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Technical Report 180

The use of predator proof fencing as a management tool in the Hawaiian Islands: a case study of Ka`ena Point Natural Area Reserve

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ABSTRACT

The Ka`ena Point Ecosystem Restoration Project was the result of a partnership between the Hawai`i Department of Land and Natural Resources, Divisions of Forestry and Wildlife and State Parks, the U.S. Fish and Wildlife Service, and the Hawai`i Chapter of The Wildlife Society. Ka`ena Point Natural Area Reserve (NAR) hosts one of the largest seabird colonies in the main Hawaiian islands, three species of endangered plants, and is a pupping ground for the endangered Hawaiian monk seals. Prior to fence construction, nesting seabirds and native plants were under constant threat from predatory animals; up to 15% of seabird chicks were killed each year prior to fledging and many endangered plants were unable to reproduce as a result of seed predation. The project involved the construction of predator-proof fencing (2m tall) to prevent feral predators such as dogs, cats, mongoose, rats and mice from entering into 20ha of coastal habitat within Ka`ena Point, followed by removal of these species.

The project was initiated with the hiring of a project coordinator, followed closely by hiring of a two-person public outreach team. The public outreach was extensive reaching over 2500 individuals via personal contact and tens of thousands more as a result of dozens of stories appearing on evening news channels, articles published in local newspapers and newsletters, and several mini-documentaries aired on local cable television shows. A website was also established to post educational materials and information on the project (www.restoreKa`ena.org). The vast majority of the public was supportive despite the vigorous objections of a few individuals.

Multiple federal, state and county permits were required. In total 12 permits were applied for and obtained over a four-year period. Two years were lost as a result of multiple contested cases filed against the project which prevented progress during their resolution. Final permit approvals were completed in November 2010, construction began on November 10, 2010 and was completed on March 30, 2011 after a two-month hiatus for the holidays

To document the effects of predator removal, extensive ecological monitoring was conducted on both native and non-native species prior to the predator removal. A permanent monitoring grid with points placed every 50m was established in the reserve to document micro-habitat shifts. Seabird populations in the reserve had been monitored intensively for over seven years, and a complete botanical, invertebrate and marine intertidal survey was conducted to document the vascular plant species present and their percent cover. Extensive rodent monitoring was also conducted to document the species present, their relative abundance, reproductive cycle, and home range to select the most effective eradication method. Based on monitoring results and regulatory restrictions, a combination of diphacinone in bait boxes, as well as live traps were used to eradicate rodents, and a combination of live-trapping and shooting was used to remove larger animals such as dogs, cats and mongoose. Invasive mammal eradication operations were initiated in February 2011 during the low point in the rodent reproductive cycle, using a combination of rodenticide in bait boxes spaced 25m apart and live multiple-catch traps placed 12.5m apart. Within three months, all predators, with the exception of mice were

eradicated from within the reserve. Mice took an additional six months to full remove and operations were completed in the fall of 2011.

The exclusion and removal of these predatory animals is anticipated to increase in the existing population of nesting seabirds, encourage new seabird species to nest at Ka`ena Point, enhance regeneration and recruitment of native plants, and benefit monk seals by reducing the risk of disease transmission. The Ka`ena Point Ecosystem Restoration Project is expected to have primarily positive effects on the resources protected in the NAR and provide the people of Hawai`i with an opportunity to visit a restored ecosystem. This was the first predator proof fence constructed in the United States at the time of its completion, and was the first project to successfully eliminate mice using the techniques discussed above.

INTRODUCTION

Introduction

Islands make up 1.3% of the U.S. land area yet they are home to 43% of species listed under the Endangered Species Act and 53% of extinctions. Invasive species are the primary threat to island ecosystems globally and are responsible for approximately two-thirds of all island extinctions in the past 400 years (Reaser et. al. 2007). Hawai`i not only is the state with the greatest number of threatened, endangered, and extinct species, but also the state with the highest proportion of endemic flora and fauna (Ziegler 2002). Non-native mammals – primarily rats, cats, mongoose, goats, sheep, and pigs – have had devastating impacts on listed and at-risk species and are major factors in population declines and extinctions in Hawai`i and elsewhere (Ziegler 2002, Reaser et. al. 2007).

In 1970, Hawai`i became one of the first states in the country to recognize the importance of its unique natural resources by establishing the Natural Area Reserves System (NARS) to "...preserve in perpetuity specific land and water areas which support communities, as relatively unmodified as possible, of the natural flora and fauna, as well as geological sites, of Hawai`i." (Hawai`i Revised Statutes § 195-1). The system presently consists of 19 reserves on five islands, encompassing more than 109,000 acres.

Ka`ena Point NAR was established in 1983, by State Executive Order 3162, to protect a portion of the most extensive remnant dune system on O`ahu from damage and degradation caused by off-road vehicle use, erosion, and the spread of invasive species. At the time the NAR was created, these factors had largely destroyed most of the native vegetation within the NAR, making it unsuitable for use by nesting seabirds. After the establishment of the NAR, vehicular access to most of the reserve was blocked, and recovery of native vegetation has been significant, with increasing numbers of endangered plants such as ‘ohai (*Sesbania tomentosa*) and recovery of the coastal naupaka (*Scaevola sericea*) community (D. Smith pers. obs.).

As the coastal habitat improved, and predator control was initiated, increasing numbers of ʻuaʻu kani, or Wedge-tailed shearwaters (*Puffinus pacificus*), and Laysan albatrosses, or mōlī (*Phoebastria immutabilis*), began to breed in the NAR. Wedge-tailed shearwater chicks hatching at Ka`ena increased in number from zero in 1994 to over 3,000 in 2011. Laysan albatross alone have increased from zero pairs in 1989 to approximately 61 nesting pairs in 2012. The dramatic increase of seabirds within the reserve is likely a combination of protection from off-road vehicles and predator control. The reserve also acts as refuge and pupping ground for the endangered Hawaiian monk seal or ʻīlioholoikauaua (*Monachus schauinslandi*). In addition, honu or green sea turtles (*Chelonia mydas*), koholā or humpback whales (*Megaptera novaeangliae*), and naiʻa or spinner dolphins (*Stenella longirostris*) are often seen just offshore.

Prior to fence construction, management techniques designed to protect the natural and cultural resources within Ka`ena Point included maintaining the existing boulder barricade, removal of invasive habitat-modifying weeds, and predator control. In cooperation with the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services (USDA-WS), the State Division of Forestry and Wildlife (DoFAW) conducted regular predator control starting in 2000, primarily using baited traps and shooting, that reduced the size of feral predator populations within Ka`ena Point NAR. However, with unlimited opportunities for predator entry, control required constant effort and expense and did not provide a consistent level of protection for the native plants and animals within the NAR. Despite ongoing predator control, the rates of predation on nesting seabirds (up to 15% per year) were too high to allow the long-term recovery of the existing seabird populations and were likely preventing other seabird species from colonizing the area. The impacts of seed predation on endangered plants, while not as extensively documented, were also likely contributing to poor reproductive success and survival.

The devastating impacts of non-native mammals such as dogs, cats, mongoose, rats, and mice on island ecosystems are well-documented (Blackburn et. al. 2004;). Predation by invasive species is second only to habitat loss as the leading cause of avian extinctions and declines on islands, with rats and domestic cats implicated in most (72%) avian extinctions caused by invasive predators (Blackburn et. al. 2004). Despite existing predator control efforts at Ka`ena, attacks by cats and dogs continued to occur. For example, in 2006, 113 fledgling wedge-tailed shearwater chicks were killed by a pack of dogs in a single incident at Ka`ena. Other high-mortality attacks at Ka`ena include a 2005 incident in which a dog killed approximately twenty shearwaters, and a 1996 incident where forty nesting shearwaters were killed in one night.

Ungulates have already been excluded from a number of large tracts of sensitive habitat in Hawai`i using fencing. However, these fences do not exclude smaller pest species such as mongooses, cats, and rodents. Impacts of feral cats and mongooses in Hawai`i have been well documented, including the predation on many endangered species, primarily birds (Hodges and Nagata 2001, Smith et. al. 2002, Laut et. al. 2003). Invasive rodents such as rats and mice constitute a potentially even greater threat to native species by contributing to extinctions as well as ecosystem level changes (Fukami et. al. 2006). In Hawai`i, rats have been documented to prey on ground-nesting seabirds, forest birds including the endangered O`ahu ‘Elepaio (*Chasiempis ibidis)* and the Laysan Finch (*Telespiza catans;* VanderWerf and Smith, 2002). As omnivorous feeders, rats are also known to eat the seeds, fruits, leaves, and shoots of a variety of plants, including stripping the bark of koa (*Acacia koa*) saplings and eating the seeds of loulu (*Pritchardia* spp.) palms and other endangered plant species (U.S. Army 2006). These actions may kill plants outright, make them more susceptible to pathogens or insects, or prevent natural reproduction. While rats can be controlled in small areas using bait stations and traps, it is extremely labor intensive and not a permanent solution. Until recently, there was no way to effectively eradicate rats and mice from larger islands, or even to exclude them from specific areas.

Finally, the predators found at Ka`ena act as carriers of leptospirosis, morbilli virus (distemper), and toxoplasmosis. The Recovery Plan for the

Hawaiian Monk Seal identifies these diseases as threats to monk seal survival. In addition, toxoplasmosis also a dangerous disease for humans. Despite existing predator control efforts, the possibility of exposure continues as long as predators can enter the reserve.

Until 2006, DoFAW was constrained by their budget from tackling the outstanding issues at Ka`ena Point. In a series of events that included the large shearwater kill discussed above, and the cancellation of a fully funded predator proof fencing project on Hawai`i island, funding was made available from the US Fish and Wildlife Service (USFWS) to construct a predator proof fence at Ka`ena Point. The funding was provided as a grant to the Wildlife Society Hawai`i Chapter (TWS) in trust for the state under the USFWS recovery program to protect endangered plant species.

Predator-proof fencing is a relatively recent technology that was developed in New Zealand and to date over 52 fences have been constructed protecting more than 10,000 ha. The fencing excludes non-native predatory animals as small as a two-day old mouse, and prevents these animals from digging under or climbing over the fence. The use of the predator-proof fencing greatly increases the effectiveness of existing animal control efforts, shifting the focus from reducing predator numbers to eradication (Long and Robley, 2004). Research undertaken in 2002 (MacGibbon and Calvert, 2002) and completed in March 2006 (Burgett et. al. 2007) demonstrated that these fences could be designed to exclude all of the mammalian pests present in Hawai`i. Biologists familiar with these fences in New Zealand stated that “far more has been achieved at a far greater pace than expected”(T. Day pers. Comm.). Benefits included a noticeable improvement in ecosystem function, a documented increase in the number and density of native invertebrates, and an increase in the diversity of plant vegetation. In one installation, the results projected to occur within ten years of construction were observed in 18 months. The predator proof fence uses technology that has been used with great success in New Zealand in both coastal and forested areas. Trial predator-proof fences were constructed on the slopes of Mauna Loa on Hawai`i, demonstrating their effectiveness in excluding rats, cats, and mongoose and allowing the development of methods to exclude mice on ‘a‘ā substrate. Ka`ena Point was the first project-level fence of its type constructed in Hawai`i and the U.S. In Hawai`i, the use of predator-proof fencing is especially promising in that it can provide areas within which the entire ecosystem, including native vegetation, can recover and where birds and snails can breed and forage free from the threats of introduced terrestrial vertebrate predators (MacGibbon and Calvert, 2002).

Anticipated benefits of predator proof fencing at Ka`ena Point are increases in the breeding Laysan albatross and Wedge-tailed shearwater populations; the establishment of new seabird breeding populations, such as the ka‘upu or Black-footed albatross (*Phoebastria nigripes*) and the ‘ou or Bulwer’s petrel (*Bulweria bulwerii*); a greater understanding of the impact of rodents on coastal ecosystems; improved health and function of the coastal strand plant community; improved natural regeneration or the re-introduction of endangered plant populations historically found at Ka`ena; reduced risk of disease transfer to basking monk seals; and a demonstration area for residents and visitors to observe what a coastal area of the Hawaiian islands might have been like in their natural state before the introduction of invasive mammals and to develop a greater appreciation of the value of the natural and cultural resources of Ka`ena Point. Over the long-term, protecting the nesting area at Ka`ena is of particular importance to vulnerable seabirds, as most of their nesting areas are located on atolls and islands at greater threat by rising sea levels than Ka`ena (Baker et. al. 2006).

The purpose of this report is to provide an overview of the entire process that was undertaken to complete this project, from the scientific aspects to the legal compliance. Since the completion of construction, multiple predator proof fencing projects have been initiated in Hawai`i and it is hoped that by compiling all the information from our experience, that it will facilitate planning of future projects.

Objectives

The principle strategic objective of this project was to promote active ecosystem restoration through the use of predator proof fencing. The specific objectives were to:

1. Conduct public outreach to obtain, and maintain community support for the project
2. Conduct pre and post biological monitoring to assess the effectiveness of predator proof fencing as a management tool in Hawai`i
3. Construct a predator proof fence capable of excluding all non-flighted mammalian predators from Ka`ena Point
4. Remove (and continue to exclude) all non-flighted mammalian predators from Ka`ena Point
5. Document changes to the recovering ecosystem in the absence of non-native predators.

The long term objectives once predators have been removed are to continue with ongoing plant restoration, begin more aggressive seabird restoration (such as social attraction and translocation) and provide the public with an opportunity to enjoy a restored ecosystem and the educational opportunities associated with having a restored ecosystem so accessible to an urban center.

Fence design

The fence encloses approximately 20ha of the Ka`ena Point NAR. The fencing corridor is approximately four meters wide and 630 meters long. The fencing alignment largely follows a World War II-era roadbed that skirts the bottom of the hill behind and above the sand dunes. By following this track at the base of the slope, the alignment places the fence along the least visually intrusive area of the point, so that the greatest area might be enclosed while minimizing interference with viewplanes and avoiding further disturbance to the delicate habitat. Figure 1.1 illustrates the area and the fence alignment.

Figure 1.1 – Fence alignment at Ka`ena Point NAR

The existing roadbed that forms the main portion of the fence corridor (Figure 1.1) is fairly level, and as a result, limited vegetation clearing was required. Ground preparation that was required along the Waianae slope involved the use of a bulldozer and excavator to move soil or rocks to form a level stable platform and to contour the ground so that rain water moves away from the fencing. Details on the construction of the fence are discussed later in this document.

The fence design has three main elements: base fence, predator-proof mesh and skirt, and predator-proof rolled hood (see Figure 1.2). The base fence provides the structural strength and framework on which predator-proof components may be added, and is made of anodized aluminum posts and stays, with stainless steel wires and fastenings.

Anodized aluminum posts set into the ground three meters (9.8 feet) apart. One meter of the post is buried, while two meters remains above ground. Marine grade stainless steel mesh with an aperture of 6 x 25 millimeters is attached to the entire face of the base fence, and is also used to form a skirt of horizontal mesh at ground level, to prevent predators from tunneling under the fencing. The mesh extends from the top of the posts to just below ground level, while the skirt extends 300 millimeters from the fence, and is cemented to the ground.

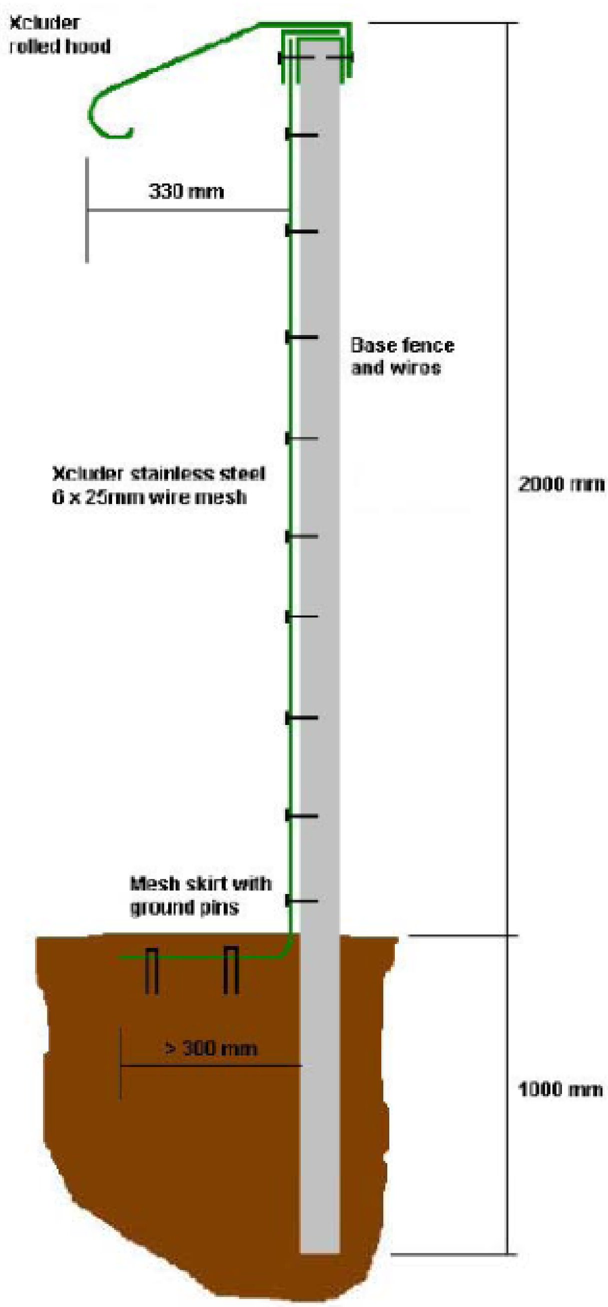


Figure 1.2 – Fence design

Figure 1.3 – Installed fence section at Ka`ena Point

Access doors were incorporated at locations where the fencing crosses existing trails at both the Mokulēʻia and Waiʻanae entrances and a third door above the Leina ka ʻUhane to allow access to a fishing koʻa (shrine). To minimize the opportunity for predator incursion if doors are propped open, a double-door system was utilized such that both doors cannot be open at the same time. Instead, a person accessing the reserve must wait for the first door to close before the second door may be opened. The area between the doors was constructed with the same quality and design as the rest of the fence and is large enough that up to nine people may enter together or so that a person can enter with a bicycle or fishing pole.

Figure 1.4: The south coastal end (left), center gate and north coastal end (right) of the fence.

Budgets and funding

Funding was obtained from six grants made specifically for this project and its related activities:

Table 1.1: Sources of funding for the Ka`ena Point Ecosystem Restoration Project

Source	Amount	Purpose
USFWS	$350,000	Fence construction, outreach, coordinatio
David and Lucille Packard Foundation	$150,000	Predator removal, seabird monitoring
David and Lucille Packard Foundation	$135,000	Fence maintenance, predator monitoring
USFWS	$70,595	Funding of public outreach ambassador
Hawai`i Tourism Authority	$50,000	Funding of public outreach ambassador
USFWS	$17,000	Public outreach for rodent control
Total	$772,595	

At the time of this report, $637,595 had been spent on this project (the fence maintenance grant of $135,000 does not begin until January 2012). A rough breakdown of how this money was spent is outlined below:

Table 1.2: Breakdown of spending for the Ka`ena Point Ecosystem Restoration Project.

Item	~Cost
Fence construction (~650m= $446/m)	$290,000.00
Predator removal (to date)	$51,000.00
Project coordination	$79,000.00
Public outreach	$69,000.00
On-site ambassador	$120,595.00
Miscellaneous and grant overhead	$28,000.00
Total	$637,595.00*

*Note that the grant of $135,000 is not included in this table as the grant period hadn't started at the time of publication

These costs do not include USFWS or DLNR staff time, and do not include the annual contract DoFAW has with USDA-WS for predator control (~$35,000/year). In addition, much of the pre-construction biological monitoring was done on a volunteer basis by a variety of individuals at both public and private institutions. All of these agencies contributed significant amounts of staff time towards the planning and execution of this project, and the actual cost of implementing this project is undoubtedly much higher. Nonetheless, these estimates can still serve as a rough guideline for future projects that are still in the planning stages.

Timeline

- 2005 – Testing of New Zealand fence technology on Hawai`i, sponsored by USFWS
- 10/2006 – > 150 seabirds killed at Ka`ena Point NAR by dogs and cats
- 11/2006 – Proposal to construct a predator proof fence at Ka`ena Point NAR
- 12/2006 – USFWS, DLNR, and The Wildlife Society, Hawai`i Chapter form a partnership to build the predator-proof fence
- 07/2007 – DLNR completes archaeological and historical properties report
- 10/2007 – Broad public and stakeholder outreach efforts commences

- 12/2007 – Draft Environmental Assessment available for public review
- 07/2008 – Modifications to fence alignment based on comments/concerns
- 07/2008 – Yearlong project on the biological monitoring of all native and pest species begins
- 10/2008 – Contested cases filed to the Board of Land and Natural Resources (BLNR)
- 05/2009 – Contested cases dismissed by BLNR due to lack of standing
- 06/2009 – Final Environmental Assessment and Cultural Assessment completed
- 08/2009 – Applications made to City & County for final project permits
- 08/2009 - Interviews conducted to hire Ka`ena Point Ambassador
- 12/2009 - David and Lucille Packard Foundation provide funding for predator removal
- 01/2010 - Right of entry permit given to TWS by the BLNR
- 01/2010 - Two (new) contested cases filed
- 08/2010 - Contested cases denied standing
- 09/2010 - Contract is signed with fencing contractor
- 11/2010 - Final permitting requirements completed
- 11/06/2010- Construction begins
- 11/16/2010- Temporary restraining order (TRO) filed against the project
- 11/18/2010- TRO denied standing in First Circuit Court
- 12/17/2010- Fence is 90% complete; break for the holidays
- 02/2011- Fence crew returns to complete project
- 02/2011- Rodent removal operations begin
- 03/2011- Fence is complete
- 06/2011- Cats, mongooses and rats have been eradicated from within the reserve
- 10/2011- Mice are eradicated from within the reserve

Limitations

Despite this project having sufficient funding and public support to complete the fence construction and initial predator removal, concerns exist over how the long-term maintenance and biosecurity of the area will be managed. Currently, there is funding through 2013 (two years post-construction) from grant money for maintenance and ongoing predator surveillance, but once this is complete the future is less certain. Several community groups and individuals have expressed an interest in assisting in maintenance operations and long-term monitoring associated with this project and it is hoped that with careful planning and coordination that these groups can be trained to provide assistance and fill in any staffing/funding gaps within DLNR. At a minimum, a maintenance and buffer pest control program that includes once-weekly inspections will need to be conducted in perpetuity in order to keep animals from re-invading the fenced area through the coastal gaps, and to conduct regular maintenance needs.

From an operational standpoint specific to the predator removal and biosecurity, there were clear limitations with the fence design which is a peninsula-style fence with unsecured openings on the coastal ends. While the openings on the coastal ends (2m and 1m respectively) are much narrower and more rugged terrain than other successful coastal peninsula fences built previously in New Zealand, the potential for re-invasion is still present and directly impacts the project's ability to conduct a true eradication and effective biosecurity. Despite these limitations, however, the level of risk associated with cancelling the project (both ecologically as well as politically) was thought to be greater than the level of risk associated with proceeding under the scenario described above, and more importantly, the predicted benefits are anticipated to far outweigh the costs. As such, efforts were made to mitigate those risks to the fullest extent possible and ensure the long term success of the project.

PERMITS AND REGULATORY PROCESS

The construction of a predator proof fence in Ka`ena Point NAR required multiple permits and regulatory checks that were required as a result of the use of federal funding, the use of state land, the nature of the cooperative agreement between the grant parties and land use regulations. The use of federal funds provided by the US Fish and Wildlife Service (USFWS) triggered a Section 7 consultation under the Endangered Species Act (ESA), National Environmental Protection act (NEPA) review, and Section 106 consultation under the National Historic Preservation Act of 1966. As significant historic properties were in the project's area of potential effect (APE) and the project could adversely affect these properties, a Section 106 Memorandum of Agreement (MOA) was required for the project.

The use of state lands triggered a State environmental review under Hawai`i Revised Statutes (HRS) Chapter 343. Construction within a state NAR required approval and cooperation of NARS staff and the System Commission.

The funding for the project was given as a grant to the Wildlife Society Hawai`i Chapter (TWS) who in turn constructed the fence on behalf of the state. Since three parties were involved in the implementation of this grant, a cooperative agreement was drafted by the Hawai`i Department of Land and Natural Resources (DLNR) to clarify each party's role in the grant and multiple permits were issued to TWS

Finally, as a result of the area being located in a county-zoned preservation district and within the designated special management area along the shoreline, a Special Management Area Use Permit (SMA), a Shoreline Setback Variance (SSV) and Shoreline Certification were required by City and County of Honolulu, Department of Planning and Permitting (DPP). As the area was also located within both a resource and limited subzone of state Conservation District, consultation with staff from the DLNR Office of Conservation and Coastal Lands was necessary to determine whether an existing Conservation District Use permit covered the project or whether a new

Conservation District Use Application was required . After consultation, it was concluded that the project was permitted under existing CDUA No. SH-2/26/82-1459, associated with the creation of the Natural Area Reserve.

Despite being located on state land, the county initially determined that a grading permit would be required for the project. It should be noted that the zoning regulations of the other counties (Maui, Hawai`i, and Kauai) provide a method to exempt projects on state land from grading and grubbing permit regulations, but the City and County of Honolulu does not. However, based on the specific information contained within the grading permit application, the City and County determined that this particular project did not require a grading permit.

Table 2.1: List of permits/consultations required for construction of a predator proof fence at Ka`ena Point NAR, issuing agency and completion date

Permit/Consultation	**Issuing Agency**	**Completion date**
ESA Section 7	USFWS	2007
EA	DLNR	June 23, 2009
Cooperative Agreement	DLNR	August 2009
NEPA	USFWS	Fall 2009
Section 106	USFWS	November 2010
SMA	DPP	Fall 2009
SSV	DPP	Fall 2009
Shoreline certification	DPP	Fall 2009
TWS right of entry permit	DLNR	Fall 2010
Grading permit	DPP	Exempt- Fall 2010
Rodenticide application permit	USFWS	February 2011

A more detailed discussion of some of the larger regulatory hurdles is presented below as an understanding of the issues, and resulting delays, encountered during these processes may provide insight to future projects on the planning process

Cooperative agreement

The funding for the project was given as a grant from USFWS to TWS who in turn constructed the fence on behalf of the state. Since three parties were involved in the implementation of this grant, a cooperative agreement was drafted by DLNR to clarify each party's role in the grant and multiple permits were issued to TWS to complete construction. The review of the cooperative agreement was brought before the BLNR for voting and approval in October 2008. BLNR meetings are open to the public and on issues where decisions are to be made, members of the public are allowed to file a request for a contested case hearing to dispute decisions under Hawai`i Administrative Rules 13-1.

During the first meeting held on 24 Oct 2008 to approve the cooperative agreement between the granting parties, four individuals filed contested case petitions against the cooperative agreement. The petitions were reviewed and denied by the BLNR at its 22 May 2009 meeting. Copies of the contested cases and their denial can be found online at the BLNR meeting website under item C-2 of the submittals 22 May 2009 meeting; copies of the cooperative agreement can be found in the submittals for the 24 October 2008 meeting.

In January of 2010 after completion of the majority of the other major permits, the project was once again brought to the BLNR to issue a right of entry permit for TWS to construct the fence. At this meeting, two additional contested case petitions were filed. As it did with the first set of contested cases, the BLNR denied the petitions at the 12 August 2010 meeting. Copies of the contested cases and their dismissals can be found online at the BLNR meeting website under item C-1 of the submittals for the 12 August 2010 meeting.

Both the cooperative agreement and right of entry permit appeared to be relatively straightforward processes, but they ultimately delayed the project by over a year as a result of the time it took to resolve the contested case requests.

The project would have been delayed even further if the petitioners had been found to have standing and a full contested case hearing had been held. While there was no way to avoid going to the BLNR twice, in retrospect, the project could have requested a right of entry permit at an earlier date (with prior chairperson approval) with a contingency clause that it was not effective until all other necessary permits were obtained. In doing this, resolution of any resulting contested case petitions could have been done concurrently with other permit applications to prevent delays in the construction date.

Environmental assessment

The first major compliance item that was initiated for this project was the preparation of an environmental assessment (EA) which began in the spring of 2007. This was done internally by DLNR and project staff who reviewed existing references relating to the Ka`ena Point area, conducted surveys for biological and historic sites, and consulted with numerous agencies, individuals and researchers to compile information on both the cultural and natural resources of Ka`ena Point. A key component of this EA was including multiple fence alignment options that either included or excluded culturally significant features, such as the Leina ka `Uhane (a point where souls are said to leap into the afterlife described in detail later), from within the fenced area with the idea being to allow the public to provide input on the various alignments during the comment period.

Given the height of the fence and the materials being used, it was expected to be a prominent feature in an otherwise open and scenic landscape and the visual effects of the fence on historic properties and their setting also needed to be taken into account. As part of the EA, a summary of known and possible historic properties at Ka`ena Point, particularly those found within the potential project area, was completed and incorporated into a cultural impact assessment that was added as an appendix to the final EA. The assessment was based primarily on field inspections conducted on 27 January and 30 June 2007 and on a review of reports and other sources available in State Parks files, including the original archaeological excavations done in the 1970's and 1980's. During the field inspections, State Parks staff and archaeologists were able to examine potential fence alignments with other parties involved in the project and to locate previously recorded historic properties. This allowed an assessment of, at least on a preliminary level, the kinds of historic properties that would need to be considered during the historic preservation review process and to propose potential fence alignments that would avoid or minimize damage to historic properties. Also discussed were actions needed to determine how the project could affect these historic properties and how those effects could be avoided or minimized. As proof of compliance with federal historic preservation laws and regulations was needed, the report also included recommendations on fulfilling those requirements.

Prior to the release of the Draft EA for public comment, pre-consultation was initiated by sending a scoping letter to over 90 government agencies, organizations and individuals that were identified as potential stakeholders for the project. During the pre-consultation period, comments were received from 21 of those entities. Comments were incorporated into the document which was then finalized for public review.

A draft EA for the Ka`ena Point Ecosystem Restoration project was made available for public comment on 23 December 2007, through publication of availability in the Bulletin of the Office of Environmental Quality Control (OEQC). The comment period was informally extended through March 2008 to accommodate comments that were received after the holidays and after a site visit with the Office of Hawaiian Affairs (OHA) in March of 2008. A total of 31 comments were received during the comment period, the majority of which were supportive of the project. Copies of all comments received during the pre-consultation and public comment period are included in the Final EA which is publically available online through OEQC.

During the spring and summer of 2008, comments were incorporated into the Final EA and further consultations were conducted within the community to notify them of the preferred fencing alignment which was to include the Leina ka ‘Uhane, with the modification of an additional gate incorporated above the Leina, and extend the fence to the existing boulder barricade on the Waialua side of the project. As the Final EA was being prepared for submission in the fall of 2008, four contested case requests were filed in response to the proposed cooperative agreement described above. Despite the two documents being unrelated to each other, DLNR felt it prudent to wait on finalizing the environmental assessment until the contested cases had been resolved. The contested cases were dismissed on 22 May 2009; the Final EA was published in the OEQC bulletin on 6 June 2009. As a result of the delay caused in publishing the Final EA, permitting activities were stalled as the remaining permits required the EA to be finalized prior to proceeding.

Special management area permit

Both Ka`ena Point State Park and the Natural Area Reserve are located in the Conservation District. The project area falls partially in the Resource Subzone (where the fencing joins the coastline) and partially in the Limited Subzone (along the old roadway). The area is zoned by the County as P-1 Restricted. The project area is located entirely within the County Special Management Area (SMA). In June 2009, DLNR applied to the City and County of Honolulu’s DPP for a SMA Use Permit. As part of the permit, DLNR provided a written statement justifying why the project was in the public interest and represented the most practicable alternative with respect to the purpose of the Special Management Area ROH 25-1. The project was also within the Shoreline Setback, which required a Shoreline Setback Variance from the City and County of Honolulu’s DPP. Similarly, the DLNR submitted an application justifying why the project was in the public interest, and represented the most practicable alternative with respect to the purpose of the shoreline setback ordinance ROH 23-1.2.

These applications required a map of the shoreline and shoreline setback prepared and certified by a registered land surveyor and certified by the State Surveyor and Director of Land and Natural Resources within one year of the application date. The application required the completion of an environmental assessment or impact statement. A mandatory public hearing was also required in the area in which the project was proposed, which occurred on October 5, 2009 with a large audience and broad public support. Then, the DPP submitted a report and recommendation to the City Council, which approved the project on October 19, 2009 (City Council Resolution 09-307).

Section 106

As a result of the USFWS providing funds for the Ka`ena Point Ecosystem Restoration Project, the project was subject to review under Section 106 of the National Historic Preservation Act (NHPA), 16 U.S.C. § 470f, and its implementing regulations, 36 C.F.R. Part 800. The project's "area of potential effect" (APE) was determined by the USFWS to include several historic properties listed in, or eligible for listing in, the National Register of Historic Places including the "Kaʻena archaeological site complex" (Site No. 50-80-03-1183), the rock formations named Leina ka ʻUhane and Pōhaku o Kauaʻi, which are of known traditional cultural significance, and structures and landscape modifications associated with the island's railway and military histories. Because the project could affect significant historic properties, the USFWS entered into a MOA with the Hawaiʻi State Historic Preservation Office to mitigate any adverse effects to these properties. The Office of Hawaiian Affairs (OHA) signed the MOA as a consulted Native Hawaiian Organization and the NAR System of the Hawai`i DoFAW and the TWS were invited signatories. To determine the area that would be directly impacted by project-related activities, a site visit was conducted prior to the commencement of work with the fencing contractors, a biologist, archaeologist, and cultural monitor. The precise fence line, the boundaries of areas where machinery was allowed, and the staging area were delineated marked. This was to ensure that no pre-contact archaeological features or endangered plants were disturbed during construction. Several properties, including World War II military modifications to the landscape and a stone wall associated with the 1897-1947 Oahu Railway and Land Company would be crossed by the fence.

Mitigation for the proposed effect included additional historic documentation of the stone wall, painting the fence green to blend with the hillside to reduce visual impacts, hiring an interpretive ranger who was aware of the culturally sensitive nature of the site to be on-site during earth moving activities as a cultural monitor, and having an archaeologist present while ground-disturbing activities were taking place (grading and post hole digging) to ensure that archaeological resources were not adversely impacted.

While planning for the Section 106 consultation began with ample lead time, it was not submitted to the reviewing agencies with enough lead time to allow for comments to be incorporated and re-reviewed. The document was also submitted sequentially, as opposed to simultaneously, to each reviewing party which lengthened the process substantially. As a result, there was a considerable rush in the week prior to construction to finalize the document to be in compliance.

During the construction period several concerns related to the Section 106 MOA were brought up by members of the public as well as by OHA. During the delivery of the heavy machinery into the reserve, which required driving machines along the two mile unimproved dirt road, two small sections of the roadbed were altered with the bulldozer to facilitate delivery of the excavator. The roadbed was not included in the original APE because it was considered a routinely-used public access route (i.e., similar to any established road or highway) and these very minor improvements were not anticipated as being needed during project planning. When the issue was raised, USFWS responded that it did not consider the roadbed to be a significant historic property. While it is over 50 years old and historic, it is highly degraded due to the frequent damage caused by off-road vehicles and has lost its historic integrity. The minor smoothing that was done did not damage any potentially historic features of the roadbed beyond what had already been done by private vehicles. The day before construction, the APE was flagged so that the flags would not blow away or be disturbed prior to construction. Flagging tape was used instead of stakes driven into the ground to minimize ground disturbance, and the variable height reflected the low stature of the vegetation in the area. As a result of the low visibility of the flags, it was unclear to those not involved in the project if the APE had in fact been flagged.

Finally, several days after construction began, the fence contractor performed ground disturbing activity for several hours on the weekend when the cultural and archaeological monitors were not present despite having previously been told that no work was to occur that weekend. As a result of these activities, the contractor was sent a written reprimand and the USFWS responded in writing to OHA over this violation of the MOA. All three of these events could have likely been prevented with improved communication between the signatories on the document and the fencing vendor.

Conclusions

With any large project, permits are an inevitable part of the process, but the time required to complete the compliance of projects of this size is often underestimated. Even with the relatively quick commencement of the permitting process for this project, there were still multiple delays that could have been avoided. A six-month delay could have been prevented by finalizing the EA and initiating the SMA permit concurrently with the resolution of the first four contested cases since there was no legal basis that required the EA finalization to wait. Similarly, a right of entry permit could have been requested prior to obtaining all other permits, but that was contingent upon obtaining those permits, and allowed for resolution of any contested cases while final permits were being applied for. And while the Section 106 did not stall the project, it came very close to preventing the construction from starting on time since the document was submitted sequentially, as opposed to simultaneously, to each reviewing party which lengthened the process substantially. As a result, this specific process should have been initiated much earlier, and to all reviewing parties simultaneously to allow time for multiple agencies to complete their reviews without repeated follow up.

Future projects should initiate their consultations and compliance paperwork well in advance of their anticipated construction date. Completing the compliance documents took longer and required more work than obtaining funding, and while most projects will likely not have as heavy a permitting burden as this project did, starting compliance paperwork while searching for funding would help to avoid some of the issues that this project ran into.

PUBLIC OUTREACH

Introduction

Ka‘ena Point NAR, and the greater Ka`ena Point area which spans from Keawa‘ula Bay (also known as “Yokohama Bay”) on the Leeward Coast to Mokuleia on the North Shore is an area with many user groups who feel strongly about how it should be used and cared for. Historically, the Ka‘ena coast supported small fishing villages, and still is an important area for Hawaiian culture. The O‘ahu Railway and Land Company began operating a railway around the point in 1898 to service sugarcane operations. The Coast Guard constructed a passing light for navigation purposes in 1920. Because of its strategic location, Ka‘ena Point was actively used by the military for coastal defense after World War I through World War II. Military use declined after World War II and the railway ceased operation in 1947.

During the 1970s, the State began to purchase lands in the area for a proposed Ka‘ena Point State Park. In 1978, a Ka‘ena Point State Park Conceptual Plan was completed. Ka‘ena Point NAR was established in 1983, composed of twelve acres on the leeward side of the point. In 1986, an additional twenty-two acres on the windward side were added to the NAR. The project area is one of the last relatively wild coastal areas on O‘ahu and has been valued as a natural escape from the pressures of urban life and its primary uses include recreation, hiking, nature study, education, and the observation of wildlife. Shore fishing, spear fishing, and gathering of marine resources have traditionally been important uses of the Ka‘ena coast.

Ka‘ena Point itself is a culturally significant landscape. There is a strong relationship in Native Hawaiian culture between the people and the land on which they live. The ‘āina (land), wai (water), and kai (ocean) formed the basis of life and established the spiritual relationship between the people and the environment. This relationship is demonstrated through traditional mele (songs), pule (prayer chants), genealogical records, and stories about particular areas, celebrating the qualities and features of the land. The relationship to the land is also shown through the strong attachments of kama‘āina to their ancestral homelands. Within the NAR is the Leina ka ‘Uhane (Soul’s Leap), a large basalt outcrop that is said to be where souls depart into the afterlife from O‘ahu, and as such, is a sacred feature in the cultural landscape of Ka‘ena.

Based on user surveys conducted in the 1990’s, upwards of 50,000 people visit K‘aena Point area each year. As a result of the diversity and number of user groups it was decided that extensive public outreach was needed to ensure the success of the project. Pre-consultation began with the advertisement for an outreach position, followed by formation of a multi-person outreach team in October 2007. Since then, the Ka‘ena Point Ecosystem Restoration Project outreach team has been very active in the communities surrounding Ka‘ena Point (both the Mokulē‘ia and Wai‘anae sides), and have consulted with thousands of individuals and community organizations to give everyone accurate information and provide them the opportunity to give feedback on the project. As a result of their work, the vast majority of people who have been contacted support this project strongly and are interested in ensuring that Ka‘ena Point NAR is protected for the long-term, despite the vocal objections of a few.

Approach

The success of this project was due in large part to the public support garnered the outreach team. They identified and initiated personal contact with as many stakeholders as possible] developing relationships with those with a strong connection to Ka‘ena. In conjunction with personal contact, materials were developed to facilitate the transfer of information (discussed in more detail below). Printed outreach materials include two brochures, a fact sheet on owls at Ka‘ena Point, a Frequently Asked Questions sheet and a teacher education packet containing brochures and lesson plan on native coastal environments in Hawai‘i. Also, a section of a real predator-proof fence (approximately 3’ wide and 6.5’ tall) was shown to stakeholders at various meetings. Finally, a project website was developed] to provide on-demand access to all relevant project information.

Outreach efforts began in the fall of 2007 in conjunction with the release of the DLNR pre-consultation scoping letter for the environmental assessment. During this time, the outreach team met with groups such as the North Shore Neighborhood Board, Wai‘anae Neighborhood Board, Mokulē‘ia Community Association, Wai‘anae Hawaiian Civic Club, Office of Hawaiian Affairs Native Hawaiian Historical Properties Council, Earthjustice Legal Defense Fund, Sierra Club, Hawaiian Trail and Mountain Club, ‘Ahahui Mālama I ka Lōkahi, the Oahu Railway Society, The Coastal Defense Study Group, Friends of Honouliuli, Hawai‘i Audubon Society and Friends of Ka‘ena. Presentations were made to teachers and hundreds of students and team members also conducted many one-on-one meetings and site visits with respected kūpuna (native Hawaiian elders), community leaders, fishers and 4x4 club members where concerns were shared and addressed wherever possible.

The outreach team also conducted surveys at Ka‘ena Point on three weekends to get input from current users of Ka‘ena Point about why they visit Ka‘ena and what they think about the proposed fencing. The same survey was administered at the popular Hawai‘i Fishing and Seafood Festival held at Pier 38. Of the 141 respondents, 95% of whom were from Hawai‘i, 82% supported constructing the fence, 15% were possibly supportive, and 3% were unsupportive.

Two articles urging public input were published in the Hawai‘i Fishing News (circulation 10,000) the newsletter of the Hawaiian Trail & Mountain Club (circulation 300), the DLNR-DOFAW newsletter (*Nā leo o ka ‘āina, Voices of the Land*) as well as via mass media. Both the *Honolulu Advertiser* and *Honolulu Star Bulletin* (the two major daily newspapers at the time) published stories. On television, news stories were aired on KHON, KHNL News 8 and KGMB. On basic cable channel OC 16’s *Outside Hawai*‘i program, a 30 minute television show broadcasted statewide, three stories were aired, including a 10 minute video created by Mara Productions. A presentation made to the Wai‘anae Neighborhood Board was aired repeatedly in early 2008 on ‘Ōlelo Community

Media. Two outreach representatives also participated in a 30 minute television show on ʻŌlelo, "William ʻĀila Presents," which aired in December 2008.

The outreach team also made a concerted effort to reach schools in the region. Letters and informational materials were sent to 16 schools and presentations were made to numerous school groups including the Sierra Club High School Hikers and the NOAA sponsored Papahanaumokuakea Ahahui Alakai program. Specific attention was paid to the Leeward Coast were Waiʻanae High, Nānākuli Intermediate/High, and Kamaile Academy had classroom presentations to introduce the project followed by a separate hike along the Waiʻanae coast. All schools were then brought together for an educational sharing/gathering (ho'ike) at Camp Erdman in Mokulēʻia. Outside Hawaiʻi also filmed some of the field trips and the hōʻike and aired two additional shows. Students worked on group projects related to Ka`ena Point, which included PowerPoint presentations, games played with elementary school students, and a series of short videos. In total presentations were made to about 125 students and approximately 70 participated in the hikes. Outreach was also conducted at fairs at four of the major colleges and universities on Oʻahu. Ka`ena Point was recently chosen as the permanent site for the "Navigating Change" program, an environmental education program based at Ka`ena Point run by the National Oceanic and Atmospheric Administration.

From 2009-2011 the state also hired a Ka`ena Point Ambassador funded by a grant from the Hawaiʻi Tourism Authority and the USFWS. The incumbent was stationed primarily in the Ka`ena Point NAR to educate the public, provide volunteer coordination and lead service visits as well as cultural monitoring during the construction period.

Materials produced

An important component of the public outreach process was developing educational materials \ to convey information and the outreach message to stakeholders and the general public. A key component of these materials was commissioning artwork of the area and its wildlife which was used as the foundation for all outreach materials thereby providing a more cohesive look. A variety of tools were used to accomplish public education including a website, brochures, magnets, FAQ's, fence replicas (miniature and full size) and signs that were posted in the reserve itself. Some of these items, such as the fence replicas, brochures and magnets, were brought to presentations and meetings to distribute directly to individuals. Others, such as FAQ's and website addresses were distributed via e-mail and media stories to a larger audience. Finally, for those that had not been informed of the project through direct contact with the outreach team or via television or printed media, signs were designed and posted on the reserve itself to inform visitors of the project and its purpose. Below is a summary and pictures, were applicable, of the specific materials developed.

Website

For widespread information dissemination, a website for the project was developed that contained all the content and downloadable copies of documents, brochures and videos. The website was set up soon after the formation of an outreach team and was initially housed under the Natural Area Reserves Section of the Hawai'i Department of Land and Natural Resources (DLNR) website. After the first year, the site was moved to a separate, easy to remember web address at www.restorekaena.org. To give a sense of what the fence might look like in the actual setting, artist's renderings were produced from three vantage points, which were available on the website. The organization of the website was as follows:

Home 2 paragraphs introducing the project

Treasures

Cultural resources

Current public use

Wildlife

Native plants

The Project

The problem- outlined predation issue with photographs

The solution- introduced the fence concept

How would a fence affect access? Views?

Get Involved how to behave in the reserve, volunteer opportunities

News and Events- media coverage, cleanups, project updates

Education outreach efforts, ambassador information, school groups

Learn More

FAQ's- downloadable copies of the FAQ's

Downloads- brochure, EA, predator removal summary

Photos and videos photo gallery, project documentary, media clips

Blog

Contact us

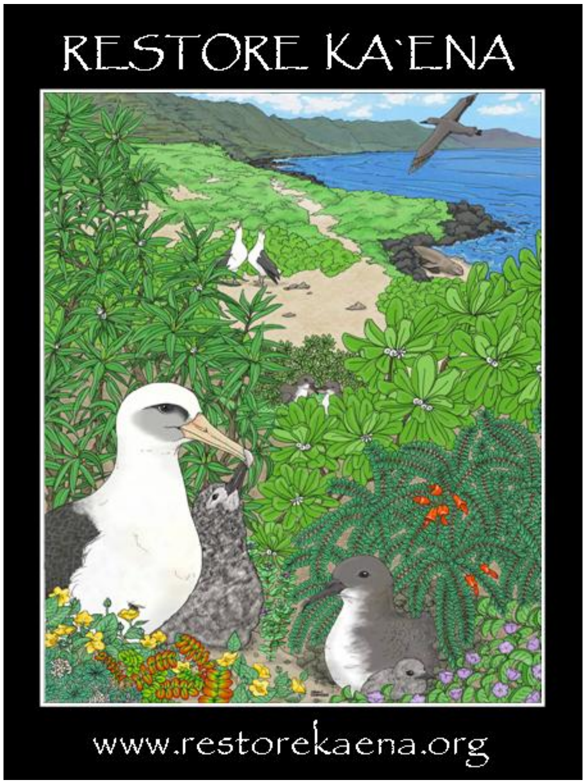
The website was updated as needed and was a convenient forum from which to distribute information, particularly when specific questions or issues were raised about a component of the project, and to announce upcoming public meetings and project events. It will remain active until the end of 2012.

Brochure

Concurrent with the development of a website a brochure was developed for distribution to individuals as well as in downloadable form on the website. As the construction date approached, a small insert was inserted that discussed the project status, construction protocols and the subsequent rodent removal so as not to reprint the entire brochure.

Magnet

At the same time that the website was moved to its unique URL, a 4" x 3" magnet was developed as an easy way to remind people to check back on the website for project updates and the latest information. The magnet was a simple black background with the project artwork as the graphic and a link to the website as seen below:



FAQ and briefing packets

An FAQ was developed as an easy to read way of answering some of the most common questions and concerns that project staff was receiving. Questions that were covered included:

Where is Ka‘ena Point?

What’s so special about Ka‘ena Point Natural Area Reserve?

What’s the problem at Ka’ena Point Natural Area Reserve?

Why are dogs not allowed?

Why build a pest-proof fence?

What will the fence look like?

Will the fence be an eyesore that takes away from the beauty of Ka‘ena Point?

How will the fence affect access?

Will cultural sites be impacted?

How long have seabirds been using Ka‘ena Point?

Will the very birds you are trying to protect fly into it and get injured or die?

What will the effects of the fence be on Pueo, the native Hawaiian Owl?

How do you know these fences work?

Who is paying for this project?

When will the fence be built?

How long will it take to build the fence and how long will it last?

How does the community feel about this project?

Will the public be able to comment on the plans for the fence?

As the construction date approached, a specific FAQ was developed since the reserve would not be closed to the public and required cooperation by everyone to make the reserve a safe place to visit during that time. Most of the common questions were addressed in the construction insert for the brochure (will the reserve remain open?, when will it be finished?, etc), but there were specific questions that were raised by community members that were addressed in the FAQ instead:

Is the construction going to impact nesting birds?

Is the fencing corridor flagged?

Were any endangered plants run over by machines and are they flagged?

Are local companies involved?

Is there a toilet for crews?

In addition to FAQ's that were geared towards the general public, an in-depth briefing packet was developed for decision makers, spokespeople and the media that provided a more in-depth summary of the project to date with sections on:

Project description

Location

Resources

Need for a predator-proof fence

Fence alignment and design

Biological monitoring

Public outreach

Chronology

The combination of the FAQ and briefing packets enabled rapid distribution of information to various individuals and groups on short notice and was invaluable in facilitating the distribution of correct information to the community. Several media advisories and news releases were developed (with accompanying video B-roll), working closely with DLNR's Public Information Officer. This was instrumental in getting media coverage at key times.

Summary

By the completion of the project, the combined outreach efforts reached nearly 3,000 people from O'ahu who may have had some connection to Ka'ena Point, and engaging those who truly care about this special place in the process of making this project the best it could be. Tens of thousands more were reached as a result of media coverage during that time. The vast majority of the public were very supportive of the project, despite a vocal minority who opposed the project. While the opponents were a vocal minority that objected to the fence primarily on spiritual grounds, they were effective at spreading their message and took a considerable amount of time to respond to. While considerable amounts of detail could be provided on those objections, they are a matter of public record and are outlined in detail in the contested case proceedings referred to earlier. For controversial projects such as these, it is important for team members to be available to respond to crises as they arise. Being pro-active is not only crucial, but one also has to react, adjust, and develop new strategies as situations arise as well as keep supporters updated throughout a potentially long and drawn out process. In conclusion, outreach is not a one-time investment where the message is disseminated in the beginning via various methods. It is a constant process that needs to adapt to the situation as it changes, and one cannot assume that a supporter will always remain so unless the team keeps in contact with them and provide updated information as needed. As a result of the dedicated and extended effort put forth by the team, this project was able to proceed to completion. With the help of a coordinated outreach team, Ka‘ena Point, one of the most publically visited state-owned natural areas in Hawai`i, and is one of the few areas that the public can enjoy and learn from watching an ecosystem restoration project in action.

CONSTRUCTION AND MAINTENANCE

A critical part of the predator proof fence construction process that is often over-looked is the relationship with the selected vendor. Establishing clear lines of communication throughout the whole process, from bidding and contracting through construction and beyond, is critical to the projects success and avoid preventable delays. This project selected Xcluder Pest Proof Fencing Co, which at the time of contract negotiations, was the only pest-proof fencing company in existence with a commercial track record. Since the completion of the Ka`ena Point fence, several other vendors, all based in New Zealand, have also emerged. Regardless, because all vendors to date are international entities and must travel to the job site and import their materials, certain precautions must be taken to prevent delays and miscommunication. This section of the report describes the contracting process with the vendor, construction logistics and long-term maintenance of the fence.

Contract with fence vendor

Each project will have different contracting requirements depending on the vendor selected and agency/institution initiating the contract. During price negotiations, particularly with an international vendor, care should be taken to ensure that all shipping, customs and local taxes are included in the final cost as in some cases the vendor may not be aware of those costs. Care should also be taken to determine how the agency will deliver funds to the vendor to prevent delays in payment reaching then. In the case of Ka`ena Point, TWS was not able to wire money internationally and instead had to send a bank check which caused considerable delays for the vendor to receive the money.

The most valuable lesson that was learned from the contracting aspect of the Ka`ena Point project was that setting concrete timelines was crucial, but meant nothing without monetary penalties attached to those deliverable dates for work that went beyond the anticipated construction period. This can go for both the agency to ensure their permits are in place ahead of time, and for the vendor to ensure the work is completed in a timely manner. In the case of Ka`ena Point, there was a degree of uncertainty on the exact start date due to the project being contingent on permit approvals and seabird breeding seasons, and the construction range stated in the contract was 1 November 2010- 31 January 2011. The construction started five days late as a result of permit delays on the project end, but as discussed later, this delay was not the ultimate cause for the protracted construction period, which ultimately ended on March 30, 2011.

Fence construction began on 06 November 2010 with the expectation that the fence would be completed prior to the holidays (22 December 2010). The contractor left for the holidays in mid-December indicating they would return after 12 January 2011. When contacted in early January, the vendor was elusive about their return date and ultimately did not return until late February when it was pointed out to them that they were in violation of their contract. The delay was caused because parts for the gate had not been ordered on time and had not made it onto a January barge for shipment to Hawai`i (despite the other fence materials being shipped in September) which meant that they could not work on the fence before the materials arrived at the end of February.

Future contracts would be well served by providing monetary penalties for work extending beyond a certain cutoff point, to provide incentives to the vendor to finish work on time. To facilitate clear communication, future contracts should also include clauses that have any off-island contractor provide copies of plane tickets/reservation so that arrival and departure times are known, copies of bills of lading with contents clearly outlined and a shipment schedule so that it is clear when materials will arrive. While a delay of one to three months may not seem significant, the commencement of the rodent removal was tied closely with the fence completion date, due to the breeding season of the rodents. As a result of the largely preventable delays, the predator removal began prior to the gates on the fence being completed which likely ended up extending the length of rodent removal due to continued immigration while the gates were not installed. In addition, since cultural and archaeological monitors were required to be present during certain phases of construction, that additional cost, the protracted rodent removal and extended employment of outreach staff cost the project a considerable amount of money.

Finally, while most predator-proof fencing contracts will state that they provide on the ground training in the maintenance and use of the fence and its components, having written instructions, and including a field-ready tool-kit list as part of the contract deliverables would have been extremely valuable and saved considerable time once regular maintenance duties were taken over. This project ended up creating our own tool kit list and maintenance instructions (complete with pictures) so that staff that were not present at the time of training would still be able to fix the fence when needed.

Construction

A construction window was established during contract negotiations tied to weather, road conditions, seabird nesting seasons and ideal rodent removal periods. Permit regulations, particularly the presence of a cultural and archaeological monitor as required under the Section 106 agreement, also dictated construction logistics to a certain extent.

Immediately prior to construction, the fence contractor was given oral as well as written instructions by project staff on appropriate behavior in the reserve as well as training on endangered species identification. The area where machinery was allowed was clearly flagged, and all endangered plants and historical features that were not to be altered were also flagged to prevent damage to the landscape. Contractors were notified of authorized walking trails, were required to bring their own portable toilet facilities and were required to pack out any waste daily. Finally, a physical copy of all permits was given to the contractor and they were required to have these with them at all times on the job site and abide by the conditions set forth in the permits at all times. For the most part, despite the delays, construction went as planned with a few minor hiccups, the most major of which is described below.

While a chain of communication was established in the contract, there was not a clear clause on who had the ultimate authority to dictate the work schedule. Because certain phases of construction were required to have both cultural and archaeological monitors present per permit requirements, there were days when work was not allowed when these monitors could not be on-site. Unfortunately there was an incident of mis-communication where the fence contractor did several hours of work without a monitor present even though they had been told not to work, which resulted in a written reprimand for both the contractor, as well as the USFWS by the permitting authority. As discussed in contract negotiations, monetary penalties tied to permit violations may have helped to prevent some of these issues.

Construction and dealing with vendors is an inherently challenging aspect of any project, and many of the issues encountered are common to any project, conservation and otherwise. While it is not possible to predict or control everything, the key changes described above could have saved this project several months, and several thousand dollars in staff time if they had been included during contract negotiations.

Maintenance

Proper and regular fence maintenance will be a critical step towards reducing the chance of re-invasion after predator removal, and a well-built pest-proof fence is only as good as the monitoring and maintenance program that supports it. Accidents, vandalism and acts of nature are likely at some stage leading to the fence being damaged or breached. A good maintenance and monitoring program will detect the breach immediately upon its occurrence, will have people and resources in place to make emergency repairs, and will reduce the likelihood of pests entering when a breach occurs. Fortunately, causes of the majority of fence breaches in New Zealand, such as treefalls, vehicles and livestock, are not issues at Ka`ena Point. Instead, human error, vandalism, and extreme wave events are more likely to cause damage at this site. A good maintenance program includes regular inspection, a rapid response protocol, and having appropriate tools and instructions available to mend repairs.

While it is anticipated that maintenance will be relatively minimal for Ka`ena Point during the first five years, there will likely be increased work required as the fence ages. Verbal training was provided by Xcluder in proper fence maintenance for all involved personnel at the conclusion of fence construction. Future projects could benefit by requesting written protocols and a toolkit list as part of their contract as this project had to develop their own which took a considerable amount of time. Fortunately, extra materials were ordered at the time of fence construction to cover the first five years of maintenance needs for the fence.

A small tool box of patch materials and tools was assembled and is carried by project staff on each visit. The most regular maintenance that needs to be performed (based on discussions with fence managers in New Zealand) are:

- Patching of any holes or warping in the mesh using wire and extra mesh on an as-needed basis (usually in response to breach reports)
- Painting of seams on hood and brackets to reduce corrosion on a regular schedule (such as quarterly)
- Regularly lubricating and tightening the screws to ensure the doors close properly and don't bounce open.
- Replacing the spring bracket in the door every 2-3 years

Inspections

A pest-proof fence will need to be physically inspected on a regular basis, ideally weekly. How regularly depends on the risks prevalent at the site. Proximity to the public (vandalism and accidental damage), the nature and size of animals adjacent to the fence (damage from large livestock such as cattle and horses), the volatility of sea-end coastlines (which could be damaged or modified in storms), the proximity, extent and size of trees, the regularity and severity of flooding, and the regularity of people entering and leaving the fenced area, plus the value of what exists inside the fence are all risks that determine the regularity of inspection. At Ka`ena Point, a complete fence inspection is done on foot weekly when perimeter bait stations are serviced and fence repairs are done on an as-needed basis. By doing inspections at the same time as regular baiting, costs are reduced considerably. This includes testing gates for functionality, sweeping out gate tracks, checking the mesh, hood and skirt along the entirety of the fence line for breaks in welds, loose bolts and scratch marks on the hood indicative of cat entry. In reality, the fence is informally inspected daily by numerous visitors using the reserve, and often obvious damage or issues are reported the day they are encountered. The formal fence inspections often find less noticeable damage, such as a weld break in the mesh that the untrained eye may not see on first glance.

During the first several months of gate operations, multiple issues were encountered with the gate interlocking mechanism (which prevents two doors from opening at once), which had been set too tightly. Typically, one door will not open until the second door is closed. In the case of Ka`ena Point, which is a popular hiking destination, the door that didn’t close most often was the door on the interior of the reserve which would become jammed with small pebbles. As a result, those entering the gates from the outside were not able to open the first exterior door, and could not see what was needed to fix it, and would pull on the door until it came off its tracks. After several weekends of this, the interlock mechanism was temporarily disabled, but the door closing mechanism was tightened so that doors would shut firmly after each opening. While this does reduce the pest-proof nature of the gates to a small degree, project staff felt that it was better to avoid further damage and risk the occasional double-door opening than have the gates completely broken. Repairs that were done during the first six months of fence inspections included one weld break, and two small acts of vandalism on the gates (kicking the door panel to where it bent, and jumping on the mesh roof panel). How to conduct fence repairs is beyond the scope of this report, and will depend on the fence design selected, and consequently, is not discussed below.

Buffer pest control

A buffer zone (using traps and poisons) is recommended around the outside of the fence perimeter to reduce the likelihood of pests entering the pest-free zone through a breach in the fence. The width of this buffer zone will depend on the species of pests present, their abundance, and the plants and animals at risk inside the fence. Several species, including rats and perhaps feral cats, seem to establish the fence as a territory boundary and regularly patrol it, increasing their chances of finding a breach before it is repaired. Consequently, pests that are strongly territorial and those that travel substantial distances often need to be the most extensively controlled. When a fence breach occurs it is important that any pests that do enter the pest-free area are detected early. If a breach goes unnoticed for some time and there is no pest detection program in place, it may become necessary for the entire fenced area to be re-poisoned or trapped to attain pest free status again.

The best way to detect pest intrusions is to establish a network of bait stations, traps or tracking tunnels around the inside of the fence line and also either a grid of stations throughout the protected area or at least scattered stations in strategic locations. Such a grid of bait stations or traps will probably have been established previously to achieve complete pest eradication; retention of the station grid will certainly assist with the early detection of any re-invaders. In one New Zealand example, a small hole occurred in a pest proof fence as a result of careless use of some farm machinery. The hole went unnoticed for a week and in that time up to 10 mice may have entered the pest-free valley. Only the established bait station and tracking tunnel network enabled the mice to be located and dealt with. The biosecurity protocols at Ka`ena Point are detailed later in this report and include all of the methods described above.

BIOLOGICAL MONITORING

Introduction

Monitoring of biological resources before and after fence construction is crucial for measuring and demonstrating the benefits and effectiveness of predator fencing as a management technique compared with traditional fencing and predator control methods. However, the types and amount of information gathered can vary dramatically depending on the site, budget, and goals, and in some cases there may be insufficient baseline data available to make the desired comparisons. In such cases, the use of simultaneous treatment and control sites located inside and outside areas that have been fenced and from which predators have been excluded can be used to measure the effects of predator fences. In the case of Ka`ena Point, sufficient baseline data already existed for some taxa (seabirds), but was lacking for others (plants and invertebrates) to make these comparisons. Extensive monitoring of a variety of taxa therefore was undertaken prior to fence construction in order to document the effects of the predator proof fence.

To facilitate consistent, repeatable monitoring for a variety of species, staff from the NAR System installed a permanent, geo-referenced, 50-m interval grid oriented on magnetic north throughout the reserve (Figure 5.1), with points marked by rebar with a 10 cm reveal. The rationale for selecting a 50-m grid was to provide an adequate number of replicates within the fenced area (N=73) for ecological comparisons and to have appropriate spacing for rodent bait stations, since 50 m is the average home range size for black rats. Except for Laysan Albatross and intertidal invertebrates, all biological monitoring was done using these grid points.

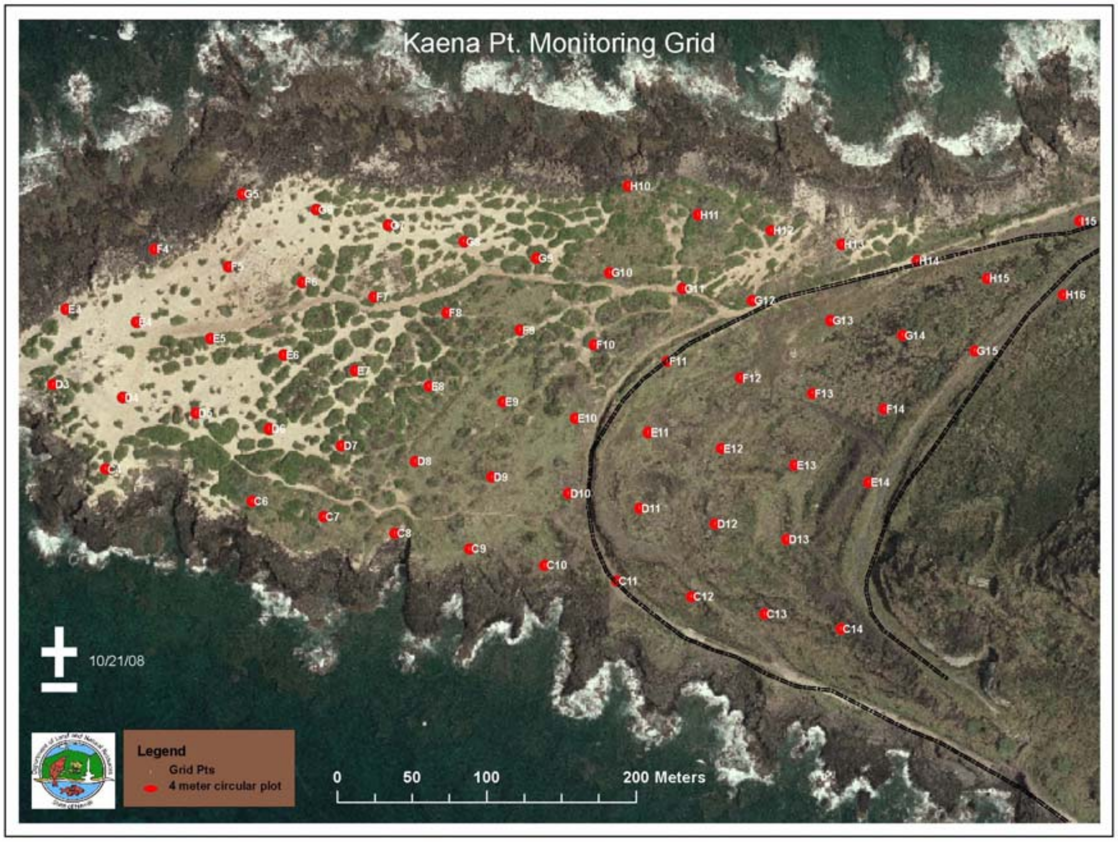


Figure 5.1- Schematic of the biological monitoring grid at Ka`ena Point

In seabird nesting areas such as Ka`ena Point, seabirds can act as the dominant species altering vegetation through physical disturbance and marine compound depositions from feces and carcasses, resulting in changes in species composition and habitat structure over time. It is thus important to monitor all aspects of the community to document these changes.

This section covers the protocols that were used to gather baseline data on each taxonomic group. The methods used for each group are presented below, but we anticipate that the before and after results for each group will be written up as stand-alone publications once sufficient 'after' data has been collected.

Seabird Monitoring

Introduced mammalian predators are one of the most serious threats to seabirds and other native bird species in Hawai`i and on many other islands (Côté and

Sutherland 1997, Scott et. al. 2001, USFWS 2006, Jones et. al. 2008). Rats, particularly black rats (*Rattus rattus*), are the primary nest predator on many island birds (Atkinson 1977, Atkinson 1985, Robertson et. al. 1994, VanderWerf and Smith 2002, VanderWerf 2009) and have caused or contributed to the extinctions or local extirpation of numerous island-nesting seabird species. Feral cats are also a serious problem for many bird species. Predation on nests by feral cats has been documented in Hawaiian seabirds, including the endangered Hawaiian Petrel (*Pterodroma sandwichensis*) (Simons and Hodges 1998, Hodges and Nagata 2001, USFWS 2005, Lohr et. al. in press).

The effectiveness of predator exclusion on bird populations can be measured by comparing population sizes, survival rates, and reproductive rates. This can be accomplished using temporal comparisons before and after fence construction, and/or simultaneous spatial comparison from inside and outside the fenced area. There is an extensive literature on bird population monitoring, and numerous techniques are available that are suitable for a variety of purposes and situations (Ralph and Scott 1980, Bibby et. al. 2000, Buckland 2006).

Bird populations may respond slowly to management and it may require several years for birds to begin using an area or for increased rates of recruitment to result in detectable population increases. It may be more feasible to detect changes in other population parameters, such as nesting success. For birds that have been extirpated, simply documenting nesting in the area following predator fencing would demonstrate success.

For the seabird species nesting at Ka`ena Point, the most suitable methods depended on their abundance and how easy they were to detect. For Laysan Albatross (*Phoebastria immutabilis*), which occur in low density but are large and easily visible, a census of nesting birds and regular nest monitoring was conducted. For Wedge-tailed Shearwaters (*Puffinus pacificus*), which occur in high densities and nest in underground burrows, census of nesting burrows was conducted at first, but the monitoring method was switched to a plot-based design.

Laysan Albatross

Laysan Albatross began nesting at Ka`ena Point in 1992 after off-road vehicles were excluded. All chicks hatched at Ka`ena Point were censused and banded with a unique, federal metal band each year by DLNR staff beginning in 1992when nesting first started . Regular monitoring of adults and chicks began in 2004 for the duration of the breeding season (Nov-Jul. Monitoring consisted of a weekly census of all birds present. Each time an adult was encountered, its location, status (incubating, brooding, or walking), and association with any other adult or chick was noted. Chicks were monitored from hatching (Feb) until fledging (July). Nest number, parent information, hatching date, disease status, and date of either fledging or death were recorded for all chicks. Starting in 2006, each bird was also given a field-readable purple plastic band numbered in white from O001-O999. Chicks that survived to fledging were banded with both a federal metal band and a field-readable plastic band.

Extensive information about the monitoring methods and results, including reproductive success, population size, and survival rates in this colony can be found in Young and VanderWerf (2008), Young et. al. (2009a,b) and VanderWerf and Young (2011). In summary, a population of approximately 365 adults are present on the colony with a maximum of 61 nests initiated in the 2012 breeding season.

Wedge-tailed Shearwaters

Wedge-tailed Shearwaters began nesting in the reserve in 1994, shortly after off-road vehicles were excluded, and a complete census during October or November of active nesting burrows has been conducted almost every year until 2008. Counts consisted of searching visually for burrows and determining whether they were occupied (presence of a chick confirmed visually or by touch), or unoccupied but active (unhatched egg, fresh droppings, feathers, tracks, or digging). Due to the increasingly large numbers of burrows and the impact a census was having on the habitat, a plot-based monitoring technique using the 50-m grid points was begun in 2008 in conjunction with a determination of what size of plot produced the most accurate results. Each point in the 50-m grid served as the center of a circular plot, and the number of burrows was counted within 4, 5, 6 and 8m radii. Plots with a radius of 8m produced results most similar to the census data likely since they represent a large total proportion of the area surveyed. From 2009 onwards, the plot design was used exclusively to monitor Wedge-tailed Shearwater reproduction.

Other Seabirds

Bulwer's Petrels nest on several islets off O`ahu but are currently not known to nest at Ka`ena Point. This species was searched for at Ka`ena by imitating its barking call at night in rocky areas preferred by this species for nesting and waiting for a response. Other nocturnal Procellariformes were monitored by listening during the dusk hours at the appropriate times of year to detect their presence. Prior to fence construction, no other seabirds were detected nesting aside from those described above.

Red-tailed Tropicbirds nest at one other location on Oahu and also on Manana Island off the eastern coast of Oahu (VanderWerf and Young, 2007). Up to seven adult Red-tailed Tropicbirds have been observed simultaneously courting at Ka`ena Point, but no nests have been observed. Individuals of this species may colonize Ka`ena Point naturally because there are colonists close by.

Invertebrate Monitoring

Invertebrates are a relatively inconspicuous but extremely important components of native ecosystems. Native invertebrate communities provide integral ecological services, including pollination and nutrient cycling, without which most Hawaiian plant species could not exist (Howarth and Mull 1992; Mitchell et. al. 2005). Changes in abundance, diversity, and species composition of the invertebrate fauna at a site may help to indicate improved ecosystem functioning. Extensive coastal strand habitat is exceedingly rare in Hawaii. Several rare invertebrate species can still be found at Ka`ena Point. A noteworthy example is a native yellow-faced bee, *Hylaeus longiceps*, which is currently being considered for federal protection (Magnacca 2007).

Because they are generally more numerous and have shorter generation times, invertebrates may show population responses to management more quickly than vertebrates. In New Zealand, abundance of beetles inside the Maungatautari predator exclosure increased 8% per month immediately after alien mammals were removed and 50 species of beetles were collected that were previously unknown at the site (Watts 2007).

There are approximately three vegetation habitat types at Ka`ena Point-coastal strand, naio shrubland, and invasive grasses. Invertebrate monitoring was done at three grid points in each habitat type at Ka`ena Point. Exact points were chosen using a random number generator to produce three selections in each habitat type in Microsoft Excel. Points D6, D7 and E7 (see Figure 5.1) were located in coastal strand sites; C7, D9 and G12 in naio shrubland, and D11, D13 and E12 were in invasive grassland. Vegetation beating, sweep netting and litter sampling were completed once at each point. In addition, one pitfall trap, one yellow pan trap and one yellow sticky card were laid out at each point (nine total) for three days.

Invertebrate specimens will be identified to species where possible. Invertebrate abundance will be measured as a total number of individuals and/or biomass captured per trapping interval / collection effort. Abundance of invertebrates in different feeding guilds (herbivores, detritivores, nectarivores, predators, parasitoids, etc.) will be examined to look for shifts in ecosystem functioning before and after predator removal. This baseline of species diversity and abundance will help determine whether predator exclusion affects invertebrate diversity, and if native species in particular will increase in abundance.

Pit-fall Traps

For ground-dwelling species, pit fall traps are an effective passive sampling method (Spence and Niemela 1994). To install pit fall traps, a shallow hole is dug in the ground and a small cup or bowl filled with a killing agent or preservative is placed inside. The lip of the container is positioned to be even with the surrounding ground, and, as a result, crawling invertebrates inadvertently fall into the container and cannot escape. Ka`ena Point pit fall traps were baited with propylene glycol (anti-freeze), and deployed for three days. Following trap collection, specimens were transferred into 70% ethanol for storage.

Yellow Pan Traps

Many insects are attracted to the color yellow, a trait which is often used to facilitate their collection (Neuenschwander, 1982). A yellow pan trap is a quick and easy way to catch specific types of invertebrates. A shallow yellow pan or bowl is either placed on the ground or into a small hole in this case so that its rim is level with the ground. The bowl is then filled with water, and several drops of detergent are added to break the surface tension. Insects that are attracted to yellow (ex. flies, wasps, and beetles) will fall in and drown. The traps will also collect invertebrates not attracted to yellow, intercepting them in the same manner as the pit-fall traps. Following collection of the pan traps, specimens were transferred to 70% ethanol for storage.

Yellow Sticky Cards

Sticky cards traps are used to collect the adult stages of flying insects (e.g., flies, gnats, shoreflies, leaf miners, winged aphids). A single Trece Incorporated Pherocon AM trap (without lure) was placed at each of the sampling points and left for three days. Sticky cards consist of 8.5” x 11” yellow card-stock, folded in two, coated with a thin veneer of a sticky paste. At each point, a trap was hung from vegetation, 0-2m from the ground, where it was visible to flying insects. Sticky cards were collected, wrapped in plastic wrap, and placed in a freezer for long-term storage.

Vegetation Beating and Sweep Netting

Vegetation beating and sweep netting are some of the most effective approaches for collecting a broad assortment of invertebrates from vegetation. To survey woody shrubs or trees, a tarp or "beat sheet" is laid under the vegetation targeted for sampling. The vegetation is then shaken by hand, or "beaten" with a sweep net handle, to dislodge invertebrates present on the foliage. Specimens were then collected by hand or with an aspirator. Since herbaceous vegetation, grasses and some shrubs do not ordinarily lend themselves to beating, they are better sampled through the use of sweep nets. Canvas insect nets were swung across vegetation, knocking off and capturing invertebrates present on the foliage. Those specimens were also collected by hand or with an aspirator. Fifteen beats and fifteen sweeps were completed at each sampling point at Ka`ena Point

Ant monitoring

Due to particular concern over the potential impacts ants may have on the ecosystem after the removal of rats, an ant monitoring protocol was established. Four replicates per habitat type (12 points total) were set up inside the reserve and 12 outside the reserve for control and experimental purposes. Ant bait (spam, peanut butter, and honey) was placed on an index card for up to two hours and then the card removed to inventory the ants. In addition, a transect design was used that bisects the preserve so that all habitat types would be surveyed, and a comparable transect was selected outside the reserve. Eleven index cards baited with peanut butter, honey, and spam were placed at 50-m intervals along the "E" transect (see Figure 5.1). Sampling was conducted twice, once each in the spring and summer.

Vegetation monitoring

The effects on native plants from browsing, trampling, gnawing and seed destruction by predators is ubiquitous and can be very serious in many areas of Hawai`i (Scowcroft and Giffin, 1983; Tomich 1986, Hess et. al. 1999). Monitoring of plant populations is important to gauge the effectiveness of predator fencing and eradication at many sites. Plant monitoring should not be limited to endangered species; changes to more common plant species that form the bulk of native habitats should also be monitored.

At Ka`ena Point, an overall inventory was done as well as a transect design that monitored percent cover, species assemblages and soil types over time to document potential changes at each grid point as a result of predator removal and associated ecosystem shifts. Each vegetation plot consisted of a 16m baseline transect, oriented from E-W, and centered on a grid point; along each baseline transect, five 16m transects oriented N-S were established at 4-m intervals producing a 16 x 16 m grid centered on the 16-m-diameter circles of the shearwater plots.

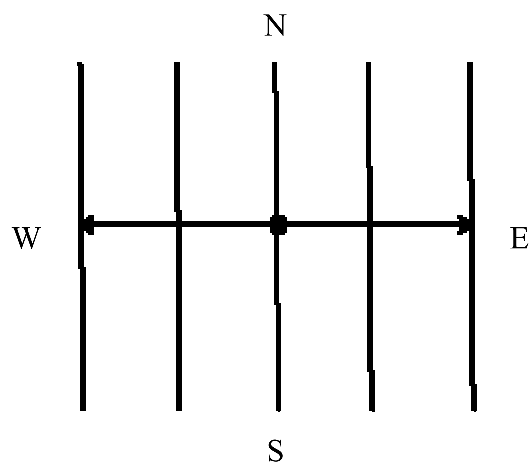


Figure 5.4- example of transect design

At every meter along the 5 N-S transects, all species intercepted by a vertical rod were counted using the point-intercept method (Mueller-Dombois and Ellenberg 1974), and the data were converted to absolute percent cover (which cannot exceed 100% for any single species, but may do so for all species combined). Substrate type (rock, sand, volcanic soil) was also recorded at all 85 point-intercept points. Data were collected at 52 of the 73 grid points; points outside the fence line, in unvegetated parts of the intertidal zone, directly on main trails, and on graded gravel slopes were omitted.

Observational data

Monitoring of plants for survival, amount of gnawing, browsing, seed predation, and other damage caused by predators is one important method of monitoring for the presence of predators, particularly at sites where baseline data on status of endangered plants is available for comparison. Natural recruitment of wild plants should also be observed and measured. At Ka`ena Point, observational data was collected on Ohai (*Sesbania tomentosa),* and coastal sandalwood (*Santalum ellipticum*), both of which are frequently targeted by rats for their fruits, and are good indicators of rodent presence.

Soil Sampling

In seabird nesting areas, seabird can act as the keystone species by altering vegetation through physical disturbance and marine compound depositions in the soil from their guano. Due to these disturbances and nutrient inputs, plant and invertebrate communities can change over time which alters habitat structure and as a result, it is important to monitor all aspects of the community to document these changes. To ensure that any changes that were associated with marine compound deposition in the soil could be quantified, soil sampling was conducted.

A push corer was used to extract ~250ml of soil samples at each grid point from the surface up to a depth of 15 cm. Samples will be sent to Agricultural Diagnostic Services at UH and have total N, P, C, pH, and salinity measured. The sampling will be repeated at least two years after predator removal to document changes in soil composition that are potentially associated with changes in seabird densities.

PREDATOR CONTROL AND BIOSECURITY OPERATIONAL PLAN

Introduction

All mammals in the Hawaiian Islands except the Hawaiian monk seal (*Monachus schauinslandi*) and the Hawaiian hoary bat (*Lasiurus cinereus semotus*) were introduced to Hawai`i by people, some intentionally for food, pets, or biocontrol agents, and others as accidental stowaways (Tomich 1986). Because Hawai`i is so isolated from continental areas, the native plants and animals that evolved in the islands are naïve to mammalian predators and often lack defenses against them (Salo et. al. 2007, Sih et. al. 2009). Polynesians colonized the Hawaiian Islands about 800 years ago (Rieth et. al. 2011) and brought with them several destructive predators including the Pacific rat (*Rattus exulans*), domestic dog (*Canis familiaris*), and domestic pig (*Sus scrofa*) (Kirch 1982, Burney et. al. 2001). Introduction of alien predators accelerated with the arrival of Europeans starting in 1778, including the black or ship rat (*R. rattus*), Norway rat (*R. norvegicus*), domestic cat (*Felis silvestris*), small Indian mongoose (*Herpestes auropunctatus*), house mouse (*Mus musculus*), and European wild boar.

Predators, particularly black rats, are the single greatest threat to seabirds worldwide (Jones et. al. 2008). Feral cats and small Indian mongooses are known to be serious predators of seabirds on Oahu and elsewhere in Hawai`i (Hodges and Nagata 2001, Smith et. al. 2002). Rodents, including black rats and Pacific rats, are known to prey on seabirds in Hawai`i (Fleet 1972, Woodward 1972, Smith et. al. 2006). Rats and house mice (*Mus musculus*) have been documented to consume native plants, their seeds, and invertebrates (Shiels 2010). There are many examples in which eradication or control of predators has resulted in recovery of native species in Hawai`i (Hodges and Nagata 2001, Smith et. al. 2002, VanderWerf and Smith 2002, VanderWerf 2009) and around the world (Côté and Sutherland 1997, Butchart et. al. 2006, Howald et. al. 2007).

Five non-native predatory mammal species are present at Ka`ena Point: feral dogs, feral cats, small Indian mongooses, black rats, and house mice. Feral dogs have been observed in the reserve only sporadically, and very few, if any, dogs are present in the reserve at any given time. Dog attacks on seabirds can occur either when feral dogs wander into the reserve or when people illegally bring pet dogs into the reserve. Feral cats are present at Ka`ena Point year round and have caused substantial damage to seabird populations in the past. Dietary analysis of feral cats caught at Ka`ena Point indicates that both seabirds and rodents are significant components of their diet (Lohr et. al. in review).

Rats and mice are thought to be important ecosystem modifiers at Ka`ena Point due to their consumption of prey at all levels of the food chain, from plants through birds. Rodents therefore were the primary target of the predator removal plan. Experience from other eradication attempts suggested that while mice do not pose the greatest risk for ecological restoration, they can be the most difficult species to eradicate for a number of reasons. Mice can:

- occupy very small home ranges (<100 m^2)
- be difficult to detect at low densities
- reinvade through small gaps in the fence, or at the fence ends
- reproduce very quickly
- occur at high densities in the absence of rats or other predators

Their response to diphacinone bait has not been thoroughly tested. Due to the uncertainty surrounding the efficacy of diphacinone in eradicating mice (Parkes et. al. 2011), the trapping grid was designed to maximize the potential for success.

Objectives

The objectives of designing the predator removal program were to select the most effective method(s) available while consideringthe pest species present, the tools legally available for use, and the timeline and funding available

It is possible that the methods chosen do not reflect the most universally effective methods employed in other countries or states, but were the ones that were most feasible given the scope and constraints on this project. Trapping data from 2000-2010 collected by the U.S. Department of Agriculture Animal and Plant Health Inspection Service Wildlife Services (Wildlife Services) were analyzed for larger mammals, and a rodent study was conducted to provide information on rodent abundance and home range size in order to effectively plan for multispecies predator removal and long term control.

Pre-eradication Pest Control and Monitoring Methods

Predator Control 2000-2010

Predator control was initiated by the DLNR starting in 1992 using 10-20 cage traps for feral cats and mongooses and several bait stations for rodents that were placed within the core seabird nesting areas (~7ha). In 2000, DLNR contracted Wildlife Services to continue and expand the predator control. Wildlife Services visited Ka`ena Point an average of three days per week to conduct control activities. Methods included the use of 9 x 9 x 26" single-door Tomahawk cage traps, Bridger or Victor #1.5 padded or offset leg-hold traps (starting in 2008), and night shooting. Up to 32 cage traps and 10 leg-hold traps were used each year (Table 6.1). Traps were placed strategically throughout the entire reserve so as best to intercept predators (Figure 6.1).

Table 6.1: Summary of cat and mongoose trapping effort at Ka`ena Point from 2000-2010.

Year	# cage traps	# cage trap-nights	# leg-hold traps	# leg-hold trap-nights
2000	unknown	unknown	0	0
2001	unknown	unknown	0	0
2002	unknown	unknown	0	0
2003	unknown	unknown	0	0
2004	31	2697	0	0
2005	31	10429	0	0
2006	32	10528	0	0
2007	32	10397	0	0

2008	30	9093	3	62
2009	27	7773	6	136
2010	25	8139	10	361

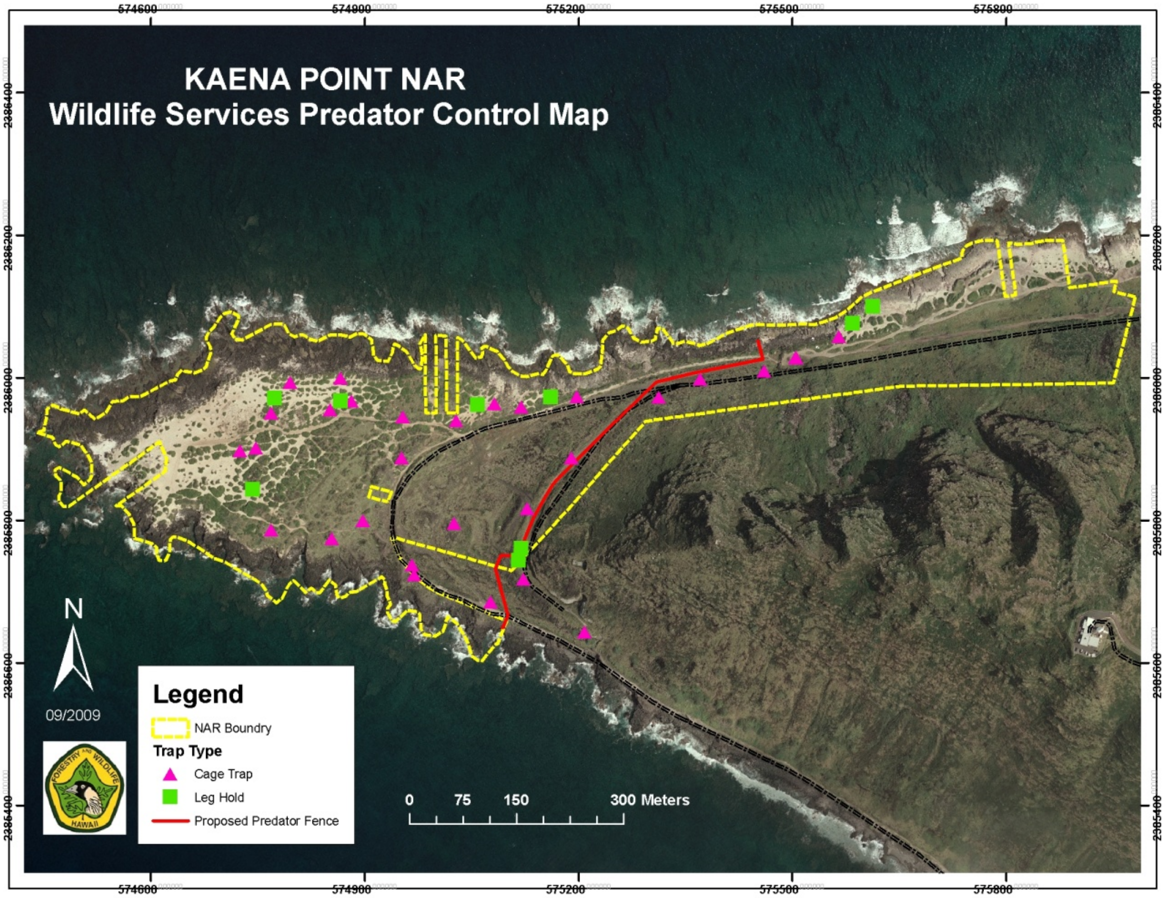


Figure 6.1: Trap placement by Wildlife Services in Ka`ena Point Natural Area Reserve in 2009.

Rodent Monitoring 2008-2009

In the fall of 2007, a permanent, 50-m geo-referenced grid oriented on magnetic cardinal compass bearings was installed in Ka`ena Point NAR to facilitate monitoring and other management activities. A combination of live and snap traps were used in April, July, and November 2008 and February 2009 to investigate rodent species composition, abundance, habitat use, and seasonal variation in rodent populations. These months were chosen because they are representative of the climatic seasons in Hawai`i. Rodent traps were placed along transects running east to west that encompassed all three habitat types discussed earlier in similar proportions.

Victor® rat snap traps were placed at 50-m intervals and baited with fresh coconut chunks along transects D and G (N=23 traps) and 4 traps spaced approximately 20m apart were placed along the shoreline at each of the proposed fence ends (N=8 traps). Victor® mouse traps were placed at 10-m intervals along a 400-m section of transect E (N=40 traps) and also were baited with fresh coconut chunks. All rodent traps were pre-baited while unset for three nights and either covered with 1" chicken-wire mesh or tied onto low lying vegetation to prevent seabird interference while allowing rodents access. Traps were then set for three nights and checked daily for catch. Trap status and rodent species caught were noted and all specimens were frozen for future analyses.

Rodent Home Range Size Estimation

Live traps were deployed during the July and November monitoring events to capture live rodents for tracking purposes To estimate rodent home-range size. Haguruma® live cage traps were used for rats and Eaton® repeater mouse traps were used for mice. Both trap types were baited with a combination of fresh coconut and peanut butter.

All rodents captured were sexed, weighed, and identified to species. A small spool of white thread was glued to the back of each rodent captured. Spools used with rats weighed less than 2g and held up to 200m of thread; much smaller spools were used for mice. The end of the thread was tied to a piece of vegetation and the rodents were released. Two or three days later, GPS tracks of the path of the rodents were taken by following the thread. Maximum distance travelled was measured for each animal, and substrate and habitat type also were noted.

Pre-eradication Pest Control and Monitoring Results and Discussion

Large Mammal Control 2000-2010

A total of 150 feral cats, 493 mongoose, and nine feral dogs were removed from Ka`ena Point NAR from January 2000 through December 2010 (Table 6.2), for an average annual removal rate of 13.6 feral cats, 44.8 mongooses, and 0.82 feral dogs.

Table 6.2. Numbers of feral cats, mongoose, and feral dogs removed by different methods at Ka`ena Point Natural Area Reserve from 2000-2010.

	Cats				Mongoose				Dogs
Year	**cage trap**	**Leg-hold**	**firearm**	**Total**	**cage trap**	**Leg-hold**	**firearm**	**Total**	**firearm**
2000	6	0	14	20	15	0	0	15	0
2001	10	0	1	11	11	0	0	11	2
2002	16	0	4	20	37	0	0	37	0
2003	14	0	12	26	34	0	0	34	0
2004	6	0	5	11	67	0	0	67	0
2005	4	0	3	7	80	0	0	80	2
2006	7	0	3	10	58	0	3	61	4
2007	3	0	3	6	51	0	0	51	0
2008	2	6	1	9	65	1	3	69	0
2009	5	9	0	14	55	2	0	57	1
2010	1	14	1	16	7	4	0	11	0
Total	74	29	47	150	480	7	6	493	9

Capture rate of feral cats in live traps declined over time, possibly because cats reaching Ka`ena Point had been trapped and released elsewhere previously and had become “trap shy”. Beginning in 2008, padded (Victor) and offset (Bridger) leg hold traps were employed in addition to live traps and catch rates rose dramatically (Figure 6.2).

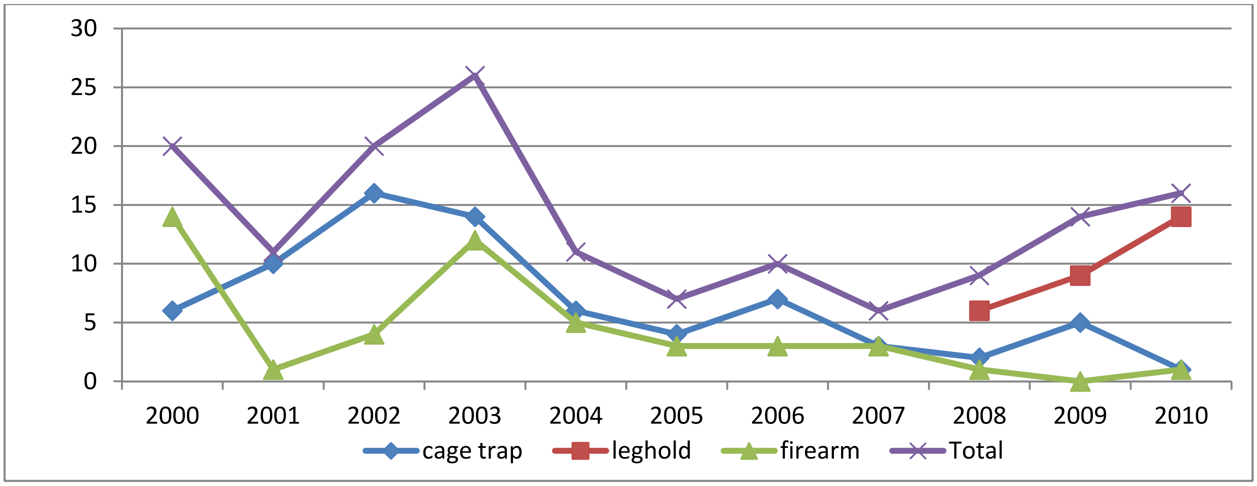


Figure 6.2: Number of cats removed by different methods at Ka`ena Point from 2000-2010.

The capture rate of feral cats was substantially higher in leg-hold traps than in cage traps (Table 6.3), with leg-hold traps being an average of 327 times more efficient than cage traps. Although the total number of cats captured each year from 2008-2010 was not as high as in some previous years (Table 6.2), these captures were achieved with many fewer traps and trap-nights (Table 6.1). For mongoose, cage traps appeared to be somewhat more effective, though leg-hold traps were deliberately placed to target feral cats, such as along cat tracks. These results indicate that cage trapping is not an effective control method for cats at this site, and that it is more expensive due to the greater trapping effort required. Padded leg-hold traps clearly are the preferred method for cat removal at Ka`ena Point.

Table 6.3: Comparison of trapping rate of feral cats and mongooses using cage traps and leg-hold traps at Ka`ena Point Natural Area Reserve.

	Cats			Mongoose
Year	#/cage trap-night	#/leg-hold trap-night	Leg-hold vs. cage traps	#/cage trap-night
2004	0.0022			0.0248
2005	0.0004			0.0077

2006	0.0007			0.0055
2007	0.0003			0.0049
2008	0.0002	0.0968	484x	0.0071
2009	0.0006	0.0662	110x	0.0071
2010	0.0001	0.0388	388x	0.0009

Seasonal Rodent Abundance and Habitat Use

Black rats and house mice were the only rodent species caught at Ka`ena Point. No Pacific rats or Norway rats were caught. Mouse catch rates were approximately two to eight times higher than rat catch rates (Figure 6.3). The pattern of seasonal abundance was similar for both species, with peaks in spring and lows in late fall, suggesting a spring reproductive peak (Figure 6.3), which agrees with other studies conducted in Hawai`i (Parkes 2009). Assuming the area sampled for mice was 0.4 ha (40 traps at 10-m intervals, yielding a strip 10-m wide and 400-m long), the density of mice ranged seasonally from 48-78/ha. Similarly, if the area sampled for rats was 6.75 ha (27 traps at 50-m intervals), the density of rats ranged from 0.6-2.1/ha depending on the season. The finding that mice are so much more abundant than rats is unusual and suggests that mice are not controlled by rats at this site, which is contradictory to several previous studies (Billing 2000, Billing & Harden 2000, Witmer et. al. 2007). Moreover, the density of mice per hectare is comparable to sites in New Zealand where rats have been eliminated but mice are still present and have experienced a competitive release. Mice were often observed in the reserve during daylight hours. To our knowledge this was one of the highest reported densities of mice co-existing with black rats in a natural setting and presented important implications for choosing a removal strategy.

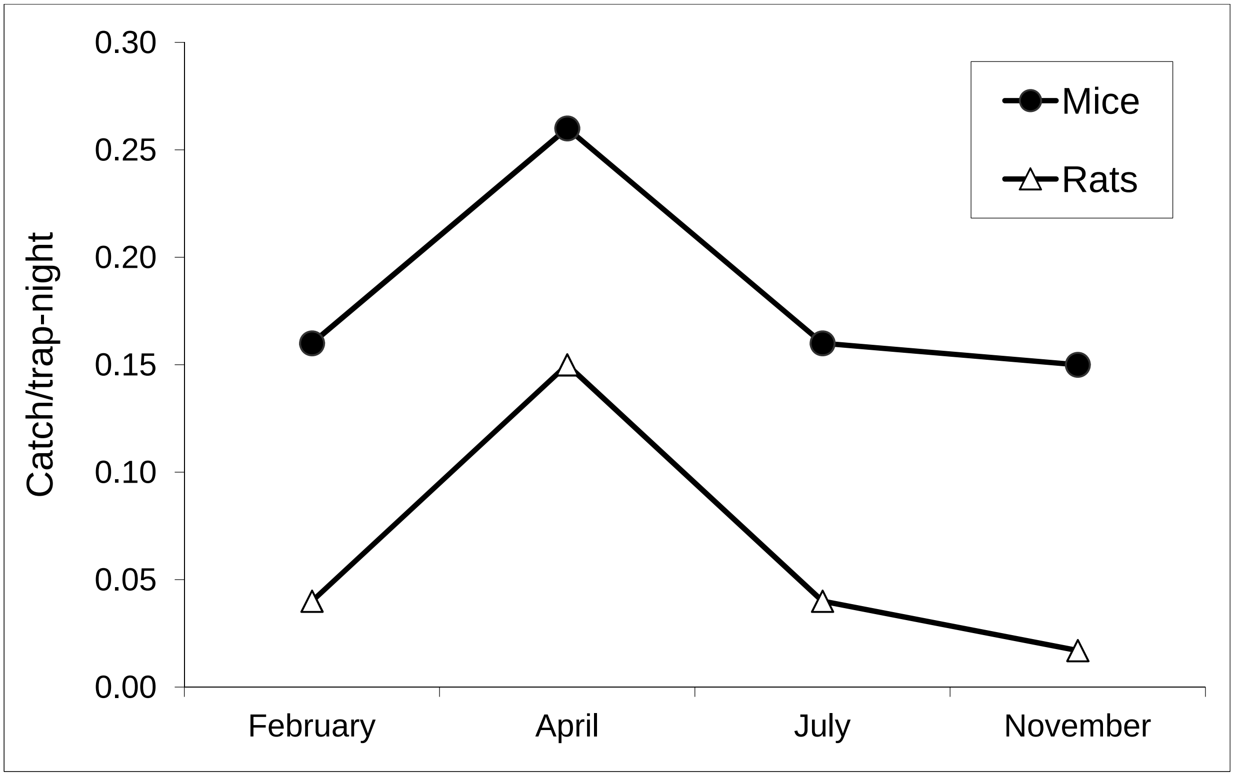


Figure 6.3: Catch rates of rodents at Ka`ena Point by season

Rodent Habitat Use and Spatial Distribution

The spatial distribution and habitat use of rodents in the reserve differed somewhat among seasons. During the peak in density in April, mice were captured in all habitat types and were widespread throughout the reserve, and rats also were found in all habitat types. When rodent densities were lower (July-February), mouse captures were more scattered, and most rats were captured near the shoreline in traps placed in the intertidal area at either end of the proposed fenceline, where marine intertidal invertebrates provide a rich source of food.

Rodent Home Range Size

A total of two rats and four mice were captured for tracking. One of the rats and one of the mice expired while in hand, so only one rat and three mice were tracked. The movements of the rat were traced using the thread after two days, during which time it was active in an area dominated by grassy vegetation and bare rocky substrate near where it was caught. The thread apparently broke during this time because neither the rat nor the spool was recovered. The size of the area covered by the rat during this time, as indicated by the path of the thread, was 45 m by 25 m, and most of the movement was centered around a cavity in the rocks that held approximately 40 L water which presumably acted as one of the few water sources in the reserve.

The three mouse tracks were followed after three days. The spool from each mouse was recovered, suggesting all three mice had groomed the spool off. Similar to the rat, the habitat used by all three mice was low grassy vegetation with a rocky substrate that provided numerous underground crevices. Maximum distance travelled from the point of capture was approximately 12m for all three mice. Because the error associated with GPS readings was large relative to the distances moved by mice, distances were directly measured in the field with a measuring tape. The home range size estimates presented here are minimum values and were based on just a few days of movements for each animal.

Monitoring conclusions

Feral cats, small Indian mongoose, black rats, and house mice were constantly present at Ka`ena Point NAR despite ongoing predator control. Mice were present at high density, while black rats were less abundant. Dogs were present only sporadically and in low numbers.

Based on our data, the most effective methods of predator removal were determined to be: 1) a combination of shooting and leg hold trapping for cats, 2) cage trapping and diphacinone poison in bait stations for mongoose, 3) shooting for feral dogs, 4) diphacinone poison in bait stations on a 25 m grid for black rats, and 5) a combination of the 25-m diphacinone bait station grid and mouse traps on a 12.5-m grid for mice. Even if the mouse home range size was larger than measured, because of the high density of mice in the reserve, it was determined that an interval of 12.5 m between mouse traps (half the distance between bait stations) might be needed to ensure that all mice were exposed to traps and/or bait stations and increase the chances of successful mouse eradication. A larger distance between mouse traps might have been sufficient, but a conservative approach was judged to be prudent. Similarly, bait stations targeting rats were spaced 25-m apart to ensure that all black rats were exposed to bait, and to allow for the possibility that Polynesian rats (which have smaller territory sizes than black rats (Shiels 2010) may be present in the reserve in low densities and were simply not detected during the trapping events.

Since the larger mammals are thought to breed year round, it was decided that control operations should begin immediately after fence construction to avoid any further predation on seabirds. Rodent removal operations were conducted in the winter prior to the commencement of the rodent breeding season in hopes of reducing the effort required to remove all animals.

Diphacinone has been used to control rodents in Hawaiian coastal habitats (F. Duvall pers. comm.) and was used to successfully eradicate Pacific rats on Mokapu Islet off of Molokai (Dunlevy & Scarf 2007). Diphacinone also has been used to eradicate black rats in a variety of locations worldwide (see Donlan et. al. 2003, Witmer et. al. 2007 for examples), though it appears to be less effective than brodificoum, particularly for mice (Parkes et. al. 2011). However, diphacinone is the only poison approved for conservation purposes in Hawai`i.

Predator Removal Operational Plan

Large Mammal Removal

Large mammals (feral dogs, feral cats, and mongooses) were continuously targeted during and immediately following fence construction to prevent losses of Laysan albatross chicks and Wedge-tailed shearwater adults. Feral dogs have been observed in the reserve only sporadically, and the activity associated with fence construction appeared to have scared them off.

Feral cats and mongooses were removed with a combination of cage-traps (9x9x26-inch single door Tomahawk traps) baited with commercial pet food, and leg hold traps (Victor #1.5 padded or Bridger offset leg hold traps). Cage traps were placed throughout the reserve, but leg-hold traps were placed strategically in locations most likely to intercept predators, particularly cats. Cat removal was supplemented with opportunistic night shooting. To help inform cat removal and improve trap placement, four remote cameras with infra-red motion-activated triggers (Scoutguard SG550) were used to identify individual cats and determine areas of high predator activity.

Rodent Removal

In order to generate baseline data on relative rodent abundance prior to removal, tracking tunnels were placed on every 50-m grid point (N=73), and 200m-long transects with mouse live-traps at 10-m intervals were placed both inside and outside the reserve, and both were run prior to commencement of baiting. Tracking tunnels also were run approximately monthly throughout the removal operation to provide an additional method of measuring rodent abundance.

Rodents were targeted with Ramik mini-bars® (HACCO Inc., Randolph, Wisconsin, USA) containing 0.005% diphacinone placed in tamper-resistant Protecta® plastic bait stations (Bell Laboratories, Madison, Wisconsin, USA) to shield them from rain and reduce the risk of poisoning to non-target species. Entrances to the stations were large enough to allow access by mongooses.

Bait stations were placed in a 25-m grid pattern throughout the reserve (Figure 6.4) and filled with up to 11 1-oz blocks per station. The maximum allowable amount of bait as specified under the product label is 16 oz/station, but we decided to place no more than 11 blocks in each station because that was the maximum number that could be accommodated on the spindles provided with the stations to prevent bait from being shaken out of the station. Bait stations were generally not placed below the vegetation line on the coast to reduce the possibility of them being washed away by high surf. With 25-m spacing, there were 291 stations in the reserve. The 50-m grid points previously installed to facilitate monitoring and management were used as starting points, and additional points were located at 25-m intervals using a laser range finder. Bait stations were serviced twice per week during the first month, and after that frequency was adjusted based on levels of take to ensure that an adequate supply of bait was available at all times. Frequency of maintenance was once per week during the second month, once every two weeks for the next three months, and once a month thereafter.

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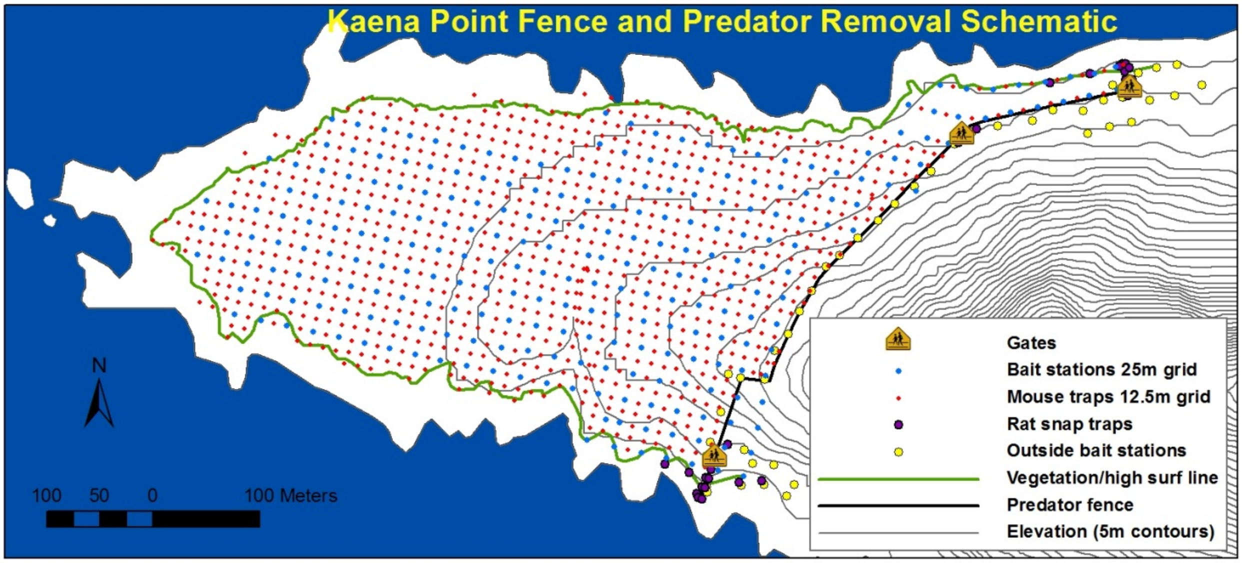

Figure 6.4. Locations of bait stations and traps used in predator removal and in detection and prevention of incursions.

Two weeks after baiting started, multiple-catch Catchmaster™ mouse live-traps baited with peanut butter were placed every 12.5m within the fence using a laser rangefinder. This resulted in lines containing only mouse traps alternating with lines that contained mouse traps and bait stations in an alternating pattern (Figure 6.4). On transects that already contained bait stations, mouse traps were alternated with bait stations, so that mouse traps were 25 m apart, but with a method of control every 12.5m since they alternated with bait stations. Live rodents were humanely euthanized using cervical dislocation. Traps were checked with the same frequency as bait stations; twice weekly during the first month and less often thereafter as needed.

At the time of writing, predator removal operations were still ongoing; final results will be published in a separate document once operations are complete.

Biosecurity

Incursion Prevention and Monitoring

Monitoring for incursions, or re-invasions that occur after fence completion, is vital to the success and sustainability of the Ka`ena Point Ecosystem Restoration Project. Preventing incursions from occurring is more cost-effective than dealing with them afterwards., Incursions should be prevented to the maximum extent practicable using all reasonable measures. However, due to the open ends of the fence at the shoreline, occasional incursions are to be expected, and having protocols in place to detect and deal with them is essential.

The first step of the biosecurity plan was the establishment of a regular fence inspection and maintenance schedule to ensure that the fence remains pest proof. This includes weekly checks for breaches and holes in the fence, and sweeping rocks, sand, and other debris from inside the gates, particularly the tracks of the sliding doors, to ensure the gates open and close properly. Section four of this document, construction and maintenance, provides more details on fence maintenance.

Secondly, to keep pest pressure off the fence, predators were controlled along the entire length of the exterior of the fence and on the interior and exterior of the fence end at each shoreline (Figure 6.4). This is accomplished using a combination of bait stations and snap traps that are checked and maintained weekly. Bait boxes containing diphacinone were placed 25m apart and up to 50m out from the fence line (i.e. two rows of parallel bait stations). On the fence ends, the bait stations were expanded in a fan-shaped pattern extending 125m from the fence ends (4-5 bait stations deep). To help prevent rats from approaching the fence ends and possibly gaining access to the reserve, rat traps were placed at 10-15 m intervals along the outside of the fence end (Figure 6.4). In case rats or mice did make it around the fence end, rat traps and mouse traps were placed at 10-15 m intervals along the inside of the fence end and along the shoreline inside the fence up to 75 m from the terminus. This system of traps inside and outside the fence formed a “gauntlet” through which predators would have to pass to reach the interior of the reserve. Rodents are likely to use the fence and the shoreline as movement corridors, so targeting these areas increased the chance of interception.

The gauntlet of rat and mouse traps provided one method of detecting incursions. another means of detecting incursions, a system of tracking tunnels throughout the reserve in a 50-m grid, which also was used to monitor the progress of predator removal, was run monthly to monitor the presence of rodents. In addition, the tracking tunnels located within the gauntlet of traps at the fence ends were checked weekly at the same time the traps were checked. It is hoped that most incursions will be contained within the gauntlets immediately inside the fence ends. If incursions are detected in the interior of the reserve (more than 100m from the ends), this will trigger an increased incursion response using additional traps and bait stations, described in the next section of this chapter.

Larger predators, including feral cats, dogs, and mongooses, can be readily tracked in the sandy soil present over much of the reserve. Searching for tracks and droppings is the primary method of detecting incursions by larger animals.

Eleven months post construction, bait stations were still deployed on a 25m grid in the interior of the reserve, and expectations are that some of these bait stations will be removed, but that a permanent 50m grid will remain in place for biosecurity purposes. In addition to extensive rodent control, regular large predator (cat and dog) control operations will continue as described above. These consist of spotlight surveys/shooting as well as targeted trapping in the surrounding areas outside the fence. To date the spotlight shooting has proven to be successful in removing cats from areas adjacent to the fence, reducing the possibility of animals moving around the fence ends into the protected area.

Incursion Response

Responding rapidly to any incursions that occur to contain them and remove all animals that have reinvaded is vital to the continuing success of the ecosystem restoration plan. Response protocols were designed to ensure that incursions are dealt with in an efficient and coordinated manner. The frequency of reinvasion will likely be related to the density and home range size of the animal in question, and each species will require a slightly different response. Response plans were therefore designed for each species and are described separately.

Dogs can be expected to occur occasionally in the reserve after the fence is complete because people may ignore the signs and bring pet dogs with them through the gates. Dog tracks are easily visible on the sandy soil, so it may be possible to determine whether any dog tracks observed are from pets that were brought through the gates by people, or feral dogs that went around the fence along the shoreline. In the event that dog tracks are detected away from the established trails and/or dog predation on seabirds is observed, USDA WS or DOFAW will be contacted immediately and shooting and/or leg-hold trapping will be scheduled until the dog is removed or there is no fresh dog sign.

The sandy soil that covers much of Ka`ena Point is also useful for detecting incursions of feral cats and mongoose, both of which have distinctive tracks. Any track lines observed will be followed to help delimit the area being used by the animal, and its entry point into the reserve if possible. In the event that a cat or mongoose enters the reserve and does not appear to leave, cage trapping and leg hold trapping will commence in areas of known activity until the animal is caught, or until it has been determined that it has left the reserve. Remote cameras with motion-sensitive triggers will be deployed continuously in the reserve to help detect incursions of all species, and to aid in trap placement and monitoring of animal movement during that period.

If rats or mice are detected more than 100m from the fence ends (i.e., beyond the regular "gauntlet" of biosecurity traps), traps will be placed every 25 m (rats) or 12.5 m (mice) for 100 m (rats) or 50 m (mice) around the site(s) of detection, and bait stations within 100 m of the detection will be stocked with diphacinone until the animal is caught or it is clear that bait is no longer being taken by rodents. Tracking tunnels will be run regularly to verify presence/absence. If rodent incursions recur frequently after fence construction, the possibility of attempting a hand broadcast each year could be considered if the necessary efficacy trials and label amendment for diphacinone are completed.

LESSONS LEARNED

As with any project that introduces a new management technique and breaks ground on a new topic, there are lessons learned along the way that can serve future projects. The goals of this report were not only to document the process that this project went through, but also to provide some constructive suggestions for future projects so that others can learn from both what was and was not done correctly. The main lessons learned from this project are outlined below and roughly follow the sections of the report. While it is recommended that readers review most of this report in depth to put these suggestions in context of the project as a whole, at the very least this can serve as a guide for where to start.

Compliance and budgeting

Compliance

With any large project, permits are an inevitable part of the process, but the time required to complete the compliance of projects of this size is often underestimated. Even with the relatively quick commencement of the permitting process for this project, there were still multiple delays that could have been avoided. A six-month delay could have been prevented by finalizing the EA and initiating the SMA permit concurrently with the resolution of the first four contested cases since there was no legal basis that required the EA finalization to wait. Similarly, a right of entry permit could have been requested prior to obtaining all other permits, but that was contingent upon obtaining those permits and allowed for resolution of any contested cases while final permits were being applied for. And while the Section 106 consultation did not stall the project, it came very close to preventing the construction from starting on time as the document was submitted sequentially, as opposed to simultaneously, to each reviewing party which lengthened the process substantially. This specific process could have been initiated much earlier, and given to all reviewing parties simultaneously to allow time for multiple agencies to complete their reviews without repeated follow up.

Future projects should initiate their consultations and compliance paperwork well in advance of their anticipated construction date. Completing the compliance documents took longer and required more work than obtaining funding, and while most projects will likely not have as heavy a permitting burden as this project did, starting compliance paperwork while searching for funding would help to avoid some of the issues that this project ran into.

While much of this report has focused on what could be improved, there are many things about this project that were done correctly. With the compliance documentation, immediate preparation of the EA was very appropriate. While it took a significant amount of time to finalize the EA, this document was the longest and most time consuming to produce and formed the foundation for applying for the remainder of the permits. It also served as a great outreach tool for those wanting more in-depth information about the projects. A well-written EA will serve projects well and help to organize the planning process.

Budget

The initial budget for this project was $350,000 provided by the USFWS that was to cover all aspects of the project. As the project progressed, and it became clear that additional work and thus funding for various items (such as outreach, biological monitoring etc.) was needed, grants were applied for from a variety of agencies resulting in a total funding amount of $772,595 which was more than double the initial estimate. Fortunately, almost all project staff were involved in applying for various grants, and this proactive approach to sourcing out funding was what made this project possible. That being said, the project could have still used additional funding.

The costs outlined above do not include USFWS or DLNR staff time, and do not include the annual predator control contract DoFAW has with USDA-WS. In addition, much of the pre-construction biological monitoring was done on a volunteer basis from a variety of individuals at both public and private institutions. Currently, there is not funding to conduct post-predator removal biological monitoring, which will be a significant cost.

All of these agencies contributed significant amounts of staff time towards the planning an execution of this project, and the actual cost of implementing this project is undoubtedly much higher. Nonetheless, these estimates can still serve as a rough guideline for future projects that are still in the planning stages.

Outreach

The success of this project was due in large part to the public support that was garnered as a result of the efforts of the outreach team. This team utilized a variety of tools, but the key to their (and ultimately the project's) success was interacting one on one with community members on a regular basis and keeping everyone informed with the correct information through a variety of sources (brochures, websites, media etc) and for the duration of the project. One of the most difficult components of this project was dealing with a very vocal, but small minority who were opposed to the project and continually spread mis-information. The outreach team was well prepared to deal with this and were mostly successful in providing correct information to the public. In all projects, there will always be a few individuals that do not support it, and at a certain point, those in charge need to make a clear decision to proceed even in the face of opposition and just continue to work at keeping all parties informed on the status of the project.

Construction and maintenance

Future contracts would be well served by providing monetary penalties for work extending beyond a certain cutoff point to provide incentive to the vendor to conduct work on time. To facilitate clear communication, future contracts should also include clauses that have any off-island contractor provide copies of plane tickets so that arrival and departure times are known, and copies of bills of lading with contents clearly outlined and a shipment schedule so that it is clear when materials will arrive.

For the construction phase of a project, establishing a clear chain of communication is not only critical, but also specifying who has ultimate authority to dictate the work schedule. Because certain phases of construction were required to have both a cultural and archaeological monitor present per permit requirements, there were days when work was not allowed when these monitors could not be on-site. Unfortunately there was an incident of mis-communication where the fence contractor did several hours of work without a monitor present when they had been told not to work which resulted in a written reprimand for both the contractor, as well as the agency under the permit guidelines. As a result, monetary penalties tied to permit violations would have helped to prevent some of these issues.

Finally, while most predator proof fencing contracts will state that they provide on the ground training in the maintenance and use of the fence and its components, having written instructions, and including a tool-kit list as part of the contract deliverables would have been extremely valuable and saved considerable time once regular maintenance duties were taken over by the project staff. This project ended up drafting its own tool kit list and maintenance instructions (complete with pictures) so that staff that were not present at the time of training would still be able to fix the fence if needed.

Biological Monitoring

Installing the permanent, geo-reference grid as described in section five was an extremely valuable tool that greatly facilitated both monitoring, and rodent removal activities and would be highly recommended for future projects. The amount and breadth of monitoring done on a variety of taxa was also a great improvement over many projects. That being said, there were a few aspects of this component of the project that could have been improved.

Specific to the botanical monitoring, performing seed predation studies on focal species and/or quantifying pre and post-predator removal seed predation rates would have been a beneficial, and immediate metric of measuring change. While the monitoring scheme chosen will document larger scale ecosystem shifts, it would have been ideal to have included specific data on the predation aspect (seed consumption) that is thought to cause the most damage to the endangered plants at Ka`ena.

For all monitoring programs, it is ideal to have comparisons not only pre- and post -predator removal comparisons from within the fenced area, but also outside (control) vs. inside (experimental) at the same time to determine if changes are part of normal environmental cycles, or if they can in fact be attributable to predator removal. While this was done for some taxa (some inverts and pest species), it was not for others, primarily as a result of a lack of a native species monitoring budget. Ideally, the pre and post monitoring would have made an excellent graduate student project, but in the absence of a grad student dedicated to conducting the monitoring and analyses, additional funding would have helped alleviate this problem.

Finally, as discussed above, budgeting not only for pre-construction monitoring, but also post-construction follow up monitoring would have greatly helped to complete the second phase of the project.

Predator removal and biosecurity

The predator removal and biosecurity components of this project have gone about as smoothly as they could have, given the obstacles faced. Due to the limitations in tools (bait box application of a first generation anti-coagulent vs. broadcast of a more effective toxicant) and the poor timing (exceptionally high rain prior to gate installation), the predator removal was still a success. This was primarily due to a small core team who were committed to going out in the field for an extended period to get the job done. Selecting detail-oriented staff who understand the differences between control and eradication is crucial, since the difference between success and failure can be as small as failing to close a single mouse trap and allowing a single rodent territory to persist.

The challenging part of conducting a predator eradication from inside a fenced area is that it must be done reasonably soon after the completion of construction to prevent predators from breeding out of control in the protected area. As a result, suggestions presented above in the compliance and construction sections that keep the construction timeline on target will also serve the removal component well.

For biosecurity, the plan that was initially drafted was modified multiple times in the field once pest behaviors around the fence ends became known. While it is crucial to have a biosecurity plan in place at the time of pest removal, it should also be expected to change over time and adapt to the specific conditions. The most important part of the biosecurity is to budget for at least weekly visits to ensure that coastal ends are continually checked for the presence of rodents.

Project Coordination

For projects of this size and scope, it is ideal to have a dedicated individual acting as the coordinator to ensure that details are not overlooked and that there is a point person for others to contact with questions. In many cases, and perhaps ideally, this would be an agency staff member with the time required to dedicate to the project who is familiar with the site, flora, fauna and regulatory framework. In this case, an outside project coordinator was contracted due to the large size of the project, and the limited time that involved agency staff had available to oversee the project's needs. Each situation (in-house vs. contracted project coordinator) will have its pluses and minuses, and what is best for future projects will depend on the size of the project, the budget and ultimate needs. In either situation though, project coordinators should anticipate dedicating at least half of their time to a project of this size during the months prior to, and during construction and predator removal.

Suitability of predator proof fencing for other sites

While Ka`ena was an ideal site for fencing in terms of the physical landscape, not all sites in Hawai`i will be as easy to construct fences on, and several features of the Ka`ena fence design could have been improved upon. Peninsula-style fences that have coastal gaps will always have significant pest incursion problems and agencies will need to budget for the time required to keep pest animals out and possibly for future re-eradications from within this type of fence design. To date this has not been a large issue at Ka`ena with larger mammals such as mongooses, cats or dogs (<2 incursions/year of each species). However, it has been a significant issue with rodents, even with a less than 2m gap at each end. At a minimum, a maintenance and buffer pest control program that includes once-weekly inspections will need to be conducted in perpetuity in order to keep animals from re-invading the fenced area through the coastal gaps, and to conduct regular maintenance needs. For fences that completely encircle a site, this could likely be reduced. As a result, for sites where there is a greater than 2m gap between the fence end and low tide mark (including cliff faces), careful consideration should be given to whether a budget exists to manage those ends properly. In many cases, an enclosure may be a more logistically and financially feasible option.

Another aspect that needs to be considered is the vegetation immediately surrounding the fence line. Predator proof fences require a 4m wide vegetation free corridor to ensure that pests cannot use vegetation to jump over the fence. In heavily forested areas this will entail substantial amounts of clearing and regular trimming to ensure that branches do not overhang and will require bringing large equipment to remote sites. Additionally, in situations where bodies of water (streams, ponds etc.) are crossed, special efforts must be made to ensure those remain pest-proof. Areas prone to flash floods and/or that have stream beds with large boulders that are dry most of the year, but then experience heavy stream flow in a short period, will be especially challenging to make pest proof and avoid damage from water and moving rocks. As such, sites that have these properties should consider these factors during not only the planning stages, but ultimately during the long term maintenance phases. Scofield et. al. (2011) provide a critical review of the effectiveness of predator proof fencing in New Zealand that addresses some of these issues.

Summary

This project while behind schedule and over budget, successfully completed construction of Hawai`i's first predator proof fence and removed all invasive mammals from the inside the fenced area. While there are many aspects of the project that could have been improved, the end goal was ultimately achieved despite some vocal (and creative) opposition. Less than one year later we are already starting to realize the biological benefits generated from releasing native species from predation pressure. While predator proof fences are certainly not suitable for every site, they are a new and valuable conservation tool that should continue to be employed in Hawai`i for some species, as this may be their last hope at survival. It is hoped that this project is the first of many.

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