Management Plan for Invasive Northern Pike in Alaska

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Executive Summary

Outside its native range in Alaska, the northern pike (*Esox lucius*) is a destructive aquatic nuisance species (ANS). Pike are native north and west of the Alaska Range, but they do not naturally occur in Southcentral Alaska or in most Southeast watersheds. Most of the ecologically and economically important salmonid production in Alaska occurs in these locations. The proliferation of pike within these areas has become a fishery management concern because pike are voracious predators and prey heavily on juvenile salmonids. Outside its native range, pike have the potential to interfere with ecosystem function and destroy economically important fisheries. Due to illegal introductions and subsequent dispersal, pike are found in several Cook Inlet watersheds including the Susitna River Basin, the Anchorage Area, and watersheds on the Kenai Peninsula. Pike have also been illegally introduced to ponds within the city of Yakutat in Southeast. Pike have been problematic in other states as well as in Alaska, and several state agencies are trying to control or eradicate them. In Alaska, fishing regulations for pike have been liberalized in hopes that angling pressure will reduce introduced populations. In addition, netting programs have been implemented to document water bodies with pike and, in some cases, reduce their abundance. Though control netting is a good start, it is clear that more efficient control methods are necessary. Alaska Department of Fish and Game (ADF&G) plans to implement extensive public outreach programs to inform the public about the consequences of illegal pike introductions to both prevent further illegal introductions and gain public support for control actions. The specific objectives of this management plan are to:

1. Increase public awareness of problems associated with invasive pike.
2. Prevent future pike introductions and re-introductions to restored areas.
3. Initiate public processes to gain support for management actions.
4. Implement scientifically sound management options to control or eradicate pike.
5. Improve wild salmon and resident fish populations that have been impacted by pike.
6. Restore enhanced fisheries that have been reduced or eliminated by pike.

ADF&G has outlined a process for accomplishing these objectives. Steps in this process include detecting populations of invasive pike, assessing habitat characteristics, proposing management alternatives for pike control, initiating a public process to communicate about control plans, implementing the chosen management action, and evaluating the success of the action. Interagency coordination and public outreach through the Department’s information and education (I&E) services will be major components of this process.

Several management alternatives for pike control are described in this plan, but some of these may not be practical in Alaska. The management alternatives that are likely to be the most effective include dewatering and/ or using fish toxicants (i.e. rotenone) in closed systems. Research on management alternatives and pike control in open systems is needed and will likely guide the future direction of this management plan. The consequences of not implementing pike control activities would be immense. Therefore, it is necessary that ADF&G, collaborating government agencies and nongovernment organizations, and the public work together to reduce and/ or eliminate pike from waters where pike have been illegally introduced.

I. Introduction

1.1 Aquatic Nuisance Species

Introduction of invasive, non-indigenous species can cause significant environmental and economic damage (Ruiz and Carlton 2003). This includes depredation on native species, shifts in trophic structure and nutrient cycling, competition for space, habitat alteration, disease transmission, hybridization, loss of biodiversity, and declines in fisheries (Taylor et al. 1984, Wilcove et al. 1998, Mack et al. 2000). A recent estimate suggested that damage costs from non-indigenous species in the United States exceed $120 billion annually, with at least $7.8 billion attributed to aquatic nuisance species (Pimental et al. 2000, 2005). Aquatic nuisance species (ANS) are non-indigenous aquatic organisms that threaten the diversity and abundance of native species; the ecological stability of infested waters; and the commercial, agricultural, aquacultural or recreational activities that depend on those waters. ANS may occur in inland, estuarine, or marine waters and presently or potentially threaten ecological processes and natural resources (ANS Task Force 1994).

Aquatic nuisance species are a national and international concern in many ports and inland waterways. In the United States, there are numerous cases where the introduction and establishment of an ANS has altered existing fish and wildlife communities. For example, in southern Florida, the interconnected canals required for water management provide dispersal opportunities for illegally released non-indigenous tropical fish. Introductions of predatory aquarium fish such as jewel cichlids (*Hemichromis letounreuxi*) and Mayan cichlids (*Cichlasoma urophthalmus)* have altered the community compositions of fishes in canals as well as adjoining natural wetlands (Loftus et al. 2005, 2006). Viable populations of predatory snakehead species (*Channa sp*.) have been detected in Florida, California, Hawaii, and Maryland. Concerns about these introductions and the potential for further dispersal prompted the U.S. Fish and Wildlife Service to classify all members of the Channidae family as “injurious wildlife”. Immediate actions were taken under the Lacey Act to protect resources from additional introductions of snakeheads by prohibiting interstate commerce (USFWS 2002), but snakeheads have since been discovered in other locations on the east coast and continue to be a concern. In the Pacific Northwest, escapes of Atlantic salmon (*Salmo salar*) from British Columbia and Washington fish farms have raised concerns of straying and mixing with wild salmon stocks (Volpe et al. 2000). Aquatic invertebrates such as zebra mussels (*Dreissena polymorpha)* and European green crabs (*Carcinus maenas*) compete with native species for space and damage municipal water supplies. These species are transported to new locations through ballast water discharged from commercial vessels (WDFW 2001, ADF&G 2002). The New Zealand mudsnail (*Potamopyrgus antipodarum)* was first introduced to Idaho in 1987 and has been transported to Washington, California, Oregon, and Montana on angler’s gear (CDF&G 2005). This invasive snail displaces native snails and other invertebrates in freshwater ecosystems (Kerans et al. 2005, Hall et al. 2006), reduces nutrients available to higher trophic levels (CDF&G 2005), provides low-quality nutrition to native predators (Ryan 1982), and can survive passage through the digestive tract of most fishes (Haynes et al. 1985).

The aforementioned examples are only a few of the ANS currently impacting aquatic ecosystems in the United States. In comparison, the state of Alaska has been less affected by ANS invasions than other states, thus far. This is, in part, due to Alaska’s strict plant and animal transportation laws, cold climate, geographic isolation, small human population, and relative lack of large-scale habitat disturbance (ADF&G 2002). The ANS that are impacting Alaskan ecosystems are threatening the natural resources of the state and the economic benefits they provide to Alaskans. In particular, northern pike (*Esox lucius* Linneaus 1758) have been introduced to watersheds containing highly productive habitat for salmonids and are currently causing declines in economically important fisheries. Northern pike are one of the highest priority threats in Alaska (ADF&G 2002) and their control outside of their native range is the focus of this management plan.

1.2 Northern Pike Introductions

(Native Range) Northern pike are circumpolar (Morrow 1980) and have one of the largest geographic distributions of all freshwater fish species (Stegemann 1989). In Eurasia, pike naturally occur from England to Siberia and south to northern Italy and China. In North America, they range from western Alaska to eastern Canada and south to Nebraska, Missouri, and Pennsylvania (Crossman 1979). Despite this large range, pike are not native to all watersheds in these regions.

(International) Northern pike occur in several countries outside their native range. In Europe, pike were introduced to Spain, Portugal, and Ireland (Welcomme 1988). In these countries, pike are valued as sport fish, although there are concerns in Ireland about potential impacts to native trout. In Africa, pike have been introduced to Algeria, Ethiopia, Madagascar, Morocco, Tunisia, and Uganda (Welcomme 1988, Lever 1996). In most cases, the origins of pike introductions are unknown, but in Morocco, pike were intentionally introduced as sport fish.

(United States) Pike naturally occur throughout most of Canada and the United States, but they have been introduced to several watersheds from which they are not native. Northern pike presently occur in watersheds outside their native range in 38 states (Figure 1). In most cases, pike were intentionally stocked to provide sport fish opportunities (Fuller 2003). Pike were also introduced to control invasive common carp (*Cyprinus carpio*) in states like Missouri and Nebraska (USFWS 2005). In many of the western states, pike have been illegally introduced causing fishery management concerns in most of those locations. Populations of northern pike resulting from illegal introductions now occur in Arizona, Idaho, Wyoming, Montana, California, and Alaska (McMahon and Bennett 1996).

1.3 Biology of Northern Pike

Northern pike are elongate, moderately compressed fish with forked caudal fins, flattened snouts and large prominent teeth (Mecklenburg et al. 2002; Figure 2). They are robust coldwater predators with high reproductive capabilities in shallow waters. Pike spawn in spring immediately after ice melts (Scott and Crossman 1973), and this often occurs in the same locations from year to year (Morrow 1980, Roach 1998). Spawning habitat consists of marshy areas with shallow water, emergent vegetation, and mud bottoms covered with mats of aquatic vegetation (Inskip 1982). Aside from spawning, pike have few habitat requirements other than prey availability (Chapman and Mackay 1984). Fecundity increases with female size, with as few as 2,000 eggs in small fish, and up to 600,000 eggs in females exceeding 30 lbs. (14.5 kg) (Morrow 1980).

Juvenile pike have a rapid growth rate (Scott and Crossman 1973, Morrow 1980); however, growth is highly dependent on temperature, availability of food, and access to suitable vegetation for cover (Morrow 1980). Growth rates are faster near the southern range boundary of 40º north latitude, but pike inhabiting northern waters tend to live longer (Scott and Crossman 1973). Fast growing pike can reach maturity during their second year of life, but most do not mature until age three or four (Morrow 1980). Competition for food, predation, and cannibalism are the primary causes of juvenile pike mortality (Hegemann 1964, Diana 1979, Raat 1988).

Pike are opportunistic predators. They are primarily piscivorous, but they will prey on amphibians, invertebrates, and vertebrates including mice, muskrats, and waterfowl (Solman 1945, Scott and Crossman 1973, Morrow 1980, Mecklenburg et al. 2002, Pierce et al. 2003). Pike will cannibalize conspecifics if other prey is not readily available (Morrow 1980, Mann 1982, Rutz 1996). Pike have broad physio-chemical tolerances (Scott and Crossman 1973) and can survive in very low dissolved oxygen conditions (Petrosky and Magnuson 1973). Despite its classification as a freshwater fish, pike can survive in salt water. Pike are known to occur in salinities as high as 10 ppt in the Baltic Sea and are able to reproduce in salinities as high as 7 ppt (Scott and Crossman 1973).

1.4 Problems with Northern Pike

(*Ecological*) Introductions of northern pike to waters outside its native range can have significant ecological consequences. Pike are highly predatory and can reduce populations of native species including mammals and waterfowl (Solman 1945) In one extreme example, Lagler (1956) estimated that an average of 1.5 million waterfowl were consumed by northern pike in a wildlife refuge in Michigan even though fish had been their primary prey.

Ratt (1988) summarized over 20 papers on the prey consumption efficiency of pike. In general, juvenile pike have a food conversion rate of 0.33, but this utilization rate declines with age. Conversion rates of adult pike have been reported at 0.18 in favorable environments, meaning that for every pound of weight gained, the pike must consume 5.5 pounds of prey. Food requirements vary with temperature, but there are significant increases in metabolism in late spring as fish recover from spawning activities (Johnson 1966). This is concurrent with the spring emergence of salmon fry from redds.

Northern pike are known to consume large portions of stocked and migrating juvenile salmonids. Petrvozvanskiy et al. (1988) showed that pike account for approximately 35% of stocked Atlantic salmon smolt mortality in the Keret River in Russia, and Larson (1985) documented a 50% loss of migrating Baltic salmon from pike predation.

In southcentral Alaska, juvenile salmon and trout, particularly coho salmon (*Oncohrynchus kisutch*), sockeye salmon (*Oncohrynchus nerka*), and rainbow trout (*Oncohrynchus mykiss*), are preferred prey for pike (Rutz 1996, 1999). All five species of pacific salmon (*Oncorhynchus sp.*), along with Arctic grayling (*Thymallus arcticus*), Arctic char (*Salvelinus alphinus*), Dolly Varden (*Salvelinus malma*), burbot (*Lota lota*), whitefish (*Coregonus nelsonii*), blackfish (*Dallia pectoralis*) and threespine stickleback (*Gasterosteus aculeatus*) are potential prey. Excessive depredation on these species can lead to the loss of species diversity in southcentral Alaska fish communities. Salmon are keystone species in Alaska and play a vital role in ecosystem functioning (Wilsson and Halupka 1995). They provide food for terrestrial predators such as brown bears and eagles, and decaying salmon carcasses release marine-derived nutrients into the terrestrial environment. This ultimately increases productivity within the system. Fewer salmon from pike predation can lead to increased competition among native predators for prey, loss of nutrient inputs, and a reduction in overall ecosystem productivity.

(Economic) In addition to ecological ramifications, the potential economic impacts of pike invasion are immense and will certainly intensify as pike continue to proliferate (Rutz 1999).

Beyond the impacts to wild fish stocks, it is increasingly difficult to justify the state's hatchery expenditures to release fish into waters that contain viable populations of pike. The Alaska Department of Fish and Game, Sport Fish Division's (the division) hatchery program produces approximately seven million fish annually and releases them into hundreds of lakes each year (ADF&G 2006). Hatchery stocking provides an average of 330,000 angler days of fishing effort beyond that of local wild stock production (Northern Economics 2004). Enhancement of fish populations in lakes provides a reliable sport harvest opportunity during the entire year and diverts angling pressure away from fragile wild stocks (ADF&G 2006). Most stocked lakes receive rainbow trout of various sizes. Catchable-sized fish (> 6 inches) are the most expensive to produce and are easy prey for large pike (Hyvarinen and Vehanen 2004). The division spends approximately $2.5 million on lake enhancement programs in Southcentral and the Interior (Jeff Milton, personal communication). On average, this generates $34.1 million annually to Alaska's economy (Northern Economics 2004). Predation on hatchery releases by illegally introduced pike jeopardizes these investments and the benefits they produce.

The American Sport Fishing Association estimates that US residents spend over $500 million on fishing trips and equipment in Alaska each year (US DOI and DOC 2001). Illegal pike introductions have negative ramifications for the long-term benefits of the Cook Inlet area fisheries. Cook Inlet fisheries are managed for harvest of surpluses generated by natural production and hatchery releases. Reductions in surpluses due to pike predation can diminish the number of fish available for commercial, sport, subsistence, and personal use fisheries. Many lodges and guiding services operate in areas where pike have been introduced to accommodate anglers participating in these fisheries. In addition, multimillion-dollar commercial fishing operations rely on harvesting salmon that originate in waters where pike have been introduced. Many local businesses depend on the sport and commercial aspects of salmon resources. Along with the fishing industry, other wildlife activities including hunting, trapping, wildlife viewing, and wildlife photography could be economically impacted. Though not easily measurable, the economic losses caused by pike predation could be enormous.

Additionally, ADF&G spends a significant amount of money on pike-related research projects and preliminary control efforts. Costs associated with these activities include personnel time, sampling gear, equipment, travel, boat fuel, and training programs. Since 2003, approximately $90,000 has been spent on pike-related activities in Southcentral Alaska with approximately $50,000 originating from USFWS Nuisance Species Program funds.

1.5 Status of Northern Pike In Alaska

(Native Range) Northern pike are native to Bristol Bay and the Interior, both north and west of the Alaska Range (Figure 3). With the exception of the Ahrnklin River drainage near Yakutat, watersheds south of the Alaska Range historically did not contain pike (Mecklenberg et al. 2002) During the Late Wisconsin glaciation of the Pleistocene, it is hypothesized that 48% of Alaska was covered with glaciers (Manley and Kaufman 2002) causing barriers to fish movement. Most populations of northern pike in Alaska entered from Beringia during this time (Lindsey and McPhail 1986).

Pike are not problematic within their native range in Alaska. Many lakes in the Interior are deeper than in Southcentral and provide better refuge for prey. Pike tend to remain in shallow, vegetated areas. Smaller fish can reside in the deeper, open areas of these lakes, and, therefore, avoid contact with pike. Interior fish species share a common evolutionary history, and prey species have adaptations for predator-avoidance in these lakes (Oswood et al. 2000). In Southcentral, coho, sockeye, and Chinook salmon (*Oncorhynchus tshawytshaw*) are the most abundant salmon species. These species usually remain in freshwater for 1-4 years before smolting and can be vulnerable to pike predation during the entire time. Chum salmon (*Onchorhyncus keta*) and pink salmon (*Onchorhyncus gorbusha*) are more prevalent in the Interior, and these species migrate to sea as fry (Mecklenburg et al. 2002) making them available to pike for only a short time. There have been a few cases where pike have been transplanted to stocked lakes where there is no record of them having prior residence. However, because pike are popular sport fish there, large individuals have been fished out, and smaller pike have not been documented to have an adverse affect on stocked fishes in these lakes (April Behr, personal communication).

Northern pike are an important subsistence and sport fish within their native range. Historically, both fresh and dried pike were used to supplement subsistence harvests. Pike continue to be an important food source in the Interior for subsistence and non-subsistence users (Burr 2004), and it is now one of the most important game fish, with an annual catch of approximately 50,000 fish (Jennings et al. 2004). Utilization of pike ranges from intensive harvest to catch and release trophy fisheries (Morrow 1980). The desire to catch pike has lead to illegal introductions outside its native range in Alaska.

(History of Pike Introductions) In the early 1950's, a pilot illegally transported pike from the Minto flats in the Yukon drainage, south across the Alaska Range into Bulchitna Lake in the Yentna River drainage. Over time, several high water events flooded the lake containing pike, providing open access to the Susitna River drainage. These circumstances led to the establishment of viable populations of pike throughout the Susitna River drainage and more importantly, an unimpeded pathway to adjacent watersheds in Cook Inlet. The proliferation of pike from the initial introduction and additional illegal introductions in areas of Northern Cook Inlet, Anchorage, the Kenai Peninsula, and Yakutat have further accelerated pike expansion into lakes and river systems that contain native resident or hatchery-produced fish.

(*Northern & Western Cook Inlet*) Since their initial introduction, pike have become established throughout most of the Susitna River drainage (Whitmore et al. 1994, Rutz 1996) the Matanuska-Susitna (Mat-Su) Valley, and lakes and creeks draining into Knik Arm and western Cook Inlet (Table 1, Figures 4 and 5). The Susitna River basin encompasses an area roughly the size of Indiana and is comprised of glacial rivers with hundreds of swift and slow-moving tributaries, sloughs, and inter-connected ponds and lakes. Pike densities are highest in the shallow, vegetated, and slow moving lakes and sloughs. Over half of the Susitna River Basin contains suitable habitat for pike (Sam Ivey, personal communication; Figure 4). These areas are also important rearing habitats for resident fishes. All five species of pacific salmon, along with rainbow trout, Arctic char, Arctic grayling, Dolly Varden, burbot, and whitefish reside in this system and share these habitats with pike for at least part of their life cycles.

At least eight additional water bodies in the Northern Cook Inlet Management Area (NCIMA) are at risk for pike invasion. Most of these are in close proximity to the Parks Highway which is the largest human travel corridor through the region. These water bodies include: Mama and Papa Bear Lake in Talkeetna, Caswell Creek along the Parks Highway, Rabideux Creek near the Susitna River bridge, the Big Lake system, the Little Susitna River system, the Jim Creek system, the Cottonwood Creek system, and the Threemile River system in western Cook Inlet (Sam Ivey, personal communication).

Several water bodies within the NCIMA that once contained healthy populations of resident fishes now contain only pike. Among these are Alexander Lake and all inlet streams, Fish Creek within the Nancy Lake canoe system, Fish Creek of Kroto slough, and Fish Lake Creek of the Yenta River (Sam Ivey, personal communication). Due to the extensive watershed area and availability of suitable habitat within the NCIMA, there is great potential for further spread of northern pike and the continued loss of resident fishes within this region.

(*Anchorage Area*) Northern pike were illegally introduced into the Anchorage area in the late 1980s or early 1990s and are currently established in seven lakes and three creeks (Table 2, Figure 6). Prior to stocking, lakes in the Anchorage area did not typically support resident fish populations other than the threespine stickleback (ADF&G 2006). Most of these lakes are land-locked, and many are manmade. Because of this, pike have not impacted wild populations of resident fishes, but stocking programs in the Anchorage area have become threatened. Stocking in Cheney Lake, for example, was discontinued when pike were introduced there. Prior to the pike introduction, Cheney Lake provided the most popular rainbow trout fishery in Anchorage. Lower Fire, Sand, and Otter lakes continue to be stocked despite established pike populations, but these lakes are deeper than Cheney, and stocked fish can seek refuge from pike.

In addition to stocked lakes, several water bodies in the Anchorage area are at risk from pike invasion. Pike have been confirmed in Campbell Creek (Steve Albert, personal communication), but are not known to be widespread. Campbell creek provides important rearing habitat for wild stocks of coho and sockeye salmon. If pike densities in Campbell Creek increase, these wild stocks may be impacted. Other systems of concern include West Chester Lagoon, Chester Creek, Rabbit Creek, and Potter Marsh which all contain ideal habitat for pike and rearing habitat for juvenile salmonids (Matt Miller and Dan Bosch, personal communication). Once fish passage is restored to Ship Creek, there would be suitable habitat for pike, and potential pike establishment could impact rearing stocks of hatchery-produced Chinook salmon. Commercial fishermen have reported catching pike in Cook Inlet on several occasions. This is disconcerting because if pike utilize Cook Inlet as a means of dispersal, they would have access to countless watersheds in Southcentral Alaska.

(*Kenai Peninsula*) Pike were introduced to Derks Lake in the Soldotna Creek drainage in the mid-1970s. From this introduction, they rapidly spread throughout the remainder of the drainage including East and West Mackey Lakes, Sevena Lake, and Soldotna Creek (Table 3, Figure 7). Historically, the Soldotna Creek drainage and Mackey Lake system had viable populations of rainbow trout, Dolly Varden, coho salmon, and sticklebacks, but now, with the exception of Denise and Sevena lakes, pike are the dominant species. Denise Lake has deep water refugia so rainbow trout and coho salmon still survive there. Pike destroyed the fish community in Sevena Lake, but resident fishes have recently begun to rebound because ADF&G control netting programs have reduced pike abundances in this lake (Rob Massengill and Kristine Dunker, personal observations). There are considerable public and Departmental concerns that pike will become established in the mainstem of the Kenai River and negatively impact the river’s world renowned salmon and trout populations. To date, pike are not known to spawn in the Kenai River. The Kenai River is a swift-moving river, and contains little suitable spawning habitat for pike. Despite this, pike have used the Kenai River as a migratory corridor. Statewide Harvest

Survey data indicates that anglers have harvested pike from river lakes including Egumen and Pederson (Jennings et al. 2004).

Although northern pike have been documented in only a few locations in the Kenai River watershed, the drainages of Moose River and Soldotna Creek contain significant habitat to support viable pike populations that potentially impact local salmon and trout production. Each year 20 to 40 percent of the coho salmon in the Kenai River system rear in the Moose River drainage. Habitat overlap with pike here could have negative social and economic consequences for Alaskans who rely on and are supported by the commercial, sport, personal use, and subsistence salmon fisheries of the Kenai River.

Another concern on the Kenai Peninsula is that pike will invade the Swanson River. Pike are in nearby Stormy Lake. This is one of the deepest lakes on the peninsula so native fishes including rainbow trout, Arctic char, coho salmon, and longnose suckers (*Catostomus catostomus*) are still present, although the once-popular rainbow trout fishery is nearly non-existent (Rob Massengill, personal communication). The Swanson River and its tributaries have runs of coho and sockeye salmon and world-class rainbow trout fisheries. Dolly Varden and other native fishes like sticklebacks, suckers, whitefish, and slimy sculpins (*Cottus cognatus*) are also present in the river. The Swanson River drains a large portion of the Kenai National Wildlife Refuge, and the introduction of pike to this system could have serious ecological consequences.

(*Southeast*) There is an isolated native population of pike near the headwaters of the Ahrnklin River. Pike were removed from this location and transplanted into a small freshwater stream system with interconnecting shallow ponds. This area is in downtown Yakutat and is known as the “Village Pond System” (Figure 8). Pike numbers have increased in this system and have drastically reduced coho salmon populations (Bob Johnson, personal communication). The “Village Pond System” is in close proximity to one of the most prestigious steelhead streams (Situk River) in Alaska. If pike invade the Situk River through natural migration or illegal introduction, there is a likelihood of devastation of the native fish community and the economy of Yakutat.

The community of Yakutat has a population of approximately 700 people. Yakutat residents rely on salmon fishing for subsistence and economic viability. The majority of fishing occurs in systems that could be threatened if pike migrate out of the Village Pond system. Up to 95 percent of the Yakutat District’s annual commercial harvests come from the Ophir/Tawah/Lost River complex and the Situk/Ahrnklin Estuary system because there are nearby fish-processing facilities and road connections to Yakutat (Bob Johnson, personal communication). Approximately 50 percent of the community depends on area fishery resources for income. Sport angling and commercial harvests provide millions of dollars annually and are the largest components of Yakutat’s economy.

Fortunately, pike are not a current threat in other southeast locations. Stream systems in Southeast support wild stocks of all five species of Pacific salmon, steelhead, rainbow trout, cutthroat trout (*Oncorhyncus clarkii*), and Dolly Varden. Fishing is a vital component of the Southeast economy. For pike to impact these fisheries, they would have to be illegally transported and stocked in Southeast streams. If this were to happen, the ecological and economic consequences to the region could be immense.

(*Prince William Sound/ Copper River*) Pike have not yet been confirmed in Prince William Sound or the Copper River Delta, although a pike was unofficially reported from a subsistence fish wheel on the Copper River near Copper Center in 2004 (Tom Taube, personal communication)**.** The Department is concerned that pike could expand into drainages of Prince William Sound and the Copper River (Figures 9 and 10) and impact native fishes. Watersheds in these areas support populations of salmon, Arctic grayling, burbot, Dolly Varden, rainbow trout and steelhead, lake trout (*Salvelinus namaycush),* humpback whitefish (*Coregonus pidschia),* and round whitefish *(Prosopium cylindraceum).* The extensive watersheds in these areas contain considerable spawning and rearing habitat for pike, and these waters are also vital rearing habitat for resident fishes.

1.6 Current Pike Eradication Projects

Attempts to control or eradicate pike are underway in several locations where illegally introduced populations exist. For example, in Montana, pike removal programs have been implemented in the Milltown damn reservoir at the confluence of the Clark Fork and Blackfoot rivers for restoration of native cutthroat trout and endangered bull trout (*Salvelinus confluentus*). The damn impedes trout migration, and non-native pike in the reservoir prey on trout that become concentrated there (Dickson 2003). Each year since 2001, the Montana Department of Fish, Wildlife, and Parks and its partners have temporarily lowered water levels of the Milltown reservoir to kill yearling pike that are stranded in back channels. This project has successfully reduced pike but has been labor intensive.

Pike removal in Lake Davis (Plumas County, California) has been an on-going process since 1994. In 1997, the California Department of Fish and Game (CDF&G) treated the lake with a common fish toxicant called rotenone (see section 5.11) to eradicate pike. Regrettably, pike were re-discovered in Lake Davis in 1999. It is unclear if a small number of pike survived the rotenone treatment, or if pike were illegally re-stocked afterwards. Prior to this treatment, the public did not understand the rationale for applying fish toxicants for pike removal, and there was a lack of public support for the project. Many tributaries that connect with Lake Davis were not targeted by the rotenone treatment, and pike in those areas likely survived. It was determined that the economic impacts from pike in Plumas County are far greater than the costs of repeating control methods (Gallo and Tsournos 2006). Therefore, the State of California is planning a second rotenone treatment (CDF&G et al. 2006). This time, CDF&G has focused a tremendous amount of effort on public outreach and education programs to explain why pike are problematic and provide information about rotenone. CDF&G is teaming with other agencies, and they plan to treat a spatially-expansive area to target pike in the tributaries as well as in the lake. Rotenone is a common control method for destroying non-indigenous and invasive fish (McClay 2000) and has been successfully used for many projects including eliminating yellow perch (*Perca flavens*), bass (*Micropterus sp*.), and golden shiners (*Notemigonus crysoleucus*) for restoration of brook trout (*Salvelinus fontinalis*) fisheries in the Adirondacks (Demong 2000) and eradicating topmouth gudgeon (*Pseudorasbora parva*) for restoration of recreational fisheries in England (Britton an Brazier 2006). In Alaska, rotenone was successfully used to eradicate an illegally introduced population of yellow perch in an unnamed landlocked lake on the Kenai Peninsula in 2000.

1.7 Alaska's Preliminary Pike Control Activities

In 1997, the Sport Fish Division initiated public outreach and education programs to inform anglers of the detriments of illegal pike stocking. Public education actions included the creation of brochures, web sites, television public announcements (funded by the Aquatic Nuisance

Species and Coastal programs administered by the U.S. Fish and Wildlife Service), and the production of a pike fishing video. These efforts were intended to increase public awareness, increase the harvest, and reduce illegal pike introductions. Prior to these actions, the division and the Alaska Board of Fisheries relaxed existing sport fishing regulations and management strategies to increase the harvest of pike. This included increasing bag and possession limits and allowing several additional harvest methods for pike. The Alaska State Legislature strengthened the penalty for illegal stocking of non-indigenous fish to a class A misdemeanor, which allows the court to seek restitution for damages to the fishery and expenses for removing introduced fish. To date, the division has invested $20,000 in these programs. The public has become more aware of the effects of illegal stocking; however, pike continue to be reported and documented in new locations within the Cook Inlet watershed, particularly in stocked land-locked lakes. The introduction of pike into stocked lakes is a clear indication that a misinformed public is illegally transporting and stocking pike. It is clear that more emphasis is needed on public education and prevention of ANS introductions.

The division has initiated preliminary pike control activities in the Northern Cook Inlet, Anchorage, Northern Kenai Peninsula, and Yakutat management areas. In these areas, test netting programs using experimental gill nets have been implemented to continuously document new locations with pike presence. Control netting programs have been implemented in select lakes such as Derks and Sevena on the Kenai Peninsula and Cheney in Anchorage to reduce abundance of pike. Bathymetric and water quality data are collected from lakes along with invertebrate samples to describe baseline physical and biological characteristics of lakes with pike. Plans and public processes are currently underway for a pike eradication project in Cheney Lake. Department staff continues to seek training and become educated in control methodologies. Despite these initial efforts, pike control and/or eradication in water bodies with introduced pike will be a colossal undertaking. The intent of this management plan is to build strong partnerships with state and federal agencies and guide collective efforts to control pike outside its native range in Alaska.

1.8 Plan Goals and Objectives

This plan initiates ADF&G's efforts to prevent, manage, and control pike in waters in the state where pike are not native. The Department has an Aquatic Nuisance Species Management Plan (ANSMP) (ADF&G 2002). The ANSMP directs the Department to develop step-down plans for individual species which include the following goals:

- Coordinate and collaborate with regional, national, and international ANS programs.
- Prevent introductions of new ANS into Alaskan waters.
- Detect, monitor, contain, and reduce ANS populations with minimal environmental impacts.
- Educate the public about the importance of preventing ANS introductions.
- Identify, develop, conduct, and disseminate research findings on ANS.
- Take appropriate action to ensure that federal and state regulations promote the prevention and control of ANS.

Additionally, ANS issues are incorporated into the Sport Fish Division's Strategic Plan (ADF&G 2003). An objective of the Strategic Plan is to protect Alaska's aquatic, riparian, and upland habitats from ANS. Key strategies to accomplish this include: documenting impacts of ANS, identifying and prioritizing habitats at risk, reviewing existing and proposed management practices for ANS, eliminating populations of ANS where practical, educating the public about ANS, developing partnerships with other agencies to address ANS issues, and reviewing or developing policies and regulations to protect Alaska's habitats from ANS.

This Management Plan for Invasive Northern Pike in Alaska merges goals and strategies from both the department's ANSMP and the Sport Fish Division's Strategic Plan with emphasis on management options for the prevention and control of pike and the restoration of fisheries and resident fish populations.

The overall objectives of this management plan are to:

1. Increase public awareness of problems associated with invasive pike.
2. Prevent future pike introductions and re-introductions to restored areas.
3. Initiate public processes to gain support for management actions.
4. Implement scientifically sound management options to control or eradicate pike.
5. Improve wild salmon and resident fish populations that have been impacted by pike.
6. Restore enhanced fisheries that have been reduced or eliminated by pike.

Necessary tasks to accomplish these objectives include: outreach and education, prevention, building partnerships, interagency coordination, research investigations and pathway analyses. ADF&G's specific approach will include the following process: detection and monitoring, assessment, proposed management, public process, management action, and evaluation (Figure 11). Interagency coordination and outreach with information and education (I&E) services are major components of this process and are included throughout to emphasize communication and coordination among participants.

II. Problem Statement

The introduction and proliferation of northern pike to watersheds outside their native range in Alaska have lead to challenges in fisheries management. Pike predation on natural and supplemented salmonid populations have threatened economically important sport, commercial, subsistence, and personal use fisheries and have interfered with natural ecosystem function. ADF&G is proposing strategies to control and/or eliminate established pike populations and to educate the public to prevent further illegal introductions. These strategies must be scientifically sound, effective in addressing area-specific issues, permitted by regulatory agencies, and cost-effective.

III. Invasive Northern Pike Management Strategy

ADF&G will attempt to eradicate northern pike that were introduced into landlocked lakes in waters in the state where pike are not native. Through these efforts, the Department hopes to develop strategies to address the colossal undertaking of pike removal in salmon rearing streams and rivers. As the Department progresses through public permitting processes to eradicate pike in lakes, these efforts will enhance awareness and educate the public on the adverse impacts of illegally-introduced pike so that further introductions may be prevented.

ADF&G's strategies:

- Use the best science and information available to research options for pike control in waters where pike are not native.
- Select the best and most cost effective options for successfully controlling pike while minimizing non-target impacts.
- Implement the plan with continuous monitoring to evaluate effectiveness.
- Involve the public in the plan and permitting process during plan implementation.
- Modify the plan and management strategies, as necessary, to achieve overall goals.
- Review the plan as necessary in coordination with state, local, and federal agencies.

ADF&G will investigate, monitor, and assess pike populations in waters in the state where pike are not native. Through inter-agency coordination and public input, supported management actions will be implemented. All recommended management actions shall be evaluated by ADF&G staff to determine the success of each action. Public notification of all Department findings and opportunities to respond to proposed management options will be available through the Sport Fish Division’s I&E services and the Department’s web pages.

IV. Planning Process

4.1 Outreach, Information & Education

I&E services and outreach efforts will focus on the prevention of illegal pike introductions, management options to control pike, and subsequent plans for fishery restoration. This will facilitate the public’s understanding of the Department’s overall plans and progress with pike control activities. The Department will promote open communication to foster public involvement and enhance collaboration among networks of cooperating agencies and organizations. Through these outreach efforts, the Department will also receive feedback on public opinions and concerns.

The internet will be the primary communication tool because of its availability to provide diverse and interactive information to broad audiences (Figure 12). ADF&G envisions a regional ANS web page that is informative, up to date, oriented toward youth, and focused on basic information about the detrimental impacts of illegal pike introductions. Additionally, this web site will contain information for each management area affected by illegal introductions of pike and proposed water bodies for assessment. An important service of the web pages will be to update the public, local governments, partners, organizations and regional staff with summaries of the Department’s assessments. Access to the Department’s findings will allow all interested parties to learn about proposed management alternatives and recommendations. This proactive educational approach will foster an informed and involved public.

4.2 Prevention

Further introductions of pike may be prevented by increasing public awareness of the ecological and economic dangers associated with illegally stocked pike. The Department’s I&E services and future websites will provide a basis for disseminating this information to the public. Communication between ADF&G and local, state, and federal government agencies, non-profit conservation organizations, and private companies will be an essential link in keeping the public updated with current information. In most cases, pike have been illegally introduced by people who were ignorant of the ramifications and simply desired a convenient pike fishery. If the public is aware and fully understands that introducing pike to waters outside its native range is both illegal and detrimental, further introductions of pike will hopefully be prevented.

4.3 Partnerships

To effectively and efficiently control invasive pike, the public processes among the Alaska Board of Fisheries, local fish and game advisory committees, and the Department must engage other agencies, local government officials, landowners, and private and non-profit organizations. Expanding and developing partnerships will ensure that diverse positions are heard and respected in considering management options for pike prevention, control, and eradication.

4.4 Interagency Coordination

The complexity of agency authority over lands in Alaska and access to state waters requires a collaborative approach to identify common goals and develop agreements on pike issues. It is paramount that partners and the public understand agency management authority for prevention, control, and restoration measures. Coordination and communication among agencies and partners is essential to provide public leadership, direction, and oversight for this plan. The goal is to ensure that public information about pike is consistent, based on sound science, and complements general concerns for ANS. Developing a communication network among agencies will provide managers with quick access to informed and involved agency staff. Additionally, this coordination will be beneficial to understand permitting application processes and cooperation on restoration measures.

4.5 Research Investigations

The research component of this plan provides for periodic evaluation of the plan in a strategic approach. Strategic evaluation merges the Department responsibilities with public involvement to improve efficiency, effectiveness, and public awareness of pike prevention, control, and restoration. Ultimately, through research and I&E services, collaborating agencies, organizations, and the public will better understand the management options under consideration by the Department.

Investigations of techniques to control or eradicate pike are necessary to provide options for restoring fisheries. Continued evaluations of pike movements through research and pathway analyses will allow detection and monitoring of current pike distributions and further pike dispersals. When practical, the Department will respond with corrective measures. Corrective measures (see section V for a list of possibilities) for pike control and restoration will be evaluated. New developments in pike prevention, control, and restoration will be fully documented and made available to others through the Sport Fish Division’s web pages and I&E services to keep the public up to date.

4.6 Pathway Analysis

To implement preventive measures and reduce the incidence of future illegal stocking, pathway analyses will be initiated to identify transportation routes for pike introductions. Understanding natural and human transportation mechanisms will assist the Department in protecting against additional introductions and reintroductions once control or restoration activities have occurred.

4.7 Steps in the Process

Detection and Monitoring (step 1)

(Fishery Status) Verification and evaluation of the presence of pike is the first step to determine the appropriate restoration management actions. The Department receives reports from the public about the presence of pike in a system. Follow-up sampling by the Department has often documented the presence of pike, but the extent and magnitude of the pike infestation remains unknown in most locations. Some steps the Department will implement to initially detect and monitor pike presence are:

- Test Netting (presence or absence)
- Pike Spawning and Rearing Habitat Evaluation
- Pathway Evaluation

Test netting will be conducted to confirm presence of pike reported by the public either verbally or through responses to the Statewide Harvest Survey (SHS) for catches of pike. The SHS is an annual postal survey administered by the Division of Sport Fish that estimates effort, catch and harvest in recreational fisheries throughout the state (Jennings et al. 2004). Verification of pike presence and an appraisal of spawning and rearing habitat are necessary to make an informed preliminary judgment on the extent of pike infestation. Evaluations of the potential pathways for pike are needed to determine approaches for further assessment. Information collected from these initial detections and monitoring efforts will be provided via the Internet and I&E services to ensure the public is informed. All information collected during the initial sampling will be archived into a GIS database.

Annual program reviews will be conducted to assist staff with planning, budgeting, and prioritizing assignments. Progress summaries and accomplishments will be incorporated into the review process with area updates summarizing field assessments and findings. The goal of this review is to prioritize water bodies to be advanced for further assessments or restoration measures. Program review participants include committee members, area and regional staff, program coordinators, and supporting partners. Initial planning documents will follow standard division operational plan formats that include objectives, tasks, evaluations, timelines, and reporting requirements with region and biometric approval.

Assessment (step 2)

An approved operational plan for multiple water bodies within an area may require a more extensive assessment of the pike population based on the following:

- Catch-per-unit-effort (CPUE) – A relative index of abundance that provides a measure of the magnitude of the pike population.
- Population Structure – Length frequency and sex-ratio analysis that allows estimation of reproductive capabilities of the population.
- Spawning Habitat Mapping – Following the methods of Inskip (1982), a spawning habitat suitability index describes the percentage of the water body that provides pike spawning habitat and rearing areas for young of the year.

The above measures will provide the information necessary to draw conclusions about the extent of the problem in waters with invasive pike and the threats to resident fish and salmon production in those waters. Based on these analyses, waters with invasive pike can be prioritized for control actions.

Data management and reporting will be important to disseminate information to the public and collaborating agencies. All pertinent information including GIS data will be archived by water body. Area pike assessments will be reported following standard division procedures- Fishery Data Series reports. Once published, reports will be available to the public through the division's web page.

Proposed Management Actions (step 3)

During annual program reviews, recommendations for pike management or fishery restoration activities in specific water bodies will be considered. Restoration recommendations will be forwarded to the director and commissioner for approval, along with a fishery briefing before any subsequent actions proceed. The fishery briefing will summarize management objectives and actions that have been implemented, results, and restoration recommendations. Approval of the fishery recommendation will initiate the public and permitting process with coordinating agencies. If use of a fish toxicant, such as rotenone, is recommended as a management option, the Department will notify the Board of Fisheries, through the commissioner's office, pursuant to Alaska Statue 16.35.200 and initiate the permitting process with Department of Environmental Conservation through the Alaska Coastal Management Program (ACMP).

Restoration work that could impact existing Department programs such as fish stocking, in accordance with the Statewide Stocking Plan for Recreational Fisheries (SSPRP), would need to be amended until restoration objectives are met. These amendments would be forwarded to the Regional Planning Team.

Public Involvement (step 4)

Public involvement is essential. The plan's prevention, I&E, and outreach components will provide the public with access to ADF&G's reports so they are informed on the assessments, results, proposed management actions, and restoration management objectives under consideration by the Department. An open dialogue between the Department, other agencies, and the public is imperative for productive consensus building on management options for pike and the restoration of fisheries when possible.

Public meetings will be scheduled, organized, and implemented under a consistent format. Prior to these meetings the Department will provide a meeting agenda and format via the Internet. During these meetings, Department staff will discuss current fishery issues for the water body under concern, proposed control and restoration options, and plans to prevent or mitigate impacts to non-target species during implementation of control actions.

Meeting summaries and results will be posted on the division's web page and supplied to involved agency staff and partners. Approved management actions will be published in a news release along with specific steps the Department intends to implement. All approved management actions and news releases will be archived in the GIS database. If the selected management action involves the use of federal funds to support rotenone application or other activities sufficient to trigger review under the National Environmental Policy Act (NEPA), all Appropriate NEPA documentation and public involvement will be undertaken.

Management Action Implementation (step 5)

As management options or restoration measures are implemented and completed, progress reports will be available via the division's webpage. This will provide easy access for involved individuals, organizations, partners, and agency staff wishing to monitor treatments.

Restoration Evaluation (step 6)

Because of the exceptional environmental tolerances, reproductive potential, and migratory behavior of pike, it will be necessary for the Department to evaluate the success of any management actions taken through a post-treatment assessment. If pike are still present after removal measures have been completed, it may be necessary to repeat or modify removal measures until the desired outcome is achieved, or until it becomes apparent that efforts should be abandoned. Results from post-treatment evaluations will be posted on the division's web page. If additional control or removal measures are required, notice will be posted on the division's web page and forwarded to involved agency staff, partners, and permitting authorities.

When desired management objectives have been met, all findings, briefings, and requests will be archived within the GIS database. A request to rescind the amendment to the Statewide Stocking Plan for Recreational Fisheries (SSPRP) will be forward to the regional supervisor by the area management biologist. Furthermore, a treatment briefing will be prepared for the director, commissioner, and Board of Fisheries.

V. Evaluation of Alternatives

5.1 Analysis of Pike Control Techniques and Management Options

Management options and techniques ADF&G may consider for controlling or eliminating pike from infested water bodies include procedures for containment, habitat manipulation, chemical treatment, removal of pike or prey species, and other biological treatments. Water bodies are identified as lacustrine and riverine because of the differences between these systems.

Techniques for Lacustrine Habitats

5.1.1 *Technique:* **Lake Barriers –** <u>Fixed and Temporary Water Control Structures</u>

5.1.2 *Advantages and Disadvantages:* Installation of lake-outlet water control structures would prohibit pike movements from lakes into connecting creeks and streams, but this could also inhibit migrations of resident fishes. To design water control structures, historical records of past water flows would have to be available so that current flows could be maintained within predictable bounds. Legal water rights issues could be a concern and would generally require a lengthy legal process to obtain approval.

5.1.3 *Costs Analysis:* Water control structures have high installation, operation, and maintenance costs associated with their implementation. Costs include engineering and design, construction and contingency, routine maintenance and labor costs. Installation costs would involve hiring a licensed and bonded engineering firm to design the water control structure. A licensed and bonded construction company with experience would be recommended. Operations and maintenance costs would include periodic repairs, cleaning and removal of debris, and staff time to complete these tasks. In addition, there would likely be legal costs associated with water rights and seeking project approval.

5.1.4 *Long-term Effects and Impacts:* Water control structures that prevent fish movements can negatively impacts adjacent lands and neighborhoods. For example, flooding of adjacent lands could occur if water control structures malfunction.

5.1.5 *Permit and Approval Requirements:* Installing water control structures would require extensive permitting and approval processes through the Department of Natural Resources (DNR).

5.1.6. *Impacts to Non-target Species:* Salmonid migration from lakes into connecting streams and creeks could be inhibited.

5.1.1 *Technique:* **Passage Restrictions** - Operation of Weirs

5.1.2 *Advantages and Disadvantages:* Lake-outlet weirs are often used to enumerate salmon escapement. To function properly, weirs require specific physical stream characteristics. To prevent pike movement, an effective weir would need very small spacing and constant maintenance. Weirs can be prone to failure under periods of high water. This method has limited utility to contain pike or prevent immigration of juvenile pike during winter conditions without some form of under ice passage restriction. In ice-free areas, electrically charged weirs have been useful in limiting the expansion of invasive fish in other states.

5.1.3 *Costs Analysis:* Weirs have high installation, operation, and maintenance costs associated with their implementation. Costs include construction, routine maintenance, and labor. Installation costs would include materials, tools, and staff time to build the weir. Operations and maintenance costs would include staff time for continuous repairs, cleaning and removal of debris, and regular removal of fish from live boxes.

5.1.4 *Long-term Effects and Impacts:* Though weirs could successfully prohibit pike dispersal during the summer and early fall, they are likely impractical in winter and early spring when pike movement beneath the ice would be unrestricted.

5.1.5 *Permit and Approval Requirements:* To install a weir, ADF&G would need to acquire access, land use, and DNR fish habitat permits through the Alaska Costal Management Program (ACMP).

5.1.6. *Impacts to Non-target Species:* There could be a high number of mortalities to resident fishes that are collected in the live boxes. If weirs are selected as a management option, live boxes will be routinely cleared. However, if high numbers of fish are collected in the live boxes at one time, mortality to resident fishes can occur from depleted dissolved oxygen or depredation from pike in the live box.

5.1.1 *Technique:* **Prey Manipulation/Control in Lakes**

5.1.2 *Advantages and Disadvantages:* As voracious predators, pike are highly dependent on the availability of prey (Diana 1979). Nilsson and Bronmark (2000) suggested that prey selection by pike is dependent on gape size, prey vulnerability, intraspecific interactions, and behavioral preferences. During periods of prey shortage, pike become cannibalistic (Hegemann 1964, Diana 1987). A popular fishery management strategy involves protection of larger sizes of predatory pike that feed on smaller pike and secondarily provide fishing opportunities. Pierce et al. (2003) indicated that stockpiling of large, older pike has limited effectiveness because of the high rate of natural mortality. Over a 15-year period, Snow (1978) reported a highly significant relationship between exploitation and natural mortality of northern pike in Wisconsin. Their analysis indicated that most of the pike caught would have been natural losses rather than survivors. Snow (1978) and Pierce et al. (2003) suggest that in prime habitats, under favorable environmental conditions, pike can be very productive and sustain the removal of half the population for extended periods before demonstrating a decline in population numbers.

In addition to manipulating the prey base by stockpiling large, cannibalistic pike, more proactive control measures involve reducing pike abundance through physical removal with gill nets and traps. This method can reduce pike abundance (e.g., Sevena Lake on the Kenai Peninsula) but tends to be inefficient. Control netting operations are labor intensive and require several repeated, if not continuous, sampling events because it is extremely difficult to capture large quantities of juvenile pike (Mann 1976). Large pike often evade nets because they tend to be sedentary unless they are spawning or foraging.

All pike are not equally vulnerable to individual fishing gears because of differences in age, size, sex, and behavior. Pike reduction programs often target females prior to spawning because they are more vulnerable near accessible spawning areas. However, the timing of pike spawning makes harvest difficult because pike spawn in shallow vegetated areas as ice recedes in spring (Rutz 1999, Hill 2004).

5.1.3 *Costs Analysis:* Although control netting has been successful in some cases, multiple years of intensive sampling has not demonstrated control netting as an efficient management option for the long term. Control netting has low costs compared with other methods because there are few construction or installation costs. Operations and maintenance costs include the initial purchasing of nets and safety equipment, periodic net repairs, travel to control sites, boat repairs and maintenance, fuel, and staff time to set and clear nets.

5.1.4 *Long-term Effects and Impacts:* If successful, control netting can reduce pike populations. However, this method has to be repeated continuously because, on its own, it will never result in the complete eradication of pike from a water body.

5.1.5 *Permit and Approval Requirements:* State and federal permits are not required for control netting, although acquiring a fish-collection permit from ADF&G would be recommended. Because many of the lakes that contain invasive pike are not in public ownership, working with and obtaining permission from private land owners is necessary.

5.1.6. *Impacts to Non-target Species:* Resident fish and other animals can and occasionally have become tangled in nets intended to control or assess pike. In the future, Department netting programs will use gear types and gear modifications that help minimize by-catch of non-target species, including fish, waterfowl, and other aquatic animals. When using nets to control or assess pike, the Department will make every feasible attempt to time such efforts to coincide with intervals of low migratory waterfowl abundance. When migratory waterfowl and/or aquatic mammals are present, the Department will take specific measures (for example, clearly mark nets with brightly colored floats and other materials making nets highly visible) to encourage avoidance by waterfowl and aquatic mammals. All efforts will be made to remove captured fish in nets as quickly as feasible to reduce attracting fish-eating mammals and birds to the nets. When it is feasible and Department personnel are available, nets will be attended to enable rapid and safe removal of birds and aquatic mammals if they are suspected to be present when nets are deployed.

5.1.1 *Technique*: **Discontinue Lake Enhancement**

5.1.2 *Advantages and Disadvantages:* Lakes with established populations of pike should perhaps no longer be stocked with hatchery-produced salmonids. This ensures that the Department will not waste hatchery-produced fish by feeding them to non-indigenous pike. However, this reduces fishing opportunities for anglers who enjoy fishing in those lakes.

5.1.3 *Costs Analysis:* This method has low costs compared with other methods. In certain respects, funds will actually be retained because there are no hatchery expenditures in lakes where enhancement has been discontinued. However, fishing license sales may decrease if popular fisheries are eliminated. Additionally, the local economy may be impacted if anglers stop purchasing fishing gear, tackle, boat fuel, etc. from businesses near those lakes. Personnel time will be required to physically assess the lakes, draft recommendations to discontinue lake enhancement, and prepare news releases to inform the public of these decisions.

5.1.4 *Long-term Effects and Impacts:* Discontinuing lake-enhancement programs will result in the elimination of popular sport fisheries.

5.1.5 *Permit and Approval Requirements:* Permits would not be required to discontinue lake-enhancement. These decisions are made at the area and regional levels.

5.1.6. *Impacts to Non-target Species:* Discontinuing lake-enhancement programs will not directly affect non-target species. However, the absence of hatchery fish will increase predation pressure from pike on other animals in the lake.

5.1.1 *Technique:* **Harvest Strategies in Lakes**

5.1.2 *Advantages and Disadvantages:* Harvest management regulations adopted by the Alaska Board of Fisheries (BOF) and administered by the Department are based on the sustainable yield principle. A harvest strategy designed to reduce a population is an unusual exception to management practices in the State of Alaska, but is within the authority of the Department's commissioner to manage, protect, maintain, improve, and extend the fish, game, and aquatic plant resources of the state in the interest of the economy and general well-being of Alaska as specified in AS 16.05.020(2) (LexisNexis 2006). Different strategies have various advantages and disadvantages.

<u>Slot limits / Trophy Management</u>: Protecting large pike can result in a population structure with fish greater than average weight, but fewer in abundance than in populations whereby all sizes are exploited.

<u>Unlimited Bag and Possession</u>: Liberalizing bag limits for pike has been marginally successful at reducing pike populations. However, anglers often target larger pike and release smaller fish. Several states now promote catch and kill pike regulations.

<u>Freshwater Commercial Fisheries</u>: Establishment of a commercial fishery for pike would be highly dependent on development of markets. Interception of non-target species during such a fishery would be a concern. Also, this may provide an economic incentive for further illegal introductions of pike.

<u>Personal Use Gillnet Fisheries</u>: Establishment of a personal use fishery could be a viable option with sufficient public demand. Concerns regarding wasting fish and the harvest of non-target species would need to be addressed.

5.1.3 *Costs Analysis:* This method has comparatively low costs. This may actually increase fishing license sales from anglers who enjoy pike fishing. Additionally, the local economy would possibly benefit if anglers purchase equipment from businesses near lakes with liberalized harvest regulations. Personnel time will be required to plan harvest strategies and seek approval from the BOF.

5.1.4 *Long-term Effects and Impacts:* In the long term, removal of the prey base (smaller pike) can result in "stunting" so that the lake is full of small, stunted pike known as "hammer-handles" that are not attractive to anglers. Also, this may create an incentive to relocate northern pike to widen their range and availability.

5.1.5 *Permit and Approval Requirements:* Harvest strategies would need to be approved by the Board of Fish (BOF).

5.1.6. *Impacts to Non-target Species:* Adopting harvest strategies for pike fishing in lakes would not have any direct impacts to non-target species.

Techniques for Riverine Habitats

5.1.1 *Technique:* **River Barriers** - Weir Operations

5.1.2 *Advantages and Disadvantages:* Weirs have been marginally effective in restricting adult-sized pike to spawning areas. However, Hill (2004) indicated that no type of simple barrier was completely effective in restricting spawning pike in the Yampa River, Colorado from accessing backwater areas. To function properly, weirs require specific physical stream characteristics. To prevent pike movement, an effective weir would need very small spacing and constant maintenance. Weirs can be prone to failure under periods of high water. Under winter conditions, this method has limited utility to contain pike or prevent immigration of juvenile pike without some form of under ice passage restriction. In ice-free areas, electrically charged weirs have been useful in limiting the expansion of invasive fish in other areas.

5.1.3 *Costs Analysis:* Weirs have high installation, operation, and maintenance costs associated with their implementation. Costs include construction, routine maintenance, and labor. Installation costs would include materials, tools, and staff time to build the weir. Operations and maintenance costs would include staff time for continuous repairs, cleaning and removal of debris, and regular removal of fish from live boxes.

5.1.4 *Long-term Effects and Impacts:* Though weirs could successfully prohibit pike dispersal during the summer and early fall, they are likely impractical in winter and early spring when pike movement beneath the ice would be unrestricted.

5.1.5 *Permit and Approval Requirements:* To install a weir, ADF&G would need to acquire access, land use, and DNR fish habitat permits through ACMP.

5.1.6. *Impacts to Non-target Species:* There could be a high number of mortalities to resident fishes that are collected in the live boxes. If weirs are selected as a management option, live boxes will be routinely cleared. However, if high numbers of fish are collected in the live boxes at one time, depleted dissolved oxygen or depredation from pike can cause mortality of resident fishes.

5.1.1 *Technique:* **Prey Manipulation/Control in Rivers**

5.1.2 *Advantages and Disadvantages:* Multiple gear types or mesh sizes would need to be employed to reduce abundance across all size classes of pike. Targeting female pike prior to spawning can be difficult due to seasonal ice conditions and the inability to access larger drainages by riverboat. If control netting is considered a viable method, timing removal to coincide with spawning would increase net catch efficiency. However, such removal would likely be limited to mature fish, and another method or approach to capture immature pike should also be considered (Mann 1976, 1985). Previous control netting operations for pike have been labor intensive and have demonstrated limited success in reducing pike abundance. The interception of non-target species, such as rearing salmon and other resident fish, would be a concern with use of small-mesh gillnets.

5.1.3 *Costs Analysis:* Although control netting has been successful in some cases, multiple years of intensive sampling have not demonstrated it to be an efficient management option for the long term. Control netting has low costs compared with other methods because there are few construction or installation costs. Operations and maintenance costs include the initial purchasing of nets and safety equipment, periodic net repairs, travel to control sites, boat repairs and maintenance, fuel, and staff time to set and clear nets or traps.

5.1.4 *Long-term Effects and Impacts:* If successful, control netting can reduce pike populations. However, this method has to be repeated continuously because, on its own, it will never result in the complete eradication of pike in open river systems.

5.1.5 *Permit and Approval Requirements:* State and federal permits are not required for control netting, although acquiring a fish-collection permit from ADF&G is recommended. Because many of the waters that contain invasive pike are only accessible via private property, working with and obtaining permission for access from private land owners would be necessary.

5.1.6. *Impacts to Non-target Species:* Resident fish and other animals can and occasionally have become tangled in nets intended to control or assess pike. In the future, Department netting programs will use gear types and gear modifications that help minimize by-catch of non-target species, including fish, waterfowl, and other aquatic animals. When using nets to control or assess pike, the Department will make every feasible attempt to time such efforts to coincide with intervals of low migratory waterfowl abundance. When migratory waterfowl and/or aquatic mammals are present, the Department will take specific measures (for example, clearly mark nets with brightly colored floats and other materials making nets highly visible) to encourage avoidance by waterfowl and aquatic mammals. All efforts will be made to remove fish from nets as quickly as possible to reduce attracting fish-eating mammals and birds. When Department personnel are available, nets will be closely monitored and tangled birds and aquatic mammals will be rapidly and safely removed.

5.1.1 *Technique:* **Harvest Strategies in Rivers**

5.1.2 *Advantages and Disadvantages:* Harvest management regulations adopted by the Alaska Board of Fisheries (BOF) and administered by the Department are based on the sustainable yield principle. A harvest strategy designed to reduce a population is an unusual exception to management practices in the state of Alaska, but is within the authority of the Department's commissioner to manage, protect, maintain, improve, and extend the fish, game, and aquatic plant resources of the state in the interest of the economy and general well-being of Alaska as specified in AS 16.05.020(2) (LexisNexis 2006). Different strategies have various advantages and disadvantages.

Unlimited Bag and Possession: Liberalized bag limits have demonstrated marginal success as a management tool for reducing populations of pike because anglers often release small pike.

Freshwater Commercial Fisheries: Establishment of a commercial fishery for pike would depend on development of markets. Interception of non-target species during such a fishery could be a concern. Also, this could provide an economic incentive for further illegal introductions of pike.

Personal Use Fisheries: Establishment of a personal use fishery could be a viable option if there is sufficient public demand. Concerns regarding wasting fish and the harvest of non-target species would need to be addressed.

5.1.3 *Costs Analysis:* This method has low costs compared with other methods. This could actually increase fishing license sales from anglers who enjoy pike fishing. Additionally, the local economy could benefit if anglers purchase equipment from businesses near creeks and streams with liberalized harvest regulations. Personnel time will be required to plan harvest strategies and seek approval from the BOF.

5.1.4 *Long-term Effects and Impacts:* In the long term, removal of the prey base (smaller pike) can result in "stunting" so that the water body is full of small, stunted pike known as "hammer-handles" that are not attractive to anglers. Also, there is a chance that anglers who enjoy the liberalized pike fishing might desire a similar fishery nearby and move pike into a new water body for this purpose.

5.1.5 *Permit and Approval Requirements:* Harvest strategies would need to be approved by the BOF.

5.1.6. *Impacts to Non-target Species:* Adopting harvest strategies for pike fishing in river systems would not have any direct impacts to non-target species.

Techniques for Habitat Manipulation

5.1.1 *Technique:* **AquaticVegetation Removal**

5.1.2 *Advantages and Disadvantages:* Pike function as ambush predators. As such, suitable habitat is needed for rearing, survival and feeding. The absence or a reduction of vegetative cover has reportedly resulted in lower pike survival and lower production (Fabricius 1950, Franklin and Smith 1963). Removing aquatic vegetation to eliminate pike is an enormous task. Cross et al. (1992) indicated removal of 10 percent of aquatic macrophytes was not sufficient to significantly change densities, size structure, or growth of pike during a 1988-89 study in three lakes to improve bluegill (*Lepomis macrochirus)* production. Removal of significant aquatic vegetation would impact the entire aquatic ecosystem and would require substantial evaluation before implementation.

5.1.3 *Costs Analysis:* Aquatic vegetation removal would have high costs associated with its implementation. Costs include either hiring a contractor to physically remove aquatic vegetation or applying an herbicide to kill aquatic vegetation. Both methods would need to be repeated as vegetation grows back. A significant amount of staff time would be necessary to gain approval and implement this project.

5.1.4 *Long-term Effects and Impacts:* The long-term ecological impact from vegetation removal could be significant. Even if pike were reduced or eliminated using this method, succession of plant species may not resemble the original plant community. For example, if an ANS plant species is present in the lake, vegetation removed to reduce pike habitat could quickly be replaced by the ANS.

5.1.5 *Permit and Approval Requirements:* Vegetation removal would require extensive permitting and approval processes through the DNR, and an ADF&G fish transport permit may be required under 5 AAC 41.005 (LexisNexis 2006) which prohibits the transportation of fish and aquatic plants.

5.1.6. *Impacts to Non-target Species:* Because of the ecological consequences of this method, non-target species would definitely be impacted. Salmonids and other native fish rear or seek refuge in aquatic vegetation to avoid predators. Many aquatic invertebrates are found in vegetated areas. Additionally, waterfowl often forage in floating mats of aquatic vegetation. Photosynthetic rates in the lake would be reduced, and dissolved oxygen concentrations would decline. This could impact the survival of all aquatic organisms in the water body.

5.1.1 *Technique:* **Physical Parameters Manipulation**

5.1.2 *Advantages and Disadvantages:* Pike are very tolerant of environmental conditions in the northern temperate zone, and are capable of surviving in waters with low oxygen (Magnuson and Karlen 1970), high pH, and high salinity (Raat 1988). Water quality may be more important to fry survival because fry are rather sensitive to low extremes of pH and to high concentrations of carbonate and bicarbonate. Pike are moderately euryionic in that they can survive in alkaline lakes with a pH averaging 9.5 for up to four months (McCarraher 1962). Pike have been documented to survive in lakes with a pH of 3.5 and are reproductively successful in waters with minimum pH values of 4.5, though embryos at this pH may be deformed (Milbrink and Johansson 1975). In cold waters, pike are tolerant of low dissolved oxygen; they are capable of surviving at 0.3 mg/l for prolonged periods and have been reported to survive beneath the ice at 0.1 mg/l for several weeks (Magnuson and Karlen 1970). Tolerance to low dissolved oxygen is inversely related to size in juvenile and adult pike. Pike have broad tolerances to changes in salinity. Their osmotic balance responds quickly when moving from fresh to salt water and from salt to fresh water. In the Baltic Sea, and other bodies of marine water, anglers have been reported actively sport fishing for pike (Johnson and Muller 1978, Muller 1982). In Alaska, the commercial gillnet fishery in marine waters of Cook Inlet has been reporting small numbers of pike since 1995 (D. Rutz, personal communication). Pike are a coldwater species sensitive to warm water. The upper incipient lethal temperature for pike is near 30^{o}C, and summer kill can be frequent in small shallow impoundments south of the latitude of Iowa in the United States (Raat 1988). Manipulation of any of these factors is difficult in closed systems, and virtually impossible in open systems with flowing water.

5.1.3 *Costs Analysis:* Costs of manipulating the physical characteristics of water bodies are likely to be high. Costs would depend on the abiotic parameter and the specific method under consideration.

5.1.4 *Long-term Effects and Impacts:* The long-term ecological impact of manipulating the abiotic environment of a water body is likely to be high as well. The length of time required for physical conditions to return to normal would depend on the abiotic parameter (i.e. dissolved oxygen, depth, etc.) chosen for manipulation and the method used to accomplish this.

5.1.5 *Permit and Approval Requirements:* Permit requirement would depend on the parameter chosen for manipulation and the associated method. Any of these manipulations would likely require a lengthy permitting process and extensive evaluation of the pre-treatment environment.

5.1.6. *Impact to Non-target Species:* Manipulation of physical parameters in lakes could result in long-term environmental impacts to the water body. Unless pike were the only species in the lake, direct adverse impacts to all other aquatic species would be expected, and there could also be indirect effects on terrestrial predators.

5.1.1 *Technique:* **Dewatering**

5.1.2 *Advantages and Disadvantages:* Dewatering spawning areas or entire water bodies can be effective and has been used to control pike numbers in commercial pike propagation operations in Europe. Some reservoirs with water control structures purposely dewater spawning areas to reduce pike production (Raat 1988). Dewatering wetlands or reservoir drawdown prior to pike spawning has been used with some success in other states.

5.1.3 *Costs Analysis:* If water control structures or drain systems are already present, costs of dewatering would be low. However, if infrastructure such as water control structures needs to be installed, costs could be very high. Water control structures have high installation, operation, and maintenance costs associated with their implementation. Costs include engineering and design, construction and contingency, routine maintenance and labor costs. Installation costs would involve hiring a licensed and bonded engineering firm, with experience, to design the water control structure. Operations and maintenance costs would include periodic repairs, cleaning and removal of debris, and staff time to complete these tasks.

This method would only need to be implemented once if complete draw-down of the water body was possible or if the water body could completely freeze in the winter. However, if de-watering is used in conjunction with spawning, treatments would need to be repeated annually which would greatly increase the cost of the project.

5.1.4 *Long-term Effects and Impacts:* If water control structures were present, water levels could be returned to normal in a short amount of time. If not, the lake or water body would not re-flood until the following spring.

5.1.5 *Permit and Approval Requirements:* Dewatering would require extensive permitting and approval processes through the DNR and potentially other government agencies.

5.1.6. *Impacts to Non-target Species:* Unless pike were the only fish species present in the water body, all salmonids, resident fishes, and other aquatic species could be killed by de-watering.

5.1.1 *Technique:* **Pressure**

5.1.2 *Advantages and Disadvantages:* The detonation of explosives in several Austrian and German lakes during World War II killed significant numbers of pike. Raat (1988), translated from Einsele (1964), reported that pike were highly sensitive to pressure changes in the water. Anatomically, pike lack muscle tissue along the ventral side, thus little protection is provided to the swim bladder and kidneys. Einsele (1964), however, noted that smaller pike in areas with more submerged vegetation survived heavy explosions. For sudden pressure changes to be effective in killing pike, either aquatic plant removal or dewatering may be necessary to allow production of pressure waves capable of actually rupturing swim bladders and kidneys.

Pressure waves generated with the use of explosives (e.g., detonation cord) have been used to kill fish. The effective range of detonation is related to the size of the discharge, distance, substrate, and presence or absence of aquatic vegetation. Additionally, Rudakovskiy et al. (1970) suggest that pneumatic emitters and gas detonators in water frighten pike. Although not a standard collection technique, use of explosives has been applied in Davis Lake, California to remove pike. However, this technique was considered inferior to the use of rotenone (Bayley and Austen 1988).

5.1.3 *Costs Analysis:* Costs associated with the use of explosives would be moderate to high. A significant amount of staff time would be required to plan the project and seek approval. Staff would either have to be trained on the use of detonation cords, or the Department would need to hire a contractor. If aquatic plant removal or dewatering were necessary, these processes would substantially add to the cost of the project.

5.1.4 *Long-term Effects and Impacts:* If aquatic plant removal was necessary, impacts to the water body could be long-term. If not, the environment in the water body would return to normal in a shorter amount of time, although, depending on the size of the treatment area, it would take some time for the turbidity to settle out.

5.1.5 *Permit and Approval Requirements:* The use of a detonation cord for pike removal would require extensive permitting and approval processes through the DNR.

5.1.6. *Impacts to Non-target Species:* Unless pike were the only fish species present in the water body, all resident fishes would be killed by the pressure wave.

Techniques for Pike or Prey Removal

Control netting and selective harvest are two techniques for pike or prey removal described in previous sections. The following are other techniques for removing pike or prey.

5.1.1 *Technique Description:* **Electrofishing**

5.1.2 *Advantages and Disadvantages:* Electrofishing has been reported as one of the least effective capture methods for pike because of the presence of large amounts of aquatic vegetation and specific pike behavior (Mann 1976). The reotaxis generated from the electric field may be high depending on the size and location of the fish in the electric field. Smaller pike in the margins of the electric field tend to be stunned and are more likely to escape detection and move into the aquatic vegetation.

5.1.3 *Costs Analysis:* Costs of electrofishing are moderate compared with other methods, depending on the type of equipment purchased. Backpack electroshockers are affordable (~ $5,000), but boat electroshockers can be substantially more expensive (~ $20,000 for an entire system). In addition, staff would need to attend training courses to become certified in the use of electrofishing equipment. Other costs would include travel to collection sites, safety equipment, boat fuel, and staff time in the field.

5.1.4 *Long-term Effects and Impacts:* Once the electrical field is turned off, there are no additional impacts to aquatic organisms.

5.1.5 *Permit and Approval Requirements:* Electrofishing may require obtaining a permit from the DNR. Acquiring a fish-collection permit through ADF&G would also be recommended.

5.1.6. *Impacts to Non-target Species:* Salmonids or other native fishes that come in contact with the electrical field could be impacted, although the degree would depend on the strength of the electrical current. Fish that are on the periphery of the electrical field will be temporarily stunned, but they would likely survive.

5.1.1 *Technique Description:* **Sterilization**

5.1.2 *Advantages and Disadvantages:* Heat-treating developing embryos in a hatchery is a method that can be used to create sterile, triploid, female pike. There are challenges involved in creating triploid pike. In theory, however, stocking a pike population in a closed environment with sterile triploids (1-2 cm in length) would decrease the reproductive potential of the population while at the same time increasing competition and cannibalism. This could reduce natural production to some degree.

5.1.3 *Costs Analysis:* Sterilization of pike would have moderate operational costs associated with its implementation. Costs would involve producing sterile, triploid female pike in state hatcheries. Staff time would be required to rear sterile pike in the hatchery and release them into water bodies with previously existing introduced populations. To evaluate long-term success in reducing reproductive potential and overall production, continuous field-monitoring of the population would be necessary. Costs for this would involve sampling equipment and staff time.

5.1.4 *Long-term Effects and Impacts:* Over time, if the triploids dominate the population, it is theoretically possible to reduce the reproductive capabilities in a closed environment. However, the likelihood of achieving this condition is very low because it would take only a few pike to continue the natural reproductive cycle that was started when illegal introductions first occurred.

5.1.5 *Permit and Approval Requirements:* An ADF&G fish transport permit under 5 AAC 41.005 (NexisLexis 2006) would need to be obtained to stock sterile pike.

5.1.6. *Impact to Non-target Species:* Sterilization of pike would not directly impact non-target species. However, introducing sterile pike into water bodies that already contain pike could further increase predation pressure on native animals in those water bodies.

5.1.1 *Technique:* **Winterkill**

5.1.2 *Advantages and Disadvantages:* The winter ice cover caps available oxygen in lakes. Many lakes contain springs which continuously introduce low concentrations of dissolved oxygen (DO) from ground water. As winter progresses in closed systems, oxygen is depleted from the benthos, and fish become concentrated within a narrow layer of oxygenated water just beneath the ice cap. During prolonged winters in Alaska, winterkill results when the DO level becomes insufficient to support fish life in shallow lakes. Pike are one of the most tolerant species to winterkill because they can survive in DO concentrations of 0.1 mg/l for several weeks at cold temperatures (Magnuson and Karlen 1970). With further research, utilizing the low oxygen condition during winter may provide an effective method for pike removal. Agencies in other states have programs for winter aeration of lakes with a history of winterkill. However, these agencies have found that through convection, rising air bubbles creates turbulence that circulates warmer anaerobic bottom waters. This causes DO levels in the lake to drop too low for fish survival. Studies in Wisconsin, Minnesota, and Illinois encourage careful monitoring of DO through the winter to determine when to begin aeration. Fishery resource managers from these states suggest lake aeration begin at DO concentrations between 4 and 5 mg/l to prevent entire fish loss from winterkill. In Alaska, it might actually be possible to use aeration to induce winterkill in lakes with introduced pike populations.

Anaerobic conditions also may be induced under the winter ice cap by adding detritus, circulating CO_2, or a combination of both. Use of this procedure may warrant further investigation. Specifically, studies of winterkill effects on lake zooplankton communities in Alaska would be needed. Bandow (1980) reported a moderate decline in primary production and a temporary reduction in dominant benthic invertebrates in warm water lakes in Minnesota, but this winterkill treatment had immediately followed a fall treatment of the same lake with rotenone.

5.1.3 *Costs Analysis:* Winterkill aeration systems have moderate installation, operation, and maintenance costs associated with their implementation. Costs include construction, routine maintenance, and labor. Installation costs would include materials, tools, and staff time to install the aeration system. Another alternative might be to hire a contractor to install the aeration system. Operations and maintenance costs would include staff time for periodic repairs. Liability insurance might also be required. Aeration systems thin the ice, and this could create hazardous conditions for public users. If all fish are killed as a result of winterkill activities, there will also be hatchery expenses to re-stock these lakes.

5.1.4 *Long-term Effects and Impacts:* Long-term impacts could include faunal changes within the zooplankton and benthic invertebrate communities. These organisms provide a foundation for lake food webs. Shifts in the community structures of these groups could impact higher trophic-level species.

5.1.5 *Permit and Approval Requirements:* A permit would be required from the DNR to install and operate an aeration system. ADF&G would publish public notices and post warning signs to warn the public of potentially hazardous ice conditions.

5.1.6. *Impacts to Non-target Species:* Unless pike are the only fish species present in the lake, all other native fishes and aquatic invertebrates would be killed by winterkill activities.

5.1.1 *Technique:* **Bounty**

5.1.2 *Advantages and Disadvantages:* Historically, bounties have rarely been used in fisheries. Prior to statehood in Alaska, a bounty was paid for tails of Dolly Varden that preyed on young salmon in an attempt to bolster salmon survival in fresh water. With improved understanding that Dolly Varden were not significant predators of young salmon, the bounty was eliminated in 1941. The use of a bounty as a management tool for invasive pike is not currently legal in Alaska, and this option may be in conflict with the State’s Constitution regarding the sustainable use of fisheries resources.

5.1.3 *Costs Analysis:* It would be a costly process to obtain legal approval to implement a bounty. In the long term, paying bounties to anglers would be expensive, and the benefits provided by this method are unlikely to justify these expenses.

5.1.4 *Long-term Effects and Impacts:* Offering a bounty may reduce pike in the short term, but this could also provide a financial incentive for people to continue illegally stocking pike.

5.1.5 *Permit and Approval Requirements:* A lengthy legal process would be involved in obtaining approval for instituting a bounty.

5.1.6. *Impacts to Non-target Species:* Instituting a bounty would not directly impact non-target species, but fish that are mis-identified as pike could accidentally be killed.

5.1.1 *Technique:* **Chemical Treatment** - Rotenone

5.1.2 *Advantages and Disadvantages:* This naturally occurring substance is derived from tropical and sub-tropical plants. Natives of South America and the South Pacific have used the juices from these plants for centuries to collect fish for consumption. In developed countries, scientists have used rotenone as a useful organic garden insecticide to control chewing insects on crops and as a livestock dip for cattle, sheep, and dogs. The development of synthetic chemical pesticides has reduced the need for rotenone, but it remains a control agent for fish. Fish are highly susceptible to rotenone because, when applied to water, it enters the blood stream through the gills, inhibits a biochemical process at the cellular level, and makes it impossible to utilize oxygen. Species of fish that have high oxygen demands at the cellular level (e.g., trout and salmon) are most sensitive to rotenone; species such as sunfish and pike are more resistant. If ingested, natural gut enzymes in fish, birds, and mammals will detoxify rotenone. Rotenone is an unstable compound that breaks down when exposed to light, heat, oxygen, and alkaline water. It spontaneously breaks down to about 20 lesser or non-toxic substances, most of which continue to degrade into carbon dioxide and water. The rate of detoxification is dependent on water temperature and water chemistry. The toxicity to fish may last up to a month in cold water. In general, most lakes treated with rotenone completely detoxify within five weeks of the treatment. The degradation of rotenone can be accelerated with the addition of oxidizing chemicals such as potassium permanganate or chlorine (American Fisheries Society 1998).

Use of rotenone as a piscicide (an agent to kill fish) requires an understanding of the conditions that can dilute the treatment. To determine appropriate concentrations, lakes, flows from inlet and outlet streams, and springs need to be measured. In the past, some applications of rotenone needed to be repeated to obtain the desired effects. Repeated treatments of rotenone have caused considerable public concern and, in some cases, bad public relation issues. Considerable interaction with the public will be needed to develop acceptance and understanding before applying rotenone to public waters. Past uses of rotenone have been controversial because of a lack of public awareness and understanding of the management decision that led to its use, the purpose of the treatment, and the benefits of its use in fisheries management.

In 2003, three lakes in the Fort Greeley area were prepared for stocking of hatchery-produced fish by applying rotenone to remove undesirable species. Prior to statehood, rotenone was used in Alaska to prepare lakes for fishery enhancement. In the 1950s, Lost Lake was treated, and in the 1960s, Little Harding and Birch lakes were treated with rotenone prior to introduction of hatchery fish. A second treatment was needed for Little Harding Lake in the mid 1970s, and Quartz Lake was also treated in the 1970s. Chena Lake received rotenone treatment in 1983, and a number of gravel pits and ponds have been treated with rotenone in recent years to provide more stocking locations in the Fairbanks area. In the Matanuska-Susitna Valley, the Kepler-Brady lake system was treated with rotenone prior to stocking in the 1960s. In 2000, an unnamed lake on the Kenai Peninsula was treated with rotenone to remove a population of illegally stocked yellow perch.

The scientific literature contains conflicting reports on the effect of rotenone on plankton communities. Anderson (1970) suggests that the use of rotenone is less devastating to zooplankton species when it is applied after they reach their reproductive peak. It took one to three years for plankton communities to retain their pre-rotenone abundance in two alpine lakes. Bandow (1980) indicated that calanoid copepods, the most abundant zooplankton at the time of rotenone treatment, did not regain their former abundance level after two years. Instead, daphnia became the most abundant zooplankter in the community. However, Bandow (1980) stated that over an extended time period, rotenone did not have detrimental impacts on rotifers.

5.1.3 *Costs Analysis:* The use of rotenone as a control measure would have high costs associated with it. Costs would include purchasing enough rotenone to treat an entire lake, potentially purchasing enough potassium permanganate to neutralize the lake after the treatment, training staff in the use of rotenone, staff time during public outreach efforts, staff time during treatment implementation, and hatchery expenses to rear fish for introduction after pike have been eradicated from waters with public access.

5.1.4 *Long-term Effects and Impacts:* Because rotenone can be neutralized and naturally breaks down within five weeks, there are few long-term impacts from this method. Zooplankton communities, however, may take longer to recover.

5.1.5 *Permit and Approval Requirements:* If rotenone is a recommended management option, the Department will be required to notify and obtain written consent from the BOF, through the commissioner's office as specified in AS 16.35.200 (LexisNexis 2006). The Department would also work with DNR and DEC as well as local governments and community councils to seek approval. Extensive public outreach efforts would be initiated to inform the public about rotenone and the Department's plans for using it to eradicate pike.

5.1.6. *Impacts to Non-target Species:* Unless pike are the only fish species present in the lake, all other native fishes would be killed by rotenone during the treatment. Terrestrial species would not be impacted.

5.1.1 *Technique:* **Chemical Treatment –** <u>Other Chemical Compounds</u>

5.1.2 *Advantages and Disadvantages:* Only four compounds are currently registered as piscicides for use in fisheries in the United States: rotenone, antimycin, 3-trifluoromethyl-4 nitrophenol (TFM), and Bayluscide. TFM and Bayluscide are used for sea lamprey control. Antimycin is an antibiotic produced by mold that can cause fish mortalities and is considered to be potentially more effective than rotenone, particularly for the treatment of streams.

5.1.3 *Costs Analysis:* The use of other chemical compounds as a control measure would also have high costs. Costs would include purchasing enough of the chemical to treat an entire water body, training staff in the use of the chemical, staff time during public outreach efforts, staff time during treatment implementation, and hatchery expenses to rear fish for introduction after pike have been eradicated.

5.1.4 *Long-term Effects and Impacts:* Long-term effects are limited for known and approved fishery piscicides.

5.1.5 *Permit and Approval Requirements:* If other chemical treatments are recommended, the Department will be required to notify and obtain written consent for use from the BOF through the commissioner's office as specified in AS 16.35.200 (LexisNexis 2006). The Department would also work with DNR and DEC as well as local governments and community councils to seek approval. Extensive public outreach efforts would be initiated to inform the public about these chemicals and the Department's plans for using them to eradicate pike.

5.1.6. *Impacts to Non-target Species:* Unless pike are the only fish species present in the lake, all other native fishes would be killed by chemical treatments. Terrestrial species would not be impacted by piscicides such as antimycin, TFM, and Balyuscide.

5.1.1 *Technique:* **Biological Treatments**

5.1.2 *Advantages and Disadvantages:* Advantages and disadvantages differ by biological treatment (Raat 1988).

Predator Introduction: In some locations in the continental United States, sterile hybrid tiger muskellunge (*Esox masquinongy)* have been introduced to control pike populations. However, these introductions were costly and were only marginally successful because it appears that pike outcompete muskellunge. The intentional introduction of a non-indigenous predator to a fish assemblage exacerbates stocking concerns unless there is a reduction in the reproductive potential of the invasive population (i.e., sterilization). Importation, transportation, and release of live non-indigenous fish is prohibited as specified in AS 16.35.210 (LexisNexis 2006). This state statute defines “non-indigenous fish” as any species of fish that is not native to the body of water into which it is to be released. This law precludes almost all predator introductions.

Disease Introduction: Although both viral and bacterial diseases of pike occur, none of them are known to cause mortality exclusively in pike. The introduction of any pathogen would be an extreme measure due to the potential mortality of resident fish populations. Therefore, any consideration of using disease introduction to control pike would be risky. Diseases that affect pike include the following:

Pike fry rhabdovirus – affects larval pike until they reach 4-5 cm in length.

Lymphosarcoma – blood cancer caused by a highly infectious virus; however, the virus and tumor growth are sensitive to water temperature.

Egtved virus – causes a hemorrhagic septicemia usually in rainbow trout that can be transmitted to salmon. Pike embryos and larvae can be infected by the virus through water, food, and injection. Pike populations can carry the virus and be potential Egtved reservoirs. Use of this disease for pike reduction is not a consideration because of the potential impacts to wild stocks of trout and salmon. Pike fry rhabdovirus and egtved virus are defined as Class I diseases of critical concern for Alaska.

Bacterial diseases- a number of fish diseases that can kill pike are caused by bacteria, including red sore, black spot, and furunculosis: however, they also affect other species of fish. For this reason, they are not considered a viable option for removal of invasive pike.

Parasite Introduction: Pike are a relatively long-lived freshwater species and, therefore, have a number of helminth and crustacean parasites. However, fatal infections with these organisms are unlikely and not well documented in the literature. In North America, trematodes and nematodes are common pike parasites, and there are several species of protozoa, cestodes, acanthocephala, and crustaceans that are parasitic on pike at various stages (Smith 1986). Use of parasites to eliminate invasive pike is not likely to be a viable control mechanism.

5.1.3 *Costs Analysis:* Costs for biological controls would be high. The costs would include research and lab-testing, rearing, introducing the biological control, and subsequent monitoring to evaluate its effectiveness in reducing populations of pike. If the biological control were to, itself, become invasive, there would be substantial costs to contain it.

5.1.4 *Long-term Effects and Impacts:* There are numerous cases where the introduction of a biological control has been more problematic in the long term than the original nuisance organisms. Pike are an example of this in some states. Introductions of non-indigenous species, whether for biological control or not, will likely have long-term ecological and economic impacts.

5.1.5 *Permit and Approval Requirements:* The introduction of a biological control would require substantial permitting and approval procedures through the DNR, USFWS, and ADF&G.

5.1.6. *Impacts to Non-target Species:* Unless pike are the only fish species present in the lake, all other native fishes would be impacted by biological controls.

5.2 Techniques for Managing A Pike Fishery

In some systems, complete eradication or even control of northern pike may prove impossible. In these cases, the alternative might be to develop fisheries to manage the existing pike populations. Management strategies for pike that could be used include instituting slot limits and managing for trophy fisheries, liberalizing bag and possession limits, and establishing commercial and personal use fisheries. These management strategies could assist the Department in meeting fishery objectives aimed at harvesting specific numbers of pike and providing specific numbers of angler days each year.

Instituting slot limits and managing for trophy fisheries would protect large size classes of pike. For example, an angler could fish for an unlimited number of pike below a certain size limit. If anglers catch a pike larger than that size limit, they would only be allowed to harvest one per day. Anglers would be required to keep all fish below that size limit that they catch. A strategy like this could theoretically reduce the number of small pike in a water body. Allowing harvests of large pike would encourage continuous angling. Larger pike would cannibalize smaller pike, and this would further reduce the pike population. A fishery such as this would have to be managed very carefully. If too many large pike were harvested, the overall pike population would become stunted. Anglers could lose interest, and fishery management objectives might not be met. Trophy fisheries could be very successful in remote locations where containment of pike is possible (i.e. low possibility of floods that could facilitate pike dispersal and limited access to other water bodies so pike could not easily be transported to new locations).

Simply liberalizing bag and possession limits might be another tactic the Department could employ. This strategy has currently been adopted by the BOF in most water bodies outside the native range for pike. This may be successful in reducing overall populations of pike and meeting fishery objectives, but the overall effectiveness of this method would depend on anglers actually harvesting pike rather than releasing them. The concern in liberalizing bag limits and not managing for large pike is that pike populations will eventually become stunted, and then maintaining angler interest may be difficult. Raising pike in hatcheries for the purpose of stocking sterile, large pike into these water bodies may be one way to counteract this problem, but this would require significant funding and time.

A third strategy might be to open commercial and/or personal use fisheries for pike. The success of these fisheries would depend on the level of interest and development of markets, but they could assist in reducing overall populations of pike.

Regardless of which management strategies were chosen, regulations would need to be adopted by the BOF, administered by the Department, and based on the sustainable yield principle.

5.3 Consequences of Inaction

If actions are not taken to control and/ or eradicate northern pike in waters outside their native range, continued adverse impacts to Alaska's environment and economy are certain. Failure to educate the public about the consequences of illegal pike introductions may result in a higher than acceptable risk that pike will continue to be illegally introduced by well-intentioned, but uninformed people. If the public is not educated and aware of the dangers of illegal pike and/or other ANS introductions, they may continue transferring ANS, compounding the ecological and economic impacts. If actions to control or eradicate pike are not undertaken, salmonids, other native fishes, amphibians, waterfowl, mammals, and the general ecology of invaded systems will continue to be impacted. Alaska's economy is based on natural resources, and the fish and wildlife resources of the state are extremely valuable. The decision not to implement pike control programs would ensure the continued loss of economically important fisheries and eliminate any possibility of restoring fisheries that have already been destroyed. As fisheries lose viability, angling-related tourism will decline, resulting in tremendous losses to the state's economy. Sales of fishing licenses and fishing gear may decline, directly impacting the Department's budget. Reduced funding for ADF&G's programming could ultimately inhibit the Department's ability to carry out its mission to protect, maintain, and improve the fish, game, and aquatic plant resources of the state, and manage their use and development for the maximum benefit of Alaskans, consistent with the sustained yield principle.

5.4 Summary of Restoration Findings

Unfortunately, no single management action, option, or tool will reverse the introduction and establishment of viable pike populations in open systems. The Department can encourage pike harvests through fishing regulations, but removing pike from large watersheds would be a significant undertaking. The combination of environmental tolerance, high reproductive potential, and the capability to quickly disperse are key characteristics of a persistent ANS. Controlling or eradicating an ANS like pike is difficult and costly.

Many other states are struggling with pike introductions in both open and closed systems. Aside from dewatering, treating small lakes with rotenone is the only proven and cost-effective method to eradicate pike. However, there has been a significant amount of public controversy regarding its use other states. In most cases, controversies may have been prevented by increasing public awareness about the benefits of rotenone and the management decisions that led to its use. Intensive trapping or netting reduces pike populations over the short term, but this is a less effective removal method overall because it is virtually impossible to catch all pike in a system. These methods are costly and require a significant amount of time. ADF&G can initiate netting efforts in selected lakes to start reducing pike populations while gaining insights and developing strategies to improve pike removal in larger lakes and open systems. Netting removal efforts are currently underway and are periodically evaluated to assess their benefits.

Candidate lakes for pike removal should have a relatively large abundance of pike or pike spawning habitat, demonstrate that hatchery releases or natural fish production are not meeting fishery management objectives, or demonstrate interference by pike in ecosystem functions. Many of the aforementioned management alternatives necessitate BOF approval, and all would require public support. Implementation of one or more of the management alternatives for pike control will benefit invaded ecosystems and lead to the restoration of Alaska's fisheries. Information services and public processes should promote an informed and involved public that will support the Department's efforts for pike control and/or eradication. This will foster partnerships between ADF&G, collaborating agencies, and the public to protect native species and restore fisheries.

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Table 1. Confirmed and suspected pike waters in the Upper Cook Inlet Management Area; Figure-No. identifies the labels in Figures 4 and 5.

Location	System / Area	Lake	Confirmed	Suspected	Figure - No.
Susitna Basin	Alexander Creek		x		4
		Alexander Lake	x		4-46
		Sucker Lake	x		4-47
		Trail Lake	x		4-48
		Rabbit Lake	x		4-49
	Lower Susitna		x		
		Figure 8 Lake	x		4-50
		Flathorn Lake	x		4-51
	Mid - Susitna		x		
		Lady Slipper	x		4-52
		Lockwood Lake	x		4-54
		Witsoe Lake	x		4-55
		Witsol Lake	x		4-58
		Unnamed	x		*
		Unnamed	x		*
		Unnamed	x		*
		Vern Lake	x		*
		Ding Dong Lake	x		*
		Yensus Lake		x	*
	Yentna River		x		4
		Fish Creek Lakes	x		4-6
		Hewitt Lake	x		4-35
		Whiskey Lake	x		4-36
		Donkey Lake	x		4-52
		Bulchitna Lake	x		4-53
		Chelatna Lake	x		4-59
		No Name (Big Bend)	x		*
		Cabin Lake (Big Bend)	x		*
		Stickleback Lake	x		*
	Skwentna River		x		4
		Shell Lake	x		4-1
		One Stone Lake	x		4-2
		No Name (East of Shell)	x		4-3
		Eight Mile Lake	x		4-4
		Seven Mile Lake	x		4-5
	Deshka River		x		4
		Neil Lake	x		4-7
		Ambler Lake	x		4-8
		Parker Lake	x		4-9
		No Name 1mi SW Parker	x		4-10
		No Name 2 mi SW Parker	x		4-11
		Trapper Lake	x		4-39
		Kroto Lake	x		4-60

Table 1. Continued…

Location	System / Area	Lake	Confirmed	Suspected	Figure - No.
		No Name Lake	x		*
	Upper Susitna		x		
		Kashwitna Lake		x	4-31
		Caswell Lake		x	4-30
		Fish Lake (Birch Ck)		x	*
		Sawmill Lake		x	*
	Nancy Lake Area	Chicken Lake	x		4-12
		Cow Lake	x		4-13
		Lynx Lake	x		4-14
		Phoebe Lake	x		4-15
		Owl Lake	x		4-16
		Little No Luck Lake		x	4-17
		Little Chicken Lake	x		4-18
		James Lake	x		4-19
		Char Lake	x		4-20
		Frazer Lake	x		4-21
		Crystal Lake (Willow)	x		4-24
		South Rolly Lake	x		4-26
		North Rolly Lake	x		4-29
		Denaina Lake (Tanaina)	x		4-33
		Rainbow Lake		x	4-38
		Big No Luck Lake	x		4-42
		Long Lake (Willow)	x		4-44
		Redshirt Lake	x		4-45
		Nancy Lake	x		4-63
		Milo Lake	x		*
		Little Frazer Lake	x		*
		Ardaw Lake	x		*
		Echo Ponds	x		*
		Candle Stick Lake	x		*
		Bains Ponds	x		*
	Little Susitna River		x		4
		Horseshoe Lake (Little-Su)		x	4-43
		Swan Lake		x	*
Susitna Tributaries	Fish Creek		x		4
	Fish Creek (Kroto)		x		4
	Lake Creek		x		4
	Fish Lake Creek		x		4
	Trappers Creek		x		4
	Sucker Creek		x		4
	Montana Creek		x		4
	Rolly Creek		x		4
	Moose Creek		x		4
	Bottle Creek		x		4
	Hewitt Creek		x		4
	Donkey Creek		x		4
	Indian Creek		x		4

Table 1. Continued…

Location	System / Area	Lake	Confirmed	Suspected	Figure - No.
	Rabideux Creek		x		4
	Kutna Creek		x		4
	Shell Creek		x		4
	Eightmile Creek		x		4
	Caswell Creek		x		4
	Johnson Creek		x		4
	Tokositna Creek		x		4
	Trapper Creek			x	4
	Talachulitna Creek			x	4
	Sunshine Creek			x	4
	Anderson Creek			x	4
	Wiggel Creek			x	4
	Birch Creek			x	4
	Chulitna River			x	4
	Witsoe Creek		x		*
	Otter Creek		x		*
	Unnamed		x		*
	Indian (Chulitna)			x	*
Knik Arm Drainage	Meadow Creek			x	4
	Fish Creek			x	4
		Memory Lake	x		4-25
		Finger Lake		x	4-27
		Knik Lake	x		4-28
		Rocky Lake	x		4-32
		Big Lake	x		4-34
		Swan Lake	x		4-37
		Wasilla Lake		x	4-40
		Andersen Lake	x		4-41
		Pear Lake (Upper Skwenta)	x		4-57
		Wallace Lake	x		4-61
		Jim Lake		x	4-62
		Blodgett Lake		x	*
		West Beaver Lake		x	*
		Mud Lake		x	*
		Big Lake cut-off Lake	x		*
		Shirley Lake (Willow)		x	*
		Prator Lake	x		*
West Cook Inlet	Chuit River		x		5
		Chuitbunga Lake	x		5-23
	Threemile Creek		x		5
		Tukallah Lake	x		5-22
		Threemile Lakes	x		*
	Nikolai River		x		5

* Unnamed or unofficially named water bodies that are not labeled on the maps

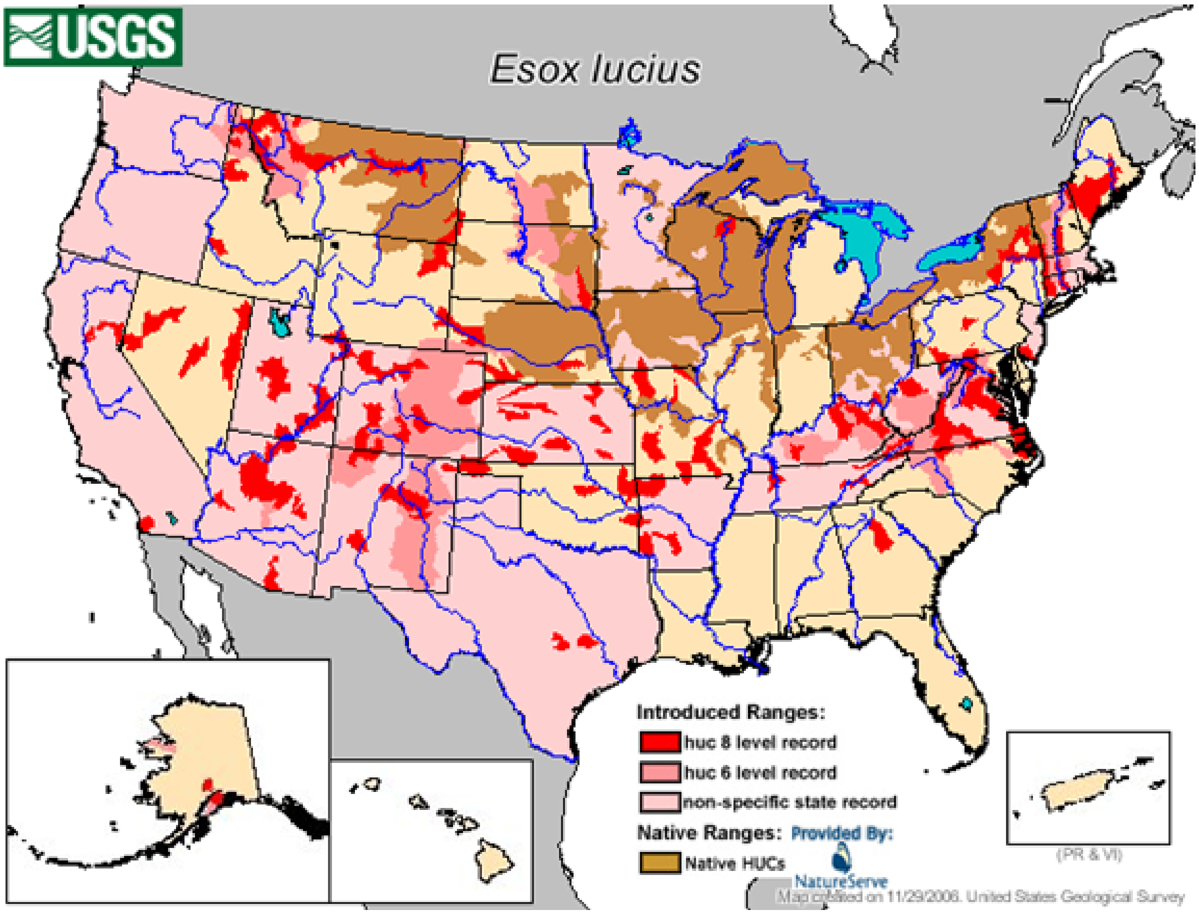
Table 2. Confirmed and suspected pike waters in the Anchorage Management Area; Figure-No. identifies the labels in Figure 6.

Location	System / Area	Lake	Confirmed	Suspected	Figure - No.
Anchorage		Cheney Lake	x		6-1
		Sand Lake	x		6-4
	Campbell Creek		x		6
Eagle River	Fire Creek		x		6
		Lower Fire Lake	x		6-2
		Upper Fire Lake	x		6-3
	Mink Creek		x		6
Elmendorf AFB		Fish Lake	x		6-5
Fort Richardson		Otter Lake	x		6-6
		Gwen Lake	x		6-7

Table 3. Confirmed and suspected pike waters in the Kenai Peninsula Management Area; Figure-No. identifies the labels in Figure 7.

Location	System / Area	Lake	Confirmed	Suspected	Figure - No.
Soldotna	Soldotna Creek		x		7
		Derks Lake	x		7-1
		Sevena Lake	x		7-2
		Cicsca Lake		X	7-5
		East Mackey Lake	x		7-14
		West Mackey Lake	x		7-15
		Union Lake	x		7-16
		Denise Lake	x		7-17
		Tree Lake	x		7-18
		Tote Road Lakes	x		7-19
		Arc Lake	x		7-20
		Scout Lake	x		7-21
	Moose River		x		7
		Watson Lake		X	7-4
		Silver Lake		X	7-6
		Mosquito Lake		X	7-7
		Camp Island Lake		X	7-8
		Grebe Lake		X	7-9
		Rock Lake		X	7-10
		Swan Lake		X	7-11
		Loon Lake		X	7-12
		Moosehorn Lake		X	7-13
		Egumen Lake	x		7-23
		Pederson Lake		X	*
Nikiski		Stormy Lake	x		7-3
		Cabin Lake		X	7-22

Locations of Non-indigenous Northern Pike Populations in the United States



Map used with permission from Pam Fuller, USGS Non-indigenous Aquatic Species Program (http://nas.er.usgs.gov)

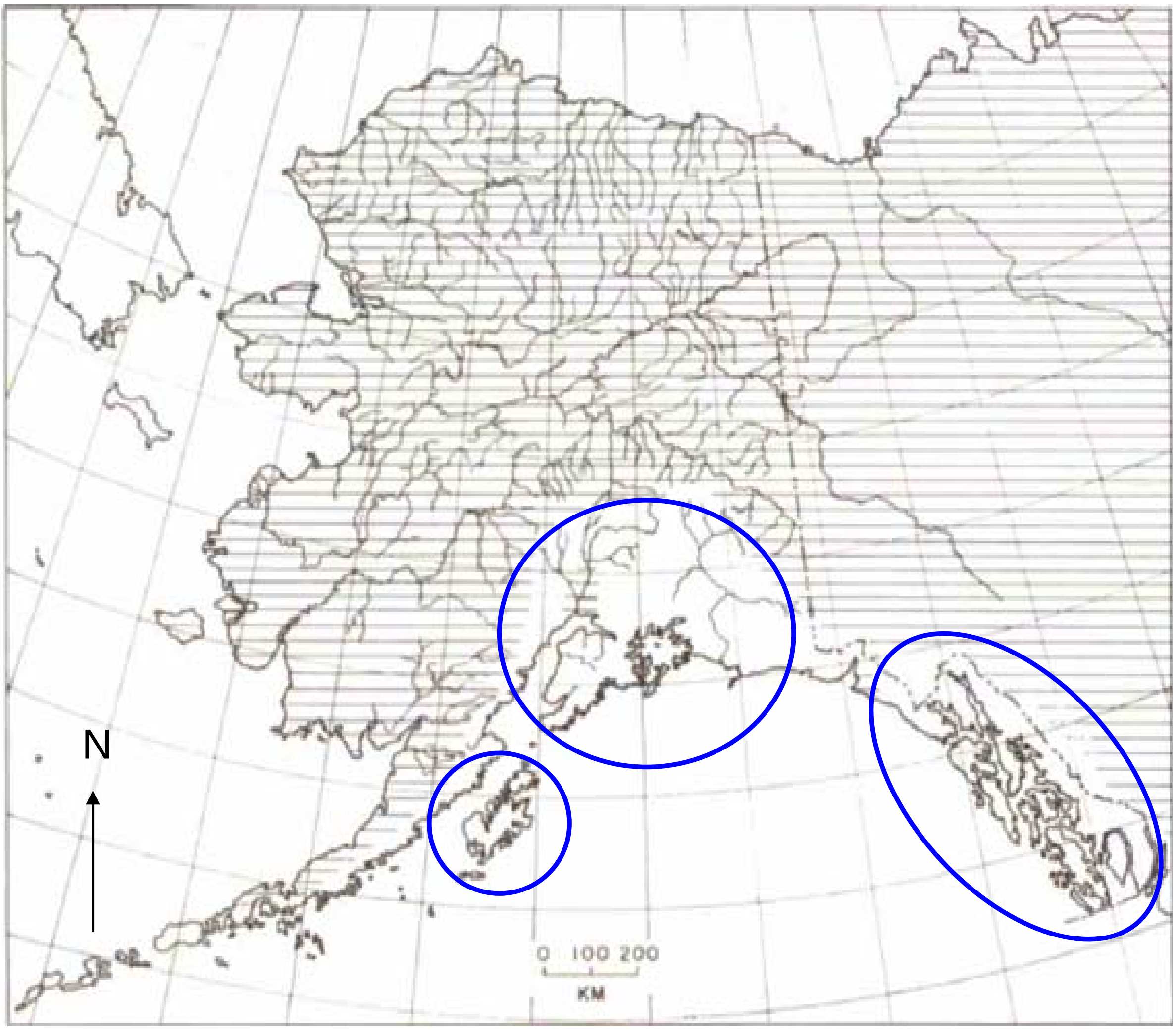
Note: HUC (Hydrologic Unit Code) is a system employed by the USGS to identify specific hydrologic areas

Figure 1

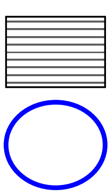
Northern Pike

Figure 2

Native and Non-native Ranges of Northern Pike Populations in Alaska



This map was originally published in Morrow 1980

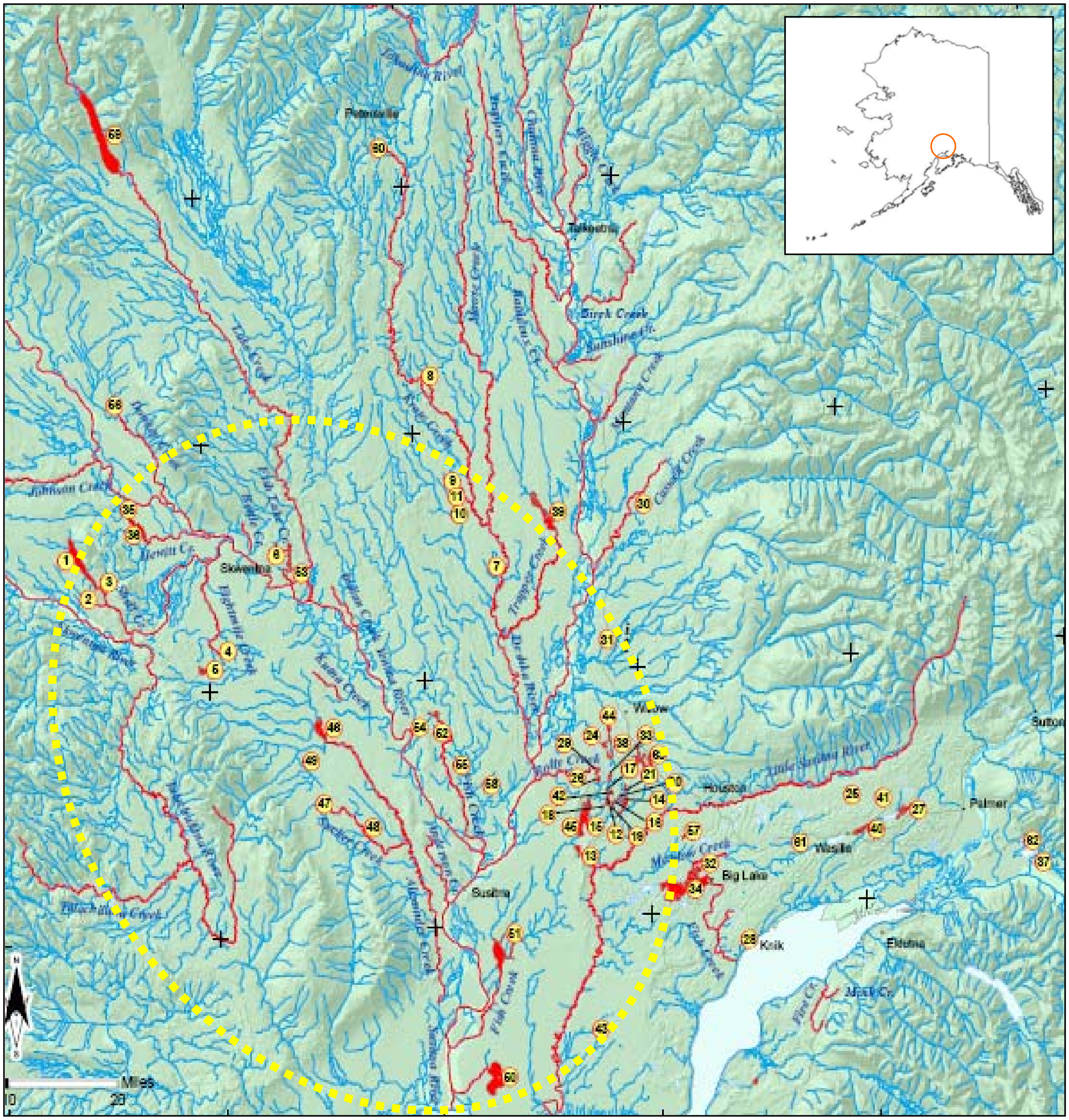


Native range of Northern Pike in Alaska and northwestern Canada

Regions in Alaska where Northern Pike are not native

Figure 3

Confirmed and Suspected Pike Waters in the Upper Cook Inlet Management Area



General area within the Susitna Basin with the most ideal habitat for pike

Figure 4

Confirmed and Suspected Pike Waters in West Cook Inlet

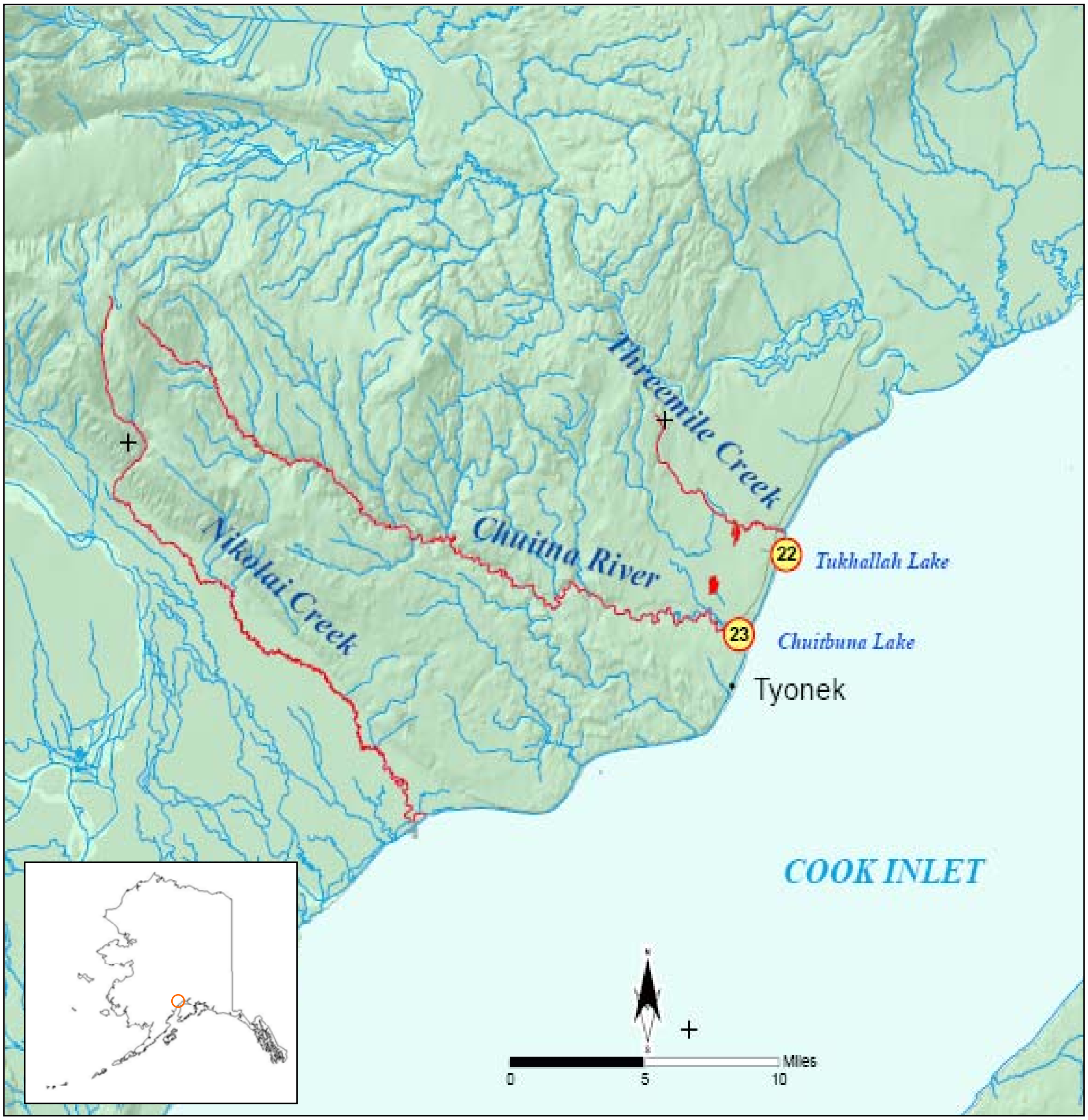


Figure 5

Confirmed and Suspected Pike Waters in the Anchorage Management Area

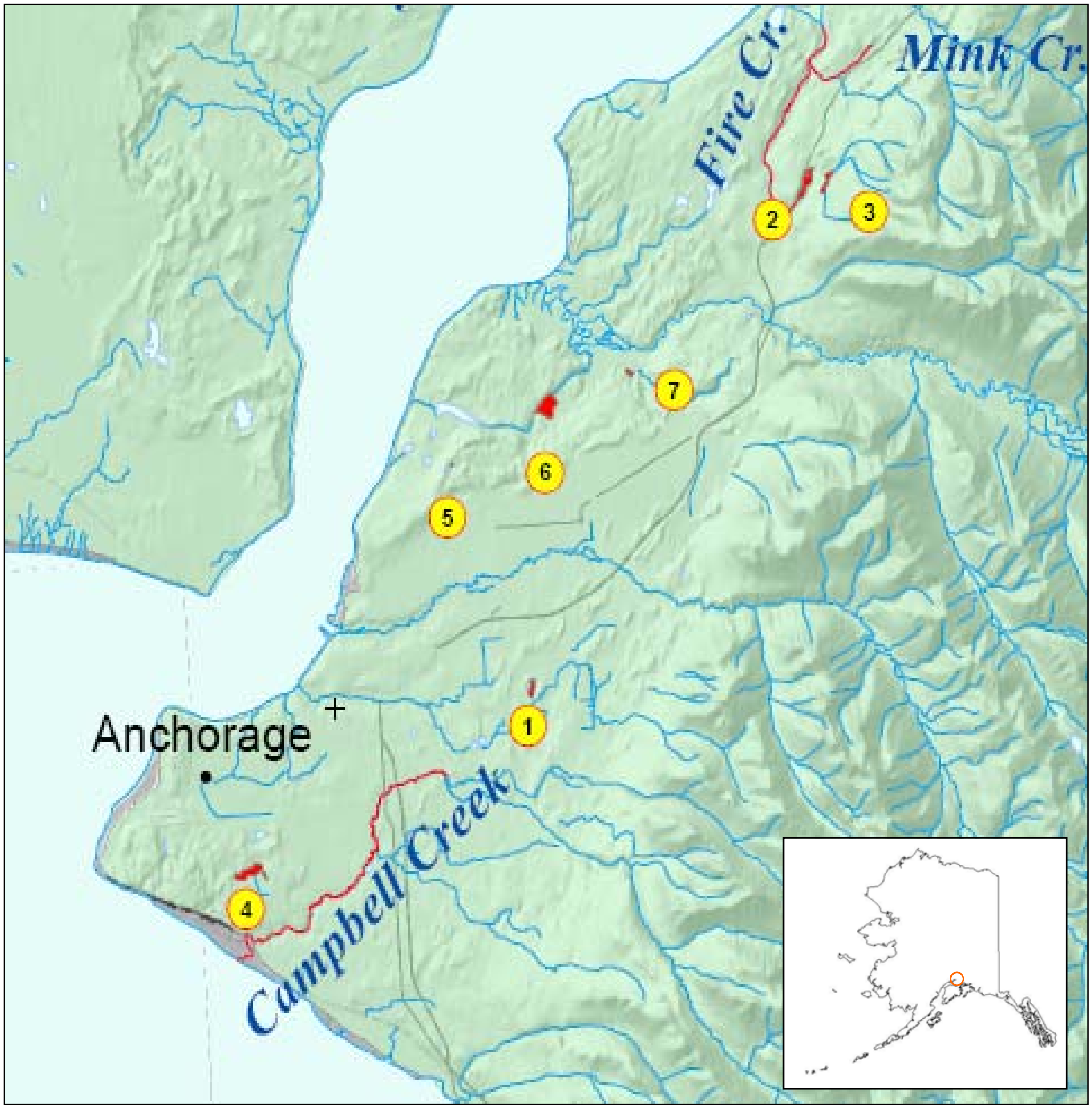


Figure 6

Confirmed and Suspected Pike Waters in the Kenai Peninsula Management Area

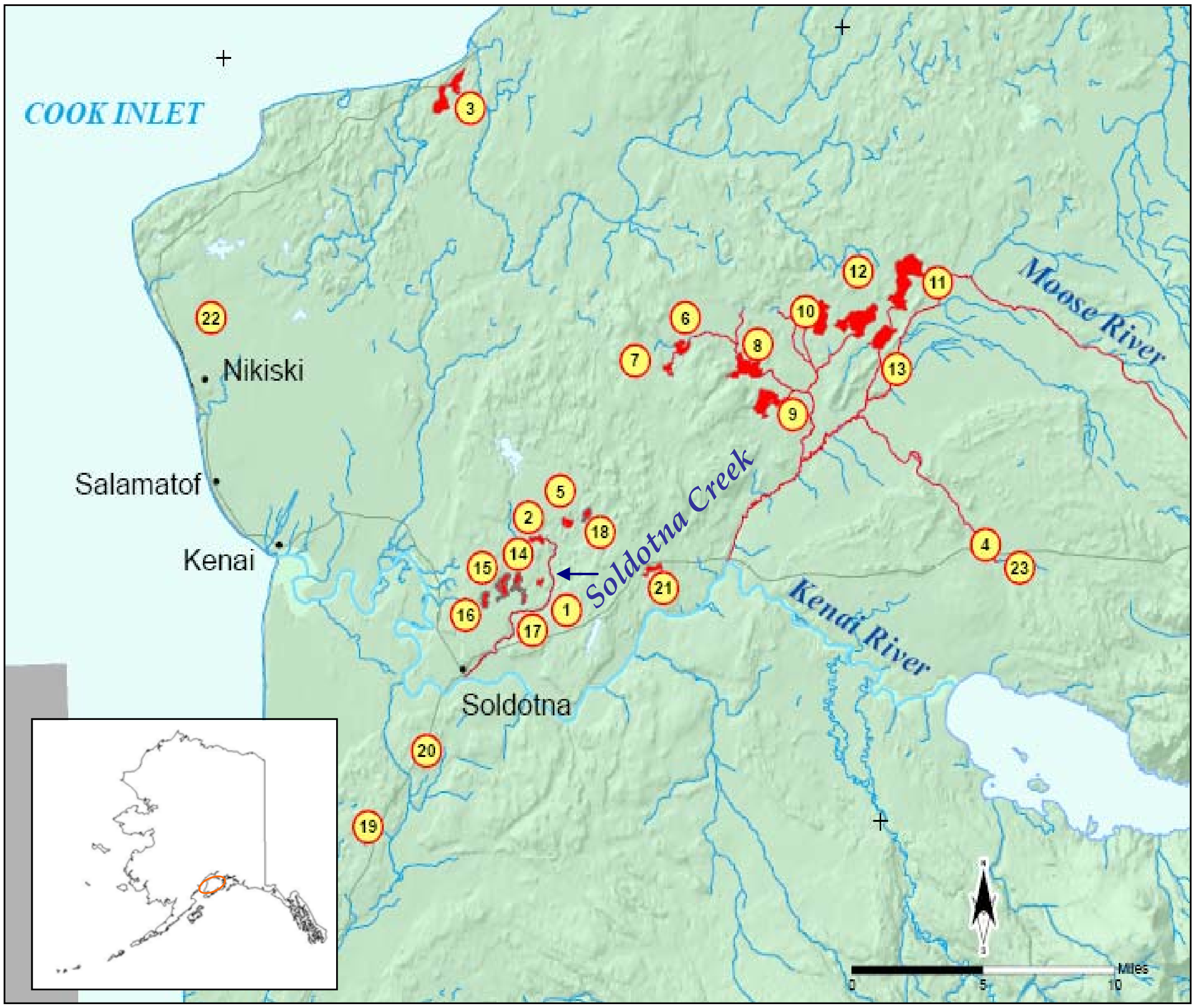


Figure 7

Yakutat Region and the Village Pond System Containing Pike

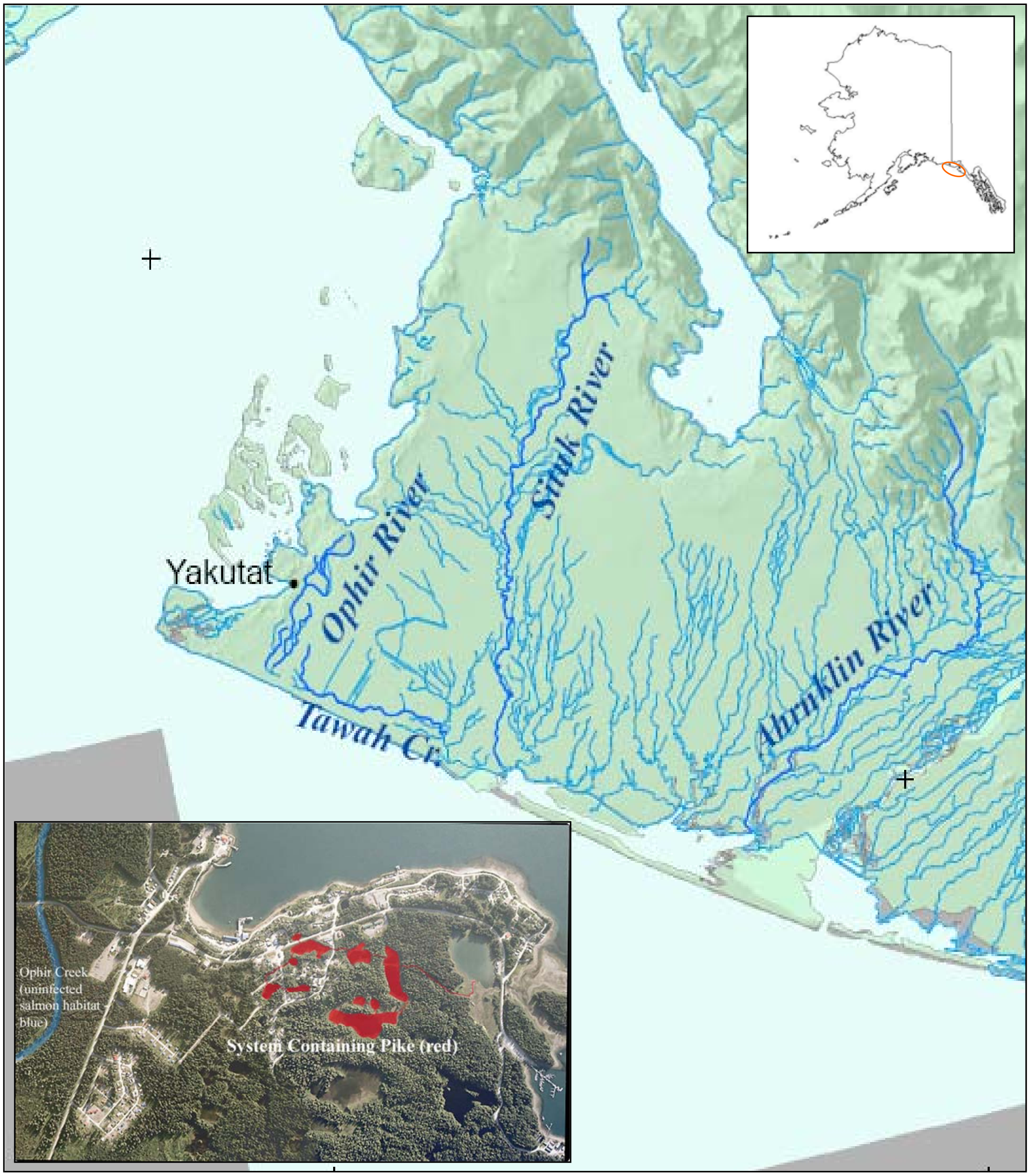


Figure 8

Prince William Sound Drainages

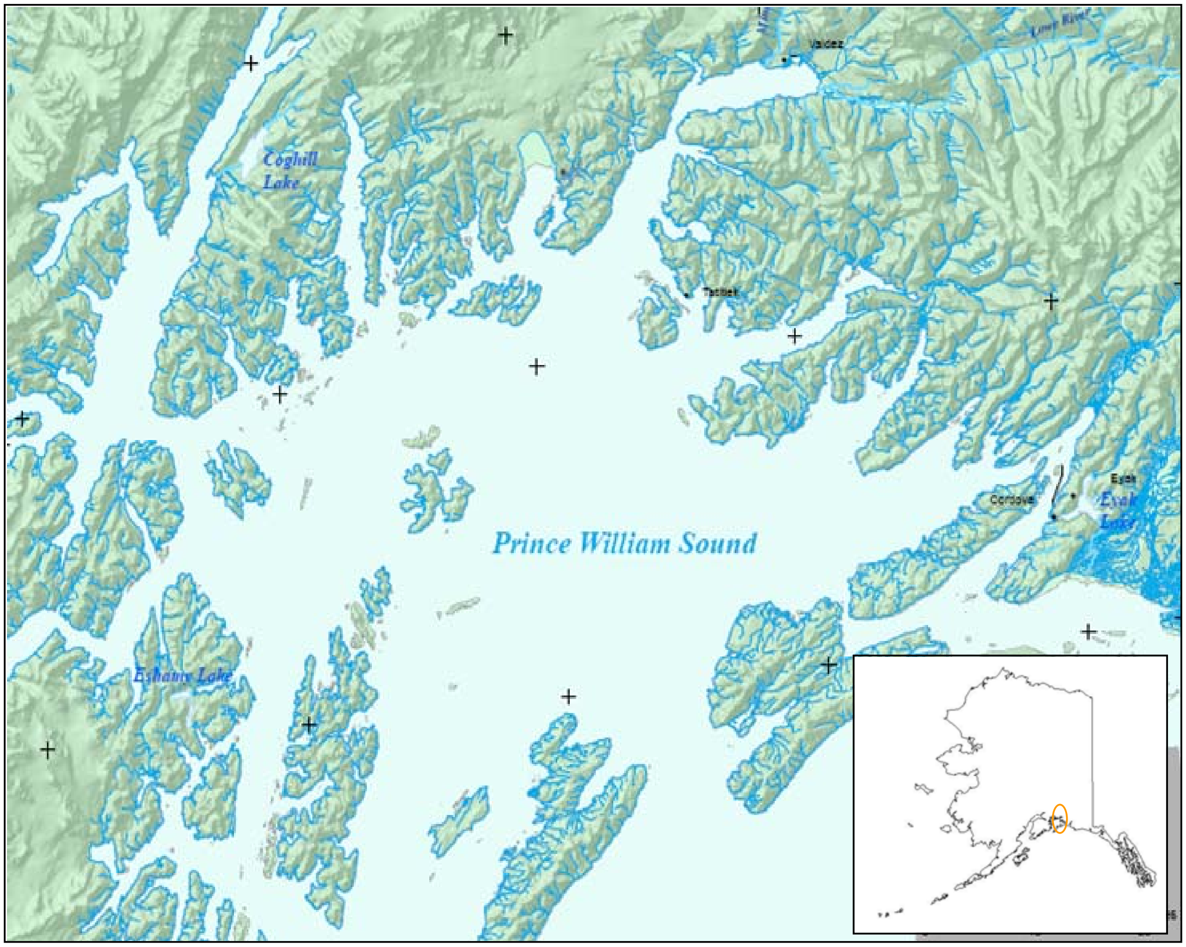


Figure 9

Copper River Drainages

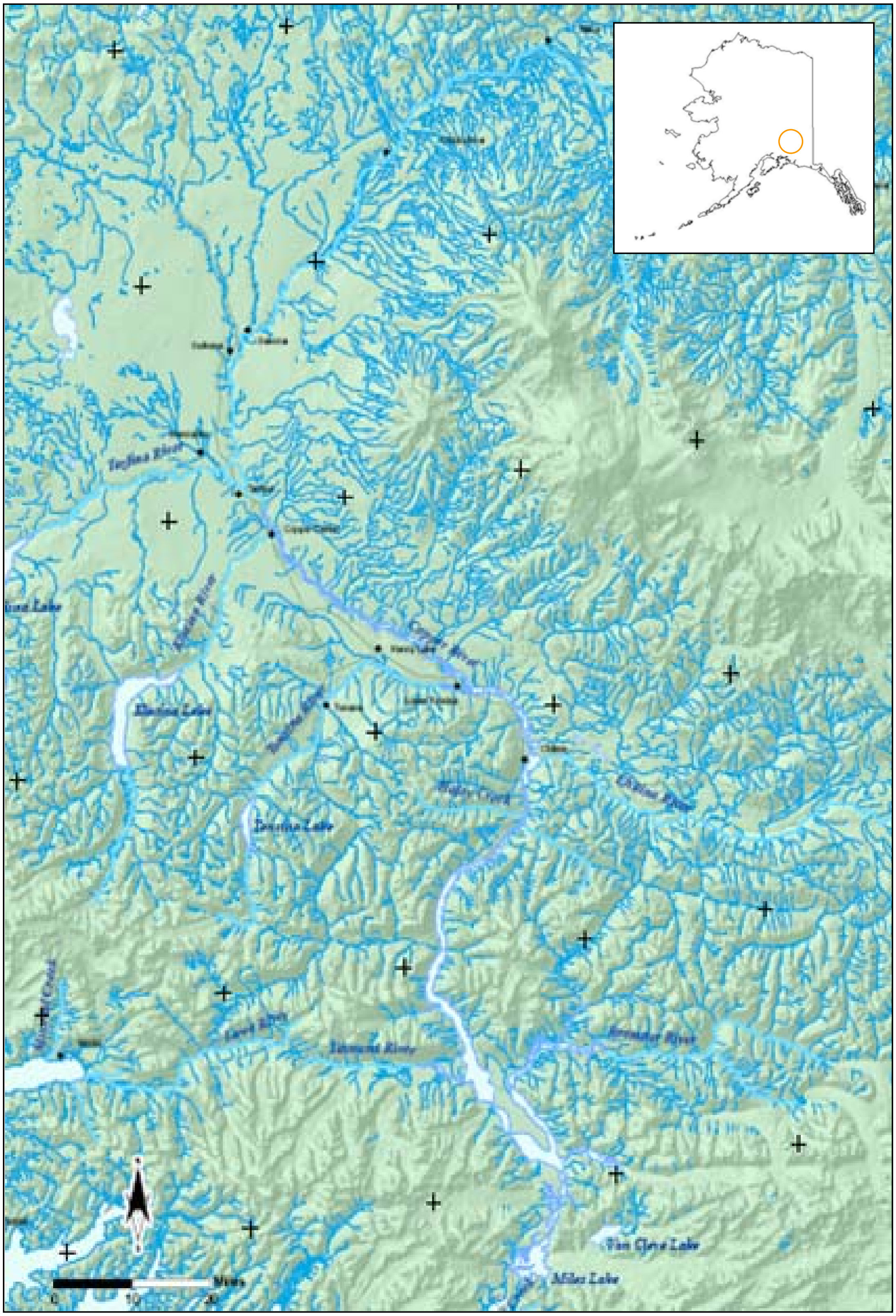


Figure 10

Pike Control Management Process

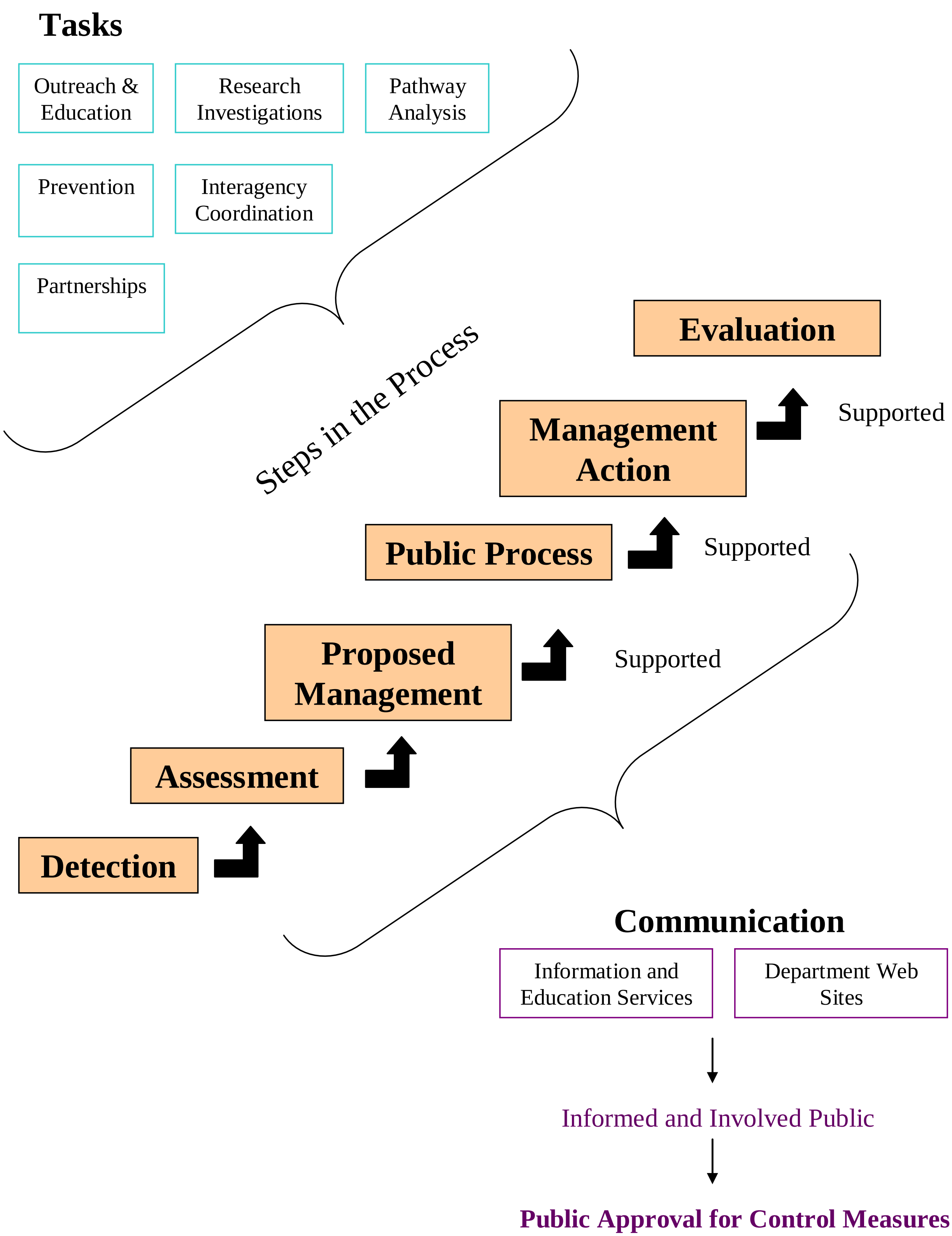


Figure 11

Web Site Organization

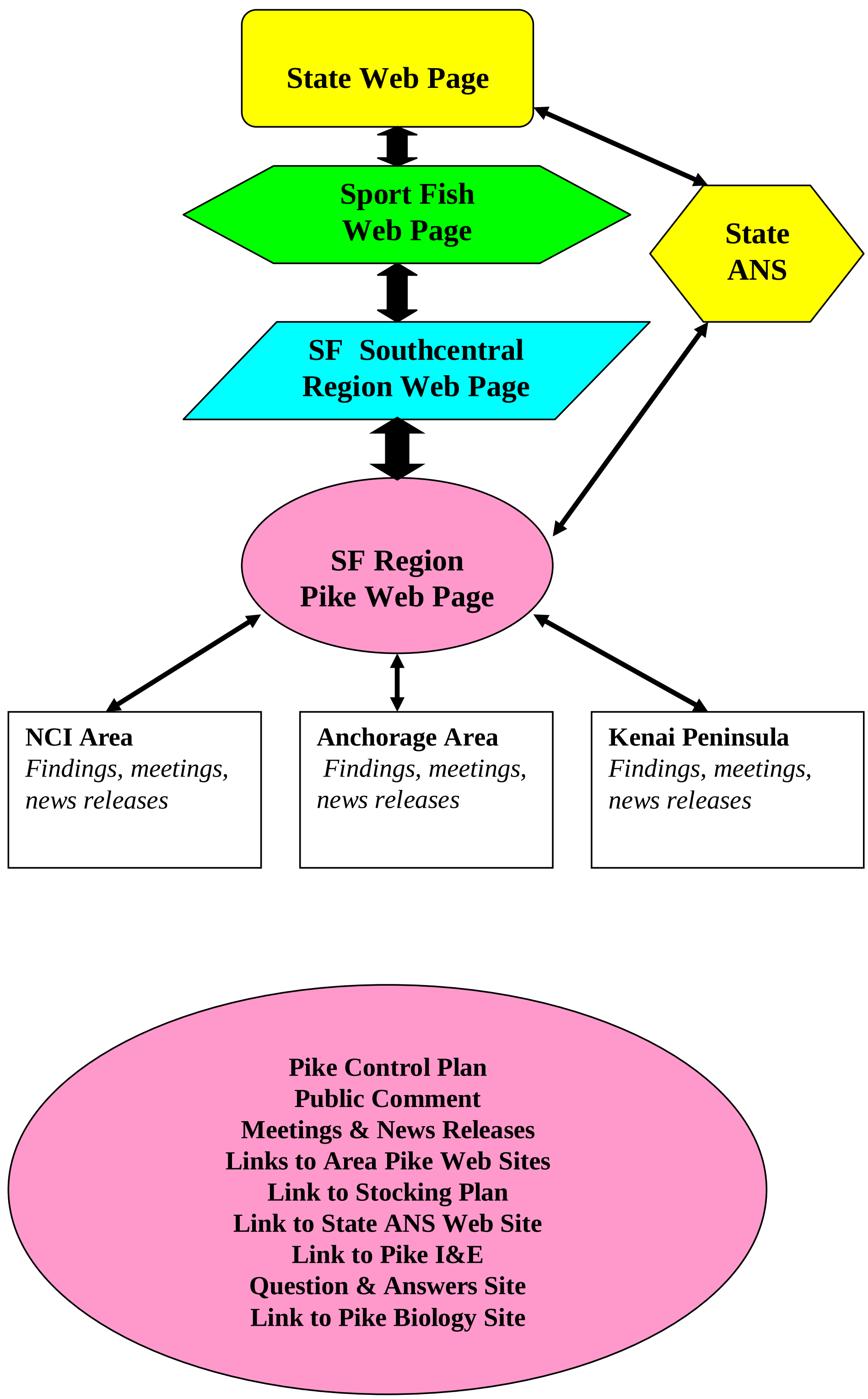


Figure 12

Appendix A. Pike Control Committee

Southcentral Alaska Northern Pike Control Committee:

Kristine Dunker, Sport Fish Division – Alaska Department of Fish and Game
Dave Rutz, Sport Fish Division – Alaska Department of Fish and Game
Sam Ivey, Sport Fish Division – Alaska Department of Fish and Game
Matthew Miller, Sport Fish Division – Alaska Department of Fish and Game
Dan Bosch, Sport Fish Division – Alaska Department of Fish and Game
Tim McKinley, Sport Fish Division – Alaska Department of Fish and Game
Rob Massengill, Sport Fish Division – Alaska Department of Fish and Game
Bob Johnson, Sport Fish Division – Alaska Department of Fish and Game
Lisa Olson, Sport Fish Division – Alaska Department of Fish and Game
Denny Lassuy, U.S. Fish and Wildlife Service

Appendix B. Planning Elements, Desired Outcomes, Tasks and Assignments

Planning Elements, Desired Outcomes, Tasks and Assignments

Vision: Fishery restoration by eradicating illegal pike introductions.

Elements	Desired Outcomes	Tasks & Assignments
Department & Divisional Leadership	Vision & Support	Confirmation
	Informed Public	Awareness
	Funding & Staffing	Planning Horizon
	Policy	Conflict Resolution
	Cooperative Agreements	Oversight
Regional		
Management	Fishery Restoration	Leadership & Support
Research	Improve Knowledge	Effective methods
Hatchery Program	Coordination	Products for restocking
Informational Services	Awareness, Prevention	Public Ed, Web Site
Administrative Support	Staff Support	
Area		
Management	Fishery Restoration	Area Leadership
I&E	Informed Public	Support
Research	Improve Knowledge	Area Assessments
Administrative Support	Staff & Public Support	
BOF & AC's	Awareness, Support, Ed	Public Participation
Public Involvement	Awareness, Support, Ed	Public Participation
Public Education	Prevention, Awareness & Informed Public	News Releases, I&E Web Site development
Partnerships		
Agencies		
State & Federal	Collaboration & Coordination, Permitting, Public Education	Program Participation
Stakeholder Groups	Awareness, Support, Ed	Participation

Appendix C. Interagency Planning Table

A. Prevention

Task	Fund Source	Task Lead	FY07	FY08	FY09	FY10	FY11
Pathway Analysis		ADF&G					
Contact Network		ADF&G					
Develop Management Strategy		ADF&G					
Implement Management Strategy		ADF&G					
Education & Outreach							
Partnerships							

B. Restoration

Task	Fund Source	Task Lead	FY07	FY08	FY09	FY10	FY11
Informed & Involved Public		ADF&G					
Detection & Monitoring		ADF&G					
Equipment		ADF&G					
Rotenone Treatment		ADF&G					
Equipment		ADF&G					
Enhancement		ADF&G					
Research		ADF&G					

C. Information and Data Management

Task	Fund Source	Task Lead	FY07	FY08	FY09	FY10	FY11
Information Dissemination							
Reporting							
Distribution Development							
Literature Search							
Database Management							
GIS Maintenance							

Appendix D. List of Acronyms

AAC – Alaska Administrative Code
ACMP – Alaska Coastal Management program
ADF&G – Alaska Department of Fish and Game
ANS – Aquatic Nuisance Species
ANSMP – Aquatic Nuisance Species Management Plan
AS – Alaska Statutes
BOF – Board of Fish
CDF&G – California Department of Fish and Game
CPUE – Catch Per Unit Effort
DNR – Department of Natural Resources
DO – Dissolved Oxygen
GIS – Geographic Information System
I & E – Information and Education
NCIMA – Northern Cook Inlet Management Area
SHS – Statewide Harvest Survey
SSPRF – Statewide Stocking Plan for Recreational Fisheries
TFM – 3-Triflouromethyl-4 Niptrophenol
USFWS – U.S. Fish and Wildlife Service