent users of the data are notified of the updates, and provided with a copy of the most recently archived version.

Every change must be documented in the edit log and accompanied by an explanation that includes pre- and post-edit data descriptions. All data collected using this protocol are subject to the following three caveats:

- 1) Only make changes that improve or update the data while maintaining data integrity.
- 2) Once archived, document any changes made to the dataset through an edit log. At end of each fiscal year, the database manager will update the central database and will post read-only versions.
- 3) Mistakes can be made during editing so updates must be compared with the original data form prior to validating the data.

Appendix K. SOP #10: Field Form Handling Procedures

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This Standard Operating Procedure describes how to process field data forms.

Field Form Handling Procedures

As the field data forms are part of the permanent record for project data, they should be handled in a way that preserves their future interpretability and information content. If changes to data on the forms need to be made either during or after field data acquisition, the original values should not be erased or otherwise rendered illegible. Instead, changes should be made as follows:

- 1) Draw a horizontal line through the original value, and write the new value adjacent to the original value with the date and initials of the person making the change.
- 2) All corrections should be accompanied by a written explanation in the appropriate notes section on the field form. These notes should also be dated and initialed.
- 3) If possible, edits and revisions should be made in a different color ink to make it easier for subsequent viewers to be able to retrace the edit history.
- 4) Edits should be made on the original field forms and on any photocopied forms.

These procedures should be followed throughout data entry and data revision. On a yearly basis, data sheets are to be scanned as PDF documents and archived (Chapter 4: Archival and Records Management, and SOP #16: Product Delivery Specifications). The PDF files may then serve as a convenient digital reference of the original if needed. Hard copies of all field forms will be archived with the Project Lead, at the park, and within the park museum/library.

Appendix K. SOP #11: Managing Photographic Images

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This Standard Operating Procedure document describes how to process photographic images collected by project staff or volunteers during the course of conducting project-related activities. Images that are acquired by other means--e.g., downloaded from a website or those taken by a cooperating researcher—are not project records and should be handled separately.

Care should be taken to distinguish data photos from incidental or opportunistic photos taken by project staff. It should be noted that this protocol does not utilize photographic images as part of the core data record but photographs may be taken of distinctive assemblages, rare fish species, and/or unique habitats. Data photos are those taken for at least one of the following reasons:

- 1) To document a particular feature or perspective for the purpose of site relocation.
Typically this will be done in conjunction with the co-located Benthic Marine Community Protocol.
- 2) To capture site habitat characteristics and possibly to indicate gross structural changes over time
- 3) To document a species detection that is also recorded in the data

Data photos are linked to specific records within the database, and are stored in a manner that permits the preservation of those database links. Other photos – e.g., of field crew members at work, or photos showing the morphology or behavior of certain fish species – may also be retained but are not necessarily linked with database records.

Effectively managing hundreds of photographic images requires a consistent method for downloading, naming, editing and documenting the images. The general process for managing data photos proceeds as follows:

- 1) File Structure Setup – Set up the file organization for images prior to acquisition
- 2) Image Acquisition
- 3) Download and Process
 - a) Download the files from the camera
 - b) Rename the image files according to convention
 - c) Copy and store the original, unedited versions
 - d) Review and edit or delete the photos
 - e) Move into appropriate folders for storage
- 4) Establish Database Links
- 5) Deliver Image Files to I&M data manager for Final Storage

File Structure Setup

Prior to data collection for any given year, project staff will need to set up a new folder under the Images folder in the project workspace as follows:

[Year]	The appropriate year – 2007, 2008, etc.
Processing	Processing workspace
[Park code]	Arrange files by park – WAPA, NPSA, etc.
Data	Data images
[Site_code]	Arranged by sampling locations, or
[Date]	by date, for images not taken at sampling locations
Miscellaneous	Non-data images taken by project staff
[Site_code]	Arranged by sampling locations, or
[Date]	by date, for images not taken at sampling locations
Originals	Renamed but otherwise unedited image file copies
[Site_code]	Arranged by sampling locations, or
[Date]	by date, for images not taken at sampling locations
Non-NPS	Images acquired from other sources

This folder structure permits data images to be stored and managed separately from non-record and miscellaneous images collected during the course of the project. It also provides separate space for image processing and storage of originals. Note: For additional information about the project workspace, refer to SOP #9: Workspace Setup and Project Records Management.

Folder Naming Standards

In all cases, folder names should follow these guidelines:

- 1) No spaces or special characters in the folder name
- 2) Use the underscore (“_”) character to separate words in folder names
- 3) Try to limit folder names to 20 characters or fewer
- 4) Dates within folder names should be formatted as YYYYMMDD (for better sorting)

Image Acquisition

Capture images at an appropriate resolution that balances space limitations with the intended use of the images. Although photographs taken to facilitate future navigation to the site do not need to be stored at the same resolution as those that may be used to indicate gross environmental change at the site, it may be more efficient to capture all images at the same resolution initially. A recommended minimum raw resolution is 1600 x 1200 pixels (approximately 2 megapixels).

Download and Processing Procedures

Step by step procedures:

- 1) Once data sheets are dry, Photocopy all data sheets and store in a labeled three ring binder showing year and type of data.
- 2) Rename the images according to convention (refer to the image file naming standards section below). If image file names were noted on the field data forms, be sure to update these to reflect the new image file name prior to data entry. See SOP #10: Field Form Handling Procedures.
- 3) Process the images in the _Processing folder. At a minimum, the following processing steps should be performed on all image files:
 - a) Copy the images to the 'Originals' folder and set the contents as read-only by right clicking in Windows Explorer® and checking the appropriate box. These originals are the image backup to be referred to in case of unintended file alteration or deletion.
 - b) Delete any poor quality photos, repeats, blurred or otherwise unnecessary photos. Low quality photos might be retained if the subject is highly unique, or the photo is an irreplaceable data photo.
 - c) Rotate the image to make the horizon level.
 - d) Photos of people should have 'red eye' glare removed.
 - e) Photos should be cropped to remove edge areas that grossly distract from the subject.
- 4) When finished, move the image files that are to be retained and possibly linked in the database to the appropriate folder – data images under the Data folder, other images under the Miscellaneous folder. Photos of interest to a greater audience should be copied to the park Digital Image Library. To minimize the chance for accidental deletion or overwriting of needed files, no stray files should remain in the processing folder between downloads.
- 5) Depending on the size of the files and storage limitations, contents of the Originals folder may be deleted if all desired files are accounted for after processing.

Large groups of photos acquired under sub-optimal exposure or lighting can be batch processed to enhance contrast or brightness. Batch processing can also be used to resize groups of photos for use on the web. Batch processing may be done in ThumbsPlus®, Extensis Portfolio® or a similar image software package.

Image File Naming Standards

In all cases, image names should follow these guidelines:

- 1) No spaces or special characters in the file name
- 2) Use the underscore (“_”) character to separate file name components
- 3) Try to limit file names to 30 characters or fewer, up to a maximum of 50 characters

- 4) Park code and year should either be included in the file name or conclusive by the directory structure

The image file name should consist of the following parts:

- 1) The date of data capture (formatted as YYYYMMDD)
- 2) The sampling location (if recorded at a sampling location)
- 3) Optional: a brief descriptive word or phrase
- 4) Optional: a sequential number if multiple images were captured
- 5) Optional: time (formatted as HHMM)

Example: 20070518_training_004.jpg (4th photo taken during training on May 18, 2007)

In cases where there are small quantities of photos it is practical to individually rename these files. However, for larger numbers it may be useful to rename files in batches. This may be done in ThumbsPlus[®], Extensis Portfolio[®] or a similar image software package. A somewhat less sophisticated alternative is to batch rename files in Windows Explorer[®], by first selecting the files to be renamed and then selecting File > Rename. The edits made to one file will be made to all others, although with the unpleasant side effect of often adding spaces and special characters (e.g., parentheses) which will then need to be removed manually.

Renaming photos may be most efficient as a two part event—one step performed as a batch process which inserts the date and transect number at the beginning of the photo name, and a second step in which a descriptive component is manually added to each file name.

Deliver Image Files to I&M Data Manager for Final Storage

Note: Please refer to SOP #16: Product Delivery Specifications.

At the end of the season, and once the year's data are certified, data images for the year may be delivered along with the working copy of the database to the Data Manager on a CD or DVD. To do this, simply copy the folder for the appropriate year(s) and all associated subfolders and images onto the disk. These files will be loaded into the project section of the PACN Digital Library.

Prior to delivery, make sure that all processing folders are empty. Upon delivery, the delivered folders should be made read-only to prevent unintended changes.

Appendix K. SOP #12: Data Entry and Verification

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This Standard Operating Procedure document describes the general procedures for entry and verification of field data in the working project database. Refer to Chapter 4 sections “Overview of Database Design” and “Data Entry and Processing” for related guidance and a clarification of the distinction between the working database and the master database. The following are general guidelines to keep in mind:

- 1) A blank working database application will be distributed to individual parks at the beginning of the field season to facilitate prompt data entry and edits by park staff.
- 2) Data entry should occur as soon after data collection as possible so that field crews keep current with data entry tasks, and catch any errors or problems as close to the time of data collection as possible. Data entry should be completed by the person who collected the data or someone who is familiar with the project and data.
- 3) A single working database application will be found in the project workspace for each park. For enhanced performance, it is recommended that users copy the front-end database onto their workstation hard drives and open it there. This front-end copy may be considered “disposable” because it does not contain any data, but rather acts as an interface with data residing in the back-end working database.
- 4) Data entry is done within Microsoft Excel[®] and then imported into the working copy of the database. As data are being entered, the person entering the data should visually review record to make sure that the data on screen match the field forms. This should be done for each transect prior to moving to the next transect for data entry.
- 5) The importing query has built-in quality assurance components such as validation rules to test for missing data or illogical combinations. Although the database permits users to

view the raw data tables and other database objects, users are strongly encouraged to only read the imported files as a way of ensuring the maximum level of quality assurance.

- 6) At regular intervals and at the end of the field season the Field Lead should inspect the data that have been entered to check for completeness and perhaps catch avoidable errors.
- 7) At the end of the field season, files will be submitted to the PACN data management staff for consolidation into the master database file.

Database Instructions

Getting Started

Given that Marine Fish data is collected at the same locations and at the same sampling events as Benthic Marine Community data, Marine Fish data will be entered in the Benthic Marine Community database. The first action to be taken is to make sure the data entry workspace is set up properly on a networked drive. If you are unclear about where this should be, contact either the local park biologists, the Data Manager or refer to SOP #9: Workspace Setup and Project Records Management.

Step by step procedures:

- 1) Store the back-end database file on the server so that others can enter data into the same back end file. The back-end file has “_be_” as part of its name. Upon saving this back-end, the user may want to append the local park code to distinguish it from other back-end files associated with other crews (e.g., benthic_marine_be_2007_KALA.mdb).
- 2) The crew’s copy of the front-end database may be stored in the same folder.
- 3) If it doesn’t already exist, also create a folder in the same network folder named “backups” or “backup_copies” for storing daily backups of the back-end database file.

Prior to using the database

Step by step procedures:

- 1) Open the front-end database. The first thing it will do is to ask to update the links to the back-end database file. This will only need to be done once for each new issue of the front-end database.

Important Reminders for Daily Database Use

- 1) The front-end will need to be copied to your workstation if it hasn’t been copied already. Do not open up and use the front-end on the network as this ‘bloats’ the database file and makes it run more slowly.
- 2) Backups should be made consistently at some point every day that data entry occurs. Normally the front-end application will automatically prompt you to make a backup either upon opening or closing the application. Backups can also be made on demand by hitting the “Back up data” button on the main menu and storing the backup file in the “backups” folder.
- 3) To save drive space and network resources, backup files should be compacted by right-clicking on the backup file in Windows Explorer® and selecting the option: “Add to Zip file”. Older files may be deleted at the discretion of the Project Lead.
- 4) New issues of the front-end application may be released as needed through the course of the field season. If this happens, there should be no need to move or alter the back-end

- file. Instead, the front-end file may be deleted and replaced with the new version, which will be named in a manner reflecting the update (e.g., benthic_marine_2007_v2.mdb).
- 5) If the front-end database gets bigger and slower, compact it periodically by selecting Tools > Database Utilities > Compact and Repair Database within Access®.

Working Database Functions

The working front-end application has the following functional components, which are accessed from the main application switchboard form that opens automatically when the application starts:

Data Entry and Review

Data entry: Choosing the option “Enter/ edit data” will open the data entry form.

Data review: Choosing the option “View/ edit records” on the data entry form opens a browser that allows a person to quickly review all the data associated with a particular sampling location and sampling date

Other Functions

View database window: Allows the user to view the database objects (tables, queries and forms)

Back up data: Creates a date-stamped copy of the back-end database file

Connect back-end database: Verifies the connection to the back-end working database file, and provides the option to redirect or update that connection. This function will need to be done at least once a year.

Update taxon table: Opens a form with taxon information that can be edited, or new taxon may be entered.

View release history: Opens a form describing known bugs and changes made to the front-end database since its first release.

Data Verification

Step by Step Procedures:

- 1) Park staff, working closely with the Project Lead and Marine Biological Technician, will be responsible for reviewing 10% of all fish data entry records for their park each field season. Review will be accomplished by comparing the original field data sheets with the Microsoft Excel® spreadsheet. Edits will be made of three randomly selected transects prior to importing the file into the Benthic Marine Community database. This review will serve as both a data verification process and a data validation process. For the purposes of data verification, if more than 10% of the reviewed records are affected by data entry errors, then all of the records will be reviewed by the park lead and corrected by the Marine Biological Technician as needed.
- 2) Using record review routines built into the Benthic Marine Community database, park staff will check if all records were imported and fish species codes were correctly assigned against the original hardcopy data sheets. Corrections to data entry errors will be tracked in order to quantify data importing error rates. If more than 10% of the imported records are affected by data entry errors, then all of the records will be reviewed by the park lead and corrected by the Marine Biological Technician as needed.

- 3) The geospatial component of the Benthic Marine Community database will be verified each field season. A database utility linking the database to ArcGIS[®] software will be used to evaluate all geospatial coordinates. Any corrections will be tracked, and an error rate greater than 10% will require a detailed review of the coordinate fields for all records. As this database functionality is finalized, it will be fully described in this SOP and in the database user manual.

Database Use Instructions

To view detailed instructions for entering and editing data, see Appendix J: Marine Fish Database User's Guide. Ultimately, it is the Project Lead's responsibility to ensure that all data entry staff understands how to enter data and follow all applicable SOPs. Data entry technicians are responsible for becoming familiar with the field data forms, the database software, database structure, and any standard codes for data entry.

Appendix K. SOP #13: Post-season Data Quality Review and Certification

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This Standard Operating Procedure document describes the procedures for validation and certification of data in the working project database. Refer also to Chapter 4 sections “Overview of Database Design”, “Quality Review”, and “Data Certification and Delivery” for related guidance and a clarification of the distinction between the working database and the master database.

After the season’s field data have been entered and processed, they need to be reviewed, validated, and certified by the Project Lead for quality, completeness, structural integrity, and logical consistency. Once the data have been through the validation process and metadata have been developed for them, they are to be certified by completing the PACN Project Data Certification Form

(http://science.nature.nps.gov/im/units/pacn/data/data_sop/PACN_Project_Data_Certification_Form.doc. Accessed 20 Aug. 2007), available on the PACN website. The completed form, certified data, and updated metadata may then be delivered to the Data Manager according to the timeline in Appendix H: Yearly Project Task List.

Data Quality Review

At the end of each field season, the Project Lead and the PACN data management staff are collectively responsible for finalizing a validated dataset. Park staff, working closely with the Project Lead and the Marine Biological Technician, will assist in data validation. Some validation (ensuring that the data make sense) methods have been incorporated into the database. Other, more specific validation routines will be worked out with the protocol Project Lead and/or

project staff and incorporated into the database as appropriate. These modifications will be described in the edit log and the functionality of the validation routines will be explained in detail in the Benthic Marine Community database user manual.

The Project Lead, in conjunction with all relevant staff, will be responsible for evaluating all of the database records for a given field season to provide final approval for a validated dataset. PACN data management staff will work closely with the Project Lead and other personnel to provide any needed database queries, reports, graphs, or export file formats to assist with this overall validation.

Completing Data Certification

Data certification is a benchmark in the project information management process that indicates that: 1) the data are complete for the period of record; 2) they have undergone and passed the quality assurance checks; and 3) that they are appropriately documented and in a condition for archiving, posting and distribution as appropriate. Certification is not intended to imply that the data are completely free of errors or inconsistencies which may or may not have been detected during quality assurance reviews.

Once a given field season's dataset has been certified, the PACN data manager will be responsible for archiving the certified dataset, posting the metadata (and dataset, if appropriate) to the appropriate NPS online data store, and distributing read-only copies of the certified datasets to the parks.

To ensure that only quality data are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. The Project Lead is primarily responsible for completing a PACN Project Data Certification Form, available on the PACN website. This brief form and the certified data should be submitted according to the timeline in Appendix H: Yearly Project Task List. Refer to SOP #16: Product Delivery Specifications for delivery instructions.

Appendix K. SOP #14: Metadata Development

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This Standard Operating Procedure document describes the guidelines for documenting data and how it should be accomplished.

Metadata Documentation

Data documentation is a critical step toward ensuring that data sets are usable for their intended purposes well into the future. This involves the development of metadata, which can be defined as structured information about the content, quality, condition and other characteristics of a given data set. Additionally, metadata provide the means to catalog and search among data sets, thus making them available to a broad range of potential data users. Metadata for all PACN monitoring data will conform to Federal Geographic Data Committee (FGDC) guidelines and will contain all components of supporting information such that the data may be confidently manipulated, analyzed and synthesized.

Updated metadata is a required deliverable that should accompany each season's certified data. For long-term projects such as this one, metadata creation is most time consuming the first time it is developed – after which most information remains static from one year to the next. Metadata records in subsequent years only need to be updated to reflect changes in contact information, taxonomic conventions, publication listings, data disposition, quality descriptions, collection methods, analysis approaches or quality assurance for the project.

Specific procedures for creating, parsing, and posting the metadata record are found in PACN Metadata Development Guidelines. (http://science.nature.nps.gov/im/units/pacn/data/data_sop/PACN_Metadata_Guidelines.pdf. Accessed 20 Aug. 2007).

General procedures:

- 1) After the annual data quality review has been performed and the data are ready for certification, the Project Lead (or a designee) updates the PACN Metadata Interview Form. (http://science.nature.nps.gov/im/units/pacn/data/data_sop/PACN_Metadata_Interview_Form.doc. Accessed 20 Aug. 2007.)
 - a. The metadata interview form facilitates metadata creation by structuring the required information into a logical arrangement of 15 main questions, many with additional sub-questions.
 - b. The first year, a new copy of the metadata interview form should be downloaded. Otherwise the form from the previous year can be used as a starting point, in which case the Track Changes tool in Microsoft Word® should be activated in order to make edits obvious to the person who will be updating the XML record.
 - c. Complete the metadata interview form and maintain it in the project workspace. Much of the interview form can be filled out by cutting and pasting material from other documents (e.g., reports, protocol narrative sections, and SOPs).
 - d. The Data Manager can help answer questions about the metadata interview form.
- 2) Deliver the completed interview form to the Data Manager according to SOP #16: Product Delivery Specifications.
- 3) The Data Manager (or GIS Specialist for spatial data) will then extract the information from the interview form and use it to create and update an FGDC- and NPS-compliant metadata record in XML format. Specific guidance for creating the XML record is contained in PACN Metadata Development Guidelines. (http://science.nature.nps.gov/im/units/pacn/data/data_sop/PACN_Metadata_Guidelines.pdf. Accessed 20 Aug. 2007).
- 4) The Data Manager will post the record and the certified, non-sensitive data to the NPS Data Store, and maintain a local copy of the XML file for subsequent updates. The NPS Data Store has help files to guide the upload process.
- 5) The Project Lead should update the metadata interview content as changes to the protocol are made, and each year as additional data are accumulated.

Identifying sensitive information

Part of metadata development includes determining whether or not the data include any sensitive information, which is partly defined as the specific locations of rare, threatened or endangered species. Prior to completing the metadata interview form, the Project Lead and park biologists should work together to identify any sensitive information in the data after first consulting SOP #15: Sensitive Information Procedures. Their findings may be documented and communicated to the Data Manager through the metadata interview form.

Appendix K. SOP #15: Sensitive Information Procedures

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

Although it is the general NPS policy to share information widely, the NPS also realizes that providing information about the location of park resources may sometimes place those resources at risk of harm, theft, or destruction. This can occur, for example, with caves, archeological sites, tribal information, and rare plant and animal species. Therefore, information will be withheld when the NPS foresees that disclosure would be harmful to an interest protected by an exemption under the Freedom of Information Act (FOIA). The National Parks Omnibus Management Act, Section 207, 16 U.S.C. 5937, is interpreted to prohibit the release of information regarding the “nature or specific location” of certain cultural and natural resources in the national park system. Additional details and information about the legal basis for this policy can be found in the NPS Management Policies (National Park Service 2006), and in Director’s Order #66.

These guidelines apply to all PACN staff, cooperators, contractors, and other partners who are likely to obtain or have access to information about protected NPS resources. The Project Lead has primary responsibility for ensuring adequate protection of sensitive information related to this project. The following are highlights of our strategy for protecting this information:

- 1) *Protected resources*, in the context of the PACN Inventory and Monitoring Program, include species that are State - or Federally-listed as threatened or endangered, and other species deemed rare or sensitive by local park taxa experts.
- 2) *Sensitive information* is defined as information about protected resources which may reveal the “nature or specific location” of protected resources. Such information must not be shared outside the National Park Service, unless a signed confidentiality agreement is in place.

- 3) In general, if information is withheld from one requesting party, it must be withheld from anyone else who requests it, and if information is provided to one requesting party without a confidentiality agreement, it must be provided to anyone else who requests it.
- 4) To share information as broadly as legally possible, and to provide a consistent, tractable approach for handling sensitive information, the following shall apply if a project is likely to collect and store sensitive information:
 - a) Random coordinate offsets in NPS Data Store of up to 2 km for data collection locations, and,
 - b) Removal of data fields from the released copy that are likely to contain sensitive information.

What Kinds of Information Can and Cannot Be Shared?

Do not share

Project staff and cooperators should not share any information outside NPS that reveals details about the “nature or specific location” of protected resources, unless a confidentiality agreement is in place. Specifically, the following information should be omitted from shared copies of all data, presentations, reports, or other published forms of information.

- 1) *Exact coordinates* – Instead, public coordinates are to be generated that include a random offset azimuth and distance. These offset coordinates can be shared freely.
- 2) *Other descriptive location data* – Examples may include travel descriptions, location descriptions, or other fields that contain information which may reveal the specific location of the protected resource(s).
- 3) *Protected resource observations at disclosed locations* – If specific location information has already been made publicly available, the occurrence of protected resources at that location cannot be shared outside NPS without a confidentiality agreement. For example, if the exact coordinates for a monitoring station location are posted to a website or put into a publication, then at a later point in time a Hawaiian petrel burrow is observed at that monitoring station, that burrow cannot be mentioned or referred to in any report, presentation, data set, or publication that will be shared outside NPS.

Do share

All other information about the protected resource(s) may be freely shared, so long as the information does not reveal details about the “nature or specific location” of the protected resource(s) that aren’t already readily available to the general public in some form (e.g., other published material). Species tallies and other types of data presentations that do not disclose the precise locations of protected resources may be shared, unless by indicating the presence of the species the specific location is also revealed (i.e., in the case of a small park).

Details for Specific Products

Whenever products such as databases and reports are being generated, handled and stored, they should be created explicitly for one of the following purposes:

- 1) *Public or general-use* – Intended for general distribution, sharing with cooperators, or posting to public websites. They may be derived from products that contain sensitive information so long as the sensitive information is either removed or otherwise rendered in a manner consistent with other guidance in this document.
- 2) *Internal NPS use* – These are products that contain sensitive information and should be stored and distributed only in a manner that ensures their continued protection. These products should clearly indicate that they are solely for internal NPS use by containing the phrase: “Internal NPS Use Only – Not For Release.” These products can only be shared within NPS or in cases where a confidentiality agreement is in place. They do not need to be revised in a way that conceals the location of protected resources.

Data Set Sharing

To create a copy of a data set that will be posted or shared outside NPS:

- 1) Make sure the public offset coordinates have been populated for each sample or observation location in tbl_Locations.
- 2) Delete any database objects that may contain specific, identifying information about locations of protected resources.

The local, master copy of the database contains the exact coordinates and all data fields. The Data Manager and/or GIS Specialist can provide technical assistance as needed to apply coordinate offsets or otherwise edit data products for sensitive information. See also “Procedures for Coordinate Offsets” below.

Maps and Other GIS Output

General use maps and other geographic representations of observation data that will be released or shared outside NPS should be rendered using offset coordinates, and should only be rendered at a scale that does not reveal their exact position (e.g., 1:100,000 maximum scale).

If a large-scale, close-up map is to be created using exact coordinates (e.g., for field crew navigation, etc.), the map should be clearly marked with the following phrase: “Internal NPS Use Only – Not For Release.”

The Data Manager and/or GIS Specialist can provide technical assistance as needed to apply coordinate offsets or otherwise edit data products for sensitive information. See also “Procedures for Coordinate Offsets” below.

Presentations and Reports

Public/general-use reports and presentations should adhere to the following guidelines:

- 1) Do not list exact coordinates or specific location information in any text, figure, table, or graphic in the report or presentation. If a list of coordinates is necessary, use only offset coordinates and clearly indicate that coordinates have been purposely offset to protect the resource(s) as required by law and NPS policy.
- 2) Use only general use maps as specified in the section on maps and other GIS output.

If a report is intended for internal use only, these restrictions do not apply. However, each page of the report should be clearly marked with the following phrase: “Internal NPS Use Only – Not For Release.”

Voucher Specimens

Specimens of protected taxa should only be collected as allowed by law. Labels for specimens should be clearly labeled as containing sensitive information by containing the following phrase: “Internal NPS Use Only – Not For Release.” These specimens should be stored separately from other specimens to prevent unintended access by visitors. As with any sensitive information, a confidentiality agreement should be in place prior to sending these specimens to another non-NPS cooperator or collection.

Coordinate Offsets

Step by Step Procedures:

- 1) Process GPS data, upload into the database, and finalize coordinate data records.
- 2) Set the minimum and maximum offset distances (project-specific, typically up to 2 km).
- 3) Apply a random offset and random azimuth to each unique set of coordinates.
- 4) Coordinates may then be either rounded or truncated so the UTM values end in zeros to give a visual cue that the values are not actual coordinates.
- 5) Do not apply independent offsets to clustered or otherwise linked sample locations (e.g., multiple sample points along a transect). Instead, either apply a single offset to the cluster so they all remain clustered after the offset is applied, or apply an offset to only one of the points in the cluster (e.g., the transect origin) and store the result in the public coordinates for each point in that cluster.
- 6) These “public” coordinates are then the only ones to be shared outside NPS – including all published maps, reports, publications, presentations, and distribution copies of the data set – in the absence of a confidentiality agreement.

The following formulas can be used to create individual offsets rounded to the nearest 100 m in Microsoft Excel®:

Angle = rand() * 359

Distance = ((Max_offset – Min_offset) * rand() + Min_offset)

Public_UTME = Round(UTME_final + (Distance * cos(Radians(Angle – 90))), -2)

Public_UTMN = Round(UTMN_final + (Distance * sin(Radians(Angle + 90))), -2)

Sharing Sensitive Information

Note: Refer to SOP #17: Product Posting and Distribution for a more complete description of how to post and distribute products, and to keep a log of data requests.

No sensitive information (e.g., information about the specific nature or location of protected resources) may be posted to the NPS Data Store or another publicly-accessible website, or otherwise shared or distributed outside NPS without a confidentiality agreement between NPS

and the agency, organization, or person(s) with whom the sensitive information is to be shared. Only products that do not contain sensitive information and are intended for public/general-use may be posted to public websites and clearinghouses.

Responding to Data Requests

If requests for distribution of products containing sensitive information are initiated by the NPS, by another federal agency, or by another partner organization (e.g., a research scientist at a university), the unedited product (e.g., the full data set that includes sensitive information) may only be shared after a confidentiality agreement is established between NPS and the agency, organization, or person(s) with whom the sensitive information is to be shared (See below for example). All data requests will be tracked according to procedures in SOP #17: Product Posting and Distribution.

Once a confidentiality agreement is in place, products containing sensitive information may be shared following these guidelines:

- 1) Always indicate in accompanying correspondence which products contain sensitive information.
- 2) Indicate in all correspondence that products containing sensitive information should be stored and maintained separately from non-sensitive information, and protected from accidental release or re-distribution.
- 3) Indicate that NPS retains all distribution rights; copies of the data should not be redistributed by anyone but NPS.
- 4) Include the following standard disclaimer in a text file with all digital media upon distribution: “The following files contain protected information. This information was provided by the National Park Service under a confidentiality agreement. It is not to be published, handled, re-distributed or used in a manner inconsistent with that agreement.” The text file should also specify the file(s) containing sensitive information.
- 5) If the products are being sent on physical media (e.g., CD or DVD), the media should be marked in such a way that clearly indicates that media contains sensitive information provided by the National Park Service.

Confidentiality Agreements

Confidentiality agreements may be created between NPS and another organization or individual to ensure that protected information is not inadvertently released. When contracts or other agreements with a non-federal partner do not include a specific provision to prevent the release of protected information, the written document must include the following standard Confidentiality Agreement:

Confidentiality Agreement – I agree to keep confidential any protected information that I may develop or otherwise acquire as part of my work with the National Park Service. I understand that with regard to protected information, I am an agent of the National Park Service and must not release that information. I also understand that by law I may not share protected information with anyone through any means except as specifically authorized by the National Park Service. I understand that protected information concerns the nature and specific location of endangered, threatened, rare, commercially valuable, mineral, paleontological, or cultural patrimony resources such

as threatened or endangered species, rare features, archeological sites, museum collections, caves, fossil sites, gemstones, and sacred ceremonial sites. Lastly, I understand that protected information must not be inadvertently disclosed through any means including websites, maps, scientific articles, presentation, and speeches.

Note: Certain states have sunshine laws that do not have exemptions for sensitive information. NPS should not create confidentiality agreements or share sensitive information with these states without first seeking the advice of an NPS solicitor.

Freedom of Information (FOIA) Requests

All official FOIA requests will be handled according to NPS policy. The Project Lead will work with the Data Manager and the park FOIA representative(s) of the park(s) for which the request applies.

Literature cited

National Park Service. 2006. Management Policies. <http://www.nps.gov/policy/mp/policies.htm>. Online. Accessed 6 Feb. 2007.

Appendix K. SOP #16: Product Delivery Specifications

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This Standard Operating Procedure document provides details on the process of submitting completed data sets, reports and other project deliverables. Prior to submitting digital products, files should be named according to the naming conventions appropriate to each product type (see below for general naming conventions).

All digital file submissions that are sent by email should be accompanied by a Product Submission Form

http://science.nature.nps.gov/im/units/pacn/data/data_sop/PACN_Product_Submissions_Form.doc (Accessed 20 Aug. 2007), which briefly captures the following information about the products:

- 1) Submission date
- 2) Name of the person submitting the product(s)
- 3) Name and file format of each product
- 4) Indication of whether or not each product contains sensitive information (see SOP #15: Sensitive Information Procedures for more detail).

This form can be obtained from the PACN website (See above) or the Data Manager. Upon notification and/or receipt of the completed products, the Data Manager or GIS Specialist will check them into the PACN project tracking application.

Product Delivery Schedule and Specifications

Table S16.1. Product delivery schedule and specifications.

Deliverable Product	Primary Responsibility	Target Date	Instructions
Annotated park dive logs	Project Lead	December 31 of the same year	Upload digital file in MicrosoftWord [®] format to the PACN Digital Library ¹ submissions folder.
Raw GPS data files	Project Lead	December 31 of the same year	Zip and send all digital files to the GIS Specialist who will post it to the PACN Digital Library ¹ .
Processed GPS data files	GIS Specialist	February 28 of the following year	Zip and upload files to the PACN Digital Library ¹ .
Digital photographs	Project Lead	February 28 of the following year	Organize, name and maintain photographic images in the project workspace according to SOP #11: <u>Managing Photographic Images</u> .
Certified working database	Project Lead	February 28 of the following year	Refer to the following section on delivering certified data and related materials. Data will be uploaded to the NPS Data Store ² , and stored in the PACN Digital Library ¹ .
Certified geospatial data	Project Lead with GIS Specialist		
Data certification report	Project Lead		
Metadata interview form	Project Lead and NPS Lead		
Full metadata (parsed XML)	Data Manager and GIS Specialist	March 15 of the following year	Upload the parsed XML record to the NPS Data Store ² , and store in the PACN Digital Library ¹ .
Annual I&M report	Project Lead and NPS Lead	April 30 of the following year	Refer to the following section on reports and publications. Final reports will be entered in NatureBib ³ , and stored in the PACN Digital Library ¹ .
5-year analysis report	Project Lead, NPS Lead, Data Analyst	Every 5 years by April 30	
Other publications	NPS Lead, Project Lead, Data Analyst	as completed	
Field data forms	NPS Lead and Project Lead	Every 5 years by April 30	Scan original, marked-up field forms as PDF files and upload these to the PACN Digital Library ¹ submissions folder. Originals go to the Park Curator for archival.
Other records	NPS Lead and Project Lead	review for retention every January	Organize and send analog files to Park Curator for archival. Digital files that are slated for permanent retention should be uploaded to the PACN Digital Library. Retain or dispose of records following <u>NPS Director's Order #19</u> ⁴ .

¹ The PACN Digital Library is a hierarchical digital filing system stored on the PACN file server. Network users have read-only access to these files, except where information sensitivity may preclude general access.

² NPS Data Store is a clearinghouse for natural resource data and metadata (<http://science.nature.nps.gov/nrdata>). Only non-sensitive information is posted to NPS Data Store. Refer to the protocol section on sensitive information for details.

³ NatureBib is the NPS bibliographic database (<http://www.nature.nps.gov/nrbib/index.htm>). This application has the capability of storing and providing public access to image data (e.g., PDF files) associated with each record.

⁴ NPS Director's Order 19 provides a schedule indicating the amount of time that the various kinds of records should be retained. Available at: <http://data2.itc.nps.gov/npspolicy/DOrders.cfm>

Specific Instructions for Delivering Certified Data and Related Materials

Data certification is a benchmark in the project information management process that indicates that: 1) the data are complete for the period of record; 2) they have undergone and passed the quality assurance checks; and 3) that they are appropriately documented and in a condition for archiving, posting and distribution as appropriate. To ensure that only quality data are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. For more information refer to SOP #13: Data Quality Review and Certification.

The following deliverables should be delivered as a package:

Certified working database: Database in Microsoft Access[®] format containing data for the current season that has been through the quality assurance checks documented in SOP #13: Data Quality Review and Certification.

Certified geospatial data: GIS themes in ESRI[®] coverage or shapefile format.

Data certification report: A brief questionnaire in Microsoft Word[®] that describes the certified data product(s) being submitted. A template form is available on the PACN website at:
http://science.nature.nps.gov/im/units/pacn/data/data_sop/PACN_Project_Data_Certification_Form.doc.

Metadata interview form: The metadata interview form is an Microsoft Word[®] questionnaire that greatly facilitates metadata creation. It is available on the PACN website at:
http://science.nature.nps.gov/im/units/pacn/data/data_sop/PACN_Metadata_Interview_Form.doc. For more details, refer to SOP #14: Metadata Development.

After the quality review is completed, the Project Lead should package the certification materials for delivery as follows:

- 1) Open the certified back-end database file and compact it (in Microsoft Access[®], Tools > Database Utilities > Compact and Repair Database). This will make the file size much smaller. Back-end files are typically indicated with the letters “_be” in the name (e.g., marine_fish_be_2007.mdb).
- 2) Rename the certified back-end file with the project name (“marine_fish”), the year or span of years for the data being certified, and the word “certified”. For example: marine_fish_2007_certified.mdb.
- 3) Create a compressed file (using WinZip[®] or similar software) and add the back-end database file to that file. Note: The front-end application does not contain project data and as such should not be included in the delivery file.

- 4) Add the completed metadata interview and data certification forms to the compressed file. Both files should be named in a manner consistent with the naming conventions described elsewhere in this document.
- 5) Add any geospatial data files that aren't already in the possession of the GIS Specialist. Geospatial data files should be developed and named according to PACN GIS Naming Conventions.
- 6) Upload the compressed file containing all certification materials to the submissions folder of the PACN Digital Library. If the Project Lead does not have access to the PACN Digital Library, then certification materials should be delivered as follows:
 - a. If the compressed file is under 5 mb in size, it may be delivered directly to the Data Manager by email.
 - b. If the compressed file is larger than 5 mb, it should be copied to a CD or DVD and delivered in this manner. Under no circumstances should products containing sensitive information be posted to an FTP site or other unsecured web portal (refer to SOP #15: Sensitive Information Procedures for more information).
- 7) Notify the Data Manager by email that the certification materials have been uploaded or otherwise sent.

Upon receiving the certification materials, the Data Manager will:

- 1) Review them for completeness and work with the Project Lead if there are any questions.
- 2) Notify the GIS Specialist if any geospatial data are submitted. The GIS Specialist will then review the data, and update any project GIS data sets and metadata accordingly.
- 3) Check in the delivered products using the PACN project tracking application.
- 4) Archive the certified products together in the PACN Digital Library.
- 5) Upload the certified data to the master project database.
- 6) Notify the Project Lead that the year's data have been uploaded and processed successfully. The Project Lead may then proceed with data summarization, analysis and reporting.
- 7) Develop, parse and post the XML metadata record to the NPS Data Store.
- 8) After a holding period of 2 years, the Data Manager will upload the certified data to the NPS Data Store. This holding period is to protect professional authorship priority and to provide sufficient time to catch any undetected quality assurance problems. See SOP #16: Product Posting and Distribution.

File naming conventions

In all cases, digital file names should follow these guidelines:

- 1) No spaces or special characters in the file name
- 2) Use the underscore (“_”) character to separate file name components
- 3) Try to limit file names to 30 characters or fewer, up to a maximum of 50 characters
- 4) As appropriate, include the project name (e.g., “marine_fish”), network code (“PACN”) or park code, and year in the file name.

Examples: PACN_marine_fish_2007_Annual_report.pdf, PACN_marine_fish_2007_July_report.doc

Appendix K. SOP #17: Product Posting and Distribution

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This Standard Operating Procedure document provides details on the process of posting and otherwise distributing finalized data, reports and other project deliverables. For a complete list of project deliverables, refer to SOP #16: Product Delivery Specifications.

Product posting and distribution

Once digital products have been delivered and processed, the following steps will be taken by the Data Manager to make them generally available:

1. Full metadata records will be posted to the NPS Data Store, which is the NPS clearinghouse for natural resource data and metadata that is available to the public at: <http://science.nature.nps.gov/nrdata>. Refer to the website for upload instructions.
2. A record for reports and other publications will be created in NatureBib, which is the NPS bibliographic database (<http://www.nature.nps.gov/nrbib/index.htm>). The digital report file in PDF format will then be uploaded and linked to the NatureBib record. Refer to the NatureBib website for record creation and upload instructions.
3. Species observations will be extracted from the database and entered into NPSpecies, which is the NPS database and application for maintaining park-specific species lists and observation data (<http://science.nature.nps.gov/im/apps/npspp/index.htm>).

These three applications serve as the primary mechanisms for sharing reports, data, and other project deliverables with other agencies, organizations, and the general public.

Holding period for project data

To protect professional authorship priority and to provide sufficient time to complete quality assurance measures, there is a 2-year holding period before posting or otherwise distributing finalized data. This means that certified data sets are first posted to publicly-accessible websites (i.e., the NPS Data Store) approximately 24 months after they are collected (e.g., data collected in June 2006 becomes generally available through the NPS Data Store in June 2008). In certain circumstances, and at the discretion of the Project Lead and Park Biologists, data may be shared before a full 2 years have elapsed.

Note: This hold only applies to raw data; all metadata, reports or other products are to be posted to NPS clearinghouses in a timely manner as they are received and processed.

Responding to Data Requests

Occasionally, a park or project staff member may be contacted directly regarding a specific data request from another agency, organization, scientist, or from a member of the general public. The following points should be considered when responding to data requests:

- 1) NPS is the originator and steward of the data, and the NPS Inventory and Monitoring Program should be acknowledged in any professional publication using the data.
- 2) NPS retains distribution rights; copies of the data should not be redistributed by anyone but NPS.
- 3) The data that project staff members and cooperators collect using public funds are public records and as such cannot be considered personal or professional intellectual property.
- 4) No sensitive information (e.g., information about the specific nature or location of protected resources) may be posted to the NPS Data Store or another publicly-accessible website, or otherwise shared or distributed outside NPS without a confidentiality agreement between NPS and the requestor. Refer to the section in this document about sensitive information and also to SOP #15: Sensitive Information Procedures.
- 5) For quality assurance, only the certified, finalized versions of data sets should be shared with others.

The Project Lead will handle all data requests as follows:

- 1) Discuss the request with other Park Biologists as necessary to work together on a response.
- 2) Notify the Data Manager of the request if s/he is needed to facilitate fulfilling the request in some manner.
- 3) Respond to the request in an official email or memo.
- 4) In the response, refer the requestor to the NPS Data Store (<http://science.nature.nps.gov/nrdata>), so they may download the necessary data and/or metadata. If the request can not be fulfilled in that manner – either because the data products have not been posted yet, or because the requested data include sensitive information – work with the Data Manager to discuss options for fulfilling the request directly (e.g., burning data to CD or DVD). Ordinarily, only certified data sets should be shared outside NPS.

- 5) If the request is for a document, it is recommended that documents be converted to PDF format prior to distributing it.
- 6) If the request is for data that may reveal the location of protected resources, refer to the section in this document about sensitive information and also to SOP #15: Sensitive Information Procedures.
- 7) After responding, provide the following information to the Data Manager, who will maintain a log of all requests in the PACN Project Tracking database:
 - a. Name and affiliation of requestor
 - b. Request date
 - c. Nature of request
 - d. Responder
 - e. Response date
 - f. Nature of response
 - g. List of specific data sets and products sent (if any)

All official FOIA requests will be handled according to NPS policy. The Project Lead will work with the Data Manager and the park FOIA representative(s) of the park(s) for which the request applies.

Special procedures for sensitive information

Products that have been identified upon delivery by the Project Lead and/or park biologists as containing sensitive information will either be revised into a form that does not disclose the locations of sensitive resources, or withheld from posting and distribution. When requests for distribution of the unedited version of products are initiated by the NPS, by another federal agency, or by another partner organization (e.g., a research scientist at a university), the unedited product (e.g., the full data set that includes protected information) may only be shared after a confidentiality agreement is established between NPS and the other organization. Refer to SOP #15: Sensitive Information Procedures for more information.

Appendix K. SOP #18: Data Analysis and Reporting

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This SOP addresses data analysis and reporting for the Marine Fish Vital Sign in the Pacific Islands Network. Data analyses for (1) species richness, (2) abundance, (3) biomass, and (4) diversity are outlined with examples to show data structure, statistical tests, and graphical plots. Integrated reporting of these four components is also outlined. This protocol outlines two initial steps of data analysis at each of the unit, landscape, and trend-assessment levels. These steps summarize and determine the range of variation for some parameters (based on present knowledge). Report types are identified according to the categories in the PACN monitoring plan, with most reporting occurring on an annual basis. Additional, multi-vital sign integration, synthesis, analysis, and reporting is not addressed in this SOP at present. The use of products identified in this protocol does not imply endorsement, effectiveness, or warranty by NPS.

Analysis Overview

Data analysis is defined here as the steps by which observations of the environment are processed for interpretation and synthesis into meaningful information that is accessible to managers. Data analysis also includes quality assurance and control efforts that occur in the field, during exploratory analysis, in summarization, during interpretation, and when drawing conclusions.

Analytical Strategies

Two initial steps are identified in data analysis for all Marine Fish Monitoring data: summarization, and establishing the range of variation. These steps are encompassed in the larger construct of data management and data stewardship which is discussed in the data management SOPs #9 – 17. Data analysis for (1) species richness, (2) abundance, (3) biomass,

and (4) diversity incorporate these two initial steps at each of the unit, landscape, trend-assessment, and synthesis levels.

- 1) Summarization: This step includes identification and documentation of outliers, missing data, quality control and quality assurance issues (see SOP #12: Data Entry and Verification and SOP #13: Post-season Data Quality Review and Certification), mean or median values, variance estimates, and other descriptive statistics. Data visualization (see Cleveland 1993, 1994, Tufte 1983, 1990, 1997) and exploratory data analyses are an integral component of this process.
- 2) Range of Variation: This step includes establishing expected boundaries for response variables, typically as quantiles, and identifying data that falls outside these expected bounds. Establishing a range of normal variation may take years or decades for many parameters, but providing managers and decision-makers with the best available information will strengthen adaptive management feedback.

Analytical Approach

We identify four basic levels of analytical methods for our monitoring data: unit level, landscape level, trend assessment level, and synthesis (Table S18.1). The unit level, the most basic element, addresses sample design questions regarding use of finite or infinite populations, and the establishment of relative, absolute, or index response variables. The landscape level identifies the spatial nature of sampling and the temporal allocation of samples, such as the revisit scheme in use. The trend assessment level integrates unit or landscape level data over time, where typically some form of regression or repeated measures ANOVA is used to identify the slope or trend. Finally, synthesis examines patterns within and across Vital Signs, and with other ecological factors, to gain broad insight on ecological processes and integrity. Unit level, landscape level, and trend assessment level are addressed here. Synthesis will be addressed within and across multiple Vital Signs and is therefore left for network level or broader scientific consideration in the future.

Table S18.1. Three approaches at the park level for analyzing Marine Fish Vital Sign monitoring data.

Level of Analysis	Description	Responsible Party
Unit Level	Quality assurance, quality control, and calculation of individual, site specific statistics from monitoring data Step 1 (Summarization): Measures of mean, median, variation, and other basic statistics. Include graphical presentation of data. Step 2 (Range of Variation): Establish historical or expected range of values, relation to relevant regulatory levels, confidence estimates. Indices or other site-specific metrics may also be developed.	Marine Biological Technician with oversight by PL and with assistance from park ecologists.
Landscape Level	Integration of unit level data across appropriate landscapes to address ecological status. Step 1: Integration of unit level summarization results across multiple locations and sites. Step 2: Integration of unit level variation results across multiple locations and sites. Additional refinement of spatial pattern analyses. Sample design, assumptions about the target population, actual data relationships, and evolving status determination methods will guide selection of appropriate methods.	MBT with oversight by PL and with assistance from park ecologists.
Trend Assessment Level	Evaluation of Vital Sign trends over time to detect change. Typically some form of regression or repeated measures ANOVA will be among the methods used. Step 1: Integration of landscape level summarization over time. Step 2: Integration of landscape level variation results over time. Includes establishing a direction and rate of change or variation that may be used to provide early warnings of trends in resources condition. Confidence levels of documenting trend will be established. Parametric, nonparametric approaches and models will be used. Trend assessment will also include accounting for influence from drivers and stressors as much as possible.	PL and MBT, with assistance and oversight by PACN Marine Ecologist.

The analyses outlined below will be applied to each of the four primary components of this Vital Sign: (1) species richness, (2) abundance, (3) biomass, and (4) diversity. These analyses should be completed within three months of field work.

Analysis Procedures-Univariate

Analysis procedures are to be documented, for each park on an annual basis, in a compiled document (e.g. Microsoft Word[®] file), referred to hereafter as an analysis log file. This file would essentially be a ‘log’ of all the quantitative and qualitative steps taken, such as various transformations tested, and screen shots of data visualizations. A check list for the steps is provided in Appendix S18.a. Each year, four such files (one for each park that is slated for initial implementation of the protocol) will be generated. These analysis log files are internal working documents, that while not subject to explicit peer-review for most reporting other than protocol and programmatic reviews, will serve as the documentation and foundation for analyses for reports which are peer-reviewed. Table S18.2 summarizes these analytical procedures for the parameters measured at the park level.

Table S18.2. Summary of analytical procedures including parameters measured at the park level.

Level of Analysis	Data Analysis Approach	Frequency of Analysis	Responsible Party
Unit	Summarization and range-of-variation for annual fish species richness, abundance, biomass, and diversity by transect for each park.	Annually, within three months of field data collection for each of the three levels	Project lead or designee
Landscape	Annual status of fish species richness, abundance, biomass, and diversity for area of interest (e.g., entire park like KAHO, individual islands in NPSA or individual units in WAPA)	Annually, within three months of field data collection for each of the three levels	Project lead or designee
Trend Assessment	multi-year change in fish species richness, abundance, biomass, and diversity for both unit level data (transects/sites) and landscape level areas of interest	Annually, within three months of field data collection for each of the three levels	Project lead or designee

Fish Species Richness: This section of the log file will reflect the following organization. Parameters or response variables of interest for the three levels are; fish species list and the number of fish species by transect.

Unit Level Analysis: This level is applied for all parameters in the current-year only. Text and Graphic Plots by individual transect of mean (or median), standard deviation (or skew and kurtosis), outliers, normal probability plot, and frequency histogram of the distribution. If multiple observers have been collecting data, the summaries should be grouped by observer to evaluate potential observer bias.

Landscape Level Analysis: This level is applied to each parameter of interest in the current-year only. Text and graphic plots grouped by area(s) of interest (e.g., multiple transects on individual islands in NPSA or individual park units in WAPA) of mean (or median), standard deviation (or skew and kurtosis), outliers, normal probability plot, and frequency histogram of the distribution. Graphical map of park that displays values for species richness at each of the transects.

Trend Assessment Level Analyses: This level is applied to the current year, previous year, five year, ten year, and other to-be-determined intervals for each parameter of interest. Text and graphic plots grouped by specific transects of mean (or median), standard deviation (or skew and kurtosis). Change detection will include repeated measures ANOVA, regression, time-series evaluation (typically requires 50 or more data points [i.e., years]), or other appropriate technique. Text and graphic plots grouped by area(s) of interest (e.g., entire park such as KAHO, individual islands in NPSA or individual park units in WAPA) of: mean (or median), standard deviation (or skew and kurtosis) of fish variables. It includes a graphical map by park that displays changes in fish species richness by transect.

Abundance: The abundance section of the log file will follow the same procedures as for fish species richness except that the response variables of interest for the three levels are taxon list and abundance level (No. hectare⁻¹ year⁻¹) for each transect.

Biomass: The biomass section of the log file will follow the same procedures as for fish species richness except that the response variable of interest for the three levels is biomass level (metric tons year⁻¹) for each transect.

Diversity: The diversity section of the log file will follow the same procedures as for fish species richness except that the response variable of interest for the three levels is diversity (H' from the Shannon-Weiner diversity index) for each transect.

Integrated Data Analysis: To be determined based on the first few years of monitoring data.

Example Procedure for Fish Species Richness Data Analysis

It should be noted that the following analytical procedures should only be conducted by an individual with advanced statistical training and experience with ArcMap[®]. In addition, many of the procedures described below may change over time due to advancements and updates in statistical tests, perspectives, techniques and software. Consequently, this example merely serves to illustrate the desirable sequence of steps necessary to examine and present the data.

Example #1: Unit analysis of fish species richness at transect level:

- 1) Copy annual data for the fixed transects from a park from an Microsoft Access[®] query into a statistical software package. The program *STATISTICA*[®] 8.0 will be used to illustrate this procedure. Keep in mind that data copied from Microsoft Access[®] is treated as text and must usually be converted into value format prior to pasting the data into a statistical program. Programs like Microsoft Excel[®] can do the value conversion. Therefore, paste the data into Microsoft Excel[®] first and save the spreadsheet.
- 2) Transform the data in Microsoft Excel[®] by creating a second block of data below the raw data using the Log(x+1) formula. See Figure S18.1 for the sample layout. For the purposes of this SOP only raw data for the fixed transects will be used in the analysis.
- 3) Then copy the block of data from Microsoft Excel[®] into *STATISTICA*[®] 8.0.
- 4) In this example, the 2007 annual data for KALA is pasted into the KALAFishStats.sta file which already contains data from the prior year (Figure S18.1). The file is structured for a repeated measures ANOVA analysis with the dependent variables in columns for each year. The numbers in rows 1-15 are the raw data and the numbers in rows 17-31 are the Log(x+1) transformed data.

Data: KALAFishStats.sta (11v by 31c)											
	1	2	3	4	5	6	7	8	9	10	11
	Transect	SpRich-2006	Abund-2006	Biom-2006	Div-2006	SpRich-2007	Abund-2007	Biom-2007	Div-2007	Var10	NewVar
1	F01	20	4.48	0.55	2.63	18	3.28	0.45	2.68		
2	F02	23	13.52	0.55	1.73	26	11.92	0.88	1.91		
3	F03	24	17.92	4.71	2.06	29	29.44	7.99	1.38		
4	F04	30	9.44	1.84	2.88	23	5.60	1.15	2.88		
5	F05	20	74.16	1.6	0.86	25	34.96	1.02	1.11		
6	F06	11	4.56	0.07	1.68	11	6.96	0.04	1.27		
7	F07	25	9.04	0.8	2.37	20	13.36	0.50	1.43		
8	F08	37	29.92	2.91	1.7	40	32.24	3.55	1.92		
9	F09	20	12.48	1.74	1.81	30	15.20	2.08	2.04		
10	F10	24	28.4	2.24	1.31	21	18.24	0.51	1.16		
11	F11	27	27.36	2.77	2.16	18	8.32	1.23	2.10		
12	F12	38	17.04	2.21	2.75	32	10.56	1.06	2.66		
13	F13	22	13.92	1.79	1.88	21	7.44	0.55	2.42		
14	F14	25	15.52	0.51	1.47	20	6.56	0.37	2.34		
15	F15	28	7.92	0.58	2.87	30	6.80	1.36	3.04		
16											
17	F01	3.04	1.70	0.44	1.29	2.94	1.45	0.37	1.30		
18	F02	3.18	2.68	0.44	1.00	3.30	2.56	0.63	1.07		
19	F03	3.22	2.94	1.74	1.12	3.40	3.42	2.20	0.87		
20	F04	3.43	2.35	1.04	1.36	3.18	1.89	0.76	1.36		
21	F05	3.04	4.32	0.96	0.62	3.26	3.58	0.70	0.75		
22	F06	2.48	1.72	0.07	0.99	2.48	2.07	0.04	0.82		
23	F07	3.26	2.31	0.59	1.21	3.04	2.66	0.41	0.89		
24	F08	3.64	3.43	1.36	0.99	3.71	3.50	1.51	1.07		
25	F09	3.04	2.60	1.01	1.03	3.43	2.79	1.12	1.11		
26	F10	3.22	3.38	1.18	0.84	3.09	2.96	0.41	0.77		
27	F11	3.33	3.34	1.33	1.15	2.94	2.23	0.80	1.13		
28	F12	3.66	2.89	1.17	1.32	3.50	2.45	0.72	1.30		
29	F13	3.14	2.70	1.03	1.06	3.09	2.13	0.44	1.23		
30	F14	3.26	2.80	0.41	0.90	3.04	2.02	0.31	1.21		
31	F15	3.37	2.19	0.46	1.35	3.43	2.05	0.86	1.40		

Figure S18.1. Marine Fish data structure in STATISTICA® 8.0. Variables are species richness (e.g. SpRich-2006), Abundance, Biomass, and Diversity on each transect by year.

- 5) Examine outliers by generating a scatterplot of the current year fish species richness data against the prior year species richness data (Figure S18.2). Select Graphs – Scatterplot from the menu (Note: skip this step in the first year because there will be no prior year data). It is important to select only the raw data and this is accomplished by the “Select Cases – SelCond” button and choosing cases less than 16. In *STATISTICA*® 8.0 this is done by enabling selection conditions and entering the code “v0<16” where v0 is variable 0 or the first column with the sequential numbers.
- 6) In the Scatterplot menu click on the advanced tab bar and click on the “Corr. and p. (linear fit)” box. Then select the X (SpRich-2006) and Y (SpRich-2007) variables.
- 7) If the correlation between the two years is less than 0.5 then examine the plot for transects that are far away from the line.
- 8) You may need to return to the original transect data to determine if the species richness value is correct and whether to include it in the data set. In this example, $r = 0.71$ so it appears that the species richness data is reasonable.

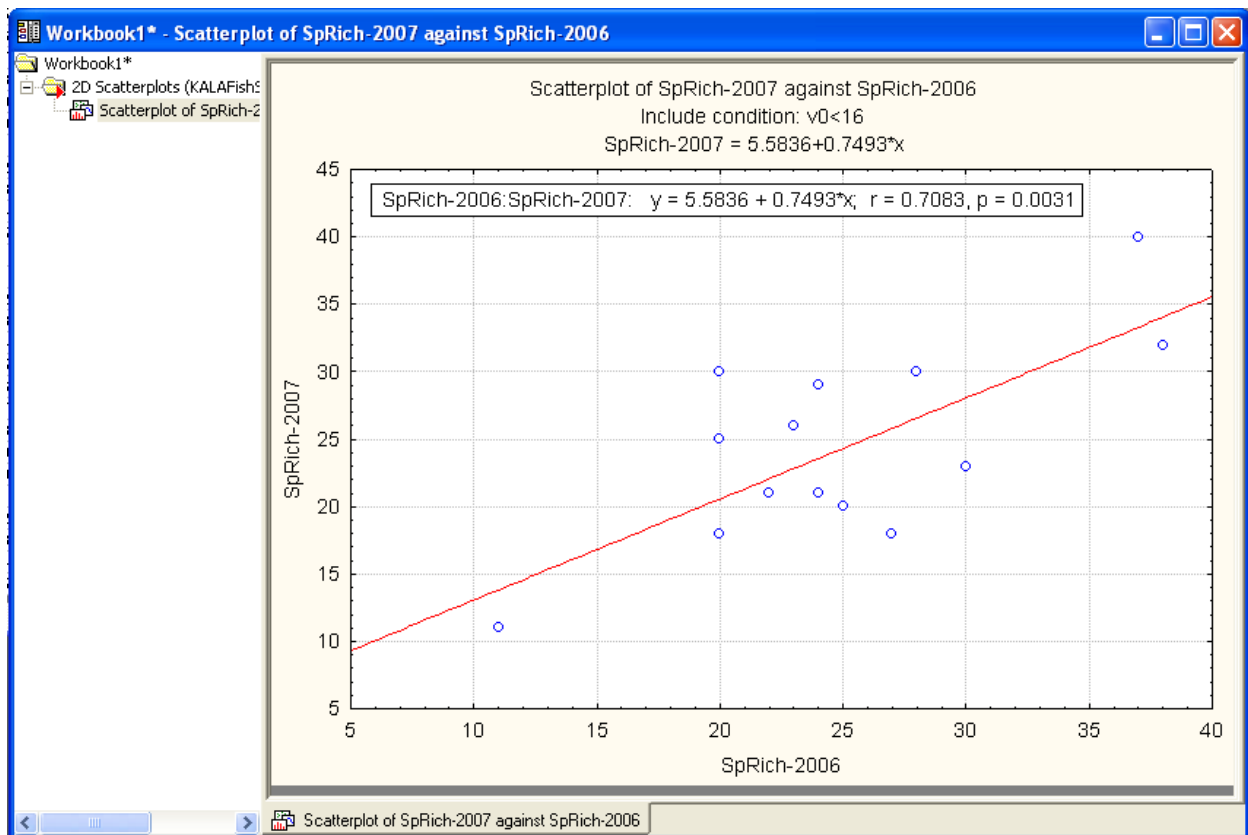


Figure S18.2. Scatterplot of fish species richness in 2007 against species richness in 2006.

- 9) Next, check the normality of the data by plotting the normal probability plot for fish species richness. Click on the Statistics – Basic Statistics/Tables – Descriptive Statistics – Prob. & Scatterplots tab.
- 10) Select the variables by pressing the Variables button. In this case select both SpRich-2006 and SpRich-2007. Again make sure that only the raw data is selected under the Select Cases button. *STATISTICA*® 8.0 will remember your selection conditions if you are doing these analyses in sequence.
- 11) Then press the Normal Probability plot and both graphs will be generated (Figure S18.3).
- 12) Ideally, the scatterplots should show the points linearly distributed and not arranged in a sigmoid or curved pattern.

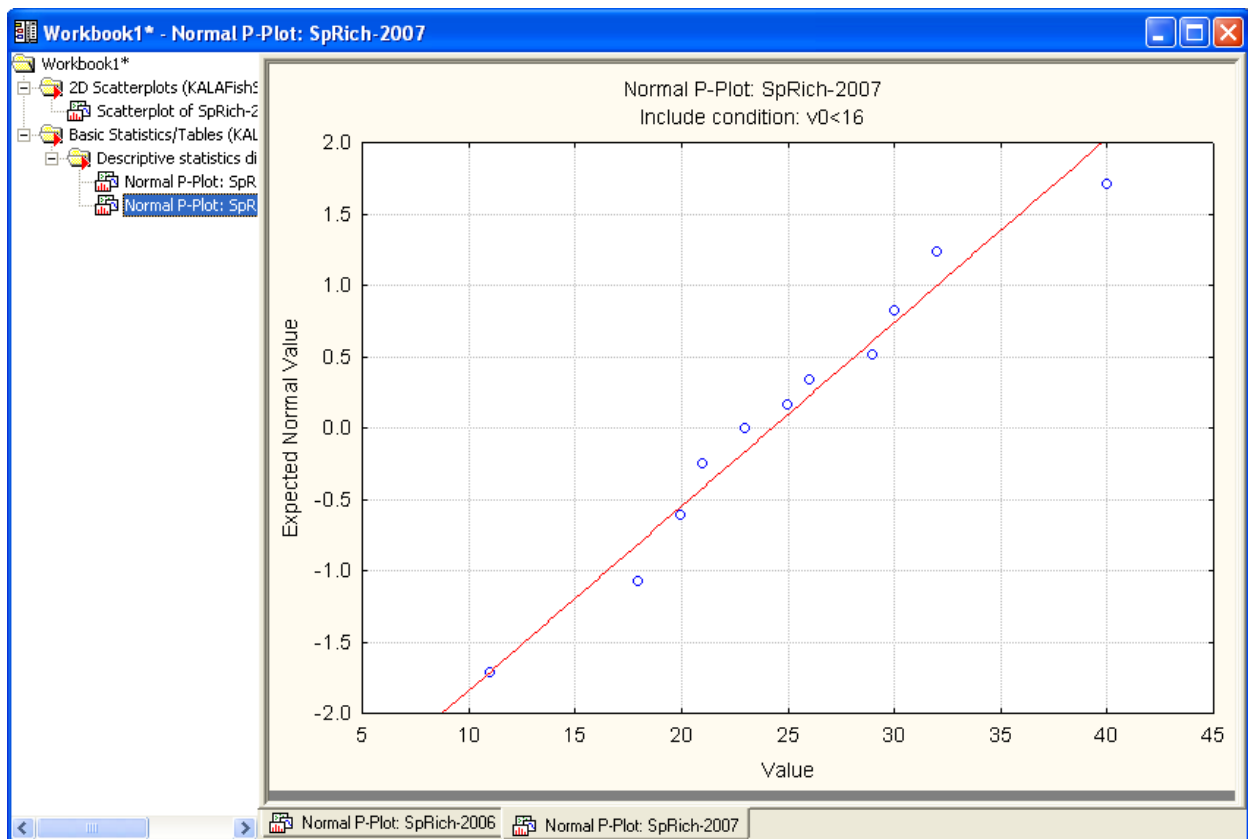


Figure S18.3. Normal probability plot of species richness for the current year (e.g., 2007).

- 13) Another test for normality is to plot the frequency histogram under Statistics – Basic Statistics/Tables – Descriptive Statistics – Normality tab (Figure S18.4). Make sure to check the “Kolmogorov-Smirnov & Lilliefors test for normality” box and click on Histograms.
- 14) The plots should look normally distributed with p values >0.05 . It should be mentioned that the repeated measures ANOVA is fairly robust to departures from normality, especially with a large sample size. Consequently, don’t worry too much if the plots are slightly skewed.
- 15) Generating the table of mean and standard deviation of fish species richness by transect is done from a query within the Microsoft Access® database (See Appendix G: Database Documentation) or from *STATISTICA*® 8.0 when performing the statistical tests. This is useful to examine the variability of fish species richness among the transects within the park and ultimately determine if the sample size is appropriate.
- 16) If the range in variances for the raw data exceed 2X or the normality plots are skewed then one needs to conduct the previous steps with the transformed data (i.e. $v0>16$ in the “Select Cases” button) prior to data analysis.

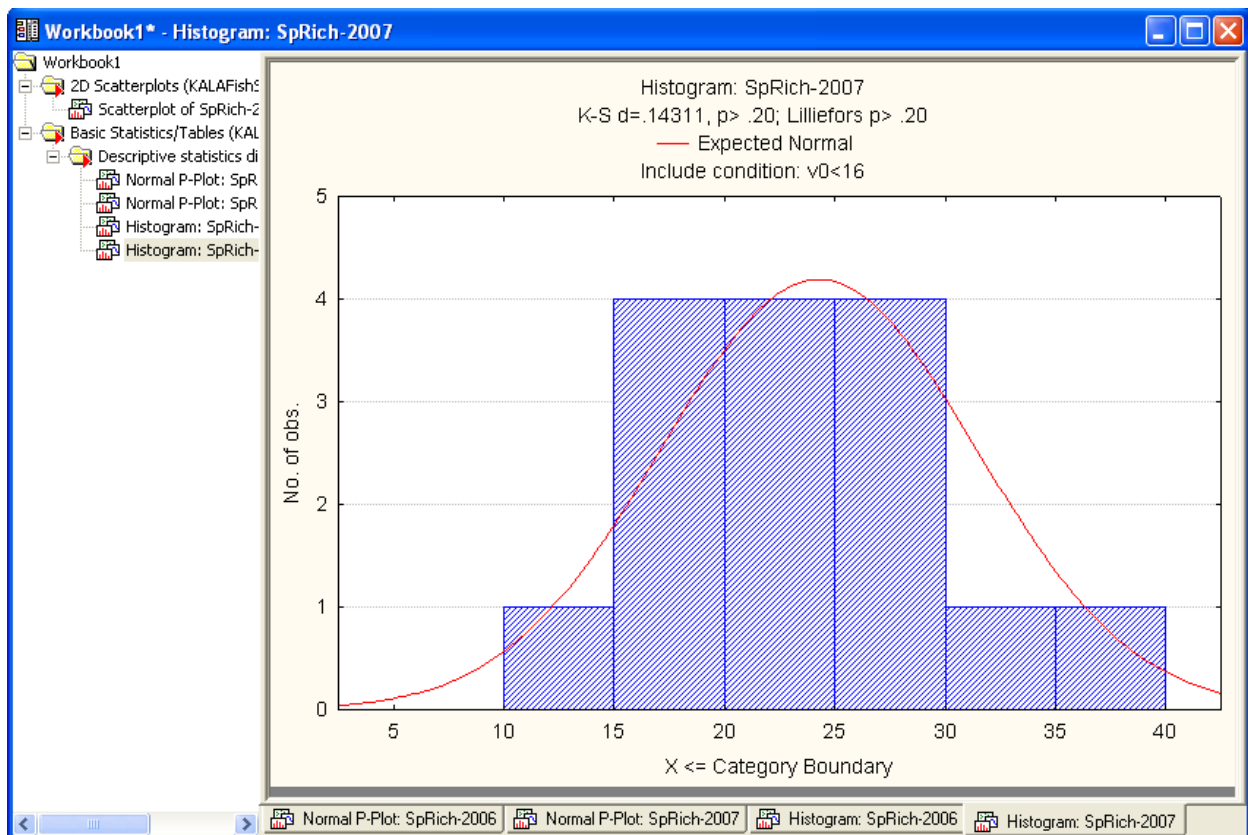


Figure S18.4. Frequency histogram of fish species richness in 2007 showing the Kolmogorov-Smirnov (K-S) & Lilliefors test for normality.

Example #2: Landscape analysis of fish species richness at park level.

- 1) Generating a table of current year mean and standard deviation of fish species richness by transect can be done in Microsoft Access® or the statistical program. Typically the Microsoft Access® table also includes abundance, biomass, and diversity along with the transect locations in UTM coordinates.
- 2) The Microsoft Access® table can be imported into ArcMap® using either File – Add Data or pressing the “Add Data” button and navigating to the file.
- 3) Once the file is in ArcMap® display the X-Y data. Note that it is beyond the scope of this SOP to provide detailed instructions on ArcMap®. It is assumed that the user has some experience with ArcMap® (<http://www.esri.com/>).
- 4) The bubble plots of fish species richness overlays graduated bubbles on the X-Y data, representing species richness by transect, on a georectified aerial image (Figure S18.5)

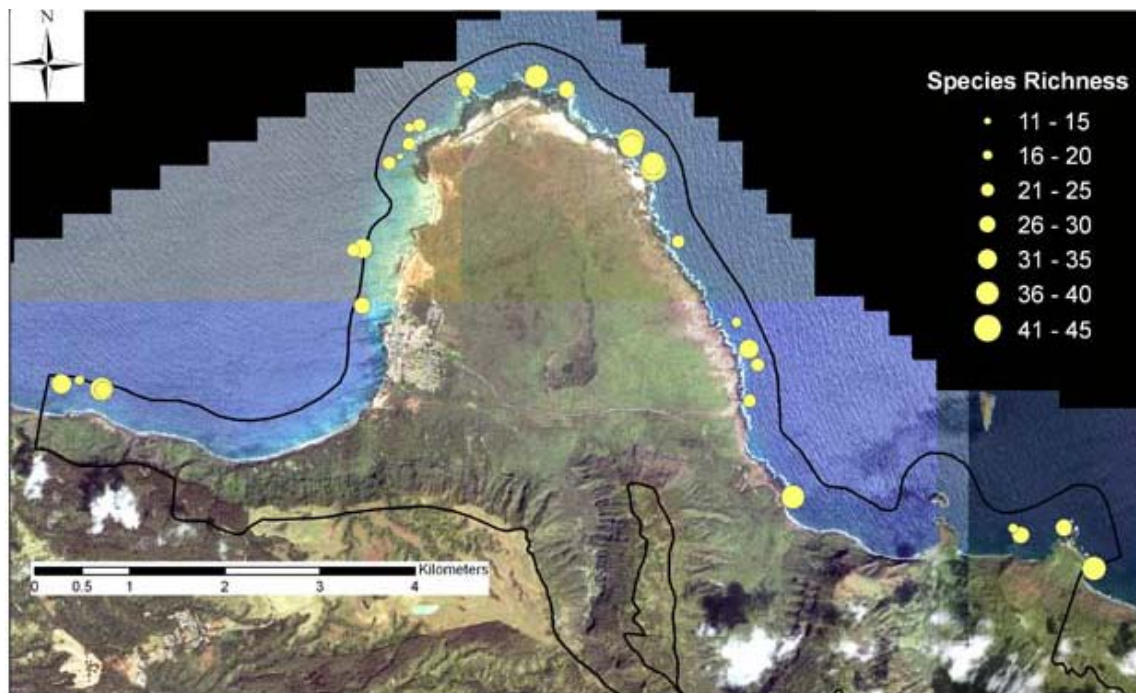


Figure S18.5. Example of graduated bubbles representing fish species richness on each transect at KALA in 2007 and overlaid on a georectified aerial image. Both fixed and temporary transects are shown.

- 5) In ArcMap[®] select the shape file and right click to display Properties. Select the Symbology tab – Quantities – Graduated symbols. For the Value field select Species Richness in the pull down box. Then adjust the symbol sizes, classification intervals, and symbol color to suit your preferences.
- 6) Press the “OK” button to display the numerical data.
- 7) The same procedure is used to create the ArcMap[®] bubble plot of abundance and other variables within the park, except use the abundance field instead of species richness in the Symbology tab with the shape file’s properties.

Example #3: Trend analysis of fish species richness for fixed transect data.

- 1) For all years after the first sampling year, it is possible to adjust the previous year’s mean and standard deviation using the mean values for both fixed and temporary transects from the current year. The adjusted mean for the prior year is a weighted average (equation 29 in Skalski 2005) of the prior year estimate of species richness and the current year estimate of species richness along with the associated variance values.
- 2) The prior year transect values are updated for subsequent analyses and plots by using an Microsoft Excel[®] spreadsheet “FixedSitePriorYearCorrection.xls” that can be provided to any users by the current Project Lead. Simply insert the prior year and current year means for both fixed and temporary transects into the table.

- 3) Then copy these mean transect values into *STATISTICA*® 8.0 and perform a simple linear regression analysis to generate the following coefficients; 1) Standard Error of B for the intercept, 2) B for the previous year, 3) Standard Error of B for the previous year, and 4) Covariances of Regression. (See example in “FixedSitePriorYearCorrection.xls” spreadsheet).
- 4) The adjusted prior year population mean and variance can now be substituted into graphs and regression analyses to examine temporal patterns. Generally, the adjusted variances will be lower which further increases the statistical power of the test (See Chapter 2 in the narrative on the benefits of the adjusted mean calculations). It is important to note that the adjusted mean calculations are only done on the previous year. Once that mean is adjusted it is no longer updated in subsequent years. For example, after adjusting 2007 data with 2008 data then in 2009 only the 2008 data is adjusted and the 2007 adjusted data is left intact.
- 5) Repeat this procedure with the other variables such as abundance, biomass, and diversity.
- 6) To plot the mean and standard deviation of species richness over time it is easiest to conduct the repeated measures ANOVA in *STATISTICA*® 8.0 on the raw data and display the resulting graphs. Then the adjusted means and variances can be substituted into the plot at a later date to see the improvement in the fit.
- 7) Start with the statistics data file shown in Figure S18.2. Select Statistics – Advanced Linear/Nonlinear Models – General Linear Models – Repeated Measures ANOVA. Make sure to only “Select Cases” for the raw data.
- 8) Under “Variables” select all of the annual species richness variables for the “Dependent variable list:”. In the example above (Figure S18.1), select columns 2 and 6.
- 9) Do not select any “Categorical predictors (factors):” and then press OK.
- 10) Under “Within effects:”, specify the number of years (current example =2) for levels and Year for Factor Name: in the first line.
- 11) After pressing OK then press the All effects/Graph button.
- 12) The resulting graph (Figure S18.6a) can be modified within *STATISTICA*® 8.0 (Figure S18.6b) for reporting purposes. The chart modifications are beyond the scope of this protocol, but almost any statistical software package has the capability to edit charts for professional presentations.

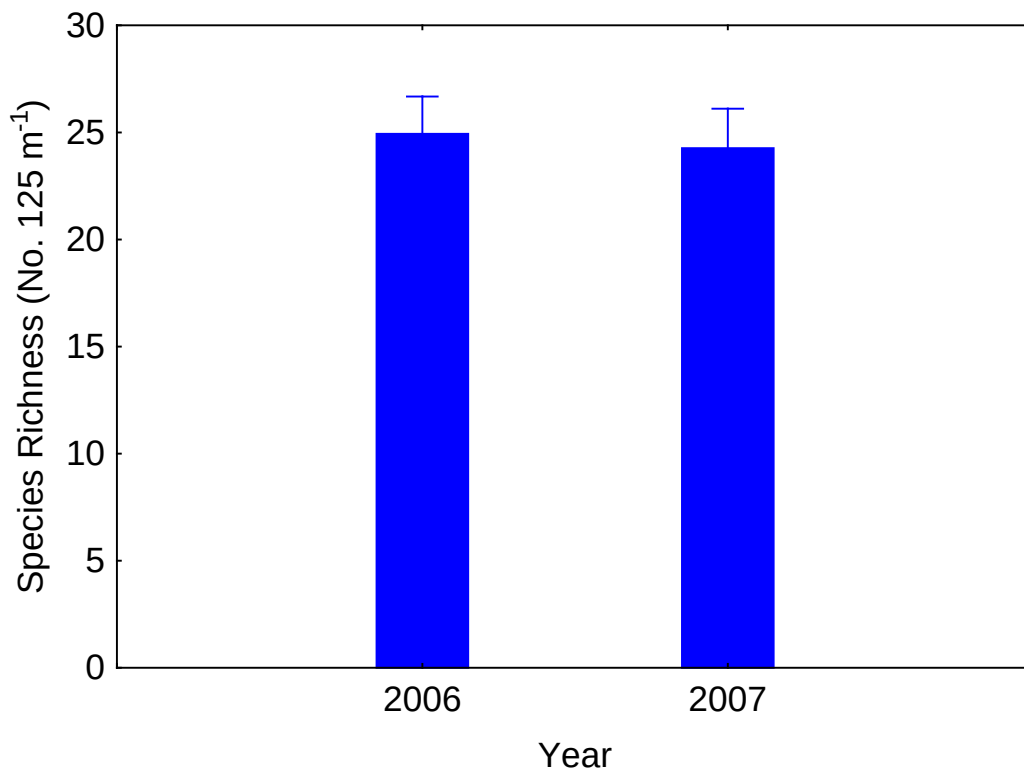
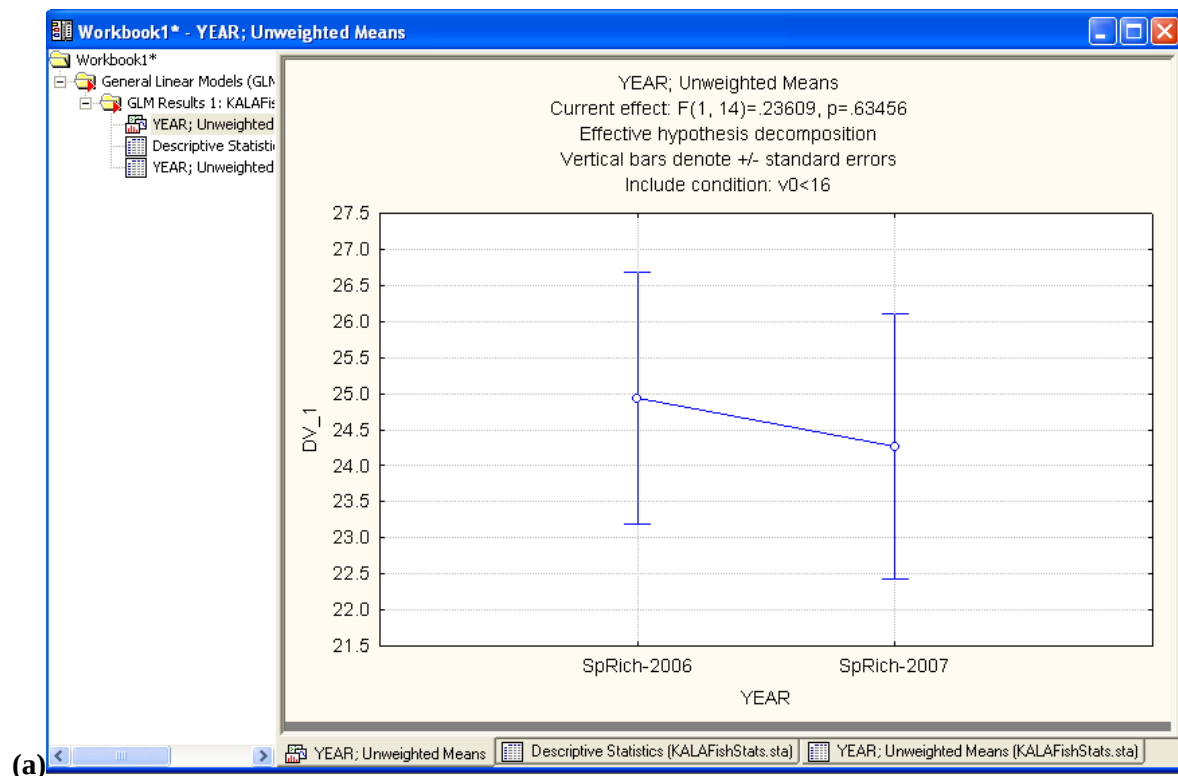


Figure S18.6. Examples of unmodified (a) and modified (b) charts depicting trends in average fish species richness at KALA across time. Error bars are Mean $\pm$ 1 Standard Error.

- 13) A repeated measures ANOVA is then conducted to determine if the temporal trend observed in Figure S18.6 is statistically significant.
- 14) If the data meet the assumptions (e.g. variances within 2x and error normally distributed) of the test then use the raw data. Otherwise, a transformation is necessary. In this example the raw data meet the assumptions but is $\log(x+1)$ transformed to illustrate the data structure and subsequent tests (See Zar 1999).
- 15) To select the transformed data, go back to the original Statistics – Advanced Linear/Nonlinear Models – General Linear Models – Repeated Measures ANOVA screen and press the “Select Cases” button. Then change the conditions from “ $v0 < 16$ ” to “ $v0 > 16$ ”.
- 16) Using the transformed data then select Statistics – Advanced Linear/Nonlinear Models – General Linear Models – Repeated Measures ANOVA.
- 17) Under “Variables” select all of the annual species richness variables for the “Dependent variable list:”
- 18) Do not select any “Categorical predictors (factors):” and then press OK.
- 19) Under “Within effects:” specify the number of years (Current example = 2) for levels and Year for Factor Name: in the first line.
- 20) Press the All effects button to see the ANOVA table (Figure S18.7). If any of the years are significant at the $\alpha = 0.05$ level then additional post-hoc tests can be performed to determine which year is accounting for the significant difference.
- 21) This is done by pressing the “More results” button and then selecting the “Post-hoc” tab.
- 22) Select the effect of interest (Year in this case) and use either the Tukey HSD or the Unequal N HSD for unequal sample sizes. Both are preferred over the other options (e.g. Newman-Keuls) because they are more conservative and widely utilized.
- 23) When reporting the results from the statistical tests using the transformed data it is important to back transform the data for presentation. For example, if the species richness data were $\log(x+1)$ transformed for statistical analysis then the back-transformation would raise 10 to the power of the transformed value minus one. For example, in Microsoft Excel[®] use the following equation: $= 10^{(\text{transformed data})-1}$. Alternatively, one can present the raw data in graphs and use the transformed data in the statistical tests.
- 24) The ArcMap[®] bubble plots of trends in species richness at a park are created using the procedures outlined above (Steps 3-7 in Example #2). This chart overlays

proportional or quantity bubbles, representing relative change in species richness, on a georectified aerial image (Figure S18.8).

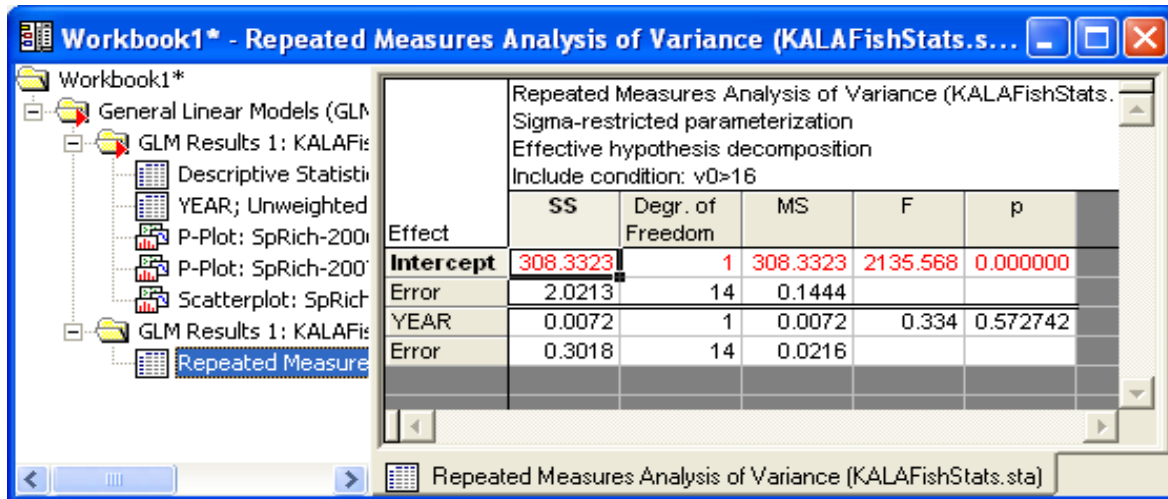


Figure S18.7. Results table for Repeated Measures ANOVA. Effects in red (e.g., Intercept) are significant at the $\alpha = 0.05$ level. In this example, there is no significant difference ($p = 0.57$) between the two years.

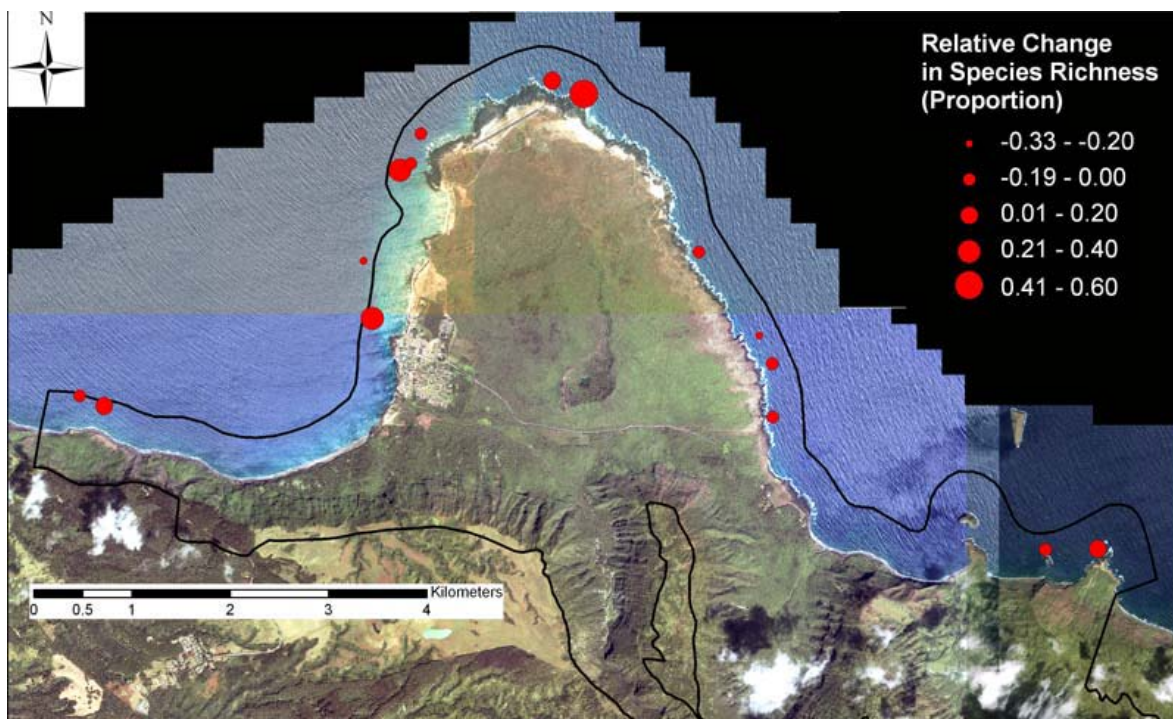


Figure S18.8. Example of quantitative bubbles representing relative change in species richness on each transect from 2006 - 2007 at KALA.

- 25) The same procedure is used to create the ArcMap[®] bubble plot of trends in abundance, biomass, and diversity within the park except use the appropriate fields in the symbology tab under properties for that shape file.

The preceding section on data analysis followed a univariate approach, but this does not preclude the descriptive techniques of multivariate analysis such as multidimensional scaling (e.g., Clarke and Warwick 2001). For example, Friedlander et al., (2007) used a multidimensional scaling plot to display spatial patterns in fish biomass using similar type data (Figure S18.9). Trend analysis could easily be conducted with a similar data structure with time samples integrated with spatial samples (See Clarke and Warwick, 2001 for examples).

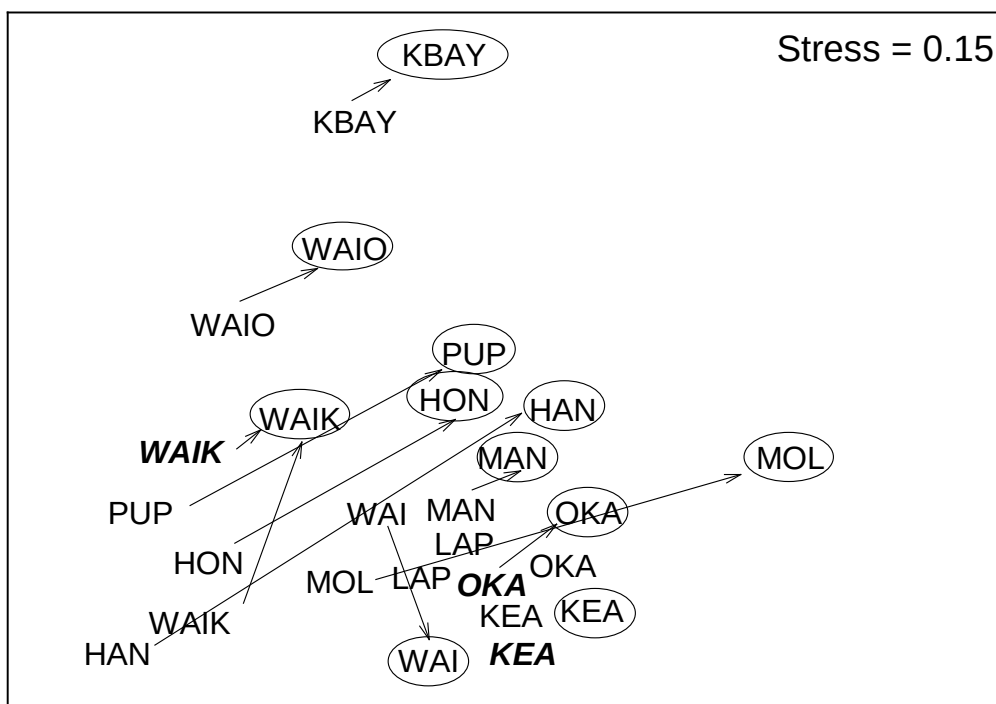


Figure S18.9: An example of a non-metric multidimensional scaling (MDS) ordination of mean fish biomass for protected areas, adjacent open areas, and fisheries management areas (FMAs). Protected areas are circled, open areas in normal font, and FMAs in bold italics. Lines denote direction and magnitude from open area or FMA to corresponding protected areas in ordination space. Figure from Friedlander et al. (2007) along with site codes.

Reporting Overview

Report Types

We anticipate that all reports generated in association with this Vital Sign will encompass fish species richness, abundance, biomass, and diversity. Unlike the analysis log files which will generate individual files for each park and each of the three analysis strategies (unit, landscape, and trend assessment levels), reporting documents will integrate both parks and analysis strategies. Table S18.3 identifies product types, purposes, targeted audiences, responsible parties, production frequency, and review processes. See SOP #16: Product Delivery Specifications and Appendix H: Yearly Project Task List for scheduling information. We have identified a cohesive suite of seven product categories: (1) program and protocol reviews, (2) monitoring protocol and project reports, (3) status and trends reports, (4) scientific writing and presentations, (5) management briefings, (6) website communication, and (7) interpretation and outreach.

Table S18.3. Summary of anticipated products, grouped by type and frequency

Type of Report	Purpose of Report	Targeted Audience	Initiated by	Frequency of Reporting	Review Process
<i>Program and Protocol Reviews</i>					
Protocol Review Reports	Document where actual procedures fall short or exceed expectations, recommend necessary changes, document changes since last protocol review report; document overall quality of protocol – particularly in terms of protocol objectives and implementation, effectiveness, and data management.	Superintendents, park resource staff, I&M staff, service-wide program managers, external scientists, partners	Project Lead	Within 1-3 years of implementation, 5-year intervals thereafter	Peer review at network and regional level
<i>Monitoring Protocol and Project Reports</i>					
Vital Signs Monitoring Protocol Reports	Document and archive annual monitoring activities and data, describe current resource condition and core analysis results, document related data management activities, document changes in monitoring protocol, communicate monitoring efforts to resource managers. During protocol development stages, will emphasize progress made and challenges encountered.	Park resource staff, PACN staff, external scientists, partners	Project Lead and I&M Marine Ecologist	Annually, compiled each March	Peer review at network level
Summary of Vital Sign Monitoring Protocol Reports	Same as annual “Vital Sign Monitoring Protocol Reports” above, but highlights key points for non-technical audiences	Superintendents, NPS interpreters, public, partners	Project Lead and I&M Marine Ecologist	Annually, compiled each March	Peer review at network level
Pilot Projects and Monitoring Research Reports	Provide background and methods of monitoring protocol development and other methods related investigations	Park resource managers, PACN Staff, external scientists, partners	Project Lead and I&M Marine Ecologist	Variable with annual status reporting, as necessary	Peer review at network level plus review appropriate to final product

Table S18.3. Summary of anticipated products, grouped by type and frequency (continued)

Type of Report	Purpose of Report	Targeted Audience	Initiated by	Frequency of Reporting	Review Process
<i>Status and Trends Reports</i>					
Trend Analysis and Synthesis Reports	Describe and interpret patterns/trends of monitored resources, identify new characteristics of resources and correlations among monitored resources, identify relationships between drivers/stressors and responses at various scales, recommend changes to management of resources (adaptive management feedback). Analysis and reporting will occur at multiple scales, including park, multi-park, and network/regional.	Park resource managers, PACN staff, external scientists, partners	Project Lead, Park ecologists	3-5 year intervals. Abbreviated annual edition, as necessary for PACN Vital Signs Program	Peer review at the network and regional level
Summary of: Trend Analysis and Synthesis Report	Executive summary of "Trend Analysis and Synthesis Report" above with key points on one page for non-technical audiences. Usually this is a bulleted list.	Superintendents, NPS interpreters, public, partners	Project Lead	Commensurate with reporting activity of "Trend Analysis and Synthesis Report"	Peer review at the network level
PACN contribution to NPS-wide "State of the Parks" Report	Describes current conditions of park resources, reports interesting trends and highlights of monitoring activities, identifies resource issues of concern, explores future issues and directions	Congress, budget office, NPS leadership, Superintendents, general public	Compiled by the Washington Support Office (WASO) from data provided by networks	Annual	Peer review at national level
<i>Scientific Writing and Presentations</i>					
PACN Vital Signs Monitoring Conference	Review and summarize information on this Vital Sign, help identify emerging issues and generate new ideas	Park resource staff, network staff, external scientists, partners	I&M Marine Ecologist, Project Lead, others	Biennial (around time PACN "Status and Trends Report" is published)	Peer review at national level
Scientific journal articles and book chapters	Document and communicate advances in knowledge, provides a broader perspective on quality assurance and peer review	External scientists, Park resource managers, and professional staff	Project Lead, Park ecologists	Variable	Peer review according to journal or book standards

Table S18.3. Summary of anticipated products, grouped by type and frequency (continued)

Type of Report	Purpose of Report	Targeted Audience	Initiated by	Frequency of Reporting	Review Process
Other symposia, conferences and workshops	Review and summarize information on this Vital Sign, help identify emerging issues and generate new ideas	External scientists, professional staff, Park resource managers, and other resource managers.	Project Lead, Park ecologists	Variable (e.g., Hawaii Conservation Conference, George Wright Society, International Coral Reef Symposium)	Peer review at network level; for papers may also be peer reviewed
<i>Management Briefings</i>					
Protected area managers briefing	Communicate highlights and potential management action items, with 1-2 page briefing statements for each protocol	Park resource staff, Network staff, agency, academic scientists, other Federal, State, and Territorial Protected Area managers, discipline specialists, interpretive staff	Program Manager, Park ecologists, Project Lead	Annually, likely in conjunction with Board of Directors administrative meetings	Peer review by network staff
Executive briefings	Update Superintendents and other VIPs on park-specific findings and potential resource issues; suggest action items where appropriate	Individual Superintendents and other VIPs	Project Lead, Park ecologists, Program Manager	As needed	Peer review by network staff
<i>Website Posting</i>					
Web-based media	Centralized repository of all final reports to ensure products are easily accessible in commonly-used electronic formats; other synthesized information on the PACN	Superintendents, Park resource staff, PACN staff, service-wide program managers, external scientists, partners, students, public	Variable, typically network webmaster	As media is completed	Peer review at network level to NPS web standards as finalized, reviewed products

Table S18.3. Summary of anticipated products, grouped by type and frequency (continued)

Type of Report	Purpose of Report	Targeted Audience	Initiated by	Frequency of Reporting	Review Process
<i>Interpretation and Outreach</i>					
Science Days	Communicate main monitoring findings as well as underlying data; discuss potential significance for management, further monitoring, potential additional research needs, and for outreach	Superintendents, park resource staff, PACN staff, protocol managers, partners, public	Project Lead, Technician, I&M Marine Ecologist and others as needed	Variable by park, annual when possible	Meeting/presentation itself is a form of review
Interpretive Conversations	Interactive conversations with park interpretive staff to discuss main monitoring findings as well as underlying data; discuss potential significance for management, further monitoring, potential additional research needs, and for outreach	Park interpretive staff, environmental educators, PACN staff	Project Lead, Technician, I&M Marine Ecologist and others as needed	Variable by park, at least annual when possible	Meeting/presentation itself is a form of review
Park Interpretive / outreach sessions	Review and summarize information on PACN Vital Signs; engage and involve greater participation in monitoring efforts	Park staff, public, partners	Project Lead, Technician, I&M Marine Ecologist and others as needed	Variable	Peer review by network, I&M staff
Park staff meetings (results synthesis)	Communicate results to non-technical audiences, discuss potential significance for management, receive feedback on resource and monitoring issues in park operations	All park staff, volunteers, and partners, especially those not typically encountered in I&M program, RM, science operations	Project Lead, Technician and others as needed	Annually for each network park	Peer review by network, I&M staff

Specific Instructions for Reports and Publications

Annual reports and trend analysis reports will use the NPS Natural Resource Publications template, a pre-formatted Microsoft Word[®] template document based on current NPS formatting standards. Annual reports will use the Natural Resource Report template. Trend analysis and other peer-reviewed technical reports will use the Natural Resource Technical Report template. Instructions for acquiring a series number and other information about NPS publication standards can be found at: <http://www.nature.nps.gov/publications/NRPM/index.cfm>. In general, the procedures for reports and publications are as follows:

- 1) The document should be formatted using the NPS Natural Resource Publications template. Formatting according to NPS standards is easiest when using the template from the very beginning, as opposed to reformatting an existing document.
- 2) The document should be peer reviewed at the appropriate level. For example, I&M Annual Reports should be reviewed by other members of the appropriate project work group. The Program Manager will also review all annual reports for completeness and compliance with I&M standards and expectations.
- 3) Upon completing the peer review, acquire a publication series number from the NPS Technical Information Center or the appropriate local or regional key official (currently the Regional I&M Coordinator).
- 4) Upload the file in PDF and Microsoft Word[®] formats to the PACN Digital Library submissions folder.
- 5) Send a printout to each Park Curator.
- 6) The Data Manager or a designee will create a bibliographic record and upload the PDF document to NRInfo according to document sensitivity.

Reporting Preparation Process

Reports identified in Table S18.3 are to be based on collected data and other science-based documentation. These reports will provide context and explanations for the results presented, as well as include any additional analyses that may result from initial investigations. The ‘analysis log’ files will serve as the basis for most of the reporting results. The biological technician for this Vital Sign is identified as the primary individual responsible for updating the analysis log files and will also be pivotal in preparation of subsequent reports. It is anticipated that the Principal Investigator, I&M personnel or another statistically trained individuals will be responsible for the statistical analyses.

Drafts of the reporting products will be organized according to the categories outlined above, with key versions and review comments archived, and final versions clearly communicated to PACN network staff to ensure distribution via websites and other channels.

Literature Cited

- Clarke, K., and R. Warwick. 2001. Change in marine communities: an approach to statistical analysis and interpretation. 2nd edition. Primer-E Ltd, Plymouth, UK.
- Cleveland, W.S. 1993. Visualizing data. Hobart Press. Summit, New Jersey, USA.
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- Friedlander, A. M., E. K. Brown, and M. E. Monaco. 2007. Coupling ecology and GIS to evaluate efficacy of marine protected areas in Hawaii. *Ecological Applications* **17**:715-730.
- Skalski, J.R. 2005. Long-term monitoring: Basic study designs, estimators, and precision and power calculations. Report submitted to National Park Service (NPS) Pacific Island Network (PACN) Inventory and Monitoring Program, Hawaii Volcanoes, Hawaii, USA.
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- Zar, J.H., 1999. Biostatistical Analysis. Prentice-Hall, Inc., Upper Saddle River, New Jersey, USA.

Table S18.4. Checklist for analysis log file.

Park:		
Section	Analysis	Date Completed
<i>Species Richness</i>	<u>Unit</u>	
	Examine outliers and treat data accordingly	
	Plot normal probability plot	
	Plot frequency histogram of distribution	
	<u>Landscape</u>	
	Generate table of current year mean and standard deviation of species richness by transect at the level of park.	
	Create ArcMap [®] bubble plot of species richness at park	
	<u>Trend</u>	
	Generate table of adjusted mean and standard deviation of species richness at the level of park for previous year.	
	Plot mean and standard deviation of species richness over all sampling periods.	
	Conduct Repeated Measures ANOVA test on species richness at the fixed transects. Transform if appropriate.	
	Create ArcMap [®] bubble plot of trend in species richness at park	
<i>Abundance</i>	<u>Unit</u>	
	Examine outliers and treat data accordingly	
	Plot normal probability plot	
	Plot frequency histogram of distribution	
	<u>Landscape</u>	
	Generate table of current year mean and standard deviation of abundance by transect at the level of park	
	Create ArcMap [®] bubble plot of abundance at park	
	<u>Trend</u>	
	Generate table of adjusted mean and standard deviation of abundance at the level of park for previous year	
	Plot mean and standard deviation of abundance over time.	
	Conduct Repeated Measures ANOVA test on abundance at the fixed transects. Transform data if appropriate.	
	Create ArcMap [®] bubble plot of trends in abundance at park	
<i>Biomass</i>	<u>Unit</u>	
	Examine outliers and treat data accordingly	
	Plot normal probability plot	
	Plot frequency histogram of distribution	
	<u>Landscape</u>	
	Generate table of current year mean and standard deviation of biomass by transect at the level of park	
	Create ArcMap [®] bubble plot of biomass at park	
	<u>Trend</u>	
	Generate table of adjusted mean and standard deviation of biomass at the level of park for previous year	

Park:		
Section	Analysis	Date Completed
	Plot mean and standard deviation of biomass over time.	
	Conduct Repeated Measures ANOVA test on biomass at the fixed transects. Transform data if appropriate.	
	Create ArcMap [®] bubble plot of trends in biomass at park	
Diversity	<u>Unit</u>	
	Examine outliers and treat data accordingly	
	Plot normal probability plot	
	Plot frequency histogram of distribution	
	<u>Landscape</u>	
	Generate table of current year mean and standard deviation of diversity by transect at the level of park	
	Create ArcMap [®] bubble plot of diversity at park	
	<u>Trend</u>	
	Generate table of adjusted mean and standard deviation of diversity at the level of park for previous year	
	Plot mean and standard deviation of diversity over time.	
	Conduct Repeated Measures ANOVA test on diversity at the fixed transects. Transform data if appropriate.	
	Create ArcMap [®] bubble plot of trends in diversity at park	

Additional univariate and multivariate variables of interest that can be extracted from Microsoft Access[®] include 1) Trophic breakdowns by transect, 2) Family breakdowns by transect 3) Species level abundance matrix by transect, 4) Species level biomass matrix by transect, and 5) Species level size frequency distribution by transect. Each of the univariate data sets (e.g. 1 & 2) would go through a similar sequence of analytical procedures. The multivariate data sets (e.g. 3, 4, & 5) would require a multivariate statistical package such as PRIMER[®] to analyze and display the multidimensional scaling plots.

Appendix 4. SOP #19: After the Field Season

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This SOP explains chronological actions after the field season for personnel involved in the Marine Fish Monitoring Protocol in the Pacific Islands Network. The field season for this protocol begins in the spring and includes the installation and maintenance of any transect or sampling equipment, underwater surveys, and ends with the clean up and storage of the equipment. This SOP outlines the proper post-season maintenance and storage for the SCUBA gear, vessel, and survey equipment for each objective of the protocol. The post-field season will follow the last dive of the season.

A master equipment list for the entire Marine Fish Vital Sign Monitoring Protocol can be found in Appendix S1.a of SOP #1 “Before the Field Season.” The master equipment list should be updated simultaneously if any SOP requiring an equipment list is revised.

SCUBA Gear

Rinse

All SCUBA gear must be rinsed with fresh water following each dive, as described in SOP #8 “Post-Dive Procedures and Equipment Maintenance.” Marine environments can accelerate wear and deterioration of sampling tools and equipment thus requiring special consideration for adequate maintenance and storage while not in use. After the final dive of the season, all field gear should be thoroughly immersed for one-half hour, and then rinsed with running clean fresh water. Allow gear to dry completely prior to returning it to the proper storage area.

Inspect for Repairs

During the final rinse and storage of equipment, inspect and identify SCUBA gear that may be in need of repair, maintenance, or replacement. An equipment list for conducting diving activities can be found in Appendix S1.a in SOP #1 “Before the Field Season.” Prepare a service schedule as required by Reference Manual #4 – Diving Management (RM-4) and coordinate the maintenance activities to accommodate the next field season.

Storage

After servicing, store the SCUBA gear in a cool, dry location away from weathering elements (e.g., sun, rain, wind).

Maintenance Log

Prepare a maintenance log that clearly identifies each piece of gear, the date serviced, and the type of maintenance performed.

Marine Fish Survey Equipment

Step by Step Procedures:

- 1) Rinse all equipment for marine fish surveys after each use and at the end of the field season with freshwater. Allow equipment to dry thoroughly prior to returning it to the proper storage areas.
- 2) After rinsing the transect tape/lines with freshwater, verify that they are functioning properly. To rinse thoroughly, unspool the transect tape in a container of freshwater. Repair or replace as necessary and re-spool on reels without twists, kinks or cuts. When dried, store the transect tapes/lines in a cool, dry location.
- 3) After identification of the equipment that may require servicing, prepare a maintenance schedule in preparation for SOP #1 “Before the Field Season.”

Research Vessel

General Maintenance

Step by Step Procedures:

- 1) Inspect all boating supplies (Appendix S1.a in SOP #1 “Before the Field Season”) to verify that they are in working order and will be ready for use during the next scheduled field season. Remove and care for engine batteries.

- 2) Inspect the mooring lines, including chafing gear, and ensure that they are undamaged and secure. Repair or replace as necessary.
- 3) Inspect anchor, shackle(s), wire(s), and chain/line for any rust, wear or breakage. Repair or replace as necessary.
- 4) Ensure that the bilge pump is in working condition.
- 5) Inventory the first aid kit (including sunscreen and water) and replace the items that have been used or are past their expiration date.
- 6) Inspect personal floatation devices (PFDs) for damage, including any straps, whistles or lights. Service or replace as needed.
- 7) Inspect emergency oxygen kit. Test equipment to insure masks and valves are working properly. Replace, refill, or service as needed.
- 8) Ensure that all electronics are in working order. Electronics include any compasses, GPS/plotter, depth finder, or CB/VHF radio.
- 9) Check the expiration dates for the fire extinguisher and flares and compare with the schedule for the next field season. Make arrangements to service or replace them before they expire.
- 10) Note the expiration dates for the boat registration and ramp fees (if required). Arrange to have them updated as necessary before the next field season.
- 11) Carefully do a visual inspection of the inner and outer hull, anchor locker, console, canopy, or antenna mounts (if any) for cracks, stress or other damage. Pay particular attention to stress areas including: cleats, line or lifting eyes, rails, and transom near engine mounts. Thoroughly flush cable channel with freshwater or clean other under deck spaces as recommended by manufacturer. Clean out and air dry under deck spaces and console interior to prevent mold, mildew or damage. Repair or replace any parts or areas as necessary. Cover the whole boat, including engine, and trailer chassis securely with a heavy duty, opaque, waterproof material secured by ropes or bungee cords. Then store the vessel as per park specific guidelines to protect the boat from the elements.

Boat Motor Maintenance

Step by Step Procedures:

- 1) Follow the manufacturer's guidelines for scheduled boat motor maintenance.
- 2) Inspect all boat motor equipment (Appendix S1.a in SOP #1 "Before the Field Season") to verify that it's in working order and will be ready for use during the next scheduled field season.

- 3) After identification of the equipment that may require servicing, or seasonal/long-term storage, prepare a maintenance schedule and coordinate the activities in preparation for the next field season.

Boat Trailer Maintenance

Step by Step Procedures:

- 1) Rinse in fresh water and allow it to dry. Inspect the boat trailer to verify that it's in working order and will be ready for use during the next scheduled field season.
- 2) Follow the manufacturer's guidelines for scheduled maintenance of the boat trailer's tires, axle bearings, frame and lights.
- 3) Note the expiration dates for the trailer registration and safety check. Arrange to have these updated as necessary before the next field season.
- 4) After identification of the equipment that may require servicing, prepare a maintenance schedule and coordinate the activities in preparation for the next field season.

Appendix K. SOP #20: Revising the Protocol

Revision Log

Only changes in this specific SOP will be logged here. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). Record the previous version number, date of revision, author of the revision; identify paragraphs and pages where changes are made, who approved the revision, and the reason for making the changes along with the new version number.

New Version Number	Revision Date	Author	Changes Made	Reasons for Change	Network Regional Reviewer Approval	Previous Version Number

Purpose

This Standard Operating Procedure explains how to make and document changes to the Marine Fish Vital Sign Monitoring Protocol narrative and associated SOPs for the PACN. Anyone editing the Protocol Narrative or any one of the SOPs needs to follow this outlined procedure in order to eliminate confusion in how data is collected, managed, analyzed, or reported. All observers should be familiar with this SOP in order to identify and use the most current methodologies.

A master equipment list for the entire Marine Fish Vital Sign Monitoring Protocol can be found in Appendix S1.a of SOP #1 “Before the Field Season.” The master equipment list should be updated simultaneously if any SOP requiring an equipment list is revised.

Rationale

The Marine Fish Vital Sign monitoring protocol narrative and associated SOPs for the PACN represents an effort to document and employ scientifically rigorous methodologies for collecting, managing, analyzing, and reporting Marine Fish monitoring data and information. However, all protocols, regardless of initial rigor require editing as new and different information, techniques, or technologies become available. Required edits should be made in a timely manner and appropriate reviews undertaken. Careful documentation of changes to the protocol, and a library of previous protocol versions are essential for maintaining consistency in data collection and for appropriate treatment of the data during data summary and analysis. The Microsoft Access[®] database for each monitoring component contains a field that identifies which version of the protocol was in use when the data were collected.

In this context of revising the protocol, the rationale for dividing this document into a Protocol Narrative with supporting SOPs is based on the following:

- 1) The Protocol Narrative is a general overview of the protocol that gives the history and justification for monitoring and an overview of the sampling methods, but does not provide all of the methodological details. The Protocol Narrative will only be revised if major changes are made to the protocol.
- 2) The SOPs, in contrast, are very specific step-by-step instructions for performing a given task. They are expected to be revised more frequently than the protocol narrative.
- 3) When an SOP is revised, in most cases, it is not necessary to revise the Protocol Narrative to reflect the specific changes made to the SOP.
- 4) All versions of the Protocol Narrative and SOPs will be archived in a Protocol Library.

Revision Procedure

All edits require review for clarity and technical soundness. Small changes or additions to existing methods should be reviewed in-house by PACN staff (e.g., version changes by hundredths). However, if there is a complete or major change in methods, then an outside review may be required (e.g., version changes by whole numbers). If there is a major change in methodology, either to the entire protocol or individual SOPs or narrative components, The Pacific West Region Inventory and Monitoring Program coordinator should be consulted to determine the appropriate level of peer review required. Typically, regional and national staff of the NPS, and outside experts in government, private sector, and academia with familiarity in marine fish monitoring in the Pacific Islands will be utilized as reviewers.

Metadata

Any changes to associated database design and organization are documented in the Metadata of the project database(s).

Notification

The Data Manager should be informed of changes to the Protocol Narrative or SOPs so the new version number can be incorporated in the Metadata of the project database. The database may have to be edited by the Data Manager to accompany changes in the Protocol Narrative or SOPs.

The appropriate PACN staff should be notified of the changes and appropriate level review process initiated as determined in collaboration between the network staff and protocol principal investigator.

Once review comments are received, incorporated, and approved, post revised versions on the internet and forward copies to all individuals with a previous version of the affected Protocol Narrative or SOPs, including the PACN Data Manager for inclusion in the network's protocol library.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 988/108137, June 2011

National Park Service
U.S. Department of the Interior



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