Wildlife and People at Risk:
A Plan to Keep Rats Out of Alaska

Ellen I. Fritts

Alaska Department of Fish and Game
Division of Wildlife Conservation

October 2007

STATE OF ALASKA

Sarah Palin, Governor

DEPARTMENT OF FISH AND GAME
Denby Lloyd, Commissioner

DIVISION OF WILDLIFE CONSERVATION
Doug Larsen, Director

For information about formats that may be available, contact our publications specialist:

Publications Specialist
ADF&G, Wildlife Conservation
P.O. Box 115526
Juneau, AK 99811-5526
(907) 465-4176
Email: dfg.dwc.publications@alaska.gov

This document should be cited as:
Fritts, E. I. 2007. Wildlife and People at Risk: A Plan to Keep Rats Out of Alaska. Alaska Department of Fish and Game. Juneau Alaska. 190 pp.

This version, updated 10/23/07, should replace all prior web versions.

Cover graphic by Katherine Hocker, ADF&G.

Wildlife and People at Risk:
A Plan to Keep Rats Out of Alaska

Ellen I. Fritts

Alaska Department of Fish and Game
Division of Wildlife Conservation

October 2007

Table of Contents

List of Figures and Tables

Abstract

This document was developed to promote protection of Alaska's wildlife from nonnative rodents, especially rats. It constitutes a statewide invasive rodent management plan, which is part of a multi-agency effort to minimize the impact of invasive species in Alaska. A literature search and interviews were conducted, and reviews were obtained from experts in Alaska and elsewhere. The plan summarizes existing information relevant to Alaska and recommends a collaborative structure for undertaking strategic actions, the Alaska Rodent Action Team. It also identifies dozens of strategic actions that are needed to prevent and eradicate invasive rodents. These fall into six categories: legal and policy, rat spill response, health and safety, community rodent prevention and control, and wildlife and habitat restoration. Additionally, the plan provides a practical guide to assist industry and local community-level efforts.

Key words: Alaska, rodent, rat, island, management, Norway rat, Roof rat, *Rattus rattus*, *Rattus norvegicus*, house mouse; *Mus musculus*; rodent prevention, rodent control, rodent eradication, strategic actions, invasive species, nonnative species, introduced predators, rat spill, restoration, seabirds, Aleutian Islands, Pribilof Islands, rodentproof, pest control, rodenticide, bait, trap, nontarget species

Executive Summary: Keeping Rats Out of Alaska

Rats are bad news: They are destructive and dangerous in the wild. Worldwide, rats have wreaked havoc on human societies, inflicting economic damages totaling billions of dollars. With the arrival and spread of rats, Alaskans now face threats to their health, safety, wildlife, habitat, and economy. Potential fiscal effects from rat infestations include high costs for prevention and removal, as well as reduction or loss of wildlife populations that anchor wildlife viewing, tourism, and related support operations.

Rats are highly effective as invaders: They are secretive, intelligent, and reproduce at very high rates. They are also ravenous predators that eat the young, eggs and sometimes adults of birds and other small animals. Well known as carriers of serious diseases in humans, rats are also responsible for diseases that can adversely affect wildlife and, potentially, consumers of those wildlife species.

Figure 1. Illustration of island life before (left) and after (right) rat infestation. R. Papish, FWS

In parallel with expansion of world shipping and commerce, rats have caused large numbers of species, especially on islands, to go extinct – sometimes in as little as a few years after the rats set foot there. Island Conservation, a California-based invasive species eradication group, estimates that rats have caused 40-60% of all recorded seabird and reptile extinctions since 1600 (Island Conservation 2006). In part due to their influence on crops, forests, and subsistence harvest of marine mammals, rats are also believed to be responsible for the demise of human culture and abandonment of Easter Island in the South Pacific.

A broad network of ports, harbors, barge landings, and airports now spans the state of Alaska, and its largest city, Anchorage, serves as a major hub for international shipping. Given the ease with which rodents can stow away unnoticed, including due to altered national security and inspection priorities, rodent infestations can be easily spread to and within Alaska. Rats also

threaten public safety by gnawing on electrical wiring and control cables, endangering vessels and aircraft, and potentially causing casualties due to fire, explosions, and accidents.

Alaska is home to diverse and unique wildlife, including animals found only here or for which the world's population concentrates here during a critical life phase such as breeding. Seabird species such as puffins, auklets, and storm-petrels that forage offshore and are absent from their nests for extended periods are at particular risk from invasive mammals such as rats.

Some of Alaska's rat-vulnerable species have very small populations, and increased predation or ecosystem upset elevates their risk of extinction. It also ups the likelihood of more Alaska species being listed under the federal Endangered Species Act, with the potential for restrictions on economic activity to aid species recovery being one result.

Research conducted in other countries over the past half century shows that depleted wildlife populations often exhibit dramatic rebound after rodent eradication or control. Experts believe that many techniques used elsewhere can be successfully used in Alaska, if undertaken in time.

Elsewhere, large numbers of projects have been successfully undertaken to rid communities and islands of invasive rodents, and to prevent reinvasion. In cases where permanent eradication is not feasible, rodent control efforts are undertaken. These, too, can have very positive results for wildlife and people. However, with the need for repeated treatments and ongoing maintenance of trapping or bait stations, control efforts are often considerably more expensive than one-time eradication projects.

Findings

1. **Non-indigenous Norway rats (*Rattus norvegicus*) are causing significant wildlife and habitat damage in Alaska**, especially in the Aleutian Islands, site of the first entry of rats into the state. Particularly hard-hit are ground-nesting seabird species that nest on remote islands that were previously predator-free.

2. **At present, heavy infestations of rats occur in the Aleutian Islands. Breeding populations of rats occur in other communities.** These include Ketchikan, Craig, Petersburg, Sitka, Juneau, Kodiak, Akutan, Dutch Harbor/Unalaska, Atka, Adak, Nome, and Fairbanks. Anchorage and the Pribilof Island communities of St. Paul and St. George have instituted anti-rodent ordinances designed to protect the local economy, wildlife, and citizens.

3. **Only one variety of rat, the *white albino* form of Norway rat, is allowed** as a pet or laboratory animal in Alaska; it is illegal to possess *any other type* for these purposes.

4. **Rats are easily spread to other locations in the state.** This occurs primarily via marine vectors (vessels, maritime shipping, shipwrecks) but also due to other cargo-related commercial activities, air transport, and release of pet rats to the outdoors. Climate change, and expansion of transpolar shipping, will increase the likelihood of rats arriving, and thriving, in Alaska.

5. **No human fatalities or disease have been attributed to rats in Alaska; however, little or no systematic information about rats is being kept.** For example, no information is obtained about: incidence of rats or rat-caused disease or casualties (e.g., vessel disablings and/or sinkings); frequency and number of interceptions of stowaway rats; or numbers of pet rats being bred, imported or illegally released to the outdoors.

6. **New wildlife regulations on rats became effective September 13, 2007.** These regulations make it illegal to knowingly or unknowingly harbor rats, or to release rats. They also require boaters, shippers, and others moving containers that may contain rats to be vigilant in checking for these animals and in taking action to control or eradicate rats when they are found.

Conclusion

Action is needed to protect all regions of Alaska from invasive rodents. Three key overall goals are to:

1. Stop invasive rodents, especially rats, from entering the state or state waters, and from spreading between areas in Alaska.
2. Eradicate rats that have been detected, or, where that is not possible, control rat populations.
3. Restore and protect Alaska's native species and habitats.

Achieving this result will require significant coordination and collaboration across many agencies, organizations, and jurisdictions. Creative funding solutions will also be needed, especially should prevention, quarantine, and eradication efforts be unsuccessful and costly long-term rodent control programs be required to protect Alaska interests.

Recommendations

1. Create a broad multi-entity task force to facilitate implementation of strategic actions that will help protect Alaska from rats and other invasive rodents. The Alaska Department of Fish and Game (ADF&G) has prepared an evaluation of the rat threat and a comprehensive list of strategic rodent-related actions, many of them outside its scope of authority, which the group may address. ADF&G has also outlined the structure and proposed membership for such a group, which is tentatively called the Alaska Rodent Action Team (AKRAT). Assigning creative, committed members to AKRAT, its subgroups, and to local-level equivalents will be fundamental to successfully implementing strategic actions.

2. Policy-maker review, at all levels, of the legal and administrative framework guiding prevention, management, and elimination of invasive rodents. This subject is complex and includes health, safety, security, banking, insurance, occupational licensing, transportation and other issues. While rodents are the target of this recommendation, a comprehensive look at all invasive species issues, including rodents and other species, is urgently needed.

3. Develop statewide and localized community, regional and/or sector-specific plans that will:

- Build awareness and stakeholder support for action against rats.

  Education, vigilance, and rapid reporting are important precursors for timely response efforts.

- Conduct aggressive prevention and quarantine efforts to prevent arrival, and spread, of rats.

  One important goal will be to ensure that ports, harbors, and vessels that traverse the state's coast and waterways be operated as rat-free zones. Another is to establish robust cargo management techniques that will stop the entry or spread of rats from already infested vessels and ports.

- Build capacity for rapid response to "spills" of rats from disabled vessels and to localized reports of nonnative rodents. Alaska must be able to deploy trained responders – before escaped rats spread out from a spill site and produce young.

  Even with good attention to outreach, prevention, and quarantine efforts, Alaska must be "at the ready" to protect its coastline and unique wildlife areas from harmful rodent invaders. Training is expected to occur in fall 2007 to expand the corps of responders available in case of a rat spill event.

- Provide information and tools that will help communities, industries, and citizens rapidly eradicate or control established populations of nonnative rodents.

  An informal multi-partner cooperative group, the Rat Outreach Group, sponsors a website (www.StopRats.org) that provides information and free rat eradication kits to the public. Meanwhile, the University of Alaska has begun work on developing training tools for use with managers of waterfront facilities.

- Eliminate invasive rodents from important wildlife areas, and restore damaged wildlife populations and habitats.

  Preliminary efforts have started: The U.S. Fish and Wildlife Service/Alaska Maritime National Wildlife Refuge has been conducting trial eradications and is expected to undertake a major effort in 2008 to eradicate rats from Rat Island, site of the first landing in Alaska of nonnative Norway rats.

Rats don't belong in Alaska. Working together, we can keep them out and help return Alaska to a rat-free state. Our health, our wildlife, and our economy depend on it.

* * *

1.0 Introduction

1.1 Background and Purpose of this Plan

Alaska has the opportunity to prevent the damage that rats and other invasive rodents have caused in other places around the world. Development of this plan was undertaken to protect wildlife, human health, and the economy in Alaska by preventing rat infestations, eradicating rats where they have established breeding colonies, and restoring damaged habitat.

The U.S. Fish and Wildlife Service (FWS) in Alaska has long dealt with issues related to damage from introduced foxes on islands in the Aleutian Archipelago. In 2001, scientists conducting research in the Alaska Maritime National Wildlife Refuge (AMNWR) also began documenting damage from invasive rats. The potential parallels with catastrophic wildlife losses seen elsewhere in the world led to concern that Alaska's wildlife and habitats were at imminent risk. The secretive nature, small size, and extraordinary reproductive potential of rats make them among one of the most destructive invasive species in the world.

The Alaska Department of Fish and Game (ADF&G) began work on this plan in 2005 after receiving a grant for that purpose from FWS. Work began with a review of existing information on rodent infestations, including potential impacts, and past control and eradication measures. By early 2006, it became clear that the subject of rodents and their management was more complex – and the potential effects of rats on wildlife, public safety and health more alarming – than FWS or ADF&G previously thought. Those most familiar with rat issues in Alaska also realized that some actions to eventually implement the plan, e.g., review and revision of state wildlife laws, needed to be accomplished in parallel with creating the plan itself. By summer 2006, ADF&G had written and received a two-year National Invasive Species Act grant with which to fund some of these activities.

In 2006, ADF&G sent out drafts of the plan seeking input from many experts, agencies, and interested members of the public. It also posted the draft plan on its invasive species website. Based on comments received, effort in early 2007 focused on designing a management structure that would help government entities develop a coordinated and effective multi-agency response to new and existing infestations. This included developing lists of needed strategic actions by category. In summer 2007, the revised plan was again reviewed by key subject matter experts.

Implementation of much of this plan is outside ADF&G's authority, and many of the things that must be done require cooperative action. Therefore, the core recommendation of this report is that a collaborative interagency group be established to facilitate implementation of strategic actions to protect Alaska from rats and other invasive rodents. ADF&G will act as the initial convener of this group, which is currently being called the Alaska Rodent Action Team (AKRAT). This plan is designed primarily as a resource document for AKRAT, and provides lists of strategic actions and information resources that we hope will be useful to the team. Practical tips for local-level rat eradication and control are also provided; these are found in Appendix H: Rat Prevention and Control.

The collaborative relationships among interested stakeholders demonstrated during the project bode well for Alaska undertaking a rapid and coordinated response to a serious and growing threat: We must act together to eliminate free-ranging rats from arriving, or from spreading even further around the state. The state's people and wildlife resources deserve no less.

1.2 The Problem with Nonnative and Invasive Species

Around the world, invasive species pose considerable threat to wildlife and ecosystems. Of all these species, invasive rodents, particularly rats (*Rattus* spp.), are among the most harmful (Atkinson 1985). Rats present one of the most serious environmental and health challenges humans face, both across the globe and in Alaska (McNeely 2001; Pimental et al. 2005; Union of Concerned Scientists 2003).

What are invasive species? Invasive species represent a harmful subset of species known as exotic, alien, nonnative, or introduced species – all of which basically mean, species that are not indigenous to a given ecosystem. Plants, animals, or other organisms become invasive when they are transported (primarily by human actions) into an area outside of their natural range where they cause economic or environmental harm, or harm to human health. One key factor in the world-wide destructiveness of invasive species, including rodents, is their ability to aggressively exploit new habitats. Another is the ease with which they traverse the globe to invade new territory, such as when they travel as unintended stowaways on planes, vessels, or other conveyances carrying people or cargo.

Examples of a few serious invasive species problems in the United States (U.S.) include:

- European green crabs, established all along the East Coast and now expanding along the West Coast, posing a potential threat to shellfish and other marine resources;
- New Zealand mudsnails, which are overwhelming and altering popular fishing streams in the West;
- Spotted knapweed, an invader just now beginning to appear in Alaska, but which has spread across millions of acres in places like Montana, causing extensive damage by reducing forage value for both livestock and wildlife; and
- Sea lamprey, rusty crayfish, and zebra mussel, which have decimated populations of native species, introduced new parasites and diseases, and changed the way ecosystems function in the world's largest freshwater resource, the Great Lakes.[1]

If effective prevention actions are not taken, Alaska also faces a potential future of unprecedented changes due to invasive species. For example, humans are believed responsible for transplanting nonnative northern pike (*Esox lucius*) into previously pike-free drainages, and descendents of these pike are now expanding into other drainages where they are not native. Because pike eat other fish, ecologists anticipate adverse consequences for other species such as salmonids, anadromous forage fish (e.g., eulachon), resident fishes (e.g., sticklebacks) and their predators such as birds and bears. Other worrisome nonnative species showing increased

[1] For more information see http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/

occurrences in Alaska are the rock pigeon (*Columba livia*), European starling (*Sturnus vulgaris*), Japanese knotweed (*Polygonum cupsidatum*), and reed canarygrass (*Phalaris arundinacea*). Meanwhile species such as European green crab (*Carcinus maenas*), colonial tunicates (*Didemnum* sp., *Botryllus* sp., *Botrylloides* sp.), and Atlantic cordgrass (*Spartina alterniflora*), are expanding north along the West Coast, toward Alaska.[2]

The rapid spread of an invasive plant or animal species is typically due to a combination of reproductive success and the ability to outcompete or otherwise disadvantage native species. This occurs through such mechanisms as reducing the local organisms' access to food, nutrients, and energy (e.g., sunlight for plants), or to other needed resources such as shelter and breeding sites. Sometimes the web of impacts and sequence of mechanisms for ecosystem change can be extremely complex and extend well beyond direct effects (Baxter et al. 2004). Others can be straightforward. For instance, where no major predator species have existed historically, the direct effect of an introduced predator species can be devastating. Introduction of an alien organism into an ecosystem can vastly alter the way that ecosystem functions.

More often than not, ecological impacts go hand-in-hand with serious impacts to human interests, including economic activities. Estimates made in 2000 concluded that invasive species cost the United States more than $137 billion per year (Normile 2004) in damage and control measures, with zebra mussels estimated to have cost the United States $750 million to $1 billion from 1989 to 2000 alone (Union of Concerned Scientists 2005). According to the Union of Concerned Scientists, this figure likely does not include costs that are less readily measured, such as damage to the smaller organisms that are the basis of food webs, as well as damage to soils and biological productivity of the land itself.

Controlling and eradicating invasive species continues to be one of the most urgent – and challenging – of all wildlife management activities (Diamond 1989, Soule 1990). This is especially true in Alaska, where invasive rodent infestations pose a threat to healthy wildlife populations and habitats that form the basis for large sectors of the economy as well as residents' quality of life. Human health can suffer, and human safety is also at risk from rat-caused damage to control systems on vessels and aircraft.

1.3 Vulnerability of Island Species and Ecosystems

Island ecosystems are among the richest and most vulnerable biological systems in the world, and it is here that scientists have focused particular conservation efforts in recent years (Krajick 2005). In Alaska and across the globe, island ecosystems have been hard hit by invasive species such as rats. Not surprisingly, invasive species are a leading cause of extinctions in island ecosystems (Groombridge 1992). In addition, islands often have endemic species, native species

[2]For information on some of these species and other invasive species challenges in the state, see the Alaska Aquatic Nuisance Management Plan (http://www.adfg.state.ak.us/special/invasive/ak_ansmp.pdf) and, for invasive plants, the Strategic Plan for Noxious and Invasive Plants Management in Alaska (http://www.cnipm.org/strategic.pdf). An additional source of information on plants is the Alaska Natural Heritage Program (http://aknhp.uaa.alaska.edu/botany/Botany_Home.htm).

that are restricted to a particular area or region. Because of their limited geographic range, endemic species are often, but not always, vulnerable to extinction.

These unique "island endemic" species are often highly adapted for life in the confined landscape where they evolved. They typically lack immunity or adaptation to alien diseases, competitors, predators or herbivores, including the rodents, cats, sheep, goats, and pigs that humans bring (Krajick 2005). Although islands cover only 3% of Earth's surface, they harbor 45% of its bird, plant, and reptile species (Krajick 2005).

1.3.1 Islands Hard Hit by Extinctions

After loss and fragmentation of habitat, biological invasions are the second greatest cause of human-induced species extinctions (Courchamp et al. 2003). This is because risk of extinction is inversely related to population size, and overall populations of each island species tend to be smaller than for species living in mainland areas.

Since 1600, island endemic species have accounted for roughly 90% of known bird and reptile extinctions worldwide and half the known extinctions for plants and mammals (B. Tershy, Director, Island Conservation. Pers. Comm. *In* Krajick 2005). Of 127 bird species that have gone extinct since 1500, 111 were island dwellers (M. de L. Brooke, Cambridge Univ., Pers. Comm. 3/30/07). Nonnative invasive predators, especially cats and rats, have been major factors in these extinctions (Diamond 1989, Moors et al. 1992). More than 80% of the world's islands or island groups have been invaded by some species of invasive rodent (Atkinson 1985, Courchamp et al. 2003, Island Conservation 2005).

Island ecosystems typically exhibit little ecological or taxonomic redundancy. Simply put, this means there is little competition among species for the same set of resources, such as food or shelter: Each species or species group occupies its own ecological "niche." On small or remote islands, for example, there may be only one or a few native insect-eating small mammal species. This phenomenon increases the concern for unintended effects that control or eradication methods intended for invasive species may have on other (nontarget) species.

Particularly on islands, large increases in introduced predators can lead to major imbalances in the whole ecosystem. The first effect may be a significant decline in prey species used by the invader. However, trickle-down effects can include changes in relative abundance of many other species, elimination of some species from habitats they occupied and depended on, or outright species extinctions. For these reasons, many wildlife conservation proponents strongly support controlling rats introduced to oceanic islands.

1.3.2 Biodiversity and Abundance Decrease

As species are eliminated, biodiversity in an area is depleted. The biodiversity of an area includes the variety of native life forms, the ecological roles they perform, and the genetic diversity they contain. A single invading species can radically alter the suite of biota on an entire island. For instance, invasion of Guam by the brown tree snake (*Boiga irregularis,* a native of Australia) resulted in loss of almost all native birds, lizards, and bats there (Krajick 2005).

Mammals can also cause large-scale reductions in other species, including plants and the birds that forage or nest among those plants. For example, pigs, goats, and donkeys caused widespread damage to the ecosystems of the Galapagos Islands after they were introduced by seafarers and settlers (Galapagos Conservancy 2006).

In more northerly latitudes, introduced rats devastated the bird population of the Queen Charlotte Islands (British Columbia) in the 1950s. Fork-tailed and Leach's storm-petrels (*Oceanodroma furcata* and *O. leucorhoa*) were eliminated entirely and tufted puffins (*Fratercula cirrhata*), which had numbered in the hundreds of thousands, are now rarely seen (PBS 2001). In Alaska, descendents of farmed foxes caused massive declines in seabird populations on hundreds of coastal islands between the 1740s and 1940s. Despite natural die-offs, foxes remained on dozens of islands to which they were introduced (Bailey 1993), limiting once-flourishing bird populations. Fox eradication efforts by FWS have helped restore ecosystem dynamics and natural food webs on many of these islands, and bird populations there are recovering. Rapid recovery of the Aleutian cackling goose (*Branta hutchinsii leucopareia*) following fox eradication allowed that bird species to be removed from the endangered species list (for more information about FWS efforts on Aleutian islands, see Appendix A: Removal of Foxes in Alaska).

1.3.3 Devastation can be Rapid and Complete

Once a nonnative species is introduced, the decline or extinction of other species can occur rapidly, often in less than a few decades and sometimes in as little as a few years. Within 20 years of arriving in the 1900s, rabbits on Hawaii's remote Laysan Island eliminated 26 plant species. In another classic example, a cat and three kittens that arrived in the 1950s in the Indian Ocean's subantarctic Kerguelen Archipelago multiplied by the 1980s into 3500 cats killing 1.2 million seabirds per year (Krajick 2005). Following introduction of the Nile perch, a large nonnative predator, into Lake Victoria, East Africa, a community of more than 400 fish species collapsed to just three codominant species, mostly within the brief period between 1975 and 1982 (Hughes 1986).

2.0 Invasive Rodents of Concern

The 29 native and nonnative rodent species found in Alaska are listed in Appendix B: Rodent Species of Alaska. The state's indigenous rodents are naturally adapted to their environments and generally do not pose a concern for human populations. In contrast, nonnative rodents such as rats and mice (i.e., rodent family Muridae) are adaptable and opportunistic, regularly infesting human habitations and hitchhiking wherever humans go.

Under normal circumstances, invasive rodents are prolific breeders. As an example, it is estimated that, even in northern latitudes, one pair of rats can reproduce into some 5000 animals within a year's time. The estimates for rats reproducing in "ideal" conditions of captivity or indoor living are thought to be several times higher.

2.1 Nonnative Rodents in Alaska

Three invasive Murid rodent species of concern in Alaska are: Norway rat (*Rattus norvegicus*), roof rat (*R. rattus*), and the house mouse (*Mus musculus*). Aggressive predators, rats are currently of greater concern than mice. Of the two rat species, Norway rats pose the greatest threat because they are more widespread in the state, and better swimmers (i.e., spread more easily) than roof rats. Therefore, much of the discussion about invasive rodents in this plan will address the Norway rat. One Cricetidae rodent species, the North American deermouse (*Peromyscus maniculatus*), is also invasive, though at the moment appears restricted to Shemya Island; techniques used to control and eradicate other invasive species may be applicable should the deermouse spread to other areas. Figure 2 shows the relative sizes of rats and mice.

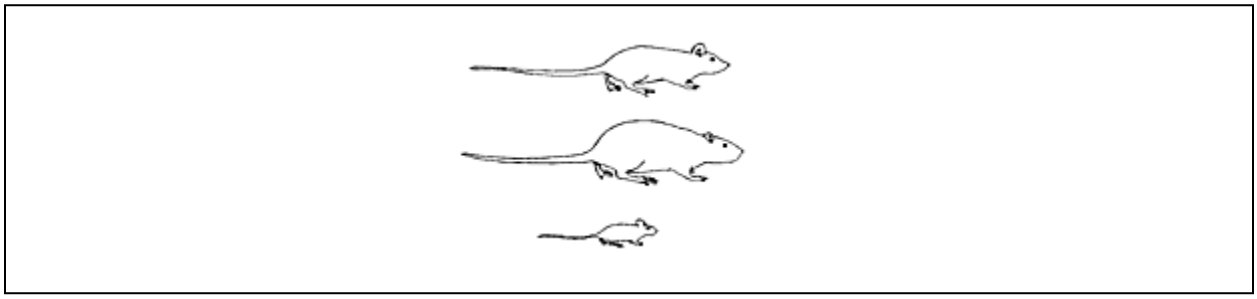


Figure 2. Relative sizes of roof rat (top), Norway rat (middle), and house mouse (bottom); body length ranges from 9 cm (3.5 in) for mice, to 24 cm (9.5 in) for the Norway rat.

2.1.1 The Norway Rat

A stocky burrowing rodent, the Norway rat (Fig. 3) is a large member of the family Muridae that was unintentionally introduced into North America by settlers who arrived on ships from Europe (Timm 1994). After reaching the east coast of the United States around 1775, the Norway rat has now spread to all 50 states. Arrival of this rat in Alaska first occurred via a shipwreck prior to 1780. The Norway rat is generally found at lower elevations but may occur wherever humans live or where abundant wild food resources exist. On Adak Island in the Aleutian Islands, rats have been found living at up to 500 m (1640 ft) in elevation (Dunlevy and Scharf 2007a).

Norway rats also have physical capabilities that enable them to gain entry to spaces and property by gnawing, climbing, jumping, swimming, and other tactics (Timm 1994).

Figure 3. Norway rat on Aleutian tundra.

Norway rats often live near water or in sewers and occasionally enter homes through toilets. Water traps do not impede their movement; in fact, they can travel upstream against a current. They are sometimes mistaken for muskrats (*Ondatra zibethicus*) and vice versa. Norway rats are excellent swimmers and readily undertake water crossings, including in the Aleutian Islands, where they can swim 200 meters and probably as much as 300-400 m (P. Dunlevy, USDA/APHIS/WS, Supervisory Wildlife Biologist, Pers. Comm. 6/13/07). In more temperate and tropical parts of the world, Norway rats have been known to swim as much as 2 km (1.2 mi; Russell and Clout 2005). They have demonstrated their swimming ability by staying afloat for 72 hours in water at 34 degrees Celsius (93.2 Fahrenheit) before tiring and eventually drowning (Meehan 1984). Rats have been observed surviving as long as 15 minutes in cold water in the Aleutians (June in Bay of Islands; P. Dunlevy, USDA/APHIS/WS, Supervisory Wildlife Biologist, Pers. Comm. 6/13/07). How much longer than this rats can remain afloat in cold water is unknown (G. Witmer, USDA/APHIS/WS, Supervisory Research Wildlife Biologist, Pers. Comm. 10/19/06).

Also called the brown rat, house rat, barn rat, sewer rat, gray rat, or wharf rat, Norway rats usually live in close association with people and are familiar to them. In urban or suburban areas they live in and around residences, in cellars, warehouses, stores, slaughterhouses, docks, and in sewers. In rural areas they may inhabit kennels, barns, granaries, silos, and livestock buildings (Timm 1994).

Although they prefer fresh foods, Norway rats thrive in human-inhabited areas where garbage is available. In wild areas, these rats subsist on vegetation and small wildlife such as birds, amphibians, worms, insects, and intertidal organisms.

On average the Norway rat is slightly larger than the roof rat (described below). Norway rats reach nearly 400 mm (40 cm [16 in] nose-to-tail; about 24 cm [9.5 in] excluding the tail), and weigh 340 to 454 g (0.7 – 1 lb). Males are usually larger than females. In wild populations, Norway rats are normally covered with coarse, brownish fur (sometimes splotched with black or

white hairs) on their dorsal surface,[3] which usually lightens to a gray or tan color nearing the underside. Various strains of these rats bred in captivity may be white, brown, black, or piebald. The tail is scaly, semi-naked and 15–20 cm (6–8 in) in length, i.e. shorter than the head and body combined. The tail is dark colored above and pale below.

The Norway rat has a blunt snout and its relatively small close-set bald ears do not reach the eyes when pulled down. Its droppings are about 1–2 cm (0.5 to 0.8 in) long with blunt ends. A rat may deposit 35–45 droppings over a 24-hour period, or some 25,000 droppings annually.

Norway rats typically have 4 to 6 litters of 6–12 young per year. Although free-ranging Norway rats in Alaska typically live only about a year, each female is capable of producing up to forty pups annually (PBS 2001). Elsewhere it is assumed that, in the wild, *R. norvegicus* is capable of reproducing for up to two years; the maximum lifespan of Norway rats in captivity is 4 years (Myers and Armitage 2004).

2.1.2 The Roof Rat

Although most rats in Alaska are Norway rats, roof rats do occur in several locations (see Section 4.1 for details). Elsewhere in the world, roof rats are more typically associated with broadleaf forests (Innes 1990), rather than the treeless maritime tundra that characterizes many Alaska coastal areas west and north of Kodiak.

Figure 4. Roof rat (*R. rattus*) killing New Zealand fantail chicks.

Roof rats thrive in attics, roof spaces, trees, and ornamental shrubbery. Although roof rats have been known to swim up to 500 meters (Russell and Clout 2005), they are better known as accomplished and agile climbers.

They prefer to nest off the ground and can be quite destructive in attics, gnawing on electrical wires and rafters.

[3] Inbreeding within island populations sometimes results in a small number of black or piebald individuals; for example, 3% of wild rats trapped in a study in the Bay of Islands, at Adak Island, Alaska, were piebald (Dunlevy and Scharf 2007a).

Roof rats generally prefer vegetables, fruits and grain. However, they also feed on perching and tree-nesting birds (Fig. 4), as well as ground- and burrow-nesting seabirds (Atkinson 1985, King 1990, Innes et al. 1998, Innes 2001, Stapp 2002).

Roof rats are also called black rats or ship rats. Their fur ranges in color from black or grizzled gray to tan, with a light belly. The tail is longer than the 16 – 22 cm (6.3 – 8.7-in) length of the combined head and body. Adults weigh from 70 – 300 g (0.2 – 0.7 lb). Their droppings are up to 1.3 cm (0.5 in) long and spindle-shaped. Roof rats live about 1 year and reach sexual maturity in 3-5 months. They have up to 6 litters of 6 to 8 young per year.

2.1.3 Rat Behavior is Predictable

Norway and roof rats are both aggressive species, and the two species are seldom found together in the same building. Norway rats are usually more aggressive, driving any roof rats from an area.

Both species of rat are curious yet fearful and wary of new things (neophobic). They constantly explore and learn about their environment, memorizing the locations of pathways, obstacles, food and water, shelter, and other elements in their domain. They quickly detect and tend to avoid new objects placed into a familiar environment. Often, objects such as traps and bait stations are avoided for several days or more following their initial placement. Juvenile Norway rats may be less neophobic than adults (Dunlevy and Scharf 2007a). Both species are susceptible to peer pressure in following one another to food (Thomas and Taylor 2002).

At first rats will avoid novel food items placed in their environment. When they do feed on new items, they may eat very small amounts, and subsequent feeding will depend on the flavor of the food and its physiological effect. If the food contains poison or some other substance that soon produces an ill effect but not death, rats may associate that food with the illness. Rats may transfer their wariness to nontoxic foods of similar types or educate other rats to avoid that food type. This so-called “bait shyness” in rats can persist for weeks or months. In combination with their natural secretiveness, this characteristic can make rats very difficult to detect. Additional information on food habits, important behaviors and other attributes of rats is provided in Appendix C: Important Rat Behaviors and Attributes.

2.1.4 The House Mouse

Usually weighing 14–28 g (0.5-1 oz) and reaching up to 9 cm (3.5 in) long (excluding tail), the house mouse is the most common rodent in urban and developed areas. Its coat is gray to brown, and the tail contains only a few hairs and is about the same length as the head and body. Mice have pointed snouts and relatively large ears. House mice often live outdoors in fields, but if tempted by indoor food sources they will migrate into structures to nest in attics, wall voids, cabinets, appliances and furniture.

Mice prefer to feed on grains but usually nibble at a wide variety of foods. Where they occur in the wild on islands lacking other mammalian predators,[4] some populations of house mice are known to attack and kill large seabird chicks.[5] To date, there have been no reports of similar behavior in Alaska.

Figure 5. A house mouse.

House mice require only 2.8 g of food and 1.4 g of water daily, surviving on food alone if it has high moisture. Usually, house mice range no more than 3–9 m (10-30 ft) from their nests or other shelter areas (harborages). In Alaska, mouse tracks have been observed in the snow leading from one house to another; similarly, in Anchorage, where many vehicles are kept in garages, mice have been observed to jump from one vehicle's wheel well or engine mount, run across a parking lot, and crawl up under another vehicle (R. Sinnott, ADF&G biologist, Pers. Comm. 7/25/06).

House mouse droppings are slender, 0.3 to 0.6 cm (0.1–0.3 in) long and rod-shaped. During a 24-hour period, a mouse deposits about 50-75 droppings. House mice live about 1 year and reach sexual maturity in 6 weeks. They have up to 8 litters of 5–6 young per year.

2.2 A history of Damage to Human Interests

2.2.1 Food and Agricultural Impacts

It has been estimated that rats cause billions of dollars per year in the destruction of crops and food stores (Myers and Armitage 2004). They consume and contaminate foodstuffs and animal feed. In addition, they may damage crops in fields prior to and during the harvest, and during food processing and storage.

One rat will eat approximately 9–18 kg (20–40 lbs) of feed per year and probably contaminates 10 times that amount with its urine and droppings. Rats also damage containers and packaging materials in which foods and feed are stored (Timm 1994). One study found that a small colony of Norway rats (10 to 26 animals), when given access to a ton of sacked wheat, would contaminate 70% of the grain after 12 to 23 weeks; the sacks were heavily damaged as well. Total damage equaled 18.2% of the total value of the wheat and the sacks (Timm 1994). Little if any work has been done to investigate the potential effects of rat infestations on agricultural activities or food storage in Alaska.

[4] It is rare for mice to be the only introduced mammal on an island (R.M. Wanless, Ph.D. candidate, Univ. of Capetown, Pers. Comm. 3/29/07).

[5] The article by Emma Marris "Mice gang up on endangered birds," in the online magazine news@nature.com includes video of footage of mice killing an albatross chick more than 200 times their size; access it at www.nature.com/news/2005/050718/full/050718-2.html (*viewer discretion advised*).

2.2.2 Human Health and Sanitation Effects

Rats have impacts on human health in a variety of categories: infectious, immunologic, and through direct and indirect injuries. Via their urine, dander, droppings, saliva, and fleas, rodents can contribute to allergies, asthma, and illness among humans.

Rats can expose humans to infectious agents such as murine typhus, leptospirosis, and hantavirus renal syndrome (Old World hantavirus). Plague is a disease that can be carried by a variety of rodents. In areas where flea-borne diseases like plague are likely, rat control efforts often include treatment of rat burrows with anti-flea substances.[6]

Rat bites are also a threat to human health. Norway rats carry bacteria in their saliva that can infect those bitten and cause a sickness known as Rat-bite fever (Myers and Armitage 2004).

Whether or not the presence of rodents results in injuries or illness, infestations of rodents create unsanitary conditions. As an example, rats spread urine along their runways and leave large numbers of droppings. In addition, when rats die they usually do so in cramped dark places, including within walls, producing noxious smells.

2.2.3 Damage to Property, Goods and Equipment

Around the world, rats cause billions of dollars annually in physical damage to public and private property and equipment, both by burrowing and through constant gnawing (Pimental et al. 1999). Rodent burrowing undermines building foundations and slabs. Burrowing also causes settling in roads and railroad track beds, and it damages the banks of earthen dams, irrigation canals and levees. Rats also harm structures by gnawing openings through doors, window sills, walls, ceilings, and floors. Considerable damage to insulated structures can occur as a result of rats burrowing and nesting in walls and attics (Timm 1994).

A rat's teeth grow 11.4–14 cm (4.5–5.5 in) per year. Like mice, rats keep their teeth short and sharp by working the teeth against each other and by gnawing on a variety of hard surfaces, including wood, metal, water pipes, concrete, cables, and electrical wires.

Rat damage can occur below as well as above ground and affect structures, electrical systems, aircraft and vessels. Such damage can pose threats to important facilities and public safety and be a factor contributing to vessels sinking, going aground, or otherwise spilling cargo, whether it be chemical (e.g., petroleum products), biological (e.g., agricultural products, invasive species), or inert.

---

[6] Additional information on diseases transmitted directly or indirectly by rats can be found on the Centers for Disease Control website at http://www.cdc.gov/rodents/diseases/index.htm.

2.2.4 Ecological Effects

Although potential public safety and other costs of rats are significant, it is in the realm of broader ecological effects, including on wildlife and habitat, that rats are probably the most destructive. This is easily the case in Alaska where, to date, the documented adverse effects on wildlife appear to far exceed any reported damage to human property or health.

Norway rats and roof rats have been opportunistic sea travelers for centuries and, along with Polynesian rats (*R. exulans*), have colonized at least 82% of the 123 major island groups worldwide (Courchamp et al. 2003). Throughout recorded history the pattern has been the same: When rats arrived on islands, local bird colonies and other populations of small animals were quickly decimated, often causing local extinctions.

The success of rats as invaders stems in part from their ability to exploit ephemeral food sources. When researchers studying rat diets on a remote Pacific island returned during the two months of the year when nesting seabirds were absent, they discovered that rats replaced the avian percentage of their protein diet with an unexpected source: hatchlings of endangered seaturtle species (F. Courchamp, Univ. of Paris XI, France; Department of Ecology, Systematics & Evolution, National Center for Scientific Research, researcher; Pers. Comm. 4/30/07).

Rat-caused species extinctions occur not only via direct predation, but also by rats eliminating common prey species used by other animals. For example, besides eating seeds and small vertebrates, rats prey heavily on insects. This, in turn, can seriously reduce native populations of obligate insect-eaters, including many birds, amphibians, and reptiles. Of the extinctions on islands in modern history, rats are estimated to have caused 80-90% of reptile and amphibian extinctions (Honnegger 1981), 50-81% of mammal extinctions (Ceballos and Brown 1995), and 80-93% of bird extinctions (King 1985). Estimates vary, but more recent articles suggest that introduced rats are responsible for 40-60% of all recorded bird and reptile extinctions since 1600 (Island Conservation 2006).

2.2.5 Known Risk to Seabirds

Many breeding seabirds are conspicuously absent from islands with an established population of introduced rats (Atkinson 1985, Ebbert and Byrd 2002, Major and Jones 2005, Island Conservation 2006). Seabirds may be particularly susceptible to rat and other invasive mammalian predators because of their unique life histories: Seabirds are long-lived and show low adult mortality, delayed attainment of sexual maturity, small clutch size, long fledgling periods, and low annual productivity. They also typically nest on the ground or in burrows or crevices. The most vulnerable are species that forage well away from the coast and are absent from their eggs and young for extended periods, such as puffins, auklets, and storm-petrels (Moors and Atkinson 1984; Major et al. 2006). Besides eating eggs and chicks, rats are also believed to kill and cache the adults of small seabird species such as auklets (*Aethia* spp.) (Major et al. 2006).

2.2.6 Ecosystems Unravel

Across the globe, seabird populations have been dramatically reduced due to introductions of rats, and the adverse effects from these rodents extend far beyond impacts to individual prey species. Rat infestations have wreaked havoc on local crops, changed the native plant communities, and caused severe soil erosion that in turn affects the breeding success of native plants and wildlife. In these and other ways, rats are able to damage entire ecosystems, sometimes irreparably.

By piecing together anthropological and ancient pollen records, researchers have now demonstrated a high likelihood that rats brought by sailing ships were ultimately responsible for the demise of the human culture and population on Easter Island in the South Pacific. Rats ate the seeds and seedlings of palm trees which had historically provided humans with food and with boat-making materials that allowed harvest of marine mammals (Hunt 2006).

Research in Alaska has shown that by eliminating colonies of nesting seabirds, introduced rats and foxes remove the source of tons of the nutrient-rich guano that fertilizes the land surface. This alters food web dynamics by reducing the diversity and biomass of plants, insects, herbivores (e.g., lemmings, ptarmigan), and native predators such as shrews and raptors (Croll et al. 2005, Maron et al. 2006). At the same time, the absence of seabirds that eat intertidal invertebrate grazers (e.g.., sea urchins) can cause the intertidal zone to become denuded of kelp (Kurle 2005). This can further unbalance relationships among native species.[7]

Little or no research has been conducted on the effects that nutrient-laden run-off has on nearby marine waters in Alaska. Similarly, it is unknown whether rat infestations on Alaska's maritime islands could cause alteration of intertidal and marine food webs supporting populations of commercially harvested fish and shellfish.

[7] The literature indicates that sea otters play a significant role in structuring nearshore communities through predation on invertebrates such as sea urchins. The role of marine birds such as common eiders is less well known (C. Harrison, Esq., Pacific Seabird Group, Vice-Chair for Conservation, Pers. Comm. 2006)

3.0 Rats in Alaska: Why be Concerned?

3.1 World-class Wildlife Resources at Risk

Alaska's geography, rich wildlife, strategic location for defense and commerce, and susceptibility to climate change contribute to placing wildlife-rich ecosystems at serious risk of degradation. The state has a number of endemic birds and animals, species whose populations are found only in, or for which the bulk of the world's population is located in, Alaska. These species are especially susceptible to decline because they are typically highly adapted to their unique environments and do not respond well to change. More importantly, many of these species have relatively small populations and/or are restricted to limited areas.

Alaska's productive seas and isolated islands provide habitat for one of the largest and most diverse assemblages of wildlife, particularly marine birds, in the world (Alaska Department of Fish and Game 2006). For centuries, most islands in western Alaska had few terrestrial mammals besides humans. In the absence of predators, bird populations flourished in ideal ground nesting and feeding conditions (PBS 2001).

Figure 6. Four of the seabird species at risk (clockwise from top left): the red-legged kittiwake, parakeet auklet, Aleutian tern, and horned puffin.

However, for more than 150 years, many of the state's coastal islands, especially in the Aleutians and Bering Sea, have experienced significant ecological degradation. In large part this was due to purposeful introduction of nonnative mammal species, particularly foxes transported to remote islands for the fur trade in the 1800s and early 1900s. The problem was compounded by infestations that have occurred after inadvertent transport of rats, most often from ship landings or groundings, beginning in the late 1700s and continuing through World War II (WWII) to the present. Unlike limited-term catastrophes such as oil spills, introduced predators exert a continuous and sometimes growing negative effect on native wildlife populations (Hatch and Piatt 1995).

3.2 Alaska's Birds on the Front Lines

About 100 million seabirds reside in marine waters of Alaska during some part of the year. Roughly half this population is composed of 50 species of nonbreeding residents, visitors, and breeding species that use marine habitats only seasonally (Gould et al. 1982). Another 30 species include 40-60 million individuals that breed in Alaska and spend most of their lives in U.S. territorial waters (Sowls et al. 1978). Alaska populations account for more than 95% of the breeding seabirds in the continental United States; eight species nest nowhere else in North America (Hatch and Piatt 1995).

Figure 7. Map of the Alaska Maritime National Wildlife Refuge.

Many of these species and subspecies are found in the 4.9-million acre Alaska Maritime National Wildlife Refuge, a unique string of rugged mist-shrouded islands stretching from the state's southeast panhandle to the remote Aleutian Islands, and to the Arctic (Fig. 7). In fact, some of these birds are unique to AMNWR's Aleutian Islands Unit, which consists of 200-plus named islands and thousands of unnamed islets, spires, and rocks extending over 1100 miles from mainland Alaska across the Bering Sea. Over 10 million seabirds representing 26 species nest on hundreds of islands of the archipelago (U.S. Fish and Wildlife Service 1988, Byrd et al. 2005).

Designated as an International Biosphere Reserve by the International Union for Conservation of Nature and Natural Resources (IUCN), this spectacular land and seascape supports the largest total nesting populations of seabirds in North America and many species not known to nest elsewhere in the world. It provides prime nesting habitat for much of the world's population of the Aleutian tern (*Sterna aleutica*), red-legged kittiwake (*Rissa brevirostris*), least auklet (*Aethia pusilla*), crested auklet (*A. cristatella*), whiskered auklet (*A. pygmaea*), parakeet auklet (*Cyclorrhynchus psittacula*), Kittlitz's murrelet (*Brachyramphus marmoratus*), and red-faced cormorant (*Phalacrocorax urile*) (Alaska Department of Fish and Game 2006; A. Sowls, FWS/AMNWR Wildlife Biologist, Pers. Comm. 1/2/07). It also supports an assemblage of resident and migratory land birds, some of them endemic to the Aleutians. For instance, McKay's bunting (*Plectrophenax hyperboreus*) is an Alaskan endemic species. Species with endemic subspecies in Alaska include races of rock ptarmigan *(Lagopus mutus),* song sparrow (*Melospiza melodia*), Lapland longspur (*Calcarius lapponicus*), gray-crowned rosy finch (*Leucosticte tephrocotis*), and winter wren (*Troglodytes troglodytes*) (Island Conservation 2006).

Rats Already Prey on Alaska's Birds

Islands that have introduced rats are largely devoid of nesting seabirds and populations of some passerine species appear greatly reduced (Gibson and Byrd in press). Of rat-infested Alaska islands, Kiska Island in the Aleutians is the only one still supporting a large seabird colony and concern exists that rats may be killing large numbers of birds there (A. Sowls, FWS/AMNWR Wildlife Biologist, Pers. Comm.).

Between 2001 and 2004, biologists on Kiska documented caches made by rats in the auklet colony that contained between 1 and 148 birds (Fig. 8; Major 2004). Such caches may contain birds killed by rats as well as scavenged birds that died of other causes, such as crashing into the rocks during high-wind events common in the Aleutians (Witmer et al. 2006).

Scientists have found that, in some years, auklet nesting success on Kiska falls to only about 10% of its potential. Rat predation could be an important factor. With high levels of rat predation, some seabird experts fear this bird colony could be eliminated in as little as 20-40 years (O'Harra 2004; Major and Jones 2005).

Auklets are not the only birds facing threats from rats: As Section 2.1.2 notes, rats can adversely impact and potentially eliminate many species of burrow-nesting seabirds. Rats may also reduce populations of shorebirds such as rock sandpiper (*Calidris ptilocnemis*), black oystercatcher (*Heomatopus bachmani*), red-necked phalarope (*Phalaropus lobatus),* and other ground-nesting species (Ebbert and Byrd 2002; Alaska Shorebird Working Group 2004; G.V. Byrd, FWS/AMNWR, Supervisory Wildlife Biologist, Pers. Comm., 7/16/07).

Figure 8. Dead auklets that were cached in a rat den on Kiska Island.

Given the broad distribution of Aleutian bird populations, difficult logistics, and finite resources for census projects, little information is available with which to assess numerical changes for most seabird species in Alaska. Nonetheless, seabird biologists believe that current tallies likely represent only a fraction of the population sizes present prior to the 1740s, when foxes were first moved to fox-free islands (Hatch and Piatt 1995), and the 1780s, when rats from ships began impacting bird nesting islands.

3.3 Potential Effects of Climate Change

Climate change is expected to increase the risk and severity of rat infestations in Alaska. There are several reasons for this: It will make high latitude shipping routes through the Chukchi and Beaufort seas more accessible (Arctic Climate Impact Assessment 2005). In addition, climate-driven changes in weather patterns are expected to produce a northward shift in North Pacific storm systems and, possibly, more violent storms.

In the past, Alaska's harsh climate is believed to have limited the ability of arriving rodents to develop self-perpetuating breeding populations. A warming climate could make it easier for rodents and other invasive species to survive and flourish. Following this line of thought, gradual overland expansion of established rat populations from British Columbia northward into Alaska is possible. However, a more immediate concern is the threat of rats from ports and

harbors in British Columbia and elsewhere along the West Coast stowing away, being brought to Alaska, and then infesting (or reinfesting) Alaska ports of call.

3.4 Endangered Species and Other Concerns

Completed in 2005, Alaska's Comprehensive Wildlife Conservation Strategy (CWCS, ADF&G 2006) outlines detailed conservation actions needed to maintain and conserve more than 70 featured wildlife species, species groups, and their habitats. Nonnative predators, particularly rats, were identified as a major threat.

For migratory species whose populations have fallen to low levels, declines caused by rat predation in Alaska can translate to a problem for the species throughout its range—i.e., including while using migration corridors and overwintering areas in other states, provinces, or countries. This means that, along a species' migratory path, other jurisdictions may face greater restrictions on personal and economic activities in order to prevent the species from being listed under the federal Endangered Species Act or going extinct. This tends to elevate the level of national and international concern over what wildlife protection actions transpire in Alaska.

The threat of rat introductions to new islands includes putting endemic taxa – species that are found only in a particular area – and other critically important seasonal wildlife concentrations or low populations at risk. For example, the red-legged kittiwake, a Beringian endemic species with a limited range, could be decimated if rats became established in the Pribilof Islands, particularly at St. George Island where 80% of the world's population of this bird nests. The potential for accidental rat introductions in the Pribilof Islands is relatively high because of the presence of commercial harbors.

Other endemic species with isolated, confined populations under threat from rodent introductions include McKay's bunting (which breeds almost entirely on St. Matthew and Hall Islands) and at least 12 endemic taxa of landbirds in the Aleutian Islands (Gibson and Byrd in press). Endemic taxa of small mammals also are at risk; these include the Pribilof shrew (confined to St. Paul Island), Amak vole (confined to Amak Island), and singing vole (confined to St. Matthew and Hall Islands).

While the impacts of introduced rats are less understood for other animal life on Alaskan islands than it is for birds, such introductions likely would cause changes, either directly or indirectly, to local intertidal communities, vegetation, and insect populations. Another concern relating to protecting endemic species is that, in all likelihood, many of the state's endemic species and subspecies have yet to be identified (ADF&G 2006).

The issue of wildlife diseases is one area that neither the CWCS nor this plan addresses in any detail. As is true for livestock, some wild mammals harvested in Alaska (e.g., caribou and seals) may be susceptible to rat-borne diseases such as various strains of morbillivirus. In European waters, including the Mediterranean and Caspian seas, morbillivirus outbreaks have caused the mortality of pinnipeds and porpoises. The source of the porpoise morbillivirus is unknown, but one of the pinniped outbreaks was due to a variant of canine distemper virus (a morbillivirus) thought to be carried by rats. There is some concern that diseases could be transferred from rats

to pinnipeds, and from there to subsistence users (M. Williams, National Marine Fisheries Service Wildlife Biologist, Pers. Comm. 11/16/06).

To date, there have been no reports of any outbreaks of wildlife disease in the state that were traced to rodents. Little or no information has been gathered that might help identify the level of risk that Alaska wildlife and their users could face from rat-related diseases.

3.5 Economic, Social, and Safety Concerns

Concern about rats stems in large part from their devastating effects on some of the unique wildlife resources in the Bering Sea and Aleutian Islands. However, the abundance and diversity of wildlife resources elsewhere in the state could also be affected, with attendant impacts on commercial, sport, and subsistence users, and wildlife-related tourism. For instance, hundreds of different species and species groups are used for subsistence purposes in the state (over 100 species of ground-nesting birds alone), and wildlife-related tourism (e.g., viewing) is growing statewide, including in remote rural areas.

Overall opportunities for the spread of rats within Alaska have increased: Transportation infrastructure and freight capacity across the state continues to expand, and reorganization and reprioritization in inspection programs occurred after the September 11, 2001 attacks on the nation. Awareness is growing about the threat rats pose for public safety and their role as a contributor to vessel disablings, shipwrecks, and spills.

These issues and concerns are addressed in following subsections. Expanded involvement and vigilance by local citizens, health agencies, maritime inspectors, and agencies such as U.S. Coast Guard (USCG) and U.S. Department of Homeland Security/Customs and Border Protection (USDHS/CBP) will be very important for protecting Alaska from further incursions by invasive rodents.

3.5.1 Wildlife Harvest and Tourism Concerns

Wildlife Harvest

Rat-caused ecosystem changes or wildlife diseases could prove detrimental to the hunting, fishing and gathering activities that are central to the economies and cultures of many families and communities in Alaska. Throughout the state, an estimated 45 million pounds (usable weight) of wild foods are harvested each year by subsistence users, with sport harvests of fish and wildlife comprising 18 million pounds (8.2×10^6 kg; R. Wolfe 2000).

Figure 9. Commercial harvest of salmon.

Subsistence and sport harvests provide a large portion of the local food supply in rural Alaska. The composition of the harvests differs from region to region based on the relative abundance of key species. However, a key element in subsistence is the use of a wide variety of wild foods, including fish, mammals, birds, and wild plants. Many subsistence users share their harvests with other households. The social bonds created through exchanges of subsistence foods are central to the survival of rural communities and many traditional cultures in Alaska and eastern Russia. Trading for coastal and inland species between regions is common. This suggests that, in a worst case scenario, effects of rat-caused reductions in subsistence harvest opportunity in one region could be felt in other regions as well.

Consisting of about 2.0 billion pounds (9.1×10^8 kg) annually, commercial fisheries harvests are estimated to comprise 97% of the total annual take of fish and wildlife in Alaska (Wolfe 2000). These harvests, and related businesses such as seafood processing, form a mainstay of local and regional economies. In the Aleutians alone, about 400 fishing vessels participate in rich commercial fishing harvests valued at over 1.5 billion dollars annually (Nuka Research and Planning Group and Cape International 2006). Striving to keep Alaska's commercial fishing industry rat-free will help prevent damage to goods and property, threats to human safety, and adverse publicity that could affect sales.

Wildlife-Related Tourism

Opportunities to view and photograph wildlife in their natural habitats are important to both Alaska's residents and visitors; studies show that wildlife viewing is second only to scenery as the most important reason that tourists come to the state (Alaska Department of Fish and Game 2006). Using a strict "primary purpose" definition, the FWS estimates that 514,000 U.S. residents aged 16 or older participated in wildlife viewing in Alaska in 2006, spending $705 million, including expenditures by nonresidents (USDOI et al. 2007). The economic impact of wildlife as a draw for international tourists has not been measured. However, Alaska's unique and abundant wildlife makes it a world-class viewing destination.

The Alaska Travel Industry Association has previously estimated the annual in-state visitor expenditures at $1.8 billion, with a significant portion attributed to the state's wildlife viewing opportunities (ADF&G 2006). The lure of viewing wildlife, including rare seabirds and unusual Asian flyway migrants, is now bringing residents and tourists to the far reaches of the state,

including Nome, Gambell, Dutch Harbor, and the Pribilofs (St. Paul/St. George). The annual net birding-related income flowing into these communities is estimated at almost half a million dollars, and rising (K. Hart, ADF&G/Division of Wildlife Conservation, Wildlife Viewing Project Coordinator, Pers. Comm. 6/29/06). Tour operators are beginning to look for ways to access viewing opportunities in other remote communities as well. Rat-related decline of wildlife, including bird populations in remote parts of the state, could reduce demand for ecotourism trips and create adverse economic effects in hub communities that provide services and support for these activities.

Figure 10. Bird-watching tourists on St. Paul Island.

3.5.2 Threats to Public Health and Safety

Lack of data is a consideration in trying to identify health and safety risks associated with rodents. Health care providers and laboratories are required to report certain diseases in humans to the Alaska Department of Health and Human Services, Division of Public Health, Section of Epidemiology. Some of those diseases could be considered rat-borne diseases. However, to date, Epidemiology has not specifically documented infectious conditions locally-acquired from rats (L. Castrodale, D.V.M., Division of Public Health/ Epidemiology, Pers. Comm. 1/12/07).

Alaska is well-known for the hazards associated with some of its industries, particularly in the marine realm. Indeed, U.S. Department of Labor statistics indicate fishing has the highest rate of occupational fatalities in the nation (U.S. Department of Labor 2006). Fires on ships can be deadly for crews and passengers because they often occur in confined spaces, generate dense acrid smoke, and result in dangerous rescues in and over frigid, turbulent water. Similarly, Alaska's frequently windy coastal conditions exacerbate the fire risk for homes, ports, and businesses in those areas.

Rats endanger public safety by gnawing on electrical wires, causing fires and other damage to vessels, aircraft, and buildings. Gnawing by rodents has caused power outages, Internet blackouts, computer crashes, fires and human deaths. Public health officials in England recently concluded that a gas explosion that destroyed a home and killed a woman in 2006 was caused by

rats gnawing pipes (as reported in Jenkins, TimesOnline, 2007). Summary information about the number of vessels damaged or disabled annually by rat gnawing is not readily available (K. Kearney, USCG District 17 Planning and Force Readiness, Pers. Comm. 10/06/06). It is known is that, between June 1990 and August 2006, in 94 of 486 (19.3%) reported Aleutian incidents involving U.S. vessels, the "first event" in an incident was an outbreak of fire (14.8%) or loss of electric power (4.5%) (USCG Marine Information for Safety and Law Enforcement database, summarized in Nuka Research and Planning Group and Cape International 2006).

Despite the development of improved firefighting equipment over time, safety advocates believe some maritime workers continue to be at risk of vessel fires, in part because altered national priorities after September 11, 2001 have caused the Coast Guard to focus more on homeland security duties than on vessel safety. For example, a new commercial fishing vessel safety law led to 1991 USCG regulations designed to increase a crewmember's chances of being rescued or surviving an accident; however, safety advocates say no corresponding changes were made to help prevent vessel casualties in the first place (Stoller, USA Today, 2003).

Protecting against rats may help prevent vessel damage and human casualties, as well as help protect wildlife resources. Measures that can be taken include requiring rat-resistant design, construction and maintenance standards for all fishing vessels and 'rat-aware' licensing standards for operators and crewmembers.

Meanwhile the potential for rodent-caused damage to aircraft means that air safety in Alaska is also a serious concern: Various foreign and U.S. domestic airlines have found mice on aircraft. In 2006, a Kansas City television station reported that it appeared mice infesting a passenger jet plane had chewed through wires of the public address system (Zigman, KDSK, 2006). International aircraft in various parts of the world have also been occasionally infested by rats (Mingchang et al. 2003). In Alaska, a USCG helicopter is known to have been endangered by a rat chewing on control cables in flight (Cdr. F. Riedlin, USCG, H60 Product Line Manager, Pers. Comm. 9/7/07).

Alaskans log more air miles annually per capita than residents of any other state, and Alaska has the highest per capita numbers of pilots and aircraft: about 1 out of 81 Alaskans is a pilot (Federal Aviation Administration 2006). Because of the threat that rat gnawing can pose to aircraft and their control systems, any report of rats (including pet rats) arriving or being sighted at Ted Stevens Anchorage International Airport, brings prompt response (Pesznecker, Anchorage Daily News 2007). The Municipality gets several such calls per year (C. Tofteberg, Municipality of Anchorage, Food Safety & Sanitation Program Manager, Pers. Comm. 2/2/07). Generally, aircraft found with rodent infestation are immediately grounded for inspection and control (Mingchang et al. 2003).

4.0 Invasive Rodents in Alaska: Current Status

4.1 Extent of Wild Rat Populations

The first documented rat introduction to Alaska occurred prior to 1780 (Breckbill 1977) when a sailing ship went aground on what is now known as Rat Island. In 1828, Norway rats traveling uninvited on Russian ships began to infest islands in southwest Alaska, and infestation increased steadily. In the early 1940s, hundreds of U.S. military ships routinely visited the Aleutians, and the rat infestation grew ever more serious (PBS 2001).

The threat that rats pose bears little relation to the number of places they are currently known to occur. Said another way, it is *where* rats occur and how easily they can be spread that is alarming and requires due preparation and vigilance.

Rats are known to have been introduced and established on at least 12 Aleutian islands over 2471 acres (1000 ha) in size and dozens of the many smaller islands that comprise the 2500-island Aleutian Archipelago (Island Conservation 2006). In total thus far, rats are known to have made

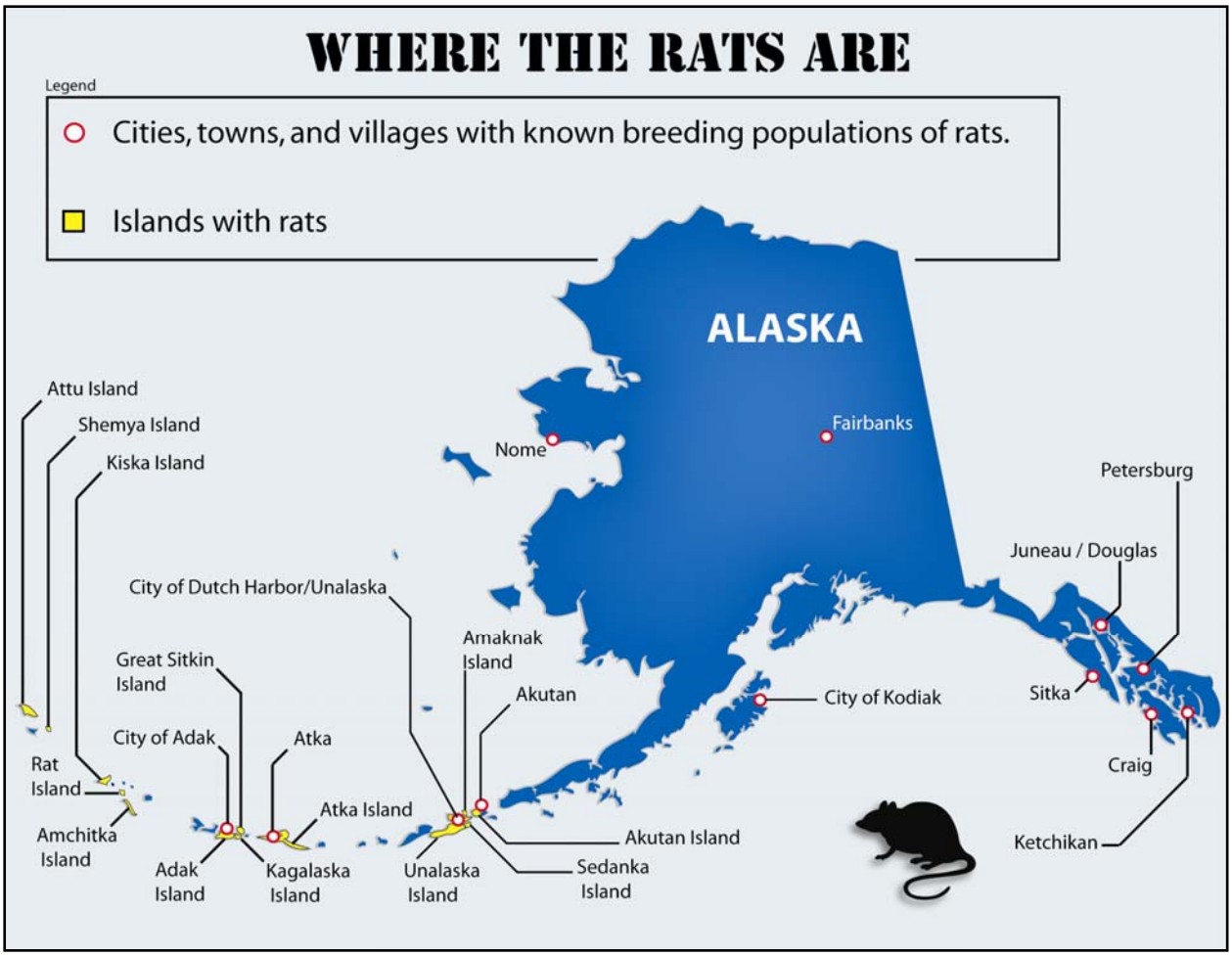


Figure 11. Map of areas with known breeding populations of Norway rats.

it to at least 21 large Alaska islands (Juneau Empire 2003). However, they may have arrived on thousands of islets, rocks, stacks, and small islands within AMNWR and elsewhere in the state that have not been surveyed. Islands adjacent to those already infested, and islands with newly established or expanded wharves, ports and harbors, are at greatest risk of rat invasions and the ecological damage they cause (Moors et al. 1992).

Figure 11 shows where rats are presently believed to occur as established breeding populations. A list of communities which have reported rats is provided in Appendix D: Rat Occurrence in Alaska. We expect that future updates to the map and community listing will be posted at www.StopRats.org.

Of the AMNWR islands currently thought to have populations of invasive rats, some islands, such as Unalaska, are believed to have been infected by early explorers and travelers. Five islands (Adak, Amchitka, Attu, Kiska, and Shemya) experienced rat introductions around the time of WWII. An additional seven islands and island groups (Akutan, Unalaska, Atka, Kagalaska, Great Sitkin, Rat, and Little Kiska) became infested sometime before or after the war (Bailey 1993).

Norway rats have also become established in Ketchikan, Juneau, Fairbanks, Sitka, Nome and Kodiak (Woodford, Alaska Wildlife News, 2005). In the past one or two years, officials in Kodiak have received increased reports from businesses and homeowners about rat activity and have responded on a case-by-case basis as resources allowed (C. T. C. Kamai, Kodiak Chief of Police, Pers. Comm. 7/25/06).

Rats have been seen in Kotzebue, Eek, and Marshall after barges unload but they are believed to have perished in the succeeding winter. Rats also occasionally arrive in Anchorage with cargo containers transiting major shipping depots, warehouses and freight centers, and at the Port of Anchorage. In addition, pest control technicians sometimes capture rats in Anchorage restaurants and food warehouses, where the rats likely arrived in a shipment (R. Sinnott, ADF&G biologist, Pers. Comm. 7/25/06). Nonetheless, Anchorage is generally considered the largest port city in the northern hemisphere without an *established* rat population.

Recently, there have been several cases (in Anchorage, Kenai, Nikiski, Clam Gulch, Wasilla) of what appear to have been pet rats being released or escaping into outdoor habitats, with the potential to develop breeding colonies (O'Harra 2003, Woodford 2005, Pesznecker 2007, T. McDonough, ADF&G Wildlife Biologist, Pers. Comm 7/26/07; R. Sinnott, ADF&G Wildlife Biologist, Pers. Comm. 9/13/06;). The ratio of accidental to intentional releases of rats is unknown.

The house mouse, another introduced rodent species, occurs in many Alaska communities and possibly also in some wild areas in the state. Anchorage has house mice, and it seems likely that house mice have been spread or could be spread from there and other freight source areas (e.g., Seattle) to many bush communities by freight operations (see Section 4.3).

At least two house mice are known to have been carried via air freight from Anchorage to St. George Island where they were intercepted and killed. Significantly, the Pribilof Island

communities of St. Paul and St. George do not have rats and only St. Paul is infested with introduced house mice.

To date, Norway rats have constituted the bulk of the rat incidents and infestations for which positive species identification was made. However, roof rats are currently known to exist on Shemya and Kodiak Islands. On Kodiak, they are only known to occur in the metropolitan area and at Bell's Flat, a suburb about 10 miles southwest of town (D. Zweifelhofer, Pers. Comm. to B. Pyle, FWS Kodiak National Wildlife Refuge, Supervisory Biologist, 12/20/06). Shemya Island also has an introduced deer mouse species (*Peromyscus maniculatus*) which is believed to have been brought in from California via military activities.

Western Canada

Neither the Norway rat nor roof rat is found in any of the northern territories of Canada. However, both species do occur in British Columbia (Natureserve 2007).

4.2 Rodents as Pets and Laboratory Subjects

Norway rats are considered important in the pet trade for two purposes: human companionship and as food for pets such as snakes (Myers and Armitage 2004). Little information is presently available about the number of rats kept as pets in the state, the volume of sales, or the number mail-ordered or brought to the state with new residents. Under current Alaska law only white albino rats may be owned as pets, and some communities further restrict entry by prohibiting the keeping of any variety of rat, or by requiring a permit to do so. For example, Anchorage has an ordinance relating to reporting, extermination, and payment of extermination costs for rats. This ordinance also prohibits rat possession except by a permitted scientific institution (see Appendix E: Example Ordinances on Rat Control).

The Psychology Department at the University of Alaska Anchorage (UAA) is the only scientific facility in Anchorage with a permit to possess rats, and it is allowed to have rats of only one sex at a time. After rats used as laboratory subjects are no longer needed by the university, they can be adopted by students. However, UAA is prohibited from adopting out rats to anyone living in Anchorage; the student must live outside Anchorage and take the rat out of Anchorage. UAA provides a rat disposition list each year to the Municipality of Anchorage. It is unclear whether any of these adopted rats reenter the city at a later date, with the same or a new owner, or are released to the outdoors in another part of the state.

ADF&G expects that there are probably many pet rats in Alaska, despite laws limiting or prohibiting such ownership, and that some releases of rats may occur when a pet owner moves or no longer wants their pet (R. Sinnott, ADF&G biologist, Pers. Comm. 7/25/06).

Few published studies exist on released domestic animals adapting to the wild (feralizing). However, the literature shows that domestic rats released into semi-natural conditions are able to

successfully dig burrows, establish breeding colonies and survive even in harsh winters with temperatures as low as -25 F (Minckler and Pease 1938; Boice 1977).[8]

As described earlier, rats arriving by air, or being found in and around aircraft and airports, pose a serious concern for air safety. In support of Anchorage's no-rats ordinance, airline workers are supposed to prevent passengers carrying pet rats from boarding Anchorage-bound flights. If pet owners arrive with a rat and do not plan to immediately board another aircraft leaving Anchorage, the Municipality provides euthanization for a small fee (C. Tofteberg, Municipality of Anchorage, Food Safety & Sanitation Program Manager, Pers. Comm. 2/2/07).

Clear guidance should be provided to the public on methods/locales for relinquishing domesticated rats that are no longer wanted. *Laboratory or pet rodents should never be released to the outdoors.*

4.3 Invasive Rodent Access to Alaska

Invasive rodents have many ways of getting into Alaska. Strategically located at the air-and-sea nexus between Asia and North America, and straddling key polar sea routes, Alaska serves as a major international hub for air and marine transportation and shipping. Major transport hubs in Alaska are Anchorage, Kodiak, Unalaska and Juneau. Within the state, more than 260 smaller rural airports, a limited road system, and modern barge service along coastal and inland waterways serve the needs of smaller communities. Each of these transportation routes serves to connect communities and industries to their sources of supply, and these expanding networks also increase opportunities for invasive rodents to be spread to new uninfected locales.

Alaska's Ground- and Inland Water-based Transportation System
Ten communities in Alaska serve as key regional transportation hubs for ground and water transportation: Anchorage, Barrow, Bethel, Dillingham, Fairbanks, Juneau, Kodiak, Ketchikan, Kotzebue, and Nome. From these hubs, fuel and freight are delivered to more than 200 outlying communities around the state. Tugs and barges are the primary method of shipping fuel and freight in Alaska's nearshore and inland waters. Transfer of cargo from ocean-going barges to smaller lightering barges allows needed supplies to reach remote coastal and river locations during ice-free months.

Meanwhile, overland shipping and freight transfer is important for communities located along the state highway system, including the Alaska Marine Highway System. None of these areas or transportation systems is immune from rodent-caused damages described earlier.

[8] In one case, a colony of about 2000 albino white rats was discovered in a landfill in Montana; these animals were believed to be descended from rats released by students from the local university (Minckler and Pease 1938). In another account, albino and hooded rats believed to be escaped pets interbred and became common in agricultural fields, houses, and buildings of Lanai City, Hawaii (Svihla 1936).

International and Alaska Marine Traffic

Despite improved navigation and mechanical equipment, remote islands along Alaska's coast remain highly vulnerable to rat spills from vessels plying the Great Circle Route (GCR) between the U.S. west coast and Asia (Fig. 12). The same is true during fishing seasons when fishing fleets, processors, freighters, and fuel barges concentrate near land.

Figure 12. The Great Circle Route, one of the busiest shipping routes in the world.

Between 1990 and July 2006, 534 incidents affecting vessel seaworthiness in foreign and U.S. vessels were reported in the Aleutians.[9] One-third of these incidents began with a loss of maneuverability.[10] For nearly 16% of incidents (76 of 486) involving U.S.-flagged vessels, grounding was the first event in a reported incident. About 90% of all reported 1990-2006 incidents involving U.S. vessels in the Aleutians were commercial fishing vessels (Nuka Research and Planning Group and Cape International 2006).[11] Coupled with the fact that there is virtually no coverage by high-powered tugs or other mechanisms to respond quickly to accidents (Shipping Safety Partnership 2006), notoriously bad weather conditions typical of the Bering Sea increase the potential for rat spills – and for rats to spread by boarding rescue craft.

[9]The domestic portion, 486 events, represented 8.2% of total Alaska reports. Incidents involving foreign vessels are believed to be underreported because there is no requirement that foreign-flagged vessels report incidents to the US Coast Guard unless the vessel is in the territorial waters of the U.S. (Nuka Research Group and Cape International 2006).

[10] This total derives from 35% of incidents (17 of 48) involving foreign vessels and 32% of incidents (157 of 486) involving U.S.-flagged vessels. In many cases, other problems (e.g., groundings, injuries, loss of life) occur once a vessel has lost maneuverability (Nuka Research Group and Cape International 2006).

[11] These totals are for reported incidents affecting seaworthiness of foreign vessels between 1991 and July 2006, and U.S. vessels from June 22, 1990 through July 2006.

The magnitude of these threats is compounded by a number of factors. First is the sheer volume of traffic that traverses by or through the Aleutian Chain: At present, an estimated 3000 ship passages per year occur through Unimak Pass in the Aleutians, with an overall estimate of 7200 trans-Pacific ship passages per year (300/month northern route and 300/month southern route); over a third of these transits are by container ships. Aleutian ports experience about 400 port calls annually from different types of ships (approximate breakdown: container ships 33%; refrigerated ships 28%; tugs towing barges 40%; Nuka Research and Planning Group and Cape International 2006). As noted in Section 3.3, it is expected that the level of ship traffic passing along Alaska's western and northern coasts will increase in coming decades. A large percentage of this traffic will pass through the Aleutian Archipelago.

Another factor that elevates the risk of rats arriving is the development and enlargement of harbors (Moors et al. 1992). Over the next 5-10 years, the U.S. Army Corps of Engineers, Alaska Department of Transportation, Denali Commission, and individual communities will be spending over $100 million dollars on new and existing harbor facilities across the state. Much of this work is being conducted prior to scheduled transfer of facility management to local communities (M. McKinnon, Denali Commission, Transportation Program Manager, Pers. Comm. 1/15/07). It is unclear whether these communities will have the financial resources to implement and maintain robust anti-rodent defenses in and around their harbors.

Similarly, other concerns exist for disposition of garbage generated aboard vessels, and difficulties in conducting educational outreach to international crews regarding sanitation, disposal of waste and disposal of any rodents that are trapped onboard. It is likely that many ships traveling the GCR are crewed by non-English speakers or persons for whom English is a second language. Some crews may contain members whose religious or other personal beliefs prohibit them from participating in extermination of ship-board rodents. Both possibilities emphasize the need to create carefully targeted and culturally appropriate outreach materials for distribution to vessel crews.

International and Intrastate (Rural) Air Traffic

Today, Alaska's largest city serves as a hub for international flights to and from the Far East and Russia. Ted Stevens Anchorage International Airport (ANC) ranks first among all U.S. air gateways with 26 percent of the tonnage of U.S. international air freight moving through it (Bureau of Transportation Statistics 2007) and, as of 2005, ranked as the world's third-busiest airport by cargo traffic, after Memphis and Hong Kong (Alaska Department of Transportation and Public Facilities 2007). It is a major sorting location for several package shipping companies, and most flights from the United States destined for Asia or vice versa make an operational stop at ANC. In addition, Federal Express and United Parcel Service both operate major hubs in Anchorage for cargo heading to and from the Far East. The United States Postal Service also operates a large facility at the airport that processes mail and parcels headed to and from Alaska communities.

The weight of air cargo handled at ANC increased significantly in the years between 1996 and 2003,[12] and it continues to grow today (Bureau of Transportation Statistics 2007). This compounds the need for adequate interception of stowaway rats. Although rats occasionally

[12] 21 percent from 1996 to 1997, and 30 percent between 1999 and 2003

arrive with passengers and air cargo on flights landing in Alaska, it appears that no active monitoring occurs to track and report on such interceptions (C. Tofteberg, Municipality of Anchorage, Food Safety & Sanitation Program Manager, Pers. Comm. 2/2/07).

Changes in Inspection Priorities after September 11, 2001
Responsibilities and staffing of agencies involved in emergency and homeland security preparedness and response have undergone changes as a result of the September 11, 2001 terrorist attacks on the nation (Makinen 2002). In turn, some of these changes are likely to have reduced Alaska's abilities to enforce agricultural or animal inspection activities -- actions that could intercept rodents and other invasive species.

One of the affected agencies is the U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS). APHIS' mission is to protect the health and value of American agriculture and natural resources. As part of its mission the agency safeguards the health of animals, plants, and ecosystems in the nation and protects natural resources against invasive species. Several acts of Congress, including the Plant Protection Act (2000), the Animal Health Protection Act (2002), and the Public Health Security and Bioterrorism Preparedness Act (2002) have expanded the scope of APHIS' mission and provided additional protective responsibilities (APHIS 2006). Today, APHIS is also charged with protecting U.S. agriculture and food systems against bioterrorism and accidental introductions of plant pests and animal diseases, through inspection of craft, cargo, and passengers at U.S. ports of entry.

Prior to creation of the U.S. Department of Homeland Security (DHS), Customs and Border Protection (CBP) staff in Alaska were under APHIS, and full-time APHIS employees were stationed at roughly 15 ports of entry across the state. However, federal immigration, customs, and some former APHIS agriculture employees have now been pooled into a single agency under DHS.

Employees from what is now known as CBP Agriculture remain at ports of entry. However, a few ports are now staffed only part-time or seasonally. Where a CBP Agriculture employee is absent, the CBP officers on site enforce agricultural concerns. This means that consistency in enforcement of agriculture and animal importation concerns can vary day to day depending on other protection responsibilities. APHIS now has only two full-time staff with which to address issues across the state -- a veterinarian in Palmer, and the State Plant Health Director in Wasilla, with most of their support staff located out of state.

5.0 Invasive Rodent Management

5.1 Approaches: Prevention versus Eradication and Control

Typically, prevention is the most cost-effective strategy for managing impacts from invasive species. It is much easier to eradicate an invasive rodent species if the invasion is halted before a breeding population becomes established and the numbers of animals skyrockets.

Rodent prevention focuses on eliminating means of entry or transfer of rodents, as well as opportunities for rodent reproductive activities: It relies on such things as improving public awareness, laws and response capability. Increased public awareness can sometimes lead to increased acceptance of, and funding for, removal efforts.

Where prevention efforts are unsuccessful and invasive rodents become established, eradication is generally considered the best strategy for addressing them, particularly on islands. Opportunities for eradication may be limited by high logistical or economic costs, but if successful, eradication is a one-time cure as long as reinvasion is prevented. In addition, it is often the case that less rodenticide is used for eradication than control (with its repeated applications) over time, so it is more cost-effective and best protects nontarget species and the environment in the long run. Although eradication of rats from islands was once believed to be impossible, it is now an accepted conservation management tool (Courchamp et al. 2003). Even so, such efforts are never undertaken lightly, especially with concerns for nontarget species and, in Alaska, for protecting users of wild foods.

Surprisingly, there is little information available on failed attempts at rat eradication. Instead, decades of research has shown that although eradication can be difficult, it is feasible if six fundamental criteria can be met: 1) there is no immigration; 2) all target animals are placed at risk; 3) rate of removal exceeds rate of increase at all population densities; 4) animals can be detected at low densities; 5) cost/benefit analysis favors eradication over control; and 6) a suitable sociopolitical environment for eradication exists (Bomford and O'Brien 1995).

Alaska's large size, rugged terrain, and difficult logistics are expected to make eradication particularly challenging in places like the Aleutians. However, the benefits of meeting those challenges may be substantial. A robust cost-effectiveness analysis could point to long-term control programs as the only reasonable option for addressing rats in some locations.

5.2 Past Rat Removal Efforts in Other Areas

Over the past 45 years rat eradication programs have been successfully undertaken on more than 332 islands around the world, from the tropics to much higher latitudes (Howald et al. 2007). The vast majority of these programs have been on islands less than 1200 acres (500 ha) in size (Island Conservation 2006, U.S. Fish and Wildlife Service 2006). However, island size has become less of a deterrent and cause of failure than in the early years of attempted rat eradications: Land managers and biologists have successfully tackled larger and larger islands

over time, with the biggest island to date being 11,290 ha (27,900-acre) Campbell Island, a remote subantarctic island of New Zealand.

New Zealand is a world leader in understanding and addressing the adverse effects of invasive species, including rats. Over the past 25 years, their scientists and land managers have undertaken increasingly complex and successful efforts to eradicate invasive species of many types. Many of these efforts involved use of toxicants, sometimes in combination with other techniques. Dozens of native invertebrates, reptiles, and birds have rebounded after eradication efforts, and nearly 70 of New Zealand's 168 mammal-invaded islands had been cleared of these predators (D. Towns, New Zealand Dept. of Conservation, Terrestrial Conservation Unit, Pers. Comm. 3/30/07).

Other countries as well as nongovernmental organizations (NGOs) have also seen successes. Great Britain has eliminated all nutrias and muskrats from within its boundaries (Gosling 1989, Genovesi 2005). Ecuador recently announced it has concluded a successful 2-year campaign to rid two of the Galapagos Islands (Isabella and Santiago) of hundreds of thousands of invasive pigs, goats, and donkeys (Galapagos Conservancy 2006).

Meanwhile, over the past eight years, the California-based organization Island Conservation has removed 41 mammal populations, including cats, from 27 Mexican Pacific islands (Krajick 2005). This NGO also successfully eradicated roof rats from Anacapa Island off California, and has partnered with The Nature Conservancy (TNC) and the FWS/AMNWR to address invasive rats in the Aleutians.

The response from native wildlife to removal of rats is often impressive. On Anacapa Island, nesting success by Xantus' murrelets (*Synthliboramphus hypoleucus;* a species proposed for California threatened status) has increased 80% since the 2001-2002 eradication of roof rats there (Krajick 2005). Even where only rat control (rather than full eradication) has occurred, the beneficial effects for wildlife are substantial. In the two years immediately following the control of ship rats on Mokoli'i Islet near O'ahu, nesting success in wedge-tailed shearwaters (*Puffinus pacificus chlororhynchus*) increased rapidly -- from only one chick fledging in the three years prior to rat eradication to 185 chicks fledging the second year after eradication (D. Smith, FWS/AMNWR Wildlife Biologist Pers. Comm. via G. V. Byrd, FWS/AMNWR, Supervisory Wildlife Biologist, 7/13/06). On Isle de la Possession in the southern Indian Ocean, the reproductive success of burrowing white-chinned petrels (*Procellaria aequinoctialis*) increased from 16% to 50% during a continued rat control program (Jouventin et al. 2003).

Some countries, such as Australia, have adopted biodiversity legislation that identifies rats as a threat and helps focus attention and resources on eliminating rat infestations that imperil the nation's health, economy, and species richness (Campbell 2006). Across the globe, there is growing interest on the part of NGOs, charitable trusts, and other philanthropic organizations in addressing rat problems, especially on islands. For instance TNC is involved in rat removal projects on Palmyra Atoll in the South Pacific, and the Aleutian Islands. Much of this effort is aimed at prevention, a cornerstone in protecting native wildlife from the effects of invasive species.

5.3 Rat Planning, Prevention and Control Efforts in Alaska

5.3.1 Alaska Maritime National Wildlife Refuge

AMNWR completed a Comprehensive Conservation Plan (CCP) in 1988 that identified restoration of Aleutian Island ecosystems through invasive predator eradications as a high priority. When implemented, this combination removal-and-restoration plan will be one of the most important and progressive conservation programs in Alaska.

As part of the CCP, the AMNWR began a rodent invasion prevention program in 1993. This effort has included a shipwreck response plan and actions to defend the Pribilof Islands and communities of St. Paul and St. George against invading rats (for more information about shipwreck response, see Appendix F: Shipwreck Response Considerations). These islands are of major wildlife importance, particularly due to their seabird colonies and marine mammal rookeries and haul outs. St. Paul Island also has a rare endemic shrew species. Parts of St. Paul and St. George Islands and all of the adjacent Walrus and Otter Islands are included in the AMNWR.

Rats are excellent climbers. If they reached the Pribilofs and became established, they likely would devastate much of the bird life and reduce shrew numbers, and they could affect marine mammals (e.g., seals) by transmitting diseases such as leptospirosis, salmonella, and toxoplasmosis (blood parasite). For these reasons, and to help protect human health and property, the AMNWR, industry, and the communities of St. Paul and St. George have worked together to lessen the likelihood of new introductions.

Consideration of large-scale eradication to remove alien rodent species from Alaskan islands really only began in earnest with the increasingly complex and successful eradication efforts conducted in New Zealand and elsewhere over the last 18 years (Section 5.2). As word about these successes began appearing in the literature, the AMNWR started inviting experts from New Zealand and California to participate in some of its training sessions and planning meetings.

Meanwhile the level of concern for Alaska's island wildlife began climbing, in part due to recent findings at Kiska Island (see Section 3.2), where rats were first introduced during WWII (Murie 1959, Bailey 1993). Three to six million least and crested auklets nest in crevices at Sirius Point, a lava dome feature which rose from the ocean in 1962 (Anchorage Daily News, Jan. 30, 1962). A popular but remote cruise ship destination, the Kiska Island auklet colony constitutes one of the largest seabird concentrations in the northern hemisphere.

Over the past 3 years, the AMNWR has also been conducting limited trials of the anticoagulant rodenticide Ramik Green (i.e., diphacinone) on Kiska Island (Witmer 2005) and in the Bay of Islands near Adak (Dunlevy and Scharf 2007b). There has also been a small-scale trial eradication of rats using diphacinone and brodifacoum baits in both bait stations and via a hand broadcast technique on 15 small islands on the west side of Adak Island (Dunlevy and Scharf 2007a, Buckelew et al. 2007). The study's purpose has been to test the effectiveness of baits under controlled conditions, and assess effects on nontarget species. Although the study was considered a success and all rats were removed, rats quickly reinvaded these satellite islands.

Testing various toxicants and techniques on smaller islands in the Aleutian Archipelago is viewed as an economical and efficient opportunity to assess the efficacy and potential impacts of larger aerial broadcast rat eradications (Island Conservation 2006). It is part of a broader campaign to drive rats from other AMNWR holdings, like Rat Island, and keep them from invading bird colonies on St. Paul, Nizki-Alaid and other rat-free AMNWR islands.

The AMNWR is preparing National Environmental Policy Act documents that would allow it to conduct a larger-scale eradication of rats from an island in the Aleutian Islands Unit starting as early as 2008 or 2009. The likely site will be Rat Island (6861 acres; 2776 ha) in the western Aleutians. Documents will define the types of actions needed for pre- and post-monitoring, conducting eradication efforts; ensuring no reinvasion by rats (quarantine); identifying actions to protect natural components of island ecosystems; and assessing results and benefits of the rat eradication. If successful, it will serve as a model for planning and conducting other island restoration projects on rat-infested islands around the state. Given results elsewhere in the world when rats are removed, experts anticipate that positive response of seabirds, landbirds, waterfowl, and shorebirds to rat removal on Rat Island and other islands will be dramatic.

5.3.2 Rat Spill Prevention and Response

Throughout history, a common means for rats to reach and infest islands has been via ships landing or going aground on island shores. Today, such an event is referred to as a "rat spill." Of all vectors for rat entry into uninhabited Alaskan islands, shipwrecks constitute the single greatest threat of invasive rodent introductions and adverse effects. For human-inhabited islands, the most likely means of alien rodent invasion is via both cargo shipping through ports and harbors, and shipwrecks.

FWS Rat Response Strike Team and Invasive Rodent Program
Starting in 1995, the FWS/AMNWR began implementing a shipwreck response program as part of its Invasive Rodent Program. The program includes implementation of a Shipwreck Response Plan by a trained Rat Response Strike Team composed of agency and non-governmental personnel. Team members are located in different communities throughout Alaska, but in a "ready state."

These individuals possess appropriate gear and current training, and they can respond in a relatively short period of time. Most are experienced field people who would redirect their normal work activities in order to respond. The goal of the program is to prevent rodents aboard ships from invading rodent-free islands following a ship's grounding.

The shipwreck response plan was developed in conjunction with FWS oil spill response program, adding prevention of rodent introductions as a primary response strategy (FWS 2005). The team of qualified responders has been extended outside FWS to include members from other federal, state, and local government agencies, industry, Tribal, and oil spill response organizations.

Figure 13. The *Selendang Ayu* shipwreck, near Unalaska Island, Alaska.

Shipwreck Response Kits and Aid to Communities

Over time, the FWS has assembled a number of shipwreck response kits with basic supplies required to combat escaping rodents. Containing varying equipment for specific types of responses, kits are placed with agency personnel, aboard salvage ships, and with local oil spill response organizations around the state. Communities with shipwreck response kits include Homer, Anchorage, Kodiak, Adak, Dutch Harbor, Juneau, St. George, St. Paul, and Dillingham.

In the AMNWR, the FWS regularly provides outreach and training to the USCG and oil spill response organizations regarding rodent awareness, prevention, and response. AMNWR employees also offer assistance to communities in developing land-based quarantine programs to prevent the spread of, or introduction of invasive rodents. Providing outreach materials is an important aspect of the quarantine program and this program has been enhanced through partnerships with non-governmental organizations NGOs like TNC. The FWS and its partners provide rodent prevention kits, which include traps and information on rodents, to ships frequenting Alaskan waters. The goal is to make vessels rodent-free and reduce the danger of them transferring rodents to new locations through cargo or shipwreck.

The FWS' AMNWR office has conducted shipwreck response (vessel boarding, control measure deployment) on four vessel groundings/wrecks in the decade-plus since the program began. None of these vessels was found to have rats. However, there have been many more potential threats from vessels in distress, and increasing levels of shipping in Arctic waters means that the threat of new rodent spills and other inadvertent introductions continues.

5.3.3 Community and Commercial Efforts

Figure 14. Rat-free harbor sign on St. Paul Island.

The level of local interest in rat prevention or control has been related to the degree of infestation and whether people perceive rats as a threat to their livelihoods and health, including wildlife harvest activities.

The Pribilof Islands are rat free and their environs are biologically very rich. These islands now have a local economy built largely around seafood processing. Over the past decade the AMNWR, industry, and the local communities in the Pribilofs have worked closely together to help prevent any rodent introductions. Proactive steps include making habitat modifications (reducing cover) around the harbor and buildings, passing rodent-related ordinances, improving garbage control, setting up defensive stations to kill arriving rodents, and conducting outreach efforts to the communities of St. George and St. Paul, ships and industry. This prevention program is now done entirely by the communities, with some technical support from the FWS, NGOs and the Alaska Department of Environmental Conservation (DEC).Vessel traffic associated with the seafood industry increases the chances of rats arriving. Rats threaten not only the cleanliness and marketability of the seafood product, but they also bring diseases that could adversely affect people and wildlife. Under St. Paul Island's "rat-free harbor ordinance" (see Appendix E), ships with rats cannot come within three miles of the harbor, and the harbormaster can refuse entry to the harbor for any vessels identified as having rats onboard. The ordinance requires the Pribilof Islands fishing industry to be part of the rodent prevention program, and this has benefited both the community and industry.

Traps and poison have been set out in both St. George and St. Paul at points where rat infiltration is most likely to occur. Once a month, workers check stations, freshen bait and anticoagulant poison in about 120 rat traps strategically placed around the harbor and buildings on St. Paul. As of May 2006 six rats have been killed at the St. Paul docks. Similar prevention efforts take place at St. George Island, with no rats caught there to date. St. George also remains free of introduced house mice; however, four mice have been caught or found dead there in incoming freight (O'Harra 2004). St. Paul has had introduced house mice for over 100 years.

The low total of rats caught may reflect the success of the ordinance to keep infected ships far from the islands' shores. However, declines in commercial fishing efforts around the Pribilofs in recent years have probably also lessened the numbers of rodents arriving in the area.

An intensive rat control program was conducted in Adak in the early 1990s, and possibly earlier, but efforts diminished in the mid 1990s after the U.S. Navy's withdrawal. Another active Bering Sea seafood processing hub, Adak has become more engaged in rat control and prevention in recent years. Adak officials have been creative in achieving multiple goals with available

funding. For example, they used BIA FireWise funds to complement rat habitat modification efforts by providing tools and manpower to cut tall grass and remove piles of burnable materials around structures; doing so removes the cover rats need for breeding and protection from predators.

Meanwhile, the communities of Sand Point and Akutan have received training in rodent awareness. As yet, local ordinances have not been passed in those communities. In Sand Point, when no rats were seen or caught after 6 months of effort, the community abandoned use of the system of traps and inspections. However, a recent sighting of a rat there has caused the community to rethink their decision.

Akutan has implemented a rat control plan similar to that of Adak – with limited habitat modification in addition to an intensive trapping program. The City of Akutan, the school and the Tribe are working together to reduce the rat population. The Aleutian Pribilof Islands Association (A/PIA) hopes to expand rat control and cleanup to the island of Atka in the near future (C. Fredenberg, A/PIA, Community Development Manager, Pers. Comm. 8/28/07).

Some mainland Alaska communities have passed ordinances intended to reduce rat-related risks to public health and safety, or adverse wildlife effects. For instance, Anchorage Municipal Code prohibits anyone owning any rats, except through a permit from the Municipality of Anchorage Department of Health and Human Services (DHHS), and eligible permittees are limited to scientific organizations and only one such entity (UAA) currently has a permit to keep rats. Municipal code allows for the Director of DHHS to grant that a pet rat could be owned under "justifiable circumstances." However, no permissions have been granted in at least 12 years (L. Morgan, Municipality of Anchorage, Environmental Services, Health and Human Services Manager, Pers. Comm. 8/8/06).

5.3.4 Education and Outreach Efforts

As researchers and citizens have begun to recognize the level of devastation caused by invasive mammals, especially rats, there has been a corresponding surge of interest in "getting the word out." Following is a list of some example rat-related activities that have occurred in Alaska in recent years, and information on who sponsored or sponsors them.

<u>Workshops and Presentations</u>

- Over the past decade, FWS and DEC have held rat control and/or information workshops in various Alaska communities including Adak, Akutan, St. Paul, and Dutch Harbor; more recently, such workshops have been held in Homer (2005) and Anchorage (2006).
- Sea Grant Program-Alaska staff gave a presentations on rats at the 2006 Pacific Coast Congress of Harbormasters and Port Directors conference and the 2007 Alaska Association of Harbormasters and Port Administrators annual meeting, both held in Juneau.
- Presentations were made by FWS (in 2004 and 2007) and ADF&G (in 2005 and 2007) at the Alaska Forum on the Environment, held in Anchorage.

Training in Use of Pesticides/Rodenticides

- FWS and DEC have conducted Integrated Pest Management (IPM) and Pesticide Certification training in several communities (e.g., Adak and Sand Point) and for agency staff of FWS, ADF&G, DEC, and USDA/APHIS/WS. Individuals can also become certified via home study or correspondence. This training is required before individuals can use rodenticides, including poison-laced baits, for trapping purposes. DEC's database lists 125 people around the state as having current certifications.

Development of Products

- A wide variety of partners (e.g., FWS, World Wildlife Fund, TNC, ADF&G, others) have combined efforts to prepare posters and brochures for harbors, villages, boats, shippers, warehouses, etc.
- FWS developed a leaflet on the ecological consequences to islands of rodent introductions**.**
- WWF and AMNWR produced a "Stop Rats!" brochure urging rat prevention aimed at vessels and harbors. The brochure has endorsement and displays the logos of a wide variety of stakeholders: ADF&G, TNC, National Oceanic and Atmospheric Administration (NOAA), Island Conservation, DEC, Marine Conservation Alliance (an industry body), Audubon, Alaska Sea Grant Marine Advisory Program (UA-SeaGrant), and the Ecosystem Conservation offices of St. Paul and St. George. Ten thousand copies have been distributed and more are being printed.
- AMNWR produced a traveling booth about rats that is a companion piece to the brochure; it will be displayed at Fish Expo and other appropriate venues.
- In cooperation with WWF and other partners, AMNWR established and began posting materials to a website called www.stoprats.org. It will be used as an outreach tool on which users can gather information, order rat prevention kits, view electronic versions of anti-rat city ordinances, share eradication tips, and access news, articles, and planning documents related to rat prevention, eradication and control.

Outreach to Particular Audiences

- Between November 2006 and February 2007, ADF&G mailed the "Stop Rats!" brochure to approximately 1,200 commercial fishing participants (catcher-processors and catcher-sellers) and began making the brochure available at its offices along the coast and in selected other locations.
- During the summer of 2006, WWF worked with FWS and TNC on a cost-share grant project for doing rat outreach. Activities and products included producing a traveling exhibit booth and brochure aimed at boat owners and workers (outlined above), as well as producing and distributing some Russian-focused prevention materials (e.g. translated rat kits and information).
- In 2005, ADF&G contacted some pet shops on the Kenai Peninsula advising them that only white (*R. norvegicus* var. *albinus*) rats may be legally possessed without a permit, and the shops got rid of their rats that were not albino white rats. ADF&G offices elsewhere in the state were also encouraged to contact local pet shops with the same message.

5.3.5 Recent Legal and Regulatory Efforts

During early 2006, the broad coalition of organizations known as the Shipping Safety Partnership sent a letter to Congress supporting H.R. 889, a bill that would fund the USCG to conduct a comprehensive assessment of risks related to marine shipping and ship traffic in the North Pacific. Getting rodents formally recognized as a risk to Alaska's and the nation's resources is viewed as a cost-effective conservation strategy to help stop ecologically damaging rodent introductions. The effort to insert language on rats was later withdrawn; apparently due to concern from some quarters about possible effects on nontarget organisms from the use of certain rodenticides in Alaska.

The Alaska Board of Game passed new regulations, effective September 13, 2007, that require boaters, shippers, and others moving containers that may contain rats to be vigilant about checking for rats and require them to take action to control or eradicate rats when they are found. The regulations do this by making it illegal to "knowingly or unknowingly" harbor rats (see Appendix G: Laws Pertaining to Rodent Management for the full text of the regulations).

5.3.6 Alaska's Comprehensive Wildlife Conservation Strategy

The dearth of information about Alaska's biodiversity was recognized during development of the CWCS (ADF&G 2006). With some exceptions, very little scientific information exists for Alaska species that are not commercially or recreationally hunted, trapped or fished. By contrast, bird conservation issues and some of Alaska's bird species have been studied for many years. The CWCS identifies rat spills and ongoing population reduction from introduced predators as key conservation concerns for most of Alaska's 40 seabird species, as well as some shorebirds, and Aleutian and Bering Sea Island endemic landbirds and small mammals (e.g., shrews and voles). Developing a statewide rodent prevention and control plan is a key step in implementing the CWCS' vision for better protecting and managing the diversity and abundance of wildlife in Alaska.

6.0 Research, Restoration and Monitoring

An important function of government wildlife agencies is to anticipate and plan for the long-term needs of wildlife populations, the habitats that produce them, and human users of those resources. This includes protecting and restoring vulnerable populations and landscapes, conducting research, and monitoring to detect changed conditions.

6.1 Conducting and Reporting on Research

The information gathered through research efforts will help inform decision-makers about threats to Alaska's wildlife, industries and citizens. It will also guide and modify any large-scale eradication efforts. In the nearer term, conducting Alaska-specific research should improve the ability of responders to contain and eliminate rats escaping during a ship's grounding, or eradicate or control a newly discovered local infestation hub. Examples of important research needs include the following:

- Conduct rodenticide bait tests to study the susceptibility of Norway and roof rats to broadcast bait.
- Study rat ecology in Alaska (e.g., food habits, seasonal habitat use, correlation of rat density/productivity with various environmental conditions, and typical invasion behavior, i.e., how rats move into and through an area).
- Quantify risks to nontarget species such as seed-eating or predatory bird species, and other components of the terrestrial and marine ecosystem.
- Evaluate and recommend potential mitigation measures, including any needed to best protect consumptive wildlife users; examples might include scheduling rodent removal efforts to not overlap or precede wildlife harvest periods.
- Study how a changing climate improves conditions for survival of rodents, e.g., increasing range and abundance of pioneering rodent species and populations in northern latitudes.

Conducting research on rat ecology in Alaska is important, and some types of research will be required in order to best focus large-scale eradication efforts here. However, based on recommendations made at a "synthesis" session held during a March 2007 interdisciplinary conference entitled "Rats, Humans, & Their Impacts on Islands: Integrating Historical and Contemporary Ecology," there is pressing urgency elsewhere in the world to develop even more effective methods of eradicating and managing rodent infestations.

6.2 Need for Pre-invasion Baseline Survey Data

Generally, it is very difficult to assess the impact of introduced species on the invaded ecosystem. This is because there is typically little pre-invasion baseline inventory data with which to compare after invasive species removal efforts.

Data for predation on small vertebrates is difficult to obtain and evidence of island bird population declines is often circumstantial or anecdotal; few data are available to conclude that rats are solely responsible for some bird species extinctions. Impacts of rodents on invertebrates

are even less studied than on birds, but there is little doubt that impacts may be substantial, as with house mice introduced to islands (LeRoux et al. 2002, Smith et al. 2002). Although mice are believed to have caused few extinctions of vertebrate species, they are implicated in extinctions of invertebrates (Moors et al. 1992). As noted in Section 2.2.6, studies suggest that predation by rats may modify entire plant communities on islands, including in the intertidal zone.

Collecting pre-eradication baseline data is essential for understanding poorly documented ecosystems and ensuring that any eradication program is undertaken with specific restoration goals and future objectives in mind (Moors et al. 1992, Zavaleta 2002). A restoration program cannot be limited to eradication of a particular nonnative species; it should also include monitoring of post-eradication ecosystem recovery and conditions.

6.3 Ecological Restoration

Ecological restoration is significantly more complex than repair of rodent-caused damage to public or private infrastructure and equipment. It involves a number of variables, particularly where more than one invading species need to be removed. However, such restoration is essential for maintaining biodiversity and for preventing species declines that might otherwise result in additional listings of species as threatened or endangered, under the U.S. Endangered Species Act.

Eliminating nonnative predators and reversing the cascading effects they initiate is especially important for species whose populations are already depleted. This is particularly true for species of seabirds that take a long time to mature, and which typically produce very few eggs per year (Coblenz 1990).

Whether on islands or the mainland, invasion by a nonnative species puts the original ‘intact’ ecosystem into an unbalanced situation. However, the likelihood of this happening is related in large part to how many other invasive species have established a foothold in the area. In other words, how compromised has this ecosystem already become? In Alaska, one scenario could involve measuring effects and effectiveness of restoration on islands from which multiple predators (e.g., both foxes and rats), or predators and herbivores (e.g., feral cattle) are removed. The response from various birds and other organisms is likely to be substantial, but scientists may find teasing out the fine details of each species’ response challenging if not impossible (Zavaleta 2002).

6.3.1 Natural Versus Assisted Restoration

There are two primary techniques for ecological restoration: natural and human-aided restoration. In natural restoration, no further intervention occurs other than to remove the nonnative species. In the latter, some human aid is provided to help species re-colonize habitats in their former range that have been cleared of nonnative invaders.

In some cases, natural recovery is possible provided there are remnant populations capable of reproducing. Examples might include populations of insects, insect-eating migratory birds, and small mammals such as voles, shrews, and lemmings. Because Alaska’s coastal islands in

Figure 15. Puffin colony on Puffin Island, Kotzebue Sound.

western and southwestern Alaska support relatively simple subarctic ecosystems, rat eradication on islands, islets, and stacks there may accomplish initial ecosystem restoration goals.

Removing one or more invading species can cause additional imbalance in an ecosystem, with stability not reachieved for many decades or, in some ecosystems, thousands of years. Eradicating one or more nonnative species may be only the first step needed in restoring a damaged ecosystem. In some of the worst case scenarios, for instance, making soil amendments and planting native flora may need to precede animal reintroductions (Krajick 2005).

In Alaska, assisted restoration may be needed for species that have been eliminated from islands in their former home range but which have life history attributes (e.g., physiological or behavioral traits) that limit their ability to colonize. Examples of a physiological barrier for a species would be the lack of long-distance flight muscles in ptarmigan. This prevents them from abandoning rat- or fox-infested islands in favor of islands at a distance that might be predator-free, or from recolonizing an island once they have been eliminated from it.

Behavioral factors can also make a species more likely to need human assistance in reestablishing extirpated populations. In particular, some species of birds may need to be translocated or attracted back to an area after rat removal, e.g. by using call playbacks and/or decoys. This applies to many highly colonial species that inhabit the Aleutians such as storm-petrels, auklets, and puffins. The breeding strategy for many of these species relies on returning to the same location and, often, the same nest site at the same time, to breed and nest

(Nysewander et al. 1982, Zeillemaker and Trapp 1986, in FWS 1988). Because individual birds are not adapted for successful breeding in low numbers, most species of colonial nesting birds would need to be moved in groups.

A good understanding of existing populations and ecosystem dynamics is critical. Careful attention should be paid to whether a species or subspecies has dropped to levels effectively too low to recover (i.e., too few individuals left to realistically employ a colonial breeding strategy). This might indicate a lower priority for tiered eradication/restoration work.

6.3.2 Recommendations Related to Restoration

Following are some recommendations on landscape-level eradication efforts intended to restore the health and abundance of native species:

- To protect nontarget species, tint rodenticide baits with bright colors that nontarget species reject, consider using bait stations these species cannot get into, and/or removing the nontarget species to captivity until baits decay.
- Following the tenet that redundancy in approaches ensures success, use overlapping grids, particularly if distributing bait aerially.
- For a broadcast application (especially on an island), ensure that the rodenticide bait application rate (measured in lbs/acre or kg/ha) is sufficient to ensure that every rat present encounters bait within its territory and succumbs to the temptation to sample a lethal dose.
- When planning rat eradications, assess potential for biological "release" (population boom) in other predators; for islands having both invasive rats and mice, strongly consider the benefits of eliminating mice at the same time as rats.
- Determine rodent reinvasion potential (including how far rats can swim, e.g., between islands or from a sinking ship to shore).
- Conduct risk analyses; aim to protect public health and, for wildlife, protect and restore the most biologically diverse and/or at-risk areas.
- Based on research results, modeling and/or other information, develop a "relative level of risk" database for priority setting for eradication efforts and shipwreck response.
  - Assign conservation values to each island or other affected land unit (e.g., presence of rats, vulnerable resources, potential for restoration, risk of reinvasion, habitat type, food availability, entry routes, operational feasibility).
  - Get data into a database and create a decision matrix.
- As appropriate for your land management responsibilities, compile presence/absence database on islands under jurisdiction, analyze distances from (re)invasion sources, and develop a "prevention index" for those lands; to aid other landowners and situations, make such indices available on the Web.
- For those other than land managers, consult any prevention index information that is available and appropriate to the locale.
- Consult species experts to determine whether recovery of an at-risk species is possible or whether its population is already too low.
- Once an area has been verified as rat-free or otherwise suitable, begin any needed efforts to aid in the recolonization and recovery of previously extirpated species.

- Evaluate progress, successes, and failures and report results in the literature or to a central clearinghouse in Alaska as examples to others of what to do or avoid doing.
- Ensure that key studies and results get translated into lay terms and made accessible to the non-scientific public; restoration efforts are often seen as "feel-good" stories and the press may pick them up, helping to maintain interest and support for de-ratting Alaska.

6.4 Ecosystem Monitoring

Ecosystem monitoring is a complex subject about which numerous articles have been written over the past several decades (Stem et al. 2005). By definition, ecosystem restoration and monitoring efforts typically involve discrete islands, island groups, and larger land masses, not the simple rehabilitation of lands in one's backyard. Thus, it is anticipated that only government agencies and/or major landowners would be engaged in these activities.

Removing invaders from an ecosystem in order to restore it can have unintended risks and ecological consequences, including unexpected indirect effects. A thorough pre-eradication assessment and long-term post-eradication monitoring of ecosystem health are both necessary, and the latter should not be limited to the biological communities directly linked to the eradicated species. As the guano-as-fertilizer example showed, effects "downstream" of these most visible symbols of ecosystem upset must also be investigated. Doing so will increase the likelihood of achieving full restoration of damaged ecosystems in the state (Courchamp et al. 2003).

Important recommendations on ecosystem monitoring include the following:

- For projects aimed at rodent removal (control or eradication), monitor to determine success for *at least two years* following rodent eradication efforts (Witmer et al. 2007a).
- Particularly in high biodiversity areas such as parks, wildlife refuges, wildlife sanctuaries, and state-designated forests, rangelands, and critical habitat areas, conduct post-treatment surveys to monitor recovery of key indicator species or assemblages including, as appropriate, plants.

7.0 A Plan for Keeping Rats out of Alaska

This plan represents another step forward in coordination of cooperative efforts to prevent and eradicate invasive rodents. Many of the people participating in existing efforts were among the many experts, agency representatives, and interested individuals who offered information and action ideas for the plan.

7.1 Key Goals of the Invasive Rodent Management Plan

Three primary goals and associated key objectives have been identified as crucial for returning Alaska to its rat-free state and restoring habitat and wildlife populations:

GOAL 1: No new invasions or spread of nonnative rodents, especially Norway rats, roof rats and house mice, into Alaska.

Key Objectives:

1A Ships, aircraft, trucks or other transport vessels entering Alaska or traveling between Alaska cities and ports are maintained as rat-free.

1B Main entry points to Alaska's island, mainland and community borders have been secured against rat invasion.

1C Effective procedures are in place throughout Alaska for quarantine, surveillance and effective response to rat sightings.

GOAL 2: Successful eradication and/or control to prevent spread of rats whenever they are detected and wherever rats have become established.

Key Objectives:

2A "Rat spill" response and eradication teams are created and ready to respond quickly and eradicate found rats.

2B Public and animal health and safety regulations, codes and procedures are in place to prevent the spread of rats, and provide for more effective discovery and control of rat populations.

GOAL 3: Effective restoration and protection of Alaska's native species and habitats.

Key Objectives:

3A Action is taken that effectively restores the natural environment and native species in areas of Alaska already infested with rats.

3B Plans are in place to take rapid and effective action to restore habitat and species that may be affected by rats in the future.

3C Necessary research is conducted to identify ways in which implementation of restoration plans here may have to differ from such activities elsewhere, due to Alaska's unique environment.

7.2 Stakeholders and Target Audiences

Table 1 lists agencies and other stakeholders who may have interests related to preventing and controlling nonnative rodent infestations. For a list of acronyms used in the plan, see Section 12.0.

Table 1. Stakeholders and Interested Parties, Alaska'Invasive Rodent Plan

Federal Agencies

- *U.S. Coast Guard (USCG)*
- *U.S. Department of the Interior (USDOI)*
    - *U.S. Fish and Wildlife Service (FWS) : Invasive Species Program, Migratory Bird Management, Coastal Program, Partners for Fish and Wildlife Program, National Wildlife Refuges, Federal Subsistence Management, Law Enforcement, others*
    - *U.S. Geological Survey (USGS), Biological Resources Discipline (BRD)*
    - *Bureau of Indian Affairs (BIA) --FireWise Program, other*
    - *Bureau of Land Management (BLM)*
    - *National Park Service (NPS)*
- *U.S. Department of Agriculture (USDA)*
    - *U.S. Forest Service (USFS): Regional Office, Chugach National Forest, Tongass National Forest*
    - *Animal and Plant Health Inspection Service (APHIS), Wildlife Services (WS), others*
- *U.S. Department of Commerce (USDOC)*
    - *National Oceanic and Atmospheric Administration /National Marine Fisheries Service (NOAA/NMFS), Office of Law Enforcement*
- *U.S. Environmental Protection Agency (EPA)*
- *U.S. Department of Health and Human Services (USDHHS), U. S. Public Health Service (USPHS), Centers for Disease Control (CDC), Division of Global Migration and Quarantine (DGMQ)*
- *U.S. Department of Defense (USDOD)*
- *U.S. Department of Homeland Security (USDHS), Customs and Border Protection (CBP)*
- *U.S. Department of Transportation (USDOT)*
    - *Federal Aviation Administration (FAA)*
    - *Maritime Division (MARAD)*

State of Alaska Agencies

- *Department of Fish and Game (ADF&G): Divisions of Wildlife Conservation (WC), Subsistence (S), Commercial Fisheries (CF), and Sport Fish (SF; including habitat/oil spill response)*
- *Department of Environmental Conservation (DEC): Divisions of Environmental Health, Solid Waste, and Spill Prevention and Response; State Veterinarian's Office*
- *Department of Natural Resources (DNR): Office of Project Management and Permitting (OPMP); Divisions of Agriculture, and Parks and Outdoor Recreation*
- *Department of Commerce, Community and Economic Development (DCCED): Division of Community Advocacy*
- *Department of Administration (DOA): Division(s) that handle occupational licensing, building inspection and safety*
- *Department of Health and Human Services (ADHSS), Public Health Service (PHS), Epidemiology Section (ES)*
- *Department of Public Safety (DPS), Division of Alaska Wildlife Troopers (AWT)*

Table 1 continued

- *Department of Transportation & Public Facilities (DOT&PF), incl. AK Marine Highway System*
- *Board of Game (BOG)*
- *Board of Veterinary Examiners*
- *Office of the Governor*
- *University of Alaska (UA): Alaska Sea Grant Marine Advisory Program (SeaGrant), University of Alaska Museum (UAM)*
- *Alaska Legislature*

Other Interested Parties

- *Universities and other educational institutions [Sea Grant, Alaska Natural Heritage Program, Alaska Cooperative Extension Service, etc.]*
- *Local/city/borough governments (harbors, public works, landfills, fire departments., health and safety, animal control, building inspection) and organizations [e.g., Alaska Municipal League (AML)]*
- *Community Coastal Districts and advocacy organizations (e.g., DNR/OPMP/Coastal Zone Program)*
- *Native Regional associations*
- *Village representative groups*
- *Nongovernmental organizations (NGOs) [The Nature Conservancy (TNC), Island Conservation, World Wildlife Fund (WWF), Audubon, Marine Conservation Alliance, Native American Fish and Wildlife Society, Shipping Safety Partnership (SSP), Alaska Community Action on Toxics, others]*
- *Wildlife viewing interests (advocacy groups, tourism businesses, support industries, etc.)*
- *International entities (Russian and Canadian, including Canadian Customs, fisheries, and wildlife agencies; New Zealand rodent eradication experts)*
- *State Fire Marshal*
- *Harbormaster and port directors' organizations*
- *Vessel and aircraft owners/operators and associated organizations*
- *Commercial fishing and fish-processing interests*
- *Farming and animal husbandry operators, 4-H clubs*
- *Landfill and waste transfer operators*
- *Shipping and warehouse representatives/organizations (air, land, and water-based cargo)*
- *Airports, airlines, and air passengers*
- *Rail yards*
- *Pest control companies*
- *Appliance recyclers/salvagers*
- *Pet shippers, wholesalers, breeders, retailers*
- *Animal shelter staff*
- *Veterinarians*
- *Realtors*
- *School districts and educators*
- *Lawmakers*
- *The insurance industry*
- *Charitable trusts and other potential funding entities*
- *The public, including visitors, citizens and workers in vulnerable or affected locales*

7.3 Agency Authorities Related to Rat Prevention and Control

Various stakeholder agencies have pieces of the authorities needed to successfully prevent and control rat infestations in Alaska. This section summarizes some of the federal, state, and local level authorities that bear on the question of how to achieve the goals outlined in Section 7.1.

U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS)

Section 4.3 summarized the mission of APHIS and how it has changed in recent years. APHIS mission activities are carried out under the provisions of specific Federal laws. Protecting and promoting U.S. agricultural health and the U.S. food system remains a major focus. However, APHIS also has diverse protection responsibilities for such issues as wildlife damage and disease management; regulation of animal welfare; and protection of public health and safety as well as natural resources that are vulnerable to invasive pests and pathogens. APHIS establishes quarantines, controls the interstate commerce of regulated articles, and directs and coordinates eradication efforts with state and federal agencies inside areas of quarantine.[13]

Through its Wildlife Services (WS) branch, APHIS works to prevent health and safety hazards that can exist due to interactions between wildlife and humans (or other animals).[14] For example, APHIS-WS conducts hazing of birds to prevent collisions with aircraft at high-risk airports, including in Alaska. In some states such as Hawaii, APHIS has a relatively large presence and its staff is actively engaged in preventing rat-caused effects on native ecosystems.

As outlined in Section 2.2.3, rodents cause fires and other damage in vessels, buildings, and aircraft. Through their constant gnawing, rats and mice pose risks to the integrity of sensitive electronics used in a wide range of applications – from transportation and commerce, to remote surveillance for national security purposes. It is unclear whether rodent-related health and safety issues and potential security threats are hazards that can be adequately covered under the current APHIS (or CBP) legal framework and Alaska staffing levels.

For more information about APHIS and its programs, see http://www.aphis.usda.gov/about_aphis/ and the agency's strategic plan at http://oars.aphis.usda.gov/lpa/about/strategic_plan/APHIS_SPlan3-05.pdf.

U.S. Department of Agriculture, Food Safety and Inspection Service (FSIS)

Responsible for ensuring the safety of meat and poultry products, FSIS provides inspection services at meat and poultry slaughtering operations and makes daily visits to processing firms to verify performance of their plant and online sanitation processes. FSIS also visits

[13] From "The Economic Effects of 9/11: A Retrospective Assessment" by G. Makinen, dated September 27, 2002 (available at http://www.fas.org/irp/crs/RL31617.pdf)
[14] Learn more about this agency at http://www.aphis.usda.gov/about_aphis/

foreign countries to assure that their inspection systems are at least equal to those in the U.S. before they are permitted to export meat and poultry to the United States.[15]

U.S. Public Health Service, Centers for Disease Control and Prevention, Division of Global Migration and Quarantine

According to the U.S. Coast Guard's "Cruise Ship Fact Sheet" [16]

> *oversight of sanitary conditions on passenger vessels is the responsibility of the U.S. Public Health Service (USPHS). The USPHS conducts both scheduled and surprise inspections of passenger vessels in U.S. ports. The inspections focus on proper sanitation for drinking water, food storage, food preparation and handling, and general cleanliness. The USPHS will provide the public with results of inspections on individual vessels, and take reports of unsanitary conditions on individual vessels.*

Involvement with issues relating to deratting on board ships is guided by international health regulations (IHRs) that were updated in 2005 (see http://www.who.int/csr/ihr/IHRWHA58_3-en.pdf). U.S. deratting requirements are covered under 42 CFR Section 71.46, and deratting is carried out by the USPHS (see http://www.cdc.gov/ncidod/dq/pdf/42cfr71.pdf). These regulations state that valid Deratting Certificates or Deratting Exemption Certificates are not required for ships to enter a U.S. seaport.[17] However, because international ports require this certificate and U.S. fees for deratting are lower than in other countries, international ships routinely ask to have this service performed while in the United States.

The Division of Global Migration and Quarantine (DGMQ) at the CDC is the USPHS agency that fulfills these responsibilities. Using commercial vendors, USPHS staff fulfills these responsibilities by conducting ship inspections (some 2000 in an average year) and issuing certificates at one of eleven U.S. ports[18] and more than 100 smaller U.S. ports. Contract services are not typically requested in Alaska because the closest approved contractor is in Seattle. Ships requesting CDC deratting services in Alaska usually receive an extension (i.e., exemption) until they visit the nearest port where these services are available; the Deratting Exemption Certificate is valid for six months, but can be extended once by the original issuer for one month.

In terms of disease prevention, including relating to rats, CDC recently expanded the number of quarantine stations around the country from 8 in 2003 to 18 in 2005. Alaska is one of the new stations, with a single staff member located in Anchorage.

---

[15] Text from "The Economic Effects of 9/11: A Retrospective Assessment" by G. Makinen, dated September 27, 2002 (available at http://www.fas.org/irp/crs/RL31617.pdf).

[16] As stated on the U.S. Coast Guard's *Cruise Ship Fact Sheet*, available at www.uscg.mil/hq/gm/cruise.pdf

[17] The United States has not required certificates since 1985, because of worldwide deratting certification activities and modern rat-proofing of ships.

[18] Since 1997, CDC has been conducting rodent infestation inspections in: Seattle, WA; San Francisco, CA; Los Angeles, CA; Honolulu, HI; Houston, TX; New Orleans, LA; Jacksonville, FL; Miami, FL; Savannah, GA; Baltimore, MD; and New York, NY.

U.S. Department of Homeland Security, Customs and Border Protection and CBP Agriculture

Customs and Border Protection (CBP) Agriculture enforces USDA regulations at ports of entry to restrict the entry of exotic species or diseases that would affect American agriculture. These regulations are described in APHIS manuals found at http://www.aphis.usda.gov/import_export/plants/manuals/index.shtml. None of these manuals cover rats.

Under APHIS' authority governing interstate commerce of regulated articles, CBP can require documentation for a rat that is being imported for scientific research or use as a pet. However, inspection for animals in transit is inconsistent; this includes enforcement of requirements that such animals have a health certificate signed by a veterinarian (S. Torrence, D.V.M., Pers. Comm. 1/2/07). CBP can also enforce other state regulations for rats (and other prohibited animals), provided the animals can be linked to a port of entry and CBP agents cite the applicable sections. Creating an importation checklist would help CBP, APHIS, USCG and others inspectors more quickly determine if a particular species is allowed in Alaska without a state permit.

The bottom line is that most rats do not make formal entry into the state. Instead, they enter unannounced, including on multitudes of domestic and foreign vessels and in international garbage on foreign-flagged cruise ships. Several of CBP's regulations make interception and documentation of such rodents extremely difficult.

CBP lacks the legal authority to regulate domestic garbage. That responsibility falls to the Alaska Department of Environmental Conservation (described later in this section). However, APHIS and CBP do have regulatory authority for international garbage: Foreign vessels are not permitted to dump untreated garbage at local landfills in Alaska, and CBP Agriculture personnel conduct ship boardings and check to see that garbage on ships is being properly treated. The regulation of international garbage and acceptance of waste from foreign vessels are regulated by APHIS under federal laws 9 CFR 94 and 7 CFR 330, respectively.

Burning of garbage destroys food and shelter for invasive rodents. To prevent the entry of exotic pests and diseases into the U.S., CBP Agriculture negotiates compliance agreements that deal with rodents indirectly by requiring all regulated garbage[19] removed from a foreign vessel (including stores) to either be incinerated to ash or steam sterilized prior to transport to a local landfill. The hauler/handler of the regulated garbage must be authorized by a compliance agreement issued by CBP and the processing facility (steam sterilizer, incinerator) must be authorized by a compliance agreement issued by CBP or USDA.

[19] As defined in 9CFR 94.5, garbage means all waste material that is derived in whole or in part from fruits, vegetables, meats, or other plant or animal (including poultry) material, and other refuse of any character whatsoever that has been associated with any such material. Materials covered by this definition would include food scraps, table refuse, galley refuse, food wrappers or packaging materials, and other waste material from stores, food preparation areas, passengers' or crews' quarters, dining rooms, or other areas on the vessel. Additionally, non-regulated waste that is commingled with regulated garbage is classified as regulated garbage (C. Rigney, D.V.M; USDA/APHIS-PPQ,VRS; Pers. Comm. 7/6/07).

Except where/when a functioning incinerator exists, garbage disposal in Alaska typically occurs by dumping and burial. In many Alaska communities, the cost of maintaining an incinerator to be in compliance with 18 AAC 60 (Solid Waste Regulations) and 18 AAC 50 (Air Quality Regulations) is sometimes prohibitive. The ability to properly segregate waste is also an issue. This means that at any particular time, Alaska may or may not have a landfill certified to receive international garbage.

Under federal law, some foreign vessels and cruise ships with specific itineraries are able to offload garbage for transport to a local landfill if they acquire and maintain 'domestic status.' This occurs automatically for vessels that have spent two years in U.S. waters. For cruise ships with specific itineraries, it requires that the vessel be inspected by CBP Agriculture and certified as free of prohibited or restricted animal products.[20] For cruise ships, this inspection occurs at the time a vessel enters Alaskan waters for the cruise season.[21] The CBP Agriculture Specialist must witness the cleaning and disinfection of the vessel and include this confirmation in the certificate. After cleaning and disinfection, the 'domestic' status becomes invalid if the vessel enters a non-Canadian foreign port.

The law is designed to ensure that domestic status is conveyed only to "clean" ships and their stores. However, it fails to address the problem of rats being spread through transport and off-loading of 'domestic' garbage to and among infested ports in Alaska and Canada.

In the past CBP Agriculture handled all of the compliance agreements for international garbage. However, this agency is in transition and some of its international garbage compliance agreements are being transferred to the USDA state plant health director.

To date, there appears to have been little coordination between CBP Agriculture and DEC, the state agency responsible for regulating domestic garbage. Because DEC also administers compliance agreements for garbage disposal, it seems likely that collaboration among DEC, CBP Agriculture and APHIS could make individual compliance agreements more effective and better protect Alaska from rats, diseases, and biosecurity risks.

U.S. Department of Homeland Security, U.S. Coast Guard

Despite perceptions to the contrary, the Coast Guard has no direct statutory/regulatory oversight over rodent issues; the USCG maintains that, given present legal structures, rats and mice are purely in the "public health" realm. As such, the appropriate federal agencies to

[20] That is, all meats and meat products (except meats that are shelf-stable), all fresh and condensed milk and cream from countries classified by the USDA to be affected with Foot and Mouth Disease, all fresh fruits and vegetables, and all eggs.

[21] A CBP Agriculture Specialist conducts an inspection at an Alaskan port to determine the status of the vessel prior to the offloading of any regulated garbage. As noted earlier, the hauler/handler and the landfill must be authorized by compliance agreements. After receiving CBP inspection and authorization to dispose of materials into an Alaskan landfill, the vessel must call only at continental US and Canadian ports during the entire cruise season. Aside from incidental travel through international waters to safely navigate between U.S. and Canadian ports, the vessel is otherwise not permitted to leave U.S. and Canadian waters off the west coast of North America (C. Rigney, D.V.M; USDA/APHIS/Plant Protection and Quarantine/Veterinary Regulatory Support; Pers. Comm. 7/16/07).

be addressing them are the Departments of the Interior and Commerce, and the U.S. Environmental Protection Agency (K. Kearney, USCG District 17 Planning and Force Readiness, Pers. Comm. 10/06/06).

U.S. Department of the Interior, U.S. Fish and Wildlife Service

The FWS works with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. Their personnel, especially those involved with migratory birds and the AMNWR, have been very active in rat-related outreach, education, and wildlife restoration efforts. To facilitate undertaking large-scale seabird restoration projects through rat eradications in the AMNWR, FWS prepared and conducted public review in 2006 of an Environmental Assessment (EA) under the National Environmental Policy Act (NEPA) for a rat eradication field efficacy trial on small islands near Adak. Actions taken under this and future EAs or environmental impact statements will form the basis of what many expect will be a multi-decade effort to rid many Alaska islands of established rat populations and restore native seabird populations.

Other Federal Agencies

As far as could be determined, there are other federal agencies that administer programs to protect resources that could be affected by rats. However, these entities are not engaged in any public outreach or assessment efforts to determine the extent or potential effects of invasive rodents on lands or resources they are responsible for administering. Agencies in this category include the USDA/USFS, USDOC/NOAA/NMFS, USDOI/NPS, EPA, and the USDOT [Federal Aviation Administration (FAA), Maritime Administration (MARAD), etc.].

State of Alaska

Alaska State Legislature: The state lacks an invasive species act identifying state agency responsibilities for preventing and managing effects from invasive plants and animals, including rodents. Currently, where responsibilities are recognized at all, they are spread among a variety of agencies depending on the subject. For instance, authority for management of invasive terrestrial plants rests with the Department of Natural Resources, while ADF&G authorities apply for invasive aquatic plants. Meanwhile, rodent- and pet-related issues fall to at least four agencies: ADF&G, DEC, Alaska Department of Health and Social Services, and Alaska Department of Community and Economic Development (through licensing of veterinarians).

It seems likely that many invasive-species-related needs, including design of rat-proofed public facilities such as harbors, could be addressed under the umbrella of a state invasive species act. Such an act might also be the place to address oddities of state statute such as the fact that, because rats and many other invasive vertebrates are classified as both "wildlife"[22] and "game," a person must have a hunting license in order to kill them.

[22] And more specifically "deleterious exotic wildlife" [5 AAC 92(52)]

Alaska Board of Game: The Alaska BOG, a seven-person panel appointed by the Governor, holds public meetings and deliberates on wildlife regulatory issues and management decisions after hearing public testimony and information from the Alaska Department of Fish and Game. Under the Board's biennial meeting schedule, statewide issues, including invasive species concerns, are not slated to be taken up until 2010. Nonetheless, the BOG agreed to hear an ADF&G-sponsored proposal concerning invasive rodents at the Board's March 2007 (Southcentral Alaska) meeting. The Board concurred with staff recommendations that taking up rodent regulations early and out of cycle will assist agencies and the public in implementing programs to both eradicate invasive rodents and keep them from spreading to other areas.

Alaska Department of Fish and Game: In Fall 2006, ADF&G evaluated Alaska laws relating to invasive wildlife species and identified existing legal language that could hamper effective management of nonnative rodents. As a result, the department submitted a proposal, adopted by the BOG and effective in September 2007, which strengthens regulatory tools needed to better protect wildlife populations, natural habitats, and human interests from these destructive pests.

One change prohibits harboring rats aboard vessels or translocating rat-infested structures. Another requires development and implementation of rodent interception and removal plans for ports, harbors, airports, and food processing facilities in which rats have been found. Still another relaxes a prior legal prohibition on use of poisons to take wildlife without advance written consent of the Board. This change was made to better align with existing DEC laws that allow sale and use of registered household rat poisons. These changes have ramifications for a number of agencies, including those involved in inspecting and deratting vessels, and managing transportation facilities.

Another issue needing legal and policy review is that of importation of invasive species, including rats, as pets or laboratory subjects. Under 5 AAC 92.029, state law prohibits keeping any variety of rat except white albino rats (*R. norvegicus* var. *albinus*). White albino rats are not necessarily sterile and, if released, can pose threats to humans, property, and wildlife similar to those posed by pigmented or white non-albino rats.

The law prohibiting entry into Alaska for other varieties of rats appears to be disregarded by some pet shops and by individuals who purchase illegal varieties for shipment from outside Alaska. Rather than being bred here, most pet rats are believed to come from out of state, with lax attention paid to animal health certification and importation rules (S. Torrence, D.V.M., Pers. Comm. 1/2/07).

Another concern is that no systematic records are kept concerning importation, ownership, or transfer/disposal of nonnative rodents, or other demonstrably invasive species that are allowed in Alaska without a permit. This makes it difficult to quantify the risks associated with escape or release of these animals into Alaska's natural habitats.

Alaska Department of Environmental Conservation: Under AS 03.05.011, DEC may issue orders, regulations, permits, quarantines, and embargoes relating to: (1) examination and

inspection of premises containing products, articles, and commodities carrying pests; and (2) establishment of quarantines for eradication of pests and diseases in livestock. The clause on "examination and inspection of premises" appears to limit DEC from directly addressing the issue of rats and ecosystems, such as whole islands infested with rats. DEC's participation in the issue of rats in natural areas would be handled through its authorities relating primarily to solid waste disposal and use of pesticides. Meanwhile DEC's authority for introduced disease concerns only the potential for an introduced disease to spread to domestic animals (K. Stricklan, DEC Solid Waste Program Manager, Pers. Comm. 6/06/07). Information on the DEC Solid Waste, Pesticide, and Environmental Health programs follows.

Solid Waste Program
State solid waste regulations currently restrict types of waste (i.e. liquids and hazardous waste), but do not specifically address waste acceptance from foreign vessels; this is regulated by USDA/APHIS. APHIS regulations require all regulated waste to be treated before it is disposed of in a landfill, by incineration or other means. As noted above, regulated waste includes food scraps or other food-related waste. Landfill owners in Alaska must operate the landfill to minimize disease vectors and wildlife attraction (K. Stricklan, DEC Solid Waste Program Manager, Pers. Comm. 11/10/06).

Pesticide Program
The DEC Pesticide Program has ongoing concerns regarding the use of toxicants, poisons, and rodenticides, including lawful uses to remove rodents; these include:

- Primary and secondary poisoning of nontarget species
- Contamination of the environment, particularly water resources
- Applicator health and safety concerns which includes proper training and certification for applicators
- Recordkeeping requirements
- Liability insurance requirements
- Posting and notification requirements
- Permitting requirements
- Storage and disposal requirements
- Pesticide spill prevention and response procedures must be in place
- Protection of children, pets, livestock etc.
- Verifying that rodenticides used are federally- and state-registered
- Verifying that Federal and State laws are being followed regarding pesticide distribution, sale, use, registration, transportation, storage, disposal, etc.
- Development of chemical resistance

Environmental Health Program
Under its Food Safety and Sanitation Program, DEC has responsibility for inspecting processing vessels, shore-side seafood processing plants, and tender vessels that supply the processors. However, processing-related vessels represent only a very small percentage of vessels in the state (R. Klein, DEC Food Safety and Sanitation Program Manager, Pers.

Comm. 6/25/07). The primary concern of the inspection program is protection of the raw materials and product. An inspection that reveals evidence of rats typically results in a requirement that, before resuming processing operations, the owner of the facility must ensure that the affected area is cleaned and sanitized. The vessel or facility must also be rat-proofed to preclude any further entry and habituation of pests.

Under state environmental health laws, DEC has the authority to adopt regulations that would make it illegal to harbor rats anywhere there could be a human health concern (e.g., vessels, warehouses, food service and sanitation facilities). Recently adopted changes to state wildlife regulations may provide DEC with increased ability to protect human health. DEC may also have mechanisms to monitor compliance with any anti-rat laws. For example, such monitoring could occur in association with inspections of seafood processing and food handling establishments.

Under AS 03.05.011, DEC does outreach to livestock operators about rats as disease vectors. Most of the agency's regulatory disease programs address rodents as increasing the risk of disease, and this angle receives emphasis in the DEC biosecurity plan for an operation. In addition, through efforts of the State Veterinarian's Office, DEC can conduct outreach to veterinarians and the public on rodent-related issues, including wildlife diseases caused by rats.

Alaska Department of Health and Social Services (ADHSS), Division of Public Health (DPH), Epidemiology Section (ES): This section monitors the occurrence of infectious conditions of public health importance, and it produces online epidemiology bulletins (http://www.epi.alaska.gov/bulletins/docs/rr2007_01.pdf).Originally designed for human healthcare providers, these bulletins now reach a diverse audience, including veterinarians operating in Alaska.

No incidents of human disease in Alaska have been specifically ascribed to rats or rat-related environmental conditions. However, this may be a consequence of the manner in which event-specific information is collected from health care providers, rather than a true indication of the public health threat – or lack thereof – from rats. In other words, under current reporting protocols, rat-caused disease (e.g., infection and fever from a rat bite) may be treated and later reported in a more general category, rather than specifically as a rat-related event (L. Castrodale, D.V.M., ADHSS/DPH/ES, Pers. Comm. 1/12/07). Methods are needed to capture and report the true medical burden of rats to humans in Alaska.

Local Governments

Realistically, local entities may be well-positioned for the responsibility of educating their constituents about rats and, where necessary, enforcing rat-related regulations. As mentioned elsewhere, communities such as St. Paul and St. George have developed strong ordinances that help protect their citizens, wildlife, and economic base from the adverse effects of rat infestations.

Anchorage Municipal Code prohibits anyone from owning any rats, except through a permit from the Municipality of Anchorage Department of Health and Human Services (DHHS) and

limits eligible permittees to scientific organizations. However, the Municipality has no effective way to monitor importation of pet rats by new residents, including from the nearby Matanuska-Susitna Valley, where ownership and breeding of rats remains legal. More local ordinances and education about these issues are needed, including information for municipal animal control staff and animal shelters.

Table 2 – Rodent Pathways to Alaska and Possible Entities with Authority or Interest

(A) Method of rat or mouse arrival/release	(B) Responsible Entity(ies) Identified to Date	(C) Which other agency(s)/entities *could/should* share responsibility
Known/Expected arrivals		
Pet shipments and breeding of rats or mice for the pet trade	Alaska Board of Game (BOG), Dept. of Public Safety/Alaska Wildlife Troopers (DPS/AWT)	Local governments; animal control officers; air freight companies; CBP inspectors; ADF&G; veterinarians
Pets arriving with new residents	BOG, DPS/AWT	CBP inspectors; USDOD; local govts; animal shelters/control depts.; ADF&G; veterinarians; airlines
Unplanned arrivals		
Swimming from an infested island or landmass		Landowner(s)?
Swimming from an infested vessel	BOG, DPS/AWT	Local govts/harbormasters; maritime industries, boat owners, USCG
Rats arriving via vessel in domestic or intl. garbage	DEC, CBP Agriculture, BOG	
Vessel landings, dockings	BOG, DPS/AWT, local governments in Pribilof Island locations	USCG; APHIS and CBP inspectors; DOT&PF; USDOT; local govt./harbormasters; maritime industries; boat owners/captains; DEC; public health agencies
Vessel groundings, disablings	USCG, FWS, DEC, EPA	Landowners (e.g., NPS, DNR); NMFS; ADF&G
Cargo containers, trucks	BOG, DPS/AWT	DOT&PF, USDOT, APHIS and CBP inspectors; shipping industry; local communities
Aircraft, airports	BOG, DPS/AWT, Municipality of Anchorage	DOT&PF; FAA; APHIS and CBP inspectors; local government; air freight and passenger industries; aircraft owners, operators & maintenance personnel
Translocation of rats to uninfested locations	BOG, DPS/AWT	Local governments, land owners (e.g., FWS, NPS), transport companies
Immigration/importation of pets into Alaska or into communities where they are outlawed by municipal code.	Local government, APHIS/CBP	Animal control & shelter personnel, veterinarians
Immigrants from nearby infested structures, containers, or from gear/nets hauled aboard		Local governments; maritime industries; U.S. Coast Guard
Release/escape of pets	BOG, DPS/AWT	Local governments, animal control & shelter personnel, veterinarians
Range expansion (e.g., overland from British Columbia, or infected locales within Alaska)		Local governments; land owners/managers; ADF&G; FWS

7.4 The Alaska Rodent Action Team Concept

ADF&G does not have authority to implement most of the actions that may be necessary to achieve the goals and objectives of the invasive rodent management plan. Many policy and legal issues may have to be addressed to provide necessary authority and funds at the federal, state and local levels. Therefore, successful long-term prevention and control of invasive rats will require significant coordination between agencies with differing missions, authorities and resources. Table 2 illustrates that many will need to be involved to address just one key issue, preventing rats from entering Alaska.

Interagency collaboration -- planning, coordination, and in some cases implementation—will be essential for success. After consulting with other organizations, the department recommends formation of an interagency Alaska Rodent Action Team (AKRAT) to act as the continuing planning entity for the statewide effort to prevent and control invasive rats. As envisioned, AKRAT will foster broad-based cooperation and coordination on rodent-related issues and needs across the state. The AKRAT will assist in identifying priority actions and timelines to achieve the goals and objectives set out in Section 7.1. ADF&G proposes to serve as the initial convener of this group.

It is hoped that many of the agencies that offered input to this plan and that need to be involved in cooperative action will provide representatives to AKRAT. This multi-organization team will help guide collaborative activities, review legal and other jurisdictional issues, and identify sources of funding and opportunities for partnering to help address identified needs. The team's executive committee can decide process details such as the duration of group work plans (e.g., annual, biennial) and how to ensure that work of the team complements efforts undertaken by the Alaska Invasive Species Working Group (AISWG).

Input received by ADF&G for this report resulted in a long list of potential tasks required to protect Alaska from invasive rodent species. Many are related to more than one goal or objective. In general, tasks appear to fall into one of six categories of necessary action: Legal and Policy; Rat Spill Response; Health and Safety; Community-based Rodent Prevention and Control; Wildlife Habitat and Restoration; and Outreach and Education. The department recommends that AKRAT initially structure itself by forming subgroups to address these same interest areas (see Table 3). A list of strategic actions, by category/subgroup, follows Table 3, together with an indication of which organizations warrant invitation to participate in that subgroup.

Table 3. Proposed Structure and Participants for AKRAT						
	Subgroup (Interest Category)					
Agency/Entity Name or Description	*Legal and Policy*	*Detection and Spill Response*	*Health and Safety*	*Community Prevention and Control*	*Outreach and Education*	*Wildlife and Habitat Restoration*
Multi-entity/X-jurisdiction						
AISWG	*X*					
Pacific Seabird Group		*?*			*?*	*X*
Natl/Intl Groups & NGOs		*X SSP*		*X Ak & Pac. Coast Hbrmstrs*	*X*	*X*
NPFMC				*X*		
Federal						
Congressional del.	*?*					
USCG	*?*	*X*	*X*	*X*	*X*	
USDOI	*X*	*X*		*X*	*?*	*X*
NPS		*X*		*X*	*?*	*X*
FWS	*X*	*X*		*X*	*X*	*X*
EPA			*?*		*?*	*?*
USFS		*X*			*?*	*X*
USDHHS/CDC	*X*		*X*	*?*		
USDA/APHIS	*X*		*X*	*X*	*?*	*X*
USDHS/CBP				*X*	*?*	
USDOD		*?*				*?*
USDOT		*?*				
USGS/BRD						*X*
BIA		*?*	*X*	*X*		
NOAA/NMFS	*?*	*X*	*X*		*X*	*X*
State of Alaska						
GOV's Office	*?*					
ADF&G/CO	*X*	*?*			*X*	
ADF&G divisions		*X CF, WC*	*?S*	*X*	*X*	*X WC*
DOA	*?*					
BOG	*?*					*?*
CFEC					*X*	
DEC		*X*	*X*	*X*	*X*	*X*
DCCED				*X*	*?*	
DNR					*X*	*X*
ADHSS/DPH/ES			*X*	*X*		
DOT&PF			*X*	*X*	*X*	
DPS/AWT	*X*			*X*	*?*	
Educ. Institutions						*?*
UA-SeaGrant		*X*	*X*	*X*	*X*	
Local, Industry, and Other						
AML	*?*	*?*	*?*	*x*		
Local Govts.		*?*	*X*	*X*	*X*	
AK Assoc. of Harbors & Port Admin.				*X*		
Industry – Tourism						*?*
Industry-Food/Seafood			*X*	*X*	*X*	
Transp.-Freight			*X*	*X*		
Veterinarians			*X*	*?*	*X*	
Transp. –Air			*X*	*X*		
AK Cons. Alliance	*?*	*?*	*?*	*?*	*?*	*?*

7.5 Strategic Actions List (2007-2010) by AKRAT Subgroup

This section sets out lists of identified potential tasks within the six recommended AKRAT subgroup areas. The goal is to achieve optimal coordination of effort at a statewide level. However, implementing this plan will require collaboration and communication at a variety of levels--both within organizations and across a broad suite of agencies and stakeholders operating in national, state and local arenas. For this reason, the plan and its appendices are presented in a manner intended to promote and facilitate local-level planning.

Many of the actions listed here can only be accomplished with the support, and sometimes behavior changes, of stakeholders involved. The success of many of the actions also hinges on good communication to target audiences. Outreach and education actions will be important elements of many of the actions outlined below. Providing the public and decision-makers with accurate and timely information about rats and rat-related efforts is critical to achieving the plan's goals and objectives.

7.5.1 Legal and Policy Aspects

Actions in this category are expected to address issues common to many organizations: e.g., legal reviews, administrative matters, program management, and multi-party collaboration. It would be appropriate for policy-level representatives to sit on this panel.

Expected Participants:
AISWG, USDOI, FWS, USDHHS/CDC, USDA/APHIS, ADF&G/CO, DPS/AWT

Other Potential Participants/Observers:
Congressional delegation representative, USCG, Governor's Office, NOAA/NMFS, BOG, AML, Alaska Conservation Alliance

Section 7.3 details the various interests of federal and state agencies and identifies some of legal and policy issues that may need to be addressed to enable each of them to effectively take appropriate action against rats.

Strengthening the legal and administrative framework surrounding rat prevention, control and eradication will be integral to achieving the goals of this planning effort. During the plan's scoping effort, contributors helped identify gaps and inconsistencies in this framework relating to management of rodent infestations in Alaska and neighboring jurisdictions. Neighboring jurisdictions include those that are physically near, and those that are "connected" to Alaska through commerce, transportation vectors, or concerns for shared migratory species. As presented below, the legal and administrative framework includes international laws and parties, and national, state, and local level actions. In concert with reviewing enforceable laws and policies, decision-makers may want to evaluate the benefits of, and need for, legal or policy *incentives* that will aid in preventing and combating rat infestations in Alaska. This could include initiatives related to public education, tax/insurance inducements, bank loan criteria, publishing inspection results, and revising liability responsibilities and penalties.

Strategic Actions: Legal and Policy

International

- Strengthen the Migratory Bird Treaty Act to promote elimination of invasive rodents; such a change would likely benefit not only the United States, but also Canada and Mexico.

Federal

- Strengthen federal and state agency authority over foreign vessels and their stores; promote collaboration to improve inspection and enforcement related to maritime operations, public health and safety, border security, and other areas.
- Clarify the USCG role in inspecting ports and quarantining cargo to avoid rodent infestations.
- Evaluate USPHS/CDC procedures allowing international ships requesting de-ratting certification to get an extension until they reach Seattle or Honolulu, the nearest U.S. ports where these contractor-provided services have been made available.
- Evaluate the benefits of passing a law similar to Australia's Environment Protection and Biodiversity Conservation Act of 1999, under which predation by nonnative rats on marine offshore islands could be defined as a key threat requiring a national threat abatement plan.
- Evaluate inserting language into the reauthorization of the National Invasive Species Act to include a focus on rodents on vessels.
- Work with the insurance industry to develop market-based incentives that help eliminate or significantly reduce sources of rat infestation and related damages in Alaska.

Federal and State

- Evaluate legal and program changes needed to facilitate USCG and other agency response to rat spills equivalent to chemical pollutants such as oil spills.
- Evaluate actions needed to assign liability for rat spills in order to have responsible agents cover the costs of clean up, eradication and ecological recovery.
- Review national and state legislation concerning rodent-related prevention, inspections, and enforcement.
- Require rat-resistant design, construction and maintenance standards for vessels plying Alaska waters, and 'rat-aware' licensing standards for operators and crewmembers.
- Establish effective cooperative agreements to enhance monitoring and enforcement of compliance agreements for burning international garbage and prevent the entry of exotic pests and diseases into Alaska.

State

- Develop and pass a comprehensive Alaska Invasive Species Act.
- Evaluate AS 16.05.255 (Regulations of the BOG; management requirements) to determine if it should be revised to address invasive species.
- Evaluate tax and insurance codes, and environmental, wildlife and public health laws and recommend language that encourages communities and businesses eliminate invasive rats in Alaska.
- Evaluate state construction code and require or promote rodent-proof construction techniques.

- Evaluate the advantages of greater penalties for illegal ownership, transport or release of rats.
- Educate the public, veterinarians and animal shelters about the need to transfer and dispose of pets to reduce rats being released to the outdoors.
- Require veterinarians licensed in the state to be cognizant of the threats that rats, including those kept as pets, pose to Alaska; add relevant rodent-related questions to examinations used for licensing veterinarians who practice in the state.
- Augment requirements for inspection of seafood processing and food handling establishments to foster compliance with new anti-rodent laws.
- Investigate and cite individuals and businesses that are not in compliance with Alaska's rodent laws, including pet shops and mail-order businesses selling varieties of rats prohibited in Alaska.

Local/Regional

- Establish and maintain transportation and food-processing facilities as rat-free facilities.
- Implement new state regulations under 5 AAC 92, including development and implementation of rodent interception and removal plans, for rodent entry or transfer points such as ports, harbors, airports, and food processing facilities.
- Adopt ordinances such as the Pribilof Islands' "Rat Free Harbor Ordinance 9.1.6" to keep freight transit, warehouse, rail yard, airport, and other nonmarine entry points rat-free.
- Improve local construction codes to require or promote rodent-proof construction techniques, e.g., for all new construction in rat-affected locales.
- Adopt ordinances, as needed, to help implement state regulations prohibiting the possession, transport or harboring of rats.
- Adopt ordinances to prevent, or control and monitor the keeping of rats as pets, including proper disposal/transfer of pets.
- As conditions and risk level warrant, hire municipal pest control officers to protect communities from rat-caused damages.

<u>Strategic Actions: Collaboration and Program Management</u>

Given the history of rat colonization elsewhere in the world and a warming climate, the threat of rats being introduced in Alaska can be expected to grow. Prompt development of long-term capability and commitment in government agencies is critical to protecting Alaska's interests over the long term. The following sections highlight ways to develop collaboration and funding tools that will help organizations, communities and agencies collectively meet the difficult challenges ahead.

Partnering and Collaboration

- Collaborate with jurisdictions and organizations that share interest in Alaska species to raise awareness about protecting wildlife and habitats from damage by rats and other nonnative species.
- Work with North Pacific coastal communities to improve inspections, port regulations, and their enforcement; highlight the example of shore-based prevention in the Pribilofs.
- Develop agreements with Canada to keep each other informed about rat infestations and support outreach and eradication efforts.

- Assess and enhance agency preparedness and resources for preventing and combating rat infestations in Alaska.
- Develop cooperative agreements for outreach, prevention, response, control and eradication programs.
- Facilitate rapid response to invasive rodent problems by developing local action plans for control and eradication of rodents.
- As needed, expand or realign staffing and resources to improve public inquiries response; perform education, mentoring, planning, response, or removal tasks; and support work of the Alaska invasive rodent action team.
- Develop and conduct training for agencies and communities.
- Identify opportunities to cross-train and mentor local and regional rat removal and/or response staffs.
- Develop reporting tools and protocols so agencies, communities, and industries/businesses can periodically report on status/progress of rat prevention and removal efforts in Alaska.
- Collaborate to conduct periodic detection and assessment in places likely to act as hop-off and arrival points in the state, or in a local area (e.g., transportation hubs, freight transit areas, border check stations).
- Promote an annual invasive rodent trapping event (e.g., "Snap the Trap" Week) – to get citizens and communities engaged in assessing Alaska's rodent infestations, and reporting them to a central location.
- Develop and maintain rat-management related websites.
- Develop and maintain coordinated data storage, retrieval, and management systems; enhance data analysis, mapping and GIS (geographic information system) capability in resource management agencies and others concerned with the potential spread of rats.
- Look for opportunities to dovetail rat control/eradication with other actions beneficial to communities (e.g., BIA FireWise funds, to create defensible space around buildings).

Funding Development

- Consider developing a catalog of potential funding sources, with information on funding program goals, deadlines, and eligibility.
- Review program criteria (e.g., grant eligibility and scoring systems) to update them for better consideration of rodent concerns.
- Collaborate to raise public, private and/or corporate donations toward rodent management initiatives, including rat eradication and wildlife restoration.
- Establish legal and program structures to process contributions; consider a non-profit with competitive project selection process.
- Investigate establishment and management of a trust fund for shipwreck response, similar to that for oil spill response funding.
- Develop a mechanism for birders and ecotourism-related operations to donate toward the cost of preparing and distributing educational materials about rats.
- Develop cost-share agreements for providing rat infestation equipment, transportation and supplies (e.g., "rat kits").
- Support funding and mission development for agencies to conduct risk analyses that would reduce adverse impacts of marine shipping in the Southern Bering Sea.

7.5.2 Rat Spill Response

This category addresses efforts needed to effect rapid and coordinated multi-party response to rat spill events along Alaska's coast and protect wildlife-rich coastal lands, especially islands, from the adverse effects of rodent introductions. A key consideration in conducting rodent response efforts is to use experienced individuals who can mentor and train others. Expanding response capability across multiple organizations and geographic locations is very important to protecting Alaska's rat-free lands.

Expected Participants:
SSP, USCG, USDOI, NPS, FWS, USFS, NMFS, ADF&G/CF, ADF&G/WC, DEC, UA-SeaGrant

Other Potential Participants/Observers:
Pacific Seabird Group, USDOD, USDOT, BIA, ADF&G/CO, AML, local governments, Alaska Conservation Alliance

Strategic Actions:

- Develop multi-agency rat eradication team program to provide shipwreck (i.e., "rat spill") response along Alaska's coast, and situation monitoring in cases of ship grounding, especially if rats were known or believed on board.
- Identify response-capabilities and prepare memoranda of agreement, detailing team response to a "rat spill" and with what resources (strategically cached supplies, etc.).
- Cross-train and mentor local and regional response staffs, to ensure timely response.
- Seek resources and commit to holding periodic multi-agency training.

7.5.3 Health and Safety

This section addresses needed efforts by health providers, health and sanitation inspectors, building inspectors, animal health workers, and interest groups involved in protecting public safety from potential effects of rat damage. Some of the potentially affected interests include veterinarians, vessel owners/operators, airports, aircraft owners/pilots, and the banking and insurance industries.

Expected Participants:
USCG, USDHHS/CDC, USDA/APHIS, BIA, NMFS, DEC, ADHSS/DPH/ES, DOT&PF, UAF/SeaGrant, local governments, food/seafood industry, freight/transportation industry, air/transportation industry

Other Potential Participants/Observers:
EPA, ADF&G/S, AML, veterinarians, Alaska Conservation Alliance

Strategic Actions:
Prevention

- Review and, as needed, improve laws relating to sanitation and health, and protection of public safety, including prevention of fires or other threats due to rat gnawing.

- Examine the role of international and domestic garbage in spreading rats, and implement local or industry-wide measures to improve handling and disposal of garbage, including refuse carried aboard vessels transiting or visiting the state.
- Establish cooperative agreements for monitoring and enforcement of compliance agreements for burning international garbage to prevent entry of nonnative rodents into Alaska.

Data-Gathering and Reporting

- Develop and implement methods to capture the true medical burden of rats to humans and animals in Alaska; establish reporting protocols for health, veterinary, and sanitation workers to gather information on such things as incidence of rat-related diseases by community (or affected animals), exposure method, treatment, etc.
- Request, synthesize, and evaluate information that would help determine the level of risk to public safety due to rats.
- Periodically report results of health- and safety-related tasks to decision-makers.

7.5.4 Community Rodent Prevention and Control

This category outlines needed efforts by communities and industry to conduct localized prevention, detection, and removal (eradication or control). Comprehensive local-level planning and prevention efforts and timely detection, assessment and removal are critical for intercepting rats and keeping them from spreading. Early detection and removal is cost-effective -- far less expensive than costs associated with ongoing rodent control, repair of damaged property, and restoration of wildlife habitats.

Expected Participants:
Alaska & Pacific Coast harbormasters and port administrators, USCG, USDOI, NPS, FWS, USDA/APHIS, USDHS/CBP, BIA, DEC, DCCED, ADHSS/DPH/ES, DOT&PF, DPS/AWT, UA-SeaGrant, AML, local governments, Alaska Association of Harbors and Port Administrators, food/seafood industry, freight/transportation industry.

Other Potential Participants/Observers:
North Pacific Fisheries Management Council (NPFMC), USDHHS/CDC, ADF&G/CF, veterinarians, Alaska Conservation Alliance

Strategic Actions:

- Develop easy-to-follow site-specific rodent response and control plans for likely rodent entry and transfer points within a community, industry, or operation.
- Determine which agency or entity will be lead for responding to local sightings, sign, or reports of rats.
- Get citizens and employees involved in conducting presence/absence surveys or more detailed assessments, e.g., annually or semi-annually, and reporting results to authorities.
- Conduct periodic *ongoing* detection efforts in:
  - Vessels operating, or expected to operate in, or transit adjacent to, Alaska waters
  - Ports, rail yards, and freight transit areas
  - U.S. and Canadian Customs check-stations
  - Coastal national wildlife refuges and national parks

  - Coastal state special areas and selected coastal state parks, particularly if containing wildlife-rich islands or located near transportation hubs
  - Communities, especially near port/harbor, airport, landfill, waste transfer stations, cargo-handling and food processing facilities
  - Communities nearest the Alaska/Canada (British Columbia) border
- On an incident-by-incident basis, move rapidly to conduct assessment and removal efforts, and report to designated authorities, for:
  - Any location or where in which the presence of unrestrained rats has been confirmed
  - Cases of likely or reported shipboard infestations, e.g., processing ships near islands, especially rat-free islands
- Include rat presence/signs in training for Alaska fishery observer programs to identify rat-free vessels and raise awareness for vessel owners.

7.5.5 Wildlife and Habitat Restoration

Activities in this category focus on assessing and restoring wildlife and habitats that are indigenous to a particular area of Alaska. The primary objective is to conduct, or gather information needed to conduct, actions that will help restore wildlife resources that are being damaged by nonnative rodents, especially rats, and protect other resources not yet affected. A key consideration in implementing rodent removal and ecosystem restoration efforts is to include individuals on the team who have relevant prior experience; this approach will help to expand capacity across organizations and geographic locations.

Expected Participants:
Pacific Seabird Group, national and international NGOs, NPS, USDOI, FWS, USFS, USDA/APHIS, USGS/BRD, NMFS, ADF&G/WC, DNR

Other Potential Participants/Observers:
EPA, USDOD, BOG, tourism industry, Alaska Conservation Alliance, educational institutions

The information gathered through research efforts will help inform decision-makers about threats to Alaska's wildlife, industries and citizens. It will also guide and modify any large-scale eradication efforts. In the nearer term, conducting Alaska-specific research should improve the ability of responders to contain and eliminate rats escaping during a ship grounding, or eradicate or control a newly discovered local infestation hub. Important research needs include the following:

Strategic Actions:
- Conduct rodenticide bait tests to study the susceptibility of Norway and roof rats to broadcast bait.
- Conduct pre- and post-removal monitoring and research to determine effects on rat-degraded ecosystems; quantitative methods should be used rather than the presence or absence of species of interest.
- Evaluate the response of native plants and animals to rodent removal.
  - Conduct pre- and post-eradication surveys for nesting birds, invertebrates, plants, and native small mammals.

    - Conduct surveys for nesting birds, invertebrates, and plants on selected islands with and without rats.
- Quantify risks to nontarget species such as seed-eating or predatory bird species, and other components of the terrestrial and marine ecosystem.
- Evaluate and recommend potential mitigation measures, including any needed to best protect consumptive wildlife users; examples might include scheduling rodent removal efforts to not overlap or precede wildlife harvest periods.
- Inventory islands for presence/absence of invasive rodents and determine to which islands, across what distances, and by what means, the rodents dispersed on their own from adjacent infested islands.
- As appropriate, conduct interdisciplinary ecosystem studies to identify whether rat-caused species and habitat changes adversely affect productivity of nearshore marine waters and, in turn, human uses of species using those waters.
- Conduct an assessment that examines the economic and other costs of long-term rodent control, e.g., by habitat type and/or remoteness, and the risks of developing bait resistance, versus the costs of large-scale one-time eradications and follow-up prevention efforts.
- Study rat ecology in Alaska (e.g., food habits, seasonal habitat use, correlation of rat density/productivity with various environmental conditions, and typical invasion behavior upon arrival).
- Study how a changing climate improves conditions for survival of rodents, e.g., increasing range and abundance of pioneering rodent species and populations in northern latitudes.
- Determine the extent of infestation, and habitat types used by rats and house mice in Southeast Alaska, Prince William Sound, and Kodiak, what they use as prey, and the degree of damage they are causing to wildlife and wildlife habitats.

Removal and Restoration Efforts

- Undertake area-wide eradications to eliminate rats that could breed additional sources of infestation.
- Secure authorization, funding and other resources needed to begin a major removal/restoration program for rat-degraded islands of the AMNWR; involve other land managers so they are trained in planning and response and are prepared to act quickly if and when rat infestations occur on their lands.

8.0 Implementing the Statewide Plan

The preceding chapters lay out goals, objectives and strategic action options designed to help protect Alaska from invasive rodents and assist in reaching the ultimate goal--to return as much of the state as possible to its original rat-free condition, and develop the commitment, resources, and expanded partnerships needed to keep it that way. Although some of the actions outlined in the plan have already begun, much more needs to be done.

The momentum for undertaking activities identified in the plan will come in part through public outreach efforts – i.e., raising awareness about the threats that rats pose. Scheduling meetings among interested cooperators should begin at once. ADF&G plans to facilitate some of these initial meetings. Meanwhile, funding sources will need to be secured with which to conduct needed activities.

This plan is focused on needed statewide coordination efforts. However, much information was gathered during the course of the planning effort that may be useful to local governments and organizations seeking to protect their communities. A number of the appendices to this report provide detailed information and guidance that may be useful to Alaskans who seek to address the rat problem. General information on planning and conducting successful rodent prevention, eradication and control efforts can be found in Appendix H. This appendix presents material in a manner designed to help facilitate "step-down" planning – i.e., creation of local-level documents focusing on issues and situations common to a locality (e.g., a region or community) or to specific stakeholder groups.

Reporting to the public on local and statewide success in Alaska's coming rodent management efforts will be very important. Some of this reporting will undoubtedly occur through efforts of AKRAT and postings to the multi-organization outreach and education website StopRats.org.

A key follow-up step will be to ensure that updates are made to the plan as needed. For example, publicizing successes, up-to-date maps, and new techniques will all foster more effective coordination. Updating the plan and related web postings will be an essential responsibility and valuable contribution of the statewide rodent action team.

Initially the plan will be posted to ADF&G's invasive species website[23] for use by interested parties. It is likely that at least parts of it will also be cross-referenced or posted to other organizations' websites. We encourage other entities to link to chapters their constituents will find useful. The more people know about invasive rodents, their effects, and treatment methods, the greater the likelihood of success in achieving a positive outcome for Alaska, its people, and its wildlife over the long term.

[23] http://www.adfg.state.ak.us/special/invasive/invasive.php

9.0 Acknowledgments

Development of this statewide invasive rodent plan was funded in part by the U.S. Fish and Wildlife Service (FWS) Alaska Coastal Conservation Grant program. Disbursed through the Service's Alaska Coastal Program, these grants support projects that advance the program's mission to conserve healthy coastal ecosystems for the benefit of fish, wildlife, and people. Projects are selected for funding on the basis of their ability to protect coastal resources, provide information which will lead to significant future gains in resource conservation, contribute pertinent information and outreach, and/or restore damaged fish and wildlife habitats in coastal Alaska. None of the statements or recommendations made in this report should be considered to constitute a statement of Service policy or as representing the Service's official position. Funds for various Alaska Department of Fish and Game management activities described here were provided by the USDOC/NOAA, via a multi-year grant provided under the National Invasive Species Act of 1996 for implementation of state or interstate invasive species management plans.

A large number of people contributed ideas and information to this project. Although there are too many people to list, I am grateful to each organization and individual that provided materials, reviewed drafts, or offered comments and ideas. Many of these entities are part of the Rat Outreach Group and the network it represents (see member list at www.stoprats.org). Also participating were the Pacific Seabird Group, Alaska Department of Health and Human Services, Animal and Plant Health Inspection Service of the U.S. Department of Agriculture, U.S. Coast Guard, U.S. Customs and Border Protection, Municipality of Anchorage, University of Alaska, the Alaska Board of Game, U.S. Geological Survey, and others.

ADF&G biologists Joe Meehan and Bob Piorkowski, together with leaders and staff of the FWS Alaska Regional Office and Alaska Maritime National Wildlife Refuge were instrumental in starting this statewide rodent planning effort. They secured initial funding and helped guide early phases of plan development. I would especially like to thank FWS Invasive Species Coordinator Denny Lassuy, and AMNWR staff members Art Sowls, Poppy Benson, and Steve Ebbert for their expertise and enthusiasm throughout the project. ADF&G Publications Specialist Patti Harper provided much-appreciated editing help.

Finally, I am indebted to the many scientists who assisted the effort by sharing results of their research, some of it unpublished. Participants at an international "Rats, Humans & Islands" conference held March 27-31, 2007 in Hawaii offered important insights. Also, several present or former employees of FWS, APHIS, and USGS shared observations from their work in Alaska and provided valuable reviews of this document.

To one and all, thank you: The energy, expertise and ideas you contributed will aid in developing long-term programs to protect human interests and wildlife resources from the threat of nonnative rodent infestations in Alaska.

10.0 Photo and Figure Credits

Figure 1. Illustration by Ram Papish, U.S. Fish and Wildlife Service (FWS)
Figure 2. From P.G. Koehler and W. H. Kern, Jr. 2005, Rat and Mouse Control, University of Florida, Institute of Food and Agricultural Sciences (Koehler and Kern, UF/IAS)
Figure 3. FWS
Figure 4. David Mudge; Courtesy New Zealand Department of Conservation
Figure 5. Copyright Phil Myers.
Figure 6. Photos courtesy FWS
Figure 7. FWS
Figure 8. Copyright Ian Jones
Figure 9. ADF&G
Figure 10. FWS
Figure 11. FWS
Figure 12. Shane T. Feirer; Courtesy The Nature Conservancy
Figure 13. Steve Ebbert, FWS
Figure 14. FWS
Figure 15. Art Sowls, FWS

Credits for Figures in Appendices

Figure C-1. Norway rat (Photo by Dr. Antonio J. Ferreira © California Academy of Sciences).
Figure C-2. Home range of Norway and roof rats; courtesy IDPH

Figure H-1. Cathy Rezabeck, FWS
Figure H-2. Illinois Department of Public Health (IDPH)
Figure H-3. From Timm 1994 (see References)
Figure H-4. From P.G. Koehler and W. H. Kern, Jr. 2005, Rat and Mouse Control, University of Florida, Institute of Food and Agricultural Sciences (Koehler and Kern, UF/IAS)
Figure H-5. Koehler and Kern, UF/IAS
Figure H-6. Koehler and Kern, UF/IAS
Figure H-7. Koehler and Kern, UF/IAS
Figure H-8. Courtesy Extension website, at www.extension.org, at Norway Rats
Figure H-9. Koehler and Kern, UF/IAS
Figure H-10. Art Sowls, FWS
Figure H-11. IDPH
Figure H-12. IDPH
Figure H-13. IDPH
Figure H-14. Koehler and Kern, UF/IAS
Figure H-15. Koehler and Kern, UF/IAS
Figure H-16. Koehler and Kern, UF/IAS

11.0 Glossary

alien species: means, with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem.

anticoagulant rodenticide: a slow-acting chronic toxicant that prevents coagulation, especially of blood

biota: the animals, plants, fungi, etc., of a region or period

biodiversity: the variety of life forms, the ecological roles they perform, and the genetic diversity they contain

clutch size: numbers of eggs laid per reproductive attempt

continental drift: gradual shifting of the Earth's crustal plates over the course of geologic time

control: means, as appropriate, eradicating, suppressing, reducing, or managing invasive species populations, preventing spread of invasive species from areas where they are present, and taking steps such as restoration of native species and habitats to reduce the effects of invasive species and to prevent further invasions.

Cricetidae: a family of the order Rodentia including hamsters, voles, and some mice

ecosystem: means the complex of a community of organisms and its environment.

endemic: a species that is restricted to, or native to, a particular area or region. Because of their limited geographic range, they are often, but not always, vulnerable to extinction.

extirpated: to be removed or destroyed totally; done away with; exterminated or eradicated; includes the aspect of being 'effectively' extirpated by having a very low remaining population.

feral: existing in an untamed state, or having returned to a wild state from domestication.

harborage: place(s) of shelter

introduction: the intentional or unintentional escape, release, dissemination, or placement of a species into an ecosystem as a result of human activity.

invasive species: an alien or nonnative species whose introduction does or is likely to cause economic or environmental harm or harm to human health.

Murid rodent or Muridae rodent: a rodent of the family Muridae, which includes true mice and rats, gerbils, and their relatives.

native species: with respect to a particular ecosystem, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem.

nonnative species: with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem

pesticide: any substance, chemical, or biological agent intended to kill, prevent, control, destroy, mitigate or repel a pest.

pet trade: the business of buying and selling animals for people to keep in or around their homes as pets or for pet food.

pinniped: any of a suborder of aquatic carnivorous mammals with all four limbs modified into flippers; includes seals, sea lions, and walruses.

prey: an animal hunted or seized for food, especially by a carnivorous animal; to seize and devour prey, as an animal does (usually followed by *on* or *upon*)

quarantine: a restraint upon the activities or communication of persons or the transport of goods designed to prevent the spread of disease or pests.

rat spill: an unplanned onshore arrival of rats, e.g., where rats disembark from a docked or grounded vessel or swim to shore from a ship that has foundered or gone aground in nearshore waters.

speciation: the process of a species evolving into different subspecies

species: a group of organisms all of which have a high degree of physical and genetic similarity, generally interbreed only among themselves, and show persistent differences from members of allied groups of organisms.

stack: a large, usually conical, circular, or rectangular pile of rock

taxa: plural of taxon, a taxonomic category such as family, genus or species.

12.0 Acronyms

ADF&G – Alaska Department of Fish and Game
ADF&G/CF - Alaska Department of Fish and Game, Commercial Fisheries Division
ADF&G/CO - Alaska Department of Fish and Game, Commissioner's Office
ADF&G/S - Alaska Department of Fish and Game, Subsistence Division
ADF&G/WC - Alaska Department of Fish and Game, Wildlife Conservation Division

ADHSS/DPH/ES – Alaska Department of Health and Social Services/Division of Public Health/Epidemiology Section
AISWG – Alaska Invasive Species Working Group
AKRAT – Alaska Rodent Action Team
AMNWR – FWS, Alaska Maritime National Wildlife Refuge
AO – Anchorage Ordinance
APHIS – USDA, Animal and Plant Health Inspection Service
A/PIA – Aleutian Pribilof Islands Association
AWT – Alaska Department of Public Safety, Alaska Wildlife Troopers
BIA – U.S. Department of the Interior, Bureau of Indian Affairs
BRD – USGS, Biological Resources Discipline
CBP – U.S. Department of Homeland Security, Customs and Border Protection
CCP – Comprehensive conservation plan
CDC – U.S. Department of Health and Human Services/Centers for Disease Control and Prevention
CF – Alaska Department of Fish and Game, Commercial Fisheries Division
CFEC – Alaska Commercial Fisheries Entry Commission
CFR – Code of Federal Regulations
CWCS – Comprehensive Wildlife Conservation Strategy
DCCED – Alaska Department of Commerce, Community and Economic Development
DEC – Alaska Department of Environmental Conservation
DGMQ - Centers for Disease Control, Division of Global Migration and Quarantine
DHHS – Municipality of Anchorage, Department of Health and Human Services
DNA - Deoxyribonucleic acid
DNR – Alaska Department of Natural Resources
DOC – New Zealand, Department of Conservation
DOT& PF – Alaska Department of Transportation and Public Facilities
DPH - Alaska Department of Health and Social Services, Division of Public Health
EA – Environmental Assessment
EPA – U.S. Environmental Protection Agency
ES - Alaska Department of Health and Social Services/Division of Public Health/Epidemiology Section
FAA – U.S. Department of Transportation, Federal Aviation Administration
FIFRA – Federal Insecticide, Fungicide and Rodenticide Act
FOSC – Federal On-scene Coordinator
FSIS - U.S. Department of Agriculture/ Food Safety and Inspection Service
FWS – U. S. Department of the Interior, U. S. Fish and Wildlife Service
GCR - Great Circle Route

GIS – Geographic information system
HACCP – Hazard Analysis and Critical Control Points
HAZWOPER – The U.S. Occupational Safety and Health Administration's "Hazardous Waste Operations and Emergency Response" Standard
IDPH – Illinois Department of Public Health
IHR – International health regulation
IPM – Integrated pest management
IUCN - International Union for Conservation of Nature and Natural Resources
MARAD – U.S. Department of Transportation, Maritime Division
NEPA - National Environmental Policy Act
NGO - nongovernmental organization
NMFS - National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
NPFMC – North Pacific Fisheries Management Council
NPS – National Park Service
OPMP - Alaska Department of Natural Resources, Office of Project Management and Permitting
PBS – Public Broadcasting System
SF – Alaska Department of Fish and Game, Sport Fish Division
SIBAP – New Zealand's Southern Islands Biodiversity Action Plan
SLN – Special Local Need (a designation under FIFRA)
SRP – Shipwreck Response Plan
SSP – Shipping Safety Partnership
TNC – The Nature Conservancy
UA – University of Alaska
UAA –University of Alaska Anchorage
UAF – University of Alaska Fairbanks
UA-SeaGrant – Alaska Sea Grant Marine Advisory Program
UF/IAS – University of Florida, Institute of Food and Agricultural Science
USCG – U. S. Coast Guard
USDA – U. S. Department of Agriculture
USDHHS – U.S. Department of Health and Human Services
USDHS – U.S. Department of Homeland Security
USDOC – U.S. Department of Commerce
USDOD – U.S. Department of Defense
USDOI – U.S. Department of the Interior
USDOT - U.S. Department of Transportation
USFS – U.S. Forest Service
USGS – U.S. Geological Survey
USGS/BRD – U.S. Geological Survey, Biological Resources Discipline
USPHS – U.S. Public Health Service
WC - Alaska Department of Fish and Game, Wildlife Conservation Division
WWF – World Wildlife Fund
WWII – World War II

13.0 References

Alaska Department of Fish and Game. 2002. Aquatic Nuisance Species Management Plan. Alaska Department of Fish and Game. Juneau, AK. 103 p.

Alaska Department of Fish and Game. 2006. Our wealth maintained: A strategy for conserving Alaska's diverse wildlife and fish resources. Alaska Department of Fish and Game, Juneau, Alaska. xviii+824 p. (http://www.sf.adfg.state.ak.us/statewide/ngplan/)

Alaska Department of Transportation, Ted Stevens Anchorage International Airport, Airport Overview, PowerPoint Presentation, online at http://dot.alaska.gov/anc/business communityRelations/presentations/06nov14AirportOverview.pdf. Accessed 8/30/07

Alaska Shorebird Working Group. 2004. Summaries of ongoing or new studies of Alaskan shorebirds during 2004. Compiled and edited by R.E. Gill, Jr.

Anchorage Daily News. 1962. Navy reports new volcano in islands: January 30, 1962. Anchorage Daily News, v. 14, n. 227, p. 1. Anchorage Alaska.

Animal and Plant Health Inspection Service (APHIS). 2006. Strategic Plan 2003-2008. U.S. Department of Agriculture. 13 pp. Accessed at http://www.aphis.usda.gov/about_aphis/downloads/APHIS_StrategicPlan-Feb2006.pdf

Animal Welfare Institute. 2005. Endangered Species Handbook. Online publication. Washington, D.C. Accessed at http://www.endangeredspecieshandbook.org/ dinos_bird.php 8/30/07.

Arctic Climate Impact Assessment. 2005. Arctic Climate Impact Assessment. Cambridge University Press, 1042 p. (http://www.acia.uaf.edu)

Atkinson, I.A.E. 1985. The spread of commensal species of *Rattus* to oceanic islands and their effect on island avifaunas. International Council for Bird Preservation, Technical Publication 3. p. 35-81.

Bailey, E.P. 1993. Fox introductions on Alaskan islands -- History, impacts on avifauna, and eradication. USDI US Fish and Wildlife Service Resource Publication 193. 53 pp.

Baker, R., G. Bodman and R. Timm. 1994. Rodent-proof construction and exclusion methods. Pages B-137 - B-150 in: S. Hygnstrom, R. Timm and G. Larson, eds. Prevention and control of wildlife damage. University of Nebraska Cooperative Extension Service, Lincoln (see http://hgic.clemson.edu/pdf/pcwdrodent_proof_construct.pdf).

Barnes, A. 1982. Surveillance and control of bubonic plague in the United States. Symp. Zool. Soc. London. 50: 237-270.

Baxter, C.V., K.D. Fausch, M. Murakami, and P.L. Chapman. 2004. Fish invasion restructures stream and forest food webs by interrupting reciprocal prey subsidies. Ecology 85(10): 2656-2663.

Beaven, B. M., R. Burns, A. Harrison, and P. Shaw (Eds.). 2000. Northern Te Urewera Ecosystem Restoration Project, Te Urewera National Park: Annual Report July 1998 – June 1999.

Boice, R. 1977. Burrows of wild and albino rats: effects of domestication, outdoor raising, age, experience, and maternal state. J Comp Physiol Psychol. 91(3):649-61

Bomford, M and P. O'Brien. 1995. Eradication or control for vertebrate pests? Wildlife Society Bulletin 23:249-255.

Bourne, J.B. 2001. Norway rat exclusion in Alberta (See http://www1.agric.gov.ab.ca/$department/ deptdocs.nsf/all/prm2579

Bradt, G.W. 1949. Farm cat as predator. Michigan Conservation 18(4):23-25.

Breckbill, R.A. 1977. Status of Norway rat. Pages 261-267 in M.L. Merritt and R.G. Fuller, eds. The environment of Amchitka Island, Alaska. Technical Information Center, Energy Research and Development Admin. Oak Ridge, TN.

Brooks, Joe E. 1994. Bionomics and Management of Commensal Rodents. U.S. Department of Agriculture/ APHIS/Animal Damage Control. Denver Wildlife Research Center, Denver, CO. 100 pp.

Brooymans, H. 2007. "Shotgun restores province's rat-free reputation: Vermin shaken from hay bales and shot after infestation near Sibbald." The Edmonton Journal. June 6, 2007.

Brown, K.P. and G.H. Sherley. 2002. The eradication of possums from Kapiti Island, New Zealand. In: *Turning the Tide: The Eradication of Invasive Species.* C.R. Veitch and M.N. Clout, Eds. IUCN Invasive Species Specialist Group, Gland, Switzerland and Cambridge,UK. p. 46-52.

Buckelew, S., G. Howald, S. MacLean, and S. Ebbert. 2007. Progress in restoration of the Aleutian Islands: Trial rat eradication, Bay of Islands, Adak, Alaska, 2006. Report to the U.S Environmental Protection Agency and U.S. Fish and Wildlife Service.

Bureau of Transportation Statistics. Ted Stevens Anchorage International Airport, Alaska—Air Freight Gateway. On the Web at http://www.bts.gov/publications/americas_freight_transportation_gateways/highlights_of_top_25_freight_gateways_by_shipment_value/anchorage/. Accessed 8/30/07.

Byrd, G.V., H.M. Renner, and M. Renner. 2005. Distribution patterns and populations trends of breeding seabirds in the Aleutian Islands. Fisheries Oceanography 4(1):139-159.

Campbell, Senator, the Hon. Ian. 2006. Media Release: You dirty rat! Protecting Australian wildlife from exotic rats. Online at http://www.environment.gov.au/minister/env/2006/mr28mar06.html. Accessed 30 August 2007.

Ceballos, G. and Brown, J.H. 1995. Global patterns of mammalian diversity, endemism, and endangerment. *Conservation Biology* 9:559-568.

Churcher, P.B. and J.H. Lawton. 1987. Predation by domestic cats in an English village. Journal of Zoology, London 212:439-455.

Coblenz, B.E. 1990. Exotic organisms: A dilemma for conservation biology. Conservation Biology. 4(3):261-265.

Colby, N. A. Bonham. 2005. New Cargo Agreement Increases Cargo Traffic in Alaska. Alaska Business Monthly, May 2005 issue.

Coleman, J.S. and S.A. Temple. 1996. On the prowl. Wisconsin Natural Resources 20(6):4-8.

Courchamp, F., J-L. Chapuis, and M. Pascal. 2003. Mammal invaders on islands: impacts, control, and control impact. Biol. Rev. 78:347-383.

Croll, D.A, J.L. Maron, J.A. Estes, E.M. Danner and G.V. Byrd. 2005. Introduced predators transform subarctic islands from grassland to tundra. Science. 307:1959-1961.

Cromarty, P.L., K.G. Broome, A. Cox, R.A. Empson, W.M. Hutchison, and I. McFadden. 2002. Eradication planning for invasive alien animal species on islands – the approach developed by the New Zealand Department of Conservation. In: *Turning the tide: the eradication of invasive species.* C.R. Veitch and M.N. Clout, eds. IUCN Invasive Species Specialist Group, Gland, Switzerland and Cambridge, UK. Pp. 85-91. (see http://issg.appfa.auckland.ac.nz/database/species/reference_files/TURTID/Cromarty.pdf)

Diamond, J. 1989. Overview of recent extinctions. In: *Conservation for the Twenty-first Century*, D. Western and M.C. Pearl, Eds. Oxford University Press, London. p. 37-41.

Donlan, C.J., B.R. Tershy, and D.A. Croll. 2002. Islands and introduced herbivores: conservation action as ecosystem experimentation. Journal of Applied Ecology 39:235-246.

Dunlevy, P. and L. Scharf. 2007a. Biology of Norway rats (*Rattus norvegicus*) in the Aleutian Islands, Adak Island, Alaska. Report to the U.S. Fish and Wildlife Service, Homer, AK. 39 pp.

Dunlevy, P. and L. Scharf. 2007b. Eradication of Norway rats using Ramik Breen in the Bay of Islands, Adak, Alaska. Report to the U.S. Fish and Wildlife Service, Homer, AK. 44 pp.

Ebbert, S.E. and G.V. Byrd. 2002. Eradications of invasive species to restore natural biological diversity on Alaska Maritime National Wildlife Refuge. pp. 102-109 *in* C. R. Veitch and M. N. Clout, eds. Turning the Tide: The Eradication of Invasive Species. IUCN SSC Invasive Species Specialist Group. IUCN. Gland, Switzerland and Cambridge, United Kingdom.

Eberhard, T. 1954. Food habits of Pennsylvania house cats. Journal of Wildlife Management 18:284–286.

Erickson, E. and D. Urban. 2002. Potential risks of nine rodenticides to birds and mammals: A comparative approach. US Environmental Protection Agency, Office of Prevention, Pesticides, and Toxic Substances. 153 pp.

Federal Aviation Adminstration. 2006. Civil Airmen Statistics. Online at http://www.faa.gov/data_statistics/aviation_data_statistics/civil_airmen_statistics/2006/. Accessed 30 August 2007.

Fitzgerald, B.M. 1988. Diet of domestic cats and their impact on prey populations. In: D.C. Turner and P. Bateson, editors. The domestic cat: the biology of its behaviour. Cambridge University Press, Cambridge. p. 123–147.

Frantz, S.C. and D.E. Davis. 1991. Bionomics and integrated pest management of commensal rodents, pp. 243-313. In: Gorman, J.R. ed. Ecology and Management of Food-Industry Pests. Association of Official Analytical Chemists, Arlington, VA.

Galapagos Conservancy. 2006 Press Release announcing Project Isabela's completion. At http://www.galapagos.org/pdf/ProjectIsabelaPR07-06-2006.pdf. Accessed 30 August 2007

Genovesi, P. 2005. Eradications of invasive alien species in Europe: a review. Biological Invasions 7:127-133.

Gibson, D.D. and G.V. Byrd. Birds of the Aleutian Islands, Alaska. Ornithological Monographs, *in press*.

Gosling, M. 1989. Extinction to order. New Scientist 121: 44-49.

Gould, P.J., D.J. Forsell, and C.J. Lensink. 1982. Pelagic distribution and abundance of seabirds in the Gulf of Alaska and eastern Bering Sea. U.S. Fish and Wildlife Service FWS/OBS-82/48. 294 pp (cited in Hatch and Piatt at http://biology.usgs.gov/s+t/noframe/b023.htm).

Groombridge, B. 1992. Global Biodiversity: Status of the Earth's Living Resources: a Report. London, UK: Chapman & Hall.

Hanson, Anne. 2006. History of the Norway rat (Rattus norvegicus) Rat behavior and biology. 7 Dec. 2006. Online at http://www.ratbehavior.org/history.htm. Accessed 30 August 2007.

Harper, G.A. 2005. Heavy rimu (*Dacrydium cupressinum*) mast seeding and rat (*Rattus* spp.) population eruptions on Stewart Island/Rakiura. New Zealand Journal of Zoology 35:155-162.

Hatch, S.A. and J.F. Piatt. 1995. Seabirds in Alaska. Pages 49-52 in E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, eds., Our living resources. U.S. Dept. Interior, National Biological Service, Wash. D.C. 530 pp.

Honnegger, R.E. 1981. List of amphibians and reptiles either known or thought to have become extinct since 1600. *Biological Conservation* 19:141-158.

Howald, G., C. Donlan, J. Galvan, J. Russell, J. Parkes, A. Samaniego, Y. Wang, D. Veitch, P. Genovesi, M. Pascal, A. Saunders and B. Tershy. 2007. Invasive rodent eradication on islands. Conservation Biology 21(5): 1258-1268.

Hughes, N.F. 1986. Changes in the feeding biology of the Nile perch (*Lates nilotica* L.)(Pisces: Centropgomidae) in Lake Victoria, East Africa, since its introduction in 1960, and its impact on the native fish community of the Nyanza Gulf. Journal of Fish Biology 29:541-548.

Hunt, Terry L. 2006. Rethinking the Fall of Easter Island. American Scientist Online, September-October 2006 issue, at http://www.americanscientist.org/template/AssetDetail/assetid/53200/page/1, Accessed 30 August 2007.

Hygnstrom, Scott E., Robert M. Timm, Gary E. Larson. 1994. Prevention and Control of Wildlife Damage. University of Nebraska-Lincoln. 2 vols. Accessed on the website of the Internet Center for Wildlife Damage Management at http://icwdm.org/handbook /allPDF/RO_B105.PDF.

Illinois Department of Public Heatlth. Prevention & Control: Municipal Rodent Management webpage at http://www.idph.state.il.us/envhealth/pcmunicipal_rodents.htm. Accessed 30 August 2007.

Innes, J. 1990. Family Muridae: *Handbook of New Zealand Mammals*. Oxford University Press, Oxford. P.206-225.

Innes, J., R. Hay, I. Flux, P. Bradfield, H. Speed, and P. Jansen. 1998. Successful recovery of North Island kokako *Callaeas cinerea wilsoni* populations, by adaptive management. Biological Conservation 87:201-214.

Island Conservation. 2005. Progress in Palmyra Atoll Restoration: Rat Eradication Trial 2005. 46 pp.

Island Conservation. 2006. Evaluation of Primary and Secondary Exposure Risks to Land Bird Species for: Experimental Use Permit Application for Field Efficacy Trial of 0.0025% Brodifacoum Broadcast Bait to Eradicate Introduced Rats from Aleutian Islands in the Alaska Maritime National Wildlife Refuge, July 20, 2006. Island Conservation, Center for Ocean Health, 100 Shaffer Rd, Santa Cruz, CA 95060.17 pp)

IUCN. Invasive Species Specialist Group of the Species Survival Commission of the World Conservation Union (IUCN). 100 OF THE WORLD'S WORST INVASIVE ALIEN SPECIES: A SELECTION FROM THE GLOBAL INVASIVE SPECIES DATABASE (http://app.iucn.org/biodiversityday/booklettext.doc)

Jackson, W.B. 1982. Norway rat and allies. In: *Wild Mammals of North America.* J.A. Chapman and G.A. Feldhamer, Eds. Johns Hopkins University Press, Baltimore. p. 1077-1088.

Jenkins, R. 2007. Explosion that killed woman was caused by rats gnawing gas pipes. TimesOnline. London, England. Published 8/9/07. Online at 1 http://www.timesonline.co.uk/tol/news/uk/article2225244.ece. Accessed 8/29/07)

Jouventin, P., J. Bried, and T. Micol. 2003. Insular bird populations can be saved from rats: a long-term experimental study of white chinned petrels *Procellaria aequinoctialis* on Ile de la Possesion (Crozet Archipelago). Polar Biology 26:371-378.

Juneau Empire. 2003. "Rats decimate seabird colony: vermin are eating auklets nesting at Kiska Island on the Aleutian Chain," web posted July 14, 2003).

King, W. 1985. Island birds: will the future repeat the past? In *Conservation of Island Birds: Case Studies for the Management of Threatened Island Birds* (ed. P.J. Moors), pp. 3-16. International Council for Bird Preservation, Cambridge UK.

King, C.M. 1990. Ship Rat. In: *The Handbook of New Zealand Mammals*. Oxford University Press, Auckland. p.206-225.

Koehler, P.B., and W. H. Kern, Jr. 2005. Rat and Mouse Control. Entomology and Nematology Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, Universityof Florida. Online at: http://edis.ifas.ufl.edu/BODY_DH044#FOOTNOTE_2

Kurle, C.M. 2005. Description of the rocky intertidal communities and Norway rat behavior on Rat Island, Alaska in 2003. US Fish and Wildlife Service Report AMNWR 05/23. Homer, Alaska. 21 pp.

Krajick, K. 2005. Winning the War Against Island Invaders. *Science* Vol. 310, pp 1410-1413 (as seen at http://www.sciencemag.org.)

LeRoux, V., J. Chapuis, Y. Frenot and P. Vernon. 2002. Diet of the house mouse on Guoillou Island, Kerguelen Archipelago. Polar Biology 25:49-57.

Major, H.L. 2004. M.S. Thesis. Impacts of introduded Norway rats (Rattus norvegicus) on least auklets (Aethia pusilla) breeding at Kiska Island, Aleutian Islands, Alaska during 2001-2003. Department of Biology, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador, Canada. 127 pp.

Major, H.L. and I.L. Jones. 2002. Impacts of the Norway rat on the auklet breeding colony at Sirius Point, Kiska Island, Alaska in 2002. Unpublished report. Department of Biology, Memorial University of Newfoundland. 27 pp.

Makinen, G. 2002. Report for Congress: The Economic Effects of 9/11: A Retrospective Assessment. Congressional Research Service, The Library of Congress, online at http://www.fas.org/irp/crs/RL31617.pdf. Accessed 30 August 2007

Maron, J.L., J.A. Estes, D.A. Croll, E.M. Danner, S.C. Elmendorf, and S.L. Buckelew. 2006. An introduced predator alters Aleutian Island plant communities by thwarting nutrient subsidies. Ecological Monographs 76(1):3-24.

McNeely, J. 2001. Invasive species: a costly catastrophe for native biodiversity. Land Use and Water Resources Research 1 (2002) 2, 1-10.

Meehan, A. 1984. Rats and mice: their biology and control. Rentokil Limited, East Grinstead, UK. Page 37.

Minckler J. and Pease F.D. 1938. A colony of albino rats existing under feral conditions. Science. 87: 460-461.

Mingchang, S., W. Baoling, L. Jianzhong, and G. Norman. 2003. Insect Vectors and Rodents Arriving in China Aboard International Transport. Journal of Travel Medicine 10 (4): 241–244.

Moors, P.J. and A.I.E. Atkinson. 1984. Status and Conservation of the World's Seabirds. Proceedings ICBP Seabird Conservation Symposium, Cambridge, England. August 1982. ICBN Technical Publication No. 2:667-690.

Moors, P.J., I.A.E. Atkinson, and G.H. Sherley. 1992. Reducing the rat threat to island birds. Bird Conservation International. Vol. 2:93-114.

Morris, K.D. 2002. Eradication of the black rat (*Rattus rattus*) on Barrow and adjacent islands on the northwest coast of western Australia. In: *Turning the Tide: The Eradication of Invasive Species.* C.R. Veitch and M.N. Clout, Eds. IUCN Invasive Species Specialist Group, Gland, Switzerland and Cambridge, UK. p. 64-70.

Mowbray, S.C. 2002. Eradication of introduced Australian marsupials (brushtail possum and brushtailed rock wallaby) from Rangitoto and Motutapu Islands, New Zealand. In: *Turning the Tide: The Eradication of Invasive Species.* C.R. Veitch and M.N. Clout, Eds. IUCN Invasive Species Specialist Group, Gland, Switzerland and Cambridge, UK. p. 226-232.

Myers, P. and D. Armitage. 2004. Rattus norvegicus. Online on Animal Diversity Web. At http://animaldiversity.ummz.umich.edu/site/accounts/information/Rattus_norvegicus.html. Accessed 30 August 2007.

NatureServe. 2007. NatureServe Explorer: An Online Encyclopedia of Life. NatureServe. Arlington, VA. http://www.natureserve.org/explorer/. Accessed 8/30/07.

New Zealand Department of Conservation. 2002. Southern Islands Biodiversity Action Plan (Vol.4). Southland Conservancy, Department of Conservation, Invercargill. (See http://www.doc.govt.nz/pdfs/southland/Publications/Bio-Action-Plan-Vol.4-complete.pdf)

Normile, D. 2004. Invasive species: expanding trade With China creates ecological backlash. Science. Vol. 306(5):968-969.

Nuka Research and Planning Group and Cape International. 2006. Vessel Traffic in the Aleutians Subarea. Updated Report to Alaska Department of Environmental Conservation (September 20, 2006). 54 pp.

Nysewander, D.R., P.A. Baird, D.J. Shields, G.J. Weiler, and J.H. Kogan. 1982. Marine bird and mammal survey of the eastern Aleutian Islands, summers of 1980-81. Unpublished Report US Fish and Wildlife Service, Anchorage, Alaska. In: US Fish and Wildlife Service. August 1988. *Maritime National Wildlife Refuge Final Comprehensive Plan, Wilderness Review and Environmental Impact Statement*. Anchorage, AK.

O'Harra, D. 2003. Forget smelling a rat – Southside residents are seeing plenty. Anchorage Daily News, October 1, 2003. Anchorage, AK.

O'Harra D. 2004. Rat patrol sniffs out pests before they can destroy Aleutian species. Anchorage Daily News. November 15, 2004. Anchorage, AK.

Pesznecker, K. 2007. "Anchorage airport rat pack down by two." Anchorage Daily News, published 2/1/07.

Pimental, D, L. Lach, R. Zuniga, and D. Morrison. 1999. Environmental and Economic Costs Associated with Non-Indigenous Species in the United States. Cornell University. Online at http://www.news.cornell.edu/releases/Jan99/species_costs.html, Accessed 30 August 2007.

Pimental, D., R. Zuniga, and D. Morrison. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52:273-288

PBS. 2001. Rat Threat in Alaska. *On* Harriman Expedition Retraced: A Century of Change Public Broadcasting System (PBS) program website, at http://www.pbs.org/harriman/1899/rats.html. Accessed 30 August 2007.

Rollins, L., A. Woolnough, and W. Sherwin. 2006. Population genetic tools for pest management: a review. Wildlife Research 33:251-261.

Russell, J.C. and M.N. Clout. 2005. *Rodent incursions on New Zealand islands*. In: Parkes, J.; Statham, M.; Edwards, G. (eds) Proceedings of the 13th Australasian Vertebrate Pest Conference. Landcare Research, Lincoln, pp. 324-330.

Russell, J.C. 2007. Invasion Biology and Genetics of Norway rats on New Zealand Islands. PhD Thesis.

Shipping Safety Partnership. 2006. Feb 10, 2006 letter from SSP to Senators Stevens and Inouye.

Smith, V., N. Avenant and S. Chown. 2002. The diet and impact of house mice on a sub-Antarctic island. Polar Biology 25:703-715.
Stem, C., R. Margoluis, N. Salafsky and M. Brown. 2005. Monitoring and evaluation in conservation: a review of trends and approaches. Conservation Biology 19:295-309.
US Fish and Wildlife Service. 1988. Alaska Maritime National Wildlife Refuge Final Comprehensive Plan, Wilderness Review and Environmental Impact Statement. Anchorage, AK.

Soule, M.E. 1990. The onslaught of alien species, and other challenges in the coming decades. Conservation Biology 4(3):233-239.

Sowls, A.L., S.A. Hatch, and C.J. Lensink. 1978. Catalog of Alaskan seabird colonies. U.S. Fish and Wildlife Service FWS/OBS-78/78. 254 pp. (cited in Hatch and Piatt, at http://biology.usgs.gov/s+t/noframe/b023.htm).

Stapp, P. 2002. Stable isotopes reveal evidence of predation by ship rats on seabirds on the Shiant Islands, Scotland. Journal of Applied Zoology 39:831-840.

Stoller, G. 2003. Despite law, fishermen face deadliest job risks. March 11, 2003. USA Today. Online at http://www.usatoday.com/money/industries/2003-03-11-fishing-safety_x.htm Accessed 30 August 2007

Svihla, A. 1936. The Occurrence of Albino and Spotted Rats Under Feral Conditions. *The American Naturalist*, Vol. 70, No. 729 (Jul. - Aug., 1936), pp. 403-404.

Thomas, B.W. and R.H. Taylor. 2002. A history of ground-based rodent eradication techniques developed in New Zealand, 1959-1993. In: *Turning the Tide: The Eradication of Invasive Species.* C.R. Veitch and M.N. Clout, Eds. IUCN Invasive Species Specialist Group, Gland, Switzerland and Cambridge, UK. p. 301-310. (see at http://issg.appfa.auckland.ac.nz/database/species/reference_files/TURTID/Thomas.pdf.)

Timm, R.M. 1994. Norway Rats. In Prevention and Control of Wildlife Damage. U.S. Department of Agriculture/APHIS/Animal Damage Control. University of Nebraska-Lincoln, Institute of Agriculture and Natural Resources, Cooperative Extension Division. Pp. B-105-B-120.

Timm, R. 2003. Devices for vertebrate pest control: are they of value? Proc. Vertebr. Pest Conf. 10:152-161.

Tomich, P. 1986. Mammals of Hawaii. 2nd Edition. Bishop Museum Press, Honolulu, HI.

Union of Concerned Scientists. 2003. Invasive Species Alaska. 16 pp. On the Web at http://www.ucsusa.org/assets/documents/invasive_species/Alaska_invasives_1.pdf. Accessed 10/8/07

Union of Concerned Scientists. 2005. Invasive Species; what are invasive species; invasive species basics (http://www.ucsusa.org/invasive_species/invasive-species-index.html (page last revised 8/25/05)

U.S. Department of the Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2007. 2006 National Survey of Fishing, Hunting and Wildlife-Associated Recreation. *State Overview*. 32pp.

U.S Department of Labor, Bureau of Labor Statistics. 2006. National Census of Fatal Occupational Injuries. 2006. Online at http://www.bls.gov/news.release/pdf/cfoi.pdf. Accessed 8/30/07

U.S. Fish and Wildlife Service. 1988. Alaska Maritime National Wildlife Refuge Final Comprehensive Plan, Wilderness Review and Environmental Impact Statement. Anchorage, AK. 660 pp.

U.S. Fish and Wildlife Service. 2005. FWS national oil spill contingency plan (revised). FWS, Division of Environmental Quality, Washington, D.C. 41 pp.

U.S. Fish and Wildlife Service. 2006. Restoration Planning on Islands in Alaska Maritime National Wildlife Refuge, Aleutian Islands Unit: Rat eradication field efficacy trial, Environmental Assessment. U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, Homer, AK. 67 pp.

Witmer, G. 2005. Field efficacy trial of 0.005% diphacinone broadcast bait to control introduced Norway rats on Kiska Island, Alaska. Unpublished Final Report, QA-1229. USDA/APHIS/WS National Wildlife Research Center, Fort Collins, CO. 20 pp.

Witmer, G., P. Burke, S. Jojola, and P. Dunlevy. 2006. The biology of introduced Norway rats on Kiska Island, Alaska, and an evaluation of an eradication approach. Northwest Science 80:191-198.

Witmer, G., F. Boyd and Z. Hillis-Starr. 2007a. The successful eradication of introduced roof rats from Buck Island using diphacinone, followed by an irruption of house mice. Wildlife Research 34:108-115.

Witmer, G., J. Eisemann and G. Howald. 2007b. The use of rodenticides for conservation efforts. Proc. Wildlife Damage management Conference 12:IN PRESS.

Wolfe, Robert. 2000. Subsistence in Alaska: A Year 2000 Update. Alaska Department of Fish and Game, Division of Subsistence. Juneau.

Woodford, R. 2005. Combating Invasive Rats in Alaska. Alaska Wildlife News. May 2005. Alaska Department of Fish and Game. Accessed at http://www.wildlifenews.alaska.gov/index.cfm?adfg=wildlife_news.view_articles&articles.

Zavaleta, E.S. 2002. It's often better to eradicate, but can we eradicate better? In: *Turning the Tide: The Eradication of Invasive Species.* C.R. Veitch and M.N. Clout, Eds. IUCN Invasive Species Specialist Group, Gland, Switzerland and Cambridge, UK. p. 393-404.

Zeillemaker, C.F. and J.L. Trapp. 1986. Changes in seabird populations on Alaid and Nizki Islands, Aleutian Islands, Alaska, following eradication of introduced foxes. Unpublished Report U.S. Fish and Wildlife Service, Alaska Maritime NWR, Adak, Alaska. In: U.S. Fish and Wildlife Service. August 1988. *Alaska Maritime National Wildlife Refuge Final Comprehensive Plan, Wilderness Review and Environmental Impact Statement*. Anchorage, AK.

Zigman, Leisa. 2006. Hidden Camera Video Shows Mice on Airplane. KSDK-TV News. 7/11/06. St. Louis Missouri.

14.0 List of Appendices

A. Removal of Foxes in Alaska

Beginning in the 1700s, Russian traders and, later, American traders stocked over 400 islands from Southeast Alaska to the Aleutians with Arctic (*Alopex lagopus*) and red foxes (*Vulpes vulpes*) for fur farming purposes. When the lucrative fur trade ended in the 1940s, many of the foxes at fur farms were released into the wild.

Besides rats, introduced nonnative mammals in Alaska have included cattle, reindeer, caribou, sheep, horses, foxes, and various types of nonindigenous prey for farmed foxes (e.g., Arctic ground squirrels, voles, hares, and marmots) (ADF&G 2006). The most widespread invasive mammal by far has been the fox.

By the start of World War II, over 400 islands, or nearly every island with beach access south of the Alaska Peninsula, in the Aleutian Islands, and throughout southcentral and southeastern Alaska was stocked with foxes, and foxes persisted on many islands after the fur trade collapsed in the 1940s (Bailey 1993). As a result, foxes were the most widespread invasive mammal on the Alaska Maritime National Wildlife Refuge (AMNWR) and, not surprisingly, Arctic and red foxes were the first invasive species targeted for eradication from AMNWR lands (Murie 1959, Bailey 1993, Ebbert and Byrd 2002).

The adverse effect of fox liberation on bird life was profound, especially in the Aleutians. For example, foxes pushed the endemic Aleutian cackling goose (*Branta hutchinsii leucopareia*) to the brink of extinction, with extinction avoided only through a captive breeding program conducted by the U.S. Fish and Wildlife Service (FWS). Foxes also decimated populations of burrow-nesting ancient murrelets (*Synthliboramphus antiquus*), Cassin's auklet (*Ptychoramphus aleuticus*), storm-petrels (*Oceanodrama* spp.), and puffins (*Fratercula* spp.), and probably numerous other seabirds and shorebirds, on many islands in the archipelago (FWS 1985, Bailey 1993).

Species casualties also included significant reductions in populations of some endemic land birds such as Evermann's rock ptarmigan (*Lagopus muta evermanni*). This is one four subspecies of rock ptarmigan that only occur on one or a few of the Aleutian Islands (Gibson and Byrd in press). It is also a species that does not readily become reestablished on isolated islands where it has been extirpated because of its relatively short flight capability over water.

Fox Eradication Efforts

Efforts to eliminate nonnative foxes and restore the natural diversity on AMNWR islands began in 1949 and expanded in the mid-1970s. Since the late 1980s, AMNWR has been removing foxes at a rate of one or two islands per year primarily by traps and shooting. Cyanide projectiles and appropriate toxic baits were used in some isolated cases. Introduced foxes remain on 5 AMNWR islands and several islands containing some AMNWR lands (S.E. Ebbert, FWS/AMNWR Wildlife Biologist, Pers. Comm., 2007). AMNWR fox eradication projects continue as scheduled.

Through its efforts, the FWS has brought about some spectacular successes and made some eye-opening discoveries. An example of the former, noted above and in plan Section 1.3.2, was the

eradication of foxes and reintroduction of the Aleutian cackling goose to its former nesting islands. The goose population grew from 300 to 30,000 individuals, allowing removal of the goose from the endangered species list in 2001. By 2005, this population had grown to 100,000 birds.

Numerous islands from which introduced foxes were removed have shown dramatic recovery of bird species of many types (seabirds, land birds, waterfowl) (Byrd et al. 1994). Where monitoring has occurred, it shows that removal of nonnative foxes has likely increased populations of 15 to 20 bird species on the AMNWR by more than 200,000 birds (Alaska Department of Fish and Game 2006). Progressing to the next step in island restoration, removal of rats from now fox-free islands is expected to further improve the chances for full recovery of native birds and other components of the native ecosystems.

Removing Other Mammals

In terms of discoveries, Section 2.2.6 of the plan noted results of studies showing how predation by foxes and rats indirectly alters food webs by changing vegetative communities. AMNWR scientists have also determined the large extent to which islands with introduced reindeer and cattle have experienced vegetation-related changes. Trampling by cattle was found to be doubly problematic because, in addition to reducing or eliminating vegetation in places and causing erosion, it also causes bird nesting burrows to collapse.

In the mid-1980s AMNWR removed wild cattle from several islands in the refuge and reindeer were removed from one AMNWR island in the early 1990s (Ebbert and Byrd 2002). However, hoofed animals remain on one island in the AMNWR and nine other islands that contain both private and refuge lands.

References Cited in Appendix A

Alaska Department of Fish and Game. 2006. Our wealth maintained: A strategy for conserving Alaska's diverse wildlife and fish resources. Alaska Department of Fish and Game, Juneau, Alaska. xviii+824 p. (http://www.sf.adfg.state.ak.us/statewide/ngplan/)

Bailey, E.P. 1993. Fox introductions on Alaskan islands -- History, impacts on avifauna, and eradication. USDI US Fish and Wildlife Service Resource Publication 193. 53 pp.

Byrd, G.V., J. L. Trapp, and C. Fred Zeillemaker. 1994. Removal of introduced foxes: a case study in restoration of native birds. Trans. 59th No. Am. Wildl. and Natur. Resour. Conf. 317-321.

Ebbert, S.E. and G.V. Byrd. 2002. Eradications of invasive species to restore natural biological diversity on Alaska Maritime National Wildlife Refuge. pp. 102-109 *in* C. R. Veitch and M. N. Clout, eds. Turning the Tide: The Eradication of Invasive Species. IUCN SSC Invasive Species Specialist Group. IUCN. Gland, Switzerland and Cambridge, United Kingdom.

Gibson, D.D. and G.V. Byrd. Birds of the Aleutian Islands, Alaska. Ornithological onographs, in press.

Murie, O.J. 1959. Fauna of the Aleutian Islands and Alaska Peninsula. U.S. Fish and Wildlife Service, North American Fauna No. 61.

U.S. Fish and Wildlife Service. April 1985. Environmental Assessment – Proposed Eradication of Introduced Fox on Alaskan Islands, Alaska Maritime National Wildlife Refuge, Alaska. Homer, Alaska. 34 pp.

B. Rodent Species of Alaska

(adapted from material submitted by S.O. MacDonald, 15 November 2006)

Note: Scientific names follow Wilson and Reeder (2005); footnotes indicate nonnative species.

RODENTIA - rodents

Sciuridae

Glaucomys sabrinus, northern flying squirrel
Marmota broweri, Alaska marmot
Marmota caligata, hoary marmot
Marmota monax, woodchuck
Spermophilus parryii, arctic ground squirrel
Tamiasciurus hudsonicus, red squirrel

Castoridae

Castor canadensis, American beaver

Dipodidae

Zapus hudsonius, meadow jumping mouse
Zapus princeps, western jumping mouse

Cricetidae

Dicrostonyx groenlandicus, northern collared lemming
Lemmus trimucronatus, brown lemming
Microtus abbreviatus, insular vole
Microtus longicaudus, long-tailed vole
Microtus miurus, singing vole
Microtus oeconomus, root vole
Microtus pennsylvanicus, meadow vole
Microtus xanthognathus, taiga vole
Myodes gapperi, southern red-backed vole
Myodes rutilus, northern red-backed vole
Neotoma cinerea, bushy-tailed woodrat
Ondatra zibethicus, common muskrat
Peromyscus keeni, northwestern deermouse
Peromyscus maniculatus, North American deermouse[1]
Phenacomys intermedius, western heather vole
Synaptomys borealis, northern bog lemming

Muridae

Mus musculus, house mouse[2]
Rattus norvegicus, brown rat[3]
Rattus rattus, roof rat[4]

Erethizontidae

Erethizon dorsatum, North American porcupine

---

[1]An introduced population of *Peromyscus maniculatus* was first discovered among buildings at the military base on Shemya Island, western Aleutians, in 1978. Mice were still present there in

2001 (samples to University of Alaska Museum) and possibly expanding their range beyond the immediate vicinity of the Base (D. Gibson, Pers. Comm. to S. MacDonald).

[2]Information on the distribution of *Mus musculus* in Alaska is nearly non-existent and preserved specimens are few. In southeast Alaska, C. P. Streator, in his notes to the U.S. Biological Survey from Juneau in August 1895, reported catching 3 house mice in the forest near town where they were common. Four specimens, dating from 1891 to 1946, are preserved from Wrangell and Sitka (California Academy of Sciences). Elsewhere in the state, there are reports from Anchorage, Eagle River, Chugiak, Palmer, Fairbanks, Kodiak Island and nearby Hog Island, Unalaska Island, and Kiska Island (University of Alaska Museum; National Museum of Natural History, Smithsonian Museum; Murie 1959, Peterson 1967, Bailey 1993). First recorded on St. Paul Island in 1872 (Manville and Young 1965), house mice there are currently restricted to the community area and dump (Ebbert and Byrd 2002).

[3]The status and distribution of the non-native *Rattus norvegicus* in Alaska remains poorly understood. See Appendix D for spreadsheets listing islands and communities with breeding populations of rats, and other sites having past reports of rats.

[4]This alien rodent has been reported from two locations in Alaska: Bell's Flat, a suburb of Kodiak (D. Zweifelhofer, FWS/Kodiak National Wildlife Refuge, Wildlife Biologist/Boat Operator, Pers. Comm. to B. Pyle, FWS/Kodiak NWR, Supervisory Wildlife Biologist, 12/20/06) and Shemya Island (Taylor and Brooks 1995). Taylor and Brooks found no live rats or recent sign, and thought rats may have perished, but there have been confirmed reports in recent years that *R. rattus* remain on Shemya.

References Cited in Appendix B

Bailey, E.P. 1993. Fox introductions on Alaskan islands -- History, impacts on avifauna, and eradication. USDI US Fish and Wildlife Service Resource Publication 193. 53 pp.

Breckbill, R.A. 1977. Status of Norway rat. Pages 261-267 in M.L. Merritt and R.G. Fuller, eds. The environment of Amchitka Island, Alaska. Technical Information Center, Energy Research and Development Admin. Oak Ridge, TN.

Ebbert, S.E. and G.V. Byrd. 2002. Eradications of invasive species to restore natural biological diversity on Alaska Maritime National Wildlife Refuge. pp. 102-109 *in* C. R. Veitch and M. N. Clout, eds. Turning the Tide: The Eradication of Invasive Species. IUCN SSC Invasive Species Specialist Group. IUCN. Gland, Switzerland and Cambridge, United Kingdom.

Manville, R.H. and S.P. Young. 1965. Distribution of Alaskan Mammals. Cir. No. 211, Bur. of Sport Fisheries and Wildlife, U.S. Govt. Print. Office, Washington, DC.

Murie, O.J. 1959. Fauna of the Aleutian Islands and Alaska Peninsula. U.S. Fish and Wildlife Service, North American Fauna No. 61.

Peterson, R.S. 1967. The land mammals of Unalaska Island: present status and zoogeography. Journal of Mammalogy 48:119-129.

Taylor, R.H. and J.E. Brooks. 1995. A survey of Shemya rodents. Project report. U.S. Fish and Wildlife Service Legacy Project 1244. Alaska Maritime National Wildlife Refuge, Homer, AK.

Wilson, D.E. and D.M. Reeder, eds. 2005. Mammal Species of the World: A Taxonomic and Geographic Reference. Johns Hopkins University Press, Baltimore.

C. Important Rat Behaviors and Attributes

Important Rat Behavior

Rats use any method to get to food, water or harborage. Rats are agile and athletic; their excellent sense of balance enables them to run on pipes, narrow ledges, and utility wires. Rats, particularly roof rats, will climb anything their claws will hold on to, including wires, pipes, and rough walls.

Like most mammals, Norway rats use a variety of ways to communicate. They are vocal, and also use visual cues such as body postures when communicating. Rats have poor eyesight and are considered color-blind; this attribute allows for poison baits to be dyed distinctive colors without causing avoidance by rats, provided the dye does not have an objectionable taste or odor. Rats use their keen sense of smell to locate food items and to recognize other rats. Their sense of taste is excellent, and they can detect some contaminants in their food at levels as low as 0.5 parts per million.

Figure C-1. Norway rat (Photo by Dr. Antonio J. Ferreira © California Academy of Sciences)

Norway rats have relatively good hearing and tactile capabilities. They are able to sense very minute vibrations in the ground, and feel their way through total darkness with their paws as well as their highly sensitive body hairs and whiskers (see Fig. C-1), which they use to explore their environment. Much of a rodent's activity in a familiar area relies heavily on the senses of touch and smell. Rats like to use regular paths or runways along walls or behind debris. To access food in the open, they will run behind things to get as close to the food as possible.

Home Range and Habitats

Each rat colony has its own territory, which can span an entire city block and contain more than 100 rats. New rat packs are started when a couple or single pregnant female establishes a nest in a previously unoccupied area. Typically, *R. norvegicus* live in large, male-dominated groups. The hierarchy of such groups is based on the size of an individual (Myers and Armitage 2004)

The movement of rats and mice is usually related to food, water, or harborage. Knowing where they are likely to go is important to controlling them. Rats and mice are active mostly at night. Rats show greatest activity the first half of the night, if food is abundant. Mice are usually active at night both right after dark and between midnight and dawn. Under certain conditions, rats may become quite bold in the presence of humans, and then a high percentage of the population may be visible. Both rats and mice will be active during daytime hours when food is scarce, when there is an overpopulation of rodents, or when a poison has been used and the population is sick. Typically, however, many more rats are present than will be seen during daylight hours.

Each evening, as they explore their territories, rats and mice learn the locations of new objects, food sources and escape routes. A rat's territory or "home range" is generally within a 15.2 –

45.6 m (50 – 150 ft) radius of the nest, while a mouse usually lives within a 3 – 9 m (10 - 30 ft) radius of the nest. In places where all their needs (food, water, shelter) are met, rodents have smaller territories (Myers and Armitage 2004). Rats seldom travel farther than 100m (300 ft) from their burrows to obtain food or water (Timm 1994).

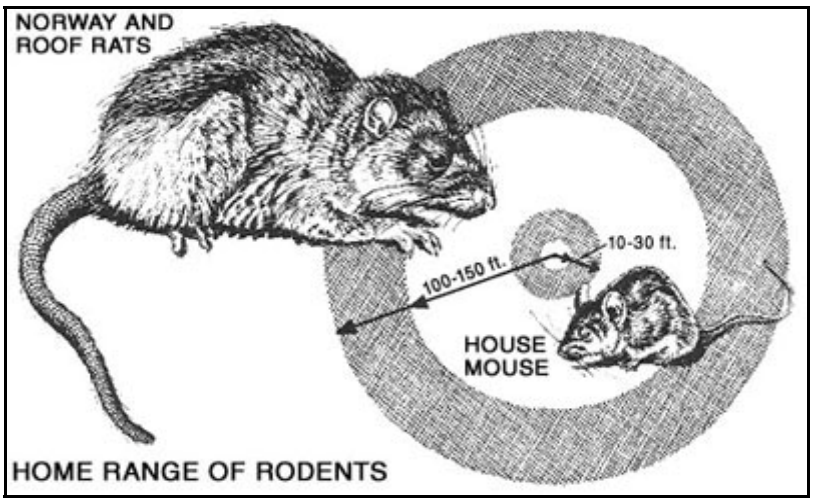


Figure C-2. Home range of Norway and roof rats. Courtesy Illinois Department of Public Health.

Naturally secretive, rats can be very hard to detect at low population densities. Although it is the standard and its effectiveness is well-studied, trapping can be inadequate as the sole technique by which to detect rats or determine their abundance (Dunlevy and Scharf 2007a). In an experiment involving one radio-tagged rat released on a rat-free island, New Zealand researchers were surprised to find that the rat was able to avoid capture for more than 18 weeks, despite using different types of rat traps as well as trained dogs (Halford 2005).

Gnawing and Burrowing

Rats burrow under buildings and other structures, beneath concrete slabs, in road beds, along stream banks, around ponds, in garbage dumps, and at other locations where suitable food, water, and shelter are present. Burrows are usually complex, consisting of food storage, nesting and "last ditch" chambers.[24] Although they can climb, Norway rats tend to inhabit the lower floors when found in multistory buildings.

Rat Reproduction

Constructed of any efficiently foraged materials (e.g., leaves, garbage, twigs, etc.), nests may be lined with shredded paper, cloth, or other fibrous material. Litters of 6 to 12 young are born 21 to 23 days after conception. Newborn rats are hairless and their eyes are closed, but they grow rapidly. They can eat solid food at 2 1/2 to 3 weeks. They become completely independent at about 3 to 4 weeks and reach reproductive maturity at 3 months of age (Timm 1994). Females may come into estrus every 4 or 5 days, and they may mate within a day or two after a litter is born.

[24] See Fig. 3, page B-107 in *Norway Rats*, by Robert Timm at http://icwdm.org/handbook/allPDF/RO_B105.PDF

Onset of breeding is timed to the annual light cycle. Information from the Aleutians indicates that there is no breeding in the winter (December to February). As one might expect, rat populations in Alaska begin to climb in the Spring, when weather conditions improve and food resources away from the coastal fringe begin to increase (Dunlevy and Scharf 2007a). Significantly, this is also the time when seabirds begin to arrive in large numbers to breed. The Spring cohort of juvenile rats become independent about the same time that many seabird chicks begin to hatch, increasing the threat of predation and reduced seabird nesting success (Major and Jones 2005). The size of the rat population peaks in the fall (September to November; Dunlevy and Scharf 2007a).

Parental care is provided by females. Because rats often nest communally, the litters of several females often occupy the same nest. In nesting groups of more than one female, if a mother is killed, the other females will take over nursing the newborns. Males do not participate in parental care (Myers and Armitage 2004).

Food Requirements

Notwithstanding their wariness of new things (neophobia; described in the plan, Section 2.1), Norway rats are opportunistic. They are also omnivorous and will eat nearly any type of food. Even so, they are very selective feeders and exhibit distinct patterns in their diet selection, often favoring specific combinations of foods found in their home range. Within a given population, the same two to four specific foods typically occur in all individuals. Even so, there is also a strong sampling component in their foraging behavior, and most rats consume at least trace amounts of novel food items (Clark 1981, Clark 1982, Dunlevy and Scharf 2007a).

Rats eat the seeds, seedlings, nuts, stems, bulbs, fruits and flowers of a large number of plant species (Campbell 1978, Allen et al. 1994, King and Moller 1997, Wilson et al. 2003, Dunlevy and Scharf 2007a). They also feed on invertebrates, both terrestrial and intertidal, including earthworms, centipedes, beetles, weevils, many insect larvae and pupae, spiders, beach fleas, slugs, snails, mussels, limpets and crabs (Jackson 1982, Navarette and Castilla 1993, Hobsen et al. 1999, Drever and Harestad 1998, Dunlevy and Scharf 2007a). Norway rats often feed along the shore and in intertidal areas, including in kelp (Dunlevy and Scharf 2007a). Some Norway rats living near the sea have been observed catching fish with their paws (Myers and Armitage 2004), and there is evidence that Norway rats may swim in the ocean to capture prey living in the holdfasts of kelp (Navarrete and Castilla 1993).

Rats may also kill or scavenge vertebrate prey, including small mammals, and the eggs, young, and sometimes adults of birds (Drummond 1960, Norman 1970, Fall et al. 1971, Jackson 1982, Atkinson 1985, King 1990, Navarette and Castilla 1993, Sugihara 1997, Drever and Harestad 1998, Hobsen et al. 1999, Cole et al. 2000, Innes 2001, Stapp 2002, Dunlevy and Scharf 2007a).

Norway rats in higher latitudes are known to prey on burrow-nesting grey-faced petrel (*Pterodroma macroptera*) eggs and chicks and sooty shearwater (*Puffinus griseus*) chicks, nesting winter wrens (*Troglodytes troglodytes*) and song sparrows (*Melospiza melodia*), ground-nesting curlews (*Numenius arquata*) and curlew sandpipers (*Calidris ferruginea*), and ground-

nesting peregrine falcon (*Falco peregrinus*) chicks. In New Zealand, other bird prey has included the eggs of ground-nesting mallard duck (*Anas platyrhynchos*; Atkinson 1985).

In and around human habitations, Norway rats prefer cereal grains, meats and fish, nuts, and some types of fruit. When given a choice, they select a nutritionally balanced diet, choosing fresh, wholesome items over stale or contaminated foods.

Although Norway rats generally prefer to eat fresh meat, fish, and grain, they can survive well on an ounce (28.3 g) per day of garbage or decayed food along with an ounce (29.6 ml) of water. Rats require 1/2 to 1 ounce (14.8 to 29.6 ml) of water daily when feeding on dry foods but need less when moist foods are available. Food items in household garbage offer a fairly balanced diet and also satisfy their moisture needs. Both Norway and roof rats commonly range 30.5 – 45.7 m (100-150 ft) from harborages in search of food or water.

Norway rats are known to cache food in burrows, particularly when their body weight is below the typical weight for an adequately fed animal (Cabanac and Sweirgeil 1989). Because young Norway rats learn foraging habits from their mothers or other "demonstrator" rats (Jackson 1982, Innes 2001), populations of rats tend to continue feeding on the same types of foods and prey over time.

For additional information on natural history of rats and mice, access the following website:

Animal Diversity:
http://animaldiversity.ummz.umich.edu/site/accounts/information/Rattus_norvegicus.html.

References Cited in Appendix C

Allen, R.B., W.G. Lee, and B.D. Rance. 1994. Regeneration in indigenous forest after eradication of Norway rats, Breaksea Island, New Zealand. New Zealand Journal of Botany 32:429-439.

Cabanac, M. and A.H. Sweirgeil. 1989. Rats eating and hoarding as a function of body weight and cost of foraging. The American Psychological Society, p. 952-957.

Campbell, D.J. 1978. The effects of rats on vegetation. In: *The Ecology and Control of Rodents in New Zealand Nature Reserves.* New Zealand Dep. of Lands and Survey, Wellington, New Zealand. P. 99-120.

Cole, R.F., L.L. Loope, A.C. Medeiros, C.E. Howe and L.J. Anderson.. 2000. Food habits of introduced rodents in high elevation shrubland of Haleakala National Park, Hawaii. Pacific Science 54(4):313-329.

Clark, D.A. 1981. Foraging patterns of black rats across a desert-montane forest gradient in the Galapagos Islands. Biotropica 13:182-194.

Clark, D.A. 1982. Foraging behavior of a vertebrate omnivore (*Rattus rattus*): meal structure, sampling, and diet breadth. Ecology 63(3):763-772.

Drever, M.C. and A.S. Harestad. 1998. Diets of Norway rats, *Rattus norvegicus*, on Langara Island, Queen Charlotte Islands, British Columbia: Implications for conservation of breeding seabirds. Canadian field-Naturalist 112:676-683.

Drummond, D.C. 1960. The food of *Rattus norvegicus* Berk. in an area of sea wall, saltmarsh and mudflat. Journal of Animal Ecology 29(2):341-347.

Fall, M.W., A.B. Medina, and W.B. Jackson. 1971. Feeding patterns of *Rattus rattus* and *Rattus exulans* on Eniwetok Atoll, Marshall Islands. Journal of Mammalogy 52(1):69-76.

Halford, B. 2005. Fugitive Rat Teaches Lesson about Rat Control. National Geographic News. October 19, 2005. Accessed at http://news.nationalgeographic.com/news/2005/10/1019_051019_island_rat.html 8/30/07.

Hobsen, K.A., M.C. Drever, and G.W. Kaiser. 1999. Norway rats as predators of burrow-nesting seabirds: Insights from stable isotope analyses. Journal of Wildlife Management 63(1):14-25.

Innes, J. 2001. Advances in New Zealand mammalogy 1990-2000: European rats. Journal of Royal Society of New Zealand 31(1):111-125.

Jackson, W.B. 1982. Norway rat and allies. In: *Wild Mammals of North America.* J.A. Chapman and G.A. Feldhamer, Eds. Johns Hopkins University Press, Baltimore. p. 1077-1088.

King, C.M. 1990. Ship Rat. In: *The Handbook of New Zealand Mammals*. Oxford University Press, Auckland. p. 206-225.

King, C.M. and M. Moller. 1997. Distribution and response of rats *Rattus rattus, R. exulans* to seedfall in New Zealand beech forests. Pacific Conservation Biology 3:143-155

Major, H.L. and I.L. Jones. 2005. Distribution, biology and prey selection of the introduced Norway rat *Rattus norvegicus* at Kiska Island, Aleutian Islands, Alaska. Pacific Conservation Biology 11(2): 105-113.

Myers, P. and D. Armitage. 2004. Rattus norvegicus. Online on Animal Diversity Web. At http://animaldiversity.ummz.umich.edu/site/accounts/information/Rattus_norvegicus.html. Accessed 30 August 2007

Navarrete, S.A. and J.C. Castilla. 1993. Predation by Norway rats in the intertidal zone of central Chile. Marine Ecology Progress Series 92:187-199.

Norman, F.I. 1970. Food preferences of an insular population of *Rattus rattus*. London Journal of Zoology 162:493-503.

Stapp, P. 2002. Stable isotopes reveal evidence of predation by ship rats on seabirds on the Shiant Islands, Scotland. Journal of Applied Zoology 39:831-840.

Sugihara, R.T. 1997. Abundance and diet of rats in two native Hawaiian forests. Pacific Science 51(2): 189-198.

Timm, R.M. 1994. Norway Rats. In Prevention and Control of Wildlife Damage. U.S. Department of Agriculture/APHIS/Animal Damage Control. University of Nebraska-Lincoln, Institute of Agriculture and Natural Resources, Cooperative Extension Division. Pp. B-105-B-120.

Wilson, D.J., W.G.Lee, R.A. Webster, and R.B. Allen. 2003. Effects of possums and rats on seedling establishment at two forest sites in New Zealand. New Zealand Journal of Ecology 27(2):147-155.

D. Rat Occurrence in Alaska

A reliable method needs to be developed for recording and reporting data about occurrence of rats in Alaska. The following tables were prepared by J. Meehan and E. Fritts (Alaska Department of Fish and Game [ADF&G]) from information provided by ADF&G and U.S. Fish and Wildlife Service staff, University of Alaska Fairbanks museum collections, and FWS Resource Publication 193 (Bailey 1993). Table D-1 indicates islands and communities where introduced rats have been sighted and for which it is confirmed or likely that a breeding population has become established; although not listed here, many islets around larger infested islands (e.g., Adak, Atka, Unalaska) are also believed to support breeding populations of rats. Table D-2 lists locations where rats have previously been reported but for which the individual rat(s) were eliminated by human action (E), rats are otherwise believed currently absent (A) or, although rats have been reported (R), the presence of a population and its breeding status are unknown.

Table D-1 -- Alaska Islands and Communities with Breeding Populations of Introduced Rats (*R. norvegicus* / *R. rattus*)

As of October 3, 2007

Site	Rat Species	Current Status? B = Breeding population is confirmed or is likely
Adak Island	Norway	B
Akutan Island	Norway	B
Amchitka Island	Norway	B
Atka Island	Norway	B
Attu Island	Norway	B
Bat Island	Norway	B
Bell's Flat (Kodiak)	Norway & roof	B
Bird Rock	Norway	B
Bolshoi Islets	Norway	B
City of Kodiak	Norway & roof	B
	Unknown, likely	
Craig	Norway	B
Fairbanks/College	Norway	B
Great Sitkin Island	Norway	B
Juneau	Norway	B
Kagalaska Island	Norway	B
Ketchikan	Norway	B
Kiska Island	Norway	B
Makarius Island	Norway	B

Nome	Norway	B
Ogangen Island	Norway	B
	Unknown, likely	
Petersburg	Norway	B
Rat Island	Norway	B
Seal Rocks	Norway	B
Sedanka island	Norway	B
Shemya Island	roof	B
Sitka	Norway	B
Unalaska		
Isl./Dutch Harbor	Norway	B

Table 2 -- Alaska Sites Having Past Reports of Rats, w/ Estimation of Current Status

As of October 3, 2007

Site	Rat Species	Current Status? A = Believed absent at present E = Believed eliminated by human actions R = Rat(s) reported; presence of breeding population is unknown
	Norway and	
Anchorage	unknown	R
Clam Gulch	Norway	E
Cordova	Norway	A
Douglas	Norway	R
Eek	Unknown	R
Homer	Norway	R
Kenai	Unknown	R
King Cove	Unknown	R
Kotzebue	Norway	R
Little Kiska Island	Unknown	A
Marshall	Unknown	R
Nikiski	Norway	R
Sand Point	Unknown	R
Sanak Island	Norway	A
Wasilla	Norway	R
Wrangell	Unknown	R

Reference Cited in Appendix D

Bailey, E.P. 1993. Fox introductions on Alaskan islands -- History, impacts on avifauna, and eradication. USDI US Fish and Wildlife Service Resource Publication 193. 53 pp.

E. Example Ordinances on Rat Control

Anchorage Ordinances 16.90.030 and .040

Following are the Municipality of Anchorage's ordinances 16.90.030 and .040 relating to rat possession (including for pets), reporting, extermination, and payment of extermination costs.

Authority: Alaska Statute (AS) 16.05.255

16.90.030 Rat control--Ownership or breeding of rats prohibited; report of presence of rats; extermination.

A. It shall be unlawful for any person to import, buy, sell or breed any member of the genus *Rattus* within the municipality, except in accordance with the terms of a written permit which has been issued therefore by the director of the department of health and human services. The director may issue a permit only to scientists, scientific institutions, research institutions or government officers, agencies, boards or commissions upon a determination that it is in the public interest to do so.

B. Any person who violates subsection A of this section shall be subject to a civil penalty of not less than $50.00 and not more than $1,000.00 for each offense, or injunctive relief to restrain the person from continuing the violation or threat of violation, or both injunctive relief and a civil penalty. Upon application for injunctive relief and a finding that a person is violating or threatening to violate subsection A of this section, the superior court shall grant injunctive relief to restrain the violation.

C. Any person who violates subsection A of this section shall be subject to a criminal fine of not less than $50.00 and not more than $300.00 for each offense.

D. Each day of violation of subsection A of this section shall constitute a separate offense.

E. Any other person with knowledge of the presence of rats within the municipality shall immediately inform the department of health and human services of such knowledge.

F. The department of health and human services or its inspectors may inspect all places for the purpose of ascertaining whether they are infested with rats and whether the requirements of subsection E of this section as to their extermination and destruction are being complied with.

G. The director of the department of health and human services, upon a finding that an infestation of rats exists within the municipality and that subsection F of this section is not being complied with, may purchase poison, traps and other materials for the purpose of exterminating and destroying the rats, and may employ and pay inspectors to prosecute the work of extermination on both private and public property in the municipality.

H. Whenever a person in possession of a place that is subject to the mandate set forth in subsection E of this section fails to perform as therein required, the department of health and human services shall at once cause the rats to be exterminated.

I. The responsibility for payment of the expenses incurred under subsection H of this section shall rest jointly and severally upon the following:

1. The owners of the property where the extermination occurred.
2. The tenants of the property where the extermination occurred.
3. The persons residing on the property where the extermination occurred.
4. Any person legally responsible for the presence of a rat by reason of negligence or otherwise.

(Anchorage Ordinance [AO] No. 83-95; AO No. 85-8)
Cross references: Environmental protection, Tit. 15 ; animals, Tit. 17 .

16.90.040 Rat control--Exception for pet rats.
The director may permit retention of pet rats under justifiable circumstances as approved by the director. Children who are outside the state with a pet rat on July 28, 1983, may bring their pet rat back to the municipality.

St. Paul Rodent Ordinance 9.1.6

(a) Rodent Control - The council finds that control of rodents on St. Paul Island is critical to preservation of bird species which inhabit the island and that introduction of rodents to the island could cause catastrophic irreversible impacts on the bird populations.

(b) Prevention Program - All structures and the land surrounding them which are used for commercial purposes to store food, and/or which produce food wastes, fish processing wastes, or other waste products which might be a food source of any rodent shall maintain a rat prevention program that will include general sanitation monitoring and a trap, sticky board and/or bait station program.

(c) Vessels - All vessels utilizing any other waters within the City shall be free of rodents. Where there is evidence of the presence of rodents on a vessel, such vessel shall be evicted from the Port of St. Paul or waters within the City's jurisdiction.

(d) Food Source Control - Any business or vessel which produces food wastes, fish processing wastes or other products or waste products which might be a food source of any rodent shall store such materials in rodent restrictive containers or dumpsters.

(e) Inspections - Any commercially used structures and any vessel type in City waters may be inspected at any time during normal business hours for compliance with this ordinance. In addition, in the event of receipt by the City of any evidence that a structure or vessel may be infested with rodents, the structure or vessel may be inspected at any time for compliance with this ordinance.

(f) Infested Structures or Vessels - Any structure or its surrounding lands or any vessel in or upon which there is sighted by any person rodents or rodent feces shall be presumed to be infested within the meaning of this ordinance. Upon receipt of evidence that a structure or vessel may be infested, the City Manager may take all measures reasonably conducive to isolating the structure or vessel and containing the infestation, including, but not limited to, requiring the cessation of any use or occupancy of same and, in the case of a vessel, requiring it to leave City waters. All costs of such containment shall be borne by the owner and user of the structure or vessel. The City Manager shall cause written notice of such action to be delivered to the person occupying the structure or on board the vessel who reasonably appears to be in charge thereof. The owner, occupant, or other interested person may within twenty-four (24) hours of receipt of said notice, request a hearing by the City Manager regarding whether the structure or vessel is infested. Such hearing shall be held within forty-eight (48) hours of request.

(i) Elimination of Infestation - The owner or user of any infested structure or vessel may be ordered by the Manager to immediately undertake efforts to fumigate, poison, or trap rodents as may be necessary for the immediate elimination of the infestation. In the event of the inability to give notice to such persons or the failure to undertake such measures within twenty-four (24) hours of oral or written notice of the need for such measures, the City may undertake such measures itself with all costs of such measures being borne by the owner and user of the structure or vessel.

(j) Rodent Information Posting - All commercial fish/crab processors operating with the Port of St. Paul or within City boundaries shall display information signs in prominent locations throughout the processing facility about the environmental dangers posed by rodentrv, how to detect rodent sign, and the process for reporting rodent sign or sightings.

Any person acting in violation of the above ordinances is, upon conviction, guilty of a City offense and is punishable as set forth in Section 8.2 of this Chapter.

F. Shipwreck Response Considerations

Assembly & Caching of Response Supplies
The U.S. Fish and Wildlife Service (FWS) has assembled shipwreck response kits with basic supplies needed to combat escaping rodents. The most basic tools for preventing a rodent invasion include snap traps, rodenticides, bait stations, sticky boards, and .22/410 shotgun/ammunition; some of these items are described in more detail in Appendix H: Rat Prevention and Control. A comprehensive listing of response kit items is shown in Table F-1, next page.

The actual response items may vary from kit to kit based on the type of response for which a kit could potentially be used. For example, some kits may contain more rodenticides while others may contain only traps and no rodenticides. As noted in Section 2.3 of the main plan, kits of different types have been stockpiled with various organizations across the state, for immediate use in the event of a rat spill event.

EPA Registration
The FWS currently holds a quarantine exemption from the U.S. Environmental Protection Agency (EPA), through Section 18 of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), to use a rodenticide with the active ingredient brodifacoum for emergency shipwreck response. The Emergency Use Exemption, subject to conditions and restrictions, allows for the use in controlling Norway rats, roof rats (*R. rattus*) and house mice (*Mus musculus*) on Alaska Maritime National Wildlife Refuge (AMNWR) and lands adjacent to the refuge with seabird populations that do not have existing invasive rodent populations. Specific islands may be treated as ship casualty incidents occur. The quarantine exemption is for application of the product Havoc Rodenticide Bait Pack Pellets (EPA reg. no. 100-1056), containing 0.005% brodifacoum, a second generation anticoagulant. The rodenticides may only be applied in bait stations or "bait tubes" that are clearly labeled and marked as to their hazard and to facilitate later recovery. Additional conditions and restrictions apply.

There is also a Special Local Need (SLN) 24C Registration for *Ramik Green*® EPA REG# 2393-498/ EPA SLN No. AK-03-0001 to be used in Alaska on National Wildlife Refuge land. This bait may be applied by hand-broadcast, in bait stations, or inside burrows.

Response Team Training
The FWS' Shipwreck Response Plan calls for a "strike team" approach for staffing a team. The shipwreck response training includes both classroom and field exercises. The strike team is trained in invasive rodent biology and behavior, and the proper handling and distribution of rodenticides for which they earn State of Alaska, Department of Environmental Conservation, certification in rodenticide application. The FWS' Team members must also have current Hazardous Waste Operations and Emergency Response (HAZWOPER) certification, and must be trained and experienced in accessing remote island locations via small boat or helicopter.

Table F-1. Rat Control: Shipwreck Response Kit

Tube Bait Stations:
8 waxed boxes containing bait tube stations #1-100 with 50 small sandbags; 50 "U" Stacks; 12 cardboard baffles

Shipwreck Kit:
Poison: Havoc *Brodifacoum* bait – 5 lbs. (75/50 gram bait packs)
Brodifacoum tube labels
MSDS sheets for poison
Wood saw 15"
Ziplock bags: 4 1-gal.
Duct tape: 1 roll
Snap traps: rat – 36; mouse – 72
Sticky boards: 24
Indicator bates: peanut butter – 21; jam – 14; cheese – 6
.22 rifle/.410 shotgun with waterproof case
Head lamp/batteries: 8 AA
Flags: 140 pink on 2' wires
Waterproof bag: 2 large
Net bag: 1
Station Instructions
"Poison Area" signs: 10
Rodent ID Chart
Chain-of-Custody forms
"*Bionomics and Management of Commensal Rodents"* – Joe Brooks
"We Alaskans – The Rats are Coming"
Shovel: small folding
Disposable camera: 27 exp.
Axe
Twine
Slingshot w/ ammo
Safety goggles
Measuring tape: 100' (33m)

Tool Box (inside kit):
Shotgun & rifle cleaning kit
Hammer: 1
Pliers: 1
Phillips screwdriver: 2
Standard screwdriver: 2
Bailing wire: roll
Sandwich bags: 150
Surveyor tape: 2 rolls, orange

Strapping tape: 1 roll
.410 2-1/2 inch shotgun shells: 25, 7-1/2 shot
.22 short rifle cartridges: 100
Peanut butter: 18 oz.
Paint pens: 2 red
Pencils: 5
Rite-in-the-Rain notebooks: 2
Field notepad: 1
Medium plastic bags: 2
Trash bags: 5
Disposable gloves: 7 pair
Plastic gloves: 2 pair large; 2 pair medium
Screws: 100 #6x1
Wire cutter/pliers
Waterproof matches: 2 boxes
Twine: 208 ft
Light twine: 200 ft
Compass
Oil: 3 in 1
Camper saw
Safety pins: 50
Nails: 70 6d
Tags: 7
Leatherman knife
Emergency strobe w/ D-cell
Mini-flashlight w/ 2 AA batteries and case

IMPORTANT! – Anyone working with rodent removal should have and use effective methods for washing hands and a means of disposing of moldy or dated bait.

G. Laws Pertaining to Rodent Management

Some of the current legal and enforcement tools available for addressing rodent management are listed below. Wherever possible, both the legal framework and entities responsible for administering the law are listed.

Federal and Alaska Pesticide-Related Laws and Responsible Entities
Administered by the U.S. Environmental Protection Agency (EPA), the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) addresses the registration, manufacture, sale, transportation and use of pesticides in the United States. This act governs many aspects of pest management and provides a basis for enforcement to ensure that all pesticide applications are performed according to label directions. "The label is the law" means product labels are legal documents that applicators should read and periodically reread and note any changes in its labeling, to make sure they use the product correctly. Local and state pest management and pesticide applicator regulations also govern the training, licensing and certification of pest management businesses and pesticide applicators.

A suite of other federal, state, and local laws is designed to protect people and other nontarget organisms against the adverse effects of pesticides. Agencies with responsibility for administering these laws in Alaska include: the Alaska Department of Environmental Conservation (DEC); the Federal Aviation Administration; the federal and state departments of transportation; Alaska Department of Commerce; and the Alaska Department of Natural Resources, Office of Project Management and Permitting (Coastal Zone Management Program). For more information on federal and Alaska pesticide terminology and laws, see:

http://www.epa.gov/pesticides/ (federal laws)
http://www.dec.state.ak.us/eh/pest/index.htm (state laws)
http://www.dec.state.ak.us/regulations/pdfs/90mas.pdf (state pesticide regulations).

Other Applicable Laws and Responsible Entities
The following section highlights some of the primary entities responsible and the legal framework guiding various aspects of rat-related assessment, response, control, and eradication activities.

Federal

U.S. Food and Drug Administration
Under the federal Food, Drug and Cosmetic Act, the U.S. Food and Drug Administration has authority to inspect food and drug manufacturing plants and warehouses for the presence of filth, insect and rodent contaminants.

U.S. Department of Agriculture/Animal and Plant Health Inspection Service (APHIS) and U.S. Department of Homeland Security/Customs and Border Protection (CBP)
Key legal instruments guiding the actions of APHIS and CBP are found in the following Congressional Acts:

- Plant Protection Act (2000)

- Animal Health Protection Act (2002)
- Public Health Security and Bioterrorism Preparedness Act (2002)

U.S. Department of Agriculture/ Food Safety and Inspection Service (FSIS)
This agency conducts similar inspections in meat and dairy processing facilities. The regulatory framework for rodent interception and management is found in 9CFR 416.2(a), Establishment grounds and facilities, which states:

(a) Grounds and pest control. The grounds about an establishment must be maintained to prevent conditions that could lead to insanitary conditions, adulteration of product, or interfere with inspection by FSIS program employees. Establishments must have in place a pest management program to prevent the harborage and breeding of pests on the grounds and within establishment facilities. Pest control substances used must be safe and effective under the conditions of use and not be applied or stored in a manner that will result in the adulteration of product or the creation on insanitary conditions.

U.S. Department of the Interior, U.S. Fish and Wildlife Service
Besides adhering to FIFRA requirements, activities on Alaska's national wildlife refuges must meet the following laws and Executive Orders applicable to rodent eradication:

- Alaska Coastal Zone Management Act
- Alaska National Interest Lands Conservation Act, Section 800, Subsistence Uses
- Clean Water Act
- Endangered Species Act
- Executive Order 13186, Guidance for Protection of Migratory Birds
- Executive Order 12899, Environmental Justice
- Magnusen-Stevens Fishery Conservation and Management Act, including Essential Fish Habitat
- Marine Mammal Protection Act
- Migratory Bird Treaty Act
- National Historic Preservation Act
- The 1964 Wilderness Act

State of Alaska

Alaska Board of Game
AS 16.05.255 authorizes the Alaska Board of Game to adopt regulations it considers advisable in accordance with AS 44.62 (Administrative Procedure Act) for the following actions relating to game including rats and other rodents:

(2) establishing open and closed seasons and areas for the taking of game;
(3) establishing the means and methods employed in the pursuit, capture, taking, and transport of game;
(5) classifying game as . . . big game animals, fur bearing animals, predators, or other categories;

(6) methods, means, and harvest levels necessary to control predation and competition among game in the state;
(7) watershed and habitat improvement, and management, conservation, protection, use, disposal, propagation, and stocking of game;
(8) prohibiting the live capture, possession, transport, or release of native or exotic game or their eggs;
(11) taking game to ensure public safety; and
(12) regulating the activities of persons licensed to control nuisance wild birds and nuisance wild small mammals.

Alaska Department of Environmental Conservation

Under AS 03.05.011, DEC may issue orders, regulations, permits, quarantines, and embargoes relating to

(1) examination and inspection of premises containing products, articles, and commodities carrying pests;
(2) establishment of quarantines for eradication of pests and diseases in livestock; and
(3) tests and analyses that may be made and hearings that may be held to determine whether the commissioner will issue a stop order or quarantine.

This statute provides the foundation for actions by the state veterinarian; it is specifically restricted for the control of diseases in animals which may or may not be food (K. Ryan, DEC Environmental Health Program Manager, Pers. Comm. 6/27/07). The department's food safety statutes are in Titles 17 and 44 and statutes relating to pesticides are found in Title 46.

Alaska Department of Fish and Game

AS 16.05.940(19) defines rats as "game," and AS 16.05.330 requires a hunting license for the taking of game. This means a person killing rats by any means needs a hunting license. Other provisions relating to rats are found in the following state wildlife regulations.

5 AAC 92.990(a)(52) – Defines as Deleterious Exotic Wildlife any Muridae rodent that is "unconfined or unrestrained."
5 AAC 92.990(a)(73) – Effective September 13, 2007, defines as Nuisance Wildlife any Deleterious Exotic Wildlife that is feral, and any animal that: invades or comes to occupy a dwelling, vessel, vehicle, structure, or storage container; causes property damage, or is an invasive or introduced nonnative species that poses immediate or long-term threats to human health, safety, or property or to native wildlife, wildlife health, or habitat.
5 AAC 92.990(a)(76) – Effective September 13, 2007, defines: "invasive species" as a nonnative species whose introduction does or is likely to cause economic or environmental harm or harm to human health; this includes all of the species listed in 5 AAC 92.990(52); and defines "Muridae rodent" as including true mice and rats, gerbils, and their relatives.
5 AAC 85.075 – Establishes no bag limits/no closed season for Deleterious Exotic Wildlife.

5 AAC 85.075 (b) – Allows take by any means (except those prohibited in 5 AAC 92.080) for Deleterious Exotic Wildlife.

5 AAC 92.080(2) – Requires written consent from the Board of Game to take wildlife using poisons; effective September 13, 2007, the use of poisons for taking deleterious exotic wildlife within a building, vessel, port, vehicle, or aircraft, is authorized without board approval when using Alaska Department of Environmental Conservation registered pesticides in their approved manner.

5 AAC 92.029 – Allows possession of specifically listed animals without a permit but prohibits their release into the wild; requires a permit for possessing all other rodent species/subspecies. [Note: Rodents that are allowed without a permit include white rats (*R. norvegicus* Var. *albinus*); white, waltzing, singing, shaker, and piebald mice (*Mus musculus* var.); fat-tailed gerbil (*Pachyuromys duprasi*); gerbil (*Gerbillus* spp.); hamster (golden) (*Mesocricetus auratus*); chinchilla (*Chinchilla laniger*); cavy (*Cavia aperea*); and guinea pig (*Cavia porcellus)*]. As of September 13, 2007, includes rats and mice in the list of Deleterious Exotic Wildlife that can be captured or destroyed if found feral or unrestrained by an owner.

5 AAC 92.230 – Effective September 13, 2007, a person may not intentionally feed deleterious exotic wildlife (including rats and mice), or negligently leave human food, pet food, or garbage in a manner that attracts these animals. However, this prohibition does not apply to use of bait for trapping Deleterious Exotic Wildlife.

5 AAC 92.141 – Effective September 13, 2007, it is unlawful for the owner or operator of a vessel, vehicle, aircraft, structure being translocated, or other means of conveyance to knowingly or unknowingly harbor live Muridae rodents, or to enter Alaska (including Alaskan waters) while knowingly or unknowingly harboring live Muridae rodents. (b) It is unlawful for an individual to release to the wild any live Muridae rodent. (c) It is unlawful for the owner or operator of a facility to knowingly or unknowingly harbor live Muridae rodents. The owner or operator of a harbor, port, airport, or food processing facility in which live Muridae rodents have been found shall develop and implement an ongoing rodent response and eradication or control plan.

5 AAC 92.210 – Allows Deleterious Exotic Wildlife to be used as food for dogs or furbearers or for bait.

<u>Alaska Department of Public Safety/Division of Alaska Wildlife Troopers</u>

Troopers from the Division of Alaska Wildlife Troopers have the authority and responsibility to enforce state wildlife statutes and regulations. A citation issued an individual or organization for a violation of the laws listed above requires a mandatory court appearance. Additionally, for individuals, a violation is a Class A misdemeanor and, upon conviction, carries a possible maximum fine of up to $10,000 and up to one year in jail. For organizations (including any commercial entity, group, or entity other than a sole individual), each violation is also a Class A misdemeanor but, upon conviction, carries a fine of up to $200,000 and up to 3 times the pecuniary gain realized by the defendant as a result of the offense or up to 3 times the pecuniary damage caused by the defendant to another, or to the property of another as a result of the offense.

Alaska Department of Health and Social Services, Division of Public Health, Section of Epidemiology

Under 7 AAC 27.020, the Department of Health and Social Services can take actions to control rodents or other animals found to carry diseases transmissible to humans. The department may, alone or in cooperation with federal or other state agencies, investigate the circumstances and extent of the threat, and quarantine or euthanize the diseased animals to protect human health. Subsection (a)(3) of this regulation provides that, in the event of a quarantine order, all peace officers are empowered to euthanize disease-carrying animals not held in restraint in facilities or on private premises. It is unclear what regulation(s), or actions, would apply in a case of human illness where the illness was traced to eating a wild animal that had itself contracted a rat-caused disease.[25]

Local

In Anchorage, the main code requirements regarding rats are in Anchorage Municipal Code 16.90.030. Possession, ownership, breeding or transport of rats of any kind is prohibited in Anchorage. Rats are not allowed on airplanes landing in Anchorage or to otherwise be transported to or through Anchorage. Enforcement tools include civil penalties of up to $1000 per day, authority to inspect all places for infestation or abatement, authority to procure extermination materials and/or to order extermination. Investigation and enforcement related to rats in Anchorage is complaint driven. Measures are taken to eradicate rats as situations are brought to the attention of municipal officials.

Anchorage Municipal Code 15.10 related to housing (primarily rental housing) places responsibility with the property owner for ratproofing, rat control and to prohibit rat harborage. This code places responsibility with the owner or occupant to keep no materials that may serve as food for rats in a site accessible to rats. "Rat" in this code is defined to include other rodents.

Local Contacts

- Anchorage: Report rats and mice to Mr. Chris Tofteberg, Food Safety & Sanitation Program Manager, 825 L Street, 5th Floor, Anchorage, AK 99519-6650. (907) 343-6509 and toftebergcj@muni.org.
- From anywhere in the state: Call 1-877-INVASIV, the ADF&G invasive species program toll free number or access http://www.adfg.state.ak.us/special/invasive/invasive.php.
- Check your local area: In some communities, it may be advisable to call the harbormaster, public health authority, or local ADF&G office.

Local Ordinances

- The Pribilof Islands' "Rat Free Harbor" Ordinance (St. Paul Rodent Ordinance 9.1.6), which is designed to keep new rats from entering at the docks and airport, appears in Appendix E.

[25] DEC's authority for introduced disease concerns only the potential for an introduced disease to spread to livestock, not humans consuming wild animals.

- The Municipality of Anchorage's ordinances 16.90.030 and .040 relating to rat possession (including for pets), reporting, extermination, and payment of extermination costs, appear in Appendix E. This ordinance carries the possibility of up to a $1,000 civil fine and injunction, plus up to $300 for each criminal offense (e.g., by a repeat offender or person who is aware of the prohibition on rats but who continues to sell or possess them).

H. Rat Prevention and Control

Table of Contents for Appendix H

Figures and Tables for Appendix H

Figure Credits for Appendix H

FIGURE H-1. Cathy Rezabeck, U.S. Fish and Wildlife Service
FIGURE H-2. Courtesy Illinois Department of Public Health (IDPH)
FIGURE H-3. From Timm 1994 (see References)
FIGURE H-4. From P.G. Koehler and W. H. Kern, Jr. 2005, Rat and Mouse Control, University of Florida, Institute of Food and Agricultural Sciences (Koehler and Kern, UF/IAS)
FIGURE H-5. Koehler and Kern, UF/IAS
FIGURE H-6. Koehler and Kern, UF/IAS
FIGURE H-7. Koehler and Kern, UF/IAS
FIGURE H-8. Courtesy Extension website, at www.extension.org, Norway Rats webpage
FIGURE H-9. Koehler and Kern, UF/IAS
FIGURE H-10. Art Sowls, FWS
FIGURE H-11. IDPH
FIGURE H-12. IDPH
FIGURE H-13. IDPH
FIGURE H-14. Koehler and Kern, UF/IAS
FIGURE H-15. Koehler and Kern, UF/IAS
FIGURE H-16. Koehler and Kern, UF/IAS

1.0 Introduction

This appendix is designed to provide background information useful in helping Alaska decision-makers, agencies, businesses, and citizens best accomplish the recommendations and actions outlined elsewhere in the plan. It addresses a wide range of topics including rodent-related program development, planning, and prevention. It also describes tools and "how-to" techniques on everything from preparing plans targeted to specific locales or sectors, to effective baiting and placement of traps. Appendix I has a list of suggested readings on these topics and others.

Whatever your level of responsibility or interest regarding invasive rodents, your efforts constitute an important element in implementing the overall statewide plan. Following the steps it lays out, and working collaboratively with other entities, will significantly improve the chances of eliminating rat infestations in Alaska and recovering damaged wildlife species and habitats.

Overview of Key Steps

Keeping rats from arriving at all is the very best strategy we can adopt. Other key steps are as follows:

- Think and act strategically, to best focus effort where it will count most.
- Improve your understanding, including about the interests of potential critics (e.g., of poisoning efforts).
- Consider the resources available to assess and address the problem.
- Review rodent management and, as appropriate, restoration tools and techniques.
- Secure support from decision-makers.
- Collaborate with other stakeholder groups to pool ideas and resources.
- Recruit energetic and committed "can do" team members -- people with prior experience in eradicating rodents as well as newcomers to mentor.
- Develop a step-wise rodent management plan for your specific situation.
- Provide training for all who will be involved in outreach and rodent management.
- "Expect the unexpected" and conduct pre-trials of techniques to be used.
- Launch your attack and remain vigilant: *Stop rodent invaders in their tracks!*

General information on each of these steps appears below. This is information that can be used at a local or sector-wide level: The Strategic Actions List (Section 7.5 of the plan) lists specific steps that need to be taken at a broader scale.

Multiple Approaches Needed
A major tenet of prevention as well as rodent removal efforts is to use *multiple approaches* and *overlapping methods* to achieve success. For instance, assume that traditional traps might not be effective for catching the first arrival of an invasive rodent species (Halford 2005). Also, in outreach and education efforts, assume that some audiences will completely tune out some of the tools used (e.g., print media, television or radio).

2.0 Conduct Outreach and Involve Stakeholders

There are a number of reasons that strategic outreach and communication efforts are essential: These activities can help change human behaviors that favor the spread of rodents, gain stakeholder consent and support for projects through public education and awareness, offer incentives for altering behavior, and help implement rodent prevention and removal projects. Information and ideas in each of these categories appear below.

Change Human Behaviors that Increase Rodent Problems
Circumstances that allow invasive rodents to spread to new areas all derive from human activities. These include settlements; construction or expansion of wharves, ports, and harbors; airstrips; importation of foodstuffs; exploitation of natural resources; establishment of military bases, weather, or research stations; shipwrecks; and sometimes boating associated with tourism and recreation (Moors et al. 1992).

Outreach, information, and education are very important in any effort to affect human behavior. A few examples include:

- Conduct outreach/education efforts to limit sources of infestation; target key transportation vectors (e.g., ship fleets, ground and air transporters) and the public.
- Develop guidance for veterinarians, animal shelters, and pet sellers about legal requirements concerning rats, and to the public on methods for relinquishing pet rats.
- Include signs of rat presence in training for Alaska fishery observer programs to identify rat-free vessels and raise rat awareness for vessel owners.
- Develop and distribute rat control kits to strategic locations (e.g., including all Alaska Department of Fish and Game [ADF&G] and U.S. Fish and Wildlife Service [FWS] coastal field offices and selected inland offices).
- Conduct ongoing education efforts to inform specific groups about current laws, and the risks that rats can pose for public safety and wildlife in Alaska; include airport workers, pilots, boat owners, veterinarians, animal control and shelter personnel, and pet owners and sellers in this type of outreach.

For an example of text to post aboard ships or in harbors, see information on the Alaska Maritime National Wildlife Refuge (AMNWR) website at:
http://alaskamaritime.fws.gov/whatwedo/bioprojects/restorebiodiversity/shipaid.htm.

Build Awareness and Stakeholder Support for Action
Information and education activities are often instrumental in gaining stakeholder support or consensus so that planned actions move forward to successful conclusions.

Examples of these activities include:

- Develop public awareness about the threats to native biodiversity, economics, and human health from introduced rodents.
- Emphasize common interests (e.g., among groups of ship owners/harbormasters, public health inspectors/inspectees, subsistence wildlife users, transboundary community managers).
- Elevate public awareness, including in other languages and foreign ports, and via the internet.

  - Stress importance of and methods for prevention.
  - Stress that ecological balance can be conserved by preventing new introductions and that already infested lands can be restored.
  - Use effective sound bites.
- Include rat information/training sessions at major Alaska-related management meetings, local/regional meetings, or conferences.
- Include the subject of invasive rodents/rats in grades K-12 school modules about adverse effects of invasive species in Alaska.
- Post rodent program information on the city or local health department website.
- Enclose materials with other common mailings such as utility bills or the telephone book.
- Distribute fact sheets to private residences, landlords and property owners, schools, food-handling facilities, businesses and institutions
- Deliver flyers and seminars to businesses; provide general program information as well as information on city codes and compliance pertinent to rodent/pest control.
- Provide training, presentations and/or other materials via appropriate venues, e.g.:
  - Meetings of employees and/or citizens
  - Meetings of maritime, fishing, shippers, and harbormasters' organizations
  - Meetings of state municipal and community planning organizations
  - In hunting and fishing regulation books, through Commercial Fisheries Entry Commission mailings, Subsistence Division outreach to rural communities, and at ADF&G offices
  - At birding and other conservation-themed conferences, including on risk management, contingency planning, and biohazards spill response.
- Develop and maintain an interactive website about invasive rodents in Alaska, and prepare/post rat-related materials, information, and news. Subtasks include activities such as:
  - Prepare and post maps of current rat distribution.
  - Keep confirmed rat sightings posted and updated until eradication at that site is deemed complete.
  - Post the Invasive Rodent Plan and any updates, as well as links to recommended readings and other websites.
  - Post information on how to get approvals/authorization for use of toxicants to control rats, and where/how to purchase recommended toxicants.
  - Maintain web-based statistics on the types of infestations in Alaska and their sources. This might help target the arenas in which strengthened public information campaigns, ordinances, or laws are needed to protect Alaska's resources and people.

Offer Effective Incentives

- Develop contest(s) to design state or regional rat prevention and control logo(s).
- Print and distribute T-shirts, hats, or other marketing items that can be given as handouts to increase citizen and employee awareness.
- Establish an awards program recognizing individuals or groups for their efforts to eliminate rats in a community, region, or broader geographic area.
- Develop methods to recognize "good performers" (e.g., through industry or health agency certification programs).

Help Implement Projects that Protect Alaska

- Develop products that inform the public about the results of research and eradication projects.
- Provide case studies or other examples on a central website for communities and others to use.
- For large-scale eradication or control operations, prepare information to help address concerns about: toxicants; potential effects to nontarget species; and effects on wildlife users.
- Develop a project-specific outreach program and media plan for preparing/circulating press releases and special interest articles.

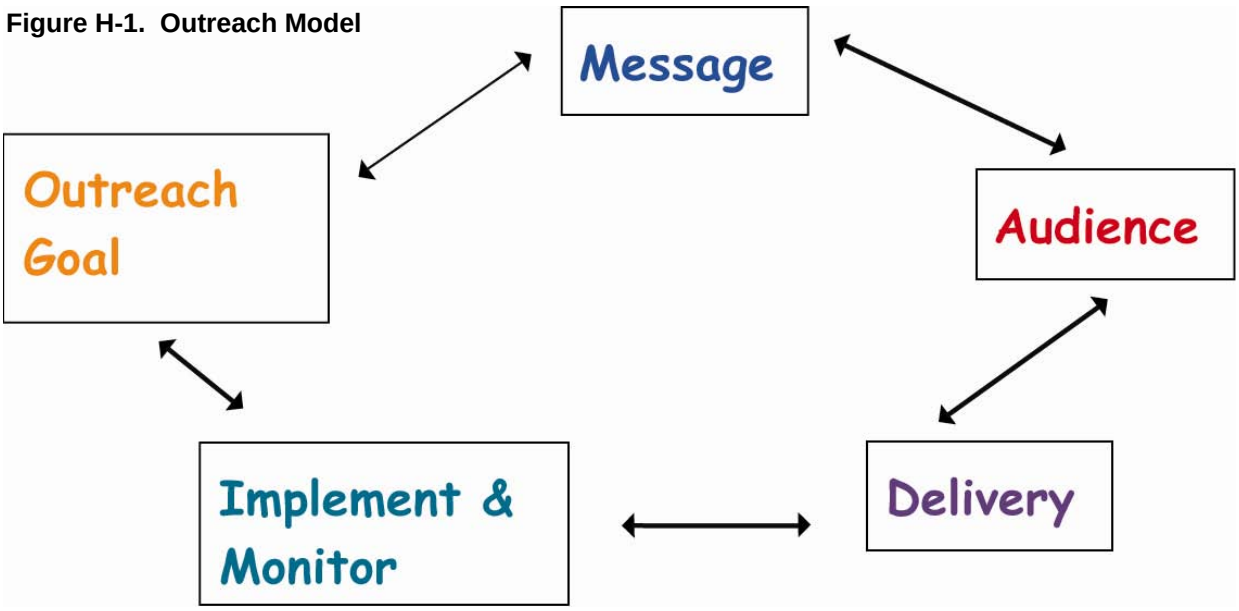
Planning Strategic Outreach Efforts

Well-planned, strategic outreach helps to guarantee that outreach goals will be met. When evaluating outreach options, it is important to recognize that some members of the audience could be strongly opposed to proposed rodent-related actions, including those designed to help protect at-risk wildlife. In many cases, working closely with potential opponents -- to understand their concerns and provide accurate information -- may help assuage fears. This can help achieve informed consent for a program even if some program elements do not align with a critic's personal values.

An important aspect of outreach and education is to publicize successes: The importance of engaging the media and citizenry in accounts illustrating progress toward individual project goals and statewide rodent goals cannot be overemphasized. Celebrating successes publicly can further educate the public about invasive species, biodiversity conservation and the many other benefits of rodent management efforts. Besides preparing newspaper, TV, and radio spots, consider inserting information into relocation information packages and submitting articles for newsletters (e.g., government, NGO, or industry publications) having instate, regional, or broader audiences.

Employing the model shown in Figure 1, and answering the questions shown below it, will help in planning strategic outreach activities.

Figure H-1. Outreach Model



Outreach Goal: What is the goal of your communication effort?

Identification of specific outreach goals, such as behavior change, project support etc. will start your outreach planning on the right foot.

Message: What do you say to your audience to achieve the outreach goal?

Make it clear, concise, and repetitive.

Audience –Which audiences (or stakeholders) are key to achieving your outreach goal?

Choose the audiences that are most important or can have the most influence. Learn about those audiences. The better you understand your audience, the better you can tailor the message and delivery to them.

Delivery - How do you deliver the message to your audience?

How does your audience receive information? Is money available for outreach? How much time do you have? Select the appropriate delivery tool for your situation. Tools can be products, programs, events, and more.

Implement and Monitor - Was the message delivered and understood?

An implementation schedule with tasks, assignments, funding, partners, and deadlines will help deliver the message. Changes to behavior, attitudes, or knowledge can be expected if the right message is being delivered to the correct audience. Identify ways to find out if the audience is receiving the message, and more importantly, if the outreach goal is being met.

Model provided by C. Rezabeck, FWS

3.0 Prevention Efforts are Mission-Critical

3.1 Redundancy and Repetition are Desirable

In order to control rat populations, reduce rat damage in infested locations, and reduce the likelihood of an infestation spreading to other areas, robust prevention activities of many types must be undertaken. The previous section described the importance of conducting outreach and training to limit sources and improve interception, and of targeting key transportation vectors and audiences. Awareness and prevention by citizens, community residents, and employees can be improved by posting information about rodents and providing periodic training. Improved personal awareness and early spotting of rodent invaders translates to earlier removal of these pests.

Overdo It
The most important consideration with regard to 'prevention' activities is to plan to purposefully overdo them. After all, "underdoing" prevention activities equates to a failure of prevention. *This point cannot be stressed enough:* Failure to prevent rodents from arriving leads to a corresponding increase in the risk of rodent populations becoming established and causing harm.

General Recommendations on Prevention
Following are some approaches that are important for helping ensure successful prevention efforts across the state:

- Intercept and eradicate invaders as near to the point of their arrival as possible.
- Kill all rats arriving at rat-free locations, and eliminate rats where they are established, including on vessels.
- *Never* release live rats (including pets or lab rats) into the wild, and never throw captured rats overboard; they are excellent swimmers and may reach land.
- Avoid transporting any structures, shipping containers, equipment or supplies that could result in accidental transplants of nonnative rodents, particularly to and among islands. If such activities cannot be avoided, take the necessary prevention measures (see following bullet).
- When preparing to undertake an activity that may risk spreading rodents, perform a Hazard Analysis and Critical Control Points (HACCP) analysis and develop the procedures needed to prevent your operations from contributing to further spread. For more information, visit the Hazard Analysis and Critical Control Point Planning For Natural Resource Management website at www.haccp-nrm.org.
- Provide periodic training for agency and other personnel to ensure no shortage of trained responders in the event of a rat spill or infestation. Responders should be well acquainted with materials in this appendix; as appropriate, they should also be certified to use rodenticides.
- Tighten local regulations, ordinances and operational procedures; this includes for refusing entry to cargo or ships that are rat-infested, regulating supplemental feeding or open trash, and requiring rodent removal actions by landowners and businesses.

- Revise insurance and tax code structures to promote human and corporate behaviors that discourage or eliminate rodent invaders.

At a day-to-day level, several factors come into play in trying to prevent rodent infestations. One key element is facilities as clean and rodent-free as possible. Eliminate attractants (including shelter, edible refuse, and other food) and exclude rodents from places where these attractants exist.

A second element of prevention, also referred to as "quarantine," focuses on maintaining a barrier to invasion (or re-invasion) by eliminating movement of rodents from one area to another. Both elements are extremely important in the fight against rats. Sections describing each of these elements follow.

3.2 Sanitation and Habitat Modification

Long-term rodent control combines sanitation, habitat modification (including exclusion) and, when necessary, the use of traps and baits. All are elements of an integrated pest management program, described later in this appendix.

Sanitation

Good housekeeping or sanitation is an important element of rodent prevention and control. Harborage refers to the shelter that rats need to avoid predators, stay warm, store or consume food, and raise their young. Rats find harborage in a variety of situations, from underneath homes and junked vehicles, to piles of fishing nets, and haphazard or tightly stored freight or cargo. Eliminating food, water, and harborage for rats and mice can reduce rodent populations rapidly.

Rodents find warmth and shelter inside structures, shipping containers, piled debris, and self-dug burrows. However, *food* is their first reason for living in and around containers and structures, including vessels. Every effort should be made to eliminate rodent food sources at and near human habitations, to rodent-proof trash containers and dumpsters, and keep dumpsters and trash cans as well as the areas beneath them clean.

Figure H-2. Garbage attracts rats.

Habitat modification serves some of the same purposes as sanitation: It also increases the ease with which premises can be inspected for rodent sign.

Recommendations on Sanitation and Habitat Modification

- Keep trash and foodstuffs (including pet food and bird seed) in metal or other rodent-proof containers and structures, preferably in rat-proof rooms.

- Replace community trash containers with rodent-proof containers; this should occur during implementation of a community's rodent management plan, particularly for areas where rodents are a recurring problem.
- Securely plug or screen dumpster drain openings, and place dumpsters as far away from structures as is practical; equip them with tight-fitting covers, and have no holes larger than 0.6 cm (0.3 in).
- To keep rodents from relying on dumpsters as a food source, keep dumpsters, trash cans, and the areas underneath and around them clean.
- Conduct trash removal regularly and frequently enough to keep rodents from relying on dumpsters as a food source. For commercial food-handling establishments, this may mean having trash removed two or more times per week.
- Make community dump improvements.
- Remove harborages such as piles of nets, rubbish, trash, junk, boxes, and protected enclosures.
- Store food on high shelves in sealed rooms and check often for rodent sign.

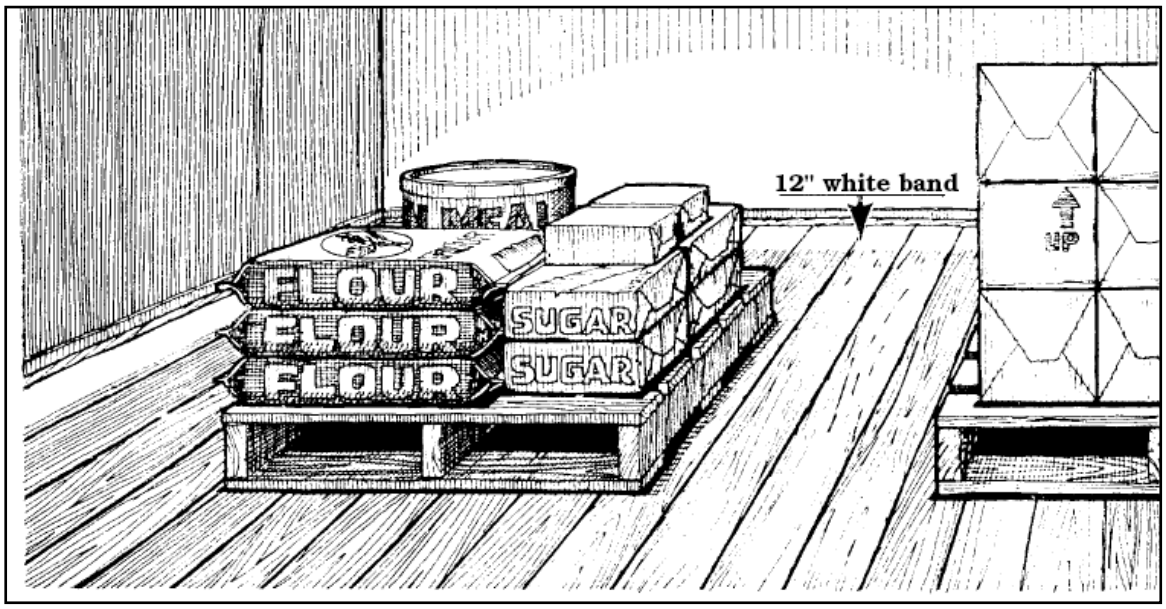


Figure H-3. A 12-inch (30-cm) white painted band makes inspection for rodent sign easier.

- Neatly organize stored items and cargo in narrow rows, preferably on elevated shelving or racks that allow easy detection of rodents or rodent sign.
- Cover or pick up pet food dishes when not in use.
- Pick home-grown fruits and vegetables when ripe so rodents will not feed on them.
- Dry up sources of water:
  - Do not allow water to puddle around structures or air conditioning units.
  - Fill faulty grades to slope away from structures.
  - Keep gutters and downspouts free of debris
  - Correct any indoor moisture problems such as leaking pipes and faucets.
  - Do not let water stand in sinks overnight.

- Keep lids on toilets – rodents have been known to drink water, and even urine, from toilets, and they can enter structures by swimming through pipes and emerging from toilets.

- Keep the perimeter of buildings and other structures clean of tall weeds and debris (including stacked lumber, fire wood, boxes, old cars, and other stored materials) to discourage rat activity and allow easier detection of rat sign.
- Use the "100 foot" rule: Cut grass, weeds and trim bushes within this distance, and store hay or firewood at least 30.5 m (100 ft) away from structures.

Exclusion

As a rule, anything that will make a structure less hospitable to rodents (sometimes called "rat stoppage") should be considered important. Often, rodents enter structures through doors, exterior vents and floor drains, as well as toilets. Along with sanitation, exclusion or rodent-proofing is the first line of defense against rodents. Rodentproofing requires the use of materials considered rodent-resistant. These materials include:

- Sheet metal (26 gauge or heavier)
- Perforated metal [24 gauge or heavier with openings no more than 0.6 cm (0.3 in)]
- Hardware cloth [19 gauge or heavier with openings no more than 0.6 cm (0.3 in)]
- Brick with mortared joints
- Cement mortar (1:3 mixture)
- Concrete (1:2:4 mixture)

Rodentproofing changes the structure of buildings in order to prevent entry of rats and mice (Baker et al. 1994). To be effective, rodentproofing must block every possible rodent entry point. Various rodent-proofing approaches take advantage of the fact that, having established contact with a wall, a burrowing rat will not dig away from it to circumvent an obstruction.

Even if rodents are not thought to be present, an important preventive measure is to seal all holes large enough to pass mice (dime-size or larger). Where rodent activity is high, building construction should take into consideration the athletic abilities of rodents; for example:

- Rats can squeeze through cracks 1.3 cm (0.5 in) wide; mice, 0.6 cm (0.3 in) wide. Any place a pencil can be poked, a mouse can go.
- Rats can climb the inside of vertical pipes 3.8 – 10.2 cm (1.5 - 4 in) in diameter.
- Rats can climb the outside of vertical pipes up to 7.6 cm (3 in) in diameter and any size pipes if within 7.6 cm (3 in) of a wall.
- Rats can jump vertically 91.4 cm (36 in), horizontally 121.9 cm (48 in), and reach horizontally or vertically 38.1 cm (15 in).
- Rats can jump 2.4 m (8 ft) from a tree to a house if the branch is 4.6 m (15 ft) above the roof.

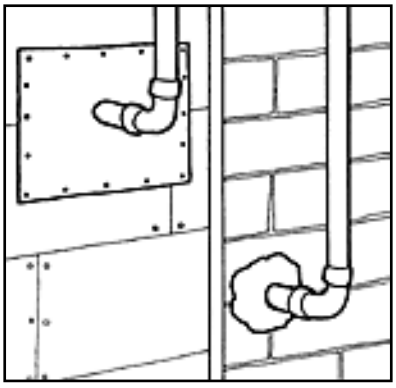


Figure H-4. Rodentproof openings around pipes with sheetmetal (left) and concrete (right).

Recommendations on Exclusion and Rodent-proofing

- Rodent-proof gnawing edges (the edge of a substance rats can gnaw through) with rodent-resistant materials; places to rodentproof are edges of doors, windows, holes where pipes enter buildings, ventilation holes in foundations, roof vents, exhaust fans, and eave vents (see Fig. H-4).
- Reduce ability of rats to move around easily; seal even the smallest holes that give them access to different areas: Seal openings larger than 1.3 cm (0.5 in) wide for rats [or 0.6 cm (0.3 in) wide for mice]. Steel wool is an effective barrier with which to plug small holes because rodents will not chew through it. Other useful materials include 0.6-cm (0.3-in) mesh metal screen or hardware cloth, concrete mixes or durable sealants for smaller openings
- Keep doors closed, with floor clearance of no more than 0.6 cm (0.3 in), and attach metal kick plates (Fig. H-5).
- To prevent rodents from climbing:
  - Attach 12-inch (0.3-m) sheet metal collars onto support poles, pillars and vertical pipes (Fig. H-6).
  - If anchor bolts or galvanized concrete nails are placed in mortar joints or siding, space them widely enough to avoid rodents using them as ladders; fill and smooth mortar joints for 12 inches on either side of galvanized barrel applications.
- Cover exterior vents (Fig. H-7), floor drains and, as needed, toilets, with screens or grates sufficient to exclude rodents, and fill spaces around drains with cement.
- Prevent rats from jumping onto or into structures; where rodent activity is high, install 1.1-m (3.5-ft) high bands of polished metal or gloss paint up from grade level around the structure.
- Reduce rat burrowing adjacent to or under building foundations or other structures by: 1) burying a metal band that extends vertically down to 0.6 m (2 ft) below grade; or 2) placing a strip of heavy gravel adjacent to their base; gravel should be at least 2.5 cm (1 in) in diameter and laid in a band at least 0.6 m (2 ft) wide and 15 cm (0.5 ft) deep (Timm 1994). Another option is to install L-shaped metal barriers buried at the foundation level (see Fig.H-8).
- Inspect frequently during the first 2 weeks of completing rodentproofing and promptly repair any breaks (searching rodents will be seeking these out). Eliminate any rodents trapped indoors due to rodentproofing.

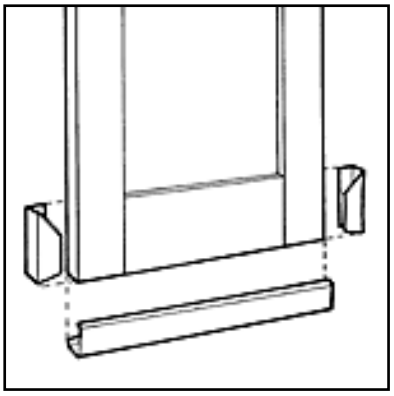


Figure H-5. Rodentproof a door, by placing a channel at bottom and cuffs at sides over the channel.

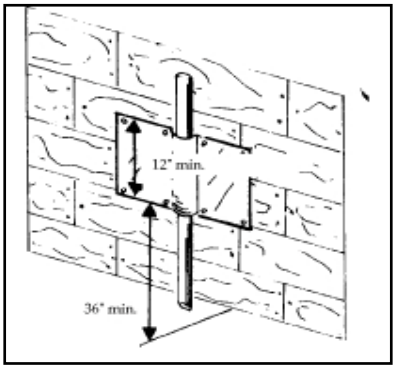


Figure H-6. Put sheet metal collar around pipes to prevent climbing.

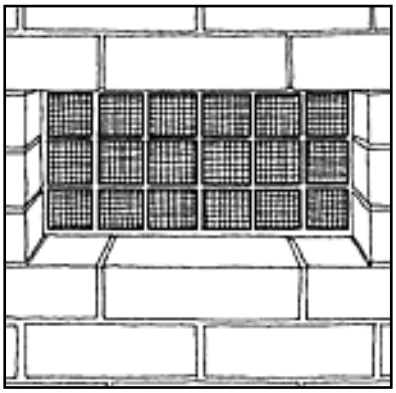


Figure H-7. Rodentproof vents.

A search of the internet reveals a variety of community ordinances aimed at preventing or controlling rat infestations. Many of them address the need for ongoing rodent exclusion efforts.

For instance, see a portion of the municipal code from Moses Lake, Washington at: *http://www.ci.moses-lake.wa.us/files/documents/municipal_code/CHAP816.pdf*. For more detailed information on rats' physical abilities and the need to design rodent-proof structures, also see Appendix C: Important Rat Behaviors and Attributes.

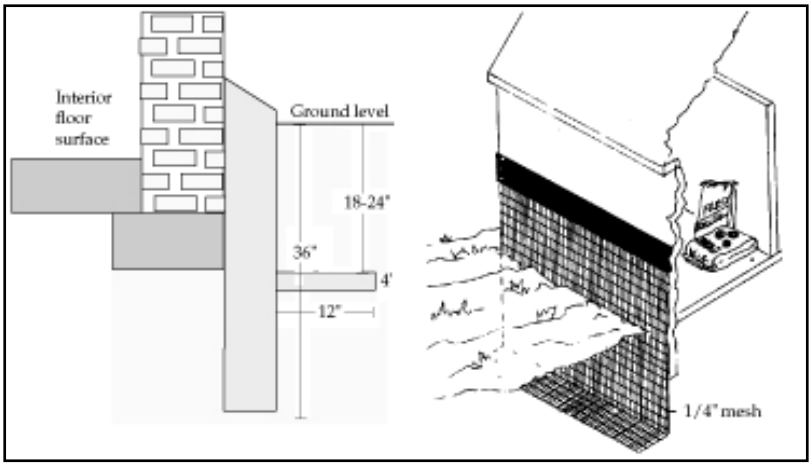


Figure H-8. Build curtain walls to keep rats out of buildings. Left: A curtain wall made of concrete that extends below ground level. Right: Wooden structures can be rodent-proofed by installing hardware cloth topped by a band of sheet metal.

Recommended reading:

Baker, R.O., G.R. Bodman, and R.M. Timm. 1994. Rodent-Proof Construction and Exclusion Methods. In Prevention and Control of Wildlife Damage. U.S. Department of Agriculture/APHIS/Animal Damage Control. University of Nebraska-Lincoln, Institute of Agriculture and Natural Resources, Cooperative Extension Division. Pp. B-137 – B-150. (see http://hgic.clemson.edu/pdf/pcwdrodent_proof_construct.pdf)

3.3 Prevention and Quarantine

Preventing rat infestations on vessels, in harbors and waterfront areas, and at freight transit points will be critical to conducting successful rodent prevention actions in Alaska. This will be especially important on islands or in ports serving outlying islands.

The idea is to keep invasive rodents from becoming established in new locations. To do this, state or local borders and coastlines must be secured against invasion by rats arriving via vessels, aircraft, and vehicles. In places where rats already occur (outside or within Alaska) and where densities of cargo, stowage, and gear around docks and freight areas create potential invasive rodent sources, it is also critical to keep rats from boarding departing vehicles, aircraft and vessels. Both elements are extremely important in the fight against rats.

Prevention Regarding Vessels and Harbors
Vessels are implicated as the source of many of the world's rodent infestations, especially on islands. Understandably, some experts have stated that no ship is rat-proof and that all should be regarded as potential sources of rat infestation (Moors et al. 1992).

One important goal is to have vessels traversing the state's coast or visiting Alaska islands and ports – and the ports themselves – be rat-free. Vessels visiting known rat-infested harbors will need to take extra precautions to avoid contracting rodent infestations and bringing them to Alaska ports of call, or within swimming/grounding distance of unique wildlife habitats.

As noted in the plan, vessel and cargo-related operations including upriver barging pose elevated risks of rodent transfer to Alaska's waterfront communities and other rodent-vulnerable locations. Also, rats have been known to swim up to 100-200 m offshore to board vessels at anchor (Harper 2005).

Basic rodent prevention recommendations in the maritime realm include the following:

- Install and maintain permanent rodent control devices (e.g., bait stations) on all vessels.
- Place *permanent rodent-poison stations* on the wharf and within a radius of about 200 m of the wharf as a further precaution against nonnative rodents infiltrating the waterfront and establishing breeding colonies.
- Use line guards for ship-to-shore lines aboard barges, ships, and other vessels; this can help keep rats from climbing aboard from an infested port.
- Prevent rodents from leaving infected vessels, cargo transfer areas, or buildings slated for relocation; also, prevent rats from boarding/transferring while vehicles, vessels, or cargo containers are in close proximity; this includes while vessels are rafted together, or during helicopter landings on distressed vessels.
- Anchor offshore rather than dockside during darkness or semi-darkness when rodents are typically most active.
- In new boat construction, use the latest in modern design features to beat rodents.
- Develop training and tools appropriate for use by owners/operators of vessels and waterfront facilities.

Prevention Techniques Relating to Cargo Transfer and Shipping

Moors et al. (1992) makes a number of recommendations focused on protecting rodent-vulnerable islands. However, many actions suggested are equally relevant to keeping rodents in infested ports, harbors, and freight transit areas from being spread to parts of Alaska that are rodent-free. Such recommendations include the following:

- Inspect cargo for rodent sign, and do not take aboard, or transfer from your vessel to an uninfested area, any cargo containing signs of rodents. Even when you do not believe rodents are present, shake out piles of stored netting or other materials in which rats (and mice) could be nesting; trawl nets from an infested ship or stored in a rat-infested port often have rats inside.
- Seal and rat-proof all boxes and crates. Boxes and crates should be constructed so that a brief inspection will reveal if rats or mice have gained entry.
- Pack and hold cargo and stores in rodent-proof buildings until loading commences. Particular care must be taken with freight containers, especially if these are loaded in places where rodents are not controlled.
- Inspect cargo and stores destined for transport by boat, plane or helicopter to ensure that such cargo and stores are rodent-free.
- Re-check cargo and stores for rodent sign during unloading. Boxes suspected of containing rats or mice must be retained on the ship or aircraft. Special care must be taken when traveling between infested and rodent-free islands in the same group.

Recommended reading:

Moors, P.J., I.A.E. Atkinson, and G.H. Sherley. 1992. Reducing the rat threat to island birds. Bird Conservation International. Vol. 2:93-114.

3.4 Special Precautions Needed for At-Risk Islands

Moors et al. (1992) also outlines four recommendations that will be crucial for excluding rodents from islands with high value resources such as unique wildlife. These are as follows:

1) Ships visiting rodent-vulnerable islands of very high conservation value must carry rat-poison stations that are in continuous operation. Crews of such ships must be given incentives to maintain a hygienic ship, report the presence of rats, and assist in removing them.
2) No wharves, jetties, slipways or airstrips should be built on any rodent-vulnerable island, mooring lines and gangways should be kept to a minimum, and vessels using any existing wharf should be anchored in the stream at night. If rat guards are used on mooring lines, they must be fitted in reverse to restrict rats to the ship. Where boat slipways are absolutely necessary, thorough checking and deployment of poison baits on a boat from another harbor or port is essential before removing it from the water.
3) Where buildings exist on a rodent-vulnerable island of very high conservation value, stores should be unpacked in a rodent-proof room to ensure that any stowaway rats or mice can be caught before they escape outside.
4) For rodent-vulnerable islands of exceptional conservation value, routine trapping and searches for rat sign should be made yearly or more frequently by skilled personnel to ensure early detection of any rats before they become properly established.

3.5 Ensure Rapid Shipwreck and Rat Spill Response

Even with good attention to outreach, prevention, and quarantine efforts, Alaska must be "at the ready" to protect its coastline and unique wildlife areas from harmful rodents aboard vessels in transit through, or adrift in, state waters. Prevention is the primary strategy for addressing the *potential* for rodent infestations that could result from a distressed vessel. It is a key element of the FWS-Alaska Region's Invasive Rodent Program and Shipwreck Response Plan (SRP), and the Rat Response Strike Team that implements it. How do these approaches work in the event of a potential rat spill?

Implementing Alaska's Shipwreck Response Plan

When migratory birds or other resources managed by the FWS are at risk from an oil spill or a potential oil spill, the FWS can receive authorization and funding from the U.S. Coast Guard (USCG) to participate in the oil spill response within the Incident Command System. During an oil spill response, the FWS provides information on resources at risk and may make recommendations regarding response strategies to prevent and minimize resource impacts; e.g., towing an adrift vessel away from a wildlife-rich island. The Service's primary duty is to provide support to the Federal On-Scene Coordinator (FOSC) regarding the impacts of oil to the ecosystem. However, based on information from FWS, the FOSC may determine that other activities, such as rat extermination, can occur concurrently using resources mobilized for the spill response. In these cases, FWS personnel also bring their shipwreck response supplies, including poison baits, for potential deployment. See Appendix F for information on rodenticide registration, response team training, and assembly and caching of response supplies.

Shipboard Assessment
When distressed vessels go aground or wreck, they often do not break up immediately. This can provide a window of opportunity to board the vessel to inspect for rodent sign and set out traps and/or poison bait stations. After a vessel grounding on a rat-free island, the FWS requests approval from the USCG to board the vessel to inspect for rats. Safety considerations play an important role in determining if, how, and by whom the vessel can be boarded.

Trained personnel (Strike Team members or others) board the wreck and employ techniques to determine if rats are present and, if so, to prevent potential rodent escape. To keep rodenticides from ending up in the water, no rodenticide baits are used if a boarded vessel is determined to be in danger of flooding or breaking apart.

Even despite a thorough reconnaissance and elimination effort aboard a distressed vessel, it is still likely that some rats will escape the vessel and go ashore. Therefore, rodent control is the primary *response* strategy following a vessel incident (particularly vessel groundings) that results in an oil spill or the threat of an oil spill on remote seabird nesting islands. The AMNWR's SRP and Rat Response Strike Team combination is a model that could be used statewide. The SRP outlines the requirements and the implementation of an emergency rodent control response effort. The strike team has the correct gear and is trained in remote island access, invasive rodent biology and behavior, and in the proper handling and distribution of rodenticides.

As soon as the FWS becomes aware of a distressed vessel or potential vessel grounding, strike team personnel immediately begin to mobilize gear and work through the logistics of getting to the incident site. Once on site, the focus is two-fold: a) to rapidly determine if rats or other invasive rodents are present on the ship, and b) if so, to contain them by effectively covering all rodent home ranges, first on the entire vessel, and second, on shore terrain in the immediate vicinity of the grounding, with traps and rodenticide bait stations. The aim is to rapidly contain and eliminate the rats, before any offspring are born.

Techniques for Containing an Invasion Force
Ship-borne invasions of rodents are considered conservation emergencies that should be treated as urgently as a fire (Moors et al. 1992). If the worst happens, and a vessel believed to contain rats breaks up, timely deployment of control measures is imperative in preventing rats from surviving and becoming established on a rat-free island. Especially in or near sensitive island environments, it is important to also ensure that response vessels and other modes of response transport are kept rodent-free.

Recent studies in New Zealand suggest that rats arriving on rat-free islands change their behavior to adapt to the rat-free environment, and that they remain around the landing site for 3-4 days before striking out on what are sometimes fairly lengthy treks to investigate their new environment (Russell 2007). However, the dispersal behavior of invading rats in Alaska is still relatively unknown with regard to area coverage and timeframe.

Strike team personnel are encouraged to "think like a rat" and inundate all potential distribution corridors and hiding places with traps and stations. They set out traps and rodenticide bait stations more densely in the immediate vicinity of the vessel and less densely with increasing

distance from the vessel. Permit restrictions limit rodenticide treatment areas to 10 acres (4.0 ha) per shipwreck.

Recommendations on Rat Spill Response

- Aboard ships, including ships in distress, if any sign of rodents is found, deploy extra traps, sticky boards, and rodenticide bait pack pellets to prevent any rodents from escaping at or near Alaska ports or lands.
- In the case of a rat spill (discharge of rats), apply rodent management treatments (e.g., traps and rodenticide baits) to ship/shore terrain in the immediate vicinity of the disabled vessel and prevent rats from boarding any boat or helicopter that arrives to aid a vessel in distress.
- Whenever possible, route ships in distress away from rat-free islands where they could discharge rats.
- Conduct shipwreck response for "rat spills" only by using trained and Alaska Department of Environmental Conservation (DEC)-certified responders.

4.0 Detecting Rodents and Evaluating Infestation Levels

Whether on vessels, remote islands or in communities, rapid reporting and confirmation of rat sightings is critical for successful protection of Alaska's interests. The sooner confirmation of a sighting occurs, the sooner a coordinated response effort can begin. This in turn will limit opportunities for rats to establish a breeding population and infect other locales or vessels. A delayed response could allow rats to swim, be inadvertently transported to other areas.

At a particular site or location, focus detection and assessment efforts where rodents are most likely to find their three greatest needs: food, water, and shelter. Routinely examine property (including ship, barge, or aircraft) and cargo for rodent sign and damage, including damaged electrical wiring and cables. A search of premises should be thorough and include: crawl spaces, attics, basements, holds, and lockers; behind and under stored materials and cargo; and around building foundations.

Determining what intervention is needed requires gathering accurate information on whether rodents are present, and if so, the species and level of infestation. It is important to trap at least one individual in order to make a positive identification as to species. The following pages describe a number of techniques for helping to determine rat presence, absence, and population levels.

Rats are usually easiest to detect and assess when their population numbers are highest. In Alaska, this corresponds to Fall (e.g., September to November in the Aleutians and Gulf of Alaska). This is when natural food sources such as seeds, fruits, nuts, tubers, and other animals are abundant. Using this logic, Fall would be the prime time to schedule periodic or ongoing monitoring of *potential* outbreaks (i.e., periodic annual or semi-annual "testing" in seemingly rat-free communities). Should rats be found, eradication efforts would follow, once natural food sources have declined.

Elsewhere, the invasive rodent plan described the relative ease with which large volumes of freight and fuel make their way across Alaska by air, ship, barge, and road. It also noted the rapid reproductive rate of rats and the challenge in detecting rats when they are still at low population levels. Given these considerations, it is particularly important to conduct *ongoing detection* for rats at locations *not thought to be* infested.

4.1 Where to Focus Detection Efforts

- Conduct periodic *ongoing* detection efforts in:
  - Vessels operating, or expected to operate in, or transit adjacent to, Alaska waters
  - Ports, rail yards, and freight transit areas
  - U.S. and Canadian Customs check-stations
  - Coastal national wildlife refuges and national parks
  - Coastal state special areas and selected coastal state parks, particularly if containing wildlife-rich islands or located near transportation hubs

  - Communities, especially near port/harbor, airport, landfill, waste transfer stations, cargo-handling and food processing facilities
  - Communities nearest the Alaska/Canada (British Columbia) border
- Conduct incident-specific detection, assessment, and removal, and report results to designated officials, for:
  - Any community, site, or locale for which a rat sighting has been confirmed
  - Cases of reported shipboard infestations, e.g., processing ships near islands, particularly those that are rat-free
  - Cases of ship foundering, as appropriate, especially near rat-free islands
  - All cases of ship grounding, particularly if rats were known or believed on board

4.2 Detection and Assessment Techniques

A variety of tools and techniques exist for identifying an infestation. They include inspecting for rodent sign; setting out sticky boards, tracking boards, and snap traps; and using black lights to locate urine trails. The following section provides details.

Rodent Sign

Since rats and mice are active at night and not typically seen during the day, it is necessary to recognize signs of their activity.

Droppings and Urine - Most people first recognize rodent problems by finding droppings (Fig. H-9) or urine stains in and around buildings. Droppings may be found along run ways, in feeding areas, and near shelter. Rodents usually have favorite toilet areas but will void almost anywhere. Old droppings are gray, dusty, and will crumble. Fresh droppings are black, shiny, and puttylike in texture. Rodents urinate while running, and the streaks are characteristic. The urine glows under ultraviolet lights and glows blue-white when fresh.

Figure H-9. Droppings of roof rat (1/2", left), Norway rat (3/4", middle) and house mouse (1/8", right).

Gnawed Objects - Rodents gnaw daily in order to keep their teeth short and sharp; rats also gnaw to gain entrance or obtain food. Teeth marks on food, building materials, wire, and edges of beams are indications of gnawing. Gnawing may be visible on doors, ledges, in corners, in wall material, on stored materials, or other surfaces wherever rats are present. Fresh accumulations of wood shavings, insulation, and other gnawed material indicate active infestations. Fresh gnawing in wood is usually light-colored with sharp, splintery edges. Old gnawing is smooth and darker. Size of entry holes (often 3.8 cm [1.5 in] in diameter or less for mice, 5.1 cm [2 in] or larger for rats) or tooth marks can be used to distinguish rat from mouse gnawing.

Runways - Rats habitually use the same paths or runways between harborage and food or water. Runs or burrows may be found next to walls, along fences, next to buildings, or under bushes and debris. Outside runways are paths 5.1 – 10.2 cm (2 – 3 in) wide and appear as smooth, hardpacked trails under vegetation. Indoors, runways are usually found along walls. Rats memorize pathways and use the same routes habitually. The presence of undisturbed cobwebs or dust indicates runways are not being used.

Rubmarks - Along runways, dark greasy rubmarks appear from contact with oil and dirt on the rodent's body. Rubmarks on walls, beams, rafters, and pipes appear as black smudges left by the rodent. New rubmarks are soft and will smudge. Old rubmarks are brittle and will flake when scratched. Rafters may show swing marks if roof rats are present (see photo at: http://www.msmosquito.com/pdf/Rat.pdf).

Tracks – Rodent footprints or tail marks may be seen on dusty surfaces or in mud (Fig. H-10). In winter, rodent tracks are frequently visible in the snow between homes and other structures (R. Sinnott, ADF&G, Pers. Comm. 7/25/06).

Figure H-10. Rat tracks in mud.

Burrows - Norway rats burrow for nesting and harborage. Burrows are usually found in earth banks, along walls, under rubbish and concrete slabs. Freshly dug dirt scattered in front of 7.6-cm (3-in) openings with runways leading to the openings is characteristic. Burrows usually are 45.7 cm (18 in) deep in most soils. Slick, hardpacked runways indicate an old established colony.

Live Rats and Dead Rats - The sighting of live rats is a sure sign of infestation. Sightings in the daytime indicate large populations, or a response to an upset such as disease or poisoning. The presence of mummified rat carcasses may indicate a former infestation but finding many fresh carcasses suggests disease or poisoning.

Sound - Sounds such as gnawing, climbing in walls, clawing, various squeaks, and fighting noises are common where rats are present, particularly at times of the day when they are most active (Timm 1994) or in quiet areas. The young often squeak while in the nest.

Determining Infestation Levels

Typically, rat sign and visual sightings are of limited value in accurately estimating rat numbers. However, they are the simplest methods and often the only practical method available (Timm 1994). Several techniques can aid in assessing rat infestation levels in storage areas, warehouses, and other structures. These include painting white swaths along the floor and lower walls[26] and creating home-made tracking plates or tracking tunnels from which a "percentage of tracking" figure can be derived. Factors to consider in making an assessment of the intensity of a rat infestation include: amount of rat sign observed, number of rats killed in traps, number of poison baits eaten, and the number of any rats that are live-trapped.

More quantitative techniques exist for assessing the level of rodent activity in an area (e.g., before and during a period of active trapping). However, each has various degrees of reliability (Dunlevy and Scharf 2007a). These include setting out commercially available tracking tunnels, gnaw blocks (a non-toxic compressed grain product) and/or gnaw sticks[27] and monitoring them daily for percent of tracking or percent of gnaw devices chewed over the course of a set period.

Enlisting Help in Making Assessments

Keeping an eye out for signs of rats is not difficult, and many industries and commercial facility plan, Section 2.2.3, Damage to Property, Goods and Equipment). However, the secretive nature and high reproductive rate of rats gives them an advantage as an invasion force: They can become well established before anyone in a locality really notices. To help intensify assessment efforts, creativity and collaboration may be needed to make vigilance and reporting 'fun' or otherwise perceived as rewarding for employees, local citizens and communities. In some places, such as Alberta, the government has taken on the role of providing citizens with the materials needed to conduct successful eradication and control efforts.

Recommendations on Identification and Assessment

- Know as much as possible about key habits and rats' preferred ship/shore habitats; their actions are predictable.
- When distinguishing the Norway rat from the roof rat, pull the tail back over the body. The tail of the roof rat will reach the nose; the tail of the Norway rat will not reach forward of the ears (for more information, see http://www.ratbehavior.org/QuizNorwayRatRoofRat.htm).
- Use multiple signs to identify rodents. If need be, get expert confirmation for any suspected sighting; someone calling to report a rat may actually have seen a different animal altogether, e.g., a muskrat or ground squirrel.
- Document the damages caused by rodents; good photos can be very useful in outreach and education efforts.
- Consult web-posted or other protocols for use in determining presence/absence of invasive rodents and level of infestation.

[26] See Fig. 7, page B-110 I *Norway Rats* by Robert M. Timm at http://icwdm.org/handbook/allPDF/RO_B105.PDF

[27] Gnaw sticks can be made from small-diameter (e.g., 5/16") dowels soaked in an attractant such as corn and peanut oil and air-dried before being firmly stuck in the ground (Dunlevy and Scharf 2007a).

- Ensure that the assessments you make are as accurate as possible; educate participants and affected parties in how to effectively locate and set traps and employ simple assessment techniques to help determine the extent of an infestation.
- Inspect for rodent sign, including gnawing or droppings:
  - Set out sticky boards, tracking boards, and traps.
  - Use black lights to illuminate urine trails; new trails glow blue-white when fresh.
  - Create "tracking tunnels" by spreading dust material like flour or talcum powder along runways; footmarks of rats (5-toe hind foot, 4-toe front foot) or tail drag marks will show in the powder.
  - To determine amount of tracking, determine the percentage of surface area covered by rat tracks. Activity at 10% or more of tracking tunnels (or "stations") is commonly used as a threshold for initiating action to control or eradicate rodents.
- Check any burrows, especially of rats, for activity by stuffing newspaper, leaves, soil, etc., into the openings, then check 24 hours later to see if rodents have reopened the burrows. If activity is noted, place a cup of rodenticide/toxicant bait pellets (which, unlike block bait, cannot easily be kicked out) deep into the burrow and recheck a few days later to see if the rodents were eliminated.
- Ensure optimal trap placement and use of trapoing techniques that reduce negative effects of rats' neophobia (see Section 6.1 below, on Trapping).
- Although rat sign and visual sightings are generally considered to be of limited value in accurately estimating rat numbers, they can give preliminary estimates as follows:
  - No sign? No rats or few present. If only a few rats are present they may have invaded only recently.
  - Old droppings and gnawing common, one or more rats seen by flashlight at night, and no rats observed in daytime? Medium numbers present.
  - Fresh droppings, tracks, and gnawing present, three or more rats seen at night, or rats seen in daytime? Large numbers present.

Exercise caution when using short duration trapping results for determining species of rodents present and their density. Because of rats' neophobia, catch rates may be low at first, even with high numbers of rats present. If more than one type of rat is present, interactions between species may also reduce initial trapping success (L. Wilson, Department of Conservation, New Zealand; Opotiki Area Office, Programme Manager Biodiversity Threats, Pers. Comm. 3/31/07).

- A conservative estimate of rat numbers can also be made by measuring rats' consumption of finely ground grain over a period of time (whole grains or pelleted foods may be carried off uneaten). Consumption may gradually increase to a maximum level over the period of a week or so as rats' natural fear of novel foods is overcome. Divide the total amount of food eaten per day by ½ ounce (15 g); this will give a minimum estimate of the rats present. Some rats eat more than ½ ounce (15 g) daily, but rats will probably also be using other foods in their environment. If too much alternative food is available, this technique will not give an adequate estimate.
- Kill all rodents captured; retain any dead rat(s) for species identification and as needed to conduct toxicant studies or DNA sampling.

- If a confirmed rat sighting is made, promptly inform community or company leadership, including distant communities or potentially affected facilities that are part of your commerce or transportation network.

5.0 Planning Ahead for Rodent Challenges

5.1 Increase Your Understanding

Whether broad or more localized in scale, rodent management programs typically face many challenges. To allay concerns and build public confidence, a program should always utilize thorough and up-to-date knowledge of rodent control. This includes knowledge of rodent biology, Integrated Pest Management (IPM) practices, rodent control devices, and the characteristics and risks associated with rodenticides. It is important to provide the public, proactively and on demand, with information on any rodent control program that is developed.

Begin by doing background reading to understand the obstacles and challenges ahead. Two key references are: "Eradication planning for invasive alien animal species on islands – the approach developed by the New Zealand Department of Conservation" (Cromarty et al. 2002), which describes the importance of having a committed project team and senior management, and "A history of ground-based rodent eradication techniques developed in New Zealand, 1959-1993" (Thomas and Taylor 2002). The latter is an important resource for anyone considering eradicating rats from an area. Both can be accessed at: http://www.hear.org/articles/turningthetide/.

The nature of rodents and their adaptability suggests that we treat each occurrence of rats in Alaska as a unique and specific incident and not automatically draw conclusions based on results elsewhere. At the same time, evidence has shown that much benefit can be gained from reading background literature and accounts of others' eradication/control efforts, conducting pre-trials or scientific research, and consulting experts or expert teams familiar with similar invasive rodent situations. A confirmed rodent infestation is not a prerequisite to begin these steps; in fact, it is best to begin education and planning efforts well ahead – as a contingency planning effort.

To be effective, rodent management operations require a detailed but concise plan, one that melds technical pest management expertise with interagency cooperation and public relations. This is especially true for efforts conducted over large areas or with many partners and jurisdictions.

The Alaska invasive rodent management plan was developed with this principle in mind. An important follow-up will be to foster creation of local plans that address issues and concerns common to a locality (e.g., a region or community) or to specific stakeholder groups. An important preliminary step is to convene stakeholders to review recommendations contained in the state plan and take steps aimed at addressing stakeholder and sector-specific interests.

A key need is to develop rodent prevention/control plans and implement rodent management programs for businesses and locales most likely to attract or encounter rodents. These include: harbors and ports, airports, warehouses, docks, freight transit points, and food-related businesses (processing, storage, shipping or preparation). It will be important to establish and maintain control/defensive stations ("biodefenses"; i.e. trap and poison stations) at all key locations for infiltration.

Prepare a Pathways Analysis
Even if a rodent infestation has not been confirmed, conducting a "pathways analysis" early in any rodent-related planning effort is highly advisable. The example shown below in Table H-1 depicts an evaluation of statewide pathways that can be used as a model for preparing a more localized evaluation.

Because rodents constitute an *invading force*, thinking and acting in strategic terms can be very helpful in keeping infestations at bay. Thought of in military terms, prevention efforts constitute the erection of a "perimeter," and doing a pathways analysis asks the questions: "Where/how are rats most likely to breach the perimeter? What do we do if that happens? What response do we bring to bear on this attacking force?"

Table H-1. Pathways Analysis: How Do Invasive Rodents Arrive and Spread in Alaska?

Known/Expected arrivals
- Pet shipments and breeding of rats for the pet trade
- Pets arriving with new residents

Unplanned arrivals (from an infested source area elsewhere in Alaska, or from Outside)
- Swimming from an infested island or boat
- Ship/boat landings, dockings, or groundings
- Cargo trucks/containers
- Aircraft
- Range expansion (e.g., overland migration from British Columbia)

Unplanned, ill-planned, or unauthorized transfers or releases
- Translocation of rats to uninfested locations (e.g., through movement of portable buildings or storage containers)
- Immigration/translocation of pets to communities where they are outlawed
- Release/escape of pets

Another useful tool in determining the best management approach is to prioritize action based on the severity of likely or potential impacts from rodents, and then consider what can be done about it. The first element is a risk prioritization, or risk analysis, described below.

Conduct a Risk Analysis
To mount an effective response and make wise decisions about resources and desired results, it will be useful to identify and protect the most at-risk areas. This can include areas of high human population or economic value. It may also include those areas that are most biologically diverse or where particularly threatened or at-risk species occur.

The following will each play into risk estimations made by land managers, public health officials, or others:
- Level of infestation
- Level of isolation (risk of rats from one area reaching another area, or a rat-caused illness spreading person-to-person)

- Level of risk to local or nearby resources (e.g., for islands, could a rat swim the separation distance?)

Use of a flowchart or similar approach for identifying categories of risk may be beneficial. It can help focus attention not only on needed action steps, and timing or sequencing issues, but it can also identify and galvanize potential cooperators, including landowners and businesses.

Integrated Pest Management
The risk analysis will factor heavily into the third step, which is to decide what needs to be done and how to go about it. As part of this step, you would likely be conducting the equivalent of an integrated pest management evaluation. IPM is a program where 1) an inspection is made and pests identified before control is implemented; 2) the need for control is assessed along with the efficacy, cost, safety and environmental effects of control methods including environmental, biological, mechanical and chemical methods; and 3) after careful consideration, the best control methods are used to manage the pest. This is a multi-faceted approach to management of rodent populations in which key questions are raised in an "if, when, where, what" construct (Brooks 1994). The point of your evaluation is to determine *if* intervention is needed or justified and, if so, *when*, *where*, and *what* intervention is needed (Frantz and Davis 1991). Eradication is the most aggressive form of control, and the approach advocated in the statewide plan. For more information on IPM, see http://www.cdc.gov/rodents/diseases/index.htm.

5.2 Evaluate Proposed Management Approaches

Robust and meticulous planning, designed to evaluate and address all contingencies, is critical in preventing and responding to rodent infestation problems. Before embarking on a complex project, be explicit about all assumptions and brainstorm to identify the things that could possibly go wrong. "What-if" discussions can help ensure that insightful 'fatal flaw' questions get asked and answered before they become moot. As an example, in conducting a project to eliminate two types of rats from a single island, New Zealand conservation officers were surprised to discover that one species of rat would not enter bait stations that had been used by the other species (Cromarty et al. 2002). Test and re-test all hypotheses. Research may be needed before some decisions on logistics are made.

Determining what management approach to use is an essential step and one that deserves careful consideration. Consult as many sources of information and expertise as possible, while moving rapidly to contain and eliminate the rodent threat. This may include searching the internet, reviewing guidebooks that might be available (e.g., from university extension offices), and/or hiring professional pest control experts. Potential sources of Alaska information include www.StopRats.org, and ADF&G's invasive species and/or rodent websites. You may also wish to contact the Alaska invasive rodent action team (see the plan Section 7.4) for materials and/or guidance. However, none of these sources is meant to preclude contacting professional pest control experts and companies that offer those services. Indeed, hiring professional services early in a rodent infestation event can be very cost effective.

Good Project Management is Fundamental
Whether you hire out or commit your own staff or volunteers, the choices you make concerning project and personnel management will be extremely important to overall success.

- Select a strong but flexible and creative manager who has a committed 'long-term eradication-and-restoration mindset' to lead the rodent prevention and eradication team for your agency, community, or organization.
- Get all needed approvals, including for access to property (land, vessels, buildings) and for application/use of pesticides. Any pesticide application on state land may require pesticide permits from DEC, and all aerial pesticide applications *do* require one. If unsure about permitting requirements, contact the appropriate agency and/or the statewide invasive species office.

Maintain Morale and Commitment
It is important to support and reward dedication, creativity and persistence in individuals and units involved in protection from, or elimination of, nonnative species such as rats.
Whether they are your strategists, project managers, or "rat incident" response team, these individuals are the front line defenders protecting property, wildlife, health, and economic interests. Prevention will be an ongoing investment. Where eradication is not possible, control efforts are likely to be ongoing.

5.3 Seek Resources and Funding

It is essential to assess the adequacy of available funding and resources. This includes the level of commitment and assistance to be expected from funding/support authorities, and the timing of available funding. Other important considerations are the energy level and dedication of individual team members, including key managers. An excellent article on these subjects is: "Eradication planning for invasive alien animal species on islands – the approach developed by the New Zealand Department of Conservation" by Cromarty et al. (2002).

Depending on the situation, the cost of eradicating or controlling rats in an area will vary greatly. Some of the pertinent factors include amount and type of supplies needed, remoteness and cost of shipping eradication supplies to the area, personnel costs, and efficacy of quarantine efforts (i.e., likelihood of reinvasion).

Funding commitments must be maintained until project objectives have clearly been met. Experts concede that, even under the best circumstances, some eradication projects and post-project monitoring will probably take a long time. Maintaining a "can-do" attitude throughout the campaign is essential. This is particularly true when few target animals remain and encounters with them become rare (Cromarty et al. 2002, Mowbray 2002). For example, in a 6-year effort to rid New Zealand's Kapiti Island of the last of its nonnative brushtail possums (*Trichosurus vulpecula*), when months would pass without a kill, managers made sure that dog-and-handler teams were given periodic assignments to hunt on the mainland, where they would have more successes (Brown and Sherley 2002, Cromarty et al. 2002).

It will be tempting for some administrators to advocate for project cessation once it appears that "not much is happening" on the ground and expenses remain high. Indeed, the last rats caught in an extended eradication campaign are the most expensive to find. By the same token, their capture is absolutely essential to an operation's success.

Enacting legislation to improve all aspects of rat prevention and response will aid significantly in meeting the goals of the plan. Similarly, the importance of increasing the capacity for agencies' invasive species programs and local entities' rodent prevention and removal programs cannot be over-emphasized.

5.4 Develop Local- or Sector-Level Action Plans

The plan you develop should be easy to follow, and robust yet flexible enough to accommodate new information and changing conditions. This is where having an astute and experienced manager in charge of the effort can really pay off.

Three considerations are particularly important in preparing any type of localized rodent management plan: Developing specific objectives for the effort; prioritizing effort; and maintaining morale and effectiveness of the team. For particularly complex removal efforts, the approach taken may need to include a logical progression of 'building-block' projects, sometimes accomplished on parallel tracks. Succeeding sections highlight these and other important considerations.

Objectives for Rodent Removal (Control/Eradication)
For each species to be controlled or eradicated from an area, it is important to develop clear objectives, performance measures, and targets. [For examples, see Sections 1.3-1.4, and 2 of New Zealand's Southern Islands Biodiversity Action Plan (SIBAP) at: http://www.doc.govt.nz/Regional-Info/013~Southland/005~Publications/Southern-Islands-Biodiversity-Action-Plan/index.asp).] As appropriate, divide your effort into different geographic management units and track progress accordingly, including via the use of a geographic information system (GIS). The amount of resources – and timing – applied to the job needs to be effective in meeting the objectives and the unique needs of each situation.

Location: Where to Target Your Efforts
When rat removal is initiated, it is important to encourage others nearby to remove their rats at the same time: The greater the area that is controlled, the more effective the results and the longer it will likely be before any new rats invade your property. Landowners and communities across a broad area can collaborate in implementing an intensive initial effort followed by regular monitoring and, as needed, contingency response efforts. This technique has been used for over 50 years across a 30-km wide by 60-km long North-South swath of the Alberta prairie. This has kept rat populations in eastern Canada from spreading westward into the country's productive prairie lands (Bourne 2001): A successful eradication effort recently occurred near Sibbald, Alberta, when a colony of rats was discovered in hay bales there (Brooymans 2007).

If assessment efforts point to conducting removal or control actions across a large or complex area, it may be necessary to prioritize activities in order to ensure success. As with any type of

pest control, rat control at a landscape or community level should not necessarily be targeted at the most degraded areas but at those facing the highest risks. If eradication appears infeasible and, instead, control is indicated, determine feasibility by evaluating rodenticide bait application rate, frequency, palatability, formulation, and type; and determine dispersal timing, seasonality, and immigration rate (seasonal and post removal) of rats.

Use multiple techniques simultaneously; if rats manage to avoid one scheme, they will be vulnerable in another. For other than on vessels, schedule the most intensive eradication efforts to occur within the late fall through spring window when wild foods are less available and bait becomes relatively more attractive to rodents; rodents often also show increased reliance/attraction to human habitations at this time. To protect key resources after control is implemented, establish feasible barriers to reinvasion.

What Treatment Method? Prioritization for Eradication vs. Control Efforts

In some cases, experts might determine that wildlife or other values are fairly uniform and that prioritization can instead take the form of prioritizing the techniques used. Some of the factors to consider include public acceptance, cost of logistics and supplies, remoteness, and potential effects on nontarget species.

In other cases, particularly in some mainland areas and for islands that see significant vessel traffic, experts could determine that complete or lasting removal of invasive rodents is unlikely. In these situations, it may be most effective to undertake a variety of approaches to controlling the spread of an infestation. In addition to aggressive prevention and quarantine efforts, habitat and sanitation modifications, and various types of trapping and/or poisoning must be used. In planning large-scale rodent removal efforts in communities, a good source of information is:

Corrigan, R. 2001. Rodent Control: a practical guide for pest management professionals. GIE Media, Cleveland, OH.

In cases involving wildlife and habitat resources, the goal should be to protect and enhance the areas of highest ecological value (sometimes scored as ‘specialness’ of species and representativeness of vegetation; New Zealand Department of Conservation 2002). For example, New Zealand’s SIBAP states as its prioritization objective: “To provide a system that ranks parcels of land according to their ecological value; facilitating sound management decisions based on all available information; in a clear, transparent, and repeatable manner” (New Zealand Department of Conservation 2002).

Especially if a rat-affected landscape is complex or the affected area large (e.g., $\geq$ 2,000 ha; 5,000 acres), identifying management units can enhance the logistics of eradication or control, and monitoring of success. As an example, SIBAP describes a system in which management units were designated within each district for better comparison of useful criteria. This approach sometimes uses topographic features (e.g., streams, ridges) to delineate unit boundaries because they are easy to locate in the field and may, in some cases, serve as a barrier for re-invasion by some species. In Alaska, identifying management units can help in developing a “relative level of risk” database, to be used in priority setting for shipwreck response or eradication efforts.

Recommended readings:

Bourne, J.B. 2001. Norway rat exclusion in Alberta. (See http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/prm2579)

New Zealand Department of Conservation. 2002. Southern Islands Biodiversity Action Plan (Vol.4). Southland Conservancy, Department of Conservation, Invercargill. (See http://www.doc.govt.nz/pdfs/southland/Publications/Bio-Action-Plan-Vol.4-complete.pdf)

Recommendations to Maximize Effectiveness of Your Planning Effort

- Review tenets of IPM; see: http://www.cdc.gov/nceh/ehs/Docs/IPM_Manual.pdf.
- In line with the tenets of adaptive management, evaluate management and removal techniques and their success; revise removal methods as needed.
- Network with others who are experienced in rodent eradication; make sure to have recognized experts review your implementation plan before beginning.
- Develop expert capability in your staff or community; if trained, committed staff members are not readily available, hire professional pest control expertise.
- Take the steps needed to eliminate or reduce problems ahead of time; test hypotheses before embarking on a large-scale eradication effort.
- Prioritize effort to best target operations and efforts.
- Conduct pre-trial or other research, as recommended, to maximize success.
- For landscape-level or complex applications, use rigorous experimental design to test methods. For example, limit variables per trial to maximize the information collected and, especially if on islands, use comparable conditions between islands to evaluate variables.
- Key aspects of rat natural history (e.g., neophobia) will help dictate the necessary approach; initially use no rodenticide bait in bait stations, and/or no toxicants in bait, to address rats' neophobia.
- Collect pre-eradication rodent DNA samples for later comparison should the same area develop a subsequent infestation. This will help determine whether an infestation is new or the failure to fully eradicate a previous one. Genetic tools can be valuable in the war on invasive or pest species; for more information on DNA sampling, techniques, and protocols, see Rollins et al. (2006).
- Keep a detailed log of activities; this includes documenting decisions made during the planning process, so that the rationale and details of a proposed management approach can be checked and re-checked by an 'outside expert team' prior to launch.
- Monitor and report on steps taken and their results; evaluate results and report to designated authorities (e.g., state invasive species office or state invasive rodent committee).
- Report to the public through newsletter articles, etc. and, as appropriate, publish in the scientific literature.

Recommended reading:

Cromarty, P.L., K.G. Broome, A. Cox, R.A. Empson, W.M. Hutchison, and I. McFadden. 2002. Eradication planning for invasive alien animal species on islands – the approach developed by the New Zealand Department of Conservation. In: *Turning the tide: the eradication of invasive species.* C.R. Veitch and M.N. Clout, eds. IUCN Invasive Species Specialist Group, Gland, Switzerland and Cambridge, UK. Pp. 85-91. (see http://issg.appfa.auckland.ac.nz/database/species/reference_files/TURTID/Cromarty.pdf)

6.0 Employ Effective Removal Methods

6.1 Trapping

Sanitation and rodent-proofing work together to enhance the effectiveness of trapping and baiting; all are components of an integrated rodent management program. Removing food sources and restricting rodent access forces rodents to roam farther away from their nests in search of food, making their contact with rodent traps and baits more likely.

The use of rodent traps and/or rodenticide/poison baits depends on the situation. Several problems with the use of traps are: trap shyness, bait shyness, evasive maneuvers and learned behaviors, and genetic resistance to rodenticide baits. Each of these will be discussed in following sections.

As with any IPM program, selection of the best methods for trapping needs to occur after careful inspection, pest identification, and assessment of the situation. While rodenticide (poison) baiting is often the best way to quickly control sizeable rodent infestations, in many situations trapping has advantages over baiting. Trapping does not use rodenticides, and trapped rodents can be regularly discarded so no odor problems result. Trapping can provide a reasonable means of initially assessing the size and characteristics of a rodent population.

Glue boards - This type of trap consists of a sticky film of glue applied to a backing of cardboard, wood or plastic. Glue boards can be constructed by placing special glue in pie tins or paper plates. The glues do not harden but will hold a rat in place. Other rats become curious and also get caught. Placing a small piece of food bait in the center of a glue board can increase effectiveness.

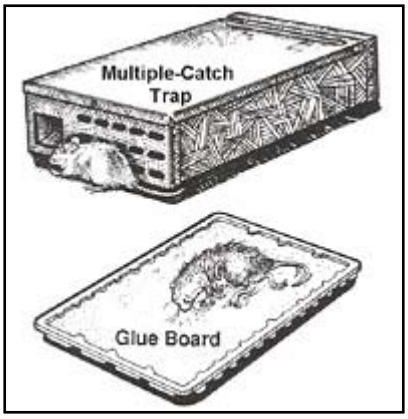


Figure H-11. Trap and glue board.

For other than a quick assessment, the use of glue traps (glue boards) should be limited; when used as part of control or eradication efforts, glue boards should always be combined with other methods. These traps can fail when they get dirty, or too hot or cold. To help keep them free of dirt and moisture, glue trap covers can be used. Alternatively, the traps can be placed in boxes with openings, in empty bait stations, and so on. Even with these precautions, however, savvy rodents will avoid them, vault over them or place debris on them to cover the sticky surface. Some people consider the glue board to result in inhumane deaths of rodents (i.e., through dehydration or starvation).

Snap Traps and Multiple Catch Traps -Traps are most useful against mice, because mice tend to be curious and rats suspicious. For mouse control in public buildings, snap traps and multiple-catch traps can be used. One multiple-catch trap can trap a dozen or more mice -- without the use of rodenticide/poison bait or pesticide.

Because some people are unwilling to kill or touch mice, they purposefully select glue boards or a live trap. Unfortunately, they then release to the outdoors any mice they catch, allowing the

former captives to reinvade the same or another structure. For this reason, use of live traps for capturing mice is strongly discouraged. If you catch mice, kill them or give them to a snake owner. *Captured mice should never be released alive to the outdoors!* Also, be aware that owning a cat that is allowed to hunt outside may increase the risk of live mice or other small mammals (voles, shrews) being brought indoors.

Unlike snap traps, multiple-catch traps are not useful against rats. The best all-around trap for both mice and rats is the snap trap (or break-back trap). Modern snap traps have expanded plastic triggers proven to catch more rodents than older traps with smaller, metal triggers (Fig. H-12). The Victor Professional kill trap has been highly recommended in the past (New Zealand Department of Conservation 2002) but may be best suited for household, warehouse, and community use.

Other brands have been found more reliable; these include traps primarily made of plastic, for use in protective stations (Dunlevy and Scharf 2007a). Meanwhile, the "search is on for a better mouse- (or rat-) trap." A newly developed "reverse-bait trigger" trap by Ka Mate Limited appears well suited to use in outdoor or other heavy-use settings in Alaska because it is less prone to misfires (e.g., from jostling or shipboard vibration) or to trapping of animals such as birds. Made of aluminum, it is particularly durable and can be bolted into place (A. Sowls, FWS/AMNWR Wildlife Biologist, Pers. Comm. 4/6/07).

Although snap traps are effective in many situations, they are generally too labor-intensive and time-consuming to be practical against large infestations of rodents. Half a dozen snap traps will capture a couple of mice in someone's kitchen, but two dozen may be required for a typical restaurant storage room, and many more are needed in a warehouse. Since mice travel only 3-9 m (10-30 ft) but rats travel 30.4 – 45.7 m (100-150 ft) from harborages, more traps are needed to trap mice than rats in a structure. Snap traps should be placed at 3-m (10-ft) intervals for mice and at 6-m (20-ft) intervals for rats. Both types of rodents are used to human odors so there is no need to use gloves when handling unbaited traps or traps baited with non-toxic (e.g., food) baits.

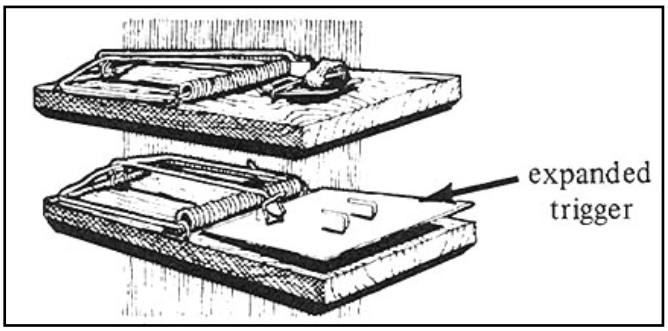


Figure H-12. Expanded trigger trap.

Runway traps – Designed to catch rats when they accidentally bump the trigger, runway traps are available commercially or can be made from snap traps by enlarging the trigger with cardboard, hardware cloth, paperclip, or screening. There is no bait to go stale, so there is an increased chance of success.

Trap Placement Considerations

Rats and mice have different behaviors around new objects. Mice are curious and will normally approach traps the first night. If you don't catch a mouse in the first few nights, the trap is in the wrong location. Whether baited or not, it is important to place traps where the rodents are, and to consider innate rodent attributes and behaviors.

Because rodents tend to run along walls, it is important to place snap traps perpendicular to the wall (i.e., at right angles to rat runs), with the trigger end against the wall. They can also be placed in tandem (back-to-back), parallel to the wall, so that rodents traveling in either direction will encounter the triggers. For examples of correct and incorrect placement of snap traps, see Fig.H-13. Traps can also be nailed, wired, or clamped to rafters and beams to take advantage of areas where rats travel.

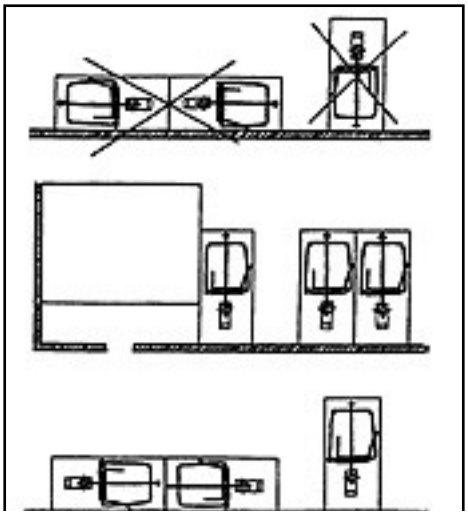


Figure H-13. Correct placement of traps: improper (top) and proper (middle and bottom)

Trap and/or Bait Shyness

Neophobia makes rats hesitant to approach new items such as traps or rodenticide bait placed into their environment. Rats may ignore newly-placed rodent bait and traps for days or even weeks, particularly if other food continues to be routinely available. Allow rats to overcome trap shyness by placing traps unset, in place, for several days. This results in better catches.

Another strategy is to "pre-bait" snap traps without setting them. Pre-baiting allows rats to adjust to presence of the traps and begin feeding on the food bait. Once routine feeding occurs, the triggers can be set. The object is to maximize the number of rodents caught and minimize the number of escapees. This is important for overall success because "experienced" individuals may train others to avoid poison-contaminated food, or they may transfer their wariness to nontoxic foods of similar types. This type of bait shyness can persist for weeks or months.

Baiting

Traps are usually effective when dealing with small numbers of rats or mice. Although unbaited snap traps do catch rodents, they work best when baited with food the rodents find attractive. The food bait must compete with other available foods, so no single food bait is ever the best bait for all locations. Rodents living on garbage or spoiled food prefer something fresh. Following are some food baits that have proven successful for rodents:

- Whole nuts for rats and mice
- Raisins or grapes for roof rats
- Sardines packed in oil, or sponges soaked in herring oil, for Norway rats
- Peanuts or peanut butter for rats and mice (soak whole peanuts in water overnight; old peanut butter becomes rancid so replace it frequently)
- Dry oatmeal is excellent for mice, and for either species oatmeal or rolled oats can be made into a paste by mixing with peanut butter.
- Bacon squares, hot dogs, sardines
- Small wads of cotton (e.g., cotton balls) for mice and rats (desired as nest material)
- Gumdrops for mice
- Especially if trapping rodents in an outdoor setting, it is important to adapt food bait locally.

Recommendations on Trap Use and Maintenance

- Use mouse traps wherever there is evidence of mouse activity; rat traps are too large to be effective for mice. The converse is also true. Use the correct-sized trap for the intended species.
- Bait station and trap placement for rats:
  - "Think like a rat" when picking optimum locations for placement of treatment devices, particularly traps; as appropriate, use a tracking powder (flour, talc) to pinpoint the best places along suspected runways to place traps.
  - Initially use unset traps, no rodenticide bait in bait stations, and/or no toxicants in bait, for at least several days to address rats' neophobia.[28]
- Set all traps to kill: *Rat escapees learn to avoid and may teach their young.*

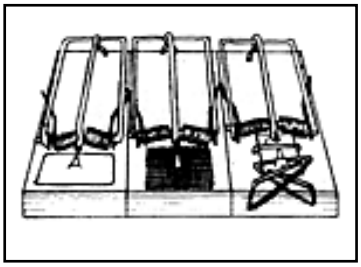


Figure H-14. Runway traps made from enlarged snap traps.

- Use a combination of snap traps, sticky boards, and poison bait boxes for best results.
- Place traps in dark areas against walls (along rodents' travel paths); also place traps in areas of food, garbage, and freight storage, and near holes; set traps where children and pets will not be hurt.
- One benefit of using traps rather than bait stations is to control where the rodents, and rats in particular, die. To prevent rats from dragging traps away, nail or otherwise anchor the traps in place.
- Place rodenticide baits and bait stations near, but not on, rat runways. Rats will quickly find them and, after a period of avoidance, will cautiously investigate them.
- To boost chances for success, set traps as double set (side by side); traps can also be placed in tandem (back-to-back), parallel to the wall so that rodents traveling in either direction will encounter the triggers.
- Set baited traps or runway traps at right angles to rat runs (Fig. H-15). A board or box can be used to narrow a runway and help guide rats into traps.
- Especially for food or not-toxic baits, thwart bait stealing by using dental floss or a twist-tie to tie baits onto snap trap triggers. To hold the trap in place on pipes or rafters, use rubber bands, nails, or hose clamps. Traps can also be nailed to rafters and beams to take advantage of areas where rats travel.
- Extend the life of snap traps by wire brushing and oiling springs if rusty.
- Regularly check the traps to make sure they are set, in good condition, and that any food or rodenticide baits used are fresh; moldy bait is less effective.

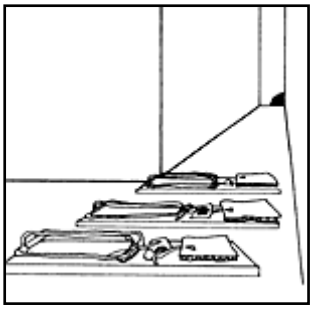


Figure H-15. Traps at right angles to rat run.

[28]An attractant that is similar to the intended bait can be sprinkled on unset traps or in unbaited bait stations during the "pre-bait period"; examples include herring oil if herring oil-soaked sponges will be the bait, or a mixture of peanut oil and rolled oats if a sticky mix of peanut butter and rolled oats is planned as bait (Dunlevy and Scharf 2007a).

6.2 Toxicant Rodenticides

Introduction

When rats are plentiful or where unsanitary conditions exist with harborage, poison baits are an effective tool to use with trapping. Baiting with rodenticides is often the most efficient and timely way to eliminate large numbers of rodents. The main disadvantage is that rodenticides are toxicants and must be used carefully to avoid harming people, pets and other nontarget animals. As with all pesticides, precautions and associated risks must be taken into account when using rodenticides. All rodenticide product labels emphasize that baits must be secured in tamper-resistant stations or placed in areas (crawlspaces, attics, sewers) inaccessible to children and nontarget animals.

Figure H-16. Tamper-proof rodent bait station.

Tamper-resistant bait stations (Fig. 12) are usually made of hard plastic or metal. The stations must lock, usually by built-in lock and key mechanisms, and the rodenticide bait blocks inside should be secured with wire or skewered on metal rods designed for that purpose. The box itself should be secured to the ground, a fence or a structure. Cable ties can be used, e.g., for attachment to fence lines. Stations also can be fastened to the ground with stakes, or attached to patio blocks by bolting or gluing. The use of patio blocks is advantageous in elevating stations above ground level to help avoid moisture problems.

Poison baits are available as ready-to-use premixed baits, and they come in a variety of forms and formulations. Parafinized bait blocks are preferred for use in bait stations, outdoor use and high humidity areas; in contrast to grain, parafinized pellet baits or pellets in “place packs” for indoor use, they cannot be shaken out of stations and carried away by rodents.

Liquid rodenticide baits also are available. Water baits are sold as packets of concentrate that are mixed with water. They are administered with a chick fount, available at most feed stores, and are useful in areas where rodent food is abundant but water is in short supply. Like solid baits, liquid baits should be placed in areas inaccessible to children and nontarget organisms.

Selection of which rodenticide bait product to use is specific to the situation. Considerations include rodent acceptance of and resistance to the rodenticide, the amount required to kill a rodent (single or multiple feedings), the bait’s toxicity and secondary poisoning potential, and the potential for contaminating food and poisoning nontarget organisms including humans.

In addition to using rodenticide bait in bait stations, such bait can be placed directly into rodent burrows. Pick up dead rats wherever they are noticed. A few cases of pet poisoning have been reported when pets feed on dead rats or mice. Anticoagulant-poisoned mice are usually dehydrated and do not produce severe odor after death. However, rats are large enough to produce an unpleasant odor for up to two-four weeks if they die in inaccessible locations. In areas where dead rats cannot be removed, it may be necessary to ventilate the area or use odor absorbent or masking products.

Anticoagulant Rodenticides

In terms of meeting rat removal objectives, many rat eradication projects worldwide have been successfully conducted using anticoagulant rodenticides (Howald et al. 2007). These rodenticides have been the most preferred materials for controlling rats since their initial development following World War II. Anticoagulants are accepted readily by rats, do not cause bait shyness, are easy to apply and, if used properly, are relatively safe to use around livestock, pets, and humans (Timm 1994). Additionally, Vitamin K_1 is an effective antidote in case of accidental poisoning.

To date, most rat eradication projects have used brodifacoum. However, eradication of rats on islands has been successfully implemented using less toxic anticoagulant rodenticides such as pindone, diphacinone and bromadiolone (Donlan et al. 2002, Morris 2002, Witmer et al. 2007a).

The U.S. Environmental Protection Agency (EPA) has expressed concern about the environmental impacts associated with the field application of brodifacoum. Of particular concern is that it can have adverse impacts on nontarget species based on its persistence in the tissues of animals (especially mammals and to some extent birds) and persistence in the environment (Erickson and Urban 2002, Witmer et al. 2007b). Even so, many commercial rodenticide products containing diphacinone and brodifacoum have been approved in the United States, each with specific labeling restrictions under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) Section 3. Some of these formulations have also been approved for special local needs under FIFRA Section 24(c), and emergency exemptions under FIFRA Section 18 to conduct rat eradication field projects in conservation areas to restore ecological processes and protect endangered species (see Appendix G). FWS has conducted studies using diphacinone and brodifacoum on Alaska islands, especially in the Aleutians and Bering Sea, to test efficacy at killing rats, and risks to nontarget wildlife (Witmer 2005, Buckelew et al. 2007, Dunlevy and Scharf 2007b).

Recommendations on Rodenticide Use

- Determine effects of rodenticides on nontarget species.
- Conduct rodenticide bait tests as appropriate to determine the "best" bait(s) based on local conditions (e.g., evaluate efficacy of toxicants if used; nontarget species risks; taste; weather resistance; hopper-size for dispersing; best timing, etc.).
    - Use bait stations to evaluate bait-take rates (accuracy is very important for future planning).
    - Determine impact of topography on application rate and investigate methods to optimize the density needed (e.g., for aerial application, determine best airspeed in different types of topography).
    - Limit variables per trial to maximum the information collected and use comparable conditions between islands to evaluate variables.
- Place poison baits near where rats live and breed or along travel routes.
- Where rodent runs are exposed and in all outdoor situations, consider using tamper-proof bait boxes; secure the rodenticide bait blocks inside the station or if loose bait pellets or meal is used, secure the station to the ground so a child, dog or scavenger could not move it.

- Place rodenticide baits in stations with an appropriate amount of bait per station; shallow containers for holding the bait are best. For added effect, water may be provided separately for the rats to drink.
- Number and label each rodenticide bait station, and map its location. The label should warn of the rodenticide within, and include the user's name and contact information.
- Have a system to record data for each station, so there will be a complete record of the date each station is checked and other appropriate information.
- Keep rodenticide labels in possession when doing an application; follow specifications and EPA label use requirements.
- Around larger commercial facilities experiencing significant rodent activity, place rodenticide bait stations 22.9 m (75 ft) apart around fence lines and at 15.2-m (50-ft) intervals against the building's exterior; indoors, place stations at 7.6-m (25-ft) intervals along exterior walls. As needed, adjust spacing to match the level of rodent activity. If bait is consistently being taken only along one corner of a structure, it may be beneficial to move bait stations from other areas to that corner, or simply to add more stations to the area experiencing the greatest rodent activity.

Unless a community, facility, or program can commit sufficient trained and certified staff to developing a rodent control plan and *regularly monitoring* and refurbishing all traps and stations, checking baits and so on, commercial pest control services should be retained for this purpose.

6.3 Nontarget Species Considerations

In any rodent removal operation unintended effects on nontarget species can be a concern. However, consideration of nontarget species effects often increases when use of rodenticide baits is being considered.

It is generally understood that leaving excessive rodenticide bait on the ground for long periods puts nontarget species at a higher than necessary risk of primary exposure. However, the chronic effects that rodenticides may have on some species, such as nontarget small mammal populations, is unknown. Mammal experts involved with developing Alaska's Comprehensive Wildlife Conservation Strategy (CWCS) noted this as a concern for the endemic small mammals (voles, lemmings, shrews) of Southwest Alaska and the Bering Sea Islands (Alaska Department of Fish and Game 2006).

This animal group is of concern because it consists of small isolated populations, and thus are susceptible to risks of extirpation from, among several other factors, direct or indirect poisoning from rodenticides. Further, endemic small mammals are of unique interest to mammalogists, evolutionary biologists, and geneticists in part because introductions of new populations (i.e., nonnative genetic stocks) to serve as food for farmed foxes may have resulted in cross-breedings and altered the process of speciation.[29] Protecting these nontarget species from undue harm and maintaining natural biotic diversity is of key interest to conservation biologists (E. Lance, FWS Endangered Species Program Wildlife Biologist and CWCS small mammals expert, Pers. Comm. 10/17/06).

[29] Evolution or divergence of one species from another

Much research has been conducted elsewhere in the world on rodenticides in terms of their coloring, presentation (bait tube) effectiveness, minimum effective dose,[30] nontarget species effects, and so on. To protect animals, rodenticide bait manufacturers and application teams sometimes tint bait pellets in bright colors that nontarget species reject but rats, which are colorblind, do not.

Factors that affect availability of bait to target species include broadcast distribution, persistence of the bait, interference competition from nontarget species, and bait station modification and placement. Typical bait station modifications to exclude nontarget species include raised platforms (with correspondingly raised entry hole) and, better yet, reduced entry hole size.[31]

To achieve optimal conservation effect, the primary goal must always be to limit or reduce the risk of exposure for nontarget species. There are a variety of other ways to mitigate the effects on nontarget species. These include distributing bait by hand, during seasons when nontarget species are absent or in low abundances, by using directional air-lift hoppers (e.g., to avoid streams), or by temporarily suspending human harvest of potentially affected nontarget species. In some situations, nontarget species can be removed to captivity until rodenticide baits decay (Krajick 2005, Witmer et al. 2007b). Even in the face of some risk to nontarget species, the overall effect on native species and ecosystems from removal of introduced rats is typically highly positive.

6.4 Large-scale Broadcast Application

As noted earlier, eradication of rats has been conducted successfully on hundreds of islands worldwide. The fundamental approach in the majority of these cases involved delivery of rodenticide-laced bait into every potential rat territory, using one of three techniques: 1) bait stations laid out in a grid pattern, 2) bait broadcast using hoppers suspended from a helicopter and/or hand broadcast application, or 3) a combination of the bait stations and broadcast approach. Choice of delivery technique depends on such things as island size and topography, nontarget risks, native species, logistics and other factors. In these studies, rodenticide bait is usually delivered when competing natural food resources declined for the season (i.e., bait was relatively more attractive to rats) (Island Conservation 2006).

Currently, under FIFRA Section 3, only one rodenticide product [Diphacinone 50: Pelleted Rodenticide Bait for Conservation Purposes (56228-35), a formulation of diphacinone] has been approved in the United States for applying in bait stations, in burrows, and/or by hand and aerial broadcast on the ground or in vegetation canopy. If also approved by the State of Alaska, this product could be used state-wide in compliance with the EPA-approved label. EPA is still reviewing an application that has been submitted for a formulation of brodifacoum.

[30] Which reduces the amount of bait required

[31] The maximum height for easy access to bait stations is 40 cm (15.7 in) for rats and 25 cm (9.8 in) for mice; minimum effective hole size opening is 35 mm (1.4 in) for roof rats, 40 mm (1.6 in) for Norway rats, and 13 mm (0.5 in) for mice (W. Pitt, USDA APHIS Wildlife Services, Pers. Comm. 3/31/07).

At present, large-scale toxicant application in Alaska using aerial means is being considered only in the Aleutian Islands. The FWS Experimental Use Permit Application indicates that, for the majority of the Aleutian Islands, the primary application method most practical for rodenticide is aerial broadcast. This is because of these islands' remoteness and large sizes [e.g., up to 70,000-acre (28,328-ha) Kiska Island]. Projects undertaken in the Aleutians will be logistically complex and expensive to implement, and may present risks to nontarget species from the broadcast use of toxic bait (Island Conservation 2006). The FWS and its partners are conducting research to identify as clearly as possible the ecological problems/benefits with use of aerial or other broadcast techniques. Application of rodenticide at the landscape level would require written approval from the BOG. Any aerial applications of rodenticide in Alaska would also require a permit from DEC.

6.5 Other Methods of Rodent Removal

Frightening

Rats are wary animals and can be frightened easily by unfamiliar sounds or sounds coming from new locations. Most rodents, however, can quickly become accustomed to new sounds heard repeatedly. For years, devices that produce ultrasonic sound that is claimed to control rodents have come and gone on the market. However, although tests of such devices have indicated that rats may be repelled from the immediate area of the ultrasound for a few days, they then return and resume normal activities. Other tests have shown the degree of repellency depends on the particular ultrasonic frequencies used, their intensity, and the preexisting condition of the rodent infestation. The bottom line appears to be that ultrasonic sound has limited effectiveness, and it is not recommended. There is little evidence to suggest that rodent responses to nonspecific, high-frequency sound is any different from their response to sound within the range human of hearing (Timm 2003).

Repellents

Rats find some types of tastes and odors objectionable, but chemical repellents are seldom a practical solution to rat infestations. Substances such as moth balls (naphthalene) or household ammonia, in sufficient concentration, may have at least temporary effects in keeping rats out of certain enclosed areas. The above materials, however, are not registered by the EPA as rat repellents. Ro-pel® (denatonium saccharide) is registered for use in repelling Norway rats and other rodents from gnawing on trees, poles, fences, shrubs, garbage, and other objects. Little information is available on its effectiveness against rats (Timm 1994). Only capsaicin (hot pepper derivative) and predator odors have provided some, but limited, rodent repellency (Gary Witmer, USDA/APHIS/WS, Supervisory Research Wildlife Biologist, Pers. Comm. 10/19/06).

Fumigants

Fumigants are airborne pesticides which are sometimes used to kill rodents and their ectoparasites (fleas, ticks, mites, etc.) in areas essentially inaccessible to humans, e.g., within rat burrows, walls of structures, cargo containers, or rail freight cars. Because fumigants can be inhaled by humans and pets or other nontarget animals, they are potentially dangerous to use. Many are restricted-use pesticides that require special equipment as well as applicator training, certification and recordkeeping. For more information on available fumigants and site-specific

physical factors that affect whether they can be used successfully, see Brooks (1994) and Timm (1994).

Clubbing and/or Shooting

In some situations, rats can be killed manually with a club or other implement. When rats have access to a structure through only one or a few entrances, it may be possible to drive them out en masse. They can then be clubbed or shot with a pellet gun or .22 firearm loaded with birdshot (Timm 1994). In some cases, flooding can be used to force rodents from their burrows or to cause mortality in the burrows.

Dogs and Cats

Many people have relied on cats and dogs to catch and kill rats, but in general cats and dogs are not good tools for control. Around most structures, rats can find many places to hide and rear their young out of the reach of such predators. An added problem is that food put out for pets is excellent rat food and most people put out more food than their pet can consume in one day. Because the pets are well-fed, their interest in hunting is diminished and rats are able to clean the food bowl while the pet is absent or asleep. Studies have shown that although predators may keep an area rat free, they cannot remove an existing infestation.

There can be other problems with enlisting the efforts of dogs and cats in the war on rats. For instance, because cat hair in fish meal is abhorrent to buyers of its Alaskan seafood products, Trident Seafoods in Sand Point tries to encourage wild predators such as weasels to police their properties for rats. Preferring live foods, weasels are not drawn to the fishmeal (C. Fredenberg, Aleutian/Pribilof Islands Association, Natural Resources Coordinator, Pers. Comm. 5/12/06).

Additionally, free-ranging dogs and cats can have devastating impacts on native wildlife species, particularly bird populations. Dogs and cats can cause disturbance, harassment, displacement, injury and direct mortality of wildlife (Sime 1999; Alaska Department of Fish and Game 2006). In urban areas, pet cats may be the main predator on songbirds and other small avian species or their young. Cats also take a high number of native rodents and shrews (R. Sinnott, ADF&G, Pers. Comm. 7/26/06). The average number of animals a single cat kills annually has been variously estimated as between 14 and 26, to as many as 1,000 (Fitzgerald 1988, Churcher and Lawton 1987, Eberhard 1954, Bradt 1949, Coleman and Temple 1996, Alaska Department of Fish and Game 2006).

Introduced Predators

It is generally advisable to avoid purposefully introducing (transplanting) any nonnative animal, including predators native to other parts of the state, and Alaska has strict regulations and permitting requirements [5 AAC 92.029(b)] designed to prevent the ecological problems that have occurred in other jurisdictions. Japan suffered an ecological catastrophe, for example, when it tried to use so-called “natural” or biotic control techniques on Amami Island in 1979: Thirty mongooses that were imported and released to control rats and poisonous snakes instead ate crops and rare endemic birds; they then multiplied out of control and were too cunning to eradicate (Krajick 2005). Introduced mongooses are also having a significant impact on native animals in Hawaii (Tomich 1986).

Other problems with introducing nonnative species, particularly to islands, are that introduced animals of the same species but a different population (or stock) can crossbreed with the original population and "genetically swamp" it. This can effectively eliminate the prior genetic diversity that might have developed through time by having separate subspecies or populations located on different islands. This concern was raised by terrestrial mammal experts who helped develop Alaska's CWCS (Alaska Department of Fish and Game 2006).

7.0 Conduct Effective Monitoring

To best implement Alaska's anti-rodent plan, monitoring will need to occur at a variety of levels: incident- or project-specific (to determine a project's success or failure), ecosystem-wide (a subset of the preceding category; important for large-scale rodent eradication and restoration projects), and community assessment (for ongoing detection efforts). It will also be important to monitor, or track, the collective progress made in ridding the state of invasive rodents.

Monitoring is essentially a systematic survey conducted at regular intervals; it keeps track of selected aspects of a particular situation and establishes baseline data from which to make evaluations as well as apply to future programs of a similar nature (Brooks 1994). Results of monitoring can help determine whether additional efforts are needed to achieve the program objectives and identify what other steps may be needed in the management program. Two types of monitoring are addressed here: incident monitoring and selective monitoring. A third type, ecosystem monitoring, is addressed in Section 6.4 of the plan.

Incident Monitoring

After any type of eradication or control effort, including in cases of a vessel grounding or wreck on a rat-free island, a monitoring program should be established. Follow-up monitoring is designed and implemented to ensure that no rodents have survived and that a rodent population has not become established.

Whether for terrestrial or marine applications, the factors to consider when developing a monitoring timeline are similar to those in an initial assessment: amount of rat sign observed, number of rats killed in traps, number of poison baits eaten, and the number of rats trapped in live traps, if used. For monitoring islands after a shipwreck, other factors to consider in developing a monitoring strategy would necessarily include size of the island, its accessibility, and available funding.

Long-term Control: Selective Monitoring

This type of monitoring is sometimes undertaken to assist in best deploying limited resources (e.g., staff and funds) for long-term control efforts. A determination is made on the likely source of rodents into an area (e.g., a breeding colony, or immigration of newcomers from elsewhere). After this, either of two types of selective monitoring are undertaken, each resulting in a different approach for the rodent control activities themselves. In one approach, control efforts are undertaken across a wide area, based on results of monitoring specific "source area(s)." In the other, control efforts are undertaken in the source area, after monitoring across a broader area indicates the rodent population has reached a pre-established threshold level (R. Pech, Landcare Research, New Zealand, Pers. Comm. 3/30/07). Monitoring is a critical and ongoing step for securing a perimeter against invading rats. Failure to monitor for changed conditions can mean the difference between success and failure of rodent control in the long term. It is a cost-effective investment of time and resources.

Key recommendations are to:

- Schedule periodic or ongoing monitoring of potential outbreaks (including in seemingly rat-free communities) when rodent populations are highest and easiest to detect. Often this is in the late summer or early fall.
- For projects aimed at rodent removal (control or eradication), monitor to determine success for at least two years following rodent eradication efforts (Witmer et al. 2007a).
- Have a central entity monitor and web-post information on the types of rodent infestations in Alaska and their sources, as well as progress in ridding Alaska of its rodent pests. This could help target the arenas in which strengthened public information campaigns, ordinances, or laws are needed.

8.0 References Cited in Appendix H

Alaska Department of Fish and Game. 2006. Our wealth maintained: A strategy for conserving Alaska's diverse wildlife and fish resources. Alaska Department of Fish and Game, Juneau, Alaska. xviii+824 p. (http://www.sf.adfg.state.ak.us/statewide/ngplan/)

Baker, R., G. Bodman and R. Timm. 1994. Rodent-proof construction and exclusion methods. Pages B-137 - B-150 in: S. Hygnstrom, R. Timm and G. Larson, eds. Prevention and control of wildlife damage. University of Nebraska Cooperative Extension Service, Lincoln (see http://hgic.clemson.edu/pdf/pcwdrodent_proof_construct.pdf).

Bourne, J.B. 2001. Norway rat exclusion in Alberta (See http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/prm2579)

Bradt, G.W. 1949. Farm cat as predator. Michigan Conservation 18(4):23-25.

Brooks, Joe E. 1994. Bionomics and Management of Commensal Rodents. U.S. Department of Agriculture/ APHIS/Animal Damage Control. Denver Wildlife Research Center, Denver, CO. 100 pp.

Brooymans, H. 2007. "Shotgun restores province's rat-free reputation: Vermin shaken from hay bales and shot after infestation near Sibbald." The Edmonton Journal. June 6, 2007

Brown, K.P. and G.H. Sherley. 2002. The eradication of possums from Kapiti Island, New Zealand. In: *Turning the Tide: The Eradication of Invasive Species.* C.R. Veitch and M.N. Clout, Eds. IUCN Invasive Species Specialist Group, Gland, Switzerland and Cambridge,UK. p. 46-52.

Buckelew, S., G. Howald, S. MacLean, and S. Ebbert. 2007. Progress in restoration of the Aleutian Islands: Trial rat eradication, Bay of Islands, Adak, Alaska, 2006. Report to the U.S Environmental Protection Agency and U.S. Fish and Wildlife Service.

Churcher, P.B. and J.H. Lawton. 1987. Predation by domestic cats in an English village. Journal of Zoology, London 212:439-455.

Coleman, J.S. and S.A. Temple. 1996. On the prowl. Wisconsin Natural Resources 20(6):4-8.

Cromarty, P.L., K.G. Broome, A. Cox, R.A. Empson, W.M. Hutchison, and I. McFadden. 2002. Eradication planning for invasive alien animal species on islands – the approach developed by the New Zealand Department of Conservation. In: *Turning the tide: the eradication of invasive species.* C.R. Veitch and M.N. Clout, eds. IUCN Invasive Species Specialist Group, Gland, Switzerland and Cambridge, UK. Pp. 85-91. (see http://issg.appfa.auckland.ac.nz/database/species/reference_files/TURTID/Cromarty.pdf)

Donlan, C.J., B.R. Tershy, and D.A. Croll. 2002. Islands and introduced herbivores: conservation action as ecosystem experimentation. Journal of Applied Ecology 39:235-246.

Dunlevy, P. and L. Scharf, in prep. Biology of Norway rats (*Rattus norvegicus*) in the Aleutian Islands, Adak Island, Alaska.

Eberhard, T. 1954. Food habits of Pennsylvania house cats. Journal of Wildlife Management 18:284–286.

Erickson, E. and D. Urban. 2002. Potential risks of nine rodenticides to birds and mammals: A comparative approach. U.S. Environmental Protection Agency, Office of Prevention, Pesticides, and Toxic Substances. 153 pp.

Fitzgerald, B.M. 1988. Diet of domestic cats and their impact on prey populations. In: D.C. Turner and P. Bateson, editors. The domestic cat: the biology of its behaviour. Cambridge University Press, Cambridge. p. 123–147.

Frantz, S.C. and D.E. Davis. 1991. Bionomics and integrated pest management of commensal rodents, pp. 243-313. In: Gorman, J.R. ed. Ecology and Management of Food-Industry Pests. Association of Official Analytical Chemists, Arlington, VA.

Halford, B. 2005. Fugitive Rat Teaches Lesson about Rat Control. National Geographic News. October 19, 2005. Accessed at 1 http://news.nationalgeographic.com/news/2005/10/1019_051019_island_rat.html 8/30/07.

Howald, G., C. Donlan, J. Galvan, J. Russell, J. Parkes, A. Samaniego, Y. Wang, D. Veitch, P. Genovesi, M. Pascal, A. Saunders and B. Tershy. 2007. Invasive rodent eradication on islands. Conservation Biology 21(5): 1258-1268.

Island Conservation. 2006. Evaluation of Primary and Secondary Exposure Risks to Land Bird Species for: Experimental Use Permit Application for Field Efficacy Trial of 0.0025% Brodifacoum Broadcast Bait to Eradicate Introduced Rats from Aleutian Islands in the Alaska Maritime National Wildlife Refuge, July 20, 2006. Island Conservation, Center for Ocean Health, 100 Shaffer Rd, Santa Cruz, CA 95060.17 pp)

Krajick, K. 2005. Winning the War Against Island Invaders. Science Vol. 310, pp 1410-1413 (as seen at http://www.sciencemag.org.)

Moors, P.J., I.A.E. Atkinson, and G.H. Sherley. 1992. Reducing the rat threat to island birds. Bird Conservation International. Vol. 2:93-114.

Morris, K.D. 2002. Eradication of the black rat (*Rattus rattus*) on Barrow and adjacent islands on the northwest coast of western Australia. In: *Turning the Tide: The Eradication of*

Invasive Species. C.R. Veitch and M.N. Clout, Eds. IUCN Invasive Species Specialist Group, Gland, Switzerland and Cambridge, UK. p. 64-70.

Mowbray, S.C. 2002. Eradication of introduced Australian marsupials (brushtail possum and brushtailed rock wallaby) from Rangitoto and Motutapu Islands, New Zealand. In: *Turning the Tide: The Eradication of Invasive Species.* C.R. Veitch and M.N. Clout, Eds. IUCN Invasive Species Specialist Group, Gland, Switzerland and Cambridge, UK. p. 226-232.

New Zealand Department of Conservation. 2002. Southern Islands Biodiversity Action Plan (Vol.4). Southland Conservancy, Department of Conservation, Invercargill. (See http://www.doc.govt.nz/pdfs/southland/Publications/Bio-Action-Plan-Vol.4-complete.pdf)

Rollins, L., A. Woolnough, and W. Sherwin. 2006. Population genetic tools for pest management: a review. Wildlife Research 33:251-261.

Russell, J.C. 2007. Invasion Biology and Genetics of Norway rats on New Zealand Islands. PhD Thesis.

Timm, R.M. 1994. Norway Rats. In Prevention and Control of Wildlife Damage. U.S. Department of Agriculture/APHIS/Animal Damage Control. University of Nebraska-Lincoln, Institute of Agriculture and Natural Resources, Cooperative Extension Division. Pp. B-105-B-120.

Timm, R. 2003. Devices for vertebrate pest control: are they of value? Proc. Vertebr. Pest Conf. 10:152-161.

Tomich, P. 1986. Mammals of Hawaii. 2nd Edition. Bishop Museum Press, Honolulu, HI.

U.S. Fish and Wildlife Service. 1988. Alaska Maritime National Wildlife Refuge Final Comprehensive Plan, Wilderness Review and Environmental Impact Statement. Anchorage, AK.

Witmer, G., F. Boyd and Z. Hillis-Starr. 2007a. The successful eradication of introduced roof rats from Buck Island using diphacinone, followed by an irruption of house mice. Wildlife Research 34:108-115.

Witmer, G., J. Eisemann and G. Howald. 2007b. The use of rodenticides for conservation efforts. Proc. Wildlife Damage management Conference 12: IN PRESS.

I. Suggested Reading Regarding Rats[32]

Brooks, J. E. 1994. Bionomics and management of commensal rodents. Denver Wildlife Research Center, unpubl. 100 pp.

DeGange, A.R., A. Sowls, L. Fairchild. 1995. A strategic plan to protect island ecosystems in Alaska from the introduction of rodents. Unpublished report prepared by FWS region Region 7, Anchorage, AK. unpubl. 11 pp.

Department of Conservation (DOC), New Zealand, in-house reports:

Investigations in Relation to Rats. Raoul Is. 1994.

Maud Island Pest and Weed Operations Plan. 1991-1996.

Northland Conservancy Island Mammal Pest Invasion Contingency Plan. 1999. 53 pp. plus appendices.

Southland Conservancy Animal Pest Invasion Plan. Vol. 1. Pest Invasion Contingency First Response. 14 pp.

Takapourewa (Stephens Island) Nature Reserve Plan for Management, draft 1992.

The Prevention of Predator Invasion … in the Nelson/Marlborough Conservancy. 1997.

Vertebrate Pest Control Manual-Toxins and Poisons. 1997. Nicole Haydock (ed.).

Eradication of cats and sheep from Socorro Island, Veitch, C.R. 25 pp.

Wellington Conservancy Mammal Contingency Plan for Islands on the Kapiti Coast and in Wellington Harbor. 1999.

Environmental Assessment-Proposed Emergency Use of Toxicants to Prevent Accidental Introductions of Rats from Shipwrecks on Islands in Alaska Maritime National Wildlife Refuge. Alaska Maritime National Wildlife Refuge, U.S. Department of Interior, U.S. Fish and Wildlife Service. 2355 Kachemak Bay Drive, Suite 101 Homer, AK 99603.

Everett, W. T. 1999 Wake Atoll Eradication Strategies. Endangered Species Recovery Council. Unpublished report. Paper prepared by ESRC, San Diego, CA.

Murphy, J. G., 1991. Report of rat eradication operations conducted under specific emergency exemption to use Talon-G containing brodifacoum in a field situation on Rose Atoll National Wildlife Refuge, American Samoa. Unpublished report.

[32] List provided by the Pacific Seabird Group

Murphy, J. G. 1994. Rat Eradication on Green Island, Kure Atoll. Unpublished report prepared by State of Hawaii, DLNR, Honolulu, and Animal Damage Control, U.S. Depart. of Agriculture, Honolulu.

Murphy, J. G. 1997. Rat Eradication on Eastern and Spit Island, Midway National Wildlife Refuge. Wildlife Services. Honolulu, HI.

Murphy, J. G. 1997. Rat Eradication on Sand Island, Midway National Wildlife Refuge. Wildlife Services. Honolulu, HI.

Murphy, J. G. 1994. Rat Eradication on Green Island, Kure Atoll. State of Hawaii, DLNR. Animal Damage Control. Depart. of Ag. Honolulu, HI.

Norman, F. I. 1975. The murine rodents *Rattus rattus, exulans* and *norvegicus* as avian predators. Atoll Research Bulletin. 182:1-13.

Ohashi, T. 1992. Application for specific emergency exemption to use Assault and Weatherblok in a field situation eradication of Polynesian Rats (*Rattus exulans*) on Rose Atoll National Widlife Refuge, American Samoa. Animal Damage Control, Depart. of Ag., Honolulu, HI.

Pain, D. J., M. de L. Brooke, J. K. Finnie, and A. Jackson. 2000. Effects of brodifacoum on the land crab of Ascension Island. J. of Wildlife Management. 64(2):380-387.

Rauzon, M. J. 2001. Vertebrate Pest Eradication and Prevention Plan for the Pacific Islands Ecoregion, Division of Ecological Services, U.S. Fish and Wildlife Service, Honolulu, HI.

Spennemann, D. H. R. and G. Rapp. 1989. Can rats colonize oceanic islands unaided? An assessment and review of the swimming capabilities of the genus *Rattus* with particular references to tropical waters. Zoologische Abhandlungen, Staatlichen Museum fur Tierkunde Dresden 45(7): 81-91.

Taylor, R. H., G. W. Kaiser, and M. C. Drever. 2000. Eradication of Norway Rats for recovery of seabird habitat on Langara Island, British Columbia. Restoration Ecology. 8(2):151-160.

U.S. Fish and Wildlife Service. 1993. Environmental assessment: proposed emergency use of toxicants to prevent accidental introductions of rats from shipwrecks on islands in the Alaska Maritime National Wildlife Refuge. Alaska Maritime National Wildlife Refuge, Homer, AK. 28 pp.